U.S. DEPARTMENT OF THE INTERIOR
U.S. GEOLOGICAL SURVEY

KWM - A BASIC program, and user's guide for a kinematic wave model for debris flow

by

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INTRODUCTION

The BASIC computer program KWM computes the parameters of the kinematic wave model for debris flows proposed by Arattano and Savage (1992) using the hydrographs recorded by two gaging stations along a channel. The model also can be used to predict the movement along a stream channel of a known mass of debris caused by a landslide or a previous debris flow. If debris volume, the amount of water required for mobilization and the mean width of the stream channel are known, the parameters H, maximum height of the initial debris mass, and L, length of the initial debris mass, can be calculated. If we then have a value for k, a parameter that accounts for changes of hydraulic radius with flow depth, and for C, the roughness coefficient, along the stream channel, the propagation of the debris flow can be predicted (Arattano and Savage, 1992).

Once the model parameters have been calculated, theoretical hydrographs can be generated by the program at any point along the channel, starting from the theoretical point of inception of the debris flow.

The program also allows for the comparison of the two recorded hydrographs and the hydrographs predicted by the model. This comparison is done by using the recorded time data of the actual hydrographs that have been corrected by adding the theoretical time elapsed from the moment of inception of the debris flow to its recording at the two stations.

In addition, if the user already knows the values of the parameters of the model, a program option can be selected that allows input, rather than calculation, of these parameters. Theoretical hydrographs at any point along the channel can then be generated.

The output of KWM are files containing time-flow height pairs. A graphics program, such as GRAPHER™, is needed to draw the hydrographs.

KWM.EXE will run on any IBM PC or PC compatible system running DOS 3.X or above and with 640 kilobytes of memory. A video graphics adapter is required to display the data graphically with a program like GRAPHER™. KWM was written using Microsoft BASIC Professional Development System version 7.1 (Microsoft Corp., 1991).

SOME USEFUL ADVICE BEFORE RUNNING THE PROGRAM

A previous ordering of the input and output data can facilitate using KWM. In particular, it is helpful to decide the

names of the output files before running the program.

In table 1 we have shown a possible set of filenames needed to run the program. We suggest creating a table like table 1 before starting KWM and using that table while running it. The first column contains suggested input filenames for the Time-Flow Height (TH) data recorded at the two stations, A and B, along the channel. The second column contains suggested output filenames for Corrected Time-Flow Height (CTH) data for the stations A and B (The extension .DAT is needed to use the graphing program GRAPHER™). The last column contains suggested filenames for Theoretical Time-Flow Height (TTH) data at stations A and B.

Together with the executable program, we have provided two files containing the hydrograph data recorded by two gaging stations for the first debris flow that occurred on October 1, 1981 in the Muddy River, Mount St. Helens (Pierson, 1986; Arattano and Savage, 1992). These files are named THA1 and THB1. They can be used, together with the data given in table 2, to demonstrate how the program runs.

CONVENTIONS USED

To set apart the information that is entered from the keyboard from the text of this report, the keyboard input is in ***bold italics.*** Single keystroke input like [ENTER] or [ESC] is capitalized and enclosed in brackets. Screen messages are boxed in with double lines and are shaded to appear like a computer display.

```
This is a sample of a screen message or prompt
```

If a problem is encountered while running the program, press and hold the [CTRL] key and the [BREAK] key to exit. This aborts the program and returns the system to DOS.

THE FIRST THING TO DO

Insert the program/data disk into the computer drive. The A: drive is usually a 5.25" drive, and the B: drive a 3.5" drive. To run the program from a floppy drive, change the working drive to the floppy drive by typing the appropriate drive letter followed by a colon (i.e. A:). If you wish to run the program from the hard drive, copy the floppy disk files to the hard disk with the DOS copy command (i.e. copy A:*.* C:*.*).

INPUT	OUTPUT	
Files containing recorded data	Files containing corrected recorded data	Files containing theoretical hydrograph data
THA THB	CTHA.DAT CTHB.DAT	TTHA.DAT TTHB.DAT

Table 1 - Example of a set of filenames needed to run the program

Δx [m]	i	h_{p1} [m]	h_{p2} [m]	u [m/s]
273	0.184	3.36	2.16	3.5

Δx distance between the two gaging stations

i slope of the channel

h_{p1} peak flow height recorded at station A

h_{p2} peak flow height recorded at station B

u mean velocity of the debris flow front between the stations

Table 2 - Field data from the first debris flow that occurred on October 1, 1981 in the Muddy River, Mount St. Helens (Pierson, 1986).

GETTING STARTED

Start the program by typing ***KWM*** and pressing the [ENTER] key. The screen is first cleared and the following title page is displayed:

```
                U.S. DEPARTMENT OF INTERIOR
                  U.S. GEOLOGICAL SURVEY

          KWM -- A BASIC program for a kinematic
                wave model for debris flows

                           by

          Massimo Arattano and Philip S. Powers


press any key to continue.
```

Press ***any key*** to proceed to the next screen.

The next screen informs the user how to quit the program in case of a problem:

```
                    * * *  IMPORTANT  * * *

  If you need to quit the program at any time press and
hold [CTRL] and then press [BREAK].


to continue with the program

PRESS ANY KEY
```

press ***any key*** to proceed.

OPTIONS FOR PARAMETER INPUT

The following screen asks if you want to compute the parameters of the model using data from two hydrographs recorded

along a channel, following the procedures outlined by Arattano and Savage (1992), or if you want to input parameters of your own. Enter 1 to perform the first calculation or 2 to perform the second.

```
Do you want to

  (1)    compute parameters of the model using two
         recorded hydrographs?

  (2)    input parameters of your own ?

  Enter 1 or 2
```

COMPUTING PARAMETERS USING TWO RECORDED HYDROGRAPHS (OPTION 1).

The input to this program option are, in order, the distance between the two gaging stations, the slope of the channel, the peak flow height recorded at station A, the peak flow height recorded at station B, an initial value for the parameter k (it can be assumed equal to 0.66, which corresponds to a wide rectangular section or to a triangular section (Arattano and Savage, 1992)), the mean velocity of the debris flow front between the two stations, and the name of the file containing the time-flow height (TH) data taken from the hydrograph recorded at the first station (for an example see column 1, row 1 in table 1). Figure 1 shows an example of a TH file from a recorded hydrograph.

At this point the user is asked for the name of the file to which the corrected hydrograph data will be written (for an example see column 2, row 1 in table 1). The hydrograph data will be corrected by adding the time, t, from the inception of the debris flow to its recording at the first station.

```
Enter the output filename for corrected hydrograph data
(station A).
```

The program will now perform the calculations to find the values for x, H, L, t and k (see Arattano and Savage (1992) for the meaning of these parameters). These values will be displayed on the screen when the calculations are complete. The display of this screen is shown on page 8.

```
0,     3.36
4.5,   3.03
7.5,   2.81
10.8,  2.43
15,    1.81
24,    1.04
33,    0.64
55.5,  0.26
58.5,  0.194
```

Figure 1 - Example of a Time-Height data file. The column on the left contains time data, the column on the right contains height data. The first point is the peak flow value and its time is thus assumed equal to zero.

Intercept is: 27.248
Correlation coefficient (r) is: 0.995

Mean velocity in the reach (m)	Peak height at 1st station (m)	Peak height at 2nd station (m)	x (m)	H (m)	L (m)	t (s)	k	C
3.50	3.36	2.16	396.4	7.92	56.55	87.8	0.172	7.86

Enter (Y)es to send screen to printer (LPT1), else press any key.

The user can send the screen diplay shown on page 8 to a printer by entering *Y* for (Y)es at the prompt.

The next program prompt is:

```
Do you want to generate a hydrograph (Y/N) ?
```

Enter *Y* for (Y)es if you want to use the calculated parameters to generate a theoretical hydrograph for any point along the channel. If you choose this option the following screen will be displayed:

```
Enter 1 to calculate theoretical hydrograph at the
        first station.
Enter 2 to calculate theoretical hydrograph at the
        second station.
Enter 3 to calculate theoretical hydrograph at a
        designated distance from the theoretical point
        of inception of the debris flow.
```

Enter *1* if you want to generate a theoretical hydrograph at the first station. Enter *2* if you want to generate a theoretical hydrograph at the second station. Enter *3* if you want to generate a theoretical hydrograph at a point you designate along the channel.

If you enter *3* the program will first ask you the distance from the theoretical point of inception of the debris flow at which you want the hydrograph. The next prompt, which is the same for all the three options, will require you to enter the number of points on the theoretical hydrograph:

```
Enter the number of points on the theoretical
hydrograph
```

To generate a theoretical hydrograph the program will calculate a user-designated number of Time-Flow Height pairs (50 points are usually sufficient).

The calculated points will be stored into a file that can then be read by a graphics program, like GRAPHER™. The following screen asks for the name of this file (for an example see column 3, row 1 in table 1). (If you use GRAPHER™ to draw the hydrograph, the extension of the filename must be .DAT.):

```
Enter the output filename for the theoretical
hydrograph (dimensional).
```

The program also allows the option of generating a non-dimensional hydrograph. The following screen asks if the user wants to utilize this option:

```
Do you also want to generate a non dimensional
hydrograph (Y/N) ?
```

The program then asks if the user wants to compute another hydrograph:

```
Would you like to compute another theoretical
hydrograph (Y/N) ?
```

Entering *N* for N(o) will allow the program to compare the predicted theoretical hydrograph at station B with the data recorded at that station. For this comparison the recorded data from station B must also be corrected by adding the calculated time from the theoretical moment of inception of the debris flow to its recording, as has been done for station A. Entering *N* for (N)o at the last prompt will cause the program to ask if the user wants to perform this correction:

```
Enter (Y)es if you would like to correct the data of
the recorded hydrograph at station B with the
calculated value of t, otherwise press any other key to
proceed.
```

The data from the hydrograph recorded at station B will need to be in a file like the one shown in Fig. 1. The following screen asks for the name of this file (for an example see column 1, row 2 in table 1):

```
Enter the input filename of hydrograph data from
station B.
```

The next prompt asks for the name of the file into which the user wants to store the corrected data (for an example see column 2, row 2 in table 1) (again, if you will use GRAPHER™ to draw the hydrograph, remember to use the extension .DAT for this file):

```
Enter the output filename for corrected hydrograph data
(station B).
```

The next prompt is:

```
Press the Space Bar to RUN the program again, or any
other key to EXIT
```

Pressing any key other than the space bar will exit the program and print:

```
ALL DONE
```

The space bar will loop back to the start of the program.

USING ALREADY KNOWN PARAMETERS (OPTION 2).

This option allows you to input the model parameters if you already know their values and do not want to use the procedure outlined in the previous section for their calculation.

With this option it is possible to generate a hydrograph at any distance from the point of inception of the debris flow (which is now an input datum).

Input to this program option are, in order, the slope of the channel, the parameter k, the roughness coefficient C (see Arattano and Savage (1992) for the meaning of this coefficient), the height, H, of the initial debris mass, the number of points of the theoretical hydrograph, and the distance from the point of inception at which the user wants the hydrograph.
The following screen will be:

```
Enter the output filename for the theoretical
hydrograph.
```

The program asks for the name of the file in which it will store the calculated points of the hydrograph (remember the extension .DAT if you will use GRAPHER™ to draw the hydrograph).
The option of calculating a non-dimensional hydrograph also exists. The following screen allows for this option:

```
Do you want to generate a non-dimensional hydrograph ?
```

If you answer *Y* for (Y)es you will need to input the name of the file in which the data for the non-dimensional hydrograph are stored. The program will perform the needed calculations and the next prompt will ask if you want to calculate another theoretical hydrograph. Entering *N* for (N)o at this prompt will take you to the end of the program and the screen will be:

```
Press Space Bar to RUN the program again, else any
other key to EXIT
```

Pressing any key other than the space bar will exit the program and print:

The space bar will loop back to the start of the program.

ALL DONE

REFERENCES

Arattano M. and Savage W.Z., 1992, Kinematic wave theory for debris flows: U.S. Geological Survey Open-File Report 92-290, 39 p.

Pierson, T. C., 1986, Flow behavior of channelized debris flows, Mount St. Helens, Washington: in Abrahms, A. D. ed., Hillslope processes: Boston, Allen & Unwin, p. 269-296.

_____, Golden Software Inc., 1985, GRAPHER™, Golden Colorado.

_____, Microsoft Corporation, 1987, Microsoft BASIC Programmer's Guide Version 7.0 For IBM Personal Computers and Compatibles, United States and Canada.

_____, Microsoft Corporation, 1991, Microsoft MS-DOS Users Guide and reference--for the MS-DOS Operating System version 5.0, United States.

```
DECLARE SUB calculate (s!, k!, h1!, h2!, L1!, H!, x1!, L!, x!, t!, U!, Tdimensional!, um!, C!)
DECLARE SUB manning (h1!, h2!, s!, k!, C!, um!)
DECLARE SUB hydro (hs!, x!, k!, L!, U!, row%, a!(), H)
DECLARE SUB shape (h1!, n!, k!, L, U)
DIM hydrotheor(150, 2)
DIM hydrographTimes(100)
DIM hydrographHeights(100)
DIM lht(100), lhh(100)

CLS

'============================================================================
'     Print a title on the screen
'============================================================================
PRINT ""
PRINT ""
PRINT "                        U.S. DEPARTMENT OF THE INTERIOR"
PRINT "                            U.S. GEOLOGICAL SURVEY"
PRINT ""
PRINT ""
PRINT "                     KWM -- A BASIC program for a kinematic"
PRINT "                          wave model for debris flows"
PRINT ""
PRINT ""
PRINT "                                        by"
PRINT ""
PRINT "                      Massimo Arattano and Philip S. Powers"
LOCATE 25, 1
COLOR 0, 7
PRINT "press any key to continue";
COLOR 7, 0

DO WHILE INKEY$ = ""
LOOP

CLS
LOCATE 5, 1
COLOR 31, 0
PRINT "                                  *** IMPORTANT ***"
LOCATE 10, 1
COLOR 7, 0
PRINT "                  If you need to quit the program at any time press and"
PRINT "                  hold [CTRL] and then press [BREAK] ";
LOCATE 22, 1
COLOR 7, 0
PRINT "to continue with the program ";
COLOR 0, 7
PRINT "PRESS ANY KEY."
COLOR 7, 0
DO WHILE INKEY$ = ""
LOOP

CLS

doagn:
CLS
ans = 0
LOCATE 10, 5
PRINT "Do you want to "
PRINT
PRINT " (1)   Compute parameters of the model using two recorded hydrographs?"
PRINT " (2)   input parameters of your own? ";
PRINT ""
PRINT ""
INPUT " Enter 1 or 2                              ", ans
IF ans < 1 OR ans > 2 THEN GOTO doagn:
```

```
IF ans = 1 THEN
        GOTO Indata:
ELSE
        INPUT "Enter the slope of the channel.  ", s
        INPUT "Enter K (exponent of the hydraulic radius).  ", k
        INPUT "Enter the coefficient C.  ", C
        INPUT "Enter the height, H, of the initial debris mass.  ", H
        L = H / s
        U = C * H ^ k * s ^ .5

redo:
        PRINT " Do you want to draw an hydrograph at a certain distance from the  "
        INPUT " theoretical point of inception of the debris flow (Y/N) ?  ", b$
        b$ = UCASE$(LEFT$(b$, 1))
         IF b$ <> "N" AND b$ <> "Y" THEN GOTO redo:
hydrcal1:

        IF b$ = "Y" THEN
            INPUT "Enter the number of points of the hydrograph.  ", row%
            INPUT "Enter the distance at which you want the hydrograph.  ", x1
            xx = x1 / L
            aa = (k + 1) / (2 * k)
            bb = (1 - k) / (2 * k)
            hs = (-xx + SQR(xx ^ 2 + 4 * aa * bb)) / (2 * bb)
            hs = hs * H
            CALL hydro(hs, xx, k, L, U, row%, hydrotheor(), H)
        END IF

redo1:

        ans$ = ""
        INPUT "Would you like to compute another theoretical hydrograph (Y/N).  ", ans$
        ans$ = UCASE$(LEFT$(ans$, 1))
        IF ans$ <> "N" AND ans$ <> "Y" THEN GOTO redo1:
        IF ans$ = "Y" THEN
           CLS
           GOTO hydrcal1:
        END IF

        GOTO done1:
END IF

Indata:

CLS
INPUT "Enter the Distance between the 2 gaging stations.  ", L1
INPUT "Enter the slope of the channel.  ", s
INPUT "Enter the peak height at the first station.  ", h1
INPUT "Enter the peak height at the second station.  ", h2
INPUT "Enter an attempt value for K (exponent of the hydraulic radius).  ", k
INPUT "Enter the mean velocity in the reach.   ", um
CLS
CALL calculate(s, k, h1, h2, L1, H, x1, L, x, t, U, Tdimensional, um, C)

theight$ = ""
loopagain:

IF theight$ = "" THEN
   drive$ = CURDIR$
   PRINT "The current drive and working directory are "; drive$
   PRINT "This will be the location of your input and output files."
   PRINT "Press ";
   COLOR 0, 7
   PRINT "[RETURN]";
   COLOR 7, 0
```

```
   PRINT " to accept the current drive and working directory,"
   INPUT "or else enter the new drive and path. ", dp$

   IF dp$ = "" THEN
      dp$ = drive$
   END IF

   INPUT "Enter the name of the input file with time, height data. "; theight$
END IF

IF datafilename$ = "" THEN
   INPUT "Enter the output filename for corrected hydrograph data (station A).  "; datafilename$
ELSE
   GOTO done:
END IF

CLS
ON ERROR GOTO error1:
OPEN dp$ + datafilename$ FOR INPUT AS #5
ON ERROR GOTO 0
CLOSE #5
PRINT

'File already existed, make selection to overwrite, append or select new name.

IF UCASE$(LEFT$(cont$, 1)) <> "Y" THEN
   COLOR 0, 7
   PRINT dp$ + datafilename$; " already exits."
   COLOR 7, 0
   ans$ = ""

   DO WHILE ans$ <> "Y" AND ans$ <> "A" AND ans$ <> "N"
         INPUT "Enter Y = Overwrite, A = Append, or else N to enter a different name. ", kpress$
         ans$ = UCASE$(kpress$)
   LOOP
   IF ans$ = "N" THEN
       datafilename$ = ""
       GOTO loopagain:
   END IF

   IF ans$ = "Y" THEN
            KILL dp$ + datafilename$
            GOTO proceed:
   END IF

   IF ans$ = "A" THEN
            append$ = "A"
            GOTO proceed:
   END IF

           datafilename$ = ""
           GOTO done:
END IF

proceed:
ON ERROR GOTO 0

IF append$ = "A" OR cont$ = "Y" THEN
         CLOSE #5
         OPEN dp$ + datafilename$ FOR APPEND AS #5
         append$ = ""
ELSE
         OPEN dp$ + datafilename$ FOR OUTPUT AS #5
END IF

done:
```

```
OPEN dp$ + theight$ FOR INPUT AS #4
ct% = 0

ON ERROR GOTO errendfile1:
WHILE NOT EOF(4)
   ct% = ct% + 1
   INPUT #4, hydrographTimes(ct%), hydrographHeights(ct%)

   IF hydrographTimes(ct%) = 0 AND hydrographHeights(ct%) = 0 THEN
      ct% = ct% - 1
      GOTO endfile1:
   END IF

WEND
endfile1:  ON ERROR GOTO 0

CLOSE #4
n = ct%

FOR i = 1 TO n
   hydrographTimes(i) = hydrographTimes(i) + Tdimensional
NEXT i

sumxy = 0
sumx = 0
sumy = 0
sumxi = 0
sumyi = 0
sumx2 = 0
sumy2 = 0
FOR i = 1 TO n
        lht(i) = LOG(hydrographTimes(i))
        lhh(i) = LOG(hydrographHeights(i))
        '
        'Compute the SUMS necessary to calculate the linear regression line.
        '
        sumxy = sumxy + lht(i) * lhh(i)
        sumx = sumx + lht(i)
        sumy = sumy + lhh(i)
        sumxi = sumxi + lht(i) / ct%
        sumyi = sumyi + lhh(i) / ct%
        sumx2 = sumx2 + lht(i) ^ 2
        sumy2 = sumy2 + lhh(i) ^ 2
NEXT i

'CSCP is the computed sum of the cross product.
cscp = sumxy - (sumx * sumyi)
cssx = sumx2 - (sumx * sumxi)
cssy = sumy2 - (sumy * sumyi)
slopem = cscp / cssx
intercept = sumyi - (slopem * sumxi)
corrcoef = ABS(cscp / (cssx * cssy) ^ .5)
Knew = -1 / (slopem)
IF ABS(Knew - k) > .00001 THEN
   CLOSE #4
   k = Knew
   CALL calculate(s, k, h1, h2, L1, H, x1, L, x, t, U, Tdimensional, um, C)
   GOTO loopagain:
ELSE
   GOTO loopout:
END IF

loopout:
```

```
FOR i = 1 TO n
        PRINT #5, USING "#####.### ####.###"; hydrographTimes(i); hydrographHeights(i)
NEXT i

CLS
PRINT USING "Intercept is:                ####.###      "; intercept
PRINT USING "Correlation coefficient (r):    #.###    "; corrcoef
PRINT
PRINT
PRINT "  Mean       Peak       Peak"
PRINT "Velocity    Height     Height     "
PRINT " in the     at 1st     at 2nd     Dist.  "
PRINT " Reach     Station    Station      x        H        L       t         k       C"
PRINT "  (m)        (m)        (m)       (m)      (m)      (m)     (s) "
PRINT "-------------------------------------------------------------------------"
PRINT USING " ##.##     ##.##      ##.##       ###.#  ##.##    ##.## ####.#    #.####  ##.##"; um; h1
PRINT
PRINT
PRINT "Enter (Y)es to send screen to printer (LPT1) else press any key.  "
ans$ = ""
DO WHILE ans$ = ""
  ans$ = INKEY$
LOOP
ans$ = UCASE$(LEFT$(ans$, 1))

IF ans$ = "Y" THEN
   OPEN "lpt1:" FOR OUTPUT AS #10
   PRINT #10, USING "Intercept is:                ####.### "; intercept
   PRINT #10, USING "Correlation coefficient (r):    #.#### "; corrcoef
   PRINT #10, "  Mean       Peak       Peak"
   PRINT #10, "Velocity    Height     Height     "
   PRINT #10, " in the     at 1st     at 2nd     Dist.  "
   PRINT #10, " Reach     Station    Station      x        H        L       t         k       C"
   PRINT #10, "  (m)        (m)        (m)       (m)      (m)      (m)     (s) "
   PRINT #10, "-------------------------------------------------------------------------"
   PRINT #10, USING " ##.##     ##.##      ##.##       ###.#  ##.##    ##.## ####.#    #.####  ##.##"
   PRINT #10, CHR$(12)
   CLOSE #10
END IF

redo2:

INPUT "Do you want to generate a hydrograph (Y/N) ?  "; a$
a$ = UCASE$(LEFT$(a$, 1))
IF a$ <> "N" AND a$ <> "Y" THEN GOTO redo2:
hydrocal:
CLS
IF a$ = "Y" THEN
        PRINT "Enter 1 to calculate theoretical hydrograph at the first station.  "
        PRINT "Enter 2 to calculate theoretical hydrograph at the second station.  "
        PRINT "Enter 3 to calculate theoretical hydrograph at a designated distance"
        INPUT "        from the theoretical point of inception of the debris flow.         ", ch

        SELECT CASE ch!
        CASE 1
           hs = h1
           xx = x
        CASE 2
           hs = h2
           xx = x + L1 / L
        CASE 3
            INPUT "Enter the distance at which you want the hydrograph.  "; x1
            xx = x1 / L
            aa = (k + 1) / (2 * k)
            bb = (1 - k) / (2 * k)
            hs = (-xx + SQR(xx ^ 2 + 4 * aa * bb)) / (2 * bb)
```

```
            hs = hs * H

         CASE ELSE
          GOTO hydrocal:
        END SELECT

CLS
inrow:
INPUT "Enter the number of points on the theoretical hydrograph.  "; row%

IF row% > 150 THEN
   PRINT "Input must be less than or equal to 150."
   GOTO inrow:
END IF

IF row% = 0 THEN
   GOTO inrow:
END IF

            CALL hydro(hs, xx, k, L, U, row%, hydrotheor(), H)
END IF

IF a$ = "Y" THEN
        CLS
redo3:

        INPUT "Would you like to compute another theoretical hydrograph (Y/N)?  "; ans$
        ans$ = UCASE$(LEFT$(ans$, 1))
        IF ans$ <> "N" AND ans$ <> "Y" THEN GOTO redo3:

        IF ans$ = "Y" THEN
           CLS
           GOTO hydrocal:
        END IF

END IF
CLS
IF a$ = "Y" THEN
        PRINT "Enter (Y)es if you would like to correct the data of the "
        PRINT "recorded hydrograph at station B with the calculated value of t,"
        INPUT "otherwise enter (N)o.  "; ans$
        ans$ = UCASE$(LEFT$(ans$, 1))
        IF ans$ <> "Y" THEN GOTO opt:
           INPUT "Enter the input filename of hydrograph data from station B.  "; theight2$
loopagain2:
        INPUT "Enter the output filename for corrected hydrograph data (station B).  "; datafile
        CLOSE #5
        CLS
        ON ERROR GOTO error2:
        OPEN dp$ + datafilename2$ FOR INPUT AS #5
        ON ERROR GOTO 0
        CLOSE #5
        PRINT

        'File already existed, make selection to overwrite, append or select new name.

        IF UCASE$(LEFT$(cont$, 1)) <> "Y" THEN
           COLOR 0, 7
           PRINT dp$ + datafilename2$; " already exits."
           COLOR 7, 0
           ans$ = ""

           DO WHILE ans$ <> "Y" AND ans$ <> "A" AND ans$ <> "N"
                 INPUT "Enter Y = Overwrite, A = Append, or else N to enter a different name. ";
                 ans$ = UCASE$(LEFT$(ans$, 1))
           LOOP
```

```
            IF ans$ = "N" THEN GOTO loopagain2:

            IF ans$ = "Y" THEN
                  KILL dp$ + datafilename2$
                  GOTO proceed2:
            END IF

            IF ans$ = "A" THEN
                  append$ = "A"
                  GOTO proceed2:
            END IF

                  datafilename2$ = ""
                  GOTO done2:
         END IF

proceed2:
         ON ERROR GOTO 0

         IF append$ = "A" OR cont$ = "Y" THEN
                  CLOSE #5
                  OPEN dp$ + datafilename2$ FOR APPEND AS #5
                  append$ = ""
         ELSE
                  OPEN dp$ + datafilename2$ FOR OUTPUT AS #5
         END IF

done2:

         OPEN dp$ + theight2$ FOR INPUT AS #4
         DIM hydrographTimes2(100)
         DIM hydrographHeights2(100)
         ct% = 0
         ON ERROR GOTO errendfile2:

         WHILE NOT EOF(4)
                  ct% = ct% + 1
                  INPUT #4, hydrographTimes2(ct%), hydrographHeights2(ct%)

                  IF hydrographTimes2(ct%) = 0 AND hydrographHeights2(ct%) = 0 THEN
                     ct% = ct% - 1
                     GOTO endfile2:
                  END IF



         WEND

endfile2:  ON ERROR GOTO 0

         CLOSE #4
         n = ct%
         ti = L1 / um

         FOR i = 1 TO n
                  hydrographTimes2(i) = hydrographTimes2(i) + Tdimensional + ti
                  PRINT #5, USING "#####.### ####.###"; hydrographTimes2(i); hydrographHeights2(i)
         NEXT i

END IF

opt:

PRINT "Press Space bar to RUN program again, or any other key to EXIT."
PRINT "";
```

```
s$ = ""

DO WHILE s$ = ""
    s$ = INKEY$
LOOP

'
' ASCII character 32 is the space bar.
'
IF s$ = CHR$(32) THEN
   CLS
    datafilename$ = ""
    datafilename2$ = ""
   CLOSE #1, #2, #3, #4, #5, #6, #7, #8, #9, #10
   GOTO doagn:
ELSE
   CLS
   GOTO done1:
END IF

done1:
CLS
LOCATE 11, 17
COLOR 0, 7
PRINT "                                          "
LOCATE 12, 17
PRINT "                ALL DONE.                 "
LOCATE 13, 17
PRINT "                                          "
COLOR 7, 0
BEEP
BEEP
BEEP
terminate:
CLOSE #1, #2, #3, #4, #5, #6, #7, #8, #9, #10
END

error1:

IF ERR = 53 THEN
        OPEN dp$ + datafilename$ FOR OUTPUT AS #5
        cont$ = "Y"
        RESUME done:
END IF

 PRINT "ERROR DETECTED.  "; ERR
 PRINT "LINE DETECTED.  "; ERL
 PRINT "Debug and restart program."
 GOTO terminate:

error2:

IF ERR = 53 THEN
        OPEN dp$ + datafilename2$ FOR OUTPUT AS #5
        cont$ = "Y"
        RESUME done2:
END IF

 PRINT "ERROR DETECTED.  "; ERR
 PRINT "LINE DETECTED.  "; ERL
 PRINT "Debug and restart program."
 GOTO terminate:

errendfile1:

IF ERR = 62 THEN
```

```
   ct% = ct% - 1
   RESUME endfile1
END IF

PRINT "ERROR DETECTED.  "; ERR
PRINT "LINE DETECTED.  "; ERL
PRINT "Debug and restart program."
GOTO terminate:

errendfile2:

IF ERR = 62 THEN
   ct% = ct% - 1
   RESUME endfile2
END IF

PRINT "ERROR DETECTED.  "; ERR
PRINT "LINE DETECTED.  "; ERL
PRINT "Debug and restart program."
GOTO terminate:


SUB calculate (s, k, h1, h2, L1, H, x1, L, x, t, U, Tdimensional, um, C)
        H = SQR((L1 * s + (k - 1) / (2 * k) * (h1 - h2)) / ((k + 1) / (2 * k) * ((1 / h2) - (1 /
        x1 = 1 / s * ((k + 1) / (2 * k * h1) * H ^ 2 - (1 - k) / (2 * k) * h1)
        L = H / s
        x = x1 / L
        t = (1 - (h1 / H) ^ 2) / (2 * k * (h1 / H) ^ (k + 1))
        CALL manning(h1, h2, s, k, C, um)
        U = C * H ^ k * s ^ .5
        Tdimensional = t * L / U

END SUB

SUB hydro (hs, x, k, L, U, row%, a(), H) STATIC
       ' subroutine to compute heights for
       ' different times at the same x

p = (hs / H) / (row% + 2)
INPUT "Enter the output filename for the theoretical hydrograph (dimensional).  ", filehydro1$

redo4:

INPUT "Do you also want to generate a non dimensional hydrograph (Y/N)  ", kk$
kk$ = UCASE$(LEFT$(kk$, 1))
IF kk$ <> "N" AND kk$ <> "Y" THEN GOTO redo4:
IF kk$ = "Y" THEN
  INPUT "Enter the output filename for theoretical hydrograph (non dimensional).  ", filehydro2$
  OPEN filehydro2$ FOR OUTPUT AS #8
END IF

 OPEN filehydro1$ FOR OUTPUT AS #7

FOR i = 1 TO row%
    a(i, 2) = ((hs / H) - (row% - i) * p)
    a(i, 1) = (x - a(i, 2)) / ((k + 1) * (a(i, 2) ^ k))

    IF kk$ = "Y" THEN
       PRINT #8, USING "#####.### ####.###"; a(i, 1); a(i, 2)
    END IF

    PRINT #7, USING "#####.### ####.###"; a(i, 1) * L / U; a(i, 2) * H
NEXT i
CLOSE #7, #8
END SUB
```