MISSOURI DEPARTMENT OF NATURAL RESOURCES
DIVISION OF ENVIRONMENTAL QUALITY
ENVIRONMENTAL SERVICES PROGRAM
Standard Operating Procedure

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SOP TITLE: Estimation of Benthic Fine Sediment Coverage in Wadeable Streams

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SUMMARY OF REVISIONS: Minor grammatical changes.

APPLICABILITY: This SOP is applied by ESP personnel who perform fine sediment (<2.0 mm) coverage estimation studies in wadeable streams.

DISTRIBUTION: MDNR Intranet
SOP Coordinator

RECERTIFICATION RECORD:

Date Reviewed:				
Initials:				

1.0 SCOPE AND APPLICABILITY

The Environmental Protection Agency listed fine sediment deposition as the number one source for stream impairment (Clean Water Act, Section 303(d); EPA 2000). Fine sediments clog interstitial voids between the larger stream substrate particles and can have destructive effects on invertebrate and fish communities (Chutter 1969; Murphy et al. 1981; Berkman and Rabeni 1987; Smale et al. 1995). Zweig and Rabeni (2001) found that the presence and absence of certain aquatic invertebrate taxa was related to the amount of fine sediment visually observed on the stream substrate. This Standard Operating Procedure (SOP) outlines one method of visually estimating the aerial coverage of fine sediment on a stream bottom.

This SOP is designed to provide guidance for the Environmental Services Program personnel to consistently and accurately visually estimate the relative percentage of fine sediment coverage on the bottom. Data generated by using this SOP are subjected to statistical analyses that may identify significant differences ($P<0.05$) among stream reaches (stations) or streams. This procedure requires little time and equipment to perform.

This procedure may be enhanced by including characterization of fine sediment for heavy metals content in mine-related studies, or to identify organic and chemical constituents of the fine sediment. It may also be modified to include a quantitative (i.e., fine sediment depth x area) component.

2.0 SUMMARY OF METHOD

Virtual sample areas are developed and placed in specific locations to promote accuracy and consistency in estimating the relative percent coverage of benthic fine sediment. The sample area should be located between riffle and pool habitat zones with a velocity not exceeding 0.5 feet per second, and the depth should not exceed 2.5 feet. Fine sediments of less than 2.0 mm are expected to be deposited on the stream bottom when the velocity is within this range (Hjulstrom 1939). During base flow, fast flowing riffles are normally zones of transport or erosion, so analysts may not observe fine sediment. Conversely, sampling in slow moving pool habitats may lead to recording only fine sediment. This riffle to pool transitional area should provide dynamic, yet conservative, estimates of fine sediment coverage.

Two analysts visually estimate the percentage of fine sediment (<2.0 mm) coverage within these virtual sample areas or *grids* (Appendix A). The grid is composed of six contiguous *transects* that are oriented perpendicular to the stream bank. The estimations of fine sediment on the stream bottom are made within each one of these transects using a single metal square called a *quadrat* (Appendix A; Appendix B). Three grids are sampled per *station* for a dataset of 18 mean estimations per station or stream. These data are then statistically compared among stations or streams.

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3.0 DEFINITIONS AND ABBREVIATIONS

3.1 Definitions

- Grid – A virtual sample area composed of six contiguous transects (Appendix A).
- Quadrat – A metal square approximately 10”x 10” (0.25 square meter) that is used to outline the sample area where fine sediment is visually estimated (see dark gray squares in Appendix A and photograph in Appendix B).
- Station – A sample reach, as defined in the *Semi-quantitative Macroinvertebrate Stream Bioassessment Project Procedure* (SMSBPP, MDNR 2012). A station length is 20 times the average stream width that contains at least two riffle complexes.
- Transect – A virtual band, measuring 12” by “the grid width,” that crosses the stream perpendicular to the stream banks, and contains numerous potential quadrat locations (Appendix A).
- Useable Grid Width – The width of the grid where sampling will occur (see 7.1.5 and 7.2.2).

3.2 Abbreviations

- ANOVA – Analysis of Variance
- EPA – United States Environmental Protection Agency
- ESP – Environmental Services Program, Division of Environmental Quality
- fps – feet per second
- ft. – foot or feet
- GPS – Global Positioning System
- mm – millimeter
- SMSBPP – Semi-quantitative Macroinvertebrate Stream Bioassessment Project Procedure (MDNR 2012)
- SOP – Standard Operating Procedure

4.0 HEALTH AND SAFETY REQUIREMENTS

4.1 Personnel should wear waders and latex or rubber gloves for protection from potentially contaminated water.

4.2 Personnel should know how to swim.

4.3 Polarized sunglasses.

5.0 PERSONNEL QUALIFICATIONS

5.1 Personnel should be trained how to properly place grids and estimate the coverage of fine sediment particles by an experienced analyst.

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5.2 Personnel should have a general understanding of statistical methods in determining significant differences among stations or streams. Also, see 7.4 *Data Compilation and Analyses*.

6.0 SUPPLIES AND EQUIPMENT

6.1 Equipment needed to collect fine sediment data in the field:

- Fine sediment sampling datasheets (one per station; Appendix C)
- Clipboard and pencil
- 1–Quadrat approximately 10” x 10” square (250 mm; Appendix B)
- 100-foot fiberglass measuring tape
- 16’ x 1” metal retractable measuring tape (one per analyst)
- 2–Metal re-rods approximately 30” long
- Hammer
- Marsh-McBirney Flowmeter and top adjusting flow rod, or other type of flowmeter
- GPS Unit
- Waders
- Latex gloves

6.2 Software needed for data analyses and reporting:

- SigmaStat® (Version 3.5 or 2.0) or other statistical analysis program
- Microsoft Excel™ or other spreadsheet program for graphs (optional)

7.0 PROCEDURE

The procedure identifies where to place and how to develop virtual grids. It also includes how to collect and analyze the data. A grid is placed to allow for conservative estimates of benthic fine sediment using consistent velocity and depth parameters. The grid is developed as six contiguous virtual transects using only one fiberglass tape, a metal retractable tape, and a flowmeter. Samples are collected or estimated by two analysts in one quadrat per transect (for exceptions see 8.0 *Special Considerations*). Data are statistically analyzed.

7.1 Placement–The suitable location must have consistent velocity and generally unidirectional flow that excludes eddies, sharp bends, near-bank vegetation, downstream of logs, boulders, or other large obstructions.

7.1.1 Sampling should be conducted at base flow.

7.1.2 From upstream to downstream: grids are located downstream of riffles and upstream from pools. If necessary, the opposite can occur. To ensure sampling uniformity, use only one of the options on all stations or streams that will be compared. Record the description on the datasheet.

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7.1.3 Maximum flow velocity (during base flow) within a grid should not exceed 0.5 fps. Record the *velocity* on the datasheet (Appendix C). See Section 8.7 for exceptions.

7.1.4 The maximum depth within a grid should not exceed 2.5 feet. Record the maximum *depth* on the datasheet (Appendix C).

7.1.5 The sample grid should not include bank aquatic vegetation, logs, or large boulders that would create large eddies. The "useable grid width" does not have to reach from bank to bank.

7.1.6 At this point, record the *dominant substrate size* category of the substrate in the overall grid area. For example: bedrock, *br*; boulder, *b*l >256 mm; cobble, *cb* 256-64 mm; pebble, *pb* 64-16 mm; gravel, *gr* 16-2 mm; sand, *sn* 2-.063 mm; silt, *sl* <0.063 mm. (Modified Wentworth Scale in Cummins 1962; Minshall 1984).

7.2 Development–The (virtual) grid is composed of subunits called transects, each with numerous potential quadrat locations (see 3.0 *Definitions and Abbreviations*, Appendix A, and Appendix B). At the suitable location –

7.2.1 Anchor a 100' fiberglass tape measure across the stream above the surface of the water. This is the downstream extent of the grid (See 8.4 *Special Considerations*).

7.2.2 Record the useable grid width, for example between 0 and 20 ft., as measured on the fiberglass tape. Record the range on the datasheet in the *width* box.

7.2.3 Using a random number sheet, select the first number that falls within the useable grid width (e.g., 1–20). The random number equates to the number of feet from the edge of the useable grid where the quadrat will be placed (see 7.3 *Sample Collection*).

7.2.4 Record the random number on the datasheet (Appendix C) in Transect 1 *Random Number* box.

7.2.5 Select a new random number for each of the six transects and record these numbers in all six transect *random number* boxes.

7.2.6 Record GPS (UTM) *location* and *description* of the grid on the datasheet.

7.3 Sample Collection–The sample observations are estimates of percent fine sediment covering the stream bottom within the quadrat; the quadrat will be moved to each transect and placed on the stream bottom at the succeeding random numbers. For exceptions, see 8.0 *Special Considerations*.

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7.3.1 While standing downstream of the fiberglass tape and facing upstream, find the transect 1 quadrat location by using the random number that equates to the measurement on the fiberglass tape.

7.3.2 Align the quadrat on the upstream edge of the fiberglass tape and place the quadrat on the stream bottom to the left of the random number.

7.3.3. Two analysts independently estimate the percentage of the fine sediment size particles within the quadrat (<2.0 mm, or approximately 1/16"; Modified Wentworth Scale in Cummins 1962; Minshall 1984). If the estimates are within ten percent of each other, record the two percentages in the *Estimates* box on the datasheet. If estimates are more than ten percent apart, the analysts must repeat the estimation process until they are within a ten percent range.

7.3.4 A description of the dominant class of fine sediment (sand/silt) may be recorded for each quadrat in the *Dominant Class Sediment* box on the datasheet.

7.3.5 Comments may also be made for each quadrat or grid regarding the depth of the sediment, organic versus inorganic, etc.

7.3.6 To construct transect 2, find the random number for transect 2 on the fiberglass tape and hold the metal retractable tape at 12" perpendicular to that number. Place the quadrat on the stream bottom at the end and to the left of the retractable tape.

7.3.7 Repeat the sample collection for transects 3–6, increasing the distance from the fiberglass tape by 12" for each transect/quadrat. Total grid will be 70" from downstream to upstream.

7.3.8 When all six transects in a grid have been sampled, locate another riffle/pool sample area within the station, and repeat steps 7.1–7.3 to place, develop, and sample another grid. Three virtual grids should be sampled within each station. See 8.0 *Special Considerations* for exceptions.

7.4 Data Compilation and Analyses–The mean of estimates for each quadrat are used in the statistical comparisons, such as among stations, grids, or dominant class sediment. One-Way ANOVA or ANOVA on Ranks (if preferred, or the percentages are not normally distributed) is used to identify if there is a significant difference in the comparisons. All pairwise or control multiple comparison procedures, such as Holm-Sidak, Tukey's, or Dunn's tests, may be used to identify the location significant differences ($P<0.05$) among stations or streams.

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7.4.1 Calculate the mean of estimates for each quadrat:

$$mean = \frac{Estimate\ 1 + Estimate\ 2}{2}$$

7.4.2 Record the mean for each transect/quadrat on datasheet in the *Mean* box.

7.4.3 In a SigmaStat® 3.5 Worksheet: Enter the station number in one column and the corresponding grid number, dominant class sediment, and fine sediment data (i.e. mean of each quadrat) in adjacent columns (see example in Appendix D).

7.4.4 Start SigmaStat® 3.5 (2006) and select: *Statistics – Compare Many Groups–Oneway ANOVA (or ANOVA on Ranks, if desired)*

7.4.5 Select *Indexed* then *Next*. For "Group", highlight the "Station" column. For the "Data" column, highlight the "fine sediment data" column and select the *Finish* button.

7.4.6 If a significant difference (P<0.05) is found among stations, follow instructions to select a means comparison (or other comparison procedure) that will identify which stations (grids or dominant class sediment) are different from each other. Save the report or copy and paste into your report.

7.4.7 Graphs can be made in SigmaStat® 3.5 or data worksheet may be exported to MS Excel for graphing.

7.4.8 One-way ANOVA may be conducted to identify differences *within* each station using the grid number as the group and fine sediment data.

7.4.9 Two-way ANOVA may be conducted with Factor A = "Station," Factor B = "Dom. Class Sed," and Data = "fine sediment data" to determine if the size of the sediment was distributed in particular areas and had an effect on the differences among stations (Appendix D).

7.5 Reporting–All data observations are usually recorded on a table, grouped by grid and transect (*y–axis*) for each station or stream (*x–axis*). The mean, standard deviation and p-value (if used, illustrating significant differences with controls) are shown for each station. Data may also be graphed to illustrate changes in relative coverage among stations or streams. Data should not be represented as a quantity or amount per area. They are relative estimates of coverage.

8.0 SPECIAL CONSIDERATIONS

8.1 This procedure should only be used in wadeable streams that are riffle/pool dominant streams, as defined in the SMSBPP (MDNR 2012). Riffle/pool dominant streams are usually Ozark streams that have a characteristic rock

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substrate, as opposed to the typical clay, mud, or sand substrates found in prairie streams. This method may not be applicable to sediment concerns in glide/pool dominant streams of northern and western Missouri.

8.2 If the useable grid width is greater than 75 feet, estimates should be collected in two quadrats per transect. Record the second quadrat in the grid's optional Transect (A) section of the datasheet.

8.3 If three riffles are not present within a station, sample two quadrats per transect and count them as separate samples.

8.4 Suspended fine sediment can temporarily decrease visibility. Analysts should stand and walk downstream of the grid to avoid disturbing the fine sediment within the grid. Allow fine sediment to settle after placing quadrat on bottom.

8.5 Avoid sampling when excessive periphyton, aquatic plant growth, or tree leaves are present on the stream bottom, which may obstruct visual observations.

8.6 Glare from the sun on the surface of the water can make visual observations difficult. Polarized sunglasses or another object used to shade the area (clipboard) can be used to decrease the glare.

8.7 If the stream is very large and a velocity of <0.5 fps is not available at a wadeable depth, the acceptable velocity may be as high as 1.5 fps.

9.0 QUALITY ASSURANCE/QUALITY CONTROL

9.1 Independent observations by two analysts decrease potential for bias and increase accuracy.

9.2 The estimates recorded by two analysts must be within ten percent of each other, which promotes consistency between observations.

10.0 REFERENCES

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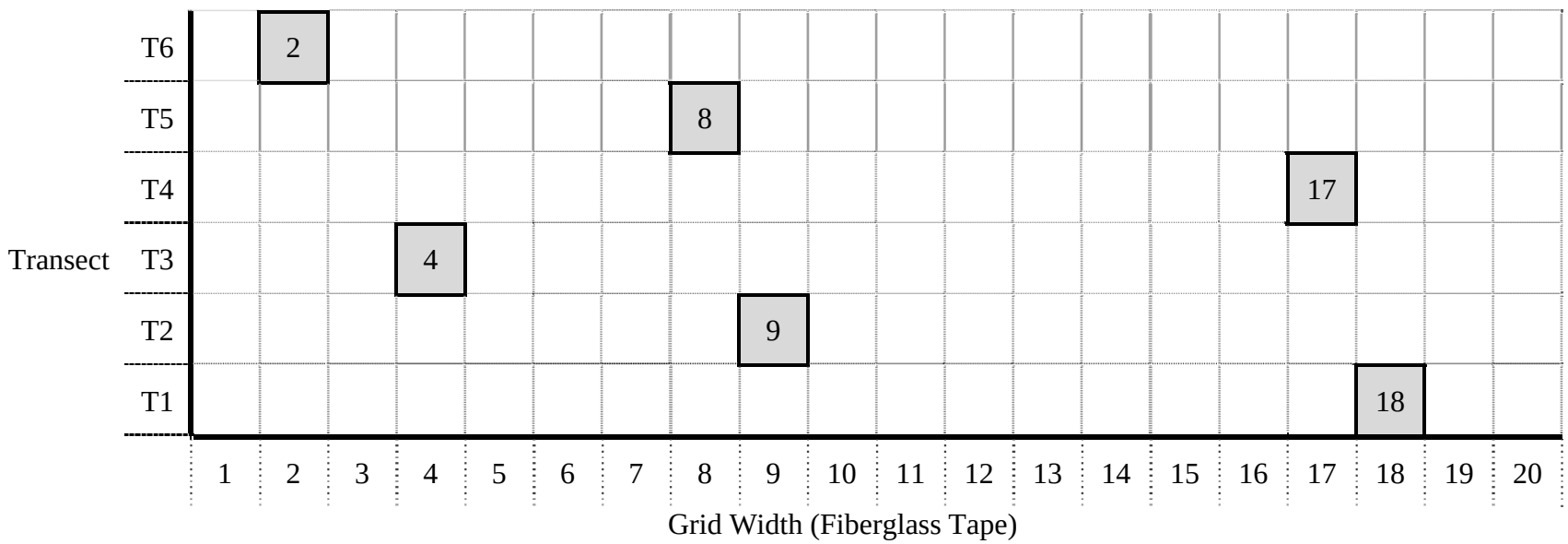
Appendix A:

Virtual grid is comprised of six transects (T1-T6) each with numerous potential quadrat locations. In this example: grid width is 20' and quadrat (see Appendix B) is placed by selecting a random number for each transect (e.g., 18, 9, 4, 17, 8, 2)

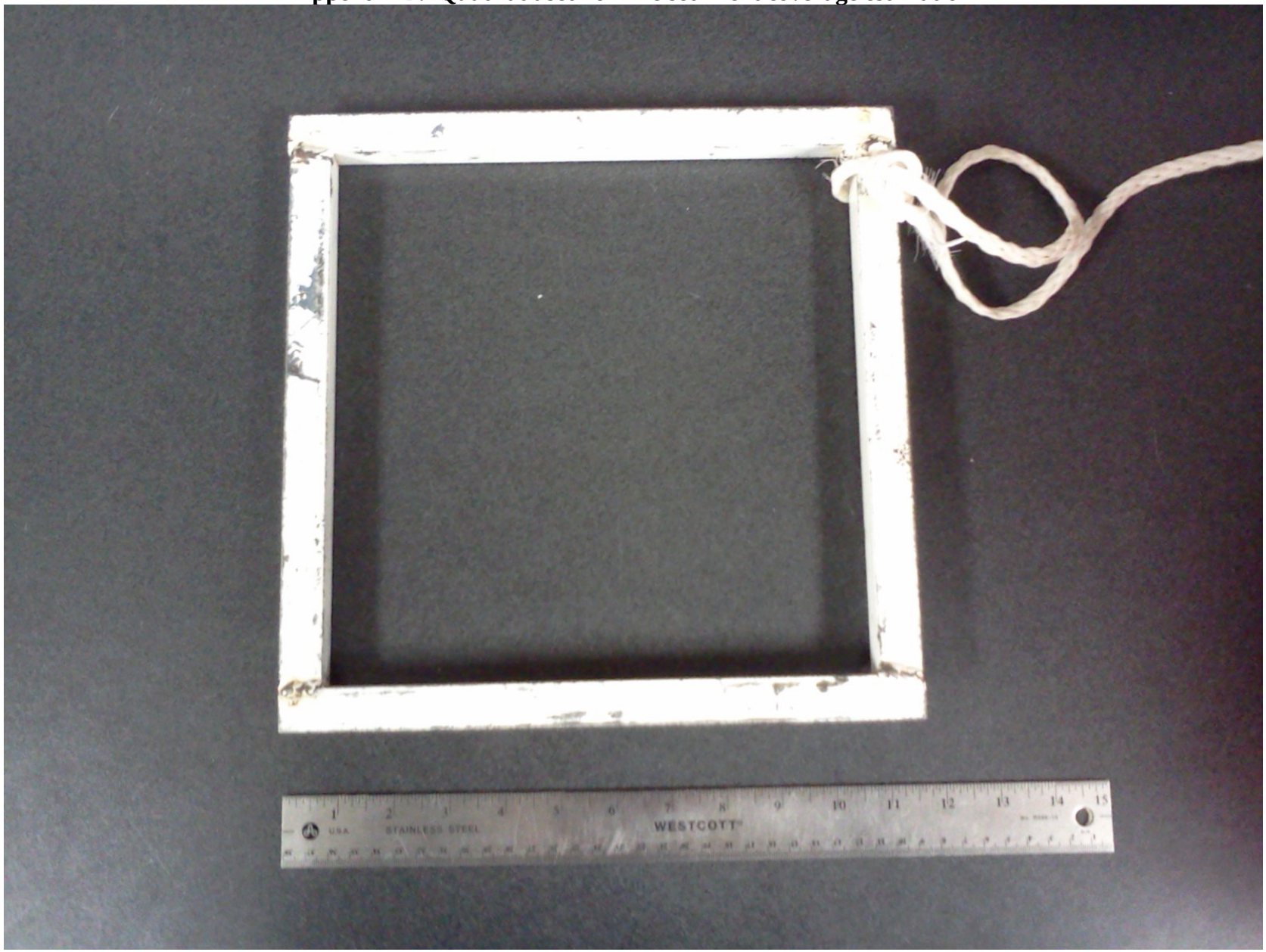
RIFFLE (upstream)

Flow↓



POOL (downstream)

Appendix B: Quadrat used for fine sediment coverage estimation



Appendix C: Datasheet

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FINE SEDIMENT PERCENT COVERAGE ESTIMATION

Stream:	Station:	County:	Date
Description:			Analyst 1:
			Analyst 2:

Grid 1						
Location: WPT #	*EPE:*		*E*		*N*	
Description:						
Velocity:	*Depth:*	*Width:*		*Dominant Substrate Size: br,bl,cb,pb,gr,sn,sl*		
TRANSECT	1	2	3	4	5	6
Random Number (quad)						
Estimates (Percentage)						
Mean						
Dom. Class Sed. (circle)	Sand/silt	Sand/silt	Sand/silt	Sand/silt	Sand/silt	Sand/silt
TRANSECT (optional)	1A	2A	3A	4A	5A	6A
Random Number (quad)						
Estimates (Percentage)						
Mean						
Dom. Class Sed. (circle)	Sand/silt	Sand/silt	Sand/silt	Sand/silt	Sand/silt	Sand/silt

COMMENTS:

Appendix C continued (Page 2 of 2)

Grid 2						
Location: WPT #	*EPE:*		*E*		*N*	
Description:						
Velocity:	*Depth:*		*Width:*		*Dominant Substrate Size: br,bl,cb,pb,gr,sn,sl*	
TRANSECT	1	2	3	4	5	6
Random Number (quad)						
Estimates (Percentage)						
Mean						
Dom. Class Sed. (circle)	Sand/silt	Sand/silt	Sand/silt	Sand/silt	Sand/silt	Sand/silt
TRANSECT (optional)	1A	2A	3A	4A	5A	6A
Random Number (quad)						
Estimates (Percentage)						
Mean						
Dom. Class Sed. (circle)	Sand/silt	Sand/silt	Sand/silt	Sand/silt	Sand/silt	Sand/silt

COMMENTS:

Grid 3						
Location: WPT #	*EPE:*		*E*		*N*	
Description:						
Velocity:	*Depth:*		*Width:*		*Dominant Substrate Size: br,bl,cb,pb,gr,sn,sl*	
TRANSECT	1	2	3	4	5	6
Random Number (quad)						
Estimates (Percentage)						
Mean						
Dom. Class Sed. (circle)	Sand/silt	Sand/silt	Sand/silt	Sand/silt	Sand/silt	Sand/silt
TRANSECT (optional)	1A	2A	3A	4A	5A	6A
Random Number (quad)						
Estimates (Percentage)						
Mean						
Dom. Class Sed. (circle)	Sand/silt	Sand/silt	Sand/silt	Sand/silt	Sand/silt	Sand/silt

COMMENTS:

Appendix D:

Example–SigmaStat® 3.5 Worksheet (Indexed Data); n=18 per station

Station	Grid	Dominant Class Sediment	Fine Sediment Mean Percentage Estimate
1	1	sand	55
1	1	silt	25
1	1	silt	17
1	1	sand	12
1	1	sand	4
1	1	silt	13
1	2	sand	2
1	2	silt	1
1	2	silt	77
1	2	sand	16
1	2	silt	12
1	2	sand	10
1	3	sand	72
1	3	sand	43
1	3	silt	59
1	3	silt	19
1	3	sand	44
1	3	silt	13
2	1	sand	14
2	1	silt	28
2	1	silt	15
2	1	sand	72
2	1	silt	77
2	1	silt	69
2	2	sand	55
2	2	sand	80
2	2	sand	22
2	2	sand	16
2	2	sand	99
2	2	silt	27
2	3	sand	5
2	3	silt	17
2	3	silt	25
2	3	sand	6
2	3	silt	4
2	3	sand	83
Continue for each station	Continue for all grids	Continue for all quadrats	Continue for all means