DEPARTMENT OF
ECOLOGY
State of Washington

Standard Operating Procedure
EAP115, Version 1.2

Watershed Health Monitoring: Measuring Riparian Cover Using a Convex Densiometer

Purpose of this document

The Washington State Department of Ecology develops Standard Operating Procedures (SOPs) to document agency practices related to sampling, field and laboratory analysis, and other aspects of the agency's technical operations.

Publication information

This SOP is available on the Department of Ecology's website at
https://fortress.wa.gov/ecy/publications/SummaryPages/1803220.html

Ecology's Activity Tracker Code for this SOP is 18-043.

Contact information

For more information contact:

Communications Consultant
Environmental Assessment Program
P.O. Box 47600, Olympia, WA 98504-7600
Phone: 360-407-7680

Washington State Department of Ecology – https://ecology.wa.gov

Location of Ecology Office	Phone
Headquarters, Lacey	360-407-6000
Northwest Regional Office, Bellevue	425-649-7000
Southwest Regional Office, Lacey	360-407-6300
Central Regional Office, Union Gap	509-575-2490
Eastern Regional Office, Spokane	509-329-3400

Washington State Department of Ecology

Environmental Assessment Program

Watershed Health Monitoring: Standard Operating Procedures for Measuring Riparian Cover Using a Convex Densiometer

Version 1.2

Author -   Chris Hartman
Date -

Reviewers -   Welles Bretherton, George Onwumere, Glenn Merritt and Meghan Rosewood-Thurman
Date -

QA Approval - William R. Kammin, Ecology Quality Assurance Officer
Date -

EAP115

Please note that the Washington State Department of Ecology's Standard Operating Procedures (SOPs) are adapted from published methods, or developed by in-house technical and administrative experts. Their primary purpose is for internal Ecology use, although sampling and administrative SOPs may have a wider utility. Our SOPs do not supplant official published methods. Distribution of these SOPs does not constitute an endorsement of a particular procedure or method.

Any reference to specific equipment, manufacturer, or supplies is for descriptive purposes only and does not constitute an endorsement of a particular product or service by the author or by the Department of Ecology.

Although Ecology follows the SOP in most instances, there may be instances in which the Ecology uses an alternative methodology, procedure, or process.

SOP Revision History

Revision Date	Rev number	Summary of changes	Sections	Reviser(s)
2/21/17	1.1	Title, footers, general formatting, updated glossary terms, updated references	All	Meghan Rosewood-Thurman
2/23/2017	1.2	cites Merritt, 2017 & Hartman, 2017 (Merritt, 2015) becomes (Hartman 2017: see Table 1)	2.1 3.5	Glenn Merritt
		"Index Station:" duplicate removed	3.8	
		"and most-frequently longer than 500 m"	3.16	
		Added reference to SOP EAP105	6.1	
		Edited Figure 3 caption		
		Edited figure 4 caption		
		Reference Hartman rather than Merritt	6.3.1	
		Cited EAP105 = Hartman, 2017	10.5	
		Updated link	10.12	

Environmental Assessment Program

Watershed Health Monitoring: Standard Operating Procedures for Measuring Riparian Cover Using a Convex Densiometer

1.0 Purpose and Scope

1.1   This document is the Environmental Assessment Program (EAP) Standard Operating Procedure (SOP) for measuring riparian, shade-producing cover using a convex densiometer during a Data Collection Event (DCE) for the Watershed Health Monitoring (WHM) program or related studies. It applies to DCEs performed using either the WHM Narrow Protocol or the WHM Wide Protocol.

2.0 Applicability

2.1   This SOP is used in combination with other SOPs to complete a DCE for the Watershed Health Monitoring Program. This method is used among densiometer stations within a site. It should only be used after completing one of the site layout SOPs (Merritt, 2017 or Hartman, 2017).

2.2   Data collected with the method outlined in this SOP are used to calculate physical habitat metrics that quantify riparian cover at a site (Janisch, 2013).

3.0 Definitions

3.1   Bankfull margin: A term used to describe the limit of the stream channel. It is a line on the bank that coincides with the water's elevation during bankfull flow.

3.2   Bankfull Stage: This stage is delineated by the elevation point of incipient flooding, indicated by deposits of sand or silt at the active scour mark, break in stream bank slope, perennial vegetation limit, rock discoloration, and root hair exposure (Endreny 2003).

3.3   Convex densiometer: A Strickler (1959)-modified convex densiometer (Figure 1).
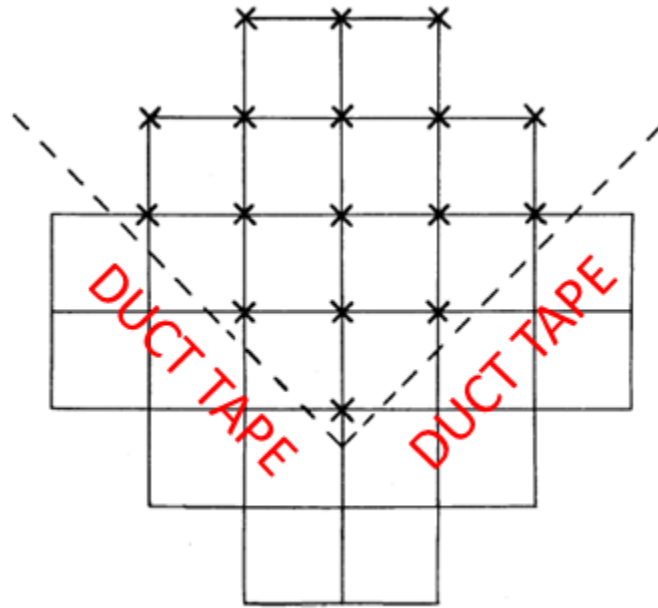

Figure 1. The taped densiometer grid, based on Strickler (1959), with 17 cross-hairs exposed.

3.4   DCE: The *Data Collection Event* is the sampling event for the given protocol. Data for a DCE are indexed using a code, which includes the site ID followed by the year, month, day, and the time (military) for the start time of the sampling event. For example: WAM06600-000222-DCE-YYYY-MMDD-HH:MM. One DCE should be completed within one working day, lasting 4-6 hours, on average.

3.5   Densiometer stations: These are the locations where the convex densiometer is used to measure riparian cover. There are different numbers of densiometer stations, depending upon the protocol (Narrow or Wide). All stations are within the main channel:

- Bank stations for Narrow Protocol – There are 22 per site (both bankfull margins of every major transect). Hold the densiometer level, and 30cm above water for wet stations and 30cm above ground for dry stations
- Bank stations for Wide Protocol – There are 11 per site (one bankfull margin per major transect). The bank measured at each transect is the determined by Hartman (2017: See Table 1). Hold the densiometer level, and 30cm above water for wet stations and 30cm above ground for dry stations.
- Mid-channel stations (only for Narrow Protocol). There are 44 per site (facing left/up/right/down at halfway across the bankfull channel at each major transect). Hold the densiometer level, and 30cm above water for wet stations and 30cm above ground for dry stations

3.6   EAP: Environmental Assessment Program

3.7   Ecology: The Washington State Department of Ecology

3.8   Index station: The distinct point location mapped by the site coordinates obtained from the Washington Master Sample List. The index station is called "X" and is generally located at major transect F; however the point may occur at any elevation in the stream between transects A and K.

3.9   Left bank: A person facing downstream will have the left bank on their left side.

3.10   Main channel: Channels in a stream are divided by islands (dry ground that rises above bankfull stage). Main channels contain the greatest proportion of flow.

3.11   Major transect: One of 11 equidistant transects across the length of a site. These transects run perpendicular to the thalweg and are labeled as follows: A (furthest downstream), B, C, D, E, F, G, H, I, J, and K (furthest upstream).

3.12   Narrow Protocol: The set of Watershed Health Monitoring SOPs that describe data collection at wadeable sites with an average bankfull width of less than 25m at the index station.

3.13   Protocol: A collection of SOPs used to accomplish a DCE. Watershed Health Monitoring uses two protocols: the *Narrow Protocol* is used for sampling wadeable streams that are less than 25m average bankfull width, and the *Wide Protocol* is used for rivers or streams that are wider than 25m average bankfull width or too deep to wade.

3.14   QAMP: Quality Assurance Monitoring Plan. The QAMP for WHM is Cusimano et al., (2006). An updated version is in early stages of development.

3.15   Right bank: A person facing downstream will have the right bank on their right side

3.16   Site: A site is defined by the coordinates provided to a sampling crew and the boundaries established by the protocol's site layout method: SOP EAP105 (Hartman, 2017) for the Wide Protocol, and SOP EAP106 (Merritt, 2017) for the Narrow Protocol. Typically, a site is centered on the index station and equal in length to 20 times the average of 5 bankfull width measurements. Sites cannot be longer than 2km nor shorter than 150m. Narrow protocol sites range from 150m to 500m long. Wide Protocol sites are up to 2km long, and most frequently longer than 500m. The most downstream end of a site coincides with major transect A; the most upstream end coincides with major transect K.

3.17   WHM: Watershed Health Monitoring. A status- and trend-monitoring program within the Environmental Assessment Program at the Washington State Department of Ecology.

3.18   Wide Protocol: The set of WHM SOPs that describes the sample and data collection at non-wadeable sites or sites wider than 25m bankfull width. It is an abbreviated version of the Narrow Protocol and is typically accomplished by use of rafts.

4.0	**Personnel Qualifications/Responsibilities**

4.1	This SOP pertains to EAP field staff performing Watershed Health Monitoring (WHM) or related studies.
4.2	All field staff must comply with the requirements of the EAP Safety Manual (Ecology, 2017).
4.3	All field staff must have completed the annual WHM program field training and be familiar with the set of SOPs that combine to describe a full DCE for the WHM program.
4.4	All field staff must be familiar with the electronic data recording tablet and web-based field forms that one uses to record and submit data for the WHM program, see SOP EAP125 (Janisch, 2017).
4.5	The field lead directing sample collection must be knowledgeable of all aspects of the project's Quality Assurance Monitoring Plan (QAMP) to ensure that credible and useable data are collected. All field staff should be briefed by the field lead or project manager on the sampling goals and objectives prior to arriving to the site.
4.6	All field staff must comply with SOP EAP070 (Parsons et al., 2016), *Minimizing the Spread of Invasive Species*.

5.0	**Equipment, Reagents, and Supplies**

5.1	Field tablet (charged) loaded with electronic field forms.
5.2	Full set of paper versions of data forms, with pencil and clip board (as contingency).
5.3	Convex densiometer (See Figure 1).
	Note: A convex densiometer has a **high**-point in the middle.
5.4	Wading/rafting gear (pre-cleaned of organisms; see Parsons et al., 2016).

6.0	**Summary of Procedure**

6.1	Based on site verification and layout, SOP EAP106 (Merritt, 2017) and SOP EAP105 (Hartman, 2017), determine if the site qualifies for the Narrow Protocol or the Wide Protocol. If using the Narrow Protocol, measure cover with the densiometer while facing each bank of each major transect, plus 4 directions in mid-channel of each major transect. (Figures 2 and 3). If using the Wide protocol, use the densiometer at just one bank for each of the 11 major transects (Figure 4).
	Note: This SOP was largely adapted from field methods of the Environmental Protection Agency's Environmental Monitoring and Assessment Program (see Stoddard et al., 2005).

Note: A complete Narrow Protocol DCE has 66 densiometer measurements; a complete Wide Protocol DCE has 11 densiometer measurements.
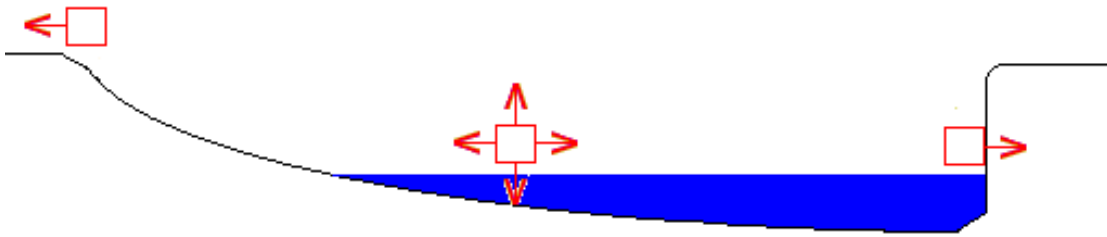

Figure 2. Densiometer stations at a major transect for the Narrow Protocol.

facing upstream   facing downstream   facing the left bank   facing the right bank

Figure 3. Densiometer measurements at 4 mid-channel stations (Figure from CSWRCB 2010; pictured is Emily Corona). Mid-channel stations are only measured for the Narrow Protocol.

Figure 4. Densiometer station at one bank of each major transect for the *Wide Protocol*. Bank choice is determined by Table 1 of Hartman (2017).

6.2   Measuring Riparian Cover for the Narrow Protocol

6.2.1   Measure and record densiometer at **22 bank stations.**

6.2.1.1   Find the "Channel" tab on each "Transect" page (Figure 5) for each major transect.

Figure 5: The "Channel" tab on the "Transect" page contains the densiometer data fields for bank stations (e.g., right bank data goes in red box).

6.2.1.2   At each bank station, **position the densiometer** properly:

- Place 30cm above water (if present) or ground at the bankfull margin.
- Ensure densiometer is level (see Figure 6)
- Face the bank with head reflection just below the visible cross-hairs (see Figure 6)

Note: *The measurement should be able to detect shade from riparian understory vegetation such as ferns and grasses*
Note: *Water might be present at the bankfull margin if the bank is vertical or undercut.*
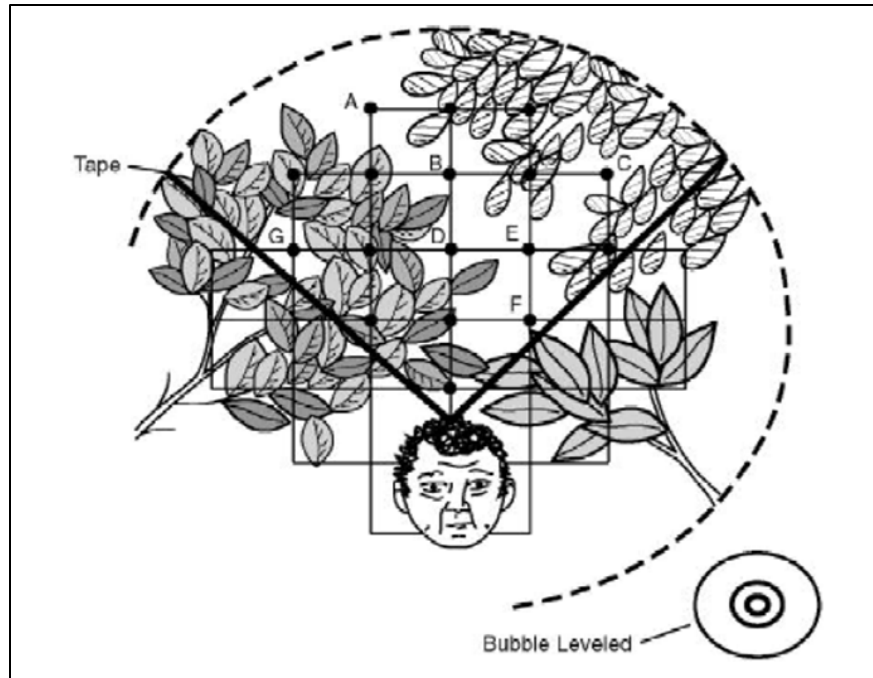
Figure 6: Position of viewer when using the densiometer (from Mulvey et al., 1992).

6.2.1.3 **Observe** the number of cross-hairs where shade-producing objects are reflected. This should be the same as 17 minus the number of cross-hairs that reflect open sky. **Record** this value on the "Transect" page (Figure 5).

Note: Count cover from anything that provides shade. This does not have to be vegetation. Bridges, culverts, or other manufactured objects count.

6.2.2 Measure and record densiometer at **4 mid-channel stations per major transect**.

6.2.2.1 Find the "Substrate" tab on each "Transect" page (Figure 7) for each major transect.

6.2.2.2 At each mid-channel station, **position the densiometer** properly:

- Place 50% of distance across bankfull channel.
- Place 30 cm above water (if present) or ground (see Figure 3).
- Ensure densiometer is level (see Figure 6).
- Face the direction in question (upstream, left, downstream, or right) with head reflection just below the visible cross-hairs (see Figure 6).

6.2.2.3 **Observe** the number of cross-hairs where shade-producing objects are reflected. This should be the same as 17 minus the number of cross-hairs that reflect open sky. **Record** this value on fields accessed through the "Substrate" tab of the "Transect" page (Figure 7).

Note: *Count cover as anything that provides shade. This does not have to be vegetation. Bridges, culverts, or other manufactured objects count.*

Figure 7. The "Substrate" tab on the "Transect" page.

6.3   Measuring Riparian Cover for the *Wide Protocol*

6.3.1   Measure and record densiometer at 11 **bank stations** assigned by site layout for the Wide Protocol (Hartman, 2017).

6.3.1.1   Find the "Channel" tab on each "Transect" page (Figure 5) for each major transect.

6.3.1.2   At each bank station, **position the densiometer** properly:

- Place 30 cm above water (if present) or ground at the bankfull margin.
- Ensure densiometer is level (see Figure 6)
- Face the bank with your head reflection just below the visible cross-hairs (see Figure 6)

Note: *The measurement should be able to detect shade from riparian understory vegetation such as ferns and grasses.*
Note: *Water might be present at the bankfull margin if the bank is vertical or undercut.*

6.3.1.3　**Observe** the number of cross-hairs where shade-producing objects are reflected. This should be the same as 17 minus the number of cross-hairs that reflect open sky. **Record** this value on the "Transect" page (Figure 5).

Note: Count cover from anything that provides shade. This does not have to be vegetation. Bridges, culverts, or other manufactured objects count.

7.0　**Records Management**

7.1　Refer to SOP EAP125 Janisch (2017) which describes the process for validating, loading, and committing completed electronic field forms to the database.

8.0　**Quality Control and Quality Assurance Section**

8.1　PROJECT QA/QC is discussed in the Quality Assurance Monitoring Plan (Cusimano et al., 2006), which is in the process of being updated.

8.2　SAMPLING PRECISION: Repeat the sampling for 10% all sites per year per Status and Trends Region. Timing of replicates should be several weeks or later than initial samples (as far apart in time as possible but within the same index period).

8.3　SAMPLING ACCURACY: Persons using this SOP must either attend the annual training event (June), or be trained by someone who did.

8.4　REPRESENTATIVENESS: Densiometer measurements should be made on the same day that all other data are collected for the DCE.

9.0　**Safety**

9.1　All field staff must comply with the requirements of the EAP Safety Manual (Ecology, 2017).

10.0　**References**

10.1　CSWRCB. 2010. The Clean Water Team Guidance Compendium for Watershed Monitoring and Assessment. State Water Resources Control Board SOP-4.9.1.1 (MCC) 2010. http://www.waterboards.ca.gov/water_issues/programs/swamp/docs/cwt/guidance/4911.pdf

10.2   Cusimano, R., G. Merritt, R. Plotnikoff, C. Wiseman, C. Smith, and WDFW. 2006. Status and Trends Monitoring for Watershed Health and Salmon Recovery: Quality Assurance Monitoring Plan. http://ecyapfass/Biblio2/documents/0603203.pdf

10.3   Ecology, 2015. Environmental Assessment Program Safety Manual. Washington State Department of Ecology. Olympia, WA. http://teams/sites/EAP/Pages/safety.aspx

10.4   Endreny, T.A. 2003. Fluvial Geomorphology Module, UCAR COMET Program and NOAA River Forecast Center, Syracuse, NY.
http://www.fgmorph.com

10.5   Hartman, C. 2017. Watershed Health Monitoring: Standard Operating Procedures for GIS-Based Verification, Layout, and Data Collection (Wide Protocol) EAP105. Washington State Department of Ecology, Environmental Assessment Program, Olympia. http://www.ecology.wa.gov/programs/eap/quality.html

10.6   Janisch, J. 2013. Dictionary of Metrics for Physical Habitat: Definitions and Calculations Used for Watershed Health Monitoring and Related Studies. Washington State Department of Ecology.
https://fortress.wa.gov/ecy/publications/SummaryPages/1303033.html

10.7   Janisch, J. 2017. Watershed Health Monitoring: Standard Operating Procedures for Managing Electronic Data Forms with a Mobile Data-Collection Device. SOP EAP125. Washington State Department of Ecology, Environmental Assessment Program, Olympia. http://www.ecology.wa.gov/programs/eap/quality.html

10.8   Merritt, G. 2017. Watershed Health Monitoring: Standard Operating Procedures for Verification and Layout of Sites (Narrow Protocol) SOP EAP106. Washington State Department of Ecology, Environmental Assessment Program, Olympia.
http://www.ecology.wa.gov/programs/eap/quality.html

10.9   Mulvey, M, L. Caton, and R. Hafele. 1992. Oregon Nonpoint Source Monitoring Protocols and Stream Bioassessment Field Manual for Macroinvertebrates and Habitat Assessment, Draft. Oregon Department of Environmental Quality, Portland, Oregon.

10.10   Parsons, J., D.Hallock, K.Seiders, B.Ward, C.Coffin, E.Newell, C.Deligeannis, and K. Welch 2016. Standard Operating Procedures to Minimize the Spread of Invasive Species, EAP 070. Washington State Department of Ecology, Environmental Assessment Program, Olympia. Version 2.1
http://www.ecology.wa.gov/programs/eap/quality.html

10.11   Strickler, G.S. 1959. Use of the densiometer to estimate density of forest canopy on permanent sample plots. Research Note No.180. United States Department of Agriculture Forest Service, Portland, Oregon.
http://www.treesearch.fs.fed.us/pubs/25832

10.12   Stoddard, J. L., D. V. Peck, S. G. Paulsen, J. Van Sickle, C. P. Hawkins, A. T. Herlihy, R. M. Hughes, P. R. Kaufmann, D. P. Larsen, G. Lomnicky, A. R. Olsen, S. A. Peterson, P. L. Ringold, and T. R. Whittier. 2005. *An Ecological Assessment of Western Streams and Rivers*. EPA 620/R-05/005, U.S. Environmental Protection Agency, Washington, DC. https://archive.epa.gov/emap/archive-emap/web/html/wstriv.html