THEORETICAL AND MATHEMATICAL MODEL TESTS OF DESIGNS OF TWO SUSPENDED SEDIMENT SAMPLING DEVICES

Prepared for

USDA FOREST SERVICE
ROCKY MOUNTAIN FOREST AND RANGE
EXPERIMENT STATION
Flagstaff, Arizona

Cooperative Research Agreement
No. 16-872-CA

Prepared by

Civil Engineering Department
Engineering Research Center
Colorado State University
Fort Collins, Colorado

D. B. Simons
R. M. Li
G. O. Brown

July 1983

CER82-83DBS-RML-GOB50

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AUTHORIZATION

This research was sponsored by the USDA Forest Service, Rocky Mountain Forest and Range Experiment Station and supported with Colorado State University matching funds. The investigations were conducted in accordance with the Cooperative Agreement No. 16-872-CA between the Rocky Mountain Forest and Range Experiment Station and Colorado State University. D. Ross Carder and Lawrence D. Garrett were the authorized project leaders for the Rocky Mountain Forest and Range Experiment Station and Daryl B. Simons and Ruh-Ming Li were the principal investigators for Colorado State University.

In accordance with the study plan, the report on the Theoretical and Mathematical Model Tests of Designs of Two Suspended Sediment Sampling Devices is submitted.

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INTRODUCTION

Study of water and sediment yields from forested watersheds is a primary task of research personnel at the Rocky Mountain Forest and Range Experiment Station, Flagstaff, Arizona. As an aid to this task, numerous water and sediment sampling sites have been constructed on selected watersheds throughout the Beaver Creek Watershed. Some sediment sampling sites utilize unique intake structures designed by Norman Champagne. One design is a converging section in the downstream direction that narrows the vertical axis. The other design is an upright pipe with a horizontally converging intake. Both designs are assumed to vertically integrate suspended sediment to provide a representative sample. However, sufficient field measurements have not been taken to verify this because of a variability and timing of significant runoff events. Since much of the suspended sediment information is collected using these samplers, it is important to have a thorough understanding of their response to different factors. Therefore, to ascertain the operating characteristics of these two suspended sediment sampling intakes, this study was undertaken so that development of a computer-based mathematical model could be used to "test" the two samplers for selected conditions. Collection of sufficient field data is necessary to verify the model. However, the model provides a sound basis for evaluation and qualitative comparisons of intake designs. These comparisons will enable redesign, if needed, of the current intake structures. Verification of the intake designs and the mathematical model can best be achieved based upon extensive field data collection over a range of flow conditions. The verification of designs is a topic for latter studies and would be of limited value unless actual field conditions were modeled.

The model developed is based on the physical processes of open channel flow and sediment transport. The model is general in application and can be used for channels of different geometry, slope, bed material, flow discharge, and flow frequencies. It accounts for sampler geometry, location, and mixing conditions in the sampler.

The following sections describe data input, results output, model applications, conclusions and recommendations. The appendices contain the program theory and listing.

DATA INPUT

General

The program SAMPLER is written in FORTRAN IV and is self contained except for requiring the IMSL subroutine MDNOR. All input units are in feet and seconds. All data are input from the main program sampler, with the exception of the sampler dimensions which are defined with DATA statements in subroutines BOX and PUMP. The program has been written to be self documenting, thus these instructions have been kept to a minimum for the sake of clarity. The user is referred to the program listing for more details.

Required Data

The program requires the following data:

1. A digitized channel cross section at the sampler location.
2. The median (D_{50}) bed material size at each cross section point.
3. The Manning's n value at each cross section point.
4. A water discharge-frequency relationship at the sampler location.
5. The slope of the energy grade line at the sampler location.
6. The Darcy-Weisbach grain roughness at the section.
7. The sediment sizes of interest.
8. The sediment sampler dimensions.

Input Formats

The following cards give the input data for program execution. The input is read from TAPE5.

Card Number	Format	Description
1	(12A5)	Title, Title of Run
2	(4I5, 2F10.4)	IR, Sampler number (1 for BOX, 2 for PUMP) ND, Number of points in the cross section NQ, Number of discharges NS1Z, Number of particle size fractions S, the slope of the energy grade line FO, the Darcy-Weisbach grain roughness
3 (Repeat card for each of NQ discharge)	(2F10.2)	Q(J), Discharge(J) in cfs Freq(J), Frequency of discharge(J) in decimal fraction
4 (Repeat card for each of ND cross section points)	(4F10.4)	X(K), Cross section point(K) horizontal distance Z(K), point(K) vertical elevation F(K), point(K) Manning's n value D(K), point(K) median (D_{50}) sediment size
5 (Repeat card for each of NS1Z+1 size fractions)	(F10.6)	DBD(I), Lower size limit of sediment range (I), last card upper size limit of fraction NS1Z

Data Statements

Data statements are used to define the sampler dimensions to allow the most flexibility in modifying sampler designs. Figures 1 and 2 show the sampler dimensions for the box and pump sampler.

The following DATA statements are in the program. The user should change these values to fit needs.

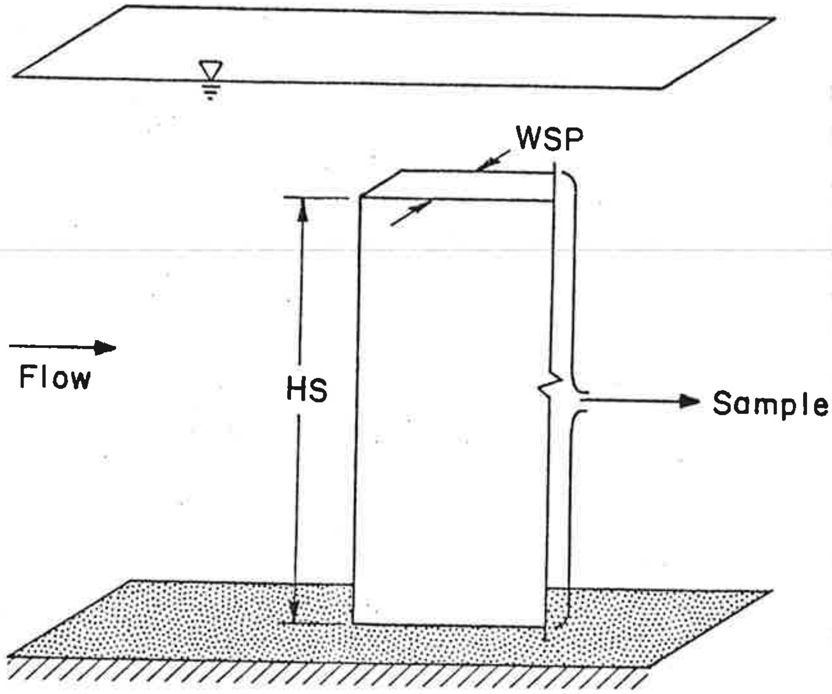

Figure 1. Box sampler dimensions.

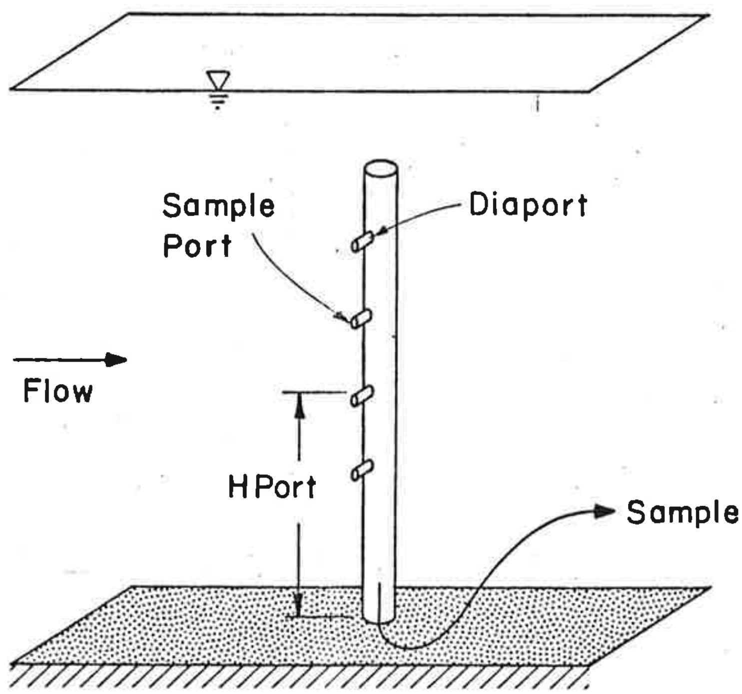

Figure 2. Pump sampler dimensions.

Subroutine BOX

```
DATA WSP/0.382/        (width of sampler)
DATA HS/1.5/           (height of sampler)
```

Subroutine PUMP

```
DATA NPORT/5/          (number of intake ports)
DATA DIAPORT/0.02/     (diameter of ports)
DATA HPORTS/0.5,1.0,1.5,2.0,2.5/  (height of ports)
```

RESULTS OUTPUT

General

All program output is printed on TAPE6. The printed output results are by and large self explanatory. Examples of the complete results for both the box and pump samplers are contained in the next section. This section will describe in general the results. The output has three main parts: 1) Input and Initial Calculations, 2) Single Discharge Flow, Transport and Sampling Calculations, and 3) Overall Sampling Calculations.

Input and Initial Calculations

The input data is listed out for user checking along with initial calculations of mean sediment size for each size range, the fall velocity for each size range, and the subsection particle size distribution. A subsection is the channel between two cross section points.

Single Discharge Flow, Transport and Sampling Calculations

For each discharge, five tables are printed out. The tables are:

1. Flow Properties, which contain the subsection discharge, velocity and depth of flow.
2. Sediment Transport by Size Fraction, which contains the total transport by size fraction.
3. Sediment Transport by Subsection and Size Fraction, which lists the sediment transport of each size fraction in each subsection. This table is useful in determining where in the section sediment is being transported.

4. Efficiency of Sampler by Subsection and Size Fraction, which lists the decimal percent of each size fraction the sampler would catch if it were placed in that subsection. This value ranges from 0.0 to 1.0. A value of 1.00 is the best. The efficiency of a sampler is also reduced by the amount of the sampler out of the water. Thus a pump sampler with only 2 of 5 ports out of the water will have a 0.40 efficiency at best. An efficiency of -1.0 shows that no sediment would be transported or sampled in that subsection.

5. Ratio of Sampled Sediment Concentration to Average by Subsection and Size Fraction, which lists the ratio of the sampled concentration to the total concentration at the cross section as if the sampler were placed at that section. This value ranges from zero to ten or higher. A value of 1.0 for each size fraction would indicate perfect sampling.

Overall Sampling Calculations

The overall sampling calculation output contains two tables. The tables are:

1. Overall Flow Frequency Weighted, Ratio of Sampled Sediment Concentration to Average, by Subsection and Size Fraction. This table lists the ratio of the sum sampled sediment for each flow multiplied by the flow frequency, and the total sediment transport for each flow multiplied by its frequency. The value should range from zero to two or more. A value of 1.0 would be best.

2. Overall Flow Frequency Weighted Ratio of Sampled Concentration to Average by Subsection. This table lists ratio of the sum of the total sampled concentration multiplied by the flow frequency, and the sum of the total sediment transport multiplied by flow frequency, if the sampler were placed in the subsection. The value will range from zero to two or more. A value of 1.0 is best.

Error Output

The program has only one error output. This output occurs when the program is unable to calculate the depth of flow. When it occurs, the following message is printed,

DOES NOT CONVERGE WITHIN 10 ITERATIONS

If this happens the user should check the input data.

EXAMPLE RUNS

Box Sampler Run

An example run was performed for the box sampler. A listing of the input and output follow. The example uses generated data that is representative of conditions in National Forests. Page 11 shows the example input data. The cross section is roughly triangular in shape with a total top width of 60 feet. Five flow discharge are used, 1000, 500, 250, 100 and 50 cfs while the flow frequencies are 0.01, 0.05, 0.10, 0.50 and 0.34 respectively. The energy slope has a relatively high value of 0.024 ft/ft, and the grain roughness is 0.25. The bed material of interest is broken into 10 size fractions ranging from 0.000051 to 0.105 feet. The medium bed material at the cross section points ranges from 0.02 to 0.15 feet. The high value of 0.15 feet at horizontal distance 39 feet was used to show the effect of a gravel bar on the calculations. Note that this size is larger than the particle size fractions used. This causes no computational problem in the program but the transport rates and sampling of sizes larger than the upper fraction are not calculated.

Pages 12 to 34 show the example output. In this example the best location for the sampler would be in subsections 9 or 12. Reviewing the "Over All" tables (page 34) shows a sampler located in those subsections would underpredict the smallest fraction by a ratio of 0.31 and underpredict the largest fraction by a ratio of 0.49. The total sediment transport would be overpredicted by a ratio of 1.13.

Box Sampler Example Input (see page 4 for explanation)

```
Card
Number

1  -  EXAMPLE RUN FOR PROGRAM SAMPLER WITH BOX SAMPLER
2  -        1   21       5    10        .0240      .2500
          1000.00         0.01
           500.00         0.05
3  -       250.00         0.10
           100.00         0.50
            50.00         0.34
           0.0000      13.5000       0.0200     0.0200
           3.0000      13.2000       0.0200     0.0200
           6.0000      12.8000       0.0200     0.0200
           9.0000      12.5000       0.0200     0.0200
          12.0000      12.1000       0.0200     0.0200
          15.0000      11.8000       0.0300     0.0150
          18.0000      11.4000       0.0300     0.0150
          21.0000      11.1000       0.0300     0.0150
          24.0000      10.7000       0.0300     0.0150
          27.0000      10.4000       0.0300     0.0100
4  -      30.0000      10.0000       0.0300     0.0100
          33.0000      10.4000       0.0300     0.0100
          36.0000      10.7000       0.0300     0.0150
          39.0000      11.1000       0.0300     0.1500
          42.0000      11.4000       0.0300     0.0150
          45.0000      11.8000       0.0300     0.0150
          48.0000      12.1000       0.0200     0.0200
          51.0000      12.5000       0.0200     0.0200
          54.0000      12.8000       0.0200     0.0200
          57.0000      13.2000       0.0200     0.0200
          60.0000      13.5000       0.0200     0.0200
        0.000051
        0.000205
        0.000410
        0.000820
        0.001640
5  -    0.003280
        0.006560
        0.013100
        0.026300
        0.052500
        0.105000
```

Box Sampler Example Output

```
S A M P L E R
SEDIMENT SAMPLER EVALUATION PROGRAM
DEVELOPED BY G.O. BROWN AND R.M. LI
AT COLORADO STATE UNIVERSITY
FOR THE USDA FOREST SERVICE
ROCKY MOUNTAIN FOREST AND RANGE EXPERIMENT STATION
FLAGSTAFF, ARIZONA

******************************************************************
*                                                                *
* EXAMPLE RUN FOR PROGRAM SAMPLER WITH BOX SAMPLER               *
*                                                                *
******************************************************************

SAMPLER NUMBER =     1

NUMBER OF CROSS SECTION POINTS =   21
NUMBER OF DISCHARGES =     5
NUMBER OF SEDIMENT SIZES =    10
FRICTION SLOPE =     .02400 FT/FT
GRAIN ROUGHNESS =     .25000

CROSS SECTION
```

POINT	HORIZONTAL	VERITICAL	N	D50
1	0.00	13.50	.020	.020000
2	3.00	13.20	.020	.020000
3	6.00	12.80	.020	.020000
4	9.00	12.50	.020	.020000
5	12.00	12.10	.020	.020000
6	15.00	11.80	.030	.015000
7	18.00	11.40	.030	.015000
8	21.00	11.10	.030	.015000
9	24.00	10.70	.030	.015000
10	27.00	10.40	.030	.010000
11	30.00	10.00	.030	.010000
12	33.00	10.40	.030	.010000
13	36.00	10.70	.030	.015000
14	39.00	11.10	.030	.150000
15	42.00	11.40	.030	.015000
16	45.00	11.80	.030	.015000
17	48.00	12.10	.020	.020000
18	51.00	12.50	.020	.020000
19	54.00	12.80	.020	.020000
20	57.00	13.20	.020	.020000
21	60.00	13.50	.020	.020000

Box Sampler Example Output (cont.)

SEDIMENT PROPERTIES

SUB SECTION	PARTICLE SIZE FRACTION 1	2	3	4	5	6	7	8	9	10
MEAN SEDIMENT SIZE IN FEET	.1022E-03	.2899E-03	.5798E-03	.1160E-02	.2319E-02	.4639E-02	.9270E-02	.1856E-01	.3716E-01	.7425E-01
FALL VELOCITY IN FT/SEC	.2799E-02	.2153E-01	.6918E-01	.1536E+00	.2596E+00	.3913E+00	.5659E+00	.8073E+00	.1145E+01	.1621E+01

SUBSECTION PARTICLE SIZE DISTRIBUTION

SUBSECTION	1	2	3	4	5	6	7	8	9	10
1	.00000	.00000	.00000	.00015	.00440	.04934	.21690	.38281	.26449	.07354
2	.00000	.00000	.00000	.00015	.00440	.04934	.21690	.38281	.26449	.07354
3	.00000	.00000	.00000	.00015	.00440	.04934	.21690	.38281	.26449	.07354
4	.00000	.00000	.00000	.00015	.00440	.04934	.21690	.38281	.26449	.07354
5	.00000	.00000	.00001	.00033	.00785	.07247	.25286	.39310	.21858	.05015
6	.00000	.00000	.00001	.00069	.01344	.10225	.30615	.36852	.17359	.03286
7	.00000	.00000	.00001	.00069	.01344	.10225	.30615	.36852	.17359	.03286
8	.00000	.00000	.00001	.00069	.01344	.10225	.30615	.36852	.17359	.03286
9	.00000	.00000	.00005	.00181	.02681	.15520	.35480	.32622	.11723	.01690
10	.00000	.00000	.00015	.00440	.04934	.21762	.38005	.26693	.07313	.00802
11	.00000	.00000	.00015	.00440	.04934	.21762	.39005	.26693	.07313	.00802
12	.00000	.00000	.00005	.00181	.02681	.15520	.35480	.32622	.11723	.01690
13	.00000	.00000	.00000	.00000	.00006	.00210	.02954	.16572	.36077	.31599
14	.00000	.00000	.00000	.00000	.00006	.00210	.02954	.16572	.36077	.31599
15	.00000	.00000	.00001	.00069	.01344	.10225	.30615	.36852	.17359	.03286
16	.00000	.00000	.00001	.00033	.00785	.07247	.26286	.38310	.21858	.05015
17	.00000	.00000	.00000	.00015	.00440	.04934	.21690	.38281	.26449	.07354
18	.00000	.00000	.00000	.00015	.00440	.04934	.21690	.38281	.26449	.07354
19	.00000	.00000	.00000	.00015	.00440	.04934	.21690	.38281	.26449	.07354
20	.00000	.00000	.00000	.00015	.00440	.04934	.21690	.38281	.26449	.07354

Box Sampler Example Output (cont.)

DISCHARGE, 1 1000.0000 CFS WITH .0100 FREQUENCY

FLOW PROPERTIES

SUB SECTION	DISCHARGE CFS	VELOCITY FT/SEC	DEPTH FT
1	0.0000	0.0000	0.0000
2	.8744	3.0571	.1381
3	8.3065	6.4970	.4262
4	22.5041	9.6646	.7762
5	33.5639	9.9345	1.1262
6	43.7994	9.8903	1.4762
7	62.6018	11.4268	1.8262
8	83.6364	12.8109	2.1762
9	107.5116	14.1864	2.5262
10	133.1256	15.4287	2.8762
11	133.1256	15.4287	2.8762
12	107.5116	14.1864	2.5262
13	83.6364	12.8109	2.1762
14	62.6018	11.4268	1.8262
15	43.7994	9.8903	1.4762
16	33.5639	9.9345	1.1262
17	22.5041	9.6646	.7762
18	8.3065	6.4970	.4262
19	.8744	3.0571	.1381
20	0.0000	0.0000	0.0000

TOTAL SEDIMENT TRANSPORT = 87.6487 CFS

SEDIMENT TRANSPORT BY SIZE FRACTION IN CFS

1	2	3	4	5	6	7	8	9	10
.9104E-06	.1765E-03	.1213E-01	.3056E+00	.3167E+01	.1409E+02	.2770E+02	.2582E+02	.1229E+02	.4249E+01

Box Sampler Example Output (cont.)

SEDIMENT TRANSPORT BY SUBSECTION AND SIZE FRACTION, IN CFS

SUB SECTION	PARTICLE SIZE FRACTION 1	2	3	4	5	6	7	8	9	10
1	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
2	.00000	.00000	.00000	.00001	.00022	.00238	.00970	.01483	.00734	.00080
3	.00000	.00000	.00000	.00014	.00355	.03749	.15705	.26336	.16691	.04051
4	.00000	.00000	.00001	.00053	.01324	.13566	.55890	.93494	.59736	.15292
5	.00000	.00000	.00003	.00142	.02851	.23449	.78135	1.06324	.54969	.11483
6	.00000	.00000	.00008	.00327	.05289	.35135	.94972	1.05229	.44003	.07476
7	.00000	.00000	.00014	.00554	.08867	.58075	1.54896	1.69946	.70137	.11906
8	.00000	.00000	.00021	.00847	.13466	.87231	2.29941	2.49834	1.01637	.17160
9	.00000	.00001	.00107	.03247	.39021	1.90755	3.80039	3.12522	.95614	.12209
10	.00000	.00007	.00469	.10796	.98280	3.63579	5.48479	3.41581	.78543	.07568
11	.00000	.00007	.00469	.10796	.98280	3.63579	5.48479	3.41581	.78543	.07568
12	.00000	.00001	.00107	.03247	.39021	1.90755	3.80039	3.12522	.95614	.12209
13	.00000	.00000	.00000	.00001	.00058	.01791	.22190	1.12359	2.11235	1.65038
14	.00000	.00000	.00000	.00000	.00038	.01192	.14948	.76425	1.45768	1.14509
15	.00000	.00000	.00008	.00327	.05289	.35135	.94972	1.05229	.44003	.07476
16	.00000	.00000	.00003	.00142	.02851	.23449	.78135	1.06324	.54969	.11483
17	.00000	.00000	.00001	.00053	.01324	.13566	.55890	.93494	.59736	.15292
18	.00000	.00000	.00000	.00014	.00355	.03749	.15705	.26336	.16691	.04051
19	.00000	.00000	.00000	.00001	.00022	.00238	.00970	.01483	.00734	.00080
20	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000

Box Sampler Example Output (cont.)

EFFICIENCY OF SAMPLER BY SUBSECTION AND SIZE FRACTION

SUB SECTION	PARTICLE SIZE FRACTION 1	2	3	4	5	6	7	8	9	10
1	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000
2	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000
3	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000
4	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000
5	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000
6	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000
7	.87017	.88596	.91996	.96027	.98504	.99594	.99933	.99995	1.00000	1.00000
8	.76857	.79118	.84229	.90967	.95865	.98551	.99660	.99956	.99998	1.00000
9	.69158	.71654	.77489	.85757	.92515	.96852	.99050	.99823	.99986	.99999
10	.63099	.65634	.71698	.80748	.88806	.94614	.99045	.99526	.99946	.99997
11	.63099	.65634	.71698	.80748	.88806	.94614	.99045	.99526	.99946	.99997
12	.69158	.71654	.77489	.85757	.92515	.96852	.99050	.99823	.99986	.99999
13	.76857	.79118	.84229	.90967	.95865	.98551	.99660	.99956	.99998	1.00000
14	.87017	.88596	.91996	.96027	.98504	.99594	.99933	.99995	1.00000	1.00000
15	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000
16	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000
17	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000
18	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000
19	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000
20	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000

Box Sampler Example Output (cont.)

RATIO OF SAMPLED SEDIMENT CONCENTRATION TO AVERAGE, BY SUBSECTION AND SIZE FRACTION

SUB SECTION	PARTICLE SIZE FRACTION 1	2	3	4	5	6	7	8	9	10
1	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
2	.00174	.00436	.01116	.03043	.08047	.19303	.40034	.65664	.68262	.21503
3	.00368	.00899	.02144	.05353	.13500	.32031	.69250	1.22771	1.63453	1.14765
4	.00551	.01352	.03202	.07686	.18573	.42776	.89647	1.60873	2.15921	1.59911
5	.01824	.03681	.07166	.13887	.26821	.49576	.84031	1.22664	1.33220	.80509
6	.05816	.09638	.15459	.24439	.38130	.56923	.78269	.93031	.81721	.40169
7	.07209	.12224	.20510	.33851	.53632	.79818	1.08552	1.27972	1.10952	.54491
8	.08567	.14748	.25542	.43715	.70703	1.05817	1.43486	1.67736	1.43408	.70051
9	.61535	.80435	1.07317	1.42736	1.78551	2.05360	2.12845	1.89228	1.21814	.45007
10	3.94921	3.90971	3.99677	4.10833	3.96917	3.51584	2.79531	1.89605	.91972	.25651
11	3.94921	3.90971	3.99677	4.10833	3.96917	3.51584	2.79581	1.89605	.91972	.25651
12	.61535	.80435	1.07317	1.42736	1.78551	2.05360	2.12845	1.89228	1.21814	.45007
13	.00000	.00001	.00004	.00038	.00302	.02173	.13847	.75430	2.98047	6.73709
14	.00000	.00000	.00004	.00030	.00229	.01639	.10486	.57549	2.30593	5.24066
15	.05816	.09638	.15459	.24439	.38130	.56923	.78269	.93031	.81721	.40169
16	.01824	.03681	.07166	.13887	.26821	.49576	.84031	1.22664	1.33220	.80509
17	.00551	.01352	.03202	.07686	.18573	.42776	.89647	1.60873	2.15921	1.59911
18	.00368	.00899	.02144	.05353	.13500	.32031	.68250	1.22771	1.63453	1.14765
19	.00174	.00436	.01116	.03043	.08047	.19303	.40034	.65664	.68262	.21503
20	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000

Box Sampler Example Output (cont.)

```
DISCHARGE,     2    500.0000 CFS WITH       .0500 FREQUENCY
FLOW PROPERTIES
```

SUB SECTION	DISCHARGE CFS	VELOCITY FT/SEC	DEPTH FT
1	0.0000	0.0000	0.0000
2	0.0000	0.0000	0.0000
3	0.0000	0.0000	0.0000
4	1.1519	3.2752	.1531
5	7.4451	5.4393	.4563
6	15.9842	6.6084	.8063
7	29.2261	8.4255	1.1563
8	45.2969	10.0242	1.5063
9	64.3297	11.5519	1.8563
10	85.5719	12.9287	2.2063
11	85.5719	12.9287	2.2063
12	64.3297	11.5519	1.8563
13	45.2969	10.0242	1.5063
14	29.2261	8.4255	1.1563
15	15.9842	6.6084	.8063
16	7.4451	5.4393	.4563
17	1.1519	3.2752	.1531
18	0.0000	0.0000	0.0000
19	0.0000	0.0000	0.0000
20	0.0000	0.0000	0.0000

```
TOTAL SEDIMENT TRANSPORT = 36.5720 CFS
SEDIMENT TRANSPORT BY SIZE FRACTION IN CFS
```

1	2	3	4	5	6	7	8	9	10
.4737E-06	.9052E-04	.6071E-02	.1492E+00	.1510E+01	.6502E+01	.1207E+02	.1026E+02	.4498E+01	.1583E+01

Box Sampler Example Output (cont.)

SEDIMENT TRANSPORT BY SUBSECTION AND SIZE FRACTION, IN CFS

SUB SECTION	PARTICLE SIZE FRACTION 1	2	3	4	5	6	7	8	9	10
1	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
2	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
3	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
4	.00000	.00000	.00000	.00001	.00031	.00328	.01348	.02100	.01103	.00147
5	.00000	.00000	.00000	.00018	.00375	.03238	.11104	.15168	.07721	.01455
6	.00000	.00000	.00002	.00077	.01302	.08990	.25009	.28093	.11861	.01937
7	.00000	.00000	.00005	.00183	.03002	.20271	.55543	.52063	.26198	.04421
8	.00000	.00000	.00009	.00344	.05549	.35809	.99375	1.10016	.45956	.07809
9	.00000	.00001	.00050	.01516	.18393	.91596	1.86333	1.56025	.49066	.06343
10	.00000	.00004	.00244	.05583	.51111	1.91832	2.94670	1.86654	.44109	.04315
11	.00000	.00004	.00244	.05583	.51111	1.91832	2.94670	1.86654	.44109	.04315
12	.00000	.00001	.00050	.01516	.18393	.91596	1.86333	1.56025	.49066	.06343
13	.00000	.00000	.00000	.00000	.00024	.00756	.09590	.49474	.95511	.75106
14	.00000	.00000	.00000	.00000	.00013	.00416	.05360	.27910	.54448	.42520
15	.00000	.00000	.00002	.00077	.01302	.08990	.25009	.28093	.11861	.01937
16	.00000	.00000	.00000	.00018	.00375	.03238	.11104	.15168	.07721	.01455
17	.00000	.00000	.00000	.00001	.00031	.00328	.01348	.02100	.01103	.00147
18	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
19	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
20	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000

Box Sampler Example Output (cont.)

EFFICIENCY OF SAMPLER BY SUBSECTION AND SIZE FRACTION

SUB SECTION	PARTICLE SIZE FRACTION 1	2	3	4	5	6	7	8	9	10
1	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000
2	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000
3	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000
4	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000
5	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000
6	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000
7	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000
8	.99707	.99752	.99843	.99936	.99981	.99996	1.00000	1.00000	1.00000	1.00000
9	.86016	.87683	.91290	.95613	.98315	.99531	.99920	.99993	1.00000	1.00000
10	.76114	.78407	.83610	.90519	.95600	.98430	.99622	.99949	.99997	1.00000
11	.76114	.78407	.83610	.90519	.95600	.98430	.99622	.99949	.99997	1.00000
12	.86016	.87683	.91290	.95613	.98315	.99531	.99920	.99993	1.00000	1.00000
13	.99707	.99752	.99843	.99936	.99981	.99996	1.00000	1.00000	1.00000	1.00000
14	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000
15	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000
16	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000
17	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000
18	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000
19	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000
20	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000

Box Sampler Example Output (cont.)

RATIO OF SAMPLED SEDIMENT CONCENTRATION TO AVERAGE, BY SUBSECTION AND SIZE FRACTION

SUB SECTION	1	2	3	4	5	6	7	8	9	10
	PARTICLE SIZE FRACTION									
1	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
2	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
3	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
4	.00179	.00453	.01176	.03265	.08824	.21917	.48500	.88899	1.06449	.40456
5	.00943	.01907	.03798	.07917	.16677	.33449	.61793	.99329	1.15271	.61767
6	.03660	.06079	.09858	.16244	.26972	.43251	.64824	.85688	.82479	.38296
7	.04728	.07908	.12900	.20991	.34011	.53336	.79741	1.03533	.99637	.47794
8	.05577	.09556	.15720	.25511	.40721	.62745	.91275	1.18908	1.13240	.54698
9	.43240	.56023	.72788	.93469	1.15179	1.34858	1.49392	1.46324	1.04914	.38552
10	2.89435	2.86181	2.89209	2.91141	2.78075	2.49567	2.09055	1.56338	.84268	.23434
11	2.89435	2.86181	2.89209	2.91141	2.78075	2.49567	2.09055	1.56338	.84268	.23434
12	.43240	.56023	.72788	.93469	1.15179	1.34858	1.48392	1.46324	1.04914	.38552
13	.00000	.00000	.00003	.00022	.00174	.01288	.08808	.53473	2.35348	5.26053
14	.00000	.00000	.00002	.00018	.00145	.01095	.07599	.46559	2.07078	4.59659
15	.03660	.06079	.09858	.16244	.26972	.43251	.64824	.85688	.82479	.38296
16	.00943	.01907	.03798	.07917	.16677	.33448	.61793	.99329	1.15271	.61767
17	.00179	.00453	.01176	.03265	.08824	.21917	.48500	.88899	1.06449	.40456
18	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
19	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
20	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000

Box Sampler Example Output (cont.)

DISCHARGE, 3 250.0000 CFS WITH .1000 FREQUENCY

FLOW PROPERTIES

SUB SECTION	DISCHARGE CFS	VELOCITY FT/SEC	DEPTH FT
1	0.0000	0.0000	0.0000
2	0.0000	0.0000	0.0000
3	0.0000	0.0000	0.0000
4	0.0000	0.0000	0.0000
5	.0270	1.0103	.0365
6	2.6301	3.2108	.2730
7	10.4284	5.5793	.6230
8	21.8674	7.4910	.9730
9	36.5855	9.2175	1.3230
10	53.9619	10.7512	1.6730
11	53.9619	10.7512	1.6730
12	36.5855	9.2175	1.3230
13	21.8674	7.4910	.9730
14	10.4284	5.5793	.6230
15	2.6301	3.2108	.2730
16	.0270	1.0103	.0365
17	0.0000	0.0000	0.0000
18	0.0000	0.0000	0.0000
19	0.0000	0.0000	0.0000
20	0.0000	0.0000	0.0000

TOTAL SEDIMENT TRANSPORT = 15.9760 CFS

SEDIMENT TRANSPORT BY SIZE FRACTION IN CFS

1	2	3	4	5	6	7	8	9	10
.2400E-06	.4520E-04	.2967E-02	.7163E-01	.7173E+00	.3044E+01	.5483E+01	.4384E+01	.1734E+01	.5389E+00

Box Sampler Example Output (cont.)

SEDIMENT TRANSPORT BY SUBSECTION AND SIZE FRACTION, IN CFS

SUB SECTION	PARTICLE SIZE FRACTION 1	2	3	4	5	6	7	8	9	10
1	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
2	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
3	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
4	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
5	.00000	.00000	.00000	.00000	.00000	.00002	.00002	0.00000	0.00000	0.00000
6	.00000	.00000	.00000	.00007	.00121	.00864	.02387	.02505	.00877	.00075
7	.00000	.00000	.00001	.00043	.00736	.05149	.14417	.15160	.06745	.01052
8	.00000	.00000	.00003	.00121	.01999	.13650	.37702	.42280	.17886	.02982
9	.00000	.00000	.00022	.00665	.08206	.41798	.86817	.73789	.23660	.03057
10	.00000	.00002	.00124	.02828	.26166	.99948	1.56367	1.00532	.24273	.02391
11	.00000	.00002	.00124	.02828	.26166	.99948	1.56367	1.00532	.24273	.02391
12	.00000	.00000	.00022	.00665	.08206	.41798	.85917	.73789	.23660	.03057
13	.00000	.00000	.00000	.00000	.00009	.00280	.03638	.19013	.37173	.28683
14	.00000	.00000	.00000	.00000	.00003	.00106	.01391	.07267	.14018	.10121
15	.00000	.00000	.00000	.00007	.00121	.00864	.02387	.02505	.00877	.00075
16	.00000	.00000	.00000	.00000	.00000	.00002	.00002	0.00000	0.00000	0.00000
17	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
18	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
19	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
20	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000

Box Sampler Example Output (cont.)

EFFICIENCY OF SAMPLER BY SUBSECTION AND SIZE FRACTION

SUB SECTION	PARTICLE SIZE FRACTION 1	2	3	4	5	6	7	8	9	10
1	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000
2	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000
3	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000
4	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000
5	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000
6	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000
7	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000
8	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000
9	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000
10	.92578	.93585	.95688	.98031	.99337	.99844	.99979	.99999	1.00000	1.00000
11	.92578	.93585	.95688	.98031	.99337	.99844	.99979	.99999	1.00000	1.00000
12	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000
13	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000
14	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000
15	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000
16	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000
17	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000
18	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000
19	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000
20	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000

Box Sampler Example Output (cont.)

RATIO OF SAMPLED SEDIMENT CONCENTRATION TO AVERAGE, BY SUBSECTION AND SIZE FRACTION

SUB SECTION	PARTICLE SIZE FRACTION 1	2	3	4	5	6	7	8	9	10
1	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
2	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
3	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
4	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
5	.00185	.00411	.00979	.02326	.04706	.07032	.04003	0.00000	0.00000	0.00000
6	.01740	.02920	.04958	.08958	.16048	.26965	.41374	.54318	.48078	.13241
7	.03043	.05107	.08457	.14385	.24590	.40547	.63034	.88375	.93229	.46817
8	.04115	.06958	.11555	.19234	.31853	.51265	.78613	1.10264	1.17895	.63276
9	.31494	.40295	.50798	.63446	.78171	.93827	1.08199	1.15021	.93217	.38768
10	2.15892	2.11142	2.06841	1.99983	1.87238	1.69399	1.47336	1.18502	.72317	.22931
11	2.15892	2.11142	2.06841	1.99983	1.87238	1.69399	1.47336	1.18502	.72317	.22931
12	.31494	.40295	.50798	.63446	.78171	.93827	1.08199	1.15021	.93217	.38768
13	.00000	.00000	.00002	.00017	.00136	.01053	.07586	.49586	2.45024	6.09551
14	.00000	.00000	.00001	.00013	.00105	.00833	.06083	.39742	1.93759	4.50259
15	.01740	.02920	.04958	.08958	.16048	.26965	.41374	.54318	.48078	.13241
16	.00185	.00411	.00979	.02326	.04706	.07032	.04003	0.00000	0.00000	0.00000
17	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	-0.00000	0.00000	0.00000	0.00000
18	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
19	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
20	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000

Box Sampler Example Output (cont.)

DISCHARGE, 4 100.0000 CFS WITH .5000 FREQUENCY

FLOW PROPERTIES

SUB SECTION	DISCHARGE CFS	VELOCITY FT/SEC	DEPTH FT
1	0.0000	0.0000	0.0000
2	0.0000	0.0000	0.0000
3	0.0000	0.0000	0.0000
4	0.0000	0.0000	0.0000
5	0.0000	0.0000	0.0000
6	0.0000	0.0000	0.0000
7	.5350	1.8599	.1199
8	5.8220	4.4122	.4398
9	15.4853	6.5352	.7898
10	28.4653	8.3243	1.1398
11	28.4653	8.3243	1.1398
12	15.4853	6.5352	.7898
13	5.8220	4.4122	.4398
14	.5350	1.8599	.1199
15	0.0000	0.0000	0.0000
16	0.0000	0.0000	0.0000
17	0.0000	0.0000	0.0000
18	0.0000	0.0000	0.0000
19	0.0000	0.0000	0.0000
20	0.0000	0.0000	0.0000

TOTAL SEDIMENT TRANSPORT = 5.3698 CFS

SEDIMENT TRANSPORT BY SIZE FRACTION IN CFS

1	2	3	4	5	6	7	8	9	10
.9374E-07	.1733E-04	.1111E-02	.2649E-01	.2651E+00	.1118E+01	.1962E+01	.1455E+01	.4591E+00	.8372E-01

Box Sampler Example Output (cont.)

SEDIMENT TRANSPORT BY SUBSECTION AND SIZE FRACTION, IN CFS

SUB SECTION	PARTICLE SIZE FRACTION 1	2	3	4	5	6	7	8	9	10
1	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
2	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
3	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
4	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
5	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
6	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
7	.00000	.00000	.00000	.00001	.00017	.00115	.00280	.00208	.00012	0.00000
8	.00000	.00000	.00000	.00019	.00339	.02404	.06744	.07453	.02989	.00413
9	.00000	.00000	.00006	.00196	.02498	.13142	.27933	.23972	.07720	.00958
10	.00000	.00001	.00049	.01119	.10577	.41452	.56293	.43233	.10616	.01037
11	.00000	.00001	.00049	.01119	.10577	.41452	.56293	.43233	.10616	.01037
12	.00000	.00000	.00006	.00196	.02498	.13142	.27933	.23972	.07720	.00958
13	.00000	.00000	.00000	.00000	.00001	.00049	.00551	.03351	.06212	.03968
14	.00000	.00000	.00000	.00000	.00000	.00002	.00027	.00093	.00025	0.00000
15	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
16	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
17	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
18	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
19	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
20	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000

Box Sampler Example Output (cont.)

EFFICIENCY OF SAMPLER BY SUBSECTION AND SIZE FRACTION

SUB SECTION	PARTICLE SIZE FRACTION 1	2	3	4	5	6	7	8	9	10
1	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000
2	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000
3	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000
4	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000
5	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000
6	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000
7	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000
8	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000
9	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000
10	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000
11	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000
12	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000
13	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000
14	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000
15	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000
16	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000
17	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000
18	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000
19	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000
20	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000

Box Sampler Example Output (cont.)

RATIO OF SAMPLED SEDIMENT CONCENTRATION TO AVERAGE, BY SUBSECTION AND SIZE FRACTION

SUB SECTION	PARTICLE SIZE FRACTION 1	2	3	4	5	6	7	8	9	10
1	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
2	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
3	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
4	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
5	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
6	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
7	.01038	.01830	.03387	.06530	.11799	.19173	.26725	.26684	.04838	0.00000
8	.02449	.04176	.07123	.12556	.21980	.36953	.59054	.87971	1.11831	.84637
9	.22502	.29027	.37127	.47688	.60852	.75939	.91961	1.06383	1.08589	.73933
10	1.63151	1.59418	1.54695	1.48363	1.40180	1.30301	1.18728	1.04374	.81235	.43535
11	1.63151	1.59418	1.54695	1.48363	1.40180	1.30301	1.18728	1.04374	.81235	.43535
12	.22502	.29027	.37127	.47688	.60852	.75939	.91961	1.06383	1.08589	.73933
13	.00000	.00000	.00001	.00011	.00094	.00759	.05699	.39550	2.32422	8.13991
14	.00000	.00000	.00001	.00006	.00050	.00394	.02579	.12000	.10055	0.00000
15	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
16	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
17	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
18	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
19	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
20	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000

Box Sampler Example Output (cont.)

DISCHARGE, 5 50.0000 CFS WITH .3400 FREQUENCY

FLOW PROPERTIES

SUB SECTION	DISCHARGE CFS	VELOCITY FT/SEC	DEPTH FT
1	0.0000	0.0000	0.0000
2	0.0000	0.0000	0.0000
3	0.0000	0.0000	0.0000
4	0.0000	0.0000	0.0000
5	0.0000	0.0000	0.0000
6	0.0000	0.0000	0.0000
7	0.0000	0.0000	0.0000
8	1.0074	2.3368	.1695
9	6.9656	4.7476	.4891
10	17.0830	6.7865	.8391
11	17.0830	6.7865	.8391
12	6.9656	4.7476	.4891
13	1.0074	2.3368	.1695
14	0.0000	0.0000	0.0000
15	0.0000	0.0000	0.0000
16	0.0000	0.0000	0.0000
17	0.0000	0.0000	0.0000
18	0.0000	0.0000	0.0000
19	0.0000	0.0000	0.0000
20	0.0000	0.0000	0.0000

TOTAL SEDIMENT TRANSPORT = 2.3342 CFS

SEDIMENT TRANSPORT BY SIZE FRACTION IN CFS

1	2	3	4	5	6	7	8	9	10
.4435E-07	.8088E-05	.5107E-03	.1216E-01	.1222E+00	.5131E+00	.8829E+00	.6213E+00	.1659E+00	.1616E-01

Box Sampler Example Output (cont.)

SEDIMENT TRANSPORT BY SUBSECTION AND SIZE FRACTION, IN CFS

SUB SECTION	PARTICLE SIZE FRACTION 1	2	3	4	5	6	7	8	9	10
1	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
2	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
3	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
4	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
5	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
6	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
7	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
8	.00000	.00000	.00000	.00002	.00037	.00261	.03687	.00633	.00146	0.00000
9	.00000	.00000	.00002	.00055	.00860	.04623	.09706	.08414	.02616	.00289
10	.00000	.00000	.00023	.00542	.05232	.20899	.33862	.22191	.05454	.00519
11	.00000	.00000	.00023	.00542	.05232	.20899	.33862	.22191	.05454	.00519
12	.00000	.00000	.00002	.00055	.00860	.04623	.09706	.08414	.02616	.00289
13	.00000	.00000	.00000	.00000	.00000	.00005	.00066	.00285	.00304	0.00000
14	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
15	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
16	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
17	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
18	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
19	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
20	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000

Box Sampler Example Output (cont.)

EFFICIENCY OF SAMPLER BY SUBSECTION AND SIZE FRACTION

SUB SECTION	PARTICLE SIZE FRACTION 1	2	3	4	5	6	7	8	9	10
1	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000
2	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000
3	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000
4	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000
5	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000
6	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000
7	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000
8	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000
9	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000
10	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000
11	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000
12	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000
13	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000
14	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000
15	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000
16	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000
17	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000
18	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000
19	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000
20	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000

Box Sampler Example Output (cont.)

RATIO OF SAMPLED SEDIMENT CONCENTRATION TO AVERAGE, BY SUBSECTION AND SIZE FRACTION

SUB SECTION	PARTICLE SIZE FRACTION 1	2	3	4	5	6	7	8	9	10
1	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
2	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
3	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
4	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
5	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
6	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
7	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
8	.01374	.02413	.04399	.08333	.15043	.25221	.38613	.50589	.43692	0.00000
9	.17153	.22303	.29028	.38441	.50497	.64677	.80539	.97209	1.13207	1.28288
10	1.39310	1.37179	1.34378	1.30424	1.25309	1.19213	1.12256	1.04545	.96218	.94035
11	1.39310	1.37179	1.34378	1.30424	1.25309	1.19213	1.12256	1.04545	.96218	.94035
12	.17153	.22303	.29028	.38441	.50497	.64677	.80539	.97209	1.13207	1.28288
13	.00000	.00000	.00001	.00007	.00064	.00513	.03726	.22750	.90806	0.00000
14	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
15	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
16	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
17	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
18	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
19	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
20	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000

Box Sampler Example Output (cont.)

OVER ALL FLOW FREQUENCY WEIGHTED, RATIO OF SAMPLED SEDIMENT CONCENTRATION TO AVERAGE,
BY SUBSECTION AND SIZE FRACTION

SUB SECTION	PARTICLE SIZE FRACTION 1	2	3	4	5	6	7	8	9	10
1	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
2	.00013	.00035	.00093	.00265	.00722	.01809	.04093	.07394	.10396	.04100
3	.00028	.00071	.00179	.00467	.01211	.03002	.06978	.14759	.24892	.21882
4	.00078	.00200	.00514	.01365	.03554	.08748	.19965	.40559	.62542	.44854
5	.00365	.00764	.01594	.03370	.06930	.13301	.23161	.38456	.52405	.37281
6	.01528	.02597	.04369	.07416	.12452	.20145	.30809	.42722	.45756	.24458
7	.02520	.04333	.07441	.12823	.21514	.34346	.51071	.67169	.66065	.38680
8	.03762	.06458	.11042	.18395	.31552	.50519	.76554	1.05818	1.13574	.63974
9	.30769	.40066	.52284	.67843	.85333	1.03122	1.18907	1.26737	1.06599	.48693
10	2.13742	2.11386	2.11559	2.10050	2.00523	1.83454	1.60359	1.29924	.82846	.29251
11	2.13742	2.11386	2.11559	2.10050	2.00523	1.83454	1.60359	1.29924	.82846	.29251
12	.30769	.40066	.52284	.67843	.85333	1.03122	1.18907	1.26737	1.06599	.48693
13	.00000	.00000	.00002	.00016	.00135	.01037	.07388	.47586	2.36044	6.15269
14	.00000	.00000	.00001	.00011	.00092	.00705	.04928	.30206	1.37305	3.71997
15	.01528	.02597	.04369	.07416	.12452	.20145	.30809	.42722	.45756	.24458
16	.00365	.00764	.01594	.03370	.06930	.13301	.23161	.38456	.52405	.37281
17	.00078	.00200	.00514	.01365	.03554	.08748	.19965	.40559	.62542	.44854
18	.00028	.00071	.00179	.00467	.01211	.03002	.06978	.14759	.24892	.21882
19	.00013	.00035	.00093	.00265	.00722	.01809	.04093	.07894	.10396	.04100
20	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000

OVER ALL FLOW FREQUENCY WEIGHTED, RATIO OF SAMPLED CONCENTRATION TO AVERAGE,
BY SUBSECTION

SUBSECTION	RATIO
1	0.00000
2	.05184
3	.10351
4	.27781
5	.28087
6	.32463
7	.51963
8	.80769
9	1.12964
10	1.46679
11	1.46679
12	1.12964
13	.58026
14	.35094
15	.32463
16	.28087
17	.27781
18	.10351
19	.05184
20	0.00000

Pump Sampler Run

An example run was performed for the pump sampler. Its input is identical to the box sampler input except for the title card. Pages 36 to 58 show the example output. In this example, the best location for the sampler would be in subsections 10 or 11. Reviewing the overall tables (page 58) shows a sampler located in those subsections would overpredict the smallest size fractions by a ratio of 2.99 and not measure any of the two largest size fractions. The total sediment transport would be underpredicted by a ratio of 0.44.

Pump Sampler Example Output

```
S A M P L E R
SEDIMENT SAMPLER EVALUATION PROGRAM
DEVELOPED BY G.O. BROWN AND R.M. LI
AT COLORADO STATE UNIVERSITY
FOR THE USDA FOREST SERVICE
ROCKY MOUNTAIN FOREST AND RANGE EXPERIMENT STATION
FLAGSTAFF, ARIZONA

*********************************************************************
*                                                                   *
* EXAMPLE RUN FOR PROGRAM SAMPLER WITH MULTIPLE PORTS               *
*                                                                   *
*********************************************************************

SAMPLER NUMBER =     2

NUMBER OF CROSS SECTION POINTS =    21
NUMBER OF DISCHARGES =     5
NUMBER OF SEDIMENT SIZES =    10
FRICTION SLOPE =     .02400 FT/FT
GRAIN ROUGHNESS =     .25000

CROSS SECTION

POINT HORIZONTAL VERITICAL    N       D50

    1     0.00    13.50     .020   .020000
    2     3.00    13.20     .020   .020000
    3     6.00    12.80     .020   .020000
    4     9.00    12.50     .020   .020000
    5    12.00    12.10     .020   .020000
    6    15.00    11.80     .030   .015000
    7    18.00    11.40     .030   .015000
    8    21.00    11.10     .030   .015000
    9    24.00    10.70     .030   .015000
   10    27.00    10.40     .030   .010000
   11    30.00    10.00     .030   .010000
   12    33.00    10.40     .030   .010000
   13    36.00    10.70     .030   .015000
   14    39.00    11.10     .030   .150000
   15    42.00    11.40     .030   .015000
   16    45.00    11.80     .030   .015000
   17    48.00    12.10     .020   .020000
   18    51.00    12.50     .020   .020000
   19    54.00    12.80     .020   .020000
   20    57.00    13.20     .020   .020000
   21    60.00    13.50     .020   .020000
```

Pump Sampler Example Output (cont.)

SEDIMENT PROPERTIES

SUB SECTION	PARTICLE SIZE FRACTION 1	2	3	4	5	6	7	8	9	10
MEAN SEDIMENT SIZE IN FEET	.1022E-03	.2899E-03	.5798E-03	.1160E-02	.2319E-02	.4639E-02	.9270E-02	.1856E-01	.3716E-01	.7425E-01
FALL VELOCITY IN FT/SEC	.2799E-02	.2153E-01	.6918E-01	.1536E+00	.2596E+00	.3913E+00	.5659E+00	.8073E+00	.1145E+01	.1621E+01

SUBSECTION PARTICLE SIZE DISTRIBUTION

SUBSECTION	1	2	3	4	5	6	7	8	9	10
1	.00000	.00000	.00000	.00015	.00440	.04934	.21690	.38281	.26449	.07354
2	.00000	.00000	.00000	.00015	.00440	.04934	.21690	.38281	.26449	.07354
3	.00000	.00000	.00000	.00015	.00440	.04934	.21690	.38281	.26449	.07354
4	.00000	.00000	.00000	.00015	.00440	.04934	.21690	.38281	.26449	.07354
5	.00000	.00000	.00001	.00033	.00785	.07247	.26286	.38310	.21858	.05015
6	.00000	.00000	.00001	.00069	.01344	.10225	.30615	.36852	.17359	.03286
7	.00000	.00000	.00001	.00069	.01344	.10225	.30615	.36852	.17359	.03286
8	.00000	.00000	.00001	.00069	.01344	.10225	.30615	.36852	.17359	.03286
9	.00000	.00000	.00005	.00181	.02681	.15520	.35480	.32622	.11723	.01690
10	.00000	.00000	.00015	.00440	.04934	.21762	.39005	.26693	.07313	.00802
11	.00000	.00000	.00015	.00440	.04934	.21762	.39005	.26693	.07313	.00802
12	.00000	.00000	.00005	.00181	.02681	.15520	.35480	.32622	.11723	.01690
13	.00000	.00000	.00000	.00000	.00006	.00210	.02954	.16572	.36077	.31599
14	.00000	.00000	.00000	.00000	.00006	.00210	.02954	.16572	.36077	.31599
15	.00000	.00000	.00001	.00069	.01344	.10225	.30615	.36852	.17359	.03286
16	.00000	.00000	.00001	.00033	.00785	.07247	.26286	.38310	.21858	.05015
17	.00000	.00000	.00000	.00015	.00440	.04934	.21690	.38281	.26449	.07354
18	.00000	.00000	.00000	.00015	.00440	.04934	.21690	.38281	.26449	.07354
19	.00000	.00000	.00000	.00015	.00440	.04934	.21690	.38281	.26449	.07354
20	.00000	.00000	.00000	.00015	.00440	.04934	.21690	.38281	.26449	.07354

Pump Sampler Example Output (cont.)

DISCHARGE, 1 1000.0000 CFS WITH .0100 FREQUENCY

FLOW PROPERTIES

SUB SECTION	DISCHARGE CFS	VELOCITY FT/SEC	DEPTH FT
1	0.0000	0.0000	0.0000
2	.8744	3.0571	.1381
3	8.3065	6.4970	.4262
4	22.5041	9.6646	.7762
5	33.5639	9.9345	1.1262
6	43.7994	9.8903	1.4762
7	62.6018	11.4268	1.8262
8	83.6364	12.8109	2.1762
9	107.5116	14.1864	2.5262
10	133.1266	15.4287	2.8762
11	133.1266	15.4287	2.8762
12	107.5116	14.1864	2.5262
13	83.6364	12.8109	2.1762
14	62.6018	11.4268	1.8262
15	43.7994	9.8903	1.4762
16	33.5639	9.9345	1.1262
17	22.5041	9.6646	.7762
18	8.3065	6.4970	.4262
19	.8744	3.0571	.1381
20	0.0000	0.0000	0.0000

TOTAL SEDIMENT TRANSPORT = 87.6487 CFS

SEDIMENT TRANSPORT BY SIZE FRACTION IN CFS

1	2	3	4	5	6	7	8	9	10
.9104E-06	.1765E-03	.1213E-01	.3056E+00	.3167E+01	.1409E+02	.2770E+02	.2582E+02	.1229E+02	.4249E+01

Pump Sampler Example Output (cont.)

SEDIMENT TRANSPORT BY SUBSECTION AND SIZE FRACTION, IN CFS

SUB SECTION	PARTICLE SIZE FRACTION 1	2	3	4	5	6	7	8	9	10
1	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
2	.00000	.00000	.00000	.00001	.00022	.00238	.00970	.01483	.00734	.00080
3	.00000	.00000	.00000	.00014	.00355	.03749	.15705	.26336	.16691	.04051
4	.00000	.00000	.00001	.00053	.01324	.13566	.55990	.93494	.59736	.15292
5	.00000	.00000	.00003	.00142	.02851	.23449	.78135	1.06324	.54969	.11483
6	.00000	.00000	.00008	.00327	.05289	.35135	.94972	1.05229	.44003	.07476
7	.00000	.00000	.00014	.00554	.08867	.58075	1.54896	1.69946	.70137	.11906
8	.00000	.00000	.00021	.00847	.13466	.97231	2.29941	2.49834	1.01637	.17160
9	.00000	.00001	.00107	.03247	.39021	1.90755	3.80039	3.12522	.95614	.12209
10	.00000	.00007	.00469	.10796	.98280	3.63579	5.48479	3.41581	.78543	.07568
11	.00000	.00007	.00469	.10796	.98280	3.63579	5.48479	3.41581	.78543	.07568
12	.00000	.00001	.00107	.03247	.39021	1.90755	3.80039	3.12522	.95614	.12209
13	.00000	.00000	.00000	.00001	.00058	.01791	.22190	1.12350	2.11235	1.65038
14	.00000	.00000	.00000	.00000	.00038	.01192	.14948	.76425	1.45768	1.14509
15	.00000	.00000	.00008	.00327	.05289	.35135	.94972	1.05229	.44003	.07476
16	.00000	.00000	.00003	.00142	.02851	.23449	.78135	1.06324	.54969	.11483
17	.00000	.00000	.00001	.00053	.01324	.13566	.55990	.93494	.59736	.15292
18	.00000	.00000	.00000	.00014	.00355	.03749	.15705	.26336	.16691	.04051
19	.00000	.00000	.00000	.00001	.00022	.00238	.00970	.01483	.00734	.00080
20	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000

Pump Sampler Example Output (cont.)

EFFICIENCY OF SAMPLER BY SUBSECTION AND SIZE FRACTION

SUB SECTION	PARTICLE SIZE FRACTION 1	2	3	4	5	6	7	8	9	10
1	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000
2	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
3	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
4	.20000	.20000	.20000	.20000	.20000	.20000	.20000	.02877	0.00000	0.00000
5	.40000	.40000	.40000	.40000	.40000	.40000	.40000	.05754	0.00000	0.00000
6	.40000	.40000	.40000	.40000	.40000	.40000	.40000	.05754	0.00000	0.00000
7	.60000	.60000	.60000	.60000	.60000	.60000	.60000	.08631	0.00000	0.00000
8	.80000	.80000	.80000	.80000	.80000	.80000	.80000	.11508	0.00000	0.00000
9	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	.14385	0.00000	0.00000
10	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	.14385	0.00000	0.00000
11	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	.14385	0.00000	0.00000
12	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	.14385	0.00000	0.00000
13	.80000	.80000	.80000	.80000	.80000	.80000	.80000	.11508	0.00000	0.00000
14	.60000	.60000	.60000	.60000	.60000	.60000	.60000	.08631	0.00000	0.00000
15	.40000	.40000	.40000	.40000	.40000	.40000	.40000	.05754	0.00000	0.00000
16	.40000	.40000	.40000	.40000	.40000	.40000	.40000	.05754	0.00000	0.00000
17	.20000	.20000	.20000	.20000	.20000	.20000	.20000	.02877	0.00000	0.00000
18	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
19	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
20	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000

Pump Sampler Example Output (cont.)

RATIO OF SAMPLED SEDIMENT CONCENTRATION TO AVERAGE, BY SUBSECTION AND SIZE FRACTION

SUB SECTION	PARTICLE SIZE FRACTION 1	2	3	4	5	6	7	8	9	10
1	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
2	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
3	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
4	.03460	.07581	.12798	.14807	.12546	.07184	.02249	.00040	0.00000	0.00000
5	.12440	.22728	.33779	.39031	.38495	.30976	.17642	.00819	0.00000	0.00000
6	.41259	.65473	.92098	1.08942	1.11212	.94902	.62065	.03849	0.00000	0.00000
7	.57209	.90824	1.28336	1.54889	1.65500	1.53455	1.15701	.09073	0.00000	0.00000
8	.73883	1.17628	1.67614	2.06202	2.27363	2.21449	1.80726	.16131	0.00000	0.00000
9	5.71959	6.87075	7.44975	7.05108	6.03932	4.62615	3.02764	.22325	0.00000	0.00000
10	39.06809	36.04588	30.95699	23.80578	16.52350	10.17998	5.34336	.31832	0.00000	0.00000
11	39.06809	36.04588	30.95699	23.80578	16.52350	10.17998	5.34336	.31832	0.00000	0.00000
12	5.71959	6.87075	7.44975	7.05108	6.03932	4.62615	3.02764	.22325	0.00000	0.00000
13	.00001	.00004	.00029	.00180	.00972	.04547	.17440	.07254	0.00000	0.00000
14	.00000	.00003	.00023	.00135	.00707	.03151	.11165	.04080	0.00000	0.00000
15	.41259	.65473	.92098	1.08942	1.11212	.94902	.62065	.03849	0.00000	0.00000
16	.12440	.22728	.33779	.39031	.38495	.30976	.17642	.00819	0.00000	0.00000
17	.03460	.07581	.12798	.14807	.12546	.07184	.02249	.00040	0.00000	0.00000
18	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
19	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
20	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000

Pump Sampler Example Output (cont.)

DISCHARGE, 2 500.0000 CFS WITH .0500 FREQUENCY

FLOW PROPERTIES

SUB SECTION	DISCHARGE CFS	VELOCITY FT/SEC	DEPTH FT
1	0.0000	0.0000	0.0000
2	0.0000	0.0000	0.0000
3	0.0000	0.0000	0.0000
4	1.1519	3.2752	.1531
5	7.4451	5.4393	.4563
6	15.9842	6.6084	.8063
7	29.2261	8.4255	1.1563
8	45.2969	10.0242	1.5063
9	64.3297	11.5519	1.8563
10	85.5719	12.9287	2.2063
11	85.5719	12.9287	2.2063
12	64.3297	11.5519	1.8563
13	45.2969	10.0242	1.5063
14	29.2261	8.4255	1.1563
15	15.9842	6.6084	.8063
16	7.4451	5.4393	.4563
17	1.1519	3.2752	.1531
18	0.0000	0.0000	0.0000
19	0.0000	0.0000	0.0000
20	0.0000	0.0000	0.0000

TOTAL SEDIMENT TRANSPORT = 36.5720 CFS

SEDIMENT TRANSPORT BY SIZE FRACTION IN CFS

1	2	3	4	5	6	7	8	9	10
.4737E-06	.9052E-04	.6071E-02	.1492E+00	.1510E+01	.6502E+01	.1207E+02	.1026E+02	.4498E+01	.1583E+01

Pump Sampler Example Output (cont.)

SEDIMENT TRANSPORT BY SUBSECTION AND SIZE FRACTION, IN CFS

SUB SECTION	PARTICLE SIZE FRACTION 1	2	3	4	5	6	7	8	9	10
1	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
2	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
3	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
4	.00000	.00000	.00000	.00001	.00031	.00328	.01348	.02100	.01103	.00147
5	.00000	.00000	.00000	.00018	.00375	.03238	.11104	.15168	.07721	.01455
6	.00000	.00000	.00002	.00077	.01302	.08990	.25009	.28093	.11861	.01937
7	.00000	.00000	.00005	.00183	.03002	.20271	.55543	.62063	.26198	.04421
8	.00000	.00000	.00009	.00344	.05549	.36809	.99375	1.10016	.45956	.07809
9	.00000	.00001	.00050	.01516	.18393	.91596	1.86333	1.56025	.49066	.06343
10	.00000	.00004	.00244	.05583	.51111	1.91832	2.94670	1.86654	.44109	.04315
11	.00000	.00004	.00244	.05583	.51111	1.91832	2.94670	1.86654	.44109	.04315
12	.00000	.00001	.00050	.01516	.19393	.91596	1.86333	1.56025	.49066	.06343
13	.00000	.00000	.00000	.00000	.00024	.00756	.09590	.43474	.95511	.75106
14	.00000	.00000	.00000	.00000	.00013	.00416	.05360	.27910	.54448	.42520
15	.00000	.00000	.00002	.00077	.01302	.08990	.25009	.28093	.11861	.01937
16	.00000	.00000	.00000	.00018	.00375	.03238	.11104	.15168	.07721	.01455
17	.00000	.00000	.00000	.00001	.00031	.00329	.01348	.02100	.01103	.00147
18	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
19	0.00000	0.00000	0.00000	0.00000	0.00000	0.00003	0.00000	0.00000	0.00000	0.00000
20	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000

Pump Sampler Example Output (cont.)

EFFICIENCY OF SAMPLER BY SUBSECTION AND SIZE FRACTION

SUB SECTION	PARTICLE SIZE FRACTION 1	2	3	4	5	6	7	8	9	10
1	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000
2	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000
3	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000
4	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
5	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
6	.20000	.20000	.20000	.20000	.20000	.20000	.20000	.02877	0.00000	0.00000
7	.40000	.40000	.40000	.40000	.40000	.40000	.40000	.05754	0.00000	0.00000
8	.60000	.60000	.60000	.60000	.60000	.60000	.60000	.08631	0.00000	0.00000
9	.60000	.60000	.60000	.60000	.60000	.60000	.60000	.08631	0.00000	0.00000
10	.80000	.80000	.80000	.80000	.80000	.80000	.80000	.11508	0.00000	0.00000
11	.80000	.80000	.80000	.80000	.80000	.80000	.80000	.11508	0.00000	0.00000
12	.60000	.60000	.60000	.60000	.60000	.60000	.60000	.08631	0.00000	0.00000
13	.60000	.60000	.60000	.60000	.60000	.60000	.60000	.08631	0.00000	0.00000
14	.40000	.40000	.40000	.40000	.40000	.40000	.40000	.05754	0.00000	0.00000
15	.20000	.20000	.20000	.20000	.20000	.20000	.20000	.02877	0.00000	0.00000
16	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
17	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
18	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000
19	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000
20	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000

Pump Sampler Example Output (cont.)

RATIO OF SAMPLED SEDIMENT CONCENTRATION TO AVERAGE, BY SUBSECTION AND SIZE FRACTION

SUB SECTION	PARTICLE SIZE FRACTION 1	2	3	4	5	6	7	8	9	10
1	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
2	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
3	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
4	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
5	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
6	.15835	.23738	.28256	.23701	.14782	.06412	.01603	.00025	0.00000	0.00000
7	.27463	.41839	.52849	.52438	.44451	.31225	.16115	.00714	0.00000	0.00000
8	.40507	.62750	.82470	.88697	.85525	.72561	.50122	.03486	0.00000	0.00000
9	3.46041	4.20374	4.61760	4.36663	3.65976	2.69482	1.66081	.11075	0.00000	0.00000
10	25.13789	23.02083	19.20945	13.97868	9.15581	5.37894	2.72999	.15732	0.00000	0.00000
11	25.13789	23.02083	19.20945	13.97868	9.15581	5.37894	2.72999	.15732	0.00000	0.00000
12	3.46041	4.20374	4.61760	4.36663	3.65976	2.69482	1.66081	.11075	0.00000	0.00000
13	.00000	.00002	.00014	.00078	.00366	.01490	.04837	.01568	0.00000	0.00000
14	.00000	.00001	.00009	.00045	.00190	.00641	.01555	.00321	0.00000	0.00000
15	.15835	.23738	.28256	.23701	.14782	.06412	.01603	.00025	0.00000	0.00000
16	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
17	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
18	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
19	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
20	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000

Pump Sampler Example Output (cont.)

DISCHARGE, 3 250.0000 CFS WITH .1000 FREQUENCY

FLOW PROPERTIES

SUB SECTION	DISCHARGE CFS	VELOCITY FT/SEC	DEPTH FT
1	0.0000	0.0000	0.0000
2	0.0000	0.0000	0.0000
3	0.0000	0.0000	0.0000
4	0.0000	0.0000	0.0000
5	.0270	1.0103	.0365
6	2.6301	3.2108	.2730
7	10.4284	5.5793	.6230
8	21.8674	7.4910	.9730
9	36.5855	9.2175	1.3230
10	53.9619	10.7512	1.6730
11	53.9619	10.7512	1.6730
12	36.5855	9.2175	1.3230
13	21.8674	7.4910	.9730
14	10.4284	5.5793	.6230
15	2.6301	3.2108	.2730
16	.0270	1.0103	.0365
17	0.0000	0.0000	0.0000
18	0.0000	0.0000	0.0000
19	0.0000	0.0000	0.0000
20	0.0000	0.0000	0.0000

TOTAL SEDIMENT TRANSPORT = 15.9760 CFS

SEDIMENT TRANSPORT BY SIZE FRACTION IN CFS

1	2	3	4	5	6	7	8	9	10
.2400E-06	.4520E-04	.2967E-02	.7163E-01	.7173E+00	.3044E+01	.5483E+01	.4384E+01	.1734E+01	.5389E+00

Pump Sampler Example Output (cont.)

SEDIMENT TRANSPORT BY SUBSECTION AND SIZE FRACTION, IN CFS

SUB SECTION	PARTICLE SIZE FRACTION 1	2	3	4	5	6	7	8	9	10
1	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
2	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
3	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
4	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
5	.00000	.00000	.00000	.00000	.00000	.00002	.00002	0.00000	0.00000	0.00000
6	.00000	.00000	.00000	.00007	.00121	.00864	.02387	.02505	.00877	.00075
7	.00000	.00000	.00001	.00043	.00736	.05149	.14417	.16160	.06745	.01052
8	.00000	.00000	.00003	.00121	.01999	.13550	.37702	.42280	.17886	.02982
9	.00000	.00000	.00022	.00665	.08206	.41798	.86817	.73789	.23660	.03057
10	.00000	.00002	.00124	.02828	.26166	.99948	1.56367	1.00532	.24273	.02391
11	.00000	.00002	.00124	.02828	.26166	.99948	1.56367	1.00532	.24273	.02391
12	.00000	.00000	.00022	.00665	.08206	.41798	.86817	.73789	.23660	.03057
13	.00000	.00000	.00000	.00000	.00009	.00280	.03538	.19013	.37173	.28683
14	.00000	.00000	.00000	.00000	.00003	.00105	.01391	.07267	.14018	.10121
15	.00000	.00000	.00000	.00007	.00121	.00864	.02387	.02505	.00877	.00075
16	.00000	.00000	.00000	.00000	.00000	.00002	.00002	0.00000	0.00000	0.00000
17	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
18	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
19	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
20	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000

Pump Sampler Example Output (cont.)

EFFICIENCY OF SAMPLER BY SUBSECTION AND SIZE FRACTION

SUB SECTION	PARTICLE SIZE FRACTION 1	2	3	4	5	6	7	8	9	10
1	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000
2	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000
3	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000
4	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000
5	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
6	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
7	.20000	.20000	.20000	.20000	.20000	.20000	.20000	.02877	0.00000	0.00000
8	.20000	.20000	.20000	.20000	.20000	.20000	.20000	.02877	0.00000	0.00000
9	.40000	.40000	.40000	.40000	.40000	.40000	.40000	.05754	0.00000	0.00000
10	.60000	.60000	.60000	.60000	.60000	.60000	.60000	.08631	0.00000	0.00000
11	.60000	.60000	.60000	.60000	.60000	.60000	.60000	.08631	0.00000	0.00000
12	.40000	.40000	.40000	.40000	.40000	.40000	.40000	.05754	0.00000	0.00000
13	.20000	.20000	.20000	.20000	.20000	.20000	.20000	.02877	0.00000	0.00000
14	.20000	.20000	.20000	.20000	.20000	.20000	.20000	.02877	0.00000	0.00000
15	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
16	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
17	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000
18	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000
19	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000
20	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000

Pump Sampler Example Output (cont.)

RATIO OF SAMPLED SEDIMENT CONCENTRATION TO AVERAGE, BY SUBSECTION AND SIZE FRACTION

SUB SECTION	PARTICLE SIZE FRACTION 1	2	3	4	5	6	7	8	9	10
1	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
2	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
3	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
4	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
5	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
6	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
7	.10548	.14602	.13985	.07820	.02897	.00657	.00070	.00000	0.00000	0.00000
8	.20872	.33337	.45912	.48865	.40637	.25255	.10285	.00317	0.00000	0.00000
9	2.04688	2.45821	2.58465	2.22003	1.62953	1.01035	.48941	.02281	0.00000	0.00000
10	16.32485	14.82462	11.96200	8.11996	4.88585	2.61173	1.17937	.05767	0.00000	0.00000
11	16.32485	14.82462	11.96200	8.11996	4.88585	2.61173	1.17937	.05767	0.00000	0.00000
12	2.04688	2.45821	2.58465	2.22003	1.62953	1.01035	.48941	.02281	0.00000	0.00000
13	.00000	.00001	.00008	.00043	.00174	.00519	.00993	.00142	0.00000	0.00000
14	.00000	.00001	.00002	.00007	.00012	.00013	.00007	.00000	0.00000	0.00000
15	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
16	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
17	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
18	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
19	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
20	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000

Pump Sampler Example Output (cont.)

DISCHARGE, 4 100.0000 CFS WITH .5000 FREQUENCY

FLOW PROPERTIES

SUB SECTION	DISCHARGE CFS	VELOCITY FT/SEC	DEPTH FT
1	0.0000	0.0000	0.0000
2	0.0000	0.0000	0.0000
3	0.0000	0.0000	0.0000
4	0.0000	0.0000	0.0000
5	0.0000	0.0000	0.0000
6	0.0000	0.0000	0.0000
7	.5350	1.8599	.1199
8	5.8220	4.4122	.4398
9	15.4853	6.5352	.7898
10	28.4653	8.3243	1.1398
11	28.4653	8.3243	1.1398
12	15.4853	6.5352	.7898
13	5.8220	4.4122	.4398
14	.5350	1.8599	.1199
15	0.0000	0.0000	0.0000
16	0.0000	0.0000	0.0000
17	0.0000	0.0000	0.0000
18	0.0000	0.0000	0.0000
19	0.0000	0.0000	0.0000
20	0.0000	0.0000	0.0000

TOTAL SEDIMENT TRANSPORT = 5.3698 CFS

SEDIMENT TRANSPORT BY SIZE FRACTION IN CFS

1	2	3	4	5	6	7	8	9	10
.9374E-07	.1733E-04	.1111E-02	.2649E-01	.2651E+00	.1118E+01	.1962E+01	.1455E+01	.4591E+00	.8372E-01

Pump Sampler Example Output (cont.)

SEDIMENT TRANSPORT BY SUBSECTION AND SIZE FRACTION, IN CFS

SUB SECTION	PARTICLE SIZE FRACTION 1	2	3	4	5	6	7	8	9	10
1	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
2	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
3	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
4	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
5	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
6	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
7	.00000	.00000	.00000	.00001	.00017	.00115	.00280	.00208	.00012	0.00000
8	.00000	.00000	.00000	.00019	.00339	.02404	.06744	.07453	.02989	.00413
9	.00000	.00000	.00006	.00196	.02498	.13142	.27933	.23972	.07720	.00958
10	.00000	.00001	.00049	.01119	.10577	.41452	.56293	.43233	.10616	.01037
11	.00000	.00001	.00049	.01119	.10577	.41452	.65293	.43233	.10616	.01037
12	.00000	.00000	.00006	.00195	.02498	.13142	.27933	.23972	.07720	.00958
13	.00000	.00000	.00000	.00000	.00001	.00049	.00651	.03351	.06212	.03968
14	.00000	.00000	.00000	.00000	.00000	.00002	.00027	.00093	.00025	0.00000
15	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
16	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
17	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
18	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
19	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
20	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000

Pump Sampler Example Output (cont.)

EFFICIENCY OF SAMPLER BY SUBSECTION AND SIZE FRACTION

SUB SECTION	PARTICLE SIZE FRACTION 1	2	3	4	5	6	7	8	9	10
1	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000
2	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000
3	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000
4	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000
5	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000
6	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000
7	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
8	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
9	.20000	.20000	.20000	.20000	.20000	.20000	.20000	.02877	0.00000	0.00000
10	.40000	.40000	.40000	.40000	.40000	.40000	.40000	.05754	0.00000	0.00000
11	.40000	.40000	.40000	.40000	.40000	.40000	.40000	.05754	0.00000	0.00000
12	.20000	.20000	.20000	.20000	.20000	.20000	.20000	.02877	0.00000	0.00000
13	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
14	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
15	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000
16	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000
17	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000
18	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000
19	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000
20	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000

Pump Sampler Example Output (cont.)

RATIO OF SAMPLED SEDIMENT CONCENTRATION TO AVERAGE, BY SUBSECTION AND SIZE FRACTION

SUB SECTION	PARTICLE SIZE FRACTION 1	2	3	4	5	6	7	8	9	10
1	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
2	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
3	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
4	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
5	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
6	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
7	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
8	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
9	.95896	1.10998	1.02593	.65158	.30102	.09714	.01850	.00023	0.00000	0.00000
10	9.34020	8.28264	6.16902	3.55771	1.73274	.70960	.22113	.00635	0.00000	0.00000
11	9.34020	8.28264	6.16902	3.55771	1.73274	.70960	.22113	.00635	0.00000	0.00000
12	.95896	1.10998	1.02593	.65158	.30102	.09714	.01850	.00023	0.00000	0.00000
13	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
14	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
15	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
16	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
17	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
18	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
19	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
20	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000

Pump Sampler Example Output (cont.)

DISCHARGE, 5 50.0000 CFS WITH .3400 FREQUENCY

FLOW PROPERTIES

SUB SECTION	DISCHARGE CFS	VELOCITY FT/SEC	DEPTH FT
1	0.0000	0.0000	0.0000
2	0.0000	0.0000	0.0000
3	0.0000	0.0000	0.0000
4	0.0000	0.0000	0.0000
5	0.0000	0.0000	0.0000
6	0.0000	0.0000	0.0000
7	0.0000	0.0000	0.0000
8	1.0074	2.3368	.1695
9	6.9656	4.7476	.4891
10	17.0830	6.7865	.8391
11	17.0830	6.7865	.8391
12	6.9656	4.7476	.4891
13	1.0074	2.3368	.1695
14	0.0000	0.0000	0.0000
15	0.0000	0.0000	0.0000
16	0.0000	0.0000	0.0000
17	0.0000	0.0000	0.0000
18	0.0000	0.0000	0.0000
19	0.0000	0.0000	0.0000
20	0.0000	0.0000	0.0000

TOTAL SEDIMENT TRANSPORT = 2.3342 CFS

SEDIMENT TRANSPORT BY SIZE FRACTION IN CFS

1	2	3	4	5	6	7	8	9	10
.4435E-07	.8088E-05	.5107E-03	.1216E-01	.1222E+00	.5131E+00	.8829E+00	.6213E+00	.1659E+00	.1616E-01

Pump Sampler Example Output (cont.)

SEDIMENT TRANSPORT BY SUBSECTION AND SIZE FRACTION, IN CFS

SUB SECTION	PARTICLE SIZE FRACTION 1	2	3	4	5	6	7	8	9	10
1	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
2	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
3	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
4	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
5	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
6	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
7	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
8	.00000	.00000	.00000	.00002	.00037	.00261	.00587	.00633	.00146	0.00000
9	.00000	.00000	.00002	.00065	.00860	.04623	.09306	.08414	.02616	.00289
10	.00000	.00000	.00023	.00542	.05232	.20899	.33862	.22191	.05454	.00519
11	.00000	.00000	.00023	.00542	.05232	.20899	.33862	.22191	.05454	.00519
12	.00000	.00000	.00002	.00065	.00860	.04623	.09306	.08414	.02616	.00289
13	.00000	.00000	.00000	.00000	.00000	.00005	.00066	.00285	.00304	0.00000
14	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
15	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
16	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
17	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
18	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
19	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
20	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000

Pump Sampler Example Output (cont.)

EFFICIENCY OF SAMPLER BY SUBSECTION AND SIZE FRACTION

SUB SECTION	PARTICLE SIZE FRACTION 1	2	3	4	5	6	7	8	9	10
1	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000
2	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000
3	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000
4	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000
5	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000
6	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000
7	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000
8	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
9	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
10	.20000	.20000	.20000	.20000	.20000	.20000	.20000	.02877	0.00000	0.00000
11	.20000	.20000	.20000	.20000	.20000	.20000	.20000	.02877	0.00000	0.00000
12	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
13	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
14	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000
15	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000
16	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000
17	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000
18	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000
19	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000
20	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000

Pump Sampler Example Output (cont.)

RATIO OF SAMPLED SEDIMENT CONCENTRATION TO AVERAGE, BY SUBSECTION AND SIZE FRACTION

SUB SECTION	PARTICLE SIZE FRACTION 1	2	3	4	5	6	7	8	9	10
1	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
2	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
3	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
4	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
5	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
6	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
7	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
8	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
9	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
10	6.23567	5.60272	4.14737	2.16244	.83549	.23383	.04098	.00052	0.00000	0.00000
11	6.23567	5.60272	4.14737	2.16244	.83549	.23383	.04098	.00052	0.00000	0.00000
12	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
13	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
14	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
15	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
16	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
17	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
18	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
19	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
20	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000

Pump Sampler Example Output (cont.)

OVER ALL FLOW FREQUENCY WEIGHTED, RATIO OF SAMPLED SEDIMENT CONCENTRATION TO AVERAGE,
BY SUBSECTION AND SIZE FRACTION

SUB SECTION	PARTICLE SIZE FRACTION 1	2	3	4	5	6	7	8	9	10
1	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
2	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
3	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
4	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
5	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
6	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
7	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
8	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
9	.43853	.54571	.62279	.61467	.54186	.43355	.30954	.02684	0.00000	0.00000
10	2.99543	2.86294	2.58797	2.07525	1.48251	.95405	.54630	.03827	0.00000	0.00000
11	2.99543	2.86294	2.58797	2.07525	1.48251	.95405	.54630	.03827	0.00000	0.00000
12	.43853	.54571	.62279	.61467	.54186	.43355	.30954	.02684	0.00000	0.00000
13	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
14	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
15	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
16	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
17	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
18	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
19	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
20	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000

OVER ALL FLOW FREQUENCY WEIGHTED, RATIO OF SAMPLED CONCENTRATION TO AVERAGE,
BY SUBSECTION

SUBSECTION	RATIO
1	0.00000
2	0.00000
3	0.00000
4	0.00000
5	0.00000
6	0.00000
7	0.00000
8	0.00000
9	.22645
10	.46227
11	.46227
12	.22645
13	0.00000
14	0.00000
15	0.00000
16	0.00000
17	0.00000
18	0.00000
19	0.00000
20	0.00000

PROGRAM APPLICATION

General

Field data adequate to evaluate the program are unavailable at this time, thus verification and calibration of the program are left to later studies. This section will outline how the program can be used until further data are available. The first and most important point to remember is that the program is best used as a comparative tool. That is, it should be used to determine which of two samplers performs better or where in a cross section to locate a sampler for optimum operation. Its use as a predictive tool is limited. It should not be used to predict the total sediment load of a stream or the concentration of a particular sample. The uncertainties in these calculations are too large and errors in sediment transport may exceed 100 percent. But since the model is physically based on the principles of hydraulics and sediment transport any errors should be conservative (they will be in all calculations). When any two calculations are compared, such as the difference or better yet the ratio of sediment transport between two size fractions, the errors should cancel each other out and the user will be able to make valid decisions.

The program can be applied in two basic manners, either design of sediment samplers or calculation of actual sediment load from measured data. The following sections describe each of these applications.

Sampler Design

The application of the program in the design of sediment samplers is straightforward. The user enters the stream parameters where the sampler will be used and trial sampler parameters. The stream parameters will include channel geometry, friction slope, bed material, flow discharge and flow frequency. The sampler parameters will include sampler type and dimensions. The program will then calculate the performance of the trial sampler at each channel subsection. The sampler design can then be changed and the program rerun, and the two designs compared. The user can continue this process until the best possible design is found.

If the user wishes to design a sampler for use on several different streams the trial and error process should be continued where the stream parameters are varied along with the sampler dimensions. This will yield not only the best sampler design, but also where in each stream the sampler should be placed. Thus the "best" design may be placed at the thalweg for one stream and higher in the section for another.

Calculation of Actual Sediment Load from Measured Data

The program can be used to calculate the actual sediment load in the stream from the measured sediment samples. To do this the user first enters the stream and sampler parameters for the flows where samples were taken and runs the program. The user then uses the results for the subsection where the sampler was located and ignores the rest. To calculate the actual average stream concentration for size fraction the user divides by the ratio of sample sediment concentration to the average. As an example consider the example box sampler (page 25) run with a discharge of 250 cfs and a sampler located in the channel thalweg (subsections 10 or 11). If the sampled sediment concentration for particle size 5 (0.0023 ft) was 100 mg/l divide by the output result of 1.87238 to obtain the actual average concentration for that flow of 53 mg/l.

Until the program is calibrated and verified, care should be taken in this application.

CONCLUSIONS AND RECOMMENDATIONS

The program has been developed with generated data which are typical of sampling conditions experienced in National Forests. In its development, the program has been found to be numerically stable under all conditions. Once familiar with the program users should have little problem with its application and are encouraged to modify the code to suit their needs. It is difficult to make any definitive conclusions without field data, but four statements can be made. First any box sampler which samples a vertical slice of the flow is superior to a point sampler which only samples at most a few spots. A box sampler that can measure the bed load and at least a part of the suspended load will have sampled concentrations much closer to the actual for both total load and load by size fraction. Its ability to sample the bed load is very important when evaluating transport in steep streams. Second, there is no perfect spot to place a sampler in a cross section. In a non-uniform channel there is no spot where a sampler will have the same sampling performance for all size fractions or all flows. Each sampler and stream must be evaluated on an individual basis. Third, for a sampler located at the stream thalweg, a sediment sample will have a larger concentration than the total flow of the finest particle sizes and a smaller concentration than the total flow of the largest. This is due to the lateral and vertical distribution of sediment in the channel. Fourth and last, it is difficult to design a sampler to work equally well at high and low flows. Review of the example output will show that for a given sampler the best location (as measured by the ratio of sampled sediment concentration to average) will move from the channel thalweg for low flows up to higher spots as flow increases. The box sampler works well at all flows but the point sampler is very sensitive to flow volume. A good design for high flow will leave most of the sample ports dry at low flow.

The following two recommendations are made to improve the applicability of this program. First, field and laboratory data should be obtained from the literature or from new studies to calibrate and verify the model. Insuring that the flow resistance and sediment transport components of the model are adequate for the cases of interest should be of particular concern. Second, laboratory studies should be carried out to define the hydraulics and entrance effects of the specific sediment samplers used.

APPENDIX A

SAMPLER PROGRAM THEORY

GENERAL

This appendix presents the theory used in program SAMPLER. There are four basic steps in the calculation of the sediment: 1) flow hydraulics, 2) sediment properties, 3) sediment transport, and 4) sampling. The following sections describes the methods and assumptions used in each of the steps and explains some of the more important assumptions. An effort has been made to point out where improvements can be made or different approaches could be used.

FLOW HYDRAULICS

General

The flow hydraulics are computed assuming one-dimensional, uniform, steady flow. This implies the following assumptions: 1) the hydraulic characteristics of flow remain constant for the time interval under consideration; 2) the flow streamlines are practically parallel, i.e., a hydrostatic pressure distribution prevails over the channel section, and 3) the secondary flow (lateral or cross-stream) is negligible when compared to the lognitudinal flow. In the program, the hydraulic properties are calculated for each discharge using a digitized channel geometry, and Manning's equation for flow resistance.

Manning's Equation

Many equations have been developed to determine channel resistance. The Manning equation is the most well known and used, and is thus used here. Another method such as described by Bathurst, Li and Simons (1979) is recommended if the stream of interest has a cobble and boulder

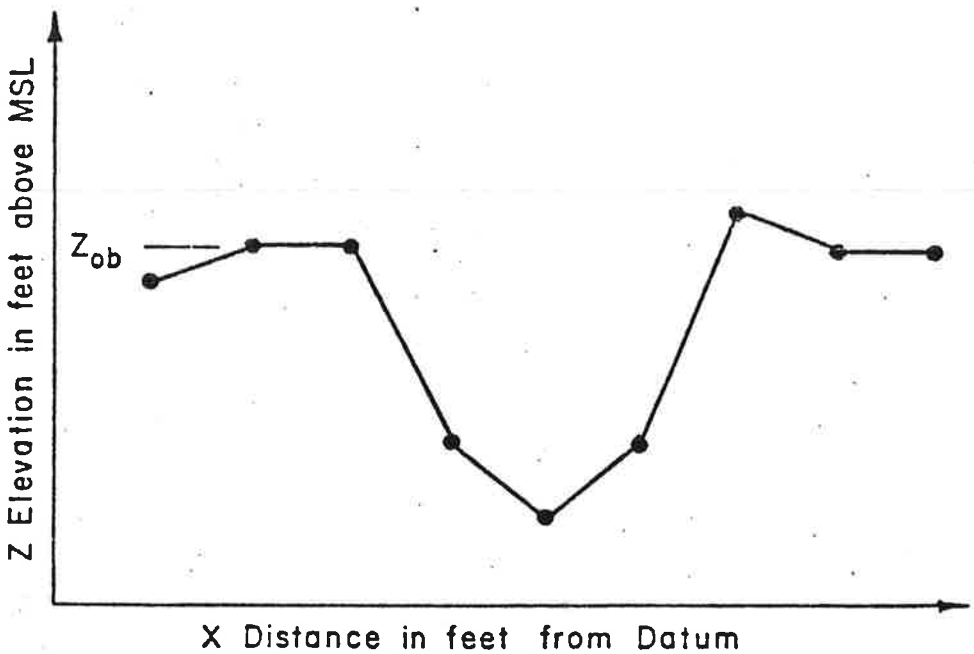

Figure A.1. Typical channel cross section.

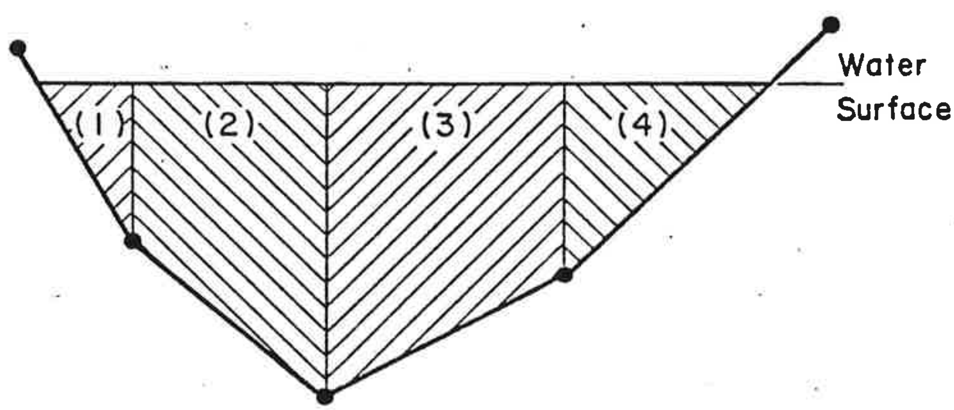

Figure A.2. Incremental areas in a cross section.

bed. The Manning equation is an empirical, uniform, steady flow equation. Errors are made when it is applied to nonprismatic natural channels with unsteady flow. It is believed that these errors are small when compared with those ordinarily occurring in the use of an uniform flow formula in natural channels (Chow, 1959). Likewise, it is believed there is no need to differentiate between total flow of water and sediment and just water flow.

The Manning equation is:

$$Q = \frac{1.486}{n} A R^{2/3} S_f^{1/2} \quad \text{(English units)} \qquad \text{(A.1)}$$

where Q = water discharge

A = water flow area

R = hydraulic radius

n = Manning channel roughness factor

Equation A.1 can be directly solved only for steady, uniform flow in channels with regular (triangle, rectangle, trapezoid, etc.) cross sections. In all other cases it must be solved in an iterative process.

Computation of Hydraulic Properties

The solution of Equation A.1 requires determination of channel hydraulic properties, area, and hydraulic radius at various depths. In these computations the hydraulic properties are computed with relationships developed using digitized channel geometry.

Channel cross sections are defined by (x,z) sets of coordinates. Figure A.1 shows a typical cross section. To allow for different Manning's n-values across the section each point is given its own n-value.

Area of flow for a given water surface elevation is computed by summing incremental areas between consecutive coordinates of the cross section. Figure A.2 illustrates this technique. Total area of flow is the summation of the increment areas, a_i:

$$A = \sum_{i=1}^{N} a_i \tag{A.2}$$

where N is the total number of cross section incremental areas. Incremental areas are computed by:

$$a_i = X_b \, D_a \tag{A.3}$$

where X_b is defined in Figure A.3.

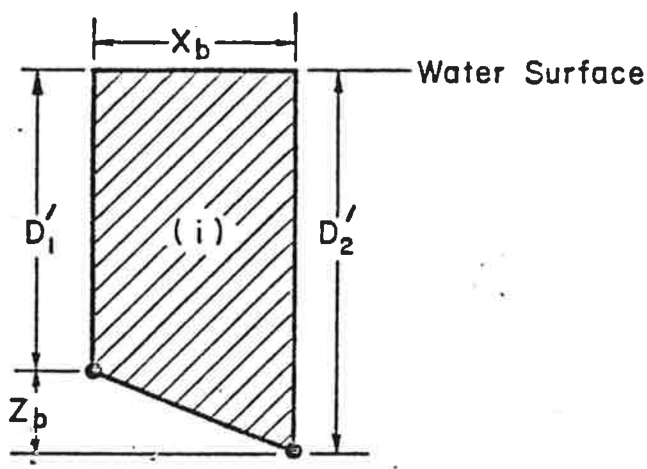

Figure A.3. Subsection area.

D_a is defined as:

$$D_a = \frac{1}{2} (D_1' + D_2') \tag{A.4}$$

where D_1' and D_2' are defined in Figure A.3. If the water surface intercepts the cross section between coordinate points as shown by increment 4 in Figure A.2, straight line interpolation between the points is used to compute the triangular area.

The wetted perimeter p_i is the length of the cross section below the water surface and is computed in increments by:

$$p_i = \sqrt{X_b^2 + Z_b^2} \quad (A.5)$$

where Z_b is defined in Figure A.3.

The incremental hydraulic radius, r_i, is calculated by:

$$r_i = \frac{a_i}{p_i} \quad (A.6)$$

The flow velocity for each increment is computed by the Manning's equation:

$$v_i = \frac{1.486}{n_{a_i}} r_i^{2/3} S_f^{1/2} \quad (A.7)$$

where n_{a_i} is the average Manning's n value at the two coordinate points which define the increment.

The incremental flow discharge is computed by continuity:

$$q_i = v_i a_i \quad (A.8)$$

where q_i is the incremental flow area and the total discharge is:

$$Q = \sum_{i=1}^{N} q_i \quad (A.9)$$

Solution for Depth of Flow

As stated previously, solution of the Manning's equation for nonregular cross requires an iterative solution method. In the program for each discharge an initial water surface elevation is assumed at the top of the section. For the trial elevation and the given friction slope the Manning equation is used to compute a trial discharge. If the trial and acutal discharges are equal the correct water surface and flow hydraulics has been found. If the two discharges are not equal the program reduces the assumed depth and tries again. These steps are repeated until the correct water elevation and flow hydraulics are found.

SEDIMENT PROPERTIES

General

Two of the sediment properties are of concern here, the particle fall velocity and the size distribution. In the program the particle fall velocity is calculated by Rubey's (1933) equation while the particle size distribution is generated with a log-normal fit.

Fall Velocity

Rubey's equation is used to calculate the particle fall velocity. Rubey's equation is:

$$w_i = \frac{(2/3\ g\ (S_s - 1)\ d_i^3 + 36v^2)^{1/2} - 6v}{d_i} \qquad \text{(A.10)}$$

where g = acceleration of gravity

S_s = specific weight of the sediment

d_i = sediment size

v = kinematic viscosity of the water.

The specific weight is assumed to be 2.65. The kinematic viscosity is a function of water temperature and is assumed to be 1.1×10^{-5}. Since the fall velocity is a function of particle size the equation is applied to each size of interest.

Sediment Size Distribution

In many cases an accurate sediment size distribution is not available for the site of a sampler or the performance of a sampler need be determined without knowing where it may be placed. Because of these reasons, the program has been designed to calculate reasonable sediment distributions with minimum data. The program requires only the sediment sizes of interest and the median sediment size.

Figure A.4 shows a typical sediment size distribution. The median sediment size, d_{50} is defined as the particle size for which 50 percent of all particles are small than. For the program the user must define the sediment sizes of interest by inputting the upper and lower particle sizes of each range. The program calculates the geometric mean, d_{g_i} for each sediment size range and uses that value for the sediment transport.

$$d_{g_i} = (d_j \; d_{j+1})^{1/2} \tag{A.11}$$

where d_j and d_{j+1} are the minimum and maximum sizes in the size range i. The program calculates the percentage of sediment in each size range using a log-normal distribution. The standard deviation, σ_g of the log-normal distribution is defined as

$$\sigma_g = \left(\frac{d_{84.1}}{d_{15.9}}\right)^{1/2} \tag{A.12}$$

Where $d_{84.1}$ and $d_{15.9}$ are the sizes of the 84.1 and 15.9 percent finer sizes. The program assumes $\sigma_g = 2.0$. Thus with the d_{50} and σ_g the program can calculate the percentage of material in each size range. In Figure A.4 the two distributions have the same $d_{84.1}$, $d_{15.9}$, and σ_g.

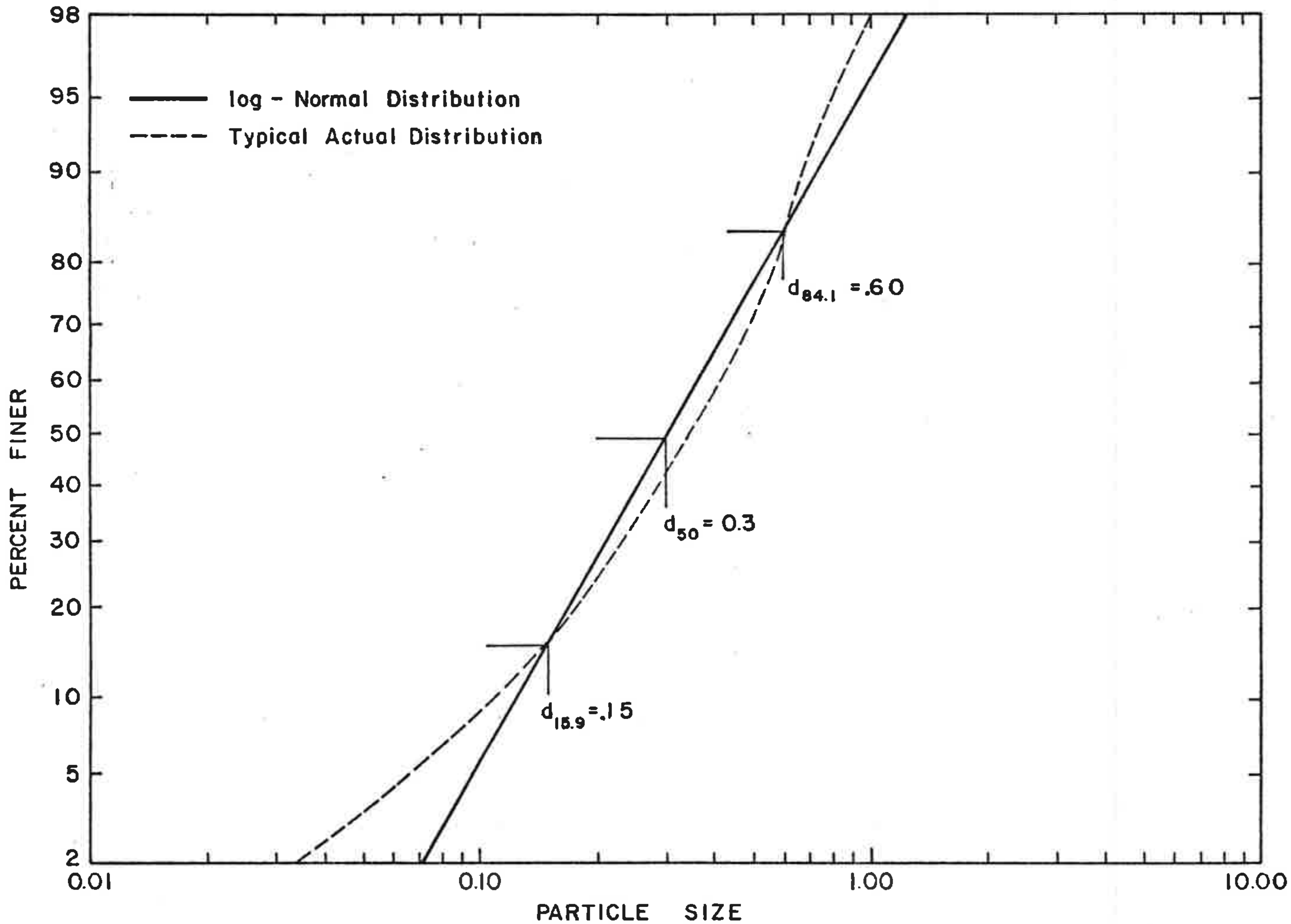

Figure A.4. Sediment size distribution.

SEDIMENT TRANSPORT

General

No theoretically complete equation for sediment transport has been developed. The reason for this lack is two-fold. First, the processes by which flowing water imparts energy to sediment particles is poorly quantified. Second, not all sediment particles are created equal. They vary in size, shape, and density. Some particles in the clay sizes are influenced strongly by ionic forces, some are not. In a given flow some particles travel entirely in suspension, some entirely by rolling along the bed, and others by a combination. Some particles can be supply limited at a given moment while at the same time other size particles are transport limited. Considering the complexity and variability of alluvial systems a complete, theoretical solution to the sediment transport equation may evade us for a long time. For the present, the engineer can select from numerous empirical equations. Simons and Sentürk (1977) present a review of the most widely known equations. In the program the Meyer-Peter and Müller bed load formula is used along with Lane and Kalinskes suspended sediment distribution.

Bed Load

The first step in the analytical calculation of sediment transport is the determination of the bed load. The bed load is defined as the transport rate of those particles which move by rolling or sliding along the bed. The Meyer-Peter and Müller (1948) formula has been found to give reasonable results in steep sand and gravel streams and is used here.

The formula developed by Meyer-Peter and Müller (MPM) is an excess shear stress type formula of the form normally classified as a DuBoy's type. The MPM formula can be written

$$q_{bv} = \frac{8\ (g/\gamma)^{1/2}}{\gamma_s'} (\tau_o - \tau_c)^{3/2} \qquad \text{(A.13)}$$

where: q_{bv} = volumetric bed load transport per unit width of channel,

τ_o = flow shear stress on the bed,

τ_c = sediment particle critical shear stress for initiation of motion,

γ = specific weight of water, and,

γ_s' = specific weight of submerged sediment.

Equation A.13 has units of length squared per time. The dimensionless coefficient with a value of eight is the result of correcting the equation to match experimental results. The flow shear stress can be evaluated a number of ways but in applications of the MPM it is customary to calculate τ_o by the relation,

$$\tau_o = \gamma DS \qquad \text{(A.14)}$$

Equation A.14 is a measure of the total tractive forces which the bed exerts on the flow, and can be obtained from a control volume analysis of a wide channel with uniform flow. The critical shear stress, τ_c is that minimum flow shear stress at which a particular size sediment particle will be transported by the flow. It is a function of the sediment particle size, shape and density. Meyer-Peter and Müller developed the relationship:

$$\tau_c = 0.047\ \gamma_s' d \qquad \text{(A.15)}$$

The dimensionless coefficient 0.047 in Equation A.15 was obtained from experiments. This relationship is a simplification of a very complex process. Shields (1936) developed a diagram developed from experiments. The original diagram has been improved by Gessler (1965) and is the most widely used method to determine τ_c. The Shields diagram is not used here for two reasons. First, it is a graphical procedure that does not lend itself easily to numerical models and second, the difference between the MPM approach and Shields' approach does not exceed 22 percent when considering a completely rough boundary (Simons and Sentürk, 1977). This difference is considered small.

Since Equation A.15 is a function of the sediment size and there is normally a range of sediment sizes in the bed, the equation is applied to each particle size fraction and the result multiplied by the percentage by weight that the size fraction occurs in the bed, or

$$q_{bv} = \sum_{i=1}^{n} p_i \frac{\gamma(g/\gamma)^{1/2}}{\gamma_s'} (\tau_o - \tau_{c_i})^{3/2} \qquad (A.16)$$

Where: i = particle size fraction

n = total number of size fraction

p_i = percentage of fraction i of the total bed.

In the application of Equation A.16 if the critical shear stress exceeds the flow shear stress, the transport is set equal to zero. Currently the program does not consider hiding effects where the larger size fractions hide the smaller sizes from the flow. If these effects are found to be significant, methods such as those proposed by Proffitt and Sutherland (1983) can be used or a single dominant shear stress based on d_{50} when all particles initiate motion as proposed by Parker, Klingaman and McLean (1982) used.

SUSPENDED BED LOAD

The suspended bed load is defined as the transport in suspension of those size fractions that occur in the bed. Suspsended bed load does not include the wash load. Wash load is the sediment which the supply from the watershed is less than the transport capacity of the stream. Since the wash is supply limited it cannot be calculated by the flow hydraulics.

Lane and Kalinske's (1941) sediment distribution is used to evaluate the suspended sediment concentrations. This program was initially developed with the Einstein (1950) distribution but serious difficulties arise in the application due to its use. A weakness of the Einstein distribution is that in its development it implicitly assumed that the sediment concentration at the water surface is zero. This assumption causes no practical problems for large particles, but for fine sands and silts in steep streams it produces an unreasonable distribution near the water surface. In its normal application where only the total transport is of concern zero surface concentration assumption causes no real problems, since the distribution is reasonable at depths greater than one-tenth the total depth of flow. But in this application where it is of great importance what concentration a sampler would measure at all depths for all particles, it causes unacceptable errors. The errors are both conceptual and numerical. Integrating the function near the surface is difficult.

Lane and Kalinske's distribution does not suffer from the zero surface concentration assumption and is a much simpler function. Figure A.5 shows a comparison between the Einstein and Lane and Kalinske's distributions. The distribution is

$$C_y = C_a \exp \left[\frac{-6W}{u_*' \beta \kappa D} (y - a)\right] \qquad (A.17)$$

where: u_*' = grain friction flow shear velocity

C_y = sediment concentration at a distance y above the bed

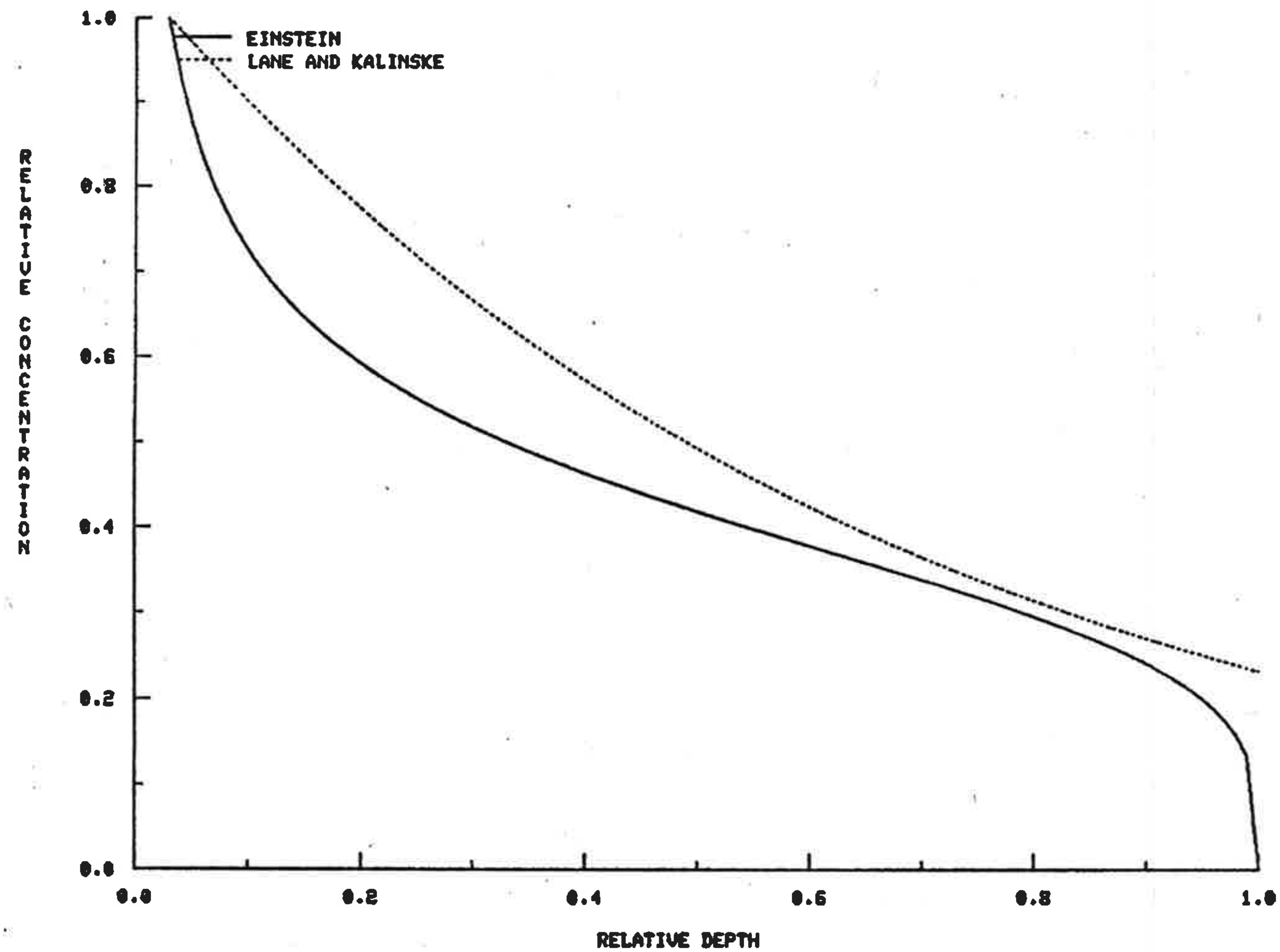

Figure A.5. Comparison between Einstein and Lane and Kalinske's sediment concentrations.

C_a = reference concentration at a distance a above the bed

κ = von Karman constant

y,a = distances above the bed

β = correction coefficient.

The value six in Equation A.17 is obtained from an integration and is a pure number. As in most studies κ is defined equal to 0.40 and β is assumed equal to 1.0. Equation A.17 can then be rewritten as

$$C_y = C_a \exp \left[\frac{-15w}{u_*' D} (y - a)\right] \tag{A.18}$$

The grain friction flow shear velocity u_*' in this application is evaluated by a form of the Darcy-Weisbach formula

$$u_*' = \frac{f}{8} \rho V^2 \tag{A.19}$$

where f = friction factor

ρ = water density

V = flow velocity.

The water density is assumed constant with ρ = 1.938 (English units). The value eight in Equation A.19 is a pure number.

To determine the total sediment transport between two depths y_1 and y_2 Equation A.18 is integrated with respect to y and evaluated between depths y_1 and y_2 to yield

$$q_{sv} = \int_{y_1}^{y_2} C_y \, d_y = C_a \frac{D}{z} \quad e^{\frac{-15w}{u_*} \frac{(y_2 - a)}{D}} - e^{\frac{-15w}{u_*} \frac{(y_1 - a)}{D}} \tag{A.20}$$

where q_s is the volume rate of suspended bed material between depths y_1 and y_2.

All variables in Equation A.20 are known except the reference depth a and the corresponding concentration C_a. Einstein (1954) used the bed load to calculate the reference concentration

$$C_a = \frac{q_{bv_i}}{a_i} \qquad (A.21)$$

where a is twice the particle size or

$$a = 2\, d_i \qquad (A.22)$$

As in the bed load calculations Equation A.20 is summed over each particle size; or

$$q_{sv} = \sum_{i=1}^{n} p_i \frac{q_{bv_i}}{a_i} \frac{Ca_i}{e^{(-15 w_i \frac{a_i}{d})}} \frac{d}{z} \left[e^{\frac{-15 w_i}{u_*} \frac{y_2}{d}} - e^{\frac{-15 w_i}{u_*} \frac{y_1}{d}} \right] \qquad (A.23)$$

For small particles the value $a_i = 2\, d_i$ will give unreasonably high reference concentrations, therefore a lower limit is set on a_i such that $a_i \geqq 0.01$ feet.

SAMPLING

General

Calculation of the theoretical sample concentration requires knowledge of the water velocity profile, the sediment concentration profile, the sampler geometry and the hydraulic performance of the sample. This study is limited to consideration of the first three items only. The hydraulic performance of a sampler cannot be adequately predicted by analytical procedures. While some theoretical evaluations are possible, it was decided to limit the scope of this contract and to leave more detailed analysis to later studies.

In this report two types of samples are considered. The first is a "box" sampler. The box sampler collects a vertical section segment of the flow from the bed to the top of the sampler or the water surface, whichever is less. This sampler replicates the intake geometry of converging section samplers. The second sampler is a multiple intake "point" sampler. This sampler has multiple ports located at various points above the bed. This sampler replicates the geometry of standard pump samples.

Since the calculations are so different for these two types of samplers, two completely different subroutines were written for the program. The user selects which routine he wishes to use.

Box Sampler

The box sampler routine assumes a vertical slice of water and sediment is taken. The sampler is assumed to take the slice from the bottom to the top of the sampler or the water surface, whichever is less. The sampler is assumed to measure the entire bed load and that portion of the suspended load into which it projects. The sampler is assumed to have constant intake dimensions of width and height. Figure A.6 shows the box sampler. Since the program does not presently consider the sampler hydraulics, this sampler geometry is applicable to any sampler which takes a vertical section.

The box sampler takes a sample from the bottom to the sampler top including all the bed load. When Equation A.16 is used to calculate the bed load, the measured sediment load, q_m, is calculated by:

$$q_m = q_{bv} + q_{svm} \tag{A.24}$$

where q_{svm} is the suspended load sediment between a_i and the sampler height, H. From Equation A.23:

$$q_{svm} = \sum_{i=1}^{n} P_i \frac{q_{bv_i}}{a_i} \int_a^H Ca_i \frac{DU_*}{-15w} \left(e^{\frac{-15w_i}{U*}\left(\frac{H-q_i}{D}\right)} - 1\right) \tag{A.25}$$

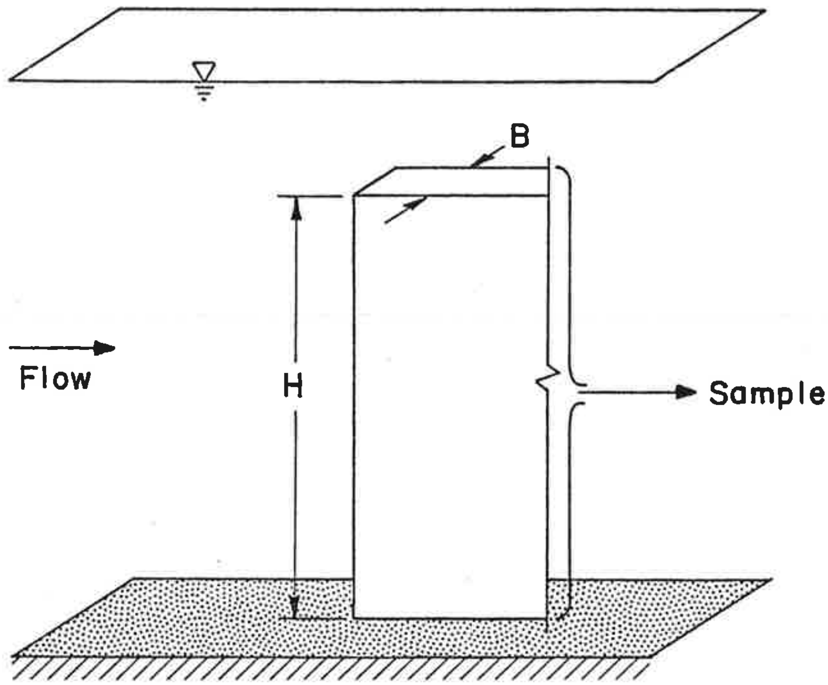

Figure A.6. Box sampler.

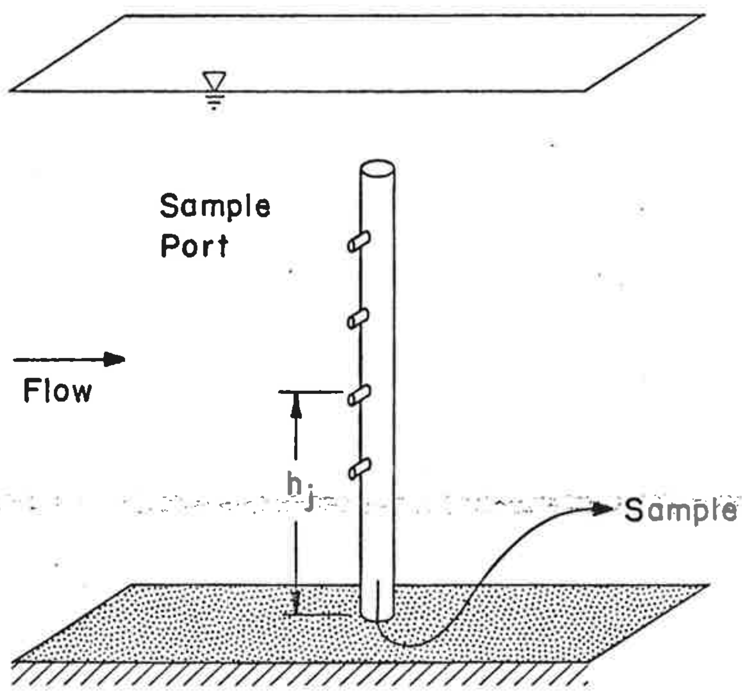

Figure A.7. Point sampler.

Sediment particles larger than the sampler width cannot be caught, likewise particle sizes that are a significant percentage of the sampler opening will many times be rejected. An empirical entrance effect has been defined for the model. The entrance function R_e is:

$$R_{e_i} = 1.0 \qquad d_i \leqq W/2$$

$$R_{e_i} = 2 - \frac{d_i}{W/2} \qquad \frac{W}{2} < d_i \leqq W \qquad (A.26)$$

$$R_{e_i} = 0 \qquad d_i > W$$

The entrance effect is multiplied with Equation A.25:

$$qm_i = R_{e_i}(q_{bv_i} + q_s v_{m_i}) \qquad (A.27)$$

The sample sediment concentration is calculated using the value of water the sampler collects, q_w, or

$$q_w = v\ H\ W \qquad (A.28)$$

where v is the subsection velocity and is defined by Equation A.7 and W is the sampler width. If the depth of flow is less than H it is used. The sampled concentration, C_{s_i} is thus:

$$C_{s_i} = \frac{q_{m_i}}{q_w} \qquad (A.29)$$

Point sampler

The second sampler considered is a point sampler. This sampler has multiple intake ports located at various points above the bed. Most pump samples can be simulated with this design. The sampler is assumed to measure the suspended load at each port and then combines the samples from each port. It is assumed none of the bed load is sampled, and sampler has constant dimensions. Figure A.7 shows the sampler.

The concentration at each point is calculated by Equations A.19, A.21 and A.22. The concentration of sediment size i at port j is

$$C_{y_{ij}} = \frac{q_{bv_i}}{a_i} \exp\left[\frac{-15w_i}{U'_*D}(h_j - a_i)\right] \qquad (A.30)$$

where h_j is the height of the port. The flow velocity at the port is calculated with a logarithmic distribution developed by Brooks (1963),

$$v_j = v + \frac{U'_*}{K} \ln\left(\frac{hp}{D} + 1\right) \qquad (A.31)$$

The mean flow velocity v, is calculated by Equation A.7 and U'_* by Equation A.19.

The volume of water per time in the sample q_{wj} at a port is obtained by multiplying the flow velocity by the port area A_p.

$$q_{wj} = v_j \cdot A_p \qquad (A.32)$$

The volume of sediment per time in the sample at a port is

$$q_{sv_{ij}} = q_{w_j} C_{y_{ij}} R_{e_i}$$

where R_{e_i}, the entrance effect, is again calculated by Equation A.26.

The sampled concentration of the combined sample is then

$$C_{s_i} = \frac{\sum_{j=1}^{W} q_{sv_{ij}}}{\sum_{j=1}^{N} q_{w_j}} \qquad (A.33)$$

APPENDIX B

PROGRAM LISTING

```
      PROGRAM SAMPLER
     1(OUTPUT,TAPE5,TAPE6=OUTPUT)
C
C     THIS IS A PROGRAM FOR SEDITMENT SAMPLER EVALUATION.
C     THE PROGRAM WAS DEVELOPED BY G.O. BROWN AND R.M. LI,
C     AT COLORADO STATE UNIVERSITY.
C
      COMMON  FO           , S            , ND           , NSIZ          ,
     1        Q(10)        , FREQ(10)     , QSJ(10)      , X(30)         ,
     2        Z(30)        , F(30)        , Q1(30)       , Y1(30)        ,
     3        XB(30)       , V1(30)       , XN(30)       , DMB(10)       ,
     4        DBD(11)      , FVB(10)      , QSD(10)      , QSDSUM(10)    ,
     5        RD(10)       , RDSUM(30,10), PD(30,10)     , QSV(30,10)    ,
     6        QBV(30,10)   , QTV(30,10)   , EFS(30,10)   , RATIO(30,10),
     7        RATIOK(30)   , QSK(30)      , RKSUM(30)    , RK(30)        ,
     8        D(30)
C
      DIMENSION            TITLE(12)
      DATA SNU/.000011/
C
C     DEFINE DEVICE NUMBERS
C
C
C     INPUT DATA
C
C     IR = SAMPLER NUMBER
C     ND = NUMBER OF POINTS IN THE CROSS SECTION
C     NQ  = NUMBER OF DISCHARGES
C     NSIZ = NUMBER OF PARTICLE SIZE FRACTIONS
C     S = SLOPE
C     FO = GRAIN ROUGHNESS
C     Q  = DISCHARGE
C     FREQ  = FREQUEENCY OF DISCHARGE
C     X = CROSS SECTION POINT HORIZONTAL DISTANCE
C     Z = CROSS SECTION POINT VERTICAL ELEVATION
C     F = CROSS SECTION POINT MANNING'S N VALUE
C     D = CROSS SECTION POINT MEDIUM SEDIMENT SIZE
C     DBD = PARTICLE SIZE LIMITS
C
C     READ IN DATA
C
      READ (5,370) (TITLE(M),M = 1,12)
      READ (5,210) IR,ND,NQ,NSIZ,S,FO
      READ (5,220) (Q(J),FREQ(J),J = 1,NQ)
      READ (5,230) (X(K),Z(K),F(K),D(K),K = 1,ND)
      NSP1 = NSIZ + 1
      READ (5,240) (DBD(I),I = 1,NSP1)
      WRITE (6,380)
      WRITE (6,390) (TITLE(M),M = 1,12)
      WRITE (6,250) IR
      WRITE (6,400) ND,NQ,NSIZ,S,FO
C
C     FIND HIGH AND LOW ELEVATIONS IN SECTION
C
      ZMIN0 = 100000.
      ZMAX0 =  - 10000.
      DO 100 K = 1,ND
```

```
         IF (Z(K).LT.ZMIN0) ZMIN0 = Z(K)
         IF (Z(K).GT.ZMAX0) ZMAX0 = Z(K)
  100 CONTINUE
      WRITE (6,410)
      WRITE (6,420) (K,X(K),Z(K),F(K),D(K),K = 1,ND)
C
C     CALL SUBROUTINE PROPAR TO GENERATE THE SIZE DISTRIBUTION
C
      CALL PROPAR
      WRITE (6,430)
      WRITE (6,440)
      WRITE (6,450)
      WRITE (6,310) (DMB(I),I = 1,NSIZ)
      NDM1 = ND - 1
C
C     CALCULATE FALL VELOCITY
C
      DO 110 I = 1,NSIZ
         FVB(I) = (SQRT(35.417 * DMB(I) *  * 3 + 36.0 * SNU *  * 2) - 6.
     1    * SNU)/DMB(I)
  110 CONTINUE
      WRITE (6,460)
      WRITE (6,310) (FVB(I),I = 1,NSIZ)
      WRITE (6,470)
      WRITE (6,330) (K,(PD(K,I),I = 1,NSIZ),K = 1,NDM1)
C
C     INITIALIZATION
C
      QSJSUM = 0.
      DO 130 K = 1,NDM1
         RKSUM(K) = 0.
         DO 120 I = 1,NSIZ
            QSDSUM(I) = 0.
            RDSUM(K,I) = 0.
  120    CONTINUE
  130 CONTINUE
C
C     ITERATE OVER EACH DISCHARGE
C
      DO 170 J = 1,NQ
         WRITE (6,280) (J,Q(J),FREQ(J))
         ZMAX = ZMAX0
         ZMIN = ZMIN0
C
C     CALL SUBROUTINE SUBQ TO DIVIDE THE TOTAL DISCHARGE INTO
C     EACH SUBSECTION
C
         CALL SUBQ (J,ZMAX,ZMIN)
         WRITE (6,480)
         WRITE (6,290) (K,Q1(K),V1(K),Y1(K),K = 1,NDM1)
C
C     CALCULATE THE SEDIMENT TRANSPORT
C
         CALL TRANSP (J)
         WRITE (6,300) QSJ(J)
```

```
      WRITE (6,490)
      WRITE (6,310) (QSD(I),I = 1,NSIZ)
      WRITE (6,320)
      WRITE (6,440)
      WRITE (6,330) (K,(QTV(K,I),I = 1,NSIZ),K = 1,NDM1)
C
C     CALCULATE WHAT THE SAMPLER CATCHES
C
      IF (IR.EQ.1) CALL BOX (J)
      IF (IR.EQ.2) CALL PUMP (J)
      WRITE (6,340)
      WRITE (6,440)
      WRITE (6,330) (K,(EFS(K,I),I = 1,NSIZ),K = 1,NDM1)
      WRITE (6,350)
      WRITE (6,440)
      WRITE (6,330) (K,(RATIO(K,I),I = 1,NSIZ),K = 1,NDM1)
      DO 150 K = 1,NDM1
         RKSUM(K) = RKSUM(K) + RATIOK(K) * QSJ(J) * FREQ(J)
         DO 140 I = 1,NSIZ
            RDSUM(K,I) = RDSUM(K,I) + RATIO(K,I) * QSD(I) * FREQ(J)
  140    CONTINUE
  150 CONTINUE
      QSJSUM = QSJSUM + QSJ(J) * FREQ(J)
      DO 160 I = 1,NSIZ
         QSDSUM(I) = QSDSUM(I) + QSD(I) * FREQ(J)
  160 CONTINUE
  170 CONTINUE
C
C     CALCULATE THE OVER ALL CATCH RATIOS
C
      WRITE (6,360)
      WRITE (6,440)
      DO 200 K = 1,NDM1
         RK(K) = RKSUM(K)/QSJSUM
         DO 190 I = 1,NSIZ
            IF (QSDSUM(I).EQ.0.0) GO TO 180
            RD(I) = RDSUM(K,I)/QSDSUM(I)
            GO TO 190
  180       RD(I) =  - 1.0
  190    CONTINUE
         WRITE (6,330) (K,(RD(I),I = 1,NSIZ))
  200 CONTINUE
      WRITE (6,260)
      WRITE (6,270) (K,RK(K),K = 1,NDM1)
C
      STOP
C
C
  210 FORMAT (4I5,2F10.4)
  220 FORMAT (2F10.2)
  230 FORMAT (4F10.4)
  240 FORMAT (F10.6)
  250 FORMAT (//,1X,16HSAMPLER NUMBER =,I5)
  260 FORMAT (//,1X,50HOVER ALL FLOW FREQUENCY WEIGHTED, RATIO OF SAMPLE
     1D,26H CONCENTRATION TO AVERAGE,,/,1X,13HBY SUBSECTION,//,1X,19HSUB
```

```
     2SECTION    RATIO,/)
 270 FORMAT (2X,I5,4X,F10.5)
 280 FORMAT (1H1,//,1X,10HDISCHARGE,,I5,1X,F10.4,10H CFS WITH ,F10.4,10
     1H FREQUENCY)
 290 FORMAT (1X,I5,3F10.4)
 300 FORMAT (///,1X,26HTOTAL SEDIMENT TRANSPORT =,F8.4,4H CFS)
 310 FORMAT (6X,10E10.4)
 320 FORMAT (1H1,1X,42HSEDIMENT TRANSPORT BY SUBSECTION AND SIZE ,16HFR
     1ACTION, IN CFS,/)
 330 FORMAT (I5,10F10.5)
 340 FORMAT (1H1,//,1X,44HEFFICIENCY OF SAMPLER BY SUBSECTION AND SIZE,
     19H FRACTION)
 350 FORMAT (1H1,//,1X,40HRATIO OF SAMPLED SEDIMENT CONCENTRATION ,43HT
     1O AVERAGE, BY SUBSECTION AND SIZE FRACTION)
 360 FORMAT (1H1,//,1X,40HOVER ALL FLOW FREQUENCY WEIGHTED, RATIO ,45HO
     1F SAMPLED SEDIMENT CONCENTRATION TO AVERAGE,,/,1X,31HBY SUBSECTION
     2 AND SIZE FRACTION)
 370 FORMAT (12A5)
 380 FORMAT (1H1,//,1X,13HS A M P L E R,/,1X,35HSEDIMENT SAMPLER EVALUA
     1TION PROGRAM,/,1X,35HDEVELOPED BY G.O. BROWN AND R.M. LI,/,1X,28HA
     2T COLORADO STATE UNIVERSITY,/,1X,27HFOR THE USDA FOREST SERVICE,/,
     31X,50HROCKY MOUNTAIN FOREST AND RANGE EXPERIMENT STATION,/,1X,18HF
     4LAGSTAFF, ARIZONA)
 390 FORMAT (//,1X,63(1H*),/,1X,1H*,61X,1H*,/,1X,1H*,1X,12A5,1H*,/,1X,1
     1H*,61X,1H*,/,1X,63(1H*))
 400 FORMAT (//,1X,32HNUMBER OF CROSS SECTION POINTS =,I5,/,1X,22HNUMBE
     1R OF DISCHARGES =,I5,/,1X,26HNUMBER OF SEDIMENT SIZES =,I5,/,1X,16
     2HFRICTION SLOPE =,F10.5,6H FT/FT,/,1X,17HGRAIN ROUGHNESS =,F10.5)
 410 FORMAT (//,1X,13HCROSS SECTION,//,1X,39HPOINT HORIZONTAL VERITICAL
     1  N      D50,/)
 420 FORMAT (1X,I5,F8.2,1X,F8.2,1X,F8.3,1X,F8.6)
 430 FORMAT (1H1,/, 19HSEDIMENT PROPERTIES)
 440 FORMAT (/,1X,3HSUB,43X,22HPARTICLE SIZE FRACTION,/,1X,7HSECTION,3X
     1,1H1,9X,1H2,9X,1H3,9X,1H4,9X,1H5,9X,1H6,9X,1H7,9X,1H8,9X,1H9,8X,2H
     210,/)
 450 FORMAT (/,1X,26HMEAN SEDIMENT SIZE IN FEET)
 460 FORMAT (/,1X,23HFALL VELOCITY IN FT/SEC)
 470 FORMAT (/,1X,37HSUBSECTION PARTICLE SIZE DISTRIBUTION)
 480 FORMAT (/,1X,15HFLOW PROPERTIES,//,1X,34HSUB    DISCHARGE  VELOCIT
     1Y   DEPTH,/,1X,33HSECTION    CFS      FT/SEC      FT,/)
 490 FORMAT (/,1X,42HSEDIMENT TRANSPORT BY SIZE FRACTION IN CFS,//,15X,
     11H1,9X,1H2,9X,1H3,9X,1H4,9X,1H5,9X,1H6,9X,1H7,9X,1H8,9X,1H9,8X,2H1
     20,/)
      END
```

```
      SUBROUTINE SUBQ (J,ZMAX,ZMIN)
C
C     THIS SUBROUTINE DETERMINES THE DEPTH OF FLOW AND SUBSECTION
C     DISCHARGE.
C
      COMMON  FO           , S            , ND           , NSIZ          ,
     1        Q(10)        , FREQ(10)     , QSJ(10)      , X(30)         ,
     2        Z(30)        , F(30)        , Q1(30)       , Y1(30)        ,
     3        XB(30)       , V1(30)       , XN(30)       , DMB(10)       ,
     4        DBD(11)      , FVB(10)      , QSD(10)      , QSDSUM(10)    ,
     5        RD(10)       , RDSUM(30,10), PD(30,10)     , QSV(30,10)    ,
     6        QBV(30,10)   , QTV(30,10)   , EFS(30,10)   , RATIO(30,10),
     7        RATIOK(30)   , QSK(30)      , RKSUM(30)    , RK(30)        ,
     8        D(30)
      DATA NAP/ 4/
      DATA TOL/ .01/
C
C     TRIAL AND ERROR FOR DEPTH OF FLOW OVER TOTAL SECTION HEIGHT
C
      IET = 1
  100 ZDIF = ZMAX - ZMIN
      DWS = ZDIF/FLOAT(NAP)
      WS = ZMIN
      DO 110 N = 1,NAP
         WS = WS + DWS
         CALL GEOM (WS,SUMQ1)
         DQ = ABS(Q(J) - SUMQ1)
         EPS = TOL * Q(J)
C
C     TEST FOR CONVERGENCE
C
         IF (DQ.LE.EPS) RETURN
         IF (SUMQ1.GT.Q(J)) GO TO 120
  110 CONTINUE
  120 ZMAX = WS
      ZMIN = WS - DWS
      IET = IET + 1
      IF (IET.LE.10) GO TO 100
      WRITE (6,130)
C
      RETURN
C
  130 FORMAT (1X, 38HDOES NOT CONVERGE WITHIN 10 ITERATIONS)
      END
```

```
      SUBROUTINE GEOM (WS,SUMQ1)
C
C     THIS SUBROUTINE CALCULATES THE EXACT HYDRAULIC PROPERTIES OF
C     A CROSS SECTION, ONCE GIVEN THE CHANNEL GEOMETRY AND THE
C     WATER SURFACE ELEVATION.
C
      COMMON  FO          , S            , ND           , NSIZ          ,
     1        Q(10)       , FREQ(10)     , QSJ(10)      , X(30)         ,
     2        Z(30)       , F(30)        , Q1(30)       , Y1(30)        ,
     3        XB(30)      , V1(30)       , XN(30)       , DMB(10)       ,
     4        DBD(11)     , FVB(10)      , QSD(10)      , QSDSUM(10)    ,
     5        RD(10)      , RDSUM(30,10), PD(30,10)     , QSV(30,10)    ,
     6        QBV(30,10)  , QTV(30,10)   , EFS(30,10)   , RATIO(30,10),
     7        RATIOK(30)  , QSK(30)      , RKSUM(30)    , RK(30)        ,
     8        D(30)
C
      SUMQ1 = 0.
      DO 140 K = 2,ND
         KM1 = K - 1
         Y1(KM1) = 0.
         V1(KM1) = 0.
         Q1(KM1) = 0.
         XB(KM1) = X(K) - X(KM1)
         IF (XB(KM1).EQ.0.) XB(KM1) = 1.0E - 6
         FM = 0.5 * (F(KM1) + F(K))
         XN(KM1) = FM
         IF (Z(K).GE.WS) GO TO 110
         IF (Z(KM1).GE.WS) GO TO 100
         DA = WS - 0.5 * (Z(KM1) + Z(K))
         Y1(KM1) = DA
         A = XB(KM1) * DA
         ZB = ABS(Z(K) - Z(KM1))
         P = SQRT(XB(KM1) * XB(KM1) + ZB * ZB)
         GO TO 130
  100    ZB = WS - Z(K)
         XB(KM1) = XB(KM1) * ZB/(Z(KM1) - Z(K))
         IF (XB(KM1).EQ.0.) XB(KM1) = 1.0E - 6
         GO TO 120
  110    IF (Z(KM1).GE.WS) GO TO 140
         ZB = WS - Z(KM1)
         XB(KM1) = XB(KM1) * ZB/(Z(K) - Z(KM1))
         IF (XB(KM1).EQ.0.) XB(KM1) = 1.0E - 6
  120    A = 0.5 * XB(KM1) * ZB
         P = SQRT(XB(KM1) * XB(KM1) + ZB * ZB)
         DA = 0.5 * ZB
         Y1(KM1) = DA
  130    CONTINUE
C
C      CALCULATE TRIAL DISCHARGE USING MANNINGS EQUATION
C
         R = A/P
         V1(KM1) = 1.486/FM * S *  * 0.5 * R *  * (2./3.)
         Q1(KM1) = V1(KM1) * A
         SUMQ1 = SUMQ1 + Q1(KM1)
  140 CONTINUE
```

```
C
      RETURN
      END
      SUBROUTINE TRANSP (J)
C
C      THIS SUBROUTINE CALCULATES SEDIMENT TRANSPORT USING MEYER-
C      PETER-MULLER'S BED LOAD FUNCTION AND LANETAND'KALINSKEE'S
C      SUSPENDED LOAD FUNCTION.
C
      COMMON  FO         , S          , ND         , NSIZ        ,
     1        Q(10)      , FREQ(10)   , QSJ(10)    , X(30)       ,
     2        Z(30)      , F(30)      , Q1(30)     , Y1(30)      ,
     3        XB(30)     , V1(30)     , XN(30)     , DMB(10)     ,
     4        DBD(11)    , FVB(10)    , QSD(10)    , QSDSUM(10)  ,
     5        RD(10)     , RDSUM(30,10), PD(30,10) , QSV(30,10)  ,
     6        QBV(30,10) , QTV(30,10) , EFS(30,10) , RATIO(30,10),
     7        RATIOK(30) , QSK(30)    , RKSUM(30)  , RK(30)      ,
     8        D(30)
C
      NDM1 = ND - 1
      QSJ(J) = 0.
      DO 100 I = 1,NSIZ
         QSD(I) = 0.
  100 CONTINUE
      PN = 8.0 * SQRT(32.2/62.4)/(2.65 * 62.4 - 62.4)
C
C     ITERATE OVER EACH SIZE FRACTION.
C
      DO 140 K = 1,NDM1
         QSK(K) = 0.
         SV = SQRT(32.2 * Y1(K) * S)
         TAO = 1/8. * 1.9379 * FO * V1(K) *  * 2.
         DO 130 I = 1,NSIZ
            QTV(K,I) = 0.
            QBV(K,I) = 0.
            QSV(K,I) = 0.
C
C     CALCULATE THE EXCESS SHEAR STRESS BY MEYER-PETER-MULLER
C
            TAC = 0.047 * (2.65 - 1) * 62.4 * DMB(I)
            TTEM = TAO - TAC
            IF (TTEM.LE.0.) GO TO 130
C
C     CALCULATE THE BED LOAD
C
            QBW = PN * TTEM *  * 1.5
            QBV(K,I) = PD(K,I) * XB(K) * QBW
C
C     CALCULATE THE SUSPENDED LOAD
C
            A = 2.0 * DMB(I)
            IF (A.LT.0.05) A = 0.05
            AR = A/Y1(K)
            IF (AR.GT.0.5) GO TO 110
            CA = QBW/(11.6 * A * SV)
```

```
          C =  - 6.0 * FVB(I)/(0.4 * SV * Y1(K))
          EO = 1/C
          EY = EXP(C * (Y1(K) - A))/C
          QSW = CA * (EY - EO)
          GO TO 120
  110     QSW = 0.
  120     QSV(K,I) = PD(K,I) * XB(K) * QSW
C
C     CALCULATE TOTAL BED MATERIAL LOAD
C
          QTV(K,I) = QBV(K,I) + QSV(K,I)
          QSD(I) = QSD(I) + QTV(K,I)
          QSK(K) = QSK(K) + QTV(K,I)
  130   CONTINUE
        QSJ(J) = QSJ(J) + QSK(K)
  140 CONTINUE
C
C     CALCULATE THE AVERAGE CONCENTRATION FOR EACH SIZE FRACTION
C
C
      RETURN
      END
```

```
      SUBROUTINE PROPAR
C
C     THIS SUBROUTINE DETERMINES THE PARTICLE SIZE DISTRIBUTION
C     GIVEN THE PARTICLE SIZES OF INTEREST.  IT ASSUMES A LOG
C     NORMAL DISTRIBUTION.
C
      COMMON  FO          , S           , ND          , NSIZ         ,
     1        Q(10)       , FREQ(10)    , QSJ(10)     , X(30)        ,
     2        Z(30)       , F(30)       , Q1(30)      , Y1(30)       ,
     3        XB(30)      , V1(30)      , XN(30)      , DMB(10)      ,
     4        DBD(11)     , FVB(10)     , QSD(10)     , QSDSUM(10)   ,
     5        RD(10)      , RDSUM(30,10), PD(30,10)   , QSV(30,10)   ,
     6        QBV(30,10)  , QTV(30,10)  , EFS(30,10)  , RATIO(30,10),
     7        RATIOK(30)  , QSK(30)     , RKSUM(30)   , RK(30)       ,
     8        D(30)
      DIMENSION             DLOG(15)    , CDF(30,15)
C
      NSP1 = NSIZ + 1
      NDM1 = ND - 1
      DO 100 I = 1,NSIZ
         DMB(I) = SQRT(DBD(I) * DBD(I + 1))
         DLOG(I) = ALOG(DBD(I))
  100 CONTINUE
      DLOG(NSP1) = ALOG(DBD(NSP1))
      DO 130 K = 1,NDM1
         D50 = SQRT(D(K) * D(K + 1))
         SD = ALOG(2.0)
         DO 110 I = 1,NSP1
            Y = (DLOG(I) - ALOG(D50))/SD
            CALL MDNOR (Y,ERF)
            CDF(K,I) = ERF
  110    CONTINUE
         DO 120 I = 1,NSIZ
            PD(K,I) = CDF(K,I + 1) - CDF(K,I)
  120    CONTINUE
  130 CONTINUE
C
      RETURN
      END
```

```
      SUBROUTINE BOX (J)
C
C     THIS SUBROUTINE CALCULATES THE AMOUNT OF SEDIMENT A SAMPLER
C     CATCHES AND THE SAMPLING EFFICIENTCY.  THIS VERSION IS FOR A
C     VERTICLE BOX SAMPLER.
C
      COMMON  FO             , S             , ND            , NSIZ           ,
     1        Q(10)          , FREQ(10)      , QSJ(10)       , X(30)          ,
     2        Z(30)          , F(30)         , Q1(30)        , Y1(30)         ,
     3        XB(30)         , V1(30)        , XN(30)        , DMB(10)        ,
     4        DBD(11)        , FVB(10)       , QSD(10)       , QSDSUM(10)     ,
     5        RD(10)         , RDSUM(30,10), PD(30,10)       , QSV(30,10)     ,
     6        QBV(30,10)     , QTV(30,10)    , EFS(30,10)    , RATIO(30,10),
     7        RATIOK(30)     , QSK(30)       , RKSUM(30)     , RK(30)         ,
     8        D(30)
C
C     DEFINE SAMPLER SIZE
C
C     WSP = SAMPLER WIDTH
C     HS  = SAMPLR HEIGHT
C
      DATA WSP/0.382/
      DATA HS/1.5/
      HS  = 1.5
      DSIN  = WSP/2.
      NDM1  = ND - 1
      DO 200 K = 1,NDM1
         SV  = SQRT(32.2 * Y1(K) * S)
         QSINK = 0.
         QQSUMK  = 0.
C
C     CALCULATE THE PERCENT OF SUSPENDED LOAD CAUGHT IN
C     THE SAMPLER.
C
         DO 180 I = 1,NSIZ
            IF (Q1(K).EQ.0.0) GO TO 150
            IF (QTV(K,I).EQ.0.0) GO TO 160
            IF (Y1(K).GT.HS) GO TO 100
            RATIOH  = 1.0
            QQ  = V1(K) * WSP * Y1(K)
            GO TO 110
  100       A = 2.0 * DMB(I)
            IF (A.LT.0.05) A = 0.05
            C =  - 6.0 * FVB(I)/(0.4 * SV * Y1(K))
            EO  = 1.0/C
            EHS  = EXP(C * (HS - A))/C
            EY  = EXP(C * (Y1(K) - A))/C
            RATIOH  = (EHS - EO)/(EY - EO)
C
C     CALCULATE THE VOLUME OF WATER IN THE SAMPLE
C
            QQ  = V1(K) * HS * WSP
C
C     CALCULATE THE ENTRANCE EFFECTS
C
```

```
  110       IF (DMB(I).GE.WSP) GO TO 120                                BOX 0560
            IF (DMB(I).GT.DSIN) GO TO 130                               BOX 0570
            RATIOE = 1.0                                                BOX 0580
            GO TO 140                                                   BOX 0590
  120       RATIOE = 0.                                                 BOX 0600
            GO TO 140                                                   BOX 0610
  130       RATIOE = 1 - (DMB(I) - DSIN)/DSIN                           BOX 0620
C                                                                       BOX 0630
C     CALCULATE THE SAMPLED SEDIMENT                                    BOX 0640
C                                                                       BOX 0650
  140       QSIN = RATIOE * (QBV(K,I)/XB(K) + RATIOH * QSV(K,I)/XB(K)) *BOX 0660
     1       WSP                                                        BOX 0670
            EFS(K,I) = (QSIN/WSP)/(QTV(K,I)/XB(K))                      BOX 0680
            RATIO(K,I) = (QSIN/QQ)/(QSD(I)/Q(J))                        BOX 0690
            QSINK = QSINK + QSIN                                        BOX 0700
            GO TO 180                                                   BOX 0710
  150       EFS(K,I) =  - 1.0                                           BOX 0720
            QQ = 0.                                                     BOX 0730
            IF (QSD(I).EQ.0.0) GO TO 170                                BOX 0740
            RATIO(K,I) = 0.                                             BOX 0750
            GO TO 180                                                   BOX 0760
  160       EFS(K,I) = 1.0                                              BOX 0770
            IF (Y1(K).LT.HS) QQ = V1(K) * WSP * Y1(K)                   BOX 0780
            IF (Y1(K).GE.HS) QQ = V1(K) * WSP * HS                      BOX 0790
            IF (QSD(I).EQ.0.0) GO TO 170                                BOX 0800
            RATIO(K,I) = 0.0                                            BOX 0810
            GO TO 180                                                   BOX 0820
  170       RATIO(K,I) = 1.0                                            BOX 0830
  180    CONTINUE                                                       BOX 0840
         QQSUMK = QQSUMK + QQ                                           BOX 0850
         IF (QQSUMK.EQ.0.0) GO TO 190                                   BOX 0860
         RATIOK(K) = (QSINK/QQSUMK)/(QSJ(J)/Q(J))                       BOX 0870
         GO TO 200                                                      BOX 0880
  190    RATIOK(K) = 0.0                                                BOX 0890
  200 CONTINUE                                                          BOX 0900
      RETURN                                                            BOX 0910
      END                                                               BOX 0920
```

```
      SUBROUTINE PUMP (J)
C
C     THIS SUBROUTINE CALCULATES THE AMOUNT OF SEDIMENT A SAMPLER
C     CATCHES AND THE SAMPLING EFFIENTCY.  THIS VERSION IS FOR A
C     MULTIPLE PORT SAMPLER
C
      COMMON  FO          , S           , ND          , NSIZ          ,
     1        Q(10)       , FREQ(10)    , QSJ(10)     , X(30)         ,
     2        Z(30)       , F(30)       , Q1(30)      , Y1(30)        ,
     3        XB(30)      , V1(30)      , XN(30)      , DMB(10)       ,
     4        DBD(11)     , FVB(10)     , QSD(10)     , QSDSUM(10)    ,
     5        RD(10)      , RDSUM(30,10), PD(30,10)   , QSV(30,10)    ,
     6        QBV(30,10)  , QTV(30,10)  , EFS(30,10)  , RATIO(30,10)  ,
     7        RATIOK(30)  , QSK(30)     , RKSUM(30)   , RK(30)        ,
     8        D(30)
C
      DIMENSION             HPORT(10)
C
C     DEFINE SAMPLER
C
C     NPORT = NUMBER OF PORTS
C     HPORT = HEIGHT OF PORT
C     DIAPORT = DIAMETER OF PORT
C
      DATA NPORT/5/
      DATA DIAPORT/0.02/
      DATA HPORT/0.5,1.0,1.5,2.0,2.5/
      DSIN = DIAPORT/2.
      NDM1 = ND - 1
C
C     ITERATE OVER EACH SUBSECTION
C
      DO 230 K = 1,NDM1
         SV = SQRT(32.2 * Y1(K) * S)
         QSINK = 0.
         QQSUMK = 0.
C
C     ITERATE OVER EACH SEDIMENT SIZE FRACTION
C
         DO 210 I = 1,NSIZ
            QQSUM = 0.
            QSIN = 0.
            RATIOH = 1.0
            IF (Q1(K).EQ.0.0) GO TO 180
C
C     ITERATE OVER EACH SAMPLING PORT
C
            DO 130 NP = 1,NPORT
               IF (Y1(K).GE.HPORT(NP)) GO TO 100
               RATIOH = FLOAT(NP - 1)/FLOAT(NPORT)
               GO TO 140
C
C     CALCULATE THE VOLUME OF WATER IN THE SAMPLE
C
  100          U = V1(K) + (SV/.4) * (ALOG(HPORT(NP)/Y1(K)) + 1.)
               QQ = (DIAPORT *  * 2/4.0) * U
               QQSUM = QQSUM + QQ
```

```
C
C     CALCULATE THE SUSPENDED LOAD CAUGHT IN THE SAMPLER
C
                IF (QTV(K,I).EQ.0.0) GO TO 110
                A = 2.0 * DMB(I)
                IF (A.LT.0.05) A = 0.05
                C =  - 6.0 * FVB(I)/(0.4 * SV * Y1(K))
                CA = QBV(K,I)/(11.6 * A * SV * XB(K))
                CH = CA * EXP(C * (HPORT(NP) - A))
                QSIN = QSIN + CH * QQ
                GO TO 130
  110           EFS(K,I) = 1.0
                IF (QSD(I).EQ.0.0) GO TO 120
                RATIO(K,I) = 0.0
                GO TO 130
  120           RATIO(K,I) = 1.0
  130        CONTINUE
C
C     CALCULATE THE ENTRANCE EFFECTS
C
  140        IF (DMB(I).GE.DIAPORT) GO TO 150
             IF (DMB(I).GT.DSIN) GO TO 160
             RATIOE = 1.0
             GO TO 170
  150        RATIOE = 0.
             GO TO 170
  160        RATIOE = 1 - (DMB(I) - DSIN)/DSIN
C
C     CALCULATE THE SAMPLED SEDIMENT
C
  170        QSIN = RATIOE * QSIN
             EFS(K,I) = RATIOE * RATIOH
             IF (QQSUM.EQ.0.0) GO TO 190
             RATIO(K,I) = (QSIN/QQSUM)/(QSD(I)/Q(J))
             QSINK = QSINK + QSIN
             GO TO 210
  180        EFS(K,I) =  - 1.0
             QQSUM = 0.
  190        IF (QSD(I).EQ.0.0) GO TO 200
             RATIO(K,I) = 0.
             GO TO 210
  200        RATIO(K,I) = 1.0
  210      CONTINUE
           QQSUMK = QQSUMK + QQSUM
           IF (QQSUMK.EQ.0.0) GO TO 220
           RATIOK(K) = (QSINK/QQSUMK)/(QSJ(J)/Q(J))
           GO TO 230
  220      RATIOK(K) = 0.0
  230 CONTINUE
      RETURN
      END
```

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