



Upper Columbia Basin Network Stream Channel Characteristics Monitoring Protocol

Narrative Version 1.2

Natural Resource Report NPS/UCBN/NRR—2016/1253





ON THIS PAGE

John Day River, John Day Fossil Beds National Monument, OR.
Photograph courtesy of the National Park Service

ON THE COVER

North Fork Big Hole River, Big Hole National Battlefield, MT.
Photograph courtesy of the National Park Service

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Natural Resource Report NPS/UCBN/NRR—2016/1253

Eric N. Starkey¹; Eric K. Archer²; Gordon Dicus¹; Kathryn M. Irvine, Ph. D.³; Thomas J. Rodhouse⁴,
and Kirk R. Sherrill¹

¹National Park Service
Upper Columbia Basin Network
105 East 2nd St. Suite 5
Moscow, ID 83843

²PIBO Effectiveness Monitoring Program
USDA Forest Service
Fish & Aquatic Ecology Unit
860 North 1200 East
Logan, Utah 84321

³Department of Mathematical Sciences
2-227 Wilson Hall
Montana State University
Bozeman, Montana 59717-2400

⁴National Park Service
Upper Columbia Basin Network
OSU Cascades-Graduate & Research Center
650 SW Columbia St. Suite 7250
Bend, OR 97702

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Change History

Original Version #	Date of Revision	Revised By	Changes	Justification	New Version #
1.0 Draft	March 2011	UCBN	Revision following peer review		1.0
1.0	March 2016	UCBN	Macroinvertebrate sampling techniques/site selection is now covered in this protocol instead of the integrated water quality monitoring protocol. Minor revisions to the data management section to reflect data migration from the PIBO Access database to a UCBN stream database. No changes were made to objectives or techniques	Revisions needed following 5 years of implementation. Integration of macroinvertebrate sampling with stream channel characteristics protocol.	1.2

1. “Version numbers increase incrementally by hundredths (e.g. version 1.01, version 1.02, ...etc) for minor changes. Major revisions should be designated with the next whole number (e.g., version 2.0, 3.0, 4.0 ...). Record the previous version number, date of revision, author of the revision, identify paragraphs and pages where changes are made, and the reason for making the changes along with the new version number.
2. Notify the UCBN Data Manager of any changes to the Protocol Narrative or SOP so that the new version number can be incorporated in the Metadata of the project database.
3. Post new versions on the internet and forward copies to all individuals with a previous version of the Protocol Narrative or SOP.

Note: Standard operating procedures (SOPs) and the United States Forest Service (USFS)-PACFISH/INFISH Biological Opinion Effectiveness Monitoring Program (PIBO) Sampling Protocol for Stream Channel Attributes are published and bound in separate documents (Appendix A and B).

Contents

	Page
Figures.....	vii
Tables.....	ix
Appendices.....	ix
Executive Summary	xi
Acknowledgments.....	xiv
Background and Objectives	1
Rationale for Monitoring Stream Channel Characteristics in the Upper Columbia Basin.....	1
Rationale for Adoption of PIBO Protocol	3
Overview of UCBN Water Resources.....	7
Objectives	14
Thresholds and Trigger Points.....	16
Sampling Design.....	17
Selection of Streams for Monitoring.....	17
Selection of Sample Reaches.....	19
Sampling Frequency.....	19
Sample Timing	20
Target Population	20
Stream Channel Characteristics Power Analysis.....	21
Benthic Macroinvertebrate Power Analysis.....	21
Strengths and Limitations.....	22
Methods.....	23
Field Season Preparations.....	23
Data Collection.....	23
Locating Stream Channel and Additional Macroinvertebrate Sample Reaches.....	24
Within Reach Sample Locations	25
After the Field Season	25
Data Handling, Analysis, and Reporting	27
Overview of Database Design.....	27

Contents (continued)

	Page
PIBO Stream Database	27
UCBN Stream Database	28
Data Analysis of Stream Channel Characteristics	30
Status of Stream Channel Characteristics.....	30
Trend in Stream Channel Characteristics	32
Data Analysis of Macroinvertebrate Data	35
Data Archival Procedures.....	35
Reporting	36
Protocol Testing and Revision.....	36
Personnel Requirements and Training	39
Personnel Requirements	39
Roles and Responsibilities.....	40
Training	41
Quality Assurance and Quality Control	41
Operational Requirements	43
Annual Workload and Schedule	43
Equipment Needs.....	43
Budget	44
Literature Cited	47
List of Acronyms and Abbreviations	53
Glossary of Terms Used by the UCBN I&M Program.....	55

Figures

	Page
Figure E-1. General roles and responsibilities for completion of stream channel monitoring in the UCBN.....	xiii
Figure 1. Conceptual model of the hydrologic, biotic, and geomorphic components and processes of UCBN lotic systems.	3
Figure 2. Distribution of sub-watersheds currently sampled by the PIBO program in relationship to the location of UCBN parks.....	5
Figure 3. Upper Columbia Basin Network parks and Bailey’s Ecoregion Provinces.	7
Figure 4. Streams in BIHO and associated HUCs, illustrating the large watershed area and total stream length outside of the park in comparison to area and stream length within the park.....	11
Figure 5. Streams in CIRO and associated HUCs. The main unit of the park includes the entire watersheds for the streams flowing through it.	12
Figure 6. Stream channel reach selection and co-location of macroinvertebrates with integrated riparian vegetation sampling locations on the John Day River.....	20
Figure 7. “The percent of variance attributed to differences across sites (grey), year effects (hollow), and residual variability (random temporal variability, sampling error, and random error; black) for bank angle, frequency of LWD, percent pool habitat, d50 of surface substrate, percent of pool tails with substrate < 6mm, and residual pool depth at 50 PIBO sites in the Interior Columbia River Basin” (Al-Chokhachy et al. 2010).	22
Figure 8. Member of the PIBO field crew pointing at a permanent reach marker.	24
Figure 9. Close up of reach marker.....	25
Figure 10. UCBN stream database summary queries form, used for QA/QC and reporting purposes.	29
Figure 11. Example of how data for percent stable banks (covered stable and false bank) and percent undercut banks for BIHO could be shown relative to the same parameters across the Columbia Basin.	32
Figure 12. A partial autocorrelation plot for residual pool depth measured for nine years at Site 607 (Salmon River).....	33
Figure 13. Example control chart for residual pool depth measured over nine years in Goat Creek relative to all other PIBO streams.....	34
The upper and lower limits are based on the annual mean ± 1 standard deviation for other streams measured in the same year	34
Figure 14. Example control chart for residual pool depth measured over nine years in Goat Creek relative to other PIBO streams with low gradients.	35
Figure 15. Staff structure for UCBN I&M program (modified from Garrett et al. 2007).	39

Tables

	Page
Table 1. Description of stream channel attributes summarized by PIBO.	6
Table 2. NPS Units in the UCBN. “X” designates what the park was originally established for.	8
Table 3. Percentage of UCBN park area in each land cover type as determined with the National Land Cover Dataset and the National Park Service digital park unit layer.....	9
Table 4. Summary of the number of water resources in UCBN parks.	10
Table 5. List of threats to UCBN water resources.	13
Table 6. Identification of UCBN stream channel monitoring reaches and stream length within the boundaries of each park as identified using NAIP imagery.....	18
Table 7. Proposed revisit design for parks in the UCBN stream channel characteristics monitoring program. “X” represents a revisit.....	18
Table 8. Example summary of parameters reported for stream channel characteristics.....	31
Note that many of the values reported for each reach are averages from multiple transects within a reach.	31
Table 9. Roles and responsibilities for implementing the stream channel characteristics monitoring program in the UCBN	40
Table 10. Annual implementation schedule for stream channel characteristics monitoring.	43
Table 11. The detailed 2010 annual budget for stream channel characteristics monitoring in the UCBN.	45
Table 12. Costs associated with each year across the 3 year revisit design.....	46

Appendices

	Page
Appendix A. Index of Standard Operating Procedures.....	59
Appendix B. Links to Effectiveness Monitoring for Streams and Riparian Areas: Sampling Protocol for Stream Channel Attributes	61
Appendix C. Hydrologic Unit Code Boundaries and PIBO Sample Reaches near UCBN Parks.....	63
Appendix D. Key Contacts within the PIBO-EM Program	71

Executive Summary

The mission of the National Park Service (NPS) 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) consists of nine widely separated NPS units located in western Montana, Idaho, eastern Washington, and central Oregon. One unit of the Nez Perce National Historical Park (NEPE), Bear Paw Battlefield, is actually located outside the network boundary in eastern Montana. This unit and one other park, Big Hole National Battlefield (BIHO), lie outside the Columbia River Basin, although administratively speaking they are part of the network. UCBN parks vary in size from 30 ha (74 ac) to more than 188,197 ha (465,046 ac), and all but two are less than 6,000 ha (14,826 ac). These park units operate with limited budgets and few staff, and are not able to provide personnel and funds for many of the natural resource concerns they face. The resources available at the network level greatly increase their capacity to meet increasingly complex resource management issues. While the parks have been identified as having significant natural resources, the majority were actually established to protect cultural and paleontological resources. The upper Columbia Basin holds a rich and fascinating cultural history, and several UCBN parks provide the nationally significant service of chronicling the pre-contact and contact cultures of the Nez Perce and Cayuse people, early pioneer and mission culture, and the tragic conflicts that arose between them. Two parks also protect and interpret globally significant fossil localities. Most also have some level of natural resource protection language included in enabling legislation or other guidance documents.

Parks of the UCBN include: Big Hole National Battlefield (BIHO), City of Rocks National Reserve (CIRO), Craters of the Moon National Monument and Preserve (CRMO), Hagerman Fossil Beds National Monument (HAFO), John Day Fossil Beds National Monument (JODA), Lake Roosevelt National Recreation Area (LARO), Minidoka Internment National Monument (MIIN), Nez Perce National Historical Park (NEPE), and Whitman Mission National Historic Site (WHMI).

The 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 are a particularly high priority vital sign 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 condition in most UCBN streams has not been directly assessed.

This protocol details the why, where, how, and when of the UCBN's stream channel characteristics monitoring program. As recommended by Oakley et al. (2003), it consists of a protocol narrative and a set of standard operating procedures (SOPs), which detail the steps required to collect, manage, and disseminate the data representing the status and trend of stream channel parameters in the network. These data in combination with other vital signs monitoring, in particular riparian vegetation condition and water quality, will provide a context for the interpretation of status and trends in stream condition. This monitoring protocol is comprised of methods developed by the United States Forest Service (USFS) - PACFISH/INFISH Biological Opinion Effectiveness Monitoring Program (PIBO). The sampling design found in the PIBO Stream Channel Attributes protocol has been extensively evaluated by the PIBO program in a number of publications (Roper et al. 2002, 2010, Archer et al. 2004, Whitacre et al. 2007) and by more than 10 years of field work (Archer et al. 2008). Kershner et al. (2004b) provides a more detailed description of the PIBO objectives, study design, and methods. PIBO also uses a riparian condition protocol that is integrated with stream channel monitoring (Leary and Ebertowski 2010) and the UCBN has adopted this as well (Starkey et al. 2011), thus ensuring a full complement of stream and riparian information will be available for each sampled stream in the UCBN over time.

The UCBN will contract with the USFS PIBO program annually to implement the PIBO stream channel protocol and collect data in UCBN parks. The intent of this protocol is to provide the written documentation required by the Pacific West Region (PWR) and the National Inventory and Monitoring (I&M) Program for NPS protocols. We have incorporated the USFS-PIBO program details and documentation to meet NPS standards. The general roles and responsibilities for completion of stream channel monitoring in the UCBN are shown on the following page and described in more detail in the Roles and Responsibilities section of this document (Figure E-1).

This protocol is a "living" document in the sense that it will be updated as new information acquired through monitoring and evaluation leads to a refinement of program objectives and methodologies. Changes to the protocol are carefully documented in a revision history log. The intent of this protocol is to ensure that a seamless and scientifically credible story about the status and trends in stream channel characteristics can be told to park visitors and managers alike. The next few years of monitoring results are eagerly awaited, as outstanding questions related to site variability, inter-annual variability, and the current stream channel condition can finally be described. From there, the focus will shift toward trend analysis, in which meaningful changes in stream channel characteristics will be detected, and appropriate management strategies can be developed.

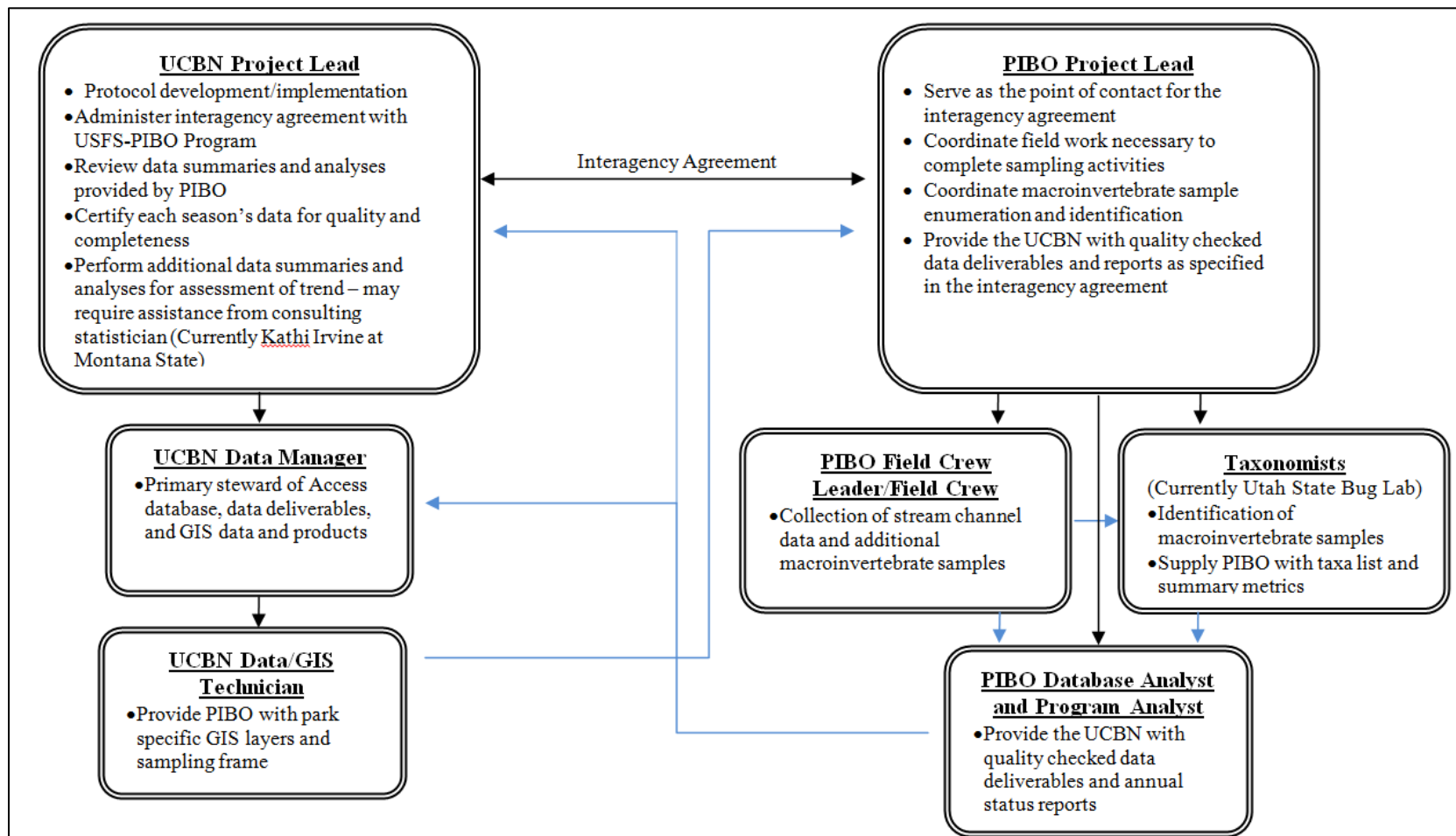


Figure E-1. General roles and responsibilities for completion of stream channel monitoring in the UCBN. Black arrows represent collaboration within and among UCBN and PIBO staff. Blue arrows represent the flow of data and data deliverables.

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 this protocol. Their willingness to collaborate with regional partners will greatly contribute to the understanding of water resources throughout the region.

Background and Objectives

Rationale for Monitoring Stream Channel Characteristics in the Upper Columbia Basin

Stream channel characteristics have been identified as a high priority vital sign 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). In addition, stream channel and bank stability have the potential to considerably affect cultural resources in or near riparian areas.

Water resources and habitats are used by many riparian, migratory, and terrestrial organisms in the network, and water resources have intrinsic value as places of natural beauty and recreation (Garrett et al. 2007). Freshwater habitats are diverse and productive ecosystems, providing habitat for aquatic plant, invertebrate, and vertebrate species including many fishes and birds. Rivers and streams, and thereby stream channels, are intimately connected to riparian zones, providing habitat for many specialist species. Additionally, most upland animals rely on aquatic habitats to one degree or another.

Water resources, including channel characteristics, in the semi-arid west have been strongly affected by human activity (Elmore and Kauffman 1994). Streams within the UCBN are of no exception and are listed by states as impaired for one or more parameters. 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, and provide insight into ecosystem change in a landscape with changing climate and dynamic human influences.

During the UCBN vital signs selection process in 2005, stream channel characteristics was identified as a high priority vital sign (Garrett et al. 2007). When asked what aspects of channel characteristics were important to monitor, resource managers identified channel and bank stability within UCBN streams as the top monitoring priority. Secondary priorities included baseline measures of sinuosity, gradient, width to depth ratios, bankfull depth, substrate composition, and substrate embeddedness. The UCBN chose to develop a separate monitoring protocol for stream channel characteristics and riparian condition due to the distinct nature of each vital sign. Despite separate protocols, the implementation and sample frame for stream channel characteristics will be integrated with both riparian vegetation and water quality monitoring protocols. The decision to have separate protocols promotes efficiency in the preparation of written reports, while allowing fieldwork to be conducted simultaneously with other monitoring activities.

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 an important aspect of natural resource monitoring in the UCBN.

Figure 1 is a conceptual model that illustrates the primary rationale for monitoring stream channel characteristics (channel morphology) in UCBN parks. This model emphasizes the “open” and three-dimensional nature of aquatic ecosystems which are influenced from upland and riparian inputs and watershed-scale drivers. The largest-scale drivers are global or regional drivers acting on entire watersheds such as precipitation, climate regime (e.g., Pacific Decadal Oscillation, El Niño Southern Oscillation [Beebee and Manga 2004]), underlying geology and topography, and large-scale disturbances including large-scale fires (Rieman et al. 2003). Global and landscape stressors include human-induced climate change, non-local pollution sources (e.g., atmospheric nitrogen deposition), alterations to hydrologic regimes through damming and irrigation withdrawals, and broad-scale cultural policies affecting water quality and fisheries policy (NRC 1996, Rahel 1997, Poff et al. 2003, Postel and Richter 2003).

Within individual drainage basins, upland land cover/land use, and cultural landscapes strongly affect aquatic ecosystems and communities by influencing hydrology, physical habitat, and nutrient, sediment, and toxicant inputs (Thompson and Lee 2000, Kershner et al. 2004a, Allan 2004). Many effects of upland habitat alteration and degradation are mediated (and “buffered”) by riparian areas and wetlands because these areas strongly affect the magnitude and timing of inputs to surface water habitats (Naiman and Bilby 1998, McKinstry et al. 2004). For instance, riparian condition strongly affects aquatic physical habitat characteristics including light availability, temperature, channel form, sediment regimes, and substrate composition (Naiman and Bilby 1998, McKinstry et al. 2004).

Figure 1 highlights the challenge of managing aquatic resources due to influences from multiple spatial scales, and the need for regional cooperation in such management efforts.

Well-articulated desired future condition statements have not yet been developed for stream channel characteristics 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 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 we will be directly measuring attributes important to park mission, visitor experience, and desired future conditions.

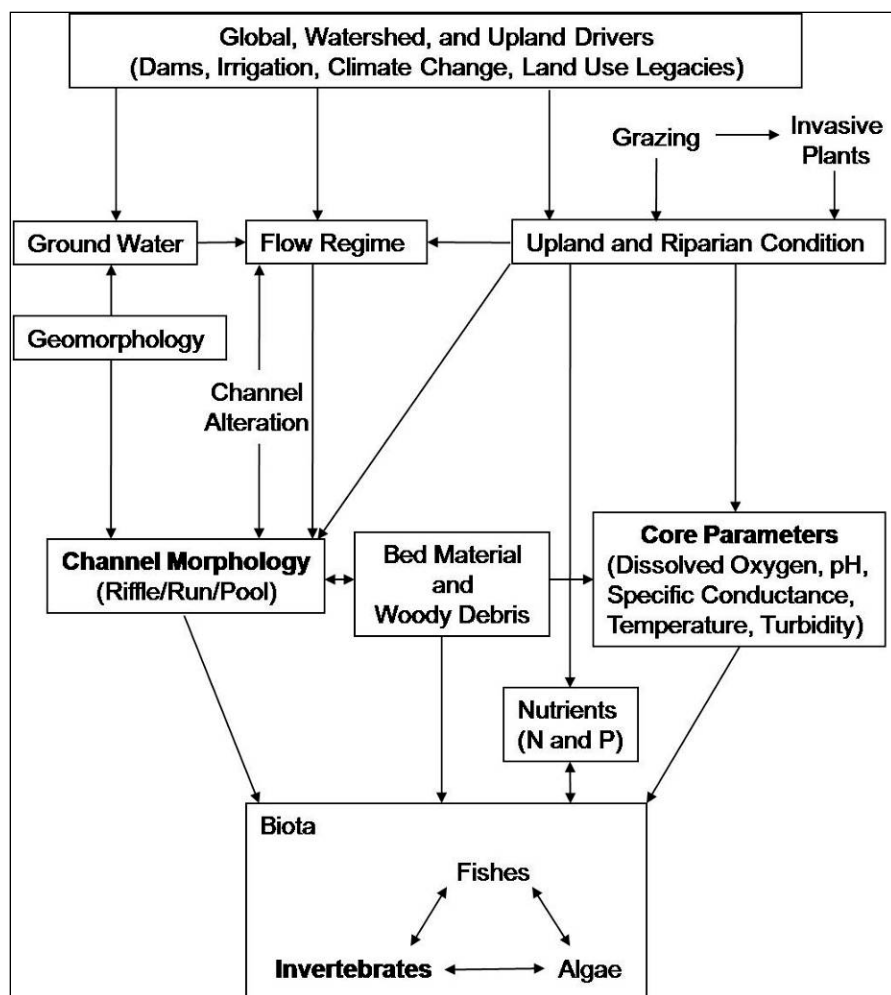


Figure 1. Conceptual model of the hydrologic, biotic, and geomorphic components and processes of UCBN lotic systems.

Rationale for Adoption of PIBO Protocol

The UCBN stream channel monitoring protocol mirrors an existing monitoring protocol developed by the United States Forest Service (USFS) PACFISH/INFISH Effectiveness Monitoring (PIBO-EM) Program (Heitke et al. 2008). In addition to the use of an existing protocol, the UCBN has formed an interagency agreement with the USFS such that the PIBO program will collect the data necessary to complete stream channel monitoring in the UCBN. The use of an existing tested protocol and trained field crew will promote 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 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. (2004b) and Henderson et al. (2005).

The original sampling design, developed by PIBO-EM established in 1998 was intended to address monitoring needs for bull trout and steelhead recovery efforts. “The program samples within the interior Columbia River basin on lands managed by U.S. Forest Service (FS) Regions 1, 4, and 6 and

the Idaho and Oregon/Washington State Offices of the Bureau of Land Management (BLM) (Heitke et al. 2008).” Figure 2 shows the current distribution of sub watersheds (6th field hydrologic unit code [HUC]) containing PIBO sample reaches. The sampling design and methods described in the PIBO Stream Channel Attributes protocol (Heitke et al. 2008) have been extensively evaluated by the PIBO program in a number of publications (Roper et al. 2002, 2003, 2010, Archer et al. 2004, Olsen et al. 2005, Whitacre et al. 2007) and by more than 10 years of field work. In addition, results from the PIBO program have been used in a wide variety of publications (Kershner et al. 2004a, Roper et al. 2007, Roper et al. 2008, Buffington et al. 2009, Al-Chokhachy et al. 2010a, 2010b, 2011, Hawkins et al. 2010, Kershner and Roper 2010). A detailed description of the PIBO programs approach to monitoring, objectives, study design, and methods is given in Kershner et al. (2004b) and Henderson et al. (2005). A summary of the stream channel attributes measured by PIBO are included in Table 1 (Heitke et al. 2008).

A number of existing stream channel characteristics monitoring methods were considered for use by the UCBN; however, no other protocol met the UCBN monitoring objectives. In addition, the PIBO protocol was the best documented protocol and has been subject to several evaluations (Roper et al. 2002, Archer et al. 2004, Whitacre et al. 2007). Other existing methods we considered include: The Environmental Monitoring and Assessment Program-Surface Waters (EMAP) (Peck et al. 2006), Quantifying Physical Habitat in Wadeable Streams (Kaufmann et al. 1999), River Stability-Field Guide (Rosgen 2008), Applied River Morphology (Rosgen 1996), Rapid Bioassessment Protocols For Use In Streams and Wadeable Rivers (Barbour et al. 1999), and other protocols as summarized in “Physical Stream Assessment- A Review of Selected Protocols for Use in the Clean Water Act Section 404 Program” (Somerville and Pruitt 2004).

The sampling frame, discussed in the sampling design section of this document, emphasizes co-location of water chemistry samples and duplicate frames used in the UCBN riparian vegetation and integrated water quality protocols. This integrated sample frame will allow data from this protocol to be useful in the interpretation of data obtained in other ongoing monitoring efforts.

The PIBO program’s assessment of stream channel condition includes the collection and identification of benthic macroinvertebrates. PIBO’s benthic macroinvertebrate sample methods and analysis are similar to those outlined in the UCBN Integrated Water Quality (IWQ) Protocol v1.0 (Starkey et al. 2008). For this reason, samples collected by the PIBO program will fulfill the requirements of both the stream channel and water quality (v 1.9) protocols (Starkey et al. 2016). In some streams, the number of sample reaches for the assessment of stream channel characteristics fall below the minimum desired samples for macroinvertebrates (6). In these cases and when stream length allows, additional macroinvertebrate samples will be collected by the PIBO program.

It is important to note that the PIBO program also conducts riparian vegetation monitoring (Leary and Ebertowski 2010). This monitoring occurs at the same time as the assessment of stream channel characteristics. As a result, the UCBN will also be adopting PIBO’s approach to riparian monitoring, the details of which are outlined in the UCBN Riparian Condition Monitoring Protocol (Starkey et al. 2011).



PIBO Sampled Sub-Watersheds / UCBN Parks

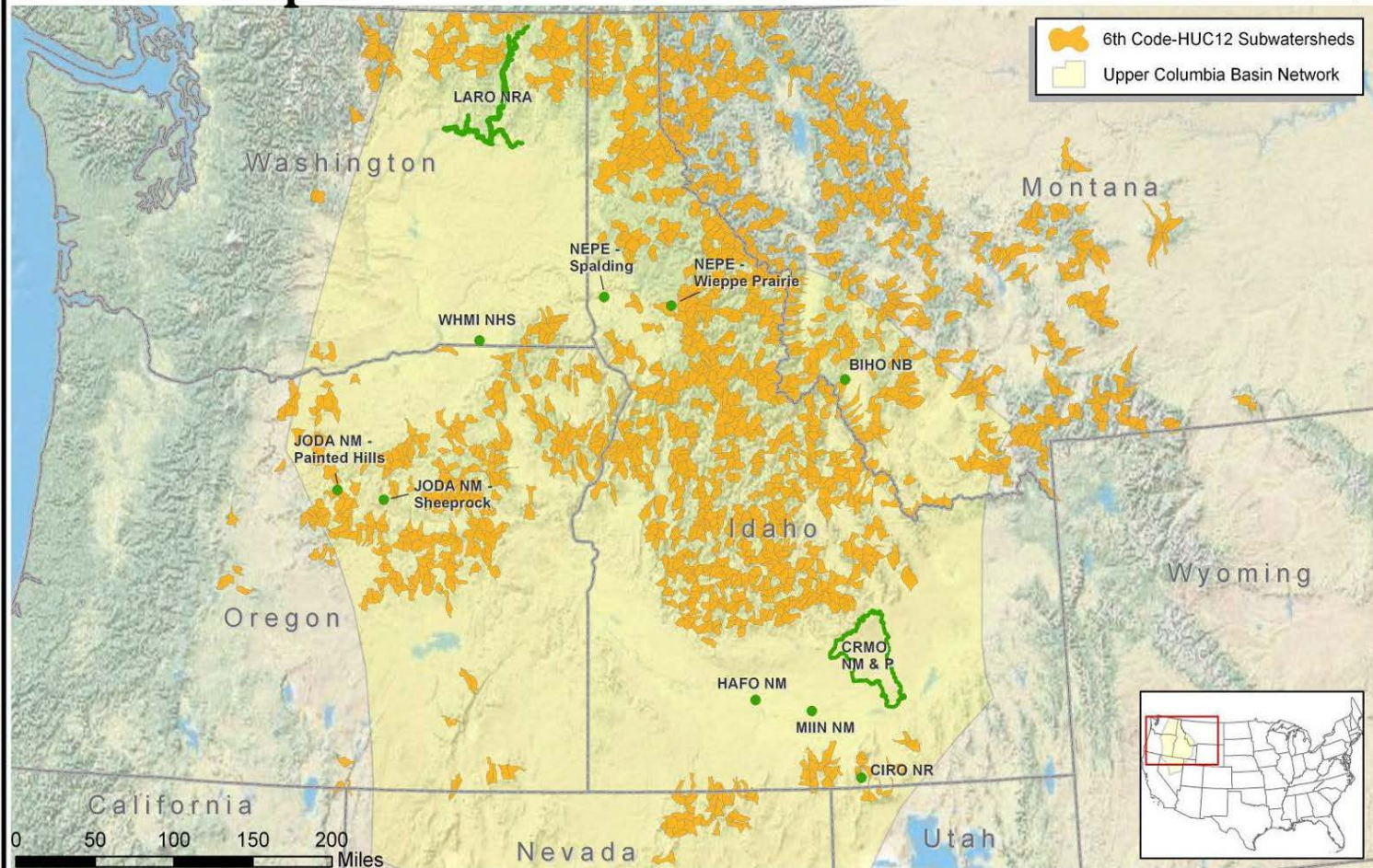


Figure 2. Distribution of sub-watersheds currently sampled by the PIBO program in relationship to the location of UCBN parks.

Table 1. Description of stream channel attributes summarized by PIBO.

Attribute	Description
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.
Length of sampling reach	Length of sampling reach measured along the thalweg
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.
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
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.
Number of pools per kilometer.	Number of pools within the sampled reach standardized to pools per kilometer.
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.
Bankfull width-to-depth ratio at transects	Average of the bankfull width-to-depth ratio from 10 cross sections at / near even numbered transects 2-20.
Wetted width-to-depth ratio at transects	Average of the wetted width-to-depth ratio from 10 cross sections at / near even numbered transects 2-20.
Bankfull width-to-depth ratio at riffles	The average of the bankfull width-to-depth ratios from four channel cross-sections.
Wetted width-to-depth ratio at riffles	Average ratio of wetted width-to-depth ratio from four channel cross-sections.
Diameter of the 16th percentile streambed particle	Typically more than 100 particles measured per reach.
Diameter of the 50th percentile streambed particle	Typically more than 100 particles measured per reach.
Diameter of the 84th percentile streambed particle	Diameter of the 16th, 50th, 84th percentile particles.
Percent pool tail fines < 2mm	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 is calculated for each grid, averaged for each pool, then averaged for all pools within the reach.
Percent pool tail fines < 6mm	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 <6mm is calculated for each grid, averaged for each pool, then averaged for all pools within the reach.
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.
Bank angle	Average of all bank angle measurements. Bank angles <45 degrees are summarized as 45 degrees.
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.

Table 1 (continued). Description of stream channel attributes summarized by PIBO.

Attribute	Description
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.

Overview of UCBN Water Resources

The lands contained in the UCBN are highly diverse. The UCBN is made up of nine widely separated NPS units located in western Montana, Idaho, eastern Washington, and central Oregon (Figure 3). Parks within the network vary in size from 30 hectares to more than 190,000 hectares, and all but two parks are less than 6,000 hectares (Table 2). UCBN park units include a total of over 245,000 hectares of land area, and units are spread over an area spanning 850 kilometers from east to west, 765 kilometers from north to south, and covering 2506 meters of vertical relief.

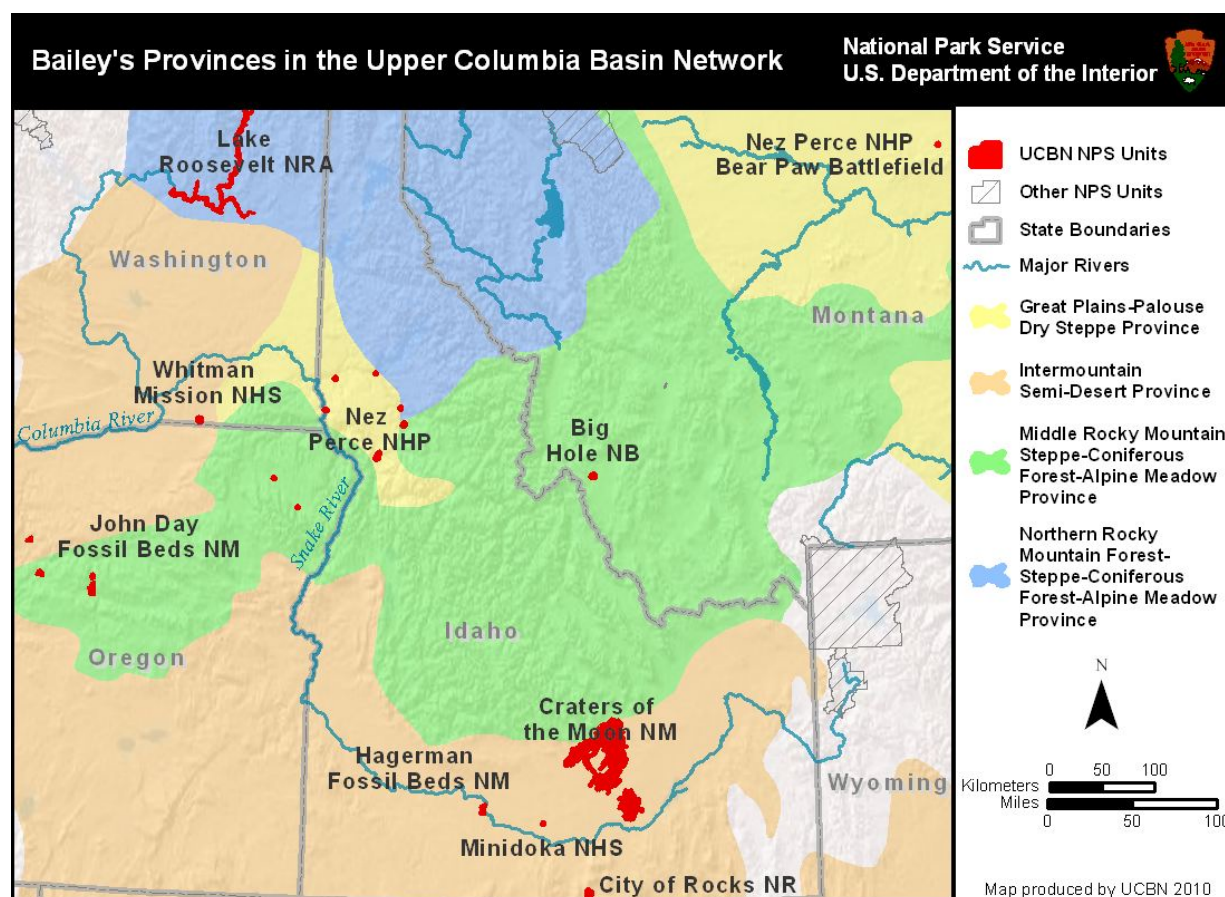


Figure 3. Upper Columbia Basin Network parks and Bailey's Ecoregion Provinces.

Table 2. NPS Units in the UCBN. “X” designates what the park was originally established for.

Park	Park Code	State	Acres	Hectares	Originally Established For		
					Cultural Resources	Natural Resources	Recreation
Big Hole National Battlefield	BIHO	MT	655	265	X	--	--
City Of Rocks National Reserve	CIRO	ID	14,107	5,708	X	X	--
Craters of the Moon National Monument and Preserve	CRMO	ID	469,711	190,081	X	X	--
Hagerman Fossil Beds National Monument	HAFO	ID	4,351	1,760	X	--	--
John Day Fossil Beds National Monument	JODA	OR	14,056	5,688	X	X	--
Lake Roosevelt National Recreation Area	LARO	WA	100,390	40,625	X	--	X
Minidoka Internment National Monument	MIIN	ID	73	30	X	--	--
Nez Perce National Historical Park	NEPE	ID	2,122	858	X	--	--
Whitman Mission National Historic Site	WHMI	WA	98	40	X	--	--

The park units fall in four different ecoregions (Bailey 1995, 1998). Note that one of the units of the Nez Perce National Historical Park (NEPE), Bear Paw Battlefield, is actually located outside of the network boundary in eastern Montana. Neither Bear Paw Battlefield nor Minidoka Internment National Monument (MIIN) contain surface water resources and will not be considered in this protocol. Most network parks lie within the upper Columbia Basin, though Big Hole National Battlefield (BIHO) lies in the upper portion of the Missouri River Basin. While all of the units have been identified as having significant natural resources, the majority of parks were established primarily to protect cultural and paleontological resources (Table 2).

The Columbia Basin is located in a transition-type climate zone and climate patterns are dominated by topographic features (Ferguson 1999, Quigley and Arbelbide 1997). Vegetation type and distribution varies depending on the soils, long-term precipitation patterns, and climate. Climate at park sites is influenced by three distinct air masses: 1) moist, marine air from the west that moderates seasonal temperatures; 2) continental air from the east and south, which is dry and cold in winter and hot with convective storms in summer; and 3) dry, arctic air from the north that brings cold air to the basin in winter and helps to cool the basin in summer (Ferguson 1999).

Winter precipitation (20-40 cm, 8-16 inches) accumulates as snowpack in much of the central Columbia and Snake River Plateaus. The mountain snowpack acts as a natural reservoir, supplies the basin with most of its useable water, and stream hydrographs are dominated by peaks in snowmelt run-off with much lower base flows occurring in late summer, fall, and winter. Summer precipitation

through the basin ranges from 20 cm to 50 cm (8-20 inches). Trends in precipitation over the last 50 to 100 years indicate a general decrease in winter precipitation and an increase in summer precipitation (Davey et al. 2006, Ferguson 1999, Mote et al. 2005).

Temperatures are generally mild in the basin because of the periodic influxes of moderating Pacific moisture. Winter mean monthly temperatures range from -10 to -3°C (-14 to 27°F) and mean monthly summer temperatures ranges from 10 to 15°C (50 to 59°F). Temperature trends in the last 50 to 100 years indicate a slight increase in winter temperatures and slight decrease in summer temperatures (Ferguson 1999). Climate change scenarios identified by the US Global Change Research Program (USGCRP) for the Rocky Mountain/Great Basin region, which includes the UCBN area, are complex but include a reduction in snowpack and an overall aridification of the region, with increased evapotranspiration negating the effects of potential increased summer precipitation (Wagner et al. 2003).

Watershed land use/land cover (LULC) has strong effects on water resources (Allan 2004). Shrubland and grassland/herbaceous habitat are the most extensive vegetation types in the UCBN parks (Table 3). However, forested vegetation is also widespread, especially in the northern portion of the network. Forest types present in the network include ponderosa pine forest, pinyon-juniper woodlands, lodgepole pine forest, aspen communities, isolated stands of Douglas-fir, and limber pine woodland. Small amounts of wetland and riparian vegetation are also present in most UCBN parks.

Table 3. Percentage of UCBN park area in each land cover type as determined with the National Land Cover Dataset and the National Park Service digital park unit layer (NPS boundary).

Land Cover	BIHO	CIRO	CRMO	HAFO	JODA	LARO	MIIN	NEPE	WHMI
Open Water	1%	--	--	1%	1%	75%	--	1%	6%
Urban	--	--	<1%	--	--	1%	--	<1%	--
Bare Rock/Sand/Clay	--	--	81%	<1%	1%	<1%	--	--	--
Transitional	18%	--	--	--	--	<1%	--	4%	<1%
Deciduous Forest	<1%	<1%	--	--	<1%	<1%	--	4%	2%
Evergreen Forest	23%	4%	--	<1%	21%	11%	--	7%	--
Mixed Forest	--	--	--	--	--	<1%	--	<1%	--
Shrubland	3%	71%	18%	53%	68%	6%	45%	17%	3%
Orchards/Vineyards/Other	--	--	--	--	--	<1%	--	--	5%
Grasslands/Herbaceous	32%	23%	1%	41%	5%	4%	29%	51%	83%
Agriculture	--	3%	<1%	5%	5%	1%	26%	16%	--
Woody Wetlands	21%	<1%	<1%	<1%		<1%	<1%	<1%	--
Emergent Herbaceous Wetlands	2%	--	--	--	<1%	<1%	--	<1%	--

Within the boundaries of UCBN parks, aquatic resources represent a very small percentage of total land cover, with the exception of LARO. However, like riparian and wetland vegetation, aquatic environments are disproportionately important in terms of biodiversity, biological productivity, and

many other ecosystem functions and values (Richardson 1994, Kauffman et al. 1997, McKinstry et al. 2004). Lotic (flowing water) environments in the UCBN include large rivers, perennial tributary creeks, irrigation ditches, and numerous seasonal and ephemeral streams, springs, and seeps. Lake Roosevelt, a large run-of-the-river reservoir in the Columbia River, and Lower Salmon Falls Reservoir in the Snake River adjacent to HAFO, function as lotic environments in the upper reaches of the reservoir and lentic (standing or still water) environments near the dams. Other lentic environments in the UCBN include small lakes and ponds, as well as floodplain and depressional wetlands. Table 4 presents the distribution of aquatic environments in the UCBN.

Table 4. Summary of the number of water resources in UCBN parks.

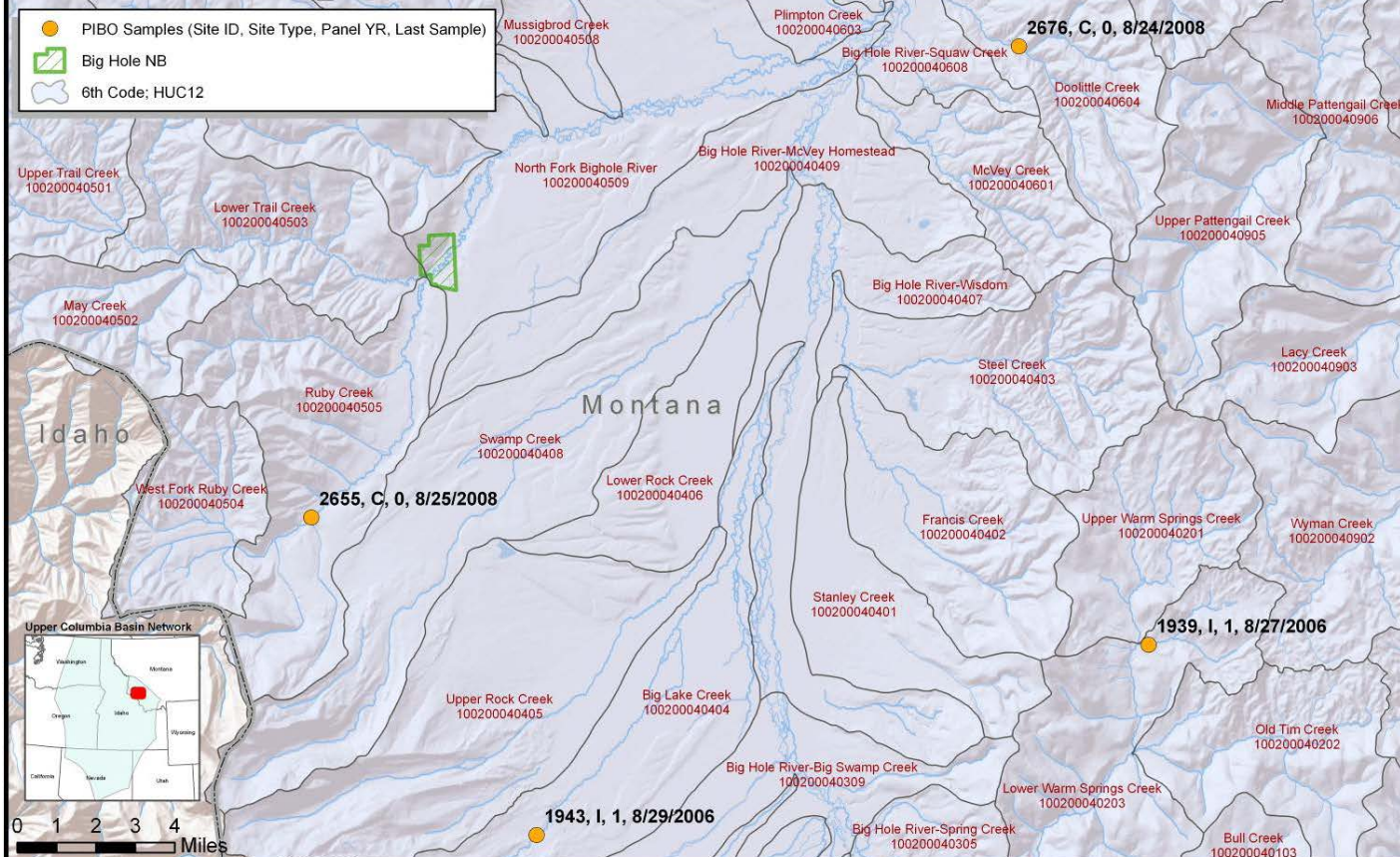
Park	Large Rivers	Small Rivers & Streams	Intermittent Streams	Irrigation Ditches	Ponds	Reservoir	Mapped Springs / Seeps	Unmapped Springs / Seeps
BIHO	--	1	--	2	--	--	--	--
CIRO	--	5	numerous	--	--	--	5	1+
CRMO	--	--	1	--	1+	--	9	numerous
HAFO	1	--	1	1		1	1+	numerous
JODA	1	2	1	2	1	--	8	6
LARO	1	5+	1+	--	--	1	--	--
MIIN	--	--	--	--	--	--	--	--
NEPE	2	2	--	--	1	--	--	--
WHMI	--	2	--	1	1	--	--	--

LULC of the watersheds that contain UCBN park units, likely have strong effects on park channel morphology given the small areas of many park units relative to the watersheds which contain them (Allan 2004). Notably, in contrast to many other parks that fully encompass one or more headwater watersheds, most UCBN parks are a small proportion of the watershed and are situated well downstream from headwaters. The small size of parks and their position within the watershed is illustrated by the example of BIHO shown in Figure 4. Consequently, LULC and other activities in upstream areas outside of park boundaries have the potential to affect water resources and channel morphology within UCBN parks. CRMO and CIRO are exceptions to this rule. For instance, the watershed for Little Cottonwood Creek is fully encompassed by CRMO. Similarly, all or most of the watersheds for streams of the main unit of CIRO (Figure 5) occur within NPS boundaries. Appendix C includes maps of each park in which stream channel monitoring will be implemented and USGS Hydrologic Unit Code (HUC) boundaries.

Most streams within the UCBN are wadeable permanent or ephemeral streams. Currently, there are few or no data regarding channel characteristics for these streams. The UCBN also includes short sections of three large rivers: the John Day River in Oregon (JODA), the Clearwater River in northern Idaho (NEPE), and the Snake River in southern Idaho (HAFO) that have watersheds extending thousands of square kilometers upstream of park units, and have or have had substantial aquatic resource monitoring, though often outside UCBN park boundaries.



PIBO Sample Reaches



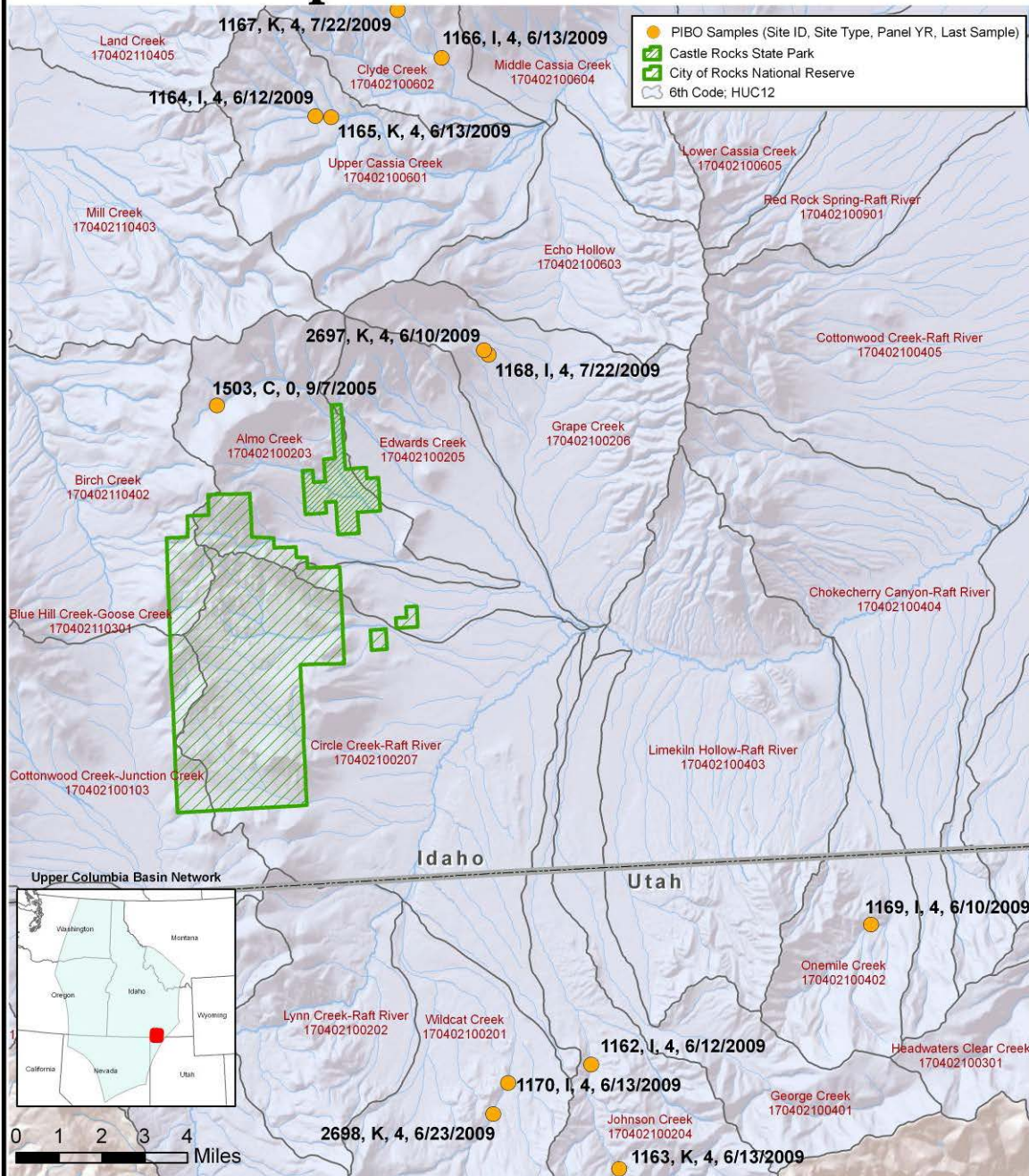
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February 2010

Figure 4. Streams in BIHO and associated HUCs, illustrating the large watershed area and total stream length outside of the park in comparison to area and stream length within the park. Note the existing PIBO sample reaches relative to the location of BIHO (denoted by yellow dots).



PIBO Sample Reaches



Produced by UCBN

February 2010

FILE: Ciro_PIBO.mxd

Figure 5. Streams in CIRO and associated HUCs. The main unit of the park includes the entire watersheds for the streams flowing through it. Note the existing PIBO sample reaches relative to CIRO.

LARO is a unique combination of these two classes because the recreation area includes Lake Roosevelt, a large reservoir on the Columbia River, with most of the watershed located in Canada. LARO also has several smaller tributaries that empty into Lake Roosevelt. Impairments of LARO aquatic resources by upstream inputs have had cascading effects on lake sediments and potential effects on human health that are now being studied by multiple agencies including the Environmental Protection Agency (EPA). A lead-zinc smelter on the Columbia River in Trail, British Columbia operated by Teck Cominco, Inc. and past and current mining activities in the Coeur d'Alene drainage basin are the two largest sources of toxins. Due to the increased monitoring efforts of lake sediments in Lake Roosevelt (e.g., Lee et al. 2006, Riedel 1997) and limited UCBN resources for network-wide water resource monitoring, stream channel monitoring at LARO is not included in this protocol.

Assessments of aquatic resources in the Columbia Basin have shown wide-spread habitat degradation. Habitat degradation, dams, excessive harvest, and introduced non-native gamefish have been implicated in the declining fisheries throughout the basin (National Research Council 1996, Quigley and Arbelbide 1997, Levin et al. 2002), particularly in anadromous (sea-run) fisheries. Extensive grazing caused removal of willow riparian vegetation in many parts of the region as early as 1860 (Elmore and Kauffman 1994). Floodplain irrigation and agriculture altered hydrology and many river and stream channels were straightened and cleaned of wood and other in-stream structures (Quigley and Arbelbide 1997). Beginning in the early 20th century, large dams were constructed along many rivers and streams in the basin for flood control, irrigation, and electricity, resulting in habitat loss, degradation, and altered hydrology. This legacy of habitat alteration is clearly evident in most UCBN aquatic environments. Lake Roosevelt, the Snake River adjacent to HAFO, the Walla Walla River and Mill Creek at WHMI, the Clearwater River adjacent to NEPE, the North Fork Big Hole River at BIHO, and the John Day River at JODA have all experienced significant habitat loss, habitat degradation, and associated declines in native fish populations that have occurred throughout the Columbia Basin (National Research Council 1996, Quigley and Arbelbide 1997).

While there is limited information available on water resources within UCBN parks, no data exist for stream channel characteristics. In 2003, a water quality questionnaire was sent to resource managers in UCBN parks to assess manager's perceptions of the threats to water quality in their parks (Table 5). Results from these surveys indicate not only threats to water quality but also to stream channel characteristics.

Table 5. List of threats to UCBN water resources.

Park	State	Data	Threats to Water Resources
Big Hole National Battlefield (BIHO)	MT	Park data - none Outside sources from 1975	Mining, agriculture, and stormwater runoff
City of Rocks National Reserve (CIRO)	ID	Park – no data since 1985	Ranching and grazing activities; residential development; gas, oil and mining operations; recreational use

Table 5 (continued). List of threats to UCBN water resources.

Park	State	Data	Threats to Water Resources
Craters of the Moon National Monument and Preserve (CRMO)	ID	1999-2003	Pesticide runoff and drift from agricultural lands, as well as weed management activities along state and county roads
Hagerman Fossil Beds National Monument (HAFO)	ID	2003	Irrigation and agricultural activities, altered subsurface hydrology, upstream agricultural and industrial effluent, altered flow regulation
John Day Fossil Beds National Monument (JODA)	OR	2003	Irrigation withdrawals and confined animal feeding upstream, untreated sewage effluent upstream
Lake Roosevelt National Recreation Area (LARO)	WA	2002-2003	Mining, permitted discharges from waste water treatment plants, residential development (septic tanks), and agriculture (grazing and farming), campsite sewage disposal, upstream industrial discharge, altered flow regulation
Minidoka Internment National Monument (MIIN)	ID	No Data	No water resources within the park boundaries
Nez Perce National Historical Park (NEPE)	ID	1975-1994	Point and non-point discharge from upstream sources – Dworshak dam, agriculture, logging, grazing, recreation, highway runoff and urbanization
Whitman Mission National Historic Site (WHMI)	WA	2000-2003	Agricultural chemical use, over allocation of irrigation water, private airfield 3 miles upstream

Objectives

The overarching programmatic goal of the UCBN Stream Channel Characteristics Monitoring Protocol is to obtain information that will aid in informed management and restoration decisions pertaining to stream channels and riparian areas within UCBN parks. The primary objective of current stream channel management in UCBN parks is to prevent extensive changes from that of historic condition and to restore stream channels, if necessary, to maintain a proper functioning system.

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 landuse 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, this protocol will address 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 in BIHO, CIRO, JODA, NEPE, and WHMI.

Justification: *Stream channel attributes have a strong effect on aquatic habitat and adjacent riparian areas. The UCBN currently monitors benthic macroinvertebrates, water chemistry, and riparian vegetation. Therefore, assessment of stream channel characteristics will assist the UCBN and resource managers better interpret results of other monitoring efforts. In addition, status information will assist in current management decisions.*

- 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 in BIHO, CIRO, JODA, NEPE, and WHMI.

Justification: *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. Changes in landuse within or upstream from park units have the potential to alter channel and substrate characteristics. These changes in channel morphology can lead to modified aquatic habitat and subsequently, impact adjacent riparian and upland resources. Understanding long term changes in channel morphology will have direct implications on the management of aquatic and terrestrial resources. In addition, trend data will assist resource managers when determining if stream restoration is necessary.*

- 3) Determine the condition of key stream channel attributes within selected wadeable UCBN stream reaches, relative to PIBO sample reaches in the same watershed.

Justification: *Channel morphology is strongly tied to conditions that exist up and downstream from the park. The ability of resource managers to successfully manage aquatic habitats is directly tied to knowledge of their section of stream relative to the watershed.*

- 4) Determine if changes in stream channels, specifically bank erosion, are likely to negatively impact cultural resources within the floodplain at BIHO.

Justification: *The majority of parks in the UCBN were established primarily to protect cultural and paleontological resources; therefore, it is critical to understand the impact of streambank erosion on areas of special interest within each park. Data on the rate of bank erosion in BIHO will provide resource managers with a means of assessing the potential for degradation of sensitive cultural resources.*

Note that monitoring objectives for benthic macroinvertebrates are outlined in the UCBN integrated water quality monitoring protocol (Starkey et al. 2016).

Given that the UCBN is directly using the PACFISH/INFISH Biological Opinion Effectiveness Monitoring Program (PIBO) protocol for stream channel attributes it is important to note the overarching goal and objectives of the PIBO program.

“The goal of the PACFISH/INFISH Biological Opinion Effectiveness Monitoring Program (PIBO) is to implement a monitoring program, within the PIBO study area (described below), with the capability of determining whether the aquatic conservation strategies within PACFISH and INFISH, or revised land management plans, are effective in maintaining or restoring the structure and function of riparian and aquatic systems” (Roper 1997).

The sampling protocol for stream channel attributes addresses the following objectives:

- 1) “Determine whether a suite of biological and physical attributes, processes, and functions of upland, riparian, and aquatic systems are being degraded, maintained, or restored across the PIBO landscape” (Roper 1997, Kershner et al. 2004b).
- 2) “Determine the direction and rate of change in riparian and aquatic habitats over time as a function of management practices” (Roper 1997, Kershner et al. 2004b).
- 3) “Determine if specific Designated Management Area practices related to livestock grazing are maintaining or restoring riparian vegetation structure and function” (Roper 1997, Kershner et al. 2004b).

All three objectives and the overarching goal of the PIBO-EM program are consistent with the objectives outlined by the UCBN. As a result, the existing protocol developed by this program will serve as the foundation for stream channel monitoring in the UCBN.

Thresholds and Trigger Points

Currently, there are no existing thresholds or trigger points established for stream channel characteristics in the UCBN. This is primarily due to the lack of existing data on current condition. Although data are available on PIBO protocol metrics from other streams in the region, natural and anthropogenically-induced variability among streams is too high to reliably use these data to assign thresholds for UCBN stream reaches. Our approach is to follow recommendations outlined by Bennetts et al. (2007) and incrementally identify and revise assessment points as data in UCBN streams become available through this monitoring partnership with PIBO. We will begin with an ad hoc assessment point of $\pm 25\%$ step change in any of the core attributes identified in Table 1 between year one and two of monitoring. After three years, we will conduct a formal evaluation of the protocol, including a revised power analysis and establish new assessment points. This process will specifically involve participation from UCBN park natural resource managers in order to ensure that new assessment points are relevant to the park management environment.

Sampling Design

The sampling design was developed through a process that involved site reconnaissance and thoughtful consideration of budget and network information requirements. The protocol team consisted of this document's authors, as well as park resource management staff. Careful consideration of PIBO protocol design characteristics was also made.

We note that, while the aim of the sampling design is to provide optimal statistical robustness and scientific rigor, other considerations including personnel safety, fiscal and logistical constraints, and the ability to integrate data with other vital signs must be considered.

As mentioned previously, the PIBO program collects benthic macroinvertebrates as part of its assessment of stream channel characteristics. For this reason, samples collected by the PIBO program will fulfill the requirements of both the UCBN stream channel and water quality protocols. In some streams, the number of sample reaches for the assessment of stream channel characteristics fall below the minimum desired samples for macroinvertebrates (6). In these cases and where stream length will allow, additional macroinvertebrate samples will be collected by the PIBO program (Table 6).

Macroinvertebrates are widely used to infer water quality because macroinvertebrate assemblages are sensitive to changing physical, chemical, and biological conditions over multiple spatial and temporal scales (Barbour et al. 1999; Karr and Chu 1999). In addition, macroinvertebrate biomonitoring in UCBN streams will provide data on the assemblage composition and structure of an important aquatic resource and aid in the detection of non-native species. Collections of macroinvertebrates will be used to infer water quality using well-developed multimetric approaches.

To achieve the measurable objectives, the PIBO program will sample selected UCBN streams, according to their protocol from May-September as indicated in Tables 6 and 7.

Selection of Streams for Monitoring

In general, monitoring locations represent the only or the largest water bodies present within each park (BIHO, CIRO, JODA, NEPE, and WHMI). Prioritization and selection of streams for monitoring were based on:

- preference for wadeable, permanent streams
- preferences and perceived information need from park resource managers
- integration with other monitoring protocols
- known data gaps
- available monitoring resources

Table 6. Identification of UCBN stream channel monitoring reaches and stream length within the boundaries of each park as identified using NAIP imagery.

Park	Stream	USGS HUCS (5 th)	Maximum Length (m) Within Park	Number of Reaches	Number of Additional Macroinvertebrate Reaches**
BIHO	North Fork Big Hole River	10020004	3,389	5	1
CIRO	Almo Creek	17040210	4,545	2	0
CIRO	Main Circle Creek	17040210	1,333	2	0
CIRO	North Fork Circle Creek	17040210	1,294	2	0
CIRO	South Fork Circle Creek	17040210	1,066	2	0
JODA-Painted Hills	Bridge Creek	17070204	6,033	2	0
JODA-Sheeprock	John Day River	17070201, 17070204	10,694	5	1
NEPE-Weippe Prairie	Jim Ford Creek	17060306	1,258	3	0
NEPE-Spalding	Lapwai Creek	17060306	374	1	0
WHMI	Doan Creek	17070102	529	1	0
WHMI	Mill Creek	17070102	151	1	0

**Note that the PIBO program collects benthic macroinvertebrates as part of its assessment of stream channel characteristics. For this reason samples collected by the PIBO program will fulfill the requirements of both the UCBN stream channel and water quality protocols. In some streams, the number of sample reaches for the assessment of stream channel characteristics fall below the minimum desired samples for macroinvertebrates (6). In these cases and where stream length will allow, additional samples will be collected by the PIBO program. At CRMO no stream channel monitoring occurs; however, benthic macroinvertebrates will be collected at a single site on the same revisit design outlined in the water quality monitoring protocol.

Table 7. Proposed revisit design for parks in the UCBN stream channel characteristics monitoring program. "X" represents a revisit.

Panel	Sampling Occasion								
	2016	2017	2018	2019	2020	2021	2022	2023	2024
JODA	X	--	--	X	--	--	X	--	--
NEPE, WHMI	--	X	--	--	X	--	--	X	--
BIHO, CIRO	--	--	X	--	--	X	--	--	X

Selection of Sample Reaches

The number of stream channel characteristic sample reaches per stream (Table 6) was determined by:

- available stream length within each park (many streams cannot accommodate more than 1 sample reach)
- integration with other monitoring protocols
- financial resources

Within each monitored stream, sample reach locations for both channel characteristics and additional benthic macroinvertebrates will be identified using reach selection criteria outlined in Kershner et al. (2004b). These reach selection criteria specify that the preferred sample reaches have “unconstrained valley bottoms with gradients less than 3 percent and have wadeable channels with bankfull widths between 1 and 15 m.” Streams with gradients over 3 percent or with bankfull widths over 15 m will still be sampled; however, the data may not be comparable to other reaches sampled by PIBO.

The location of the first sample reach will be determined by moving upstream from the park boundary until the sample crew identifies the first pool tail (Figure 6). Reach length is a function of the average bankfull width, such that as width increases so does the total reach length, with a minimum reach length of 160 m and a maximum reach length of 480 m. A minimum of 21 transects are sampled within each reach (Figure 6) and the top of the reach “is located at the first pool tail encountered after the 21st transect (Heitke et al. 2008).” Transects will continue to be established until a pool tail is identified or 25 transects have been sampled. A more detailed description of reach and transect establishment can be found in Archer et al. 2012, Heitke et al. (2008), and Kershner et al. (2004b). Pools are clearly defined in the “Pools” section of the PIBO Sampling Protocol for Stream Channel Attributes (Archer et al. 2012). Subsequent sample reaches within the park will be determined by moving upstream from a previous sample reach until another pool tail is identified. It is important to note that these reaches will be re-measured every three years according to Table 7. These sample reaches will be co-located and co-sampled with ongoing riparian and water quality monitoring.

At CRMO where no stream channel characteristic monitoring occurs, the X-Site established under the integrated water quality protocol version 1.0 (Starkey et al. 2008) will serve as the bottom of the reach. Sample procedures at CRMO will follow the PIBO methods outlined below.

Sampling Frequency

Parks will be sampled using a three-year rotating panel design (Table 7). The stream reaches will be permanently marked the first year of sampling as outlined in SOP 4. The proposed revisit design matches that of the Integrated Water Quality and Riparian protocols. As a result, sampling of stream channel characteristics and water quality monitoring will occur in the same years. This design promotes efficient data collection and adds to the interpretation of data gathered by the Integrated Water Quality Protocol. While more frequent samples would be preferred, the UCBN seeks to balance the need for statistical robustness with available financial resources.

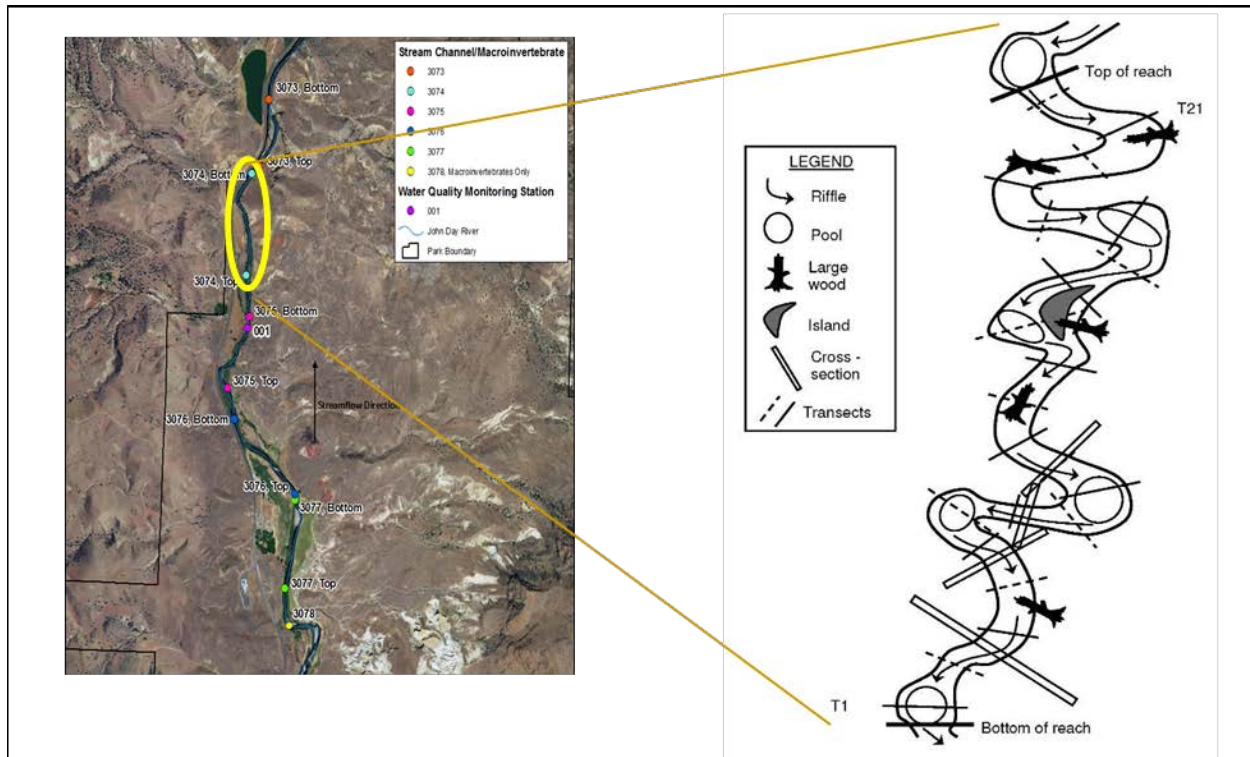


Figure 6. Stream channel reach selection and co-location of macroinvertebrates with integrated riparian vegetation sampling locations on the John Day River. The reach overview indicates the position of the reach relative to pools (directly from the PIBO Sampling Protocol for Stream Channel Attributes Heitke et al. 2008).

Sample Timing

Stream channel monitoring will occur between the months of May and September under base-flow conditions. The timing of sampling will match that of riparian vegetation and integrated water quality monitoring. Ideally, benthic macroinvertebrates will be sampled during the index period recommended by Hayslip (2007) and Montana DEQ (2006). This index period for streams in Idaho, Oregon, and Washington is between July 1st and October 15th and in Montana is between June 21st and September 21st. The major reason for sampling within this index period is that State DEQ offices and the EPA have developed multimetric indices and established reference conditions based on data collected during these time periods. In addition, sampling during these time periods will help ensure data collected by the UCBN is integrated with other regional data sources. It has also been suggested that sampling during this time period is advantageous because benthic macroinvertebrates reach their maximum representation, and the instream environment has stabilized following high spring flows (Hayslip 2006).

Target Population

The target population for stream channel characteristics monitoring is defined as; wadeable streams with permanent water, having less than a 3% gradient and bankfull widths between 1 and 15 m, in unconstrained valley bottoms, sampled between the months of May and September. The sample population may be restricted due to the fact that the PIBO Sampling Protocol for Stream Channel

Attributes has been designed primarily for streams meeting the above criteria (Kershner et al. 2004b). Most streams fall well within the target criteria identified above, with the possible exception of the Circle Creek drainage (CIRO) and the John Day River (JODA). Circle Creek may exceed a 3% gradient while the John Day River may have bankfull widths over 15 m. Streams with gradients over 3 percent or with bankfull widths over 15 m will still be sampled; however, the data may not be comparable to other reaches sampled by PIBO.

Stream Channel Characteristics Power Analysis

Statistical power analyses require information on sample size, effect size, and sample variance (Sokal and Rohlf 1995). The latter is currently unavailable for stream channel parameters and locations within UCBN parks. However, the PIBO program has conducted analysis to determine the minimum sample sizes needed to detect differences among physical variables when accounting for observer variability and stream heterogeneity across multiple streams/watersheds (Archer et al. 2004). Results of this study are not reported here because the power analysis was conducted to assess the ability to detect change at a larger spatial scale than UCBN parks.

Due to the wide range of variables that affect stream channels, it is important for the UCBN to account for local variability when determining power to detect trend. As noted by the PIBO program, (Figure 7) site to site variability for most stream channel attributes is relatively high. As a result, the UCBN lacks the ability to calculate power for an existing PIBO site and have the results be meaningful for monitoring sites selected by the UCBN. After three years of monitoring, the UCBN will conduct a power analysis specific to each selected stream. Figure 7 illustrates that year-to-year variability is a very small proportion of overall variability in stream channel attributes, indicating that power to detect temporal trends within a reach may be relatively high for some attributes. Given this initial assessment that stream channel attributes are likely to be stable under typical environmental conditions and anthropogenic impacts in UCBN parks, we expect that changes of a magnitude relevant to management in both stream channel and riparian condition attributes, when and if they occur, will be readily detected as significant departures from recent trends.

Benthic Macroinvertebrate Power Analysis

Currently, assessing statistical power for macroinvertebrate indices is difficult for UCBN streams because within-site and interannual estimates of variability in macroinvertebrate assemblage structure are not yet available. Available data from regional streams suggests that increasing sample size (e.g., number of replicates/site) decreases variability and improves the probability of detecting uncommon or rare species. For example, in Wyoming streams, increasing the number of samples at each location asymptotically reduces the mean change in taxa richness between samples (Gary Lester, EcoAnalysts, Inc., personal communication). The data from Wyoming suggests that six replicates per stream will provide a reasonable trade-off between cost and power. After the first rotation of sampling, the sampling design for macroinvertebrates will be revisited to estimate power using estimates of variability obtained from the first samples. In particular the evaluation will examine whether it is reasonable to reduce the number of replicates per stream and use these sample resources to increase the spatial extent (add more streams) or temporal frequency of macroinvertebrate sampling (e.g., move to a 2 year rotating panel).

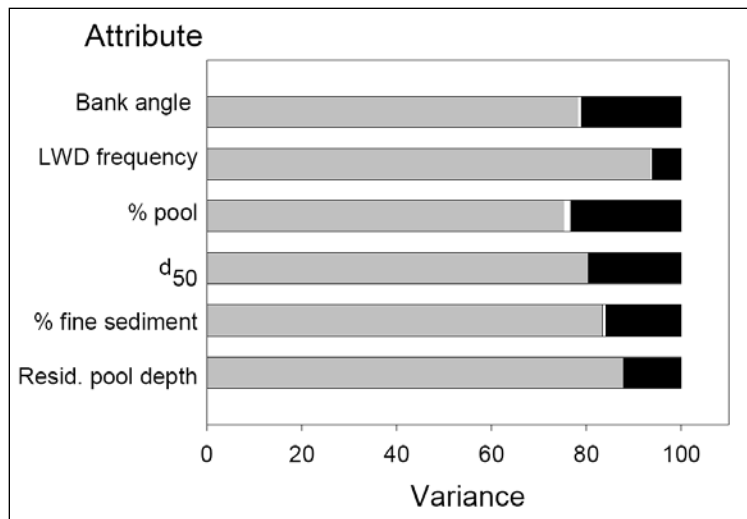


Figure 7. “The percent of variance attributed to differences across sites (grey), year effects (hollow), and residual variability (random temporal variability, sampling error, and random error; black) for bank angle, frequency of LWD, percent pool habitat, d₅₀ of surface substrate, percent of pool tails with substrate < 6mm, and residual pool depth at 50 PIBO sites in the Interior Columbia River Basin” (Al-Chokhachy et al. 2010).

Strengths and Limitations

The selected approach provides several benefits to the UCBN, park resource managers, and regional stakeholders. The design will provide long term data on status and trends in stream channel characteristics within UCBN parks. In addition, due to the integration of our approach with existing regional monitoring efforts, park resources can be assessed relative to regional trends in channel condition. Cross agency cooperation will bolster regional natural resource management due to the use of comparable/quality data.

The data will assist in the assessment of management actions aimed at improving streams within UCBN park and watershed boundaries. The collection of macroinvertebrate assemblage samples over long periods will provide a valuable record of biotic responses to changes in water quality, human impacts, and changing climatic conditions using standardized and accepted protocols. The macroinvertebrate samples will also inventory an important biological resource for which little data are currently available. The design will provide a representative picture of status and trend in the small and medium sized streams and rivers within the UCBN.

Overall, the UCBN stream channel characteristics monitoring protocol will provide a well-documented baseline of background conditions given the modest level of funding available to conduct stream channel monitoring. Detection of concerning trends will help the network and affected parks pursue additional funding and resources to address emerging problems through targeted research.

Methods

Field Season Preparations

The UCBN has entered into an interagency agreement with the USFS PIBO program for the purpose of data collection of stream channel characteristic attributes at 5-15 NPS sites per year. Annual development and obligation of funds towards this agreement will occur between January and March each year. For planning purposes and to aid the contracting officer, this agreement should be approved no later than March each year.

The documents necessary for completion of this agreement are:

- 1) Individual Acquisition Plan (IAP) completed on the PWR SharePoint site
- 2) Detailed scope of work (SOW)
- 3) Purchase Request (PR) form

Other useful supporting documentation is:

- 1) Government estimate
- 2) Determinations and findings form

Procedures for completing these documents and required information are outlined in SOP 1.

Examples of each document listed above can be found in Appendix 7 of the SOPs.

In the first year of monitoring each stream, the UCBN will identify sample reaches using an approach similar to that used by the PIBO program. The location of the first sample reach within each park will be determined by moving upstream from the park boundary until the sample crew identifies the first pool tail. Subsequent sample reaches within the park will be determined by moving upstream from a previous sample reach until another pool tail is identified. To assist PIBO field crews, the UCBN will provide GIS spatial data layers containing the park boundaries prior to the start of field work. It is important to note that after the first sample rotation, each reach will be re-sampled according to the rotating panel design (sample reaches will become fixed). Existing sample location waypoints can be found in Appendix 12 of the Stream Channel Characteristics SOP document.

The UCBN aquatic biologist will be responsible for assuring that PIBO field crews have obtained the necessary annual park collection permits. Equipment lists and PIBO protocol specific pre-field season procedures are outlined in the PIBO Sampling Protocol for Stream Channel Attributes (Archer et al. 2012).

Data Collection

All data collection will be conducted by the USFS PIBO Program in accordance with the PIBO Sampling Protocol for Stream Channel Attributes (Archer et al. 2012 and Heitke et al. 2008). These protocols are available from the PIBO website (<http://www.fs.fed.us/biology/fishecology/emp/> Accessed 20 January 2010).

Locating Stream Channel and Additional Macroinvertebrate Sample Reaches

Sample reach selection will differ 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 this boundary restriction, the location of the first sample reach will be determined by the field crew moving upstream from the park boundary until the first pool tail is identified (Figure 6). Subsequent sample reaches within the park will be determined by moving upstream from a previous sample reach until another pool tail is identified. Pools are clearly defined in the “Pools” section of the PIBO Sampling Protocol for Stream Channel Attributes (Archer et al. 2012 and Heitke, et al. 2008). Additional benthic macroinvertebrate sample locations will be identified in the same manner and should fall above the most upstream stream channel sample reach. The top and bottom of each sample reach will be permanently marked using a 1 inch by 3 inch piece of aluminum with PIBO EM scratched into them (Figures 8 and 9). The top of the reach will be labeled as TR for Top Reach and the bottom of the reach as BR for Bottom Reach. In subsequent years, during sample reach revisits, field crews will navigate back to the same sample reach using a reach description, photographs, topographic map and UTM coordinates.



Figure 8. Member of the PIBO field crew pointing at a permanent reach marker.



Figure 9. Close up of reach marker.

Within Reach Sample Locations

Stream channel characteristics

Reach length is a function of the average bankfull width, such that as width increases so does the total reach length, with a minimum reach length of 160 m and a maximum reach length of 480 m. A minimum of 21 transects are sampled within each reach (Figure 6) and the top of the reach “is located at the first pool tail encountered after the 21st transect (Heitke et al. 2008).” Transects will continue to be established until a pool tail is identified or 25 transects have been sampled.

Benthic macroinvertebrates

Within each sample reach, 2 macroinvertebrate samples will be collected using a fixed area design (0.72 m²) 500 µm mesh net from the each of the first 4 fast-water habitats (riffles/runs) (n=8) upstream from the bottom of the reach. The exact sample locations within the fast-water habitat will be determined using random numbers. All 8 samples will be combined into a single composite sample for the entire reach. Methods may differ slightly when special situations, such as beaver dams and partial flow exist. These “special situations” are covered in Archer et al. 2012.

After the Field Season

Post field season activities will include the review of summarized data, reports, and macroinvertebrate identification provided by the PIBO Program. After these deliverables have been reviewed, season closeout and certification procedures, as outlined in the data management SOP 7, will be followed.

Data Handling, Analysis, and Reporting

While the following section outlines procedures for stream channel characteristics data handling, analysis, and report development, additional details and context for this section may be found in the UCBN Data Management Plan (Dicus and Garrett 2007), which describes the overall data management strategy for the network. The UCBN monitoring plan also provides a good overview of the network's data management and reporting plan (Garrett et. al. 2007).

Overview of Database Design

As highlighted elsewhere, the PIBO program will conduct the stream channel characteristics data collection, and will enter the data into the PIBO stream database as well as perform PIBO standardized quality assurance and quality control procedures. The PIBO program will provide the quality-certified PIBO stream database to the UCBN as an annual data deliverable. Once this database has been received and checked by the UCBN, a subset of the data associated with UCBN macroinvertebrate and stream channel monitoring sites will be migrated into a "UCBN stream database." Migration of PIBO data to the UCBN stream database is performed to facilitate long-term archival of the monitoring data and to support data storage in a format conducive for quality control and reporting processes. Each database is discussed independently below.

PIBO Stream Database

The PIBO stream database is a Microsoft Access database that houses multi-year data from all locations sampled by the PIBO program. This database consists of backend tables populated with QA/QC checked data following field work. Details of the database, including a description of core and lookup tables and a logical model of table relationships, are presented in the Data Management SOP 7.

Data Entry

The PIBO program uses a two-step process for entering their stream channel characteristics and macroinvertebrate data. The first step is entering the data into a Microsoft Access database designed to hold the raw data and to facilitate quality review checks on that raw data. Specific procedures for entering and checking this raw data are outlined in PIBO's Stream Raw Data Checks SOP (SOP Appendix 2). The second step involves consolidation of the raw data into more meaningful data summaries, which are then migrated to the PIBO Stream database where additional quality review checks are carried out. Specific procedures for data migration and data quality review within the PIBO Stream database are outlined in PIBO's Summarized Stream Data QA SOP (SOP Appendix 3).

Data Quality Control/Quality Assurance

The PIBO program conducts quality assurance and quality control (QA/QC) procedures on their data before and after they are entered in a database (SOP Appendix 2 and 3). These QA/QC checks ensure the UCBN is receiving quality data deliverables. In addition to these checks, the UCBN project lead will review all data from the PIBO program for quality, completeness, and logical consistency. The UCBN project lead will work with PIBO to remedy any problems and document fixes. If all errors and inconsistencies cannot be fixed, the resulting errors will be documented and included in the metadata and certification report.

Metadata Procedures

The UCBN will request that metadata be provided with the PIBO stream database when it is delivered annually to the UCBN. However, final metadata will be produced by the UCBN for the compiled multi-year UCBN stream database (see below).

Sensitive Information

Part of metadata development includes determining whether or not the data include any sensitive information, which includes specific locations of rare, threatened, or endangered species. Prior to completing metadata, the Project Leader and Park Resource Manager should work together to identify any sensitive information in the data. Their findings should be documented and communicated to the Data Manager. We do not anticipate that sensitive information will be present in the stream channel characteristics monitoring program at this time.

Data Certification and Delivery

Data certification is a benchmark in the project information management process that indicates that 1) the data are complete for the period of record; 2) they have undergone and passed the quality assurance checks; and 3) that they are appropriately documented and in a condition for archiving, posting, and distribution. Certification is not intended to imply that the data are completely free of errors or inconsistencies which may not have been detected during quality assurance reviews.

Delivery of a PIBO database to the UCBN represents a preliminary “certification” by the PIBO program that the dataset is complete and that all of their raw data checks (SOP Appendix 2) and summarized data QA procedures (SOP Appendix 3) have been completed. The UCBN then completes final data certification for all tabular and spatial data. The UCBN Project Leader is primarily responsible for completing final certification, but works closely with the UCBN Data Manager. The completed form (SOP Appendix 6), certified data, and updated metadata should be delivered to the Data Manager according to the timeline in Table 9 in the Operational Requirements section. Additional details of the certification and delivery processes are included in SOP #7. Final certification of data will occur, led by the UCBN Project Leader, prior to migration of data into the UCBN stream database.

UCBN Stream Database

The UCBN Stream database is a Microsoft Access database that is consistent with NPS I&M Natural Resource Database Template version 3.2 and UCBN standards (NPS 2007). This database houses multiple years of stream channel and macroinvertebrate data collected at selected UCBN streams. It consists of a customized front-end that links to the UCBN stream database backend in order to allow users to produce summaries for selected stream channel metrics (Figure 10). Details of the database, including a description of core and lookup tables and a logical model of table relationships, are presented in the Data Management SOP 7.

Figure 10. UCBN stream database summary queries form, used for QA/QC and reporting purposes.

Data Migration

Following review of the stream database submitted by PIBO, the macroinvertebrate and stream channel monitoring site data will be migrated into the UCBN stream database. Migration of PIBO data to the UCBN stream database is performed to facilitate long-term archival of the monitoring data and to support data storage in a format conducive for quality control and reporting processes. Procedures for data migration are outlined in the Data Management SOP 7

Data Quality Review

Post data migration, all records will be reviewed and cross checked with the original QA/QC'd data in the PIBO stream database. This quality review ensures that all UCBN macroinvertebrate and stream channel monitoring site data was migrated completely and accurately.

Metadata Procedures

Data documentation is a critical step toward ensuring that datasets are useable for their intended purposes well into the future. This involves the development of metadata, which can be defined as structured information about the content, quality, and condition of data. Additionally, metadata provides the means to catalog datasets within intranet and internet systems, making data available to a broad range of potential users. Metadata for all UCBN monitoring data will conform to Federal Geographic Data Committee (FGDC) and NPS guidelines and will contain all components of supporting information such that the data may be confidently manipulated, analyzed, and synthesized. For long-term projects such as this one, metadata creation is the most time consuming the first time it is developed – after which most information remains static from one year to the next. Metadata records in subsequent years then only need to be updated to reflect current publications, references, taxonomic conventions, contact information, data disposition and quality, and to describe any changes in collection methods, analysis approaches or quality assurance for the project.

Specific procedures for metadata development and posting are outlined in the UCBN Data Management Plan. In general, the Project Leader and the Data Manager (or Data Technician) will work together to create and update an FGDC- and NPS-compliant metadata record in XML format. The Project Leader will update the metadata content as changes to the protocol are made, and each year as additional data are accumulated. Protocol revisions should be tracked so that any changes are obvious to those who will use it to update the XML metadata file. At the conclusion of the field season, the Project Leader will be responsible for providing a completed, up-to-date metadata questionnaire form to the Data Manager. The Data Manager will facilitate metadata development by creating and parsing metadata records, and by posting such records to national clearinghouses as described below.

Sensitive Information

Part of metadata development includes determining whether or not the data include any sensitive information, which includes specific locations of rare, threatened, or endangered species. Prior to completing metadata, the Project Leader and Park Resource Manager should work together to identify any sensitive information in the data. Their findings should be documented and communicated to the Data Manager. We do not anticipate that sensitive information will be present in the stream channel characteristics monitoring program at this time.

Data Certification and Delivery

Only certified data from the PIBO program (see above) will be migrated into the UCBN stream database.

Data Analysis of Stream Channel Characteristics

Stream channel data will be used to examine status, variability, and eventually trend in core stream channel parameters. Once data have been acquired and quality checked, the PIBO program will generate summary tables with descriptive statistics using automated scripts that will ensure quality control of the analysis. Basic summary analyses will be performed using Microsoft Access software, and additional analyses will be conducted in other stand-alone environments such as the R statistical language and environment (<http://www.r-project.org/>). In addition, summary tables may be created using in the UCBN stream database summary queries form.

Status of Stream Channel Characteristics

The annual status of bank stability, percent undercut, bank angle, percent fines, and other key stream channel characteristics will be reported for each reach and stream in a tabular form similar to the format in Table 8. A more detailed stream habitat summary will be provided by the PIBO program in the form of a Microsoft Excel file.

Table 8. Example summary of parameters reported for stream channel characteristics. Note that many of the values reported for each reach are averages from multiple transects within a reach.

Parameter (Units)	Reach			Mean	Standard Deviation
	1	2	3		
Average bankfull width from riffles (m)	6.91	7.25	6.10	6.75	0.59
Average bankfull width from transects (m)	5.23	6.83	5.58	5.88	0.84
Length of the reach (m)	127.50	178.90	187.60	164.67	32.48
Gradient of stream reach (%)	0.71	0.95	0.91	0.86	0.12
Sinuosity of stream reach (ratio)	1.32	1.58	1.68	1.52	0.19
Residual pool depth (m)	0.44	0.44	0.42	0.43	0.01
Number of pools per kilometer.(# / km)	47.06	44.72	47.97	46.58	1.68
Percent pools (%)	52.24	54.00	58.48	54.91	3.22
Bankfull width to depth ratio at riffles (ratio)	34.42	23.32	27.32	28.35	5.62
Wetted width to depth ratio at riffles (ratio)	47.07	44.31	54.52	48.63	5.28
D16 (m)	0.004	0.008	0.002	0.005	0.003
D50 (m)	0.038	0.036	0.030	0.035	0.004
D84 (m)	0.077	0.075	0.082	0.078	0.004
Percent pool tail fines < 2mm (%)	3.22	2.17	6.50	3.96	2.26
Percent pool tail fines < 6mm (%)	24.75	5.67	13.17	14.53	9.61
Bank angle (degrees)	124.00	101.00	102.00	109.00	13.00
Percent stable banks (covered stable and false bank)	40.48	36.36	52.17	43.00	8.20
Percent stable banks (covered stable, false bank, and uncovered stable). (%)	95.24	95.45	100.00	96.90	2.69
Average undercut depth (m)	0.04	0.06	0.06	0.05	0.01
Percent undercut banks (%)	21.95	31.25	21.62	24.94	5.47
Percent of bank angles < 90 (%)o	21.95	37.50	29.73	29.73	7.78
Large wood frequency (pieces / km)	219.60	106.20	250.50	192.10	75.98
Large wood volume (m3 / km)	24.05	12.07	18.67	18.26	6.00

In addition to tabular summaries, plots of stream channel characteristics relative to existing PIBO reaches sampled in the same year will quickly convey status and a regional comparison (Figure 11). The ability to compare UCBN streams to those elsewhere in the region is one of the strengths of using existing PIBO methods. Figure 11 provides an example of how data will be shown for percent stable banks (covered stable and false bank) and percent undercut banks for BIHO. Data from individual reaches and transects within a stream will highlight areas of particular concern relative to cultural resources. If results indicate areas of stream channel degradation that might threaten cultural resources, the UCBN will work with park natural resource managers to identify causes, solutions, and/or more specific research needs.

Annual reports will include short narratives highlighting conditions that are of concern, other major results and recommendations for future monitoring.

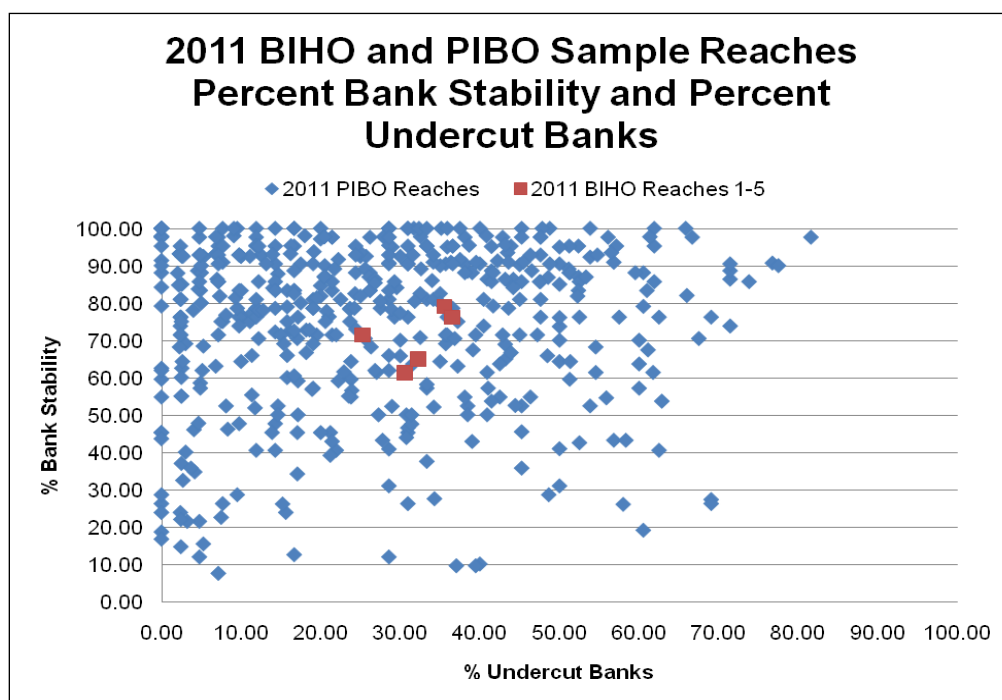


Figure 11. Example of how data for percent stable banks (covered stable and false bank) and percent undercut banks for BIHO could be shown relative to the same parameters across the Columbia Basin.

Trend in Stream Channel Characteristics

Assessment of Trend - UCBN Stream Scale:

Assessment of trend at the stream-scale will be evaluated using non-parametric methods for trend detection. Due to the high stream-to-stream variability (Figure 7), we are interested in the annual trends over time for a particular stream within the UCBN. Also, for many of the park units there is only one stream within the target population. For each stream, a fixed number of reaches will be surveyed once every three years (see Tables 5 and 6). For those streams with only 1 reach sampled, the standard nonparametric Mann Kendall test for monotonic trend will be used for trend detection. This test is commonly used in the water quality literature for sampling schemes with only one site sampled over time and is appropriate for estimating trends in stream channel characteristics as well (e.g., Helsel and Hirsch 2002). This test is preferred because of the tendency of stream channel parameters to be inconsistent with the assumptions of simple linear regression (i.e., normality, linearity, independence). A more detailed description of the Mann Kendall test and R code is given in the Data Analysis and Reporting SOP # 9.

The Mann Kendall test p-value will be adjusted if there is evidence of autocorrelation, common in time series data (Helsel and Hirsch 2002). An exploratory technique to investigate autocorrelation in time series data is the partial autocorrelation function. The partial autocorrelation measures the degree of linear association between the observations for a given lag after accounting for correlation

at all previous lags. Figure 12 displays an example partial autocorrelation plot indicating no evidence of autocorrelation from pilot data provided by the PIBO program for a single sample reach. If the vertical line exceeds the horizontal dashed lines, this suggests evidence of correlation at that particular lag. For the R function to adjust the p-value for autocorrelation see the Data Analysis and Reporting SOP # 9.

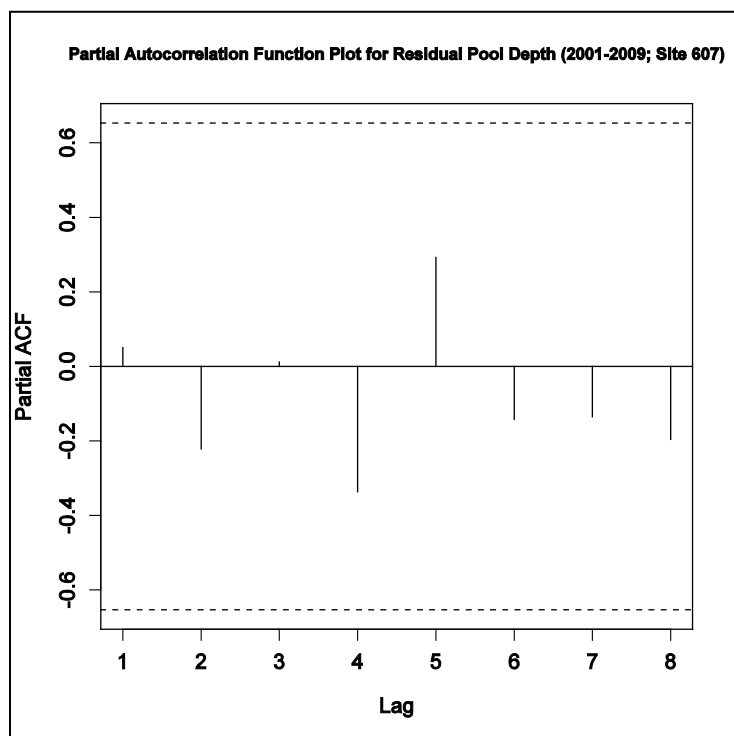


Figure 12. A partial autocorrelation plot for residual pool depth measured for nine years at Site 607 (Salmon River). This plot suggests there is no evidence of autocorrelation for any lag.

For streams with multiple reaches surveyed each year, we are interested in a stream-wide assessment of trend. The Kendall statistic will still be used to quantify monotonic trend, but the statistic will be calculated for each reach separately, and a test of homogeneity of trends among reaches can be used (as in van Belle and Hughes 1984).

Assessment of Trend - Relative to Regional Condition:

To assess the trends over time observed in UCBN streams in the context of the entire PIBO program, a control chart approach will be used (Morrison 2008). There are two ways to consider the stream channel characteristics trends in UCBN compared to the greater region measured by PIBO. The first is to consider each UCBN stream relative to all other streams sampled by PIBO. Figure 13 displays an example for Goat Creek measured for nine years relative to all other streams sampled in the same year. The limits are based on the annual mean ± 1 standard deviation for all PIBO streams. The solid horizontal line represents the grand mean over all sites and years as a measure of “baseline conditions.” This visual display gives a sense of the regional trends over time and the trends for one UCBN stream reach. The bounds move up and down according to the regional trends over time, whereas the line and red circles show the UCBN stream trend over time.

Based on this assessment, this particular target reach of Goat Creek would appear within the bounds of the average residual pool depth for the region for most years. However, this is based on all streams spanning a wide range of environmental characteristics that may or may not be similar to the conditions within UCBN streams. This is just one way to visualize the data in the context of the entire region sampled by PIBO. An alternative comparison will be made between UCBN streams and all PIBO streams with similar environmental/geomorphic characteristics, for instance low stream gradients or a similar range of elevation.

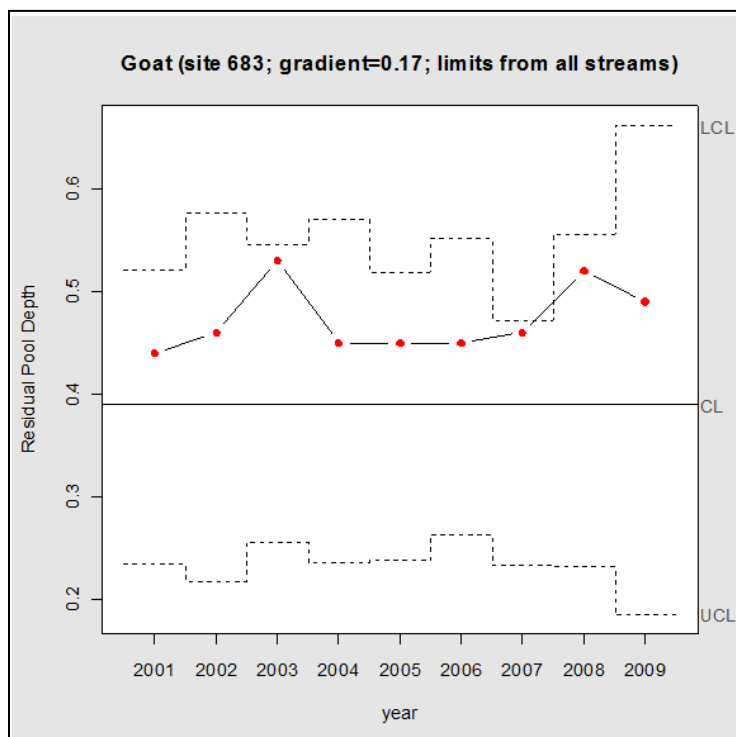


Figure 13. Example control chart for residual pool depth measured over nine years in Goat Creek relative to all other PIBO streams. The upper and lower limits are based on the annual mean ± 1 standard deviation for other streams measured in the same year. The solid line with red circles is the mean for Goat Creek for each year. The horizontal line is the overall mean of residual pool depth for all other streams sampled in 2001-2009.

Figure 14 displays an example based on residual pool depth measured in Goat Creek over nine years. This figure shows the trend in residual pool depth at Goat Creek in the context of other low gradient streams measured in the same year.

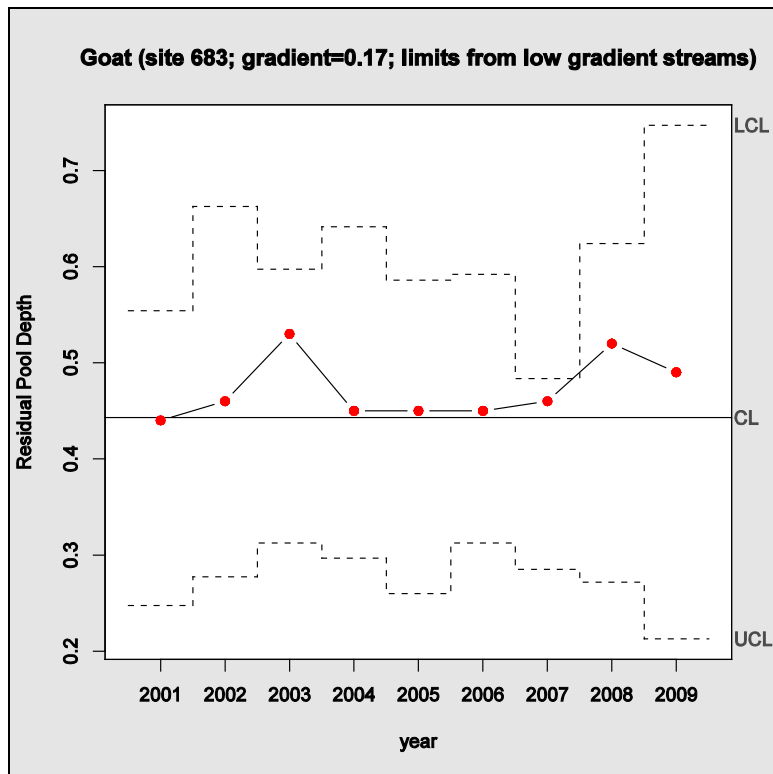


Figure 14. Example control chart for residual pool depth measured over nine years in Goat Creek relative to other PIBO streams with low gradients. The upper and lower limits are based on the annual mean plus/minus the standard deviation for other low gradient streams measured in the same year. The solid line is the mean for Goat Creek for each year. The horizontal line is the overall mean of residual pool depth for all low gradient streams sampled in 2001-2009.

Data Analysis of Macroinvertebrate Data

While collection of benthic macroinvertebrate data is done concurrently with stream channel characteristics monitoring; analysis, interpretation and reporting of data will occur in conjunction with continuous water quality data. This co-analysis of vital signs will facilitate better interpretation of results generated from both data sets. See the UCBN integrated water quality protocol for more details (Starkey et al. 2016).

Data Archival Procedures

Once the annual data certification has been completed, the UCBN stream database, and related UCBN reports will be archived on the UCBN server, posted to the UCBN website, and posted to the national web-accessible secure Integrated Resource Management Application (IRMA) hosted by the NPS Washington Areas Support Office (WASO) or National I&M program.

A review of archive and expendable data products will be undertaken by the Project Lead and Data Manager during season close-out each year. An example of an expendable data product is an intermediate draft of an annual report that was saved during report preparation.

Reporting

A summary will be produced annually, with a more detailed status and trend report produced for each stream after three years of data become available. The annual summary will:

- List project personnel and their roles.
- List locations sampled during the current year.
- Provide a watershed condition determination (status) for each sampled stream based on the distributions of stream habitat (index scores), temperature (deviation from reference condition), and macroinvertebrate O/E scores (observed/expected).
- Provide a summary of channel characteristics and macroinvertebrate samples by location and park.
- Provide trend estimates for key stream characteristics after three years of data become available.
- Evaluate data quality and identify any data quality concerns and/or deviations from protocols that affect data quality and interpretability.
- Evaluate and identify suggested or required changes to the protocol.

The annual summary report will be developed by the UCBN Project Lead. A 1-2 page resource brief will be prepared by the UCBN for public consumption, and will be provided to park interpretive staff for distribution to interested visitors. A template for the resource brief is included in SOP #9. An NPS template for producing maps with ESRI ArcGIS or ArcView software is available at <http://imgis.nps.gov/templates.html> (Accessed on 24 February 2010).

A more in-depth analysis and report will be produced after three years of data become available for each stream (6 years after initial sample year, Table 7 highlights revisit schedule), or as the importance of emerging information warrants. This report will provide greater analytical and interpretive detail, and will evaluate the relevance of findings to long-term management and restoration goals. The report will also evaluate operational aspects of the monitoring program, such as whether the sampling period remains appropriate.

The status reports should use the NPS Natural Resource Publications Natural Resource Data Series (NRDS) template, and trend reports should use the NPS Natural Resource Publications Natural Resource Report (NRR) template. Both the NRDS and NRR series templates are pre-formatted Microsoft Word template document based on current NPS formatting standards. This template, guidelines for its use and documentation of the NPS publication standards are available at the following address: <http://www.nature.nps.gov/publications/NRPM/index.cfm> (Accessed on 25 March 2016).

Protocol Testing and Revision

Version 1.0 (draft) of this protocol was the first version and was submitted for formal peer review in May 2010. Version 1.2 (2016) was developed to include minor revisions to data management and benthic macroinvertebrate procedures. Subsequent protocol testing will occur during each field season and evaluation of existing protocols and recommended revisions will be documented in annual reports and during season close-out.

Revisions to this protocol and the SOPs are expected. Sampling sites should be revised only if management priorities shift significantly, and should be done only in consultation with park management and careful consideration of statistical consequences. All revisions will be carefully documented using the protocol development and revision log in SOP 11 and the change history log at the front of each SOP and this narrative.

Revisions to the PIBO Sampling Protocol for Stream Channel Attributes may occur. These changes will be documented by the USFS PIBO Effectiveness Monitoring Program. The most recent version of their monitoring protocol can be found at

http://www.fs.fed.us/biology/fishecolony/new.html#pibo_reports (Accessed on 25 March 2016).

Personnel Requirements and Training

Personnel Requirements

Successful implementation of the protocol requires various levels of involvement by the following UCBN staff: Aquatic Biologist, UCBN I&M Network Program Manager, Data Manager, and Data/GIS Technician (Figure 15). In addition, this protocol requires extensive involvement by the PIBO Project Lead and Field Technicians. To a large extent, the implementation of this protocol depends on a working relationship between UCBN and PIBO staff. A list of key contacts within the PIBO program is listed in Appendix D.

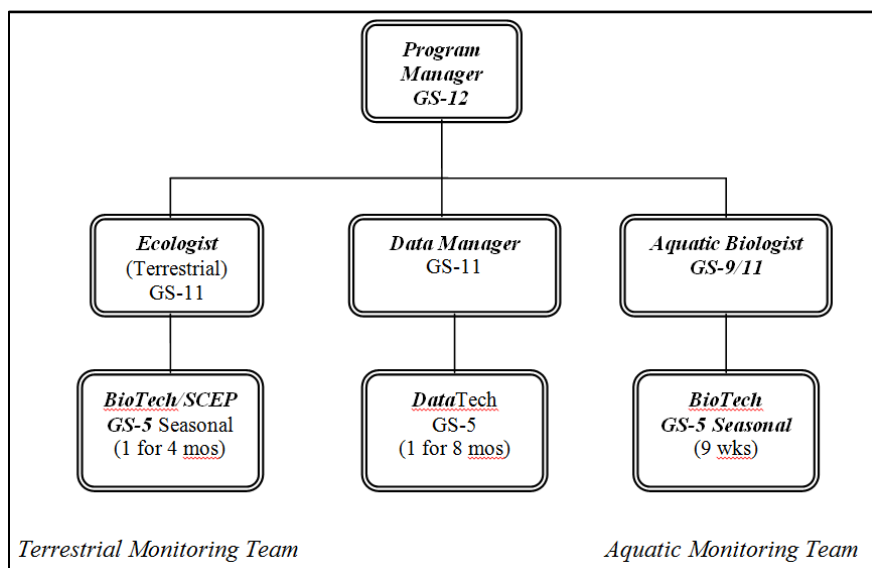


Figure 15. Staff structure for UCBN I&M program (modified from Garrett et al. 2007).

The UCBN Aquatic Biologist is responsible for: facilitating cooperation between the UCBN and PIBO, the completion of the interagency agreement, reviewing data deliverables, season closeout procedures, archiving of data, and performing additional data analysis and reporting. The PIBO Project Leader will serve as the point of contact for the interagency agreement and will coordinate the field work necessary to complete sampling activities as outlined in the PIBO Sampling Protocol for Stream Channel Attributes. The PIBO programs seasonal field technicians will conduct all sampling activities for the assessment of stream channel characteristics and the collection of macroinvertebrate samples. The PIBO Program will select qualified taxonomists for macroinvertebrate sample identification and enumeration to ensure a quality data product. Participation from the UCBN Data Manager will be necessary to review the database(s) provided by PIBO at the end of each sample season. The roles and responsibilities are summarized in Table 9.

Roles and Responsibilities

Table 9. Roles and responsibilities for implementing the stream channel characteristics monitoring program in the UCBN. Current or anticipated staff for 2010-11 are named here.

Role	Responsibilities	Position
UCBN Project Lead	- Project oversight and administration - Collaborate with Network Program Manager on tracking project objectives, budget, personnel requirements, and progress toward meeting monitoring objectives - Collaborate with PIBO Program Lead on tracking the completion of field work, macroinvertebrate identification, and reporting. - Facilitate communications between NPS resource managers and PIBO field crew - Coordinate and ratify changes to protocol - Coordinate the interagency agreement between the UCBN and PIBO. - Review data summaries and analyses provided by PIBO - Perform additional data summaries and analyses - Maintain and archive project records - Project operations and implementation - Certify each season's data for quality and completeness - Complete reports, metadata, and other products according to schedule	UCBN Aquatic Biologist
PIBO Project Leader	- Serve as the point of contact for the interagency agreement - Coordinate field work necessary to complete sampling activities as outlined in the PIBO Sampling Protocol for Stream Channel Attributes. - Coordinate macroinvertebrate sample enumeration and identification. - Provide the UCBN with quality checked data deliverables and summaries as specified in the interagency agreement.	PIBO Project Leader
Technicians	- Assist with field collections of stream channel data and additional macroinvertebrate samples - Assist with data compilation	Seasonal PIBO employees
Taxonomists	- Identify and enumerate macroinvertebrates - Certify QA/QC	Independent contractor of PIBO program
Data Manager	- Consultant on data management activities - Facilitate check-in, review, and posting of data, metadata, reports and other products to national databases according to schedule - Assist with data migration procedures - Maintain and update database application - Provide database training as needed - Work with Project Lead to analyze spatial data and develop metadata for spatial data products - Primary steward of Access database and GIS data and products	UCBN Data Manager
Data/GIS Technician	Assist with preparation of maps for inclusion in annual reports	UCBN Data/GIS Technician

Table 9 (continued). Roles and responsibilities for implementing the stream channel characteristics monitoring program in the UCBN. Current or anticipated staff for 2010-11 are named here.

Role	Responsibilities	Position
Science Communication Specialist	• Assist with the preparation of resource briefs • Prepare and distribute field monitoring posters to park visitor centers.	UCBN Science Communication Specialist
Network Program Manager	• Project leader oversight • Administration and budget • Consultant on all phases of protocol review and implementation • Review of annual and 3-year reports	UCBN Program Manager

Training

The PIBO program conducts training for field crews every May prior to the start of data collection. Field crews consist of Stream Morphology/Habitat Technicians and Riparian Vegetation Survey Technicians. Crews receive 12 days of intensive training, with a series of courses on each measurable attribute. The technicians are able to implement protocol methods in a series of “practice reaches.” Following the completion of training and practice data collection, field crews are evaluated at a “repeat measure” site to ensure adherence to methods outlined in the Sampling Protocol for Stream Channel Attributes (Heitke et al. 2008) and the Sampling Protocol for Vegetation Parameters (Leary and Ebertowski 2010).

Quality Assurance and Quality Control

Quality assurance and quality control for stream channel characteristics are covered in detail by the PIBO programs “Summarized Data QA” and “Introduction to Raw Data Checks” documents. These can be found in the UCBN Stream Channel Characteristics Protocol – SOP Appendices 2 and 3. Note that these are working documents that will be updated by the PIBO program as needed.

Unlike many existing stream channel monitoring protocols, the PIBO program has extensively documented observer variability (repeatability) in several publications (Roper et al. 2002, and Archer et al. 2004). As a result of these studies, the stream channel attributes protocol has been modified to reduce the potential error caused by multiple observers (Henderson et al. 2005).

In addition, after the pilot year (2010) the UCBN will conduct at least one un-announced site visit per season while PIBO field crews are in parks collecting data. This will help insure that the UCBN is receiving the data as outlined in the PIBO sampling protocols.

Operational Requirements

Annual Workload and Schedule

The annual workload of this monitoring protocol is outlined in Table 9 of the preceding section on Roles and Responsibilities. Table 9 provides a thorough overview of the general roles and responsibilities required to complete all aspects of this monitoring protocol following rigorous and comprehensive data management practices as outlined in the UCBN Data Management Plan (Dicus and Garrett 2007). The budget table (Table 11) demonstrates that adequate resources have been allocated to data management, analysis, and reporting activities. The SOPs provide a comprehensive step-by-step description of the annual workload and tasks required for completion, including data management tasks and report delivery. The annual start-up for stream channel monitoring begins in January with the initiation of an interagency agreement, final reporting, and close-out activities for the previous year. An evaluation of the UCBN protocol and any necessary changes must be made by February. Table 10 provides additional details of the annual schedule.

Equipment Needs

Equipment needs for this protocol are relatively extensive and would represent a considerable amount of capital expense initially to implement the protocol. However, given the interagency agreement established between the UCBN and the PIBO program the UCBN will forego these expenses. The PIBO program will provide all of the necessary equipment and vehicles to complete stream channel monitoring and the collection of additional macroinvertebrate samples. A list of PIBO equipment needs is provided in the PIBO Sampling Protocol for Stream Channel Attributes (Archer et al. 2012).

Table 10. Annual implementation schedule for stream channel characteristics monitoring.

Month	Administration	Stream Channel Characteristics	Macroinvertebrates (MI)	Data Management/Reporting
January	Annual work plan complete.	--	--	Analysis, reporting and close-out of previous year's data
February	Administer and modify existing interagency agreements, if necessary	--	--	Data certification complete; Data archival and posting, Final annual report for previous year complete
March	--	Provide PIBO with GIS layers of park(s) that will be sampled	--	--
April	--	--	--	--
May	Finalize PIBO sample schedule and notify parks	PIBO conducts annual field crew training and begins field work	--	--
June	--	PIBO samples selected streams in the UCBN	PIBO collects additional MIs if necessary	--

Table 10 (continued). Annual implementation schedule for stream channel characteristics monitoring.

Month	Administration	Stream Channel Characteristics	Macroinvertebrates (MI)	Data Management/Reporting
July	--	PIBO samples selected streams in the UCBN	PIBO collects additional MIs if necessary	--
August	Budget preparation for new fiscal year	PIBO samples selected streams in the UCBN	PIBO collects additional MIs if necessary. PIBO submits MIs for identification	--
September	--	--	Ensure MI's have been delivered for identification	--
October	--	--	--	Draft resource brief preparation
November	--	--	--	--
December	UCBN annual work plan drafted	--	--	Preliminary analysis of current year's results

Budget

Below is the annual operational budget for the stream channel characteristics monitoring protocol (Table 11). The total available FY 2010 stream channel monitoring funds are \$53,154. The cost of the interagency agreement will depend upon the number of samples to be completed in a given year. Table 12 outlines costs associated with each year across the 3 year revisit design (Tables 6 and 7).

Table 11. The detailed 2010 annual budget for stream channel characteristics monitoring in the UCBN.

Category	Expenditures	Time Allotted	% of time spent on DM*	Cost in dollars DM*	Cost in dollars (2010)
<i>Permanent Personnel</i>	Project leader (Aquatic Biologist) @ \$1,385/week ***	6 months	50%	\$16,620	\$33,240
	Data Manager @ \$1,692/week***	2 weeks	100%	\$3,384	\$3,384
	UCBN Program Manager @2,000/wk ***	1 week	--	--	\$2000
	Data/GIS Technician @ \$1,080/week ***	1 week	50%	\$540	\$1,080
	Science Communication Specialist @ \$750/week	1 week	30%	--	\$750
<i>Interagency Agreement with USFS PIBO-EM</i>	Collection of stream channel characteristics data, travel, data processing, and annual reporting.	6 months	30%	\$3,750	\$12,500
<i>Park Personnel</i>	Resource management staff	2 days	--	--	In-Kind support
<i>Travel</i>	Project leader	--	--	--	\$2,000
<i>Laboratory</i>	Macroinvertebrate sample processing (Additional samples @ \$200.00)		50%	\$100	\$200
<i>Operations/Equipment</i>	Included in cost of interagency agreement	--	--	--	--
TOTAL	--	--	--	\$24,394**	\$53,154

* DM = data management

** More than 30% of the stream channel monitoring budget is dedicated to data management, analysis, and reporting activities

*** Includes benefits

Table 12. Costs associated with each year across the 3 year revisit design.

Total Cost by Year*	Sample Year	Park	Park Unit	State	Stream	# of Full PIBO Sites*	# of Additional Macro-invertebrate Reaches**
\$ 17,700.00	1	JODA	Sheep Rock	OR	John Day River	5	1
	1	JODA	Painted Hills	OR	Bridge Creek	2	0
\$15,000.00	2	NEPE	Spalding	ID	Lapwai Creek	1	0
	2	NEPE	Weippe Prairie	ID	Jim Ford Creek	3	0
	2	WHMI	--	WA	Mill Creek	1	0
	2	WHMI	--	WA	Doan Creek	1	0
\$32,700.00	3	BIHO	--	ID	North Fork Big Hole River	5	1
	3	CIRO	Castle Rocks	ID	Almo Creek	2	0
	3	CIRO	City of Rocks	ID	Main Stem Circle Creek	2	0
	3	CIRO	City of Rocks	ID	North Fork Circle Creek	2	0
	3	CIRO	City of Rocks	ID	South Fork Circle Creek	2	0

* \$2,500 per full PIBO site (stream channel, riparian veg., and macroinvertebrates)

** \$200 per additional macroinvertebrate reach

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List of Acronyms and Abbreviations

BIHO: Big Hole National Battlefield
CIRO: City of Rocks National Reserve
CRMO: Craters of the Moon National Monument and Preserve
DEQ: Department of Environmental Quality
EPA: United States Environmental Protection Agency
GPS: Global Positioning System
HAFO: Hagerman Fossil Beds National Monument
HUC: Hydrologic Unit Code
JODA: John Day Fossil Beds National Monument
LARO: Lake Roosevelt National Recreation Area
LULC: Land use – land cover
MIIN: Minidoka Internment National Monument
NEPE: Nez Perce National Historical Park
NOAA: National Oceanographic and Atmospheric Administration
PIBO-EM: PACFISH/INFISH Biological Opinion Effectiveness Monitoring Program
QA/QC: Quality Assurance/Quality Control
SOP: Standard Operating Procedure
UCBN: Upper Columbia Basin Network
USFS: United States Forest Service
USGCRP: United States Global Change Research Program
USGS: United States Geological Survey
WHMI: Whitman Mission National Historic Site
WRD: Water Resources Division of NPS

Glossary of Terms Used by the UCBN I&M Program

Definitions from HACH Environmental (2006) and EPA (2006) Rosgen (2008)

Aggradation: A rising of local base stream channel level due to sediment depositional processes.

Benthic macroinvertebrates: Aquatic larval stages of insects such as dragonflies, aquatic insects such as aquatic beetles, crustaceans such as crayfish, worms, and mollusks. These small creatures live throughout the stream bed attached to rocks, vegetation, and logs and sticks or burrowed into stream bottoms.

Biological assemblages: Key groups of animals and plants—such as benthic macroinvertebrates, fish, or algae—that are studied to learn more about the condition of water resources.

Biological integrity: State of being capable of supporting and maintaining a balanced community of organisms having a species composition, diversity, and functional organization comparable to that of the natural habitat of the region.

Channel incision: The process of a lowering of local base level. The degree of incision is measured by bank height ratio.

Ecoregions: Ecological regions that are similar in climate, vegetation, soil type, and geology; water resources within a particular ecoregion have similar natural characteristics and similar responses to stressors.

Ephemeral channel: Channel that flows only in response to precipitation.

Hydrologic Unit Code (HUC): The United States is divided and sub-divided into successively smaller hydrologic units which are classified into four levels: regions, sub-regions, accounting units, and cataloging units. The hydrologic units are arranged within each other, from the smallest (cataloging units) to the largest (regions). Each hydrologic unit is identified by a unique hydrologic unit code (HUC) consisting of two to eight digits based on the four levels of classification in the hydrologic unit system.

Incision: A process relating to abandonment of an active floodplain and a lowering of local base level.

Index period: The index period is the period of time that macroinvertebrate samples should be collected to minimize seasonal variation.

Instream fish habitat: Areas fish need for concealment and feeding. These areas include large wood within the stream banks, boulders, undercut banks, and tree roots.

Intermittent (ephemeral) streams: Streams that flow only during part of the year, such as in the spring and early summer after snowmelt.

Macroinvertebrate Index of Biotic Condition: The sum of a number of individual measures of biological condition, such as the number of taxa in a sample, the number of taxa with different habits and feeding strategies, etc.

Metric: A metric is a characteristic of the biota that changes in some predictable way with increased human influence.

National Hydrography Dataset: Comprehensive set of digital spatial data - based on U.S. Geological Survey 1:100,000 scale topographic maps - that contains information on surface water features such as streams, rivers, lakes, and ponds.

Nutrients: Substances such as nitrogen and phosphorus that are essential to life but can overstimulate the growth of algae and other plants in water. Excess nutrients in streams and lakes can come from agricultural and urban runoff, leaking septic systems, sewage discharges, and similar sources.

O/E (Observed/Expected) ratio of taxa loss: A ratio comparing the number of taxa expected (E) to exist at a site to the number that are actually observed (O). The taxa expected at individual sites are based on models developed from data collected at reference sites.

Parameter: A quantity (stream channel variable) which is constant under a given set of conditions, but may be different under other conditions.

Perennial streams: Streams that flow continuously throughout the year.

Physical habitat: For streams and rivers, the area in and around the stream or river, including its bed, banks, instream and overhanging vegetation, and riparian zone.

Power analysis: The **power** of a statistical test is the probability that the test will reject a false null hypothesis, or in other words that it will not make a Type II error. As power increases, the chances of a Type II error decrease, and vice versa. The probability of a Type II error is referred to as β . Therefore power is equal to $1 - \beta$. Power is a function of effect size or minimum detectable change, variance of the parameter (e.g., standard error of the mean), and sample size. A power analysis determines the probability of correctly rejecting a false null hypothesis given fixed values of effect size, variance, and sample size.

Probability-based design: A type of random sampling technique in which every element of the population has a known probability of being selected for sampling.

Reach: A discrete segment of a stream.

Reference condition: The least disturbed condition available in an ecological region; determined based on specific criteria and used as a benchmark for comparison with other sample sites in the region.

Riparian: Pertaining to a stream or river and its adjacent area.

Riparian disturbance: A measure of the evidence of human activities in and alongside streams, such as dams, roadways, pastureland, and trash.

Riparian vegetative cover: Vegetation corridor alongside streams and rivers. Intact riparian vegetative cover reduces pollution runoff, prevents streambank erosion, and provides shade, lower temperatures, food, and habitat for fish and other aquatic organisms.

Sample reach: Refers to the area in which one PIBO stream channel survey is completed. Reach length is a function of the mean bankfull width. (i.e. the wider the stream the longer the site). The minimum reach length is 160 m and the maximum is 480 m. Each sample reach is subdivided into a minimum of 21 equidistant transects. Additional benthic macroinvertebrate reaches are established in the same manner.

Sinuosity: An index of channel pattern determined from the ratio of stream length to valley length or the ratio of valley slope to channel slope.

Stream order: Stream size, based on the confluence of one stream with another. Firstorder streams are the origin or headwaters. The confluence or joining of two 1st order streams forms a 2nd order stream, the confluence of two 2nd order streams forms a 3rd order stream, and so on.

Stream slope: Determined by the change in elevation of the bed surface over a measured length of channel. It is expressed as a ratio of elevation (rise) over distance (run).

Streambank erosion: The land associated with streambanks that is eroded by a variety of processes, including fluvial entrainment, mass wasting, freeze-thaw, dry ravel, rill erosion, ice scour and other processes.

Streambed sediments: Fine sediments and silt on the streambed. In excess quantities, they can fill in the habitat spaces between stream pebbles, cobbles, and boulders and suffocate macroinvertebrates and fish eggs.

Stressors: Factors that adversely affect—and therefore degrade—aquatic ecosystems. Stressors may be chemical (e.g., excess nutrients), physical (e.g., excess sediments on the streambed), or biological (e.g., competing invasive species).

Taxa: Plural of taxon; groupings of living organisms, such as phylum, class, order, family, genus, or species. Scientists organize organisms into taxa in order to better identify and understand them.

Temperature: A measure of heat present in water. Aside from dissolved oxygen, temperature is considered the single most important parameter. Knowledge of water temperature is essential to the measurement of dissolved oxygen, conductivity (salinity), pH, alkalinity, biological/biochemical oxygen (needed to meet the metabolic needs of aerobic - requiring DO - organisms) and virtually every other water quality parameter. Temperature controls metabolism (utilization of inorganic and organic matter for life processes) of aquatic animals and plants. Temperature is largely responsible for biochemical reactions and is one of the most important cues for beginning and ending of spawning, migration, and many other phenomena.

Thalweg: The line connecting the lowest of deepest points along a stream bed, valley or reservoir, whether under water or not.

Transect: A path or line along which one counts and studies various aspects of a stream, river, or other study area.

Wadeable streams: Streams that are small and shallow enough to adequately sample by wading, without a boat.

Waterbody: Any lotic or lentic water occurring within the Upper Columbia Basin Network.

Width/Depth Ratio: The ratio of bankfull surface width to mean bankfull depth. The width/depth ratio is a dimensionless value that describes the channel shape (large number = wide and shallow; small number = narrow and deep) and is used as a delineative criteria for stream classification and in departure analyses for channel stability.

Appendix A. Index of Standard Operating Procedures

Note that SOPs are bound and published as a separate document

SOP 1: Preparations Prior to the Field Season

SOP 2: Training Field Personnel

SOP 3: Finding GPS Waypoints

SOP 4: Sampling Stream Channel Attributes

SOP 5: Benthic Macroinvertebrate Sample Collection

SOP 6: Decontamination of Equipment for Aquatic Invasive Species

SOP 7: Data Management

SOP 8: Data Migration

SOP 9: Data Analysis and Reporting

SOP 10: Post Field Season Activities

SOP 11: Administrative Record/Protocol Revision

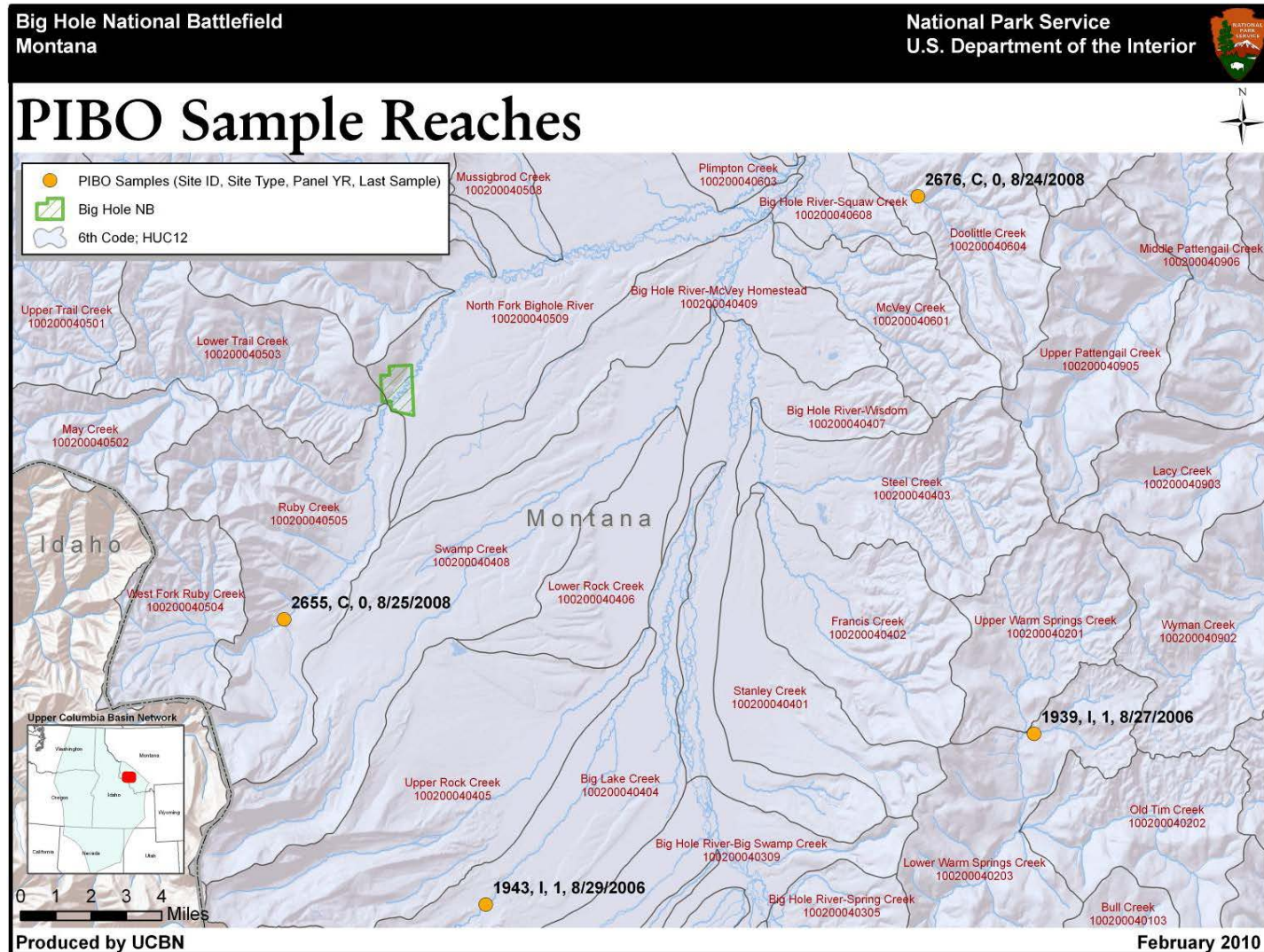
Appendix B. Links to Effectiveness Monitoring for Streams and Riparian Areas: Sampling Protocol for Stream Channel Attributes

Note that the sampling protocols listed below are United States Forest Service – PACFISH/INFISH Biological Opinion Effectiveness Monitoring Program (PIBO-EM) publications that are available as additional holdings through IRMA. They represent the basis for the UCBN stream channel characteristics monitoring methods. Version 1.0 of the UCBN stream channel monitoring protocol used Heitke et al. 2008 and version 1.2 uses Archer et al. 2012.

Archer, E. K., R. A. Scully, R. Henderson, B. B. Roper, and J. D. Heitke. 2012. Effectiveness monitoring for streams and riparian areas: sampling protocol for stream channel attributes PACFISH/INFISH- Biological Opinion Effectiveness Monitoring Program (PIBO-EM). Logan, UT. <https://irma.nps.gov/DataStore/DownloadFile/548575> (Accessed 04/28/2016)

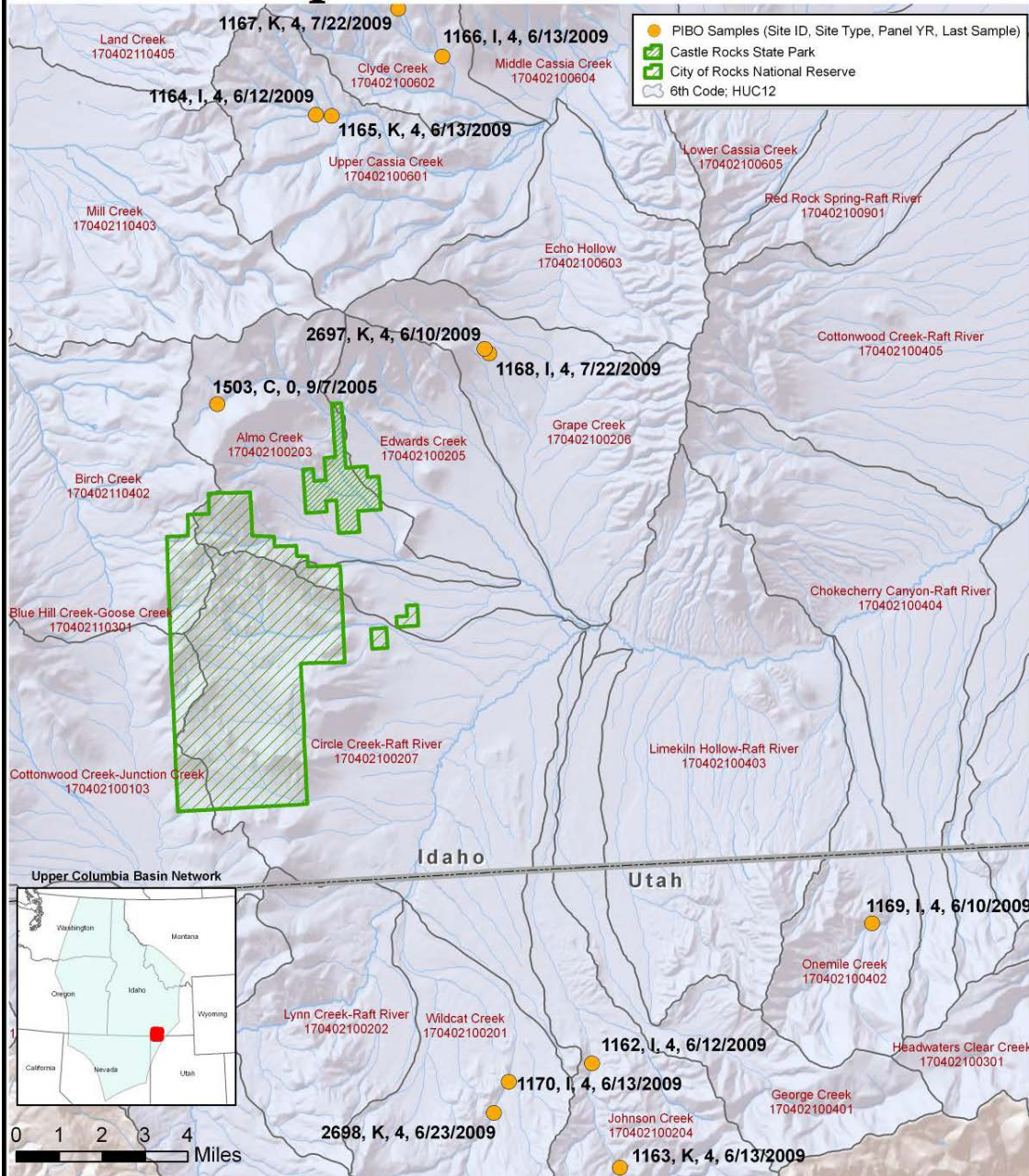
Heitke, J. D., E. J. Archer, D. D. Dugaw, B. A. Bouwes, E. A. Archer, R. C. Henderson, J. L. Kershner. 2008. Effectiveness monitoring for streams and riparian areas: sampling protocol for stream channel attributes. PACFISH/INFISH- Biological Opinion Effectiveness Monitoring Program (PIBO-EM). Logan, UT. <https://irma.nps.gov/DataStore/DownloadFile/548576> (Accessed 04/28/2016)

Appendix C. Hydrologic Unit Code Boundaries and PIBO Sample Reaches near UCBN Parks



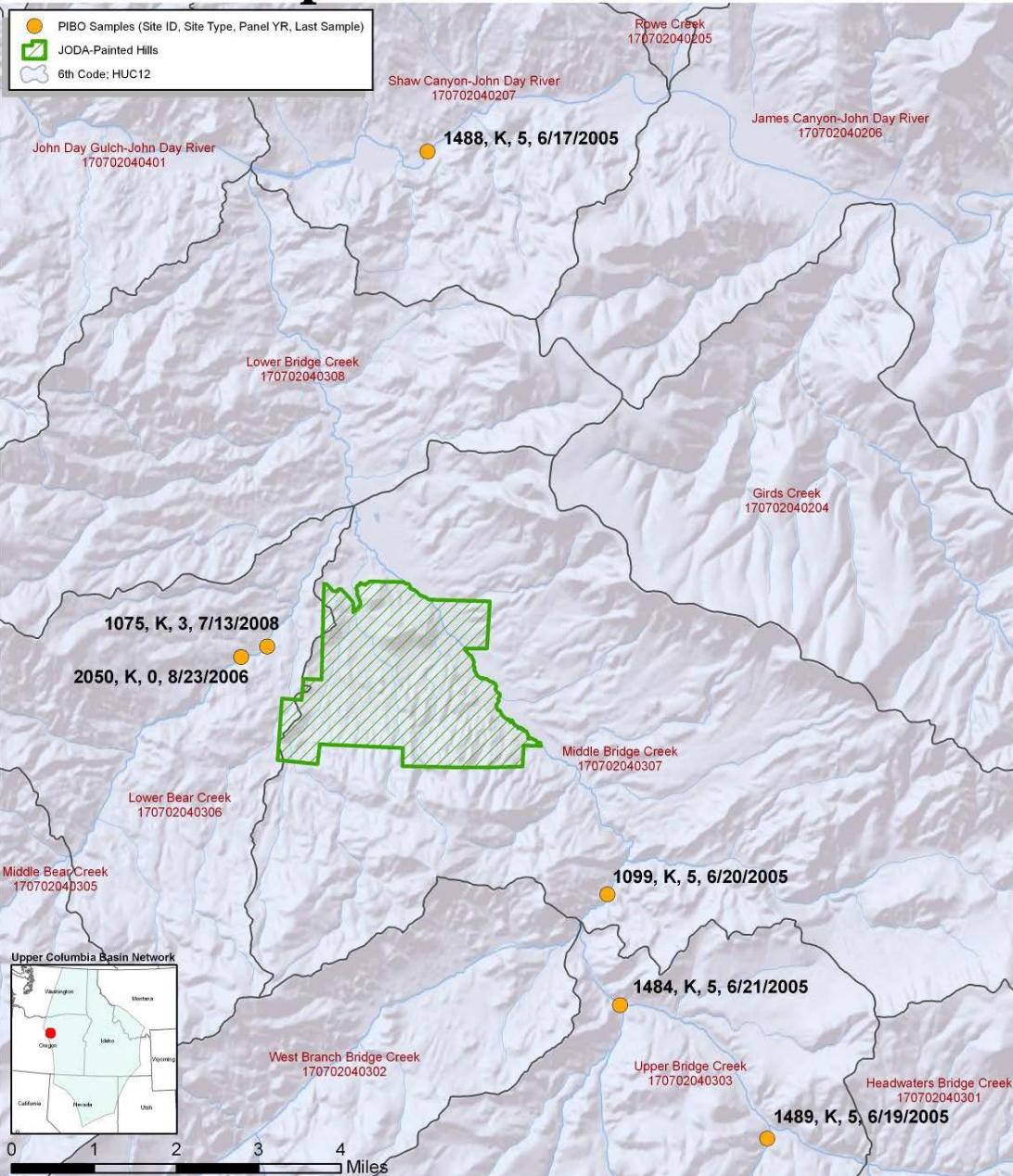


PIBO Sample Reaches





PIBO Sample Reaches



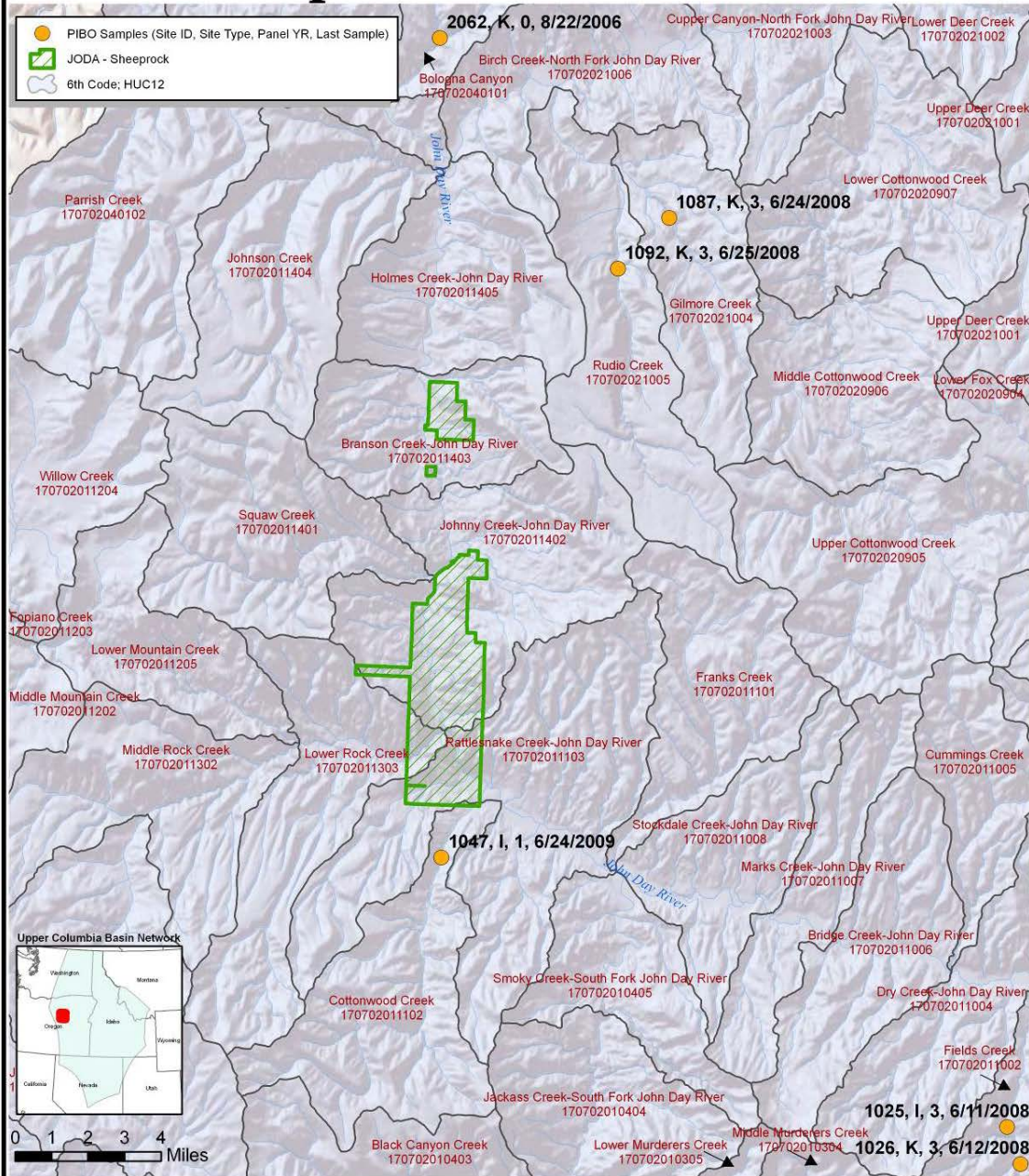
Produced by UCBN

February 2010

FILE: JODAsheeprock.mxd



PIBO Sample Reaches

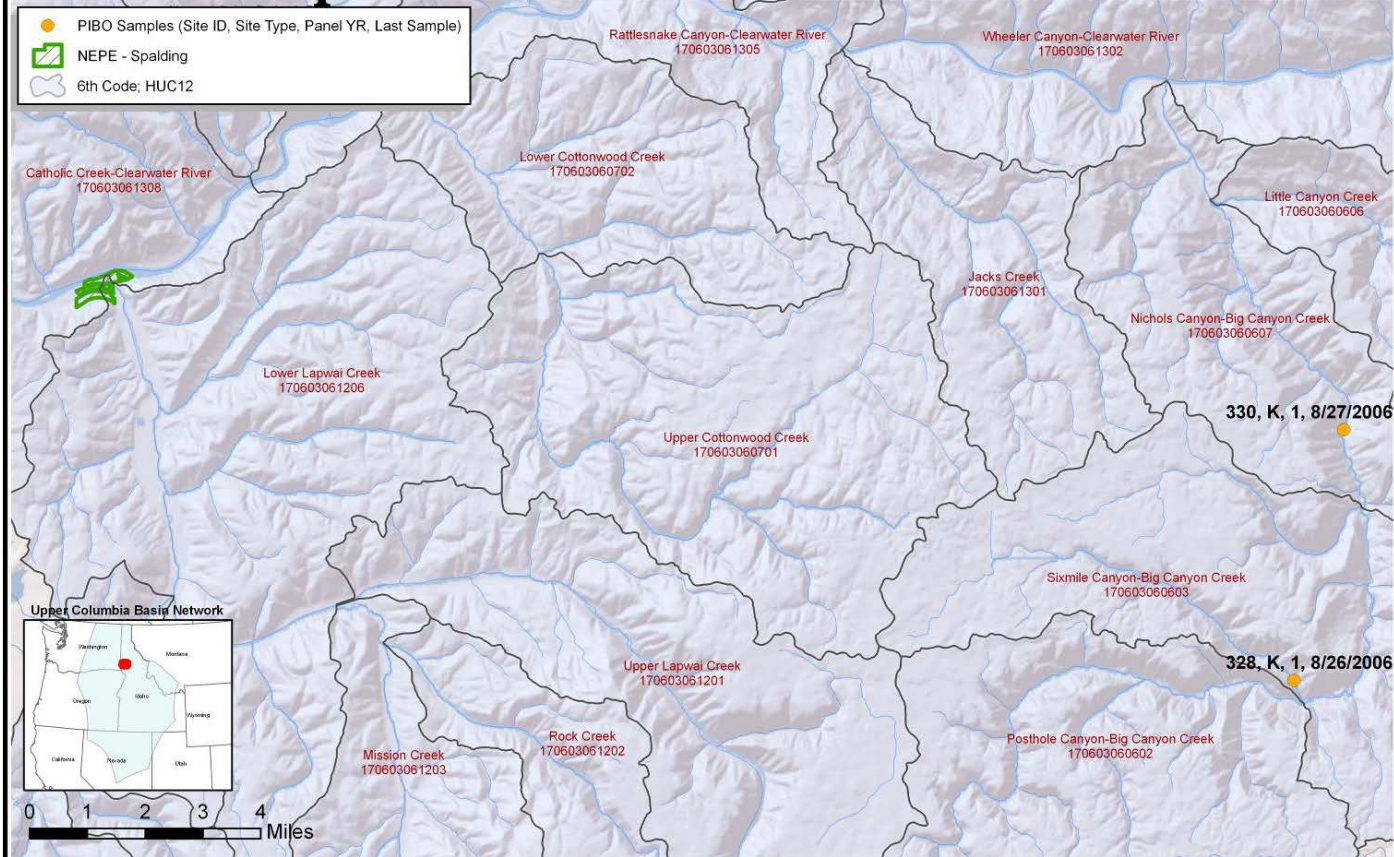


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FILE: JODASheeprock.mxd

February 2010



PIBO Sample Reaches



Produced by UCBN

February 2010

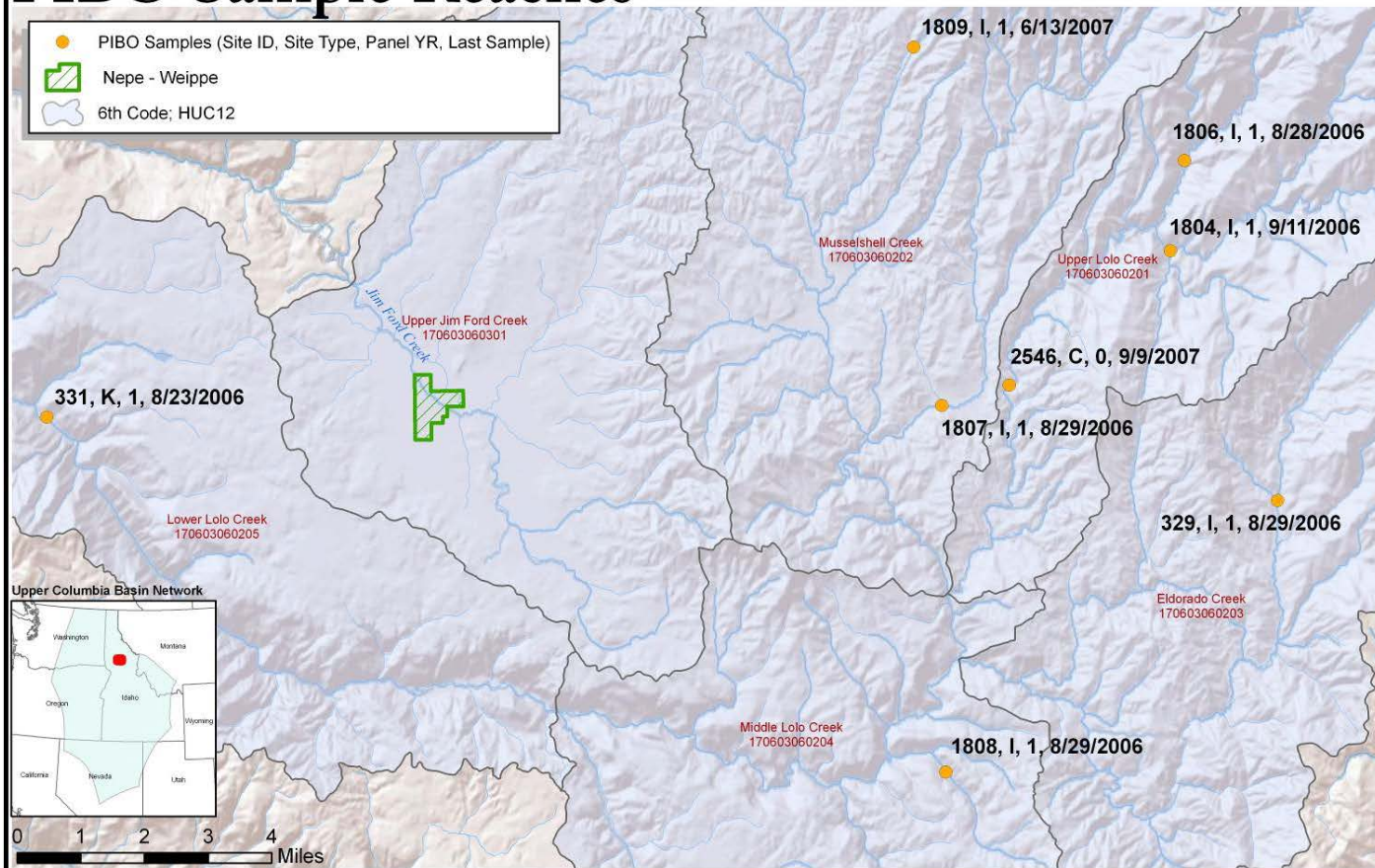
FILE: Spalding_PIBO.mxd



PIBO Sample Reaches



- PIBO Samples (Site ID, Site Type, Panel YR, Last Sample)
- Nepe - Weippe
- 6th Code; HUC12



0 1 2 3 4 Miles

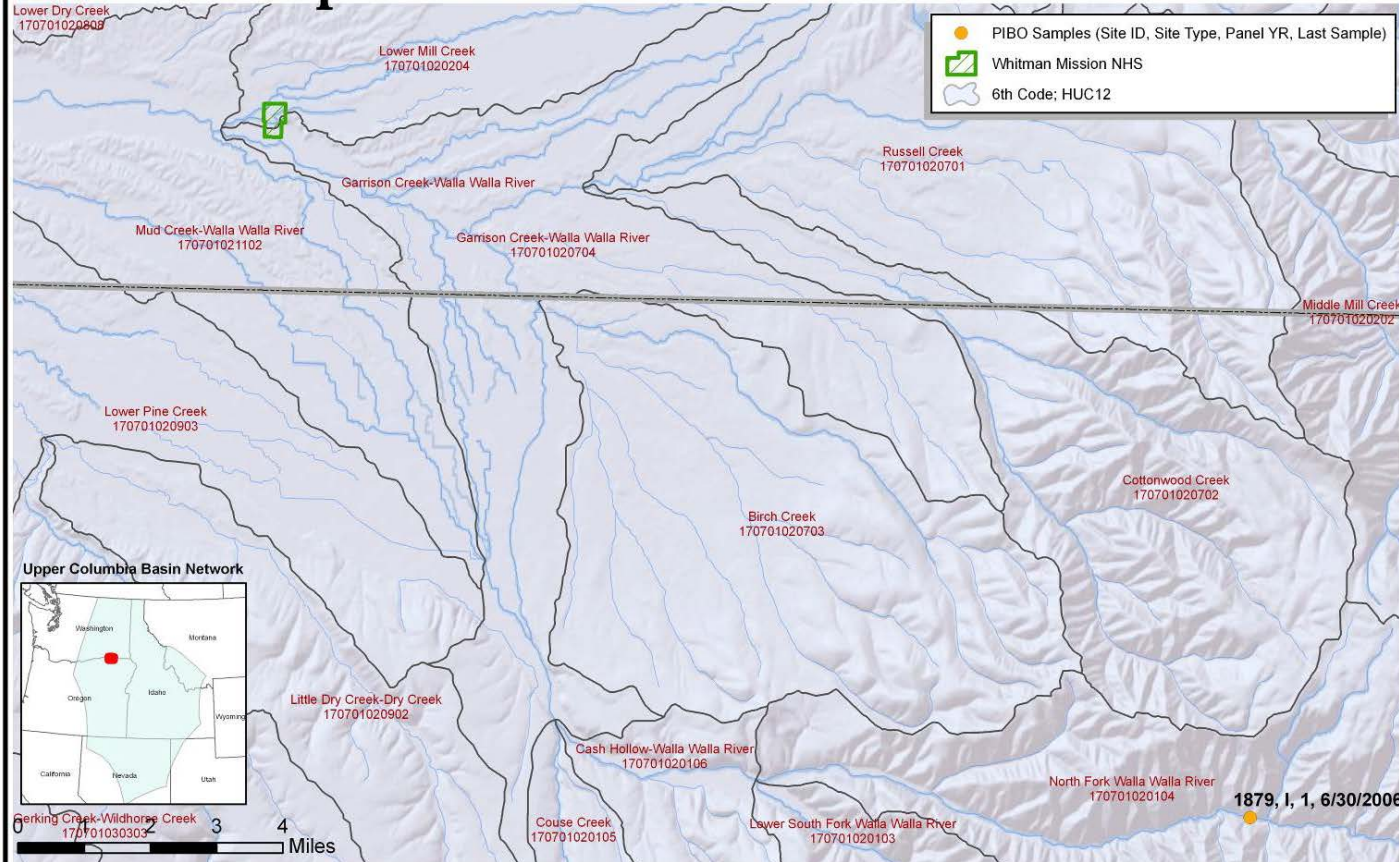
Produced by UCBN

FILE: Weippe_PIBO.mxd

February 2010



PIBO Sample Reaches



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FILE: Whitman_PIBO.mxd

Appendix D. Key Contacts within the PIBO-EM Program

Position/Affiliation*	Name	Telephone	Email
Program Leader; Aquatic Ecologist (USFS)	Eric K. Archer	435-760-3549	earcher@fs.fed.us
Program Analyst, Aquatic Ecologist (USFS)	Vacant	435-755-3597	
Field Team Leader, Aquatic Ecologist (USFS)	Lucie Law	435-755-3579	lucierlaw@fs.fed.us
Database Analyst (USFS)	Jeff Ojala	435-755-3578	jvojala@fs.fed.us
Program Botanist, Botanist (USFS)	Andrew Vanwagenen	435-755-3562	avanwagenen@fs.fed.us
Field Coordinator (USFS)	Cody Lund	435-755-3597	codyalund@fs.fed.us

*The Physical address for all key contacts is: US Forest Service, Forest Service Sciences Lab, Fish & Aquatic Ecology Unit, 860 North 1200 East, Logan UT, 84321

The Department of the Interior protects and manages the nation's natural resources and cultural heritage; provides scientific and other information about those resources; and honors its special responsibilities to American Indians, Alaska Natives, and affiliated Island Communities.

NPS 963/133644, August 2016

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1201 Oakridge Drive, Suite 150
Fort Collins, CO 80525

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