WATER SURFACE PROFILES

(STANDARD STEP METHOD)

for the

HP-41 C/CV/CX

Table of Contents

APPENDIX

PROGRAM DESCRIPTION

Program Title: Water Surface Profiles - Standard Step Method

Programmer: Paul B. Winslow (P. Eng.)

Location: Winnipeg, Manitoba

Date: October 24, 1983

Program Description, Equations, Variables, etc: This program is intended for calculating water surface profiles for steady gradually varied flow in natural or man-made channels. The computational procedure (generally known as the Standard Step Method) is based on the solution of the One-Dimensional Energy Equation with energy loss due to friction evaluated with Manning's equation. The program was developed following the methodology of the HEC-2 Computer Program developed by Bill S. Eichert of the US Army Corps of Engineers Hydrologic Engineer Center. The following two equations are solved by an iterative procedure to calculate an unknown water surface elevation at a cross-section:

$$WS_2 + \frac{\alpha_2 V_2^2}{2g} = WS_1 + \frac{\alpha_1 V_1^2}{2g} + h_e \qquad (1)$$

$$h_e = L\overline{S_f} + C \left| \frac{\alpha_2 V_2^2}{2g} - \frac{\alpha_1 V_1^2}{2g} \right| \qquad (2)$$

Where:

WS_1, WS_2 = Water surface elevations at ends of reach (see Figure 1).

V_1, V_2 = Mean velocities (total discharge / total flow area) at ends of reach.

α_1, α_2 = Velocity coefficients for flow at each end of reach.

g = acceleration of gravity
(32.174 feet/second^2 - Imperial System)
(9.807 metres/second^2 - Metric System)

h_e = Energy head loss.

L = Discharge-weighted reach length (feet or metres).

$\overline{S}_f$ = Representative friction slope for reach.

C = Expansion or Contraction loss coefficient.

$| \quad |$ = Absolute Value.

THE VALUE OF L:

If the option of the user is not overbank flow, L is equal to the input value of the thalweg length of the main channel. However, if the option of overbank flow is selected by the user, the discharge-weighted reach length, L, is calculated as:

$$L = \frac{L_{lob}\overline{Q}_{lob} + L_{ch}\overline{Q}_{ch} + L_{rob}\overline{Q}_{rob}}{\overline{Q}_{lob} + \overline{Q}_{ch} + \overline{Q}_{rob}} \qquad (3)$$

Where:

L_{lob}, L_{ch}, L_{rob} = Reach lengths specified for flow in the left overbank, main channel and right overbank, respectively.

$\overline{Q}_{lob}, \overline{Q}_{ch}, \overline{Q}_{rob}$ = Arithmetic average of flows at the ends of the reach for the left overbank, main channel and right overbank, respectively.

THE VALUE OF $\overline{S}_f$:

The user of this program has the option to select one of two methods for the calculation of the representative friction slope:

$$\overline{S}_f = \frac{(Q_1 + Q_2)^2}{(K_1 + K_2)} \qquad (4)$$

$$\overline{S}_f = \frac{S_{f1} + S_{f2}}{2} \qquad (5)$$

Where:

K_1, K_2 = Conveyance at ends of reach.

Q_1, Q_2 = Discharge at ends of reach.

$\overline{S}_{f1}, \overline{S}_{f2}$ = Friction slope at ends of reach.

Equation (4) is known as the Average Conveyance Equation. This option has been used by HEC2 since 1971 and is the "Default" equation used by this program; that is, the user specifically requested for an affirmative response to use this equation in the program.

Equation (5) is known as the Average Friction Slope Equation. This option was used by HEC2 prior to 1971. The user can override the "Default" and select this equation.

Both of these equations produce satisfactory results provided that reach lengths are not too long. The advantage sought in either equation is to be able to maximize reach lengths without sacrificing profile accuracy. Research has indicated that Equation (5) is the most suitable for M1 profiles; that is the friction slope at the current cross-section is greater than the friction slope at the preceding cross-section. Equation (4), the "Default", is generally the most suitable for all conditions, and therefore should be used unless the user knows that all profiles in the calculation will be of the M1 type.

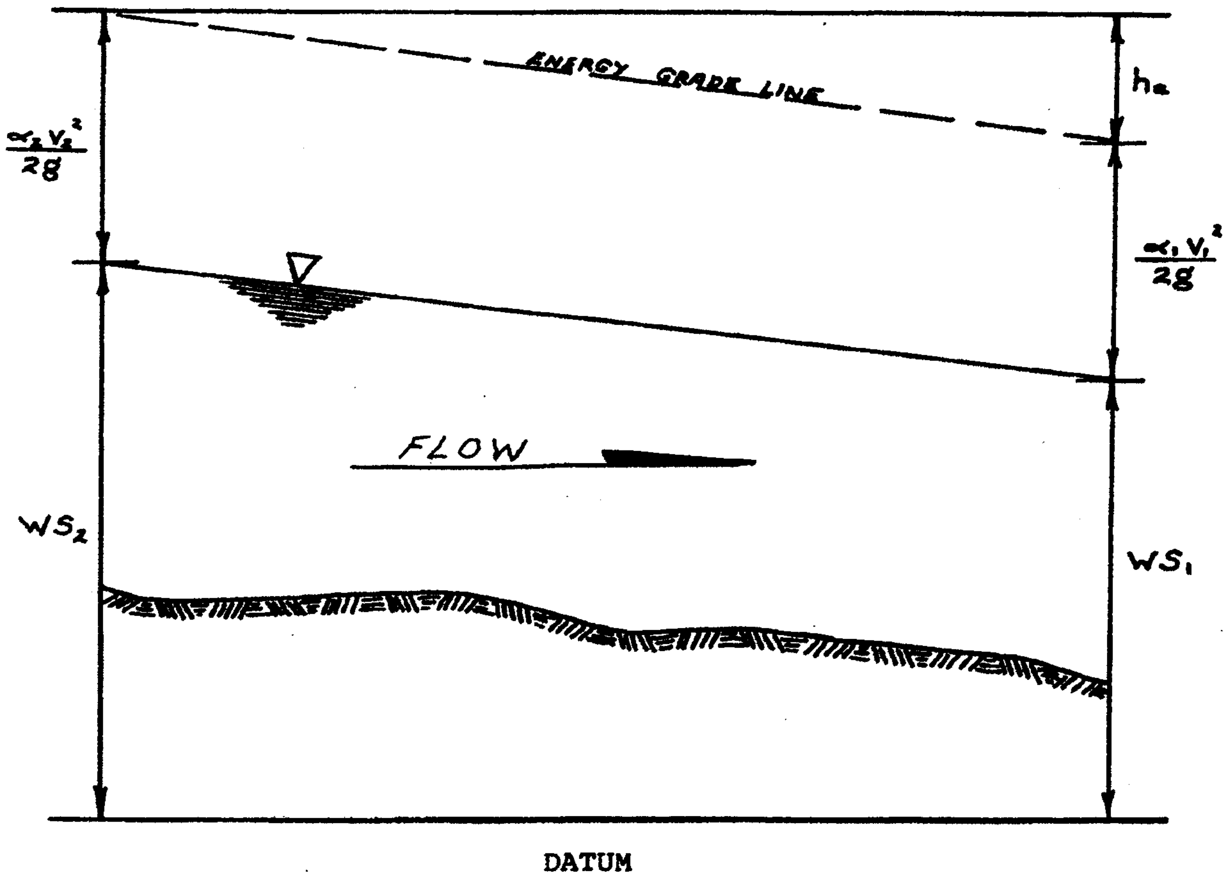


FIGURE 1
REPRESENTATION OF TERMS IN THE ENERGY EQUATION

The determination of total conveyance and the velocity coefficient for a cross-section requires that flow be subdivided into units for which velocity is uniformly distributed. The approach used in this program is to subdivide flow in the overbank areas using the input cross-section stations (zero or negative X coordinates) as the basis for subdivision. Conveyance is computed within each subdivision by the equation:

$$K = \frac{1.486}{n} a r^{2/3} \qquad \text{- Imperial Units} \qquad (6)$$

$$K = \frac{a r^{2/3}}{n} \qquad \text{- Metric Units} \qquad (7)$$

Where:

K = Conveyance for the subdivision.

n = Manning's "n" for the subdivision.

a = Flow area for the subdivision.

r = Hydraulic radius for subdivision (area divided by wetted perimeter).

Flow in the main channel is not subdivided in normal applications. Total conveyance for the cross-section is obtained by summing the incremental conveyances.

VELOCITY COEFFICIENT α:

The velocity coefficient, α, is obtained with the following equation:

$$\alpha = \frac{(A_t)^2 \left[(K_{lob})^3 / (A_{lob})^2 + (K_{ch})^3 / (A_{ch})^2 + (K_{rob})^3 / (A_{rob})^2\right]}{(K_t)^3} \qquad (8)$$

Where:

A_t = Total flow area of the cross-section.

A_{lob}, A_{Ch}, A_{rob} = Flow areas of the left overbank, main channel and right overbank, respectively.

K_t = Total conveyance of the cross-section.

K_{lob}, K_{Ch}, K_{rob} = Conveyance of the left overbank, main channel and right overbank, respectively.

COMPUTATION PROCEDURE

The unknown water surface elevation at a cross-section is determined by an iterative solution of equations (1) and (2). The procedure is as follows:

1. Assume ("GUESS") a water surface elevation at the upstream cross-section.

2. Based upon the assumed water surface elevation, determine the corresponding total conveyance and velocity head.

3. With values from Step 2, compute $\overline{S}_f$ and solve equation (2) for h_e.

4. With values from Step 2 and 3, solve equation (1) for WS_2.

5. Compare the computed value of WS_2 with the assumed in Step 1; repeat Steps 1 through 5 until the values agree to within 0.01 feet for the Imperial System or 0.01 metres for the Metric System.

Criteria used for assuming water surface elevations in the iterative procedure is to assume on the first trial an upstream stage higher by 0.01 feet for the Imperial System or 0.01 metres for the Metric System. For subsequent trials the error between the computed value and the assumed water surface elevation is multiplied by 0.92, and then this value is subtracted from the previous guess for the next trial. (Tests have indicated that this 0.92 value generally provides the quickest convergence of equations (1) and (2). Lack of remaining program room in the HP-41CV prevents the use of the same method of convergence as used by HEC-2).

CRITICAL DEPTH:

For the first cross-section, the user is asked to input the starting water level. A check is then made to ascertain if the starting water level that has been input is greater than or equal to critical depth. If it is, the water surface elevation that has been input, will be the starting elevation. If it is not, then the nearest one-half foot mark higher in the Imperial System is tried (or 0.20 metres is added to the input level in the Metric System). The check is then repeated until the starting elevation is greater than or equal to critical depth. When it is, then that elevation is used for the starting water elevation. Once the "balanced" water surface elevation has been obtained for the upstream cross-section, a check is also made to ascertain if it is indeed, greater than critical depth. If it is, the computed value for the water surface elevation will be printed. If it is not, repeated trials are made at 0.01 feet for the Imperial System (or 0.01 metres for the Metric System) until critical depth (or higher) is calculated. At all times, when the water surface elevation is less than critical depth, a message to that effect is printed by the program:

-- WARNING --
CRITICAL DEPTH ASSUMED

The user should be aware of critical depth assumptions and determine the reason for their occurrence. In many cases, they can result from reach lengths being too long or from misrepresentation of the effective flow areas for cross-sections. (See Note 5 in the Helpful Hints Section).

The check on critical depth is made from the formula:

$$A^3 = \frac{Q^2 \, T \, \alpha}{g} \qquad (9)$$

Where:

A	=	Area of the cross-section.
Q	=	Flow.
T	=	Top width of the cross-section.
α	=	Velocity coefficient.
g	=	acceleration of gravity. (32.174 feet/second^2 - Imperial System) (9.807 metres/second^2 - Metric System)

EXPANSION OR CONTRACTION "SHOCK" LOSS COEFFICIENTS, "C":

The user has the option of selecting the expansion or contraction loss coefficients. The program automatically assigns a standard value for these coefficients (namely .3 and .1 respectively) unless directed otherwise. It also automatically determines which of those values to use and multiplies it by the Absolute Value of the change in velocity head between adjacent cross-sections. When the velocity head increases in the downstream direction, a contraction coefficient is used; or conversely, when the velocity head decreases in the downstream direction, an expansion coefficient is used. Typical values are shown below for transition "Shock" losses:

COEFFICIENTS, C

	Contraction	Expansion	Comment
No transition loss	0.0	0.0	
Gradual transitions	0.1	0.3	Standard in the program
Bridge transitions	0.3	0.5	
Abrupt transitions	0.6	0.8	

NOTE: The maximum value for the expansion coefficient would be 1.0. Note that the expansion coefficient is always greater than the corresponding contraction coefficient.

FRICTION LOSS COEFFICIENTS:

Because Manning's coefficient of roughness "n" depends on such factors as type and amount of vegetation, channel configuration and stage, the user has the option to describe the channel and overbank roughness with three "n" values. Both the friction loss coefficients and "transition" loss coefficients are inserted by the user upon prompt along with the cross-section data. (Refer to a table of commonly used Manning's "n" values on Page 14).

For automatic operation, the user must input all of the friction loss coefficients and 'transition" loss coefficients before the main program is run. The user should be aware of this limitation and carefully describe to the best judgement, the values that may fit over the entire range of stage and discharge, otherwise, for subsequent jobs of the same run, if it is desired to modify the "n" values and/or "transition" losses as specified, the user has no other alternative than to purge the old cross-section data files and re-input new ones.

BASIC DATA REQUIREMENTS:

The program objective is quite simple – compute water surface elevations at all locations of interest for given flow values. Data needed to perform these computations include: The starting water surface elevation, discharge, loss coefficients, Manning's "n" values, cross-section geometry and reach lengths.

FLOW REGIME:

Profile computations for sub-critical flow begin at a downstream cross-section with known (or assumed) starting conditions and proceeds upstream. (Note: - super critical flow, that is, proceeding downstream, can not be handled by this program). In other words, the program will not allow profile computations to cross the critical depth.

DISCHARGE:

Discharge is specified by the user upon prompt along with the cross-section data. If, for subsequent jobs of the same run (ie: re-runs), the initial flows can be modified. To do this, the user may "over-ride" the initial discharge that has been recorded on the data files upon prompt. For the re-runs, if the flow is constant, that is, it does not change for the entire profile to be calculated, the program will execute automatically. If the flow is not constant, the user has no alternative other than "babysitting" the calculator while that profile calculation proceeds to key in the new flow when required upon prompt.

CROSS-SECTION GEOMETRY:

Boundary geometry for the analysis of flow in natural streams is specified in terms of ground surface profiles (cross-sections) and the measured distances between them (reach lengths). Cross-sections are located at intervals along a stream to characterize the flow carrying capability of the stream and its adjacent flood plains. They should extend across the entire flood plain and should be perpendicular to the anticipated flow lines (approximately perpendicular to contour lines). Occasionally, it may be necessary to lay out cross-sections in a curved or dog-leg alignment to meet this requirement. Every effort should be made to obtain cross-sections that accurately represent the stream and flood plain geometry. However, ineffective flow areas of the flood plain, such as stream inlets, small ponds or indents in the valley floor should generally not be included in the cross-section geometry.

Cross-sections are required at representative locations throughout a stream length and at locations where changes occur such as discharge, slope, shape or roughness, locations where levees begin or end and at bridges or control structures such as weirs. Where abrupt changes occur, several cross-sections should be used to describe the change regardless of the distance. Cross-section spacing is also a function of stream size, slope and the uniformity of cross-section shape. In general, large uniform rivers of flat slope normally require the fewest number of cross-sections per mile. The purpose of the study also affects the spacing of cross-sections.

The choice of friction loss equation may also influence the spacing of cross-sections. For instance, cross-section spacing may be maximized when calculating an M1 profile with the average friction slope equation.

Each cross-section in a data set is identified automatically in the program by succeeding numbers commencing at FILENAME: 1.00. The section numbers are used to identify the files in which the data for each cross-section stored on the cassette tape. Each data point in the cross-section is given a station number corresponding to the horizontal distance from the first point on the left. The elevation and a corresponding station number of each data point are input as variables, (with stations as integers). Entry of a zero or negative station integer will cause prompts for the user to input an "n" value. Up to 25 data points may be used to describe the cross-section geometry.

Cross-section data is traditionally oriented looking downstream, since the program considers the left side of the stream to have the lowest station numbers and the right side to have the highest. The left and right station separating the channel from the overbank areas are specified by an "n" value. End points of a cross-section that are too low (below the computed water surface elevation) will automatically be extended vertically.

The user should always check the output against the input to determine, if in fact, the computed water surface elevation at a particular cross-section is greater than the highest ground elevation that has been entered. The user will then know, if or if not, a vertical extension has been applied.

There are numerous options in this program which will allow the user to easily add, or modify cross-section data. For example, when the user wishes to repeat a surveyed cross-section, subsequent files are set up to identify the cross-section, provide reach length information, and to allow the user to modify the vertical dimensions of the repeated cross-section data. This feature saves valuable input time and for instance, can be applied to uniform dimensioned canals with both zero or sloping gradients.

REACH LENGTHS:

The measured distances between cross-sections are referred to as reach lengths. The reach lengths for the left overbank, right overbank and main channel used in computations are specified input. Channel reach lengths are typically measured along the thalweg. Overbank reach lengths should be measured along the anticipated path of the center of mass of the overbank flow. Often, these three values will be equal. There are however, conditions where they will differ, such as at river bends, or where the main channel meanders considerably but the overbanks are straight. Where the distance between cross-sections for channel and overbanks are different, the program determines a discharge-weighted reach length which is based on the discharges in the main channel and left and right overbank segments of the reach. Refer to Equation (3) for an explanation on how this is done.

PROGRAM INPUT:

The program is divided into two parts. Part one is for data input and part two evaluates the input and computes the output.

File name for data input for either Imperial or Metric units is "SECTION".

Program "SECTION", automatically assigns the file name, allows the user to input the cross-sections geometry, friction and shock loss coefficients, reach lengths and flows.

The program follows the convention of HEC-2 for the description of the cross-section. This convention is; elevation first followed by the corresponding station.

There are options to allow the user to select single channel or overbank flow, and the repetition of cross-section geometry without having to manually re-key the data. If the latter option is chosen, that is, the channel configuration is identical except that it may or may not have a slope, the channel cross-section data can be modified by vertical adjustments of the repeated cross-section.

In the case of accidental entries, the program contains a "Failsafe" which will allow the user to input corrected data. Refer to Page 19.

PROGRAM OUTPUT:

Program output is computed by 'WASPIMP" for Imperial units or "WASPMET" for Metric units. There are options which allow the user to select the method of calculation for the representative friction slope and to initiate reruns of the same job for the computation of a water surface profile with different starting water levels and/or flow.

A special note is printed to inform the user of critical depth assumption. Cross-section data output prints the section number, starting water surface elevation, total flow, "shock" loss coefficients, length of reaches, the cumulative length of the main channel since start, the total submerged area and the computed water surface elevation. If the user selects the overbank flow option, both submerged area and length of reach is printed for the left overbank, main channel and right overbank subdivisions. All values are displayed to two decimal places.

OUTPUT DATA DESCRIPTION

Section No:	Number of the current cross-section is automatically set up by the calculator and used for the FILE NAME. The first cross-section is numbered 1.00, second cross-section is numbered 2.00, and etc.
Q cfs or cms:	Total flow for the entire cross-section.
C_c:	Contraction flow loss coefficient. (Standard, unless otherwise specified is 0.10).
C_e:	Expansion flow loss coefficient. (Standard, unless otherwise specified is 0.30).
L_{lob}:	Length of reach input for the left overbank subdivision.
L_{rob}:	Length of reach input for the right overbank subdivision.
$L_{mn.\ chl}$:	Length of reach input for the main channel subdivision.
A_{lob}:	Submerged area in the left overbank subdivision.
A_{rob}:	Submerged area in the right overbank subdivision.
$A_{mn.\ chl}$:	Submerged area in the main channel subdivision.
A_{total}:	Total submerged area.
WS INPUT:	The starting water surface elevation that was input by the user for cross-section 1.00.
WS START:	If the starting water surface elevation input by the user is greater than or equal to critical depth, both WS INPUT and WS START will coincide. If WS INPUT is less than critical depth, WS START will be computed and output to the next nearest one-half foot (Imperial System) or 0.20 metre interval (Metric System).
CWSEL:	Computed water surface elevation.

-- WARNING –
CRITICAL DEPTH ASSUMED: Message to inform the user if WS INPUT or balanced CWSEL is less than critical depth.

OPERATING LIMITS AND WARNINGS:

The following assumptions are implicit in the analytical expressions used in the program. Flow is steady, gradually varied and one-dimensional. River channels must have small slopes, say less than 1:10.

A maximum of twenty-five data points are allowable per cross-section. (Each cross-section elevation and its corresponding station is one data point).

Other limitations have been described such as loss coefficients and super-critical flow.

Cross-sections are extended vertically if the two end points of the cross-section are not entered high enough. The user should analyze the output VERSUS the input to ascertain if the cross-section end points have indeed been extended. The user may find this extension a powerful and useful feature in the case of confined channel flow by a dyke. However, if no artificial confinement in reality is desired, the user must ensure that the two end points inserted in the cross-section data are high enough to eventually confine the water, no matter what distance they occur from the main channel. Sometimes, this can lead to other problems and the user may have to modify the cross-section to counteract this problem. (Refer to the HELPFUL HINTS section - Item 6b).

All station values (that is X coordinates) must be input as integers. Upon entry of a zero or negative X coordinate value, this will always prompt the user to specify an "n" value. This latter requirement of the program is necessary as it is used to define the left overbank, main channel and right overbank subdivisions.

EQUIPMENT REQUIREMENTS:

1. HP-41CV, HP-41CX or HP-41 with four memory modules.

2. HP digital cassette drive #82161A.

3. HP thermal printer #82162A.

4. HP-IL module #82160A.

MANNING'S "n"

Manning's "n" is a dimension less number that defines the flow resistance to a unit of bed surface. Resistance is a function of size, bed shape, and constructional bed forms (eg: ripples). Manning's "n" incorporates many physical factors including the channel roughness, irregularity of the channel cross-section, channel alignment and bends, vegetation, sedimentation, scouring and channel obstructions. The following table presents a list of commonly used values for Manning's "n":

Type and Description	Min.	Design	High
Earth bottom, rubble sides	0.028	0.032	0.035
Drainage ditches, large, no vegetation			
with < 2.5 hydraulic radius	0.040		0.045
with 2.5 - 4.0 hydraulic radius	0.035		0.040
with 4.0 - 5.0 hydraulic radius	0.030		0.035
with > 5.0 hydraulic radius	0.025		0.030
Small drainage ditches	0.035	0.040	0.040
Stony bed, weeds on bank	0.025	0.035	0.040
Straight and uniform	0.017	0.0225	0.025
Winding, sluggish	0.0225	0.025	0.030
(A) Clean straight bank, full stage, no rifts or deep pools	0.025		0.033
(B) Same as (A) but some weeds and stones	0.030		0.040
(C) Winding, some pools and shoals, clean	0.035		0.050
(D) Same as (C), lower stages, more ineffective slopes and sections	0.040		0.055
(E) Same as (C), some weeds and stones	0.033		0.045
(F) Same as (D), stony sections	0.045		0.060
(G) Sluggish river reaches, rather weedy or with very deep pools	0.050		0.080
(H) Very weedy reaches	0.075		0.150

In the case of large, clean excavated ditches with no vegetation, Manning's "n" values could be assumed on the basis of the hydraulic radius. The hydraulic radius (R) is the area of the cross-section (A) divided by its wetted perimeter (WP). For parabolic channels where the water surface width is greater than the depth of water, the hydraulic radius may approximate a value close to two-thirds the depth. For those channel geometries that approximate trapezoidal or rectangular cross-sections and where the bottom width is greater than the average depth, the hydraulic radius will be close to the average depth. The hydraulic radius of a channel with a triangular cross-section, the hydraulic radius may be approximated as one-half the depth.

For natural channels, many uncertainties associated with Manning's equation can be minimized by basing the variables on accurately measured data. Specifically, the channel cross-section must be accurately surveyed to obtain measurements of the width, depth and hydraulic radius.

SOME HELPFUL HINTS FOR THE PROGRAMMER

1. Unlike HEC-2, this program will not insert interpolated cross-sections upon request. Therefore, it is necessary for the programmer to insert cross-sections that are close enough if the velocity head becomes too great to accurately determine the energy gradient. Such an occurrence can happen if the channel raises or lowers, or expands of contracts abruptly while the reach lengths are excessive. Whenever there is a substantial difference in shape between previous and current cross-sections, the user should try to interpolate intermediate cross-section data for the program, provided that such interpolation is actually representative of the stream geometry. The number of interpolated cross-sections to be added may vary with discharge.

2. It has been generally been proven that best results can be attained if the first two cross-sections that are input into the program occur over a fairly short reach length. Length of reach for these cross-sections will vary according to flow and/or the starting water surface elevations. There generally is no real "rule of thumb" that can be suggested, except the user through experience, can fairly well tell the optimum reach length to use. <u>If data is lacking, the user can set up dummy cross-sections between the first two known cross-sections by interpolation</u>.

3. The user has the option available in this program to compute water surface profiles for channels with tributary stream systems. This is taken into account by the "<u>CHANGE IN FLOW</u>" option. To ensure profile accuracy, when in the vicinity of tributary confluences, the user should ensure that representative short reach lengths are used in the close proximity of the tributary confluence with the main stream.

4. Divided flow of the main channel can be handled by this program. Such occurrences may happen when flow spits around an island or some unsubmerged obstacle. Close reach lengths should be inserted prior to, by it and following the obstacle in order to give a true representation of the actual stream. As the velocity is computed using the total flow and total area of the main channel, the programmer may have to make allowances by reforming the cross-sections at the obstacle particularly if the reach lengths are not identical and/or velocities on each side are not proportionally divided. It may be advantageous for the user to use the option of overbank flow (provided it is not already used). Example three shows the method. This process can be quite tricky. Example three outlines three methods that can be used and the priority of usage.

5. The message "Assumed Critical Depth" should be verified by inspection of the channel properties. Additional cross-sections may be needed for insertion in order to preserve the assumption of gradually varied flow if the critical depth occurrence is not justified.

6. The user should be aware that ineffective flow areas of the flood plain in overbank flows should be excluded. Ineffective flow areas often include stream inlets, small ponds or indents in the valley floor.

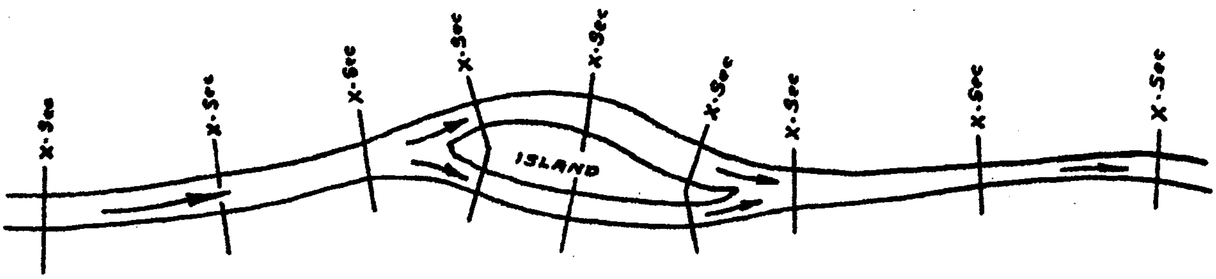
6b. The user should always carefully analyze the output for inaccuracies that can sometimes occur particularly in a wide, flat flood plain with water flowing a relatively low depth. This inaccuracy can occur because the computed area will be a small value while on the other hand, the computed wetted perimeter will be large. In this case, the programmer, through experience, can slightly alter the geometry of a wide a flat flood plain to more truly represent the flow in the subdivision by introducing a slight slope to shorten the overall width of the flood plain.

7. Cross-section end points are automatically projected vertically if they were not originally input high enough. If this vertical extension could produce unreasonable results, the input data should be corrected and the job rerun. (Refer to 6b).

8. Page 18 shows an example of cross-section data input in a divided flow situation, followed by example for cross-section input in the vicinity of a tributary situation.

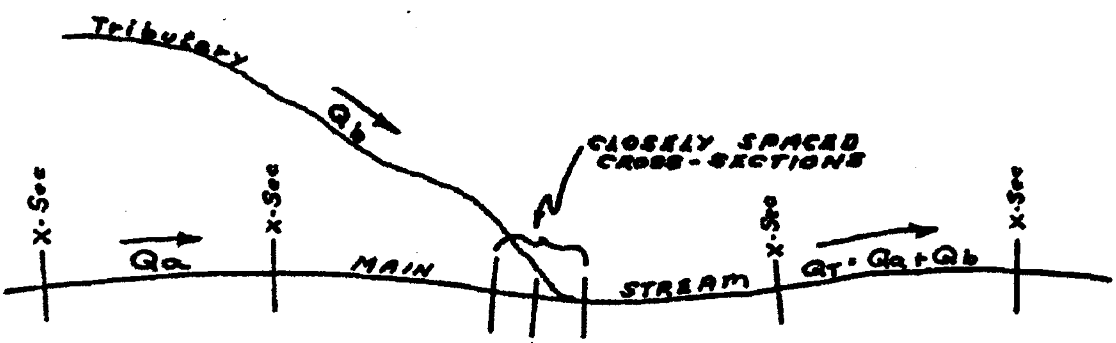
9. Time of computation with the calculator and this program varies and depends upon many factors such as length of reach, flow, number of data points entered to describe the cross-section, and the starting water surface elevation. Usually the computation time to compute the CWSEL for each section is relatively small. On the average, I would say that a "balanced" condition can be established at a cross-section between one to five minutes. Sometimes less.

EXAMPLE OF DIVIDED FLOW INPUT



Cross-Sections closely spaced prior to, around and after the obstacle.

EXAMPLE OF X-SECTION INPUT BY A TRIBUTARY



Cross-Sections closely spaced prior to and after the tributary confluence.

10. <u>A User's "Failsafe" is provided for Data Input</u>. In the program used for input, ie: "SECTION", the user will find a label, namely A. This is the User's Failsafe which can be used for any "Goof-ups" of any data input for the cross-section. In order to use this label, the user must first complete the input for one data point (X and Y coordinates). Then execute the label. Upon doing so, this will return the program for entry of new and correct data. The following example shows how this works and exhibits two errors that have initially been entered for input.

No. of points?	4	R/S	Four data points are to be entered
Elev?	10	R/S	
Sta?	0	R/S	First data point completed.
n?	.040	R/S	Prompt for Manning's "n".
Elev?	0	R/S	
Sta?	11	R/S	Second data point completed.
Elev?	10	R/S	← Oops. Should have been zero.
Sta?	31	R/S	← The "X" coordinate was completed.

The second data point being completed, the user can:

XEQ Alpha A Alpha			← Execute label A
Elev?	0	R/S	← Correct value was entered.
Sta?	21	R/S	← Oops. Should have been 31.

The second data point being completed, the user can:

XEQ Alpha A Alpha			← Execute label A
Elev?	0	R/S	
Sta?	31	R/S	Third data point completed.
Elev?	10	R/S	
Sta?	41	R/S	Fourth data point completed.

USER INSTRUCTIONS

STEP	INSTRUCTIONS	INPUT DATA/ UNITS	KEYS	OUTPUT DATA/ UNITS
	PART ONE This assumes the program "SECTION" has been placed on tape.			
1	Connect the calculator, thermal printer and digital cassette drive in series.			
2	Execute Alpha SIZE Alpha 093.		[XEQ] [093]	
3	Key Alpha SECTION Alpha.			
4	Execute Alpha READP Alpha. The input portion of the program will be read into the calculator, at which time a tone will be heard.			
5	Execute Alpha SECTION Alpha.		[XEQ]	
6	The user will first be prompted by the question: "NO. OF SECTIONS?". Key in the number of cross-sections, including the first, that are intended to be input over the entire profile. Then press R/S.	Number of cross-sections	[R/S]	
7	The user will be prompted with the question: "IDENTICAL SECTIONS?" If all cross-section station points throughout the entire intended profile and including the Manning's "n" values are identical, then the answer is YES and key 1. If the cross-section station points and/or Manning's "n" are not identical, key any other number. Press R/S after the number is keyed.	1or eg: 0	[R/S]	

USER INSTRUCTIONS

STEP	INSTRUCTIONS	INPUT DATA/ UNITS	KEYS		OUTPUT DATA/ UNITS
8	If NO was the reply to the previous question, go to step 10.				
9	The user will be prompted with the question: "HAS CHANNEL A SLOPE?" This means that if the channel has a slope, a factor can be added to all previous elevation points at each cross-section. The user should be aware that not only does the channel bottom increase or decrease to conform with the slope, but also will all other elevation points of the cross-section. If this is correct, then YES is the answer and key 1. If NO is the answer, then all cross-sections up the channel will remain unmodified from the first (that is, the slope of the channel is zero). Key any other number. After this number is keyed, press R/S.	1 or eg: 0		R/S	
10	The user will be prompted by the question: "OVERBANK FLOW?" If the flow is overbank; that is each cross-section subdivision can be assigned a different Manning's "n" value, and/or reach length, then the answer is YES and key 1. If NO, that is, a singular main channel exists with no change in "n" values occurring across the cross-section, key any other number. After the numbers are keyed, press R/S.	1 or eg: 0		R/S	
11	The user will be prompted by the question: "CHANNEL FLOW?" Key	Q in cfs or m^3s			

USER INSTRUCTIONS

STEP	INSTRUCTIONS	INPUT DATA/ UNITS	KEYS		OUTPUT DATA/ UNITS
	the flow in total, then press R/S.			R/S	
12	The user will be prompted by the question: "NO. OF POINTS?". It asks how many data points are there in the first downstream cross-section. One data point consists of elevation and station, (that is the Y and X coordinates). Up to twenty-five data points may be input per cross-section. Key the number and press R/S.	Number of data points?		R/S	
13	Prompt now will be "ELEV?". Key the elevation of the first data point of section 1.00 and then press R/S. The traditional convention is left to right, looking downstream.	Elevation? in feet or metres		R/S	
14	Prompt now will be "STA?". Note that all corresponding station points must be input as positive integers, except the first corresponding station which must be keyed as 0.0 or as a negative integer. If overbank flow is specified, corresponding station points at all subdivision boundaries must be keyed as negative integers. Key the station number, press CHS, (change sign if not zero), then press R/S. Zero or negative integers cause prompts for Manning's "n" values.	Station? in feet or metres Either zero or negative Keyed as integer only		R/S	
15	Prompt now will be "N?". Whenever the program reads a negative integer for the station, the next prompt will be for a Manning's "n" value. Key the "n" value and press R/S.	"n" value		R/S	

STEP	INSTRUCTIONS	INPUT DATA/ UNITS	KEYS		OUTPUT DATA/ UNITS
16	Prompt now will be "ELEV?" Key the elevation of the second data point, then press R/S.	Elevation? feet or metres		R/S	
17	Prompt now will be "STA?" If the overbank flow has not been specified, key the corresponding station as a positive integer. If overbank flow has been specified, the user has the option of declaring this station point as the end of the left overbank subdivision and the beginning of the main channel. If this is true, key the station as a negative integer. If not, key the station as a positive integer, then press R/S.	Station? feet or metres Key as integer. Positive or negative value if an "n" value is requested		R/S	
18	If a negative integer was keyed in Step 17, prompt will be "N?". If a positive integer was keyed in Step 17, prompt will be "ELEV?". Repeat Steps 16 and 17, or if overbank flow is specified, repeat Steps 15, 16 and 17 until all data points have been keyed into the calculator. <u>If overbank flow is specified, three "n" values must be keyed, to designate the left overbank, main channel and right overbank subdivisions</u>.	Elevation or "n" value. After each input the user must press R/S.		R/S	
19	All pertinent data for the first section will now be set up on file on the digital cassette, designated as file 1.00. A print message will indicate that this has been completed with "SECTION 1.00 OK". The registers being read and verified, the user now	Filename 1.00 is filed on the tape in the cassette.			

STEP	INSTRUCTIONS	INPUT DATA/ UNITS	KEYS		OUTPUT DATA/ UNITS
	awaits the next prompt designating the start of the next cross-section. This begins with the question: "CHANGE IN FLOW?". If flow at the next cross-section is to be changed, YES is the answer, key 1. If NO is the answer, key any other number. After the numbers have been keyed, press R/S.	Change in flow? 1 or eg: 0		R/S	Registers are read and are recorded on to tape. The data is now verified. If okay, a message is printed.
20	If NO was the answer to the question in Step 19, go to Step 22.				
21	Prompt will be: "NEW CHANNEL FLOW?" Key the new flow and press R/S.	Q either cfs or cms.		R/S	
22	Prompt now will be "LOSS COEFF. CHGE?" (Standard in the program for the flow loss coefficients is 0.1for the contraction coefficient and 0.3 for the expansion coefficient. These values are generally considered the normal for most mild channel transitions). <u>If it desirable to change the coefficients, then YES is the answer</u>, key 1. If NO, key any other number. Press R/S.	Change in the C values? 1or eg: 0		R/S	
23	If NO was keyed to the question in Step 22, go to Step 30.				
24	Prompt now will be "CONTRACTION VALUE CHANGE?" <u>If this is the number that must be changed, then</u>	New Cc? 1 or eg: 0			

STEP	INSTRUCTIONS	INPUT DATA/ UNITS	KEYS	OUTPUT DATA/ UNITS
	YES is the answer, key 1. If NO, key any other number. Press R/S.		[R/S]	
25	If NO was keyed to the question in Step 24, go to Step 29.			
26	Prompt now will be the question: "NEW CONTRACTION VALUE? 0 to 1". Key the new value, then press R/S.	New Cc. from 0 to 1	[R/S]	
27	Prompt now will be the question: "EXPANSION VALUE CHANGE?" <u>If this number is to be changed, YES is the answer</u>, key 1. If NO, key any other number. After the numbers are keyed, press R/S.	New Ce? 1or eg: 0	[R/S]	
28	If NO was the answer to the question in Step 26, go to Step 30.			
29	Prompt now will be the question: "NEW EXPANSION VALUE? 0 to 1. Key the new value and press R/S.	New Ce. from 0 to 1	[R/S]	
30	If overbank flow was not specified, go Step 33.			
31	Prompt now will be the question: "DIST. LOB?" (Length of reach for the left overbank subdivision between the two cross-sections). Overbank lengths should be measured along the anticipated path of the center of mass of the overbank flow. Key the number and press R/S.	L_{lob} feet or metres	[R/S]	

USER INSTRUCTIONS

STEP	INSTRUCTIONS	INPUT DATA/ UNITS	KEYS	OUTPUT DATA/ UNITS
32	Prompt now will be the question: "DIST. ROB?" (Length of reach for the right overbank subdivision between the two cross-sections). Measured as per instructions in Step 31. Key the number and press R/S.	L_{rob} feet or metres	R/S	
33	Prompt now will be the question: "DIST. M. CHL?" (Length of reach for main channel between the two cross-sections). This reach length is typically measured along the thalweg. Key the number and press R/S.	$L_{mn.\ chl}$ feet or metres	R/S	
34	If in Step 6, identical sections were requested, go to Step 36.			
35	The user will now be prompted for the description of the cross-section; that is the number of points, the elevation, station, Manning's "n" value, etc. The procedure follows exactly the same format and user input as Steps 12 through 18. Go to Step 38.			
36	If the user indicated in Step 9 that the channel had no slope, go to Step 38.			
37	Prompt now will be: "ADD FACTOR?" The user in this Step has indicated that the cross-section stations are identical and that all cross-section elevations can be added to by some factor to compensate for the channel slope. For example, suppose the channel has a uniform slope of one percent	Factor to be added to all elevation values in feet or metres		

STEP	INSTRUCTIONS	INPUT DATA/ UNITS	KEYS	OUTPUT DATA/ UNITS
	(downstream to upstream), and the measured length between the two cross-sections was one hundred feet. the user has the option of modifying all elevations of the upstream cross-section by the addition of one foot to all the downstream elevations that were previously input. Key this factor, then press R/S.	If the factor is negative, then key the number then CHS.	R/S	
38	All pertinent data that has been stored in the calculator for the second cross-section will now be set up on file on the digital cassette tape and will be designated as SECTION 2.00.	SECTION 2.00 is set up on tape.		
39	Prompts now will begin as per Steps 19 through 38 to set up files for SECTIONS 3.00, 4.00, 5.00 and etc. These prompts always begin with the prompt: "CHANGE IN FLOW?" As per the first file that was set up on the tape, a print message will indicate that all pertinent data has been recorded and verified. When the number of cross-sections that was input matches the number of cross-sections that was keyed in Step 6, the calculator program will stop automatically.			
40	The user will now be ready to analyze the input data and compute the water surface profile. Refer now to Part Two.			

USER INSTRUCTIONS

STEP	INSTRUCTIONS	INPUT DATA/ UNITS	KEYS		OUTPUT DATA/ UNITS
	<u>PART TWO</u> This assumes the programs used for analysis have been placed on tape.				
1	Connect the calculator, thermal printer and digital cassette drive in series.				
2	Execute Alpha SIZE Alpha 093. (Disregard this Step if the calculator has not been altered since Step 2 of Part One.	SIZE	XEQ	093	
3	If Metric Units are input, go to Step 5.				
4	Key Alpha WASPIMP Alpha. (Water Surface Profiles Imperial System). Go to Step 7.				
5	Key Alpha WASPMET Alpha. (Water Surface Profiles Metric System).				
6	Execute Alpha READP Alpha. The program used for analysis will now be read into the calculator, at which time a tone will be heard.		XEQ		
7	Execute Alpha WASPIMP Alpha (Imperial System) or Alpha WASPMET Alpha (Metric System).		XEQ		
8	The user will be prompted with the question: "TITLE?" A combination of 16 letters, numbers and spaces can be keyed into the calculator in the Alpha mode to describe the stream or project. After the title is keyed, press	Job Name			

USER INSTRUCTIONS

STEP	INSTRUCTIONS	INPUT DATA/ UNITS	KEYS	OUTPUT DATA/ UNITS
	Alpha followed by R/S.		R/S	
9	The user will now be prompted by a question: "OVERBANK Q?" If flow is to be computed using the left overbank, main channel and right right overbank subdivision, then the answer is YES, key 1. If NO, key any other number. After the numbers are keyed, press R/S.	Overbank flow? 1 or eg: 0	R/S	
10	The prompt now will be: "AV. CONVEYANCE EQN?" <u>The user is asked if it is desirable to compute the water surface profile by the average conveyance equation</u>. If YES, key 1. If NO, key any other number. Upon the decision of using NO, the water surface profile will be computed using the average friction slope equation. If all profiles are not expected to be of the M1 type, the user is advised to select the "Default" equation and to key 1. After the numbers are keyed, press R/S.	$\bar{S}f$? The users choice for the equation 1 or eg: 0	R/S	
11	The program will now begin reading file 1.00 as set up from Part One, and print section number: 1.00, flow in cfs or cms, and the flow loss coefficients C_c and C_e. (If the "Default" was selected by the user, then the values for C_c and C_e would be 0.10 and 0.30 respectively). The user will now be prompted with the question: "WS START?" Key in the starting water surface elevation for the downstream	Starting water surface elevation to use for the profile?		

USER INSTRUCTIONS

STEP	INSTRUCTIONS	INPUT DATA/ UNITS	KEYS	OUTPUT DATA/ UNITS
	cross-section (ie: cross-section 1.00) and press R/S.		R/S	
12	Unless the user requests a rerun, the prompt of Step 11 will be the last that is required of the user. The calculator will automatically compute the water surface profile for each cross-section that has been input and will stop after the last cross-section file set up from Part One has been read and analyzed. The user will be alerted that the computation is finished by two BEEPS. The program automatically terminates. Refer to the examples that follows for input and output.			
13	For multiple water surface profiles, (subsequent jobs of the same run), execute Alpha RERUN Alpha. If it is desired to compute the water surface profile using a different representative friction equation in a subsequent job, go to Step 22.	Reruns	XEQ	
14	The user will be prompted with the question: "CHANGE Q?". <u>If flows already set up on files from Part One are to be modified for the next run, then YES is the answer</u>, key 1. If NO, key any other number. After the numbers are keyed, press R/S.	Is flow to be changed? 1 or eg: 0	R/S	
15	If NO was keyed to the question in Step 14, go to Steps 20 and 21.			

STEP	INSTRUCTIONS	INPUT DATA/ UNITS	KEYS		OUTPUT DATA/ UNITS
16	Prompt will be the question: "CONST. Q?" If the flow to be input is constant throughout, key 1. If not, key any other number. After the numbers are keyed, press R/S.	Is flow constant? 1 or eg: 0		R/S	
17	If NO was the response in Step 16, go to Step 20.				
18	Prompt now will be: "NEW Q?". Key the new flow and press R/S.	Q in cfs or cms		R/S	
19	The program will now begin with the reading of file 1.00. Refer to Steps 11, 12 and 13 of Part Two.				
20	The program will now begin with the printing of Section 1.00 at which time a tone will be heard to alert the user along with a prompt: "NEW Q?" Key the new flow and press R/S.	Q in cfs or cms		R/S	
21	Refer to Steps 11 and 12 of Part Two. As new files are subsequently read, after the section number has been printed, the user will again be alerted by a tone, and prompted for the input of new flows. If it is inconvenient for the user to "babysit" the calculator for the input of new flows, then it is advisable to set up new files as per Part One with the new flows. This can be done using the same tape after purging the initial files that were set up in Part One and making up new ones. Alternatively, it can be done by setting up new files on a separate tape.				

STEP	INSTRUCTIONS	INPUT DATA/ UNITS	KEYS		OUTPUT DATA/ UNITS
22	If the initial request for computation of the representative friction slope for the reach was to be done by the average conveyance equation (the "Default"), and it is desirable on the rerun to have it computed by the average friction slope equation, clear Flag 08. (cf 08).	$\bar{S}_f$ changing method Clear or Set Flag 08		CF 08	
	If the initial request for computation of the representative friction slope for the reach was to be done by the average friction slope equation and it is desirable on the rerun to have it computed by the average conveyance equation, set Flag 08. (SF 08).			SF 08	
	Having cleared or set the flags, then execute Alpha RERUN Alpha. Now go to steps 14 through 21 of Part Two.		XEQ		

USER INSTRUCTIONS

STEP	INSTRUCTIONS	INPUT DATA/ UNITS	KEYS	OUTPUT DATA/ UNITS
	PART THREE			
1	The user is probably aware that the files set up for the cross-sections are permanently recorded on the tape contained in the cassette drive. Once the user is satisfied with the results of the computation, the files must be erased as no new file can be set up on the same cassette with the same file name for new jobs.	Purging old files.		
2	Three methods are available to the user to purge the tapes. Two of these methods are manual and the third is automatic.			
3	Method One (Manual).			
a	Key Alpha FILENAME Alpha where FILENAME is file name is 1.00, 2.00, 3.00, etc.			
b	Execute Alpha PURGE Alpha.			
c	Repeat Steps a and b until all the cross-section files are purged.			
4	Method Two (Manual).			
a	Key 1 STO 00 and f FIX 2.			
b	Key Alpha f CLA Alpha.			
c	Execute Alpha ARCL Alpha 00.			
d	Execute Alpha PURGE Alpha.			
e	Key 1 and Alpha ST+ Alpha 00.			
f	Repeat steps b through e until all the cross-section files are purged.			

USER INSTRUCTIONS

STEP	INSTRUCTIONS	INPUT DATA/ UNITS	KEYS	OUTPUT DATA/ UNITS
5	Method 3 (Automatic)	Using a program that has been set up on the cassette		
a	Key Alpha BYE Alpha.			
b	Execute Alpha READP Alpha.			
c	Execute BYE.			
d	This program will ask for the starting file number.			
e	In this case, the usual answer is 1. Key 1 then press R/S.			
f	The program will ask the ending file number. Key the ending file number.	Filename is BYE		
g	The program will automatically purge files from 1.00 to N.00. When completed the program will clear all storage registers, automatic memory stack, X register, alpha register, all flags and will set the fixed display to 4.			

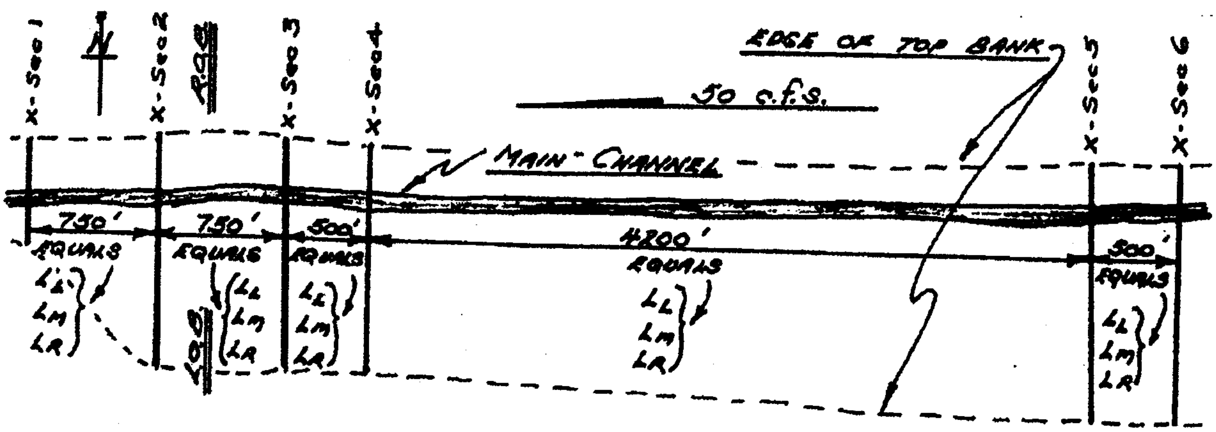
EXAMPLE ONE

A Simple Example of Overbank Flow - Imperial System Units

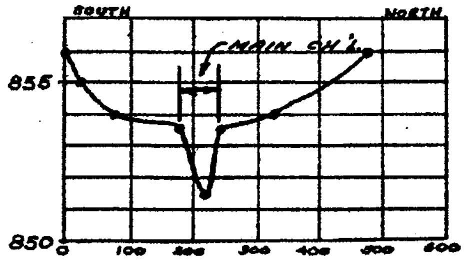
Name of Job: Tidewater Creek

PLAN VIEW OF THE AREA

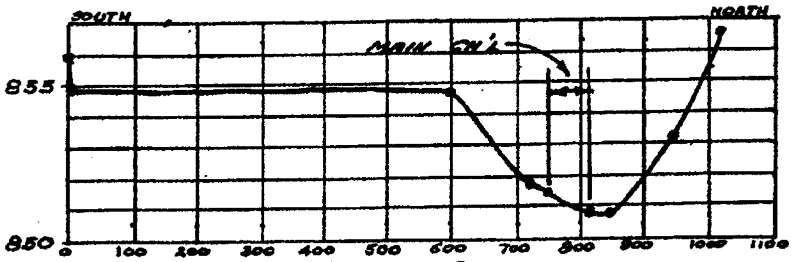
(Not to scale)



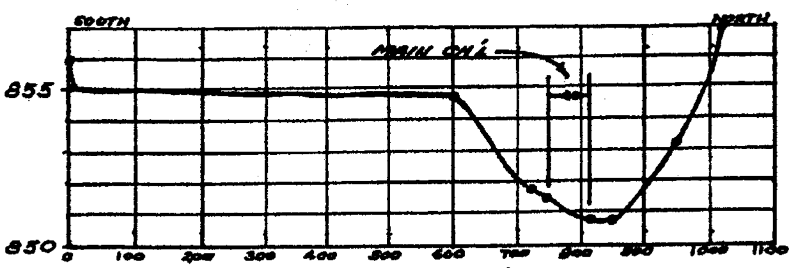
Cross-sections for the channel length to be studied are shown on Page 36.



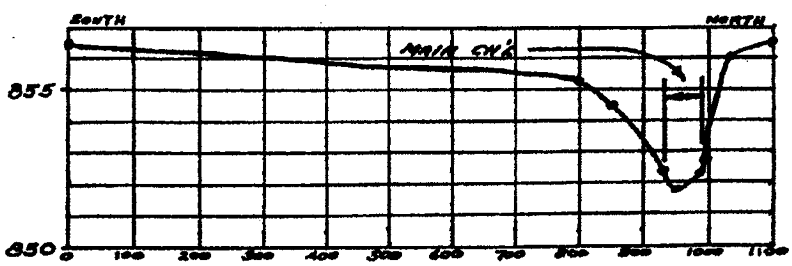
SECTION 1



SECTION 2



SECTIONS 3 & 4



SECTIONS 5 & 6

Cross-Sections For Tidewater Creek

Scales: Horizontal 1″ = 200 Feet
Vertical 1" = 5 Feet

Cross-Section 1	Elevation		Station	
Q - 50 cfs	856.0		0 ←	
n_{lob} - 0.085	855.0		20	left overbank
$n_{mn\ chl}$ - 0.040	854.0		80	
n_{rob} - 0.085	853.6 ←		180 ←	
C_c - 0.10	851.4	open	210	main channel
C_e - 0.30	853.6 ←		240 ←	
	854.0		320	right overbank
	856.0		480 ←	

Cross-Section 2	Elevation		Station	
Q - no change	856.0		0 ←	
n_{lob} - 0.100	854.9		1	left
$n_{mn\ chl}$ - 0.040	854.8 ←	heavily	600	overbank
n_{rob} - 0.100	851.8	wooded	720	
C_c - 0.00	851.5 ←		750 ←	main
C_e - 0.00	850.9 ←	open	810 ←	channel
	850.9	heavily	850	
Length of Reach	853.1 ←	wooded	950	right overbank
equal at 750 feet.	856.7		1020 ←	

Cross-Section 3	Elevation		Station	
Q - no change	856.0		0 ←	
n_{lob} - 0.100	855.0		1	
$n_{mn\ chl}$ - 0.040	854.8 ←	heavily	600	left overbank
n_{rob} - 0.100	851.8	wooded	720	
C_c - 0.00	851.5 ←		750 ←	main
C_e - 0.00	850.9 ←	open	810 ←	channel
	850.9	heavily	850	
Length of Reach	853.1 ←	wooded	950	right overbank
Equal at 750 feet.	857.0		1020 ←	

Cross-Section 4	Elevation		Station	
Q - no change	856.0		0 ←	
n_{lob} - 0.090	855.0		1	left overbank
$n_{mn\ chl}$ - 0.040	854.8 ←	heavily	600	
n_{rob} - 0.090	851.8	wooded	720	
C_c - 0.00	851.5 ←	open	750 ←	main channel
C_e - 0.00	850.9 ←		810 ←	
	850.9	heavily	850	
Length of Reach	853.1 ←	wooded	960	right overbank
Equal at 500 feet.	857.0		1020 ←	

Cross-Section 5	Elevation		Station	
Q - no change	856.5		0 ←	
n_{lob} - 0.090	855.2		800	left overbank
$n_{mn\ chl}$ - 0.040	854.5 ←	heavily	850	
n_{rob} - 0.090	852.4 ←	wooded	930 ←	
C_c - 0.00	851.8	open	950	main channel
C_e - 0.00	852.2		990	
	852.6 ←	heavily	995 ←	
Length of Reach	856.0 ←	wooded	1035	right overbank
Equal at 4200 feet.	856.5		1100 ←	

Cross-Section 6	Elevation		Station	
Q - no change	856.5		0 ←	
n_{lob} - 0.090	855.2		800	left overbank
$n_{mn\ chl}$ - 0.040	854.5 ←	heavily	850	
n_{rob} - 0.090	852.4 ←	wooded	930 ←	
C_c - 0.00	851.8	open	950	main channel
C_e - 0.00	852.2		990	
	852.6 ←	heavily	995 ←	
Length of Reach	856.0 ←	wooded	1035	right overbank
Equal at 500 feet.	856.5		1100 ←	

The Input Using 'PART ONE'

"SECTION" program is loaded into the calculator and is now ready for Section 1.00

		Keys	
NUMBER OF SECTIONS?		6	R/S
IDENTICAL SECTIONS?	No	0	R/S
OVERBANK FLOW?	Yes	1	R/S
CHANNEL FLOW?	50		R/S
NO. OF POINTS?	8		R/S
ELEV?	856.0		R/S
STA?	0		R/S
N?	.085		R/S
ELEV?	855.0		R/S
STA?	20		R/S
ELEV?	854.0		R/S
STA?	80		R/S
ELEV?	853.6		R/S
STA?	(-) 180		R/S
N?	.040		R/S
ELEV?	851.4		R/S
STA?	210		R/S
ELEV?	853.6		R/S
STA?	(-) 240		R/S
N?	.085		R/S
ELEV?	854.0		R/S
STA?	320		R/S
ELEV?	856.0		R/S
STA?	480		R/S

The data for Section 1.00 was saved on the cassette. Now ready for Section 2.00

		Keys	
CHANGE IN FLOW?	No	0	R/S
LOSS COEFF. CHG?	Yes	1	R/S
CONTRACTION VALUE CHANGE?	Yes	1	R/S
NEW CONTRACTION VALUE?	0.0		R/S
EXPANSION VALUE CHANGE?	Yes	1	R/S
NEW EXPANSION VALUE?	0.0		R/S
DIST. LOB?	750.0		R/S
DIST. ROB?	750.0		R/S
DIST. M. CHL?	750.0		R/S
NO. OF POINTS?	9		R/S
ELEV?	856.0		R/S
STA?	0		R/S
N?	.100		R/S
ELEV?	854.9		R/S
STA?	1		R/S
ELEV?	854.8		R/S
STA?	600		R/S
ELEV?	851.8		R/S
STA?	720		R/S
ELEV?	851.5		R/S
STA?	(-) 750		R/S
N?	.040		R/S
ELEV?	850.9		R/S
STA?	(-) 810		R/S
N?	.100		R/S
ELEV?	850.9		R/S
STA?	850		R/S
ELEV?	853.1		R/S
STA?	950		R/S
ELEV?	856.7		R/S
STA?	1020		R/S

The data for Section 2.00 was saved on the cassette. Now ready for Section 3.00

CHANGE IN FLOW?	No	0	R/S

and etc. for the rest of the cross-sections. Finally once Section 6 has been recorded and verified on tape in the cassette drive, program "SECTION" Stops.

PART TWO of Example One

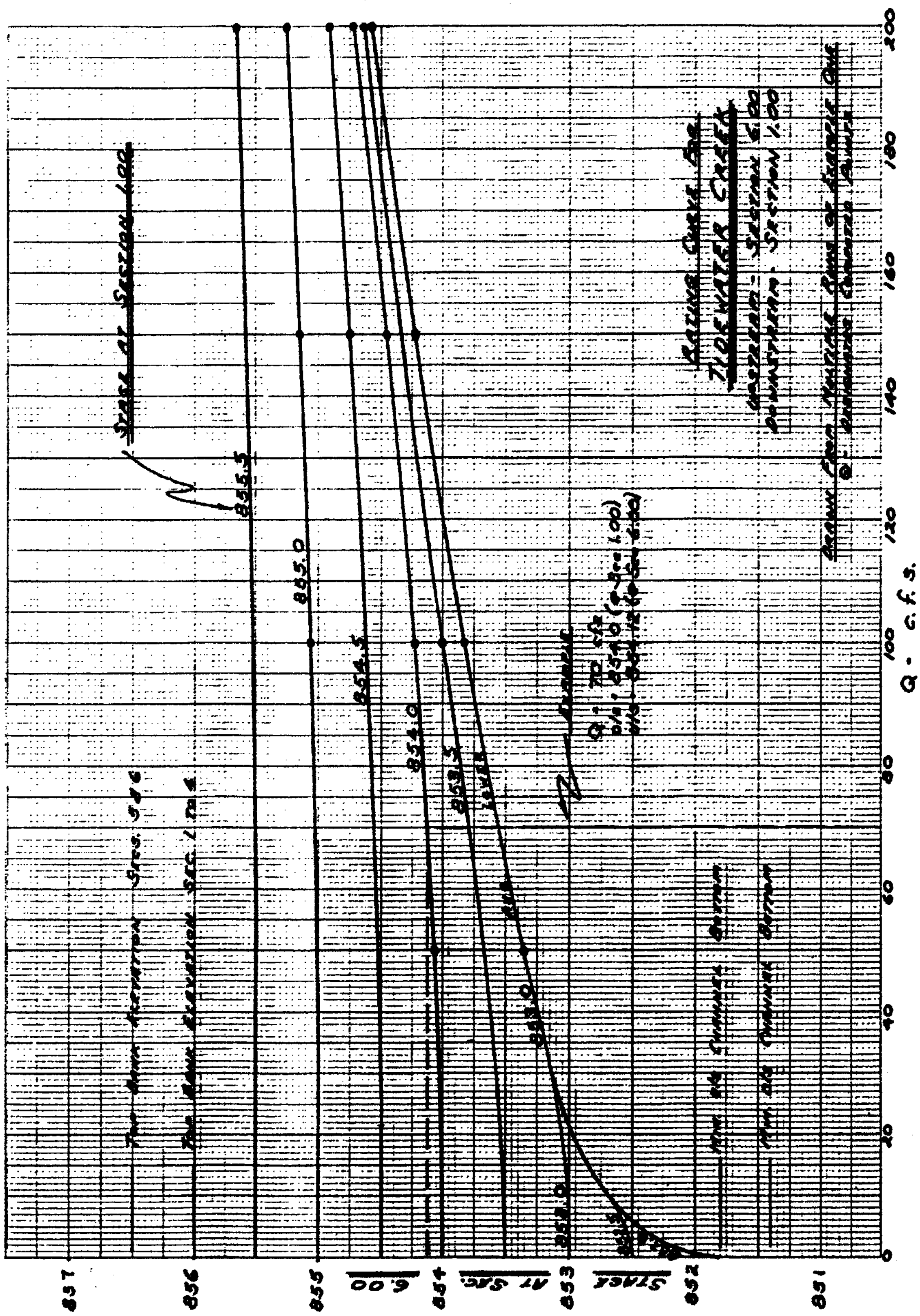
Program "WASPIMP" is loaded into the calculator

		Keys	
TITLE?	TIDEWATER CREEK		R/S
OVERBANK Q?	Yes	1	R/S
AV. CONVEYANCE EQN?	Yes	1	R/S
WS START?	853.0		R/S

OUTPUT FOR EXAMPLE ONE

```
W. S. PROFILES

TITLE: TIDEWATER CREEK

SECTION NO: -  1.00
Q. cfs - 50.00
Cc. - 0.10    Ce. - 0.30
WS. INPUT:  853.00
WS. START:  853.00
A. lob - 0.00
A. rob - 0.00
A. mn. chl - 34.91
A. total - 34.91

SECTION NO: -  2.00
Q. cfs - 50.00
Cc. - 0.00    Ce. - 0.00
L. lob - 750.00
L. rob - 750.00
L. mn. chl - 750.00
Cum. L. - 750.00
A. lob - 75.83
A. rob - 195.48
A. mn. chl - 112.92
A. total - 384.23
CWSEL:  853.00

SECTION NO: -  3.00
Q. cfs - 50.00
Cc. - 0.00    Ce. - 0.00
L. lob - 750.00
L. rob - 750.00
L. mn. chl - 750.00
Cum. L. - 1,500.00
A. lob - 77.02
A. rob - 197.53
A. mn. chl - 113.80
A. total - 388.34
CWSEL:  853.10

SECTION NO: -  4.00
Q. cfs - 50.00
Cc. - 0.00    Ce. - 0.00
L. lob - 500.00
L. rob - 500.00
L. mn. chl - 500.00
Cum. L. - 2,000.00
A. lob - 77.84
A. rob - 209.99
A. mn. chl - 114.40
A. total - 402.23
CWSEL:  853.11

SECTION NO: -  5.00
Q. cfs - 50.00
Cc. - 0.00    Ce. - 0.00
L. lob - 4,200.00
L. rob - 4,200.00
L. mn. chl - 4,200.00
Cum. L. - 6,200.00
A. lob - 14.63
A. rob - 2.69
A. mn. chl - 78.97
A. total - 96.29
CWSEL:  853.28

SECTION NO: -  6.00
Q. cfs - 50.00
Cc. - 0.00    Ce. - 0.00
L. lob - 500.00
L. rob - 500.00
L. mn. chl - 500.00
Cum. L. - 6,700.00
A. lob - 17.92
A. rob - 3.49
A. mn. chl - 85.04
A. total - 106.44
CWSEL:  853.37
```

Several runs were made with varied flows and starting water surface elevations. Page 42 shows a <u>RATING CURVE</u> for Tidewater Creek from Cross-Section 1 to Cross-Section 6.

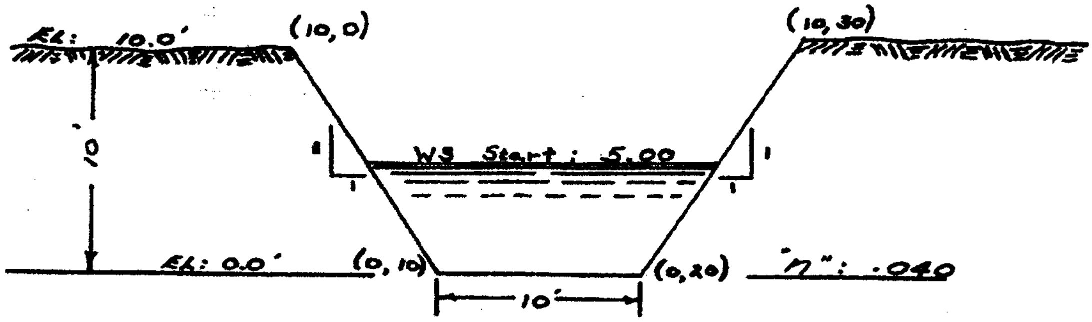

RATING CURVE FOR
TIDEWATER CREEK
UPSTREAM - SECTION 6.00
DOWNSTREAM - SECTION 1.00
STAGE AT SECTION 1.00
STAGE AT SEC. 6.00
Q - c.f.s.
855.5
855.0
854.5
854.0
853.5
853.0
857
856
855
854
853
852
851
0
20
40
60
80
100
120
140
160
180
200

EXAMPLE TWO

This is a simple example for main channel flow.

Name of job: IDEAL CHANNEL

This example is an excavated trapezoidal channel with zero gradient, bottom width of 10 feet and side slopes 1 to 1. The elevation and station coordinates for this channel is shown using Y and X HEC-2 convention coordinates. Dimensions are Imperial.



Program "SECTION" is loaded into the calculator and ready for Section 1.00.

		Keys	
NO. OF SECTIONS?		6	R/S
IDENTICAL SECTIONS?	Yes	1	R/S
HAS CHANNEL A SLOPE?	No	0	R/S
OVERBANK FLOW?	No	0	R/S
CHANNEL FLOW?	100		R/S
NO. OF POINTS?	4		R/S
ELEV?	10.0		R/S
STA?	0		R/S
N?	.040		R/S
ELEV?	0		R/S
STA?	10		R/S
ELEV?	0		R/S
STA?	20		R/S
ELEV?	10		R/S
STA?	30		R/S

This data is filed on tape in the digital cassette drive. Now ready for Section 2.00

		Keys	
CHANGE IN FLOW?	No	0	R/S
LOSS COEFFICIENT CHANGE?	No	0	R/S
DIST MN CHL?	50.0		R/S
CHANGE IN FLOW?	No	0	R/S

and etc. for the rest of the cross-sections having lengths of reach of 100, 500, 1000, and 2000 for cross-sections 3, 4, 5 and 6 respectively.

Program "WASPIMP" is now loaded into the calculator.

		Keys	
TITLE?	IDEAL CHANNEL		R/S
OVERBANK FLOW?	No	0	R/S
AV. CONVEYANCE EQN?	Yes	1	R/S
WS START?	5.00		R/S

The calculator will now run and stop after the computation for cross-section 6.00 is completed.

A rerun is then executed, but this time it will make use of the average friction slope equation.

		Keys	
Clear Flag 8		f CF 08	
XEQ Alpha RERUN Alpha			R/S
CHANGE Q?	No	0	R/S
WS START?	5.00		R/S

The calculator will now run and stop after the computation for cross-section 6.00 is completed. (Note that in this rerun, the program does not ask for input for the "TITLE".

The output for EXAMPLE TWO is shown on page 45.

OUTPUT FOR EXAMPLE TWO

$\overline{S}_f$ - average conveyance equation.

```
TITLE:  IDEAL CHANNEL

SECTION NO: -  1.00
Q. cfs - 100.00
Cc. - 0.10    Ce. - 0.30
WS. INPUT:  5.00
WS. START:  5.00
A. total - 75.00

SECTION NO: -  2.00
Q. cfs - 100.00
Cc. - 0.10    Ce. - 0.30
L. mn. chl - 50.00
Cum. L. - 50.00
A. total - 75.20
CWSEL:  5.01

SECTION NO: -  3.00
Q. cfs - 100.00
Cc. - 0.10    Ce. - 0.30
L. mn. chl - 100.00
Cum. L. - 150.00
A. total - 75.74
CWSEL:  5.04

SECTION NO: -  4.00
Q. cfs - 100.00
Cc. - 0.10    Ce. - 0.30
L. mn. chl - 500.00
Cum. L. - 650.00
A. total - 78.43
CWSEL:  5.17

SECTION NO: -  5.00
Q. cfs - 100.00
Cc. - 0.10    Ce. - 0.30
L. mn. chl - 1,000.00
Cum. L. - 1,650.00
A. total - 83.19
CWSEL:  5.40

SECTION NO: -  6.00
Q. cfs - 100.00
Cc. - 0.10    Ce. - 0.30
L. mn. chl - 2,000.00
Cum. L. - 3,650.00
A. total - 91.23
CWSEL:  5.78
```

$\overline{S}_f$ - average friction slope equation.

```
SECTION NO: -  1.00
Q. cfs - 100.00
Cc. - 0.10    Ce. - 0.30
WS. INPUT:  5.00
WS. START:  5.00
A. total - 75.00

SECTION NO: -  2.00
Q. cfs - 100.00
Cc. - 0.10    Ce. - 0.30
L. mn. chl - 50.00
Cum. L. - 50.00
A. total - 75.20
CWSEL:  5.01

SECTION NO: -  3.00
Q. cfs - 100.00
Cc. - 0.10    Ce. - 0.30
L. mn. chl - 100.00
Cum. L. - 150.00
A. total - 75.74
CWSEL:  5.04

SECTION NO: -  4.00
Q. cfs - 100.00
Cc. - 0.10    Ce. - 0.30
L. mn. chl - 500.00
Cum. L. - 650.00
A. total - 78.44
CWSEL:  5.17

SECTION NO: -  5.00
Q. cfs - 100.00
Cc. - 0.10    Ce. - 0.30
L. mn. chl - 1,000.00
Cum. L. - 1,650.00
A. total - 83.20
CWSEL:  5.40

SECTION NO: -  6,00
Q. cfs - 100.00
Cc. - 0.10    Ce. - 0.30
L. mn. chl - 2,000.00
Cum. L. - 3,650.00
A. total -.91.33
CWSEL:  5.79
```

Note that the results in this particular case are nearly identical.

The following output is a rerun for IDEAL CHANNEL with a very low starting water surface elevation. Critical depth assumption is noted. (Note that normally the programmer might have inserted additional cross-sections in this particular case).

$\overline{S}_f$ - average conveyance equation.

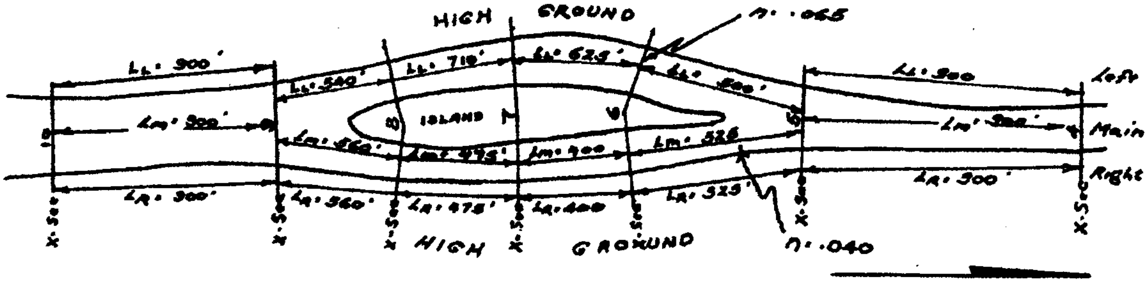
```
SECTION NO: -  1.00
Q. cfs - 100.00
Cc. - 0.10    Ce. - 0.30
WS INPUT:  0.50

      --WARNING--
 CRITICAL DEPTH ASSUMED

WS. START:  1.50
A. total - 17.25

SECTION NO: -  2.00
Q. cfs - 100.00
Cc. - 0.10    Ce. - 0.30
L. mn. chl - 50.00
Cum. L. - 50.00
A. total - 27.83
CWSEL:  2.27

SECTION NO: -  3.00
Q. cfs - 100.00
Cc. - 0.10    Ce. - 0.30
L. mn. chl - 100.00
Cum. L. - 150.00
A. total - 34.00
CWSEL:  2.68

SECTION NO: -  4.00
Q. cfs - 100.00
Cc. - 0.10    Ce. - 0.30
L. mn. chl - 500.00
Cum. L. - 650.00
A. total - 47.61
CWSEL:  3.52

SECTION NO: -  5.00
Q. cfs - 100.00
Cc. - 0.10    Ce. - 0.30
L. mn. chl - 1,000.00
Cum. L. - 1,650.00
A. total - 60.49
CWSEL:  4.25

SECTION NO: -  6.00
Q. cfs - 100.00
Cc. - 0.10    Ce. - 0.30
L. mn. chl - 2,000.00
Cum. L. - 3,650.00
A. total - 75.14
CWSEL:  5.01
```

$\overline{S}_f$ - average friction slope equation.

```
SECTION NO: -  1.00
Q. cfs - 100.00
Cc. - 0.10    Ce. - 0.30
WS. INPUT:  0.50

      --WARNING--
 CRITICAL DEPTH ASSUMED

WS. START:  1.50
A. total - 17.25

SECTION NO: -  2.00
Q. cfs - 100.00
Cc. - 0.10    Ce. - 0.30
L. mn. chl - 50.00
Cum. L. - 50.00
A. total - 30.50
CWSEL:  2.45

SECTION NO: -  3.00
Q. cfs - 100.00
Cc. - 0.10    Ce. - 0.30
L. mn. chl - 100.00
Cum. L. - 150.00
A. total - 35.68
CWSEL:  2.79

SECTION NO: -  4.00
Q. cfs - 100.00
Cc. - 0.10    Ce. - 0.30
L. mn. chl - 500.00
Cum. L. - 650.00
A. total - 49.73
CWSEL:  3.64

SECTION NO: -  5.00
Q. cfs - 100.00
Cc. - 0.10    Ce. - 0.30
L. mn. chl - 1,000.00
Cum. L. - 1,650.00
A. total - 62.42
CWSEL:  4.35

SECTION NO: -  6.00
Q. cfs - 100.00
Cc. - 0.10    Ce. - 0.30
L. mn. chl - 2,000.00
Cum. L. - 3,650.00
A. total - 77.04
CWSEL:  5.10
```

EXAMPLE THREE

This is an example for using overbank flow to define a divided flow section of channel. The following drawing shows the area of concern:



This demonstrates a divided flow condition around an island. There are three methods which can be used to define a divided flow condition.

METHOD ONE:

This method can be used provided that the overflow option has not previously been selected. All cross-sections must be set up using the overbank option. The left and right overbanks must be defined, however, if they do not exist, they can be given a small width on high ground of say, one foot. Cross-sections 1 to 3 (not shown), 4, 5, 9, 10 and upwards (not shown) would be set up in this manner. Cross-sections 6, 7 and 8 would be set up using the left overbank to define the channel division on the left side and the main channel to define the channel division on the right side of the island. The right overbank subdivision for cross-sections 6 to 8 would again be non-existent, but they could be described using a small width. Caution should be the "watchword" to define the division of flow particularly if the flow is not proportionally split in relation to the submerged channel areas. In addition, the Manning's "n" values that are selected for each subdivision should be carefully chosen to be representative.

METHOD TWO:

If the overbank flow option has previously been requested, then the main channel can incorporate the left and right subdivisions around the island. Using this method, the user cannot describe separate reach lengths and Manning's "n" values. The program automatically computes the total submerged area of the main channel and the flow for the main channel is applied to this area. Provided that reach lengths around both sides of the island are reasonably identical and the flow is proportionate with respect to the submerged area, this method will produce satisfactory results. However, if more than three cross-sections are necessary to describe the obstruction or if conditions exist whereby the conditions for reach lengths and Manning's "n" values are not satisfied, the user should invariably try Method Three.

METHOD THREE:

Method Three should only be used when running a backwater around any obstacle where more than three cross-sections are required to define the flow spit particularly if the flows are not proportionate with respect to the submerged area and/or reach lengths and the Manning's "n" values are not identical for each divided channel. With this method, separate runs must be undertaken up each divided channel assuming a flow split through each channel and the process repeated until a "balanced" condition on the upstream end is obtained.

Referring to the drawing, the user would stop the program at cross-section 5.00. The CWSEL (computed water surface elevation) for that particular section would be used as the starting water surface level for each divided channel, endeavouring to obtain a "match" for the CWSEL at cross-section 9.00. Once a "balanced" condition has been found, the user would commence cross-section 9.00 using the CWSEL for the match as the starting water level for the rest of the upstream cross-sections.

Separate tapes will be needed. Each would define the downstream cross-sections (1.00 to 5.00), each divided channel (5.00 to 9.00) assuming some proportional flow split and the upstream cross-sections (9.00, 10.00 and upwards). (The user will recall that each starting file is designated a FILENAME 1.00. No two files can be set up on the same tape with the same filename).

PRIORITY:

1. Use Method Two, provided reach lengths are reasonably identical, the flow proportionate with respect to the submerged area, and no more than three cross-sections are necessary to define the obstacle.

2. Use Method One, provided the overbank flow option has not been previously used.

3. Use Method Three as a last resort. Method Three will entail several trials to guess at the split in flow in order to obtain a balanced condition at the upstream end of the obstacle. It may prove difficult when a range of differing starting water levels and flows are used on reruns beginning at downstream end (cross-section 1) in order to prepare an overall rating curve for the entire reach. In this case, a balanced condition at the upstream end of the obstacle may be found satisfactory using a particular starting flow split and water surface elevation at the start of the obstacle but this balanced condition may not be necessarily satisfied when a differing combination of flows and starting water levels are applied. If that happens, then separate reruns will be necessary to find the individual balanced conditions

which can be applied to each of the several range of flows and starting water levels.

EXAMPLE FOUR

This example demonstrates how to do reruns. Using Example Two as the input data, a subsequent job is to be run to obtain a water surface profile using a differing flow and starting water surface elevation. It is assumed that a previous profile was computed using the average friction slope equation, but in this rerun, it was deemed advisable to use the average conveyance equation.

		Keys	
Set Flag 8		f SF 08	
XEQ Alpha RERUN Alpha			R/S
CHANGE Q?	Yes	1	R/S
NEW Q?	200		R/S
WS START?	6.00		R/S

The output for this rerun is shown below.

```
SECTION NO: -  1.00
Q. cfs - 200.00
Cc. - 0.10    Ce. - 0.30
WS. INPUT:  6.00
WS. START:  6.00
A. total - 96.00

SECTION NO: -  2.00
Q. cfs - 200.00
Cc. - 0.10    Ce. - 0.30
L. mn. chl - 50.00
Cum. L. - 50.00
A. total - 96.61
CWSEL:  6.03

SECTION NO: -  3.00
Q. cfs - 200.00
Cc. - 0.10    Ce. - 0.30
L. mn. chl - 100.00
Cum. L. - 150.00
A. total - 97.79
CWSEL:  6.08

SECTION NO: -  4.00
Q. cfs - 200.00
Cc. - 0.10    Ce. - 0.30
L. mn. chl - 500.00
Cum. L. - 650.00
A. total - 103.65
CWSEL:  6.34

SECTION NO: -  5.00
Q. cfs - 200.00
Cc. - 0.10    Ce. - 0.30
L. mn. chl - 1,000.00
Cum. L. - 1,650.00
A. total - 113.46
CWSEL:  6.77

SECTION NO: -  6.00
Q. cfs - 200.00
Cc. - 0.10    Ce. - 0.30
L. mn. chl - 2,000.00
Cum. L. - 3,650.00
A. total - 128.55
CWSEL:  7.39
```

EXAMPLE FIVE

This example demonstrates the execution of a rerun with non-constant flows.

As per Example Four, choose the method for computing $\bar{S}_f$. If in doubt which method was previously chosen and how the calculator was set:

f FS? 08. If YES, then the average conveyance equation was used. If NO, then the average friction slope was used.

		Keys	
XEQ Alpha RERUN Alpha			R/S
CHANGE Q?	Yes	1	R/S
CONST. Q?	No	0	R/S

Now cross-section 1.00 is read from tape. A tone will be heard.

NEW Q?	102.0	R/S
WS START?	5.00	R/S

Cross-section 1.00 is computed and File 2.00 is read from tape. A tone will be heard.

NEW Q?	105.0	R/S

and etc., for subsequent cross-sections. The output for this rerun is shown below.

```
SECTION NO: -  1.00
Q. cfs - 102.00
Cc. - 0.10    Ce. - 0.30
WS. INPUT:  5.00
WS. START:  5.00
A. total - 75.00

SECTION NO: -  2.00
Q. cfs - 105.00
Cc. - 0.10    Ce. - 0.30
L. mn. chl - 50.00
Cum. L. - 50.00
A. total - 75.20
CWSEL:  5.01

SECTION NO: -  3.00
Q. cfs - 107.00
Cc. - 0.10    Ce. - 0.30
L. mn. chl - 100.00
Cum. L. - 150.00
A. total - 75.79
CWSEL:  5.04

SECTION NO: -  4.00
Q. cfs - 130.00
Cc. - 0.10    Ce. - 0.30
L. mn. chl - 500.00
Cum. L. - 650.00
A. total - 79.31
CWSEL:  5.21

SECTION NO: -  5.00
Q. cfs - 135.00
Cc. - 0.10    Ce. - 0.30
L. mn. chl - 1,000.00
Cum. L. - 1,650.00
A. total - 87.20
CWSEL:  5.59

SECTION NO: -  6.00
Q. cfs - 139.00
Cc. - 0.10    Ce. - 0.30
L. mn. chl - 2,000.00
Cum. L. - 3,650.00
A. total - 100.07
CWSEL:  6.10
```

REGISTERS USED IN THE PROGRAM

00	-	Used for the cross-section points of the current computation.
01	-	
02	-	
03	-	
04	-	WS_1 for the first cross-section, (ie: WS START) and WS_2 for trials.
05	-	K^3/A_2 for subdivisions lob, mn. chl and rob.
		also for $\bar{Q}_{lob} L_{lob} + \bar{Q}_{mn.\,chl} L_{mn.\,chl} + \bar{Q}_{rob} L_{rob}$.
06	-	Area and $\bar{S}_f$.
07	-	The current Manning's "n" value.
08	-	Location of register.
09	-	Intermediate Values
10	-	Total area, $\bar{Q}_{lob}$ and $\bar{Q}_{lob} + \bar{Q}_{mn.\,chl} + \bar{Q}_{rob}$.
11	-	Total conveyance and $\bar{Q}_{mn.\,chl}$.
12	-	Wetted perimeter (WP) and $\bar{Q}_{rob}$.
13	-	Top width.
14	-	Loop control.
15	-	Loop control.
16 to 64	-	Even numbered registers Elevation ("Y") values.
17 to 65	-	Odd number registers Station ("X") values and "n" as fractional.
66	-	Section number.

67 - L_{lob}.

68 - L_{rob}.

69 - $L_{mn. chl}$.

70 - Q_1.

71 - Q_2.

72 - Shock Loss Coefficient "C". (The C_c value multiplied by ten is the integer and C_e value is the fraction).

73 - Number of cross-sections.

74 - K_{T1}.

75 - A_{T1}.

76 - α_1.

77 - K_{T2}.

78 - A_{T2}.

79 - α_2.

80 - $A_{1\ lob}$.

81 - $A_{1\ rob}$.

82 - $A_{1\ mn. chl}$.

83 - $A_{2\ lob}$.

84 - $A_{2\ rob}$.

85 - $A_{2\ mn. chl}$.

86 - The discharge-weighted reach length "L" and the "balance" error for equations (1) and (2).

87 - WS_1.

88 - The cumulative length.

89 - Velocity Head: $\alpha_1 v_1^2 / 2g$.

90 - Velocity Head: $\alpha_2 v_2^2 / 2g$.

91 - $C \mid \alpha_2 v_2^2 / 2g - \alpha_2 v_2^2 / 2g \mid$

92 - New rerun flow.

FLAGS

Flags set and/or cleared at various times:

00	-	If the left side of a subdivision is submerged.
01	-	If the right side of a subdivision is submerged.
02	-	Upstream cross-section.
03	-	Downstream and upstream cross-sections.
04	-	Cross-sections are identical.
05	-	Overbank flow or if cleared, single channel flow.
06	-	Flows will change.
07	-	Transition "Shock" loss coefficient change.
08	-	Average Conveyance or if cleared, the average Friction Slope equation.
09	-	Set if the cross-sections are identical but the invert elevation change. Also set if the water surface elevation is below critical.
10	-	Rerun with new flow.
11	-	Downstream cross-section.
13	-	Prints lowercase letters or if cleared, prints upper case letters.

LISTING

PROGRAM "SECTION" LISTING

```
01♦LBL "SECTION"
```

← Program "SECTION" for either the Imperial or Metric system data input.

```
02 ADV
03 CLX
04 CF 04
05 CF 05
06 CF 06
07 CF 07
08 CF 09
09 CLRG
10 1
11 STO 66
```

← Section number.

```
12♦LBL 00
13 FIX 4
14 SF 11
15 1
16 RCL 66
```

← Section number.

```
17 X≤Y?
18 GTO 02
19 "NO. OF SECTIONS"
20 "⊢?"
21 PROMPT
```

← Number of cross-sections along the entire length of the channel.

```
22 1
23 +
24 STO 73
25 "IDENTICAL SECTI"
26 "⊢ONS?"
27 PROMPT
```

← Are all cross-sections identical. Yes or no.

```
28 1.0000
29 X=Y?
30 SF 04
31 FC? 04
32 GTO 01
33 "HAS CHANNEL A S"
34 "⊢LOPE?"
35 PROMPT
```

← FLAG 4 is set if all cross-sections are identical in shape. (ie: having a uniform base width and side slopes. The invert elevations may or may not differ).

```
36 1.0000
37 X=Y?
38 SF 09
39♦LBL 01
```

← FLAG 9 is set if the cross-sections are identical in shape but the invert elevations are different.

```
40 "OVERBANK FLOW?"
41 PROMPT
```

Is the overbank option wanted? Yes or no.

```
42 1.0000
43 X=Y?
44 SF 05
```

← FLAG 5 is set if overbank flow exists.

```
45 1.3
46 STO 72
```

← This is the standard transition "shock" loss coefficient. Cc is the integer & Ce the fraction.

```
47 "CHANNEL FLOW?"
48 PROMPT
```

← What is the flow?

```
49 STO 70
50 STO 71
```

← $Q_1 = Q_2$ for the first cross-section in registers 70 and 71.

```
51 GTO 10
52♦LBL 02
53 RCL 66
54 RCL 73
55 X=Y?
56 GTO 19
57 FC? 04
58 XEQ 15
59 "CHANGE IN FLOW?"
60 PROMPT
```

← Is there a change in flow? Yes or no.

```
61 1.0000
62 X=Y?
63 SF 06
64 FS?C 06
65 XEQ 03
```

← FLAG 6 is set if the flows change. This flag is tested, then cleared.

```
66 "LOSS COEFF. CHG"
67 "⊢E?"
68 PROMPT
```

← Do you want to change the transition "Shock" loss coefficient? Yes or No.

```
69 1.0000
70 X=Y?
71 SF 07
72 FS?C 07
73 GTO 04
74 GTO 07
```

← FLAG 7 is set when a change to the transition loss coefficients is wanted. The flag is tested, then cleared.

```
75♦LBL 03
76 "NEW CHANNEL FLO"
77 "⊢W?"
```

← If yes, what is the new channel flow?

PROGRAM "SECTION" LISTING

```
 78 PROMPT
 79 STO 71
```

← Q_2 for the upstream cross-section.

```
 80 RTN
 81♦LBL 04
 82 "CONTRACTION VAL"
 83 "├UE CHANGE?"
```

← Prompt for if a new contraction value is wanted. Yes or no.

```
 84 PROMPT
 85 1.0000
 86 X=Y?
 87 GTO 05
 88 GTO 06
 89♦LBL 05
 90 RCL 72
 91 FRC
 92 STO 72
 93 "NEW CONTRACTION"
 94 "├ VALUE? 0 TO 1"
```

← If yes, what is that new contraction value? Input number from zero to one.

```
 95 PROMPT
 96 10
 97 *
 98 ST÷ 72
 99 "EXPANSION VALUE"
100 "├ CHANGE?"
```

← Prompt for if a new expansion value is wanted. Yes or no.

```
101 PROMPT
102 1.0000
103 X=Y?
104 GTO 06
105 GTO 07
106♦LBL 06
107 RCL 72
108 INT
109 STO 72
110 "NEW EXPANSION V"
111 "├VALUE? 0 TO 1"
```

← If yes, what is that new expansion value? Input number from zero to one.

```
112 PROMPT
113 ST÷ 72
114♦LBL 07
115 FS? 05
```

← FLAG 5 is tested and cleared.

```
116 GTO 08
117 "DIST. M. CHL?"
```

← What is the length of reach for the main channel? <u>No overbank flow</u>.

```
118 PROMPT
119 STO 69
120 GTO 09
121♦LBL 08
122 "DIST. L OB?"
```

← What is the length of reach for the left overbank subdivision?

```
123 PROMPT
124 STO 67
125 "DIST. R OB?"
```

← What is the length of reach for the right overbank subdivision?

```
126 PROMPT
127 STO 68
128 "DIST. M. CHL?"
```

← What is the length of reach for the main channel subdivision?

```
129 PROMPT
130 STO 69
131♦LBL 09
132 FS? 09
133 XEQ 16
134 FS? 04
135 GTO 14
136♦LBL 10
137 "NO. OF POINTS?"
```

← How many data points (Y and X coordinates) are there in this cross-section? Each data point consists of a Y (Elevation) and a X (Station). Up to 25 points to describe a cross-section can be entered. This label also sets up the control loop for storage of these values.

```
138 PROMPT
139 2
140 *
141 12
142 +
143 1000
144 /
145 16.00002
146 +
147 STO 14
148 .002
149 +
150 STO 15
```

PROGRAM "SECTION" LISTING

```
151♦LBL 11
152 RCL 15
153 INT
154 STO 00
155♦LBL 12
156 "ELEV?"
157 PROMPT
158 STO IND 00
159 "STA?"
160 PROMPT
161 X≤0?
162 GTO 13
163 "N?"
164 PROMPT
165 CHS
166 ÷
167♦LBL 13
168 RCL 00
169 1
170 ÷
171 X<>Y
172 STO IND Y
173 ISG 15
174 GTO 11
175♦LBL 14
176 FIX 2
177 CLA
178 ARCL 66
179 60
180 CREATE
181 0
182 SEEKR
183 14.073
184 WRTRX
185 VERIFY
186 RCL 71
187 STO 70
188 "SECTION"
189 "├ "
190 ARCL 66
```

← What is the Elevation (Y value)? (steps 156–157)

← What is the station (X value) that corresponds to the elevation? This value is input as an integer. It can be entered as a zero, positive or negative number. Upon entering a zero or negative integer, this will cause a prompt for the input of a Manning's "n" number. The Y values and X values (either positive or negative integers) are stored in even and odd registers (from 16 up to 65 inclusive) respectively. Manning's "n" values are stored as a fractional of the X value. (steps 159–160)

←This label contains the routine for creating a file for the cross-section on the cassette drive tape. (step 175)

←The data stored on tape for the cross-section is now verified. When this has been completed, the user will be notified if all input data has been correctly stored. (step 185)

```
191 "├ OK."
192 PRA
193 GTO 18
194♦LBL A
195 DSE 15
196 GTO 11
197 GTO 11
198♦LBL 15
199 RCL 73
200 100000
201 /
202 ST÷ 66
203 RCL 66
204 RCL 70
205 RCL 71
206 RCL 72
207 CLRG
208 STO 72
209 RDN
210 STO 71
211 RDN
212 STO 70
213 RDN
214 STO 66
215 RCL 66
216 FRC
217 100000
218 *
219 STO 73
220 RCL 66
221 INT
222 STO 66
223 RTN
224♦LBL 16
225 "ADD FACTOR?"
226 PROMPT
227 STO 01
228 RCL 14
229 STO 15
230 16
231 STO 02
232 RCL 01
```

← This label is the user's "FAILSAFE". (step 194)

← This label temporarily moves pertinent data into the stack. All storage registers are then cleared. Following this, the stack is moved back into the appropriate storage registers. This readies the program to receive data for the next cross-section. (step 198)

← This asks if a factor can be added to all Elevation (Y values) for the current cross-section with respect to the previous. If the cross-section is identical to the previous one, (not necessarily slope), this feature can save the user valuable input time. (step 224)

PROGRAM "SECTION" LISTING

```
233 ST+ IND
02
234♦LBL 17
235 2
236 ST+ 02
237 RCL 01
238 ST+ IND
02
239 ISG 15
240 GTO 17
241 RTN
242♦LBL 18
243 1
244 ST+ 66
245 GTO 00
246♦LBL 19
247 "ALL SEC
TIONS IN"
248 ACA
249 "PUT"
250 ACA
251 PRBUF
252 CF 04
253 CF 05
254 CF 09
255 STOP
256 .END.
```

NOTE: This feature should not be used if an addition to all ground elevations may actually misrepresent the actual condition. This program automatically prevents overtopping of a channel by the addition of a vertical "WALL". Any adjustment to the ground elevation could prevent this feature from occurring. Therefore, the user should always check the output versus the input.

← This label reports and prints a notification to the user that all cross-section data for the entire channel length have now been input. Before stopping, the program readies the calculator for the user to call-up the output program. (This is either "WASPIMP" the Imperial version or "WASPMET" - the Metric version).

PROGRAM "WASPIMP" LISTING

```
01♦LBL "WASPIMP"
02 ADV
03 FMT
04 "W. S. PROFILES"
05 ACA
06 PRBUF
07 ADV
08 "TITLE: "
09 ACA
```

← Imperial version for the output of the computed water surface profile.

```
10 "TITLE?"
11 PROMPT
12 ACA
13 PRBUF
14 ADV
15 FIX 2
16 CLRG
17 CF 02
18 CF 04
19 CF 05
20 CF 08
21 CF 10
```

← What is the title for this job? The title will be printed.

```
22 "OVERBANK Q?"
23 PROMPT
24 1.00
25 X=Y?
26 SF 05
```

← Does this run have overbank flows? If yes, FLAG 5 is set.

```
27 "AV. CONVNCE EQN?"
28 PROMPT
29 1.00
30 X=Y?
31 SF 08
32 GTO 55
```

← Do you want to use the "Default" average conveyance equation? If yes, FLAG 8 is set.

```
33♦LBL 00
34 CLA
35 ARCL 66
36 0
37 SEEKR
38 14.073
39 READRX
```

← Routine to read the files set up by the input program "SECTION" stored on tape in the cassette drive. Register 66 is the station number.

```
40♦LBL 01
41 "SECTION NO: - "
42 ACA
43 RCL 66
44 ACX
45 PRBUF
46 FS? 10
47 XEQ 41
48 XEQ 40
49 XEQ 23
50 FC? 02
51 GTO 03
52 FC? 05
53 GTO 02
```

← This and the following label is used for printing the section number (excluding the first), the subdivision reach lengths for the left and right overbanks (if any) and/or the length of the main channel reach. Following this, the computed discharge-weighted reach length "L" will be printed. FLAG 10 is set if a RERUN is executed with new flow. Subroutine 23 prints the "C" values selected.

```
54 "L. "
55 ACA
56 SF 13
57 "LOB -"
58 ACA
59 CF 13
60 RCL 67
```

← $L_{lob.}$

```
61 ACX
62 PRBUF
63 "L. "
64 ACA
65 SF 13
66 "ROB -"
67 ACA
68 CF 13
69 RCL 68
```

← $L_{rob.}$

```
70 ACX
71 PRBUF
72♦LBL 02
73 "L. "
74 ACA
75 SF 13
76 "MN. CHL -"
77 ACA
78 CF 13
79 RCL 69
```

← $L_{Mn. Chl.}$

PROGRAM “WASPIMP” LISTING

```
80 ACX
81 PRBUF
82 RCL 69
83 ST+ 88
84 "C"
85 ACA
86 SF 13
87 "UM. "
88 ACA
89 CF 13
90 "L. -"
91 ACA
92 RCL 88
93 ACX
94 PRBUF
95 GTO 04
96♦LBL 03
96 "WS STAR
T?"
98 PROMPT
99 STO 04
100 "WS. INP
UT:"
101 "├ "
102 ARCL 04
103 PRA
104♦LBL 04
105 SF 03
106 XEQ 25
107 XEQ 06
108 XEQ 05
109 FS? 02
110 GTO 16
111 RCL 11
112 STO 74
113 3
114 Y↑X
115 RCL 10
116 STO 75
117 X↑2
118 /
119 1/X
120 RCL 05
```

← Cumulative Length. (step 83)

← What is the Starting Water Level? After input, that input number will be stored in reg. 4 and unless it is below critical, it is printed. (step 96)

← K_1 (d/s) total. (step 112)

← A_1 (d/s) total. (step 116)

```
121 *
122 STO 76
123 RCL 70
124 XEQ 34
125 RCL 76
126 XEQ 35
127 RCL 75
128 X<Y?
129 GTO 31
130 FS?C 09
131 XEQ 33
132 "WS. STA
RT:"
133 "├ "
134 ARCL 04
135 PRA
136 FS? 05
137 XEQ 48
138 XEQ 28
139 FS? 05
140 XEQ 52
141 SF 02
142 GTO 53
143♦LBL 05
144 RCL 06
145 FS? 03
146 STO 83
147 FC? 03
148 STO 84
149 CF 03
150 X=0?
151 RTN
152 RCL 12
153 RCL 06
154 X<>Y
155 /
156 ENTER↑
157 .666667
158 Y↑X
159 RCL 06
160 *
161 1.486
162 *
```

← α_1 (d/s). (step 122)

← A test is made to find if the water surface elevation that been input is on the “RIGHT SIDE” of critical by the formala:

$$A = [\, Q^2 \alpha T/g \,]^{1/3}$$

T_1 (d/s) in reg. 13
Q_1 (d/s) in reg. 70
A_1 (d/s) in reg. 75
α_1 (d/s) in reg. 76

← The input starting water surface elevation is printed, or if the test for critical failed, then a water surface elevation equal to or greater than critical is used for the starting water surface elevation and that number is printed. Subroutine 48 computes the areas. Subroutine 28 prints the data, ie:

$A_{1\,lob}$ (d/s) in reg. 83
$A_{1\,rob}$ (d/s) in reg. 84
$A_{1\,mn\,chl}$ (d/s) in reg. 85
$A_{1\,total}$ (d/s) in reg. 75

Subroutine 52 sets up the registers ready for the reading of the upstream cross- section. FLAG 2 is set and Label 53 initiates the next trial.

←This is the computation for Manning’s Equation. (step 157)

PROGRAM "WASPIMP" LISTING

```
163 RCL 07
164 /
165 ST+ 11
166 3
167 Y↑X
168 RCL 06
169 X↑2
170 /
171 ST+ 05
172 RCL 06
173 ST+ 10
174 0
175 STO 12
176 STO 06
177 RTN
178♦LBL 06
179 CF 00
180 CF 01
181 RCL 15
182 INT
183 STO 08
184 1
185 +
186 RCL IND
X
187 X≥0?
188 GTO 07
189 RDN
190 17
191 X≠Y?
192 XEQ 05
193 RCL 08
194 1
195 +
196 RCL IND
X
197 CHS
198 FRC
199 STO 07
200♦LBL 07
201 RCL IND
08
202 RCL 04
```

← Labels 6 through 14 do the examination of each subdivision of the channel. They determine if the subdivisions are partially or wholly submerged. If the left side is submerged, then FLAG 0 is set. If the right side is submerged, then FLAG 1 is set. If the subdivisions are partially submerged, then the intersection of the water surface with the ground level is computed.

← X is not equal to Y
XEQ Alpha X f SIN Y? Alpha

Area, wetted perimeter and etc., for each subdivision of the cross-section can then be calculated.

← The absolute "n" value of a subdivision is placed in register 7.

```
203 X<>Y
204 X<=Y?
205 GTO 08
206 GTO 09
207♦LBL 08
208 SF 00
209♦LBL 09
210 CF 01
211 RCL 08
212 2
213 +
214 RCL IND
X
215 RCL 04
216 X<>Y
217 X<=Y?
218 SF 01
219 FS? 00
220 GTO 10
221 FS? 01
222 GTO 14
223 ISG 15
224 GTO 06
225 RTN
226♦LBL 10
227 RCL IND
08
228 STO 00
229 RCL 08
230 1
231 +
232 RCL IND
X
233 INT
234 ABS
235 STO 01
236 FS? 01
237 GTO 13
238♦LBL 11
239 RCL 08
240 2
241 +
242 RCL IND
```

PROGRAM "WASPIMP" LISTING

```
X
243 RCL IND
08
244 -
245 X=0?
246 GTO 12
247 1/X
248 STO 09
249 RCL 08
250 3
251 ÷
252 RCL IND
X
253 INT
254 ABS
255 RCL 08
256 1
257 ÷
258 RCL IND
X
259 INT
260 ABS
261 X<>Y
262 RDN
263 -
264 ST* 09
265 RCL 04
266 FS? 00
267 STO 02
268 FS? 01
269 STO 00
270 RCL IND
08
271 -
272 ST* 09
273 RCL 08
274 1
275 ÷
276 RCL IND
X
277 INT
278 ABS
279 ST÷ 09
280 RCL 09
281 FS? 00
282 STO 03
283 FS? 01
284 STO 01
285 XEQ 15
286♦LBL 12
287 ISG 15
288 GTO 06
289 RTN
290♦LBL 13
291 RCL 08
292 2
293 ÷
294 RCL IND
X
295 STO 02
296 RCL 08
297 3
298 ÷
299 RCL IND
X
300 INT
301 ABS
302 STO 03
303 XEQ 15
304 ISG 15
305 GTO 06
306 RTN
307♦LBL 14
308 RCL 08
309 2
310 ÷
311 RCL IND
X
312 STO 02
313 RCL 08
314 3
315 ÷
316 RCL IND
X
317 INT
318 ABS
```

PROGRAM "WASPIMP" LISTING

Step	Comment
319 STO 03	
320 GTO 11	
321♦LBL 15	← This label begins the computation for the areas, wetted perimeters, hydraulic radii, top widths, and etc.
322 RCL 04	
323 RCL 00	
324 -	
325 RCL 04	
326 RCL 02	
327 -	
328 +	
329 2	
330 /	
331 X=0?	
332 RTN	
333 RCL 03	
334 RCL 01	
335 -	
336 *	
337 ST+ 06	
338 RCL 02	
339 RCL 00	
340 -	
341 X↑2	
342 RCL 03	
343 RCL 01	
344 -	
345 ST+ 13	
346 X↑2	
347 +	
348 SQRT	
349 ST+ 12	
350 RTN	
351♦LBL 16	← This label is for the upstream cross-sections.
352 SF 03	
353 RCL 11	
354 STO 77	← Total $K_{2\ total}$ (u/s).
355 3	
356 Y↑X	
357 RCL 10	
358 STO 78	← Total $A_{2\ total}$ (u/s).
359 X↑2	
360 /	
361 1/X	
362 RCL 05	
363 *	
364 STO 79	← $\alpha_{2\ total}$ (u/s).
365 FS? 09	
366 GTO 21	
367 RCL 70	← Q_1 (d/s).
368 RCL 71	← Q_2 (u/s).
369 +	
370 STO 11	← $Q_1 + Q_2$.
371 FC? 08	← If FLAG 8 is clear, go to subroutine 24.
372 GTO 24	
373 RCL 74	← K_1 (d/s) total.
374 RCL 77	← K_2 (u/s) total.
375 +	← $K_1 + K_2$
376 1/X	
377 RCL 11	$\bar{S}_f$ is computed by equation [4], (or [5] if subroutine 24 is used) and is stored in reg. 6
378 *	
379 X↑2	
380 STO 06	
381♦LBL 17	
382 RCL 70	← Q_1 (d/s).
383 RCL 75	← $A_{1\ total}$ (d/s).
384 XEQ 54	
385 RCL 76	← α_1 (d/s).
386 *	
387 STO 89	← α_1 (d/s) v_1^2 (d/s) / 2g
388 RCL 71	← Q_2 (u/s).
389 RCL 78	← $A_{2\ total}$ (u/s).
390 XEQ 54	
391 RCL 79	← α_2 (u/s).
392 *	
393 STO 90	← α_2 (u/s) v_2^2 (u/s) / 2g
394 RCL 89	
395 -	
396 ABS	
397 STO 91	← $\lvert \alpha_2 v_2^2/2g - \alpha_1 v_1^2/2g \rvert$
398 XEQ 18	← This subroutine obtains the proper "C" value.
399 ST* 91	
400 RCL 69	
401 STO 86	← L
402 FS? 05	← If FLAG 5 is set, the discharge-weighted length is computed.
403 XEQ 20	
404 RCL 86	

PROGRAM "WASPIMP" LISTING

Step	Comment
405 RCL 06	
406 *	← $L\bar{S}_f$
407 RCL 91	
408 ÷	← Equation [2] and
409 RCL 89	Equation [1] is ready to be
410 ÷	solved.
411 RCL 87	← WS_1
412 ÷	
413 STO 86	
414 RCL 04	← WS_2
415 RCL 90	← $\alpha_2 v_2^2 / 2g$
416 ÷	
417 RCL 86	
418 -	
419 STO 86	← The balance "Error"
420 ABS	for equations [1] and [2].
421 GTO 26	
422♦LBL 18	← This subroutine
423 RCL 90	computes the proper "C"
424 RCL 89	value. If $(\alpha_2\ v_2^2 / 2g)$ >
425 X>Y?	$(\alpha_1\ v_2^2 / 2g)$, then C_e is
426 GTO 19	used. If not, C_c is used.
427 RCL 72	
428 FRC	
429 RTN	
430♦LBL 19	
431 RCL 72	
432 INT	
433 10	
434 /	
435 RTN	
436♦LBL 20	← This subroutine solves
437 XEQ 48	equation [3] for "L".
438 RCL 80	← $A_{1\ lob}$.
439 XEQ 45	
440 STO 10	← $Q_{1\ lob}$.
441 RCL 82	← $A_{1\ mn\ chl}$.
442 XEQ 45	
443 STO 11	← $Q_{1\ mn\ chl}$.
444 RCL 81	← $A_{1\ rob}$.
445 XEQ 45	
446 STO 12	← $Q_{1\ rob}$.
447 RCL 83	← $A_{2\ lob}$.

Step	Comment
448 XEQ 46	
449 RCL 10	
450 XEQ 47	
451 STO 10	← $\bar{Q}_{lob}$.
452 RCL 67	← L_{lob}.
453 *	
454 STO 05	← $\bar{Q}_{lob} L_{lob}$.
455 RCL 85	← $A_{2\ mn\ chl}$.
456 XEQ 46	
457 RCL 11	
458 XEQ 47	
459 ST+ 10	← $\bar{Q}_{lob} + \bar{Q}_{mn\ chl}$.
460 RCL 69	← $L_{mn\ chl}$.
461 *	
462 ST+ 05	← $\bar{Q}_{lob} L_{lob} + \bar{Q}_{main} L_{lob}$.
463 RCL 84	← $A_{2\ rob}$.
464 XEQ 46	
465 RCL 12	
466 XEQ 47	
467 ST+ 10	← $\bar{Q}_{lob} + \bar{Q}_{main} + \bar{Q}_{rob}$.
468 RCL 68	← $L_{2\ rob}$.
469 *	
470 ST+ 05	← $\bar{Q}_L L_L + \bar{Q}_M L_M + \bar{Q}_R L_R$.
471 RCL 10	
472 1/X	
473 RCL 05	
474 *	
475 STO 86	← $\dfrac{\bar{Q}_L L_L + \bar{Q}_M L_M + \bar{Q}_R L_R}{\bar{Q}L + \bar{Q}M + \bar{Q}R} = L$
476 RTN	
477♦LBL 21	← This and the next
478 RCL 71	subroutine is used to check
479 XEQ 34	if the computed WS_2 is on
480 RCL 79	the "RIGHT SIDE" of
481 XEQ 35	critical.
482 RCL 78	T_2 (u/s) in reg. 13
483 X<Y?	Q_2 (u/s) in reg. 71
484 GTO 36	A_2 (u/s) in reg. 78
485♦LBL 22	α_2 (u/s) in reg. 79
486 FS?C 09	If the balanced WS_2 is "OK", this subroutine is
487 XEQ 33	used to set up the registers
488 RCL 71	for the next cross-section.
489 STO 70	← Q_2 becomes Q_1.
490 RCL 77	

PROGRAM "WASPIMP" LISTING

```
491 STO 74
```
← $K_{2\,Total}$ becomes $K_{1\,Total}$.

```
492 RCL 78
493 STO 75
```
← $A_{2\,Total}$ becomes $A_{1\,Total}$.

```
494 RCL 79
495 STO 76
```
← $\alpha_{2\,total}$ becomes $\alpha_{1\,total}$

```
496 XEQ 28
```
← Subroutine to print the areas.

```
497 FS? 05
498 XEQ 52
```
← See subroutine 52.

```
499 "CWSEL:"
```
← Prints the CWSEL.

```
500 "├ "
501 ARCL 04
502 PRA
503 GTO 53
504♦LBL 23
```
← This subroutine prints the transition "SHOCK" losses that were selected. That is: "Cc." and "Ce." respectively.

```
505 "Cc. -"
506 ACA
507 RCL 72
508 INT
509 10
510 /
511 ACX
512 FMT
513 "Ce. -"
514 ACA
515 RCL 72
516 FRC
517 ACX
518 PRBUF
519 RTN
520♦LBL 24
```
← $\bar{S}_f$ in this subroutine is computed by the average friction slope equation.

```
521 RCL 70
522 RCL 74
523 /
524 X↑2
525 STO 06
526 RCL 71
527 RCL 77
528 /
529 X↑2
530 RCL 06
531 XEQ 47
532 STO 06
533 GTO 17
534♦LBL 25
```
← This subroutine sets up the registers for the next loop.

```
535 RCL 14
536 STO 15
537 0
538 STO 10
539 STO 11
540 STO 12
541 STO 13
542 STO 06
543 STO 05
544 RTN
545♦LBL 26
```
← This computes the balance error. If the absolute error is less than .01 (ie: +/- .005) it's okay.

```
546 .005
547 X≤Y?
548 GTO 21
549♦LBL 27
```
← The balance error is multiplied by 0.92 and readied for the next trial.

```
550 RCL 06
551 .92
552 *
553 GTO 39
554♦LBL 28
```
← Subroutines 28 to 30 inclusive are used for the printout of areas.

```
555 FC? 05
556 GTO 29
557 "A. "
558 ACA
559 SF 13
560 "LOB -"
561 ACA
562 CF 13
563 RCL 03
```
← A_{lob}

```
564 ACX
565 PRBUF
566 "A. "
567 ACA
568 SF 13
569 "ROB -"
570 ACA
571 CF 13
572 RCL 04
```
← A_{rob}

```
573 ACX
574 PRBUF
575 "A. "
576 ACA
```

PROGRAM "WASPIMP" LISTING

```
577 SF 13
578 "MN. CHL
 -"
579 ACA
580 CF 13
581 RCL 85
```

← $A_{Mn. Chl.}$

```
582 ACX
583 PRBUF
584♦LBL 29
585 "A. "
586 ACA
587 SF 13
588 "TOTAL -
"
589 ACA
590 CF 13
591 FS? 02
592 GTO 30
593 RCL 75
```

← $A_{1\ Total}$ for the first cross-section.

```
594 ACX
595 PRBUF
596 RTN
597♦LBL 30
598 RCL 78
```

← $A_{2\ Total}$ for all other cross-sections.

```
599 ACX
600 PRBUF
601 RTN
602♦LBL 31
```

← This subroutine is used if the input WS_1 is actually on the "WRONG SIDE" of critical. Labels 31 and 32 are used to find which side of a half foot mark that the input number is. A new number is then generated to the next highest and nearest one half foot interval to use for the next test trial.

```
603 RCL 04
604 FRC
605 .5
606 X<=Y?
607 GTO 32
608 XEQ 37
609 .5
610 GTO 38
611♦LBL 32
612 XEQ 37
613 1
614 GTO 38
615♦LBL 33
```

← This subroutine prints the warning for the critical depth assumption.

```
616 ADV
617 FMT
618 "--WARNI
NG--"
619 ACA
620 PRBUF
621 FMT
622 "CRITICA
L DEPTH "
623 ACA
624 "ASSUMED
"
625 ACA
626 PRBUF
627 ADV
628 RTN
629♦LBL 34
```

← This and the next subroutine is part of the upstream critical depth computation. Value "T" is stored in register 13.

```
630 X↑2
631 RCL 13
632 *
633 RTN
634♦LBL 35
635 *
636 32.174
```

← g.

```
637 /
638 3
639 1/X
640 Y↑X
641 RTN
642♦LBL 36
```

← The upstream cross-sections are retried at a .01 foot increase.

```
643 .01
644 GTO 38
645♦LBL 37
```

← This subroutine obtains the integer value of WS_1.

```
646 RCL 04
647 INT
648 STO 04
649 RTN
650♦LBL 38
651 ST+ 04
652 SF 09
```

← FLAG 9 is set if on the "WRONG SIDE" of critical.

```
653 GTO 04
654♦LBL 39
```

← This subroutine sets up a new trial for WS_2.

```
655 ST- 04
656 GTO 04
657♦LBL 40
```

PROGRAM "WASPIMP" LISTING

```
658 "Q.  "          ← This subroutine prints out the flow values.
659 ACA
660 SF 13
661 "CFS -"
662 ACA
663 CF 13
664 RCL 71          ← Q2 (Note for the first cross-section, Q1 and Q2
665 ACX               are stored in registers 70 and 71).
666 PRBUF
667 RTN
668♦LBL 41          ← This subroutine is part of the "RERUN" label.
669 RCL 92
670 STO 70
671 FS? 04
672 GTO 42          ← The user is alerted to manually input new flows
673 BEEP              when the flow is not constant over the entire
674 "NEW Q?"          length of the channel.
675 PROMPT
676 STO 92
677♦LBL 42
678 STO 71          ← Q2.
679 FS? 04
680 RTN
681 1
682 RCL 66          ← Section Number.
683 X≠Y?            ← X is not equal to Y
                      XEQ Alpha X f SIN Y? Alpha
684 RTN
685 RCL 92
686 STO 70          ← For the first cross-section Q2 becomes Q1.
687 RTN
688♦LBL "RER        ← This is the RERUN label.
UN"
689 ADV
690 CLRG
691 CF 02
692 CF 04
693 CF 10
694 "CHANGE
Q?"
695 PROMPT
696 1.00
697 X=Y?
698 XEQ 43
699 GTO 55
700♦LBL 43
701 SF 10           ← FLAG 10 is set if new flows are to be input.
702 "CONST.
Q?"
703 PROMPT
704 1.00
705 X=Y?
706 XEQ 44
707 RTN
708♦LBL 44
709 SF 04           ← FLAG 4 is set if the new flows are constant
710 "NEW Q?"          over the entire length of the channel.
711 PROMPT
712 STO 92
713 RTN
714♦LBL 45          ← This, and the next subroutine computes the
715 RCL 75            value of "L".
716 /               ← A1 Total and Q1 are stored in registers 75 and 70
717 RCL 70            respectively.
718 *
719 RTN
720♦LBL 46
721 RCL 78          ← A2 Total.
722 /
723 RCL 71          ← Q2.
724 *
725 RTN
726♦LBL 47          ← This subroutine computes the "MEANS".
727 +
728 2
729 /
730 RTN
731♦LBL 48          ← Subroutines 48 to 51 do part of the calculation for
732 RCL 83            the channel areas. A lob and A rob are stored in
733 RCL 84            registers 83 and 84 respectively
734 ÷
735 CHS
736 FS? 02
737 GTO 50
738♦LBL 49
739 RCL 75          ← A1 total.
740 GTO 51
```

PROGRAM "WASPIMP" LISTING

Listing	Comment
741♦LBL 50	
742 RCL 78	← A_2 total.
743♦LBL 51	
744 +	
745 STO 85	← A_{main} (1 or 2).
746 RTN	
747♦LBL 52	← Subroutine to set up the areas for another run.
748 RCL 83	
749 STO 80	← $A_{2\,lob}$ becomes $A_{1\,lob}$.
750 RCL 84	
751 STO 81	← $A_{2\,rob}$ becomes $A_{1\,rob}$.
752 RCL 85	
753 STO 82	← $A_{2\,main}$ becomes $A_{1\,main}$.
754 RTN	
755♦LBL 53	← Subroutine to set the WS elevation for next run.
756 RCL 04	
757 STO 87	← WS_2 becomes WS_1.
758 .01	
759 ST+ 04	← "OUR FIRST GUESS" at WS_2.
760 1	
761 ST+ 66	
762 RCL 66	← Section Number.
763 RCL 73	← Checks to see whether or not, all cross sections have been computed.
764 X=Y?	
765 GTO 56	
766 ADV	
767 GTO 00	
768♦LBL 54	← This subroutine is used to compute $V^2/2g$.
769 /	
770 X↑2	
771 64.348	← 2g.
772 /	
773 RTN	
774♦LBL 55	← This subroutine assigns the section number 1.00.
775 1	
776 STO 66	
777 GTO 00	
778♦LBL 56	← This subroutine alerts the user when the entire channel has been completely computed.
779 BEEP	
780 BEEP	
781 STOP	
782 .END	

PROGRAM "WASPMET" LISTING

← Metric version for the output of the computed water surface profile. This program is similar to the Imperial version. For clarity, all "GO TO" statements and "SUBROUTINE" labels are identical with respect to the Imperial version.

```
01♦LBL "WASPMET"
02 ADV
03 FMT
04 "W. S. PROFILES"
05 ACA
06 PRBUF
07 FMT
08 SF 13
09 "METRIC VERSION"
10 ACA
11 CF 13
12 PRBUF
13 ADV
14 "TITLE: "
15 ACA
16 "TITLE?"
17 PROMPT
18 ACA
19 PRBUF
20 ADV
21 FIX 2
22 CLRG
23 CF 02
24 CF 04
25 CF 05
26 CF 08
27 CF 10
28 "OVERBANK Q?"
29 PROMPT
30 1.00
31 X=Y?
32 SF 05
33 "AV. CONVNCE EQN?"
34 PROMPT
35 1.00
36 X=Y?
37 SF 08
38 GTO 55
39♦LBL 00
40 CLA
41 ARCL 66
42 0
43 SEEKR
44 14.073
45 READRX
46♦LBL 01
47 "SECTION NO:  - "
48 ACA
49 RCL 66
50 ACX
51 PRBUF
52 FS? 10
53 XEQ 41
54 XEQ 40
55 XEQ 23
56 FC? 02
57 GTO 03
58 FC? 05
59 GTO 02
60 "L. "
61 ACA
62 SF 13
63 "LOB -"
64 ACA
65 CF 13
66 RCL 67
67 ACX
68 PRFUF
69 "L. "
70 ACA
71 SF 13
72 "ROB -"
73 ACA
74 CF 13
75 RCL 68
76 ACX
77 PRBUF
78♦LBL 02
79 "L. "
```

PROGRAM "WASPMET" LISTING

```
 80 ACA
 81 SF 13
 82 "MN. CHL
-"
 83 ACA
 84 CF 13
 85 RCL 69
 86 ACX
 87 PRBUF
 88 RCL 69
 89 ST÷ 88
 90 "C"
 91 ACA
 92 SF 13
 93 "UM. "
 94 ACA
 95 CF 13
 96 "L. -"
 97 ACA
 98 RCL 88
 99 ACX
100 PRBUF
101 GTO 04
102◆LBL 03
103 "WS STAR
T?"
104 PROMPT
105 STO 04
106 "WS. INP
UT:"
107 "├ "
108 ARCL 04
109 PRA
110◆LBL 04
111 SF 03
112 XEQ 25
113 XEQ 06
114 XEQ 05
115 FS? 02
116 GTO 16
117 RCL 11
118 STO 74
119 3
120 Y↑X
121 RCL 10
122 STO 75
123 X↑2
124 /
125 1/X
126 RCL 05
127 *
128 STO 76
129 RCL 70
130 XEQ 34
131 RCL 76
132 XEQ 35
133 RCL 75
134 X<Y?
135 GTO 31
136 FS?C 09
137 XEQ 33
138 "WS. STA
RT:"
139 "├ "
140 ARCL 04
141 PRA
142 FS? 05
143 XEQ 48
144 XEQ 28
145 FS? 05
146 XEQ 52
147 SF 02
148 GTO 53
149◆LBL 05
150 RCL 06
151 FS? 03
152 STO 83
153 FC? 03
154 STO 84
155 CF 03
156 X=0?
157 RTN
158 RCL 12
159 RCL 06
160 X<>Y
161 /
```

PROGRAM "WASPMET" LISTING

```
162 ENTER^
163 .666667      ←This is the computation
164 Y^X           for Manning's Equation.
165 RCL 06
166 *
167 RCL 07
168 /
169 ST+ 11
170 3
171 Y^X
172 RCL 06
173 X^2
174 /
175 ST+ 05
176 RCL 06
177 ST+ 10
178 0
179 STO 12
180 STO 06
181 RTN
182♦LBL 06
183 CF 00
184 CF 01
185 RCL 15
186 INT
187 STO 08
188 1
189 +
190 RCL IND
X
191 X≤0?
192 GTO 07
193 RDN
194 17
195 X≠Y?          ← X is not equal to Y
                  XEQ Alpha X f SIN Y? Alpha
196 XEQ 05
197 RCL 08
198 1
199 +
200 RCL IND
X
201 CHS
202 FRC
203 STO 07
204♦LBL 07
205 RCL IND
08
206 RCL 04
207 X<>Y
208 X<=Y?
209 GTO 08
210 GTO 09
211♦LBL 08
212 SF 00
213♦LBL 09
214 CF 01
215 RCL 08
216 2
217 +
218 RCL IND
X
219 RCL 04
220 X<>Y
221 X<=Y?
222 SF 01
223 FS? 00
224 GTO 10
225 FS? 01
226 GTO 14
227 ISG 15
228 GTO 06
229 RTN
230♦LBL 10
231 RCL IND
08
232 STO 00
233 RCL 08
234 1
235 +
236 RCL IND
X
237 INT
238 ABS
239 STO 01
240 FS? 01
241 GTO 13
```

PROGRAM "WASPMET" LISTING

```
242♦LBL 11
243 RCL 08
244 2
245 ÷
246 RCL IND
X
247 RCL IND
08
248 -
249 X=0?
250 GTO 12
251 1/X
252 STO 09
253 RCL 08
254 3
255 ÷
256 RCL IND
X
257 INT
258 ABS
259 RCL 08
260 1
261 ÷
262 RCL IND
X
263 INT
264 ABS
265 X<>Y
266 RDN
267 -
268 ST* 09
269 RCL 04
270 FS? 00
271 STO 02
272 FS? 01
273 STO 00
274 RCL IND
08
275 -
276 ST* 09
277 RCL 08
278 1
279 ÷
280 RCL IND
X
281 INT
282 ABS
283 ST÷ 09
284 RCL 09
285 FS? 00
286 STO 03
287 FS? 01
288 STO 01
289 XEQ 15
290♦LBL 12
291 ISG 15
292 GTO 06
293 RTN
294♦LBL 13
295 RCL 08
296 2
297 ÷
298 RCL IND
X
299 STO 02
300 RCL 08
301 3
302 ÷
303 RCL IND
X
304 INT
305 ABS
306 STO 03
307 XEQ 15
308 ISG 15
309 GTO 06
310 RTN
311♦LBL 14
312 RCL 08
313 2
314 ÷
315 RCL IND
X
316 STO 02
317 RCL 08
318 3
```

PROGRAM "WASPMET" LISTING

```
319 +
320 RCL IND
X
321 INT
322 ABS
323 STO 03
324 GTO 11
325♦LBL 15
326 RCL 04
327 RCL 00
328 -
329 RCL 04
330 RCL 02
331 -
332 +
333 2
334 /
335 X=0?
336 RTN
337 RCL 03
338 RCL 01
339 -
340 *
341 ST+ 06
342 RCL 02
343 RCL 00
344 -
345 X↑2
346 RCL 03
347 RCL 01
348 -
349 ST+ 13
350 X↑2
351 +
352 SQRT
353 ST+ 12
354 RTN
355♦LBL 16
356 SF 03
357 RCL 11
358 STO 77
359 3
360 Y↑X
361 RCL 10
362 STO 78
363 X↑2
364 /
365 1/X
366 RCL 05
367 *
368 STO 79
369 FS? 09
370 GTO 21
371 RCL 70
372 RCL 71
373 +
374 STO 11
375 FC? 08
376 GTO 24
377 RCL 74
378 RCL 77
379 +
380 1/X
381 RCL 11
382 *
383 X↑2
384 STO 06
385♦LBL 17
386 RCL 70
387 RCL 75
388 XEQ 54
389 RCL 76
390 *
391 STO 89
392 RCL 71
393 RCL 78
394 XEQ 54
395 RCL 79
396 *
397 STO 90
398 RCL 89
399 -
400 ABS
401 STO 91
402 XEQ 18
403 ST* 91
```

PROGRAM "WASPMET" LISTING

```
404 RCL 69
405 STO 86
406 FS? 05
407 XEQ 20
408 RCL 86
409 RCL 06
410 *
411 RCL 91
412 ÷
413 RCL 89
414 ÷
415 RCL 87
416 ÷
417 STO 86
418 RCL 04
419 RCL 90
420 ÷
421 RCL 86
422 -
423 STO 86
424 ABS
425 GTO 26
426♦LBL 18
427 RCL 90
428 RCL 89
429 X≤Y?
430 GTO 19
431 RCL 72
432 FRC
433 RTN
434♦LBL 19
435 RCL 72
436 INT
437 10
438 /
439 RTN
440♦LBL 20
441 XEQ 48
442 RCL 80
443 XEQ 45
444 STO 10
445 RCL 82
446 XEQ 45
447 STO 11
448 RCL 81
449 XEQ 45
450 STO 12
451 RCL 83
452 XEQ 46
453 RCL 10
454 XEQ 47
455 STO 10
456 RCL 67
457 *
458 STO 05
459 RCL 85
460 XEQ 46
461 RCL 11
462 XEQ 47
463 ST÷ 10
464 RCL 69
465 *
466 ST÷ 05
467 RCL 84
468 XEQ 46
469 RCL 12
470 XEQ 47
471 ST÷ 10
472 RCL 68
473 *
474 ST÷ 05
475 RCL 10
476 1/X
477 RCL 05
478 *
479 STO 86
480 RTN
481♦LBL 21
482 RCL 71
483 XEQ 34
484 RCL 79
485 XEQ 35
486 RCL 78
487 X<Y?
488 GTO 36
489♦LBL 22
```

PROGRAM "WASPMET" LISTING

```
490 FS?C 09
491 XEQ 33
492 RCL 71
493 STO 70
494 RCL 77
495 STO 74
496 RCL 78
497 STO 75
498 RCL 79
499 STO 76
500 XEQ 28
501 FS? 05
502 XEQ 52
503 "CWSEL:"
504 "⊢  "
505 ARCL 04
506 PRA
507 GTO 53
508♦LBL 23
509 "Cc. -"
510 ACA
511 RCL 72
512 INT
513  10
514 /
515 ACX
516 FMT
517 "Cl. -"
518 ACA
519 RCL 72
520 FRC
521 ACX
522 PRBUF
523 RTN
524♦LBL 24
525 RCL 70
526 RCL 74
527 /
528 X↑2
529 STO 06
530 RCL 71
531 RCL 77
532 /
533 X↑2
534 RCL 06
535 XEQ 47
536 STO 06
537 GTO 17
538♦LBL 25
539 RCL 14
540 STO 15
541 0
542 STO 10
543 STO 11
544 STO 12
545 STO 13
546 STO 06
547 STO 05
548 RTN
549♦LBL 26
550 .005
551 X≤Y?
552 GTO 21
553♦LBL 27
554 RCL 86
555 .92
556 *
557 GTO 39
558♦LBL 28
559 FC? 05
560 GTO 29
561 "A.  "
562 ACA
563 SF 13
564 "LOB -"
565 ACA
566 CF 13
567 RCL 83
568 ACX
569 PRBUF
570 "A.  "
571 ACA
572 SF 13
573 "ROB -"
574 ACA
575 CF 13
```

← **This computes the balance error. If this is less than .01m (ie: +/- .005) it's okay.** (refers to step 549♦LBL 26)

PROGRAM "WASPMET" LISTING

```
576 RCL 84
577 ACX
578 PRBUF
579 "A. "
580 ACA
581 SF 13
582 "MN. CHL
 -"
583 ACA
584 CF 13
585 RCL 85
586 ACX
587 PRBUF
588♦LBL 29
589 "A. "
590 ACA
591 SF 13
592 "TOTAL -
"
593 ACA
594 CF 13
595 FS? 02
596 GTO 30
597 RCL 75
598 ACX
599 PRBUF
600 RTN
601♦LBL 30
602 RCL 78
603 ACX
604 PRBUF
605 RTN
606♦LBL 31
607 .2
608 GTO 38
609♦LBL 33
610 ADV
611 FMT
612 "--WARNI
NG--"
613 ACA
614 PRBUF
615 FMT
```

← This subroutine is used if the input WS_1 is actually on the "WRONG SIDE" of critical. If so, a new WS_1 number, 0.2M higher than the previous is used for the next trial.

```
616 "CRITICA
L DEPTH "
617 ACA
618 "ASSUMED
"
619 ACA
620 PRBUF
621 ADV
622 RTN
623♦LBL 34
624 X↑2
625 RCL 13
626 *
627 RTN
628♦LBL 35
629 *
630 9.807          ← g.
631 /
632 3
633 1/X
634 Y↑X
635 RTN
636♦LBL 36
637 .01
638 GTO 38
639♦LBL 38
640 ST+ 04
641 SF 09
642 GTO 04
643♦LBL 39
644 ST- 04
645 GTO 04
646♦LBL 40
647 "D. "
648 ACA
649 SF 13
650 "CMS -"
651 ACA
652 CF 13
653 RCL 71
654 ACX
655 PRBUF
656 RTN
```

PROGRAM "WASPMET" LISTING

```
657♦LBL 41
658 RCL 92
659 STO 70
660 FS? 04
661 GTO 42
662 BEEP
663 "NEW Q?"
664 PROMPT
665 STO 92
666♦LBL 42
667 STO 71
668 FS? 04
669 RTN
670 1
671 RCL 66
672 X≠Y?        ← X is not equal to Y
                 XEQ Alpha X f SIN Y? Alpha
673 RTN
674 RCL 92
675 STO 70
676 RTN
677♦LBL "RER
UN"
678 ADV
679 CLRG
680 CF 02
681 CF 04
682 CF 10
683 "CHANGE
Q?"
684 PROMPT
685 1.00
686 X=Y?
687 XEQ 43
688 GTO 55
689♦LBL 43
690 SF 10
691 "CONST.
Q?"
692 PROMPT
693 1.00
694 X=Y?
695 XEQ 44
696 RTN
697♦LBL 44
698 SF 04
699 "NEW Q?"
700 PROMPT
701 STO 92
702 RTN
703♦LBL 45
704 RCL 75
705 /
706 RCL 70
707 *
708 RTN
709♦LBL 46
710 RCL 78
711 /
712 RCL 71
713 *
714 RTN
715♦LBL 47
716 +
717 2
718 /
719 RTN
720♦LBL 48
721 RCL 83
722 RCL 84
723 +
724 CHS
725 FS? 02
726 GTO 50
727♦LBL 49
728 RCL 75
729 GTO 51
730♦LBL 50
731 RCL 78
732♦LBL 51
733 +
734 STO 85
735 RTN
736♦LBL 52
737 RCL 83
738 STO 80
739 RCL 84
```

PROGRAM "WASPMET" LISTING

```
740 STO 81
741 RCL 85
742 STO 82
743 RTN
744◆LBL 53
745 RCL 04
746 STO 87
747 .01
748 ST÷ 04
749 1
750 ST÷ 66
751 RCL 66
752 RCL 73
753 X=Y?
754 GTO 56
755 ADV
756 GTO 00
757◆LBL 54
758 /
759 X↑2
760 19.614          ← 2g.
761 /
762 RTN
763◆LBL 55
764 1
765 STO 66
766 GTO 00
767◆LBL 56
768 BEEP
769 BEEP
770 STOP
771 .END.
```

FINAL NOTES

If the output portion of this program, in particular WASPIMP, is to be keyed in by hand, the user will need to execute a "PACK" several times in order to get the last few lines into the calculator.

For computing water surface profiles in a channel which contains structures such as controls, culverts or bridges in the reach, end the program at the downstream end of the structure. Compute the head loss through the structure using the computed downstream water surface elevation and flow. Add the calculated head loss through the structure to the computed downstream water surface elevation to obtain an upstream water surface elevation. Use the calculated upstream water surface elevation to resume the computation of the channel water surface profile upstream of the structure. If multiple runs are to be conducted, the most efficient method would be to have the channel downstream and upstream portions below and above the structure described on separate cassette tapes.

Computing water surface profiles by the Standard Step Method using an HP-41C, CV or CX calculator pushes them to their ultimate capabilities. Swiftness of calculation is obviously no match to the lightning speed of HEC2 and HEC-RAS and the lack of program room certainly prevents the use of the many options that these two programs offer to the user. Nevertheless, programs WASPIMP and WASPMET does provide a practical demonstration of the powerful capabilities of a high-end HP hand-held Alpha-Numeric calculator.

Even with the program limitations, used In the field, without the benefit of a Mainframe or PC computer on hand containing a version of either HEC-2 or HEC-RAS, this set of programs embracing the capability to handle such tasks as channel improvement, provided a very suitable alternative for the solution of water surface profiles over the span of many years.

A future practical development could be a set of programs which include the ability to compute a set of Mannings "n" values for a channel derived from accurately surveyed cross-sectional data, varying stream flows and a series of water surface elevations gauged at every cross-section of the channel reach corresponding to each varying discharge.

APPENDIX

```
01♦LBL "SEC
TION"
02 ADV
03 CLX
04 CF 04
05 CF 05
06 CF 06
07 CF 07
08 CF 09
09 CLRG
10 1
11 STO 66
12♦LBL 00
13 FIX 4
14 SF 11
15 1
16 RCL 66
17 X>Y?
18 GTO 02
19 "NO. OF
SECTIONS"
20 "⊢?"
21 PROMPT
22 1
23 +
24 STO 73
25 "IDENTIC
AL SECTI"
26 "⊢ONS?"
27 PROMPT
28 1.0000
29 X=Y?
30 SF 04
31 FC? 04
32 GTO 01
33 "HAS CHA
NNEL A S"
34 "⊢LOPE?"
35 PROMPT
36 1.0000
37 X=Y?
38 SF 09
39♦LBL 01
40 "OVERBAN
K FLOW?"
41 PROMPT
42 1.0000
43 X=Y?
44 SF 05
45 1.3
46 STO 72
47 "CHANNEL
FLOW?"
48 PROMPT
49 STO 70
50 STO 71
51 GTO 10
52♦LBL 02
53 RCL 66
54 RCL 73
55 X=Y?
56 GTO 19
57 FC? 04
58 XEQ 15
59 "CHANGE
IN FLOW?"
60 PROMPT
61 1.0000
62 X=Y?
63 SF 06
64 FS?C 06
65 XEQ 03
66 "LOSS CO
EFF. CHG"
67 "⊢E?"
68 PROMPT
69 1.0000
70 X=Y?
71 SF 07
72 FS?C 07
73 GTO 04
74 GTO 07
75♦LBL 03
76 "NEW CHA
NNEL FLO"
77 "⊢W?"
78 PROMPT
79 STO 71
80 RTN
81♦LBL 04
82 "CONTRAC
TION VAL"
83 "⊢UE CHA
NGE?"
84 PROMPT
85 1.0000
86 X=Y?
87 GTO 05
88 GTO 06
89♦LBL 05
90 RCL 72
91 FRC
92 STO 72
93 "NEW CON
TRACTION"
94 "⊢ VALUE
? 0 TO 1"
95 PROMPT
96 10
97 *
98 ST+ 72
99 "EXPANSI
ON VALUE"
100 "⊢ CHANG
E?"
101 PROMPT
102 1.0000
103 X=Y?
104 GTO 06
105 GTO 07
106♦LBL 06
107 RCL 72
108 INT
109 STO 72
110 "NEW EXP
ANSION V"
111 "⊢ALUE?
0 TO 1"
112 PROMPT
113 ST+ 72
114♦LBL 07
115 FS? 05
116 GTO 08
117 "DIST. M
. CHL?"
118 PROMPT
119 STO 69
120 GTO 09
121♦LBL 08
122 "DIST. L
OB?"
123 PROMPT
124 STO 67
125 "DIST. R
OB?"
126 PROMPT
127 STO 68
128 "DIST. M
. CHL?"
129 PROMPT
130 STO 69
131♦LBL 09
132 FS? 09
133 XEQ 16
134 FS? 04
135 GTO 14
136♦LBL 10
137 "NO. OF
POINTS?"
138 PROMPT
139 2
140 *
141 12
142 +
143 1000
144 /
```

```
145 16.00002
146 +
147 STO 14
148 .002
149 +
150 STO 15
151♦LBL 11
152 RCL 15
153 INT
154 STO 00
155♦LBL 12
156 "ELEV?"
157 PROMPT
158 STO IND
00
159 "STA?"
160 PROMPT
161 X>0?
162 GTO 13
163 "N?"
164 PROMPT
165 CHS
166 +
167♦LBL 13
168 RCL 00
169 1
170 +
171 X<>Y
172 STO IND
Y
173 ISG 15
174 GTO 11
175♦LBL 14
176 FIX 2
177 CLA
178 ARCL 66
179 60
180 CREATE
181 0
182 SEEKR
183 14.073
184 WRTRX
185 VERIFY
186 RCL 71
187 STO 70
188 "SECTION
"
189 "⊢ "
190 ARCL 66
191 "⊢  OK."
192 PRA
193 GTO 18
194♦LBL A
195 DSE 15
196 GTO 11
197 GTO 11
198♦LBL 15
199 RCL 73
200 100000
201 /
202 ST+ 66
203 RCL 66
204 RCL 70
205 RCL 71
206 RCL 72
207 CLRG
208 STO 72
209 RDN
210 STO 71
211 RDN
212 STO 70
213 RDN
214 STO 66
215 RCL 66
216 FRC
217 100000
218 *
219 STO 73
220 RCL 66
221 INT
222 STO 66
223 RTN
224♦LBL 16
225 "ADD FAC
TOR?"
226 PROMPT
227 STO 01
228 RCL 14
229 STO 15
230 16
231 STO 02
232 RCL 01
233 ST+ IND
02
234♦LBL 17
235 2
236 ST+ 02
237 RCL 01
238 ST+ IND
02
239 ISG 15
240 GTO 17
241 RTN
242♦LBL 18
243 1
244 ST+ 66
245 GTO 00
246♦LBL 19
247 "ALL SEC
TIONS IN"
248 ACA
249 "PUT"
250 ACA
251 PRBUF
252 CF 04
253 CF 05
254 CF 09
255 STOP
256 .END.
```

```
 01♦LBL "WAS
PIMP"
 02 ADV
 03 FMT
 04 "W. S. P
ROFILES"
 05 ACA
 06 PRBUF
 07 ADV
 08 "TITLE:
"
 09 ACA
 10 "TITLE?"
 11 PROMPT
 12 ACA
 13 PRBUF
 14 ADV
 15 FIX 2
 16 CLRG
 17 CF 02
 18 CF 04
 19 CF 05
 20 CF 08
 21 CF 10
 22 "OVERBAN
K Q?"
 23 PROMPT
 24 1.00
 25 X=Y?
 26 SF 05
 27 "AV. COV
NCE EQN?"
 28 PROMPT
 29 1.00
 30 X=Y?
 31 SF 08
 32 GTO 55
 33♦LBL 00
 34 CLA
 35 ARCL 66
 36 0
 37 SEEKR
 38 14.073
 39 READRX
 40♦LBL 01
 41 "SECTION
 NO: - "
 42 ACA
 43 RCL 66
 44 ACX
 45 PRBUF
 46 FS? 10
 47 XEQ 41
 48 XEQ 40
 49 XEQ 23
 50 FC? 02
 51 GTO 03
 52 FC? 05
 53 GTO 02
 54 "L. "
 55 ACA
 56 SF 13
 57 "LOB -"
 58 ACA
 59 CF 13
 60 RCL 67
 61 ACX
 62 PRBUF
 63 "L. "
 64 ACA
 65 SF 13
 66 "ROB -"
 67 ACA
 68 CF 13
 69 RCL 68
 70 ACX
 71 PRBUF
 72♦LBL 02
 73 "L. "
 74 ACA
 75 SF 13
 76 "MN. CHL
-"
 77 ACA
 78 CF 13
 79 RCL 69
 80 ACX
 81 PRBUF
 82 RCL 69
 83 ST+ 88
 84 "C"
 85 ACA
 86 SF 13
 87 "UM. "
 88 ACA
 89 CF 13
 90 "L. -"
 91 ACA
 92 RCL 88
 93 ACX
 94 PRBUF
 95 GTO 04
 96♦LBL 03
 97 "WS STAR
T?"
 98 PROMPT
 99 STO 04
100 "WS. INP
UT:"
101 "⊢ "
102 ARCL 04
103 PRA
104♦LBL 04
105 SF 03
106 XEQ 25
107 XEQ 06
108 XEQ 05
109 FS? 02
110 GTO 16
111 RCL 11
112 STO 74
113 3
114 Y↑X
115 RCL 10
116 STO 75
117 X↑2
118 /
119 1/X
120 RCL 05
121 *
122 STO 76
123 RCL 70
124 XEQ 34
125 RCL 76
126 XEQ 35
127 RCL 75
128 X<Y?
129 GTO 31
130 FS?C 09
131 XEQ 33
132 "WS. STA
RT:"
133 "⊢ "
134 ARCL 04
135 PRA
136 FS? 05
137 XEQ 48
138 XEQ 28
139 FS? 05
140 XEQ 52
141 SF 02
142 GTO 53
143♦LBL 05
144 RCL 06
145 FS? 03
146 STO 83
147 FC? 03
148 STO 84
149 CF 03
150 X=0?
151 RTN
152 RCL 12
153 RCL 06
154 X<>Y
155 /
156 ENTER↑
157 .666667
158 Y↑X
```

```
159 RCL 06
160 *
161 1.486
162 *
163 RCL 07
164 /
165 ST+ 11
166 3
167 Y↑X
168 RCL 06
169 X↑2
170 /
171 ST+ 05
172 RCL 06
173 ST+ 10
174 0
175 STO 12
176 STO 06
177 RTN
178◆LBL 06
179 CF 00
180 CF 01
181 RCL 15
182 INT
183 STO 08
184 1
185 +
186 RCL IND
X
187 X>0?
188 GTO 07
189 RDN
190 17
191 X≠Y?
192 XEQ 05
193 RCL 08
194 1
195 +
196 RCL IND
X
197 CHS
198 FRC
199 STO 07
200◆LBL 07
201 RCL IND
08
202 RCL 04
203 X<>Y
204 X<=Y?
205 GTO 08
206 GTO 09
207◆LBL 08
208 SF 00
209◆LBL 09
210 CF 01
211 RCL 08
212 2
213 +
214 RCL IND
X
215 RCL 04
216 X<>Y
217 X<=Y?
218 SF 01
219 FS? 00
220 GTO 10
221 FS? 01
222 GTO 14
223 ISG 15
224 GTO 06
225 RTN
226◆LBL 10
227 RCL IND
08
228 STO 00
229 RCL 08
230 1
231 +
232 RCL IND
X
233 INT
234 ABS
235 STO 01
236 FS? 01
237 GTO 13
238◆LBL 11
239 RCL 08
240 2
241 +
242 RCL IND
X
243 RCL IND
08
244 -
245 X=0?
246 GTO 12
247 1/X
248 STO 09
249 RCL 08
250 3
251 +
252 RCL IND
X
253 INT
254 ABS
255 RCL 08
256 1
257 +
258 RCL IND
X
259 INT
260 ABS
261 X<>Y
262 RDN
263 -
264 ST* 09
265 RCL 04
266 FS? 00
267 STO 02
268 FS? 01
269 STO 00
270 RCL IND
08
271 -
272 ST* 09
273 RCL 08
274 1
275 +
276 RCL IND
X
277 INT
278 ABS
279 ST+ 09
280 RCL 09
281 FS? 00
282 STO 03
283 FS? 01
284 STO 01
285 XEQ 15
286◆LBL 12
287 ISG 15
288 GTO 06
289 RTN
290◆LBL 13
291 RCL 08
292 2
293 +
294 RCL IND
X
295 STO 02
296 RCL 08
297 3
298 +
299 RCL IND
X
300 INT
301 ABS
302 STO 03
303 XEQ 15
304 ISG 15
305 GTO 06
306 RTN
307◆LBL 14
308 RCL 08
309 2
310 +
311 RCL IND
X
```

```
312 STO 02
313 RCL 08
314 3
315 +
316 RCL IND
X
317 INT
318 ABS
319 STO 03
320 GTO 11
321◆LBL 15
322 RCL 04
323 RCL 00
324 -
325 RCL 04
326 RCL 02
327 -
328 +
329 2
330 /
331 X=0?
332 RTN
333 RCL 03
334 RCL 01
335 -
336 *
337 ST+ 06
338 RCL 02
339 RCL 00
340 -
341 X↑2
342 RCL 03
343 RCL 01
344 -
345 ST+ 13
346 X↑2
347 +
348 SQRT
349 ST+ 12
350 RTN
351◆LBL 16
352 SF 03
353 RCL 11
354 STO 77
355 3
356 Y↑X
357 RCL 10
358 STO 78
359 X↑2
360 /
361 1/X
362 RCL 05
363 *
364 STO 79
365 FS? 09
366 GTO 21
367 RCL 70
368 RCL 71
369 +
370 STO 11
371 FC? 08
372 GTO 24
373 RCL 74
374 RCL 77
375 +
376 1/X
377 RCL 11
378 *
379 X↑2
380 STO 06
381◆LBL 17
382 RCL 70
383 RCL 75
384 XEQ 54
385 RCL 76
386 *
387 STO 89
388 RCL 71
389 RCL 78
390 XEQ 54
391 RCL 79
392 *
393 STO 90
394 RCL 89
395 -
396 ABS
397 STO 91
398 XEQ 18
399 ST* 91
400 RCL 69
401 STO 86
402 FS? 05
403 XEQ 20
404 RCL 86
405 RCL 06
406 *
407 RCL 91
408 +
409 RCL 89
410 +
411 RCL 87
412 +
413 STO 86
414 RCL 04
415 RCL 90
416 +
417 RCL 86
418 -
419 STO 86
420 ABS
421 GTO 26
422◆LBL 18
423 RCL 90
424 RCL 89
425 X>Y?
426 GTO 19
427 RCL 72
428 FRC
429 RTN
430◆LBL 19
431 RCL 72
432 INT
433 10
434 /
435 RTN
436◆LBL 20
437 XEQ 48
438 RCL 80
439 XEQ 45
440 STO 10
441 RCL 82
442 XEQ 45
443 STO 11
444 RCL 81
445 XEQ 45
446 STO 12
447 RCL 83
448 XEQ 46
449 RCL 10
450 XEQ 47
451 STO 10
452 RCL 67
453 *
454 STO 05
455 RCL 85
456 XEQ 46
457 RCL 11
458 XEQ 47
459 ST+ 10
460 RCL 69
461 *
462 ST+ 05
463 RCL 84
464 XEQ 46
465 RCL 12
466 XEQ 47
467 ST+ 10
468 RCL 68
469 *
470 ST+ 05
471 RCL 10
472 1/X
473 RCL 05
474 *
475 STO 86
476 RTN
477◆LBL 21
478 RCL 71
```

```
479 XEQ 34
480 RCL 79
481 XEQ 35
482 RCL 78
483 X<Y?
484 GTO 36
485♦LBL 22
486 FS?C 09
487 XEQ 33
488 RCL 71
489 STO 70
490 RCL 77
491 STO 74
492 RCL 78
493 STO 75
494 RCL 79
495 STO 76
496 XEQ 28
497 FS? 05
498 XEQ 52
499 "CHSEL:"
500 "├   "
501 ARCL 04
502 PRA
503 GTO 53
504♦LBL 23
505 "Cc. -"
506 ACA
507 RCL 72
508 INT
509 10
510 /
511 ACX
512 FMT
513 "Ce. -"
514 ACA
515 RCL 72
516 FRC
517 ACX
518 PRBUF
519 RTN
520♦LBL 24
521 RCL 70
522 RCL 74
523 /
524 X↑2
525 STO 06
526 RCL 71
527 RCL 77
528 /
529 X↑2
530 RCL 06
531 XEQ 47
532 STO 06
533 GTO 17
534♦LBL 25
535 RCL 14
536 STO 15
537 0
538 STO 10
539 STO 11
540 STO 12
541 STO 13
542 STO 06
543 STO 05
544 RTN
545♦LBL 26
546 .005
547 X>Y?
548 GTO 21
549♦LBL 27
550 RCL 86
551 .92
552 *
553 GTO 39
554♦LBL 28
555 FC? 05
556 GTO 29
557 "A. "
558 ACA
559 SF 13
560 "LOB -"
561 ACA
562 CF 13
563 RCL 83
564 ACX
565 PRBUF
566 "A. "
567 ACA
568 SF 13
569 "ROB -"
570 ACA
571 CF 13
572 RCL 84
573 ACX
574 PRBUF
575 "A. "
576 ACA
577 SF 13
578 "MN. CHL
 -"
579 ACA
580 CF 13
581 RCL 85
582 ACX
583 PRBUF
584♦LBL 29
585 "A. "
586 ACA
587 SF 13
588 "TOTAL -
"
589 ACA
590 CF 13
591 FS? 02
592 GTO 30
593 RCL 75
594 ACX
595 PRBUF
596 RTN
597♦LBL 30
598 RCL 78
599 ACX
600 PRBUF
601 RTN
602♦LBL 31
603 RCL 04
604 FRC
605 .5
606 X<=Y?
607 GTO 32
608 XEQ 37
609 .5
610 GTO 38
611♦LBL 32
612 XEQ 37
613 1
614 GTO 38
615♦LBL 33
616 ADV
617 FMT
618 "---WARNI
NG---"
619 ACA
620 PRBUF
621 FMT
622 "CRITICA
L DEPTH "
623 ACA
624 "ASSUMED
"
625 ACA
626 PRBUF
627 ADV
628 RTN
629♦LBL 34
630 X↑2
631 RCL 13
632 *
633 RTN
634♦LBL 35
635 *
636 32.174
637 /
638 3
639 1/X
640 Y↑X
641 RTN
```

```
642♦LBL 36
643 .01
644 GTO 38
645♦LBL 37
646 RCL 04
647 INT
648 STO 04
649 RTN
650♦LBL 38
651 ST+ 04
652 SF 09
653 GTO 04
654♦LBL 39
655 ST- 04
656 GTO 04
657♦LBL 40
658 "Q. "
659 ACA
660 SF 13
661 "CFS -"
662 ACA
663 CF 13
664 RCL 71
665 ACX
666 PRBUF
667 RTN
668♦LBL 41
669 RCL 92
670 STO 70
671 FS? 04
672 GTO 42
673 BEEP
674 "NEW Q?"
675 PROMPT
676 STO 92
677♦LBL 42
678 STO 71
679 FS? 04
680 RTN
681 1
682 RCL 66
683 X≠Y?
684 RTN
685 RCL 92
686 STO 70
687 RTN
688♦LBL "RER
UN"
689 ADV
690 CLRG
691 CF 02
692 CF 04
693 CF 10
694 "CHANGE
Q?"
695 PROMPT
696 1.00
697 X=Y?
698 XEQ 43
699 GTO 55
700♦LBL 43
701 SF 10
702 "CONST.
Q?"
703 PROMPT
704 1.00
705 X=Y?
706 XEQ 44
707 RTN
708♦LBL 44
709 SF 04
710 "NEW Q?"
711 PROMPT
712 STO 92
713 RTN
714♦LBL 45
715 RCL 75
716 /
717 RCL 70
718 *
719 RTN
720♦LBL 46
721 RCL 78
722 /
723 RCL 71
724 *
725 RTN
726♦LBL 47
727 +
728 2
729 /
730 RTN
731♦LBL 48
732 RCL 83
733 RCL 84
734 +
735 CHS
736 FS? 02
737 GTO 50
738♦LBL 49
739 RCL 75
740 GTO 51
741♦LBL 50
742 RCL 78
743♦LBL 51
744 +
745 STO 85
746 RTN
747♦LBL 52
748 RCL 83
749 STO 80
750 RCL 84
751 STO 81
752 RCL 85
753 STO 82
754 RTN
755♦LBL 53
756 RCL 04
757 STO 87
758 .01
759 ST+ 04
760 1
761 ST+ 66
762 RCL 66
763 RCL 73
764 X=Y?
765 GTO 56
766 ADV
767 GTO 00
768♦LBL 54
769 /
770 X↑2
771 64.348
772 /
773 RTN
774♦LBL 55
775 1
776 STO 66
777 GTO 00
778♦LBL 56
779 BEEP
780 BEEP
781 STOP
782 .END.
```

```
 01◆LBL "WAS
PMET"
 02 ADV
 03 FMT
 04 "W. S. P
ROFILES"
 05 ACA
 06 PRBUF
 07 FMT
 08 SF 13
 09 "METRIC
VERSION"
 10 ACA
 11 CF 13
 12 PRBUF
 13 ADV
 14 "TITLE:
"
 15 ACA
 16 "TITLE?"
 17 PROMPT
 18 ACA
 19 PRBUF
 20 ADV
 21 FIX 2
 22 CLRG
 23 CF 02
 24 CF 04
 25 CF 05
 26 CF 08
 27 CF 10
 28 "OVERBAN
K Q?"
 29 PROMPT
 30 1.00
 31 X=Y?
 32 SF 05
 33 "AV. COV
NCE EQN?"
 34 PROMPT
 35 1.00
 36 X=Y?
 37 SF 08
 38 GTO 55
 39◆LBL 00
 40 CLA
 41 ARCL 66
 42 0
 43 SEEKR
 44 14.073
 45 READRX
 46◆LBL 01
 47 "SECTION
NO: - "
 48 ACA
 49 RCL 66
 50 ACX
 51 PRBUF
 52 FS? 10
 53 XEQ 41
 54 XEQ 40
 55 XEQ 23
 56 FC? 02
 57 GTO 03
 58 FC? 05
 59 GTO 02
 60 "L. "
 61 ACA
 62 SF 13
 63 "LOB -"
 64 ACA
 65 CF 13
 66 RCL 67
 67 ACX
 68 PRBUF
 69 "L. "
 70 ACA
 71 SF 13
 72 "ROB -"
 73 ACA
 74 CF 13
 75 RCL 68
 76 ACX
 77 PRBUF
 78◆LBL 02
 79 "L. "
 80 ACA
 81 SF 13
 82 "MN. CHL
-"
 83 ACA
 84 CF 13
 85 RCL 69
 86 ACX
 87 PRBUF
 88 RCL 69
 89 ST+ 88
 90 "C"
 91 ACA
 92 SF 13
 93 "UM. "
 94 ACA
 95 CF 13
 96 "L. -"
 97 ACA
 98 RCL 88
 99 ACX
100 PRBUF
101 GTO 04
102◆LBL 03
103 "WS STAR
T?"
104 PROMPT
105 STO 04
106 "WS. INP
UT:"
107 "⊢ "
108 ARCL 04
109 PRA
110◆LBL 04
111 SF 03
112 XEQ 25
113 XEQ 06
114 XEQ 05
115 FS? 02
116 GTO 16
117 RCL 11
118 STO 74
119 3
120 Y↑X
121 RCL 10
122 STO 75
123 X↑2
124 /
125 1/X
126 RCL 05
127 *
128 STO 76
129 RCL 70
130 XEQ 34
131 RCL 76
132 XEQ 35
133 RCL 75
134 X<Y?
135 GTO 31
136 FS?C 09
137 XEQ 33
138 "WS. STA
RT:"
139 "⊢ "
140 ARCL 04
141 PRA
142 FS? 05
143 XEQ 48
144 XEQ 28
145 FS? 05
146 XEQ 52
147 SF 02
148 GTO 53
149◆LBL 05
150 RCL 06
151 FS? 03
152 STO 83
153 FC? 03
154 STO 84
155 CF 03
156 X=0?
157 RTN
```

```
158 RCL 12
159 RCL 06
160 X<>Y
161 /
162 ENTER↑
163 .666667
164 Y↑X
165 RCL 06
166 *
167 RCL 07
168 /
169 ST+ 11
170 3
171 Y↑X
172 RCL 06
173 X↑2
174 /
175 ST+ 05
176 RCL 06
177 ST+ 10
178 0
179 STO 12
180 STO 06
181 RTN
182•LBL 06
183 CF 00
184 CF 01
185 RCL 15
186 INT
187 STO 08
188 1
189 +
190 RCL IND
X
191 X>0?
192 GTO 07
193 RDN
194 17
195 X≠Y?
196 XEQ 05
197 RCL 08
198 1
199 +
200 RCL IND
X
201 CHS
202 FRC
203 STO 07
204•LBL 07
205 RCL IND
08
206 RCL 04
207 X<>Y
208 X<=Y?
209 GTO 08
210 GTO 09
211•LBL 08
212 SF 00
213•LBL 09
214 CF 01
215 RCL 08
216 2
217 +
218 RCL IND
X
219 RCL 04
220 X<>Y
221 X<=Y?
222 SF 01
223 FS? 00
224 GTO 10
225 FS? 01
226 GTO 14
227 ISG 15
228 GTO 06
229 RTN
230•LBL 10
231 RCL IND
08
232 STO 00
233 RCL 08
234 1
235 +
236 RCL IND
X
237 INT
238 ABS
239 STO 01
240 FS? 01
241 GTO 13
242•LBL 11
243 RCL 08
244 2
245 +
246 RCL IND
X
247 RCL IND
08
248 -
249 X=0?
250 GTO 12
251 1/X
252 STO 09
253 RCL 08
254 3
255 +
256 RCL IND
X
257 INT
258 ABS
259 RCL 08
260 1
261 +
262 RCL IND
X
263 INT
264 ABS
265 X<>Y
266 RDN
267 -
268 ST* 09
269 RCL 04
270 FS? 00
271 STO 02
272 FS? 01
273 STO 00
274 RCL IND
08
275 -
276 ST* 09
277 RCL 08
278 1
279 +
280 RCL IND
X
281 INT
282 ABS
283 ST+ 09
284 RCL 09
285 FS? 00
286 STO 03
287 FS? 01
288 STO 01
289 XEQ 15
290•LBL 12
291 ISG 15
292 GTO 06
293 RTN
294•LBL 13
295 RCL 08
296 2
297 +
298 RCL IND
X
299 STO 02
300 RCL 08
301 3
302 +
303 RCL IND
X
304 INT
305 ABS
306 STO 03
307 XEQ 15
308 ISG 15
309 GTO 06
310 RTN
311•LBL 14
```

```
312 RCL 08
313 2
314 +
315 RCL IND
X
316 STO 02
317 RCL 08
318 3
319 +
320 RCL IND
X
321 INT
322 ABS
323 STO 03
324 GTO 11
325♦LBL 15
326 RCL 04
327 RCL 00
328 -
329 RCL 04
330 RCL 02
331 -
332 +
333 2
334 /
335 X=0?
336 RTN
337 RCL 03
338 RCL 01
339 -
340 *
341 ST+ 06
342 RCL 02
343 RCL 00
344 -
345 X↑2
346 RCL 03
347 RCL 01
348 -
349 ST+ 13
350 X↑2
351 +
352 SQRT
353 ST+ 12
354 RTN
355♦LBL 16
356 SF 03
357 RCL 11
358 STO 77
359 3
360 Y↑X
361 RCL 10
362 STO 78
363 X↑2
364 /
365 1/X
366 RCL 05
367 *
368 STO 79
369 FS? 09
370 GTO 21
371 RCL 70
372 RCL 71
373 +
374 STO 11
375 FC? 08
376 GTO 24
377 RCL 74
378 RCL 77
379 +
380 1/X
381 RCL 11
382 *
383 X↑2
384 STO 06
385♦LBL 17
386 RCL 70
387 RCL 75
388 XEQ 54
389 RCL 76
390 *
391 STO 89
392 RCL 71
393 RCL 78
394 XEQ 54
395 RCL 79
396 *
397 STO 90
398 RCL 89
399 -
400 ABS
401 STO 91
402 XEQ 18
403 ST* 91
404 RCL 69
405 STO 86
406 FS? 05
407 XEQ 20
408 RCL 86
409 RCL 06
410 *
411 RCL 91
412 +
413 RCL 89
414 +
415 RCL 87
416 +
417 STO 86
418 RCL 04
419 RCL 90
420 +
421 RCL 86
422 -
423 STO 86
424 ABS
425 GTO 26
426♦LBL 18
427 RCL 90
428 RCL 89
429 X>Y?
430 GTO 19
431 RCL 72
432 FRC
433 RTN
434♦LBL 19
435 RCL 72
436 INT
437 10
438 /
439 RTN
440♦LBL 20
441 XEQ 48
442 RCL 80
443 XEQ 45
444 STO 10
445 RCL 82
446 XEQ 45
447 STO 11
448 RCL 81
449 XEQ 45
450 STO 12
451 RCL 83
452 XEQ 46
453 RCL 10
454 XEQ 47
455 STO 10
456 RCL 67
457 *
458 STO 05
459 RCL 85
460 XEQ 46
461 RCL 11
462 XEQ 47
463 ST+ 10
464 RCL 69
465 *
466 ST+ 05
467 RCL 84
468 XEQ 46
469 RCL 12
470 XEQ 47
471 ST+ 10
472 RCL 68
473 *
474 ST+ 05
475 RCL 10
476 1/X
477 RCL 05
```

```
478 *
479 STO 86
480 RTN
481♦LBL 21
482 RCL 71
483 XEQ 34
484 RCL 79
485 XEQ 35
486 RCL 78
487 X<Y?
488 GTO 36
489♦LBL 22
490 FS?C 09
491 XEQ 33
492 RCL 71
493 STO 70
494 RCL 77
495 STO 74
496 RCL 78
497 STO 75
498 RCL 79
499 STO 76
500 XEQ 28
501 FS? 05
502 XEQ 52
503 "CWSEL:"
504 "⊢ "
505 ARCL 04
506 PRA
507 GTO 53
508♦LBL 23
509 "Cc. -"
510 ACA
511 RCL 72
512 INT
513 10
514 /
515 ACX
516 FMT
517 "Ce. -"
518 ACA
519 RCL 72
520 FRC
521 ACX
522 PRBUF
523 RTN
524♦LBL 24
525 RCL 70
526 RCL 74
527 /
528 X↑2
529 STO 86
530 RCL 71
531 RCL 77
532 /
533 X↑2
534 RCL 86
535 XEQ 47
536 STO 86
537 GTO 17
538♦LBL 25
539 RCL 14
540 STO 15
541 0
542 STO 10
543 STO 11
544 STO 12
545 STO 13
546 STO 86
547 STO 85
548 RTN
549♦LBL 26
550 .005
551 X>Y?
552 GTO 21
553♦LBL 27
554 RCL 86
555 .92
556 *
557 GTO 39
558♦LBL 28
559 FC? 05
560 GTO 29
561 "A. "
562 ACA
563 SF 13
564 "LOB -"
565 ACA
566 CF 13
567 RCL 83
568 ACX
569 PRBUF
570 "A. "
571 ACA
572 SF 13
573 "ROB -"
574 ACA
575 CF 13
576 RCL 84
577 ACX
578 PRBUF
579 "A. "
580 ACA
581 SF 13
582 "MN. CHL
 -"
583 ACA
584 CF 13
585 RCL 85
586 ACX
587 PRBUF
588♦LBL 29
589 "A. "
590 ACA
591 SF 13
592 "TOTAL -
"
593 ACA
594 CF 13
595 FS? 02
596 GTO 30
597 RCL 75
598 ACX
599 PRBUF
600 RTN
601♦LBL 30
602 RCL 78
603 ACX
604 PRBUF
605 RTN
606♦LBL 31
607 .2
608 GTO 38
609♦LBL 33
610 ADV
611 FMT
612 "---WARNI
NG---"
613 ACA
614 PRBUF
615 FMT
616 "CRITICA
L DEPTH "
617 ACA
618 "ASSUMED
"
619 ACA
620 PRBUF
621 ADV
622 RTN
623♦LBL 34
624 X↑2
625 RCL 13
626 *
627 RTN
628♦LBL 35
629 *
630 9.807
631 /
632 3
633 1/X
634 Y↑X
635 RTN
636♦LBL 36
637 .01
638 GTO 38
639♦LBL 38
640 ST+ 04
```

```
641 SF 09
642 GTO 04
643◆LBL 39
644 ST- 04
645 GTO 04
646◆LBL 40
647 "Q. "
648 ACA
649 SF 13
650 "CMS -"
651 ACA
652 CF 13
653 RCL 71
654 ACX
655 PRBUF
656 RTN
657◆LBL 41
658 RCL 92
659 STO 70
660 FS? 04
661 GTO 42
662 BEEP
663 "NEW Q?"
664 PROMPT
665 STO 92
666◆LBL 42
667 STO 71
668 FS? 04
669 RTN
670 1
671 RCL 66
672 X≠Y?
673 RTN
674 RCL 92
675 STO 70
676 RTN
677◆LBL "RER
UN"
678 ADV
679 CLRG
680 CF 02
681 CF 04
682 CF 10
683 "CHANGE
Q?"
684 PROMPT
685 1.00
686 X=Y?
687 XEQ 43
688 GTO 55
689◆LBL 43
690 SF 10
691 "CONST.
Q?"
692 PROMPT
693 1.00
694 X=Y?
695 XEQ 44
696 RTN
697◆LBL 44
698 SF 04
699 "NEW Q?"
700 PROMPT
701 STO 92
702 RTN
703◆LBL 45
704 RCL 75
705 /
706 RCL 70
707 *
708 RTN
709◆LBL 46
710 RCL 78
711 /
712 RCL 71
713 *
714 RTN
715◆LBL 47
716 +
717 2
718 /
719 RTN
720◆LBL 48
721 RCL 83
722 RCL 84
723 +
724 CHS
725 FS? 02
726 GTO 50
727◆LBL 49
728 RCL 75
729 GTO 51
730◆LBL 50
731 RCL 78
732◆LBL 51
733 +
734 STO 85
735 RTN
736◆LBL 52
737 RCL 83
738 STO 80
739 RCL 84
740 STO 81
741 RCL 85
742 STO 82
743 RTN
744◆LBL 53
745 RCL 04
746 STO 87
747 .01
748 ST+ 04
749 1
750 ST+ 66
751 RCL 66
752 RCL 73
753 X=Y?
754 GTO 56
755 ADV
756 GTO 00
757◆LBL 54
758 /
759 X↑2
760 19.614
761 /
762 RTN
763◆LBL 55
764 1
765 STO 66
766 GTO 00
767◆LBL 56
768 BEEP
769 BEEP
770 STOP
771 .END.
```

```
 01◆LBL "BYE
"
 02 CLRG
 03 FIX 2
 04 "STARTIN
G FILE N"
 05 "⊢UMBER?
"
 06 PROMPT
 07 STO 01
 08 "ENDING
FILE NUM"
 09 "⊢BER?"
 10 PROMPT
 11 STO 02
 12◆LBL 01
 13 CLA
 14 ARCL 01
 15 PURGE
 16 1
 17 ST+ 01
 18 RCL 02
 19 RCL 01
 20 X<=Y?
 21 GTO 01
 22 GTO 02
 23◆LBL 02
 24 CLRG
 25 CLST
 26 CLX
 27 CLA
 28 CLΣ
 29 CF 00
 30 CF 01
 31 CF 02
 32 CF 03
 33 CF 04
 34 CF 05
 35 CF 06
 36 CF 07
 37 CF 08
 38 CF 09
 39 CF 10
 40 CF 11
 41 CF 12
 42 CF 13
 43 FIX 4
 44 STOP
 45 END
```