



Upper Columbia Basin Network Stream Channel Characteristics and Riparian Condition Annual Report 2015

Big Hole National Battlefield (BIHO)

Natural Resource Data Series NPS/UCBN/NRDS—2016/1045



ON THE COVER

North Fork Big Hole River, June 2015, Big Hole National Battlefield.
NPS Photo

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Executive Summary

The mission of the National Park Service is “to conserve unimpaired the natural and cultural resources and values of the national park system for the enjoyment of this and future generations” (NPS 1999). To uphold this goal, the Director of the NPS approved the Natural Resource Challenge to encourage national parks to focus on the preservation of the nation’s natural heritage through science, natural resource inventories, and expanded resource monitoring (NPS 1999). Through the Challenge, 270 parks in the national park system were organized into 32 inventory and monitoring networks.

The Upper Columbia Basin Network (UCBN) has identified 14 priority park vital signs, indicators of ecosystem health, which represent a broad suite of ecological phenomena operating across multiple temporal and spatial scales. Our intent has been to come up with a balanced and integrated “package” of vital signs that meets the needs of current park management, but will also be able to accommodate unanticipated environmental conditions in the future. Stream channel characteristics and riparian condition are particularly high priority vital signs for five of the nine UCBN parks. The UCBN contains more than 34 rivers, streams, ponds and reservoirs located in nine park units spread over four large western states. Unlike many National Parks that are large and often encompass entire watersheds, most UCBN parks and water bodies are small and embedded in large watersheds with diverse land use. Stream channel and riparian conditions in most UCBN streams have not been directly assessed.

Data from the 2015 field sampling effort was collected following methods detailed in the UCBN stream channel characteristics and riparian condition monitoring protocols (Starkey et al. 2011a, Starkey et al. 2011b) and the United States Forest Service- PACFISH/INFISH Biological Opinion (PIBO) peer reviewed protocols (Heitke et al. 2009, Leary and Ebertowski 2010). The UCBN stream channel characteristics protocol was formally peer-reviewed and approved for implementation in December 2010. The UCBN riparian condition protocol was formally peer-reviewed and approved for implementation in September 2011. These protocols can be found on the UCBN website at: <http://science.nature.nps.gov/im/units/ucbn/>.

Note that field work for this protocol is completed by PIBO through an interagency agreement with the UCBN. Benthic macroinvertebrates were also collected by PIBO according to their peer reviewed protocol (Heitke et al. 2009). Results of macroinvertebrate sampling are reported in the UCBN integrated water quality annual report 2015 for BIHO (Starkey 2016).

This annual report details the status of key stream channel characteristics and riparian attributes obtained from the first season of monitoring on the North Fork Big Hole River within Big Hole National Battlefield (BIHO). This report is intended as a release of basic data sets and data summaries. Care has been taken to assure accuracy of raw data values, but thorough analysis and interpretation of the data has not been completed. More extensive analysis and discussion of stream channel characteristics and riparian condition will occur as part of the trend analysis, which will be available after 3 years of monitoring data become available.

Acknowledgments

Funding for this project was provided through the National Park Service Natural Resource Challenge and the Servicewide Inventory and Monitoring Program. We would like to thank the PACFISH/INFISH- Biological Opinion Effectiveness Monitoring Program (PIBO-EM) for their many contributions to the UCBN stream channel characteristics and riparian condition protocols. Their willingness to collaborate with regional partners will greatly contribute to the understanding of water resources throughout the region. The UCBN would also like to thank BIHO staff for providing accommodations during field work and for the review of this report.

Introduction and Background

In 2015, the UCBN began its second year of stream channel characteristics and riparian condition monitoring on North Fork Big Hole River at Big Hole National Battlefield (BIHO). Stream channel characteristics and riparian condition have been identified as high priority vital signs in the Upper Columbia Basin Network (UCBN). Stream channel and bank morphology, stability, and composition are fundamental and directly measurable attributes of lotic systems that directly affect riparian vegetation, water quality, and aquatic fauna, particularly macroinvertebrates and fish (Garrett et al. 2007). Water resources, including stream channels and riparian plant communities, in the semi-arid west have been strongly affected by human activity (Elmore and Kauffman 1994); and streams within the UCBN are of no exception. Most UCBN streams and their aquatic resources, such as migratory fish, are strongly influenced by activities in the larger watersheds outside park boundaries. Understanding the current status of freshwater ecosystems will help guide management and restoration efforts within park boundaries, assist with collaborative efforts between nearby landowners, and provide insight into ecosystem change in a landscape with changing climate and dynamic human influences.

As many authors have noted, there is an intimate connection between stream channels and the surrounding landscape (Gregory et al. 1991, Elmore and Kauffman 1994, Richards et al. 1996, Rosgen 1996, Sweeney et al. 2004). Stream channels are a product of regional geomorphology, hydrology, riparian vegetation, upland vegetation, land use and water use. Within a stream, channel characteristics profoundly influence habitat for macroinvertebrates and fish. This connection between the surrounding landscape, stream channels, and aquatic habitat makes monitoring channel characteristics and riparian condition an important aspect of natural resource monitoring in the UCBN.

Well-articulated desired future condition statements have not yet been developed for stream channel characteristics or riparian condition in UCBN parks. However, the mission statements for the NPS as a whole and for the individual parks clearly state the intent “to conserve unimpaired the natural and cultural resources and values of the national park system for the enjoyment of this and future generations” (NPS 1999). Stream channels and riparian areas are of particularly high importance due to their connection to both aquatic and terrestrial ecosystem health, as well as their impact on cultural resources. It is assumed that desired future conditions for all UCBN parks will include streams and rivers that support natural processes, and provide visitors with recreational and scenic experiences. By monitoring stream channel characteristics and riparian condition the UCBN will be directly measuring attributes important to park mission, visitor experience, and desired future conditions.

Objectives

The overarching programmatic goal of the UCBN Stream Channel Characteristics and Riparian Condition Monitoring Protocols is to obtain information that will aid management and restoration decisions pertaining to stream channels and riparian areas within UCBN parks. The primary objective of current stream channel and riparian management in UCBN parks is to prevent extensive changes from that of historic conditions and to restore stream channels and riparian communities, if necessary, to maintain a system with biotic integrity and good hydrologic function.

Stream Channel Characteristics

Given the lack of available data on channel characteristics in UCBN parks, the following fundamental questions drive much of the UCBN's inquiry.

- Are stream channel attributes improving or degrading over time?
- Do planform and cross section measures collected within UCBN streams indicate changes in land use or management practices?
- How do UCBN stream channel conditions compare to those in the watershed and region?
- Do cross section measures collected within UCBN streams indicate impaired habitat for macroinvertebrates or fishes?
- Are cultural resources at risk of degradation due to stream bank erosion?

In light of these questions and the broader goals outlined above, the stream channel characteristics monitoring protocol addresses the following specific measurable monitoring objectives:

1. Determine the status of bank stability, percent undercut, bank angle, percent fines, and other key stream channel characteristics for selected Wadeable stream reaches.
2. Determine the direction and magnitude of change over time for bank stability, percent undercut, bank angle, percent fines, and other key stream channel characteristics, and establish whether those changes reflect impacts from management or land use activities.
3. Determine the condition of key stream channel attributes within selected Wadeable UCBN stream reaches, relative to PACFISH/INFISH Biological Opinion Effectiveness Monitoring Program (PIBO) sample reaches in the same watershed.
4. Determine if changes in stream channels, specifically bank erosion, are likely to negatively impact cultural resources within the floodplain.

Riparian Condition

Given the lack of available data on riparian condition in UCBN parks, the following fundamental questions drive much of the UCBN's inquiry.

- What is the status of biotic integrity and hydrologic function of UCBN riparian zones?
- What is the direction and magnitude of change in UCBN riparian zone condition, as indicated by greenline and channel cross-section measures of vegetation cover collected along select UCBN streams?
- How do UCBN riparian conditions compare to those in the watershed and region?
- Do cover measures collected along UCBN streams indicate impaired habitat for macroinvertebrates or fishes (e.g., reduced shading)?

In light of these questions and the broader goals outlined above, the riparian condition monitoring protocol addresses the following specific measurable monitoring objectives:

1. Determine the status of riparian condition, as measured by greenline and channel cross section wetland ratings (i.e., obligate wetland riparian plant species cover), effective ground cover, and greenline woody vegetation cover for selected wadeable stream reaches.
2. Determine the direction and magnitude of change over time for obligate wetland riparian plant species cover, effective ground cover, and woody vegetation cover.
3. Determine the condition of riparian zones along selected wadeable UCBN stream reaches, relative to PIBO sample reaches in the same watershed.
4. Determine the status and trend in the cover of non-native invasive plant species found along UCBN streams, as estimated from PIBO sample reaches.

Study Area

North Fork Big Hole River- Big Hole National Battlefield (BIHO)

Big Hole National Battlefield is in the North Fork Big Hole River subwatershed, in Hydrologic Unit Code (HUC 12) 100200040509 (United States Geologic Survey [USGS]), Big Hole subbasin (HUC 8) 1002004, in Beaverhead County, Montana (Figures 1 and 2 Appendix B). The drainage area above the park is approximately 241 square km (150 square miles) (NPS 1997). According to Corrao and Erixson 2011, the Big Hole watershed is dominated by the following cover types: closed tree canopy (44%), herbaceous-grassland/shrub-steppe (23%), open tree canopy (17%), and shrubland (15%).

North Fork Big Hole River is classified as an A-1 surface water (Admin. Rules of MT 2015, 17.30.610 [through 5/09/2008]). As such, designated beneficial uses for North Fork Big Hole River include: agricultural, aquatic life, drinking water, and primary contact recreation (MT DEQ 2009, Admin. Rules of MT 2015, 17.30.622 [through 8/08/2014]). In 2006, the North Fork Big Hole River was identified as impaired and was placed on the 303(d) list (MT DEQ 2006). Probable causes of impairment included: “sediment-related listings (siltation, suspended solids, turbidity, bank erosion), metals (cadmium, copper, lead, mercury, and zinc), thermal modification, nutrients, riparian and fish habitat degradation, habitat alteration, habitat modification, channel incisement, and flow alteration (dewatering)” (MT DEQ 2009). Since that time, MT DEQ has developed total maximum daily loads (TMDLs) that address temperature, sediment, nutrients, and metal pollution (see MT DEQ 2009). In 2012 and 2014, North Fork Big Hole River was listed as a category 4A water, meaning that it has a pollution problem, but has total maximum daily loads (TMDL) being actively implemented to reduce pollution (MT DEQ 2012 and MT DEQ 2014). The probable causes of impairment are listed as alteration in stream-side or littoral vegetative covers, low flow alterations, and sedimentation/siltation.

In 2012, five sample sites/reaches were established along the North Fork Big Hole River between the northern park boundary and the confluence of Trail and Ruby Creeks (Figures 1-3) (Site ID 3211, 3213, 3214, 3215, and 3216). Both stream channel characteristics and riparian condition were evaluated at each of the 5 reaches. A sixth sample site was established and assessed for macroinvertebrates only (Figure 3) (3217). These same sites were re-sampled in 2015.



Figure 1. North Fork Big Hole River, SiteID: 3213, SiteName: 524-02-I.

Big Hole National Battlefield

Regional Location Map

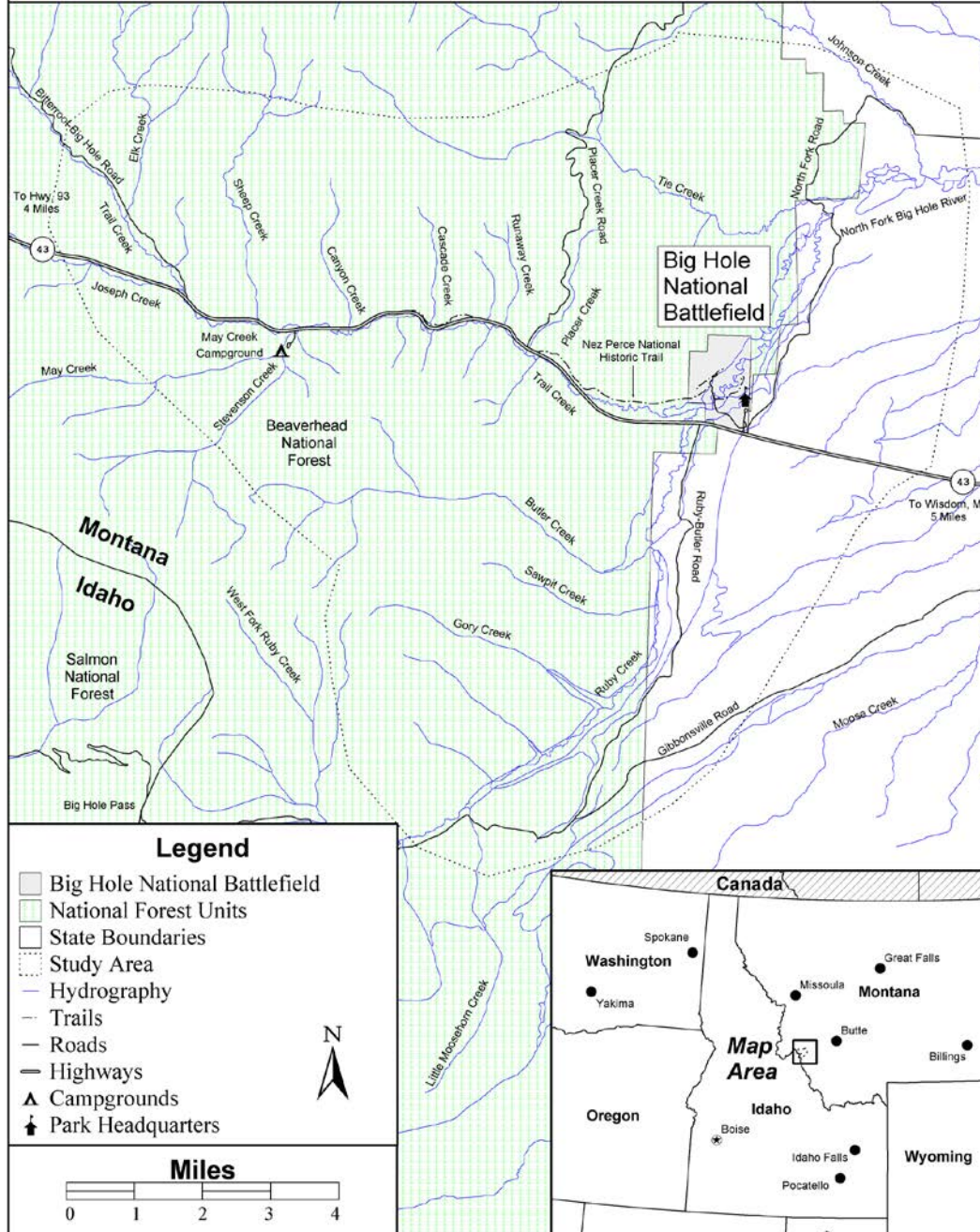


Figure 2. Big Hole National Battlefield regional map (NPS 1997).



Stream Channel, Macroinvertebrate Sample Reaches and Water Quality Monitoring Station

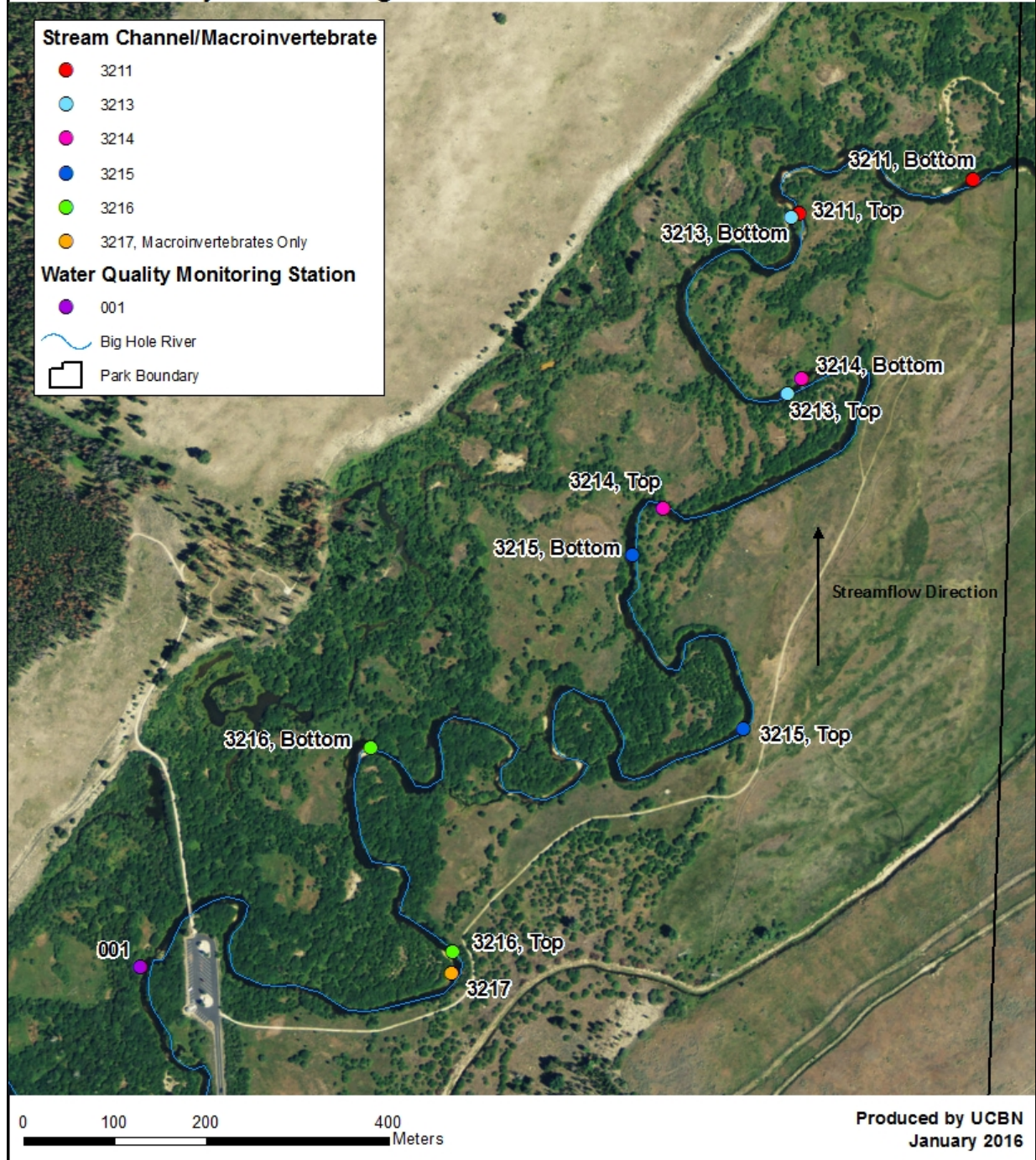


Figure 3. Top and bottom of stream channel characteristic and riparian condition monitoring sites in North Fork Big Hole River 2015.

Methods

Data from the 2015 field sampling effort was collected following methods detailed in the UCBN stream channel characteristics and riparian condition monitoring protocols (Starkey et al. 2011a, Starkey et al. 2011b). The UCBN's protocols mirror existing monitoring protocols developed by the United States Forest Service (USFS) PACFISH/INFISH Effectiveness Monitoring (PIBO-EM) Program (Heitke et al. 2009, Leary and Ebertowski 2010). In addition to the use of existing protocols, the UCBN has formed an interagency agreement with the USFS such that the PIBO program collects the data necessary to complete stream channel and riparian monitoring in the UCBN. The use of existing tested protocols and a trained field crew promotes data quality and integration of data from the UCBN with data collected throughout the region. This approach will provide a unique opportunity to examine park stream channel and riparian resources relative to regional status and trends. A more detailed description of the PIBO programs purpose and approach to monitoring can be found in Kershner et al. (2004) and Henderson et al. (2005).

To achieve the measurable objectives, the PIBO program established sites as described below and sampled North Fork Big Hole River in August, during base flow conditions.

Data Collection

All data collection was conducted by the USFS PIBO Program in accordance with the PIBO Sampling Protocol for Stream Channel Attributes (Heitke et al. 2009) and Sampling Protocol for Vegetation Parameters (Leary and Ebertowski 2010). These protocols are available from the PIBO website (<http://www.fs.fed.us/biology/fishecology/new.html> Accessed 30 June 2015).

Locating Stream Channel and Riparian Sample Reaches

Sample reach selection differed slightly from standard PIBO methods due to the restriction placed on the sampling design by park boundaries. Typically sample reach locations are chosen by moving upstream from the bottom of a randomly selected 6th field HUC until a pool tail is reached. As a result of the park boundary restriction, the location of the first sample reach was determined by the field crew moving upstream from the park boundary until the first pool tail was identified.

Subsequent sample reaches within the park were determined by moving upstream from a previous sample reach until another pool tail was identified. Pools are clearly defined in the "Pools" section of the PIBO Sampling Protocol for Stream Channel Attributes (Heitke, et al. 2009). It is important to note that stream channel and riparian sample reaches are co-located. The top and bottom of each sample reach were permanently marked using a 1 inch by 3 inch piece of aluminum with PIBO EM scratched into them. The top of each reach was labeled with the site number and TR for Top Reach and the bottom of each reach with the site number and BR for Bottom Reach. In subsequent years, during revisits, field crews will navigate back to the same sample reach using a reach description, photographs, topographic map and UTM coordinates. Reach descriptions, photographs and topographic maps are archived on the UCBN server.

Results

Note that this report is a data series report and intended as a release of basic data sets and data summaries. Care has been taken to assure accuracy of raw data values, but thorough analysis and interpretation of the data has not been completed. More extensive analysis and discussion of stream channel characteristics and riparian condition will occur as part of the trend analysis, which will be available after 3 years of monitoring data become available.

Stream Channel Characteristics/Riparian Condition

The status of individual stream channel parameters is shown in Table 1. Greenline wetland ratings and status of individual riparian attributes are shown in Table 2. A summary of weeds encountered during the riparian assessment is given in Table 3. Descriptions of each parameter are given in Appendix C.

Data collected in 2015 represents the second stream channel and riparian assessment of the North Fork Big Hole River. Results may be compared to 2012 data found in Starkey (2013). The next assessment will occur in 2018, with a preliminary assessment of trend in 2021.

Table 1. Vital sign summary table for stream channel characteristics in North Fork Big Hole River within BIHO, August 2015.

Parameter (Units)	Abbreviation	3211/8834 N.F. Big Hole 1	3213/8835 N.F. Big Hole 2	3214/8836 N.F. Big Hole 3	3215/8837 N.F. Big Hole 4	3216/8838 N.F. Big Hole 5	Mean	Standard Deviation
Index of physical habitat integrity	HabIndex	18.4	18.4	18.4	18.4	18.4	18.4	0.0
Average bankfull width from transects (m)	Bf	12.6	12.4	13.1	11.9	13.7	12.7	0.7
Gradient of stream reach (%)	Grad	0.104	0.362	0.075	0.190	0.161	0.2	0.1
Sinuosity of stream reach (ratio)	Sin	1.9	2.1	1.9	1.6	1.4	1.7	0.3
Residual pool depth (m)	PoolDp	0.5	0.8	0.8	0.7	0.8	0.7	0.1
Percent pools (%)	PoolPct	65.9	78.6	61.6	70.4	86.2	72.6	9.9
Number of pools per kilometer.(# / km)	PoolFrq	31.8	25.5	13.0	19.9	14.9	21.0	7.7
Bankfull width to depth ratio at transects (ratio)	WDTrans	17.1	16.8	16.1	14.2	16.1	16.0	1.1
Wetted width to depth ratio at transects (ratio)	WDwetTrans	23.1	41.6	22.0	26.4	29.4	28.5	7.9
Diameter of the 50th percentile streambed particle (m)	D50	0.02650	0.01100	0.00500	0.02200	0.01000	0.0	0.0
Percent pool tail fines < 2mm (%)**	PTFines2	5.4	1.2	13.8	6.1	3.6	6.0	4.7
Percent pool tail fines < 6mm (%)**	PTFines6	7.1	1.7	17.8	6.7	5.1	7.6	6.0
Average bank angle (degrees)	BnkAngl	103	85	82	97	97	92.8	8.9
Percent stable banks (covered stable, false bank, and uncovered stable). (%)	Stab	92.9	100.0	100.0	97.6	100.0	98.1	3.1
Vegetated Stability	VegStab	69.1	96.0	93.8	88.1	75.0	84.4	11.8
Percent of bank angles < 90 (%) ^o	UnCutPct	35.1	42.0	57.5	35.7	44.7	43.0	9.1
Large wood frequency (pieces / km)	LWfrq	0.0	0.0	0.0	11.4	0.0	2.3	5.1
Large wood volume (m ³ / km)	LWVol	0.0	0.0	0.0	0.3	0.0	0.1	0.1

Table 2. Vital sign summary table for riparian condition along North Fork Big Hole River, August 2015.

Parameter (Units)	Abbreviation	Site ID/Reach ID, Stream					Mean	Standard Deviation
		3211/8834 N.F. Big Hole 1	3213/8835 N.F. Big Hole 2	3214/8836 N.F. Big Hole 3	3215/8837 N.F. Big Hole 4	3216/8838 N.F. Big Hole 5		
Greenline total cover (%)	GLTotalCv	77.4	86.7	83.3	87.6	87.9	84.6	4.4
Greenline relative alien cover (%)	GLRAC	1.8	0.7	0.5	2.2	1.1	1.3	0.7
Greenline relative cover nativity unknown (%)	GLUnid	10.7	4.8	2.8	0.0	22.7	8.2	9.0
Cross-section total cover (%)	XSTotalCv	80.0	78.5	92.5	90.0	97.3	87.7	8.1
Cross-section relative alien cover (%)	XSRAC	5.6	8.8	2.9	9.5	9.2	7.2	2.9
Cross-section relative cover nativity unknown (%)	XSUnid	19.1	16.6	8.0	0.0	22.9	13.3	9.3
Reach native cover (%)*	RchNtvCv	64.6	73.1	81.3	84.0	66.5	73.9	8.6
Reach alien cover (%)	RchAlnCv	2.7	3.0	1.3	4.7	4.4	3.2	1.4
Reach cover nativity unknown (%)	RchUnidCv	11.2	7.5	4.3	0.0	21.0	8.8	8.0
Reach total cover (%)	RchTotalCv	78.5	83.6	86.9	88.6	91.9	85.9	5.1
Richness native (# native species)	SNtv	18	16	19	20	18	18.2	1.5
Richness alien (# non-native species)	SAln	2	1	1	2	2	1.6	0.5
Effective ground cover (%)	EGC	95.2	100.0	99.0	96.2	98.7	97.8	2.0
Greenline woody cover (%)	GLwoodyCv	26.2	22.0	15.1	27.4	34.5	25.1	7.2
Greenline wetland rating (unitless)	GLWetRat	74.3	82.1	83.9	79.2	75.8	79.1	4.1
Cross-section wetland rating (unitless)	XSWetRat	68.4	54.3	73.3	73.0	62.0	66.2	8.1

Table 3. Vital sign summary table for weeds in riparian areas along North Fork Big Hole River within BIHO, 2015. Note that species listed as weeds are listed as noxious weeds in the INVADERS Database System <http://invader.dbs.umt.edu> (Rice 2016).

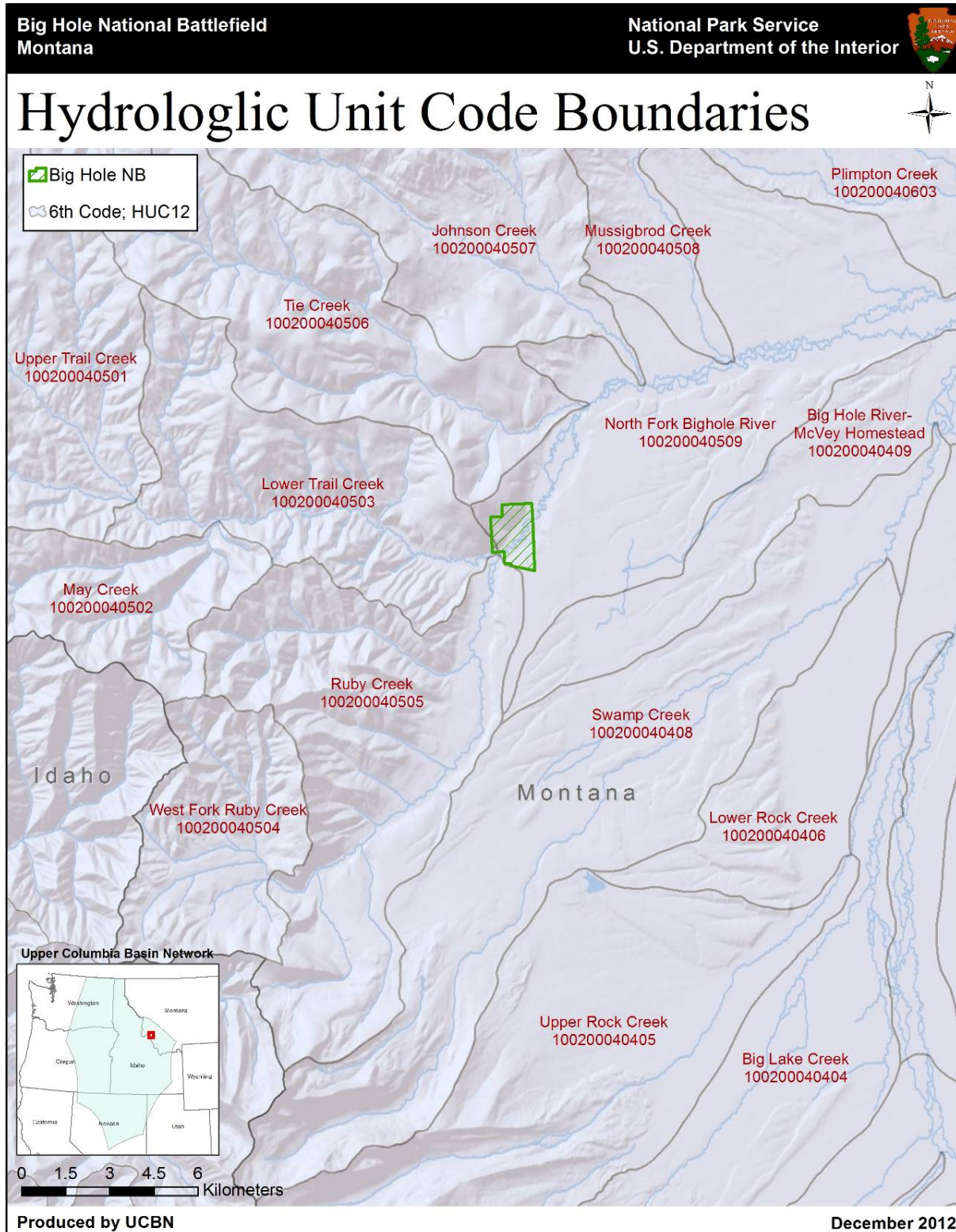
Site ID	Reach ID	Stream	Plant Species	Common Name	Greenline weed cover (%)	Cross-section weed cover (%)
3211	8834	N.F. Big Hole 1	<i>Equisetum arvense</i>	field horsetail	1.19	1.05
3215	8837	N.F. Big Hole 4	<i>Equisetum arvense</i>	field horsetail	1.90	0.00
3216	8838	N.F. Big Hole 5	<i>Cirsium arvense</i>	Canada thistle	0.50	4.75
3216	8838	N.F. Big Hole 5	<i>Equisetum arvense</i>	field horsetail	0.50	0.33

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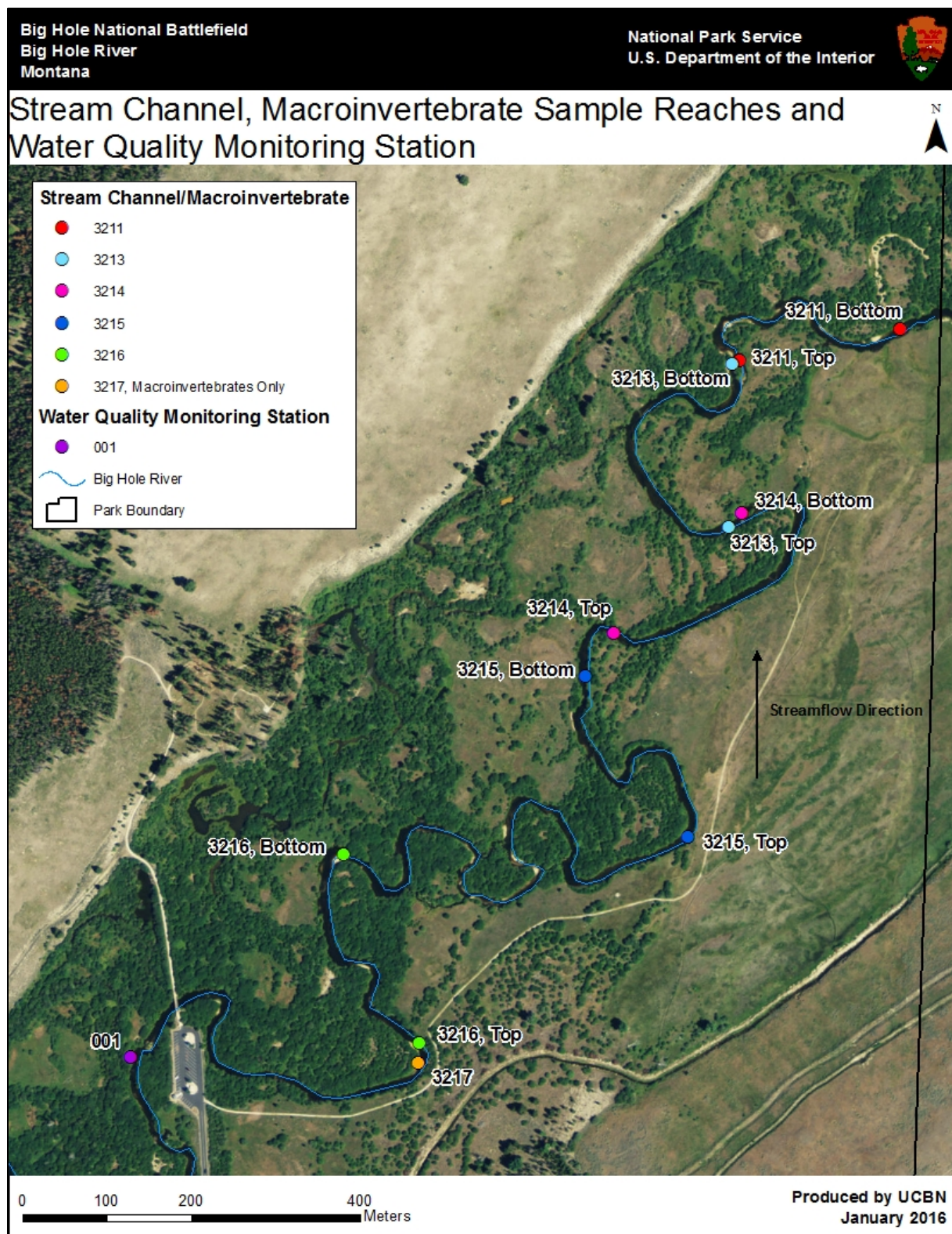
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Appendix A Hydrologic Unit Code Boundaries, BIHO



Appendix B. Stream Channel/Riparian Monitoring Locations BIHO 2015



Appendix C. Parameter Descriptions for Riparian, Stream Channel and Weed Monitoring

The descriptions of each parameter have been provided by PIBO as part of the data summaries for stream channel and riparian monitoring.

Riparian Condition

Cross-section relative alien cover: The proportion of cross-section plant cover coming from non-native species. Calculated as species cover of non-natives divided by total species cover, and multiplied by 100. (Magee et al. 2008.)

Cross-section relative cover nativity unknown: The relative cross-section plant cover of species with nativity status unknown. Calculated as cover of species with nativity unknown divided by total species cover, and multiplied by 100. NOTE: This value is relativized, and not comparable to other reported (actual) cover values.

Cross-section total cover: Total plant cover for riparian cross-section. Because cover is estimated for two layers (1m and below, above 1m) total species cover can be a maximum of 200 percent.

Cross-section wetland rating: A measure of the abundance of wetland species in the riparian area. A wetland rating of 100 indicating all obligate wetland species and 1 being all upland species. The rating is calculated for each reach by summing the product of the relative cover of each species for which a wetland indicator status can be determined and a value corresponding to the species' wetland indicator status (1=upland, 25= facultative upland, 50=facultative, 75=facultative wet, 100=obligate wetland. Coles-Ritchie et al. 2007). The cross-section sample area was a fixed area, 3 to 9.5 m from the greenline.

Effective ground cover: The percent of the riparian area (not including the greenline) with effective ground cover. The cross-section average percent cover of bare soil is subtracted from 100 to calculate effective ground cover. Live vegetation within 1 m of the ground, litter, and rocks greater than 2.5 cm are considered effective ground cover. Prior to 2009, data for calculating effective ground cover were collected at the four corners of the quadrat, rather than for the entire quadrat. Because of the different methods, 2009 to the present dates effective ground cover data are not comparable to earlier years.

Greenline relative alien cover: The proportion of greenline plant cover coming from non-native species. Calculated as species cover of non-natives divided by total species cover, and multiplied by 100. (Magee et al. 2008.)

Greenline relative cover nativity unknown: The relative greenline plant cover of species with nativity status unknown. Calculated as cover of species with nativity unknown divided by total species cover, and multiplied by 100. NOTE: This value is relativized, and not comparable to other reported (actual) cover values.

Greenline total relative cover: Total plant relative cover for greenline. Because cover is estimated for two layers (1m and below, above 1m) total species cover can be a maximum of 200 percent.

Greenline wetland rating: A measure of the abundance of wetland species along the streambank. A wetland rating of 100 indicating all obligate wetland species and 1 being all upland species. The rating is calculated for each reach by summing the product of the relative cover of each species for which a wetland indicator status can be determined and a value corresponding to the species' wetland indicator status (1=upland, 25= facultative upland, 50=facultative, 75=facultative wet, 100=obligate wetland. Coles-Ritchie et al. 2007).

Greenline woody cover: The sum of the relative cover of woody species along the greenline. These could be any woody species, such as willows, pines, or currants. Greenline woody cover can be up to 200% because cover estimates are a combination of two layers.

Reach alien cover: Non-native species cover for combined greenline and cross-section. Because cover is estimated for two layers (1m and below, above 1m) total species cover can be a maximum of 200 percent.

Reach cover nativity unknown: Species relative cover with nativity status unknown for combined greenline and cross-section. Because cover is estimated for two layers (1m and below, above 1m) total species cover can be a maximum of 200 percent.

Reach native cover: Native species relative cover for combined greenline and cross-section. Because cover is estimated for two layers (1m and below, above 1m) total species cover can be a maximum of 200 percent.

Reach total cover: Total species relative cover for combined greenline and cross-section. Because cover is estimated for two layers (1m and below, above 1m) total species cover can be a maximum of 200 percent.

Richness alien: Number of non-native species for combined greenline and cross-section.

Richness native: Number of native species for combined greenline and cross-section.

Richness nativity unknown: Number of species with nativity status unknown for combined greenline and cross-section.

Richness total: Total number of species for combined greenline and cross-section.

Stream Channel Characteristics

Average bankfull width from transects: Bankfull widths are measured at each transect. This is the average of the 21-25 transects typically measured at each reach.

Bank angle: Average of all bank angle measurements. Bank angles <45 degrees are summarized as 45 degrees.

Bankfull width-to-depth ratio at riffles: 2001-2008. Average of the bankfull width-to-depth ratios from four channel cross-sections. Cross-sections were measured at the widest location (bankfull width) in the first 4 riffles within straight stream segments. Each ratio was calculated as bankfull width divided by the bankfull depth. Bankfull depth was calculated as the total bankfull area divided by the bankfull width. Some reaches had <4 cross sections if suitable locations could not be found.

Bankfull width-to-depth ratio at transects: $\geq$ 2009. Average of the bankfull width-to-depth ratio from 10 cross sections at / near even numbered transects 2-20. If there were <6 suitable measurements, or water surface was not level ($>0.03\text{cm}$ variance between banks) no value is reported. Each ratio was calculated as bankfull width divided by the bankfull depth. Bankfull depth was calculated as the total bankfull area divided by the bankfull width.

Diameter of the 50th percentile streambed particle: Diameter of the 50th percentile particles. Typically more than 100 particles measured per reach. Bedrock and bank particles are measured but later excluded from the calculation. Sampling methods have changed. Presently, five particles are collected along each transect (2004-present). From 1998-2003, measured particles were gathered within riffle habitat.

Gradient of stream reach: The difference between the elevation of the water surface at the bottom of the reach and the elevation of the water surface at the top of the reach divided by the reach length (measured along the thalweg). The result is multiplied by 100 to express the value as a percent.

Large wood frequency: Number of category 1 large wood pieces measured within the reach and then standardized to per kilometer. Category 1 criteria: length $\geq 1\text{m}$, diameter $\geq 0.1\text{m}$, some portion must be within the bankfull channel and below the bankfull elevation.

Large wood volume: Volume of category 1 large wood pieces measured within the reach and then standardized to per kilometer. Category 1 criteria: length $\geq 1\text{m}$, diameter $\geq 0.1\text{m}$, some portion must be within the bankfull channel and below the bankfull elevation.

Length of sampling reach: Length of sampling reach measured along the thalweg

Number of pools per kilometer: Number of pools within the sampled reach standardized to pools per kilometer.

Percent of bank angles < 90°: Number of transect locations with bank angles <90 degrees divided by the total number of transect bank measurements. The result is multiplied by 100 to express the value as a percent.

Percent pool tail fines: Quantified using a 0.36m x 0.36m grid with 50 intersections. The grid is placed at 3 locations along each pool tail. The percentage of particles <2mm and <6mm is calculated for each grid, averaged for each pool, then averaged for all pools within the reach.

Percent pools: Sum of all qualifying pool lengths divided by the reach length. The result is multiplied by 100 to express the value as a percent.

Percent stable banks: The number of covered stable, uncovered stable, and false bank measurements divided by the total number of measurements. The result is multiplied by 100 to express the value as a percent.

Residual pool depth: Average of the residual pool depth values for all pools in a reach. Residual pool depth is calculated for each qualifying pool by subtracting the pool tail depth from the max depth.

Sinuosity of stream reach: Reach length measured along the thalweg divided by the straight valley length from the bottom of the reach to the top of the reach. Straight valley length is presently determined using UTM coordinates, but was measured using a tape measure <2009.

Wetted width-to-depth ratio at riffles: 2001-2008. Average ratio of wetted width-to-depth ratio from four channel cross-sections. Cross-sections were measured at the widest location (bankfull width) in the first 4 riffles within straight stream segments. Each ratio was calculated as wetted width divided by the wetted depth. Wetted depth was calculated as the total wetted area divided by the wetted width. Some reaches had <4 cross sections if suitable locations could not be found.

Wetted width-to-depth ratio at transects: $\geq$ 2009. Average of the wetted width-to-depth ratio from 10 cross sections at / near even numbered transects 2-20. If there were <6 suitable measurements, or water surface was not level (>0.03 cm variance between banks) no value is reported. Each ratio was calculated as wetted width divided by the wetted depth. Wetted depth was calculated as the total wetted area divided by the wetted width.

Weeds

Common name: Common name of plant species.

Cross-section weed cover (%): The percent cover of the species in the riparian cross-section, 3 to 9.5 m from the greenline, that is on a combined list of noxious weeds, based on Rice (2016), for any of five states (ID, MT, NV, OR, WA) in the study area.

Greenline weed cover (%): The relative cover along the greenline of the species that is on a combined list of noxious weeds, based on Rice (2016), for any of five states (ID, MT, NV, OR, WA) in the study area.

Plant species: Scientific name of plant species.

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