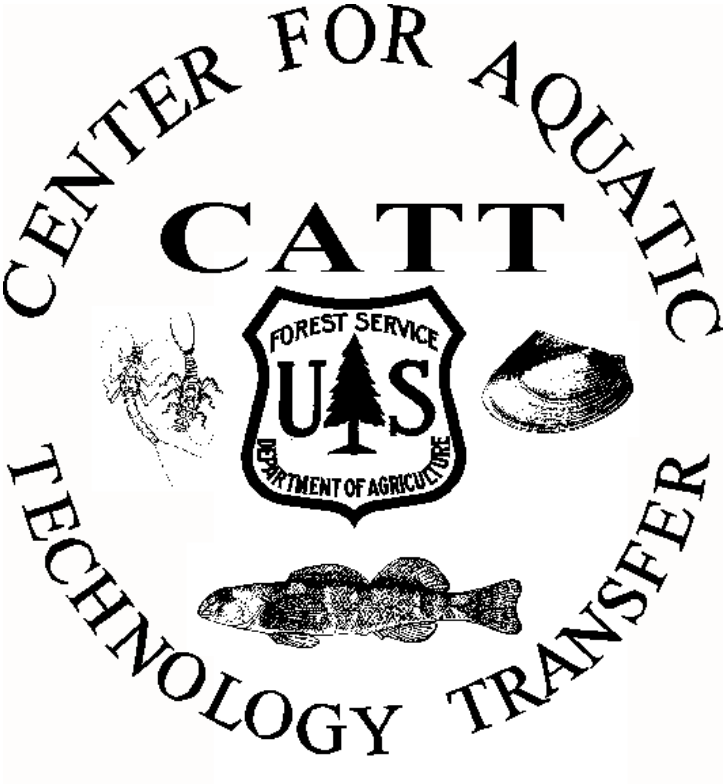
Summary of Stream Habitat and Fish Inventories on the Enoree Ranger District of the Sumter National Forest, South Carolina 2008



United States Department of Agriculture Forest Service
Southern Research Station
Center for Aquatic Technology Transfer
1710 Ramble Rd.
Blacksburg, VA 24060-6349

C. Andrew Dolloff, Team Leader

Report prepared by:
Colin Krause and Craig Roghair
December 2008

USDA

Southern Research Station

Table of Contents

List of Tables

List of Figures

Introduction

In spring 2008 the Sumter National Forest (SNF) requested assistance from the USDA Forest Service, Southern Research Station, Center for Aquatic Technology Transfer (CATT) with stream inventories in the Hunting Creek watershed (Figure 1). Six unnamed tributaries of Hunting Creek on the Enoree Ranger District will undergo various modifications, including channel stabilization, stabilizing bank erosion, floodplain establishment, and riparian plantings (LeMaster, 2008). Our initial inventories in 2008 will collect habitat and fish data on pre-treatment conditions. Follow-up inventories in 2010, 2012, and 2014 will provide post-treatment information. The CATT deployed 1 biologist and 5 technicians to the Enoree Ranger District on the Sumter National Forests from July 7 to 9, 2008 to quantify pre-treatment stream habitat conditions and fish assemblage composition.

Methods

Site Selection

Stream enhancement measures are planned for six unnamed tributaries of Hunting Creek. The majority of the stream enhancements will occur on Tributary E and F; the remaining 4 (A-D) will only see limited stabilization work (Figure 1). Therefore, Tributary E and F were chosen by SNF Fish Biologist, Jeanne Riley, for stream habitat monitoring. Because these tributaries do not maintain a consistent baseflow, sites for fish data collection are located in mainstem Hunting Creek. One of the fish sites is located upstream of the confluences of Tributaries E and F within the mainstem (on South Carolina Department of Transportation land) and the other downstream (on National Forest land) (Figure 1).

Habitat Inventory

Crews performed a modified basinwide visual estimation technique (BVET) habitat inventory (Dolloff et al. 1993). Water in tributaries was mostly underground so habitat attributes within the dry channels were recorded every 50 m rather than for individual habitat units (Appendix).

The following attributes were recorded within the bankfull channel over 50m reaches:

- Distance (m) (50m, 100m, 150m…)
- Dominant and Subdominant Substrate
- Bank Instability (%)
- Large Wood
- Isolated units (pools, glides, riffles…) and the following associated information:
    - Distance at unit start (m)
    - Distance at unit end (m)
    - Wetted width (m)
    - Max depth (cm)
    - Avg depth (cm)
    - Percent fines

At the end of each 50m reach (i.e. each 50m interval) the following attributes were measured:

- Bankfull Channel Width (m)
- Bank Height (m) for both left and right bank

In addition, we noted, photographed, and recorded GPS coordinates for stream features including:

- Waterfalls
- Tributaries
- Side channels
- Braided channels
- Seeps (springs)
- Landslides
- Bridges
- Fords
- Dams
- Culverts

Fish Inventory

Crews electrofished two 100 m reaches on Hunting Creek (Figure 1). We placed block nets at the up and downstream ends of both sites. We performed 3-pass electrofishing using a single Smithroot DC unit at the upstream site and two Appalachian Aquatics (125v AC) units at the downstream site. After each pass we recorded the following for each species: total captures, batch weight, and maximum and minimum length. We paused at least one hour between each pass to allow the water to clear.

Results

The CATT and SNF personnel completed habitat inventories on the two selected tributaries of Hunting Creek (Table 1-3) and fish inventories at two sites on Hunting Creek (Table 4-5). The majority of Tributary E and F were underground (i.e. dry). Tributary E was predominately dry with only isolated pools; 3 pools were located in the first 50 m from the Hunting Creek confluence and 6 were between 550-700 m from the confluence. Only one fish was observed in one of the 6 pools and others contained only tadpoles. Tributary F had a 200 m section, starting 500 m upstream from the confluence, which had pools containing fish. The rest of Tributary F, extending from the confluence to 500 m and then 700 m to the headwater at 1,165 m, was underground. We collected a total of 14 species at the upstream site and 13 at the downstream site in Hunting Creek. Data collected by the CATT can be used to describe current stream condition and serve as a baseline for future comparisons.

Data Availability

Summer 2008 habitat and fish data are ready for migration into the Natural Resource Information System water module (NRIS). We will format the data according to the Regional NRIS Water standards and migrate the data as the new NRIS water module comes online. As data are migrated into NRIS Water the CATT will coordinate development of custom query and reporting tools for the SNF. In the interim, the CATT is available to assist with data analysis and report preparation. Jeanne Riley, SNF Fish Biologist, received a copy of all data in electronic format.

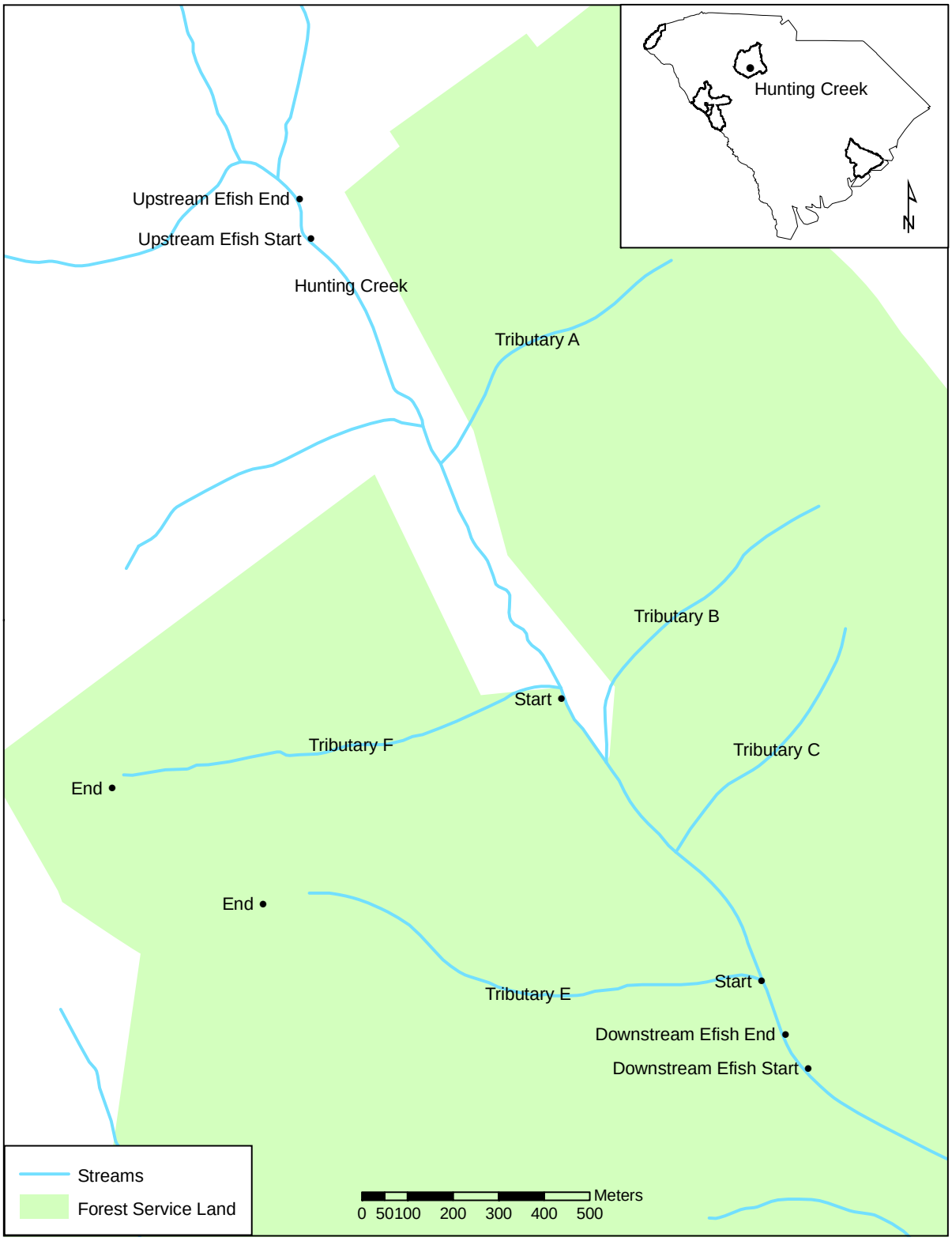


Figure 1. Location of the upstream and downstream electrofishing sites on Hunting Creek and the start and end locations of the BVET inventories on Tributary E and Tributary F (Enoree Ranger District, SC).

Table 1. Summary of channel characteristics inventoried for two unnamed tributaries of Hunting Creek on the Enoree Ranger District.

Channel Characteristics	Tributary E	Tributary F
Sample Size (n)	26	23
Average Bank Instability (%)	16.9	36.7
Average Bankfull Width (m)	1.6	2.7
Average Bank Height (m)	0.9	1.4

Table 2. Number of large wood pieces per kilometer in unnamed tributaries E and F.

Large Wood (pieces per km)	Tributary E	Tributary F
1-5 m long, 10-55 cm diameter	35	41
1-5 m long, > 55 cm diameter	0	2
> 5 m long, 10-55 cm diameter	25	10
> 5 m long, > 55 cm diameter	1	0
Total:	62	53

Table 3. Percent and count of 50 m habitat reaches with specified dominant and subdominant substrate types (see Appendix for substrate size criteria).

	Tributary E				Tributary F			
	Dominant		Subdominant		Dominant		Subdominant	
Substrate	%	n	%	n	%	n	%	n
Organic matter	8	2	23	6	22	5	17	4
Clay	0	0	8	2	0	0	0	0
Silt	0	0	12	3	0	0	0	0
Sand	77	20	19	5	43	10	52	12
Small gravel	15	4	31	8	4	1	9	2
Large gravel	0	0	8	2	22	5	17	4
Cobble	0	0	0	0	0	0	0	0
Boulder	0	0	0	0	0	0	0	0
Bedrock	0	0	0	0	9	2	4	1

Table 4. Count of fish captured in each of 3 electrofishing passes through 100 m of stream at the upstream and downstream site in Hunting Creek. Population estimates with 95% confidence intervals are also shown for species that had descending depletions (Kwak, 1991).

		Upstream Site					Downstream Site				
		Count of Fish			Population Estimate		Count of Fish			Population Estimate	
Species	Scientific Name	Pass 1	Pass 2	Pass 3	N	±	Pass 1	Pass 2	Pass 3	N	±
Bluehead chub	*Nocomis leptocephalus*	55	44	7	119	9	22	4	2	28	1
Bluespotted sunfish	*Enneacanthus gloriosus*	0	0	0	NA	NA	0	0	1	NA	NA
Creek chub	*Semotilus atromaculatus*	69	20	15	112	7	28	11	3	44	3
Creek chubsucker	*Erimyzon oblongus*	67	11	8	88	3	10	2	0	12	0
Eastern mosquitofish	*Gambusia holbrooki*	0	0	0	NA	NA	10	7	2	22	5
Flier	*Centrarchus macropterus*	0	0	1	NA	NA	0	0	0	NA	NA
Golden shiner	*Notemigonus crysoleucas*	0	1	0	NA	NA	0	0	0	NA	NA
Green sunfish	*Lepomis cyanellus*	2	6	4	NA	NA	14	4	3	23	3
Redbreast sunfish	*Lepomis auritus*	120	54	28	226	13	36	21	16	102	19
Redfin pickerel	*Esox americanus americanus*	9	2	0	11	0	3	4	1	NA	NA
Sandbar shiner	*Notropis scepticus*	15	14	3	38	7	10	5	2	19	3
Striped jumprock	*Moxostoma rupiscartes*	5	1	0	6	0	0	0	0	NA	NA
Swallowtail shiner	*Notropis procne*	29	25	10	85	16	17	9	6	40	9
Tessellated darter	*Etheostoma olmstedi*	13	11	5	40	12	7	0	1	NA	NA
Yellow bullhead	*Ameiurus natalis*	2	0	1	NA	NA	1	0	2	NA	NA
Yellowfin shiner	*Notropis lutipinnis*	4	0	0	NA	NA	19	4	0	23	1

Table 5. Count of fish captured (N), batch weight (g), and length (mm) of smallest (min) and largest (max) fish from all 3 electrofishing passes through 100 m of stream at the upstream and downstream site in Hunting Creek.

		Upstream Site				Downstream Site			
		N	Batch	Length (mm)		N	Batch	Length (mm)	
Species	Scientific Name		Wt. (g)	Min	Max		Wt. (g)	Min	Max
Bluehead chub	*Nocomis leptocephalus*	106	253	21	105	28	167	50	110
Bluespotted sunfish	*Enneacanthus gloriosus*	0				1	3	0	55
Creek chub	*Semotilus atromaculatus*	104	451	31	132	42	281	68	126
Creek chubsucker	*Erimyzon oblongus*	86	830	61	145	12	145	51	125
Eastern mosquitofish	*Gambusia holbrooki*	0				19	19	26	55
Flier	*Centrarchus macropterus*	1	23	108	108	0			
Golden shiner	*Notemigonus crysoleucas*	1	7	97	97	0			
Green sunfish	*Lepomis cyanellus*	12	206	53	138	21	89	40	69
Redbreast sunfish	*Lepomis auritus*	202	1525	31	135	73	514	39	128
Redfin pickerel	*Esox americanus americanus*	11	143	81	190	8	73	94	135
Sandbar shiner	*Notropis scepticus*	32	76	44	89	17	46	54	81
Striped jumprock	*Moxostoma rupiscartes*	6	193	140	158	0			
Swallowtail shiner	*Notropis procne*	64	103	42	72	32	43	43	68
Tessellated darter	*Etheostoma olmstedi*	29	34	28	59	8	14	48	70
Yellow bullhead	*Ameiurus natalis*	3	27	46	90	3	55	94	125
Yellowfin shiner	*Notropis lutipinnis*	4	6	37	76	23	38	50	71

Literature Cited

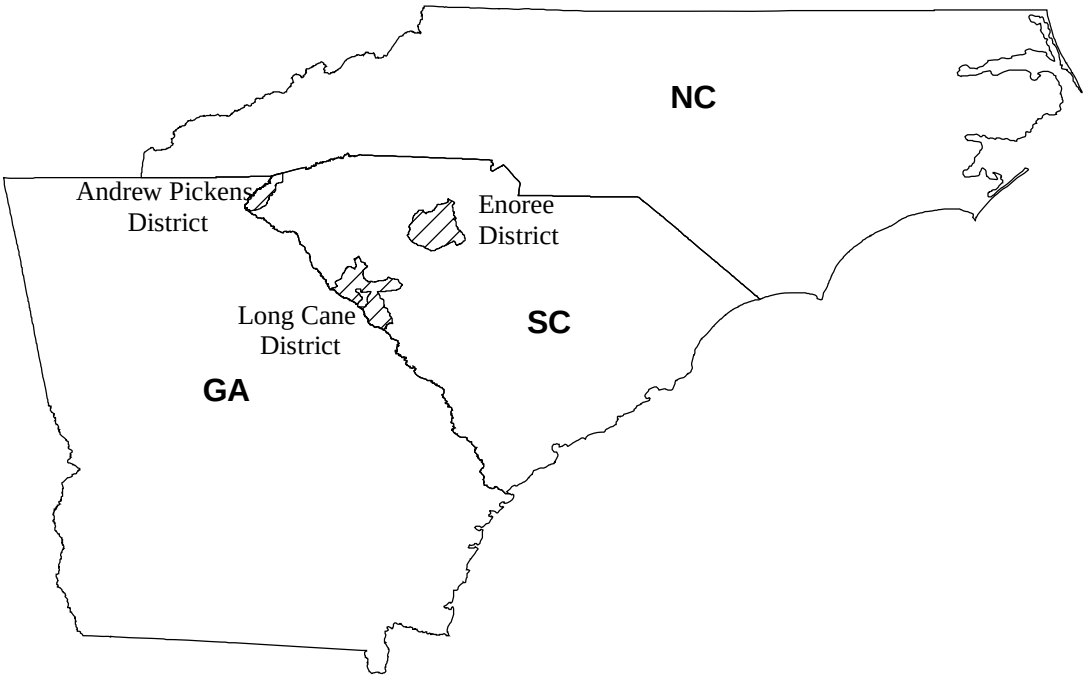
Dolloff, C. A., D. G. Hankin, and G. H. Reeves. 1993. Basinwide estimation of habitat and fish populations in streams. General Technical Report SE-83. Asheville, North Carolina: U.S. Department of Agriculture, Southeastern Forest Experiment Station.

Kwak, T. J. 1991. Modular microcomputer software to estimate fish population parameters, production rates and associated variance. Ecology of Freshwater Fish 1:73-75.

LeMaster, E. L. 2008. Environmental Assessment, Hunting Creek Stream Enhancements. Enoree Ranger District, Sumter National Forest: U.S. Department of Agriculture, Forest Service.

Appendix : Field Methods for Habitat Inventory

Guide to Stream Habitat Characterization using the BVET Methodology in Piedmont and Mountain Streams on the Sumter National Forest, SC



Prepared by:

Craig N. Roghair and Colin Krause

2008

Table of Contents

Introduction

The basinwide visual estimation technique (BVET) is a versatile tool used to assess streamwide habitat conditions in wadeable size streams and rivers. A crew of two individuals performs the survey using two-stage visual estimation techniques described in Hankin and Reeves (1988) and Dolloff et al. (1993). In its most basic form the BVET combines visual estimates with actual measurements to provide a calibrated estimate of stream area with confidence intervals, however the crew may inventory any number of other habitat characteristics as they walk length of the stream. Experienced crews can survey an average of 2.0 – 3.0 km per day, but this will vary depending on stream size and the number of stream characteristics inventoried.

Before a crew begins a BVET survey they must receive adequate training, both in the classroom and in the field. Estimating and measuring a large number of habitat characteristics can confuse and overwhelm an inexperienced crew. Individuals must have an understanding of the basic concepts behind the BVET and be familiar with habitat characteristics before they can effectively and efficiently perform a survey.

The USFS Center for Aquatic Technology Transfer (CATT) has been working directly with resource managers on the Sumter National Forest (SNF) since the 2001 to implement BVET surveys and adapt them to the Forest's specific needs. More than 15 habitat characteristics are currently estimated or measured during SNF BVET habitat surveys. We review the survey annually and add and remove attributes as needed to maximize efficiency and relevancy with regards to emerging techniques and Forest issues. Changes are made only after careful review to ensure consistency with data collected in the past. See 'Changes to BVET survey for 2004' for a list of survey changes.

This document was developed to serve as a guide for classroom and field instruction for the SNF BVET habitat survey and to provide a post-training reference for field crews. It includes an overview of the BVET survey, defines habitat characteristics, instructs how to measure and when to record characteristics, and provides reference sheets for use in the field. Each trainee should receive a copy of this manual and is encouraged to take notes in the spaces provided.

References cited in this manual:

Armantrout, N. B., compiler. 1998. Glossary of aquatic habitat inventory terminology. American Fisheries Society, Bethesda, Maryland.

Dolloff, C. A., D. G. Hankin, and G. H. Reeves. 1993. Basinwide estimation of habitat and fish populations in streams. General Technical Report SE-83. Asheville, North Carolina: U.S. Department of Agriculture, Southeastern Forest Experimental Station.

Hankin, D. G., and G. H. Reeves. 1988. Estimating total fish abundance and total habitat area in small streams based on visual estimation methods. Canadian Journal of Fisheries and Aquatic Sciences 45:834-844.

Rosgen, D.L. 1996. Applied River Morphology. Wildland Hydrology Books, Pagosa Springs, Colorado.

Changes to BVET survey in 2008

Inventory modified for dry streams to increase number of attributes data is collected for.

Other minor changes, mostly modifications in terminology and definitions to provide increased clarity, are found throughout the manual.

Outline of BVET Habitat Survey

The survey is comprised of the following steps:

1) Enter 'header' information in the data sheet
    - 'Header' information includes date, stream, start location, crew, etc. and is **vitally** important to record for future reference

2) Select an appropriate measurement interval and a random number
    - In streams < 1.0 km measure every 5^{th} unit (random number 1-5), in streams > 1.0 km measure every 10^{th} unit (random number 1-10)
    - The random number designates the first habitat unit (i.e. the n^{th} unit) in which the crew will perform measurements

3) Enter downstream of the starting point, then move upstream and begin the survey
    - Tie off the hipchain, proceed upstream to the starting point, reset the hipchain to zero, and proceed upstream estimating parameters and recording data in every habitat unit

4) At the n^{th} unit perform visual estimates, then perform measurements
    - If the random number '3' were chosen, the crew would stop after making estimates in the 3^{rd} pool (and 3^{rd} riffle) and perform the necessary measurements

5) Progress upstream estimating characteristics for every unit until the next n^{th} unit is reached, then repeat step 4
    - In the above example, if the interval were 10 units, the crew would stop at the 13^{th}, 23^{rd}, 33^{rd}, etc. pool (and 13^{th}, 23^{rd}, 33^{rd}, etc. riffle) and repeat measurements done in pool 3 and riffle 3.
    - The crew should also take care to record roads, trails, tributaries, dams, waterfalls, road crossing types, riparian features (wildlife openings, trails, campsites, roads, timber harvest, etc.), and other pertinent stream features as they progress upstream. Be sure to record hipchain distances when noting such features.

Repeat steps 4 and 5 until the end of the stream is reached.

The following sections describe the BVET habitat survey in detail:

Section 1: Getting Started – equipment lists, header information, random numbers, starting the survey

Section 2: Habitat Characteristics – definitions, how to estimate or measure, when to record

Section 3: Wrapping Up – what to do when the survey is completed

Appendix: field guide, random number tables, equipment checklist

Section 1: Getting Started

Equipment List

hipchain	compass
extra string for hipchain	backpack
wading rod	pencils
50 m tape measure	flagging
clinometer	markers
thermometer	waterproof backup datasheets
convex densiometer	clipboard
datalogger	BVET manual and field guide
GPS unit	felt bottom wading boots or waders
topographic map	

Other useful equipment: lunch, water, water filter, 1st aid kit, toilet paper, rain gear, radio/cell phone

The crew consists of two individuals, the 'observer' and the 'recorder'. The observer wears the hipchain and carries the wading rod. The recorder wears the data logger and carries other equipment in the backpack. The duties of each individual are listed below.

Duties

Observer	Recorder
Designate habitat units	Record data
Measure distance	Determine n^{th} unit location
Estimate width	Classify and count LWD
Estimate depths	Document features
Classify substrates	
Estimate percent fines	
Estimate bank instability	

Both crew members are needed to measure actual widths, channel widths, riparian widths, bank height, canopy cover, water temperature, and gradient at designated units. Although the crew has assigned duties, they should not hesitate to consult with each other if they have questions or feel that a mistake may have been made. Working as a team will provide the best possible results.

Header Information

Header information is **vitally important** for future reference. Take the time to record all categories completely and accurately.

Stream Name	Full name of stream
District	National Forest District name
Quad	USGS 1:24,000 quadrangle name
Date	Record date(s) of survey
Recorder	Full name of recorder
Observer	Full name of observer
GPS	coordinates at survey start and end, always record in NAD27 CONUS, UTM
Start Location	**Detailed** written description of start point
Notes	Record signs of activity in area, water conditions, other pertinent information

Random Numbers

Before beginning the survey, select a number from a random numbers table (see Appendix) to determine the first habitat unit at which to make measurements. For long surveys (> 1.0 km) select a random number between 1 and 10 (i.e. measure every 10 unit), for shorter streams use a number between 1 and 5 (i.e. measure every 5^{th} unit). See the appendix for random numbers tables.

The crew needs to measure units more frequently during shorter surveys to provide enough paired samples for data analysis. Paired samples are units in which both visual estimates and actual measurements are made. The more paired samples, the tighter the confidence intervals for stream area estimates.

After the crew records a paired sample they continue upstream making visual estimates and stopping to make additional measurements at the pre-determined interval. For example, if the random number was 3 and the crew was measuring every 5^{th} unit, the crew would make measurements on the 3^{rd} pool and 3^{rd} riffle and then every 5^{th} pool and riffle thereafter (8, 13, 18, 23, etc).

Starting the Survey

After the crew has organized their gear, determined their measurement interval, selected a random number, and recorded all the header information they are ready to begin the habitat survey. The observer should enter the stream slightly downstream of the starting point, tie off the hipchain, progress upstream to the starting point, reset the hipchain to zero and begin walking upstream through the first habitat unit. As the observer moves upstream they use the wading rod to measure depth at several locations in the habitat unit and make observations of unit type, width, substrates, embeddedness, and bank instability. When they reach the upstream end of the habitat unit they stop, report the distance, then turn to face the unit and report the unit type, estimated width, maximum and average depth, riffle crest depth (where appropriate), dominant and subdominant substrate classes, percent embeddedness, and bank instability to the recorder.

As the observer moves upstream through the unit, the recorder follows behind, recording the amount of LWD in the habitat unit. The recorder also assigns a number to the habitat unit. The recorder tells the observer if a unit is designated for measurements (i.e. if it is the n^{th} unit) only after they have recorded visual estimates.

The crew continues upstream making estimates in every habitat unit and making estimates and measurements in every n^{th} unit until the survey endpoint is reached.

Definitions of habitat characteristics, how to measure and when to record them, and what to do when the survey is complete are covered in the following sections.

Section 2: Stream Attributes

Unit Type (see abbreviations)

Definitions:*

Unit Type	Abbreviation	Definition
Riffle	**R**	**Fast water, turbulent, gradient <12%**; shallow reaches characterized by water flowing over or around rough bed materials that break the surface during low flows; also **include rapids** (turbulent with intermittent whitewater, breaking waves, and exposed boulders), **chutes** (rapidly flowing water within narrow, steep slots of bedrock), and **sheets** (shallow water flowing over bedrock) if gradient <12%
Cascade	**C**	**Fast water, turbulent, gradient ≥12%**; highly turbulent series of short falls and small scour basins, with very rapid water movement; also **include sheets** (shallow water flowing over bedrock) and **chutes** (rapidly flowing water within narrow, steep slots of bedrock) if gradient ≥12%
Run	**RN**	**Fast water, non-turbulent, gradient <12%**; deeper than riffles with little or no surface agitation or flow obstructions and a flat bottom profile
Pool	**P**	**Slow water, surface turbulence may or may not be present, gradient <1%**; generally deeper and wider than habitat immediately upstream and downstream, concave bottom profile; **includes dammed pools, scour pools, and plunge pools**
Glide	**G**	**Slow water, no surface turbulence, gradient <1%**; shallow with little to no flow and flat bottom profile
Swamp	**S**	Channel poorly defined or non-existent, water dispersed across wide area
Underground	**UNGR**	Stream channel is dry or not containing enough water to form distinguishable habitat units

*modified from Armantrout (1998)

How to estimate:
Habitat units are separated by 'breaks'. Breaks can be obvious physical barriers, such as a debris dam separating two pools or a small waterfall separating a pool and riffle, or may be less obvious transitional areas. Questions often arise as to whether a break is substantial enough to split two habitat units and where the exact location of the break occurs. When in doubt, the observer should consult with the recorder and the team should 'think like a fish'. To determine if a break should be made, consider whether a fish would have to make an effort to move across the break and into the next habitat unit. If not, then it is probably a single habitat unit.

The channel may have both pool and riffle type habitat in the same cross-sectional area. Determine the predominate habitat type and record it as the unit type. For example if an area contains both pool and riffle, but the majority of the flow is into and out of the pool habitat, then call a pool.

Questions also often arise as to the minimum size of individual habitat units. Generally, if a habitat unit is not at least as long as the wetted channel is wide, then do not count it as a separate habitat unit. This rule may need to be adjusted for streams wider than 5 m. Use best professional judgment in such cases.

See the section 2.1 for a list of features that should also be recorded while performing the survey.

When to record: every habitat unit

Unit Number (#)

Definition:
Count of habitat units of similar types, used to determine location of n^{th} units

How to estimate:
When counting habitat units, group pools and glides (slow water) together, and group riffles, runs, and cascades (fast water) together. For example, consider the following series of habitat units:

Pool – Riffle – Pool – Pool – Riffle - Cascade – Riffle - Glide – Riffle – Pool – Run – Pool – Riffle

Habitat units in this series would be counted in the following manner (similar types are shaded same color):

Unit Type	Unit Number
P	1
R	1
P	2
P	3
R	2
C	3
R	4
G	4
R	5
P	5
RN	6
P	6
R	7

In the above example, the crew has counted six slow water (pool/glide) units and seven fast water (riffle/run/cascade) units.

If '3' were chosen as the random number, the crew would estimate and then measure habitat data for Pool 3 and Cascade 3. When the crew reaches pool or glide 13 and riffle, run, or cascade 13, they would repeat procedures followed in the 3^{rd} units.

When to record: every habitat unit

Distance (m)

Definintion:
Number of meters from the start of the survey to the upstream end of the habitat unit or distance from the start of the survey to upstream end of a feature, used as spatial reference for data analysis and to locate features in the future.

How to estimate:
The observer walks upstream in the middle of the stream channel with a hipchain measuring device. When they reach the upstream break between habitat units or the upstream end of a feature they stop and report the distance to the recorder.

Care should be taken to keep the hipchain string in the middle of the stream, especially around bends and meanders. If the hipchain should break, retreat to the location where the break occurred, tie off the hipchain, and continue. If the hipchain is reset for any reason be sure to note it in the comments.

When to record: every habitat unit or feature

Estimated Width (m)

Definition:
Average wetted width of the habitat unit as estimated visually, used to calculate stream area. Wetted width is the distance from the edge of the water on one side of the main channel to the edge of the water on the opposite side of the main channel.

How to estimate:
The observer notes the general shape and width of the unit while walking to the upstream end. When they reach the upstream end of the unit the observer stops, turns to face the unit, and estimates the average wetted width. Measure the wetted width of the stream before starting each day to calibrate yourself.

When to record: every habitat unit

Maximum and Average Depth (cm)

Definitions:
Maximum Depth – vertical distance from substrate to water surface at deepest point in habitat unit
Average Depth – average vertical distance from substrate to water surface in habitat unit

How to estimate:
The observer uses a wading rod marked in 5 cm increments to measure water depth as they walk upstream through the habitat unit. Water depth in deepest spot is recorded as the maximum depth. Average depth is the average of several depth measurements taken throughout the habitat unit.

When to record: every habitat unit

Riffle Crest Depth (cm)

Definition:
Vertical distance from the substrate to the water surface at the deepest point in the riffle crest. The riffle crest is the shallowest continuous line (usually not straight) across the channel where the water surface becomes continuously riffled in the transition area between a riffle (or a run or cascade) and a pool (or glide) (Armantrout 1998); think of it as the last place water would flow out of the pool if the riffle ran dry.

How to estimate:
When the observer reaches the upstream end of a riffle (or a run or cascade) leading into a pool (or glide), they use the wading rod to measure the deepest point in the riffle crest. Record the depth in the RCD column for the riffle habitat row.

When to record: at the upstream end of any riffle, run, or cascade leading into a pool or glide

Dominant and Subdominant Substrate (1-9)

Definitions:
Dominant Substrate: size class of material that covers the greatest amount of surface area in the wetted channel of the habitat unit
Subdominant Substrate: size class of material that covers the 2nd greatest amount of surface area in the wetted channel of the habitat unit

How to estimate:
The following size classes are used to categorize substrates*. The substrate 'Number' is entered into the dominant and subdominant substrate columns on the datasheet.

Type	Number	Size (mm)	Description
Organic Matter	1		dead leaves, detritus, etc. – **not live plants**
Clay	2		sticky, holds form when rolled into a ball
Silt	3		slippery, does not hold form when rolled into a ball
Sand	4	silt – 2	grainy, does not hold form when rolled into ball
Small Gravel	5	3-16	sand to thumbnail
Large Gravel	6	17-64	thumbnail to fist
Cobble	7	65-256	fist to head
Boulder	8	>256	larger than head
Bedrock	9		solid rock, parent material, may extend into bank

** these size classes are based on the modified Wentworth scale*

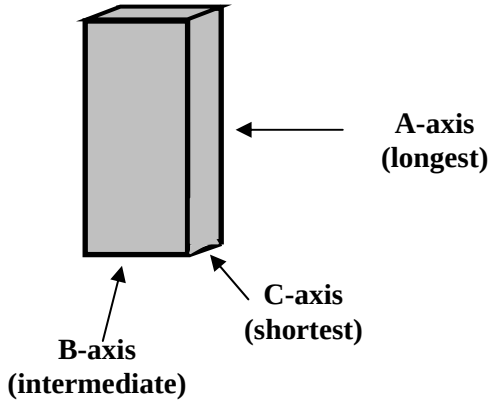
As the observer walks through the unit they scan the substrate. When they reach the upstream end of the unit they stop, turn to face the unit, and determine the dominant and subdominant substrate classes.

Estimate substrate size along the intermediate axis (b-axis). The b-axis is not the longest or shortest axis, but the intermediate length axis (see below). It is the axis that determines what size sieve the particle could pass through. Remember that your eyes are naturally drawn to larger size substrates. Be careful not to bias your estimate by focusing on the large size substrate.

Some units will contain a mixture of particle sizes. Consult with the recorder and use your best professional judgment to choose the dominant and subdominant sizes.

In units where the substrate is covered in moss, algae, or macrophytes classify the underlying substrate and make note of the plant growth in the comments. Only call organic substrate where there is dead and down leaves or other detritus covering the bottom of the unit.

When to record: every habitat unit



Percent Fines (%)

Definition:
Percent of the total surface area of the stream bed in the wetted area of the habitat unit that consists of sand, silt, or clay substrate particles (i.e. particles < 2 mm diameter).

How to estimate:
As the observer walks through the habitat unit they note the amount of sand, silt, and clay in the habitat unit. When they reach the upstream end of the unit, they stop, turn to face the unit and estimate the amount of the total surface area within the wetted channel that consists of sand, silt, or clay.

Where to estimate: every habitat unit

Bank Instability (%)

Definition:
Percent of bank material between the edge of the wetted channel and the top of the bankfull channel that consists of exposed erodible materials, estimated separately for left and right banks (left and right as looking upstream). Erodible materials are any material that is part of the bank structure that may become mobile during bankfull flows, for example: clay, silt, sand, or soil not held in place by rooted vegetation.

How to estimate:
As the observer walks through the habitat unit or section they note areas containing exposed erodible bank materials. When they reach the upstream end of the unit they stop, turn to face the unit, and estimate the percent of left and right banks that consist of exposed erodible materials

When to record: every habitat unit

Large Wood (1-4 and rootwad)

Definition:
Count of dead and down wood within the bankfull channel of a habitat unit

How to estimate:
The recorder classifies and counts LW as they walk through the habitat unit. LW counts are grouped by the size classes listed below:

Category	Length (m)	Diameter (cm)	Description
1	<5	10-55	short, skinny
2	<5	>55	short, fat
3	>5	10-55	long, skinny
4	>5	>55	long, fat
RW	rootwad	rootwad	roots on dead and down tree

Only count woody debris that is:
- > 1.0 m in length and > 5.0 cm in diameter
- within the bankfull channel
- fallen, not standing dead

- Count rootwads separately from attached pieces of LW
- Estimate the diameter of LW at the widest end of the piece
- A piece that is forked, but is still joined counts as only one piece of LW
- Only count each piece one time, do not count a piece that is in two habitat units twice
- Enter the total count for each size category into the appropriate column on the datasheet

Where to estimate: every habitat unit

Actual Width (m)

Definition:
Average wetted width of the habitat unit as measured with 50 m tape, used to calculate stream area. Wetted width is the distance from the edge of the water on one side of the main channel to the edge of the water on the opposite side of the main channel.

How to measure:
Use a meter tape to measure the wetted width of the stream in at least three locations. Average the measurements to obtain the average wetted width.

Where to measure: n^{th} habitat units

Bankfull Channel Width (m)

Definition:
Average width of channel at bankfull elevation as measured with meter tape. Depending on channel type, bankfull may or may not be represented by the top of the banks. Use bankfull indicators to locate the top of the bankfull channel (Rosgen 1996).

How to measure:
Determine the location of bankfull water depth on both banks of the habitat unit and measure across the channel perpendicular to flow from bankfull to bankfull. Make at least three measurements across the bankfull channel.

Where to measure: n^{th} riffles, runs, or cascades

Riparian Width (m)

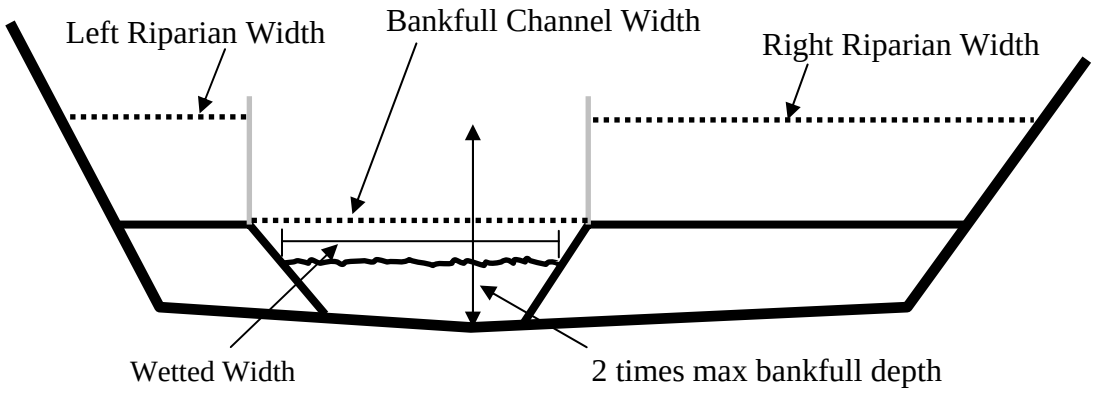
Definition:
Width of the riparian area at an elevation of two times the maximum bankfull depth, measured for both left and right banks (left and right as oriented facing upstream). Maximum bankfull depth is the greatest vertical distance from the substrate to the top of the bankfull channel across a bankfull transect.

How to measure:

1. Stretch a measuring tape across the top of the bankfull channel – this is your bankfull transect
2. Use a wading rod to find the maximum bankfull depth
3. Place the clinometer against the wading rod at two-times the maximum bankfull depth
4. Using the clinometer to maintain a slope of zero degrees, site perpendicular to the channel to the intersection with the nearest landform. It may be necessary to site to an intermediate point, move the wading and clinometer, and site again if the tape measure is too short or the view is obstructed
5. Measure the distance from the edge of the bankfull channel to the landform – do this separately for the left and right (as facing upstream) riparian areas

Note: if riparian width is more than 50 m, record 51 as the riparian width and note in 'Comments' that riparian width was longer than meter tape

Where to measure: n^{th} riffles, runs, or cascades



Bank Height (m)

Definition:
Vertical distance from edge of bankfull channel to top of bank, measured for both left and right (as facing upsteam) banks

How to measure:
Measure with wading rod or tape measure the vertical distance from the edge of the bankfull channel to the top of the bank (these will be different in entrenched channels), record left and right banks separately

When to record: n^{th} riffles, runs, or cascades

Canopy Cover (%)

Definition:
Percent of overhead area covered by tree canopy, measured with convex spherical densiometer

How to measure:

1) stand in center of stream channel with the densiometer laid flat in palm of hand
2) count the number of squares that are completely covered by canopy
3) add in the squares that are partially covered
4) multiply by four to get percent canopy cover (there are approximately 25 squares on the densiometer)
    - For example, if 3 squares were completely covered, 8 squares were half covered, and 12 squares were a quarter covered and the correction factor were 4, then the percent canopy cover would be (3+4+3)*4 = 40%.

Be sure to consult the densiometer instructions for variations in use and correction factors between different densiometer manufacturers

When to record: n^{th} riffles, runs, or cascades

Water Temperature (C)

Definition:
Temperature of the water in degrees Celsius.

How to measure:
Place the thermometer in moving water in an area not exposed to direct sunlight. Leave the thermometer sit for at least three minutes, then record the water temperature in degrees Celsius.

Where to measure: n^{th} riffles, runs, or cascades

Gradient (%)

Definition:
Change in vertical elevation per unit of horizontal distance of the water surface (Armantrout 1998)

How to measure:
Gradient is measured in riffles with a clinometer using the following steps:

1) observer stands at upstream end of riffle, recorder stands at downstream end of riffle
2) recorder sites upstream to the height of their eye on the observer using clinometer
3) record the **percent** slope, **not the degrees** (tip the clinometer all the way back to determine which side of the scale is percent)

The recorder should determine the height of their eye on the obsrever at the beginning of the survey. Be certain that the observer and recorder are standing with their feet in the same position (preferably with feet at top of water surface) within the stream channel. If the observer is standing on top of a boulder and the recorder is standing in a depression, the measured gradient will be incorrect.

Where to measure: n^{th} riffles, runs, or cascades

Features

Definition: points on a stream that could potentially serve as landmarks, may be natural or manmade

How to measure: record the distance to the upstream end of a feature; measure characteristics of features and record them in the 'Comments' section of datasheet

When to record: wherever found, record distance to most upstream point of feature

Feature	Abbreviation	What to Record
Channel Features		
Waterfall[1]	**FALL**	Distance, estimated height
Tributary	**TRIB**	Distance, average wetted width, into main channel on left or right (as facing upstream)
Gully[2]	**GU**	Distance, width, bank height, on left or right (as facing upstream)
Side channel[3]	**SCH**	Distance, average wetted width, whether it is flowing into or out of main channel on left or right (as facing upstream)
Braid[4]	**BRD**	Distance at start and distance at end; continue with normal survey up channel with greatest discharge
Seep (Spring)	**SEEP**	Distance, left or right bank (as facing upstream), size, coloration
Landslide	**SLID**	Distance, left or right bank (as facing upstream), estimated size
Crossing Features		
Culvert[5]	**V**	Distance, length, type (single pipe, cement box, etc.), size (diameter or height), road or trial name and type (gravel, paved, unpaved horse trail, ATV, etc.), perched or not perched, slope
Bridge	**BRG**	Distance, width, height, road or trail name and type (gravel, paved, dirt, horse, ATV, etc.)
Ford	**FORD**	Distance, road or trail name and type (gravel, paved, dirt, horse, ATV, etc.)
Dam	**DAM**	Distance, type, condition, estimated height, dam use, name of road or trail, if applicable; include beaver dams
Other	**OTR**	Distance, description of feature not listed above, example: found water intake pipe going to house here; old burned out shack on side of stream; Big Gap campground on left; alligator slide here, etc.

1 must be vertical with water falling through air to be a waterfall and not a cascade, do not record unless >1m high
2 narrow channel formed by rapid erosion, may be several meters deep, carry water only during and immediately after rain, perennial flowing channels should be recorded as tributaries-note that they are entrenched in 'Comments'
3 two channels, continue with normal survey up channel with most volume
4 three or more channels intertwined, continue with normal survey up channel with most volume
5 continue with normal survey through culverts, if you can't walk through it then determine the habitat type, water depth, substrate (if any; you can leave substrate blank on culverts if none present, note this in comments), etc. by looking into the pipe and walk over the top of it with the hipchain

The abbreviation is recorded in 'Unit Type' and other information is recorded in appropriate location on datasheet or in 'Comments'. Features are not assigned a unit number. These features serve as landmarks for future surveys and can be important in data interpretation. Crews are encouraged to use the 'Comments' and 'Other' to help fully describe stream conditions.

We cannot stress enough the importance of fully and accurately describing features. This means getting out a quadrangle map and finding road, trail, and tributary names and recording them in 'Comments' and taking the time to describe the location of features in relation to landmarks found on quadrangle maps.

Section 3: Dry Stream

If the stream is dry the inventory will change from a habitat unit based approach to a reach approach. Data is collected over 50m reaches and at each 50m interval additional attributes are measured.

The following attributes will be recorded over 50m reaches:

- **Unit Type** is recorded as Underground
- **Distance (m)** (50m, 100m, 150m…)
- **Dominant and Subdominant Substrate**
- **Bank Instability (%)**
- **Large Wood**
- **Features**
- **Isolated units** (pools, glides, riffles…) should be recorded in the comments along with the following information
    - Distance at unit start (m)
    - Distance at unit end (m)
    - Wetted width (m)
    - Max depth (cm)
    - Avg depth (cm)
    - Percent fines

At the end of each 50m reach (i.e. each 50m interval) the following attributes are measured:

- **Bankfull Channel Width (m)**
- **Bank Height (m)** for both left and right bank

Section 4: Wrapping Up

End the survey where:

- Forest Service property ends
- stream is dry for more than 1000 m
- stream channel is < 1.0 m wide for more than 500 m

Record the following in the Comments:

- Time and date
- Reason for ending the survey
- GPS coordinates
- Detailed written description of location using landmarks for reference

** be sure the header information is completed **

When you return to home base:

- Immediately download the data and check file to be sure all data downloaded
- Check header information to be sure it is complete
- Note in all files if more than one file was used during the survey
- Save to the computer and create a backup copy
- If using paper, make a photocopy of the data and store in secure location
- Record on master list that survey is complete, with data and names of crewmembers

Section 5: Summary

Before starting, determine interval, select random number, fill in header information

Record for every habitat unit:

- Reach Number – when entering a new reach
- Unit Type
- Unit Number
- Distance
- Estimated Width
- Maximum Depth
- Average Depth
- Dominant Substrate
- Subdominant Substrate
- Rosgen Channel Type
- Percent Fines
- Bank instability
- Large Woody Debris

Record for every riffle, run, or cascade leading into a pool or glide:

- Riffle Crest Depth

Record for every n^{th} pool:

- Measured Width

Record for every n^{th} riffle:

- Measured Width
- Channel Width
- Riparian Width (left and right)
- Bank height
- Gradient
- Water temperature

Record features and full feature descriptions wherever they are encountered.

When end of survey is reached, record reason for ending, date, and time, be sure data is saved in safe location, and record survey start and end points on master maps.

Appendix: Field Guide, Random Numbers Table, Equipment Checklist

Record for every habitat unit:

Unit Type: pool, riffle, run, cascade, glide, feature (see below)
Unit Number: group pools & glides; group riffles, runs, cascades
Distance: (m) at upstream end of unit
Estimated Width: (m) visual estimate of average wetted width
Maximum Depth: (cm) deepest spot in unit
Average Depth: (cm) average depth of unit
Dominant Substrate: (1-9) covers greatest amount of surface area in unit
Subdominant Substrate: (1-9) covers 2nd most surface area in unit
Percent Fines: (%) percent of bottom consisting of sand, silt, or clay
Bank Instability (L & R): (%) percent of bank with exposed erodible material between wetted and bankfull
Large Woody Debris: (1-4) count of dead and down wood in the bankfull channel

Record in every riffle, run, or cascade leading into a pool or glide:

Riffle Crest Depth: (cm) maximum depth in riffle crest between riffle and pool, last place water would run out of pool if riffle ran dry

Record for every nth pool:

Actual (**Measured) Width:** (m) measurement of average wetted width

Record for every nth riffle, run, or cascade:

Actual (**Measured) Width:** (m) measurement of average wetted width
Bankfull Channel Width: (m) measurement of bankfull channel width
Riparian Width: (L&R) (m) measurement of floodplain
Bank Height: (m) vertical distance from bankfull to top of bank
Gradient: (%) slope of the water surface from upstream to downstream end of riffle
Canopy Cover: (%) percent of overhead area covered by tree canopy, measured with densiometer
Water Temperature: (C) temperature of water in main channel

Unit Types

Riffle (R) fast water, turbulent, gradient <12%; includes rapids, chutes, and sheets if gradient <12%
Cascade (C) fast water, turbulent, gradient ≥12%, includes sheets and chutes if gradient ≥12%
Run (RN) fast water, little to no turbulence, gradient <12%, flat bottom profile, deeper than riffles
Pool (P) slow water, may or may not be turbulent, gradient <1%, includes dammed, scour, and plunge pools
Glide (G) slow water, no surface turbulence, gradient <1%, shallow with little flow and flat bottom profile
Swamp (S) channel poorly defined or non-existent, water dispersed across wide area
Underground (UNGR) distance at upstream end, why dry

Stream Features

Waterfall (FALL) distance, height
Tributary (TRIB) distance, width, in on L or R
Gully (GU) distance, width, bank height, on L or R
Side Channel (SCH) distance, width, in or out on L or R
Braid (BRD) distance at downstream and upstream ends
Seep or Spring (SEEP) distance, on left or right, amount of flow
Landslide (SLID) distance, L or R, est. size and cause
Culvert (V) distance, type, size, road or trail name & type
Bridge (BRG) distance, height, width, road or trail name & type
Dam (DAM) distance, type, est. height, road or trail name &type
Ford (FORD) distance, road or trail name & type
Other (OTR) record distance, describe feature in comments

Substrates

1. **Organic Matter**, dead leaves detritus, etc., not living plants
2. **Clay**, sticky, holds form when balled
3. **Silt**, slick, does not hold form when balled
4. **Sand**, >silt-2mm, gritty, doesn't hold form
5. **Small Gravel**,3-16mm, sand to thumbnail
6. **Large Gravel**, 17-64mm, thumbnail to fist
7. **Cobble**, 65-256mm, fist to head
8. **Boulder**, >256, > head
9. **Bedrock**, solid parent material

Large Woody Debris

1. <5m long, 10-55cm diameter
2. <5m long, >55cm diameter
3. >5m long, 10-55cm diameter
4. >5m long, >55cm diameter

rootwad – count separately from attached LWD and record in comments

wood must be >1.0m long, >5cm diameter to be counted

Measuring Riparian Width

Place clinometer against the wading rod at two times max bankfull depth
Use the clinometer as a level – keep the slope at 0.0 – and site to the nearest landform perpendicular to the channel
Measure the distance from the edge of the bankfull channel to the intersection with the landform
Do this for both the left and right banks
If riparian width in more than 50 m, record 51 as the riparian width and in 'Comments' note that riparian was > 50 m wide

End survey

Where stream is less than 0.5 m wide for more than 500 m, where the channel runs dry for more than 500 m, is swamp for more than 500 m or where forest boundary is reached. Comment on why survey was ended. Record time of day, detailed description of location, and GPS coordinates at endpoint, and be sure all header info is filled in on datasheets.

Random numbers for measuring every 5th unit

4	3	5	1	5	1	2	5	2	3
2	5	2	5	2	2	1	5	4	1
3	2	5	1	2	1	3	1	5	3
5	4	1	5	1	3	5	4	2	5
4	2	2	5	2	2	5	5	2	1
4	2	5	2	2	4	5	5	5	2
3	5	4	1	5	1	4	1	3	3
1	4	2	2	1	4	3	1	5	3
5	4	3	3	2	4	1	2	5	1
4	4	1	1	3	5	1	5	5	4

Random numbers for measuring every 10th unit

3	7	10	5	1	2	2	7	10	6
4	2	3	8	9	2	4	4	6	9
3	3	8	4	3	9	9	7	5	5
1	3	5	5	2	6	5	2	2	6
3	7	8	6	3	8	8	5	2	10
10	9	6	9	4	3	10	7	2	10
6	10	5	4	8	10	4	1	4	10
4	3	4	3	2	3	4	4	3	7
5	1	7	9	7	3	10	7	10	3
9	6	8	6	2	2	1	9	10	5

Choose a new random number at the beginning of each stream survey
Use the number for the entire stream
Use the first table for streams < 1.0 km long, the second table for streams >1.0 km long

Equipment Checklist

hipchain
extra string for hipchain
wading rod
tape measure
clinometer
thermometer
convex densiometer
datalogger
backup battery for datalogger
GPS unit
backpack
pencils
flagging
markers
waterproof backup datasheets
clipboard
BVET manual
BVET field guide on waterproof paper
topographic maps
compass
water
water filter
lunch
first aid kit
radio/cell phone
toilet paper
felt bottom wading boots
raingear

Remember the following for the start of each new stream or reach:

- Select a random number
- Determine measuring interval
- Fill in header information completely