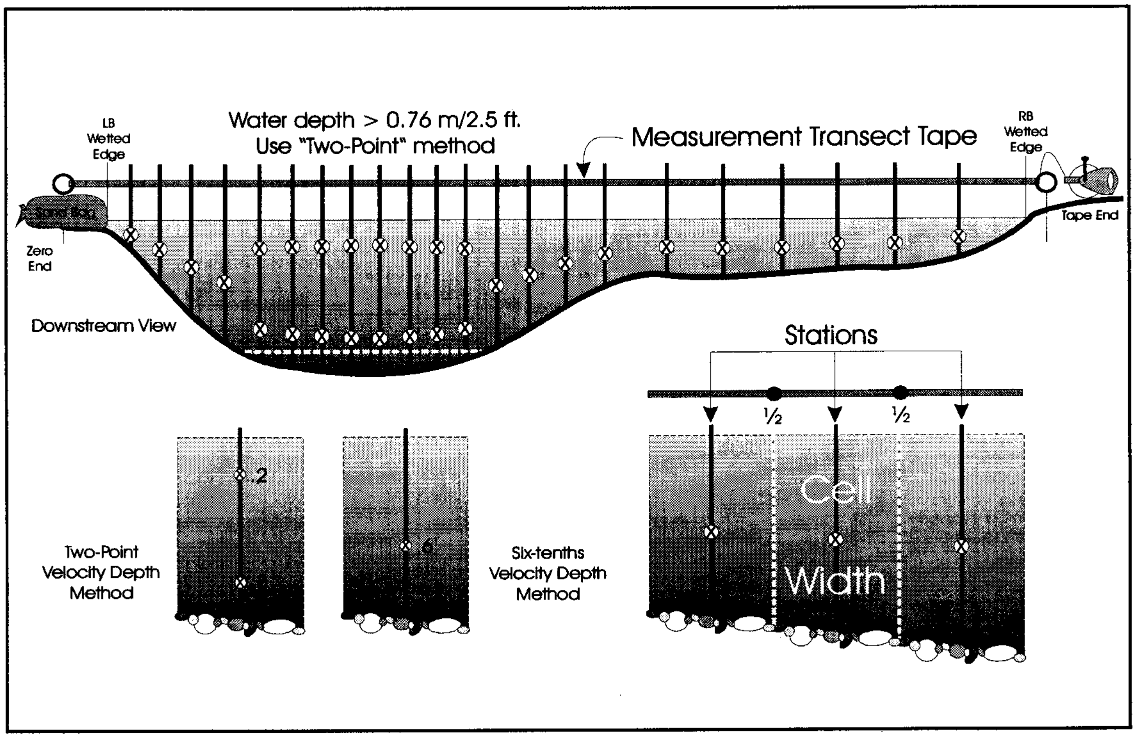
TFW Monitoring Program

METHOD MANUAL

for

WADABLE STREAM DISCHARGE MEASUREMENT



by:
Allen E. Pleus

NW Indian Fisheries Commission

June 1999

Timber Fish & Wildlife

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Abstract

The TFW Monitoring Program method manual for the Wadable Stream Discharge Measurement (WSDM) method provides a standard method for the assessment and monitoring of stream discharge on wadable streams. The TFW method follows the USGS protocols (Rantz and others, 1982) with minor modifications for smaller stream systems. Discharge measurements are required for the TFW Habitat Unit and Large Woody Debris Surveys and when conducting portions of the Spawning Habitat Availability and Stream Temperature Surveys.

This introduction section describes the purpose of the WSDM method and describes the cooperator services provided by the TFW Monitoring Program. Following the introduction, sections are presented in order of survey application including: pre-survey preparation, methods, post-survey documentation, data management, and references. An appendix is also provided that includes: copy masters of field forms; examples of completed field forms; a standard field and vehicle gear checklist, and USGS procedures for float and volumetric discharge measurements.

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Manual cover, method illustrations, and layout by Allen Pleus unless otherwise noted.

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Copying of the Method Manual

All TFW Monitoring Program method manuals are public documents. No permission is required to copy any part. The only requirement is that they be properly cited. Copies of the methods manuals are available from the TFW Monitoring Program at the Northwest Indian Fisheries Commission or from the Washington Dept. of Natural Resources.

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Wadable Stream Discharge Measurement

1. Introduction

The TFW Monitoring Program method manual for the Wadable Stream Discharge Measurement (WSDM) method provides a standard method for the assessment and monitoring of stream discharge on wadable streams. The TFW method follows the USGS protocols (Rantz and others, 1982) with minor modifications for smaller stream systems. Discharge measurements are required for the TFW Habitat Unit and Large Woody Debris Surveys and when conducting portions of the Spawning Habitat Availability and Stream Temperature Surveys.

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1.1 Purpose

The Timber-Fish-Wildlife Monitoring Program (TFW-MP) provides standard methods for monitoring changes and trends in stream channel morphology and habitat characteristics. The WSDM method has been approved by TFW's Cooperative Monitoring, Evaluation and Research Committee (CMER) and is accepted as a standard method for monitoring on forest lands in Washington state by tribal governments, state natural resource agencies, timber companies, environmental organizations, and others. The purpose of the WSDM method is to:

1. Determine discharge at the time of the monitoring survey; and/or
2. Determine appropriate flows for repeat surveys.

1.2 Cooperator Services

The TFW Monitoring Program provides services to support TFW cooperators collecting discharge data consistent with program goals. Services include preseason training through annual workshops and on-site visits and database/data archiving services. These services are offered free of charge. TFW method manuals are available for the following surveys:

- Stream Segment Identification
- Reference Point Survey
- Habitat Unit Survey
- Large Woody Debris Survey
- Stream Temperature Survey
- Spawning Gravel Composition Survey
- Spawning Habitat Availability Survey
- Spawning Gravel Scour Survey
- Wadable Stream Discharge Meas. Method

The field forms provided in the manuals have been designed for consistent and accurate recording of WSDM data. The forms have been refined based on research and monitoring experience to reduce data errors caused by factors such as legibility, required parameter field calculations, and data transfer during database entry.

To find out more about TFW Monitoring Program services and products, contact us or visit our link on the NWIFC homepage. The address is:

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2. Pre-Survey Preparation

This section describes what and how to gather, prepare, and pack for transportation all necessary survey equipment and materials required for field crews to complete the field portion of the WSDM method. These lists are not intended to cover all possible survey equipment and materials that could be of use and may duplicate items required by other surveys being conducted in conjunction with the discharge measurement.

2.1 Survey Equipment

Acquire, check, and calibrate survey equipment well before the date the survey is scheduled to begin. The following list of survey equipment contains items necessary for crews to conduct the WSDM method. The equipment includes:

Survey Equipment

- Measurement tape (30 to 50 m; accuracy ± 0.10 m)
- Flow meter system
- Spare parts and batteries
- Surveyor chaining pins or other tape anchors
- Standard field and vehicle gear (Appendix D)

All measurements must be in metric units (cubic meters per second - CMS) for entry into the TFW-MP database. If using English units (CFS), stream discharge measurements must be converted to metric units before database entry. Mixing measurement unit types (metric/English) within a survey is strongly discouraged due to potential for multiple conversion errors.

Check all measurement equipment for damage before using. Calibrate all measurement equipment to a standard of known accuracy before and after the survey to ensure that the instruments provided accurate data during collection. A flow meter system includes wading rod, meter unit, cables, sensor unit, and spare parts. Check to make sure assembly tools (depending upon system) are included and batteries are fresh. Flow meter equipment is fragile and should be packed in protective cases. Read and follow manufacturer calibration, care, and maintenance guidelines. Never transport the sensor unit attached to the wading rod as minor bumps can affect calibration or damage the equipment.

Select wading gear to accommodate stream and survey conditions. On most streams, having one crew with chest waders is important for taking measurements in the deeper parts of the channels. Having only knee or hip boots for a larger stream limits access and prevents accurate measurement of unit surface areas and residual pool depths. However, it is important to note that use of chest waders in fast flowing streams can be dangerous. Also consider future repeatability of each option. For example, data collected wading wet or swimming may not be comparable to data collected using knee or hip boots due to access limitations the next time the survey is done.

2.2 Survey Materials

Survey materials are those items necessary for crews to locate and document the stream segment and access points, site conditions, and for recording field data. The basic materials include:

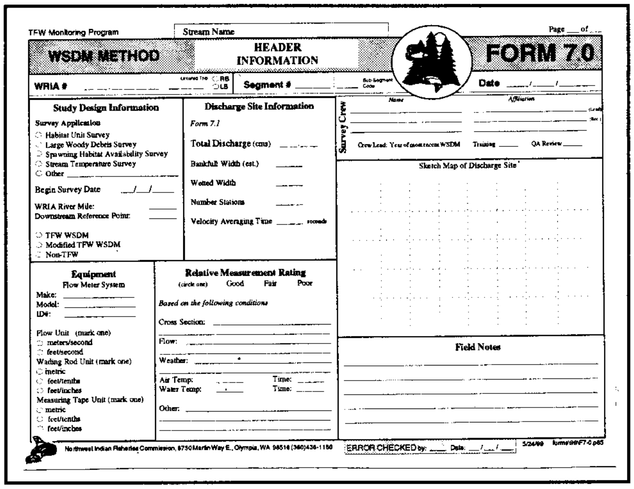
Survey Materials

- USGS 7.5 minute topographic map worksheet
- Road map
- Header information forms of associated surveys
- Copy of WSDM Forms 7.0 and 7.1 (Appendix A)

Start by gathering and organizing site access information and working on logistical factors. Obtain directions and maps; contact landowners and secure permission to access property; acquire necessary permits and passes; and determine if the access roads are gated and get gate keys or make necessary arrangements with landowner to open access. Next, begin the survey documentation by preparing and completing header and preliminary information on the field data forms. Refer to Appendix B for examples of completed field forms.

2.2.1 *WSDM "HEADER INFORMATION" Form 7.0*

One Form 7.0 is completed for each discharge measurement. Use the Form 7.0 copy master to make a copy on waterproof paper (Figure 1). Most header information can be copied directly from the associated survey's completed *HEADER INFORMATION* form. Instructions on filling-out the "Discharge Site Information," "Relative Measurement Rating," and "Sketch Map of Discharge Site" boxes will be covered in the discharge measurement method section. The Water Resource Inventory Area number (WRIA #), unlisted tributary number (Unlisted Trib), segment number (Segment #), Sub-Segment Code, and Begin Survey Date are key fields used to associate discharge data with specific surveys.


TFW Monitoring Program
Stream Name
Page ___ of ___
WSDM METHOD
HEADER INFORMATION
FORM 7.0
WRIA # ______ Unlisted Trib ○ RB ○ LB
Segment # ______ Sub-Segment Code ______
Date ___/___/___

Study Design Information
Survey Application
○ Habitat Unit Survey
○ Large Woody Debris Survey
○ Spawning Habitat Availability Survey
○ Stream Temperature Survey
○ Other ______
Begin Survey Date ___/___/___
WRIA River Mile: ______
Downstream Reference Point: ______
○ TFW WSDM
○ Modified TFW WSDM
○ Non-TFW

Discharge Site Information
Form 7.1
Total Discharge (cms) ______
Bankfull Width (est.) ______
Wetted Width ______
Number Stations ______
Velocity Averaging Time ______ seconds

Survey Crew
Name | Affiliation (Lead) (Rec)
Crew Lead: Year of most recent WSDM Training ______ QA Review ______

Sketch Map of Discharge Site

Equipment
Flow Meter System
Make: ______
Model: ______
ID#: ______
Flow Unit (mark one)
○ meters/second
○ feet/second
Wading Rod Unit (mark one)
○ metric
○ feet/tenths
○ feet/inches
Measuring Tape Unit (mark one)
○ metric
○ feet/tenths
○ feet/inches

Relative Measurement Rating
(circle one) Good Fair Poor
Based on the following conditions
Cross Section: ______
Flow: ______
Weather: ______
Air Temp: ______ Time: ______
Water Temp: ______ Time: ______
Other: ______

Field Notes

Northwest Indian Fisheries Commission, 6730 Martin Way E., Olympia, WA 98516 (360)438-1180
ERROR CHECKED by: ______ Date: ___/___/___
5/24/99 forms\99\F7-0.p65

Figure 1. WSDM "HEADER INFORMATION" Form 7.0.

Header Section

Stream Name: Record the WRIA-designated stream name. Use "Unnamed" where appropriate.

WRIA #: Record the six digit Water Resource Inventory Area (WRIA) number (00.0000).

Unlisted Trib: Only streams without assigned WRIA numbers require unlisted tributary numbers. For streams with WRIA numbers, fill this space with three zeros (000). For unlisted tributaries, record a three digit cooperator-designated unlisted tributary number (001 - 999) and mark the appropriate RB/LB circle.

Segment #: Record the one to three digit segment number (1 - 999).

Sub-Segment Code: If the survey reach is a sub-segment, record the number or letter character sub-segment code (1 - 99 or a - zz). Record a "0" if not a sub-segment.

Date: Enter the date the form is being filled-out.

Survey Crew Section

Record the names and affiliations of the lead, recorder, and other field crew involved in data collection for the survey. Affiliations correspond to employers such as a tribe, government agency, industry, environmental group, consulting company, etc. Record the most recent year that the lead crew person received official TFW Monitoring Program on-site and/or annual workshop WSDM training, and/or a QA Review. Note any other relevant training or field experience in the *Field Notes* section.

Study Design Information Section

Survey Application: Mark the circle corresponding to the survey that the discharge data is associated. Choices include: Habitat Unit, Large Woody Debris, Spawning Habitat Availability, Stream Temperature, and Other surveys.

Begin Survey Date: Record the beginning survey date of the specific survey to which the discharge data is associated.

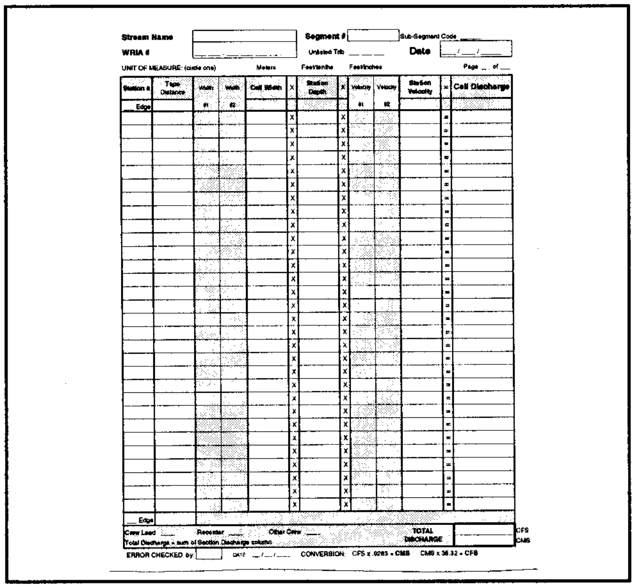
WRIA River Mile: Estimate the discharge measurement location on the stream and record the river mile to the nearest 0.1 mile based on the WRIA catalog.

Equipment Section

Record the make, model, and identification number of the flow meter system. Mark the circle corresponding to whether the flow readings will be in metric or English units. Mark the circle to record the wading rod unit of measure. Mark the circle to record the measuring tape unit of measure. All measurement equipment must be in the same units to prevent calculation errors. Document the type of wading gear and any other measurement equipment used during the survey in the *Field Notes* section.

2.2.2 WSDM "FLOW DATA" Form 7.1

Use the Form 7.1 copy master to make multiple field copies onto waterproof paper (Figure 2). Copies can be made single-sided or duplex with the header information on one side and flow data on the other.


Stream Name
WRIA #
Segment #
Sub-Segment Code
Unlisted Trib
Date
UNIT OF MEASURE: (circle one) Meters Feet/tenths Feet/inches
Page __ of __

Station #	Tape Distance	Width	Width	Cell Width	X	Station Depth	X	Velocity	Velocity	Station Velocity	=	Cell Discharge
Edge		#1	#2					#1	#2			
__ Edge												

Crew Lead ___ Recorder ___ Other Crew ___ TOTAL DISCHARGE CFS CMS
Total Discharge = sum of Section Discharge column
ERROR CHECKED by: DATE __/__/__ CONVERSION: CFS x .0283 = CMS CMS x 35.32 = CFS

Figure 2. WSDM "FLOW DATA" Form 7.1.

Record the *Stream Name/WRIA #/Unlisted Trib/Segment #/Sub-Segment Code* as documented on Form 7.0. Record the initials of the crew lead, recorder, and other crew in the spaces provided in the lower gray bar at the bottom of the page. Leave the *Page __ of __* and *Date* spaces blank as they are recorded in the field during the survey. Circle the unit of measure near the top of the form to which all columns will apply.

3. Wadable Stream Discharge Measurement Method

This section provides procedures for conducting the Wadable Stream Discharge Measurement method and describes how to document information on the field forms. It is organized in a sequential format to facilitate accurate and consistent application of the methods. This section can be copied for crews to take out into the field. Form 7.1 has been designed to record, organize, and track the information gathered using this method. It is important that the survey be started and completed as soon after the discharge measurement as possible. In general, monitoring value decreases with increasing changes in discharge during a survey.

Monitoring surveys should not be conducted during periods of high water associated with storms or during periods of rapidly fluctuating discharge. If crews note that the discharge has or is changing substantially (± 10%), the survey should be suspended until the flows return to original levels as documented with an additional discharge measurement. If the discharge does not return to the original level, then the data should be thrown out and the segment re-surveyed at a more stable discharge. The number of discharge measurements needed during a given survey depends upon stream and weather conditions, survey length, study design objectives, and quality assurance plan requirements. Future surveys of the same segment should be conducted at a discharge similar to that of the original survey (± 10%).

There are nine basic steps to the discharge method. These are: 1) select a discharge measurement site; 2) establish the measurement transect; 3) assemble and test the flow meter system; 4) establish the measurement station interval; 5) record wetted edge locations, station number, and tape distance; 6) measure and record station depth and velocity; 7) calculate cell width for each measurement station; 8) calculate total discharge; and 9) document discharge information on Form 7.0.

Step 1: *Select a discharge measurement site.*

Select a suitable measurement location as close to the downstream survey starting point as possible, but within the reach being surveyed. Investigate the wetted stream channel for a site that has as many of the following attributes as possible:

Desired WSDM Site Attributes

- Along a straight channel reach;
- adequate water depth across the entire wetted channel to completely cover the velocity sensor at its lowest setting;
- adequate water velocity to operate the equipment (see minimum manufacturer specifications);
- a relatively uniform stream bed free of numerous boulders, heavy aquatic growth, or other obstructions; and
- a relatively uniform flow free of eddies, slack water, and excessive turbulence.

Avoid areas with flow diversions, side-channels, undercut banks, or other obstructions. When a few small obstructions are present at an otherwise suitable site, it is acceptable to remove them. Place the obstructions downstream of the site so that they do not affect flow conditions along the measurement cross section. Examples of obstructions include small organic debris such as leaves, twigs and branches, and larger sediment particles such as cobble and boulders with less than 50% of their mass embedded in the channel bed surface. Avoid channel bed disturbance that causes a continuous movement of smaller sediment particles downstream while removing obstructions or while taking measurements.

Temporary damming along shallow margins of the measurement site is acceptable to divert flow into deeper sections where the water level would not other wise completely cover a velocity sensor. The use of sand bags is recommended as they cause the least disturbance to the channel bed. Sandbags can also be used to fill in small under-cut bank areas if necessary. Empty bags are easily transported and filled with sand and gravel from dry bars near the measurement site. After the cross section has been modified, the flow should be allowed to stabilize before starting the discharge measurement. Always return the site to its original condition after the measurement process is completed.

Step 2: *Establish the measurement transect.*

Stretch a measuring tape across the wetted portion of the stream channel perpendicular to the main direction of flow. Anchor the ends of the tape at convenient dry locations just past the wetted edges of the channel. Use spring clips and surveyor chaining pins, large spikes, or pieces of branches found near the site to anchor each end of the tape securely. The tape should have minimal sag and not be touching the water surface.

Step 3: *Assemble and test the flow meter system.*

Assemble and test the flow meter system to ensure that it is working properly based on manufacturer specifications. This includes the flow sensor unit (probe/rotor assembly), the sensor cable, the data indicator/logger/meter, and the wading rod.

Step 4: *Establishing measurement stations.*

For most wadable streams, a minimum of 25 measurement stations is required (Figure 3). Begin by dividing the total wetted width of the transect by 25 to calculate an average interval distance.

Locate the first station one interval distance from the wetted edge as measured from the zero end of the transect tape. The second and subsequent measurement stations can be calculated by adding one full interval distance to the previous measurement station. The interval spacing technique is used as a guideline to meet the minimum number of measurement stations. However, it is not recommended that all measurement stations be spaced equally unless the discharge is evenly distributed across the stream. The intervals between stations should be closer in those parts of the transect that have the greater depths and velocities. Stations are placed to represent average depth and velocity conditions within an area (cell) defined as half the distance

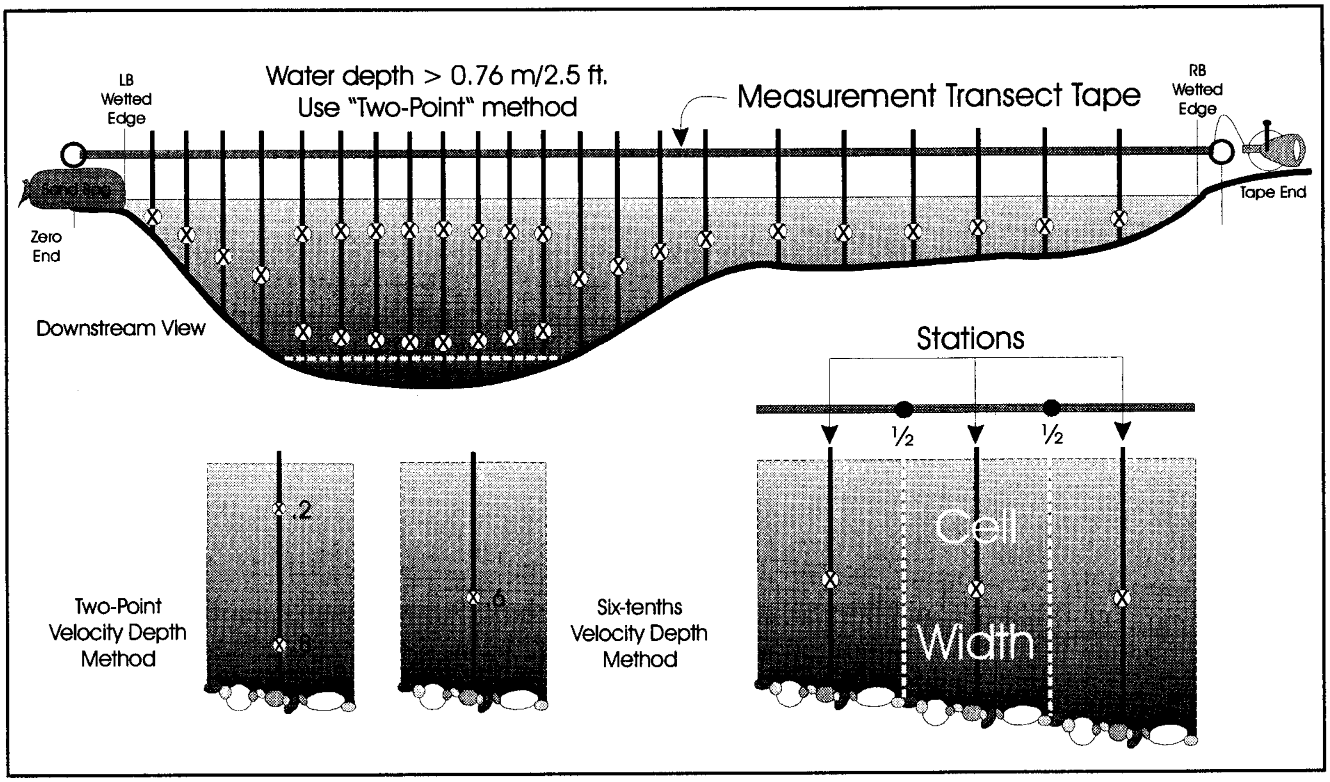


Figure 3. Cross section of stream showing tape position, depth and velocity measurement stations, and cell width boundaries.

from the last station plus half the distance to the next station. Adjust station locations so that cell boundaries fall wherever noticeable breaks or discontinuity in velocity and depth occur. On more uniform stream sections, no single discharge measurement should represent more than 10% of the total discharge.

For smaller and/or shallower streams, the number of stations can be reduced depending upon the size, depth, and uniformity of the stream channel. A uniform flow has little vertical or horizontal changes in flow direction so variability across the transect is reduced. These flow conditions are generally found in shallower water, where the channel bed is flat, composed of small sediment, and there is little or no surface turbulence. The 10% rule can be overridden on very small streams where the physical limitations or temporary channel modifications placed to overcome limitations allow less than 10 measurement stations. Always record the reasoning used for reducing the number of measurement stations on Form 7.0.

Step 5: *Record wetted edge locations, station number, and tape distance.*

Record the starting wetted channel edge location (viewed facing downstream) as either right bank (RB) or left bank (LB) in the top left hand __ *Edge* box on the form. Record the wetted edge location along the transect tape to the nearest 0.01 meter (0.1 foot) in the *Tape Distance* column. Record the ending wetted channel edge bank and location in the bottom left hand __ *Edge* and *Tape Distance* boxes.

On the first blank row, record the measurement station number in the *Station #* column starting with "1" and numbering sequentially (e.g., 1, 2, 3, 4, etc.). Record each station's location as distance along the transect tape in the *Tape Distance* column to the nearest 0.01 meter (0.1 foot; 1 inch).

Step 6: *Measure and record water depth and velocity at the station.*

Measure the water depth at the measurement station using the wading rod and record it in the *Station Depth* column to the nearest 0.01 meter (0.1 foot). Measure the station's average flow velocity at appropriate time interval and depths and record it in the *Station Velocity* column to the nearest 0.01 meter per second (0.1 feet per second).

Station depth is the distance from the surface of the channel bed to the water surface with the wading rod held vertically plumb. The recorder can guide the crew lead in determining if the rod is plumb. On higher velocity streams, read the water depth off the rod as the average distance between the stacked water level on the upstream side and the depression level on the downstream side.

Station velocity is measured with the wading rod held vertically plumb, the sensor unit at a 90 degree angle to and just downstream of the transect line, averaged over a minimum period of time, and using either the six-tenths or two-point sensor depth technique. The direction of the sensor unit can be adjusted to face the direction of flow where the water intersects the transect tape at less than 45 degree angle. Allow the velocity sensor to adjust to the speed of the current before the velocity measurement is started. Slower water may require a 5 to 10 second adjustment for some models. The crew holding the wading rod should stand in a position that least affects the velocity of the water passing the current meter. That position is usually obtained by facing the bank so that the water flows against the side of the leg and the body is positioned at least 0.5 m (1.5 ft) downstream from the wading rod.

Always check the sensor unit before and after each station measurement for proper function, especially if the water has suspended particulates, algae, or other aquatic vegetation. In some cases, it may be necessary to clean the sensor after each immersion.

Selecting an Appropriate Velocity Averaging Time

On most stream systems with normal summer low-flow conditions, velocity is averaged at each station over a minimum 40 second period of time. This is to compensate for pulsations in flow that are common along the length and width of stream systems. Velocity averaging times are increased to a minimum of 70 seconds on stations where velocity readings are less than 0.31 meters per second (1.0 feet per second). Lower velocity situations have been shown to have greater magnitudes of flow pulsations.

In situations where equipment meters have set averaging times less than the minimum requirements, two separate velocity averaging time measurements are required. Record the first measurement in the *Velocity #1* column and the second in the *Velocity #2* column. Calculate the average station velocity by adding the two velocities together and dividing by 2 and record the result in the *Station Velocity* column.

Six-Tenths Velocity Depth Technique

One velocity measurement is required using the "six-tenths" velocity depth technique where the station's water depth is less than 0.76 meter (2.5 feet). In this technique, a single station velocity is taken with the sensor unit positioned at 0.6 of the total water depth as viewed from the water surface. Viewed from the other direction, the sensor unit is positioned at 0.4 of the depth above the stream bed. Top setting wading rods are designed to automatically calculate this depth by lining up markings on the depth rod with those along the top of the guide rod based on the station's total water depth. For example, for a station depth of 1.8, the "1" on the depth rod is lined up with the "8" on the guide rod handle resulting in the sensor position just above the 0.7 water depth mark on the guide rod shaft. This position can be calculated manually by multiplying the station depth by 0.4 (e.g., 1.8 x 0.4 = 0.72). Record the results in the *Station Velocity* column.

Two-Point Velocity Depth Technique

Two velocity measurements are required using the "two-point" velocity depth technique where the station depth is equal to or greater than 0.76 meter (2.5 feet). In this method, station velocity measurements are taken at 0.2 and 0.8 of the depth below the surface. Record the velocity at the 0.2 depth in the *Velocity #1* column and the velocity at the 0.8 depth in the *Velocity #2* column. Calculate the average station velocity by adding the two velocities together and dividing by 2 and record the result in the *Station Velocity* column.

On top setting wading rods, the 0.2 depth is determined by dividing the total depth by 2 and using the result to adjust the sensor depth using the six-tenths method (2.8/2 = 1.4). The 0.8 depth is determined by multiplying the total depth by 2 and using the result to adjust the sensor depth using the six-tenths method (2.8 x 2 = 5.6). The 0.2 depth is calculated manually by multiplying the station depth by 0.8 (2.8 x 0.8 = 2.24), and the 0.8 depth is calculated by multiplying the station depth by 0.2 (1.8 x 0.2 = 0.56).

Difficult Situations

Two Velocity #1 and #2 calculations at one station: In situations where a cooperator must take two averaged velocities plus use the two-tenths velocity depth method, use two rows to record. The first row is used to record the average velocity at the 0.2 depth and the second row for the 0.8 depth. Next, calculate the average velocities for the 0.2 and 0.8 depths and record the result in the margins of the form. Last, calculate the station velocity by adding the 0.2 and 0.8 depth velocities and dividing by two. Record the result in the *Station Velocity* column.

Very low flows: On stream systems where flow levels prevent an accurate discharge measurement using standard flow meters, a float or volumetric measurement technique may be used (Rantz and others, 1982). Refer to Appendix D for a copy of the USGS methods.

Step 7: *Calculate cell width for each measurement station.*

Cell widths are calculated by taking half the distance from the last station and adding it to half the distance to the next station. Record the first cell width distance in the *Width #1* column and the second width distance in the *Width #2* column. Edge cell widths are calculated by adding the distance from the wetted edge to the adjacent station plus half the distance to the next station. Calculate the total cell width by adding the two width distances together and recording the result in the *Cell Width* column to the nearest 0.01 meter (0.1 feet; 1 inch).

Step 8: *Calculate total discharge.*

Calculate the discharge for each cell by the multiplying together the following three factors along the same row: *Cell Width* (x) *Station Depth* (x) *Station Velocity*. Make sure that all three numbers were recorded in the same measurement units (meters, feet and inches, or feet and tenths). Record the result in the *Cell Discharge* column to the nearest 0.01 CMS (0.1 CFS). Next, add together all measurements in the cell discharge column and record the result in the *Total Discharge* box to the nearest 0.01 CMS (0.1 CFS). If the total discharge is in cubic feet per second (CFS), multiply the total by .0283 to convert the unit of measurement from CFS to

CMS. It is recommended that calculations be completed in the field so measurements can be retaken if an error is detected.

Step 9. *Document discharge information on Form 7.0.*

Discharge Site Information

Copy the total discharge measurement in cubic meters per second (CMS) from Form 7.1 to 7.0 in the space provided. Estimate the bankfull width at the discharge site to the nearest meter or foot as a relative indicator of flow conditions at the time of the discharge. Calculate the wetted width of the discharge transect by subtracting the zero-end wetted edge tape distance from the measurement-end tape distance at the opposite wetted edge. Record the number of measurement stations used for the total discharge. Record the velocity averaging time in seconds used for determining station velocity. Record the nearest downstream reference point if that survey has already been conducted and the discharge site's distance upstream to the nearest ±5.0 meters along the center of the channel.

Relative Measurement Rating

Circle either the "Good," "Fair," or "Poor" rating describing the subjective accuracy of the discharge measurement. These ratings are based on site conditions at the time of the discharge measurement. Direct factors include equipment function, physical characteristics of the cross section, water depth and velocity, wind, number of measurement stations, and measurement technique. Indirect factors include those affecting the work environment such as precipitation, air and water temperatures, and crew preparedness. For example, a "Good" rating would be expected where the channel bed below the transect was uniform in shape with small gravel and no overhanging brush, the flow was evenly distributed with little or no surface turbulence, the weather was sunny and calm, the air temperature was warm, and other factors like mosquitos weren't a problem.

Sketch Map of Discharge Site

Sketch an overhead view of the immediate discharge site area showing general wetted channel shape, habitat unit identity, transect line, and any factors that were suspected to affecting the measurement rating.

4. Post-Survey Documentation

After completion of the field portion of the WSDM method, field forms need to be organized, supplemental information and calculations completed where needed, and all forms and information error checked before the data is ready to be entered into the database. The objective of this section is to organize the data to ensure that a survey can be repeated the same way by different crews.

4.1 Finalizing Forms 7.0 and 7.1

Organize the forms and check for missing sheets. Systematically check each WSDM form for completeness. All parameter blanks and boxes should contain information or a "/" to designate that no information was available or needed.

4.1.1 Form 7.0: Field Notes Section

This section is provided to make brief notes related to unique discharge conditions and problems encountered. Note any modifications to the TFW-MP WSDM method used to meet individual cooperator needs. Additional information can be included on the back of the form or on separate sheets of paper. If separate sheets are used, they need to be included in the *Page __ of__* information and have the key header information listed at the top of each page.

4.1.2 Form 7.1

Calculate any *Cell Width*, *Station Velocity*, *Cell Discharge*, and *Total Discharges* that were not completed in the field.

4.2 Error Checking

Error checking of field forms is a very important task and sufficient time should be taken to complete it. It is best done during or immediately after data collection because it becomes more difficult to reconcile discrepancies and track down correct information as time passes. Contact the TFW-MP for assistance in determining how to handle missing data fields.

Review Forms 7.0 and 7.1 plus all other documents compiled during the WSDM. Have a second person look them over for completeness, legibility and errors. Every page of every form requires error checking for legibility, complete and consistent header information, and obvious measurement, transcription, and calculation errors. The WSDM method is especially prone to calculation or unit conversion errors. Work systematically through each section and when completed, put your initials and date in the *Error Checked by* box at the bottom of each page. If the person error checking the data is not a crew member, their full name and task should be recorded in the *Field Notes* section of Form 7.0.

5. Data Management

Discharge data is used to support other TFW surveys and therefore is entered on the header forms of the respective surveys. Discharge data is shown in the header sections of the reports for the following surveys: Habitat Unit, Large Woody Debris, Spawning Habitat Availability, and Stream Temperature. Up to three discharge measurements and dates can be reported for each survey. Stream Temperature Survey reports display the upstream and downstream discharge measurements and calculates the difference between them.

6. References

Rantz, S.E., and others. 1982. Measurement and computation of streamflow: volume 1. Measurement of stage and discharge. Geological Survey Water-Supply Paper 2175. US Dept of the Interior. US Gov't Printing Office, Washington.

9. Appendixes

Appendix A
Form 7.0 and 7.1 Copy Masters

Appendix B
Completed Examples of Forms 7.0 and 7.1

Appendix C
Standard Field and Vehicle Gear Checklist Copy Master

Appendix D
USGS Float and Volumetric Measurement Methods

Appendix A

Form 7.0 and 7.1 Copy Masters

(Keep original copy master with manual)

Stream Name

WSDM METHOD

HEADER INFORMATION

FORM 7.0

WRIA # ___ ___ . ___ ___ ___ ___   Unlisted Trib ___ ___ ___ ○ RB ○ LB   **Segment #** ________ ______ Sub-Segment Code   **Date** _____/_____/________

Study Design Information

Survey Application

- ○ Habitat Unit Survey
- ○ Large Woody Debris Survey
- ○ Spawning Habitat Availability Survey
- ○ Stream Temperature Survey
- ○ Other ____________________

Begin Survey Date ___/___/_____

WRIA River Mile: _______

- ○ TFW WSDM
- ○ Modified TFW WSDM
- ○ Non-TFW

Discharge Site Information

Form 7.1

Total Discharge (cms) __ __.__ __

Bankfull Width (est.) _______

Wetted Width _______

Number Stations _______

Velocity Averaging Time _______ seconds

Downstream Reference Point: _______
Distance from Dwnstrm RP: _______

Survey Crew

Name	*Affiliation*	
____________	____________	(Lead)
____________	____________	(Rec.)
____________	____________	

Crew Lead: Year of most recent WSDM   Training _____   QA Review _____

Sketch Map of Discharge Site

Equipment

Flow Meter System

Make: ______________
Model: ______________
ID#: ______________

Flow Unit (mark one)
- ○ meters/second
- ○ feet/second

Wading Rod Unit (mark one)
- ○ metric
- ○ feet/tenths
- ○ feet/inches

Measuring Tape Unit (mark one)
- ○ metric
- ○ feet/tenths
- ○ feet/inches

Relative Measurement Rating

(circle one) Good Fair Poor

Based on the following conditions

Cross Section: ____________________

Flow: ____________________

Weather: ____________________

Air Temp: ______ Time: ______
Water Temp: ______ Time: ______

Other: ____________________

Field Notes

TFW Monitoring Program

WSDM FLOW DATA

FORM 7.1

Stream Name ____ **Segment #** ____ Sub-Segment Code ____

WRIA # __ __ . __ __ __ __ Unlisted Trib __ __ __ **Date** ___/___/___

UNIT OF MEASURE: (circle one) Meters Feet/tenths Feet/inches

Page ___ of ___

Station #	Tape Distance	Width #1	Width #2	Cell Width	X	Station Depth	X	Velocity #1	Velocity #2	Station Velocity	=	Cell Discharge
___ Edge												
					X		X				=	
					X		X				=	
					X		X				=	
					X		X				=	
					X		X				=	
					X		X				=	
					X		X				=	
					X		X				=	
					X		X				=	
					X		X				=	
					X		X				=	
					X		X				=	
					X		X				=	
					X		X				=	
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					X		X				=	
					X		X				=	
					X		X				=	
					X		X				=	
					X		X				=	
					X		X				=	
					X		X				=	
					X		X				=	
					X		X				=	
___ Edge												

Crew Lead ___ Recorder ___ Other Crew ___

Total Discharge = sum of Section Discharge column

TOTAL DISCHARGE ____ CFS ____ CMS

ERROR CHECKED by: ____ DATE: ___/___/___ CONVERSION: CFS x .0283 = **CMS** CMS x 35.32 = **CFS**

Appendix B

Completed Examples of Forms 7.0 and 7.1

Stream Name KENNEDY CREEK

WSDM METHOD — HEADER INFORMATION — FORM 7.0

WRIA # 14.0012 | Unlisted Trib 000 ○RB ○LB | **Segment #** 11 | 0 Sub-Segment Code | **Date** 6/6/99

Survey Crew

Name	Affiliation	
AMY MORGAN	TFW MONITORING PROGRAM	(Lead)
DEVIN SMITH	〃	(Rec.)

Crew Lead: Year of most recent WSDM Training '99 QA Review '99

Study Design Information

Survey Application

- ● Habitat Unit Survey
- ○ Large Woody Debris Survey
- ○ Spawning Habitat Availability Survey
- ○ Stream Temperature Survey
- ○ Other ______

Begin Survey Date 6/6/99

WRIA River Mile: 12.4

- ● TFW WSDM
- ○ Modified TFW WSDM
- ○ Non-TFW

Discharge Site Information

Form 7.1

Total Discharge (cms) __.__

Bankfull Width (est.) 11.5

Wetted Width 5.4

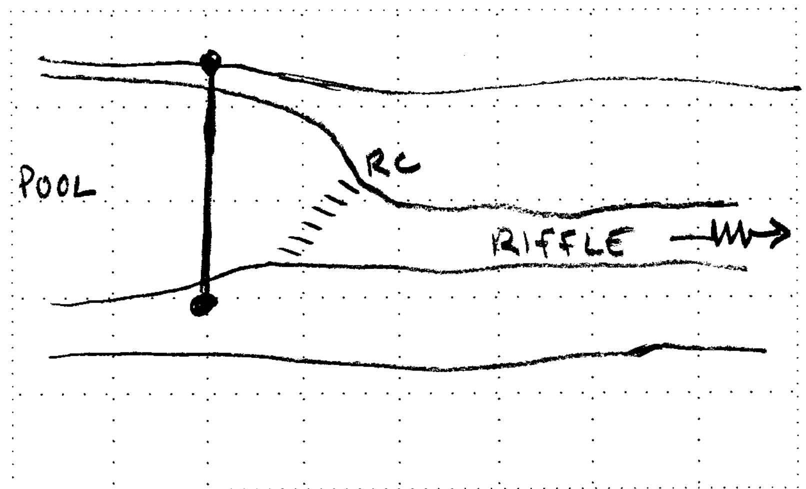
Number Stations 25

Velocity Averaging Time 40 seconds

Downstream Reference Point: Ø

Distance from Dwnstrm RP: 16m

Sketch Map of Discharge Site



Equipment

Flow Meter System

Make: SWOFFER

Model: 2100

ID#: 010

Flow Unit (mark one)

- ● meters/second
- ○ feet/second

Wading Rod Unit (mark one)

- ● metric
- ○ feet/tenths
- ○ feet/inches

Measuring Tape Unit (mark one)

- ● metric
- ○ feet/tenths
- ○ feet/inches

Relative Measurement Rating

(circle one) (Good) Fair Poor

Based on the following conditions

Cross Section: NO OBSTRUCTIONS SMALL GRAVEL

Flow: UNIFORM

Weather: CLOUDY, CALM, COOL

Air Temp: 18°C Time: 1021

Water Temp: 14°C Time: 1045

Other: USE SANDBAG ON RB IN SHALLOW AREA

Field Notes

ERROR CHECKED by: AP Date: 6/8/99

TFW Monitoring Program

WSDM FLOW DATA

FORM 7.1

Stream Name KENNEDY CREEK **Segment #** 11 Sub-Segment Code 0

WRIA # 14.0012 Unlisted Trib 000 **Date** 6/7/99

UNIT OF MEASURE: (circle one) (Meters) Feet/tenths Feet/inches

Page 1 of 1

Station #	Tape Distance	Width #1	Width #2	Cell Width	X	Station Depth	X	Velocity #1	Velocity #2	Station Velocity	=	Cell Discharge
LB Edge	2.8											
1	3.0	0.2	0.1	0.30	X	.18	X	.11	.13	.120	=	0.006
2	3.2	0.1	0.1	0.20	X	.24	X	.22	.22	.220	=	0.011
3	3.4				X	.26	X	.21	.22	.215	=	0.011
4	3.6				X	.28	X	.29	.29	.290	=	0.016
5	3.8				X	.25	X	.26	.28	.270	=	0.014
6	4.0				X	.21	X	.25	.26	.255	=	0.011
7	4.2				X	.21	X	.23	.23	.230	=	0.010
8	4.4				X	.21	X	.27	.27	.270	=	0.011
9	4.6				X	.22	X	.27	.28	.275	=	0.012
10	4.8				X	.23	X	.30	.32	.310	=	0.014
11	5.0				X	.25	X	.35	.31	.330	=	0.017
12	5.2				X	.21	X	.33	.34	.335	=	0.014
13	5.4				X	.29	X	.32	.32	.320	=	0.019
14	5.6				X	.33	X	.35	.35	.350	=	0.023
15	5.8				X	.35	X	.34	.35	.345	=	0.024
16	6.0	↓	↓	↓	X	.46	X	.33	.37	.350	=	0.032
17	6.2	0.10	0.05	0.15	X	.51	X	.43	.44	.435	=	0.033
18	6.3	0.05	0.05	0.10	X	.47	X	.55	.55	.550	=	0.026
19	6.4	0.05	0.05		X	.43	X	.53	.54	.535	=	0.023
20	6.5	0.05	0.05	↓	X	.38	X	.56	.58	.570	=	0.022
21	6.6	0.05	0.10	0.15	X	.39	X	.59	.58	.585	=	0.034
22	6.8	0.10	0.10	0.20	X	.33	X	.60	.61	.605	=	0.040
23	7.0				X	.27	X	.65	.65	.650	=	0.035
24	7.2				X	.19	X	.65	.65	.650	=	0.025
25	7.4				X	.11	X	.49	.48	.485	=	0.011
26	7.6	↓	↓	↓	X	.08	X	.37	.36	.365	=	0.006
27	7.8	0.10	0.40	0.5	X	.06	X	.21	.21	.210	=	0.006
					X		X				=	
					X		X				=	
					X		X				=	
RB Edge	8.2	*10% DISCHARGE = 0.051 ▶ ALL CELLS W/IN CRITERIA										

Crew Lead AM Recorder DS Other Crew —

Total Discharge = sum of Section Discharge column

TOTAL DISCHARGE 17.87 CFS / 0.51 CMS

ERROR CHECKED by: AP DATE: 6/8/99 CONVERSION: CFS x .0283 = **CMS** CMS x 35.32 = **CFS**

Appendix C

Standard Field and Vehicle Gear Checklist Copy Master

(Keep original copy master with manual)

✔ STANDARD FIELD GEAR

- ☐ Field clip board/form holder
- ☐ Survey Forms (on waterproof paper)
- ☐ Copy of survey methods
- ☐ Maps- topographic and road
- ☐ Pencils & erasers
- ☐ Permanent ink marker
- ☐ Calculator
- ☐ 150 mm ruler
- ☐ Pocket field notebook

- ☐ Survey Vest
- ☐ Compass
- ☐ Safety whistle
- ☐ Spring clips (2)
- ☐ Vinyl flagging
- ☐ Pocket knife/multi-purpose tool

- ☐ Backpack or canvas tote bag
- ☐ First aid kit
- ☐ Water bottle and/or filtration system
- ☐ Food/energy bars
- ☐ Rain gear
- ☐ Leather gloves
- ☐ Safety glasses
- ☐ Bug repellant
- ☐ Sun screen
- ☐ Small flashlight or headlamp
- ☐ Matches/fire starter
- ☐ Emergency blanket
- ☐ Snake bite kit (eastern Washington)

✔ STANDARD VEHICLE GEAR

- ☐ Waterproof plastic tote box
- ☐ Backup fiberglass tape
- ☐ Comprehensive first aid kit
- ☐ Rain tarp
- ☐ Rope (100 ft.)
- ☐ Extra water
- ☐ Extra food
- ☐ Extra dry clothes
- ☐ Extra batteries

- ☐ Spare tire/jack/tire iron
- ☐ Tire sealant/inflator
- ☐ Tow strap
- ☐ Come-along winch
- ☐ Fire shovel
- ☐ Fire extinguisher
- ☐ CB radio (to monitor logging activity)
- ☐ Cell phone/VHF radio
- ☐ Brush cutter
- ☐ Ax/bow saw/chain saw
- ☐ Tire chains

✔ For remote work, extra survival & safety gear is recommended.

This gear list is provided as a guideline for outfitting field crews and is not intended to cover all situations. Local conditions may require additional or different gear.

Appendix D

USGS Float and Volumetric Measurement Methods

CHAPTER 8. MEASUREMENT OF DISCHARGE BY MISCELLANEOUS METHODS

GENERAL

This chapter deals with the measurement of discharge when conditions are such that it is not feasible to use either a velocity meter or tracer-dilution equipment. The situations and methodologies discussed include the following:

A. High flow
   1. Timed observation of floats

B. Low flow
   1. Volumetric measurement
   2. Use of a calibrated portable weir plate
   3. Use of a calibrated portable Parshall flume

C. Unstable flow—roll waves or slug flow
   1. Use of photographic techniques

Not discussed here is the practice followed in many countries, other than the U.S.A., in which discharge is measured by observing the head on gaging-station controls that are built in conformity with laboratory-rated weirs or flumes. The transfer of a laboratory discharge rating to a structure in the field requires the existence, and maintenance, of similitude between laboratory model and prototype, not only with regard to the structure, but also with regard to the approach channel. For example, scour and (or) fill in the approach channel will change the head-discharge relation, as will algal growth on the control structure. Both the structure and the approach channel must be kept free from accumulations of debris, sediment, and vegetal growth. Flow conditions downstream from the structure are significant only to the extent that they control the tailwater elevation, which may influence the operation of structures designed for free-flow conditions.

The existence or development of conditions that differ from laboratory conditions will necessitate in place calibration of the control to establish the extent of departure from the laboratory discharge ratings. In place calibration requires the measurement of discharge by current meter or by other means, as described in chapters 5 through 9. Because experience in the U.S.A. has indicated that departure from laboratory conditions is the norm, rather than the exception, gaging-station controls are always calibrated in place by the U.S. Geological Survey.

The reader who is interested in the measurement of discharge by the use of precalibrated controls is referred to publications by the World Meteorological Organization (1971) and the International Standards Organization (1969).

APPENDIX D

FLOATS

Floats are seldom used in stream gaging but are useful in an emergency for measuring high discharges under the following circumstances:

1. No conventional or optical current meter is available.
2. A current meter is available but the measurement structure—bridge or cableway—has been destroyed, and equipment for measuring from a boat is unavailable.
3. A conventional current meter is available, but floating ice or drift make it impossible to use the meter.

Surface floats are used in those situations, and they may be almost any distinguishable article that floats, such as wooden disks; bottles partly filled with either water, soil, or stones; or oranges. Floating ice cakes or distinguishable pieces of drift may be used if they are present in the stream.

Two cross sections are selected along a reach of straight channel for a float measurement. The cross sections should be far enough apart so that the time the float takes to pass from one cross section to the other can be measured accurately. A traveltime of at least 20 s is recommended, but a shorter time may be used for streams with such high velocities that it is not possible to find a straight reach of channel having adequate length. The water-surface elevation should be referenced to stakes along the bank at each cross section and at one or more intermediate sites. Those elevations will be used at a later date, when conditions permit, to survey cross sections of the measurement reach, and the end stakes will be used to obtain the length of the reach. The surveyed cross sections will then be used to derive an average cross section for the reach.

In making a float measurement a number of floats are distributed uniformly across the stream width, and the position of each with respect to distance from the bank is noted. The floats should be introduced a short distance upstream from the upstream cross section so that they will be traveling at the speed of the current when they reach the upstream section. A stopwatch is used to time their travel between the end cross sections of the reach. The estimated position of each float with respect to the bank is also noted at the downstream cross section.

If there is no bridge or cableway from which to introduce the floats in the stream, the floats will have to be tossed in from the streambank. If that is the situation that exists at a wide stream, it may be impossible to position any floats in the central core of the stream where most of the flow occurs. A float measurement of discharge made under those conditions would be meaningless. However, the difficulty of introducing floats at intervals across the entire width of a wide stream can be overcome if a boat can be obtained for the purpose.

The velocity of a float is equal to the distance between the end cross sections divided by the time of travel. The mean velocity in the vertical is equal to the float velocity multiplied by a coefficient whose value is dependent on the shape of the vertical-velocity profile of the stream and on the depth of immersion of the float with respect to stream depth. A coefficient of 0.85 is commonly used to convert the velocity of a surface float to mean velocity in the vertical.

The procedure for computing the discharge is similar to that used in computing the discharge for a conventional current-meter measurement. (See chapter 5.) The discharge in each subsection of the average cross section is computed by multiplying the area of the subsection by the mean vertical velocity for that subsection. The total discharge is equal to the sum of the discharges for all subsections.

Float measurements of discharge that are carefully made under favorable conditions may be accurate to within ±10 percent. Wind may adversely affect the accuracy of the computed discharge by its effect on the velocity of the floats. If a nonuniform reach is selected and few floats are used in the cross section, measurement results may be in error by as much as 25 percent.

VOLUMETRIC MEASUREMENT

The volumetric measurement of discharge is only applicable to small discharges, but it is the most accurate method of measuring such flows. In that method the hydrographer observes the time required to fill a container of known capacity, or the time required to partly fill a calibrated container to a known volume. The only equipment required, other than the calibrated container, is a stopwatch.

The container is calibrated in either of two ways. In the first method, water is added to the container by known increments of volume, and the depth of water in the container is noted after the addition of each increment. In the second method, the empty container is placed on a weighing scales, and its weight is noted. Water is added to the container in increments, and after each addition the total weight of container and water is noted, along with the depth of water in the container. The equation used to determine the volume corresponding to a depth that was read is

$$V = \frac{W_2 - W_1}{w}, \qquad (42)$$

where

V = volume of water in container, in cubic feet or cubic meters,
W_2 = weight of water and container, in pounds or kilograms,

W_1 = weight of empty container, in pounds or kilograms, and
w = unit weight of water, 62.4 lb/ft^3 or 1,000 kg/m^3.

Volumetric measurements are usually made where the flow is concentrated in a narrow stream, or can be so concentrated, so that all the flow may be diverted into a container. Examples of sites presenting the opportunity for volumetric measurement of discharge are a V-notch weir; an artificial control where all the flow is confined to a notch or to a narrow width of catenary-shaped weir crest; and a cross section of natural channel where a temporary earth dam can be built over a pipe of small diameter, through which the entire flow is directed. Sometimes it is necessary to place a trough against the artificial control to carry the water from the control to the calibrated container. If a small temporary dam is built, the stage behind the dam should be allowed to stabilize before the measurement is begun. The measurement is made three or four times to be certain no errors have been made and to be sure the results are consistent.

Volumetric measurements have also been made under particular circumstances when no other type of measurement was feasible. One such circumstance involved a small stream that was in actuality a series of deep pools behind broad-crested weirs that acted as drop structures to dissipate the energy of the stream. At low flows the depth of water on the weir crest was too shallow to be measured by current meter, and the velocity in the pools was too slow for such measurement. To measure the discharge a large container of known volume was placed on a raft held close to the downstream weir face by ropes operated from the banks. A sharp-edged rectangular spout of known width was held so that one end butted tightly against the downstream face of the weir, the base of the spout being held just below the weir crest. The other end of the spout led to the container of known volume. Timed samples of the flow, sufficient to fill the container, were taken at a number of locations along the downstream face of the weir, the raft being moved laterally across the stream, from location to location, by the ropes. The procedure was analogous to making a conventional current-meter discharge measurement. Instead of measuring depth and velocity at a series of observation sites in the cross section, as is done in a current-meter measurement, the discharge per width of spout opening was measured at a series of observation sites. The discharge measured at each site was multiplied by the ratio of subsection width to spout width to obtain the discharge for the subsection. The total discharge of the stream was the summation of the discharges computed for each subsection.

A portable weir ↑ ɜrmining discharge

APPENDIX D