STANDARD OPERATING PROCEDURE FOR DIPPING BAR STREAM FLOW VELOCITY MEASUREMENTS

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Revision Page

Date	Rev#	Summary of Changes	Sections
	1	Initial Approval	

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1.0 Scope & Application:

This SOP applies to measuring stream flow velocities by use of a dipping bar. The dipping bar method is applicable for streams with depths of less than 60 centimeters (cm), and maximum flow velocities of 1.5 meters per second (m/s).

2.0 Summary of Method:

The dipping bar method measures stream velocity based on the principle of torque balance. As the measuring section of the bar is placed in the stream, water pushes against it causing the bar to rotate. A weighted bar at the top of the instrument is adjusted to counter the force, bringing the measuring rod back to a vertical position. The value read from the divisions on the weight bar is recorded along with the immersion depth of the measuring rod. A velocity value can then be calculated utilizing a slide rule, programmed calculator, or computer spreadsheet. The shape and design of the dipping bar is such that the value calculated from the measurements is an average velocity of the vertical column of water measured. If a series of these measurements are taken along a cross-section of stream a discharge value can be determined.

3.0 Definitions:

Discharge: Volume per unit time, units include liter/sec, cubic feet/sec, cubic meter/sec.

Velocity: Distance per unit time, units include cm/sec, ft/sec.

4.0 Health and Safety Considerations:

4.1 When working with potentially hazardous materials or situations, follow EPA, OSHA, and specific health or safety procedures.

4.2 All proper personal protection clothing and equipment is to be worn.

5.0 Equipment and Supplies:

5.1 Dipping Bar Equipment Box, containing:
- 5.1.1 Measuring rod
- 5.1.2 Weight rod
- 5.1.3 Body of dipping bar
- 5.1.4 Handle

5.0 Equipment and Supplies (cont'd):

5.1.5 Slide Rule
5.1.6 Calculator
5.1.7 Dipping Bar Instruction Manual
5.1.8 Calculator Instruction Manual

5.2 Miscellaneous Equipment

5.2.1 Waders
5.2.2 Measuring tape with centimeter divisions, attached to metal stake, with clamp on end of measuring tape.
5.2.3 2 each 3-foot long wooden or metal stakes
5.2.4 Sledge Hammer
5.2.5 Pencils/Pens
5.2.6 Field Notebook
5.2.7 Stream Discharge Worksheets (optional, example given in section 8.0)
5.2.8 Clipboard (optional)
5.2.9 Laptop computer with discharge calculation program (optional, program discussed in section 9.0)

6.0 Preparation for Measurement

6.1 Stream Cross-Section Set-up

6.1.1 Establish stream cross-section location. Desirable characteristics for site location include:
6.1.1.1 A Straight section of stream, away from stream bends.
6.1.1.2 Stream flow approximately parallel to stream banks.
6.1.1.3 Regular stream cross-sectional depth profile (shallow at edges, deep in middle).
6.1.1.4 Constant stream gradient.
6.1.1.5 No obstacles protruding water surface (i.e stones, plants, bridge piers)

6.1.2 Drive stake attached to measuring tape into one of the stream banks. Position a second stake on the opposite bank, such that a line intersecting the two stakes will be perpendicular to the flow of the stream. Drive second stake into ground.

6.1.3 Stretch measuring tape across stream tape and attach to stake using clamp. Make sure the tape is tightly stretched across the stream.

6.1.4 Walk along tape section to check to make sure the tape is perpendicular to stream flow. Do this by looking down at tape and observing objects (sand particles) BELOW the water surface, flowing past the tape. The objects should intersect the tape at right angles. **Note:** *Do not use objects on the surface to judge the intersection angle of the flow, as surface flow is affected by wind and other forces, and will not indicate true stream flow direction.*

6.2 Dipping Bar Assembly

To aid in assembly of dipping bar, **figure 1** is provided. Numbers in parenthesis correspond to part numbers in figure 1.

6.2.1 Screw the measuring bar (1) into the body of the device (3).

6.2.2 Pull back locking ring (5) on the handle and fix it in place by turning it counter-clockwise.

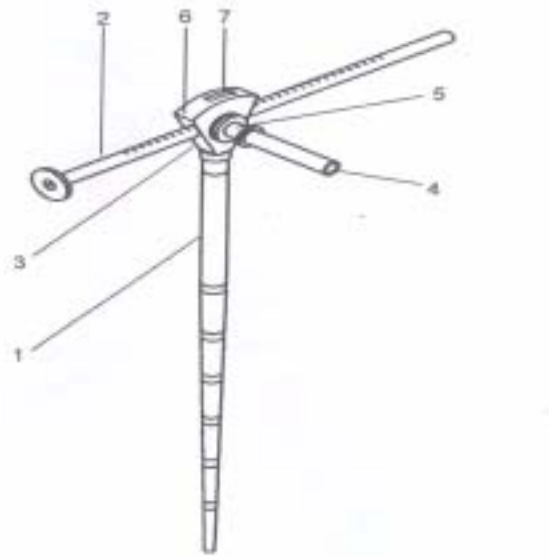

Figure 1

6.2.3 Determine which way the individual using the dipping bar will be facing when taking measurements, keeping in mind that his/her shoulders will be parallel to the direction of flow, directly facing either of the stream banks. Observe the direction of flow. If the flow is moving from the measuring person's **right to left**, then insert the handle (4) into the body of the device from the side marked

"TAUCHSTAB nach JENS" and secure it on the opposite side by means of the sliding toggle. If the flow is moving from **left to right**, then insert the handle (4) into the body of the device from the side marked "DIPPING BAR acc.to JENS", securing it to the other side by means of the sliding toggle.

6.2.4 Insert the weight bar (2) into to the device from the side with the reading edge (6) (notched edge). Hold the device firmly at the measuring bar so that the handle (4) can freely rotate when the weight bar is pushed through.

To check assembly, hold the dipping bar by the handle so that it swings freely. Turn the handle, moving the weighted bar and bringing the scale value to "0" at the reading edge. The leveling bubble (7) should indicate that the measuring bar is now perpendicular with respect to the stream bottom.

7.0 Taking and Recording a Measurement

7.1 Create a table with columns for measurement number, measuring tape value, width, immersion depth, scale value, and velocity. A recommended format for the table is provided in figure 2.

7.2 Determine the measuring tape value at one edge of the stream, enter that value into the tape value column in measurement number 1 row (figure 2). Since there is no water at the edge of the stream no flow reading will be taken, enter 0 into the remaining columns.

7.3 Determine where the next flow measurement will be taken and note the corresponding tape value. Little or no flow often occurs at the edges of a stream, therefore the second measurement should be taken where there will be enough stream flow to deflect the dipping bar.

7.4 When measuring, stand on the downstream side of the tape measure with shoulders parallel to the direction of stream flow. Hold the dipping bar in one hand, making sure that the weighted end of the bar is on the downstream side.

7.5 Immerse the measuring bar into the stream until the tip is touching the stream bed. Raise the measuring bar up slightly until the measuring bar swings freely. The handle of the unit should be perpendicular to the direction flow.

Dipping Bar acc. Jens Field Worksheet

Stream Name _____ **Samplers** _____

Date _____

Measurement Number	Tape Value (cm)	Width (cm)	Immersion Depth (cm)	Scale	Velocity (cm/sec)
1					
2					
3					
4					
5					
6					
7					
8					
9					
10					
11					
12					
13					
14					
15					
16					
17					
18					
19					
20					
21					
22					
23					
24					
25					

Weather:

Notes:

Figure 2: Recommended format for Field Worksheet for use with Dipping Bar. (This table can be found electronically in G:\ALLSHARE\SAMPLING_SOP\DippingBarCalc.xls).

7.6 Turn the handle of the unit until the leveling bubble indicates that the measuring bar is in the perpendicular. Turn the locking ring on handle (without turning the handle) and lock weight bar in place.

7.7 Record the immersion level of the water on the measuring bar (values are in centimeters). In fast flowing waters the water level on the upstream side of the measuring bar will be higher than the downstream side water level. Use the midpoint between these two water levels to determine the immersion depth.

7.8 Record the scale value of the weight bar along the reading edge.

7.9 Repeat steps 7.3 to 7.8 for subsequent points along the tape measure. The intervals between points on the tape measure need not be regular, but the closer the measurements the more accurate they will be with a minimum distance of ten centimeters. In sections where flow velocity is changing rapidly, intervals between measuring points should be small to capture the changes in velocity.

7.10 When measurements are complete, record the tape distance on the far edge of the stream. The stream edge depth and scale values should both be recorded as zero.

8.0 Storage and Care of Dipping Bar

After use, the dipping bar components should be disassembled and dried prior to placing them back into their proper positions within the storage box. If used, the calculator and slide rule should be place back in the box as well.

9.0 Calculation of Velocity and Discharge

This section describes three methods for determining velocity and discharge by use of a pre-programmed calculator, a computer spreadsheet, or a slide rule.

9.1 Programmed Calculator Method

The program used by the calculator determines the average velocity at the measuring point, and the total discharge of the stream cross-sectional area. The programmed calculator is provided with the dipping bar.

9.1.1 Determine the width between each measurement taken, as well as the overall

width of the stream section. These units should be in centimeters and are usually in increments of ten or fifty centimeters, or one meter.

9.1.2 Switch the calculator on. Press the FILE, the screen will show ABFLUSS F1. Press EXE, the screen will then show BREITE (CM)? 0.

9.1.3 Enter the width of the first measurement taken in centimeters. Do not enter 0 as the first value as the program automatically includes this. Press the EXE button.

9.1.4 The next screen will show TIEFE (cm) ? 0. Enter the depth of the first measurement point taken in centimeters. Press the EXE button.

9.1.5 The next screen will show SKALA ? 0. Enter the scale value from the weight bar for the first measurement point. Press the EXE button.

9.1.6 The next screen will show the average flow velocity in cm/s at the measuring point. This value will be saved by the calculator for determining discharge, however, ***it is recommended that this value be written down.*** Press EXE.

9.1.7 Repeat steps 9.1.3 thru 9.1.6.

9.1.8 After the last entry of width, you will then enter a depth of 0 and press EXE. This will conclude the calculation. The next screen will show the discharge of the stream cross section in cubic meters per second.

The details of the program are provided in the manual accompanying the dipping bar.

9.2 Computer Spreadsheet Method

A simple Excel Spreadsheet has been created to determine average velocity and the discharge in the cross-sectional area of the stream Figure 3. The spreadsheet uses the same equations as those used in the programmed calculator method. The worksheet used to calculate velocity and discharge along with an example of the spreadsheet output, can be found in:
G:\ALLSHARE\SAMPLING_SOP\DippingBarCalc.xls.

Velocity and Discharge Calculation using Dipping Bar acc. Jens

Stream Name _____ **Samplers** _____

Date _____

Tape Value (cm)	Width (cm)	Immersion Depth (cm)	Scale	Velocity (cm/sec)	Discharge cm^3/sec
0	0	0	0	0	0.00
50	50	10	7	44.11	22054.20
100	50	15	10	100.00	50.00
150	50	15	12	47.15	35365.40
200	50	20	14	44.11	44108.40
250	50	25	21	48.32	60397.91
300	50	30	26	49.08	73618.94
350	50	20	19	51.38	51384.73
400	50	10	5	37.28	18639.20
450	50	5	3	40.84	10209.11
500	50	0	0	0	0.00

Discharge: 0.316 m^3/sec

Weather:

Notes:

Figure 3: Example format for spreadsheet for calculating velocity and discharge.

9.3 Slide Rule Method

If either a calculator or computer are not available, average flow velocities at each measuring point can be determined, with reduced accuracy, by using the slide rule accompanying the dipping bar. The following describes the steps for using the slide rule

9.3.1 Determine the immersion depth at the measuring point. If the depth is between 5 and 34 cm, use the side of the slide rule marked "TAUCHSTAB nach JENS", if depth is greater than 35 cm use the side of the slide rule marked "DIPPING BAR acc.to JENS"

9.3.2 Rotate slide until line in bottom window corresponds to scale value for the measuring point.

9.3.3 The corresponding depth determines which window on the slide will be used. For values in between those on the slide rule, round up.

9.3.4 The average velocity in centimeters per second is the value which the line on the slide crosses in the corresponding depth window. Record this value.

9.3.5 To determine discharge for the measurement interval, multiply the measurement interval by the depth of the measuring point and the average velocity. Record this value.

9.3.6 Repeat steps 8.3.1 through 8.3.5 for each measuring point.

9.3.7 Total discharge for the cross-section is determined by summing the discharges in each of the measurement intervals.

10.0 Reference:

10.1 Operation Manual for DIPPING BAR acc. to JENS, 1997, Hydro-Bios, Kiel-Holtenau, Germany, 14pp.