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QUALITY CONTROL/QUALITY ASSURANCE DOCUMENTATION

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1.0 SCOPE AND APPLICABILITY

This document presents the North Dakota Department of Environmental Quality, Division of Water Quality's (DWQ) Standard Operating Procedure (SOP) for measuring stream discharge at wadable streams, round culverts, and weirs. This SOP applies to all DWQ field staff, non-DWQ cooperators, and citizen volunteers.

2.0 BACKGROUND

Stream discharge measurements are used to help inform water body condition and uses (for example, water quality assessments) and are needed for pollutant loading calculations (for example, Total Maximum Daily Loads). Flow data is available on major rivers in North Dakota from United States Geological Survey (USGS) gaging stations and water level data is available from select stream sites from ND Department of Water Resources remote sensing stations (PRESENS). Flow data on non-major rivers and streams throughout the state is largely unavailable. Where hydrologic conditions and watershed size are similar, the Drainage Area Ratio (DAR) method may be applied to estimate unknown streamflow. Where the DAR method is not appropriate or requires supplemental data (due to dissimilar hydrologic conditions and drainage areas), flow data can be collected using a wading rod.

Flow is measured to calculate instantaneous discharge and to develop a hydraulic volume rating curve. For hydraulic rating curve development stage measurements are collected over the entire range of stage and flow for accuracy.

The rating curve is calculated either mathematically using a slope equation that best fits the field data [discharge (cfs) = M (stage (ft)) + B], or by plotting the relationship. When calculating the relationship, M is the slope and B is the y-axis intercept. Both will be derived from a regression using flow as the dependent variable and stage as the independent variable.

Ideally the regression R^2 value should be greater than 0.85 and significant at the $p \leq 0.05$ level. When graphed the calculated curve should be a close fit to the actual data at the high flow, median flow, and low flow. When a satisfactory equation has been calculated for a particular site, it can then be used for many years to estimate average daily discharge with a minimum of annual maintenance measurements.

Careful selection of sampling sites can greatly reduce the amount of work required to calculate accurate discharge measurements. Ideal sites are weirs, bridges, box culverts and round culverts. The advantage of these sites is that a minimum number of measurements are needed to determine a significant flow and stage relationship, and discharge measurements are possible from above during high flow periods. When none of the above situations exist and the stream is small enough, a temporary weir may be constructed to aid in collecting flow measurements.

Flow readings should be collected from the same location throughout the study period. If for any reason the location must be moved, data will be collected at both sites over a wide enough range in flow to ensure accuracy is not lost during transition. The new location will be noted in the field log along with an explanation as to why it was moved.

3.0 HEALTH AND SAFETY WARNING

A minimum of 2 field personnel should be present. Field personnel should take appropriate precautions when working on, in, or around water. All personal should be equipped with safety equipment such as personal flotation devices (PFD's), communication device, etc.

Field personnel should be aware that hazardous conditions potentially exist at every waterbody. If unfavorable conditions are present at the time of measurement, the site visit should be rescheduled. If hazardous weather conditions arise during measurements, such as lightning, high winds, or high flow/flooding, personnel should cease measuring and move to a safe location.

Field personnel should also be aware of wildlife, insects, and plants that could be harmful as well as heat and cold related illnesses. A first aid kit should be accessible for any potential cuts, stings, bites, or contact with poisonous plants. Ensure there is access to drinking water, sunscreen, insect repellant, and extra clothing.

4.0 PRECAUTIONS

- Care should be taken not to disturb sediment and/or substrate during sample collection.
- Use calibration checks to ensure devices are working correctly.
- Sensor must be checked before each sampling season to ensure that they are in working condition. Send to manufacturer for maintenance if necessary.
- Do not use damaged equipment.
- All units should be in imperial.
- Handheld meters should not be left in vehicles overnight and should be stored at room temperature. Note: if using a pygmy meter, the shipping plug should be installed.

- Wading rod should not be used as walking stick to prevent damage.

5.0 INTERFERENCES

In waterbodies that have muddy or soft bottoms it is preferred to use a device such as a FlowMate 2000 or Pygmy meter, rather than an ADCP device. These devices can be used independently, or in conjunction with FlowTracker 2 (SOP 7.33) measurements as a benchmark.

6.0 PERSONNEL QUALIFICATIONS/RESPONSIBILITIES

All personnel taking field measurements using a discharge measuring device must read this SOP and acknowledge they have done so via a signature page (see Appendix B). New field personnel must also demonstrate successful performance of the method. The signature page will be signed by both trainee and trainer to confirm that training was successfully completed and that the new personnel is competent in carrying out this SOP. The signature page will be kept on-file at DWQ along with the official hard copy of this SOP.

7.0 EQUIPMENT AND SUPPLIES

- ☐ Flo - Mate 2000 or CMD 9000 Digimeter with pygmy meter
- ☐ Wading rod
- ☐ User manuals
- ☐ Field Measurement Form (Appendix A)
- ☐ D or 9v batteries (min. 2)
- ☐ 5-gallon bucket
- ☐ Stakes
- ☐ Hammer
- ☐ Measuring tape reel
- ☐ Adjustable wrench
- ☐ Microfiber cloth
- ☐ Sprayer with clean water
- ☐ Waders
- ☐ Personal Flotation Devices (PFD)
- ☐ Communication device
- ☐ First aid kit
- ☐ Clip board
- ☐ Pencils / pens

- Sunscreen
- Bug spray

8.0 PROCEDURE

Collecting Discharge in Wadable Streams

Measuring stream discharge is accomplished by collecting cross sectional measurements of flow velocities, stream width and stream depth. General guidelines for distance between measurements are 1 foot for streams 20 feet wide or less, 2 feet for streams 21 to 40 feet across, and 3 feet for streams greater than 40 feet (Turnipseed, D., and Sauer, V. 2010).

No individual section measured should exceed 10 percent of the total stream discharge. If a segment exceeds 10 percent, additional measurements will be collected until less than 10 percent of total flow is represented in all sections.

Flow velocity in segments 3 feet or less will have a single measurement collected at 60 percent of the total depth. Segments greater than 3 feet will have 2 measurements collected: one at 20 percent of the total depth and one at 80 percent of the total depth (Turnipseed, D., and Sauer, V. 2010).

1. Fill out upper portion of Field Measurement Form (Appendix A) including STORET number, date, time, sampler(s), description of site, gauge height, method, and type of meter.
2. Anchor the tape at the near shore and stretch it across the stream at a perpendicular to stream flow.
3. Check meter calibration according to owner’s manual.
4. Segment 1 begins at the left edge of water (left bank facing downstream).
5. The first reading is at the water’s edge and recorded as segment 1. Distance, depth, and velocity are all zero.
6. Enter the waterbody downstream of the tape. Face into the current with the rod upstream of your body so as not to influence flow.
7. The second reading should be taken as soon as the stream reaches a depth of 0.2 or 0.4 feet, or one half of the distance to the following segment.
8. Record the distance from point 1 and the water depth.
9. Adjust the velocity meter to 60% of the depth.
10. Slowly pivot the velocity meter back and forth until the greatest velocity at that segment is found.
11. Record the velocity.

12. Repeat steps 6 through 9 until the opposite bank is reached. The final reading is the right edge of water. As was the case with segment 1, depth and velocity are zero.
    a. Discharge will be calculated individually for each segment. The flow is the area multiplied by velocity. The total discharge is the sum of segments.

Collecting Discharge in Round Culverts

1. Measure the radius (R) of the culvert in feet.
2. Measure water depth (D) in center of culvert in feet.
3. Measure velocity (V) in the center of the culvert at 60% of total water depth, if 3 feet deep or less. Measure the velocity (V) at 20% and 80% of total water depth if greater than 3 feet deep.
4. Calculate the area (A) of the discharge with the following formula:
5. $Area\ (A) = \frac{\pi R^2}{2} + [R - D\sqrt{R^2 - (R-D)^2} + R^2 arcos(\frac{R-D}{R})]$
6. Calculate discharge (cfs) by the following formula:
7. Discharge (cfs) = V (0.8)*A
8. Where: V (0.8) = average velocity of the discharge
    a. A = area of the discharge

Collecting Discharge at a Weir

1. To physically measure discharge over a weir the procedure is the same as in an open stream bed. The first reading is taken on the edge of the nearest wall of the weir, the second and subsequent readings are taken over the top of the weir ending on the farthest wall.

2. To mathematically estimate discharge over a weir the following formula is used:

$Q = MLH' \sqrt{2} GH$

Where: Q = discharge in cubic feet/second (cfs)

$M = (0.405 + 0.\frac{00984}{H})'(1 + 0.55(\frac{H}{P+H})^2)$

L = length of weir in feet

H = head (feet)

G = the acceleration due to gravity = 32.16 feet/second

P = the height (feet) of the head over the downstream surface

When using the above equation many variables affect the accuracy of the output. To ensure accurate computations, a limited amount of physical discharge measurements should be collected, with a variation of less than five percent.

9.0 DATA AND RECORDS MANAGEMENT

Discharge measurements will be recorded using a Field Measurement Form (Appendix A). Discharge forms should be scanned and saved in the Y drive (see below). All calculations should be done in Excel and saved with the scanned Discharge Form.

Y:\WATER\SURFACE\9_RiverAssessment\Flow Tracker 2\Data Downloads\[Site Number]\[Date:YYYY_MM__DD]

10.0 QUALITY ASSURANCE AND QUALITY CONTROL

The meter(s) should be calibrated before sampling trip following the manufacturer's instructions. If discharge at a section is questionable, either remeasure or test results against a different device if available.

11.0 ANS DECONTAMINATION

In waters that have been classified as ANS infested, the meter (and accompanying equipment) must be decontaminated. To decontaminate the meter a clean water source should be used. Rinse the probe with clean water, hand dry, and air dry for 8 hours completely before storing. Please refer to the NDDEQ Aquatic Nuisance Species Decontamination Measures (SOP 7.26) for further details.

12.0 REFERENCES

Gibs, J., Wilde, F., and Heckathron H. 2007. *Use of Multiparameter Instruments for Routine Field Measurements. U.S. Geological Survey TWRI Book. Version 1.1.* U.S. Geological Survey

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Turnipseed, D., and Sauer, V. 2010. *USGS Discharge Measurements at Gaging Stations. Chapter 8 of Book 3, Section A.* U.S. Geological Survey. Reston, Virginia.

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APPENDIX A
Field Measurement Form

Field Measurement Form

North Dakota Department of Environmental Quality
Division of Water Quality
Watershed Management Program

Project Code:		Project Name:	
Site Identification:		Site Description:	
Date:	Sampler(s):		
Method:	Meter No.	Meter Type:	Discharge Units:
No. Sections:	Stage Start:	Stage End:	Stage change:
Samples Collected:	Time Start:	Time End:	Time change:
Comments:			

Distance from Point (ft)	Width (ft)	Depth (ft)	Velocity(ft/sec)	Area (ft^2)	Discharge (cfs)

Distance from Point (ft)	Width (ft)	Depth (ft)	Velocity(ft/sec)	Area (ft^2)	Discharge (cfs)

APPENDIX B

SOP Acknowledgement and Training Form

SOP Acknowledgement and Training Form

This SOP must be read, and this form signed annually. This form must be kept with the latest version of the SOP.

Document Title:	
Document Revision Number:	
Document Revision Date:	

<u>Please sign below in accordance with the following statement:</u>
"I have read and understand the above referenced document. I agree to perform the procedures described in this SOP in accordance with the document until such time that it is superseded by a more recent approved revision."

Printed Name	Signature	Date

SOP Acknowledgement and Training Form (cont.)

Trainee: Sign below to acknowledge that training on this SOP was received, understood, and all questions/concerns were addressed by the trainer.

Trainer: Sign below to acknowledge that training on this SOP was completed for the individual listed and that training is competent to perform the procedures described within.

Date of Training	Trainee Printed Name	Trainee Signature	Trainer Printed Name	Trainer Signature