A COMPUTER PROGRAM FOR ANALYZING CHANNEL GEOMETRY

By R. Steven Regan and Raymond W. Schaffranek

U.S. GEOLOGICAL SURVEY

Water-Resources Investigations Report 85-4335

ABOUT THE COVER

The right-hand side of the cover illustrates five cross sections of the tidal Potomac River (depicted on the left) plotted in isometric projection. This plot, modified for publication purposes, is typical of output capable of being generated by the Channel Geometry Analysis Program documented herein.

Reston, Virginia
1985

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CONVERSION FACTORS

Inch-pound units are used for input and output by the program presented in this report. For readers who prefer to use metric (International System) units rather than inch-pound units, conversion factors are listed below.

Multiply inch-pound units	By	To obtain metric units
foot (ft)	0.3048	meter (m)
mile (mi)	1.609	kilometer (km)
cubic foot per second (ft^3/s)	0.02832	cubic meter per second (m^3/s)

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ABSTRACT

A computer program is presented that permits the analysis, interpretation, and quantification of the physical properties of an open-channel reach as defined by a sequence of cross sections. The primary function of the program is to compute the area, width, wetted perimeter, and hydraulic radius of cross sections at successive increments of water-surface elevation (stage) from data that consists of coordinate pairs of cross-channel distances and land-surface or channel-bottom elevations. Longitudinal rates-of-change of cross-sectional properties are also computed. In addition, the mean properties of a channel reach can be computed.

The program provides 16 output options that format the input cross-sectional data or the computed cross-sectional properties as digital plots, line-printer plots, tabular lists, and (or) sequential files. These output formats include: plots of cross sections; plots of cross-sectional area and (or) channel width as functions of stage; tabular lists of computed, stage-dependent, cross-sectional properties (area, width, wetted perimeter, hydraulic radius, average depth, and symmetry); files of computed cross-sectional properties; plots of cross sections in isometric projection; plots of cross-sectional area at a fixed stage as a function of longitudinal distance along an open-channel reach; and files of computed cross-sectional area as a function of stage for subdivisions of a cross section.

INTRODUCTION

Implementation of surface-water flow/transport models requires detailed description of the physical characteristics of the waterbody being simulated. It is therefore necessary to obtain a comprehensive set of data that accurately depicts the cross-sectional properties and channel geometry. These basic data need to be compiled, evaluated, and analyzed prior to, and perhaps coincident with, model implementation, calibration, and verification. The Channel Geometry Analysis Program (CGAP) described herein has been designed and developed to compute, display, and otherwise format cross-sectional data for such purposes. CGAP was devised to provide an easy efficient means to process and evaluate cross-sectional data that consists of sets of coordinate pairs of cross-channel distances and land-surface or channel-bottom elevations defining the cross sections of an open-channel reach. CGAP offers numerous output options that facilitate the analysis and interpretation of the physical properties of an open-channel reach. Computed cross-sectional properties and channel geometry can be prepared and output in a format entirely compatible with the input requirements of the branch-network, unsteady-flow model (Schaffranek and others, 1981).

Although support of mathematical/numerical models such as the branch-network flow model was the main impetus for the development of CGAP (Holtschlag, 1981, Oltmann, 1979, and Stedfast, 1982), later adaptations and enhancements have extended its utility to a wider variety of computational procedures. One such application is the determination of cross-sectional area as a function of stage for subdivisions of a cross section as required with the conventional midsection-discharge computation technique (Buchanan and Somers, 1965).

The basic physical properties computed at successive increments of stage by CGAP are: cross-sectional area, channel width, wetted perimeter, hydraulic radius, average depth, and cross-sectional symmetry. Longitudinal rates-of-change of area, width, wetted perimeter, hydraulic radius, and average depth, between successive cross sections, are also computed. CGAP can compute the properties of an individual cross section or the mean properties of a sequence of cross sections defining a segment of an open-channel reach. Cross-sectional coordinate data can be input in program-standard, user-specified, or step-backwater-program (Shearman, 1976) format. CGAP has 16 options that produce of the following forms of output: tabular lists, sequential files, or graphical plots in digital or line-printer format.

CGAP is written in FORTRAN 77 and uses CalComp[1] digital-plotter subroutine references for graphic generation. It, therefore, provides compatibility with plotting software made available by a host of vendors and, thereby, enables digital output to be produced on a wide variety of graphic devices, such as CalComp, Zeta, Houston Instruments, and Versatec plotters. The capability to produce CGAP-generated output on a particular graphics device is, however, solely dependent upon the plotting software utilized in the particular program version. One set of software illustrated in an example execution of CGAP herein, permits digital output to be produced on, among others, Tektronix, Hewlett Packard, and Tab graphic devices.

This report describes the processing technique and sequence, as well as, the requirements and constraints for the input data and computational-control parameters of CGAP. Each output option is discussed and its format is illustrated. Processing considerations pertaining to particular output options are also identified. Appendices included in this report contain all information necessary to execute CGAP. Appendix I includes examples of the execution procedures for use of the program on the U.S. Geological Survey (USGS)/Water Resources Division (WRD) Prime and USGS/ Information Systems Division (ISD) Amdahl computer systems. Detailed specifications for coding input records, as well as, definition, type specification, value range, and constraints for associated parameters are given in Appendix II. Program error messages are described in Appendix III. (Previous versions of CGAP have been referred to as the XSGEOM or PARS program.)

CHANNEL-GEOMETRY DATA

Model implementation -- one of the principal uses of CGAP -- in the one-dimensional sense, as with a single riverine channel or the multiple channels of an interconnected network, primarily entails characterization of the overall channel layout and description of the individual cross-sectional properties. In the case of an

[1]Use of trade names in this report is for identification purposes only and does not constitute endorsement by the U.S. Geological Survey.

interconnected network, channel characterization necessarily includes depicting the channels as a sequence of reaches (branches) delimited by, and possibly connected at, junctions, representing the extremities and (or) confluences of the individual reaches. Thus, the first step in any one-dimensional model implementation involves delineating the channel system and defining the open-channel reaches comprising the system. Selection of suitable cross-section locations at which to represent an open-channel reach and accurate determination of the stage-dependent cross-sectional properties are two of the most important considerations in model implementation.

As the first step toward delineating the open-channel system for a particular model application, it can be helpful to review existing hydrologic and hydrographic data sources (topographic maps, navigational charts, water-resources investigation atlases, and so on). Oftentimes these will help determine model boundaries, identify required field-data-collection activities, and define the overall scope of the modeling effort. After the channels to be included in the model have been selected initially, a determination must also be made as to whether or not they need to be further subdivided into shorter subreaches (segments) for modeling purposes -- as is frequently the case. Important considerations in subreach delineation include both aspects of accurate channel representation and adherence to numerical simulation constraints. (Open-channel reach delineation guidelines for modeling purposes are presented by Lai and others, 1978, and Schaffranek and others, 1981.) Several output options of CGAP, particularly well-suited for analyses of longitudinal cross-sectional variations, can aid this decision-making process. (Other general, although equally important and useful, guidelines pertaining to cross-section selection are presented by Davidian, 1984.)

Subsequent to final determination of subreach delineations, it is necessary to describe the stage-dependent, cross-sectional properties at the identified locations. Typically, these properties are defined in terms of area, width, wetted perimeter, and hydraulic radius. Various options of CGAP facilitate the computation of such functional relationships and the generation of computer files for subsequent program use. The basic cross-sectional data required to compute these properties can frequently be obtained from agencies such as the National Ocean Service of the National Oceanic and Atmospheric Administration or the U.S. Army Corps of Engineers. Data required to be obtained via direct field measurement should be collected by employing standard hydrographic-survey techniques (Benson and Dalrymple, 1967).

The basic data needed to compute the stage-dependent cross-sectional properties typically consist of land-surface or channel-bottom elevations measured and referenced horizontally to a channel-bank location and referenced vertically to a common datum plane, such as NGVD of 1929. Cross-sectional data should be measured along a line normal to the flow direction at the thalweg of the channel. A sufficient number of land-surface or channel-bottom elevations must be determined so that linear interpolation between coordinate-data points accurately describes the cross-sectional properties at all possible stages of flow. Coordinate-data points can be referenced to a point on the left or right channel bank or to any location within the cross section. However, use of a left channel bank reference point is the normal convention, which is assumed by CGAP.

Once the required coordinate data have been compiled, they must then be uniformally formatted and consolidated into a single data file for input to CGAP. The individual sets of coordinate-data points that define the cross-sectional geometry should be ordered successively beginning with either the most upstream or most downstream cross section. Such ordering is not entirely mandatory for use by CGAP, but it is frequently a typical requirement of the computational programs subsequently using CGAP-generated cross-sectional data files. (Downstream order is anticipated by the branch-network flow model; refer to the section on Cross-section order for additional information.) After this input file of cross-sectional data is created it can be analyzed using the various options of CGAP and selectively segmented to finally produce the desired stage-dependent cross-sectional properties in the required format. Repetitive use is made of this input data file by CGAP. Thus, once created, the primary file of cross sections can remain intact for subsequent use or archival.

Particular applications of CGAP may require that additional channel-geometry information such as cross-sectional datum adjustments, channel segment lengths, and cross-sectional skew angles be determined and specified. If cross-sectional data are derived from various sources, datum adjustments may need to be applied to provide a common reference for all data -- a mandatory requirement for model use. Furthermore, segment lengths, defining the thalweg distance between successive cross sections, are needed to longitudinally reference cross sections for plotting purposes and to facilitate the computation of longitudinal rates-of-change of cross-sectional properties. Skew angles may also need to be specified if the cross-sectional data were not measured along a line normal to the flow direction at the channel thalweg.

Other special computational parameters, required by CGAP to control the processing of cross-sectional data, such as the range of stage-dependent computations, plot scaling factors, and so forth, may also need to be determined to analyze the data and to produce a particular output. The variety of output types, formats, and media provided by CGAP avail the user a host of options to analyze, quantify, and depict the cross-sectional properties of an open-channel reach, whether for modeling or other computational purposes. The output file-generation options provide for direct communication of computed cross-sectional properties to user-application programs such as the branch-network flow model. Refer to the Input Considerations and Output Descriptions sections for assistance in determining the computational-control parameters required to produce a particular output format, and to Appendix II for the definition, detailed specifications, and constraints of all input parameters.

COMPUTATIONAL METHODS

The method used to compute cross-sectional properties in CGAP was devised and programmed to minimize computer time. Equations are developed to describe the cross-sectional properties of area, width, wetted perimeter, hydraulic radius, average depth, and cross-sectional symmetry as functions of stage from coordinate pairs of cross-channel distances and channel-bottom elevations. These equations are formulated using a Cartesian coordinate system. The y-axis is defined as the transverse axis (across the channel) along which cross-channel distances are specified. The x-axis is referred to as the longitudinal axis (coincident with the thalweg) along which segment lengths are determined. Land-surface and channel-bottom elevations are referenced to the vertical z-axis.

The minimum cross-sectional area, A_{min}, that is, the cross-sectional area below the minimum stage, Z_{min}, as specified for computation by the user, is computed by summing the incremental areas formed by the subdivision of the cross section at the locations of the coordinate-data points (figure 1). The computational procedure developed to compute A_{min} requires that the portion of the cross section containing A_{min}

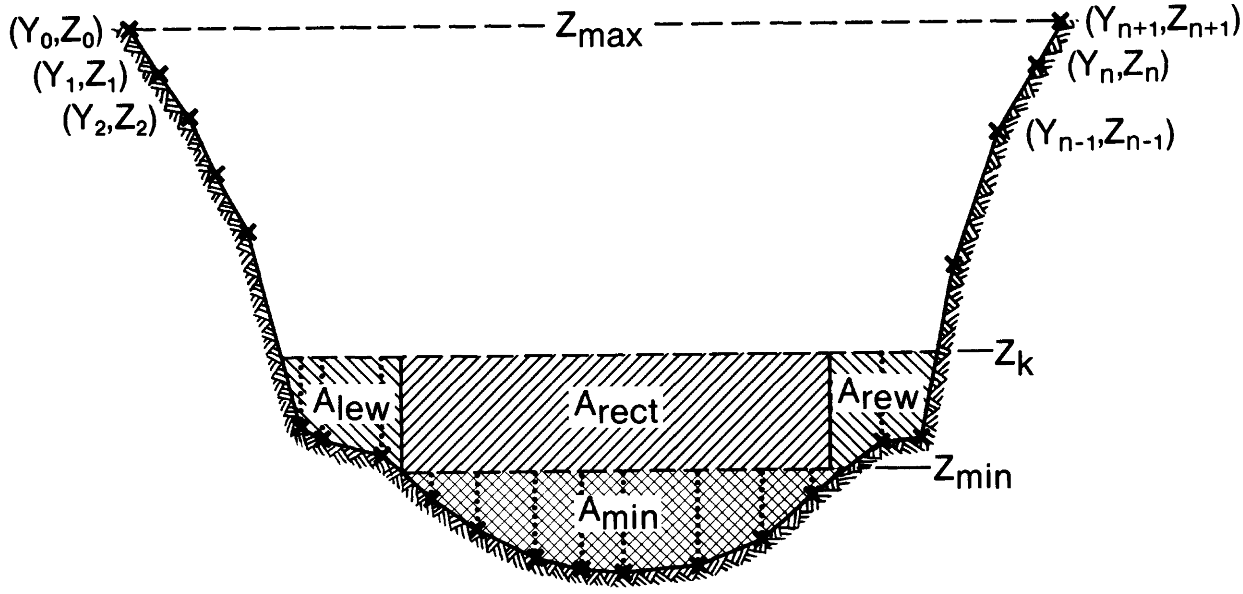

Figure 1.--Generalized sketch of a channel cross section illustrating method of area computation.

(considered to be the main channel) be defined by at least two coordinate-data points and be represented by a single channel below Z_{min}. Cross-sectional areas, A_k, below succeeding stages, Z_k, are computed as the sum of A_{min} and the area of the cross section above Z_{min}. The area of the cross section above Z_{min} is computed by adding the area of a rectangle, A_{rect}, whose area equals the channel width at Z_{min} times the difference between Z_k and Z_{min}, to the areas near the left and right edges-of-water, A_{lew} and A_{rew}, respectively, that are not enclosed in A_{rect}. Starting at Z_{min}, values of A_k are computed at successive increments of stage until Z_k is greater than or equal to the maximum stage specified for computation, Z_{max}. (The computational procedure for determining channel width and wetted perimeter is similar.) The area, A_k, of the cross section below each stage, Z_k, is computed as:

$$A_k = A_{min} + A_{rect} + A_{lew} + A_{rew}$$

where A_{min} = the cross-sectional area below Z_{min},

A_{rect} = the area of the rectangle that is the product of the channel width at Z_{min} and the difference between Z_k and Z_{min}, and

A_{lew} and A_{rew} = the areas of the cross section near the left and right edges-of-water, respectively.

If necessary, and possible, channel-bank elevations are extrapolated to Z_{max}. Extrapolation of the left channel bank to Z_{max} is possible whenever Z_1 defines a channel-bank elevation greater than Z_2. The coordinates (Y_0,Z_0) of the extrapolated point are defined as:

$$Y_0 = Y_1 + (Z_{max}-Z_1) * (Y_1-Y_2) / (Z_1-Z_2) \quad \text{and} \quad Z_0 = Z_{max}.$$

Extrapolation of the right channel bank to Z_{max} is possible whenever Z_n defines a channel-bank elevation greater than Z_{n-1}. The coordinates (Y_{n+1},Z_{n+1}) of the extrapolated point are similarly defined as:

$$Y_{n+1} = Y_n + (Z_{max}-Z_n) * (Y_n-Y_{n-1}) / (Z_n-Z_{n-1}) \quad \text{and} \quad Z_{n+1} = Z_{max}.$$

Hydraulic radius is computed as area divided by wetted perimeter and average depth as area divided by channel width. A ratio of hydraulic radius to average depth is also computed. (This ratio approaches one as the ratio of average depth to channel width approaches zero.)

CGAP also computes an index of cross-sectional asymmetry, A2, (the notation for the asymmetry index is adopted from Knighton, 1981) at each stage Z_k. It is based on the horizontal displacement of the thalweg from the channel centerline and the difference between the thalweg depth and the average depth of the cross section. It therefore incorporates aspects of both horizontal and vertical symmetry and is determined by the following equation:

$$A2 = 2 * (B_{thal}-B_{mid}) * (H_{thal}-H_{bar}) / A_k$$

where B_{thal} = the channel width from the left edge of water to the thalweg,

B_{mid} = the channel width from edge of water to the channel centerline,

H_{thal} = the thalweg depth, and

H_{bar} = the average depth of the cross section.

Values of the asymmetry index generally are in the range $-1<A2<1$ for most natural channels. A value of zero indicates the cross section is symmetric with respect to the thalweg at stage Z_k. Absolute values greater than one indicate a high degree of asymmetry (Knighton, 1981), negative values indicating the cross section is asymmetric to the left (the thalweg is offset to the left of the centerline) at stage Z_k.

Cross-sectional area, channel width, and wetted perimeter are computed for the main channel and for any subchannels left and right of the main channel at each stage. Hydraulic radius, average depth, the ratio of hydraulic radius to average depth, the cross-sectional asymmetry index, and the longitudinal rates-of-change of cross-sectional area, channel width, wetted perimeter, hydraulic radius, and average depth are computed for the entire cross section (the total of the main channel and any subchannel values) at each stage.

PROGRAM ORGANIZATION

CGAP consists of a main program and 15 subroutines. Figure 2 illustrates the subroutine functions and calling hierarchy of CGAP. Subroutine IDINFO formats a header page for output on the line printer. Subroutine CHARAC is called by IDINFO to prepare text for printing in the header page. The LSTOPT subroutine produces a tabular list of the input data records on the line printer. Subroutine XTRPBN performs the extrapolation of channel-bank elevations. CALAWP computes the cross-sectional area, width, wetted perimeter, hydraulic radius, average depth and

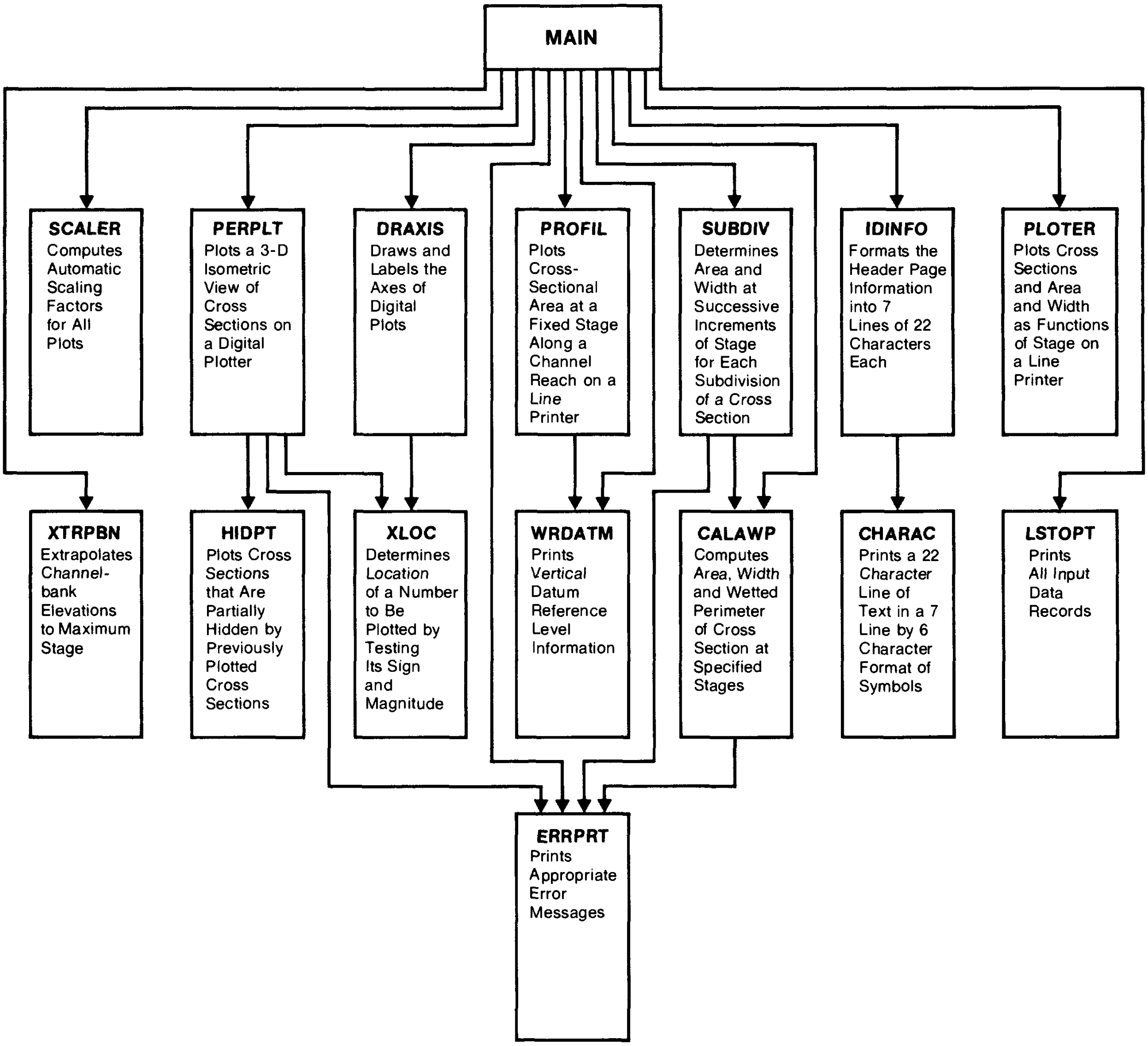

Figure 2.--Schematic diagram of subroutine functions and calling hierarchy of the Channel Geometry Analysis Program.

symmetry for a specified range of stage. Subroutine SUBDIV divides a cross section into subunits and calls the CALAWP subroutine to obtain subunit areas and widths at successive increments of stage. Subroutine SCALER computes default plot scaling factors. The PLOTER subroutine creates line-printer plots of cross sections and of cross-sectional area and channel width as functions of stage. DRAXIS draws and labels the plot axes of digital plots. Subroutine PROFIL generates line-printer plots of cross-sectional area at a fixed stage as a function of longitudinal distance along the channel. Subroutine PERPLT plots a three-dimensional isometric view of cross sections on a digital plotter. Subroutine HIDPT is called by PERPLT to determine those portions of a cross section that are partially hidden by the previously plotted cross section. The WRDATM subroutine prints the vertical datum reference level information. XLOC is a function that determines digital plot coordinates. ERRPRT is the error-message-handling routine.

PROCESSING DESCRIPTION

Eight record types constitute the input to CGAP. They are defined as the IDENTITY, DATA FORMAT, PARAMETER, COMMENT, SUBDIVISION, COORDINATE DATA, PROCESSING CONTROL, and PARAMETER ALTERATION records.[2] The IDENTITY record identifies the river or estuary name, the station names delimiting the open-channel reach, and the identification numbers of the cross sections contained within the reach. The DATA FORMAT record defines the input COORDINATE DATA (CD) record format, optionally specifies alternate Fortran unit numbers for output files, signals the optional input of cross-sectional data in step-backwater-program format, and specifies which of the two input files contains the PARAMETER, COMMENT, and SUBDIVISION (PCS) and CD records. Values coded on the PARAMETER record define computational parameters that control the processing of the associated CD records. COMMENT records are optionally input as deemed necessary by the user to annotate the printed output for a cross section. The optional SUBDIVISION record contains cross-channel distances at which a cross section is to be subdivided. The CD records consist of the set of cross-channel distance and land-surface or channel-bottom elevation data points that define the cross-sectional geometry. PROCESSING CONTROL records specify parameters that control processing of the input cross sections and determine the type and format of the output produced. PARAMETER ALTERATION records allow for modification of initially input PARAMETER records assigned to specific cross sections for a particular output option.

The processing sequence of input records is the same for all output options. CGAP first reads the IDENTITY and DATA FORMAT records, retrieves the current date and time from the computer system, and checks the validity and format of the input records. If input of step-backwater-program formatted data is indicated, CGAP generates default PARAMETER records, reformats the cross-sectional data records to the default input format (see Appendix II), and temporarily stores these in a standard-format file. (The standard-format file is used by CGAP to store input PCS and CD records so that multiple program options can be utilized during a single execution.) Otherwise, CGAP reads the PCS and associated CD records of the first cross section, sorts the CD records by cross-channel distance, removes any duplicate records (that is, removes records specifying identical cross-channel distances), and formats the CD records in default input format. This set of PCS and CD records is then stored in the standard-format file. All sets of PCS and CD records are similarly processed and stored in the standard-format file as sequentially input to the program. The processing sequence of the input records, as described above, to create the standard-format file is illustrated in flow-chart form on the left-hand side of figure 3.

After all PCS and CD record sets have been stored in the standard-format file, a PROCESSING CONTROL record and any associated PARAMETER ALTERATION records are read. CGAP then reads the first set of PCS and associated CD records from the standard-format file. Next, CGAP adjusts the cross-channel distances for the cross-section skew angle, determines the segment length between this and any previous cross section, applies datum adjustments, and normalizes the land-surface and channel-bottom elevations to zero. The minimum stage specified for computation by the user is checked and automatically modified, if necessary, so that at least two channel-bottom elevations and only one channel exist at this minimum stage. (These

[2]Names of the input record types are capitalized whenever referenced in this report.

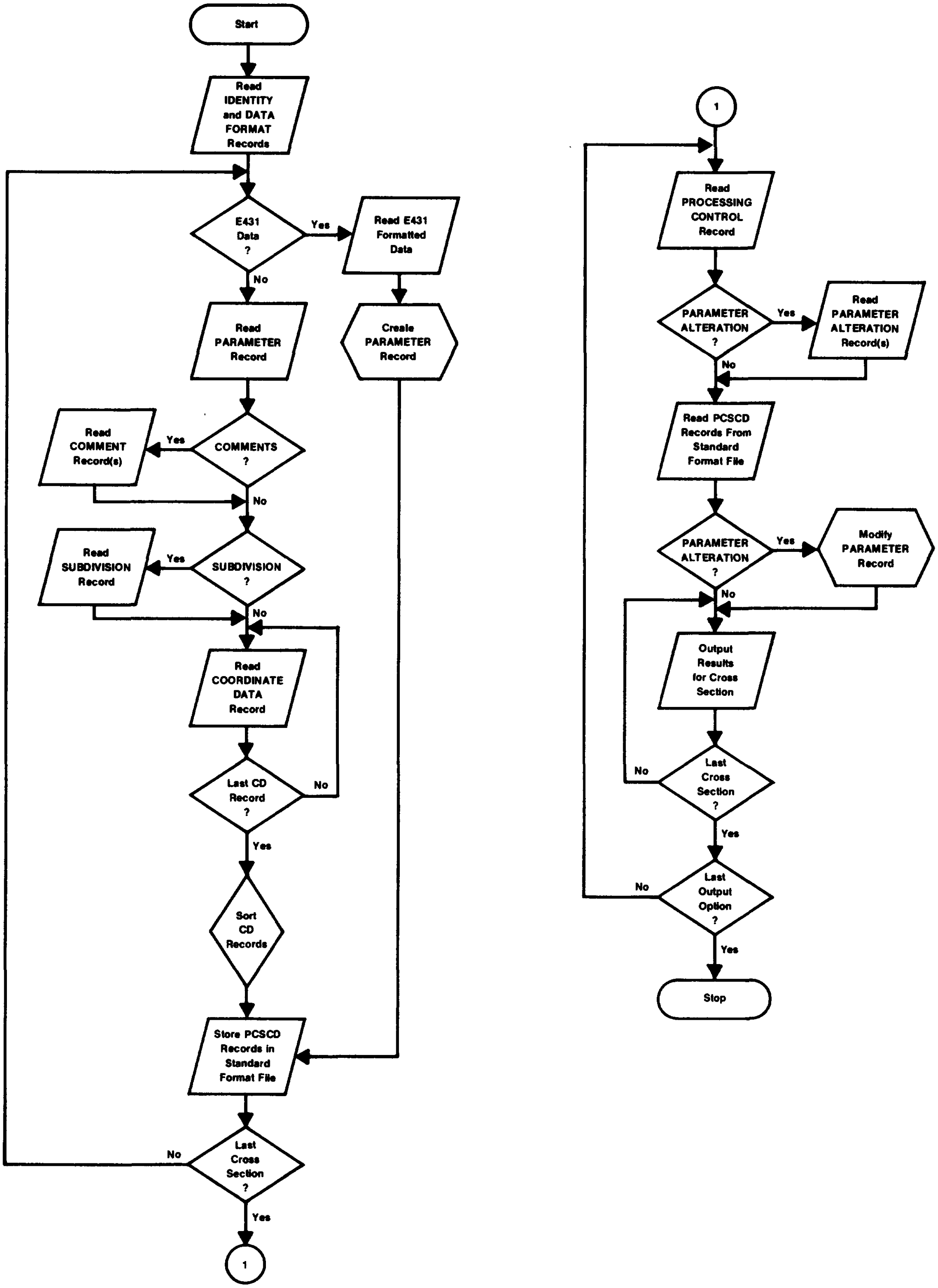

Figure 3.--Flow chart of the input processing sequence of the Channel Geometry Analysis Program.

two conditions are required by the methods used to compute cross-sectional area.) CGAP then normalizes the cross-channel distances to zero at the minimum input distance, which is treated as the left edge of water. If the channel-bank elevations do not accommodate the maximum stage specified for computation by the user, CGAP extrapolates new channel-bank elevations, if possible, or reduces the maximum stage. The remaining PCS and CD record sets are then read from the standard-format file and similarly processed. After the requested output is produced, CGAP attempts to read any subsequent PROCESSING CONTROL and associated PARAMETER ALTERATION records and then reprocesses each set of PCS and CD records for each output option requested. The right-hand side of figure 3 illustrates the data processing sequence as performed for each output option.

INPUT CONSIDERATIONS

The basic input requirements of CGAP are the same for all output options; thus, a thorough analysis of the geometry of a open-channel reach can be accomplished with a minimum of data manipulation. To apply CGAP to a set of cross-sectional data, however, certain considerations must be taken into account. CGAP performs numerous checks to verify input information and will attempt to modify input parameters to make them consistent with program computational procedures. In this section, major input requirements pertaining to cross-section order, step-backwater-program formatted data, and file structure are discussed. Detailed identification of record position, definition, type specification, value range, and default assignment for all program parameters, as well as example input file setups, are given in Appendix II. Procedures for executing CGAP on the USGS/WRD Prime and USGS/ISD Amdahl computer systems are described in Appendix I.

Cross-section order

Cross sections can be input to CGAP in any order. However, cross sections are typically input in downstream order for model purposes (the order anticipated by the branch-network, unsteady-flow model (Schaffranek and others, 1981)) or upstream order for backwater computations (the order used by the step-backwater analysis program (Shearman, 1976)). If cross sections are input in upstream order, the computed longitudinal rates-of-change of cross-sectional area, channel width, wetted perimeter, hydraulic radius, and average depth will, in general, be negative for a typical riverine reach in which the physical dimensions of the channel expand in the downstream direction. It may also be desirable for cross sections to be input in upstream order to use the three-dimensional isometric plot option of CGAP, as for many open-channel reaches upstream order often provides a better isometric view. CGAP does not alter the input order of cross sections, therefore, if cross sections are not in order the computed rates-of-change will be meaningless. Furthermore, it is recommended that the coordinate-data (CD) points defining a particular cross section be input in order by cross-channel distance, however CGAP will sort them.

File structure

Input to CGAP can be separated into two files or be wholly contained in a single file. This single file is referred to, herein, as the **instream** file. An instream file is always required. It must contain the IDENTITY, DATA FORMAT, PROCESSING CONTROL, and any optional PARAMETER ALTERATION records. The second input file, herein designated as the **PCSCD** file, can contain COORDINATE DATA (CD) records only; contain PARAMETER, COMMENT, SUBDIVISION (PCS), and associated CD records; or be a null file if all records are input via the instream file. If the PCSCD file contains only CD records, associated PCS records must be in the instream file and they must correspond to, and be in the same input order as, the associated sets of CD records.

For large data sets it is recommended that the CD records be stored in the PCSCD file and all other records be stored in the instream file. This simplifies assigning parameter values when using several output options, as only those records that control data processing are then contained in the instream file. It may also be desirable to further simplify the instream file by storing PCS records in the PCSCD file as well. However, if different parameter value assignments are needed for various output options, PARAMETER ALTERATION records would then be required in the instream file. Use of PARAMETER ALTERATION records in this fashion precludes the need to manually edit the PCSCD file.

Parameters, assigned on the DATA FORMAT record, identify the contents of each input file. Alternate Fortran unit numbers for all output files can also be assigned by parameters on the DATA FORMAT record. The use of alternate unit numbers facilitates the transmittal of program output directly to a dedicated device, such as a tape drive or digital plotter.

Step-backwater data

Whenever cross-sectional data are input in step-backwater-program (E431) format, CGAP generates PARAMETER records with default specifications and temporarily transforms the CD records to standard CGAP format. (The processing sequence for E431-formatted data is illustrated in flow-chart form in figure 3.) If alternative PARAMETER record values are desired for utilizing E431-formatted data, PARAMETER ALTERATION records can be used. (See Appendix II for an example input setup using E431-formatted data with PARAMETER ALTERATION records.)

No COMMENT or SUBDIVISION records are created by CGAP; nor can any be input for E431-formatted data unless the data are permanently transformed to an acceptable (such as CGAP standard) format. To specify COMMENT and SUBDIVISION records for E431-formatted data it is necessary to preprocess the data, either externally or by using CGAP output option 9, to create a standard-format file that can be modified to include these records and be used as the PCSCD file. (Refer to the Output Description section for an explanation of option 9.)

OUTPUT DESCRIPTION

There are 16 output options in CGAP. Output can be in the form of line-printer pages (formatted 132 characters wide and 61 lines long), digital plotter commands, and (or) 80-character record files. Table 1 defines these options and their associated program identifier codes. In this section, output formats are illustrated and program parameters that control critical aspects of each output format are discussed. (Refer to Appendix I for execution procedures on the USGS/WRD Prime and USGS/ISD Amdahl computer systems and to Appendix II for the definition, detailed specifications, and constraints for all input parameters of CGAP.)

Table 1.--Output option descriptions and example figure references.

OPTION	OUTPUT DESCRIPTION	FIGURE
1	Cross-sectional area as a function of stage plotted on a line printer	4
2	Channel width as a function of stage plotted on a line printer	[1]4
3	Cross-sectional area and channel width as functions of stage plotted on a line printer	[2]4
4	Cross sections plotted individually on a line printer	6,8
5	Cross-sectional area, channel width, wetted perimeter, hydraulic radius, average depth, and cross-sectional symmetry as functions of stage listed in tabular form on a line printer	13
6	Cross-sectional area and channel width as functions of stage stored in a sequential file	14,15
7	Cross sections plotted in isometric projection on a digital plotter	10
8	Wetted perimeter and hydraulic radius as functions of stage stored in a sequential file	[1]14,15
9	PARAMETER, COMMENT, SUBDIVISION, and COORDINATE DATA records retained in the standard-format file	([3])
10	PARAMETER, COMMENT, SUBDIVISION, and COORDINATE DATA records listed in tabular form on a line printer	12
11	Cross-sectional area as a function of stage plotted on a digital plotter	5
12	Channel width as a function of stage plotted on a digital plotter	[1]5
13	Cross-sectional area and channel width as functions of stage plotted on a digital plotter	[2]5
14	Cross sections plotted individually on a digital plotter	7,9
15	Cross-sectional area at a fixed stage as a function of longitudinal distance along a river reach plotted on a line printer	11
16	Cross-sectional area and channel width as functions of stage for subdivisions of cross sections listed in tabular form on a line printer and stored in a sequential file	16

[1]Similar output format.
[2]Multiple output produced.
[3]See Processing Description section for explanation of the file contents and Appendix II for formats of the file records.

For all output options except 9, CGAP prints a header page identifying the output format, channel name, reach extent, cross-section numbers, processing date, and current program version. For all options except 9 and 10, CGAP prints the cross-section number, any associated COMMENT records, and any modifications made to, or errors found in, the cross-sectional data and processing parameters for each cross section. Should either the user-defined minimum or maximum stages for computation be modified, an appropriate message is printed. After the requested output is produced a message is printed to indicate that processing is complete; this is an indication that processing has completed normally and that the requested output has been successfully generated. If abnormal termination occurs a message is printed that identifies the error condition encountered. Program error messages are explained in Appendix III.

Plots

CGAP generates various types of graphical plots. These include plots of: cross-sectional area as a function of stage (options 1, 3, 11, and 13), channel width as a function of stage (options 2, 3, 12, and 13), individual cross sections (options 4 and 14), cross sections of a channel reach in three-dimensional isometric projection (option 7), and cross-sectional area at a fixed stage as a function of longitudinal distance along a channel reach (option 15). Isometric projection plots are generated for production on digital plotters. Plots of cross-sectional area as a function of longitudinal channel distance are produced on line printers. All other plots can be generated on either digital plotters or line printers. Automatic scaling is performed by CGAP for all plots. Although the format of plots is primarily fixed, variation of certain plot aspects, including scaling, is possible through user-specifiable program-control parameters. For line printers, a single plot, dimensioned 130 characters wide by 55 lines high, is generated per printer page. The default digital plot size is 7 by 9 inches, which includes a one inch allowance for axes labeling.[3]

Cross-sectional Area as a Function of Stage

CGAP produces plots of cross-sectional area as a function of stage on a line printer or digital plotter via output options 1 and 11, respectively. For line-printer plots, cross-sectional areas are plotted as individual points at each user-specified increment of stage (DELTAZ) starting at the user-defined minimum stage for computation (ZMIN) and ending at the user-defined maximum stage for computation (ZMAX). For digital plots straight-line segments connect these values. The axes of line-printer plots are scaled as efficiently as possible, however, partial plots can occur. For digital plots, the axes are scaled so as to accommodate the entire plot. It is possible to override the automatic scaling with user-defined stage and (or) area scaling increments (ZINC and AINC). The size of digital plots is controlled by the user-defined length of the y-axis of the plot (LENY), unless values for ZINC and (or) AINC are specified. (DELTAZ, ZMIN, ZMAX, ZINC, and AINC are specified on PARAMETER records and LENY on the PROCESSING CONTROL record.) Scaling factors and datum information are shown at the top center of line-printer plots. Channel name, cross-section number, and datum information are shown at the top center of digital plots. Figures 4 and 5 illustrate plots of cross-sectional area as a function of stage generated on a line printer and digital plotter, respectively.

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[3]For publication purposes, CGAP digital plots illustrated in this report have been reduced approximately 50 percent. (At full scale one axis increment equals one inch.)

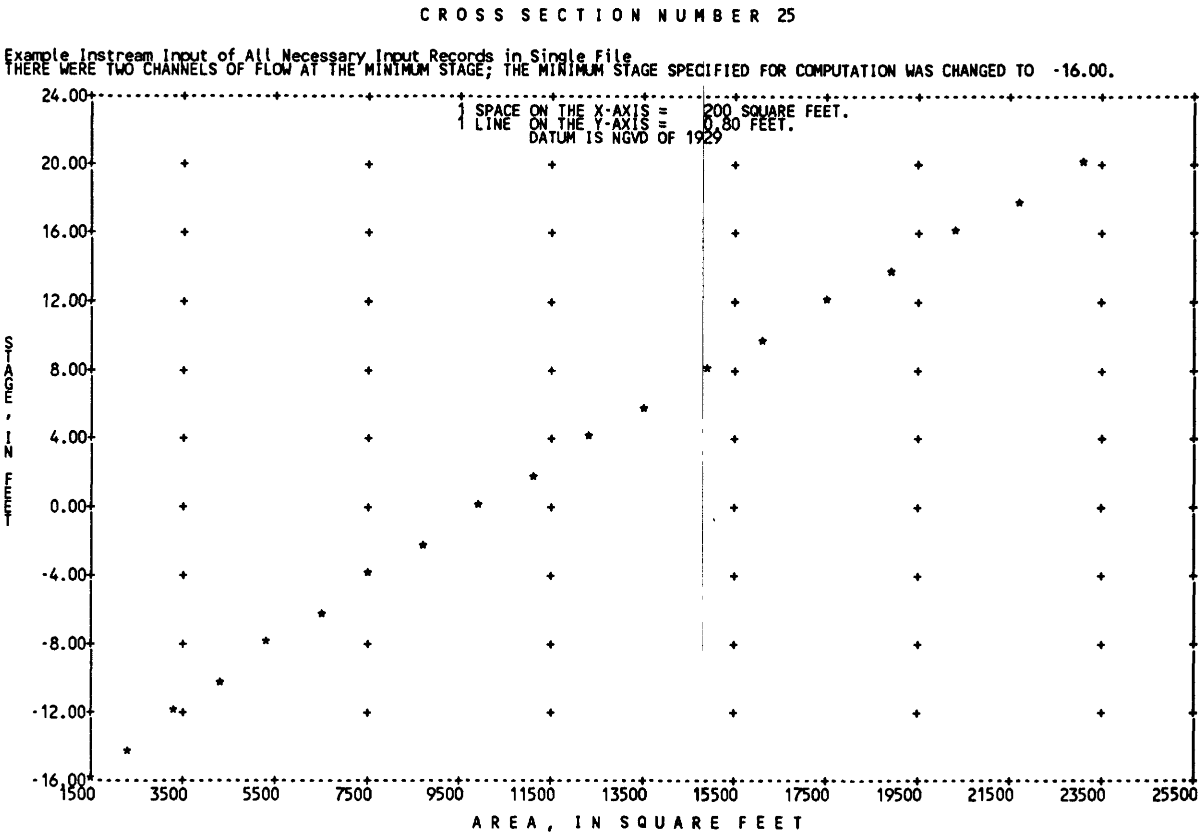

Figure 4.--Sample program-generated line-printer plot of stage-dependent cross-sectional area.

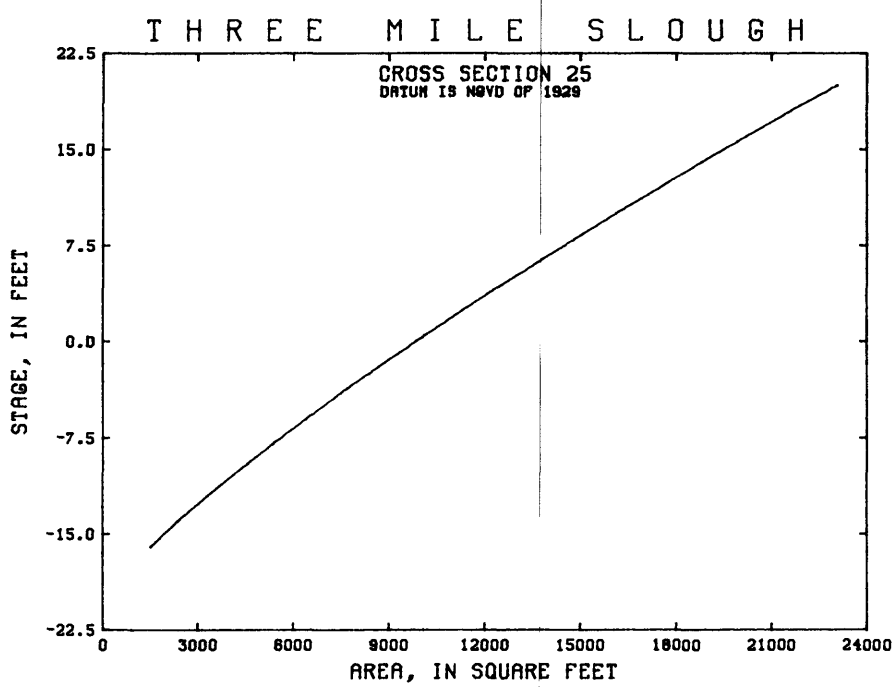

Figure 5.--Sample program-generated digital plot of stage-dependent cross-sectional area.

Channel Width as a Function of Stage

CGAP produces plots of channel width as a function of stage on a line printer and digital plotter via output options 2 and 12, respectively. Format and plot scaling are similar to the plots of cross-sectional area as a function of stage described above and illustrated in figures 4 and 5. As in plots of cross-sectional area as a function of stage, the automatic scaling of CGAP can be overridden for plotting channel width as a function of stage by assigning the user-defined stage and (or) width scaling increments (ZINC and WINC). (ZINC and WINC are specified on PARAMETER records.)

Cross-sectional Area and Channel Width as Functions of Stage

CGAP will also produce plots of both cross-sectional area and channel width as functions of stage using singular output option 3 or 13. For option 3, plots are produced on a line printer, whereas plots are generated for a digital plotter using option 13. Format and plot scaling are identical to the plots of cross-sectional area as a function of stage illustrated in figures 4 and 5.

Cross Sections

CGAP can plot the cross sections of an open-channel reach individually (options 4 and 14) or collectively in a three-dimensional isometric projection (option 7). Automatic scaling of cross-section plots is also performed by CGAP, however, for plots of individual cross sections user-defined scaling factors can be specified as described below.

Individual

Plots of individual cross sections can be produced on a line printer or digital plotter using output options 4 and 14, respectively. CGAP generates plots with the y-axis of the plot indicating land-surface and channel-bottom elevations referenced to the channel thalweg or to a common datum and the x-axis of the plot defining distances from the channel-bank reference point. The axes are automatically scaled so as to accommodate the entire cross section on both line printer and digital plots. However, it is possible to override the automatic scaling with user-defined stage and cross-channel distance scaling increments (ZINC and DINC). The size of digital plots is controlled by the user-defined length of the y-axis of the plot (LENY) unless values for ZINC and (or) DINC are specified. Axes-scaling, vertical-datum, and thalweg-elevation information are identified at the top center of line-printer plots. The channel name, cross-section number, and vertical-datum information are displayed at the top center of digital plots and thalweg-elevation information appears at the lower right corner. Channel-bank elevations extrapolated to the user-defined maximum stage of computation (ZMAX) are included in the plots. Figures 6 and 7 illustrate cross-section plots -- with default scaling -- generated on a line-printer and digital plotter, respectively. Figures 8 and 9 illustrate the same cross section plotted with various user-defined scaling increments (ZINC and DINC) and vertical-datum adjustment values (DACORR and DAREF). (ZINC, DINC, ZMAX, and DACORR are specified on PARAMETER records and DAREF and LENY on the PROCESSING CONTROL record.)

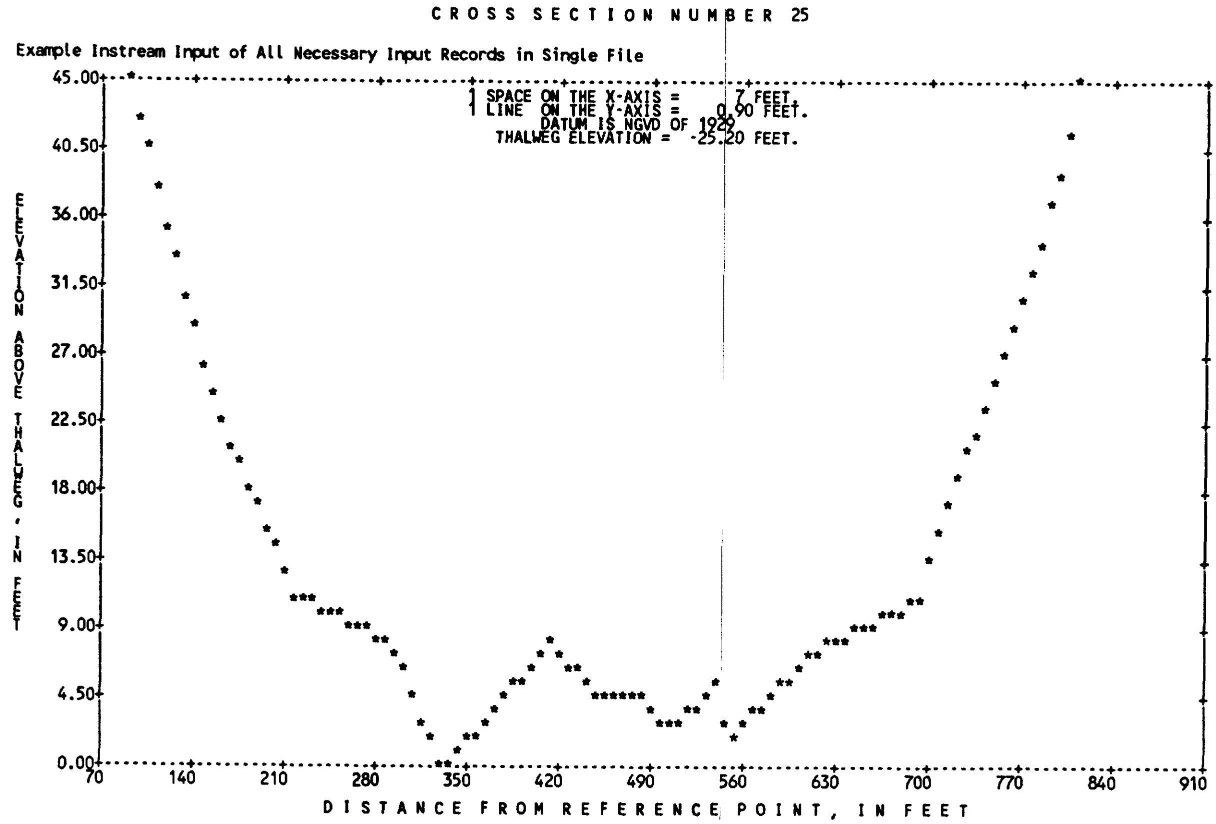

Figure 6.--Sample program-generated line-printer plot of a channel cross section (automatic program scaling).

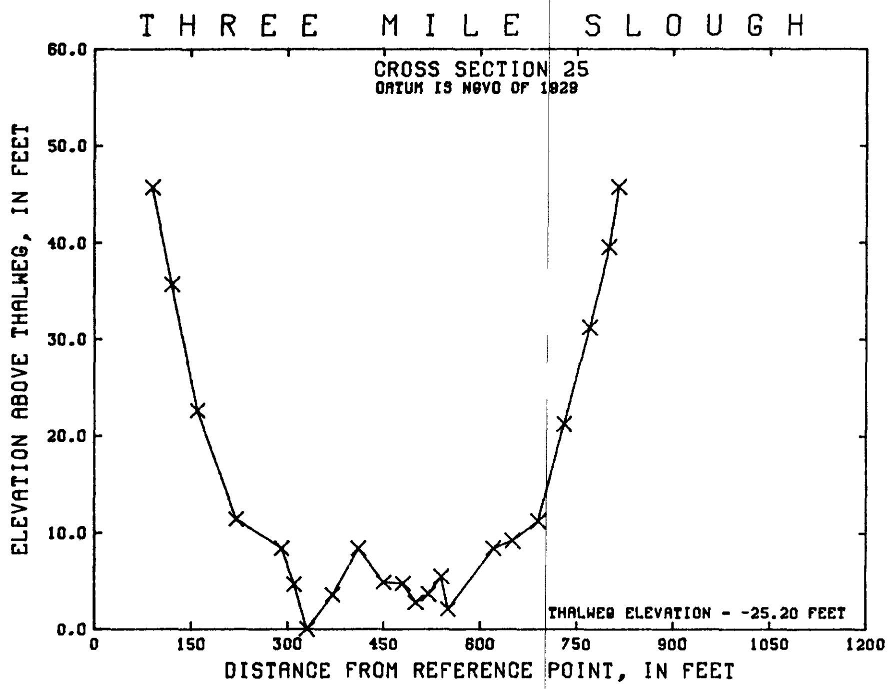

Figure 7.--Sample program-generated digital plot of a channel cross section (automatic program scaling).

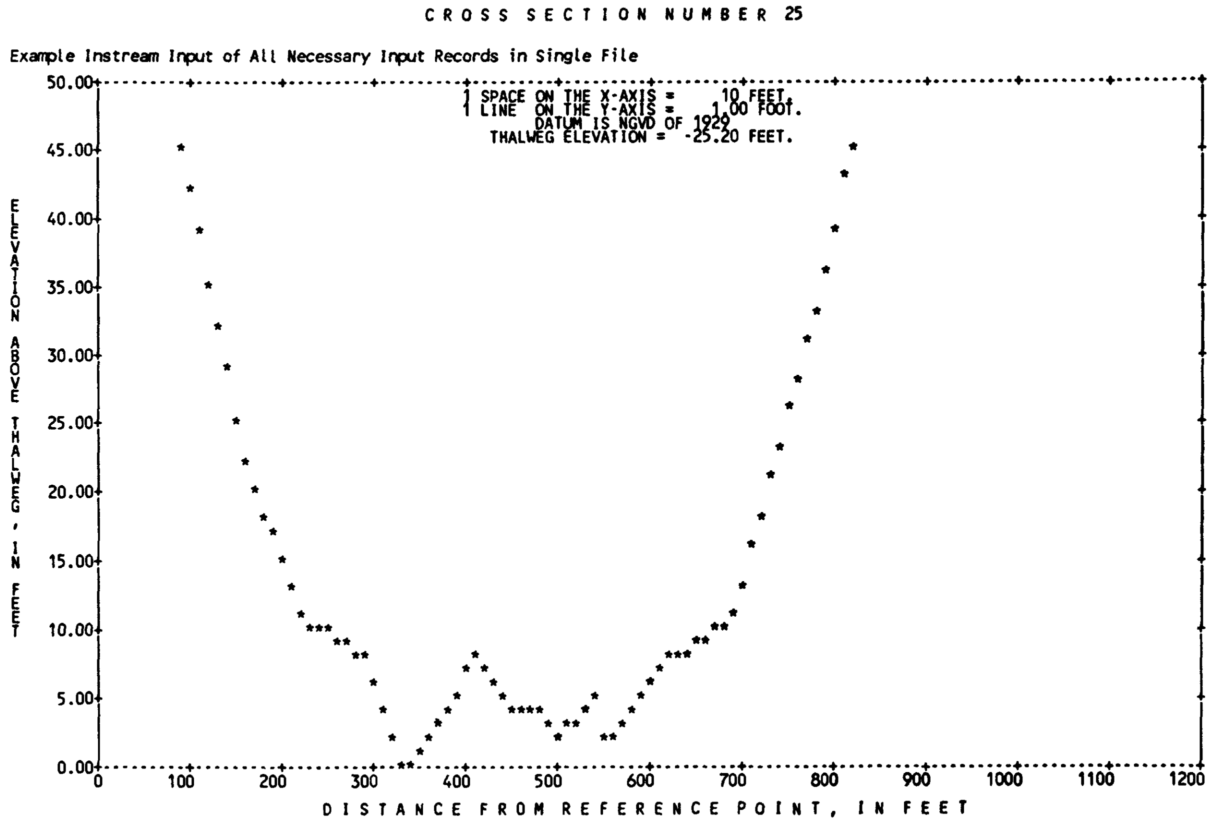

Figure 8.--Sample program-generated line-printer plot of a channel cross section (user-defined elevation scale of 5 feet and distance scale of 100 feet).

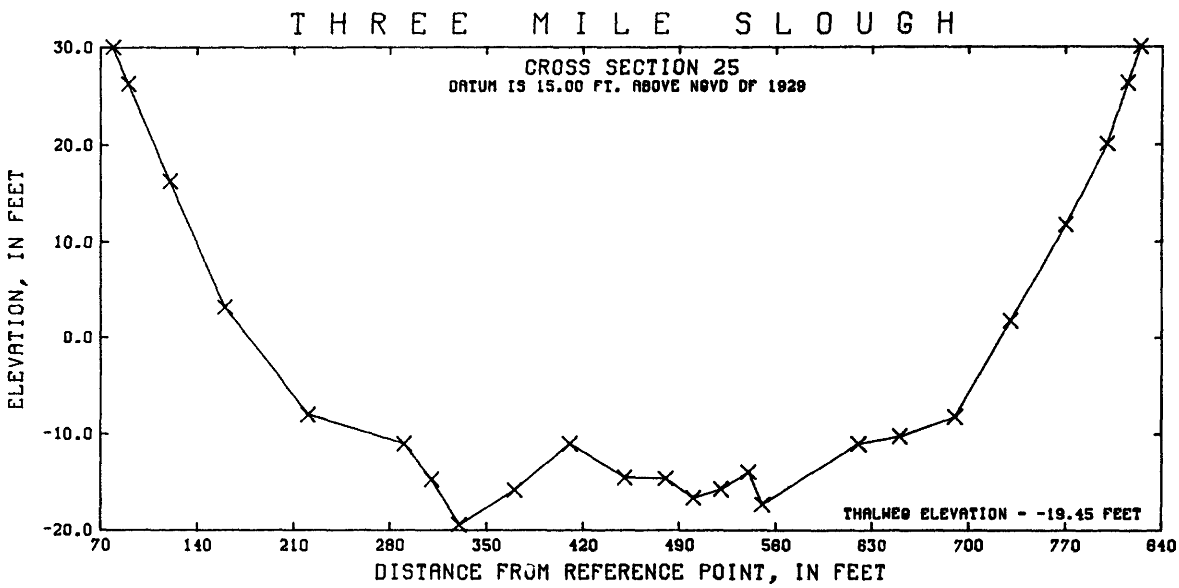

Figure 9.--Sample program-generated digital plot of a channel cross section (user-defined elevation scale of -10 feet, distance scale of 70 feet, datum correction of -9.25 feet, and datum reference level of 15 feet).

Isometric Projection

Output option 7 provides the capability to plot the cross sections of an open-channel reach in a three-dimensional isometric view on a digital plotter. If the reach contains more than five cross sections, it will be subdivided and plotted in two or more subreaches with a maximum of five cross sections plotted in each. The last cross section of any particular subreach will be repeated as the first cross section of the next. The y-axis of the plot of each individual cross-section is scaled based on the minimum input land-surface or channel-bottom elevation of *all* input cross sections and the user-defined maximum stage of computation (ZMAX) of the *first* cross section in the channel reach. Spacing of cross sections in the plot is controlled by user-defined segment lengths (NDSD). Cross sections in the plot are aligned along the channel thalweg. The degree of rotation of the channel thalweg from the x-plot axis (THEDEG) can be specified by the user to control the orientation. (ZMAX and NDSD are specified on PARAMETER records and THEDEG on the PROCESSING CONTROL record.) Figure 10 illustrates an isometric view of a channel reach.

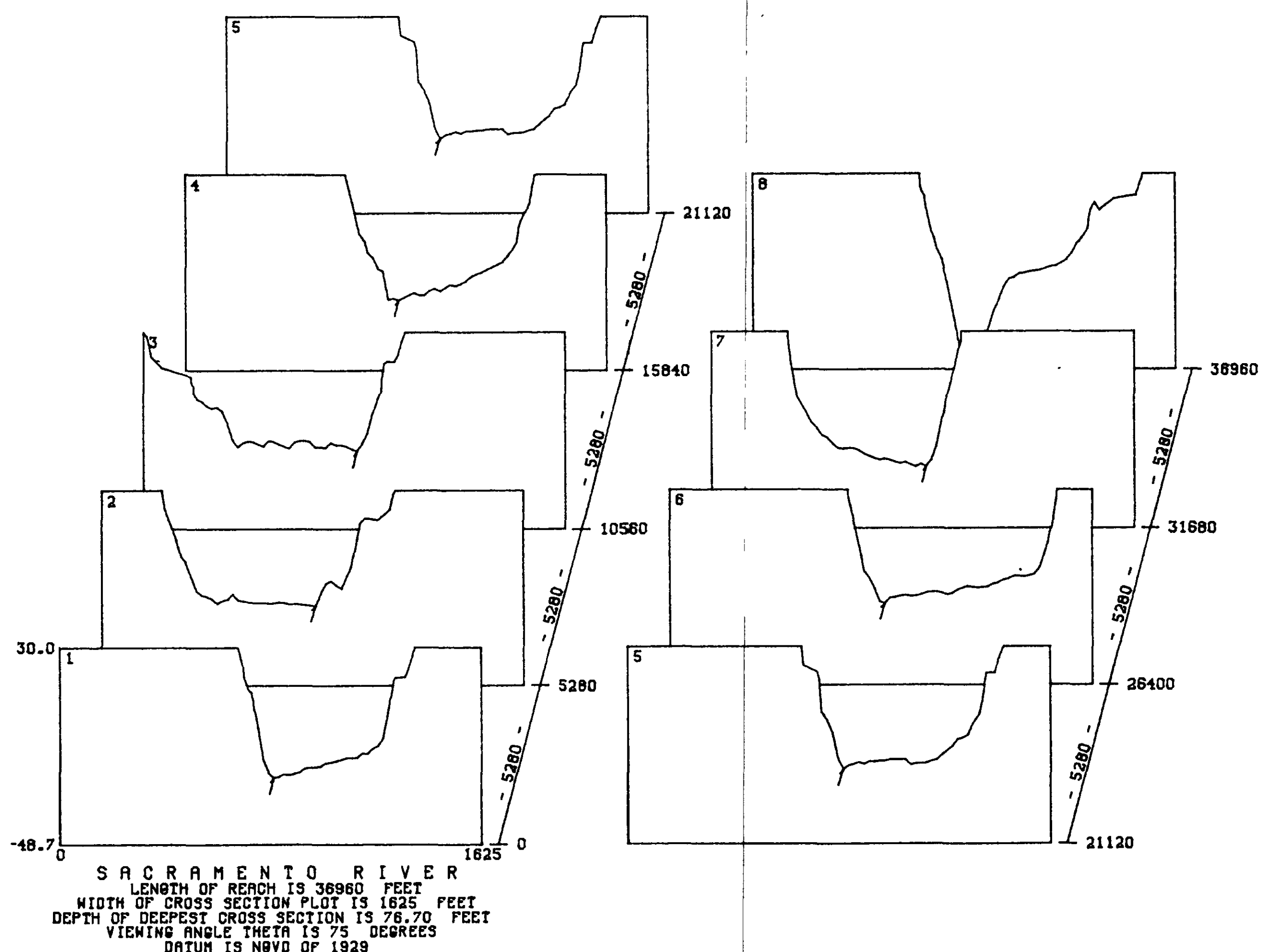

Figure 10.--Sample program-generated digital plot of a three-dimensional isometric view of an open-channel reach.

Cross-sectional Area as a Function of Longitudinal Distance along a Channel Reach

Line-printer plots of cross-sectional areas, at fixed user-specified stages, as a function of longitudinal distance along an open-channel reach can be generated using output option 15. (See figure 11.)[4]

An entire set or any consecutive subset of cross sections can be included in the output produced using option 15. The first cross section (identified by the cross-section number NXPOS) and the number of consecutive cross sections (NSET) to be included in the plot can be specified. The number of stages per printed page (NSTAGE), at which cross-sectional areas are to be plotted, is also definable. If necessary, the number of stage/cross-sectional area functional relationships shown on the last two plot pages is automatically varied to produce a more even distribution. (NXPOS, NSET, and NSTAGE are specified on the PROCESSING CONTROL record.)

The total number of fixed stages at which cross-sectional areas are plotted is based on the three user-defined parameters for *all* cross sections to be included in the plot: the stage increment (DELTAZ) of the *first* cross section, the *largest* minimum stage of computation (ZMIN), and the *smallest* maximum stage of computation

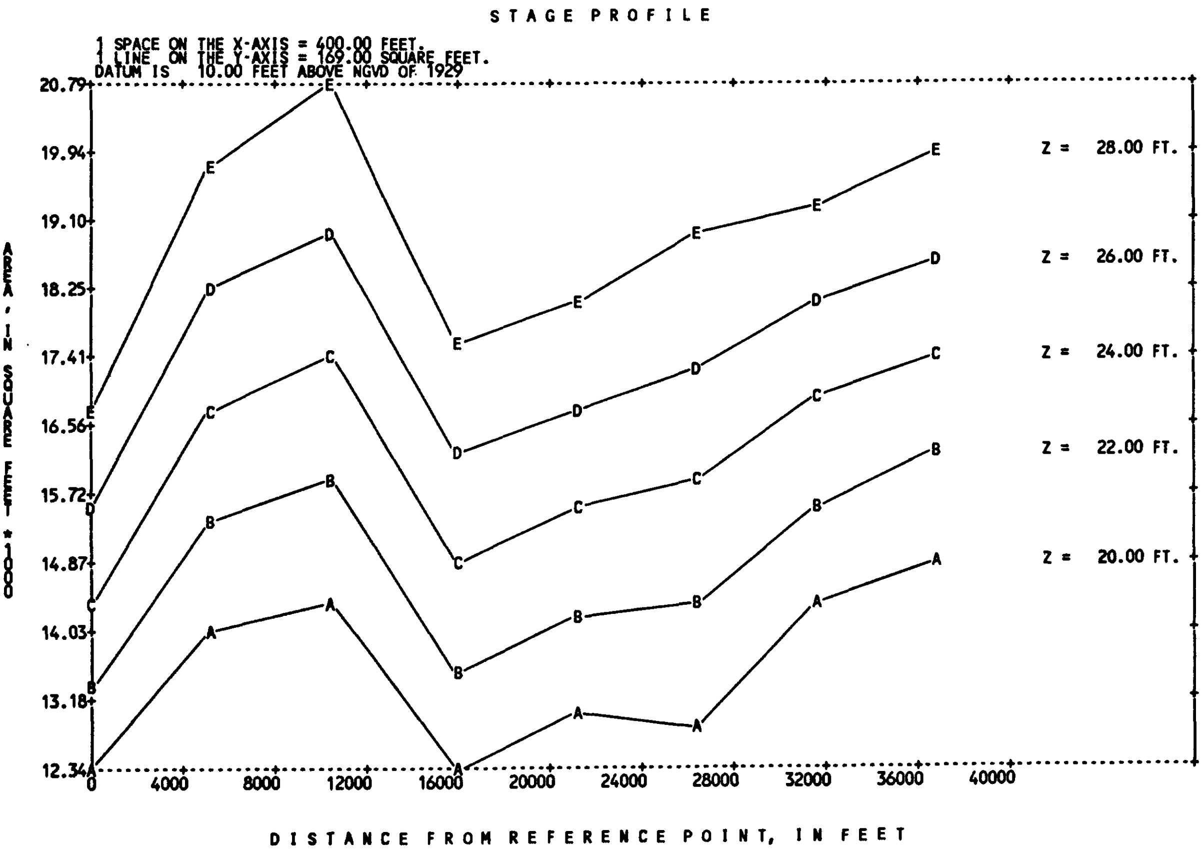

Figure 11.--Sample program-generated line-printer plot of cross-sectional area as a function of longitudinal distance along an open-channel reach.

[4]For publication purposes, line segments have been drawn to enhance the plot.

(ZMAX). Cross-sectional areas are plotted for each stage as a function of the cross-section location as defined by its longitudinal distance (NDSD). (DELTAZ, ZMIN, ZMAX, and NDSD are specified on PARAMETER records.)

Figure 11 illustrates the plot format generated by option 15 using the cross sections shown in figure 10 as input. Note, that if the areas at two or more stages at a cross-section location are approximately equal based on the plot resolution, CGAP only shows the value at the lowest stage.

Tabular Lists

CGAP can produce line-printer listings of input records (option 10) and computed stage-dependent properties (option 5) in tabular format.

Input records

A formatted line-printer listing of the input PARAMETER, COMMENT, SUBDIVISION (PCS), and COORDINATE DATA (CD) records representing each cross section can be produced using output option 10. For each cross section input, CGAP lists, under appropriate headings, the values of the PARAMETER record and SUBDIVISION record, if present, and prints any corresponding COMMENT records. Input coordinate-data values are listed in pairs in a table consisting of five columns. Figure 12 illustrates the output format of option 10 for the input records of two cross sections. CGAP performs no computations under option 10, it simply provides a concise tabular listing of the input records. The output is formatted such that all of the data for a cross section are confined to a single line-printer page.

CROSS SECTION	COMMENT RECORDS	MINIMUM STAGE	MAXIMUM STAGE	STAGE INCREMENT	X-S ANGLE VARIANCE	DISTANCE OR LENGTH	FIRST GROUP	SECOND GROUP	ELEVATION TO DATUM	DEPTH SCALE	DIST SCALE	NUMBER OF SUBS	AREA SCALE	WIDTH SCALE
25	1	-24.00	20.00	2.00	0.0	0	1	0	0.00	0.0	0.0	5	0.0	0.0

SUBDIVISION POINTS

180.00 270.00 400.00 500.00 600.00 0.00

Example Instream Input of All Necessary Input Records in Single File
DATUM IS NGVD OF 1929

DISTANCE	ELEVATION	NO.	DISTANCE	ELEVATION	NO.	DISTANCE	ELEVATION	NO.	DISTANCE	ELEVATION	NO.	DISTANCE	ELEVATION	NO.
90.0	20.5	1	120.0	10.5	2	160.0	-2.6	3	220.0	-13.8	4	290.0	-16.8	5
310.0	-20.5	6	330.0	-25.2	7	370.0	-21.6	8	410.0	-16.8	9	450.0	-20.3	10
480.0	-20.4	11	500.0	-22.4	12	520.0	-21.5	13	540.0	-19.7	14	550.0	-23.1	15
620.0	-16.8	16	650.0	-16.0	17	690.0	-14.0	18	730.0	-4.0	19	770.0	6.0	20
800.0	14.3	21	815.0	20.5	22									

CROSS SECTION	COMMENT RECORDS	MINIMUM STAGE	MAXIMUM STAGE	STAGE INCREMENT	X-S ANGLE VARIANCE	DISTANCE OR LENGTH	FIRST GROUP	SECOND GROUP	ELEVATION TO DATUM	DEPTH SCALE	DIST SCALE	NUMBER OF SUBS	AREA SCALE	WIDTH SCALE
26	0	-34.00	20.00	2.00	0.0	900	0	0	0.00	0.0	0.0	0	0.0	0.0

DATUM IS NGVD OF 1929

DISTANCE	ELEVATION	NO.	DISTANCE	ELEVATION	NO.	DISTANCE	ELEVATION	NO.	DISTANCE	ELEVATION	NO.	DISTANCE	ELEVATION	NO.
80.0	20.5	1	100.0	14.3	2	120.0	2.8	3	200.0	-7.5	4	250.0	-8.0	5
300.0	-10.4	6	340.0	-9.2	7	430.0	-16.6	8	500.0	-30.7	9	550.0	-39.2	10
556.0	-40.0	11	600.0	-18.8	12	656.0	3.2	13	676.0	15.7	14	684.0	20.5	15

Figure 12.--Sample program-generated line-printer output of a tabular list of input data records.

Stage-Dependent Properties

Tabular lists of cross-sectional properties computed as functions of stage can be produced using output option 5. CGAP computes and prints cross-sectional area, channel width, wetted perimeter, hydraulic radius, average depth, a ratio of hydraulic radius to average depth, and an index of cross-sectional symmetry at successive user-defined increments of stage (DELTAZ) between user-defined minimum (ZMIN) and maximum (ZMAX) stages. Output for the second and all subsequent cross sections also shows the rates-of-change in cross-sectional area, channel width, wetted perimeter, hydraulic radius, and average depth between successive cross sections. Note, that rates-of-change are only meaningful if cross sections are input in either upstream or downstream order and cross-section locations along the channel thalweg, as defined by longitudinal distance (NDSD), are properly specified. (DELTAZ, ZMIN, ZMAX, and NDSD are specified on PARAMETER records.)

Figure 13 illustrates option 5 output for two cross sections of an open-channel reach. Stage-dependent properties computed for cross section 25 using DELTAZ of 2, ZMIN of -14, and ZMAX of 15 are listed in figure 13A; those computed for cross section 26 using DELTAZ of 4, ZMIN of -22, and ZMAX of 15 are listed in figure 13C; while computed rates-of-change between cross sections 25 and 26, based on an NDSD difference of 900, are listed in figure 13B. CGAP determines the number of stages at which rates-of-change are computed on the basis of DELTAZ, ZMIN, and ZMAX as specified for the second cross section of the pair. Rates-of-change are only computed at a given stage if stage-dependent properties were computed for both cross sections (that is, no interpolations are performed). The parenthesized values that appear to the left of the cross-sectional area, channel width, and wetted perimeter values in figure 13C are the totals for adjacent subchannels to the left of the main channel (occurring, for instance, where an island or sandbar is present in the cross section). Values for the main channel do not include subchannel totals.

Files

CGAP can generate sequential files of PARAMETER, COMMENT, SUBDIVISION, and COORDINATE DATA records in program-standard format and files of computed stage-dependent cross-sectional properties. These generated files can subsequently be used as input to user-application programs, such as flow/transport simulation models, that require cross-sectional data. Output options 6, 8, 9, and 16 produce these sequential files. Option 16 and options 6 and 8 (when computing mean cross-sectional properties for an open-channel reach) also produce tabular line-printer output.

Input Records

Output option 9 affords the capability to save the input PARAMETER, COMMENT, SUBDIVISION (PCS), and COORDINATE DATA (CD) records in a standard-format file. This file can be modified, subsequently, using a text editor to include desired parameter values and any COMMENT and (or) SUBDIVISION records. It can then be used as the PCSCD input file to CGAP by turning on the IDEV and KDEV flags to indicate that the PCS and CD records are present in the PCSCD file. (IDEV and KDEV are specified on the DATA FORMAT record.) Option 9 can be used, for example, to transfer step-backwater-program formatted cross-sectional data into CGAP-standard format for subsequent processing. To save the standard-format file, the appropriate file handling assignments must be made; these vary depending on the computer system used. (Refer to Appendix I for appropriate file handling instructions.)

C R O S S   S E C T I O N   N U M B E R   25

Example Instream Input of All Necessary Input Records in Single File
DATUM IS NGVD OF 1929
THALWEG ELEVATION = -25.20 FEET

STAGE	(LEFT CHANNELS) AREA (RIGHT CHANNELS)	WIDTH	WETTED PERIMETER	HYDRAULIC RADIUS	AVERAGE DEPTH	RATIO OF RADIUS/DEPTH	ASYMMETRY ON THALWEG
-14.00	2359	465	468	5.04	5.07	0.99	-0.66
-12.00	3316	488	491	6.76	6.80	0.99	-0.48
-10.00	4310	506	510	8.45	8.51	0.99	-0.38
-8.00	5341	525	529	10.10	10.17	0.99	-0.32
-6.00	6410	544	548	11.69	11.79	0.99	-0.28
-4.00	7516	563	567	13.25	13.36	0.99	-0.25
-2.00	8660	580	585	14.80	14.93	0.99	-0.23
0.00	9833	594	600	16.40	16.56	0.99	-0.21
2.00	11035	608	614	17.96	18.15	0.99	-0.20
4.00	12266	622	629	19.50	19.71	0.99	-0.19
6.00	13524	636	644	21.01	21.26	0.99	-0.18
8.00	14810	650	658	22.52	22.80	0.99	-0.17
10.00	16122	663	672	24.00	24.32	0.99	-0.17
12.00	17461	676	685	25.47	25.82	0.99	-0.16
14.00	18827	689	699	26.92	27.31	0.99	-0.16

(A)

R A T E   O F   C H A N G E   I N   T H E   F O L L O W I N G   S T A G E   R E L A T E D
P A R A M E T E R S   B E T W E E N   C R O S S   S E C T I O N S   25 AND 26

DATUM IS NGVD OF 1929

STAGE	AREA	WIDTH	WETTED PERIMETER	HYDRAULIC RADIUS	AVERAGE DEPTH
-22.00		U N A B L E	T O D E T E	R M I N E	
-18.00		U N A B L E	T O D E T E	R M I N E	
-14.00	0.296	-0.279	-0.273	0.008	0.008
-10.00	-0.787	-0.236	-0.230	0.004	0.004
-6.00	-1.398	-0.111	-0.104	0.000	0.000
-2.00	-1.832	-0.106	-0.099	-0.001	-0.001
2.00	-2.221	-0.090	-0.083	-0.001	-0.001
6.00	-2.592	-0.100	-0.093	-0.001	-0.001
10.00	-3.022	-0.116	-0.107	-0.001	0.000
14.00	-3.512	-0.129	-0.120	0.000	0.000

(B)

C R O S S   S E C T I O N   N U M B E R   26

DATUM IS NGVD OF 1929
THALWEG ELEVATION = -40.00 FEET

STAGE	(LEFT CHANNELS) AREA (RIGHT CHANNELS)	WIDTH	WETTED PERIMETER	HYDRAULIC RADIUS	AVERAGE DEPTH	RATIO OF RADIUS/DEPTH	ASYMMETRY ON THALWEG
-22.00	1277	137	142	8.98	9.35	0.96	0.42
-18.00	1880	165	172	10.92	11.39	0.96	2.43
-14.00	2625	214	222	11.83	12.27	0.96	0.53
-10.00	(4) 3598	(22) 272	(22) 281	11.88	12.24	0.97	0.98
-6.00	5152	444	454	11.34	11.60	0.98	1.27
-2.00	7011	485	496	14.12	14.44	0.98	1.05
2.00	9036	527	539	16.77	17.15	0.98	0.92
6.00	11191	546	560	19.99	20.49	0.98	0.77
10.00	13402	559	576	23.29	23.96	0.97	0.66
14.00	15666	573	591	26.50	27.35	0.97	0.58

(C)

Figure 13.--Sample program-generated line-printer output of a tabular list of stage-dependent cross-sectional properties. A, List of stage-dependent properties for cross section 25. B, List of rates-of-change of stage-dependent properties between cross sections 25 and 26. C, List of stage-dependent properties for cross section 26.

Cross-sectional Area and Channel Width as Functions of Stage

CGAP outputs cross-sectional areas and channel widths, computed at successive user-defined increments of stage (DELTAZ) starting at the user-defined minimum stage for computation (ZMIN) and ending at the user-defined maximum stage for computation (ZMAX), to a sequential file and to the line printer via option 6. This option also permits the averaging of cross-sectional properties defined by two or more input cross sections. The set of cross sections for which average cross-sectional properties is to be computed is referred to as a mean group. To designate cross sections to the same mean group, assign them identical mean group numbers (MN1 or MN2). The total number of fixed stages at which average cross-sectional properties are computed for a mean group is based on three user-defined program parameters: the stage increment (DELTAZ) of the *first* cross section and the *smallest* ZMIN and *largest* ZMAX specified for *all* cross sections included in the mean group. (DELTAZ, ZMIN, ZMAX, MN1, and MN2 are specified on PARAMETER records.) (Refer to Appendix II for further explanation of the assignment of cross sections to mean groups.) Tables of computed cross-sectional properties are output to a sequential file that is in the input format expected by the branch-network flow model (Schaffranek and others, 1981). Figure 14 illustrates the sequential file format generated by this option for a mean group consisting of three cross sections.

```
19
   514.000 63431.437  1780.820                                        1
   516.000 68043.719  2005.213                                        1
   518.000 72160.656  2111.739                                        1
   520.000 76490.672  2218.266                                        1
   522.000 81003.000  2280.876                                        1
   524.000 85608.531  2324.667                                        1
   526.000 90314.390  2398.857                                        1
   528.000 95141.219  2427.981                                        1
   530.000100026.328  2457.105                                        1
   532.000105400.437  2859.965                                        1
   534.000111338.156  3077.756                                        1
   536.000118117.093  4306.973                                        1
   538.000126922.656  4498.571                                        1
   540.000136111.374  4690.170                                        1
   542.000146274.624  5281.501                                        1
   544.000156964.562  5408.433                                        1
   546.000167905.218  5519.630                                        1
   548.000178992.749  5567.895                                        1
```

Figure 14.--Line-printer listing of the program-generated sequential file of cross-sectional area and channel width as functions of stage using output option 6.

Option 6 output can also be produced in an alternate file format by turning on the alternate punch (ALTPCH) flag. (ALTPCH is specified on the PROCESSING CONTROL record.) The output for each cross section consists of two tables. The first table consists of cross-sectional area as a function of stage, whereas the second consists of channel width as a function of stage. Each table is preceded by a record identifying the number of stage-dependent relationships computed. The computed stage-dependent properties are output in pairs, with up to five pairs per record. Figure 15 illustrates the alternate file format of option 6 for two input cross sections.

37									
-16.0	1515	-15.0	1916	-14.0	2359	-13.0	2833	-12.0	3316
-11.0	3808	-10.0	4310	-9.0	4821	-8.0	5341	-7.0	5871
-6.0	6410	-5.0	6958	-4.0	7516	-3.0	8083	-2.0	8660
-1.0	9243	0.0	9833	1.0	10431	2.0	11035	3.0	11647
4.0	12266	5.0	12891	6.0	13524	7.0	14164	8.0	14810
9.0	15463	10.0	16122	11.0	16789	12.0	17461	13.0	18141
14.0	18827	15.0	19519	16.0	20217	17.0	20921	18.0	21629
19.0	22344	20.0	23063						
37									
-16.0	379	-15.0	422	-14.0	465	-13.0	478	-12.0	488
-11.0	497	-10.0	506	-9.0	516	-8.0	525	-7.0	534
-6.0	544	-5.0	553	-4.0	563	-3.0	572	-2.0	580
-1.0	587	0.0	594	1.0	601	2.0	608	3.0	615
4.0	622	5.0	629	6.0	636	7.0	643	8.0	650
9.0	656	10.0	663	11.0	670	12.0	676	13.0	683
14.0	689	15.0	695	16.0	701	17.0	706	18.0	711
19.0	717	20.0	722						
28									
-34.0	150	-32.0	264	-30.0	410	-28.0	585	-26.0	787
-24.0	1018	-22.0	1277	-20.0	1564	-18.0	1880	-16.0	2226
-14.0	2625	-12.0	3082	-10.0	3602	-8.0	4296	-6.0	5152
-4.0	6061	-2.0	7011	0.0	8003	2.0	9036	4.0	10105
6.0	11191	8.0	12289	10.0	13402	12.0	14527	14.0	15666
16.0	16820	18.0	17994	20.0	19187				
28									
-34.0	49	-32.0	65	-30.0	80	-28.0	94	-26.0	108
-24.0	122	-22.0	137	-20.0	151	-18.0	165	-16.0	184
-14.0	214	-12.0	243	-10.0	294	-8.0	377	-6.0	444
-4.0	465	-2.0	485	0.0	506	2.0	527	4.0	539
6.0	546	8.0	553	10.0	559	12.0	566	14.0	573
16.0	582	18.0	592	20.0	602				

Figure 15.--Line-printer listing of the program-generated sequential file of cross-sectional area and channel width as functions of stage using the alternate punch facility of output option 6.

Wetted Perimeter and Hydraulic Radius as Functions of Stage

CGAP can also produce output of wetted perimeter and hydraulic radius values computed at specified stages using option 8. The line-printer and sequential-file output formats of this option are similar to those of option 6.

Cross-Section Subdivision

Output option 16 provides the capability to subdivide a cross section into as many as seven subunits, compute the cross-sectional area and channel width at successive user-defined increments of stage (DELTAZ) between specified minimum (ZMIN) and maximum (ZMAX) stages, and store tables of cross-sectional area and channel width as functions of stage for each subunit in a sequential file. This file can then be used as input to user-application programs requiring subunit properties. The number of subdivisions (NSUBS) desired for each cross section is specifiable. (DELTAZ, ZMIN, ZMAX, and NSUBS are specified on PARAMETER records.) The cross-channel distances (SUBD) at which the cross section is to be subdivided are defined on the SUBDIVISION input record. In addition to the filed output, CGAP prepares and prints a tabular list of cross-sectional area and channel width as functions of stage for each subunit of the cross section. Figure 16 illustrates the sequential file output format for a subdivided cross section.

CROSS SECTION NUMBER 25

SUBDIVISION 1 (	90.0 -	180.0)
20.0	1265	88
18.0	1094	82
16.0	935	76
14.0	788	70
12.0	654	64
10.0	531	58
8.0	420	52
6.0	321	46
4.0	235	40
2.0	161	34
0.0	99	28
-2.0	49	22
SUBDIVISION 2 (	180.0 -	270.0)
20.0	2943	90
18.0	2763	90
16.0	2583	90
14.0	2403	90
12.0	2223	90
10.0	2043	90
8.0	1864	90
6.0	1684	90
4.0	1504	90
2.0	1324	90
0.0	1144	90
-2.0	965	90
-4.0	785	90
-6.0	605	90
-8.0	433	81
-10.0	282	70
-12.0	152	60
SUBDIVISION 3 (	270.0 -	400.0)
20.0	5284	130
18.0	5024	130
16.0	4764	130
14.0	4504	130
12.0	4244	130
10.0	3984	130
8.0	3724	130
6.0	3464	130
4.0	3204	130
2.0	2945	130
0.0	2685	130
-2.0	2425	130
-4.0	2165	130
-6.0	1906	130
-8.0	1646	130
-10.0	1386	130
-12.0	1127	130
-14.0	867	130
-16.0	607	129
-18.0	384	103
-20.0	204	76

Figure 16.--Line-printer listing of the program-generated sequential file of cross-sectional area and channel width as functions of stage using output option 16 for three subdivisions of a channel cross section.

SUMMARY

The Channel Geometry Analysis Program (CGAP) provides the capability to process, analyze, and format cross-sectional data for input to flow/transport simulation models or other computational programs. CGAP allows for a variety of cross-sectional data input formats through use of variable format specification. The program accepts data from various computer media and provides for modification of machine-stored parameter values. CGAP has been devised to provide a rapid and efficient means of computing and analyzing the physical properties of an open-channel reach defined by a sequence of cross sections.

CGAP's 16 options provide a wide range of methods by which to analyze and depict a channel reach and its individual cross-sectional properties. Output products include tabular lists of cross-sectional area, channel width, wetted perimeter, hydraulic radius, average depth, and cross-sectional symmetry computed as functions of stage; plots of cross sections; plots of cross-sectional area and (or) channel width as functions of stage; tabular lists of cross-sectional area and channel width computed as functions of stage for subdivisions of a cross section; plots of cross sections in isometric projection; and plots of cross-sectional area at a fixed stage as a function of longitudinal distance along an open-channel reach. A Command Procedure Language program and Job Control Language procedure exist to facilitate program execution on the U.S. Geological Survey Prime and Amdahl computer systems, respectively.

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APPENDIX I

Program Execution Preparation

The first step in preparing to execute CGAP is to code the necessary input program-control and data records according to the format specified in Appendix II. Appendix II provides the abbreviated definition, value range, default assignment, and program application considerations for all program parameters, describes the input record formats, and gives three example instream file setups. (Additional commentary on cross-section order, file structure, and step-backwater-program formatted data is also provided in the Input Considerations section).

An interactive Command Procedure Language (CPL) program has been developed to facilitate execution of CGAP on the U.S. Geological Survey (USGS)/Water Resources Division (WRD) Prime computer system. The CPL program is described below and example interactive executions are illustrated.

A Job Control Language (JCL) cataloged procedure, also called CGAP, has been established to facilitate execution of CGAP on the USGS/Information Systems Division (ISD) Amdahl computer system. A description of the symbolic parameters of the cataloged procedure, as well as sample setups of the JCL statements required for program execution, are included herein. CGAP is invoked from a load module library residing on a private online disk.

If errors are detected by CGAP during execution, an appropriate diagnostic message is printed. For additional explanation of program diagnostic messages refer to Appendix III.

Prime

To execute CGAP on a USGS/WRD Prime computer system, all required input and output files must be opened to the correct PRIMOS file unit numbers. A Prime Command Procedure Language (CPL) program, CGAP.CPL, that is designed to perform all necessary file handling and to initiate program execution, has been developed and is available on the Northeast Region research (RVARES node) Prime computer in Reston, Virginia. The CPL program can be run interactively or as a batch job.

To execute CGAP interactively on a Prime computer issue the following PRIMOS command:

CPL *pathname*,

where

pathname is the disk pathname of the CPL program.

For example,

CPL SWB>CGAP.CPL.

The CPL program prompts for all required file handling information. The response to each prompt must be terminated by a carriage return or simply consist of a carriage return when the default condition is desired. The initial CPL prompt is for the pathname of the instream file (PRIMOS file unit 1, Fortran file unit 5). This file must contain the IDENTITY, DATA FORMAT, PROCESSING CONTROL, and optional PARAMETER ALTERATION records. The next CPL prompt is for the pathname of the PCSCD file (PRIMOS file unit 6, Fortran file unit 10). This file can be empty or contain either COORDINATE DATA (CD) or PARAMETER, COMMENT, SUBDIVISION (PCS), and CD records. If all input records are contained in the instream file, the appropriate response to the prompt for the PCSCD file is a carriage return. (All input data records are described in Appendix II.)

The CPL program next prompts the user for the remainder of the file handling information. It asks if the program output files are to be opened under assigned or default names and Fortran unit numbers, respond 'Y' or 'N'. The default condition is to use CPL-assigned names and unit numbers. Alternate unit numbers for output files can only be specified if they are also specified on the DATA FORMAT record of the instream file (see Appendix II for coding instructions). File types, default names, and Fortran unit numbers are listed in the following table:

FILE	FILE TYPE	DEFAULT NAME	DEFAULT UNIT
instream	INPUT	CGAP.DATA	5
PCSCD	INPUT	(NONE)	10
line printer	OUTPUT	CGAP.PRINTER	66
punch	OUTPUT	CGAP.OUT6OR8	7
digital plotter	OUTPUT	CGAP.PLOTFILE	9
standard format	IN/OUT	CGAP.STANDARD	67
subdivision	OUTPUT	CGAP.OUT16	16

The pathname of the instream file is used by the CPL program as a basis for naming all output files. Each output file name is of the form *XXX.filetype*, (*XXX* is the portion of the instream pathname up to the first occurrence of the string .DAT and *filetype* can be PRINTER, OUT6OR8, OUT16, PLOTFILE, or STANDARD.) Therefore the string .DAT must not occur in the instream pathname except as a file-name suffix. For example, if the pathname of the instream file is entered as USER>DATA>XS_SACRAMENTO.DATA the line-printer file is given the pathname USER>DATA>XS_SACRAMENTO.PRINTER. Note that if the string .DAT does not occur in the instream pathname, output file names will be assigned based on the full pathname of the instream file. If these default names and Fortran file unit numbers are not chosen, by responding with 'N', the CPL program prompts for alternate names and units. The desired pathname, unit number, or carriage return is entered after the prompts for each file. A carriage return indicates to the CPL program to use the default file name and Fortran unit number.

The CPL program next prompts for whether or not the file opening information is to be displayed on the user's terminal, respond 'Y' or 'N'. The default condition is to suppress the information. The file-opening information includes the pathname, Fortran unit number, PRIMOS device number and octal unit number of each file as it is opened. The last prompt is to determine if the standard-format file (Fortran file unit 67) is to be saved, answer with 'Y' to save, otherwise it will be deleted upon program termination. The standard-format file is used by CGAP as a scratch file to store PCS and CD records so that multiple program options can be utilized during a single execution. To retain the standard-format file, as required for output 9, the appropriate CPL assignments must be made as described below. After all files are open, the CPL program initiates execution of CGAP and closes all files upon program termination.

To execute the CPL program as a Prime batch job simply type the PRIMOS command:

JOB *pathname* **-ARGS** *infile5 infile10 savedisk*

where

Pathname is the CPL program pathname,

infile5 is the instream file pathname,

infile10 is the PCSCD file as described above in the interactive procedure, and

savedisk is an optional argument, which, if input as any non-blank character, will signal the CPL program to save the standard-format file.

For example,

JOB SWB>CGAP.CPL -ARGS CGAP.DATA CGAP10.DAT SAVE.

If all input records are contained in *infile5*, *infile10* can be omitted. If it is necessary to save the standard-format file a pathname must be entered for *infile10* to complete the argument list of the CPL program. If *infile5* contains all input records, a dummy pathname can be entered for *infile10* when required. After the job is submitted the CPL program opens and assigns default unit numbers to all input/output files using the default names identified above and initiates execution of CGAP. To get a paper copy of the line-printer output use the PRIMOS SPOOL command with the -FTN option. The -FTN option enables the Fortran carriage-control characters.

In the example interactive execution below, all input records are contained in the instream file USER>DATA>SAVE.DATA; therefore, a carriage return is entered for the PCSCD file prompt. The CPL program then prompts for all required information for file names and unit numbers. For this case, alternate names and unit numbers are desired, thus a response of 'N' is entered to the prompts for default names and units. In this example, names were specifically defined for the print, punch, plotter, and standard-format files and the unit numbers for the print, plotter, and standard-format files were changed to match the units coded on the DATA FORMAT record of the instream file. It was decided to display the file opening information, as indicated by the response of 'N' to the prompt, and it was not necessary to save the standard-format file.

```
================================================================================
OK> CPL CGAP

Type a carriage return when a default name/unit is desired
or the file is not needed.

Type name of instream file (unit 5): USER>DATA>SAVE.DATA <CR>

Type name of PCSCD file (unit 10): <CR>

Do you wish default names for output files y/n: N <CR>

Type name of line-printer output file: PRINT.OUT <CR>

Type name of option 6 or 8 punched output file: GEOM.SACRAMENTO <CR>

Type name of digital-plotter output file: PLOT.OUT <CR>

Type name of standard-format data file: STANDARD <CR>

Type name of subdivision output file: <CR>

Do you wish default unit numbers for output files y/n: N <CR>

** These unit numbers must be coded on DATA FORMAT record **

Type unit number of line-printer file: 50 <CR>

Type unit number of option 6 or 8 output file: <CR>

Type unit number of plotter file: 80 <CR>

Type unit number of standard-format file: 55 <CR>

Type unit number of subdivision file: <CR>

Do you wish to suppress file opening information y/n: N <CR>

Do you wish to save the standard-format file y/n: N <CR>

OPEN FORTRAN UNIT 5 PROGRAM CONTROL INSTREAM FILE
File name: <SWMOD>USER>DATA>SAVE.DATA
Fortran Unit 5, Primos Unit 1, Octal unit 1

OPEN DEFAULT FORTRAN UNIT 67 STANDARD-FORMAT FILE
File name: <SWMOD>USER>PROG>STANDARD
Fortran Unit 55, Primos Unit 43, Octal unit 53

OPEN DEFAULT FORTRAN UNIT 66 PROGRAM PRINTED OUTPUT
File name: <SWMOD>USER>PROG>PRINT.OUT
Fortran Unit 50, Primos Unit 38, Octal unit 46
```

```
OPEN DEFAULT FORTRAN UNIT 7 OPTION 6 OR 8 OUTPUT FILE
File name: <SWMOD>USER>PROG>GEOM.SACRAMENTO
Fortran Unit 7, Primos Unit 3, Octal unit 3

OPEN DEFAULT FORTRAN UNIT 9 DIGITAL PLOTTER COMMANDS FILE
File name: <SWMOD> PROG>PLOT.OUT
Fortran Unit 80, Primos Unit 68, Octal unit 104

OPEN DEFAULT FORTRAN UNIT 16 SUBDIVISION OUTPUT FILE
File name: <SWMOD>USER>DATA>SAVE.OUT16
Fortran Unit 16, Primos Unit 12, Octal unit 14

RUNNING CHANNEL GEOMETRY ANALYSIS PROGRAM . . .

**** STOP
OK>
==========================================================================
```

Although CGAP is adaptable to any CalComp-compatible plotting software library, the following example interactive execution illustrates use of the program as linked to an author-enhanced version of DIGSDISSPLA that includes an interactive graphics device initiation routine. (DIGSDISSPLA is a particular set of graphics emulator routines designed to convert CalComp subroutine references to the DISSPLA software language, which is a product of Integrated Software Systems Corporation, San Diego, California. DIGSDISSPLA, which is supplied to all USGS/WRD Prime sites in the DISSPLA software package, is a member of the Device Independent Graphics System (written communication, Harbaugh, 1983). Prime users need to confirm the plotter software status and availability for use with their local site administrator.) For this example interactive execution, all input records are contained in the instream file, therefore a carriage return is entered for the PCSCD file prompt. A carriage return is also entered for the next four prompts, as the default conditions satisfy the requirements for this execution. (These default conditions are to permit the use of the default file names and Fortran unit numbers, to suppress the file opening information, and not to save the standard file.) The next two prompts are issued by the device initiation routine. (This routine is a simple user-modifiable routine designed to enable selected graphics devices to receive CGAP output by using the appropriate DISSPLA device emulator.) The final two prompts of this particular execution are issued by the DISSPLA subroutine driver for Hewlett Packard (HP) plotters to determine the particular HP plotter being used.

```
==========================================================================
OK> CPL CGAP

Type a carriage when a default name/unit is desired
or the file is not needed.

Type name of instream file (unit 5): USER>DATA>SAVE.DATA <CR>

Type name of PCSCD file (unit 10): <CR>

Do you wish default names for output files y/n: <CR>
```

```
Do you wish default unit numbers for output files y/n: <CR>

Do you wish to suppress file opening information y/n: <CR>

Do you wish to save the standard-format file y/n: <CR>

RUNNING CHANNEL GEOMETRY ANALYSIS PROGRAM . . .

 ENTER PLOTTER DEVICE TYPE
  TEKTRONIX TERMINALS     = TEK
  TEKTRONIX 4100 SERIES   = TK4
  TAB GRAPHICS TERMINAL   = TAB
  DISSPLA POSTPROCESS     = POS
  HEWLETT PACKARD         = HP
  GRAPHON TERMINAL        = GRP
  HIPLOT TERMINAL         = HIP
  DIGITAL VT100 TERMINAL  = VT1
  ZETA PLOTTERS           = ZET
  CALCOMP PLOTTERS        = CAL
HP
 ENTER PAGE SIZE PARAMETERS IN INCHES (X,Y)
20.0 20.0
 ENTER PLOTTER MODEL NUMBER
7221
 ENTER MODEL:  0=A 1=B 2=C 3=S 4=T
2
((
 END OF DISSPLA 9.2 -- 2684 VECTORS IN 1 PLOTS.
 RUN ON 2/20/86 USING SERIAL NUMBER 0 AT USGS/WRD
 PROPRIETARY SOFTWARE PRODUCT OF ISSCO, SAN DIEGO, CA.
 785 VIRTUAL STORAGE REFERENCES; 4 READS; 0 WRITES.
**** STOP
OK>
=======================================================================
```

Amdahl

In order to facilitate use of CGAP from remote terminals connected to the USGS/ISD Amdahl computer system, the program has been compiled and loaded into an online library. To simplify the job control language (JCL) requirements a cataloged procedure, also called CGAP, has been developed and is available to execute the program from this library. The first step in preparing the program for execution is to set up the JCL statements necessary to invoke the cataloged procedure. Subsequent examples show the JCL required for three sample executions of the program using this cataloged procedure. The following table lists and defines the symbolic parameters in the cataloged procedure, CGAP, which is available through the private procedure library VG48AEP.PROCLIB. Appropriate symbolic parameter assignments can be determined by referring to the following table.

Symbolic parameters of the CGAP cataloged procedure

symbolic parameter	default	to be used with options	description
PROG	CGAP	ALL	Version of the Channel Geometry Analysis Program to be executed.
ECORE	400K	ALL	Region size (K bytes) required to execute the program.
ETIME	1	ALL	Execution time for the program, where time is specified in minutes.
PLOTLIB	SYS1.FLATBEDC	ALL	CalComp-compatible plotting software library to be linked to CGAP.
INUNIT	3350	ALL (optional)	Unit type of the device containing the PCSCD file.
INVOL	(None)	ALL (optional)	Volume serial number of the device containing the PCSCD file.
INNAME	NULLFILE	ALL (optional)	Data set name of the PCSCD file.
SFUNIT	3350	ALL	Unit type of the device to contain the standard-format file.
SFVOL	SYSDK	ALL	Volume serial number of the device to contain the standard-format file.
SFNAME	&&XSECTION	ALL	Data set name of the standard-format file.
SFDISP	NEW	ALL	Current disposition of the standard-format file. Code OLD if it exists.
PTUNIT	3350	7,11-14	Unit type of the device to contain the file of digital plotter commands.
PTVOL	(None)	7,11-14	Volume serial number of the device to contain the file of digital plotter commands.
PTNAME	NULLFILE	7,11-14	Data set name of the file of digital plotter commands.
SDUNIT	SYSDK	16	Unit type of the device containing the subdivision file.
SDVOL	(None)	16	Volume serial number of the device to contain the subdivision file.

symbolic parameter	default	to be used with options	description
SDNAME	NULLFILE	16	Data set name of the subdivision file.
SDDISP	OLD	16	Current disposition of the subdivision file. Code NEW if a new file is to be created.
OFUNIT	3350	6,8	Unit type of the device to contain the computed stage-relationships output file.
OFVOL	(None)	6,8	Volume serial number of the device to contain the computed stage-relationships output file.
OFNAME	NULLFILE	6,8	Data set name of the computed stage-relationships output file.
OFDISP	OLD	6,8	Current disposition of the computed stage-relationships output file. Code NEW if a new file is to be created.

There are five data files identified in the table above. The PCSCD file (identified by the symbolic parameter prefix IN) contains only CD (COORDINATE DATA) records or both PCS (PARAMETER, COMMENT, and SUBDIVISION) and CD records. If the PCSCD file is an empty or null file, the PCS and associated CD records must follow the DATA FORMAT record of the instream file. If the PCSCD file contains only CD records, the PCS records in the instream file must be in the same order as the associated CD records in the PCSCD file. The instream file for Amdahl program executions is considered to be that portion of the job setup following **CGAP.SYSIN DD *** and preceding the next occurrence of /*. The standard-format file is used by CGAP as a scratch file to store PCS and CD records so that multiple program options can be utilized during a single execution. To retain the standard-format file, as required for output option 9, the appropriate job control parameter assignments must be made for the symbolic parameters identified by the prefix SF. If plots are to be produced using an electromechanical pen plotter or other digital plotter, the symbolic parameters identified by the prefix PT must be set to appropriate values to describe the digital plotter commands output file. If cross sections are to be divided into subunits, the subdivision symbolic parameters identified by the prefix SD must be specified to declare the file that will contain the tables of cross-sectional area as a function of stage for the subdivided cross sections. If files of computed cross-sectional area and channel width or wetted perimeter and hydraulic radius as functions of stage are desired (output options 6 and 8), the symbolic parameters identified by the prefix OF must be specified to declare the attributes of the file to contain these stage-dependent properties.

In the example setup below, a blank record follows the IDENTITY record of the instream file. Therefore, all the program parameters that are specified on the DATA FORMAT record are assigned their default values. Thus, the IDEV and KDEV flags that designate the location of PCS and CD records are assigned the value zero. This specifies that the PCS and CD records are to be input from the instream file following the IDENTITY and DATA FORMAT records and preceding the PROCESSING CONTROL records. (Note that the CD records are not specifically shown in the example setup but are implied.)

```
================================================================================
//COMPUTER JOB STATEMENT
//PROCLIB DD DSN=VG48AEP.PROCLIB,DISP=SHR
//CGAP EXEC CGAP,SDNAME='USERID.SUBDIV.OUT',SDVOL='SWB999'
//CGAP.SYSIN DD *
        THREE MILE SLOUGH          RIO VISTA        1-5

 1     -2400   2400    100          120                                  5
     60000   27000   50000   40000   18000
     ( coordinate-data records for first cross section )

 2     -3400   2400    100      900  120                                 3
     20000   60000   40000
     ( coordinate-data records for second cross section )

 3     -5400   2400    100      800  320
     ( coordinate-data records for third cross section )

 4     -1400   2400    100      900  420
     ( coordinate-data records for fourth cross section )

 5     -1400   2400    100      900  5 1
     ( coordinate-data records for fifth cross section )

   5
  16
/*
//
================================================================================
```

On the DATA FORMAT record of the instream file in the following setup, the IDEV and KDEV flags that designate the location of PCS and CD records are assigned the values of one and zero, respectively. This specifies that PARAMETER records followed by COMMENT records and SUBDIVISION record, if any, are included in the instream file and the sets of corresponding COORDINATE DATA records defining each cross section reside on disk in the PCSCD file designated as USERID.XSSACRMN.DAT by the INNAME symbolic parameter.

```
================================================================================
//COMPUTER JOB STATEMENT
//PROCLIB DD DSN=VG48AEP.PROCLIB,DISP=SHR
//CGAP EXEC CGAP,SDNAME='USERID.SUBDIV.OUT',SDVOL='SWB999',
// INNAME='USERID.XSSACRMN.DAT',INVOL='SWB999'
//CGAP.SYSIN DD *
        THREE MILE SLOUGH          RIO VISTA        1-5

                                                                           1 0
 1  2  -2400   2400    100          120                            5
```

```
COMMENT RECORD 1 : THREE MILE SLOUGH
COMMENT RECORD 2 : FIRST CROSS SECTION
     60000    27000    50000    40000    18000

 2  2  -3400   2400    100      900  120                        3
COMMENT RECORD 1 : THREE MILE SLOUGH
COMMENT RECORD 2 : SECOND CROSS SECTION
     20000    60000    40000

 3  2  -5400   2400    100      800  320
COMMENT RECORD 1 : THREE MILE SLOUGH
COMMENT RECORD 2 : THIRD CROSS SECTION

 4  2  -1400   2400    100      900  420
COMMENT RECORD 1 : THREE MILE SLOUGH
COMMENT RECORD 2 : FOURTH CROSS SECTION

 5  2  -1400   2400    100      900  520
COMMENT RECORD 1 : THREE MILE SLOUGH
COMMENT RECORD 2 : FIFTH CROSS SECTION

   5
  16
/*
//
==============================================================================
```

In the following setup, both IDEV and KDEV are specified as one on the DATA FORMAT record. This specifies that the PCS and CD records reside on disk in the PCSCD file. The PCSCD file is designated as USERID.XSSACRMN.DAT by the INNAME symbolic parameter. (Note the use of PARAMETER ALTERATION records after each PROCESSING CONTROL record to change the values on the original PARAMETER records contained in the PCSCD file.)

```
==============================================================================
//COMPUTER JOB STATEMENT
//PROCLIB DD DSN=VG48AEP.PROCLIB,DISP=SHR
//CGAP EXEC CGAP,SDNAME='SUBDIV.OUT',SDVOL='SWB999',
// INNAME='USERID.XSSACRMN.DAT',INVOL='SWB999'
//CGAP.SYSIN DD *
        THREE MILE SLOUGH          RIO VISTA             1-5

                                                                           1 1
   5          2
 3     -5400   2400    100      800  320
 1     -2400   2400    100           120
  16          1
 2     -3400   2400    100      900  120
/*
//
==============================================================================
```

APPENDIX II

Program Input Coding Instructions

Eight basic record types constitute input to CGAP. All records and variables must be input to CGAP in the proper quantities, locations, and types as identified below. The number of cross sections input to CGAP is unlimited, except when using the three-dimensional isometric plot option or for a means computation using output option 6 or 8. In these cases, the number of input cross sections must not exceed 100. All available parameter defaults can be taken simply by having the appropriate record position(s) blank. If all parameters of a particular record have acceptable defaults, the defaults can be exercised by inserting a blank record. Decimal points need not be coded for numeric values unless more accuracy is required than the assumed number of decimal places provides, as long as the values are right justified in the positions alloted for the field. Commas must not be used in numbers. The following table defines the parameters specified on each record and gives their format and default value, as well as provides descriptive information pertaining to their proper use.

IDENTITY Record (one required per execution, characters should be centered in the assigned field so as to appear centered in the output title page)

Variable	Position	Format	Values	Default	Options	Definition
IBCD	7-28	22A1	------	blank	All	River or estuary name.
STANAM	30-51	22A1	------	blank	All	Station names identifying the reach extent.
XSRANG	53-57	5A1	------	blank	All	Range of cross-section numbers included in the reach, for example: 1-11.

DATA FORMAT Record (one required per execution)

Variable	Position	Format	Values	Default	Options	Definition
FORM[1]	1-60	15A4	------	([2])	All	Valid FORTRAN format statement (including outside parentheses) defining the input format of each COORDINATE DATA record.
IPRT	63-64	I2	------	66[3]	All	FORTRAN file unit number of line-printer output.
IPUN	65-66	I2	------	7[3]	All	FORTRAN file unit number of punched output.

[1]Input order is distance, elevation, and sequence number as defined by the COORDINATE DATA record.

[2]Default standard format is (T15,F8.1,T26,F8.2,T39,I2). Only one set of coordinate pairs can be input per record.

[3]These parameters cannot be altered when using the AMDAHL JCL procedure CGAP.

PLTUNT	67-68	I2	------	9[3]	All	FORTRAN file unit number of digital plotter output.
STNDRD	69-70	I2	------	67[3]	All	FORTRAN file unit number of standard-format file.
SBDUNT	71-72	I2	------	16[3]	All	FORTRAN file unit number of subdivision output file.
E431	76	I1	0/1	0	All	Flag to indicate that cross-sectional data are in step-backwater-program format (0=no,1=yes).
IDEV	78	I1	0/1	0	All	Flag to indicate that COORDINATE DATA (CD) records are in the PCSCD file, not in the instream file (0=no,1=yes).
KDEV	80	I1	0/1	0	All	Flag to indicate that PARAMETER, COMMENT, and SUBDIVISION records are in the PCSCD file with the CD records (0=no,1=yes).

PARAMETER Record (one required per cross section)

Variable	Position	Format	Values	Default	Options	Definition
NSTA	1-2	I2	------	0	All	Identifies cross section by a unique, non-zero number.
NCOM	5	I1	$0 \leq N \leq 5$	0	All	Number of COMMENT records following this record.
ZMIN[4]	6-12	F7.2	------	0[5]	All	Minimum stage for computations, referenced to the common datum of the cross-sectional data.
ZMAX[4]	13-19	F7.2	------	0[5]	All	Maximum stage for computations, referenced to the common datum of the cross-sectional data.

[4]ZMIN, ZMAX, and DELTAZ must be chosen such that cross-sectional properties are not computed for more than 80 stage values for option 16, 40 values for options 6 and 8 using mean groups, and 250 values for all other options. The value of ZMAX specified for the first cross section and used for all cross sections for option 7 must be selected such that the water surface is confined within the channel-bank elevations or a valid channel-bank extrapolation can be made for all cross sections.

[5]If ZMIN and ZMAX both equal zero or E431-formatted data are input, ZMAX defaults to an integer value of the maximum elevation minus 10% of the range of land-surface and channel-bottom elevations for the cross section. ZMIN defaults to an integer value of one more than the minimum elevation plus 10% of the elevation range.

DELTAZ[4]	20-26	F7.2	------	1	All	Computational stage increment.
DEG	27-29	F3.0	0≤N≤90	0	All	Absolute value of the degree variation of the cross-section line from a line perpendicular to the flow direction at the channel thalweg.
NDSD[6]	30-35	I6	------	0	5,7,15, and 16	Identifies cross-section locations by distance from a longitudinal reference point or as a segment length between successive cross sections.
MN1[7]	37-38	I2	0≤N≤99	0	6,8	First mean group that is to include this cross section.
MN2[7]	39-40	I2	0≤N≤99	0	6,8	Second mean group that is to include this cross section.
DACORR[8]	41-48	F8.2	------	0	All	Correction to be added to cross-section elevations to attain a common datum.
ZINC[9]	50-55	F6.1	------	0	1-4	Stage scale increment for cross-section and stage-dependent relationship plots.
DINC[9]	57-62	F6.1	------	0	11-14	Distance scale increment for cross-section plots.

[6]If NDSD equals zero for the first input cross section, CGAP expects all values of NDSD to be specified as segment lengths, thus the first cross section cannot be used as a longitudinal reference point. If plotting of a subset of the input cross sections is desired using option 15, two alternative procedures are available to select the cross sections depending on how NDSD is specified. If NDSD is specified as a longitudinal distance from a reference point, unwanted PCS and CD record sets can be removed from the input file(s), manually, using a text editor and the program will plot the remaining cross sections. If NDSD is specified as segment lengths, however, unwanted PCS and CD sets cannot be removed from the program input file(s) without adjusting subsequent segment lengths. (NDSD is set to the value coded in positions 29-35 of type 3 or 4 records of E431-formatted data upon input to CGAP.)

[7]If MN1 and MN2 equal zero for all input cross sections when requesting a means computation (option 6 or 8), the output will consist of a separate geometry table for each cross section. However, if MN1 and MN2 equal zero for a given cross section, whereas MN1 and (or) MN2 are specified for any other cross section, no geometry table will be produced for the given cross section. To get a single mean geometry table for all input cross sections, each cross section must be assigned to the same mean group, which is accomplished by assigning a common value to either MN1 or MN2 for each cross section. Mean group numbers need not be assigned in sequential order and groups can consist of cross sections that are not input in sequential order. The geometry table output order for a means computation is from the smallest mean group number to the largest. The second instream file setup below shows an example of the setting of MN1 and MN2 to yield five geometry tables from the eight input cross sections; two tables are produced from a single cross section and three from the average of two or three cross sections.

[8]DACORR is not applied to ZMIN or ZMAX.

NSUBS[10]	64	I1	0≤N≤6	0	16	Number of subdivision points coded on SUBDIVISION record.
AINC[9]	65-70	F6.1	------	0	1,3,11, 13	Area scale increment for plots of stage-dependent cross-sectional area.
WINC[9]	71-76	F6.1	------	0	2,3,12, 13	Width scale increment for plots of stage-dependent channel width.

COMMENT Records (optional, up to 5 per cross section)

Variable	Position	Format	Values	Default	Options	Definition
IDEN	1-80	20A4	------	blank	All	Descriptive information pertaining to individual cross sections used to annotate printed output.

SUBDIVISION Record (optional, one per cross section, input only if subdivisions are requested, that is NSUBS≠0)

Variable	Position	Format	Values	Default	Options	Definition
SUBD[11]	3-50	6F8.2	------	0	16	Distance from the cross-channel reference point at which the cross section is to be subdivided.

---

[9]For line-printer plots, ZINC is the elevation or depth represented by 5 lines and DINC, AINC, and WINC are the cross-channel distance, cross-sectional area, and channel width, respectively, represented by 10 spaces. If either axis is specified too small to accommodate the plot on a single line-printer page a partial plot occurs and an appropriate message is printed. For digital plots, ZINC is the elevation or depth represented by one increment (one inch at full plot size) on the y-axis of the plot and DINC, AINC, and WINC are the cross-channel distance, cross-sectional area, and channel width, respectively, represented by one increment on the x-axis of the plot. The axes lengths of digital plots are increased by CGAP to accommodate plotting the entire cross section or stage-dependent relationship at the specified scale, thereby overriding the axes lengths as determined by LENY of the PROCESSING CONTROL record. If a non-zero value is input for ZINC but not for DINC, AINC, or WINC, the length of the x-axis of the plot is still set to 5/4 of LENY. If a value of zero is entered for either axis scaling parameter, that axis is automatically scaled by CGAP. For cross-section plots, a negative value of ZINC signals CGAP to plot elevations to the specified datum reference, otherwise the channel thalweg is used as the plot reference.

[10]A value greater than zero will signal CGAP to read a SUBDIVISION record after any COMMENT records.

[11] If two subdivisions are desired, input one value of SUBD and set NSUBS of the PARAMETER record to one. For example, given a single value of 25, the section between the minimum cross-channel distance and 25 feet from the cross-channel reference point constitutes the first subdivision and the section between the 25-foot location and the maximum cross-channel distance the second subdivison. Specified values greater than or equal to the maximum cross-channel distance are ignored. If only one value is specified and it is greater than or equal to the maximum cross-channel distance the entire cross section is used in the computation.

COORDINATE DATA Records (up to 100 per cross section, including one trailing blank record)

Variable	Position	Format	Values	Default	Options	Definition
Y	15-22	F8.1	------	0	All	Distance from the cross-channel reference point. Negative distances are permitted.
Z	26-33	F8.2	------	0	All	Land-surface or channel-bottom elevation at point.
NUM[12]	39-40	I2	------	0	All	Optional arbitrary data point sequence number.

PROCESSING CONTROL Record(s) (one required per execution; others optional)

Variable	Position	Format	Values	Default	Options	Definition
IOPT	3-4	I2	0<N≤16[13]	5	All	Output option.
LENY[14]	5-6	I2	4, 6, 8 10, 12	6	11-14	Length of the y-axis of digital plot, in inches.
THEDEG	7-9	F3.0	0≤N≤360	75	7	Degree rotation of thalweg from x-axis of the plot defining the viewing angle of the channel reach for isometric plots.
NPAR	13-15	I3	0≤N≤50	0	All	Number of PARAMETER ALTERATION records to follow.

[12] Although NUM is read, CGAP assigns new sequence numbers to the sorted coordinate-data points. Therefore, NUM can be omitted from COORDINATE DATA records, unless both Y and Z are zero. In this case, a non-zero value must be specified for NUM. A trailing blank record is always required to identify the end of a set of cross-sectional data.

[13] **1**: Cross-sectional area as a function of stage plotted on line printer (lp); **2**: Channel width as a function of stage plotted on lp; **3**: Cross-sectional area and channel width as functions of stage plotted on lp; **4**: Cross sections plotted individually on lp; **5**: Cross-sectional area, channel width, wetted perimeter, hydraulic radius, average depth, and cross-sectional symmetry as functions of stage listed on lp; **6**: Cross-sectional area and channel width as functions of stage stored in a file; **7**: Cross sections plotted in an isometric projection on digital plotter (dp); **8**: Wetted perimeter and hydraulic radius as functions of stage stored in a file; **9**: PCS and CD records retained in the standard-format file; **10**: PCS and CD records listed on lp; **11**: Cross-sectional area as a function of stage plotted on dp; **12**: Channel width as a function of stage plotted on dp; **13**: Cross-sectional area and channel width as functions of stage plotted on dp; **14**: Cross section plotted individually on dp; **15**: Cross-sectional area at a fixed stage as a function of longitudinal distance along a river reach plotted on lp; **16**: Cross-sectional area and channel width as functions of stage for subdivisions of cross sections listed on lp and stored in a file.

[14] The length of the x-axis of the plot is automatically scaled 1/4 larger.

ALTPCH	18	I1	0/1	0	6,8	Flag to indicate that the alternate output file format is to be used (0=no,1=yes). (Otherwise, the output file is in the branch-network flow model format.)
DAREF	19-26	F8.2	------	0	All	Elevation to be added to the coordinate-data elevations of all cross sections.
NXPOS	27-28	I2	------	1	15	Cross-section number (NSTA) of the initial cross section included in option 15 output.
NSET	29-30	I2	0≤N≤50	50	15	Number of consecutive cross sections to be included in option 15 output.
NSTAGE	31-32	I2	0≤N≤5	5	15	Number of stages to be shown on each plot in option 15 output.
DTMNAM	33-52	A20	------	'NGVD OF 1929'	All	Reference name of common datum for output labeling.

PARAMETER ALTERATION Record(s) (optional, NPAR records input following each PROCESSING CONTROL record)

(Identical in format to a PARAMETER record)[15]

[15]PARAMETER ALTERATION records provide the capability to override the PARAMETER record initially assigned to a cross section upon input. This facilitates the use of different parameter values for various output options during a single execution. All applicable variables must be specified. NCOM and NSUBS of the originally input PARAMETER records cannot be altered. Each PARAMETER ALTERATION record applies only to the preceding PROCESSING CONTROL record. It temporarily overrides, but does not permanently replace, the corresponding originally assigned PARAMETER record. CGAP uses the originally input PARAMETER records for any subsequent output option requests specified by a PROCESSING CONTROL record. PARAMETER ALTERATION records do not need to be input in the same order as the original PARAMETER records. PARAMETER ALTERATION records are keyed to the original PARAMETER records by means of the cross-section identification number NSTA. CGAP ignores any PARAMETER ALTERATION record that does not match a PARAMETER record. For cross-sectional data input in step-backwater-program (E431) format the cross-section number used by CGAP is the value coded in positions 3 and 4 of the type 3 record of the E431-formatted data. Use this value as the cross-section number (NSTA) for the corresponding PARAMETER ALTERATION record.

All records can be input to CGAP via FORTRAN file unit number 5 (instream file). IDENTITY, DATA FORMAT, PROCESSING CONTROL, and optional PARAMETER ALTERATION records must always be input via the instream file. COORDINATE DATA (CD) records can be input from a separate file via FORTRAN file unit number 10 (PCSCD file). PARAMETER, COMMENT, and SUBDIVISION (PCS) records can be input along with the associated CD records from the PCSCD file or they can be included in the instream file.

Three instream file setups are shown below. The records shown in the first setup were used to produce figures 4-9, 12, 13, 15, and 16. This setup, which executes 10 CGAP options, also illustrates the use of a user-defined, coordinate-data-input format (specified on the DATA FORMAT record) and PARAMETER ALTERATION records.

```
==========================================================================
        THREE MILE SLOUGH            RIO VISTA        1-35
(F8.1,F8.2,5X,I2)
25  1  -2400   2000    200           1                          5
Example Instream Input of All Necessary Input Records in Single File
   180.0   270.0   400.0   500.0   600.0
    90.0    20.5     02
   120.0    10.5     05
   160.0   -02.6     08
   220.0   -13.8     15
   290.0   -16.8     19
   310.0   -20.5     21
   330.0   -25.2     23
   370.0   -21.6     26
   410.0   -16.8     29
   450.0   -20.3     33
   480.0   -20.4     36
   500.0   -22.4     37
   520.0   -21.5     39
   540.0   -19.7     41
   550.0   -23.1     42
   620.0   -16.8     44
   650.0   -16.0     46
   690.0   -14.0     49
   730.0   -04.0     51
   770.0    06.0     54
   800.0    14.3     56
   815.0    20.5     99

26      -3400   2000    200        900
    80.0    20.5     01
   100.0    14.3     02
   120.0    02.8     04
   200.0   -07.5     09
   250.0   -08.0     12
   300.0   -10.4     16
   340.0   -09.2     18
```

```
   430.0    -16.6      23
   500.0    -30.7      26
   550.0    -39.2      31
   556.0    -40.0      32
   600.0    -18.8      34
   656.0     03.2      36
   676.0     15.7      42
   684.0     20.5      99

   1
  11
   4
  14
   4          1
25  1  -2500   1500    500                           5.0  100.0 5
  14          1   15.0
25  1  -2500   1500    100                  -9.25   -10.0   70.0 5
  10
   5          2
26     -2200   1500    400       900
25     -1400   1500    200
   6          1  1
25  1  -1600   2000    100                                       5
  16
===============================================================================
```

The following instream file setup is for a seven-mile channel reach defined by eight cross sections. Since this is a large data set, it is desirable to input the CD records to CGAP from the PCSCD file. The separation of the CD records from the other input records simplifies assigning parameter values, as only those records that control data processing are contained in the instream file. On the DATA FORMAT record of this setup, the IDEV variable is assigned a value of one to indicate that the CD records are contained in the PCSCD file. (Note, a user-defined, coordinate-data-input format is specified for the CD records on the DATA FORMAT record.) This setup was used to produce figures 10 and 11.

```
===============================================================================
        SACRAMENTO RIVER     SACRAMENTO - FREEPORT  1-8
(13X,2F9.1,I9)                                                                1
 1        0.0    30.0      2.        0  1    -100.0
 2        0.0    30.0      2.     5280       -100.0
 3        0.0    30.0      2.     5280  2    -100.0
 4        0.0    30.0      2.     5280  2 3  -100.0
 5        0.0    30.0      2.     5280  2 3  -100.0
 6        0.0    30.0      2.     5280  3    -100.0
 7        0.0    30.0      2.     5280  4    -100.0
 8        0.0    30.0      2.     5280  5 4  -100.0
    7
   15              10.0   1 8 5
===============================================================================
```

On the DATA FORMAT record of the following instream file setup, the E431 variable is assigned a value of one to indicate that step-backwater-program (E431) formatted cross-sectional data are to be input to CGAP. This setup also shows the use of E431-formatted data with PARAMETER ALTERATION records (the last three records of the file, that is, those that follow the PROCESSING CONTROL record). The setup was used to produce figure 14.

```
==============================================================================
            OHIO RIVER           AT GREENUP, KY       5-8
                                                                          1
3  8000 355.6 9   27 01  460
5  8001        0  1  5606  220  1  5526  250  1  5506  270  1  5496  290  1  5476
5  8002      370  1  5466  420  1  5436  430  1  5156  480  1  4856  500  1  4756
5  8003      560  1  4736  590  1  4676  740  1  4606  880  1  4612  990  1  4619
5  8004     1150  1  4648 1270  1  4669 1380  1  4550 1490  1  4745 1530  1  4766
5  8005     1550  1  4846 1570  1  4906 1590  1  5006 1610  1  5256 1620  1  5446
5  8006     1750  1  5456 1790  1  5503
6  8007 00 01 045 045
3  7000 354.0 9   35 01  467
5  7001        0  1  5606   20  1  5506   70  1  5456  230  1  5406  330  1  5356
5  7002      850  1  5306 1480  1  5306 2465  1  5356 2820  1  5356 2850  1  5306
5  7003     2945  1  5256 2980  1  5106 3025  1  5006 3060  1  4906 3070  1  4856
5  7004     3225  1  4741 3365  1  4769 3506  1  4756 3630  1  4758 3750  1  4747
5  7005     3840  1  4753 3905  1  4710 4105  1  4716 4220  1  4719 4670  1  4718
5  7006     4720  1  4671 4785  1  4693 4845  1  4847 4865  1  4856 4880  1  4906
5  7007     4950  1  5056 4960  1  5106 4980  1  5106 5010  1  5206 5080  1  5498
6  7008 00 01 045 045
3  6000 352.0 9   34 01  472
5  6001     2890  1  5456 3090  1  5406 3300  1  5356 3410  1  5206 3860  1  5156
5  6002     3960  1  5056 4670  1  5206 4840  1  5256 4940  1  5256 4975  1  5206
5  6003     5020  1  5106 5060  1  5006 5100  1  4897 5115  1  4856 5200  1  4806
5  6004     5390  1  4799 5445  1  4760 5580  1  4751 5700  1  4740 5830  1  4730
5  6005     5950  1  4727 6075  1  4735 6200  1  4728 6325  1  4725 6455  1  4726
5  6006     6500  1  4793 6720  1  4856 6725  1  4906 6740  1  5006 6760  1  5106
5  6007     6800  1  5256 6825  1  5306 6920  1  5306 6920  1  5504
6  6008 00 01 045 045
3  5000 350.0 9   35 01  470
5  5001        0  1  5606  190  1  5506  240  1  5456  770  1  5406 1000  1  5356
5  5002     2055  1  5356 2440  1  5406 2520  1  5406 2880  1  5356 3670  1  5356
5  5003     3750  1  5406 4940  1  5406 4970  1  5356 5820  1  5356 6070  1  4906
5  5004     6085  1  4856 6180  1  4808 6300  1  4747 6450  1  4735 6580  1  4712
5  5005     6720  1  4703 6895  1  4720 6995  1  4740 7210  1  4747 7250  1  4801
5  5006     7340  1  4856 7350  1  4906 7370  1  5006 7445  1  5056 7485  1  5106
5  5007     7595  1  5356 7625  1  5406 7690  1  5406 7790  1  5506 7825  1  5606
6  5008 00 01 045 045
  6       3
 7     514.0  550.0  2.0       5000  1
 6     514.0  550.0  2.0       4500  1
 5     514.0  550.0  2.0       4000  1
==============================================================================
```

APPENDIX III

Error Messages

The following diagnostic messages are generated by CGAP. The program also issues various explicit warning messages for less severe error conditions. Additional comments are given below each message.

The following errors, except for errors 6-9, are caused by incorrect input data or parameter specifications and will result in program termination.

---

1 FLAG SPECIFYING THE LOCATION OF THE CD RECORDS IS NOT ZERO OR ONE
The value for IDEV on the DATA FORMAT record must be 0, 1, or blank. Set to 1 if COORDINATE DATA records are contained in the alternate input file (PCSCD file).

2 NO SUBDIVISION RECORD FOUND
If the value on the PARAMETER record for NSUBS is greater than zero a SUBDIVISION record must follow.

3 MAXIMUM STAGE SPECIFIED IS LESS THAN OR EQUAL TO MINIMUM STAGE SPECIFIED
The value of ZMAX on the PARAMETER record must be greater than the value of ZMIN.

4 NO BLANK RECORD ENCOUNTERED SIGNALING END OF CROSS-SECTION INPUT
No blank record was found after reading 100 COORDINATE DATA records. A blank record must follow the COORDINATE DATA for each cross section.

5 DEGREE VARIATION FROM THE THALWEG IS NEGATIVE
The value for DEG on the PARAMETER record must be a positive number less than 90.

6 NO STAGE FOUND EQUAL TO ZERO
Stages were not normalized to zero by CGAP.

7 NO STAGE FOUND THAT IS GREATER THAN MINIMUM STAGE FOR COMPUTATION
ZMIN was set by CGAP to a value greater than or equal to the maximum elevation of the coordinate-data points..

8 FIRST DATA POINT IS BELOW MINIMUM STAGE SPECIFIED FOR COMPUTATION
The value of ZMIN must be less than the elevation of the first COORDINATE DATA point for each cross section.

9 LAST DATA POINT IS BELOW MINIMUM STAGE SPECIFIED FOR COMPUTATION

The value of ZMIN must be less than the elevation of the last COORDINATE DATA point for each cross section.

10 SUBDIVISION RECORD FOUND WHEN NO SUBDIVISION POINTS WERE SPECIFIED

If the value on the PARAMETER record for NSUBS is 0 there must not be a SUBDIVISION record present in the input file.

11 INPUT RECORDS ARE OUT OF SEQUENCE, OR THERE ARE MISSING OR EXTRA RECORDS

An end of file or I/O error was encountered while reading an input file. Check the input file(s) for missing or misplaced records and ensure the correct file name was specified.

12 DEGREE VARIATION FROM THALWEG IS GREATER THAN OR EQUAL TO 90

The value of DEG on the PARAMETER record must be a positive number less than 90.

13 END OF FILE ENCOUNTERED FOLLOWING INPUT OF THE DATA FORMAT RECORD

CGAP expected PARAMETER, COMMENT, SUBDIVISION, COORDINATE DATA and PROCESSING CONTROL records to be input after the DATA FORMAT record of the instream file. Check the value of IDEV on the DATA FORMAT record and the contents of the instream file.

14 END OF FILE ENCOUNTERED ON FORTRAN FILE UNIT 10, NO COORDINATE DATA FOUND

CGAP expected the COORDINATE DATA records to be located in the PCSCD file (IDEV=1). Check the file name specified for the PCSCD file and the value of IDEV.

The following errors are caused by incorrect program input data or PARAMETER specifications and will not result in program termination but will result in discontinued processing of the current output option.

---

15 STAGE FOUND THAT IS LESS THAN MINIMUM ELEVATION OF REACH FOR OPTION 7

Invalid elevation data or datum corrections caused the minimum elevation to be set incorrectly.

16 NO STAGE FOUND THAT IS LESS THAN MAXIMUM STAGE SPECIFIED

The value of ZMAX must be greater than the elevation of the lowest data point input.

17 MORE THAN 50 PARAMETER ALTERATION RECORDS INPUT

There must be no more than 50 PARAMETER ALTERATION records input for any particular output option.

18 INVALID MEAN PAIRS SPECIFIED

The value for both MN1 and MN2 must be an integer value greater than or equal to 1 and less than or equal to 99.

19 MAXIMUM STAGE IS LESS THAN OR EQUAL TO MINIMUM STAGE IN MEANS COMPUTATION

The largest value of ZMAX must be greater than the smallest value of ZMIN in a mean group.

20 DISTANCE TO NEXT CROSS SECTION IS NEGATIVE

The value for NDSD of each PARAMETER record must be positive.

21 MORE THAN 100 CROSS SECTIONS INPUT FOR MEANS COMPUTATION

There can be no more than 100 cross sections input for means computation using output option 6 or 8.

22 ATTEMPT TO CONTINUE IN OPTION 15 WHEN LAST PLOT DOES NOT CONTAIN MAXIMUM STAGE

The values for ZMIN and DELTAZ must be such that ZMAX is an integral multiple of DELTAZ above ZMIN, where ZMIN, ZMAX, and DELTAZ are the values specified on the PARAMETER record of the first cross section specified for inclusion in option 15 output.

23 MORE THAN 50 CROSS SECTIONS INPUT FOR OPTION 15

There must be no more than 50 cross sections specified for inclusion in the computations for output option 15. Check value of NSET on the PROCESSING CONTROL record.

24 DOWNSTREAM DISTANCE IS LESS THAN OR EQUAL TO ZERO

The value for NDSD of each PARAMETER record for all but the first cross section must be greater than 0.

25 INVALID OUTPUT OPTION REQUEST

IOPT must be an integer value greater than or equal to 1 and less than or equal to 16.

26 NEGATIVE VALUE INPUT FOR DISTANCE SCALE INCREMENT ON PARAMETER RECORD

The cross-channel distance scaling factor, DINC, for cross-section plots can only be positive. (The channel-bottom elevation scaling factor, ZINC, can be positive or negative.) Verify DINC value on PARAMETER record.

27 SUBDIVISION POINT IS OUT OF BOUNDS (RIGHT OF REW OR LEFT OF LEW)

The values of the SUBDIVISION record must fall between the minimum and maximum cross-channel distance for the cross section to be subdivided.

28 MINIMUM STAGE CHANGED BY PROGRAM TO A VALUE GREATER THAN MAXIMUM STAGE

Two consecutive data points and a single channel must exist below ZMIN in order to satisfy computational requirements. Check the COORDINATE DATA to ensure values are elevations and have the correct sign. Verify the ZMIN and ZMAX values specified on the PARAMETER record.

29 NUMBER OF SUBDIVISION POINTS SPECIFIED ON A PARAMETER RECORD IS GREATER THAN 6

The value for NSUBS of each PARAMETER record must be less than or equal to 6.

30 COMPUTATIONS AT MORE THAN 250 STAGES WERE REQUESTED

The values of ZMIN, ZMAX and DELTAZ must be specified such that computations are performed at no more than 250 stages.

31 ATTEMPT TO ALTER MAXIMUM STAGE WHILE EXECUTING ISOMETRIC PLOT OPTION

The value of ZMAX on the PARAMETER record of the first cross section must be wholly contained in the channel-bank elevation of all input cross sections for option 7. It is taken as ZMAX for all cross sections and overrides the other ZMAX values specified. Ensure that extrapolation to ZMAX is possible.

32 NO STAGE FOUND THAT IS LESS THAN MAXIMUM STAGE FOR ISOMETRIC PLOT OPTION

The value of ZMAX on the PARAMETER record of the first cross section must be greater than the lowest data point of all cross sections to be plotted for option 7. It is taken as ZMAX for all cross sections and overrides the other ZMAX values specified.

33 MORE THAN 100 CROSS SECTIONS INPUT FOR ISOMETRIC PLOT OPTION

There must be no more than 100 cross sections input for an isometric projection plot request, output option 7.

34 OPTION 16 REQUESTED BUT NO SUBDIVISION POINTS SPECIFIED OR INPUT

NSUBS was specified as zero on all PARAMETER records and no SUBDIVISION records were input for an output option 16 request.

35 CROSS SECTION NUMBER OF FIRST CROSS SECTION TO BE USED IN OPTION 15 NOT FOUND

The cross-section number specified as NXPOS of the PROCESSING CONTROL record did not match any cross-section number as specified by NSTA on PARAMETER records. Verify that NXPOS designates the cross-section number of the first cross section desired to be included in option 15 output.

36 FORTRAN FILE UNIT NUMBERS 5, 6, AND 11 CANNOT BE USED

A Fortran file unit number for an output file was set to 5, 6, or 11. Check the DATA FORMAT record to ensure that IPRT, STNDRD, and all other output file unit numbers are not set to one of these values. (These unit numbers are used by CGAP for input and output files.)

*U.S. GOVERNMENT PRINTING OFFICE: 1986-491-405:20122