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Status and Trends Monitoring for Watershed Health & Salmon Recovery: Field Data Collection Protocol

Wide Streams and Rivers

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Status and Trends Monitoring for Watershed Health & Salmon Recovery: Field Data Collection Protocol

Wide Streams and Rivers

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Introduction

Background

Purpose of this Document

This document serves as an instruction manual. It is intended for field crews that sample large streams and rivers for Washington's *Monitoring for Watershed Health & Salmon Recovery* program (WHSR). This manual complements a separate document that describes methods for sampling narrow (wadeable) streams (Merritt 2009). Wide rivers and streams are those that are determined to be larger than 25 m wide at the bankfull stage or those that are only accessible for sampling by using a boat. This protocol is applied by floating downstream with rafts. For wide, shallow streams it is applied by wading upstream. WHSR is designed to assess streams and rivers on non-federal lands of the state over 4-year periods, with an average of 2 Status and Trends Regions (STRs) sampled annually. Sampling began in 2009 with the Puget Sound STR.

History

In the last decade, there has been a growing interest in establishing statewide monitoring program for gathering consistent and integrated information on chemical, physical, and biological habitat. This is largely a result of federal mandates. For example, section 4(f)(1)(B) of the Endangered Species Act (ESA) indicates that de-listing requires an explicit analysis of the physical or biological conditions that affect the species' continued existence (NOAA 2007). The Clean Water Act (CWA, Section 101(a)) states: "The objective of this Act is to restore and maintain the chemical, physical, and biological integrity of the Nation's waters." WHSR is a response.

The 2001 Washington State Legislature passed Substitute Senate Bill 5637 requiring the development of a comprehensive strategy and action plan for measuring our success in recovering salmon and maintaining watershed health. This led to the development of *The Washington Comprehensive Monitoring Strategy for Watershed Health and Salmon Recovery* (MOC 2002). This *Comprehensive Monitoring Strategy* calls for a statewide approach using several types of monitoring. Extensive (status and trends) monitoring is first on the list.

In 2005, the Salmon Recovery Funding Board (SRFB) provided support to the Department of Ecology (Ecology), the Department of Fish and Wildlife (WDFW) and the Conservation Commission (CC) for development of a sampling framework and Quality Assurance Monitoring Plan (QAMP; Cusimano et al. 2006). The framework and QAMP were developed through a series of public workshops (http://www.ecy.wa.gov/programs/eap/stsmf/).

In 2008, the Washington State Legislature provided start-up funding to the Puget Sound Partnership (PSP) to prepare for a 2009 field monitoring season in 2 of the 8 regions as proposed by the QAMP. Ecology was then tasked, through an Interagency Agreement with the PSP, to provide this manual and a database system, based on the QAMP.

Program Goal

The goal of WHSR is to provide quantitative, statistically valid, and consistent estimates of the status and trends in physical, chemical, and biological conditions of Washington's rivers and streams. The data collected can be used to report on the health of salmonid habitat. Reports that can use this data include:

- State of the Salmon in Watersheds Reports (GSRO 2009)
- Pacific Coastal Salmon Recovery Fund, Reports to Congress (NOAA 2009a)
- CWA Integrated Assessment (EPA 2006)

Monitoring Objectives

Monitoring objectives in the QAMP are supported by this protocol and include:

- Assess at multiple scales
- Assess with high statistical confidence
- Identify metrics and methods

Assess at multiple scales

This program was designed to be used for monitoring rivers and streams at multiple scales (e.g. statewide or regionally). The QAMP calls for the state to be fully assessed for status within a 4-year period, with 2 Status and Trends Regions (STRs) assessed within a year. Additional surveys at any scale can use this data to save monitoring costs, as long as these WHSR protocols are used.

Assess with high statistical confidence

WHSR is intended to provide a high level of statistical confidence (at least 80%). Precision is defined by the statistics of the EPA-designed framework, and the number of sites sampled. An excellent explanation on calculating the precision for the sample survey can be found at the EPA website (EPA 2009): http://www.epa.gov/nheerl/arm/surdesignfaqs.htm#manysamples.

Using consistent protocols among as many sites as possible, increases the precision of status estimates.

Metrics and methods

Indicators

Indicators were chosen to include *Limiting Factors* of salmon production (GSRO 2008, NOAA 2009a) especially those statistically related to stream biotic community scores and those for which we have detected wide-spread low metric scores during the summer season. The kinds of metrics that can describe these Limiting Factors are described in the QAMP (Cusimano 2006; see Figure 3 page 14).

Field Methods

Methods were chosen so that a small crew could access and sample each stream site within one reasonable working day. The intent is not to thoroughly characterize individual streams, but to describe the population of streams throughout the monitored region.

There are often better methods than those described here for characterizing individual sites, but many of these are impractical for status and trends monitoring. We have opted for fast, inexpensive, easily-trained methods that are repeatable.

For physical habitat measurements we have decided to heavily rely on Integrated Status and Effectiveness Monitoring Program (ISEMP) methods that have been in development since 2004 (Hillman 2004, NOAA 2009b). The ISEMP methods are useful because they:

- Integrate methods from multiple established federal programs.
- Incorporated lessons learned from comparison studies (e.g., Roper *et al* 2008, PNAMP 2007).
- Fit a flexible database structure which we could adapt (Rentmeester 2008).
- Have been demonstrated as logistically feasible.
- Provide field data that can be calculated using published instructions (Kaufmann et al 1999).

The methods for large streams and rivers are an abbreviation of the protocol for small streams (Merritt 2009). They are also largely based on the methods of the United States Environmental Protection Agency (Peck *et al* 2005; Lazorchak and others 2000).

Pre-season Site Selection

Overview

Before the season, each of the 387,237 points on the Washington Master Sample shapefile (WA_master_strah_112408) will be evaluated to generate a list of candidate sampling sites. Master sample sites were statistically chosen using line work from a 1:24,000-scale hydrography frame (*WDNR watercourses, February 2005).*

Sites have been delineated based on status and trends region (STR) membership. Each site is assessed to see if it meets sampling criteria, including statistical *target* status and *accessibility* status. Each Master Sample site is evaluated in sequence from lowest to highest SITE_ID on the list. Evaluation for some sites on the list will not be complete until a crew can make on-site observations during the July-October index period.

These are the statistical **target criteria**:

1. Located in the Status and Trends Region (STR) of interest.
2. Not on federal land.
3. Member of a size class needing representation.
4. The stream on the sample frame is also in the National Hydrography Dataset (NHD).
5. Flow is significant, perennial, continuous, and in a natural channel.
6. Freshwater.

These are the **access criteria**:

1. It is safe to access.
2. It is physically accessible
3. Permission has not been denied.

Target Status

Region

The STRs are based on Salmon Recovery Regions (SRRs) that were described by the Governor's Salmon Recovery Office (http://www.governor.wa.gov/gsro). The goal is to identify 50 sites and alternates in each STR (Table 1) that meet target criteria. These site lists will then be provided to field crews so that they can determine whether the streams can be safely accessed and sampled during the STR's designated field season. The procedure is to be started months before the field season.

Table 1. Status & Trends Regions.

Status & Trends Region	**Salmon Recovery Regions included**
Puget STR	Puget Sound, & Hood Canal/Puget Sound SRRs
Coastal STR	Coastal SRR
Lower Columbia STR	Lower Columbia SRR
Mid Columbia STR	Mid Columbia SRR
Upper Columbia STR	Upper Columbia SRR
Snake STR	Snake SRR
Northeast Washington STR	Northeast Washington SRR
No Region STR	None

The "*salmon_rr*" attribute of the Master Sample shapefile represents the Salmon Recovery Regions

Non-federal

Exclude sites on federal lands using reconnaissance and parcel research. A first cut can be provided using attributes of the Master Sample file.

Size

Strahler order

The 50 sites in each STR will be allocated according to size class defined by Strahler (1952) stream order. This size designation is based on a hierarchy of tributaries. Headwaters are 1st order. Same-order streams converge into the next higher order. For our purposes, the Strahler order is based on attributes of a 1:100,000-scale hydrography dataset (Horizon-Systems 2006). Since the sample frame is at 1:24,000-scale, some streams are too small to appear on the map that defines Strahler order. These are assigned 0-order.

We work down the Master Sample list in ascending order of SITE_ID until 10 sites and alternates are found for each Strahler stream order class below (and also satisfy the other selection criteria):

- 0-order
- 1st order
- 2nd order
- 3rd order
- 4th order or larger

In general, 0-order through 3rd order streams will require use of the protocol for small streams (Merritt 2009) and higher order streams will require use of the protocol for large streams and rivers (this document).

Great Rivers

The main-stem Columbia River belongs to a group of water systems classified as "Great Rivers". This is a class that we are excluding from Washington's WHSR program, due to the necessary differences in sampling techniques. If a point represents a water course on the main-stem Columbia River, it is disqualified.

NHD

Target sites must be on streams that are represented by the National Hydrography Dataset (NHD) at 1:24,000-scale (available here: http://nhd.usgs.gov/data.html). These streams are identical in geometry to the watercourses that are now in use by the Department of Ecology.

Flow

Significant

The stream or river must have significant flow. If the point represents a watercourse that is actually a lentic system (lake, pond, reservoir, wetland), it is disqualified.

Continuous

If the point represents a water course that is interrupted (subsurface) for more that 50% of the site length, it is disqualified.

Perennial

If the point represents a water course that stops flowing on a seasonal basis or longer, it is disqualified.

Natural Channel

Any constructed channel is non-target. This includes canals, ditches, pipelines or other water courses that would not exist without having been created by humans. Straightened or channelized streams however, although degraded, are considered "natural" channels because they existed prior to humans. Straightened or channelized streams would *not* be excluded from sampling unless they fail other target or access criteria.

Freshwater

We want to exclude points that are associated with water that is not fresh. Freshwater means that the water is estimated to have more than 95% of its water column with < 1 ppt salinity at any time during July-October. Multiple cues may be used to make this estimation (e.g. vegetation and proximity to a known estuary).

Access Status

Safety

Safety consideration can be estimated prior to the season, but it is ultimately the responsibility of individual crew members at the time of arrival to decide if the stream is safe to enter. Some reasons for disqualifying a site from sampling on a given date might include:

- Water is too swift.
- Hydraulic hazards such as "strainers" would be unavoidable
- Raft "put-in" or "take-out" are too steep or are in dangerous traffic.
- Hostile people or dogs.
- Hornets (e.g. for allergic staff).

Note: The Department of Ecology imposes the following requirements for employed or contracted staff that use rafts or kayaks to sample for the WHSR:

- Class I or II waters (www.americanwhitewater.org) – the boat operator must have at least 40 hours of rafting or kayaking experience in rivers or streams.
- Class III waters (www.americanwhitewater.org) – the boat operator must have at least 120 hours of rafting or kayaking experience in rivers or streams.
- Boat operators must be formally trained in whitewater safety.
- Each raft or two-person kayak should be equipped with site-appropriate safety gear.

Physical barriers

A site can be disqualified from sampling if it would take more than a day to sample, including transit.

Permission

Property owners will be contacted prior to sampling. This requires researching the parcel information in the preceding months. A site should be disqualified from sampling if permission has been denied by land-owners or resource managers. Large streams or rivers are often navigable waters with public rights to access. Be sure to obtain permission from owners of private launches and permits for public launches where they are required.

Work Flow

Weekly

Schedule at least one whole day to sample each site. Depending upon travel distances, the work day might last longer than 8 hours. Plan weekly schedules accordingly.

Deliver water and sediment samples to the Manchester Environmental Laboratory by Friday morning of each week. This might require adjusting the sample schedule to package and ship within deadlines.

It generally works well to allocate more than a day each week for planning, cleaning, repair, and administrative duties. Contact landowners as necessary.

At the beginning of each week, gather all bankfull width and transect information and air photographs that were generated during the pre-season map work. This information, along with a loaded GPS, will let you know the exact coordinates of sampling stations within your site. If there are missing pieces, generate this information before heading to the field.

Daily

When using boats, first, drop them off (with gear) at the designated “put-in”. Then, a shuttle vehicle should be dropped off at the designated “take-out”. While driving between the “put-in” (upstream) and “take-out” (downstream), make sure that you pass the site coordinates (“X”). The “X” should be located between the “put-in” and “take-out”.

It might be helpful to organize as follows. Load one boat with gear for sampling physical habitat and chemistry. Load a separate boat with gear (including electrofishing apparatus) for sampling biological assemblages.

The relative timing of daily monitoring activities is variable and should be performed considering efficiency of effort. It depends upon site-specific conditions. However, there are certain specific requirements in how the crew should organize its day. These are:

1) Sample water as late in the day as possible (normally at the last transect), but prior to any in-stream activities at that sample station.
2) *In situ* measurements (time 1) should be done upon arrival to the stream site.
3) *In situ* chemistry (time 2), is measured just prior to departure, at the same time as sampling for water chemistry.

Table 2 provides an example of how a typical data collection event might be accomplished by a 4 person crew with two boats of 2 persons each.

Table 2. Idealized daily work flow[1].

ACTIVITY	CREW	Time Since Arrival On-site (Hrs) 1	2	3	4	5	6
Water samples	Habitat						
In situ chemistry	Habitat						
Sediment samples	Habitat	*	*	*	*	*	*
Physical Habitat	Habitat						
Benthic assemblage[2]	Bio						
Vertebrate assemblage	Bio						

[1]Verifiy site location prior to sampling or launching.
[2] Benthic invertebrates are sampled by compositing aliquots from each of 8 transects.
*Sediment can be sampled for chemistry wherever suitable material is found.

Table 3 lists general locations within the site where each of these activities is performed. In wide streams and rivers, the crew visits only one side of each transect. However they will make some observations regarding both sides of the stream at each transect (Table 4), at plots indicated in Figure 1.

Table 3. Activities by station within a site.

Top transect (Transect K) [f]	Transects	Thalweg Stations	Bottom transect (Transect A)
In situ measures (1st)	Wetted width	Thalweg Depth	In situ measures (2nd)
GPS coordinates	Bankfull width	Habitat Unit presence	Water samples
	Bar width	Side Channel presence	Sediment sample
	Substrate sizes	Edge Pool presence	GPS coordinates
	Substrate depths	Bar presence	
	Fish cover by class		
	Shade		
	Human Influence		
	Riparian Vegetation		
	Benthos[a]		
	Vertebrate presence[b]		
	Large Woody Debris		
	GPS coordinates		

[a] The benthos sample is a composite from 8 randomly selected transects.
[b] Aquatic vertebrates are sampled from the full length of the site, but records are updated at each new transect.

Table 4. Locations at each transect for observation and sampling.

Side	Location	Observation or Sample
Visited side	littoral plot	benthos kicks (8 of 11 transects)
Visited side	littoral plot	fish cover
Visited side	transect	substrate size class
Visited side	transect	depth
Visited side	transect	bankfull height
Visited side	transect at bankfull stage	Shade (densiometer)
Visited side	littoral plot + dry channel to bankfull margin	Large woody debris tally
Both sides	bankfull margin at transect (20 meters long)	bank instability
Both sides	riparian plot	human disturbance
Both sides	riparian plot	vegetation structure

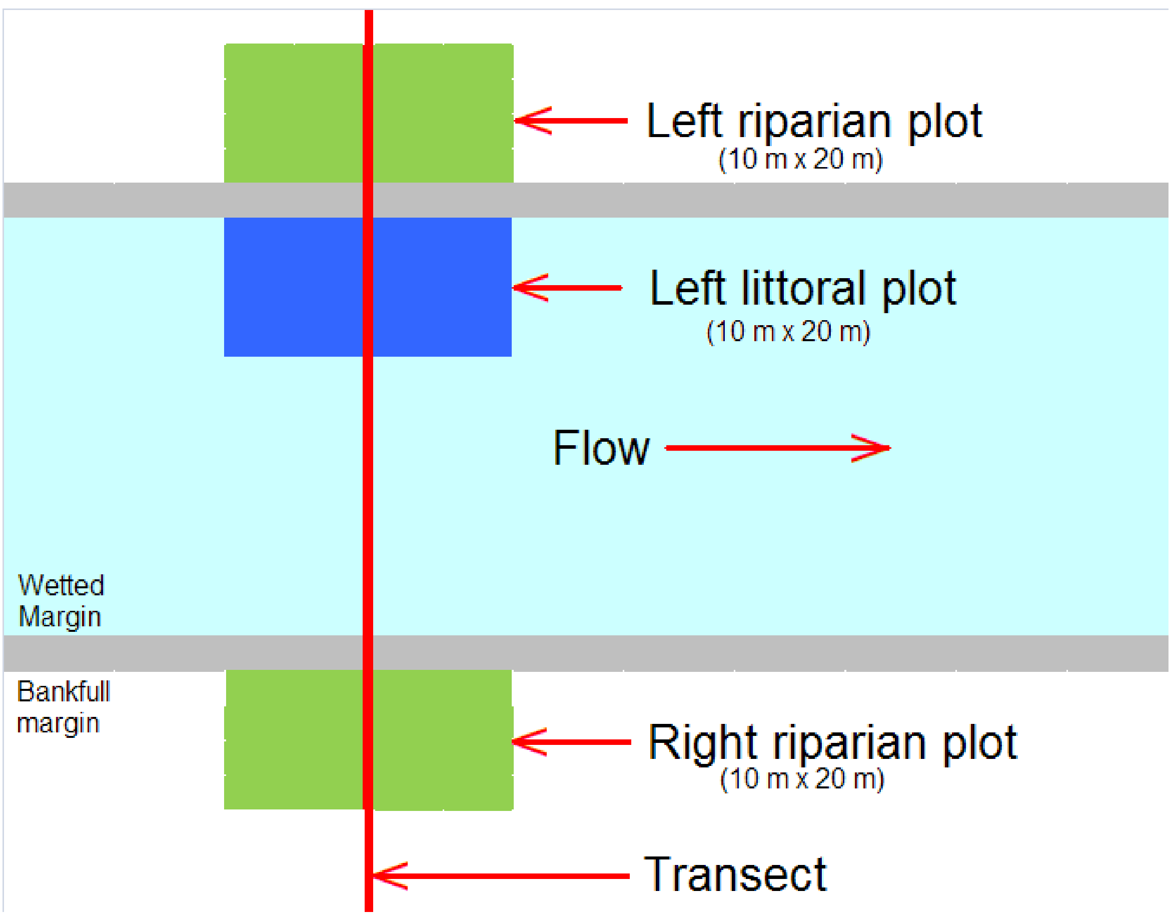

Figure 1. Plot locations for a transect where the crew visits the left side.

Verification

Sampling crews will arrive at the candidate sample site, and verify that they are at the correct location (Appendix A), that the site meets target criteria, and that it is safe to enter. This protocol for sampling wide streams is normally restricted to sites that are at least 25 meters wide at the coordinates (sites more than 500 m long). Narrower streams can be included if they are too deep to wade.

Water Sampling and *In Situ* Measurements

Initial (time 1) *in situ* measurements should be performed prior at the first transect encountered at the stream. After verifying the site location (Appendix A), the crew can start by preparing the *in situ* instruments. The method for calibrations is in Appendix B. The method for *in situ* measurements is in Appendix C. Water sampling should be conducted according to the method described in Appendix D. Water samples and final (time 2) *in situ* measurements are made at the last transect encountered, just prior to departure from the site.

Sediment

One person collects a sediment chemistry sample from a composite three scoops from shallow waters within the site (Appendix E). These scoops should be collected prior to staff entering waters within the vicinity of collection.

Benthos

One person will sample benthos from a composite of 8 kick samples randomly selected from 11 transects (Appendix F). Each kick sample should be collected prior to staff entering waters within the vicinity of collection and prior to electrofishing activities.

Habitat

At any station within the site, persons measuring habitat should follow (in time) persons collecting water, sediment or benthos. The most efficient allocation and timing of staff to different tasks is dependent upon site-specific conditions. For example, sites with large quantities of large woody debris might best be measured by having one person dedicated to counting wood. Methods for measuring physical habitat are listed in Appendices G through P.

Special Note: When a raft is used for sampling, habitat forms are completed in reverse sequence of transects (K to A). Therefore, it is very important to label data forms with transect identities prior to sampling.

Sampling the Vertebrate Assemblage

Generally start sampling the vertebrate assemblage following the start of other activities and work concurrently. Sample all accessible habitats in the main channel from the bottom of the site to the top (when wading) and from top to bottom (when floating). Refer to Appendix Q.

Data Form Review

Examples of the field data forms are found in Appendix R. Prior to leaving the site, field data forms should be reviewed for completeness and accuracy. Crews will submit completed forms to Ecology on a regular basis but not later than November 15. The Department of Ecology will then scan the field forms to upload data and check for errors.

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Appendix A

Site Verification and Layout for Wide Streams and Rivers

Purpose and Scope

This method explains how to verify that a candidate large stream or river site is suitable for sampling. It also describes how to establish the boundaries and stations within the site. Once a site is deemed suitable for sampling, a *Data Collection Event* (DCE) can be established to uniquely identify the sampling event.

Definitions

Definitions of acronyms and other terms are found in Table A-1.

Table A-1. Definitions.

Term or Acronym	Definition
alluvial reach	Where the form of the streambed is composed of appreciable quantities of sediments that are transported and deposited in concert with stream flow (Armantrout 1998). Most sites sampled for Status and Trends will fall into this category.
bedrock reach	Where the streambed **lacks fill material** except for temporary storage spots. Bedrock channels generally are **confined** by valley walls. (Montgomery and Buffington 1998)
braided reach	Braided reaches are characterized by **wide channels** containing **series of bars**. They have a **high supply of sediment**. They have **mobile bed** forms. They lack valley confinement and are characterized erodible banks. (Montgomery and Buffington 1993).
cascade reach	Cascade reaches occur on **steep slopes** where energy is high. They are characterized by disorganized **cobbles and boulders** and by **confined** valley walls. (Montgomery and Buffington 1998)
colluvial reach	Portion of the stream network that is **typically in headwaters** and typically consists of **intermittent or ephemeral flow**. In colluvial valleys, expect long-term **accumulation of sediment**, punctuated by periodic **catastrophic erosion**. (Montgomery and Buffington 1998). Colluvial material is of **mixed sizes**. It is recently eroded and transported locally through sheet flow such as avalanche or **landslide** (Armantrout 1998).

DCE	Data Collection Event. Data are indexed using this code which includes the SITE_ID, the date, and the time that the event began. It uses this format: **WAM06600-NNNNNN-dce-20YY-MMDD-HHMM** **NNNNNN** = the number portion of the SITE_ID. **YY** = the last two numeric digits of the year that the event occurred. **MM** = the two numeric digits for the month that the event occurred. **DD** = the two numeric digits for the day within the month that the event occurred. **HHMM** = the military time when the event began.
GPS	Global Positioning System.
Index Station	This is sometimes called "X". It is the location of the coordinates that represent the site. Normally "X" is located in the middle of the site length (i.e. at major transect F), but sometimes the site position can be adjusted to avoid changes in Strahler stream order or to avoid property where access has been denied.
major transect	One of 11 equidistant transects across the length of a site. These are labeled as follows: A (lowest), B,C,….K (highest)
plane-bed reach	Plane-bed reaches are characterized by a relatively **featureless gravel/cobble bed**. There is an **absence of tumbling flow**, but may include glides, riffles or rapids. They **lack lateral flow**. Bed surfaces are often armored.
pool-riffle reach	Pool riffle reaches are typically **unconfined**, with a **laterally oscillating sequence of bars, pools, and riffles**. There is local sediment accumulation in discrete bars. (Montgomery and Buffington 1998)
regime reach	Mobile bed forms provide the primary flow resistance. Regime channels are typically **low-gradient sand bedded channels**. Low slope, frequency and presence of ripples or dunes throughout the channel bed distinguish regime channels from pool-riffle channels (Montgomery and Buffington 1993).
Site	A site is defined by the coordinates provided to a sampling crew and the boundaries established by the site layout method. Typically, the site extends 10 bankfull widths downstream from the coordinates and 10 bankfull widths upstream. The site also includes all riparian plots examined during the *Data Collection Event*. The site consists of many stations at which measurements or samples are collected.
Station	Any location within the site where an observation is made or part of a sample is collected.

step-pool reach	Step-pool reaches consist of **coarse materials** that are **organized into discrete series of steps** separating pools containing finer materials. They consist of alternating turbulent flow over steps and tranquil flow in pools. (Montgomery and Buffington 1998)
Thalweg	Path of a stream that follows the deepest part of the channel (Armantrout, 1998).
thalweg transect	One of 101 equidistant transects across the length of a site. Labeling includes the name of the major transect. For example the thalweg transects between (and including) major transects A and B would be labeled as follows: A0, A1, A2, A3, A4, A5, A6, A7, A8, A9, B0 (i.e.., thalweg transect A0 is identical to major transect A)

Personnel Responsibilities

This method is performed in 2 phases. The first part is done during the pre-season by one staff at a computer terminal that has geographic information systems (GIS) or mapping software. The second phase is performed by 2 or more persons on-site, during the sample season. Staff performing this method must be trained.

Equipment, Reagents, Supplies

Pre-season supplies

- Computer with GIS or web-based mapping capability
- GPS

Field supplies

- GPS
- *GPS Positions Form*
- Measuring rod
- 50-m tape
- Laser rangefinder
- Soft-lead pencil
- *Site Verification Form*
- No. 2 pencil
- Maps

Summary of Procedure

Pre-season Site Mapping

Using mapping software, one person plots the Master Sample Index Station coordinates (X). Overlay this point onto an ortho-photograph and a topographic map. Use the maps to estimate bankfull width near the X. Then determine site length: normally 20 times the bankfull width (but not greater than 2 km) and determine the distance between each of 11 equidistant transects across the site. Plot the transects. Normally, the middle transect (i.e. "F") should pass through X.

Plot transects (as in Figure A-1) and record data (as in Table A-2).

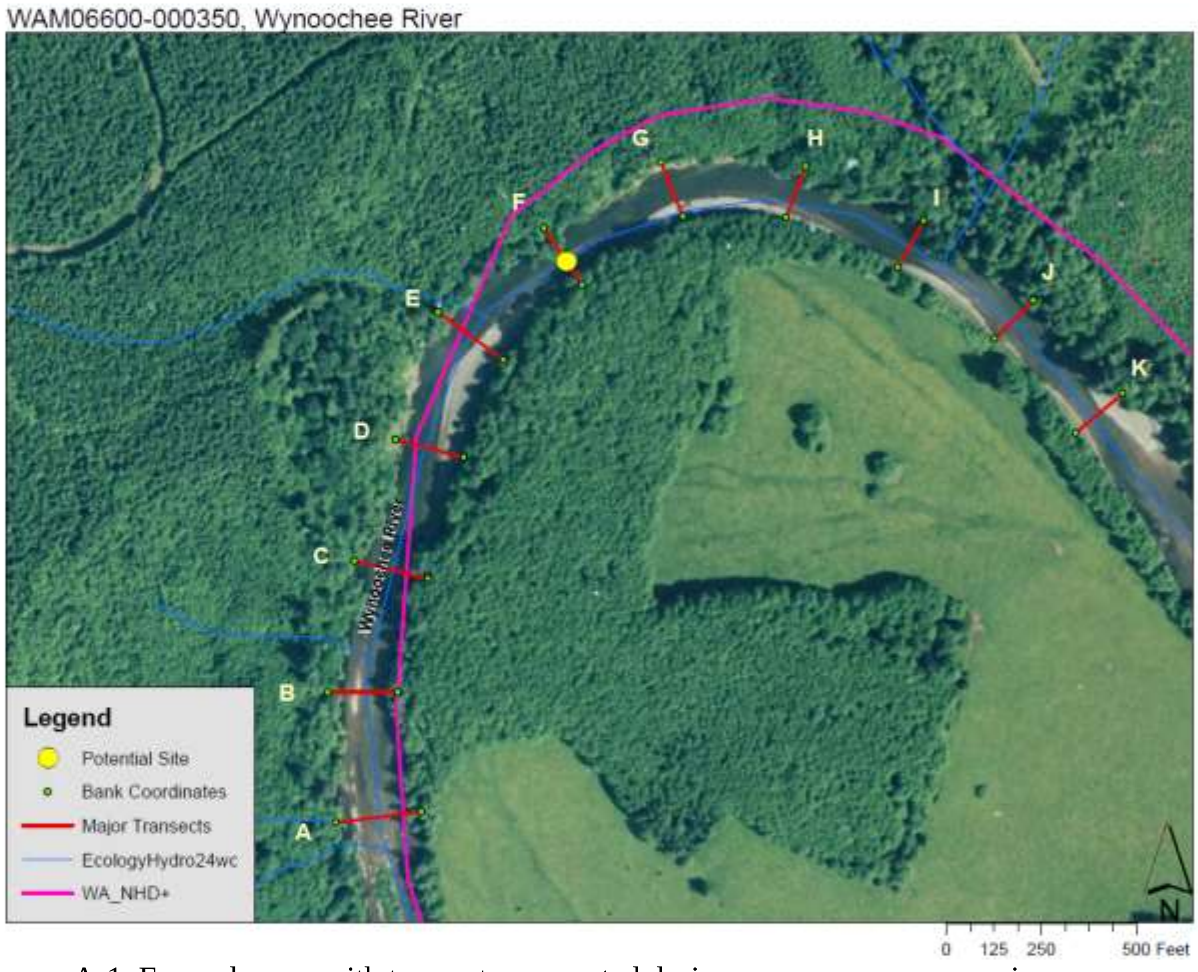


Figure A-1. Example map with transects, generated during a pre-season map review.

Table A-2. Example data gathered during pre-season map review.

Site:	WAM06600-000350	Wynoochee River		Stream Site Length (m):	1020
Index Station Lat/Long (dd):		47.1781994033	-123.638866297	Index Station BFW (m):	55
Station	Left Bank		Right Bank		BFW (m)
	Latitude (dd)	Longitude (dd)	Latitude (dd)	Longitude (dd)	
A	47.17418	-123.64018	47.17408	-123.64107	70
B	47.17504	-123.64047	47.17501	-123.6412	56
C	47.17586	-123.64019	47.17597	-123.64097	62
D	47.17675	-123.63987	47.17686	-123.64059	58
E	47.17746	-123.63948	47.17778	-123.64018	65
F	47.17802	-123.63869	47.17842	-123.63911	55
G	47.17854	-123.63764	47.17893	-123.6379	48
H	47.17857	-123.63655	47.17895	-123.63637	45
I	47.17825	-123.63535	47.17859	-123.63509	43
J	47.17776	-123.63429	47.17805	-123.6339	44
K	47.1771	-123.63341	47.1774	-123.63293	50
Put In					
Take Out					
Comments	Stream site length based on average BFW of 51m near the index station.				

Bankfull Width

Using computer mapping software with an ortho-photographic map and a topographic map, measure the estimated bankfull channel width at each of 5 transects near the Index Station:

1. The Index Station (X)
2. 1 bankfull width upstream from X
3. 2 bankfull widths upstream from X
4. 1 bankfull width downstream from X
5. 2 bankfull widths downstream from X

Record the average (nearest meter) of these 5 bankfull width measurements. Bankfull margins can be estimated by observing where the maps display sharp changes in slope, vegetation, and substrate. Refer to Merritt (2009) for details of how the bankfull margin is estimated on-the-ground.

Site Length

Determine site length in whole meters. Multiply the average bankfull width times 20. This value is the site length for a path that follows the main flow of the river. However, if the average bankfull width is ≥ 100 m the site length will be 2,000 m.

Transects and Coordinates

Draw 11 equidistant transects (e.g. Figure A-1) that are each perpendicular to the flow. Try to estimate where the thalweg would be and measure between transects at that path. Label transects from A (bottom) to K (top). Normally, F lies on the Index Station (X). Although the location of the Index Station's coordinates can never be changed, the relative position of X can be adjusted for reasons such as

- to keep the top or bottom of the site in lands where permission has not been denied, or
- to keep from changing Strahler stream order (at the 1:100,000 scale), or
- to account for barriers such as lakes, or other obstables

Record the coordinates (decimal degrees) for the intersection of each bank with each transect (e.g., Table A-2). Enter these as waypoints into the GPS unit.

GPS Positions Form

Some field information should be completed prior to leaving the office. This will require knowing the stations that the crew will need to visit during the field season. The sequence of banks that crews will visit is determined by the flip of a coin (Table A-3).

Table A-3. The bank visit sequence as determined by a coin flip.

HEADS		TAILS	
Transect	Bank	Transect	Bank
A	Right	A	Left
B	Right	B	Left
C	Right	C	Left
D	Left	D	Right
E	Left	E	Right
F	Right	F	Left
G	Right	G	Left
H	Left	H	Right
I	Left	I	Right
J	Right	J	Left
K	Right	K	Left

Once a sequence is determined, begin pre-filling the *GPS Positions Form*. An example is provided by blue text in Figure A-2.

Reviewed by (Initials): G.M

Status and Trends Program - GPS Positions Form

DCE: W A M 0 6 0 0 - 0 0 0 3 5 0 - D C E - 2 0 0 9 - 0 8 0 7 - 1 0 : 1 5
(Site Number; YY; MMDD; HH : MM)

Station	Bank (circle one)	Master Lat dec deg e.g. 47.123456	Master Lon dec deg e.g. 120.123456	GPSlatDD e.g. 47.123456	GPSLonDD e.g. 120.123456	Accuracy	Accuracy Units (ft, EPE, etc.)	Flag
INDEX STATION	L (R)	47.1781994033	123.638866297	47.13840	123.63908	3	m	
A0	L (R)	47.17408	123.64107	47.17505	123.64105	3	m	
B0	L (R)	47.17501	123.64120	47.17500	123.64121	4	m	
C0	L (R)	47.17597	123.64097	47.17595	123.64099	3	m	
D0	(L) R	47.17675	123.63987	47.17676	123.63985	3	m	
E0	(L) R	47.17746	123.63948	47.17745	123.63949	4	m	
F0	L (R)	47.17842	123.63911	47.13840	123.63908	3	m	
G0	L (R)	47.17893	123.63790	47.17893	123.63791	4	m	
H0	(L) R	47.17857	123.63655	47.17855	123.63654	5	m	
I0	(L) R	47.17825	123.63535	47.17824	123.63532	5	m	
J0	L (R)	47.17805	123.63390	47.17807	123.63390	5	m	
K0	L (R)	47.17740	123.63293	47.17739	123.63295	5	m	
PUTIN	L R							
TAKEOUT	L R							

ALL COORDINATES TO BE RECORDED IN NAD83

Position comments including accuracy

Directions to access point

From Montesano, drive north about 20 miles on Wynoochee Valley Rd.

Draft

Figure A-2. The *GPS Positions Form* with example data entered during pre-season (blue text) and on-site during the field sampling event (red text).

Sample event and navigation

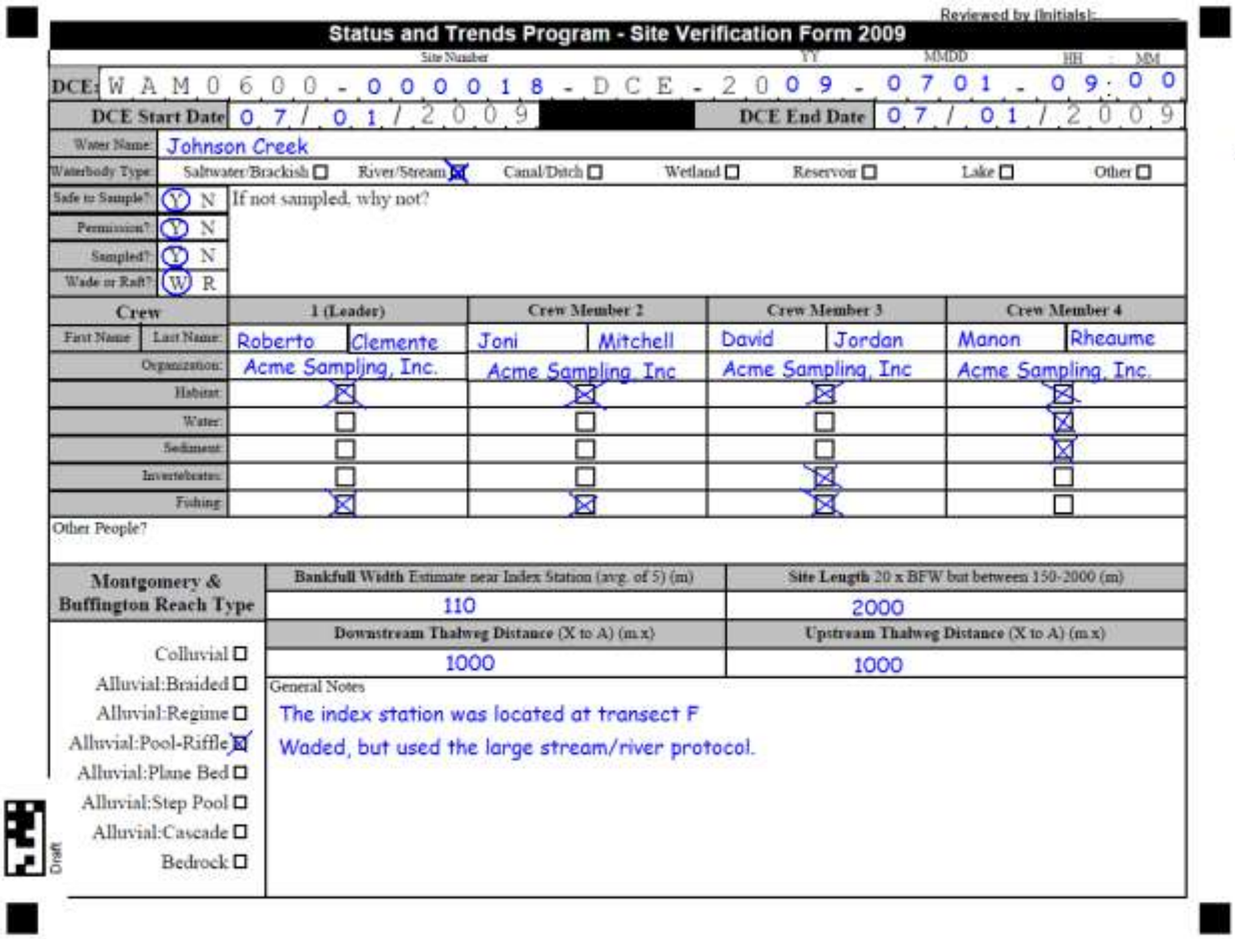
The crew first navigates to the site using the coordinates provided by the pre-season mapping exercise (Figures A-1 and A-2) and a GPS receiver. They then verify that they are at the correct site and determine if the stream is suitable for sampling and whether a raft will be required. If the site is shallow and wadeable, start at Transect A and walk upstream to sample. If the site requires use of a boat, then float downstream through the site and begin sampling at the top (Transect K). Usually, the appropriate method can be determined before reaching the site, based on pre-season reconnaissance.

Establish the Data Collection Event

Upon arrival to the first sample station (either Transect A or K), record the date (MMDD) and time (military) portion of the DCE on the GPS Positions Form (Figure A-2) . Record the GPS-measured coordinates for the each sample station on the GPS Positions Form. Also note the precision of each GPS measurement. Other notes on location can also be recorded. Record the turn-by-turn directions taken to reach the site's access point.

Determine Site Suitability

After arrival and recording the DCE, determine whether the site is suitable for sampling. Refer to the *Site Verification Form* (Figures A-3, and A-4).



Reviewed by (Initials):

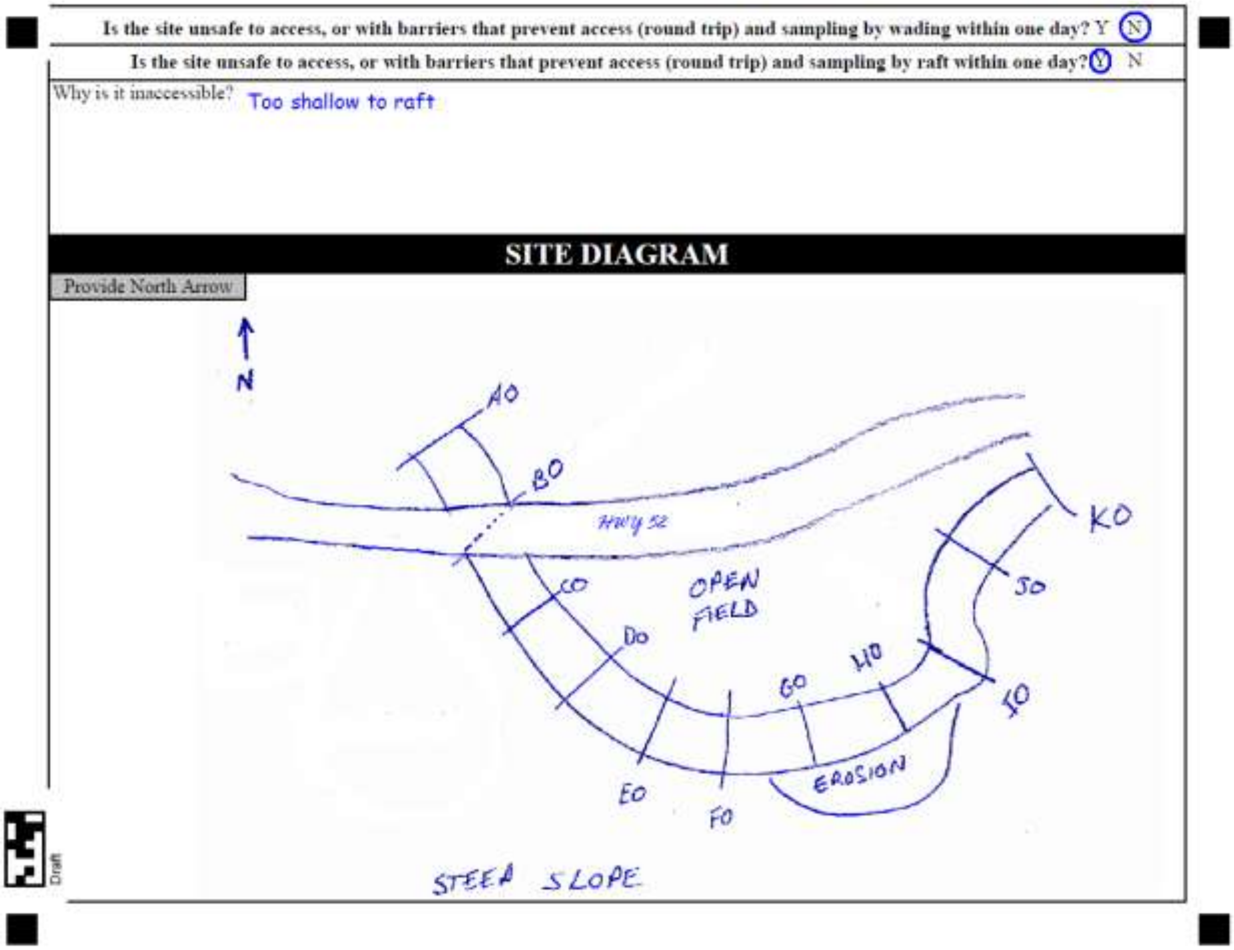
Status and Trends Program - Site Verification Form 2009

DCE:	WAM0600-000018-DCE-2009-0701-09:00			
DCE Start Date	07/01/2009	DCE End Date	07/01/2009	
Water Name:	Johnson Creek			
Waterbody Type:	Saltwater/Brackish ☐ River/Stream ☒ Canal/Ditch ☐ Wetland ☐ Reservoir ☐ Lake ☐ Other ☐			
Safe to Sample?	(Y) N	If not sampled, why not?		
Permission?	(Y) N			
Sampled?	(Y) N			
Wade or Raft?	(W) R			
Crew	1 (Leader)	Crew Member 2	Crew Member 3	Crew Member 4
First Name / Last Name:	Roberto Clemente	Joni Mitchell	David Jordan	Manon Rheaume
Organization:	Acme Sampling, Inc.	Acme Sampling, Inc	Acme Sampling, Inc	Acme Sampling, Inc.
Habitat:	☒	☒	☒	☒
Water:	☐	☐	☐	☒
Sediment:	☐	☐	☐	☒
Invertebrates:	☐	☐	☒	☐
Fishing:	☒	☒	☒	☐
Other People?				

Montgomery & Buffington Reach Type	Bankfull Width Estimate near Index Station (avg. of 5) (m)	Site Length 20 x BFW but between 150-2000 (m)
	110	2000
	Downstream Thalweg Distance (X to A) (m.x)	Upstream Thalweg Distance (X to A) (m.x)
Colluvial ☐	1000	1000
Alluvial:Braided ☐	General Notes	
Alluvial:Regime ☐	The index station was located at transect F	
Alluvial:Pool-Riffle ☒	Waded, but used the large stream/river protocol.	
Alluvial:Plane Bed ☐		
Alluvial:Step Pool ☐		
Alluvial:Cascade ☐		
Bedrock ☐		

Draft

Figure A-3. The front side of the *Site Verification Form* with example data.



Is the site unsafe to access, or with barriers that prevent access (round trip) and sampling by wading within one day? Y (N)

Is the site unsafe to access, or with barriers that prevent access (round trip) and sampling by raft within one day? (Y) N

Why is it inaccessible? Too shallow to raft

SITE DIAGRAM

Provide North Arrow

Figure A-4. The back side of the *Site Verification Form*, with example data.

Verify that conditions at the site are suitable for sampling.. Complete the appropriate fields in the top third of the front side of the *Site Verification Form*, indicating whether the site is being sampled, and if so, whether this is by wading or by rafting. The site should not be sampled if it is deemed:

- Unsafe to enter
- To have permission denied by land owners
- Not a stream or river (e.g. a wetland, lake)
- Not freshwater
- Within an artificial channel (e.g. canal or ditch)
- Not perennial
- Not with surface flow for more than 50% of the length.

Crew

Record the names of crew members. Also note the organization that each staff represents. The crew lead will be recorded in column 1. Staff sampling roles can be recorded later, after the day is done, by using the check boxes provided on the form.

Site

Enter site length and width data onto the Site Verification Form (Figure A-3). This information is derived from pre-season notes (e.g. Figure A-1 and Table A-2).

Bed Form

Assess the site for its predominant reach type according to Montgomery and Buffington (1993, 1997). Review the source materials hot-linked in the references to help understand the differences between bed forms. These references discuss details and provide images of examples.

First decide whether the site is predominated by a reach that is colluvial, alluvial, or bedrock. Colluvial streams have a low chance of being sampled by this Status and Trends program, because we are limiting our sample to perennial streams. Bedrock streams are confined locations with little depositional material present. Most streams sampled will be alluvial.

Next, if the site is predominantly alluvial, decide which one of the following sub-classifications can be used to describe the site.

- cascade
- step-pool
- plane-bed
- pool-riffle
- regime
- braided

Cascade streams and step-pool streams are unlikely to be wide streams or rivers where this protocol is used.

Place an X in the appropriate box of the *Site Verification Form* (Figure A-3) to describe the predominant bed form within the site. Refer to the references (Montgomery and Buffington, 1993, 1997, 1998) and the definitions table (Table A-1) for help. Figures A-5 and A-6 might help.

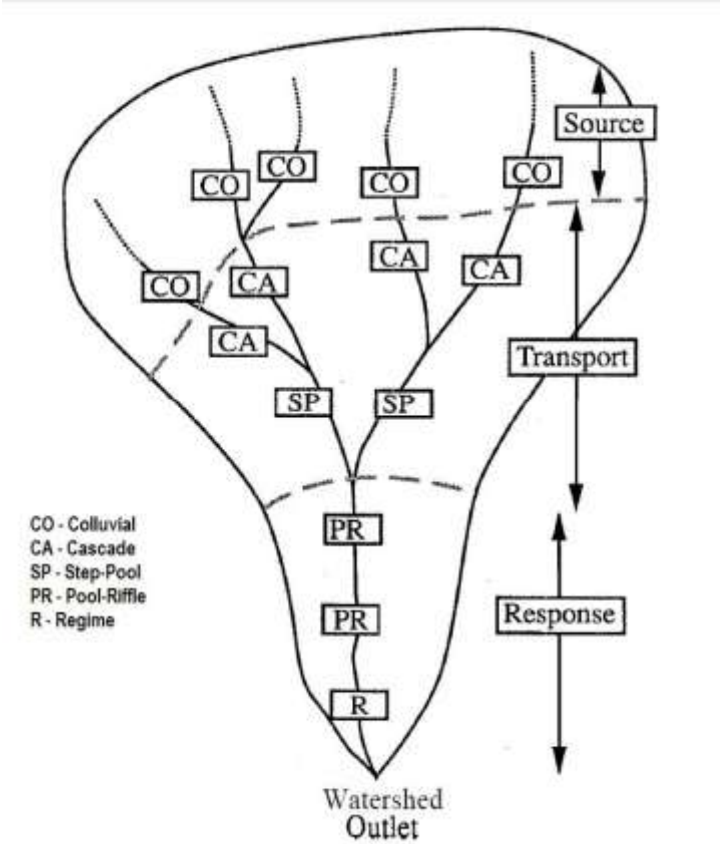


Figure A-4. Idealized positions (aerial view) of bed form types within a watershed. Modified from figure 22 of Montgomery and Buffington (1993).

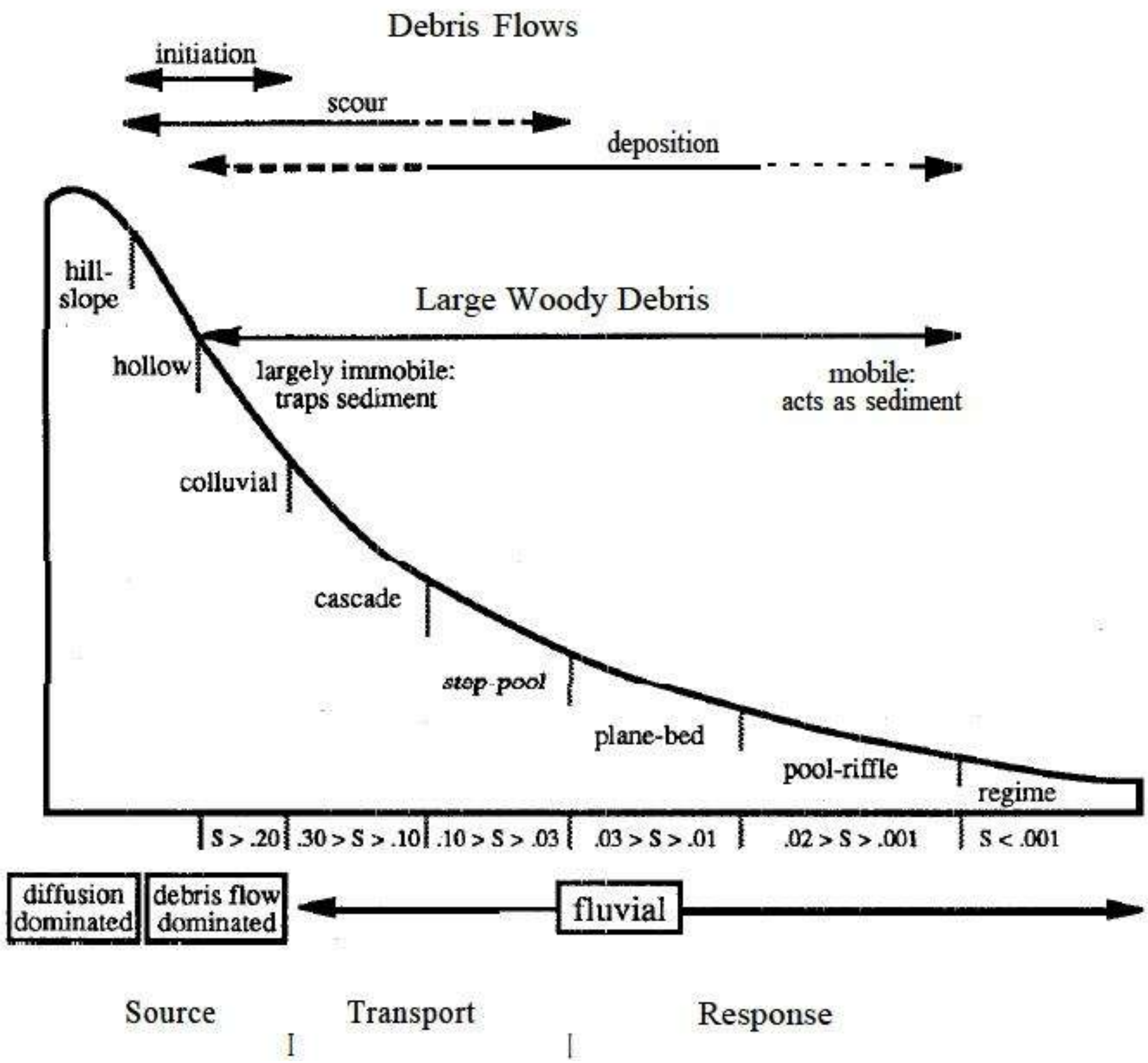


Figure A-5. Idealized positions (plan view) of bed form types within a watershed (from figure 16 of Montgomery and Buffington (1993)).

Navigate within the site

Use the GPS waypoints established before the season (Figures A-1 and A-2) to locate each transect sampling station. Upon arrival at each station, record the measured field position on the GPS Positions Form (Figure A-2), including accuracy.

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Appendix B

Quality Control for Field Meters at Wide Streams & Rivers

Purpose and Scope

This method explains how to quality assure field meters used for wide streams and rivers in the *Monitoring for Watershed Health and Salmon Recovery Program* (WHSR) Instruments included on this method include those for instantaneous measurements of :

- temperature,
- pH
- conductivity,
- dissolved oxygen
- turbidity
- velocity

Definitions

Definitions of acronyms and other terms are found in Table B-1.

Table B-1. Definitions.

Term or Accronym	Definition
DCE	Data Collection Event. Data are indexed using this code which includes the SITE_ID, the date, and the time that the event began.
NIST	National Institute of Standards and Technology
QC	Quality control. A quality control check is a measurement of a standard value to estimate the accuracy of an instrument.
QCCS	A quality control standard suitable for assessing errors of pH and conductivity of dilute neutral pH waters (Metcalf and Peck 1993). A dilute phosphate standard is prepared as a 100-fold dilution KH_2PO_4 and Na_2HPO_4 standard buffer solution (NIST pH buffer 6.865). It has a theoretical **pH value of pH 6.98** and calculated **conductivity value of 75.3 µS cm^{-1} at 25 ˚C**. The stock solution should be kept refrigerated, but the 1:100 dilution should have no detectable change in pH or conductivity for at least 15 months when stored in polyethylene containers between 10-40 ^{o}C.

Personnel Responsibilities

This method is performed by 1 or more persons. This method is applied at every DCE, before and after sampling, although some of the tasks are required less frequently. Staff performing this method must have been trained.

Equipment, Reagents, Supplies

General

- Notebook and pencil
- Tap Water
- De-ionized water (DI)
- Lab tissues (e.g. KimWipes®)
- Maintenance kit for meters (e.g. Hydrolab kit (Swanson, 2007))
- *Chemistry and Sampling Form*

pH Meter

- pH Calibration form
- pH meter (e.g. Hydrolab MiniSonde)
- pH meter manual (e.g. Hach 1999, 2006a)
- Batteries
- QCCS (Metcalf and Peck 1993)
- pH Standards
    - pH 7 buffer (7.00) – e.g. VWR - 23197-996
    - pH 4 buffer (4.01) – e.g. VWR - 23197-998
    - pH 10 buffer (10.01) – e.g. VWR - 23197-994
- Dilute pH Standards (only twice per season)
    - pH 7 standard (6.97) – e.g. Thermo 700702
    - pH 4 standard (4.10) – e.g. Thermo 700402
    - pH 9 standard (9.15) – e.g. Thermo 700902

Conductivity Meter

- Conductivity Meter (e.g. Hydrolab MiniSonde)
- Conductivity Calibration Form
- Conductivity meter manual (e.g. Hach 1999, 2006a)
- Batteries
- QCCS (Metcalf and Peck 1993)
- Conductivity Standard (100 µS) – e.g. VWR 23226-589
- Conductivity Standard (1,000 µS) – e.g. VWR 23226-603
- Conductivity Standard (alternate as available)

Dissolved Oxygen Meter

- D.O. Meter (e.g. Hydrolab MiniSonde)
- D.O. Calibration Form
- Batteries
- Dissolved oxygen meter manual (e.g. Hach 1999, 2006a,b)
- Barometer
- Winkler sampling supplies (see Mathie0 2007)

Turbidimeter

- Turbidimeter (e.g. Hach Model 2100P)
- Turbidi manual (e.g. Hach 2001)
- Batteries
- Turbidity calibration standards (e.g. StableCal®, Hach No. 26594-0x)
- Turbidity quality control check standards (e.g. Gelex®, Hach No. 24641-05)

Summary of Procedure

Calibrate and check field instruments. Some of these quality control activities are performed daily or weekly when sampling. A few are done only occasionally.

Daily Quality Control

Each day, before sampling, calibrate the conductivity and pH meters. Check their calibrations before and after sampling, normally morning and evening. Each morning, calibrate the dissolved oxygen and turbidity meters; check the turbidimeter calibration.

The order of daily calibrations is normally:

1) Conductivity,
2) pH ,
3) Dissolved Oxygen, then
4) Turbidity

For each sample event (DCE), document that water quality control procedures are up-to-date using the *Chemistry and Sampling Form* (Figure B-1).

Reviewed by (Initials): JS

Status and Trends - Chemistry and Sampling Form

	Site Number		YY	MMDD	HH : MM
DCE:	W A M 0 6 0 0 - 0 0 0 0 0 0	- D C E -	2 0 1 0 -	0 8 1 5 -	1 0 : 0 0

IN SITU WATER QUALITY CALIBRATION

	Unit No.	Operator: Joe Schmoe			Flag
T	23	checked vs NIST	(Yes)	No	F1
DO	23	Sensor Calibrated	(Yes)	No	
pH	23	Calibrated and Checked	(Yes)	No	
Cond	23	Calibrated and Checked	(Yes)	No	
Turb	T-3	Calibrated and Checked	(Yes)	No	F2

Notes (in situ) F1 - Temperature probe checked 6/25 this year.
F2 - Turb. calibrated & checked 6/25 + checked today.

Sed:%Gravel 0 0 5 %Sand 0 0 5 %Fines 0 9 0

In Situ Chemistry

Time1 1 0 : 1 5 hrs — Start Location (e.g. F0) K 0
Temp1 0 6 . 3 deg C
pH1 0 6 . 9 4 pH Units
DO1 1 0 . 9 mg/L — %Sat1 1 0 2 . 5
Cond 0 0 0 2 7 . 8 uS/cm @ 25C

Time2 1 9 : 5 0 hrs — End Location (e.g. K0) A 0
Temp2 0 7 . 0 deg C
pH2 0 7 . 0 0 pH Units
DO2 1 0 . 9 mg/L — %Sat2 0 9 9 . 5
Cond 0 0 0 2 7 . 9 uS/cm @ 25C

Sample	Primary Sample: No. of Jars	Duplicate Sample: No. of Jars	Destination	Sample ID or Fish Common Name	Flag
TPN	1	0	Manchester Envtl Lab	Work Order + 0 5	F1
Tot P	1	0	Manchester Envtl Lab	Work Order + 0 5	F1
Cl	1	0	Manchester Envtl Lab	Work Order + 0 5	F1
Turb	1	0	Field measurement with Hach 2100P		
Sed PAH	1	0	Manchester Envtl Lab	Work Order + 0 6	F1
Sed Metals*	1	0	Manchester Envtl Lab	Work Order + 0 6	F1
Benthos	1	0	Temp. storage at base facility	DCE	
Fish Spp1	1	0	Temp. storage at base facility	torrent sculpin	
Fish Spp2	1	0	Temp. storage at base facility	unspecified lamprey	
Fish Spp3	1	0	Temp. storage at base facility	longnose dace	

Water Sample Location (e.g. A5) A 0

Sample Notes (explain flags): F1 Manchester Work Order 10-08-041

FIELD TURBIDITY: 0 . 5 NTU

Draft

*Sediment Metals jar includes sample material to be analyzed for TOC

Note: Use standard Manchester Environmental Lab forms for tracking water and sediment samples.

Figure B-1. The *Chemistry and Sampling Form*, with example quality control data highlighted.

Conductivity

Calibrate the conductivity meter each day according to manufacturer's instructions.

Choose the conductivity calibration standard to be slightly higher than expected stream values. For example, most wadeable streams west of the Cascades or high-elevation streams will need to be calibrated with 100 µS conductivity standards. Some larger or eastern rivers might need to be calibrated with > 100 µS conductivity standards.

Check the conductivity meter calibrations twice daily:

1) After calibration but before sampling, and
2) After sampling.

Daily Conductivity Calibration			
Person Calibrating			
Date			
Meter serial number or ID			
Probe seriel number of ID			
Battery Voltage			
Standard Solution Theoretical Value			
Temperature of standard			Degrees C
Calibrated to Theoretical ?	Yes ☐		
QCCS (am) Cond			µS/cm at 25 C
QCCS (am) Temp			Degrees C
QCCS (am) 65.3 to 85.3 µS/cm at 25 C ?	Yes ☐		
QCCS (pm) Cond			µS/cm at 25 C
QCCS (pm) Temp			Degrees C
QCCS (am) 65.3 to 85.3 µS/cm at 25 C ?	Yes ☐	No ☐	
Notes			

Figure B-2. The Conductivity Calibration Form.

Measure the conductivity and temperature of the QCCS. **Conductivity should measure between 65.3 and 85.3 µS/cm at 25 ˚C**. Re-calibrate if the pre-sampling check fails these criteria. Qualify (flag) the DCE's conductivity data if the post-sampling check fails these criteria.

pH

Calibrate the pH meter each day according to manufacturer's instructions.

Choose the pH calibration standards to bracket expected stream values. For example, most streams west of the Cascades or high-elevation streams will need to be calibrated with pH 7 and pH 4 standards. Larger rivers or eastern streams might need to be calibrated using pH 7 and pH 10 standards. Theoretical pH values of each standard buffer are found in Table B-2.

Daily pH Calibration					
Person Calibrating					
Date					
Meter serial number or ID					
Probe seriel number of ID					
Battery Voltage					
#1 Temp					Degrees C
#1 pH					units
#2 Temp					Degrees C
#2 pH					units
QCCS (am) pH					units
QCCS (am) Temp					Degrees C
QCCS (am) 6.78 to 7.18 ?	Yes	☐			If NO, recalibrate
QCCS (pm) pH					units
QCCS (pm) Temp					Degrees C
QCCS (pm) 6.78 to 7.18 ?	Yes	☐	No	☐	If NO, flag data
Notes					

Figure B-3. The pH Calibration Form.

Table B-2. Theoretical pH values by temperature for each pH standard buffer.

Temp (˚C)	4[a]	7[b]	10[c]
4	4.00	7.09	10.26
5	4.00	7.08	10.25
6	4.00	7.08	10.23
7	4.00	7.07	10.22
8	4.00	7.07	10.21
9	4.00	7.06	10.2.0
10	4.00	7.06	10.18
11	4.00	7.05	10.17
12	4.00	7.05	10.16
13	4.00	7.04	10.14
14	4.00	7.04	10.13
15	4.00	7.03	10.12
16	4.00	7.03	10.11
17	4.00	7.02	10.10
18	4.00	7.02	10.09
19	4.00	7.02	10.08
20	4.00	7.01	10.06
21	4.01	7.01	10.05
22	4.01	7.01	10.04
23	4.01	7.00	10.03
24	4.01	7.00	10.02
25	4.01	7.00	10.01
26	4.01	6.99	10.00
27	4.01	6.99	9.99
28	4.01	6.99	9.98
29	4.01	6.99	9.98
30	4.02	6.98	9.97

Buffers: [a] Thermo 7.00, [b] Thermo 4.01, [c] Thermo 10.01.
From: www.thermo.com/com/cda/resources/resources_detail/1,2166,13217,00.html

Check the pH meter calibrations twice daily:

1) After calibration but before sampling, and
2) After sampling.

Measure the pH and temperature of the QCCS. The **pH should measure between 6.78 and 7.18 pH units**. Re-calibrate if the pre-sampling check fails these criteria. Qualify (flag) the DCE's pH data if the post-sampling check fails these criteria.

Dissolved Oxygen

Calibrate the DO meter each day according to manufacturer's instructions and record data onto the *D.O. Calibration Form* (Figure B-4).

Each month, compare field measurements with Winkler titrations. Calibrate the dissolved oxygen meter at an air pressure and altitude similar to expected ambient stream conditions. Measure the barometric pressure (mm Hg) during calibration. Use Table B-3, if necessary, for converting to these pressure units.

Daily D.O. Calibration				
Person Calibrating				
Date				
Meter serial number or ID				
Probe seriel number of ID				
Battery Voltage				
Calibration Altitude				ft
Calibration Air Pressure				mm Hg
Calibrated sucessfully?	Yes			If NO, recalibrate
Notes				

Figure B-4. The D.O. calibration Form.

Table B-3 unit conversions for pressure.

Atmospheres	Bars	mm Hg	inches Hg
1	1.01325	760	29.92126
0.9869233	**1**	750.0617	29.52999
0.001315789	0.001333224	**1**	0.03937008
0.03342105	0.03386388	25.4	**1**

Turbidity

Check the turbidity calibration each day, prior to sampling. Use the *Turbidity Calibration Check Form* (Figure B-5). If the calibration check is greater than 5% from the calibrated value, recalibrate and check again.

Daily Turbidity Check		
Person Checking		
Date		
Meter serial number or ID		
	TRUE	MEASURED
Cell 1	NTU	NTU
Cell 2	NTU	NTU
Cell 3	NTU	NTU
Notes		

Figure B-5. The Turbidity Calibration Check Form.

Occasional Quality Control

Table B-4 displays the schedule for occasional quality control activities.

Table B-4. Timing of occasional quality control activities.

Parameter	Jun	Jul	Aug	Sep	Oct	Operation
Temperature	X				X	Compare to NIST
pH	X				X	Compare buffers
Turbidity	X		X		X	Calibrate (and check)
Dissolved oxygen	X	X	X	X	X	Compare to Winkler

Temperature

At the start and end of the field season, compare the measurements from the temperature probe against measurements of an NIST thermometer. Verify that meter measures to within 1˚ C of the thermometer.

pH

Before and after the season, check the regular pH calibrations against dilute pH standards :

- pH 7 standard (6.97) – e.g. Thermo 700702
- pH 4 standard (4.10) – e.g. Thermo 700402
- pH 9 standard (9.15) – e.g. Thermo 700902

Calibrate first with the regular buffers as for the daily calibrations (e.g. first 7 and 4), then check using the QCCS. Re-calibrate, this time using the dilute standards (e.g. 6.97 and 4.10). Measure the QCCS and compare the difference in QCCS measures between calibrations.

Repeat for the high-pH calibrations (7 and 10; 6.97 and 9.15). Theoretical values by temperature for the dilute pH standards are found in Table B-5.

Turbidity

Calibrate and check the turbidimeter at least 3 times according to manufacturer's instructions: before the season, after the season, and mid-season. However, calibrate and check the turbidimeter more frequently if daily checks indicate the need.

Dissolved Oxygen

Once monthly, check the accuracy of the DO meter. Collect a Winkler sample at the same location and time as an *in situ* DO reading. Winkler samples are collected and analyzed according to Mathieu (2007).

Table B-5. Theoretical values by temperature for the dilute pH standards

Temp (˚C)	4[a]	7[b]	9[c]
10	**4.10**	**7.01**	**9.27**
11	**4.10**	**7.01**	**9.26**
12	**4.10**	**7.00**	**9.25**
13	**4.10**	**7.00**	**9.25**
14	**4.10**	**7.00**	**9.24**
15	**4.10**	**7.00**	**9.23**
16	**4.10**	**6.99**	**9.22**
17	**4.10**	**6.99**	**9.21**
18	**4.10**	**6.99**	**9.21**
19	**4.10**	**6.98**	**9.20**
20	**4.10**	**6.98**	**9.19**
21	**4.10**	**6.98**	**9.18**
22	**4.10**	**6.97**	**9.18**
23	**4.11**	**6.97**	**9.17**
24	**4.11**	**6.97**	**9.16**
25	**4.11**	**6.97**	**9.16**
26	**4.11**	**6.96**	**9.15**
27	**4.11**	**6.96**	**9.14**
28	**4.12**	**6.96**	**9.13**
29	**4.12**	**6.95**	**9.13**
30	**4.12**	**6.95**	**9.12**

[a] Orion 700402, [b] Orion 700702, [c] Orion 700902

References

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Hach Company. 2001. Model 2100P Portable Turbidimeter Instrument and Procedure Manual. Catalog Number 46500-88.

Hach Company. 2006a. Hydrolab DS5X, DS5, and MS% Water Quality Multiprobes, User manual, February 2006, Edition 3. http://www.hydrolab.com/pdf/S5_Manual.pdf

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Marsh-McBirney, Inc. 1990. Flo-Mate™ Model 2000 Portable Flow Meter Instruction Manual. Marsh-McBirney, Inc., Frederick, MD. http://www.marsh-mcbirney.com/support_manuals.tpl

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http://www.ecy.wa.gov/programs/eap/qa/docs/ECY_EAP_SOP_035MeasuringDO_v1_1.pdf

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Swanson, T. 2007. Standard Operating Procedures for Hydrolab® DataSonde® and MiniSonde® Multiprobes, Version 1.0. Washington Department of Ecology, Environmental assessment Program, Olympia, WA.
http://www.ecy.wa.gov/programs/eap/qa/docs/ECY_EAP_SOP_033Hydrolab.pdf

Appendix C

In Situ Measurements in Wide Streams & Rivers

Purpose and Scope

This method explains how to collect on-site measurements of temperature, dissolved oxygen, pH, and conductivity at wadeable streams for the Status and Trends Program using portable meters (e.g. Hydrolab Minisonde).

It requires adherence to calibration techniques discussed elsewhere in this procedure.

Definitions

Definitions of acronyms and other terms are found in Table C-1.

Table C-1. Definitions.

Term or Accronym	**Definition**
DCE	Data Collection Event. Data are indexed using this code which includes the SITE_ID, the date, and the time that the event began.
index station	The point location mapped by the site coordinates. It is sometimes called "X". This is normally located at the mid-elevation of the stream site.
NIST	National Institute of Standards and Technology
QC	Quality control. A quality control check is a measurement of a standard value to estimate the accuracy of an instrument.
thalweg transect	There are 101 equally spaced thalweg transects dividing the length of the stream site. They are labeled A0, A1, A2,A3, A4, A5, A6, A7, A8, A9, B0,….K0. Transect A0 is at the bottom of the site. K0 is at the top.

Personnel Responsibilities

This method is performed by 1 or more persons. This method is applied at every DCE, at the start *and* end of the sampling event. Staff performing this method must have been trained.

Equipment, Reagents, Supplies

- No. 2 pencil
- Chemistry and Sampling Form
- Completed Calibration Forms
- Meters (for temperature, conductivity, pH, and dissolved oxygen)
- Meter maintenance kits (e.g. Swanson, 2007)
- Meter Manuals (Hach 1999, Hach 2006a, Hach 2006b)

Summary of Procedure

Calibrate the instruments before sampling according to calibration methods discussed elsewhere in this protocol. Check the instrument after calibration (before sampling), and after sampling, according to the same methods. Measure the stream twice.

Verify Quality Control

Prior to sampling

Ensure that the calibrations and that QC checks have been performed according to methods described elsewhere in this protocol. Circle "Yes" on the top section of the Chemistry and Sampling Form (Figure C-1) for each sensor that checked out. Proceed with measurements using sensors that are within criteria.

After sampling

Post-sampling calibration checks can be performed during the following day. Be sure to qualify data that were collected preceding calibration checks that failed to meet criteria.

Measure

Measure these parameters twice during a DCE, once at the start and once at the end:

- pH
- water temperature
- dissolved oxygen
- oxygen percent saturation
- specific conductivity

Record time (military) and location (thalweg transect). The first set of *in situ* measurements should usually be made near transect A0 (when wading) or K0 (when boating). The second set of *in situ* measurements should usually be made near transect K0 (when wading) or A0 (when boating). Measurements should *always* be taken within the boundaries of the site (between transects A0 and K0).

Place the probes into the stream and let them thermally equilibrate to the stream temperature. This might take 3-5 minutes. Then hold the sensors so that they are just below the surface of the water, and completely immersed. Avoid any turbulence. Make sure that readings are stable. On the Chemistry and Sampling Form (Figure C-1), record temperature (˚ C, nearest tenth), pH (pH unit, nearest hundredth), specific conductivity (µS/cm at 25˚ C, nearest tenth), dissolved oxygen (mg/L, nearest tenth), and oxygen percent saturation (nearest tenth).

Reviewed by (Initials): JS

Status and Trends - Chemistry and Sampling Form

	Site Number		YY	MMDD	HH : MM
DCE:	W A M 0 6 0 0 - 0 0 0 0 0 0	- D C E -	2 0 1 0	- 0 8 1 5	- 1 0 : 0 0

IN SITU WATER QUALITY CALIBRATION	Unit No.	Operator: Joe Schmoe		Flag
T	23	checked vs NIST	(Yes) No	F1
DO	23	Sensor Calibrated	(Yes) No	
pH	23	Calibrated and Checked	(Yes) No	
Cond	23	Calibrated and Checked	(Yes) No	
Turb	T-3	Calibrated and Checked	(Yes) No	F2

Notes (in situ) F1 - Temperature probe checked 6/25 this year.
F2 - Turb. calibrated & checked 6/25 + checked today.

Sed:%Gravel 0 0 5 %Sand 0 0 5 %Fines 0 9 0

In Situ Chemistry

Time1 1 0 : 1 5 hrs — Start Location (e.g. F0): K 0
Temp1 0 6 . 3 deg C
pH1 0 6 . 9 4 pH Units
DO1 1 0 . 9 mg/L — %Sat1 1 0 2 . 5
Cond 0 0 0 2 7 . 8 uS/cm @ 25C

Time2 1 9 : 5 0 hrs — End Location (e.g. K0): A 0
Temp2 0 7 . 0 deg C
pH2 0 7 . 0 0 pH Units
DO2 1 0 . 9 mg/L — %Sat2 0 9 9 . 5
Cond 0 0 0 2 7 . 9 uS/cm @ 25C

Sample	Primary Sample: No. of Jars	Duplicate Sample: No. of Jars	Destination	Sample ID or Fish Common Name	Flag
TPN	1	0	Manchester Envtl Lab	Work Order + 0 5	F1
Tot P	1	0	Manchester Envtl Lab	Work Order + 0 5	F1
Cl	1	0	Manchester Envtl Lab	Work Order + 0 5	F1
Turb	1	0	Field measurement with Hach 2100P		
Sed PAH	1	0	Manchester Envtl Lab	Work Order + 0 6	F1
Sed Metals*	1	0	Manchester Envtl Lab	Work Order + 0 6	F1
Benthos	1	0	Temp. storage at base facility	DCE	
Fish Spp1	1	0	Temp. storage at base facility	torrent sculpin	
Fish Spp2	1	0	Temp. storage at base facility	unspecified lamprey	
Fish Spp3	1	0	Temp. storage at base facility	longnose dace	

Water Sample Location (e.g. A5): A 0

Sample Notes (explain flags): F1 Manchester Work Order 10-08-041

FIELD TURBIDITY: 0 . 5 NTU

Draft

*Sediment Metals jar includes sample material to be analyzed for TOC

Note: Use standard Manchester Environmental Lab forms for tracking water and sediment samples.

Figure C-1. The *Chemistry and Sampling Form*, with example *in situ* data highlighted.

References

Hach Company. 1999. Surveyor® 4 Water Quality Display User's Manual. HL#003070, REVISION B.

Hach Company. 2006a. Hydrolab DS5X, DS5, and MS% Water Quality Multiprobes, User manual, February 2006, Edition 3. http://www.hydrolab.com/pdf/S5_Manual.pdf

Hach Company. 2006b. Instruction Sheet: Hach LDO™ Sensor. February 2006 Edition 4.

Mathieu, N. 2007. Standard Operating Procedure for Measuring Dissolved Oxygen in Surface Water, Version 1.1. Washington Department of Ecology, Environmental assessment Program, Olympia, WA. http://www.ecy.wa.gov/programs/eap/qa/docs/ECY_EAP_SOP_035MeasuringDO_v1_1.pdf

Swanson, T. 2007. Standard Operating Procedures for Hydrolab® DataSonde® and MiniSonde® Multiprobes, Version 1.0. Washington Department of Ecology, Environmental assessment Program, Olympia, WA. http://www.ecy.wa.gov/programs/eap/qa/docs/ECY_EAP_SOP_033Hydrolab.pdf

Appendix D

Water Sampling
in Wide Streams & Rivers

Purpose and Scope

This method explains how to collect water samples at wide stream and rivers for WHSR. Grab-water samples are collected for these 5 parameters:

1. Total Phosphorus (by colorimetric analysis)
2. Total Nitrogen (by persulfate method)
3. Chloride
4. Turbidity
5. Total Suspended Solids

This method also describes how to determine field turbidity (NTU) during the day of collection.

Definitions

Definitions of acronyms and other terms are found in Table D-1.

Table D-1. Definitions.

Term or Accronym	**Definition**
CL	chloride
DCE	Data Collection Event. Data are indexed using this code which includes the SITE_ID, the date, and the time that the event began. It uses this format: **WAM06600-NNNNNN-dce-20YY-MMDD-HHMM** **NNNNNN** = the number portion of the SITE_ID. **YY** = the last two numeric digits of the year that the event occurred. **MM** = the two numeric digits for the month that the event occurred. **DD** = the two numeric digits for the day within the month that the event occurred. **HHMM** = the military time when the event began.

Index Station	The point location mapped by the site coordinates. It is sometimes called “X”. This is normally located at the mid-elevation of the stream site.
Master Sample	The list of 387,237 probabilistic sites (statewide). These sites were selected with a randomized (GRTS) design from the February 2005 version of the Washington State Department of Natural Resources watercourses (1:24,000).
MEL	Manchester Environmental Laboratory
NTU	Nephelometric Turbidity Unit
SITE_ID	A unique 15-digit site identification code provided by the Master Sample list. It begins with “WAM06600-“
Thalweg Transect	One of 101 equidistant transects across the length of a site. Labeling includes the name of the major transect. For example the thalweg transects between (and including) major transects A and B would be labeled as follows: A0, A1, A2, A3, A4, A5, A6, A7, A8, A9, B0 (i.e.., thalweg transect A0 is identical to major transect A)
TP	total phosphorus
TPN	total persulfate nitrogen
TSS	total suspended solids
TURB	turbidity

Personnel Responsibilities

This method is performed by 1 or more persons. This method is applied at every DCE, at the start of the sampling event. Staff performing this method must have been trained.

Equipment, Reagents, Supplies

Water Sampling

- No. 2 pencil
- *Chemistry and Sampling Form*
- *Laboratory Analyses Required Form*
- Gloves - Non-powdered nitrile
- Garbage bag
- Cooler, Ice
- Sample Tags (with laboratory-assigned sample numbers)
- Jar#26 for TP (Figure D-1)
- Jar#19 for TPN (Figure D-2)
- Jar#22 for Cl (Figure D-3)
- Jar#22 for TURB (Figure D-3)
- Jar#23 for TSS (Figure D-4)

Figure D-1. The 60-mL jar for total phosphorus water samples: (Manchester Laboratory Index # 26).

Figure D-2. The 125-mL jar for total persulfate nitrogogen water samples:
(Manchester Laboratory Index # 19).

Figure D-3. The 500-mL jar. (Manchester Laboratory Index # 22).
There is one each for chloride and tubidity water samples:

Figure D-4. The 1000-mL jar for total susppended solids water samples: (Manchester Laboratory Index # 23).

Turbidity Measurement

- Turbidimeter (e.g. Hach Model 2100P)
- Turbidi manual (e.g. Hach 2001)
- Batteries

Summary of Procedure

This method is based on Joy (2006). Collect water samples at the last transect encountered during the day, but before other in-stream activities at that station. Fill stream water into each of 5 polypropylene jars (Table D-2). Immediately chill the samples in the dark. Deliver samples for most parameters (total phosphorous, total nitrogen, total suspended solids, and chloride) to the Manchester Environmental Laboratory (MEL) weekly. Samples for each week should be received at MEL by Friday morning. Turbidity will be analyzed by the field crew, on the day of collection, ideally inside an office or hotel room.

Table D-2. Handling requirements for water samples.

PARAMETER	JAR SIZE	HOLDING TIME BEFORE ANALYSIS[a]
TP [b]	60 mL	28 days
TPN [c]	125 mL	28 days
CL	500 mL	28 days
TURB	500 mL	48 hours
TSS	1000 mL	7 Days

a All water samples need to be chilled (0-6 ˚C).
b The jar for total phosphorus is pre-acidified with 0.25 mL 1:1 HCl
c The jar for total persulfate nitrogen is pre-acidified with 0.25 mL 1:1 H2SO4

Pre-sampling preparation

Sample Numbers, Jars and Tags

Prior to the field season, the Department of Ecology's Environmental Assessment Program (EAP) will help to prepare by performing two tasks.

1) EAP will obtain sample numbers from the Manchester Environmental Laboratory by submitting a *Pre-sampling Notification Form* (MEL, 2008).
2) EAP will order the sample jars and labels from the Manchester Environmental Laboratory by submitting the *Sample Container Request Form* (MEL, 2008).

Collecting Samples

Water samples can be collected anywhere within the site (between transect K0 and A0) where water is deep enough. However at wide streams & rivers, normally collect water samples at the last transect visited. Collect from upstream of your position. If using a boat, collect samples after navigating to mid-channel. If you are filling jars from the boat, make sure that you fill them from the upstream side of the boat.

For each jar, remove the lid just before sampling. Be careful not to contaminate the cap, neck, or the inside of the bottle.

Chloride (CL), Turbidity (TURB) and Total Suspended Solids (TSS)

Stand in relatively deep, relatively non-turbulent water. Face upstream. Hold the container near its base, reach out in front of yourself as far a possible, and plunge it (mouth down) below the surface to about elbow depth. Make sure not to disturb sediments. Leave enough headspace so that the laboratory staff can mix the sample.

Total Phosphorus (TP) and Total Persulfate Nitrogen (TPN)

Stand in relatively deep, relatively non-turbulent water. Face upstream. Hold the container upright and place the lid over the mouth so that only a small area forms an opening (Figure D-5). Immerse the jar 15 cm (6 in) while holding the cap in position with your fingers as far away from the opening as possible. Carefully monitor the filling rate to avoid overfilling.

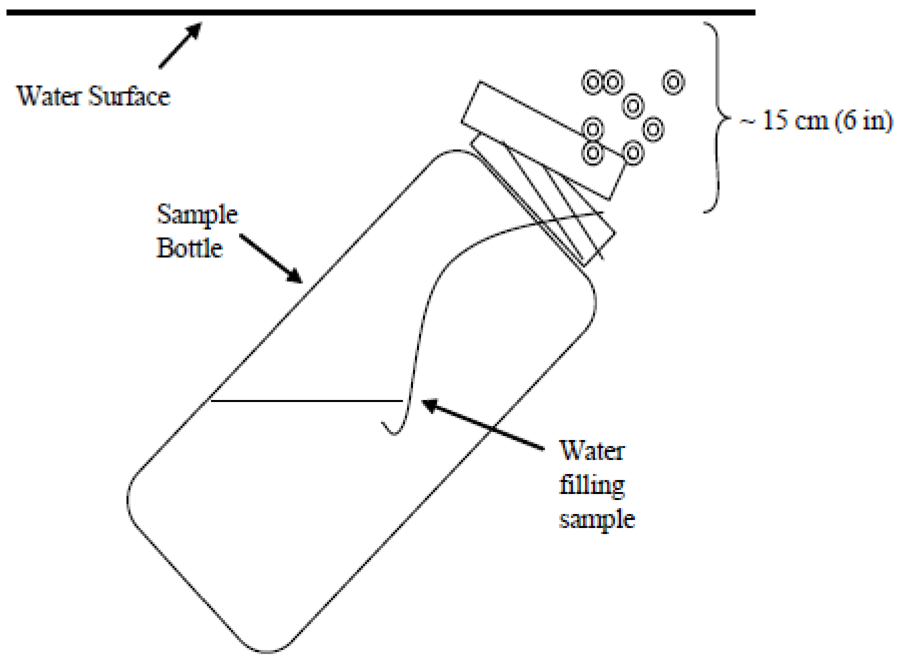


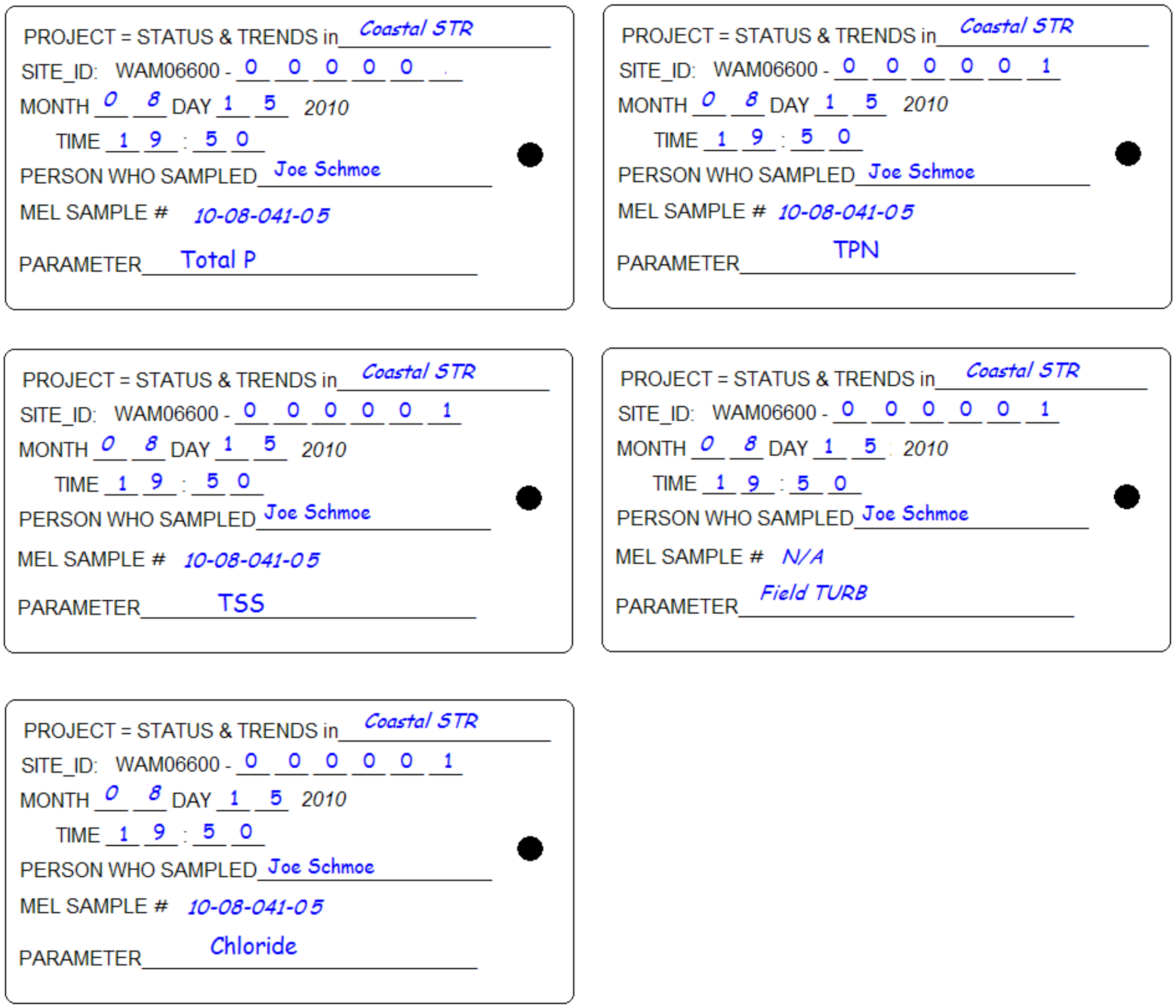
Figure D-5. Cap position during sample collection, when using jars that have been pre-filled with acid preservative (TPN and TP).

Field Processing

Labeling

For each jar, loop the string of the sample tag over the lid until it is secure. Use at least three loops for 250 mL jars and at least two loops for 500 mL jars or larger. Check the tag to ensure that the Master Sample SITE_ID number is recorded (this is the 6-digit number that follows "WAM06600-"

on the SITE_ID. Also record the data and time that appears in the DCE. Use waterproof ink or pencil. An example tag is provided in Figure D-6.



PROJECT = STATUS & TRENDS in Coastal STR
SITE_ID: WAM06600 - 0 0 0 0 0
MONTH 0 8 DAY 1 5 2010
TIME 1 9 : 5 0
PERSON WHO SAMPLED Joe Schmoe
MEL SAMPLE # 10-08-041-05
PARAMETER Total P

PROJECT = STATUS & TRENDS in Coastal STR
SITE_ID: WAM06600 - 0 0 0 0 0 1
MONTH 0 8 DAY 1 5 2010
TIME 1 9 : 5 0
PERSON WHO SAMPLED Joe Schmoe
MEL SAMPLE # 10-08-041-05
PARAMETER TPN

PROJECT = STATUS & TRENDS in Coastal STR
SITE_ID: WAM06600 - 0 0 0 0 0 1
MONTH 0 8 DAY 1 5 2010
TIME 1 9 : 5 0
PERSON WHO SAMPLED Joe Schmoe
MEL SAMPLE # 10-08-041-05
PARAMETER TSS

PROJECT = STATUS & TRENDS in Coastal STR
SITE_ID: WAM06600 - 0 0 0 0 0 1
MONTH 0 8 DAY 1 5 2010
TIME 1 9 : 5 0
PERSON WHO SAMPLED Joe Schmoe
MEL SAMPLE # N/A
PARAMETER Field TURB

PROJECT = STATUS & TRENDS in Coastal STR
SITE_ID: WAM06600 - 0 0 0 0 0 1
MONTH 0 8 DAY 1 5 2010
TIME 1 9 : 5 0
PERSON WHO SAMPLED Joe Schmoe
MEL SAMPLE # 10-08-041-05
PARAMETER Chloride

Figure D-6. Example tags for water chemistry jars.

Storage

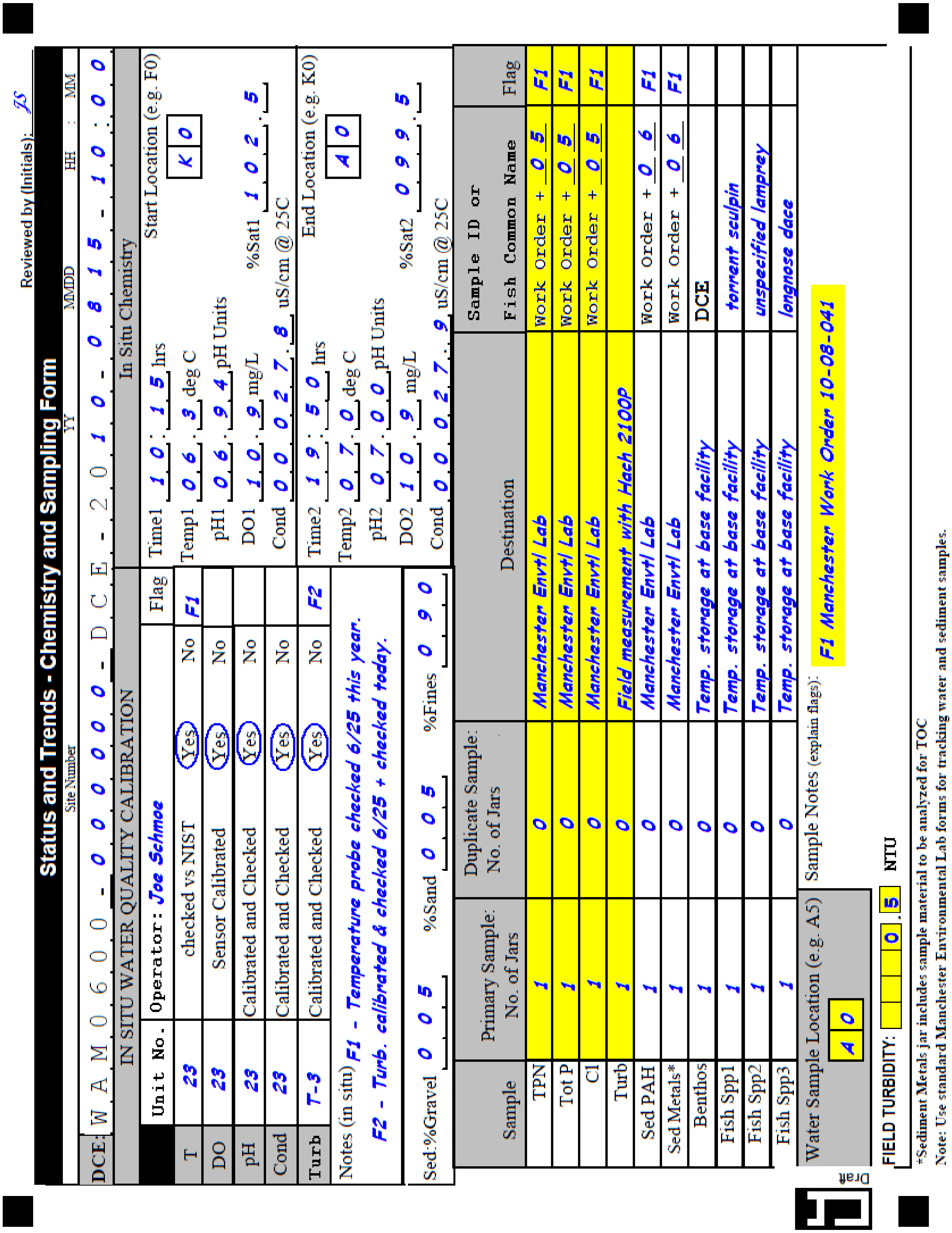
If you are sampling close to your vehicle or are in a raft, immediately place samples in a cooler of ice. If you are sampling remotely, maintain samples in a sealed black garbage bag that is immersed in the stream and in the shade until you are ready to leave the site (Peck and others 2006). Place samples into a cooler of ice as soon as possible.

Chemistry and Sampling Form

Complete the relevant portions of the *Chemistry and Sampling Form* (Figure D-7) including how many jars were collected for each parameter. Also make sure that the header information is complete and that the sample location is specified according to the code for the closest Thalweg Transect.

Sample Delivery

Sample Crews will complete a *Laboratory Analyses required Form* (Figure D-8 and MEL, 2008) and submit it with samples (except turbidity) during weekly shipments to the Manchester Environmental Laboratory. The Laboratory Analyses Required (LAR) form will serve as a chain-of-custody form. Turbidity will be measured by the field crew within the day of collection.



Status and Trends - Chemistry and Sampling Form

Reviewed by (Initials): JS

DCE: W A M O 6 0 0 - 0 0 0 0 0 0 - D C E - 2 0 1 0 - 0 8 1 5 - 1 0 : 0 0
(Site Number; YY; MMDD; HH : MM)

IN SITU WATER QUALITY CALIBRATION				
Unit No.	Operator: Joe Schmoe			Flag
T	23	checked vs NIST	Yes No	F1
DO	23	Sensor Calibrated	Yes No	
pH	23	Calibrated and Checked	Yes No	
Cond	23	Calibrated and Checked	Yes No	
Turb	T-3	Calibrated and Checked	Yes No	F2

Notes (in situ) F1 - Temperature probe checked 6/25 this year.
F2 - Turb. calibrated & checked 6/25 + checked today.

Sed:%Gravel 0 0 5 %Sand 0 0 5 %Fines 0 9 0

In Situ Chemistry

Time1 1 0 : 1 5 hrs Start Location (e.g. F0) K 0
Temp1 0 6 . 3 deg C
pH1 0 6 . 9 4 pH Units
DO1 1 0 . 9 mg/L %Sat1 1 0 2 . 5
Cond 0 0 0 0 2 7 . 8 uS/cm @ 25C
Time2 1 9 : 5 0 hrs End Location (e.g. K0) A 0
Temp2 0 7 . 0 deg C
pH2 0 7 . 0 0 pH Units
DO2 1 0 . 9 mg/L %Sat2 0 9 9 . 5
Cond 0 0 0 0 2 7 . 9 uS/cm @ 25C

Sample	Primary Sample: No. of Jars	Duplicate Sample: No. of Jars	Destination	Sample ID or Fish Common Name	Flag
TPN	1	0	Manchester Envtl Lab	Work Order + 05	F1
Tot P	1	0	Manchester Envtl Lab	Work Order + 05	F1
Cl	1	0	Manchester Envtl Lab	Work Order + 05	F1
Turb	1	0	Field measurement with Hach 2100P		
Sed PAH	1	0	Manchester Envtl Lab	Work Order + 06	F1
Sed Metals*	1	0	Manchester Envtl Lab	Work Order + 06	F1
Benthos	1	0	Temp. storage at base facility	DCE	
Fish Spp1	1	0	Temp. storage at base facility	torrent sculpin	
Fish Spp2	1	0	Temp. storage at base facility	unspecified lamprey	
Fish Spp3	1	0	Temp. storage at base facility	longnose dace	

Water Sample Location (e.g. A5) A 0

Sample Notes (explain flags): F1 Manchester Work Order 10-08-041

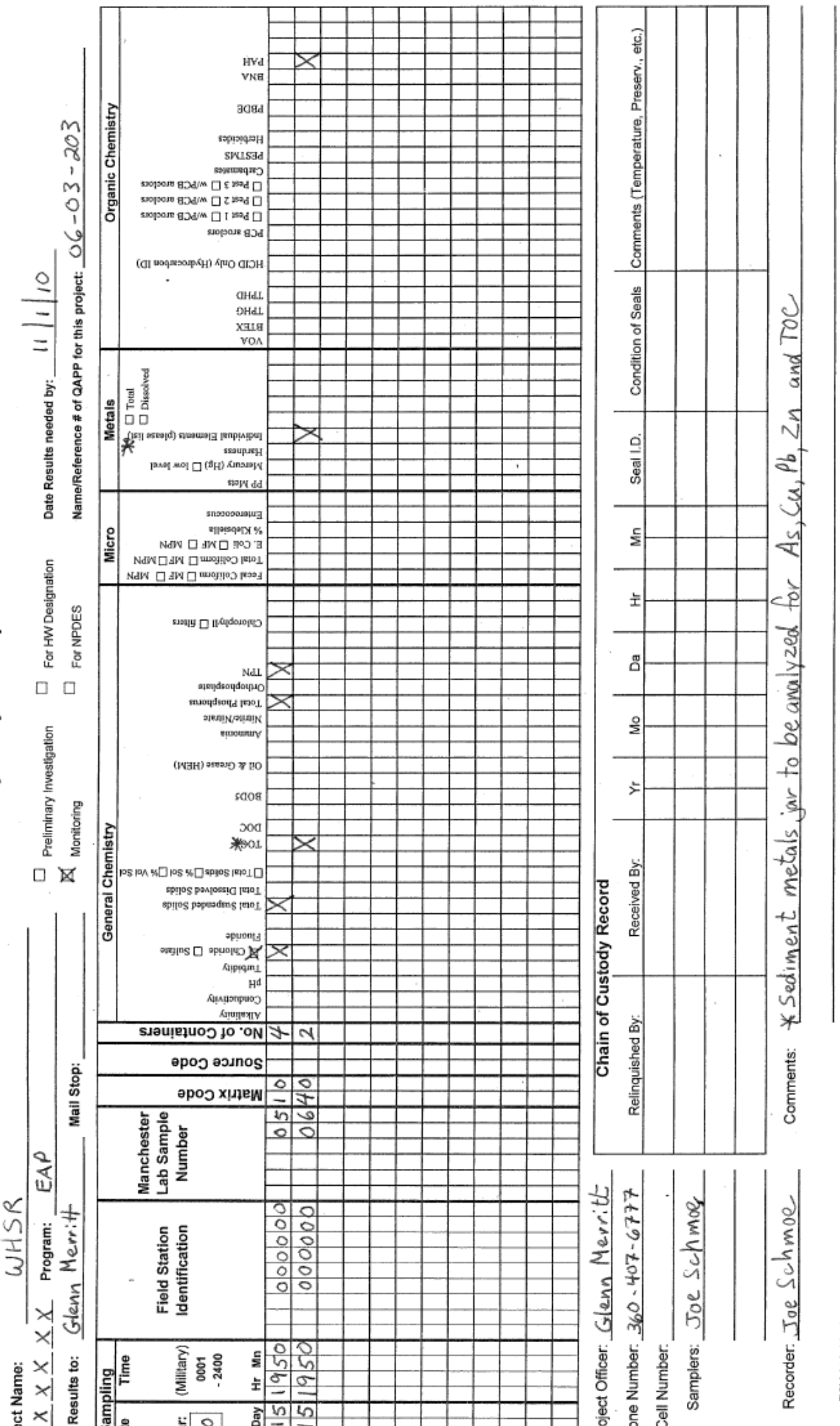
FIELD TURBIDITY: 0 . 5 NTU

*Sediment Metals jar includes sample material to be analyzed for TOC

Note: Use standard Manchester Environmental Lab forms for tracking water and sediment samples.

Draft

Figure D-7. The *Chemistry and Sampling Form*, with example water sampling data highlighted.



Laboratory Analyses Required

Page 1 of 1

Project Name: WHSR

SIC: X X X X X Program: EAP

Send Results to: Glenn Merritt Mail Stop:

☐ Preliminary Investigation ☐ For HW Designation

☒ Monitoring ☐ For NPDES

Date Results needed by: 11/1/10

Name/Reference # of QAPP for this project: 06-03-203

Date (Mo Day), Year: 2010	Time (Military) 0001-2400 (Hr Mn)	Field Station Identification	Manchester Lab Sample Number	Matrix Code	Source Code	No. of Containers	Analyses marked
08 15	1950	000000		05 10		4	Chloride, Total Suspended Solids, Total Phosphorus, TPN
08 15	1950	000000		06 40		2	TOC*, Individual Elements* (please list), PAH

Chain of Custody Record

Relinquished By:	Received By:	Yr	Mo	Da	Hr	Mn	Seal I.D.	Condition of Seals	Comments (Temperature, Preserv., etc.)

Project Officer: Glenn Merritt

Phone Number: 360-407-6777

Cell Number:

Samplers: Joe Schmoe

Recorder: Joe Schmoe

Comments: *Sediment metals jar to be analyzed for As, Cu, Pb, Zn and TOC

ECY 040-115 (Rev. 10/05)

Figure D-8. Example *Laboratory Analysis Required Form* for sample shipment from 1 DCE.

Measuring Turbidity

Measure turbidity within 24 hrs of collection. Find a flat, sturdy surface on which to work that is protected from wind and sun. Calibrate and check the turbidimeter as discussed elsewhere in this protocol. Remove the 500 mL sample from refrigeration, slightly agitate it, then decant the mixed contents into the turbidimeter sample cell. Degas the contents of the sample cell by applying a vacuum. (Figure D-7). This is done by fitting a syringe to a stopper on the cell and drawing the plunger upward until gas bubbles appear. Release slowly. Let the sample rest for 15-20 seconds.

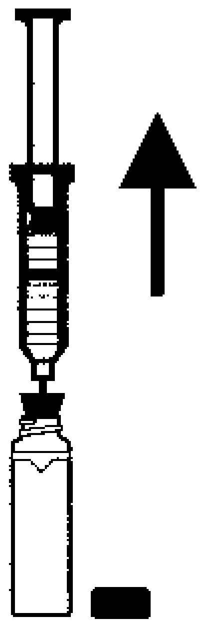


Figure D-9. Degassing the contents of the turbidity sample cell.

Follow the manufacturer's instructions for measurement of the sample using the turbidimeter. Record field turbidity results (NTU) onto the *Chemistry and Sampling Form* (Figure D-7)

References

Joy, J. 2006. Standard Operating Procedure for Manually Obtaining Surface Water Samples SOP EAP015. Washington State Department of Ecology, Environmental Assessment Program, Olympia.
http://www.ecy.wa.gov/programs/eap/qa/docs/ECY_EAP_SOP_015ManuallyObtainingSurfaceWaterSamples.pdf

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http://www.epa.gov/wed/pages/publications/authored/EPA620R-06003EMAPSWFieldOperationsManualPeck.pdf

Appendix E

Sediment Chemistry Sampling

Purpose and Scope

This method explains how to collect a site-composite sediment sample in the Status and Trends Program. Stream sites are sampled within day-long data collection events (DCEs). Each composite sample will be composed of scoops taken from 3 separately-located shallow-water stations in the site. To detect the presence of select contaminants at the site, the sample will be analyzed for metals (copper, lead, zinc, arsenic) and a standard list of polynuclear aromatic hydrocarbon (PAH) compounds. To help interpret the results, the sample will also be analyzed for total organic carbon and grain size composition.

Definitions

Definitions of acronyms and other terms are found in Table F-1.

Table F-1. Definitions.

Term or Accronym	**Definition**
DCE	Data Collection Event
GC/MS	Gas Chromatography Mass Spectrometry
ICP	Inductively Coupled Plasma
Index Station	The point location mapped by the site coordinates. It is sometimes called “X”. This is normally located at the mid-elevation of the stream site.
MEL	Manchester Environmental Laboratory
MSDS	Material Safety Data Sheet. Written, printed, or electronic information (on paper, microfiche, or on-screen) that informs manufacturers, distributors, employers or employees about a hazardous chemical, its hazards, and protective measures as required by material safety data sheet and label preparation, Chapter 296-839 WAC.
PAH	Polynuclear Aromatic Hydrocarbon. For Status and Trends there are 24 standard analytes: Naphthalene 2-Methylnaphthalene 1-Methylnaphthalene 2-Chloronaphthalene Acenaphthylene

	Acenaphthene Dibenzofuran Fluorene Phenanthrene Anthracene Carbazole Phenanthrene, 3,6-dimethyl- Fluoranthene Pyrene Retene Benzo(k)fluoranthene Benzo(a)pyrene Perylene Indeno(1,2,3-cd)pyrene Dibenzo(a,h)anthracene Benzo(ghi)perylene Chrysene Benzo(b)fluoranthene Benzo(a)anthracene
TOC	Total Organic Carbon

Personnel Responsibilities

This sampling method is performed by 1 person in the field. Pre-sampling pre-cleaning activities should be performed by staff familiar with MSDS and safety procedures. This method is applied at every DCE. Staff performing this method must have been trained.

Equipment, Reagents, Supplies

- Stainless steel bowl (about 6)
- Stainless steel spoon (about 6)
- Turkey baster (3)
- No. 2 pencil
- *Chemistry and Sampling Form*
- *Laboratory Analyses Required Form*
- Gloves - Non-powdered nitrile
- Cooler, Ice
- Garbage Bag
- Sample Tags (with laboratory-assigned sample numbers)
- Jars (provided by the laboratory)
- Aluminum foil
- Wash bottle (labeled) with Liquinox or Alconox
- Wash bottle (labeled) with acetone (pesticide grade)
- Wash bottle (labeled) with 10% nitric acid
- MSDS
- Personal protective gear as specified by the MSDS
- Fume hood

Summary of Procedure

These procedures are derived from methods described in Johnson (1997), Blakely (2008a), and Manchester Environmental Laboratory (2008). Surface sediment samples are collected for laboratory analyses (Table F-2). The crew will analyze grain sizes of the sample while in the field. Samples are chilled immediately and delivered to the laboratory or a courier within 14 days of collection, but normally within 24 hours.

Table E-2. Laboratory methods for sediment chemistry samples.

Analysis	Analytical Method	Reporting Limits
TOC	PSEP (1986, with 1997 update)[a] MEL (2008) page 120	0.1%
As	ICP Method 200.7 (EPA 1983) [b] , MEL (2008) page 134	0.1 mg/Kg, dry
Cu	ICP Method 200.7 (EPA 1983) [b] MEL (2008) page 134	0.1 mg/Kg, dry
Pb	ICP Method 200.7 (EPA 1983) [b] MEL (2008) page 134	0.1 mg/Kg, dry
Zn	ICP Method 200.7 (EPA 1983) [b] MEL (2008) page 134	5 mg/Kg, dry
PAHs	GC/MS Method 8270 (EPA 1996) [b] MEL (2008) page 164	40 µg/Kg, dry

a Find method quality objectives in Blakely (2008b), Table 8.
b Find method quality objectives in Meredith and Furl (2008), Table 2.

Pre-sampling preparation

Sample Numbers, Jars and Tags

Prior to the field season, the Department of Ecology's Environmental Assessment Program (EAP) will help to prepare by performing two tasks.

1) EAP will obtain sample numbers from the Manchester Environmental Laboratory by submitting a *Pre-sampling Notification Form* (MEL 2008).
2) EAP will order the sample jars and labels from the Manchester Environmental Laboratory by submitting the *Sample Container Request Form* (MEL 2008).

Pre-cleaning

On a weekly basis, field crews will pre-clean enough sampling tools to last a week (including spares). Alternately, larger batches of utensils could be cleaned and wrapped at the Department of Ecology and then shipped to remote field crews.

These are the pre-washing steps for each bowl, spoon and turkey baster:

1) Wash in Liquinox detergent, then
2) Rinse (three times) with tap water, then
3) Wash with 10% nitric acid, then
4) Rinse with deionized water, then
5) **In fume hood**, rinse with acetone, then
6) **In fume hood,** rinse with hexane, then

7) **In fume hood,** air dry, then
8) Wrap with aluminum foil (shiny side of foil facing out).
9) Properly dispose of hazardous wastes.

Sampling

Use pre-cleaned equipment that has been wrapped in foil.

Collect the sample by compositing from each of three suitable locations near the point of arrival. A suitable location will have these characteristics:

- Surface sediment is dominated by particles < 2 mm diameter,
- Water depth above the sediment is < than 30 cm,
- The station is always under water throughout the day.
- Anywhere within 10 bankfull widths (upstream or downstream) of the index station.
- Upstream from where staff have entered the stream channel.

Using a stainless steel spoon, sample the top 2 cm of sediment and place it into a stainless steel mixing bowl. Let the sample settle, then use the turkey baster to remove overlying water. Homogenize the sample by stirring with the spoon until a uniform color and texture is achieved.

PAH Sample

Transfer sediment with the spoon into an 8-oz glass, wide-mouth jar (described as #6 by MEL, 2008). Only fill the jar to about 80% capacity so that there is room for expansion during freezing. Screw the lid closed, label it, and place it into a cooler of ice. Record sample information on the *Chemistry and Sampling Form* (Figure E-1). Use the appropriate column depending upon whether documenting the primary sample or a duplicate for the date. For each sample:

- Record “MANCHESTER ENVTL LAB” for the “Destination”
- Record “1” for “No. Jars”.

Metals and TOC Sample

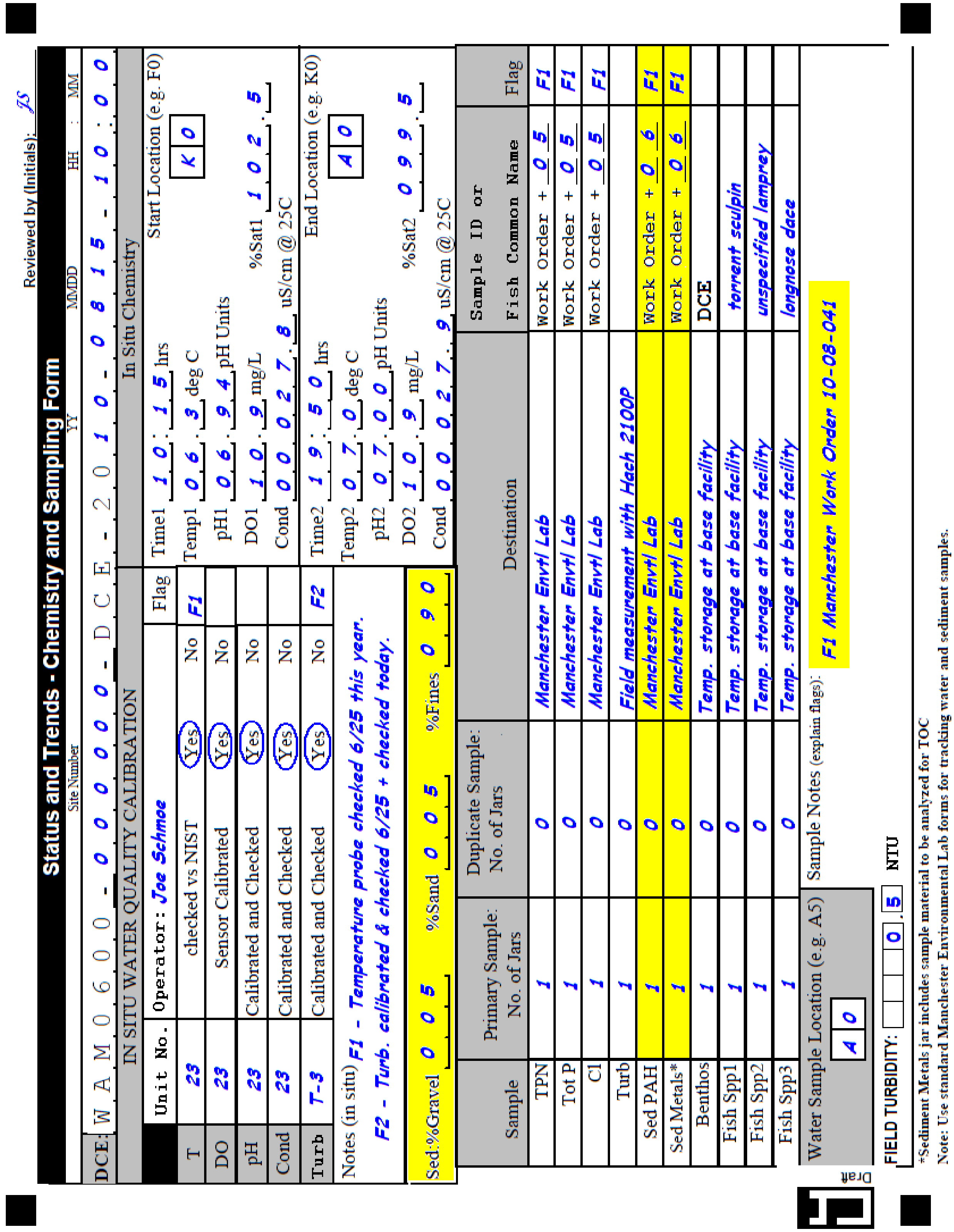
Transfer sediment with the spoon into an 8-oz glass, wide-mouth jar (described as #6 by MEL, 2008). Only fill the jar to about 80% capacity so that there is room for expansion during freezing. Screw the lid closed, label it, and place it into a cooler of ice. Record sample information on the *Chemistry and Sampling Form* (Figure E-1). Use the appropriate column depending upon whether documenting the primary sample or a duplicate for the date. For each sample:

- Record “MANCHESTER ENVTL LAB” for the “Destination”
- Record “1” for “No. Jars”.

Grain Size Analysis

Visually estimate the composition of the sediment in the composite sample. Record percent gravel, percent sand, and percent fines on the *Chemistry and Sampling Form* (Figure E-1). Gravel should never be a dominant component of the sample. Sand is gritty to the touch whereas fines are not. You can check the feel of *residue in the bowl* for presence of sand or fines *only* after sample jars have been filled and placed on ice.

- Gravel (> 2mm)
- Sand (2-16 mm)
- Fines (silt/clay/muck)


Reviewed by (Initials): JS

Status and Trends - Chemistry and Sampling Form

DCE: W A M 0 6 0 0 - 0 0 0 0 0 0 - D C E - 2 0 1 0 - 0 8 1 5 - 1 0 : 0 0
(Site Number / YY / MMDD / HH : MM)

IN SITU WATER QUALITY CALIBRATION

	Unit No.	Operator: Joe Schmoe			Flag
T	23	checked vs NIST	(Yes)	No	F1
DO	23	Sensor Calibrated	(Yes)	No	
pH	23	Calibrated and Checked	(Yes)	No	
Cond	23	Calibrated and Checked	(Yes)	No	
Turb	T-3	Calibrated and Checked	(Yes)	No	F2

Notes (in situ) F1 - Temperature probe checked 6/25 this year.
F2 - Turb. calibrated & checked 6/25 + checked today.

Sed:%Gravel 0 0 5 %Sand 0 0 5 %Fines 0 9 0

In Situ Chemistry

Time1 1 0 : 1 5 hrs — Start Location (e.g. F0) K 0
Temp1 0 6 . 3 deg C
pH1 0 6 . 9 4 pH Units
DO1 1 0 . 9 mg/L — %Sat1 1 0 2 . 5
Cond 0 0 0 2 7 . 8 uS/cm @ 25C

Time2 1 9 : 5 0 hrs — End Location (e.g. K0) A 0
Temp2 0 7 . 0 deg C
pH2 0 7 . 0 0 pH Units
DO2 1 0 . 9 mg/L — %Sat2 0 9 9 . 5
Cond 0 0 0 2 7 . 9 uS/cm @ 25C

Sample	Primary Sample: No. of Jars	Duplicate Sample: No. of Jars	Destination	Sample ID or Fish Common Name	Flag
TPN	1	0	Manchester Envtl Lab	Work Order + 05	F1
Tot P	1	0	Manchester Envtl Lab	Work Order + 05	F1
Cl	1	0	Manchester Envtl Lab	Work Order + 05	F1
Turb	1	0	Field measurement with Hach 2100P		
Sed PAH	1	0	Manchester Envtl Lab	Work Order + 06	F1
Sed Metals*	1	0	Manchester Envtl Lab	Work Order + 06	F1
Benthos	1	0	Temp. storage at base facility	DCE	
Fish Spp1	1	0	Temp. storage at base facility	torrent sculpin	
Fish Spp2	1	0	Temp. storage at base facility	unspecified lamprey	
Fish Spp3	1	0	Temp. storage at base facility	longnose dace	

Water Sample Location (e.g. A5) A 0

Sample Notes (explain flags): F1 Manchester Work Order 10-08-041

Draft

FIELD TURBIDITY: 0 . 5 NTU

*Sediment Metals jar includes sample material to be analyzed for TOC
Note: Use standard Manchester Environmental Lab forms for tracking water and sediment samples.

Figure E-1. *The Chemistry and Sampling Form*, with sediment chemistry data highlighted.

Field Processing

Storage

If you are sampling close to your vehicle, immediately place samples in a cooler of ice. If you are sampling remotely, maintain samples in a sealed black garbage bag that is immersed in the stream and in the shade until you are ready to leave the site. Place samples into a cooler of ice as soon as possible.

Labeling

For each jar, loop the string of the sample tag over the lid until it is secure. Use at least three loops for 250 mL jars and at least two loops for 500 mL jars or larger. Check the tag to ensure that the Master Sample SITE_ID number is recorded (this is the 6-digit number that follows "WAM06600-" on the SITE_ID. Also record the data and time that appears in the DCE. Use waterproof ink or pencil. An example set of tags is provided in Figure E-2.

Sample Delivery

Sample Crews will complete a *Laboratory Analyses required Form* (Figure E-3 and MEL, 2008) and submit it with weekly sample shipments to the Manchester Environmental Laboratory. The Laboratory Analyses Required (LAR) form will serve as a chain-of-custody form. Sediment chemistry samples have a 14-day field holding time (while at 0-6 ˚C).

PROJECT = STATUS & TRENDS in *Coastal STR*

SITE_ID: WAM06600 - 0 0 0 0 0 0

MONTH 0 8 DAY 1 5 2010

TIME 1 9 : 5 0

PERSON WHO SAMPLED Joe Schmoe

MEL SAMPLE # *10-08-041-06*

PARAMETER sediment: Cu, Zn, As, Pb, TOC

PROJECT = STATUS & TRENDS in *Coastal STR*

SITE_ID: WAM06600 - 0 0 0 0 0 0

MONTH 0 8 DAY 1 5 2010

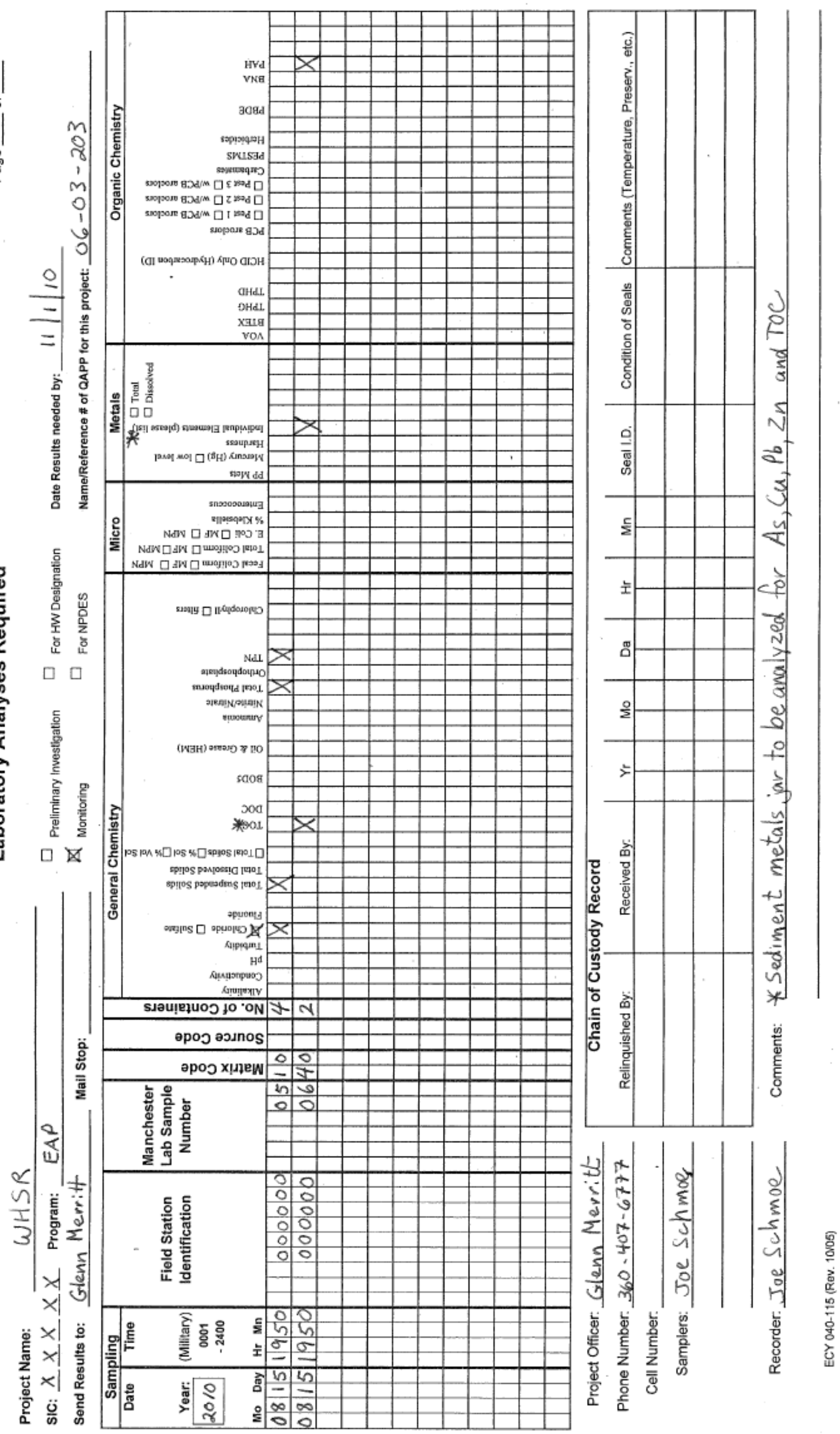
TIME 1 9 : 5 0

PERSON WHO SAMPLED Joe Schmoe

MEL SAMPLE # *10-08-041-06*

PARAMETER sediment: PAH

Figure E-2. Example tags for sediment chemistry sample jars.



Laboratory Analyses Required — Page 1 of 1

Project Name: WHSR
SIC: X X X X X Program: EAP
Send Results to: Glenn Merritt Mail Stop:

☐ Preliminary Investigation ☒ Monitoring ☐ For HW Designation ☐ For NPDES

Date Results needed by: 11/1/10
Name/Reference # of QAPP for this project: 06-03-203

Date (Year: 2010) Mo Day	Time (Military) Hr Mn	Field Station Identification	Manchester Lab Sample Number	Matrix Code	Source Code	No. of Containers	Analyses marked
08 15	1950	000000		0510		4	Chloride, Total Suspended Solids, Total Phosphorus, TPN
08 15	1950	000000		0640		2	TOC*, Individual Elements (please list)*, PAH

Project Officer: Glenn Merritt
Phone Number: 360-407-6777
Cell Number:
Samplers: Joe Schmoe
Recorder: Joe Schmoe

Chain of Custody Record

Relinquished By:	Received By:	Yr	Mo	Da	Hr	Mn	Seal I.D.	Condition of Seals	Comments (Temperature, Preserv., etc.)

Comments: * Sediment metals jar to be analyzed for As, Cu, Pb, Zn and TOC

ECY 040-115 (Rev. 10/05)

Figure E-3. Example *Laboratory Analysis Required Form* for sample shipment from 1 DCE.

References

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Meredith, C. and C. Furl. 2008. Addendum #1 to Quality Assurance Project Plan: Depositional History of Mercury in Selected Washington Lakes Determined from Sediment Cores. Washington State Department of Ecology, Olympia. Publication No. 06-03-113ADD1. http://www.ecy.wa.gov/biblio/0603113add1.html

PSEP. 1986 (March) . Puget Sound Estuary Program: Recommended Protocols for Measuring Selected Environmental Variables in Puget Sound, Total Organic Carbon. U.S. Environmental Protection Agency, Region 10, Office of Puget Sound, Seattle, Washington.

PSEP. 1997 (April). Puget Sound Estuary Program: Recommended Guidelines for Measuring Organic Compounds in Puget Sound Water, Sediment and Tissue Samples. U.S. Environmental Protection Agency, Region 10, Office of Puget Sound, Seattle, Washington.

Appendix F

Sampling Benthos
in Wide Streams & Rivers

Purpose and Scope

This method describes how to collect benthic macroinvertebrate samples for the WHSR program. Data will be used to describe biological integrity and ecological quality (or taxonomic loss). It applies to wide streams and rivers. This method requires measurement of the associated physical and chemical environmental variables described in other methods within this protocol.

Definitions

Definitions of acronyms and other terms are found in Table F-1.

Table F-1. Definitions.

Term or Accronym	**Definition**
Biological Integrity	"The ability to support and maintain a balanced, integrated, and adaptive community of organisms having a species composition, diversity and functional organization comparable to those of natural habitats within a region" (Karr and Dudley, 1981).
Ecological Quality	For this method, ecological quality refers to the ratio of observed to expected natural taxa (Wright et al 2000). This is the observed number of native taxa collected relative to the number of taxa predicted based on a model of reference condition.
Kick	One of the 8 components to a site's composite benthos sample. One kick is collected at each of 8 transects within the site. The area of a kick is 1 ft^2 (0.093 m^2) of stream bottom.

Personnel Responsibilities

One person or more performs this activity. Staff performing this method must have been trained.

Equipment, Reagents, Supplies

- Wide-mouth polyethylene jar (128 oz or 3.8 L)
- D-Frame kick net with these characteristics
  - Frame mouth that is 1 ft (30.5 cm) wide by 1 ft tall.
  - 500-µm mesh net
- 95% Ethanol (add 3 parts by volume for each part sample)
- Label (waterproof) for jar exterior
- Label (waterproof) for jar interior
- Soft-lead pencil
- Clear tape
- Electrical tape
- Pocket knife
- Wading gear

Summary of Procedure

Invertebrate sampling in wide streams and rivers is performed concurrently with other activities, while wading upstream or floating downstream. One kick sample is collected at each of 8 transects and added to the composite sample for the site. This method is taken from Hayslip (2007) with some details provided by Peck et al (2006).

Identify kick stations

There are 11 transects in the site (A-K). Randomly pick 8 of these for sampling benthos. Sample the side of the stream where habitat is also surveyed. The designated side (left or right) for each transect is determined during pre-season site layout. Refer to the *GPS Positions Form* (Figure F-1).

Reviewed by (Initials):

Status and Trends Program - GPS Positions Form

Site Number · YY · MMDD · HH : MM

DCE: W A M 0 6 0 0 - 0 0 0 0 0 0 - D C E - 2 0 _ _ - _ _ _ _ - _ _ : _ _

Station	Bank (circle one)	Master Lat dec deg e.g. 47.123456	Master Lon dec deg e.g. 120.123456	GPSlatDD e.g. 47.123456	GPSLonDD e.g. 120.123456	Accuracy	Accuracy Units (ft, EPE, etc.)	Flag
INDEX STATION	L (R)	47.1781994033	123.638866297					
A0	L (R)	47.17408	123.64107					
B0	L (R)	47.17501	123.64120					
C0	L (R)	47.17597	123.64097					
D0	(L) R	47.17675	123.63987					
E0	(L) R	47.17746	123.63948					
F0	L (R)	47.17842	123.63911					
G0	L (R)	47.17893	123.63790					
H0	(L) R	47.17857	123.63655					
I0	(L) R	47.17825	123.63535					
J0	L (R)	47.17805	123.63390					
K0	L (R)	47.17740	123.63293					
PUTIN	L R							
TAKEOUT	L R							

ALL COORDINATES TO BE RECORDED IN NAD83

Position comments including accuracy

Directions to access point

Draft

Figure F-1. The *GPS Positions Form*, with example pre-season data.

At each of the 8 transects, imagine a littoral zone that extends 10 meters away from the wetted bank, 10 meters upstream and 10 meters downstream (Figure F2). Find a location within the littoral zone for collecting a 1 ft x 1 ft kick sample. It should be:

- Representative of the entire plot (as much as practical)
- Shallow enough to deploy the kick net
- Away from backwaters, eddies, or other edge habitat.

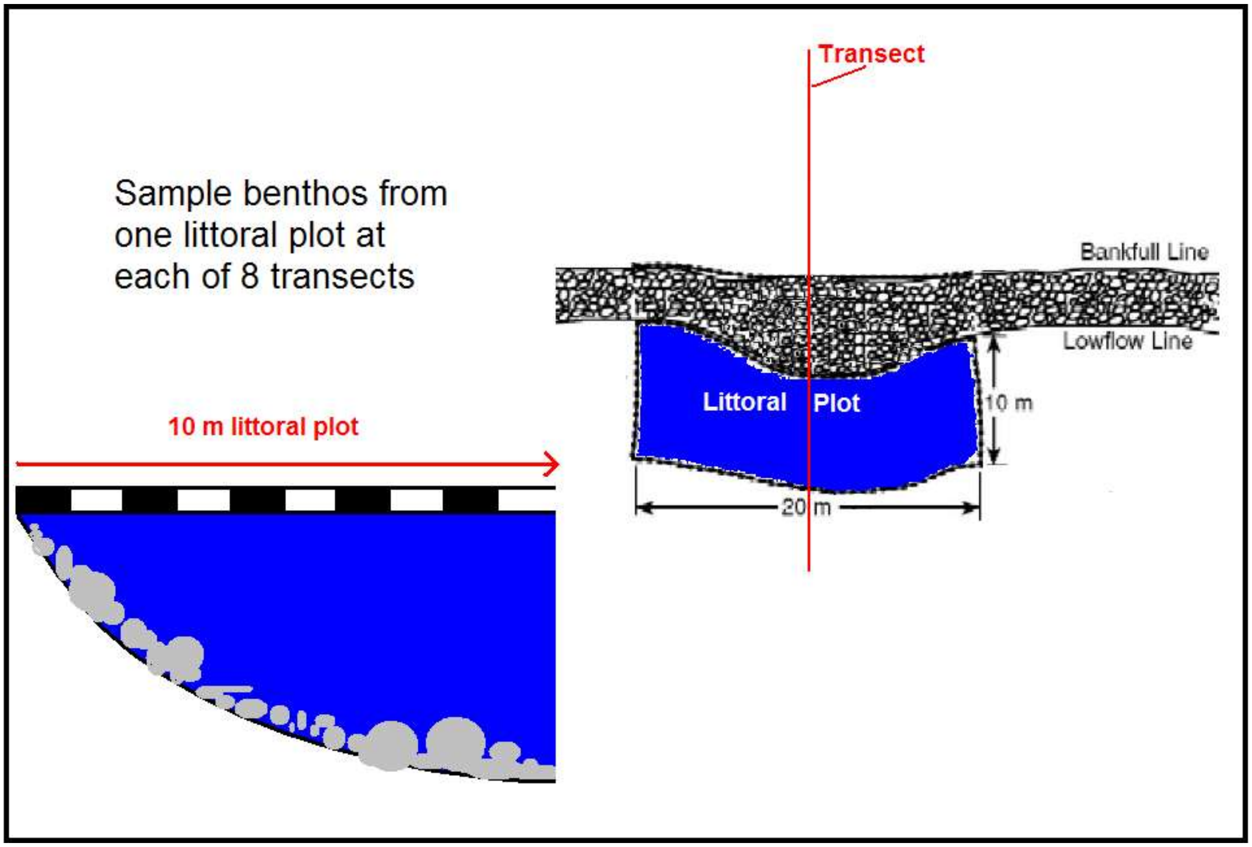


Figure F-2. The littoral plot from which a 1-ft x 1-ft kick is collected at each of 8 transects.

Collect each kick

A different procedure is needed depending upon whether the station sits within flowing water or slack water. Flowing water is where the stream current can sweep organisms into the net. Slack water is where water is so slow that active net movement is required to collect organisms.

Flowing water stations

Once the kick station is determined, place the net opening into the face of flow. Position the net quickly and securely on the stream bottom to eliminate gaps under the frame. Collect benthic macroinvertebrates from a 1 ft^2 (0.093 m^2) quadrat located directly in front of the frame mouth.

Work from the upstream edge of the quadrat backward and carefully pick up and rub stones directly in front of the net to remove attached animals. Quickly inspect each stone to make sure you have dislodged everything and then set it aside. If a rock is lodged in the stream bottom, rub it a few times concentrating on any cracks or indentations.

After removing all large stones, keeping the sampler securely in position, starting at the upstream end of the quadrat, kick the top 4 to 5 cm of the remaining finer substrate within the quadrat for 30 seconds.

Pull the net up out of the water. Immerse the net in the stream several times or splash the outside of the net with stream water to remove fine sediments and to concentrate organisms at the end of the net. After completing the sample, hold the net vertically and rinse material to the bottom of the net.

After taking a sample, examine the contents of the net. Pick out coarse rocks and sticks. Closely examine them for clinging organisms; pick these animals off of the debris and place them into the sample jar. Discard the debris and empty the net's remaining contents into the sample jar.

Add enough ethanol to the sample jar so that the resulting solution consists of 1/3 sample and 2/3 ethanol (by volume).

Slack water stations

Visually define a rectangular quadrat with an area of 1 ft^2 (0.093 m^2). Inspect the stream bottom within the quadrat for any heavy organisms, such as mussels and snails. Remove these organisms by hand and place them into the sample jar. Pick up any loose rocks or other larger substrate particles within the quadrat and hold them in front of the net. Use your hands to rub any clinging organisms off of rocks or other pieces of larger substrate (especially those covered with algae or other debris) into the net. After scrubbing, place the larger substrate particles outside of the quadrat.

Vigorously kick the remaining finer substrate within the quadrat with your feet while dragging the net repeatedly through the disturbed area just above the bottom. Keep moving the net all the time so that the organisms trapped in the net will not escape. Continue kicking the substrate and moving the net for 30 seconds.

After 30 seconds, remove the net from the water with a quick upstream motion to wash the organisms to the bottom of the net.

After taking a sample, examine the contents of the net. Pick out coarse rocks and sticks. Closely examine them for clinging organisms; pick these animals off of the debris and place them into the sample jar. Discard the debris and empty the net's remaining contents into the sample jar.

Add enough ethanol to the sample jar so that the resulting solution consists of 1/3 sample and 2/3 ethanol (by volume).

Special circumstances

For samples located within dense beds of long, filamentous aquatic vegetation, kicking may not be effective. Use a knife to sample only the vegetation that lies ***within*** the quadrat. Don't include parts of the strands that extend beyond the quadrat.

Label and Seal the Composite sample

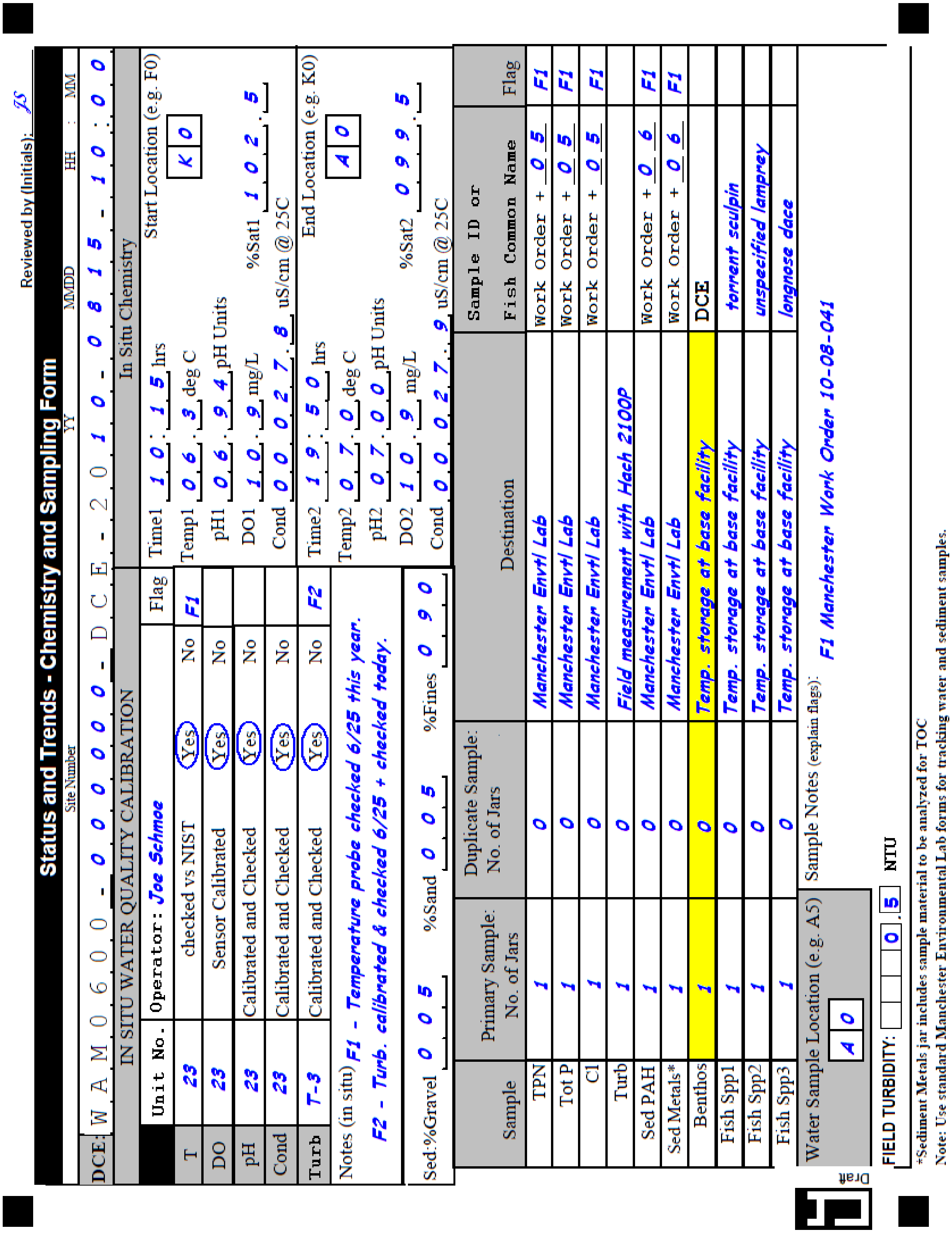
Using a number 2 pencil, complete two benthos jar labels (Figure F-3). Place one into the sample. Screw on the lid and seal it closed using electrical tape. Attach the other benthos label to the outside of the jar using clear tape. Record the DCE, which includes the Site_ID, and site arrival time (year, month, day, hour, and minute). It should match the DCE recorded on the Site Verification Form. Be sure to note which transects were sampled, and which of these were sampled using the slack water technique..

Figure F-3. The benthos jar label

500 µ D-frame kick	**Benthos Jar Label** Jar ___ of ___
Project	2010 Monitoring in the ____________________ STR
Stream	
Who collected? (full name)	
8 1-ft^2 Transects **(circle all sampled)**	A B C D E F G H I J K Transects sampled using slack-water technique: ____________________
Collectors Notes	
DCE	WAM06600-__ __ __ __ __ __-dce-2010__ __ __ __-__ __ __ __ m m d d h h m m

Enter Data to the Chemistry and Sampling Form

The sample jars will be stored by field crews and delivered *en mass* to the analytical laboratory at the end of the field season. The Chemistry and Sampling Form (Figure F-4) will be used to keep track of sample jar information. Note the SampleID and number of jars per SampleID. If there is more than one jar for a SampleID, then ensure that the jars are located together. Taping the jars together with clear tape may be helpful. For destination, note the immediate place to where the sample will be stored, shipped, or delivered.



Reviewed by (Initials): JS

Status and Trends - Chemistry and Sampling Form

DCE: W A M 0 6 0 0 - 0 0 0 0 0 0 - D C E - 2 0 1 0 - 0 8 1 5 - 1 0 : 0 0
(Site Number; YY; MMDD; HH : MM)

IN SITU WATER QUALITY CALIBRATION

	Unit No.	Operator: Joe Schmoe			Flag
T	23	checked vs NIST	(Yes)	No	F1
DO	23	Sensor Calibrated	(Yes)	No	
pH	23	Calibrated and Checked	(Yes)	No	
Cond	23	Calibrated and Checked	(Yes)	No	
Turb	T-3	Calibrated and Checked	(Yes)	No	F2

Notes (in situ) F1 - Temperature probe checked 6/25 this year.
F2 - Turb. calibrated & checked 6/25 + checked today.

Sed:%Gravel 0 0 5 %Sand 0 0 5 %Fines 0 9 0

In Situ Chemistry

Time1 1 0 : 1 5 hrs — Start Location (e.g. F0) K 0
Temp1 0 6 . 3 deg C
pH1 0 6 . 9 4 pH Units
DO1 1 0 . 9 mg/L — %Sat1 1 0 2 . 5
Cond 0 0 0 2 7 . 8 uS/cm @ 25C
Time2 1 9 : 5 0 hrs — End Location (e.g. K0) A 0
Temp2 0 7 . 0 deg C
pH2 0 7 . 0 0 pH Units
DO2 1 0 . 9 mg/L — %Sat2 0 9 9 . 5
Cond 0 0 0 2 7 . 9 uS/cm @ 25C

Sample	Primary Sample: No. of Jars	Duplicate Sample: No. of Jars	Destination	Sample ID or Fish Common Name	Flag
TPN	1	0	Manchester Envtl Lab	Work Order + 0 5	F1
Tot P	1	0	Manchester Envtl Lab	Work Order + 0 5	F1
Cl	1	0	Manchester Envtl Lab	Work Order + 0 5	F1
Turb	1	0	Field measurement with Hach 2100P		
Sed PAH	1	0	Manchester Envtl Lab	Work Order + 0 6	F1
Sed Metals*	1	0	Manchester Envtl Lab	Work Order + 0 6	F1
Benthos	1	0	Temp. storage at base facility	DCE	
Fish Spp1	1	0	Temp. storage at base facility	torrent sculpin	
Fish Spp2	1	0	Temp. storage at base facility	unspecified lamprey	
Fish Spp3	1	0	Temp. storage at base facility	longnose dace	

Water Sample Location (e.g. A5) A 0

Sample Notes (explain flags): F1 Manchester Work Order 10-08-041

FIELD TURBIDITY: 0 . 5 NTU

Draft

*Sediment Metals jar includes sample material to be analyzed for TOC

Note: Use standard Manchester Environmental Lab forms for tracking water and sediment samples.

Figure F-4. The *Chemistry and Sampling Form*, with example benthos data highlighted.

References

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Appendix G

Bank Measurements at Transects in Wide Streams & Rivers

Purpose and Scope

This method explains how to collect measurements for WHSR at each of 11 equidistant transects at each site. Measurements in this procedure will be restricted to one main channel.

Instruments included on the procedure include distance measuring devices (e.g., measuring rod, laser rangefinder, 50-m measuring tape), and hand-levels.

Definitions

Definitions of acronyms and other terms are found in Table G-1.

Table G-1. Definitions.

Term or Acronym	**Definition**
bankfull depth	This is the sum of thalweg wetted depth and bankfull height.
bankfull height	Vertical distance between surface of water and bankfull stage. For Status and Trends, this is measured in centimeters.
bankfull stage	This stage is delineated by the elevation point of incipient flooding, indicated by deposits of sand or silt at the active scour mark, break in stream bank slope, perennial vegetation limit, rock discoloration, and root hair exposure (Endreny 2009).
bankfull width	Horizontal distance between the bankfull stage on the left bank and the bankfull stage on the right bank. For Status and Trends, this is measured in tenth of meters.
bar	A dry area within the wetted channel. It does not extend vertically as high as the bankfull stage.
DCE	Data Collection Event. Data are indexed using this code which includes the SITE_ID, the date, and the time that the event began. It uses this format:

	WAM06600-NNNNNN-dce-20YY-MMDD-HHMM **NNNNNN** = the number portion of the SITE_ID. **YY** = the last two numeric digits of the year that the event occurred. **MM** = the two numeric digits for the month that the event occurred. **DD** = the two numeric digits for the day within the month that the event occurred. **HHMM** = the military time when the event began.
floodplain	The part of the valley floor over which a river spreads during seasonal or short-term floods (Small and Witherick 1986)
island	A dry area between channels. It extends vertically at least as high as the bankfull stage.
left bank	A person facing downstream will have the left bank on their left side.
main channel	Channels in a stream are divided by islands (dry ground that rises above bankfull stage). Main channels contain the greatest proportion of flow. For this method it is called channel number 0.
major transect	One of 11 equidistant transects across the length of a site. These are labeled as follows: A0 (lowest), B0,C0,….K0 (highest) A major transect will cross the main channel and side channels.
right bank	A person facing downstream will have the right bank on their right side.
side channels	Channels that contain less flow than the main channels. These are identified and enumerated (1,2,3 etc.) as encountered (see the method for thalweg measurements) during the DCE.
site	A site is defined by the coordinates provided to a sampling crew and the boundaries established by the site layout method. Typically, the site extends 10 bankfull widths downstream from the coordinates and 10 bankfull widths upstream. The site also includes all riparian plots examined during the *Data Collection Event*. The site consists of many stations at which measurements or samples are collected.
station	Any location within the site where an observation is made or part of a sample is collected.
thalweg	Path of a stream that follows the deepest part of the channel (Armantrout, 1998).
thalweg transect	One of 101 equidistant transects across the length of a site. Labeling includes the name of the major transect. For example the thalweg transects between (and including) major transects A0and B0 would be labeled as follows: A0, A1, A2, A3, A4, A5, A6, A7, A8, A9, B0

	(i.e.., thalweg transect A0 is identical to major transect A0)
transect	A line of study that crosses the direction of flow, divided into intervals where observations are collected.
wetted width	Farthest horizontal distance between water edge on the left and right sides of a channel.

Personnel Responsibilities

This method is performed by 2 persons. This method is applied at every DCE, at each major transect. Staff performing this method must have been trained.

Equipment, Reagents, Supplies

- No. 2 pencil
- measuring rod
- 50-m tape
- laser rangefinder
- hand level
- clinometer
- calculator

Summary of Procedure

Refer to the *Major Transect Form* (Figures G-1 and G-2). At each of the major Transects (A0-K0), assess the main channel. Measure these channel characters: bankfull width, wetted width, bar width, bankfull height (one bank), and bank instability (both banks). Describe flags.

BANK		
		Flag
Wetted Width XXX.X m	32.0	
Bar Width XX.X m	0	
Bankfull Width XXX.X m	35.5	
R Bankfull Height cm		F1
L BankfullHeight cm	32	
LB Instability %	50	
RB Instability %	10	

Figure G-1. A portion of the *Major Transect Form*, with example data for this method.

Flag	Comments
F1	Bankfull height was measured on left bank only - according to protocol

Figure G-2. A portion of the *Major Transect Form*, with an example flag qualifier**.**

Channel Dimensions

Bankfull Stage

At the transect, visually estimate the bankfull stage. This is best done after considerable training. There are at least four good on-line sources of training materials for identifying bankfull stage:

1. http://preview.tinyurl.com/8aabbm (Buffington 2007)
2. http://www.dnr.wa.gov/Publications/fp_bfw_video_pt1.wmv
   http://www.dnr.wa.gov/Publications/fp_bfw_video_pt2.wmv (Grizzel 2008)
3. http://www.stream.fs.fed.us/publications/bankfull_west.html (Leopold et al 1995)
4. http://www.fgmorph.com/fg_3_5.php (Endreny 2009)

Use this visual estimate to help understand where to measure *bankfull width* and *bankfull height*.

Bankfull Width

After locating the bankfull stage at each bank, measure the ***bankfull width*** (Figure G-3) to the nearest tenth of a meter. Record this value on the *Major Transect Data Form* (Figure G-1). Width measurements can be made using either a 50-m tape, a measuring rod, or a laser rangefinder. In most rivers, the laser rangefinder is the most efficient tool. Record an average of at least three readings for each measurement with the laser rangefinder.

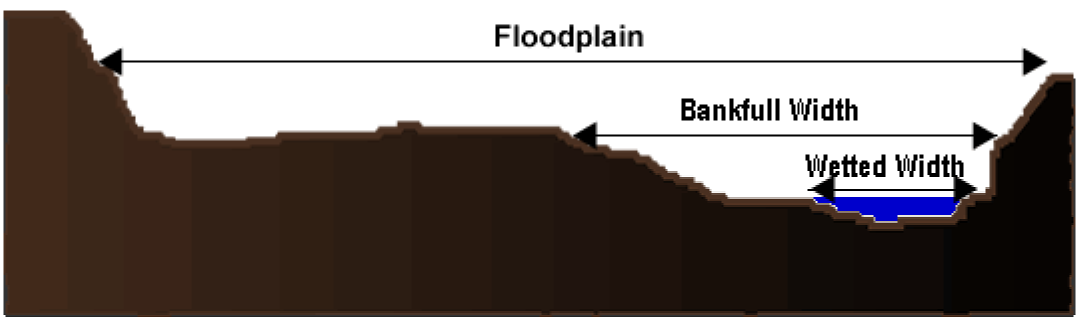

Figure G-3. Diagram of widths at the transect (Modified from Endreny 2009).

Wetted Width

Observe the wetted margins of the channel. On the *Major Transect Data Form* (Figure G-1), record the ***wetted width*** (or horizontal distance between these margins) to the nearest tenth of a meter. Do *not* subtract for bars.

Bar Width

Estimate the width of each bar within the wetted channel. Record the sum (nearest tenth of a meter) for ***bar width***. This can be a visual estimate where bars are beyond reach.

Bankfull Height

Bankfull height is measured using a surveyor’s rod with hand level or clinometer. On the *Major Transect Form* (Figure G-1), record bankfull height data in whole centimeters. Record either the ***right bankfull height*** or the ***left bankfull height*** (Figure G-4), depending upon the side indicated by pre-season site layout (the side at which you are standing).

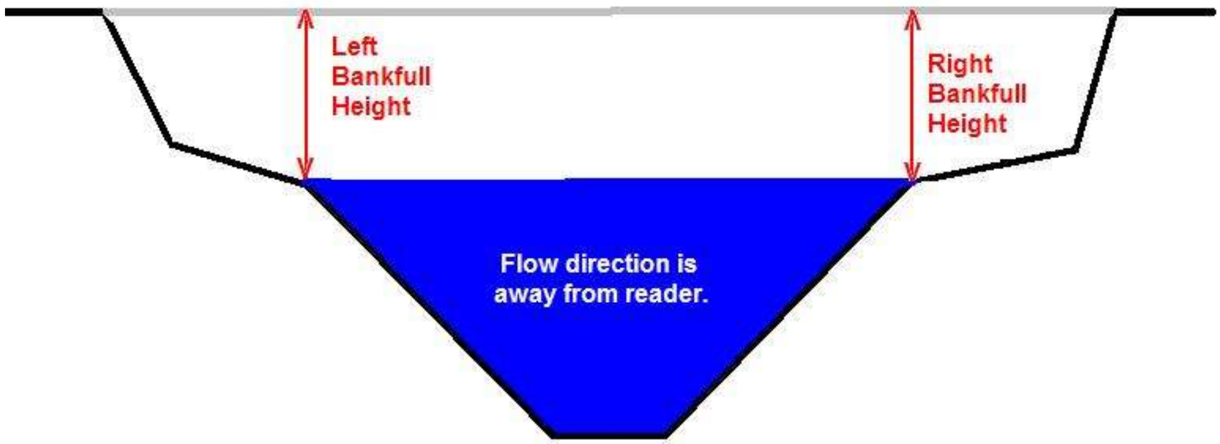

Figure G-4. Diagram of the left OR right bankfull height measurement.

Bank Instability

Evaluate bank instability at both the left and right banks. Evaluate how much of a 10-m length of each bank (centered on the primary transect) is unstable. Limit your observations of bank stability to the portion of the bank at and below the bankfull stage.

A bank is unstable if it has eroding or collapsing banks. It may have the following characteristics:

- sparse vegetation on a steep surface
- tension cracks
- sloughing

On the *Major Transect Form* (Figure G-1), record ***right bank instability*** (%) and ***left bank instability*** (%).

References

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http://www.stream.fs.fed.us/publications/videos.html#eastandwest

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Appendix H

Substrate and Depth Measurements at Transects in Wide Streams & Rivers

Purpose and Scope

This method explains how to measure substrate characteristics for WHSR at each of 11 equidistant transects at each site. Measurements in this procedure will be restricted to one bank at each transect. Measurements will be restricted to the main channel. This method must be preceded by the Major Transects Method.

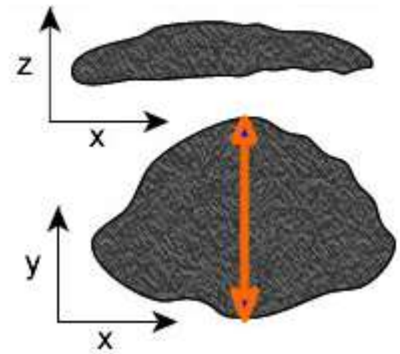
Instruments included on the procedure include distance measuring devices (e.g., measuring rod, or 50-m measuring tape, caliper), leveling device (hand level or clinometer) and a10-cm PVC ring.

Definitions

Definitions of acronyms and other terms are found in Table H-1.

Table H-1. Definitions.

Term or Accronym	**Definition**
bankfull depth	This is the vertical distance between the channel bed surface and the mean height of bankfull stage.
bankfull height	Vertical distance between surface of water and bankfull stage. For Status and Trends, this is measured in centimeters. It is measured at the left and right wetted margins of each major transect and a mean value is computed for each channel at that transect.
bankfull stage	This stage is delineated by the elevation point of incipient flooding, indicated by deposits of sand or silt at the active scour mark, break in stream bank slope, perennial vegetation limit, rock discoloration, and root hair exposure (Endreny 2009).
bankfull width	Horizontal distance between the bankfull stage on the left bank and the bankfull stage on the right bank. For Status and Trends, this is measured in tenth of meters.
intermediate axis	The diameter of a particle that is neither the longest nor the shortest of mutually perpendicular axes (Bain 1999, Harrelson et al 1994). See below

	for a diagram from Endreny (2009): 
left bank	A person facing downstream will have the left bank on their left side.
main channel	Channels in a stream are divided by islands (dry ground that rises above bankfull stage). Main channels contain the greatest proportion of flow. For this method it is called channel number 0.
major transect	One of 11 equidistant transects across the length of a site. These are labeled as follows: A0 (lowest), B0,C0,….K0 (highest) A major transect will cross the main channel and side channels.
right bank	A person facing downstream will have the right bank on their right side.
side channels	Channels that contain less flow than the main channels. These are identified and enumerated (1,2,3 etc.) as encountered (see the method for thalweg measurements) during the data collection event.
site	A site is defined by the coordinates provided to a sampling crew and the boundaries established by the site layout method. Typically, the site extends 10 bankfull widths downstream from the coordinates and 10 bankfull widths upstream. The site also includes all riparian plots examined during the *Data Collection Event*. The site consists of many stations at which measurements or samples are collected.
station	Any location within the site where an observation is made or part of a sample is collected.
transect	A line of study that crosses the direction of flow, divided into intervals where observations are collected.
wetted width	Farthest horizontal distance between water edge on the left and right sides of a channel.

Personnel Responsibilities

This method is performed by 2 persons. This method is applied at every DCE, at one bank of each major transect. Staff performing this method must have been trained.

Equipment, Reagents, Supplies

- No. 2 pencil
- measuring rod
- 50-m tape
- PVC ring
- hand-level
- clinometer
- calculator

Summary of Procedure

Evaluate each of the major transects (A0-K0) in the main channel. Evaluate the appropriate bank that was designated on the GPS Positions Form during the pre-season site layout. At designated stations on the transect (Table H-2, Figure H-1), record wetted depth (cm), bankfull depth (cm), substrate type code, and embeddedness (%).

Table H-2. Substrate and depth stations for wide streams and rivers.

Station	Frequency	Description	Observations/transect
Bank station	1 bank, every transect	The bankfull margin	1
Dry stations	At 1 side of every transect, where dry increments are present	Located at 10%, 20%, 30% *etc.* across the bankfull channel	variable: normally 1 or 2
Wetted station	1 plot, every transect	1) Average Substrate is estimated for littoral plot. 2) Depth is measured at margin of plot	1

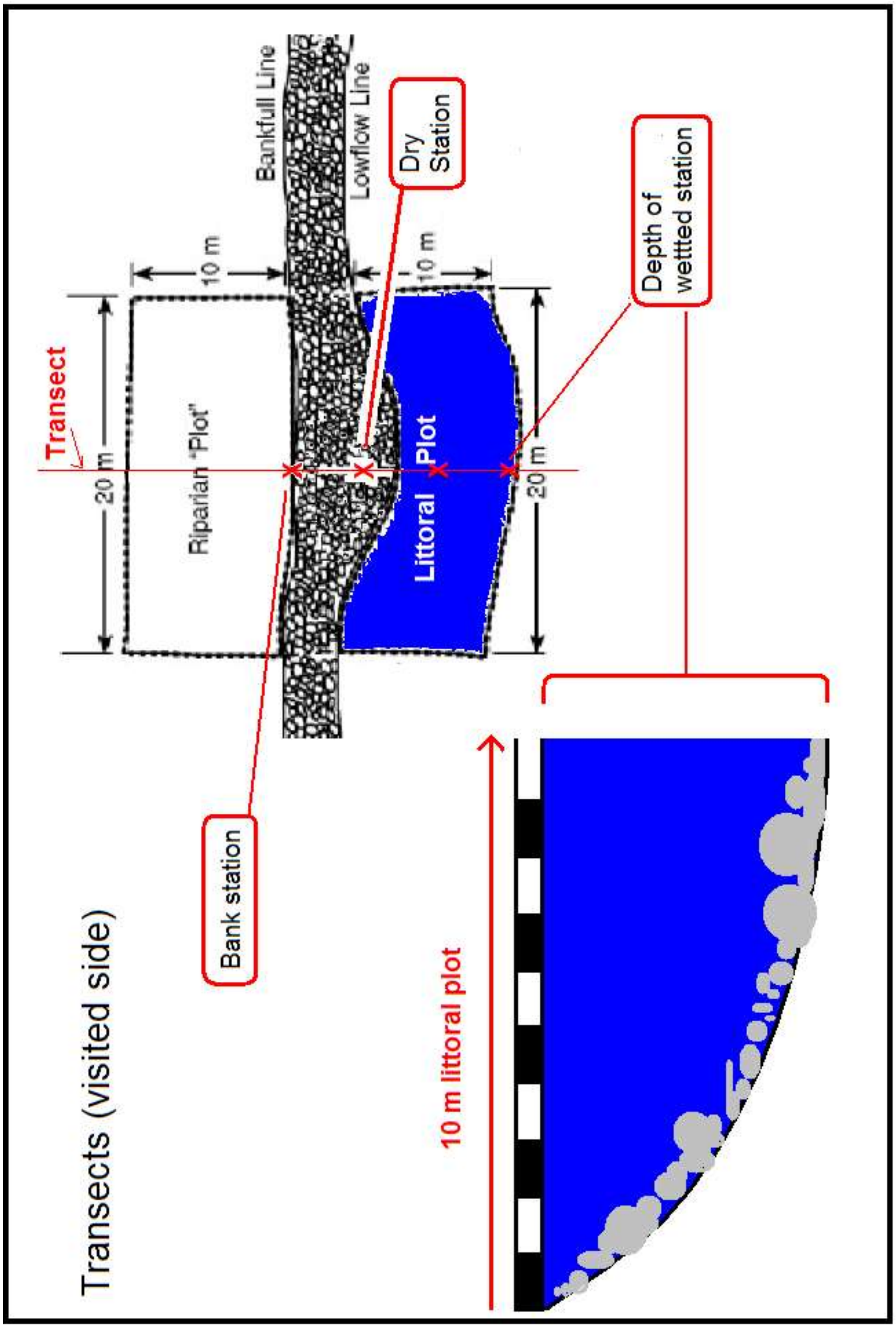


Figure H-1. Diagram of the visited side of a major transect in a wide stream or river.

Record data on the *Major Transect Data Form* (Figure H-2). Insert data for depths, substrate type and embeddedness next to each station. Describe flags (Figure H-3).

SUBSTRATE					
	Wet Depth	BF Depth XXX CM	Size Class	Embd. 0-100%	Flag
left bank					
.1					
.2					
.3					
.4					
.5					
.6					
~~.7~~	9		GC	10	F2
.8	-7	13	WD	90	F1
.9	0	12	FN	100	
right bank		0	SA	100	

Figure H-2. Part of the *Major Transect Form* with example right bank data for this method.

Flag	Comments
F1	WD = partially buried Douglas fir log, about 60 cm diameter
F2	Average substrate & embeddedness for 10x20m plot. Depth at plot margin

Figure H-3. Part of the *Major Transect Form* with example flag descriptions.

Station Depth

- **Bank station**: Record bankfull depth. This is always 0 cm by definition.
- **Dry stations**: Measure the vertical distance between bankfull margin and the substrate point. Record this as bankfull depth (cm). Also record wetted depth as distance above water surface (negative) to indicate that this is a dry station. If this station is at the wetted margin, wetted depth is 0.
- **Wetted station**: Measure the wetted depth (cm) at the far edge of the plot. This is 10 m across the transect from the margin of the wetted channel. Record data on the Major Transect Form (Figure H-1) in the row adjacent to the last dry station. Cross out the increment to indicate that it is a wetted station.

Substrate Type

At the bank station and at each dry station, estimate the substrate particle type. Use the measuring rod to find these evenly-spaced locations and observe the particle that is situated at the front edge of the rod. Estimate the size class of the particle based on the intermediate axis length. Record the ***substrate type code***. The choices are listed in Table H-3. For fine gravel, coarse gravel and cobble use calipers to measure the intermediate axis length of the particle and confirm your estimate of size. For larger sizes, use the measuring rod to confirm your estimate. Particles smaller than 100 mm are evaluated using a 10 cm ring surrounding the sample point. All particles within the ring are evaluated for size and embeddedness, not just the point. Record the estimated average for surface substrate within the ring.

For the wetted station, **v**isually estimate the mean (typical) substrate particle size for the 10 m x 20 m, plot. Record the appropriate ***substrate type code*** from Table H-3.

Table H-3. Substrate type codes, types, and sizes.

CODE	TYPE	SIZE RANGE	SIZE GUAGE
RS	Bedrock (smooth)	> 4 m	larger than a car
RR	Bedrock (rough)	> 4 m	larger than a car
RC	Concrete/Asphalt	> 4 m	larger than a car
XB	Large Boulder	1-4 m	meter stick to car
SB	Small boulder	>250 mm – 1 m	basketball to meter stick
CB	Cobble	>64 mm – 250 mm	tennis ball to basketball
GC	Gravel, coarse	>16 mm to 64 mm	marble to tennis ball
GF	Gravel, fine	>2 mm to 16 mm	ladybug to marble
SA	Sand (2-16 mm)	>0.06 mm to 2 mm	gritty to ladybug
FN	Fines (silt/clay/muck)	< 0.06 mm	non gritty
HP	Hardpan - hardened fines	any size	
WD	Wood	any size	
OT	Other (doesn't fit choices above)	any size	

Embeddedness

At the bankfull station and each dry station, estimate ***embeddedness*** (%). This is the fraction of a particle's surface that is surrounded by (embedded in) sand or finer sediments (≤ 2 mm). By default, sand or fines are 100% embedded. By default, bedrock is 0% embedded.

Particles smaller than 100 mm are evaluated using a 10 cm ring surrounding the sample point. All particles within the ring are evaluated for size and embeddedness, not just the point. Record the estimated average for surface substrate within the ring.

For the wetted station, **v**isually estimate the mean (typical) substrate embeddedness for the 10 m x 20 m, plot. Record the percentage.

References

Bain, M.B. 1999. Substrate. Pages 95 to 103 *in* M.B. Bain and N.J. Stevenson, editors. Aquatic habitat assessment: common methods. American Fisheries Society, Bethesda, Maryland.

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Appendix I

Shade Measurement at Transects in Wide Streams & Rivers

Purpose and Scope

This method explains how to measure shade for WHSR at each of 11 transects at each site. Measurements in this procedure will be restricted to one main channel. This method must be preceded by pre-season site layout.

Instruments included on the procedure include a distance measuring device (e.g., measuring rod), and a convex densiometer (modified according to Mulvey *et al.* (1992)).

Definitions

Definitions of acronyms and other terms are found in Table I-1.

Table I-1. Definitions.

Term or Accronym	**Definition**
bankfull channel width	Horizontal distance between the bankfull stage on the left bank and the bankfull stage on the right bank.
bankfull stage	This stage is delineated by the elevation point of incipient flooding, indicated by deposits of sand or silt at the active scour mark, break in stream bank slope, perennial vegetation limit, rock discoloration, and root hair exposure (Endreny 2009).
left bank	A person facing downstream will have the left bank on their left side.
main channel	Channels in a stream are divided by islands (dry ground that rises above bankfull stage). Main channels contain the greatest proportion of flow. For this method it is called channel number 0.
major transect	One of 11 equidistant transects across the length of a site. These are labeled as follows: A0 (lowest), B0,C0,….K0 (highest) A major transect will cross the main channel and side channels.
right bank	A person facing downstream will have the right bank on their right

	side.
station	Any location within the site where an observation is made or part of a sample is collected.
side channels	Channels that contain less flow than the main channels. These are identified and enumerated (1,2,3 etc.) as encountered (see the method for thalweg measurements) during the data collection event.
site	A site is defined by the coordinates provided to a sampling crew and the boundaries established by the site layout method. Typically, the site extends 10 bankfull widths downstream from the coordinates and 10 bankfull widths upstream. The site also includes all riparian plots examined during the *Data Collection Event*. The site consists of many stations at which measurements or samples are collected.
transect	A line of study that crosses the direction of flow, divided into intervals where observations are collected.

Personnel Responsibilities

This method is performed by 1 person. This method is applied at every DCE, at each major transect. Staff performing this method must have been trained.

Equipment, Reagents, Supplies

- No. 2 pencil
- *Major Transect Form*
- measuring rod or 50-m tape
- Modified convex densiometer

Summary of Procedure

Refer to the *Major Transect Form* (Figure I-1). At each of the major Transects (A0-K0), assess the main channel. Use a convex densiometer (Lemmon, 1957) that has been modified according to Mulvey *et al* (1992; figure J-2); it has 17 intersections.

DENSIOMETER MEASUREMENTS

(0-17Max)

		Flag			Flag
CenUp			CenR		
CenL			Left		
CenDwn			Right	17	

Figure I-1. Densiometer portion of The *Major Transects Form*, with example data for a transect where the right bank was designated for sampling.

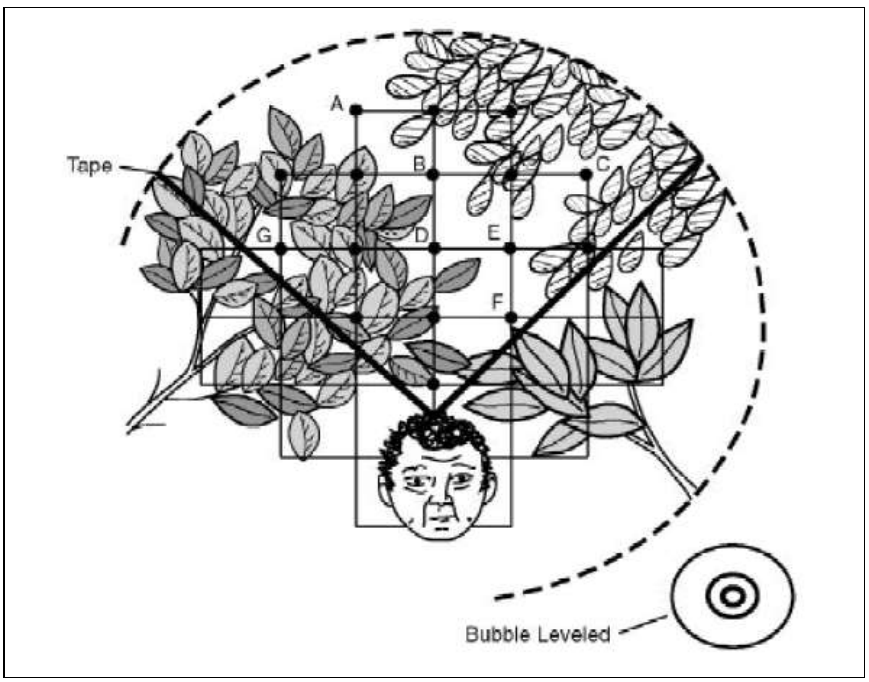


Figure I-2. An example reading from a modified convex densiometer. It shows 10 of 17 intersections with shade (a score of "10"). Note the proper positions of the bubble and head reflection (From Mulvey *et al*. 1992).

Go to the transect bankfull margin, at the bank that was designated during pre-season site layout. Hold the densiometer level and 30 cm above the surface. Record how many of the 17 cross-hairs have shade over them. Readings should be able to detect shade from riparian understory vegetation such as ferns.

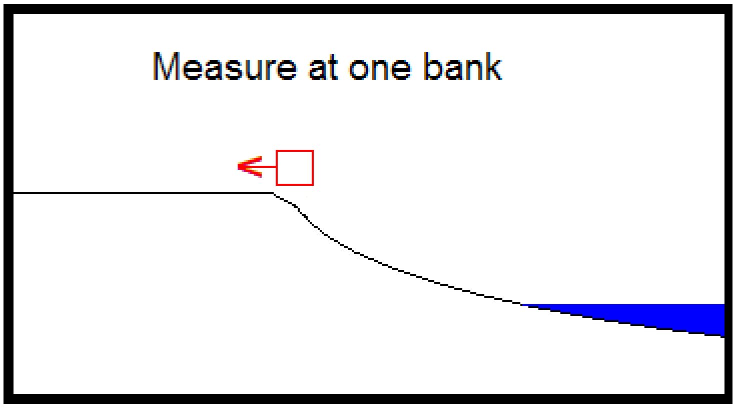


Figure I-3. The densiometer position at the bankfull margin.

References

Lemmon, P.E. 1957. A New Instrument for Measuring Forest Overstory Density. Journal of Forestry. 55(9):667-668.

Mulvey, M, L. Caton, and R. Hafele. 1992. Oregon Nonpoint Source Monitoring Protocols and Stream Bioassessment Field Manual for Macroinvertebrates and Habitat Assessment, Draft. Oregon Department of Environmental Quality, Portland, Oregon.

Endreny, T.A. 2009. *Fluvial Geomorphology Modules*, State University of New York College of Environmental Science and Forestry, National Oceanic and Atmospheric Administration, and the University Corporation for Atmospheric Research. www.fgmorph.com

Appendix J

Estimating Fish Cover
at Transects in Wide Streams & Rivers

Purpose and Scope

This method explains how to estimate fish cover for WHSR at each of 11 transects at each site. Measurements in this procedure will be restricted to one main channel. This method must be preceded by the pre-season site layout for establishing major transects and determining which bank to assess at each transect.

Instruments included on the procedure include a distance measuring device (e.g., measuring rod).

Definitions

Definitions of acronyms and other terms are found in Table J-1.

Table J-1. Definitions.

Term or Accronym	**Definition**
Artificial structures	For this method: potential cover for aquatic vertebrates provided by human-introduced objects.
Boulders	For this method: potential cover for aquatic vertebrates provided by rocks over basketball-size.
Brush (dead)	For this method: potential cover for aquatic vertebrates provided by dead pieces of wood that are < 10 cm diameter *or* < 2 m long
Bryophytes	For this method: potential cover for aquatic vertebrates provided by non-vascular plants such as mosses that reproduce using spores.
DCE	Data Collection Event. Data are indexed using this code which includes the SITE_ID, the date, and the time that the event began. It uses this format: **WAM06600-NNNNNN-dce-20YY-MMDD-HHMM** **NNNNNN** = the number portion of the SITE_ID. **YY** = the last two numeric digits of the year that the event occurred. **MM** = the two numeric digits for the month that the event occurred.

	DD = the two numeric digits for the day within the month that the event occurred. **HHMM** = the military time when the event began.
Filamentous algae	For this method: potential cover for aquatic vertebrates provided by long, streaming filaments of microscopic algal cells that often occur in eutrophic water. Not to be confused with macrophytes and flowering aquatic plants.
Live trees/Roots	For this method: potential cover for aquatic vertebrates provided living woody vegetation that is within the water.
Macrophytes	For this method: potential cover for aquatic vertebrates provided by floating, submerged, or emergent water loving plants and wetland grasses that could provide cover for fish or macroinvertebrates. This category excludes mosses.
Main channel	Channels in a stream are divided by islands (dry ground that rises above bankfull stage). Main channels contain the greatest proportion of flow. For this method it is called channel number 0.
major transect	One of 11 equidistant transects across the length of a site. These are labeled as follows: A0 (lowest), B0,C0,….K0 (highest). A major transect will cross the main channel and side channels.
Overhanging Vegetation	For this method: potential cover for aquatic vertebrates provided by vegetation that hangs to within 1 m of the water surface. Higher vegetation (e.g. perches for kingfishers or other predators) does not count.
Side channels	Channels that contain less flow than the main channels. These are identified and enumerated (1,2,3 etc.) as encountered (see the method for thalweg measurements) during the data collection event.
site	A site is defined by the coordinates provided to a sampling crew and the boundaries established by the site layout method. Typically, the site extends 10 bankfull widths downstream from the coordinates and 10 bankfull widths upstream. The site also includes all riparian plots examined during the *Data Collection Event*. The site consists of many stations at which measurements or samples are collected.
Transect	A line of study that crosses the direction of flow, divided into intervals where observations are collected.
Undercut banks	For this method: potential cover for aquatic vertebrates provided by banks (at the wetted margin) that extend over deeper water. Fish cover assessment is by area, rather than length. Therefore undercut banks rarely provide more than 10% cover for a plot.
Woody debris (dead)	For this method: potential cover for aquatic vertebrates provided dead pieces of wood that are ≥ 10 cm diameter *and* ≥ 2 m long.

Personnel Responsibilities

This method is performed by 1 person. This method is applied at every DCE, at each major transect. Staff performing this method must have been trained.

Equipment, Reagents, Supplies

- No. 2 pencil
- *Major Transect Form*
- measuring rod or 50-m tape

Summary of Procedure

This method is derived from that of Peck *et al.* (2006).

Within the main channel, evaluate 11 plots (Figure J-1) with these characteristics:

- Centered at each major transect
- Extends 10 meters upstream of each transect
- Extends 10 meters downstream of each transect
- Extends 10 meters stream-ward from the wetted margin
- Beneath the wetted surface

Visually assess the percentage of the water surface that has fish cover provided by each of 10 cover types. Consider cover for any size or species of fish. Exclude vegetation more that a meter above the water surface (e.g. king fisher perches).

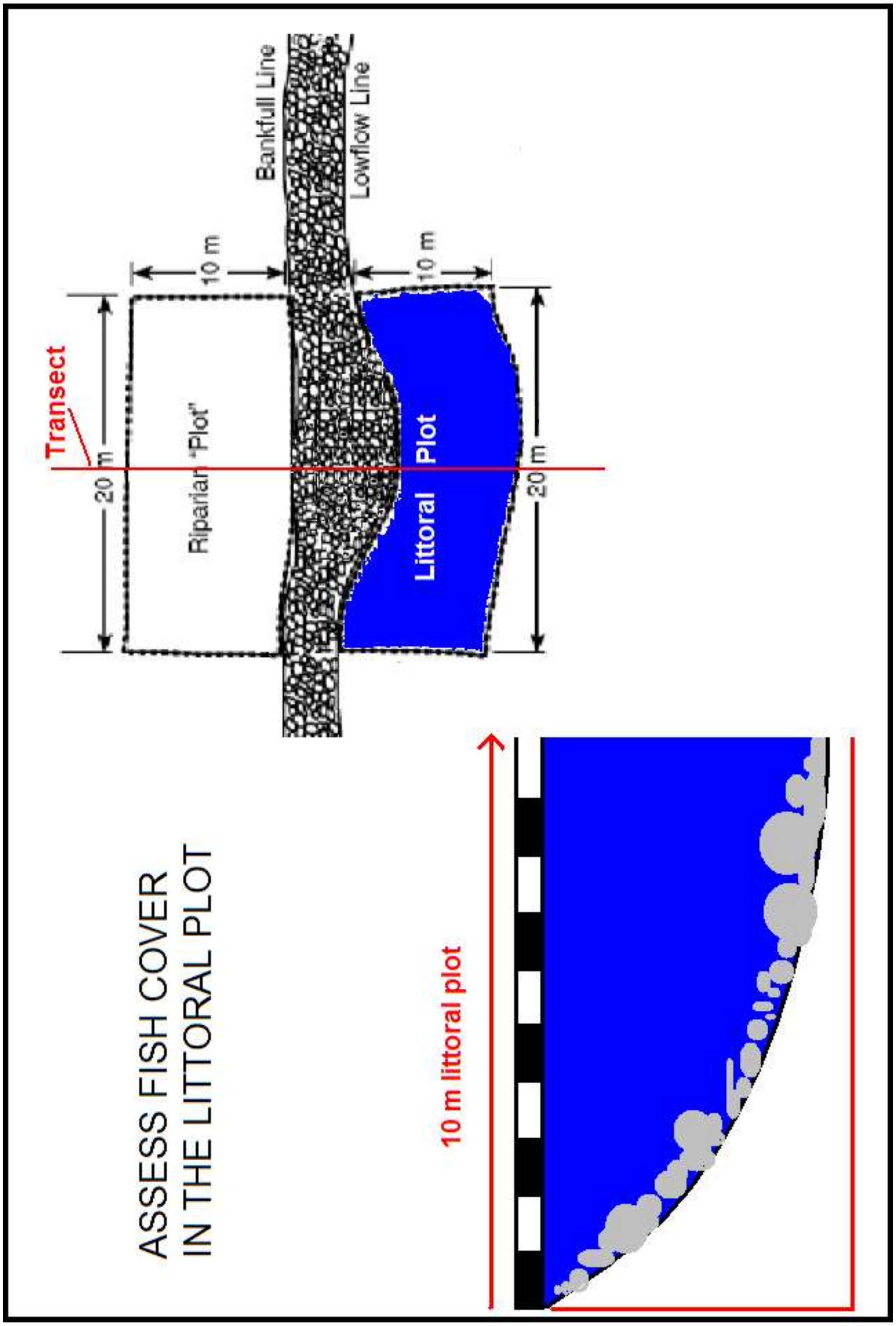


Figure J-1. Fish cover plots (littoral plots) at the visited side of each major transect.

Refer to the *Major Transect Form* (Figure J-2). Circle the cover code that best characterizes each cover type.

FISH COVER	0 = Absent (0%) 1 = Sparse (<10%) 2 = Moderate (10-40%) 3 = Heavy (40-75%) 4 = Very Heavy (>75%) (circle one)	
	Cover in Channel	Flag
Filamentous Algae	0 1 2 3 4	
Macrophytes	0 1 2 3 4	
Woody Debris	0 1 2 3 4	
Brush	0 1 2 3 4	
Live Trees or Roots	0 1 2 3 4	
Overhanging Veg. =<1 m of Surface	0 1 2 3 4	
Undercut Banks	0 1 2 3 4	
Boulders	0 1 2 3 4	
Artificial Structures	0 1 2 3 4	
Bryophytes	0 1 2 3 4	

Figure J-2. Fish Cover portion of The *Major Transects Form*, with example records.

References

Peck, D.V., Herlihy, A.T., Hill, B.H., Hughes, R.M., Kaufmann, P.R., Klemm, D.J., Lazorchak, J.M., McCormick, F.H., Peterson, S.A., Ringold, P.L., Magee, T., and Cappaert, M.R. Environmental Monitoring and Assessment Program-Surface Waters, Western Pilot Study, Field Operations Manual for Wadeable Streams. EPA/620/R-06/003. U.S. Environmental Protection Agency, Washington, D.C.
http://www.epa.gov/wed/pages/publications/authored/EPA620R-06003EMAPSWFieldOperationsManualPeck.pdf

Appendix K

Human Influence at Transects in Wide Streams & Rivers

Purpose and Scope

This method explains how to collect measurements for WHSR at each of 11 equidistant transects at each site. Measurements in this procedure will be restricted to one main channel. This method must be preceded by the pre-season site layout for establishing major transects and determining which bank to assess at each transect.

Definitions

Definitions of acronyms and other terms are found in Table L-1.

Table K-1. Definitions.

Term or Accronym	Definition
Bankfull stage	This stage is delineated by the elevation point of incipient flooding, indicated by deposits of sand or silt at the active scour mark, break in stream bank slope, perennial vegetation limit, rock discoloration, and root hair exposure (Endreny 2009).
Left bank	A person facing downstream will have the left bank on their left side.
Main channel	Channels in a stream are divided by islands (dry ground that rises above bankfull stage). Main channels contain the greatest proportion of flow. For this method it is called channel number 0.
major transect	One of 11 equidistant transects across the length of a site. These are labeled as follows: A0 (lowest), B0,C0,….K0 (highest) A major transect will cross the main channel and side channels.
Right bank	A person facing downstream will have the right bank on their right side.
Side channels	Channels that contain less flow than the main channels. These are identified and enumerated (1,2,3 etc.) as encountered (see the method for thalweg measurements) during the DCE.

Personnel Responsibilities

This method is performed by 1 person. This method is applied at every DCE, at each major transect. Observations are made at both banks of the main channel. Staff performing this method must have been trained.

Equipment, Reagents, Supplies

- No. 2 pencil
- *Major Transect Data Form*
- measuring device (rod, tape, rangefinder)

Summary of Procedure

This procedure is derived from Peck et al. (2006) and Moberg (2007).

Refer to the *Major Transect Data Form* (Figures K-1 and K-2). At each of the major Transects (A0-K0), assess the main channel. Record the appropriate ***influence proximity code*** for each of 13 human ***influence types*** (Figure K-1) relative to riparian plots (Figure K-3) on one bank of the transect. The appropriate bank was designated during pre-season layout. The riparian plot dimensions can be estimated rather than measured. On steeply sloping channel margins, plot boundaries are defined as if they were projected down from an aerial view.

Influence proximity codes are:

- 0 = absent
- 1 = beyond the plot, but within 30 meters of the bankfull margin.
- 2 = within the 10 meter by 10 m riparian plot.
- 3 = at least partially within the bankfull channel.

HUMAN INFLUENCE	0=not present, 1= 10-30m, 2= 0-10m, 3= on bank								
	Left Bank				Right Bank				Flag
Wall/Dike/Revetment/ Riprap/Dam	**0**	1	2	3	**0**	1	2	3	
Buildings	**0**	1	2	3	0	1	**2**	3	F1
Unpaved Motor Trail	0	**1**	2	3	**0**	1	2	3	
Clearing or Lot	**0**	1	2	3	**0**	1	2	3	
Human Foot Path	**0**	1	2	3	**0**	1	2	3	
PavedRoad/Railroad	0	**1**	2	3	**0**	1	2	3	
Pipes (Inlet/Outlet)	**0**	1	2	3	0	1	2	**3**	F2
Landfill/Trash	0	**1**	2	3	0	1	2	**3**	F3
Park/Lawn	0	1	**2**	3	**0**	1	2	3	
Row Crops	**0**	1	2	3	**0**	1	2	3	
Pasture/Range/Hay Field	**0**	1	2	3	**0**	1	2	3	
Logging Operations	**0**	1	2	3	**0**	1	2	3	
Mining Activity	**0**	1	2	3	**0**	1	2	3	

Figure K-1. A portion of the *Major Transect Form*, with example data.

Flag	Comments
F1	single-family home
F2	possible irrigation source
F3	beer cans

Figure K-2. A portion of the *Major Transect Form* with example comments for data flags.

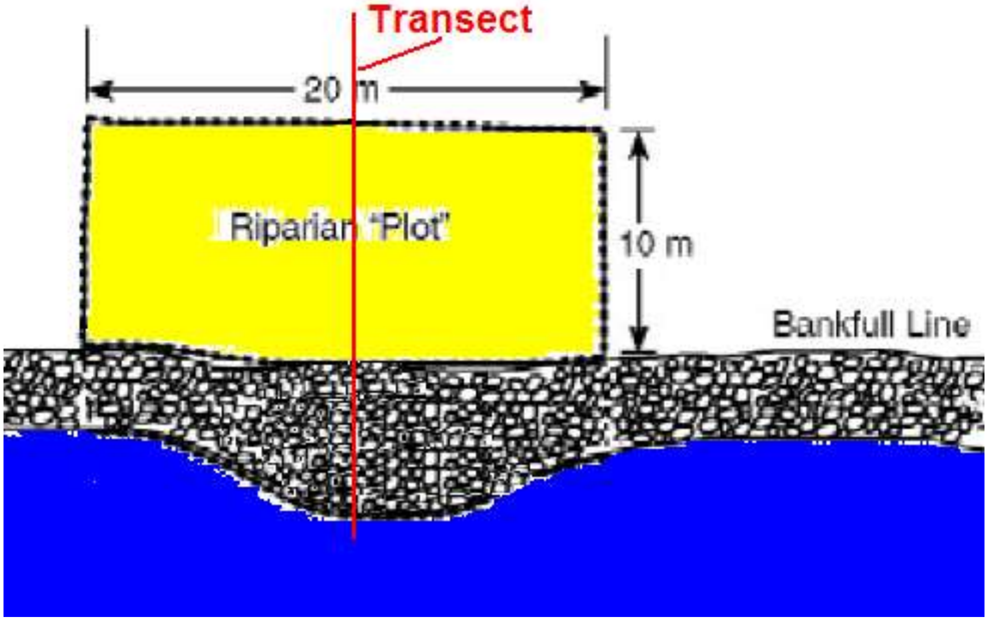


Figure K-3. One of two riparian plots at a transect.

References

Peck, D.V., Herlihy, A.T., Hill, B.H., Hughes, R.M., Kaufmann, P.R., Klemm, D.J., Lazorchak, J.M., McCormick, F.H., Peterson, S.A., Ringold, P.L., Magee, T., and Cappaert, M.R. Environmental Monitoring and Assessment Program-Surface Waters, Western Pilot Study, Field Operations Manual for Wadeable Streams. EPA/620/R-06/003. U.S. Environmental Protection Agency, Washington, D.C. http://www.epa.gov/wed/pages/publications/authored/EPA620R-06003EMAPSWFieldOperationsManualPeck.pdf

Moberg, J. 2007. A field manual for the habitat protocols of the Upper Columbia Monitoring Strategy. Prepared for and funded by Bonneville Power Administration's Integrated Status and Effectiveness Monitoring Program. Terraqua, Inc. Wauconda, WA http://www.nwfsc.noaa.gov/research/divisions/cbd/mathbio/isemp/docs/isemphabitatprotocolsfieldmanualdraft070615.pdf

Appendix L

Riparian Vegetation Structure at Transects in Wide Streams & Rivers

Purpose and Scope

This method explains how to collect measurements for WHSR at each of 11 transects at each site. Observations in this procedure will be restricted to one main channel. This method must follow pre-season site layout.

Definitions

Definitions of acronyms and other terms are found in Table L-1.

Table L-1. Definitions.

Term or Acronym	Definition
Bankfull stage	This stage is delineated by the elevation point of incipient flooding, indicated by deposits of sand or silt at the active scour mark, break in stream bank slope, perennial vegetation limit, rock discoloration, and root hair exposure (Endreny 2009).
Broadleaf evergreen	Non-coniferous trees that maintain foliage through the seasons. A native example for Washington is the madrona (*Arbutus menziesii*)
Canopy	The functional definition for this method: Vegetation above 5 m high within a 10 m x 10 m riparian plot.
Coniferous	Any of various mostly needle-leaved or scale-leaved, chiefly evergreen, cone-bearing gymnospermous trees or shrubs such as pines, spruces, and firs. This includes larch.
Cover	This can be thought of as the amount of shadow cast by a particular layer alone when the sun is directly overhead. Conceptually remove vegetation from higher layers before estimating.
DCE	Data Collection Event. Data are indexed using this code which includes the SITE_ID, the date, and the time that the event began. It uses this format: **WAM06600-NNNNNN-dce-20YY-MMDD-HHMM** **NNNNNN** = the number portion of the SITE_ID. **YY** = the last two numeric digits of the year that the event occurred. **MM** = the two numeric digits for the month that the event occurred.

	DD = the two numeric digits for the day within the month that the event occurred. **HHMM** = the military time when the event began.
Deciduous	Non-coniferous trees that shed their leaves annually. Examples include alder, oak, maple, and cottonwood.
Duff	Organic matter in various stages of decomposition on the floor of the forest.
Forbs	A broad-leaved herb other than a grass, such as those that grow in a field, prairie, or meadow.
Ground cover	The functional definition for this method: Vegetation or bare ground below 0.5 m high within a 10 m x 10 m riparian plot.
Herbs	Plants whose stems do not produce woody, persistent tissue. They generally die back at the end of each growing season.
Left bank	A person facing downstream will have the left bank on their left side.
Main channel	Channels in a stream are divided by islands (dry ground that rises above bankfull stage). Main channels contain the greatest proportion of flow. For this method it is called channel number 0.
major transect	One of 11 equidistant transects across the length of a site. These are labeled as follows: A0 (lowest), B0,C0,….K0 (highest)
Mixed	Vegetation type if more than 10% of the cover is made up of an alternate type.
Right bank	A person facing downstream will have the right bank on their right side.
Side channels	Channels that contain less flow than the main channels. These are identified and enumerated (1,2,3 etc.) as encountered (see the method for thalweg measurements) during the DCE.
Understory	The functional definition for this method: Vegetation below 5 m high but above 0.5 m high within a 10 m x 10 m riparian plot.

Personnel Responsibilities

This method is performed by 1 person. This method is applied at every DCE, at each major transect. Observations are made at both banks of the main channel. Staff performing this method must have been trained.

Equipment, Reagents, Supplies

- No. 2 pencil
- *Major Transect Data Form*

Summary of Procedure

This procedure is derived from Peck et al. (2006) and Moberg (2007).

Refer to the *Major Transect Data Form* (Figure L-1). At each of the major Transects (A0-K0), in the main channel, evaluate a 10 m x 20 m riparian plot (Figure L-2) on the bank that was designated during pre-season site layout.. The riparian plot dimensions can be estimated rather than measured. On steeply sloping channel margins, plot boundaries are defined as if they were projected down from an aerial view.

Conceptually divide the riparian vegetation into three layers:

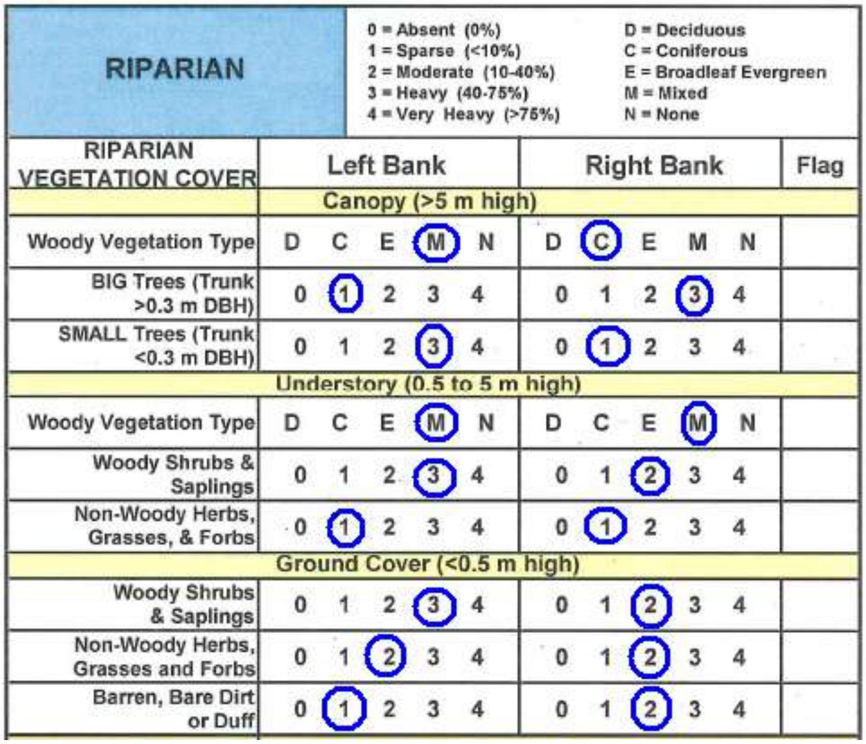
- Canopy (> 5 m high),
- Understory (0.5 to 5 m high),
- Ground Cover layer (< 0.5 m high).

Within each layer, consider the type of vegetation present and the amount of cover provided. Do this independently of what is contained in higher layers.

Cover quantity is coded on the field form (Figure L-1) as follows:

- 0 - absent
- 1- sparse (< 10% cover)
- 2 - moderate (10-40% cover)
- 3 - heavy (40-75% cover)
- 4 – very heavy (> 75% cover)

The maximum cover in each layer is 100%, so the sum of the cover for the combined three layers could add up to 300%. Ground cover scores must add to 100%.



RIPARIAN	0 = Absent (0%) 1 = Sparse (<10%) 2 = Moderate (10-40%) 3 = Heavy (40-75%) 4 = Very Heavy (>75%)	D = Deciduous C = Coniferous E = Broadleaf Evergreen M = Mixed N = None	
RIPARIAN VEGETATION COVER	Left Bank	Right Bank	Flag
Canopy (>5 m high)			
Woody Vegetation Type	D C E (M) N	D (C) E M N	
BIG Trees (Trunk >0.3 m DBH)	0 (1) 2 3 4	0 1 2 (3) 4	
SMALL Trees (Trunk <0.3 m DBH)	0 1 2 (3) 4	0 (1) 2 3 4	
Understory (0.5 to 5 m high)			
Woody Vegetation Type	D C E (M) N	D C E (M) N	
Woody Shrubs & Saplings	0 1 2 (3) 4	0 1 (2) 3 4	
Non-Woody Herbs, Grasses, & Forbs	0 (1) 2 3 4	0 (1) 2 3 4	
Ground Cover (<0.5 m high)			
Woody Shrubs & Saplings	0 1 2 (3) 4	0 1 (2) 3 4	
Non-Woody Herbs, Grasses and Forbs	0 1 (2) 3 4	0 1 (2) 3 4	
Barren, Bare Dirt or Duff	0 (1) 2 3 4	0 1 (2) 3 4	

Figure L-1. A portion of the *Major Transect Data Form*, with example data.

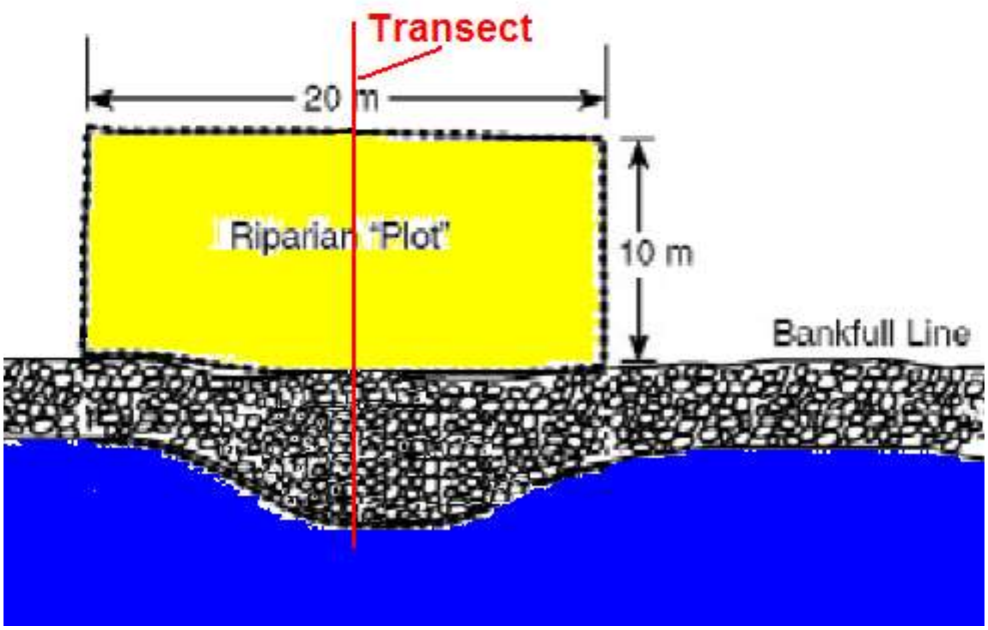


Figure L-2. One of two riparian plots at a transect.

Canopy

On the *Major Transect Form* (Figure L-1), circle the appropriate vegetation **type code** (D, C, E, M, or N). Type codes are defined on the form. The M (mixed) code means that there is any percentage of a second vegetation type.

Then circle the appropriate cover **quantity code** (0, 1, 2, 3, or 4) for each of 2 classes:

- Big trees – trees having trunks larger than 0.3 m diameter (at breast height)
- Small trees– trees having trunks smaller than 0.3 m diameter (at breast height)

Understory

On the *Major Transect Form* (Figure I-1), circle the appropriate vegetation **type code** (D, C, E, M, or N) for any *woody* vegetation that might be present. Then circle the appropriate cover **quantity code** (0, 1, 2, 3, or 4) for each of 2 classes:

- Woody vegetation - such as shrubs, saplings, or tree trunks
- Non-woody vegetation - such as herbs, grasses, or forbs

Ground Cover

Circle the appropriate cover **quantity code** (0, 1, 2, 3, or 4) for each of 3 classes:

- Woody (living)
- Non-woody (living)
- Bare dirt (or decomposing debris)

The sum of cover quantity ranges for these 3 types of ground cover should include 100%.

References

Endreny, T.A. 2009. *Fluvial Geomorphology Modules*, State University of New York College of Environmental Science and Forestry, National Oceanic and Atmospheric Administration, and the University Corporation for Atmospheric Research. www.fgmorph.com

Peck, D.V., Herlihy, A.T., Hill, B.H., Hughes, R.M., Kaufmann, P.R., Klemm, D.J., Lazorchak, J.M., McCormick, F.H., Peterson, S.A., Ringold, P.L., Magee, T., and Cappaert, M.R. Environmental Monitoring and Assessment Program-Surface Waters, Western Pilot Study, Field Operations Manual for Wadeable Streams. EPA/620/R-06/003. U.S. Environmental Protection Agency, Washington, D.C. http://www.epa.gov/wed/pages/publications/authored/EPA620R-06003EMAPSWFieldOperationsManualPeck.pdf

Moberg, J. 2007. A field manual for the habitat protocols of the Upper Columbia Monitoring Strategy. Prepared for and funded by Bonneville Power Administration's Integrated Status and Effectiveness Monitoring Program. Terraqua, Inc. Wauconda, WA http://www.nwfsc.noaa.gov/research/divisions/cbd/mathbio/isemp/docs/isemphabitatprotocolsfieldmanualdraft070615.pdf

Appendix M

Measuring Thalweg Depth

Purpose and Scope

This method explains how to collect incremental depth measurements for WHSR when traversing the length of the stream site. It also describes assessing the presence of bars and edge pools. Observations in this method will be restricted to the main channel.

Definitions

Definitions of acronyms and other terms are found in Table M-1.

Table M-1. Definitions.

Term or Acronym	Definition
bankfull stage	This stage is delineated by the elevation point of incipient flooding, indicated by deposits of sand or silt at the active scour mark, break in stream bank slope, perennial vegetation limit, rock discoloration, and root hair exposure (Endreny 2009).
bankfull width	Horizontal distance between the bankfull stage on the left bank and the bankfull stage on the right bank. For Status and Trends, this is measured in tenth of meters.
bar	Bars are dry or exposed portions of the streambed. For this method, we are only counting bars that are surrounded by water (e.g. mid-channel bars or diamond bars). Bars are lower in elevation than the bankfull stage (islands are higher).
edge pool	Slow water at the edge of the wetted channel (but connected) where velocity is slow and often in a separate direction from the main flow. Imagine a line along the wetted edge of the wetted channel that is conceptually drawn across the mouth of the edge pool. The depth somewhere behind that line must be at least 30 cm. Edge pools must be at least 0.5 m long behind that imaginary line. Examples of edge pools include backwater pools, secondary channel pools, or alcoves that meet the size criteria described above.
left bank	A person facing downstream will have the left bank on their left side.
main channel	Channels in a stream are divided by islands (dry ground that rises above bankfull stage). Main channels contain the greatest proportion of flow. For this method it is called channel number 0.
major transect	A subset of the thalweg transects. Each of 11 equidistant transects across

	the length of a site. These are labeled as follows: A0 (lowest), B0, C0….K0 (highest).
right bank	A person facing downstream will have the right bank on their right side.
thalweg	Path of a stream that follows the deepest part of the channel (Armantrout, 1998).
thalweg depth	Water depth along the path of the thalweg.
thalweg transect	The stream site is conceptually divided longitudinally into 100 segments, separated by 101 thalweg transects. Thalweg transects are separated by 0.2 (site average) bankfull widths from each other. The thalweg transects are labeled from the bottom of the site to the top as follows: A0, A1, A2, A3, A4, A5, A6, A7, A8, A9, B0…K0.

Personnel Responsibilities

This method is performed by 2 persons: one measures and another records. This method is limited to the main channel. It must be preceded by the method for verification and site layout. Staff performing this method must have been trained.

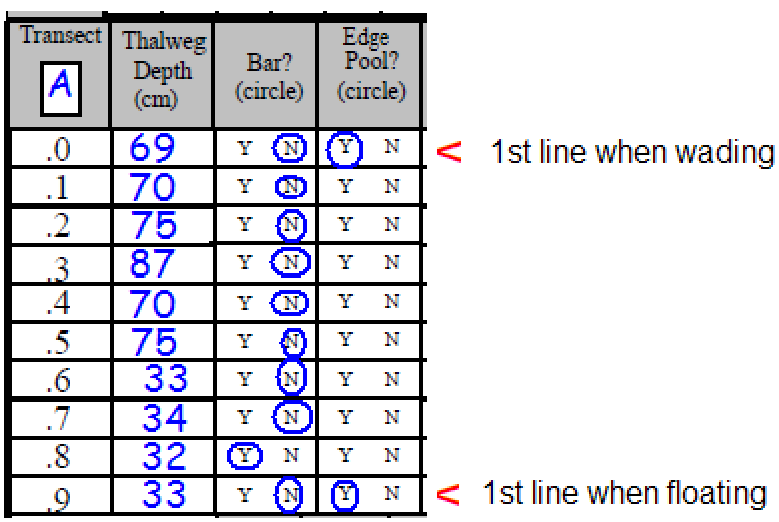
Equipment, Reagents, Supplies

- No. 2 pencil
- *Thalweg Data Form*
- Measuring rod
- Clinometer
- Hand-held sonar

Summary of Procedure

This procedure is derived from Peck et al. (2006) and Moberg (2007).

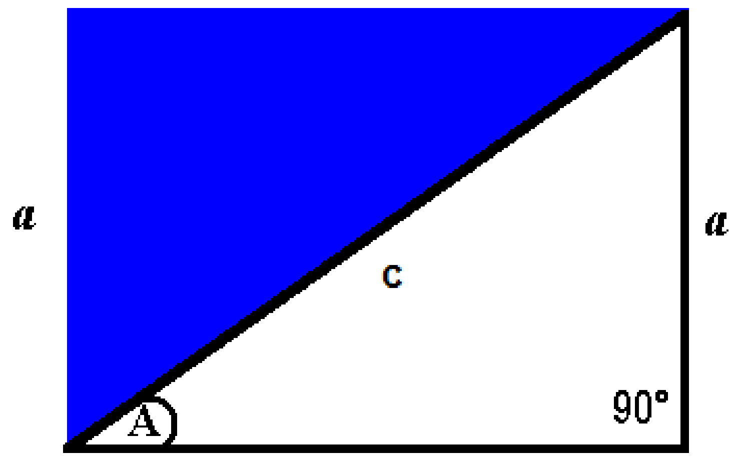
Refer to the *Thalweg Data Form* (Figure M-1). While walking up the main channel (or floating down), measure thalweg depth (cm) at each of 100 thalweg transects. Use either a measuring rod or a sonar. Convert sonar measurements to centimeters if the meter won't adjust. To reference location, record the letter code for the lowest major transect referenced (e.g. A). Record depth and occurrence data into the appropriate thalweg transect row (e.g. .0)



Transect A	Thalweg Depth (cm)	Bar? (circle)	Edge Pool? (circle)
.0	69	Y (N)	(Y) N
.1	70	Y (N)	Y N
.2	75	Y (N)	Y N
.3	87	Y (N)	Y N
.4	70	Y (N)	Y N
.5	75	Y (N)	Y N
.6	33	Y (N)	Y N
.7	34	Y (N)	Y N
.8	32	(Y) N	Y N
.9	33	Y (N)	(Y) N

Figure M-1. A portion of the *Thalweg Data Form*, with example data.

It is important that field crews provide a thalweg depth value for *every* thalweg station. When wading, depths in pools can sometimes be too deep to reach. In these cases, measure from an angle using a clinometer and trigonometry (Figure M-2). In other cases, the crew might need to make estimates. Be sure to record notes in the “Thalweg Notes” portion of the form, when depths are based on information other than direct measurements.



Known:

Angle A is measured with a clinometer
Hypotenuse (c) is measured with survey rod

Find:

Opposite side length (thalweg depth) = a

sin A = a/c

Figure M-2. Using trigonometry to determine depth from an angle.

While measuring thalweg depth, also evaluate whether each of these features is present at each thalweg transect:

- bar
- edge pool

Circle “Y” for “yes” and “N” for “no”.

References

Armantrout, N. B., Compiler. 1998. Glossary of Aquatic Habitat Inventory Terminology. American Fisheries Society, Bethesda, Maryland.

Endreny, T.A. 2009. *Fluvial Geomorphology Modules*, State University of New York College of Environmental Science and Forestry, National Oceanic and Atmospheric Administration, and the University Corporation for Atmospheric Research. www.fgmorph.com

Peck, D.V., Herlihy, A.T., Hill, B.H., Hughes, R.M., Kaufmann, P.R., Klemm, D.J., Lazorchak, J.M., McCormick, F.H., Peterson, S.A., Ringold, P.L., Magee, T., and Cappaert, M.R. Environmental Monitoring and Assessment Program-Surface Waters, Western Pilot Study, Field Operations Manual for Wadeable Streams. EPA/620/R-06/003. U.S. Environmental Protection Agency, Washington, D.C.
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Moberg, J. 2007. A field manual for the habitat protocols of the Upper Columbia Monitoring Strategy. Prepared for and funded by Bonneville Power Administration's Integrated Status and Effectiveness Monitoring Program. Terraqua, Inc. Wauconda, WA
http://www.nwfsc.noaa.gov/research/divisions/cbd/mathbio/isemp/docs/isemphabitatprotocolsfieldmanualdraft070615.pdf

Streamnet, 2002. Public Education Glossary of Habitat Related Terms. Last Updated March 5, 2002
http://www.streamnet.org/pub-ed/ff/Glossary/glossaryhabitat.html

Appendix N

Large Woody Debris Tally for Wide Streams & Rivers

Purpose and Scope

This method explains how to count pieces of large woody debris for WHSR in wide streams & rivers of western Washington. Observations are limited to eleven large woody debris plots in the main channel. This method applies to streams of Puget Sound, Coastal, and the Lower Columbia Status and Trends Regions.

Definitions

Definitions of acronyms and other terms are found in Table N-1.

Table N-1. Definitions.

Term or Acronym	Definition
DCE	Data Collection Event. Data are indexed using this code which includes the SITE_ID, the date, and the time that the event began. It uses this format: **WAM06600-NNNNNN-dce-20YY-MMDD-HHMM** **NNNNNN** = the number portion of the SITE_ID. **YY** = the last two numeric digits of the year that the event occurred. **MM** = the two numeric digits for the month that the event occurred. **DD** = the two numeric digits for the day within the month that the event occurred. **HHMM** = the military time when the event began.
LWD	Large woody debris. This is dead wood that is at least 10 cm diameter and more than 2 m long.
Main channel	Channels in a stream are divided by islands (dry ground that rises above bankfull stage). The main channel contains the greatest proportion of flow. For this method it is called channel number 0.
major transect	One of 11 equidistant transects across the length of a site. These are labeled as follows: A0 (lowest), B0,C0,….K0 (highest)
Side channels	Channels in a stream are divided by islands (dry ground that rises above bankfull stage). Side channels are those that contain less flow than the main channel. These are identified and enumerated (1,2,3 etc.) as encountered during the DCE.
thalweg transect	One of 101 equidistant transects across the length of a site. Labeling includes the name of the major transect. For example the thalweg transects between (and including) major transects A and B would be labeled as follows: A0, A1, A2, A3, A4, A5, A6, A7, A8, A9, B0 (i.e.., thalweg transect A0 is identical to major transect A)

Personnel Responsibilities

This method is performed by 1 person. This method is applied at every DCE. Observations are made while walking upstream in the main channel or while floating downstream in the main channel. Observations are made at one bank for each of 11 equidistant transects on the site. Staff performing this method must have been trained.

Equipment, Reagents, Supplies

- No. 2 pencil
- *Thalweg Data Form*
- Measuring rod
- Calipers

Summary of Procedure

This procedure is derived from Peck et al (2006) and Moberg (2007).

One person, while walking upstream or floating downstream, stops at one side of the stream for each of 11transects. The side of the stream was established during per-season site layout. Tally large woody debris pieces that enter a plot (Figure N-1) with these dimensions:

- 10 meters into the water from the wetted margin
- 10 meters upstream from the transect
- 10 meters downstream from the transect
- Back on dry ground as far as the bankfull channel margin

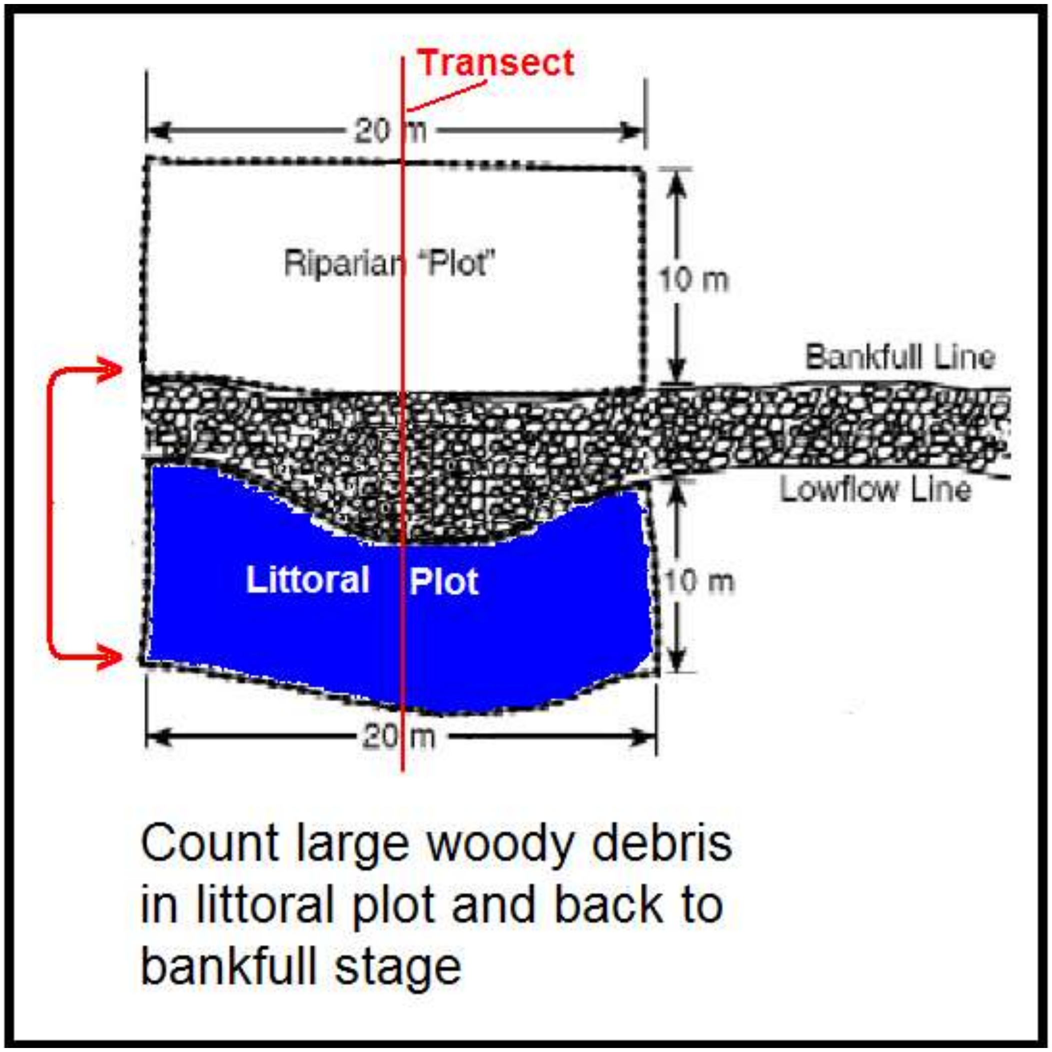


Figure N-1. The large woody debris tally plot at each transect.

Pieces are tallied according to 12 size classes (4 diameter classes for each of 3 length classes). Size criteria depend upon region (Tables N-2, N-3, and N-4).

Table N-2. Large woody debris (LWD) regions.

Status & Trend Region	LWD Region
Puget Sound	West
Coastal	West
Lower Columbia	West
Mid Columbia	East
Upper Columbia	East
Snake	East
Northeast Washington	East
Unlisted Washington	East

Table N-3. Large woody debris (LWD) diameter classes by region.

LWD Region	Thin Diameter (cm)	Medium Diameter (cm)	Wide Diameter (cm)	Extra-Wide Diameter (cm)
East	10 to 15	> 15 to 30	> 30 to 60	> 60
West	10 to 30	> 30 to 60	> 60 to 80	> 80

Table N-4. Large woody debris (LWD) length classes by region.

LWD Region	Short (m)	Medium (m)	Long (m)
East	1 to 3	> 3 to 6	> 6
West	2 to 5	> 5 to 15	> 15

Considering taper

Wood pieces have a taper. Considerations for taper are illustrated in Figure N-2. The diameter of a log is based on the thickest end. The length of a log only counts the portion that has a diameter of more than 10 cm.

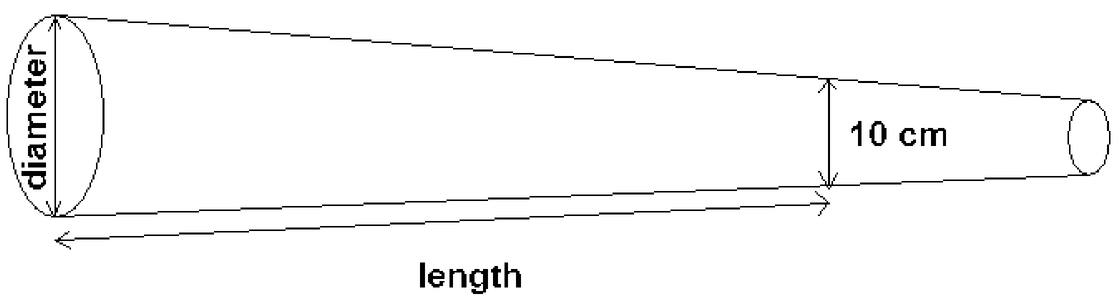
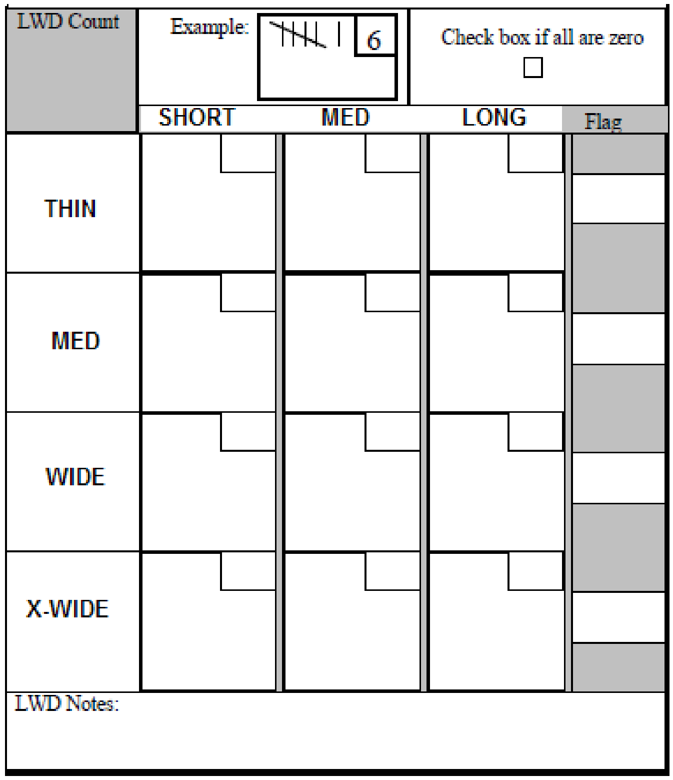


Figure N-2. Diagram of how to estimate the dimensions of a log.

Record

Refer to the *Thalweg Data Form* (Figure N-3). Identify and tally LWD pieces that lie in the large woody debris plot. After tallying, sum the marks separately for each size class and enter the number into the corresponding box for each class.



LWD Count	Example: ~~||||~~ | 6		Check box if all are zero ☐	
	SHORT	MED	LONG	Flag
THIN				
MED				
WIDE				
X-WIDE				

LWD Notes:

Figure N-3. A portion of the *Thalweg Data For.*

References

Moberg, J. 2007. A field manual for the habitat protocols of the Upper Columbia Monitoring Strategy. Prepared for and funded by Bonneville Power Administration's Integrated Status and Effectiveness Monitoring Program. Terraqua, Inc. Wauconda, WA http://www.nwfsc.noaa.gov/research/divisions/cbd/mathbio/isemp/docs/isemphabitatprotocolsfieldmanualdraft070615.pdf

Peck, D.V., Herlihy, A.T., Hill, B.H., Hughes, R.M., Kaufmann, P.R., Klemm, D.J., Lazorchak, J.M., McCormick, F.H., Peterson, S.A., Ringold, P.L., Magee, T., and Cappaert, M.R. 2006. Environmental Monitoring and Assessment Program-Surface Waters, Western Pilot Study, Field Operations Manual for Wadeable Streams. EPA/620/R-06/003. U.S. Environmental Protection Agency, Washington, D.C. http://www.epa.gov/wed/pages/publications/authored/EPA620R-06003EMAPSWFieldOperationsManualPeck.pdf

Appendix O

Habitat Unit Descriptions along the Main Channel Thalweg

Purpose and Scope

This method explains how to identify and count habitat units for WHSR when traversing the length of the stream site. The habitat unit descriptions are based on the Hawkins *et al*. (1993) classification system (Figure P-1). Observations in this method will be restricted to the main channel.

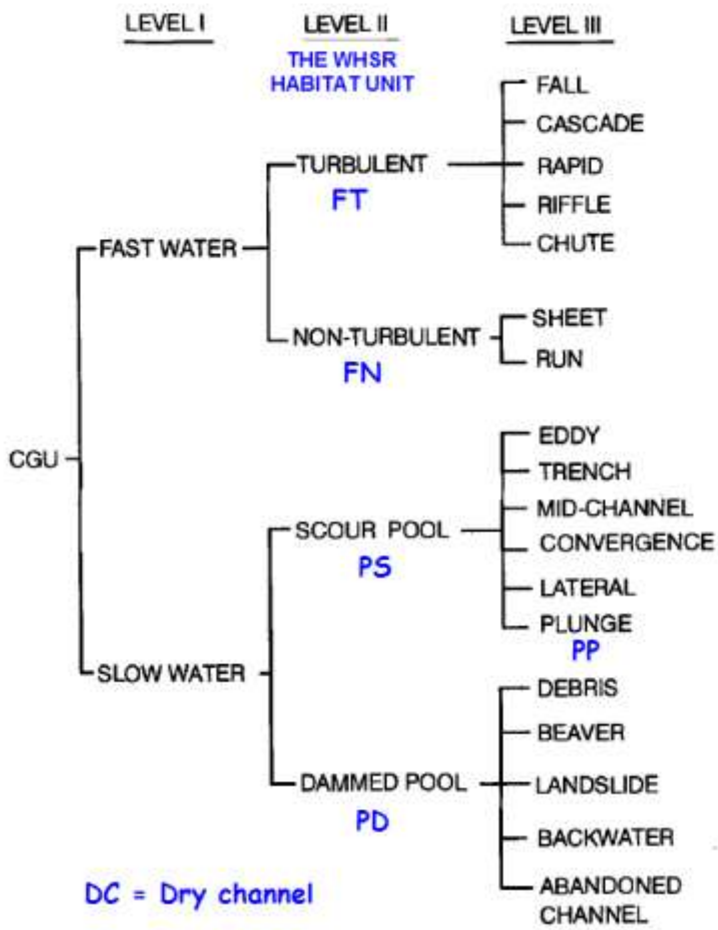


Figure O-1. Categories of channel geomorphic units (CGU) described by Hawkins *et al* (1993) and their three levels of resolution. This figure is modified from Hawkins *et al* (1993), with WHSR habitat unit codes displayed in blue text.

Definitions

Definitions of acronyms and other terms are found in Table O-1.

Table O-1. Definitions.

Term or Acronym	Definition
Bankfull stage	This stage is delineated by the elevation point of incipient flooding, indicated by deposits of sand or silt at the active scour mark, break in stream bank slope, perennial vegetation limit, rock discoloration, and root hair exposure (Endreny 2009).
Bankfull width	Horizontal distance between the bankfull stage on the left bank and the bankfull stage on the right bank. For Status and Trends, this is measured in tenth of meters.
Dammed pool	A pool formed by impounded water from complete or nearly complete channel blockage (Armantrout, 1998)
DCE	Data Collection Event. Data are indexed using this code which includes the SITE_ID, the date, and the time that the event began. It uses this format: **WAM06600-NNNNNN-dce-20YY-MMDD-HHMM** **NNNNNN** = the number portion of the SITE_ID. **YY** = the last two numeric digits of the year that the event occurred. **MM** = the two numeric digits for the month that the event occurred. **DD** = the two numeric digits for the day within the month that the event occurred. **HHMM** = the military time when the event began.
Dry channel	A habitat unit is designated as dry channel (DC) where flow is subsurface.
Fast non-turbulent	Habitat unit with smooth, laminar flow that is less deep than in pools. Examples include a sheet or run.
Fast turbulent	Habitat unit with supercritical flow, with hydraulic jumps sufficient to entrain air bubbles and create whitewater (Armantrout, 1998). Examples include water-falls, cascades, rapids, and riffles.
Habitat Unit	Habitat units are "quasi-discrete areas of relatively homogeneous depth and flow that are bounded by sharp physical gradients… Different types of units are usually in close enough proximity to one another that mobile stream organisms can select the type of unit that provides the most suitable habitat" (Hawkins et al. 1993). For Status and Trends, any unit (with two exceptions) must be at least **as long as *half* their wetted width** and they must include the thalweg. Plunge pools and dry channels are the exceptions. Plunge pools can be shorter than half their width. Dry channels have no wetted width and only need to extend 20% of a site's bankfull width (1/100th of the entire stream site's length).
Left bank	A person facing downstream will have the left bank on their left side.
Main channel	Channels in a stream are divided by islands (dry ground that rises above bankfull stage). Main channels contain the greatest proportion of flow.

	For this method it is called channel number 0.
major transect	A subset of the thalweg transects. Each of 11 equidistant transects across the length of a site. These are labeled as follows: A0 (lowest), B0, C0….K0 (highest).
minor transect	A subset of the thalweg transects. Each of 10 equidistant transects across the length of a site. These are situated mid-way between major transects and are labeled as follows: A5, B5, C5….K5.
Plunge pool	A pool created by water that passes over an obstruction and drops steeply to scour a basin in the streambed below (Armantrout 1998). This plunge type of scour pool is coded separately because its length criteria are different. Plunge pools can be shorter than half the wetted width.
Pool	For Status and Trends, this is a habitat unit that has a maximum depth at least 1.5 times its crest depth.
Pool crest depth (scour pools)	Thalweg depth at the shallowest tail-out (downstream) end of the pool.
Pool crest depth (dammed pools)	Thalweg depth at the shallowest upstream end of the pool.
Pool maximum depth	Deepest thalweg depth in a pool habitat unit.
Right bank	A person facing downstream will have the right bank on their right side.
Scour pool	Pool created by the scouring action of current flowing against an obstruction (Armantrout 1998). Examples include eddy pools, trench pools, mid-channel pools, convergence pools, and lateral scour pools.
Side channels	Channels that contain less flow than the main channels. These are identified and enumerated (1,2,3 etc.) as encountered (see the method for thalweg measurements) during the DCE.
Thalweg	Path of a stream that follows the deepest part of the channel (Armantrout, 1998).
Thalweg depth	Water depth along the path of the thalweg.
thalweg transect	The stream site is conceptually divided longitudinally into 100 segments, separated by 101 thalweg transects. Thalweg transects are separated by 0.2 (site average) bankfull widths from each other. The thalweg transects are labeled from the bottom of the site to the top as follows: A0, A1, A2, A3, A4, A5, A6, A7, A8, A9, B0…K0.

Personnel Responsibilities

This method is performed by 1 person and who dictates data to a second person who records. This method is applied at every DCE. Observations are made while wading upstream or floating downstream in the thalweg of the main channel. Staff performing this method must have been trained.

Equipment, Reagents, Supplies

- No. 2 pencil
- *Thalweg Data Form*
- Measuring rod
- 50-m tape or laser rangefinder

Summary of Procedure

This procedure is derived from Moberg (2007).

Refer to the *Thalweg Data Form* (Figures 0-1 and 0-2). Identify and code habitat units consecutively during the walk upstream or when floating downstream. A separate Thalweg Data Form is recorded for each set of observations that span between major transects (e.g. one form for J9 to J0, another for I9 to I0, etc). Data will include:

- type code,
- unit identity (number),
- pool forming code, and
- depths (for pools).

Habitat Unit Number	Habitat Unit Type FT, FN, PS, PD, PP, DC	Pool Forming Code (N, W, R, B, F)		HU Width (m.x)	Max Pool Depth (cm)	Crest Pool Depth (cm)	Channel Unit Notes:
		Code 1	Code 2				
1	PD	W	B	3.5	90	30	Pool formed by both boulder & wood
2	PP	W		4.2	75	15	
3	FN	W		4.8			

Figure O-1. A portion of the *Thalweg Data Form*, with example data for habitat unit type, pool forming code, habitat unit width, and pool depths.

Transect A	Thalweg Depth (cm)	Bar? (circle)	Edge Pool? (circle)	Habitat Unit Number	
.0		Y N	Y N	1	< 1st line when wading
.1		Y N	Y N	1	
.2		Y N	Y N	1	
.3		Y N	Y N	1	
.4		Y N	Y N	2	
.5		Y N	Y N	2	
.6		Y N	Y N	3	
.7		Y N	Y N	3	
.8		Y N	Y N	3	
.9		Y N	Y N	3	< 1st line when floating

Figure O-2. A portion of the Thalweg Data Form, with example data for habitat unit locations relative to thalweg transects.

Type Code

With each step up the thalweg, evaluate the wetted channel for conformity to the Hawkins *et al* (1993) classification system (Figure O-1). We are focusing on Level II designations. The main division is between slow water (pools) and fast water (e.g., cascades, riffles, or runs). All habitat units (except plunge pools or dry channels) must be at least as long as half the wetted width. All pools have specific depth criteria (Table O-1): the maximum depth must be at least 1.5 times the depth at the pool crest. Record the unit type code (Table O-2) on the *Thalweg Data Form* (Figure O-2).

Habitat units in rivers can be very long. The type of unit in which you reside might not be clear until you pass through the unit completely, For example, you might believe that you are in an FN unit. If the unit maintains constant depth as you drift downstream, your initial assignment would be correct. If however, depth increases significantly before reaching a tail-out, you may need to revise some previous observations to PS. Make good notes when you start a new habitat unit. Graphical representation of thalweg depths can help with edits to habitat unit assignments.

Table O-2. Habitat unit type codes.

Unit Type	Description
FT	Fast Turbulent (riffle, cascade, waterfall)
FN	Fast Non-Turbulent (sheet, run)
PS	Scour pool
PD	Dammed pool
PP	Plunge pool
DC	Dry channel

Unit Number

After you designate the habitat unit type (Table P-3), assign a habitat unit number. These are consecutive number counts for the whole stream site. For each form, record data for any new habitat units that appear since the last encountered major transect. For example, if habitat units numbered 1, 2, and 3 were recorded between major transects A and B, then new units encountered between B and C would begin with habitat unit number 4.

Pool Forming Code

On the *Thalweg Data Form* (Figure O-2), record the pool forming code (Table P-3) to describe the obstruction that led to pool formation. Assign “N” for habitat units other than pools. If pool formation could be associated with two types (e.g. boulder *and* large wood), use both columns on the form, with one code per column.

Table O-3. Pool forming codes.

Pool Forming Code	**Description**
N	Not a pool
W	Large Woody Debris
R	Root wad
B	Boulder/Bedrock
F	Fluvial (non-specific stream process)

Habitat Unit Width

Estimate the average wetted width (nearest tenth of a meter) of the habitat unit for the full course of its length. Record this value on the *Thalweg Data Form* (Figure P-2) A measurement is not required. Just consider the relative width compared to the width measurements performed at nearby major transects and minor transects.

Pool Depths

With a measuring rod, measure water depth (cm) in each of two locations in the thalweg of pools:

- at the crest
- at maximum depth.

Crest depth is measured differently, depending upon the pool type. For scour pools and plunge pools, the crest depth is measured where water exits the pool. For dammed pools, the crest depth is measured where water enters the pool.

Record crest depth and maximum depth on the *Thalweg Data Form* (Figure P-2). No data need to be recorded for non-pool habitat units.

Position

After identifying and describing habitat units (Figure O-1), record the position of each habitat unit relative to thalweg stations (Figure O-2).

References

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

Endreny, T.A. 2009. *Fluvial Geomorphology Modules*, State University of New York College of Environmental Science and Forestry, National Oceanic and Atmospheric Administration, and the University Corporation for Atmospheric Research. www.fgmorph.com

Hawkins, C.P., JL. Kershner, P.A. Bisson, M.D. Bryant, L.M. Decker, S.V. Gregory, D.A. McCullough, C.K. Overton, G.H. Reeves, R.J. Steedman, and M.K. Young. 1993. Hierarchical approach to classifying stream habitat features. Fisheries 18:3-12.

Moberg, J. 2007. A field manual for the habitat protocols of the Upper Columbia Monitoring Strategy. Prepared for and funded by Bonneville Power Administration's Integrated Status and Effectiveness Monitoring Program. Terraqua, Inc. Wauconda, WA http://www.nwfsc.noaa.gov/research/divisions/cbd/mathbio/isemp/docs/isemphabitatprotocolsfieldmanualdraft070615.pdf

Appendix P

Side-Channel Descriptions

Purpose and Scope

This method explains how to identify and count side-channels of waded streams for WHSR when traversing the length of the stream site. Observations are limited to portions of side channels that occur next to the sampled part of the main channel (above Transect A0 and below Transect K0).

Definitions

Definitions of acronyms and other terms are found in Table Q-1.

Table Q-1. Definitions.

Term or Acronym	Definition
DCE	Data Collection Event. Data are indexed using this code which includes the SITE_ID, the date, and the time that the event began. It uses this format: **WAM06600-NNNNNN-dce-20YY-MMDD-HHMM** **NNNNNN** = the number portion of the SITE_ID. **YY** = the last two numeric digits of the year that the event occurred. **MM** = the two numeric digits for the month that the event occurred. **DD** = the two numeric digits for the day within the month that the event occurred. **HHMM** = the military time when the event began.
Main channel	Channels in a stream are divided by islands (dry ground that rises above bankfull stage). The main channel contains the greatest proportion of flow. For this method it is called channel number 0.
major transect	One of 11 equidistant transects across the length of a site. These are labeled as follows: A0 (lowest), B0,C0,….K0 (highest)
Side channels	Channels in a stream are divided by islands (dry ground that rises above bankfull stage). Side channels are those that contain less flow than the main channel. These are identified and enumerated (1,2,3 etc.) as encountered during the DCE.
thalweg transect	One of 101 equidistant transects across the length of a site. Labeling includes the name of the major transect. For example the thalweg

	transects between (and including) major transects A and B would be labeled as follows: A0, A1, A2, A3, A4, A5, A6, A7, A8, A9, B0 (i.e.., thalweg transect A0 is identical to major transect A)

Personnel Responsibilities

This method is performed by 1 person who dictates to another. This method is applied at every DCE. Observations are made while walking upstream to measure thalweg depths of the main channel. Staff performing this method must have been trained.

Equipment, Reagents, Supplies

- No. 2 pencil
- *Thalweg Data Form*
- Measuring rod
- Field notebook

Summary of Procedure

This procedure is derived from Moberg (2007).

Refer to the *Thalweg Data Form* (Figures S-1 and S-2). Identify and count side channels occurring within the length of the sample site. Estimate their widths.

Identify and count

Identify and code side channels consecutively for the entire streams site. Number them as encountered while walking upstream. Note their presence for each of the 101 Thalweg Transects of the stream site. This will require 11 *Thalweg Data Forms* to complete (A-K).

Transect A	Thalweg Depth (cm)	Bar? (circle)	Edge Pool? (circle)	Habitat Unit Number	Side Channel Numbers				
.0		Y N	Y N						
.1		Y N	Y N		1				
.2		Y N	Y N		1				
.3		Y N	Y N		1				
.4		Y N	Y N		1	2			
.5		Y N	Y N		1	2			
.6		Y N	Y N		1	2			
.7		Y N	Y N		1	2			
.8		Y N	Y N		1	2	3		
.9		Y N	Y N		1	2	3		

Figure Q-1. A portion of the *Thalweg Data Form*, with example data showing the presence or absence of side-channels at each Thalweg Transect.

Estimate Width

For each side-channel, visually estimate the average wetted width (nearest tenth of a meter). Consider only the part of the side-channel that is within extent of the sample site (between A0 and K0). Record the width of each side-channel on the *Thalweg Data Form* (Figure Q-2).

Side Channel Number	Width (m.x)	Side Channel Notes:
1	1.0	left side of main channel
2	2.3	diverts from channel 1, not from main channel
3	3.7	Right side of main channel

Figure Q-2. A portion of the *Thalweg Data Form*, with example data for channel width estimates.

References

Moberg, J. 2007. A field manual for the habitat protocols of the Upper Columbia Monitoring Strategy. Prepared for and funded by Bonneville Power Administration's Integrated Status and Effectiveness Monitoring Program. Terraqua, Inc. Wauconda, WA http://www.nwfsc.noaa.gov/research/divisions/cbd/mathbio/isemp/docs/isemphabitatprotocolsfieldmanualdraft070615.pdf

Appendix Q

Sampling the Vertebrate Assemblage in Wide Streams & Rivers

Purpose and Scope

This method describes how to detect the presence and relative abundance of aquatic vertebrate species at each site for WHSR. It applies to wide streams and rivers. This method requires measurement of the associated physical and chemical environmental variables described in other methods within this protocol. Sampling should be done using use a backpack electrofisher when the site is shallow and wadeable. Sampling should be done using a raft-mounted electrofisher for deep or non-wadeable sites.

Definitions

Definitions of acronyms and other terms are found in Table Q-1.

Table Q-1. Definitions.

Term or Accronym	**Definition**
Ambient conductivity	Conductivity (µS/cm) of the water for the ambient water temperature. Electrofishing success depends on *ambient* conductivity rather than specific conductivity. It can be estimated from specific conductivity with this formula from Reynolds (1996): $C_a = C_s/[1.02^{(Ts-Ta)}]$ Ambient conductivity is *the* most important habitat factor affecting electrofishing efficiency.
DCE	Data Collection Event. Data are indexed using this code which includes the SITE_ID, the date, and the time that the event began. It uses this format: **WAM06600-NNNNNN-dce-20YY-MMDD-HHMM** **NNNNNN** = the number portion of the SITE_ID. **YY** = the last two numeric digits of the year that the event occurred. **MM** = the two numeric digits for the month that the event occurred. **DD** = the two numeric digits for the day within the month that the event occurred.

	HHMM = the military time when the event began.
DNA	Deoxyribonucleic acid (DNA) is a long molecule in organisms that carries trait information including species identity.
Duty Cycle	Duty cycle is the percentage of time that the output pulse is “on” during the time period between pulse cycles. On the Smith-Root LR-20 electrofisher, the duty cycle switch is located on the upper left center of the control panel. Increasing duty cycle might increase stress to fish. This feature is not part of common raft-mounted electrofishers.
FPARS	FPARS is the Forest Practices Application and Review System (WDNR, 2009). They use detection sampling and habitat modeling to assign stream type codes. The codes describe whether fish are expected to use each stream.
Frequency	This describes the pulse rate per second. On the Smith-Root LR-20 electrofisher, the frequency switch is located on upper left of the front panel. Most pulsed DC electrofishing is done at 30-60 Hz. Increasing voltage increases the rate of fish injuries. This feature is not part of common raft-mounted electrofishers.
galvanotaxis	This is electrically-**induced movement** (usually toward the anode, but sometimes toward the cathode too). When pulsed DC current is supplied to water, fish are electrically induced to swim toward the electrode. This is called galvanotaxis.
Habitat unit	Habitat units are “quasi-discrete areas of relatively homogeneous depth and flow that are bounded by sharp physical gradients… Different types of units are usually in close enough proximity to one another that mobile stream organisms can select the type of unit that provides the most suitable habitat” (Hawkins et al. 1993). For WHSR, any unit (with two exceptions) must be at least **as long as *half* their wetted width** and they must include the thalweg. Plunge pools and dry channels are the exceptions. Plunge pools can be shorter than half their width. Dry channels have no wetted width and only need to extend 1/100th of the entire stream site’s length.
ITIS_SN	Taxonomic serial number provided by ITIS (2009)
Major transects	The length of the stream is divided by 11 equidistant major transects: A0 (bottom) to K0 (top).
narcosis	A state of electrically-induced **immobility with slack muscles**. As fish are induced into galvanotaxis and approach the anode, their reaction changes to narcosis (muscle relaxation and loss of equilibrium). While under narcosis, the fish may continue to swim, upside down, toward the anode. Narcosis can sometimes be achieved near the cathode too (Reynolds, 1996).
Power	This is the energy delivery rate. Electrofishing can be viewed as a power-based phenomena. Electrofishing effectiveness is based on how much power is transferred to the fish. Power transfer is most efficient when water conductivity closely matches the conductivity of fish flesh (near 100

	µS/cm for most species).
Segment	Wetted stream area that is defined between major transects. There are 10 segments in each site. For example segment A is the portion of the stream site that is situated between major transects A0 and B0.
species-life stage	The age status for each species captured: juvenile or adult. Habitat requirements and characteristics can change for species as their status changes from juvenile to adult. Some undergo transformation from a larval stage (e.g. lamprey and frogs). Others may just generally get larger.
Specific conductivity	Electrical conductivity is a measure of water's ability to conduct electricity, and therefore a measure of ionic activity and content. It is the reciprocal of specific resistivity. Specific conductivity is conductivity adjusted to 25˚ C (reported in µS/cm at 25˚ C). This is what most field conductivity meters report.
tetany	A state of electrically-induced **immobility with rigid muscles**. Tetany is usually achieved near the anode, but sometimes near the cathode. Fish captured before they reach tetany experience a lower risk of injury.
thalweg	Path of a stream that follows the deepest part of the channel (Armantrout, 1998).
Voltage	Voltage is the electrical force, or "pressure", that causes current to flow in a circuit. It is measured in VOLTS (V). As ambient conductivity of water decreases below (approximately) 100 µS/cm, the output voltage must be increased to elicit a response from fish. On the Smith-Root LR-20 electrofisher, the voltage range switch is located on the left side of the front panel. Increasing voltage increases the rate of fish injuries.

Personnel Responsibilities

When wading, three persons perform this activity: an electrofisher operator, a dip netter, and third person who monitors and processes the animals collected. When rafting, two persons perform the activity, a boat operator and a netter who processes the samples. The netter should always be limited to 1 person for consistency.

Field supervisors and crew members must be trained prior to electrofishing. For fishing in waters containing listed salmon or steelhead, the federal government (NOAA, 2000) has special requirements for field supervisors and crew members.

Equipment, Reagents, Supplies

When wading

- Vertebrate Collection Form
- Clip board, pencils
- Field notebook
- Backpack electrofisher unit (e.g. Smith-Root LR-20)
- Anode with ring (with as large a diameter bore as possible)
- Cathode (rat-tail)
- Battery (fully charged)
- Electrically insulated gloves
- Electrically insulated waders and wading shoes
- Polarized sun glasses
- Caps with visor
- Measuring Board
- Taxonomic Keys
- Buckets or live wells
- Camera
- Dipnet (1/8" mesh)
- Aquarium net
- Wading shoes (clean)
- Calipers
- Loop or magnifying glass
- Several of 500-1000 ml jars with ethanol (vouchers)
- Voucher labels
- Abrasive cloth for electrode maintenance

When rafting

- Vertebrate Collection Form
- Clip board, pencils

- Field notebook
- Raft and associated safety gear
    - trailer and tie-downs
    - life vests
    - helmets
    - knives
    - throw bags
    - air pump
    - patch kit
    - dry bags/dry boxes
- Shuttle vehicle
- Electrodes
- GPP Box
- Connecting chords (between GPP Box, foot switch, generator)
- Foot safety switch
- Generator, fueled
- Electrically insulated gloves
- Polarized sun glasses
- Caps with visor
- Measuring Board
- Taxonomic Keys
- Buckets or live wells
- Camera
- Dipnet (1/8" mesh)
- Aquarium net
- Calipers
- Loop or magnifying glass
- Several of 500-1000 ml jars with ethanol (lab. checks)
- Leatherman
- Duct tape

Summary of Procedure

To preserve sample integrity, electrofishing is conducted after sampling for invertebrates. When floating, the electrofishing boat (biology crew) follows the habitat boat so they can see where transects are located (the habitat boat will be navigating to each transect with the GPS). The crew first prepares their fishing equipment to best suit the stream conditions and minimize fish injuries. They then walk up (or float down) through the stream site to perform a single-pass electrofishing sample.

Pre-sampling Preparations

Prior to the start of the season, staff should be trained in principles and techniques of electrofishing. This will help to minimizing harm to staff or to fish during the field season. A free on-line course is available from the United States Fish and Wildlife Service, National Conservation Training Center (USFWS, 2010) at this link: http://training.fws.gov/EC/Course_descriptions/FIS2C01.htm

Carefully read the sampling permits and NOAA (2000) guidance to determine special requirements. The Scientific Collection Permit from the Washington State Department of Fish and Wildlife is likely to stipulate persons to be contact prior to each sampling event (e.g. regional biologists). It is also likely to include restrictions from sampling in warm water. Discuss sampling options with the regional fish biologist.

The crew members should each be trained in all electrofishing roles. Practice sessions should be performed prior to sampling, at a location external to the range of threatened or endangered species.

Absence of spawning fish

Prior to sampling verify that there are no salmonids or bull trout present in spawning condition. Pre-season research on the timing of runs can help. During the site layout the crew should also perform a visual confirmation.

Settings - Backpack electrofisher

Complete an electrofisher log (e.g. Figure Q-1) to determine that the instrument settings will maximize capture efficiency and minimize harm to aquatic vertebrates. The electrofisher log will also help to keep track of settings that work well for each type of stream. The United States Department of Interior (Brenkman and Connelly, 2008; Connelly and Brenkman, 2008) uses settings of 60 Hz and 400–600 v where this is effective in National Parks of the Northwest.

Header information

Record the identity of the electrofisher (serial number). Also record the identity of electrodes that you are using (to track malfunctions). Record the site and date. Note the depth, width and substrate of the stream.

Water temperature

Prior to electrofishing, measure and record water temperature (˚C). Check the permit restrictions and notes form discussions with the regional fish biologist to see if fishing can proceed.

Ambient conductivity

Prior to electrofishing, measure specific conductivity (i.e., the value recorded in $\mu S \cdot cm^{-1}$ at 25˚ C during *in situ* chemistry sampling). Record this on the electrofisher log, to the left of the value for the observed water temperature. Convert this into an estimated ambient conductivity value (µS·cm^{-}), by dividing the specific conductivity by the "denominator" (D) value in the column to the right of water temperature.

Testing

Test the operation of the electrofisher while situated well outside the sample site. Evaluate settings to ensure that the audio and light signals are emitting at a standard pace. Also check to see that fish are attracted to the anode with the least possible application of electrical intensity. When ambient conductivity is approximately 100 µS·cm^{-1} (about the same as fish flesh), little power is required to effectively fish. For lower conductivity water, higher voltage will be needed. For higher conductivity water, more current will be needed. Details on set-up and testing can be found in Smith-Root (2007).

If captured fish demonstrate signs of injury, lower the settings.

ELECTROFISHER LOG FOR LR-20

	LR-20 SN:			Site Depth (cm)	Stream:			
	AnodeE No.			Site Wet Width (m)	WAM06600-__ __ __ __ __ __			
	Cathode No.			Dom. substrate: ORGANIC ROCKY (circle one)	Date ___ ___ / ___ ___ / 2009			
TRIAL	FREQ (HZ)	Duty Cycle (%)	Voltage (V)	RESPONSE OF FISH	Specific Cond SC uS/cm at 25 C	Water Temp ? C	D	Ambient Cond SC ÷ D uS/cm
1						4	1.52	
2						5	1.49	
3						6	1.46	
4						7	1.43	
5						8	1.40	
6						9	1.37	
7						10	1.35	
8						11	1.32	
9						12	1.29	
10						13	1.27	
11						14	1.24	
12						15	1.22	
13						16	1.20	
14						17	1.17	
15						18	1.15	
16						19	1.13	
17						20	1.10	
18						21	1.08	
19						22	1.06	
20						23	1.04	
	15 Hz	10%	50 V	Start testing here (if no info. available)		24	1.02	
	35 Hz	20%	300 V	example for low conductivity water		25	1.00	
	30 Hz	15%	250 V	example for high conductivity water	notes			
	60 Hz	35%	600 V	Try to stay below these				

Figure Q-1. The backpack electrofisher log for tracking optimal settings.

Settings - Raft-mounted electrofisher

Also maintain a log for the raft-mounted electrofisher. Use a field notebook and record similar data: temperature, conductivity, instrument settings, and notes regarding fish responses. Also make notes regarding depth, clarity, and dominant substrate.

Start with the following GPP box settings (Figure Q-2):

- Emergency OFF switch in the "up" position
- Voltage Range = Low (50-500)
- Power = 60 %
- Mode = DC
- Pulses per second = 30

When you test your setting, examine the Output Current Meter. It should read between 2-4 amps. If there is less than 2 amps, start turning up the dials. First increase pulse rate to 60 pps. If that does not work, then incrementally increase *Power* settings to 80%, then 100%. If that does not work, then set *Power* back to 40% and increase voltage *Range* to High (500-1000). Work through the same progression with the *Range* on high until you display 2-4 amps. Beware excessive load on the generator at high settings.

Figure Q-2. Initial settings for a raft-mounted GPP box: low range: 60% power, 30-pps DC.

Test the operation of the electrofisher while situated well upstream from the top of the sample site (Transect K0). Evaluate settings to ensure that the unit is working properly. Also check to see that fish are attracted to the anode with the least possible application of electrical intensity. If fish demonstrate signs of injury, lower the settings.

Prior to sampling, reset the timer to zero and record clock time in the notebook.

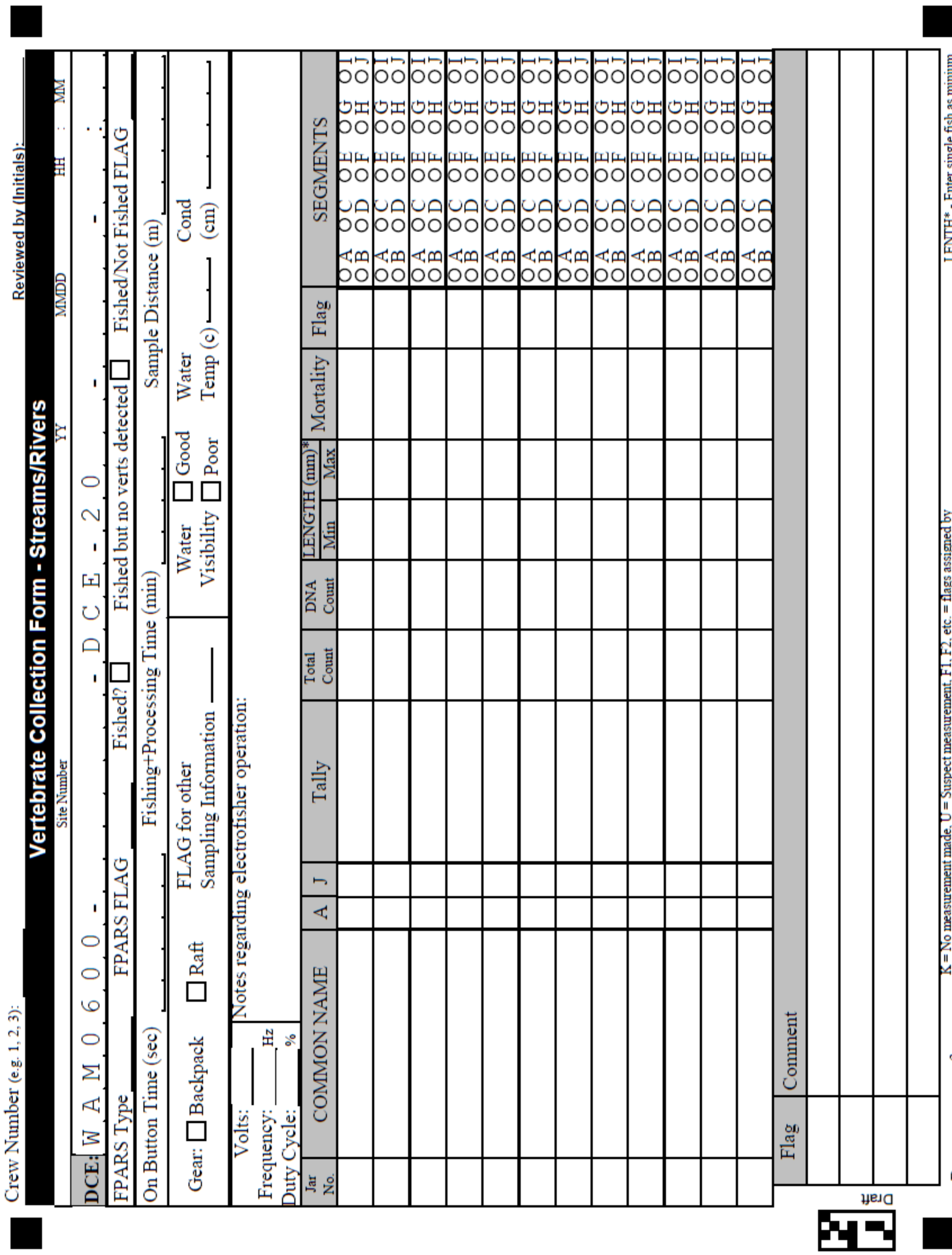
Vertebrate Assemblage Sampling

By Wading

The crew walks upstream sampling all wadeable habitats equally, spending no more than about 20 minutes in each segment (or 3.5 hours total). One person operates the electrofisher while another nets the vertebrates. A third person processes the fish and records data onto the *Vertebrate Collection Form* (Figure Q-3).

By Raft

The crew floats downstream, sampling all safely-accessible habitats. Fishing is most effective along the margins where fish are likely to be within the effects of the electrical field. Stay to the side of the stream where the next bank and riparian habitat measures will be collected. One person operates the raft. Another person nets, processes the vertebrates, and records data onto the *Vertebrate Collection Form* (Figure Q-3).



Crew Number (e.g. 1, 2, 3): ______ Reviewed by (Initials): ______

Vertebrate Collection Form - Streams/Rivers

DCE: W A M 0 6 0 0 - ______ - D C E - 2 0 __ - ____ - __ : __
(Site Number, YY, MMDD, HH : MM)

FPARS Type ______ FPARS FLAG ______ Fished? ☐ Fished but no verts detected ☐ Fished/Not Fished FLAG ______

On Button Time (sec) ______ Fishing+Processing Time (min) ______ Sample Distance (m) ______

Gear: ☐ Backpack ☐ Raft FLAG for other Sampling Information ______ Water Visibility ☐ Good ☐ Poor Water Temp (c) ______ Cond (cm) ______

Volts: ______ Frequency: ______ Hz Duty Cycle: ______ % Notes regarding electrofisher operation:

Jar No.	COMMON NAME	A	J	Tally	Total Count	DNA Count	LENGTH (mm)* Min	Max	Mortality	Flag	SEGMENTS
											○A ○C ○E ○G ○I ○B ○D ○F ○H ○J
											○A ○C ○E ○G ○I ○B ○D ○F ○H ○J
											○A ○C ○E ○G ○I ○B ○D ○F ○H ○J
											○A ○C ○E ○G ○I ○B ○D ○F ○H ○J
											○A ○C ○E ○G ○I ○B ○D ○F ○H ○J
											○A ○C ○E ○G ○I ○B ○D ○F ○H ○J
											○A ○C ○E ○G ○I ○B ○D ○F ○H ○J
											○A ○C ○E ○G ○I ○B ○D ○F ○H ○J
											○A ○C ○E ○G ○I ○B ○D ○F ○H ○J
											○A ○C ○E ○G ○I ○B ○D ○F ○H ○J
											○A ○C ○E ○G ○I ○B ○D ○F ○H ○J
											○A ○C ○E ○G ○I ○B ○D ○F ○H ○J

Flag	Comment

Page ______ of ______ K = No measurement made, U = Suspect measurement, F1, F2, etc. = flags assigned by each field crew LENTH* - Enter single fish as minium

Draft

Figure Q-3. The Vertebrate Collection Form (front).

Electrofisher Operation

Operate the electrofisher according to manufacturer's instructions (e.g. Smith-Root 2007a, 2007b). At the start of the site (transect A0 when wading; transect K0 when floating), reset the timer and record the time-of-day in a notebook. Tell all staff nearby that you are ready to begin electrofishing. Before you start, they should acknowledge that they know where the safety switch is located and that they are ready for you to begin. Check with staff to see if anyone would like to use ear plugs (for boat-mounted electrofisher) Then start.

Sampling is complete when wading to the top of a habitat unit that is nearest to transect K0 or when floating to transect A0.

Tell the data recorder the following information:

- *on-button* time (seconds) in the display
- clock time (minutes) elapsed during sampling
- distance (m) travelled over the length of the stream

Netting

If working in open sunlight, netting must be performed while wearing polarized sun glasses and a brimmed cap. The netter captures vertebrates that move toward the anode. They then place the animals into a bucket (live-well) of fresh stream water. Specimens can be protected from harm by carefully performing these duties:

- Net the fish away from the electrodes
- Do *not* net fish unless your net is empty
- Minimize animals' exposure to air and sunlight
- Pass specimens off for processing quickly
- Do not crowd the live-well
- Keep fresh water in the live well

Processing the Sample

Processing includes data recording. The person processing receives or nets the animals then completes the *Vertebrate Collection Form* (Figure Q-3). Representative photographs should be taken of each *species-life stage*. After processing, in most cases, live animals are released in quiet water at a location well away from samplers. A few select hard-to-identify fish specimens (e.g., lampreys, sculpins, or dace) may be retained for later identification in a laboratory or by a professional taxonomist.

Be sure to examine all animals for electrofishing-induced injuries. If you see them, tell the electrofisher operator to turn down the settings.

Header Information

Begin recording data by completing header information on the *Vertebrate Collection Form* (Figure Q-3). This includes temperature and conductivity data (from the electrofisher log) and your opinion on water visibility (clarity).

When sampling is done, record on-button time (seconds), *fishing + processing* time (minutes), and sample distance (m) along the thalweg.

Count and Presence

1) Identify specimens to species using taxonomic keys, e.g.
   a. Corkran and Thoms (1996)
   b. Jones *et al* (2005)
   c. Leonard *et al* (1993)
   d. Page and Burr (1991)
   e. Pollard *et al* (1997)
   f. Stebbins (2003)
   g. Wydoski and Whitney (2003).
2) Each new life stage (juvenile or adult) per species encountered is assigned a sequential Tag Number. For each tag number, record the designated **common name** (Tables Q-2 and Q-3). Check “J” for juvenile or “A” for adult. If species life stage cannot be easily discerned (e.g. for sculpins or dace) combine records for all individuals in that species; check “U” for undefined.
3) Record a tally mark for each new observation per *species-life stage*. Sum these to complete the “Total Count” column when sampling is complete.
4) Fill in the circle for each segment where a member of a *species-life stage* is observed.
5) Keep track of how many animals die during collection and processing. Record totals in the “Mortality” column of the form.
6) Count the number of animals in each species-life-stage that are retained for later taxonomic analysis. These totals are recorded in the “Voucher Count” column.
7) Make a note (using the flag and comments fields) of any abnormalities observed on animals. This includes deformities, lesions, tumors, fin erosion, or other notable features.

Table Q-2. Scientific name, common name, and taxonomic serial number (ITIS, 2009) for fishes that inhabit freshwaters of Washington.

FAMILY	SCIENTIFIC NAME	COMMON NAME	ITIS_SN
Acipenseridae	*Acipenser transmontanus*	WHITE STURGEON	161068
Acipenseridae	*Acipenser medirostris*	GREEN STURGEON	161067
Clupeidae	*Alosa sapidissima*	AMERICAN SHAD	161702
Catostomidae	*Catostomus catostomus*	LONGNOSE SUCKER	163894
Catostomidae	*Catostomus macrocheilus*	LARGESCALE SUCKER	163896
Catostomidae	*Catostomus platyrhynchus*	MOUNTAIN SUCKER	163909
Catostomidae	*Catostomus columbianus*	BRIDGELIP SUCKER	163897
Cobitidae	*Misgurnus anguillicaudatus*	ORIENTAL WEATHERFISH	163978
Cyprinidae	*Mylocheilus caurinus*	PEAMOUTH	163521

Cyprinidae	*Acrocheilus alutaceus*	CHISELMOUTH	163531
Cyprinidae	*Couesius plumbeus*	LAKE CHUB	163535
Cyprinidae	*Rhinichthys umatilla*	UMATILLA DACE	201910
Cyprinidae	*Rhinichthys cataractae*	LONGNOSE DACE	163384
Cyprinidae	*Ptychocheilus oregonensis*	NORTHERN PIKEMINNOW	163523
Cyprinidae	*Gila bicolor*	TUI CHUB	163544
Cyprinidae	*Carassius auratus*	GOLDFISH	163350
Cyprinidae	*Tinca tinca*	TENCH	163348
Cyprinidae	*Notemigonus crysoleucas*	GOLDEN SHINER	163368
Cyprinidae	*Rhinichthys falcatus*	SPECKLED DACE	163387
Cyprinidae	*Cyprinus carpio*	COMMON CARP	163344
Cyprinidae	*Rhinichthys falcatus*	LEOPARD DACE	163386
Cyprinidae	*Richardsonius balteatus*	REDSIDE SHINER	163528
Fundulidae	*Fundulus diaphanus*	BANDED KILLIFISH	165646
Poeciliidae	*Gambusia affinis*	WESTERN MOSQUITOFISH	165878
Esocidae	*Esox lucius x Esox masquinongy*	TIGER MUSKELLUNGE	none
Esocidae	*Esox americanus*	GRASS PICKEREL	162140
Umbridae	*Novumbra hubbsi*	OLYMPIC MUDMINNOW	162161
Gadidae	*Lota lota*	BURBOT	164725
Gasterosteidae	*Gasterosteus aculeatus*	THREESPINE STICKLEBACK	166365
Gasterosteidae	*Culaea inconstans*	BROOK STICKLEBACK	166399
Centrarchidae	*Lepomis cyanellus*	GREEN SUNFISH	168132
Centrarchidae	*Lepomis macrochirus*	BLUEGILL	168141
Centrarchidae	*Lepomis gibbosus*	PUMPKINSEED	168144
Centrarchidae	*Lepomis gulosus*	WARMOUTH	168138
Centrarchidae	*Micropterus dolomieu*	SMALLMOUTH BASS	550562
Centrarchidae	*Micropterus salmoides*	LARGEMOUTH BASS	168160
Centrarchidae	*Pomoxis nigromaculatus*	BLACK CRAPPIE	168167
Centrarchidae	*Ambloplites rupestris*	ROCK BASS	168097
Centrarchidae	*Pomoxis annularis*	WHITE CRAPPIE	168166
Embiotocidae	*Cymatogaster aggregata*	SHINER PERCH	169739
Moronidae	*Morone saxatilis*	STRIPED BASS	167680
Percidae	*Perca flavescens*	YELLOW PERCH	168469
Percidae	*Sander vitreus*	WALLEYE	168506
Percopsidae	*Percopsis transmontana*	SAND ROLLER	164410
Petromyzontidae	*Lampetra spp.*	LAMPREY[a]	159700
Petromyzontidae	*Lampetra richardsoni*	WESTERN BROOK LAMPREY	159707
Petromyzontidae	*Lampetra ayresii*	RIVER LAMPREY	622248
Petromyzontidae	*Lampetra tridentata*	PACIFIC LAMPREY	159713
Pleuronectidae	*Platichthys stellatus*	STARRY FLOUNDER	172893
Osmeridae	*Spirinchus thaleichthys*	LONGFIN SMELT	162049
Osmeridae	*Hypomesus pretiosus*	SURF SMELT	162030

Osmeridae	*Thaleichthys pacificus*	EULACHON	162051
Salmonidae	*Oncorhynchus mykiss*	RAINBOW TROUT OR STEELHEAD	161989
Salmonidae	*Salvelinus confluentus*	BULL TROUT	162004
Salmonidae	*Oncorhynchus kisutch*	COHO SALMON	161977
Salmonidae	*Oncorhynchus clarkii*	CUTTHROAT TROUT	161983
Salmonidae	*Prosopium williamsoni*	MOUNTAIN WHITEFISH	162009
Salmonidae	*Salvelinus namaycush*	LAKE TROUT	162002
Salmonidae	*Prosopium coulterii*	PYGMY WHITEFISH	162011
Salmonidae	*Thymallus arcticus*	ARCTIC GRAYLING	162016
Salmonidae	*Salvelinus malma*	DOLLY VARDEN	162000
Salmonidae	*Coregonus clupeaformis*	LAKE WHITEFISH	161941
Salmonidae	*Oncorhynchus nerka*	SOCKEYE SALMON	161979
Salmonidae	*Salmo trutta*	BROWN TROUT	161997
Salmonidae	*Oncorhynchus keta*	CHUM SALMON	161976
Salmonidae	*Oncorhynchus gorbuscha*	PINK SALMON	161975
Salmonidae	*Oncorhynchus tshawytscha*	CHINOOK SALMON	161980
Salmonidae	*Salvelinus fontinalis*	BROOK TROUT	162003
Salmonidae	*Oncorhynchus aguabonita*	GOLDEN TROUT	161987
Cottidae	*Cottus aleuticus*	COASTRANGE SCULPIN	167230
Cottidae	*Cottus gulosus*	RIFFLE SCULPIN	167234
Cottidae	*Cottus beldingii*	PAIUTE SCULPIN	167238
Cottidae	*Cottus cognatus*	SLIMY SCULPIN	167232
Cottidae	*Cottus asper*	PRICKLY SCULPIN	167233
Cottidae	*Cottus bairdii*	MOTTLED SCULPIN	167237
Cottidae	*Cottus confusus*	SHORTHEAD SCULPIN	167240
Cottidae	*Cottus perplexus*	RETICULATE SCULPIN	167248
Cottidae	*Leptocottus armatus*	PACIFIC STAGHORN SCULPIN	167302
Cottidae	*Cottus marginatus*	MARGINED SCULPIN	167247
Cottidae	*Cottus rhotheus*	TORRENT SCULPIN	167252
Ictaluridae	*Noturus gyrinus*	TADPOLE MADTOM	164003
Ictaluridae	*Ameiurus natalis*	YELLOW BULLHEAD	164041
Ictaluridae	*Ameiurus melas*	BLACK BULLHEAD	164039
Ictaluridae	*Pylodictis olivaris*	FLATHEAD CATFISH	164029
Ictaluridae	*Ictalurus punctatus*	CHANNEL CATFISH	163998
Ictaluridae	*Ameiurus nebulosus*	BROWN BULLHEAD	164043

[a]There is no field taxonomic key for lamprey larvae (ammocoetes) in Washington.

Table Q-3. Scientific name, common name, and taxonomic serial number (ITIS, 2009) for amphibians that inhabit Washington.

FAMILY	SCIENTIFIC NAME	COMMON NAME	ITIS_SN
Frogs and Toads			
Ascaphidae	*Ascaphus truei*	TAILED FROG	173546
Ascaphidae	*Ascaphus montanus*	ROCKY MOUNTAIN TAILED FROG	661593
Bufonidae	*Bufo woodhousii*	WOODHOUSE'S TOAD	173476
Bufonidae	*Bufo boreas*	WESTERN TOAD	173482
Hylidae	*Pseudacris regilla*	PACIFIC TREEFROG	207313
Pelobatidae	*Spea intermontana*	GREAT BASIN SPADEFOOT	206991
Ranidae	*Rana clamitans*	GREEN FROG	173438
Ranidae	*Rana catesbeiana*	AMERICAN BULLFROG	173441
Ranidae	*Rana aurora*	RED-LEGGED FROG	173446
Ranidae	*Rana cascadae*	CASCADES FROG	173450
Ranidae	*Rana luteiventris*	COLUMBIA SPOTTED FROG	550546
Ranidae	*Rana pipiens*	NORTHERN LEOPARD FROG	173443
Ranidae	*Rana pretiosa*	OREGON SPOTTED FROG	173458
Salamanders and Newts			
Ambystomatidae	*Ambystoma macrodactylum*	LONG-TOED SALAMANDER	173601
Ambystomatidae	*Ambystoma gracile*	NORTHWESTERN SALAMANDER	173597
Ambystomatidae	*Ambystoma mavortium*	WESTERN TIGER SALAMANDER	668193
Dicamptodontidae	*Dicamptodon tenebrosus*	PACIFIC GIANT SALAMANDER	550242
Dicamptodontidae	*Dicamptodon copei*	COPE'S GIANT SALAMANDER	173742
Dicamptodontidae	*Dicamptodon spp.*	GIANT SALAMANDER	173740
Plethodontidae	*Plethodon larselli*	LARCH MOUNTAIN SALAMANDER	173662
Plethodontidae	*Plethodon dunni*	DUNN'S SALAMANDER	173654
Plethodontidae	*Ensatina eschscholtzii*	ENSATINA	173732
Plethodontidae	*Plethodon vandykei*	VAN DYKE'S SALAMANDER	173671
Plethodontidae	*Plethodon vehiculum*	WESTERN RED-BACKED SALAMANDER	173672
Rhyacotritonidae	*Rhyacotriton olympicus*	OLYMPIC TORRENT SALAMANDER	173745
Rhyacotritonidae	*Rhyacotriton cascadae*	CASCADE TORRENT SALAMANDER	550250
Rhyacotritonidae	*Rhyacotriton kezeri*	COLUMBIA TORRENT SALAMANDER	550251
Salamandridae	*Taricha granulosa*	ROUGH-SKINNED NEWT	173620

Animal Lengths

Record the minimum and maximum length (mm) of each *species-life stage* for the DCE. Measure the total length for every *species-life stage*, except for adult frogs. These are measured from snout to vent. Do not measure all individuals, only those that are smaller or larger than those already observed.

Voucher specimens

Voucher specimens will be obtained for all species captured, to verify field identifications. In the large majority of cases the voucher will consist of photographs from representative specimens using guidelines of Stauffer *et al* (2001) and AREMP (2007). Record an audio tag to each photograph with a description of each specimen, location, and date. Try to capture the relevant features that distinguish species. For example, for suckers, not only capture a lateral view, but also try to capture a ventral image of the head and jaw.

In a few cases, hard-to-photograph specimens (e.g. small individuals) of fishes may be preserved in a labeled polyethylene jar. Fill each jar with ethanol by diluting a 95% stock solution (2:1) in water including the fish (Bean, 1882). After a day or two, replace this with a stronger ethanol solution (3:1of ethanol to water). This should preserve the fish for a few months for more close examination in the laboratory. Complete 2 tags (Figure Q-4) on Write-In-Rain paper. Insert one inside the jar; tape the other to the outside. Keep species separated.

Stream Name:	
Site ID: WAM06600- ___ ___ ___ ___ ___ ___	**Collected:** **Month___ ____/Day ___ ____ Year 20___ ___**
Lat (dd):	**Lon(dd):**
T-R-S:	**County:**
WRIA:	**Name of collector:**
Method of capture:	
Field estimated ID (common name):	
Field estimated ID (Genus species):	
Specimen sizes (mm) when live:	

Figure Q-4. Label (on Write-in-Rain paper) for voucher jars.

In even fewer cases, the crew will decide that DNA-based identification might be necessary. Whole specimens should be placed into a zip-sealed bag, labeled (Figure T-3), kept on ice, and delivered (frozen) to a local museum. Lamprey ammocoetes are examples of fish that should be represented in DNA analysis.

FPARS Type

For sites where field sampling is prohibited (no permits), analyze the FPARS Type and record the value on the *Vertebrate Collection Form* (Figure Q-3). Perform this activity any time during the index period (July1 to October 15). This activity is performed by examining the FPARS interactive map (WDNR, 2009) to determine which code best applies to the stream site. Acceptable choices are “F” (Fish bearing) or “N” (Not fish bearing).

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Appendix R

Field Forms for Wide Streams & Rivers

For Wide Streams and Rivers, there are 7 data forms that will be scanned using the Teleform system to enter data into the WHSR system. These are:

- *GPS Positions Form*
- *Site Verification Form*
- *Site Diagram*
- *Chemistry and Sampling Form*
- *Major Transect Form*
- *Thalweg Data Form*
- *Vertebrate Collection Form*

Except for the 2-sided *Vertebrate Collection Form*, these occur back-to back (Table R-1).

Table R-1. The juxtaposition of field forms and number of copies needed per data collection event (DCE).

Front Side	Back side	Copies per DCE
Site Verification Form	Site Diagram	1
Chemistry and Sampling Form	form from other protocol[1]	1
Major Transect Form	Thalweg Data Form	11
form from other protocol[1]	GPS Positions Form	1
Vertebrate Collection Form front	Vertebrate Collection Form back	1

[1] Merritt, GD. 2009. DRAFT. Status and Trends Monitoring for Watershed Health & Salmon Recovery: Field Data Collection Protocol for Wadeable Streams. http://www.ecy.wa.gov/programs/eap/stsmf/docs/01SnTWadeableManA-Vv3bhfl.pdf

See figures R-1 to R-8 for each of the forms that will be scanned into the WHSR Database using the Teleform system.

Status and Trends Program - Site Verification Form 2009

Reviewed by (Initials):

Site Number			
DCE: W A M 0 6 0 0 - ____	- D C E - 2 0 __ (YY)	- ____ (MMDD)	- __ : __ (HH : MM)
DCE Start Date __ / __ / 2 0 0 9		**DCE End Date** __ / __ / 2 0 0 9	

Water Name:

Waterbody Type: Saltwater/Brackish ☐ River/Stream ☐ Canal/Ditch ☐ Wetland ☐ Reservoir ☐ Lake ☐ Other ☐

Safe to Sample?:	Y N	If not sampled, why not?
Permission?:	Y N	
Sampled?:	Y N	
Wade or Raft?:	W R	

Crew	1 (Leader)	Crew Member 2	Crew Member 3	Crew Member 4
First Name / Last Name:				
Organization:				
Habitat:	☐	☐	☐	☐
Water:	☐	☐	☐	☐
Sediment:	☐	☐	☐	☐
Invertebrates:	☐	☐	☐	☐
Fishing:	☐	☐	☐	☐

Other People?

Montgomery & Buffington Reach Type	**Bankfull Width** Estimate near Index Station (Avg of 5) (m)	**Site Length** 20 x BFW but between 150-2000 (m)
	Downstream Thalweg Distance (X to A) (m.x)	**Upstream Thalweg Distance** (X to A) (m.x)

Colluvial ☐
Alluvial:Braided ☐
Alluvial:Regime ☐
Alluvial:Pool-Riffle ☐
Alluvial:Plane Bed ☐
Alluvial:Step Pool ☐
Alluvial:Cascade ☐
Bedrock ☐

General Notes

TO BE REVISED

Draft

Figure R-1. The Site Verification Form.

Is the site unsafe to access, or with barriers that prevent access (round trip) and sampling by wading within one day? Y N

Is the site unsafe to access, or with barriers that prevent access (round trip) and sampling by raft within one day? Y N

Why is it inaccessible?

SITE DIAGRAM

TO BE REVISED

Provide North Arrow

Draft

Figure R-2. The Site Diagram Form.

Reviewed by (Initials):________

Status and Trends - Chemistry and Sampling Form

DCE: W A M 0 6 0 0 - ______ - D C E - 2 0 __ - ____ - __ : __
(Site Number / YY / MMDD / HH : MM)

IN SITU WATER QUALITY CALIBRATION				
Operator ________		Unit # ______		Flag
T	Temp probe was checked vs NIST	Yes	No	
DO	Sensor Calibrated	Yes	No	
pH	Sensor Calibrated and Checked	Yes	No	
Cond	Sensor Calibrated and Checked	Yes	No	

Notes (in situ)

Sed:%Gravel ____ %Sand ____ %Fines ____

In Situ Chemistry

Time1 __:__ hrs — Start Location (e.g. F0) [|]
Temp1 __.__ deg C
pH1 __.__ pH Units
DO1 __.__ mg/L — %Sat1 ____.__
Cond ______.__ uS/cm @ 25C

Time2 __:__ hrs — End Location (e.g. K0) [|]
Temp2 __.__ deg C
pH2 __.__ pH Units
DO2 __.__ mg/L — %Sat2 ____.__
Cond ______.__ uS/cm @ 25C

TO BE REVISED

Sample	Primary Sample: No. of Jars	Duplicate Sample: No. of Jars (or ITIS for Fish Spp)	Destination	Tracking No. (if shipped)	Flag
TPN					
Tot P					
Cl					
Turb					
Sed PAH					
Sed Metals*					
Benthos					
Fish Spp1					
Fish Spp2					
Fish Spp3					

Water Sample Location (e.g. A5) [|]

Sample Notes (explain flags):

Draft

*Sediment Metals jar includes sample material to be analyzed for TOC

Note: Use standard Manchester Environmental Lab forms for tracking water and sediment samples.

Figure R-3. The Chemistry and Sampling Form.

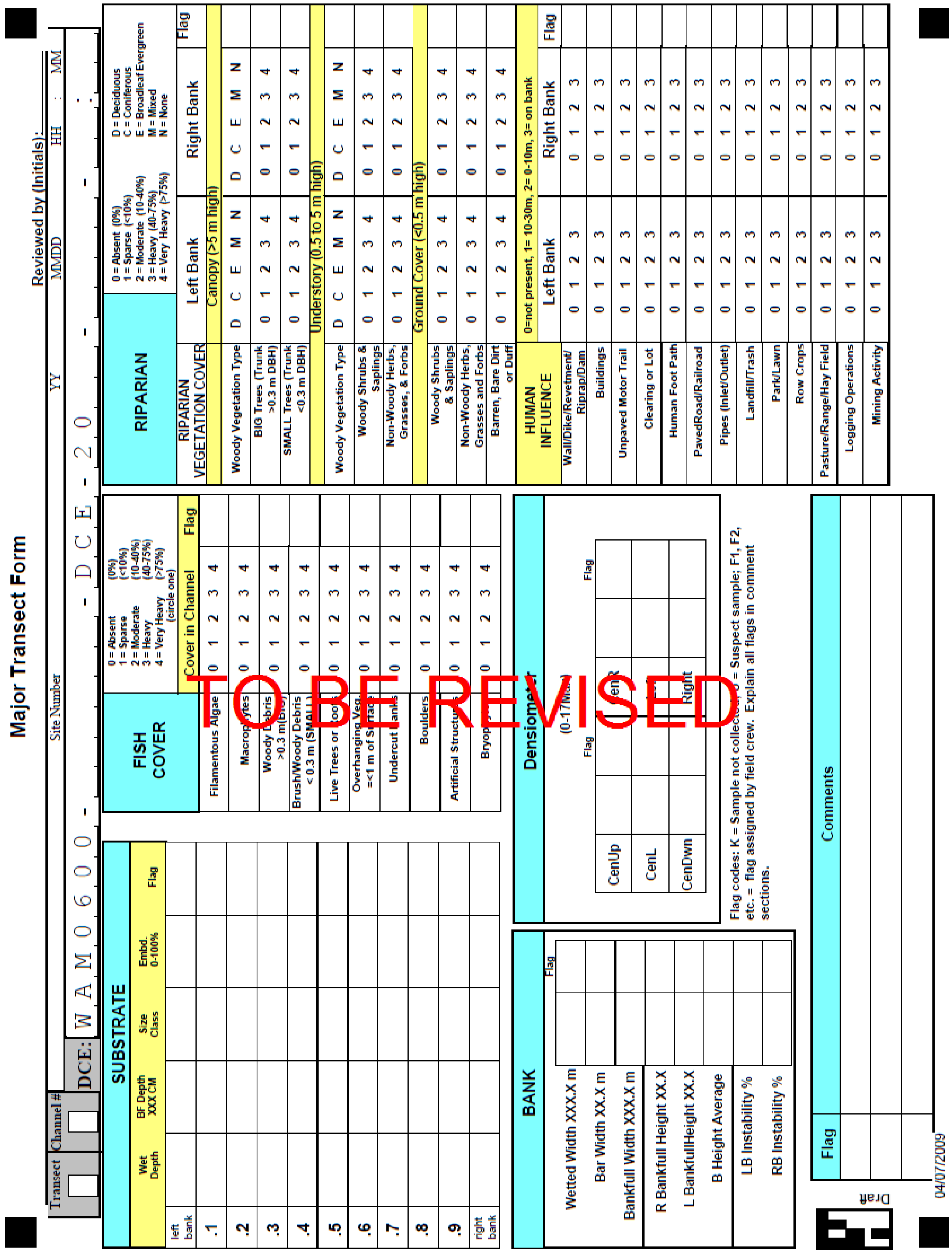


Figure R-4. The Major Transect Form.

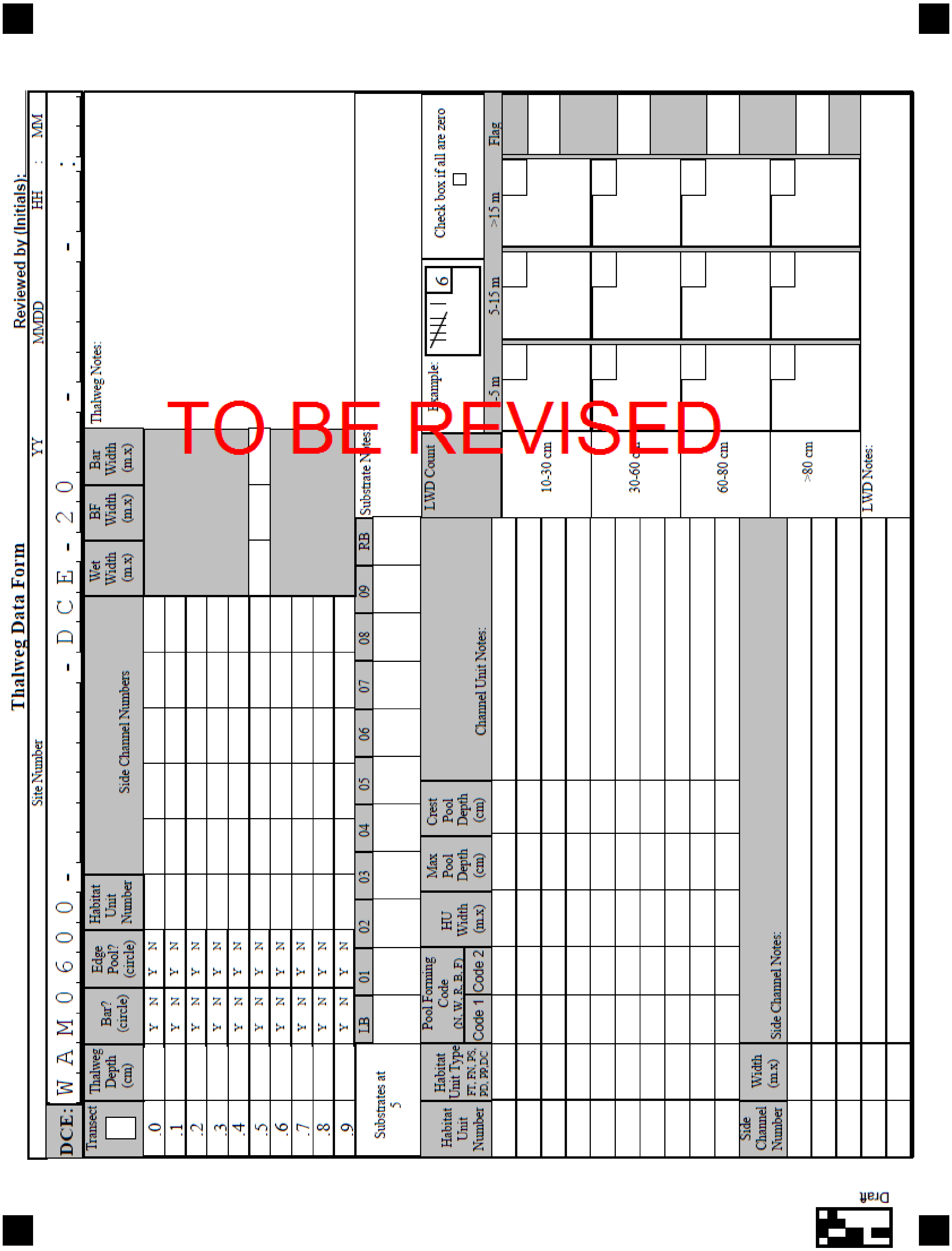
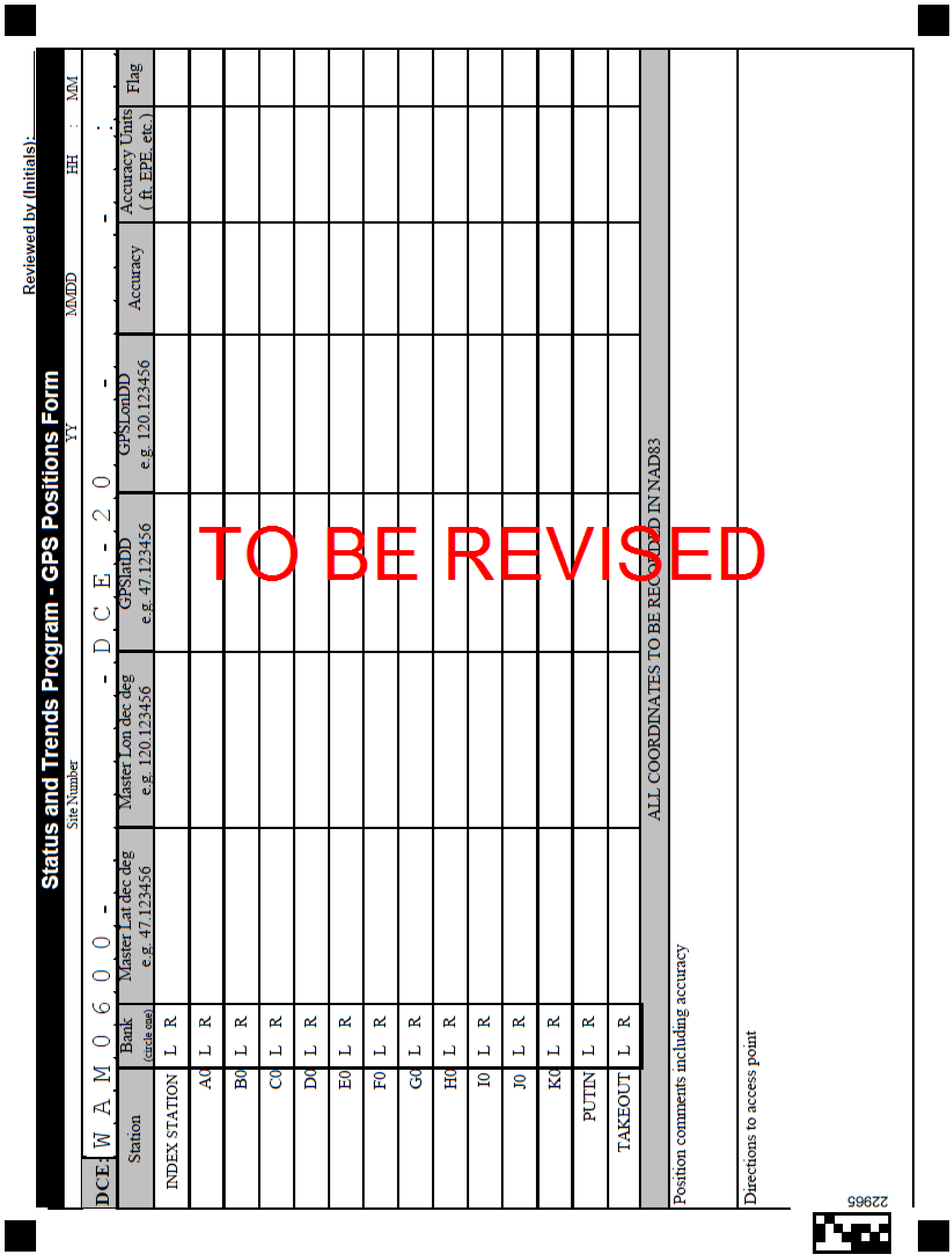


Figure R-5. The Thalweg Data Form



Reviewed by (Initials): ____

Status and Trends Program - GPS Positions Form

DCE: W A M 0 6 0 0 - [Site Number] - D C E - 2 0 [YY] - [MMDD] - [HH : MM]

Station	Bank (circle one)	Master Lat dec deg e.g. 47.123456	Master Lon dec deg e.g. 120.123456	GPSlatDD e.g. 47.123456	GPSLonDD e.g. 120.123456	Accuracy	Accuracy Units (ft, EPE, etc.)	Flag
INDEX STATION	L R							
A0	L R							
B0	L R							
C0	L R							
D0	L R							
E0	L R							
F0	L R							
G0	L R							
H0	L R							
I0	L R							
J0	L R							
K0	L R							
PUTIN	L R							
TAKEOUT	L R							

ALL COORDINATES TO BE RECORDED IN NAD83

Position comments including accuracy

Directions to access point

TO BE REVISED

22965

Figure R-6. The GPS Positions Form.

Reviewed by (Initials): ____

Vertebrate Collection Form - Streams/Rivers

DCE: W A M 0 6 0 0 - (Site Number) - D C E - 2 0 (YY) - (MMDD) - (HH : MM)

FPARS Type ____ FPARS FLAG ____ Fished: Y N Verts Detected: Y N Not Fished FLAG ____

On Button Time (sec) ____ Fishing+Processing Time (min) ____ Sample Distance (m) ____

Gear: ☐ Backpack ☐ Raft FLAG for other Sampling Information ____ Water Visibility ☐ Good ☐ Poor Water Temp (c) ____ Cond (cm) ____

Volts: ____
Frequency: ____ Hz
Duty Cycle: ____ %

Notes regarding electrofisher operation:

TO BE REVISED

Jar No.	COMMON NAME	A	J	Tally	Total Count	Voucher Count	LENGTH (mm)* Min	LENGTH (mm)* Max	Mortality	Flag	SEGMENTS
											○A ○B ○C ○D ○E ○F ○G ○H ○I ○J
											○A ○B ○C ○D ○E ○F ○G ○H ○I ○J
											○A ○B ○C ○D ○E ○F ○G ○H ○I ○J
											○A ○B ○C ○D ○E ○F ○G ○H ○I ○J
											○A ○B ○C ○D ○E ○F ○G ○H ○I ○J
											○A ○B ○C ○D ○E ○F ○G ○H ○I ○J
											○A ○B ○C ○D ○E ○F ○G ○H ○I ○J
											○A ○B ○C ○D ○E ○F ○G ○H ○I ○J
											○A ○B ○C ○D ○E ○F ○G ○H ○I ○J
											○A ○B ○C ○D ○E ○F ○G ○H ○I ○J
											○A ○B ○C ○D ○E ○F ○G ○H ○I ○J
											○A ○B ○C ○D ○E ○F ○G ○H ○I ○J

Flag	Comment

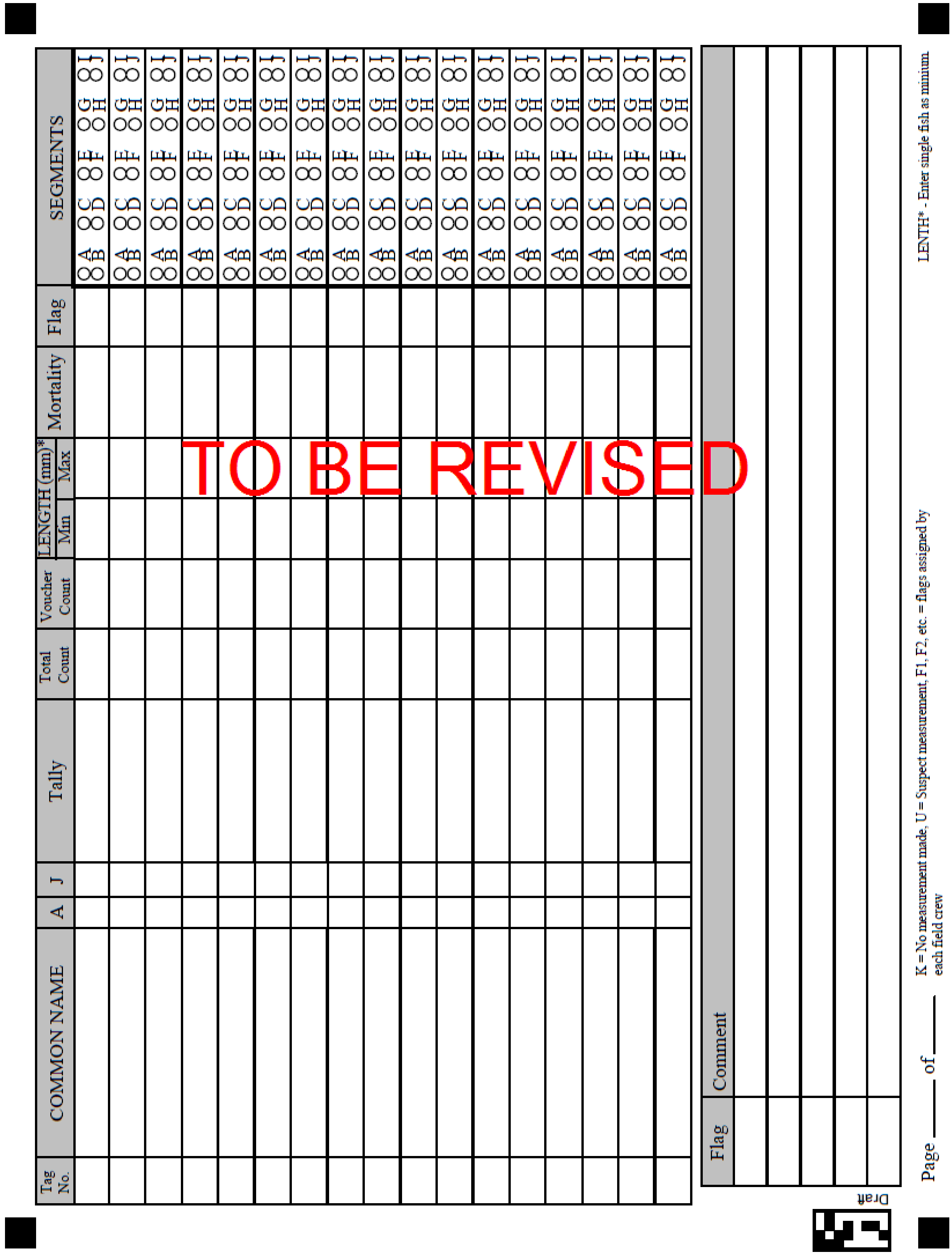
Draft

Page ____ of ____

K = No measurement made, U = Suspect measurement, F1, F2, etc. = flags assigned by each field crew

LENTH* - Enter single fish as minium

Figure R-7. The Vertebrate Collection Form (front).



Tag No.	COMMON NAME	A	J	Tally	Total Count	Voucher Count	LENGTH (mm)* Min	Max	Mortality	Flag	SEGMENTS
											○A ○B ○C ○D ○E ○F ○G ○H ○I ○J
											○A ○B ○C ○D ○E ○F ○G ○H ○I ○J
											○A ○B ○C ○D ○E ○F ○G ○H ○I ○J
											○A ○B ○C ○D ○E ○F ○G ○H ○I ○J
											○A ○B ○C ○D ○E ○F ○G ○H ○I ○J
											○A ○B ○C ○D ○E ○F ○G ○H ○I ○J
											○A ○B ○C ○D ○E ○F ○G ○H ○I ○J
											○A ○B ○C ○D ○E ○F ○G ○H ○I ○J
											○A ○B ○C ○D ○E ○F ○G ○H ○I ○J
											○A ○B ○C ○D ○E ○F ○G ○H ○I ○J
											○A ○B ○C ○D ○E ○F ○G ○H ○I ○J
											○A ○B ○C ○D ○E ○F ○G ○H ○I ○J
											○A ○B ○C ○D ○E ○F ○G ○H ○I ○J
											○A ○B ○C ○D ○E ○F ○G ○H ○I ○J
											○A ○B ○C ○D ○E ○F ○G ○H ○I ○J
											○A ○B ○C ○D ○E ○F ○G ○H ○I ○J
											○A ○B ○C ○D ○E ○F ○G ○H ○I ○J

TO BE REVISED

Flag	Comment

Draft

Page ______ of ______

K = No measurement made, U = Suspect measurement, F1, F2, etc. = flags assigned by each field crew

LENTH* - Enter single fish as minium.

Figure R-8. The Vertebrate Collection Form (back).