

Washington State Department of Ecology

Environmental Assessment Program

Standard Operating Procedures for Surveying Morphology and Surface Flow of Headwaters Channels

Version 1.0

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EAP014

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Signatures on File

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.

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

Environmental Assessment Program

Standard Operating Procedure for Surveying Morphology and Surface Flow of Headwaters Channels

1.0 Purpose and Scope

- 1.1 This document is the Environmental Assessment Program (EAP) Standard Operating Procedure (SOP) for assessing seasonal dry-down and wet-up patterns of headwaters (Dept. of Natural Resources water Types 4 and 5) channels.
- 1.2 In seasonally dry climates, surface runoff to drainages is much reduced for several months. During this period, streams deriving volume primarily from surface flow or interflow rather than ground water may dry down completely until rainfall resumes. Other streams, however, express complex dry-down and wet-up patterns. These patterns are often non-uniform, varying along channel length in response to water sources, gradient, substrate, and evapo-transpirational demand. To assess these patterns, as well as changes between years or following disturbances such as clearcutting, surface flow can be tracked via a two stage process. In stage 1, a confluence-to-PIP, gradient and morphology survey is applied, dividing the channel into adjacent, numbered, sub-segments. In stage 2, categorical surface-flow codes are assigned by walking the channel and rating each segment. The bank-full zone (BFZ) thus functions as a segmented belt transect which can be repeatedly rated for surface flow over time. The resultant data can be displayed as a time series of polyline shapefiles showing length and bearing of each segment, geo-referenced to GPS coordinates, and a categorical color gradient indicating percent surface flow. Lastly, a general approach for estimating volume (optional) is outlined.

2.0 Applicability

- 2.1 Headwaters or other low-order streams which are: 1) difficult to digitize due to forest canopy, 2) not represented/inaccurately represented on state hydrology layers, 3) analyzed via detailed channel morphology-surface flow pattern relationships, 4) revisited to describe through time.

3.0 Definitions

- 3.1 Bankfull: if the stream is entrenched, then a scour line, bench, or top of the point bar. If the stream is not entrenched, then the top of the bank.
- 3.2 Bankfull zone: width of the channel between ordinary bankfull marks on opposite banks. It is essentially a belt transect of variable width.
- 3.3 Headwall: cirque-like or amphitheater-shaped hollow (often <30 m wide) at the uppermost end of a drainage basin, collecting and focusing broad seepages into channelized flow. This feature may be absent in low-gradient terrain or when surface flow is initiated by a spring.

- 3.4 Headwaters: terminal watershed basins where transfer of ground and sheet flow to channelized surface flow is initiated. Headwaters streams are often short, of high gradient, of low basin area, and seasonal.
- 3.5 Percent surface flow: for a given channel segment, wetted channel length divided by total segment length, in meters, rounded to the nearest 10%.
- 3.6 Perenniality initiation point (PIP): uppermost point in the basin where surface water is flowing down slope in a defined channel. When a headwall is present, the headwall is the PIP. Otherwise, the PIP is the break point between seasonal and perennial flow. For further detail, see Forest Practices Board Manual, Section 23.
- 3.7 Type 4 water: perennial stream <2 ft diameter bankfull. A subset of WA Dept. of Natural Resources (DNR) new waters classification Type N_p (non-fish bearing perennial).
- 3.8 Type 5 water: seasonal stream < 2 ft diameter bankfull. A subset of DNR new waters classification Type N_s (non-fish bearing seasonal).
- 3.9 Wide angle augmentation system (WAAS): one form of real-time differential correction, using the International Terrestrial Reference Frame (ITRF 2000) and broadcasting on NAVSTAR channels. Usually (but not always) available during optimal GPS windows.
- 4.0 Personnel Qualifications/Responsibilities**
- 4.1 Ability to create shapefiles, populate/edit attribute tables, and assign projections. Understanding of datums, coordinate systems and other terms related to GPS operation. Understanding of slope correction. Prior experience working safely and efficiently on steep forested or slash-covered slopes and/or steep-walled headwaters channels. Ability to navigate on unimproved roads with maps and compass. First aid training.
- 4.2 Typical Job Class: aptitude for field tasks is more relevant than job class.
- 5.0 Equipment, Reagents, and Supplies**
- 5.1 Equipment: compass, clinometer, laser range finder (or hipchain or 50 m tape), 15 m tape, WAAS-enabled GPS receiver, clipboard, height gauge, water proof calculator, copy of survey methods, satellite constellation forecast.
- 5.2 Reagents: none
- 5.3 Supplies: data sheets, pencils, flagging, paint markers, extra batteries

6.0 Summary of Procedure

- 6.1 STREAM MORPHOLOGY SURVEY: Methods 6.2-6.6 outline key features of DNR's small stream morphology survey. In its simplest form, segment breaks are determined only by 5% change in gradient (Method 6.2). To avoid very long and possibly uninformative segmentation, however, channel confinement ratio and change in gradient are weighted together. Often changes in both factors coincide due to influence on stream energy. Begin the survey at the confluence (bottom of the basin). Number each segment sequentially, beginning with segment 1. Repeat methods 6.2-6.4 until the headwall is reached. Rate segment type (6.5) as endpoints are defined. Collect latitude and longitude at the confluence and top of each segment. Time the survey to overlap optimal GPS windows (see EAP SOP 013).
- 6.1.1 NOTE: Channel geometry can be derived from other data sources such as LIDAR or DNR aerial photos but mapping surface flow via this method requires segmentation.
- 6.2 Percent Gradient: Construct a height gauge from a branch or pole by marking eye height of one of the crew members (crew member 1) on the pole. Wearing the string box, move the pole upchannel (crew member 2) while sighting the marker with a clinometer (crew member 1) until gradient change >5% or length >45 m. Read the clinometer carefully and use the correct scale. This is the preliminary segment endpoint. Mark this point, then assess channel confinement.
- 6.3 Confinement Ratio: Walk the section of channel just surveyed for gradient. If bank height is roughly uniform along the section, locate maximum depth to the ordinary high water mark. Double this height, then move perpendicular to the channel, intercepting the bank on each side at this height. This is the estimated 100-yr floodplain boundary. Divide the 100-yr floodplain width by the bankfull width at this point, then assign one of the ratio categories below. Sections of channel under slumps are confined.
- 6.3.1 Ratio
- | | |
|-------------|---------------------|
| ≤ 2 | Confined |
| $2 < x < 4$ | Moderately Confined |
| ≥ 4 | Unconfined |
- 6.3.2 If bank height is non-uniform, calculate confinement for each sub-region. A change in confinement category indicates a segment boundary. If necessary, adjust the preliminary endpoint. Turn on the laser range finder, toggle to slope correction mode, then measure segment length to the nearest meter. If instead using a tape, apply slope correction later. Sections of uniform gradient and bank height occasionally exceed 45 m. In such cases violating the 45 m length rule may be appropriate. Our experience indicates short segments (<20 m) outnumber long segments. Note whether lengths are slope corrected on the data sheet.

- 6.4 Bearing: Using a compass, estimate the predominant upslope segment bearing to the nearest degree. Note compass type (quadrant, azimuth, etc) and whether lengths are slope corrected on the data sheet.
- 6.5 Coordinates: Confirm the receiver datum is NAD83, the coordinate system is latitude/longitude, and the display units are meters. Record segment break latitude and longitude as well as EPE and number of satellite fixes. If receiving WAAS correction write WAAS in the EPE column. See EAP SOP 013 to optimize GPS accuracy. If the satellite constellation is not favorable, collect coordinates another time.
- 6.6 Segment Type: Assign the single best descriptive code. Work through options as a dichotomous key—e.g., defined vs. not, flowing vs. dry, etc.
- 6.6.1 Defined channel, flowing water
- 6.6.1.1 A dominated by forest floor
- 6.6.1.2 B dominated by mud & sand
- 6.6.1.3 C pea gravel (<1" diam.)
- 6.6.1.4 D gravel (1"-4" diam. aggregate)
- 6.6.1.5 E cobble (4"-10" diam. aggregate)
- 6.6.1.6 F boulder (>10" diam. aggregate)
- 6.6.2 Defined channel, still water
- 6.6.2.1 G $\geq 50\%$ of segment is pool
- 6.6.3 Defined channel, no water
- 6.6.3.1 Use above codes, followed by 1 (e.g., D1)
- 6.6.4 Other
- 6.6.4.1 U $\geq 50\%$ of segment is underground
- 6.6.4.2 I $\geq 50\%$ of segment is wetland
- 6.6.4.3 J headwall
- 6.6.4.4 I/J combination of wetland and headwall
- 6.7 SURFACE FLOW SURVEY: Methods 6.7-6.8 rapidly assess drying and wet up patterns of headwaters (T5/T4) streams. After estimating percent wet channel length, a second categorical code is assigned to describe the dominant surface water pattern of the segment (i.e., dry, pooling, etc) on the day of the survey. To describe how streams change over the dry season, repeat the survey monthly or coordinate with rainfall/ high evapotranspirational demand to produce a time series of shapefiles.

6.7.1 NOTE: Surface water pattern is a coarse estimate. For example, when pooling and intermittent flow both apply to a segment only the dominant pattern is recorded. Users could, however, add additional fields to the data sheet to record multiple codes, then apply multi-field symbology definitions. Also notice that >80% surface flow is assigned continuous flow and that <20% flow is defined as dry. This is because dominant segment pattern was estimated. Users will have to select their own cutoffs given the coarseness (nearest 10%) of the survey.

6.8 Percent Surface Flow: Prior to the survey, fill in segment number and segment length (L) on the data sheet. Measure or estimate total length of wetted channel (WL) to the nearest m. Calculate % flow as (wetted length/total segment length)*100. Round to the nearest 10%.

6.8.1 Code1: This is a categorical description of the dominant surface water pattern on each segment. If only interested in wetted segment length, ignore it. Otherwise, select the single code below which best describes surface flow patterns of the segment. These codes can be combined with percent surface flow for a richer analysis of the data.

6.8.2 Flow categories:

| | Symbol | Term | Definition |
|---------|--------|-------------------|---|
| 6.8.2.1 | CF | continuous flow | unbroken flow (80-100%) |
| 6.8.2.2 | I | intermittent flow | 20-70% CF or broken flow |
| 6.8.2.3 | P | pooling | >50% standing water, >20% wetted |
| 6.8.2.4 | S | seep | H2O film, broad/many sources, >20% wetted |
| 6.8.2.5 | W | wetland | >50% wetland veg, braiding, gley soil |
| 6.8.2.6 | D | dry | <20% surface water, includes moist soil |

6.9 Diagram: Use this block to sketch general wetted and dry sections of each segment. Indicate relative locations of tributary junctions, seeps, etc. The top of the diagram space is the top of the segment (direction of flow arrow points to bottom of segment).

6.9.1 Repeat for each segment until end of channel is reached.

6.10 Shapefiles: Import latitude/longitude pairs into ArcMap, either as geographic coordinates or an appropriate projection. These coordinates provide an independent estimation of stream geometry which can be compared to the line shapefile. Using ArcMap's length-bearing tool (or equivalent) build a polyline shapefile from the stream segment data, originating at the confluence GPS point. If confidence in the confluence coordinates is low (common due to basin walls and overstory), georeference the polyline to several segment break points where overstory interference was minimal.

6.11 VOLUME: Headwaters dry-season volumes are frequently < 200 ml/s, too low and shallow to be assessed by standard stream-gauging methods. Alternatives such as weirs or salt dilution trials may also be impractical or harmful to biota. Area can, however, be calculated for a series of flow cross sections along the channel and combined with rhodamine velocity trials to estimate volume. Such a series can be used to bracket

headwaters tributaries or seeps and assess consistency of cross section estimates. Though potentially somewhat coarse for non-basalt lined channels, such estimates provide detail about surface volume magnitude useful for modeling.

7.0 Records Management

7.1 Stream Segmentation and Morphology form. Attached as Appendix 1

7.2 Surface Flow Survey form. Attached as Appendix 2

8.0 Quality Control and Quality Assurance Section

8.1 Data Collection: At each segment break confirm the record is complete and the clinometer was read as percent. Each staff member should 1) understand the data sheet and various codes, 2) be able to accurately measure length to 50 m, 3) understand how to collect latitude and longitude via global positioning system (GPS) receiver (see EAP SOP 013, GPS coordinates) .

8.2 Data Entry: 1) After transfer of data to a db file or spreadsheet, each entry of each record is proofed twice (separate staff). Alternatively, data can be double punched and the tables compared. 2) Data is then filtered categorically on each field to validate format.

8.3 Stream location: Line shapefiles and coordinates pairs provide two independent methods of estimating stream channel geometry (length and dominant bearing of each section). For improved accuracy post-processing is necessary.

9.0 Safety

9.1 As needed be aware of slash and forest undergrowth, poison oak, steep slopes, large animals and bees, fire, potholes, washboards, road dust, log trucks, target practice, and hunters.

10.0 References

10.1 Bigley, R. 2001. Stream Segmentation Protocol. Washington Dept. of Natural Resources. Unpublished correspondence.

10.2 Janisch, J. 2006. EAP013: Standard operating procedure for determining coordinates via hand-held GPS receivers. WA Dept of Ecology.

10.3 Washington Forest Practices Board Manual, 2006 (revision ongoing).
<http://www.dnr.wa.gov/forestpractices/board/manual/>

Appendix 2: Surface flow survey form

2007 Forest and Fish T5 Surface Flow Survey

Region _____
Stand _____

Stream _____
Crew _____

page _____ of _____
Date _____
last rain? _____

| DOF ↓ | DOF ↓ | DOF ↓ | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
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| Seg # | %flow | code1 | diagram | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
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code1: dominant surface flow pattern. select only one code. document complex cases with written comments as needed.

| | | |
|----|-------------------|---|
| CF | continuous flow | 80-100% unbroken flow |
| I | intermittant flow | 20-70% CF or broken flow |
| P | pooling | >50% standing water, >20% wetted |
| S | seep | H2O film, broad/many sources, >20% wetted |
| M | mud/marsh | >50% wetland veg, braiding, gley soils |
| D | dry | <20% surface water, includes moist soil |

%flow wetted segment length divided by total length *100
round to nearest 10%

other coments:
A audible
T tributary (t1, etc)

code1: rate surface flow, not channel morphology
DOF: direction of flow (each segment) L: segment total length, m WL: segment wetted length, m

Note: Do not print these in color. Color used to create gray scale.