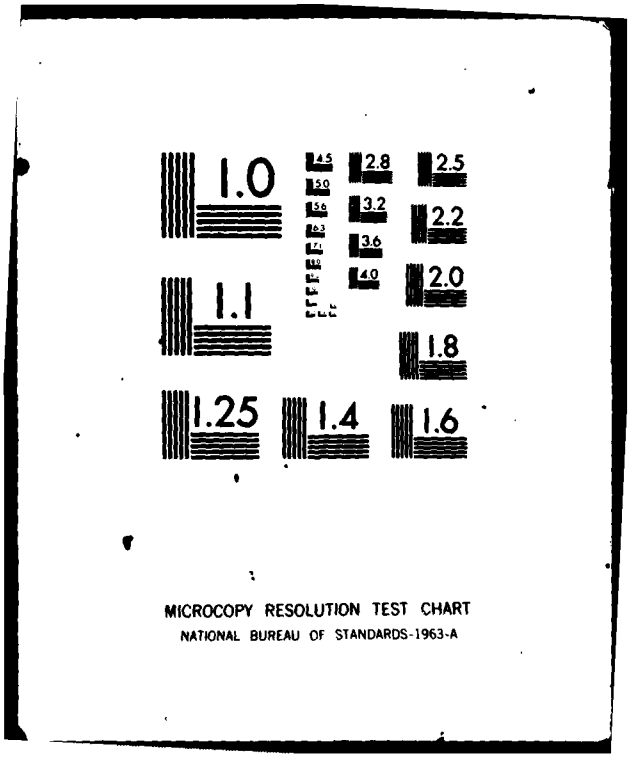
AD-A096 165 ARMY ENGINEER WATERWAYS EXPERIMENT STATION VICKSBURG--ETC F/G 20/4
H6122 - CONJUGATE DEPTH IN A CIRCULAR OPEN CHANNEL - PROGRAM NU--ETC(U)
JUN 78 M T HEBLER

UNCLASSIFIED NL

END
DATE FILMED
4-81
DTIC


1.0
1.1
1.25
1.4
1.6
2.8
2.5
3.2
2.2
3.6
2.0
4.0
1.8
MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

ELECTRONIC COMPUTER PROGRAM ABSTRACT

TITLE OF PROGRAM
H6122 - Conjugate Depth in a Circular Open Channel

PROGRAM CODE NUMBER
722-F3-R0-6AH

PREPARING AGENCY
Hydraulic Analysis Division, Hydraulics Laboratory, U. S. Army Engineer Waterways Experiment Station, P. O. Box 631, Vicksburg, MS 39180

AUTHOR(S)	DATE PROGRAM COMPLETED	STATUS OF PROGRAM	
		PHASE	STAGE
Martin T. Hebler	Jan 1974 Documented Jun 78	Origin	Operational

A. PURPOSE OF PROGRAM

To compute the conjugate depth at a hydraulic jump in a circular open channel.

References: (1) Chow, Ven Te, Open Channel Hydraulics, McGraw-Hill, 1959, pp. 53-56.
(2) Schied, Francis, Numerical Analysis, Schaum's Outline Series, McGraw-Hill, 1968, pp 315-317.

B. PROGRAM SPECIFICATIONS

SEE FOLLOWING PAGE

LEVEL IV

C. METHODS

The program is written in G635 time-share series, FORTRAN IV, and is part of a Conversationally Oriented Real-Time Program-Generating System (CORPS). The program consists of a main program and three subroutines. The main program handles all I/O requirements with the subroutines handling the computation.

D. EQUIPMENT DETAILS

The program was developed and is operational on the WES G635, Vicksburg, MS. It is also operational on HIS 66/80, Macon, GA, and Boeing CDC, Seattle, WA.

E. INPUT-OUTPUT

The required inputs which are entered at execute time are: discharge, cfs; diameter, ft; number of flow depths, and flow depth, ft. The output consists of the given data, plus the flow depth and corresponding conjugate depth in tabular form.

F. ADDITIONAL REMARKS

Complete documentation of this program is available from the Engineer Computer Programs Library, Technical Information Center, WES.

B. PROGRAM SPECIFICATIONS:

Language: ANSI FORTRAN (FORTRAN IV)

Solution Requirements: The run command

RUN WESLIB/CORPS/H6122, R

plus the input variables defined in (E).

Method of Analysis: Solves the momentum equation for the conjugate depth by application of Newton's Tangent Method.

Core Requirements G635: 11 K words

External Storage: None

Restrictions: Velocity distribution is uniform across flow section and the invert slope is small (i.e., < 10 degrees).

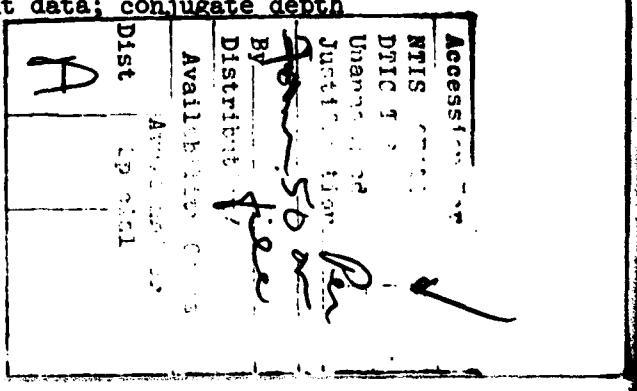
General Equation:

$$A_1\bar{y}_1 + \frac{Q^2}{gA_1} = A_2\bar{y}_2 + \frac{Q^2}{gA_2}$$

where: Q is discharge (cfs), g is acceleration of gravity (32.2 ft/sec^2), A_1 and A_2 are the respective cross-section areas (ft^2) for flow depth and conjugate depth, and $\bar{y}_1$ and $\bar{y}_2$ are the distances (ft) of the centroid of the respective water areas A_1 and A_2 below the water surface.

Range of Quantities: Unlimited for practical application.

Accuracy: Governed by accuracy of input data; conjugate depth computed to ±0.001 ft in H6122.



REF: ER 1110-1-10 - ENGINEERING AND DESIGN - Engineering Computer Program Library Standards and Documentation, Appendix B

PART I: ENGINEERING DESCRIPTION

1. PROGRAM NUMBER: 722-F3-R0-6AH

2. TITLE: H6122 - Conjugate Depth in a Circular Open Channel

3. REVISION LOG: N/A

4. PURPOSE OF PROGRAM: To compute conjugate depth at a hydraulic jump in a circular open channel.

References:

a. Chow, Ven Te, Open Channel Hydraulics, McGraw-Hill, 1959, pp 53-56.

b. Schied, Francis, Numerical Analysis, Schaum's Outline Series, McGraw-Hill, 1968, pp 315-317.

5. STEP SOLUTION:

a. The inputs, discharge (Q) cfs, diameter (D) ft, and flow depth (y_1) ft, are entered.

b. Computational steps:

(1) Specific force (F_1) at y_1 using subroutine H6125

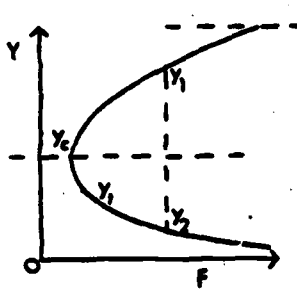
(2) Specific force difference (FD) between that at full conduit flow and F_1

$$FD = \frac{4Q^2}{g\pi D^2} + \frac{\pi D^3}{8} - F_1$$

(3) If FD < 0, the conjugate depth (y_2) > D. The flow depth (y_1) is printed with the message CON DEPTH > DIAMETER. Control is then returned to the main program. If FD $\geq$ 0, then step (4) is entered.

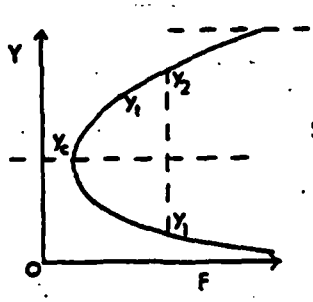
(4) Critical depth (y_c) using subroutine H6141

(5) Determine trial conjugate depth (y_t) . If $y_c < y_1$, then $y_t = \frac{y_c}{2}$



SPECIFIC FORCE CURVE

If $y_c = y_1$, then conjugate depth (y_2) is equal to y_c ; y_2 is returned to the main program. If $y_c > y_1$, then $y_t = \frac{D + y_c}{2}$



SPECIFIC FORCE CURVE

(6) Specific force (F_t) and area (A_t) at y_t using subroutine H6125

(7) Define function $F(y_t)$ to be used for Newton's Tangent Method

$$F(y_t) = F_t - F_1$$

(8) First derivative of $F(y_t)$ with respect to y_t

$$\frac{d}{dy_t} F(y_t) = A_t - \frac{2Q^2}{gA_t^2} (y_t D - y_t^2)^{1/2}$$

(9) Conjugate depth (y_2) is calculated using Newton's Tangent Method

$$y_2 = y_t - \frac{F(y_t)}{\frac{d}{dy_t} F(y_t)}$$

(10) If $y_2 \leq 0.0$, then $y_t = \frac{y_c}{2^m}$, where $m = 2,3,\ldots$, depending on the number of times the condition $y_2 \leq 0.0$ occurs. Transfer is to step (6) and the process is repeated until $y_2 > 0.0$. Step (11) is then entered.

(11) If $y_2 > D$, then $y_t = D - \frac{D - y_c}{2^m}$, where $m = 2,3,\ldots$, depending on the number of times the condition $y_2 > D$, occurs. Transfer is to step (6) and the process is repeated until $y_2 \leq D$. Step (12) is then entered.

(12) If $|y_2 - y_t| \geq .001$, then y_t is set equal to y_2 and the procedure transfers to step (6) and is repeated until the $|y_2 - y_t| < .001$. When $|y_2 - y_t| < .001$, then the value of the conjugate depth (y_2) is returned to the main program.

c. The given data, plus the conjugate depth, are printed.

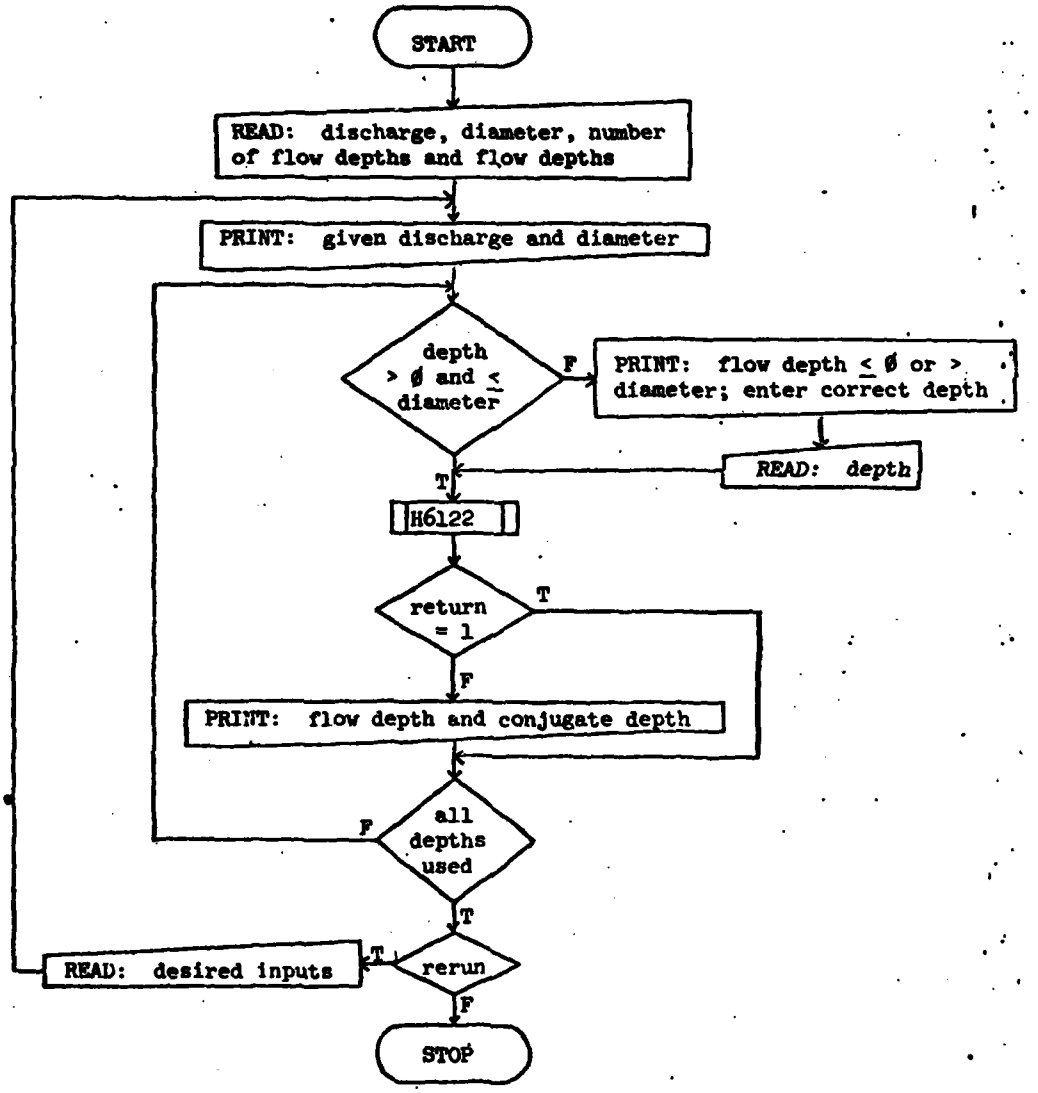
6. ACCURACY: Governed by accuracy of input data; conjugate depth is computed to $\pm$.001 ft.

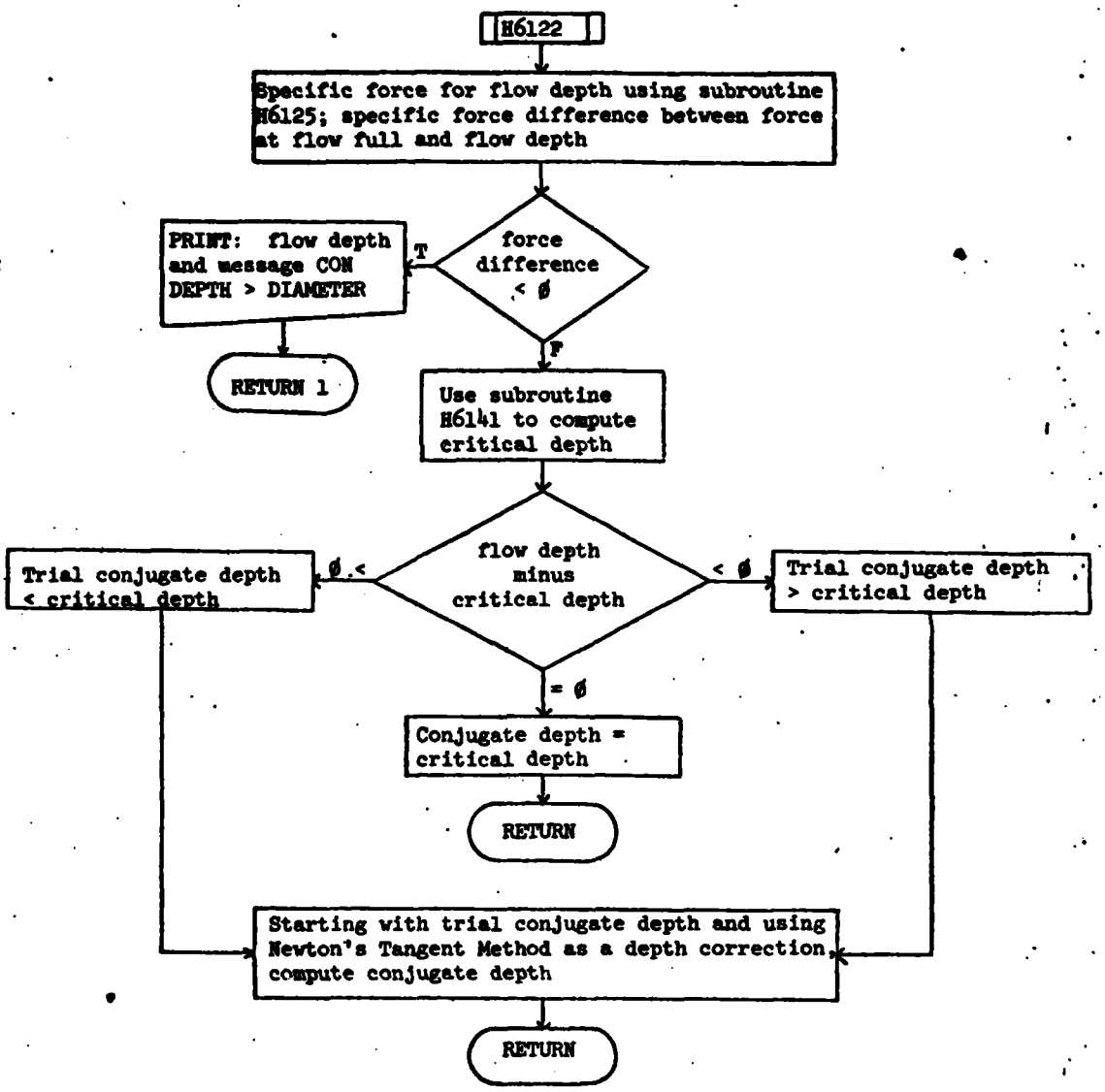
7. REMARKS: Velocity distribution is uniform across flow section and the invert slope is small (i.e., < 10 degrees).

PART II: COMPUTER FUNCTIONAL DESCRIPTION

1. REVISION LOG: N/A

2. FUNCTIONAL FLOW CHART:




H6122
Specific force for flow depth using subroutine H6125; specific force difference between force at flow full and flow depth
force difference < ∅
T
PRINT: flow depth and message CON DEPTH > DIAMETER
RETURN 1
F
Use subroutine H6141 to compute critical depth
flow depth minus critical depth
∅ <
Trial conjugate depth < critical depth
< ∅
Trial conjugate depth > critical depth
= ∅
Conjugate depth = critical depth
RETURN
Starting with trial conjugate depth and using Newton's Tangent Method as a depth correction, compute conjugate depth
RETURN

3. EQUIPMENT AND OPERATING SYSTEM: The program was developed on a G635 timeshare system in which input/output equipment consisted of a Model 33 remote teletype. It is now operational on the WES G635, Vicksburg, MS; HIS 66/80, Macon, GA; and Boeing CDC, Seattle, WA.

4. INPUT REQUIREMENTS: The required inputs are entered via the user's time-share terminal device in free field format. All input cues and reads are performed in the main program. The subroutines handle the computations. Since computations are done in the subroutine, and subroutines H6125 and H6141 are subordinate to H6122, the necessary inputs to subroutine H6122 are passed via the CALL statement. The calling sequence is:

$$\text{CALL H6122}(arg_1,\ldots,arg_4, \$N)$$

where:

arg_1 - discharge, cfs

arg_2 - diameter, ft

arg_3 - flow depth, ft

arg_4 - conjugate depth, ft

$N - N is a statement number for the nonstandard return due to conjugate depth > diameter

All arguments are floating point, except N, which is integer. Arguments 1-3 are inputs and arg_4 is output. N is a STATEMENT NUMBER which directs the return from the subroutine to that STATEMENT NUMBER in the main program.

5. SECONDARY STORAGE INPUT: None

6. INPUT DATA DESCRIPTION: The following names are used for the input variables in program H6122.

DISCH - discharge, cfs (arg_1)

DIAMTR - diameter, ft (arg_2)

N - number of flow depths, integer

Y - flow depth, ft (arg_3)

7. OUTPUT DATA DESCRIPTION: The following names are used for the output variables in program H6122.

DEPTH2 - conjugate depth, ft (arg_4)

8. PROGRAM ERROR MESSAGES:

a. In the main program, if the flow depth is $\leq$ 0 or > diameter the following message is printed:

FLOW DEPTH 6.00 ft < OR = 0 OR > DIAMETER

The message is repeated until a valid flow depth is entered.

b. In subroutine H6122, the value of the flow depth is printed and then the message CON DEPTH > DIAMETER is printed on the same line.

For example: 1.20 CON DEPTH > DIAMETER

Return is then to the statement number in the main program specified by N in the CALL statement.

9. VARIABLE DEFINITIONS:

N - number of flow depths, $0 < N \leq 25$

y - flow depth, ft; dimensioned max 25

DEPTH1 - flow depth, ft; equal to Y(I) for I = 1,...,N

CRIT - critical depth, ft; returned from subroutine H6141

DEPTH2 - conjugate depth, ft

DEPTHT - trial conjugate depth, ft

DIAMTR - diameter, ft

DISCH - discharge, cfs

F - function of trial conjugate depth used for Newton's Tangent Method, ft^3; the value of the function is a specific force difference between that at trial conjugate depth and flow depth

FP - first derivative of function (F) with respect to trial conjugate depth, ft^2

FORCE - specific force, ft^3; returned from subroutine H6125

F1 - working storage to hold FORCE at a constant when FORCE is returned from H6125 as the specific force at flow depth, ft^3

FMAX - specific force difference between that at full conduit flow and flow depth, ft^3

G - acceleration of gravity, 32.2 ft/sec^2

HFILE - five character name of program; passed to WESLIB count routine HACCT

LQZ - equal 1, execute all input cues and reads; equal 2, call WESLIB routine RERUN and enter only desired inputs

LQX - equal 1, print instructions from RERUN; equal 3, no print

JKL - direct return from RERUN to desired input read

KKK - total number of inputs; passed to RERUN

M - powers of 2 to converge Newton's Tangent Method if trial conjugate depth ≤ 0 or $>$ diameter

PI - constant for π; value = 3.14159265

WK1 - working storage = $\frac{\text{Top Width}}{2}$; returned from subroutine H6125

ZZZZZ - character; equal RE, rerun; equal ST, stop

10. EXAMPLE CASE: Compute the conjugate depth for 6 given flow depths.

a. Input data:

Discharge (DISCH) = 100.00 cfs

Diameter (DIAMTR) = 5.00 ft

Number of flow depths (N) = 6

Flow depths (Y(I), for I = 1,N) = 1.00, 1.43, 2.50, 4.00, 4.50, and 5.00 ft

b. Output:

```
INPUT  H6122-CONJUGATE DEPTH(S) IN A CIRCULAR OPEN CHANNEL

AA-ENTER DISCHARGE,CFS.
=100
AB-ENTER DIAMETER,FT.
=5
AC-ENTER THE NUMBER OF DEPTH(S) FOR WHICH THE CONJUGATE DEPTH IS TO BE
CALCULATED. MUST NOT EXCEED 25 DEPTHS.
=6
AD-ENTER THE  6 DEPTH(S) SEPARATED BY COMMAS.
=1,1.43,2.5,4,4.5,5

OUTPUT  H6122-CONJUGATE DEPTH(S) IN A CIRCULAR OPEN CHANNEL

DISCHARGE =        100.00 CFS
DIAMETER =          5.00 FT

   FLOW      CONJUGATE
   DEPTH       DEPTH
   (FT)        (FT)
   1.00    CON DEPTH > DIAMETER
   1.43    CON DEPTH > DIAMETER
   2.50        3.23
   4.00        1.97
   4.50        1.72
   5.00        1.52

ENTER RERUN OR STOP
=STOP
```

REF: ER 1110-1-10 - ENGINEERING AND DESIGN - Engineering and Computer Program Library Standards and Documentation, Appendix C

PART III: FILE DOCUMENTATION

1. REVISION LOG: N/A

2. TITLE: H6122 - Conjugate Depth in a Circular Open Channel

3. SOURCE PROGRAM LISTINGS: See pages 12-15

4. NUMERICAL AND LOGICAL ANALYSIS: Solves the momentum equation for the conjugate depth by application of Newton's Tangent Method.

5. SUBROUTINES NOT DOCUMENTED IN ABSTRACT: The following subroutines are used in program H6122.

a. SUBROUTINE H6125 (DISCH, DIAMTR, DEPTH, A, WK1, FORCE)

The subroutine statement for H6125 as documented in program H6125 is:

SUBROUTINE H6125 (DISCH, DIAMTR, DEPTH, ENERGY, FORCE)

The argument list was changed to (a.) to facilitate the solution of program H6122. This change has no effect on H6125 as documented.

b. SUBROUTINE H6141 (DISCH, DIAMTR, DEPTH, CRIVEL)

Complete documentation of these subroutines is available from the Engineer Computer Program Library, Technical Information Center, WES.

6. Miscellaneous: The program is part of the CORPS computer system. CORPS is an acronym standing for Conversationally Oriented Real-Time Program-Generating System. The program is now operational on the WES G635, Vicksburg, MS; HIS 66/80, Macon, GA; and Boeing CDC, Seattle, WA.

The source listing on page 12 contains the first line run command and brief for H6122. This first line run command runs the binary H6122B of the source listing on pages 13-15 (Fortran source of H6122) and attaches the WESLIB routines HACCT and RERUN.

```
0001*#RUN WESLIB/CORPS/H6122B,R;WESLIB/RERUN,R;WESLIB/HACCT,R
0800 63THIS PROGRAM COMPUTES CONJUGATE DEPTH(S) IN A CIRCULAR CHANNEL.
0805 36VELOCITY DISTRUBUTION COEF. = UNITY.
0810 61  INPUTS REQUIRED ARE DISCHARGE-CFS, DIAMETER-FT, AND FLOW
0815 09DEPTH-FT.
0820 53  OUTPUT INCLUDES THE GIVEN DATA AND CONJUGATE DEPTH
0825 58  IF CONJUGATE DEPTH > DIAMETER,THEN THE VALUE OF THE FLOW
0830 55DEPTH IS PRINTED AND THE MESSAGE  CON DEPTH > DIAMETER.
0999*06FINISH
```

```
00001*$RUN *=;/CORPS/H6122B(NOGO)
10000 CHARACTER*5 HFILE
10010 DIMENSION Y(25)
10020 HFILE=5HH6122
10030 LQZ=1;LQX=1
10040 15000 CONTINUE
10045 PRINT 10050
10050 10050 FORMAT(/"INPUT  H6122-CONJUGATE DEPTH(S) IN A CIRCULAR OPEN
10055&CHANNEL"//)
10060 CALL HACCT(HFILE)
10070 GO TO(15003,15016),LQZ
10080 15003 PRINT 15004
10090 15004 FORMAT("AA-ENTER DISCHARGE,CFS.")
10100 15005 READ,DISCH
10110 GO TO(15007,15016),LQZ
10120 15007 PRINT,"AB-ENTER DIAMETER,FT."
10130 15008 READ,DIAMTR
10140 GO TO(15010,15016),LQZ
10150 15010 PRINT 15111
10155 15111 FORMAT("AC-ENTER THE NUMBER OF DEPTH(S) FOR WHICH THE CONJUG
10157&ATE DEPTH IS TO BE"/"CALCULATED. MUST NOT EXCEED 25 DEPTHS.")
10160 15011 READ,N
10170 GO TO(15013,15016),LQZ
10180 15013 PRINT 15113,N
10185 15113 FORMAT("AD-ENTER THE ",I2," DEPTH(S) SEPARATED BY COMMAS.")
10190 15014 READ,(Y(I),I=1,N)
10200 GO TO(15019,15016),LQZ
10210 15016 KKK=4
10220 CALL RERUN(KKK,LQX,JKL)
10230 GO TO(15005,15008,15011,15014,15019),JKL
10240 15019 PRINT 15020,DISCH,DIAMTR
10250 15020 FORMAT(/"OUTPUT  H6122-CONJUGATE DEPTH(S) IN A CIRCULAR OPEN
10255& CHANNEL"//"DISCHARGE = ",F13.2," CFS"/"DIAMETER = ",F13.2," FT"//
10260&4X,"FLOW",5X,"CONJUGATE"/4X,"DEPTH",6X,"DEPTH"/4X,"(FT)",7X,"(FT)"
10270&)
10280 DO 15027 I=1,N
10290 DEPTH1=Y(I)
10300 CALL H6122(DISCH,DIAMTR,DEPTH1,DEPTH2,$15027)
10310 PRINT 15028,DEPTH1,DEPTH2
10320 15027 CONTINUE
10330 15028 FORMAT(F8.2,F11.2)
10340 PRINT," "
10350 LQZ=2
10360 CHARACTER ZZZZZZ*2
10370 16000 PRINT, "ENTER RERUN OR STOP"
10380 READ 16001, ZZZZZZ
10390 16001  FORMAT(A2)
10400 IF(ZZZZZZ.EQ.2HRE) GO TO 15000
10410 IF(ZZZZZZ.EQ.2HST) GO TO 20000
10420 PRINT,"ERROR *** RETYPE"
```

```
10430 GO TO 16000
10440 20000  STOP;END
20000 SUBROUTINE H6122(DISCH,DIAMTR,DEPTH1,DEPTH2,*)
20010 G=32.2;PI=3.14159265;N=2
20020 CALL H6125(DISCH,DIAMTR,DEPTH1,AREA,WK1,FORCE)
20030 F1=FORCE
20040 FMAX=PI*DIAMTR**3/8.+4.*DISCH**2/(G*PI*DIAMTR**2)-F1
20050 IF(FMAX) 10050,10080,10080
20060 10050 IF(DIAMTR-DEPTH1) ,10080,
20070 PRINT 10060,DEPTH1;RETURN 1
20080 10060 FORMAT(F8.2,"   CON DEPTH > DIAMETER")
20090 10080 CALL H6141(DISCH,DIAMTR,CRIT,CV)
20100 IF(CRIT-DEPTH1) 10100,10110,10120
20110 10100 DEPTHT=CRIT/N;N=2*N;GO TO 10130
20120 10110 DEPTH2=CRIT;RETURN
20130 10120 DEPTHT=DIAMTR-(DIAMTR-CRIT)/N;N=2*N
20140 10130 CALL H6125(DISCH,DIAMTR,DEPTHT,AREA,WK1,FORCE)
20150 F=FORCE-F1
20160 FP=AREA-2.*DISCH**2*WK1/(G*AREA**2)
20170 DEPTH2=DEPTHT-F/FP
20180 IF(DEPTH2.LE.0.) GO TO 10100
20190 IF(DEPTH2.GT.DIAMTR) GO TO 10120
20200 IF(ABS(DEPTH2-DEPTHT).LT..001) RETURN
20210 DEPTHT=DEPTH2;GO TO 10130
20220 END
30000 SUBROUTINE H6125(DISCH,DIAMTR,DEPTH,A,WK1,FORCE)
30010 G=32.2;WK1=SQRT(DEPTH*DIAMTR-DEPTH**2)
30020 WK2=2.*DEPTH-DIAMTR;WK3=ARCOS(-WK2/DIAMTR)
30030 A=WK1*WK2/2.+WK3*DIAMTR**2/4.
30040 AY=WK1*(DEPTH**2/3.-DEPTH*DIAMTR/3.+DIAMTR**2/4.)+DIAMTR**2*WK2*W
30050&K3/8.
30060 ENERGY=DEPTH +DISCH**2/(2.*G*A**2)
30070 FORCE=AY+DISCH**2/(G*A)
30080 RETURN
30090 END
40000 SUBROUTINE H6141(DISCH,DIAMTR,DEPTH,CRIVEL)
40010 DEPTH=DIAMTR/2.
40020 G=32.2
40030 SFAC=DISCH/SQRT(G)
40040 5 CALL H6125(DISCH,DIAMTR,DEPTH,AREA,WK1,FORCE)
40050 SECFAC=AREA*SQRT(AREA/(2.*WK1))
40060 DY=DEPTH/(SFAC/SECFAC)-DEPTH
40070 IF(DY.GT.-0.01.AND.DY.LT.0.01) GO TO 10
40080 DY=DY/2.
40090 DEPTHC=DEPTH-DY
40100 IF(DEPTHC.LE.0.0.OR.DEPTHC.GE.DIAMTR) DEPTHC=DEPTH/2.
40110 DEPTH=DEPTHC
40120 GO TO 5
40130 10 CRIVEL=DISCH/AREA
40140 RETURN
```

```
40150 END
```


DATE
ILME