MODEIN2 AND COLBY:
COMPUTER CODES FOR SEDIMENT
TRANSPORT COMPUTATIONS

by

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Engineering Sciences
JUL 1 1983
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</tr>
<tr>
<td></td>
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<td>29</td>
</tr>
</tbody>
</table>
I. MODEIN2:

The Modified Einstein Procedure
1. INTRODUCTION

Program MODEIN2 computes the total sediment load and its size distribution in sandbed channels. The procedure used is the Modified Einstein Procedure (MEP) developed by the U.S. Geological Survey [1] and the U.S. Bureau of Reclamation [2,3]. Essentially, the MEP is based on the direct measurement of hydraulic quantities, bed-material size and the suspended load (except within a small distance near the bed) in an alluvial channel. The procedure extrapolates the sediment discharge in the unmeasured zone, thus calculating the total sediment load. The MEP has the same phenomenological structure as Einstein's Bed-Load function [4] with some modifications in the empirical components.

The sediment load computation by the MEP is more accurate than by other computational methods, mainly because the MEP is based on the direct measurement of the hydraulic and sediment transport quantities. This is especially true in sandbed channels where a large proportion of the total sediment load is transported in the sampled zone and is actually measured. The MEP is only applicable where the basic hydraulic and sedimentation parameters have been measured in the field.

2. MAIN FEATURES OF MODEIN2

Program MODEIN2 basically follows the computational procedure outlined in reference (2). However, in order to make the program more reliable, two additional features have been included:

1) The calculation of the Rouse number for fractions other than the reference size is based on the correction suggested on reference (3).

2) The integral functions that are used in the procedure are evaluated by using the algorithm developed by Li (5). The method consists of expanding the integral functions in the form of power series.
With this approach, the computer time is considerably reduced, and the desired degree of accuracy can be selected by the user to satisfy the needs of a particular problem. In the analysis of several test runs with different values of the convergence parameter CONV, a value of CONV=0.01 has generally been found to satisfy both accuracy and computer time requirements.

3. INPUT-OUTPUT DESCRIPTION

MODEIN2 can be set up to read and analyze as many runs as needed. For each series of runs analyzed at one time, the program provides an option to use either the 1:2 ratio sieve sizes in reference [2] or any other series specified by the user.

The output can be limited to the sedimentation quantities related to total load, or extended to print additional hydraulic parameters and intermediate computational values.

Details of input-output controls follow:

A) NUMBER OF SETS CARD. This is the first card in the input record and contains the value of NDATA in format I5. NDATA is the number of sets to be analyzed at one time. Each set of input data consists of a group of variables related to one observation, as detailed below. It should be emphasized that one observation may relate to the computation of the sediment load in the whole of the cross section or the load in a subsection or a vertical, as the case may be.

This first card is to be followed by the individual sets of input data, each consisting of the following.

B-1) GENERAL DATA CARDS. Two cards should be used for the input of the general data (13 variables in format 8F10.0).
The following names are used for the variables:

<table>
<thead>
<tr>
<th>VARIABLES</th>
<th>FORTRAN NAME</th>
<th>UNITS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Water Discharge</td>
<td>DISCH</td>
<td>cu ft per sec</td>
</tr>
<tr>
<td>Average Velocity</td>
<td>UAVE</td>
<td>ft per sec</td>
</tr>
<tr>
<td>Hydraulic Depth</td>
<td>DEPTH</td>
<td>ft</td>
</tr>
<tr>
<td>Water Surface Width</td>
<td>W</td>
<td>ft</td>
</tr>
<tr>
<td>Area of Cross-Section</td>
<td>AREA</td>
<td>sq ft</td>
</tr>
<tr>
<td>Temperature</td>
<td>TEMP</td>
<td>°F</td>
</tr>
<tr>
<td>Kinematic Viscosity</td>
<td>XNU</td>
<td>sq ft per sec</td>
</tr>
<tr>
<td>65 Percent Finer Diameter</td>
<td>D65</td>
<td>ft</td>
</tr>
<tr>
<td>for Bed Material</td>
<td></td>
<td></td>
</tr>
<tr>
<td>35 Percent Finer Diameter</td>
<td>D35</td>
<td>ft</td>
</tr>
<tr>
<td>for Bed Material</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Average Concentration</td>
<td>CONC</td>
<td>ppm</td>
</tr>
<tr>
<td>Sampled Suspended Load</td>
<td>QSM</td>
<td>tons per day</td>
</tr>
<tr>
<td>Portion of Depth Not Sampled</td>
<td>DN</td>
<td>ft</td>
</tr>
<tr>
<td>Average Depth of Sampling</td>
<td>DS</td>
<td>ft</td>
</tr>
</tbody>
</table>

B-2) INPUT-OUTPUT OPTIONS CARD. The values of JIN and JOUT should be punched in format 211 according to the following options:

JIN: Selects the number and range in the size fractions that will be analyzed. ND is the number of fractions. The following options can be used:

JIN=1 The size fractions utilized in reference (2) will be used. In this case, the first two size fractions will be used and the third one deleted, hence resulting in ND=10

JIN=2 The size fractions mentioned in reference (2) will also be used, but the first two size fractions will be deleted and the third one used instead, resulting in ND=9.

JIN=3 The user has the option of specifying the number and range of the size fractions to be computed, up to nine fractions. If this option is chosen, then ND should be read immediately after the input-output card, in format I1. Also, changes in the data arrays should be made, as will be detailed below (see B-3).

JOUT: Selects the type of output desired. The following options can be used for JOUT:
JOUT=1 In this case, the output will consist of the general data, the check on convergence of $Z$ prime and the final results in 20 columns, as follows:

1) Geometric mean diameter, in ft
2) PSI
3) PHI shear
4) Percentage of bed material in size fraction
5) Bed load transport, in tons/day
6) Percentage of suspended load in size fraction
7) Sampled transport in size fraction
8) Multipliers
9) $A'$ values
10) $A''$ values
11) Geometric mean diameter, in ft
12) $J'$ one prime
13) $J'$ two prime
14) $J'$ one double prime
15) $J'$ two double prime
16) Product of $J$'s
17) $I'$ one double prime
18) $I'$ two double prime
19) Product of $I$'s
20) Computed load, in tons/day

JOUT=2 Only columns 1, 4, 5, 6 and 20 will be printed and the rest will be omitted. Additionally, the lower and upper limits of the size fraction range, in mm, $DRL(J)$ and $DRU(J)$, will be printed on the left side of the five previously mentioned columns.

B-3) DATA ARRAYS CARDS. The number of cards and the input depends on the value of JIN.

JIN=1 Ten cards are required in this case, each containing both the values of the fraction of bed material $FB(J)$ and the fraction of suspended load $FS(J)$ punched in format 2F10.0, for each particular size range.

JIN=2 The input consists of nine cards with the same information as in JIN=1 punched in format 2F10.0.

JIN=3 In addition to the percentages $FB(J)$ and $FS(J)$, the range of the computational size fractions should be specified. Hence, $DRL(ND)$,
DRU(ND), FB(ND) and FS(ND) should be punched in format 4F10.0, being
DRL(J) and DRU(J) the lower and upper limits of each particular size
fraction range in mm respectively. Note that size fractions should be
punched in the order of increasing size.

A sequence of three runs is illustrated for the following job setup.
Different integer selections for JIN and JOUT have been used for illus-
tration. The corresponding output follows the data card assembly
example.
4. FORTRAN NAMES FOR INPUT AND OUTPUT VARIABLES

**INPUT**

- Water discharge: DISCH
- Average velocity: UAVE
- Hydraulic depth: DEPTH
- Water surface width: W
- Area: AREA
- Temperature: TEMP
- Kinematic viscosity: XNU
- 65 percent finer diameter for bed-material: D65
- 35 percent finer diameter for bed-material: D35
- Average concentration: CONC
- Sampled suspended load: QSM
- Portion of depth not sampled: ON
- Average depth of sampling: DS

**OUTPUT**

- Geometric mean diameter, in ft: D(J)
- PSI: PSI(J)
- PHI shear: PHISH(J)
- Percentage of bed-material in size fraction: FB(J)
- Bed-load transport, in tons/day: XIBQB(J)
- Percentage of suspended load in size fraction: FS(J)
- Sampled transport in size fraction: QSP(J)
- Multipliers: XMULT(J)
- Z prime values: ZP(J)
- A double prime values: APP(J)
- Geometric mean diameter, in ft: D(J)
- J-one prime: COL16(J)
- J-two prime: COL17(J)
- J-one double prime: COL18(J)
- J-two double prime: COL19(J)
- Product of J's: COL20(J)
- I-one double prime: COL21(J)
- I-two double prime: COL22(J)
- Product of I's: COL23(J)
- Computed load, in tons/day: FQL(J)
- Trial Z: ZTRY
- Real Q_s': RQSP
- Computed Q_s': CRQSP
- Difference of real and computed Q_s': DCRQ
- Settling velocity: VS(J)
- Total bed load: TBL
- Total suspended bed material load: TSL
- Total bed material load: TQL
5. EXAMPLES

Setup of Data Cards for MODEIN2
COMPUTATION OF TOTAL SEDIMENT LOAD BY THE MODIFIED EINSTEIN PROCEDURE

DATA INPUT

<table>
<thead>
<tr>
<th>SET</th>
<th>1</th>
</tr>
</thead>
<tbody>
<tr>
<td>WATER DISCHARGE</td>
<td>230.00 C.F.S.</td>
</tr>
<tr>
<td>AVERAGE VELOCITY</td>
<td>2.08 FT./SEC.</td>
</tr>
<tr>
<td>HYDRAULIC DEPTH</td>
<td>1.94 FT.</td>
</tr>
<tr>
<td>WATER SURFACE WIDTH</td>
<td>111.00 FT.</td>
</tr>
<tr>
<td>AREA</td>
<td>113.00 SQ.FT.</td>
</tr>
<tr>
<td>TEMPERATURE</td>
<td>64.00 DEG. FAHREN.</td>
</tr>
<tr>
<td>KINEMATIC VISCOSITY</td>
<td>.0000114 SQ.FT./SEC.</td>
</tr>
<tr>
<td>D35</td>
<td>.000750 FT.</td>
</tr>
<tr>
<td>AVERAGE CONCENTRATION</td>
<td>.30 FT.</td>
</tr>
<tr>
<td>SAMPLED SUSPENDED LOAD</td>
<td>163.0000 TONS/DAY</td>
</tr>
<tr>
<td>PORTION OF DEPTH NOT SAMPLED</td>
<td>.10 FT.</td>
</tr>
<tr>
<td>AVERAGE DEPTH AT SAMPLING</td>
<td>1.22 FT.</td>
</tr>
</tbody>
</table>

CONVERGENCE OF SUBROUTINE ZPCOM IS CHECKED BY PRINTING OUT VALUES INVOLVED

<table>
<thead>
<tr>
<th>ITER.</th>
<th>ZTRY</th>
<th>RQSP</th>
<th>CRQSP</th>
<th>DCRQ</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

ITER. ZTRY RQSP CRQSP DCRQ
1 1.19938 .43475 .43227 .00248
2 1.26422 .27654 .35925 .08271
3 1.31664 .27654 .28385 .00731

ARAYS ZP AND VS BEFORE LEAST SQUARE FIT

<table>
<thead>
<tr>
<th>J</th>
<th>ZP(J)</th>
<th>VS(J)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>.79943</td>
<td>.067624</td>
</tr>
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<td>4</td>
<td>.12930</td>
<td>.152940</td>
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<tr>
<td>5</td>
<td>1.316644</td>
<td>.258550</td>
</tr>
</tbody>
</table>

ARAYS ZP AND VS AFTER LEAST SQUARE FIT
<table>
<thead>
<tr>
<th>J</th>
<th>D(J)</th>
<th>PSI(J)</th>
<th>PHISH(J)</th>
<th>FB(J)</th>
<th>XI8Q8(J)</th>
<th>FS(J)</th>
<th>QSP(J)</th>
<th>XMULT(J)</th>
<th>ZP(J)</th>
<th>APP(J)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0.000037</td>
<td>5.489</td>
<td>5.1128</td>
<td>0.000</td>
<td>0.000</td>
<td>0.000</td>
<td>0.000</td>
<td>0.000</td>
<td>0.000</td>
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<tr>
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<td>0.000</td>
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<td>0.000</td>
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<tr>
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<tr>
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<td>0.037118</td>
<td>5.489</td>
<td>5.1128</td>
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<td>0.000</td>
<td>0.000</td>
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<td>0.000</td>
<td>0.000</td>
<td>0.000</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>J</th>
<th>D(J)</th>
<th>COL16(J)</th>
<th>COL17(J)</th>
<th>COL18(J)</th>
<th>COL19(J)</th>
<th>COL20(J)</th>
<th>COL21(J)</th>
<th>COL22(J)</th>
<th>COL23(J)</th>
<th>COMP+LOAD</th>
</tr>
</thead>
<tbody>
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<td>1</td>
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<td>0.00000</td>
<td>0.00000</td>
<td>0.00000</td>
</tr>
<tr>
<td>7</td>
<td>0.01950</td>
<td>0.00000</td>
<td>0.00000</td>
<td>0.00000</td>
<td>0.00000</td>
<td>0.00000</td>
<td>0.00000</td>
<td>0.00000</td>
<td>0.00000</td>
<td>0.00000</td>
</tr>
<tr>
<td>8</td>
<td>0.037118</td>
<td>0.00000</td>
<td>0.00000</td>
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<td>0.00000</td>
<td>0.00000</td>
<td>0.00000</td>
<td>0.00000</td>
<td>0.00000</td>
</tr>
</tbody>
</table>

**TOTAL BED LOAD** 42.4046 TONS/DAY
**TOTAL SUSPENDED LOAD** 449.0211 TONS/DAY
**TOTAL LOAD** 491.4246 TONS/DAY
COMPUTATION OF TOTAL SEDIMENT LOAD BY THE MODIFIED EINSTEIN PROCEDURE

DATA INPUT

SET 2
WATER DISCHARGE 16300.0 C.F.S.
AVERAGE VELOCITY 4.11 FT./SEC.
HYDRAULIC DEPTH 10.20 FT.
WATER SURFACE WIDTH 384.00 FT.
AREA 3968.00 SQ.FT.
TEMPERATURE 62.00 DEG.F.
KINEMATIC VISCOSITY 0.000104 SQ.FT./SEC.
0.000073 FT.
0.00050 FT.
AVERAGE CONCENTRATION 1160.00 PPM.
SAMPLED SUSPENDED LOAD 51051.6000 TONS/DAY
PORTION OF DEPTH NOT SAMPLED 0.00 FT.
AVERAGE DEPTH AT SAMPLING 9.70 FT.

CONVERGENCE OF SUBROUTINE ZPCOM IS CHECKED BY PRINTING OUT VALUES INVOLVED

ITEM ZTRY RQSP CRQSP DCKQ

DRL(J) DRU(J) D(J) F8(J) X18Q8(J) FS(J) FQL(J)

0.00200 0.06250 0.00037 0.000000 0.000000 0.000000 40986.697
0.06250 0.12500 0.00290 0.040000 7.651876 0.100000 9178.504
0.12500 0.25000 0.00580 0.060000 443.675863 0.100000 11992.569
0.25000 0.50000 0.01160 0.140000 214.292539 0.000000 746.373

TOTAL BED LOAD 665.813 TONS/DAY
TOTAL SUSPENDED LOAD 61829.5613 TONS/DAY
TOTAL LOAD 62494.1426 TONS/DAY
APPENDIX A: REFERENCES


APPENDIX B:

LISTING
PROGRAM MODEIN2 (INPUT, OUTPUT, TAPE5=INPUT, TAPE6=OUTPUT)

DEVELOPED
COLORADO STATE UNIVERSITY ENGINEERING RESEARCH CENTER, FORT COLLINS, COLORADO, 1972

PURPOSE
COMPUTATION OF TOTAL SEDIMENT DISCHARGE

THE MODIFIED EINSTEIN PROCEDURE

REFERENCES
U.S. NUCLEON OF RECLAMATION PUBLICATION

STEP METHOD FOR COMPUTING TOTAL SEDIMENT LOAD

BY THE MODIFIED EINSTEIN PROCEDURE, JULY 1959

(REVISIb AND ADJUDIMENT) COMPUTATION OF Z FOR USE

IN THE MODIFIED EINSTEIN PROCEDURE, JUNE 1966

COE USAGE
CDC 6400 SCOPE 3.3 SYSTEM DEFAULT VALUE

43000 OCTAL.

CENTRAL PROCESSOR

APPROXIMATELY 8 SEC.

TIME FOR ONE

APPROXIMATELY 1 SEC.

SET OF DATA

INPUT AND OUTPUT DESCRIPTION

THE FIRST CARD IN THE INPUT LOGICAL RECORD SHOULD CONTAIN

THE VALUE OF NO DATA IN FORMAT IS. NO DATA IS THE NUMBER OF SETS

OF INPUT DATA TO BE READ TO THE COMPUTER AT A TIME. A SET OF INPUT

DATA CONSISTS OF A GROUP OF VARIABLES NECESSARY TO SPECIFY

A PROBLEM AS DETAILED BELOW.

THE FIRST CARD IS TO BE FOLLOWED BY THE NUMBER OF SETS OF INPUT

DATA EACH ONE CONSISTING OF THE FOLLOWING. IN THE ORDER SHOWN

(OPTION IS THE SAME AS THAT USED IN REFERENCE B)

1) GENERAL DATA, 13 VARIABLES TO BE PUNCHED IN FORMAT (8F10,0)

FOLLOWING IS A LIST OF THE VARIABLES. FOR THOMAN AND UNITS

WATER DISCHARGE

AVERAge VELOCITY

HYDRAULIC DEPTH

AREA

THERMAL VISCOSITY

65 PERCENT FINEST DIAMETER

35 PERCENT FINEST DIAMETER

AVERAGE CONCENTRATION

SAMPLED SUSPENDED LOAD

PORTION DEPTH NOT SAMPLED

AVERAGE DEPTH OF SAMPLING

2) INTEGER SELECTORS JIN AND JOUT TO BE PUNCHedin FORMAT 211.

JIN SELECTS THE NUMBER AND RANGE IN THE COMPUTATIONAL

SIZE FRACTIONS. NO IS THE NUMBER OF SIZE FRACTIONS.

IF JIN=1, THE SIZE FRACTIONS IN THE USBP PUBLICATION WILL BE

USED. THE FIRST TWO SIZE FRACTIONS WILL BE USED AND THE THIRD

DELETED, RESULTING IN NO 1. NO IS THE NUMBER OF SIZE FRACTIONS

USED. IN THIS CASE THE FIRST TWO SIZE FRACTIONS WILL BE DELETED

AND THE THIRD USED INSTEAD RESULTING IN NO 3. NO IS THE NUMBER

OF SIZE FRACTIONS. IF THIS OPTION IS CHOSEN, NO SHOULD BE READ IN THE CARD IMMEDIATELY FOLLOWING.

IN FORMAT 11.

JOUT SELECTS THE TYPE OF OUTPUT DESIRED.

IF JOUT=1, OUTPUT WILL CONSIST OF THE GENERAL DATA. CHECK ON

CONVERGENCE OF Z PRIME, AND THE FINAL RESULTS IN 20 COLUMNS AS

FOLLOW.

1) GEOMETRIC MEAN DIAMETER IN FT.

AVERAGE VELOCITY

AVERAGE DEPTH

AVERAGE CONCENTRATION

AVERAGE AREA

YIELD

2) Double Prime Values

3) DATA ARRAYS.
AND PERCENT OF SUSPENDED LOAD IN SIZE FRACTIONS FS(10) SHOULD BE PUNCHED IN FORMAT 2F10.0 IF JIN=2, FH(N) AND FS(N) SHOULD BE PUNCHED IN FORMAT 2F10.0 IF JIN=3, THE VALUE OF COMMUTATIONAL SIZE FRACTIONS SHOULD BE SPECIFIED IN ADDITION TO THE PERCENTAGES FH AND FS.

THIS OPTION IS CHOSEN, UML(NU), UHU(ND), FB(NU) AND FS(ND) SHOULD BE PUNCHED IN FORMAT 2F10.0 DHL(J) AND DHH(J) ARE THE LOWER AND UPPER LIMITS OF THE SIZE FUNCTION VOLUME, IN MUH RESPECTIVELY. NOTE THAT SIZE FRACTIONS SHOULD BE PUNCHED IN ORDER OF INCREASING SIZE.

COMMON /ALL/ DISCH,UAVE,DEPTH,W,AREA,TEMP,XNU,D65,D35,CONC,WM,ON,DM
COMMON /ALLB/ (111),VS(111),FS(10),FS(10),XMULT(10),JIN,JOUT,ND,NDM
COMMON /ALLC/ JSPT(10),XHIB(10),FOL(10)
COMMON /ALDD/ P,AP,APP(10),J(10)
COMMON /ALLE/ DHL(11),DHH(11)
COMMON /ALLF/ C0(2),C1(2),Cn(2),Cm(2)
DIMENSION COL(10),COLH(10),COLV(10),COLY(10),COLZ(10),CPS(10),P(10)
COMMON (S,10) NO DATA READ (S,10) NDATA
DO 290 L=1,NDATA
JU=0
WHITE (6,360)
WHITE (6,370)
CALL INPUT2
CALL INPUT2
WHITE (6,360)
WHITE (6,370)
WRITE (6,390) L,DISCH_UAVE,DEPTH,W,AREA,TEMP,XNU,D65,D35,CONC,WM,ON,DM
CALCULATING HYDRAULIC RADIUS*SLOPE RS, PERCENTAGE OF FLOW SAMPLED MOO
PFS, AND SEDIMENT DISCHARGE THROUGH THE SAMPLED ZONE QSPT
CALL RHSCOM (X,RH)
CALL PLATE4 (X,PPFS,XKS)
QSPT=QSM*PPS
CALCULATING PSI(J)
DO 120 J=1,NO
XPST=2.65*DS5/RS
YPS1=0.6641(J)/RS
XPST=XPST-YPS1
IF (XPST,LT,0.1) GO TO 110
PSI(J)=XPST
GO TO 120
PSI(J)=YPS1
120 CONTINUE
CALCULATING RED LOAD DISCHARGE XIBO(B,J) AND PERCENTAGE OF SUSPENDED MATERIAL IN VARIOUS SIZE FRACTIONS QSP(T,J)
DO 130 J=1,NO
XK=PSI(J)
CALL PLATES (XX,YY)
PHISH(J)=YY
XHIB(J)=J,2.0E1200.*PHISH(J)/2.0*(J)*1.5PS(F,J)
QSP(J)=FS(J)*QSPT
130 CONTINUE
CALCULATING P, A PRIME AP AND A DOUBLE PRIME AP(J)
DXK=0.2*XPDEPTH/XXS
P=2.363*ALOG10(DXKS)
AP=DN/DS
DO 140 J=1,NO
APP(J)=2*D(J)/DEPTH
140 CONTINUE
CALL SDN(N,K)
NK=N+1
WHITE (6,300)
CALCULATING ZP AND VS ARRAYS TO BE FED TO LEAST SQUARE SUBROUTINE
LSZPVS
CONTINUE
DO 150 J=1,NK
CALL ZPSCOM (J,IDZ)
IF (1NZ,EQ,1) GO TO 290
150 CONTINUE
CONTINUE
170 CONTINUE
IF (JOUT.EQ.2) GO TO 190
WRITE (6,320) MOD 1930
WRITE (6,340) MOD 1930
WRITE (6,350) MOD 1930
180 CONTINUE
CALL LSZPVS (N1,NK,VS,ZP,A,B)
A=EXP(A)
DO 190 J=1,NK
XZP(J)=0.0
ZP(J)=AVS(J)**B
190 CONTINUE
190 CONTINUE
CALCULATING SEDIMENT LOAD BY USING MODIFIED EINSTEIN'S INTEGRAL
CHARTS 9,10,11 AND 12
200 CONTINUE
IF (JOUT.EQ.2) GO TO 220
IF (K.LT.J) GO TO 210
WRITE (6,330) MOD 2000
210 CONTINUE
IF (JOUT.EQ.2) GO TO 220
WRITE (6,340) MOD 2000
WRITE (6,350) MOD 2000
220 CONTINUE
TOL=0
TBL=0
DO 260 I=1,NK
XM=AVP(I)
ZM=ZP(I)
IF (FB(I).LT.0.01.AND.FS(I).LT.0.01) GO TO 240
IF (FB(I).LT.0.01) GO TO 230
CALL POWER (ZM,AP,OL1(I),OL2(I),OL3(I),OL4(I),OL5(I),OL6(I),OL7(I),OL8(I),OL9(I),OL10(I),OL11(I),OL12(I),OL13(I),OL14(I),OL15(I),OL16(I),OL17(I),OL18(I),OL19(I),OL20(I),OL21(I),OL22(I),OL23(I))
IF (FB(I).LT.0.01) GO TO 240
CALL POWER (ZM,AP,OL3(I),OL4(I),OL5(I),OL6(I),OL7(I),OL8(I),OL9(I),OL10(I),OL11(I),OL12(I),OL13(I),OL14(I),OL15(I),OL16(I),OL17(I),OL18(I),OL19(I),OL20(I),OL21(I),OL22(I),OL23(I))
GO TO 250
CONTINUE
CALL POWER (ZM,AP,OL1(I),OL2(I),OL3(I),OL4(I),OL5(I),OL6(I),OL7(I),OL8(I),OL9(I),OL10(I),OL11(I),OL12(I),OL13(I),OL14(I),OL15(I),OL16(I),OL17(I),OL18(I),OL19(I),OL20(I),OL21(I),OL22(I),OL23(I))
CONTINUE
GO TO 250
250 CONTINUE
TQL=TQL+FQL(I)
TBL=TBL+XMULT(I)
CONTINUE
260 CONTINUE
PRINTING OUTPUT
WHITE (6,400) GO TO 270
WRITE (6,410) MOD 2620
WRITE (6,420) MOD 2620
1 J=1,NK
XZP(J)=0.0
ZP(J)=AVS(J)**B
1 (J)=1,NK
270 CONTINUE
WHITE (6,430) MOD 2680
WHITE (6,440) MOD 2680
1 J=1,NK
WHITE (6,450) MOD 2700
WHITE (6,460) MOD 2700
1 (J)=1,NK
280 CONTINUE
WHITE (6,470) MOD 2750
290 CONTINUE
STOP
300 FORMAT (/10X,'CONVERGENCE OF SUBROUTINE ZPCOM IS CHECKED BY SUBROUTINE ZPCOM, PRIN')
310 FORMAT (/10X,'OUT VALUES INVOLVED: //')
320 FORMAT (/10X,'340 FORMAT (/10X,'350 FORMAT (/10X,'}) OF SUBROUTINE ZPCOM. THE FIRST 1000 VALUES ARE AT')
340 FORMAT (/10X,'FUNCTIONS, THE FIRST 1000 VALUES ARE AT')
350 FORMAT (/10X,'FUNCTIONS, THE FIRST 1000 VALUES ARE AT')
COMPUTATION OF TOTAL SEDIMENT LOAD BY THE MODIFIED EINSTEIN PHOCEOU Procedure

**FORMAT (IH1) MOD 2890

12.7,13H E.F.S. \* 10X,34H AVERAGE VELOCITY MOD 2940

212.7,13H E.F./SEC. \* 10X,34H HYDRAULIC DEPTH MOD 2950

312.7,13H FT. \* 10X,34H WATER SURFACE WIDTH MOD 2960

412.7,13H FT. \* 10X,34H AREA MOD 2970

512.7,13H SQ.FT. \* 10X,34H TEMPERATURE MOD 2980

612.7,13H FT. \* 10X,34H KINEMATIC VISCOSITY MOD 2990

712.7,13H FT. /SEC. \* 10X,34H WATER DISCHARGE MOD 3000

812.7,13H FT. \* 10X,34H U35 MOD 3010

912.7,13H FT. \* 10X,34H AVERAGE CONCENTRATION MOD 3020

1012.7,13H PPM. \* 10X,34H SAMPLED SUSPENDED LOAD MOD 3030

1112.7,13H TONS/DAY \* 10X,34H PORTION OF DEPTH NOT SAMPLED MOD 3040

1212.7,13H FT. \* 10X,34H AVERAGE DEPTH AT SAMPLING MOD 3050

1312.7,13H F1/3 MOD 3060

**FORMAT (I/) MOD 3070

100 FORMAT (5X,1HJ,1X,4HD(J),7X,6HPSI(J),7X,5XFT(J),4X,5X,4XMOD 3040

18HX108(J),7X,5XFT(J),4X,8X,4XMOD 3040

2P(J/) MOD 3100

420 FORMAT (4X,12,4X,F12.4,F12.3,F12.5,F12.6) MOD 3110

430 FORMAT (7X,5X1J,1X,4HD(J),7X,8X,4XMOD 3120

10X,5XFT(J),4X,8X,4XMOD 3120

20L2(MJ,4X,8X,4XMOD 3140

400 FORMAT (5X,12,4X,F12.4,F12.3,F12.6) MOD 3150

450 FORMAT (5X,12,4X,F12.4,F12.3,F12.6) MOD 3160

1 XIRU(J) \* 1X,5XFT(J) MOD 3170

460 FORMAT (5X,6F12.4,F12.3) MOD 3180

470 FORMAT (5X,7X TOTAL HOM LOAD MOD 3190

F16,5,4,9H TONS/MOD 3200

25X,34H TOTAL SUSPENDED LOAD MOD 3210

C END MOD 3620
SUBROUTINE INPUT1
THIS SUBROUTINE READS IN THE BASIC VARIABLES OF THE PROBLEM
COMMON /ALL/ DISCH,UAVE,DEPTH,W,AREA,TEMP,XNU,065,D35,CONC,QSM,ON
10S READ (5*,110) DISCH,UAVE,DEPTH,W,AREA,TEMP,XNU,065,D35,CONC,QSM,ON
10S RETURN
END

110 FORMAT (8F10.0)
END

SUBROUTINE INPUT2
THIS SUBROUTINE READS IN ADDITIONAL INPUT AND FINDS THE VALUE OF
THE NUMBER OF SIZE FRACTIONS TO BE USED IN THE COMPUTATION
COMMON /ALL/ DRL(11),ORU(11)
COMMON /ALLB/ D(11),VS(11),FB(10),FS(10),XMULT(10),JIN,JOUT,ND,NO2
1*ND2 COMMON /ALLE/ DRL(11),ORU(11)
DRL(1)=.0030DRL(2)=.01555DRL(3)=.002 SDRL(4)=.0425SDRL(5)=.125
DRL(6)=.254SDRL(7)=.5DRL(8)=1. SDRL(9)=2.5DRL(10)=4.5DRL(11)=6.
ORU(1)=.0125 ORU(2)=.025 ORU(3)=.05 ORU(4)=.1 ORU(5)=.2
ORU(6)=.35 ORU(7)=.5 ORU(8)=1. ORU(9)=2. ORU(10)=4.
ORU(11)=8.
READ (5*,110) ORU(J),J=I,NO2 MOD 3500 IF (JIN.EQ.3) GO TO 150
DO 160 J=I,ND2 MOD 3510 110 CONTINUE MOD 3560
MOD 3570
120 CONTINUE MOD 3580
MOD 3580
130 DO 140 J=I,ND2 MOD 3590
MOD 3600
140 CONTINUE MOD 3610
MOD 3610
150 CONTINUE MOD 3620
MOD 3620
160 CONTINUE MOD 3630
MOD 3630
MOD 3640
MOD 3640
MOD 3650
MOD 3650
MOD 3660
MOD 3660
MOD 3670
MOD 3670
MOD 3680
MOD 3680
MOD 3690
MOD 3690
MOD 3700
MOD 3700
MOD 3710
MOD 3710
MOD 3720
MOD 3720
MOD 3730
MOD 3730
MOD 3740
MOD 3740
MOD 3750
MOD 3750
MOD 3760
MOD 3760
MOD 3770
MOD 3770
MOD 3780
MOD 3780
MOD 3790
MOD 3790
MOD 3800
MOD 3800
MOD 3810
MOD 3810
MOD 3820
MOD 3820
MOD 3830
MOD 3830
MOD 3840
MOD 3840
MOD 3850
MOD 3850
MOD 3860
MOD 3860
MOD 3870
MOD 3870
MOD 3880
MOD 3880
MOD 3890
MOD 3890
MOD 3900
MOD 3900
MOD 3910
MOD 3910
C
C 190 FORMAT (2I1)
200 FORMAT (2F10.0)
210 FORMAT (I1)
220 FORMAT (4F10.0)
C
END
SUBROUTINE RSCOH (X,RS)
    THIS SUBROUTINE COMPUTES THE VALUE OF RS BY ITERATION
COMMON / ALL/ DISCH+UAVE+DEPTH+W+AREA+TEMP+XNU+D65+D35+CONC+QSM+ON+N
    IDS
1  X=1.6
    TOL=O.001
    XKS=D65
110 \[ XKS=12.27*X*DEPT/H/XKS \]
  SHRS=UAVE/(32.65*ALOG10(XDKS))
  USHP=SHRS*O.66
  DEL=11.6*XNU/USHP
  DELK=KX+DEL
  CALL PLAT4J (DELKJS+X2)
  DEL=X-X2
  IF (APS(DELX).LT.STOL) GO TO 120
  X=X2
  GO TO 110
120 CONTINUE
    XOKS=12.27*X*OEPTH/XKS
  SRRS=UAVE/(32.65*ALOG10(XDKS))
  RS=SRRS*SRRS
    RETURN
    END

SUBROUTINE PLAT4J (X,PFS,XKS)
    THIS SUBROUTINE SUBSTITUTES PLATE FOUR FOR THE ANALYTICAL EXPRESSION O F PFS
COMMON / ALL/ DISCH+UAVE+DEPTH+W+AREA+TEMP+XNU+D65+D35+CONC+QSM+ON+N
    IDS
1  XKS=D65
    A=30.2*X/XKS
    YDS=O.5*ALOG(A*O5)-O5
    YDN=O.5*ALOG(A*0N)-DN
    PFS=(YOS-YON)/YDS
    RETURN
    END

SUBROUTINE SDR (N,K)
    THIS SUBROUTINE COUNTS THE NUMBER OF SIZE FRACTIONS K FOR WHICH THERE IS BOTH BED AND SUSPENDED DISCHARGE, AND THE NUMBER OF SIZE SMALLER THAN FIRST K.
COMMON / ALL/ D(11),V5S(11),FD(10),FS(10),XMULT(10),JIN,JOUT,ND,NDI
    MOD
1  N=O CONTINUE
    IF (FD(J+1).GT.0.00.AND.FS(J+1).GT.0.00) GO TO 130
    IF (K.NE.0) GO TO 120
    N=1
    MOD
120 J=J+1
    IF (J.EQ.ND) RETURN
    MOD
130 J=J+1
    IF (J.EQ.ND) RETURN
    MOD
    END
SUBROUTINE LSZPS VS(NI,NK,K,X,V,A,B)
C THIS SUBROUTINE CALCULATES A LEAST SQUARE FIT FOR ZPRIME ZP(K) AND
VS(K)
DIMENSION X(N1), Y(N1)
SUMX=O, SUMY=O, SUMXY=O, SUMX2=O,
DO 110 J=NI,NK
XL=ALOG(X(J)) SUMX=SUMX+XL YL=ALOG(Y(J)) SUMY=SUMY+YL
SUMXY=SUMXY+XY X=XL*YL SUMX2=SUMX2+X2
110 CONTINUE
XMEAN=SUMX/N
YMEEAN=SUMY/N
B=(SUMXY-SUMX*SUMY/N)/(SUMX2-SUMX*SUMX/N)
A=YMEEAN-B*XMEAN
RETURN
END

SUBROUTINE MULCOM (K,NI,NK,KK)
C THIS SUBROUTINE CALCULATES THE MULTIPLIERS XMULT(J)
COMMON /ALLB/ D(N1),VS(N1),FB(10),FS(10),XMULT(10),JIN,JOUT,ND,NO
1=NO2
DIMENSION SBS(9)
IF (K.EQ.0) GO TO 160 IF (K.EQ.2) GO TO 110
KK=NI GO TO 140
110 CONTINUE VALUES(J)=FS(J)*FB(J)
120 CONTINUE IF (SBS(J).GT.SBS(NK)) GO TO 130
KK=NI
130 CONTINUE GO TO 140
140 CONTINUE VALUES(J)=FS(J)*FB(J)
150 CONTINUE GO TO 170
160 WRITE (6,180)
170 CONTINUE RETURN
C 180 FORMAT (10X,9F2.0) BECAUSE NO SIZE FRACTION CONTAINS BOTH BED AND SUSPENDED DISCHARGE, THE COMPUTATIONS ARE ABORTED.
C END

SUBROUTINE PLATE8 (X,Y)
C THIS SUBROUTINE APPROXIMATES PLATE 8 BY A LINE IN LOG-LOG PAPER
Y=-0.33*ALOG10(X)+1.08
RETURN
C END
**SUBROUTINE ZPCOM (J, IDZ)**

**THIS SUBROUTINE COMPUTES ZPHI ME ZP BY ITERATION**

**FOR EACH TRIAL VALUE OF ZP IT IS CALCULATED, AND THEN, WITH ANOTHER PROXY, ITERATION MOO FIRST. A TRIAL VALUE OF ZP IS CALCULATED, AND THEN, WITH ANOTHER TRIAL. A LINEAR INTERPOLATION IS MADE. CONVERGENCE IS VERY FAST.**

**COMMUN /ALLB/ 0(11), VS(11), F(11), T(11), XMULT(11), JIN, JOUT, ND, NOD, NIO**

**1ND2**

**COMMUN /ALLC/ QSP(11), XIHOH(10), XOL(10)**

**COMMUN /ALLD/ P, AP, P(10), ZP(10)**

**IF (QSP, LT, 1.673) GO TO 110**

**IDZ = 1**

**WRITE (6, 1) IDZ**

**RETURN**

**110 CALL PLATE8 (QSP, XTRY)**

**STEP = 0.01**

**WRITE (6, 110)**

**KOUNT = 0**

**120 CONTINUE**

**KOUNT = KOUNT + 1**

**IF (KOUNT .GT. 10) GO TO 140**

**CALL POWER (ZTRY, XM, XIIPP, OUM1, XIJPP, OUM2, 0.01)**

**CALL POWER (ZTRY, AP, OUM3, XIJPP, OUM4, XIJPP, 0.01)**

**CRUSP = XIIPP / XIJPP * (P + XIJPP + XIJPP)**

**OCRQ = CRUSP - RQSP**

**IF (JOUT.EQ.2) GO TO 130**

**WRITE (6, 120) KOUNT, THY, RQSP, CRUSP, OCRQ**

**130 CONTINUE**

**TOL = 0.01 * RQSP**

**IF (ABS(DQSM_ro L.T. TOL) GO TO 150**

**CALL POWER (ZTRY, XM, XIIPP, OUM1, XJIPP, OUM2, 0.01)**

**CALL POWER (ZTRY, AP, OUM3, XJIPP, OUM4, XJIPP, 0.01)**

**CROSSP = XIIPP / XJIPP * (P * XJIPP + XJIPP)**

**TEM = (RQSP - OCRQ) / STEP**

**IF (OCRQ .LT. TOL) GO TO 150**

**IF (CRUSP .LT. RQSP) ZTRY = ZTRY - TEM**

**IF (CRUSP .GT. RQSP) ZTRY = ZTRY + TEM**

**60 TO 120**

**140 CONTINUE**

**WRITE (6, 140)**

**150 CONTINUE**

**ZP(J) = ZTHY**

**RETURN**

**C 160 FORMAT (11X, 10X, BHRQSP OUT OF PERMISSIBLE RANGE IN THIS SET OF CALCS)**

**170 FORMAT (11X, 30X, THIS SUBROUTINE APPLIES TO A SERIES OF EQUATIONS)**

**180 FORMAT (11X, 76X, THIS SUBROUTINE DOES NOT CONVERGE WITH 10 ITERATIONS, LAST VALUE OF ZP(J) WILL 4E USED/)**

**190 FORMAT (11X, 132, IF CMCTY (J) WIL 4E USED/)**

**END**

**SUBROUTINE PLATE3 (X, Y)**

**THIS SUBROUTINE APPROXIMATES PLATE 3 BY A SERIES OF EQUATIONS**

**IF (X .LE. 0.40) GO TO 110**

**GO TO 270**

**110 Y = 1.769 * ALOG10 (X / 0.080)**

**GO TO 270**

**120 IF (X, GT, 0.40, AND, X, LE, 0.56) GO TO 130**

**GO TO 270**

**130 Y = 1.495 * ALOG10 (X / 0.059)**

**GO TO 270**

**140 IF (X, GT, 0.56, AND, X, LE, 0.76) GO TO 150**

**GO TO 160**

**150 Y = 0.92 * ALOG10 (X / 0.0145)**

**GO TO 270**

**160 IF (X, GT, 0.76, AND, X, LE, 0.96) GO TO 170**

**GO TO 180**

**170 Y = 0.292 * ALOG10 (X / 2.9E-06)**

**GO TO 180**

**180 IF (X, GT, 0.96, AND, X, LE, 1.13) GO TO 190**

**GO TO 200**

**190 Y = 0.377 * ALOG10 (632000.0 / X)**

**GO TO 200**

**200 IF (X, GT, 1.35, AND, X, LE, 3.00) GO TO 210**

**GO TO 220**

**210 Y = 1.115 * ALOG10 (34.4 / X)**

**GO TO 220**

**220 IF (X, GT, 3.00, AND, X, LE, 4.00) GO TO 230**

**GO TO 240**

**230 Y = 0.725 * ALOG10 (128.0 / X)**

**GO TO 240**

**240 IF (X, GT, 4.00, AND, X, LE, 6.70) GO TO 250**

**GO TO 260**

**250 Y = 0.399 * ALOG10 (2160.0 / X)**

**GO TO 260**

**260 IF (X, GT, 6.70) Y = 1.0**

**270 RETURN**

**END**
SUBROUTINE PLATES (X,Y)  

THIS SUBROUTINE APPROXIMATES PLATE 5 BY A SERIES OF EQUATIONS  

IF (X.LE.0.77) Y=(7.56/X)**2 + 0.1  
IF (X.GT.0.77.AND.X.LE.1.22) Y=(5.35/X)**2 + 1.9  
IF (X.GT.1.22.AND.X.LE.4.10) Y=(4.10/X)**2 + 0.7  
IF (X.GT.4.10.AND.X.LE.6.10) Y=(3.10/X)**2 + 3.3  
IF (X.GT.6.10.AND.X.LE.11.0) Y=(4.66/X)**2 + 2.6  
IF (X.GT.11.0.AND.X.LE.22.5) Y=(5.28/X)**2 + 12.66  
RETURN  
END  

SUBROUTINE POWER (Z,A,X11,X12,XJ1,XJ2,CONV)  

THIS SUBROUTINE EVALUATES II 1Z J1 AND J2 INTEGRALS  

NOTATIONS  
XII = VALUE OF II INTEGRAL  
X12 = VALUE OF IZ INTEGRAL  
XJ1 = VALUE OF J1 INTEGRAL  
XJ2 = VALUE OF J2 INTEGRAL  
N = ORDER OF APPROXIMATION + 1  
CONV = CONVERGENCE CRITERION

N=1  
FACT=0.216*A**(Z-1.0)/(1.0-A)**2  
XII=0.  
X12=0.  
XJ1=0.  
XJ2=0.  
ALG=ALOG(A)  
C=1.  
D=2.  
E=D+1.  
F=F+1.  
AEX=A**F  
GO TO 120  
110 N=N+1  
C=C*D/FN  
D=E  
E=F+D+1.  
AEX=A**F  
GO TO 120  
120 IF (ARS(E).LE.0.001) GO TO 130  
XJ2=XJ2+C*(1.0-ALG)/E  
XJ1=XJ1+C*(ARSL-1.0)**2-AEX*ALG/E  
GO TO 140  
130 XJ2=XJ2-C*ALG  
GO TO 140  
140 IF (N.LE.1) GO TO 150  
CJ1=ARS(1.0-FJ2/XJ1)  
CJ2=ARS(1.0-FJ2/XJ2)  
IF (CJ1.LE.CONV.AND.CJ2.LE.CONV) GO TO 160  
150 FJ1=FJ1+1.0  
FJ2=FJ2  
GO TO 110  
160 XI1=FACT*XJ1  
X12=FACT*XJ2  
RETURN  
END  

END
II. COLBY:

Colby's Bed Material Load Method
1. INTRODUCTION

Program COLBY computes bed material load by Colby's Method [1]. Data input consists of average velocity (ft per sec), hydraulic depth (ft), water surface width (ft), temperature (°F), median bed material size (mm) and fine material concentration (ppm). A remark included as part of the output indicates whether the computations were carried out in a normal fashion, or if one or more variables were out of the value range specified in this method. If velocity, depth or bed material size are out of range, the program fails to give any results. If temperature or fine material concentration are out of range, the program extrapolates and gives a result, albeit of limited value.

2. INPUT-OUTPUT DESCRIPTION

INPUT:

A) NUMBER OF SETS CARD

It is the first card in the input logical record and should contain the value of NDATA, in format I5. NDATA is the number of sets of input data to be fed to the computer at a time. A set of input data consists of a group of variables necessary to specify a problem, as detailed below.

B) INPUT DATA CARDS

The first card in input is followed by the sets of input data, to be punched in format 6F10.0. A set of input data consists of the following variables, relating to a channel cross section.

<table>
<thead>
<tr>
<th>VARIABLES</th>
<th>FORTRAN NAME</th>
<th>UNITS</th>
</tr>
</thead>
<tbody>
<tr>
<td>1) Average Velocity</td>
<td>V</td>
<td>ft per sec</td>
</tr>
<tr>
<td>2) Hydraulic Depth</td>
<td>D</td>
<td>ft</td>
</tr>
<tr>
<td>3) Water Surface Width</td>
<td>W</td>
<td>ft</td>
</tr>
<tr>
<td>4) Temperature</td>
<td>TF</td>
<td>°F</td>
</tr>
<tr>
<td>5) Median Bed Material Size</td>
<td>D50</td>
<td>mm</td>
</tr>
<tr>
<td>6) Fine Material Concentration</td>
<td>FML</td>
<td>ppm</td>
</tr>
</tbody>
</table>
OUTPUT:

Output consists of the total bed material transport in tons/day, and a remark on how the computations were carried out. If REMARK=OK, the computations were carried out successfully. If REMARK=OOR, velocity, depth or bed material size is out of range. If REMARK=TOOR, temperature is out of range. If REMARK=FOOR, fine material concentration is out of range.

<table>
<thead>
<tr>
<th>VARIABLE</th>
<th>RANGE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average Velocity</td>
<td>1-10 ft per sec</td>
</tr>
<tr>
<td>Hydraulic Depth</td>
<td>1-100 ft</td>
</tr>
<tr>
<td>Temperature</td>
<td>32-100 °F</td>
</tr>
<tr>
<td>Median Bed Material Size</td>
<td>0.1-0.8 mm</td>
</tr>
<tr>
<td>Fine Material Concentration</td>
<td>0-200000 ppm</td>
</tr>
</tbody>
</table>

3. FORTRAN NAMES FOR INPUT AND OUTPUT VARIABLES

<table>
<thead>
<tr>
<th>VARIABLE</th>
<th>FORTRAN NAME</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average Velocity</td>
<td>V</td>
</tr>
<tr>
<td>Hydraulic Depth</td>
<td>D</td>
</tr>
<tr>
<td>Water Surface Width</td>
<td>W</td>
</tr>
<tr>
<td>Temperature</td>
<td>TF</td>
</tr>
<tr>
<td>Median Bed Material Size</td>
<td>D50</td>
</tr>
<tr>
<td>Fine Material Concentration</td>
<td>FML</td>
</tr>
<tr>
<td>Bed Material Transport</td>
<td>GT</td>
</tr>
</tbody>
</table>
4. EXAMPLES

Setup of Data Cards for COLBY
### COMPUTATION OF TOTAL RED MATERIAL TRANSPORT BY COLBY'S METHOD

<table>
<thead>
<tr>
<th>SET</th>
<th>AVERAGE VELOCITY</th>
<th>HYDRAULIC DEPTH</th>
<th>WATER SURFACE WIDTH</th>
<th>TEMPERATURE</th>
<th>MEDIAN BED MATERIAL SIZE</th>
<th>FINE MATERIAL CONCENTRATION</th>
<th>BED MATERIAL TRANSPORT</th>
<th>REMARK</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>9.92 FT./SEC.</td>
<td>4.14 FT.</td>
<td>234.00 FT.</td>
<td>70.00 DEG.FAHREN.</td>
<td>.32 MM.</td>
<td>10000.00 PPM.</td>
<td>76173.08304 TONS/DAY</td>
<td>OK</td>
</tr>
<tr>
<td>2</td>
<td>11.00 FT./SEC.</td>
<td>4.14 FT.</td>
<td>234.00 FT.</td>
<td>70.00 DEG.FAHREN.</td>
<td>.32 MM.</td>
<td>10000.00 PPM.</td>
<td></td>
<td>OOR</td>
</tr>
<tr>
<td>3</td>
<td>9.92 FT./SEC.</td>
<td>4.14 FT.</td>
<td>234.00 FT.</td>
<td>105.00 DEG.FAHREN.</td>
<td>.32 MM.</td>
<td>10000.00 PPM.</td>
<td>59231.54605 TONS/DAY</td>
<td>TOOR</td>
</tr>
<tr>
<td>4</td>
<td>9.92 FT./SEC.</td>
<td>4.14 FT.</td>
<td>234.00 FT.</td>
<td>70.00 DEG.FAHREN.</td>
<td>.32 MM.</td>
<td>300000.00 PPM.</td>
<td>810518.47909 TONS/DAY</td>
<td>FOOR</td>
</tr>
</tbody>
</table>
APPENDIX A: REFERENCES

APPENDIX B:

LISTING
PROGRAM COLBY (INPUT,OUTPUT;TAPE5=INPUT;TAPE6=OUTPUT)

DEVELOPED
COLORADO STATE UNIVERSITY ENGINEERING RESEARCH
CENTER, FORT COLLINS, COLORADO 80524

PURPOSE
COMPUTATION OF RED MATERIAL LOAD BY COLBY

METHOD
REFINEMENT
COLDY & K., DISCHARGE OF SANDS AND MEAN VELOCITY
IN SAND-RICH STREAMS; PROFESSIONAL

REFERENCE
PAPEN, H.-W. & A. TENNISON, S. U.S. GEOLOGICAL SUR.

COVE USAGE
CDC 6400 SCOPE 3.3 SYSTEM DEFAULT VALUE:

COMPILATION TIME
APPROXIMATELY 1 SEC.

CENTRAL PROCESSOR

TIME FOR ONE

SET OF DATA
LESS THAN 0.6 SEC.

INPUT AND OUTPUT DESCRIPTION

THE FIRST CARD IN THE INPUT LOGICAL RECORD SHOULD CONTAIN THE
VALUE OF NDATA, IN FORMAT I5. NDATA IS THE NUMBER OF SETS OF INPUT
DATA TO BE READ TO THE COMPUTER AT A TIME. A SET OF INPUT DATA
CONSISTS OF A GROUP OF VARIABLES NECESSARY TO SPECIFY A PROBLEM
AS DETAILLED BELOW.

THE FIRST CARD IN INPUT IS FOLLOWED BY THE SETS OF INPUT DATA.
TO BE PUNCHED IN FORMAT OF 10.0

A SET OF INPUT DATA CONSISTS OF THE FOLLOWING VARIABLES:

1) AVERAGE VELOCITY  V  F.P.S.
2) HYDRAULIC DEPTH  D  FT.
3) WATER SURFACE WIDTH  W  FT.
4) TEMPERATURE  T  DEG. FAHREN.
5) MEDIAN RED MATERIAL SIZE  D50  MM.
6) FINE MATERIAL CONCENTRATION  D159  ppm.

OUTPUT CONSISTS OF THE TOTAL RED MATERIAL TRANSPORT IN TONS/DAY,
AND A REMARK ON HOW THE COMPUTATIONS WERE CARRIED OUT.

IF REMARK = OK, THE COMPUTATIONS WERE CARRIED OUT SUCCESSFULLY.
IF REMARK = 000, VELOCITY, DEPTH OR RED MATERIAL SIZE IS OUT OF
RANGE.
IF REMARK = 100, TEMPERATURE IS OUT OF RANGE.
IF REMARK = 200, FINE MATERIAL CONCENTRATION IS OUT OF RANGE.

VARIABLE
RANGE

AVERAGE VELOCITY
0.0-10.0 F.P.S.

HYDRAULIC DEPTH
1-100 FT.

WATER SURFACE WIDTH
32-100 DEG. FAHREN.

MEDIAN RED MATERIAL SIZE
0.1-0.8 MM.

FINE MATERIAL CONCENTRATION
0-200000 ppm.

COMMON /CLBY/ G(+,5)=F(5)+10*T(7,+)+P(11)+DF(10)+CF(5)+DP(11)+D50+DFML

1(V6(5)+USG(6)+TEMP(7)

DIMENSION II(2), JJ(2), KK(2), XX(2), YY(2), ZZ(2), XZ(2), XXA(2), 1

WRITE (6,159)

READ (5,162) NDATA

DO 157 I=1,NDATA

HEAD (5,153) V=DWTF*D50+FML

WHITE (6,150) LDW=DWTF*D50+FML

DATA ((4),1),E(4),K(1,3),I(1,3)

1 0,2,5,4,7,4,9,0,1,0,0,9,0,0,9,0,0,9,0,0,9,0,0,9,0,0,9,0,0,9,0,0,9,0,0,9,0,0,9,0,0,9,0,0,9,0,0,9,0,0,9,0,0,9,0,0,9,0,0,9,0,0,9,0,0,9,0,0,9,0,0,9,0,0,9,0,0,9,0,0,9,0,0,9,0,0,9,0,0,9,0,0,9,0,0,9,0,0,9,0,0,9,0,0,9,0,0,9,0,0,9,0,0,9,0,0,9,0,0,9,0,0,9,0,0,9,0,0,9,0,0,9,0,0,9,0,0,9,0,0,9,0,0,9,0,0,9,0,0,9,0,0,9,0,0,9,0,0,9,0,0,9,0,0,9,0,0,9,0,0,9,0,0,9,0,0,9,0,0,9,0,0,9,0,0,9,0,0,9,0,0,9,0,0,9,0,0,9,0,0,9,0,0,9,0,0,9,0,0,9,0,0,9,0,0,9,0,0,9,0,0,9,0,0,9,0,0,9,0,0,9,0,0,9,0,0,
IF (D50.LT.D50G(I)).AND.(D50.GT.D50G(I+1)) GO TO 111
GO TO 112
I0=I I=I+1
IF (D50.GE.D50G(I)).AND.(D50.LE.D50G(I+1)) GO TO 119
GO TO 120
I0=I I=I+1
IF (I<J+1) GO TO 130
IF (I<J+1) GO TO 140
IF (I<J+1) GO TO 150
IF (I<J+1) GO TO 160
IF (I<J+1) GO TO 170
IF (I<J+1) GO TO 180
IF (I<J+1) GO TO 190
IF (I<J+1) GO TO 200
IF (I<J+1) GO TO 210
IF (I<J+1) GO TO 220
IF (I<J+1) GO TO 230
IF (I<J+1) GO TO 240
IF (I<J+1) GO TO 250
IF (I<J+1) GO TO 260
IF (I<J+1) GO TO 270
IF (I<J+1) GO TO 280
IF (I<J+1) GO TO 290
IF (I<J+1) GO TO 300
IF (I<J+1) GO TO 310
IF (I<J+1) GO TO 320
IF (I<J+1) GO TO 330
IF (I<J+1) GO TO 340
IF (I<J+1) GO TO 350
IF (I<J+1) GO TO 360
IF (I<J+1) GO TO 370
IF (I<J+1) GO TO 380
IF (I<J+1) GO TO 390
IF (I<J+1) GO TO 400
IF (I<J+1) GO TO 410
IF (I<J+1) GO TO 420
IF (I<J+1) GO TO 430
IF (I<J+1) GO TO 440
IF (I<J+1) GO TO 450
IF (I<J+1) GO TO 460
IF (I<J+1) GO TO 470
IF (I<J+1) GO TO 480
IF (I<J+1) GO TO 490
IF (I<J+1) GO TO 500
IF (I<J+1) GO TO 510
IF (I<J+1) GO TO 520
IF (I<J+1) GO TO 530
IF (I<J+1) GO TO 540
IF (I<J+1) GO TO 550
IF (I<J+1) GO TO 560
IF (I<J+1) GO TO 570
IF (I<J+1) GO TO 580
IF (I<J+1) GO TO 590
IF (I<J+1) GO TO 600
IF (I<J+1) GO TO 610
IF (I<J+1) GO TO 620
IF (I<J+1) GO TO 630
IF (I<J+1) GO TO 640
IF (I<J+1) GO TO 650
IF (I<J+1) GO TO 660
IF (I<J+1) GO TO 670
IF (I<J+1) GO TO 680
IF (I<J+1) GO TO 690
IF (I<J+1) GO TO 700
IF (I<J+1) GO TO 710
IF (I<J+1) GO TO 720
IF (I<J+1) GO TO 730
IF (I<J+1) GO TO 740
IF (I<J+1) GO TO 750
IF (I<J+1) GO TO 760
IF (I<J+1) GO TO 770
IF (I<J+1) GO TO 780
IF (I<J+1) GO TO 790
IF (I<J+1) GO TO 800
IF (I<J+1) GO TO 810
IF (I<J+1) GO TO 820
IF (I<J+1) GO TO 830
IF (I<J+1) GO TO 840
IF (I<J+1) GO TO 850
IF (I<J+1) GO TO 860
IF (I<J+1) GO TO 870
IF (I<J+1) GO TO 880
IF (I<J+1) GO TO 890
IF (I<J+1) GO TO 900
IF (I<J+1) GO TO 910
IF (I<J+1) GO TO 920
IF (I<J+1) GO TO 930
IF (I<J+1) GO TO 940
IF (I<J+1) GO TO 950
IF (I<J+1) GO TO 960
IF (I<J+1) GO TO 970
IF (I<J+1) GO TO 980
IF (I<J+1) GO TO 990
IF (I<J+1) GO TO 1000
IF (I<J+1) GO TO 1010
IF (I<J+1) GO TO 1020
IF (I<J+1) GO TO 1030
IF (I<J+1) GO TO 1040
IF (I<J+1) GO TO 1050
IF (I<J+1) GO TO 1060
IF (I<J+1) GO TO 1070
IF (I<J+1) GO TO 1080
IF (I<J+1) GO TO 1090
IF (I<J+1) GO TO 1100
IF (I<J+1) GO TO 1110
IF (I<J+1) GO TO 1120
IF (I<J+1) GO TO 1130
IF (I<J+1) GO TO 1140
IF (I<J+1) GO TO 1150
IF (I<J+1) GO TO 1160
IF (I<J+1) GO TO 1170
IF (I<J+1) GO TO 1180
IF (I<J+1) GO TO 1190
IF (I<J+1) GO TO 1200
IF (I<J+1) GO TO 1210
IF (I<J+1) GO TO 1220
IF (I<J+1) GO TO 1230
IF (I<J+1) GO TO 1240
IF (I<J+1) GO TO 1250
IF (I<J+1) GO TO 1260
IF (I<J+1) GO TO 1270
IF (I<J+1) GO TO 1280
IF (I<J+1) GO TO 1290
IF (I<J+1) GO TO 1300
IF (I<J+1) GO TO 1310
IF (I<J+1) GO TO 1320
IF (I<J+1) GO TO 1330
IF (I<J+1) GO TO 1340
IF (I<J+1) GO TO 1350
IF (I<J+1) GO TO 1360
IF (I<J+1) GO TO 1370
IF (I<J+1) GO TO 1380
IF (I<J+1) GO TO 1390
IF (I<J+1) GO TO 1400
IF (I<J+1) GO TO 1410
IF (I<J+1) GO TO 1420
IF (I<J+1) GO TO 1430
IF (I<J+1) GO TO 1440
IF (I<J+1) GO TO 1450
IF (I<J+1) GO TO 1460
IF (I<J+1) GO TO 1470
IF (I<J+1) GO TO 1480
IF (I<J+1) GO TO 1490
IF (I<J+1) GO TO 1500
IF (I<J+1) GO TO 1510
IF (I<J+1) GO TO 1520
IF (I<J+1) GO TO 1530
IF (I<J+1) GO TO 1540
IF (I<J+1) GO TO 1550
IF (I<J+1) GO TO 1560
IF (I<J+1) GO TO 1570
IF (I<J+1) GO TO 1580
IF (I<J+1) GO TO 1590
IF (I<J+1) GO TO 1600
IF (I<J+1) GO TO 1610
IF (I<J+1) GO TO 1620
IF (I<J+1) GO TO 1630
IF (I<J+1) GO TO 1640
IF (I<J+1) GO TO 1650
IF (I<J+1) GO TO 1660
IF (I<J+1) GO TO 1670
IF (I<J+1) GO TO 1680
IF (I<J+1) GO TO 1690
IF (I<J+1) GO TO 1700
IF (I<J+1) GO TO 1710
IF (I<J+1) GO TO 1720
IF (I<J+1) GO TO 1730
IF (I<J+1) GO TO 1740
IF (I<J+1) GO TO 1750
IF (I<J+1) GO TO 1760
IF (I<J+1) GO TO 1770
IF (I<J+1) GO TO 1780
IF (I<J+1) GO TO 1790
IF (I<J+1) GO TO 1800
IF (I<J+1) GO TO 1810
IF (I<J+1) GO TO 1820
IF (I<J+1) GO TO 1830
IF (I<J+1) GO TO 1840
IF (I<J+1) GO TO 1850
IF (I<J+1) GO TO 1860
IF (I<J+1) GO TO 1870
IF (I<J+1) GO TO 1880
IF (I<J+1) GO TO 1890
IF (I<J+1) GO TO 1900
IF (I<J+1) GO TO 1910
IF (I<J+1) GO TO 1920
GTUC = XG(1) * XM * XD / XDEN
GTUC = 10.0 * GTUC

GTUC IS UNCORRECTED GT IN LB/SEC/FT

NEXT APPLY F.M. LOAD AND TEMPERATURE CORRECTIONS

IF (TF = 60.1) 132 + 131 + 132
  CFT = 1
  GO TO 137
132 CONTINUE
  IT = 0
  IT2 = 0
  GO 135 I = 1 + 6
  IF (TF < TEMP(I)) .AND. (TF .LE. TEMP(I + 1)) GO TO 133
  GO TO 134
133 CONTINUE
  IT = I
  IT2 = I + 1
  GO TO 136
134 CONTINUE
135 CONTINUE
136 CONTINUE
  XT(1) = ALOG10 {T(I + 1) / T(I)}
  XT(2) = ALOG10 {T(I + 2) / T(I) / T(I + 1)}
  XT(3) = ALOG10 {T(I + 1) / T(I2 + 1) / T(I2 + 2)}
  XNT = ALOG10 {TEMP(I + 2) / TEMP(I)}
  XCT(I) = XT(I) + XNT * (XT(I2) - XT(I))
  XCT(2) = XT(1) + XNT * (XT(I2) - XT(I))
  CFT = XCT(1) + XCT(2) / XDEN
  CFT = 10.0 * CF

FINE MATERIAL LOAD CORRECTION

137 CONTINUE
  IF (FML = 100) 138 + 139
138 CONTINUE
  CF = 1
  GO TO 140
139 CONTINUE
  IF (FML = 1.1 .EQ. 5) REMARK = SHFOOR
  GO TO 140
140 CONTINUE
  ID1 = 0
  ID2 = 0
  GO 141 I = 1 + 9
  IF (ID .GE. DF(I)) .AND. (DF(I) .LE. DF(I + 1)) GO TO 140
  GO TO 141
141 CONTINUE
  ID1 = I
  ID2 = I + 1
  GO TO 142
142 CONTINUE
  IF (REMARK .EQ. SHFOOR) 143 + 144
143 CONTINUE
  IF = 1
  IF = 4
  IF = 5
  IF = 6
  GO TO 148
144 CONTINUE
  IF = 0
  IF = 4
  IF = 5
  GO TO 148
145 CONTINUE
  IF = 4
  IF = 5
  GO TO 148
146 CONTINUE
147 CONTINUE
148 CONTINUE
  XF(I) = ALOG10 (F(I + 1) / F(I))
  XF(2) = ALOG10 (F(I + 2) / F(I))
  XF(3) = ALOG10 (F(I + 2) / F(I2) / F(I2 + 1))
  XNT = (FML - CF(I)) / (DF(I) - CF(I))
  XCT(I) = XF(I) + XNT * (XF(I + 2) - XF(I + 1))
  XCT(2) = XF(I) + XNT * (XF(I2) - XF(I))
  XCT(I2) = XCT(I) + XCT(2) / DF(I2)
  CFF = XCT(I) + XCT(2) / XCT(I2)
  CFF = 10.0 * CF

CONTINUE
149 CONTINUE
  TCF = CF * TCF - 1.0
  CF = 1
  IF (DF50 .GE. 0.20) .AND. (DF50 .LE. 0.30) GO TO 154
  DF1 = 0
  IF = 6
  GO 152 I = 1 + 10
  IF (DF50 .GE. DP(I)) .AND. (DF50 .LE. DP(I + 1)) GO TO 150
  GO TO 151
150 CONTINUE
  IP1 = 0
  IF = 0
  IP2 = 0
  GO TO 153
151 CONTINUE
152 CONTINUE
153 CONTINUE
  PF = ALOG10 (P/IP2)
  PF = 1
  PF = 5
  PF = 10
  GO TO 155
155 CONTINUE
  PF = 0.1
  GO TO 156
156 CONTINUE
  PF = 0.01
  GO TO 157
157 CONTINUE
  PF = 0.001
  GO TO 158
158 CONTINUE
  PF = 0.0001
  GO TO 159
159 CONTINUE
  PF = 0.00001
  GO TO 160
160 CONTINUE
  IF = 0
  IF = 4
  IF = 5
  GO TO 161
161 CONTINUE
  IF = 1
  IF = 4
  IF = 5
  GO TO 161
162 CONTINUE
163 CONTINUE
164 CONTINUE
  XF(I) = ALOG10 (F/I)
CFO = 1.0 * CFD
CONTINUE

WHITE (6,151) REMARK
GO TO 156

CONTINUE

WHITE (6,158) REMARK
CONTINUE

CONTINUE

COMPUTATIONS COULD NOT BE CARRIED OUT /5X, 24 MDUE
DATA OUT OF RANGE */5X, REMARK */10/**)
COMPUTATION OF TOTAL BED MATERIAL */10X, 26 MTAN
SPONT BY COLBYS METHOD */10/**)

COMPUTATION OF TOTAL BED MATERIAL */10X, 26 MTAN
SPONT BY COLBYS METHOD */10/**)

COMPUTATION OF TOTAL BED MATERIAL */10X, 26 MTAN
SPONT BY COLBYS METHOD */10/**)

END