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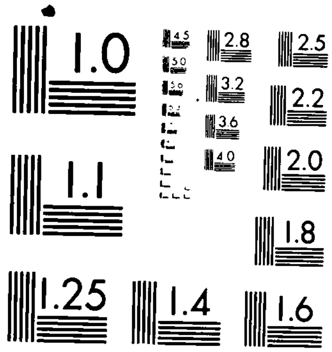

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INSTRUCTION REPORT HL-85-1

USER'S MANUAL FOR THE GENERALIZED COMPUTER PROGRAM SYSTEM

OPEN-CHANNEL FLOW AND SEDIMENTATION TABS-2

Main Text and Appendices A Through O

by

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US ARMY ENGINEER WATERWAYS EXPERIMENT STATION

August 1985

Final Report

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19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

Computer programs--Handbooks, manuals, etc. (LC)
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Sediment transport--Computer programs (LC)
TABS-2 (Computer programs) (WES)

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

TABS-2 is a generalized numerical modeling system for open-channel flows, sedimentation, and constituent transport. It consists of more than 40 computer programs to perform modeling and related tasks. The major modeling components--RMA-2V, STUDH, and RMA-4--calculate two-dimensional, depth-averaged flows, sedimentation, and dispersive transport, respectively. The other programs in the system perform digitizing, mesh generation, data management, graphical display, output analysis, and model interfacing tasks. Utilities

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20. ABSTRACT (Continued).

include file management and automatic generation of computer job control instructions.

TABS-2 has been applied to a variety of waterways, including rivers, estuaries, bays, and marshes. It is designed for use by engineers and scientists who may not have a rigorous computer background. Use of the various components is described in Appendices A-O.

The bound version of the report does not include the appendices. A looseleaf form with Appendices A-O is distributed to system users.

PREFACE

The TABS-2 system described herein was developed over the period 1972-1984. This User's Manual was prepared at the US Army Engineer Waterways Experiment Station (WES) with funding provided by the Office, Chief of Engineers, US Army, under the Improvement of Operations and Maintenance Techniques (IOMT) research program. Funding for the various components of the system came from several sources within the Corps of Engineers, but the largest portion of those funds came from the IOMT Program. Technical monitors of the IOMT program were Messrs. J. L. Gottesman and C. W. Hummer, Jr.

The principal sources for the programs and procedures are the staff of the WES Hydraulics Laboratory; Resource Management Associates, Lafayette, Calif.; University of California, Davis; US Army Corps of Engineers Hydrologic Engineering Center; and the WES Environmental Laboratory. Sources of individual programs in the TABS-2 system are given in this manual where the programs are described.

Personnel of the WES Hydraulics Laboratory performed their portion of system development under direction of Messrs. H. B. Simmons and F. A. Herrmann, Jr., former and present Chiefs of the Hydraulics Laboratory, respectively; M. B. Boyd, Chief of the Hydraulic Analysis Division; R. A. Sager, Chief of the Estuaries Division; G. M. Fisackerly, Chief of the Harbor Entrance Branch; R. A. Boland, Chief of the Hydrodynamics Branch; and E. C. McNair, Chief of the Sedimentation Branch. Messrs. W. A. Thomas and W. H. McAnally supervised development of the programs and system and prepared this report. Authors of the appendices, published separately in looseleaf form, are cited in each appendix.

Hydraulics Laboratory personnel making major contributions to development of the TABS-2 system were S. A. Adamec, R. F. Athow, D. P. Bach, R. C. Berger, B. Brown, Jr., C. J. Coleman, R. R. Copeland, B. Park-Donnell, J. D. Ethridge, Jr., M. A. Granat, S. S. Grogan, R. E. Heath, S. B. Heltzel, J. V. Letter, Jr., R. D. Schneider, T. M. Smith, D. M. Stewart, J. P. Stewart, A. M. Teeter, and M. J. Trawle. Dr. V. E. LaGarde, WES Environmental Laboratory, performed initial development of many DMS-A programs. Messrs. A. Melidor, St. Louis District, and J. Hines, Vicksburg District, performed field trials of many of the programs. Mr. Hines initiated development of the Greenville Reach mesh.

Commanders and Directors of WES during the preparation of this manual were COL Nelson P. Conover, CE, COL Tilford C. Creel, CE, and COL Robert C. Lee, CE; Technical Director was Mr. F. R. Brown. Commander at time of publication was COL Allen F. Grum, USA, and Technical Director was Dr. Robert W. Whalin.

CONTENTS

INDEX BY PROGRAM NAME

TABS-2 SYSTEM MANUAL

INDEX (continued)

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

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

Multiply	By	To Obtain
cubic feet per second	0.02831685	cubic metres per second
feet	0.3048	metres
feet per second	0.3048	metres per second
inches	25.4	millimetres

USER'S MANUAL FOR THE GENERALIZED
COMPUTER PROGRAM SYSTEM

OPEN-CHANNEL FLOW AND SEDIMENTATION

TABS-2

Main Text

PART I: INTRODUCTION

Purpose

1. This report describes use of the TABS-2 system for numerical modeling. The purpose of the TABS-2 system is to provide a complete set of generalized computer programs for two-dimensional (2-D) numerical modeling of open-channel flow, transport processes, and sedimentation. These processes are modeled to help solve hydraulic engineering and environmental problems in waterways. The system is designed to be used by engineers and scientists who need not be computer experts.

Description

2. TABS-2 is a collection of generalized computer programs and utility codes integrated into a numerical modeling system for studying 2-D hydraulics, transport, and sedimentation problems in rivers, reservoirs, bays, and estuaries. A schematic representation of the system is shown in Figure 1.

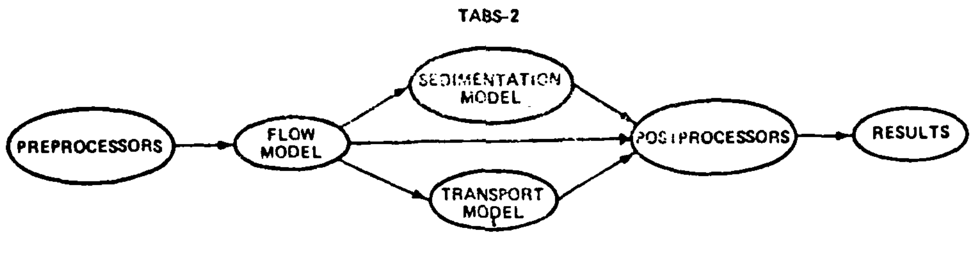

Figure 1. TABS-2 schematic

It can be used either as a stand-alone solution technique or as a step in the hybrid modeling approach. The basic concept is to calculate water-surface elevations, current patterns, dispersive transport, sediment erosion, transport and deposition, resulting bed-surface elevations, and feedback to hydraulics. Existing and proposed geometry can be analyzed to determine the impact of project designs on flows, sedimentation, and salinity. The calculated velocity pattern around structures and islands is especially useful.

3. The three basic components of the system are:

a. "Two-Dimensional Model for Open-Channel Flows," RMA-2V.

b. "Sediment Transport in Unsteady Two-Dimensional Flows, Horizontal Plane," STUDH.

c. "Two-Dimensional Model for Water Quality," RMA-4.

4. RMA-2V is a finite element solution of the Reynolds form of the Navier-Stokes equations for turbulent flows. Friction is calculated with Manning's equation and eddy viscosity coefficients are used to define turbulence characteristics. A velocity form of the basic equation is used with side boundaries treated as either slip (parallel flow) or static (zero flow). The model automatically recognizes dry elements and corrects the mesh accordingly. Boundary conditions may be water-surface elevations, velocities, or discharges and may occur inside the mesh as well as along the edges.

5. The sedimentation model, STUDH, solves the convection-diffusion equation with bed source terms. These terms are structured for either sand or cohesive sediments. The Ackers-White procedure is used to calculate a sediment transport potential for the sands from which the actual transport is calculated based on availability. Clay erosion is based on work by Partheniades and the deposition of clay utilizes Krone's equations. Deposited material forms layers, as shown in Figure 2, and bookkeeping within the STUDH code allows up to 10 layers at each node for maintaining separate material types, deposit thickness, and age. The code uses the same mesh as RMA-2V.

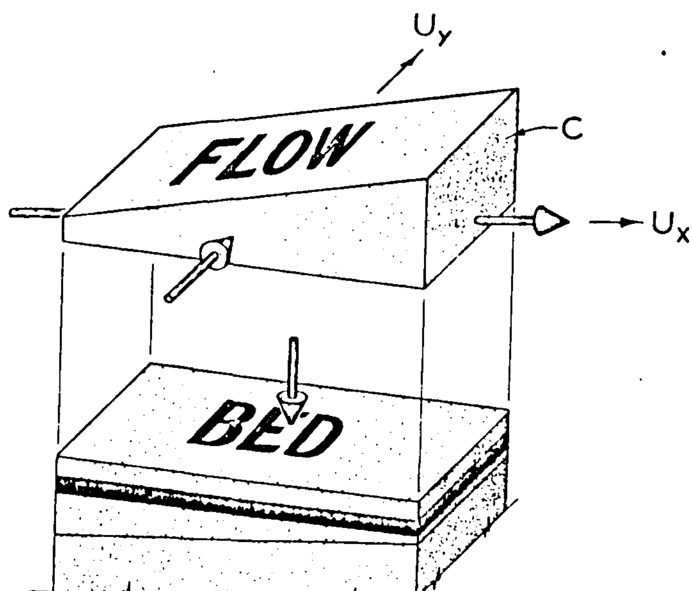

Figure 2. Bed layering in STUDH

6. Transport calculations with RMA-4 are made using a form of the convection-diffusion equation that has general source-sink terms. Up to seven conservative substances or substances requiring a decay term can be routed. The code uses the same mesh as RMA-2V.

7. Each of these generalized computer codes (RMA-2V, STUDH, and RMA-4) can be used as a stand-alone program. To facilitate the preparation of input data and to aid in analyzing results, a family of utility programs was developed for the following tasks:

a. DIGITIZING

b. MESH GENERATION

c. SPATIAL DATA MANAGEMENT

d. GRAPHICAL OUTPUT

e. OUTPUT ANALYSIS

f. FILE MANAGEMENT

g. INTERFACES

h. AUTOMATIC JOB CONTROL LANGUAGE

The codes for accomplishing these tasks are shown in PART V of this manual.

8. One can assume the nature of the computations by their stated purpose; but to better illustrate the roll these utility codes play in TABS-2, an analogy between the steps in a physical modeling study and a numerical modeling study of the same problem is useful.

9. Both fixed- and mobile-boundary hydraulic problems are classified as "boundary value" problems. The project area has to be defined and a boundary drawn completely around it. The space within the boundary becomes the study area and hydraulic processes in the area depend on what occurs at the boundaries. In a physical model study, the geometry of that space is molded to create a scale model of the prototype. In a numerical model study, hydrographic maps are DIGITIZED into (x,y,z)-coordinates to create a digital map of that space. Next, in a physical model study, the model is flooded, the tailwater elevation is set at the downstream boundary, the flow is set at the upstream boundary, and the interior of the model automatically responds to those BOUNDARY CONDITIONS. In a numerical model, the concept is the same, but the procedure for executing the numerical model is somewhat more abstract. First, the digital map will have more data points than can be used in today's computers, so points are consolidated into computation nodes. These nodes are then linked together, using quadrilateral or triangular shapes, into a computation space. These shapes, called elements, form a mesh and the

process of developing the mesh is called MESH GENERATION. The step similar to flooding the physical model, called INITIAL CONDITIONS in the numerical model study, requires that an initial depth of water be prescribed at each node in the mesh. The tailwater and headwater conditions are prescribed (i.e., the BOUNDARY CONDITIONS) and the model is run, at which time the computer solves the basic equations at each node and produces the internal response to the BOUNDARY CONDITIONS. For this reason, it is called a boundary value problem.

10. Whereas the response of the physical model can be easily viewed, the response of the numerical model is simply spatial data sets of numbers. They are called spatial because the computer program produces a set of numbers at each node within the model boundary (i.e., over the model space) and a typical mesh will have several thousand nodes. The analysis of numerical model behavior requires the evaluation of these numbers as well as their gradients in the (x,y) plane. (For example, a water-surface profile becomes a water-surface plane because there is a calculated water-surface elevation at each node.) The handling, storing, and comparing of large sets of spatial data are extremely important parts of the TABS-2 system, as shown by references to SPATIAL DATA MANAGEMENT, GRAPHICAL OUTPUT, and OUTPUT ANALYSIS utilities. Their purpose is to aid in analyzing and displaying results of the numerical model study.

11. Each time a new set of boundary conditions is prescribed or a new design change in geometry is proposed, another spatial data set is produced. The task of storing, retrieving, and using these data sets requires careful indexing and labeling. A FILE MANAGER was developed to handle that task.

12. Occasionally, spatial data sets must be manipulated before being used by another program. Special INTERFACE utilities were prepared for those occasions.

13. Finally, an AUTOMATIC JOB CONTROL LANGUAGE (JCL) procedure file was developed for executing the TABS-2 programs. It allows input and output file names to be assigned at execution time and keeps the details of the JCL transparent to the user. This procedure file, called PROCLV, is complete with a "HELP" command that describes the input data.

Scope

14. This user's manual provides instructions for coding data for the TABS-2 system. Sufficient theory is provided to guide in the selection of coefficients and in decisions regarding applicability. A major factor in this class of computer programs is problem size, and this manual shows how to change array dimensions as needed to fit the programs to the size of problems being analyzed. Although modeling is very much an art, some general

procedures are useful in every study. These are presented in this manual.

15. This document does not show the complete theoretical development of the computer programs. References are made to other reports where details are presented. The development of "representative data" is generally beyond the scope of this document, and yet that is the key to most successful modeling studies. The criteria to use in assessing numerical model performance depend upon the specific model and the questions being asked of it. Only limited material is presented in this document for assessing model performance criteria. The absence of diagnostics and error messages does not guarantee satisfactory model performance.

A Comparison of 1-D and 2-D Numerical Modeling

16. The one-dimensional (1-D) backwater calculation is a familiar numerical model in which river cross sections are described, a tailwater elevation is established, a water discharge is established, and the resulting water-surface profile is calculated by solving the 1-D form of the energy equation. In that calculation, the geometry is described by cross section and reach lengths (i.e., the distance between cross sections). The alignment of each cross section should make it perpendicular to the approaching flow. Although the location of the cross section is frequently shown on the study area map, that section should be replaced by a single computation node to depict the reality of the 1-D solution. Although the cross sections can be irregular in shape, the resulting calculated velocity is but an average.

17. The 2-D model on the other hand, does not work directly from cross sections. However, there is still a requirement for geometry. This is satisfied by the finite element (FE) mesh. One significant difference is that the computation points (i.e., the NODES) do not have to be in a straight line perpendicular to the flow. Since the equations are continuous in space, which is characteristic of the finite element method, the computation points can fall in a random pattern. However, it is desirable to be systematic, so that many times the nodes will appear to lie along cross sections perpendicular to the flow.

18. In coding cross sections for 1-D computations, as many as 100 points are sometimes used. That is not the case with the 2-D geometry. Only one elevation point is permitted at each corner node and the program assumes a straight-bottom line between corner nodes. Therefore, if the FE mesh is seven elements wide, the cross section will be defined by eight bed elevations. That may not capture the true prototype, cross-section geometry.

19. On the other hand, the 1-D models solve simplified equations at each cross section, whereas the 2-D models solve more, and more complex, equations at every node. As a result,

substantial effort is made in an attempt to minimize the number of nodes while adequately capturing significant geometry and hydraulic features in 2-D work.

20. The 2-D hydraulic code, like a 1-D code, can be run as a steady-state solution or it can be run as a dynamic simulation. For a steady-state case, the tailwater elevation is prescribed along with the inflow of water and the program calculates the water surface, u-velocity, and v-velocity at each node. Manning n-values are used for friction roughness and turbulent losses are accounted for with diffusion coefficients; calibration is required to reproduce observed prototype water-surface elevations. Water-surface profiles from 1-D computations are straightforward, but less so with results from the 2-D models. This system will plot a water-surface contour map of the modeled area. In addition, velocity vectors and unit discharge vectors can be obtained.

21. The above discussions addressed hydraulic calculations. Sediment calculations in this system are somewhat less advanced than those in HEC-6 in some respects. For example, only a single grain-size sediment can be analyzed, and armoring is not addressed. However, the objective of calculating bed-surface elevations for feedback to hydraulics is achieved. Since calculations are node by node, the cross-section shape can deform depending on hydraulics and inflowing sediment load. Work is under way to add more sophisticated calculations to TABS-2.

22. A major difference between the 2-D and 1-D modeling is the cost. A 1-D model can simulate system behavior for years, for about the same costs as the 2-D model can simulate for a few days. It is necessary to use a statistical approach to make annual as well as long-term projections.

23. Neither the 1-D nor the 2-D sediment models are designed for local scour. It is possible, however, to code embankment and pier details into the 2-D model and calculate that portion of erosion resulting from the contraction and the resulting nonuniform discharge distribution. That leaves only the turbulence-generated scour as undefined.

Origin of the System

24. TABS-2 was assembled by personnel in the Estuaries Division and the Hydraulic Analysis Division, Hydraulics Laboratory, US Army Engineer Waterways Experiment Station (WES). It was operated on the CRAY 1 computer, Boeing Computer Services, from 1980 through September 1983 when the Corps of Engineers began shifting work to CYBERNET according to the new contract for ADP services.

25. The individual codes in the system came from several sources. The first to be developed was RMA-2. It was completed

by W. R. Norton, I. P. King, and Gerald T. Orlob in 1973* with funding from the Walla Walla District, Corps of Engineers. Further details are given in a report to the Association of Bay Area Governments.** The modified code for TABS-2 is presented in the RMA-2V appendix of this manual. In brief, the original version was a mass formulation and that was changed to a velocity formulation of the basic equations resulting in the "V" suffix on the code designator (RMA-2V). A capability to wet and dry portions of the mesh also was added. A number of other revisions have been made by WES personnel.

26. The sediment calculations program, STUDH, is a WES modification of the program written by Ranjan Ariathurai, Robert C. MacArthur, and Ray B. Krone† of the University of California, Davis, for the Dredged Material Research Program of the Corps of Engineers. That original cohesive transport model was modified by WES to transport sand. Ariathurai, who is now with Resource Management Associates, modified his original program for wetting and drying and for element shape, and his results were incorporated into STUDH by Estuaries Division personnel of WES. The bed structure module, provision for combined sand-clay runs, and internal extrapolation are among many WES modifications to the program.

27. The salinity transport program, RMA-4, was obtained from Resource Management Associates. It was originally developed for the East Bay Municipal Utility District, California. WES has revised the program in some ways.

28. The utility programs in the systems came from several sources. The network generator, GFGEN, is a WES modification of RMA-1, which came from Resource Management Associates. The spatial data analysis codes are adaptations of programs developed by V. E. LaGarde, Environmental Laboratory, WES. The TABS-2 data management system was developed by WES Hydraulics Laboratory personnel. The automatic mesh generator AUTOMSH is composed of two codes obtained from Sandia National Laboratories, entitled QMESH and RENUM, plus WES-generated interface codes. Most of the other codes were designed and written by WES Hydraulics Laboratory personnel.

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* W. R. Norton, I. P. King, and G. T. Orlob. 1973. "A Finite Element Model for Lower Granite Reservoir," prepared for US Army Engineer District, Walla Walla, Wash.

** W. R. Norton and I. P. King. 1977. "Operating Instructions for the Computer Program, RMA-2," Resource Management Associates, Lafayette, Calif.

† R. Ariathurai, R. C. MacArthur, and R. B. Krone. 1977 (Oct). "Mathematical Model of Estuarial Sediment Transport," Technical Report D-77-12, US Army Engineer Waterways Experiment Station, Vicksburg, Miss.

Applications

29. The range of applicability of the TABS-2 system is still being explored. In general, it should be useful in subcritical flow systems in which armoring is not a major consideration and flow can be described by depth-averaged velocity. It has been used to model both sand movement and the movement of cohesive material. It has been applied in estuaries, rivers, and reservoirs, including those listed below:

River Applications:

- Lock and Dam 2, Red River
- Lock and Dam 26, Mississippi River
- Greenville Reach, Mississippi River
- Yazoo Backwater Area Pumping Plant
- Upper Mississippi River Tow Navigation
- Atchafalaya River at Morgan City
- Lock and Dam 3, Red River
- Containment Area Design

Tidal Applications:

- Columbia River Entrance
- Cape Fear River
- Atchafalaya Bay
- Norfolk Harbor
- Chesapeake Bay
- New York Harbor
- Kings Bay
- Terrebonne Marshes
- Charleston Harbor
- Portsmouth Harbor
- Corpus Christi Bay

30. Some of these studies involved the siting of training structures to reduce navigation channel and harbor shoaling. The volume and location of maintenance dredging were key parameters in comparing those alternative plans. In addition, changes in estuarine circulation patterns and salinity intrusion caused by depth changes were calculated for some of the estuarine areas.

Limitations

31. Long continuous simulation studies are not feasible because of the computation cost. Periods on the order of weeks or longer are modeled in piecewise fashion with results extrapolated between successive periods of real-time modeling. Study areas should be made as small as practicable to reduce computational costs.

32. The 2-D approximation involves integrating the governing equations over depth. Thus variations of velocity or constituent concentration with depth are not predicted. Depending upon the degree of variation with depth occurring in the waterway and the desired detail of results, this approximation may or may not be an important factor.

33. Each of the major component programs in the system has specific limitations. See the documentation for each of them for their special limitations.

Future Improvements

34. This report describes version 2.0 of the TABS-2 system. The system and its component programs are undergoing revision to improve their capabilities and performance. Improvements will be documented and reported to system users. Users are encouraged to notify WES of any improvements that they would like to see in the programs or documentation.

Related Systems

35. Both steady-flow and unsteady-flow work are being packaged in the 1-D TABS-1 system. It is designed for long-term simulations--50 to 100 years--and calculates the water-surface and the bed-surface profiles. Two programs that approximate the hydrograph with a histogram of steady flows are being considered: a network version of HEC-6 and quasi-2-D version of HEC-6 (HAD-1) in which flow and sediment movement are calculated by strip. The network code has been applied to several studies, and HAD-1 has been applied to the Atchafalaya Delta and to Canton Reservoir.

36. TABS-3 is the 3-D version of TABS-2; it is presently under development at WES.

37. The TABS-2 system is frequently used in conjunction with a numerical ship and tow simulator. The simulator consists of a minicomputer that solves equations to simulate maneuvers of vessels, a set of pilot controls, and monitors to display visual and radar scenes to the pilot. The ship and tow simulator is described in Appendix C.

Organization of the Manual

38. This user's manual consists of the main text and 15 appendices. The main text provides an overview of the system. Appendix A is a bibliography on related numerical modeling topics; Appendix B is a glossary of terms used; and Appendix C gives details of one system application. Appendices D-O provide

descriptions of and instructions for using the various components of the system.

PART II: SYSTEM DESIGN

Capability of the System

39. The primary considerations in developing TABS-2 were to produce a systematic numerical method to:

- Establish relations between the factors that cause shoaling problems in navigation channels,
- Quantify the impact of alternatives being considered to possibly reduce the amount of shoaling and dredging in a navigation project,
- Predict the maintenance required for proposed new projects or project improvements.

That objective was accomplished by the development of the TABS-2 modeling system. In fact, the TABS-2 system goes beyond the original objective in that it is capable of analyzing a considerably broader class of problems. It is potentially useful for planning, engineering, and real estate functions as well as construction and operations. Hydraulic computations can be made for fixed-bed problems, if desired, without performing a sediment study at all. The velocity field can be calculated for a ship-tow simulator, for example, and losses at channel junctions can be calculated. Flow around islands and head loss at bridge crossings, particularly where multiple openings are involved, provide a new design capability. The power of the method lies in its ability to calculate the flow pattern across as well as along the flow field.

40. TABS-2 is an uncoupled computation of the mobile boundary hydraulics problem. RMA-2V is executed as a fixed-bed calculation. Resulting hydraulics parameters are passed to STUDH using a file interface, and they are used in the sediment transport computations. When "significant" bed changes are computed by STUDH, a new set of bed elevations is passed back to RMA-2V and hydraulic computations are updated. (Note: STUDH automatically adjusts the magnitude of velocities in the RMA-2V output file in response to calculated bed changes.) The bed structure in STUDH allows 10 layers at each node. Properties of each layer can be independently varied. Consolidation with time and overburden is permitted. Sand transport and clay transport are computed separately.

41. The SPATIAL DATA analysis programs offer a new capability for analyzing and displaying field measurements as well as calculated data sets. Of particular importance is the capability to subtract one spatial data set from another, to summarize the incremental changes between them, and to display the difference as a contour plot or a factor map.

42. The theoretical basis for each of the computer programs is presented in the appendices of this manual. In general, hydraulic computations can be run in a steady-state mode, thereby producing a direct solution of the equations, or they can be run as a dynamic simulation. The sediment computations are structured only for the dynamic mode.

43. Having the full nonlinear equations allows the hydraulic computations to predict large-scale eddies. However, these codes are considered to be far-field codes; that is, they are not designed to resolve eddy and vortex problems close to structures. There is no fluid-structure interaction built into the programs. On the other hand, the codes can calculate the impact of a structure, such as a dike or a bridge pier, on the current pattern; and based on that impact, the resulting erosion or deposition is calculated.

44. Each finite element code requires a computational mesh. Historically, development of the mesh has consumed enormous amounts of study time. The implementation of automatic mesh generators in this system provides a method for streamlining the mesh generation.

45. The finite element method was selected for this system for a number of reasons. Among them are: (a) the solution is continuous over the area of interest, (b) boundary condition specification is extremely flexible, (c) resolution can range from very fine to very coarse in the same mesh, (d) computational cells can be oriented in many directions, and (e) model boundary and interior shapes can be exactly represented. The latter two reasons are particularly important in navigation channel studies where size and channel alignment are so variable. The finite element approach allows computations to be made node by node rather than averaged over an element.

Components of the System

46. Two-dimensional, mobile boundary hydraulics problems are considerably more complex than one can address with a single computer program. Partitioning the overall problem into a set of tasks led to the tasks and computer codes listed in Table 1. Paragraphs 3-7 discuss the major components briefly. For descriptions of the individual programs, see the appropriate appendix.

Files

47. TABS-2 contains two basic file subsystems: (a) the FE Subsystem and (b) the WESDMS Subsystem. The FE Subsystem files are created by and for the primary computation codes: the

RMA-2V computer program for hydraulic calculations, the STUDH computer program for sediment transport calculations, and the RMA-4 computer program for dispersive transport calculations. The WESDMS Subsystem files are used for spatial data management. Consequently, the digitizer, digital mapping, adding and subtracting digital maps from one another to get shoaling or scour volumes, etc., use the WESDMS Subsystem files. The vector and contour plotting programs can read files from either subsystem. Interface programs are available for transferring data from one of these file subsystems to the other. These programs are described in Appendix M: Interfaces and in Appendix L: Data Management System A. The file structures are described in Appendix N: Files and FMS.

48. The finite element computer codes, which make up the primary computation programs in TABS-2, are linked together by files. For example, the geometry of the study area is digitized and processed during the finite element network generation task. The resulting file is saved for use by the RMA-2V flow model, by the STUDH sediment transport model, by the RMA-4 transport model, and by various utility programs in the systems. The geometric data file structure is described in Appendix N: Files and FMS.

49. The flow model produces a file of hydraulic parameters that is read by the sediment transport model, by the salinity transport model, and by the utility programs. The file structure is described in Appendix N under Flow Model Files.

50. The sediment transport model produces a file of concentrations and bed elevation changes that can be read by the sediment utilities. In addition, it produces an updated finite element network file that has the new bed elevations calculated by the sediment transport model. The new file can be read by the flow model. These files are described in Appendix N under Sediment Model Files.

51. The Transport Model produces a file of concentrations that can be read by the contour program. This file is described in Appendix N under the section Transport Model Files.

52. Numerous other files can be produced. These are described in Appendix N also.

Structure of the Geometry Data Base

53. The computer program, "Water-Surface Profiles" (HEC-2), produced by the Hydrologic Engineering Center, has set a standard for geometry data because of its widespread use both in and out of the Corps of Engineers. However, that data structure requires only two of the three spatial coordinates. TABS-2, on the other hand, requires all three spatial coordinates; and the data file structure is established by the Flow Model, RMA-2V. It is completely different from HEC-2, as can be seen by comparing the

flow model's file structure in Appendix N with the HEC-2 manual.

Data Management

54. Data management is essential to a well-executed numerical model study. The TABS-2 data management system (DMS) is quite specialized for numerical modeling studies, but it also contains some parts that are applicable to a wide range of engineering studies.

55. Data management in TABS-2 is accomplished in several ways at the user's choice. The WES Data Management System A is used to process, store, and manipulate spatially distributed data.

56. The TABS-2 DMS consists of:

a. Manual data handling procedures.

b. Gridding and grid transformation programs.

c. Programs to perform data manipulation and display.

d. Files management.

Items a-c above are described in Appendix L: Data Management System A. Item d is described in Appendix N: Files and FMS and in Appendix O: PROCLV.

Job Control Language (PROCLV)

57. The TABS-2 system includes a procedure file that is invoked from an interactive terminal and automatically writes job control language (JCL) to cause any program in the system to be executed, assigns input files, saves output files, and routes results to the appropriate device. Only one line of information is needed. Details for using this procedure are presented in Appendix O.

PART III: HOW TO USE THE SYSTEM

Access

58. TABS-2 is available at the primary computer site for the Corps of Engineers. Interested users should notify the Chief of the Hydraulic Analysis Division of the Hydraulics Laboratory at WES.

59. The system is maintained on the Corps contract computing site, which is presently CYBERNET. Library versions of the programs and procedure files are stored on the TABS-2 user number. Approved users are given read and execute permissions for the system programs.

60. PROCLV, the procedure file used to generate job control language and submit batch jobs, is transferred to each user's number and installed there. The installation procedure customizes PROCLV to the user's needs.

Summary of Steps

61. This section summarizes the steps in applying TABS-2. Details for step 3 and following steps are presented in the appendices of this report where each code is described. A more detailed list of steps is given in Table 2. The following steps assume that access to the system has been established.

Step 1. STATEMENT OF PURPOSE AND END PRODUCT

62. For the most part, numerical modeling answers questions posed by the modeler rather than simulates the behavior of the proposed prototype project. Rarely will it "surprise" the modeler with unexpected problems. Consequently, the questions to ask of the model must be formulated before the study gets under way. Other questions usually surface as the study progresses, but the desired end product of the study needs to be specified at the beginning.

Step 2. FIELD DATA ACQUISITION

63. This is self-explanatory except for the question "What data are needed?" In general, the same prototype data are required for a numerical model study as are required for a physical model study: geometry, roughness, structures and other man-made changes, hydrology, sedimentation, hydraulic character, development plans, operational policies, and performance criteria. APPENDIX F discusses field data collection.

Step 3. MESH LAYOUT AND DESIGN

64. Mesh layout, entitled Network Generation in Appendix D,

begins by defining the model limits. They should extend several river widths on either side of the study area so the parameters prescribed as boundary conditions will be outside the influence of changes occurring in the study area. The next task is to sketch the desired mesh on an overlay and establish regions having similar hydraulic properties. Then, digitize the boundary around each region for input into the mesh generator. The output from the mesh generator is combined with card image run control data, without bed elevations, and input into GFGEN where the curved boundaries of the mesh are calculated and elements are re-ordered for more efficient computations. The output file from GFGEN is the network needed by RMA-2V except bed elevations are usually not yet coded. Bed elevations can be input from the beginning, but it is not recommended. Normally, run the RMA-2V "leak" test at this point by assuming the bed is at elevation "zero" or some other appropriate, constant value. Running a flat-bottom leak test first will shorten total study time. The final step in network generation is to determine the bed elevation at each corner node in the mesh.

Step 4. RUN LEAK TEST IN RMA-2V

65. The purpose of the leak test is to check the mesh, boundaries, and boundary condition types for leaks. The performance criterion is continuity of water. The approach is to establish a condition of a horizontal pool and an inflow velocity, or discharge, equal to zero. If water leaks out of the network, either the network or boundary conditions contain errors. A second leak test with actual bottom elevations is performed as a final check on network adequacy. Details are given in the RMA-2V user instructions, Appendix F.

Step 5. ESTABLISH THE INITIAL CONDITIONS

66. Initial conditions refer to the intial depths of water and velocity at every node. The first choice is always a constant elevation and zero velocity because that is easiest to code. If computations converge that approach is successful, but if computations fail to converge use the HOTSTART procedure explained in the RMA-2V documentation.

Step 6. RUN TESTS IN RMA-2V

67. Testing always starts with verification to field or other appropriate data. After this point, the desired tests are run. The most difficult task in running tests is maintaining adequate documentation of what is being tested, the results, and how this test differs from those before and after it. Careful note-keeping is strongly recommended and some techniques are described in the appendices, particularly Appendix N.

Step 7. RUN TESTS IN STUDH

68. There is no leak test for STUDH, but it is important to establish a sequence of tests that start with a simple condition

and proceed toward the more complex. Attempt to define a case in which a steady-flow water discharge and a steady-state sediment concentration at the boundary can be run with negligible change in the bed elevations. When that case runs satisfactorily, begin time-dependent boundary conditions or flow field runs. Always limit changes to one parameter at a time. Details for running STUDH are presented in Appendix G.

Step 8. CYCLE BETWEEN STUDH AND RMA-2V

69. The STUDH program will produce a new geometry file that can be cycled back through RMA-2V as needed. A general rule of thumb is to allow the bed surface to change by a foot or 10 percent of the depth before rerunning RMA-2V, but each study must be prepared to modify that general rule if results so indicate.

Study Management

70. Key words appropriate for 2-D numerical modeling studies are plan-monitor-evaluate. An inadequate plan of study will often cause the study time to increase, thereby increasing manpower and computer costs. Inadequate monitoring of ADP usage can allow the entire annual budget for ADP to be spent early in the project. Inadequate evaluation of study results will lead to misinterpretation. This type of study will produce many more numbers than the engineer is historically accustomed to, so the procedures for evaluating results must be carefully thought out.

71. The review of results produced by 2-D numerical models should always include volumes or total masses as well as the rates and distributions which are calculated and printed out by the programs. Always ascertain that the geometry, as defined by connecting the (x,y,z) coordinates of the finite element network with a series of planes, closely approximates the prototype, that n-values are assigned in accordance with standard procedures for estimating hydraulic roughness, and that the diffusion coefficients are reasonable. Although mentioned last, the diffusion coefficients issue is by no means of least importance. Head loss at contractions and eddy formations are strongly controlled by the diffusion coefficients. Often, a sensitivity study is the only method for testing the role the diffusion coefficients play in the results of a particular study.

PART IV: EXAMPLE PROBLEM

72. Appendix C contains an example problem that illustates the steps in applying TABS-2. The following example uses the results of an application on the Mississippi River near Greenville, Mississippi, to briefly illustrate model performance.

73. The Greenville Reach of the Mississippi River starts at the Greenville Bridge, river mile 531.33, and extends about 15 miles upstream (Figure 3). The Potamology Research Section, US Army Engineers Division, Lower Mississippi Valley, developed the computational network, provided hydrographic survey data, flow velocities, float measurements, and water-surface elevations for testing the performance of the RMA-2V code for hydraulic calculations. Results of that application are presented below.

Figure 3. Vicinity map, Greenville reach, Mississippi River

74. The finite element mesh is shown in Figure 4. It contains 336 elements and 1,078 nodes. Sandbars and dikes complicate the mesh development as illustrated in the inset to Figure 4. The Leland bar dike No. 4 is located at about river mile 537 on the right bank side of the channel. It is about 1,500 ft long and 30 ft high at the outer end, and it is built into the mesh by five elements. During high flows, it is entirely submerged, but during low flows, this structure is out of the water. Numerous other dikes, functioning and coded in the same fashion, are visible along this reach of the river.

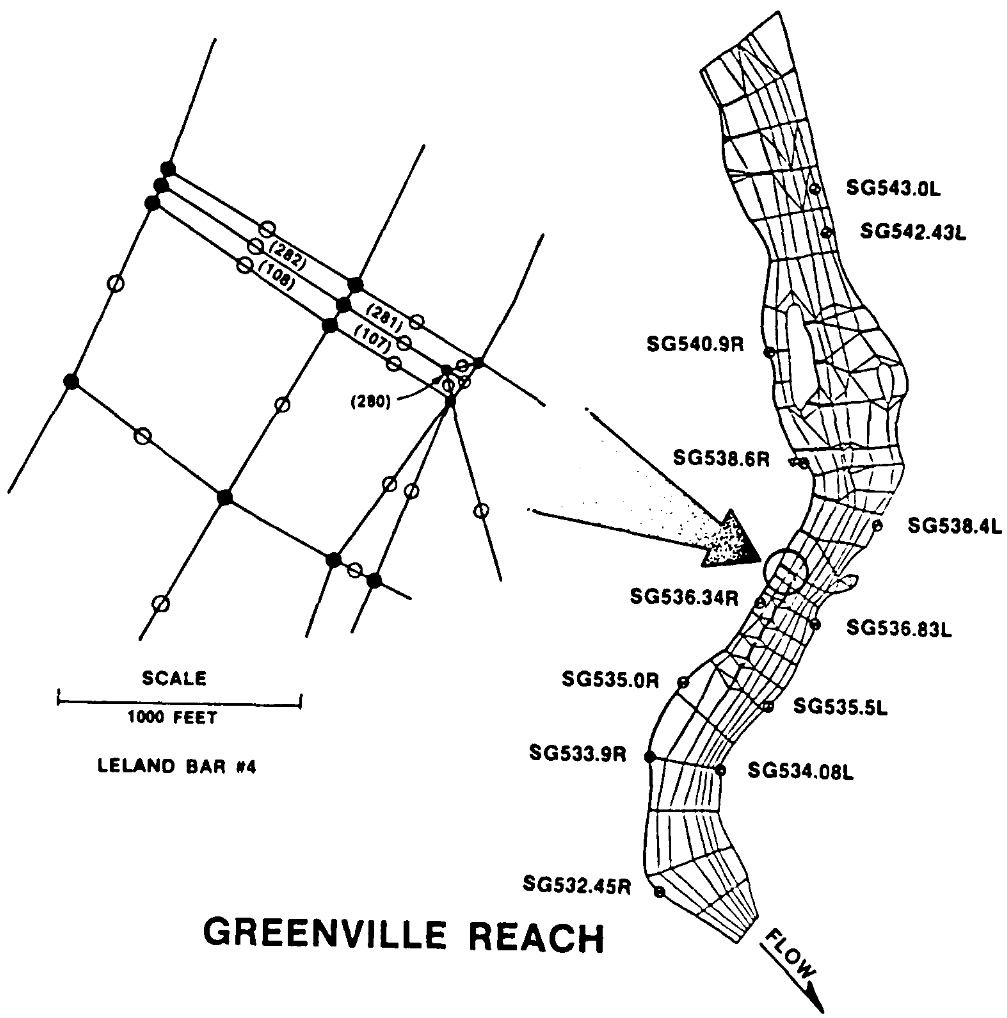


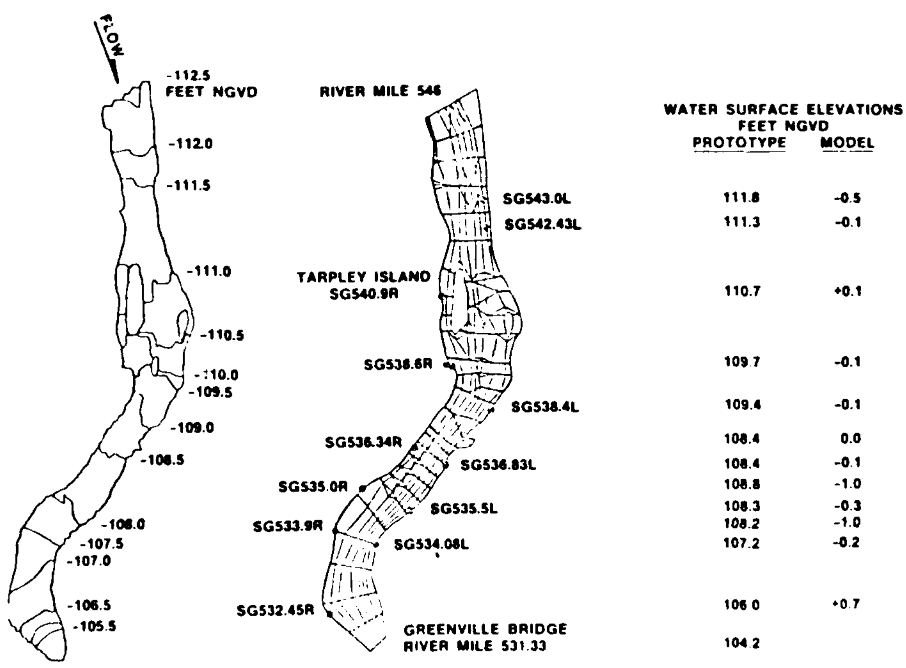
Figure 4. The finite element mesh, Greenville reach

75. Another type of dike in the Greenville reach is the vane dike. It is positioned in the channel at a slight angle to the current and is not attached to the bank. There are five vane dikes in the Greenville reach, each one requiring four elements to model its shape and size. The resulting mesh provided the necessary resolution for the computations.

76. The hydrographic survey of 9 March 1981 was digitized and incorporated in the computation mesh. Depths ranged from 5 to 75 ft. The corresponding water discharge and water-surface elevation at the Greenville Bridge gage, 677,500 cfs and 104.2 ft NGVD, respectively, were encoded as boundary conditions. The n-values and eddy viscosity coefficients, E , were assigned as follows:

Feature	n-Values	E_{xx}	E_{yy}	E_{xy}	E_{yx}
River channel elements	0.0275	250	250	250	250
Dike-field elements	0.043	250	250	250	250
Vane-dike elements	0.045	250	250	250	250
Other dike elements	0.055	250	250	250	250

77. Three model responses were ob erved: Water-surface elevations, current patterns/velocity d stributions, and unit discharge at a cross section. Model and prototype water surfaces are shown in Figure 5. Model results were within 1/2 ft of the



GREENVILLE REACH (Q = 677,500 CFS, 9 MARCH 1981)

Figure 5. Water-surface elevations

prototype except for three gages where the difference ranged up to 1 ft. Most gages were within a tenth of a foot. In addition to the tabular data at gages, contours of the water surface were developed. Of particular interest is the steep gradient, on the inside of the bend, between elevation 109 and 111.

78. Figure 6 shows the model velocity vectors near Tarpley Island. The dots are float positions taken at 30-sec intervals. Vector lengths were scaled so perfect agreement is three dots long. The results, both in magnitude and direction, were very good. (Note the eddies forming downstream of the Tarpley Island Dike.)

79. Not only velocity vectors but also flow distribution matched prototype data remarkably well as shown in Figure 7. The calculated flow distribution around Tarpley Island matches prototype measurements within 2 percent.

80. Figure 8 shows two vector plots--one for velocity and one for unit discharge. To obtain greater readability, the horizontal scale is compressed. Both plots show the greatest intensity crossing from the left bank to the right bank just upstream from Greenville Bridge. The unit discharge vectors show a narrow band of high discharge that is of importance to sediment and channel alignment studies, whereas the velocity vectors show the most information for navigation studies.

81. In general, the codes performed well. Wetting and drying of elements caused some numerical problems that can only be solved by relatively small element sizes at present. The application took about 2 months and served as a training aid in addition to testing the code performance.

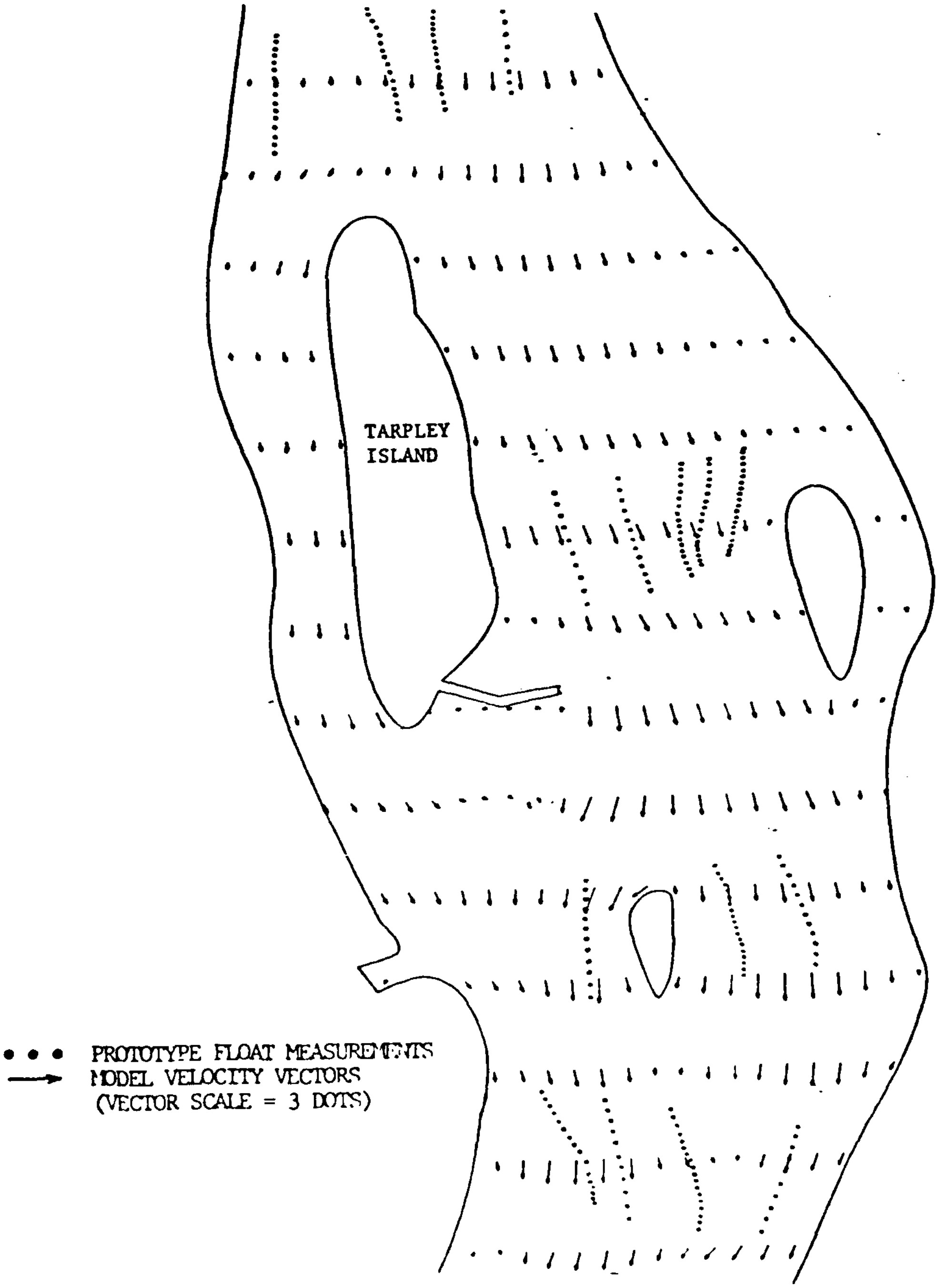


Figure 6. Comparison of model and prototype velocities, Greenville reach

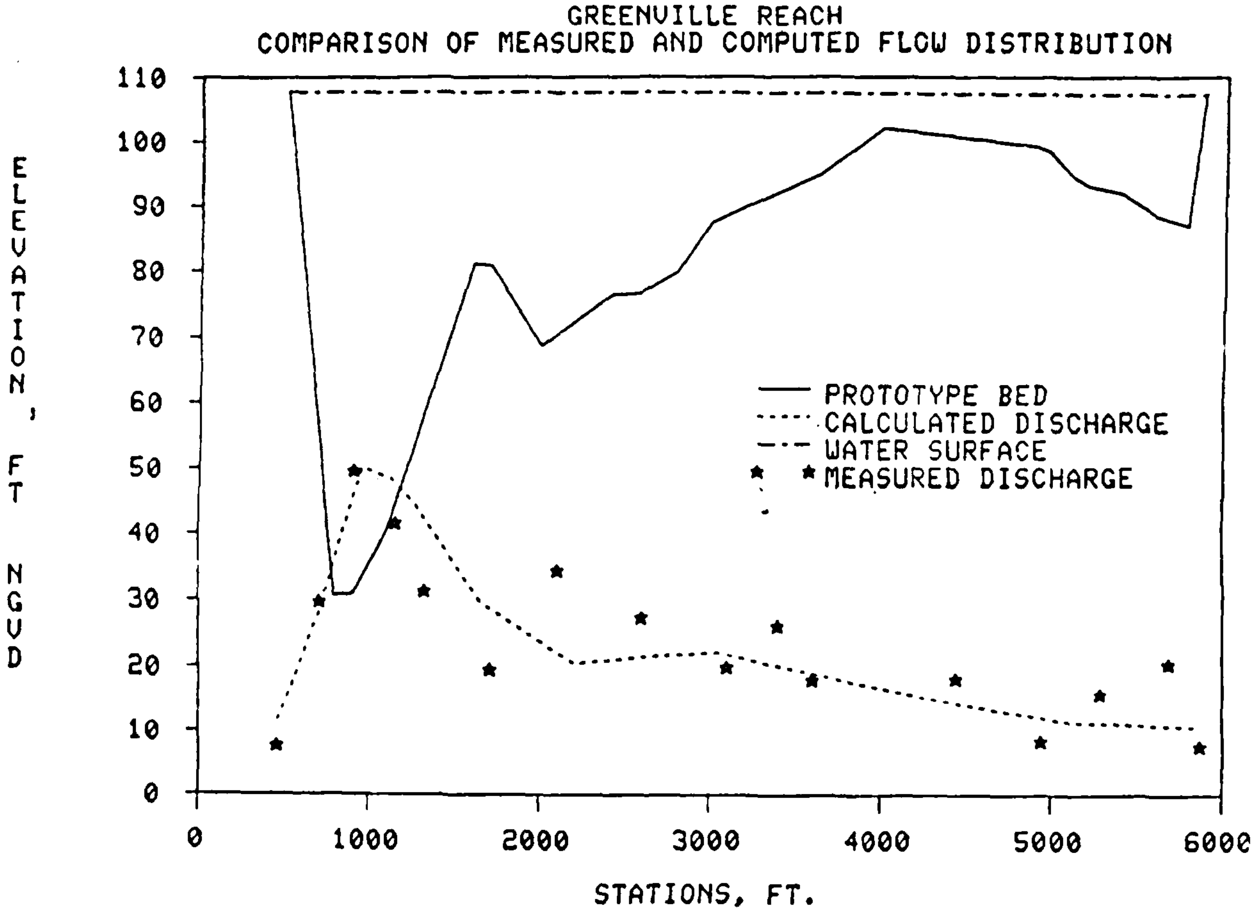
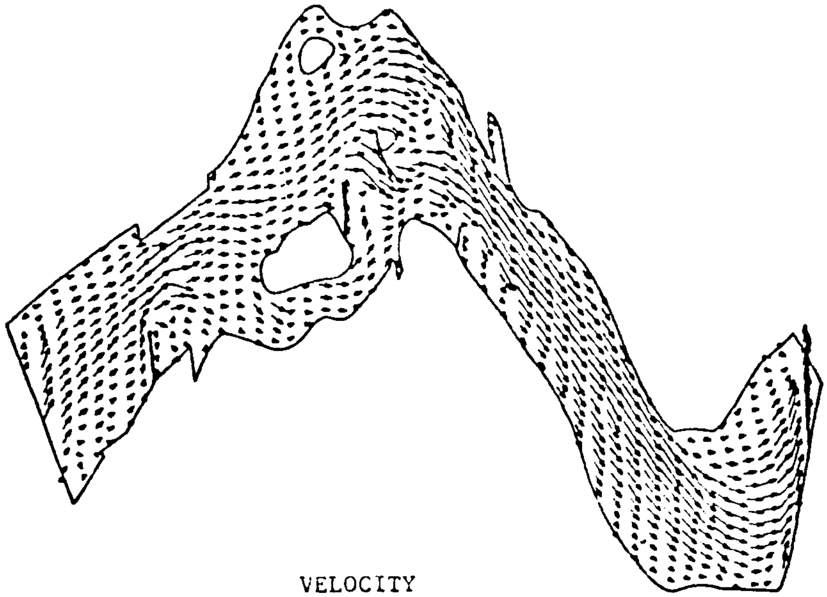
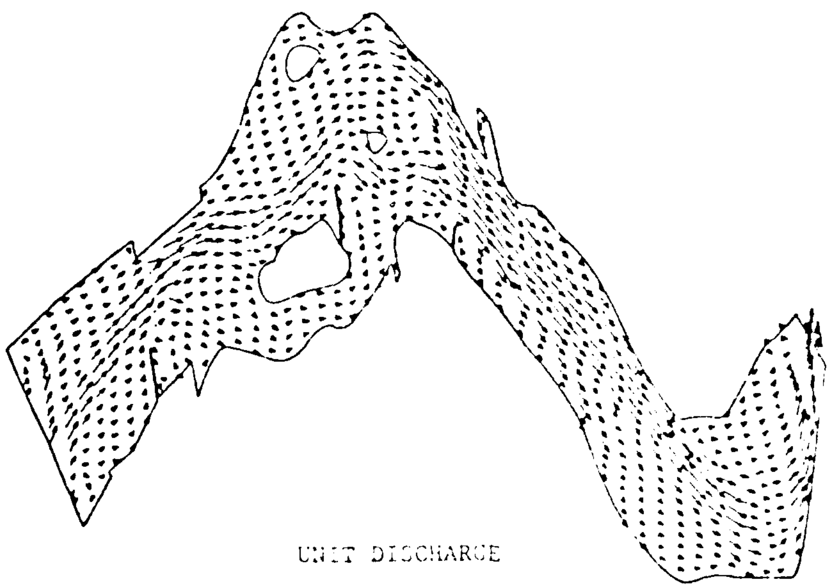


Figure 7. Flow distribution comparison



VELOCITY



UNIT DISCHARGE

Figure 8. Vector plots, Greenville reach

PART V: INDEX OF PROGRAMS

82. Several indices are provided to help the user locate programs within this manual. An index of programs by categories appears after the table of contents. Table 1 lists the major task categories and the programs that accomplish those tasks. Table 3 lists the programs and procedures by name and gives the manual location that describes their use. Each appendix contains a table of contents listing the programs contained there.

Table 1

TABS-2 Tasks and Programs

Task	Purpose	Computer Programs
DIGITIZING	o Create a digital map of the study area in (x,y,z) coordinates.	MESH DMSDIG
	o Establish the (x,y) coordinates for the boundary around the finite element mesh and in complex studies, boundaries of each subregion in that mesh.	
MESH GENERATION	o Locate computation nodes in the study area and link them together into elements.	AUTOMSH GFGEN
	o Assign element types, first external boundary nodes, calculate curved sides, and produce the input file for RMA-2V geometry in the proper forms	EDGRG
FLOW MODELING	o Calculate water-surface elevation, the u-velocity and the v-velocity for a specific set of boundary conditions.	RMA-2V
SEDIMENT MODELING	o Calculate the concentration of sediment in the flow, erode transport and deposit, and change bed elevations at each node.	STUDH
TRANSPORT MODELING	o Calculate the salt, temperature, orother constituent concentration in the flow field.	RMA-4
SPATIAL DATA MANAGEMENT	o Transform randomly spaced data to a uniform grid (i.e., such as velocities from RMA-2V to a uniform spacing for plotting).	ELEVGRD
	o Interpolate gridded data from one cell size to another.	TRANSA
	o Interpolate from gridded data to irregularly spaced points (i.e., such as extracting nodal elevations from the digital map file).	RETPNT
	o Subtract two spatial data sets.	GRDSUB
	o Create a factor map.	FACGRD
GRAPHICAL OUTPUT	o Plot velocity vectors.	VPLOT
	o Plot contour maps.	CONTOUR
	o Plot drogue path from RMA-2V output.	DROGUEPLOT SEDGRAF
OUTPUT ANALYSIS	o Analytical and statistical summaries.	POSTSED
	o Comparisons of one data set or result with another - as model to prototype.	POSTHYD
	o Accumulations of rates into volumes.	ACE
FILE MANAGEMENT	o Store, retrieve, and provide common analysis of temporal, spatially distributed data sets.	
	o Maintain a history and "family tree information" of the contents in a file.	
INTERFACES	o Change output from one code into form required to input to another.	ENGMET
	o Jobstream model runs from coarse meshes to inset meshes.	JOBSTREAM
JOB SUBMISSION	o Automatic job control language.	PROCLV
	o Submit batch jobs to computer.	
	o Track job's progress.	

Table 2

Summary of Steps for a Typical Applications

1. Prepare statement of purposes and end products desired.

2. Assemble available prototype information--charts, maps, flow measurements, etc.

3. Sketch mesh limits and element layout.

4. Refine mesh sketch, number nodes and elements (manually or by AUTOMSH), and set up connection table.

5. Establish boundary condition nodes.

6. Identify nodes on curved boundaries and assign slopes.

7. Digitize manually developed mesh or region boundaries for automatic mesh generation.

8. Edit and merge files for GFGEN input.

9. Run GFGEN or (EDGRG), then edit slope error problems.

10. Rerun GFGEN until all major slope errors are fixed and network is reordered efficiently.

11. Create RMA-2V run control file for steady-state, flat-bottom leak test and run.

12. If mesh leaks, correct problems.

13. Install actual bed elevations, then rerun leak test. Correct leaks and oozes.

14. Run RMA-2V verification tests.

15. Run RMA-2V base test.

16. Create STUDH run control file with nonerodible bed and constant boundary concentrations. Run short test and correct any problems that occur.

17. Modify STUDH run control file to show desired bed condition and initial and boundary conditions. Run initial test and correct any problems that appear.

18. Run STUDH verification tests.

19. Run STUDH base tests.

20. Revise computational mesh as needed for plan to be tested.

21. Run RMA-2V plan tests.

22. Produce graphical and tabular hydrodynamic results output.

23. Run STUDH plan tests.

24. Produce graphical and tabular sedimentation results output.

25. Report results.

Table 3
Program Name Index

PROGRAM	PURPOSE	APPENDIX	PAGE
ACE	Assemble STUDH events, compute bed change and dredging volumes, plot sediment transport vectors.	J	J-1-1
AUTOMSH	Create computational meshes.	D	D-1-1
BATHVOL	Compute volume of sediment difference between two surveys.	L	L-15-1
BIN2FOR	Transform binary model output files to formatted files.	J	J-3-1
BTHAREA	Compute areas within contours.	L	L-14-1
CONFEG	Convert digitizer file to GFGEN format	E	E-3-1
CONTOUR	Plot contour map of specified data.	I	I-1-1
DROGUEPLT	Plot path of a drogue moving with current.	I	I-2-1
DMSDIG	Digitize data from a map or graph.	L	L-1-1
DGPLT	Plot digitized data for checking.	L	L-2-1
DIRECT	Display a plot on a graphics device.	I	I-3-1
DUMPER2	Print gridded data in swaths.	L	L-16-1
EDGRG	Edit computational network interactively.	D	D-2-1
ELEVGRD	Create standard DMS data format file from randomly spaced data.	L	L-10-1
ENGMET	Translate RMA-2V output from English units to SI units for use by STUDH.	M	M-1-1
FNDNODE	Locate a node in a computational mesh.	D	D-5-1
FACGRD	Set up factor or patch map.	L	L-12-1
FO2UN	Transform formatted file to DMS binary form.	L	L-5-1
FOR2BIN	Transform formatted model output files to binary files.	J	J-4-1
4VIEW	Plot psuedo-3-D graphs.	I	I-4-1

(Continued) (Sheet 1 of 3)

Table 3 (Continued)

PROGRAM	PURPOSE	APPENDIX	PAGE
GET	Accumulate STUDH output results for use by ACE.	J	J-1-1
GFGEN	Create geometric data file for use by models.	D	D-3-1
GCS/META	METAPLOT version of GCS.	I	I-5-1
GRDSUB	Subtract one set of gridded data from another and writes results to a file.	L	L-13-1
JOBSTREAM	Compute boundary conditions for an inset computational network from results of a larger network model run.	M	M-2-1
MESH1	Merge tabular data into a gridded data set.	L	L-7-1
MESH2	Merge standard hydrographic survey data into a gridded data set.	L	L-8-1
MESH3	Merge gridded data from several maps.	L	L-9-1
METAPLOT	Produce graphics output files.	I	I-6-1
POSTHYD	Analyze results of an RMA-2V run and plot time-histories.	J	J-3-1
POSTSED	Summarize results of a STUDH run.	J	J-2-1
PROCLV	Construct job control language and submit batch jobs to run programs.	O	O-1
RETPNT	Interpolate gridded data to provide data at specified points.	L	L-11-1
REFMT	Convert special digitizer data files to standard format.	L	L-3-1
RMA-2V	Compute 2-D flow and water levels	F	F-1
RMA-4	Compute transport of dissolved and suspended substances.	H	H-1
SEDGRAF	Produce factor map of STUDH results.	I	I-3-1
STUDH	Compute transport, erosion, and deposition of sediments.	G	G-1

(Continued) (Sheet 2 of 3)

Table 3 (Concluded)

PROGRAM	PURPOSE	APPENDIX	PAGE
TRANSA	Transform data from one grid system to another.	L	L-4-1
UN2FO	Transform binary form data to formatted form.	L	L-6-1
VPLOT	Produce vector plots of RMA-2V velocity results.	I	I-7-1
WDGPLT	Plot wet and dry areas of computational mesh.	I	I-8-1

(Sheet 3 of 3)

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APPENDIX B: GLOSSARY

This glossary presents definitions of some of the terms used in this manual. The definitions are sometimes limited to how the work is used in the manual instead of a general definition. Also included are some related modeling definitions that are quoted from an American Society of Civil Engineers task committee report, "Modeling Hydraulic Phenomena: A Glossary of Terms" (July 1982, Journal of the Hydraulics Division, Vol 108, HY7). Those definitions are marked with "(ASCE)" after the definition. Since WES Hydraulics Laboratory personnel participated in that task committee, many of the definitions are consistent with TABS-2 use.

ACCURACY - The difference between the approximate solutions obtained using a numerical model and the exact solution of the governing equations. (ASCE)

ADJUSTMENT - Variation of the parameters in a model to ensure a close reproduction by the model of a set of prototype conditions. (ASCE)

ALGORITHM - A set of numerical steps or routines to obtain a numerical output from a numerical input. (ASCE)

ALIASING - Occurrence of an apparent shift in frequency of a periodic phenomenon. It arises as the consequence of the choice of discrete-space or time sampling points to represent a continuous process. The choice may introduce a spurious periodic solution or mask a real periodic phenomenon. (ASCE)

ANALYTICAL MODEL - Mathematical model in which the solution of the governing equations is obtained by algebraic analysis.

BINARY DATA - Data that are stored in binary form and not separated by spaces or other delimeters. Binary data files cannot be interpreted by mortals.

BOUNDARY CONDITIONS - Water levels, flows, concentrations, etc., that are specified at the boundaries of the area being modeled. A specified tailwater elevation and incoming upstream discharge are typical boundary conditions.

BOUNDARY CONDITIONS - Definition or statement of conditions or phenomena at the boundaries. (ASCE)

BOUNDARY EFFECT - Consequence of dissimilarities between the model boundary conditions and the conditions occurring in the prototype at the location of the model boundaries. (ASCE)

CALCOMP - A proprietary line of graphics devices and software that are recognized as standard in computer graphics applications.

CALIBRATION - Adjustment of a model's parameters such as roughness or dispersion coefficients to make it reproduce observed prototype data.

CARD - A cardboard input medium that is not generally used by TABS-2. The input data are organized into lines of information and each line (a card image) is called a card.

CARD IMAGE DATA - Information that is to be read by a program as input. The information is punched on computer cards or keyed into a file that contains one line of information corresponding to each read statement in the program.

CHARACTERISTICS METHOD - Method in which the governing partial differential equations of a mathematical model are transformed into characteristic (ordinary differential) equations.

CODED DATA - Data that are stored in ASCII form and are thus readable by ordinary means, e.g., a text editor program.

COLD START - A model run using initial conditions that are not expected to be close to conditions as solved by the model, e.g., a level water surface and zero velocities.

CONCEPTUAL MODEL - A *simplification* of prototype behavior used to demonstrate concepts. (ASCE)

CONFIRMATION - Process in which a model of a specific design is built and tested to confirm that a design is adequate and no major phenomenon has been overlooked.

CONSISTENCY - The choice of a set of approximations that yield a solution in which the approximations are subsequently justified. For example, the assumption of linearity can be tested for consistency by checking the relative magnitude of the neglected or linearized terms using the derivative solution. (ASCE)

CONVERGENCE - The state of tending to a unique solution. A given scheme is convergent it an increasingly finer computatonal grid leads to a more accurate solution. (ASCE)

DETERMINISTIC MODEL - Mathematical model in which the behavior of every variable is completely determined by the governing equations. (ASCE)

DIGITIZATION - Representation of a continuous process by numerical (digital) values. (ASCE)

DIGITIZE - Convert data from map or graphical form to digital form for use by the programs.

DIRECT SCHEME - Scheme for finding values of certain dependent variables at given values of the independent variables and time ("dependent variable scheme"). (ASCE)

DISCRETIZATION - The procedure of representing a continuous variable by discrete values at specified points in space and/or time.

DISCRETIZATION ERROR - Error introduced by the discrete representation of a continuous variable.

DISSIPATIVE SCHEME - Computational scheme designed to damp or eliminate numerical production of energy. (ASCE)

DYNAMIC MODEL - A mathematical model in which the independent variables are adjusted to allow for the influence of time-dependent behavior of the dependent variables. (ASCE)

EMPIRICAL MODEL - Representation of a real system by a mathematical description based on experimental data rather than on general physical laws. (ASCE)

EXPLICIT SCHEME - Scheme in which the governing equations of a numerical model are arranged to update the dependent variable explicitly in terms of previously known values. (ASCE)

FILTERING - The procedure of removing or smoothing undesired perturbations. (ASCE)

FINITE DIFFERENCE METHOD - Method in which differentials of the governing equations of a numerical model are written and solved in finite difference form.

FINITE ELEMENT METHOD - Method of solving the governing equations of a numerical model by dividing the spatial domain into elements in each of which the solution of the governing equations is approximated by some continuous function. (ASCE)

FIXED FORMAT - Input structure that requires data to appear within specified areas of a line (i.e., specified "card columns") and corresponding to a preset sequence.

FREE-FIELD - Input structure that requires a preset sequence of data without limiting how the data ae written within that sequence. Free-field input variables may be separated by commas or spaces.

GRID - Network of points covering the space or time-space domain of a numerical model. The points are usually regularly spaced. (modified ASCE)

HEURISTIC MODEL - Representation of a real system by a mathematical description based on reasoned, but unproven argument. (ASCE)

HOTSTART - A model run using initial conditions that are expected to be close to conditions as solved by the model. Usually these hotstart initial conditions are results saved from a previous model run.

HYBRID MODEL - Model combining at least two modeling techniques (e.g., physical and numerical) in a closely coupled fashion.

HYDRAULIC MODEL - Physical model using water as fluid. (ASCE)

IMPLICIT SCHEME - Scheme in which the governing equations of a numerical model are arranged to obtain solutions for the dependent variable simultaneously at all grid points corresponding to any one time. The computed values depend not only on known values at a previous instant in time but also on the other unknown neighboring values at the surrounding grid points at time being calculated. (ASCE)

INITIAL CONDITIONS - The value of water levels, velocities, concentrations, etc., that are specified everywhere in the mesh at the beginning of a model run. For iterative solution, the initial conditions represent the first estimate of the variables the model is trying to solve for.

INTERACTIVE MODEL - Numerical model which allows interaction by the modeler during computation.

LINEAR MODEL - Mathematical model based entirely on linear equations. (ASCE)

LOGICAL UNIT - A numerical designation that a computer program interprets as a device that it should attach to read from or write to. In practice, where several different files stored on disk are to be accessed, each file is given a unique logical unit number. Whenever the program is told to read or write on logical unit 14 (sometimes called TAPE14) it somehow figures out where that file is and accesses it.

MATHEMATICAL MODEL - A model that uses mathematical expressions to represent a physical process.

MESH - The network of computational points (nodes) linked together by the element connection tables to form a digital representation of the modeled areas geometry.

MODEL - A representation of a physical process or thing that can be used to predict the process's or thing's behavior or state. (A story about real life.)

Examples:

A conceputal model: If I throw a rock harder, it will go faster.

A mathematical model: $F = ma$

A hydraulic model: Columbia River physical model

MOVABLE-BED MODEL - Model in which the bed and/or side material is erodible and transported in a manner similar to the prototype.

NETWORK - Same as mesh.

NGVD - National Geodetic Vertical Datum, vertical datum plane reference that has replaced mean sea level.

NONLINEAR MODEL - Mathematical model using one or more non-linear equations.

NUMERICAL DIFFUSIVITY - The second-order term introduced as a result of discretization of the governing differential equations using either forward or backward differences. (ASCE)

NUMERICAL DISPERSION - The effect on the numerical solution of numerical diffusivity. (ASCE)
NUMERICAL MODEL - A model that uses numerical (computational) methods to obtain solutions to mathematical expressions.

ONE-DIMENSIONAL MODEL - Model defined on one space coordinate, i.e., variables are averaged over the other two directions (e.g., wave propagation in a narrow channel). (ASCE)

PROBABILISTIC MODEL - Mathematical model in which the behavior of one or more of the variables is either completely or partially subject to probability laws. (ASCE)

PROTOTYPE - The full-sized structure, system process, or phenomenon being modeld. (ASCE)

QUASI-STEADY-STATE MODEL - Model in which time-dependent variables are simulated by a sequence of steady-state models.

QUASI-THREE-DIMENSIONAL MODEL - A combination of two-dimensional models used to simulate variations in three dimensions. (ASCE)

RECORD - A group of words in a binary file. It corresponds to a line of information in a card image file. A record is usually terminated by an end of line mark.

ROUNDOFF ERROR - The error introduced by rounding of results from individual arithmetic operations because only a finite number of digits can be retained after each operation.

RUN CONTROL DATA - Information that is to be read by a program and used to specify the input parameters for a program run, such as duration of simulation.

SCHEMATIZATION - Representation of a continuum by discrete elements, e.g., dividing a real river into reaches with constant parameters.

SCHEME (numerical or computational) - Systematic program of action for solving the governing equations of a mathematical model. (ASCE)

SEMI-EMPIRICAL MODEL - Representation of a real system by a mathematical description based on general physical laws but containing coefficients determined from experimental data. (ASCE)

SIMULATION - Replication of the prototype using a model. (ASCE)

SIMULATION MODEL - Mathematical model in which detailed values of the various parameters are computed both with respect to space and time.

SLIP FLOW - A boundary condition specification in which water is allowed to flow along a side boundary with a finite speed and no fri tion loss. Also called parallel flow.

SPIN-UP - The process by which a model moves from an unrealistic set of initial conditions (a COLDSTART) to results that represent steady or quasi-steady results that are not strongly influenced by the initial condition.

STABILITY (numerical or computational) - The ability of a scheme to control the propagation or growth of small perturbations introduced in the calculations. A scheme is unstable if it allows the growth of error, so that it eventually obliterates the true solution. (ASCE)

STEADY-STATE MODEL - Model in which the variables being investigated do not change with time. (modified ASCE)

STOCHASTIC MODEL - See Probabilistic Model. (ASCE)

THEORETICAL MODEL - Representation of a real system by a mathematical description. (ASCE)

THREE-DIMENSIONAL MODEL - Model defined on three space coordinates. (ASCE)

TRUNCATION ERROR - The error introduced by replacing the differentials of a differential equation by finite differences using truncated Taylor series expansions.

TWO-DIMENSIONAL MODEL - Model defined on two space coordinates, (i.e., variables are averaged over the third direction). (ASCE)

UNSTEADY-STATE MODEL - Model in which the variables being investigated change with time. (modified ASCE)

VALIDATION - Comparison oi model results with a set of prototype data not used for verification. (ASCE)

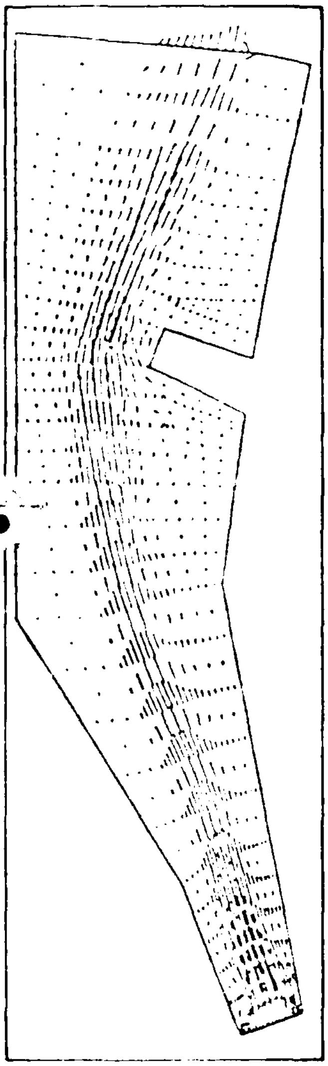
VERIFICATION - The process or state by which a model is adjusted and shown to be a satisfactory representation of observed prototype behavior.

WORD - A data value in a record. The word can be a floating point number, fixed point number, or packed 8-character bytes. Word length--8, 16, 32, or 64 bits--depends on the computer hardware.

APPENDIX C: EXAMPLE PROBLEM

This appendix reproduces a WES report on application of the TABS-2 system to a reach of the Arkansas River at Little Rock, Arkansas.

US Army Corps of Engineers



HYDRAULICS LABORATORY

04/85

MISCELLANEOUS PAPER HL-85-3

IMPACT OF PROPOSED RUNWAY EXTENSION AT LITTLE ROCK MUNICIPAL AIRPORT ON WATER-SURFACE ELEVATIONS AND NAVIGATION CONDITIONS IN ARKANSAS RIVER

by

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May 1985

Final Report

Prepared for

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Little Rock, Arkansas 72203

C3 EXAMPLE PROBLEM

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Sediment transport (LC)

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

A 2-D numerical hydrodynamic model was coupled with a 2-D numerical sediment transport model to predict the impact of a proposed runway extension on water-surface elevations in the Arkansas River at Little Rock, Arkansas. The hydrodynamic results were also used as input data to a ship simulator to predict the impact of the proposed runway on navigation characteristics.

The proposed runway will have a noticeable effect on the water-surface
(Continued)

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20. ABSTRACT (Continued).

profile in the study reach. However, the increased head loss will not violate the 0.5 ft-maximum swellhead criterion. Velocities at and downstream of the constriction will increase approximately 1 fps, or at least 10 percent. While there are some effects on navigation observed due to the proposed project, there does not appear to be any significant increase in navigation difficulty due to the runway extension.

PREFACE

The work described herein was performed by the US Army Engineer Waterways Experiment Station (WES) with funding by the US Army Engineer District, Little Rock. The numerical models STUDH and RMA-2V and their several utility computer codes were developed with funds from the US Army Engineer District, Portland, and the Chief of Engineers Improvement of Operations and Maintenance Techniques research program.

Personnel of the WES Hydraulics Laboratory performed this study under the direction of Messrs. H. B. Simmons and F. A. Herrmann, Jr., former and present Chiefs of the Hydraulics Laboratory, and M. B. Boyd, Chief of the Hydraulics Analysis Division. Mr. W. A. Thomas was project manager. Messrs. J. P. Stewart and R. F. Athow, Estuaries Division, performed the numerical model studies. Dr. L. L. Daggett and Mr. B. M. Comes performed the ship simulation study. Messrs. Stewart and Daggett prepared this report.

Commanders and Directors of WES during this study and the preparation and publication of this report were COL Tilford C. Creel, CE, and COL Robert C. Lee, CE. Technical Director was Mr. F. R. Brown.

CONTENTS

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

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

Multiply	By	To Obtain
cubic feet per second	0.02831685	cubic metres per second
feet	0.3048	metres
feet per second	0.3048	metres per second
miles (US statute)	1.60934	kilometres
pounds-seconds per square foot	4.8824	kilograms-seconds per square metre
miles per hour	1.609344	kilometres per hour

IMPACT OF PROPOSED RUNWAY EXTENSION AT LITTLE ROCK MUNICIPAL AIRPORT ON WATER-SURFACE ELEVATIONS AND NAVIGATION CONDITIONS IN ARKANSAS RIVER

PART I: INTRODUCTION

Background

1. On 27 September 1983, the Little Rock Municipal Airport Commission made application for a Department of the Army permit to place fill material and bank stabilization stone on the left bank of Fourche Creek at mile 1.7* and on the right bank of the Arkansas River at mile 161.3 in connection with the construction of the Adams Field Runway 4R-22L, Pulaski County, Arkansas (Figure 1). The runway would be placed on fill material varying in height from approximately 258.0 ft NGVD on the south end to 259.75 ft NGVD on the north end.

Purpose of Study

2. Personnel of the US Army Engineer Waterways Experiment Station (WES) visited the US Army Engineer District, Little Rock (SWL), and photographed significant features of the study area. Hydraulic and sediment data were obtained to develop and verify the numerical models.

3. The purpose of this study was to determine whether or not the proposed runway will satisfy the established criteria for maximum head loss resulting from construction along the Arkansas River. The maximum allowable swellhead criterion for any new construction is 0.5 ft. An additional objective was to predict changes in navigation characteristics resulting from construction of the new runway.

Approach

4. The solution recommended to SWL was to design a numerical model of the study area using the TABS-2 system. Recently developed in the WES Hydraulics Laboratory, the TABS-2 offers a unique approach to solving complex water

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

resource problems. It is a modular system composed of many distinct computer programs linked together by pre- and postprocessors. Each of the major computer programs solves a particular type of problem--hydrodynamics, water quality, or sediment transport. If a new program is needed for a particular application or if new, state-of-the-art programs become available, the modular construction of TABS-2 allows these new programs to be easily incorporated into the system. Thus the modeler is assured of using the best available tools to solve the problem.

5. The two numerical models used in the head loss portion of the study were "A Two-Dimensional Finite Element Program for Problems in Horizontal Free Surface Hydromechanics" (RMA-2V) and "Sediment Transport in Unsteady, Two-Dimensional Flows Horizontal Plane" (STUDH). Both programs employ the finite element method to solve the governing equations. A brief description of RMA-2V and STUDH appears in Appendices B and C, respectively. The ship hydrodynamics model used to predict changes in navigation characteristics was developed by Hydronautics, Inc., and incorporated into the WES ship/tow simulator facility. Appendix D describes this model.

6. The proposed study plan consisted of seven steps:

a. Develop a finite element grid with a downstream boundary at the I-440 Bridge and an upstream boundary at the M-P Railroad bridge.

b. Use the computer program (RMA-2V) to calculate flow patterns and water-surface elevations for base conditions and also for the plan condition with the proposed runway. This fixed-bed numerical model would be calibrated for base conditions using SWL's water-surface profile for the Standard Project Flood (SPF) of 625,000 cfs, and verified to the profile of the Navigation Design Flood (NDF) of 310,000 cfs.

c. Use the flow field for the SPF computed in b as input to (STUDH). This model will predict the new riverbed elevations resulting from the SPF.

d. Rerun the hydrodynamic model using the updated bed elevations to determine water-surface elevations during the SPF under base conditions.

e. Repeat steps c and d for the plan condition--i.e., with the proposed runway in the grid--and compare the water-surface elevations with those for the base conditions.

f. Run the hydrodynamic code for the NDF under base and plan conditions.

g. Use the results of f to run the WES ship simulation model and compare navigation characteristics under base and plan conditions.

PART II: THE HEAD LOSS STUDY (Q = 625,000 cfs)

The Hydrodynamic Model

7. Data requirements for the hydrodynamic model include:

   a. The computational grid.

   b. Roughness coefficients.

   c. Turbulent exchange coefficients.

   d. Boundary conditions.

   e. Initial water-surface elevation.

8. The computational grid used by RMA-2V and STUDH is created by a preprocessor code, GFGEN. In addition to a title card and run control data, input to GFGEN consists of an element connection table that identifies the nodes defining each element and a list of x- and y-coordinates and bed elevations for every corner node in the grid. The program then computes coordinates and bed elevations for the midside nodes, computes slopes for all boundary nodes, generates plots of the grid, and writes the geometry file used by RMA-2V and STUDH.

9. For this study, an automatic grid generator was used to create the element connection table and nodal x- and y-coordinates for input to GFGEN. Input to the grid generator consisted of sufficient coordinate locations for each row and column to define the geometry of the study area. Rows were aligned along contour lines and columns, along pile dikes. The program then created the element connection table and corner node coordinates. Elevation data were obtained from 1978 sediment range surveys that were transferred to the aerial mosaic and contoured. A plot of the grid was overlaid on the mosaic and elevations were determined at each corner node. The final grid for the base test contained 316 elements and 1,009 nodes (Figure 2). For the plan test, the elements defining the runway were removed from the grid (Figure 3). Initial bathymetry is shown in Figure 4.

10. Manning's n values and the turbulent exchange coefficients were input by element type. The computational grid was partitioned into three regions as shown in Figure 5. The overbank areas with thick grass, trees, and debris were assigned an n-value of 0.060 and a turbulent exchange coefficient of 100 $lb\text{-}sec/ft^2$. The areas between pile dikes and along steep elevation gradients were given an n-value of 0.35 and a turbulent exchange coefficient

of 75.0 lb-sec/ft^2. The channel elements were assigned an n-value of 0.020 and a turbulent exchange coefficient of 50.0 lb-sec/ft^2. The n-values were obtained from 1-D backwater runs provided by SWL. They were adjusted somewhat during the calibration process and are in agreement with values recommended in Chow's Open Channel Flow. The turbulent exchange coefficients were adopted from previous WES model studies using RMA-2V.

11. Boundary condition types for the hydrodynamic model consisted of velocity specifications at the upstream boundary and water-surface elevations at the downstream boundary as shown in Figure 6. Land boundaries were given a slip (parallel) flow specification and nodes along the I-440 embankment were given a zero flow specification. For the SPF discharge of 625,000 cfs, a channel velocity of 11.8 fps was prescribed along the upstream end of the grid and a tailwater of 248.5 ft NGVD was specified at the downstream end. For the navigation design flood, the upstream channel velocity was 8.3 fps and the tailwater elevation was 240.5 ft NGVD. Nonchannel velocity specifications were lowered in proportion to the depth. The velocities selected agreed fairly well with previous studies and yielded the desired discharge.

12. SWL provided water-surface profiles for the two design flows, 310,000 cfs and 625,000 cfs. Since the higher flow was the one of most concern, RMA-2V was calibrated to that flow. The lower discharge was used for verification purposes. The two parameters for calibration were Manning's n and the tailwater elevation. Referring to Figure 5, we reduced the nonchannel n-values from the initial estimates of 0.10 and 0.06 to 0.06 and 0.035, respectively. The channel roughness was not changed. Referring to Figure 6, the tailwater at the downstream boundary of the grid (mile 159.8) was lowered so the computed water-surface elevations tied in to SWL's curve at mile 160.1. Results of the 625,000-cfs calibration are shown in Figure 7. Only the tailwater and upstream velocities were changed for the 310,000-cfs verification run. The resulting profile is shown in Figure 8.

The Sediment Transport Model

13. The primary objective of this study was to predict the impact of the runway extension on the water-surface profile upstream of the project for a design flood of 625,000 cfs. To accurately predict the water-surface elevations, however, it was first necessary to predict what the bed configuration

would be during such a flood. To do this, the sediment transport model, STUDH, was run for both base and plan conditions.

14. In addition to the hydrodynamic results computed by RMA-2V, the input requirements for the sediment transport model include grain sizes, initial sediment concentration throughout the grid, and inflowing sediment concentrations at the upstream boundary.

15. Grain-size information was obtained from the "East Belt Freeway Arkansas River Bridge: Preliminary Report" (Garver and Garver 1977). This report showed an average grain size of 0.12 mm in the south overbank, 0.14 mm in the north overbank, and 0.27 mm in the main channel and stone dike areas. These values were measured at the bridge site. Boring data included in the dike design blueprints showed that typical sediments were poorly graded sand with some gravel. Based on these data, an average grain size of 0.27 mm was selected for the sediment transport model.

16. Initial sediment concentrations and boundary condition concentrations were both obtained from Project Design Memorandum No. 5-3 (USAED, Little Rock, 1960). The rating curve used is shown in Figure 9. This source, rather than more recent measurements, is expected to produce the most likely concentrations when extrapolated to 625,000-cfs flow.

17. The magnitude of bed change computed by STUDH depends upon the duration of the simulation. Since there was not a design hydrograph for the SPF, SWL used the 1957 flood to determine the time between bank-full flow and the peak. This turned out to be 228 hr. The resulting bathymetry for base and plan conditions is shown in Figures 10-13.

Results

18. The new bathymetry was then input to the hydrodynamic model to compute water-surface elevations. Figures 14-17 show current patterns for the base and plan conditions. In the base test, approximately 12 percent of the flow passed over Gates Island at the site of the proposed runway. The plan condition diverted this water into the main channel, increasing the velocities by 1 fps. The resulting jet lowered the water-surface elevations downstream of the structure for nearly 2 miles. Upstream of the runway, water-surface elevations were raised about 0.1 ft. Figure 18 shows the predicted impact of the runway extension on the water-surface profile of the design flood.

PART III: THE NAVIGATION STUDY

The Navigation Model

19. In 1983, tests were conducted on a typical 15-barge tow operating on the Upper Mississippi River to determine the effects of a reduced dredging policy. That study included making a preliminary estimate of the hydrodynamic coefficients of a 15-barge tow and a 6-barge tow. Then a full set of towing tank tests was performed to determine the deepwater hydrodynamic coefficients, the shallow-water adjustments to these coefficients, the bank effects, and the effects of dikes and irregular bottoms (e.g., large sand waves). It was found that the estimation of the deepwater effects for the tow were reasonably accurate; however, there were not sufficient data on which to base the estimates of the shallow-water and bank effects. Data were available for deep-draft vessels, principally tankers, but the behavior of shallow-draft tows was found to be significantly different. The effects of dikes and irregular bottoms were not significant enough to warrant detailed modeling. Those simulated tows were extensively tested by river pilots and given high ratings on the realism of their performance in both deep pool and restricted channel conditions.

20. For the purposes of the Little Rock Airport Study, a 6-barge tow with the configuration of 3 wide and 2 long was used. The overall tow length was 530 ft and the beam was 105 ft. This is the assumed makeup of a typical large tow on the McLellan-Kerr Waterway because it readily fits into the 600- by 110-ft locks on the waterway. The towboat characteristics are those of the 3,000- to 3,500-HP class. Since some differences were found between the estimated and the tested 15-barge tow used for the Upper Mississippi study, the estimated 6-barge tow was developed from the tested 15-barge tow by adjusting coefficients based on the procedures developed by Hydronautics, Inc., for estimating the coefficients. This involved adjusting the coefficients according to dimension or mass ratios. The same shallow-water and bank effects were used as determined in the 15-barge tow tests. For the Little Rock simulation, the tow operated in relatively deep water with depth-to-draft ratios of 3 or greater and at large distances from the banks, at least two beam widths. Therefore the shallow-water and bank effects are assumed to be small.

21. Results of standard maneuvering tests for the estimated 6-barge tow

tow used in this study and the tested 15-barge tow are shown in Table 1. As can be seen, the 6-barge tow travels at a faster rate than the heavier 15-barge tow and stops and turns quicker than the larger tow. In addition, prototype tests have been conducted for a similar size, powered tow but with a different configuration. These tests provide a comparison of the tow speed/power relation. These tows were 3,330- to 2,670-hp towboats and the tow was 1,160 ft long and 54 ft wide. This is about equivalent in carrying capacity to the 3 by 2 tow but is a more slender configuration and, therefore, less resistant.

Table 1

Comparison of Tow Maneuvering Characteristics

	Estimated 6-Barge Tow	Measured 15-Barge Tow
30-deg turning circle		
Advance	1,779 ft	3,720 ft
Transfer	885 ft	1,781 ft
Full speed ahead	9.79 mph	7.68 mph
Crash stop		
Stopping time	4.10 sec	14.0 sec
Distance	1,032 ft	2,509 ft
Crash stop with rudder		
Stopping time	4.10 sec	14.2 sec
Distance	1,030 ft	2,577 ft

The full ahead speed for these tows is 11.6 and 11.9 mph, respectively. The 6-barge tow used for this study falls between the 15-barge tow and the more slender equivalent 6-barge tow as expected. During the test runs, the tow was operated at 90 percent of full throttle which is equivalent to 2,700 hp.

22. The condition selected to test the impacts on navigation due to the constriction of the waterway with the proposed airport extension was the highest flow at which navigation is permitted. This flow is 310,000 cfs and overtops the overbank areas on both sides of the waterway. The airport expansion would then create a blockage to the flow over the Gates Island on the right-hand descending bank and redirect the flow into the navigation channel. At the highest flow under which navigation is permitted, the potential for cross-currents will be the highest and therefore the impacts on navigation will be the greatest.

23. The approach taken in this study was to compare the navigation conditions for the existing, or base, conditions with the conditions created with the airport extension in place, i.e., the plan condition. These conditions were compared for both downbound and upbound transits. Since the airport extension plan does not protrude into the navigation channel per se, the navigation channel dimensions do not change. The only change then is in the current magnitude and direction in the vicinity of the extension. These current patterns were determined using the RMA-2V model using a flow of 310,000 cfs and the appropriate tailwater elevation from SWL's water-surface profiles.

24. The general flow patterns for the base and plan are shown in Figures 19 and 20, respectively. The expanded view of the currents in the vicinity of the airport extension given in Figures 21 and 22 shows in more detail the changes in the flow due to the runway. Changes in the direction of flow are concentrated on the right-hand descending side of the channel and do not appear to extend into the navigation portion of the channel which is on the left-hand side of the channel. There is an increase of 1 to 1.5 fps in the magnitude of the currents in the navigation channel.

25. For purposes of the navigation model, 30 cross sections of velocities and depths were extracted from the RMA-2 model results within the navigation channel. For this purpose, the navigation channel was taken as either the bank line, the 9-ft water depth contour, or the end of the dikes. The actual marked navigation channel lies within this definition. The currents extracted from the RMA-2 results for the base and plan are shown in Figures 23 and 24. Again, the magnified views given in Figures 25 and 26 show that the impact on the currents in the navigation channel is minor and consists of increased velocity magnitudes in the contracted portion of the channel and some limited change in direction immediately below the airport extension. It should be noted that the channel cross sections are concentrated in the area of the planned construction so that these effects are properly modeled for the navigation tests.

26. Figures 27 and 28 show the modeled currents and the navigation channel boundaries for the base and plan conditions, respectively. The dike fields and the airport extension are displayed for reference purposes. The navigation buoys are also included in the figures although they are difficult to distinguish among the current vectors.

27. In order to provide direct comparison of the impacts of the airport extension, the navigation transits were made under the control of an autopilot which is designed to correct for errors or changes in heading and distance off course and to minimize the rate of rotation. An advance look-ahead feature is included that is a function of the magnitude of the heading change in the desired course. Using the autopilot provides a consistent level of control of the tow. Any significant impacts would be expected to be evident in the track lines or in the difficulty of the navigation, e.g., increased rudder activity and/or reduced rudder reserve. The autopilot track lines to be followed, shown in Figures 29 and 30, are identical for base and plan. The track lines in the base condition (Figure 29) are for a downbound transit and the track lines in the plan condition (Figure 30) are for an upbound transit.

Results

28. The transit paths for the downbound transits of the tow are shown in Figures 31 and 32 for the base and plan conditions, respectively. It can be seen by overlaying these two plots that the path taken by the tow is not significantly affected by the runway. In both cases, the tow has some difficulty in changing course just downstream from the location of the proposed airport extension. The upbound transit track lines are shown in Figures 33 and 34 for the base and plan conditions, respectively. Notice that the upbound tow has more control in making the turns as the changes in the course line are very distinct. The tow is also going much slower as noted by the dense line with small incremental steps of the tow being plotted at constant time intervals. Again, it is difficult to detect any significant differences in the path followed by the upbound tow. The track line is more dense and hence the tow is going slower just downstream of the extension in the plan condition. Also, both upstream transits terminated when the maximum run time was exceeded. The transit through the plan condition is much shorter than the base condition transit. This is an indication of the increase in water velocity in the plan condition.

29. In order to understand the navigation activities required to make these transits, plots of the rudder and engine activities and the tow speed and distance off-track were generated. The plots for the downbound tow for the base and plan condition are shown in Figures 35 and 36, respectively; the

upbound transit activities are shown in Figures 37 and 38. For reference purposes, the navigation mile locations are indicated on the abscissa with triangles beginning with navigation mile 118.0 and proceeding downstream from left to right. Again, it is noted that the downbound transits are proceeding at a much higher speed, approximately 12 to 15 mph, while the upbound transits vary between 1 and 5 mph. Also, the downbound transits require more extensive rudder activity and have larger deviations from the desired track line. However, it is difficult to distinguish any significant differences between the base and plan for transits in the same direction.

30. To assist in this analysis, comparison plots of the clearance to the edge of the navigation channel and of the rudder settings and speed were developed. Figure 39 shows that the downbound transits for the base and plan conditions maintained nearly the same clearances on the port and starboard sides. Differences appear to be 20 ft or less. The upbound transits, shown in Figure 40, may have experienced larger differences between the base and plan conditions with the area between navigation miles 115.0 and 115.5 finding the tow about 30 ft closer to the starboard channel edge with the airport extension in place. However, since there is over 1,000 ft of clearance on the port side there is adequate channel available for the tow to move away from the starboard side.

31. The amount of rudder activity required for both the upbound and downbound tows is nearly the same, as is shown in Figures 41 and 42. In all cases, there is at least 10 deg of rudder reserve remaining for emergency maneuvers and except for a few cases rudder settings are less than 15 deg. The differences in forward speed are evident and the increased current effects on the speed are quite distinct between navigation miles 114.0 and 115.0.

PART IV: CONCLUSIONS

32. The proposed runway will have a noticeable effect on the water-surface profile in the study reach. However, the increased head loss will not violate the 0.5-ft maximum swellhead criterion. Velocities at and downstream of the constriction will increase approximately 1 fps, or about 10 percent.

33. While there are some effects on navigation observed due to the proposed project, there does not appear to be any significant increase in navigation difficulty due to the airport extension evident in the autopilot runs. There is a distinct decrease in forward speed for upbound tows due to the increased velocities. It is evident from the "full speed ahead" values in Table 1 that for tows of this size, the power of the towboat cannot be any smaller than that used for the model tow. This is true for the existing conditions as well as the proposed runway extension, however.

34. The best data available within time and budgetary constraints have been used and state-of-the-art solution techniques have been applied to predict the impact of the proposed runway on water-surface profiles and navigation characteristics. Results show that the impact will not be significant.

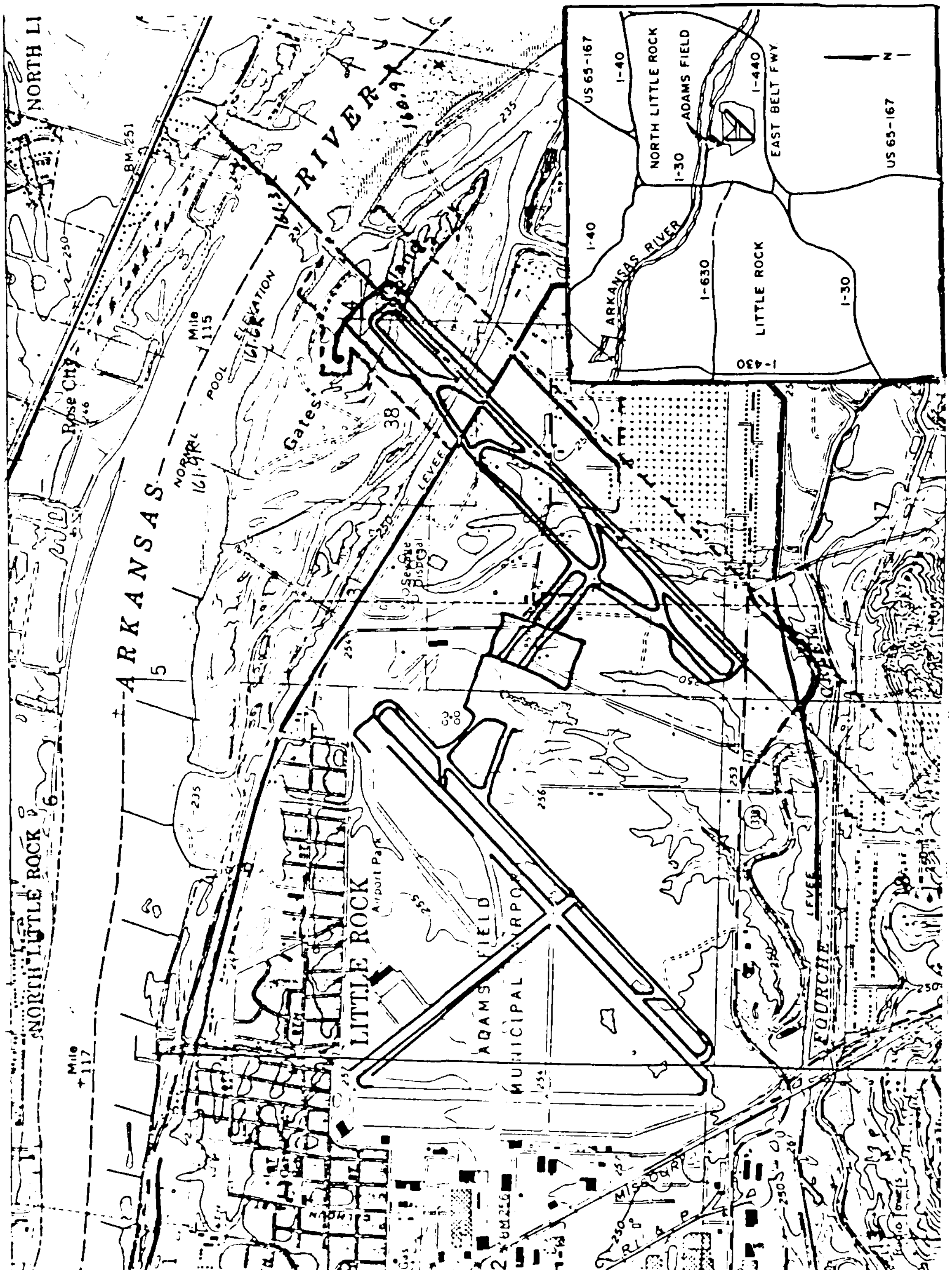

Figure 1. Location map

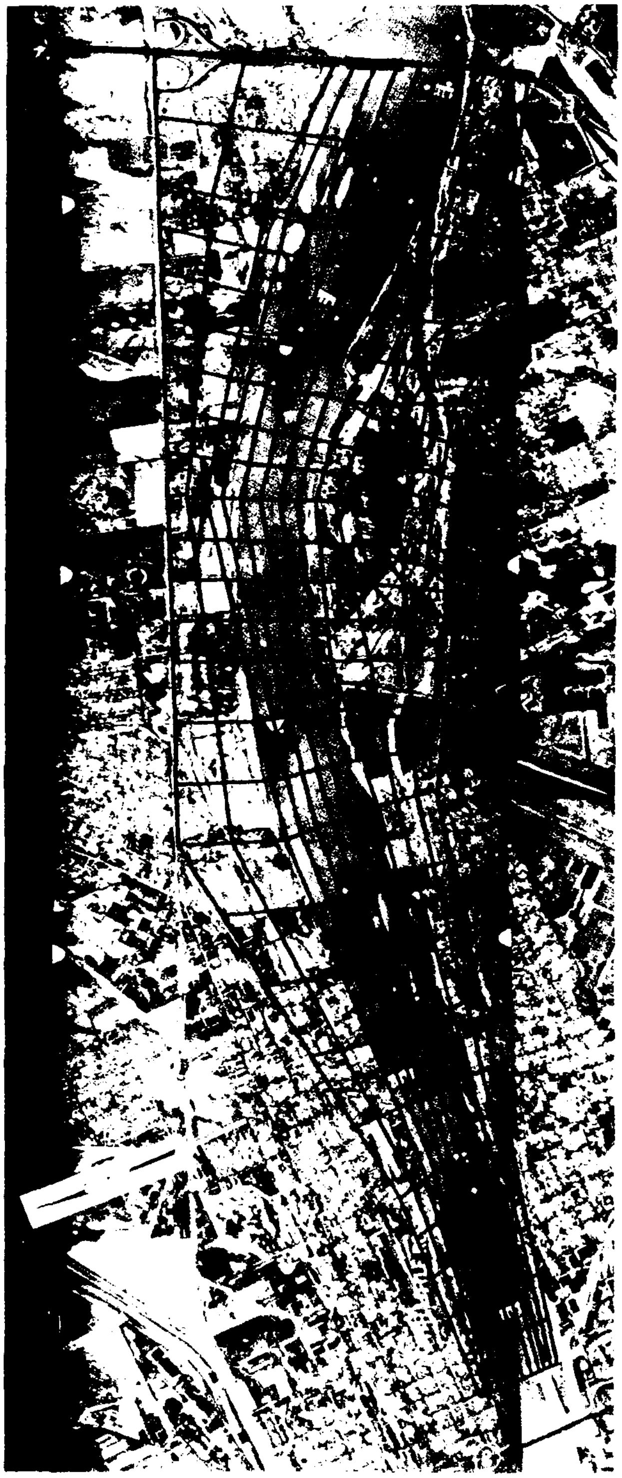

Figure 2. Computational grid for base test

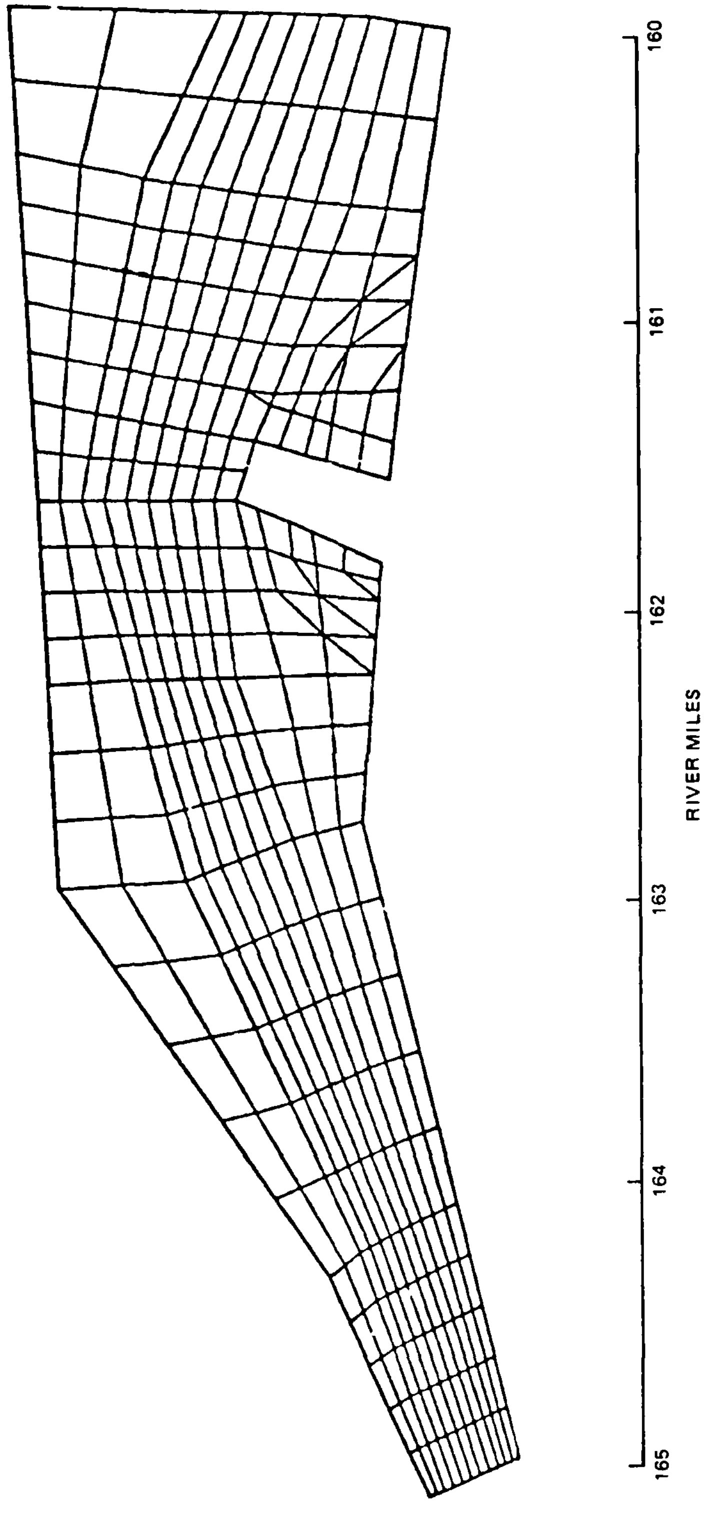

Figure 3. Computational grid for plan test, 625,000 cfs

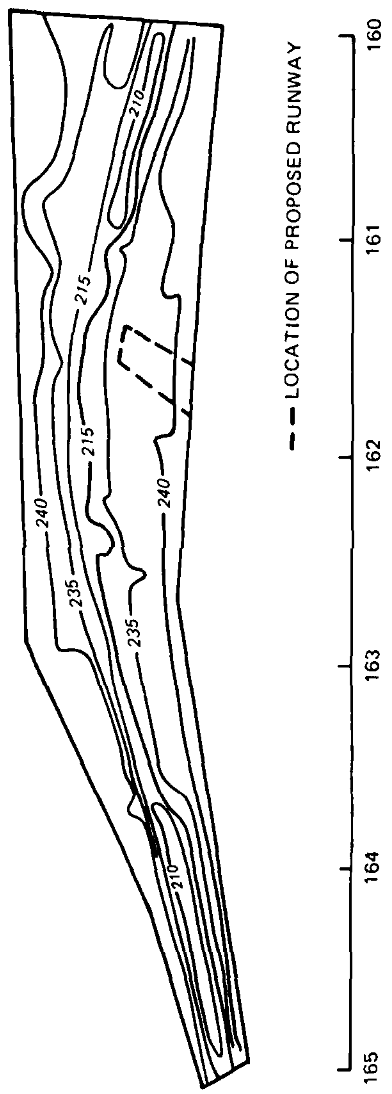

Figure 4. Initial bed elevations

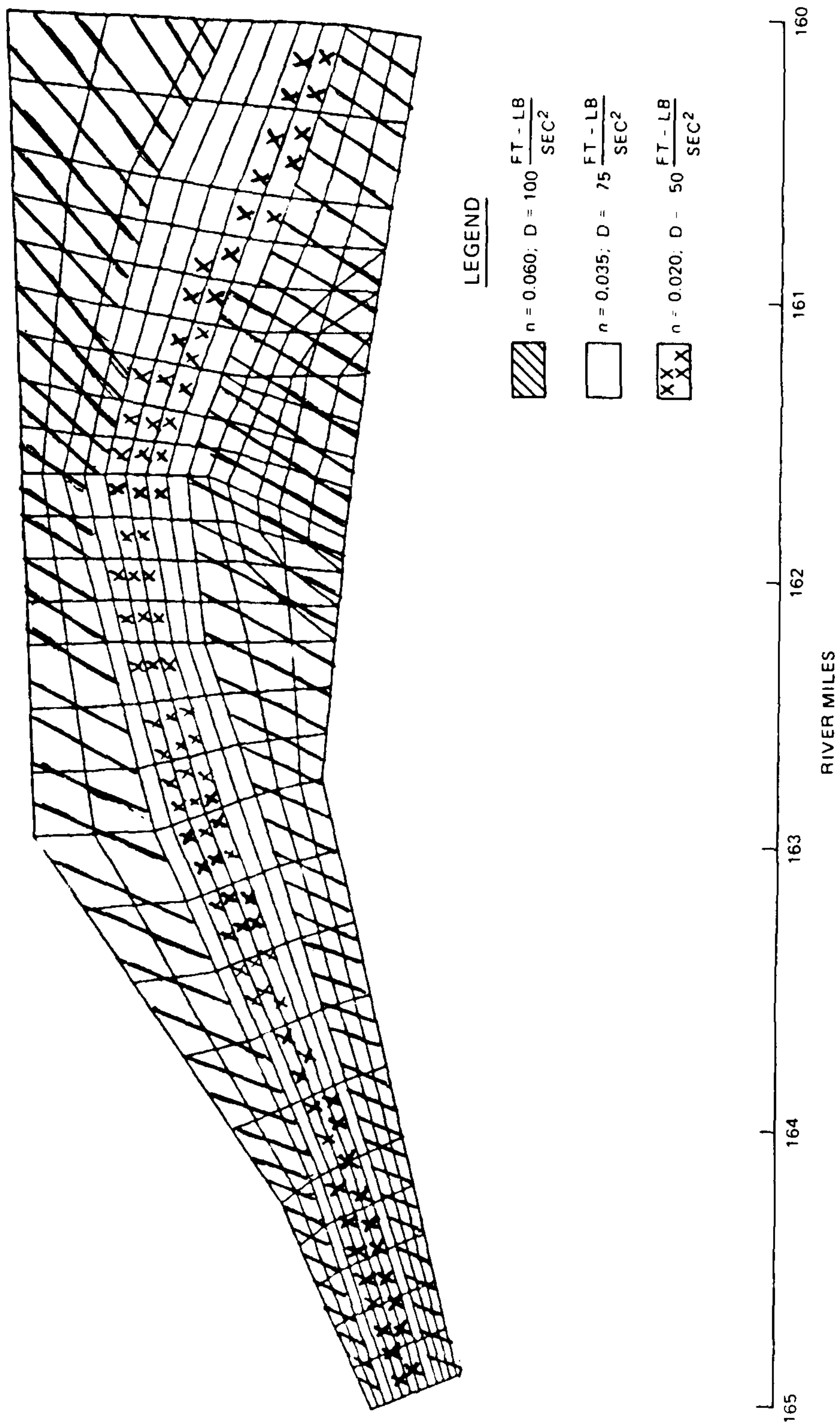

Figure 5. Element types

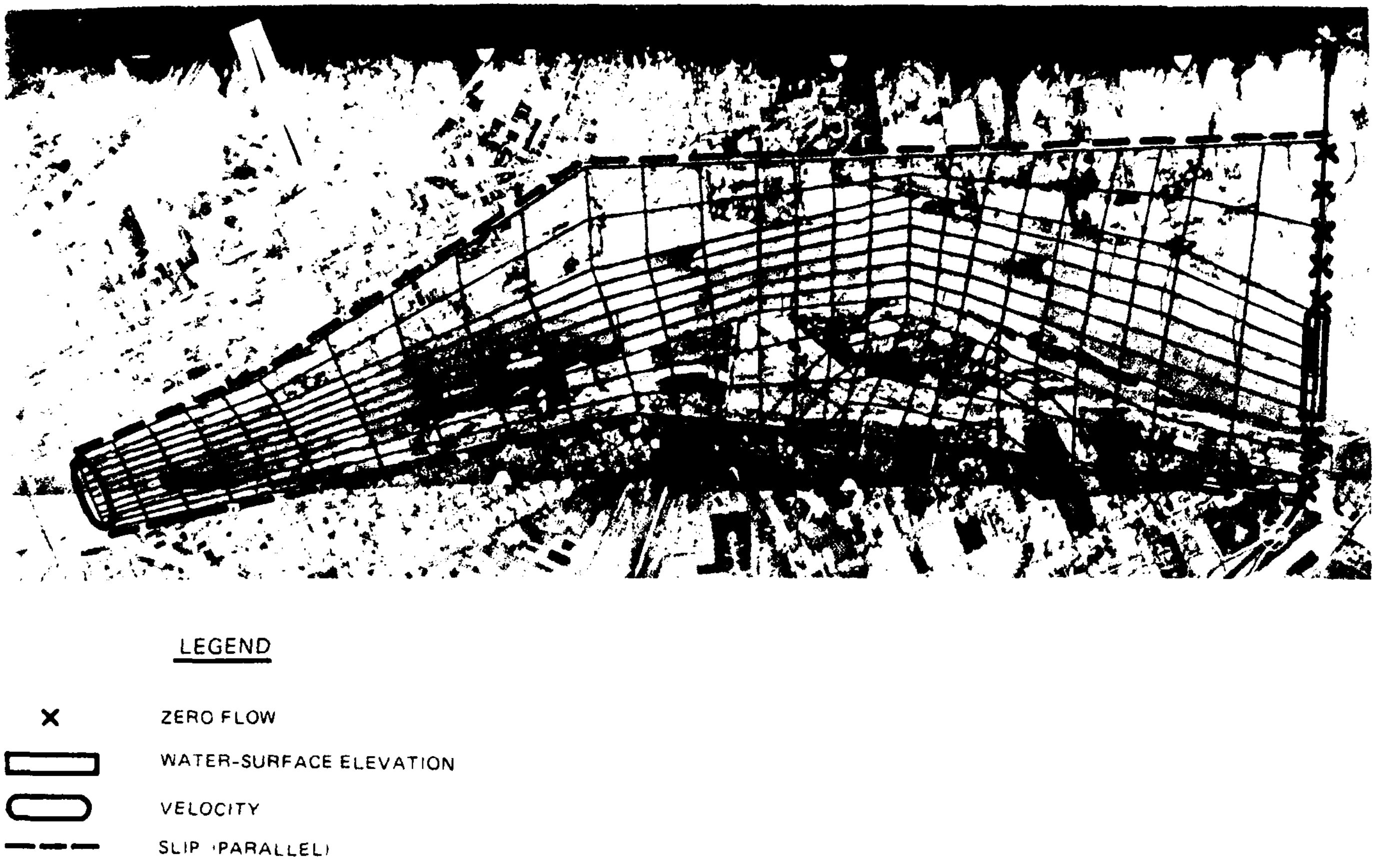

Figure 6. Boundary condition specification

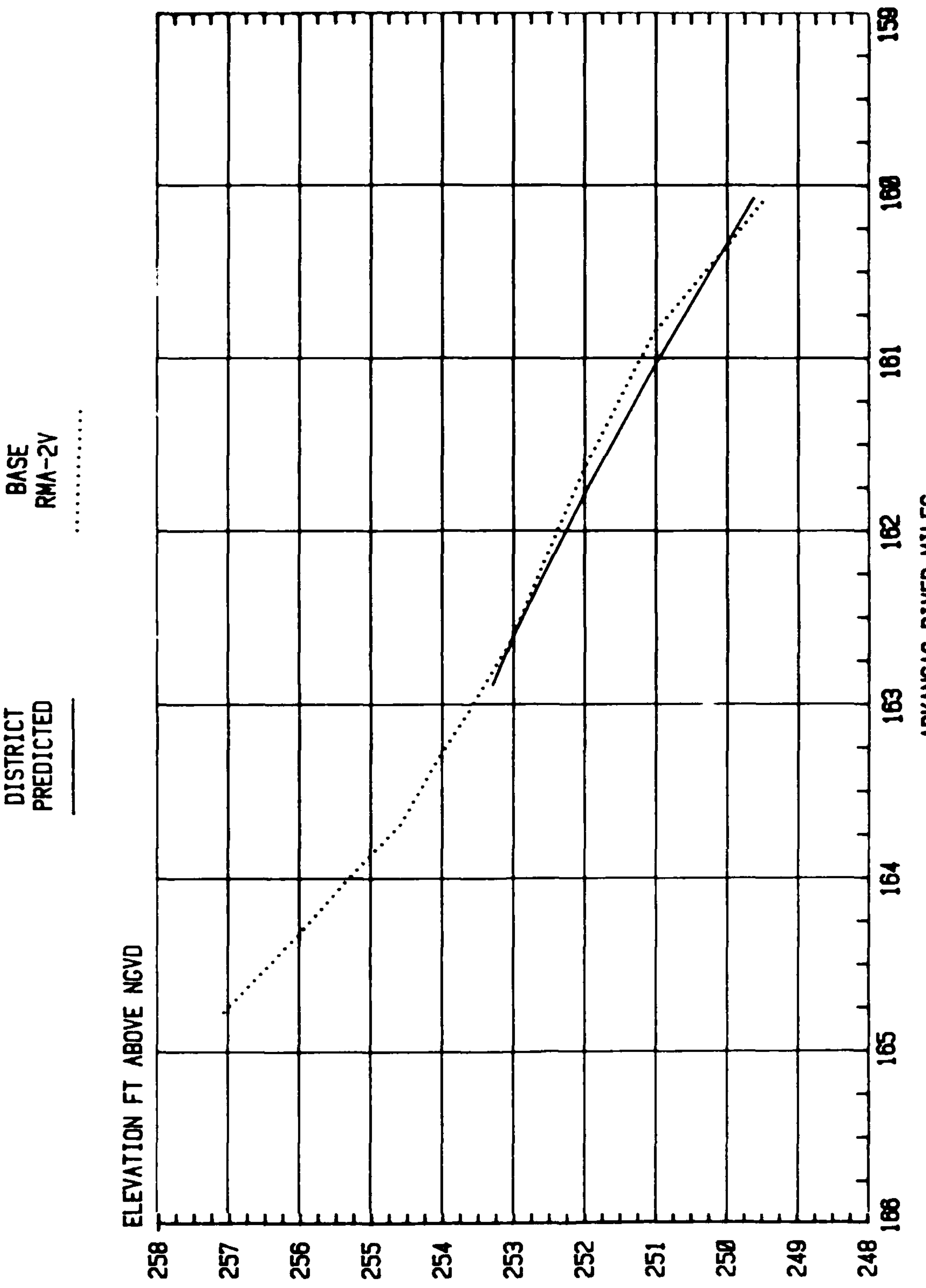

Figure 7. Calibration of RMA-2V

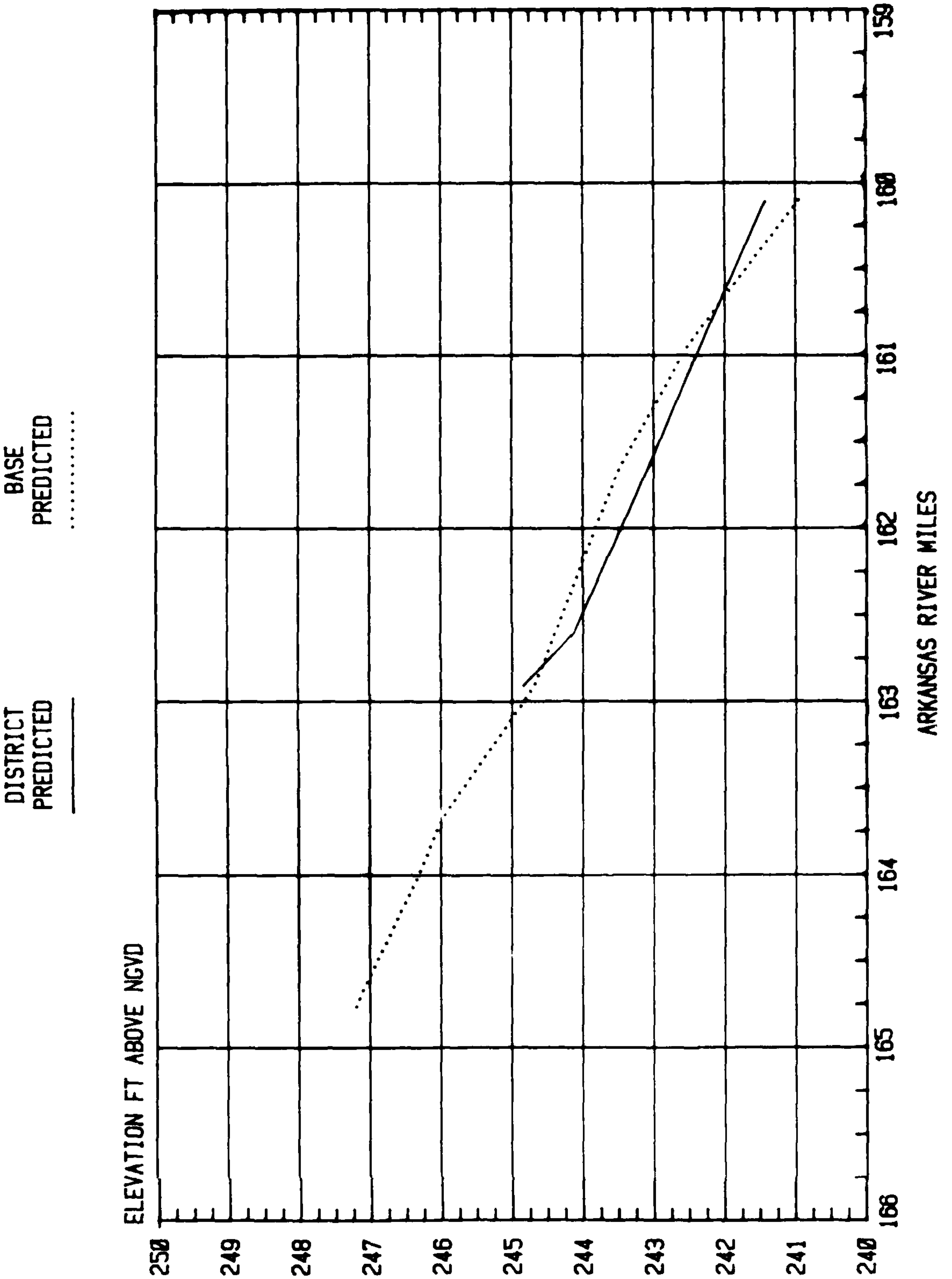

Figure 8. Verification of RMA-2V

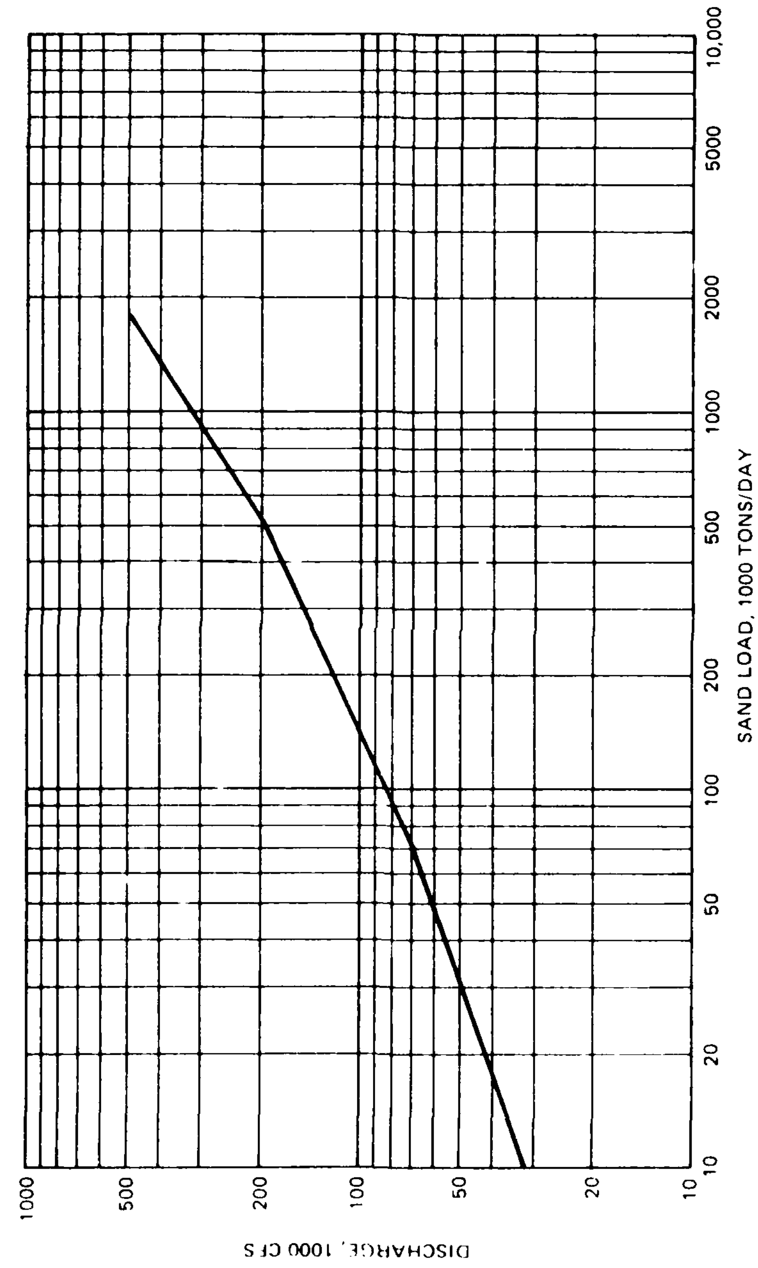

Figure 9. Sediment load rating curve

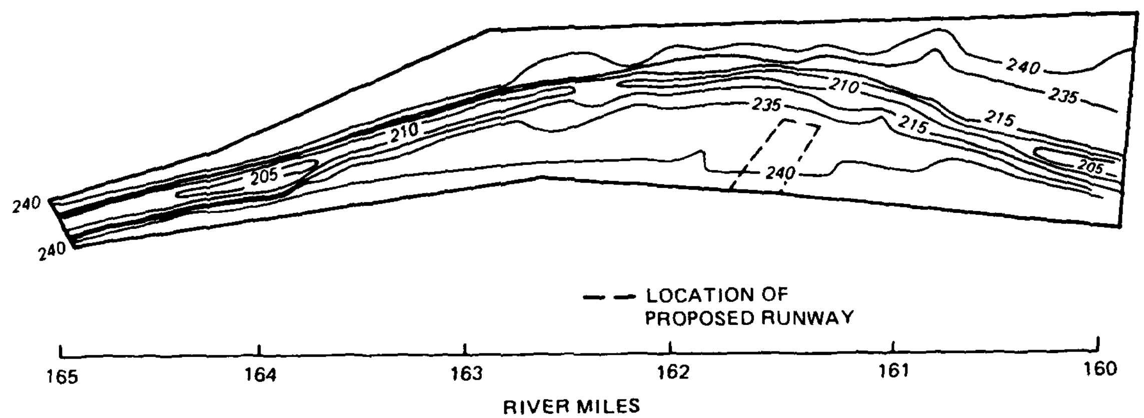

Figure 10. Postflood bathymetry for base test, after 228 hr of sediment transport

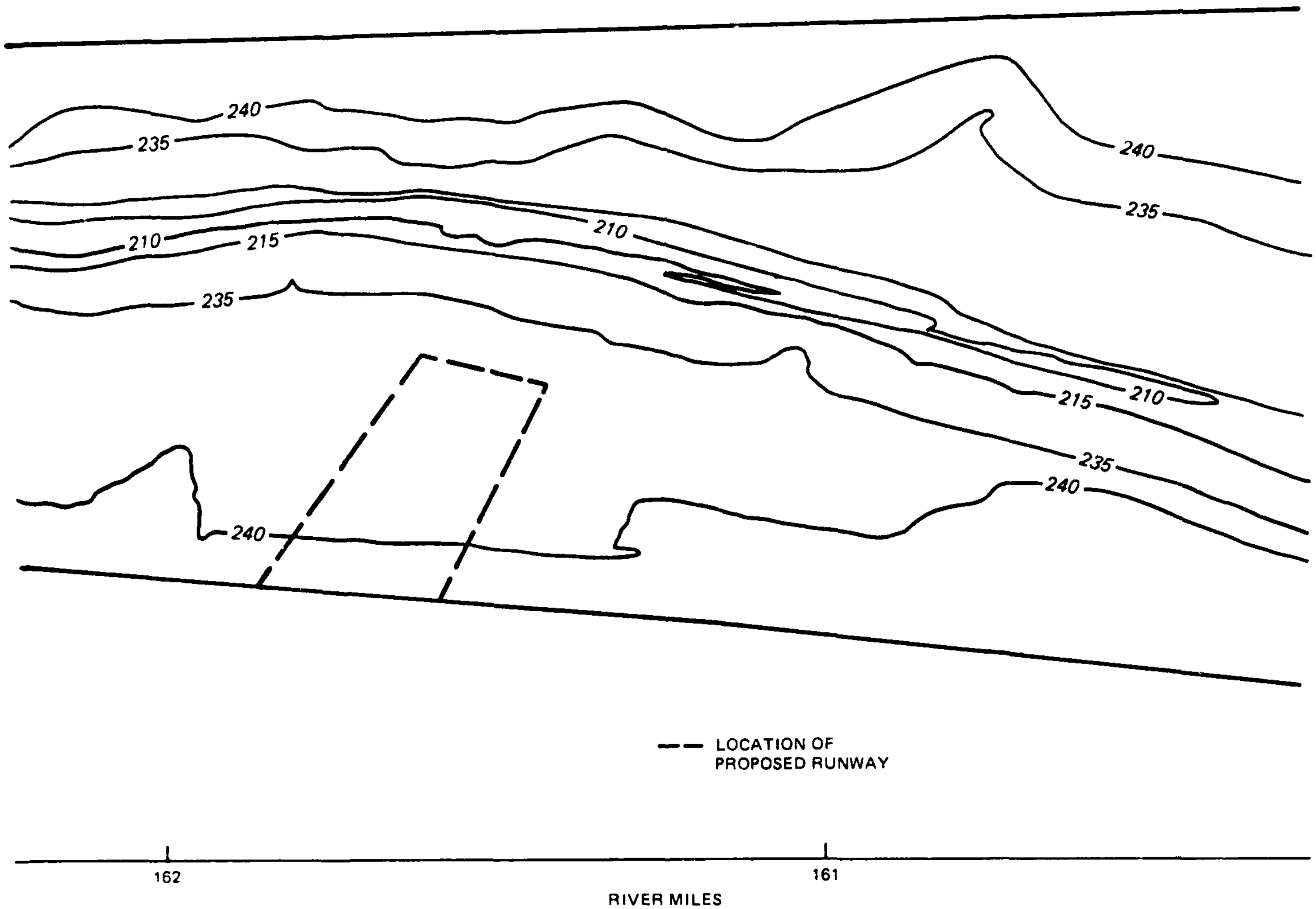

Figure 11. Magnification of postflood bathymetry for base test, after 228 hr of sediment transport

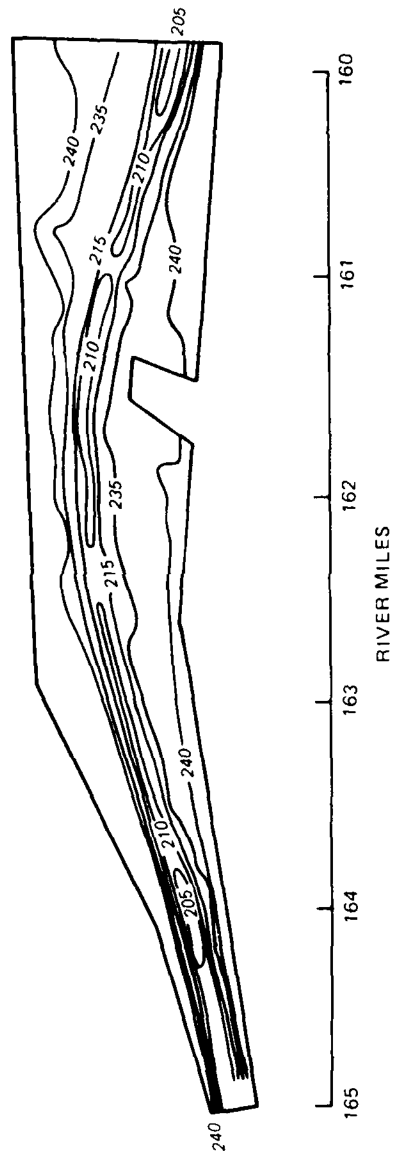

Figure 12. Postflood bathymetry for plan test, after 228 hr of sediment transport

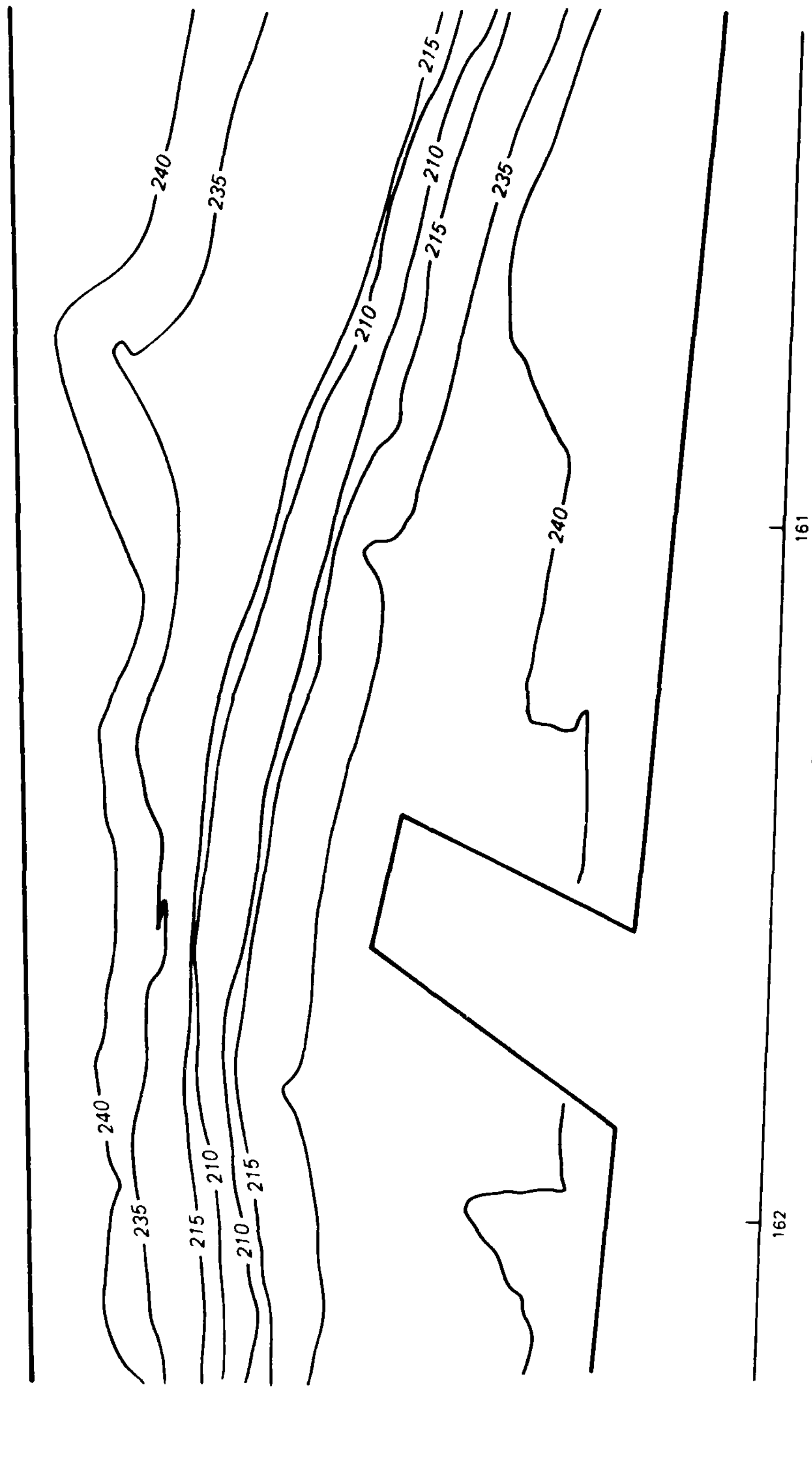

Figure 13. Magnification of postflood bathymetry for plan test, after 228 hr of sediment transport

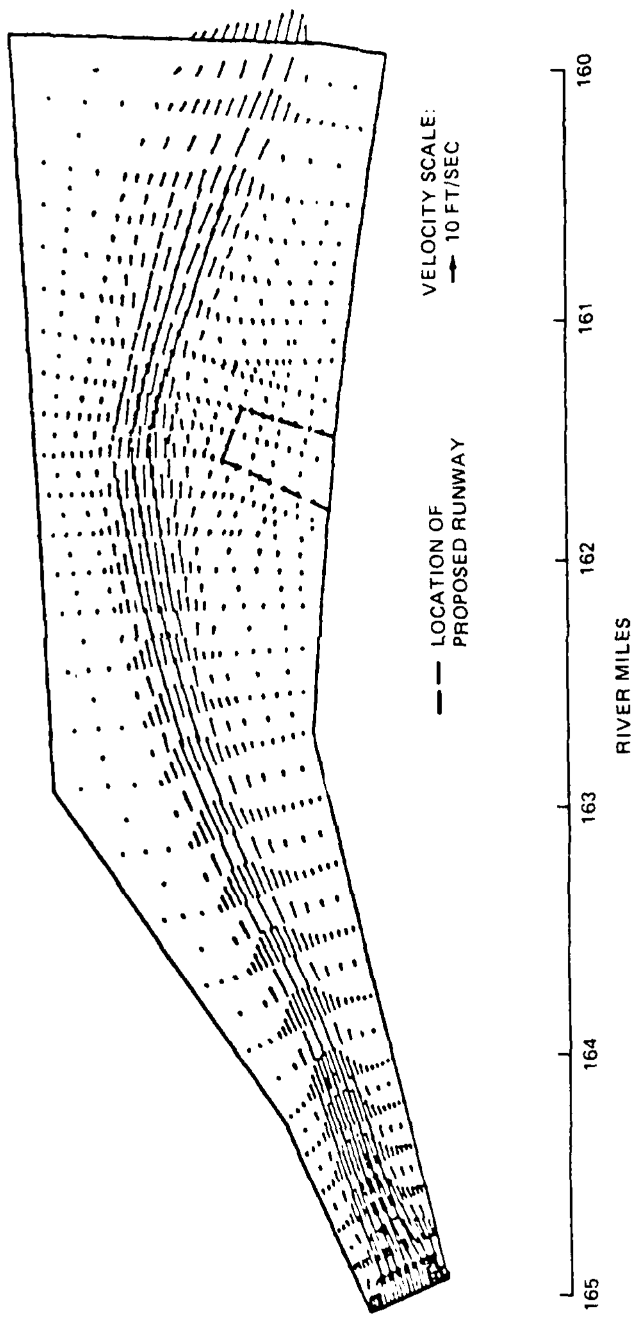

Figure 14. Postflood current patterns for base test, after 228 hr of sediment transport

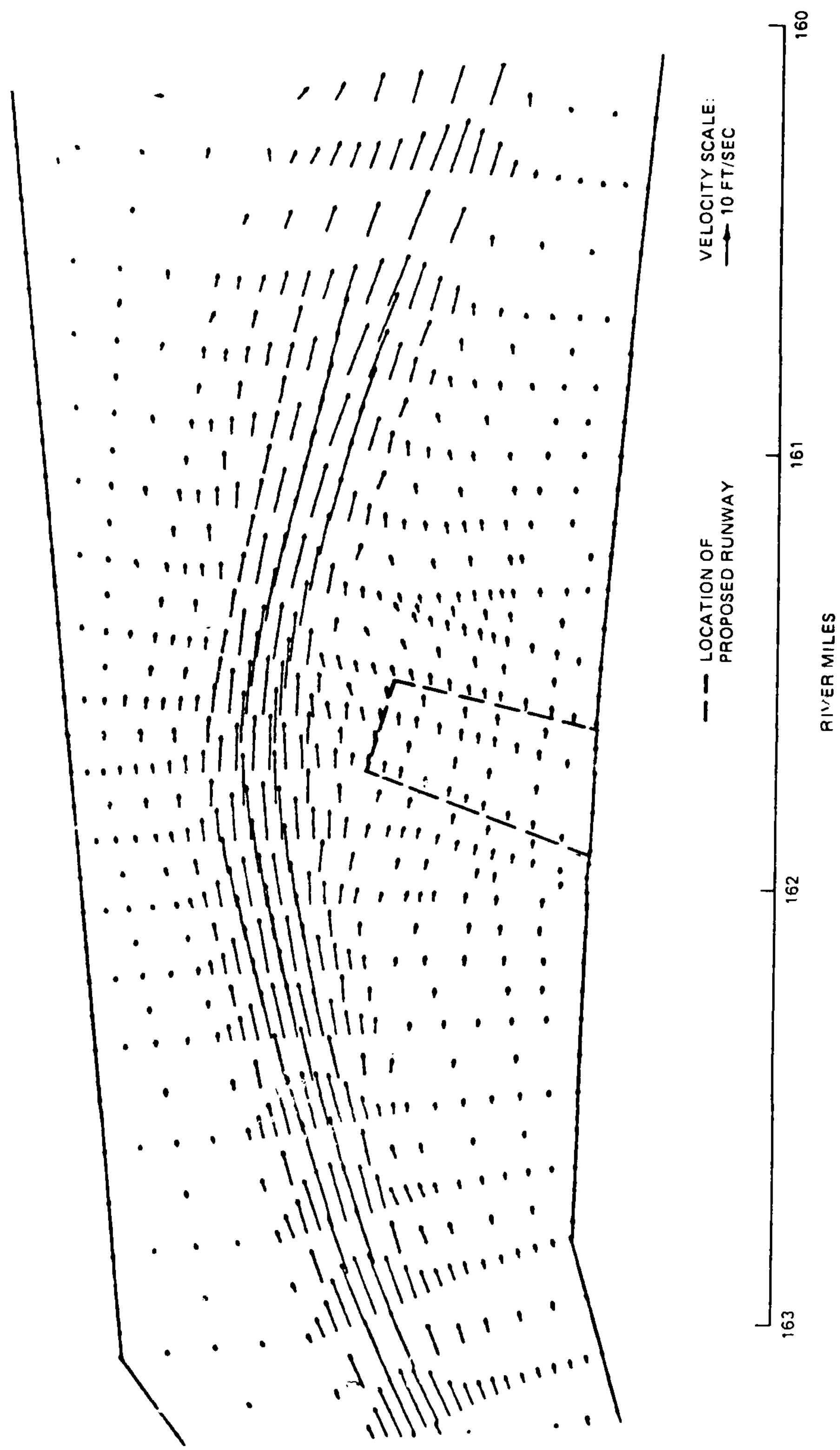

Figure 15. Magnification of postflood current patterns for base test, after 228 hr of sediment transfer

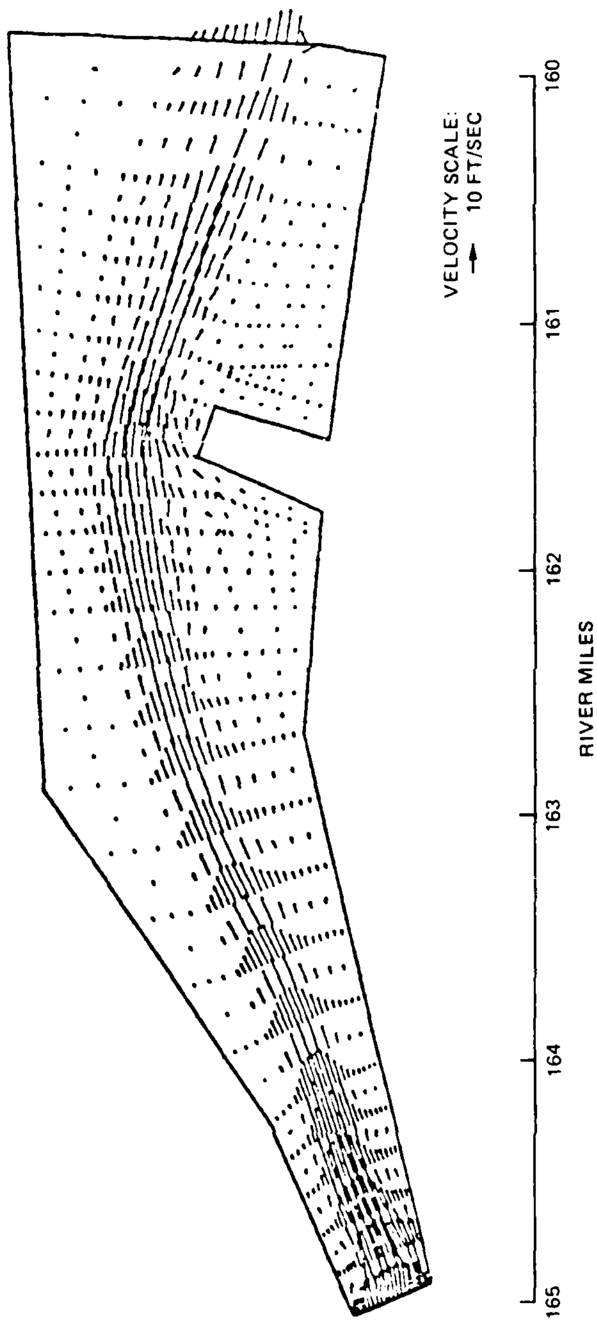

Figure 16. Postflood current patterns for plan test after 228 hours of sediment transport

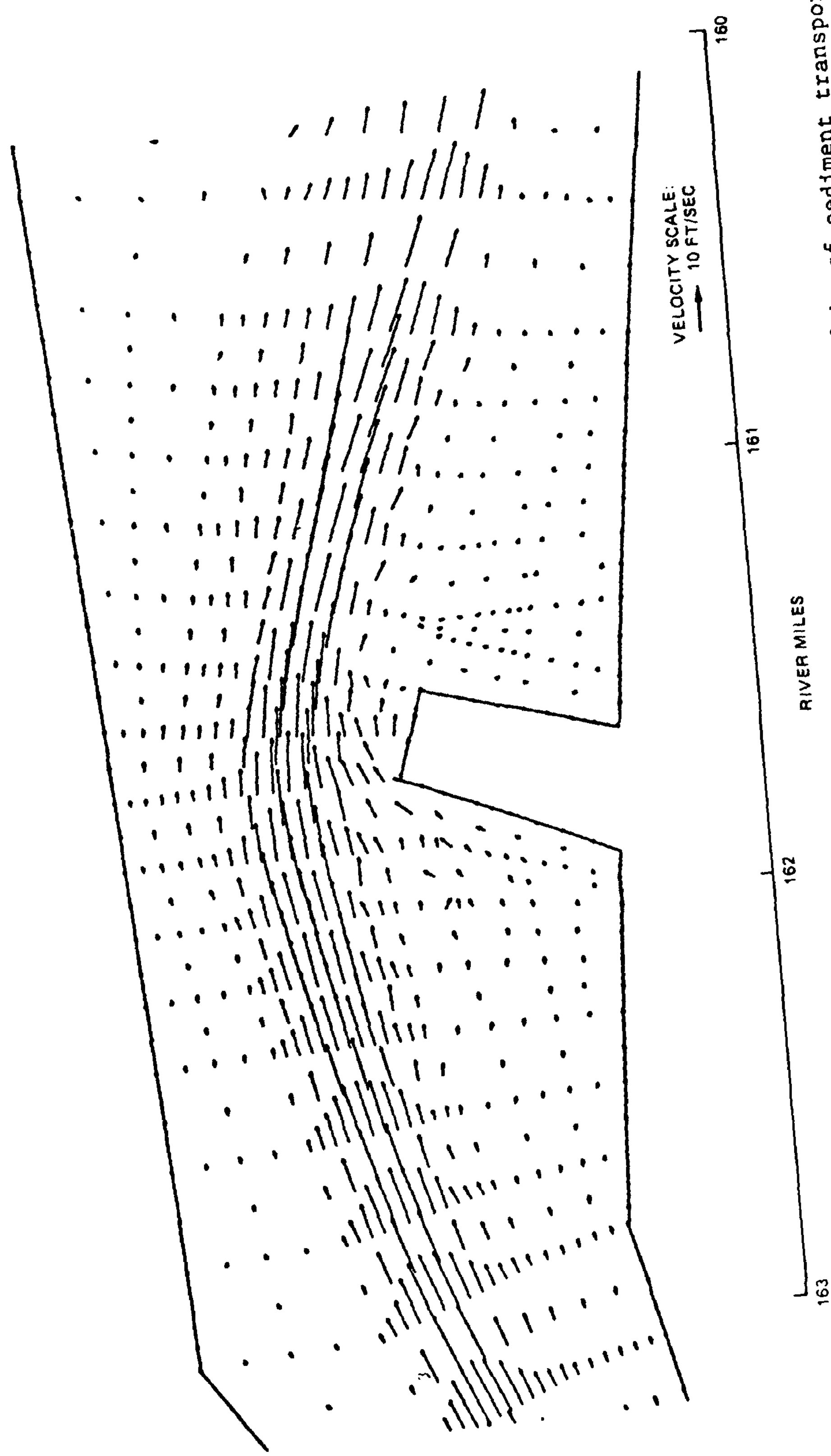

Figure 17. Magnification of postflood current patterns for plan test after 228 hr of sediment transport

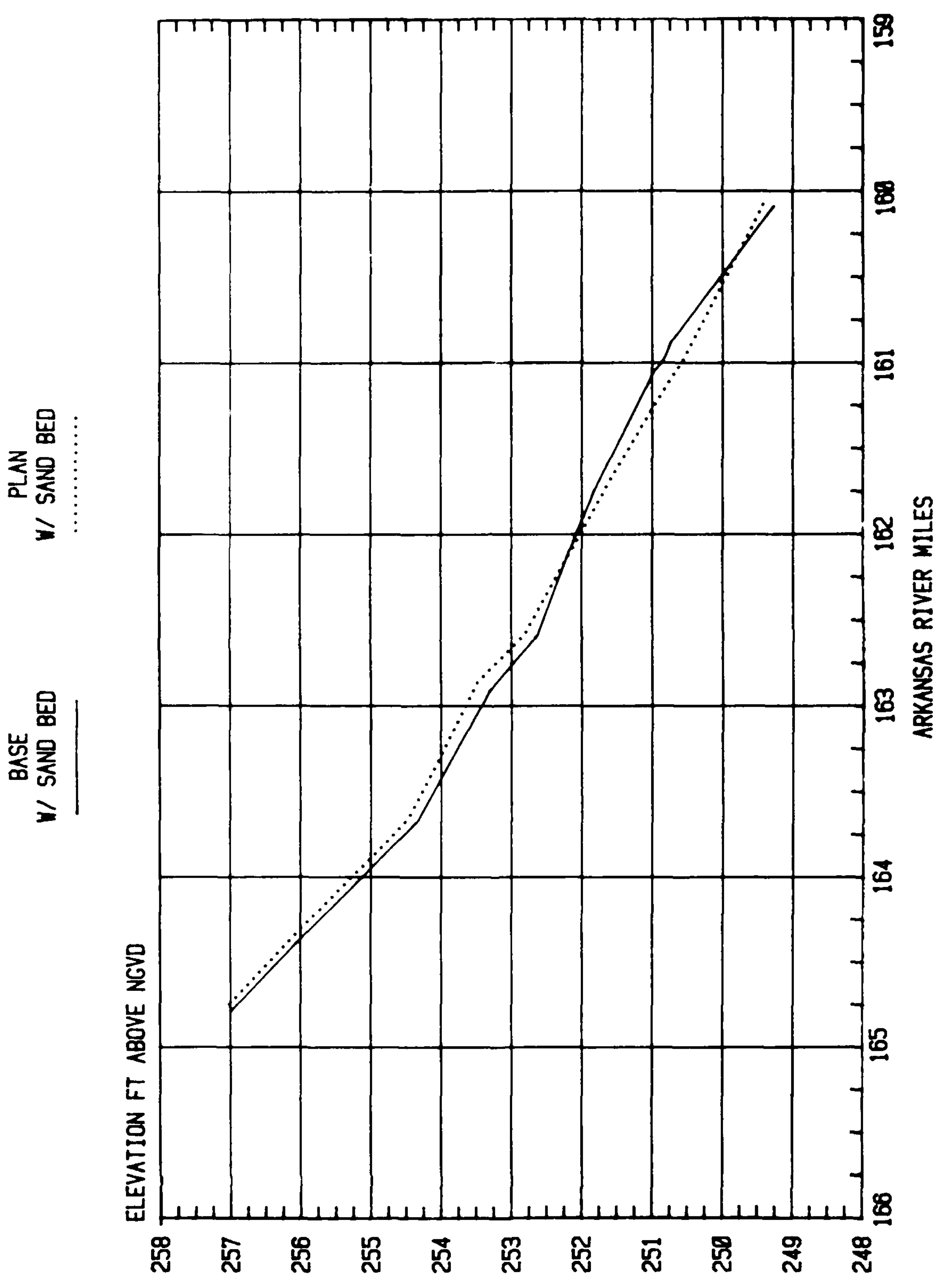

Figure 18. Predicted water-surface profiles for base and plan tests

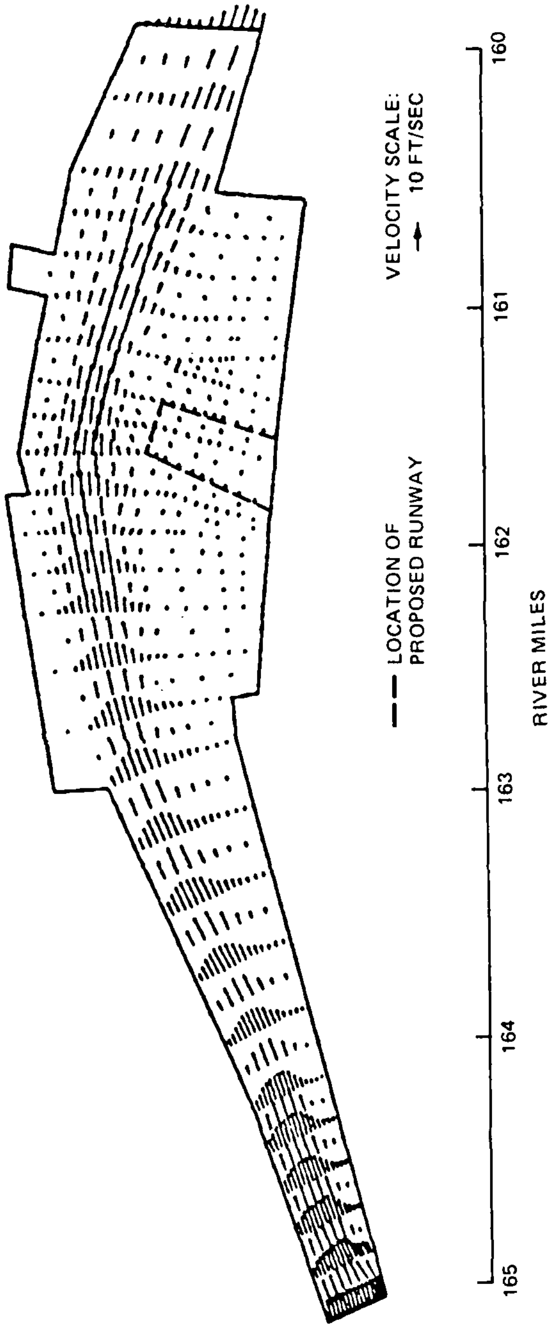

Figure 19. Flow patterns for navigation design flood, base test

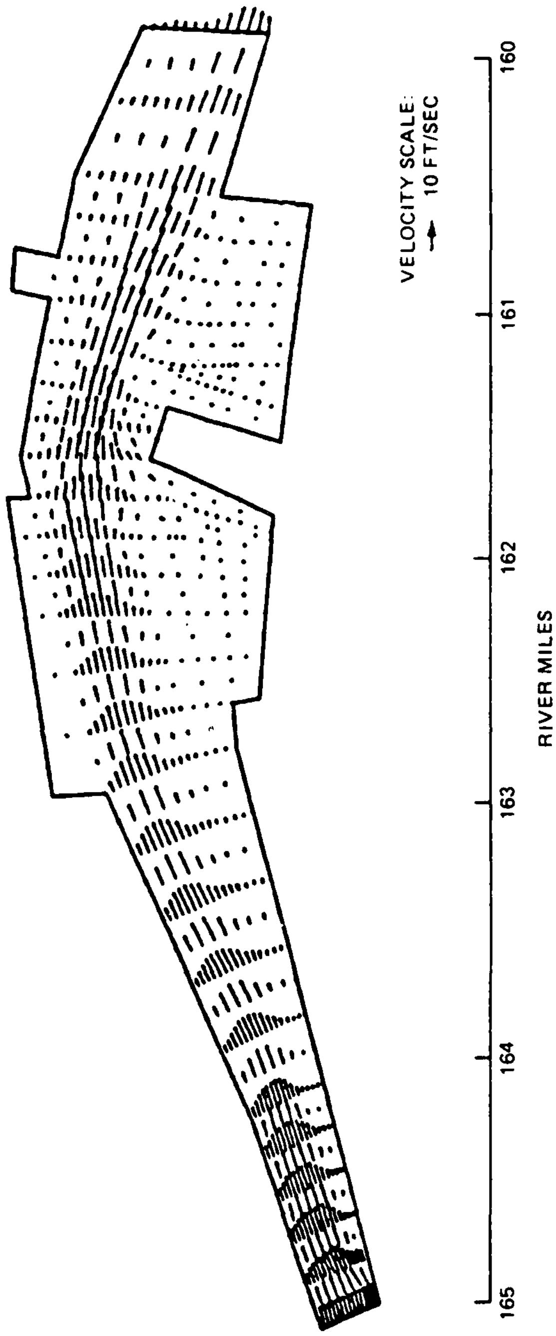

Figure 20. Flow pattern for navigation design flood, plan test

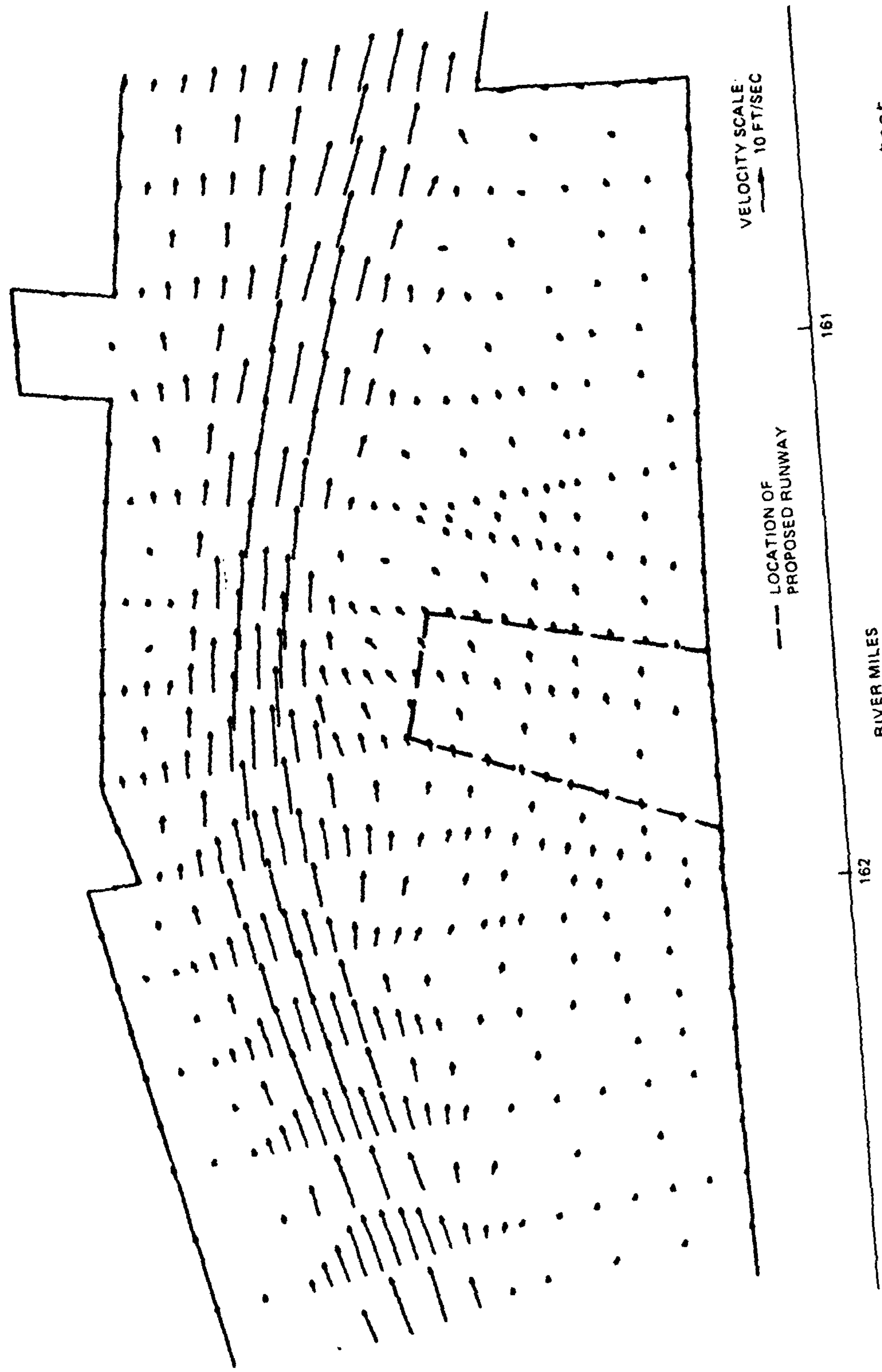

Figure 21. Magnification of flow pattern for navigation design flood base test

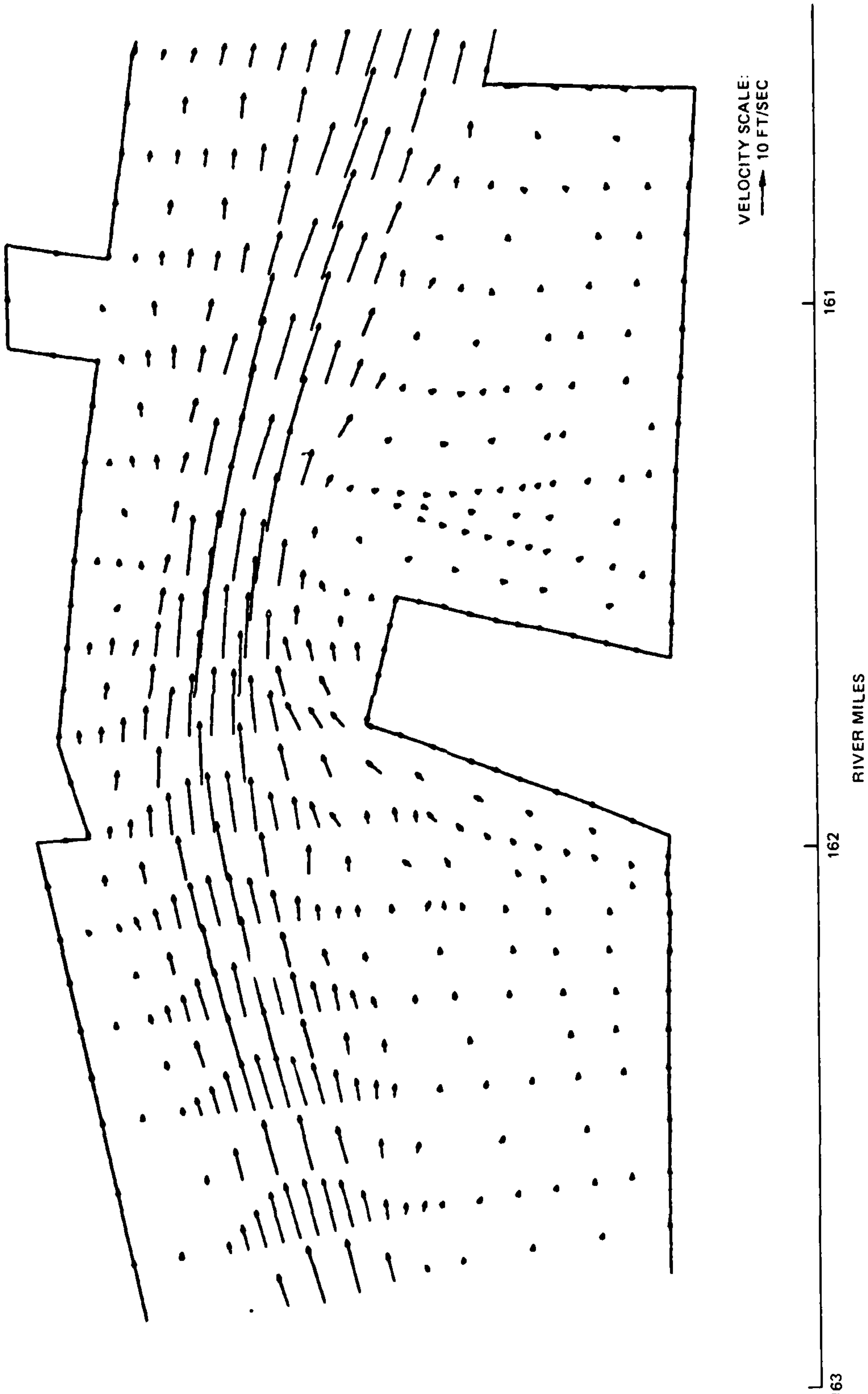

Figure 22. Magnification of flow pattern for navigation design flood plan test

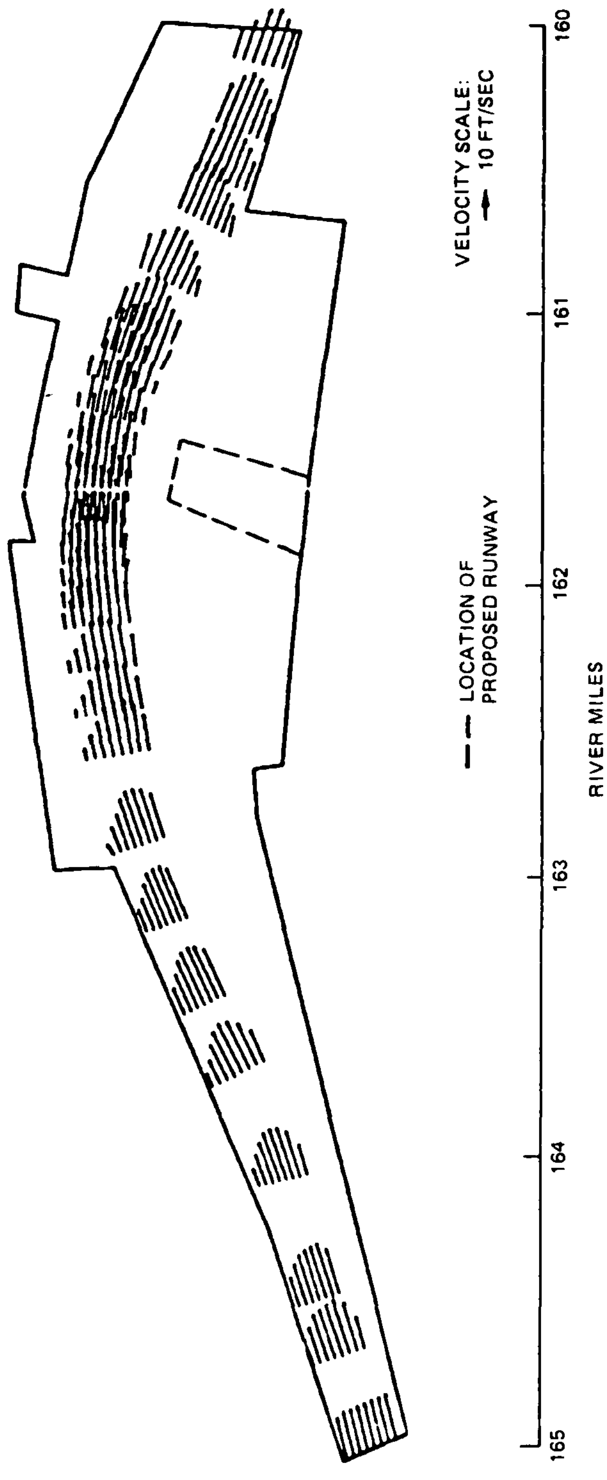

Figure 23. Flow pattern in navigation channel, base test

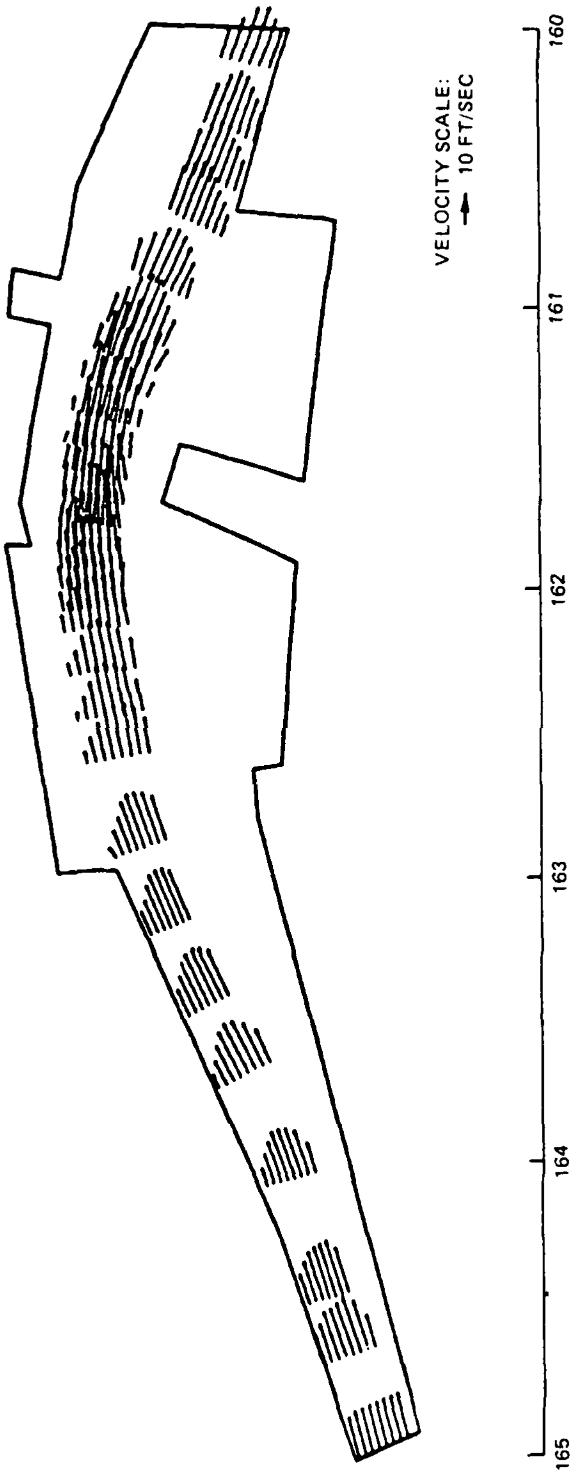

Figure 24. Flow pattern in navigation channel, plan test

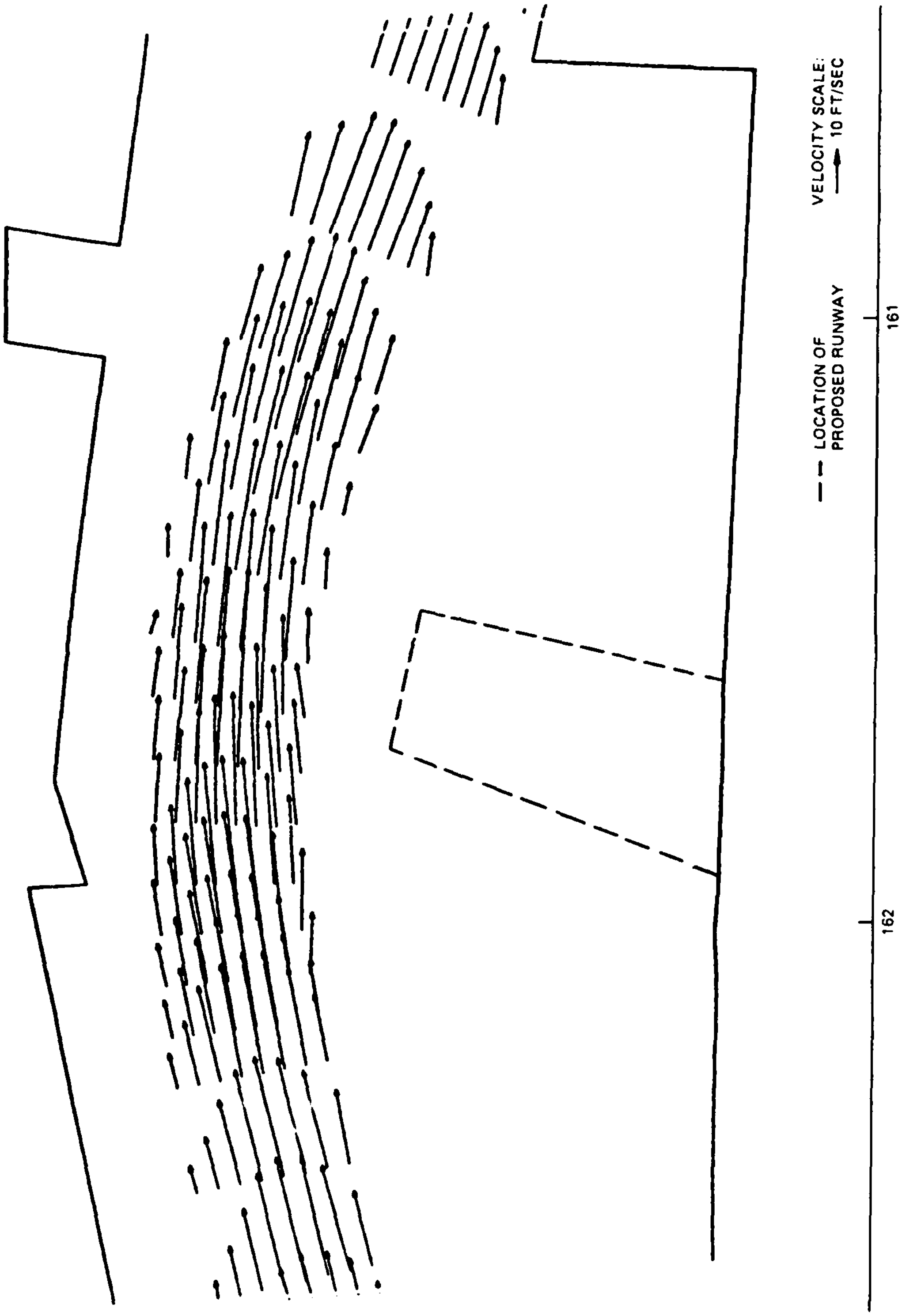

Figure 25. Magnification of flow pattern in navigation channel, base test

Figure 26. Magnification of flow pattern in navigation channel, plan test

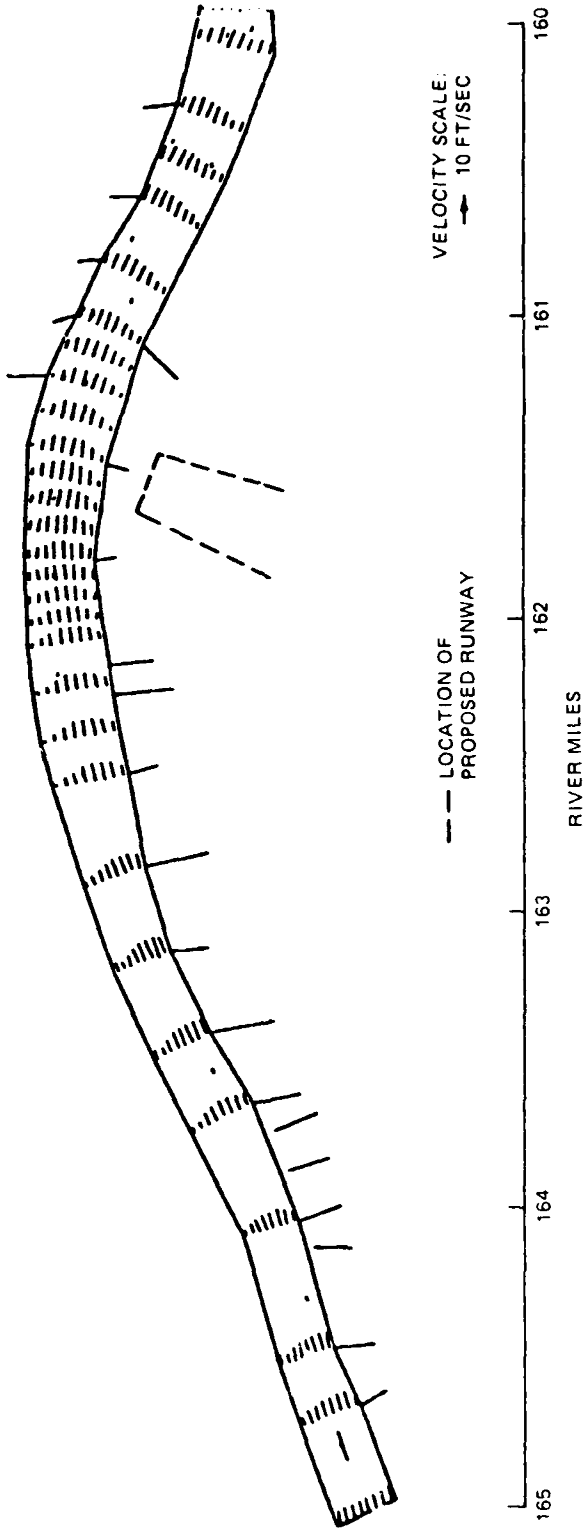

Figure 27. Navigation channel boundaries, base test

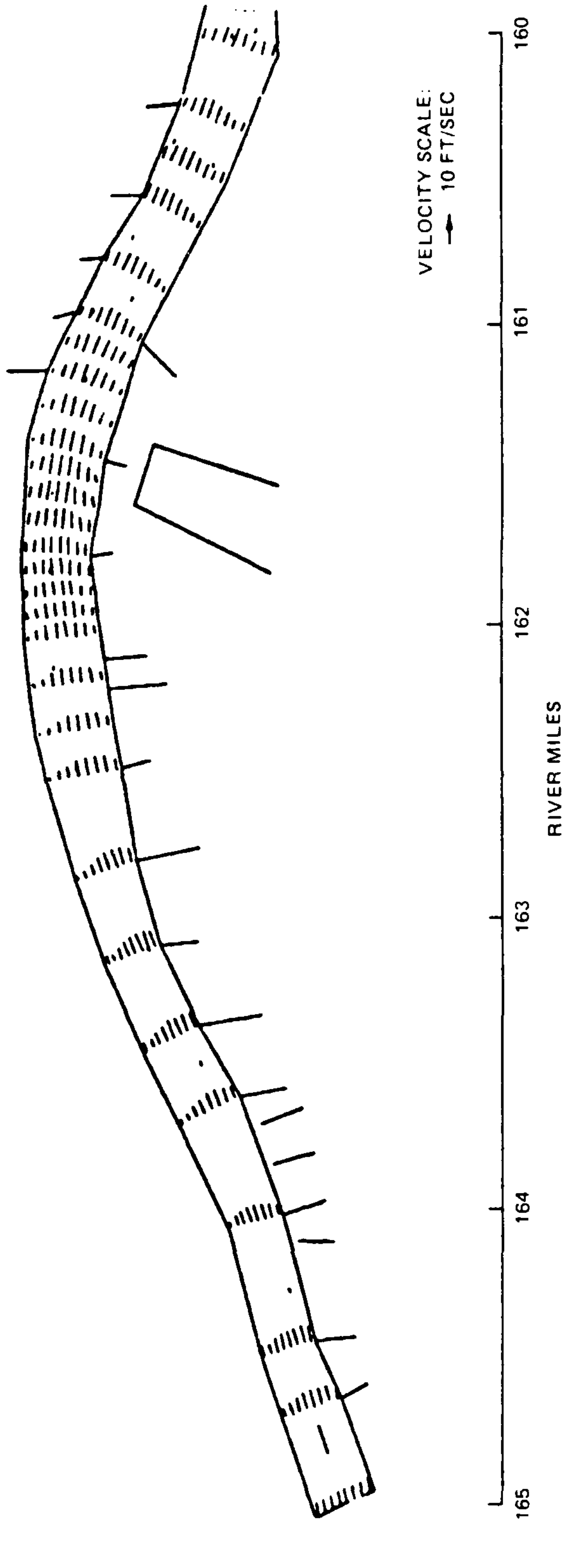

Figure 28. Navigation channel boundaries, plan test

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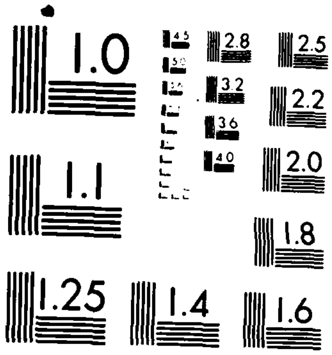


MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS 1963-A

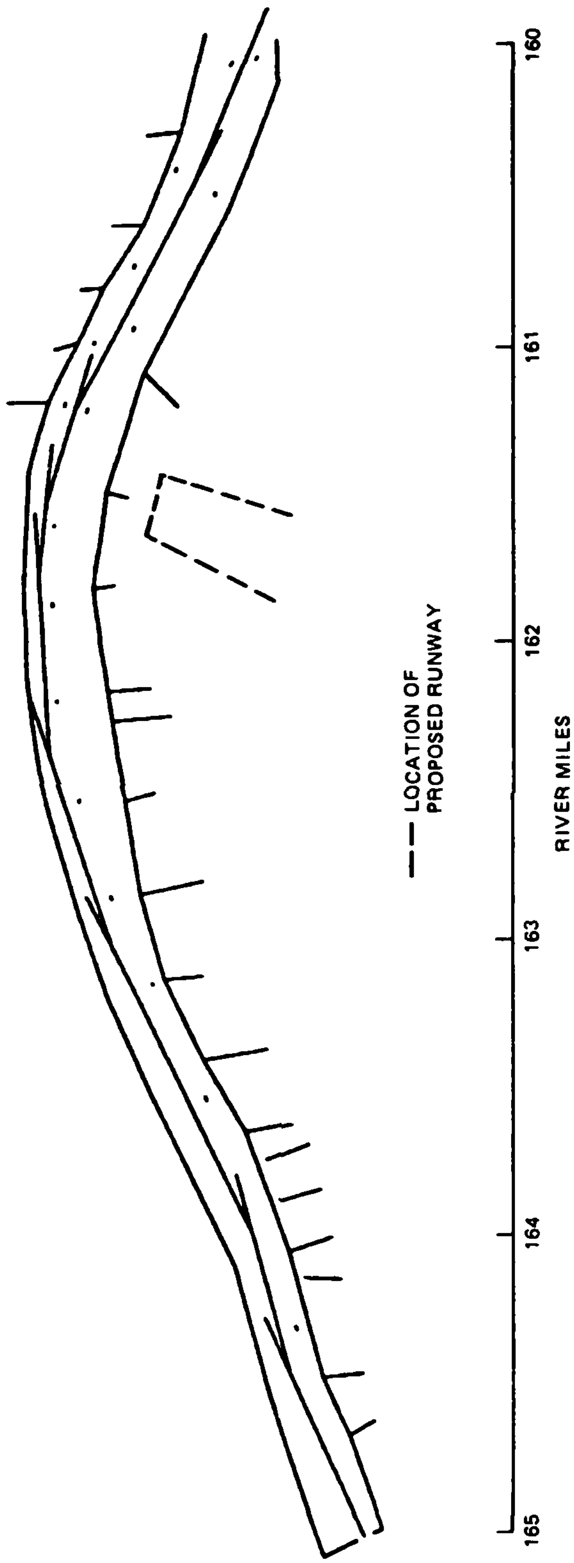


Figure 29. Autopilot track, base test

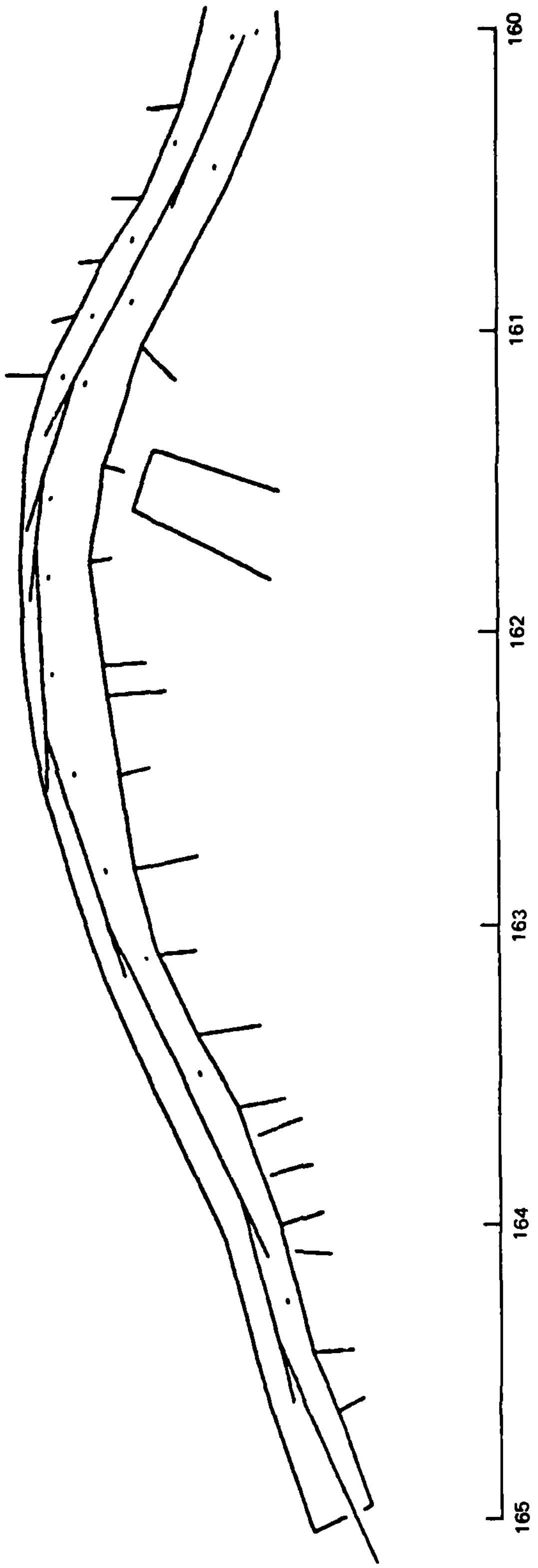


Figure 30. Autopilot track, plan test

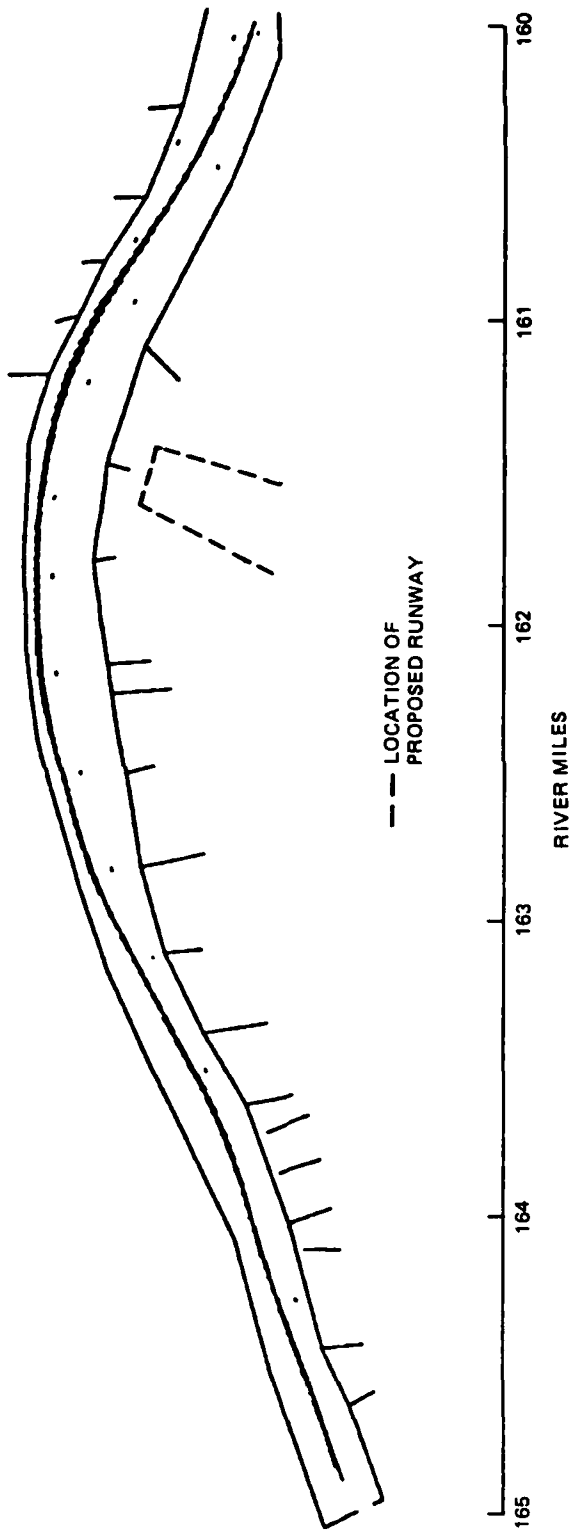


Figure 31. Transit path of downbound tow, base test

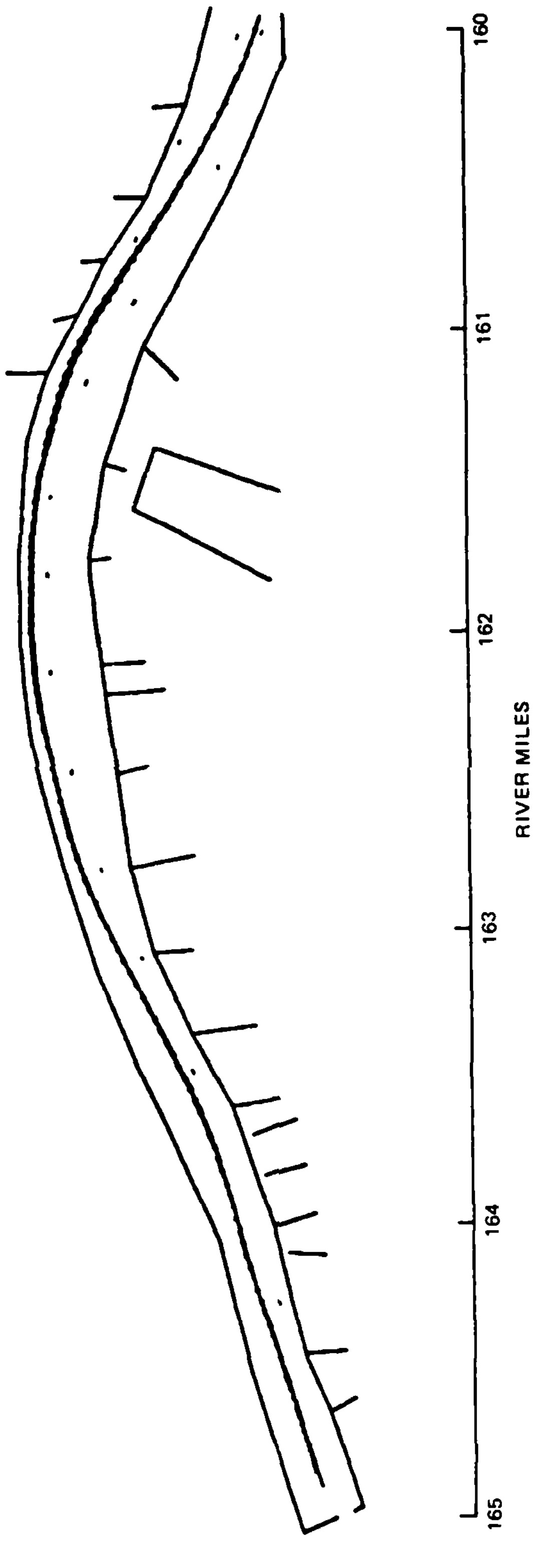


Figure 32. Transit path of downbound tow, plan test

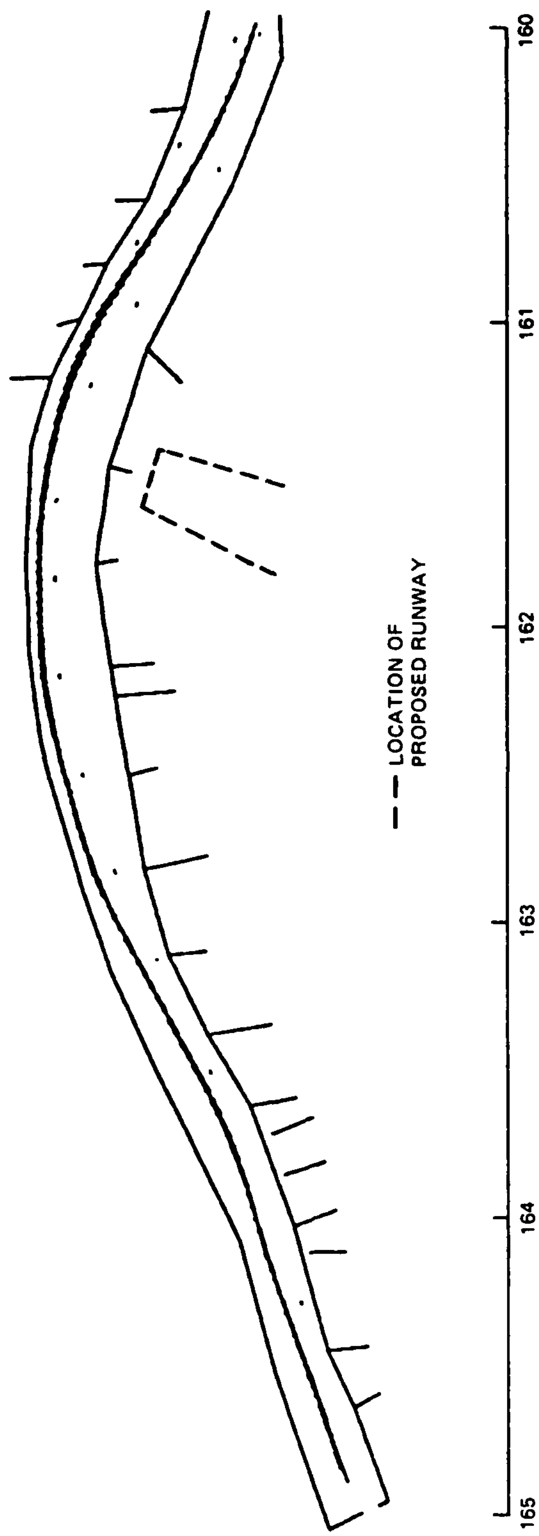


Figure 33. Upbound tow transit path, base test

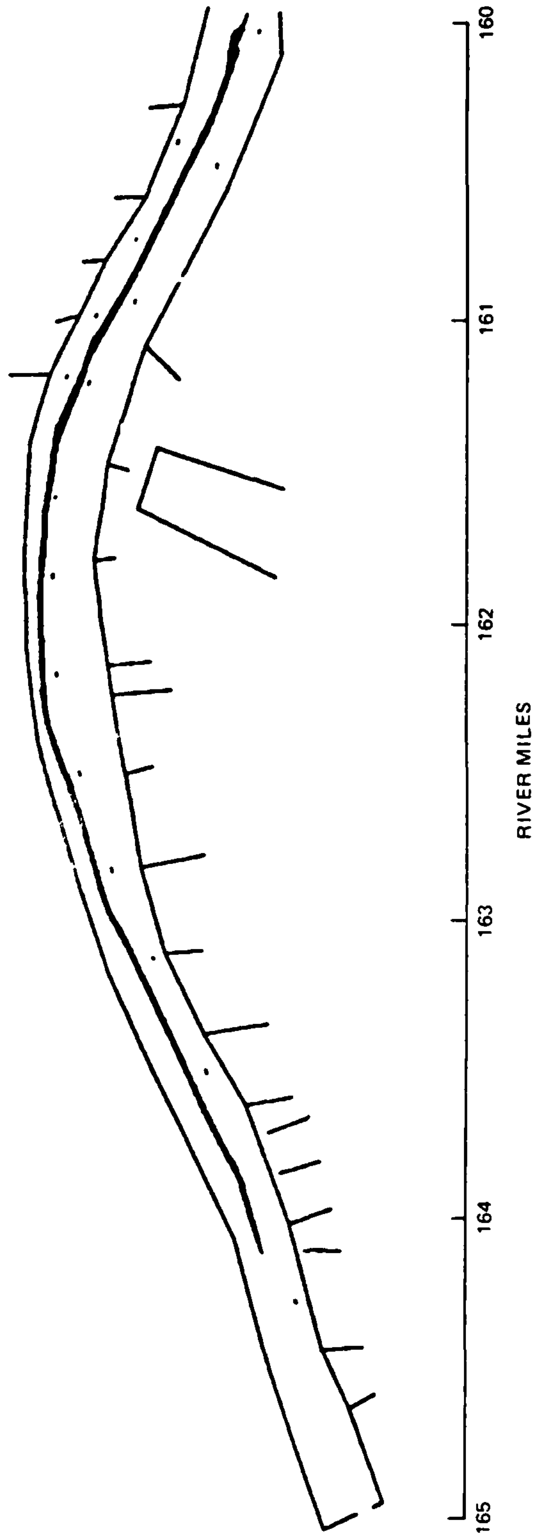


Figure 34. Upbound tow transit path, plan test

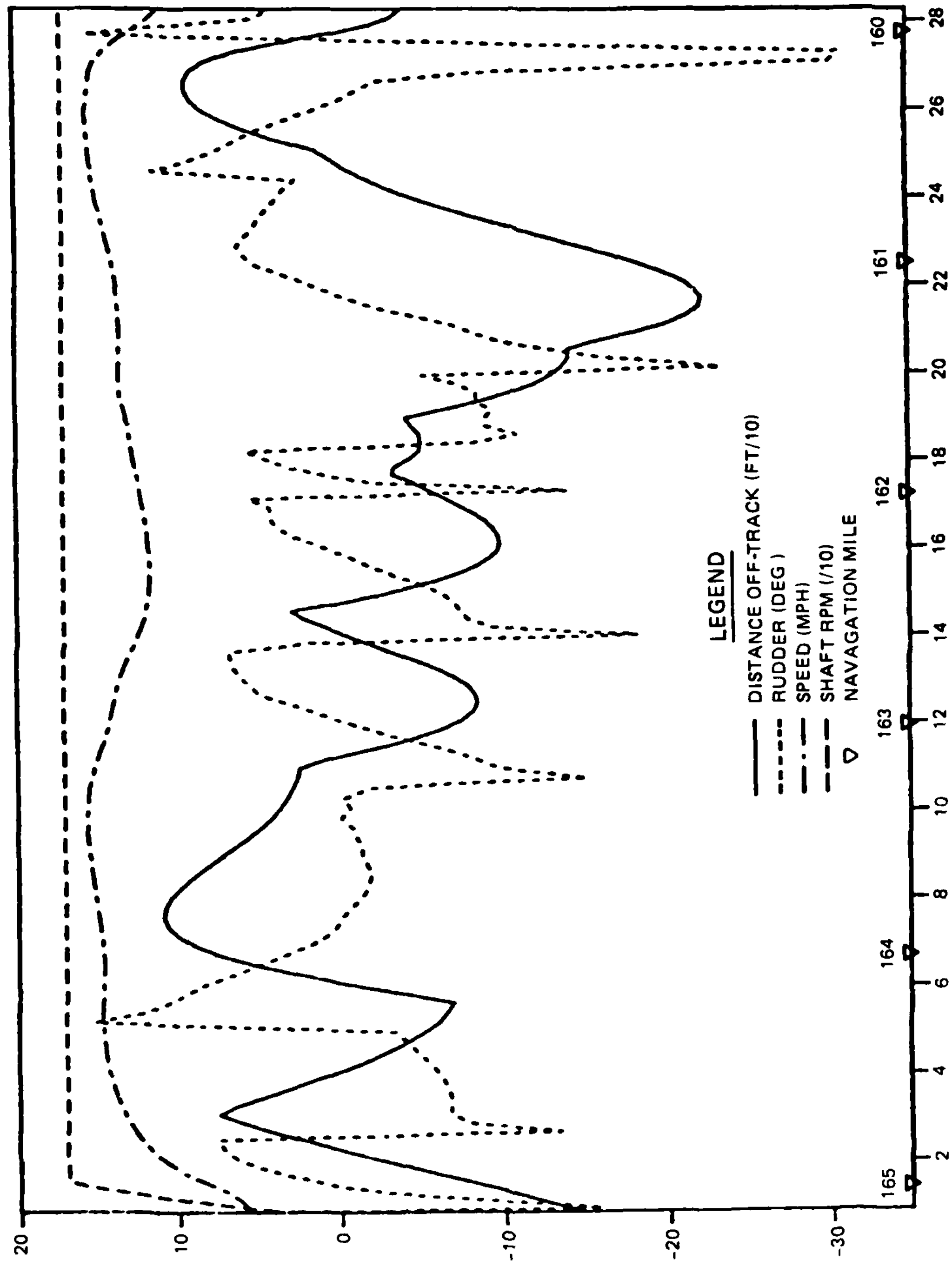


Figure 35. Transit recorder for downbound tow, base test

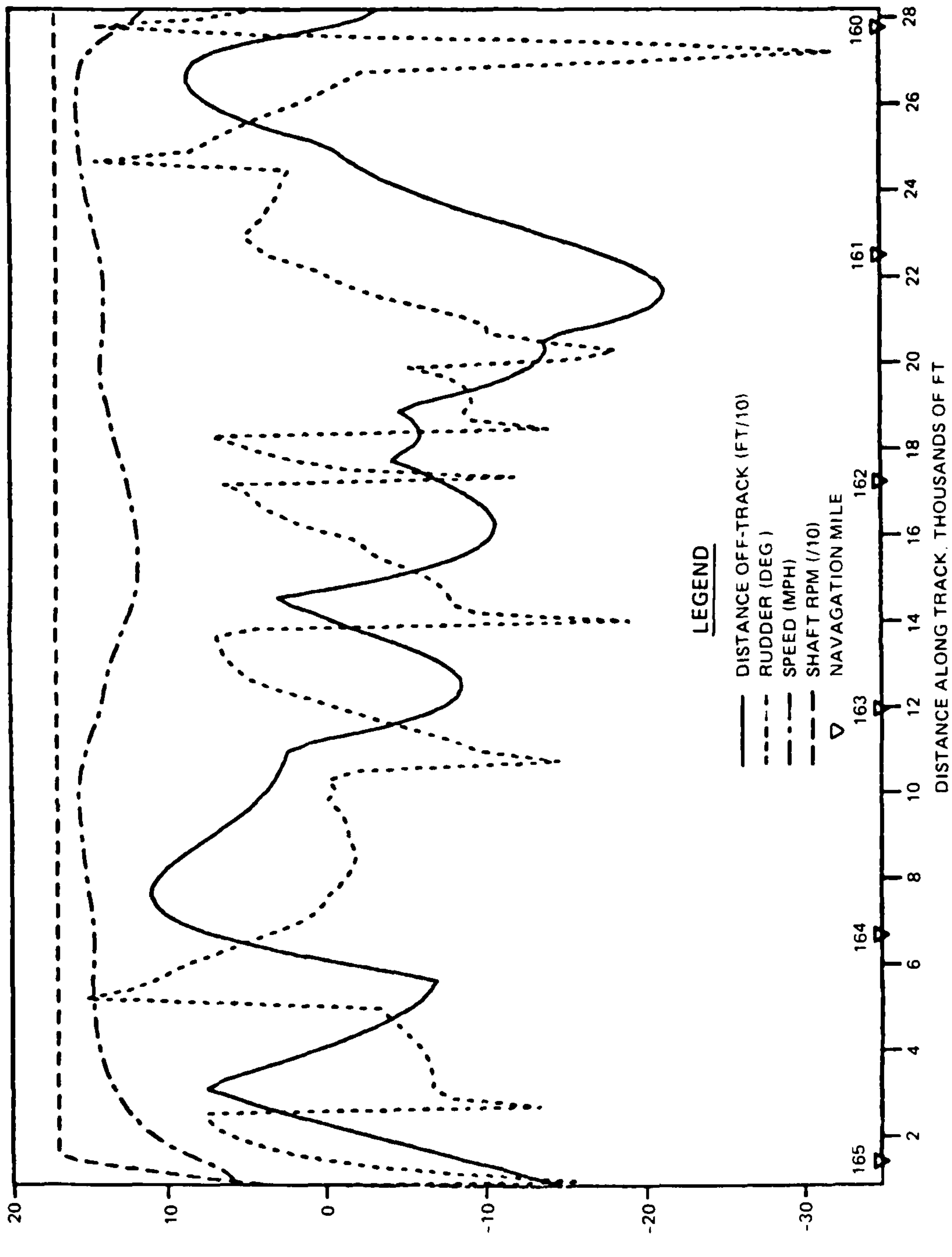


Figure 36. Transit recorder for downbound tow, plan test

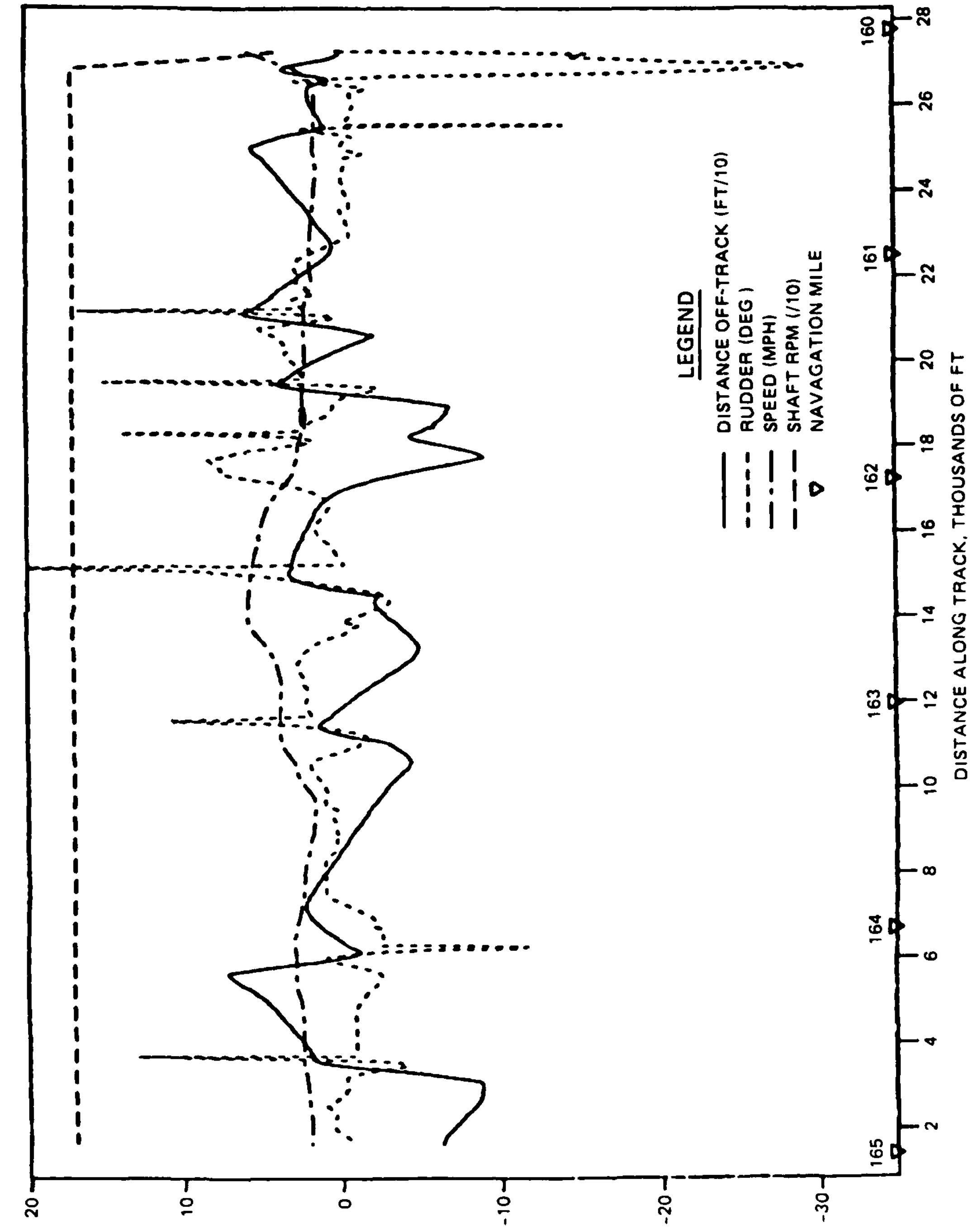


Figure 37. Transit recorder for upbound tows, base test

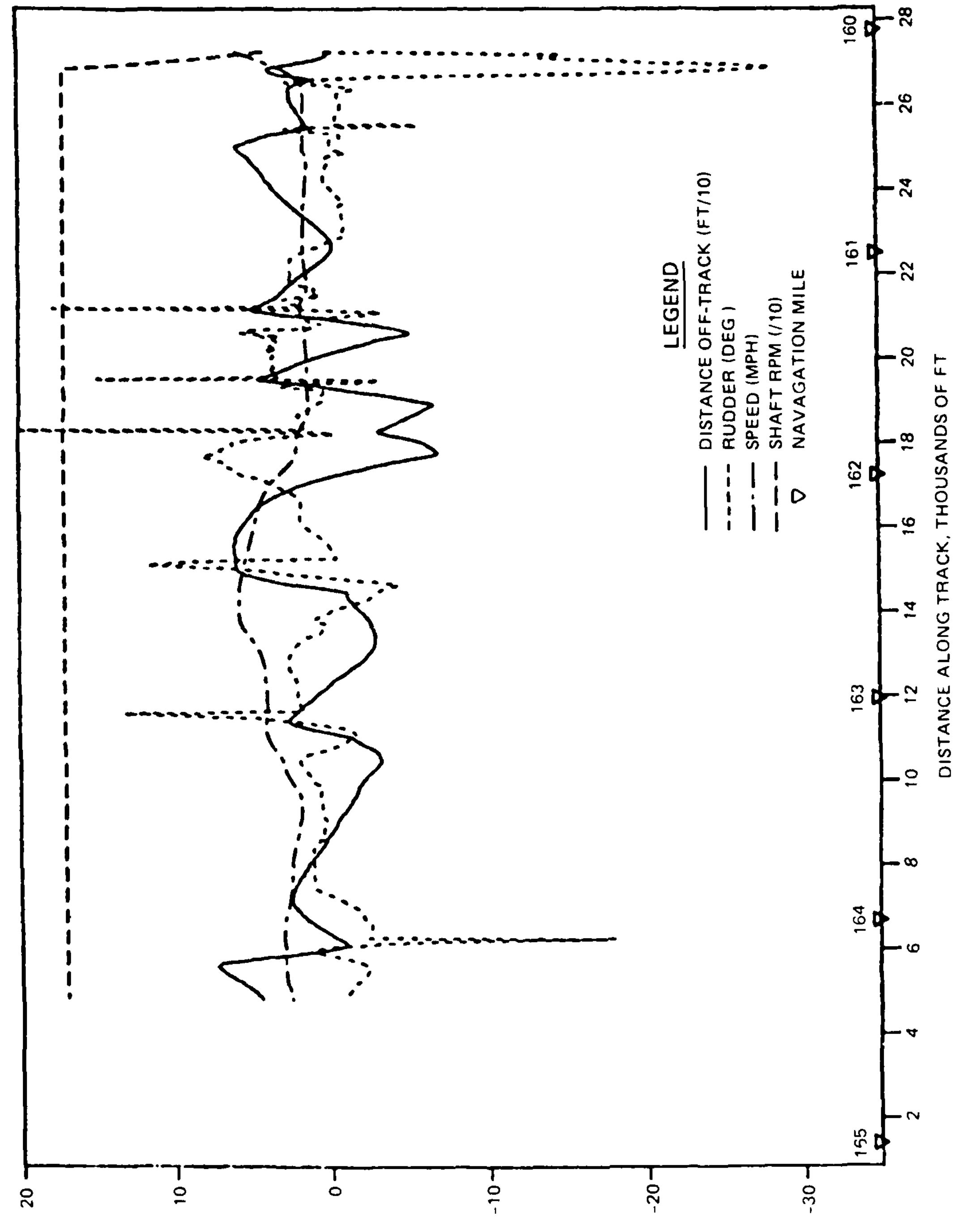


Figure 38. Transit recorder for upbound tows, plan test

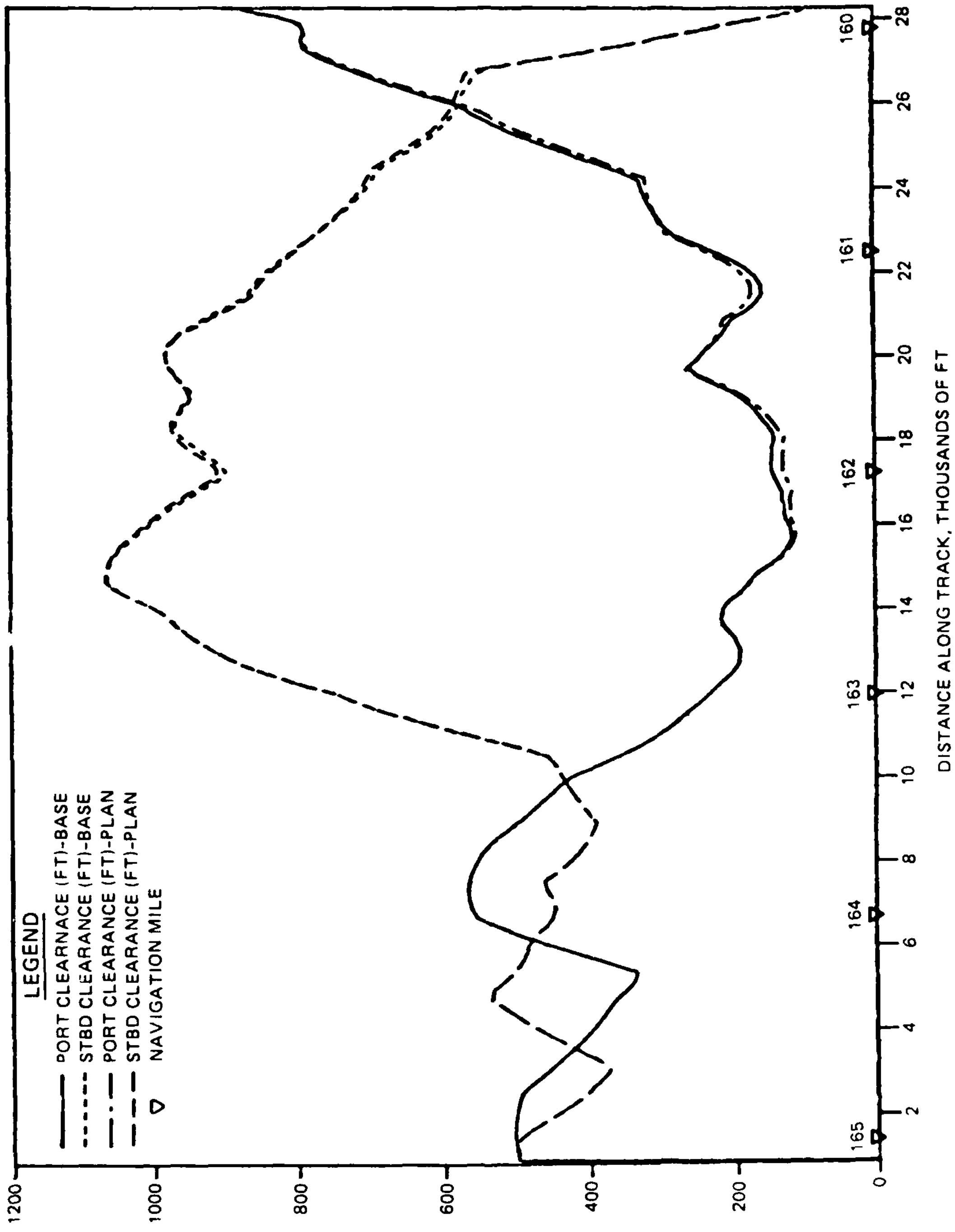


Figure 39. Tow clearance in the navigation channel, downbound tow

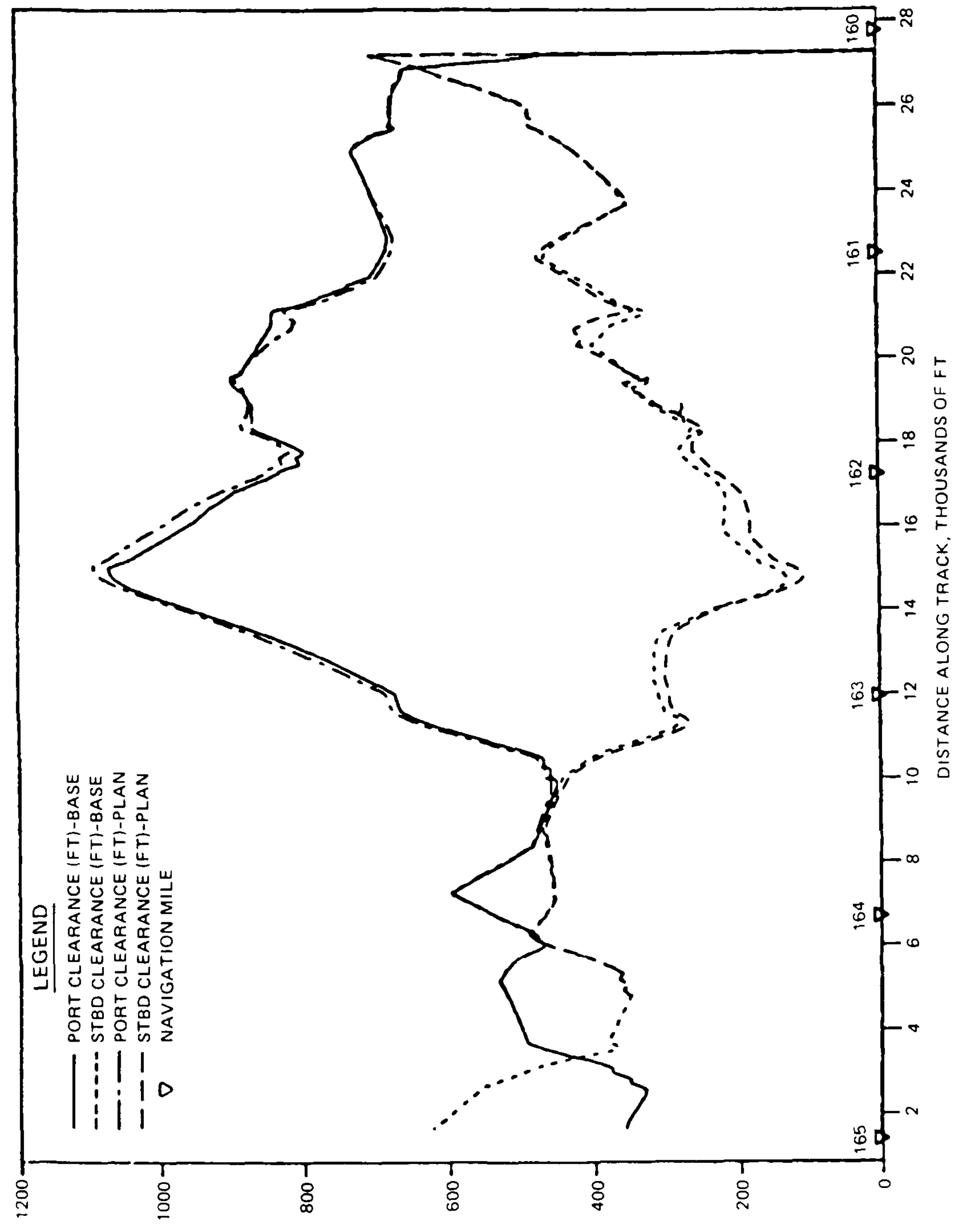


Figure 40. Tow clearance in the navigation channel, upbound tow

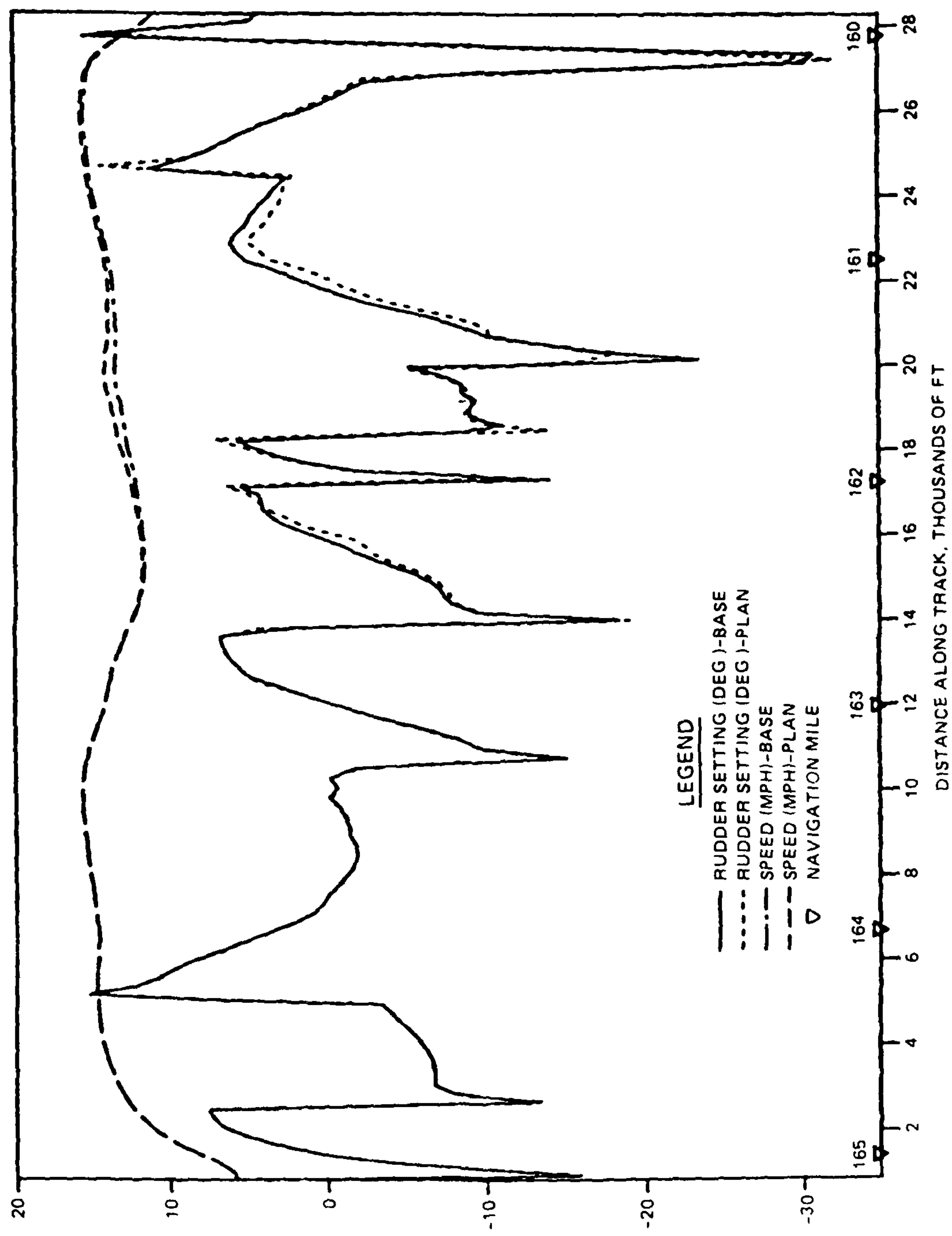


Figure 41. Rudder setting, downbound tow

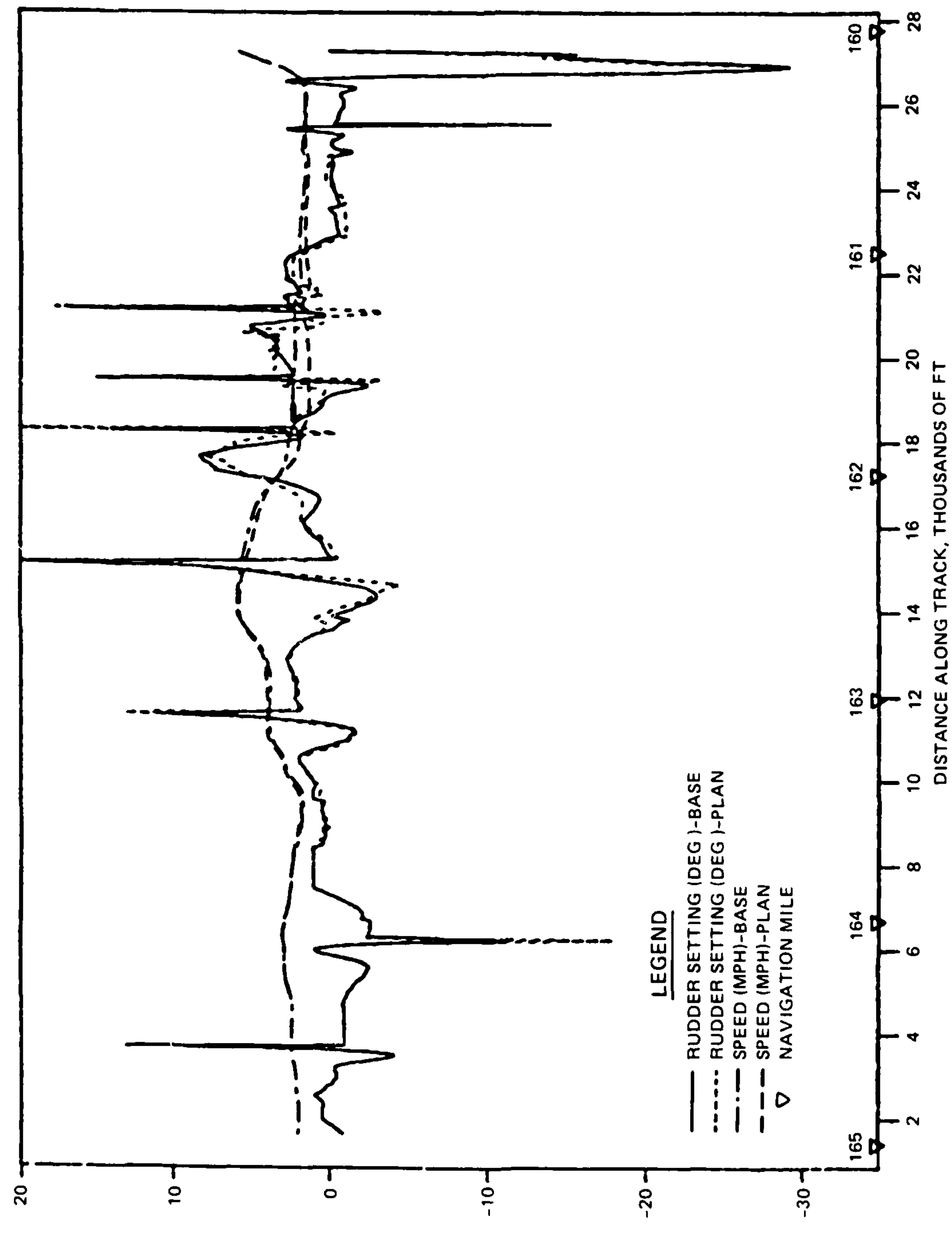


Figure 42. Rudder setting, upbound tow

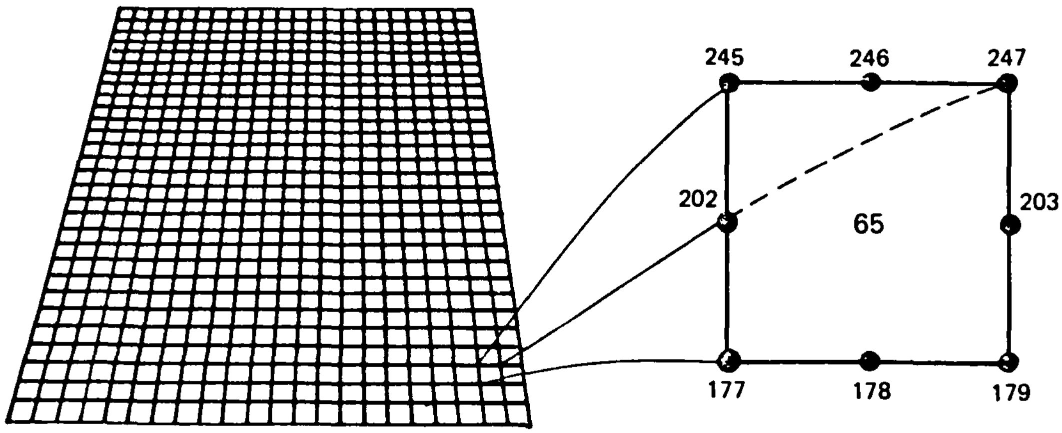
APPENDIX A: FINITE ELEMENT MODELING

1. The two numerical models used in this effort employ the finite element method to solve the governing equations. To help those who are unfamiliar with the method to better understand this report, a brief description of the method is given here. For a more thorough treatment, see Zienkiewicz (1971) or Desai (1979).

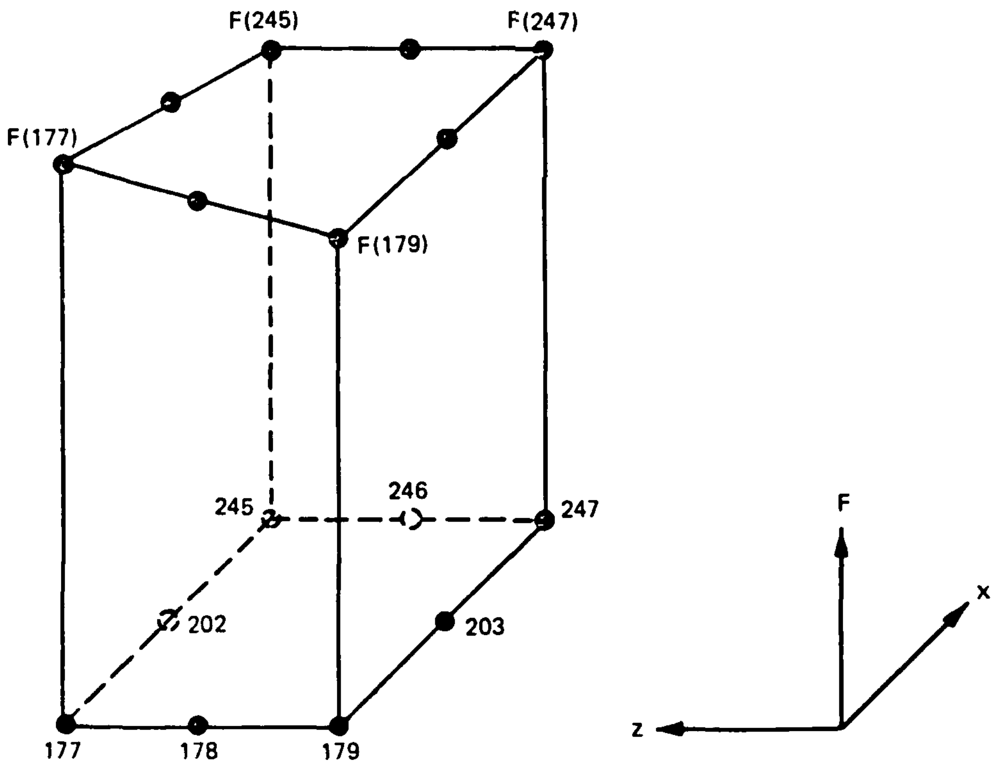
2. The finite element method approximates a solution to equations by dividing the area of interest into smaller subareas, which are called elements. The dependent variables (e.g., water-surface elevations and sediment concentrations) are approximated over each element by continuous functions which interpolate in terms of unknown point (node) values of the variables. An error, defined as the deviation of the approximation solution from the correct solution, is minimized. Then, when boundary conditions are imposed, a set of solvable simultaneous equations is created. The solution is smooth and continous over the area of interest.

3. In one-dimensional problems, elements are line segments. In two-dimensional problems, the elements are polygons, usually either triangles or quadrilaterals. Nodes are located on the edges of elements and occasionally inside the elements. The interpolating functions may be linear or higher order polynomials. Figure A1 illustrates a quadrilateral element with eight nodes and a linear solution surface.

4. Most water resource applications of the finite element method use the Galerkin method of weighted residuals to minimize error. In this method the residual, the total error between the approximate and correct solutions, is weighted by a function that is identical with the interpolating function and then minimized. Minimization results in a set of simultaneous equations in terms of nodal values of the dependent variable (e.g., water-surface elevations or sediment concentration). Time-dependent problems can have the time portion solved by the finite element methods, but it is generally more efficient to express derivatives with respect to time in finite difference form.



a. Eight nodes define each element



b. Linear interpolation function

Figure A1. Two-dimensional finite element mesh

APPENDIX B: THE HYDRODYNAMIC MODEL, RMA-2V

1. The generalized computer program RMA-2 solves the depth-integrated equations of fluid mass and momentum conservation in two horizontal directions. The form of the solved equations is

$$\frac{\partial u}{\partial t} + u\frac{\partial u}{\partial x} + v\frac{\partial u}{\partial y} + g\frac{\partial h}{\partial x} + g\frac{\partial a_o}{\partial x} - \frac{\varepsilon_{xx}}{\rho}\frac{\partial^2 u}{\partial x^2} - \frac{\varepsilon_{xy}}{\rho}\frac{\partial^2 u}{\partial y^2}$$

$$-2v\omega \sin \phi + \frac{gu}{C^2h}\left(u^2 + v^2\right)^{1/2} - \frac{\xi V_a^2}{h} \cos \Psi = 0 \qquad \text{(B1)}$$

$$\frac{\partial v}{\partial t} + u\frac{\partial v}{\partial x} + v\frac{\partial v}{\partial y} + g\frac{\partial h}{\partial y} + g\frac{\partial a_o}{\partial y} - \frac{\varepsilon_{yx}}{\rho}\frac{\partial^2 v}{\partial x^2} - \frac{\varepsilon_{yy}}{\rho}\frac{\partial^2 v}{\partial y^2} + 2\omega u \sin \phi$$

$$+ \frac{gv}{C^2h}\left(u^2 + v^2\right)^{1/2} - \frac{\xi V_a}{h} \sin \Psi = 0 \qquad \text{(B2)}$$

$$\frac{\partial h}{\partial t} + \frac{\partial}{\partial x}(uh) + \frac{\partial}{\partial y}(vh) \qquad \text{(B3)}$$

where

u = depth-integrated horizontal flow velocity in the x-direction

t = time

x = distance in the x-direction (longitudinal)

v = depth-integrated horizontal flow velocity in the y-direction

y = distance in the y-direction (lateral)

g = acceleration due to gravity

h = water depth

a_o = elevation of the bottom

ε_{xx} = normal turbulent exchange coefficient in the x-direction

ρ = fluid density

ε_{xy} = tangential turbulent exchange coefficient in the x-direction

ω = angular rate of earth's rotation

Φ = latitude

C = Chezy roughness coefficient

ξ = coefficient relating wind speed to stress exerted on the fluid

V_a = wind velocity

Ψ = angle between wind direction and x-axis

ε_{yx} = tangential turbulent exchange coefficient in the y-direction

ε_{yy} = normal turbulent exchange coefficient in the y-direction

2. The Chezy roughness formulation of the original code was modified in the input portion so that Manning's n roughness coefficients may be specified from input Manning's n values and initial water depth.

3. Equations B1, B2, and B3 are solved by the finite element method using Galerkin weighted residuals. The elements may be either quadrilaterals or triangles and may have curved (parabolic) sides. The shape functions are quadratic for flow and linear for depth. Integration in space is performed by Gaussian integration. Derivatives in time are replaced by a nonlinear finite difference approximation. Variables are assumed to vary over each time interval in the form

$$f(t) = f(o) + at + bt^c \qquad t_o \leq t < t_1 \qquad \text{(B4)}$$

which is differentiated with respect to time, and cast in finite difference form. Letters a , b , and c are constants. It has been found by experiment that the best value for c is 1.5 (Norton and King 1977).

4. The solution is fully implicit and the set of simultaneous equations is solved by Newton-Raphson iteration. The computer code executes the solution by means of a front-type solver that assembles a portion of the matrix and solves it before assembling the next portion of the matrix. The front solver's efficiency is largely independent of bandwidth and thus does not require as much care in formation of the computational mesh as do traditional solvers.

5. The code RMA-2V is based on the earlier version RMA-2 (Norton and King 1977) but differs from it in several ways. First, it is formulated in terms of velocity (v) instead of unit discharge (vh), which improves some aspects of the code's behavior; it permits drying and wetting of areas within the grid; and it permits specification of turbulent exchange coefficients in directions other than along the x- and y-axis.

APPENDIX C: THE SEDIMENT TRANSPORT MODEL, STUDH

1. The generalized computer program STUDH solves the depth-integrated convection-dispersion equation in two horizontal dimensions for a single sediment constituent. The form of the solved equation is

$$\frac{\partial C}{\partial t} + u \frac{\partial C}{\partial x} + v \frac{\partial C}{\partial y} = \frac{\partial}{\partial x} \left(D_x \frac{\partial C}{\partial x} \right) + \frac{\partial}{\partial y} \left(D_y \frac{\partial C}{\partial y} \right) + \alpha_1 C + \alpha_2 \qquad \text{(C1)}$$

where

C = concentration of sediment

u = depth-integrated velocity in x-direction

v = depth-integrated velocity in y-direction

D_x = dispersion coefficient in x-direction

D_y = dispersion coefficient in y-direction

α_1 = coefficient of concentration dependent source/sink term

α_2 = coefficient of source/sink term

STUDH is related to the generalized computer program SEDIMENT II (Ariathurai, MacArthur, and Krone 1977) developed at the University of California, Davis, under the direction of R. B. Krone. STUDH is the product of joint efforts of WES personnel (under the direction of W. A. Thomas) and R. Ariathurai, now a member of Resource Management Associates.

2. The source/sink terms in Equation C1 are computed in routines that treat the interaction of the flow and the bed. Separate sections of the code handle computations for clay bed and sand bed problems. In the tests described here, only sand beds were considered. The source/sink terms were evaluated by first computing a potential sand transport capacity for the specified flow conditions, comparing that capacity with the amount of sand actually being transported, and then eroding from or depositing to the bed at a rate that would approach the equilibrium value after sufficient elapsed time.

3. The potential sand transport capacity in these tests was computed by the method of Ackers and White (1973), which uses a transport power (work rate) approach. It has been shown to provide superior results for transport under steady-flow conditions (White, Milli, and Crabbe 1975) and for combined waves and currents (Swart 1976). WES flume tests have shown that the concept is valid for transport by estuarine currents.

4. The total load transport function of Ackers and White is based upon a dimensionless grain size

$$D_{gr} = D \left[\frac{g(s - 1)}{\nu^2} \right]^{1/3} \qquad \text{(C2)}$$

where

D = sediment particle diameter

g = acceleration due to gravity

s = specific gravity of the sediment

ν = kinematic viscosity of the fluid

and a sediment mobility parameter

$$F_{gr} = \left[\frac{\tau^n \quad \tau'^{(1-n)}}{\rho g \quad D(s - 1)} \right]^{1/2} \qquad \text{(C3)}$$

where

τ = total boundary shear stress

n = a coefficient expressing the relative importance of bed-load and suspended-load transport, given in Equation C5

τ' = boundary surface shear stress

ρ = water density

The surface shear stress is that part of the total shear stress which is due to the rough surface of the bed only, i.e., not including that part due to bed forms and geometry. It therefore corresponds to that shear stress which a plane bed would exert on the flow.

5. The total sediment transport is expressed as a potential concentration

$$G_p = k \left(\frac{F_{gr}}{A} - 1 \right)^m \frac{sD}{h} \left(\sqrt{\frac{\rho}{\tau}} U \right)^n \qquad \text{(C4)}$$

where U is the average flow velocity, h is the water depth, and k, m, and A are coefficients as defined below. For $1 < D_{gr} < 60$

$$n = 1.00 - 0.56 \log D_{gr} \qquad \text{(C5)}$$

$$A = \frac{0.23}{\sqrt{D_{gr}}} + 0.14 \tag{C6}$$

$$\log C = 2.86 \log D_{gr} - (\log D_{gr})^2 - 3.53 \tag{C7}$$

$$m = \frac{9.66}{D_{gr}} + 1.34 \tag{C8}$$

For $D_{gr} > 60$

$$n = 0.00 \tag{C9}$$

$$A = 0.17 \tag{C10}$$

$$k = 0.025 \tag{C11}$$

$$m = 1.5 \tag{C12}$$

6. Bed shear stresses for combined waves and currents are calculated by STUDH using the equation

$$\tau'_{wc} = \left(\frac{f_w u_{om} + f_c U}{u_{om} + U}\right) \frac{\rho}{2} \left(U + \frac{u_{om}}{2}\right)^2 \tag{C13}$$

for surface shear stress (plane beds) and

$$\tau_{wc} = \frac{1}{2} f_c \rho U^2 + \frac{1}{4} f_w \rho u_{om}^2 \tag{C14}$$

for total shear stress, where

f_w = shear stress coefficient for waves

f_c = shear stress coefficient for currents

U = average flow velocity

u_{om} = maximum wave orbital velocity near the bed

ρ = density of water

Equations C13 and C14 are based on the work of Jonsson (1966), and Bijker and Swart (Swart 1976). Development of the equations is given by McAnally and Thomas (1981).

7. Using Equations C13 and C14 for shear stresses in the Ackers-White equations (Equations C2-C12) results in a potential sediment concentration, G_p. This value is the depth-averaged concentration of sediment that will occur if an equilibrium transport rate is reached with a nonlimited supply of sediment. The rate of sediment deposition (or erosion) is then computed as

$$R = \frac{G_p - C}{t_c} \qquad \text{(C15)}$$

where

C = present sediment concentration

t_c = time constant

For deposition, the time constant is

$$t_c = \text{larger of} \begin{cases} \Delta t \\ \text{or} \\ \dfrac{C_{Ld} h}{V_s} \end{cases} \qquad \text{(C16)}$$

and for erosion it is

$$t_c = \text{larger of} \begin{cases} \Delta t \\ \text{or} \\ \dfrac{C_{Le} h}{U} \end{cases} \qquad \text{(C17)}$$

where

Δt = computational time-step

C_{Ld} = response time coefficient for deposition

h = water depth

V_s = sediment settling velocity

C_{Le} = response time coefficient for erosion

U = average current speed

8. Equation C1 is solved by the finite element method using Galerkin weighted residuals. Like RMA-2V, which uses the same general solution technique, elements are quadrilateral and may have parabolic sides. Shape functions are quadratic. Integration in space is Gaussian. Time-stepping is performed by a Crank-Nicholson approach with a weighting factor (theta) of 0.66. The solution is fully implicit and front-type solver is used similar to that in RMA-2V.

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APPENDIX D: THE NAVIGATION MODEL

1. The effects of the proposed runway extension on navigation operations through the study reach were studied using a ship hydrodynamics model developed for use in modeling shallow-draft pushtows. The model was developed by Hydronautics, Inc., and is incorporated into the WES ship/tow simulator facility. This model is a mathematical model for the maneuvering of a river tow and consists of the coupled differential equations of motion in three degrees of freedom (surge, yaw, and sway) in the X,Y plane and the complete set of hydrodynamic coefficients and external forces which are required in order to numerically integrate these equations. There are also auxiliary equations that describe the response of the steering and propulsion system to command signals.

2. A complete set of three coupled differential equations with all of the necessary terms to simulate normal maneuvers of surface ships is presented in Goodman et al. (1976) and a description of the application of these equations to the towboat simulator is given by Miller (1979). These equations have been used successfully for a number of years to calculate the maneuver trajectories for a wide range of surface ship types in deep and shallow water. These equations have been modified to account for maneuvering characteristics that are unique to river tows. A right-hand orthogonal system of moving axes, fixed in the body, with its origin normally located at the center of mass of the body is used for reference. The positive direction of the axes, angles, linear velocity components, angular velocity components, forces, and moments are given in Figure D1. The numerical values for the hydrodynamic coefficients used in the equations are written in terms of the complete barge flotilla/towboat configuration and are nondimensional. Thus the values of the coefficients can be applied to geometrically similar tows. The values of the coefficients embrace the interaction effects between the rudder and hull, propeller and hull, and propeller and rudder as determined from towing tank model tests of the complete configuration.

3. An important consideration in the maneuvering of a river tow is the effect of current which can vary significantly along the length of the tow. As a result, it is necessary to introduce the effect of the current velocity into the mathematical model. The approach adopted was to define the hydrodynamic terms in the equations based on the relative velocities and yaw rate between

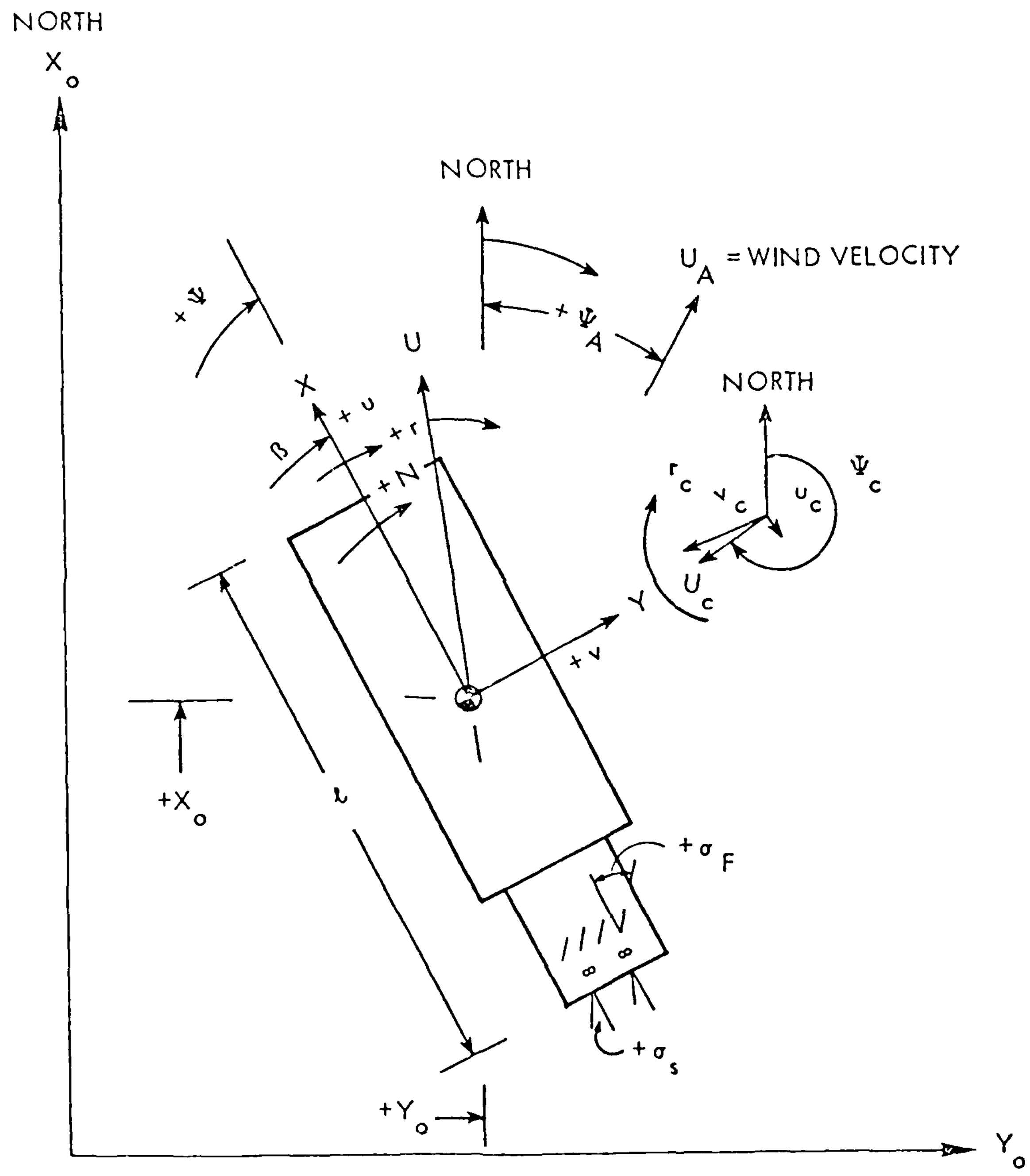

Figure D1. Sign convention for river tow maneuvering simulation the hull and the fluid rather than the inertial velocities and yaw rate. The relative velocities and relative yaw rate can be calculated by the vector addition of the inertial velocity and inertial yaw rate and the current velocities and the current yaw rate. In the numerical integration, the procedure is to define a matrix of current speeds and directions at points on the X,Y plane. Based on the location of the bow, midship, and stern of the tow, an interpolation in the current speed and direction matrix is carried out to obtain the current speed and direction at the bow, midship, and stern. Then a mean longitudinal and lateral current velocity in the body axis system is computed as the average of the values at the bow, midship, and stern. The variation of the lateral velocity along the tow is accounted for by the apparent current yaw rate defined by the difference in the lateral velocities at the bow and stern divided by the tow length. This accounts for variations.

4. Towboat propulsion systems differ from those in ships. Tows perform backing operations frequently, and because of this, they have two sets of rudders. Thus terms are included to account for the forces and moments created by the flanking and steering rudders which can be operated independently. In addition, many tows are propelled with twin propellers that are independently powered. Terms have been included for twin propeller forces and moments which may operate at different rpm's and different directions of rotation.

5. In realistic maneuvers, river tows operate both ahead and astern and in some cases at large drift angles. In order to properly represent the hydrodynamic forces and moments which act in such conditions, different sets of hydrodynamic coefficients are used depending on the relative drift angle. Thus the hydrodynamic coefficients vary depending on whether the motion is ahead or astern and whether the drift angle is near 90 or 270 deg.

6. In addition, tows often operate in shallow water and near banks. In shallow-water operations, the tow maneuvering characteristics change significantly--typically becoming more stable and thus less maneuverable. Adjustments are made to the hydrodynamic coefficients to reflect these changes and, like the determination of the deepwater hydrodynamic coefficients, are developed from model tests at various depth-to-draft ratios. Bank forces are a function of the distance from and the orientation to the banks. Computations for the bank forces and moments are included in the hydrodynamic equations.

7. The equations of motion are solved stepwise in time in the computer program. At each time-step, the current velocity, depth of water, and distance

from the port and starboard bank are determined at the bow, midship, and stern of the tow. Currents and depths are entered to the model as cross sections with up to 30 cross sections and 8 points per cross section being allowed. Port and starboard bank conditions are defined for each cross section by specifying the overbank depth and slope of the bank.

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APPENDIX D

FINITE ELEMENT NETWORK GENERATION

W. A. Thomas, W. H. McAnally, Jr., and D. P. Bach

CONTENTS

APPENDIX D: FINITE ELEMENT NETWORK GENERATION

PART I: INTRODUCTION

1. Numerical modeling requires that a set of computation points be established in space, assigned a number, assigned a bed elevation, and referenced to each other in space. Because the finite element method allows randomly placed points, as opposed to the regularly spaced grids in finite difference schemes, developing the spatial locations and reference table can be a sizable task. The process is called network generation in this document. Both manual and automated methods have been used with most emphasis given to the automated method in recent years.

2. At the present level of development, automatic mesh generation in TABS-2 is a four-step process. The first three steps apply to initial development. The fourth step applies only to the modification of existing meshes. The steps are:

a. Model boundaries are established and regions having similar properties are located (i.e., channels, floodplains, dike fields, dikes, etc.)

b. The boundaries are digitized, input data describing the mesh density are provided, and the mesh is processed through program AUTOMSH to construct a computational network.

c. The output from AUTOMSH is processed through GFGEN where final mesh layout and geometry are developed for input to programs RMA-2V, STUDH, and RMA-4.

d. Modifications to the mesh are made, if needed, using either the refinement capability in GFGEN, the interactive mesh editor EDGRG, or manual revision using a text editor.

3. The three computer programs, AUTOMSH, GFGEN, and EDGRG, are presented and their use is described in this appendix. Programs CONFEG, which transforms coordinate systems, and FNDNODE, which reads a GFGEN output file and finds the five closest nodes to a given set of coordinates, are described here also.

Elements and Nodes

4. The process of mesh generation starts with a map of the study area. This map should show elevation and roughness information. The objective is to locate computation points in space so that straight lines connecting adjacent computation points follow the bed elevation, roughness types, or sediment character-

istics between those points. Computation points should also be located at sharp changes in the water- surface elevation or the velocity field such as convergence zones. When computation points are not located in sufficient detail at hydraulic, sediment, and salinity controls, the accuracy of the computation is compromised. Wetting and drying of shallows is accomplished by setting entire elements wet or dry.* Thus element layout becomes important for properly identifying wet and dry areas of the mesh.

5. The computation points are called nodes, and nodes are connected to each other by lines that create either triangular or quadrilateral elements. The TABS-2 programs allow both element shapes in the same mesh, but experience has shown it very desirable to be systematic.

6. Each node and element must be numbered. An example of the element-nodal point scheme is shown in Figure D1. Although this mesh is regular, there is no requirement that it be so. The point of interest is the element numbered 65 which has eight nodes around it. Those at the corners are called corner nodes. Those midway between corners are called midside nodes. The nodes are also common to adjacent elements and that must be specified in a nodal connection table. Figure D2 shows the element nodal point connection table for the vicinity of element 65. Each node has two numbers -- one <u>relative</u> to the element and one <u>absolute</u>. In either case, the numbering scheme starts at a corner node. Relative position #1 is the lower right corner of element number 1, and numbering proceeds counterclock-wise around the element. The position table on Figure D2 illustrates that principle.

X and Y Coordinates

7. Each corner node needs location (x,y) coordinates and a bed elevation (z) to be specified. The mesh generator AUTOMSH provides the (x,y) coordinate for corner nodes and GFGEN calculates midside locations as well as allows the corner node z coordinates to be input.

8. AUTOMSH uses the (x,y) coordinates of the boundary. It allows node density to be specified and then calculates the (x,y) locations of each corner node, both in the interior and along the boundary; calculates the node numbers and element numbers; and develops the element-nodal point connection table. The result is a file can be ready directly by GFGEN, which is the next step in mesh generation. Details for using AUTOMSH are shown in Addendum D-1.

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* Actually, complete drying does not occur. When the water depth falls below some small, preset value, that area of the mesh is removed from the calculations even though some water remains there.

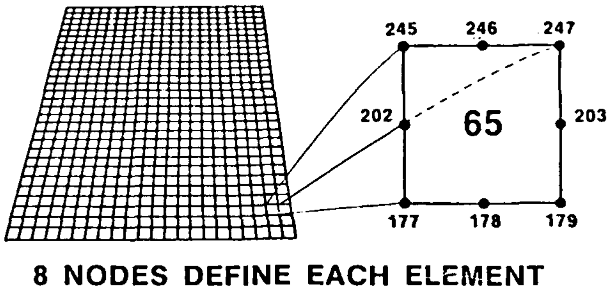
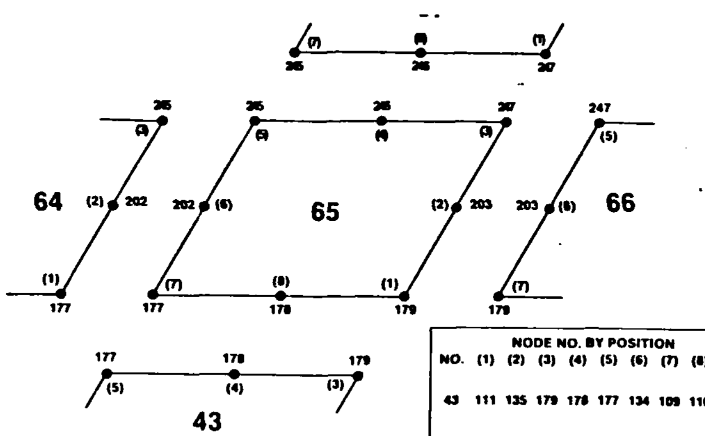


Figure D1. Nodes and elements



NO.	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	NODE NO. BY POSITION							
43	111	135	179	178	177	134	109	110
64	177	202	245	244	243	201	175	176
65	179	203	247	246	245	202	177	178
66	181	204	249	248	247	203	179	180
87	247	271	315	314	313	270	245	246

Figure D2. Element connection table

PART II: NETWORK CREATION

9. Creation of the proper finite element network is a fundamental aspect of finite element modeling. Although averaging or differencing is not involved, the finite element shape functions distribute calculated values over the element. Therefore nodal points should be carefully located to capture changes of depth and energy gradient so that the average over the element contains these extremes. Automatic mesh generators (the mesh is the set of lines, elements, and nodes in the FE network) can locate the (x,y) coordinates of nodes so they best fit the continuous surface requirement of the finite element shape functions; but the automatic mesh generators do not consider the z-coordinate in that procedure (the bed elevation) nor do they take sharp changes in gradients into account. Consequently, the judgment of the user is essential to ensure that these factors are incorporated into the network. Good judgment is also needed to locate the upstream and downstream boundaries of the network. Boundaries that are too close will contaminate results in the area of interest. Boundaries at locations where flow is strongly nonuniform may cause erratic results.

External boundaries

10. The external boundary of a network refers to the lines of nodes that have elements along only one side of them as opposed to internal lines of nodes. Examples of external boundaries are the ends and sides of the network and islands, piers, or other internal features that are not overtopped by the flow.

11. The significance of external boundaries stems from the 2-D nature of the computations. In 1-D computations, flow always travels parallel to the sides of the numerical network. That is not the case in 2-D computations; and consequently, the calculated velocity vectors can intersect the sidewall of the network rather than be parallel to it, just as they do the end boundaries. The result is a leak. It is necessary to identify all external boundaries using input data so RMA-2V can avoid leak problems.

12. An external boundary line can be either a straight line, a sequence of straight-line segments having sharp corners where one element joins another, or a smooth, quadratic curve. For the second case, the velocity components at each node must usually be zero. When a smooth (straight-line or quadratic) curve is prescribed, RMA-2V will calculate the boundary tangent at each node and align the velocity vector so that flow is parallel to the boundary at that point. Consequently, leaks are avoided by the proper specification of boundary conditions.

Wetting and Drying

13. Areas of the network that become almost dry are resolved by manipulatin, the individual elements. If any node in an element is dry, t' entire element is removed from the computations. This procedure produces two problems: an irregular side-boundary having sharp corners rather than the smooth external boundary of the original network, and numerical shocks each time an element is added or removed. In wet/dry mode, the program aligns the boundary velocity vectors with the irregular boundary to prevent leaks and to allow a slip-flow along the newly formed external boundary. Both the velocity and its time derivatives at the present and past iteration are thus recalculated. This special treatment of flow along a boundary applies only to partially dry meshes. It is not applicable along external boundaries. By keeping elements small, numerical shock can be minimized and by increasing the number of iterations between dry-mesh-checks, stability can be increased.

14. The finite element mesh controls both lateral and vertical boundaries. The degree to which it models lateral boundaries can be observed by overlaying the mesh on a map or aerial mosaic. The agreement with vertical boundaries is more difficult to ascertain. That is, bed elevations are coded at each corner node, and the program constructs a bed-plane in each element. It is important that the elevations in that bed-plane model the true elevations of the bed throughout the element. It is difficult to visualize the 2-dimensional model planes, but if elements are aligned along cross sections, the FE bed can be plotted on the cross section to check bed elevations. Corner node elevations are connected by straight lines.

15. An (x,y) coordinate can have only one elevation (i.e., elements cannot stand on their edge).

GFGEN

16. The final step in the initial development of a mesh is to process the AUTOMSH output file with GFGEN. It checks the mesh for potential errors, merges all bed elevations, locates all curved boundary slopes, optimizes element number sequence for most efficient computations, and creates plot files of the mesh. The output from GFGEN is the finite element network for the TABS-2 programs. Instructions for using GFGEN are shown in Addendum D-2.

17. The matrix solvers used in the TABS-2 system programs do not rely on a narrow bandwidth for efficient computations. The programs use frontal pivotal elimination routines that require a reduction in the front width. The process is called reordering and is performed by GFGEN or AUTOMSH. The computational cost savings possible with effective reordering makes it worth some additional effort to achieve. See the GFGEN User Instructions for further discussion of reordering.

Mesh Editing and Modification

18. The interactive program EDGRG permits shifting existing elements and nodes around and/or adding new ones. This is useful when it is necessary to reuse an existing mesh or add detail in a new mesh where the automatic calculations are inadequate. Details for using EDGRG are shown in Addendum D-3. The network can also be modified by using a text editor to change the AUTOMSH output file (GFGEN input).

Graphics

19. AUTOMSH, GFGEN, and EDGRG each have graphics capability. They are explained along with other details of using those programs in the addenda.

Planned Improvements

20. Because of the importance of mesh generation, an optional alternate mesh generator is under development.

ADDENDUM D-1: USER INSTRUCTIONS FOR PROGRAM AUTOMSH, AUTOMATIC MESH GENERATION

Purpose

1. AUTOMSH is a group of utility programs that are used to automatically create computational meshes for the TABS-2 models. Given information on the regions to be covered by the mesh and the desired density of elements, it creates a computational network, including node locations and element connection tables. Output from AUTOMSH serves as input to the geometry file generator, GFGEN.

Origin of Program

2. AUTOMSH consists of four programs plus a plotter code--PREMESH, QMESH RENUM, POSTMSH, AND QPLOT, respectively. QMESH, RENUM, and QPLOT were obtained from Sandia National Laboratories, Albuquerque, New Mexico. PREMESH and POSTMSH were written by D. P. Bach of the Estuaries Division, Hydraulics Laboratory, WES. RENUM was modified by D. P. Bach.

Description

3. AUTOMSH is a batch-oriented family of codes that are linked together so an entire mesh can be generated in a single submission to the computer.

4. PREMESH takes digitizer data along with card image input data for run control and writes an input file for QMESH plus a list of midside nodes for POSTMSH.

5. QMESH is the mesh generator. It fills each region with elements and smooths out irregularities.

6. RENUM reorders node numbers to achieve a minimum front width for a uniform number scheme. A companion code, QPLOT, reads RENUM output files and plots sections of the mesh.

7. POSTMSH adds midside nodes and boundary curvature in the form of a slope which is tangent to the boundary line at that node, and writes a file for input to GFGEN.

8. GFGEN is not part of the AUTOMSH family. It is the finite element geometry file generator for the TABS-2 system.

The Mesh Generation Process

9. The following procedure should be used:

   a. Lay a plastic overlay on a chart or map of area of interest. All markings should be in fine pen or pencil to improve accuracy during digitizing.

   b. Draw lines dividing the area into REGIONS, with each REGION having no more than 13 separate LINES defining it. REGIONS should be chosen based on desired RMA-2V element types (for defining roughness and eddy viscosity coefficients) and on the amount of control that is desired over the mesh. Each REGION and the LINES separating the different REGIONS should be numbered.

   c. Digitize the lines defining each region. During digitization, curved LINES should be defined with as fine a resolution as practical.

   d. Extra care should be taken in digitizing the points at the beginning and end of each LINE, as accuracy is especially important there.

Figure D-1-1 shows the AUTOMSH procedure in flow chart form.

10. The run control input to PREMESH consists of card images containing a keyword that identifies the data that are on the rest of the card. These cards may appear in any order, with the exception of the end card. The special keywords include COMMEN, LINE, REGION, SCHEME, TOL, MULT, and END. Instructions for these card image data are given beginning on page D-1-10. Input to subsequent programs is generated automatically. The format for digitizer file input (logical unit 01) to PREMESH is given in Table D-1-1.

11. Program QMESH. QMESH was released in 1974 by Sandia Laboratories, a prime Department of Energy contractor. Because PREMESH provides an interface to QMESH, full documentation for QMESH is not presented here. The QMESH input data are described in R. E. Jones, 1974 "User's Manual for QMESH, a Self-Organizing MESH Generation Program," Sandia Report No. SLA-74-0239, Sandia National Laboratories, Albuquerque, NM. The smoothing methods that QMESH employs are described in R. E. Jones, 1974, "QMESH: A Self-Organizing Mesh Generation Program," Sandia Report No. SLA-73-1008, Sandia National Laboratories, Albuquerque, NM.

12. Program RENUM. RENUM requires no input directly from the user. The program has been modified to use the front-minimizing technique described in Mark Hoit and E. L. Wilson, 1983, "An Equation Numbering Algorithm Based on a Minimum Front Criteria," Computers & Structures, Vol 16, No. 1-4, pp. 115-133, Pergamon Press Ltd., Great Britain.

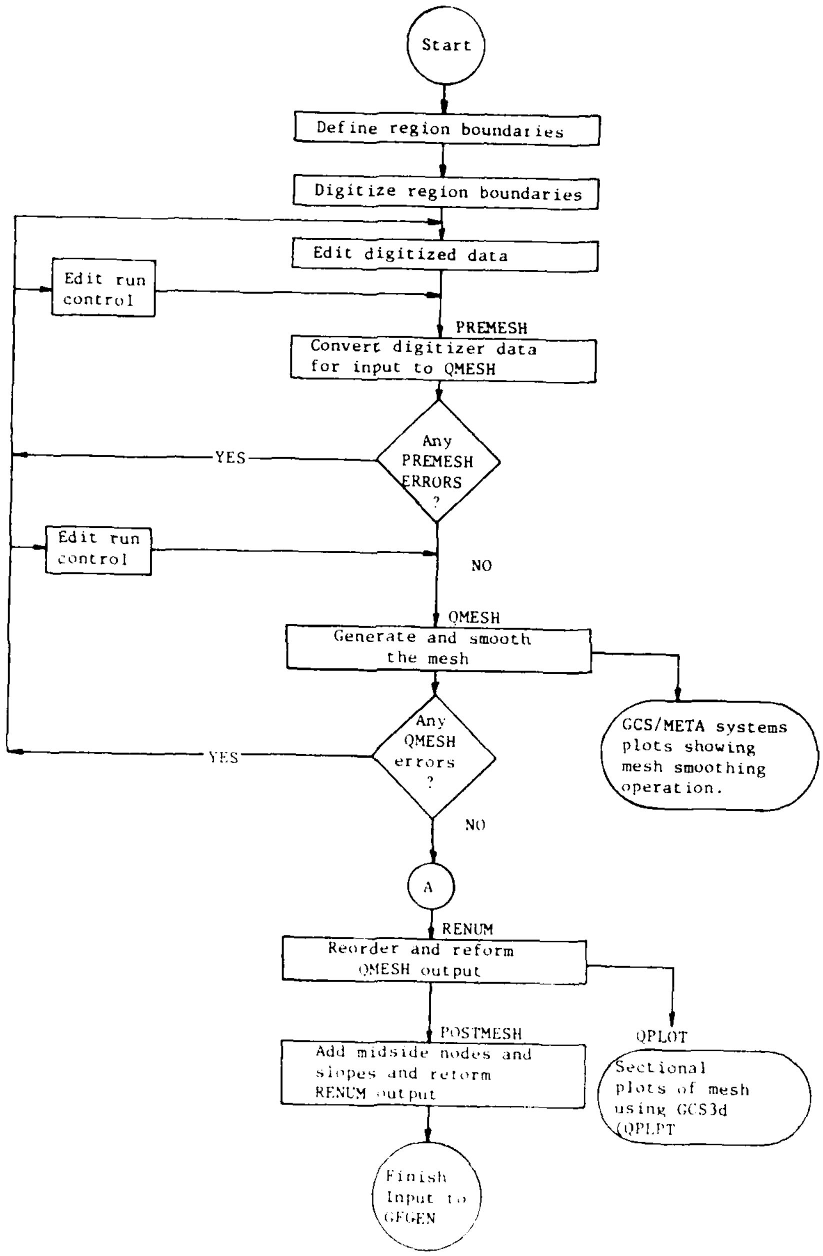


Figure D-1-1. AUTOMSH procedure

13. <u>Program POSTMSH</u>. POSTMSH requires no direct input from the user. The program reads files that are generated by PREMESH (mid-side node locations) and by RENUM (grid specification without mid-side nodes). Slopes at corner nodes are computed by the following formula:

$$\frac{dy}{dx_1} = \frac{-3Y_1 + 4Y_2 - Y_3}{-3X_1 + 4X_2 - X_3}$$

where

$\frac{dy}{dx}_1$ = slope at corner node 1

X_1, Y_1 = coordinates of node 1

X_2, Y_2 = coordinates of tentative mid-side node

X_3, Y_3 = coordinates of corner node 2

Output

14. Output from PREMESH consists of a QMESH input file on logical unit 5, a tentative list of midside nodes on logical unit 85 (2F12.1 format), and diagnostics on the standard printer file.

15. Output from POSTMSH is a coded data file that is in the proper format to be used by program GFGEN, the geometry file generator. GFGEN is described in Addendum D-3.

Example

16. The following listings show the card image input data file and the digitizer data file. The mesh plot, out of GFGEN, follows the data listings (Figure D-1-2).

<u>Card image input file</u>

```
COMMEN      YAZOO BACKWATER AREA - ALTERNATIVE 1
LINE            1          -4
LINE            3          -4
LINE            5          -3
LINE            6          -2
LINE            7          -9
LINE            8          -2
LINE            9          -8
```

LINE	10	-8
LINE	11	-4
LINE	12	-4
LINE	13	-6
LINE	14	-3
LINE	15	-9
LINE	16	-8
LINE	17	-6
LINE	22	-8
LINE	23	-2
LINE	24	-5
LINE	25	-2
LINE	28	-4
LINE	29	-5
LINE	32	-3
LINE	33	-2
LINE	34	-3
LINE	35	-5
LINE	36	-2
LINE	37	-2
LINE	38	-2
LINE	39	-2
LINE	40	-3
LINE	43	-4
LINE	44	-3
LINE	45	-3
LINE	46	-3
LINE	47	-2
LINE	48	-4
LINE	49	-11
LINE	50	-3
LINE	51	-11
LINE	55	-4
LINE	56	-7
LINE	57	-4
LINE	58	-2
LINE	59	-1
LINE	60	-2
LINE	61	-2
LINE	62	-2
LINE	63	-2
LINE	64	-1
LINE	65	-4
LINE	66	-1
LINE	67	-4
LINE	68	-4
LINE	69	-6
LINE	70	-4
LINE	71	-6
LINE	72	-8
LINE	73	-1
LINE	74	-15
LINE	75	-1
LINE	76	-11
LINE	77	-15

```
LINE          78          -1
LINE          79          -8
LINE          80          -1
LINE          81         -15
LINE          82          -1
LINE          83          -1
LINE          84          -1
LINE          85          -1
LINE          86          -2
LINE          87          -2
LINE          88          -4
LINE          89          -4
REGION   2     1    60    61    62
REGION   1     2    88    86    65    87    89    68
REGION   2     3     8    10     6     9
REGION   1     4     5    13    14    15    16     3    17     1    10
REGION   1     5    81    82    77    83
REGION   1     6    72    77    78    79    80    74
REGION   2     7    23    22    25    16
REGION   1     8    11    70    83    71    73    28
REGION   1     9    17    71    84    68    85    69    70
REGION   2    10    14    32    33    34    35
REGION   2    11    33    36    37    38
REGION   2    12    34    40    58    29    24    39
REGION   1    13    43    73    74    75    76
REGION   2    14     5    45    46    44
REGION   2    15    46    47    48    49    50    51
REGION   2    16    12    52    48    56
REGION   2    17    43    54    55    53
REGION   1    18    28    53    57    49    52    59
REGION   1    19    85    89    66    67
REGION   1    20    84    62    63    64    88
TOL         10.0
MULT         1.0
END
```

<u>Digitizer data file used as input to PREMESH</u>

```
  Yazoo
     4    10
  3173  2654
321250724100
  1649   227
331880718770
   503  1636
326570713500
 -5555     5
  1268   273
  1365    65
  1369    57
 -5555     7
  1016   802
  1264   283
  1268   273
 -5555    15
```

943	777
1177	285
1184	270
-5555	14
1184	270
1283	62
1289	48
-5555	13
1369	57
1298	51
1289	48
-5555	32
1289	48
1227	44
988	100
601	373
594	379
-5555	33
594	379
574	547
577	562
-5555	34
577	562
691	605
708	609
908	369
1099	280
1120	271
1184	270
-5555	36
594	379
258	431
216	439
-5555	37
216	439
206	601
205	620
-5555	38
205	620
3005	2402
3024	2432
3033	2455
3039	2481
3050	2507
3060	2531
3070	2566
3077	2590
3087	2615
3096	2640
3102	1660
3106	2681
3108	2692
-5555	57
3108	2692
-5555	55

3108	2692
2357	2762
2345	2763
-5555	54
2345	2763
2224	2468
2022	2213
1426	1711
1046	1598
745	1560
567	1596
556	1597
-5555	56
2343	1443
1760	1218
1400	1045
1135	875
1114	858
-9999	-9999

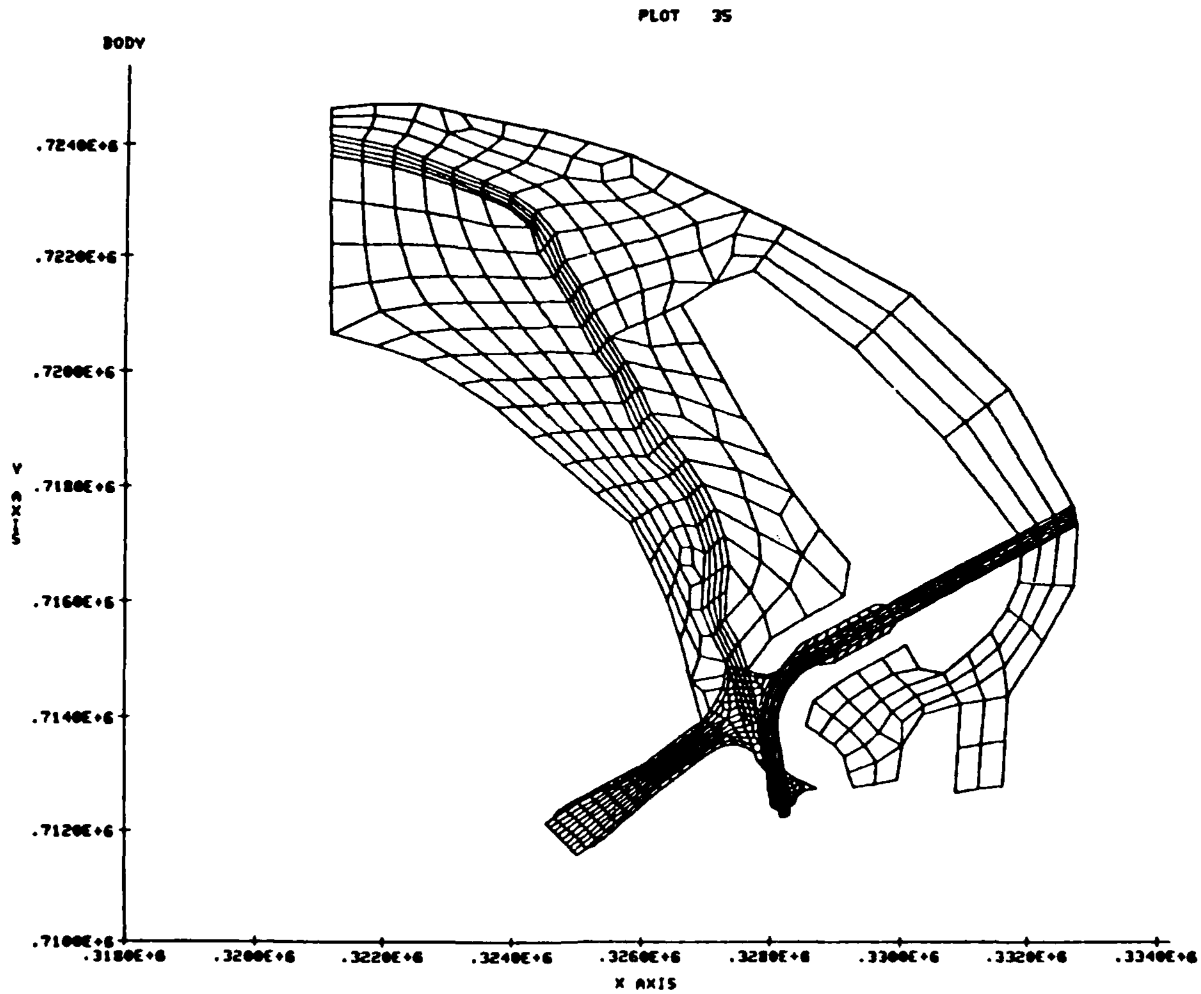


Figure D-1-2. Yazoo backwater area network plot

Input Instructions

17. The following pages provide instructions for card-image run control input to program PREMESH. Seven card types are used as shown in the table below.

Card Type	Purpose	Page
COMMEN	Provide run title.	D-1-11
LINE	Define a line bordering a region.	D-1-12
REGION	Define a region to be filled with elements.	D-1-13
SCHEME	Control the mesh smoothing scheme.	D-1-14
TOL	Specify tolerance for inaccurate digitizing of LINE endpoints.	D-1-15
MULT	Specify multiplier to convert digitizer coordinates.	D-1-16
END	Signals end of input and controls type and quantity of output.	D-1-17

COMMEN card

Columns	Format*	Description
1-6	A	The keyword COMMEN
11-80	A	Run title

The run title on the COMMEN card is passed through all of the AUTOMSH programs and is placed at the top of the GFGEN input file.

* A = Alphanumeric
F = Floating point numerical
I = Integer numerical

LINE card Required

Columns	Format	Description
1-4	A	The keyword LINE
11-15	I	The identifier of the LINE (1-999).
16-25	F	If positive, arc length between nodes in mesh coordinates (needs finely defined LINE) If negative, indicates the numbe of panels this line is to be broken into. Default = +100.0
26-35	F	Factor to decrease nodal spacing with a tighter curve radius in mesh units/degrees (arc length = previous length - factor*degrees). Ignored if the boundary flag (column 40) is zero. Default = 0.0.
36-40	I	Boundary or curved side conditio 0 = Not boundary or curved LINE. 1 = Fit slopes to this boundary. Default = 0

The use of a negative value in columns 16-25 seems to be the easiest way to set up the mesh. The factor to decrease the nodal spacing can be used to cluster nodes around corners. Using a negative value in columns 16-15, a LINE can be defined by minimum of two points--start and finish. Be sure to take care in digitizing start and finish points.

REGION card Required

Columns	Format	Description
1-6	A	The keyword REGION
7-10	I	The element type* for this REGION.
11-15	I	The identifying number for this REGION (1-999)
16-80	13I5	A list of LINES defining this REGION, in connecting consecutive order.

A maximum of thirteen (13) LINES defining each REGION is allowed. The line order may be clockwise or counterclockwise. Best results are obtained if an even number of element nodes are produced along the REGION's boundaries.

* Element types are used by RMA-2V to define eddy viscosity and roughness coefficients.

SCHEME card Optional

Columns	Format	Description
1-6	A	The keyword SCHEME
11-15	I	The identifying number of the region to which this card applies. A zero indicates that this card applies to all regions.
16-80	A	The series of letters specifying a QMESH smoothing scheme. Default = MSP(RS(D)S) P (no scheme card)

This card controls the most powerful part of QMESH--its wide variety of smoothing algorithms. The selected default (which is a little different from QMESH's default) was chosen as the most stable for the TABS type of mesh. However, this default is probably not the best choice for all possible regions, so the user is free to experiment with different smoothing SCHEMES.

A discussion of the various scheme commands is given beginning on page D-1-18.

TOL card Optional

Columns	Format	Description
1-3	A	The keyword TOL
11-15	I	Distance for PREMESH to look for points while forming REGION boundaries, in mesh coordinates Default (TOL card omitted) = 10.0

This card specifies a TOLerance for "sloppy" and inaccurate digitization. A value greater than 100 feet should never be used. If a setting of greater than 100 feet appears to be needed, the digitizer input file should be edited instead, as the input data is incorrect, not inaccurate. Once again, extreme care should be taken during digitization.

MULT card   Optional

Columns	Format	Description
1-4	A	The keyword MULT
11-15	F	A value by which the transformation mesh coordinates are to be scaled. Default (MULT card omitted) = 1000.0

This card specifies the setting of the decimal point for the grid coordinate specification on record types 4, 6, and 8 on the digitizer input file.* A value less than 1 allows fractional grid coordinates to be used, while a value greater than 1 will permit the use of grid coordinates greater than 999,999.0 units. Also, to ensure proper mapping from digitizer to mesh coordinates, make sure that each x-coordinate and each y-coordinate on card types 4, 6, and 8 are different.

* See Appendix E.

END card Required

Columns	Format	Description
1-3	A	The keyword END
15	I	IDEBUG - QMESH print control Default = 3. 5 = Echo print input cards and fatal error messages 4 = Same as 5 plus printer plots of perimeter of each region and notice of successful restructuring, deletions, etc. 3 = Same as 4 plus a list of nodes generated by each QMESH line, each line making up the perimeter and a statistical analysis of the final mesh on each region (3 is default used if no END card used) 2 = Same as 3 plus a more complete trace of restructuring and deletions and, in case of error, a dump of the input table. 1 = Same as 2 plus a complete trace of restructuring card deletion

This card signals the end of PREMESH's run control input and tells QMESH how much output is desired.

SCHEME Commands

18. The following paragraphs describe the various scheme commands and were copied from R. E. Jones, 1974, "User's Manual for QMESH, A Self-Organizing Mesh Generation Program," Sandia Report No. SLA-74-0239, Sandia National Labs, Albuquerque, NM.

"QMESH normally develops an initial mesh for each region without direction from the user. (The exception is the M command discussed below.) The SCHEME card directs the processing after the initial mesh is set up, including the order and types of mesh modifications to be attempted, parameter adjustments, production of plots, and special printing.

"If no SCHEME cards are supplied by the user, QMESH will use a default scheme, which at the time of this writing is SP(RS(D)S)P. The user may supplant this default scheme by supplying a SCHEME card with REGION number left blank or set to zero. Then that stated SCHEME will be used for all regions not having specific SCHEME cards. A SCHEME card with a specific REGION number supplied (in columns 11 to 15) will take precedence for that region over QMESH's default as well as over any SCHEME cards with zero or blank REGION numbers. Thus, a typical mode of operation might be for the user to supply a fairly simple zero region number SCHEME to apply to most regions, and then supply more elaborate specific SCHEMEs for the few difficult regions. A simple SCHEME which would suffice for many relatively simple regions would be simply P, which would cause the initial mesh to be plotted. Alternatively, SP, to smooth the initial mesh and plot the result might be used. If no plotting is desired, simply S might do, or the SCHEME could even be blank. See the end of this (fourth) section for further examples.

"The SCHEME codes (commands) are grouped in the following pages into related categories. The most important SCHEME commands for most users will be P, S, R, D, and the left and right parenthesis which are used to define loops. The categories are:

- Initial mesh defining commands
- Smoothing commands
- Restructuring and related commands
- Plot commands
- Print commands
- Loop and branching commands

Initial Mesh Defining Commands

"M (Mesh) If this letter appears as the first letter of the scheme, QMESH will determine for itself a reasonable shape and orientation for the initial mesh, based on relative location of natural corners of the region. Otherwise, the first LINE or SIDE given on the REGION card will become the base of the (logically rectangular) initial mesh.

"O (Originate) This command causes the initial mesh to be regenerated. All previous structural or smoothing operations are thus lost. The purpose of this command is to allow several different trial schemes to be experimented with on one SCHEME card. (See examples of schemes.)

Smoothing Commands

"S (Smooth) S causes the appropriate routine to be called, provided some activity has occurred since the last S was encountered. That activity could be any successful restructure or element deletion (R, W, D), a necklace installation (N), a smoothing parameter change (H, I, J, A), a change in the smoothing algorithm being used (1,2,. . .), or a reorignation of the initial mesh (O). If no such activity has occurred since the last S was encountered, this smoothing operation is skipped (as it evidently would be a waste of time).

"1,2,. . .,6 These commands control the choice of smoothing algorithm to be invoked by subsequent S commands. The choice of smoothing algorithms may be changed as often as desired in a scheme. The choices are:

1 'Equipotential' smoothing if the mesh is not structurally modified from the initial mesh; otherwise 'area pull and Laplacian' smoothing

2 'Area pull and Laplacian' smoothing

3 'Centroid inverse area push and Laplacian' smoothing

4 'Centroid area pull' smoothing

5 Laplacian smoothing

6 Length-weighted Laplacian smoothing.

"I or + I (Iterations) This command causes the maximum allowable number of iterations (i.e., sweeps of the mesh) for smoothing processors to be increased by half (50%). Initially the maximum number of iterations is set to $M_1 + M_2$, where the initial rectangular mesh is of size M_1 intervals by M_2 intervals.

"-I This command causes the maximum allowable number of iterations to be used by smoothing processors to be decreased by one third (33.3%). Thus, the series +I -I or -I + I would leave the maximum number of iterations essentially unchanged.

"J or +J This command causes the node movement tolerance for convergence of smoothing to be increased by a factor equal to the cube root of 2.

"-J Causes the node movement tolerance for convergence of smoothing to be decreased by a factor equal to the cube root of 2. (This causes smoother meshes to be generated but costs more execution time.)

"H or +H Causes , the relaxation factor which is usually 1.0, to be increased by 0.25.

"-H Causes to be decreased by 0.25.

"A or +A (Alpha) Causes , which is the weight for the area pull portion of the "area pull and Laplacian" smoother, to be increased by 0.1. The initial value of is 0.7. As increases toward 1.0, the areas of the elements tend to become more nearly equal.

"-A Causes to be decreased by 0.1.

Restructuring and Related Commands

"R (Restructure) The restructure processor attempts to restructure the mesh in as many places as feasible to improve the shapes of elements. A significant amount of the execution time of the R command is in its initial phase, after which one or more restructures are performed quite efficiently.

"W (Worst Element) This processor calls the same routine as does the R command, but the number of restructures allowed is limited to one. (Hence, W is less efficient than R and should only be used when there is some reason to limit the number of restructures.)

"D (Deletion) The deletion processor finds the "sharpest" element in the mesh and deletes it by "squashing" it in its thin direction provided no boundary conditions would be violated and that the quotient of the smaller diagonal divided by the larger diagonal in no larger than tan (V/2). (See V command.)

"V or +V Causes the parameters V used by the D processor to be increased by 2.5°. The initial value of V is 45°. The larger V is, the more likely it is that the D processor will be able to delete an element (and vice versa).

"-V Causes the parameter V used by the D processor to be decreased by 2.5°.

"N (Necklace) This command causes an extra ring to be inserted just inside the perimeter of the region. This 'necklacing' processor does no analysis to see if this ring of elements is 'needed,' but just inserts it. Thus, it should never be used inside a loop. A necklace may be installed at any time, but the usual time would be very early in the SCHEME, and it will often need to be followed only by a smoothing operation.

Plot Commands

"P (Plot) This command causes a plot of the mesh in its form at that moment to be done, provided a smoothing operation or a structural change has occurred since the last P command. (Thus repetitious plots are avoided.)

"+P Normally a plot of the entire body is done after all regions have been processed. However, if no P commands are encountered in processing any region, this body plot is usually skipped. The +P command requests that the body plot be generated even though no individual regions are being plotted. It only needs to appear in the SCHEME for one of the regions.

"-P This command causes the body plot not to be done. It only needs to appear in the SCHEME for one of the regions.

"L This causes a printer plot showing all the nodes in the region to be done. This printer plot does not show lines joining nodes, but may still be useful, especially if the region does not have any elements.

Print Commands

"The parameter IDEBUG in column 15 of the END card is the primary control over printing. In addition, the following commands on the SCHEME card can request dumps or timing information.

"C (Current) This command requests a dump of the current state of the mesh. Tables describing all elements, lines, nodes, and their interconnections will be printed. (This table is rather large when the mesh is large, so it should only be requested when really needed, as for program debugging.)

"B (Body) This command requests that a complete list of the elements and nodes in the entire body be printed after all regions have been processed. It only needs to appear in the SCHEME card for one region of the body.

"T (Time) The T requests that the central processor time used by each command be printed if it is longer than 10 milliseconds. This of course only applies to commands appearing after the T, so the T should be placed early in the SCHEME if all timing information is desired.

"-T This command turns off the printing that was requested by an earlier T command.

"+T This command causes the cumulative execution time for this region up to the moment the +T is encountered to be printed. The +T does not conflict with the T or -T Command, and it may be used as often as desired.

"L See Plot Commands.

Loop and Branching Commands

"A loop is defined by enclosing in parenthesis the portion of the SCHEME that is to be repeated. The operation of all loops is controlled by a parameter called the 'activity flag'. This flag begins in the off state, and is turned on by the activities of necklacing (N), successful restructures (R or W), or successful deletions (D), or the presence of an 'active subloop'--i.e., a subloop which actually repeats at least once. If an activity occurs in a pass through a loop, then the loop is repeated (and hence is itself 'active').

"(The left parenthesis marks the beginning of a loop (or subloop). When it is encountered the current value of the activity flag is saved away on a stack and then the flag is turned off.

") The right parenthesis marks the end of a loop. If the activity flag is on at this point the loop is declared to be active, the activity flag is turned off, and control is transferred back to the first command in the loop to begin the next pass. If the activity flag is off, the loop is exited. Then, if the loop was not active (i.e., it did not repeat even once) the activity flag is reset to the value it had when the loop was entered. If the loop was active, the activity flag is turned on, reflecting that this was an active 'subloop.'

"F (Finished) If the activity flag is off when this letter is encountered, processing of the mesh for this region is usually stopped, just as if the end of the SCHEME had been reached. However, if there is a comma or period somewhere after the F, then instead of stopping, control will transfer to the first command after that next comma or period. If the activity flag is on when the F is encountered, processing continues as if the F were not present.

"G (Go) If the activity flag is on when a G is encountered, control transfers to the next comma or period, if there is one. If there is no comma or period, processing of the mesh for this region stops. If the activity flag is off when the G is encountered, processing continues as if the G were not present.

", (comma) The comma acts as a point for F and G commands to transfer to. Otherwise it is a 'do nothing,' and can be used like a blank to clarify readability of the scheme.

". (period) The period acts as a point for F and G commands to transfer to. Otherwise, it causes termination of processing of the mesh for this region just as if the end of the SCHEME had been reached.

"Z (Zero) This letter turns off the activity flag. (See the example schemes below.)

Examples of Schemes

"Schemes may be very simple to very complex depending on:

- the amount of processing needed to produce a satisfactory mesh on the region,
- the degree of control of program parameters the user wants to exercise,
- the amount and kinds of output desired,
- the need to experiment with different orders of processes, etc.

"The simplest possible SCHEME card is one with no commands (i.e., the card is blank except for the word 'SCHEME'). If there are no commands on the SCHEME card for a region, QMESH simply writes the description of the initial mesh for that region on the output tape (see description of the REGION card) and proceeds to the next region. Note this is very different from including no SCHEME card, in which case the default scheme in QMESH is used. At this writing this default scheme is equivalent to the following SCHEME card:

```
Col. 1       Col. 16 or later
SCHEME       SP(RS(D)S)P
```

This scheme plots the smoothed initial mesh and also the final mesh if it is different from the first plot. The actual SCHEME used, whether it is the default or is user defined, will be printed out by QMESH.

"A very simple, but often sufficient SCHEME card is

```
SCHEME      P
```

in which the initial mesh is simply plotted before the mesh is written on the output tape. Alternatively, since the initial mesh sometimes has elements crowded too closely near the boundary of the region, one may smooth before plotting:

```
SCHEME      SP
```

If no plots are desired, no P's should appear in the SCHEME. Thus, simply S, or a blank SCHEME might be used. Or to use the default SCHEME except get no plots, simply eliminate the P's from the default scheme: S(RS(D)S). Another possibility is to request only a final body plot by using the +P Command.

"One can experiment with various smoothers by smoothing and plotting several times. (Of course only the last plot will relate to the mesh description on the tape.) For example,

```
SCHEME      P      SP      2SP      3SP
```

or, the parameters for the 'area pull and Laplacian' smoother might be varied:

SCHEME 2SP ASP ASP

"Many meshes will benefit from the use of restructuring alone is desired (i.e., no element deletion), schemes such as the following can be used.

SCHEME (RS)P

SCHEME (SR)P

The first scheme here says, 'Attempt restructuring; if successful, smooth and repeat; plot when done.' The second scheme is almost identical, except a smoothing operation is done before the first restructuring attempt. Any restructuring which then occurs will cause the loop to repeat, so that the mesh is always smoothed after restructuring.

"When restructuring is necessary to produce an acceptable mesh, it will typically also be necessary to use element deletion. There are two basic restructure/delete loops: (SRS(D)) and (SRSD). Each of these might profitably be preceded by an (SR) loop. Generally the (SRS(D)) loop would be used with large regions in order to save time in the smoothing routine, which tends to be the most costly operation. Often, though, the (SRSD) loop will produce nicer meshes than the other loop but require more execution time. The reader may wish to consider the following sampling of schemes, each of which could reasonably be used on many regions.

SCHEME (SRS (D)) P

SCHEME (SR)((D)SRS) P

SCHEME (SWSD) P

SCHEME ((SR)(D)S) P

Note we have not included in the above any schemes with element deletion but no restructuring. While this would be possible, it is felt that the use of restructuring is preferable to use of element deletion only. Also, it should be noted that element deletion should normally not be used with regions which are intentionally skewed, or tilted, as the deletion processor would tend to go berserk, deleting elements that would be considered normally shaped. Of course the -V Command can be used to control the deletion processor's appetite. In addition, a scheme with a conditional branch such as the following might be used to avoid entering a loop involving element deletion unless the region has abnormalities other than just a tilt:

SCHEME SRF ((D)SRS) ,P

"The user may experiment with alternate schemes rather easily by using the initial mesh reoriginating command (letter O). For example (execution times are also being printed here):

SCHEME (SRS(D))P+T O(SRSD)P+T O(SR)P+T

"The following schemes are presented without discussion to illustrate additional scheme possibilities:

```
SCHEME      NSP
SCHEME      M(SRS(D)P)L
SCHEME      III -J-J-J 3S P
SCHEME      SR(S D SZR)P
SCHEME      S DG +VDG +VDG +VVDGP .(SRSD) P
```

Table D-1-1
Digitizer File Format for Input to Program PREMESH*

Card Number	Field	Format	Description
1	1	A12	Identification for file
2	1	I6	ITYPE = 4
	2	I6	ICODE = -10
3	1	"	NX1 = Digitizer x-coordinate of first point of transformation
	2	"	NY1 = Digitizer y-coordinate
4	1	"	MX1 = Grid x-coordinate of first point
	2	"	MY1 = Grid y-coordinate
5	1	"	NX1 = Digitizer x-coordinate of second point
	2	"	NY2 = Digitizer y-coordinate
6	1	"	MX2 = Grid x-coordinate of second point
	2	"	MY2 = Grid y-coordinate
7	1	"	NX3 = Digitizer x-coordinate of third point
	2	"	NY3 = Digitizer y-coordinate
8	1	"	MX3 = Grid x-coordinate of third point
	2	"	MY3 = Grid y-coordinate
9	1	"	ICODE = -5555 to start each LINE
	2	"	NVAL = Identifying number of LINE
10	1	"	IX = Digitizer x-coordinate of point defining LINE
	2	"	IY = y-coordinate of point along LINE
** Repeat types 9 and 10 until all lines are input. Curved boundary LINES should be digitized as finely as possible.**			
11	1	I6	ICODE = -9999 to end digitizer input.

*This format may be written by the program DMSDIG.

ADDENDUM D-2: USER INSTRUCTIONS FOR PROGRAM EDGRG, INTERACTIVE MESH EDITOR

Purpose

1. EDGRG is a utility program that is used to interactively edit TABS-2 computational meshes.

Origin of Program

2. EDGRG was written by D. P. Bach of the WES Estuaries Division.

Description

3. EDGRG reads the input file for GFGEN (output file from AUTOMSH) and, responding to interactive commands, revises and plots the mesh. It can add, delete, or move elements and nodes and fit curved boundaries. At the end of an editing session, the user can save the output file, which is a copy of the input file with changes that have been made during the session.

Use

4. EDGRG requires a TEKTRONIX-type graphics terminal.

Input

5. Input consists of a standard GFGEN (Addendum D-3) input file and interactive commands. To begin mesh editng session, make the GFGEN input file local by typing

GET, TAPE1 = filename <RETURN>

Then execute EDGRG by typing

BEGIN,EDGRG,PROCLV <RETURN>

5. At the beginning of execution, the program displays on the screen some information about the input file (title, number of nodes, elements, etc.). When the user presses the return (or enter) key, the screen is erased, the bell sounds and a "C?" prompt appears. The C? prompt indicates that the program is waiting for a command. Table D-2-1 lists the available commands.

Interactive commands

6. Windowing. The "W" command is used to window in on portions of the mesh so that the plotted mesh is larger and

easier to review and edit. Five windowing methods are available.

7. Windowing by specifying nodes at the corners is performed by giving the "W" command at the "C?" prompt. The program will respond with "NODES?." The user then keys in the numbers of four corner (not mid-side) nodes that define the minimum and maximum x- and y-coordinates of the window. The displayed line will look like this:

```
C?  W     NODES?  nxmin,nxmax,nymin,nymax
```

where

nxmin = node with x-coordinate that corresponds to left side of the window

nxmax = node with x-coordinate that corresponds to right side of the window

nymin = node with y-coordinate that corresponds to bottom of the window

nymax = node with y-coordinate that corresponds to top of the window

Using mid-side nodes or nodes that have a maximum below a minimum will result in a nonexistent window.

8. Windowing by coordinates is activated by the "WC" command. It wil result in the prompt "COORDINATES." The prompt and responses are:

```
C? WC     COORDINATES?  xmin,xmax,ymin,ymax
```

where the coordinate responses are in actual units and define the desired window.

9. Windowing around a specific node or element is obtained by the "WN" or "WE" command. The program responds by asking which node or element is desired.

10. Windowing by use of the cross hairs requires that a plot of the mesh or of a previous window be displayed on the screen. In response to the "C?" prompt, type "C" <RETURN> and the cross hairs will appear. Position the crosshairs at the lower lefthand corner of the desired window and type "W" <RETURN>. The cross hairs will reappear. Position them at the upper right-hand corner of the desired window and type a space, then <RETURN>. This completes definition of the window.

11. Once defined, the window will remain in effect until redefined or the session ends. The PW command will plot the windowed portion of the mesh.

12. Creating nodes. Nodes are created by typing the "C" command to display the cross hairs. When the cross hairs appear, position them at the location where the node is desired, then type "C" <RETURN>. The program will assign a number to the new node. It will then request the bed elevation for the new node (prompt "ELEV?") and slope (prompt "SLOPE?"). If the new node does not lie on a element side that is to be curved, enter "NO" to the "SLOPE?" prompt. If a slope is needed, it can be specified by typing in a value or it can be computed by the program. To have the program compute slope, type in "COMPUTE" <RETURN> , in response to the "SLOPE?" command. The crosshairs will then appear. Place them at the location on the curved boundary where the adjacent mid-side should be located and type a space then <RETURN>. When all new nodes have been created, type "CS" at the "C?" prompt and the requested slopes will be computed by the program.

13. Creating elements. When the "CE" command is entered to create an element, the program will prompt with "NODES?." In response, type in a list of four corner node numbers, separated by commas, that define the new element. For triangles, the fourth node number should be zero. The corner nodes should be entered in counter-clockwise order. The program will assign an element number.

14. If the entered nodes correspond to an existing element side that is to be curved, the program will ask if the new side is to be curved also. The request will appear as:

"Is SIDE node1 node2 node3 to be curved?"

If the side is to be curved, type"YES" <RETURN>. If it is not, type "NO" <RETURN>.

15. The program will assign a number to the new element.

Output

16. EDGRG will write a new GFGEN input file at the end of the editing session. To save it for future use, you must save that file (TAPE2). Use

SAVE,TAPE2 = filename

17. A summary of the editing session is written to TAPE91. If a record of the session is desired, print TAPE91 locally or route it to an RJE printer.

18. A list of deleted node and element numbers that were not reassigned during the session are written to TAPE3. If you wish to reuse those nodes and elements later, save TAPE3 and make it local for the next editing session, then type RR (restore) at the first C? prompt.

Table D-2-1

EDGRG Commands

Command	Result
PG	Plot entire mesh
PN	Plot node numbers without erasing mesh on screen
PE	Plot element numbers without erasing mesh on screen
W	Define window on part of mesh (see paragraph 6-11)
WC	Window by coordinates
WE	Window by element
WN	Window by node
PW	Plot that portion of the mesh as defined by previous window (W) command
DN	Delete node. Program will request node number to be deleted.
C	Display cross hairs. Used to window and create nodes (see paragraph 12)
CS	Compute slopes at nodes newly created and flagged as those to have slope computed
DE	Delete element. Program will request element number to be deleted
CE	Create element (see paragraph 13)
E	Exit EDGRG and write output file (TAPE2 must be saved to preserve results of editing)
RR	Restore run (see paragraph 18)
RS	Erase screen
Q	Query. Displays results of editing so far in present session

ADDENDUM D-3: PROGRAM GFGEN

VERSION 3.0

Purpose

1. GFGEN's purpose is to create a geometry and finite element mesh file for input to the TABS-2 modeling system programs and to plot the created mesh.

Origin of Program

2. GFGEN is composed of elements from programs written by Resource Management Associates, Lafayette, California, and the WES Hydraulics Laboratory.

Description

3. The program GFGEN has these capabilities:

- a. Read node and element data and construct a finite element computational mesh for use by other programs in the TABS-2 modeling system.
- b. Identify errors and potential errors in the constructed mesh.
- c. Renumber the mesh, omitting unused node and element numbers.
- d. Fit curved element sides to land boundaries and interior element sides as specified.
- e. Develop an element solution order that permits most efficient operation of models using the mesh.
- f. Print a summary and create a plot of the generated mesh.
- g. Write a file that contains the mesh information and geometry in format suitable for use by other TABS-2 programs.

Use

Curved Element Sides

4. Curved element sides may be created for external boundaries (the sides of the model) or for element sides within the mesh. They may fit by either or both of two optional techniques. These are described below:

5. Boundary Option I. Slopes are specified at all corner nodes where curved boundaries are to be placed and a list of mid-side nodes on the curved boundary is given. The program calculates the necessary curved boundary to satisfy the specified slopes. If certain slope errors are detected, a warning is printed. If the fix-slope option is on (IFXSLP=1), the program attempts to modify specified slopes near the error to eliminate it. Option I requires use of the GC, GM, and perhaps the GF card.

6. Boundary Option II. A starting corner node, a direction to proceed, and an ending corner node are specified. The program will automatically generate a smooth, curved boundary from the starting node to the ending node. If desired, slopes at some nodes can be prespecified and the automatic computation will force the curved boundary to meet that specified slope. Option II requires use of the GB and GS cards. After the curved boundary has been created once, change these cards to GCN and GMN cards with slopes inserted to save computer costs.

7. Note that Option I can be exercised on one part of the mesh and Option II on another part. If both options are specified for the same portion of the mesh, Option II will override Option I.

8. Problem elements. The shape described by a curved element side is that of a second order curve. It can contain only one inflection point between two corner nodes. An example of a curved boundary is shown in Figures D-1-2 and D-3-1a. If a boundary is curved very sharply, as shown in Figure D-3-1b, then the mid-side node will fall quite close to one of the adjacent corner nodes. Mid-side nodes that fall outside the middle third of the curved arc length prompt GFGEN to issue a warning about "middle third rule" violation and print the fraction of arc length at which the mid-side falls. Middle third rule violations that are close to a fraction of either 0.333 or 0.666 can usually be tolerated by the models. Fractions less than 0.2 or more than 0.8 usually lead to model inaccuracy and even instability.

9. Sharply curving boundaries can cause the elements that they border to be poorly constructed. GFGEN contains some error detection but cannot identify all potential errors. Curved sides are shown in Figure D-3-2. Part a shows a well-formed element. Part b shows a poorly formed element that has the curved boundary crossing the opposite side. Part c of the figure shows an ele-

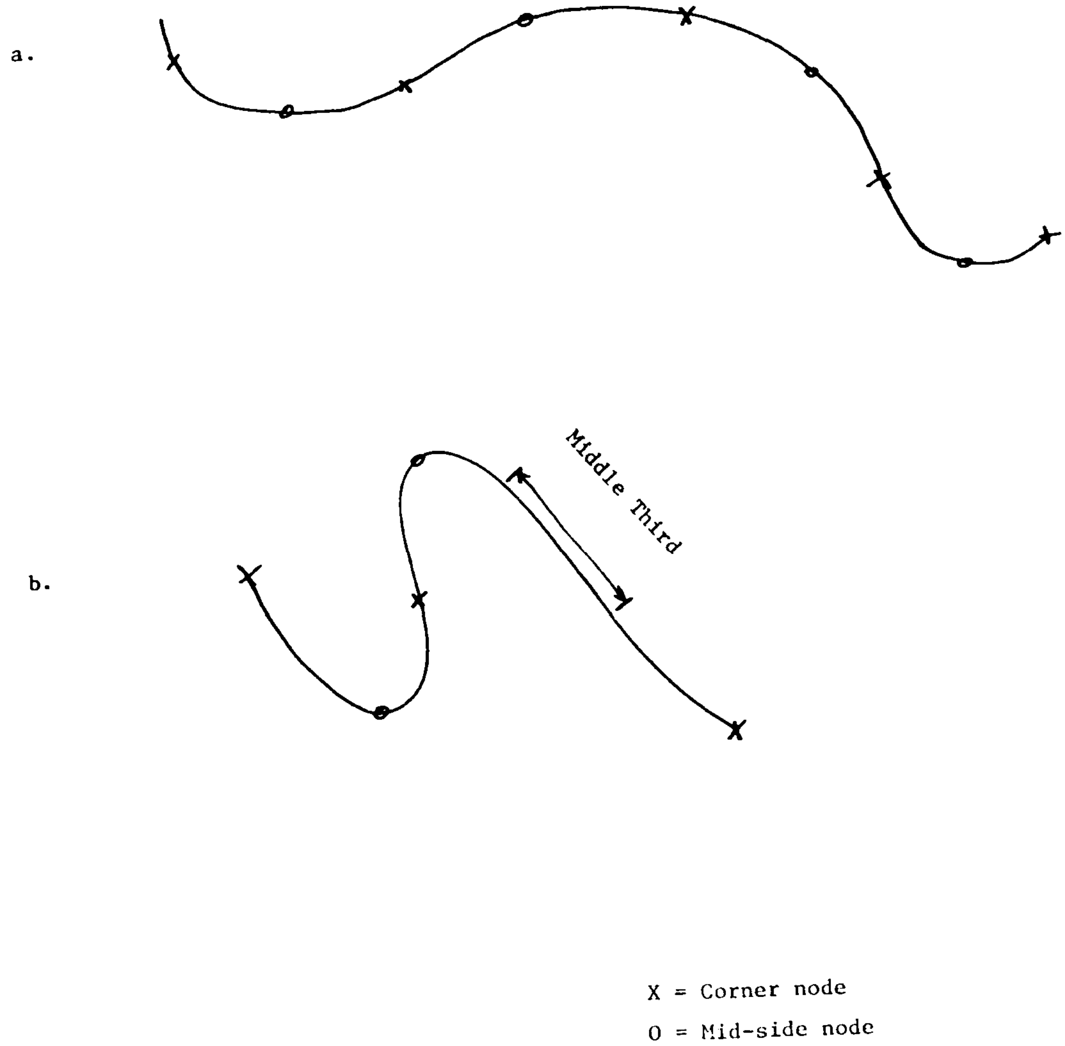
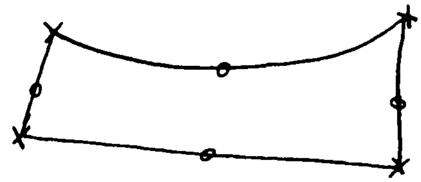
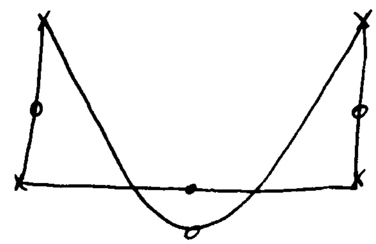


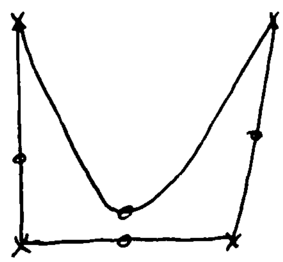
Figure D-3-1. Curved boundaries



a. Well-formed element



b. Badly formed element with side overrun



c. Badly formed element with needle-like corners

Figure D-3-2. Elements with curved sides ment with very sharp corners. The element in Figure D-ˆ-2b would cause the models to produce erroneous results or fail. The element in Figure D-3-2c might or might not cause problems depending on its location in the mesh and gradients near it. Poorly formed elements can be avoided in the mesh creation process by careful location of corner nodes. Each newly formed mesh should be plotted and examined carefully to identify and remedy problems such as shown in Figure D-3-2.

Reordering

10. The simultaneous equation solver used by the models runs more efficiently (and thus, considerably more cheaply) if the solution sequence is optimized by reordering the mesh. Reordering does not change any element or node numbers; it changes the sequence in which the elemental equations are assembled.

11. The program will attempt various reordering schemes as directed and give the matrix bandwidth and band sum and front sum for each scheme. It will automatically select the ordering scheme that minimizes the front sum. The cost savings associated with reordering are large enough that it is strongly recommended that the user spend some time carefully generating the optimum reordering scheme. Once reordering is complete, only the best list should be used in subsequent runs so that computation costs are minimized. Two options are available for reordering:

12. Reordering Option I. Option I requires that the GO card be used to give a starting list of nodes to begin the reordering process. Many starting lists should be tried.

13. When using Option I reordering, consider the following points. In general, choose reordering lists that make up a continuous line along one end of the mesh. Try lists on several edges of the mesh and of varying length. Be warned that a very short list (less than five nodes) may cause the front width (number of equations assembled simultaneously) to become too large for program dimensions. Try inflow or outflow boundaries as reordering lists.

14. When the starting node list leading to the smallest front sum is found, try multiple versions of that list, including slightly shorter and slightly longer lists. Try reversing the order that the nodes are listed (left to right instead of right to left, etc.).

15. Reordering Option II. Option II performs automatic reordering of the mesh without requiring a starting list or location like Option I. Option II usually creates a reordered mesh slightly less efficient than that generated by a rigorous application of Option I. Option II is also available in AUTOMSH.

16. Option II cannot tolerate missing elements (skipped element numbers) nor elements with negative values of IMAT (card

GE). Because it takes a substantial amount of processor time, Option II should not be used as a matter of routine.

Input

17. Input consists of control data, described here, which are in card image and may be either on cards or on disk file identified as logical unit 08. Alternate input is a geometry file previously created by GFGEN. Input data on logical unit 08 are in the standard TABS format. Briefly, each card image begins with a two or three character identification string followed by the data. Data may be formatted in column fields or free format separated by spaces or commas.

Output

18. Output consists of printed results, a plot file, and a geometry file. Printed output includes echo prints of input data; a list of elements, associated nodes, and element types; slopes at the nodes; a list of boundary nodes; high and low element and node numbers; unused element and node numbers.

19. Error messages. Messages showing mesh errors are printed if switched on by the GF card. Three error messages are given. The Middle Third Rule violation means that a midside node on a curved boundary has been calculated to lie outside the middle third of the arc forming the element side. As discussed in paragraph 8 of this addendum, middle third rule violations need not always be fixed. The Slope Rule Error indicates that the slopes given at two adjacent corner nodes will cause the boundary to reverse directions between the nodes as shown in Figure D-3-1C. The user may intend for the reversal to occur, but if not, a boundary discontinuity exists that requires special treatment in the flow model. Ill-defined elements are identified if an element has:

a. Any number of nodes other than 6 or 8.

b. A node list containing a zero.

c. A node list that does not alternate corner and midside node numbers.

Keeping track of runs

20. Keeping track of runs is made easier by use of consistent file naming conventions (Appendix N), use of a file management system (Appendix N), and use of job tracking sheets as illustrated in Figure D-3-3.

Example-Card Image Input Data

21. Table D-3-1 lists the card image input data needed for GFGEN instructions. An example listing of the card image input data file for GFGEN is shown in Figure D-3-3. The T3, SL, GE,

GFGEN JOB SHEET

JOB EXECUTED ________ DATE OF RUN ________ TIME OF RUN ________

JOB PRINTED ____ ____ SUBMITTED BY ________ SBUS ____ PRI___PO___

* * * * * * * * * * * * REVISION NO. = ______ * * * * * * * * * * * * *

NODES = ________ REORDERED? YES OR NO

ELEMENTS = ________ MESH CHECK = 0 OR 1 OR 2 OR 3

PLOT = NO or ALL or PARTIAL (if partial, give limits=____,____,____,____)

ROTATION = ______ DEGREES
ELEM HGHT = ______
NODE HGHT = ______

* *

PURPOSE =

FIGURE D-3-3. GFGEN job sheet

```
T3 YAZOO BACKWATER AREA - ALTERNATIVE 1
$L 3,0,6
GB 315,311,1
GB 333,336,348
GB 350,352,392
GB 388,387,339
GB 399,406,928
GB 948,959,994
GB 971,972,740
GB 12,15,804
GB 314,310,393
GC 804,.7622
GO 2866,986,2870,991,2876,993,2878,994,0
GS 589,-3.14
GS 455,.4628,449,.9868
GS 518,.6157,519,.6000
GS 27,-.667,29,-.571,37,-.9908,39,-.9694
GS 41,-3.333,137,-2.222,232,-4.545,629,-4.083
GS 87,-.2450,65,-.2550,64,-.2450,43,-.2550
PO 1,1,0,0.002,.002,0,.07,.07
GE    1    1   997    2   998    4   999    3   1000   2 0.
GE    2    6  1001    4   998    2  1002    5   1003   2 0.
GE    3    3   999    4  1004   44  1003   43   1006   2 0.
GE    4   45  1007   44  1004    4  1001    6   1008   2 0.
GE    5    8  1009    6  1003    5  1010    7   1011   2 0.
GE    6   46  1012   45  1008    6  1009    8   1013   2 0.
GE    7    8  1011    7  1014    9  1015   10   1016   1 0.
GE    8   46  1013    8  1016   10  1017   47   1018   1 0.
GE    9   10  1015    9  1019   11  1020   12   1021   1 0.
GE   10   47  1017   10  1021   12  1022   48   1023   1 0.
GE   11   12  1020   11  1024   13  1025   14   1026   1 0.
GE   12   48  1022   12  1026   14  1027   49   1028   1 0.
GE   13   14  1025   13  1029   15  1030   16   1031   1 0.
GE   14   49  1027   14  1031   16  1032   50   1033   1 0.
GE   15   17  1034   18  1035   16  1020   15   1036   2 0.
GE   16   18  1037   51  1038   50  1032   16   1035   2 0.
GE   17   19  1039   20  1040   18  1034   17   1041   2 0.
GE   18   20  1042   52  1043   51  1037   18   1040   2 0.
GE   19   21  1044   22  1045   20  1039   19   1046   2 0.
GE   20   22  1047   53  1048   52  1042   20   1045   2 0.
GE   21   23  1049   24  1050   22  1044   21   1051   2 0.

                 o                    o
                 o                    o
                 o                    o
GNN   1    321098.90    724680.40    75.00
GNN   2    321103.40    724518.60    75.00
GNN   3    321784.60    724743.10    75.00
GNN   4    321784.87    724532.24    75.00
GNN   5    321105.40    724356.60    75.00
GNN   6    321711.39    724314.76    75.00
```

Figure D-3-4. Example input for GFGEN

and GNN cards were written by AUTOMSH. The only additional cards needed to execute GFGEN are the:

GB Automatic boundary slope calculation

GS Override GB-card option at selected nodes

GO Element reordering for more efficient computations

PO Mesh plot details

22. AUTOMSH writes the GE-card for each element (giving the element/node connection table, the element type, and its orientation in the mesh) and the GNN card for each corner node in the mesh (giving its (x,y,z) location in that sequence. For example, the GNN card at the bottom of the sample listing shows (321098.90, 724680.40, and 75.00) for the (x,y,z) coordinates, respectively. AUTOMSH prints all but the z-value, and it sets all z coordinates to "0." It is necessary to obtain a plot of the mesh, with node numbers, to determine the node number for the z-coordinate.

23. Notice also that node numbers in the example listing increase by 1; yet they are corner nodes only. Mid-side node numbers are included in the element connection table (GB-cards), however, and will be located by GFGEN using straight interpolation if they are not on boundary lines.

24. A plot of the finite element network is shown in Figure D-3-4. It is the first of three plot files requested on the PO-card. The second plot file has the same image as the first plus element numbers and the third plot file has that same image but node numbers are displayed rather than element numbers. It is this plot which must be requested, at map scale, to code the z-coordinate for each corner node.

Input Instructions

25. The following pages provide instructions for preparing card-image run control input to program GFGEN. Table D-3-1 summarizes the input data types.

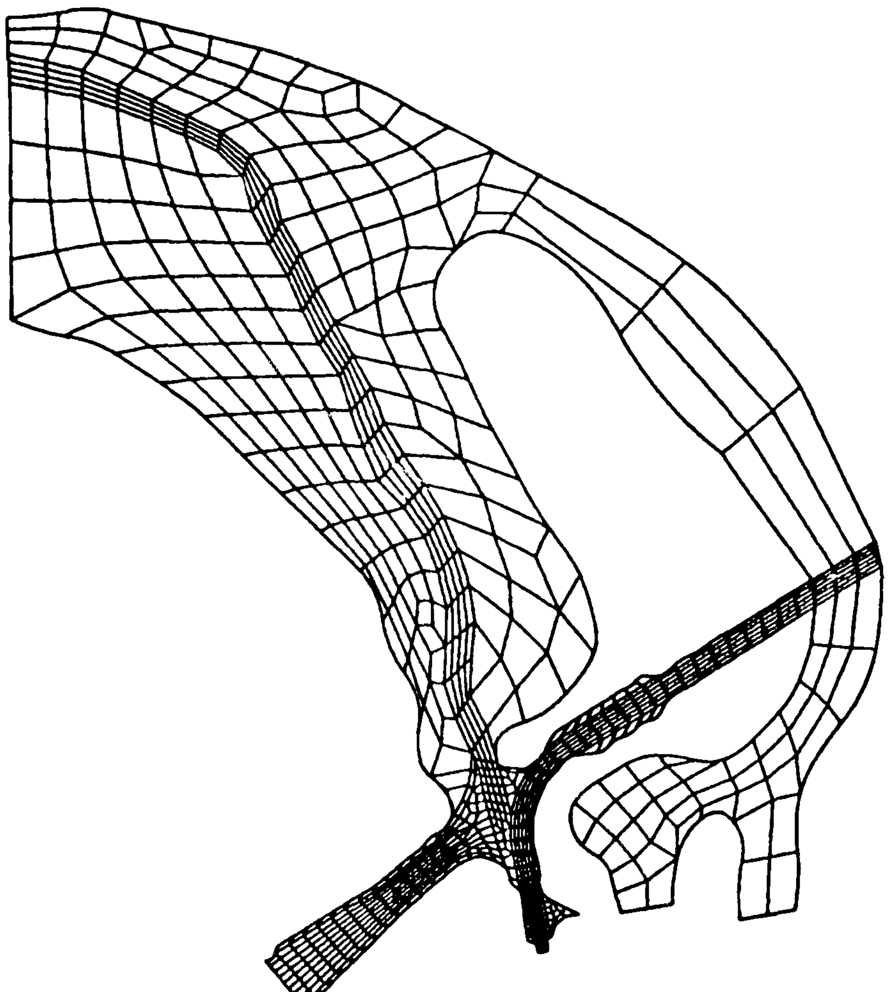


Figure D-3-5. Example mesh plot produced by GFGEN

Table D-3-1

GFGEN Version 3.0 Data Card Sequence

Card	Content	Required?	Page
T1-T3	Titles	Yes	D-3-12
$F	Format control	No	D-3-14
$L	Input/output files	No	D-3-15
GB	Boundary for automatic curve fitting to sides	No	D-3-16
GC	Corner nodes and slopes for specified curve fitting to sides	No	D-3-17
GM	Mid-side nodes on specified curve-fitted boundaries	No	D-3-18
GF	Mesh debug controls	No	D-3-19
GG	Automatic mesh generator controls	No	D-3-20
GO	Mesh reordering controls	No	D-3-21
GR	Mesh refining controls	No	D-3-22
GS	Specified corner node slopes to override automatic slope computation	No	D-3-23
GX	Geometry scales	No	D-3-24
PO	Plot controls	No	D-3-25
PP	Partial plot controls	No	D-3-26
GE	Element arrays	Yes, if GG not used	D-3-27
GN	Node descriptions	Yes, if GG not used	D-3-28

T1 Cards Title Cards Optional

Field	Variable	Value	Description
Col 1	ICG	T	
Col 2	IDT	1	
2-10	Title		Title information

T3 Card | Title Cards | One required

Field	Variable	Value	Description
Col 1	ICG	T	
Col 2	IDT	3	
2-10	Title		Title information

$F CARD Format Control Optional

Field	Variable	Value
Col 1	ICG	$
Col 2	IDT	F

If the $F is present, the program expects formatted input according to (3A1,F5.0,9F8.0) or (3A1,I5,9I8) on all cards except for the GE cards which are (2A1,6X,I8,8I4,I8,F8.0). If the $F is not included, free-field formats are used, and variables are separated by spaces or commas. If free-field input is used, variables on each card must appear in sequence, even if they are set to 0.

$L CARD Input/Output Data Logical Unit Numbers Optional

Field	Variable	Value	Description
Col 1	ICG	$	
Col 2	IDT	L	
1	LUNIT	+	LU on which results of the network generation are to be written. This file will serve as input to the models or to another GFGEN run. Usually LU 03.
		0	No output file will be written.
2	IGIN	+	LU for an existing network which is to be read in and revised. If, IGIN <0, only the reordering list will be read. Usually LU 04.
		0	No existing network will be read.
3	LP	+	LU for standard printed output.
		0	Default to 6, line printer.
4	NRPT	+	If an existing network is to be refined and it is desired to interpolate velocities and depths at the refined nodes: NRPT is the LU on which interpolation information is written by program REFINE.
		0	No interpolation needed.

GB CARD Boundary to be Automatically Fit with Curved Sides Optional

Field	Variable	Value	Description
Col 1	ICG	G	
Col 2	IDT	B	
Col 3	ISI	ƀ	
1	LOC_1	+	Corner node at which curved boundary computation is to begin.
2	LOC_2	+	Next corner node in curved boundary computation (indicates direction that computation is to go).
3	LOC_3	+	Last corner node in curved boundary computation.
4	Repeat fields 1-3 as needed or insert additional GB cards to complete the lists of curved boundary computation. Do not break a 3-field sequence between cards. Continuation cards are coded the same as the first card.		

GC CARD Corner Nodes on Curved Sides Optional

Field	Variable	Value	Description
Col 1	ICG	G	
Col 2	IDT	C	
Col 3	ISI	N	
1	LOC_1	+	Corner node number for $ALPHA_1$
2	$ALPHA_1$	+	Slope at node LOC_1
3	LOC_2	+	Corner node number for $ALPHA_2$
4	$ALPHA_2$	+	Slope at node LOC_2
5	Continue coding until all corner nodes with slopes are listed. Continuation cards are coded the same as the first card. Do not break a node-slope pair between cards.		

Not needed for boundaries where Option II is used.

GM CARD — Mid-side Nodes on Curved Sides — Optional

Field	Variable	Value	Description
Col 1	ICG	G	
Col 2	IDT	M	
Col 3	ISI	N	
1	LOC_1	+	Mid-side node for which location and slope are to be computed.
2	LOC_2	+	Mid-side node for which location and slope are to be computed.
3	Continue coding until all midside nodes which are to have location and slope computed are listed. Continuation cards are coded the same as the first card.		

Not needed for boundaries where Option II is used.

GF CARD — Mesh Debug Controls — Optional

Field	Variable	Value	Description
Col 1	ICG	G	
Col 2	IDT	F	
1	IDEBUG	1	Print high and low element and node numbers, ill-defined elements, unused elements and nodes bad slope specifications, and all boundary nodes.
		2	Perform all of optional 1 plus generate node cross-reference list.
		3	Perform all of options 1 and 2 plus eliminate all unused nodes.
		4	Perform all of option 3 plus eliminate undefined elements and write a new GFGEN input file on logic unit 98.
2	IFXSP	1	Attempt to correct slope rule errors at listed nodes.
		0	No slope corrections.
3	NODA	+	List of mid-side nodes between corner nodes that can be adjusted to correct slope rule errors. Limit of 100. Continue coding on additional cards if needed, starting with field 1.

GG CARD Automatic Mesh Generator Optional

Field	Variable	Value	Description
Col 1	ICG	G	
Col 2	IDT	G	
1	NY	+	Number of element panels in x-direction
2	NY	+	Number of element panels in y-direction
3	XL	+	Mesh length in x-direction
4	XY	+	Mesh length in y-direction
5	XR	+	x-direction geometric spacing (usually 1)
6	YR	+	y-direction geometric spacing (usually 1)

GO CARD — Mesh Reordering — Optional

Field	Variable	Value	Description
Col 1	ICG	G	
Col 2	IDT	0	
1	IRO	1	Reorder mesh using lists of starting nodes given
		2	Reorder using automatic technique
		3	Reorder using both options 1 and 2
2	LISTN	+	A list of nodes (corners and mid-sides) in sequence to be used as starting line in reordering. Multiple lists may be input. The last number in each list must be a zero or negative number.

For continuation cards, LISTN begins in the first field. Do no repeat IRO for subsequent lists. Reordering is strongly recommended as a last step before running the models. See documentation for suggestions.

GR CARD — Mesh Refining — Optional

Field	Variable	Value	Description
Col 1	ICG	G	
Col 2	IDT	R	
1-4	LISTR	+	3 or 4 node numbers on the existing mesh that will be used to form a new element using the cited nodes as corner nodes in the new element. One new element per card.

GS CARD — Fixed Boundary Slopes — Optional

Field	Variable	Value	Description
Col 1	ICG	G	
Col 2	IDT	S	
1	LOC_1	+	Corner node at which automatic slope computation will be forced to use specified slope
	$SLOPE_1$		Specified slope

Repeat fields 1 and 2 as needed or insert additional GS cards to complete the list. Do not break a location-slope pair between cards.

GX CARD | Geometry Scales | Optional

Field	Variable	Value	Description
Col 1	ICG	G	
Col 2	IDT	X	
1	XFACT	+	Scale factor to multiply input x-coordinates by to get model distances
		0	Default is 1
2	YFACT	+	Scale factor to multiply input y-coordinates by to get model distances
		0	Default is 1

PO CARD | Plot Controls | Optional

Presence of this card indicates that at least one plot is to be drawn.

Field	Variable	Value	Description
Col 1	ICG	P	
Col 2	IDT	0	
		0	Plot without node numbers or elevations plotted.
1	IPNN*	1	Node numbers will be plotted.
		2	Corner node elevations will be plotted.
		3	Both nodes and corner node elevations will be plotted.
2	IPEN*	0	Plot without element numbers or IMAT's plotted.
		1	Element numbers will be plotted.
		2	Element types (IMAT) will be plotted.
		3	Both element numbers and IMAT's will be plotted.
3	HORIZ	+	Maximum horizontal size of plot
		0	Use XSCALE and YSCALE
4	VERT	+	Maximum vertical size of plot
		0	Use XSCALE and YSCALE
5	XSCALE	+	Scale factor for x-dimensions
		0	Use HORIZ and VERT
6	YSCALE	+	Scale factor for y-direction
		0	Use HORIZ and VERT
7	AR	+	Plot rotation in degrees clockwise from x-axis
8	HITEL	+	Height in inches of element numbers on plot
		0	Default is .21
9	HITNN	+	Height in inches of node numbers on plot
		0	Default is .21

Plot information is written to logical unit 99.

*Each plot option produces a separate plot. Thus IPNN = 3 , IPEN = 0 will produce three plots--one with the mesh only, one with node numbers, and one with corner node elevations.

PP CARD Partial Plot Options Optional

Presence of this card indicates that a partial plot is to be drawn.

Field	Variable	Value	Description
Col 1	ICT	P	
Col 2	IDT	P	
2	NXPMIN	+	Node number of minimum x location in partial plot
3	NXPMAX	+	Node number of maximum x location in partial plot
4	NYPMIN	+	Node number of minimum y location in partial plot
5	NYPMAX	+	Node number of maximum y location in partial plot

Note that windowing is performed after any requested plot rotation if a plot is rotated by the PO card. The choices of maximum and minimum coordinates should be in terms of the rotated plot.

GE CARD | Element Arrays | Optional

Field	Variable	Value	Description
Col 1	ICG	G	
Col 2	IDT	E	
1	JELE	+	Element number
2-9	NOP	+	6 or 8 element node numbers beginning with any corner and going counterclockwise around the element. For triangles, the last two nodes mu be entered as zero.
10	IMAT	+	Element type**
11	TH	+	Direction of eddy viscosity tensor for this type element.

* For formatted reads this card is read as (2A1,6X,I8,8I4,I8,F8.0)

** Element types are used by the RMA-2V to define eddy viscosity coefficients and roughness coefficients.

Use one card per element.

GN CARD — Nodal Descriptions — Optional

Field	Variable	Value	Description
Col 1	ICG	G	
Col 2	IDT	N	
Col 3	ISI		Coding options
		b̸	Constant value to be used at all nodes of number J and higher
		N	Values to be assigned to node J only (insert all ISI=b̸ cards before first N card)
1	J	+	Node number (first node for ISI=b̸)
2	CORD(J,1)	+	x-coordinate of node J
3	CORD(J,2)	+	y-coordinate of node J
4	WD(J)	+	Bed elevation at node J

ADDENDUM D-4: USER INSTRUCTIONS FOR PROGRAM CONFEG

Purpose

1. CONFEG is an interactive program that reads a DMSDIG (see Appendix E) digitizer file containing node numbers and coordinates and transforms the digitizer coordinates into the coordinate system of the user's TABS-2 mesh. The output file from CONFEG can be merged with other text files to create a complete GFGEN input data set.

Origin of the Program

2. CONFEG was written by Steve Adamec of WES.

Description

3. A mesh node file created by DMSDIG has nodal coordinates given in inches. CONFEG converts these units to prototype feet using an interactively-input scale factor. The program also shifts the datum plane for depths as needed, using an interactively-supplied value.

4. CONFEG produces an output file on logical unit 2 (file TAPE2) that must be saved and merged with other data (using a text editor) to create a complete GFGEN input data set.

Use

5. CONFEG runs interactively with an input digitizer file and creates an output GFGEN node coordinate file. Scale factors and an elevation datum reference are requested interactively when the program executes. The following interactive commands will execute CONFEG:

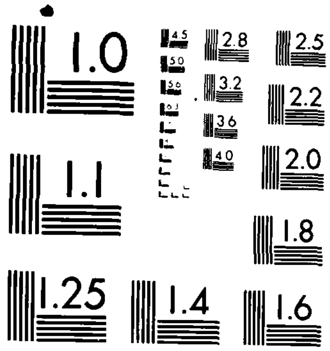
```
GET,CONFEG/UN=CER0H9
FTN,I=CONFEG,L=0
GET,TAPE1-XXXXXXX      (DMSDIG digitizer file)
LGO

     ---PROGRAM EXECUTES---
     ---INTERACTIVE INPUT WILL BE REQUESTED---

REPLACE,TAPE2=YYYYYYY (CONFEG output)
```

AD-A162 390 USER'S MANUAL FOR THE GENERALIZED COMPUTER PROGRAM SYSTEM OPEN-CHANNEL FL (U) ARMY ENGINEER WATERWAYS EXPERIMENT STATION VICKSBURG MS HYDRA 3/8

UNCLASSIFIED W A THOMAS ET AL AUG 85 WES/IR/HL-85-1 F/G 13/2 NL


1.0
1.1
1.25
1.4
1.6
1.8
2.0
2.2
2.5
2.8
3.2
3.6
4.0

Digitizer File Format

Record Number	Word Number	Format	Description
1	1-10	10A8	Problem title, 80 characters
2	1	I15	Digitizer x-coordinate of reference point 1.
	2	I15	Digitizer y-coordinate of reference point 1.
3	1	E15.0	Grid x-coordinate of reference point 1.
	2	E15.0	Grid y-coordinate of reference point 1.
4	1	I15	Digitizer x-coordinate of reference point 2.
	2	I15	Digitizer y-coordinate of reference point 2.
5	1	E15.0	Grid x-coordinate of reference point 2.
	2	E15.0	Grid y-coordinate of reference point 2.
6	1	E15.0	Map scale (user's coordinates/map inches).
7+	1	I10	Node number.
	2	I10	Digitizer x-coordinate of node.
	3	I10	Digitizer y-coordinate of node.
	4	F10.0	Depth at node.

** Input a record type 7 for each node, execution ends when an end-of-file is encountered.**

ADDENDUM D-5: USER INSTRUCTIONS FOR PROGRAM FNDNODE

Purpose

1. To find the five nearest nodes within a TABS-2 computational mesh, given a pair of coordinates in the user's coordinate system or in latitude and longitude, FNDNODE has been used to assign node numbers to sets of field data location coordinates.

Origin of Program

2. FNDNODE was written by Don Bach, WESHE-H.

Description

3. FNDNODE searches a GFGEN binary output file for the five closest nodes to each set of input coordinates. If the user inputs the coordinates in latitude and longitude, a transformation is made to the user's grid coordinate system, based on three transformation points.

Use

4. FNDNODE is accessed through PROCLV. Figure D-5-1 shows the HELP section on this program.

```
FNDNODE
PURPOSE- TO SPAWN A BATCH JOB TO RUN FNDNODE ON TH 205

CALL--BEGIN,FNDNODE,PROCLV,ID,I1FND,O1R1,RJE <CR>

     ID = USER NAME
  I1FND = INPUT DATA FOR FNDNODE
   O1R1 = GEOMETRY OUTPUT, FROM GFGEN, BINARY
    RJE = USER NUMBER OF RJE PRINTER FOR PRINTED
          OUTPUT DESTINATION (DEFAULT = CER0G9
REVERT. HELP
```

Figure D-5-1. PROCLV's HELP information on FNDNODE

Input

5. FNDNODE needs two input files: a run control card image file and a binary geometry file created by GFGEN.

Output

6. Output consists of printed results that show the locations of the five closest nodes to the input coordinates. The distance of the selected nodes to the coordinate pair is also output. Sample printer output is shown in Figure D-5-2.

```
RUN TITLE = PROGRAM TEST NO. 2, ATCHAFALAYA MESH 2, COORDINATE CONVERSION

TRANSFORMATION COORDINATES-
POINT 1- LAT =  29.58886111 LONG =  91.23522222 X =     381183.93 Y =    275345.02
POINT 2- LAT =  29.62411111 LONG =  91.25816667 X =     373882.79 Y =    288157.84
POINT 3- LAT =  29.67122222 LONG =  91.23419444 X =     381484.69 Y =    305295.16
BANNERS FROM RMA1 FILE--
WESHE  DMS VERSION  1.00, DATED    OCT 1981,  THIS FILE IS FROM    RMA1-V  VERS
ION 2.00 DATED   OCT 1981.
DMS - AG02XXXXXXXXGVGSEXXX GRADE = B           PERSON = BACH        DESCRIPTION =
ATCHAFALAYA BAY STUDY, MESH 2 (MEDIUM FINE GRID, ENTIRE AREA, BASE GEOMETRY)  /
31 JAN 82, 2038 NODES, 596 ELEMENTS, NEW RE-ORDERING LIST

STATION ID = NODE+1929
LAT =  29.63447222 LONG =  91.24155556
     379157.37 Y=   291929.57
NODE= 1929 DISTANCE=.32344E+00 NODE= 1930 DISTANCE=.21412E+03 NODE= 1931 DISTANCE=.42793E+03
   NODE= 1933 DISTANCE=.17625E+04  NODE= 1934 DISTANCE=    0.E+04
STATION ID = NODE+1929+NO+COORDINATE+CONVERSION
X=    379157.64 Y=   291929.40
NODE= 1929 DISTANCE=.00000E+00 NODE= 1930 DISTANCE=.21381E+03 NODE= 1931 DISTANCE=.42762E+03
   NODE= 1933 DISTANCE=.17624E+04  NODE= 1934 DISTANCE=    0.E+04
   EOR--
   EOF-
```

Figure D-5-2. Sample printer output from FNDNODE

Card Image Data Input Instructions

7. The run control file starts with a run title on line 1. The three points of transformation are next, followed by station identifiers and the coordinates for which to find the closest nodes. If the three transformation coordinates are omitted, the code automatically assumes that no transformation from latitude and longitude to the user's grid coordinates is to be performed. FNDNODE automatically distinguishes between latitude and longitude and the grid coordinates. After the first card, all input is free field. The run control input is described in Table D-5-1. An example run control input file is listed in Figure D-5-3.

Examples

```
PROGRAM TEST 2, ATCHAFALAYA MESH 2, COORDINATE CONVERSION
29:35:19.9 91:14:6.8 381183.92 275345.02
29:37:26.8 91:15:29.4 373882.79 288157.84
29:40:16.4 91:14:3.1 381484.69 305295.16
NODE+1929 29:38:4.1 91:14:29.6
NODE+1929+NO+COORDINATE+CONVERSION 379157.64 291929.40
```

Figure D-5-3. Sample run control input to FNDNODE

Table D-5-1

Run Control Input to FNDNODE

Card	Field	Description
1	1	80 characters of run title
2	1	Latitude of transformation point 1, in the form dd:mm:ss
	2	Longitude of transformation point 1, in the form dd:mm:ss
	3	Grid x-coordinate of transformation point 1
	4	Grid y-coordinate of transformation point 1
3	1	Latitude of transformation point 2, in the form dd:mm:ss
	2	Longitude of transformation point 2, in the form dd:mm:ss
	3	Grid x-coordinate of transformation point 2
	4	Grid y-coordinate of transformation point 2
4	1	Latitude of transformation point 3, in the form dd:mm:ss
	2	Longitude of transformation point 3, in the form dd:mm:ss
	3	Grid x-coordinate of transformation point 3
	4	Grid y-coordinate of transformation point 3

Note: Cards 2 through 4 may be omitted if no transformation is to be performed.

Card	Field	Description
5	1	Up to 80 characters of identifier for this set of coordinates with no embedded blands nor commas
	2	Either x-coordinate or latitude (in the form dd:mm:ss) of point to be searched for
	3	Either y-coordinate or longitude (in the form dd:mm:ss) of point to be searched for

Note: Enter a card 5 for each input coordinate pair.

APPENDIX E: DIGITIZING INSTRUCTIONS

William A. Thomas, Ben Brown, Jr.,

Ronald E. Heath, and Donald P. Bach

CONTENTS

APPENDIX E: DIGITIZING INSTRUCTIONS

PART I: INTRODUCTION

1. There are two tasks that usually benefit from digitizer capability: (a) encoding the (x,y)-coordinates around regions in the finite element network and (b) encoding the (x,y,z)-coordinates for the digital map of the model area. TABS-2 provides a digitizer program, DMSDIG, resident on the host computer, that will receive data from a Tektronix 4954 tablet and create a digitizer file for use by the mesh generator programs and the spatial data analysis programs. DMSDIG may be used to create digitizer files for these TABS-2 programs: PREMESH, ELEVGRD, REFMT, RETPNT, and FACGRD. The use of DMSDIG to create digitizer files for PREMESH and ELEVGRD is described in this appendix.

2. DMSDIG is both equipment- and site-specific. Although the use of DMSDIG is more efficient and effective than digitizing by hand, digitizing on a remote host computer is nonetheless a slow and tedious process. The use of a local, dedicated micro- or minicomputer system for digitizing is far more efficient and is highly recommended. (Information on microcomputer versions of DMSDIG is available on request.) Therefore the digitized data file structure is also presented so those offices having their own digitizing procedures can have the flexibility to create TABS-2 compatible digitizer files. The structure of the PREMESH digitizer file, used in the development of finite element networks, is described in Appendix D: Finite Element Network Generation, Addendum D-1: AUTOMSH. The structure of the ELEVGRD digitizer file, used in the creation of digital maps, and other DMS-A compatible digitizer file structures are described in Appendix L: Data Management System A; Addendum L-10: ELEVGRD, Addendum L-3: REFMT, Addendum L-11: RETPNT, and Addendum L-12: FACGRD. Instructions for accessing DMSDIG are also shown in Appendix L, Addendum L-1: DMSDIG.

3. The output file from DMSDIG is a coded (card image) file that can be set up without using DMSDIG by simply reading coordinates from graph paper and keying them into a file using an editor.

4. DMSDIG is an interactive, FORTRAN program that accepts data from the digitizer tablet and writes it, in coded form, to a file.

5. Two plot-back programs, DGPLT and DIGPLT, are provided for quality control via visual inspection of the digitizer file. DGPLT, described in Appendix L; Addendum L-2: DGPLT, is used to inspect DMS-A compatible digitizer files, including ELEVGRD digitizer files. DGPLT is a batch, FORTRAN program that produces Calcomp plots on the WES DPS-1 computer. DIGPLT is a batch, FORTRAN program used to inspect PREMESH digitizer files.

Instructions for the use of DIGPLT are given in PART III of this Appendix.

6. DMSDIG and DGPLT were written and the initial documentation prepared by Mr. Donald P. Bach, Estuaries Division, Hydraulics Laboratory (HL), WES. The digitizer table interface routines used in DMSDIG were developed by Mr. Stephen A. Adamec, Jr., Estuaries Division, HL, WES. DIGPLT was written by Mr. Ronald E. Heath, Hydraulic Analysis Division, HL, WES.

PART II: DIGITIZING INSTRUCTIONS FOR THE TEKTRONIX 4954 TABLET

Map Selection

7. Proper map selection is critical to obtaining the desired accuracy during the digitizing process. The Tektronix 4954 tablet has a resolution of 0.01 in. with a precision of ±0.0025 in. per inch of tablet surface. Accumulated error over the surface of a well maintained tablet should not exceed ±0.10 in. In practice, few tablet operators will be able to locate points consistently with a precision of ±0.02 in. Consider that 0.02 in. on a 1:24,000-scale map is 40 ft and that an accumulated error of 0.10 in. means that points on opposite ends of the map may be displaced by 200 ft with respect to each other. While these results might be acceptable for an estuary or large river, a larger scale map would be required for digitizing a channel with a bottom width of 150 ft.

Map Preparation

8. All maps (and other sources of spatial data) used in the study should be referenced to the same real (x,y,z)-coordinate system. State planar coordinate systems are recommended for horizontal control and the National Geodetic Vertical Datum, 1929, is recommended for vertical control. Maps should be prepared for digitizing by writing the real coordinates of the upper left and lower right corners on the map as shown in Figure E1. When digitizing for ELEVGRD, the area of interest must be contained entirely within the map boundaries as defined by connecting the map corners. When digitizing for PREMESH, a third point with known (x,y)-coordinates is required. This point must not lie on a straight line between the known map corners.

Digitizer Instructions

General instructions

9. BEFORE ATTEMPTING TO USE DMSDIG, study the example DMSDIG sessions for either ELEVGRD (Figure E2) or PREMESH (Figure E3) and read the section on error messages.

Step 1. Position the map to be digitized and its overlay (if used) on the tablet, smooth out any wrinkles, and fasten the map to the tablet with drafting tape. When digitizing data for ELEVGRD, the map should be carefully aligned so that the map's coordinate system is parallel to the edges of the tablet. Map alignment is not critical when digitizing data for PREMESH. There is a dead area about an

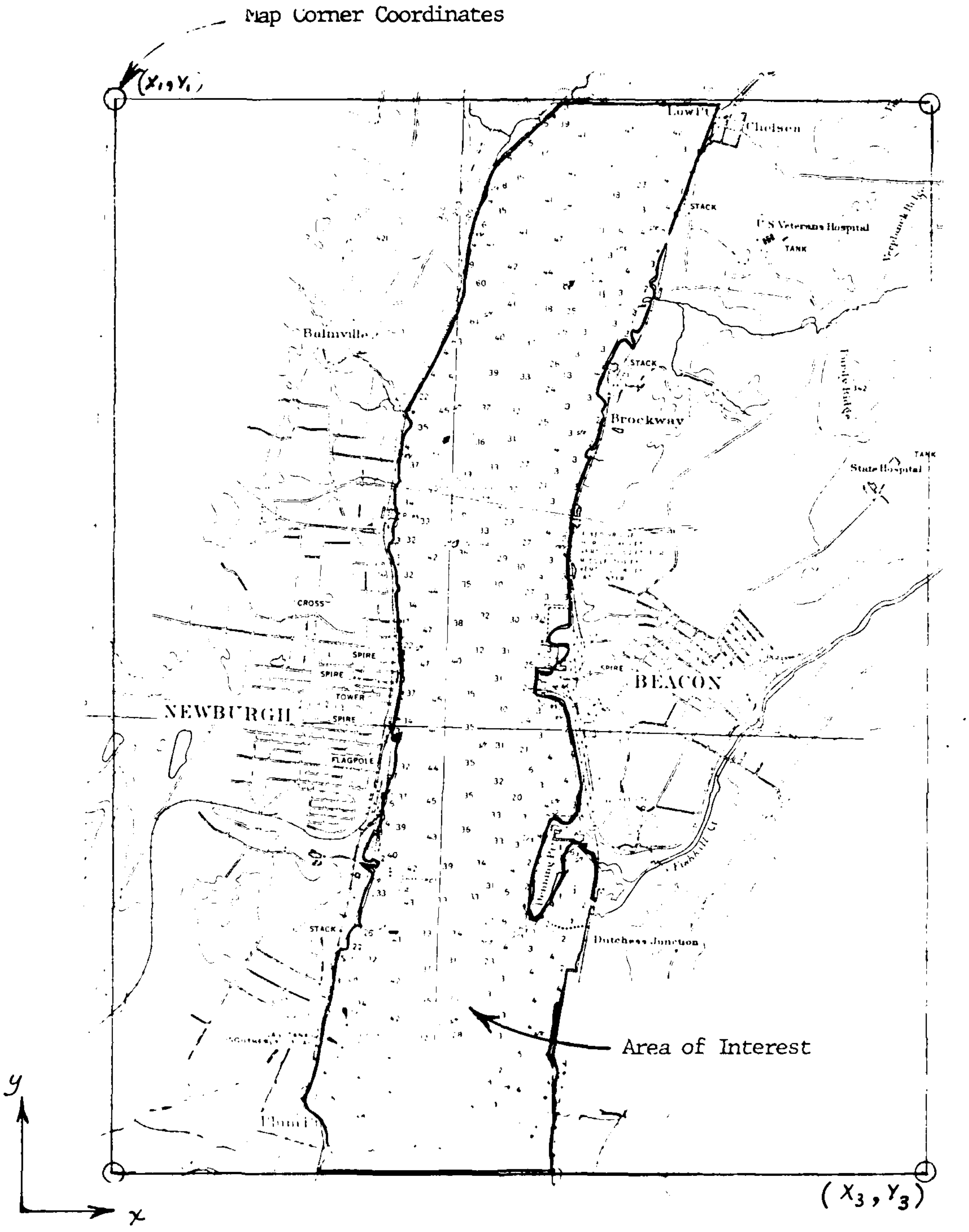


Figure E1. Example map

```
GET,DMSDIG/UN=CEROH9

DMSDIG
 PROGRAM DMSDIG -- ENTER <CR> FOR HELP
 WHICH PROGRAM IS TO READ MY OUTPUT FILE?
RESPONSE 1.  ? ELEVGRD
               ENTER MAP NUMBER AND DATA TYPE
RESPONSE 2.  ? 111,3
               DEPTHS ARE TO BE INPUT
               DIGITIZE UPPER LEFT CORNER
               DIGITIZE UPPER RIGHT CORNER
               DIGITIZE LOWER LEFT CORNER
               DIGITIZE LOWER RIGHT CORNER
               ENTER COORDINATES OF UPPER LEFT CORNER
RESPONSE 3.  ? 111,444
               ENTER COORDINATES OF LOWER RIGHT CORNER
RESPONSE 4.  ? 444,111
               DIGITIZE AREA OF INTEREST, ENDING INPUT WITH THE SAME POINT TWICE
               BE SURE TO USE A CLOCKWISE ROTATION
               8 POINTS INPUT
               ENTER -9999 TO SIGNAL END OF DATA ENTRY
               INITIALIZING TO SINGLE POINT MODE
               ENTER <CR> TO TOGGLE TO MULTIPLE POINT MODE OR TO TOGGLE BACK
               IN MULTIPLE POINT MODE, ENTER THE SAME POINT
               TWICE TO END DIGITIZER INPUT
               ENTER        DEPTH
RESPONSE 5.    ?
               TOGGLED TO MULTIPLE POINT MODE
               ENTER        DEPTH
RESPONSE 6.    ? 15
               DIGITIZE        DEPTH LOCATION(S)
               ENTER        DEPTH
RESPONSE 7.    ? 14
               DIGITIZE        DEPTH LOCATION(S)
               ENTER        DEPTH
RESPONSE 8.    ?
               TOGGLED TO SINGLE POINT MODE
               ENTER        DEPTH
RESPONSE 9.    ? 17
               DIGITIZE        DEPTH LOCATION(S)
               ENTER        DEPTH
RESPONSE 10.   ? 21
               DIGITIZE        DEPTH LOCATION(S)
RESPONSE 11.   ?
               TOGGLED TO MULTIPLE POINT MODE
               ENTER        DEPTH
RESPONSE 12.   ? 25
               DIGITIZE        DEPTH LOCATION(S)
               ENTER        DEPTH
RESPONSE 13.   ? -9999
               RUN COMPLETE, SAVE TAPE3 !!!
RESPONSE 14.   /SAVE,TAPE3=NEISHB1
```

Figure E2. ELEVGRD digitizing session sample

```
GET,DMSDIG/UN=CEROH9

DMSDIG
 PROGRAM DMSDIG -- ENTER <CR> FOR HELP
 WHICH PROGRAM IS TO READ MY OUTPUT FILE?
RESPONSE 1.  ? PREMESH
             ENTER FILE ID
RESPONSE 2.  ? WATPRE
             DIGITIZE TRANSFORMATION POINT #1
             ENTER COORDINATES OF TRANSFORMATION POINT #1
RESPONSE 3.  ? 1100,1200
             DIGITIZE TRANSFORMATION POINT #2
             ENTER COORDINATES OF TRANSFORMATION POINT #2
RESPONSE 4.  ? 600,500
             DIGITIZE TRANSFORMATION POINT #3
             ENTER COORDINATES OF TRANSFORMATION POINT #3
RESPONSE 5.  ? 1400,800
             ENTER -9999 TO EXIT PROGRAM
             ENTER PREMESH LINE NUMBER
RESPONSE 6.  ? 1
             DIGITIZE POINTS DEFINING LINE, ENDING WITH A DOUBLE POINT
             2 POINT LOCATIONS INPUT
             ENTER PREMESH LINE NUMBER
RESPONSE 7.  ? 2
             DIGITIZE POINTS DEFINING LINE, ENDING WITH A DOUBLE POINT
             9 POINT LOCATIONS INPUT
             ENTER PREMESH LINE NUMBER
RESPONSE 8.  ? 3
             DIGITIZE POINTS DEFINING LINE, ENDING WITH A DOUBLE POINT
             2 POINT LOCATIONS INPUT
             ENTER PREMESH LINE NUMBER
RESPONSE 9.  ? 4
             DIGITIZE POINTS DEFINING LINE, ENDING WITH A DOUBLE POINT
             10 POINT LOCATIONS INPUT
             ENTER PREMESH LINE NUMBER
RESPONSE 10. ? -9999
             RUN COMPLETE, SAVE TAPE3 !!!
               0.090 CP SECONDS EXECUTION TIME.
RESPONSE 11. /REPLACE,TAPE3=PREIN
             PREIN REPLACED
```

Figure E3. PREMESH digitizing sample session inch wide around the edges of the tablet. No data can be digitized in this area.

Step 2. Turn on power for the Tektronix 4014 terminal and the digitizer controller.

Step 3. Log in to the host computer where DMSDIG is installed.

Step 4. Execute the DMSDIG program as documented in Appendix L of this manual.

Data entry

10. DMSDIG uses prompts and informative messages to guide the tablet operator through the digitization process. The process always begins with the request "Which program is to read my output file?" The operator should respond by entering the name of the program from the keyboard, as shown in Figure E2, Response 1. A list of valid program names can be obtained by entering only a carriage return. (The symbol <CR> means carriage return.) Prompts beginning with "ENTER" are requests to enter data from the keyboard. Prompts beginning with "DIGITIZE" are requests to enter one or more points by positioning the digitizer mouse cross hairs over the point to be digitized and pressing any button on the mouse.

ELEVGRD

11. This option is used to encode bed elevations or depths by encoding multiple points having the same value, tracing a contour, or encoding a value for each (x,y) point digitized. ELEVGRD uses the data from the digitizer file to produce an array of values on a regular grid. Figure E2 is a sample digitizing session for ELEVGRD.

Response 1. Keyboard entry: ELEVGRD<CR>

Response 2. Keyboard entry: map number,data type<CR>

Map number: user-defined, up to six digits

Data type: 3 for encoding depths
4 for encoding bed elevations

Digitize: The map corners one point at a time as requested

Response 3. Keyboard entry: x,y<CR>

(x,y)-coordinates of upper left map corner
Must be integer values of six digits or less.

Response 4. (x,y)-coordinates of lower right map corner.

Digitize: Perimeter of study area (area of interest), starting and ending on the same point.

Response 5. Keyboard entry: <CR>

Response 6. Enter and digitize the first depth value.

Depth below reference plane
Must be an integer value of six digits or less.

Digitize: One or more points (or a depth contour) at the depth entered for Response 6.

Response 7. Enter and digitize a new depth value

Response 8. Keyboard entry: <CR>

Switches from multipoint mode to single-point mode.

Response 9. Keyboard entry: depth<CR>

Digitize: The location of this depth value.

Response 10. Enter and digitize a new depth value.

Response 11. Switch back to multipoint mode.

Response 12. Enter and digitize a new depth value.

Response 13. Keyboard entry: -9999<CR>

This entry terminates the execution of DMSDIG.

Response 14. Keyboard entry: SAVE,TAPE3=pfn

where pfn is the permanent file name

A sample digitizer file that could have been generated by this session is shown in Figure E4. The digitizer file should be checked for errors before any attempt is made to process it via ELEVGRD.

PREMESH

12. This option is used to encode the (x,y)-coordinate forming PREMESH lines. The AUTOMSH program, which includes PREMESH, uses the digitizer file to define the boundaries of regions used for network generation. Figure E3 is a sample DMSDIG session for PREMESH.

Response 1. Keyboard entry: PREMESH<CR>

Response 2. Keyboard entry: file-id<CR>

One to six character user defined title

Digitize: The first transformation point

```
 111       3     MAP NO. AND DATA TYPE 3=DEPTH
  50    2000     DIGITIZER TABLET, UPPER LEFT  CORNER
2000    2000     DIGITIZER TABLET, UPPER RIGHT CORNER
  50       0     DIGITIZER TABLET, LOWER LEFT  CORNER
2000       0     DIGITIZER TABLET, LOWER RIGHT CORNER
 111     444     UPPER LEFT CORNER (x,y), KEYBOARD
 444     111     LOWER RIGHT CORNER (x,y), KEYBOARD
-5555      0     FLAG
 111     220     BEGIN (x,y) COORDINATES OF BOUNDARY
 235     345          AROUND STUDY AREA
 250     140
 255     400
 270     350
 350     319
 400     355
 440     330     END OF STUDY AREA BOUNDARY COORDINATES
-7777     15     DEPTHS: FOLLOWED BY THEIR LOCATIONS
 250     140
 350     319
 300     200
 260     160
 345     300
 410     310
-7777     14
 111     220
 235     345
 120     250
-7777     17
 400     355
-7777     21
 440     330
-7777     25
 255     400
 270     350
-9999  -9999     END OF FILE
```

Figure E4. Sample digitizer file

Three transformation points are used to determine grid rotation and scaling. These points must not lie on a straight line.

Response 3. Keyboard entry: x,y<CR>

(x,y)-coordinates of first transformation point. Integer values of six digits or less.

Response 4. Digitize second transformation point and enter its coordinates.

Response 5. Digitize third transformation point and enter its coordinates.

Response 6. Keyboard entry: line-number<CR>

PREMESH line number, an integer value < 1000. Line numbers do not have to be entered in order.

Digitize: Line segment ending with a double point.

Response 7. Enter new line number and digitize new line.

Response 8. (Same as Response 7)

Response 9. (Same as Response 7)

Response 10. Keyboard entry: -9999<CR>

Terminates execution of DMSDIG.

Response 11. Keyboard entry: REPLACE,TAPE3=pfn<CR>

where pfn is the permanent file name.

Figure E5 is a sample PREMESH digitizer file that could have been generated by this session. The file should be checked for errors before any attempt is made to process it via AUTOMSH. DIGPLT can be used to quickly locate most of the common errors.

Error Messages

REENTER LAST LINE

13. This message indicates that the host did not receive part of the signal transmitted by the digitizer. This may occur if the operator attempts to digitize points faster than the host can receive them. If digitizing a map corner or transformation point, terminate the session and start over. When digitizing point locations for ELEVGRD or PREMESH lines, recovery is accomplished by terminating that line and reentering the entire sequence of points. The digitizer file will contain both the bad and good points at the end of the session, and the bad sequence must be edited out of the file after the session.

```
WATPRE
     4        10     MAP NUMBER AND DATA TYPE
   800       900     TRANSFORMATION POINT NO. 1 ON THE TABLET
  1100      1200     COORDINATES OF POINT NO. 1
   300       200     TRANSFORMATION POINT NO. 2
   600       500     COORDINATES OF POINT NO. 2
  1100       500     TRANSFORMATION POINT NO. 3
  1400       800     COORDINATES OF POINT NO. 3
 -5555         1     FLAG TO BEGIN (x,y) COORDINATES OF LINE 1
  1000       830
   500       800
 -5555         2     FLAG FOR LINE 2
   500       800
   450       750
   400       700
   380       640
   370       600
   400       490
   440       410
   480       380
   500       350
 -5555         3     FLAG FOR LINE 3
   500       350
  1100       200
 -5555         4     FLAG FOR LINE 4
  1100       200
  1160       280
  1230       292
  1300       300
  1340       410
  1360       504
  1320       620
  1250       710
  1130       790
  1000       830
 -9999     -9999     FLAG TO END DATA FILE
```

Figure E5. Sample PREMESH digitizer file

ERROR, UNSUPPORTED PROGRAM

14. The response to the question: "Which program is to read my output file?" was not recognized. Check the spelling and try again.

<-ERROR IN COL. #,RETYPE RECORD FROM THIS FIELD

15. The host receved input in a format other than the one it expected. Reenter the data as instructed.

Miscellaneous errors

16. The appearance of blank lines on the terminal screen while the operator is digitizing a sequence of points indicates that the host is not receiving all of the digitized points. Slow down and reenter the entire sequence of points. The bad sequence is retained in the digitizer file and must be deleted after the session.

17. When entering PREMESH lines or using the ELEVGRD multipoint mode, each sequence of digitized points is terminated by digitizing the same point twice. If the digitizer mouse is accidently moved and DMSDIG does not recognize the double-point entry, try again and edit the extra points out of the digitizer file after the session.

PART III: PLOTTER INSTRUCTIONS, DIGPLT

18. PREMESH digitizer files are plotted with DIGPLT, a batch, FORTRAN program that creates a meta-file (plot file) that can be displayed on a graphics device using the DIRECT program described in PART II of Appendix I: Graphical Output, Meta System. The meta-file contains only one plot frame. An example plot is shown in Figure E6.

19. DIGPLT is dimensioned to handle a total of 20,000 (x,y) digitizer points and 200 PREMESH lines. The only input required by DIGPLT is the PREMESH digitizer file generated by DMSDIG which is read from unit 1. The meta-file is written on unit 99 and is the only output generated by the program.

20. DIGPLT is normally executed on the host computer from a Tektronix 4014 compatible graphics terminal via the PROCLV command sequence:

```
BEGIN,DIGPLT,PROCLV,I1G1,P1DG
```

where

I1G1 = digitizer file name

P1DG = plot file name

The DIGPLT procedure in PROCLV makes an internal call to the PROCLV procedure, META, after the plot file has been saved. The META procedure executes the DIRECT program, and the user can display the plot file by entering one or more of the DIRECT commands described in PART II of Appendix I.

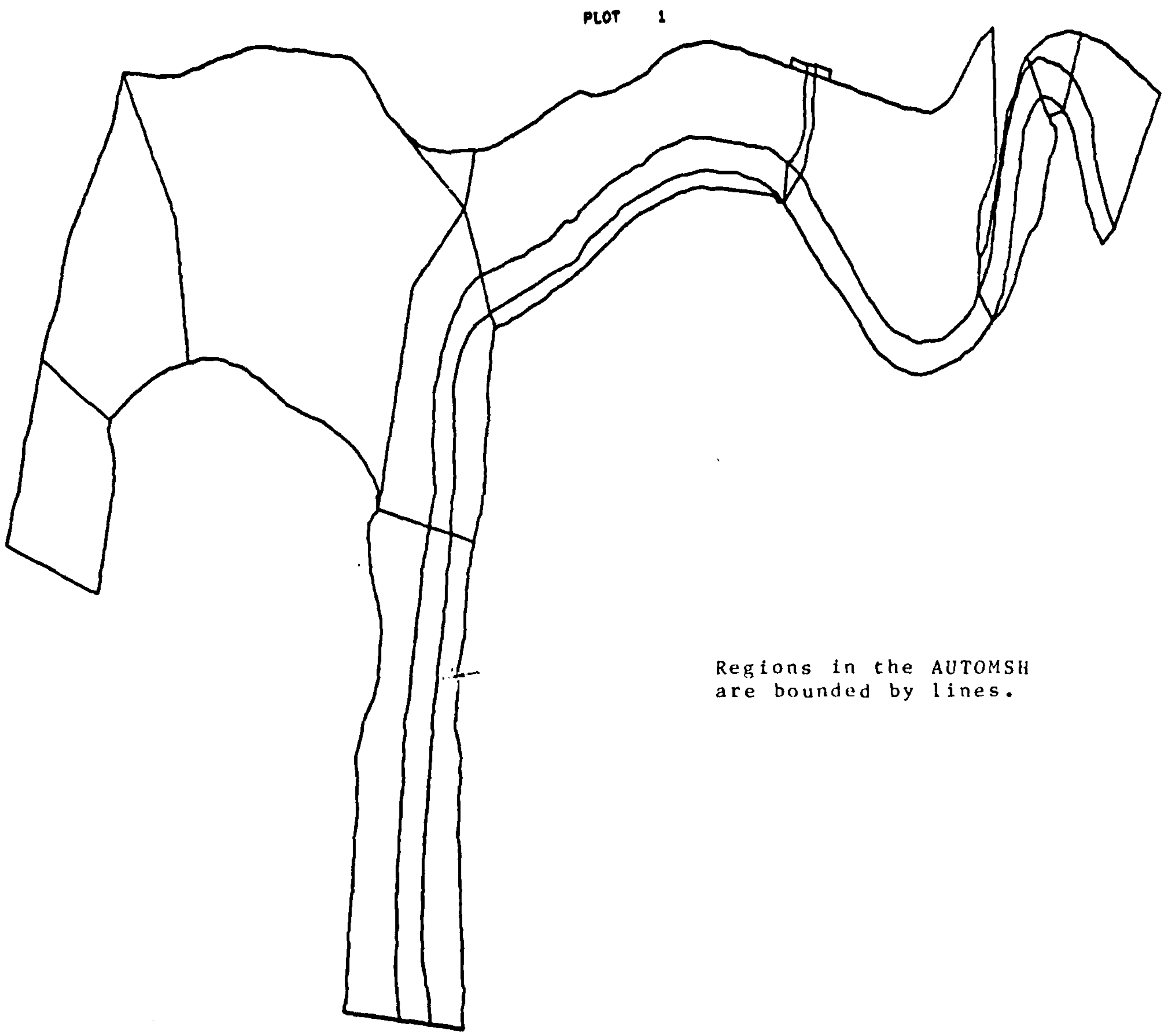


Figure E6. Example plot, PREMESH digitizer file

PART IV: OPERATING INSTRUCTONS FOR THE DIGITIZER AT THE WES INSTRUMENTATION SERVICES DIVISION

21. The following steps apply to the digitizer in the Instrumentation Services Division (ISD) at WES:

Step 1. Carefully lay the map to be digitized and ts overlay (if used) on the tablet with the map's coordinate system parallel to the tablet's lower edges. Smooth out any wrinkles and fasten the map to the tablet using drafting tape. Remember that there is a dead area that is about 1-in. wide around the edges of the tablet. No data can be obtained within this dead area.

Step 2. Turn on power for all of the equipment, including the digitizer controller, the tape handler, and the Monsanto counter (if connected).

Step 3. Install a wire ring on the back side of a magnetic tape. Mount and thread the tape. After threading, push the load button twice.

Step 4. Make sure that the switch on the digitizer controller is set to "ABSOLUTE."

Step 5. Make sure that the record mode switch on the digitizer controller is set to "POINT."

Step 6. Make sure that the fixed data switches on the digitizer controller are set to "0011."

Step 7. If digitizer data are already present on the tape, set the switch on the buffer controller to "FILE SEARCH." Push the buffer controller reset button. Put the tape controller on-line by pushing its on-line button. The tape should skip one file. More files can be skipped by taking the handler off-line, then back on-line for each file to be skipped. The on-line button will light up when the handler is on-line.

Step 8. Set the mode switch on the buffer controller to "WRITE."

Step 9. Push the master reset button on the digitizer controller.

Step 10. Push the reset button on the buffer controller.

Step 11. Put the tape handler on-line, if it is not already.

Step 12. For each point to be digitized, carefully place the cross hairs of the digitizer mouse at the exact point location on the map and push any button on the mouse to record the point location. The magnetic tape should advance one record.

Step 13. Use the digitizer's keyboard to add alphanumeric data. The special fill button will finish off any short records with blanks. Do not use the return key.

Step 14. Alternate steps 10 and 11 to obtain the correct format for the program that is to read this digitizer data.

Step 15. When finished, add two end-of-file marks to the end of the tape by pushing the EOF button on the buffer controller twice. Put the tape handler off-line. Rewind the tape by pushing the rewind button on the tape handler. When the tape is rewound, it may be unloaded by pushing the load button on the handler.

22. ISD's digitizer will write tapes in the following format:

12 character records (2I6 format)
1 record per block
9-tracks
800 bpi
odd parity
ASCII character set with ASCII parity bit low

23. The digitizer tape may be read by the WES DPS-8 and stored on disc by the following GCOS job control (executed from the time-sharing CONVERT subsystem):

```
10$$N
20$:IDENT:userid,name
30$:OPTION:FORTRAN,NOMAP
40$:FORTY:NFORM,NLNO,NLSTIN
50$:SELECT(userno/PGRM/NEWCOPE,R)
100$:EXECUTE
110$:FFILE:01,NSTDLB,NOSRLS,FIXLNG/3,BUFSIZ/3,ASA9
120$:TAPE9:01,X1D,,digitizer tape no.,,DEN8
130$:FILE:02,X2D,10L,NEW,filename
132$:DATA:I*
134$number of files on the tape
140$:ENDJOB
```

24. Once the digitizer data are on the DPS-8 disk, line numbers must be added by using the following time-sharing commands:

```
OLD filename
SEQUX 10001,1
RESA filename
```

If any data fill the first field of six, an extra blank will be added between the line number and the data value that must be removed using the text editor. If this file is to be used on any other computer the line must be removed by using the "STRIP" command.

25. The digitizer data can be read and written to a tape that can be read over an RJE using the following GCOS job control:

```
10$$N
15$:IDENT:userid,name
20$OPTION:FORTRAN,NOMAP
30$:FORTY:NFORM,NLNO,NLSTIN
40$$SELECT(userno/PGRM/NEWCOPE,R)
80$:EXECUTE
90$:FFILE:02,NSTDLB,NOSRLS,FIXLNG/3,BUFSIZ/3,ASA9
100$:TAPE9:01,X1D,,tape number,,DEN8
110$:FILE:02,X2S,10L,m
112$:DATA:I*
114# number of files on the tape (n)
120$:UTL2
130$:FILE:IN,X2D
140$:TAPE9:OT,1T1D,,,,filename,,DEN8
150FDEF IN,GFRC,ASCII.
160FDEF OT,NLAB,IBM,CI80,F80.
170FOPT IN AND OT,RECCT.
180PROC REWIND IN. COPY IN TO OT nFILES.
190$:ENDJOB
```

The above JCL creates a digitizer tape having the following characteristics:

- 80 character records
- 1 record per block
- 9 tracks
- 800 bpi
- odd parity
- EBCDIC character set

APPENDIX F: USER INSTRUCTIONS FOR RMA-2V, A TWO-DIMENSIONAL MODEL FOR FREE-SURFACE FLOWS

William A. Thomas and William H. McAnally, Jr.

TABLE OF CONTENTS

APPENDIX F: RMS-2V USER INSTRUCTIONS

VERSION 3.0

PART I: INTRODUCTION

Purpose

1. This program computes water-surface elevations and horizontal velocity components for subcritical, free-surface flow in 2-D flow fields.

Origin of the Program

2. The original RMA-2 was developed by Norton, King, and Orlob (1973), of Water Resources Engineers, for the Walla Walla District, Corps of Engineers, and delivered in 1973. Subsequent enhancements have been made by King and Norton, now with Resource Management Associates, and by the WES Hydraulics Laboratory, culminating in the version of the code supported in the TABS-2 system. Personnel in the Estuaries and Hydraulic Analysis Divisions of the WES developed a new data input module, changed from Chezy to Manning's roughness equation, added various output controls, and streamlined the program for vector processing.

Potential Applications

3. This program is designed for far-field problems in which vertical accelerations are negligible and the velocity vectors at a node generally point in the same directions over the entire depth of the water column at any instant of time. It expects a homogeneous fluid with a free surface. Both steady- and unsteady-state problems can be analyzed. A surface wind stress can be imposed.

4. The program has been applied to calculate flow distribution around islands, flow at bridges having one or more relief openings, flow in contracting and expanding reaches, flow into and out of off-channel hydropower plants, flow at river junctions, flow into and out of pumping plant channels, and general flow patterns in rivers, reservoirs, and estuaries.

Limitations

5. This program is not designed for near-field problems where flow-structure interactions (like vortices, vibrations, or vertical accelerations) are of interest. Areas of vertically

stratified flow are beyond this program's capability unless it is used in a hybrid modeling approach. It is 2-D in the horizontal plane, and zones where the bottom current is in a different direction from the surface current must be analyzed with considerable subjective judgment regarding long-term energy considerations. It is a free-surface calculation for subcritical flow problems.

PART II: PROGRAM DESIGN

Design

6. The program is designed to be a fixed-bed, hydraulic computation with the resulting water-surface elevations and velocity components written to a file in a batch-oriented mode of computer operation. It uses a finite element technique to solve the Reynolds form of the Navier-Stokes equations for turbulent flows. Friction is calculated with a Manning's-type equation and eddy viscosity coefficients are used to define turbulent exchanges. A version soon to be released uses an extra equation to compute turbulent exchanges rather than a constant eddy viscosity.

7. All input data are expected to be in English units and all output files are in English units. A new version, soon to be released, will accept input data and produce output data in metric (SI) units at the user's option.

8. In its original formulation, the model used unit discharge as the flow variable and no wetting and drying of the mesh was allowed. This version of the code, RMA-2V, uses velocity as the flow variable and allows the mesh to change with the variation in stage during a simulation. To accomplish this, the original program was modified to define wet and dry elements at each solution step so that no depth was allowed to go below the prestated nominal outline. A coordinate system was adopted as illustrated in Figure F1.

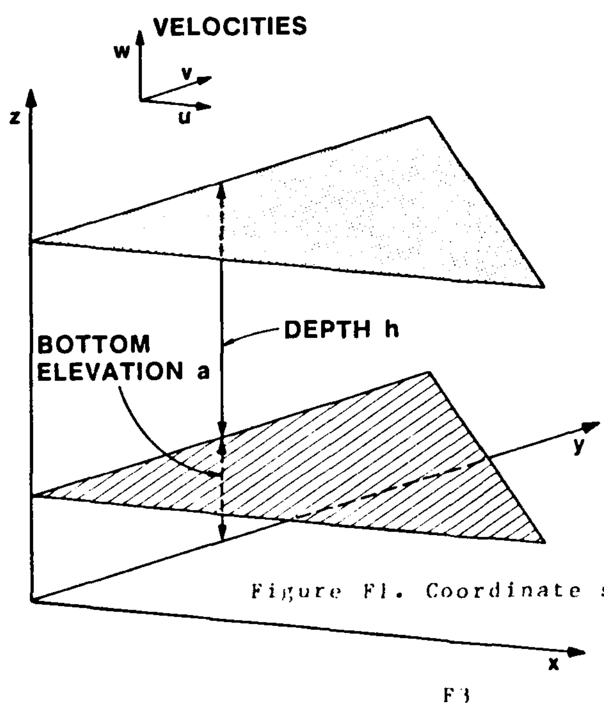


Figure F1. Coordinate system

Governing Equations

(The following paragraphs are copied from Norton and King (1977).)

"The basic depth averaged equation of flow may be written as:

$$f_u = \frac{\partial u}{\partial t} + u\frac{\partial u}{\partial x} + v\frac{\partial u}{\partial y} - \frac{1}{\rho}\left(\varepsilon_{xx}\frac{\partial^2 u}{\partial x^2} + \varepsilon_{xy}\frac{\partial^2 u}{\partial y^2}\right) + g\frac{\partial a}{\partial x} + g\frac{\partial h}{\partial x} + \tau_x = 0 \quad \text{(F1)}$$

$$f_v = \frac{\partial v}{\partial t} + u\frac{\partial v}{\partial x} + v\frac{\partial v}{\partial y} - \frac{1}{\rho}\left(\varepsilon_{yx}\frac{\partial^2 v}{\partial x^2} + \varepsilon_{yy}\frac{\partial^2 v}{\partial y^2}\right) + g\frac{\partial a}{\partial x} + g\frac{\partial h}{\partial y} + \tau_y = 0 \quad \text{(F2)}$$

$$f_c = \frac{\partial h}{\partial t} + h\left(\frac{\partial u}{\partial x} + \frac{\partial v}{\partial y}\right) + u\frac{\partial h}{\partial x} + v\frac{\partial h}{\partial y} = 0 \quad \text{(F3)}$$

where

u,v = velocities in the Cartesian directions

x,y,t = Cartesian coordinates and time

= density

g = acceleration due to gravity

a = elevation of bottom

h = depth

τ_x, τ_y = external traction, in this case bottom friction, wind, and Coriolis effects, i.e,

bottom friction — wind — Coriolis effect

$$\tau_x = \frac{gu}{\left(\frac{1.486}{n} h^{1/6}\right)^2}\left(u^2+v^2\right)^{1/2} - \frac{\zeta}{h} V_a^2 \cos\psi - 2\omega v \sin\phi$$

$$\tau_y = \frac{gv}{\left(\frac{1.486}{n} h^{1/6}\right)^2}\left(u^2+v^2\right)^{1/2} - \frac{\zeta}{h} V_a^2 \cos\psi + 2\omega u \sin\phi$$

where

n = Manning n-value

$\mathcal{J}$ = empirical wind shear coefficient

V_a = wind speed and direction

ω = rate of earth's angular rotation

ϕ = local latitude

1.486 = conversion from metric to English units

"If we multiply Equations 1 and 2 through by h , we obtain the basic momentum equations which together with the continuity Equation 3 are used in this model, i.e.:

$$f_u = h\frac{\partial u}{\partial t} + hu\frac{\partial u}{\partial x} + hu\frac{\partial u}{\partial y} - \frac{h}{\rho}(\varepsilon_{xx}\frac{\partial^2 u}{\partial x^2} + \varepsilon_{xy}\frac{\partial^2 u}{\partial y^2}) + gh(\frac{\partial a}{\partial x} + \frac{\partial h}{\partial x})$$
$$+ \frac{gu}{C^2}(u^2 + v^2)^{1/2} - \mathcal{J} V_a^2 \cos\psi - 2h\omega v \sin\phi = 0 \qquad (F4)$$

$$f_v = h\frac{\partial v}{\partial t} + hv\frac{\partial v}{\partial x} + hv\frac{\partial v}{\partial y} - \frac{h}{\rho}(\varepsilon_{yx}\frac{\partial^2 v}{\partial x^2} + \varepsilon_{yy}\frac{\partial^2 v}{\partial y^2}) + gh(\frac{\partial a}{\partial y} + \frac{\partial h}{\partial y})$$
$$+ \frac{gv}{C^2}(u^2 + v^2)^{1/2} - \mathcal{J} V_a^2 \sin\psi + 2\omega hu \sin\phi = 0 \qquad (F5)$$

"Finite element equations

"The finite element is implemented in exactly identical fashion to that described in King, Norton, and Orlob (1973) with the exception that u and v are primary variables and not the flow quantities uh and vh as used previously.

"An element coefficient matrix and right-hand side vector take the form:

$$\int N^T \frac{\partial fu}{\partial u} dA, \int N^T \frac{\partial fu}{\partial v} dA, \int N^T \frac{\partial fu}{\partial h} dA \qquad \int N^T f_u \, dA$$

$$\int N^T \frac{\partial fv}{\partial u} dA, \int N^T \frac{\partial fv}{\partial v} dA, \int N^T \frac{\partial fv}{\partial h} dA \quad \text{and} \quad \int N^T f_v \, dA$$

$$\int M^T \frac{\partial fc}{\partial u} dA, \int M^T \frac{\partial fc}{\partial v} dA, \int M^T \frac{\partial fc}{\partial h} dA \qquad \int N^T f_c \, dA$$

"The terms then take the following form after partial integration to restructure certain terms:

$$\int N^T f_u \, dA = \int_A \{N^T [h\frac{\partial u}{\partial t} + hu\frac{\partial u}{\partial x} + hv\frac{\partial u}{\partial y} + gh\frac{\partial a}{\partial x} + \frac{gu}{C^2}(u^2 + v^2)^{1/2}$$

$$- \zeta V_a^{\,2} \cos\phi - 2hwv \sin\phi + \frac{\partial h}{\partial x}\frac{\varepsilon_{xx}}{\rho}\frac{\partial u}{\partial x} + \frac{\partial h}{\partial y}\frac{\varepsilon_{xy}}{\rho}\frac{\partial u}{\partial y}]$$

$$+ N_x^{\,T}[\varepsilon_{xx}\frac{h}{\rho}\frac{\partial u}{\partial x} - \frac{gh^2}{2}] + N_y^{\,T}[\varepsilon_{xy}\frac{h}{\rho}\frac{\partial u}{\partial y}]\}dA - \int_{\Delta x} N^T h\frac{\varepsilon_{xx}}{\rho}\frac{\partial u}{\partial x} dy$$

$$- \int_{\Delta y} N^T h\frac{\varepsilon_{xy}}{\rho}\frac{\partial u}{\partial y} dx + \int_{\Delta x} N^T gh^2 \, dx + \int_{\Delta y} N^T gh^2 dy$$

$$\int N^T f_v \, dA = \int_A \{N^T [\frac{\partial v}{\partial t} + hu\frac{\partial v}{\partial x} + hv\frac{\partial v}{\partial y} + gh\frac{\partial a}{\partial y} + \frac{gv}{C^2}(u^2 + v^2)^{1/2}$$

$$- \zeta V_a^{\,2} \sin\phi + 2hwu \sin\phi + \frac{\partial h}{\partial y}\frac{\varepsilon_{yx}}{\rho}\frac{\partial v}{\partial x} + \frac{\partial h}{\partial y}\frac{\varepsilon_{yy}}{\rho}\frac{\partial v}{\partial y}]$$

$$+ N_x^{\,T}[\varepsilon_{yx}\frac{h}{\rho}\frac{\partial v}{\partial x}] + N_y^{\,T}[\varepsilon_{yy}\frac{h}{\rho}\frac{\partial v}{\partial y}]\}dA - \int_{\Delta x} N^T h\frac{\varepsilon_{yx}}{\rho}\frac{\partial v}{\partial x} dy$$

$$- \int_{\Delta y} N^T h\frac{\varepsilon_{yy}}{\rho}\frac{\partial v}{\partial y} dy + \int_{\Delta x} N^T gh^2 dx \int_{\Delta y} N^T gh^2 dy$$

$$\int M^T f_c \, dA = \int_A \{M^T [h(\frac{\partial u}{\partial x} + \frac{\partial v}{\partial y}) + \frac{\partial h}{\partial t} + u\frac{\partial h}{\partial x} + v\frac{\partial h}{\partial y}]\}dA$$

where

N = the shape function representing velocities

M = the shape function representing heads

"The coefficient matrix then has the following contributions:

$$\int N^T \frac{\partial f_u}{\partial u} dA = \int_A \{N^T [(\frac{\alpha h}{\Delta t} + h\frac{\partial u}{\partial x} + \frac{g}{C^2}\frac{2u^2+v^2}{(u^2+v^2)^{1/2}})N + (hu + \frac{\partial h}{\partial x}\frac{\varepsilon_{xx}}{\rho})N_x$$

$$+ (hv + \frac{\partial h}{\partial y}\frac{\varepsilon_{xy}}{\rho})N_y + Nx^T \varepsilon_{xx}\frac{h}{\rho}N_x + N_y^{\,T}\varepsilon_{xy}\frac{h}{\rho}N_y\}dA$$

$$\int N^T \frac{\partial f_u}{\partial v} dA = \int_A \{N^T [h\frac{\partial u}{\partial y} + \frac{g}{C^2} \frac{uv}{(u^2+v^2)^{1/2}} - 2wh \sin\phi]N\}dA$$

$$\int N^T \frac{\partial f_u}{\partial h} dA = \int_A \{N^T [(\frac{\partial u}{\partial t} + u\frac{\partial u}{\partial x} + v\frac{\partial u}{\partial y} + g\frac{\partial a}{\partial x} - 2wv \sin\phi)M + \frac{\varepsilon_{xy}}{\rho} \frac{\partial u}{\partial x} M_x$$
$$+ \frac{\varepsilon_{xy}}{\rho} \frac{\partial u}{\partial y} M_y] + N_x{}^T [\frac{\varepsilon_{xx}}{\rho} \frac{\partial u}{\partial x} - gh]M + N_y{}^T \frac{\varepsilon_{xy}}{\rho} \frac{\partial u}{\partial y} M\}dA$$

$$\int N^T \frac{\partial f_v}{\partial u} dA = \int_A \{N^T [h\frac{\partial v}{\partial x} + \frac{g}{C^2} \frac{uv}{(u^2+v^2)^{1/2}} + 2hw \sin\phi]N\}dA$$

$$\int N^T \frac{\partial f_v}{\partial v} dA = \int_A \{N^T [(\frac{\alpha h}{\Delta t} + h\frac{\partial v}{\partial y} + \frac{g}{C^2} \frac{u^2+2v^2}{(u^2+v^2)^{1/2}})N + (hu + \frac{\partial h}{\partial x} \frac{\varepsilon_{yx}}{\rho})N_x$$
$$+ (hv + \frac{\partial h}{\partial y} \frac{\varepsilon_{yy}}{\rho})N_y] + N_x{}^T \frac{\varepsilon_{yx}}{\rho} hN_x + N_y{}^T \frac{\varepsilon_{yy}}{\rho} hN_y\}dA$$

$$\int N^T \frac{\partial f_v}{\partial} dA = \int \{N^T [(\frac{\partial v}{\partial t} + u\frac{\partial v}{\partial x} + v\frac{\partial v}{\partial y} + g\frac{\partial a}{\partial y} + 2wu \sin\phi)M + \frac{\varepsilon_{yx}}{\rho} \frac{\partial v}{\partial x} M_x$$
$$+ \frac{\varepsilon_{yy}}{\rho} \frac{\partial v}{\partial y} M_y] + N_x{}^T \frac{\varepsilon_{yx}}{\rho} \frac{\partial v}{\partial x} M + N_y{}^T [\frac{\varepsilon_{xy}}{\rho} \frac{\partial v}{\partial y} - gh]M\}dA$$

$$\int M^T \frac{\partial f_c}{\partial u} dA = \int_A M^T (\frac{\partial h}{\partial x} N + h N_x) dA$$

$$\int M^T \frac{\partial f_c}{\partial v} dA = \int_A M^T (\frac{\partial h}{\partial y} N + h N_y) dA$$

$$\int M^T \frac{\partial f_c}{\partial h} dA = \int_A M^T [(\frac{\partial u}{\partial x} + \frac{\partial v}{\partial y} + \frac{\alpha}{\Delta t})M + u M_x + v M_y] dA$$

Note that the surface integrals have been eliminated in this statement. On the interior boundaries, the finite element assumption assumes that they cancel out. The external boundaries do, however, generate values for the integrals and they are incorporated in the model." (End of quote from Norton and King (1977))

Solution of the Nonlinear Equations

9. The governing equations are solved implicitly in their complete, nonlinear form--a solution that requires a method of successive approximations. Details of the solutions scheme for this program are presented in King, Norton, and Orlob (1973). Briefly, the Galerkin method of weighted residuals is used to cast the governing equations into a set of simultaneous equations. The Newton-Raphson iterative method of successive approximations is then used to solve the system of simultaneous equations. The procedure requires an initial approximation, called INITIAL CONDITION, to start the computations. Convergence from that first estimate to the final solution usually takes three to five iterations. The better the first estimate approximates the solution, the fewer the number of iterations required for convergence.

Convergence

10. Convergence of this solution scheme, like any nonlinear set of equations, is not guaranteed. In general, the smaller the velocities, the more likely the solution will converge in an all wet mesh. Convergence is more of a problem in partially wet meshes than in all wet meshes because numerical shocks are created each time an element is added to or removed from the flow field. Techniques developed to overcome convergence problems are presented in the section on Preparation of Input Data in this appendix.

11. The measure of how well the solution has converged is printed after each iteration. The convergence parameters are related to x- and y-velocity components and depth. The values printed, the differences between trial and computed values, should approach zero with each successive iteration; when they do not, the solution is said to diverge, and once divergence is indicated, the computations will seldom recover. A better initial approximation is usually required.

12. The user must decide if the solution has converged satisfactorily within the specified number of iterations. An average depth tolerance of 0.01 ft is used in 1-D programs and is adequate for this program also. There may be situations in which other tolerances are appropriate. The key is whether or not significant changes occur in the water-surface elevations or the x- and y-velocities if some other tolerance is accepted.

13. The maximum difference between trial and computed values of the computed parameters is larger than the average difference values, and the location of this maximum is shown by node number. If it should occur in an area of primary interest, the user should be sure the adopted convergence tolerance does not affect decisions based on model results.

14. Presently, there is no equation in RMA-2V that monitors divergence and corrects conditions to ensure convergence. When divergence occurs, the first recourse is to increase energy loss coefficients. However, the larger the coefficients, the more likely the computations will suppress actual eddies that will form in the prototype. Therefore, consider re-forming the finite element network when excessively large turbulent loss coefficients become necessary.

Energy Transfers

15. Three energy transfer computations are included in the governing equations: bed friction, surface wind friction, and turbulence exchanges. Surface wind stress is rarely used since 2-D models do not properly describe wind-induced currents. Turbulence exchanges become more dominant in slow-velocity flow (like reservoirs) and when large or numerous changes in flow direction or magnitude occur.

Bed friction

16. Bed friction is calculated with Manning's equation and the range of n-values one would use in other numerical, hydraulic models for steady or unsteady flow computations (e.g., HEC-2, DWOPER, etc.) are satisfactory for this program. Of course, small adjustments may be required to reconstitute observed or previously calculated water-surface elevations, but those are calibration adjustments and the procedure for calibrating this program is the same trial-and-error approach as followed in calibrating other numerical models. Since bed friction does not have to account for composite cross-sectioned roughness as in 1-D models, the values in a 2-D model may differ somewhat from those of a 1-D model.

Surface wind friction

17. Wind friction on the water surface is an energy component not available in the traditional, 1-D models and not generally used in this program. The equation is shown in the governing equations of this appendix. Like bed friction, the wind friction equation requires a coefficient for momentum transfer, and the value of that coefficient is not readily defined. It is deemphasized in TABS-2 because wind-driven currents are three-dimensional in nature and wind setup can be superimposed on the final result of the no-wind condition.

Turbulence exchanges

18. Momentum exchanges due to velocity gradients are approximated in the governing equations by multiplying a turbulent exchange coefficient, (shown in the text as the letter "E"), times the second derivative of the velocity with respect to the x- and y-directions. The units for E are $lb\text{-}sec/ft^2$. The progr m allows for the exchange coefficient to be specified in a local coordinate system for each element. This permits the user to input an exchange coefficient for directions parallel to and perpendicular to the direction of flow at each element in the mesh.

19. Although it is difficult to establish the value for E, analogy with physical conditions suggests that turbulence transfers depend on the momentum of the fluid and the distance over which that momentum applies divided by the fluid velocity and the surface area of the element. Therefore, as element size increases, E should increase, or as the velocity increases E should increase for the turbulent transfer rate to remain constant. That is, multiplying the units of E by ft/ft yields $ft\text{-}lb/ft/sec/ft^2$ where the ft/sec represents a velocity and ft^2 represents an area term.

20. Turbulence exchanges are sensitive to changes in the direction of the velocity vector. Conversely, small values of the turbulent exchange coefficients allow the velocity vectors too much freedom to change directions in the iterative solution. The result is a numerically unstable problem for which the program will diverge rather than converge on a solution. The recourse is to continue increasing E until a stable solution is achieved, then save a HOTSTART file, using the HOTSTART file to begin a run with more appropriate values. Procedures to follow in establishing E values are presented in the section of this appendix titled Preparation of Input Data.

Steady and Unsteady Calculations

21. In their complete form, the governing equations can solve dynamic problems. However, the finite element method allows the time dependent terms to be either turned on or turned off with input data. Consequently, a steady-state solution can be run directly, or by simply adding the time-dependent input data the complete, unsteady flow equations will be solved. Not only is that useful in backwater-type problems, but it is also useful for establishing initial conditions in an unsteady flow calculation.

22. The unsteady calculations advance in time stepwise using an implicit solution. The time derivatives are replaced by a nonlinear finite difference approximation in which values are assumed to vary over each time interval as follows:

$$f(t) = f(o) + at + bt^c \qquad t_o < t < t_1$$

where

f(t) = value at end of time-step

f(o) = value at beginning of time-step

a,b,c = coefficients assumed to be constant

The coefficients a, b, and c were established by numerical experiments and are not input variables. The value of c is 1.5 (Norton and King 1977). This nonlinear time function is extremely powerful in combination with the implicit solution. As a result, relatively long computation times are permissible (even 1-hr time-steps have been succesfully used in an estuary where the tidal range was 8 ft).

Finite Element Implementation

Element description

23. The finite element model RMA-2V accepts quadrilateral and triangular isoparametric elements. The elements are defined by eight and six node points, respectively. In each case four/three of the nodes are placed at the vertices and four/three nodes on the sides. The exact position of the mid-side node determines the curved shape of the side. For straight-sided elements, the location is precisely at the middle of the side. For curved boundaries, the mid-side node may lie at a location that is not halfway between corners. Within an element, quadratic approximations are used to represent the velocities u and v and linear approximations are used for the depth h . Where two elements join together the functions are continuous. See APPENDIX D: MESH GENERATION for a discussion of desirable element characteristics.

Network of elements

24. The proper finite element (FE) network is the most fundamental aspect of successful finite element modeling. Although averaging or differencing is not involved, the finite element shape functions distribute calculated values over the element. Therefore nodal points should be carefully located to capture changes of depth and changes in energy gradient so that these extremes are captured. Automatic mesh generators (the mesh is the set of lines, elements, and nodes in the FE network) can locate the (x,y)-coordinates of nodes so they best fit the continuous surface requirement of the finite element shape functions; but the automatic mesh generators do not consider the z-coordinate (the bed elevation) in that procedure nor do they take sharp changes in gradients into account. Consequently, the

judgment of the user is essential to ensure that these factors are incorporated into the network.

External boundaries

25. The external boundary of a network refers to the lines of nodes that have elements along only one side of them as opposed to internal lines of sides. Examples of external boundaries are the sides of the network; the ends of it; and islands, piers, or other internal features that are not overtopped by the flow.

26. The significance of external boundaries stems from the 2-D nature of the computations. That is, in 1-D computations, flow always travels parallel to the sides of the numerical flume or river. That is not the case in 2-D computations; and consequently, the calculated velocity vectors can intersect the sidewall of the numerical flume or river, rather than be parallel to it, just as it does the end boundaries. The result is a "leak." It is necessary to identify all external boundaries using input data so RMA-2V can avoid leak problems.

27. An external boundary line can be either a straight line, a sequence of straight line segments having sharp corners where one element joins another, or a smooth, quadratic curve. For the second case, the velocity components at each node must be zero unless the wetting and drying feature is turned on. When a smooth (straight line or quadratic curve) is prescribed, RMA-2V will calculate its tangent at each node and align the velocity vector so that flow is parallel to the boundary at that point. Consequently, leaks are avoided by the proper specification of boundary conditions.

28. A wetting and drying feature allows the model to represent the process by which shallow areas emerge as the water level falls. This is commonly encountered in tidal flats and river overbank areas. This feature should be used only when the cross-sectional area or surface area of the flow changes significantly during a flow event. The library version of the program considers whole elements to be either dry or we . Because of numerical problems associated with very small depths, elements are considered "dry" and removed from the calculation when depths reach a small critical value.

Wetting and drying

29. Areas of the network that become dry are resolved by manipulating the individual elements. If any node in an element is dry, the entire element is removed from the computations. This procedure produces two problems: an irregular side boundary having sharp corners rather than the smooth external boundary of the original network, and numerical shocks each time an element is added or removed. Logic in the program aligns the boundary velocity vectors with the irregular boundary to prevent leaks and to allow a slip flow along the newly formed external boundary.

Both the velocity and its time derivatives at the present and past iteration are thus recalculated. This special treatment of flow along a boundary applies only to partially dry meshes. It is not applicable along external boundaries. The problem of numerical shocks has not been completely resolved. By keeping elements small, the shock can be minimized and by increasing the number of iterations between dry-node-checks, stability can be increased. An experimental version of the program moves the external boundaries with the water's edge, partially wetting or drying boundary elements. That version is both more difficult to use and more expensive to run.

Boundary Conditions

30. There are five ways that conditions can be specified at each node: no boundary condition, flow boundary condition, parallel flow boundary condition (i.e., slip flow), corner boundary conditions (stagnation point), and water-level boundary condition. The use of no boundary condition allows the program to compute both velocity components and the depth at that node. The use of any other specification removes either the depth or the velocity components from the computations and the program expects those values to be entered as input data or otherwise prescribed.

31. The normal use of boundary conditions allows the numerical model to resemble a flume in its operational characteristics. External boundary nodes along the downstream end of the network are assigned a water-level boundary condition. That is like setting the tailgate on a physical model to control the water depth at the exit. Boundary nodes along the upstream end of the network are assigned an exact flow or discharge boundary condition. That is like setting the inflow valve on a physical model because it controls the water discharge in the computations. Each side wall of the network is assigned a parallel flow (i.e., slip flow) boundary condition which allows the program to calculate the velocity adjacent and parallel to the side wall as well as the flow depth there.

32. The water level boundary condition allows the program to adjust the water depth as needed to obtain the optimum solution of the finite element equations. The minimization principles in the solution technique reach optimums when all heads, even those along the exit boundary, can be adjusted individually to preserve overall network optimizations. The result is water surfaces at the exit boundary nodes that differ slightly from those coded as the boundary conditions. If the calculated levels vary significantly from specified values, something is wrong with the way the problem is being posed. See PART V.

33. Normally, all interior nodes are left in the computations (i.e., the "no boundary condition" option); however, one attribute of the finite element method is that a water-level or

discharge condition can be prescribed anywhere in the network and not just along the boundaries or at predetermined nodes. Therefore it is possible to code boundary conditions at internal nodes in the network. This makes it possible to simulate structures that are not explicitly represented by the mesh and to construct barriers of zero width, a very powerful technique.

34. It is possible to overspecify the boundaries of the problem. For example, do not code a tailwater elevation, a head water elevation, and the flow velocity because that attempts to force both a slope and the water discharge. Theory does not allow such nor can it be accomplished in a flume unless the roughness is a dependent variable. Also, overspecification of the problem is more likely when including internal nodes in the boundary conditions data set. Therefore, establish model performance criteria very carefully to make certain the results are not contaminated when boundary specifications are being assigned to internal nodes.

35. No special equations are required for boundary nodes. Where boundary conditions are prescribed, those nodes are simply left out of the computation matrix and the prescribed values are substituted in their place.

Iteration Control

36. The program requires the iteration control to be input, and in general, it is not possible to predict the number of iterations that will be required to solve a particular problem. Some experimentation must be done. The recommended procedure is this. First, converge the problem to a steady-state solution with four iterations. Output will be produced at each cycle and one can assess the speed and degree of convergence from the CONVERGENCE PARAMETERS printed at the top of the output. With experience, it will soon become obvious if the solution has properly converged or not. If the solution has not converged, one is faced with a choice of modifying either the number of iterations, the turbulent exchange coefficients, or the network itself. If convergence is achieved in fewer than four iterations, reduce the cycles in future runs. When a satisfactory degree of convergence is achieved, one has a steady-state solution plus background from which to judge the convergence of time-dependent problems. If one wishes to move to the unsteady solution, the number of iterations per time-step can usually be reduced to two.

37. Judge unsteady-state convergence in relation to that achieved for the steady-state case. As before, a certain amount of experimentation may be necessary to achieve optimum convergence, but a little experience and testing will show the best approach.

38. When dry nodes are allowed, there is an iteration control that specifies how many iterations will be made between checks to determine which nodes are dry. This must be assigned separately from that for the primary computations.

Input and Output

39. Four input data files and three output files are available in RMA-2V. These are shown in Tables F1 and F2. The file names are those used as in the instructions for the procedure file, PROCLV, which generates job control and submits the jobs (see Appendix O). The tables show the standard (default) logical units for the files. The standard units may be changed by input.

Table F1

Input Files

PROCLV Name	Standard Logical Unit Numbers	File Contents	Source	File Type
I1R2	5	Card image input for run control	Editor	Coded
I2R2	5,7	Card image input boundary conditions	Editor	Coded
I3R2	1	Hotstart from prior run	RMA-2V	Binary
O1R1	14	Geometry data file	GFGEN	Binary

Table F2

Output Files

PROCLV Name	Standard Logical Unit Numbers	File Contents	Source	File Type
O1R2	22	Water-surface elevations and velocities	RMA-2V	Binary
O2R2	2	Hotstart file	RMA-2V	Binary
----	6	Line printer output	RMA-2V	Coded

40. Since file information tends to change as the programs mature, always check the "HELP" command in PROCLV for the latest file requirements.

41. The required input files are the "Card Image Input Data for Run Control" and the "Geometry Input File." Instructions for preparing the card image file are given in this appendix. The geometry file is produced by the utility program GFGEN and instructions for executing that code are presented in Appendix D, Network Generation.

42. Printout is automatically directed to the standard line printer unit when using PROCLV. The output buffer is emptied so all print lines created by the program appear in the printout.

Graphics

43. No graphics are produced by RMA-2V. Instead, the output file is ready for use by utility programs which prepare vector plots, contours, or other output.

PART III: PROGRAM USE

44. Use of the program involves three processes: properly assessing the nature of the problem, the dominant energy forces, and energy dissipation mechanisms; coding data in the form which allows RMA-2V to model that problem;and analyzing the results. This document focuses on the second of those processes, but the first and third are probably the more important so far as model realism is concerned (realism being the accuracy to which the model simulates the prototype processes).

Geometry

45. The finite element mesh (the geometry file created by GFGEN) controls both lateral and vertical boundaries. The degree to which it models lateral boundaries can be observed by overlaying the mesh on a map or aerial mosaic. The agreement with vertical boundaries is more difficult to ascertain. That is, bed elevations are coded at each corner node, and the program constructs a bed plane in each element. It is important that the elevations in that bed-plane model the true elevations of the bed throughout the element. It is difficult to visualize the 2-D model planes, but if elements are aligned along cross sections, the FE bed can be plotted on the cross section to check bed elevations. Corner node elevations are connected by straight lines in the model geometry.

46. An (x,y)-coordinate can have only one elevation (i.e., elements cannot stand on their edge).

Initial Conditions

47. The initial water surface elevations in the RMA-2V model is called the INITIAL CONDITION water level. It can be prescribed as a level water surface or the HOTSTART option can be used to prescribe a sloping water surface.

48. The water depth is calculated at each node from the initial water-surface elevation and the bed elevation in the geometry file. It is important that the initial condition water-surface elevation be higher than the model bed and the depth greater than critical depth. Those cases where the bottom slope is substantial sometimes go unnoticed and the initial water surface is assigned at the downstream boundary when that elevation is below the bed surface of the upstream boundary.

49. Partially dry meshs are permitted, but model start-up is particularly painful so avoid arbitrarily causing a dry condition. Adopt the estimated average water surface in the model for the initial condition until a better estimate is obvious.

50. The initial condition flow velocity is taken to be zero in coldstart runs. In hotstart runs, the velocities at the end of the previous run are used as the initial condition.

Initial Conditions and Convergence

51. Usually, reservoir and estuary problems run with no particular convergence problems. They usually have relatively small gradients and large diffusion coefficients. River problems, or rivers in conjunction with reservoirs or estuaries, are more likely to have convergence problems. When divergence occurs, the success of the study depends largely on the ingenuity of the modeler. The following procedure to solve convergence problems has evolved through several studies.

- o Increase turbulent loss coefficients to 1000
- o Reduce boundary condition velocities to 4 ft per sec or less
- o Save the HOTSTART file

52. If convergence is achieved, the HOTSTART file should then be used for the initial condition by using the HOTSTART option, described in this section. If the solution does not converge, continue increasing turbulent loss coefficients and/or decreasing the boundary velocities until convergence is achieved.

53. Once a suitable HOTSTART file is available, return turbulent loss coefficients and boundary velocities to the desired values and rerun the job using the HOTSTART file as input. If the solution continues to diverge, repeat the HOTSTART procedure while "creeping up" on the desired values by using as a starting place those which worked.

54. When start-up is difficult, always check the results for surprises such as peculiar gradients, velocity magnitudes, or velocity directions.

55. Partially wet meshes are usually difficult to work with. The above procedure may fail, in which case the recourse is to estimate which elements will be dry, assign an element type (IMAT) of zero, and reprocess the mesh through GFGEN. It is not necessary to construct curved boundaries since the RMA-2V code will ensure parallel flow in that case if the wetting and drying feature is turned on.

Manning n-values

56. Bed shear stress is calculated with the Manning equation. Only bottom friction is included in the calculations;

n-values can be assigned by element, by element type, or a constant value can be assigned to the entire mesh. The value depends on boundary roughness and not element size or shape. Only one value can be prescribed for an element and that coefficient does not vary in time, with depth change, or with discharge change. For some cases (e.g. deep inner channels), a composite roughness coefficient reflecting bank roughness should be used.

Turbulence Coefficients

57. Values for E , the turbulence coefficients, will usually affect results significantly up to some maximum value but there is very little guidance available for establishing them. If E is too small, flow can change directions in the model without causing a sufficiently large momentum transfer. On the other hand, if E is too small, the flow characteristics will approach that of an inviscid fluid or the program may abort by diverging rather than completing the solution. The more likely problem is to choose E's that are too large.

58. In general terms, turbulent exchange coefficients should be proportional to water depth, flow speed, and element size. Vreugdenhil (1973) gives the following expression for proportionality:

$$E \sim \frac{6h}{C} \sqrt{gV^2}$$

where

h = water depth

C = Chezy coefficient

V = flow speed

He warns, however, that this equation gives only an order of magnitude estimate and the needed value may be considerably different. Note that it does not account for element size.

59. For high values of E , the computations are more likely to converge to a solution but eddies may be diffused out of existence. The velocity distribution will tend to diffuse laterally while showing fairly realistic directions of the vectors. The energy gradient will be steeper than the prototype unless the channel is a prismatic cross section on a straight alignment.

60. The Table F3 shows values of E used in a few prior studies and in Norton and King (1977).

Table F3

Values of Turbulent Exchange Coefficients

Type of Problem	Values of Turbulent Exchange Coefficients (Eddy Viscosity) $lb\text{-}sec/ft^2$
Homogeneous horizontal flow around an island--turbulent range	10 - 100
Homogeneous horizontal flow at a confluence--turbulent range	25 - 100
Dynamic flow in upper San Francisco Bay	250 - 1000
Steady-state flow for thermal discharge to a slow moving river	100 - 1000
Tidal flow in a marshy estuary	50 - 200
Slow flow through a shallow pond	0.3

61. Turbulence exchange coefficients are assigned by element type, and up to 10 different types can be established. Four values are needed for each element. When all elements' sides are about the same size,all four values are the same.

62. The coefficients are direction-dependent, and as long as a uniform value is used for the entire mesh, direction is not a problem. However, long and narrow elements will often require a sma'ler E value for the narrow dimension than for the long one. Rather than coding for the x- and y-directions, it is possible to code for the (s,n) directions where s is along a streamline and n is transverse to that direction. The angle of the element is then entered and the program calculates E for the (x,y) coordinates for each element.

Wind Shear Stress Coefficient

63. Shear stress exerted on the water by wind depends on input of a wind stress coefficient. Bretschneider (1966) showed a value of 2.6E-3. Wang (1979) gave the following equation for the wind friction coefficient:

$$\zeta = 10^{-3} \cdot (1 + 0.07\ (u_{10} - 5))$$

where

ζ = the friction coefficient

u_{10} = wind speed 10 m above the ground in metres per second

Wang's value is less than Bretschneider's for wind speeds up to 28 mps. Thereafter Wang's value will exceed Bretschneider's. No value should be accepted without justification. These are given to indicate order of magnitude.

Boundary Conditions

64. Coding boundary conditions (BC) involves three tasks: (a) identifying external boundary nodes, (b) selecting the type of BC, and (c) establishing the values of the BC. Both steady and unsteady flow situations use the same procedure for determining BC except that timing data becomes important in the unsteady flow problems. That is discussed in the section Coding for Unsteady Flow Computations.

Identifying boundary nodes

65. GFGEN will print a table of all external boundary nodes, and all of these, both corner and mid-side nodes, must be included in the BC data set. It is possible to specify BC at internal nodes, but such a technique must be approached with some experimentation using vector plots and continuity checks to display model performance.

Boundary condition types

66. Although several types of BC are possible at each node, some combinations can violate hydraulic theory and must be avoided. The program does not diagnose such violations; the user must specify the proper type. The following combinations are recommended or, in some cases, discouraged; but it is good practice to always devise simple test cases to ascertain correct model behavior. The user can specify water level, discharge, velocity, or flow direction.

67. A good combination of boundary condition types is a head (water level) at the downstream boundary and a discharge at the upstream. Often, the flow reverses so the concept of upstream and downstream is lost; but the program will perform equally well if the head is specified at the upstream boundary and the discharge at the downstream. Avoid prescribing both at the same boundary, however. In general, any flow condition that can be created in a flume of a fixed slope by manipulating head gates and tailgates is a legitimate combination of boundary types in RMA-2V. Unsteady flow problems will run with the same boundary condition types as will the steady flow problems. Water-level

specifications or outflow discharge specifications at constrictions where velocity magnitudes are high may cause the solution to diverge.

68. There are several combinations of types to avoid. For example, do not prescribe a head at each end of the network plus a velocity or discharge at one end or the other. That over-specifies the hydraulics of the problem. Do not specify a velocity and a discharge type in the same opening. An example of under specification is to request a discharge at the upstream end and a discharge at the downstream end and no head boundary condition at all. (Note: The IC-Card is an initial condition, not a boundary condition.) A 5-digit code is used to specify what type of boundary condition is being prescribed. The code is explained below. See pagragraphs 30-34 for a discussion of these specifications.

<u>Boundary Condition Specification Code</u>

TYPE CODE = XXY00

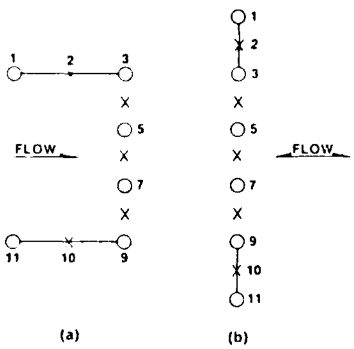
- Y — Water-level specification control
- XX — Flow specification control

Value of XX	What Is Specified
00	Flow is not specified
01	Slip flow
11	Velocity
31	Unit discharge ($qx \neq 0$)
13	Unit discharge ($qx = 0$)

Value of Y	What Is Specified
0	Water-surface is not specified
2	Water-surface elevation*

69. Even when the proper combinations are being used, special handling is required at the two ends (or sides) of an opening in the boundary. Figure F2 illustrates the types that have successfully executed. The nodes located at 3 and 9 are unique because these are the limits of the opening--its width.

* See Part V for warnings.



O = corner nodes
X = mid-side nodes

Figure F2. Boundary openings

70. Nodes 1, 2, 10, and 11 can be either stagnation or slip, type 11000 or 1000, respectively. Nodes 4, 5, 6, 7, and 8 can be type 200, 11000, or 31000, which are head, velocity, and discharge, respectively, as required to model the physics of the problem. Nodes 3 and 9 can be type 200 when nodes 4 through 8 are coded as type 200 but if so the mesh will "leak" between nodes 2 and 3 and between 9 and 10. To avoid that leak, code nodes 3 and 9 as type 11000 and assign velocity (zero or finite) or 1200 for head and slip flow. In general, do not code type 11200 because that overspecifies the boundary condition.

71. Attempts have been made to assign type 1000 (slip condition) at node locations 3 and 9 but the solution failed to converge. Attempts to code nodes 3 and 9 as type 31000 (Q-boundary data) also sometimes results in failure to converge. In general, type 11000 specifications are preferred to type 31000 because they are more likely to converge satisfactorily.

Establishing boundary values

72. The entire study results, and decisions based on those results, will depend on the boundary values that are established. It is essential for the energy forces at the boundary to statistically represent the dominant energy in the prototype. However, the question addressed here is not "How representative is the

boundary condition?," but "How can we distribute a total value among the many nodes along a boundary?"

73. Some experimentation is usually required in prescribing boundary condition. A reasonable first estimate for water surface across a river is a horizontal line. A reasonable first estimate for a water discharge across a river is to proportion the total flow by applying the conveyance portion of Manning's equation at each node, allowing for wetted perimeter along the banks.

$$K_i = \frac{1.486}{n_i} \cdot D_i^{5/3} \cdot W_i$$

$$q_i = \frac{Q \cdot (K_i/K_t)}{W_i}$$

where

K = conveyance

n = Manning n-value

D = water depth at the node

W = width of flow represented by node i

q_i = flow per foot of width at node i

Q = total flow

subscripts

i = node i on that boundary opening

t = total for that boundary opening

74. Not only must the amount of flow be estimated for each node but also the direction of the velocity vector must be estimated. Incorrectly specified directions (relative values of x and y components) can cause spurious results at some distance into the mesh or even nonconvergence. A sketch of the streamlines will aid in establishing the proper direction.

75. Test the boundary values by running a steady-state condition and plotting the velocity vectors back on the finite element mesh. When computations fail to converge, the problem may be due to inaccurate boundary values. Check velocities and depths at the boundary openings. Also, a velocity distribution that changes radically from the boundary element to the next few

elements downstream indicates unsuitable boundary values. Modify either magnitude, directions, or both, based on model results. At the same time, observe the velocities and depths in the primary area of interest to make certain that the above inaccuracies on boundaries do not significantly affect results there.

76. In reservoirs and estuaries, it is more difficult to establish distributions of head, flow, or velocity than it is in rivers. Devise tests that let the program aid in establishing boundary values. Locate boundaries sufficiently far from the area of interest to minimize problems with boundary values. It may be necessary to make runs with the boundaries in different locations to evaluate their effects. See Appendix D for proper location of mesh boundaries.

HOTSTART

77. The name given to the technique of saving computed results at the end of a run so the run can be resumed is called HOTSTART. This feature is available for both steady and unsteady flow computations and its use is encouraged for both. It takes very little computer resource since only the results from the last iteration of the last computation are saved. The advantage is that a better initial condition is prescribed by using the HOTSTART option, resulting in more rapid convergence in the computations.

78. The process is activated by requesting a restart file ($L Card). That file can then be given a name upon execution of the job by using PROCLV. This run is called the creation or coldstart run.

79. The HOTSTART file produced by the coldstart run is used in much the same way as it is created. The $L-Card, variable "NB", instructs the program to read the HOTSTART file, and that file is made available by PROCLV.

80. In steady flow computations, the TZ and TI cards are the same for hotstarting and coldstarting. The program keys on the presence or absence of the HOTSTART logical unit number "NB" on card $L. NSTART should be zero.

81. MBAND. MBAND is the logic control variable that directs the program to either skip to the next time-step (MBAND = 0) or remain at the last time-step of the previous run (MBAND = 1) for the first computations of the HOTSTART run. It is input on the TZ card.

82. Set MBAND to 0 for normal HOTSTART runs. Set it to 1 if there is a need to make additional iterations at the final time step of the prior run. This need may arise from incomplete convergence at the end of the previous run.

Coding for Steady Flow Computations

83. An example of the card image input data coded for the Yazoo Backwater Area is shown in Part IV of this appendix. Table F7 summarizes the purpose of these data cards and PART V contains coding instructions for each variable on each card. The suggested procedure for coding is to consider the cards in this example as the required input data; then start with the title cards and go down the list coding the variables to describe the new problem. Do not consider the values in this example as typical values.

84. Some cards are flagged as optional in the coding instructions (i.e., GC cards), but they request continuity computations which will be essential to the interpretation of results. Always include GC-Cards.

85. Notice that timing data are present (TZ Card and others). That is recommended as a means of referencing the event; however, it is not required for steady-state, coldstart computations. DELT, TMAX, NCBC, or NSTART should not be coded on the TZ-card for steady-state runs.

Coding for Unsteady Flow Computations

86. Coding for unsteady flow is only a slight extension of coding for steady flow. The key is the timing information. New terms, SIMULATION, HYDROGRAPH, TIME ZERO, COMPUTATION TIME INTERVAL, TMAX, NSTART, and NITN are discussed in this section. Example F2 shows the card image input used to begin an unsteady flow computation from a steady flow HOTSTART file.

Simulation hydrograph and time zero

87. Timing is introduced when the boundary conditions (i.e., head, velocity, or discharge) vary in time. The concept is that depicted by a hydrograph at a gage, as shown in Figure F3.

88. When the changes in boundary values are introduced and the RMA-2V code allowed to run in the dynamic mode, changes at all interior nodes are calculated and displayed as a function of time. The changes in boundary values become the SIMULATION HYDROGRAPH. The beginning of the simulation is called TIME ZERO. In coding prototype events, the true date and time make referencing easier, so a TZ Card is provided so the actual date and time corresponding to TIME ZERO can be coded.

Computation time interval, DT

89. Although the program uses an implicit solution scheme, some experimentation is usually required when establishing DT.

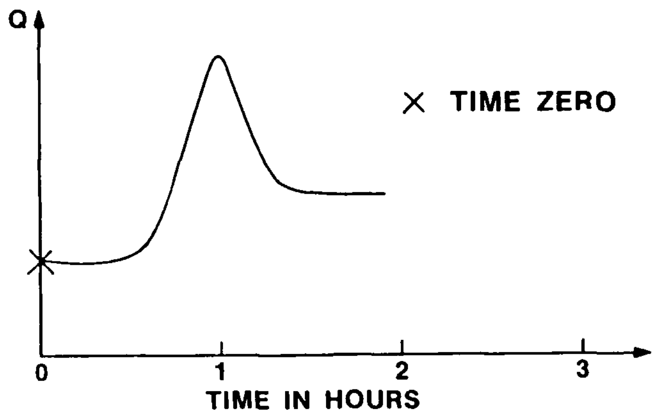


Figure F3. Simulation hydrograph

Start with a value appropriate for 1-D computations, and increase DT to the largest value that is numerically stable and physically representative of the problem. For example, 1-hr timesteps can be used in some tidal problems, even when amplitude is 6 to 8 ft, with a good reconstitution of observed gage records and current patterns. The required time-step size may be dependent on element sizes, strength of flows, flow patterns, and rate of boundary condition change. Many tidal studies with this type of model employ 30-min time-steps satisfactorily, but experimentation should be used to ensure that any time-step is appropriate for a given problem.

90. Another factor to consider is that the computation time interval must be constant for the entire simulation whereas the physics of the problem requires that the maximum, minimum, and breakpoints in the simulation hydrograph fall on DT increments. That is, computations are made only at DT increments and to evaluate the response inside the study area to changes in boundary values requires knowledge of the significant breakpoints in the boundary hydrograph. Always plot the simulation hydrographs and mark the DT intervals along the abscissa. The concept is illustrated in Figure F4.

91. Figure F5 shows two identical hydrographs to illustrate the difference between coding to start an unsteady flow computation and coding to resume one from a HOTSTART file.

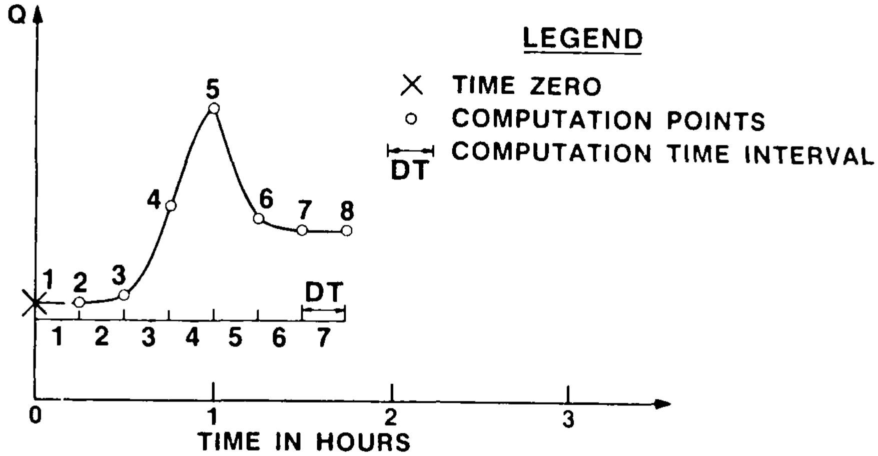


Figure F4. Computation points on the simulation hydrograph

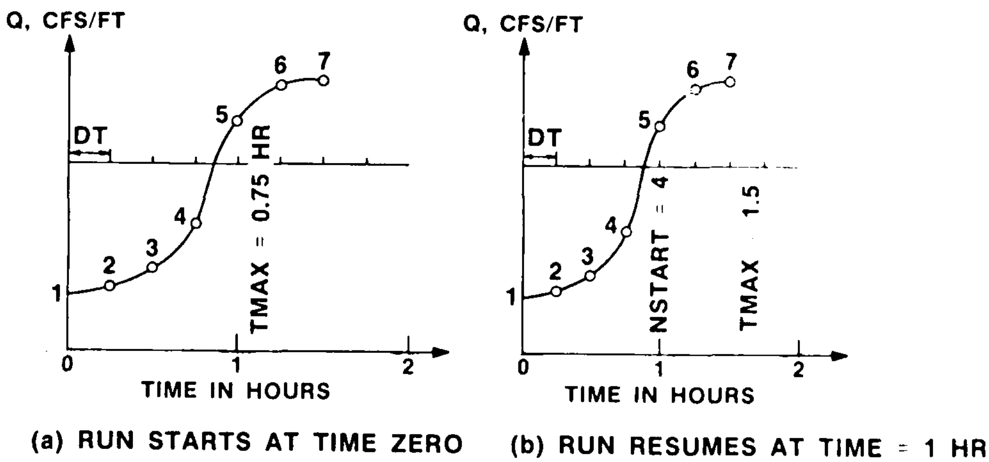


Figure F5. Timing for unsteady flow calculations

Figure 5A shows computations beginning at TIME ZERO and ending at TMAX = 0.75 hr (TZ Card). Figure 5b depicts computations resuming at Time = 0.75 hr and ending at 1.50 hr. The significant parameters are shown below.

	(a)	(b)
TZERO	0	0
DT	0.25	0.25
NCBC	1	1
NSTART	1	4
MBAND	0	0
NITI	5	0
NITN	2	2

Model spin-up

92. The unsteady flow computation almost always starts from a "coldstart". That is, the true velocity and depth field in the model are not known and an approximation is made just to get computations under way. The model must simulate a long enough period of time to establish a condition like that existing in the prototype at time zero. The procedure is called Model Spin-up, and the response is a repetition of water-surface elevations and velocities from one cycle of the boundary condition to the previous one. Like time-step size, the necessary length of spin-up time will vary from one problem to another. Unlike some models that require many hours of spin-up, fully implicit models spin-up rapidly, in as few as three or four time-steps in many cases; however, some physical situations where inertial forces are important in flow patterns (e.g. large gyres) may require longer spin-up times.

93. Once spin-up is achieved, it is customary to save the model result in a HOTSTART file so that future runs can skip the spin-up costs. However, the number of repetitions of the boundary conditions required for model spin-up is found by experimenting.

94. It is important to make the computation time interval used for model spin-up the same length as that for the unsteady flow computations so the time derivatives written to the HOTSTART file match the restart requirement.

PART IV: EXAMPLES OF CARD IMAGE INPUT DATA

Example F1: The Yazoo Backwater Area Pump Station, Steady Flow Case

95. The mesh for the Yazoo application is shown in Figure F6. It has been annotated for use in describing the card image input data that follow.

96. The problem under investigation was site location for a proposed pumping station in the Yazoo Backwater Area near Vicksburg, Mississippi. The levee area was drained by a gravity flow structure, the Steel Bayou Drainage Structure, at location D on the mesh. Locations A and B were inflow points, and the proposed site for the pump station is location C. The levee is not shown, but it ran along the bottom of the grid. External boundaries of the mesh followed the elevation 80-ft contour because pumping started when the water level exceeded that elevation. The question being addressed was, "Can the proposed channels deliver the 17,000-cfs design discharge to the pumps?" A steady flow test was followed by an unsteady flow test.

97. The steady-state input data card images for Example 1 are shown in Figure F7. Notice that the boundary cards in the data listing (BC Cards) are grouped by inflow/outflow point. It is not necessary to arrange them in sequential order. Moreover, each BC card will prescribe type and value at two nodes which splits the first BC card in the B-boundary set between locations A and B. Finally, boundary type 31000 is coded for inflow points A and B, but two discharge components plus the water-surface elevation are shown on the cards. That is possible because the program never actually uses those water surfaces as boundary conditions since the boundary "type" controls the computations. A water-surface elevation (type 200 BC) was prescribed at boundaries card D, however.

98. The type 11000 BC cards listed after the D-boundary data set specify stagnation points at external nodes in the mesh where a smooth, curved boundary could not be established (a stagnation point has u = 0 and v = 0). The type 1000 BC cards are slip boundary nodes (i.e., smooth, curved boundaries).

Example F2: The Yazoo Backwater Area Pump Station Unsteady Flow from Coldstart

99. The card image input data file for the unsteady flow test is shown in Figure F8. That file is set up for a hotstart. Three points are pertinent: (a) timing controls have been added to the TZ Card of the steady flow data set; (b) iteration control has been added to the FI Card; and (c) boundary condition data at the end of computation time, steps 1 and 2 have been added to the steady flow file.

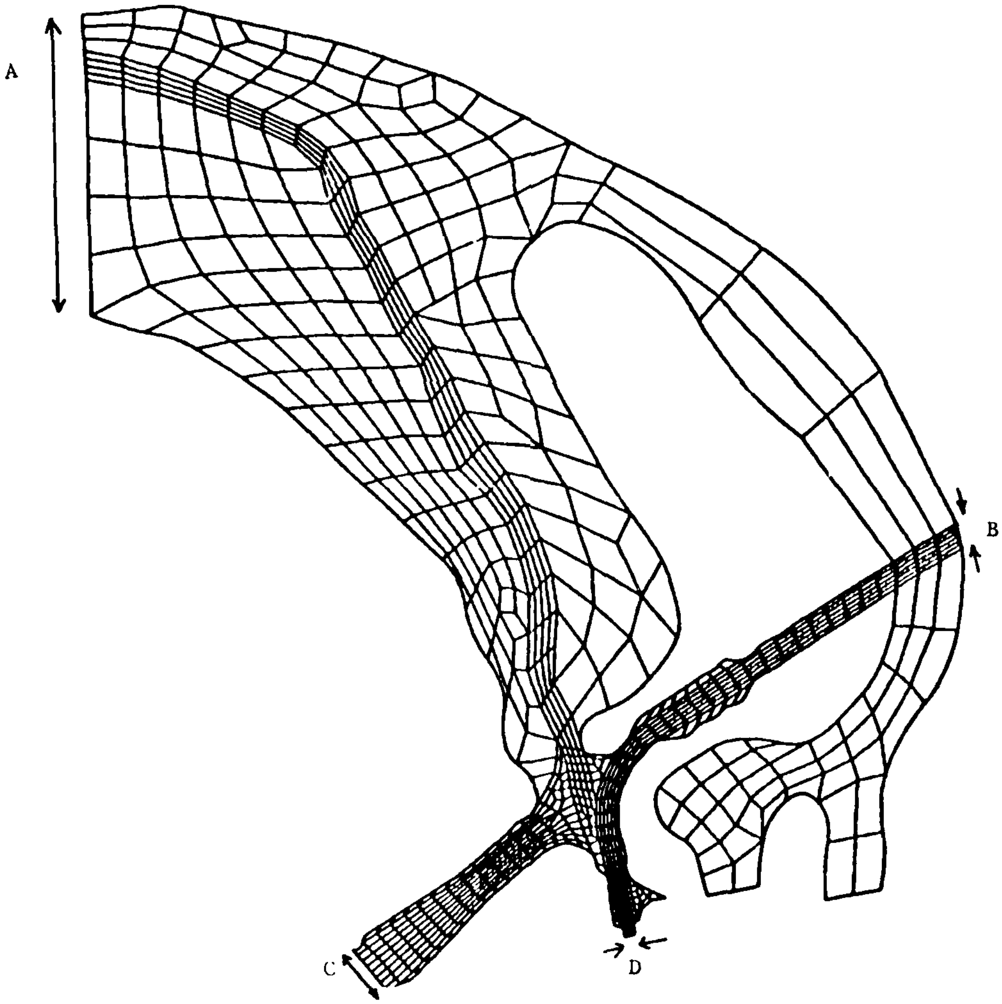


Figure F6. Yazoo backwater area, Alternative 1

Example F1

```
    T1  YAZOO BACKWATER AREA   RMA2 INPUT FILE
    T3  ALTERNATIVE NO. 1   EL 85 UPSTREAM LOW-WATER GRID
    $L,,,14,22
    TR,0,0,1
    G1,32,,,436
    GC,9,804,805,802,785,751,749,746,743
    GC 740
    GC,7,315,318,321,324,327,330,333
    GC,12,1,2,5,7,9,11,13,15
    GC 17,19,21,23
    GC,9,971,974,977,980,983,986,991,993
    GC 994
    GC,7,442,443,444,445,446,447,448
    GD,.275
    TZ,83,12,14,120000
    TI,5
    FT,20
    HNT 8312,14120000,1,.020,2,.150,3,.050
    EX,1,50,50,2,50,50,3,50,50
    EY,1,50,50,2,50,50,3,50,50
    IC,87
    BCN,83,12,14,120000,1,11000
    BCN 997,31000,.223,,,2,31000,.223
    BCN 1002,31000,.223,,,5,31000,.223
    BCN 1010,31000,.223,,,7,31000,.223
    BCN 1014,31000,4.152,,,9,31000,5.643
    BCN 1019,31000,10.105,,,11,31000,14.568
A   BCN 1024,31000,11.348,,,13,31000,8.128
    BCN 1029,31000,5.146,,,15,31000,.219
    BCN 1036,31000,.219,,,17,31000,.219
    BCN 1041,31000,.219,,,19,31000,.219
    BCN 1046,31000,.219,,,21,31000,.219
    BCN 1051,31000,.219,,,23,11000
    BCN 315,11000,,,,1617,31000,-23.54,-14.00,80.88
    BCN 318,31000,-44.13,-26.25,80.88,1624,31000,-44.13,-26.25,80.88
    BCN 321,31000,-44.13,-26.25,80.88,1631,31000,-44.13,-26.25,80.88
B   BCN 324,31000,-44.13,-26.25,80.88,1638,31000,-44.13,-26.25,80.88
    BCN 327,31000,-44.13,-26.25,80.88,1645,31000,-44.13,-26.25,80.88
    BCN 330,31000,-44.13,-26.25,80.88,1652,31000,-23.54,-14.00,80.88
    BCN 333,11000,,,,804,200,,,85.00
    BCN 2552,200,,,85.00,805,200,,,85.00
    BCN 2550,200,,,85.00,802,200,,,85.00
    BCN 2520,200,,,85.00,785,200,,,85.00
C   BCN 2456,200,,,85.00,751,200,,,85.00
    BCN 2454,200,,,85.00,749,200,,,85.00
    BCN 2450,200,,,85.00,746,200,,,85.00
    BCN 2446,200,,,85.00,743,200,,,85.00
    BCN 2441,200,,,85.00,740,200,,,85.00
    BCN 971,11000,,,,2849,11000
    BCN 974,11000,,,,2854,11000
    BCN 977,11000,,,,2858,11000
    BCN 980,11000,,,,2862,11000
D   BCN 983,11000,,,,2866,11000
    BCN 986,11000,,,,2870,11000
    BCN 991,11000,,,,2876,11000
    BCN 993,11000,,,,2878,11000
    BCN 994,11000,,,,399,11000
    BCN 1662,11000,,,,339,11000
    BCN 393,11000,,,,1613,11000
    BCN 314,11000,,,,350,11000
```

Figure F7. RMA-2V input file

Example F2

```
T1  YAZOO BACKWATER AREA   RMA2 INPUT FILE
T3  ALTERNATIVE NO. 1   EL 80 UPSTREAM LOW-WATER GRID
$L,1,2,14,22
TR,0,0,0
G1,32,,,436
GC,9,804,805,802,785,751,749,746,743
GC 740
GC,7,315,318,321,324,327,330,333
GC,12,1,2,5,7,9,11,13,15
GC 17,19,21,23
GC,9,971,974,977,980,983,986,991,993
GC 994
GC,7,442,443,444,445,446,447,448
GD,.275
TZ,83,12,14,120000,.50,2.00,1,3,0
TI,0,2
FT,20
HNT 8312,14120000,1,.020,2,.150,3,.050
EX,1,50,50,2,50,50,3,50,50
EY,1,50,50,2,50,50,3,50,50
IC,85
BCN,83,12,14,120000,1,11000
BCN 997,31000,.223,,,2,31000,.223
BCN 1002,31000,.223,,,5,31000,.223
BCN 1010,31000,.223,,,7,31000,.223
BCN 1014,31000,4.152,,,9,31000,5.643
BCN 1019,31000,10.105,,,11,31000,14.568
BCN 1024,31000,11.348,,,13,31000,8.128
BCN 1029,31000,5.146,,,15,31000,.219
BCN 1036,31000,.219,,,17,31000,.219
BCN 1041,31000,.219,,,19,31000,.219
BCN 1046,31000,.219,,,21,31000,.219
BCN 1051,31000,.223,,,23,11000
BCN 315,11000,,,,1617,31000,-23.54,-14.00,80.88
BCN 318,31000,-44.13,-26.25,80.88,1624,31000,-44.13,-26.25,80.88
BCN 321,31000,-44.13,-26.25,80.88,1631,31000,-44.13,-26.25,80.88
BCN 324,31000,-44.13,-26.25,80.88,1638,31000,-44.13,-26.25,80.88
BCN 327,31000,-44.13,-26.25,80.88,1645,31000,-44.13,-26.25,80.88
BCN 330,31000,-44.13,-26.25,80.88,1652,31000,-23.54,-14.00,80.88
BCN 333,11000,,,,804,11000
BCN 2552,11000,,,80.38,805,11000,,,80.38
BCN 2550,11000,,,80.38,802,11000,,,80.38
BCN 2520,11000,,,80.38,785,11000,,,80.38
BCN 2456,11000,,,80.38,751,11000,,,80.38
BCN 2454,11000,,,80.38,749,11000,,,80.38
BCN 2450,11000,,,80.38,746,11000,,,80.38
BCN 2446,11000,,,80.38,743,11000,,,80.38
BCN 2441,11000,,,90.38,740,11000
BCN 971,200,,,85,2849,200,,,85
BCN 974,200,,,85,2854,200,,,85
BCN 977,200,,,85,2858,200,,,85
BCN 980,200,,,85,2862,200,,,85
BCN 983,200,,,85,2866,200,,,85
BCN 986,200,,,85,2870,200,,,85
BCN 991,200,,,85,2876,200,,,85
BCN 993,200,,,85,2878,200,,,85
BCN 994,200,,,85,399,11000
BCN 1632,11000,,,,339,11000
BCN 393,11000,,,,1613,11000
BCN 314,11000,,,,350,11000
BCN 1541,1000,,,,1539,1000
BCN 1537,1000,,,,1535,1000
BCN 1534,1000,,,,1548,1000
BCN 1547,1000,,,,1550,1000
BCN 1552,1000,,,,1554,1000
BCN 2132,1000,,,,2129,1000
BCN 2124,1000,,,,2018,1000
BCN 1993,1000,,,,1992,1000
BCN 1990,1000,,,,1978,1000
BCN 1959,1000,,,,1927,1000
BCN 1910,1000,,,,1893,1000
BCN 1874,1000,,,,1877,1000
BCN 1861,1000,,,,1848,1000
BCN 1827,1000,,,,1822,1000
BCN 1809,1000,,,,1796,1000
BCN 1703,1000,,,,1770,1000
BCN 1608,1000
BCN,83,12,14,123000,751,31000,-18.15,-14.80
BCN 2454,31000,-18.15,-14.80
BCN,83,12,14,130000,785,31000,-18.15,-14.80
BCN 2456,31000,-18.15,-14.80,,749,31000,-18.15,-14.80
BCN,83,12,14,133000,2520,31000,-18.15,-14.80
BCN 2450,-18.15,-14.80,,746,31000,-18.15,-14.80
BCN,83,12,14,140000,802,31000,-18.15,-14.80
BCN 2446,31000,-18.15,-14.80
END OF FILE
```

Figure F8. RMA-2V input file dynamic run started from HOTSTART

100. The change in boundary conditions with time for the dynamic simulation is recorded on the BCN cards. The first list of BCN cards is the initial or steady-state boundary conditions in which every node is specified. This list must be included whether or not the steady-state conditions are to be run. In the next list are the boundary conditions tht change during the second time-step. Boundary lists are separated by time and date specifications. The boundary condition lists continue through the simulated time frame. This same boundary list is used for all the dynamic runs regardless of beginning or ending time step.

101. After the last BC Card in the data set for time zero is placed the first BC Card for the end of time-step 1 (the end of the first computation time interval). The program will key on date/time data to detect the start of each new set (time-step) of BC cards. Moreover, only the nodes where BC values have changed need to be coded, and sequence is not important except for easy reference by the user. Figure F8 illustrates coding and placing BC Cards in proper sequence. The first card in each set starts out

BCN,83,12,14,

followed by the time in hours, minutes, and seconds (i.e., 120000,123000, and 130000, respectively

102. Timing controls on the TZ Card show DT and TMAX to be 0.5 and 1.0, respectively. That is, the duration of the simulation hydrograph is 1.0 hr and the computation time-step is 0.5 hr. Iteration control on the TI card shows a value of 0 for the initial solution and 2 for each solution thereafter (which was computed during the coldstart run). This instructs the program to make two dynamic iterations through the Newton-Raphson convergence procedure, which is satisfactory for this problem and works for most. However, some experimentation is required in each study to establish the number of iterations.

PART V: TESTING PROCEDURES

103. Steps used in applying RMA-2V for a typical problem are shown in Table 2 of the main body of this report. That table is reproduced here as Table F4. Steps 1 through 10 deal with creating a computational mesh. Steps 11-13 use initial runs of RMA-2V to complete debugging of the mesh by locating leaks and oozes. Step 14 tests the capability of the mesh and of the input RMA-2V parameters to handle the flows and gradients that are typical of the planned application.

104. A sample job sheet to use in recording job submission for RMA-2V is reproduced at the end of the appendix. Systematic use of a logbook using this jobsheet form or one like it is strongly recommended for efficient use of the program.

Leaks and Oozes

105. Leaks are caused by errors in the geometry file. If a node or element is omitted or misplaced in the element connection tables, water will flow out of the mesh as if it were an outflow boundary. These errors and missing boundary condition specifications are detected by a leak test. A leak test is performed by setting a horizontal pool in the model and specifying that no inflow occurs. (Specify elevation at tailwater boundaries and zero discharge at inflow boundaries.) The initial leak test should be performed with four iterations, steady-state, and a flat bottom--all bed elevations at the same value. If a boundary node has been left unspecified, or if an error has been made in the element connection table, the leak will be vividly portrayed by substantial velocities within the mesh. Single leaks can be identified by examining standard printed output. The maximum convergence parameter will be at or adjacent to the leak. Multiple leaks are more difficult to trace because they can make the entire mesh behave wildly. In those cases, plots can be used to locate the highest velocity magnitudes and thus the leaks. Several correction-retest cycles may be needed to identify and eliminate all leaks.

106. After the flat bottom leak test has been successfully executed, actual bed elevations should be specified at all corner nodes and the leak test repeated. Usually, this test will not show any strong leaks but may demonstrate oozes. Oozes are caused by poorly formed curved boundaries and some combinations of element shape and depth change. They can be identified by persistent small currents that occur during an otherwise successful leak test. The precise causes of oozes are not often obvious, so the procedures for eliminating them are largely experimental. The first step should be to smooth bed elevations and/or to increase resolution (more elements) in the vicinity of the ooze. If element sizes change dramatically near an ooze, try making size changes between adjacent elements more gradual.

Check curved element sides to avoid needle-like corners and very tight curves. See Appendix D: Network Generation for a discussion of curved boundaries.

Flow Stability

107. After leaks and oozes have been banished from the model, test steady-state flows of about the magnitude to be used in production work. Run a flat bottom test first. If the model runs to a stable condition, plot vectors to see if the flow patterns appear reasonable. Nonstable solutions or discontinuous flow patterns indicate inadequate resolution in the mesh, a poor choice of boundary condition specifications, or unsuitable values for eddy viscosity and/or bottom roughness. Some experimentation (for example, see paragraphs 50-59) is required to solve such problems.

108. As described earlier, the water level (head) boundary condition specification of type 200 may not be exactly satisfied in the fully converged solution. Calculated heads should closely approximate (within 0.2 ft) the value specified. If they do not, the conditions are improperly posed. The problem may arise from a boundary that is near a flow obstruction, in a divergence, convergence, or channel curve. If so, the boundary must be relocated. Model results should not be used if large differences between calculated and specified water levels occur.

Verification

109. Adjustment of parameters to verify the model to observed prototype data is a trial-and-error process. Several guidelines should be followed.

- a. Do not assume that field data are correct. Examine them carefully to ensure reasonableness, consistency, and absence of contamination by unmodeled processes (wind, etc.). A suspicious attitude toward all field data is essential.

- b. Change only one model parameter (roughness, geometry, etc.) in each run and make careful, systematic notes of the change and its effect on the results.

- c. When changing a parameter for the first time, change it by more than you feel is needed so that its effect is pronounced and the appropriate value is bracketed. For example, if the first test used a Manning's coefficient of 0.020 and you want to increase it, first try 0.050, then decide on an intermediate value.

- d. In unsteady flow problems, watch for spin-up time. Don't use results from the spin-up period.

Table F4

Summary of Steps for a Typical Applications

1. Prepare statement of purposes and end products desired.

2. Assemble available prototype information -- charts, maps, flow measurements, etc.

3. Sketch mesh limits and element layout.

4. Refine mesh sketch, number nodes and elements (manually or by AUTOMSH), and set up connection table.

5. Establish boundary condition nodes.

6. Identity nodes on curved boundaries and assign slopes.

7. Digitize manually developed mesh or region boundaries for automatic mesh generation.

8. Edit and merge files for GFGEN input.

9. Run GFGEN or (EDGRG), then edit slope error problems.

10. Rerun GFGEN until all major slope errors are fixed and network is reordered efficiently.

11. Create RMA-2V run control file for steady-state, flat-bottom leak test and run.

12. If mesh leaks, correct problems.

13. Install actual bed elevations, then rerun leak test. Correct leaks and oozes.

14. Run steady flow tests with flat bottom, then repeat with actual bed elevations. Correct any problems.

15. Run RMA-2V verification tests.

16. Run RMA-2V base test.

17. Create STUDH run control file with inerodible bed and constant boundary concentrations. Run short test, and correct any problems that occur.

18. Modify STUDH run control file to show desired bed condition and initial and boundary conditions. Run initial test and correct any problems that appear.

19. Run STUDH verification tests.

20. Run STUDH base tests.

Table F4 (Concluded)

21. Revise computational mesh as needed for plan to be tested.

22. Run RMA-2V plan tests.

23. Produce graphical and tabular hydrodynamic results output.

24. Run STUDH plan tests.

25. Produce graphical and tabular sedimentation results output.

26. Report results.

REFERENCES

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Wang, D. P. 1979 (May). "Wind-Driven Circulation in the Chesapeake Bay, Winter, 1975," Journal of Physical Oceanography.

Bretschneider, C. L. 1966. "Wave Generation by Wind, Deep and Shallow Water," in Estuary and Coastline Hydrodynamics, A. T. Ippen, editor, McGraw-Hill, New York.

Vreugdenhil, C. B. 1973. "Secondary Flow Computations," Publication No. 114, Delft Hydraulics Laboratory Delft, The Netherlands.

04/85

RMA-2V JOB SHEET

JOB EXECUTED ________ DATE OF RUN __/__/__ TIME OF RUN _____

JOB PRINTED ________ SUBMITTED BY ________ SBUS _____PRI=____

* *

PURPOSE: ____

____

____

____

* *

INPUT DATA

FILES: CODED INPUT = __________ , GFGEN = __________

CODE24 = __________ BC FILE = __________

HOTSTART = __________

ITERATIONS:

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22

23	24	25	26	27	28	29	30

BACKGROUND CONSTANTS:	IMAT	1	2	3	4	5	6	7	8	9
	EXX									
	EXY									
	EYX									
	EYY									
	"N"									

* *

OUTPUT DATA

FILES: RMA-2V = __________ HOTSTART = ______________

* *

RMA-2V JOB SHEET (CONTINUED)

GRAPHICS OUTPUT

VPLOT: RUN ____________ DATE _____________ SBUS ____________

TIME STEP
PLOTTED:

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22

23	24	25	26	27	28	29	30

* *

ADDENDUM F-1: CARD IMAGE INPUT DATA CODING INSTRUCTIONS

1. This description of input data is written in the language for a standard eight-column format in which the first two columns are reserved for "Card Group" and "Data Type" alpha-characters, respectively. These two columns are considered to be field 0. The rest of field 1, columns 3 through 8, is read in several combinations of columns. The instructions use the following syntax: "1,Cxx" where the "1" refers to field 1, "C" to the column and the "xx" are column numbers.

2. Of the cards shown in the following table, network (mesh) data are prepared by GFGEN are not usually input as card image data. The other cards are prepared here. The sequence of cards should be in the order shown in Table F-1-1. Input variables are summarized in Table F-1-2.

3. Either free field or the standard eight-column card fields are permitted with the default being to free field. In standard eight column fields, unneeded variables can be omitted, but in free field unneeded variables are depicted by commas. Card image input is summarized in Table F-1-3 following the input instructions.

Table F-1-1

RMA-2 Version 3.2 Data Card Sequence

Card	Content	Required
T1-T3	TITLE CARDS	1+
$F	FORMATTED DATA SET	
$L	INPUT/OUTPUT FILE NUMBERS	NO
TR	TRACE PRINTOUT CONTROLS	NO
G1	GEOMETRY, GENERAL GEOMETRY PARAMETERS	YES
GC	GEOMETRY, CONTINUITY CHECK LINES	NO
GD	GEOMETRY, DRY NODE CAPABILITY	YES
GE	GEOMETRY, ELEMENT CONNECTION TABLE	NO
GT	GEOMETRY, ELEMENT CONNECTION TABLE	IF GE PRESENT
GV	GEOMETRY, EDDY VISCOSITY TENSOR	IF GE PRESENT
GN	GEOMETRY, NODAL POINT COORDINATES	IF GE PRESENT
GY	GEOMETRY, BOTTOM ELEVATIONS	IF GE PRESENT
TZ	TIMING, TIME ZERO	YES
TI	TIMING, NUMBER OF ITERATIONS COUNTER	YES
FT	FLUID PROPERTIES, TEMPERATURE	YES
HN	HYDRAULICS, MANNING N-VALUES	YES
EX	TURBULENT EXCHANGE COEFFICIENTS, E, X-PLANE	YES
EY	TURBULENT EXCHANGE COEFFICIENTS, E, Y-PLANE	YES
IC	INITIAL CONDITIONS, WATER-SURFACE ELEVATION	YES
BC	BOUNDARY CONDITIONS	*
BA	BOUNDARY, AZIMUTH OF FLOW	*

(continued)

* EITHER BC-CARDS OR COMPARABLE DATA ON BA-BT CARDS

Table F-1-1 (Concluded)

Card	Content	Required
BS	BOUNDARY, CURRENT SPEED	*
BH	BOUNDARY, WATER-SURFACE ELEVATION	*
BU	BOUNDARY, U-VELOCITY	*
BV	BOUNDARY, V-VELOCITY	*
BT	BOUNDARY, TYPE OF BOUNDARY CONDITIONS	*
BW	BOUNDARY, SURFACE WIND FIELD	NO

*EITHER BC-CARDS OR COMPARABLE DATA ON BA-BT CARDS

Table F-1-2

Input Variables

Variable	Description	Card
AO	THE BOTTOM ELEVATION OF EACH NODE	GY
AZI	THE AZIMUTH OF CURRENT DIRECTIONS, BOUNDARY CONDITION NODES	BA
CORD	THE (X,Y) COORDINATES OF THE NODE	GN
DSET	THE WATER DEPTH AT WHICH A WET NODE IS CONSIDERED TO BECOME DRY	GD
DSETD	THE WATER DEPTH AT WHICH A DRY NODE BECOMES REWET	GD
DELT	LENGTH OF COMPUTATION TIME-STEP	TZ
ELEV	THE AVERAGE INITIAL WATER-SURFACE ELEVATION OVER THE MESH	IC
IBUP	LOGICAL UNIT NUMBER FOR DYNAMIC BOUNDARY CONDITIONS INPUT TO RMA-2V	$L
ICG	CARD GROUP IDENTIFIER, ALL CARDS	ALL
IDT	DATA TYPE IDENTIFIER, ALL CARDS	ALL
IFILE	LOGICAL UNIT NUMBER FOR GFGEN GEOMETRIC DATA FILE	SL
IMAT	THE ELEMENT TYPE (N-VALUE AND EDDY COEFFICIENTS)	GT
IPLI	SWITCH TO CONTROL PRINTING OF RESULTS AFTER EACH ITERATION IN RMA-2V	TR
IPRT	SWITCH TO PRINT ELEMENT INPUT DATA, INITIAL CONDITIONS AND N-VALUES	TR
ISET	NUMBER OF CORNER NODES ON CONTINUITY LINE	GC
ISI	INPUT SPECIAL CODING INFORMATION (I.E., READ FROM COLUMN 3 TO DETECT IF DATA ARE CODED BY NODE OR JUST A CONSTANT FOR ENTIRE MESH)	ALL

(continued)

Table F-1-2 (Continued)

Variable	Description	Card
ITSI	NUMBER OF TIME-STEPS BETWEEN SUCCESSIVE PRINTOUTS	TR
FLD	INPUT VARIABLE DATA ON EACH CARD ARE READ INTO THE FLD ARRAY AND LATER PLACED INTO THE PROPER VARIABLE NAME FOR USE IN RMA-2	ALL
LI	THE NUMBER OF ITERATIONS BETWEEN CHECKS FOR DRY NODE	GD
LINE	CORNER NODE NUMBERS FOR CONTINUITY CHECK	GC
MBAND	FLAG TO TELL PROGRAM A RUN STARTS IN THE MIDDLE OF CONVERGENCE ITERATIONS	TZ
NB	LOGICAL UNIT NUMBER FOR FILE CONTAINING INITIAL CONDITIONS	$L
NBX	NUMBER OF NODES WITH BOUNDARY CONDITIONS SPECIFIED	GI
NCBC	NUMBER OF TIME-STEPS BETWEEN BOUNDARY CONDITION DATA, DYNAMIC RUN	TZ
NFIX	ARRAY CONTAINING LOGIC FLAGS FOR BOUNDARY CONDITION DATA TYPE	BC,BA-BH
NITI	NUMBER OF ITERATIONS FOR INITIAL SOLUTION (OR STEADY-STATE COMPUTATION)	TI
NITN	NUMBER OF ITERATIONS FOR EACH DYNAMIC COMPUTATION	TI
NITND	NUMBER OF ITERATIONS BETWEEN CHECKS FOR DRY NODES, DYNAMIC CASE	GD
NLL	LOGICAL UNIT NUMBER FOR RMA-2V TO WRITE-RESTART FILE	$L
NOP	NODAL POINT-ELEMENT CONNECTION TABLE FOR RMA-2V	GE
NOPT	LOGICAL UNIT NUMBER FOR RMA-2V TO WRITE RESULTS FOR TRANSFER TO STUDH	$L
NSTART	STARTING TIME-STEP NUMBER	TZ
OMEGA	LATITUDE OF MESH (APPROXIMATE AVERAGE)	GI

(continued)

Table F-1-2 (Concluded)

Variable	Description	Card
ORT	EDDY DIFFUSION AND N-VALUE ARRAY BY ELEMENT TYPE	EX,EY,HN
TEMP	AVERAGE INITIAL WATER TEMPERATURE	FT
SIGMA	SURFACE WIND FIELD	BW
SPEC	ARRAY CONTAINING BOUNDARY CONDITION SPECIFICATIONS	BC,BA-BH
TITLE	TITLE CARDS ARE READ INTO ARRAY TITLE	T1-T3
TH	AZIMUTH OF X-DIRECTION OF AN ELEMENT FOR SPECIFYING EDDY DIFFUSION COEFFICIENTS	GV
TMAX	TOTAL TIME FOR SIMULATION	TZ
XMANN	A CONSTANT MANNING N-VALUE FOR RMA-2V DEFAULT LOGIC	HN
XSCALE	SCALE FACTOR FOR X-COORDINATES	G1
YMANN	MANNING N-VALUE ASSIGNED BY ELEMENT NUMBER	HN
YSCALE	SCALE FACTOR FOR Y-COORDINATES	G1

NOTES:

IECHO - variable in PREHYD defaults to zero and will echo print. A value other than zero, no echo print.

IWIND - variable in PREHYD defaults to zero for no wind data. A value other than zero, wind data are present.

YMANN - if no HNE cards present, YMANN is set to ORT(IMAT(NOP (1,1)) ≠ 0, otherwise YMANN is set to XMANN. Only one value of YMANN is set for the above conditions.

T1-T3 CARDS Job Title One Required

Any number of T1 and T2 cards may be used and sequence is not significant. Only one T3 card may be used, and it must be the last title card in the set. The program reads the "3" as meaning END OF T CARDS.

Field	Variable	Value	Description
*0, C1	ICG	T	
0, C2	IDT	1,2,3	
1, C3-8	FLO(1)	Any	Any alpha-numeric data
2-10	TITLE	Any	Any alpha-numeric data

$F CARD Formatted or Free Field Input Optional

Card is required for formatted input data. Card must be left out for free field input.

Field	Variable	Value	Description
0, C1	ICG	$	
0, C2	IDT	F	

SL CARD I/O Data Logical Unit Numbers Optional

Card image data described in these pages are read from logical unit (LU) 5 (LU) 7 and the ECHO PRINT is (LU) 6.

Field	Variable	Value	Description
0,C1	ICG	$	
0,C2	IOT	L	
2	NB	0	Initial conditions for RMA-2V will be coded in this data set.
		1	Initial conditions will be read from logical unit #1 - a HOTSTART is requested.
3	NTL	0	No HOTSTART file will be written.
		2	RMA-2V will write a HOTSTART file on logical unit #2.
4	IFILE	0	Geometric data and grid will be coded in this data set and passed to RMA-2V on LU #5.
		14	Geometric data and grid will be attached on logical unit 14 for RMA-2V.
5	NOPT	0	RMA-2V will not save results for STUDH or the other utilities.
		22	RMA-2V will write results of hydraulic calculations (x-velocity, y-velocity, and water-surface elevations on logical unit 22.
6	IBUP		The logical unit on which dynamic boundary conditions will be input to RMA-2V.
		5	Same file as run control.
		99	Different file (LU 99) from run control.

TR CARD TRACE Printout Control Required

Field	Variable	Value	Description
0, C1	ICG	T	
0, C2	IDT	R	
2	IPRT		Control for output printing:
		0	Node and element input data suppressed
		1	All input data printed except initial conditions
		2	Initial conditions from restart
		3	Manning's n-value table
3	ITSI		No. of time-steps between successive prints
		0	0; all time-steps are printed
		2	Every other time-step
		3	Every third time-step
		+	Etc.
4	IPLI		Switch to control printing of iterations
		0	All iterations printed during convergence
		1	Only last iteration printed

G1 CARD Grid, General Geometry Parameters Required

Field	Variable	Value	Description
0, C 1	ICG	G	
0, C 2	IDT	1	
2	OMEGA	0,+	Local average latitude degrees
3	XSCALE	0,+	Scale factor for X-coordinates. Default is 1.0
4	YSCALE	0,+	Scale factor for X-coordinates. Default is 1.0
5	NBX	+	Number of nodes with boundary conditions specified
6	AZIX		Azimuth of the positive direction of the x-axis
		0	Defaults to 90 degrees
		+	Enter azimuth of positive direction of x-axis in degrees

GC CARD | Continuity Calculation | Optional

Flow continuity can be calculated at up to nine lines across part or all of the grid. Prescribe the boundary line first since that line is used in calculating the percents displayed on all subsequent lines. Code corner nodes only. Code all lines in the same direction; otherwise, sign changes will occur in the printout. In general, code right to left when facing downstream. The first list should be the inflow boundary because it will be assumed to 100%.

Field	Variable	Value	Description
0,C	1 ICG	G	
0,C	2 IDT	C	
2	ISET(K)	+	Number of values specified for this set of GC cards. Up to 16 values may be input.
3-10	LINE(K,J)	+	Corner node $number_1$, . . . $number_8$. If a continuation card is needed (>8 numbers in formatted input), start in field 1.

GD CARD — Grid, Dry Node Capability — Required

Field	Variable	Value	Description
0, C 1	ICG	G	
0, C 2	IDT	D	
2	DSET	+	Water depth below which a node is considered "dry" by RMA-2V (.275 ft is recommended)
3	LI		Number of iterations between checks for dry nodes.
		0	0 prevents dry node calculations
		2	Recommended
4	DSETD	+	Water depth at which a dry node is considered to become wet again by RMA-2V. (0.4 ft is recommended)
5	NITND	+	No. of dynamic calculation iterations to use when wetting and drying is turned on.
6	DSETCK	+	Criterion for deciding when adequate convergence on depth has occurred and iterations can be terminated. (0.5 is recommended)
7	DVEL	+	Residual flow speed assigned to dry elements. (0.2 fps is recommended)

GE CARD Grid, Element Connection Table Optional

The element connection table will usually be provided by this grid preprocessor and will reside on logical unit 14. If so, this card should be omitted. Otherwise, code the Nodal Point-Element Connection Table.

Field	Variable	Value	Description
0, C 1	ICG	G	
0, C 2	IDT	E	
2	J	+	Element number
3-10	NOP(J,K)	+	Up to 8 node numbers for element J, listed counterclockwise around the element STARTING FROM ANY CORNER. Can input NE number of GE CARDS.

GT CARD Grid, Element Types Required if GE card present

Field	Variable	Value	Description
0, C 1	ICG	G	
0, C 2	IDT	T	
1,C 56&78	FLO(1)	+	Year and month (i.e., 8302 = 1983, month #2)
2	FLD(2)	+	Day, hour, minute, and second code a 2-digit number for each (i.e., 01 07 00 00, respectively)
3	J	+	Element number
4	IMAT(J)	+	Element type
5-10		+	Need as many (J, IMAT(J) sets) as GE cards present. If > 4 sets, use continuation cards and start in Field 1.

04/85

GV CARD — Grid, Eddy Viscosity Tensor — Required if GE card present

Field	Variable	Value	Description
0, C 1	ICG	G	
0, C 2	IDT	V	
4-8	FLO(1)	+	Year and month
2	FLO(2)	+	Day, hour, minute, and second
3	J	+	Element number
4	TH(J)	-,0,+	Direction of eddy viscosity tensor
5-10			Need as many (J, TH (J) sets) as GE Cards present. If >4 sets, use continuous cards and start in Field 1.

GN CARD — Grid, Nodal Point Coordinates — Required if GE or GY card present

The coordinate values read are multiplied by the appropriate scale factors, XSCALE and ZSCALE from G1-CARD, and should in the proper X- and Y-coordinates (feet) after transformation.

Field	Variable	Value	Description
0, C 1	ICG	G	
0, C 2	IDT	N	
2	J	+	Node number
3	CORD(J,1)	-,0,+	X-coordinate
4	CORD(J,2)	-,0,+	Y-coordinate
5-10			Continue to fill card in sets of (J, CORD (J,1), CORD(J,2)) thru Field 10. If sets >3, use continuation cards and start in Field 2. Leave Field 1 blank except for code GN.

GY Card — Nodal Point Elevation — Optional (one GN card is is required for each GY card)

Field	Variable	Value	Description
0, C1	ICG	G	
0, C2	IDT	Y	
1, C3	ISI	ƀ	Constant elevation for entire mesh.
		C	Elevations by corner node. Mid side values are calculated by straight line interpolation.
		N	Elevations by nodal point.
1, C7,8	FLD(1)	+	Last 2 digits of year for data on this card.
1, C7,8	FLD(1)	+	Month number.
2	FLD(2)	+	DAY/HOUR/MINUTE/SECOND as one continuous value, 2 digits for each.
3	I	+	Node number.
4	AO(I)	+	Elevation at node I.
5	etc.		Continue coding (node number elevation) sets.
			To continue on another GY card, code the number in Field 1 and its elevation in Field 2 . . . etc.

TZ CARD | Computation Time | Required

Field	Variable	Value	Description
0, 1	ICC	T	
0,C 2	IDT	Z	
2	FLD(2)	+	Year of time zero (i.e., 1983)
3	FLD(3)	+	Month of time zero (Jan = 01)
4	FLD(4)	+	Day of time zero (i.e., 01)
5	FLD(5)	+	Hour, minute, and second for time zero. Code as two digits each. End with period unless right justifies.
6	DELT	+	DT = length of the computation time interval for dynamic run, hours.
		0	Leave blank for steady-state conditions.
7	TMAX	+	Ending time for the dynamic run in hours.
		0	Leave blank for steady-state conditions
8	NCBC	1	Number of computation time-steps between boundary condition values. (Must be 1 in this version of RMA-2V)
9	NSTART	+	The number to use when resuming a run. RMA-2V will skip down in the boundary conditions file until it reaches the "NSTART" set and read those to resume computations. For HOTSTART runs, this should be equal to the last time-step of the prior run plus 1.
		0	The previous run time step.
10	MBAND	0	Initial run or restarting on the first iteration in the convergence scheme.
		1	Restart at an intermediate iteration in the convergence scheme.

TI CARD Number of Iterations Required

Field		Variable	Value	Description
0,	1	ICG	T	
0,C	2	IDT	I	
2		NITI	+	Number of iterations for initial solution
3		NITN	+	Number of iterations for each time-step after the first one in a dynamic run

FT Card Water Temperature Required

Field	Variable	lue	Description
0, 1	ICG	F	
0,C 2	IDT	T	
2	TEMP	+	Average initial water temperature (^{o}C)

HN CARD — Manning N-Value — Required

Three options are available for coding n-values as explained below. They key on variable ISI: Option 1 = a constant value for the entire grid; 2 = a value by element type; or 3 = a value by element number. These options are listed in the sequence which they should be coded, and their priority is that option 3 overrides 2 and option 2 overrides 1 upon execution.

Field	Variable	Value	Description
0,C 1	ICG,IDT	H	Card type = hydraulic parameter
0,C 2		N	Data type = n-values
1,C3	ISI		Option 1 = REQUIRED constant n-value for entire grid
		T	Option 2 = n-value prescribed by element type
		E	Option 3 = n-value prescribed by element number
1,$C_{4,5}$	FLD(1)	+	Last row digits of year for data on this card
1,$C_{6,7}$	FLD(1)	+	Month number for data on this card
2	FLD(2)	+	Code a 2-digit number for each of the following - day, hour, minute, second
3	FLD(3)	+	As appropriate option suggests, code element type, number of element, or number for the n-value (Option 1)
4	FLD(4)	+	Code the number
5	FLD(5)	+	Code the next element type number or element number
6	FLD(©)	+	Code the n-value corresponding to FLD(5)
			Continue coding sets of (type vs n) or (element no. vs n). If more than 4 are required, continue on an HN Card starting in Field 1.

EX Card — Turbulent Exchange Coefficient, X-plate — Required

Turbulent exchange coefficients should be coded by element type. In equation notation the value for E_{xx} and for E_{xy} are coded on this card.

Values for E_{yx} and E_{yy} are coded on the EY-cards.

Field	Variable	Value	Description
0, 1	ICG		
0,C 2	IDT		
2	J	+	Element type number for the set of turbulent exchange coefficients
3	ORT(J,1)	+	Turbulent exchange coefficient E_{xx} = the x-direction in the x-plane (lb-sec/ft^2)
4	ORT(J,2)	+	Turbulent exchange coefficient $E_{x}y$ = the y-direction in the x-plane (lb-sec/ft$^{2)}$
5-10		+	Continue to fill card in sets of (J,ORT(J,1), ORT(J,2)) thru field 10. If sets >3, use continuation cards and start in field 2. Leave Field 1 blank except for code EX.

EY CARD Turbulent Exchange Coefficient, Y-plane Required

Field	Variable	Value	Description
0, 1	ICG	E	
0,C 2	IDT	Y	
2	J	+	Identification number for a set of turbulent exchange coefficients
3	ORT(J,3)	+	Turbulent exchange coefficient E_{yx} = the x-direction in the z-plane ($lb\text{-}sec/ft_2$)
4	ORT(J,4)	+	Turbulent exchange coefficient Eyy = the y-direction in the z-plane ($lb\text{-}sec/ft_2$)
5-10		+	Continue to fill card in sets of (J,ORT(J,3), ORT(J,4)) thru field 10. 1ᶠ sets >3, use continuation cards and start in Field 2. Leave Field 1 blank except for code EZ.

See instructions for the E_{xx} and E_{xy}.

IC CARD Water-Surface Elevation Required

Field	Variable	Value	Description
0, 1	ICG	I	
0,C 2	IDT	C	
2	ELEV	+	Average initial water-surface elevation (ft)

BC CARD　　　Boundary Conditions　　　Optional

The three required boundary conditions (BC) parameters can be coded on this card type: U-velocity, V-velocity, and head. In addition, a five-digit number that tells the program the parameter type is coded as well as the nodal point number. Code one BC set for each boundary node. Stack BCN card after BC b̸ cards when using more than one option. Both corner and mid-side boundary nodes require boundary conditions.

Field	Variable	Value	Description
0,C 1	ICG	B	Card group identifier
0,C 2	IDT	C	Data type identifier
1,C3	ISI	b̸	Use the BC on this card for all boundary nodes equal to or greater than the one specified in FLD(6)
		N	Sets the BC at the specified node number
1,C4-8		blank	
2	YEAR	+	Code the 4 digit year (i.e., 1983)
3	MNTH	+	Code the 2 digit month number
4	DAY	+	Code the 2 digit day number
5	TIME	+	Code hour/minute/second as a 6 digit value (i.e., 1:30 p.m. = 133000)
6	J	+	Code the node number for the BC in FLDS 7-10
7	NFIX(J)		This 5 digit number tells RMA-2 what type of boundary condition to use. Decoding zeros are not required.
		1000	Slip boundary at this node.
7C52		0	X-velocity will be calculated
		1	X-velocity is specified in FLD(8)
		3	Nonzero X-unit discharge is specified in FLD(8)
7C53		0	Y-velocity will be calculated
		1	Y-velocity or Y-unit discharge is specified in FLD(9) (if the x-unit discharge is zero, a 3 should be used)
7C54		0	Water-surface elevation will be calculated
		2	Water-surface elevation is specified in FLD(10)
7C55		0	Always

BC CARD (Continued)

Field	Variable	Value	Description
7C56		0	Always
8	SPEC(J,1)	-,0,+	The x-component of velocity or unit discharge, ft/sec or $ft_3/sec/ft$
9	SPEC(J,2)	-,0,+	The y-component of velocity or unit discharge, ft/sec or $ft_3/sec/ft$
10	SPEC(J,3)	-,0,+	Water-surface elevations, ft

BA CARD Boundary, Azimuth of Flow Optional

Alternatives to the BC-Card are sets of cards (BA - BS or BQ - BH) or (BU - BV - BH) on which the same three boundary parameters are coded as on the BC-cards, but they are coded in alternate formats which may be more convenient. The first set allows an azimuth to be used along with a current or discharge to establish the inflowing velocity components: BA-card = azimuth of the boundary velocity vector; BS = speed of the boundary velocity, and BH = the water-surface elevations. The BQ-card can be used in place of BS. The value of NFIX is determined by the program based on card types present. The BA-card should precede the others and azimuths on it will be used to calculate either velocity components or unit discharge components until another BA-card is read. Only those values which differ from previous values must be changed.

Field	Variable	Value	Description
0,C 1	ICG	B	Card group identifier
0,C 2	IDT	A	Data type identifier
1,C3	ISI	b̸	The azimuth on this card is for all boundary nodes equal to or greater than FLD(3).
		N	The azimuth is coded by node.
1,C5,6	YEAR	+	Code the last 2 digits of the year for this data
1,C7,8	MNTH	+	Code the month number (01 to 12)
2	DAY/TIME	+	Code the DAY/HOUR/MINUTE/SECOND as a continuous 8-digit number
3	J1	+	Node number for azimuth in FLD(4)
4	AXI1	0,+	Code the azimuth, in degrees and decimals of a degree, of the velocity vector (or unit discharge vector). Grid orientation is defined on the GI-card.
5	J2		
6	AZI2	0,+	Etc.
			Begin continuation BA-card in FLD(1)

BS-CARD Boundary Current Speed Optional

The magnitude of the velocity vector is coded on this card type. The input data program will convert BS data to U- and V-velocity components using the azimuth on the preceeding BA-card. Sign of the component is calculated from its azimuth and the specified grid orientation (GI-Card). NFIX is assigned a value of 11x00 at each node having a BS value where the x denotes a value to be assigned by presence of BH-card data.

Field	Variable	Value	Description
0,C1	ICG	B	Card group identifier
0,C2	IDT	S	Data type identifier
1,C3	IS1	b̸	Use the boundary condition (BC) in FLD(4) for all boundary nodes equal to or greater than FLD(3)
		N	The node number is coded for each BC value on this card
1,C5,6	YEAR		Code last 2 digits of the year for data on this card
1,C7,8	MNTH		Code 2 digit month number (i.e., 01)
2	DAY/TIME		Code DAY/HOUR/MIN/SEC as a single 8 digit number (i.e., 07 10 15 00 for 10:25 a.m. on Day 7)
3	J1	+	Node number
4	VVEC1	0,+	Current speed in fps at node J1. Sign will be determined from the azimuth of the vector
5	J2		Next node
6	VVEC2		Current speed at node J2, fps
			Etc.
			Begin continuation card with node number in FLD(1).

BQ CARD | Boundary, Unit Discharge | Optional

This card type can be used instead of the BS-cards. The program will assign NFIX as 33x00 where the x denotes the values to be assigned by BH card data.

Field	Variable	Value	Description
0,C1	ICG	B	Card group identifier
0,C2	IDT	Q	Data type identifier
1,C3	ISI	ƀ	Use the unit discharge in FLD(4) for all boundary nodes equal to or greater than FLD(3)
		N	The node number is coded for each BC value on this card
1,C5,6	YEAR	+	Code the last 2 digits of the year for data on this card
1,C7,8	MNTH	+	Code the 2 digit month number
2	DAY/TIME	+	Code DAY/HOUR/MINUTE/SECOND as a continuous, 8-digit number
3	J1	+	Node number
4	QVEC1	0,+	The unit discharge, cfs/ft, at node J. The program will calculate QU- and QV- unit discharge vectors from QVEC by using the azimuth on the preceding BA-card. NFIX is automatically set to 3. The sign of QU- and QV- is calculated from azimuth and grid orientation.
5	J2	+	Next boundary node
6	QVEC2	0,+	The unit discharge at J2
			Begin continuation cards with node number in FLD(1).

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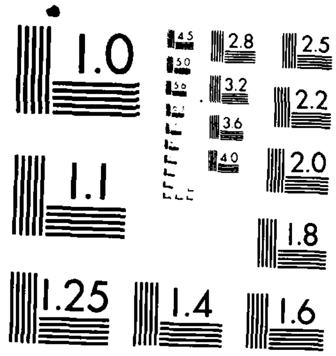

MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

BH-CARD | Boundary, Head | Optional

As an alternate to BC-Cards, the water-surface elevation should be coded on this BH-Card type when BC-Cards are not being used. NFIX is assigned xx200 at each node where BH data exist with the xx's denoting values to be assigned by BS, BQ, BU, or BV cards.

Field	Variable	Value	Description
0,C1	ICG	B	Card group identifier
0,C2	IDT	H	Data type identifier
1,C3	ISI	ƀ	The water surface elevation on this card will be used for all boundary nodes equal to or greater than FLD(3). (Be careful not to over specify the water surface!)
		N	The water surface BC is coded by node
1,C5,6	YEAR	+	Code the last 2 digits of the year for this date
1,C7,8	MNTH	+	Code the month number
2	DAY/TIME	+	Code the day/hour/minute/second as a single 8-digit number (i.e., 1:45 a.m. on 2 Jan would be 02014500)
3	J1	+	Node number for water-surface elevation in FLD(4)
4	SPEC(J,3)	-,0,+	Water-surface elevation in ft
5	J2	+	Etc.
			Begin continuation card with node number in FLD(1)

BU-CARD | Boundary, U-Velocity | Optional

Code the x-component of velocity.

Field	Variable	Value	Description
0,C1	ICG	B	Card group identifier
0,C2	IDT	U	Data type identifier
1,C3	ISI	ɓ	The U-velocity on this card is for all boundary nodes equal to or greater than FLD(3)
		N	The U-velocity is coded by node number
1,C5,6	YEAR	+	Code the last 2 digits of the year for this data point
1,C7,8	MNTH	+	Code the month number (01 to 12)
2	DAY/TIME	+	Code the Day/Hour/Minute/Second as a continuous 8-digit number
3	J1	+	Node number for the velocity in FLD(4)
4	SPEC(J,1)	-,0,+	Code the x-component of the velocity. The positive direction of the x-axis is the +U direction
5	J2		Etc.
			Begin continuation BU card with node number in FLD(1).

BV CARD | Boundary, V-velocity | Optional

Code the Y-component of velocity

Field	Variable	Value	Description
0,C1	ICG	B	Card group identifier
0,C2	IDT	V	Data type identifier
1,C3	ISI	ɓ	The V-velocity on this card is for all boundary nodes equal to or greater than FLD(3)
		N	The V-velocity is coded by node number
1,C5,6	YEAR	+	Code the last 2 digits of year for this data point
1,C7,8	MNTH	+	Code month number (01 to 12)
2	DAY/TIME	+	Code the Day/Hour/Minute/Second as a continuous 8-digit number
3	J1	+	Node number for the velocity in FLD(4)
4	SPEC(J,1)	-,0,+	Code the Y-component of the velocity. The positive direction of the Y-axis is the +V direction
5	J2		Etc.
			Begin continuation BU card with Node Number in FLD(1).

BT-CARD | Boundary Type | Optional

The RMA-2 program expects each boundary node to have been assigned a 5-digit number specifying the type of boundary condition data to be prescribed. The variable name is NFIX. Suppos NFIX = abcde. The "a" digit describes x-direction flow or velocity; the "b" digit describes y-direction flow or velocity; the "c" digit describes head and digits "d" and "e" are not presently used but must be present for the number to be complete. Consequently, d = e = 0. Leading zeros are not required. Only use BT card to override the NFIX determined by the Program; consequently, it should be last in the B-card Group sets.

Field	Variable	Value	Description
0,C1	ICG	B	Card group identifier
	IDT	T	Data type identifier
1,C3	ISI	␢	Assign the NFIX value of FLD(4) to all boundary nodes
		N	Assign the NFIX value by node number
1,C5,6	YEAR	+	Code the last 2 digits of the year for this data point
1,C7,8	MNTH	+	Code the month number (01 to 12)
2	DAY/TIME	+	Code the Day/Hour/Minute/Second as a continuous 8-digit number
3	J1	+	Node number for the NFIX in FLD(4)
4	NFIX(1)	abcde	This 5-digit number is read as a real number and partitioned into 5 parts
		1000	Denotes a slip boundary in either direction
		a=1	The U-velocity will be prescribed
		=3	The unit discharge component in the X-direction will be prescribed
		0	The U-velocity will be calculated
		b=1	The V-velocity will be prescribed
		b=3	The unit discharge component in the Y-direction will be prescribed
		0	The V-velocity will be calculated
		c=2	The head (i.e., water surface elevation) will be prescribed
		=0	The head will be calculated
		d=0	Required
		e=0	Required

BW-CARD Wind Velocity Optional

Field	Variable	Value	Description
0,C 1	ICC	B	Card group identifier
0,C 2	IDT	W	Data type identifier
1,C 3	ISI	b̸	The wind data in fields 6 and 7 of this card will be used at all nodes equal to or greater than J1.
		N	Wind data are coded by name
2	FLD(2)	+	Year
3	FLD(3)	+	Month
4	FLD(4)	+	Day, hour, minute, and second
5	J1	+	Node number
6	SIGMA(J,1)		Wind velocity (miles/hour)
7	SIGMA(J,2)		Azimuth of wind vector in degrees
8-10		+	Continue to fill card in sets of (J,SIGMA(J,1) SIGMA(J,2)) thru Field 10. If >2 sets, use continuation BW-card with J starting in FLD(2).

Table F-1-3. Summary of Card Image Input

T1									
T3									
$L									
TR									
G1									
GC	JMAX	LINE	(I,J)						
GC LINE(1,9) LINE		(1,10)							
GC	JMAX	ETC.							
GD									
GE	N	NOP(N,1)	NOP(N,2)	NOP(N,3)	NOP(N,4)	NOP(N,5)	NOP(N,6)	NOP(N,7)	NOP(N,8)
GE									
GT//YRMODAHRSC		N	IMAT(1)						
GT N_5	$IMAT_5$								
GV//YRMODAHRMNSC		N	TH(1)						
GV N_5	TH_5								
GN	J_1	(CORD(J,1)) X	CORD(J,2)) Z	J_2	CORD( )	CORD( )	J_3	CORD( )	CORD( )
GN xxxx	J_4				J_5			J_6	
GY YRMODAHRMNSC		J_1	AO_1	J_2	AO_2				
TZ	YEAR	MONTH	DAY	HRMNSC	DELT	TMAX	NCBC	NSTART	MBAND
TI	NITI	NITN							
FT	TEMP								
HN	XMAN								
HM YRMODAHRMNSC		I_1	YMANN(1)	I_2	YMANN(2)				
HT YRMODAHRMNSC		J_1	ORT(J,5)	J_2	ORT(J,5)				
EX	J_1	ORT(J,1)	ORT(J,2)	J2	ORT(J,1)	ORT(J,2)	J_3	ORT(J,1)	ORT(J,2)
EX	J_4	ORT(J,1) . . .							
EY	J_1	ORT(J,3)	ORT(J,4) . . .						
EY	J_4	ORT(J,3)	ORT(J,4) . . .						
IC	ELEV								
BC YRMODAHRMNSC		J_1	NFIX(J)	SPEC(J,1)	SPEC(J,2)	SPEC(J,3)			
BC	J_2					J_3	ETC.		
BW	YEAR	MONTH	DAHRMNSC	J_1				J_2	
BW	J_3				J_4			J_5	
BW HYMODAHRMNSC		J - WIND SPEED, MPH							

Table F-1-3 (Continued)

BX	YRMODAHRMNSC	- WIND DIRECTION, AZ					
BS		BOUNDARY CONDITIONS, CURRENT SPEED, ps					
BA		BOUNDARY CONDITIONS, AZIMUTH PRESCRIBED, ps, DEGREES FROM TRUE NORTH					
BQ		BOUNDARY CONDITIONS, Q SPECIFIED					
BU		BOUNDARY CONDITIONS, X-VELOCITY SPECIFIED					
BH		BOUNDARY CONDITIONS, HEAD SPECIFIED					
BT		BOUNDARY CONDITIONS, VFIX SPECIFIED					
BW		BOUNDARY CONDITIONS, Y-VELOCITY SPECIFIED					
		FORM OF ALL CARDS AFTER THE BW-TYPE DATA (I.E., BS, BA, BQ, BU, BH, BT, BU)					
BS	YRMODAHRMNSC	J1	(FOS)	J2	FFS	ETC.	PREHYD calculates components for x- & y- and assigns NFIX
BA	YRMODAHRMNSC	J1	A_{o1})	J2	(A_{o2})		

APPENDIX G

A USER'S MANUAL FOR THE GENERALIZED COMPUTER PROGRAM, SEDIMENT TRANSPORT IN UNSTEADY, 2-DIMENSIONAL FLOW, HORIZONTAL PLANE

STUDH

by

William A. Thomas, William H. McAnally, Jr., and Stephen A. Adamec Jr.

PREFACE

The program described herein was developed over the period 1972-1982 at several institutions under funding from a number of sources. The version described herein and preparation of this user's manual was performed at the US Army Engineer Waterways Experiment Station (WES) with funding provided by the Office, Chief of Engineers (OCE), US Army, under the Improvement of Operations and Maintenance Techniques (IOMT) research program.

Original program development was performed by Dr. Ranjan Ariathurai under the direction of Dr. R. B. Krone at the University of California, Davis (UCD). It was extended by Drs. Ariathurai, Krone, and R. C. MacArthur at UCD with funding provided by the US Army Engineer Dredged Material Research Program. The result of that effort was program SEDIMENT II. Enhancements were subsequently made by Dr. Ariathurai while working at Nielson Engineering and Research, Inc., under contract to WES. Funds were provided by the US Army Engineer District, Portland. Major revisions to the program were performed by personnel of WES (in consultation with Dr. Ariathurai) with funds from the OCE research program, IOMT. During the latter stages of program development, Dr. Ariathurai developed new versions of SEDIMENT II called SEDIMENT 4H and SEDIMENT 4H.MLT, also funded by the IOMT program. Some of the features of those programs were then adapted for use in STUDH by WES personnel.

Personnel of the WES Hydraulics Laboratory performed their portion of program development under the direction of Messrs. H. B. Simmons and F. A. Herrmann, Jr., former and present Chiefs of the Hydraulics Laboratory; M. B. Boyd, Chief of the Hydraulics Analysis Division; R. A. Sager, Chief of the Estuaries Division, G. M. Fisackerly, Chief of the Harbor Entrance Branch, and E. C. McNair, Chief of the Sedimentation Branch. Mr. W. A. Thomas designed the program structure, wrote much of the code, and supervised program development. Additional coding was performed by Messrs. W. H. McAnally, Jr., and S. A. Adamec, Jr. Other WES personnel participating in coding and testing were C. B. Berger, B.P. Donnell, J. D. Ethridge, Jr., J. V. Letter, Jr., and R. D. Schneider. Messrs. Thomas, McAnally, and Adamec prepared this report.

Commanders and Directors of WES during preparation of this report were COL Nelson P. Conover, CE, COL Tilford J. Creel, CE, and COL Robert C. Lee, CE. Technical Director was Mr. F. R. Brown.

CONTENTS

APPENDIX G

A USER'S MANUAL FOR THE GENERALIZED COMPUTER PROGRAM, SEDIMENT TRANSPORT IN UNSTEADY, 2-DIMENSIONAL FLOW, HORIZONTAL PLANE

STUDH

Version 3.3

PART I: INTRODUCTION

Purpose

1. This report describes use of the generalized computer program (model), Sediment Transport in Unsteady, 2-Dimensional Flow, Horizontal Plane (STUDH) Version 3.3, dated December 1983. The program STUDH is used to compute transport, deposition, and erosion of sediments in two-dimensional (2-D) open channel flows.

Origin of Program

2. The initial program development was accomplished by Dr. Ranjan Ariathurai (1974) in partial fulfillment of the requirements for his Doctor of Philosophy degree at the University of California, Davis. That work, a 2-D model in the horizontal plane, was extended to include the vertical plane by Ariathurai, MacArthur, and Krone (1977) under contract with the US Army Corps of Engineers, Dredged Material Research Program. Dr. Ariathurai consulted with Waterways Experiment Station (WES) personnel duringthe early testing phases of the program during which time he made several enhancements to the program.

3. Starting with that basic work, WES personnel and Dr. Ariathurai produced the code described in this manual. Dr. Ariathurai subsequently developed several new versions of the models with funding from WES. Selected features of those mode.s have been adopted and placed in this model.

Potential Applications

4. STUDH can be applied to clay and/or sand bed sediments where flow velocities can be [illegible], i.e., the speed and direction can be satisfactorily represented as a depth-averaged velocity. It is useful for both deposition and erosion studies and, to a limited extent, for [illegible] studies. The program

treats two categories of sediment--noncohesive, which is referred to as sand here, and cohesive, which is referred to as clay.

Limitations

5. Both clay and sand may be analyzed, but the model considers a single, effective grain size for each and treats each separately. Fall velocity must be prescribed along with the water-surface elevations, x-velocity, y-velocity, diffusion coefficients bed density, critical shear stresses for erosion, erosion rate constants, and critical shear stress for deposition.

6. Studies cannot utilize long simulation periods because of their computation cost. Study areas should be made as small as possible to avoid an excessive number of elements when dynamic runs are contemplated. The same computation time interval must be satisfactory for both the transverse and longitudinal flow directions.

7. The program does not compute water surface elevations or velocities; therefore these data must be provided. For complicated geometries, a numerical model for hydrodynamic computations, RMA-2V, is used.

PART II: PROGRAM DESIGN

Capability of the Program

8. Either steady-state or transient flow problems can be analyzed. The exchange of material with the bed can be calculated or suppressed. The computation mesh can be created by the program or it can be created separately (Appendix D) and read in. Default values may be used for many sediment characteristics or these values may be prescribed by input data. Either the smooth wall velocity profile or the Manning's equation may be used to calculate bed shear stress due to currents. Shear stresses for combined currents and wind waves may be calculated. The program can perform an internal extrapolation that produces longer period simulations at lower cost.

Conceptual Basis

9. The program is based on the following conceptual model:

a. Basic processes in sedimentation can be grouped into *erosion, entrainment, transportation, and deposition.*

b. Flowing water has the potential to erode, entrain, and transport sediment whether or not sediment particles are present.

c. Sediment on the streambed will remain immobile only as long as the energy forces in the flow field remain less than the critical shear stress threshold for erosion.

d. Even when sand particles become mobile, there may be no net change in the surface elevation of the bed. A net change would result only if the rate of erosion was different from the rate of deposition--two processes which go on continuously and independently.

e. Cohesive sediments in transport will remain in suspension as long as the bed shear stress exceeds the critical value for deposition. In general, simultaneous deposition and erosion of cohesive sediments do not occur.

f. The structure of cohesive sediment beds changes with time and overburden.

g. The major portio of sediment in transport can be characterized as being transported in suspension, even that part of the total load that is transported close to the bed.

Theoretical Basis

10. The derivation of the basic finite element formulation is presented in Ariathurai (1974) and Ariathurai , MacArthur, and Krone (1977) and summarized below. There are four major computations.

- o Suspended sediment concentration using the convection-diffusion equation with a bed source term
- o Bed shear stress
- o Bed source quantity
- o Bed model

Convection-diffusion equation

11. The basic convection-diffusion equation is presented in Ariathurai, MacArthur, and Krone (1977),

$$\frac{\partial C}{\partial t} + u\frac{\partial C}{\partial x} + v\cdot\frac{\partial C}{\partial y} = \frac{\partial}{\partial x}\left(D_x\frac{\partial C}{\partial x}\right) + \frac{\partial}{\partial y}\left(D_y\frac{\partial C}{\partial y}\right) + \alpha_1 C + \alpha_2 \qquad \text{(G1)}$$

where

C = concentration, kg/m_3

t = time, sec

u = flow velocity in x-direction, m/sec

x = primary flow direction, m

v = flow velocity in y-direction, m/sec

y = direction perpendicular to x , m

D_x = effective diffusion coefficient in x-direction, m^2/sec

D_y = effective diffusion coefficient in y-direction, m^2/sec

α_1 = a coefficient for the source term, 1/sec

α_2 = the equilibrium concentration portion of the source term, $kg/m^3/sec$

This equation is then cast into the finite element form using quadratic shape functions, N ,

$$\sum_{ne=1}^{NE} \iint_{D_{ne}} \left[N_j \left\{ Q + u \frac{\partial \hat{c}}{\partial x} + v \frac{\partial \hat{c}}{\partial y} - \alpha_1 \hat{c} \right\} + \frac{\partial N_j}{\partial x} D_x \frac{\partial \hat{c}}{\partial x} + \frac{\partial N_j}{\partial y} D_y \frac{\partial \hat{c}}{\partial y} \right] dx\, dy$$

$$+ \sum_{i=1}^{NL} \int_{\zeta} N_j q_i^s \, d\zeta = 0 \qquad \text{(G2)}$$

where

NE = total number of elements

N = the quadratic shape functions

Q = $(\partial \hat{c}/\partial t) + \alpha_2$ for the transient problem

$\hat{c}$ = the approximate concentration in an element as evaluated from shape functions and nodal point values of c

NL = total number of boundary segments

ζ = the local coordinate

q_i^s = flux from source on boundary i

The transient equation is expressed as

$$[T] \frac{\partial \{C\}}{\partial t} + [K]\{C\}\{F\} = 0 \qquad \text{(G3)}$$

where each element in the computation mesh contributes the following terms to the global matrix

$$[T] = \iint_D \{N\}^T [N] \; dx\, dy$$

$$[K] = \iint_D \left[K_j \left\{ u \frac{\partial \hat{C}}{\partial x} + v \frac{\partial \hat{C}}{\partial y} - \alpha_1 \hat{C} \right\} + \frac{\partial N_j}{\partial x} D_x \frac{\partial \hat{C}}{\partial x} + \frac{\partial N_j}{\partial y} D_y \frac{\partial \hat{C}}{\partial y} \right] dx\, dy$$

(the steady state system coefficient matrix)

$$\{F\} = -\iint_D [N]^T \{\alpha_2\} \; dx\, dy + \int_\zeta [N]^T \{q\} \; d\zeta$$

(the steady-state system coefficient matrix)

12. Applying the Crank-Nicholson scheme, where θ is the implicitness coefficient, gives the following equation, where n refers to the present, n+1 to the future time-step, and t the computation time interval.

$$\left\{ \frac{[T]}{\Delta t} + \theta [K]^{n+1} \right\} \{C\}^{n+1} = \left\{ \frac{[T]}{\Delta t} - (1 - \theta)[K]^n \right\} \{C\}^n \qquad \text{(G4)}$$

$$+ \; \theta \{F\}^{n+1} + (1 - \theta)\{F\}^n$$

Bed shear stress

13. Several options are available for computing bed shear stresses using

$$\tau_b = \rho u_*^2 \qquad \text{(G5)}$$

where

ρ = water density

u_* = shear velocity

a. Smooth-wall log velocity profile,

$$\frac{\bar{u}}{u_*} = 5.75 \log \left(3.32 \frac{u_* D}{\nu} \right) \qquad \text{(G6)}$$

which is applicable to the lower 15 percent of the boundary layer when

$$\frac{u_* D}{\nu} > 30 \qquad \text{(G7)}$$

where

u = mean flow velocity

D = water depth

ν = kinematic viscosity of water

b. The Manning shear stress equation,

$$u_* = \frac{\sqrt{g}\bar{u}n}{\sqrt{CME}\ D^{1/6}} \qquad (G8)$$

where

g = acceleration due to gravity

n = Manning's roughness value

CME = coefficient of 1 for metric units and 1.486 for English units

c. A Jonsson-type equation for surface shear stress (plane beds) caused by waves and currents,

$$u_* = \sqrt{\frac{1}{2}\left(\frac{f_w u_{om} + f_c \bar{u}}{u_{om} + u}\right)\left(\bar{u} + \frac{u_{om}}{2}\right)} \qquad (G9)$$

where

f_w = shear stress coefficient for waves

u_{om} = maximum orbital velocity of waves

f_c = shear stress coefficient for currents

d. A Bijker-type equation for total shear stress caused by waves and currents,

$$u_* = \sqrt{\frac{1}{2} f_c \bar{u}^2 + \frac{1}{4} f_w u_{om}^2} \qquad (G10)$$

For further information on the shear stress computation equations, see McAnally and Thomas (1980).

14. At each time-step, the velocity field is recalculated to reflect the effect of depth changes. The input velocity magnitude at each node is multiplied by the ratio of the initial water depth to new water depth before proceeding with the next time-step calculation of bed shear stress.

The bed source

15. The form of the bed source term, $S = \alpha_1 C + \alpha_2$, as given in Equation G1 is the same for deposition and erosion of both sands and clays. Methods of computing the alpha coefficients depend on the sediment type and whether erosion or deposition is

occurring.

16. Sand transport. The supply of sediment from the bed (i.e., the sediment reservoir) is controlled by the transport potential of the flow and availability of material in the bed. The bed source term is

$$S = \frac{C_{eq} - C}{t_c} \quad \text{(G11)}$$

where

S = source term

C_{eq} = equilibrium concentration (transport potential)

C = sediment concentration in the water column

t_c = characteristic time for effecting the transition

17. There are many transport relations for calculating C_{eq} for sand size material. The Ackers-White (1973) formula was adopted for this model because it performed satisfactorily in tests by WES and others (White, Milli, and Crabbe 1975; Swart 1976), because it seems to be complete, and because it is reasonably simple. The transport potential is related to sediment and flow parameters by the expressions in the following paragraphs.

18. The characteristic time, t_c, is somewhat subjective. It should be the amount of time required for the concentration in the flow field to change from C to C_{eq}. In the case of deposition, t_c is related to fall velocity. The following expression was adopted.

$$t_c = \text{larger of} \begin{cases} C_d \dfrac{D}{V_s} \\ \text{or } DT \end{cases} \quad \text{(G12)}$$

where

t_c = characteristic time

C_d = coefficient for deposition

D = flow depth

V_s = fall velocity of a sediment particle

DT = computation time interval

In the case of scour, there are no simple parameters to employ. The following expression is used.

$$t_c = \text{larger of} \begin{cases} C_e \dfrac{D}{\bar{\bar{u}}} \\ \text{or} \\ DT \end{cases} \tag{G13}$$

where

C_e = coefficient for entrainment

V = flow speed

19. Clay transport. Deposition rates of clay beds are calculated with the equations of Krone (1962).

$$S = \begin{cases} -\dfrac{2V_s}{D} C \left(1 - \dfrac{\tau}{\tau_d}\right) \text{ for } C < C_c & \text{(G14)} \\ \\ -\dfrac{2V_k}{D} C^{5/3} \left(1 - \dfrac{\tau}{\tau_d}\right) \text{ for } C > C_c & \text{(G15)} \end{cases}$$

where

= bed shear stress

d = critical shear stress for deposition

C_c = critical concentration = 300 mg/l

20. Erosion rates are computed by a simplification of Partheniades (1962) results for particle by particle erosion. The source term is computed by

$$S = \frac{P}{D}\left(\frac{\tau}{\tau_e} - 1\right) \tag{G16}$$

where

P = erosion rate constant

τ_e = critical shear stress for particle erosion

21. When bed shear stress is high enough to cause mass failure of a bed layer, the erosion source term is

$$S = \frac{T_I \rho_L}{D\Delta t} \quad for \quad \tau > \tau_s \tag{G17}$$

where

T_L = thickness of the failed layer

ρ_L = density of the failed layer

Δt = time interval over which failure occurs

τ_s = bulk shear strength of the layer

The bed model

22. The sink-source term in Equation G1 becomes a source-sink term for the bed model, which keeps track of the elevation, composition, and character of the bed. Bed change computations utilize the Crank-Nicholson weighting of the time-step contributions.

23. Sand beds. Sand beds are considered to consist of a sediment reservoir of finite thickness, below which is a nonerodible surface. Sediment is added to or removed from the bed at rate determined by the value of the sink/source term at the previous and present time-steps. The mass rate of exchange with the bed is converted to a volumetric rate of change by the bed porosity parameter.

24. Clay beds. Clay or mixed sand and clay beds are treated as a sequence of layers. Each layer has its own characteristics as follows:

a. Thickness.

b. Density.

c. Age.

d. Bulk shear strength.

e. Type.

In addition, the layer type specifies a second list of characteristics.

a. Critical shear stress for erosion.

b. Erosion rate constant.

c. Initial and 1-year densities.

d. Initial and 1-year bulk shear strengths.

e. Consolidation coefficient.

f. Clay or sand.

New clay deposits form layers up to a specified initial thickness and then increase in density and strength with increasing overburden pressure and age. Variation with overburden occurs by increasing the layer type value by one for each additional layer deposited above it. Change with time is governed by the equations

$$f(t) = \begin{cases} f(t_o) + [f(t_1) - f(t_o)] \log (9t + 1) & 0 \le t \le 1 \text{ year} \quad \text{(G18a)} \\ f(t_1) + M \log t & 1 \text{ year} \le t \quad \text{(G18b)} \end{cases}$$

where

f = time-varying characteristic of density or bulk strength

t_o = time = zero

t_1 = time = 1 year

t = time

M = consolidation coefficient

Mass deposition rates are converted to volumetric deposits by the specified density for the type 1 layer, and erosion rates are converted to a corresponding volume by the actual density of the eroding layer.

25. Use of the layer type can be used to control whether or not erosion and consolidation are allowed to occur, and to keep track of sand layers in a mixed bed problem. The layer structure and time-varying consolidation can be used to specify a subsidence rate for the modeled area.

26. Bed change extrapolation. The model is run in a time-varying mode. The time-varying solution of the bed model may be advanced in time by direct time-stepping, in which all of the equations are solved at each time-step, or by extrapolation, in which results of direct time-stepping are projected into the

future. The extrapolation capability allows simulation for an extended period of time at a fraction of what time-stepping would cost for the same duration.

27. The computer program applies four constraints to limit or control the duration of an extrapolation time period as follows:

- a. The water depth changes by no more than P_L percent, and/or
- b. The water depth average change is no more than D_L meters at N_L nodes, or
- c. The specified maximum time limit, T_L, is reached
- d. The maximum number of extrapolation periods permitted by input data is reached.

28. For each node at which the depth change violates the specified limits, an extrapolation time to reach the limit is computed. If N_L nodes reach the depth change limit, the extrapolation time is set equal to the average of the individual node time limits.

29. When an extrapolation time has been determined as described above, the bed change rate for the just-completed time-stepped simulation is averaged with that since the end of the previous time-stepped simulation, weighted by specified factors zeta and 1-zeta, respectively. The resulting average rate of bed change at each node is multiplied by the extrapolation time to yield a maximum extrapolated change (MEC) in bed elevation for the extrapolation interval. From this point, sand and clay bed extrapolations are treated differently.

30. If the specified depth constraint limits the extrapolation time period to less than the value of T_L, the model returns to time-stepped modeling for the next interval. It steps forward in time for the same number of time-steps used in the initial period, then extrapolates again as described above. A specified limit on number of extrapolation periods sets the maximum number of extrapolations permitted, which is simply a cost-control limit.

31. In addition to the overall controls described above, extrapolated bed changes at every node are always limited by these three constraints:

- a. Erosion is limited to that which exhausts the bed of available sediment.
- b. Deposition is limited to 99 percent of the water depth.

c. In mixed bed layering, erosion is halted when the sediment type (sand or clay) changes from that which was on top during the time-stepped period.

32. The thickness of the sediment reservoir is increased or decreased by the MEC subject to the restrictions described above. Two options are available for clay or mixed bed extrapolation. In the preferred method, bed layer extrapolation, variation of bed properties is considered during the extrapolation and the MEC is used only as an upper limit on depth change. The alternate method does not consider nor change bed structure during the extrapolation period, it merely raises or lowers the bed elevation by the MEC.

33. Bed layer extrapolation is treated as follows:

a. At nodes with a sand layer on top, extrapolation is handled in the same manner as for all-sand beds, except that the sand reservoir thicknessisequal to the layer thickness.

b. At nodes with a depositing clay layer on top, the net sediment mass deposited is extrapolated. This extrapolated mass is then deposited on the bed and subjected to the same overburden and time rates of consolidation used in time-stepping. Either the net increase in bed elevation after consolidation or the MEC, whichever is smaller, is used for the extrapolation change.

c. At nodes with an eroding clay layer, the program returns to a time-stepping mode of operation to calculate bed shear stresses and erosion rates at each time-step without solving the convection-diffusion equation each time. Erosion continues at each node until a nonerodible layer is encountered or until the extrapolation period is complete. The erosion depth at any node can be no greater than the MEC.

Program Organization

34. STUDH consists of two primary modules. An input module (PRESED) reads input data cards and organizes the data into the proper sequence required by the computational module. After all data have been read and organized, PRESED calls the computational module, HORSED.

35. Each module is organized with a main routine and supporting subroutines as shown in Figures G1-G3. Figure G1 illustrates the organization of PRESED and HORSED modules. These figures show the subroutine listing in alphabetical order, not in the sequence of calls from the code. Occasionally, a subroutine name will appear more than once. Each subroutine is assigned a number on the figure when that subroutine is first listed and the number is repeated for subsequent listings. This is intended to show each external reference to a subroutine not only by the main subprogram of the module but also by each subroutine in the module.

36. STUDH uses 52 labeled common blocks for storage of data needed by more than one subroutine. The library source version of the program is in update format using comdeck labels for each of the common blocks.

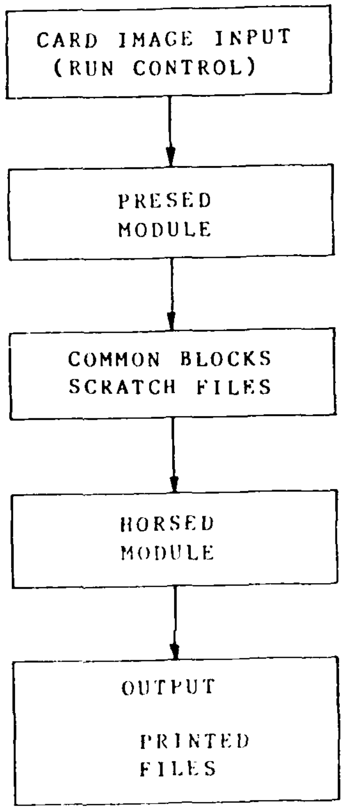

Figure G1. STUDH program organization

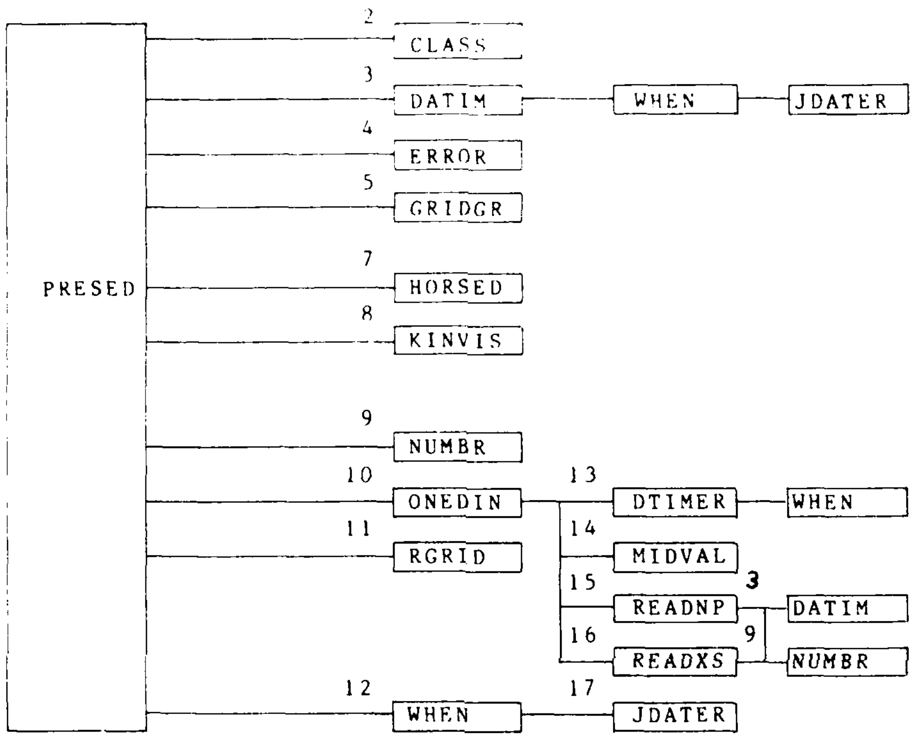

Figure G2. PRESED module organization

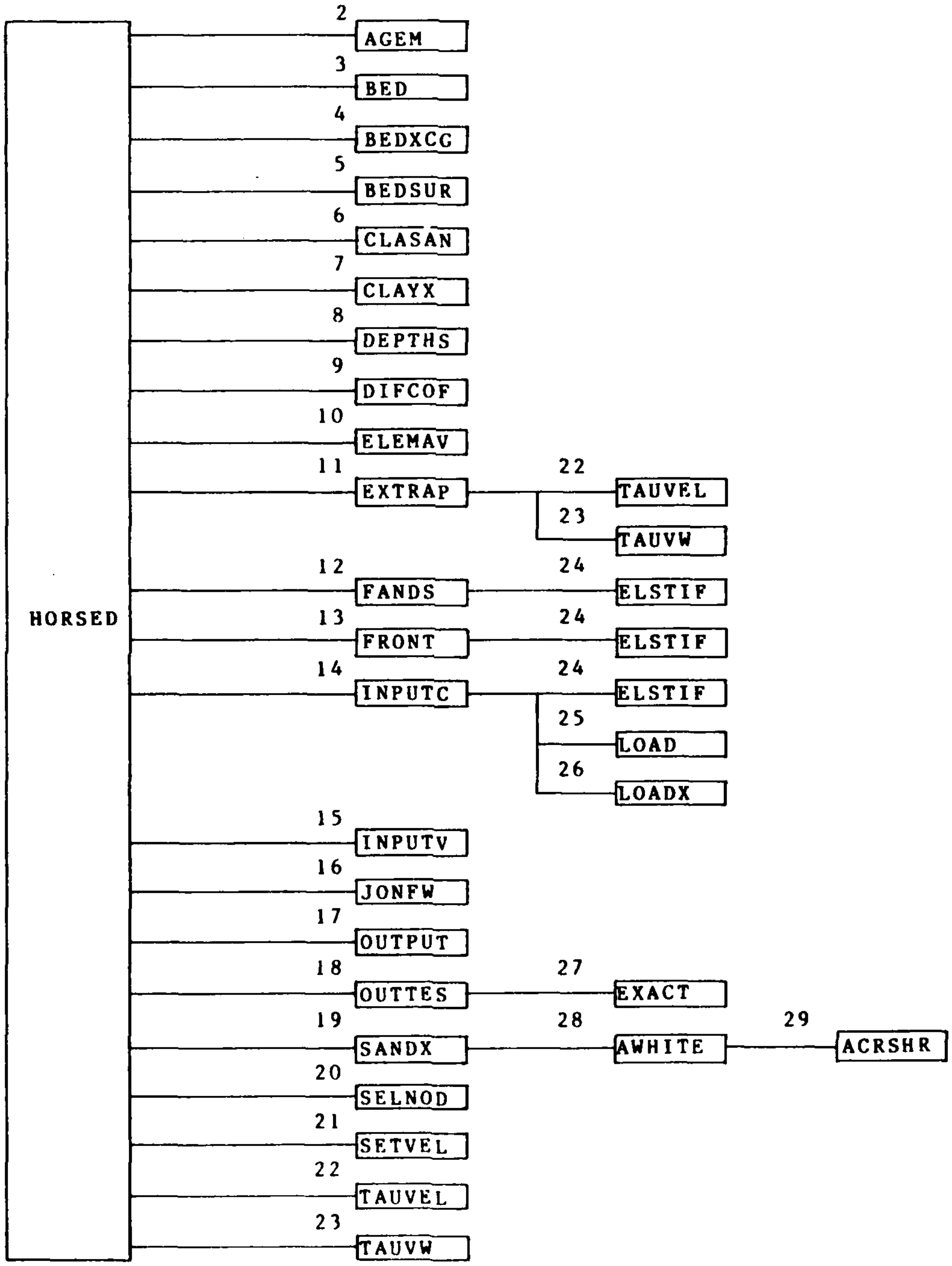

Figure G3. HORSED module organization

PART III: PROGRAM USE

Introduction to Program Use

37. STUDH can be used by engineers and scientists to solve sediment transport problems that are satisfactorily described as unsteady, suspended transport in two horizontal dimensions with bed interaction.

38. Users are cautioned that the program is relatively easy to use but somewhat more difficult to use properly. Persons using the program are assumed to be familiar with using a computer system. Knowledge of numerical methods is useful. It is essential that the user possess considerable knowledge of hydraulic and sedimentation processes and that he or she understand the computer program and its proper use. This latter requirement can be obtained only by careful training in practical application of STUDH.

Use of the Modeling System

39. As mentioned previously, *STUDH* requires that hydrodynamic data be externally supplied, usually by a numerical hydrodynamic model. A modeling sytem, TABS-2, has been designed to satisfy this and other needs for a comprehensive modeling package. TABS-2 consists of RMA-2V, a general purpose program for hydrodynamic modeling, in addition to STUDH and a number of utility programs that develop input, translate data, analyze output, and provide graphical output from the models.

Access to the Program

40. A library version of the program is maintained. To obtain access to the program and/or have it modified to run on another machine, contact WES. Revisions to the model will be made occasionally, but all input decks will be compatible with the new version. Users with access to the program receive a documentation page describing current program capabilities and access instructions.

Procedure and Input/Output Files for Executing STUDH

41. STUDH is executed via PROCLV, the Job Control Language procedure file developed for TABS-2. Current instructions for accessing and using that procedure are contained in Appendix O: PROCLV in this manual. PROCLV expects the default logical unit

assignments as shown on the $L card instructions.

42. STUDH33 is a FORTRAN program in PROCLV. It is compiled at execution time and becomes an interactive tutor which guides the user, step by step, through the assignment of file names for all input and output files at execution time. If any of the specified input files do not exist on the computer, the program will abort.

43. A sample session with STUDH33 is shown opposite. Output from STUDH33 is the job control language which submits STUDH for execution. It will automatically attach the input files and save the output requested. Printout from STUDH automatically goes to the line printer.

44. Table G1 shows the required and optional input data files for STUDH. The generic file names are those used in the procedure file documentation (see Appendices N and O).

Table G1

Standard Input Files

Generic File Name	Standard Logical Unit	Contents	Status
--	05	Run control data	Required
OMGED	12	Metric geometry file	Required
OMWSE	9	Metric water surface elevations	Optional*
OMVEL	11	Metric velocity input	Optional*
IWS3	3	Wave data input	Optional
O2S3	70	Prior extrapolation output	Optional
O1S3	87	Concentration/bed change hotstart	Optional
O3S3	88	Cohesive bed structure hotstart	Optional

*Required if the hydrodynamic data are not specified by run control input.

```
C>BEGIN,STUDH33,PROCLV,

*STUDH 3.3 JOB SETUP*

ENTER JOB TIME LIMIT (<CR> FOR 120[10):
I>
ENTER 1 OR 2 DIGIT JOB PRIORITY (<CR> FOR 2):
I>

ENTER YOUR LAST NAME:
I>THOMAS

ENTER FILENAME FOR STUDH CONTROL INPUT:
I>GRINST1
ENTER FILENAME FOR METRIC GEOMETRY (<CR> IF NONE):
I>GROWR11
ENTER FILENAME FOR METRIC VELOCITIES (<CR> IF NONE):
I>GRR2OU1
ENTER FILENAME FOR WATER SURFACE (<CR> IF NONE):
I>GRR2WSL
ENTER FILENAME FOR WAVE INPUT (<CR> IF NONE):
I>
ENTER FILENAME FOR HOTSTART (<CR> IF NONE):
I>
ENTER FILENAME FOR EXTRAP.  INPUT (<CR> IF NONE):
I>
ENTER FILENAME FOR CONC/DELBED OUTPUT (<CR> IF NONE):
I>GRSTOU1
ENTER FILENAME FOR EXTRAP.OUTPUT (<CR> IF NONE):
I>

     ENTER DMS 20 CHARACTER CATALOG NAME FOR FILE (CR)
     SITE-SOURCE-PLAN-CFS-COND-STORE-FORM-CAT-SUBCAT-MISC
       (1)  (1)   (2) (2)  (6)  (1)   (1) (1)   (1)  (3)
       LAST COLUMN IS HERE!

     I>11016709MR8111S1000

ENTER THE GRADE FOR THIS FILE <CR>

I>0

ENTER YOUR LAST NAME <CR>

I>THOMAS

ENTER 80 CHAR OR DESCRIPTIONS <CR> THEN 80 MORE <CR>

I>THIS DEMONSTRATES THE INTERACTIVE SESSION TO RUN STUDH
I>15NOV1983    W. A. THOMAS

DOES EVERYTHING LOOK OK?  ENTER (YES OR NO) <CR>
```

45. Jobs executed on a vector processing computer produce binary files that can be read only on those respective machines. PROCLV automatically directs utilities and the main codes to the proper machine for saving and accessing files.

46. The file referred to as STUDH CONTROL INPUT in the STUDH33 session is the card image input for STUDH described in this document. It is usually entered into a file with the editor and consequently is an ASCII character set that can be transferred back and forth from the front end computer to the vector processing computer.

Description of Card Image Input Data

47. Input to the program consists of card image data in the format used by HEC-6 (Thomas 1976) and, optionally, data files on disk or tape. The card images may be actual cards or lines in a data file. Card images consist of 10 fields of 8 columns each. The first two columns are used to identify the type of data on the card. Coding instructions for input data are given in Addendum G-1.

48. Eleven classes of input data describe the computational mesh, physical constants, properties of the flow, and properties of the sediment. The following paragraphs describe the input data in detail. A summary of input data is given in Addendum G-1.

Title cards (T1, T3)

49. These cards contain descriptive information used to identify a model run. As many T1 cards can be used as are needed. The final title card must be a T3 card. Information on the T3 card is saved with the program output files (along with data management banners, if used), so it can be used to identify the data file.

Run control cards ($T, $L, $H, $$END)

50. These cards are used to control various aspects of program control. The $T cards dictate at what time-steps output is to be printed and input files are to be read. Information requested by the $T cards may be given there or in an alternate format following the $$END card, but the requested information must be furnished. The PS cards specify the mesh locations at which output is printed. THE $L card is not usually needed but is available in case the user wishes to change some of the input or output logical unit designations. If the card is omitted, all logical units assume the default values shown.

51. The $H card is used to control HOTSTART runs of the program. In a coldstart, a model run begins fresh, not using the results of any previous run as a starting point. In a hotstart,

some of the variables, such as concentration or bed thickness, begin with values that were computed in a previous run.

52. The files needed for hotstarting a model run are written every time the program is run; however, unless they are saved by job control, the files are not retained. In order to make a hotstart run, first submit a model run in which logical output units 18 (bed structure) and/or 7 (concentrations and bed elevation changes) are saved. Then submit a run with the appropriate hotstart switches on the $H card and access logical input units 88 (bed structure) and/or 87 (concentrations and bed elevation changes).

53. In a coldstart run, all of the important processes must spin-up from an artificial condition such as a uniform sediment concentration field. The spin-up time is the length of time a simulation must run before the solution has recovered from the artificial initial condition. For example, in a sand bed problem, if the initial sediment concentrations are too low in one area, erosion of the bed may occur there during spin-up, even if the prototype bed is stable in that area. To overcome this problem, a second hotstart model run would be made in which concentrations are hotstarted from the previous run, but bed structure and bed elevation changes are coldstarted.

54. Use of the $H card permits any one or a combination of the three variables (concentration, bed elevation, and bed structure) to be used in a hotstart.

Trace Printout (TR cards)

55. Use of the $TP card or the first card following $$END controls the output of the important model results of concentration and bed change. The primary purpose of the trace printout controls is to assist in diagnosing problems with a run, but they also provide for printing of some parameters that may be useful in interpreting model results. If a trace printout is selected, it will print only at the times dictated by the $TP or $$END cards, and only at the locations specified on the PS cards if they are present.

Geometry cards (G1,G3,GB,GS,GE,G4,GN,G7, and GD)

56. The program contains an internal mesh generator for those problems that do not require separate modeling of flows. In those cases, it may be convenient to use the internal mesh generator, but in general, it is more efficient to use the separate TABS-2 mesh generation programs.

57. When a mesh has been separately generated, its specifications of model locations and bed elevation cannot be overridden by use of the GY and GN cards. Hotstarting bed elevation

change with a $H card does not change the original bed elevation; but by giving a nonzero bed elevation change, it alters the effective elevation of the bed for that run.

58. For model runs in which a portion of the mesh may be out of the water at some time, a GD card is required. Otherwise, an error is diagnosed. The GD card permits specification of a water depth (DSET) at which drying is assumed to occur and the node is removed from calculations. The value of DSET should correspond (in metric units) to the value of the rewetting depth (DSETD) used in the RMA-2V run that supplied the hydrodynamics.

Timing and run length control (TZ and TE cards)

59. The TZ card specifies the starting date and time of the run. If time-varying boundary conditions are used, all of these variables must be specified. The card also specifies the computational interval and number of time-steps to be run.

60. Choice of a computational interval is dependent on the size of mesh cells used, speed of the flow, effective settling velocity of the sediment, and how well the modeler wishes to resolve small-scale bed features. For most production work, an interval of 15 min (900 sec) has been found satisfactory, but some experimentation may be required to find the best value.

61. To obtain the number of time-steps needed to reach a given length of run, use the equation

$$\text{No. of time-steps} = \frac{\text{Run Length}}{\text{Computational Interval}} + 1$$

62. Use of the TE card permits longer run times to be used at a cost (computer cpu time) lower than possible with direct time-stepping. This is accomplished by an interval extrapolation procedure.

63. Figure G4 illustrates the extrapolation process for results of the bed elevation change (DELBED) at one node in a hypothetical model run. During the first time-stepping cycle (A), the bed elevation changes at each computational interval (t), with deposition during some intervals and erosion during others. Over the time-stepping period, more deposition occurs, soDELBED at the end of the run is positive. The length of the time-stepping cycle, T_{TS}, is as specified on the TZ card.

64. At the end of the first time-stepping cycle, extrapolation No. 1 begins. The net bed elevation change from time zero to T_{TS} is used to calculate an average rate of bed change at each node. This average rate of change is assumed to remain constant during the first extrapolation (B). The extrapolation period length, T_{E1}, is determined by how long it takes to reach one of several limits on bed change or run length.

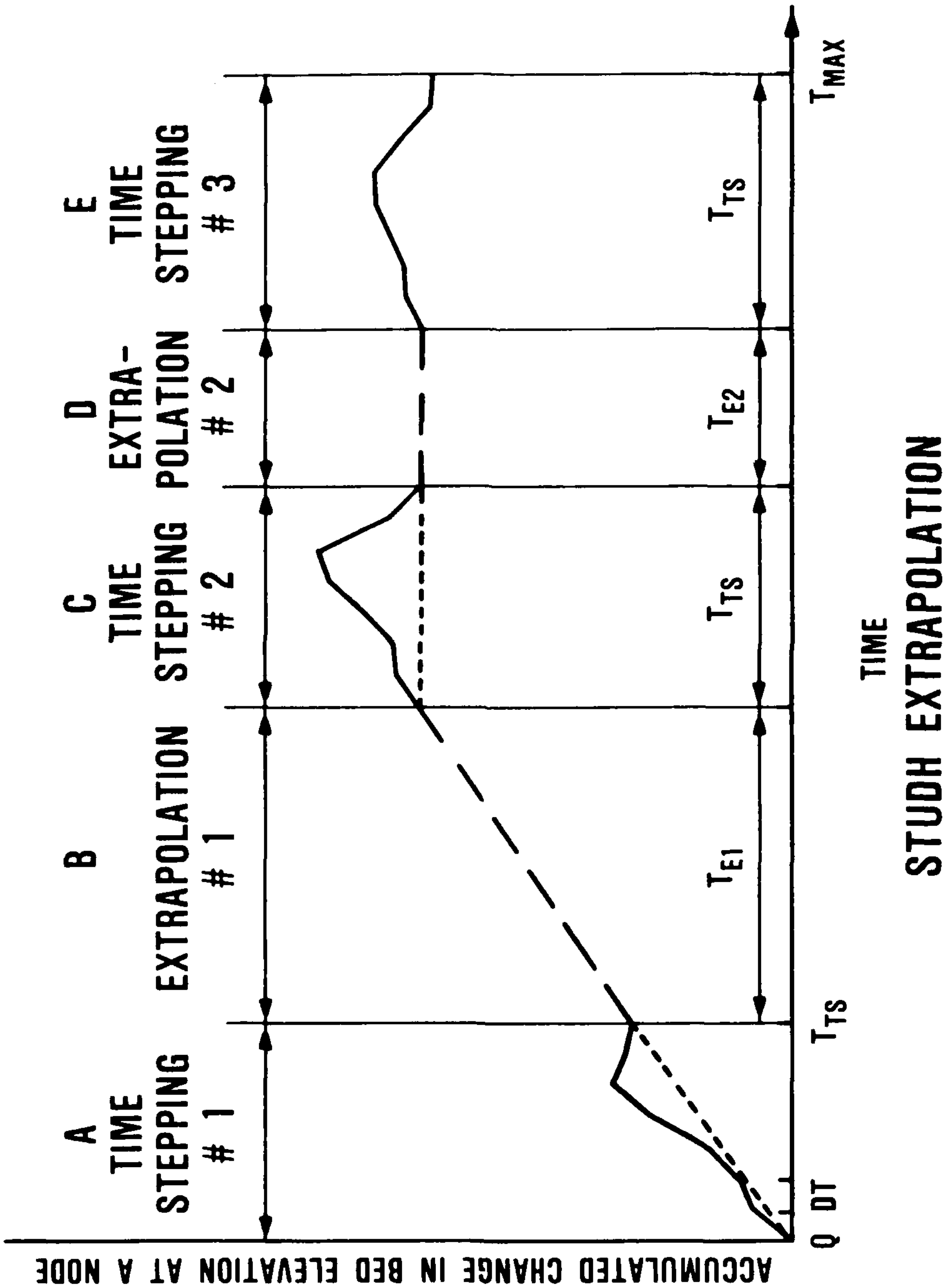

Figure G4. Extrapolation procedures

These limits are discussed later. During the extrapolation, concentration and flow velocities do not change.

65. At the end of extrapolation No. 1, time-stepping is repeated (C). The unit flows and boundary conditions are exactly repeated from time-stepping No. 1, but velocities, concentrations, and erosion/deposition rates are recomputed using the new bed elevations. Note that since the water is now shallower at the example node, deposition rates are lower and erosion rates are higher than before. The length of time-stepping No. 2 is exactly the same as No. 1, T_{TS} .

66. At the end of time-stepping No. 2, the average rate of bed change over that interval is calculated and used for extrapolation No. 2 (D). Extrapolation No. 2 is shorter than extrapolation No. 1, either because the elevation change at some nodes is greater than before or because the time limit (Tmax) is approaching. Each run must end with a complete time-stepping cycle of duration T_{TS} .

67. At the end of time-stepping No. 3 (E), the run is completed.

68. Three limits are used to determine how long an extrapolation period lasts. EXDYMX is the maximum absolute bed change in metres that will be permitted at one or more nodes (when more than one node is used EXDYMX is the maximum average change permitted at the number of specified nodes). EXPDMX is the maximum bed elevation change in terms of percent of water depth. Thus a 1-m bed elevation change in 10-m deep water is equivalent to 2 m in water 20 m deep. For multiple nodes, the average is used. The third limit on extrapolation time is the maximum time (EXDT) that the model run is to reach. Since each model run must end with a complete cycle of time-stepping, extrapolation will end at a time that permits the final time-stepping to occur, even if the depth limits are not exceeded.

69. If the depth limits are imposed on a single node, extrapolation times may be very short. To avoid having one badly behaving node abort an extrapolation, the variable NONOD may be used. IF NONOD is greater than one, the average depth change at NONOD number of nodes and EXPDMX are used for calculating permitted extrapolation time.

70. Values of EXDYMX, EXPDMX, and NONOD must be developed by experimentation, but typical choices are 0.5 m, 10 percent, and 20, respectively.

71. In the hypothetical example shown in Figure G4, only the most recent time-stepping period results are used to determine the average rate of bed elevation change at each node. This corresponds to an implicitness factor (ZETA) of 1.0. For smaller values of ZETA, the last two time-stepping periods are used to compute a weighted average rate of bed change, with small values

of ZETA emphasizing the prior time-stepping period over the most recent one.

72. The program gives the option of leaving bed structure constant during the extrapolation period or attempting to compute the effect of continued bed change during extrapolation. The value of MTEX controls this option. A value of zero is less expensive and should be used unless a good reason exists for evaluating bed structure. The computation procedure is an attempt to reproduce changes that would occur if genuine time-stepping were occurring, but the calculations can only offer a rough approximation to the actual processes.

73. The variable MEX on the TE card is used to prevent runaway costs in extrapolation runs. It limits the number of time-stepping sequences that are performed and can cause a run to fall short of the desired time. If it is too small, the desired time will not be reached and a warning will be printed. If it is too large, computer costs may be excessive.

Implicitness factor (TT card)

74. The program uses the Crank-Nicholson time-stepping scheme that employs an implicitness factor, Theta . A value of 0.66 is recommended, but variations from 0.5 (equal weighting of this time-step and the previous time-step) to 1.0 (no influence from the previous time-step) are permitted. A higher value of Theta produces results that are more stable but increases numerical (artificial) dispersion of sediment.

Selective print (PS card)

75. The PS card specifies the mesh locations at which model results are printed. Times of printed output are selected by the STP or IFF card sets. If the PS card is omitted, all nodes and elements are included in the printed output. If elements are specified on the PS card, only those elements and nodes surrounding them are included in the printout.

Sediment size classes (SA,SR,ST, and WC cards)

76. The program requires that sediment sizes and/or their characteristics be specified. For noncohesive sediment bed problems, input allows for multiple grain sizes on the SA card, BUT AT PRESENT THE PROGRAM CONSIDERS ONLY ONE SIZE AT EACH NODE. The grain size specified on the SA card is applied to every node in the mesh. Values at specific nodes may be changed by use of the SR and ST cards. The ST card specifies grain sizes to be used in noncohesive sediment transport equations and the SR card specifies the effective grain size to be used in bed roughness calculations (Ackers-White transport equations only). These two sizes will be the same only for plane beds in straight channels. Bed forms and channel curvature introduce form roughness that causes the SR sizes to be larger than sizes used for transport computations.

77. Note that the SA, SR, and ST cards constitute a cascading set of defaults. If neither an SR nor ST card is present, the grain size on the SA card will be used at all nodes for both transport and effective roughness. If SR cards are present, they override the SA card at those nodes specified and become the default values for the ST card values. Finally, use of ST cards overrides the SR and SA card input at every node specified on the ST card.

78. Two characteristic length parameters are requested on the SA card. CLDE is the length factor for deposition. The default is a value of 1, corresponding to an average settling depth equal to the water depth. For fine sediments that are distributed throughout the water column, a value of 0.5 is recommended. For coarser sediments in less turbulent flows, a smaller value is suggested. CLER is the length factor for erosion. The default value of 10 is suggested, but more investigation is needed to find the best value.

79. Settling velocities are specified on the WC cards. This settling velocity is an effective fall velocity which goes up with grain size, goes down with increasing turbulence, goes up with increasing aggregation (cohesive sediments), and goes up if a too large value of CLDE is used. The best starting point for noncohesive sediments are fall velocities for spherical particles of equal diameters. Figure G5 shows a typical graph for settling velocities.

80. For cohesive sediments, the settling velocity of particles can vary enormously with sediment type, salinity, turbulence, and other chemical and physical conditiions. Laboratory or field tests are needed to define effective settling velocities (see Appendix K).

Cohesive sediment characteristics (SC and DT cards)

81. Figure G6 illustrates the relation between the various critical shear stresses for cohesive sediments. These values must generally be determined by laboratory or field experimentation, but published results for similar sediments can be used if caution is exercised.

82. Values specified on the SC card for critical shear stresses for erosion and the erosion rate constant are overridden by those contained on the DT cards. The DT cards are used to assign characteristics to various types of cohesive sediment bed layers. These characteristics are assigned to existing bed layers as specified on the DC cards and to new layers as they are deposited. Freshly deposited sediments are assigned a type 1 designation and increase to higher numbered types as the thickness of sediment above them increases. Data for the DT cards should come from laboratory tests on the sediments to be modeled.

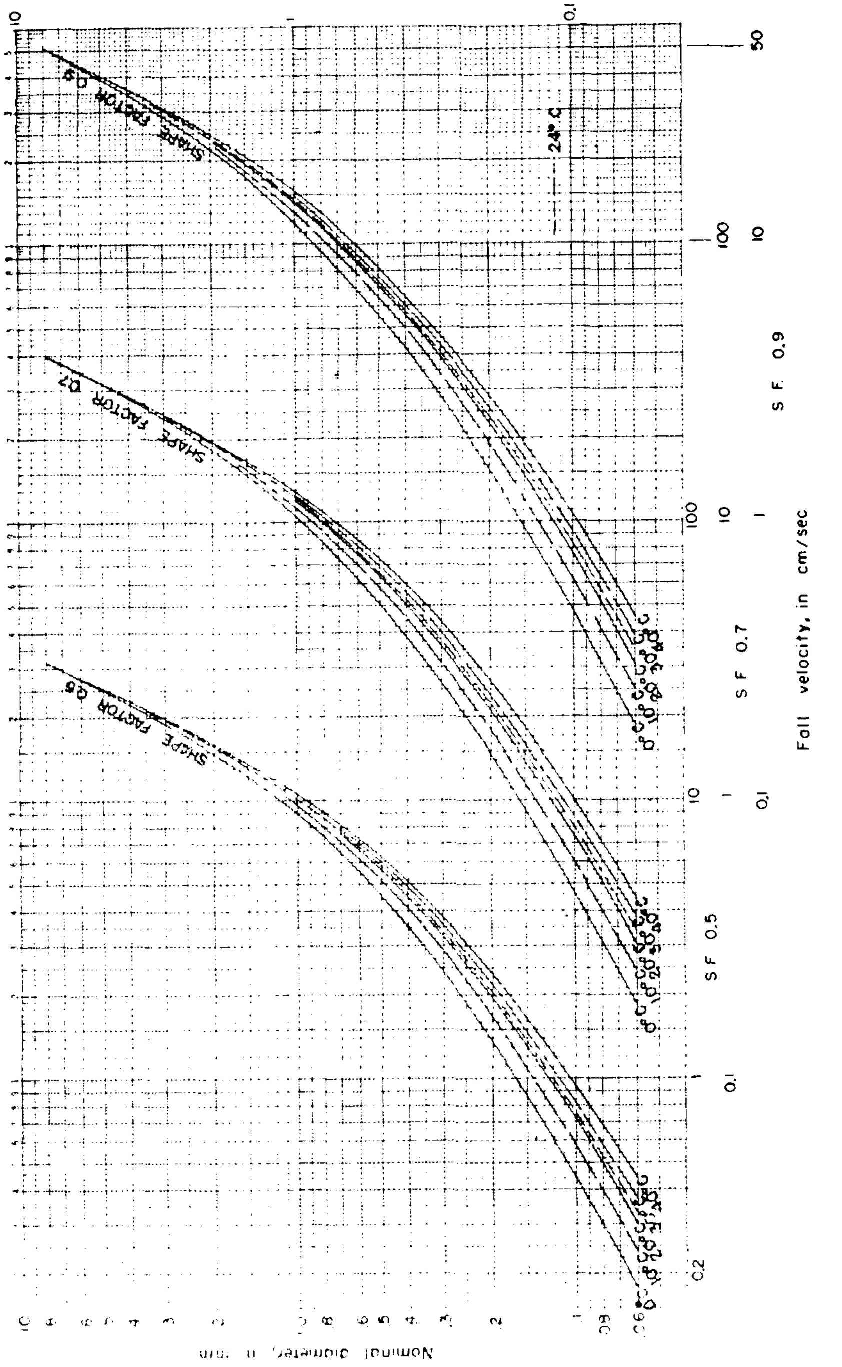

FIG. 2—RELATION OF NOMINAL DIAMETER AND FALL VELOCITY FOR NATURALLY WORN QUARTZ PARTICLES
FALLING ALONE IN QUIESCENT DISTILLED WATER OF INFINITE EXTENT

(From: "Some Fundamentals of Particle Size Analysis," 1957, Committee on Sedimentation, Interagency Committee on Water Resources)

Figure . Equivalent settling velocities

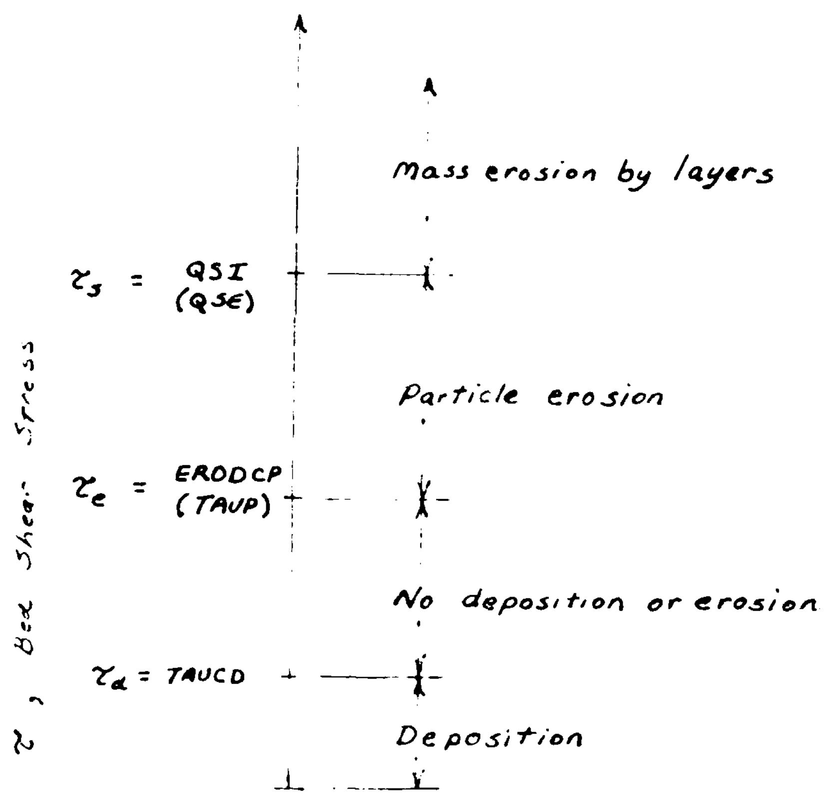

Figure G6. Cohesive bed behavior as a function of shear stress

83. Dry density as specified on the DT cards can be calculated by the following formula:

$$\rho_{dry} = \rho_s \frac{(\rho_B - \rho_w)}{(\rho_s - \rho_w)} \qquad \text{(G19)}$$

where

S = density of individual sediment particles

B = bulk (wet) density of sediment

w = density of water entrained in the sediment

Note that a lower density for layer types 1-4 will result in fluffier deposits, increased thickness of deposited layers, and greater bed change.

84. Density and shear strength of cohesive layers generally increase as they consolidate. The shifting to higher layer types in the program accounts for this, but the computations associated with layer consolidation are fairly involved. If these computations are not needed for accuracy, it is more economical to decrease the number of layers that are subject to consolidation (MNCL on the SC card) and increase the typical thickness of the consolidating layers (THKTYP on the DT cards).

Bed structure (DV and DC cards)

85. The thickness of the sediment bed at the beginning of a run is specified on the DV (noncohesive) and DC (cohesive) cards. If that thickness is eroded, it is assumed that nonerodible rock has been reached. The DC cards specify which layer types (DT cards) are present, how thick each is, and how old each is. During extrapolation runs (TE card), the age of a layer is used to perform calculations for consolidation with time.

86. In hotstart runs ($H card), the bed structure from a previous run is used and information on the DC and DV cards is disregarded.

Effective diffusion (EX and EY cards)

87. Diffusion of suspended sediment occurs because of turbulence in the flow field. When the transport equation is simplified by averaging over depth, as in STUDH, dispersion is introduced because of vertical variations in the flow field and settling of the sediment through the water column. In practice, this effect is lumped together with turbulent diffusion and the effect of averaging in time and the combined effect is called dispersion or effective diffusion. In numerical modeling of the transport equations, an additional dispersive effect is introduced when the continuous horizontal concentration profile is

represented in a discretized fashion by the numerical mesh. In this program, these various effects are combined in a pair of effective diffusion coefficients given on the EX and EY cards.

88. Selection of appropriate values for the dispersive coefficients is not a straightforward task. Elder (1959) gave approximate expressions for longitudinal (direction of flow) turbulent diffusion coefficients as

$$D_e = 5.93\ Du_* \tag{G20}$$

and for the transverse (perpendicular to the flow direction) diffusion coefficient as

$$D_t = 0.23\ Du_* \tag{G21}$$

where

D = water depth, and

u_* = shear velocity as given by equation 8.

Experimentally derived values of the constants in Equations G20 and G21 are often orders of magnitude greater than those given. This is attributed to nonuniformity of the flow, wind effects, wave effects, and so on.

89. In choosing an effective diffusion coefficient to use in numerical modeling, consideration must also be given to the mesh cell size. Exact relations are not available, but generally, larger element sizes require larger diffusion coefficients.

90. Allen Teeter of the WES Hydraulics Laboratory has suggested that an equation of the form

$$E = K_1\ (K_2 Du_* + 10^{-5} \ell^2) \tag{G22}$$

where

ℓ = the element size

K_1 and K_2 = constants

91. Equations G20-G22 differentiate between dispersion coefficients parallel and transverse to the direction of flow. Since the coefficients in the present version of STUDH apply in the x- and y-directions, not necessarily in the flow directions, these equations can be used only as a guide.

92. Fortunately, in most applications, effective diffusion is smaller than convection by the calculated flow velocities, so a wrong choice does not affect the results very much unless the chosen coefficient is far too large. The best approach then is to use a moderately high value (say 50 m^2/sec) during the first few runs, then reducing the coefficients to the least values that

will run without introducing excessive numerical instability (as revealed by negative concentration).

93. Table G2 lists some previous applications and the effective diffusion coefficients that were used.

Table G2

Example Dispersion Coefficients

Location	Typical Current Speed, mps	Typical Element Size, km	Dispersion Coefficient m^2sec
Medium-size river	1 - 1.5	0.1 - 0.5	100
Open bay	0.5 - 1.0	0.75	100
Tidal river	0.2 - 1.0	0.1 - 0.3	5-10

Initial concentration (IC cards)

94. The nodal concentrations at the first time-step are specified on the IC cards, or in a file if a hotstart is used (paragraph 51,$H).

95. Depending on the length of a run, the initial concentrations can have a significant effect on the results. If they are too high, deposition will be high for the first few timesteps; and unless the run is long enough to overcome this start-up anomaly, the end result will be biased. For noncohesive sediments, the same will be true if the initial concentrations are too low.

96. To overcome these problems, it is best to use field data to obtain an approximation to actual concentrations; to make an initial spin-up run to stabilize concentrations, then hotstart; or to run for a period long enough to make start-up perturbations small with respect to the results produced.

Boundary conditions (BC cards)

97. BC cards are used to prescribe concentrations at the water boundaries of the models. Concentrations need not be specified at land boundaries. Boundary concentrations are best when based on field measurements; but for noncohesive sediments, the model is somewhat more flexible.

98. If the model boundaries are sufficiently far from the area of interest in noncohesive sediment bed studies, the model will tend to compensate for imprecise boundary concentrations. If concentrations are too low on an incoming flow boundary, the model will erode material from the bed (if the specified reservoir thickness is adequate) to put enough sediment in transport

to equal the bed material transport capacity. If concentrations are too high, the excess material will deposit, again bringing the concentration to that needed to satisfy transport capacity. The rows of computational elements near the boundaries will have erroneous deposition/erosion effects under these conditions and results therefore should not be used.

99. This tendency for noncohesive bed models to heal the boundary conditions is a fortunate one, but it should not be strained. For example, a too-high boundary concentration will form a delta at the inflow point. If the model run is long enough, the delta will propagate throughout the area of interest, producing erroneous results. The boundaries should be sufficiently removed from the problem area and an attempt should be made to adjust boundary concentrations that are seriously different from near-equilibrium conditions. Note that this healing process does not apply to cohesive sediments.

100. For boundaries at which there is always flow out of the model, for example, a downstream section in a nontidal river, boundary concentrations can be left unspecified, and the program will calculate the outflowing concentrations.

Description of Output

101. Output from a model run consists of summaries of input data, computed parameters, and computed results. Input data summaries include an echo of all card image input data and a tabulation of options and sediment characteristics that have been chosen. A number of data set codes are output that are of use primarily in debugging. A listing of program dimensions is provided and data management system banners from input files (geometry, hydrodynamics, and hotstart data) are printed. These summaries should be carefully reviewed to ensure that input data were correctly specified and interpreted by the program. Examples are shown in Figures G7-G9.

102. At selected time-steps, some results and some associated parameters are printed for selected nodes and elements (see paragraph 75). Standard results output includes suspended sediment concentration in kilograms per cubic metre at the nodes (Figure G10); flow speed in metres per second; water depth in metres; total bed change in metres from the start of the run; volume of bed change in cubic metres for the elements; and net bed change (algebraic sum) and gross bed change (sum of absolute values) in cubic metres over the entire mesh to that point in the run (Figure G11).

103. Extrapolation runs produce printed output during extrapolation periods showing which nodes control the extrapolation and the amount of extrapolated depth change at the nodes. An example is shown in Figure G12.

```
PRINTER AND FILE I/O TIMING CONTROLS...
          1111111111222222222233333333334444444444555555555566666666667777777778
12345678901234567890123456789012345678901234567890123456789012345678901234567890
--------------------------------------------------------------------------------


    PRINTER...
300003

    VELOCITIES...
100000

    DEPTHS...
100000
                 BANNER HEADINGS ON GEOMETRY INPUT

               WESHE  DMS VERSION  1.00. DATED    OCT 1981.  THIS FILE IS FROM    GFGEN    VERS
              ION 3.10 DATED   MAR 1984.                                  ENG-MET RMA1GEO FILE
               DMS = LOCK AND DAM 1        GRADE = A          PERSON = LYNCH      DESCRIPTION =
              LOCK AND DAM 1 RED RIVER
              CORRECTED ELEVATIONS
```

Figure G7. Sample STUDH printout showing input/output controls and geometry input file banners

```
MODULE = HORSED, IPRE =      1


NSTOP=  OQ = 92,000 CFS  INPUT CONC = .67 KG/M3   5 DAY RUN

 NOPT IGEOM IPLOT NGRID    NP    NE   NPX ICODE  NTTS  IVEL NCCOD IDIF1  IBED  ISET  IDEP ICONC ISOLV
    3     1     0     4  2958   931     0     0     6     1    -1     4     4     4     1     4     1

          BANNER HEADINGS ON INPUT WATER SURFACE ELEV.

      WES HYD DMS VERION  1.0 DATED   OCT 81.    THIS FILE IS FROM   RMA2-VELOCITY
         VERSION =   2.30 DATED    JUNE,  1983. WETTING AND DRYINGENG-MET WAT SUR FILE
      DMS = 1                     GRADE = 1           PERSON = COPELAND   DESCRIPTION =
     N CALIBRATION
     E=25
      WESHE  DMS VERSION  1.00. DATED    OCT 1981.  THIS FILE IS FROM    GFGEN   VERS
     ION 3.10 DATED   MAR 1984.
      DMS = LOCK AND DAM 1        GRADE = A           PERSON = LYNCH      DESCRIPTION =
     LOCK AND DAM 1 RED RIVER
     CORRECTED ELEVATIONS

NEW FLOW FIELD...            TIME STEP=     1,  TOTAL TIME=   .0

            BANNER HEADINGS ON VELOCITY INPUT ,

        WES HYD DMS VERION  1.0 DATED   OCT 81.    THIS FILE IS FROM   RMA2-VELOCITY
           VERSION =   2.30 DATED    JUNE,  1983. WETTING AND DRYINGENG-MET VELOCITYFILE
        DMS = 1                     GRADE = 1           PERSON = COPELAND   DESCRIPTION =
       N CALIBRATION
       E=25
        WESHE  DMS VERSION  1.00. DATED    OCT 1981.  THIS FILE IS FROM    GFGEN   VERS
       ION 3.10 DATED   MAR 1984.
        DMS = LOCK AND DAM 1        GRADE = A           PERSON = LYNCH      DESCRIPTION =
       LOCK AND DAM 1 RED RIVER
       CORRECTED ELEVATIONS
```

Figure G8. Sample STUDH printout showing input codes and hydrodynamic input files banners

```
*** CONC/DELBED HOTSTART EXPECTED ON UNIT 87

        BANNER HEADINGS ON HOTSTART CONC/DELBED INPUT

       WES HYC DMS VERSION 1.0 DATED   OCT 81     THIS FILE IS FROM   STUDH      VERS
      ION  3.30   DATED   AUG 1983    .
      ............................................................................
      ............................................................................
      ............................................................................
      ............................................................................
      ............................................................................
      ............................................................................
      ............................................................................
      ............................................................................

*********************************************************************************************
***STUDH CONCENTRATION/DELBED HOTSTART AT HOUR    9.00
*********************************************************************************************
```

Figure G9. Sample STUDH printout showing hotstart announcement and hotstart input file banners

****

TIME STEP # 6
TOTAL TIME .180E+05
DELTA TIME .360E+04

NODE POINT CONCENTRATIONS....(BY SELECTED NODES)

NODE	CONC	NODE	CONC	NODE	CONC	NODE	CONC	NODE	CONC	NODE	CONC
1	.5363	588	.5501	787	.5699	1354	.5318	2176	.6049	2317	.5350
2	.5363	589	.5473	788	.5696	1356	.5331	2178	.6024	2318	.5346
3	.5363	590	.5435	790	.5768	1357	.5346	2180	.5992	2319	.5356
4	.5363	602	.5307	812	.6392	1359	.5362	2182	.5952	2320	.5362
5	.5363	603	.6258	813	.6481	1361	.5376	2184	.5899	2321	.5375
6	.5363	604	.6352	817	.5779	1363	.5387	2186	.5833	2322	.5371
7	.5363	608	.5504	833	.5405	1365	.5395	2188	.5761	2323	.5380
8	.5363	609	.5528	834	.5385	1367	.5399	2190	.5698	2324	.5334
9	.5363	610	.5275	835	.5361	1369	.5401	2192	.5647	2325	.5330
13	.5363	620	.5557	836	.5332	1371	.5296	2194	.5606	2326	.5255
14	.5363	621	.5588	837	.5299	1372	.5292	2196	.5573	2327	.5272
15	.5363	622	.5624	838	.5269	1373	.5280	2198	.5543	2328	.5217
21	.5363	623	.5671	839	.5261	1374	.5303	2199	.5501	2329	.5261
22	.5363	624	.5726	840	.5296	1375	.5286	2200	.5517	2330	.5228
23	.5363	625	.5796	841	.5363	1376	.5316	2201	.5480	2331	.5283
31	.5363	626	.5868	842	.5383	1377	.5297	2202	.5499	2332	.5264
32	.5363	627	.5928	843	.5364	1378	.5333	2207	.6286	2333	.5316
33	.5363	628	.5974	844	.5350	1379	.5315	2208	.6291	2334	.5301
43	.5363	629	.6009	845	.5346	1380	.5338	2210	.5389	2335	.5347
44	.5363	630	.6037	922	.6400	1381	.5351	2212	.5354	2336	.5333
45	.5363	631	.6061	923	.6482	1382	.5362	2214	.5349	2337	.5373
57	.5363	632	.6079	929	.6387	1383	.5372	2216	.5360	2338	.5360
58	.5363	633	.6097	930	.6463	1384	.5384	2218	.5374	2339	.5396
59	.5363	634	.6114	945	.6423	1385	.5388	2220	.5388	2340	.5332
65	.5363	635	.6132	946	.6354	1386	.5401	2222	.5397	2341	.5423
66	.5363	636	.6175	951	.6304	1387	.5399	2224	.5397	2342	.5395
67	.5363	637	.6252	952	.6363	1388	.5414	2226	.5396	2343	.5409
73	.5363	638	.6320	972	.6241	1389	.5407	2227	.5343	2344	.5419
74	.5363	639	.6419	973	.6289	1390	.5423	2228	.5389	2345	.5464
75	.5363	640	.6527	976	.6187	1391	.5412	2229	.5313	2346	.5430
76	.5363	641	.6700	977	.6140	1392	.5427	2230	.5368	2347	.5467

Figure G10. Sample STUDH printout showing sediment concentration at selected nodes

****SUBROUTINE BEDSUR....
NSTEP= 1

	N	DEPTH	U	W	Z/D(OLD)	Z/D(NEW)	DELBED	ALPHAM	ELEV	BSHEAR	NODE	LAYER	TYPE	THICKNESS	DENSITY	SHR STRNGTH	AG	ITE
*	1*	1.8305	.13982E-01	-.80925E-01	.0	-.37593E-04	.0	.0	29.926	.10726E-01	1*	1	9	1.0000	402.00	900.00	.0	.0
*	2*	1.8811	.98566E-01	-.52090E-01	.0	-.29868E-04	.0	.0	29.926	.16787E-01	2*	1	9	1.0000	402.00	900.00	.0	.0
*	3*	1.8817	.10122	-.28812E-01	.0	-.31649E-04	.0	.0	29.925	.16916E-01	3*	1	9	1.0000	402.00	900.00	.0	.0
*	4*	1.7203	.95417E-01	.79924E-01	.0	-.27912E-04	.0	.0	29.093	.23325E-01	4*	1	9	1.0000	402.00	900.00	.0	.
*	5*	1.5989	.26806E-01	.36354E-01	.0	-.53381E-04	.0	.0	29.261	.37695E-02	5*	1	9	1.0000	402.00	900.00	.0	.0
*	6*	1.4063	.22711E-01	.28265E-01	.0	-.60561E-04	.0	.0	29.413	.25891E-02	6*	1	9	1.0000	402.00	900.00	.0	.0
*	7*	1.2548	.43309E-01	.43163E-03	.0	-.66384E-04	.0	.0	29.566	.37229E-02	7*	1	9	1.0000	402.00	900.00	.0	.0
*	8*	1.2544	-.55162E-02	.32510E-02	.0	-.71584E-04	.0	.0	29.566	.11524E-03	8*	1	9	1.0000	402.00	900.00	.0	.0
*	9*	1.2539	.17423E-01	-.21728E-01	.0	-.69404E-04	.0	.0	29.566	.16505E-02	9*	1	9	1.0000	402.00	900.00	.0	.0
*	10*	1.2536	.27367E-02	-.38553E-02	.0	-.71599E-04	.0	.0	29.566	.71788E-04	10*	1	9	1.0000	402.00	900.00	.0	.0
*	11*	1.2533	.41470E-01	.29417E-01	.0	-.54818E-04	.0	.0	29.566	.48696E-02	11*	1	9	1.0000	402.00	900.00	.0	.0
*	12*	1.4072	-.27070E-01	.37732E-01	.0	-.42683E-04	.0	.0	29.413	.16623E-01	12*	1	9	1.0000	402.00	900.00	.0	.0
*	13*	1.5511	-.30257E-01	.38343E-01	.0	-.52560E-04	.0	.0	29.261	.44163E-02	13*	1	9	1.0000	402.00	900.00	.0	.0
*	14*	1.6365	-.30736E-01	.37394E-01	.0	-.50329E-04	.0	.0	29.185	.42312E-03	14*	1	9	1.0000	402.00	900.00	.0	.0
*	15*	1.7123	-.35576E-01	.28283E-01	.0	-.45572E-04	.0	.0	29.108	.27354E-02	15*	1	9	1.0000	402.00	900.00	.0	.0
*	16*	1.73[illegible]	-.17131E-01	[illegible]	.0	-.40140E-04	.0	.0	29.032	.11865E-02	16*	1	9	1.0000	402.00	900.00	.0	.0
*	17*	1.6533	-.17345E-01	.10623E-01	.0	-.47432E-04	.0	.0	28.956	.89333E-05	17*	1	9	1.0000	402.00	900.00	.0	.
*	18*	1.7095	-.12380E-01	.41550E-02	.0	-.52223E-04	.0	.0	29.103	.39633E-03	18*	1	9	1.0000	402.00	900.00	.0	.0
*	19*	1.5560	.13061E-0[illegible]	-.37482E-03	.0	-.57525E-04	.0	.0	29.261	.14221E-04	19*	1	9	1.0000	402.00	900.00	.0	.0
*	20*	2.2715	.45345E-02	-.57331E-02	.0	-.39437E-04	.0	.0	29.545	.23022E-03	20*	1	9	1.0000	402.00	900.00	.0	.0
	21*	2.9373	.35719E-05	-.15214E-01	.0	-.29347E-04	.0	.0	27.928	.46530E-03								

Figure G11. Sample STUDH printout showing trace print information from subroutine BEDSUR

```
*****SUBROUTINE EXTRAPOLATE*****


EXTRAPOLATION NO.     1

CONSTRAINTS ON MAX. PERMISSIBLE EXTRAPOLATION ARE          2.000  METERS, AND/OR
                                                          20.000  PERCENT OF DEPTH AT  100 NODES, OR
                                                       432000.00  SECONDS.


     RRAT        ERAT              DT         RTIP       NTTS,

 .555556E-04  .0               3600.00    18000.00       6


CALCULATED EXTRAPOLATION TIME PERIOD (SEC)=  396000.00

ZETA =                .500

IS CONTROLLED BY TIME LIMIT

TIME T0 = STARTING TIME
TIME T1 = START OF PREVIOUS STUDH SIMULATION PERIOD= .0
TIME T2 = END OF PREVIOUS STUDH SIMULATION PERIOD   = 18000.000
TIME T3 = END OF THIS STUDH EXTRAPOLATION PERIOD    = 414000.00
PERCENT OF TOTAL TIME PERIOD OF STUDY (TIMEX/EXDT) = 95.833333
```

Figure G12. Sample STUDH printout showing internal extrapolation results

104. A number of specialized output results are available through the trace printout (TR) cards. Most are detailed listings of the input data or parameters calculated from input data. KSW(3) controls output in the bed computation module and can provide for detailed results of bed structure and rates of erosion/deposition. Table G3 lists the column headings in this output and explains what each means.

TABLE G3. BEDSUR AND BEDXCG OUTPUT HEADINGS

HEADING	MEANING
AGE	Age of a clay layer, years
ALPHAM	Amount of clay mass erosion, kg
BSHEAR	Shear stress on the bed, newtons per sq in.
CONC	Average concentration of noncohesive sediment in the water column, kg per cu m
CPOT	Concentration of noncohesive sediment in the water column that would correspond to full transport capacity, kg per cu m
DELBED	Bed change since the beginning of computations, m
DENSITY	Dry density of clay bed layers, kg per cu m
DEPTH	Water depth, m
DYBED	Bed change during the current time-step
E/D(NEW)	Erosion/deposition rate at the present time-step, kg per sec per sq m. Positive values indicate erosion
E/D(OLD)	Erosion/deposition rate at the previous time-step
ELEV	Bed surface elevation, m
N or NODE	Node number
SHR STRENGTH	Shear stress at which mass erosion of a cohesive bed layer occurs, newtons per sq m
THICKNESS	Thickness of a cohesive bed layer, m
TTHICK	Thickness of a noncohesive bed, m
TYPE	Clay bed layer type as shown on DT cards
U	Current speed in the x-direction, m per sec
V	Current speed in the y-direction, m per sec

105. Two output files are created by every run of the model and a third is also created if an extrapolation run is performed. If these files are saved by job control, the information may be retrieved and printed by the postprocessors or subsequent runs (hotstart runs). Table G4 lists the output files and their generic names (see Appendices N and O).

106. TAPE7 contains sediment concentration and cumulative bed change at every node, every time-step. TAPE18 contains cohesive bed structure at every node for the final time-step. These files are created by every model run. TAPE99, created only during extrapolation runs, contains bed elevations at the end of the model run.

Table G4
Standard Output Files

Generic File Name	Standard Logical Unit	Contents
01S3	7	Concentration/bed change results
02S3	99	Extrapolated bed change results
03S3	18	Cohesive bed structure results
OEGEO	19	English geometry file
--	06	Printed output

Job Tracking

107. Keeping track of STUDH jobs is made easier by orderly methods of recording jobs and naming files (see Appendix N). The File Management System, described in Appendix N, can be quite useful, as can be job tracking sheets as shown in Figure G13. Rigorous record keeping about all runs made and their results is strongly recommended. Also see Appendix N.

04/85

STUDH JOB TRACKING WORKSHEET

JOB NAME ___________ DATE __/__/__ TIME LIMIT (SECS) ____ PRI ___

DESTINATION UN ___________ SUBMITTED BY _____ JOB COST ___________

JOB PRINTED ___________ SPECIAL UPDATES ____________

****

TYPE OF RUN

SAND __ CLAY __ SAND/CLAY __

W/EXTRAPOLATION __ PRODUCTION __ TEST ONLY __

NUMBER OF TIME-STEPS ___ TIME-STEP (HR.) ___ TOTAL SIMULATION TIME ___

****

JOB DESCRIPTION:

____

____

____

____

____

****

INPUT DATA

RUN CONTROL _________ GEOMETRY __________ VELOCITIES __________

WATER SURFACE _________ HOTSTART _________ WAVES _________

****

OUTPUT DATA

CONCENTRATION/DELBED ___________ EXTRAPOLATION __________

****

Figure G13. Example Job Tracking Sheet

REFERENCES

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NOTATION

α_1 = coefficient for the source term 1/sec

α_2 = equilibrium concentration portion of the source term $kg/m^3/sec$

C = Chezy roughness coefficient

c = concentration of sediment, kg/m^3

CME = coefficient of 1 for metric units and 1.486 for English units

C_c = critical concentration = 300 mg/l

C_d = coefficient for deposition

C_e = coefficient for entrainment

C_{eq} = equilibrium concentration

$\hat{C}$ = approximate concentration in an element as evaluated from the shape functions and nodal point values of c

D = water depth

D_s = effective grain size

D_x = effective diffusion coefficient in x-direction, m^2/sec

D_y = effective diffusion coefficient in y-direction, m^2/sec

DT = computation time interval

ΔT = computation time interval

f = time-varying characteristic

f_c = shear stress coefficient for currents

f_w = shear stress coefficient for waves

GP = transport potential

GS = transport capacity

g = acceleration due to gravity

i = number of grain size class

M = consolidation coefficient

N = quadratic shape functions

NE = total number of elements

NL = total number of boundary segments

n = Manning's roughness value

P = erosion rate constant

PI = percent of bed surface covered by grain size, expressed as a function

Q = $(\hat{C}/\Delta t) + \alpha_2$ for the transient problem

q_i^s = flux from source on boundary i

ρ = water density

L = density of the failed layer

S = source term

T_1 = thickness of the failed layer

t = time, sec

t_c = characteristic time

t_o = time zero

t_1 = time, 1 year

= bed share stress

τ_d = critical shear stress for deposition

τ_e = critical shear stress for particle erosion

τ_s = bulk shear strength of the layer

u = flow velocity in x-direction, m/sec
u_{om} = maximum orbital velocity of waves
u_* = shear velocity
v = flow velocity in y-direction, m/sec
ν = kinematic viscosity of water
V_k = $V_s/(C_c)^{4/3}$
V_s = fall velocity of a sediment particle
V = mean flow velocity
x = primary flow direction, m
y = direction perpendicular to x , m
ξ = local coordinate

ADDENDUM G-1: CODING INSTRUCTIONS FOR CARD IMAGE INPUT DATA

1. A summary of cards in this data set is shown in Table G-1-1. A summary of the variables is shown by card in Table G-1-2 at the end of this addendum.

2. Card image data are coded in 80-column lines consisting of 10 fields of 8 columns each. Blanks are read as zero except where noted otherwise. The first two columns, referred to as field zero, are card identifications that indicate the type of data on that card. Column 1 is the card group, e.g., G = geometry, F = fluid, etc., and Column 2 is the data type within that group, e.g., Q = discharge, N = Manning's n , etc. Figure G-1-1 illustrates field numbering.

Coding Options for Nodal Point Data

3. Four options are provided for coding nodal point data. These are: (a) constant value for all nodes, (b) constant value by cross section, (c) value at each corner node, and (d) value at each node. Column 3 of the data card conveys the coding option. More than one option may be used provided the cards are arranged with increasing option numbers.

4. Terminology is defined in Figure G-1-2. Cross sections are denoted by Roman numerals. Thus cross-section II consists of nodes 3, 7, 11, 15, 19, 23, and 27. Positive directions of flow correspond to the positive x- and y-axes as shown in Figure G-1-2.

Option 1

5. Coding a blank in Column 3 and a constant value in Field 2 causes that value to be assigned to every node. For example, "HU   1.0" would assign an x-velocity of 1 to every node in the data set. Options 2 through 4 may also be included as desired, to change from the constant value at selected locations, but always arrange cards in the sequence of increasing option numbers.

Option 2

6. Coding an X in Column 3 activates the cross-section option (only available when using CARD G3 or G4). In Figure G-1-2, cross sections are denoted by Roman numerals I, II, III, etc. When coding with the cross-section option, all nodes along the section are assigned the constant value. For example, "HUX   0.5" would set x-velocity at 0.5 at nodes 5, 8, 13, 16, 21, 24, and 29. Values at midsection nodes, i.e., those between cross sections such as 4, 12, 20, 28, etc., are calculated by straight-line interpolation between corner nodes after all cross-section data have been read. Numbering does not

FIELD ¶ 0 ¶ 1 ¶ 2 ¶

COLUMN 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16

FIELD ¶ 3 ¶ 4 ¶

COLUMN 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32

FIELD ¶ 5 ¶ 6 ¶

COLUMN 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48

FIELD ¶ 7 ¶ 8 ¶

COLUMN 49 50 51 52 53 54 55 56 57 58 59 60 61 62 63 64

FIELD ¶ 9 ¶ 10 ¶

COLUMN 65 66 67 68 69 70 71 72 73 74 75 76 77 78 79 80

Figure G-1-1. Field numbering

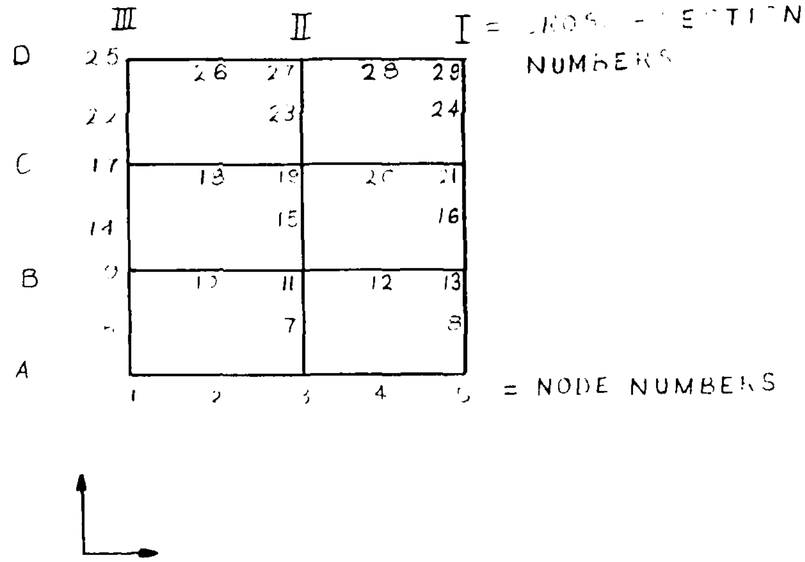

Figure G-1-2. Coding option terminology

have to be sequential; the end of cross-section-type data is signified by a blank, zero, or negative node number. A new data-type (Column 2), or a new card-group (Column 1) signifies a new input parameter.

Option 3

7. Coding a C in Column 3 activates the corner node option. For example, "HUC 1. 0" would set the x-velocity at node 1 to zero. The corner node option may be used for all or part of the corner nodes. Numbering does not have to be sequential. All mid-side nodes will be calculated by straight-line interpolation. A blank, zero or negative node number signifies the end of corner node data on a card. A new data type card or a new card-group type signifies a new input parameter.

Option 4

8. For coding individual node values, an N is placed in Column 3. Both corner and mid-side nodes may be prescribed with this option. As in Options 2 and 3, numbering does not have to be sequential nor do all nodes have to be included. However, only those node numbers coded will be assigned a value with this option. A blank, zero, or negative node number is interpreted as the end of data.

Coding Date/Time Data

9. On some data cards, a provision is made for assigning a date and time to the data that follow. This information is placed in Columns 5-8 of Field 1 and in Field 2. Columns 5-6 are the last two digits of the year. Columns 7-8 are the month number. Field 2 contains the day, hour, minute, and second in two-column digits.

Coding Values

10. All values, other than card identification, year, and month, are read as real number variables. If no decimal is used, the data should be right-justified in the eight-column field. If a decimal is included, they may be placed anywhere in the field. Unless otherwise noted, only positive values should be used. Where noted in the coding instructions, a blank or zero entry in a field causes default values to be assigned.

Continuation Cards

11. Some input data cards may call for continuation cards. For an example, see the summary sheet in Addendum G4 for the DV card. When using continuation cards, the first three columns are duplicated on each card, but after the first card, date and time are not coded and coding begins in Field 1.

Input Instructions

12. Table G-1-1 lists the card image input for STUDH. Instructions for each card are described in the following pages. Table G-1-2 at the end of the addendum summarizes input data requirements.

Table G-1-1

STUDH Version 3.3 Sequence of Cards

Group	Content	Required?		Page
T1-T3	Title cards	One		G-1-8
SL	Input/output file numbers	No		G-1-9
ST	Timing controls	No		G-1-11
SH	Hotstart controls	No		G-1-16
TR	Trace printout controls	No		G-1-17
G1	Geometry parameters, general	Yes		G-1-20
G3, GB, GS, GE or	Mesh generator	Yes		G-1-22
G4	Rectangular mesh generator	Yes	if geometry	G-1-27
GN	Nodal point coordinates	Yes	not input	G-1-28
GY	Bed elevations	Yes	on file	G-1-29
GD	Mesh drying	No		G-1-30
PG	Acceleration due to gravity	No		G-1-31
TZ	Time zero	Yes		G-1-32
TE	Extrapolation in time	No		G-1-33
TT	Theta for implicitness	No		G-1-35
PS	Print selector	No		G-1-36
SA and/or	Sand (noncohesive) parameters	For sand		G-1-37
SC	Clay (cohesive) parameters	For clay		G-1-38
DV	Bed deposit volume	For sand		G-1-39
DT	Bed layer types	No		G-1-40
DC	Bed layers	Yes, for clay if not input from file		G-1-42
FT	Fluid temperature	Yes		G-1-43
FD	Fluid density	Yes		G-1-44
HS	Hydraulics, shear stress method	Yes		G-1-45
HN	Hydraulics, Manning's n values	If HS (2) = 2 or 3		G-1-46
HH	Hydraulics, water-surface elevations	Yes		G-1-47
HU and	Hydraulics, x velocity	Yes	if not input	G-1-48
HV or	Hydraulics, y velocity	Yes	from tile	G-1-50
QX and	Hydraulics, x discharge	Yes		G-1-52
QY	Hydraulics, y discharge	Yes		G-1-54
EX	Dispersion coefficient, x-direction	Yes		G-1-56
EY	Dispersion coefficient, y-direction	Yes		G-1-58
IC	Initial conditions, sediment concentrations	Yes		G-1-59
SR	Sediment size, representative for roughness	No		G-1-60
ST	Sediment size, representative for transport (sand only)	No		G-1-61

Table G-1-1 (Concluded)

Card Group	Content	Required?	Page
WC	Fall velocity, sediment particles	Yes	G-1-62
BC	Boundary condition, sediment concentration	Yes	G-1-63
$$END	End of data	Yes	G-1-64
IFF(J,2)	Printout control, type and timing	Yes	G-1-65 G-1-65
IVCØD(J)	Input velocity field, timing	Yes if $T cards not used	G-1-65
IDIF(J)	Input dispersion coefficients, timing	Yes	G-1-65
IDEPC(J)	Input depth of flow, timing	Yes	G-1-65
ISVS(J)	Input settling velocity, timing	Yes	G-1-65

T1-T3 CARDS Job Title One required

Any number of T1 and T2 cards may be utilized and sequence is not significant to the program. But only one T3 card may be included and it must be the last title card in the set. Information from the T3 card is saved on the tape of STUDH results, and the program reads the "3" as meaning END OF T-CARDS.

Field	Variable	Value	Description
Col 1	ICG	T	Card group
Col 2	IDT	1,2,3	Data type
1	ISI	Any	Comment
2-10	TITLE	Any	Any alpha-numeric data can be coded. For example, stream name, model name, date, study name, model run number.

$L CARD — Input Data Logical Unit Numbers — Optional

Card image data described in these pages are read from logical unit (LU) 5 by the PRESED module. Module HORSED reads from a variety of logical units that are usually disk files. These files are either written by PRESED or supplied by another program (e.g., RMA-2V or GFGEN). The default values must be used if PROCLV (Appendix O) is used.

Field	Variable	Value	Description
0	ICG	$	
	IDT	L	
2	--	-	Not used
3	LP	+	LU for standard printed output
		0	Default to 6, line printer
4	INB	+	LU for fluid properties data
		0	Default to 4
5	INC	+	LU for initial and boundary conditions concentrations
		0	Default to 8
6	IND	+	LU for water surface elevations
		0	Default to 9
7	INE	+	LU for dispersion coefficients
		0	Default to 10
8	INF	+	LU for water velocities
		0	Default to 11
9	ING	+	LU for computational mesh geometry
		0	Default to 12
10	INH	+	LU for bed structure data
		0	Default to 13

CARD NUMBER 2

Field	Variable	Value	Description
0	ICG	$	
	IDT	L	
2	IN1	+	LU for general data
		0	Default to 14
3	KPU	+	LU for end results file (Hotstart concentration and bed elevation changes)
		0	Default to 7

$L CARD (continued)

Field	Variable	Value	Description
4	KPL	-	Not used
5	INJ	+	LU for bed roughness
		0	Default to 1
6	INK	+	LU for settling velocities
7	INHOT	+	LU to read concentration and bed change hotstart data
		0	Default to 87 (hotstart will occur only if a $H card is present)
8	KOHOTB	+	LU to write clay bed structure for subsequent hotstart
		0	Default to 18
9	INHOTB	+	LU to read hotstart clay bed structure
		0	Default to 88

(Hotstart will occur only if a $H card is present. Hotstart output files are always written. If they are desired for future use, save them using job control.)

$STP CARD | Print Controls | Optional

These cards may be used instead of the IFF, etc., cards (p. G-1-65). They specify the time-step numbers at which printed output will be produced ($STP) and at which particle fall velocities ($STF), water surface elevations ($TD), flow velocities ($TV), and dispersion coefficients ($TC) will be read in. The $T cards should be placed in the order shown here.

Field	Variable	Value	Description
Col 1	ICG	$	Card group $ = Command
Col 2	IDT	T	Data type T = Timing control
Col 3	ISI(1)	P	P = Print timing control
1	IFF	1	Print concentration
		2	Print bed elevation and volume change
		3	Print both

Fields 2-10 can be used (interchangeably) in two ways:

(1) A single time-step can be entered in each field. This time-step will print with the print type defined in Field 1.

(2) Three consecutive fields can be used to specify an implied loop (much like FORTRAN) with a beginning value, ending value, and an increment. However, the increment must be coded in the third field as a negative number. The time-steps selected will have the print type specified in Field 1.

Single fields and implied loops (three fields) can be mixed in Fields 2-10 and all will have the print type specified in Field 1.

Repeat $TP cards until all desired output time-steps have been selected.

$STF CARD   Fall Velocity Input Controls   Optional

These cards may be used instead of the IFF, etc., cards (p. G-1-65). They specify the time-step numbers at which printed output will be produced ($TP) and at which particle fall velocities ($TF), water-surface elevations ($TD), flow velocities ($TV), and dispersion coefficients ($TC) will be read in. The $T cards should be placed in the order shown here.

Field	Variable	Value	Description
Col 1	ICG	$	Card group $ = Command
Col 2	IDT	T	Data type T = Timing control
Col 3	ISI(1)	F	F = Fall velocity input

Fields 2-10 can be used (interchangeably) in two ways:

(1) A single time-step can be entered in each field.

(2) Three consecutive fields can be used to specify an implied loop (much like FORTRAN) with a beginning value, ending value, and an increment. However, the increment must be coded in the third field as a negative number.

Single fields and implied loops (three fields) can be mixed in Fields 2-10

Repeat STF cards until all desired time-steps are specified.

$TD CARD Water-Level Input Controls Optional

These cards may be used instead of the IFF, etc., cards (p. G-1-65). They specify the time-step numbers at which printed output will be produced ($TP) and at which particle fall velocities ($TF), water-surface elevations ($TD), flow velocities ($TV), and dispersion coefficients ($TC) will be read in. The $T cards should be placed in the order shown here.

Field	Variable	Value	Description
Col 1	ICG	$	Card group $ = Command
Col 2	IDT	T	Data type T = Timing control
Col 3	ISI(1)	D	D = Water Depths

Fields 2-10 can be used (interchangeably) in two ways:

(1) A single time-step can be entered in each field.

(2) Three consecutive fields can be used to specify an implied loop (much like FORTRAN) with a beginning value, ending value and an increment. However, the increment must be coded in the third field as a negative number.

Single fields and implied loops (three fields) can be mixed in Fields 2-10.

Repeat $TD cards until all desired time-steps are specified.

$TC CARD Dispersion Coefficient Input Controls Optional

These cards may be used instead of the IFF, etc., cards (p. G-1-65). They specify the time-step numbers at which printed output will be produced ($TP) and at which particle fall velocities ($TF), water-surface elevations ($TD), flow velocities ($TV), and dispersion coefficients ($TC) will be read in. The $T cards should be placed in the order shown here.

Field	Variable	Value	Description
Col 1	ICG	$	Card group $ = Command
Col 2	IDT	T	Data type T = Timing control
Col 3	ISI(1)	C	C = Concentration input

Fields 2-10 can be used (interchangeably) in two ways:

(1) A single time-step can be entered in each field.

(2) Three consecutive fields can be used to specify an implied loop (much like FORTRAN) with a beginning value, ending value, and an increment. However, the increment must be coded in the third field as a negative number.

Single fields and implied loops (three fields) can be mixed in Fields 2-10

Repeat $TC cards until all desired time-steps are specified.

$TV CARD Velocity Input Controls Optional

These cards may be used instead of the IFF, etc., cards (p. G-1-65). They specify the time-step numbers at which printed output will be produced ($TP) and at which particle fall velocities ($TF), water-surface elevations ($TD), flow velocities ($TV), and dispersion coefficients ($TC) will be read in. The $T cards should be placed in the order shown here.

Field	Variable	Value	Description
Col 1	ICG	$	Card group $ = Command
Col 2	IDT	T	Data type T = Timing control
Col 3	ISI(1)	V	V = Velocity input

Fields 2-10 can be used (interchangeably) in two ways:

(1) A single time-step can be entered in each field.

(2) Three consecutive fields can be used to specify an implied loop (much like FORTRAN) with a beginning value, ending value, and an increment. However, the increment must be coded in the third field as a negative number.

Single fields and implied loops (three fields) can be mixed in Fields 2-10

Repeat $TV cards until all desired time-steps are specified.

$H CARD Hotstart Controls Optional

The parameters on this card cause the program to begin with values computed at the end of a previous model run, thus continuing the computations of the previous run (hotstart). The previous run must have saved output of the desired parameters.

Field	Variable	Value	Description
0	ICG	$	
	IDT	H	
2	KCHOT	+	Hotstart concentrations using those from last time-step of previous run.
		0	No concentration hotstart.
3	KDBHOT	+	Hotstart net bed change (DELBED) using last time-step of previous run
		0	No DELBED hotstart
4	KBSHOT	+	Hotstart bed structure (thickness of layers, etc.) using last time-step of previous run for clay and mixed beds.
		0	No bed structure hotstart

TR CARD — Trace Printout — Optional

Note: Use a continuation card to define trace variables KSW(11)-KSW(20).

Field	Variable	Value	Description
0	ICG	T	T = Card group
	IDT	R	R = Data type
1	IECHO	-1	No printout of input data cards
		0	Print out each input card as it is read in
		+1	In addition to input, print FE mesh
		+2	In addition to above, list boundary nodes and Data Set Codes.
2	KSW(2)	0	No trace printout in Subroutine GRIDGR
		1	Print NETNP (1st and last node on x-section).
		2	In addition to above, print FE mesh
3	KSW(3)	0	No trace printout in Subroutine BEDSUR or in BEDXCG.
		1	Print the following in BEDSUR: Node, u-velocity, v-velocity, bed exchange rate at beginning of computation time interval, bed exchange rate at end of computation time interval (kg/m^3 sec), change in bed elevation during computation interval, mass erosion rate, bed elevation, and bed shear stress (newtons/sq m). Plus the following from Subroutine BEDXCG: Node, u-velocity, v-velocity, water depth, depth of sand in bed, suspended load concentration potential transport (kg/m^3), bed elevations, alpha1, and alpha2.
		2	Print the following in BEDSUR: Node, layer No., layer type, layer thickness (m), layer density (kg/cu m), layer strength (N/SM), layer age (yr), and change in bed elevation (m) at each time-step.
		-2	Same as above for initial conditions only
		3	Print both Options 1 and 2 in BEDSUR at each time-step.
		-3	Same as above for initial conditions only.

TR Card (Continued)

Field	Variable	Value	Description
4	KSW(4)	0	No trace printout in Subroutine ELSTIF2.
		1	Print Element Shape Function coefficients and their derivatives.
5	KSW(5)	0	No trace printout in Subroutine AWHITE and its interface SANDX.
		1	Print the following SANDX: Node, D35, velocity vector, depth of water, bed shear stress, water density, kinematic viscosity of water, sediment concentration. Plus the following from AWHITE: Size class number, grain size, and the Ackers-White coefficients (DGR, AWN, AWA, AWM, AWC, USTFG, USTCG, FGR, GCR, CBAR).
6	KSW(6)	0	No trace printout in Subroutine HORSED.
		1	Print Initial Conditions Data by node.
		2	In addition to the above, print element data.
		3	In addition to above, print nodal point co-ordinates and the element connections table.
7	KSW(7)	0	No trace printout in Subroutine ONEDIN.
		1	Trace array sizes and data set codes.
8	KSW(8)	0	No trace printout in Subroutine CLASS.
		1	Print class interval data.
9	KSW(9)	0	No trace printout in Subroutine DEPTH.
		-1	Print out water depths for initial conditions.
		+1	Print out water depths at each time-step.
10	KSW(10)	0	No trace printout in Subroutine DIFCOF.
		-1	Print Diffusion Coefficients for initial conditions.
		+1	Print diffusion coefficients for each time step.

TR CARD (Continued)

Field	Variable	Value	Description
1	KSW(11)	0	No trace printout in Subroutine INPUTV
		-1	Print u- and v-velocity components for Initial Conditions.
		1	Print velocity components for each time-step.
2	KSW(12)	0	No trace printout in Subroutine SETVEL.
		-1	Print settling velocity of particles for initial conditions.
		+1	Print settling velocities for each time step.
3	KSW(13)	0	No trace printout in Subroutine EXTRAP.
		1	Trace printout of extrapolation coefficients.
4	KSW(14)	0	No trace printout in Subroutine JONFW.
		1	Wave particle orbit length, wave velocity and current velocity near the bed, wave Reynolds no. and wave friction factor.
5	KSW(15)	0	No trace printout in subroutine DRYNOD.
		1	Print out list of dry nodes and elements.

G1 CARD Required

General description of the finite element network.

Field	Variable	Value	Description
0	ICG,IDT	G1	Card identification begins in Column 1
2	IHV	0	Data set is for Horizontal Model (only option at present).
		1	Data set is for Vertical Model
3	UMILE	-,0,+	Identifies the upstream limit of study area by river mile. If this value is omitted, the program defaults to 0.
4	DMILE	-,0,+	Identifies the downstream limit of study area by river mile. If this value is omitted, the program defaults to 0.
5	XSCALE	+	The X-coordinates will be multiplied by variable to scale from map to prototype size.
		0	The program defaults to 1.0.
6	YSCALE	+	The Y-coordinates will be multiplied by variable to scale from map to prototype size.
		0	The program defaults to 1.0
7	NE	0,+	Enter the number of elements in the finite element network when reading in the computation mesh from cards or from a previously generated tape file. Leave blank when networks are to be generated by the proram Subroutines RGRID or GRID.
8	NP	0,+	Enter the number of node points when reading the finite element network from cards or a previously generated tape file. It may be left blank when the network is being computed in Subroutines GRID or RGRID.
9	NPX	0,+	Enter the number or corner nodes when reading the finite element network from cards. This variable should be used in conjunction with NE and NP variables above.

G1 CARD (Continued)

Field	Variable	Value	Description
10	METRIC	0	The computer program expects all input data to be in metric units.
		*1	The computer program expects all input data to be in English units. It is converted into metric units immediately upon reading and all computations and output are produced in metric units.

* Not yet available.

G3 CARD Mesh Generator Optional

This card is required to use the internal mesh generator.

Field	Variable	Value	Description
0	ICG,IDT	G3	Card identification begins in Column 1
2	WTLMAX	0	The program will default to a fully iso-parametric computation mesh.
		1	The program will use a LAPLACE approximation to the isoparametric mesh.
3	*WIDTH	0	Vertical model width. Values are coded on GW cards.
		+	The program will assign this width to all nodes. It can be modified at any or all cross sections or nodes (see Options GWX or GWN cards) if desired.
4	DEPTH	0	Horizontal model options. Depth will be calculated from water surface (HH-Cards) minus bed surface elevations (GY-Cards). Ignore this variable when coding for vertical modes.
		+	The program will assign this constant depth to all nodes plus modify it at selected modes if desired (HHN and GYN-cards)

Total nodes = 3*NE+2 (NPAN+NXS) - 1.

* Not used.

GB CARD | Mesh Generator (Continued) | Required if G3 card is present

Code XY coordinates on this card to prescribe the outside boundary geometry and all interior nodes will be calculated automatically. The program assumes the coordinate on this GB card is connected to the coordinate on the previous GB card if an INCR value (GB-6) is entered. In addition, GB cards can be used to "fix" the location of any coordinates, thereby overriding the automatic computations.

Field	Variable	Value	Description
0	ICB,IDT	GB	Card identification begins in Column 1
2	RMILE		This variable is *optional*. It is convenient to identify cross sections by river mile when mesh points are aligned in a systematic fashion across the river or estuary.
3	N	+	The node point number for each new node.
		-	The number has already been read on GB cards.
4	XP	0,+	When N is positive, enter the X-coordinate of the node.
5	YP	-,0,+	The y-coordinate of the node.
6	INCR	-,+	The numbering increment between corner nodes from the previous GB card to this one segment. Enter a negative value if node numbers are decreasing.
		0	Do not enter a numbering increment for the first nodal point. Do not enter an INCR when simply prescribing (freezing) the location of a node.
7	INCR2	-,+	The numbering increment between the corner node and midpoint node along a circular arc.
		0	When not using a circular arc.
8	D	0	Corner nodes are spaced equidistance apart on this segment of the boundary (i.e., all elements are the same size).
		+	Enter the ratio for changing element size along this boundary. Values greater than 1.0 increase the size. Values between 1 and 0 decrease the size.
		-	Do not use.

GB CARD (Continued)

Field	Variable	Value	Description
9	XC		Leave this value blank for a straight line.
		-,0,+	A point on a circular arc which is not an end point. Do not use (0,0) for (XC,YC) because program will treat it as a blank.
10	YC		Leave this value blank for a straight line.
		-,0,+	The companion to XC (GB-9). Do not use (0,0) for (XC,YC).

GS CARD — Mesh Generator (Continued) — Required if G3 card is present

The parameters on this card prescribe the number of elements along as well as across the computation mesh. One GE card must follow to describe element connections.

Field	Variable	Value	Description
0	ICB,IDT	GS	Card identification begins in Column 1
2	NXS	+	The total number of cross sections along the computational space described by the following GE card. It includes both end sections in that space. Do not count mid-side nodes as cross sections.
3	NPAN	+	The number of panels (i.e., elements) across the computational space. In terms of backwater notation, NPAN would be the number of subsections at a cross section.
4	INCRP		Increment for calculating nodal point numbers around each tier of elements in this computational space. If left blank, the program will calculate INCRP as follows. INCRP = 3 * NPAN + 2.
5	NBEL		Connect meshes. Base element number for first tier.
6	DELEL		Numbering increment from base element to adjoining element.

GE CARD — Mesh Generator (Continued) — Required if G3 card is present

The parameters on this card connect the nodes prescribed on GB cards into the sequence of elements which forms the finite element computation mesh.

Field	Variable	Value	Description
0	ICB,IDT	GE	Card identification in Column 1
2	NTE	+	Code the element number
		0	The program will default to element number 1. NTE is the number of the element whose nodes are specified on this card.
3	NODP(1)	+	This is the first of eight nodal point numbers which describe the element NTE. It must be the lowest numbered corner node at the outer edge of the element.
		-	"Connect Meshes" option only. Code Node 1 as a negative if changing direction from previously generated mesh.
4	NODP(2)	+	Proceed counterclockwise around the element. See Field 3 description for details. Negative nodes not permitted unless indicated in the Value Column.
5	NODP(3)	+	"
6	NODP(4)	+	"
7	NODP(5)	+	"
8	NODP(6)	+	"
9	NODP(7)	+	"
		-	
10	NODP(8)	+	"
		-	

G4 CARD Rectangular Mesh Generator

The parameters on this card are only required if using the rectangular mesh generator.

Field	Variable	Value	Description
0	ICG,IDT	G4	Card identification begins in Column 1
2	TML	0	The program will default to the distance between UMILE and DMILE shown on Card G1. If these were not prescribed, TML must be entered on this card as follows:
		+	Total model length in metres.
3	*WIDTH		When a constant width geometry is desired in the vertical model.
		+	Enter the value here.
		0	The program will look for GW-cards.
4	DEPTH		When a constant depth geometry is desired in the horizontal model.
		+	The program will subtract this value from the water surface elevation at all nodes to determine the bed surface elevation.
		0	The program will expect bed surface elevations to be entered on GY-cards.
5	NXS	+	The total number of cross sections in the computation mesh. This includes one at each end boundary. Do not count mid-side nodes as cross sections.
6	NPAN	+	The total number of elements across each cross section.
7	XR	0	The program will use uniform spacing in the x-direction for calculating the distance between corner nodes.
		+	For values greater than 1, the length will increase in the x-direction. For values between 0 and 1, the length will decrease in the x-direction.
8	YR		Same as XR except in the y- or z-direction.

* Not used.

GN Card | Nodal Point Coordinates | Optional

The coordinate of nodal points can be prescribed on GN cards by coding the (x,y) values at each corner node. When this option is selected, a GE card is required for each element and only coding Options 1, 4, and 5 are permitted for all other input parameters. Code 3 points per card. Omit GN cards if geometry is attached on an external file. Begin continuation card in Field 2.

Field	Variable	Value	Description
Col 1	ICG	G	Card group G = geometric data.
Col 2	IDT	C	Data type C = corner nodes.
2	Node	+	Code the nodal point number.
3	X	+	Code the x-coordinate.
4	Y	+	Code the y-coordinate.
5	Node	+	Repeat (NODE, X, Y) for 3 points per card.

Note that data on these cards will not override data on an external geometry file.

GY CARD — Initial Bed Elevations — Optional

When coding more than one time point, enter the YEAR/MONTH/DAY/HOUR/MINUTE/SECOND for each successive time using the format for the first one. If two or more options are used for coding this data type, stack the cards in the order shown for Col 3 below.

Field	Variable	Value	Description
Col 1	ICG	G	Card group G = Geometry.
Col 2	IDT	Y	Data type Y = Bed elevation.
Col 3	ISI_1		Coding options.
		ƀ	Blank = constant value for all nodes.
		X	X = constant for this cross section.
		C	C = value at corner node only.
		N	N = value by node.
Col 5-6	YEAR	+	Code the last two digits of the year.
Col 7-8	MONTH	+	Code the month number (01-12).
2	DAY HOUR MINUTE SECOND	+ + + +	Code the DAY, HOUR, MINUTE AND SECOND for this event. Use 2 columns for each (01-31) (01-60), etc.
3	LOC_1	+	Code the locator for $ELEV_1$ for ƀ option - LOC = 1 for X option - LOC = cross-section number for C option - LOC = corner node number for N option - LOC = node number.
4	$ELEV_1$	+	Code the bed elevation in metres.
5	LOC_2	+	Code the locator for $ELEV_2$.
6	$ELEV_2$	+	Code the bed elevation for node or X-Section LOC_2.
(7-10)	etc.		Use all 10 fields...start continuation cards in Field 1 and do NOT code date/time. Leave at least one blank LOC-field at the end of data even if it requires an additional card. Note: LOC_1, LOC_2, etc., do not have to be sequential

Note that data specified on these cards will not override data on an external geometry file.

GD CARD | Mesh Drying | Optional

Field	Variable	Value	Description
Col 1	ICG	G	Card group G = geometry.
Col 2	IDT	D	Data type D = drying.
2	IDRY	0	Default. Depths are not checked for dry nodes.
		+	Depths are checked for dry nodes and elements and those with depth less than DSETD are excluded from computations.
3	DSETD	+	Critical water depth for node to be considered dry. Default is 0.1219 M (This should have the metric equivalent to DSETD used in the RMA-2V run supplying hydrodynamic data to this run).
4	DRYEXP	0	Default. All nodes are considered in the extrapolation computations, regardless of depth.
		+	Water depth below which the extrapolation limit EXPDMX (p. G26) is disabled to prevent very shallow or dry areas from dominating the extrapolation.

PG CARD Physical Properties (acce ration of gravity) Optional

The program defaults to standard acceleration of gravity at 45 deg latitude and sea-level elevation, which is 9.801 mps^2. If refinement is needed to other latitudes, elevations, or planets, code as shown below.

Field	Variable	Value	Description
0	ICG,IDT	PG	Card group = P (physical properties). Data type = G (acceleration due to gravity).
2	ACGR		Acceleration due to gravity in metres per second.
		0	Default value is 9.802 m/s^2 (32.174 fps^2).

TZ CARDS — Computation Time — Required

Field	Variable	Value	Description
Col 1	ICG	T	Card group T = Time.
Col 2	IDT	Z	Data type Z = zero.
2	YEAR	+	Code the starting year for this calculation (four digits).
3	MONTH	+	Code the month number.
4	DAY	+	Code the day.
5	HOUR MINUTE SECOND	+ + +	Use two columns for each starting in Column 35.
6	DT	+	Code the computation interval length in seconds (required).
7	NTTS	+	Code the number of computation intervals for this job.

TE CARD — Extrapolation in Time — Optional

The parameters on this card are only required if using the Extrapolation-in-Time option.

Field	Variable	Value	Description
0	ICG,IDT	TE	Card identification begins in Column 1.
2	IDLB	99	Logical unit on which previous extrapolation results are stored and read in as initial condition.
		0	No previous extrapolation.
3	MEX	+	Maximum number of time-stepping cycles. Used to prevent runaway costs. This parameter should not be used to control extrapolation time.
4	TIMEX	+	Starting time of this simulation in seconds.
5	EXDYMX	+	Maximum permissible bed elevation change during the extrapolation, metres. This is the first of three constraints used by EXTRAP to compute permissible extrapolation time.
6	EXPDMX	+	Maximum permissible bed elevation change expressed as a percent of water depth. This is the second of three constraints used by EXTRAP to compute the permissible extrapolation time.
7	EXDT	+	End-of-run time (seconds) is the third of three constraints) and ultimate constraint used to control the maximum permissible extrapolation time.
8	ZETA	+	Implicitness factor. ZETA can range between 0.000001 and 1.0 in selecting the influence of history on extrapolation rate.
		0	Defaults to 1.0 = most recent simulation rate is used and all prior simulation rates are disregarded.
9	NONOD	+	Number of nodes at which depth limits must be exceeded before extrapolation is stopped.
		0	Default is one node.

TE CARD Extrapolation in Time (Continued)

Field	Variable	Value	Description
10	MTEX	1	Clay or mixed bed extrapolation approach control. 1 = bed layer structure is considered during extrapolation using the same model as subroutine BEDSUR.
		0	Bed layer structure is not considered or changed by extrapolation. Only bed elevations are changed, except erosion is limited to thickness of sediment in bed.

The extrapolation routine takes the results of the real-time computations and extends them forward in time without recalculating the erosion and deposition at each time-step. At intervals, it stops and detailed calculations are resumed before subsequent extrapolations are made.

EXDYMX and EXPDMX are used to control the maximum bed change that can occur in an extrapolation period. EXDT is the total simulation time that is desired. MEX limits the number of real-time simulations that are used in an extrapolation sequence. Used to prevent runaway costs, it may halt an extrapolation run before EXDT is reached.

In applications where wetting and drying is occuring, successful extrapolation may require use of the DRYEXP variables on the GD card (p. G-1-30).

TT CARD — Crank-Nicholson THETA — Optional

Field	Variable	Value	Description
Col 1	ICG	T	Card group T = time.
Col 2	IDT	T	Data type T = Theta.
2	TETA*	0.5	This produces the most sensitive model response but often causes computations to oscillate.
		1.0	This produces the least sensitive model response and often smooths results too much.
		0	The default value is 0.5.

*Recommended value = 0.66

PS CARD Selective Printout Optional

Print, normal and trace options, may be restricted to preselected elements.

Field	Variable	Value	Description
0	ICG	P	Card group P = print out controls.
	IDT	S	Data type S = selective locations by element.
1	$IHAVE_1$	+	Code the element number. Values may be in any order and embedded blank fields are permissible.
2	IHAVE2	+	Continue coding values, using continuation PS-Cards, until all desired locations are specified.

SA CARD — Sediment Size Classes, Noncohesive — Optional (Required for sand bed problems)

Note: Use only 1 grain size at present. Code SANDL = SANDU and CLASSA = 1

Field	Variable	Value	Description
0		SA	Card group = S (sediment size classes).
2	MTC	--	Default is not available.
		7	Ackers-White transport function.
3	SANDL	0	Default for minimum size is 0.0625 mm.
		+	Enter desired value in mm.
4	SANDU	0	Default for maximum size is 2 mm.
		+	Enter desired value in mm.
5	CLASSA	0	Default is 1 class.
		+	Enter the desired number. The class interval is calculated for the log of particular sizes.
6	SGSA	0	Default specific gravity 2.65.
		+	Enter the desired specific gravity of sand grains.
7	GSF	0	Default grain shape factor is 0.7.
		+	Enter the desired grain shape factor.
8	CLDE	0	Default characteristic length factor for deposition is 1.0 (times depth).
		+	Enter the desired factor.
9	CLER	0	Default characteristic length factor for erosion is 10.0 (times depth).
		+	Enter the desired factor.

SC CARD — Sediment Characteristics, Cohesive — Optional (Required for cohesive bed problems)

Field	Variable	Value	Description
0		SC	Card group = S.
2	MTCL	0	Default not available.
		1	Original Krone and Partheniades equations for deposition and erosion.
3	TAUCD	0	Default for critical shear stress for deposition is 0.06 newtons/m^2.
		+	Enter desired value in newtons/m^2.
4	ERØDCP	0	Default for critical shear stress for particle erosion is 0.06 newtons/m^2.
		+	Enter desired value in newtons/m^2.
5	ERØCØN	0	Default for constant in erosion equation is 0.002 kg/m^2/sec.
		+	Enter desired value.
6	SGCL	0	Default for specific gravity of clay particles is 2.65.
7	MNCL	0	Default for maximum number of consolidating layers = 4.
		+	Enter desired value. It must be less than LNBL which is preset to 10.

Note: For mixed sand and clay bed runs, both SA and SC cards are required. The separate sand/clay runs are performed in the sequence in which these two cards appear.

DV CARD — Volume of Sand Bed Sediment — Required for sand only runs

When coding more than one time point, enter the YEAR/MONTH/DAY/HOUR/MINUTE/SECOND for each successive time using the format for the first one. If two or more options are used for coding this data type, stack the cards in the order shown for Column 3 below.

Field	Variable	Value	Description
Col 1	ICG	D	Card group D = bed deposit
Col 2	IDT	V	Data type V = Volume of sediment reservoir
Col 3	ISI_1		Coding options
		ƀ	Blank = constant value for all nodes
		X	X = constant for this cross section
		C	C = value at corner nodes only
		N	N = value by node
Col 5-6	Year	+	Code the last two digits of the year
Col 7-8	MONTH	+	Code the month number (01-12)
2	DAY HOUR MINUTE SECOND	+ + + +	Code the DAY, HOUR, MINUTE, and SECOND for this event. Use two columns each (01-31) (01-60), etc.
3	LOC_1	+	Code the locator for $TTHICK_1$ for ƀ option - LOC = 1 for X option - LOC = cross-section number for C option - LOC = corner node number for N option - LOC = node number
4	$TTHICK_1$	+	Code depth of sediment layer in meters
5	LOC_2	+	Code the locator for $TTHICK_2$
6	$TTHICK_2$	+	Code the depth of sediment at LOC_2
(7-10)	etc.		Use all 10 fields...start continuation cards in Field 1 and do NOT code date/time. Leave at least 1 blank LOC-field at the end of data even if it requires an additional card.

DT CARD — Characteristic Deposit by Type of Cohesive Material — Optional

Each node can be assigned up to 10 layers for describing the characteristics of the initial, cohesive (silt or clay) (DC-card) bed deposits. Each layer is assigned a "type" number, and the characteristics of those "types" should be prescribed on these DT-cards. Up to 10 DT cards are permitted; code 1 type per DT card.

Field	Variable	Value	Description
Col 1	ICG	D	Card group D = deposits
Col 2	IDT	T	Data type T = characteristics of deposits by type
Col 8	ITYPE	+	Type numbers 1 through 10 are permitted Start with 1 Layer type No. 1 must be freshly deposited, unconsolidated material. Layers with ITYPE greater than MNCL (SC card) do not consolidate
2	THKTYP	+	Code the typical layer thickness in meters for this type of bed material
		0	Default value is 0.03 m
3	TAUP	+	The bed shear stress at which cohesive particles begin to erode, newtons/m^2
		0	Program defaults to 0.06 newtons/m^2
4	PERC	+	Erosion rate constant for particle erosion
		0	Default value is 0.002 kg/m^2/sec
5	QSI	+	The bed shear stress at which cohesive layers begin to erode in mass, newtons/m^2
		0	Program defaults to 0.06, 0.12, 0.41, and 3.4 for layers 1-4, respectively, and 3.4 for layer types 5-LNBL
6	QSE	+	The bed shear stress at which cohesive layers 1 year old begin to erode in mass, newtons/m^2
		0	Program defaults to 1.1 times the default values of QSI

DT CARD (Continued)

Field	Variable	Value	Description
7	RHOI	+	The initial dry density of a deposit of this type of cohesive material in kg/m3
		0	The program defaults to 90, 108, 144, and 263 for layers 1-4, respectively, and 402 for layer types 5-LNBL
8	RHOE	+	The consolidated dry density of deposits of this type of cohesive material at age = 1 year
		0	The program defaults to 1.1 times the default values of RHOI
9	CCC	+	The consolidation coefficient relating the change from RHOE and QSE to time in years
		0	Program defaults to 256 kg/m^3

Note: Values of the variables in Fields 5-9 vary widely among sediment types. Default values may be grossly wrong for a given sediment.

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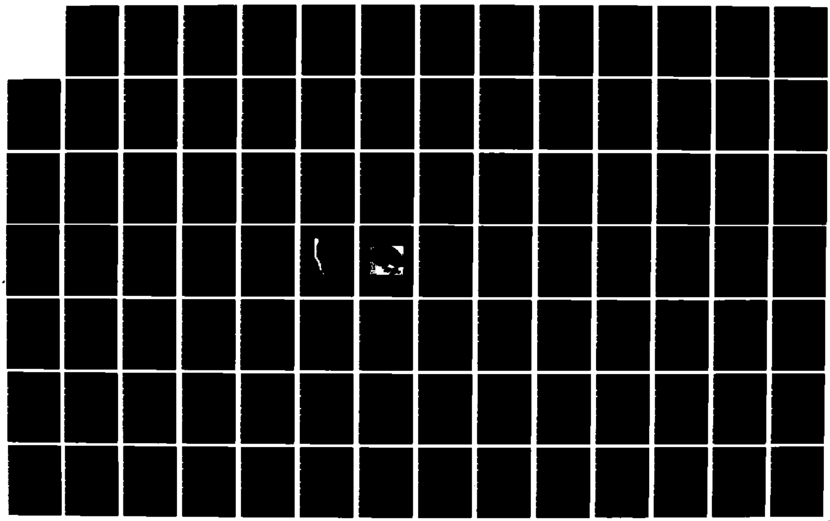

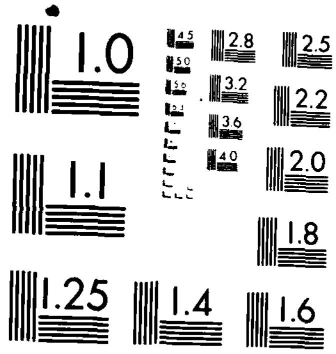

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DC CARD — Layering of Cohesive or Mixed Sediments in the Bed — Required for cohesive bed problems unless tape input provides this information

There are two coding options as described in the introduction, Coding Options for Nodal Point Data, and shown below for "Column 3."

Field	Variable	Value	Description
Col 1	ICG	D	Card group D = deposits in the bed
Col 2	IDT	C	Data type C = clay
Col 3			Coding options
		ƀ	= constant value, use at all nodes
		N	N = values for nodes (place all ƀ cards before first N cards)
Col 5-6	YEAR	+	Code the last two digits of the year when bed was sampled
Col 7-8	MONTH	+	Code a two-digit number for month (JAN = Ø1 to DEC = 12)
2	DAY HOUR MINUTE SECONDS	+	Code DAY, HOUR, MINUTE, and SECOND the bed sample was taken. Start in Column 9 and use 2 columns for each. A blank is read as zero. (This field is read as F8.0 and partitioned into columns of two digits each)
3	Node	+	Code the node number
4	LAYER	+	Code the layer number for this data type. Numbering starts with one for the lowest layer and increases upward (maximum of LNBL, dimensioned to 10)
5	ITYPE	+	Assign one of the clay types coded previously on DT cards
6	THICKL	+	Code the total layer thickness in meters
		0	Program assigns thickness on the DT card for this type of deposit
7	AGE	+	Code the age, years, of the deposit at time zero TZ card

FT CARD — Water Temperature — Required

When coding more than one time point, enter the YEAR/MONTH/DAY/HOUR/MINUTE/SECOND for each successive time using the format for the first one. If two or more options are used for coding this data type, stack the cards in the order shown for Column 3 below.

Field	Variable	Value	Description
Col 1	ICG	F	Card group F = Flow
Col 2	IDT	T	Data type T = Temperature
Col 3	ISI_1		Coding options
		b̸	Blank = constant value for all nodes
		X	X = constant value for all nodes on this cross section
		C	C = values by corner nodes
		N	N = values by node
Col 5-6	YEAR	+	Code the last two digits of the year
Col 7-8	MONTH	+	Code the month number (01-12)
2	DAY HOUR MINUTE SECOND	+ + + +	Code the DAY, HOUR, MINUTE, and SECOND for this event. Use two columns each (01-31) (01-60), etc.
3	LOC_1	+	Code the locator for WTC_1 for b̸ option - code first node for X option - code cross-section number for C option - code corner node for N option - code node
4	WTC_1	+	Code water temperature in degrees Centigrade
5	LOC_2	+	Code the locator for WTC_2
6	WTC_2	+	Code water temperature at LOC_2
(7-10)	etc.		Use all 10 fields...start continuation cards in field 1 and do NOT code date/time. Leave at least one blank LOC-field at the end of data even it if requires an additional card.

FD CARD | Fluid Density | Required

When coding more than one time point, enter the YEAR/MONTH/DAY/HOUR/MINUTE/SECOND for each successive time using the format for the first one. If two or more options are used for coding this data type, stack the cards in the order shown for Col 3 below.

Field	Variable	Value	Description
Col 1	ICG	F	Card group F = Fluid
Col 2	IDT	D	Data type D = Density
Col 3	ISI1		Coding options
		b̸	X = constant value for all nodes on this cross section
		C	C = values by corner nodes
		N	N = values by node
Col 5-6	YEAR	+	Code the last two digits of the year
Col 7-8	MONTH	+	Code the month number (01-12)
2	DAY HOUR MINUTE SECOND	+ + + +	Code the DAY, HOUR, MINUTE, and SECOND for this event. Use two columns each (01-31) (01-60), etc.
3	LOC_1	+	Code the locator for RHO_1 for b̸ option - LOC = 1 for X option - LOC = cross-section number for C option - LOC = corner node number for N option - LOC = node number
4	RHO_1	+	Code fluid density in kg/m^3
5	LOC_2	+	Code the locator for RHO_2
6	RHO_2	+	Code density at location 2
(7-10)	etc.	+	Use all 10 fields...start continuation cards in Field 1 and do NOT code date/time. Leave at least one blank LOC-field at the end of data even if it requires an additional card

HS CARD Bed Shear Stress Required

Field	Variable	Value	Description
Col 1	ICG	H	Card Group H = Hydraulic data
Col 2	IDT	S	Data type S = Shear stress
2	MSC		Code the option number for shear stress computations
		1	Shear stress computation using the log-velocity distribution for a smooth wall
		2	Manning equation (must enter n-values on HN-cards)
		3	Wave shear stress by ACKRSHR

HN CARD — Manning n-values — Required if HS (2) = 2 or 3

When coding more than one time point, enter the YEAR/MONTH/DAY/HOUR/MINUTE/SECOND for each successive time using the format for the first one. If two or more options are used for coding this data type, stack the cards in the order shown for Column 3 below.

Field	Variable	Value	Description
Col 2	ICG	H	Card group H = Hydraulics
Col 2	IDT	N	Data type N = n-values
Col 3	ISI_1		Coding options
		b̸	Blank = constant value for all nodes
		X	X = constant value for all nodes on this cross section
		C	C = values by corner nodes
		N	N = values by node
Col 5-6	YEAR	+	Code the last two digits of the year
Col 7-8	MONTH	+	Code the month number (01-12)
2	DAY HOUR MINUTE SECOND	+ + + +	Code the DAY, HOUR, MINUTE, and SEC ND for this event. Use two columns each (01-31) (01-60), etc.
3	LOC_1	+	Code the locator for $XNVALU_1$ for b̸ option - LOC = 1 for X option - LOC = cross-section number for C option - LOC = corner node number for N option - LOC = node number
4	$XNVALU_1$	+	Code n-value
5	LOC_2	+	Code the locator for $XNVALU_2$
6	$XNVALU_2$	+	Code the n-value at location 2
(7-10)	etc.		Use all 10 fields...start continuation cards in Field 1 and do NOT code date/time. Leave at least one blank LOC-field at the end of data even if it requires an additional card

HH CARD — Water Surface Elevations — Required if water levels not input on file

When coding more than one time point, enter the YEAR/MONTH/DAY/HOUR/MINUTE/SECOND for each successive time using the format for the first one. If two or more options are used for coding this data type, stack the cards in the order shown for Column 3 below.

Field	Variable	Value	Description
Col 1	ICG	H	Card group H = Hydraulics
Col 2	IDT	H	Data type H = Water surface
Col 3	ISI_1		Coding options
		ȸ	Blank = constant value for all nodes
		X	X = constant value for all nodes on this cross section
		C	C = values by corner nodes
		N	N = values by node
Col 5-6	YEAR	+	Code the last two digits of the year
Col 7-8	MONTH	+	Code the month number (01-12)
2	DAY HOUR MINUTE SECOND	+ + + +	Code the DAY, HOUR, MINUTE, and SECOND for this event. Use two columns each (01-31) (01-60), etc.
3	LOC_1	+	Code the locator for WS_1 for ȸ option - LOC = 1 for X option - LOC = cross-section number for C option - LOC = corner node number for N option - LOC = node number
4	WS_1	+	Code the value for water surface in meters
5	LOC_2	+	Code the locator for WS_2
6	WS2	+	Code water surface for location 2
(7-10)	etc.		Use all 10 fields...start continuation cards in Field 1 and do NOT code date/time. Leave at least one blank LOC-field at the end of data even if it requires an additional card

HU CARD X-Velocity Required if not on file and no CX, QZ cards used

When coding more than one time point, enter the YEAR/MONTH/DAY/HOUR/MINUTE/SECOND for each successive time using the format for the first one. If two or more options are used for coding this data type, stack the cards in the order shown for Column 3 below.

Field	Variable	Value	Description
Col 1	ICG	H	Card group H = Hydraulics
Col 2	IDT	U	Data type U = velocity in X-direction
Col 3	ISI_1		Coding options
		ɓ	Blank = constant value for all nodes
		X	X = constant value for all nodes on this cross section
		C	C = values by corner nodes
		N	N = values by node
Col 5-6	YEAR	+	Code the last two digits of the year
Col 7-8	MONTH	+	Code the month number (01-12)
2	DAY HOUR MINUTE SECOND	+ + + +	Code the DAY, HOUR, MINUTE, and SECOND for this event. Use two columns each (01-31) (01-60), etc.
3	LOC_1	+	Code the locator for XVEL(1,1) for ɓ option - LOC = 1 for X option - LOC = cross-section number for C option - LOC = corner node number for N option - LOC = node number
4	XVEL(1,1)	+	Code X-velocity in m/sec, + X-direction
		-	When X-velocity is in negative X-direction
5	LOC_2	+	Code the locator for XVEL(2,1)
6	XVEL(2,i)	+	Code X-velocity at location 2
		-	When LOC_2 velocity is in negative X-direction

HU CARD X-Velocity (Continued)

Field	Variable	Value	Description
(7-10)	etc.		Use all 10 fields...start continuation cards in Field 1 and do NOT code date/time. Leave at least one blank LOC-field at the end of data even if it requires an additional card

HV CARD Y-Velocity Required if not on file and no QX, QY cards used

When coding more than one time point, enter the YEAR/MONTH/DAY/HOUR/MINUTE/SECOND for each successive time using the format for the first one. If two or more options are used for coding this data type, stack the cards in the order shown for Column 3 below.

Field	Variable	Value	Description
Col 1	ICG	H	Card group H = Hydraulics
Col 2	IDT	W	Data type V = Y-velocity
Col 3	ISI_1		Coding options
		ƀ	Blank = constant value for all nodes
		X	X = constant value for all nodes on cross section
		C	C = values by corner nodes
		N	N = values by node
Col 5-6	YEAR	+	Code the last two digits of the year
Col 7-8	MONTH	+	Code the month number (01-12)
2	DAY HOUR MINUTE SECOND	+ + + +	Code the DAY, HOUR, MINUTE, and SECOND for this event. Use two columns each (01-31) (01-60), etc.
3	LOC_1	+	Code the locator for XVEL(1,2) for ƀ option - LOC = 1 for X option - LOC = cross-section number for C option - LOC = corner node number for N option - LOC = node number
4	XVEL(1,2)	+ -	Code Y-velocity in m/sec, + Y-direction When Y-velocity component points in the negative Y-direction
5	LOC_2	+	Code the locator for XVEL(2,2)
6	XVEL(2,2)	-	When LOC_2 velocity is in negative Y direction

HV CARD Y-Velocity (Continued)

Field	Variable	Value	Description
(7-10)	etc.		Use all 10 fields...start continuation cards in Field 1 and do NOT code date/time. Leave at least one blank LOC-field at the end of data even if it requires an additional card

QX CARD — X-Direction Discharge — Required if velocities are not on file and no HU, HV cards used

When coding more than one time point, enter the YEAR/MONTH/DAY/HOUR/MINUTE/SECOND for each successive time using the format for the first one. If two or more options are used for coding this data type, stack the cards in the order shown for Column 3 below.

Field	Variable	Value	Description
Col 1	ICG	Q	Card group Q = Discharge
Col 2	IDT	X	Data type X = X-velocity
Col 3	ISI_1		Coding options
		ƀ	Blank = constant value for all nodes
		X	X = constant value for all nodes on cross section
		C	C = values by corner nodes
		N	N = values by node
Col 5-6	YEAR	+	Code the last two digits of the year
Col 7-8	MONTH	+	Code the month number (01-12)
2	DAY HOUR MINUTE SECOND	+ + + +	Code the DAY, HOUR, MINUTE, and SECOND for this event. Use two columns each (01-31) (01-60), etc.
3	LOC_1	+	Code the locator for XVEL(1,2) for ƀ option - LOC = 1 for X option - LOC = cross-section number for C option - LOC = corner node number for N option - LOC = node number
4	XVEL(1,1)	+	Code X-discharge in m^3/sec, + X-direction
		-	When X-discharge is in negative X-direction
5	LOC_2	+	Code the locator for XVEL(2,2)
6	XVEL(2,1)	-	When LOC_2 discharge is in negative X-direction

QX CARD X-Direction Discharge (Continued)

Field	Variable	Value	Description
(7-10)	etc.		Use all 10 fields...start continuation cards in Field 1 and do NOT code date/time. Leave at least one blank LOC-field at the end of data even if it requires an additional card

QY CARD | Y-Discharge | Required if velocities not on file and no HU, HV cards used

When coding more than one time point, enter the YEAR/MONTH/DAY/HOUR/MINUTE/SECOND for each successive time using the format for the first one. If two or more options are used for coding this data type, stack the cards in the order shown for Column 3 below.

Field	Variable	Value	Description
Col 1	ICG	Q	Card group Q = discharge
Col 2	IDT	V	Data type Y = in Y-direction
Col 3	ISI_1		Coding options
		b̸	Blank = constant value for all nodes
		X	X = constant value for all nodes on this cross section
		C	C = values by corner nodes
		N	N = values by node
Col 5-6	YEAR	+	Code the last two digits of the year
Col 7-8	MONTH	+	Code the month number (01-12)
2	DAY HOUR MINUTE SECOND	+ + + +	Code the DAY, HOUR, MINUTE, and SECOND for this event. Use two columns each (01-31) (01-60), etc.
3	LOC_1	+	Code the locator XVEL(1,2) for b̸ option - LOC = 1 for X option - LOC = cross-section number for C option - LOC = corner node number for N option - LOC = node number
4	XVEL(1,2)	+	Code Y-discharge in m^3/sec, + Y-direction
		-	When Y-discharge component points in the negative Y-direction
5	LOC_2	+	Code the locator for XVEL(2,2)
6	XVEL(2,2)	+	Code discharge at location 2
		-	When LOC_2 discharge is in negative Y-direction

QY CARD Y-Discharge (Continued)

Field	Variable	Value	Description
(7-10)	etc.		When all 10 fields...start continuation cards in Field 1 and do NOT code date/time. Leave at least one blank LOC-field at the end of data even if it requires an additional card

EX CARD — Effective Diffusion, X-Direction — Required

When coding more than one time point, enter the YEAR/MONTH/DAY/HOUR/MINUTE/SECOND for each successive time using the format for the first one. If two or more options are used for coding this data type, stack the cards in the order shown for Column 3 below.

Field	Variable	Value	Description
Col 1	ICG	E	Card group = effective diffusion
Col 2	IDT	X	Data type = X-direction
Col 3	ISI_1		Coding options
		ɓ	Blank = constant value for all nodes
		X	X = constant value for all nodes on this cross section
		C	C = values by corner nodes
		N	N = values by node
Col 5-6	YEAR	+	Code the last two digits of the year
Col 7-8	MONTH	+	Code the month number (01-12)
2	DAY HOUR MINUTE SECOND	+ + + +	Code the DAY, HOUR, MINUTE, and SECOND for this event. Use two columns each (01-31) (01-60), etc.
3	LOC_1	+	Code the locator for DIF(1,2) for ɓ option - LOC = 1 for X option - LOC = cross-section number for C option - LOC = corner node number for N option - LOC = node number
4	DIF(1,2)	+	Code the X-diffusion coefficient in m^2/sec
5	LOC_2	+	Code the locator for DIF(2,2)
6	DIF(2,2)	+	Code the X-diffusion coefficient for LOC_2 in sq m per sec

EX CARD Effective Diffusion, X-Direction (Continued)

Field	Variable	Value	Description
(7-10)	etc.		Use all 10 fields...start continuation cards in Field 1 and do NOT code date/time. Leave at least one blank LOC-field at the end of data even if it requires an additional card

EY CARD — Effective Diffusion, Y-Direction — Required

When coding more than one time point, enter the YEAR/MONTH/DAY/HOUR/MINUTE/SECOND for each successive time using the format for the first one. If two or more options are used for coding this data type, stack the cards in the order shown for Column 3 below.

Field	Variable	Value	Description
Col 1	ICG	E	Card group = effective diffusion
Col 2	IDT	Y	Data type = Y- direction
Col 3	ISI_1		Coding options
		ƀ	Blank = constant value for all nodes
		X	X = constant value for all nodes on this cross section
		C	C = values by corner nodes
		N	N = values by node
Col 5-6	YEAR	+	Code the last two digits of the year
Col 7-8	MONTH	+	Code the month number (01-12)
2	DAY HOUR MINUTE SECOND	+ + + +	Code the DAY, HOUR, MINUTE, and SECOND for this event. Use two columns each (01-31) (01-60), etc.
3	LOC_1	+	Code the locator for DIF(1,2) for ƀ option - LOC = 1 for X option - LOC = cross-section number for C option - LOC = corner node number for N option - LOC = node number
4	DIF(1,2)	+	Code the Y-diffusion coefficient in m^2/sec
5	LOC_2	+	Code the locator for DIF(2,2)
6	DIF(2,2)	+	Code the Y-diffusion coefficient for LOC_2
(7-10)	etc.		Use all 10 fields...start continuation cards in field 1 and do NOT code date/time. Leave at least one blank LOC-field at the end of data even if it requires an additional card

IC CARD | Initial Concentration | Required

When coding more than one time point, enter the YEAR/MONTH/DAY/HOUR/MINUTE/SECOND for each successive time using the format for the first one. If two or more options are used for coding this data type, stack the cards in the order shown for Column 3 below.

Field	Variable	Value	Description
Col 1	ICG	I	Card group I = initial value (state value)
Col 2	IDT	C	Data type C = concentration
Col 3	ISI_1		Coding options
		ƀ	Blank = constant value for all nodes
		X	X = constant value for all nodes on this cross section
		C	C = values by corner nodes
		N	N = values by node
Col 5-6	YEAR	+	Code the last two digits of the year
Col 7-8	MONTH	+	Code the month number (01-12)
2	DAY HOUR MINUTE SECOND	+ + + +	Code the DAY, HOUR, MINUTE, and SECOND for this event. Use two columns each (01-31) (01-60), etc.
3	LOC_1	+	Code the locator for $CONC_1$ for ƀ option - LOC = 1 for X option - LOC = cross-section number for C option - LOC = corner node number for N option - LOC = node number
4	$CONC_1$	+	Code concentration in kg/m^3
5	LOC_2	+	Code the locator for $CONC_2$
6	$CONC_2$	+	Code concentration at LOC2
(7-10)	etc.		Use all 10 fields...start continuation cards in field 1 and do NOT code date/time. Leave at least one blank LOC-field at the end of data even if it requires an additional card

SR CARD Effective Grain Size for Roughness Optional

NOTE: If an SR is not used, the EFDR array defaults to SD(1) as determined from the SA card data.

When coding more than one time point, enter the YEAR/MONTH/DAY/HOUR/MINUTE/SECOND for each successive time using the format for the first one. If two or more options are used for coding this data type, stack the cards in the order shown for Column 3 below.

Field	Variable	Value	Description
Col 1	ICG	S	Card group S = sediment
Col 2	IDT	R	Data type R = roughness size
Col 3	ISI1		Coding options
		ƀ	Blank = constant value for all nodes
		X	X = constant value for all nodes on this cross section
		C	C = values by corner nodes
		N	N = values by node
Col 5-6	YEAR	+	Code the last two digits of the year
Col 7-8	MONTH	+	Code the month number (01-12)
2	DAY HOUR MINUTE SECOND	+ + +	Code the DAY, HOUR, MINUTE, and SECOND for this event. Use two columns each (01-31) (0'-60), etc.
3	LOC_1	+	Code the locator for $EFDR_1$ for ƀ option - LOC = 1 for X option - LOC = cross-section number for C option - LOC = corner node number for N option - LOC = node number
4	$EFDR_1$	+	Code Der
5	LOC_2	+	Code the locator for $EFDR_2$
6	$EFDR_2$	+	Code D_{er} at location 2
(7-10)	etc.		Use all 10 fields...start continuation cards in Field 1 and do NOT code date/time. Leave at least one blank LOC-field at the end of data even if it requires an additional card

ST CARD — Effective Grain Size for Transport — Optional

NOTE: If an ST card is not used, the EFDT array defaults to the EFDR array specified by the SR card.

When coding more than one time point, enter the YEAR/MONTH/DAY/HOUR/MINUTE/SECOND for each successive time using the format for the first one. If two or more options are used for coding this data type, stack the cards in the order shown for Column 3 below.

Field	Variable	Value	Description
Col 1	ICG	S	Card group S = sediment
Col 2	IDT	T	Data type T = transport size
Col 3	ISI_1		Coding options
		ƀ	Blank - constant value for all nodes
		X	X = constant value for all nodes on this cross section
		C	C = values by corner nodes
		N	N = values by node
Col 5-6	YEAR	+	Code the last two digits of the year
Col 7-8	MONTH	+	Code the month number (01-12)
2	DAY HOUR MINUTE SECOND	+ + + +	Code the DAY, HOUR, MINUTE, and SECOND for this event. Use two columns each (01-31) (01-60), etc.
3	LOC_1	+	Code the locator for $EFDT_1$ for ƀ option - LOC = 1 for X option - LOC = cross-section number for C option - LOC = corner node number for N option - LOC = node number
4	$EFDT_1$	+	Code grain size
5	LOC_2	+	Code the locator for $EFDT_2$
6	EFDT2	+	Code grain size at location 2
(7-10)	etc.		Use all 10 fields...start continuation cards in Field 1 and do NOT code date/time. Leave at least one blank LOC-field at the end of data even if it requires an additional card

WC CARD | Settling Velocity | Required

When coding more than one time point, enter the YEAR/MONTH/DAY/HOUR/MINUTE/SECOND for each successive time using the format for the first one. If two or more options are used for coding this data type, stack the cards in the order shown for Column 3 below.

Field	Variable	Value	Description
Col 1	ICG	W	Card group W = settling velocity
Col 2	IDT	C	Data type C = clay, silt, and sand
Col 3	ISI_1		Coding options
		ƀ	Blank = constant value for all nodes
		X	X = constant value for all nodes on this cross section
		C	C = values by corner nodes
		N	N = values by node
Col 5-6	YEAR	+	Code the last two digits of the year
Col 7-8	MONTH	+	Code the month number (01-12)
2	DAY HOUR MINUTE SECOND	+ + + +	Code the DAY, HOUR, MINUTE, and SECOND for this event. Use two columns each (01-31) (01-60), etc.
3	LOC_1	+	Code the locator for VS_1 for ƀ option - LOC = 1 for X option - LOC = cross-section number for C option - LOC = corner node number for N option - LOC = node number
4	VS_1	+	Code settling velocity in m/sec
5	LOC_2	+	Code the locator for VS_2
6	VS_2	+	Code settling velocity for particles at location 2
(7-10)	etc.		Use all 10 fields...start continuation cards in Field 1 and do NOT code date/time. Leave at least one blank LOC-field at the end of data even if it requires an additional card

BC CARD — Boundary Concentrations — Required

When coding more than one time point, enter the YEAR/MONTH/DAY/HOUR/MINUTE/SECOND for each successive time using the format for the first one. If two or more options are used for coding this data type, stack the cards in the order shown for Column 3 below.

Field	Variable	Value	Description
Col 1	ICG	B	Card group B = boundary nodes
Col 2	IDT	C	Data type C = concentrations
Col 3	ISI_1		Coding options
		b̸	Blank = constant value for all nodes
		X	X = constant value for all nodes on this cross section
		C	C = values by corner nodes
		N	N = values by node
Col 5-6	YEAR	+	Code the last two digits of the year
Col 7-8	MONTH	+	Code the month number (01-12)
2	DAY HOUR MINUTE SECOND	+ + + +	Code the DAY, HOUR, MINUTE, and SECOND for this event. Use two columns each (01-31) (01-60), etc.
3	LOC_1	+	Code the locator for $SPEC_1$ for b̸ option - LOC = 1 for X option - LOC = cross-section number for C option - LOC = corner node number for N option - LOC = node number
4	$SPEC_1$	+	Code concentration at boundary node(s) in kg/m^3
5	LOC_2	+	Code the locator for $SPEC_2$
6	$SPEC_2$	+	Code concentration at location 2
(7-10)	etc.		Use all 10 fields...start continuation cards in Field 1 and do NOT code date/time. Leave at least one blank LOC-field at the end of data even if it requires an additional card

$$END End of Job

Field	Variable	Value	Description
Col 1	ICG	$	Card type $ = Command
Col 2	IDT	$	Data type $ = Command
Col 3-5	ISI	END	The program tests for $$ and the word END is only for the user

ITERATION CONTROL FOR INPUT/OUTPUT
REQUIRED CARDS

The following cards follow the $$END if no $T cards are used. They must be omitted if $T cards follow the T3 card.

Card	Purpose
IFF(2,I)	Print out at selected time-steps
IVCOD(I)	Read in velocity files at selected time-steps
IDIF(I)	Read in diffusion coefficient files at selected time-steps
IDEPC(I)	Read in depths at selected time-steps
ISVS(I)	Read in new fall velocities at selected time-steps

Note: All these cards are read as 80I1. Consequently, to print results, code 1 (concentrations only), 2 (bed elevation/volume changes only), or 3 (both concentration and bed surface information) in the column number corresponding to the time-step when printout is desired.

To read a new velocity field or diffusion coefficient set or depth file or fall velocity of grains file, code 1 in the card column corresponding to the time-step when data should be read.

For example, to print results at the time-step 2 (i.e., the end of the first computation time-internal, DT) code 3 in column 2 of the IFF (2,i) card.

Table G-1-2
Summary of Data Card Image Input

CARD	CONTENTS									
TI		TITLE INFORMATION								
T3		FINAL TITLE CARD BEFORE READING NUMERIC DATA								
SL			LP	INB	INC	IND	INE	INF	ING	[illegible]
SL		INI	KPU	KPL	INJ	INK	INHOT	KOHOTB	INHOT[illegible]	
STF		IFF								
STF		ISVS								
STD		IDEC								
STC		IDIF								
STV		IVCOD								
SH		KCHOT	KDBHOT	KBSHOT						
TR	IECHO	KSW(2)	KSW(3)	KSW(4)	KSW(5)	KSW(6)	KSW(7)	KSW(8)	KSW(9)	[illegible]
TR	KSW(11)	KSW(12)	KSW(13)	KSW(14)	KSW(15)					
G1		IHV	UMILE	DMILE	XSCALE	YSCALE	NE	NP	NPX	[illegible]
G3		WTLMAX	WIDTH	DEPTH						
GB		RMILE	N	XP	YP	INCR	INCR2	D	XC	YC
GS		NXS	NPAN	INCRP	NBEL	DELEL				
GE		NTE	NODP(1)	NODP(2)	NODP(3)	NODP(4)	NODP(5)	NODP(6)	NODP(7)	[illegible]
G4		TML	WIDTH	DEPTH	NXS	NPAN	XR	YR		
GN		NODE1	X1	Y1	NODE2	X2	Y2	NODE3	X3	Y3
GY		YRMNDAHRMNSE	LOC1	ELEV1	LOC2	ELEV2	LOC3	ELEV3	LOC4	[illegible]
GY		LOC5	ETC							
GD		IDRY	DSET							
PG		ACGR								
TZ		YEAR	MONTH	DAY	HRMNSE	DT	NTTS			
TE		IDLB	MEX	TIMEX	EXCYMX	EXDT	ZETA	NONOD	MTEX	
TT		TETA								
PS		IHAVE1	IHAVE2							
SA		MTC	SANDL	SANDU	CLASSA	SGSA	GSF	CLDE	CLEP	
SC		MTCL	TAUCD	ERODCP	ERUCON	SGCL	MNCL			
DV		YRMNDAHRMNSE	LOC1	TTHICK1	LOC2	TTHICK2	LOC3	TTHICK3		

Table G-1-2 (Continued)

[illegible]	[illegible]	[illegible]	[illegible]	QS[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	N	LAYER	ITYPE	THICK[illegible]	A[illegible]		
[illegible]	[illegible]	[illegible]	W[illegible]	LOC2	W[illegible]			
[illegible]	[illegible]	[illegible]	W[illegible]	LOC[illegible]	WA[illegible]			
[illegible]	[illegible]							
[illegible]	[illegible]	[illegible]	XNVAL[illegible]	[illegible]	XNVAL[illegible]			
[illegible]	[illegible]	LOC[illegible]	WS[illegible]	L[illegible]	WS2			
[illegible]	[illegible]	[illegible]	[illegible]	LOC2	[illegible]2			
[illegible]	[illegible]	[illegible]	[illegible]	LOC2	[illegible]Y2			
[illegible]	[illegible]	[illegible]	[illegible]	L[illegible]	[illegible]Y2			
[illegible]	[illegible]	[illegible]	[illegible]FX1	LOC2	DIFX2			
[illegible]	[illegible]	LOC[illegible]	DIFY[illegible]	LOC2	DIFY2			
[illegible]	[illegible]	LOC[illegible]	[illegible]NC1	LOC2	CONC2			
[illegible]	[illegible]	LOC1	CONC[illegible]	LOC2	[illegible]ONC2			
[illegible]	[illegible]	LOC1	EFDR1	LOC2	EFDR2			
[illegible]	[illegible]	LOC1	EFDT1	LOC2	EFDT2			
[illegible]	[illegible]	LOC[illegible]	VS1	LOC2	VS2			
[illegible]	[illegible]	[illegible]	SPEC1	LOC2	SPEC2			

APPENDIX H: USER INSTRUCTIONS FOR RMA-4,

TWO-DIMENSIONAL MODEL FOR WATER QUALITY

(This appendix is not yet available.)

TABS-2

APPENDIX I. GRAPHICS DISPLAYS

William A. Thomas, Stephen A. Adamec Jr., and Donald P. Bach

Contents

APPENDIX I: GRAPHICS DISPLAYS

PART I: INTRODUCTION

1. Output from the TABS-2 programs can be displayed in graphical form using Tektronix-compatible and Calcomp-compatible devices and line printers. Items that can be plotted include:

- a. The finite element mesh.
- b. Velocity vectors from RMA-2V.
- c. Sediment mass transport vectors from STUDH.
- d. Time history plots of model output.
- e. Contour maps of:
  - (1) Bed elevations.
  - (2) Water depths.
  - (3) Water surface elevations.
  - (4) Velocities.
  - (5) Bed changes (erosion/deposition).
  - (6) Sediment concentrations.
  - (7) Constituent concentations.
  - (8) Particle paths.
- f. Factor of sediment concentrations and bed changes.

Graphical output is also produced by output analysis programs, which are described in Appendix J. Table I1 shows the plots available, the plotting program which creates the plot file, and the program creating the data file that serves as input to the plotting program. For instructions on the individual programs, see the addenda to this appendix or the program index in the TABS manual main volume.

2. The plot files are created by GCS and/or METAPLOT and, when using PROCLV, are saved as permanent files. They should be directed to the desired plotting device by using the DIRECT program, also in PROCLV. Instructions for obtaining plots are contained in this appendix.

Table II
Summary of Plots

Plot	Plotting Program	Data Sources From Programs
Mesh by region and total mesh	QMESH	QMESH
Finite element mesh	GFGEN	GFGEN
Finite element mesh with wet and dry areas defined	WDGPLT	GFGEN, RMA-2V
Velocity vector map	VPLOT	GFGEN, RMA-2V
Sediment mass vector map	ACE	ENGMET, STUDH
Contour bed elevations	CONTOUR	GFGEN
Contour depths	CONTOUR	GFGEN, RMA-2V
Contour water-surface elevations	CONTOUR	GFGEN, RMA-2V
Contour velocities (magnitude)	CONTOUR	GFGEN, RMA-2V
Contour ELEVGRD or TRANSA data	CONTOUR	ELEVGRD
Contour depth changes	CONTOUR	ENGMET, STUDH
Contour concentrations	CONTOUR	ENGMET, STUDH
Contour first constituent on RMA-4 file	CONTOUR	GFGEN, RMA-4
Path of drogue transported by flow field	DROGUEPLT	RMA-2V
Time history of water level and/or velocity	POSTHYD*	RMA-2V
Factor map of concentrations and/or depth changes	SEDGRAPH	RMA-2V
Time history of concentrations and/or depth changes	POSTSED*	STUDH

*See Appendix J

PART II. METAPLOT SYSTEM

Introduction

3. METAPLOT is a device independent plotting software package supported in the TABS-2 system. The purpose is to display plots on graphics terminals or direct them to a hard copy device. The programs were obtained from Air Force Weapons Laboratory, Kirtland Air Force Base, New Mexico. They have been modified by Messrs. S. A. Adamec and D. P. Bach, Estuaries Division, WES, to operate on BCS and CYBERNET. The plots themselves are created by separate programs that are described in Part III.

Program Design

Hardware and capability

4. METAPLOT supports a variety of plotting devices. The present implementation permits use of Tektronix-type graphics terminals, Digital Equipment Corporation VT-125 terminals, and CALCOMP devices. The plot file can have any number of plots, and they can be viewed in any sequence. Both line segment and character strings are plotted. Images can be plotted at their generated area and scale or regions can be established and the images can be magnified up to 200 times their original scale.

Software components

5. The METAPLOT system consists of a library of plotting routines that are used by the TABS-2 graphics programs to create device independent plot files (META files) and a conversion program, DIRECT. Direct converts META files commands into commands appropriate to the desired plotting device. In interactive mode, DIRECT also performs windowing and other image manipulation. A version of the Graphics Compatibility System (GCS) has been developed that writes META files for use by program DIRECT.

Problem size

6. This program handles data as an external file and therefore does not require redimensioning to be compatible with code changes in other programs in the TABS-2 system.

Program Use

7. There are three steps in using METAPLOT.

- o Generate and save the plot file.
- o Direct the plot file to a graphics device.
- o Create the plots.

8. Those programs that generate plotter output are shown in Table II. These are executed using PROCLV. The plot file, like other input/output files, is assigned a permanent file name by the user at execution time and is automatically saved by PROCLV.

9. The DIRECT program is initiated by the command sequence

"BEGIN, META, PROCLV, plot file name, device"

where "plot file name" is the permanent file name of the plot file and "device" is the device on which the plot is to be produced. Device choices are "TEKTRNX" (for Tektronix-type terminals) which is the default, "PRINTER," which assumes a 132-column line printer, or "VT125." The plot file is directed to the terminal which responds by clearing the screen, beeping and printing the word "READY." For CALCOMP devices, replace "META" with "METAB."

10. If "READY" does not appear, the terminal is not set at 1200 baud, the default transmission in DIRECT. Change DIRECT to the terminal baud rate using the BAUD command (see DIRECT COMMANDS). The system will then be ready to accept DIRECT commands and generate the requested plot images.

11. Use the plot command to generate the first image as follows:

PLOT n

where n is the sequence number of the plot (nth plot in the file).

12. After the plot finishes, the terminal will beep and halt. Control is returned to the user who can then obtain a hard copy of the plot, magnify (i.e., change scale) the plot, establish a region within the plotted image, or exercise any of the other DIRECT commands.

13. When magnifying or establishing a region, two commands must be issued. The first is:

MAGNIFY S

or REGION S T U V

which sets up the plot space. The subscript variables S, T, U, and V are described in the section on commands. The second command required to plot a region is:

PLOT nR

where "n" is defined as above and "R" is a suffix character activating the region or magnify command.

14. If the R is left off, the plot will be at the same size and scale as the original. Once a region or magnification is established, it can be used with any plot number, n, by simply including R with that sequence number in the plot command.

Input

15. The plot file and DIRECT commands, which are issued interactively, are the only input data required.

Output

16. The plot image is drawn on the screen or hardcopy device. No other output is created.

Example

17. Each of the items listed in Table II requires the DIRECT programs to create the images. The procedure is illustrated and described in the examples which follow this general description of DIRECT.

DIRECT Commands

18. DIRECT commands are 1 to 40 characters in length and are reasonably free field, allowing abbreviations and arbitrary delimiters between fields. Commands may include integer or real numeric values. The form of these fields is described below.

19. An integer value begins with the first numeric character (i.e., digit) and continues up to but not including the first non-numeric character. The numeric value is the value associated with the string of digits.

20. A real value begins with the first digit, decimal point, or minus sign; it continues up to but not including the first character which is not a digit, decimal point, minus sign, or letter "E." Examples of character strings and the associated real values are given in Table I2.

21. In the command descriptions that follow, "M," "N," and "K" refer to integer values and "S," "T," "U," and "V" refer to real values. Numeric strings of the type described above should be typed within the command at these points. In all commands only the first character is mandatory, and that character determines the command being used. Any other characters, including those characters that spell out the command in English, may be used freely. Note however, that the characters "A," "H," "S," "V," and "N," when they appear anywhere in the command other than the first character, cause additional effects. This is explained in the suffix characters section.

Table I2
Command Value Examples

Character String	Numeric Value
1	1.00
-2.34	-2.34
4.56E-3	$4.56*10^{(-3)}$
.01	.01
2E4	$2.00*10^{4}$
1E-4	1.00*10(-4)

22. The numeric fields within commands may be delimited with arbitrary nonnumeric characters. A typical delimiter character could be a blank, comma, slash, or equal sign. The actual character chosen would depend upon ease of typing and the subjective preference for readability.

Basic Commands

23. The following descriptions of the DIRECT commands was originally written by Bob Conley of AFWL. WES personnel have modified the descriptions somewhat to match modifications to the system and format of this report.

END

This command terminates DIRECT execution.

BAUD M

This command informs direct of the line speed currently being used. This command must be used if the BAUD rate is not equal to 1200; otherwise, portions of the plots may be lost during screen erase, or undefined results will occur during hard copy generation.

PLOT
PLOT M
PLOT M N
PLOT M N K

The "PLOT" command is used to display a plot or range of plots on the terminal screen. If both M and N are present, then all plots with plot numbers from M to N, inclusive, will be displayed. If M is absent, then all plots in the file will be displayed. If K is present, then both M and N are required to be present also. In this case, the three values work the same way as the implied "DO" notation in FORTRAN and plots numbered M, M+K, M+2K, ..., are displayed; the last plot in the range to be displayed will have plot number less than or equal to N. When a range of plots is displayed, there will be no pause between plots. The characters "R," "H," "S," "V," and "N" may be used to select additional attributes for the displayed plots. See the suffix characters description below for an explanation of the effects.

+M
-M

These commands are used to display a plot whose number is M greater than or M less than the plot number of the last displayed plot. If M is absent, a default value of 1 is assumed. (If no plot has been displayed, then the last displayed plot number is zero.) The characters "R," "H," "S," "V," and "N" may be used to select additional attributes for the displayed plot. See the suffix characters description below for an explanation of the effects.

COPY
COPY M
COPY M N
COPY M N K

The COPY command is used to display a plot or range of plots on the terminal screen and produce hard copy on the hard copy unit. The effects of "M," "N," and "K" are the same for the COPY command as for the PLOT command. The characters "R," "H," "S," "V," and "N" may be used to select additional attributes for the displayed plots. See the suffix characters description below for an explanation of the effects.

SOFTWARE

The SOFTWARE command is used to select software character generation. This command will remain in effect until changed by the HARDWARE command, and overrides any software or hardware commands within the file. The software characters should be used when the exact size and orientation of characters are desired. Since software characters are produced by drawing each line segment of the character as a small vector, the time required to complete a displayed plot is considerably greater than that with hardware characters.

HARDWARE

The HARDWARE command is used to select hardware character generation. This command will remain in effect until changed by the SOFTWARE command, and overrides any software or hardware commands within the file. The hardware characters are used when the exact size and/or orientation is not important in the displayed plots. Most terminals have very restricted capability in the hardware generation of characters, but the plots are displayed extremely rapidly when hardware characters are selected. Hardware characters are selected by default until the first occurrence of a software command.

QUERY

The QUERY command will cause the current date, time, baud rate, hardware or software character status, accumulated CPU time for this DIRECT execution, plot number, screen parameters, region parameters (if defined), and certain model number parameters to be displayed on the terminal.

REGION S T U V

The REGION command explicitly defines a region rectangle. The parameters S, T, U, and V are in the coordinate system of the screen rectangle (these units are displayed in the QUERY command); the screen rectangle is defined by a call to subroutine SCREEN in the program that generated the file being viewed. "S" and "T" are the minimum and maximum X-axis values and "U" and "V" are the minimum and maximum Y-axis values for the region. The relation of screen and region is illustrated in the following diagram.
Once a region has been defined, the "R" suffix may be used to cause the plots to be displayed with the region plotted to fill the terminal or plotter display. See the suffix characters below for an explanation of the effects.

SCREEN

V
REGION

U
S T

MAGNIFY S

The MAGNIFY command is used to implicitly define a region. The magnification factor (in diameters of magnification) is given by "S." After this command is sent, a graphics cursor (either cross hairs or a blinking arrow) will appear on the terminal. The cursor should be positioned to the point which is to become the center of the region, and then the space bar is pressed. Some terminals also need the carriage return key to be pressed after the space bar is pressed; you can tell if the carriage return is needed by observing the result of pressing the space bar. If the graphics cursor becomes an alpha cursor (a rectangular cursor which may or may not blink) at the same location as the graphics cursor, then the carriage return must be pressed. If the graphics cursor becomes an alpha cursor at the left edge of the terminal screen, or if no alpha cursor is displayed, no carriage return is needed. The region will be defined with a center point at the point specified, and such that the region represents the desired magnification of the screen. Once a region has been defined, the "R" suffix may be used to cause the plots to be displayed with the region made to fill the terminal or plotter display; see the suffix characters description below for an explanation of the effects.

The MAGNIFY command will cause whatever image is displayed to be magnified. If the terminal has an already magnified image, the MAGNIFY command will cause that image to undergo magnification, resulting in a cumulative magnification of the original screen. Magnification values less than 1.0 cause less magnification. However, the cumulative magnification may never be less than 1.0; if such a reduction is needed, the REGION command is the only way to achieve it. In this case, the region parameters are entered to define a region larger than the screen rectangle.

Suffix characters

The effects of the basic commands "+," "-," "Plot," or "_," may be modified using suffix characters. The suffix characters may appear anywhere in the command except at the first character position, which always must be the basic command character.

Each command may be modified by any number of the suffix characters, providing two mutually exclusive operations are not specified in the same command. For example, it makes little sense to use the "S" and "H" suffix characters in the same command because one cannot select software and hardware characters at the same time.

R

If a region has been defined with either the REGION or MAGNIFY command, the "R" suffix causes the region to fill the terminal or plotter display area. If the "R" suffix character is not used, then the entire screen rectangle will be made to fill the display area. For example, the command P3R would cause plot number 3 to be displayed so that the region fills the terminal display area.

H

The "H" suffix character will cause hardware characters to be selected prior to displaying the plot. The character mode will remain hardware until a SOFTWARE command or an "S" suffix character is encountered. The "H" suffix allows hardware characters to be selected on a plot-by-plot basis, within the command causing the display. It eliminates the need to enter a separate HARDWARE command.

S

The "S" suffix character will cause software characters to be selected prior to displaying the plot. The character mode will remain software until a HARDWARE command or an "H" suffix character is encountered. The "S" suffix allows software characters to be selected on a plot-by-plot basis, within the command causing the display. It eliminates the need to enter a separate SOFTWARE command.

V

The "V" suffix character will prevent the screen from being erased before the next plot is displayed; it therefore causes plots to be overlayed.

N

The "N" suffix character is used only with the COPY command. Normally the COPY command causes the hardcopy to be generated before the plot number line is added at the top of the terminal display area. The "N" suffix will cause the plot number line to be generated before the automatic hard copy is produced. This is useful in causing the hard copies to be numbered.

PART III: PLOTTING PROGRAMS

24. Plotting programs are listed in Table I1. Descriptions of the programs and user instructions for some of them are contained in the addenda to this appendix and others. If a program's primary purpose is to create a plot, it has been included here. If it produces a plot, but its primary purpose is some other task, the program is described in one of the other appendices. See the program index in the main volume to locate user instructions for each program.

Plotting Finite Element Meshes

25. The plot file for the finite element mesh is produced by the batch program, GFGEN. Details are provided in APPENDIX D: Finite Element Network Generation. After the plot file is created and saved, using PROCLV, it can be directed to a graphics terminal for plotting by using the instructions in paragraph 8 of this appendix. An example result is shown in Figure I1.

26. A GFGEN plot file contains one to five plots:

n	Description
1	The mesh
2	The mesh plus element numbers
3	The mesh plus node numbers
4	The mesh with element material types (IMAT) labeled
5	The mesh with corner node bed elevations labeled

27. For information leading to the creation of the GFGEN mesh and plot file, see Appendix D in this document.

Plotting Results

28. Programs CONTOUR, VPLOT, DROGUEPLT, 4VIEW, and SEDGRAPH are used to produce graphical output from model results. CONTOUR produces contour maps of any model output and is described in Addendum I-1.

29. Programs VPLOT (Addendum I-2) and DROGUEPLT (Addendum I-3) are used to plot RMA-2V velocity results. VPLOT creates a file of vector plots showing current speed and direction as arrows. Figures I2 and I3 show examples. DROGUEPLT creates a plot file showing the path of a drogue that has been transported by currents calculated by RMA-2V. An example drogue plot is shown in Figure I4.

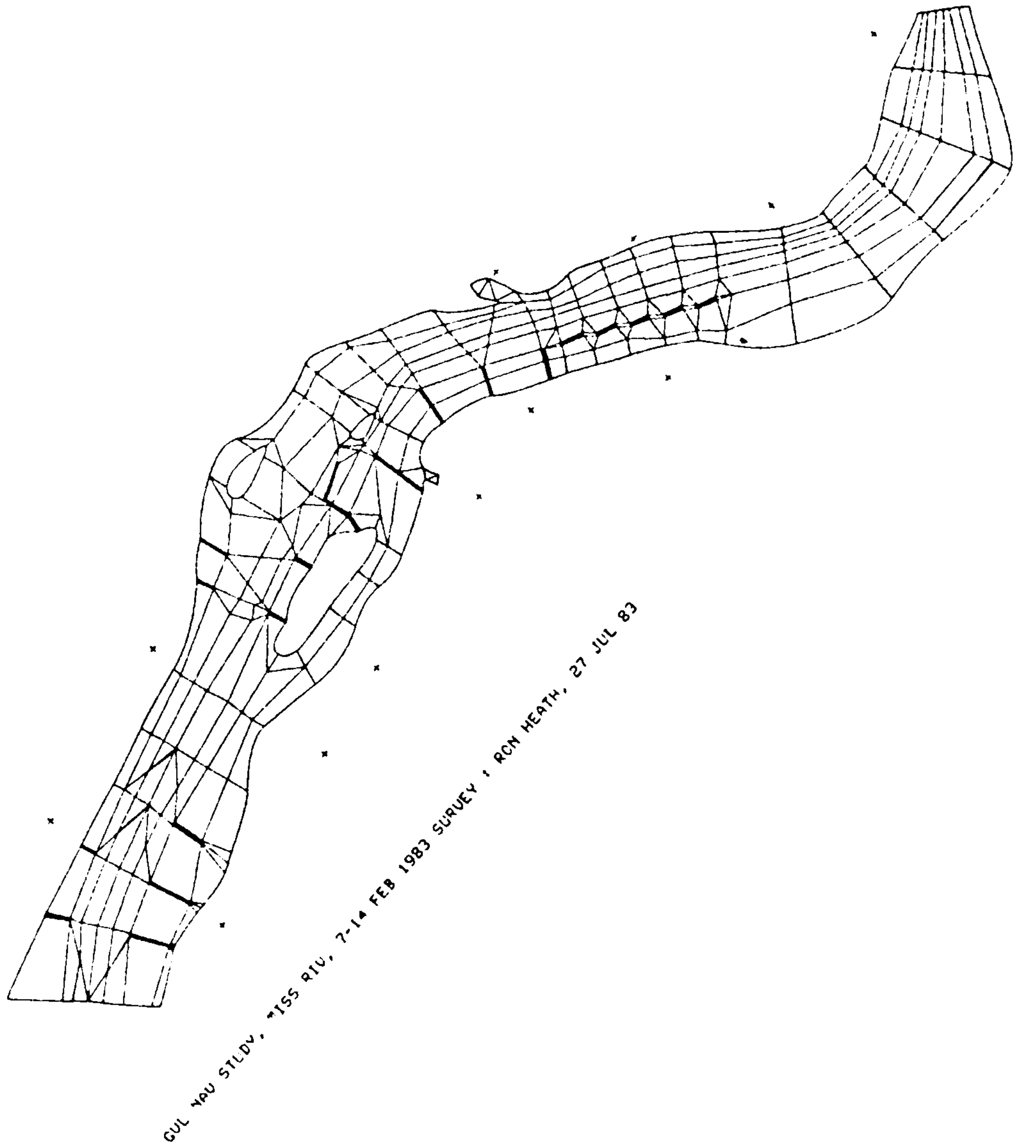

Figure 11. Sample mesh plot

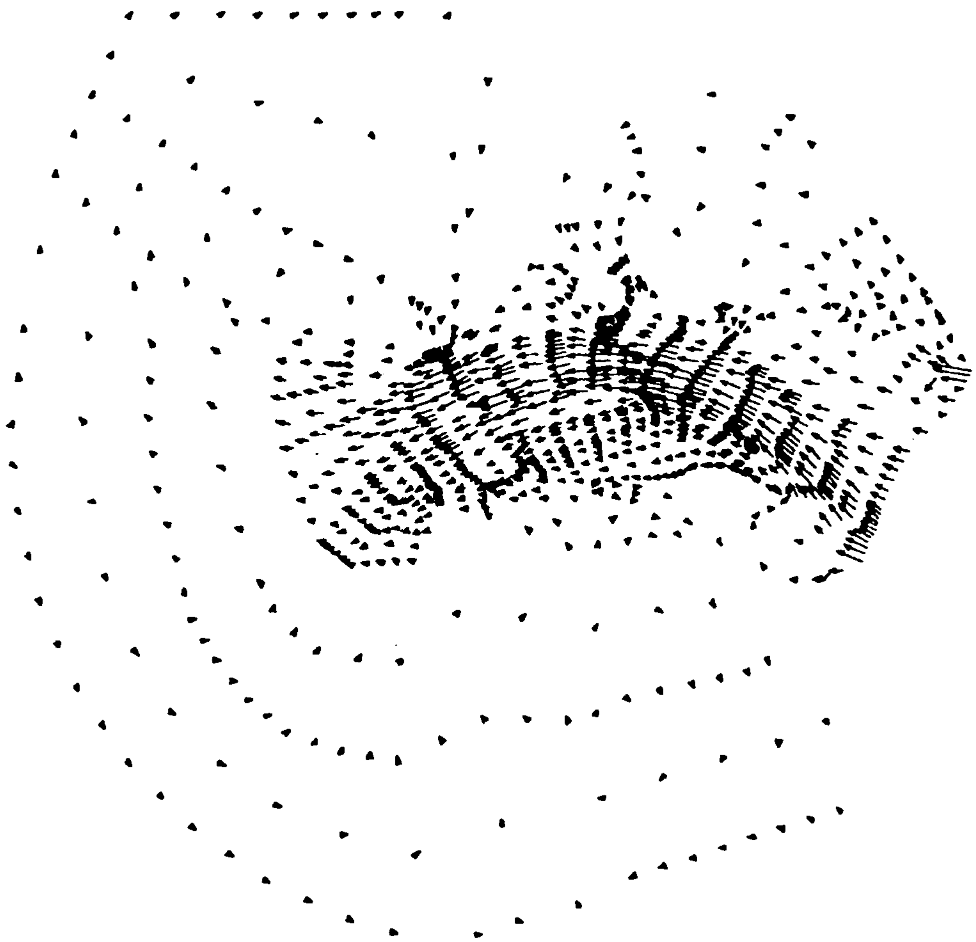

Figure I2. VPLOT plot of velocities at nodes

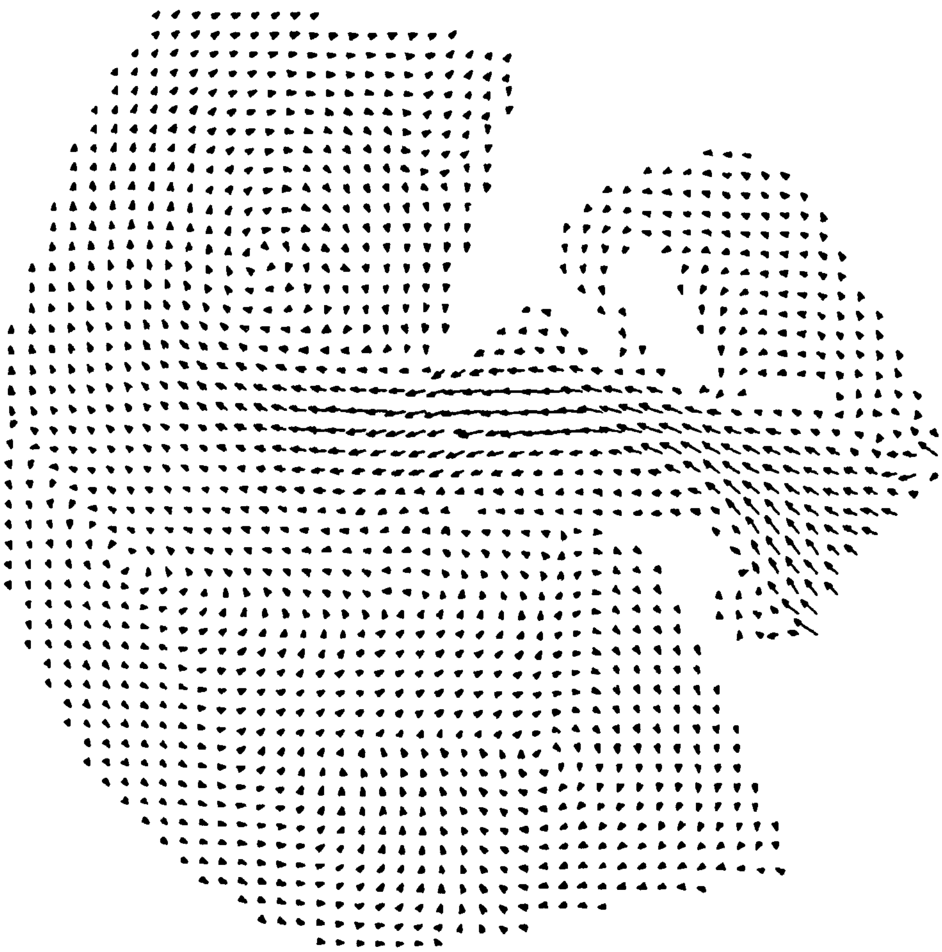

Figure 13. VPLOT plot of velocities on regular grid

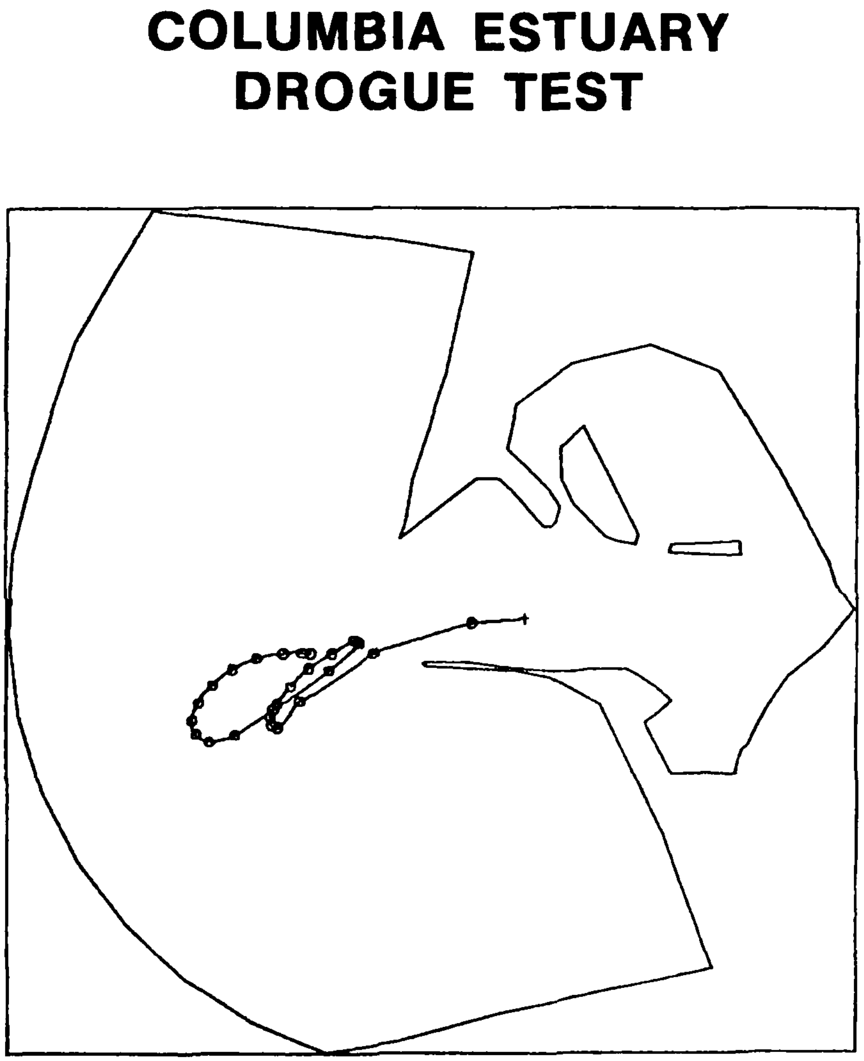

Figure I4. DROGUEPLT plot

30. Program 4VIEW produces quasi-3-D plots of DMS-A gridded data. Each plot contains views of the data from four directions. Its use is described in Addendum I-4 and an example is given in Figure I5.

31. Program SEDGRAPH is used to display STUDH results of bed elevation change or concentration as shown in Figure I6. The program's use is described in Addendum I-5.

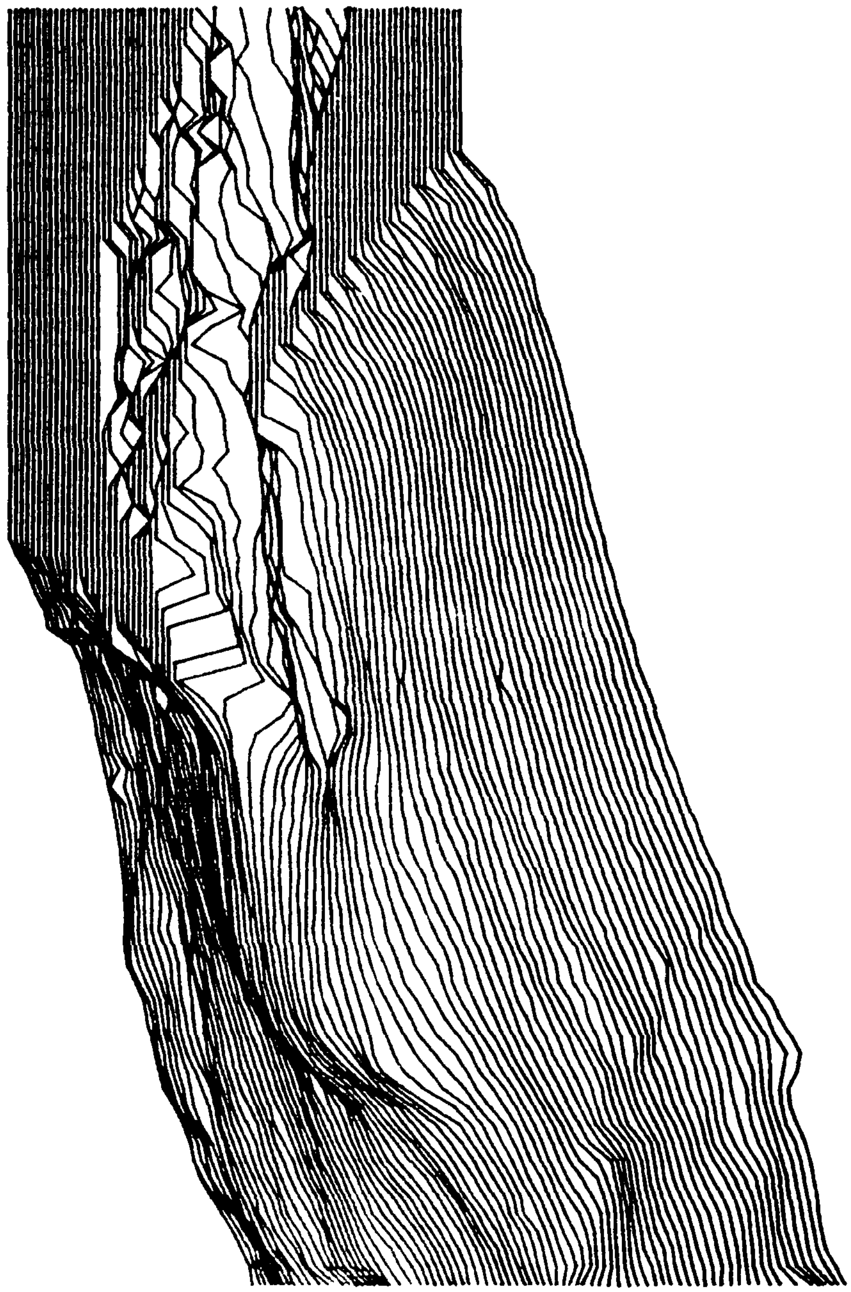

Figure 15. 4VIEW plot

Figure 16. SEDGRAPH plot

ADDENDUM I-1: USER INSTRUCTIONS FOR PROGRAM CONTOUR

Purpose

1. CONTOUR is a batch program for contouring output from the TABS-2 system. The input can be uniformly gridded or it can have the random spacing of the finite element mesh.

Origin of the program

2. The program was developed by Mr. D. P. Bach of WES. The gridding subroutines LOCATE, POINT, and their subordinate subroutines were written by the staff of Resource Management Associates. All graphical output is produced by the Graphics Compatibility System (GCS) which was supplied by the WES Automated Technology Center and modified by Mr. Bach.

Description

3. CONTOUR will accept data from GFGEN, RMA-2V, RMA-4, STUDH, ELEVGRD, and TRANSA and produce plot files. The RMA-3 subroutine LOCATE and subroutine POINT are used to grid the output from the finite element models. All graphical output is written by the GCS Library using the GCSMET driver. Output is directed to Tektronix type terminals using METAPLOT (META in PROCLV) and to Calcomp using (METAB in PROCLV).

4. CONTOUR will contour bed elevations from a GFGEN output file. It will also contour water-surface elevations, depths, or velocities from the RMA-2V output file. It can contour any type of data that has been created with ELEVGRD or TRANSA. CONTOUR will also contour bed changes or sediment concentrations from a STUDH output file. It can contour the first constituent in an RMA-4 output file. When interpolating model results, it uses the same slope functions that were used in the model solution; thus, it exactly reproduces that solution for contouring.

Use

5. CONTOUR requires a card image data file and either one or two binary data files, depending on the source of data to be contoured. Table I-1-1, Coding Instructions, shows the required files. In brief, contouring requires a finite element mesh file plus the file with the desired results from RMA-2V, RMA-4, or STUDH. GFGEN, ELEVGRD, and TRANSA data can be contoured with only one binary file. The files must be available prior to executing CONTOUR.

6. The program produces one output file which is saved by PROCLV. The user can then direct the output to a graphics terminal and/or to a Calcomp plotter. A job summary statement is sent to the line printer. If a "DUMP" is requested, it goes to the line printer also.

Plot size

7. The plot area on a Tektronix 4014 screen is considered to be 14.3 by 10.9 in. The hard copy unit reduces that image size to 8.5 by 6.5 in. For CALCOMP devices, the size is 8.5 by 11 in. Optionally, CONTOUR will adjust its plot size in an attempt to achieve a user-specified scale.

Plot orientation and scale

8. CONTOUR does not permit grid rotation and it calculates its own scale if the user does not override with the PSCALE command.

Contour values

9. Specific contours may be requested or the starting value, ending value, and interval may be prescribed. Details are given in the coding instructions at the end of this section.

Execution

10. CONTOUR is executed with PROCLV. A typical command line is shown in the APPENDIX O: PROCLV. Current procedure may differ slightly and can be listed by requesting

BEGIN,HELP,PROCLV,CONTOUR

Plotting does not begin when CONTOUR is executed. The output file will be saved by PROCLV and can be attached and directed to the plotting device by the command sequence "BEGIN,META,PROCLV, plotfile."

Examples

Example 1

11. The first example illustrates the CONTOUR input data required to contour sediment concentrations that were calculated by STUDH. The input was coded into a permanent file called INCONDB using an editor, and that file was attached to CONTOUR at execution time via PROCLV. The contents of INCONDB are

ATCHAFALAYA MESH 12 (1967 DELTA)

'C',, 'LINE', 5.,,105.,,10

12. These two lines contain three pieces of data. The first is title information for the plot. The second line tells the contour program the data file to be contoured is Concentrations and thus in the STUDH output format. Also, the second line of data tells the contour program the smallest, the largest, and the interval between contour lines. These commands are described below. The result is shown in Figure I-1-1. Note the contour lines are numbered and the legend at left gives the concentration for each line number.

13. Figure I-1-2 is a magnification of the area around X = 332500, Y = 210000. This plot file of concentrations was created by executing CONTOUR with PROCLV as follows:

BEGIN, CONTOUR, PROCLV, BACH, INCONDB,, S30TBAY, CONPLDB

14. The STUDH output is file S30TBAY and the output contour plot file is CONPLDB. Plotting does not start automatically. PROCLV stores CONPLDB as a permanent file and the following command is required to direct that file to the terminal.

BEGIN, META, PROCLV, CONPLDB.

15. The terminal will respond with a beep and the message "READY" on the screen. It is then under control of METAPLOT and commands are expected from the keyboard to activate plotting, these are described in METAPLOT in this appendix.

Example 2

16. An example of plotting bed elevation contours from an GFGEN output file is shown in Figure I-1-3. The input commands for contour are coded into file INCONDB as follows

ATCHAFALAYA MEST 12 (1967 DELTA)

'BED ELEVATIONS',,'LINE', 5.,,100.,,10.,

'DUMP',, 'NX',200, 'NY',200

17. This input will cause a printout of gridded data between NX = 1 to 200 and NY = 1 to 200 on the line printer. CONTOUR was executed with PROCLV by typing

BEGIN, CONTOUR, PROCLV, BACH, INCONDB, AGOMI2A,,CONPLDB

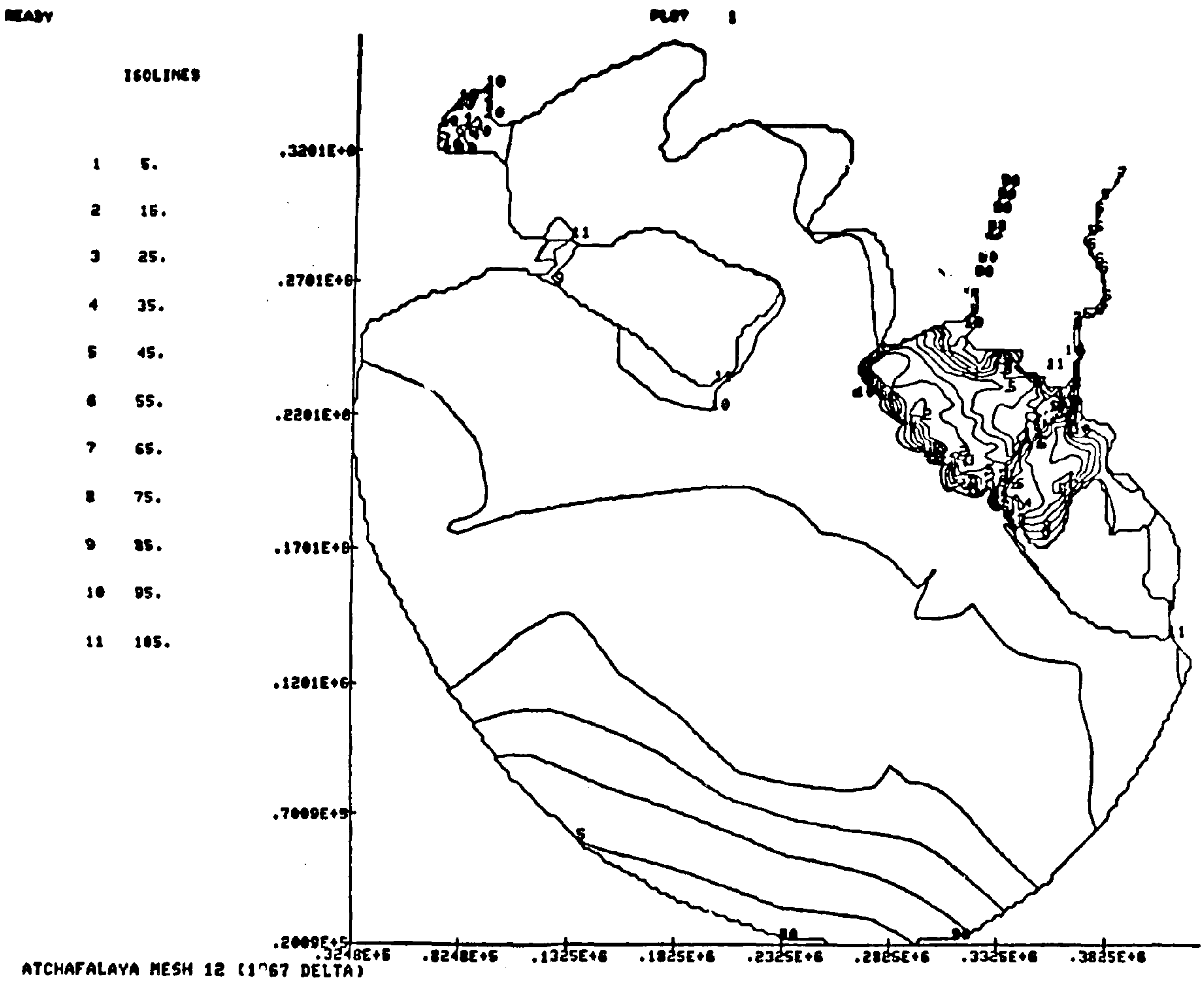

Figure I-1-1. Contour plot of sediment concentration

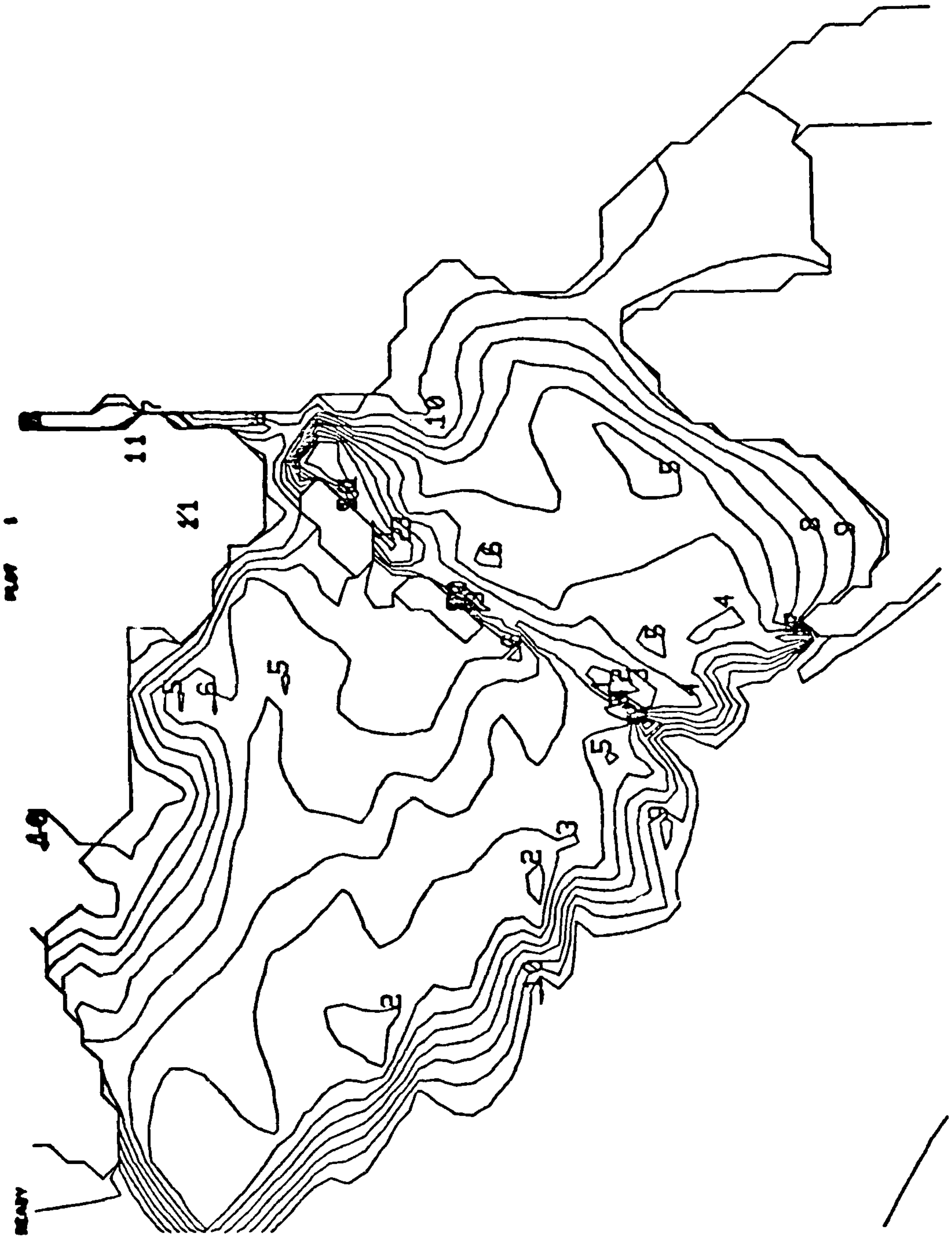

Figure I-1-2. Magnified plot of water depth
(artificially rotated to fit page)

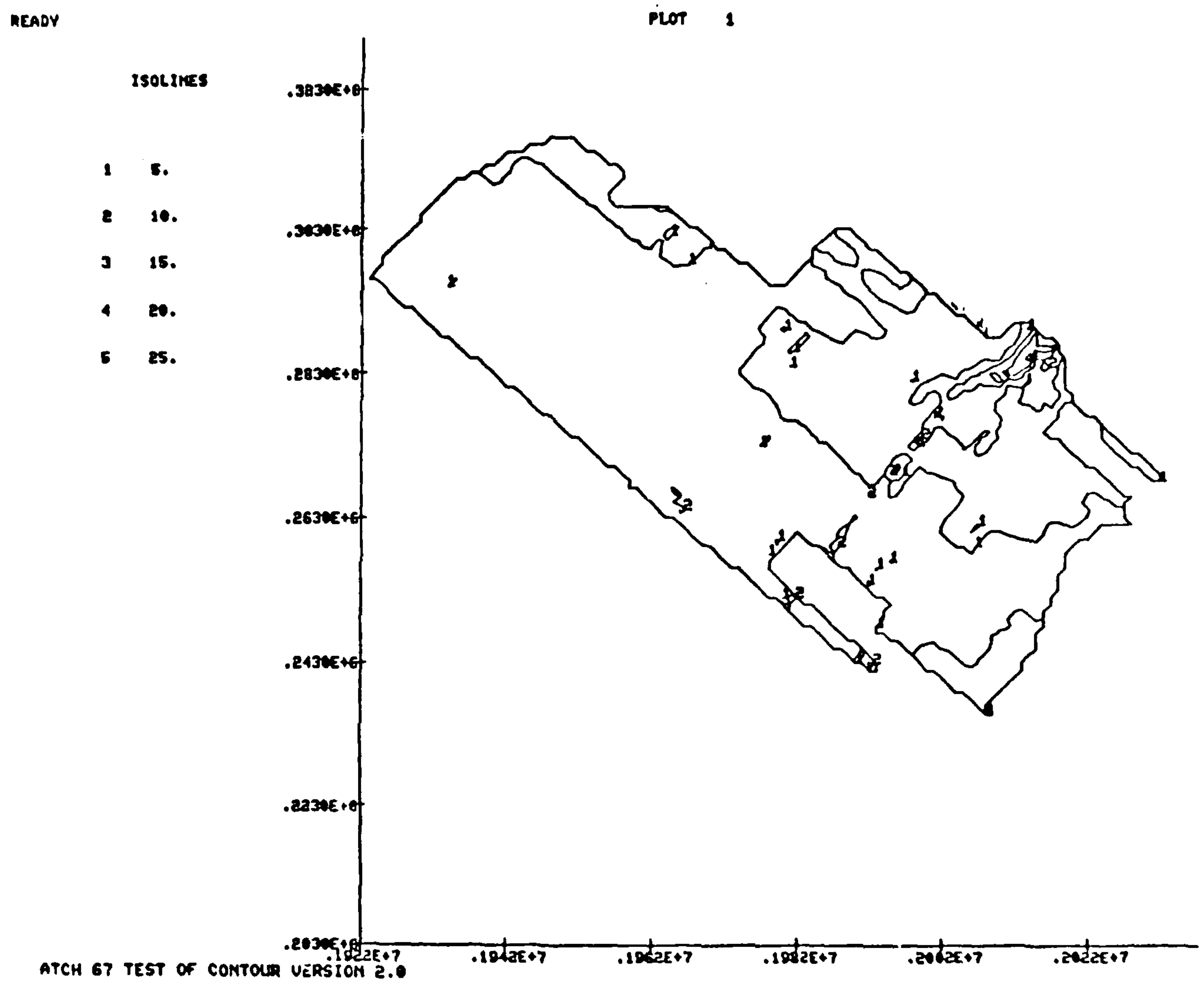

Figure I-1-3. Contours of bed elevations

Card Image Data Coding Instructions

18. The card image data file contains the plot title plus instructions for reading the binary data file(s) and setting the contour interval. It is created with the editor and saved as a "coded" data file, rather than a binary data file. Table I-1-1 shows the coding instructions, the sources of other data needed before CONTOUR can be executed, the disposition of the output data file, and the command syntax. The commas ",," indicate a null numeric field. Abbreviations are shown below each command.

19. Please note the different style of these card input instructions as compared with those in the main programs. After the Title line, the CONTOUR program expects a 'command' followed by a numeric value. The command should be set off by the apostrophes and arguments separated by commas. (Free-field input structure.) More than one command can appear on a line, but the line length should not exceed 80 columns.

Table I-1-1
Coding Instructions

Function	Additional Input Data Required*		Output Written*	Run Control Command
I. Types of Data That Can Be Contoured:				
Bed elevations	01R1		PLCO	'BED ELEVATIONS',, or 'B',, (Note that the numeric field is "null.")
Depths	01R1	01R2	"	'DEPTHS',, or 'DE',,
Water surface elevations	01R1	01R2	"	'WATER ELEVATIONS',, or 'WA'
Velocities	01R1	01R2	"	'VELOCITIES',, or 'V',,
ELEVGRD or TRANSA data	01EG		"	'ELEVGRD',, or 'E',, or 'TRANSA',, or 'TR',,
Depth changes		01S3	"	'DEPTH CHANGES',, or 'DC',,
Concentrations		01S3	"	'CONCENTRATIONS',, or 'C',,
First constituent on RMA4 file	01R1	01R4	"	'RMA4',,
New bed elevations from STUDH		01S3		'NEW BED', or 'NB',,
II. Contour Instructions:				
Set contour window (not valid when using 'READ',, command			"	'XMIN', xminvalue, (coordinate value) 'XMAX', xmaxvalue, 'YMIN', yminvalue, 'YMAX', ymaxvalue, The numeric field here specifies a limit along one of the two major axes in input data coordinates. Defaults are maximums or minimums found on the input file.
Set number of lines in each direction			"	'NX', number of grid lines in x-direction, 'NY', number of grid lines in y-direction, Default = 100. Maximum = 500.
Set scale factor			"	'SCALE', scale value, or 'SC', scale value, Default = 1.0 DATA = DATA*SCALE+DATUM
Set datum			"	'DATUM', datum value, or 'DA', datum value, Default = 0.0 DATA = DATA*SCALE+DATUM

TABLE I-1-1 (continued)

Function	Additional Input Data Required*	Output Written*	Run Control Command
Produce grid swath dump		Swath dump (like DUMPER2) on line printer	'DUMP', value, or 'DU', value, where value = 0 for dump of data to be contoured. 1 for dump of element assignments to each grid point 2 for both options above
Define individual contour line		Plot (OUTCON)	'LINE', contour value, or 'L', contour value,
Define contour lines by "DO-LOOP" method		-	'LINE', start value,, end value,, increment, or 'L', start value,, end value,, increment,
Select timestep to use		-	'TIMESTEP', time-step number, or 'TI', time-step number, Default = last time-step (Numbering starts at 1)
Distort plot to fill screen			'DISTORT',,
Scale plot			'PSCALE', plot scale, DEFAULT = self scaled
III. File Handling Instructions:			
Read intermediate grid array (Not valid for ELEVGRD/TRANSA contouring)	LOCATE information from previous CONTOUR run (SVG)	-	'READ',, This option is used to save computer time by avoiding calling LOCATE, which maps elements onto grid locations Must first 'SAVE' the file.
Write intermediate grid array (Not valid for ELEVGRD/TRANSA contouring)		Locate information to use in subsequent runs (SVG) Plot (outcon)	'SAVE',, This option is used to save computer time by avoiding the use of LOCATE.
Write ELEVGRD/ TRANSA type file		ELEVGRD file (ELG) Plot (outcon) DMS-A file FEG file	'WRITE', scale, This option can be used to send gridded data to programs such as 4-VIEW and BATHVOL. It can also be used to "hot-start" CONTOUR, avoiding the gridding process while experimenting with different contour values.

* See Table N7 in Appendix N for explanation of the file codes.

ADDENDUM I-2: USER INSTRUCTIONS FOR PROGRAM VPLOT

Purpose

1. VPLOT creates a plot file of velocity vectors from RMA-2V results. It will plot at all nodes in the finite element mesh, plot at selected nodes only, or interpolate onto a regular grid and plot the interpolated velocities.

Origin of Program

2. The original VPLOT program was obtained from the Ohio River Division, Corps of Engineers, in connection with the Edinger Model. The Corps' Hydrologic Engineering Center (HEC) modified that program to be compatible with the Resource Management Associates (RMA) 2-D finite element hydrodynamic models. The interpolation scheme was added by WES, using shape functions from RMA-3--a program originally written by RMA. Subsequent modifications have been made by WES personnel.

Description

3. VPLOT is a batch-oriented program that reads GFGEN and RMA-2V output files and creates a velocity-vector or unit discharge-vector plot file using the METAPLOT system (i.e., Calcomp look-alike calls). The length of the vector is scaled to the magnitude of the velocity or unit discharge, the direction shows direction of flow, and the base of the vector is plotted at the node. Unless instructed otherwise, VPLOT will plot a vector at every node in the finite element mesh; however, nodes can be selected or a uniform grid can be interpolated if desired. Interpolation utilizes the RMA-2V shape functions so the interpolated results are exactly as calculated by RMA-2V.

4. Only these nodes inside the wet portion of a mesh will be plotted. External boundaries can be drawn at the option of the user.

5. A plot file can be directed to a Calcomp device where the plots may be scaled to overlay the base map and/or the file may be directed to an interactive terminal.

Plot size

6. The plot area on a Tektronix 4014 screen is considered to be 14.3 by 10.9 in. The hard copy unit reduces that image size to 8.5 by 6.5 in. CALCOMP plot sizes are user-specified.

Plot orientation and scale

7. The term plot orientation refers to the alignment of the (x,y) axis of the mesh with the (x,y) axis of the plotting device. The x-axis of the graphics device is longer than the y-axis. When the finite element mesh is longer in the x-direction than it is in the y-direction, the best utilization of plotting space corresponds with the problem shape. However, when the study area is longer in the y-direction than in the x-direction, plotting space is wasted. VPLOT allows the (x,y) axis of the mesh to be rotated to best utilize plotting space. The amount of rotation, which can be any angle, is prescribed in degrees with the default being zero. The coordinates of the mesh are modified as shown below with all plotting and scaling being referenced to that rotated mesh.

$$XR = CORD(J,1)*COSAR + CORD(J,2)*SINAR$$

$$YR = CORD(J,2)*COSAR - CORD(J,1)*SINAR$$

where

CORD(J,1) = the x-coordinate at node J

CORD(J,2) = the y-coordinate at node J

SINAR = Sin (ARR)

COSAR = Cos (ARR)

ARR = azimuth of rotated y-axis in radians

8. Two scales are established: (a) the scale for plotting the rotated (x,y) axis and (b) the velocity-vector length scale. Regarding the space scale, VPLOT will either scale the XR- and YR-dimensions of the study area to fit the plotting area, or the scales can be supplied by the user. In either case, the mesh size is converted into inches as follows:

$$XC = (XR - XZERO)/XS$$

$$YC = (YR - YZERO)/YS$$

where

XC,YC = plotting positions of the nodal point coordinates in inches

XR,YR = the rotated mesh coordinates in prototype units

XS,YS = the x-axis and y-axis scales in prototype units per inch

XZERO = the smallest XR-coordinate in the mesh

YZERO = the smallest YR-coordinate in the mesh

9. VPLOT calculates vector length by scaling the u- and v-velocity components as follows

H = u/HS

V = v/VS

where

H = calculated plot length for the x-component of velocity vector, inches

HS = plotting scale for the u-component of velocity, fps/inch

u = calculated x-component, fps

V = calculated plot length for the u-component of velocity vector, inches

VS = plotting scale for the v-component of velocity, fps/inch

v = y-component of velocity, fps

10. When axes have been rotated, the velocity vector components are also rotated prior to plotting as follows

HR = H*COSAR + V*SINAR

VR = V*COSAR   H*SINAR

where

H,V = described above

COSAR = Cosine of the azimuth of the rotated coordinate axes

SINAR = sine of the aximuth of the rotated coordinate axes

The base of the velocity vector is plotted at (XC,YC) and the tip of the arrowhead is plotted at (XC+HR, YC+VR).

11. To highlight zones of velocity greater than the maximum scale length, a solid arrowhead will be displayed when either the u- or the v-component exceeds a "maximum value" that is prescribed in the input data as VECMAX (J1-7).

Use

12. VPLOT requires one to three input data files and produces one output file, summarized in Table I-2-1. All input files must be created before executing VPLOT.

13. Graphs are not displayed when VPLOT is executed; the plot file is created and saved. It is then ready to be directed to plotting devices by using METAPLOT.

Table I-2-1

Summary of Files for VPLOT

Description of Data	Source/File	File Type
Input		
Mesh data	GFGEN/01R1	Binary
Hydraulic data	RMA-2V/01R2	Binary
Card image input data	Editor	Coded
Output		
Velocity vector plot file	VPLOT/PLVP	Binary

*See Table N7 in Appendix N for explanation of file codes.

14. VPLOT is executed with PROCLV. A typical command line is shown in the APPENDIX O: PROCLV. Current procedure may differ slightly and can be listed by requesting

BEGIN,HELP,PROCLV,VPLOT

15. Plotting does not begin when VPLOT is executed. The VPLOT output file will be saved by PROCLV and can be attached and directed to the plotting device by METAPLOT.

16. VPLOT writes a short printout back to the line printer separate from the plots.

Example

17. The following Card Image Input data file produced the vector plot shown on Figure I-2-1.

```
T1  LITTLE ROCK AIRPORT RUNWAY EXTENSION---ARKANSAS RIVER 12/9/83 RFA
J1     1.0       1.0       0.       0.      10.      10.     15.0     00.0
J2       3         0         0         0       1        0
```

XS =	1.0	ITYPE =	3
YS =	1.0	ISEL =	0
HORIZ =	0.	IPNN =	0
VERT =	0.	ISTEPS =	0
HHS =	10.	IBOUND =	1
VVS =	10.	ITONLY =	0
VECMAX =	15.0		

Instructions for Coding Card Image Input Data

18. The input data should be coded in eight column fields with the card type coded in columns 1 and 2. The instructions that follow show details. Variable names appearing in the input are shown in Table I-2-2. A list of the input card images is given in Table I-2-3.

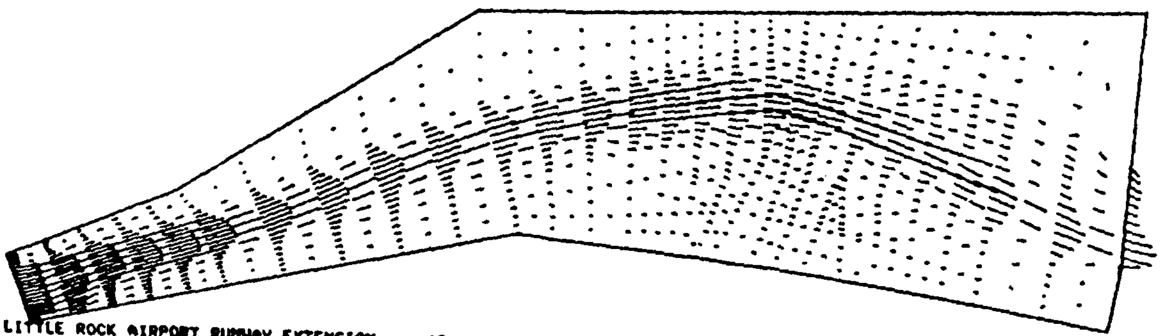

Figure I-2-1. Example vector plot

Table I-2-2
Summary of Variable Names on Input Cards

Variable	Card	Variable	Card
AR	J1	NODLST	PN
		NPXMAX	VW
HHS	J1	NPXMIN	VW
HORIZ	J1	NPYMAX	VW
		NPYMIN	VW
IBOUND	J2		
IBNPLT	J2	TITLE	T1
ICG	all	TPL	VT
IN	VN	VECMAX	J1
INODES	J2	VERT	J1
IPNN	J2	VVS	J1
		NX	RG
ISEL	J2	NY	RG
ISTEPS	J2	XS	J1
ITONLY	J2		
ITYPE	J2	YS	J1

Table I-2-3
Sequence of Card Image Input

Card	Content	Required?
T1	Title for plots	Yes
J1	Scaling and orientation parameters	Yes
J2	Run options	Yes
VN	Nodesat which vectors are to bedrawn	If ITYPE = 1
VW	Plot window	If ITYPE = 2
RG	Regular grid intervals	If ITYPE < 0
VT	Times at which plots are to be drawn	If ITONLY > 0
PN	Pinpoint location of a node	No

T1 Card | Title Card | Required

Record title information on one card.

Field	Variable	Value	Description
0		T1	Card identification.
1-3	TITLE		Enter up to 20 character plot title

J1 Card | Job Parameters | Required

Field	Variable	Value	Description
0	ICG	J1	Card group identification
1	XS	+	Scale factor for the x-axis of the mesh (Code as 1666.67 for 1:20,000 scale map, i.e., 20,000/12 = 1666.67)
		0	Program will search HORIZ, VERT then YS for use as x-axis scale for mesh
2	YS	+	Scale factor for the y-axis of the mesh when creating a distorted plot (not recommended)
		0	Program will search for HORIZ VERT then XS for use as the y-axis scale for the mesh
3	HORIZ	+	Maximum plot size in inches for the x-axis of the mesh. If coded HORIZ will override XS
		0	Program will search VERT, then XS for the x-axis scale for the mesh
4	VERT	+	Maximum plot size in inches for the y-axis of the mesh. If coded, VERT will override YS
		0	Program will search HORIZ then YS for the y-axis scale
5	HHS	+	Code the x-velocity scale factor in feet/sec/inch of plot (i.e., 5 = 5 fps per inch of Calcomp plot; 5 = 5 fps per 1/2 inch Tektronix 4014 plot)
		0	Never
6	VVS	+	Code the y-velocity scale factor. For undistorted plots, VVS = HHS
		0	Never
7	VECMAX	+	The maximum velocity component for open arrowheads. If either u or v velocities exceed VECMAX, the arrowhead is shaded. If both u and v velocities exceed VECMAX, the

J1 Card (continued)

Field	Variable	Value	Description
			vector is set at 45 deg in addition to the shaded arrowhead
8	AR	+,-	Azimuth of the y-axis of the mesh in degrees when it is desirable to rotate the vector plot. AR is measured from the y-axis of the plotter device (i.e., vertical on Tektronix and across the paperon drum plotter), positive clockwise
		0	No rotation

J2 Card — Job Control Parameters — Required

Field	Variable	Value	Description
0	ICG	J2	Card group J2
1	ITYPE		Type of vector plot requested
		0,3	Default, full finite element mesh plot
		1	Plot selected nodes, finite element mesh
		2	Plot selected window, finite element mesh
		-2	Interpolate from finite element mesh onto regular grid and plot selected window
		-3	Interpolate from finite element mesh onto regular grid and plot entire space
			Type of per-unit-width-discharge vector plot requested
		10	Plot selected node, FE mesh
		20	Plot selected window, FE mesh
		-20	Interpolate from FE mesh onto regular grid and plot selected window
		30	Plot a full finite element mesh
		-30	Interpolate from FE mesh onto a regular grid and plot a full finite element mesh
2	ISEL	+	The number of nodes coded on VN cards. Required if ITYPE = 1
		0	Only required when ITYPE is not equal to 1
3	IPPN	0	Node numbers are not written on the plot (preferred)
		1	Node numbers are written on each node plotted.
4	ISTEPS	0	Steady state, yields 1 plot
		+	Code the number of time-steps in the RMA-2V dynamic run output file for which a vector plot is desired
5	IBOUND	1	Plot the external boundaries as a solid line (preferred)
		0	Do not plot external boundaries
6	ITONLY	0	No VT card is present
		+	Enter the number of time-steps coded on VT cards

Field	Variable	Value	Description
7	IBNPLT	0	Do not plot locations of boundary nodes
		+	Plot locations of boundary nodes
8	INODES	0	Plot vector at all nodes in specified plot area (default)
		1	Plot only corner nodes in the specified plot area
		2	Plot only midside nodes in the specified plot area

VN Card | Selected Nodes for Vector Plots | Optional

Include this card when ITYPE = 1 or 10 (J1 Card)

Field	Variable	Value	Description
0	ICG	VN	Card group identification = VN
1	IN(1)	+	Enter the first node to have the vector plotted
2	IN(2)	+	Continue coding 10 nodes per card until all nodal points have been entered for the vector plots
	etc.		Code ISEL (J2-2) nodes

VW Card   Rectangular Window   Optional

Field	Variable	Value	Description
0	ICG	VW	Card identification = VW
1	NPXMIN	+	The node number of the smallest X-coordinate in the window
2	NPXMAX	+	The node number of the largest X-coordinate in the window
3	NPYMIN	+	The node number of the smallest Y-coordinate in the window
4	NPYMAX	+	The node number of the largest Y-coordinate in the window

Include VW card when ITYPE = ¶2¶ or ¶20¶ (J2 card)

RG Card | Regular Grid Scale | Optional

Field	Variable	Value	Desciption
0	ICG	RG	Card group definition = RG
1	NX	+	Horizontal axis spacings for regular grid plotting Default = 50
2	NY	+	Vertical axis spacings for regular grid plotting Default = 25

Include RG card when ITYPE (J2 card) is negative.

VT Card Selected Time for Vector Plots Optional

Field	Variable	Value	Description
0	ICG	VT	Card group identification = VT
1	TPL(1)	+	Code the time in decimal hours for the first vector plot
2	TPL(2)	+	Continue coding the times in sequential order until ITONLY values have been entered

Include this card when ITONLY (J2 Card) is positive.

PN Card | Plot Node Location | Optional

Field	Variable	Value	Description
0	ICG	PN	Card group identification = PN
1	NODLST	+	Code the node numbers where you want a "+" sign plotted for references. Up to "MM3" values are permitted. Code continuation cards exactly the same as the first card. Program will count the number of values coded and stop automatically

ADDENDUM I-3: USER INSTRUCTIONS FOR PROGRAM DROGUEPLT

Purpose

1. DROGUEPLT's purpose is to trace the movement of a drogue with time when placed in a flow field computed by RMA-2V.

Origin of Program

2. DROGUEPLT was written by J. P. Stewart of WES using interpolating routines from RMA-3, which were written by Resource Management Associates.

Description

3. The program plots the movement of one drogue for a maximum of 25 hr. A maximum of 400 nodes may be used to describe the land boundary.

4. Results at the finite element mesh points are converted to a rectangular grid with each grid cell assigned the element number within which it lies. The rectangular grid is used to approximately locate which element the drogue is occupying at each computation interval. The drogue coordinates are converted to local coordinates, which are tested to see if they lie between -1 and 1. If so, the correct element has been located and the drogue velocity is computed using the shape functions. The model results time-step increment is divided into 36 equal parts. The drogue is moved a distance equal to

$$x = V_x \frac{TINCR}{36} \quad \text{and}$$

$$y = V_y \frac{TINCR}{36} \quad .$$

The new x, y coordinates are then used along with the rectangular grid to approximately locate the element within which the drogue lies, and the process is repeated.

5. If the local drogue coordinates do not lie between -1 and 1, a second iteration is made by choosing the appropriate adjacent element. This is determined by checking whether the local coordinate is less than -1 or greater than 1. When the correct element is located, the drogue velocity is computed as described above.

Use

5. DROGUEPLT is executed from PROCLV. Card Image Run Control input is described below. Required input includes the GFGEN geometry file (OIR1) on logical unit 3, and the RMA-2V results file (OIR2) on logical unit 6.

Card Image Data Input Instructions

6. Card Image run control data input is described in the following pages. Input is fixed format.

Card 1. (13A6) Title Required

Name	Value	Description
TITLE	--	Title to appear on printed output

Card 2. (F10.0, 2I5) Timing Control Required

Name	Value	Description
TINCR	+	Length of velocity input time-steps in seconds
NSTEPS	+	Number of time-steps to be read from tape unit 6
ISTRT	+	Time-step at which the drogue is to be placed in the water

Card 3. (2F10.0) Initial Drogue Location Required

Name	Value	Description
XDR(1)	+	Initial location of the drogue
YDR(1)	+	

Card 4. (3I5) Job Options Required

Name	Value	Description
IPT1	0	No grid print
	1	Swath dump of grid is printed
IS3		Tape unit for GFGEN file (default = 3)
IS6	+	Tape unit for RMA-2V file (default = 6)

Card 5. (4F10.0, 2I5) Griding Description Required

Name	Value	Description
XORG	+	X-coordinate at origin
YORG	+	Y-coordinate at origin
XGRID	+	Grid spacing
YGRID	+	Grid spacing
NX	+	Number of columns
NY	+	Number of rows

Card 6. (16I5) Element Control Required

Name	Value	Description
		Every element must be flagged.
IMAT	0	Element is ignored
	1	Element is used in the computation

Card 7. (I5) Land Boundary Control Required

Name	Value	Description
NPTS	+	Number of points to be read describing land boundaries

Card set 8. (16I5) Land Boundary Nodes Required if NPTS > 0

Name	Value	Description
NBP(J)	+	Node number along a land boundary
	9999	Flags end of a land segment. Used to lift plotter pin before starting a new segment, such as an island
	Blank	End of land boundary description

NOTE: Use as many cards as needed to describe the land boundary.

Card set 9. (10A8) Axis Titles

Name	Value	Description
HEADER		2 title cards to appear on the plot. Titles should be centered in an 80-column field

ADDENDUM I-4: USER INSTRUCTIONS FOR PROGRAM 4VIEW

Purpose

1. Program 4VIEW is a batch program that produces 3-D line drawings of DMS-A gridded data.

Use

2. Input to 4VIEW consists of Card Image run control and a gridded data file. The gridded data file, input as logical unit 10, is in the format produced by the DMS-A as described in Appendix L.

3. Output consists of a plot file on logical unit 3.

4. 4VIEW is available through PROCLV:

BEGIN,4VIEW,PROCLV,id,I3RP,I14V,O14V,rje <CR>

where
- id = user's name
- I3RP = DMS-A gridded data file name
- I14V = run control input file name
- O14V = plot output file name
- rje = destination of printed output

5. The run control input to 4VIEW consists of one card (line) and is as follows:

Variable Number	Format	Description
1	I1	View for plot number 1 = 0 for no plot = 1 for front = 2 for rear = 3 for right = 4 for left
2	I1	View for plot number 2
3	I1	View for plot number 3
4	I1	View for plot number 4
5	F4.1	Vertical exaggeration (scale factor)
6	I6	Minimum x-value of grid to be plotted
7	I6	Maximum x-value
8	I6	Minimum y-value
9	I6	Maximum y-value
10	F10.0	Dimension in inches of long dimension of page to be plotted (28.0 is maximum)
11	F10.0	Pedestal height in inches (position where area of interest is to be drawn)

ADDENDUM I5: USER INSTRUCTIONS FOR PROGRAM SEDGRAF

Purpose

1. Program SEDGRAF displays one through nine ranges of desposition/erosion or concentration data from the sediment model (STUDH) in a factor map display.

Origin of the Program

2. SEDGRAF was written by S. A. Adamec of WES.

Use

3. The irregularly spaced nodal results are interpolated to a 100 by 100 regular grid. For each plotting range, the user must specify starting and ending values and a symbol (such as "." or "1"). The symbol # is reserved for land. The user must specify which time-step is to be displayed from the STUDH results (if you want the last time-step of a run that lasted 20 time-steps, you would specify 19 since STUDH runs one time-step before producing results) and the component to plot (1=concentration, 2=bed change).

4. The program will window in on a particular area of the mesh if the user specifies four nodes that form a box around the area of interest.

5. SEDGRAF requires a GFGEN geometry file as input on logical unit 1 and a STUDH results file as input on unit 2. The card image input data are read from unit 8 and the output METAFILE (plot file) is on unit 99. The input data for SEDGRAPH is read in free-format. All fields are separated by commas and the symbols for each range must be enclosed in single quotes ('.').

6. Letters, numbers, and symbols may be used as factor plotting labels. Commonly used symbols are letters for varying degrees of erosion and numbers for varying degrees of deposition. When plotting concentrations, it is advisable to also include a minus sign for negative concentrations between -0.01 and -1000. to warn of patches of negative concentrations.

7. The scale of plotting chosen may mask some local results because of averaging. To obtain details of results, windowing is necessary.

Card Image Data Input Instructions

Card 1 (Free-Format) NUMSTP,NCOM,IWINDOW

NUMSTP = The number of the data record to be displayed
NCOM = The component to plot (1=CONCENTRATION,2=BED CHANGE)
IWINDOW = Turns windowing on or off (0=OFF,1=ON)

Card 1A (Free-Format, Include Only
if Window from Card 1 is Equal to 1) NXMIN,NXMAX,NYMIN,NYMAX

NXMIN = NODE FOR MINIMUM X-COORDINATE
MXMAX = " " MAXIMUM
NYMIN = " " MINIMUM Y-COORDINATE
NYMAX = " " MAXIMUM

Card 2 (40A1) (ITITLE(I),I=1,40) ITITLE = PLOT
TITLE (40 CHARACTERS OR LESS)

CARDS 3 THRU 11 (FREE-FORMAT, USE ONLY AS MANY AS
YOU NEED UP TO MAXIMUM OF 9) VMIN,VMAX,SYMBOL

VMIN = STARTING VALUE FOR THIS RANGE
VMAX = ENDING VALUE FOR HIS RANGE
SYMBOL = PLOTTING SYMBOL FOR THIS RANGE (MUST BE IN SINGLE QUOTES)
SEDGRAF is run from PROCLV. See Appendix O for instructions.

ADDENDUM I-6: USER INSTRUCTIONS FOR PROGRAM WDGPLT

Purpose

1. Program WDGPLT produces plots of wet and dry portions of the finite element grid during an RMA-2V simulation. The first plot produced by WDGPLT is a plot of the entire grid as produced by program GFGEN. For each user-selected time step, two plots are produced--one of the wet area and one of the dry area. The grid plots may be rotated and scaled by the user.

Origin of the Program

2. WDGPLT was written by S. A. Adamec of the WES Hydraulics Laboratory.

Use

3. Program WDGPLT can be accessed through PROCLV in the following manner:

BEGIN,WDGPLT,PROCLV,ID,I1WD,O1R1,O1R2,O1WD,RJE

where

ID = user name
I1WD = filename for WDGPLT card input (may be null)
O1R1 = GFGEN output geometry file
O1R2 = RMA-2 output hydrodynamic file
O1WD = output Metaplot file from WDGPLT
RJE = user name of RJE printer for printed output

Input

4. Input to WDGPLT consists of a geometry file (GFGEN output) on logical unit 1, an RMA-2V output file on logical unit 2, and card image run control on logical unit 6.

Output

5. Output from WDGPLT consists of a GCS/META Metaplot file and a short printed output. The metafile can be post-processed by DIRECT into Calcomp or graphics terminal plots.

Instructions for Card Image Input Data

6. Each input data card contains eight real input data

fields of ten places each (8E10.0). The input title card is 80 characters wide. If any or all of cards 1 through 7 are omitted, WDGPLT will plot all of the time steps on the RMA-2V output file.

Card 1 (8E10.0):

Field 1	AROT --	grid rotation factor in degrees CCW from the positive x-axis
Field 2	SCALE --	coordinate scale factor to be applied to all coordinates by multiplication
Field 3	TSEL --	if nonzero, plot only the user-selected times on cards 2-7

Cards 2-7 (8E10.0:

Fields 1-8	TUSER(J),J=1,NUTS --	user-selected times for plotting. Code 8 values to a card up to a maximum of 48 values (6 cards)

Card 8 (A80):

	IUTIT --	an 80-character plot title

APPENDIX J: OUTPUT ANALYSIS

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APPENDIX J: OUTPUT ANALYSIS

Introduction

1. The purpose of output analysis programs is to assist the modeler in interpreting model results. Graphics displays, an essential tool in output analysis, are described in Appendix I. This appendix describes those programs which provide output analyses that are primarily nongraphical, though each of them also produces graphical displays.

Programs

2. Three programs are described here:

a. Program POSTHYD analyzes ouput from RMA-2V and is described in Addendum J-1. POSTHYD will also accept field or physical model data for comparison with RMA-2V results.

b. Program POSTSED analyzes ouput from STUDH. It is described in Addendum J-2.

c. Program ACE accumulates results from one or more STUDH runs, combines them as events of specified duration, and computes shoaling and dredging volumes. ACE is described in Addendum J-3.

ADDENDUM J-1: USER INSTRUCTIONS FOR PROGRAM POSTHYD

Purpose

1. POSTHYD is a general purpose postprocessor for RMA-2V. The code will produce various plots, comparisons, and listings of statistics from a run of the 2-D hydrodynamic code. Water-surface elevations, velocity magnitude/direction, and velocity ebb/flood magnitude plots can be produced. Comparisons, both graphical and tabular, can be made between two RMA-2V runs or an RMA-2V run and data from the field or from a physical model. A ranked correlation coefficient can be computed for the comparison. Run statistics include maximum and minimum values for depths and current speed.

Origin of Program

2. POSTHYD was written by P. P. Bach of the WES Hydraulics Laboratory.

Description

3. Graphics Compatibility System (GCS) calls are used for plotting. The adjustment to the flood direction is performed by a least squares curve fit through the data. The correlation coefficient calculation is performed by code written by D. W. Harp in December 1979 and is available through the WES Engineering Computer Programs Library (ECPL program number 704-F7-F4150).

Use

4. POSTHYD is executed from PROCLV. The Cyber Control Language procedure call is as follows:

BEGIN,POSTHYD,PROCLV <CR>

Answer the questions that the procedure asks.

Input

5. The various input data files are described in Table J-1-1.

6. The run control cards to POSTHYD use a modified HEC format, with a card identifier in columns 1-3. The rest of each card is read in free-field, with commas or spaces separating each item. A null value for an item is represented by two consecutive commas. Character items that contain embedded spaces or commas must be enclosed with apostrophes.

Table J-1-1
Input Data Files

FORTRAN Logical Unit(s)	Input Data
1-5	RMA-2V time-history data files, in chronological order: the file supplied on Unit 2 should have been "hotstarted" from the run that produced the file being supplied on Unit 1.
21-30	Data files for comparison. These can be output from RMA-2V, field data, or physical model data.
40-41	GFGEN geometry files, the file being supplied on Unit 40 goes with the data on Units 1-5, and the file supplied on Unit 41 goes with the data on units 21-30. If nodataare supplied on Unit 41, and a comparison is made between two RMA-2V runs, then the program will use the file supplied on Unit 40 for both RMA-2V runs.
50	Run control inputtoPOSTHYD, as described in the following pages.

7. A summary of POSTHYD run control input is given in Table J-1-2. Figure J-1-1 illustrates sample run control input. Details of run control input are given following Table J-1-4.

8. Input file formats for data to be compared with RMA-2 results are given in Table J-1-3 (field data), J-1-4 (physical model tide data), and J-1-5 (physical model velocity data).

Output

9. POSTHYD output consists of printed tabular results and plots. Figure J-1-2 shows a sample tabular output from POSTHYD. Graphical output is written to logical unit 77 and is in standard TABS format for META system plotting. Sample plots are shown in Figures J-1-3 - J-1-5.

```
T1  MESH4 VS MESH1 570K CFS GL=100.00                      5-17-85
T2  M4        M1
PL     0.        50.
CS    RMA2
PN     634       0.      WS
PN     634       0.      EFM  ,,  0.
PN     216       0.      WS
PN     216       0.      EFM  ,, 20.
PN    1023       0.      WS
PN    1023       0.      EFM  ,,  20.
PN     737       0.      WS
PN     737       0.      EFM  ,,  315.
PL     0.        0.      99.    110.
PP    00.,1031,1023,1015,1007,999,647,646,645,644,643,642,641,625
EN
```

Figure J-1-1. POSTHYD sample run control input

PROGRAM POSTHYD.... MESH4 VS MESH1 78K CFS GL=100.00
RMA2 NODE 216

TIME HISTORY TABLE
RMA2 NODE 216

TIME (HOURS)	X-VEL (FT/SEC)	Y-VEL (FT/SEC)	MAGNITUDE (FT/SEC)	DEPTH (FT)	WS ELEV (FT)	WET/DRY STATUS	WS ELEV (FT)
.00	-.115	-.043	.123	5.507	100.507	WET	100.013
1.00	-.341	.040	.344	5.391	100.391	WET	100.024
2.00	-.491	-.005	.491	5.185	100.185	WET	100.090
3.00	-.269	-.061	.276	5.152	100.152	WET	100.248
4.00	.113	.166	.201	5.411	100.411	WET	100.475
5.00	.280	.368	.463	5.714	100.714	WET	100.701
6.00	.274	.329	.428	5.884	100.884	WET	100.868
7.00	.198	.166	.258	5.942	100.942	WET	100.951
8.00	.080	-.018	.082	5.929	100.929	WET	100.942
9.00	-.062	-.158	.170	5.854	100.854	WET	100.857
10.00	-.186	-.233	.298	5.733	100.733	WET	100.727
11.00	-.267	-.290	.394	5.582	100.582	WET	100.572
12.00	-.309	-.355	.470	5.408	100.408	WET	100.402
13.00	-.326	-.411	.525	5.225	100.225	WET	100.223
14.00	-.337	-.449	.562	5.040	100.040	WET	100.039
15.00	-.345	-.470	.583	4.855	99.855	WET	99.853
16.00	-.349	-.477	.591	4.675	99.675	WET	99.673
17.00	-.345	-.469	.583	4.510	99.510	WET	99.508
18.00	-.333	-.444	.555	4.372	99.372	WET	99.368
19.00	-.312	-.400	.507	4.269	99.269	WET	99.265
20.00	-.280	-.339	.439	4.212	99.212	WET	99.207
21.00	-.237	-.260	.352	4.210	99.210	WET	99.206
22.00	-.188	-.160	.247	4.269	99.269	WET	99.266
23.00	-.128	-.029	.131	4.386	99.386	WET	99.386
24.00	-.023	.118	.120	4.546	99.546	WET	99.547
25.00	.100	.234	.254	4.735	99.735	WET	99.737
26.00	.190	.303	.357	4.941	99.941	WET	99.947
27.00	.237	.339	.414	5.156	100.156	WET	100.163
28.00	.255	.354	.436	5.366	100.366	WET	100.371
29.00	.255	.347	.431	5.555	100.555	WET	100.560
30.00	.240	.316	.397	5.714	100.714	WET	100.719
31.00	.207	.262	.334	5.830	100.830	WET	100.837
32.00	.153	.183	.239	5.896	100.896	WET	100.902
33.00	.077	.081	.112	5.901	100.901	WET	100.905
34.00	-.031	-.046	.055	5.845	100.845	WET	100.846
35.00	-.151	-.166	.224	5.738	100.738	WET	100.737
36.00	-.243	-.261	.357	5.593	100.593	WET	100.591
37.00	-.297	-.337	.449	5.422	100.422	WET	100.420
38.00	-.320	-.399	.512	5.235	100.235	WET	100.237
39.00	-.330	-.443	.553	5.045	100.045	WET	100.049
40.00	-.335	-.468	.575	4.857	99.857	WET	99.861
41.00	-.337	-.475	.583	4.674	99.674	WET	99.678
42.00	-.334	-.467	.574	4.508	99.508	WET	99.510
43.00	-.323	-.440	.546	4.367	99.367	WET	99.369
44.00	-.300	-.396	.497	4.264	99.264	WET	99.265
45.00	-.266	-.333	.426	4.208	99.208	WET	99.208
46.00	-.221	-.254	.336	4.208	99.208	WET	99.208
47.00	-.171	-.154	.230	4.268	99.268	WET	99.268

Figure [illegible]

PROGRAM POSTHYD.... MESH4 VS MESH1 78K CFS GL=100.00
RMA2 NODE 216

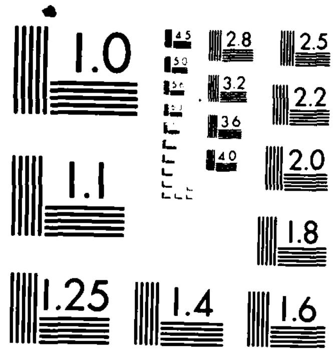
TIME HISTORY TABLE
RMA2 NODE 216

TIME (HOURS)	X-VEL (FT/SEC)	Y-VEL (FT/SEC)	MAGNITUDE (FT/SEC)	DEPTH (FT)	WS ELEV (FT)	WET/DRY STATUS	X-VEL (FT/SEC)	Y-VEL (FT/SEC)	MAGNITUDE (FT/SEC)
.00	-.115	-.043	-.123	5.507	100.507	WET	-.112	-.069	-.132
1.00	-.341	.040	-.344	5.391	100.391	WET	-.105	-.048	-.116
2.00	-.491	-.005	-.491	5.185	100.185	WET	-.060	.060	.085
3.00	-.269	-.061	-.276	5.152	100.152	WET	.059	.241	.249
4.00	.113	.166	.201	5.411	100.411	WET	.188	.361	.407
5.00	.280	.368	.463	5.714	100.714	WET	.252	.356	.436
6.00	.274	.329	.428	5.884	100.884	WET	.237	.259	.352
7.00	.198	.166	.258	5.942	100.942	WET	.156	.120	.197
8.00	.080	-.018	.082	5.929	100.929	WET	.024	-.041	-.047
9.00	-.062	-.158	-.170	5.854	100.854	WET	-.117	-.168	-.204
10.00	-.186	-.233	-.298	5.733	100.733	WET	-.208	-.237	-.315
11.00	-.267	-.290	-.394	5.582	100.582	WET	-.251	-.282	-.377
12.00	-.309	-.355	-.470	5.408	100.408	WET	-.271	-.322	-.421
13.00	-.326	-.411	-.525	5.225	100.225	WET	-.288	-.356	-.458
14.00	-.337	-.449	-.562	5.040	100.040	WET	-.306	-.380	-.487
15.00	-.345	-.470	-.583	4.855	99.855	WET	-.321	-.391	-.506
16.00	-.349	-.477	-.591	4.675	99.675	WET	-.329	-.391	-.511
17.00	-.345	-.469	-.583	4.510	99.510	WET	-.328	-.378	-.501
18.00	-.333	-.444	-.555	4.372	99.372	WET	-.316	-.351	-.472
19.00	-.312	-.400	-.507	4.269	99.269	WET	-.293	-.307	-.424
20.00	-.280	-.339	-.439	4.212	99.212	WET	-.258	-.245	-.355
21.00	-.237	-.260	-.352	4.210	99.210	WET	-.210	-.162	-.265
22.00	-.188	-.160	-.247	4.269	99.269	WET	-.150	-.053	-.159
23.00	-.128	-.029	-.131	4.386	99.386	WET	-.063	.083	.104
24.00	-.023	.118	.120	4.546	99.546	WET	.048	.192	.198
25.00	.100	.234	.254	4.735	99.735	WET	.138	.253	.288
26.00	.190	.303	.357	4.941	99.941	WET	.185	.289	.343
27.00	.237	.339	.414	5.156	100.156	WET	.206	.309	.372
28.00	.255	.354	.436	5.366	100.366	WET	.213	.314	.380
29.00	.255	.347	.431	5.555	100.555	WET	.209	.301	.367
30.00	.240	.316	.397	5.714	100.714	WET	.188	.268	.328
31.00	.207	.262	.334	5.830	100.830	WET	.149	.214	.261
32.00	.153	.183	.239	5.896	100.896	WET	.088	.138	.164
33.00	.077	.081	.112	5.901	100.901	WET	.003	.036	.036
34.00	-.031	-.046	-.055	5.845	100.845	WET	-.101	-.081	-.130
35.00	-.151	-.166	-.224	5.738	100.738	WET	-.189	-.179	-.260
36.00	-.243	-.261	-.357	5.593	100.593	WET	-.244	-.251	-.350
37.00	-.297	-.337	-.449	5.422	100.422	WET	-.275	-.307	-.412
38.00	-.320	-.399	-.512	5.235	100.235	WET	-.293	-.350	-.456
39.00	-.330	-.443	-.553	5.045	100.045	WET	-.309	-.379	-.489
40.00	-.335	-.468	-.575	4.857	99.857	WET	-.322	-.395	-.509
41.00	-.337	-.475	-.583	4.674	99.674	WET	-.330	-.396	-.516
42.00	-.334	-.467	-.574	4.508	99.508	WET	-.329	-.383	-.505
43.00	-.323	-.440	-.546	4.367	99.367	WET	-.318	-.354	-.475
44.00	-.300	-.396	-.497	4.264	99.264	WET	-.294	-.308	-.426
45.00	-.266	-.333	-.426	4.208	99.208	WET	-.258	-.244	-.355
46.00	-.221	-.254	-.336	4.208	99.208	WET	-.209	-.162	-.265
47.00	-.171	-.154	-.230	4.268	99.268	WET	-.149	-.054	-.158

Figure J-1-2. POSTHYD sample output (continued)

AD-A162 390 USER'S MANUAL FOR THE GENERALIZED COMPUTER PROGRAM SYSTEM OPEN-CHANNEL FL (U) ARMY ENGINEER WATERWAYS EXPERIMENT STATION VICKSBURG MS HYDRA 6/8

UNCLASSIFIED W A THOMAS ET AL AUG 85 WES/IR/HL-85-1 F/G 13/2 NL


1.0
1.1
1.25
1.4
1.6
1.8
2.0
2.2
2.5
2.8
3.2
3.6
4.0

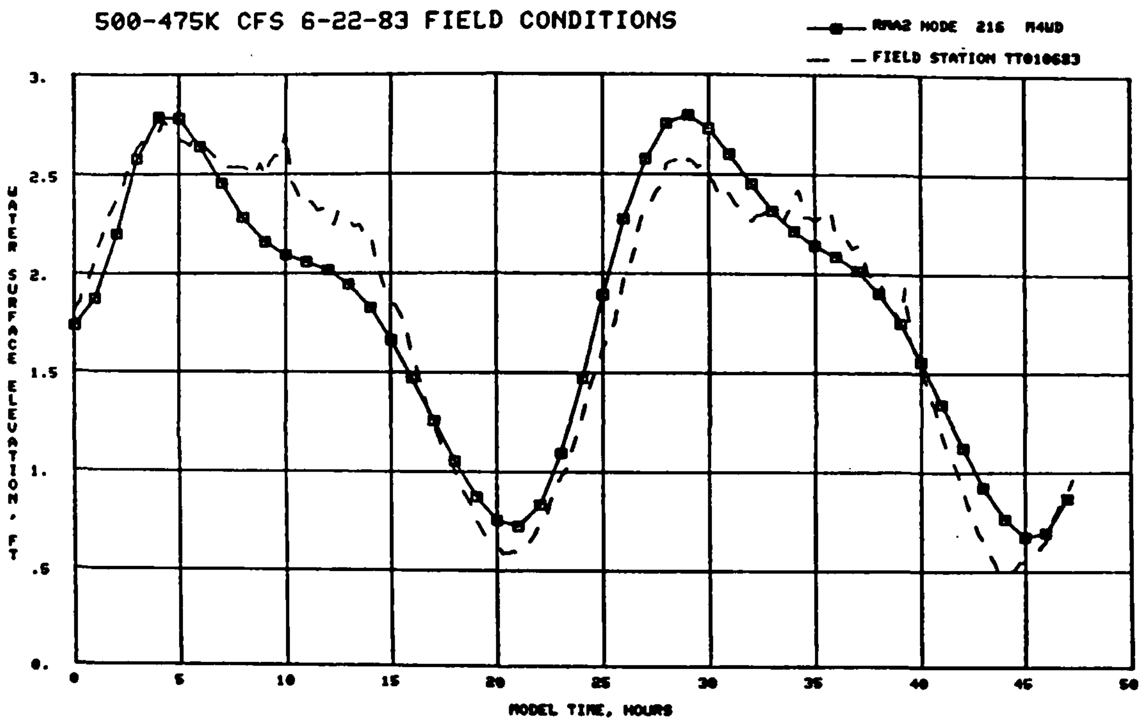


Figure J-1-3. POSTHYD sample water level time-history plot

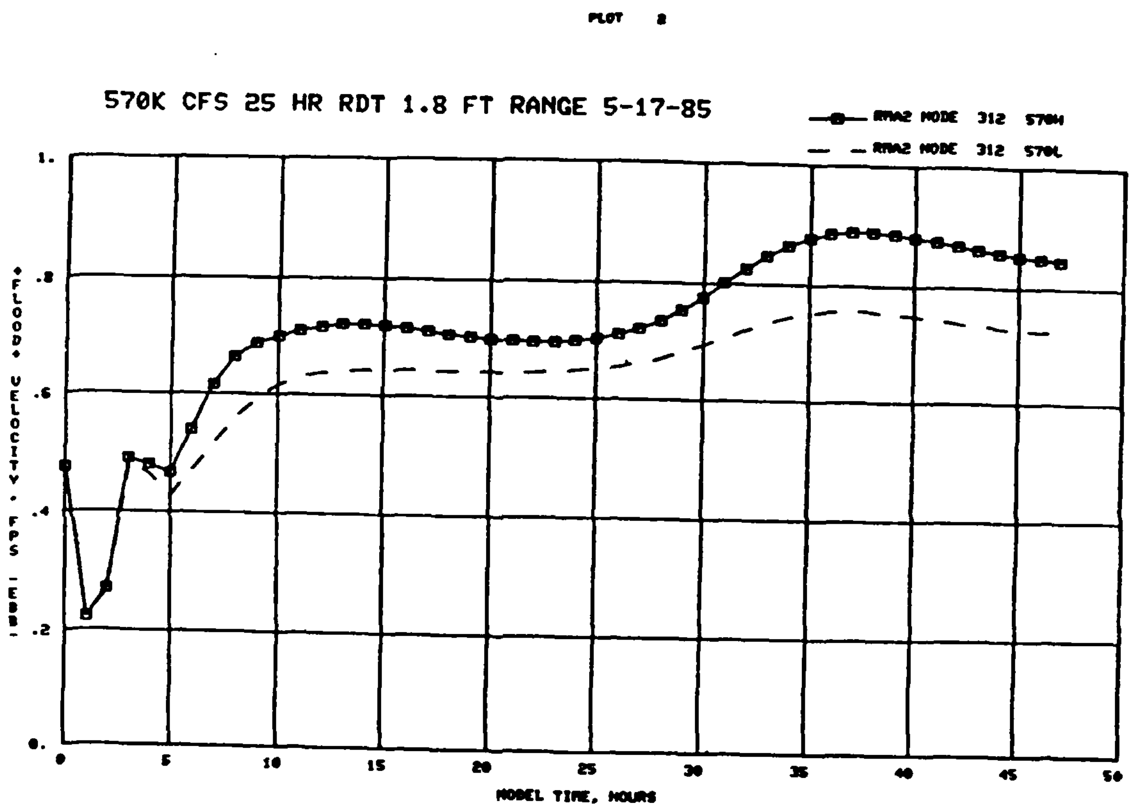


Figure J-1-4. POSTHYD sample velocity time-history plot

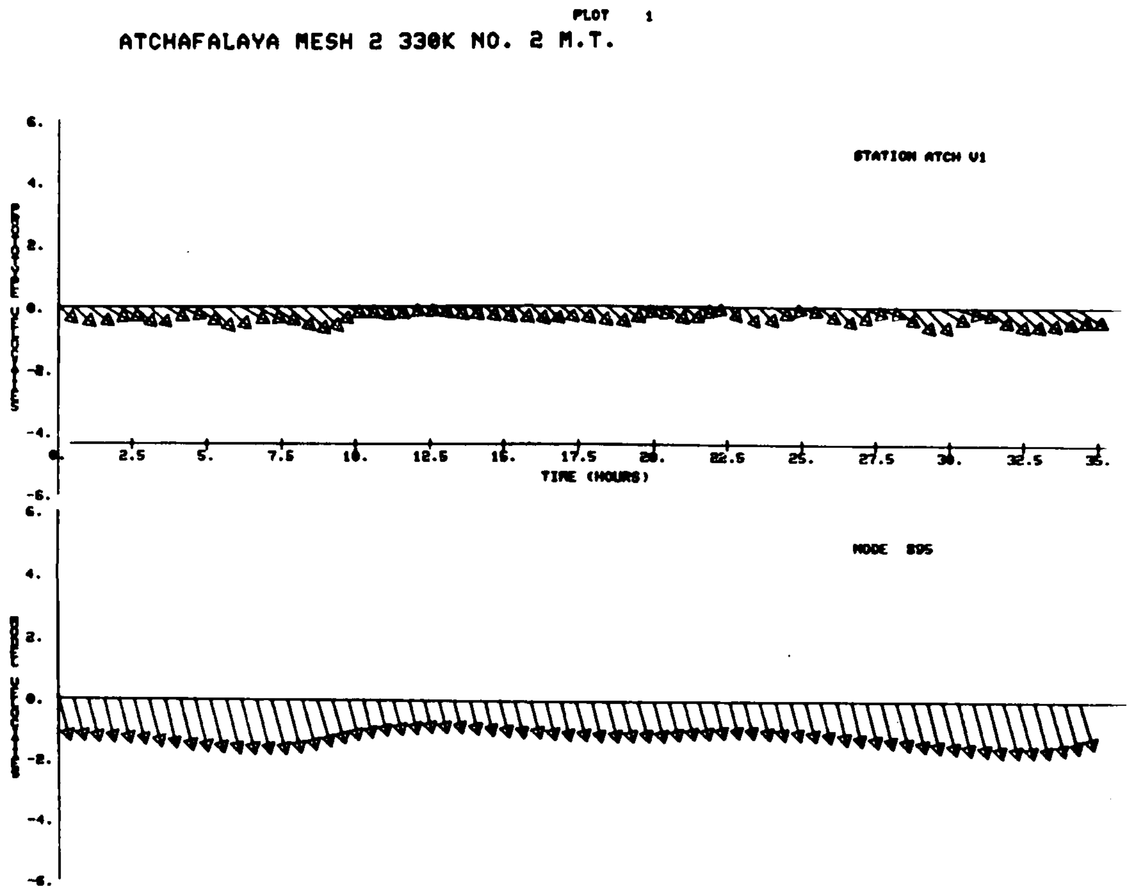


Figure J-1-5. POSTHYD sample stick plots

Table J-1-2

POSTHYD Run Control Commands

Card	Content	Page
T1	Main run title	J-1-13
T2	Legend notations for plotting	J-1-14
PL	Plot axis limits	J-1-15
SC	Plot curve symbol control	J-1-16
LC	Plot curve line control	J-1-17
CS	Control of source of comparison	J-1-18
PN	Plot time-history at individual node	J-1-19
PP	Produce profile plot along selected nodes	J-1-21
CC	Produce continuity check along selected nodes	J-1-22
*	Continuation card used by the PP and CC commands	J-1-23

Table J-1-3

Field Data Input Format*

Record Number	Columns	Format	Description
1	1-80	A	A title describing the station and type of data.
2	1-8	A	8 characters identifying the station.
	24-25	I	Starting month number (1-12).
	26-27	I	Starting day (1-31).
	28-29	I	Starting year (1-99).
	32-33	I	Starting hour (1-24).
	34-35	I	Starting minute (0-59).
	53-57	I	Time increment, in minutes.
	64-69	I	Number of data points.
	70-77	A	8 Character identifier for type of data. =" TIDEFIL" for tides. =" X-VEL " for the x-velocity components. ="Y-VEL " for the y-velocity components.
3+	11-80	10F7.0	Data points, 10 per line until all data are input.

*Note: Files may contain multiple stations and data types. The field type comparison file follows a format that was developed by B. P. Donnell for the Atchafalaya Bay Delta growth study.

Table J-1-4

Physical Model Tidal Input Data Format*

Record Number	Columns	Format	Description
1	1-7	I	Line number.
	8-80	A	Characters identifying the data file.
2	1-7	I	Line number.
	8-11	I	Number of stations on this file.
3+*	1-7	I	Line number.
	8-11	I	Station identifier for the following tidal data set.
4+*	1-7	I	Line number.
	8-14	F	Value of water-surface elevation.

*Notes: 1. Insert a record type 4 for each data point for a particular station. Use a record type 3 to start off the data for each of the stations counted in record type 2.

2. This option has not been implemented yet.

Table J-1-5

Physical Model Velocity Input Data Format

Record Type	Columns	Format	Description
1	1-7	I	Line number.
	8-80	A	Identifying title for this file.
2	1-7	I	Line number.
	8-10	I	Number of stations on this file.
3+*	1-7	I	Line number.
	8-11	I	Station identifier.
	12-14	I	Number of depths for which data were taken at this station.
	15-18	A	Meter number taking data.
	19-25	F	Total depth at this station.
	26-32	F	Depth for the bottom reading.
	33-39	F	Depth for the middepth reading.
	40-47	F	Depth for the surface reading.
	48-56	F	X-coordinate for station.
	57-64	F	Y-coordinate for station.
4+*	1-7	I	Line number.
	8-14	F	Velocity magnitude, in ft/sec.
	15-18	I	Velocitydirection, indegrees clockwise from north divided by 10.
	73-79	A	Depth for data, equals "BOTTOM ," "MIDDEPT," or "SURFACE".

*Notes: 1. Input a record type 4 for each time-step. Insert a card type 3 before the data for each station counted on record type 2.

2. This option has not been implemented yet.

T1 CARD: Main Run Title

Field	Variable	Description
Col. 1-Col. 2	ICI	Card keyword = T1.
1	ITIT	Up to 77 characters of title that will be printed at the top of the tables and plots.

T2 CARD: Legend Notations for Plotting

Field	Variable	Description
Col. 1- Col. 2	IC1	Card keyword = T2.
1	LEG(1)	Upto8 characters of informationto be usedto identify the base curve in the legend field. If this field is null, a blank is assumed.
2	LEG(2)	Identifier for the second curve. If null or not supplied, a blank is assumed.

Note: If the T2 card is omitted, blanks are assumed for LEG(1) and LEG(2)

PL CARD: Plot Axis Limits

Field	Variable	Description
Col. 1- Col. 2	IC1	Card keyword = PL.
1	XMIN	Minimum value for the X-axis (time), in model hours.
2	XMAX	Maximum value for the X-axis. Note: If both XMIN and XMAX are null, the X-axis will be self scaled.
3	YMIN	Minimum value for the Y-axis (data), in whateverunits the databeing plotted are in.
4	YMAX	Maximum value for the Y-axis. Note: If both YMIN and YMAX are null or notsupplied,the Y-axis will be self scaled.

Note: If the PL card is not supplied, both the X- and Y-axes will be self-scaled.

SC CARD: Plot Curve Symbol Control

Field	Variable	Description
Col. 1- Col. 2	IC1	Card keyword = SC.
1	ISYM(1)	Symbol type to be used to locate each data point on the base curve. The valid symbol types are as follows: -1 = plot no symbols 0 = plot square symbols 1 = plot octagons 2 = plot triangles 3 = plot crosses 4 = plot x's 5 = plot diamonds 11 = plot asterisks 14 = plot 5-pointed stars If ISYM(1) is null, a value of 0 is assumed.
2	ISYM(2)	Symbol type to be used to locate each data point on the comparison curve. If ISYM(2) is null or not supplied, a value of -1 is assumed.

Note: If the SC card is not supplied, values of 0 for ISYM(1) and -1 for ISYM(2) are assumed.

LC CARD: Plot Curve Line Control

Field	Variable	Description
Col. 1- Col. 2	LC1	Card keyword = LC.
1	IDSH(1)*	Line type control for the basecurve. If IDSH(1) is null,a value of 0 (meaning plot a solid line) is assumed.
2	IDSH(2)*	Line type control for the comparison curve. IfIDSH(2) is null or not supplied a value of 56 (the GCS default for a dashed line) is assumed.

Note: If the LC card is not supplied, values of 0 for IDSH(1) and 56 for IDSH(2) are assumed.

*Line control uses the GCS dash index codes. See The Graphics Compatibility System (GCS), Programmer's Reference Manual, Automated Technology Center, U. S. Army Engineer Waterways Experiment Station, Vicksburg, Miss., for an explanation.

CS CARD: Control of Source of Comparison

Field	Variable	Description
Col. 1- Col. 2	IC1	Card keyword = CS.
1	CDATA	= FIELD if data for the comparison are to be read from a field data file. = PHYSICAL if data for the comparison are to be read from a physical model data file. = RMA2V if two RMA-2V runs are to be compared. = NO if no comparisons are to be made.
2	DATUM	Value to be subtracted from RMA-2V water surface elevations before plotting, in feet.
3	MEAN	If MEAN is not equal to NO, the comparison curve will be forced to have the same mean as the base curve. If MEAN is not supplied or null, a value of NO is assumed.

Note: If the CS card is not supplied, no comparison curves will be drawn.

PN CARD: Plot Time-History at Individual Node

Field	Variable	Description
Col. 1-Col. 2	IC1	Card keyword = PN.
1	NODE(1)	Node from RMA-2V base file to be plotted.
2	RT(1,1)	Starting time for reading RMA-2V base file. If RT(1,1) is null, the plot will begin at the first timestep on the file.
3	IPLT	= WS to plot water surface elevations. =VMD to plot velocity magnitude and direction vectors. =EFM to plot ebb-flood magnitude curves. If IPLT is null, no plots are produced.

** The following field is supplied only if CDATA (see CS card) is RMA2 **

4	NODE(2)	Node from RMA-2V comparison file to be plotted. If NODE(2) is null or not supplied, NODE(2)=NODE(1).

** The following field is supplied only if CDATA is FIELD or PHYSICAL **

4	ISTA	The station identifier for the comparison curve, 10 characters in length

** The following field is supplied only if IPLT is VMD **

5	DIR	Angle of rotation of vectors on plot, counterclockwise from the time axis, in degrees. If DIR is null or not supplied, a value of zero is assumed. This allows vectors that have an angle of 0 or 180 degrees to be shown more clearly.

** The following field is supplied only if IPLT is EFM **

5	DIR	Direction of flood, in degrees clockwise from the north. If DIR is negative, the absolute value of DIR will be adjusted based on a least squares fit to the data being plotted. If DIR is null or not supplied, a value of zero is assumed.

** Field 5 is not supplied nor nulled if IPLT is WS **

PN Card: Plot Time History at Individual Node (continued)

** The following two fields are supplied only if CDATA is FIELD **

6	STIME(1)	Starting date at which to read field data, in MMDDYY format.
7	STIME(2)	Starting time at which to read field data, in HHMM format.

** The following field is supplied only if CDATA is PHYSICAL or RMA2 **

6	RT(2,1)	Starting time at which to read physical or RMA-2V data.If RT(2,1) is null or not supplied, RT(2,1)=RT(1,1).

** The following field is supplied only if CDATA is PHYSICAL and IPLT is EFM or VSD **

7	VTYPE	= SURFACE to plot surface velocities. = MIDDEPTH to plot middepth velosities. = BOTTOM to plot bottom velotities. = AVERAGE to plot average velocities. If VTYPE is null or not supplied, a value of AVERAGE is assumed.

PP CARD: Produce Profile Plot Along Selected Nodes

Field	Variable	Description
Col. 1- Col. 2	IC1	Card keyword = PP.
1	RT(1,1)	Time at which to read the RMA-2V base file for the profile plot.
2+	LINEC	Nodes where water-surface elecations are to be computed,as many as an 80-column card can hold. Continue on the & card.

CC CARD: Produce Continuity Check Along Selected Nodes

Field	Variable	Description
Col. 1- Col. 2	IC1	Card keyword = CC.
1	RT(1,1)	Time at which to read the RMA-2V base file for the continuity check.
2+	LINFC	Nodes defining the continuity cross section. The nodes must connect with each other, and both mid-side and corner nodes must be specified. As many nodes as an 80-column card can hold can be specified on this card. Continue with more nodes on the & card.

& CARD: Continuation Used by the PP and CC Commands

Field	Variable	Description
Col. 1- Col. 2	IC1	Card keyword = & .
1+	LINEC	More nodes defining the data needed by the previous PP or CC card. As many nodes that can fit on an 80 column card can be supplied. Multiple & cards can be used, up to a limit of 100 nodes. The & card must immediately follow its PP or CC card.

ADDENDUM J-2: PROGRAM POSTSED

Purpose

1. POSTSED produces an analysis of a STUDH output file and prints pertinent deposition, erosion, and concentration statistics for each time-step on the file. The user may optionally select certain nodes (by element or node) for which the concentration/bed change values are to be printed at each time-step. Nodal deposition and/or concentration data can be plotted on a line printer or any GCS/META-supported graphics device.

Use

2. POSTSED is accessed through PROCLV by the command:

BEGIN,POSTSED,PROCLV,file1,file2,file3,name,pri

where

file1 = name of the card image run control input file

file2 = name of the STUDH output file

file3 = name of the GCS/META plot file (if needed)

name = your last name

pri = optional job priority (default is P3)

Input data

3. Input data consist of the STUDH output file and a card image run control file. The card image file uses a modified HEC input format, with the first three columns of each card reserved for card-identifiers. The remainder of the card is free field, with commas separating each numeric field. Do not exceed 15 numeric fields on any input card. Input cards may appear in any order or may be omitted from the card image input file.

4. Table J-2-1 lists the run control input card images needed to run the program. A detailed description of each card image follows the table.

Output

5. Output consists of printed results and plot files. Example outputs are shown in Figures J-2-1 - J-2-7. At the each time-step, the number of nodes experiencing deposition/erosion are listed and a statistical breakdown of the bed changes is

printed. Optionally, the same breakdown may be applied to concentration data. Selective printing of nodal concentration/bed change values is also available at each time-step.

6. Files containing printer plots or CCS/META plots are written for bed change and/or concentration as directed by the card image input file. Examples are shown in Figures J-2-4 - J-2-7. Plotting of the files is accomplished by the META system (see Appendix I).

*** TIME = 90000.00(25.00) ***

POSITIVE CONCENTRATIONS

NUMBER OF + CONCENTRATION NODES 1087
MAXIMUM CONCENTRATION AT NODE 1484
MINIMUM CONCENTRATION AT NODE 747

MIN	MAX	PERCENTAGE
.69026809E-09	.30370941E+02	98.62
.30370941E+02	.60741882E+02	.55
.60741882E+02	.91112824E+02	.09
.91112824E+02	.12148376E+03	.28
.12148376E+03	.15185471E+03	.18
.15185471E+03	.18222565E+03	.18
.18222565E+03	.21259659E+03	.00
.21259659E+03	.24296753E+03	.00
.24296753E+03	.27333847E+03	.00
.27333847E+03	.30370941E+03	.00
.30370941E+03	.33408035E+03	.00
.33408035E+03	.36445129E+03	.00
.36445129E+03	.39482224E+03	.00
.39482224E+03	.42519318E+03	.00
.42519318E+03	.45556412E+03	.09
		100.00

NEGATIVE CONCENTRATIONS

NUMBER OF - CONCENTRATION NODES 825
MAXIMUM CONCENTRATION AT NODE 1478
MINIMUM CONCENTRATION AT NODE 1755

MIN	MAX	PERCENTAGE
-.87887227E-10	-.11538900E+02	98.30
-.11538900E+02	-.23077800E+02	.73
-.23077800E+02	-.34616699E+02	.12
-.34616699E+02	-.46155599E+02	.12
-.46155599E+02	-.57694499E+02	.00
-.57694499E+02	-.69233399E+02	.12
-.69233399E+02	-.80772299E+02	.12
-.80772299E+02	-.92311199E+02	.12
-.92311199E+02	-.10385010E+03	.00
-.10385010E+03	-.11538900E+03	.00
-.11538900E+03	-.12692790E+03	.24
-.12692790E+03	-.13846680E+03	.00
-.13846680E+03	-.15000570E+03	.00
-.15000570E+03	-.16154460E+03	.00
-.16154460E+03	-.17308350E+03	.12
		100.00

NUMBER OF NODES W/ ZERO CONCENTRATION= 448

Figure J-2-1. Example statistical output from POSTSED

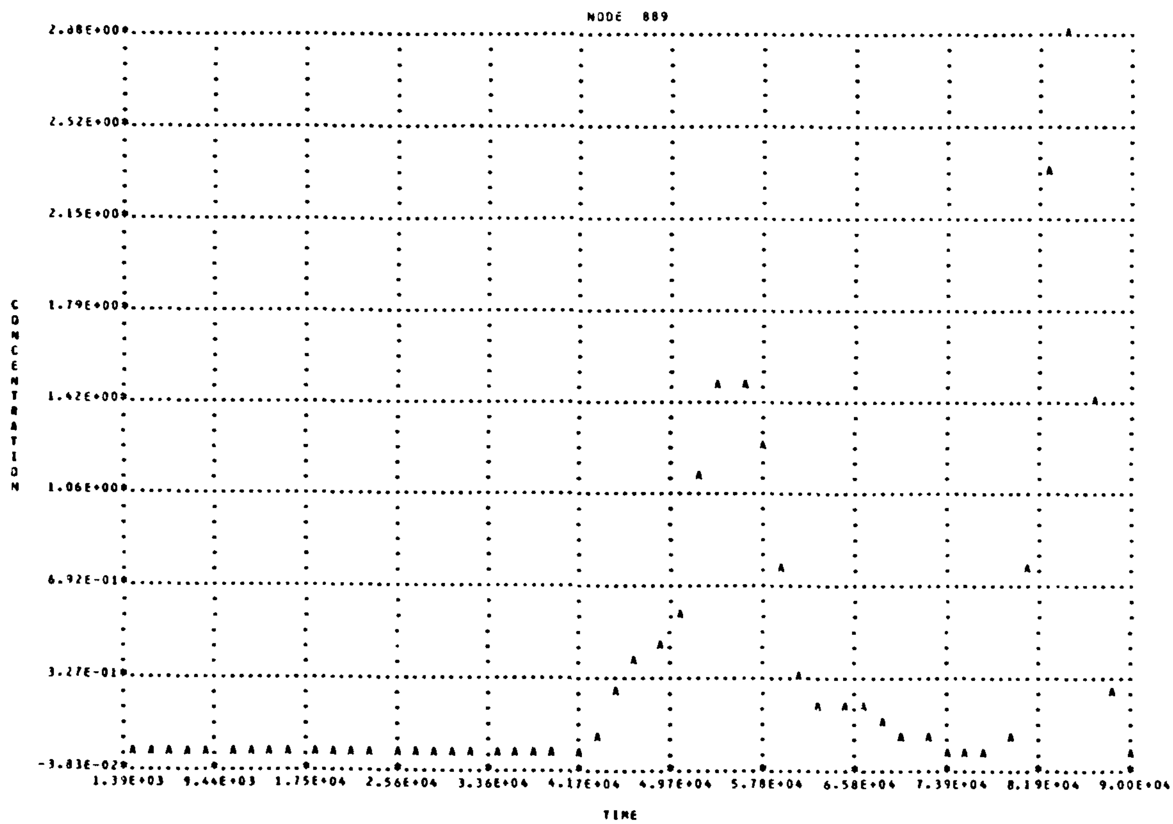


Figure J-2-2. Example printer plot output of concentration history

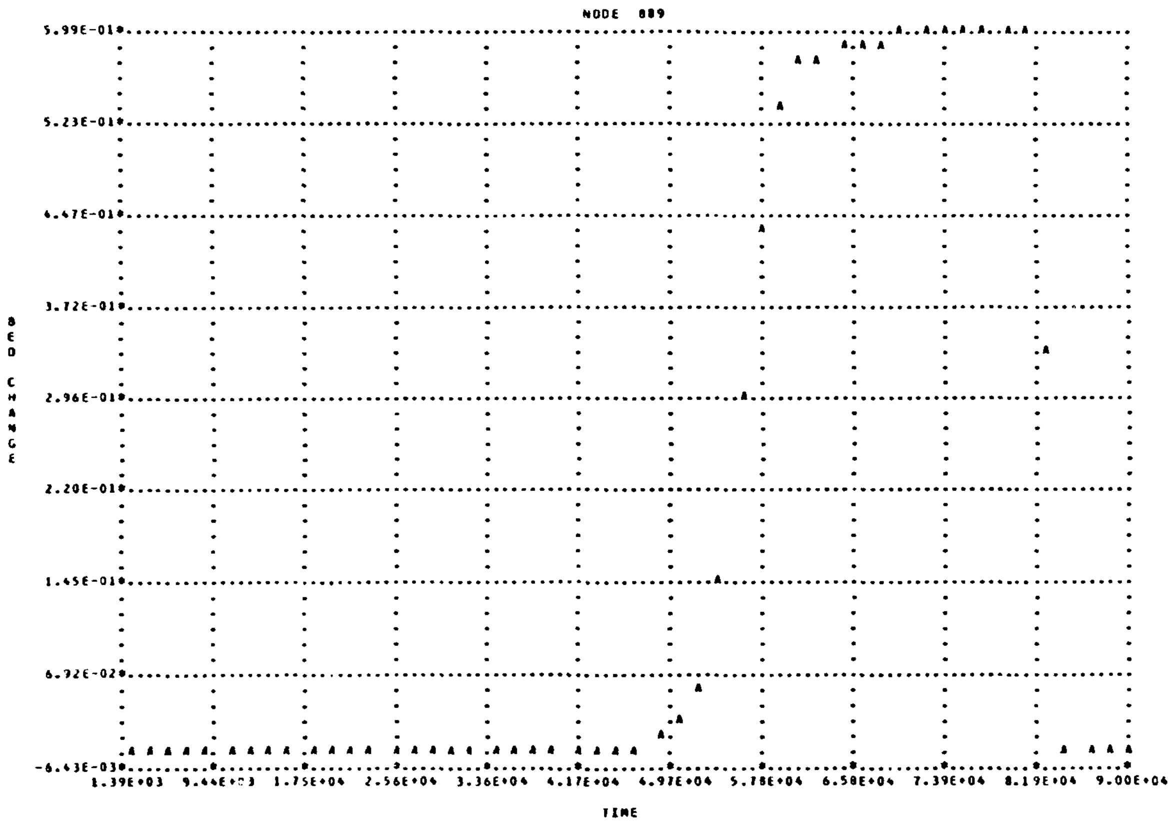


Figure J-2-3. Example printer plot output of bed change history

*** TIME = 90000.00(25.00) ***

DEPOSITION

NUMBER OF DEPOSITION NODES 1411
MAXIMUM DEPOSITION AT NODE 2023
MINIMUM DEPOSITION AT NODE 1920

MIN	MAX	PERCENTAGE
.10148092E-05	.90684925E-01	97.38
.90684925E-01	.18136883E+00	.92
.18136883E+00	.27205274E+00	.28
.27205274E+00	.36273665E+00	.50
.36273665E+00	.45342056E+00	.43
.45342056E+00	.54410447E+00	.00
.54410447E+00	.63478838E+00	.14
.63478838E+00	.72547229E+00	.07
.72547229E+00	.81615620E+00	.00
.81615620E+00	.90684011E+00	.14
.90684011E+00	.99752402E+00	.00
.99752402E+00	.10882079E+01	.00
.10882079E+01	.11788918E+01	.07
.11788918E+01	.12695758E+01	.00
.12695758E+01	.13602597E+01	.07
		100.00

*** N O E R O S I O N ***

NUMBER OF NODES W/ NO ACTIVITY= 949

Figure J-2-4. Example printout showing erosion and deposition numerical distribution

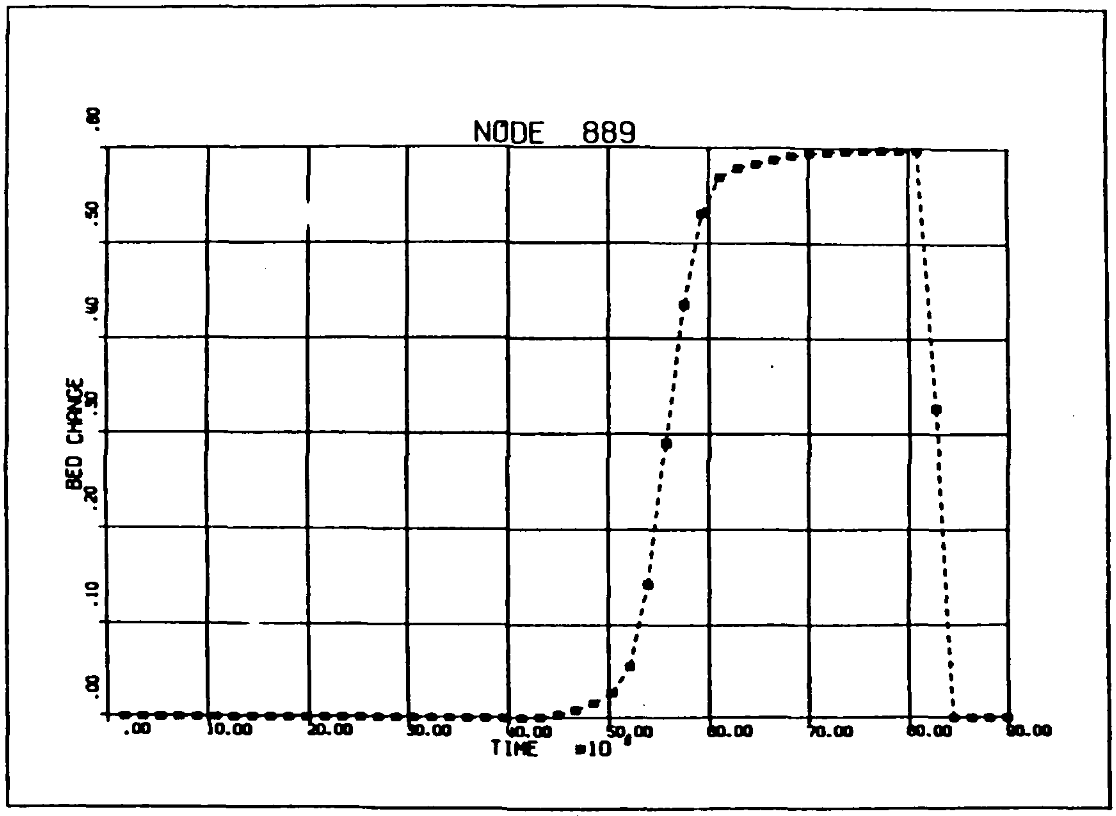


Figure J-2-5. Example plot of bed change time history

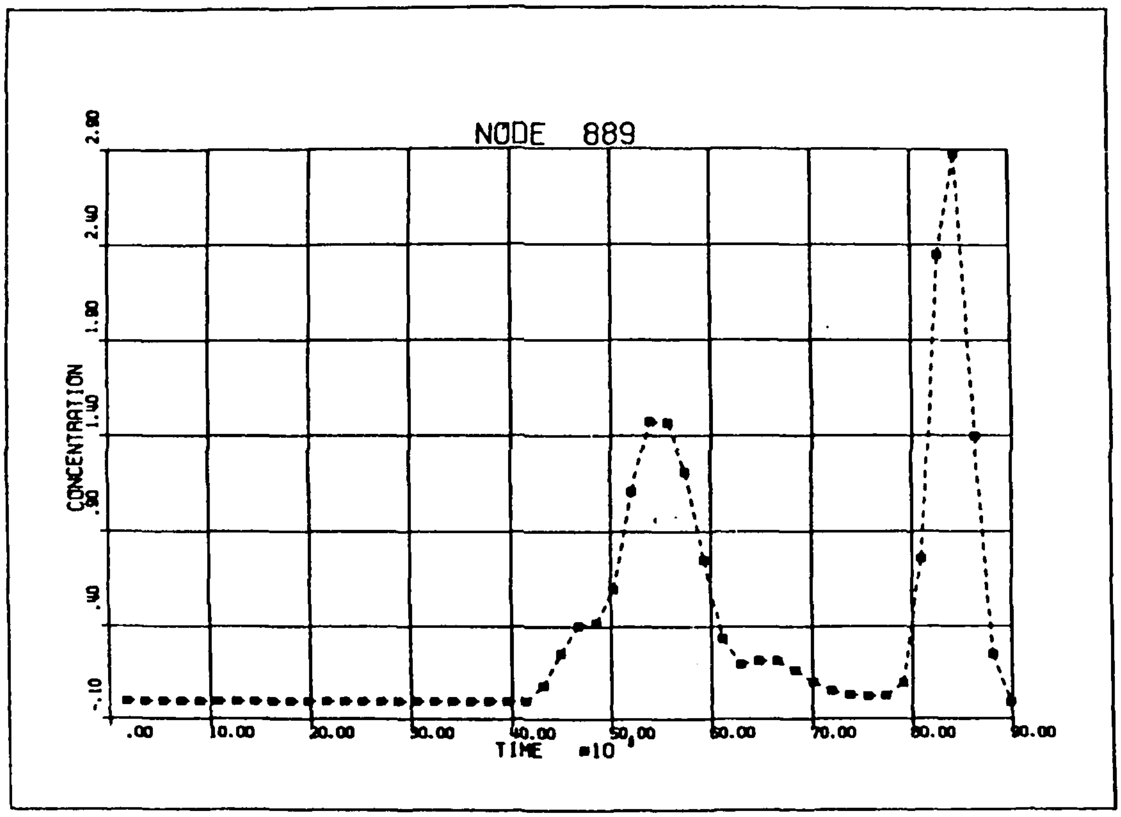


Figure J-2-6. Example plot of concentration time history

Table J-2-1

POSTSED Run Control Card Images

T1 CARD Main Run Title — Optional

Field	Variable	Description
Col. 1-Col.2	ICG	Card keyword = T1
1	ITITLE	80-character user title. POSTSED does not use the title. It is user identification of the file.

PS CARD Selective Print by Node or Element Optional

Field	Variable	Description
Col. 1- Col. 2	ICG	Card keyword = PS
Col. 3	ISI	Can be blank or "N." If blank, the following numeric fields are assumed to be element numbers whose nodes are used in selective print. If "N," the following numeric fields are assumed to be node numbers.
1-15	IWANTL	Node or element numbers.

NOTE: If the PS cards are omitted, there will be no selective print and all nodes will be printed. PS and PSN cards may be mixed and may appear in any order.

PO CARD Selective Plotting by Node or Element Optional

Field	Variable	Description
Col. 1- Col. 2	ICG	Card keyword = PO
Col. 3	ISI	See description of this field on PS card above
1	IPTYPE	Type of plot desired for the following nodes or elements If = 1 Concentration vs time If = 2 Bed change vs time If = 3 Both concentration and bed change vs. time plots will be produced.
2-15	IWANTP	Node or element numbers for plotting

NOTE: PO and PON cards may be mixed and may occur in any order. If omitted, no plotting will occur.

AX CARD Plot Axis Limits Optional

Field	Variable	Description
Col. 1- Col. 2	ICG	Card keyword = AX
Col. 3	ISI	Must be "D" (for bed change) or "C" for concentration). If "D," axes limits apply to bed change plots. If "C," axes limits apply to concentration plots.
1	XMIN	Minimum value for X-(time) axis in model seconds
2	XMAX	Maximum value for X-(time) axis in model seconds
3	YMIN	Minimum value for Y-(data) axis in metres or Kg/cubic metre
4	YMAX	Maximum value for Y-(data) axis in metres or Kg/cubic metre

NOTES:

1. For X-axis self-scaling, set XMIN=XMAX=0.0
   For Y-axis self-scaling, set YMIN=YMAX=0.0
   If no AX cards are present, all plot axes will be self-scaled.

2. If both bed change and concentration plots are to be produced, two AX cards may be inserted.

GT CARD | Graphics Type Selection | Optional

Field	Variable	Description
Col. 1 - Col. 2	ICG	Card keyword = GT
1	IPTYPE	Selects the graphics system used to display plots If IPTYPE = 0, produce printer plots If IPTYPE = 1, use GCS/META and create a plot file

NOTE: If no GT card is supplied, printer plots will be used. If the GCS/META option is selected, the user must supply an appropriate plot file name in the call to PROCLV. The GCS META option can be exercised here and the result changed to a printer plot during execution of META (see Appendix I).

DT CARD Define Type of Statistical Listing Optional

Field	Variable	Description
Col. 1 - Col. 2	ICG	Card keyword = DT
1	ISTYPE	Must be 0,1,2 or 3 0 = no statistical listings 1 = concentration statistics only 2 = bed change statistics only 3 = bed change and concentration statistics will be listed

NOTE: If no DT card is present, ISTYPE = 0 is assumed.

ADDENDUM J-3: ACE

Purpose

1. Program ACE produces calculated results from runs of the sedimentation model STUDH. It uses the STUDH output results file, RMA-2V output results file, and mesh geometry file to calculate sediment transport rates, shoaling volumes, and dredging volumes, and to create vector plots of unit sediment discharge.

Origin of the Program

2. This program was developed by modifying VPLOT (APPENDIX I, Addendum I-2). The developers were William A. Thomas, James D. Ethridge, Jr., and J. Phillip Stewart, Hydraulics Laboratory, Waterways Experiment Station.

Desription

3. ACE is a batch-oriented program that reads ENGMET (Appendix M) output files of the GFGEN (Appendix D) finite element network and the RMA-2V hydraulics; it reads the STUDH output file of sediment concentrations and changes in bed surface elevation; it reads card image input data that control the execution and then produce the requested vector plot files and printed shoaling and dredging volumes.

4. Products of the program are:

a. Vector plots of sediment discharge at selected timesteps.

b. Vector plot of net sediment discharge over a complete STUDH run.

c. Plots of shoaling distribution (ft, cu ft, and percent of total) over distance.

d. Tabular listings of shoaling volumes.

e. Tabular listings of maintenance dredging volumes.

f. Tabular listings of model to prototype ratios of shoaling volumes.

5. The sediment discharge rate is calculated at every node; however, plotting can be restricted to selected nodes or windows. This program does not yet allow the uniform grid option that is

available in VPLOT, only values at the finite element node locations are plotted.

6. Vector lengths are scaled to the unit sediment discharge at the node, and the tail of the vector lies on the node coordinates.

Instantaneous sediment discharge

7. The sediment concentrations from STUDH are converted from kg/m3/sec to discharge in tons/day/foot of width using the following equations

$$QS_x = COEF * C * u * D$$

$$QS_y = COEF * C * v * D$$

where

COEF = 86,400 (sec/day) * 3.282 (ft2/m2) * 62.4 (#/ft3) * 1/2000 (ton/#) * 1/1000

$$= 29.01535 \frac{\text{sec} \times \text{tons} \times \text{PPP}}{\text{day} \times \text{m2} \times \text{ft} \times \text{PPT}}$$

C = sediment concentration in PPT

D = depth in metres

u = x-velocity component in m/s

v = y-velocity component in m/s

PPP = parts of sediment per part of mixture

PPT = parts of sediment per 1000 parts of mixture

Scaling the (x,y) plane

8. Two scales are required: (a) the scale for plotting the (x,y) plane and (b) the vector length scale. The (x,y) plane is scaled for CALCOMP plots by prescribing the scale factor in prototype units per inch (i.e., ft/inch of plot). Graphics terminal plots fit the image to a reduced screen size that allows for tilting and legend space around the image.

9. The origin for all plots is determined by:

XZERO = MIN(CORD (I,1))   I = 1 to number of nodes

YZERO = MIN(CORD (I,2))

where

CORD (I,1) = x-coordinate of node I

CORD (I,2) = y-coordinate of node I

The (x,y) positions are then converted to plot inches by

CORD (I,1) = (CORD(I,1) - XZERO)/XS

CORD (I,2) = (CORD(I,2) - YZERO)/YS

where

XS = scale in the x-direction, prototype units/inch

YS = scale in the y-direction, prototype units/inch

Normally, XS is equal to YS, which produces undistorted plots.

Scaling vector lengths

10. The other scale, vector length, is somewhat more complicated to describe because two different sets of data appear as vector plots:

a. The *instantaneous* mass rate of sediment transport per foot width for each time-step, and

b. The accumulated mass per foot width over all time-steps in the simulation period.

11. Scaling instantaneous mass-rate vectors. The STUDH program will write the concentrations and accumulated bed changes to the output file for the initial condition and for each time-step in the simulation. ACE will read that file, calculate the rate of unit mass discharge (tons/day/ foot of width) for each node and will convert that mass rate to plot-inches using either HHS (tons/day/foot of width per 1/2 inch of plot) or EXVSIH (percent exceedance). The first option, HHS (J2 card) is as follows.

$$U = QS_x/HHS$$

$$V = QS_y/VVS$$

where

HHS = vector mass-discharge rate scale in the x-direction (tons/day/ft)/(1/2 inch)

U = the calculated x-component of the plot vector in inches

VVS = the vector mass discharge rate scale in the y-direction (tons/day/ft)/(1/2 inch)

V = the calculated y-component of the plot vector in inches

12. The other vector length scale option is based on exceedance frequency. That option allows the program to automatically scale vector lengths without using the maximum mass rate value to develop the scale. The benefit is that one extreme value does not suppress the lengths of an entire plot file.

13. The exceedance percent allows that percent of mass discharge rates to exceed the magnitude of the vector plot scale. Consequently, when the plot file is created, vector lengths may exceed the permissible value prescribed by VECMAX (J2 card) in inches. Such an occurrence causes the program to highlight the nodal value by a heavy arrowhead when either the x- or the y-component exceeds VECMAX. When both components exceed VECMAX, vector direction defaults to ± 45 deg from the + x-axis in addition to the heavy arrowhead.

14. Usually, an exceedance value of 10 percent is tolerable. The program uses 5 percent if left in default mode.

15. Scaling the accumulated mass vector. The other set of data presented as vector plots is the accumulated mass of sediment moving at the node over the simulation period. The same scaling concepts apply as described above for mass-rate vectors, but different variable names are supplied. The variable prescribing tons/foot of width is HORIZ. (The companion variable, VERT, defaults to HORIZ.) The variable for the exceedance option is EXVSAM (card J1, field 7). Because values will have units of tons/foot rather than of tons/day/foot, the vector length scale will probably be different than that of instantaneous values. Plotting accumulated vectors mass highlights nodes having maximum or minimum sediment discharge, which will reflect sources and sinks in the study area. Paths of net sediment motion will be shown also.

Computing shoaling and dredging volumes

16. ACE computes volumes of sedimentation and dredging requirements by accumulating STUDH results. It takes each STUDH run output as one event and multiplies the depth changes for that event by the specified number of times that event is expected to occur. For example, conside a STUDH run that represents one day of sedimentation at a given river flow if that flow occurs 25 days per year, ACE will multiply the STUDH-computed bed change at each node by 25 and add those results to any other events in the series. By linking events for several representative discharges, an entire year of sedimentation results can be calculated.

17. Shoaling. Shoaling rates are calculated for specified elements by accumulating bed changes for all events and their

durations. Shoaling is defined as net bed changes--the algebraic integral of depth changes over an element. Thus equal quantities of erosion and deposition in an element will lead to a zero shoaling rate for that element.

18. Dredging. Like shoaling rates, dredging rates are calculated for specified elements by accumulating bed changes for all events and their durations. However, in dredging, negative volumes do not offset positive volumes. Deposition quantities appear as dredging volumes only if they result in a water depth less than the specified channel dimensions.

19. Dredging is triggered at a node if the calculated bottom elongation is above the specified channel bottom. Once dredging is triggered, the dredged volume is calculated to be the quantity needed to restore channel depth plus overdredging. Overdredging (specified on the DO card) can be any combination of advance maintenance and allowable overdepth, but only one value is permitted.

Use

20. ACE is executed with PROCLV. A typical command line is shown in Appendix O: PROCLV. Current procedure may differ from that typical example, and it can be listed by requesting the 'help' option in PROCLV.

21. ACE uses five input files and three output files. They are summarized in Table J-3-1.

22. ACE creates a plot file which can then be directed to either a graphics terminal or pen-plotter using METAPLOT (Appendix J).

Plot size

23. The entire study area can be plotted or plots can be made by selecting nodes, elements, or a plot window. A plot can be produced for each time-step plus an accumulated mass plot can be produced for the entire simulation period.

Example

24. Figure J-3-1 shows an example card listing for creating vector plots and a dredging computation.

Card Image Data Input Instructions

25. The input data should be coded in 8-column fields with the card type in columns 1 and 2. Table J-3-2 summarizes input data. Coding details follow. An example is shown in APPENDIX C: EXAMPLE PROBLEM.

Table J-3-1

Summary of Files for ACE

Description of Data	Source/File*	File Type
Input		
Finite Element Network	ENGMET/01EM	Binary
Water-Surface Elevations	ENGMET/02EM	Binary
Flow Velocity Components	ENGMET/03EM	Binary
Sediment Concentrations/ Bed Changes	STUD0/01S3	Binary
Card Image Input Data	EDITOR/INPUT	Coded
Output		
Sediment Discharge Vector Plot	ACE/01AC	Binary
Sediment Concentrations/ Bed Changes	ACE/02AC	Binary
Line Printer	ACE/OUTPUT	Coded

* See Table N7, Appendix N, for a description of file codes.

```
T1        LITTLE ROCK, ARK, RUNWAY EXTENSION  ACE EXAMPLE BASE TEST
J1       2      14       1      [illegible]   0     0     10     0     1     0
J2   154.2   154.2     100      [illegible]  1[illegible]  0    -1     0    31     1.
J3       2       1   3600.
VT1
VE     443      17     338       1
DP       5       0     200
DE   160.1     210       2      17     18
DE   160.3     210       2      28     29
DE   160.5     210       2      39     40
DE   160.7     210       2      50     51
DE   160.9     210       2      61     62
SO       5
SM   160.1       2      17      18
SM   160.3       2      28      29
SM   160.5       2      39      40
SM   160.7       2      50      51
SM   160.9       2      61      62
SP
T2   BED CHANGE AT THE END OF 225 HOURS
DD       1      10
S[illegible]EDGE
$$END
```

Figure J-3-1. Example of ACE card image input data

Table J-3-2

Summary of Card Image Run Control Input for ACE

Card	Content	Page
T1	Title	J-3-8
J1,J2,J3	Job parameters	J-3-9
VT	Time-step selection for plots	J-3-13
FT	Time-step selection for tables	J-3-14
VN	Vector plot node selection	J-3-15
VW	Rectangular window option	J-3-16
VE	Vector plots element selection	J-3-17
GE	Mesh plot element selection	J-3-18
PN	Printed results, node selection	J-3-19
DO	Dredging options	J-3-20
DE	Dredging locations	J-3-21
SO	Shoaling volumes option, model	J-3-22
SM	Shoaling locations, model	J-3-23
SP	Shoaling volumes option, prototype	J-3-24
SN	Shoaling locations and volumes, prototype	J-3-25
T2	Event sequence title	J-3-26
ED	Events duration	J-3-27
[illegible]	[illegible], command	J-3-2[illegible]
RE	Event accumulation reset	J-3-29
[illegible]	End of job	J-3-30

T1 Card Title Card

Record title information on one card.

Field	Variable	Value	Description
0		T1	Card identification
1-10	TITLE		Title information

J1 Card Job Parameters

Field	Variable	Value	Description
0		J1	Card identification
1	IOPTION		Vector plot scales and shoaling and dredging computations are controlled by the IOPTION parameter. Must be 0 if NFILES>1 on J3 card.
		0	No vector plot. Shoaling and dredging computations are made.
		1	A vector plot is made and the scale is described with input data (J2 card, field 5 and J2 card, field 6).
		2	Vector scale is calculated at each time-step in each event.
		3	The same vector scale is used to plot all time-stepsinanevent. (not yet available)
		4	The vector plots all use the same scale at all time-steps in all events.
2	JCONC		The logical unit for saving calculated bed change results from the shoaling and dredging computations.
		0	Results will not be saved.
		14	The results are saved on logical unit 14.
3	IDSC		A logic control record for reading the STUDH concentration file (ICONC).
		0	STUDH output file having three records, title, geometry, DBed-concentration, with Delbed concentration repeated for each line.
		1	A "GET" file. The three records are present for the first events but thereafter only three exist for the last time step in remaining events.
4	ITSHOL	0	No trace printout will be produced during the shoaling computations.
		1	Trace printout will be provided in subroutine SHOAL.

J1 Card (Continued)

Field	Variable	Value	Description
5	ITDRG	0	No trace printout in subroutine DREDGE.
		1	Trace printout will be provided in subroutine DREDGE.
6	ITRON	0	Only the final results are printed from subroutine EXCEED showing scale computation.
		3	A table showing the percentage of concentration in each class interval for the total 20 class intervals.
7	EXVSAM	0 - 100	The vector scale length in subroutine EXCEED. It is the percentage of nodes that can have the accumulated mass vector equal to or greater than the maximum vector length. The consequence is that a heavy arrowhead is placed on the end of the vector. Usually up to half dozen or dozen of these in a plot of a thousand nodes is tolerable.
8	EXVSGM	0 - 100	The accumulated mass plotting scale when a "global" scaling requirement is requested (J1 card, field 1). (See EXVSAM above.)
9	EXVSIM	0 - 100	Vector scale for an instantaneous mass vector. It should be included even if the previous two variables have been used.
10	IPC		IPC controls whether velocities, concentrations, and bed change values will be printed or not. It is optional and works only if NFILES = 1 on J3 card.
		0	No printout will be made.
		1	The velocities, concentrations, and bed changes will be printed at the nodes selected for plotting vectors. Consequently, that option has to be exercised (PT-card).
		2	Velocities, concentrations, and bed changes will be printed for nodes read in card PN.

J2 Card — Job Parameters (Continued)

Field	Variable	Value	Description
0		J2	Card identification.
1	XS	+	The grid scale factor of the X-coordinate (units per inch).
2	YS	+	The grid scale factor of the Y-coordinate.
3	HORIZ		Horizontal scale for plotting accumulated mass vectors in units of tons per day to foot of width for each inch of plotter paper.
4	VERT		NOT PRESENTLY AVAILABLE FOR USE.
5	HHS	+	Scale for plotting instantaneous mass movement at each time-step in units of tons per day per foot of width for each inch of plot.
6	VVS	-	Vertical scale vector a comparison to HHS above for possible later expansion.
7	ISEL		A logic variable for partial grid vector plots.
		-1	Use the rectangular window option by prescribing the number of the minimum and maximum X and Y nodal point values in the grid. (Need VW Card)
		-2	Nodal points will be selected by reading in element numbers. (VE Cards, which follow).
		0	Mass vector will be plotted at every node.
		+1	A list of selected nodal point numbers will be read from cards VCN.
8	ITNN	0	Node numbers are not written on the plot.
		1	Node numbers are written by each vector plotted.
9	ISTEPS	+	This controls the number of records read from tape ICONC. STUDH output files have time concentration and bed change data for the entire run. Only the ISTEPS record is saved internally by code. ISTEPS must equal NTTS on the TZ card of the creating STUDH run control file.
10	VECMAX	+	The maximum length of a vector, usually 1.0 in. is satisfactory.

J3 Card   Required

Field	Variable	Value	Description
0		J2	Card identification
1	MEX1		Number of extrapolations used in STUDH run. (Note that this is one less than the value of MEX in the STUDH run.)
2	MSTEPS	+	Number of time-steps on ENGMLT velocity and water-surface output files.
3	DT	+	Length of time-step, sec
4	NFILES	+	Number of STUDH output files to be read (see paragraph 7)
5	ISHPLT		Shoaling distribution plot option
		+1	Cubic feet vs. river mile
		+2	Cubic feet vs. river mile and percent shoaling vs. river mile
		+3	Cubic feet vs. river mile, percent shoaling vs. river mile, and feet of shoaling vs. river mile

VT Card Selected Timesteps for Vector Plots Required if IOPTON>0 Omit if NFILES > 1

IFF (A6,IOUT)

An 80-column record having VT in columns 1 and 3 followed by the value 1 corresponding to the time-step where such instantaneous mass rate plot is requested.

To plot the accumulated mass, code 1 in the column folowing the last time-step number.

(Note: This card is not coded in 8-column fields.)

PT Card Selected Timesteps for Printed Results Required if IPC = 1

IFF(AD,KPTH)

An 80-column record having PT in columns 1 and 2 followed by the value 1 corresponding to the time-step to where the concentration and bed change printouts are requested.

VN Card | Vector Plots,Selected Nodes Options | Required if ISEL>0

Field	Variable	Value	Description
0	IX	VN	Card identification.
1	IN(1)	+	Enter the first node number where vector is to be plotted
2	IN(...ISEL)	+	Continue coding 10 nodes per card until all nodal points have been entered for the vector plots.
1	NSN	+	Enter the number of nodes coded on VN cards
2	IN(1)	+	First node number where vector is to be plotted. Sequence is not important.
3	IN(...)	+	Continue entering node numbers until NSN values are coded.

Continuation Cards

Field	Variable	Value	Description
0	IX	VN	Card identification
1	IN(10)	+	Continue coding 10 numbers per card
.			
.			
.			
10	etc.		

VW Card | Rectangular Window Option | Required if ISEL = -1

Field	Variable	Value	Description
0		VW	Card identification
1	NPXMIN	+	The nodal point number for the X-coordinate having the minimum value in the window.
2	NPXMAX	+	The nodal point number of the X-coordinate having the maximum value in the window.
3	NPYMIN	+	The nodal point number of the Y-coordinate having the minimum value in the window.
4	NPYMAX	+	The nodal point number of the Y-coordinate having the maximum value in the window.

VE Card Vector Plots, Selected Element Option Required if ISEL = -2

Field	Variable	Value	Description
0		VE	Card identification.
1	NELA	+	The number of elements to be read in.
2	IELMT(1)	+	The first element numbers at which the velocity vector is to be plotted.
3	IELMT(..	+	Continue entering element numbers until NELA values are coded

Continuation Cards

Field	Variable	Value	Description
0		VE	Card identification
1	IELMT(10)	+	Continue coding 10 numbers per card
.			
.			
.			
10	etc.		

GE Card Select Elements for the Mesh Plot

Field	Variable	Value	Description
0		GE	Card identification.
1	NGRD	+	The number of elements coded in this data set.
2	IHAVE(1)	+	The first element number for which the mesh will be plotted.
3	IHAVE(2)	+	Continue coding all 10 fields. Start continuation card with GE in columns 1 and 2 and code all 10 fields per card.

PX Card — Selected Nodes for Printout — Required if IPC = 2 present

Field	Variable	Value	Description
0		PX	Card identification.
1	NNPC	+	NNPC nodes have been selected for printout.
2	NODC	+	First nodal number where printout is requested. They may be in any order, but the printout is made in the same order as values are coded on the card. Follow coding procedure on previous cards.

DO Card | Dredging Option Parameters | Required

Field	Variable	Value	Description
0		DO	Card Identification.
1	NDP	0	No dredging locations are prescribed.
		+	"NDR" dredging stations are coded on cards which follow.
2	DOD	0,+	Depth of overdredging for this job.*
3	DATUM	-,0,+	Enter the datum of the dredged channel elevation when it is other than that datum described in the hydraulic and sediment computations for the estuary elevation, e.g., the datum plane for channel depth may be mean low water whereas the datum plane for the models may be some arbitrary datum.

* Overdredging is used here in the sense of dredging a channel to a depth greater than the design depth for any reason. The over-dredged amount may be allowable overdepth, advance maintenance, other or all of these.

DE Card | Dredging Locations | Optional if NDP>0 (BO card)

Field	Variable	Value	Description
0		DE	Card identification.
1	KMILE	-,0,+	Enter the navigation channel mile at which dredging results apply for those elements coded on this card. This value is for spatial reference only. It does not enter into the computations.
2	ELDC	-,0,+	Enter the elevation of the dredged channel.
3	NEX	+	This variable permits dredging in more than one element and the individual amounts accumulated to one value for printout at location or mile are shown in field 1 of this card. NEX is the number of elements.
4	KPR	+	Element number of the first element to be included in the dredging volume at this location. Enter "NEX" number of elements. Up to three are permitted without redimensioning the program.

SO Card | Shoaling Volume Option, Model Data | Required

Field	Variable	Value	Description
0		SO	Card identification.
1	MELDR	0	No shoaling locations (SM Cards) follow.
		+	"MELDR" shoaling locations are coded on SM cards which follow this.

SM Card — Shoaling Locations, Model Data — Required if MELDR>0

Field	Variable	Value	Description
0		SM	Card identification.
1	RMILE	-,0,+	Enter the channel mile at which shoaling results computed for the elements on this card should apply. (This is useful for correlating computer results with prototype data and maps.)
2	NEN	+	This variable permits accumulating shoaling volumes for more than one element to be printed at the location or mile shown in field 1. "NEN" is any number of elements up to 3. The element numbers will follow in subsequent fields on this card.
3	IDRG		Code the element number for those elements where the bed change is to be computed to get a shoaling volume and then added together for a result at this river mile.
4	IDRGE(I,..)	+	
5	IDRGE(I,NEN)	+	Up to NEN values should be prescribed across the card.

SP Card Shoaling Volumes Option, Prototype Data Required

If prototype data are available, code the values on the SN cards which follow this card and the program will calculate ratios between model results and the prototype.

Field	Variable	Value	Description
0		SP	Card identification.
1	NPD	0,+	No prototype shoaling data are included (no SN cards)
		+	The number of SN cards that follow

SN Card Shoaling Locations, Prototype Ratio Required

Field	Variable	Value	Description
0		SN	Prototype bed change in feet by element.
1	$IPROD_1$	+	Element number for the bed change shown in field 2.
2	$PROD_1$	-,0,+	Bed change in feet for the event being described on the HD cards which follow.
3	$IPROD_2$	+	Element number for the bed change shown in field 4.
4	PROD2	-,0,+	Bed change in feet, etc.
	etc.		Code 5 pairs per card.

T2 Card Event Sequence Title Required

Code up to 72 characters of the title information to describe the condition of the events which follow.

Events are discussed in paragraph __.

HD Card The Duration of Each Event Required

Field	Variable	Value	Description
0		HD	Card identification.
1	NEVTS	+	The total number of durations coded in this job. The durations follow in subsequent fields across this card.
2+	DDi	+	The duration of the first event on the sediment tape in days where the sequence of durations on this card should match the sequence of data on the sediment tape file.

$DREDGE Command Card-Dredge Optional

This command causes the computer program to calculate the amount of dredging. At the end of event analysis results are printed in terms of volume as well as percent distribution.

FE Card Event Accumulation Reset Optional

This is a special control to reset accumulators when more than one event has been placed in the job stream and each one is to begin with the same initial condition for shoaling and dredging which is the value 0.

$SEND Card End of Job Card

Field	Variable	Value	Description
0		$SEND	

04/85

APPENDIX K: FIELD DATA NEEDS

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APPENDIX K: FIELD DATA NEEDS

CONTENTS

APPENDIX K: FIELD DATA NEEDS

PART I: INTRODUCTION

Objective

1. This appendix discusses what field data are needed for a modeling effort and gives an overview of how they can be obtained.

Uses of Field Data

2. Field (prototype) data are used in a model study to describe the geometry of the area to be modeled, to identify the important processes, to provide input data to the models, and to provide a standard with which model results can be compared (verification).

Sources of Field Data

3. Primary sources for hydraulic field data are direct collection of the data and the publications and records of state and Federal agencies. A combination of data from these sources is usually necessary.

4. Federal agencies collecting substantial amounts of hydraulic field data are the Army Corps of Engineers, U. S. Geological Survey (USGS), Fish and Wildlife Service, Bureau of Reclamation, and National Ocean Survey (NOS). The USGS and NOS publish nearly all of the data that they collect, while the other agencies publish part of their data and retain the rest in their files. A list of addresses for making data inquiries is given in Addendum K-1. Secondary sources of data include universities, private companies, and the technical literature.

Special Considerations

Synoptic measurements

5. Model studies exhibit some special needs that are different from most other uses of field data. Prominent among these is the requirement that much of the data be synoptic, or taken over the area of interest at the same time.

6. Nearly synoptic data are needed so that one set of boundary conditions are responsible for data at all locations and

so that relationships can be established between processes at the data collection locations. For most situations, this does not mean that measurements are made at the same instant, but within a time interval of minutes or even hours. (Some data, such as short period wave measurements, must often be obtained within a few seconds at several locations.) Where circumstances or resources prohibit nearly synoptic data collection, some means of compensation must be applied. For example, data collected on successive days might overlap where one station is sampled every day to serve as a reference station.

7. Meaningful verification of a model to field data usually requires that measurements must be made over the area modeled during steady or quasi-steady conditions. For example, if several ranges in a modeled reach of a river are to be measured, the measurements should be made for an essentially constant stage and discharge. If the stage is changing slowly, then measurement at all ranges during a 1, or possibly 2-day period will be under sufficiently constant conditions. For a tidal waterway where measurements are made at regular intervals over a tidal cycle, optional data collection occurs when the tidal range does not vary dramatically prior to or during a survey.

8. Environmental conditions prior to and during data collection must be considered. For example, if the process of primary interest is tidal propagation across a broad bay, measurement of water levels during a period of a sustained strong wind will greatly diminish the value of the data.

Vertical control

9. Establishing an accurate datum plane for water level and hydrographic measurements is important for model development and use. It is also nearly impossible. Despite claims for datum plane accuracy, level nets are notoriously inaccurate for use in obtaining water surface elevations and slopes. In tidal waters, the problems are worse since there is often considerable subsidence and level circuits over marsh and water are so difficult. Because datum plane measurements are so inaccurate, there is no particular point in being dogmatic about rigorous vertical control. Accept whatever you are given but do not believe in it very much.

Personnel and organization

10. Many organizations have excellent equipment and well-trained personnel for collecting field data. Unfortunately, that does not mean that they are able to make field measurements that are suitable for use in a model study. The overall design and specification of a data collection effort should be done by the modeler. The detailed design and execution should be performed by personnel who are familiar with the study and with modeling. The modeler should, as a matter of course, be present and actively participating in a majority of the data collection effort. Ignore this advice at your peril.

Organization of the Appendix

11. Part II of this appendix describes the kinds of data needed for a model application and where the data come from. Collection and analysis methods are discussed only when it is necessary to provide information beyond that given in the "National Handbook of Recommended Methods for Water Data Acquisition" (USGS 1977).

PART II: FIELD DATA NEEDS AND COLLECTION

12. This portion of the appendix describes the field data that are needed in a model study and discusses some aspects of collection and analysis methods. Field data needs are summarized in Tables K1-K4.

All Modeling

13. Data that are required for all modeling efforts include those listed in Table K1. Bank lines, bed elevations, and structure details are needed for generating the computational network of the prototype. Most of the data can be obtained from charts and photographs of the area, though some additional surveying may be needed.

14. Since structures such as dikes and jetties can be represented as solid, permeable, submerged, or dry in the TABS-2 system, data on their design and condition are needed. The mesh can then be created in a fashion that most accurately describes the structure. Side-scan sonar surveys can be profitably used in some situations to obtain a description of underwater conditions.

15. Digitizing of data from charts and maps is discussed in Appendix E: Digitizer Instructions.

16. Analysis of successive hydrographic surveys is used to generate scour and fill patterns and deposition volumes used in sedimentation model verification. This use of the data is important, but the previous warning about vertical control is especially pertinent here. The modeler must remember that hydrographic surveys contain both random and systematic errors. Systematic errors in excess of 1 ft are unfortunately common. If accurate measurement of bed elevation changes are essential, the modeler should turn to techniques other than soundings, such as sedimentation stakes or density profiles over artificial reflectors. It should also be noted that acoustic surveys of fluffy bottom material can be very misleading (see paragraph 37).

Hydrodynamic Modeling

17. Table K2 lists the field data requirements for hydrodynamic modeling.

Water levels

18. Water levels are used to formulate boundary conditions and to calculate or estimate boundary roughness coefficients. Establishing an accurate vertical datum for the water-level data is important, but it is rarely achieved. In inland waters, the

levels are needed for a sufficient variety of conditions so as to represent the range of flows that are to be tested. For example, if flood flows are to be tested, water levels during high flows are needed.

19. In tidal waters, several tidal cycles of continuous or frequent intermittent water-level measurements are needed. The water-level records can be used directly and/or in analyzed (phase relations, tidal range, or constituents) form. A 30-min sampling interval is usually sufficient. Durations of 30 days are commonly required.

20. In areas where vessel traffic or wind creates short-period waves at a water-level gage, some effort may be required to filter short-period oscillations before measuring. Ordinary stilling well port design (a circular orifice or short tube) transmit short period oscillations to the well nonlinearly, and postmeasurement analyses cannot reliably remove them. Linear stilling well ports are needed (Fisackerly, et al. 1985).

Current velocities/discharges

21. Current speed and direction measurements are used to calculate boundary conditions, either as velocities or discharges, and to verify the model. Direction should be measured in degrees from true north. For some boundaries, such as powerhouses, disharges may be obtained from the operating agency and then used to calculate boundary conditions.

22. Velocity measurements are sometimes needed at locations or under conditions where an above-the-water platform (boat or structure) cannot be manned for the desired measurement period. In those cases, in situ recording meters are needed. For an example of in situ meter application, see Fisackerly et al. (1985)

23. The number of velocity measurement points needed at a cross section depends on the channel width, depth, and shape and characteristics of the flow. In general, two or three locations in a cross section are needed with at least three points measured in the vertical at each location.

Turbulent exchange and roughness coefficients

24. Turbulent exchange and roughness coefficients cannot be measured directly. They are a function of morphology, flow characteristics and computational mesh.

Sedimentation Modeling

25. Data requirements for performing sedimentation modeling are summarized in Table K3. Some of the data are needed for either cohesive or noncohesive sediments and are denoted as being always or usually needed. Some are needed only for one type of sediment and that is noted in the "when needed" column.

Grain sizes and settling velocities

26. Sediment grain sizes and settling velocities must be analyzed before determining values to be used as model input. The input data needed by the model are effective grain size and settling velocity. This is particularly important for settling velocity since measurements are made in quiescent water (settling tubes) whereas the effective settling velocity includes turbulent resuspension in the flow.

27. Cohesive sediments exhibit different settling velocities in the laboratory than in the natural environment. This is caused by changes in aggregation of the particles during sampling and storage. Laboratory measurements of settling velocities should be supplemented by on-site measurements with an Owens tube. See Fisackerly et al. (1985) for a discussion of Owens tube measurements.

Concentrations

28. Sediment concentration profiles in the vertical are needed even in a two-dimensional model study. The concentration profiles can be used to deduce settling velocities and critical shear stresses in some cases. Standardized equipment and sampling procedures are described in the Recommended Methods Handbook (USGS 1977).

29. Under conditions of high suspended sediment concentrations and steep concentration gradients (sometimes referred to as fluff or fluid mud) or density current in estuaries and reservoirs, discrete sampling of concentrations in the vertical can lead to erroneous conclusions. The behavior of very fine sediments in high concentrations leads to irregular concentration profiles. If such conditions exist, continuous concentration profiles should be measured by delivering a densimeter through the water column (Parker and Kirby 1981). Density profile information can also be used for establishing bed elevations and the unit weight of bed deposits.

Bed gradation, density, structure, and consolidation coefficients

30. Density measurements can be made on cohesive bed sediments. The profile of bed density with distance into the bed can be determined in situ by a densimeter (Parker and Kirby 1981) for low densities and by laboratory tests on slices of short cores for compacted sediments. Density profiles in newly deposited material may also be measured in the laboratory by analyzing deposits made in a settling column from resuspended bed samples. Inspection of cores and laboratory analyses of slices from the cores can provide information on layering of various sediments.

Critical shear stresses

31. Indirect methods. Indirect estimates of critical shear stresses for deposition and erosion of cohesive sediments can be made by measuring certain parameters and comparing them with values obtained by laboratory tests on similar sediments. Measurements of mineralogy, cation exchange ratio, and sodium adsorption ratio can be used to characterize the sediments and thus the critical shear stresses. For examples see Krone (1972 and 1973) and Ariathurai and Arulanandan (1978).

32. Direct methods. Direct methods of obtaining critical shear stresses involve performing flume tests on sediment samples, then calculating the critical shear stresses from test results. These tests usually require large sample volumes, specialized flumes, or both.

33. A second direct method uses a rotating cylinder apparatus in which a core of sediment is placed. Smaller samples can be used, but the method may require remolding of samples and does not work for very loose, fresh deposits.

34. Direct methods for obtaining critical shear stresses are fairly difficult to perform and the results may be affected drastically by seemingly minor test procedures. A better way is needed.

Dispersion coefficients

35. Dispersion coefficients cannot be measured directly. They are a function of flow characteristics, the vertical sediment concentration profile, and the computational mesh.

Deposition/erosion patterns

36. Deposition/erosion patterns and volumes are usually obtained by comparing successive hydrographic surveys. The results are complicated by surveying errors and inaccuracies (see paragraph 16) and dredging activities. For a discussion of some of the problems involved and how to handle them, see Letter and McAnally (1977 and 1981).

37. Areas of cohesive sediment beds sometimes have thick layers of very low density deposits on the bed. These deposits are often transitory, occurring during periods of low velocity and resuspending if velocities increase (such as tidal cycle behavior in coastal areas). Low density deposits can cause acoustic sounding equipment to provide depth measurements that are seriously (several feet) in error. For such conditions, densimetric surveys may be needed.

38. Appendix L of this report discusses methods of analyzing hydrographic data for scour and fill computations.

Table K1
Field Data Required for Mesh Creation

Data Required	When Needed	Used for	Obtained from
Banklines location	Always	Defining mesh boundaries	Hydrographic/topographic charts, historical water-level records, aerial photos
Bed elevations	Always	Assigning bed elevations at each node	Hydrographic/topographic surveys
Structures design and condition	Usually	Defining mesh	Design drawings, condition surveys

Table K2
Field Data Required for Hydrodynamic Models

Data Required	When Needed	Used for	Obtained from
Water levels	Always	BC,* verification, calculation of roughness	Direct measurement
Current velocity (discharge)	Always	BC and verification	Direct measurement
Boundary roughness	Always	Model input	Observation of channel forms and vegetation. Analysis of water levels and discharges.
Eddy viscosity	Always	Model input	Estimated/calculated from knowledge of flows and mesh
Wind velocity	Sometimes	Wind BC and prototype understanding	Direct measurement or weather records
Climatic data	Sometimes	Prototype understanding	Direct measurement or weather records
Water temperature	Always	Model input	Direct measurement
Latitude	Always	Model input	Map

*BC = Boundary conditions

Table K3
Field Data Required for Sedimentation Model

Data Required	When Needed	Used For	Obtained From
Grain sizes	Always for noncohesive	Model input	Lab measurements of samples
Settling velocities	Always	Model input	Lab measurements of samples
Concentration (sediment supply)	Always	BC,* IC** and verification	Lab measurements of samples
Bed roughness	Usually	Model input	Observations of channel forms and vegetation. Analysis of water levels and discharges or velocity profiles
Bed density	Usually	Model input for cohesive	Lab measurement of samples
Bed shear strength	Usually	Model input for cohesive	Lab measurement and calculations
Critical shear stress	Always	Model input for cohesive	Lab measurement and calculations
Bed consolidation coefficients	Usually	Model input for cohesive	Lab measurement and calculations
Bed structure	Always	Model input	Analysis of cores
Water temperature/ density	Always	Model input	Direct measurement/ calculation
Dispersion coefficients	Always	Model input	Calculated or estimated
Deposition/ erosion patterns & volumes	Usually	Verification	Calculated from multiple hydrographic surveys

*BC = Boundary Conditions
**IC = Initial Conditions

Table K4
Field Data Required for Transport Model

Data Required	When Needed	Used For	Obtained From
Concentration	Always	BC, IC, verification, calculation of dispersion coefficients	Direct or lab measurement
Dispersion coefficients	Always	Model input	Calculated or estimated
Decay coefficients	Usually	Model input	Calculated or estimated

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USGS. 1977. "National Handbook of Recommended Methods for Water Data Acquisition," U. S. Department of the Interior, Geological Survey, Reston, Virginia.

ADDENDUM KI: SOURCES OF FIELD DATA

U. S. Geological Survey
Reston, VA 22092
and District offices

U. S. Army Corps of Engineers (district offices)

U. S. Fish and Wildlife Service (district offices)

U. S. Bureau of Reclamation (local offices)

National Ocean Survey
National Oceanic and Atmospheric Administration
Rockville, MD

Environmental Protection Agency (regional offices)

State organizations similar to Geological Survey and Fish and Wildlife Service

Soil Conservation Service (district offices)

Universities

APPENDIX L: DATA MANAGEMENT SYSTEM A

Donald P. Bach, William H. McAnally, Jr.,
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APPENDIX L: DATA MANAGEMENT SYSTEM A

CONTENTS

APPENDIX E: DATA MANAGEMENT SYSTEM A

PART I: INTRODUCTION

Purpose

1. The purpose of this appendix is to describe the Waterways Experiment Station (WES) Data Management System A (DMS-A) and to provide a manual for the system's use.

2. The primary objectives of the DMS-A are to provide for accurate, effective, and rapid access of spatially distributed data for use in hydraulic studies of rivers, lakes, estuaries, and coastal waters.

Data Base Management

3. A data base consists of a collection of information stored in a systematic fashion. In early computer applications, most data bases were loosely organized and dependent on the programs that accessed them. As data bases grew larger, two needs arose--storage schemes that permitted rapid access to the data and access methods that allowed more than one program to use data from the base. From these needs evolved modern data base management systems (DBMS) which exibit the following characteristics:

- a. Data are stored in a systematic fashion that minimizes redundancy yet maximizes speed of data location, retrieval, and identification.
- b. Within certain categories, the structure of the data storage is the same for all data types.
- c. Data may be added, deleted, or changed without recreating the entire data base.
- d. The programs that store and retrieve the data are separate from those that analyze or display the data.

4. A complete, universally applicable DBMS is not often used since most uses are so specialized that carrying all the capabilities of a universal system becomes unnecessarily expensive. The Corps of Engineers uses several DBMS, such as SIR (Scientific Information Retrieval) and SYSTEM 2000, mostly for use with field measurements.

WES DMS-A

5. The DMS-A system is used by the Hydraulic Analysis and Estuaries Divisions of the WES Hydraulics Laboratory. The basic DMS-A file structure and several of the DMS-A programs were developed under the supervision of Dr. Victor LaGarde, of the WES Environmental Laboratory. The DMS-A system is a subelement of the TABS-2 data management system, which also includes the Columbia River hybrid modeling system, the TABS-2 file management system, and various utility programs. Funds to convert the system to numerical modeling applications were provided by the US Army Engineer District, New Orleans.

6. The three major computer sites for DMS-A are the WES Honeywell DPS-8 (WES), the CYBERNET computer system, and the WES Environmental Laboratory's Prime minicomputer. Not all of the most current versions of the codes are running at these sites, but they are installed on any computer system as needed.

7. The DMS-A consists of

a. Manual data handling procedures

b. Gridding and grid transformation programs

c. Program modules to accomplish frequently executed manipulation and display tasks.

Item c above includes some tasks that are not usually considered part of a data base management system. They are included because they are almost universally applicable to spatially distributed data.

Character of the Data

8. The DMS-A is designed principally for use with spatially distributed data, which consists of a set of location coordinates plus a set of parameters associated with each location at a particular time. Temporally distributed data consist of a series of parameters as they vary in time at a given location. Nearly all data used in hydraulic studies consist essentially of a set of space-time coordinates plus parameters associated with the coordinates. The nature of data and analyses commonly used in hydraulic studies requires that both spatially distributed and temporally distributed formats be available. Although DMS-A is used for data that are primarily spatially distributed, time variations can be treated within the system.

9. Spatially distributed data occur in two forms--continuous and factor. Continuously varying data are samplings of variables that can take on any scalar value from a continuous range of real values. The variable changes continuously over the space being sampled, such as the elevations of a water body.

Factor data have discrete values that are keyed to a particular state or classification. Normally, factor data will have a constant value over a closed area, such as bed sediment classification (gravel, sand, silt, or clay).

10. Hydraulic data are generally derived from four sources--field measurements, physical model measurements, numerical model output, and results of data analyses. The following list classifies the data most frequently encountered in hydraulic studies:

a. Hydraulic

(1) Current speed and direction
(2) Surface elevations and stages
(3) Discharge
(4) Tidal constituents (amplitude and phase)
(5) Hydraulic roughness parameters (Manning's n, etc.)

b. Meteorological

(1) Wind speed and direction
(2) Barometric pressure
(3) Air and water temperature
(4) Precipitation

c. Sediment

(1) Suspended sediment concentration and character--grain sizes, mineralogy, etc.
(2) Bed material characteristics--color, density, grain-size parameters, mineralogy, etc.
(3) Sediment discharge

d. Wave Information

(1) Wave height and period/length
(2) Wave direction
(3) Spectral distribution
(4) Orbital velocities and amplitudes

e. Water quality

(1) Salinity
(2) Temperature
(3) Other water quality parameters

f. Batnymetry

(1) Water depths/bed elevations
(2) Bed elevation changes

g. Geometry

(1) Computational mesh point locations and node numbers.
(2) Mesh geometry specifications (element connections, etc.).
(3) Assigned or computed mesh parameters (eddy viscosity, element area, etc.)

Fundamental data structure

11. When the WES DMS-A was written, computer limitations on storage size and speed made large numbers of floating point arithmetic operations impractical. Therefore the WES DMS-A was written to utilize integers for many of the system's calculations. When processing data for which decimal fractions are used, the data are multiplied by an appropiate power of 10 prior to processing and divided by the same factor after processing, allowing the user control over the precision of the integer computations.

PART II. PROGRAMS AND PROCEDURES

12. The procedures typically involved in a study are discussed in this part of the appendix. The programs normally utilized in these procedures are mentioned and are also listed in Table 11 along with a brief description of their function.

Data Preparation

13. Data which are to be initially placed in the system are usually in graphical form such as maps. These data are manually digitized and thereafter the only manual procedures performed are error checking and editing.

14. A rectangular coordinate system is imposed on the data, usually either the Universal Transverse Mercator (UTM), state planar, or an arbitrary rectangular system. Unless the area of interest is very small or very large, the state planar system is used.

Digitizing

15. The first step in the digitizing process is to position the map on the digitizer tablet with the rectangular coordinate system of the map parallel to the x-axis (lower horizontal limit) of the digitizer. The DMS-A programs will make corrections for distortions in the map's rectangular coordinate system.

16. The digitizer at the WES Instrumentation Services Division (ISD) is configured to write records containing two integer fields of six digits. For this reason, the DMS-A programs read digitizer data in a FORTRAN 2I6 format. Program DMSDIG has been developed to control Tektronix digitizers and it also writes the 2I6 format. A DMS-A digitizer file consists of an identifying record, six records containing transformation information, area of interest definition to limit computations to a specific area of the grid (if needed), and records containing the needed input--elevations, depths, coordinates, etc., for the particular DMS-A program. Special flags are included in this file to ensure that the correct program reads the file, and that data mismatches such as comparing depths and elevations do not occur. Instructions for using the ISD digitizer and the Tektronix 4954 digitizer are given in APPENDIX F: Digitizing Instructions. Table L2 illustrates the format of the first ten record types of a digitized data file. Records 11-14 vary depending on the type of data.

17. A digitizer file format has been developed to make digitizing faster and to allow for better error correction. This new file format type must be read through Program REFMT to

check the data and convert it be be read by ELEVGRP. Digitizer input file for REFMT follows the 2I6 format.

18. The area of interest specification allows flagging portions of a map where nonexistent or bad data exist. It also can be used to limit gridding computations across islands, jettys, levees, and dikes. The area of interest is defined by a series of points that enclose the region of the map for which data is presented. The points are digitized in a clockwise direction around the area. If a large number of maps (e.g., various dates) for a given project are digitized, the precise area of interest for each map will often be different because of differences in locating the suggested area.

19. A set of programs called MESH merges different input digitizer files that have been developed separately. MESH1 merges scalar data that is in tabular form identified by a station number to a set of x-y locations corresponding to make a complete digitizer file. MESH1 is often used with sediment measurements. MESH2 is designed to work with standard hydrographic survey data (strings of soundings). MESH3 reads in data sets generated from multiple maps of subareas to a master set for the entire area of interest.

Overlays

20. When repetitive digitizing is to be performed for the same basic map coverage at a given scale, the use of overlays is recommended. In order to sinplify data processing at later stages, it is necessary to have consistent corner coordinates for each of the series of maps to be digitized. For this purpose, overlays can be constructed on transparent film which has the four map corner coordinates for the series of maps and the line segments connecting the corners. It is also recomended that internal control points be included whenever maps of variable coverage and orientation are to be digitized for the same project location. The control points can be checked for consistency to reduce the chance of undetected errors in fitting the overlay.

Quality control

21. Each of the programs in the DMS-A contains quality control procedures, primarily those that check data values to see if they fall within reasonable bounds. Quality control programs display the data graphically to permit inspection. Program DGPLT checks digitized data format and plots the area of interest, the four corner coordinates and connecting segments for use with overlays, and the digitized location coordinates of the raw data.

Gridding and grid transformation

22. Spatially distributed data usually are gridded, that is, values are stored for even increments of distance along the

x- and y-axes of an orthogonal coordinate system. Raw model results are often ungridded, but intermediate results are usually in gridded form. Output is always gridded unless the specific application requires ungridded data.

23. Gridded data are often assigned to cells rather than points. Data cells are identified by their size (dx and dy), location (x and y), and cell index (i,j) where cell (1,1) is the upper left corner of the grid. In DMS-A, all gridded data are written in a specific binary format for fast access and smaller storage, except for the Honeywell version that has some coded records at the top of the file. The format of a DMS-A gridded data file (output from ELEVGRD) is as shown in Table L3. Since DMS-A files are in binary form, data written in this format need to be converted to a coded form (ASCII, BCD, EBCDIC, etc.) for transfer between computer sites or between mainframes of different manufacture at the same computer site. Program UN2FO converts the DMS-A binary format for transfer and program FO2UN converts the coded data back to the standard binary format after transfer. It is recommended that all computations performed on a particular DMS-A grid be done on the same computer.

24. Program ELEVGRD transforms spatially random data points into uniformly gridded data. Interpolation to a grid location is performed by a five-step process:

a. The nearest input data points are located.

b. The slope of the variable surface is computed at the location.

c. A local Cartesian coordinate system is placed with the origin at the grid location and local y-axis in the direction of the maximum rate of change.

d. The nearest input data point in each quadrant of the local coordinate system is located.

e. The grid-location value is calculated using:

$$Z(g) = \frac{\sum_{i=1}^{4} \frac{Z(i)}{d(i)^2}}{\sum_{i=1}^{4} \frac{1}{d(i)^2}}$$

where

$Z(g)$ = data value at the grid location
$Z(i)$ = input data point in the i^{th} quadrant of local coordinate system

d(i) = distance between the grid location and the closest input data point in the i^{th} quadrant

25. Program TRANSA transforms gridded data from a coded format to the DMS-A standard format.

26. Program FACGRD reads digitizer files of data defining area of constant factors and grids them, writing a standard DMS-A formatted file.

27. TABS-2 numerical model results may be converted to a DMS-A grid by using CONTOUR, which will read output from GFGEN, RMA-2V, RMA-4, and STUDH. Computed model results such as depth, bed elevation, water-surface elevation, velocity magnitude, water quality concentration, sediment concentration, and bed changes may be gridded by CONTOUR. Program CONTOUR is described in APPENDIX I: Graphics.

Data reviews

28. A DMS-A gridded data file may be dumped to a line printer using program DUMPER2. This dump is in the form of 132 column wide vertical swaths through the grid. Both ELEVGRD and CONTOUR will also produce DMS-A swath dumps. Grids may also be checked graphically using contour plots (from CONTOUR) or using 3-dimensional line plots (from 4VIEW). Programs CONTOUR and 4VIEW are described in APPENDIX I: Graphics Displays.

Data Processing

29. The DMS assumes that most users will provide their own programs for analyzing data, but some procedures are so commonly used that they have been included in the DMS-A.

30. Program GRDSUB reads two sets of gridded data and calculates the difference between them, producing a new gridded data set that represents the change between the input sets. It is commonly used to calculate depth changes between two hydrographic surveys.

31. Program BTHAREA computes the area between selected contours in bathymetric or topographic data. It is commonly used to determine the distribution of water depths and average depth or elevation over an area. A companion program, BATHVOL, computes the integral of the differences between two gridded data sets. It is commonly used to compute the shoaling volume between two hydrographic surveys. Both BTHAREA and BATHVOL can use FACGRD's output to produce area and volume reports by sub-areas or patches.

32. Data values at selected points within a DMS-A grid may be obtained using RETPNT. Input to RETPNT is either a digitizer file or the input file for program GFGEN. Program GFGEN, which generates geometry files for the TABS-2 models, is described in APPENDIX D: Network Generation.

Data Retrieval and Display

33. The data retrieval system used for interfacing with the DMS-A in the WES Hydraulics Laboratory is accomplished by means of the TABS-2 file management system (FMS). The FMS is host computer site-specific, and this appendix will only address the manipulation of files once accessed. It should be emphasized that an important component of any efficient DBMS is a reliable file management system. The FMS is discussed in APPENDIX A: Files and File Management System.

34. Programs used to display spatially distributed data produce tabular listings, printer plots, and output from CRT and pen plotters. Program DGPLT may be used to graphically display the map corners, area of interest, and the data point locations from an ELEVGRD digitizer input file. DUMPER2 prints gridded data in tabular form such that the data can be inspected or contoured by hand. Program 4VIEW, mentioned earlier as a quality control device, is also used to produce 3-dimensional plots of surfaces over the x-y grid lines. The program creates four plots with viewpoints from the four axis locations so that four different views are presented.

35. Program CONTOUR produces contour plots on a 2-D coordinate system from a DMS-A grid.

PART III. TYPICAL APPLICATIONS

Adding Bed Elevation to GFGEN Input Files

36. Automatic numerical mesh generators, such as AUTOMSH, do not use the x-y locations of their elements and nodal points. This limitation is necessary to allow the mesh smoothing schemes to be flexible. Also, the user is more free to experiment with various mesh configurations, and different bed geometries for a given mesh can be easily installed.

37. The sources for digitized data may be Corps of Engineers condition surveys, USGS quadrangle sheets, and/or NOS navigation charts. If more than one source is used, the separate digitizer files need to be combined using MESH3. The master digitizer file is then converted to DMS-A gridded format using ELEVGRD. The GFGEN file is then processed by RETPNT to obtain interpolated nodal values from the DMS-A grid.

38. The above method was used in a model study of Atchafalaya Bay, La., to create a mesh with 1967 bed elevations from a mesh with 1977 bathymetry. In that case, 1967 depth data were processed by ELEVGRD, then that output file and the 1977 GFGEN input file were used by RETPNT to create a data file with new elevations. Because the 1967 data did not cover the entire Atchafalaya grid, the interface between the RETPNT output data and the 1977 mesh had to be smoothed by hand.

39. Data other than bed elevations can be added to numerical meshes in the same manner as the bed elevation additions.

Postconstruction Verification

40. The WES Postconstruction Verification (PCV) research project looked at how sucessfully physical models have predicted changes in the hydraulic and sedimentary regimes within a project due to new construction. Information from the PCV analysis was used to improve in modeling techniques.

41. The DMS-A provides a good means of organizing results of PCV sedimentation studies, which analyze large volumes of spatially distributed bathymetric data. Since comprehensive field surveys of postconstruction conditions are usually not available, Corps of Engineers condition surveys were usually used to define project depths. Both preconstruction and postconstruction surveys were digitized and read through ELEVGRD to create a DMS-A grid of depths for each map.

42. Sediment model analyses re usually performed on a sectional or elemental basis, and it is necessary to perform PCV field analyses using the same sections that were used in the model study. A DMS-A grid of the computational sections was written by FACGRD using a digitizer file defining section limits.

43. Two depth grids and the section grid were read through BATHVOL to determine the shoaling and scouring volumes for time periods both prior to project construction and after construction. The percentages of shoaling change for each section were then compared with the model shoaling predictions.

44. The DMS-A system was used in the PCV analysis of the Tillamook Bay, Oreg., physical model.

Sediment Model Verification

45. The initial sedimentation verification analyses of both numerical and physical models can be performed using DMS-A in the same manner as the PCV analysis. The prototype condition survey maps showing data for the verification period are used to compute the shoaling rates that the model is expected to reproduce.

Atchafalaya Bay Deltaic Growth Extrapolation

46. The study of deltaic growth in Atchafalaya Bay, La., using extrapolation techniques is an example of a specialized use of the DMS-A. Bathymetric data from various sources were converted to the DMS-A gridded format using ELEVGRD. Then an extrapolati analysis using regression techniques was performed by computer codes written to read the DMS-A gridded format.

TABLE 11
PROGRAMS OF THE DMS

PROGRAM NAME	FUNCTION
	DIGITIZING PROGRAMS
DMSDIG	Readdigitizertabletoutputand converts it to input format for ELEVGRD, REFMT, RETPNT, PREMESH, FACGRD, CONPEG
DGPLT	Quality control on digitized data, plots digitized data
	FORMATING PROGRAMS
REFMT	Converts special digitizer files into format required by ELEVGRD
TRANSA	Transforms gridded data from one grid system to another
FO2UN	Converts data file coded by UN2FO back to standard DMS gridded binary format
UN2FO	Converts DMS gridded data files to a form that can be transferred between computers
	GRID TRANSFORMATIONS
MESH1	Merges tabular data into an x-y gridded data set
MESH2	Merges standard hydrographic survey data into x-y gridded data set
MESH3	Merges gridded digitized data from several maps
ELEVGRD	Transforms and interpolates randomly located data into a gridded data set
RETPNT	Extracts data values at randomly specified locations by interpolating from a gridded data set
FACGRD	Sets up a patch or factor map

TABLE L1 (continued)

PROGRAM NAME	FUNCTION
	DATA TRANSFORMATIONS
GPOSUB	Writes a set of gridded differences between two data sets with a common grid
BATHAREA	Calculates areas between contours from a gridded data set
BATHVOL	Computes volumes between two sets of gridded data
	DATA REVIEW
DUMPER2	Prints swaths of gridded data

Table L2
Digitizer Data File Format for Card Types 1-10*

Card Number	Field Number	Description
1	1	Map number
	2	Code specifying data type For depths = 3 For elevations = 4 For AUTOMSH lines = 10
3	1	Digitizer x-coordinate of upper left map corner.
	2	Digitizer y-coordinate of upper left map corner.
4	1	Digitizer x-coordinate of upper right map corner.
	2	Digitizer y-coordinate of upper right map corner.
5	1	Digitizer x-coordinate of lower left map corner.
	2	Digitizer y-coordinate of lower left map corner.
6	1	Digitizer y-coordinate of lower left right map corner.
	2	Digitizer y-coordinate of lower right map corner.
7	1	Grid x-coordinate of upper left map corner in 1,000 units.
	2	Grid y-coordinate of upper left map corner in 1,000 units.
8	1	Grid x-coordinate of lower right map corner in 1,000 units.
	2	Grid y-coordinate of upper left map corner in 1,000 units.
9	1	Special code = -5555 to signal start of area of interest data.
10+	1	Digitizer x-coordinate of point defining area of interest.
	2	Digitizer y-coordinate of point defining area of interest.

* Card Types 11 and higher vary depending on the type of data digitized. See the Addenda for examples.

Table L3

ELEVGRD Output Data File Format

Record Number	Word Number	Standard Format	Honeywell Format	Description
1	1	Binary	I10	LENDAT = data type (3 for depths 4 for elevations)
	2	Binary	I10	NXUL = UTM x-coordinate of the upper left corner of the map
	3	Binary	I10	NYUL = UTM y-coordinate of the upper left corner of the map
	4	Binary	I10	NXLR = UTM x-coordinate of the lower right corner of the map
	5	Binary	I10	NYLR = UTM y-coordinate of the lower right corner of the map
2-7	1-22*	Binary	22A6	NAME = 6 lines of 132 characters each of identifying information
8	1	Binary	F5.3	DATASC = Flag for data units (1.0 for English, .305 for metric)
	2	Binary	I6	NXRE = Number of grid points in the x-direction
	3	Binary	I6	NYRE = Number of grid points in the y-direction
	4	Binary	F6.1	DX = Grid increment in the x-direction
	5	Binary	F6.1	DY = Grid increment in the y-direction
9-NYRE+8	1-NXRE	Binary	binary	N = Two dimensional array containing data values at each grid cell

*The number of words that are required for storage of the identification lines varies depending on the computer word size and character set. For the standard version of DMS-A "CHARACTER NAME*132" IS USED.

ADDENDUM L-1: USER INSTRUCTIONS FOR PROGRAM DMSDIG

Purpose

1. The purpose of DMSDIG is to read digitized data from a Tektronix 4954 tablet and convert it to the proper input format for ELEVCRB, REFMT, RETPNT, FACGRID, PREMESH, and CONFEG.

Use

2. Execution is started with the following control cards on CYBERNET:

```
GET,DMSDIG/UN=CER0H9<CR>
DMSDIG <CR>
```

3. Follow the instructions given by the program. After execution terminates, type:

```
REPLACE,TAPE3=digitizerfilename <CR>
```

5. Subroutine TEK4954 may only be used under CDC NOS timesharing. Other non-ANSI statements are noted in the code. The program may be easily modified to read data from Tektronix 4953 tablets.

Output

6. Output consists of the digitized data on logical unit 3.

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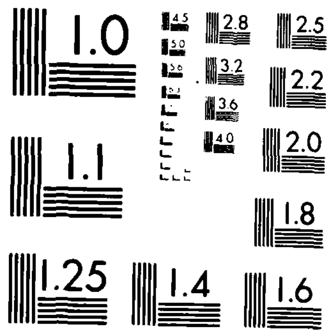
UNCLASSIFIED W A THOMAS ET AL AUG 85 WES/IR/HL-85-1 F/G 13/2 NL



MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS 1963 A

ADDENDUM L-2: USER INSTRUCTIONS FOR PROGRAM DGPLT

Purpose

1. The purpose of DGPLT is to plot the location of each digitized point, the map overlay corners, and the area of interest from a digitizer file.

Description

2. Using the map corner coordinates on the input file, all of the input data are transformed to plot inches and sent as input to the CALCOMP plotting routines.

Use

3. The program is available on the WES DPS-8 and CYBERNET. The followng is the deck structure for execution under the DPS-8 CONVERT subsystem (JRN command):

```
10$SN
15$:IDENT:usernumber,name
20$:OPTION:FORTRAN,NOMAP
30$:FORTY:NFORM,NLNO,NLSTIN,FDS
40$:LIMITS:01,38K,10000
50$$SELECT(userno/PGRM/DGPLT,R)
60$:UPDATE
70$:ALTER:m,n

      -- your replacement cards for lines m through n --

4990$:USE:DRUM
5000$:EXECUTE
5010$:LIMITS:20,14K,100000
5020$:PRMFL:02,R,L,your digitizer input file
5030$:TAPE7:03,NID,,,*CPLB
5040$:ENDJOB
```

4. To execute the program on CYBERNET, use PROCLV (Appendix O).

5. The spatial digitizer data file is in standard format on logical unit 02, with five digit line numbers added for the DPS-8 version. The input to ELEVGRD consists of standard digitizer card types 1-10 (see Table L2) and card types 11-13 as shown below:

Card Number	Field Number	Description
11+	1	Special code = -7777
	2	Data point value.
12+	1	Digitizer x-coordinate of data point.
	2	Digitizer y-coordinate of data point.

** Alternate card types 11 and 12 for each data value location **

Card Number	Field Number	Description
13	1	Special end-of-data code = -9999
	2	Special end-of-data code = -9999

Output

6. Output consists of a plot on logical unit 03.

ADDENDUM L-3: USER INSTRUCTIONS FOR PROGRAM REFMT

Purpose

1. The purpose of program RFMT is to convert a digitizer file from a format that is easily used by the person doing the digitizing to a format used by the ELEVGRD program. It will also check for bad data.

Description

2. Each coordinate and data point are matched in a one-to-one correspondence. Digitizer coordinates are checked for being in the range between 99999 and -99999. Data points are checked for being in the range between 1000 and -1000. The program stops when it finds an error. It will not catch all errors. A look at the entire file is suggested. *Also, DGPLT is a good diagnostic* program.

Use

Input

3. Input digitizer data are read on logical unit 01. After the normal digitizer header cards, the data are grouped into sets, starting with a record which looks like: "฿-7777 NNNNNN" where NNNNNN is the data set number, followed by the digitizer coordinates for each data point in the set in 2I6 format, followed by a record which looks like:

"฿-4444฿-4444"

followed by the data values for each point in the set, in 6X, I6 format. The symbol "฿" indicates a blank character.

Output

4. The output file (logical unit 02) is in standard DMS gridded format as described in Appendix N. In this format, the data can be read by ELEVGRD.

ADDENDUM L-4: USER INSTRUCTIONS FOR PROGRAM TRANSA

Purpose

1. The purpose of TRANSA is to convert regularly gridded data to the DMS-A gridded format.

Description

2. The code reads in the user's grid and finds the minimum and maximum of the coordinates. A truncated form of the coordinates and the data are written to the random scratch file. The output array is filled with the area of noninterest code -999. The coordinates are reread from the scratch file and converted to the grid index using a transformation based on the hard-wired grid spacing. Grid cells not having data remain set to -999. Output is placed on file code 02.

3. The grid spacing (DX for x-direction, DY for y-direction), units flag (DATASC = 1.0 for English, .305 for metric), and the data type flag (NX = 3 for depths, 4 for elevation) are all hardwired into the code.

Use

4. The program is available on the WES DPS-8 and CYBERNET. The following is the deck structure for execution under the DPS-8 CONVERT subsystem (JRN command):

```
10$$N
15$:IDENT:usernumber,name
20$:OPTION:FORTRAN,NOMAP
30$:FORTY:NFORM:NLNO,NLSTIN,FDS
40$:LIMITS:10,26K,,5000

     -- card images of the TRANSA program --

5000$:EXECUTE
5010$:LIMITS:100,68K,,6000
5015$:FILE:20,X3R,20R
5020$:PRMFL:01,R,L,your input gridded data file
5030$:TAPE9:02,X2D,,,,your name
5040$:DATA:I*

     -- your run control input --

6000$:ENDJOB
```

5. The program is executed on CYBERNET through PROCLV (see Appendix O).

6. Regularly gridded data are read in on logical unit 01. The output file on logical unit 02 is in DMS-A standard gridded form.

7. The TRANSA run control input is as follows:

Card Number	Format	Description
1-12	22A6	12 lines of identification information for DMS formatted output.

The gridded input format is as follows:

Card Number	Field Number	Format	Description
1+	1	3X,F10.2	x-coordinate of grid point.
	2	3X,F10.2	y-coordinate of grid point.
	3	3X,F10.2	Data value at grid point.

** Input a card type 1 for each grid cell **

ADDENDUM L-5: USER INSTRUCTIONS FOR PROGRAM FO2UN

Purpose

1. The purpose of program FO2UN is to convert a gridded data file that has been coded by UN2FO back to the standard DMS-A binary gridded format.

Description

2. The 80-column-wide coded data files are converted to the binary DMS-A gridded format.

3. FO2UN is executed on CYBERNET by use of PROCLV. Input consists of an UN2FO (Addendum L-6) output file on logical unit 01. Output is a DMS-A binary data file on logical unit 02.

ADDENDUM L-6: USER INSTRUCTIONS FOR PROGRAM UN2FO

Purpose

1. The purpose of program UN2FO is to convert DMS-A gridded data files to a form that can be transferred between computers.

Description

2. The binary DMS-A gridded data files are converted to an 80-column-wide coded format (card image).

Use

3. UN2FO is executed through PROCLV (see Appendix O). The binary input file is read on logical unit 11 and the formatted output file is written to logical unit 01.

4. The deck setup for execution under the Honeywell DPS-8 convert subsystem (JRN command) is as follows:

```
10$$N
20$:IDENT:userid,name
30$:OPTION:FORTAN,NOMAP
40$:FORTY:NFORM,NLNO,NLSTIN,FDS
50 C PROGRAM UN2FO
60 DIMENSION N(1000)
70 REWIND 11
75 READ(11,5) LENDAT,MXUL,MYUL,MXLR,MYLR
80#5 FORMAT(8I10)
82 WRITE(1,6)LENDAT,MXUL,MYUL,MXLR,MYLR
85#6 FORMAT(5I10,30X)
90 PRINT, "IDENT READ ON INPUT TAPE"
100 DO 21 I=1,6
110 READ(11,3)(N(J),J=1,22)
120#3 FORMAT(22A6)
130 PRINT3,(N(J),J=1,22)
135 WRITE(1,4)(N(J),J=1,22)
140#4 FORMAT(11A6,14X)
150#21 CONTINUE
160 READ(11,7)DATASC,NXRE,NYRE,DX,DY
170#7 FORMAT(F5.0,5X,2I6,2F6.0)
180 WRITE(1,8)DATASC,NXRE,NYRE,DX,DY
190#8 FORMAT(F5.3,5X,2I6,2F6.1,46X)
200 DO 64 I=1,NYRE
210 READ(11)(N(J),J=1,NXRE)
220 WRITE(1,5)(N(J),J=1,NXRE)
230#64 CONTINUE
240 REWIND 11
250 REWIND 1
```

```
260 PRINT, "RUN COMPLETE"
270 STOP
280 END
290$:EXECUTE
300$:TAPE9:11,X1D,,,,your DMS-A tape number
310$:FILE:01,X2S,10L
320$:UTL2
330$:FILE,IN,X2D
340$:TAPE9:OT,1T1D,,,,filename,,DEN8
350FDEF IN,GFRC.
360FDEC OT,NLAB,IBM,CI80,F80.
370FOPT IN AND OT,RECCT.
380PROC REWIND IN. COPY IN TO OT 1 FILE.
390$:ENDJOB
```

The above jcl will write a tape.

ADDENDUM L-7: USER INSTRUCTIONS FOR PROGRAM MESH1

Purpose

1. The purpose of program MESH1 is to mesh spatially digitized data from a sediment characteristics map with tabular values for depth, mean grain size, sorting coefficient, and sand, silt, and clay percentages.

Description

2. The input digitizer coordinates are matched with the selected tabular data to form an ELEVGRD digitizer input file. The transformation coordinates and the area of interest definition are simply copied from the input file to the output file.

Use

3. MESH1 runs under the Honeywell DPS-8 time-sharing system. The program and data files must be on the individual user's disk file space. To run the code, log in to the Honeywell and type "FRN MESH1." The program will interactively ask the user input and output file names and what kind of data are needed to be output. MESH1 will write depths, mean grain sizes, sorting coefficients, sand sample percentages, silt sample percentages, clay sample percentages, and silt plus clay sample percentages.

Input

4. The spatial digitizer data file is in standard format on logical unit 01, with five-digit line numbers added for the DPS-8 version. The input card image records 1-10 are in standard format (Table L2) and card types 11-12 are shown below:

Card Number	Field Number	Description
11+	1	Special code = -7777
	2	Data point number.
12+	1	Digitizer x-coordinate of data point.
	2	Digitizer y-coordinate of data point.

** Alternate Card Types 11 and 12 for each data value location **

Card Number	Field Number	Description
13	1	Special end-of-data code = -9999
	2	Special end-of-data code = -9999

5. The tabular data file (logical unit 02) is as follows, with a five-digit line number added for the DPS-8 version only. Input a data record for each digitized point location.

Field Number	Format	Description
1	11x,F4.1	Depth value at this point. It will be multiplied by 10 and truncated on output.
1	F5.3	Mean grain size at this point. It will be multiplied by 1000 and truncated on output.
2	F4.2	Sorting coefficient at this point. It will be multiplied by 100 and truncated on output.
3	I2	Sand sample percentage at this point.
4	I2	Silt sample percentage at this point.
5	I2	Clay sample percentage at this point.
6	I3	Point number

Output

6. The output file from MESH1 is suitable for input directly to ELEVGRD for conversion to the standard DMS-A gridded format.

ADDENDUM L-8: USER INSTRUCTIONS FOR PROGRAM MESH2

Purpose

1. The purpose of program MESH2 is to mesh spatially digitized data from a bottom elevation map with fathometer values along transects or ranges.

Description

2. The input digitizer coordinates of the start and the end of the ranges of depth data are matched with the depth data to form an ELEVGRD digitizer input file. The transformation coordinates and the area of interest definition are copied from the input file to the output file. The starting points of ranges, ends of the ranges, and distances along ranges are used to compute discrete x and y digitizer coordinates for each data point.

3. The map corner coordinates in the input digitizer file must be perfectly rectangular.

Use

4. MESH2 runs under the DPS-8 time-sharing system. The program and data files must be on the individual user's disk file space. To run the code, log in to the Honeywell and type "FRN MESH2." The program will interactively ask the user input and output file names.

5. The spatial digitizer data file on logical unit 01 is in standard format, with five-digit line numbers added for the DPS-8 version. The input card types 1-10 are standard digitizer format (Table L2) and card types 11-14 are shown below.

Card Number	Field Number	Description
11+	1	Special code = -7777
	2	Range number.
12+	1	Digitizer x-coordinate of start of range.
	2	Digitizer y-coordinate of start of range.
13+	1	Digitizer x-coordinate of end of range.
	2	Digitizer y-coordinate of end of range.

** Alternate Card Types 11, 12, and 13 for each range of data **

14	1	Special end-of-data code = -9999
	2	Special end-of-data code = -9999

6. The depth data file on logical unit 02 is as follows, with a seven-digit line number added for the DPS-8 version only. There are four distance/depth data pairs per input record. A value of 999999 for the distance signals the end of data for a particular range.

Card Number	Field Number	Format	Description
1	1	A	File descriptor (skipped over).
2	1	A	File descriptor (skipped over).
3+	1,3,5,7	F10.1	Distance of data point from start of the range, in UTM or user's coordinates. = 999999 to signal the end of data for a particular range. Start the next range on a new card image.
	2,4,6,8	F7.2	Depth value,multiplied by 100 and truncated on output.

** Input enough card type 3's as needed for all input data points for all of the ranges **

7. The output file (logical unit 03) from MESH2 is suitable for input directly to ELEVGRD for conversion to the standard DMS-A gridded format.

ADDENDUM L-9: USER INSTRUCTIONS FOR PROGRAM MESH3

Purpose

1. The purpose of program MESH3 is to mesh separate digitizer data files into a single digitizer input file.

Description

2. The program expects each input file to contain an area of interest and it will handle any number of area of interest patches per file. A total of four input files can be used. All of the input data can be translated, but not rotated, to be matched together. All input is assumed to have come from the same digitizer. Maps being meshed together do not have to be adjacent to each other or meshed together into a rectangle.

3. The input digitizer coordinates are translated to match the coordinates on the input file that was chosen as the base file, using the corner UTM or user's coordinates.

Use

4. MESH 3 runs under the Honeywell DPS-8 time-sharing system and CYBERNET PROCLV. The program and data files must be on the individual user's disk file space. The program will interactively ask the user input and output files names and which input file should be used to compute the output file's scale.

5. The spatial digitizer data files (logical units 1-4) are in standard format, with five-digit line numbers added for the Honeywell version. The input card types 1-10 are shown in Table L2 and card types 11-13 are in the format shown below:

Card Number	Field Number	Description
11+	1	Special code = -7777
	2	Data value at a point.
12+	1	Digitizer x-coordinate of data point.
	2	Digitizer y-coordinate of data point.

** Alternate Card Types 11 and 12 for each data value location **

Card Number	Field Number	Description
13	1	Special end-of-data code = -9999
	2	Special end-of-data code = -9999

ADDENDUM L-10: USER INSTRUCTIONS FOR PROGRAM ELEVGRD

Purpose

1. The purpose of program ELEVGRD is to create a DMS-formatted grid from a file of randomly scattered X, Y, and Z data.

Description

2. Input digitizer coordinates are converted to the user's grid coordinates. Depths are assigned to each regular grid cell based on a linear nearest neighbors averaging scheme. (see paragraph 24 of Appendix L.)

Use

3. The program is available on the WES DPS-8 and CYBERNET.

4. Deck structure for execution under the DPS-8 CONVERT subsystem:

```
$SN
$:OPTION:FORTRAN,NOMAP
$:USE:.GTLIT
$:FORTY:NFORM,NLNO,NLSTIN,FDS
$:LIMITS:,28K

     -- card images of the ELEVGRD program --

$:EXECUTE
$:LIMITS:10,70K,,20000
$:FILE:20,X3R,25R
$:FILE:21,X4R,25R
$:PRMFL:10,R,L,your userid/your scattered data input file
$:PRMFL:11,W,L,your userid/your DMS grid file
$:DATA:I*

     your run control input

$:ENDJOB
```

5. The CYBERNET version of ELEVGRD is available through PROCLV (see Appendix O).

Input

6. Run control input (CYBERNET only) is shown below. Each keyword is in columns 1-3. The following fields are on the same card, separated by spaces (free format). It is read on logical unit 05.

Card Keyword	Data Value	Description
GRS	real	Grid spacing in user's units.
MET	none	Supply keyword only if using metric units. Default is English units.
SCA	real	Number by which to multiply the input data. This value is used to control the precision of integer operations.
ECH	none	Supply keyword if an echo of the input data are desired. Default is no echo.
DMP	character	Grid swath dump control option. = FULL for a dump of the entire DMS-formatted grid. = PARTIAL for a dump of the DMS-formatted grid without grid lines that are totally out of the area of interest. = NONE for no grid swath dump (default)
T	character	Title to add to top of DMS-formatted grid. Up to 12 lines of titles may be supplied.

7. The input file of data (logical unit 10) at scattered X and Y locations may be generated using the digitizer at Instrumentation Services Division, using the Tektronix digitizer under the control of a program called DMSDIG, or by hand. The file format is standard digitizer file format as shown in Table L2. Card types 11-13 are as shown below.

Card Type	Field	Description
11+	1	Special code = -7777
	2	Depth or elevation value.
12+	1	Digitizer x-coordinate of location of depth value.
	2	Digitizer y-coordinate of location of depth value.

** Alternate Card Types 11 and 12 for each x, y, z trio. Also, multiple cards of Type 12 can follow a single Type 11 card for areas with a constant depth or elevation. **

Card Type	Field	Description
13	1	Special end-of-data code = -9999.
	2	Special end-of-data code = -9999.

Output

8. DMS gridded data are written as output to logical unit 11.

ADDENDUM L-11: USER INSTRUCTIONS FOR PROGRAM RETPNT

Purpose

1. The purpose of program RETPNT is to retrieve data at specified random locations from a DMS-formatted regular grid.

Description

2. The program computes a weighted average data value for each requested point based on the values at the four corners of the grid cell within which the point is located.

Use

3. RETPNT is available on the WES DPS-8 and on CYBERNET. Deck structure for execution under the DPS-8 CONVERT subsystem:

```
$$N
$:OPTION:FORTRAN,NOMAP
$:USE:.GTLIT
$:FORTY:NFORM,NLNO,NLSTIN,FDS
$:LIMITS:,28K

        -- card images of the RETPNT program --

$:EXECUTE
$:PRMFL:10,R,L,userid/your grid file
$:PRMFL:11,W,L,userid/your output file
$:PRMFL:20,R,L,userid/your specified point file
$:ENDJOB
```

4. The CYBERNET version of RETPNT is available through PROCLV and it will work directly on GFGEN input files to add bed elevations after nodal x and y coordinates have been set.

Input

5. Run control input expected on logical unit 20 (used only when working with GFGEN input files, free field TABS format) is shown below. Each keyword is in Column 1-3. Data values are in succeeding columns in free format:

Card Keyword	Data Value	Description
DAT	real	Datum of TABS grid, elevation of zero depth (Default = 100.0)
ORI	real	x-coordinate of TABS coordinate system offset relative to DMS grid file (Default = 0.0)
	real	y-coordinate of TABS coordinate offset relative to DMS grid (Default = 0.0)
SCA	real	The depth data on the DMS gridded file is divided by this value. (Default = 1.0)
SCB	real	The coordinates on the GFGEN input file are divided by this value so that they can fit 216 format. (Default = 10.0)
RMA	none	Special keyword to tell RETPNT to process an GFGEN input file. This keyword is optional if other run control cards are supplied.

6. A digitizer file of specified point locations (logical unit 10), is supplied if the program is not working with GFGEN files). The format is shown below:

Card Type	Field	Description
1	1	Special code, set = -1
	2	Same as data type code on DMS gridded data file. Depths = 3, elevations = 4.
2	1	Special flag, set = -9
	2	Special flag, set = -9
3	1	x-coordinate of upper left map corner in 1000's of state grid feet
	2	y-coordinate of upper left map corner in 1000's of state grid feet
4	1	x-coordinate of lower right map corner in 1000's of state grid feet
	2	y-coordinate of lower right map corner in 1000's of state grid feet
5	1	Digitizer x-coordinate of upper left map corner
	2	Digitizer y-coordinate of upper left map corner
6	1	Digitizer x-coordinate of upper right map corner
	2	Digitizer y-coordinate of upper right map corner

Card Type	Field	Description
7	1	Digitizer x-coordinate of lower left map corner
	2	Digitizer y-coordinate of lower left map corner
8	1	Digitizer x-coordinate of lower right map corner
	2	Digitizer y-coordinate of lower right map corner
9	1	Special code = -2
	2	Special code = -2
10a+	1	Special code = -7777
	2	Point number to be retrieved.
10b+	1	Digitizer x-coordinate of point to be retrieved
	2	Digitizer y-coordinate of point to be retrieved

*** Alternate Card Types 10a and 10b for each data point value to be retrieved ***

Card Type	Field	Description
11	1	Special end-of-data code = -9999
	2	Special end-of-data code = -9999

Output

7. Raw RETPNT output is written on logical unit 11 in the following format:

Field	Format	Description
1	I10	Point number
2	I10	x-coordinate of point
3	I10	y-coordinate of point
4	F10.2	Data value at point location = 0.00 if point lies within grid, but outside of the area-of-interest. Points that are off of the grid are set to 1.00 on the DPS-8 and are not written to this file on the CYBERNET version.

ADDENDUM L-12: USER INSTRUCTIONS FOR PROGRAM FACGRD

Purpose

1. The purpose of FACGRD is to transform a digitized boundary region into a DHS-A formatted grid for use as an overlay to an ELEVGRD or TRANSA output file. It can be used to define patches of constant factors within which the ELEVGRD or TRANSA data can be analyzed.

Description

2. The program reads the input digitizer file and the data cards. The entire array is filled with -999. The program then assigns to each grid cell the appropriate patch number within which it is located. Cells outside the area of interest retain a value of -999.

Use

3. The program is available on the WES DPS-8 and CYBERNET. The following is the deck structure for execution under the DPS-8 CONVERT subsystem (JRN command):

```
10$$:
20$:OPTION:FORTRAN:NOMAP
30$:FORTY:NFORM,NLNO,NLSTIN,FDS
40$:LIMITS:05,32K,,10000

     -- card images of the FACGRD program --

5000$:EXECUTE
5010$:LIMITS:20,45K,,20000
5020$:PRMFL:01,R,L,digitizer input file
5030$:TAPE9:11,X2D,,,,your name
5040$:DATA:I*

     -- your run control input --

6000$:ENDJOB
```

4. FACGRD is executed on CYBERNET through PROCLV (Appendix O).

5. The FACGRD run control input (logical unit 01) is as follows:

Card Number	Word Number	Format	Description
1	1	free	Grid spacing in UTM or user's units.
2	2	free	Unit type flag = 1.0 for English units. = .305 for metric units.
3-15	1-22	22A4	12 lines of identification information for DMS formatted output.

6. The spatial digitizer data file is in standard format for card types 1-10 (see Table L2), with five-digit line numbers added for the Honeywell version. Card types 11-13 are in the format shown below:

Record Number	Word Number	Description
11+	1	Special code = -6666
	2	Patch number.
12+	1	Digitizer x-coordinate of point defining patch
	2	Digitizer y-coordinate of point defining patch

** Input a Card Type 12 for each data point defining a particular patch, going around the patch in a clockwise rotation. Alternate Card Types 11 and 12 for each patch.

Record Number	Word Number	Description
13	1	Special end-of-data code = -9999
	2	Special end-of-data code = -9999

ADDENDUM L-13: USER INSTRUCTIONS FOR PROGRAM GRDSUB

Purpose

1. The purpose of GRDSUB is to subtract two DMS-A formatted gridded data files and create a new DMS-A gridded file.

Description

2. The corner coordinates, title information, and grid size data are read from the two input files. If the grid spacing is not the same, the program stops. Title data for the output file is read from the run control input. The program checks to be sure that the maps overlay exactly. If not, the program stops. If so, the program proceeds to substract FILE1 - FILE2 = output file. If a particular grid cell falls outside of the area of interest on either of the input files, the output grid cell is set to the area-of-noninterest code, -999.

Use

3. The program is available on the WES DPS-8 and CYBERNET. The following is the deck structure for execution under the DPS-8 CONVERT subsystem (JRN command):

```
10$$N
15$IDENT:usernumber,name
20$:OPTION:FORTRAN,NOMAP
30$:FORTY:NFORM,NLNO,NLSTIN,FDS
40$:LIMITS:01,29K,,10000
50$$SELECT(userno/PGRM/GRDSUB,R)
60$:UPDATE
70$:ALTER:first line,last line

     -- your replacement cards for your personal changes --

5000$:EXECUTE
5010$:LIMITS:02,17K,,10000
5020$:TAPE9:01,X1D,,your DMS grid no. 1
5030$:TAPE9:02,X2D,,your DMS grid no. 2
5040$:TAPE9:03,XD,,,output file name
5050$:DATA:I*

     -- your run control input --

6000$:ENDJOB
```

4. GRDSUB is executed on CYBERNET through PROCLV (Appendix O).

5. The GRDSUB run control input (logical unit 05) is as follows:

Card Number	Format	Description
1	free	Data type flag = 3 for depths = 4 for elevations
	free	UTM x-coordinate of upper left map corner.
	free	UTM y-coordinate of upper left map corner.
	free	UTM x-coordinate of lower right map corner.
	free	UTM y-coordinate of lower right map corner.
2-13	22A6	12 lines of identification information for DMS formatted output.

6. Input DMS gridded data files are read on logical units 01 and 02. The difference file between the two gridded data sets is written to logical unit 03.

APPENDIX L-14: USER INSTRUCTIONS FOR PROGRAM BTHAREA

Purpose

1. The purpose of BTHAREA is to calculate the area above and between specified bathymetric contour levels using data supplied on a DMS-A formatted file. The program will optionally produce reports based on sections or patches of the area of interest.

Description

2. The program reads the information section of both the input files and checks to make sure that each grid overlays properly. If so, the area between contours is computed. If data are supplied on logical unit 11, the computations are performed by patch.

Use

3. The program is available on the WES DPS-8 and CYBERNET. The following is the deck structure for execution under the DPS-8 CONVERT subsystem (JRN command):

```
10$$N
15$:IDENT:usernumber,name
20$:OPTION:FORTRAN,NOMAP
30$:FORTY:NFORM,NLNO,NLSTIN,FDS
40$:LIMITS:01,31K,,10000
50$$SELECT(userno/PGRM/BATHAREA,R)
60$:UPDATE
70$:ALTER:m,n

     -- your replacement cards for lines m through n --

5000$:EXECUTE
5010$:LIMITS:10,20K,,10000
5020$:TAPE9:10,X1D,,your DMS-A gridded data value tape number
5030$:TAPE9:11,X2D,,your DMS-A gridded patch tape number
5040$:DATA:I*

     -- your run control input --

6000$:ENDJOB
```

4. BTHAREA is executed on CYBERNET by PROCLV (see Appendix O).

5. The run control input (logical unit 05) to BTHAREA is as follows:

Card Number	Word Number	Format	Description
1	1	Free	The number of patches to be read from logical unit 11. Set = 0 if no patches or sections are to be used.
	2	Free	Scale factor for input data values. Should be the same sign as the input data.
2	1	Free	Number of specified bathmetric contours.
	2+	Free	User defined contour levels.

** Input a Card Type 2 for each contour level **

6. The gridded data file is read on logical unit 10. The gridded patch data file is read on logical unit 11. Output is printed only.

ADDENDUM L-15: USER INSTRUCTIONS FOR PROGRAM BATHVOL

Purpose

1. The purpose of BATHVOL is to compute shoaling volumes between two survey dates within user defined contour intervals. The program will optionally produce reports based on sections or patches of the area of interest.

Description

2. The program reads the information section of all the input files and checks to make sure that each grid overlaps the other properly. If so, the two survey dates are subtracted and the depth change for each grid cell is converted to a volume change. If data are supplied on logical unit 11, the computations are performed by patch. The shoaling volumes are also compared to project depths (shoaling above and scouring below).

3. The depth data read from logical unit 10 must overlap exactly with the data read on logical unit 12. The two input depth files should have the same scale factor. The patch numbers must be sequential from one to the total number of patches.

Use

4. The program is available on the WES DPS-8 and CYBERNET. The following is the deck structure for execution under the DPS-8 CONVERT subsystem (JRN command):

```
10$$:
15$:IDENT:usernumber,name
20$:OPTION:FORTRAN,NOMAP
30$:FORTY:NFORM,NLNO,NLSTIN,FDS
40$:LIMITS:01,31K,,10000
50$$SELECT(userno/PGPM/BATHVOL,R)
60$:UPDATE
70$:ALTER:m,n

     -- your replacement cards for lines m through n --

5000$:EXECUTE
5010$:LIMITS:15,20K,,10000
5020$:TAPE9:10,X1D,,your DMS-A gridded data value tape number
                        for earlier date
5030$:TAPE9:11,X2D,,your DMS-A gridded patch tape number
5035$:TAPE9:12:X3D,,your DMS-A gridded data value tape number
                        for latter date
5040$:DATA:I*
```

-- your run control input --

6000$:ENDJOB

5. Execution on CYBERNET is controlled by PROCLV (Appendix O).

6. Run control input (logical unit 05) to BATHVOL is as follows:

Card Number	Word Number	Format	Description
1	1	Free	The number of patches to be read from FORTRAN unit 11. Set = 0 is no patches or sections are to be used.
	2	Free	Scale factor for input depth values. Should be same sign as the depth data.
2	1	Free	Number of project depth specifications. Set = -1 if none are to be used.
3+	1	Free	Number of patches to use this project depth. The counting of patched begins with patch number 1 and is cumulative.
	2	Free	Project depth specification.

** Input a card type three for each different project depth **

Card Number	Word Number	Format	Description
4+	1	free	Number of specified bathymetric contours.
	2+	free	User defined contour levels.

** Input a field type 2 for each contour level **

7. Gridded data are input from logical unit 10 (earliest in time) and logical unit 12 (latest in time). The gridded patch data (from FACGR3) are read on logical unit 11.

ADDENDUM L-16: USER INSTRUCTIONS FOR PROGRAM DUMPER2

Purpose

1. The purpose of program DUMPER2 is to produce a readable dump from data that are in binary DMS-A format.

Description

2. The program prints the data across the paper in rows and columns. For wide dumps, the swaths are printed sequentially and can be reconstructed by taping the paper swaths side to side.

Use

3. DUMPER2 reads in a DMS-A formattted grid on logical unit 10. The dump, in the form of vertical swaths through the grid, is written to the line printer file. At Cybernet, DUMPER2 is accessed through PROCLV (see Appendix O).

APPENDIX M: INTERFACE PROGRAMS

William H. McAnally, Jr., William A. Thomas,
Donald P. Bach, and Barbara Park-Donnell

CONTENTS

APPENDIX M: INTERFACE PROGRAMS

PART I: INTRODUCTION

Purpose

1. This appendix describes several computer programs that serve as interfaces between the major programs of the TABS-2 numerical modeling system.

2. The interface programs process output from one program so that it is in a form and format suitable for input to a second program.

Origin of the Programs

3. Programs ENGMET, BIN2FOR, and FOR2BIN were written by personnel of the WES Hydraulics Laboratory. Program JOBSTREAM was written by Hydraulics Laboratory personnel using in part a program named RMA-3, which was written by Resource Management Associates. Programs TRANSA, ELEVGRD, and GRDSUB were written by personnel of the WES Enviromental Laboratory.

PART II: PROGRAM DESIGN AND APPLICATION

ENGMET

4. ENGMET is a batch-oriented, interface program which converts GFGEN and RMA-2V output from English to metric units for use by the sediment transport program STUDH. It will also change the datum plane, alter the computation time interval, and alter the length of simulation hydrograph in the RMA-2V output file.

5. Work is under way on versions of RMA-2V and STUDH that will operate in either system of measurement units at the user's choice. These versions will be released when testing is complete.

6. User instructions for ENGMET are given in Addendum M-1.

BIN2FOR

7. BIN2FOR reads binary output files from GFGEN, RMA-2V, RMA-4, or STUDH and rewrites them in formatted form. It was originally written to transfer model output files from Boeing Computer Services to CYBERNET but has been retained because of its usefulness. Program FOR2BIN reverses the process.

8. Output files from the major programs are written in binary form that is unique to the vector processing computer. As a result, those files can be read only by the computer that wrote them. This isolates the output files and prohibits accessing them from the front end computer unless a program like BIN2FOR is used.

9. Running BIN2FOR creates a formatted data file containing the output results from GFGEN, RMA-2V, RMA-4, or STUDH. That file may then be read by a front-end computer program, written to a tape for transfer, or accessed and modified by an editor program. At present, the TABS-2 system does not emphasize use of these formatted files, but we can envision development of several applications that may be added later to the system.

10. User instructions for BIN2FOR are given in Addendum M-2.

FOR2BIN

11. FOR2BIN reverses the process of BIN2FOR, reading formatted files created by BIN2FOR and writing binary output files on the vector processing computer. It was developed for transfer of files to CYBERNET. The only obvious application of the program would be to replace GFGEN output files that had been transformed by BIN2FOR and then edited. In most cases, it will be

better to rerun GFGEN. Other uses of the program may be developed.

12. User instructions for FOR2BIN are give in Addendum M-3.

JOBSTREAM

13. Program JOBSTREAM creates input boundary condition files for RMA-2V, RMA-4, and STUDH models using output files from previous runs of those programs on a larger mesh. It is used for running inset computational meshes that overlap or lie within other meshes.

14. The JOBSTREAM approach of running successively finer yet smaller meshes is widely used in finite difference modeling. It permits detailed resolution of an area of high interest without the computational burden of high resolution over the entire area being modeled. It is not widely used in finite element modeling since resolution can go from very fine to very coarse in the same mesh. The need for such an approach does arise occasionally and is therefore included as part of the TABS-2 system.

15. User instructions for JOBSTREAM are given in Addendum M-4.

Other Interfaces

16. Other interface programs that are described elsewhere in this manual include ELEVGRD, GRDSUB, TRANSA, FO2UN, and UN2FO.

17. Program GRDSUB (Appendix L) is a spatial data analysis program used in the WES Data Management System A. It subtracts one set of gridded data from another and writes the differences to a file for analysis.

18. ELEVGRD converts data that are scattered in nonuniform x and y locations to a set of DMS-formatted, gridded data points. It is described in Appendix L.

19. Program TRANSA converts regularly gridded data to DMS-A formatted gridded data points. It is described in Appendix L.

ADDENDUM M-1: USER INSTRUCTIONS FOR PROGRAM ENGMET

Purpose

1. The purpose of this program is to convert RMA-2V and GFGEN output from English to metric units. It also allows adjustments to the elevation datum and will interpolate between time-steps or extrapolate additional time-steps.

Origin of Program

2. This program was written by Messrs. Donald P. Bach and Stephen A. Adamec, Jr., Estuaries Division, Hydraulics Laboratory, Waterways Experiment Station. The program has been modified by several members of the staff.

Description

8. The program reads bed elevations from a GFGEN file and allows for changes by card input. Coordinates and elevations are converted to metric units. Next, the number of time-steps to be input and desired to be output is read from cards, and the RMA-2V file is read. The velocities and water-surface elevations are converted to metric units, and a water-surface elevation file and a velocity file are written. If extrapolation or interpolation are desired, these operations are performed and new output files written. If requested, a check of the output files is performed by copying a few nodal point values for each time-step to the line printer.

Use

Input

4. Three input files are required: (a) a card image input data file for run control, (b) a binary output file from GFGEN (logical unit 01) which contains the finite element network, and (c) a binary output file from RMA-2V that contains flow velocities and water-surface elevations (logical unit 02). These are all in English units.

Output

5. Three metric output files are produced by ENGMET: (a) the finite element network file (logical unit 03), (b) the water-surface elevation file (logical unit 04), and (c) the velocity

file (logical unit 07). All three of these are binary and in metric units. In addition to these, an optional printout can be requested.

6. Optional output prints the water surface and x- and y-velocity components at every node and for every time-step. Beware of the size of the printout when using this option. Consider it only for debugging.

Card Image Input Data

7. A description of the card image input for ENGMET is shown in Table M-1-1. Note that the nonstandard format is the only option for ENGMET data at this time.

Table M-1-1

Card Image Input Data for ENGMET

Card 1. Format (I5,2F5.0)

Column	Variable	Value	Description
5	NOM	+	Number of node-depth pairs to be input from cards as update to the geometry file
10	DATUMC		Datum correction (ft) Water depths read in for nodes on card 1A are subtracted form DATUMC to obtain the bed elevation at these modes

Card 1A. Format 8(I5,F5.0) (Required only if NOM > 1)

Column	Variable	Value	Description
5	NODE	+	Node number
10	DEP	+	Depth (ft)
15	NODE	+	Node number
20	DEP	+	Depth (ft)
	.		
	.		
	.		

Continue for NOM pairs of data

Card 2. Format (5I5)

Column	Variable	Value	Description
5	ITM	+	Number of input time-steps from RMA-2V to convert
10	ITOM	0	Not used
15	IFO	0	No output check is printed
		1	Output check is printed
20	ITIOM	>1	Factor used in interpolation (ITIOM = 2 will double the number of time-steps)
		<1	No interpolation
25	NSKIP	+	Number of input time-steps to skip in RMA-2V output file before beginning metric conversion (used to eliminate spin-up time)

Addendum M-2: PROGRAM BIN2FOR

Purpose

1. The purpose of BIN2FOR is to convert binary data files generated by either GFGEN, RMA-2V, RMA-4, or STUDH to coded files.

Origin of Program

2. This program was written by Mrs. Barbara Park-Donnell, Estuaries Division, Hydraulics Laboratory, Waterways Experiment Station.

Description

3. Alpha records are written in a 20A4 format. DMS IREC and FREC information (see Appendix N) is written in I2 and F2.1 formats. Floating point data are converted to an E14.8 format and integer data to an I8 format. The program is run in a batch mode.

Use

4. The binary final results file from either GFGEN, RMA-2V, RMA-4, or STUDH is input on logical unit 10, with the corresponding coded file output on logical unit 20. [See ITYPE1]

5. The binary HOTSTART file from either RMA-2V, RMA-4, or STUDH is input on logical unit 11 with the corresponding coded file output on logical unit 21. [See ITYPE2]

6. A second binary HOTSTART file from STUDH is input on logical unit 12 with the corresponding text file output on logical unit 22. [See ITYPE3]

7. Card image input data for run control are on logical unit 05.

8. The program may be run from PROCLV. See Appendix O for command instructions.

Card Image Data Input Instruction

9. Only one line of input run control information is required. That input is described in Table M-2-1, "Description of Card Image Input Data for Run Control." Valid requests for conversions are shown in Table M-2-2, "Valid Conversion Options."

Table M-2-1

Card Image Input Data for Run Control

Field	Variable	Value*	Description
1	ICODE	GFGEN	Processing GFGEN files
		RMA2	Processing RMA-2V files
		RMA4	Processing RMA-4 files
		STUDH	Processing STUDH files
2	ITYPE1	FINAL	Processing a final results file from the given value of ICODE
		CONDLBED	Processing STUDH concentration delbed (valid only if ICODE=STUDH)
		______	Leave blank if only processing a HOTSTART (valid only if ICODE=RMA-2)
3	ITYPE2	HOTRMA2	Processing a HOTSTART file from RMA-2V (if ICODE=RMA-2)
		HOTRMA4	Processing a HOTSTART file from RMA-4 (if ICODE=RMA-4)
		HOTBEDST	Processing a Bed Structure HOTSTART from STUDH (if ICODE=STUDH and ITYPE1=FINAL or CONDLBED)
		HOTBEDEL	Processing a Bed Elevation HOTSTART from STUDH (if ICODE=STUDH, and ITYPE1=FINAL or CONDLBED)
		______	Not HOTSTART processing
4	ITYPE3	HOTBEDEL	Processing a Bed Elevation HOTSTART from STUDH (if ICODE=STUDH, and ITYPE2= HOTBEDST)
		______	Not processing 2 STUDH HOTSTARTS

* Fields are eight columns wide and data should be left-justified. Table M-2-2 shows valid options for fields 1-4.

Table M-2-2

Valid Conversion Options

FIELD 1	FIELD 2	FIELD 3	FIELD 4
GFGEN	FINAL		
RMA2	FINAL		
RMA2	FINAL	HOTRMA2	
RMA2		HOTRMA2	
RMA4	FINAL		
RMA4	FINAL	HOTRMA4	
STUDH	FINAL		
STUDH	FINAL	HOTBEDST	
STUDH	FINAL	HOTBEDEL	
STUDH	FINAL	HOTBEDST	HOTBEDEL
STUDH	CONDLBED		
STUDH	CONDLBED	HOTBEDST	
STUDH	CONDLBED	HOTBEDEL	
STUDH	CONDLBED	HOTBEDST	HOTBEDEL

ADDENDUM M-3: Program FOR2BIN

Purpose

1. To convert coded data files generated by BIN2FOR to binary files of the form produced by GFGEN, RMA-2V, RMA-4, or STUDH.

Origin of Program

2. This program was written by Mrs. Barbara Park-Donnell, Estuaries Division, Waterways Experiment Station.

Use

3. The output file from BIN2FOR, for either GFGEN, RMA-2V, RMA-4, or STUDH, is input on logical unit 10, and the binary output file from FOR2BIN will be written on logical unit 20. [See ITYPE1]

4. The HOTSTART file from either RMA-2V, RMA-4, or STUDH generated by BIN2FOR is input on logical unit 11, with the corresponding binary file output on logical unit 21. [See ITYPE2]

5. A second HOTSTART file from BIN2FOR of STUDH is input on logical unit 12, with the corresponding binary file output on logical unit 22. [See ITYPE3]

6. Card image data for run control are on logical unit 05.

7. The program may be run from PROCLV. See Appendix O for command instructions.

Card Image Data Input Instructions

8. Only one line of input run control information is required. That input is described in Table M-3-1, "Description of Card Image Input Data for Run Control." Valid conversion options are shown in Table M-3-2.

Table M-3-1

Card Image Input Data for Run Control

Field*	Variable	Value*	Description
1	ICODE	GFGEN	Processing GFGEN files
		RMA2	Processing RMA-2V files
		RMA4	Processing RMA-4 files
		STUDH	Processing STUDH files
2	ITYPE1	FINAL	Processing a final results file from the given value of ICODE
		CONDLBED	Processing STUDH concentration del-bed (valid only if ICODE=STUDH)
		______	Leave blank if only processing a HOTSTART (valid only if ICODE=RMA2)
3	ITYPE2	HOTRMA2	Processing a HOTSTART file from RMA-2V (if ICODE=RMA-2)
		HOTRMA4	Processing a HOTSTART file from RMA4 (if ICODE=RMA4)
		HOTBEDST	Processing a bed structure HOTSTART from STUDH (if ICODE=STUDH and ITYPE1=FINAL or CONDLBED)
		HOTBEDEL	Processing a bed elevation HOTSTART from STUDH (if ICODE=STUDH and ITYPE1=FINAL or CONDLBED)
		______	Not HOTSTART processing
4	ITYPE3	HOTBEDEL	Processing a bed elevation HOTSTART from STUDH (if ICODE=STUDH, and ITYPE2=HOTBEDST)
		______	Not processing 2 STUDH HOTSTARTS

* Fields are eight columns wide and data should be left-justified in each field. Table M-3-1 should be valid options for fields 1-4.

Table M-3-2

Valid Conversion Options

FIELD 1	FIELD 2	FIELD 3	FIELD 4
GFGEN	FINAL		
RMA2	FINAL		
RMA2	FINAL	HOTRMA2	
RMA2		HOTRMA2	
RMA4	FINAL		
RMA4	FINAL	HOTRMA4	
STUDH	FINAL		
STUDH	FINAL	HOTBEDST	
STUDH	FINAL	HOTBEDEL	
STUDH	FINAL	HOTBEDST	HOTBEDEL
STUDH	CONDLBED		
STUDH	CONDLBED	HOTBEDST	
STUDH	CONDLBED	HOTBEDEL	
STUDH	CONDLBED	HOTBEDST	HOTBEDEL

ADDENDUM M-4: PROGRAM JOBSTREAM, VERSION 1.0

Purpose

1. The purpose of JOBSTREAM is to create a set of boundary conditions for an inset mesh using TABS-2 modeling system results from another mesh.

Description

2. JOBSTREAM is a batch-oriented program, composed of algorithms from programs written by the Waterways Experiment Station Hydraulics Laboratory and Resource Management Associates, Lafayette, California.

3. The finite element method allows variable mesh size across the modeled area, but there are still times when the modeler needs a computational mesh that fits inside a large one or overlaps it. Operating in a JOBSTREAM mode permits the modeler to run the larger mesh, then use those results as boundary conditions for a second mesh.

4. In this description of the program, the term inset mesh is used to denote that mesh that gets the boundary conditions and *runs second. The mesh running first and supplying boundary* conditions is called the coarse mesh. The terminology was chosen to reflect a standard jobstream approach, but the inset mesh may actually be coarser than and lie outside the coarse mesh.

5. Use of the jobstream approach requires some care by the modeler. If the inset mesh boundaries are too close to the problem area, the inset mesh solution may be inconsistent with the coarse mesh solution. Some experimentation may be required to locate proper boundaries for the inset mesh.

6. The program reads output results from the coarse mesh to calculate boundary conditions for the inset mesh, using shape functions where needed. The program will prepare boundary condition files for RMA-2V hydrodynamic model runs or STUDH sedimentation model runs. A future version of the program will do so for RMA-4 dispersive transport model runs.

7. Inset mesh nodes may be coincident with nodes in the coarse mesh or fall within coarse mesh elements. Numbering of the two meshes need not be related to each other.

Use

8. Inset mesh nodes may be coincident with coarse mesh nodes or they may lie within an element of the coarse mesh. If the two nodes are coincident, the program reads data (velocity and water-surface elevations, or concentration) at the coarse mesh node and specifies that data for the inset mesh node. If the inset mesh node does not occupy the same location as a coarse mesh node, shape functions are used to calculate a value at the inset node, using results from the coarse mesh element in which it lies.

9. Program JOBSTREAM is part of the TABS-2 2-D modeling system. It uses the standard TABS-2 input data structure.

10. Input consists of control data, described here, which is in card image and may be either on cards or a disk file identified as logical unit 5; mesh geometry files for both the inset and coarse meshes; and a model results file for the coarse mesh. Output consists of echo prints of input data, optional printed output of the calculated boundary conditions, and an output file containing boundary conditions in the format required by the models.

11. The object code may be executed using PROCLV. If PROCLV is used, the input/output logical units noted as "usual" on the $L card are required.

Card Image Data Input Instructions

12. Table M-4-1 shows the data card sequence used as card image run control. Input is in the modified HEC-6 standard. The user may choose between free-field input and 10-8 column fields.

13. The following pages describe the card image input data for run control in detail. Table M-4-2 illustrates a typical job input file. Prepare the card image input data file before executing the program.

Table M-4-1

JOBSTREAM Version 1.0 Data Card Sequence

Card	Content	Required
T1	Title	Yes
$F	Format control	No
$M	Model designation	Yes
$L	Input/output files	No
TZ	Time controls	Yes
GN	Node correspondence list	Yes

TI Card Job Title Required

Field	Variable	Value	Description
Col 1	ICG	T	
Col 2	IDT	1	
2-10	TITLE		Any alpha-numeric data

$F Card | Format Control | Optional

Field	Variable	Value	Description
Col 1	ICG	$	
Col 2	IDT	F	

If the $F Card is present, the program expects all input (except Card $M) to be formatted according to either (2A1, F6.0, 9F8.0) or (2A1, I6, 9I8). If it is not present, free-field format is expected.

$M CARD Model Type Required

Field	Variable	Value	Description
Col 1	ICG	$	
	IDT	M	
1	MOD	R2	For model RMA-2V
		S3	For model STUDH
		R4	For model RMA-4 (not available yet)
2	VER	+	Model version

For formatted reads, the format is (2A1, 4X, A2, 4X, A4)

$L Card Input/output Logical Unit Numbers Optional

Field	Variable	Value*	Description
Col 1	ICG	$	
Col 2	IDT	L	
1	IN	+	Unit for control data. T1 through $M cards are read on logical unit 5
		0	Default = 5
2	LP	+	Unit for printed output
		0	Default = 6
3	ING	+	Unit for coarse mesh geometry file
		0	Default = 14
4	INGI	+	Unit for inset mesh geometry file
		0	Default = 15
5	INR	+	Unit for coarse mesh model results
		0	Default = 22
6	IFIL	+	Unit for output boundary conditions
		0	Default = 30

*PROCLV uses default values for logical units.

TZ Card | Time Controls | Required

Field	Variable	Value	Description
Col 1	ICG	T	
Col 2	IDT	Z	
1	TST	+	Starting time for boundary condition file
2	TINC	+	Time increments between boundary conditions in same units as results file
3	TDAT	+	Starting date
4	NSTPS	+	No. of time-steps to be placed in boundary condition file
		0	Will be calculated from TEND
5	TEND	+	Ending time for boundary condition file
		0	Will be calculated from NSTPS
6	IOUT	1	Print boundary conditions
		0	Do not print boundary conditions

GN Card | Boundary Node List | Required

Field	Variable	Value	Description
Col 1	ICG	G	
Col 2	IDT	N	
1	NODI	+	Node number in inset mesh boundary for which boundary conditions are to be calculated
2	NODE	+	Node number in coarse mesh that has exactly same location as NODI
		0	Program expects a value for NELE
3	NELE	+	Element number in coarse mesh within which NODI falls
		0	Program expects a value for NODI
4	NFIX	+	Type of boundary specification for RMA-2V
			See RMA-2V documentation for allowable codes of NFIX

Code one set of nodes per card

Table M-4-2

Card Image Run Control Data File Example

```
T1      DYNAMIC BC FILE FOR MESH 4 DERIVED VIA JOBSTREAM FROM MESH 1 800K CFS
$M     R2
$L      5    6  10   20   30  40
TZ      0.    .5   0    0   0 1
GN      191  191   65  00200
GN      205  205   65  00200
GN      230  230   65  00200
GN      231  231   65  00200
GN      232  232   65  00200
GN      245  245   77  00200
GN      269  269   77  00200
GN      270  270   77  00200
GN      271  271   77  00200
GN      285  285   88  00200
GN      308  308   88  00200
GN      309  309   89  00200
GN      310  310   89  00200
GN      325  325  101  00200
GN      335  335   94  00200
GN      336  336   95  00200
GN      337  337   95  00200
GN      338  338   96  00200
GN      339  339   96  00200
GN      340  340   97  00200
GN      341  341   97  00200
GN      342  342   98  00200
GN      343  343   98  00200
GN      344  344   99  00200
GN      345  345   99  00200
GN      346  346  100  00200
GN      347  347  100  00200
GN      348  348  101  00200
GN      349  349  101  00200
GN     1039 1039  294  00200
GN     1042 1042  294  00200
GN     1043 1043  294  00200
GN     1044 1044  294  00200
GN     1048 1048  296  00200
GN     1050 1050  296  00200
GN     1051 1051  296  00200
GN     1052 1052  296  00200
GN     1054 1054  297  00200
GN     1055 1055  297  00200
GN     1057 1057  298  00200
GN     1058 1058  298  00200
GN     1059 1059  298  00200
GN     1060 1060  298  00200
GN      329  329  217  00200
GN      330  330   92  00200
GN      331  331   92  00200
GN      332  332   93  00200
GN      333  333   93  00200
GN      334  334    9  00200
GN      747  747  217  00200
GN     1029 1029  144  11000
GN     1030 1030  144  11000
GN     1031 1031  144  11000
GN     1033 1033  145  11000
GN      850 1032  145  11000
```

APPENDIX N: FILES AND FILES MANAGEMENT SYSTEM

William H. McAnally, Jr. and Barbara Park-Donnell

CONTENTS

PART I: INTRODUCTION

1. This appendix describes the files used within the TABS-2 system and the files management system.

2. Standard file formats are used to improve portability of the files, reduce programming effort, and increase readability of the files. The files management system was created to help keep track of where data are stored. Computer files are the standard input medium for TABS-2. Many files are formatted as card images, but in general, actual cards are not used.

3. Four types of file formats are used: card-image run control, Data Management System A (DMS-A) input, DMS-A output, and model output. Program run control files, which serve as input to the programs and specify what the run is to accomplish, are usually ASCII and appear as card images with lines 80 characters long. Some run control files use the HEC form of input with an alphanumeric identifier at the beginning of each line. Eventually, all run control will be in this format. Run control files are created and modified by use of a time-sharing editor. Data Management System A files and model output files are described in PARTS II and III of this appendix.

4. PART IV of this appendix describes the TABS-2 File Management System. Part V describes an optional file naming convention that has been adopted by the WES Hydraulics Laboratory Estuaries Division and is recommended to the user.

PART II: DMS-A FILES

5. The WES Data Management System A (DMS-A) is designed to store, retrieve, and provide common analyses of data that are distributed in space. It works with both gridded (i.e., on a uniform spacing) and nongridded data. The DMS-A is described in Appendix L.

6. Some DMS-A data are stored as integers, thus data must be multiplied by an appropriate power of 10 to obtain the desired degree of precision if decimal fractions occur in the data.

7. Most DMS-A data files are stored in binary form. Map information is stored at the beginning of each data file in several sets of records, each record in 2I6 form. Table N1 lists the form for digitizer data input files for program ELEVGRD. Output from the various programs may use a standard format or an alternate, specialized format. See Apendix L for details of the various formats. The DMS-A binary file format is shown below:

Record	Word	Variable	Type	Description
1	1	LENDAT	INTEGER	Code for type of data = 3 for depths = 4 for elevations
	2	NXUL	INTEGER	X-coordinate of upper left corner of grid
	3	NYUL	INTEGER	Y-coordinate of upper left corner of grid
	4	NXLR	INTEGER	X-coordinate of lower right corner of grid
	5	NYLR	INTEGER	Y-coordinate of lower right corner of grid
2-7	1	NAME	CHARACTER*132	Title information for file
8	1	DATASC	REAL	Scale factor for gridded data
	2	NXRE	INTEGER	Number of grid cells in the X-direction
	3	NYRE	INTEGER	Number of grid cells in the Y-direction
	4	DX	REAL	Grid spacing in X-direction
	5	DY	REAL	Grid spacing in Y-direction
9 to NXRE+B	1 to NYRE	N	INTEGER	Gridded data values. The first value corresponds to the upper left corner of the grid. Area of non-interest values are -999.

PART III: MODEL OUTPUT FILES

8. Files produced as output by the models have a common format for the identifying block of information at the beginning of each file (header records) but vary in the form that actual model results are stored. Storing all output in the same form would be convenient but would greatly increase storage costs since many blank records would be stored. Files written by GFGEN, RMA-2V, STUDH, RMA-4, and ENGMET write output files as described below.

Header Records

9. Header records are common to all of the output files. They contain both numeric and character information used to describe file contents. Table N2 shows the header records structure and their contents. Record 2 is compiled by PROCLV. Most of the programs will print out all header records from the files that they read. Figure N1 shows a typical set of headers printed in the STUDH output.

```
     BANNER HEADINGS ON INPUT WATER SURFACE ELEV.

 WES HYD DMS VERION  1.0 DATED   OCT 81.    THIS FILE IS FROM   RMA2-VELOCITY
    VERSION =   2.30 DATED   JUNE,  1983. WETTING AND DRYINGENG-MET WAT SUR FILE
 DMS = 1                    GRADE = 1            PERSON = COPELAND   DESCRIPTION =
N CALIBRATION
E=25
 WESHE  DMS VERSION  1.00. DATED    OCT 1981.  THIS FILE IS FROM    GFGEN   VERS
ION 3.10 DATED   MAR 1984.
 DMS = LOCK AND DAM 1       GRADE = A            PERSON = LYNCH      DESCRIPTION =
LOCK AND DAM 1 RED RIVER
CORRECTED ELEVATIONS
```

Figure N1. Example header records

GFGEN Files

10. After the two header records, program GFGEN output files list the computational network description. Record 3 is written (binary write) as shown below.

Record 3

NP,NE((CORD(J,K),K=1,2),ALPHA(J),WD(J),J=1,NP)

((NOP(I,L),L=1,8),IMAT(I),TH(I),IEM(I),I=1,NE)

where

```
       NP = number of nodes
       NE = number of elements
CORD(J,K) = x- and y-coordinates of node J
 ALPHA(J) = slope of element side at node J
    WD(J) = bed elevation at node J
 NOP(I,L) = list of 6 or 8 nodes surrounding element I
  IMAT(I) = element type of element I
    TH(I) = angle for eddy viscosity tensor in element I
      IEM = element reordering sequence
```

RMA-2V Files

11. Every RMA-2V run writes one results file. If requested, it will also write a HOTSTART file. The first two records in both files are the standard header records.

Results

The third and fourth records of the results file are of the form

```
3.  (TITLE(I),I=1,20)

4.  T,NP,((VEL(J,K),J=1,3),K=1,NP), (NDRY(K),K=1,NP))NE,
                   (IMAT(L),L=1,NE)
```

where

```
        T = time
       NP = number of nodes
 VEL(1,K) = x-direction velocity at node k, time T
 VEL(2,K) = y-direction velocity at node k, time T
 VEL(3,K) = water-surface elevation at node k, time T
  NDRY(K) = flags for wet and dry nodes
  IMAT(L) = flags for active and inactive elements
```

Set 4 is repeated for each time-step that the program executes.

HOTSTART

12. The third record set of the HOTSTART file is of the form

```
T,NP,NE,NITSV,((VEL(J,K),J=1,3),K=1,NP)
(VDOT(J,K),J=1,3),K=1,NP),(VOLD(J,K),J=1,3),K=1,NP)
(VDOTO(J,K),J=1,3),K=1,NP),(NDRY(I),I=1,NP)
```

where

T = time
NP = number of nodes
NE = number of elements
NITSV = iteration number
VEL(J,K) = x- and y-velocities and water-surface elevation at node K, time T
VDOT(J,K) = derivatives of velocities and water-surface elevation at node K, time T
VOLD(J,K) = derivatives fvelocitiesandwater-surface elevation, time T - T (old time-step)
VDOTO(J,K) = derivatives of velocities and water-surface elevation, time T - T (old time-step)
NDRY(I) = flags for wet and dry nodes

The HOTSTART file contains only one time-step which is the final set of results.

STUDH

13. The sediment model STUDH produces three output files--a concentration and bed elevation change file, a (clay) bed structure HOTSTART file, and a final bed elevation file. Each output file contains the two standard header records and each is written in binary form.

Concentration and bed elevation change

14. The concentration and bed elevation change file contains results from every time-step. It contains computed sediment concentrations and the cumulative bed change from the beginning of the run. Record set 5 is repeated for each time-step.

Record 3

NTTS,(TITLE(I),I=1,18),IYR,IMO,IDA,IHR,IMN,ISC

where

NTTS = number of time-steps

TITLE(I) = alphanumeric title from T3 card

IYR = year

IMO = month

IDA = day

IHR = hour

IMN = minute

ISC = second

Record 4

```
NP,NE,((CORD(I,J),J=1,2),I=1,NP),((NOP(I,J),J=1,8),
I=1,NE),(AT(I),I=1,NE),(ELEV(I),I=1,NP),(CONC(I),I=1,NP)
```

where

NP = number of nodes

NE = number of elements

CORD(I,J) = x-, y-coordinate of node number I

NOP(I,J) = element connection table for element I

AT(I) = element angle for element I

ELEV(I) = elevation for node I

CONC(I) = concentration for node I

Record 5

```
T,(CONC(I),I=1,NP),(DELBED(I),I= ,NP)
```

where

T = time
CONC(I) = sediment concentration at node I
DELBED(I) = bed change at node I
NP = number of nodes

Bed structure

15. Record 3 of the bed structure file (clay and mixed beds only) is of the form

```
TF,(NLAY(I),I=1,NP),((RHOB(I,J),THICKL(I,J)
AGE(I,J),ITYPE(I,J),SST(I,J),J=1,NLAY(I)),I=1,NP)
```

where

TF = final successful time-step
NLAY(I) = number of bed layers at node I
RHOB(I,J) = bed dry density of layer J, node I
THICKL(I,J) = thickness of layer J, node I
AGE(I,J) = age of layer J, node I

ITYPE(I,J) = type number of layer J, node I
SST(I,J) = shear strength of layer J, node I
NP = number of nodes

Final bed elevation

16. The final bed elevation results file contains the computed bed elevation at the final time-step of the run. Record 3 is the number of nodes in the mesh. Record 4 is of the form

(TITLE(I),I=1,18,TIMEX,(ELEV(I),I=1,NP)

where

TITLE = title from the input T3 card
TIMEX = time of final time-step
ELEV(I) = bed elevation at node I
NP = number of nodes

RMA-4

17. RMA-4 writes a final results file and a hotstart file. Records 1 and 2 of each file are standard header records.

Results

18. Record 3 of the RMA-4 results file is of the form:

T,NQUAL,NP,((TOLD(J,K),J=1,NP),K=1,NQUAL),
(UL(J),J=1,NP),(VL(J),J=1,NP)

where

T = time

NQUAL = number of constituents being modeled

NP = number of nodes

TOLD = concentrations at time T, constituent number K, node J

UL = x-component of velocity at time T, node J

VL = y-component of velocity at time T, node J

19. This record is written for each time-step.

HOTSTART

20. The HOTSTART information file contains the following data in Record 3 for the last time-step only.

```
WRITE(IS8)NSTEP,TOLD(NP,6),TDOT(NP,6),WTEMP(NP)
```

where

NSTEP = time-step number

TOLD = concentrations at time NSTEP, up to maximum dimension of TOLD

TDOT = derivative of concentrations at time NSTEP, up to maximum dimensions of TDOT

WTEMP = water temperature at time NSTEP, up to maximum dimensions of WTEMP

PART IV: FILE MANAGEMENT SYSTEM

21. The WESDMS File Management System (FMS) is designed to be an automated notebook that keeps track of data files in the TABS-2 system. Early numerical modelers used black, three-ring notebooks to keep notes about each run, the files that it created, and magnetic tapes containing backup or archived copies of files. The success of the black notebook system always depends on the dedication of the modeler to keep the notebook up-to-date. On large studies that generate many files and employ more than one modeler, a more rigorous and automatic approach is needed.

22. TABS-2 file management is an optional approach that includes index files, a maintenance program embedded in the procedure files, and a file naming convention. A file-naming convention is described in PART V. The file indices are kept in files that the FMS program can search to locate a given data set. The index files are updated automatically by the procedure for PROCLV.

PROCLV

23. The FMS program in the procedure file must be specifically activated in order to maintain the file indices. If it is activated, each file-producing run causes an entry to be made in the FMS indices. A 20-character catalog code requested in the PROCLV prompt sequence must be answered properly or the index update program will abort.

File Codes

24. The FMS is based on a 20-character catalog code that identifies the source and nature of each file. It grew out of a file-naming convention adopted for some projects in the WES Hydraulics Laboratory. The 20 characters are composed of 10 concatenated variables as shown in Figure N2.

FMS Maintenance

25. The FMS maintenance program is used to add new files to the index, to search for a specific file, back up a file, or remove (purge) a file from the system. It can be run in interactive or batch mode. Addendum N-1 provides user instructions.

FMS Indices

26. Table N3 shows the master index for the 11 sort variables for the two categories of Data and Code. This index is composed of a set of "FIRST,/LAST" pointers for each sort variable. Tables N4 and N5 define the index file structure for the two categories of Code and Data, respectively. The "first" pointer directs the search to the location of the "FROM/NEXT' pointer. Continuing in this manner, a quick forward or backward search of a sort variable is possible. For a search of any given 20-character catalog name, the above technique is used to compose the pointer numbers of the sort variables involved. The intersection of these lists provides all entries meeting the given specifications.

a. SOURCE (1 CHARACTER)

F = FIELD DATA
P = PHYSICAL MODEL
1 = GFGEN INPUT
G = GFGEN OUTPUT
2 = RMA-2V INPUT
R = RMA-2V OUTPUT
3 = STUDH INPUT
S = STUDH OUTPUT
H = HEC6 OUTPUT
K = SOCHMJ OUTPUT
P = CODE - PLOT
A = CODE - ANALYSIS
M = CODE - MODELING
D = CODE - DATA HANDLING
T = CODE - MAINTAIN

b. PLAN (2 CHARACTERS)

Any 2 characters

c. STORAGE MEDIA (1 CHARACTER)

T = TAPE - SITE 1 TAPE
D = DISC - SITE 1 FRONT END
F = DISC - SITE 1 BACKEND
M = MASS - SITE 1 MASS STORAGE
1 = TAPE - SITE 2 TAPE
2 = DISC - SITE 2 FRONT END
3 = DISC - SITE 2 BACKEND
4 = MASS - SITE 2 MASS STORAGE
C = CARD IMAGE

d. STUDY NO (1 CHARACTER)

Any character

e. TEST CONDITION (6 CHARACTERS)

Any 6 characters

Figure N2. FMS catalog codes

f. FORMAT (1 CHARACTER)

F = FORMAT
V = BINARY VECTOR MACHINE
C = BINARY FRONT END
S = SOURCE CARD
L = UPDATE LIBRARY, VECTOR MACHINE
U = UPDATE LIBRARY, FRONT END
D = UPDATE DIRECTIVE

g. DATA CATEGORY (1 CHARACTER)

H = HYDRAULIC
S = SEDIMENT
W = WAVE
Q = WATER QUALITY
B = BATHYMETRY
G = GEOMETRY
D = DMS FILES

h. GRADE (1 CHARACTER)

A = EXCELLENT
B = GOOD
C = FAIR
D = POOR
F = SEE LIBRARIAN

i. DATA SUBCATEGORY (2 CHARACTERS)

SE = SURFACE ELEVEVATION
QX = DISCHARGE
VX = VELOCITY
TX = TEMPERATURE
PX = PRESSURE
RX = RAINFALL
HD = WAVE HEIGHT-PER-DIR
SD = SPECTRAL DISTRIBUTION
HR = HARMONIC RESIDUAL
FX = FILTERED RESIDUAL
SS = SUSPENDED SEDIMENT
BM = BED MATERIAL
SX = SALINTY

j. VERSION (1 CHARACTER)

L = LIBRARY VERSION
R = RESEARCH VERSION
1 = FIRST VERSION
2 = SECOND VERSION
3 = THIRD VERSION

Figure N2. (concluded)

PART V: FILE-NAMING CONVENTIONS

24. A standard way to name files is a useful instrument in the modeler's toolbox. The TABS-2 system uses a reasonably consistent file-naming convention for program files and although a standard convention is not required for data files, it is strongly recommended. In this manual and in the procedure file, PROCLV, generic file names are used.

Program File Names

25. In general, program files are named with a prefix that is an acronym for the program name and version (e.g., STUDH version 3.3 has the prefix S33), a middle portion that indicates the structure of the file (e.g., CS means a card image source file), and a suffix that indicates program status or owner (e.g., LV means library version, JS might indicate Jaqueline Sibernetic's personal version). The complete name would be S33CSLV or perhaps S33CSJS. Note that the procedure file names used to run these programs are not the same as the file names.

Data File Names

26. If only one person is going to be running the programs or accessing the data files on a project and that one person possesses total recall, this section is not applicable. For mortals with fallible memories and shared projects, a standard naming convention for data files is more than a convenience, it is our life line to sanity.

27. A file-naming convention should follow the 3-S rule--be simple, slavishly followed, and written down. Beyond those requirements, it can be almost anything. Table N6 shows a convention that the WES Estuaries Division adopted several years ago. It is based on the coding shown in Figure N2.

Generic File Names

28. In the programs documentation and PROCLV on-line helps, input and output files are identified by generic file names. These generic file names are coded in a way that partially identifies them. The generic names are listed in Table N7.

29. The generic file names are for illustration purposes. They SHOULD NOT be used as names for actual files containing data.

Table N1

ELEVGRD Digitizer Input File Structure

Record Set No.	Variable Name	Description
1	MAP	MAP = map number (from title block of maps, e.g., 246)
	ITYPE	User's code for data type
2	ICODE	ICODE = -9
	ICODE	
3	NXUL	
	NYUL	
4	NXUR	Digitizer coordinates of the 4 map corners
	NYUR	UL = upper left
		UR = upper right
5	NXLL	LL = lower left
	NYLL	LR = lower right
6	NXLR	
	NYLR	
7	MXUL	
	MYUL	Map grid coordinates of the upper left and lower right map corners in 1000s ft
8	MXLR	
	MYLR	
9	ICODE	ICODE = 5555; CODE before area of interest data.
	NVAL	NVAL = 0
10	NX	
	NY	
	.	Coordinates of area of interest.
	.	
	.	
11	NCODE	NCODE = -7777 - before depth data
	MCODE	MCODE = range number used for checking data
12 (1-N)	NX	
	NY	N digitizer coordinates of a string of depth readings
	.	
	.	
	.	
13	NCODE	NCODE = -9999
	NCODE	-9999
14+		Varies with file type

Table N2

Standard Header Records in Model Output Files

Record No.	Sequence No.	Contents	Form
1	1	40 - 4-character words	Model identifier (RMA-2V, STUDH, etc.) of last model used
1	2	60 - 4-character words	Run control information input interactively
1	3	100 - 4-character words	Record 1 from previous model's output file that was used as input
1	4	100 - 4-character words	Record 1 from GFGEN if last model used was STUDH, otherwise null
2	1	40 Integer variables	Run contents identification flags
2	2	40 Real variables	Run contents identifiers
3+		See individual models	

Table N3

FMS Master Index File Structure

```
PT ( 1)    SOURCE        -
PT ( 2)    STUDY NUMBER   -
PT ( 3)    PLAN            -
PT ( 4)    CONDITION        -
PT ( 5)    STORE             -
PT ( 6)    FORMAT             ---- DATA POINTERS FIRST/LAST
PT ( 7)    CATALOG           -
PT ( 8)    SUBCATALOG       -
PT ( 9)    GRADE           -
PT (10)    ID             -
PT (11)    TAPENO        -

PT (12)    SOURCE        -
PT (13)                   -
PT (14)    FORM            -
PT (15)    VERS             -
PT (16)    STORE             -
PT (17)                       ---- CODE POINTERS FIRST/LAST
PT (18)                      -
PT (19)                     -
PT (20)                    -
PT (21)    ID             -
PT (22)    TAPENO        -
```

Table N4

FMS Code Index File Structure

1.	SOURCE	:	POINTER FROM/TO NEXT CODE TYPE
2.			
3.	FORM	:	POINTER FROM/TO NEXT CODE OF THAT FORM
4.	VERS	:	POINTER FROM/TO NEXT CODE OF THAT VERSION
5.	STORE	:	POINTER FROM/TO NEXT CODE OF THAT STORAGE MEDIA
6.	GRADE	:	POINTER FROM/TO NEXT CODE OF THAT GRADE
7.			
8.			
9.			
10.	IDUSER	:	POINTER FROM/TO NEXT CODE OF THAT USERID
11.	TAPENO	:	POINTER FROM/TO NEXT CODE OF THAT TAPE NUMBER
12.	TAPENO		SYMBOL FOR TAPE NUMBER
13.	GRADE		SYMBOL FOR GRADE
14.	IDUSER		SYMBOL FOR USERID
15.	PASSWD		SYMBOL FOR PASSWORD
16.	SOURCE		SYMBOL FOR SOURCE
17.			
18.	FORM		SYMBOL FOR FORM
19.	VERS		SYMBOL FOR VERSION
20.	STORE		SYMBOL FOR STORAGE MEDIA
21.	PERSON		SYMBOL FOR PERSON
22.			
23.			
24.	MISC		SYMBOL FOR MISCELLANEOUS
25.-			
26.	-FILENM		SYMBOL FOR COMPUTER FILE NAME
27.-			
28.	EDNM		SYMBOL FOR EDITION NUMBER
29.	DNOW		SYMBOL FOR DATA CODE WAS ENTERED IN FMS
30.	DBACK		SYMBOL OF POTENTIAL STORAGE DATA
31.	LIBRARY		SYMBOL FOR LIBRARIANS NAME IF VERS=L
32.	DESC		SYMBOL FOR DESCRIPTION OF DATA FILE

Table N5

FMS Data Index File Structure

1.	SOURCE	:	POINTER FROM/TO NEXT DATA OF THAT SOURCE
2.	STUDY	:	POINTER FROM/TO NEXT DATA OF THAT STUDY NUMBER
3.	PLAN	:	POINTER FROM/TO NEXT DATA OF THAT PLAN NUMBER
4.	COND	:	POINTER FROM/TO NEXT DATA OF THAT CONDITION NUMBER
5.	STORE	:	POINTER FROM/TO NEXT DATA OF THAT STORAGE MEDIA
6.	FORMAT	:	POINTER FROM/TO NEXT DATA OF THAT FORMAT
7.	CAT	:	POINTER FROM/TO NEXT DATA OF THAT CATALOG
8.	SUBCAT	:	POINTER FROM/TO NEXT DATA OF THAT SUBCATALOG
9.	GRADE	:	POINTER FROM/TO NEXT DATA OF THAT GRADE
10.	USERID	:	POINTER FROM/TO NEXT DATA OF THAT USERID
11.	TAPENO	:	POINTER FROM/TO NEXT DATA OF THAT TAPE NUMBER
12.	TAPENO	:	SYMBOL FOR TAPE NUMBER
13.	GRADE	:	SYMBOL FOR GRADE
14.	IDUSER	:	SYMBOL FOR USERID
15.	PASSWD	:	SYMBOL FOR PASSWORD
16.	SOURCE	:	SYMBOL FOR SOURCE
17.	STUDYN	:	SYMBOL FOR STUDY NUMBER
18.	PLAN	:	SYMBOL FOR PLAN
19.	COND	:	SYMBOL FOR CONDITION NUMBER
20.	STORE	:	SYMBOL FOR STORAGE MEDIA
21.	FORMAT	:	SYMBOL FOR FORMAT
22.	CAT	:	SYMBOL FOR CATALOG
23.	SUBCAT	:	SYMBOL FOR SUBCATALOG
24.	MISC	:	SYMBOL FOR MISCELLANEOUS FIELD
25.			
26.	-FILENM	:	SYMBOL FOR COMPUTER FILE NAME
27.	-		
28.	EDNM	:	SYMBOL FOR EDITION NUMBER
29.	DNOW	:	SYMBOL FOR DATA OF ENTRY INTO INDEX
30.	DBACK	:	POTENTIAL SYMBOL FOR DATA OF BACKUP STORAGE
31.	PERSON	:	SYMBOL FOR PERSON RESPONSIBLE FOR DATA FILE
32.	DESC	:	SYMBOL FOR DESCRIPTION OF DATA FILE

Table N6

Data File-Naming Convention

Character No.	Meaning	Example
1	Project	C = Columbia River, A = Atchafalaya Bay
2	Program	S = STUDH, R = RMA-2V
3	Data use	I = Input, O = Output
4-5	Plan or mesh number	BL = Base low flow
6-7	Run number codes	1 = 1

Table N7

Index by Generic Input/Output File Name

Generic File Name	Purpose of File	Source	Units	File Type
I1CO	Card image data to run CONTOUR	Editor	*	Coded
I1EG	Card image data to run ELEVGRD	Editor	English	Coded
I2EG	Digitized input to ELEVGRD	DMSDIG or Editor	English	Coded
I1EM	Card image data to run ENGMET	Editor	English	Coded
I2EM	Update data for datum & MSL for ENGMET	Editor	English	Coded
I1GI	Digitizer file for input to PREMESH	Digitizer	English	Coded
I2GI	Card image data to run PREMESH	Editor	English	Coded
I3GI	Output from PREMESH; scratch	PREMESH	English	
I1MP	Local METAPLOT file for graphics	METAB	*	Binary
I1RP	Card image data for RETPNT	Editor	English	Coded
I2RP	Computation grid coordinator	I1RI Digitizer	English	Coded
I3RP	DMS-A format gridded data file	ELEVGRD	English	Binary
I1RI	Card image data for GFGEN	Editor	English	Coded
I2RI	Geometry = O1RI from previous GFGEN run	GFGEN	English	Binary
I1R2	Card image data for RMA-2V	Editor	English	Coded
I2R2	Card image boundary conditions data for RMA-2V	Editor or custom program	English	Coded
I3R2	HOTSTART input file for RMA-2V	RMA-2V	English	Binary
I1R4	Card image data for RMA-4	Editor	Metric	Coded

* Units can be either English or metric, depending on the requirement of the model.

Table N7 (continued)

Index by Generic Input/Output File Name

Generic File Name	Purpose of File	Source	Units	File Type
I2R4	HOTSTART input file for RMA-4	RMA-4	Metric	Binary
I1S3	Card image data for STUDH	Editor	Metric	Coded
I1VP	Card image data for VPLOT	Editor	Same as data source	Coded
O1CO	File of interpolated values on uniform grid	Contour	*	Binary
O1EG	File of interpolated values on uniform grid	ELEVGRD	*	Binary
O1EM	Geometry for STUDH	ENGMET	Metric	Binary
O2EM	Water-surface elevations for STUDH	ENGMET	Metric	Binary
O3EM	Velocities for STUDH	ENGMET	Metric	Binary
O1G1	Mid-side nodes from AUTOMSH	AUTOMSH	English	Coded
O2G1	Nodal coordinates & connection table for corner nodes, boundary flags & material types	RENUM	English	Binary
O3G1	PLOT file from QMESH for METAPLOT to view smoothness	QMESH	English	Binary
O4G1	Output from AUTOMSH for use in input to GFGEN	POSTMSH	English	Coded
O1RP	A new GFGEN input file	RETPNT	English	
O2RP	Scratch file in TABS-2	RETPNT	English	Coded
O1R1	Geometry data for RMA-codes	GFGEN	English	Binary
O2R1	New, clean GFGEN card image input data (i.e. unused elements & nodes eliminated)	GFGEN	English	Coded
O1R2	Water surface and velocity output file	RMA-2V	English	Binary

* Units can be either English or metric, depending on the requirement of the model.

ADDENDUM N1: USER INSTRUCTIONS FOR FMS-HL

This program may be run interactively or in batch mode. To make an interactive run type the following:

```
CLEAR
GET,FMSHLLV/PW=----------.
FTN,I-FMSHLLV,L=OUT
LGO.
```

As the program asks questions, answer appropriately. A sample session is given below. The following pages provide sample input for various FMS operations.

INPUT DATA SET (A)

```
ENTER VALUE FOR BATCH   IF BATCH = 0   INSTRUCTIONS ARE WRITTEN
                                       TO FILE CODE 06          (I1)
                           BATCH = 1   ONLY ERROR MESSAGES
                                       ARE PRINTED
                 ECHO   IF ECHO  = 0   INPUT IS NOT ECHOED
                                       TO FILE CODE 06          (I1)
                           ECHO  = 1   INPUT IS ECHOED TO FILE
                                       CODE 06 AS ENTERED

IN GENERAL, FOR BATCH RUNS ENTER "11"
            FOR INTERACTIVE RUNS ENTER "00"
```

INPUT DATA SET (B)

```
WELCOME TO THE FILE MANAGEMENT SYSTEM OF THE WESHL DMS
ALL COMMANDS MUST BEGIN IN COLUMN 1.
ENTER ONE OF THE FOLLOWING:  "N" - CREATE A NEW FILE
                             "A" - ADD AN EXISTING FILE TO FMS
                             "S" - SEARCH FOR A FILE
                             "B" - BACKUP A FILE
                             "P" - PURGE A FILE
                             "E" - EXIT PROGRAM
```

FOR "N" - CREATE A NEW FILE AND SET (A) = 00

```
I>N

  AT ANY POINT DURING THE QUESTION/ANSWER SECTION
  YOU MAY TYPE IN A "?" FOR AN INSTRUCTION MENU.

  ENTER "CODE" OR "DATA" AS THE TYPE OF FILES TO BE CREATED.

I>____
  ENTER "Y" IF YOU NEED PROMPTS TO NAME YOUR FILE
  ENTER "N" IF YOU CAN ENTER ENTIRE FILE NAME INFO SOLO.

I>Y
```

```
  ENTER PROJECT CODE (1 DIGIT)

I>_
  ENTER SOURCE (1 DIGIT)

I>_
  ENTER STORAGE MEDIA (1 DIGIT)

I>_
  ENTER FORMAT (1 DIGIT)

I>_
  ENTER USER DEFINED MISCELLANEOUS (4 DIGITS)
  THERE IS NOT A MENU FOR THE MISC FIELD

I>____
  ENTER COMPUTER FILE NAME
  (MAX 30 CHAR.  IF YOUR COMPUTER HAS FEWER CHAR FOR
  FIELD THEN LEFT-JUSTIFY AND RETURN.)

I>__________
  ENTER FILE'S PASSWORD (10 DIGITS).  IF NONE THEN ENTER 0.

I>__________
  ENTER USERID THAT YOUR FILE WILL BE CATALOGED IN

I>__________
  ENTER EDITION NO. (2 DIGITS) IF APPLICABLE OR "--"

I>__
  ENTER GRADE (1 DIGIT)

I>__
  ENTER YOUR LAST NAME (10 CHARACTERS)

I>__________
  ENTER A BRIEF FIL  DESCRIPTION (80 CHARACTERS)

I>THIS IS A TEST OF FMS HANDLING A NEW FILE
  ------------------------------------------
  ENTER VERSION

I>

IF YOU WISH TO DO MORE FMS FUNCTINOS, TYPE "M"

I>NO MORE
```

FOR BATCH "N" - CREATE A NEW FILE

```
JOB,CM200000,T70,P04. DONNELL/601-634-2730/HYD SEDIMENT/
USER,CEROH8.XXXX.
GET,FMSHLLV.
FTN,I-FMSHLLV.                  -
LGO.                            -
EXIT,U.                          -
DAYFILE,DAYBD.                    -
REPLACE,DAYBD.                     - CYBER CONTROL LANGUAGE
REWIND,OUTPUT.                    -
COPY,OUTPUT,OUTBD.               -
REPLACE,OUTBD.                  -
CATLIST.                       -
11                              -     BATCH OPTION
N                               -     NEW
DATA                            -     DATA FILE
N                               -     NO PROMPTS
A                               -     SITE = ATCHAFALAYA
AFXXXXXXXXXDVWHPTOOB            -     CATALOG NAME
TOOBD                           -     FILE NAME
0                               -     NO PASSWORD
CEROH8                          -     USER ID
--                              -     NO EDITION NUMBER
F                               -     GRADE
DONNELL                         -     PERSON RESPONSIBLE
BOLOGNA FILE FOR TESTING NEW DATA ENTRY BATCH//////////////////////
M                               -     MORE FMS FUNCTIONS
11                              -     BATCH
N                               -     NEW
CODE                            -     CODE FILE
N                               -     NO PROMPTS
A                               -     SITE = ATCHAFALAYA
AAXXXXXXXXXDUCHRTEST            -     CATALOG NAME
TO1BD                           -     FILE NAME
0                               -     NO PASSWORD
CEROH8                          -     USERID
--                              -     NO EDITION NUMBER
F                               -     GRADE
DONNELL                         -     PERSON RESPONSIBLE
BOLOGNA FILE FOR TESTING NEW CODE ENTRY BATCH/////////////////////
1                               -     VERSION
NO MORE                         -     NO MORE FMS FUNCTIONS
*WEOI
```

FOR "A" - ADD AN EXISTING FILE TO FMS AND SET (A = 00

ENTER "Y" IF YOU NEED PROMPTS TO NAME YOUR FILE
ENTER "N" IF YOU CAN ENTER ENTIRE FILE NAME INFOR SOLO.

```
I>Y
 ENTER PROJECT CODE (1 DIGIT)

I>_
 ENTER SOURCE (1 DIGIT)

I>_
 ENTER STUDY NUMBER (1 DIGIT)

I>_
 ENTER PLAN NO. (2 DIGITS)

I>__
 ENTER CONDITIONS (6 DIGITS)

I>______
 ENTER STORAGE MEDIA (1 DIGIT)

I>_
 ENTER FORMAT (1 DIGIT)

I>_
 ENTER DATA CATEGORY (1 DIGIT)

I>_
 ENTER DATA SUBCATEGORY (2 DIGITS)

I>__
 ENTER USER DEFINED MISCELLANEOUS (4 DIGITS)
 THERE IS NOT A MENU FOR THE MISC FIELD

I>____
 ENTER COMPUTER FILE NAME
 (MAX 30 CHAR. IF YOUR COMPUTER HAS FEWER CHAR FOR
 FILE THEN LEFT-JUSTIFY AND RETURN.)

I>______________________________
 ENTER FILE'S PASSWORD (10 DIGITS). IF NONE ENTER 0

I>__________
 ENTER USERID THAT YOUR FILE WILL BE CATALOGED IN

I>______
 ENTER EDITION NO. (2 DIGITS) IF APPLICABLE

I>__
 ENTER GRADE (1 DIGIT)

I>_
 ENTER YOUR LAST NAME (10 DIGITS)
```

I>____________
ENTER A BRIEF FILE DESCRIPTION (80 CHARACTERS)

I>____

I>NO MORE

FOR BATCH "A" - ADD AN EXISTING FILE TO INDEX

```
BTCHBD EDITED AND REPLACED.
C>LIST
JOB,CM200000,T70,P04,DONNELL/601-634-2730/HYD SEDIMENT/
USER,CEROH8,XXXX.
GET,FMSHLLV.
FTN,I-FMSHLLV.
LGO.
EXIT,U.
DAYFILE,DAYBD.
REPLACE,DAYBD.
REWIND,OUTPUT.
COPY,OUTPUT,OUTBD.
REPLACE,OUTBD.
CATLIST.
11                                  -           BATCH OPTION
A                                               ADD
DATA                                -           DATA FILE
N                                   -           NO PROMPTS
A                                   -           SITE = ATCHAFALAYA
A1XXXXXXXXXDFGXXBIGA                -           CATALOG NAME
AGVIBIG                             -           FILE NAME
0                                   -           NO PASSWORD
CEROH8                              -           USER ID
--                                  -           NO EDITION NUMBER
A                                   -           GRADE
DONNELL                             -           PERSON
ATCHAFALAYA BIG GRID INPUT FOR RMA-1V (ABOUT 1900 NODES - 600 ELEMENTS)
M                                   -           MORE TO COME
11                                  -           BATCH OPTION
A                                   -           ADD
CODE                                -           CODE FILE
N                                   -           NO PROMPTS
A                                   -           SITE = ATCHAFALAYA
AMXXXXXXXXXDSGXXVV22                -           CATALOG NAME
R1VCSF2                             -           FILE NAME
0                                   -           NO PASSWORD
CEROH8                              -           USER ID
--                                  -           NO EDITION NUMBER
A                                   -           GRADE
DONNELL                             -           PERSON
RMA-1V LIBRARY VERSION WITH COMDECK AND CHANGES FOR BIG GRID RUNS.....
L                                   -           LIBRARY VERSION
B.DONNELL                           -           LIBRARIAN'S NAME
NO MORE                             -           NO MORE FMS FUNCTIONS
*WEOI.
```

FOR "S" - SEARCH THE PROJECT INDEX

```
I>S
 ENTER "CODE" OR "DATA"

I>____
 ANSWER THE FOLLOWING WITH THE REQUIRED NO. OF DIGITS
 OTHERWISE ENTER "?"
 ENTER SITE (1 DIGIT) - THEN RETURN
        SOURCE (1 DIGIT)
        STUDY NO. (1 DIGIT)
        PLAN (2 DIGITS)
        CONDITION (6 DIGITS)
        STORAGE (1 DIGIT)
        FORMAT (1 DIGIT)
        CATEGORY (1 DIGIT)
        SUBCATEGORY (2 DIGITS)
        GRADE (1 DIGIT)
        USERID (10 DIGITS)
        TAPE NO. (10 DIGITS)

I>_
I>_
I>_
I>__
I>______
I>_
I>_
I>_
I>__
I>_
I>__________
I>__________

IF YOU'VE MADE A MISTAKE TYPE "T"

I>OK

NO. = 8
       A   CEROH8      0      D  X    XX XXXXXX D   F   D   XX PFMS

FILE NAME = AINDX                    EDITION NO. = --

CREATED = 81/05/20.  STORED=          PERSON= DONNELL  DESCRIPTION=
FMS POINTER INDEX FOR ATCHAFALAYA PROJECT - DO NOT ALTER!! SEE B.P.
DONNELL!!
000000    000000    000000    000000    000000    000000    000000
000000    000000    000000
 IF YOU WISH TO DO MORE FMS FUNCTIONS, TYPE "M"

I>_
```

FOR BATCH "S" - SEARCH THE INDEX

```
OLD,TBCHBD
C>LIST
JOB,CM200000,TYO,P04.  DONNELL/601-634-2730/HYD SEDIMENT/
USER,CEROH8,XXXX.
GET,FMSHLLV/PW=------.
FTN,I=DMSIBD.
LGO.
EXIT,U.
DAYFILE,DAYBD.
REPLACE,DAYBD.
REWIND,OUTPUT.
COPY,OUTPUT,OUTBD.
REPLACE,OUTBD.
CATLIST.
01                     -      BATCH=0  ECHO=1
S                      -      SEARCH
CODE                   -      CODE FILES
A                      -      ATCHAFALAYA INDEX
?                      -      SOURCE
?                      -      STUDY NO.
??                     -      PLAN
?????                  -      CONDITION
D                      -      STORAGE
?                      -      FORMAT
?                      -      CATEGORY
??                     -      SUBCATEGORY
F                      -      GRADE
??????????             -      USER ID
??????????             -      TAPE NO.
OK GO                  -      NO MISTAKES
M                      -      MORE FMS FUNCTIONS
01                     -      BATCH=0  ECHO=1
S                      -      SEARCH
DATA                   -      DATA FILE
A                      -      ATCHAFALAYA INDEX
?                      -      SOURCE
?                      -      STUDY NO.
??                     -      PLAN
??????                 -      CONDITION
?                      -      STORAGE
?                      -      FORMAT
?                      -      CATEGORY
??                     -      SUBCATEGORY
F                      -      GRADE
??????????             -      USER ID
??????????             -      TAPE NO.
OK                     -      NO MISTAKES
NO MORE                -      NO MORE FMS FUNCTIONS
*WEOI.
```

FOR "P" - PURGE A FILE ON BCS DISK

```
I>P
 ENTER PURGE PERMISSION PASSWORD
 ENTER "CODE" OR "DATA"
 ENTER CATALOG NAME (20 CHARACTERS)
 ENTER GRADE (1 DIGIT)
 ENTER USERID (10 CHARACTERS)
 ENTER VERSION (1 CHARACTER)

I>______
I>____
I>____________________
I>_
I>__________
I>_

IF YOU WISH TO DO MORE PURGES TYPE "M"

I>NO
```

APPENDIX O: PROCLV, PROCEDURE FILES FOR JOB CONTROL

Barbara Park-Donnell

APPENDIX O: PROCLV, PROCEDURE FILES FOR JOB CONTROL

PART I. INTRODUCTION

1. PROCLV is a master procedure file which is used to run the computer codes associated with TABS-2. The purpose of the master procedure is to permit the user to run TABS-2 jobs without learning details of job control language. It accomplishes this by providing a prewritten set of job control language (JCL) that can be selected by the user in a prompt-driven interactive session.

2. The procedure file is written in Cyber Control Language (CCL) and the corresponding control language for the vectorizing computer on which the programs run.

3. PROCLV was written by B. Park-Donnell, D. P. Bach, and S. A. Adamec, Jr., of the WES Hydraulics Laboratory.

PART II. USE OF PROCLV

PROCLV Installation

4. PROCLV is installed on each user's disk storage area. Installation is accomplished by accessing the library version of the file, PROCLV2, moving it to the user number where it is to be used, and customizing it.

5. Once a customized PROCLV procedure file is established, a more user-friendly computer environment is established. The TABS-2 modeler is not required to learn either front-end or vector machine JCL. The modeler's efforts may be concentrated on the project and not the pecularities of the computer.

6. For each user number running the TABS-2 system, PROCLV2 is edited, following the NEWU instructions, as seen in Figure 01, and a resulting customized procedure file, PROCLV, is stored. Three steps are required to customize PROCLV on Cybernet. Using a terminal in communication with Cybernet front end computer, the user enters these commands:

```
GET,PROCLV=PROCLV2/UN=CER0H9

BEGIN,HELP,PROCLV,NEWU

XEDIT,PROCLV
      .
      .
      .
```

The second step gives instructions for editing the file as shown in Figure 01.

Capabilities

7. The current contents and capabilities of a customized PROCLV can be obtained by the command:

```
BEGIN,HELP,PROCLV
```

Figure 02 shows the messages that will be printed by this command and the categories of the modules available. Detailed information for each of the modules can be obtained by the command:

```
BEGIN,HELP,PROCLV,module name
```

where module name is the name of the program or group of programs for which information is needed.

TABS 2 Programs

8. In general, the procedure call for a given program is the same as the program name, but there are some exceptions. Table 01 lists the TABS-2 programs and gives the procedure name to use and the appendix that describes the program.

System Utilities

9. Several system utilities are available through PROCLV. These utilities perform housekeeping and monitoring chores that are commonly used by modelers. For example, GENOB creates an object version of a program and is used to create custom versions of the programs. Other utilities are listed in Table 02.

10. JSTS (Job Status) is a particularly useful time-sharing utility program. It tracks a batch job as it moves through input, execution, and output. If the user requests, JSTS will attach a job as it enters the output queue, make the output a local file, and automatically go into XEDIT. PROCLV HELP gives instructions for JSTS. To use it, type the following once:

GET,JSTS/UN=CER0F9 <CR>

Thereafter in the same time-sharing session, JSTS may be invoked by typing:

JSTS,job,instruct <CR>

where

job = the 7 character job name to track, or L* will automatically find
1) last job submitted from a procedure file,
2) if none, last job submitted from present terminal, or
3) if none, last job routed.

T* will automatically find
1) last job submitted from a terminal or
2) if none, last job routed.

instruct = additional instructions to execute after job returns.

D* means make the job a local file to the terminal and go into XEDIT; then a <CR> in XEDIT mode will automatically list dayfile.

G* means make the job a local file to the terminal.

Generic File Names

12. The HELP prompts in PROCLV use generic file names to identify input and output files. These generic names have been developed to help the user understand the file contents. The generic name concept is explained in Appendix A: Files and FAS. Table 03 lists the generic names and their functions.

13. The user must not use the generic file names as actual file names when invoking PROCLV.

```
/BEGIN,HELP,PROCLV2,NEWU
NEWU
====
INFORMATION ON SETTING UP THIS FILE FOR NEW USERS. ALL CHANGE COMMANDS ARE IN
XEDIT FORMAT.

TO OBTAIN THE MASTER PROCEDURE FILE
               GET,PROCLV=PROCLV2/UN=CEROH9
               BEGIN,INSTALL,PROCLV
  - ANSWER THE QUESTIONS THE PROC ASKS -
  - WILL CHANGE USER NUMBERS, PASSWORDS, AND PROBLEM SIZE -
  - FOR ANY ADDITIONAL CHANGES, SEE BELOW -
               XEDIT,PROCLV

TO SET UP LINK INFO ON CYBER 205 (NECESSARY TO MOVE 205 FILES TO KOE)
              BEGIN,LINKNEW,PROCLV (CR)  (AFTER THIS PROCEDURE FILE IS SET UP)

TO CHANGE FROM WES PHONE NUMBER ---
               C/(601)634-3111/YOURPHONE/*
                     WHERE    YOURPHONE = NEW PHONE NUMBER
  EXAMPLE -- C/(601)634-3111/(601)634-3163/*

TO CHANGE ORGANIZATION AND LOCATION FROM USAEWESHE, VICKSBURG ---
               C/USAEWESHE, VICKSBURG/YOURORG, YOURLOC/*
                     WHERE    YOURORG = NEW ORGANIZATION NAME
                              YOURLOC = NEW CITY AND STATE

TO CHANGE MAILING INFORMATION USED TO MAIL CALCOMP PLOTS ---
               C/WATERWAYS EXPERIMENT STATION/YOURPLACE/
               C/HYDRAULICS LABORATORY/YOUROFFICE/
               C/P.O. BOX 631/YOURPO/
               C/HALLS FERRY ROAD/YOURSTREET/
               C/VICKSBURG, MS 39180/YOURTOWN/
                     WHERE    YOURPLACE = NEW STATION OR DISTRICT
                              YOUROFFICE = NEW OFFICE OR DIVISION
                              YOURPO = NEW POST OFFICE BOX
                              YOURSTREET = NEW STREET ADDRESS
                              YOURTOWN = NEW CITY, STATE AND ZIP CODE

TO SET UP LINK INFO ON CYBER 205 (NECESSARY TO MOVE 205 FILES TO KOE)
              BEGIN,LINKNEW,PROCLV (CR)  (AFTER THIS PROCEDURE FILE IS SET UP)

*** YOUR FINAL VERSION OF THIS PROCEDURE SHOULD BE NAMED "PROCLV" ****
REVERT. HELP
```

Figure 01. PROCLV installation instructions

```
/BEGIN,HELP,PROCLV2
HELP
WESHE OPERATING SYSTEM, OCTOBER 3, 1984, GENERAL INFORMATION

LISTING OF AVAILABLE CATAGORIES ....

1)  UTILITIES (UTIL)      - THE USER'S SURVIVAL KIT.
2)  PREPROCESSING (PREP) - CODES HANDLING GRID PREPARATION
3)  MODELS (MODE)         - ALL SUPPORTED TABS-2 FE NUMERICAL MODELS
4)  POSTPROCESSING (POST)- CODES EXAMINING FE MODEL RESULTS
5)  DMSA   (DMSA)         - CODES USED IN DATA MANAGEMENT SYSTEM A
6)  NEWU   (NEWU)         - INFORMATION ON CUSTOMIZING THE MASTER PROC

FOR HELP ON AVAILABLE CATAGORIES,TYPE----
    BEGIN,HELP,PROCLV,CATNAME  <CR>
        WHERE CATANAME = THE 1ST 4 CHARACTERS OF 1 OF THE ABOVE CATAGORIES

************************************************************************
WHEN ALL ELSE FAILS, CALL WES-HE TABS-2 HOTLINE:(601)634-2801 OR (X-2821)
************************************************************************
REVERT. HELP
```

Figure 02. PROCLV MAIN HELP

```
/BEGIN,HELP,PROCLV,UTIL
UTIL
UTILITIES
=========
     ASKDMS  - ADDS FILE MANAGEMENT SYSTEM INFORMATION TO MODEL JCL FILES
     BIN2FOR - CONVERTS 205 BINARY TABS-2 FILES TO FORMATTED
     FNDNODE - FINDS A NODE IN A FE GRID GIVEN COORDINATES
     FOR2BIN - CONVERTS FORMATTED TABS-2 FILES TO 205 BINARY (F2BCSL3)
     GENOB   - UPDATE AND COMPILE PROGRAMS ON THE CYBER 205
*    GRANT   - GIVES A NEW USER NUMBER PERMISSION TO ALL LIBRARY WESHE CODES
X    JABT    - ABORT A JOB RUNNING ON BATCH USER NUMBER
X    JDVT    - DIVERT A JOB CHARGED TO BATCH USER NUMBER TO A DIFFERENT RJE ID
X    JFND    - LISTS ALL JOBS CHARGED TO YOUR BATCH USER NUMBER
     JSTS    - JOB STATUS TRACKING SYSTEM FOR CYBERNET
X    JPRI    - CHANGE THE PRIORITY OF A JOB CHARGED TO BATCH USER NUMBER
     LINKNEW - SETS UP DATA FOR THE CYBER 205 LINK COMMAND TO USE
     MAIL    - ADDS BANNERS TO A FILE, OPTIONALLY PRINT SHIFTS IT, AND
               SENDS IT TO AN RBF PRINTER
     META    - METAPLOT ONLINE POSTPROCESSOR
     METAB   - METAPLOT CALCOMP POSTPROCESSOR (BATCH JOB)
     READSBU - READS CYBER 205 SBU FILE AND EXTIMATES COMPUTER COST TO DATE
     TABSMSG - PRINTS ONLINE MESSAGE ABOUT TABS-2 SYSTEM STATUS
     205COM  - SENDS A COMMAND TO THE CYBER 205 FOR EXECUTION

************************************************************************
NOTE:  *  INDICATES THAT PROCEDURE IS NOT YET IMPLEMENTED ON CYBERNET
       X  INDICATES THAT PROCEDURE IS REPLACED BY A STOCK CDC UTILITY
************************************************************************

FOR HELP ON PARAMETERS, TYPE----
    BEGIN,HELP,PROCLV,PROCNAME <CR>
        WHERE PROCNAME = ONE OF THE NAMES LISTED ABOVE
REVERT. HELP
```

Figure 03. PROCLV UTILITIES HELP

```
/BEGIN,HELP,PROCLV,PREP
PREP
PREPROCESSING
=============
    AUTOMSH - CREATES GRIDS BY REGION (RUNS PREMESH, QMESH, RENUM, AND POSTMSH)
    EDGRG   - EDIT GRIDS GRAPHICALLY (EDGRG)
    ELEVGRD - MAKES REGULAR GRID FROM SCATTERED DIGITIZER DATA
    GFGEN   - RUNS THE TABS BATCH PREPROCESSOR (GFGEN)
    JOBSTRM - SETS UP BOUNDARY CONDITIONS FOR INSET GRID
    QPLOT   - PLOTS OUTPUT FROM RENUM, WINDOWING BY SECTION
    RETPNT  - PULLS VALUES AT SELECTED LOCATIONS FROM REGULAR GRID
              CAN BE USED TO ADD WATER SURFACE ELEVATIONS TO GFGEN INPUT FILE

FOR HELP ON PARAMETERS, TYPE----
   BEGIN,HELP,PROCLV,PROCNAME <CR>
      WHERE PROCNAME = ONE OF THE NAMES LISTED ABOVE
REVERT. HELP
/BEGIN,HELP,PROCLV,MODE
MODE
MODELS
======
    ENGMET  - RUNS CONNECTION BETWEEN RMA2V AND STUDH (ENGCSL3)
    RMA2V   - RUNS THE TABS 2-D FE VELOCITY MODEL (RMA2V VERSION 23)
    RMA4    - RUNS THE TABS 2-D FINITE ELEMENT QUALITY MODEL (RMA4)
    STUDH33 - RUNS THE TABS 2-D SEDIMENTATION MODEL (STUDH VERSION 33)

FOR HELP ON PARAMETERS, TYPE----
   BEGIN,HELP,PROCLV,PROCNAME <CR>
      WHERE PROCNAME = ONE OF THE NAMES LISTED ABOVE
REVERT. HELP
```

Figure 04. PROCLV PREPROCESSING HELP

```
MODE
MODELS
======
     ENGMET  - RUNS CONNECTION BETWEEN RMA2V AND STUDH (ENGCSL3)
     RMA2V   - RUNS THE TABS 2-D FE VELOCITY MODEL (RMA2V VERSION 23)
     RMA4    - RUNS THE TABS 2-D FINITE ELEMENT QUALITY MODEL (RMA4)
     STUDH33 - RUNS THE TABS 2-D SEDIMENTATION MODEL (STUDH VERSION 33)

FOR HELP ON PARAMETERS, TYPE----
    BEGIN,HELP,PROCLV,PROCNAME <CR>
        WHERE PROCNAME = ONE OF THE NAMES LISTED ABOVE
REVERT. HELP
/
```

Figure 05. PROCLV MODELS HELP

```
/BEGIN,HELP,PROCLV,POST
POST
POSTPROCESSING
==============
     ACE     - CREATES VECTOR PLOTS OF SEDIMENT TRANSPORT FOR 1 OR MORE
               HYDROGRAPH SOLUTIONS OF STUDH CONC DEL/BED FILES, AND
               COMPUTES SHOALING VOLUMNS. (ACEOBL3)
     CONTOUR - CONTOURS DATA FROM GFGEN, RMA2, RMA4, AND STUDH (CONTOUR)
     POSTHYD - GENERAL PURPOSE RMA2V POSTPROCESSOR
     PSTQUAL - GENERAL PURPOSE RMA4 POSTPROCESSOR
     POSTSED - ANALYZES DEPOSITION/EROSION ACTIVITY FROM STUDH
     SEDGRAF - PLOTS CONCENTRATION/BED-CHANGE FROM STUDH
     VPLOT   - PLOTS VELOCITY VECTORS FROM RMA2V
     WDGPLOT - PLOTS WET/DRY PORTIONS OF GRID FROM RMA2V RESULTS

FOR HELP ON PARAMETERS, TYPE---
    BEGIN,HELP,PROCLV,PROCNAME (CR)
        WHERE PROCNAME = ONE OF THE NAMES LISTED ABOVE.
REVERT. HELP
```

Figure 06. PROCLV POSTPROCESSING HELP

```
/BEGIN,HELP,PROCLV,DMSA
DMSA
DATA MANAGEMENT SYSTEM A
========================
*    BATHVOL - COMPUTES VOLUMES BETWEEN 2 SETS OF GRIDDED DATA
*    BTHAREA - CALCULATES ARES BETWEEN CONTOURS
*    DGPLT   - QUALITY CONTROL AND PLOT OF DIGITIZED DATA
*    DMSDIG  - CONVERT DIGITIZER TABLET OUTPUT TO INPUT FOR:
               ELEVGRD,REFMT,RETPNT,PREMESH,FACGRD,CONPEG
*    DUMPER2 - PRINTS SWATHS OF GRIDDED DATA (DUMPS OUTPUT OF ELEVGRD & TRANSA)
     ELEVGRD - CREATES A REG DMS-FORMATTED GRID FROM RANDOMLY DISTRIBUTED
               (X,Y,Z) DIGITIZED DATA
*    FACGRD  - SETS UP A PATCH OR FACTOR MAP
*    FO2UN   - CONVERT UN2FO OUTPUT BACK TO DMS GRIDDED BINARY
*    4VIEW   - PLOTS 3D LINE PLOTS FROM ELEVGRD FILE WITH 4 POINTS OF VIEW
*    GRDSUB  - WRITES A SET OF GRIDDED DIFFERENCES BETWEEN 2 GRIDDED DATA SETS
*    MESH1   - MERGES TABULAR DATA INTO (X-Y) GRIDDED DATA SETS
*    MESH2   - MERGES STANDARD HYDROGRAPHIC SURVEY DATA INTO (X-Y) GRIDDED DATA
*    MESH3   - MERGES GRIDDED DIGITIZED DATA FROM SEVERAL MAPS
*    REFMT   - CONVERTS SPECIAL DIGITIZER FILES INTO FORMAT REQUIRED BY ELEVGRD
     RETPNT  - RETRIEVES DATA PTS FROM A PREVIOUSLY CREATED DMS FORMATTED GRID
*    TRANSA  - TRANSFORMS GRIDDED DATA FROM 1 GRID SYSTEM TO ANOTHER
*    UN2FO   - CONVERT DMS GRIDDED DATA FILES TO FORM PORTABLE BETWEEN COMPUTERS

*************************************************************************
NOTE: * INDICATES THAT PROCEDURE IS NOT YET IMPLEMENTED ON CYBERNET
*************************************************************************
REVERT. HELP
```

Figure 07. PROCLV DMS-A HELP

Table 01
Program Procedure Name Index

PROGRAM*	PURPOSE	APPENDIX
ACE	Assemble STUDH events, compute bed change and dredging volumes, plot sediment transport vectors.	J
AUTOMSH	Create computational meshes.	D
BATHVOL	Compute volume of sediment difference between two surveys.	L
BIN2FOR	Transform binary model output files to formatted files.	J
BTHAREA	Compute areas within contours.	L
CONFEG	Convertdigitizerfile toGFGENformat	D
CONTOUR	Plot contour map of specified data.	I
DROGUEPLT (DRGPLT)	Plot path of a drogue moving with current.	I
DMSDIG	Digitize data from a map or graph.	L
DGPLT	Plot digitized data for checking.	L
DIRECT	Display a plot on a graphics terminal.	I
(META)	Display a plot on a CALCOMP device.	I
DUMPEL2	Print gridded data in swaths	L
EDGRG	Edit computational network interactively.	D
ELEVGRD	Create standard DMS data format file from randomly spaced data.	L
ENGMET	Translate RMA-2V output from English units to SI units for use by STUDH.	M
FACGRD	Set up factor or patch map.	L
FO2BN	Transform formatted file to DMS binary form.	L

*See PROCLV HELP for latest information on availability. Procedure names shown in parentheses if different from program name.

Table 01 (Continued)

PROGRAM*	PURPOSE	APPENDIX
FOR2BIN	Transform formatted model output files to binary files	J
4VIEW	Plot psuedo-3-D graphs.	I
GFGEN	Create geometric data file for use by models.	D
GRDSUB	Subtracts one set of gridded data from another and writes results to a file.	L
JOBSTREAM (JOBSTRM)	Computes boundary conditions for an insetcomputationalnetworkusing results of a larger network model run.	M
MESH1	Merges tabular data into a gridded data set	L
MESH2	Merges standard hydrographic survey data into a gridded data set.	L
MESH3	Merges gridded data from several maps.	L
POSTHYD	Analyze results of an RMA-2V run and plot time-histories.	J
POSTSED	Summarize results of a STUDH run.	J
RETPNT	Interpolates gridded data to provide data at specified points.	L
REFMT	Convert special digitizer data files to standard format.	L
RM -2V (RMA2V)	Compute two-dimensional flow and water levels.	F
RMA-4 (RMA4)	Compute transport of dissolved and suspended substances.	H
SEDGRA	Produce factor map of STUDH results.	I

---

*See PROCLV HELP for latest information on availability. Procedure names shown in parentheses if different from program name.

Table 01 (Continued)

PROGRAM*	PURPOSE	APPENDIX
STUDH (STUDH33)	Compute transport, erosion, and deposition of sediments.	G
TRANSA	Transforms data from one grid system to another.	L
UN2FO	Transform binary form data to formatted form.	L
VPLOT	Produce vector plots of RMA-2V velocity results.	I
WDGPLT	Plot wet and dry areas of computational mesh as calculated by RMA-2V.	I

---

*See PROCLV HELP for latest information on availability. Procedure names shown in parentheses if different from program name.

Table 02

System Utility Procedure Index

Procedure & Program Name	Purpose
ASKDMS	Add FMS information to JCL file
GENOB	Create object code program file from source or update code
JABT*	Abort a job
JDVT*	Divert a batch job to a different RJE
JFND*	List all batch jobs running under your user number
JPRI*	Change priority of a batch job
JSTS	Track a job through system and make its output a local file when complete
LINKNEW	
MAIL	Adds banners to a file and sends it to a printer
205COM	Sends a command to the CYBER 205

* Has been replaced by a CYBER command. PROCLV HELP contains instructions on command.

AD-A162 390 USER'S MANUAL FOR THE GENERALIZED COMPUTER PROGRAM SYSTEM OPEN-CHANNEL FL (U) ARMY ENGINEER WATERWAYS EXPERIMENT STATION VICKSBURG MS HYDRA 8/8

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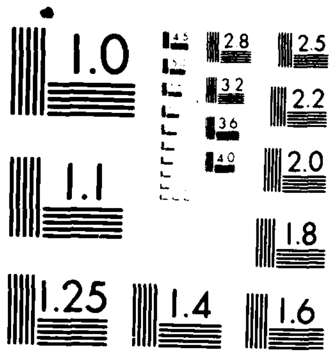
1.0
2.8
2.5
3.2
2.2
3.6
4.0
2.0
1.1
1.8
1.25
1.4
1.6

Table 03 (continued)

Index by Generic Input/Output File Name

Generic File Name	Purpose of File	Source	Units	File Type
I2R4	HOTSTART input file for RMA-4	RMA-4	Metric	Binary
I1S3	Card image data for STUDH	Editor	Metric	Coded
I1VP	Card image data for VPLOT	Editor	Same as data source	Coded
O1CO	File of interpolated values on uniform grid	Contour	*	Binary
O1EG	File of interpolated values on uniform grid	ELEVGRD	*	Binary
O1EM	Geometry for STUDH	ENGMET	Metric	Binary
O2EM	Water-surface elevations for STUDH	ENGMET	Metric	Binary
O3EM	Velocities for STUDH	ENGMET	Metric	Binary
O1G1	Mid-side nodes from AUTOMSH	AUTOMSH	English	Coded
O2G1	Nodal coordinates & connection table for corner nodes, boundary flags & material types	RENUM	English	Binary
O3G1	PLOT file from QMESH for METAPLOT to view smoothness	QMESH	English	Binary
O4G1	Output from AUTOMSH for use in input to GFGEN	POSTMSH	English	Coded
O1RP	A new GFGEN input file	RETPNT	English	
O2RP	Scratch file in TABS-2	RETPNT	English	Coded
O1R1	Geometry data for RMA-codes	GFGEN	English	Binary
O2R1	New, clean GFGEN card image input data (i.e. unused elements & nodes eliminated)	GFGEN	English	Coded
O1R2	Water surface and velocity output file	RMA-2V	English	Binary

* Units can be either English or metric, depending on the requirement of the model.

Table 03

Index by Generic Input/Output File Name

Generic File Name	Purpose of File	Source	Units	File Type
I1CO	Card image data to run CONTOUR	Editor	*	Coded
I1EG	Card image data to run ELEVGRD	Editor	English	Coded
I2EG	Digitized input to ELEVGRD	DMSDIG or Editor	English	Coded
I1EM	Card image data to run ENGMET	Editor	English	Coded
I2EM	Update data for datum & MSL for ENGMET	Editor	English	Coded
I1G1	Digitizer file for input to PREMESH	Digitizer	English	Coded
I2G1	Card image data to run PREMESH	Editor	English	Coded
I3G1	Output from PREMESH; scratch	PREMESH	English	
I1MP	Local METAPLOT file for graphics	METAB	*	Binary
I1RP	Card image data for RETPNT	Editor	English	Coded
I2RP	Computation grid coordinator	I1R1 Digitizer	English	Coded
I3RP	DMS-A format gridded data file	ELEVGRD	English	Binary
I1R1	Card image data for GFGEN	Editor	English	Coded
I2R1	Geometry = O1R1 from previous GFGEN run	GFGEN	English	Binary
I1R2	Card image data for RMA-2V	Editor	English	Coded
I2R2	Card image boundary conditions data for RMA-2V	Editor or custom program	English	Coded
I3R2	HOTSTART input file for RMA-2V	RMA-2V	English	Binary
I1R4	Card image data for RMA-4	Editor	Metric	Coded

* Units can be either English or metric, depending on the requirement of the model.

Table 03 (concluded)

Index by Generic Input/Output File Name

Generic File Name	Purpose of File	Source	Units	File Type
02R2	HOTSTART RMA-2V	RMA-2V	English	Binary
01R4	Quality parameters OUTPUT file	RMA-4	Metric	Binary
02R4	HOTSTART RMA-4	RMA-4	Metric	Binary
01S3	Bed change and concentrations	STUDH	Metric	Binary
PLCO	Plot file of values to be contoured	Contour	*	Binary
PLR1	Plot file of FE mesh	GFGEN or QPLOT	English	Binary
PLVP	Plot file of velocity vectors	VPLOT	*	Binary

* Units can be either English or Metric, depending on the requirement of the model.

END

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