OKLAHOMA CONSERVATION COMMISSION
WATER QUALITY DIVISION

STANDARD OPERATING PROCEDURE

FLOW MEASUREMENT
(SEMI-SUBMERGIBLE OBJECT METHOD)

1.0 PROCEDURAL SECTION

1.1 Scope and Application

Flow affects everything from the concentration of various substances in the water to the distribution of habitats and organisms throughout the stream. Many of the collections and procedures require a measurement of flow.

1.2 Summary of Method[10]

This procedure describes a way to calculate flow without using a flow meter. **Flow = volume / time**. In most cases it is impossible to measure the volume of water in a stream directly. Since volume is a product of length and cross sectional area, **flow = (length x cross sectional area) / time**, and since velocity is a measure of length (or distance) / time, **flow = velocity x cross sectional area**. To calculate flow, the velocity of the water and the cross sectional area of the stream's channel will be measured.

1.2.1 Definitions[1]

- Discharge: The volume of water moving past a point in a unit of time
- Float: Item used to measure the amount of time to travel a known distance
- Flow: The volume of water that passes a point in the stream in a unit of time: **flow = volume / time**
- Velocity: Speed of water moving past a given point: **velocity = length (distance) / time**
- Volume: Amount of water in the stream: **volume = length x cross sectional area**

1.3 Health and Safety Warnings

- Avoid deep or swift water without proper safety devices (e.g. personal flotation devices, etc).

1.4 Cautions

- Flow should not be measured by wading in the stream if the velocity is high or the stage is deep. Wearing waders can be dangerous in the event they fill with water. Common sense should prevail.
- When possible use a float that will be partially submerged in the water. It will give a more accurate indication of the velocity of the water and will be less subject to wind resistance.
- Choose a straight section of stream free of turbulence, eddies, slack backwater areas, and obstacles like boulders and woody debris.
- In shallow water a smaller float may be necessary.

1.5 Interference

- Obstacles that catch the float
- Wind that blows the float on top of the water
- Eddies and backwater areas where the flow is not consistent

1.6 Personnel Qualification

Field personnel must be trained and evaluated on flow measurement technique. Flow measurement is subject to approval by the QA Officer and/or the Environmental Monitoring Coordinator. Training will be done through dry run exercises in the field to familiarize field personnel with procedures and techniques. Blue Thumb volunteers will have a staff member present when measuring flow.

1.7 Apparatus & Materials

- Pencils
- Clipboard
- Flow Measurement Data Sheet
- Tape measure
- Visible float (orange, floating key chain, tennis ball, rubber ducky, etc.)
- Stopwatch
- Calculator
- Improvised stadia rod marked in 0.1 of feet

[10] Text taken directly or in part from The Streamkeeper's Field Guide, 1996.

1.8 Instrument/Method Calibration

Not applicable

1.9 Preparation

1.9.1 Improvised Stadia Rod

Use a 2 meter section of PVC pipe or a wooden dowel or metal rod (such as rebar). Mark 0.1 foot intervals, with major divisions at each 0.5 and 1.0 foot mark. This rod can be used to read depth measurements in feet and tenths of feet at the same time.

1.9.2 Float

Use an orange peel, a water soaked block of wood or other natural material that sinks at least half way, is visible from shore, will not be moved by wind, is expendable and non polluting (e.g. not ping pong balls and plastic jugs) (USDA Forrest Service general technical report RM-45) unless the float is readily and routinely retrievable.

1.9.3 Site Data

You will need the official site name, the WBID #, and the legal location.

1.10 Measurement

1.10.1 Velocity

- Choose a section of run that is as straight and uniform in width as possible and is free of turbulence, eddies, slack backwater areas, and obstacles like boulders and woody debris. The section should be shallow enough to wade across safely. In general, the length of the section should be about three times the width; however, do not sacrifice the other conditions if this is not possible. A ten foot or even shorter distance will work.
- Mark the start and finish lines in some manner. Measure the length (distance) of the stream section you have chosen. Record this distance on the data sheet.
- Person #1 wades in the stream above the upstream starting line with the float in hand. Person #2 wades in the stream below the downstream finish line. Person #3, if available, stands on the bank next to the finish line, stopwatch and clipboard in hand. If there are only 2 people, the one at the finish line holds the stopwatch.
- Person #1 drops the float on the surface, upstream from the starting line. As the float passes the starting line, person #1 signals, “Go!” and person #2 starts the stopwatch. (It is more accurate to start the float this way than trying to drop it exactly at the starting line.)
- When the float crosses the finish line, person #2 signals, “Stop!” or stops the stopwatch, catches the float, and records the time in seconds that it took the float to travel the measured distance.
- Discard any trials in which the float gets caught in debris, rocks, or eddies.
- Because the velocity of the water varies across the width of the stream, repeat this process several times, sending the float down different flow paths. Starting at one side of the stream, send the float down progressively farther from the bank, at one or two foot intervals until you reach the other side. This way you will be able to sample the full range of velocities that occur across the width of the stream.

1.10.2 Cross Sectional Area

- Stretch a tape measure across the stream at the starting point of the velocity float trials. The tape measure should be perpendicular to stream flow and just above the surface of the water. The first person holds the “0” point on the tape measure even with one wetted edge of the stream. A second person on the opposite bank holds the tape measure level, taut, and even with the other edge. Someone is prepared to record information on the data sheet.
- Another person, measuring rod in hand, starts six inches from the wetted edge and moves along the tape measure at one- foot intervals. The rod is used to measure the depth of the water (distance from the water surface to the stream bottom) at the mid-point of each one-foot interval. (The first and last measurements are made six inches from the edges.) The in-stream person calls out these measurements to the person on the bank who records them on the data sheet. Note: if the stream is wider than 20 feet, measure depths at two-foot intervals and start and end 1-foot from the bank.
- If measured at one-foot intervals, each depth is roughly equivalent to the area of a one-foot-wide section of the stream. The sum of these areas (or depths) is the total cross-sectional area of the stream at the point measured. The mid-point

depth is used because it is a better approximation of the area of the one-foot-wide section than the depth at the beginning or end of the section.
- Repeat steps 1-3 at the mid-point between the start and finish lines (Cross Section 2) and at the finish line (Cross Section 3.)
- Calculate the flow using the instructions on the data sheet and in Section 1.14 of this document.

1.11 Sample Handling & Preservation
Not applicable

1.12 Sample Preparation and Analysis
Not applicable

1.13 Troubleshooting
Consult with the QA Officer or the Environmental Monitoring Coordinator

1.14 Data Acquisition, Calculation & Data Reduction

1.14.1 Average Surface Velocity
- Average the time (in seconds) in the Velocity Float Trials.
- Divide the distance between the start and finish lines (in feet) by the average time.
- Record this number as the average surface velocity.

1.14.2 Cross Sectional Area
- Sum the depth measurements (in feet) for each cross section.
- Average the sums for the three cross sections.
- Multiply the average cross sectional area by the interval between depth measurements. (Did you measure depth every one foot? Did you measure every two feet?)

1.14.3 Corrected Surface Velocity
- Multiply the Average Surface Velocity by 0.85.

1.14.4 Flow Calculation
- Multiply the Corrected Surface Velocity by the Average Cross Sectional Area. The results will be in cubic feet per second (CFS).

1.15 Computer Hardware & Software
Not applicable

1.16 Data Management & Records Management

1.16.1 Field Notation
Data should be recorded following procedures outlined in the **Procedure for Completing Field Data Sheets SOP**. If the Data is going to be submitted to OCC-Water Quality, a **Site Collection Sheet** must be completed with the final flow value reported in CFS.

1.16.2 Timed Flow Measurement Data Sheet
All measurements should be recorded on the **Timed Flow Measurement Data Sheet** (see **SOP Appendix: Data Sheets**).

The following bullets will describe how the sheet should be filled out:

SITE INFORMATION

- SITE NAME: Record the stream name from the USGS 7-1/2' map name. If a county map, soil map, or other map has a different name, the USGS 7-1/2' map takes precedence.

If a stream is unnamed on the USGS map, but named on another map, use that name, but write the name of the map in parentheses beside the stream name.

- WBID #: Record the Water Body Identification number.
- LEAD INVESTIGATOR: The person responsible for data custody and reporting.
- DATE: Record the site date in MM/DD/YR format.
- TIME: Record the site time in military format. The "site time" is when initial activities began at the site. The site time should be the same on all forms associated with this site.

SURFACE VELOCITY (refer to section 1.14.1)

CROSS SECTIONAL AREA (refer to section 1.14.2)

CORRECTED SURFACE VELOCITY (refer to section 1.14.3)

COMMENTS

1.16.3 Chain-of-Custody Procedure

Not applicable

2.0 QA/QC SECTION

2.1 Training

Training will be done through dry run exercises in the field to familiarize field personnel with procedures and techniques. All operators are required to become familiar with the SOP document. Prior to solo flow measurement, field personnel are evaluated in a field setting for proper use of equipment and flow measurement protocol. Annual field audits are performed on flow measurers following procedures outlined in the Quality Management Plan.

2.2 Maintenance

Not applicable

2.3 QC Procedures

If the float is delayed or stopped by an eddy or snag more than once, then the site selected is inappropriate; identify a new measurement location.

Field personnel will be checked annually by measuring flow using this method, immediately followed by measuring flow using a flow meter at the same location.

3.0 REFERENCES

Murdoch, Tom and Martha Cheo, (1996) The Streamkeeper's Field Guide: Watershed Inventory and Stream Monitoring Methods, The Adopt-A-Stream Foundation, Everett, WA.

USDA Forrest Service general technical report RM-45

4.0 APPENDIX A

STANDARD OPERATING PROCEDURE
Field Summary

Flow Measurement Using a Semi-Submergible Object

Preparation
Prepare a rod to make depth measurements. Gather possible floats of an assortment of sizes and densities including a fresh piece of citrus fruit.

Equipment
- Pencils
- Clipboard
- Flow Measurement Data Sheet
- Tape measure
- Visible floats (orange, floating key chain, tennis ball, rubber ducky, etc.)
- Stopwatch
- Depth measurement rod
- Calculator

Flow Measurement
1. Choose an appropriate run three times as long as it is wide.
2. Mark a "Start" line and a "Finish" line on the bank and measure the distance between them. Record the distance.
3. Choose an appropriate float for the conditions.
4. Drop the float into the water above the start line. Start timing (in seconds) the float when it crosses the "Start" line. Stop timing the float when it crosses the "Finish" line. Retrieve the float. Record the time.
5. Discard any trials in which the float gets caught in debris, rocks, or eddies.
6. Repeat this process sending the float down different flow paths across the width of the stream.

Cross Sectional Area
1. Stretch a measuring tape across the "Start" line. The tape should be perpendicular to the stream flow and just above the surface of the water.
2. Starting six inches from the edge of the stream, measure the depth (in feet) of the water at one-foot intervals. If the stream is wider than 20 feet, measure at two-foot intervals. Record these depths on the data sheet.
3. Repeat this process at the mid-point between the "Start" and "Finish" lines.
4. Repeat this process at the "Finish" line.

Calculations
1. Average the times (sec).
2. Divide the distance between the start and finish lines (ft) by average time (sec) to get average surface velocity (ft/sec).
3. Sum the depth measurements (ft) for each cross section.
4. Average the sums (ft).
5. Multiply average cross sectional sum by the interval between depth measurements to get average cross sectional area. (Did you measure depth every one foot? Did you measure every two feet?)
6. Multiply the average surface velocity by 0.8 to get corrected surface velocity.
7. Multiply corrected surface velocity by the average cross sectional area to get flow (cubic feet per second).

Field Notation
All measurements made at each site should be recorded on the **Timed Flow Measurement Data Sheet**. Data should be recorded following procedures outlined in the Procedure for Completing Field Forms SOP. If the Data is going to be submitted to OCC-Water Quality, a **Site Collection Sheet** must be filled-out with the final flow value reported in CFS.

Timed Flow Measurement Data Sheet:

SITE INFORMATION

- SITE NAME: Use the USGS 7-1/2’ map name. If a county map, soil map, or other map has a different name, the USGS 7-1/2' map takes precedence. If a stream is unnamed on the USGS map, but named on another map, use that name, but write the name of the map in parentheses beside the stream name.
- WBID #: Record the Water Body Identification number.
- LEAD INVESTIGATOR: The person responsible for data custody and reporting.
- DATE: Record double digit month, day and year (MM/DD/YR).
- TIME: Record the starting time of all activities that occurred at this location. The site time should be the same on all forms associated with this site. Use military form.

SURFACE VELOCITY (refer to section 1.14.1)

CROSS SECTIONAL AREA (refer to section 1.14.2)

CORRECTED SURFACE VELOCITY (refer to section 1.14.3)