DRAFT

WATER QUALITY MONITORING PROTOCOLS - REPORT NO. 2

ESTIMATING INTERGRAVEL SALMONID LIVING SPACE USING THE COBBLE EMBEDDEDNESS SAMPLING PROCEDURE

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COBBLE EMBEDDEDNESS PROTOCOL

Introduction:

Cobble embeddedness was originally conceived as a method for measuring the amount of fine sediment filling the interspaces surrounding streambed cobbles. Early measures of embeddedness were developed by Klamt (1976), and Kelly and Dettman (1980). Cobble embeddedness measurements have been made in Idaho since 1977 by qualitative estimation (Bjornn, and others, 1977; and Brusven, Meehan, and Biggam, 1979). Quantitative protocols were later developed by Burns (1984). Applications have varied broadly (Munther and Frank, 1986a and 1986b; Torquemada and Platts, 1988; Potyondy, 1988; Clark, 1989). Efforts by several fisheries biologists, hydrologists and water quality specialists to develop a consensus method was led by Skille and King (1989).

Cobble embeddedness is a surrogate measurement of the interstitial space of streambed cobble habitats. The interstitial space found in streambed cobble habitats is important to at least one component of the cold water biota beneficial use of waters, juvenile fish. Juvenile salmonids use the interstitial space primarily as overwintering habitat, but also for feeding and refuge cover during summer months. If this habitat is not available, juvenile salmonids must either find other suitable habitat by migrating from the stream reach or find replacement overwintering habitat (Bustard and Narver, 1975b; Hillman, Griffith and Platts, 1986).

Draft sediment criteria developed by the State of Idaho have included the level of cobble habitat embeddedness as a criterion. The draft criterion permits no statistically significant increase in the level of embeddedness over the natural level. Natural levels are determined for streams of the same grade and stream power (or similar geomorphology). The criterion recognizes that interstitial cobble space is an important fish habitat (Bustard and Narver, 1975a; Hillman, Griffith and Platts, 1986). It assumes the loss of habitat through filling by fine sediment is a loss which cannot be fully replaced by alternate habitats.

The purpose of this report is to define state-of-the-art protocols for sampling and analyzing cobble embeddedness to determine living space requirements for young fish. The ultimate objective is to acheive uniform measurement and assessment accross the State of Idaho. Cobble embeddedness is obviously an important measure of aquatic environmental quality. The science has progressed far enough to allow making reliable estimates of intergravel space for application to water quality management.

Review of Cobble Embeddedness Methods:

Two basic methods of quantitatively measuring cobble embeddedmess have been developed. The Burns method was developed for a assessment on specific habitats in granitic streams where no alternative juvenile rearing space is available. The other method was developed by Jack Skille of the Idaho Division of Environmental Quality and Jack King of the U. S. Forest Services' Intermountain Research Station after a significant quantity of data had been collected using the Burns method. The Skille-King approach was developed with the benefit of experience gathered as the Burns method was applied more widely. Accordingly the Skille-King method attempts to correct perceived errors in the earlier methods.

The Burns method was developed for the South Fork Salmon River drainage. Pool tailouts are the prime winter rearing habitat in this drainage where less alternate habitat is available. The method specifies very specific depth and flow rate in order to sample cobble habitats. Cobbles within a specified size range are drawn from a 60cm diameter sampling hoop. Each cobble is measured for depth embedded by fine sediment. Each cobble measurement is considered a sample, and a total of 100 are used to estimate mean embeddedness. Remaining cobble in the final hoop are measured in order not to bias the sample.

A study by the Boise National Forest in Idaho using the Burns method compared measurements on many streams forest-wide. Measurements were conducted on adjacent pool tailouts (Potyondy, 1988). Results of the study demonstrated large spacial variability of cobble embeddedness within a stream reach.

The Skille-King approach was developed to address the problem of spacial variability so that changes over space and time could be more accurately predicted. Using this approach, the mean of measurements on all cobbles in a hoop is considered a single sample. This approach circumvents the statistical problem that cobbles within a hoop not independant. The method also surveys the cobble embeddedness of a stream reach approximately 10 stream widths in length. This approach permits representative sampling of all cobble habitats found in the reach, thereby accounting for spacial variability.

The protocols discussed here, and now recommended for use are the basic quantitative methods of Burns and Edwards (1985), and the sampling design and statistical treatments of Skille and King (1989). The intersticial space index (ISI) or measure of un-embedded substrate can be calculated from the above methods and is the preferred metric for reporting substrate embeddedness effects on salmonid rearing. Percent embeddedness is highly variable in space and time and its measure can be influenced by the location of sediment within the substrate matrix. ISI is less highly variable and is not affected by the location of fine sediment.

EQUIPMENT:

Sampling Hoop:

Embeddedness measurement is made on cobbles drawn from a metal sampling hoop 60 cm inside diameter. The standard hoop is built of 1/8" diameter stainless steel rod. Hoops have also been constructed of 1/4" braided cable fastened with cable clamps. These hoops can be folded for carrying, but when released return to the 60 cm hoop dimensions.

Scale:

The scaling device is composed of a transparent ruler mounted on a plexiglass frame (Figure 1). The scaler facilitates measurement of cobble diameter, depth that cobble is embedded in the substrate, and total verticle height of cobble.

Miscellaneous Equipment:

Necessary equipment for working in streams requires hip or chest waders and arm length rubber gloves. A fiberglass open reel measuring tape, tag line, or equivalent is required to survey the sampling grid. Forms are required to record data (Appendix I). A programmable hand calculator is useful to generate random numbers for sampling. The calculator is also used to make the statistical tests for adequacy of the sample size. A pry bar is useful for dislodging cobble cemented in the streambed.

Transect Location Method:

Using the Skille-King (1989) sampling design, the average stream width is determined from several random measurements. Ten transects are then located over a twenty times streamwidth reach length. Transects are located by placing the initial transect randomly, 0-10 feet upstream of the starting point and locating the additional ten transects two streamwidths apart sequentially upstream. This transect arrangement insures a representative sample of the cobble habitats located in the stream reach.

Sampling Hoop Location:

Three sampling hoops are located on each transect. Location on the transect is designated by generating random numbers between the endpoints and centering the hoop at that point of the transect. The hoop must lay in less than 45 cm of water to measure cobble embeddedness. If the random location occurs in water exceeding 45 cm depth, the hoop is moved to the nearest location along the transect where depth is equal to or less than 45 CM.

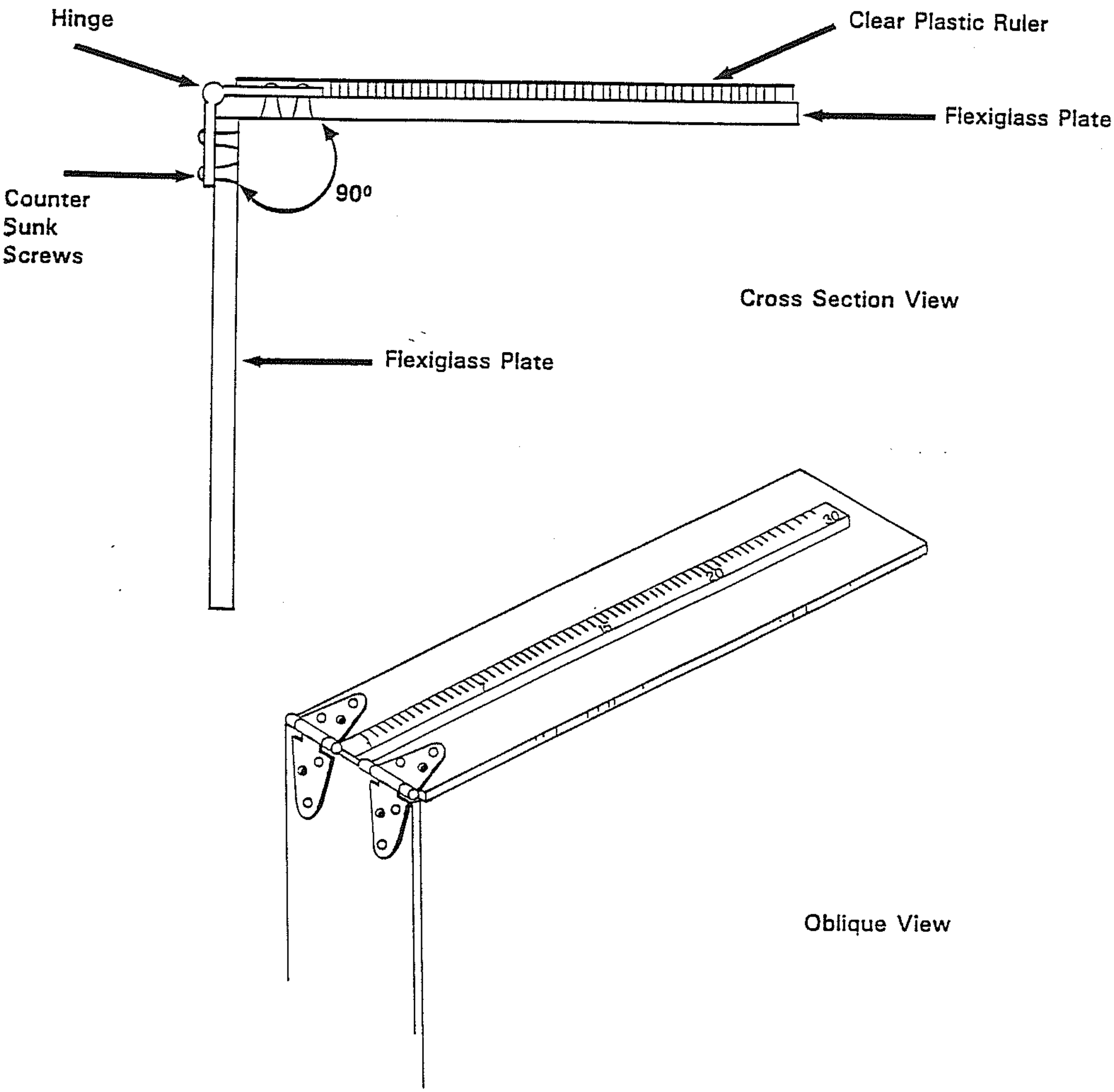
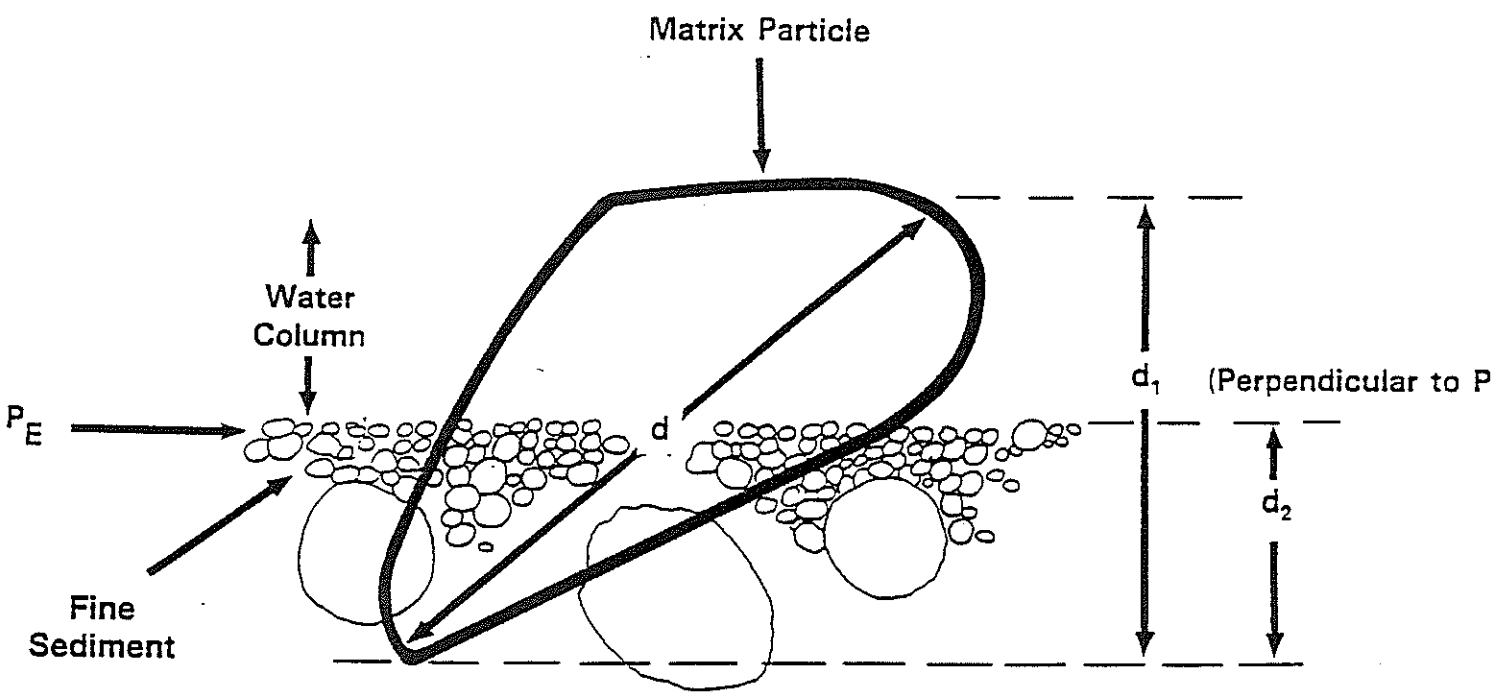


Figure 1. Embeddedness measuring scale (approximately 1/3 of actual size).

Cobble Measurement:

Within the boundaries of each hoop, all rocks between 4.5 and 30 cm are measured for embeddedness by fine sediment (>6.35 mm). Free matrix rocks are removed first from the hoop and their total depth (Dt) measured (figure 2). Embedded rocks are then removed and measured. Embedded rocks are removed by placing the thumb and opposing finger at the plane of embeddedness and lifting the rock. Care should be taken not to disturb adjacent rocks. With the thumb and finger defining the plane of embeddedness, the total depth (Dt) and embedded depth (De) are measured using the plexiglass scale. In some cases, periphytin or macroinvertebrates define the plane of embeddedness such that marking the plane with the thumb and finger is not necessary. The process is repeated until all rocks meeting the size criteria in the top layer are removed. Embeddedness for the hoop is calculated from the measurements.

After completing measurements on all cobbles within a hoop, the rocks removed should then be replaced on the plot area.



$$E = \frac{d_2}{d_1}(100)$$

Figure 2. Embeddedness measurement parameters. Pe is the plane of embeddedness, d is the maximum rock diameter, d1 is the total verticle rock length, and d2 is the verticle depth below the plane of embeddedness. E is percent embeddedness.

MEASUREMENT OF PERCENT FINES:

If more than 10% of the area within the hoop is covered by surface fines (with no rocks visible), a weighting method developed by Torquemade and Platts (1989) is used. The percentage of the hoop area covered by surface fines is estimated to the nearest 10% visually, or by measurement. On each hoop, the percent of the hoop area in 100% fines is estimated. Fines are defined as that fraction of substrate less than .25 inch (6.35mm) in diameter .

There are three ways to estimate percent surface fines within the hoop. The visual estimate by areal components is rapid and reduces sampling effort and cost, but is the least accurate. This technique requires familiarity with comparisons to known areal distributions, and as much as 20% error may be encountered with its application. An example of a known comparison to percent surface fines is illustrated in figure 3.

The grid technique represents a much more objective means of characterizing surface percent fines. A metal grid is placed directly over the hoop, and openings in the grid directly over areas of 100% fine sediment are counted. A one inch diameter grid provides 450 openings for assessment of percent fines. The number of openings over fine sediment are divided by the total number of openings - 450, to derive percent surface fines quantitatively.

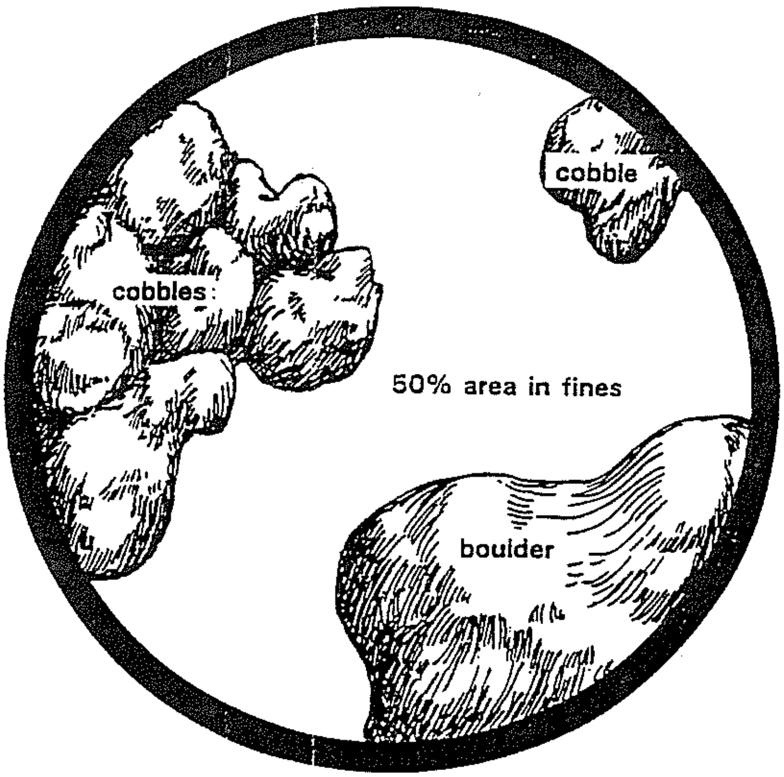


Figure 3. Distribution of particles in an embeddedness measuring hoop. That portion of the hoop containing fines is considered fully embedded (100%).

The scale technique also permits objective quantification of surface fines. A 24 inch scale is place on the hoop roughly parallel to the thalweg of the stream. Each "inch" marker on the scale placed directly on fines in the substrate is counted. After making counts with the scale in this position, the scale is then placed on the hoop perpendicular to the starting position, and counts of fines are made again. Using a scale in this fashion permits making up to 48 counts of locations with fine sediment. The number of scale marker locations counted is then divided by 48 to calculate percent surface fines.

The weighted cobble embeddedness is calculated from the equation:

$$\%\ \text{weighted embeddedness} = \frac{\text{hoop area in fines}\ \%\ \times 100 + \text{remaining}\ \%\ \times\ \%\ \text{embedded}}{100}$$

This weighting of surface fine sediment is required to adequately estimate the amount of intergravel living space.

Determination of Sample Size:

Using the Skille-King sampling design, the embeddedness measurement from each hoop is a sample. Three samples from each transect will provide thirty measurements. Dependent of the cobble habitat variability of the stream, thirty measurements may be sufficient or too few. The number of samples necessary can be calculated on-site with the equation:

$$n= \frac{t^2\ s^2}{E^2}$$

Where n=Number of samples

t=Student's t

S=Standard deviation

E=Level of precision desired

The standard deviation can be calculated from the samples taken. The level of precision desired is a matter of personal preference, but a 95% confidence interval is suggested. Student's t can be found on a chart of precision level and degrees of freedom (samples measured). From these values the sufficient number of sample can be measured.

A computer program has been developed to facilitate the statistical calculations, other useful calculations and data storage and retrieval.

Additional Measurements:

Some additional measurements are of value to aid in interpreting the embeddedness data collected and to compare embeddedness values obtained for one stream reach with others. It is important when making comparisons with reference or baseline sites that the parameters marked with a star (*) are collected. The average velocity, depth, and habitat type should be the same at comparison sites:

- * Surface velocity
- * Depth in center of hoop
- * Habitat type (Appendix II)
- Distance from waters edge and distance from Thalweg
- Comments on unusual conditions

MONITORING:

This protocol is recommended for use where appropriate in Idaho's coordinated nonpoint source water quality monitoring program (Clark, 1990).

When the objective is to monitor changes in stream sediment over time, it is best to calculate the amount of vertically exposed rock. The problem with expressing the data as a percentage of embeddedness is that this does not reflect the amount of exposed rock used for living space by aquatic organisms. Living space is calculated by summing the difference: De minus Dt, for all samples within a hoop and dividing by the surface area of the hoop (.2826 square meters). The result is the interstitial space index expressed in meters/sq. meter.

The amount of interstitial space and percent embeddedness can both be calculated from the same field measurements. The choice may depend on the study objectives (evaluating fish habitat, macroinvertebrate habitat, etc.). It is best to choose the interstitial space index when monitoring changes over time or differences between streams. The interstitial space index is calculated directly from field measurements using the computer analysis system discussed in the previous section.

Preliminary evaluation of the interstitial space index indicates that it has a good correlation with number and total length of verticle exposure of free matrix particles. In addition, good correlations with percent fine sediment have been observed. We have also observed that ISI data fit a normal probability distribution, therefore a set of data from one sampling location can be adequately fit to a regression curve predicting interstitial space index from free matrix cobbles and percent fine sediment. Using the regression model, future monitoring requires sampling only the numbers and sizes of free matrix material, and the hoop percentage of fine sediment, greatly reducing the time commitments to sampling.

The procedure requires following the full standard protocol, collecting and measuring all cobbles during the first field sampling period. A regression analysis of ISI versus free matrix cobbles and percent fine sediment would be conducted on the data to determine if a significant relationship ($R2 > .80$) can be derived. With a reliable predicition, future sampling would require measuring only Dt on free matrix cobbles, or percent fine sediment, or both.

Subsequent monitoring requires revisiting the same transects as previously established in the stream. At each transect, the exact location of the previously sampled plots must be relocated. The investigator moves 3 feet upstream of the transect line, or immediately upstream, in front of, the previously sampled hoop. This establishes the new hoop location and allows replication of data without siting on previously disturbed substrate.

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APPENDIX I

DATA FORM

COBBLE EMBEDDEDNESS FIELD FORM

Stream____________________ Crew____________________

Transect Number________________ Date____________________

Transect spacing__________ ft

HOOP #'s:			
Distance from right bank:			
Percent surface fines:			
Habitat:			
Water Depth:			

								Hoop #
								Hoop #
								Hoop #

COMMENTS:

APPENDIX II

HABITAT TYPES

HABITAT DEFINITIONS

RIFFLE: A shallow rapids where the water flows swiftly over completely or partially submerged obstructions to produce surface agitation, but standing waves are absent.

POCKET WATER: A series of small pools surrounded by swiftly flowing water, usually caused by eddies behind boulders, rubble or logs, or by potholes in the stream bed.

RUN: An area of swiftly flowing water, without surface agitation or waves, which approximates uniform flow and in which the slope of the water surface is roughly parallel to the overall gradient of the stream reach.

POOL: A portion of the stream with reduced velocity, often with water deeper than the surrounding areas, and which is frequently usable by fish for resting and cover.

APPENDIX III

EMBEDDEDNESS COMPUTER ANALYSIS PROGRAM

INTRODUCTION:

The Embeddedness Analysis System is designed to provide for storage and analysis of data collected as part of the embeddedness protocols set forth in this document. The computer program is written in BASIC language and runs on BASIC, BASICA, or QUICKBASIC for IBM or compatible computers. Copies of the computer program can be obtained by sending a 3.5 inch floppy disk, formatted IBM or compatible to: Idaho Department of Health and Welfare, Division of Environmental Quality, C/O Surface Water Section, 1410 North Hilton, Boise, Idaho, 83720.

The following descibes operation of the program and calculations made to derive outputs for data interpretation. There are 6 major screens in the structure of the program and a main menu from which various sub-routines are accessed. The program is designed for ease of data entry, therefore all responses are preceded by a prompt for information.

Startup:

The program is initiated from the directory in which the batch file - EMB.BAT - resides. The program is started by writing: "EMB". The search path for this directory must include access to BASICA, and the file - EMBED.BAS - must reside in the resident directory. The entry screen (Screen #1) then appears. Press enter to continue.

The entry screen (Screen #1) then appears. Press enter to continue.

Main menu:

The main menu as shown in Screen #2 allows the user to select from among 5 options. Option #1 allows for data entry into the system. Option 2 examines several statistics on the data, including means, standard deviations, and sample size adequacy. Option #3 statistically analyzes embeddedness data for comparison to other stations, or to individual values such as numeric criteria. Option #4 provides for editing of data entered into the system for any station previously saved.

The user select a number from the main menu, and the program then branches to the appropriate subroutine. If number 5 is selected, the screen is returned to DOS.

Data entry:

Screen #'s 3 and 4 represent the general data entry prompts from the program. As shown in Screen #3, the user is requested for the total number of hoops at the station, a filename for the station, and whether or not measurements on free matrix cobbles will be entered. The filename for the station must be less than eight characters in length. A dot with three additional characters appended to the end of the filename is optional. When asked if "you intend to enter De/Dt data for free matrix cobbles", an answer of "N" assumes that De/Dt measurements were not made on the free matrix cobbles in the hoop. In this case, the program will prompt the user for the "number of free matrix cobbles" in the hoop. As stated in the Monitoring Section, it is desirable to measure Dt on free matrix cobbles for assessment of living space.. If such measurements were made, the answer to the last query should be "Y".

At Screen #4, the data entry screen, the depth of embeddedness for each cobble is prompted with De:, and the total verticle height of the cobble is prompted with Dt:. The user enters these values for all cobbles on the hoop. While entering data, as the bottom of the screen is reached, the program will as if you would like to change any of the entries. A "Y" answer will automatically permit making changes to the entered data. A "N" answer will cause the system to clear the present screen, and continue the data entry routine.

After all data have been entered the user must enter a "0" for De and "0" for Dt. This prompts the system to ask if you would like to change any of the numbers entered (on that screen), followed by a new screen (not illustrated) which asks for the habitat type, number of free matrix cobbes, and the percent surface fines.

After entering the information in the last screen, the program calculates embeddedness and interstitial space for that hoop, and goes on to the next hoop for data entry. After entering data for all hoops, the subroutine ends and returns to the main menu.

Embeddedness is calculated by the following formula:

(sum of all De measurements/sum of all Dt measurements) X 100

Interstitial space index is calculated by the following:

sum of the diff (Dt-De) X .0035

The value - .0035 converts the data to meters on a 60 cm plot area, that is: (.001/.2826).

Statistics:

Screen #5 illustrates the output resulting from selecting #2 on the Main Menu. This section of the program starts with a prompt for the input data file. This is the filename used to describe the previously input data. The name must be written exactly as it was saved while executing Section #1.

In the example given, the filename "Rock.cr" was entered into the system. The program then read in the data from the file, and calculated the standard statistics presented. These include: Total number of hoops sampled, a calculation of mean embeddedness from all hoops, a calculation of mean interstitial space index from all hoops, the numbers of various habitat types, the bottom size distribution of substrate particles, and the sample size statistics.

Embeddedness here is calculated as the mean of embeddedness calculations for all hoops at the station. In this case, the ten hoops averaged 96.2 percent embeddedness. Interstitial space was also averaged from the calculations for interstitial space index on all hoops. The mean index in the example is .049 m/m2.

The estimated 95% confidence sample size is calculated from the statistic. The output presents three confidence levels around the mean embbededness. Usually, 5% confidence is used as the accurate predictor of mean embeddedness. In this example, the program indicates that 11 samples are required to predict the mean within 5% at a 95% confidence on the t statistic.

The last presentation on Screen #5 presents the probability statistics on any given sample size. The program prompts the user for a sample size. In this example, a sample size of 5 was entered. Based on the output presented, if the sample size was only 5, the mean would be predicted with a probability test power of .92 (or an error of .8). Again, all probability statistics are based on standard equations in the t stastic.

Making comparisons:

Section number 3 from the main menu accesses a subroutine that tests for difference in populations between two sets of data (two different stations) or between one set of data and a single value such as a numerical embeddedness standard (see Screen #6).

The user is asked for the name of the data file at which point the filename is entered. Then three test options are made available: test 1 tests embeddedness against a single value or numeric criteria; test 2 compares the population against a baseline or natural embeddedness sample, where the standard deviations of the two populations are assumed to be equal; and test 3 compares the embeddedness population against a baseline or natural sample, where the standard deviations are assumed to be unequal. The selection of a test depends on the nature of the baseline or natural embeddedness data. If they are established as a mean of samples from paired watershed, option number 2 is the preferred test. In this case, data from the baseline sample must reside in a file in the same directory as the comparison sample. The system will ask for the name of this file.

After selecting a test method, embeddedness values from each hoop in the sample are displayed followed by the station mean embeddedness and standard deviation, t value, degrees of freedom, and a tabled t value for 95% confidence. From these data, a test result is displayed and conclusions presented.

SCREEN #1: ENTRY

EMBEDDEDNESS ANALYSIS SYSTEM
VERSION 2.1 - 1990

by Tim Burton

press ENTER to continue >

SCREEN #2: Main Menu

```
MAIN MENU
===========

1     INPUT data into the system
2     Analyze data for EMBEDDEDNESS SAMPLE SIZE adequacy
3     DATA COMPARISONS and HYPOTHESIS TESTS
4     EMBEDDEDNESS and INTERSTITIAL SPACE INDEX tables
5     UPDATE RAW DATA in the system
6     EXIT system

Please SELECT a number: 1
```

SCREEN #3: MAIN MENU SELECTION NUMBER 1:

```
    EMBEDDEDNESS DATA ENTRY ROUTINE

What is the total number of hoops for this station (0 to end): 10

Please write the filename you intend to use: Rock.cr

Do you intend to enter De/Dt data for free matrix cobbles? (Y/N):

Yes
```

SCREEN #4: DATA ENTRY SCREEN

```
For HOOP #  1:

     INPUT DATA  -  Embedded depth (De), and Total depth (Dt)
                    for free matrix cobbles, enter 0 for De
                    (Write 0,0 after last input)

          De: 12              Dt: 67
          De: 125             Dt: 150
          De: 0               Dt: 200
          De: 44              Dt: 85
          De: 0               Dt: 0

Would you like to change any of these (Y/N)?  -  N
```

SCREEN #5: MAIN MENU SELECTION NUMBER 2:

```
What is your input data file name:  Rock.cr

     ........READING IN THE DATA.......

          DATA FOR: ROCK.CR

          NUMBER OF HOOPS=  10
          MEAN EMBEDDEDNESS=  96.26068  percent
          MEAN INTERSTITIAL SPACE INDEX=  .0492183  m/m2

          NUMBER OF POOLS=  4
          NUMBER OF RIFFLES=  4
          NUMBER OF RUNS/GLIDES=  2

          Bottom Size Distribution:
               Percent FINES=  80.5
               Percent GRAVEL=  8.58
               Percent COBBLE=  10.92
               Percent BOULDER=  0

          The estimated 95% confidence sample size is:
               At 10% limits around the mean=  2
               At 5% limits around the mean=  11
               At 1% limits around the mean=  285


FOR SAMPLE SIZE OF  5  PROBABILITY OF A TYPE II ERROR=  7.550
(Concluding that the mean is not adequately predicted)

Test power=  .9244934
```

SCREEN #6: MAIN MENU SELECTION NUMBER 3:

```
DATA FOR: Rock.cr

     TEST FOR SIGNIFICANCE OF MEANS USING 'T' DISTRIBUTION

TEST 1: Natural baseline embeddedness is a single value

TEST 2: Natural baseline embeddedness is a population, test s=s

TEST 3: Natural baseline embeddedness is a population, test s<>s

Select one: 1
Baseline embeddedness= 55%


SAMPLE 1 :

NUMBER OF ELEMENTS 10

MEAN EMBEDDEDNESS AT HOOP 1 =  100
MEAN EMBEDDEDNESS AT HOOP 2 =  100
MEAN EMBEDDEDNESS AT HOOP 3 =  100
MEAN EMBEDDEDNESS AT HOOP 4 =  100
MEAN EMBEDDEDNESS AT HOOP 5 =  100
MEAN EMBEDDEDNESS AT HOOP 6 =  78.10345
MEAN EMBEDDEDNESS AT HOOP 7 =  96.81818
MEAN EMBEDDEDNESS AT HOOP 8 =  87.68519
MEAN EMBEDDEDNESS AT HOOP 9 =  100
MEAN EMBEDDEDNESS AT HOOP 10 =  100

Sample mean=  96.26068

Sample Standard Deviation=  7.464093


T-VALUE=  17.48072

DEGREES OF FREEDOM=  9

THE T VALUE AT 95% CONF FOR  9 DEGREES OF FREEDOM=  2.262

REJECT Ho: NATURAL BASELINE = COMPARISON SAMPLE
     Conclude that the sample is in violation of the
     sediment criteria

95% confidence interval (lower bound)= 81.124 % embeddedness
```

SCREEN #7: MAIN MENU SELECTION #4 - EMBEDDENESS/INTERSTITIAL SPACE INDEX

DATA FOR: SF Payette River

NUMBER OF HOOPS= 13

Hoop #	1	Embeddedness= 64	ISI=	.626327 m/m2
Hoop #	2	Embeddedness= 56	ISI=	1.673744 m/m2
Hoop #	3	Embeddedness= 58	ISI=	1.923331 m/m2
Hoop #	4	Embeddedness= 63	ISI=	1.31281 m/m2
Hoop #	5	Embeddedness= 59	ISI=	2.793863 m/m2
Hoop #	6	Embeddedness= 60	ISI=	1.394197 m/m2
Hoop #	7	Embeddedness= 56	ISI=	1.33758 m/m2
Hoop #	8	Embeddedness= 88	ISI=	.3255485 m/m2
Hoop #	9	Embeddedness= 66	ISI=	.7112527 m/m2
Hoop #	10	Embeddedness= 75	ISI=	.9362047 m/m2
Hoop #	11	Embeddedness= 67	ISI=	2.649063 m/m2
Hoop #	12	Embeddedness= 46	ISI=	5.630338 m/m2
Hoop #	13	Embeddedness= 86	ISI=	.8386413 m/m2

MEAN EMBEDDEDNESS= 65.25537 percent

STANDARD DEVIATION EMBEDDEDNESS= 11.40327 percent

MEAN INTERSTITIAL SPACE INDEX= 1.704069 m/m2

STANDARD DEVIATION INTERSTITIAL SPACE INDEX= 1.339195 m/m2

SCREEN #8: MAIN MENU SELECTION #4 CONTINUED

DATA FOR: SF PAYETTE RIVER

Hoop #	Surface fines	# Free matrix	Total Dt of free matri
1	20 %	0	0 m/m2
2	10 %	0	0 m/m2
3	10 %	1	48 m/m2
4	10 %	0	0 m/m2
5	25 %	1	65 m/m2
6	30 %	0	0 m/m2
7	20 %	0	0 m/m2
8	70 %	0	0 m/m2
9	20 %	0	0 m/m2
10	40 %	1	68 m/m2
11	30 %	2	121 m/m2
12	10 %	7	667 m/m2
13	70 %	0	0 m/m2