DEPARTMENT OF
ECOLOGY
State of Washington

Dictionary of Metrics for Physical Habitat

Definitions and Calculations Used for Watershed Health Monitoring and Related Studies

October 2013 (Updated February 2020)

Publication No. 13-03-033

Publication and Information

This report is available on the Department of Ecology's website at
https://fortress.wa.gov/ecy/publications/SummaryPages/1303033.html

Data to which calculations described in the dictionary apply are available at Ecology's Environmental Information Management (EIM) website https://fortress.wa.gov/ecy/eimreporting/Default.aspx. Search Study IDs: RSM_EFS1, RSM_EFS1_P, RSMP_PLES2015, RSMP_PC_PLES2015, RSMP_RD_PLES2015, WHM_BIO, WHM_BIO_P, WHM_COB0, WHM_COB_P, WHM_EFF0, WHM_EFF0_P, WHM_EFF1, WHM_EFF1_P, WHM_EFF2, WHM_EFF2_P, WHM_EFF3, WHM_EFF3_P, WHM_EFF4, WHM_EFF4_P, WHM_EPA, WHM_EPA_P, WHM_ERR, WHM_ERR_P, WHM_ERR1, WHM_ERR1_P, WHM_ERR2, WHM_ERR2_P, WHM_KCY, WHM_KCY_P, WHM_PCD0, WHM_PCD0_P, SAM_PLES, WHM_SEN, WHM_SEN_P, WHM_UFW0, WHM_UFW0_P, WHM_WAM0, WHM_WAM0_P, WHM_WAM1, WHM_WAM1_P, WHM_WAM2, WHM_WAM2_P, WHM_WHB.

The calculations also apply to these supperseeded and no longer searchable study IDs: BioMonitoringProgram, STMEcology, STMEcology2009, STMEcology2010, STMEcology2011, STMKingCounty, STMKingCounty2009, STMKingCounty2010, STMPugetSen, STMPuyallupTribe, STMWASen.

The Activity Tracker Code for development of this dictionary is 11-092.

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Dictionary of Metrics for Physical Habitat

Definitions and Calculations Used for Watershed Health Monitoring and Related Studies

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Table of Contents

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Abstract

Over the past decade, study of natural resource conditions has shifted from observations at scattered, hand-selected sites to much more intensive, statistically robust approaches, such as GRTS[1] probability sampling. Observations resulting from such sampling are formulated as summaries called *metrics*. Metrics are related to variables: a variable is what we study; a metric is how we describe it.

Watershed Health Monitoring Web[2] (WHMWeb) is part of a new tool, built by the Washington Department of Ecology, that translates statistically robust regional assessments of watershed conditions into metrics diagnostic of watershed health. The core of this tool is a metric calculation engine. WHMWeb is an interface from which users (1) can access a list of sites that have been surveyed and (2) call the associated metrics. Metrics are displayed in an ASP.Net web page, behind which is a SQL Server database[3]. Metrics are updated daily, with an overnight refresh.

Metrics reporting from WHMWeb are specific to fresh flowing surface waters (and environs) of the state of Washington, as represented on the National Hydrography Dataset (NHD), and meeting the population definition used for watershed health monitoring and related studies. Various study designs are used, some probabilistic, such as GRTS, and some not. The emphasis is water quality and physical habitat for stream-associated organisms.

This dictionary defines physical habitat metrics reporting from WHMWeb and describes their calculations. It is intended as a reference, as a list of available metrics, and to promote transparency and confidence in use of results reported by WHMWeb. Observations, from which metrics are derived, also report from WHMWeb.

Conversely, this metric dictionary is not intended as (1) an exhaustive source of metric formulations, (2) a user guide for querying the WHMWeb interface, or (3) a description of observations.

Approximately 265 metrics report from WHMWeb as of December 2016.

[1] Generalized random tessellation stratified.
https://archive.epa.gov/nheerl/arm/web/html/survey_overview.html

[2] Watershed Health Monitoring
https://ecology.wa.gov/Research-Data/Monitoring-assessment/River-stream-monitoring/Habitat-monitoring/Watershed-health

Acknowledgements

The author of this metric dictionary thanks the following people for their contributions:

- Philip R. Kaufmann, U.S. Environmental Protection Agency
- David P. Larsen, Pacific States Marine Fisheries Commission
- Curt Seeliger, Scientific Research Associates
- Thomas M. Kincaid, U.S. Environmental Protection Agency
- Steve Rentmeester, Sitka Technology Group
- Lillian Herger, U.S. Environmental Protection Agency
- Scott Stolnack, King County
- Frank Leonetti, Snohomish County
- Mike Rustay, Snohomish county
- Washington State Department of Ecology staff:
  - Glenn Merritt
  - Warren Opfer
  - Jill Lemmon
  - Chris Hartman
  - Karen Adams
  - Elkin Julio
  - Christopher Moore
  - Rusty Nyffler
  - Karol Erickson

Dictionary of Metrics

Watershed Health Monitoring Web (WHMWeb)[4] is part of a metric calculation engine. To date, procedures for calculating approximately 265 metrics are available to WHMWeb. A dictionary of these metrics follows.

The dictionary is organized hierarchically. The highest level of organization is categories, in which closely related metrics are grouped. Category names are organized alphabetically. Within categories, metrics are ordered by other characteristics. Typically the ordering is from simple to complex, thus taking into account dependencies rather than alphabetical relationship. Some categories contain only a single group or a single metric. Diagrammatic relationships are included for a few complex, higher-level diagnostic metrics to illustrate their dependencies.

Additionally, the structure of this dictionary is modular. Each group of metrics can stand alone. Provided for each metric is thus a long descriptive name, a definition, a short name reported by WHMWeb (i.e., WHM export ID), and a calculation. Readers can trace each metric through steps in the definition and calculation by following the parenthetical notations in each sub-group. Any dependencies are identified for the reader, as are key technical references. A modular structure adds some length to the dictionary but simplifies a potential future integration of the dictionary with WHMWeb.

Also, throughout the dictionary is reference to the term *data collection event* (DCE). DCEs combine study location IDs with dates of visitation. Thus, all site visitation IDs, even those which are repeat visits, are unique. All data within WHMWeb are ordinated to DCEs. All calculations described in the dictionary apply at the scale of individual DCEs.

Calculations for most of these metrics are modeled after those developed by the Environmental Monitoring and Assessment Program (EMAP), a research project of the U.S. Environmental Protection Agency (EPA). These calculations are currently used in EPA's National Aquatic Resources Surveys (NARS). Methods for collecting the underlying data also are mostly modeled on federal sources: those of EMAP, particularly the Western Pilot; those of NARS, particularly Peck et al. (2005, 2006); and those of the National Marine Fisheries Service's Integrated Status and Effectiveness Monitoring Program (ISEMP)[5]. For further detail about data underlying the metrics, see the associated quality assurance monitoring plan (Cusimano et al., 2006) and protocols, one for wadeable streams (Merritt, 2009) and one for wide streams and rivers (Merritt, 2010). Where reported, the sample form of the standard deviation (SD) equation is used to estimate population SDs.

[4] Watershed Health Monitoring
https://ecology.wa.gov/Research-Data/Monitoring-assessment/River-stream-monitoring/Habitat-monitoring/Watershed-health

[5] Integrated Status and Effectiveness Monitoring Program (ISEMP)
http://www.nwfsc.noaa.gov/research/divisions/cb/mathbio/isemp.cfm

There are, however, important modifications and additions to some field methods and metrics. These changes are based on National Oceanic and Atmospheric Administration 2004-2005 methods for the Integrated Status and Effectiveness Monitoring Program (Hillman, 2004) or Moberg (2006, 2007). These include:

- Referencing the bankfull channel rather than the wetted channel for
  - Riparian observations
  - Substrate transects
  - Defining site length
- Using 11 stations per transect for observing substrate particles.
- Defining habitat unit criteria methods.
- Assessing bank instability.
- Assigning large wood size categories for eastern Washington.
- Using 100 thalweg increments for all sizes of streams.
- Calculating residual pool depths (PoolUnitDepth) based on the difference between maximum depth and crest depth of field-identified pool habitat units.[6]

A few metric calculations which are still being resolved, such as other measures of bank extent and quality, will be described in a future update of the dictionary.

Note that the calculations described are not fully generalized, but instead refer back to (1) the underlying SQL Server database where the observations are housed and (2) procedures which calculate the metrics. The term *is.null* occurs in the calculations, for example, because null values are allowed in some value fields within the database tables. Procedures test for null values, as needed, when counting observations. Transparency of calculations is key to interpreting metrics, so effort is made to convey how the calculations actually work.

Lastly, included are metrics specific to 12 high-level indicators identified previously by the Washington Forum on Salmon Recovery and Watershed Health. These high-level indicators collectively account for over 100 metrics:

- Wetted width
- Bankfull width
- Channel gradient
- Percent pools
- Residual pool depth
- Pool maximum depth
- Pool crest depth
- Large woody debris frequency
- Large woody debris volume
- Percent fine sediment
- Canopy cover
- Vegetation structure

[6] This supplements rather than replaces the EPA residual pool metric, ResidualPoolArea100.

In interpreting these and other metrics described by the dictionary, readers seeking inferences to particular locations are encouraged to review GRTS probability sampling theory.

Data-collection methods to which the dictionary applies were updated in 2017. Updated methods are not yet offered as citeable documents, so they are temporarily acknowledged here. For copies of the updated methods or earlier methods (Merritt, 2009; Merritt, 2010), contact G. Merritt: gmer461@ecy.wa.gov.

EAP073	Collection of Freshwater Benthic Macroinvertebrates in Streams and Rivers
EAP095	Collecting Water Samples
EAP105	GIS-Based Verification, Layout, and Data Collection (Wide Protocol)
EAP106	Verification and Layout of Sites (Narrow Protocol)
EAP107	Measuring Transect Coordinates with a Global Positioning System (GPS)
EAP108	Collecting In Situ Water Quality
EAP109	Estimating Stream Discharge (Narrow Protocol)
EAP110	Sample Sediment for Chemistry
EAP111	Periphyton Sampling, Processing and Identification in Wadeable Streams
EAP112	Assessing Bank Erosion Vulnerability
EAP113	Measuring Channel Dimensions
EAP114	Estimating Substrate Sizes and Embeddedness at Major Transects
EAP115	Measuring Riparian Cover Using a Convex Densiometer
EAP116	Estimating Fish Cover
EAP117	Assessing Riparian Vegetation Structure
EAP118	Visual Assessment of Human Influence
EAP119	Thalweg Profiling
EAP120	Quantifying Habitat Units
EAP121	Counting Large Woody Debris
EAP122	Measuring Stream Slope (Narrow Protocol)
EAP123	Measuring Compass Bearings (Narrow Protocol)
EAP124	Vertebrate Assemblage Sampling
EAP125	Managing Electronic Data Form Functionality using a Mobile Data-Collection Device

Metric Category: Bank Quality

Reported	WHM export ID
Bank instability ratings, count	N BankInstab
Bank instability rating, average	X BankInstab

METRIC CATEGORY: **Bank Quality**

Group: Bank instability
Scope: All non-null observations per DCE, entire site reach

Reported: Bank instability ratings, count (i)
Bank instability rating, average (ii)

Definition:
(i) count, of bank instability observations associated with the main channel (channel 0) as observed at the ends of each channel-spanning transect. Unit = observations of instability.

(ii) average, of bank instability observations associated with the main channel (channel 0), as rated at the ends of each channel-spanning transect. Unit = percent.

WHM export ID:
(i) N_BankInstab
(ii) X_BankInstab

Observation type: Visual assessment
Allowed observation values: ≥ 0 to ≤ 100
Data collection schema: Plots at ends of 11 evenly-spaced cross-channel transects, transects perpendicular to channel. Site reach length is variable, 150 - 2000 m.
Maximum observations (DCE): 22; 1 observation per bank X 11 transects
Minimum reporting qualifiers: Survey at least 77% complete (17 plots rated)
Reporting years (to date): 2009-2017

Calculation:
(i) count(Bank instability observations) < > is.null[1]
(ii) (Σ((Bank instability ratings, left bank and right bank)) / N_BankInstab

[1]**X_BankInstab was experimental during 2009 – 2012**. New, different bank quality metrics are planned for 2013 onward to incorporate discussion of status of Puget Sound tributaries (see below).

Dependencies: Sufficient bank instability observations collected

Assumptions: Observations sufficient to accurately characterize bank instability.

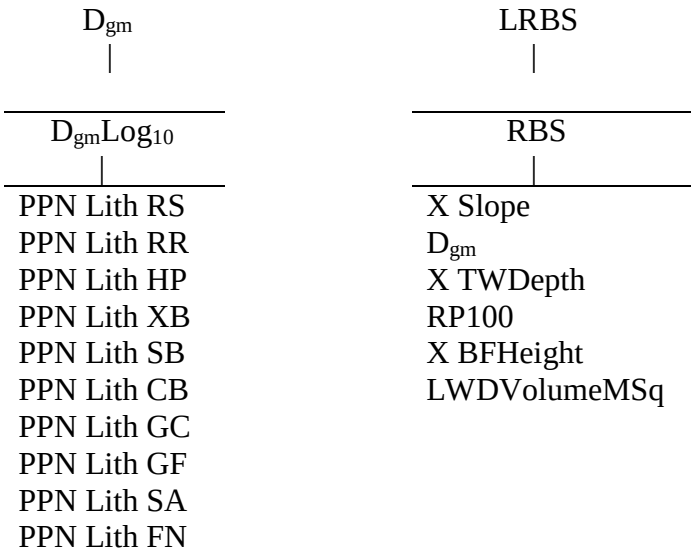
Source: We did not reference other sources for method of metric calculation. The field method was derived from Moberg (2007):

Further documentation:
https://fortress.wa.gov/ecy/publications/summarypages/1203029.html

Metric Category: Bed Stability

Reported	WHM export ID
Number of lithic substrates sized, count	N Lith
Proportion of lithic substrates sized as	
smooth bedrock (4000-8000 mm)	PPN Lith RS
rough bedrock (4000-8000 mm)	PPN Lith RR
hardpan (4000-8000 mm)	PPN Lith HP
large boulders (1000-4000 mm)	PPN Lith XB
small boulders (250-1000 mm)	PPN Lith SB
cobble (64-250 mm)	PPN Lith CB
coarse gravel (16-64 mm)	PPN Lith GC
fine gravel (2-16 mm)	PPN Lith GF
sand (0.06-2 mm)	PPN Lith SA
fines (0.001-0.06 mm)	PPN Lith FN
Log_{10} of geometric mean substrate diameter	$D_{gm}Log_{10}$
Geometric mean substrate diameter	D_{gm}
Relative bed stability	RBS
Log_{10} of relative bed stability	LRBS

Diagrammatic hierarchical relationship of D_{gm} and LRBS to dependencies which also report from WHMWeb:



METRIC CATEGORY: **Bed Stability**

Groups: Geometric mean substrate size
Scope: All non-null observations per DCE, entire site reach

Reported: Substrate particle diameter observations, as

Number of lithic substrates sized, count (i)

Definition: (i) count, of lithic substrate particle diameter observations, as observed, bank-to-bank, along channel-spanning transects, associated with the main channel (channel 0). Unit = observations of particle diameter.

WHM export ID: (i) N_Lith[1]

Observation type:	Count
Allowed metric values:	≥ 0 to ≤ 100
Data collection schema:	Cross-channel transects, bank to bank, where transects are perpendicular to stream current and equidistant along the site reach. Site reach length is variable, 150 - 2000 m.
Maximum observations (DCE),	
narrow protocol:	231, 11 observations X 21 transects
wide protocol:	121, 11 observations X 11 transects
Minimum reporting qualifiers:	Observations at least 70% complete
Reporting years (to date):	2009-2017

Calculation:

(i) for all substrate particle diameter observations,
{where Substrate_Type_Code < > is.null},

(count (Substrate_Type_Code) < > is.null))

Dependencies: Number of substrate observations within acceptable range.

Assumptions: Observations sufficient to accurately characterize substrate particle diameter as observed along the site reach.

Sources: Kaufmann et al., 1999; Hillman, 2004; Peck et al., 2005, 2006.

Further documentation:
https://fortress.wa.gov/ecy/publications/summarypages/1203029.html

[1] if N Lith = 0 then procedure bypasses calculation of PPN Lith* & Dgm. Filter accounts for substrate of 100% pavement. Pavement is classified as non-lithic.

METRIC CATEGORY: **Bed Stability**

Groups: Geometric mean particle size
Scope: All non-null observations per DCE, entire site reach

Reported: Proportion lithic substrate, for particle-diameter categories observed, as

Smooth bedrock (RS), (i)	Cobble (CB), (vi)
Rough bedrock (RR), (ii)	Coarse gravel (GC), (vii)
Hardpan (HP), (iii)	Fine gravel (GF), (viii)
Large boulders (XB), (iv)	Sand (SA), (ix)
Small boulders (SB), (v)	Fines (FN), (x)

Categorical diameter ranges:

(i) 4000- 8000 mm	(vi) 64-250 mm
(ii) 4000- 8000 mm	(vii) 16-64 mm
(iii) 4000- 8000 mm	(viii) 2-16 mm
(iv) 1000-4000 mm	(ix) 0.06-2 mm
(v) 250-1000 mm	(x) silt, clay, non-gritty, 0.001 – 0.06 mm

Definition: For substrate particle-diameter categories (i - x):

narrow protocol; direct observation of lithic substrates present:

(i - x) areal proportion, of channel bed, along the site reach, *composed of* the specified particle diameter category, as observed, bank-to-bank, at channel-spanning transects, associated with the main channel (channel 0). A result of 1.0 indicates that the channel bed, as observed along the site reach, was *composed of* a single substrate particle diameter category. Unit = unitless.

wide protocol; lithic substrate particle diameters present generally indirectly inferred from probing with poles or rods due to deeper water:

(i - x) areal proportion, of channel bed, along the site reach, *dominated by* the specified lithic particle diameter category, as observed, bank-to-bank, at channel-spanning transects, associated with the main channel (channel 0). A result of 1.0 indicates that the channel bed, as observed along the site reach, was *dominated by* a single substrate particle diameter category. Unit = unitless.

WHM export ID:

(i) PPN_Lith_RS	(vi) PPN_Lith_CB
(ii) PPN_Lith_RR	(vii) PPN_Lith_GC
(iii) PPN_Lith_HP	(viii) PPN_Lith_GF
(iv) PPN_Lith_XB	(ix) PPN_Lith_SA
(v) PPN_Lith_SB	(x) PPN_Lith_FN

Observation type:	Categorical rating
Allowed metric values:	≥ 0 to ≤ 100
Data collection schema:	Cross-channel transects, bank to bank, where transects are perpendicular to stream current and equidistant along the site reach. Site reach length is variable, 150 - 2000 m.
Maximum observations (DCE),	
narrow protocol:	231, 11 observations X 21 transects
wide protocol:	121, 11 observations X 11 transects
Minimum reporting qualifiers:	
narrow protocol:	Observations at least 70% complete
wide protocol:	All 11 transect required
Reporting years (to date):	2009-2017

Calculation:

(i - ix) for each unique substrate particle diameter category,
{where Substrate_Type_Code < > is.null},
{where Substrate_Type_Code = *i*}

(count (Substrate_Type_Code) < > is.null)) / (N_Lith)

where, N_Lith = count of particle diameter observations.

Dependencies: N Lith within acceptable range.

Assumptions: Diameter ranges sufficient to accurately characterize substrate particle diameter as observed along the site reach.

Sources: Kaufmann et al., 1999; Hillman, 2004; Peck et al., 2005, 2006.

Further documentation:
https://fortress.wa.gov/ecy/publications/summarypages/1203029.html

METRIC CATEGORY: **Bed Stability**

Groups: Geometric mean particle diameter
Scope: All non-null observations per DCE, entire site reach

Reported: As observed, for all lithic substrate particle-diameter categories combined,

Log_{10} of geometric mean bed substrate diameter (i)
Geometric mean bed substrate diameter (ii)

See URL below for definitions of categorical particle-diameter ranges

Definition: These two metrics build on calculations for proportions of lithic substrates.

(i) an exponent, determined from a logarithmic average diameter of each lithic substrate category, and from the proportion of each lithic category observed along the site reach, bank-to-bank, at channel-spanning transects, associated with the main channel (channel 0). Unit = log 10 millimeters.

(ii) the geometric central tendency of lithic substrate particle diameter, as a function of the exponent, (i). Unit = millimeters.

WHM export ID: (i) $D_{gm}Log_{10}$
(ii) D_{gm}

Observation type:	Categorical rating
Allowed metric values:	≥ 0 to ≤ 100
Data collection schema:	21 cross-channel transects, bank to bank, where transects are perpendicular to stream current and equidistant along the site reach. Site reach length is variable, 150 - 2000 m.
Maximum observations (DCE),	
narrow protocol:	231, 11 observations X 21 transects
wide protocol:	121, 11 observations X 11 transects
Minimum reporting qualifiers:	Observations at least 70% complete
Reporting years (to date):	2009-2017

Calculation:

(i) for proportion of each unique proportion of lithic substrate diameter class, *a* to *x* {where Substrate_Type_Code < > is.null}, use

(Proportion_Lithic_Substrate) * (Log_{10}_Class_Mean_Diameter) = *Y*

resulting in, for diameter classes *a* to *x*, Y_a, …., Y_x

where,

Substrate Type	Code	Log_{10} Class Mean Diameter
Smooth bedrock	RS	3.752574989
Rough bedrock	RR	3.752574989
Hardpan	HP	3.752574989
Large boulders	XB	3.301029996
Small boulders	SB	2.698970004
Cobble	CB	2.102059991
Coarse gravel	GC	1.505149978
Fine gravel	GF	0.752574989
Sand	SA	-0.460409377
Fines	FN	-2.110924375

then $\Sigma (Y_a + \ldots + Y_x) = i = D_{gm}Log_{10}$

See below for definitions of proportions of lithic substrates.

(ii) base 10 to the *i*th power, or 10^i

Dependencies: Proportions of lithic substrates within acceptable ranges.

Assumptions: Diameter ranges sufficiently narrow to accurately characterize substrate particle diameter as observed along the site reach.

See Faustini and Kaufmann (2007) for discussion of D_{gm} vs. D50.

Sources: Kaufmann et al., 1999; Hillman, 2004; Peck et al., 2005, 2006; Faustini and Kaufmann, 2007.

Further documentation
https://fortress.wa.gov/ecy/publications/summarypages/1203029.html

Link to definitions
proportions of lithic substrates.

METRIC CATEGORY: **Bed Stability**

Groups: Relative bed stability
Scope: All non-null observations per DCE, entire site reach

Reported: As observed, for all lithic substrate particle-diameter categories combined, the index

Relative bed stability (i)
Log_{10} of relative bed stability (ii)

See below for definitions of categorical particle-diameter ranges

Definition: This metrics builds on calculations for proportions of lithic substrates, which are combined, along with several dependencies, through a set of equations into,

(i) an index, of the influence of human disturbance on stream sediments, as "the ratio of bed surface geometric mean particle diameter (D_{gm}) divided by estimated critical diameter (D_{cbf}) at bankfull flow, based on a modified Shield's criterion for incipient motion" (Kaufmann et al., 2008). Stream sediments move frequently if the observed average lithic particle size of a stream bed is smaller than that which the evaluated stream is capable of moving. The degree of this instability of the stream bed is assessed by RBS (Kaufmann et al., 2008). We calculate the form of RBS presented by Kaufman et al. (2008), which takes into account a reduction in bed-shear stress resulting from channel-form roughness. For ease of cross-comparison with other studies, we calculate the index for a water temperature of 20 °C. Unit = none, dimensionless ratio.

(ii) (i) above, as Log_{10}RBS. Unit = none, dimensionless.

These definitions are identical to those of Kaufmann et al. (2008) and Kaufmann et al. (2009).

WHM export ID: (i) RBS
(ii) LRBS

Observation type:	Measurements and categorical ratings
Allowed metric values:	-6 to +2
Expected typical range:	-5 to +1
Data collection schema:	Cross-channel transects, bank to bank, where transects are perpendicular to stream current and equidistant along the site reach. Site reach length is variable, 150 - 2000 m.
Maximum observations (DCE),	
narrow protocol:	231, 11 observations X 21 transects
wide protocol:	121, 11 observations X 11 transects

Minimum reporting qualifiers,

narrow protocol:	Observations at least 70% complete
wide protocol:	All 11 transects required
if wadeable:	All 11 transects required
Reporting years (to date):	2009-2017

Calculation:

(i) determination of relative stability of a stream bed,

where, the constants,

ρ = 988.2 kg m^{-3}, mass density of freshwater at 20 °C
ρ_{sed} = 2650 kg m^{-3}, average density of silicate minerals
v = 1.004E-6 m^2 s^{-1}, kinematic viscosity of water at 20 °C
g = 9.81 m s^{-2}, gravitational acceleration

and where, the dependencies,

EPA notation			our equivalent
S	=	slope of reach water surface, m m^{-1},	X Slope
d_{th}	=	mean thalweg depth, m	X TWdepth
$d_{th\text{-}bf}$[1]	=	mean (thalweg depth + bankfull height above water surface), m	X BFDepth
d_h	=	hydraulic mean depth ---- approximated as 0.65(d_{th})	
$d_{h\text{-}bf}$	=	hydraulic mean depth at bankfull ---- approximated as 0.65($d_{th\text{-}bf}$)	
d_{res}	=	mean thalweg residual depth, m	X ResPoolArea100
Wd	=	wood volume per bankfull channel planform area (i.e., wood depth), m^3 m^{-2}	LWD VolumeMSq
D_{gm}	=	geometric mean bed surface particle diameter, from systematic pebble counts, m	D_{gm}

[1]: $d_{th\text{-}bf}$: = approximation of R_{bf} in determining RBS at bankfull (personal communication, P. Kaufmann 5/2013)

are defined elsewhere in our metric dictionary. See links to below.

then,

a) calculate hydraulic radius at bankfull, approximated as

R_{bf} = 0.65$d_{th\text{-}bf}$

b) calculate total hydraulic resistance, as

C_t = $1.21 d_{res}^{1.08} (d_{res} + Wd)^{0.638} d_{th}^{-3.32}$, where if $C_t < C_p$, $C_t = C_p$, else C_t

c) calculate particle hydraulic resistance, as

C_p = $1/8\{2.03 \text{ Log}_{10} (12.2 d_h / D_{gm})\}^{-2}$, where if $C_p < 0.002$, else 0.002

d) calculate particle Reynolds number at bankfull, as

R_{e_p} = $\{(g R_{bf} S)^{0.5} D_{gm}\} / \nu$

e) calculate Shields number, from particle Reynolds number at bankfull flow, as

θ = $0.04 Re_p^{-0.24}$, if $Re_p \leq 26$

θ = $0.5\{0.22 Re_p^{-0.6} + 0.06(10^{-7.7 \ Rep\wedge(-0.6)})\}$, if $Re_p > 26$

f) calculate RBS at bankfull flow, as

a ratio comparing observed mean bed particle diameter to the diameter of particles that can be mobilized at bankfull flow,

RBS = $D_{gm} / D_{critical\_bankfull}$

= $D_{gm} / (0.604 R_{bf} S / \theta)$

= $1.66 \theta D_{gm} / (R_{bf} S)$

or $1.66 \theta D_{gm} / \{R_{bf} (C_p/C_t)^{1/3} S\}$

where $(C_p/C_t)^{1/3}$ is an adjustment applied to bankfull shear stress to account for channel-form roughness

g) calculate LRBS at bankfull flow, as

LRBS = Log_{10} (RBS)

Dependencies: As listed above.

Assumptions: Observations sufficient to accurately characterize substrate particle diameter as observed along the site reach.

Source: Kaufmann et al., 1999, 2008, 2009.

Further documentation:
https://fortress.wa.gov/ecy/publications/summarypages/1203029.html

Links to definitions,

Proportions of Lithic Substrates
X Slope
X TWDepth
ResPoolArea
LWDVolumeMSq
D_{gm}

Metric Category: Channel Dimensions

Reported	WHM export ID
Channel slope, average	X Slope
Bankfull width,	
count	N BFWidth
average	X BFWidth
std. dev.	SD BFWidth
Wetted width,	
count	N WetWidth
average	X WetWidth
std. dev.	SD WetWidth
Length of site reach, distance	Site Length
Thalweg increment, distance	TWIncrement
Thalweg depth,	
count	N TWDepth
average	X TWDepth
std.dev.	SD TWDepth
Bankfull height,	
count	N BFHeight
average	X BFHeight
std. dev.	SD BFHeight
Bankfull depth,	
count	N BFDepth
average	X BFDepth
std. dev.	SD BFDepth
Wetted cross section,	
count	N Wet WxD
average	X Wet WxD
std. dev.	SD Wet WxD
Bankfull cross section,	
count	N BF WxD
average	X BF WxD
std. dev.	SD BF WxD

Residual pool depths, count	N ResPoolArea
Vertical residual pool area, total	ResPoolArea
Standardized vertical residual pool area, total	ResPoolArea100

Diagrammatic hierarchical relationship of ResPoolArea100 to dependencies which also report from WHMWeb:

ResPoolArea100
|
ResPoolArea
|
Site Length
X Slope
N TWStations
X TWDepth
SD TWDepth

METRIC CATEGORY: **Channel Dimensions**

Group: Slope
Scope: All non-null observations per DCE, entire site reach

Reported: Slope of study reach, average (i)

Definition: (i) average, elevational change between upstream and downstream ends of a site reach along the main channel (channel 0), as observed during a DCE. Unit = percent.

WHM export ID:	(i) X_Slope
Observation type:	Measurement
Allowed values:	> 0
Data collection schema:	Length of site reach Site reach length is variable, 150 - 2000 m.
Maximum observations (DCE):	1
Minimum reporting qualifiers:	1
Reporting years (to date):	2009-2017

Calculation:
(i) Usually determined at site by field staff.

Dependencies: None.

Assumptions: In cases where X_Slope is determined from digital imagery, elevation data is sufficiently accurate.

Sources: Kaufmann et al., 1999; Peck et al., 2005, 2006.

Further documentation:
https://fortress.wa.gov/ecy/publications/summarypages/1203029.html

METRIC CATEGORY: **Channel Dimensions**

Group: Channel width
Scope: All non-null observations per DCE, entire site reach

Reported: Bankfull width, count (i)
Bankfull width, average (ii)
Bankfull width, standard deviation (iii)

Definition: (i) count, of bankfull width observations associated with the main channel (channel 0), at each channel spanning transect. Unit = observations of bankfull width.

(ii) average, of bankfull width observations, as the horizontal distance between bankfull margins (often present as scour lines), bank-to-bank and perpendicular to stream current, associated with the main channel (channel 0), at each channel-spanning transect. Unit = meters.

(iii) standard deviation, of bankfull width observations associated with the main channel (channel 0), as an estimate of dispersion from the sample average. Unit = meters.

WHM export ID:	(i) N_BFWidth (ii) X_BFWidth (iii) SD_BFWidth
Observation type:	Measurement
Allowed values:	> 0
Data collection schema:	Cross-channel transects, perpendicular to channel. Site reach length is variable, 150 - 2000 m.
Maximum observations (DCE),	
narrow protocol:	21; 1 bankfull width observation X 21 transects
wide protocol:	11; 1 bankfull width observation X 11 transects
Minimum reporting qualifiers,	
narrow protocol:	11 observations
wide protocol:	Observations at least 80% complete
Reporting years (to date):	2009-2017

Calculation:

(i) count(BFWidth) < > is.null
(ii) (Σ (BFWidth)) / N_BFWidth
(iii) (Σ ((BFWidth– X_BFWidth)^2)/(N_BFWidth-1))^1/2

Dependencies: N_BFWidth must be known to calculate X_BFWidth and SD_BFWidth.
Assumptions: Observations sufficient to accurately characterize bankfull width of site reach.
Sources: Kaufmann et al., 1999; Peck et al., 2005, 2006.
Further documentation: https://fortress.wa.gov/ecy/publications/summarypages/1203029.html

METRIC CATEGORY: **Channel Dimensions**

Group: Channel width
Scope: All non-null observations per DCE, entire site reach

Reported: Wetted width, count (i)
Wetted width, average (ii)
Wetted width, standard deviation (iii)

Definition:

(i) count, of wetted width observations associated with the main channel (channel 0), as observed at each channel-spanning transect. Unit = observations of wetted width.

(ii) average, of wetted width measurements, as the horizontal distances between wetted margins (i.e., shorelines), bank-to-bank and perpendicular to stream current, associated with the main channel (channel 0), at each channel-spanning transect. Unit = meters.

(iii) standard deviation, of wetted width measurements associated with the main channel (channel 0), as an estimate of dispersion from the sample average. Unit = meters.

WHM export ID:
(i) N_WetWidth
(ii) X_WetWidth
(iii) SD_WetWidth

Observation type: Measurement
Allowed values: > 0
Data collection schema: Evenly-spaced, cross-channel transects, perpendicular to channel. Site reach length is variable, 150 - 2000 m.
Maximum observations (DCE),
narrow protocol: 21; 1 wetted width observation X 21 transects
wide protocol: 11; 1 wetted width observation X 11 transects
Minimum reporting qualifiers: Observations at least 80% complete
Reporting years (to date): 2009-2017

Calculation:

(i) count(WWidth) < > is.null
(ii) (Σ (WWidth)) / N_WetWidth
(iii) (Σ ((WWidth – X_WetWidth)^2)/(N_WetWidth-1))^1/2

Dependencies: N_WetWidth must be known to calculate X_WetWidth and SD_WetWidth

Assumptions: Observations sufficient to accurately characterize wetted width of site reach.

Sources: Kaufmann et al., 1999; Peck et al., 2005, 2006.

Further documentation: https://fortress.wa.gov/ecy/publications/summarypages/1203029.html

METRIC CATEGORY: **Channel Dimensions**

Groups: Site length
Scope: All non-null observations per DCE, entire site reach

Reported: Length of site reach, distance (i)
Thalweg increment, distance (ii)

Definition: (i) length, as 20 initial bankfull widths, the upper and lower ends of the site reach determined by centering, on the sample point, a distance equal to 20 initial bankfull widths, along the sinuous watercourse of the main channel (channel 0). Unit = meters.

(ii) increment, between thalweg stations associated with the main channel (channel 0) where each increment of the main channel (channel 0) = 1/100 of total length of the site reach. Unit = meters.

WHM export ID: (i) Site_Length
(ii) TWIncrement[1]

[1] included due to role in calculation of several other metrics.

Observation type: Measurement
Allowed values,
(i) 150 – 2000
(ii) 1.5 – 20
Data collection schema:
(i) Observations of bankfull width.
(ii) Site reach. Length of site reach is variable, 150 - 2000 m.
Maximum observations (DCE),
(i) 5
(ii) 1, as length of site reach
Minimum reporting qualifiers: Observations complete
Reporting years (to date): 2009-2017

Calculation:

(i) to lay out the site reach, let

Initial_BFWidth = $(width_1 + \ldots.. + width_5) / 5$, then

Initial_BFWidth X 20, rounded to nearest m,

except if
(i) < 150, then (i) = 150
(i) > 2000, then (i) = 2000,

where the site reach is centered on coordinates from a Generalized Random Tessellation Stratified probability sample draw,

and where, Initial_BFWidth = a bankfull width observation used only to lay out the site reach.

(ii) Site_Length / 100

except if

(i) < 150, then 1.5
(i) > 2000, then 20

Dependencies: Site Length is 20 times the average five pre-sampling estimates of the bankfull width of the water body being sampled. The exception is extremes (i.e., < 7.5 m wide or > 100 m wide). See further documentation for handling of extremes.

Assumptions: Site coordinates and bankfull marks interpreted correctly.

Sources: Kaufmann et al., 1999; Hillman, 2004; Peck et al., 2005, 2006.

Further documentation:
https://fortress.wa.gov/ecy/publications/summarypages/1203029.html

METRIC CATEGORY: **Channel Dimensions**

Group: Channel depth
Scope: All non-null observations per DCE, entire site reach

Reported: Thalweg depth, count (i)
Thalweg depth, average (ii)
Thalweg depth, standard deviation (iii)

Definition: (i) count, of thalweg depth observations associated with the main channel (channel 0), where each increment of the main channel (channel 0) = 1/100 of total length of the site reach. Unit = observations of thalweg depth.

(ii) average, of thalweg depth observations, as the vertical distance between the channel bed and water surface elevation, perpendicular to the water surface and at the deepest cross-channel point, at each channel increment associated with the main channel (channel 0). Unit = centimeters.

(iii) standard deviation, of thalweg depth observations associated with the main channel (channel 0), as an estimate of dispersion from the sample average. Unit = centimeters.

WHM export ID:	(i) N_TWDepth (ii) X_TWDepth (iii) SD_TWDepth
Observation type:	Measurement
Allowed values:	≥ 0
Data collection schema:	100 equally-spaced thalweg stations along the length of the site reach beginning at the downstream end of the reach. Site reach length is variable, 150 - 2000 m.
Maximum observations (DCE):	100 thalweg stations per site reach, 1 observation per station
Minimum reporting qualifiers:	Observations 100% complete
Reporting years (to date):	2009-2017

Calculation:

(i) count(TWDepth) < > is.null
(ii) (Σ (TWDepth)) / N_TWDepth
(iii) (Σ ((TWDepth – X_TWDepth)^2)/(N_TWDepth-1))^1/2

Dependencies: N_TWDepth must be known to calculate X_TWDepth and SD_TWDepth.

Assumptions: Observations sufficient to accurately characterize thalweg of site reach.

Sources: Kaufmann et al., 1999; Hillman, 2004; Peck et al., 2005, 2006.

Further documentation: https://fortress.wa.gov/ecy/publications/summarypages/1203029.html

METRIC CATEGORY: **Channel Dimensions**

Group: Channel depth
Scope: All non-null observations per DCE, entire site reach

Reported: Bankfull height, count (i)
Bankfull height, average (ii)
Bankfull height, standard deviation (iii)

Definition: (i) count, as the number of transects associated with the main channel (channel 0), where bankfull height was recorded for at least one bank, as observed at the ends of each channel-spanning transect, left bank to right bank, where each transect is perpendicular to stream current. Unit = observations of bankfull height.

(ii) average, overall, of bankfull height observations per transect, as the vertical distances, water surface-to-high-water mark, as observed at the ends of each channel-spanning transect , associated with the main channel (channel 0). Unit = centimeters.

(iii) standard deviation, of average bankfull height observations per transect associated with the main channel (channel 0), as an estimate of dispersion from the sample average. Unit = centimeters.

WHM export ID:
(i) N_BFHeight
(ii) X_BFHeight
(iii) SD_BFHeight

Observation type: Measurement
Allowed metric values: ≥ 0
Data collection schema: Evenly-spaced, cross-channel transects, equidistant and perpendicular to channel. Site reach length is variable, 150 - 2000 m.
Maximum observations (DCE),
narrow protocol: 22; 1 observation X 2 banks X 11 transects
wide protocol: 11, 1 observation X 1 bank X 11 transects
Minimum reporting qualifiers: Observations at least 80% complete
Reporting years (to date): 2009-2017

Calculation:

(i) count(transects) where, for each transect,
left_BF_Height + right_BF_Height < > is.null

(ii) if left_BF_Height and right_BF_Height,
average(left_BF_Height + right_BF_Height) = BFH
else if left_BF_Height or right_BF_Height,

(*_BF_Height) = BF_Height, where * = left or right
average(BF_Height) = BFH
else exclude transect from average
(∑(BFH)) / N_ BFHeight

(iii) (Σ ((BFH – X_BFHeight)^2)/(N_BFHeight - 1))^1/2

where BFH = average bankfull height per transect

Dependencies: None

Assumptions: Bankfull stage has been correctly identified. Measurement from bankfull stage to water surface is plumb.

Sources: Kaufmann et al., 1999; Peck et al., 2005, 2006.

Further documentation: https://fortress.wa.gov/ecy/publications/summarypages/1203029.html

METRIC CATEGORY: **Channel Dimensions**

Group: Channel cross section
Scope: All non-null observations per DCE, entire site reach

Reported: Bankfull depth, count (i)
Bankfull depth, average (ii)
Bankfull depth, standard deviation (iii)

Definition:

(i) count, of paired bankfull height and thalweg depth observations associated with the main channel (channel 0), as observed at each channel-spanning transect. Unit = pairs of bankfull height and thalweg depth.

(ii) average, of bankfull depths, as the vertical distances between the bankfull mark and the water surface plus the thalweg depth, associated with the main channel (channel 0), as observed for each channel-spanning transect. Unit = centimeters.

(iii) standard deviation, of bankfull depths associated with the main channel (channel 0), as an estimate of dispersion from the sample average. Unit = centimeters.

WHM export ID:	(i) N_BFDepth (ii) X_BFDepth (iii) SD_BFDepth
Observation type:	Measurement
Allowed metric values:	≥ 0
Data collection schema:	11 cross-channel transects, equally-spaced and perpendicular to channel. Site reach length is variable, 150 - 2000 m.
Maximum observations (DCE),	
narrow:	30; (1 bankfull height X 2 banks) + 1 thalweg depth per transect X 10 transects
wide:	20; (1 bankfull height X 1 bank) + 1 thalweg depth per transect X 10 transects
Minimum reporting qualifiers:	Observations at least 80% complete
Reporting years (to date):	2009-2017

Calculation:

(i) count(transects) where, for each transect,
{left_BF_Height + right_BF_Height < > is.null}
and TW_Depth < > is.null

(ii) if left_BF_Height < > is.null and right_BF_Height < > is.null,
(average(left_BF_Height + right_BF_Height) +TW_Depth) = BF_Depth
if left_BF_Height or right_BF_Height,

(*_BF_Height+TW_Depth) = BF_Depth, where * = left or right
else exclude transect from average
(∑(BF_Depth)) / N_ BFDepth

(iii) (Σ ((BF_Depth – X_BFDepth)^2)/(N_BFDepth - 1))^1/2

where, TW_Depth = an observation of thalweg depth.

Dependencies: Paired bankfull height and thalweg depth per transect were recorded.

Assumptions: Equivalent to direct measurement of maximum depth at winter bankfull condition.

Source: Kaufmann et al., 1999; Peck et al., 2005, 2006.

Further documentation: https://fortress.wa.gov/ecy/publications/summarypages/1203029.html

METRIC CATEGORY: **Channel Dimensions**

Group: Channel cross section
Scope: All non-null observations per DCE, entire site reach

Reported: Wetted cross-sectional area, count (i)
Wetted cross-sectional area, average (ii)
Wetted cross-sectional area, standard deviation (iii)

Definition: (i) count, of paired wetted width and thalweg depth observations associated with the main channel (channel 0), as observed at each channel-spanning transect. Unit = observations of paired wetted width and thalweg depth.

(ii) average, of wetted cross-sectional areas, approximated by a rectangle with Side A of horizontal distance between wetted shorelines, bank-to-bank and perpendicular to stream current, and Side B of thalweg depth, at each channel-spanning transect associated with the main channel (channel 0). Unit = square meters.

(iii) standard deviation, of wetted cross-sectional area estimates associated with the main channel (channel 0), as an estimate of dispersion from the sample average. Unit = square meters.

WHM export ID:	(i) N_Wet_WxD (ii) X_Wet_WxD (iii) SD_Wet_WxD
Observation type:	Measurement
Allowed metric values:	≥ 0
Data collection schema:	Cross-channel transects, equidistant and perpendicular to channel. Site reach length is variable, 150 - 2000 m.
Maximum observations (DCE),	
narrow protocol:	21; (1 wetted width + 1 thalweg depth) X 21 transects
wide protocol:	11; (1 wetted width + 1thalweg depth) X 11 transects
Minimum reporting qualifiers:	Observations at least 80% complete
Reporting years (to date):	2009-2017

Calculation:

(i) count(transects) where, for each transect,
WWidth and TW_Depth < > is.null

(ii) if, for each transect,
WWidth and TW_Depth < > is.null
then
WWidth X TW_Depth = Wet_WxD

else exclude transect from average

$$(\sum(\text{Wet\_WxD})) / \text{N\_Wet\_WxD}$$

(iii) $(\Sigma ((\text{Wet\_WxD} - \text{X\_Wet\_WxD})^2)/(\text{N\_Wet\_WxD} - 1))^{1/2}$

where, TW_Depth = an observation of depth.
WetWidth = an observation of wetted width.

Dependencies: Complete pairs of wetted widths and thalweg depths.

Assumptions: Observations sufficient to accurately characterize cross-sectional area of site reach.

Sources: Kaufmann et al., 1999; Peck et al., 2005, 2006.

Further documentation: https://fortress.wa.gov/ecy/publications/summarypages/1203029.html

METRIC CATEGORY: **Channel Dimensions**

Group: Channel cross section
Scope: All non-null observations per DCE, entire site reach

Reported: Bankfull cross-sectional area, count (i)
Bankfull cross-sectional area, average (ii)
Bankfull cross-sectional area, standard deviation (iii)

Definition: (i) count, of bankfull width observations associated with the main channel (channel 0), as observed at each channel-spanning transect. Unit = observations of bankfull width.

(ii) average, of bankfull cross-sectional areas, approximated by a rectangle with Side A of horizontal distance between bankfull shorelines, bank-to-bank and perpendicular to stream current, and Side B of bankfull depth, at each channel-spanning transect associated with the main channel (channel 0). Unit = square meters.

(iii) standard deviation, of bankfull cross-sectional area estimates associated with the main channel (channel 0), as an estimate of dispersion from the sample average. Unit = square meters.

WHM export ID:	(i) N_BF_WxD (ii) X_BF_WxD (iii) SD_BF_WxD
Observation type:	Measurement
Allowed values:	> 0
Data collection schema:	Cross-channel transects, equidistant and perpendicular to channel. Site reach length is variable, 150 - 2000 m.
Maximum observations (DCE):	11; (1 bankfull width + 1 bankfull height) X 11 transects
Minimum reporting qualifiers:	Observations at least 80% complete
Reporting years (to date):	2009-2017

Calculation:

(i) count(transects) where, for each transect,
Bankfull width < > is.null
TW_Depth < > is.null
BF_Height < > is.null

(ii) if, for each transect,
{Bankfull width < > is.null
BF_Height < > is.null
TW_Depth < > is.null},
(Bankfull width) X (BF_Height + TW_Depth) = BF_WxD
else exclude transect from average

$$(\sum(BF\_WxD)) / N\_BF\_WxD$$

(iii) $$(\Sigma ((BF\_WxD - X\_BF\_WxD)^2)/(N\_BF\_WxD - 1))^{1/2}$$

where, TW_Depth = observations of thalweg depth
BF_Height = observations of bankfull height
BF_Width = observations of bankfullwidth

Dependencies: Paired bankfull widths, bankfull heights, and thalweg depths

Assumptions: Observations sufficient to accurately characterize cross-sectional area of site reach.

Sources: Kaufmann et al., 1999; Peck et al., 2005, 2006.

Further documentation: https://fortress.wa.gov/ecy/publications/summarypages/1203029.html

METRIC CATEGORY: **Channel Dimensions**

Groups: Residual pool area
Scope: All non-null observations per DCE, entire site reach

Reported: Residual pool areas, count (i)
Vertical residual pool area, total (ii)
Standardized vertical residual pool area, total (iii)

Definition:

(i) count, of individual depth-to-residual surface estimates, as calculated from the Stack equation, one estimate per thalweg station, for all observations associated with the main channel (channel 0). Unit = observations of depth-to-residual surface.

(ii) summation, of vertical cross sectional area of each residual pool intersected by the thalweg profile, as observed along the site reach, where incremental cross-sectional areas are approximated by a rectangle with Side A of depth of the residual pool, as adjusted to the local datum, and Side B of thalweg increment. Unit = square meters.

(iii) average, as for (ii), except standardized to per 100 meter of site reach. Unit = square meters.

WHM export ID:
(i) N_ResPoolDepth
(ii) ResPoolArea
(iii) ResPoolArea100

Observation type:	Count Derived from Site_Length, X_Slope, N_TWStations
Allowed metric values:	
(i)	100
(ii)	≥ 0
(iii)	≥ 0
Data collection schema:	100 thalweg stations, equidistant along the site reach, where the distance between stations is 1 / 100th of the site reach length. Site reach length is variable, 150 - 2000 m.
Maximum observations (DCE):	100 thalweg stations per site reach, 1 observation per station
Minimum reporting qualifiers:	Observations 100% complete
Reporting years (to date):	2009-2017

Calculation:

(i) for each thalweg station,
{where (Thalweg_Depth) < > is.null}
use length of reach = Site_Length
use count of thalweg stations = N_TWStations

use TWIncrement = Site_Length / N_TWStations
use slope of reach = X_Slope
use average thalweg depth = X_TWDepth
use standard deviation thalweg depth = SD_TWDepth
use A = (X_TWDepth – SD_TWDepth)

apply Stack equation (1988) to estimate distance to residual surface from local datum as,

a) if,

first thalweg observation for reach, then first distance to residual surface, DTRS, as minimum of
(A +(0.12 + 0.25(X_Slope))*TWIncrement) OR (first Thalweg_Depth)

then depth of residual pool, DRP, for first thalweg station, if any, as,
first Thalweg_Depth – DTRS
then vertical cross-sectional area for first thalweg increment, as
((DRP/100)*TWIncrement = Individual_ResPoolArea

b) else,

distance to residual surface, DTRS, as
for *n* thalweg depths,
((*n* – i*th* Thalweg_Depth) +(0.12 + 0.25(X_Slope))*TWIncrement), OR
first Thalweg_Depth)
then depth of residual pool, DRP, for first thalweg station, if any, as,
first Thalweg_Depth – DTRS
then vertical cross-sectional area for first thalweg increment, as
((DRP/100)*TWIncrement = Individual_ResPoolArea
repeat for each thalweg observation

c) count (all(Individual_ResPoolArea)) < > is.null

(ii) for all thalweg observations
∑(Individual_ResPoolArea) = ResPoolArea

(iii) ResPoolArea / (Site_Length / 100)

Dependencies: Site_Length, X_Slope, N_TWStations, X_TWDepth, SD_TWDepth.

Assumptions: Reach slope was determined with sufficient accuracy. Results are sensitive to slope.

Sources: Kaufmann et al., 1999: Hillman, 2004; Peck et al., 2005, 2006; Stack, 1988

Further documentation: https://fortress.wa.gov/ecy/publications/summarypages/1203029.html

Metric Category: Fish Cover

Reported	WHM export ID
Number of fish cover type observations, count	N_FishCover
Average cover, of type	
Artificial structures	XFC_Artificial
Boulders	XFC_Boulder
Brush / woody debris, < 0.3 m diameter	XFC_Brush
Bryophytes	XFC_Bryophytes
Algae	XFC_Algae
Live trees or roots	XFC_TreesRoots
Macrophytes	XFC_Macrophytes
Overhanging vegetation	XFC_OvHgVeg
Undercut	XFC_Undercut
Woody debris > 0.3 m diameter	XFC_LWD
Proportion cover, of type	
Artificial structures	PFC_Artificial
Boulders	PFC_Boulder
Brush / woody debris, < 0.3 m diameter	PFC_Brush
Bryophytes	PFC_Bryophytes
Algae	PFC_Algae
Live trees or roots	PFC_TreesRoots
Macrophytes	PFC_Macrophytes
Overhanging vegetation	PFC_OvHgVeg
Undercut	PFC_Undercut
Woody debris, > 0.3 m	PFC_LWD
Average cover, combined types,	
Non-aquatic vegetation types	XFC_NoAqVeg
Natural cover types	XFC_Natural
Persistent types	XFC_Persistent
Proportion cover, combined types,	
Non-aquatic vegetation types	PFC_NoAqVeg
Natural cover types	PFC_Natural
Persistent types	PFC_Persistent

METRIC CATEGORY: **Fish Cover**

Groups: Mean fish cover
Scope: All non-null observations per DCE, entire site reach

Reported: Number of fish cover observations by type, count (i)

Definition: (i) count, of transects[1] where any type of fish-cover observation occurred, for all channel-spanning transects associated with the main channel (channel 0). Unit = observations of fish cover.

[1] though plots are of interest, plots are defined by the transect ID, and the relationship of fish cover evaluation plots to transects is 1 : 1.

WHM export ID:	(i) N_FishCover
Observation type:	Count
Allowed metric values:	≥ 0 to ≤ 11
Data collection schema,	11 cross-channel transects, perpendicular to stream current and equidistant along the site reach, with1 plot per transect. Site reach length is variable, 150 - 2000 m.
narrow protocol:	Plot covers 10 m of wetted channel, extending 5 m upstream and 5 m downstream of each transect.
wide protocol:	Plots cover 20 m of littoral zone, extending 10 m upstream and 10 m downstream of each transect.
Maximum plot count (DCE):	11, 1 plot X 11 transects
Minimum reporting qualifiers:	Observations at least 63% complete (7 of 11 transects rated)
Reporting years (to date):	2009-2017

Calculation:

(i) for each transect,
where fish cover type ratings are stored as Fish_Cover_Percent

if any Fish_Cover_Percent < > is.null,
count(unique(Transect_Code))

Dependencies: A given plot evaluated for at least one type of fish cover.

Assumptions: Observations sufficient to accurately characterize fish cover types observed.

Sources: Kaufmann et al., 1999; Peck et al., 2005, 2006.

Further documentation: https://fortress.wa.gov/ecy/publications/summarypages/1203029.html

METRIC CATEGORY: **Fish Cover**

Groups: Mean fish cover
Scope: All non-null observations per DCE, entire site reach

Reported: Fish cover types observed, as

Artificial structures, average (i)	Live trees or roots, average (vi)
Boulders, average (ii)	Macrophytes, average (vii)
Brush / woody debris, < 0.3 m diameter average (iii)	Overhanging vegetation, ≤ 1 m of water surface, average (viii)
Bryophytes, average (iv)	Undercut, average (ix)
Algae, average (v)	Woody debris > 0.3 m diameter, average (x)

Definition: For fish cover types (i-x):

(i-x) average, of fish cover ratings per plot, for a given fish-cover type, associated with the main channel (channel 0), as observed, at channel-spanning transects. Unit = percent.

categorical % cover ratings assigned:

0:	0% of water surface
5:	1-10% of water surface
25:	11-40% of water surface
57.5:	41-75% of water surface
87.5:	> 75% of water surface

WHM export ID:

(i) XFC_Artifical	(vi) XFC_TreesRoots
(ii) XFC_Boulder	(vii) XFC_Macrophytes
(iii) XFC_Brush	(viii) XFC_OvHgVeg
(iv) XFC_Bryophytes	(ix) XFC_Undercut
(v) XFC_Algae	(x) XFC_LWD

Observation type: Categorical rating
Allowed values: ≥ 0 to ≤ 87.5
Data collection schema: 11 cross-channel transects, perpendicular to stream current and equidistant along the site reach, with 1 plot per transect. Site reach length is variable, 150 - 2000 m.
narrow protocol: Plot covers 10 m of wetted channel, extending 5 m upstream and 5 m downstream of each transect.
wide protocol: Plots cover 20 m of littoral zone, extending 10 m upstream and 10 m downstream of each transect.
Maximum observations (DCE): 11 per cover type, 1 observation X 11 transects
Minimum reporting qualifiers: Observations at least 63% complete (7 of 11 plots rated)
Reporting years (to date): 2009-2017

Calculation:

(i-ix) for a given fish cover type, e.g., Artificial structures
where fish cover type ratings are stored as Fish_Cover_Percent

$$(\Sigma (Fish\_Cover\_Percent)) / N\_FishCover$$

where, N_FishCover = count of observations of fish cover

Dependencies: N_FishCover within acceptable range.

Assumptions: Observations sufficient to accurately characterize fish cover types observed.

Sources: Kaufmann et al., 1999; Peck et al., 2005, 2006.

Further documentation: https://fortress.wa.gov/ecy/publications/summarypages/1203029.html

METRIC CATEGORY: **Fish Cover**

Groups: Proportion fish cover
Scope: All non-null observations per DCE, entire site reach

Reported: Fish-cover types observed, as

- Artificial structures, proportion (i)
- Boulders, proportion (ii)
- Brush / woody debris, < 0.3 m diameter, proportion (iii)
- Bryophytes, proportion (iv)
- Algae, proportion (v)
- Live trees or roots, proportion (vi)
- Macrophytes, proportion (vii)
- Overhanging vegetation, ≤ 1 m of water surface, proportion (viii)
- Undercut, proportion (ix)
- Woody debris, > 0.3 m diameter, proportion (x)

Definition: For fish cover types (i-x):

(i-x) proportion, of plots containing a given fish-cover type to total plots evaluated, as observed, bank-to-bank, at channel-spanning transects associated with the main channel (channel 0). A value of 1 indicates a fish cover type was observed on all plots. Unit = unitless.

WHM export ID:

- (i) PFC_Artificial
- (ii) PFC_Boulder
- (iii) PFC_Brush
- (iv) PFC_Bryophytes
- (v) PFC_Algae
- (vi) PFC_TreesRoots
- (vii) PFC_Macrophytes
- (viii) PFC_OvHgVeg
- (ix) PFC_Undercut
- (x) PFC_LWD

Observation type: Count
Allowed metric values: ≥ 0 to ≤ 1
Data collection schema, 11 cross-channel transects, perpendicular to stream current and equidistant along the site reach, with 1 plot per transect. Site reach length is variable, 150 - 2000 m.
narrow protocol: Plot covers 10 m of wetted channel, extending 5 m upstream and 5 m downstream of each transect.
wide protocol: Plots cover 20 m of littoral zone, extending 10 m upstream and 10 m downstream of each transect.
Maximum observations (DCE): 11 per cover type, 1 observation X 11 transects
Minimum reporting qualifiers: Observations at least 63% complete (7 of 11 plots rated)
Reporting years (to date): 2009-2017

Calculation:

(i-x) for a given fish cover type, e.g., Artificial structures
where fish cover type ratings are stored as Fish_Cover_Percent

(count (where (Fish_Cover_Percent) < > is.null)) / N_FishCover

where, N_FishCover = count of fish cover observations.

Dependencies: N_FishCover within acceptable range.

Assumptions: Observations sufficient to accurately characterize fish cover types observed.

Sources: Kaufmann et al., 1999; Peck et al., 2005, 2006.

Further documentation: https://fortress.wa.gov/ecy/publications/summarypages/1203029.html

METRIC CATEGORY: **Fish Cover**

Groups: Mean fish cover
Scope: All non-null observations per DCE, entire site reach

Reported: Combined fish cover types observed, as

Non-aquatic vegetation types, average (i)
Natural cover types, average (ii)
Persistent types, average (iii)

Definition: For combined fish cover types (i-iii):

(i) average, as sum of all means of individual fish cover type, except for Aquatic Vegetation types (Macrophytes or Bryophytes or Filamentous Algae), as observed, bank-to-bank, at channel-spanning transects associated with the main channel (channel 0). Value may exceed 100% because seven metrics are summed. Unit = percent.

(ii) same as for (i), except limited to natural fish cover types (all types except Artificial Structures). Value may exceed 100% because nine metics are summed. Unit = percent.

(iii) same as for (i), except limited to persistent fish cover types (Artificial Structures or Boulders or Live Trees and Roots or Large Wood or Undercut Banks). Value may exceed 100% because five metrics are summed. Unit = percent.

categorical % average cover ratings assigned:

0: if 0% of water surface
5: if 1 -10% of water surface
25: if 11- 40% of water surface
57.5: if 41-75% of water surface
87.5: if> 75% of water surface

WHM export ID:
(i) XFC_NoAqVeg
(ii) XFC_Natural
(iii) XFC_Persistent

Observation type: Categorical ratings
Allowed metric values:
(i) ≥ 0 to ≤ 612.5
(ii) ≥ 0 to ≤ 787.5
(iii) ≥ 0 to ≤ 437.5
Data collection schema, 11 cross-channel transects, perpendicular to stream current and equidistant along the site reach, with 1 plot per transect. Site reach length is variable, 150 - 2000 m.
narrow protocol: Plot covers 10 m of wetted channel, extending 5 m upstream and 5 m downstream of each transect.

wide protocol:	Plots cover 20 m of littoral zone, extending 10 m upstream and 10 m downstream of each transect.
Maximum observations (DCE):	11 per cover type, 1 observation per transect X 11 transects
Minimum reporting qualifiers:	Observations at least 63% complete (7 of 11 plots rated)
Reporting years (to date):	2009-2017
Calculation:	

(i-iii) for the means of specified individual fish cover types, XFC_*, such as XFC_NoAqVeg,

(Σ ((XFC_*) < > is.null))

See below for definitions of means of individual fish cover types.

Dependencies: N_FishCover within acceptable range.

Assumptions: Observations sufficient to accurately characterize fish cover types observed.

Sources: Kaufmann et al., 1999; Peck et al., 2005, 2006.

Further documentation: https://fortress.wa.gov/ecy/publications/summarypages/1203029.html

Link to definitions, individual fish cover types

METRIC CATEGORY: **Fish Cover**

Groups: Proportion fish cover
Scope: All non-null observations per DCE, entire site reach

Reported: Combined fish cover types observed, as

Non-aquatic vegetation types, proportion (i)
Natural cover types, proportion (ii)
Persistent types, proportion (iii)

Definition: For combined fish-cover types (i-iii):

(i) proportion, as ratio of the number of FishCover rating plots where any cover type except Aquatic Vegetation (i.e., Macrophytes or Bryophytes or Filamentous Algae) was observed, to total plots evaluated, as observed, bank-to-bank, at channel-spanning transects associated with the main channel (channel 0). A value of 1 indicates a fish cover type other than Aquatic Vegetation was observed on all plots. Unit = unitless.

(ii) same as for (i), except limited to natural FishCover types (i.e., all types except Artificial Structures). A value of 1 indicates a fish cover type other than Artificial Structures was observed on all plots. Unit = unitless.

(iii) same as for (i), except limited to persistent FishCover types (i.e., Artificial Structures or Boulders or Live Trees and Roots or Large Wood or Undercut Banks). A value of 1 indicates these fish cover types were observed on all plots. Unit = unitless.

WHM export ID: (i) PFC_NoAqVeg
(ii) PFC_Natural
(iii) PFC_Persistent

Observation type:	Count
Allowed metric values:	≥0 to ≤1
Data collection schema,	11 cross-channel transects, perpendicular to stream current and equidistant along the site reach, with 1 plot per transect. Site reach length is variable, 150 - 2000 m.
narrow protocol:	Plot covers 10 m of wetted channel, extending 5 m upstream and 5 m downstream of each transect.
wide protocol:	Plots cover 20 m of littoral zone, extending 10 m upstream and 10 m downstream of each transect.
Maximum observations (DCE):	11 per DCE, 1 observation per transect X 11 transects
Minimum reporting qualifiers:	Observations at least 63% complete (7 of 11 plots rated)
Reporting years (to date):	2009-2017

Calculation:

(i-iii) for plots where any of the specified fish cover types are observed,

where fish cover type ratings are stored as Fish_Cover_Percent, count each plot once, as

(count (where (Fish_Cover_Percent) < > is.null)) / N_FishCover

where, N_FishCover = count of fish cover observations.

Dependencies: N_FishCover within acceptable range.

Assumptions: Observations sufficient to accurately characterize fish cover types observed.

Sources: Kaufmann et al., 1999; Peck et al., 2005, 2006.

Further documentation: https://fortress.wa.gov/ecy/publications/summarypages/1203029.html

Metric Category: Habitat Unit Dimensions

Reported	WHM export ID
Pool crest depth, count	N_PoolCrestDepth
Pool crest depth, average	X_PoolCrestDepth
Pool maximum depth, count	N_PoolMaxDepth
Pool maximum depth, average	X_PoolMaxDepth
Pool unit depth, count	N_PoolUnitDepth
Pool unit depth, average	X_PoolUnitDepth
Pool unit depth, std.dev.	SD_PoolUnitDepth

METRIC CATEGORY: **Habitat Unit Dimensions**

Group: Residual pool depth
Scope: All non-null observations per DCE, entire site reach, all detected pools

Reported:
- Pool crest depth, average (i)
- Pool maximum depth, average (ii)
- Pool unit depth, standard deviation (v)
- Pool unit depth, count (iii)
- Pool unit depth, average (iv)

Definition: Description of pool characteristics for each detected pool along the site reach, surveyed using stream profile consisting of 100 thalweg observations stations, as

(i) count, of pool crest depth observations associated with the main channel (channel 0), one per pool. Unit = observations of pool crest depth.

(ii) count, of pool maximum depth observations associated with the main channel (channel 0), one per pool. Unit = observations of maximum pool depth.

(iii) average, of depth observations associated with the main channel (channel 0), one per pool, as the distance, water surface-to-crest of substrate

a) at the downstream rim of each scour pool or plunge pool,
b) at the upstream shallow point of each dammed pool.

Unit = cm.

(iv) same as for (iii), except substituting pool maximum depth for pool crest depth. Unit = cm.

(v) count, of differences, pool maximum depth minus pool crest depth, for all pairs of depth observations, one pair per pool. Unit = unitless.

(vi) average, of differences, pool maximum depth minus pool crest depth, for all pairs of depth observations, one pair per pool associated with the main channel (channel 0). Unit = cm.

(vii) standard deviation, of differences, pool maximum depth minus pool crest depth, associated with the main channel (channel 0), as an estimate of dispersion from the sample average. Unit = cm.

WHM export ID:
- (i) N_PoolCrestDepth
- (ii) N_PoolMaxDepth
- (iii) X_PoolCrestDepth
- (iv) X_PoolMaxDepth
- (v) N_PoolUnitDepth
- (vi) X_PoolUnitDepth
- (vii) SD_PoolUnitDepth

Observation type: measurement
Allowed observation values: ≥ 0

Data collection schema:	reach of main channel, divided into habitat units. Number and length of habitat units is variable. Site reach length is variable, 150 - 2000 m.
Maximum observations (DCE)	no limit, typically < 20
Minimum reporting qualifiers:	habitat unit survey 100% complete. No missing or out-of-sequence habitat units.
Reporting years (to date):	2009-2017

Calculation:

(i) for all pools observed,
count(PoolCrestDepth observations) as N_PoolCrestDepth

(ii) for all pools observed,
count(PoolCrestDepth observations) as N_PoolMaxDepth

(iii) (Σ(PoolCrestDepth)) / N_PoolCrestDepth
(iv) (Σ(PoolMaxDepth)) / N_PoolMaxDepth
(v) (count(pairs(PoolCrestDepth and PoolMaxDepth)))
(vi) (Σ(paired(PoolMaxDepth - PoolCrestDepth))) / N_PoolUnitDepth
(vi)
(Σ ((PoolMaxDepth -PoolCrestDepth)) – X_PoolUnitDepth)^2) / (N_PoolUnitDepth-1))^1/2

Dependencies: Pool count > 1 to calculate SD_PoolUnitDepth.

Assumptions: Observations sufficient to accurately characterize residual pool characteristics.

Sources: Kaufmann et al., 1999; Peck et al., 2005, 2006.

Further documentation: https://fortress.wa.gov/ecy/publications/summarypages/1203029.html

Metric Category: Habitat Unit Extent

Reported	WHM export ID
Relative length of site reach as	
Dry channel	PCT_Dry
Wetted channel	PCT_Wet
Fast turbulent	PCT_FastT
Fast non-turbulent	PCT_FastNT
Fast (turbulent + non-turbulent)	PCT_Fast
Plunge pool	PCT_PoolPlunge
Scour pool	PCT_PoolScour
Dammed pool	PCT_PoolDammed
Pools, all types combined, (plunge + scour + dammed)	PCT_Pool

METRIC CATEGORY: **Habitat Unit Extent**

Groups: Dry, Wet, Fast, Pool
Scope: All non-null observations per DCE, entire site reach

Reported: Channel habitat types observed, as relative lengths of

Dry channel (i)	Plunge pool (vi)
Wetted channel (ii)	Scour pool (vii)
Fast turbulent (iii)	Dammed pool (viii)
Fast non-turbulent (iv)	Pool (plunge + scour + dammed) (ix)
Fast (turbulent + non-turbulent) (v)	

Definition: For habitat types (i-ix):

(i-ix) percent, of thalweg stations, associated with a given habitat type, where each increment of the main channel (channel 0) is assigned a habitat type code, and each increment = 1/100 of total length of the site reach. Unit = percent.

Fast, turbulent water includes falls, rapids, riffles, and chutes.

Fast, non-turbulent water includes sheets and runs.

WHM export ID:

(i) PCT_Dry	(vi) PCT_PoolPlunge
(ii) PCT_Wet	(vii) PCT_PoolScour
(iii) PCT_FastT	(vii) PCT_PoolDammed
(iv) PCT_FastNT	(ix) PCT_Pool
(v) PCT_Fast	

Observation type:	Category assigned from visual survey
Allowed values:	Habitat type codes
Data collection schema:	100 equally-spaced thalweg profile stations, at the end of each increment of the main channel one code assigned per station. Site reach length is variable, 150 - 2000 m.
Maximum observations (DCE)	100 thalweg stations per site reach, 1 observation per station
Minimum reporting qualifiers:	Observations 100% complete
Reporting years (to date):	2009-2017

Calculation:

(i-ix) For each Habitat Type, e.g., Dry channel

count (stations of Habitat Type) / count (N_TW Depth) X 100

Note: thalweg depths are counted instead of stations as an observation could be omitted.

where, N_TWDepth = count of thalweg depth observations

Dependencies: N TWDepth must be known to calculate percent site length as habitat type.

Assumptions: Observations sufficient to accurately characterize Habitat unit descriptions are accurate.

Sources: Kaufmann et al., 1999; Peck et al., 2005, 2006.

Further documentation: https://fortress.wa.gov/ecy/publications/summarypages/1203029.html

Metric Category: Large Woody Debris

Metrics for large woody debris (LWD) generally follows the approach of Kaufmann et al. (1999), which provides a more compact description of these metrics. Here, the approach is to document each metric reported, and its calculation, either as a count or as a volume. Metrics for individual LWD size classes and those which combine LWD size classes are handled separately.

Reported	WHM export ID
Adjustment, counts, protocol = wide	note to users
Count, pieces, each Diameter x Length class	
Diameter class 1 x Length class 1	LWDPiecesD1L1
Diameter class 1 x Length class 2	LWDPiecesD1L2
Diameter class 1 x Length class 3	LWDPiecesD1L3
Diameter class 2 x Length class 1	LWDPiecesD2L1
Diameter class 2 x Length class 2	LWDPiecesD2L2
Diameter class 2 x Length class 3	LWDPiecesD2L3
Diameter class 3 x Length class 1	LWDPiecesD3L1
Diameter class 3 x Length class 2	LWDPiecesD3L2
Diameter class 3 x Length class 3	LWDPiecesD3L3
Diameter class 4 x Length class 1	LWDPiecesD4L1
Diameter class 4 x Length class 2	LWDPiecesD4L2
Diameter class 4 x Length class 3	LWDPiecesD4L3
Count, pieces, two or more Diameter X Length classes combined	
All large wood, Size classes 1 to 5	LWDPieces
All large wood, Size classes 2 to 5	LWDPiecesStoX
All large wood, Size classes 3 to 5	LWDPiecesMtoX
All large wood, Size classes 4 to 5	LWDPiecesLtoX
Normalized count, pieces per 100 m,	
Diameter class 1 x Length class 1 per 100m	LWDPieces100mD1L1
Diameter class 1 x Length class 2 per 100m	LWDPieces100mD1L2
Diameter class 1 x Length class 3 per 100m	LWDPieces100mD1L3
Diameter class 2 x Length class 1 per 100m	LWDPieces100mD2L1
Diameter class 2 x Length class 2 per 100m	LWDPieces100mD2L2
Diameter class 2 x Length class 3 per 100m	LWDPieces100mD2L3
Diameter class 3 x Length class 1 per 100m	LWDPieces100mD3L1
Diameter class 3 x Length class 2 per 100m	LWDPieces100mD3L2
Diameter class 3 x Length class 3 per 100m	LWDPieces100mD3L3
Diameter class 4 x Length class 1 per 100m	LWDPieces100mD4L1
Diameter class 4 x Length class 2 per 100m	LWDPieces100mD4L2

Diameter class 4 x Length class 3 per 100m	LWDPieces100mD4L3
Normalized count, pieces per 100m, two or more size classes combined	
All large wood, Size classes 1 to 5 per 100 m	LWDPieces100m
All large wood, Size classes 2 to 5 per 100 m	LWDPieces100mStoX
All large wood, Size classes 3 to 5 per 100 m	LWDPieces100mMtoX
All large wood, Size classes 4 to 5 per 100 m	LWDPieces100mLtoX
Normalized count, pieces per square meter	
Diameter class 1 x Length class 1 per m^2	LWDPiecesMSqD1L1
Diameter class 1 x Length class 2 per m^2	LWDPiecesMSqD1L2
Diameter class 1 x Length class 3 per m^2	LWDPiecesMSqD1L3
Diameter class 2 x Length class 1 per m^2	LWDPiecesMSqD2L1
Diameter class 2 x Length class 2 per m^2	LWDPiecesMSqD2L2
Diameter class 2 x Length class 3 per m^2	LWDPiecesMSqD2L3
Diameter class 3 x Length class 1 per m^2	LWDPiecesMSqD3L1
Diameter class 3 x Length class 2 per m^2	LWDPiecesMSqD3L2
Diameter class 3 x Length class 3 per m^2	LWDPiecesMSqD3L3
Diameter class 4 x Length class 1 per m^2	LWDPiecesMSqD4L1
Diameter class 4 x Length class 2 per m^2	LWDPiecesMSqD4L2
Diameter class 4 x Length class 3 per m^2	LWDPiecesMSqD4L3
Normalized count, pieces per square meter, two or more size classes combined	
All large wood, Size classes 1 to 5 per m^2 (i)	LWDPiecesMSq
All large wood, Size classes 2 to 5 per m^2 (ii)	LWDPiecesMSqStoX
All large wood, Size classes 3 to 5 per m^2 (iii)	LWDPiecesMSqMtoX
All large wood, Size classes 4 to 5 per m^2 (iv)	LWDPiecesMSqLtoX
Volume per site, each size class	
Diameter class 1 x Length class 1 (i)	LWDVolumeD1L1
Diameter class 1 x Length class 2 (ii)	LWDVolumeD1L2
Diameter class 1 x Length class 3 (iii)	LWDVolumeD1L3
Diameter class 2 x Length class 1 (iv)	LWDVolumeD2L1
Diameter class 2 x Length class 2 (v)	LWDVolumeD2L2
Diameter class 2 x Length class 3 (vi)	LWDVolumeD2L3
Diameter class 3 x Length class 1 (vii)	LWDVolumeD3L1
Diameter class 3 x Length class 2 (viii)	LWDVolumeD3L2
Diameter class 3 x Length class 3 (ix)	LWDVolumeD3L3
Diameter class 4 x Length class 1 (x)	LWDVolumeD4L1
Diameter class 4 x Length class 2 (xi)	LWDVolumeD4L2
Diameter class 4 x Length class 3 (xii)	LWDVolumeD4L3
Volume per site, two or more size classes combined	
All large wood, Size classes 1 to 5 (i)	LWDVolume

All large wood, Size classes 2 to 5 (ii)	LWDVolumeStoX
All large wood, Size classes 3 to 5 (iii)	LWDVolumeMtoX
All large wood, Size classes 4 to 5 (iv)	LWDVolumeLtoX
Normalized volume, per 100m, each size class	
Diameter class 1 x Length class 1 per 100m	LWDVolume100mD1L1
Diameter class 1 x Length class 2 per 100m	LWDVolume100mD1L2
Diameter class 1 x Length class 3 per 100m	LWDVolume100mD1L3
Diameter class 2 x Length class 1 per 100m	LWDVolume100mD2L1
Diameter class 2 x Length class 2 per 100m	LWDVolume100mD2L2
Diameter class 2 x Length class 3 per 100m	LWDVolume100mD2L3
Diameter class 3 x Length class 1 per 100m	LWDVolume100mD3L1
Diameter class 3 x Length class 2 per 100m	LWDVolume100mD3L2
Diameter class 3 x Length class 3 per 100m	LWDVolume100mD3L3
Diameter class 4 x Length class 1 per 100m	LWDVolume100mD4L1
Diameter class 4 x Length class 2 per 100m	LWDVolume100mD4L2
Diameter class 4 x Length class 3 per 100m	LWDVolume100mD4L3
Normalized volume, per 100m, size classes combined	
All large wood, Size classes 1 to 5 per 100 m	LWDVolume100m
All large wood, Size classes 2 to 5 per 100 m	LWDVolume100mStoX
All large wood, Size classes 3 to 5 per 100 m	LWDVolume100mMtoX
All large wood, Size classes 4 to 5 per 100 m	LWDVolume100mLtoX
Normalized volume, per square meter, each size class	
Diameter class 1 x Length class 1 per m^2	LWDVolumeMSqD1L1
Diameter class 1 x Length class 2 per m^2	LWDVolumeMSqD1L2
Diameter class 1 x Length class 3 per m^2	LWDVolumeMSqD1L3
Diameter class 2 x Length class 1 per m^2	LWDVolumeMSqD2L1
Diameter class 2 x Length class 2 per m^2	LWDVolumeMSqD2L2
Diameter class 2 x Length class 3 per m^2	LWDVolumeMSqD2L3
Diameter class 3 x Length class 1 per m^2	LWDVolumeMSqD3L1
Diameter class 3 x Length class 2 per m^2	LWDVolumeMSqD3L2
Diameter class 3 x Length class 3 per m^2	LWDVolumeMSqD3L3
Diameter class 4 x Length class 1 per m^2	LWDVolumeMSqD4L1
Diameter class 4 x Length class 2 per m^2	LWDVolumeMSqD4L2
Diameter class 4 x Length class 3 per m^2	LWDVolumeMSqD4L3
Normalized volume, per square meter, size classes combined	
All large wood, Size classes 1 to 5 per m^2	LWDVolumeMSq
All large wood, Size classes 2 to 5 per m^2	LWDVolumeMSqStoX
All large wood, Size classes 3 to 5 per m^2	LWDVolumeMSqMtoX
All large wood, Size classes 4 to 5 per m^2	LWDVolumeMSqLtoX

METRIC CATEGORY: **Large Woody Debris**

Adjustments are applied to LWD tallies when wide rivers are inventoried.

Group: Adjustment to counts, inventory of LWD for wide rivers
Scope: Protocol = wide, all non-null observations per DCE

There are three adjustments. In the first, counts of LWD tallied while surveying a single stream bank are scaled up to approximate a tally of both stream banks. In the second, the 200 m subsample of surveyed study reach is scaled to the full length of study reach. In the third, counts of LWD tallied during the survey are scaled to account for incomplete sub-sampling, if any.

if protocol = wide, then

adjust for surveying a single bank, as

$(\Sigma \ (LWD\_Count))*2 = X$

adjust for sub-sampling and incomplete sub-sampling, as

X *[(Number of transects observed* 0.1*Site_Length) /
(Number of transects observed* 0.1*200)],

which reduces to

X *[Site_Length / 200]

See LWD, Pieces per Site for an example of these adjustments in use.

METRIC CATEGORY: **Large Woody Debris**

Group: Pieces per Site
Scope: All non-null observations per DCE, entire site reach

Reported: Count, of large woody debris, as

Diameter class 1 x Length class 1 (i)	Diameter class 3 x Length class 1 (vii)
Diameter class 1 x Length class 2 (ii)	Diameter class 3 x Length class 2 (viii)
Diameter class 1 x Length class 3 (iii)	Diameter class 3 x Length class 3 (ix)
Diameter class 2 x Length class 1 (iv)	Diameter class 4 x Length class 1 (x)
Diameter class 2 x Length class 2 (v)	Diameter class 4 x Length class 2 (xi)
Diameter class 2 x Length class 3 (vi)	Diameter class 4 x Length class 3 (xii)

where: categorical diameter class, categorical length class,

Western Washington

D1 = 10-30 cm	L1 = 2-5 m
D2 = > 30-60 cm	L2 = > 5-15 m
D3 = > 60-80 cm	L3 = > 15 m
D4 = > 80 cm	

Eastern Washington

D1 = 10-15 cm	L1 = 1-3 m
D2 = > 15-30 cm	L2 = > 3-6 m
D3 = > 30-60 cm	L3 = > 6 m
D4 = > 60 cm	

Definition: For each individual (Diameter x Length class) of large wood, (i-xii)

(i–xii) count, of large woody debris of a given (Diameter x Length) class, either as intersecting or contained within the bankfull zone of the main channel (channel 0), as visually observed along the length of site reach. Any pieces of dead trees of minimum dimensions are counted, including coarse roots and large limbs if not attached to a bole. Length minima are 2 m, Western Washington, and 1 m, Eastern Washington. Diameter minimum in all cases is ≥ 10 cm. Unit = count per site.

WHM export ID:

(i)	LWDPiecesD1L1	(vii)	LWDPiecesD3L1
(ii)	LWDPiecesD1L2	(viii)	LWDPiecesD3L2
(iii)	LWDPiecesD1L3	(ix)	LWDPiecesD3L3
(iv)	LWDPiecesD2L1	(x)	LWDPiecesD4L1
(v)	LWDPiecesD2L2	(xi)	LWDPiecesD4L2
(vi)	LWDPiecesD2L3	(xii)	LWDPiecesD4L3

Observation type: Count
Allowed metric values: ≥ 0
Data collection schema,

narrow protocol: Length of site reach, sub-divided into 10 equal-length sections.

wide protocol: Length of site reach is sub-sampled by observing 10 littoral – bankfull plots (each 20 meters long), on a single bank, one plot each at 10 of eleven transects. No observations are taken at the last transect (transect K).

Study-reach length is variable, 150 - 2000 m.

Maximum observations (DCE): No limit
Minimum reporting qualifiers: ≥ 80% of site reach surveyed
Reporting years (to date): 2009-2017[1]

[1] Beginning with data collected in 2012, a distinction was made between LWD in contact with substrate of the bankfull zone vs. LWD suspended above the bankfull zone. The latter is defined as LWD not modifying flow when the channel is in the bankfull condition. Some progress on metrics for suspended LWD is expected sometime after 2016.

Calculation:

(i - xii) for each unique (Diameter x Length) class,
{ where LWD_Count < > is.null}

(Σ (LWD_Count))

then, if protocol = wide,

adjust for surveying a single bank, as

(Σ (LWD_Count))*2 = X

adjust for sub-sampling, 200 m of channel, as

X * (Number of transects observed* 0.1*Site_Length /
Number of transects observed* 0.1*200)]

which reduces to

X *[Site_Length / 200]

where Site_Length = total length of the site reach surveyed.

Dependencies: Large woody debris survey was completed. Counts were adjusted when the wide protocol was used.

Assumptions: LWD diameter and length categories are sufficiently detailed to characterize channel conditions. For the wide protocol, we assume that the center of the channel (between left and right littoral zones) contains minimal pieces of large woody debris. We further assume that counts of LWD on the surveyed channel bank approximate counts of LWD on the unsurveyed, opposite channel bank.

Sources: Kaufmann et al., 1999; Hillman, 2004; Peck et al., 2005, 2006.

Further documentation: https://fortress.wa.gov/ecy/publications/summarypages/1203029.html

METRIC CATEGORY: **Large Woody Debris**

Group: Pieces per Site
Scope: All non-null observations per DCE, entire site reach

Reported: Count, of large woody debris, two or more size classes combined, as

All large wood, Size classes 1 to 5 (i)
All large wood, Size classes 2 to 5 (ii)
All large wood, Size classes 3 to 5 (iii)
All large wood, Size classes 4 to 5 (iv)

Definition: For each case of combined size classes of large wood, (i - iv)

(i – iv) count, of large woody debris of specified size classes, either as intersecting or contained within the bankfull zone of the main channel (channel 0), as visually observed along the length of site reach. Any pieces of dead trees of minimum dimensions are counted, including coarse roots and large limbs if not attached to a bole. Length minima are 2 m, Western Washington, and 1 m, Eastern Washington. Diameter minimum in all cases is ≥ 10 cm. Unit = count per site.

where

Size-class 1 = D1L1
Size-class 2 = D1L2, D2L1, D3L1
Size-class 3 = D1L3, D2L2, D4L1
Size-class 4 = D2L3, D3L2, D3L3, D4L2
Size-class 5 = D4L3

See below for individual (Diameter x Length) class definitions

WHM export ID:
(i) LWDPieces
(ii) LWDPiecesStoX
(iii) LWDPiecesMtoX
(iv) LWDPiecesLtoX

Observation type: Count
Allowed metric values: ≥ 0
Data collection schema,
narrow protocol: Length of site reach, sub-divided into 10 equal-length sections.
wide protocol: Length of site reach is sub-sampled by observing 10 littoral – bankfull plots (each 20 meters long), on a single bank, one plot each at 10 of eleven transects. No observations are taken at the last transect (transect K).

Study-reach length is variable, 150 - 2000 m.

Maximum observations (DCE): No limit
Minimum reporting qualifiers: ≥ 80% of site reach surveyed
Reporting years (to date): 2009-2017[1]

[1] Beginning with data collected in 2012, a distinction was made between LWD in contact with substrate of the bankfull zone vs. LWD suspended above the bankfull zone. The latter is defined as LWD not modifying flow when the channel is in the bankfull condition. Some progress on metrics for suspended LWD is expected sometime after 2016.

Calculation:

(i - iv) for each unique size class, *a* to *x*
{where LWD_Count < > is.null},

(Σ (LWD_Count)), as = Y_a, …., Y_x

then Σ (Y_a+ ….+ Y_x)

Note: if protocol = wide,

adjust counts, upscaling to both banks and length of surveyed channel.
See first entry, LWD category.

Dependencies: Large woody debris survey was completed. Counts were adjusted when the wide protocol was used.

Assumptions: LWD diameter and length categories are sufficiently detailed to characterize channel conditions. For the wide protocol, we assume there are minimal numbers of pieces of LWD mid-channel (i.e., between left and right littoral zones). We further assume that counts of LWD on the surveyed channel bank approximate counts of LWD on the unsurveyed, opposite channel bank.

Sources: Kaufmann et al., 1999; Hillman, 2004; Peck et al., 2005, 2006.

Further documentation: https://fortress.wa.gov/ecy/publications/summarypages/1203029.html

METRIC CATEGORY: **Large Woody Debris**

Group: Pieces per 100 m
Scope: All non-null observations per DCE, entire site reach

Reported: Normalized count, of large woody debris, as

Diameter class 1 x Length class 1 per 100m (i)	Diameter class 3 x Length class 1 per 100m (vii)
Diameter class 1 x Length class 2 per 100m (ii)	Diameter class 3 x Length class 2 per 100m (viii)
Diameter class 1 x Length class 3 per 100m (iii)	Diameter class 3 x Length class 2 per 100m (ix)
Diameter class 2 x Length class 1 per 100m (iv)	Diameter class 4 x Length class 1 per 100m (x)
Diameter class 2 x Length class 2 per 100m (v)	Diameter class 4 x Length class 2 per 100m (xi)
Diameter class 2 x Length class 3 per 100m (vi)	Diameter class 4 x Length class 3 per 100m (xii)

where:	categorical diameter class,	categorical length class,
Western Washington		
	D1 = 10-30 cm	L1 = 2-5 m
	D2 = > 30-60 cm	L2 = > 5-15 m
	D3 = > 60-80 cm	L3 = > 15 m
	D4 = > 80 cm	
Eastern Washington		
	D1 = 10-15 cm	L1 = 1-3 m
	D2 = > 15-30 cm	L2 = > 3-6 m
	D3 = > 30-60 cm	L3 = > 6 m
	D4 = > 60 cm	

Definition: For each individual (Diameter x Length) class of large wood, (i-xii),

(i–xii) normalized count, of large woody debris of a given (Diameter x Length) class, either as intersecting or contained within the bankfull zone of the main channel (channel 0), per 100 m of channel, as visually observed along the length of site reach. Any pieces of dead trees of minimum dimensions are counted, including coarse roots and large limbs if not attached to a bole. Length minima are 2 m, Western Washington, and 1 m, Eastern Washington. Diameter minimum in all cases is ≥ 10 cm. Unit = count per 100m.

WHM export ID:				
	(i)	LWDPieces100mD1L1	(vii)	LWDPieces100mD3L1
	(ii)	LWDPieces100mD1L2	(viii)	LWDPieces100mD3L2
	(iii)	LWDPieces100mD1L3	(ix)	LWDPieces100mD3L3
	(iv)	LWDPieces100mD2L1	(x)	LWDPieces100mD4L1
	(v)	LWDPieces100mD2L2	(xi)	LWDPieces100mD4L2
	(vi)	LWDPieces100mD2L3	(xii)	LWDPieces100mD4L3

Observation type: Count
Allowed metric values: ≥ 0

Data collection schema,

narrow protocol: Length of site reach, sub-divided into 10 equal-length sections.

wide protocol: Length of site reach is sub-sampled by observing 10 littoral – bankfull plots (each 20 meters long), on a single bank, one plot each at 10 of eleven transects. No observations are taken at the last transect (transect K).

Study-reach length is variable, 150 - 2000 m.

Maximum observations (DCE): No limit
Minimum reporting qualifiers: ≥ 80% of site reach surveyed
Reporting years (to date): 2009-2017[1]

[1] Beginning with data collected in 2012, a distinction was made between LWD in contact with substrate of the bankfull zone vs. LWD suspended above the bankfull zone. The latter is defined as LWD not modifying flow when the channel is in the bankfull condition. Some progress on metrics for suspended LWD is expected sometime after 2016.

Calculation:

(i - xii) for each unique (Diameter x Length) class,
{where (LWD_Count) < > is.null}

(Σ (LWD_Count) * 100) / (Site_Length)

Note: if protocol = wide,

adjust counts, upscaling to both banks and length of surveyed channel. See first entry, LWD category.

where, Site_Length = total length of site reach surveyed.

See below for definitions of individual (Diameter x Length) classes.

Dependencies: Large woody debris survey was completed. Counts were adjusted when the wide protocol was used.

Assumptions: LWD diameter and length categories are sufficiently detailed to characterize channel conditions. For the wide protocol, we assume that the center of the channel (between left and right littoral zones) contains minimal pieces of large woody debris. We further assume that counts of LWD on the surveyed channel bank approximate counts of LWD on the unsurveyed, opposite channel bank.

Sources: Kaufmann et al., 1999; Hillman, 2004; Peck et al., 2005, 2006.

Further documentation: https://fortress.wa.gov/ecy/publications/summarypages/1203029.html

Link to definitions, Individual LWD Diameter x Length classes

METRIC CATEGORY: **Large Woody Debris**

Group: Pieces per 100 m
Scope: All non-null observations per DCE, entire site reach

Reported: Normalized count, large woody debris, size classes combined, as

All large wood, Size classes 1 to 5 per 100 m (i)
All large wood, Size classes 2 to 5 per 100 m (ii)
All large wood, Size classes 3 to 5 per 100 m (iii)
All large wood, Size classes 4 to 5 per 100 m (iv)

Definition: For each case of combined size classes of large wood, (i - iv)

(i – iv) normalized count, of large woody debris of specified size classes, either as intersecting or contained within the bankfull zone of the main channel (channel 0), per 100 m of channel, as visually observed along the length of site reach surveyed. Any pieces of dead trees of minimum dimensions are counted, including coarse roots and large limbs if not attached to a bole. Length minima are 2 m, Western Washington, and 1 m, Eastern Washington. Diameter minimum in all cases is ≥ 10 cm.
Unit = count per 100 m.

where

Size-class 1 = D1L1
Size-class 2 = D1L2, D2L1, D3L1
Size-class 3 = D1L3, D2L2, D4L1
Size-class 4 = D2L3, D3L2, D3L3, D4L2
Size-class 5 = D4L3

See below for individual (Diameter x Length) class definitions.

WHM export ID:
(i) LWDPieces100m
(ii) LWDPieces100mStoX
(iii) LWDPieces100mMtoX
(iv) LWDPieces100mLtoX

Observation type: Count
Allowed metric values: ≥ 0
Data collection schema,
narrow protocol: Length of site reach, sub-divided into 10 equal-length sections.
wide protocol: Length of site reach is sub-sampled by observing 10 littoral – bankfull plots (each 20 meters long), on a single bank, one plot each at 10 of eleven transects. No observations are taken at the last transect (transect K).

Study-reach length is variable, 150 - 2000 m.

Maximum observations (DCE): No limit
Minimum reporting qualifiers: ≥ 80% of site reach surveyed
Reporting years (to date): 2009-2017[1]

[1] Beginning with data collected in 2012, a distinction was made between LWD in contact with substrate of the bankfull zone vs. LWD suspended above the bankfull zone. The latter is defined as LWD not modifying flow when the channel is in the bankfull condition. Some progress on metrics for suspended LWD is expected sometime after 2016.

Calculation:

(i - iv) for each unique size class, *a* to *x*
{where LWD_Count < > is.null},

(Σ (LWD_Count)), as = Y_a, …., Y_x

then (Σ (Y_a + ….+ Y_x) * 100) / (Site_Length)

Note: if protocol = wide,

adjust counts, upscaling to both banks and length of surveyed channel.
See first entry, LWD category.

Dependencies: Large woody debris survey was completed. Counts were adjusted when the wide protocol was used.

Assumptions: LWD diameter and length categories are sufficiently detailed to characterize channel conditions. For the wide protocol, we assume that the center of the channel (between left and right littoral zones) contains minimal pieces of large woody debris. We further assume that counts of LWD on the surveyed channel bank approximate counts of LWD on the unsurveyed, opposite channel bank.

Sources: Kaufmann et al., 1999; Hillman, 2004; Peck et al., 2005, 2006.

Further documentation: https://fortress.wa.gov/ecy/publications/summarypages/1203029.html

METRIC CATEGORY: **Large Woody Debris**

Group: Pieces per square meter
Scope: All non-null observations per DCE, entire site reach

Reported: Normalized count, as large woody debris encountered of,

Diameter class 1 x Length class 1 per m^2 (i)	Diameter class 3 x Length class 1 per m^2 (vii)
Diameter class 1 x Length class 2 per m^2 (ii)	Diameter class 3 x Length class 2 per m^2 (viii)
Diameter class 1 x Length class 3 per m^2 (iii)	Diameter class 3 x Length class 3 per m^2 (ix)
Diameter class 2 x Length class 1 per m^2 (iv)	Diameter class 4 x Length class 1 per m^2 (x)
Diameter class 2 x Length class 2 per m^2 (v)	Diameter class 4 x Length class 2 per m^2 (xi)
Diameter class 2 x Length class 3 per m^2 (vi)	Diameter class 4 x Length class 3 per m^2 (xii)

where: categorical diameter class, categorical length class,

Western Washington

D1 = 10-30 cm	L1 = 2-5 m
D2 = > 30-60 cm	L2 = > 5-15 m
D3 = > 60-80 cm	L3 = > 15 m
D4 = > 80 cm	

Eastern Washington

D1 = 10-15 cm	L1 = 1-3 m
D2 = > 15-30 cm	L2 = > 3-6 m
D3 = > 30-60 cm	L3 = > 6 m
D4 = > 60 cm	

Definition: For each individual (Diameter x Length) class of large wood, (i-xii),

(i–xii) normalized count, of large woody debris of a given (Diameter x Length) class per square meter of estimated bankfull-channel surface area of the site reach, either as intersecting or contained within the bankfull zone of the main channel (channel 0), as visually observed along the length of site reach surveyed. Any pieces of dead trees of minimum dimensions are counted, including coarse roots and large limbs if not attached to a bole. Length minima are 2 m, Western Washington, and 1 m, Eastern Washington. Diameter minimum in all cases is ≥ 10 cm.
Unit = count per square meter.

WHM export ID:

(i)	LWDPiecesMSqD1L1	(vii)	LWDPiecesMSqD3L1
(ii)	LWDPiecesMSqD1L2	(viii)	LWDPiecesMSqD3L2
(iii)	LWDPiecesMSqD1L3	(ix)	LWDPiecesMSqD3L3
(iv)	LWDPiecesMSqD2L1	(x)	LWDPiecesMSqD4L1
(v)	LWDPiecesMSqD2L2	(xi)	LWDPiecesMSqD4L2
(vi)	LWDPiecesMSqD2L3	(xii)	LWDPiecesMSqD4L3

Observation type: Count
Allowed metric values: ≥ 0
Data collection schema,
narrow protocol: Length of site reach, sub-divided into 10 equal-length sections.
wide protocol: Length of site reach is sub-sampled by observing 10 littoral – bankfull plots (each 20 meters long), on a single bank, one plot each at 10 of eleven transects. No observations are taken at the last transect (transect K).

Study-reach length is variable, 150 - 2000 m.

Maximum observations (DCE): No limit
Minimum reporting qualifiers: ≥ 80% of site reach surveyed
Reporting years (to date): 2009-2017[1]

[1] Beginning with data collected in 2012, a distinction was made between LWD in contact with substrate of the bankfull zone vs. LWD suspended above the bankfull zone. The latter is defined as LWD not modifying flow when the channel is in the bankfull condition. Some progress on metrics for suspended LWD is expected sometime after 2016.

Calculation:

(i - xii) for each unique Diameter x Length class,
{where (LWD_Count) < > is.null}

(Σ (LWD_Count)) / (Site_Length * X_BFWidth)

Note: if protocol = wide,

adjust counts, upscaling to both banks and length of surveyed channel.
See first entry, LWD category.

where, Site_Length = total length of site reach surveyed
X_BFWidth = average bankfull width

See below for definitions of individual (Diameter x Length) classes.

Dependencies: Large woody debris survey was completed. Counts were adjusted when the wide protocol was used.

Assumptions: LWD diameter and length categories are sufficiently detailed to characterize channel conditions. For the wide protocol, we assume that the center of the channel (between left and right littoral zones) contains minimal pieces of large woody debris. We further assume that counts of LWD on the surveyed channel bank approximate counts of LWD on the unsurveyed, opposite channel bank.

Sources: Kaufmann et al., 1999; Hillman, 2004; Peck et al., 2005, 2006.

Further documentation: https://fortress.wa.gov/ecy/publications/summarypages/1203029.html

Link to definitions, individual LWD Diameter x Length classes

METRIC CATEGORY: **Large Woody Debris**

Group: Pieces per square meter
Scope: All non-null observations per DCE, entire site reach

Reported: Combined normalized count, two or more size classes, as large woody debris of,

All large wood, Size classes 1 to 5 per m^2 (i)
All large wood, Size classes 2 to 5 per m^2 (ii)
All large wood, Size classes 3 to 5 per m^2 (iii)
All large wood, Size classes 4 to 5 per m^2 (iv)

Definition: For each case of combined size classes of large wood, (i - iv)

(i – iv) normalized count, of large woody debris of specified size classes per square meter of estimated bankfull-channel surface area of the site reach, either as intersecting or contained within the bankfull zone of the main channel (channel 0), as observed along the length of site reach surveyed. Any pieces of dead trees of minimum dimensions are counted, including coarse roots and large limbs if not attached to a bole. Length minima are 2 m, Western Washington, and 1 m, Eastern Washington. Diameter minimum in all cases is ≥ 10 cm. Unit = count per square meter.

where

Size-class 1 = D1L1
Size-class 2 = D1L2, D2L1, D3L1
Size-class 3 = D1L3, D2L2, D4L1
Size-class 4 = D2L3, D3L2, D3L3, D4L2
Size-class 5 = D4L3

See below for individual (Diameter x Length) class definitions

WHM export ID:
(i) LWDPiecesMSq
(ii) LWDPiecesMSqStoX
(iii) LWDPiecesMSqMtoX
(iv) LWDPiecesMSqLtoX

Observation type: Count
Allowed metric values: ≥ 0
Data collection schema,
narrow protocol: Length of site reach, sub-divided into 10 equal-length sections.
wide protocol: Length of site reach is sub-sampled by observing 10 littoral – bankfull plots (each 20 meters long), on a single bank, one plot each at 10 of eleven transects. No observations are taken at the last transect (transect K).

Study-reach length is variable, 150 - 2000 m.

Maximum observations (DCE): No limit
Minimum reporting qualifiers: ≥ 80% of site reach surveyed
Reporting years (to date): 2009-2017[1]

[1] Beginning with data collected in 2012, a distinction was made between LWD in contact with substrate of the bankfull zone vs. LWD suspended above the bankfull zone. The latter is defined as LWD not modifying flow when the channel is in the bankfull condition. Some progress on metrics for suspended LWD is expected sometime after 2016.

Calculation:

(i - iv) for each unique size class, *a* to *x*
{where LWD_Count < > is.null},

(Σ (LWD_Count)) as = Y_a, …., Y_x

then Σ (Y_a + ….+ Y_x) / (Site_Length * X_BFWidth)

Note: if protocol = wide,

adjust counts, upscaling to both banks and length of surveyed channel.
See first entry, LWD category.

Dependencies: Large woody debris survey was completed. Counts were adjusted when the wide protocol was used.

Assumptions: LWD diameter and length categories are sufficiently detailed to characterize channel conditions. For the wide protocol, we assume that the center of the channel (between left and right littoral zones) contains minimal pieces of large woody debris. We further assume that counts of LWD on the surveyed channel bank approximate counts of LWD on the unsurveyed, opposite channel bank.

Sources: Kaufmann et al., 1999; Hillman, 2004, Peck et al., 2005, 2006

Further documentation: https://fortress.wa.gov/ecy/publications/summarypages/1203029.html

METRIC CATEGORY: **Large Woody Debris**

Group: Volume per Site
Scope: All non-null observations per DCE, entire site reach

Reported: Volume, of large woody debris of

Diameter class 1 x Length class 1 (i)	Diameter class 3 x Length class 1 (vii)
Diameter class 1 x Length class 2 (ii)	Diameter class 3 x Length class 2 (viii)
Diameter class 1 x Length class 3 (iii)	Diameter class 3 x Length class 3 (ix)
Diameter class 2 x Length class 1 (iv)	Diameter class 4 x Length class 1 (x)
Diameter class 2 x Length class 2 (v)	Diameter class 4 x Length class 2 (xi)
Diameter class 2 x Length class 3 (vi)	Diameter class 4 x Length class 3 (xii)

where: categorical diameter class, categorical length class,

Western Washington

D1 = 10-30 cm	L1 = 2-5 m
D2 = > 30-60 cm	L2 = > 5-15 m
D3 = > 60-80 cm	L3 = > 15 m
D4 = > 80 cm	

Eastern Washington

D1 = 10-15 cm	L1 = 1-3 m
D2 = > 15-30 cm	L2 = > 3-6 m
D3 = > 30-60 cm	L3 = > 6 m
D4 = > 60 cm	

Definition: For each individual (Diameter x Length class) of large wood, (i-xii)

(i–xii) volume, as large woody debris of a given unique (Diameter x Length) class, either as intersecting or contained within the bankfull zone of the main channel (channel 0), as visually observed along the length of site reach. Any pieces of dead trees of minimum dimensions are counted, including coarse roots and large limbs if not attached to a bole. Length minima are 2 m, Western Washington, and 1 m, Eastern Washington. Diameter minimum in all cases is ≥ 10 cm. Unit = cubic meters per site.

WHM export ID:

(i)	LWDVolumeD1L1	(vii)	LWDVolumeD3L1
(ii)	LWDVolumeD1L2	(viii)	LWDVolumeD3L2
(iii)	LWDVolumeD1L3	(ix)	LWDVolumeD3L3
(iv)	LWDVolumeD2L1	(x)	LWDVolumeD4L1
(v)	LWDVolumeD2L2	(xi)	LWDVolumeD4L2
(vi)	LWDVolumeD2L3	(xii)	LWDVolumeD4L3

Observation type: Count
Allowed metric values: ≥ 0
Data collection schema,

narrow protocol: Length of site reach, sub-divided into 10 equal-length sections.

wide protocol: Length of site reach is sub-sampled by observing 10 littoral – bankfull plots (each 20 meters long), on a single bank, one plot each at 10 of eleven transects. No observations are taken at the last transect (transect K).

Study-reach length is variable, 150 - 2000 m.

Maximum observations (DCE): No limit
Minimum reporting qualifiers: ≥ 80% of site reach surveyed
Reporting years (to date): 2009-2017[1]

[1] Beginning with data collected in 2012, a distinction was made between LWD in contact with substrate of the bankfull zone vs. LWD suspended above the bankfull zone. The latter is defined as LWD not modifying flow when the channel is in the bankfull condition. Some progress on metrics for suspended LWD is expected sometime after 2016.

Calculation:

(i - xii) for each unique Diameter x Length class,
{where (LWD_Count) < > is.null}

(Σ (LWD_Count)) * Volume_factor / (Site_Length * X_BFWidth),
using volume factor as,

Western Washington

(i)	0.065	(vii)	1.047
(ii)	0.182	(viii)	2.909
(iii)	0.436	(ix)	6.981
(iv)	0.377	(x)	3.393
(v)	1.047	(xi)	9.425
(vi)	2.513	(xii)	22.619

Eastern Washington

(i)	0.018	(vii)	0.209
(ii)	0.043	(viii)	0.503
(iii)	0.096	(ix)	1.131
(iv)	0.052	(x)	0.838
(v)	0.126	(xi)	2.011
(vi)	0.283	(xii)	4.524

where, Site_Length = total length of site reach surveyed.
X_BFWidth = average bankfull width.

Volume_factor =average volume of a single piece of LWD of the unique Diameter X Length class, as, for (i-xii)[2],

[2] Source (see Robison):

Volume = π * [0.5*(minDiam+(maxDiam+minDiam)/3)]^2*[minLength+(maxLength – minLength)/3] [3]

Upper limits:	Length	Diameter
Western Washington:	30 m	2 m
Eastern Washington:	15 m	1.2 m

[3] applies also to Kaufman et al., 1999 replacing,

Volume = π * [4/3 * (minDiam/2)^2] * [4/3 * minLength]

See definitions of individual (Diameter x Length) classes elsewhere in this section.

Note: if protocol = wide,

adjust counts, upscaling to both banks and length of surveyed channel. See first entry, LWD category.

Dependencies: Large woody debris survey was completed. Counts were adjusted when the wide protocol was used.

Assumptions: LWD diameter and length categories are sufficiently detailed to characterize channel conditions. For the wide protocol, we assume that the center of the channel (between left and right littoral zones) contains minimal pieces of large woody debris. We further assume that counts of LWD on the surveyed channel bank approximate counts of LWD on the unsurveyed, opposite channel bank.

Sources: Robison, 1997; Kaufmann et al., 1999; Hillman, 2004; Peck et al., 2005, 2006.

Further documentation: https://fortress.wa.gov/ecy/publications/summarypages/1203029.html

METRIC CATEGORY: **Large Woody Debris**

Group: Volume per Site
Scope: All non-null observations per DCE, entire site reach

Reported: Volume, of large woody debris, two or more size classes combined, as

All large wood, Size classes 1 to 5 (i)
All large wood, Size classes 2 to 5 (ii)
All large wood, Size classes 3 to 5 (iii)
All large wood, Size classes 4 to 5 (iv)

Definition: For each case of combined size classes of large wood, (i - iv)

(i – iv) volume, of large woody debris of specified size classes, either as intersecting or contained within the bankfull zone of the main channel (channel 0), as visually observed along the length of site reach. Any pieces of dead trees of minimum dimensions are counted, including coarse roots and large limbs if not attached to a bole. Length minima are 2 m, Western Washington, and 1 m, Eastern Washington. Diameter minimum in all cases is ≥ 10 cm. Unit = cubic meters per site.

where

Size-class 1 = D1L1
Size-class 2 = D1L2, D2L1, D3L1
Size-class 3 = D1L3, D2L2, D4L1
Size-class 4 = D2L3, D3L2, D3L3, D4L2
Size-class 5 = D4L3

See below for individual (Diameter x Length) class definitions

WHM export ID:
(i) LWDVolume
(ii) LWDVolumeStoX
(iii) LWDVolumeMtoX
(iv) LWDVolumeLtoX

Observation type: Count
Allowed metric values: ≥ 0
Data collection schema,
narrow protocol: Length of site reach, sub-divided into 10 equal-length sections.

wide protocol: Length of site reach is sub-sampled by observing 10 littoral – bankfull plots (each 20 meters long), on a single bank, one plot each at 10 of eleven transects. No observations are taken at the last transect (transect K).

Study-reach length is variable, 150 - 2000 m.

Maximum observations (DCE): No limit
Minimum reporting qualifiers: ≥ 80% of site reach surveyed
Reporting years (to date): 2009-2017[1]

[1] Beginning with data collected in 2012, a distinction was made between LWD in contact with substrate of the bankfull zone vs. LWD suspended above the bankfull zone. The latter is defined as LWD not modifying flow when the channel is in the bankfull condition. Some progress on metrics for suspended LWD is expected sometime after 2016.

Calculation:

(i - xii) for each unique Diameter x Length class,
{where (LWD_Count) < > is.null}

(Σ (LWD_Count)) * Volume_factor / (Site_Length * X_BFWidth),
using volume factor as,

Western Washington

(i)	0.065	(vii)	1.047
(ii)	0.182	(viii)	2.909
(iii)	0.436	(ix)	6.981
(iv)	0.377	(x)	3.393
(v)	1.047	(xi)	9.425
(vi)	2.513	(xii)	22.619

Eastern Washington

(i)	0.018	(vii)	0.209
(ii)	0.043	(viii)	0.503
(iii)	0.096	(ix)	1.131
(iv)	0.052	(x)	0.838
(v)	0.126	(xi)	2.011
(vi)	0.283	(xii)	4.524

where, Site_Length = total length of site reach surveyed.
X_BFWidth = average bankfull width.
Volume_factor =average volume of a single piece of LWD of the unique Diameter X Length class, as, for (i-xii)[2],

[2] Source (see Robison):

$$\text{Volume} = \pi * [0.5*(\text{minDiam}+(\text{maxDiam}+\text{minDiam})/3)]^2*[\text{minLength}+(\text{maxLength} - \text{minLength})/3]^3$$

Upper limits:	Length	Diameter
Western Washington:	30 m	2 m
Eastern Washington:	15 m	1.2 m

[3] applies also to Kaufman et al., 1999 replacing,

$$\text{Volume} = \pi * [\ 4/3 * (\text{minDiam}/2)^2] * [4/3 * \text{minLength}]$$

See definitions of individual (Diameter x Length) classes elsewhere in this section.

Note: if protocol = wide,

adjust counts, upscaling to both banks and length of surveyed channel.
See first entry, LWD category.

Dependencies: Large woody debris survey was completed. Counts were adjusted when the wide protocol was used.

Assumptions: LWD diameter and length categories are sufficiently detailed to characterize channel conditions. For the wide protocol, we assume that the center of the channel (between left and right littoral zones) contains minimal pieces of large woody debris. We further assume that counts of LWD on the surveyed channel bank approximate counts of LWD on the unsurveyed, opposite channel bank.

Sources: Robison, 1997; Kaufmann et al., 1999; Hillman, 2004; Peck et al., 2005, 2006.

Further documentation: https://fortress.wa.gov/ecy/publications/summarypages/1203029.html

METRIC CATEGORY: **Large Woody Debris**

Group: Volume per 100 m
Scope: All non-null observations per DCE, entire site reach

Reported: Normalized volume, as large woody debris of

Diameter class 1 x Length class 1 per 100m (i)	Diameter class 3 x Length class 1 per 100m (vii)
Diameter class 1 x Length class 2 per 100m (ii)	Diameter class 3 x Length class 2 per 100m (viii)
Diameter class 1 x Length class 3 per 100m (iii)	Diameter class 3 x Length class 2 per 100m (ix)
Diameter class 2 x Length class 1 per 100m (iv)	Diameter class 4 x Length class 1 per 100m (x)
Diameter class 2 x Length class 2 per 100m (v)	Diameter class 4 x Length class 2 per 100m (xi)
Diameter class 2 x Length class 3 per 100m (vi)	Diameter class 4 x Length class 3 per 100m (xii)

where: categorical diameter class, categorical length class,

Western Washington

D1 = 10-30 cm	L1 = 2-5 m
D2 = > 30-60 cm	L2 = > 5-15 m
D3 = > 60-80 cm	L3 = > 15 m
D4 = > 80 cm	

Eastern Washington

D1 = 10-15 cm	L1 = 1-3 m
D2 = > 15-30 cm	L2 = > 3-6 m
D3 = > 30-60 cm	L3 = > 6 m
D4 = > 60 cm	

Definition: For each individual (Diameter x Length) class of large wood, (i-xii),

(i–xii) normalized volume, of large woody debris of a given unique (Diameter x Length) class, either as intersecting or contained within the bankfull zone of the main channel (channel 0), per 100 m of channel, as visually observed along the length of site reach. Any pieces of dead trees of minimum dimensions are counted, including coarse roots and large limbs if not attached to a bole. Length minima are 2 m, Western Washington, and 1 m, Eastern Washington. Diameter minimum in all cases is ≥ 10 cm. Unit = cubic meters per 100 m.

WHM export ID:

(i)	LWDVolume100mD1L1	(vii)	LWDVolume100mD3L1
(ii)	LWDVolume100mD1L2	(viii)	LWDVolume100mD3L2
(iii)	LWDVolume100mD1L3	(ix)	LWDVolume100mD3L3
(iv)	LWDVolume100mD2L1	(x)	LWDVolume100mD4L1
(v)	LWDVolume100mD2L2	(xi)	LWDVolume100mD4L2
(vi)	LWDVolume100mD2L3	(xii)	LWDVolume100mD4L3

Observation type: Count
Allowed metric values: ≥ 0

Data collection schema,

narrow protocol:	Length of site reach, sub-divided into 10 equal-length sections.
wide protocol:	Length of site reach is sub-sampled by observing 10 littoral – bankfull plots (each 20 meters long), on a single bank, one plot each at 10 of eleven transects. No observations are taken at the last transect (transect K).
	Study-reach length is variable, 150 - 2000 m.

Maximum observations (DCE):	No limit
Minimum reporting qualifiers:	≥ 80% of site reach surveyed
Reporting years (to date):	2009-2017[1]

[1] Beginning with data collected in 2012, a distinction was made between LWD in contact with substrate of the bankfull zone vs. LWD suspended above the bankfull zone. The latter is defined as LWD not modifying flow when the channel is in the bankfull condition. Some progress on metrics for suspended LWD is expected sometime after 2016.

Calculation:

(i - xii) for each unique Diameter x Length class,
{where (LWD_Count) < > is.null}

(Σ (LWD_Count)) * Volume_factor / (Site_Length * X_BFWidth),
using volume factor as,

Western Washington

(i)	0.065	(vii)	1.047
(ii)	0.182	(viii)	2.909
(iii)	0.436	(ix)	6.981
(iv)	0.377	(x)	3.393
(v)	1.047	(xi)	9.425
(vi)	2.513	(xii)	22.619

Eastern Washington

(i)	0.018	(vii)	0.209
(ii)	0.043	(viii)	0.503
(iii)	0.096	(ix)	1.131
(iv)	0.052	(x)	0.838
(v)	0.126	(xi)	2.011
(vi)	0.283	(xii)	4.524

where, Site_Length = total length of site reach surveyed.

X_BFWidth = average bankfull width.
Volume_factor =average volume of a single piece of LWD of the unique Diameter X Length class, as, for (i-xii)[2],

[2] Source (see Robison):

Volume = π * [0.5*(minDiam+(maxDiam+minDiam)/3)]^2*[minLength+(maxLength – minLength)/3] [3]

Upper limits:	Length	Diameter
Western Washington:	30 m	2 m
Eastern Washington:	15 m	1.2 m

[3] applies also to Kaufman et al., 1999 replacing,

Volume = π * [4/3 * (minDiam/2)^2] * [4/3 * minLength]

See definitions of individual (Diameter x Length) classes elsewhere in this section.

Note: if protocol = wide,

adjust counts, upscaling to both banks and length of surveyed channel.
See first entry, LWD category.

Dependencies: Large woody debris survey was completed. Counts were adjusted when the wide protocol was used.

Assumptions: LWD diameter and length categories are sufficiently detailed to characterize channel conditions. For the wide protocol, we assume that the center of the channel (between left and right littoral zones) contains minimal pieces of large woody debris. We further assume that counts of LWD on the surveyed channel bank approximate counts of LWD on the unsurveyed, opposite channel bank.

Sources: Robison, 1997; Kaufmann et al., 1999; Hillman, 2004; Peck et al., 2005, 2006.

Further documentation: https://fortress.wa.gov/ecy/publications/summarypages/1203029.html

Link to definitions, individual LWD Diameter x Length classes

METRIC CATEGORY: **Large Woody Debris**

Group: Volume per 100 m
Scope: All non-null observations per DCE, entire site reach

Reported: Normalized volume, large woody debris, size classes combined, as

All large wood, Size classes 1 to 5 per 100 m (i)
All large wood, Size classes 2 to 5 per 100 m (ii)
All large wood, Size classes 3 to 5 per 100 m (iii)
All large wood, Size classes 4 to 5 per 100 m (iv)

Definition: For each case of combined size classes of large wood, (i - iv)

(i – iv) normalized volume, of large woody debris of specified size classes, either as intersecting or contained within the bankfull zone of the main channel (channel 0), per 100 m of channel, as visually observed along the length of site reach. Any pieces of dead trees of minimum dimensions are counted, including coarse roots and large limbs if not attached to a bole. Length minima are 2 m, Western Washington, and 1 m, Eastern Washington. Diameter minimum in all cases is ≥ 10 cm. Unit = cubic meters per 100 m.

where

Size-class 1 = D1L1
Size-class 2 = D1L2, D2L1, D3L1
Size-class 3 = D1L3, D2L2, D4L1
Size-class 4 = D2L3, D3L2, D3L3, D4L2
Size-class 5 = D4L3

See below for individual (Diameter x Length) class definitions.

WHM export ID:
(i) LWDVolume100m
(ii) LWDVolume100mStoX
(iii) LWDVolume100mMtoX
(iv) LWDVolume100mLtoX

Observation type: Count
Allowed metric values: ≥ 0
Data collection schema,
narrow protocol: Length of site reach, sub-divided into 10 equal-length sections.
wide protocol: Length of site reach is sub-sampled by observing 10 littoral – bankfull plots (each 20 meters long), on a single bank, one plot each at 10 of eleven transects. No observations are taken at the last transect (transect K).

Study-reach length is variable, 150 - 2000 m.

Maximum observations (DCE): No limit
Minimum reporting qualifiers: ≥ 80% of site reach surveyed
Reporting years (to date): 2009-2017[1]

[1] Beginning with data collected in 2012, a distinction was made between LWD in contact with substrate of the bankfull zone vs. LWD suspended above the bankfull zone. The latter is defined as LWD not modifying flow when the channel is in the bankfull condition. Some progress on metrics for suspended LWD is expected sometime after 2016.

Calculation:

(i - xii) for each unique Diameter x Length class,
{where (LWD_Count) < > is.null}

(Σ (LWD_Count)) * Volume_factor / (Site_Length * X_BFWidth),
using volume factor as,

Western Washington

(i)	0.065	(vii)	1.047
(ii)	0.182	(viii)	2.909
(iii)	0.436	(ix)	6.981
(iv)	0.377	(x)	3.393
(v)	1.047	(xi)	9.425
(vi)	2.513	(xii)	22.619

Eastern Washington

(i)	0.018	(vii)	0.209
(ii)	0.043	(viii)	0.503
(iii)	0.096	(ix)	1.131
(iv)	0.052	(x)	0.838
(v)	0.126	(xi)	2.011
(vi)	0.283	(xii)	4.524

where, Site_Length = total length of site reach surveyed.
X_BFWidth = average bankfull width.
Volume_factor =average volume of a single piece of LWD of the unique Diameter X Length class, as, for (i-xii)[2],

[2] Source (see Robison):

$$\text{Volume} = \pi * [0.5*(\text{minDiam}+(\text{maxDiam}+\text{minDiam})/3)]^2*[\text{minLength}+(\text{maxLength} - \text{minLength})/3]^3$$

Upper limits:	Length	Diameter
Western Washington:	30 m	2 m
Eastern Washington:	15 m	1.2 m

[3] applies also to Kaufman et al., 1999 replacing,

$$\text{Volume} = \pi * [\ 4/3 * (\text{minDiam}/2)^2] * [4/3 * \text{minLength}]$$

See definitions of individual (Diameter x Length) classes elsewhere in this section.

Note: if protocol = wide,

adjust counts, upscaling to both banks and length of surveyed channel. See first entry, LWD category.

Dependencies: Large woody debris survey was completed. Counts were adjusted when the wide protocol was used.

Assumptions: LWD diameter and length categories are sufficiently detailed to characterize channel conditions. For the wide protocol, we assume that the center of the channel (between left and right littoral zones) contains minimal pieces of large woody debris. We further assume that counts of LWD on the surveyed channel bank approximate counts of LWD on the unsurveyed, opposite channel bank.

Sources: Robison, 1997; Kaufmann et al., 1999; Hillman, 2004; Peck et al., 2005, 2006.

Further documentation: https://fortress.wa.gov/ecy/publications/summarypages/1203029.html

METRIC CATEGORY: **Large Woody Debris**

Group: Volume per square meter
Scope: All non-null observations per DCE, entire site reach

Reported: Normalized volume, as large woody debris of,

Diameter class 1 x Length class 1 per m^2 (i)	Diameter class 3 x Length class 1 per m^2 (vii)
Diameter class 1 x Length class 2 per m^2 (ii)	Diameter class 3 x Length class 2 per m^2 (viii)
Diameter class 1 x Length class 3 per m^2 (iii)	Diameter class 3 x Length class 3 per m^2 (ix)
Diameter class 2 x Length class 1 per m^2 (iv)	Diameter class 4 x Length class 1 per m^2 (x)
Diameter class 2 x Length class 2 per m^2 (v)	Diameter class 4 x Length class 2 per m^2 (xi)
Diameter class 2 x Length class 3 per m^2 (vi)	Diameter class 4 x Length class 3 per m^2 (xii)

where: categorical diameter class, categorical length class,

Western Washington

D1 = 10-30 cm	L1 = 2-5 m
D2 = > 30-60 cm	L2 = > 5-15 m
D3 = > 60-80 cm	L3 = > 15 m
D4 = > 80 cm	

Eastern Washington

D1 = 10-15 cm	L1 = 1-3 m
D2 = > 15-30 cm	L2 = > 3-6 m
D3 = > 30-60 cm	L3 = > 6 m
D4 = > 60 cm	

Definition: For each individual (Diameter x Length) class of large wood, (i-xii),

(i–xii) normalized volume, of large woody debris of a given unique (Diameter x Length) class per square meter of estimated bankfull-channel surface area of the site reach, either as intersecting or contained within the bankfull zone of the main channel (channel 0), as visually observed along the length of site reach. Any pieces of dead trees of minimum dimensions are counted, including coarse roots and large limbs if not attached to a bole. Length minima are 2 m, Western Washington, and 1 m, Eastern Washington. Diameter minimum in all cases is ≥ 10 cm.
Unit = cubic meters per square meter.

WHM export ID:

(i)	LWDVolumeMSqD1L1	(vii)	LWDVolumeMSqD3L1
(ii)	LWDVolumeMSqD1L2	(viii)	LWDVolumeMSqD3L2
(iii)	LWDVolumeMSqD1L3	(ix)	LWDVolumeMSqD3L3
(iv)	LWDVolumeMSqD2L1	(x)	LWDVolumeMSqD4L1
(v)	LWDVolumeMSqD2L2	(xi)	LWDVolumeMSqD4L2
(vi)	LWDVolumeMSqD2L3	(xii)	LWDVolumeMSqD4L3

Observation type:	Count
Allowed metric values:	≥ 0
Data collection schema,	
narrow protocol:	Length of site reach, sub-divided into 10 equal-length sections.
wide protocol:	Length of site reach is sub-sampled by observing 10 littoral – bankfull plots (each 20 meters long), on a single bank, one plot each at 10 of eleven transects. No observations are taken at the last transect (transect K). Study-reach length is variable, 150 - 2000 m.
Maximum observations (DCE):	No limit
Minimum reporting qualifiers:	≥ 80% of site reach surveyed
Reporting years (to date):	2009-2017[1]

[1] Beginning with data collected in 2012, a distinction was made between LWD in contact with substrate of the bankfull zone vs. LWD suspended above the bankfull zone. The latter is defined as LWD not modifying flow when the channel is in the bankfull condition. Some progress on metrics for suspended LWD is expected sometime after 2016.

Calculation:

(i - xii) for each unique Diameter x Length class,
{where (LWD_Count) < > is.null}

(Σ (LWD_Count)) * Volume_factor / (Site_Length * X_BFWidth),
using volume factor as,

Western Washington

(i)	0.065	(vii)	1.047
(ii)	0.182	(viii)	2.909
(iii)	0.436	(ix)	6.981
(iv)	0.377	(x)	3.393
(v)	1.047	(xi)	9.425
(vi)	2.513	(xii)	22.619

Eastern Washington

(i)	0.018	(vii)	0.209
(ii)	0.043	(viii)	0.503
(iii)	0.096	(ix)	1.131
(iv)	0.052	(x)	0.838
(v)	0.126	(xi)	2.011
(vi)	0.283	(xii)	4.524

where, Site_Length = total length of site reach surveyed.
X_BFWidth = average bankfull width.
Volume_factor =average volume of a single piece of LWD of the unique Diameter X Length class, as, for (i-xii)[2],

[2] Source (see Robison):

Volume = π * [0.5*(minDiam+(maxDiam+minDiam)/3)]^2*[minLength+(maxLength – minLength)/3] [3]

Upper limits:	Length	Diameter
Western Washington:	30 m	2 m
Eastern Washington:	15 m	1.2 m

[3] applies also to Kaufman et al., 1999 replacing,

Volume = π * [4/3 * (minDiam/2)^2] * [4/3 * minLength]

See definitions of individual (Diameter x Length) classes elsewhere in this section.

Note: if protocol = wide,

adjust counts, upscaling to both banks and length of surveyed channel.
See first entry, LWD category.

Dependencies: Large woody debris survey was completed. Counts were adjusted when the wide protocol was used.

Assumptions: LWD diameter and length categories are sufficiently detailed to characterize channel conditions. For the wide protocol, we assume that the center of the channel (between left and right littoral zones) contains minimal pieces of large woody debris. We further assume that counts of LWD on the surveyed channel bank approximate counts of LWD on the unsurveyed, opposite channel bank.

Sources: Robison, 1997; Kaufmann et al., 1999; Hillman, 2004; Peck et al., 2005, 2006.

Further documentation: https://fortress.wa.gov/ecy/publications/summarypages/1203029.html

Link to definitions, individual LWD Diameter x Length classes

METRIC CATEGORY: **Large Woody Debris**

Group: Volume per square meter
Scope: All non-null observations per DCE, entire site reach

Reported: Combined normalized volume, two or more size classes, as large woody debris of,

All large wood, Size classes 1 to 5 per m^2 (i)
All large wood, Size classes 2 to 5 per m^2 (ii)
All large wood, Size classes 3 to 5 per m^2 (iii)
All large wood, Size classes 4 to 5 per m^2 (iv)

Definition: For each case of combined size classes of large wood, (i - iv)

(i – iv) normalized volume, of large woody debris of specified size classes per square meter of estimated bankfull-channel surface area of the site reach, either as intersecting or contained within the bankfull zone of the main channel (channel 0), as observed along the length of site reach. Any pieces of dead trees of minimum dimensions are counted, including coarse roots and large limbs if not attached to a bole. Length minima are 2 m, Western Washington, and 1 m, Eastern Washington. Diameter minimum in all cases is ≥ 10 cm. Unit = cubic meters per square meter.

where

Size-class 1 = D1L1
Size-class 2 = D1L2, D2L1, D3L1
Size-class 3 = D1L3, D2L2, D4L1
Size-class 4 = D2L3, D3L2, D3L3, D4L2
Size-class 5 = D4L3

See URL below for individual (Diameter x Length) class definitions

WHM export ID:
(i) LWDVolumeMSq
(ii) LWDVolumeMSqStoX
(iii) LWDVolumeMSqMtoX
(iv) LWDVolumeMSqLtoX

Observation type: Count
Allowed metric values: ≥ 0
Data collection schema,
narrow protocol: Length of site reach, sub-divided into 10 equal-length sections.
wide protocol: Length of site reach is sub-sampled by observing 10 littoral – bankfull plots (each 20 meters long), on a single bank, one plot each at 10 of eleven transects. No observations are taken at the last transect (transect K).

Study-reach length is variable, 150 - 2000 m.

Maximum observations (DCE): No limit
Minimum reporting qualifiers: ≥ 80% of site reach surveyed
Reporting years (to date): 2009-2017[1]

[1] Beginning with data collected in 2012, a distinction was made between LWD in contact with substrate of the bankfull zone vs. LWD suspended above the bankfull zone. The latter is defined as LWD not modifying flow when the channel is in the bankfull condition. Some progress on metrics for suspended LWD is expected sometime after 2016.

Calculation:

(i - xii) for each unique Diameter x Length class,
{where (LWD_Count) < > is.null}

(Σ (LWD_Count)) * Volume_factor / (Site_Length * X_BFWidth),
using volume factor as,

Western Washington

(i)	0.065	(vii)	1.047
(ii)	0.182	(viii)	2.909
(iii)	0.436	(ix)	6.981
(iv)	0.377	(x)	3.393
(v)	1.047	(xi)	9.425
(vi)	2.513	(xii)	22.619

Eastern Washington

(i)	0.018	(vii)	0.209
(ii)	0.043	(viii)	0.503
(iii)	0.096	(ix)	1.131
(iv)	0.052	(x)	0.838
(v)	0.126	(xi)	2.011
(vi)	0.283	(xii)	4.524

where, Site_Length = total length of site reach surveyed.
X_BFWidth = average bankfull width.
Volume_factor =average volume of a single piece of LWD of the unique Diameter X Length class, as, for (i-xii)[2],

[2] Source (see Robison):

Volume = π * [0.5*(minDiam+(maxDiam+minDiam)/3)]^2*[minLength+(maxLength – minLength)/3] [3]

Upper limits:	Length	Diameter
Western Washington:	30 m	2 m
Eastern Washington:	15 m	1.2 m

[3] applies also to Kaufman et al., 1999 replacing,

$$\text{Volume} = \pi * [\ 4/3 * (\text{minDiam}/2)^2] * [4/3 * \text{minLength}]$$

See definitions of individual (Diameter x Length) classes elsewhere in this section.

Note: if protocol = wide,

adjust counts, upscaling to both banks and length of surveyed channel. See first entry, LWD category.

Dependencies: Large woody debris survey was completed. Counts were adjusted when the wide protocol was used.

Assumptions: LWD diameter and length categories are sufficiently detailed to characterize channel conditions. For the wide protocol, we assume that the center of the channel (between left and right littoral zones) contains minimal pieces of large woody debris. We further assume that counts of LWD on the surveyed channel bank approximate counts of LWD on the unsurveyed, opposite channel bank.

Sources: Robison, 1997; Kaufmann et al., 1999, Hillman, 2004; Peck et al., 2005, 2006.

Further documentation: https://fortress.wa.gov/ecy/publications/summarypages/1203029.html

Metric Category: Riparian Cover

Reported	WHM export ID
Densiometer readings at bank(s), count	N_DensioBank
Densiometer readings at channel center, count	N_DensioCenter
Densiometer readings at bank(s), average	X_DensioBank
Densiometer readings at channel center, average	X_DensioCenter

METRIC CATEGORY: **Riparian Cover**

Group: Cover density
Scope: All non-null observations per DCE, entire site reach

Reported: Densiometer readings at bank(s), count (i)
Densiometer readings at channel center, count (ii)
Densiometer readings at bank(s), average (iii)
Densiometer readings at channel center, average (iv)

Definition: (i) count, of densiometer readings, left bank or right bank, as one reading per bank, at the point where each cross-channel transect intersects the bankfull margin, for all observations associated with the main channel (channel 0). Unit = observations by densiometer.

(ii) count, of densiometer readings, channel center, as four reading per transect (Center left, Center right, Center upstream, Center downstream), at each cross-channel transect, for all observations associated with the main channel (channel 0). Unit = observations by densiometer.

Each reading is a tally of shaded grid-line intersections. Tallies range from 0 (no intersections shaded) to 17 (all intersections shaded). These tallies are what is averaged.

(iii) average, of readings of shaded (i.e., non-sky) densiometer grid-line intersections, as observed where the bankfull margins intersect each transect, for all observations associated with the main channel (channel 0). Unit = percent.

(iv) average, of readings of shaded (i.e., non-sky) densiometer grid-line intersections, as observed at the center of the bankfull channel, for all observations associated with the main channel (channel 0). Unit = percent.

WHM export ID:	(i) N_DensioBank
	(ii) N_DensioCenter
	(iii) X_DensioBank
	(iv) X_DensioCenter
Observation type,	
(i, ii):	Count, of plots
(iii, iv):	Count (as tallies of grid-cell intersections)
Allowed metric values,	
(i):	≥ 0 to ≤ 22
(ii):	≥ 0 to ≤ 44
(iii, iv) :	≥ 0 to ≤ 100
Data collection schema:	11 cross-channel transects, equidistant and perpendicular to stream current. Site reach length is variable, 150 - 2000 m.

Maximum observations (DCE),
(i , iii):
narrow protocol: 22; 1 reading per bank X 2 banks X 11 transects
wide protocol: 11, 1 reading X 11 transects (one bank only)
(ii, iv):
narrow protocol, only: 44; 4 readings per transect center X 11 transects
Minimum reporting qualifiers: Observations at least 80% complete
Reporting years (to date): 2009-2017

Calculation:

(i) if, for each transect,
{Position = Bank and Value < > is.null}
count(Value) = N_DensiBank

(ii) if, for each transect,
{Position = Center and Value < > is.null}
count(Value) = N_DensiCenter

(iii) if, for each transect,
{Position = Bank and Value < > is.null}
else exclude transect from average
∑ ((Count_Densiometer_Cells)/17 X 100)

(iv) if, for each transect,
{Position = Center and Value < > is.null}
else exclude transect from average
∑ ((Count_Densiometer_Cells)/17 X 100)

Dependencies: Number of densiometer readings within acceptable range.

Assumptions: Observations sufficient to accurately characterize cross-sectional area of site reach.

Sources: Kaufmann et al., 1999; Peck et al., 2005, 2006.

Further documentation: https://fortress.wa.gov/ecy/publications/summarypages/1203029.html

Metric Category: Riparian Disturbance

Reported	WHM export ID
Human influence plots, count	N_HumanInfluence
Proximity weighted presence, each disturbance type	
Buildings	PWP_Bldg
Landfills or trash	PWP_Trash
Logging	PWP_Log
Mining	PWP_Mine
Park or lawn	PWP_Lawn
Pasture, rangeland, or hayfield	PWP_Range
Paved road or railroad	PWP_Pave
Unpaved road or motor trail	PWP_Unpav
Human foot path	PWP_Path
Clearing or lot	PWP_Clear
Pipes, in or out	PWP_Pipe
Row crops	PWP_Crop
Wall, dike, or revetment	PWP_Dike
Proximity weighted presence, combined human influence types	
All	PWP_All
Agricultural	PWP_Ag
Percent disturbance, by proximity to channel	
At bank, all human-influence types	PCT_BankAny
At bank, agricultural human-influence types	PCT_BankAg
Close to bank, all human influence types	PCT_CloseAny
Close to bank, all human influence types	PCT_CloseAg

METRIC CATEGORY: **Riparian Disturbance**

Group: Riparian Disturbance
Scope: All non-null observations per DCE, entire site reach

Reported: Human influence plots, count (i)

Definition: (i) count, of human influence observations associated with the main channel (channel 0), at each channel spanning transect. Unit = observations of human influence.

WHM export ID:	(i) N_HumanInfluence
Observation type:	Count
Allowed values:	> 0
Data collection schema:	Plots at ends of 11 evenly-spaced cross-channel transects, transects perpendicular to channel. Site reach length is variable, 150 - 2000 m.
Maximum observations (DCE):	22; 1 observation per bank X 11 transects
Minimum reporting qualifiers:	Planned observations at least 80% complete
Reporting years (to date):	2009-2017

Calculation:

(i) count(Human Influence rating) < > is.null

Dependencies: None

Assumptions: Observations sufficient to calculate weighted proximity scores for human influence types associated with the site reach.

Sources: Kaufmann et al., 1999; Peck et al., 2005, 2006.

Further documentation: https://fortress.wa.gov/ecy/publications/summarypages/1203029.html

METRIC CATEGORY: **Riparian Disturbance**

Group: Proximity weighted presence
Scope: All non-null observations per DCE, left and right banks, entire site reach

Reported: Proximity-weighted presence of human influence types:

Buildings (i)	Unpaved road or motor trail (viii)
Landfills or trash (ii)	Human foot path (ix)
Logging (iii)	Clearing or lot (x)
Mining (iv)	Pipes, in or out (xi)
Park or lawn (v)	Row crops (xii)
Pasture, rangeland, or hayfield (vi)	Wall, dike, or revetment (xiii)
Paved road or railroad (vii)	

Definition: All human influence types (i-xiii) have the same general definition:

(i-xiii) average, of categorical weights assigned to all rated plots for the proximity to the stream channel of a given human-influence type, as observed during a visual search of the region surrounding each cross-channel transect.
Unit = unitless

categorical weights assigned:

1.5	At least partially inside the bankfull-channel margins
1	Present 0-10 m from bankfull channel margin
0.66	Present >10-30 m from bankfull channel margin
0	Not present or > 30 m from bankfull channel margin

WHM export ID:

(i) PWP_Bldg	(viii) PWP_Unpav
(ii) PWP_Trash	(ix) PWP_Path
(iii) PWP_Log	(x) PWP_Clear
(iv) PWP_Mine	(xi) PWP_Pipe
(v) PWP_Lawn	(xii) PWP_Crop
(vi) PWP_Range	(xiii) PWP_Dike
(vii) PWP_Pave	

Observation type: Categorical weight assigned from visual estimate
Allowed values: ≥ 0 to ≤ 1.5
Data collection schema,
for weights < 1.5: 10 m X 10 m plots centered at ends of 11 evenly-spaced cross-channel transects, transects perpendicular to channel.
for weight = 1.5: Region in the channel surrounding the transects, 5 m upstream, 5 m downstream.

	Site reach length is variable, 150 - 2000 m.
Maximum observations (DCE):	22 per metric; 1 observation per bank X 11 transects
Minimum reporting qualifiers:	Observations at least 80% complete
Reporting years (to date):	2009-2017

Calculation:

(i-xiii) for a given disturbance type,

$$\left(\Sigma \text{ (Left bank proximity score)} + \Sigma \text{ (Right bank proximity score)} \right) / \text{N\_HumanInfluence}$$

where, N_HumanInfluence = count of human influence observations.

Dependencies: N_HumanInfluence must be known to calculate proximity weighted presence.

Assumptions: Observations sufficient to accurately characterize each rated human influence type.

Sources: Kaufmann et al., 1999; Peck et al 2005, 2006.

Further documentation: https://fortress.wa.gov/ecy/publications/summarypages/1203029.html

METRIC CATEGORY: **Riparian Disturbance**

Group: Proximity weighted presence
Scope: All non-null observations per DCE, left and right banks, entire site reach

Reported: Proximity-weighted presence of human influence types:

All (i)
Agricultural (ii)

Definition: (i) average, of all categorical proximity weights assigned to all rated plots for the proximity to the stream channel of all 13 human-influence types, as observed during a visual search of the plots. Unit = unitless.

(ii) same as for (i), except limited to agricultural human influence types (pasture /rangeland/ hayfield, and row crops).

categorical weights assigned:

1.5	At least partially within the bankfull channel margins
1	Present 0-10 m from bankfull channel margin
0.66	Present >10-30 m from bankfull channel margin
0	Not present or > 30 m from bankfull channel margin

WHM export ID: (i) PWP_All
(ii) PWP_Ag

Observation type: Categorical weight assigned from visual estimate of proximity.

Allowed observation values,
(i) minimum: 0
maximum: 19.5
(ii) minimum: 0
maximum: 3

Data collection schema,
for weights < 1.5: 10 m X 10 m plots centered at ends of 11 evenly-spaced cross-channel transects, perpendicular to channel.
for weight = 1.5: Region in the channel surrounding the transects, 5 m upstream, 5 m downstream.
Site reach length is variable, 150 - 2000 m.

Maximum observations (DCE): 22 per metric; 1 observation per bank X 11 transects
Minimum reporting qualifiers: observations at least 80% complete
Reporting years (to date): 2009-2017

Calculation:

(i) for all human influence types combined,

$$(\Sigma \text{(Left bank proximity score)} + \Sigma \text{(Right bank proximity score)}) / N\_HumanInfluence$$

(ii) same as for (i), except only for agricultural human influence types

where, N_HumanInfluence = count of human influence observations.

Dependencies: N_HumanInfluence is the devisor for estimating proximity-weighted-presence.

Assumptions: Observations sufficient to accurately characterize each rated human influence type.

Sources: Kaufmann et al., 1999, Peck et al., 2005, 2006.

Further documentation: https://fortress.wa.gov/ecy/publications/summarypages/1203029.html

METRIC CATEGORY: **Riparian Disturbance**

Group: Percent disturbance
Scope: All non-null observations per DCE, left and right banks, entire site reach

Reported: Percent disturbance by extent of channel:

At bank, all human-influence types (i)
At bank, agricultural human-influence types (ii)
Close to bank, all human influence types (iii)
Close to bank, all human influence types (iv)

Definition:

(i) percent, of all rated plots where any human-influence type, as detected during a visual search of the plots, was observed up to 30 m from the bankfull channel margin. . Unit = percent.

(ii) same as for (i), except limited to agricultural human influence types (pasture/ rangeland/ hayfield, and row crops). Unit = percent.

(iii) percent, of all rated plots where any human-influence type, as detected during a visual search of the plots, was observed up to 10 m from the bankfull channel margin. Unit = percent

(iv) same as for (iii), except limited to agricultural human influence types (pasture or rangeland or hayfield and row crops). Unit = percent.

WHM export ID:

(i) PCT_BankAny
(ii) PCT_BankAg
(iii) PCT_CloseAny
(iv) PCT_CloseAg

Observation type:	Categorical weight assigned from visual estimate of proximity
Allowed observation values:	≥ 0 to ≤ 1.5
Data collection schema,	Plots at either end of 11 equidistant, cross-channel transects, perpendicular to channel. Site reach length is variable, 150 - 2000 m.
narrow protocol:	Plots are 10 m long.
wide protocol:	Plots are 20 m long.
Maximum observations (DCE):	22 per metric; 1 observation per bank X 11 transects
Minimum reporting qualifiers:	Surveys at least 77% complete
Reporting years (to date):	2009-2017

Calculation:

(i) for any plot where any human influence proximity score = 1.5

((count(Left bank plots) + count(Right bank plots)) / N_HumanInfluence) x 100

(ii) same as for (i), except only those plots with agricultural human influence types

(iii) same as for (i), except where any human influence proximity score >= 1

(iv) same as for (ii), except only those plots with agricultural human influence types

where, N_HumanInfluence = count of human influence observations.

Dependencies: N_HumanInfluence and proximity scores for human influence types.

Assumptions: Observations sufficient to accurately characterize each rated human influence type.

Sources: Kaufmann et al., 1999; Peck et al., 2005, 2006.

Further documentation: https://fortress.wa.gov/ecy/publications/summarypages/1203029.html

Metric Category: Riparian Vegetation Structure

Reported	WHM export ID
Numbers of riparian vegetation plots, by vegetation layer	
Overstory, count	N_Canopy
Understory, count	N_Understory
Ground-covering, count	N_Ground
Ratio of presence of riparian vegetation, per layer, to total observations	
Overstory, ratio	PPN_Canopy
Understory, ratio	PPN_Understory
Ground-covering, ratio	PPN_Ground
Ratio of presence of riparian vegetation, layers combined, to total observations	
(Overstory or Understory)	PPN_RipVegAboveGnd
(Overstory or Understory or Ground-covering)	PPN_CanUnderstoryGnd
Ratio, presence of a specific riparian vegetation type to total observations	
Coniferous overstory	PPN_CanConif
Deciduous overstory	PPN_CanDecid
Broadleaf overstory	PPN_CanBrdlf
Mixed overstory types	PPN_CanMixed
Coniferous understory	PPN_UnderstoryConif
Deciduous understory	PPN_UnderstoryDecid
Broadleaf understory	PPN_UnderstoryBrdlf
Mixed understory	PPN_UnderstoryMixed
Index, as percent of plot, each vegetation type	
Large overstory trees	IDX_CanopyLG
Small overstory trees	IDX_CanopyST
Large + small trees	IDX_UnderstoryHerb
Herbaceous understory	IDX_UnderstoryWood
Woody understory	IDX_GroundHerb
Herbaceous + woody understory	IDX_GroundWood
Herbaceous ground-cover	IDX_GroundBare
Woody ground cover	IDX_Canopy
Herbaceous+woody ground cover	IDX_Understory
Bare soil and litter	IDX_Ground
Index, as percent of plot, vegetation types combined	

(Large + small overstory trees) + (Woody + herbaceous understory)	IDX_CanUnderstory
(Large + small overstory trees) + (Woody + herbaceous understory) + (Woody + herbaceous ground cover)	IDX_CanUnderstoryGnd
(Large + small overstory trees) + (Woody understory)	IDX_CanUnderstoryWood
(Large + small overstory trees) + (Woody understory) + (Woody ground cover)	IDX CanUnderstoryWoodGndWood

METRIC CATEGORY: **Riparian Vegetation Structure**

Groups: Extent of site reach
Scope: All non-null observations per DCE, entire site reach

Reported: Riparian vegetation plots, by vegetation layer, as

Overstory, count (i)
Understory, count (ii)
Groundcover count (iii)

where: overstory is canopy and stems of trees > 5 m in height
understory is canopy and stems of trees > 0.5 to ≤ 5 m in height

Definition: (i) count, of plots where the presence of overstory vegetation was evaluated. Plots occur at the ends of each channel-spanning transect, for all transects associated with the main channel (channel 0). Unit = observations of overstory.

(ii) same as for (i), except limited to understory vegetation

(iii) same as for (i), except limited to ground-covering vegetation

WHM export ID: (i) N_Canopy
(ii) N_Understory
(iii) N_Ground

Observation type:	Count
Allowed metric values:	≥ 0 to ≤ 22
Data collection schema,	11 cross-channel transects, perpendicular to stream current and equidistant along the site reach, with a vegetation plot at each end of each transect. Site reach length is variable, 150 - 2000 m.
narrow protocol:	Each plot is 10 m long, centered on the transect, and extends 10 m back horizontally from the bankfull channel margin.
wide protocol:	Each plot is 20 m long, centered on the transect, and extends 10 m back horizontally from the bankfull channel margin.
Maximum observations (DCE):	22, 1 observation per bank X 2 banks X 11 transects
Minimum reporting qualifiers:	Observations at least 80% complete (18 of 22 plots rated)
Reporting years (to date):	2009-2017

Calculation:

(i) if, for each transect,
{Vegetation_Layer = Canopy}

{any(Left_Bank_Cover score) < > is.null}
count(Left Bank plots) = N_LeftBank
if, for each transect,
{Vegetation_Layer = Canopy}
{any(Right_Bank_Cover score) < > is.null}
count(Right Bank plots) = N_RightBank

N_LeftBank_Veg + N_RightBank_Veg = N_Canopy

(ii) same as for (i) except Vegetation_Layer = Understory

(iii) same as for (i) except Vegetation_Layer = Ground Cover

Dependencies: Counts of rated plots within acceptable range.

Assumptions: Observations sufficient to accurately characterize vegetation layers observed.

Sources: Kaufmann et al., 1999; Hillman, 2004; Peck et al., 2005, 2006.

Further documentation: https://fortress.wa.gov/ecy/publications/summarypages/1203029.html

METRIC CATEGORY: **Riparian Vegetation Structure**

Groups: Extent of site reach
Scope: All non-null observations per DCE, entire site reach

Reported: Observed presence of riparian vegetation, from a single vegetation layer, as

Overstory, proportion (i)
Understory, proportion (ii)
Groundcover proportion (iii)

where: overstory is canopy and stems of trees > 5 m in height
understory is canopy and stems of trees > 0.5 to ≤ 5 m in height

Definition: (i) proportion, as observed plots containing overstory vegetation to total plots evaluated. Plots occur at the ends of each channel-spanning transect, for all transects associated with the main channel (channel 0). A value of 1 indicates overstory (i.e., canopy) was observed on all plots. Unit = unitless.

(ii) same as for (i), except limited to understory (i.e., mid-layer) vegetation

(iii) same as for (i), except limited to ground-covering vegetation

WHM export ID: (i) PPN_Canopy
(ii) PPN_Understory
(iii) PPN_Ground

Observation type:		Count
Allowed metric values:		≥ 0 to ≤ 1
Data collection schema,		11 cross-channel transects, perpendicular to stream current and equidistant along the site reach, with a vegetation plot at each end of each transect. Site reach length is variable, 150 - 2000 m.
	narrow protocol:	Each plot is 10 m long, centered on the transect, and extends 10 m back horizontally from the bankfull channel margin.
	wide protocol:	Each plot is 20 m long, centered on the transect, and extends 10 m back horizontally from the bankfull channel margin.
Maximum observations (DCE):		22, 1 observation per bank X 2 banks X 11 transects
Minimum reporting qualifiers:		Observations at least 80% complete (18 of 22 plots rated)
Reporting years (to date):		2009-2017

Calculation:

(i) if, for each transect,
{Vegetation_Layer = Canopy}
{any(Left_Bank_Cover score) < > 0 and < > is.null}

count(Left Bank plots) = N_LeftBank_Veg

if, for each transect,

{Vegetation_Layer = Canopy}

{Vegetation_Description < > Bare}

{any(Right_Bank_Cover score) < > 0 and < > is.null}

count(Right Bank plots) = N_RightBank_Veg

N_LeftBank_Veg + N_RightBank_Veg = N_VegetationObserved

N_VegetationObserved / N_Canopy = PPN_Canopy

(ii) same as for (i) except Vegetation_Layer = Understory

(iii) same as for (i) except Vegetation_Layer = Ground Cover

where, N_Canopy = count of total overstory vegetation observations

and, similarly,

N_Understory = count of total understory vegetation observations

N_Ground = count of total ground covering vegetation observations.

Dependencies: Counts of rated plots within acceptable range.

Assumptions: Observations sufficient to accurately characterize vegetation layers observed.

Sources: Kaufmann et al., 1999; Hillman, 2004; Peck et al., 2005, 2006.

Further documentation: https://fortress.wa.gov/ecy/publications/summarypages/1203029.html

METRIC CATEGORY: **Riparian Vegetation Structure**

Groups: Extent of site reach
Scope: All non-null observations per DCE, entire site reach

Reported: Observed presence of riparian vegetation, overall, from one or more layers, as

(Overstory or Understory), proportion (i)
(Overstory or Understory or Ground-covering), proportion (ii)

where: overstory is canopy and stems of trees > 5 m in height
understory is canopy and stems of trees > 0.5 to ≤ 5 m in height

Definition: (i) ratio, as plots containing either overstory or understory vegetation, or both, to total plots evaluated. Plots occur at the ends of each channel-spanning transect, for all transects associated with the main channel (channel 0). A value of 1 indicates overstory or understory was detected on all observed plots. Unit = unitless.

(ii) same as for (i), except considers presence of overstory or understory or ground-covering vegetation.

WHM export ID: (i) PPN_RipVegAboveGnd
(ii) PPN_CanUnderstoryGnd

Observation type: Count
Allowed values: ≥ 0 to ≤ 1
Data collection schema: 11 cross-channel transects, perpendicular to stream current and equidistant along the site reach, with a vegetation plot at each end of each transect. Site reach length is variable, 150 - 2000 m.
narrow protocol: Each plot is 10 m long, centered on the transect, and extends 10 m back horizontally from the bankfull channel margin.
wide protocol: Each plot is 20 m long, centered on the transect, and extends 10 m back horizontally from the bankfull channel margin.
Maximum observations (DCE): 22, 1 observation per bank X 2 banks X 11 transects
Minimum reporting qualifiers: Observations at least 63% complete (7 of 11 plots rated)
Reporting years (to date): 2009-2017

Calculation:

(i) if, for each transect,
{Vegetation_Description < > Bare}
{Vegetation_Layer = Canopy} or
{Vegetation_Layer = Understory}
and, for both Canopy and Understory,

{each(Left_Bank_Cover score) < > 0 and < > is.null}
count(Left Bank plots) = N_LeftBank_Veg

if, for each transect,
{Vegetation_Description < > Bare}
{Vegetation_Layer = Canopy} or
{Vegetation_Layer = Understory}
and, for both Canopy and Understory,
{each(Right_Bank_Cover score) < > 0 and < > is.null}
count(Right Bank plots) = N_RightBank_Veg

N_LeftBank_Veg + N_RightBank_Veg = N_VegetationObserved

if, for each transect,
{Vegetation_Description < > Bare}
{Vegetation_Layer = Canopy} or
{Vegetation_Layer = Understory}
{any(Left_Bank_Cover score) < > is.null}
count(Left Bank plots) = N_LeftBank
if, for each transect,
{Vegetation_Description < > Bare}
{Vegetation_Layer = Canopy} or
{Vegetation_Layer = Understory}
{any(Right_Bank_Cover score) < > is.null}
count(Right Bank plots) = N_RightBank

N_LeftBank_Veg + N_RightBank_Veg = N_Plots

N_VegetationObserved / N_Plots = PPN_*

where PPN_* = PPN_ RipVegAboveGnd

(ii) same as for (i) except Vegetation_Layer = Canopy or Understory or Ground Cover

Dependencies: Counts of rated plots within acceptable range.

Assumptions: Observations sufficient to accurately characterize vegetation layers observed.

Sources: Kaufmann et al., 1999; Hillman, 2004; Peck et al., 2005, 2006.

Further documentation: https://fortress.wa.gov/ecy/publications/summarypages/1203029.html

METRIC CATEGORY: **Riparian Vegetation Structure**

Groups: Extent of site reach
Scope: All non-null observations per DCE, entire site reach

Reported: Observed presence of riparian vegetation, as

Coniferous overstory, proportion (i)	Coniferous understory, proportion (v)
Deciduous overstory, proportion (ii)	Deciduous understory, proportion (vi)
Broadleaf overstory, proportion (iii)	Broadleaf understory, ratio (vii) proportion (vii)
Mixed overstory types, ratio (iv) proportion (iv)	Mixed understory, ratio (viii) proportion (viii)

where: overstory is canopy and stems of trees > 5 m in height
understory is canopy and stems of trees > 0.5 to 5 m in height

Definition:

(i-iv) proportion, as observed plots containing a specific type of overstory vegetation to total plots evaluated. Plots occur at the ends of each channel-spanning transect, for all transects associated with the main channel (channel 0). A value of 1 indicates the specific type of overstory (i.e., canopy) was observed on all plots. Unit = unitless.

(v-viii) proportion, as observed plots containing a specific type of understory vegetation to total plots evaluated. Plots occur at the ends of each channel-spanning transect, for all transects associated with the main channel (channel 0). A value of 1 indicates the specific type of understory (i.e., mid-layer) was observed on all plots. Unit = unitless.

WHM export ID:

(i)	PPN_CanConif	(v)	PPN_UnderstoryConif
(ii)	PPN_CanDecid	(vi)	PPN_UnderstoryDecid
(iii)	PPN_CanBrdlf	(vii)	PPN_UnderstoryBrdlf
(iv)	PPN_CanMixed	(viii)	PPN_UnderstoryMixed

where Can = canopy and Und = understory.

Observation type: Count
Allowed metric values: ≥ 0 to ≤ 1
Data collection schema: 11 cross-channel transects, perpendicular to stream current and equi-distant along the site reach, with a vegetation plot at each end of each transect. Site reach length is variable, 150 - 2000 m.
narrow protocol: Each plot is 10 m long, centered on the transect, and extends 10 m back horizontally from the bankfull channel margin.

wide protocol: Each plot is 20 m long, centered on the transect, and extends 10 m back horizontally from the bankfull channel margin.

Maximum observations (DCE): 22, 1 observation X 2 banks X 11 transects

Minimum reporting qualifiers: Observations at least 68% complete (15 of 22 plots rated)

Reporting years (to date): 2009-2017

Calculation:

where Vegetation_Type = * ---> Coniferous
Deciduous
Broadleaf Evergreen
Mixed (at least 10% of type)

(i-iv) if, for each transect,
{Vegetation_Layer = Canopy}
{any(Left_Bank_Vegetation_Type) = *}
count(Left Bank plots) = N_LeftBank_Veg
if, for each transect,
{Vegetation_Layer = Canopy}
{any(Right_Bank_Cover_Type) = *}
count(Right Bank plots) = N_RightBank_Veg

N_LeftBank_Veg + N_RightBank_Veg = N_VegetationObserved

N_VegetationObserved / N_Canopy = PPN_CanConif

(v-viii) if, for each transect,
{Vegetation_Layer = Understory}
{any(Left_Bank_Vegetation_Type) = *}
count(Left Bank plots) = N_LeftBank_Veg
if, for each transect,
{Vegetation_Layer = Understory}
{any(Right_Bank_Cover_Type) = *}
count(Right Bank plots) = N_RightBank_Veg

N_LeftBank_Veg + N_RightBank_Veg = N_VegetationObserved

N_VegetationObserved / N_Canopy = PPN_CanConif

then repeat for each combination of vegetation layer and vegetation type, (ii) to (viii).

where, N_Canopy = count of total overstory vegetation observations
and, similarly,
N_Understory = count of total understory vegetation observations
N_Ground = count of total ground-covering vegetation observations.

Dependencies: Counts of rated plots within acceptable range.

Assumptions: Observations sufficient to accurately characterize vegetation layers observed.

Sources: Kaufmann et al., 1999; Hillman, 2004; Peck et al., 2005, 2006.

Further documentation: https://fortress.wa.gov/ecy/publications/summarypages/1203029.html

METRIC CATEGORY: **Riparian Vegetation Structure**

Groups: Percent of plot index
Scope: All non-null observations per DCE, entire site reach

Reported: Observed percentage of riparian vegetative cover, from a single vegetation layer, as

Large overstory trees, index (i)	Woody ground cover, index (viii
Small overstory trees, index (ii)	Bare soil and litter, index (x)
Herbaceous understory, index (iii)	Large + small trees, index (iii)
Woody understory, index (iv)	Herbaceous + woody understory, index (vi)
Herbaceous ground-cover, index (vii)	Herbaceous+woody ground cover, index (ix)

Definition: For each category of vegetative cover (i – x),

(i – x) average, of plot-level vegetative cover ratings, to total number of vegetation plots evaluated. Plots occur at the ends of each channel-spanning transect, for all transects associated with the main channel (channel 0). Unit = percent.

categorical % average cover ratings assigned:

0:	if 0% plot area
5:	if 1 -10% plot area
25:	if 11-40% plot area
57.5:	if 41-75% plot area
87.5:	if > 75% plot area

WHM export ID:

(i) IDX_CanopyLT	(vi) IDX_GroundWood
(ii) IDX_CanopyST	(vii) IDX_GroundBare
(iii) IDX_UnderstoryHerb	(viii) IDX_Canopy
(iv) IDX_UnderstoryWood	(ix) IDX_Understory
(v) IDX_GroundHerb	(x) IDX_Ground

where overstory = Canopy

Observation type: Count, categorical rating
Allowed metric values:
(i - vii): ≥ 0 to ≤ 87.5
(viii – x): ≥ 0 to ≤ 115
Data collection schema, 11 cross-channel transects, perpendicular to stream current and equidistant along the site reach, with a vegetation plot at each end of each transect. Site reach length is variable, 150 - 2000 m.
narrow protocol: Each plot is 10 m long, centered on the transect, and extends 10 m back horizontally from the bankfull channel margin.

wide protocol: Each plot is 20 m long, centered on the transect, and extends 10 m back horizontally from the bankfull channel margin.

Maximum observations (DCE): 22, 1 observation per bank X 2 banks X 11 transects

Minimum reporting qualifiers: Observations at least 68% complete (15 of 22 plots rated)

Reporting years (to date): 2009-2017

Calculation:

(i - vii) if, for each transect,
{Vegetation_Layer = Canopy} and
{Vegetation_Description = Big Trees}
{any(Left_Bank_Cover score) < > 0 and < > is.null}
∑(Left Bank plots) = T_LeftBank_IDX

if, for each transect,
{Vegetation_Layer = Canopy} and
{Vegetation_Description = Big Trees}
{any(Right_Bank_Cover score) < > 0 and < > is.null}
∑(Right Bank plots) = T_RightBank_IDX

T_LeftBank_IDX + T_RightBank_IDX = T_VegObserved_IDX

if, for each transect,
{Vegetation_Layer = Canopy} and
{Vegetation_Description = Big Trees}
{any(Left_Bank_Cover score) < > is.null}
count(Left Bank plots) = N_LeftBank_IDX

if, for each transect,
{Vegetation_Layer = Canopy} and
{Vegetation_Description = Big Trees}
{any(Right_Bank_Cover score) < > is.null}
count(Right Bank plots) = N_RightBank_IDX

N_LeftBank_IDX + N_RightBank_IDX = N_Plots_IDX

T_VegObserved_IDX / N_Plots_IDX = IDX_CanopyLT

then repeat for each combination of vegetation layer and vegetation type, (ii) to (vii).

(viii) IDX_CanopyLT + IDX_CanopyST, for plots rating both small and large trees

(ix) IDX_UnderstoryWood + IDX_UnderstoryHerb

(x) IDX_GroundWood + IDX_GroundHerb

Dependencies: Counts of rated plots within acceptable range.

Assumptions: Observations sufficient to accurately characterize vegetation layers observed.

Sources: Kaufmann et al., 1999; Hillman, 2004; Peck et al., 2005, 2006.

Further documentation: https://fortress.wa.gov/ecy/publications/summarypages/1203029.html

METRIC CATEGORY: **Riparian Vegetation Structure**

Groups: Percent of plot index
Scope: All non-null observations per DCE, entire site reach

Reported: Sums of indices of riparian vegetative cover, multiple vegetation layers, as

(Large + small overstory trees) + (woody + herbaceous understory), index (i)
(Large + small overstory trees) +
(Woody + herbaceous understory) +
(Woody + herbaceous ground cover), index (ii)
(Large + small overstory trees) + (woody understory), index (iii)
(Large + small overstory trees) +
(Woody understory) +
(Woody ground cover), index (iv)

Definition: For categories of vegetative cover (i – iv),

(i – iv) index, as sum of site averages, of vegetative cover ratings per plot. Plots occur as observed in the riparian or upslope area at the ends of each channel-spanning transect, for all transects associated with the main channel (channel 0). Unit = percent.

categorical % cover ratings assigned:
0: if 0% plot area
5: if 1 - 10% plot area
25: if 11-40% plot area
57.5: if 41-75% plot area
87.5: if > 75% plot area

WHM export ID:
(i) IDX_CanUnderstory
(ii) IDX_CanUnderstoryGnd
(iii) IDX_CanUnderstoryWood
(iv) IDX_CanUnderstoryWoodGndWood

where overstory = Canopy or Can, ground cover = Gnd

Observation type: Count, categorical rating
Allowed metric values:
(i) ≥ 0 to ≤ 230
(ii) ≥ 0 to ≤ 345
(iii) ≥ 0 to ≤ 202.5
(iv) ≥ 0 to ≤ 290
Data collection schema, 11 cross-channel transects, perpendicular to stream current and equidistant along the site reach, with a vegetation plot at each end of each transect. Site reach length is variable, 150 - 2000 m.

narrow protocol:	Each plot is 10 m long, centered on the transect, and extends 10 m back horizontally from the bankfull channel margin.
wide protocol:	Each plot is 20 m long, centered on the transect, and extends 10 m back horizontally from the bankfull channel margin.
Maximum observations (DCE):	22, 1 observation per bank X 2 banks X 11 transects
Minimum reporting qualifiers:	Observations at least 68% complete (15 of 22 plots rated)
Reporting years (to date):	2009-2017

Calculation:

(i) IDX_Canopy + IDX_Understory

(ii) IDX_Canopy + IDX_Understory + IDX_Ground

(iii) IDX_Canopy + IDX_UnderstoryWood

(iv) IDX_Canopy + IDX_UnderstoryWood + IDX_GroundWood

See below for definition of single vegetation-layer metrics,

IDX_Canopy, IDX_Understory, IDX_Ground, IDX_UnderstoryWood, IDX_GroundWood

Dependencies: Counts of rated plots within acceptable range.

Assumptions: Observations sufficient to accurately characterize vegetation layers observed.

Sources: Kaufmann et al., 1999; Hillman, 2004; Peck et al., 2005, 2006.

Further documentation: https://fortress.wa.gov/ecy/publications/summarypages/1203029.html

Link to definitions, single vegetation-layer metrics (IDX)

Metric Category: Side Channel Quantity

Reported	WHM export ID
Maximum occurrence of side channels	SC_Max
Longitudinal extent of side channels	PPN_SideChannel

METRIC CATEGORY: **Side Channel Quantity**

Group: Side Channels
Scope: All non-null observations per DCE, entire site reach

Reported: Maximum occurance of side channels, count (i)
Longitudinal extent of side channels, proportion (ii)

Definition:

(i) maximum of counts, along thalweg transects perpendicular to the main channel, as extended from each thalweg station, of the number of side channels intersected. Only the first three side channels per thalweg station are counted. A count of three means at least three side-channels were observed. Unit = dimensionless.

(ii) proportion, as the count of thalweg stations where at which at least one side channel was observed, to the count of total thalweg stations rated. Observations are along the thalweg transects perpendicular to the main channel (channel 0). A value of 1 means that side channels were observed at all thalweg stations. Unit = dimensionless.

WHM export ID:	(i) SCMax (ii) PPN_SideChannel
Observation type:	Visual assessment
Allowed values:	0, 1, 2, 3
Data collection schema:	Observations along thalweg transects perpendicular to the main channel of the site reach at each of 100 equidistant thalweg stations. Site reach length is variable, 150 - 2000 m.
Maximum observations (DCE):	100
Minimum reporting qualifiers:	Observations 100% complete. Habitat unit survey 100% complete. No missing or out-of-sequence habitat units.
Reporting years (to date):	2009-2017

Calculation

(i) for the number of observations, *a* to *x*, as counts of side channels Y_a to Y_x

$\text{Max}(Y_a, \ldots Y_x)$

(ii) for the number of observations, *a* to *x*, as counts of side channels Y_a to Y_x

1) where $Y_a, \ldots Y_x > 0$, count of observations$(Y_a, \ldots Y_x)$ = C

2) count of all observations$(Y_a, \ldots Y_x)$ = D

3) C / D

Dependencies: All 100 thalweg stations must be visited and rated.

Assumptions: Side channels are detectable through topography and brush.

Sources: Kaufmann et al., 1999; Peck et al., 2005, 2006.

Further documentation: https://fortress.wa.gov/ecy/publications/summarypages/1203029.html

Metric Category: Sinuosity

Reported	WHM export ID
Sinuosity of site reach, index	Sinuosity

METRIC CATEGORY: **Sinuosity**

Group: Sinuosity
Scope: All non-null observations per DCE, entire site reach

Reported: Sinuosity of site reach, index (i)

Definition: (i) index, of deviation from the straight-line, point-to-point distance between the upper and lower ends of the site reach, as the ratio of shortest direct point-to-point aerial transit path to overall length of sinuous watercourse as estimated by the sum of site-level reach sub-segment lengths. Unit = dimensionless.

Reported for protocol = narrow only.

WHM export ID:	(i) Sinuosity
Observation type:	Derived from bearing readings
Allowed values:	≥ 1
Data collection schema:	Observations parallel to thalweg of the site reach sufficient to characterize reach. Site reach length is variable, 150 - 2000 m.
Maximum observations (DCE),	
narrow protocol:	30
wide protocol:	not reported
Minimum reporting qualifiers,	
narrow protocol:	20
wide protocol:	not reported
Reporting years (to date):	2009-2017

Calculation:

(i) where protocol = narrow, and bearing < > is.null,

((Σ(Northing))^2 + (Σ(Easting))^2)^0.5 / Σ(Segment length),

where Northing and Easting are the sine and cosine decompositions of bearing readings.

Dependencies: Lengths and bearings of site reach segments must be known.

Assumptions: Observations sufficient to accurately characterize sinuosity of site reach.

Sources: Kaufmann et al., 1999; Peck et al., 2005, 2006.

Further documentation: https://fortress.wa.gov/ecy/publications/summarypages/1203029.html

Metric Category: Substrate

Reported	WHM export ID
Entire reach	
Embeddedness, count	N_Embed
Embeddedness, average	X_Embed
Embeddedness, std. dev.	SD_Embed
Mid-channel	
Embeddedness, mid-channel, count	N_EmbedCenter
Embeddedness, mid-channel, average	X_EmbedCenter
Embeddedness, mid-channel, std. dev.	SD_EmbedCenter
Number of all substrates observed, count	N_Substrate
Percent substrate, each diameter category	
Smooth bedrock	PCT_BedrockS
Rough bedrock	PCT_BedrockR
Pavement (i.e., concrete)	PCT_Pavement
Large boulders	PCT_BoulderL
Small boulders	PCT_BoulderS
Cobble	PCT_Cobble
Coarse gravel	PCT_GravelC
Fine gravel	PCT_GravelF
Sand	PCT_Sand
Fines	PCT_Fines
Hardpan	PCT_Hardpan
Wood	PCT_Wood
Other	PCT_Other
Percent substrate, diameter categories combined	
Bedrock, Smooth or rough	PCT_Bedrock
Coarse gravel and larger	PCT_GravelCx
Fine gravel and smaller	PCT_GravelFb
Sands and fines	PCT_SandFines
Boulder, large and small	PCT_Boulder

METRIC CATEGORY: **Substrate**

Group: Embeddedness
Scope: All non-null observations per DCE, entire site reach

Reported: Embeddedness, count (i)
Embeddedness, average (ii)
Embeddedness, standard deviation (iii)

Definition: (i) count, as all embeddedness observations for all channel-spanning transects associated with the main channel (channel 0). Unit = observations of embeddedness.

(ii) average, of all embeddedness observations associated with the main channel (channel 0), bank to bank, for all channel-spanning transects, where transects are perpendicular to stream current. Unit = percent.

(iii) standard deviation, of all embeddedness observations associated with the main channel (channel 0), as an estimate of dispersion from the sample average. Unit = percent.

WHM export ID:	(i) N_Embed (ii) X_Embed (iii) SD_Embed
Observation type:	Visual numeric ratings
Allowed values, precision:	0 – 100
Data collection schema,	11 evenly-spaced, cross-channel transects, perpendicular to channel. Site reach length is variable, 150 - 2000 m.
narrow protocol:	11 equidistant observation stations, bank to bank, per transect.
wide protocol:	Work at one side of the channel. Observe at dry stations. Estimate an average for the littoral plot.
Maximum observations (DCE):	121; 11 observations X 11 transects
Minimum reporting qualifiers,	
narrow protocol:	observations at least 80% complete (97 of 121)
wide protocol:	22 (at least two observations per transect)
Reporting years (to date):	2009-2017

Calculation:

(i) count(Embeddedness rating) < > is.null
(ii) (Σ (Embeddedness rating)) / N_Embed
(iii) (Σ ((Embeddedness rating – X_Embed)^2)/(N_Embed-1))^1/2

Dependencies: N Embed must be known to calculate X_Embed and SD_Embed

Assumptions: Observations sufficient to accurately characterize bed character of site reach.

Sources: Kaufmann et al., 1999; Hillman, 2004; Peck et al., 2005, 2006.

Further documentation: https://fortress.wa.gov/ecy/publications/summarypages/1203029.html

METRIC CATEGORY: **Substrate**

Group: Embeddedness
Scope: Non-null mid-*active* channel observations per DCE, entire site reach
Narrow protocol data only.

Reported: Embeddedness, mid-*active* channel, count (i)
Embeddedness, mid-*active* channel, average (ii)
Embeddedness, mid-*active* channel, standard deviation (iii)

Definition: (i) count, of embeddedness observations at three stations (mid-channel, 1/10th of channel width left of mid-channel, 1/10th of channel width right of mid-channel) for all channel-spanning transects associated with the main channel (channel 0). Unit = mid-channel observations of embeddedness.

(ii) average, of embeddedness observations at three stations (mid-channel, left of mid-channel, right of mid-channel), for all channel-spanning transects associated with the main channel (channel 0). Unit = percent.

(iii) standard deviation, of all non-null, mid-channel embeddedness observations associated with the main channel (channel 0), as an estimate of dispersion from the sample average. Unit = percent.

WHM export ID: (i) N_EmbedCenter
(ii) X_EmbedCenter
(iii) SD_EmbedCenter

Observation type: Visual numeric ratings
Allowed values, precision: 0 – 100
Data collection schema: 11 evenly-spaced cross-channel transects, perpendicular to channel, equidistant mid-channel observations.
Site reach length is variable, 150 - 2000 m.
Maximum observations (DCE): 33; 3 observations X 11 transects
Minimum reporting qualifiers: Observations at least 80% complete
Reporting years (to date): 2009-2017

Calculation:

(i) count(mid-channel(Embeddedness ratings)) < > is.null
(ii) (Σ (mid-channel(Embeddedness rating)) / N_EmbedCenter
(iii) (Σ ((mid-channel(Embeddedness rating)) – X_EmbedCenter)^2) / (N_EmbedCenter-1))^1/2

Dependencies: N_EmbedCenter must be known to calculate X_EmbedCenter and SD_EmbedCenter
Assumptions: Observations sufficient to accurately characterize center-of-channel character of site reach.
Sources: Kaufmann et al., 1999; Hillman, 2004; Peck et al., 2005, 2006.
Further documentation: https://fortress.wa.gov/ecy/publications/summarypages/1203029.html

METRIC CATEGORY: **Substrate**

Groups: Percent substrate by size
Scope: All non-null observations per DCE, entire site reach

Reported: Substrate particle observations, as

Number of all substrates sized, count (i)

Definition: (i) count, of total substrate observations, lithic and non-lithic, as observed, bank-to-bank, along channel-spanning transects, associated with the main channel (channel 0). Unit = observations of substrate.

WHM export ID: (i) N_Substrate

Observation type:	Count
Allowed metric values:	≥ 0 to ≤ 231
Data collection schema:	
narrow protocol:	21 cross-channel transects, bank to bank, where transects are perpendicular to stream current and equidistant along the site reach.
wide protocol:	11 cross-channel transects, variable number of stations (2 to 11 per transect).
Maximum observations (DCE),	
narrow protocol:	231, 11 observations X 21 transects
wide protocol:	121, 11 observations X 11 transects
Minimum reporting qualifiers,	
narrow protocol:	Observations at least 70% complete (15 of 21 transects rated)
wide protocol:	22 (2 observations X 11 transects)
Reporting years (to date):	2009-2017

Calculation:

(i) for all substrate observations, lithic and non-lithic,
{where Substrate_Type_Code < > is.null},

(count (Substrate_Type_Code) < > is.null))

Dependencies: Number of substrate observations within acceptable range.

Assumptions: Observations sufficient to accurately characterize substrate particle diameter as observed along the site reach.

Sources: Kaufmann et al., 1999; Hillman, 2004; Peck et al., 2005, 2006.

Further documentation: https://fortress.wa.gov/ecy/publications/summarypages/1203029.html

METRIC CATEGORY: **Substrate**

Groups: Percent substrate by size
Scope: All non-null observations per DCE, entire site reach

Reported: Percent substrate of particle diameter categories observed, as

Smooth bedrock (RS), (i)	Coarse gravel (GC), (viii)
Rough bedrock (RR), (ii)	Fine gravel (GF), (ix)
Hardpan (HP), (iii)	Sand (SA), (x)
*Pavement (i.e., concrete), (RC) (iv)	Fines (FN), (xi)
Large boulders (XB), (v)	Wood (WD), (xii)
Small boulders (SB), (vi)	Other (OT), (xiii)
Cobble (CB), (vii)	

**RC is now only recorded if pavement is of size > 4000 mm. If <4000 mm then concrete is classified as Other (OT).*

Categorical diameter ranges:

(i) >4000 mm	(viii) >16-64 mm
(ii) >4000 mm	(ix) >2-16 mm
(iii) >4000 mm	(x) 0.06-2 mm
(iv) Pavement	(xi) silt, clay, non-gritty (0.001-0.06)
(v) >1000-4000 mm	(xii) all sizes
(vi) >250-1000 mm	(xiii) not as above
(vii) >64-250 mm	

Definition: For substrate particle diameter categories (i-xiii):

(i-xiii) ratio, adjusted to percent, as observations of the given substrate size category to total substrate observations, as observed, bank-to-bank, at channel-spanning transects, associated with the main channel (channel 0). A value of 100 indicates that the channel bed, as observed along the site reach, was dominated by a single substrate particle diameter category. Unit = percent.

WHM export ID:

(i) PCT_BedrockS	(viii) PCT_GravelC
(ii) PCT_BedrockR	(ix) PCT_GravelF
(iii) PCT_Hardpan	(x) PCT_Sand
(iv) PCT_Pavement	(xi) PCT_Fines
(v) PCT_BoulderL	(xii) PCT_Wood
(vi) PCT_BoulderS	(xiii) PCT_Other
(vii) PCT_Cobble	

Observation type: Categorical rating
Allowed metric values: ≥ 0 to ≤ 100

Data collection schema,

narrow protocol:	21 cross-channel transects, bank to bank, where transects are perpendicular to stream current and equidistant along the site reach.
wide protocol:	11 cross-channel transects, variable number of stations (2 to 11 per transect).
	Site reach length is variable, 150 - 2000 m.

Maximum observations (DCE),

narrow protocol:	231, 11 observations X 21 transects
wide protocol:	121, 11 observations X 11 transects

Minimum reporting qualifiers,

narrow protocol:	Observations at least 70% complete (15 of 21 transects rated)
wide protocol:	22 (2 observations X 11 transects)

Reporting years (to date): 2009-2017

Calculation:

(i-xiii) for each unique substrate particle diameter category,
{where Substrate_Type_Code < > is.null},
{where Substrate_Type_Code = *i*}

((count (Substrate_Type_Code) = *i* < > is.null)) /
count(Substrate_Type_Code)*100
or, ((count (Substrate_Type_Code) = *i* < > is.null)) /
(N_Substrate)*100

Dependencies: N Substrate within acceptable range.

Assumptions: Observations sufficient to accurately characterize substrate particle diameter as observed along the site reach.

Sources: Kaufmann et al., 1999; Hillman, 2004; Peck et al., 2005, 2006.

Further documentation: https://fortress.wa.gov/ecy/publications/summarypages/1203029.html

METRIC CATEGORY: **Substrate**

Groups: Percent substrate by size
Scope: All non-null observations per DCE, entire site reach

Reported: Combined percent, two or more particle diameter categories, of substrates as

Bedrock, smooth or rough (i)
Coarse gravel and larger (ii)
Fine gravel and smaller (iii)
Sands and fines (iv)
Boulder, large and small (v)

See below for definitions of combined substrate particle-diameter categories.

Definition: For each case of combined particle-diameter categories of substrate, (i - v)

(i - v) ratio, adjusted to percent, of channel bed, along the site reach, dominated by the specified particle-diameter categories, as observed, bank-to-bank, at channel-spanning transects, associated with the main channel (channel 0). Unit = percent.

Combined particle diameter categories (see pg 128 for further detail):

(i) BedrockS, BedrockR
(ii) BedrockS, BedrockR, Hardpan, BoulderL, BoulderS, Cobble, GravelC
(iii) GravelF, Sand, Fines
(iv) Sand, Fines
(v) BoulderL, BoulderS

WHM export ID:
(i) PCT_Bedrock
(ii) PCT_GravelCx
(iii) PCT_GravelFb
(iv) PCT_SandFines
(v) PCT_Boulder

Observation type: Categorical rating
Allowed metric values: ≥ 0 to ≤ 100
Data collection schema,
narrow protocol: 21 cross-channel transects, bank to bank, where transects are perpendicular to stream current and equidistant along the site reach.
wide protocol: 11 cross-channel transects, variable number of stations (2 to 11 per transect).
Site reach length is variable, 150 - 2000 m.

Maximum observations (DCE),
narrow protocol: 231, 11 observations X 11 transects
wide protocol: 121, 11 observations X 21 transects
Minimum reporting qualifiers,
narrow protocol: Observations at least 70% complete (15 of 21 transects rated)
wide protocol: 22 (2 observations X 11 transects)
Reporting years (to date): 2009-2017

Calculation:

(i - v) for each unique substrate particle diameter category, *a* to *x* {where Substrate_Type_Code < > is.null},

(count (Substrate_Type_Code)) as = Y_a, …., Y_x

then $\Sigma (Y_a + \ldots + Y_x) / (\text{count(Substrate\_Type\_Code)} * 100$

Dependencies: none.

Assumptions: Observations sufficient to accurately characterize substrate particle diameter as observed along the site reach.

Sources: Kaufmann et al., 1999; Hillman, 2004; Peck et al., 2005, 2006.

Further documentation: https://fortress.wa.gov/ecy/publications/summarypages/1203029.html

Link to definitions, substrate particle diameters

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Note: The above protocol is out-of-date. Updated standard operating procedures will be available in 2018 here: https://ecology.wa.gov/Research-Data/Monitoring-assessment/River-stream-monitoring/Habitat-monitoring/Habitat-monitoring-methods and from glenn.merritt@ecy.wa.gov

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Note: The above protocol is out-of-date. Updated standard operating procedures will be available in 2018 here: https://ecology.wa.gov/Research-Data/Monitoring-assessment/River-stream-monitoring/Habitat-monitoring/Habitat-monitoring-methods and from glenn.merritt@ecy.wa.gov

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Appendices

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Appendix A. Alphabetical List of Metrics Reporting from WHMWeb

This list relates WHM export IDs (i.e., metric name) to metric categories.

Metric Name	unit	Metric Category
D_{gm}	millimeter	BedStability
$D_{gm}Log_{10}$	millimeter, log_{10}	BedStability
IDX Canopy	percent	RiparianVegetationStructure
IDX CanopyLT	percent	RiparianVegetationStructure
IDX CanopyST	percent	RiparianVegetationStructure
IDX CanUnderstory	percent	RiparianVegetationStructure
IDX CanUnderstoryGnd	percent	RiparianVegetationStructure
IDX CanUnderstoryWood	percent	RiparianVegetationStructure
IDX CanUnderstoryWoodGndWood	percent	RiparianVegetationStructure
IDX Ground	percent	RiparianVegetationStructure
IDX GroundBare	percent	RiparianVegetationStructure
IDX GroundHerb	percent	RiparianVegetationStructure
IDX GroudWood	percent	RiparianVegetationStructure
IDX Understory	percent	RiparianVegetationStructure
IDX UnderstoryHerb	percent	RiparianVegetationStructure
IDX UnderstoryWood	percent	RiparianVegetationStructure
LRBS	dimensionless index	BedStability
LWDPieces	count per site	LargeWoodyDebris
LWDPieces100m	count per 100 meters	LargeWoodyDebris
LWDPieces100mD1L1	count per 100 meters	LargeWoodyDebris
LWDPieces100mD1L2	count per 100 meters	LargeWoodyDebris
LWDPieces100mD1L3	count per 100 meters	LargeWoodyDebris
LWDPieces100mD2L1	count per 100 meters	LargeWoodyDebris
LWDPieces100mD2L2	count per 100 meters	LargeWoodyDebris
LWDPieces100mD2L3	count per 100 meters	LargeWoodyDebris
LWDPieces100mD3L1	count per 100 meters	LargeWoodyDebris
LWDPieces100mD3L2	count per 100 meters	LargeWoodyDebris
LWDPieces100mD3L3	count per 100 meters	LargeWoodyDebris
LWDPieces100mD4L1	count per 100 meters	LargeWoodyDebris
LWDPieces100mD4L2	count per 100 meters	LargeWoodyDebris
LWDPieces100mD4L3	count per 100 meters	LargeWoodyDebris
LWDPieces100mLtoX	count per 100 meters	LargeWoodyDebris
LWDPieces100mMtoX	count per 100 meters	LargeWoodyDebris
LWDPieces100mStoX	count per 100 meters	LargeWoodyDebris

LWDPiecesD1L1	count per site	LargeWoodyDebris
LWDPiecesD1L2	count per site	LargeWoodyDebris
LWDPiecesD1L3	count per site	LargeWoodyDebris
LWDPiecesD2L1	count per site	LargeWoodyDebris
LWDPiecesD2L2	count per site	LargeWoodyDebris
LWDPiecesD2L3	count per site	LargeWoodyDebris
LWDPiecesD3L1	count per site	LargeWoodyDebris
LWDPiecesD3L2	count per site	LargeWoodyDebris
LWDPiecesD3L3	count per site	LargeWoodyDebris
LWDPiecesD4L1	count per site	LargeWoodyDebris
LWDPiecesD4L2	count per site	LargeWoodyDebris
LWDPiecesD4L3	count per site	LargeWoodyDebris
LWDPiecesLtoX	count per site	LargeWoodyDebris
LWDPiecesMSq	count per square meter	LargeWoodyDebris
LWDPiecesMSqD1L1	count per square meter	LargeWoodyDebris
LWDPiecesMSqD1L2	count per square meter	LargeWoodyDebris
LWDPiecesMSqD1L3	count per square meter	LargeWoodyDebris
LWDPiecesMSqD2L1	count per square meter	LargeWoodyDebris
LWDPiecesMSqD2L2	count per square meter	LargeWoodyDebris
LWDPiecesMSqD2L3	count per square meter	LargeWoodyDebris
LWDPiecesMSqD3L1	count per square meter	LargeWoodyDebris
LWDPiecesMSqD3L2	count per square meter	LargeWoodyDebris
LWDPiecesMSqD3L3	count per square meter	LargeWoodyDebris
LWDPiecesMSqD4L1	count per square meter	LargeWoodyDebris
LWDPiecesMSqD4L2	count per square meter	LargeWoodyDebris
LWDPiecesMSqD4L3	count per square meter	LargeWoodyDebris
LWDPiecesMSqLtoX	count per square meter	LargeWoodyDebris
LWDPiecesMSqMtoX	count per square meter	LargeWoodyDebris
LWDPiecesMSqStoX	count per square meter	LargeWoodyDebris
LWDPiecesMtoX	count per site	LargeWoodyDebris
LWDPiecesStoX	count per site	LargeWoodyDebris
LWDVolume	cubic meters per site	LargeWoodyDebris
LWDVolume100m	cubic meters per 100 meters	LargeWoodyDebris
LWDVolume100mD1L1	cubic meters per 100 meters	LargeWoodyDebris
LWDVolume100mD1L2	cubic meters per 100 meters	LargeWoodyDebris
LWDVolume100mD1L3	cubic meters per 100 meters	LargeWoodyDebris
LWDVolume100mD2L1	cubic meters per 100 meters	LargeWoodyDebris
LWDVolume100mD2L2	cubic meters per 100 meters	LargeWoodyDebris
LWDVolume100mD2L3	cubic meters per 100 meters	LargeWoodyDebris
LWDVolume100mD3L1	cubic meters per 100 meters	LargeWoodyDebris
LWDVolume100mD3L2	cubic meters per 100 meters	LargeWoodyDebris
LWDVolume100mD3L3	cubic meters per 100 meters	LargeWoodyDebris
LWDVolume100mD4L1	cubic meters per 100 meters	LargeWoodyDebris

LWDVolume100mD4L2	cubic meters per 100 meters	LargeWoodyDebris
LWDVolume100mD4L3	cubic meters per 100 meters	LargeWoodyDebris
LWDVolume100mLtoX	cubic meters per 100 meters	LargeWoodyDebris
LWDVolume100mMtoX	cubic meters per 100 meters	LargeWoodyDebris
LWDVolume100mStoX	cubic meters per 100 meters	LargeWoodyDebris
LWDVolumeD1L1	cubic meters per site	LargeWoodyDebris
LWDVolumeD1L2	cubic meters per site	LargeWoodyDebris
LWDVolumeD1L3	cubic meters per site	LargeWoodyDebris
LWDVolumeD2L1	cubic meters per site	LargeWoodyDebris
LWDVolumeD2L2	cubic meters per site	LargeWoodyDebris
LWDVolumeD2L3	cubic meters per site	LargeWoodyDebris
LWDVolumeD3L1	cubic meters per site	LargeWoodyDebris
LWDVolumeD3L2	cubic meters per site	LargeWoodyDebris
LWDVolumeD3L3	cubic meters per site	LargeWoodyDebris
LWDVolumeD4L1	cubic meters per site	LargeWoodyDebris
LWDVolumeD4L2	cubic meters per site	LargeWoodyDebris
LWDVolumeD4L3	cubic meters per site	LargeWoodyDebris
LWDVolumeLtoX	cubic meters per site	LargeWoodyDebris
LWDVolumeMSq	cubic meters per sq meter	LargeWoodyDebris
LWDVolumeMSqD1L1	cubic meters per sq meter	LargeWoodyDebris
LWDVolumeMSqD1L2	cubic meters per sq meter	LargeWoodyDebris
LWDVolumeMSqD1L3	cubic meters per sq meter	LargeWoodyDebris
LWDVolumeMSqD2L1	cubic meters per sq meter	LargeWoodyDebris
LWDVolumeMSqD2L2	cubic meters per sq meter	LargeWoodyDebris
LWDVolumeMSqD2L3	cubic meters per sq meter	LargeWoodyDebris
LWDVolumeMSqD3L1	cubic meters per sq meter	LargeWoodyDebris
LWDVolumeMSqD3L2	cubic meters per sq meter	LargeWoodyDebris
LWDVolumeMSqD3L3	cubic meters per sq meter	LargeWoodyDebris
LWDVolumeMSqD4L1	cubic meters per sq meter	LargeWoodyDebris
LWDVolumeMSqD4L2	cubic meters per sq meter	LargeWoodyDebris
LWDVolumeMSqD4L3	cubic meters per sq meter	LargeWoodyDebris
LWDVolumeMSqLtoX	cubic meters per sq meter	LargeWoodyDebris
LWDVolumeMSqMtoX	cubic meters per sq meter	LargeWoodyDebris
LWDVolumeMSqStoX	cubic meters per sq meter	LargeWoodyDebris
LWDVolumeMtoX	cubic meters per site	LargeWoodyDebris
LWDVolumeStoX	cubic meters per site	LargeWoodyDebris
N BankInstab	count	BankQuality
N BF WxD	count	ChannelDimensions
N BFDepth	count	ChannelDimensions
N BFHeight	count	ChannelDimensions
N BFWidth	count	ChannelDimensions
N Canopy	count	RiparianVegetationStructure
N DensioBank	count	RiparianCover

N DensioCenter	count	RiparianCover
N Embed	count	Substrate
N EmbedCenter	count	Substrate
N FishCov	count	FishCover
N Ground	count	RiparianVegetationStructure
N HumanInfluence	count	RiparianDisturbance
N Lith	count	BedStability
N PoolCrestDepth	count	HabitatUnitDimensions
N PoolMaxDepth	count	HabitatUnitDimensions
N PoolUnitDepth	count	HabitatUnitDimensions
N ResPoolDepth	count	ChannelDimensions
N Substrate	count	Substrate
N TWDepth	count	ChannelDimensions
N Understory	count	RiparianVegetationStructure
N Wet WxD	count	ChannelDimensions
N WetWidth	count	ChannelDimensions
PCT BankAg	percent	RiparianDisturbance
PCT BankAny	percent	RiparianDisturbance
PCT Bedrock	percent	Substrate
PCT BedrockR	percent	Substrate
PCT BedrockS	percent	Substrate
PCT Boulder	percent	Substrate
PCT BoulderL	percent	Substrate
PCT BoulderS	percent	Substrate
PCT CloseAg	percent	RiparianDisturbance
PCT CloseAny	percent	RiparianDisturbance
PCT Cobble	percent	Substrate
PCT Dry	percent	HabitatUnitExtent
PCT Fast	percent	HabitatUnitExtent
PCT FastNT	percent	HabitatUnitExtent
PCT FastT	percent	HabitatUnitExtent
PCT Fines	percent	Substrate
PCT GravelC	percent	Substrate
PCT GravelCx	percent	Substrate
PCT GravelF	percent	Substrate
PCT GravelFb	percent	Substrate
PCT Hardpan	percent	Substrate
PCT Other	percent	Substrate
PCT Pavement	percent	Substrate
PCT Pool	percent	HabitatUnitExtent
PCT PoolDammed	percent	HabitatUnitExtent
PCT PoolPlunge	percent	HabitatUnitExtent
PCT PoolScour	percent	HabitatUnitExtent

PCT Sand	percent	Substrate
PCT SandFines	percent	Substrate
PCT Wet	percent	HabitatUnitExtent
PCT Wood	percent	Substrate
PFC Algae	proportion	Fish Cover
PFC Artificial	proportion	Fish Cover
PFC Boulders	proportion	Fish Cover
PFC Brush	proportion	Fish Cover
PFC Bryophytes	proportion	Fish Cover
PFC LWD	proportion	Fish Cover
PFC Macrophytes	proportion	Fish Cover
PFC Natural	proportion	Fish Cover
PFC NoAqVeg	proportion	Fish Cover
PFC OvHgVeg	proportion	Fish Cover
PFC Persistent	proportion	Fish Cover
PFC TreesRoots	proportion	Fish Cover
PFC Undercut	proportion	Fish Cover
PPN CanBrdlf	proportion	RiparianVegetationStructure
PPN CanConif	proportion	RiparianVegetationStructure
PPN CanDecid	proportion	RiparianVegetationStructure
PPN CanMixed	proportion	RiparianVegetationStructure
PPN Canopy	proportion	RiparianVegetationStructure
PPN CanUnderstoryGnd	proportion	RiparianVegetationStructure
PPN Ground	proportion	RiparianVegetationStructure
PPN Lith CB	proportion	BedStability
PPN Lith FN	proportion	BedStability
PPN Lith GC	proportion	BedStability
PPN Lith GF	proportion	BedStability
PPN Lith HP	Proportion	BedStability
PPN Lith RR	proportion	BedStability
PPN Lith RS	proportion	BedStability
PPN Lith SA	proportion	BedStability
PPN Lith SB	proportion	BedStability
PPN Lith XB	proportion	BedStability
PPN SideChannel	Proportion	SideChannels
PPN RipVegAboveGnd	proportion	RiparianVegetationStructure
PPN Understory	proportion	RiparianVegetationStructure
PPN UnderstoryBrdlf	proportion	RiparianVegetationStructure
PPN UnderstoryConif	proportion	RiparianVegetationStructure
PPN UnderstoryDecid	proportion	RiparianVegetationStructure
PPN UnderstoryMixed	proportion	RiparianVegetationStructure
PWP Ag	proportion	RiparianDisturbance
PWP All	proportion	RiparianDisturbance

PWP Bldg	proportion	RiparianDisturbance
PWP Clear	proportion	RiparianDisturbance
PWP Crop	proportion	RiparianDisturbance
PWP Dike	proportion	RiparianDisturbance
PWP Lawn	proportion	RiparianDisturbance
PWP Log	proportion	RiparianDisturbance
PWP Mine	proportion	RiparianDisturbance
PWP Path	proportion	RiparianDisturbance
PWP Pave	proportion	RiparianDisturbance
PWP Pipe	proportion	RiparianDisturbance
PWP Range	proportion	RiparianDisturbance
PWP Trash	proportion	RiparianDisturbance
PWP Unpav	proportion	RiparianDisturbance
RBS	dimensionless index	BedStability
ResPoolArea	square meters	ChannelDimensions
ResPoolArea100	centimeters	ChannelDimensions
SCMax	Dimensionless count	SideChannels
SD BF WxD	square meters	ChannelDimensions
SD BFDepth	centimeters	ChannelDimensions
SD BFHeight	centimeters	ChannelDimensions
SD BFWidth	meters	ChannelDimensions
SD Embed	percent	Substrate
SD EmbedCenter	percent	Substrate
SD PoolUnitDepth	centimeters	HabitatUnitDimensions
SD TWDepth	centimeters	ChannelDimensions
SD Wet WxD	square meters	ChannelDimensions
SD WetWidth	meters	ChannelDimensions
Sinuosity	dimensionless index	Sinuosity
Site Length	meters	ChannelDimensions
TWIncrement	meters	ChannelDimensions
X BankInstab	percent	BankQuality
X BF WxD	square meters	ChannelDimensions
X BFDepth	centimeters	ChannelDimensions
X BFHeight	centimeters	ChannelDimensions
X BFWidth	meters	ChannelDimensions
X DensioBank	percent	RiparianCover
X DensioCenter	percent	RiparianCover
X Embed	percent	Substrate
X EmbedCenter	percent	Substrate
X PoolCrestDepth	centimeters	HabitatUnitDimensions
X PoolMaxDepth	centimeters	HabitatUnitDimensions
X PoolUnitDepth	centimeters	HabitatUnitDimensions
X Slope	percent	ChannelDimensions

X TWDepth	centimeters	ChannelDimensions
X Wet WxD	square meters	ChannelDimensions
X WetWidth	meters	ChannelDimensions
XFC Algae	percent	Fish Cover
XFC Artificial	percent	Fish Cover
XFC Boulders	percent	Fish Cover
XFC Brush	percent	Fish Cover
XFC Bryophytes	percent	Fish Cover
XFC LWD	percent	Fish Cover
XFC Macrophytes	percent	Fish Cover
XFC Natural	percent	Fish Cover
XFC NoAqVeg	percent	Fish Cover
XFC OvHgVeg	percent	Fish Cover
XFC Persistent	percent	Fish Cover
XFC TreesRoots	percent	Fish Cover
XFC Undercut	percent	Fish Cover

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Appendix B. Glossary

Allowed metric values: Range of values which a metric can assume, given the data collection schema. Metrics assuming values outside this range should be reviewed for errors.

ASP.Net: Framework supporting development of dynamic web pages, developed initially by Microsoft ®.

Assumptions: Conditions under which the resultant metric is expected to be reasonable.

Calculation: Generalized steps in the calculation of each metric.

Data collection event (DCE): An identification code associated with each observation. It identifies the site visited and the date of the visit. DCEs are unique. A single site visited twice in the same year would result in two unique DCEs.

Data collection schema: Key details about how observations underlying the metrics were collected, such as whether transects were bank to bank and perpendicular to the channel, or evenly spaced along the study reach.

Definition: What the metric actual represents, as a characteristic of the channel or riparian area where observations occurred, and the associated reporting unit, if any.

Dependencies: Metrics used to calculate other metrics. The latter are typically of higher level or more derived. For a dependent metric to report, the dependencies must be calculable.

Group: Second-highest hierarchical organizational level of the dictionary, describing clusters of related metrics within the metric categories considered.

Hardpan: Hardened or cemented sand & fines that are estimated to act as a lithic particle of ≥4000 mm diameter.

Littoral zone: An operational definition for WHMWeb, as, for streams and rivers, the area near the wetted margin of the channel.

Maximum observations (DCE): Upper limit on the number of observations possible, per DCE (see *Data collection event,* above), as well as how the limit is derived. Separate limits are given for wide and narrow protocols, if different.

Metric category: Highest hierarchical organizational level of the dictionary, identifying the broadest general groupings of metrics considered.

Minimum reporting qualifiers: Tests of completeness of observations underlying the metrics, for a given DCE.

Narrow protocol: Sampling approach for sites that are narrower than 25 meters bankfull width.

Observation type: Informs users of the dictionary of what the observations underlying the metric of interest actually are, such as counts.

Reported: Long descriptive name and type (e.g., count, average) of the metric reported. Reported IDs are analogous to WHM export IDs, the latter being more compact and not always identifying the metric type. Both reported IDs and WHM metric IDs play roles in defining metrics in the database. WHM export IDs are what reports from WHMWeb, see below.

Reporting years: Years of sampling, to date, for which metrics will be available. The goal is to load sample data through 2012 into the calculation engine by November 2013.

Riparian: Relating to the banks along a natural course of water.

Riparian plot: For WHMWeb, a survey area, centered on a transect and extending 10 m back horizontally from the bankfull margin of the main channel.

Site: Entire survey reach for a given data collection event, including any stations along the reach where observations or sample collection occurred. Maximum site length is 2000 meters. Minimum site length is 150 meters.

SQL Server: A database server implementing structured query language (SQL).

Station: Location within a site where observations or sample collection occurred. For example, each depth measurement along the site thalweg profile occurs at a different station.

WHM export ID: Compact name unique to each metric and analogous to reported IDs (see reporting, above). WHM export IDs are the metric identifiers exporting from the WHMWeb metric calculation engine. Both reported IDs and WHM export IDs play roles in defining metrics in the database, but WHM export IDs are generally what users of WHMWeb will seek.

Surface waters of the state: Lakes, rivers, ponds, streams, inland waters, salt waters, wetlands and all other surface waters and water courses within the jurisdiction of Washington State.

Units: As used in the dictionary refers generally to proportions, percentages, and SI units associated with metrics reporting from WHMWeb. The exceptions are counts, which are often various types of observations.

Wide protocol: Sampling approach for sites associated with flowing water bodies wider than 25 meters bankfull width, or too deep or too swift to wade.

Units of Measurement

°C	degrees centigrade
cm	centimeter
kg	kilogram, a unit of mass equal to 1,000 grams
km	kilometer, a unit of length equal to 1,000 meters
m	meter
mm	millimeter