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A User Guide for Performing Stream Habitat Surveys in Southeast Alaska

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February 2013

Alaska Department of Fish and Game **Divisions of Sport Fish and Commercial Fisheries**

Symbols and Abbreviations

The following symbols and abbreviations, and others approved for the Système International d'Unités (SI), are used without definition in the following reports by the Divisions of Sport Fish and of Commercial Fisheries: Fishery Manuscripts, Fishery Data Series Reports, Fishery Management Reports, and Special Publications. All others, including deviations from definitions listed below, are noted in the text at first mention, as well as in the titles or footnotes of tables, and in figure or figure captions.

Weights and measures (metric)

centimeter	cm
deciliter	dL
gram	g
hectare	ha
kilogram	kg
kilometer	km
liter	L
meter	m
milliliter	mL
millimeter	mm

Weights and measures (English)

cubic feet per second	ft^3/s
foot	ft
gallon	gal
inch	in
mile	mi
nautical mile	nmi
ounce	oz
pound	lb
quart	qt
yard	yd

Time and temperature

day	d
degrees Celsius	°C
degrees Fahrenheit	°F
degrees kelvin	K
hour	h
minute	min
second	s

Physics and chemistry

all atomic symbols	
alternating current	AC
ampere	A
calorie	cal
direct current	DC
hertz	Hz
horsepower	hp
hydrogen ion activity (negative log of)	pH
parts per million	ppm
parts per thousand	ppt, ‰
volts	V
watts	W

General

Alaska Administrative Code	AAC
all commonly accepted abbreviations	e.g., Mr., Mrs., AM, PM, etc.
all commonly accepted professional titles	e.g., Dr., Ph.D., R.N., etc.
at	@
compass directions:	
east	E
north	N
south	S
west	W
copyright	©
corporate suffixes:	
Company	Co.
Corporation	Corp.
Incorporated	Inc.
Limited	Ltd.
District of Columbia	D.C.
et alii (and others)	et al.
et cetera (and so forth)	etc.
exempli gratia (for example)	e.g.
Federal Information Code	FIC
id est (that is)	i.e.
latitude or longitude	lat. or long.
monetary symbols (U.S.)	$, ¢
months (tables and figures): first three letters	Jan,...,Dec
registered trademark	®
trademark	™
United States (adjective)	U.S.
United States of America (noun)	USA
U.S.C.	United States Code
U.S. state	use two-letter abbreviations (e.g., AK, WA)

Mathematics, statistics

all standard mathematical signs, symbols and abbreviations	
alternate hypothesis	H_A
base of natural logarithm	*e*
catch per unit effort	CPUE
coefficient of variation	CV
common test statistics	(F, t, χ^2, etc.)
confidence interval	CI
correlation coefficient (multiple)	R
correlation coefficient (simple)	r
covariance	cov
degree (angular)	°
degrees of freedom	df
expected value	*E*
greater than	>
greater than or equal to	≥
harvest per unit effort	HPUE
less than	<
less than or equal to	≤
logarithm (natural)	ln
logarithm (base 10)	log
logarithm (specify base)	$log_{2,}$ etc.
minute (angular)	'
not significant	NS
null hypothesis	H_O
percent	%
probability	P
probability of a type I error (rejection of the null hypothesis when true)	α
probability of a type II error (acceptance of the null hypothesis when false)	β
second (angular)	"
standard deviation	SD
standard error	SE
variance	
population	Var
sample	var

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ABSTRACT

Management of freshwater aquatic ecosystems requires an understanding of interactions among biotic and abiotic components on the landscape. Quantitative information on individual habitat metrics and the cumulative habitat associated with freshwaters allows comparisons across spatial and temporal scales. The stream habitat survey methods described in this manual will assist in the collection of spatially-explicit data associated with meaningful biological and hydrological attributes that are common in Southeast Alaska. The reach-based protocol outlined in this manual provides a means for documenting existing channel and riparian conditions at the individual reach scale, juxtaposed with fish species and life stage distribution across the watershed being surveyed. Providing a spatial context to all physical and biological data components will enhance the ability of managers to conduct more meaningful landscape-level resource assessments, as well as their ability to quantitatively track and manage change over time.

Key words: channel type, GIS, GPS, Southeast Alaska, stream habitat survey protocol, stream reach.

INTRODUCTION

This document is intended to provide guidance to entities conducting stream habitat surveys in watersheds across Southeast Alaska (SEAK). The stream habitat survey outlined in this document was designed to provide quantitative information on habitat for fluvial waters in SEAK. This information is commonly used by biologists and land managers for basic aquatic inventory and assessment, to establish monitoring programs, and to inform or prioritize habitat restoration efforts. Specific guidelines are presented for each procedure used by survey staff, including: pre-trip planning; onsite data collection; and post-trip data processing for all information generated from the survey. All codes used for data recording and subsequent data entry are defined in this document. Adhering to the survey methodology described in this manual will allow field observers to conduct work with minimal differences in procedures, yielding more consistent and repeatable results. In addition, we have provided excerpts from the United States Department of Agriculture–Forest Service (USFS) Tier II stream survey protocol (USDA 2001) (Appendix A1), which was designed to address many of the parameters our stream habitat surveys encompass, and focuses on the Tongass National Forest channel type user guide (Paustian 1992) described below.

Watersheds are part of a landscape hierarchy: at the finest scale are individual features (e.g., fish, pieces of wood, stream barriers, culverts, etc.) that are found within channel units (e.g., pools and riffles), and individual channel units fall within reaches, which in turn comprise valley segments, all of which ultimately comprise an individual watershed (Figure 1). Stream reaches consist of multiple individual channel units, but have relatively uniform physical characteristics (e.g., gradient, substrate, incision depth, etc). Valley segments help to define longer sections of large river systems (not typical in SEAK), and ultimately, watersheds.

The underlying unit of scale used for the survey methods described in this manual is the reach level: it is the scale at which physical habitat parameter statistics are aggregated and reported (e.g., counts of pools and large wood). Identification of distinct reaches in SEAK is synonymous with the stream classification system used to describe geomorphically distinct stream segments in the context of the watershed, better known as the Tongass channel type classification system. This classification scheme is based on geomorphic process groups, which describe the interrelationship between watershed runoff, landform relief, geology, and glacial or tidal influences on fluvial erosion and deposition processes (Paustian 1992; USDA 2001). Individual reaches within each of the valley segments are defined by physical attributes, including channel gradient, channel pattern, stream bank incision, side slope angle, and riparian vegetation composition.

The reach-based stream survey protocol outlined in this manual provides a means of documenting the current channel and riparian condition at the individual reach scale, as well as the distribution of fish species across the watershed being surveyed. Attributing geographic spatial information (i.e., latitude-longitude coordinates collected with Global Positioning System [GPS]) to physical and biological data allows full integration with a Geographic Information System (GIS). Providing a spatial context to all data components will enhance the ability to conduct more meaningful landscape level resource assessments, including those associated with freshwater habitats.

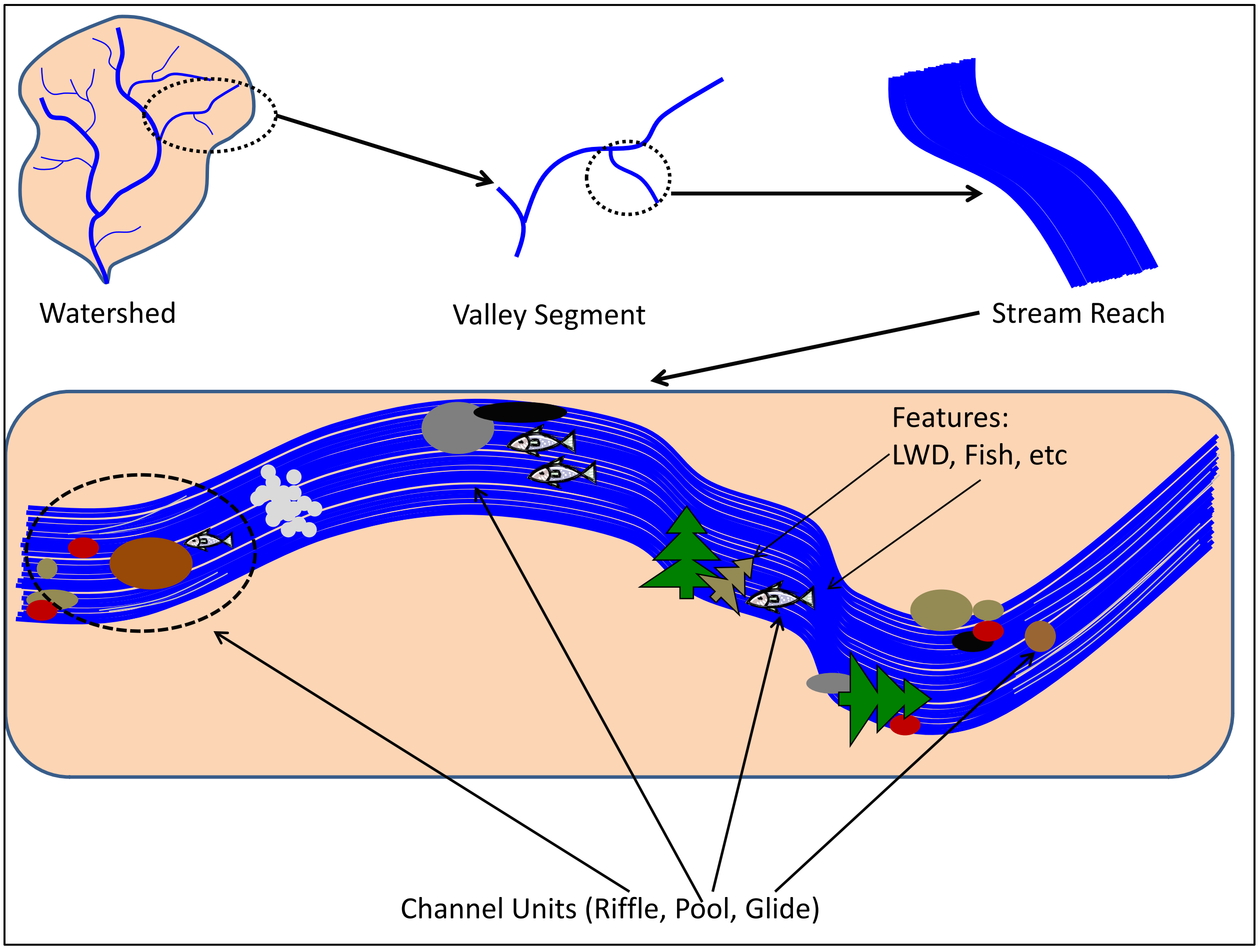

Figure 1.–Illustration of landscape hierarchy with a focus on freshwater habitats.

PRE-TRIP PLANNING

PRE-TRIP SUMMARY

There are a variety of reasons to conduct fish habitat surveys using this protocol, but in all instances, proper planning is critical for successful efforts. Pre-trip planning includes identifying specific goals and objectives of the study, which in turn will dictate parameters that need to be considered prior to conducting the work. Selecting appropriate survey dates will be crucial for some projects. For example, surveys intended to identify important spawning areas for coho salmon will need to occur at a time when they return to the spawning grounds. On the other hand, if the goal of the project is to document the baseline habitat condition in a particular subbasin to adequately apply best management practices prior to timber harvest, then survey timing may not need to correspond with seasonal patterns of fish use or distribution.

The next step would be to obtain as much existing information as possible about the survey area, prior to conducting surveys. One valuable source of spatial ecological data for SEAK is the Southeast Alaska GIS Library (Southeast Alaska GIS Library 2010; http://seakgis.alaska.edu/), which is a cooperative, interagency data sharing project that houses geospatial data for SEAK. Spatial data that is available through the GIS Library can be acquired and used to generate reconnaissance level maps prior to conducting field surveys. These maps could include a multitude of features across the watershed, including the identification and delineation of streams, lakes, fish barriers, roads, and topographic contours. Additionally, each of these GIS layers includes attribute data that further describe the features of interest (e.g., stream coverages include channel types and stream lengths). This gives users a means of accurately finding specific target locations within a project area as well as aiding in logistical considerations. For example, if an area is scheduled for timber harvest and road building, it would be helpful to obtain the proposed unit boundaries and road locations, as well as all hydrologic delineations, prior to conducting the survey, to ensure that streams in those areas are fully evaluated during the survey.

After existing information for the survey area has been compiled, a pre-trip summary (Appendix B1) should be completed. Field crew leaders should clearly identify the specific objectives of the intended work, logistical concerns and arrangements, crew members assigned, trip duration and work tasks, as well as specific locations needing special attention during the survey. These summaries are useful to the field staff responsible for conducting the survey by informing them about project objectives and tasks, as well as providing additional information about the study area that would be important to know before departing (e.g., land access/ownership, additional gear needs, etc.).

Another component of the pre-trip summary that should be addressed by the project manager or crew leader is to assign a unique five-character alpha-numeric project code (e.g., TAK12) to the specific effort. This project code will be required for survey data to be imported or entered into the Alaska Department of Fish & Game, Sport Fish (ADFG-SF) *Odyssey* database after the survey is complete. This coding may not be necessary for data processing by non-ADFG-SF entities, unless they wish to contribute and populate the Odyssey database. The code is made up of three letters representing the project area (e.g., TAK to represent the Taku), followed by two numbers, with the first representing the chronologically numbered visit to particular site (e.g., 1 for trip #1), and the second being a number representing the year of the trip (e.g., 2 for 2012). This code is important for internal ADFG-SF data management, and is combined with the GPS receiver ID and associated waypoint data to form a unique ID in the database, which will be important for developing table relationships in the database.

Prior to conducting field work, it is important for crew leaders to make sure that the GPS units are ready for use and that all crew members know how to operate them. Without the proper use of GPS units, the spatial component of the survey data can be lost, or unusable. Appendices C1 and C2 provide additional information regarding initial GPS setup and initialization, as well as the proper capture of waypoint data attained from consumer-grade GPS units.

GEAR LIST

The following equipment list is the minimum required for stream habitat surveys, and should be organized and taken on all field trips. For these surveys, a field crew should consist of at least one two-person team; many surveys involve more than one team. A full set of gear should be available for each team, and if budgets allow, for each team member.

- Minnow traps (1/8” mesh Gee style), dip-net (3–10”), and clear plastic tub or equivalent to be used for fish species that need identification or closer inspection
- Bait (preferably salmon eggs that have been treated with Betadine[1] solution and cured in Borax)
- Thermometer (Celsius)
- Abney hand level (preferably with 10 minute veneer scale) or clinometers
- 30 m or longer fiberglass tape measure
- Handheld GPS and remote antenna (12 channel; assign unique single letter or number to each unit if multiple GPS units are in use by more than one survey team)
- Digital camera (with sufficient flash memory; assign unique single letter or number to each if multiple cameras are in use by more than one survey team)
- Extra batteries for camera, GPS, rangefinder, radios, etc.
- Datasheets (printed on water proof paper), pencils, erasers
- GIS map and aerial photos (printed on water proof paper) of area to be surveyed that includes delineation of all relevant landscape features (e.g., hydrology, roads, topography, landownership, timber harvest)
- GIS topographic map (1:63k; 1:250k) for area to be surveyed and adjacent lands to aid in logistical planning
- Field vests
- USFS channel type verification field cards
- Waders and wading boots
- Field notebooks (Rite in the Rain No. 311)
- Ziploc bags for protection of electronic or digital devices
- Two tally whackers per crew member (for counting macro-pools and large wood/key wood)
- Laser rangefinder (for determining length of side channels, bankfull width, etc.)
- Dowel stick or polyvinyl chloride (PVC) pipe with centimeter and meter tick marks (for measuring pool depths and large wood diameters)
- Vegetation class codes list (identification key to riparian vegetation communities)
- Riparian disturbance class codes list (dichotomous key for identification of riparian disturbances)
- Satellite phone
- VHF handheld radio
- Laptop computer (stored in a waterproof case and left at field camp) to be used for end-of-day GIS inspection, evaluation of current day’s spatial data capture, and safe and immediate backup of electronic data files

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[1] Product names used in this report are included for scientific completeness, but do not constitute product endorsement.

POST-TRIP DATA PROCESSING

Upon return from a survey, field crew leaders or observers should complete a trip summary (Appendix B2), which provides a brief narrative summarizing objectives, anadromous habitat, areas of special concern, results from field efforts, and any other notable information pertaining to the survey. All data collected on digital devices, including waypoint files from GPS receivers and digital photograph files from cameras, will be uploaded into the respective modules of the ADF&G-SF's *Odyssey* database. All attribute data recorded on the data forms will be entered into the respective modules of the database. After all data has been entered into the database, it should be incorporated into a GIS and compared to current Anadromous Waters Catalog (AWC) to determine if any AWC nominations can be submitted as a result of the surveys.

STREAM SURVEY OVERVIEW

INTRODUCTION

This stream habitat survey is a reach-based characterization and assessment survey that is spatially enabled through the collection of GPS waypoints. While in the field, the capture of spatially explicit data points is an integral part of the survey. Attributing the spatial information (i.e., latitude and longitude coordinates) to physical and biological data provides users with a spatial context for understanding the influence and importance of various ecological parameters at a location through a GIS. Waypoints are collected by a field crew as physical and biological features are encountered within the context of that reach. Stream surveys can be conducted in an upstream or downstream direction as dictated by logistical factors or efficiency. Essentially, every fish or habitat-related feature encountered by the crew is associated with a waypoint. Individual waypoints may be associated with a single feature or with multiple features encountered at the same location. Additional data may be collected at each feature encountered to further define and describe the feature of interest. Figure 2 is a simple schematic of the relationship between waypoints and features encountered while performing a stream survey.

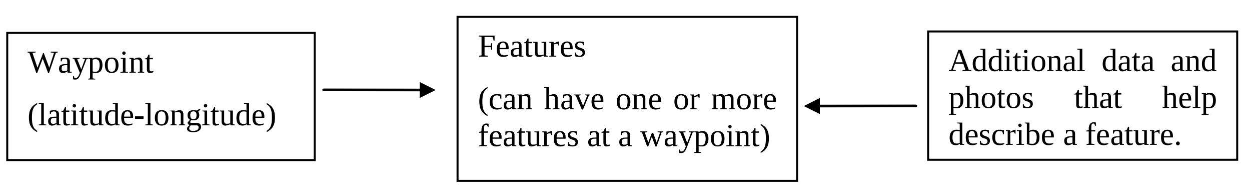


Figure 2.–Simplified schematic identifying the relationship between waypoints, features, and additional data collected during a stream habitat survey.

Field survey data can be of two types: 1) physical, in that the feature encountered physically exists on the ground (e.g., a waterfall); or 2) descriptive, meaning a location where no feature physically exists, but the information collected further defines or quantifies a physical feature and may assist with a variety of post-processing or updates to hydrography delineation that occur following a field trip. Other examples of physical features include stream crossing structures (e.g., bridges and culverts), a stream confluence, or a barrier to upstream fish movement (e.g., waterfalls). Examples of descriptive features include waypoints taken at the start and end points of a stream survey, places where fish are observed, and waypoints captured at regular intervals to help map the course of the stream. A GPS waypoint is captured and associated with each data recording, regardless of data type. A complete list and description of features to be used during a stream survey is included later in this document.

Some of the data collected in the field pertain to specific locations or features on the stream being surveyed, while other data are associated with a single continuous stream reach. Reach-based information can be further distinguished by data associated with mainstem channels or side channels off of the mainstem channel. Recording data separately for mainstem channels and side channels provides a means to characterize off-channel habitat individually or apart from mainstem habitat. The data from mainstem and side channel surveys can also be merged to form a comprehensive and cumulative characterization and quantification of the single continuous stream reach. Waypoints at the upstream and downstream ends of reaches are collected to define the linear extent of the main channel reach and are referred to as reach breaks (BRK), whereas the tops and bottoms of side channels generally coincide with stream divergence (DIV) or confluence (CON) points, each of which are described later in this manual. An additional waypoint is collected at a representative location within the reach (or side channel), generally near the middle, where specific data related to the reach (or side channel) are collected; these locations are referred to as channel type verification points (CTV) for main channel reaches, and side channel attribute points (SAP) for side channels. Figure 3 provides an overview of the collection of this information.

In summary, the stream survey consists of four primary activities:

1) Mapping the stream course – a stream mapping waypoint (MAP) is collected at least every 20 m (or less, depending on sinuosity) as field crews follow the stream course. Note that this is done concurrently (or in addition) with the following three activities.
2) Mapping habitat features encountered along the stream – a waypoint is taken at features important in characterizing existing stream habitat. Additional information in the form of measurements, photographs, etc., may also be collected to further describe the feature of interest.
3) Collecting information to describe stream reaches and side channel extents – geomorphic reach breaks (where the physical characteristics of the stream change significantly or transition into different channel types) located on the mainstem channel are identified by collecting a waypoint and additional information at the downstream and upstream ends of each reach. Additional information collected to describe individual stream reaches is described in detail in the "Channel Type Verification Points (CTV)" section below. Similarly, the upstream and downstream ends of side channels are identified and described in a similar way as for mainstem channel reaches (explained in detail in the "Side Channel Attribute Points (SAP)" section below).
4) Collecting other data, including fish observations and stream discharge – fish observations via a variety of methods (minnow trapping, foot surveys, snorkel surveys, etc) as well as stream discharge information can also be collected depending on the objectives of the survey. These activities can be concurrent with the habitat survey or performed separately.

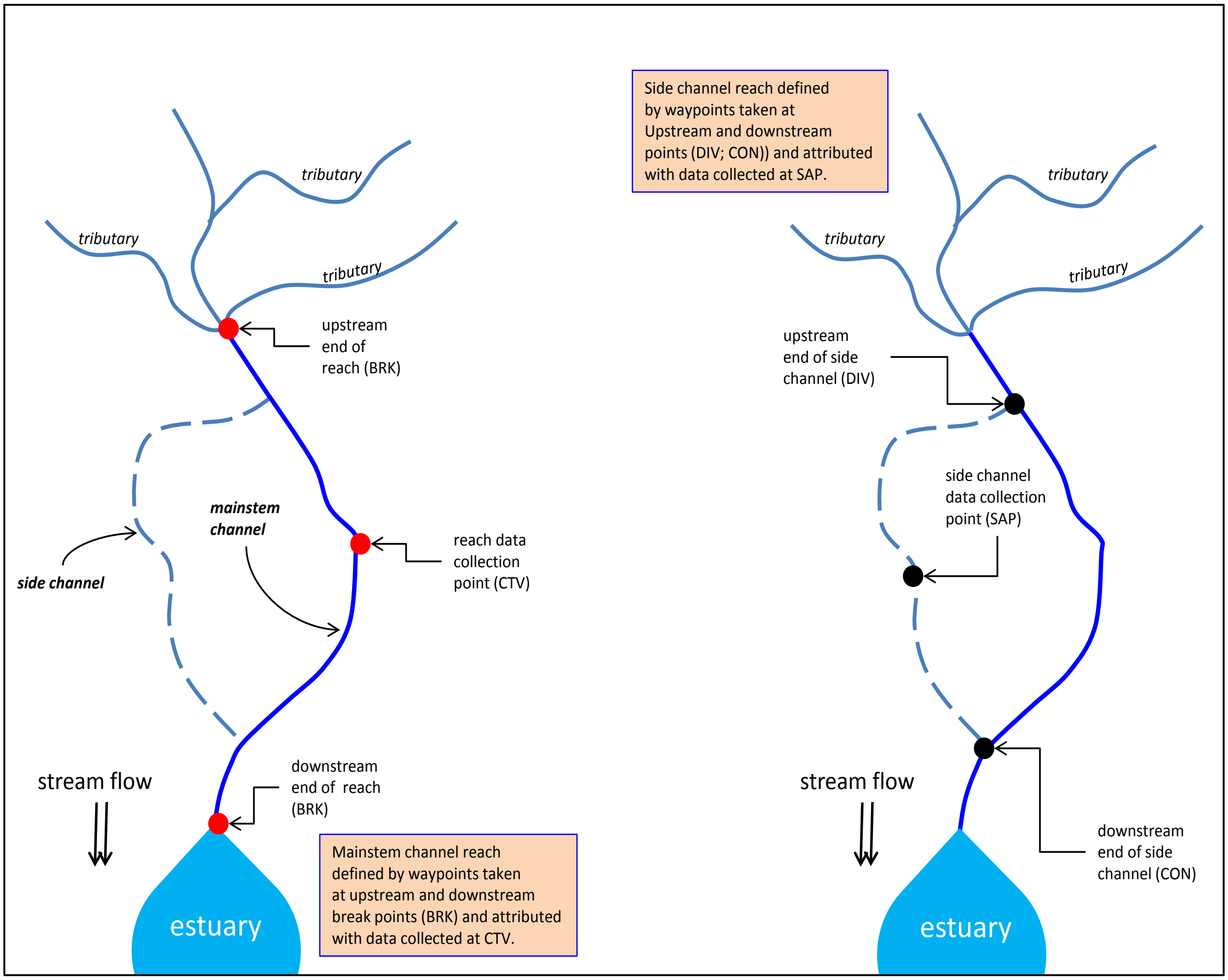


Figure 3.–The relationship between waypoints collected during a stream habitat survey and defined reaches along a stream channel.

DATASHEET OVERVIEW

The stream survey datasheet is the master datasheet (Appendix D1). All features encountered in the field are initially recorded on this datasheet, along with the associated waypoint(s) and GPS accuracy (m). For many features, this is the only datasheet needed to record any associated information. Currently, there are 53 different feature codes (Appendix E1) used to characterize points of interest encountered during a stream survey, which will be defined later. Some features require more explicit data collection to fully describe (or measure) the feature (e.g., dimensions of a culvert). These ancillary data are recorded on a separate datasheet, but referenced via the original waypoint number collected and recorded on the master stream survey datasheet. Each of the datasheets that capture related, but more explicit, information on features originally referenced on the stream survey datasheet are listed below and are further described in related sections and in Appendices D1 through D7.

Additional datasheets used in stream surveys include:

1) Reach datasheet (Appendix D2)
2) Side channel datasheet (Appendix D3)
3) Fish observation datasheet (Appendix D4)
4) Culvert datasheet (Appendix D5)
5) Sketch map datasheet (Appendix D6)

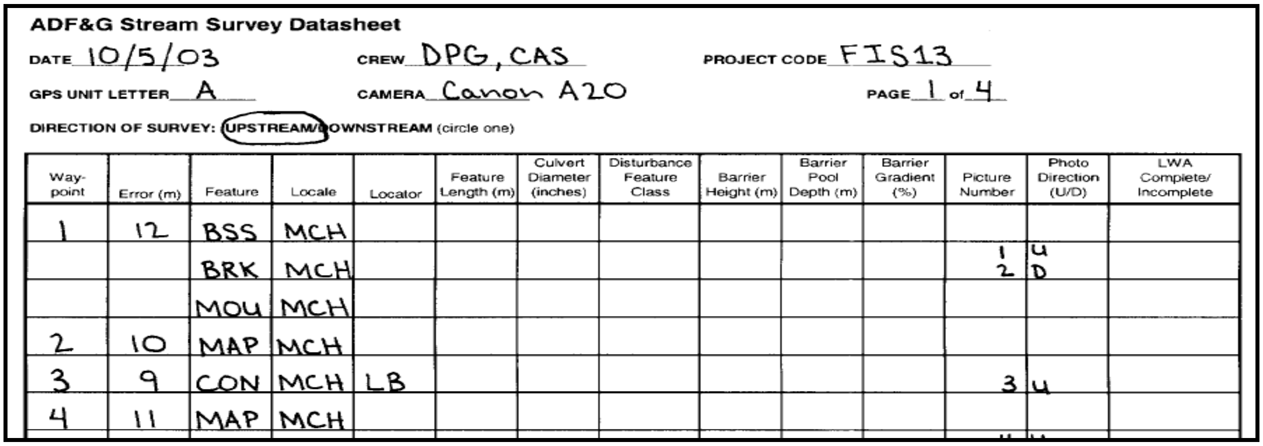
WHERE TO BEGIN

A convenient place to start systematically surveying a watershed or subbasin is at the mouth of the stream (i.e., salt water) or at the downstream confluence with a lake or larger stream. From there, a field crew can work upstream and complete a survey of the mainstem before moving to tributaries and side channels. Alternatively, if more than one crew is conducting the stream survey, one crew of two can survey the mainstem while another crew can proceed with surveying the side channels and tributaries as they are encountered. Alternatively, surveys can be performed in a downstream orientation starting on the mainstem or on tributary streams. Surveys conducted in a downstream direction should be started at a geomorphic reach break. Regardless of which direction the survey is conducted, the direction of travel should be noted by circling upstream or downstream at the top of the stream survey datasheet (see Figure 4). The requirement to have spatial data captured at all locations of interest allows surveys to occur in any direction or from any starting point (BSS). Regardless of whether surveys are conducted in an upstream or downstream orientation, or whether they are begun at confluences or waterbody mouths (MOU), the general theory is to fully map a stream course or reach throughout its extent. It should be understood that sampling strategies can vary depending on watershed size, complexity, and logistical constraints.

BEGINNING A STREAM SURVEY

Appendices C1 and C2 provide guidelines on the setup, initialization, and use of GPS units, information that is critical to the collection of spatial data obtained from these devices. If using more than one GPS unit or camera during a particular trip, it is important to assign a unique letter to each. Use an engraver if possible, and permanently etch the GPS units and cameras on the body with a unique alpha character (A–Z). GPS units and cameras may have the same alpha character (e.g., “A” for the camera and “A” for the GPS). Upon download after a survey, the waypoints and photos that are downloaded from each device will be saved with file names that include the unique identification (ID) for the device. This unique ID (and files associated with it) will ensure that the database connects to files saved from the appropriate GPS and camera used during the survey. The creation of this unique ID in the database is not completed by the observers, but rather behind the scenes in a series of programmatic “post-processing” steps; therefore, those doing data entry do not have to worry about forming or entering the unique ID for each “station” in the database.

Begin the stream survey by turning on the GPS unit and filling out the header information on the stream survey datasheet (Appendix D1) while the GPS unit searches for satellites. Once the GPS unit is ready, collect a waypoint at the starting location for the survey. Record the waypoint number and corresponding GPS accuracy on the stream survey datasheet; this waypoint will always be associated with a feature code of begin stream survey (BSS), regardless of which direction the survey is conducted (i.e., upstream or downstream). If working in an upstream



ADF&G Stream Survey Datasheet

DATE 10/5/03 CREW DPG, CAS PROJECT CODE FIS13

GPS UNIT LETTER A CAMERA Canon A20 PAGE 1 of 4

DIRECTION OF SURVEY: UPSTREAM/DOWNSTREAM (circle one)

Way-point	Error (m)	Feature	Locale	Locator	Feature Length (m)	Culvert Diameter (inches)	Disturbance Feature Class	Barrier Height (m)	Barrier Pool Depth (m)	Barrier Gradient (%)	Picture Number	Photo Direction (U/D)	LWA Complete/ Incomplete
1	12	BSS	MCH										
		BRK	MCH								1 2	U D	
		MOU	MCH										
2	10	MAP	MCH										
3	9	CON	MCH	LB							3	U	
4	11	MAP	MCH										

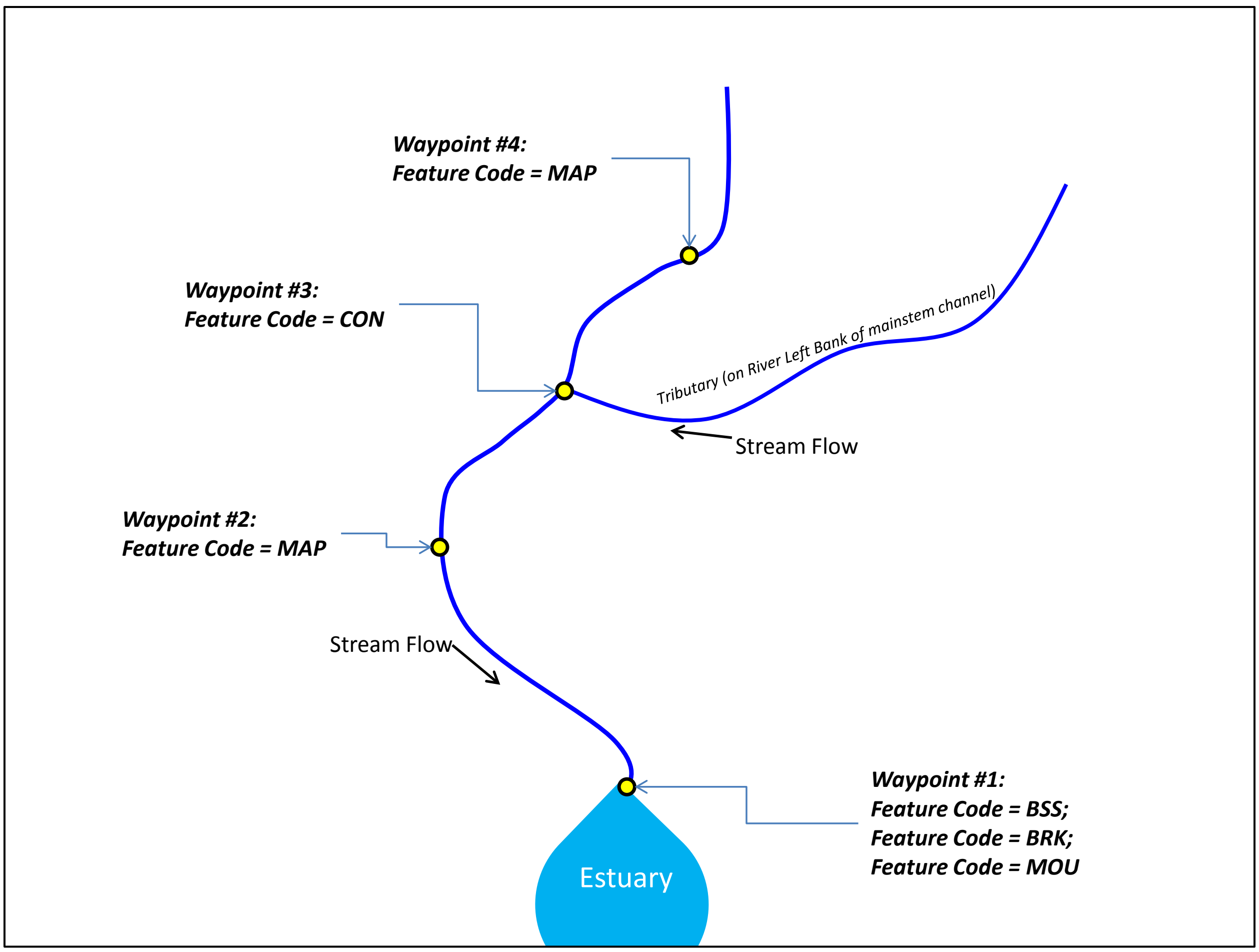


Figure 4.–Multi-component figure illustrating the relationship between waypoints collected along a stream course (bottom) and data recorded on the stream survey datasheet (top).

direction, the starting location waypoint will also likely be associated with one of the following features: stream reach break (BRK); stream mouth at estuary (MOU); or stream confluence (CON). If working in a downstream orientation, it may be advantageous to begin the survey at a barrier, stream confluence, or stream crossing structure, although a reach break is the preferred starting point. Regardless of direction of survey, a BSS feature code will be recorded along with any other feature codes corresponding to other features at this beginning point.

The rest of this discussion will provide an overview of the capture of data as if working in an upstream orientation. The approach is the same regardless of direction of survey.

Observers should continue surveying upstream, collecting waypoints and associated positional errors for features encountered. Stream course waypoints should be collected at least every 20 m. If no physical features are encountered within a 20 m stretch of the stream, a waypoint should be collected and the stream mapping point (MAP) feature code assigned to it; this will assist in delineation of the actual stream course once back in the office. Always record the locale for each feature. The choices for locale are main channel (MCH), side channel (SCH), slough (SLO), or beaver pond margin (BPM). If features pertain to a particular bank of the stream, this should be noted in the locator field (RB for downstream right bank, LB for downstream left bank, BB for both banks, and SS for spans main channel). If a barrier to fish passage (i.e., feature code BRR) is encountered, additional data defining the barrier is accommodated for on the stream survey datasheet (see section on barriers below for more detail). Riparian disturbances (see section on riparian disturbances below for more detail) should also be noted (i.e., feature code RDB); associated data for riparian disturbance features are also captured on the stream survey datasheet (e.g., locator, length, and class). Some of the other features that may be observed while conducting stream surveys require associated data to be collected and recorded on one of the other datasheets (Appendices D1 through D7); collecting data associated with these features will be addressed later in this section.

In addition to collecting waypoints and associated data at significant features along the stream, specific data related to each stream reach encountered will also be collected. At a representative point on the stream reach being surveyed, generally near the middle of the reach, collect a waypoint and record the feature as a channel type verification (CTV) point on the main stream survey datasheet. After filling out the waypoint and feature information on the stream survey datasheet, the remaining data specifically associated with the CTV point will be recorded on the reach datasheet (Appendix D2). Some of the data collected at CTV points include channel bed width measurements, macro pool counts, stream gradient information, large wood counts, etc. For further detail on reach-based data collection, see the "Channel Type Verification Points (CTV)" section below. The relationship between waypoints collected, the reach datasheet, and the stream survey datasheet is further depicted in Figure 5.

SKETCH MAPS

It is useful to sketch field maps of the project area as the survey progresses. These sketch maps should reference waypoint numbers to key stream features, especially at points where tributaries and side channels enter the main channel (i.e., confluences). These sketch maps prove to be beneficial for day-to-day field activities, logistical support, and post-processing the mapping data upon return to the office. This is especially true where complex side channel and tributary habitat is present. The sketch maps provide up-to-date information on stream channels that have and have not been surveyed throughout the project area, and provide the information necessary for locating points where work will need to begin on subsequent days of the survey. An example of a sketch map is provided in Appendix D7. The sketch map can later be scanned and incorporated into the stream survey database, making it possible to spatially link the map with a series of waypoints.

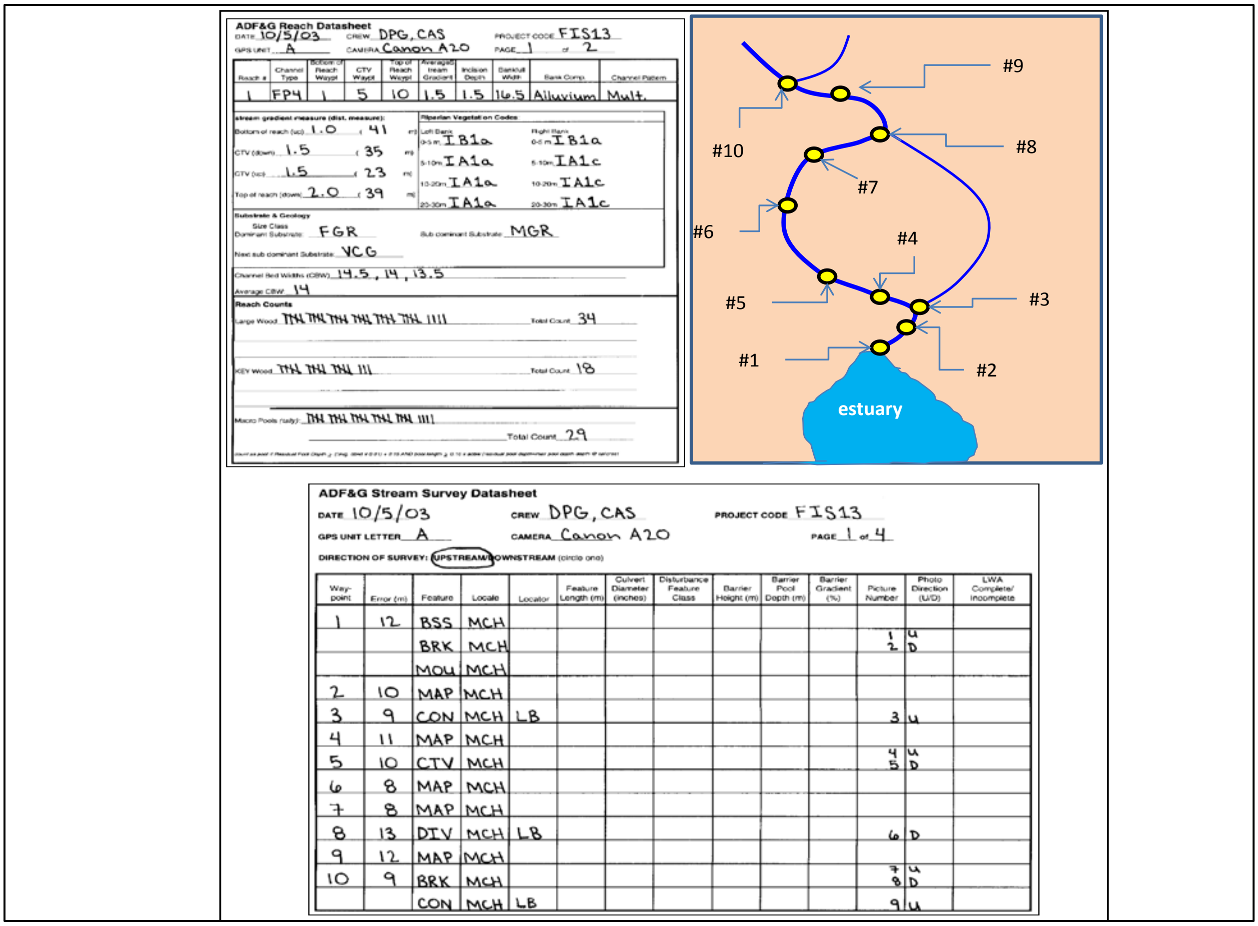


Figure 5.–Multi-component figure documenting the relationship between waypoints collected along the stream course (top right), reach-related channel type information (top left), and the main datasheet where feature codes are recorded for each waypoint taken during a survey.

PHOTOGRAPHY

Capturing photographs during stream surveys is an important part of this protocol, and is a critical component for documenting the following: 1) baseline riparian conditions, 2) general hydrological and biological patterns, 3) channel type calls made in the field, and 4) species identification for flora and fauna encountered. For those reasons, it is important to capture photographs of features so they can later be associated with the spatial data in the database during post-processing steps. Note that photographs *are required* at several unique features (e.g., BRK, CTV, BRR, etc.), including both upstream and downstream facing photos in some instances (Appendix E1).

Digital cameras produce a sequential filename associated with each photo taken; observers should be aware of the fact that different camera manufacturers have different filename formats. The entire file number does not need to be recorded in the picture number field on the stream survey datasheet, only the number at the end of the file name. For example, some Canon cameras produce filenames in the format "IMG_xxxx.jpg," of which only the "x's" at the end of the filename need to be recorded, not the "IMG_". Record the make and model of the camera and the unit ID in the stream survey datasheet header. If multiple crews are surveying a project area, then one camera should always be used in tandem with the same GPS unit (i.e., camera A is always used with GPS unit A and camera B is always used with GPS unit B). Camera and GPS tandems do not need to have the same alpha character; the important thing is to keep the same camera and GPS unit combination together during a trip so that the correct photo files match up with the correct waypoint numbers for each GPS unit used on the trip. The importance of this relationship may not be realized in the field, but will become apparent back in the office when attempting to figure out which photo files belong with which GPS units. Because of this association, duplicate photograph filenames are avoided.

FEATURES AND ASSOCIATED DATA

FEATURE OVERVIEW

As mentioned earlier in this document, the specific data that gets recorded on datasheets and in the database are dependent on the feature code(s) identified for the waypoint. A table containing all current feature codes that are used during stream surveys is provided in Appendix E1. Appendix E1 also identifies additional data that need to be collected and recorded for each feature code.

FEATURES REQUIRING EXTENSIVE DATA

As shown in Appendix E1, many of the features encountered during stream surveys have associated data that get recorded, which commonly consists of the locale, locator, and photographs, all of which are recorded on the stream survey datasheet. However, there is a subset of features that have a more extensive associated set of data fields, some of which are recorded on separate datasheets. For features that have data associated with them, the waypoint and feature information is first filled out on the stream survey datasheet, then additional information is recorded on another datasheet. Features that require information in addition to waypoint, error, feature, locale, locator, and photo fields include:

1) Channel type verification points (CTV)
2) Side channel attribute points (SAP)
3) Fish observations (FOP)
4) Stream crossing structures (SXNG category)
5) Barriers to fish passage (BARR category)
6) Riparian disturbance (RDB)

Channel type verification points (CTV) have the most extensive set of data fields associated with them, as they characterize an entire reach that may be hundreds of meters in length and encompass many waypoints. The first four features listed above have a separate datasheet for recording data. Data fields associated with barriers (BARR feature category) and riparian disturbances (RDB) are accommodated for on the stream survey datasheet. Each of the six feature codes or categories listed above are described in detail in the sections that follow.

CHANNEL TYPE VERIFICATION POINTS (CTV)

One of the primary objectives of this protocol is to identify the extents of geomorphically distinct reaches (i.e., channel types) within a given stream network, and to characterize the habitat within those reaches, each of which are homogenous throughout their extent. Channel type designations help define the parts of a drainage basin by characterizing the physical attributes of the reach, such as channel gradient and pattern, incision depth, bank containment, and riparian plant communities (Paustian 1992). In this way, channel type classification defines the general characteristics of the stream channel and provides a means to predict responses to natural or human influences. Individual channel types can be aggregated together into nine process groups that describe the interrelationship between watershed runoff, landform relief, geology, and glacial or tidal influences on fluvial erosion and deposition processes. Identifying individual channel types while in the field usually starts out as a subjective process but one that can become objective after observers are trained to look for changes in the physical attributes of the stream channel and the surrounding landforms. Appendix F1 contains a flow chart that explains the differences in the nine fluvial process groups found in SEAK, which allows users to begin looking at streams in the context of hydrologic patterns and processes. Excerpts from the USFS channel type users guide (Appendix A1) identify distinguishing characteristics of individual channel types and provide cues for field observers to identify distinct stream reaches.

All data specifically associated with reach or channel type characteristics are recorded on the stream survey and reach datasheets. The stream survey datasheet captures the individual waypoints that delineate the lower and upper break points (i.e., BRK feature code) of distinct reaches, as well as the reach qualifying CTV points. The reach datasheet captures all information specific to a single reach. This includes supporting information for the channel type determination made for each specific reach (e.g., gradient, dominant substrate, incision depth, bankfull width, channel pattern, and riparian vegetation). Other information recorded here includes attributes that characterize the quality of fish habitat within the reach, but do not directly support the channel type designation (i.e., large wood, key wood, and macro pools); each of these attributes are tallied throughout an individual reach.

All stream reaches have beginning and ending points, and are coded as BRK points when encountered in the field. For each reach, two BRK points will be observed and recorded: one for the downstream end, and one for the upstream end. Successive reaches will share a common break point because they are physically attached to each other. Figure 6 provides a schematic of this scenario.

After a waypoint has been captured for the downstream BRK point, observers will record the relevant data on the stream survey datasheet, with MCH for locale and BRK for feature code. Observers can also begin filling out the reach datasheet, including the header information, the "Bottom of Reach Waypoint," and the reach number (numbered consecutively up or down the stream).

The remaining data on the reach datasheet includes information specific to the CTV waypoint and reach tallies that describe fish habitat throughout the reach (i.e., wood and macro pool counts). CTV points capture pertinent data necessary for characterizing channel types, including average stream gradient, incision depth, bankfull width, bank composition, channel pattern, riparian vegetation, and dominant, subdominant, and next subdominant substrate. Data collected at CTV points, and the waypoint itself, are ideally taken at a representative section near the middle of the reach. Data recorded at CTV points are intended to capture the relatively homogenous and cumulative characters of the individual stream reach.

CTV Data Explanation

The verification data collected at CTV points warrants further explanation. The following explanations are for data fields identified on the reach datasheet, in the order they appear.

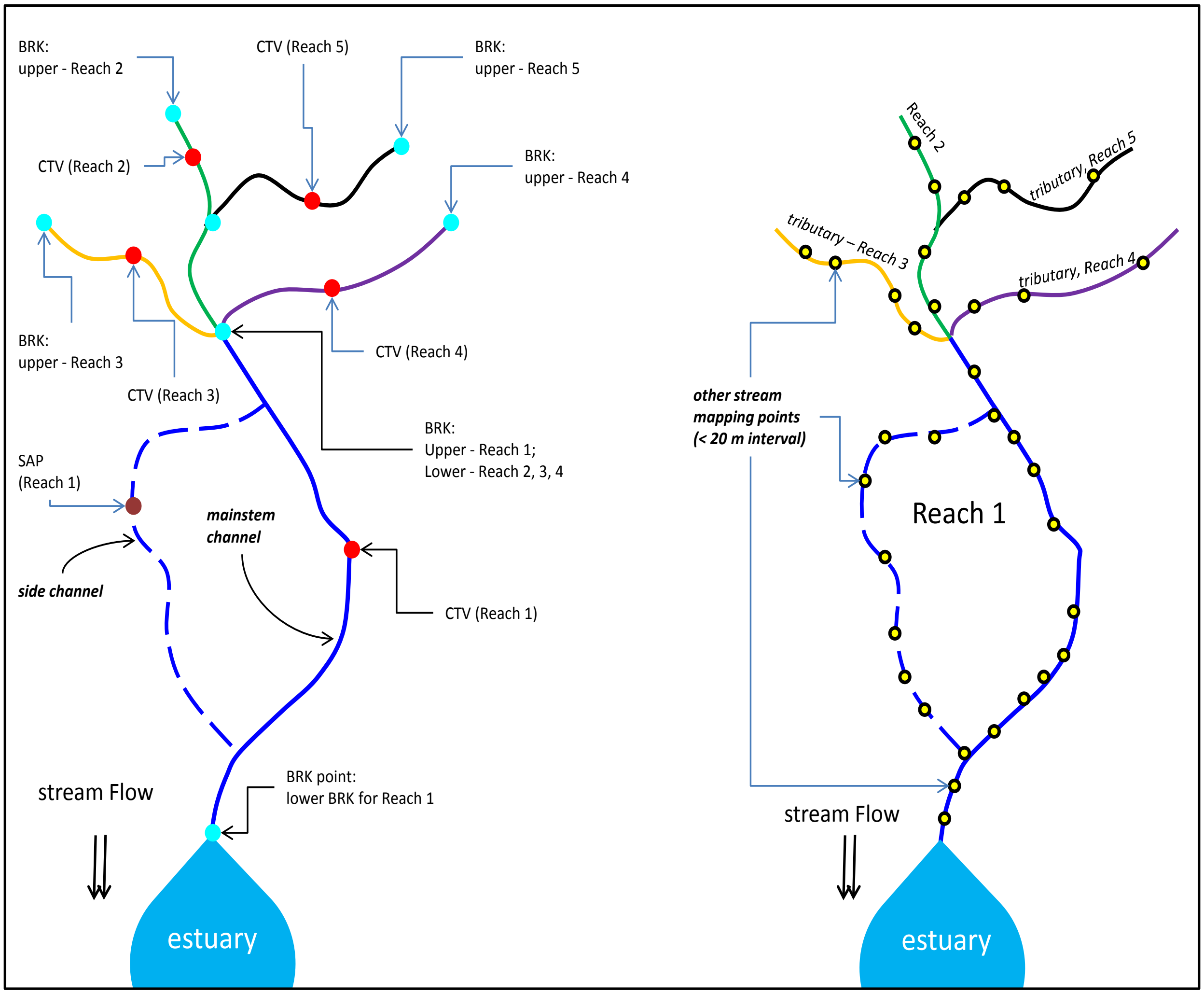


Figure 6.–The relationship between reach breaks, channel type verification points, and the reaches they correspond to.

Average Stream Gradient

Stream gradient is defined as the average change in vertical elevation per unit of horizontal distance in a stream channel. Gradients are measured with the use of an Abney hand level, or clinometer, at four different locations along a reach: 1) from the downstream reach BRK point, looking upstream; 2) at the CTV point (measured both upstream and downstream); and 3) from the upstream BRK point, measuring downstream. Observers may want to take more gradient measures throughout the reach if there appears to be variation. Stream gradient should be measured to the nearest 0.5% if using a clinometer, or to the nearest 10 minutes with the Abney level. It is important to record both the type of instrument being used and the scale you are using on the instruments, as Abney levels and clinometers both have percent and degree scales.

To ensure consistent measurements of gradient, two Abney poles (wooden rods or PVC pipe of standard length) of the same height should be employed: one pole will support the instrument being used to take the gradient measurement, and the other will serve as the target for taking the measurement. Note that the target pole should have a mark or flagging on it where the instrument taking the measurement reads 0% or zero degrees when on level ground. This will reduce observer and measurement errors, and ensure consistency across observers and terrain.

Incision Depth

Incision depth is defined as a measure of the long-term erosional properties of a stream channel and is measured as the vertical distance (m) between the first major slope break, above bankfull stage, and the channel bottom at the thalweg (Figure 7). For measures of incision depth associated with asymmetrical stream banks, select the steeper or longer slope that will most likely influence water quality (USDA 2001). Incision depth should be measured to the nearest 0.5 m and can be measured with a rangefinder or tape measure.

Bankfull Width

Bankfull width is the lateral extent of the water surface at bankfull depth; bankfull depth is the water surface elevation required to completely fill the channel to a point above which water would spill onto the floodplain (Figure 8). Bankfull width should be measured to the nearest 0.5 m using a rangefinder or tape measure.

Bank Composition

Bank composition refers to the dominant material composing both stream banks. Four codes are used to describe the material that composes the stream bank, which include:

1. Alluvium – stream bank is composed of unconsolidated clastic material, including boulders, cobble, gravel, sand, silt, and clay, that was deposited by running water; may have very infrequent bedrock occurrence (<2%) throughout the reach.
2. Bedrock – bedrock outcroppings occur at >15% of entire reach.
3. Mixed – stream bank contains a mixture of alluvium and bedrock; bedrock occurrence is consistent, but not extensive (i.e., 2–15% of stream reach).
4. Organic mat – stream bank contains a mixture of organic material, silt, and vegetation in consolidated form; primarily occurs in palustrine channel types.

Channel Pattern

Channel pattern refers to the connectivity of the mainstem channel, with two possible choices: single or multiple. Single channels typically have very little or no side channel habitat present. Multiple channels are characterized by numerous side channels, contained within the floodplain extent, throughout the reach.

Substrate

The dominant, subdominant, and next subdominant substrate classes of the stream channel are identified at the CTV point. Observers should determine the three most common size classes of substrate present near the CTV point, and rank them according to overall presence. Codes have been developed for the most prevalent substrate size classes observed in SEAK (USDA 2001), which will aid in identifying specific substrates found in stream channels (Table 1). Stream reaches may only have a single consistent substrate, in which case only a dominant substrate class is identified.

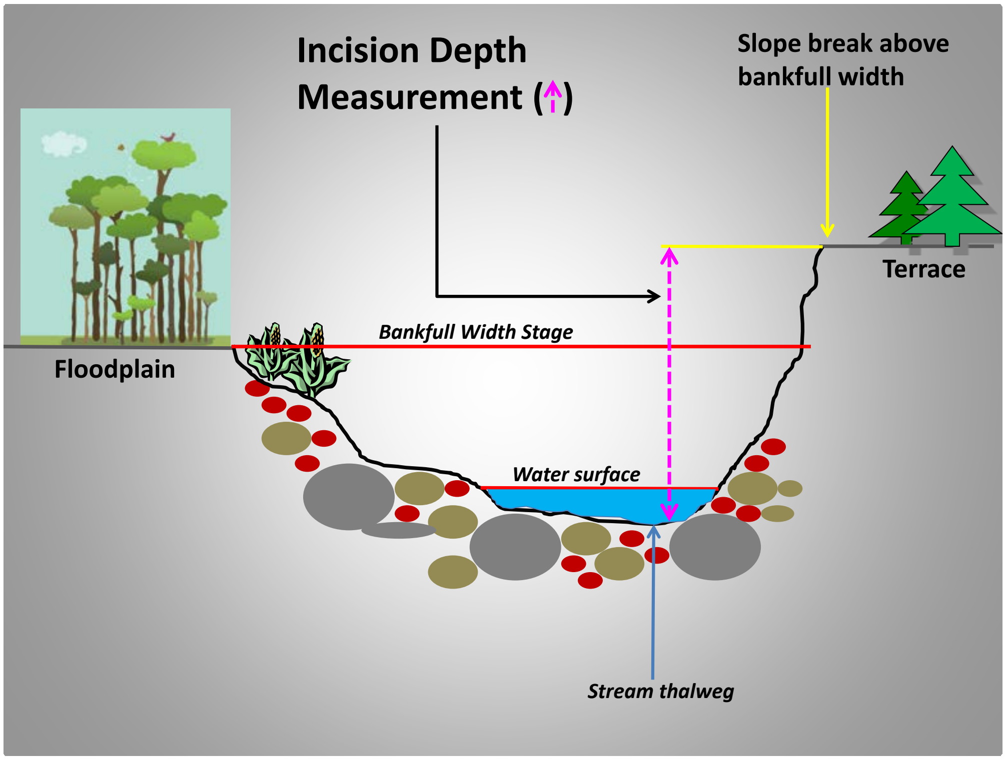


Figure 7.–Illustration of stream cross section showing the measurement of incision depth.

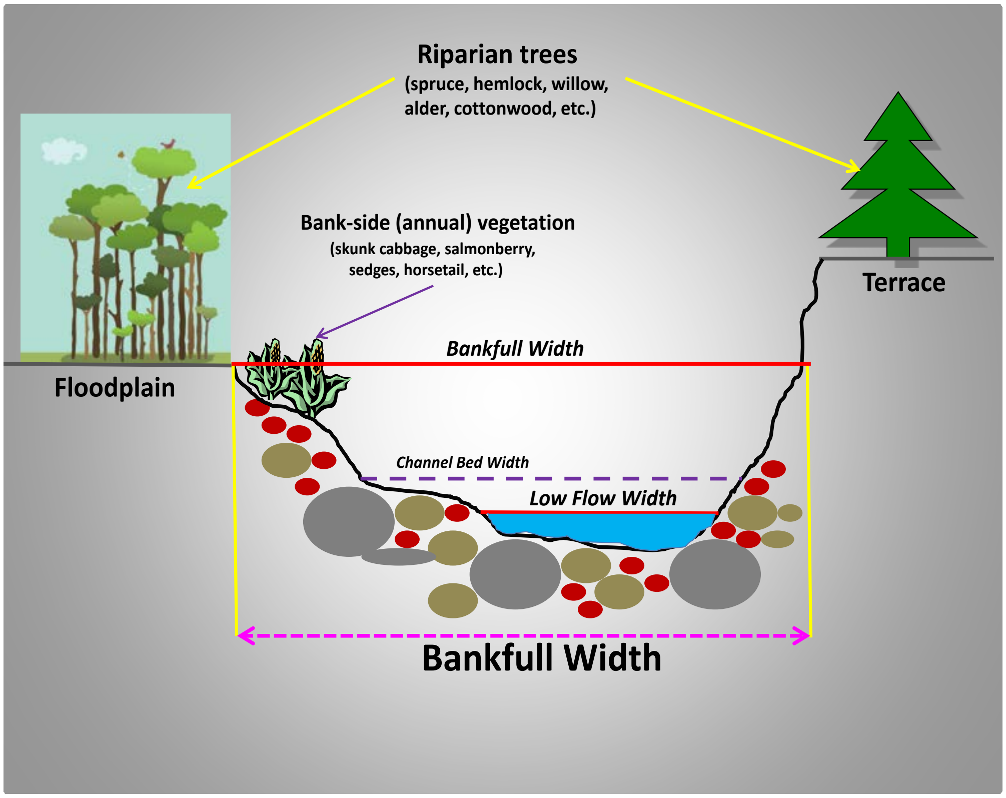


Figure 8.–Stream cross section showing the measurement of bankfull width.

Table 1.–Size classes and codes used for identification of substrate associated with channel type verification points.

Substrate	Code	Size class (mm)
Organic	ORG	Organic
Sand/silt	SS	<2
Very fine gravel	VFG	2–3.9
Fine gravel	FGR	4–7.9
Medium gravel	MGR	8–15.9
Coarse gravel	CGR	16–31.9
Very coarse gravel	VCG	32–63.9
Small cobble	SC	64–127.9
Large cobble	LC	128–255.9
Small boulder	SB	256–512
Large/medium boulder	LMB	>512
Bedrock	BR	Bedrock

Riparian Vegetation

Appendix G1 contains a dichotomous key developed by Viereck et al. (1992) that is used to identify key riparian vegetation communities that are commonly encountered throughout SEAK. Alpha-numeric codes are supplied for each of the dominant vegetation communities. The dominant vegetation should be recorded for both banks of the stream and recognizing that vegetation often changes due to the riparian influence of the stream channel, this will be recorded for four distinct distance classes (i.e., intervals) from the stream bank. The distance classes are: 0–5 m, 6–10 m, 11–20 m, and 21–30 m away from the stream bank.

Channel Bed Width

Channel bed width (CBW) is defined as the horizontal distance between the bottom of the left bank and the bottom of the right bank. This measurement is independent of present flow conditions (i.e., not necessarily wetted width). This measure is different from bankfull width, in that it is defined by the bottom of the bank rather than the point at which water would spill over onto the floodplain (Figure 7). The measurements should be recorded to the nearest 0.5 m.

As with bankfull width measurements, rangefinders provide an easy and accurate means of determining these parameters quickly, in all but the narrowest of stream channels. Channel bed width measurements should be taken at least three times within a reach and should be taken near the start of a reach. Ideally, an initial channel bed width will be taken directly above the reach break. At least two more measurements should be taken upstream of the initial measurement, and separated by a distance of approximately five times the initial channel bed width measurement. After these three measurements have been acquired, the average will be recorded in the average CBW field of the reach datasheet. The average CBW will be used to determine minimum dimensions for large and key wood pieces (i.e., diameter and length) and macro pools (i.e., pool depth, which will be explained in more detail below).

Large and Key Wood

Large wood is defined as all pieces of wood, including rootwads, within the bankfull width, that are greater than 10 cm in diameter and longer than 1 m in length.

In the context of this user guide, *key wood* is defined as pieces of wood, within the bankfull width, that are large relative to the channel size and appear to contribute to important hydrologic functions, including formation of pools and cover. The size of a piece of wood that will be considered a piece of *key wood* is dependent on the average channel bed width of a given stream channel. The qualifying dimensions of *key wood* pieces are scaled to the average channel bed width (Table 2).

Large wood and *key wood* are recorded as tallies at the bottom of the reach datasheet. The total counts for large and key wood represent the total number of qualifying wood pieces counted in that particular stream reach. It is important to note that each piece of wood should only be tallied once; *key wood* pieces should not get counted as *large wood*. For example, a single piece of wood that has a rootwad that meets the minimum qualifying dimensions for *key wood* and has a stem that only meets the dimensions for a piece of *large wood*, should only get counted as a single piece of *key wood*. Similarly, if a single piece of wood has both a rootwad and a stem that meet minimum qualifying dimensions for key pieces, that piece should only be tallied as a single piece of *key wood*.

Table 2.–Qualifying dimensions for key wood pieces, based on the average channel bed width (CBW) of the stream reach being surveyed.

Average CBW (m)	Key piece diameter (m)	Key piece stem length (m)	Rootwad diameter (m)
0–4.9	0.3	>3	>1
5–9.9	0.3	>7.6	>3
10–19.9	0.6	>7.6	>3
≥20	0.6	>15	>3

Macro Pools

The last piece of data collected on the reach datasheet is macro pool counts; the total count for macro pools represents the total number counted in that particular stream reach. Macro pools are defined by characteristics of the stream reach being surveyed, including the average channel bed width, residual pool depth, and the length of suspected macro pools. The process for calculating and identifying what will be considered a macro pool for a stream reach is fairly detailed and warrants special attention. A complete description for identifying macro pools is found in Appendix H1.

SIDE CHANNEL ATTRIBUTE POINTS (SAP)

Side channels are defined as distinct stream channels, with an axis of flow running approximately parallel to the mainstem, and are fed with water from the mainstem. Side channels are separated from the main channel by vegetated islands. In some instances, side channels themselves will include braids, which are diversions of flow from the main channel, across flat sections of the channel bed, but lack vegetated islands in between.

Under this protocol, side channels are defined with more precise detail, to separate them out from the numerous braided channels found on some mainstem channel habitats. Habitat associated with the mainstem is classified as a side channel only when the length of the channel is greater than 50 m and if woody vegetation exists between the channel and the habitat from which it originates (i.e., the mainstem). This means that all side channels less than 50 m in length, or side channels lacking vegetated islands between it and the mainstem, are treated as braids and considered part of the main channel habitat.

It can be difficult to deal with complex braided sections of streams, due to close proximity of numerous braided channels to the mainstem. This complex habitat can be difficult to interpret when trying to delineate the hydrography once back in the office. Each waypoint collected during stream surveys has an average positional error of approximately 10 m associated with it. Therefore, any stream mapping waypoint that is taken within this margin will have potential for confusion upon return to the office; detailed sketch maps drawn while conducting surveys will help alleviate confusion once waypoints have been downloaded in the office and hydrography updates begin.

Side channels always have a point downstream where they reconnect to the mainstem channel (i.e., CON feature code) and a point upstream where they divert water away from the mainstem channel (i.e., DIV feature code). Side channels should not be confused with tributaries (i.e., TRB feature code), which also have a CON with the mainstem channel, but do not have an upstream DIV point from the main channel. For each side channel encountered, waypoints taken at the CON and DIV will get recorded on the stream survey datasheet; all other data associated with the side channel will get recorded on the side channel datasheet. The side channel datasheet includes many similar fields to those on the reach datasheet. Side channel number is obtained by consecutively numbering each side channel encountered during the survey. The waypoints associated with the CON, DIV, and the side channel attribute point (i.e., SAP feature code, which is analogous to the CTV point located on mainstem channels) are recorded on the side channel datasheet. Other data collected on side channels include: channel bed widths; average channel bed width; and tallies of large wood, key wood, and macro pools. Each of these parameters are collected in the same manner as those associated with the main channel, but are recorded on the side channel datasheet.

Two fields that do not have analogous counterparts on the reach datasheet are *length of side channel* and *flow*. The length of the side channel is measured from the downstream CON point to the upstream DIV point. Again, rangefinders prove invaluable for measures of length and width, although measuring tapes or hip chains may also be used. For longer side channels it is also possible to calculate the length of the side channel in GIS by interpreting GPS waypoints captured in the field along with sketch maps. Flow refers to the presence of surface water in the side channel streambed and includes three possible options: dry, intermittent, or continuous.

Side channels often do not contain surface flow for their entire length during low to moderate flow periods. In these instances it is not possible to get a complete count of macro pools because pools cannot be discerned without surface flow. In cases such as this, the survey is performed on the length of the side channel where water is present, and therefore the number of macro pools recorded for a side channel is only for the portions containing water. On the side channel datasheet, the length of the side channel that was actually surveyed (i.e., the watered portions in this example) is recorded as opposed to the total length of the side channel. A waypoint should be collected where the stream loses surface flow (i.e., SSF feature code) and will get recorded on the stream survey datasheet. It should be noted that when observers encounter a side channel that loses surface flow or one that is dry under the conditions present, the entire side channel should still be evaluated and mapped. After a waypoint is captured denoting SSF, the survey can continue, with the exception that information on pools cannot be collected from this point back to the mainstem channel DIV or CON point.

Fish Observation Points (FOP)

Fish observations made during stream surveys should be recorded for:

1. Determination of stream status for entry or update to the AWC or Fish Distribution Database System (FDDS);
2. Determining presence or absence of fish;
3. ADF&G “index count” or salmon smolt data collection effort;
4. Supporting evidence to determine whether or not a barrier prohibits fish migration; or
5. Producing CPUE or fish population density estimates.

Fish observations made while conducting stream surveys makes it possible for the fish data to be correlated to habitat attributes, with the purpose of determining patterns of fish distribution in relation to habitat characteristics. The goal of mapping stream channels and collecting data on biological and hydrological attributes associated with them is strengthened by the collection of fish data in those stream channels.

All fish observations will be recorded on the stream survey datasheet as fish observation points (i.e., FOP feature code). As with all features encountered during a stream survey, a corresponding waypoint is captured to spatially locate the FOP. After the initial FOP has been recorded on the stream survey datasheet, observers will record additional information associated with the FOP on the fish observation datasheet (Appendix D4). Additional information recorded on the fish observation datasheet includes: the method of observation or capture (e.g., minnow trap, seine, visual observation, snorkel survey, etc.); species; life stage; meso-habitat (riffle, glide, scour pool, etc.); count; etc. A list of common species to SEAK and their corresponding species codes is provided in Appendix I1**.**

Stream Crossing Structures (SXNG feature category)

When a road crosses a stream, it affects fish habitat to varying degrees. For this reason, road crossings and associated structures (e.g., culverts or bridges) should be documented. Certain structures (e.g., bridges or open-bottom culverts) do not necessarily jeopardize or limit fish passage; however, they may have direct, indirect, or cumulative effects on both fish populations and their habitats. Log culverts and log stringer bridges, while not often a fish passage issue, may fail over time, which would result in roadbed sediments getting deposited into fish habitat. Other structures, such as corrugated metal or plastic pipes, may impede passage. Pipes may not function adequately for the following reasons:

1) Excessive gradient (i.e., they are too steep, leading to high water velocities in the culvert);
2) Undersized (i.e., they are too small for the stream, causing the roadbed and stream banks on the upstream side of the road to scour and lead to high water velocities in the culvert);
3) The culvert outlet is excessively perched above the culvert outlet pool, presenting a potentially insurmountable barrier for fish; and
4) The culvert may become damaged or blocked causing fish passage and erosion problems.

For all structures, photos should be taken from upstream and downstream vantage points. While observing a structure, check for USFS markings (e.g., writing on the inside of the culvert or an aluminum tag hung near the culvert) that may indicate a previous survey has been performed on the structure. For explanations on information to be collected at culvert pipes, see Appendix D5. A feature code should accompany waypoints collected at these structures and recorded initially on the stream survey datasheet. Classes describing these stream crossing structures are provided in Table 3.

Table 3.–Class codes and descriptions of stream crossing structures.

Class code	Description
ANB	Abutment with no bridge in place
BRG	Bridge, undefined
CMA	Corrugated metal pipe arch (i.e., squash pipe)
CMP	Corrugated metal pipe
CPP	Corrugated plastic pipe
LGC	Log culvert
LSB	Log stringer bridge
MOD	Modular bridge
PMB	Permanent (long-term) bridge
RRM	Removed structure
SXG	Stream crossing

BARRIERS (BARR FEATURE CATEGORY)

Barriers include all potential barriers to fish movement, whether they are temporary or permanent. Considering that field crews conduct stream surveys under a variety of flow conditions, both with and without fish trapping gear, and the subjective qualities of what defines a barrier, it is important that all potential barriers be recorded. Additionally, some barriers may impede the passage of certain species and life stages, but not of others. For these reasons, all potential barriers are given a barrier class that further describes the geomorphic, anthropogenic or hydrologic controls of the barrier. A list of barrier classes and descriptions is provided in Table 4.

Additionally, measurements may be collected that are dependent upon the gradient of the barrier. For barriers with 100% (i.e., ≥45º) gradient, a vertical height should be measured. For barriers with gradient less than 100% (i.e., <45º), a length and gradient (using an Abney level or clinometer) should be measured. For all barriers where a plunge pool exists at the bottom, the depth of that plunge pool should be measured, if possible, or estimated visually.

RIPARIAN DISTURBANCE (RDB)

Under this protocol, the observation of riparian disturbance (i.e., RDB feature code) is defined as any activity, natural or anthropogenic, that occurs ≤5 m from either bank of the stream and has potential impact on the stream, stream bank, or riparian zone. Appendix J1 includes a dichotomous key containing common disturbance classes observed during stream surveys. In every instance where RDB is recorded on the stream survey datasheet, additional information will be recorded, including: an associated feature class code; length of disturbance, parallel to the stream; and a locator to identify which bank is affected.

Table 4.–Barrier classes commonly encountered during stream habitat surveys in Southeast Alaska.

Class code	Description
BRR	Barrier, undefined
EBD	Ephemerally fixed barrier, beaver dam
EDJ	Ephemerally fixed barrier, debris jam
EGD	Ephemerally fixed barrier, hydro-geomorphically dynamic
ELF	Ephemerally fixed barrier, low flow
EOT	Ephemerally fixed barrier, other
ESS	Ephemerally fixed barrier, spring source
GCH	Geologically fixed barrier, chute
GCS	Geologically fixed barrier, cascade
GLK	Geologically fixed barrier, lake shore
GOT	Geologically fixed barrier, other
GSL	Geologically fixed barrier, stream limit
GWG	Geologically fixed barrier, high gradient waterfall
HCU	Human induced barrier, culvert
HDB	Human induced barrier, debris
HDM	Human induced barrier, dam
HOT	Human induced barrier, other
HWE	Human induced barrier, weir

SUMMARY/RECOMMENDATIONS/APPLICATIONS

The stream survey method presented in this manual is a detail-oriented protocol that was established to assist staff in the collection of spatially explicit data associated with meaningful biological and hydrological characterization of freshwater streams and rivers in SEAK. It also provides specific documentation of methods that were employed by the ADF&G-SF while performing stream habitat surveys across SEAK between 2001–2012. It therefore provides the ability to interpret the characterization of waters surveyed by the ADF&G-SF in the past, or generate quantitative information on habitat condition across watersheds or administrative boundaries, as well as across time, which is essential for effective watershed management. Stream monitoring and evaluation programs, including those associated with restoration activities, will be enhanced if a consistent and repeatable approach forms the basis of their program, including a written description of methods employed during data collection.

Many of the individual components of this stream survey protocol are similar to data captured by fishery biologists and hydrologists in the past. The additional collection of spatial data (i.e., GPS coordinates) bridges the gap between historic stream habitat surveys and present efforts aimed at accurately identifying where these attributes occur across the landscape. However, as with any protocol, it is important to collect data in a consistent manner in order to yield useful results. For these reasons, it is imperative that users become familiar with the procedures outlined in this document and that questions are asked when instructions are not clear.

In addition, because a large component of our surveys is based on the identification of channel types, potential users are urged to acquire a copy of the Tongass channel type classification system (Paustian 1992). This document provides an introduction into the stream classification process, as well as identification of the individual channel types based on hydrological, geological, and riparian parameters. An excerpt from this document is provided in Appendix K1 that highlights the differences between the different channel types. If professionals in the field have access to a GPS unit and a desire to include their stream habitat data in a centralized GIS database administered by the ADF&G-SF, then their data will likely be accepted if the protocol and relevant strategies addressed in this document are adhered to.

Note that even though this protocol is presented as a systematic stream survey, individual components of the protocol can be performed separately. This protocol applies to the documentation of many stream characteristics, including fish observations, channel type classifications, and presence of culverts and barriers. It also extends to waypoints that simply map stream position, where no other feature information is obtained beyond that necessary to delineate the position and shape of a stream network.

We present several case scenarios in Appendix L where the methods described in this document were used to provide baseline information on fluvial habitats in SEAK. Specific examples are provided that illustrate deficiencies in hydrographic delineation and classification prior to field surveys and how the new information has contributed to revised mapping efforts and informed land management considerations. Observers interested in learning more should contact the following ADF&G-SF staff who contributed to the development of this manual and have performed multiple stream habitat surveys in SEAK:

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REFERENCES CITED

Bilby, R. E., and J. W. Ward. 1989. Changes in characteristics and function of woody debris with increasing size of streams in western Washington. Transactions of the American Fisheries Society. 118:368–378.

Buchanan, T. J., and W. P. Somers. 1969. Discharge measurements at gaging stations: U.S. Geological Survey Techniques of Water-Resources Investigations, Book 3, Chapter A8. http://pubs.usgs.gov/twri/twri3a8/.

Chen, G., D. Konnoff, G. Reeves, B. House, A. Thomas, R. Wiley, and G. Haugen. 1994. Section 7 fish habitat monitoring protocol for the upper Columbia River basin: June 1994. Region 6 Technical Paper 10-94. USDA Forest Service, Pacific Northwest Region, Intermountain Region and Northern Region.

Coghill, K. T. 1996. An evaluation of the statistical power of existing stream survey data on the Tongass National Forest, with recommendations for an improved monitoring program. USDA Forest Service, Pacific Northwest Research Station, Juneau.

Dunne, T., and L. B. Leopold. 1978. Water in environmental planning. W.H. Freeman and Co., San Francisco.

Harrelson, C. C., C. L. Rawlins, and J. P. Potyondy. 1994. Stream channel reference sites: an illustrated guide to field technique. Gen. Tech. Rep. RM-245. USDA Forest Service, Rocky Mountain Forest and Range Experiment Station, Fort Collins, CO.

King, R., and J. P. Potyondy. 1993. Statistically testing Wolman pebble counts: changes in percent fines. Stream Notes. Stream Systems Technology Center, Rocky Mountain Station, USDA, Forest Service.

Knighton, D. 1987. Fluvial forms and processes (second edition). E. Arnold Publishers Ltd., London.

Leopold, L. B., M. G. Wolman, and J. P. Miller. 1964. Fluvial processes in geomorphology. W.H. Freeman and Company, San Francisco, CA.

Marcus, W. A., S. C. Ladd, J. A. Stoughton, and J. W. Stock. 1995. Pebble counts and the role of user-dependent bias in documenting sediment size distributions. Water Resources Research 31(10):2625–2631.

Maxwell, J. R., C. J. Edwards, M. E. Jensen, S. J. Paustian, H. Parrott, and D. M. Hill. 1995. A hierarchical framework of aquatic ecological units in North America (Nearctic Zone). USDA Forest Service, North Central Experiment Station, GTR NC-176.

Merrit, R. W., and K. W. Cummins. 1996. An introduction to the aquatic insects of North America (3rd edition). Kendall/Hunt Publishing Company, Dubuque, IA.

Murphy, M. L., and K. V. Koski. 1989. Input and depletion of woody debris in Alaska streams and implications for streamside management. North American Journal of Fisheries Management 9:427–436.

Paustian, S. 1992. Channel type user guide for the Tongass National Forest, Southeast Alaska. USDA Forest Service, R10-TP-26.

Platts, W. S., W. F. Megahan, and G. W. Minshall. 1983. Methods for evaluating stream, riparian, and biotic conditions. USDA Forest Service, GTR INT-138.

Robison, G. E., and R. L. Beschta. 1990. Coarse woody debris and channel morphology interactions for undisturbed streams in southeast Alaska. USA Earth Surface Processes and Landforms. 15:149–156.

Rosgen, D. L. 1996. Applied river morphology. Western Hydrology. Lakewood, CO.

Southeast Alaska GIS Library. 2010. Southeast Alaska GIS library at UAS. Web page. Accessed April 2012. http://seakgis.alaska.edu/.

USDA. 1996a. Soil and Water Conservation Handbook. FSH 2509.22-96-1. Forest Service, Alaska Region, Juneau.

USDA. 1996b. WinXSPRO a channel cross-section analyzer: Draft User's Manual. Forest Service, Rocky Mountain Experiment Station, Fort Collins, CO.

REFERENCES CITED (Continued)

USDA. 2001. Alaska region aquatic habitat management handbook. Chapter 20. USDA Forest Service. FSH 2090.21. R-10 Amendment 2090.21-2001-1.

Viereck, L. A., C. T. Dyrness, A. R. Batten, and K. J. Wenzlick. 1992. The Alaska vegetation classification. USDA Forest Service, Pacific Northwest Research Station, Oregon. PNW-GTR-286.

Washington Forest Practices Board. 1993. Standard methodology for conducting watershed analysis. Version 2.0, p. F-32.

Wiedmer, M. 1999. Fish habitat survey data entry: upper limits of fish distribution. January 7, 1999 memorandum. Alaska Department of Fish and Game.

Wolman, M. G. 1954. A method of sampling coarse river bed material. Trans. Am. Geophys. Union. 35(6): 951–956.

Woodsmith, R. D., and J. M. Buffington. 1996. Multivariate geomorphic analysis of forest streams: implications for assessment of land use impacts on channel condition. Earth Surface Processes and Landforms, 21:377–393.

GLOSSARY

Alluvium - unconsolidated clastic material deposited by running water, including gravel, sand, silt, and clay. Alluvium often contains a mix of different sized parent material, none of which is held together by other materials (i.e., mud, clay, etc).

Bank composition - in the context of this manual, bank composition refers to the dominant stream bank material with 4 possible choices that characterize individual reaches or channel types:

Alluvium – may have very infrequent bedrock occurrence, <2% throughout the reach.

Bedrock – bedrock outcroppings occur at >15% of entire reach.

Mixed – mixture of alluvium and bedrock characterize stream bank material. Bedrock occurrences are consistent, but not extensive (2–15% of stream reach).

Organic mat – generally associated with palustrine channel types; stream bank contains a mixture of organics, silt, and vegetation in consolidated form.

Bankfull width - the lateral extent that surface water would extend at bankfull depth, or the water elevation that is required for the channel to become completely filled and spill out on to the adjacent flood plain.

Barrier (fish) - any structure or stream channel characteristic that impedes or blocks upstream or downstream movement of fish. Geological, ephemeral, animal, or human factors may control barriers. Barriers may also have differing effects at species- or life stage-specific levels of influence.

Channel bed width - the horizontal distance between the bottom of opposite banks of a stream; this measure is independent of stream flow.

Channel pattern - refers to the general connectivity of the mainstem channel; in the context of this manual, 2 possible choices include:

Single – reaches characterized as single generally have very few (i.e., <5% of overall length of the reach) braids or side channels.

Multiple – reaches characterized as multiple may have numerous side channel and braided habitat present, often separated by bars or vegetated islands.

Channel type - may be analogous to reach or geomorphic reach, but further defined by a name and described by differences in surrounding landscape and/or in the stream channel. Channel types are a component of the stream mapping hierarchy that includes fluvial process groups and is currently used in the Tongass National Forest (USFS) as part of a stream mapping protocol.

Channel type verification point (CTV) - in the context of this manual, CTV points refer to waypoints collected near the middle of individual reaches. Data collected at these points characterize the entire reach by a set of predetermined parameters, including stream gradient, dominant substrate, bankfull width, average channel bed width, and incision depth. After each of these parameters are identified, observers use this information to make a final determination of the specific channel type for the reach.

Colluvium - unconsolidated material, including gravel, sand, silt, and clay that is deposited or moved by gravity. The material accumulating at the bottom of some steep slopes or cliffs (e.g., talus) is an example of colluvium.

Confluence - the point at which two or more streams join or combine and become a single entity or stream channel.

Coverage (in GIS) - a vector (containing X and Y values) data storage format for storing the location, shape, and attributes of geographic features. Coverages, for use in GIS, may include streams, lakes, towns, vegetation classes, etc.'

Database - a collection of related files organized for efficient retrieval of information.

Dichotomous key - an identification tool that provides users with a series of choices between alternative characters to lead users to a result or a further choice; each step progressively narrows down a list of possible outcomes until only 1 taxon, group, or element remains.

Ecoregion - the broadest class of a landscape hierarchy that is used as a framework for grouping ecosystems into logical associations; in the context of this manual, ecoregions are delineated by broad factors such as physiography, lithology, and surficial geology.

Fluvial process group - in the context of this manual, process group refers to the taxonomic groupings of channels based on processes that formed them. These process groups reflect the long term interaction of geology, landform, climate, and riparian vegetation. Note that fluvial process groups are part of the stream channel hierarchy in which channel types further describe each of the process groups.

Geomorphic reach - in the context of this manual, geomorphic reach is synonymous with channel type; geomorphic reach is a section of stream between two specified points that are identified through distinct changes in the surrounding landscape (e.g., landform, side slope length, angle, incision, etc.) as well as in the stream channel (e.g., stream gradient, bankfull width, etc). See also *Reach.*

Geographical information system (GIS) - refers to the software that enables users to combine layers of information to provide a comprehensive understanding of a specified location, area, environment, etc.

Global positioning system (GPS) - a worldwide navigation system that uses information from orbiting satellites to determine the position (i.e., latitude and longitude) as marked by an instrument designed to receive these signals.

GPS positional accuracy (error) - this is value, identified by the GPS unit, that estimates the precision of a given location (i.e., waypoint) relative to the strength of signals from orbiting satellites. Generally, the higher the value, the less precise the coordinates are.

Incision depth - a measure of the long term erosional properties of a stream channel; measured as the vertical distance between the first major slope break above bankfull stage and the channel bottom at the thalweg.

Intermittent flow - stream channels with intermittent flow are characterized by portions of the channel that do not contain water, but have signs that water does move through the area at other times (e.g., lack of vegetation in the channel, scouring of the streambed, etc). Intermittent channels may have isolated pools throughout.

Key wood - in the context of this manual, key wood is the number of significantly large pieces of wood within the bankfull stage. The size of key wood is dependent on the average channel bed width of a given stream channel, thereby providing a channel bed width 'scaled' account of important woody debris.

Landform - recognizable physical forms of the earth's surface, having characteristic shapes and produced by natural causes.

Large wood - in the context of this manual, large wood refers to all pieces of wood, within the bankfull stage, that is ≥10 cm in diameter and is ≥1 m in length.

Layer (in GIS) - layers reference geographic data stored in a data source, such as a coverage, and defines how to display it. Layers might include a collection of similar geographic features (e.g., coverages).

Macro pool - in the context of this manual, macro pools are defined by surrounding characteristics, such as average channel bed width, residual pool depth, and the length of the macro pools themselves.

Mainstem channel - in the context of this manual, the mainstem channel refers to the stream channel that collects the majority of the water flow.

Reach - a relatively homogenous section of stream having a repetitious sequence of habitat types and relatively uniform physical characteristics such as slope, depth, substrate, and bank cover; a section of stream between two specified points.

Reach break (BRK) - in the context of this manual, reach breaks refer to a point at the beginning or end of individual stream reaches or channel types. Reach breaks are always associated with changes in stream habitat characteristics, such as landform, stream gradient, substrate, incision depth, or bankfull width.

Residual pool depth - in the context of this manual, residual pool depth equals the maximum depth minus the pool tail crest depth, which is the depth of water over the hydraulic control. The depth at the pool tail crest is taken at the deepest point where the water surface slope breaks into the downstream riffle, or plunges to a pool below the upstream pool.

Riparian area - the area of land located adjacent to a stream or other body of water and can be identified by soil characteristics and distinctive vegetation. Riparian areas include wetlands and those portions of the flood plain and valley bottoms that support riparian vegetation.

Riparian disturbance (RDB) - riparian disturbance refers to a variety of processes, natural or human induced, that may originate in the riparian zone and may have potential for impact on the stream channel.

Side channel (SCH) - in the context of this manual, side channels are distinct stream channels, with an axis of flow running approximately parallel to the mainstem, that are fed with water from the mainstem. Side channels are separated from the main channel by vegetated islands and must be at least 50 m long.

Side channel attribute point (SAP) - in the context of this manual, SAP points are analogous to a CTV point on the mainstem. SAP points refer to waypoints collected near the middle of an individual side channel. Data collected at this point includes channel bed widths, average channel bed width, and tallies of large wood, key wood, and macro pools.

Sinuosity - the ratio of channel length between two points on a channel, to the straight distance between the two points; departure from a straight line.

Slough - channels that receive water from tributaries, mainstem channels, or side channels as a function of rising water levels (i.e., backwater). Sloughs are generally considered to be dead end channels with no true source (i.e., spring fed, snow melt, etc).

Spatial data - data that have values for X and Y (i.e., latitude and longitude), enabling it to be precisely located on a map or in the context of a GIS.

Stream gradient - in a stream channel, stream gradient is the average change in vertical elevation per unit of horizontal distance.

Thalweg - the deepest part of a stream channel.

Tributary - a stream channel which empties flow into another stream channel, before its terminus in a lake or saltwater. Tributaries differ from side channels, in that its origin is geographically distinct from that of the mainstem channel in which it ends.

Watershed - a region, or area, bounded by a water parting feature (e.g., ridge, mountain, etc.) and ultimately drains to a particular body of water; may be synonymous with catchment area or basin.

Waypoint - as received from a GPS unit, a waypoint is a position stored in memory in a variety of formats (e.g., degrees-minutes-seconds, latitude and longitude) which enables a location to be located precisely, given the associated positional accuracy or error.

APPENDIX A: EXCERPTS FROM THE USFS (REGION 10) TIER II STREAM SURVEY PROTOCOL

The Tier II survey was designed to provide consistent, quantitative estimates of habitat parameters necessary to evaluate the condition of a stream relative to forest riparian habitat management objectives (RHMO). The Tier II survey protocol identifies variables that can be measured efficiently by a two-person survey crew. Habitat units are defined and discrete categories established to minimize observer bias, reduce measurement error, and enable replication and comparison of data across time and space. These habitat objectives will help define the natural variation for key indices of channel condition and fish habitat, and are the basis for describing the desired condition of healthy, fully functioning stream ecosystems.

The Tier II survey includes the following measurements, explained in detail below:

1. Channel Morphology Measurements
2. Stream Survey
   i. Record GPS coordinates of starting and end survey point
   ii. Length
   iii. Channel Bed Width (measured at a distance of every fifth approximate average channel bed width)
   iv. Pool Count
   v. Beaver Pond Area
3. Large Wood
4. Disturbance
5. Stream Buffer
6. Side Channel
7. Fish presence by species and Migration Barrier

23.1 – CHANNEL MORPHOLOGY MEASUREMENTS

Conduct a minimum of one channel morphology survey per channel type. Channel types generally should be classified to a minimum length of 100 m. Record:

1. Hip chain station (distance) relative to a known geographical point
2. Channel incision depth*
3. Entrenchment ratio (optional, calculated)*
4. Flood-prone width (optional)*
5. Bankfull width*
6. Average channel bed width (to scale macro pool and key piece wood counts at beginning of each survey segment)
7. Bankfull depth (mean and maximum)*
8. Channel gradient (measured at the water surface)*
9. Channel pattern
10. Channel sinuosity*
11. Channel substrate*
12. Stream discharge estimate (optional)

* National core attribute for aquatic habitat inventory

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There is tremendous complexity and geomorphic variability among and within forested streams (Woodsmith and Buffington 1996). Discharge, gradient, topography, geologic control, glacial influence, and substrate are just a few factors that influence the stream channel. Measurement error can compound the difficulty of accounting for natural variability. The channel morphology measurements adopted for the survey protocol, and recorded on the stream morphology data card shown in 22.5 – Exhibit 01, consume more time but yield more precise data than visual estimates. Careful stratification of reach map units into channel types (Maxwell et al. 1995; Paustian 1992), and identification and isolation of physical anomalies, will reduce between stream variation and improve the power to detect statistically significant differences between groups of streams when in fact a difference exists (Coghill 1996). Any survey data added to the regional database must be assigned to a channel type.

Although the channel type classification system uses discrete categories to describe average stream morphology, streams occur along a continuum, and may exhibit overlap in parameter values (Rosgen 1996). One or more morphological characteristics used to classify channels may overlap the normal range of two discrete channel types. How then do you classify channels with a morphological variable that overlaps channel types (that is, at the tail of the range of distribution)? As a rule-of-thumb, the highest value habitat and most sensitive management areas should receive preference when assigning channel type in the streams database (23.1 – Exhibit 01).

The flood plain, estuarine and palustrine channel types have very high ecological values. These types, and alluvial fans having high sensitivity to management activities should be mapped as accurately as possible. A channel that is a mixture of process groups, or transitional between process groups should be assigned to the more variable (less homogenous) category. Channels may include short sections that differ from habitat upstream or downstream. Survey objectives and the extent of the anomaly should be considered to determine if such inclusions should be mapped as a separate channel types. The channel type mapping resolution is usually a minimum segment length of 100 m.

Criteria used to define stream reaches and compare between valley segment or reach level stream classes include sinuosity, channel entrenchment, bankfull channel width, stream gradient, channel pattern, and substrate particle size distribution. Measure these geomorphic parameters at a minimum rate of one location per mapped channel type. Additional sites may be needed to capture variability. Conduct morphology measurements at least every 1,000 m when a single channel type covers a very long segment of stream.

As a Tier II survey progresses upstream, new channel types may be encountered. To stratify correctly, you must identify and distinguish actual channel type transitions and breaks from small inclusions. The Alaska Region channel type key 22.1 – Exhibit 01 provides an overview of the channel types. Paustian (1992) provides a very detailed description and photographs of each channel type. The *Channel Type Field Key of the Tongass National Forest* is a good field reference for channel type identification and classification.

All of the measurements listed below must be taken and recorded separately at each channel morphology survey site.

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23.1 – Exhibit 01

Channel Type Process Group Homogeneity From Most to Least Homogenous.

Flood Plain, Estuary, and Palustrine > Alluvial Fan, Glacial Outwash, and Low Gradient Contained > Moderate Gradient–Mixed Containment, Moderate Gradient Contained, and High Gradient Contained

23.11 – Channel Incision Depth

Record the incision depth (m) for the left and right bank. Record left and right bank side slope length (m) and side slope angle. [Note: This measurement is optional for low relief landforms.]

Incision depth together with entrenchment ratio describes the degree of channel confinement and containment. These attributes measure the ability of the stream channel to contain large flow events within the channel area. They also indicate the limits of fish distribution within the drainage because tributaries to steeply incised channels often have waterfalls that are barriers to fish passage. Channel containment influences stream energy, and hence transport and storage of sediment and large wood. Stream bank erosion, mass wasting, and shallow wasting potential are influenced by entrenchment. Incision depth, the metric used for channel entrenchment, is the vertical distance (m) between the first landform slope break above bankfull stage and the channel bottom at the thalweg. If the stream banks are asymmetrical, base the incision depth on the steeper or longer slope, whichever is most likely to influence water quality. Two methods are provided on the stream morphology data card (22.5 – Exhibit 01) to record this parameter within the appropriate range. The depth of incision could be measured or classified into one of several ranges. Incision depth as a function of side slope angle and length are shown in 23.11 – Exhibits 01 and 02, which can be measured to derive the incision depth trigonometrically.

Calculations for many commonly encountered combinations of slope length and angle are provided in an incision depth chart (22.55 – Exhibit 01).

The side slope length and angle, used to calculate incision depth, also describes the potential for sediment and debris recruitment from the landforms immediately adjacent to a channel. These landforms are measured along the slope distance using a clinometer and hip chain or laser range finder, perpendicular to a representative portion of the sample channel type. Survey objectives should dictate which method is used. Estimation is quicker, but is increasingly difficult to accurately gauge side slope characteristics as the channel entrenchment increases. A record of side slope length and angle with derived incision depth provides useful information when classifying streams, evaluating slope stability risk, or designing road crossing and drainage structures.

These typical cross section profiles (23.11 – Exhibit 02) show the relationship between depth and flood-prone width for shallow and deep channel entrenchment. Incision depth can be calculated if the side slope angle and side slope length are known.

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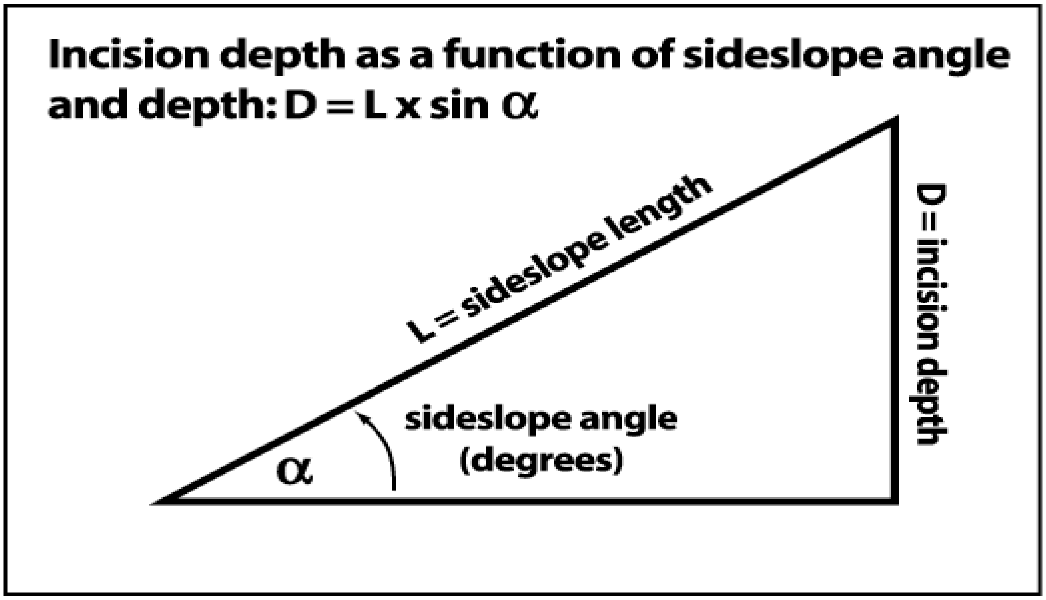
23.11 – Exhibit 01
Incision Depth as a Function of Side slope Angle and Length



23.11 – Exhibit 02 is a separate document.

23.12 – Entrenchment Ratio

Entrenchment ratio is used to describe the degree to which floods are contained by the channel. The ratio is the flood-prone width divided by the bankfull channel width (Rosgen 1996). Flood-prone width is measured at an elevation of two times the maximum bankfull depth, using a level or clinometer, stadia rod and metric tape. This measurement can be difficult to obtain when the side slope angle is low, particularly when vegetation obscures the rod. If the flood-prone distance on one bank exceeds the bankfull width, you may optionally record the flood-prone distance as greater than 2.5 times the bankfull width. The exception may be asymmetrical channel profiles. The flood-prone width is an approximation of the 50-year flood plain width (Rosgen 1996). This coincides with design criteria for Alaska Region system roads as discussed in best management practices 14.17, bridge and culvert design and installation (USDA 1996a).

23.13 – Bankfull Stream Width and Depth

Record bankfull channel width (m) measured with a surveyor's tape strung across the channel perpendicular to the stream bank. Bankfull stream width (m) is the distance from bank-to-bank at the elevation of bankfull flow (Dunne and Leopold 1978). Rosgen (1996) comprehensively discusses field procedures to determine bankfull stage. The WinXSPRO (USDA 1996b) software package may be used to graphically display the bankfull point (22.52 – Exhibit 01), obtain stage discharge estimates, and generate channel summary statistics such as the dimensionless bankfull channel width-to-depth ratio.

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Channel cross section sites should occur at riffle sections. Select a straight and narrow section of riffle, free of undercut banks and obstructions such as large woody debris accumulations. The tape should be stretched across the channel to a point well beyond the bankfull point. The objective is to capture not only the bankfull stage, but also the lower angle. On wide channels, a stadia rod and survey instrument should be used to obtain accurate measurements. On narrow channels, it may be possible to obtain accurate measurements by measuring from the stream bottom to a tape stretched parallel to the water surface. Clinometers or hand levels should be checked for accuracy before use since errors in calibration are common.

Depth and distance measurements should be made from the left bank to right bank facing downstream (23.18a – Exhibit 02), and include the following locations:

Left bank pin - LBP	Right edge of water - REW
Left bankfull - LBF	Bottom of right bank - BRB
Top left bank - TLB	Top right bank - TRB
Bottom of left bank - BLB	Right bankfull - RBF
Left edge of water - LEW	Right bank pin - RBP
Thalweg - T*	

*The thalweg is the deepest section of the channel.

20% distance intervals from BLB to BRB

Bankfull mean depth is cross sectional area divided by channel width. This value is approximated by summing the depths then dividing the sum of the depth by *(n + 1)*, where n is the number of measurements. The *(n + 1)* divisor incorporates the edges of the channel that have zero depth. Mean depths computed by dividing by n are greater that the true correctly computed mean depth (cross sectional area/width). Mean depth computed by dividing by *n + 1* are also greater than the true computed mean depth, but the difference between the true and the *n + 1* divided mean depth result tends to be reduced with an increased number of depth measurements (Platts et al. 1983). Measure at least 10 equally spaced depth measurements between the LBF and RBF in place of making additional depth measurements at significant changes in slope features for irregular channels.

From the cross sectional profile several other parameters can be derived: bankfull maximum depth, bankfull width-to-maximum depth ratio, wetted width-to-depth ratio, bankfull width-to-average depth ratio, and channel bed width.

23.14 – Average Channel Bed Width

Channel bed width is independent of the current water level, and equates to the distance between the bottom of the left bank (BLB) and bottom of the right bank (BRB) (23.18a – Exhibit 02). The bottom of bank should be identified on the basis of channel geometry whenever possible.

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Some rules of thumb can help in identifying the edge of the channel bed in an alluvial channel when bed and bank gradually blend:

1. "Bed" means the active streambed.
2. The stream channel bed is the site of temporary storage of active bedload sediment, transported by ordinary streamflow of sufficient magnitude. In contrast, stream bank material commonly consists of soil, rock, roots and other vegetation with stronger cohesive forces. This contrast can be used to identify the break between channel bed and banks.
3. There is usually a break in slope at the edge of the bed, where the bed ends and the stream bank begins. This is the bottom of bank, BLB to BRB (23.18a – Exhibit 02).
4. There is usually a break in slope at the top of the bank, where the bank ends and the floodplain or side slope begins.
5. The break between established vegetation and the active bed material usually occurs between the bottom and top of bank.

The qualifying size for key pieces of large wood and macro pools changes with channel bed width size. In order to count key piece wood or macro pools, an approximate average channel bed width must be determined and recorded prior to surveying each stream segment. Calculation of approximate average channel bed width begins with an initial measurement near the beginning of the survey segment followed by two additional width measurements (upstream and downstream respectively from the initial one), at distances of five times the width of the initial measurement. The initial measurement should be taken far enough upstream such that the downstream measurement fits within the survey segment. Record the average of the three measurements as an approximate channel bed width, and use that figure to scale macro pool and key piece wood counts.

Average channel bed width over the length of the stream segment is derived from channel bed width measurements taken at distance intervals equal to five times the approximate channel bed width. For example, if the approximate channel bed width averaged 10 m, record the measured channel bed width (to the nearest 0.5 m) at 50 m intervals. At meander point bars, where the break in slope from bottom to top of bank is not apparent, measure the edge of the channel bed at the margin of established vegetation.

23.15 – Channel Gradient

Measure at the water surface and record to nearest 0.5% slope.

Channel gradient (reach gradient) is the change in water surface elevation between end points of a channel segment. Measure the reach gradient using a survey level, tape and stadia rod over at least 20 channel widths to approximate water surface slope near bankfull stage. When measuring slope over shorter distances, bankfull slope can be approximated by measuring the slope from one distinct channel feature to a similar one upstream, such as from the top of a riffle to the top of the next riffle.

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Slope is a very sensitive parameter, especially when applied to Manning's equation. Therefore, slope should be recorded to three significant digits (0.001 as a dimensionless unit, or 0.1 %).

23.16 – Stream Channel Pattern

Record the prevalent channel pattern for the channel segment as single or multiple.

The stream morphology data card (22.5 – Exhibit 01) contains fields to record stream channel pattern as single or multiple. For large streams, channel pattern can be derived from an air photo. When combined with observations on channel morphology (that is, gradient, substrate, width/depth ratio), channel pattern provides insights on sediment regime, flood plain condition, and channel stability.

A single pattern stream has only one channel. A multiple pattern stream has more than one channel. Multiple channel patterns include streams that divide into two or more distinct channels that do not reconnect to the original channel (for example, Alluvial Fan process group), and multiple interlaced channels that are separated by bars (for example, Flood Plain and Glacial Outwash process groups).

Multiple channels, such as the flood plain (FP5) segment of the Katlian River shown in 23.16 – Exhibit 01, are complex systems. Habitats are complex, including vegetated and unvegetated bars along the main channel and several large secondary channels or side channels. All habitat units should be recorded for any given segment of channel surveyed. Arbitrarily ignoring habitat within a side channel, however insignificant relative to the whole channel segment, will bias the sample.

The width and length of side channels and separating channels are factors that affect data recording procedures. Data from habitat units that are separated by short bars (for example, small islets) or short diversions around debris jams within the bankfull width of the channel should be lumped with the larger channel. Data for side channels should be kept separate from data attributed to main channels. To reiterate, the minimum qualifying sizes of macro pools and key pieces of wood must be scaled to the average channel bed width of the channel or side channel in which they are located.

23.16 – Exhibit 01 is a separate document.

23.17 – Channel Sinuosity

Channel sinuosity is a dimensionless ratio between the channel thalweg length and the valley floor length. Channel sinuosity provides an indication of how the stream channel maintains a balance between sediment load and discharge. Highly sinuous channels dissipate energy along the stream banks. Low sinuous channels have higher bedload transport.

Channel length is the distance between the start and endpoint of the channel segment measured with a hip chain along the stream thalweg. Valley floor length is defined as the straight-line distance between the start and end of the segment measured on an orthophoto. Straight channels are defined as having sinuosity less than 1.5, and are often influenced by structural controls that limit lateral bank erosion. Meandering channels are sinuous, and have a ratio of channel length to

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valley length of 1.5 or greater (Leopold et al. 1964). Meandering channels may have regular or irregular meander bends, and are generally alluvial channels.

23.18 – Substrate

The objectives of the pebble count are to characterize the bed material within a riffle section through a particle size class analysis. Substrate data are used for:

1. Channel type classification.
2. Characterization of the natural range of variability for substrate material within channel types.
3. Indirect index of the channel roughness, stream velocity, and power.
4. Indicator of biological productivity/diversity.
5. Monitoring indicator, particularly percent fines.

23.18a – Sampling Procedure

Streambed materials are characterized by a pebble count (Wolman 1954), which consists of a random selection and measurement of particles from the streambed. A point at the boot tip is used to locate and select individual particles encountered along a transect (23.18a – Exhibit 01).

Two sources of observer bias can significantly influence data precision and repeatability: (1) biased selection by particle size, and (2) errors in measurement of particles (Marcus et al. 1995). The tendency is to select larger rocks. To minimize this source of error, observers should point to the substrate directly in front of a mark at the tip of their boot, objectively selecting the first particle that touches the tip of the index finger. Consistent measurement of particles is assured by the use of calipers or gravel templates. The use of gravel templates is recommended for classifying each sampled particle into a size class. However, if calipers are used, measurements should be taken along the intermediate axis (23.18a – Exhibit 01). Measure the length of streambed particles along the intermediate axis. The intermediate axis of the substrate particle equates to the controlling size for sieved particles.

Establish 5 pebble count transects at each morphology survey site. Take 20 boot tip samples along each transect for a total of 100 particle samples. Transects should be perpendicular to the stream (parallel to the cross section), and extend across the channel bed to the point coinciding with the bottom of the bank, BLB and BRB (23.18a – Exhibit 02). One transect should be along the taped cross section. Two transects should be made upstream from the tape, and two transects downstream from the tape. If the riffle is large enough, transects should be located in 5 m increments away from the tape. The objective is to sample proportionately across the entire channel bed (not just the wetted bottom), and to capture within-site variability along the longitudinal profile.

In general, pebbles should be selected at a uniformly spaced interval obtained by dividing the measured channel bed width by five to determine the distance between samples. Some latitude is allowed in spacing so that each particle is independent of the previous one to avoid problems with serial correlation. Serial correlation can be avoided by establishing a sampling interval that is at least as far apart as the largest dominant size of material in the reach (something around the

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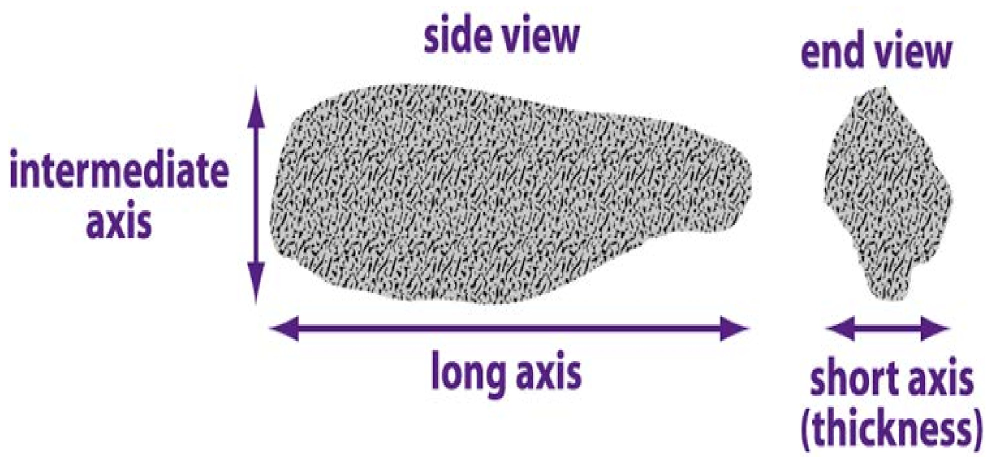
d95 size, that is, not necessarily the largest rocks found in the section). Avoid measuring individual particles more than once, and have individual particles far enough apart so as not to influence each other. Reaches with bedrock will often violate this guideline.

Substrate sample measurements are made along the intermediate axis of the substrate particle (23.18a – Exhibit 01), and particles are classified and tallied within one of twelve size classes on the morphology data card (22.5 – Exhibit 01). Alternatively, individual substrate particle measurements may be recorded to the nearest millimeter.

23.18a – Exhibit 01
Substrate Sample Measurements



23.18a – Exhibit 02 is a separate document.

23.18b – Particle Size Analysis

Sediment particle size data can be plotted to develop a particle size distribution curve (23.18b – Exhibits 01 and 02). The median particle size “d50” is the diameter where 50% of the substrate sample size distribution is finer, and 50% coarser. The d50 is useful for modeling sediment transport and the transport capacity of the channel (Knighton 1987). The d50 metric also provides some insight into the biological capability of that stream. Channels dominated by d50 that correspond to sands or silts generally have a lower diversity of aquatic macro-invertebrates. Fine sediments tend to have lower productivity of salmonids unless an abundance of macrophytes are present. Shifting sands afford poor food conditions and attachment sites for aquatic invertebrates (Merritt and Cummins 1996). Fissures and interstitial spaces in the substrate may provide rearing habitats for insects and small fish.

The “d84” is used in WinXSPRO stage discharge estimates as an indirect indicator of channel roughness. To quickly determine the d50 and d84 values, draw a line from the 50 and 84% cumulative frequency distributions on the Y-axis line to the plotted cumulative frequency curve. At the intersection, draw another down to the substrate class on the X-axis (23.18b – Exhibit 02). Interpolate if the lines fall between 2 size classes, and use the median value for that size class.

-continued-

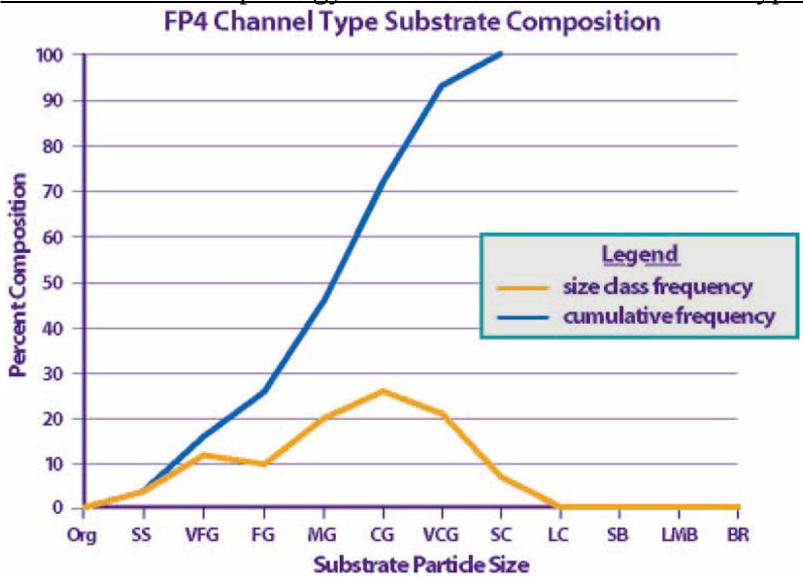
Surface particle size data can provide an assessment of the impacts of management-related disturbances. Differences between disturbed and undisturbed areas may be traced back to sediment sources such as eroding banks, road fill failures, timber harvest-initiated landslides and debris torrents, or mine tailings. Statistically significant changes to the d50 size, a measure of central tendency, using standard statistics are difficult to demonstrate partly due to the naturally large range of sizes included in the distribution. Furthermore, most management-related sediment issues are related to introduction of fine sediment into streams. A change in the percentage of a selected reference size (for example, less than 4 mm) has been shown to be a more sensitive measure of changes to substrate composition than measures of central tendency. Changes to the percent reference size can be analyzed using contingency tables and the Chi-square statistic (King and Potyondy 1993). Repeated measurements of particle size distributions through time can reveal changes and effects influenced by land management activities. For example, if the substrate size distribution at a particular section decreases through time, a review of activities in the watershed may indicate a correlation with a road failure located upstream. Similarly, a heavy accumulation of logging slash may trap fine sediments and lead to changes in substrate characteristics.

23.18b – Exhibit 01 [Compare these to the ones in the_FD table]
Example of Substrate Composition Data from a Flood Plain Channel (FP4)

Substrate	Code	Size class (mm)	% composition
Organic	ORG	Organic	0
Sand/Silt	SS	< 2	4
Very Fine Gravel	VFG	2–3.9	12
Fine Gravel	FGR	4–7.9	10
Medium Gravel	MGR	8–15.9	20
Coarse Gravel	CGR	16–31.9	26
Very Coarse Gravel	VCG	32–63.9	21
Small Cobble	SC	64–127.9	7
Large Cobble	LC	128–255.9	0
Small Boulder	SB	256–512	0
Lg/Med Boulder	LMB	>512	0
Bedrock	BR	Bedrock	0

-continued-

23.18b – Exhibit 02
Frequency Distribution for Substrate Composition Data
Collected at a Morphology Site in a Flood Plain Channel Type (FP4)



23.19 – Discharge Estimate (optional for Tiers II and III)

Discharge can be measured directly or derived from channel morphology measurements (for example, stream gradient, cross section, and particle size). The precision of the indirect method (WinXSPRO Analyzer), sensitive to channel conditions, is best suited for streams with uniform flow.

Direct discharge measurement by the float method (Harrelson et al. 1994).

1. Measure and mark two points, two to three channel widths apart near the cross section.
2. Toss a float into the channel and record the time required to travel the measured distance.
3. Repeat the procedure several times at different distances from the bank to get an average surface velocity.
4. Multiply the average by 0.85 to calculate a mean velocity, then multiply the mean velocity by the cross sectional area to calculate discharge (Q = V * A).

For measurements requiring greater accuracy, surveyors should follow the techniques outlined in *Discharge Measurements at Gaging Stations* (Buchanan and Somers 1969). Floats should be dense and float at least halfway under the surface of the water so as to be transported by the current, but unaffected by wind yet still visible at the surface.

The indirect method uses the WinXSPRO Channel Cross Section Analyzer. The program can be used to calculate discharge estimates for different stages using data collected for the morphology surveys. Accuracy of the analysis depends upon the stream reach conditions. Marked changes in

-continued-

channel geometry and discontinuities in flow (that is, steps, falls, hydraulic jumps, pools and backwaters) should be avoided.

23.2 – STREAM SURVEY

23.21 – Length of Stream Surveyed

Record the length of stream surveyed for each channel type.

For each habitat survey, record the length of stream surveyed for each channel type. Evaluations of habitat quality will be based on the number of pools and of pieces of large wood per unit length of stream. It is generally not possible to sum all the habitat units to determine survey length. Habitat units often lie parallel within a length of stream, not in a strictly linear arrangement. Consequently, summing the unit lengths can greatly overestimate the survey length. During the survey, run a hip chain up the center line of the channel (midway between the banks) to keep track of the distance of stream covered by the survey.

23.22 – Channel Bed Width

Record channel bed width measured at a distance of every fifth approximate average channel bed width (see section 23.13 – Average Channel Bed Width).

23.24 – Beaver Pond

Estimate the area of beaver ponds (average length x width in m^2) and record the location of beaver ponds as left bank, right bank, or main channel.

Beaver ponds are often large, complex, and difficult to circumnavigate. Use a tape or range finder to estimate the pond surface area. Include all ponds that would be connected to the stream during bankfull flow, and estimate the average length and width in meters. Do not include beaver dams built on flood terraces above the bankfull zone. For both main channels and side channels, record the location of beaver ponds as left bank, right bank, or main channel. Aerial photos should be used to supplement the beaver pond data obtained during surveys. In channels with a series of beaver ponds (for example, PA5), it is usually not possible to get an accurate count of LWD in either the pond or dam.

23.3 – LARGE WOOD

For the Tier II survey, count all pieces that meet minimum qualifying dimensions and that are within the bankfull width of the stream zones 1 and 2 (23.33 – Exhibit 01) such that the total count includes key pieces. Identify, and tally separately, how many of those qualifying pieces are key pieces (23.32 – Exhibit 01). Do not count wood in beaver ponds or dams.

23.31 – Minimum Qualifying Dimensions

Count all pieces of wood (including rootwads) that meet the following minimum dimensions:

Diameter = 0.1 m (measured at widest point) and length = 1 m

-continued-

23.32 – Key Pieces of Large Wood

Large wood plays an important role in stabilizing banks, moderating the transport of sediments, providing cover, and in forming pools. The functional role of wood in a stream depends on its size relative to the size of the stream. In very large rivers, a small piece of wood does not stay in place as long as a big piece or a cluster of pieces, and is not likely to play as important a role in channel forming processes. Wood pieces that are large relative to the channel size have important geomorphic functions, and are termed key pieces. The minimum dimensions of key pieces are described for ranges of average channel bed width (23.32 – Exhibit 01).

When conducting the count of all qualifying pieces (that is, total pieces), do not count any piece of wood twice even if it spans more than one habitat unit, or zone, or also qualifies as a key piece stem and/or rootwad. Key pieces of wood simply represent a special subset of qualifying pieces.

For Tier II surveys, there should be 2 data fields: one to tally qualifying pieces of LWD, and one to tally qualifying key pieces. A single piece of large wood (for example, tree) may have both a rootwad and stem that meet minimum qualifying dimensions for key pieces. Tally such a tree as a single key piece.

Example: While surveying a stream, Fred Fishsqueezer encounters a spruce tree lying across the stream within zones 1, 2, 3, and 4. At least one meter of the tree lies within portions of two macro pools, a riffle, and a beaver pond. Fred uses professional judgment, and assigns the tree to one of the two pools. He does not include the tree in the other habitat units, since he has already counted it with the pool. The entire tree counts as a single LWD piece.

Fred's tree also qualifies as a key piece. Both the rootwad and stem exceed minimum qualifying dimensions for a key piece, but it is still tallied as a single key piece.

Large woody debris tallies provide a useful metric to describe stream habitat characteristics. Perhaps more important than the quantity of LWD, is the presence of large pieces. Large pieces anchor accumulations that create complex habitats, and interact with flow in channel formation. Long-term stability is a function of channel size and power, the shape and size of the wood, the proportion of wood that lies in the flood plain, orientation with respect to streamflow, and the degree to which the wood is anchored or bedded into the streambed or stream bank (Bilby 1984). Bilby and Ward (1989) showed a strong positive relation between the length and diameter of stable debris and channel width. Stable wood pieces are assumed to provide persistent fish habitat. Such large stable wood is termed key pieces. Minimum key piece diameter and stem length dimensions are identified according to average channel bed width (23.32 – Exhibit 01). Murphy and Koski (1989) determined key piece dimensions for Southeast Alaska.

-continued-

23.32 – Exhibit 01

Large Wood Key Piece Dimensions by Average Channel Bed Width

Average channel bed width (m)	Key piece diameter (m)	Key piece stem length (m)	Rootwad diameter (m)
0–4.9	0.3	>3	>1
5–9.9	0.3	>7.6	>3
10–19.9	0.6	>7.6	>3
≥20	0.6	>15	>3

23.33 – Zones and Special Cases

There are four zones of influence for large woody debris (23.33 – Exhibit 01) (Robison and Beschta 1990). Zone 1 is within the wetted width. Zone 2 is the area within the bankfull width that is above wetted height and below the bankfull height. Zone 3 is the space within the bankfull width and above the bankfull height. Zone 4 is everything that occurs outside the bankfull width. All qualifying boles and rootwads with at least one meter within zones 1 or 2 must be counted (no matter how many zones the large wood occurs in, count as only one piece). All qualifying dead wood should be included in the count, regardless of orientation (that is, standing, down or leaning). Qualifying living trees may be included if they contribute to the formation of pools. That would normally not include Sitka alder branches that arch out over the water, red alder on vegetated bars, or trees on flood plains that may be swept by high flows, unless they contribute to pool formation (23.33 – Exhibit 02). Wood positioned within the bankfull width but elevated above the bankfull height is in zone 3. Those pieces are normally not included in large wood counts unless 1 m or more of that piece extends into zone 2. The exception is for wood stacked in a pile from the streambed (as opposed to wood suspended from a bank). In cases where wood is stacked from the streambed, count all pieces including those with less than 1 m within zone 2.

23.4 – DISTURBANCE

Measure and record the length and type of disturbed stream bank and record the stream bank location. The disturbance should originate at or above the bankfull elevation.

Stream bank erosion is a key indicator of channel condition or stability. Stable banks maintain or help restore low width-to-depth ratios and provide favorable habitat for aquatic and riparian dependent wildlife. A change in the measure of disturbance to a stream bank may indicate a shift in equilibrium within a stream, and trigger a more intensive search for the source.

For both the right and left banks, record the length of stream (m) that is disturbed and greater than 1 m in length. Also record the type of disturbance. Only record the length of disturbance at the source (that is, do not estimate downstream impacts). For example, if the disturbance is blowdown or mass movement, it is likely that logs or sediment from the disturbance will be deposited along the bank downstream. Do not include this downstream area in your

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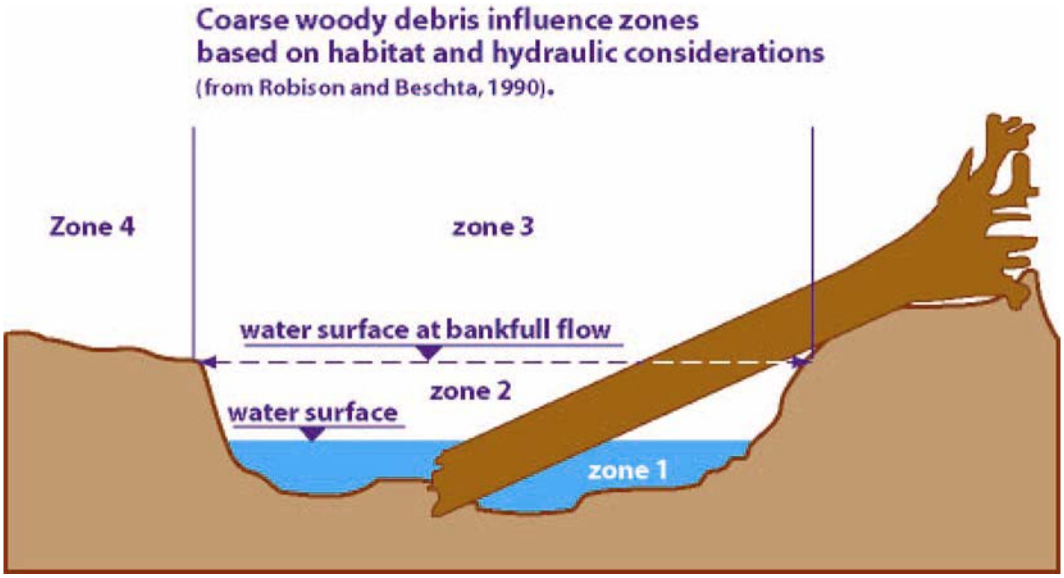
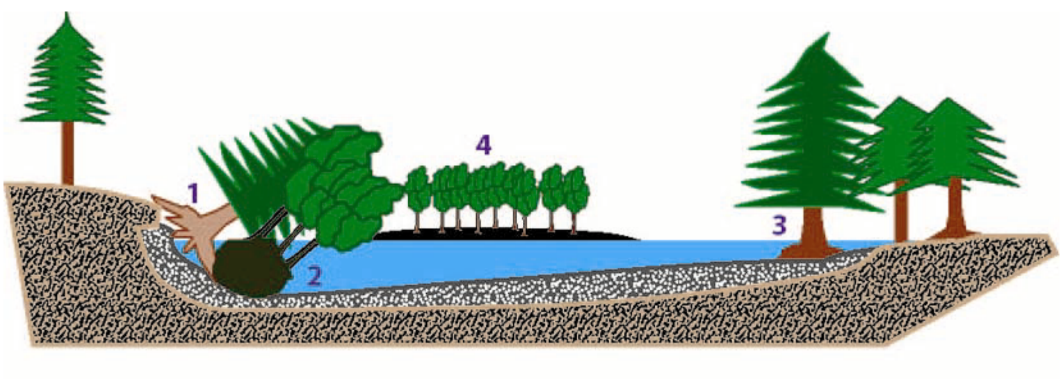
23.33 – Exhibit 01
Large Wood Zones of Influence (Robison and Beschta 1990)



23.33 – Exhibit 02
When Standing or Partially Standing Trees Qualify as Large Woody Debris



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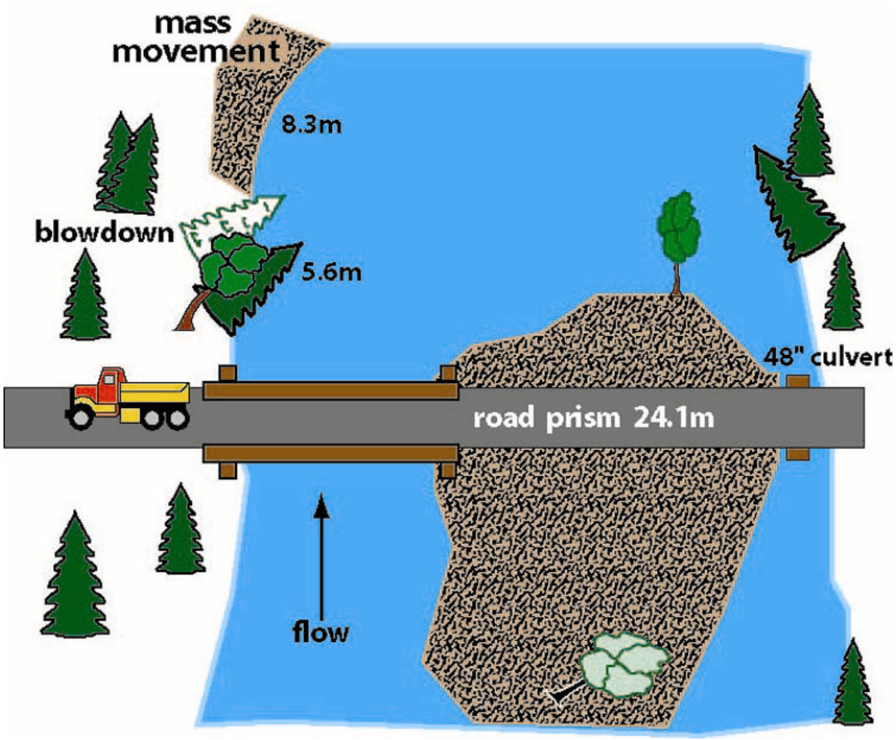
measurement. Roads should be within two channel bed widths and affect the stream if they are to be counted. Restrict the length of disturbance to those portions of the bank where the impact entered the stream (23.4 – Exhibit 01).

Measure and record the length and type of disturbed stream bank and record the stream bank location. Disturbance type may be identified as one of the following categories: mass movement (MM), road (RD), blowdown (BD), or other (OT).

23.4 – Exhibit 01
Stream bank Disturbance That Directly Impacts the Stream



23.5 – Stream Buffer

Measure and record the length (m) of stream bank bordered by timber harvest, classify the average buffer width, and record stream bank location (orientation facing downstream).

Measure and record the length of each bank that is bordered by timber harvest. Include all ages of clearcut through the stem exclusion phase of regeneration. Estimate and record the average width of the stream buffer perpendicular to the stream within one of five categories: no harvest, no buffer, 1 to 29 m, 30 to 60 m, or greater than 60 m. Buffer width should be determined from the edge of the bankfull channel or side channel to the stump. Blowdown within the buffer or large spacing between trees (for example, palustrine channel type) should not affect the buffer width estimate. Record the stream bank location of each buffer as left bank, right bank, or both

-continued-

banks oriented facing downstream. While this information will provide a general record of harvest activity, for monitoring purposes follow the procedures outlined in *Buffer Effectiveness Monitoring Protocol*[2].

23.6 – SIDE CHANNEL MEASUREMENTS

Measure and record the following:

1. Measure and record the length of all side channels.
2. Record the stream bank location (left or right bank) and distance of side channel inlet and outlet relative to an LLID or GIS segment node.
3. Record approximate average channel bed width of side channel.
4. Record minimum required residual pool depth.
5. Record channel bed width measured at a distance of every fifth approximate average channel bed width.
6. Record whether the channel is flowing, intermittent, or dry.
7. Record the number of qualifying macro pools.
8. Record the number of qualifying pieces of large wood.
9. Record the number of key pieces scaled to the average channel bed width of the side channel.
10. Record maximum pool depth and pool tail crest depth.

Side channels can provide extensive fish rearing habitat and refuge from floods, particularly in large flood plain channels. Arbitrarily bypassing a side channel during a survey will give an erroneous indication of habitat complexity and quality. Include all side channels across a valley regardless of size or current flow stage.

To distinguish a side channel from a braid, consider the stability of the intervening island with respect to size and permeability. The intervening island should be at least as long as the bankfull width of the channel. Given that rule-of-thumb for size, permanent vegetation or cohesive soil between the channels, and lack of interconnections other than at bankfull flows, denotes a side channel. For all side channels that appear active at some time during the year, measure length and average channel bed width.

A field-derived average channel bed width is needed to assess macro pool and LWD key piece-qualifying criteria, and to establish intervals to measure channel bed width throughout the channel. Calculate the approximate average channel bed width from three width measurements taken at distances equal to approximately five times the first channel bed width measurement. Measurements should occur at every fifth channel bed width throughout the channel to enable more accurate calculation of channel bed width for the entire side channel. Side channel lengths must be kept separate from the main survey length.

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[2] Kelliher, D. Buffer effectiveness monitoring protocol 1999. USDA-Forest Service, Tongass National Forest, unpublished.

Channel bed width and length provide a measure of potential habitat area, but flow stage also influences the availability of that habitat. Record flow stage as flowing (continuous), intermittent, or dry. Channels with discontinuous flow or isolated pools should be recorded as intermittent. Dry channels have no pooled or standing water.

The location of the upstream and downstream ends of the side channel should be recorded with respect to both distance from major tributary or channel type change, and left or right bank alignment. Record distance measurements at the center of the side channel where it joins the main channel.

23.7 – FISH DISTRIBUTION

Note fish presence by species at the end of each stream segment. Record latitude and longitude or other location indicator of upstream limit of fish in-hand for inclusion in the Alaska Catalog of Anadromous Waters.

Check for presence of fish in Class III and Class IV stream reaches. Record at least once per stream class. Note that lack of detection does not conclusively preclude the presence of fish.

23.71 – Fish Migration Barriers

Complete fish barrier information on the morphology data card (22.5 – Exhibit 01). Record the location of the barrier (latitude and longitude or hip chain distance, distance from a major tributary mouth).

The adult salmonid migration blockage table (22.6 – Exhibit 01) provides objective criteria to evaluate fish migration barriers. A morphology data card (22.5 – Exhibit 01) should be completed for barrier falls that cause a change in the stream classification, or that present an enhancement opportunity. This is in addition to stream morphology data recorded at least once per channel type at a representative riffle.

Accurately locate each fish barrier and record the following information:

1. Barrier type (beaver, debris dam, vertical falls, chute/cascade, culvert, boulder, manmade dam, other).
2. Temporal nature (ephemeral or permanent).
3. Maximum height of falls or biggest single step if cascading (m).
4. Maximum depth of plunge pool (m).
5. Chute/cascade gradient and length (m).
6. Culvert perch height relative to the hydraulic control (if applicable).

Some hydro-geomorphic blockages may persist for decades, yet ultimately are ephemeral (Wiedmer 1999). A draft State of Alaska barrier classification system discusses these as ephemerally fixed, hydro-geomorphically dynamic barriers. In such cases, current upstream migration appears blocked by hydrological or geomorphic conditions, although landscape-scale conditions are in flux over brief geologic time. Examples may include mass wasting, responses to tectonic disturbance, glacial advance or retreat, and dynamic channel formation.

Additional portions of the morphology data card (22.5 – Exhibit 01) may be pertinent, depending on survey objectives. For example, if a fish ladder has enhancement potential, then stream gradient, a cross sectional profile, and boot tip substrate surveys can provide information useful to design engineers.

APPENDIX B: ADF&G-SF TRIP REPORTS

Appendix B1.–ADF&G-SF pre-trip summary report format.

ADF&G-SF Pre-trip Summary/Description Report

Project Name:____________________

Number of field trips scheduled under project:_______________

Location:____

Dates and duration of field trip(s):____

____

Personnel: (list crew members who will be present for each trip)____

____

Project objectives: (list or describe the objectives of the field trip as discussed before leaving for the field)________

____

____

Issues needing resolution: (list specific details related to any concerns that require input from outside entities)_____

____

____

Equipment needs: (transportation, culvert gear, traps and bait, etc.)____

____

____

Outputs: (list reports and/or data that will be generated and for which agencies or private entities)________________

____

____

Landowners: (list all landowners for the project area)____

____

Contact person/information: (include landowner, engineer and/or AMB involved)___________________________

____

____

Appendix B2.–ADF&G-SF trip summary report format.

ADF&G-SF Trip Summary Report

Project Name:____________________

Number of field trips under project:________________________

Location:____

Dates and duration of field trip(s):____

____

Personnel: (list crew members who were present for each trip)____

____

Project objectives: (list or describe the objectives of the field trip as discussed before leaving for the field)________

____

____

Trip summary: (in narrative form, describe how and if project objectives were met)___________________________

____

____

RCS highlights: (bring attention to RCS related tasks completed; for example: # of stream crossings, # of culverts (and condition), severe road condition problems, etc.)____

____

AWC highlights: (bring attention to AWC issues; for example: total # of anadromous streams encountered, # of new anadromous streams which need to be nominated, # of anadromous streams which need to be revised (upper extent, poor location, etc.), and other relevant notes)____

____

Issues needing resolved: (list specific details related to any concerns that require input from outside entities)______

____

____

Status of data: (include whether data has been entered, whether photos and waypoints have been downloaded, and whether spreadsheets and maps have been created and organized into the appropriate folders)___________________

____

Work needing to bring project to completion: (include a brief summary of what steps are necessary to bring project to completion (i.e., does data still need to be entered or checked for QC or is more field work required?))_________

____

____

Contact person/information: (include landowner, engineer and/or AMB involved)____________________________

____

Trip summary completed by:____

Date:_______________________

APPENDIX C: ADF&G-SF TECHNICAL GUIDELINES FOR GPS UNIT INITILIZATION, POSITION ACCURACY, DATUM SETUP, AND GPS USE

INITIALIZATION

To initialize a unit for the first time, take the GPS receiver outside with a clear, 360 degree field of view and turn it on. Navigate through the LCD display until the unit is acquiring satellites. The unit will begin acquiring fixes on satellites and storing the orbital data for each satellite in an almanac, which is stored and remembered in the unit. This setup should complete the initialization of the unit.

The following steps ensure that GPS units by different manufacturers are collecting comparable data and that the position error (accuracy) is recorded with field data. Map datum should be set to NAD 83 (North American datum). Observers should always verify that a waypoint was recorded in the memory of the unit; methods are outlined below for "marking" a waypoint, which is the mechanism allowing storage of waypoints for GPS units.

Garmin 12XL

Datum setup:

1. Go to the navigation setup page
2. Select the "MAP DATUM" field and press *Enter*
3. Select "NAD 83" and press *Enter*

Determine position accuracy:

1. Use the Position Averaging Function when marking a waypoint.
2. After you have pressed the *Mark* key, highlight the "AVERAGE?" field and press *Enter*.
3. The Figure of Merit (FOM) field will display an estimate of accuracy of the averaged position. The FOM will continue to change and gradually stabilize as the GPS unit gets more positions. Record this value every time you record a position (i.e., latitude and longitude).

Garmin GPS 76

Datum setup:

1. Go to Main Menu (hit menu button twice from any screen)
2. Arrow down to Setup and hit enter
3. Arrow right to Location and hit enter
4. Arrow down to Location Format and hit enter
5. Select decimal degrees as format (hddd.ddddd°) and hit enter
6. Arrow down to Map Datum and hit enter
7. Select NAD83 Alaska and hit enter

Determine position accuracy:

If three or more satellites are acquired, the GPS unit will automatically give an accuracy reading, which is located at the top right corner of the LCD display. Make sure to record this accuracy (or error) in feet along with the associated waypoint number.

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Magellan GPS 315/320

Datum setup:

1. Press the *Menu* key and select “SETUP” and press *Enter*
2. Select “MAP DATUM” and press *Enter*
3. Select “PRIMARY” and press *Enter*
4. Select datum (NAD 83) and press *Enter*

Determine position accuracy:

1. Go to the “POSITION” screen
2. Record the EPE (Estimated Position Error) located below the date

MARK A WAYPOINT

The unit has to be turned on and receiving at least three satellites to mark a waypoint.

To mark a waypoint, press and hold the ENTER key. When you hold the ENTER key the GPS unit captures its current position and displays the Mark Waypoint Page. The "Ok" button is highlighted. Pressing the ENTER key will store the new waypoint using the default settings for the symbol and name.

CHANGE THE NAME OF A WAYPOINT

Press the MENU key twice to display the main menu. Highlight "points" and press ENTER again. Select the desired waypoint from the list and press ENTER to display the Waypoint page. Place the highlight over the name field and press ENTER. Using the ROCKER key scroll through the alpha-numeric list and make a selection. To move to the next placeholder, press the ROCKER to the right. When finished, press ENTER to accept the changes.

GO TO A WAYPOINT

Press the NAV key. Highlight "go to point" then press the ENTER key. Highlight "waypoints" then press the ENTER key. Highlight the waypoint you want to navigate to and press the ENTER key. Highlight the "goto" button and press the ENTER key.

The GPS is now navigating to the chosen waypoint. (For a GPS to navigate it has to be moving.)

The Pointer Page displays a Pointer and Compass Ring. The Pointer will always point toward your destination while the Compass Ring reflects the direction you are traveling. In short, when you are headed directly toward your destination, the Pointer will be pointed toward the top of the display, aligned with the vertical line on the Compass Ring. If you are no longer heading toward your destination, the Pointer will turn away from the top of the display to point toward your destination. To get headed toward your destination again, turn until the Pointer is realigned with the vertical line in the Compass Ring and pointed toward the top of the display.

APPENDIX D: ADF&G-SF DATASHEETS ASSOCIATED WITH STREAM SURVEYS

Appendix D1.–ADF&G-SF stream survey datasheet, including descriptions for the header information and data fields included on the datasheet.

ADF&G Stream Survey Datasheet

DATE____________ CREW____________________ PROJECT CODE__________________

GPS UNIT LETTER_________ CAMERA___________ PAGE____ of_____

DIRECTION OF SURVEY: UPSTREAM/DOWNSTREAM (circle one)

Way-point	Error (m)	Feature	Locale	Locator	Feature Length (m)	Culvert Diameter (inches)	Disturbance Feature Class	Barrier Height (m)	Barrier Pool Depth (m)	Barrier Gradient (%)	Picture Number	Photo Direction (U/D)	LWA Complete/ Incomplete

Date: survey date (mm/dd/yyyy).

Crew: survey crew initials.

Project Code: the five-character code identifying the project the data was collected under.

GPS Unit Letter: unique letter identifying the GPS unit used to collect the waypoints.

Camera: camera model (uniquely identified if multiple were used).

Direction of Survey: circle "upstream" if working upstream; circle "downstream" if working in a downstream direction.

Waypoint #: unique waypoint number captured with the GPS to identify features encountered during a survey.

Error: associated GPS error or accuracy (record measurement units if known).

Feature: feature code representing the feature or measurement performed at that waypoint (Appendix E1).

Locale: macro-habitat where waypoint was captured; 1 of 4 options:

MCH = main channel
SCH = side channel
SLO = slough
BPM = on beaver pond margin

Locator: refers to which bank a stream bank oriented feature occurs on; 1 of 4 options:

LB = left bank
RB = right bank
BB = both banks
SS = spans entire stream channel

Feature Length: length (m) of features warranting additional information.

-continued-

Culvert Diameter: horizontally measured diameter of a culvert measured at the culvert's widest point.

Disturbance Feature Class: code used to classify riparian disturbances, barriers, and stream crossing structures.

Barrier Height: height (m) of features warranting additional information.

Barrier Pool Depth: depth (m) of barrier pool if one is present.

Barrier Gradient: gradient (% or degrees and minutes) of a barrier feature.

Picture Number: picture file number if photograph was captured.

Photo Direction (U/D): direction photo was taken; 1 of 2 options:

U = facing upstream
D = facing downstream

LWA Complete/Incomplete: when a large wood accumulation (LWA) is recorded for a feature code, observers should record if the LWA completely traverses the stream from bank to bank or if it was incomplete.

Appendix D2.–ADF&G-SF reach datasheet, including descriptions for the data fields included on the datasheet.

ADF&G Reach Datasheet

DATE_________________ CREW________________ PROJECT CODE_______________

GPS UNIT_____________ CAMERA______________ PAGE__________of__________

Reach #	Channel Type	Bottom of Reach Waypt	CTV Waypt	Top of Reach Waypt	Average Stream Gradient	Incision Depth	Bankfull Width	Bank Comp.	Channel Pattern

stream gradient measure (dist. measure):

Bottom of reach (up)__________(m)

CTV (down)________________(m)

CTV (up)__________________(m)

Top of reach (down)__________(m)

Riparian Vegetation Codes:

Left Bank	Right Bank
0-5 m___________	0-5 m___________
5-10m___________	5-10m_________
10-20m_________	10-20m_________
20-30m _________	20-30m _________

Substrate & Geology

Size Class

Dominant Substrate: _______________ Sub dominant Substrate:____________

Next sub dominant Substrate:_______________

Channel Bed Widths (CBW)____

Average CBW:_____________

Reach Counts

Large Wood____Total Count_______________

____

____

KEY Wood____Total Count_______________

____

____

Macro Pools *(tally)*:____

____________________________________Total Count_______________

count as pool if Residual Pool Depth ≥ ((avg. cbw) x 0.01) + 0.15 AND pool length ≥ 0.10 x acbw (residual pool depth=max pool depth-depth @ tailcrest)

Note: Header information is described in Appendix D1.

-continued-

Reach #: sequential number for each individual stream reach encountered on a project.

Channel Type: Tongass channel type of the stream reach (see Appendix K1 for possible values).

Bottom of Reach Waypt: unique waypoint number associated with the downstream end (BRK) of the reach.

CTV Waypt: unique waypoint associated with the CTV point.

Top of Reach Waypt: unique waypoint number associated with the upstream end (BRK) of the reach.

Average Stream Gradient: average stream gradient of reach (%).

Incision Depth: vertical distance (m) between the first major slope break above bankfull stage and the channel bottom at the thalweg (Figure 6).

Bankfull Width: horizontal distance (m) between the lateral extent of water surface elevation at bankfull depth (Figure 7).

Bank Composition: dominant material composing the stream bank; 1 of 4 choices:

Alluvium - unconsolidated material
Bedrock - bedrock controlled
Mixed - mixture of alluvium and bedrock
Organic Mat - composed primarily of organics

Channel Pattern: dominant pattern of the surveyed channel; 1 of 3 choices:

Singular - stream consists of single channel
Multiple - dominated by off channel habitat
Braided - dominated by braids

Stream Gradient: four entries are provided which capture the stream survey gradient measure and the distance the gradient (m) was measured over.

Dominant Substrate: most dominant substrate in streambed (Table 1).

Subdominant Substrate: next most common substrate in streambed (Table 1).

Next Subdominant Substrate: third most common substrate in streambed (Table 1).

Channel Bed Width: horizontal distance (m) between bottoms of left and right bank.

Average CBW: average (m) of at least three measures of channel bed width.

Large Wood (tally): number of large wood pieces (> 10 cm diameter and 1 m in length) within entire reach.

Key Wood (tally): number of key wood pieces scaled by average CBW (Table 2) within entire reach.

Macro Pools (tally): number of macro pools scaled by average CBW (Appendix H1) within entire reach.

Riparian Vegetation Codes: dominant vegetation community code (Appendix G1) found on both banks (right bank and left bank) at four distinct distance classes from stream bank and recorded for both the left bank and right bank.

Appendix D3.–ADF&G-SF side channel datasheet and field definitions, including descriptions for the data fields included on the datasheet.

ADF&G Side Channel Datasheet

DATE__________________ **CREW**_________________ **PROJECT CODE**_______________

GPS UNIT______________ **CAMERA**_______________ **PAGE**___________**of**___________

DIRECTION OF SURVEY: UPSTREAM/DOWNSTREAM (circle one)

Reach # / Side Channel Identifier*	Bottom of Side Channel Waypt	Top of Side Channel Waypt	Side Channel Attribute Waypt	Length of Side Channel Surveyed (meters)	Flow

Channel Bed Width's:____

Average CBW:___________

Large Wood *(tally)* :____

____

(> 0.1 m diam. And ≥ 1.0 m length)

Key Wood *(tally)* :____

Macro Pools *(tally)* :____

count as pool if Residual Pool Depth ≥ ((avg. cbw) x 0.01) + 0.15 AND pool length ≥ 0.10 x acbw

residual pool depth = max pool depth - depth at tailcrest

Note: Appendices D1 and D2 describe all header and data field information on this form with the exception of the following:

Length of Side Channel Surveyed: the length, in meters (measured with a range finder, measuring tape, or hip chain), of the side channel surveyed. If segment(s) of the side channel were not surveyed due to lack of surface flow, these segments should not be included in the length measurement.

Flow: describes the presence of surface flow in the side channel; 1 of 3 choices:

Dry - surface flow not present
Intermittent - surface water present but not continuously covering streambed over the side channel's length
Continuous - surface water present throughout side channel

Appendix D4.–ADF&G-SF fish observation datasheet, including descriptions for the data fields included on the datasheet.

ADF&G Fish Observation Datasheet

DATE____________ CREW____________________ PROJECT CODE______________

GPS UNIT_________ PAGE_______OF __________

Way-point	Capture Method	# of traps	Time In	Time Out	Water Temp	Meso Habitat	Species	Count	Life Stage	Comments

Note: Header information is described in Appendix D1.

Waypoint: unique waypoint number associated with the FOP.

Capture Method: type of fish observation; 1 of 5 options:

MTR - minnow trap
VOG - visual observation on the ground
SEI - seine, any kind
DIP - dipnet
SRK - snorkel/scuba

# of Traps: number of traps used, if capture method was MTR.

Time In: time (military) traps were placed in location to soak.

Time Out: time (military) traps were removed and checked.

Water Temp: water temperature (°C).

Meso-habitat: unique habitat that FOP was observed in/at

BW - backwater pool
SR - scour pool
CS - cascade
GL - glide
RF - riffle
SL - slough

Species: species encountered at FOP (see Appendix I1 for complete list).

Count: number of fish counted, by species, at FOP.

Life Stage: life history stage of fish encountered at FOP

ADT - adult
JUV - juvenile (sexually immature)
YOY – young-of-the-year
UNK - unknown life stage

Comments: Any associated comments dealing with FOP, including activity (e.g., spawning, rearing, smolting, holding, unknown).

Appendix D5.–ADF&G-SF culvert survey datasheet, including descriptions for the data fields and a figure identifying the features in the data fields.

ADF&G Culvert Survey Datasheet

DATE__________ PROJECT CODE____________________

GPS UNIT_________ PAGE_______ of_________

Crew__________________

Wpt#	Corregations			Substrate				Culvert Diameter (in)	Perch Height (in)	Pipe Gradient (deg/min)	Percent Block		OHW (ft)	Fail Mech.	USFS #
				Depth		Coverage									
	Width(in)	Depth(in)	Spir/Ann	Inlet	Outlet	Inlet	Outlet				Inlet	Outlet			

Note: Header information is described in Appendix D1.

Wpt#: Waypoint number taken originally from the stream survey datasheet.

Corrugation Measurements:

Width (in): Measure the distance between the top of adjacent pipe corrugations.

Depth (in): Measure the depth of the pipe corrugations.

Spir/Ann**:** Note if the corrugations are either Spiral or Annular in type.

Substrate Characterization:

Depth @ Inlet: Measure the depth of substrate at culvert inlet.

Depth @ Outlet: Measure the depth of substrate at culvert outlet.

Coverage @ Inlet: Estimate the % coverage of substrate in culvert at inlet.

Coverage @ Outlet: Estimate the % coverage of substrate in culvert at outlet.

Culvert Diameter: with surveyor's tape, measure the diameter of the culvert horizontally.

Perch Height (in): Measure the distance from the bottom of the culvert to the surface of the water at the culvert outlet.

Pipe Gradient (degrees/minutes): Measure the gradient of the top of the culvert from the inlet to the outlet using an abney level.

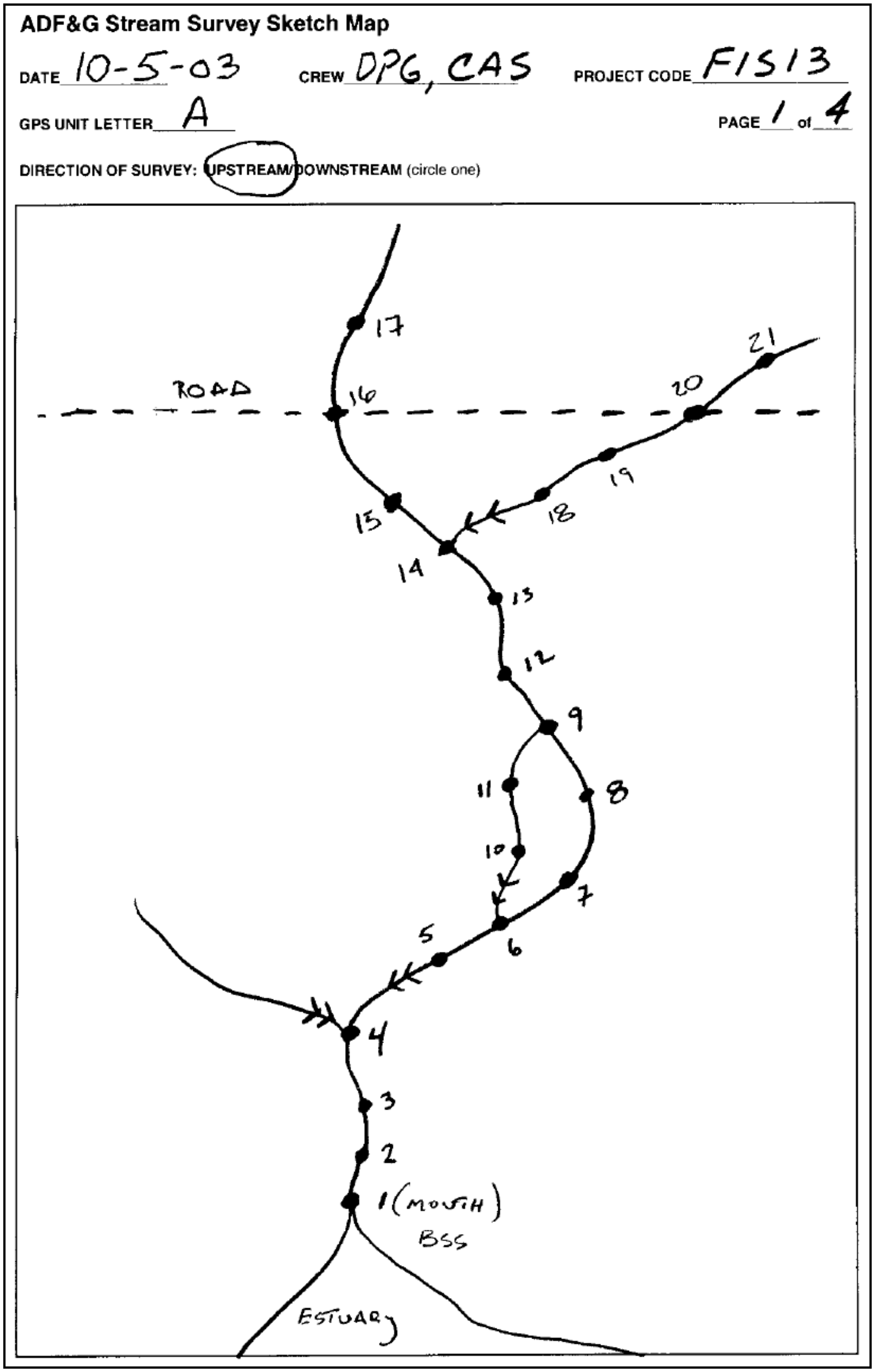
Percent Block: Estimate the % of the culvert opening that is blocked by debris at Inlet and Outlet.

Ordinary High Water (OHW) width (ft): Measure the width of ordinary high water at the culvert inlet.

Fail Mech. (Failure Mechanism): Identify the primary reason (if any) for culvert failure (e.g., damaged culvert, blocked culvert, perched culvert, multiple reasons, etc).

USFS #: Identify the USFS number assigned to the culvert if a tag is present.

Appendix D6.–ADF&G-SF sketch map datasheet.



Note: Header information is described in Appendix D1.

APPENDIX E: FEATURE CODES USED DURING STREAM SURVEYS

Appendix E1.–Table containing feature codes that are used during stream surveys. “R” indicates a field that requires data for that specific feature code. “P” indicates that a photograph is required for that specific feature code.

Feature code	Feature description	Locale	Locator	Feature length	Culvert diameter	Feature class	Barrier height	Barrier pool depth	Barrier gradient	Picture number	Additional fields on separate datasheet
ANB	Abutment w/no bridge									R	
BIA[a]	Bottom of index area	R									
BRG	Bridge, undefined									R	
BRK	Stream reach break	R								P[b]	
BRR[c]	Barrier[c]	R				R	R	R	R	P	
BSS	Begin stream survey	R									
BVP	Beaver pond	R	R								
CBW	Channel bed width										R
CMA	Corrugated metal pipe arch (squash pipe)	R			R					P	
CMP	Corrugated metal pipe	R			R					P	
CON	Confluence	R	R							P	
CPG	Ground control point	R	R							P	
CPP	Corrugated plastic pipe	R	R		R					P	
CTV	Channel type verification point	R								P[b]	R
DIS	Stream flow discharge measurement	R								P	R
DIV	Divergence of water	R	R							P	
EBD	Ephemerally fixed barrier, beaver dam	R					R	R	R	P	
EDJ	Ephemerally fixed barrier, debris Jam	R					R	R	R	P	
EOT	Ephemerally fixed barrier, other	R					R	R	R	P	
ESS	End of stream survey	R								P[b]	
FHA	Fish habitat absent	R	R							P[b]	
FHP	Fish habitat present	R	R							P[b]	

-continued-

Feature code	Feature description	Locale	Locator	Feature length	Culvert diameter	Feature class	Barrier height	Barrier pool depth	Barrier gradient	Picture number	Additional fields on separate datasheet
FOP	Fish observation point	R	R								R
GAG	Stationary gaging instrument	R								P	
GCH	Geologically fixed barrier, chute-high gradient	R					R	R	R	P	
GCS	Geologically fixed barrier, cascade-high gradient	R					R	R	R	P	
GOT	Geologically fixed barrier, other	R					R	R	R	P	
GWF	Geologically fixed barrier, waterfall	R					R	R	R	P	
HWE	Human-induced barrier, weir	R								P	
INC	Survey ended, reach incomplete	R								P	
INL	Point where stream enters lake	R								P	
LGC	Log culvert	R			R					P	
LSB	Log stringer bridge	R			R					P	
LWA	Large wood accumulation	R	R								
MAP	Stream mapping point	R									
MOD	Modular bridge	R									
MOU	Stream mouth at estuary	R									
OCP	Off-channel pool	R	R								
OUT	Point where stream exits a lake	R									
PMB	Permanent (long-term) bridge	R								P	
RDB	Riparian disturbance	R	R	R		R				P	
REF	Reference point	R	R								
RRM	Removed structure	R	R							P	
RSA	Removed stream abutment	R	R							P	
SAP	Side channel attributing point	R								P	R

-continued-

Appendix E1.–Page 3 of 3.

Feature code	Feature description	Locale	Locator	Feature length	Culvert diameter	Feature class	Barrier height	Barrier pool depth	Barrier gradient	Picture number	Additional fields on separate datasheet
SGD	Stream gradient	R								P	R
SSF	Subsurface flow	R									
SSL	Landslide in stream from above	R	R	R		R				P	
SST	Start of stream	R									
SXG[d]	Road crosses stream[d]	R		R	R	R				P[b]	R
TIA[a]	Top of index area	R									
TRB	Tributary	R	R								
UEF	Upper extent of fish habitat	R									

[a] Feature code(s) used specifically for ADF&G-SF (internal program) adult salmonid index surveys.

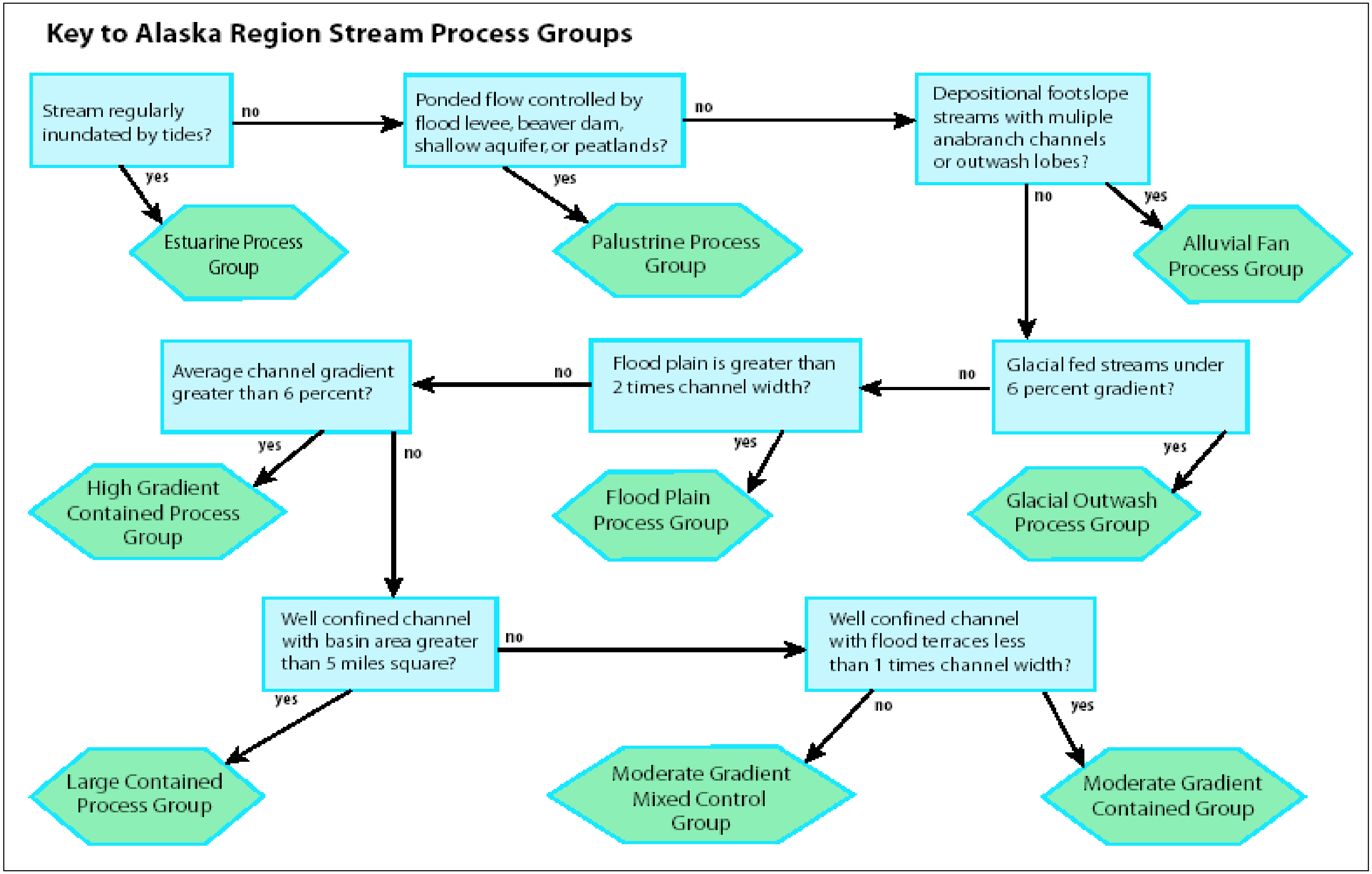
[b] Both upstream and downstream facing photos are required.

[c] The fields required for barriers vary depending on barrier class and gradient; see section above describing barriers.

[d] The fields required for stream crossing structures vary depending on structure class; see section above describing stream crossings.

APPENDIX F: PROCESS GROUP FLOWCHART

Appendix F1.–Flowchart describing the Alaska Region fluvial process groups (from USDA 2001).



APPENDIX G: DIACHOTOMOUS KEY FOR RIPARIAN VEGETATION

Appendix G1.–Dichotomous key to riparian vegetation classes that are commonly observed in Southeast Alaska, adapted from Viereck et al. (1992).

I. Trees >3 m tall with canopy cover of ≥10%. If not, got to II.

IA. >75% of tree cover contributed by coniferous species. If not, go to IB.

IA1. Tree canopy of 60–100%. If not, go to IA2.

IA1a Sitka spruce dominates overstory and regeneration. Occupies wet sites in SE AK, primarily in alluvial flood plains.

IA1b. Western hemlock dominates overstory; other species <25% of overstory.

IA1c. Sitka spruce and western hemlock each contribute >30% cover. Sitka spruce constitutes most of overstory, western hemlock usually provides most of understory. Occurs on moist sites throughout SE AK.

IA1d. Western hemlock dominates. Sitka spruce >25% cover but < western hemlock.

IA1e. Western hemlock and Alaska cedar dominate (each contributes 25–75% of canopy cover). Occurs on a variety of upland sites from sea level to subalpine.

IA1f. Mountain hemlock dominates canopy cover. Occurs near treeline, normally on saturated soil throughout SE AK.

IA1g. Western hemlock and Western red cedar dominate (each contribute 25–75% of canopy). Alaska cedar and mountain hemlock may also be significant. Occurs on low-producing, poorly drained sites in southern SE AK.

IA1h. Silver fir and Western hemlock dominate (each contributes 25–75% of canopy cover). Sitka spruce and western red cedar may also be important. Limited distribution in southernmost SE AK.

IA1i. Subalpine fir dominates canopy cover. Other important species include Sitka spruce, mountain hemlock, and Alaska cedar. Occurs I scattered locations near treeline in SE AK.

IA2. Tree canopy of 25–60% cover. If not, go to IA3.

IA2a. Sitka spruce dominates overstory. Other species <25% of canopy cover. Often occurs in alluvial deposits and glacial moraines and outwash in SE AK.

IA2b. Western hemlock and Sitka spruce dominate overstory (each contribute25–75% of canopy cover). Occurs from low to mid elevations in SE AK.

IA2c. Mountain hemlock dominates overstory. Other trees <25% of canopy cover. Primarily on high mountain slopes in SC and SE AK.

IA2d. Dominated by various combinations of Alaska cedar, western hemlock, Mountain Hemlock, Sitka spruce, lodgepole pine, Western Red cedar, and Pacific yew. Stands with 3–5 overstory conifer species common on level or gently sloping wet sites in SE AK.

IA3. Tree canopy of 10–25% cover.

IA3a. Lodgepole pine dominates overstory. Other species <25% of canopy cover. Generally on boggy, poorly drained sites in SE AK.

IA3b. Sitka spruce dominates overstory. Other species <25% of canopy cover. On poorly drained sedge peat in SE and coastal SC AK.

IB. >75% of tree cover contributed by broadleaf species. If not, go to IC.

IB1. Tree canopy of 60–100% cover. If not, go to IB2.

IB1a. Red alder dominates overstory. Other species <25% of canopy cover.

IB1b. Black cottonwood dominates overstory. Other species <25% of canopy over. Generally along streams in SE and SC AK.

-continued-

IB2. Tree canopy of 25–60% cover. If not, go to IB3.

IB3. Tree canopy of 10–25% cover.

IC. Broadleaf or coniferous species both contribute 25–75% of tree cover.

IC1. Tree canopy of 60–100% cover. If not, go to IC2.

IC2. Tree canopy of 25–60% cover. If not, go to IC3.

IC3. Tree canopy of 10–25% cover.

II. Erect to decumbent (reclining or laying on the ground with the tip ascending) woody shrubs with cover ≥25% OR dwarf trees (<3m tall) with cover ≥ 10% cover. If not, go to III.

IIA. Dwarf trees (<3m tall) with cover ≥ 10% cover. If not, go to IIB.

IIA1. Dwarf tree canopy of 60–100% cover. If not, go to IIA2.

IIA1a. Mountain hemlock dominates overstory. Sitka spruce may be present. Occurs at treeline in SE AK.

IIA1b. Subalpine fir dominates overstory. Mountain hemlock and Sitka spruce may be present. Forms dense stands at elevational treeline in SE AK.

IIA2. Dwarf canopy of 25–59% cover. If not, go to IIA3.

IIA2b. Mountain hemlock dominates overstory. Sitka mountain ash may be present. Common on peatlands and sometimes on exposed ridges in SEAK.

IIA3. Dwarf tree canopy of 10–25% cover.

IIB. Shrubs >1.5 m tall and ≥25% cover dominate. If not, go to IIC.

IIB1. Shrub canopy cover >75%. If not, go to IIB2.

IIB1a. Willow species dominate overstory (<25% other canopy species). Characteristic of floodplains.

IIB1b. Alder species dominate overstory (<25% other canopy species). Common on steep slopes, floodplains and stream banks.

IIB1d. Alder and willow co-dominate overstory. (each contributes 25–75% of canopy cover). Occurs on floodplains terraces and drainages on slopes.

IIB1f. Standing water present most or all of growing season Alder & willow typically dominate. Common in Interior, SC, and SE AK on sites with poorly drained soil and hummocky micro relief with depressions containing standing water.

IIB2. Shrub canopy cover 25–74% OR ≥ 2% IF little or no other vegetation cover resent.

IIB2a. Willow species dominate overstory (<25% other canopy species). Occupies a variety of sites, from dunes to river banks. Most common in Interior, W, SC and Arctic AK.

IIB2b. Alder species dominate overstory (<25% other canopy species). Found throughout state, but not as abundant as closed alder communities.

IIB2d. Alder and willow co-dominate overstory. (each contributes 25–75% of canopy cover). On floodplain terraces and steep slopes near treeline in Interior and N AK

IIB2f. Standing water present most or all of growing season. alder (usually) and Willow typically dominate. Occurs on floodplains and drainages in Interior and SC AK.

IIC. Shrubs 0.2–1.5 m tall and ≥25% cover dominate. If not, go to IID.

IIC1. Shrub canopy cover >75%. If not, go to IIC2.

-continued-

IIC1b. Willow species dominate overstory (<25% other canopy species). Common in Interior, W and N AK along streams and lakes.

IIC1d. Ericaceous (e.g. copperbush Cladothamnus pyrolaeflorus) species dominate. Near treeline in SE AK (copperbush Cladothamnus pyrolaeflorus).

IIC1e. Alder and Willow co-dominate overstory. (each contributes 25–75% of canopy cover). Reported from SE AK on poorly drained soils.

IIC2. Shrub canopy cover 25–74% OR $\geq$ 2% If little or no other vegetation cover present.

IIC2e. Ericaceous species dominate (<25% other canopy species). Wet peal soils. Common in maritime climates of SE and SC AK and Aleutian Is. Hydrophytic sedges and sphagnum mosses generally present.

IIC2i. Willow species dominate overstory (<25% other canopy species); graminoids dominate understory on peat soils (in subarctic and subalpine regions within treeline). Occurs in wet stream bottoms and depressions in Interior, SW, SC and SE AK.

IIC2j. Sweetgale and graminoids dominate on extremely wet (often standing water) on peat soils. Occupies poorly drained lowlands and pond margins in SE, SC and SW AK.

IID. Shrubs < 0.2 m tall and ≥ 25% cover OR ≥ 2% IF little or no other

vegetation cover present.

IID1. Dryas species dominate. If not, go to IID2.

IID1a. Dryas species dominate.

IID1b. Dryas species and sedges dominate.

IID1c. Dryas species and fruticose lichens dominate.

IID2. Ericaceous species dominate. If not, go to IID3.

IID2c. Crowberry Empetrum nigrum dominates.

IID2d. Mountain heath Phyllodoce aleutica dominates. Common on alpine slopes.

IID2e. Cassiope species dominate. Widespread on moist alpine sites.

IID3. Willow species dominate.

III. Herbaceous (non-woody) vegetation dominates with <25% scrub and <10% forest cover. If not, go to IV.

IIIA. Grasses and sedges dominate (rushes and horsetails are treatedas forbs). If not, go to IIIB.

IIIA1. Graminoids dominate on well- to excessively drained sites. If not, go to IIIA2. Grasslands of well drained, dry sites, such as south facing bluffs, old beaches and sand dunes.

IIIA1a. Elymus species dominate. Occurs on beaches, dunes, gravel outwash flats, and dry slopes mostly in coastal areas, but occasionally in AK and Brooks ranges and Interior AK.

IIIA1d. Medium height grasses and broad leaved herbs dominate.

IIIA1e. Hair grasses Deschampsia species dominate. Common in Aleutian Is.and along southern coast of AK. Often diverse stands with small numbers of a great many species.

IIIA2. Graminoids dominate or co-dominate on mesic sites. Grasslands on moist sites, but usually not with standing water (tussocks often present).

IIIA2a. Bluejoint Calamagrostis dominates (includes lawns). Found throughout AK except for SE and Arctic AK. Occupies large areas in SC and SW Alaska. Includes installed and maintained lawns.

IIIA2b. Bluejoint Calamagrostis and herbs co-dominate. Widely distributed in southern half of state.

-continued-

IIIA2c. Bluejoint Calamagrostis dominates with conspicuous shrubs providing <25% cover. Extensive in SW AK and probably also common in SC and Interior AK.

IIIA2d. Sedges in tussock growth form dominate (in arctic and alpine regions beyond treeline). Widely distributed throughout W, N and Interior AK.

IIIA2e. Sedges and grasses dominate in various combinations (in arctic and alpine regions beyond treeline).

IIIA2f. Sedges and broad-leaved herbs co-dominate (in arctic and alpine regions beyond treeline

IIIA2g. Grasses and broad-leaved herbs co-dominate (in arctic and alpine regions beyond treeline).

IIIA2h. Sedges dominate with conspicuous willow component providing <25% cover (in arctic and alpine regions beyond treeline).

IIIA2i. Sedges dominate with conspicuous shrub birch component providing <25% cover (in arctic and alpine regions beyond treeline).

IIIA2j. Sedges dominate with conspicuous dryas component providing <25% cover (in arctic and alpine regions beyond treeline).

IIIA3. Graminoids dominate or co-dominate on wet (saturated or flooded most or all of growing season)

IIIA3c. Sedges and broad-leaved herbs co-dominate (in arctic and alpine regions beyond treeline). Found on very wet, poorly drained sites with standing water, such as oxbow lakes and alpine bogs. Apparently widely distributed throughout AK.

IIIA3d. Tall sedges emerging from standing water (> 0.1 m deep) dominate.

IIIA3e Grasses emerging from standing water (>0.15 m deep) dominate. Common in ponds, slow-flowing streams, lake margins, and thermokarst pits in N and W AK. Depth of water ranges from seasonally flooded to 2 m.

IIIA3f. Coarse, relatively tall Sedges in saturated/shallow soils dominate (in subarctic and subalpine regions within tree limit). Common in very wet areas on floodplains, margins of ponds, lakes, and sloughs and in depressions in upland areas. Reported from W, SC, SE, Interior AK and Aleutian Is.

IIIA3g. Sedges in saturated or shallow flooded(≤ 0.15 m deep) soils dominate with conspicuous shrub component providing < 25% cover (in subarctic and subalpine regions within tree limit). Occupies upper parts of coastal marshes in SC and SE AK.

IIIA3h. Salt tolerant Grasses (e.g., Puccinellia) dominate. Commonly occupies tidal mud flats along entire AK coast.

IIIA3i. Salt tolerant sedges (e.g., Carex) dominate. Commonly occupies tidal mud flats along entire AK coast.

IIIA3j. Delicate, low sedges on bog peats dominate (in subarctic and subalpine regions within tree limit). Develops on peat deposits, sometimes forming quaking sedge mats, in filled lakes, ponds, and depressions throughout the southern two-thirds of AK.

IIIA3k. Mosses (e.g., sphagnum) dominate with delicate, low sedges present and usually co-dominant on peat soils (in subarctic and subalpine regions within tree limit). Occurs on peat soils, including seepage slopes, raised bogs, slope bogs, early stages of flat bogs, and floating bogs in SE and SC AK and Aleutian Is.

IIIB. Forbs (broad-leaved herbs), rushes (Juncaceae), horsetails (Equisetaceae), and ferns dominate. If not, go to IIIC.

IIIB1. Forbs dominate on dry sites (often sparsely vegetated pioneer communities). On dry sites, usually rocky and well-drained; mostly tundra sites. If not, go to IIIB2.

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IIIB1a. Open herb communities colonizing previously unvegetated nonalpine sites. Found throughout AK on floodplains, river banks and eroding bluffs.

IIIB1b. Wide variety of herbs and sedges dominate on sites covered by late melting snow beds.

IIIB1c. Sparse herb communities on alpine rock outcrops, talus and blockfields.

IIIB2. Forbs dominate in mesic soils.

IIIB2a. Mixture of herbs dominate.

IIIB2b. Fireweed Epilobium angustifolium dominates.

IIIB2c. Tall (0.5–1.5 m) Umbilliferae (e.g., Heracleum and Angelica) dominate.

IIIB2d. Ferns (e.g., Athyrium and Dryopteris) dominate.

IIIB3. Forbs dominate on wet (saturated or flooded most or all of growing season) sites.

IIIB3a. Herbs (e.g., Equisetum, Menyanthes trifoliata, and Potentilla palustris) emerging from standing water (> 0.15 m) – found in ponds and sloughs

IIIB3b. Herbs on saturated or shallow flooded (≤ 0.15 m deep) nonpeat soils dominate (in subarctic and subalpine regions within tree limit).

IIIB3c. Broad-leaved herbs on saturated or shallow flooded (≤ 0.15 m deep) peat soils (often floating mat) dominate (in subarctic and subalpine regions within tree limit).

IIIB3d. Halophytic herbs dominate on tidal areas inundated ≥ a few times/month by salt water.

IIIC. Bryophytes (mosses and liverworts) and/or lichens dominate. If not, go to IIID.

IIIC1. Bryophytes (mosses and liverworts) dominate. If not, go to IIIC2.

IIIC1a. Bryophytes (e.g., Gymnocolea, Scapania, and Nardia) dominate on nonwet sites. Vascular plants are virtually absent.

IIIC1b. Bryophytes (e.g., Rhacomitrium, Grimmia, and Andreaea) dominate on nonwet sites. Vascular plants are virtually absent. Occurs on gravelly slopes, sand dunes and mounds. Cover is usually sparse.

IIIC2. Lichens dominate.

IIIC2a. Crustose lichen species dominate. Occurs on extremely harsh, dry, windblown rocky sites with little or no soil development primarily in alpine regions throughout Alaska

IIIC2b. Foliose and Fruticose lichen species dominate. Other plant types are absent or nearly so. Occurs on dry fell fields and exposed ridges.

IIID. Plants with floating or submerged leaves dominate. Plants may also have emergent leaves and flowers.

IIID1. Aquatic communities in fresh water.

IIID1a. Pond lilies Nuphar and Nymphaea dominate.

IIID1b. Common Marestail Hippuris vulgaris dominates. Standing water may dry up for several weeks during growing season. Emergents are absent or nearly so.

IIID1c. Aquatic buttercup Ranunculus species dominate or co-dominate.

IIID1d. Berreed Sparganium species dominate.

IIID1e. Water milfoil Myriophyllum spicatum dominate.

IIID1f. Pondweeds Potamogeton species dominate.

IIID1g. Water star wort Callitriche species dominate.

IIID1h. Aquatic Cryptogams (e.g., mosses Fontinalis, liverwort Scapania, lichen Siphula, and quillwort Isoetes) dominate.

-continued-

IIID2. Aquatic communities in brackish water.

IIID2a. Four-leaf marestail Hippuris tetraphylla dominates.

IIID2b. Brackish water-tolerant pondweed Potamogeton, wigeongrass Ruppia spiralis, or horned pondweed Zannichellia palustris dominate.

IIID3. Aquatic communities in marine water

IIID3a. Eelgrass Zostera marina dominates.

IIID3b. Marine algae dominates.

IV. <2% vegetative cover.

APPENDIX H: GUIDE FOR IDENTIFYING MACRO POOLS

Appendix H1.–Identification, description, and measurement guidelines for delineation of macro pools associated with reaches and side channels. Excerpts included in this appendix are from the USDA Forest Service Aquatic Habitat Management Handbook (USDA 2001).

POOL COUNTS

Record the number of macro pools per reach.

Three criteria must be met before a habitat unit can be recorded as a macro pool. Habitat units that meet all three criteria, including beaver ponds, must be counted as macro pools, even if they don't "look" like what the surveyor considers to be a pool. By adhering to these rules, pool counts will be more consistent and repeatable. The criteria that define macro pools are described as follows:

1. Residual Pool Depth. Residual pool depth equals the maximum depth minus the pool tail crest depth, which is the depth of water over the hydraulic control. The depth at the pool tail crest is taken at the deepest point where the water surface slope breaks into the downstream riffle, or plunges to a pool below the upstream pool.

2. Minimum Pool Length or Width. Macro pools must meet minimum size criteria relative to the channel size. The channel bed width is used to determine macro pool qualifying dimensions. Average channel bed width is estimated at the beginning of each stream survey segment and used as a standard measure throughout that segment.

3. Hydraulic Control. Hydraulic control is a channel feature that controls the depth of a stream at a habitat unit for a given range of discharges. Examples might include the pool tail crest, a log, or a boulder.

Pool morphology and measurement of residual depth were explained in *Monitoring Protocol for the Upper Columbia River Basin* (Chen et al. 1994):

> A pool begins where there is a noticeable change in bed elevation caused by the pool-forming element(s). The head of a pool is defined as the location where the effect of scour creates a change in bed elevation resulting in increased depth. Downstream of the scour, hydraulic forces decline so that deposition occurs, and the bed elevation slopes upward. The pool then enters a shallow, sometimes long, pool tail area with a more gradual bed slope. The pool ends at the pool tail crest…where the bed elevation is greatest (that is, shallowest depth)…
>
> …Determination of residual depth requires a measurement of maximum pool depth and the pool tail crest depth. The pool thalweg (defined as the longitudinal axis that follows the deepest contour of the pool) is first located. Surface-to bottom depth measurements are taken along the thalweg with a graduated rod and the greatest depth is recorded as the maximum depth. The pool tail crest depth is determined by locating the tail crest…and then measuring the surface-to-bottom depth at this point.…
>
> To calculate the residual depth for a pool, the pool tail crest depth is subtracted from the maximum depth. The residual depth represents the hypothetical depth of the pool if flow was reduced so that the stream became a series of standing, nonconnected pools…

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The relative importance of different sized pools depends on the size of stream in which they are located. For example, a pool with residual depth of 17 cm may be important fish habitat in a stream 2 m wide. However, in a stream 30 m wide, this pool would be insignificant. Therefore, minimum residual pool depth is scaled to channel width using a formula adopted from the Washington Forest Practices Board (1993).

((Average Channel Bed Width)*(0.01)) + 0.15 m = Minimum Residual Pool Depth

A pool qualifies as a macro pool if it equals or exceeds the minimum residual depth. Record the average channel bed width and corresponding residual pool depth, established as the minimum qualifying depth, for use in identifying macro pools.

Residual pool depth is equal to the difference between the pool's maximum water depth and the pool tail crest water depth. Because residual depth is independent of stream stage, measurements taken in a given pool at both high and low flows will yield the same residual depth.

In some cases, it will not be possible to measure the water depth at the pool tail (for example, debris jams or beaver dams where multiple pieces of wood or debris function as the hydraulic control. In these cases, count the habitat unit as a pool if minimum residual depth and area standards are met.

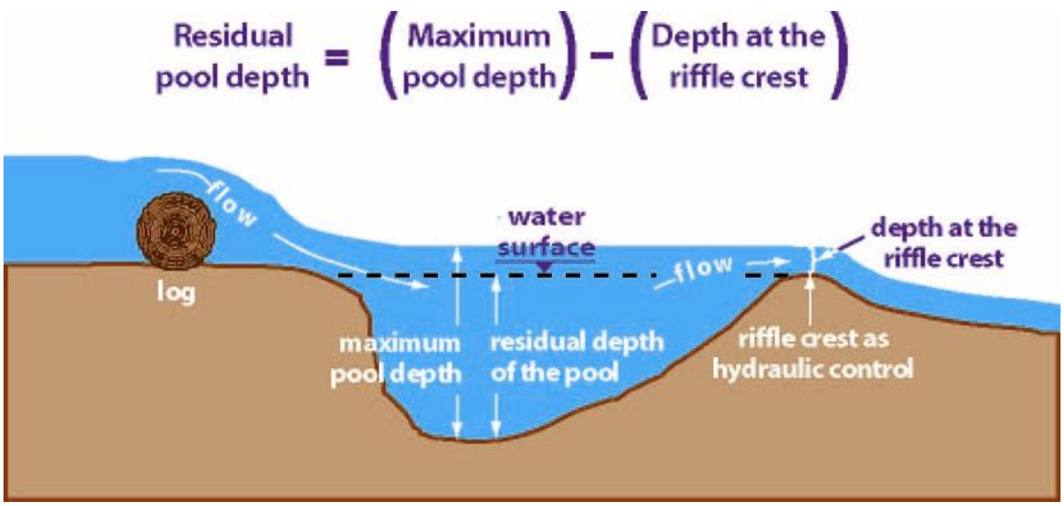

Figure 4.–Residual pool depth

Minimum Pool Length or Width

The minimum pool length or width must be greater than or equal to 10% of the average channel bed width to prevent inclusion of numerous pool-like depressions formed by localized scour. Smaller habitat units do not qualify as a macro pool.

Macro pool length or width = 0.10 * average channel bed width

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Hydraulic Control

The hydraulic control of a pool can be understood by envisioning the water shutoff. Water would spill until level with the low point in the basin. The low point would be the pool tail crest, and would be the hydraulic control for that pool. The remaining wetted surface would be the residual pool area. Residual pool area is independent of flow stage. Uneven relief of the stream bottom can make it difficult to determine if irregular shaped basins are a single pool or two or more pools side-by-side. Basins that share the same hydraulic control should be counted as a single macro pool. If adjoining pools each have their own hydraulic control, they must be counted as individual macro pools (provided they meet minimum criteria for residual depth and dimension).

To find the hydraulic control (pool tail crest), start at the deepest part of the pool and follow the thalweg downstream. Take spot measurements to determine the deepest point in the pool and the depth at the pool tail crest. Look not only for the shallowest point, but also for transitions in surface flow conditions (e.g., tranquil to turbulent). A change in gradient can also indicate the pool tail crest. In very low gradient channels, a hand level may be needed to distinguish between more than one possible tail.

There may be ridges or high spots in the bed of a pool. Take care to distinguish those ridges from a true tail crest. Calculate residual pool depth between the deepest point and the ridge. If the calculated residual depth is great enough to qualify the unit as a pool, then that lump may or may not be the pool tail crest. In figure 5, it may appear reasonable to identify the mid-pool high spot as a pool tail crest and to conclude that the picture depicts two pools. To test whether this is correct, consider whether the two proposed pools each have their own hydraulic control, or if they share a single control. If they each have their own hydraulic control, then they must be counted as two pools (providing they each meet the criteria of minimum residual pool depth and minimum pool area). If they both share the same hydraulic control, then they must be lumped together as a single large pool.

Make the final determination of the hydraulic control by picturing what would happen if stream discharge were reduced. Remember that the pool tail crest (hydraulic control) is where water flows out of the pool. As the water level goes down, the pool tail crest should be the last place still connecting the pool to the rest of the stream before the water drops so low that the pool becomes an isolated basin. Looking again at the example in Figure 5, you will see that as the water level drops, the hydraulic control becomes exposed before the mid-pool high point. There is a single hydraulic control for the entire unit. Consequently, this should be recorded as one pool.

Boulders in Pools

A special case occurs when a pool contains large boulders. In some circumstances, it may appear that the shallow point over the boulders is the pool tail crest. To determine whether or not these shallow spots constitute a true pool tail crest, envision what would happen if the stream surface level decreased. The pool tail crest should be the last place still connecting the pool to the rest of the stream before the water drops so low that the pool becomes an isolated basin. If the water receded, would the boulders resemble islands? Or, would they become part of the perimeter of the basin? If they become islands, they are not pool tail crests. If they become part of the

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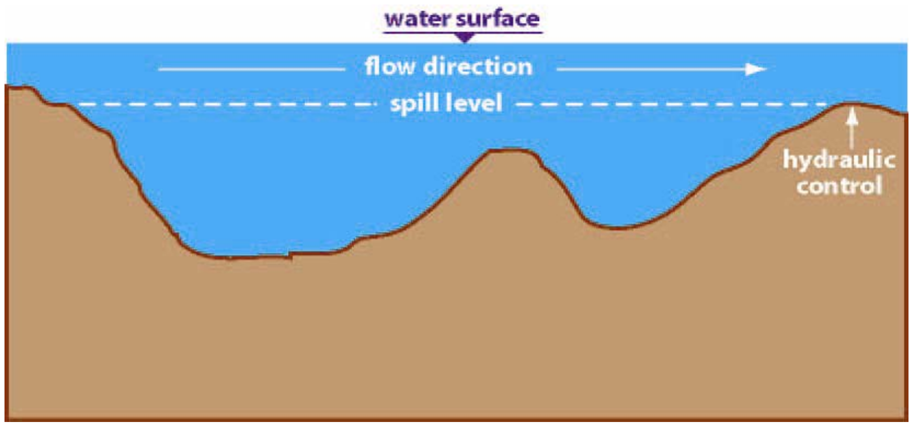

Figure 5.–Longitudinal profile of a pool with one hydraulic control

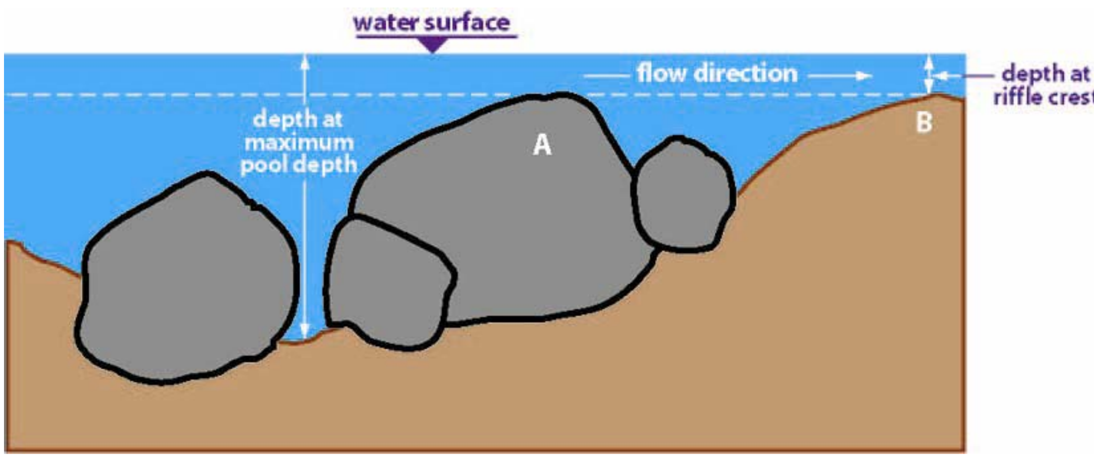

Figure 6.–Boulders or logs within a pool.

perimeter, then they might be the pool tail crest, but only if they are the final connection to the rest of the stream. Scour or irregular shapes around the base of the boulders often leave channels for water to flow downstream, even though the top of the boulders may be shallower than the pool tail crest depth.

Boulders or logs within a pool may or may not be the hydraulic control. In figure 6, if the boulder ponds water and functions as a basin perimeter, then it would form a pool with a tail crest at the top of boulder "A." If water could flow around the boulder, then the pool tail crest would be at the high point "B."

Connected Pools

Sometimes a pool will appear longitudinally divided into two parallel pools separated by a shallow area (often sand or fine gravel). It can be difficult to determine if there is one big pool with a high point running down the center of it, or if it is actually two pools. If the water level

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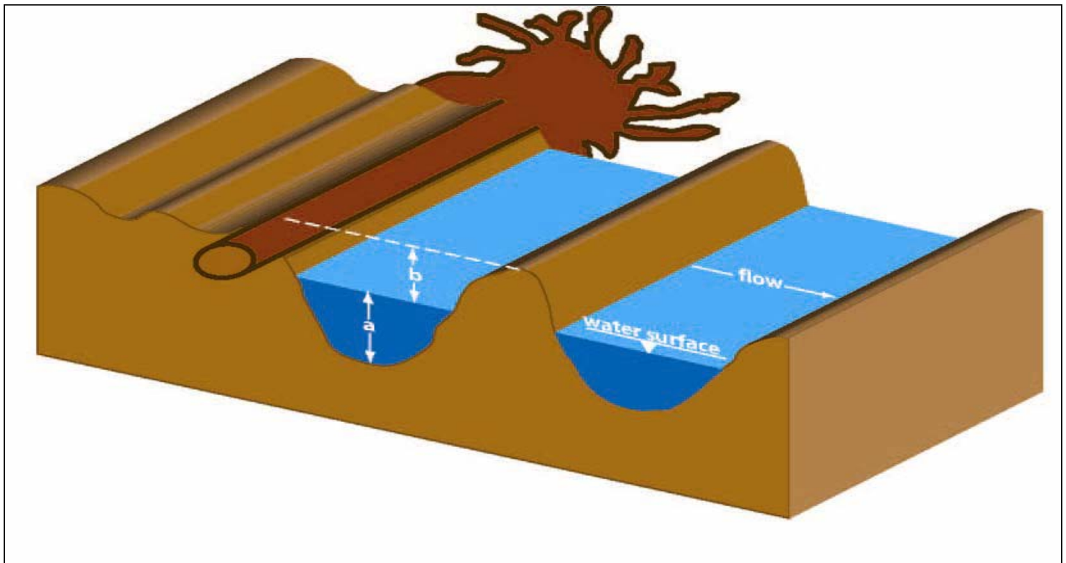
dropped, would the pool be split down the middle forming two pools that are connected to the stream? Or, would it become isolated from the rest of the stream first, with the lump still under the water? If it first becomes split, then it is two pools and you should be able to locate two hydraulic controls. If it first becomes isolated, then it is only one pool and will have only one hydraulic control.

Isolated Pools (no surface outflow)

Occasionally you will find a pool that is deep and big enough to qualify as a pool, but it will be isolated with no apparent surface flow connecting it to the rest of the stream. If it lies within the bankfull margins then it must be counted. The residual pool depth is still the elevation difference between the deepest point of the pool and the pool tail (Figure 7).



Isolated pools are unconnected to surface flow at the stage encountered. Determine residual pool depth by adding the depth at a, the deepest point of the pool, to b, the vertical distance from the pool tail crest to the water surface.

Figure 7.–Isolated pools

APPENDIX I: FISH SPECIES CODES

Appendix I1.–List of species codes for use on the fish observation and adult index escapement survey datasheets. For species encountered, but not include on this list, full names should be recorded.

Species code	Species
ACI	Sturgeon, unspecified
ATG	Green sturgeon
ATW	White sturgeon
CAC	Arctic char
CBT	Brook trout
CDV	Dolly Varden
CHR	Char, unspecified
CLK	Lake trout
DAL	Alaska blackfish
ERC	Trout-perch
FAR	Arctic flounder
FLN	Righteye flounders, unspecified
FST	Starry flounder
GAD	Cod, unspecified
GAR	Arctic cod
GBR	Burbot
GPA	Pacific cod
GRA	Arctic grayling
GSA	Saffron cod
HAM	American shad
HER	Herring, unspecified
HPA	Pacific herring
IDA	Salmonid, unspecified
KNS	Ninespine stickleback
KSB	Stickleback, unspecified
KTS	Threespine stickleback
LAC	Arctic-Alaskan brook lamprey, paired species
LAK	Alaskan brook lamprey
LAR	Arctic lamprey
LMO	Atlantic salmon
LMP	Lamprey, unspecified
LPC	Pacific lamprey
LRV	River lamprey

-continued-

Species code	Species
LWB	Western brook lamprey
MIN	Lake chub
NOS	Longnose sucker
OEU	Eulachon, hooligan
OLS	Longfin smelt
OPS	Pond smelt
ORM	Rainbow smelt
OSM	Smelt, unspecified
OSS	Surf smelt
PIK	Northern pike
QQQ	Other species not listed
SAM	Salmon species, unspecified
SCK	Chinook salmon
SCM	Chum salmon
SCO	Coho salmon
SPI	Pink salmon
SSE	Sockeye salmon
STH	Steelhead
TCT	Cutthroat trout
TRB	Rainbow trout
TRT	Trout, unspecified
UCR	Coastrange sculpin
UFH	Fourhorn sculpin
ULP	Sculpin, unspecified
UNK	General fish observation, no species information
UPR	Prickly sculpin
UPS	Pacific staghorn sculpin
USH	Sharpnose sculpin
USL	Slimy sculpin
VVV	No collection effort
WAK	Alaska whitefish
WAR	Arctic cisco
WBC	Bering cisco

-continued-

Appendix I1.–Page 3 of 3.

Species code	Species
WBD	Broad whitefish
WHB	Humpback whitefish
WHC	Humpback whitefish complex
WHF	Whitefish, unspecified
WIN	Inconnu
WLC	Least cisco
WLK	Lake whitefish
WPG	Pygmy whitefish
WRN	Round whitefish
XXX	No fish collected or observed
YMA	Shiner perch
YYP	Yellow perch
ZZZ	General fish observation, no species information

APPENDIX J: RIPARIAN DISTURBANCE CODES

Appendix J1.–Dichotomous key used to identify riparian disturbance classes that are commonly observed in Southeast Alaska.

Disturbance class codes

I. Anthropogenic disturbance

- IA. Unique
  - IA1. Timber harvest
    - IA1a. 0–1 year post-harvest
    - IA1b. 1–5 year post-harvest
    - IA1c. 10–20 year post-harvest
    - IA1d. 20+ year post-harvest
  - IA2. Construction
    - IA2a. 0–1 year post-construction
    - IA2b. 1–5 year post-construction
    - IA2c. 10–20 year post-construction
    - IA2d. 20+ year post-construction
  - IA3. Enhancement/restoration
    - IA1a. Bank stabilization
    - IA1b. Riparian thinning
    - IA1c. Fisheries related
    - IA1d. Rip-rap
- IB. Repeated seasonal
  - IB1. Foot traffic
    - IB1a. Anglers
    - IB1b. Nonanglers
  - IB2. Vehicle traffic
    - IB2a. Nonrecreational (e.g., road vehicle)
    - IB2b. Recreational (e.g., ATV, snowmachine, etc.)
- IC. Permanent
  - IC1. Pervious surfaces
    - IC1a. Urban/commercial landscaping
    - IC1b. Agricultural
    - IC1c. Gravel
    - IC1d. Other

-continued-

- IC2. Impervious surfaces
  - IC2a. Parking area
  - IC2b. Paved trail/walkway
  - IC2c. Concrete wall/abutment

II. Natural disturbance

- IIA. Water/flood
  - IIA1. Bank disturbance (e.g., slumping, undercutting, erosion, etc.)
    - IIA1a. Wood inputs
    - IIA1b. Sediment inputs
  - IIA2. Chronic sediment deposition from tributary
- IIB. Windthrow
- IIC. Glacial retreat
- IID. Fire
- IIE. Mass wasting
  - IIE1. Avalanche
  - IIE2. Creep/solifluction
  - IIE3. Landslide
  - IIE4. Debris torrent
- IIF. Natural tree mortality

APPENDIX K: FLUVIAL PROCESS GROUPS AND CHANNEL TYPES

Appendix K1.–Excerpts from the USDA Forest Service channel type user guide for the Tongass National Forest (Paustian 1992; revised October 2010), including descriptions for process groups and the channel types that occur within each of the process groups.

ESTUARINE PROCESS GROUP (ES)

These are all intertidal streams and are directly influenced by tidal inundation. Estuarine channels are associated with saltwater marshes, meadows, mudflats, and gravel deltas that are all predominantly depositional environments. The size of associated riparian areas encompasses the entire estuarine wetland system.

Micro Estuarine Channel (ESO)

Bank full width < 1.5 m

Small Estuarine Channel (ESS; formerly ES1, ES2, ES3)

The ESS is normally associated with salt chucks, shallow embayments along coastal forelands and large glacial river deltas.

Medium Estuarine Channel (ESM)

ESM streams occur exclusively within estuary landforms, usually draining a small to moderate size watershed. These channels are most commonly found in drainages along outer coastal beaches.

Large Estuarine Channel (ESL; formerly ES4)

ESL streams occur in small estuaries, usually less than 100 acres in size. These streams are most commonly associated with small, high relief drainage basins that empty into inland straits and inlets.

PALUSTRINE PROCESS GROUP (PS)

Channels within this process group are very low gradient (<1%) streams, associated with low relief landforms and wetland drainage networks. Water movement is slow and sediment transport is low. These channel types typically act as traps and storage areas for fine organic and inorganic sediments. Channel banks are generally stable and flood plain depositional features, such as gravel bars, are absent. Riparian area size is highly variable, but may encompass very large wetlands.

Micro Palustrine Channel (PAO)

Bank full width < 1.5 m

Small Palustrine Channel (PAS; formerly PA1)

PAS streams often occur in association with muskegs on low relief landforms. Channel pattern may be highly sinuous. These streams are commonly associated with ponds and small lakes.

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Medium Palustrine Flow Channel (PAM; formerly PA2)

PAM channels are associated with extensive wetlands on low relief landforms. The PAM channel is often a lake inlet or outlet stream. Drainage basin size is moderate to large.

Large Palustrine Channel (PAL)

PAL streams are located on low relief glacial outwash flood plains. These channels typically occupy relic glacial braided channels and are recharged by clear groundwater flow.

Backwater or Groundwater Fed Slough (PAH; formerly PA3)

Glacial outwash flood plains and river terrace lowlands adjacent to active flood plains are associated with the PAH channel.

Beaver Dam/Pond Channel (PAB; formerly PA5)

PAB streams are found on valley bottom flood plains and low relief landforms. The PAB channel type is characterized by a series of beaver impoundments.

FLOOD PLAIN PROCESS GROUP (FP)

These are low gradient (<2%) channels where alluvial deposition is prevalent. These are generally lowland and valley bottom streams and rivers. High stream flows are not commonly contained within the active channel banks and some degree of flood plain development is evident. In larger streams and river systems the riparian area width from the main channel banks can extend well beyond 30 m from stream banks.

Micro Flood Plain Channel (FPO; formerly FP0)

Bank full width < 1.5 m

Foreland Uplifted Beach Channel (FPB; formerly FP1)

FPB streams occur on near shore areas of glacial forelands. These channels tend to flow parallel to the coastline and occupy depressions between relic beach dune deposits. These streams are found in lower reaches of drainage systems, upland from current estuaries or shorelines.

Foreland Uplifted Estuarine Channel (FPE; formerly FP2)

The FPE stream is found on uplifted estuaries, prevalent in recently deglaciated forelands and large mainland river deltas.

Small Flood Plain Channel (FPS; formerly FP3)

FPS streams are located in the valley bottoms and may also occur within flat lowlands or low elevation drainage divides. Frequently, FPS streams lie adjacent to the toe of footslopes or hillslopes, adjacent to main trunk, valley bottom channels. The flood plain of large, low gradient alluvial channels (FPM or FPL) may be dissected by FP3 streams. Where FPS streams occur parallel to footslopes or in valley bottom locations, high gradient streams typically feed them. In small drainage basins, HCV or MMS channels may directly precede a FPS stream. Less frequently, FPS streams are situated on mountainslope benches.

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Medium Flood Plain Channel (FPM; formerly FP4)

FPM channels are mainstem streams in broad valley bottoms that generally have extensive flood plains. Alluvial fans, dissected footslopes, and hillslope and lowland landforms may directly abut FPM flood plains. FPM channels are typically sinuous, with extensive gravel bars, multiple channels, and alluvial terraces. These channels are typically at the lower end of the stream and, therefore, have large drainage basins.

Large Flood Plain Channel (FPL; formerly FP5)

FPL channels are usually found in broad valley bottoms of large to very large watersheds. Normally, these channels have extensive valley flood plains and river terraces. Smooth meander bends, numerous overflow side channels, extensive gravel bars and large clumps of log jams are characteristic of this channel type.

Glacial Outwash Process Group (GO)

Mountain glacier meltwater is the source of runoff to these streams. Consequently, these streams carry extremely high sediment loads and turbid water. Glacial outwash channel types are alluvial channels with stream gradients usually less than 3%. Riparian areas are wide and may extend for more than 1,000 m in large braided outwash plain river systems.

Glacial Alluvial Fan Channel (GAF; formerly AF8)

The GAF occurs on alluvial cone landforms in glacial drainage basins. At least 15% of the drainage area must be covered by a glacier or permanent snowfield to qualify as a GAF channel. Channel gradients are commonly greater than 6%. Channel pattern is variable, usually singular at the apex of the cone and branching at the terminus. Suspended glacial silt load is high in these channels.

Glacial Outwash Side Channel (GSC; formerly GO1)

The GSC channel type is usually situated within the broad, glacial valley or foreland landform. The GSC channel is a side channel that bisects the glacial river terrace and is connected to the main GOL or GOB river channel.

Small Glacial Outwash Side Channel (GOS)

Bank full width < 20 m.

Medium Glacial Outwash Channel (GOM; formerly GO4)

The GOM channel type occurs in the mid to upper valley position in glacial watersheds. Adjacent flood terrace areas are primarily composed of glacial outwash or till. Large valley glaciers and snowfields occur upstream of the GOM channel type. Snow avalanche cones and subalpine mountain slopes typically occur adjacent to GOM channels.

Large Meandering Glacial Outwash Channel (GOL; formerly GO2)

The GOL streams occur in middle to lower valley positions in large drainage basins. Valleys are U-shaped, with large, discontinuous flood terraces adjacent to GOL streams. Flood plains are the

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typical adjacent landform in broad valley bottom areas, but inclusions of lowland and hill landforms can occur. These channels are often found at the outlet of glacial lakes.

Large Braided Glacial Outwash Channel (GOB; formerly GO3)

GOB channels occur in very large, glacial drainage basins. They are located in broad, glacial valley bottoms or on outwash plains. Large flood plains occur adjacent to these channels.

Cirque Channel (GOC; formerly GO5)

GOC streams occur in alpine cirque basins or hanging valley floors. Runoff is derived from the meltwater discharge of a mountain glacier or perennial snowfields. Adjacent valley sideslopes are usually steep and avalanche prone.

Glacial Outwash Estuarine Channel (GES; formerly ES8)

GES streams are associated with large glacial river deltas. These watersheds typically have greater than 15% of their drainage area covered by active glaciers and snowfields.

Alluvial Fan Process Group (AF)

These are low to moderate gradient (<5%) stream channels that are strongly influenced by alluvial sediment deposition. These are generally tributary streams that are located on foot-slope landforms in a transitional area between valley flood plains and steep mountain slopes. Sediment deposition tends to create elongated island of bare cobbles and gravel between a multi-branched channel network. Alluvial fan deposits are formed by the rapid change in transport capacity as the high energy mountain slope stream segments spill onto the valley bottom. Drainage channels change course frequently, resulting in a multi-branched stream network. Riparian areas commonly associated with these poorly contained streams are very narrow at the top of the fans and become wider as the fan spreads out.

Micro Alluvial Fan Channel (AFO)

Bankfull width < 1.5 m.

Moderate Gradient Alluvial Fan (AFM; formerly AF1)

The AFM channel type is exclusively associated with the alluvial fan landform. Normally, this landform is positioned between steep mountainslopes or hillslopes and flat valley bottoms or lowlands. In many valleys, AFM streams lie adjacent to and merge with low gradient flood plain streams.

High Gradient Alluvial Cone Channel (AFH; formerly AF2)

AFH streams are typically situated on alluvial fan landforms in steep sided, V-shaped valleys. These streams are located on transitional areas between mountain sideslopes and valley floors. AFH channels are frequently located directly downstream from HCM and HCS channels. Less frequently, AFH streams occur on sloping lowlands preceded by an HCV stream. These channels have shallow incision, with poor flow containment. Channel pattern is single to multi-branched.

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LOW GRADIENT CONTAINED PROCESS GROUP (LC)

These low to moderate gradient (1–3%) channels are moderately incised with good flow containment. Stream flow is well contained by adjacent landforms in this group of channel types. These are larger valley or lowland streams often having limited areas of alluvial sediment deposition within the confines of the upper banks. Riparian areas are discontinuous (riparian zone is not always distinguishable, and is generally less than 46 m wide.

Micro Low Gradient Contained Channel (LCO)

Bankfull width < 1.5 m.

Small Low Gradient Contained Channel (LCS; formerly LC1)

LCS channels are normally situated in broad valley bottoms largely composed of lowlands landforms. Hills and mountainslopes may abut one bank of the LCS channel type. Frequent bedrock outcrops along stream banks generally control lateral channel migration.

Medium Low Gradient Contained Channel (LCM; formerly LC2)

LCM streams flow through narrow valleys situated in the middle to lower sections of a watershed. Hill slopes and mountain slopes composing the valley walls may lie directly adjacent to the LCM channel. The adjacent valley floor is consistently narrow, with little river terrace development. Bedrock knickpoints, short falls, cascades, and boulder runs may be present.

Large Low Gradient Contained Channel (LCL)

LCL streams have a bank full width greater than or equal to 20 m.

MODERATE GRADIENT MIXED CONTROL PROCESS GROUP (MM)

These are moderate gradient (2–6%) streams where sediment deposition processes are limited. Channel banks are frequently composed of boulder or bedrock materials that limit later channel migration and floodplain development along many segments of these channel types. High flows are mostly contained within the active stream channel. Riparian areas seldom extend beyond 30 m from stream banks.

Micro Moderate Gradient Mixed Control Channel (MMO)

Bankfull width < 1.5 m.

Small Moderate Gradient Mixed Control Channel (MMS; formerly MM1)

The MMS stream is normally situated in the middle reaches of small drainage basins. Accordingly, drainage basin area is small. Commonly, and HCV channel will precede an MMS in the basin network. The MMS will often flow into an MMM reach. MMS streams may also occur as upstream tributaries to FPS and MCM reaches. Bank material is normally a mixture of alluvial and colluvial deposits. Small bedrock knickpoints and short cascades or falls may be present.

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Medium Moderate Gradient Mixed Control Channel (MMM; formerly MM2)

MMM channels are normally found in the middle to lower portion of moderate size drainage basins. MMM streams are often confined by mountainslope, footslope, and hillslope landforms, but they can develop a narrow flood plain. Bedrock knickpoints with cascades or falls may be present.

Large Moderate Gradient Mixed Control Channel (MMM; formerly MM2)

Bankfull width is greater than or equal to 20 m.

MODERATE GRADIENT CONTAINED PROCESS GROUP (MC)

Stream flow in this process group is completely contained by adjacent landforms and upper channel banks. Stream bank and streambed erosion is frequently controlled by the presence of bedrock outcrops. These channels are efficient sediment transport and delivery conduits. Gravel bars are infrequent channel features. Riparian areas are limited to the stream bank influence zone, generally less than 30 m.

Micro Moderate Gradient Contained Channel (MCO)

Bankfull width < 1.5 m.

Small Moderate Gradient Contained Channel (MCS; formerly MC1)

The MCS is found consistently in glacially scoured lowland landforms. Hillslope landforms are often immediately adjacent to these streams. Less frequently, the MCS is situated in middle to upper valley positions or low elevation drainage divides.

Medium Moderate Gradient Contained Channel (MCM; formerly MC2 and MC3)

MCM channels are associated with glacially scoured lowland and low relief hillslope landforms. These well contained channels are confined by adjacent landforms. MCM channels are typically main tributary or upper valley streams with small to moderate sized drainage basins. Bedrock control of channel banks and stream bed is prevalent, resulting in a single linear to rectangular channel pattern.

Large Moderate Gradient Contained Channel (MCL; formerly LC2)

MC3 streams are exclusively associated with the valley bottom gorge landform. This channel typically cuts through bedrock and has very long, steep, sideslope walls. One or more major falls are normally present.

HIGH GRADIENT CONTAINED PROCESS GROUP (HC)

This process group includes channel types that are shallowly to deeply incised, high gradient (over 6%), mountain slope streams. High to moderate gradient glacial meltwater streams are also included in this process group. These first and second order headwater channels are characterized as primary sediment source zones. Relatively high stream energy enables these streams to transport large sediment loads during spring and fall freshets. The associated riparian area generally extends to the upper stream bank slope break. Secondary differences based on revised incision depth ranges include:

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- Low incision - < m
- Moderate incision - ≥ 2 m to 6 m

Micro High Gradient Contained Channel (HCO; formerly HC0)

Bankfull width ≤ 1.5 m.

High Gradient Low Incision Channel (HCL; formerly HC1 and HC2)

HCL streams are mostly restricted to hill and lowland landforms. The HCL channel type consists of narrow, high gradient, shallow to moderately incised streams. HCL streams are commonly tributaries to MCS and MCM channel types. They also occur in conjunction with HCV streams, where localized geologic knickpoints influence incision depth. Although not deeply incised, they are well contained and are usually influenced by bedrock control.

High Gradient Moderate Incision Channel (HCM; formerly some channels known as HC5 or HC6, but field confirmation is necessary to cross walk)

The HCM streams have incision depth of 2–6 m. Stream bank composition is predominately alluvium, although bedrock segments may occur as inclusions.

High Gradient Deep Incision Channel (HCD; formerly HC4, HC6, HC9)

The HCD channels are found in steep sided, narrow, V-shaped valleys. Flow containment is excellent, due to the deep incision and close proximity of valley sideslopes. Cascades, low vertical falls, and bedrock knickpoints are common features. Incision depth > 6 m.

High Gradient Upper Valley Channel (HCV; formerly HC3)

The HCV channels have a variable incision and are located in valley bottoms.

APPENDIX L: APPLICATION OF STREAM HABITAT SURVEY AND CASE SCENARIO EXAMPLES

The ADF&G-SF has conducted stream habitat surveys in multiple watersheds across SEAK since 2001. Individual watersheds were selected for survey for a diversity of reasons, although all were considered based on a perceived need for improved delineation, habitat classification, or habitat assessment. Fish distribution surveys often were conducted in conjunction with stream habitat surveys that further expanded the utilities of surveys with regard to better understanding fishery habitat and fish distributions and occurrence.

The majority of streams in Southeast Alaska were initially and historically delineated using techniques afforded through the use of stereo image pair evaluation, "heads-up" digitizing in a GIS environment using the best available imagery, and in some cases various renditions initially based on hand drawings derived from field notes and eventually scanned and made into the blue lines we associate with streams. The size and remote qualities of much of SEAK contributed to logistical difficulties and expense that did not justify or warrant the field effort that would be necessary to perform a significant amount of field surveys. Additionally, the process of mapping fluvial waters in the field prior to the widespread use of the GPS (and subsequent improvements in accuracy available to all GPS users) and rendering them in a product available to wider audiences was confounded for multiple reasons, including accuracy and reproduction.

Although advancement in GPS, GIS, and data sharing technologies have minimized concerns for spatial accuracy and reproduction associated with stream delineation, the fact still remains that most fluvial waters in SEAK could be better mapped, delineated, and characterized with ground efforts. Examples are provided below in which field efforts using the stream habitat survey outlined in this manual led to considerable improvements in the following:

- hydrologic delineation and characterization;
- identification and assessment of riparian features and in-stream structures;
- identifying fish distribution patterns.

This information was used for a variety of purposes associated with timber harvest layout, road system development and arrangement, fishery access, watershed prioritization, and to better understand fish distribution or abundance patterns with respect to habitat parameters.

Example 1 – Pre- and post-survey stream mapping and delineation:

ADF&G-SF crews worked closely with forest planners from the Sealaska Regional Corporation to aid them during timber unit layout. Project objectives focused on improving the delineation of streams in several areas that were identified for timber harvest. ADF&G-SF crews began stream mapping efforts at saltwater, capturing GPS waypoints at regular intervals (<20 m) and continuing until they reached the end of aquatic habitat or to previously identified unit boundaries. The revised delineation of streams in this area allowed Sealaska Regional Corporation to plan timber harvest units in accordance with buffer standards identified in the Alaska Forest Resources and Practices Act (FRPA), by having the most accurate mapping of streams available. Figure A illustrates how the delineation of streams in this area was revised based on stream mapping.

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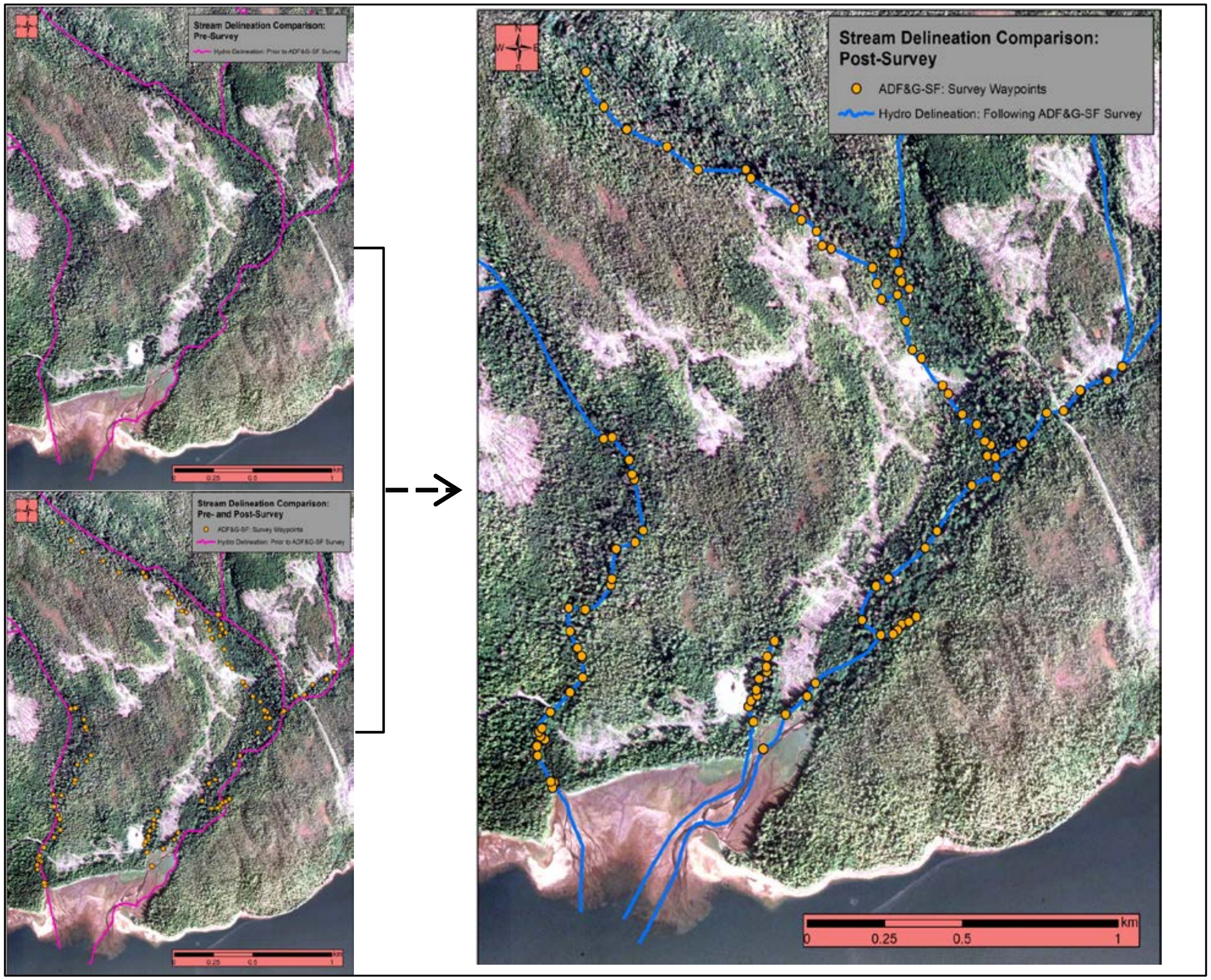

Figure A.–Multi-component figure depicting stream delineation prior to survey (upper left), new stream mapping waypoints following field survey (lower left) and revised delineation following field survey and editing of hydrography in GIS.

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Example 2 – Pre- and post-survey stream mapping, delineation, classification (channel type), and fish distribution assessment:

While addressing the objectives of a steelhead habitat capability study, ADF&G-SF crews intensively mapped, inventoried, and classified all anadromous waters in the Peterson Creek drainage on the mainland north of Juneau. Seasonal fish distribution surveys were also conducted in all waters to identify temporal changes in fish use. GPS waypoints were captured on all such waters at regular intervals (<20 m) and stream reaches were classified into individual channel types.

The delineation of tributaries of Peterson Creek in the lower portion of the watershed was minimal prior to ADF&G-SF survey, although the mainstem appeared to be adequately mapped, at least with respect to position. We identified numerous tributaries of varying length during our surveys and mapped and delineated these waters using standards identified above. Prior to ADF&G-SF survey, the total mapped stream length in the lower watershed (Figure B) was approximately 5.58 km; following surveys and GIS integration and evaluation, a total of 15.23 km of stream was identified and delineated. The result of stream mapping and delineation efforts now presents a much more accurate depiction of the mainstem and associated tributaries in the lower watershed.

In conjunction with the work identified above to simply map the location and position of fluvial waters, ADF&G-SF crews also classified individual stream reaches by geomorphic and hydrologic attributes that are used to identify unique channel type designations. Channel type classification provides a means of understanding the interrelationship between watershed input, adjacent landform relief, and geology on fluvial erosion and deposition processes. As such, it provides the ability to define the characteristics of individual stream reaches and to plan for probable responses to natural and human influences and activities. The Tongass National Forest uses the channel type classification as a principal tool for managing aquatic and riparian habitats in SEAK. The ADF&G-SF routinely classifies all stream reaches by channel type during stream habitat surveys thereby mirroring efforts of the USFS and Tongass National Forest.

The post-survey results associated with stream delineation (Figure B) and channel type classification (Figure C) in the Peterson Creek watershed provided better hydrologic mapping and characterization than was previously available. It also allowed the ADF&G-SF to better identify potential fish bearing waters in the watershed, especially with respect to anadromous fish. The fish distribution surveys completed by the ADF&G-SF in the Peterson Creek watershed (Figure D) led to new AWC nominations that provide a level of protection for these waters that was not previously afforded. The fish distribution surveys also allowed the ADF&G-SF to address focal objectives of the steelhead habitat capability study, which included identifying steelhead occupancy across temporal (seasons) and spatial scales (stream reaches, watersheds). Further evaluation of steelhead occupancy with regard to stream reaches and the individual physical habitat parameters measured during stream habitat surveys provided a means to assess the importance and relative contribution to cumulative habitat where steelhead were observed in the system. Figure E and Table 1 identify how the ADF&G-SF summarized channel type classification and delineation as well as physical habitat metrics to better understand steelhead habitat preference and occupancy.

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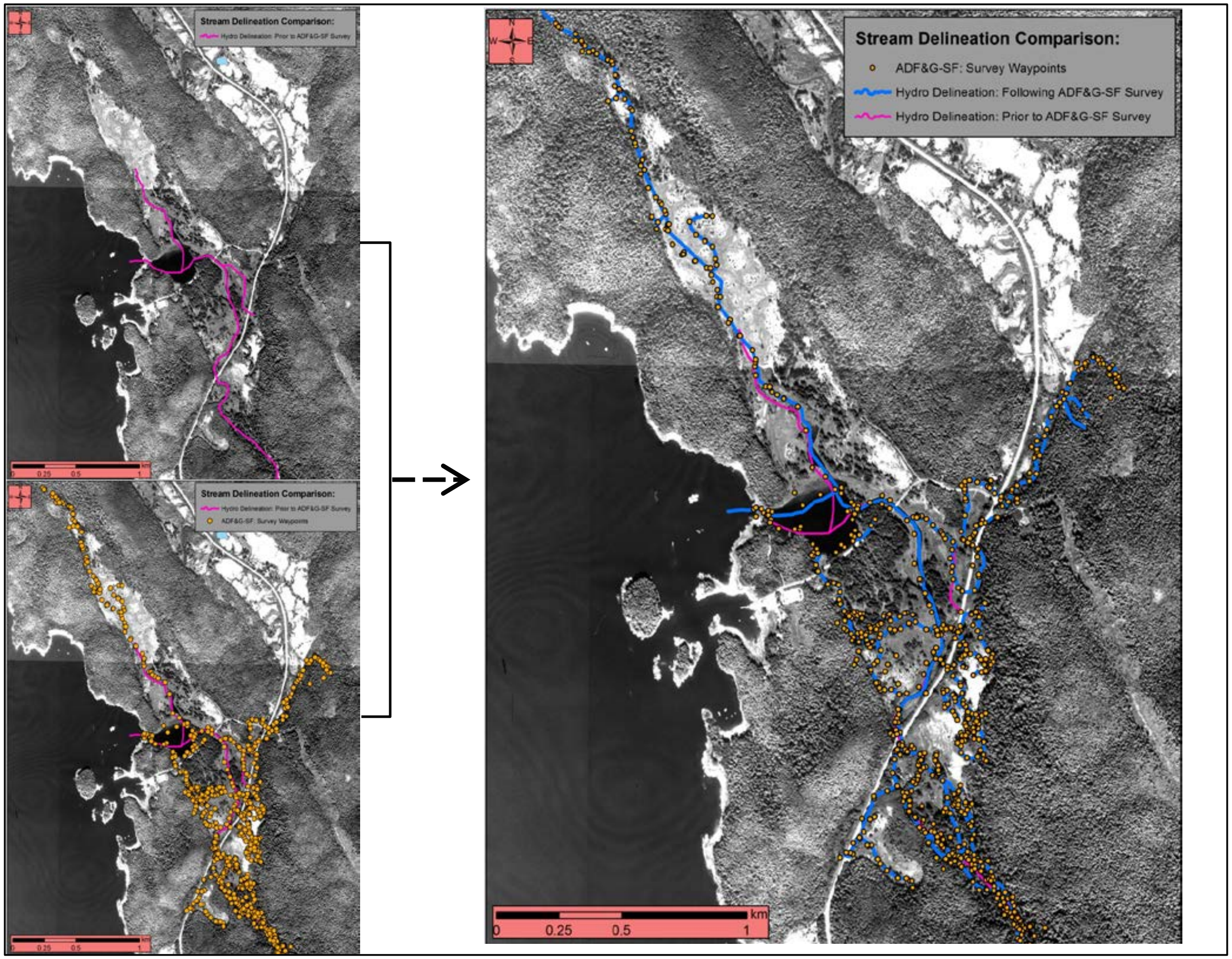

Figure B.–Multi-component figure depicting Peterson Creek stream delineation prior to survey (upper left), new stream mapping waypoints following field survey (lower left) and revised delineation following field survey and editing of hydrography in GIS.

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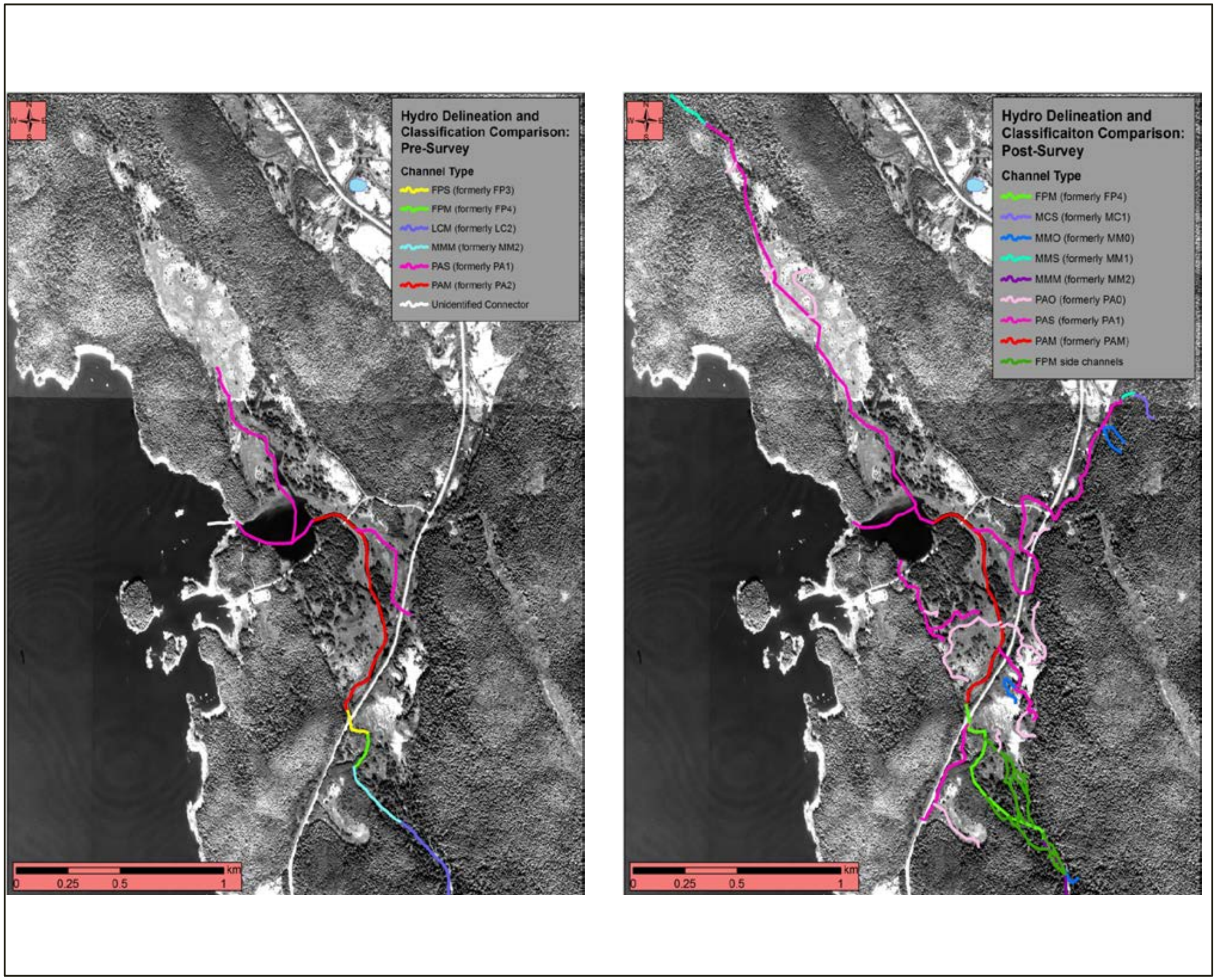

Figure C.–Multi-component figure depicting Peterson Creek stream delineation and classification prior to survey (left map) and revised delineation and classification (right map) following field surveys and editing of hydrography in GIS.

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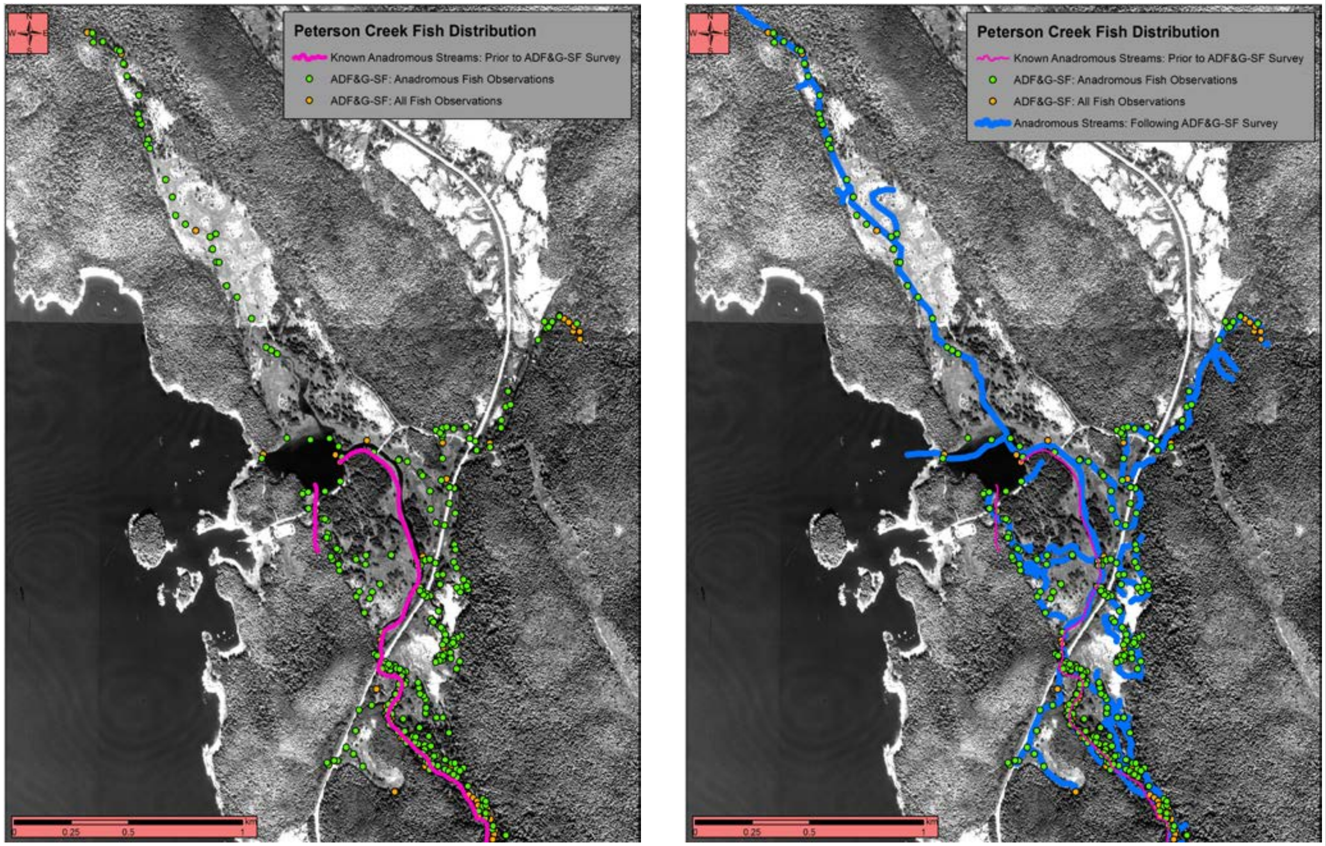

Figure D.–Multi-component figure depicting known anadromous fish distribution in Peterson Creek prior to survey (left map) and following field surveys (right map).

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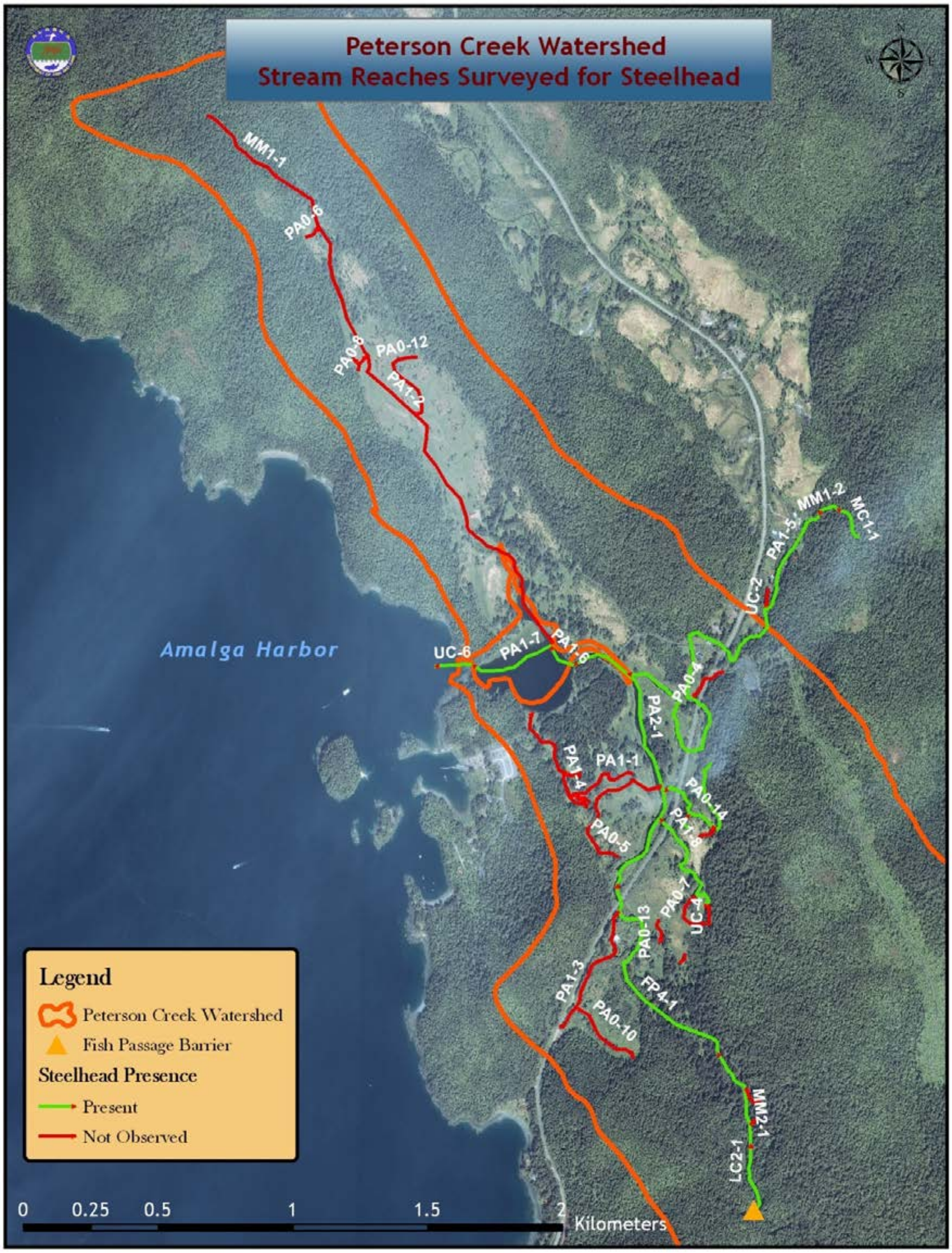

Figure E.–Delineation and identification of individual stream reaches surveyed by the ADF&G-SF during the steelhead habitat capability project in the Peterson Creek watershed.

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Table 1.–Stream reach habitat characteristics observed and quantified for the Peterson Creek watershed.

Reach label[a]	Reach length (m)	Mean channel bed width (m)	Total area (ha)	Stream gradient (%)	Large wood count	Key wood count	Macro pool count	Large wood density	Key wood density	Macro pool density
FP4-1	908.09	13.27	1.21	0.45	295	26	22	244.76	21.57	18.25
FS0-1	40.58	1.17	0.00	11.70	2	0	1	422.45	0.00	211.22
LC2-1	266.15	11.88	0.32	1.50	34	1	15	107.58	3.16	47.46
MC1-1	153.96	3.08	0.05	6.40	31	6	9	653.02	126.39	189.59
MM0-1	101.87	2.62	0.03	3.20	9	0	0	337.79	0.00	0.00
MM1-1	364.29	1.31	0.05	6.70	92	16	8	1924.14	334.63	167.32
MM1-2	83.58	3.40	0.03	5.25	19	5	2	668.60	175.95	70.38
MM2-1	381.02	20.30	0.77	1.50	257	78	9	332.27	100.85	11.64
PA0-10	307.96	0.75	0.02	0.60	0	0	0	0.00	0.00	0.00
PA0-11	80.20	0.54	0.00	–	–	–	–	–	–	–
PA0-12	354.44	0.55	0.02	0.30	0	0	0	0.00	0.00	0.00
PA0-13	98.98	0.61	0.01	–	–	–	–	–	–	–
PA0-14	582.69	0.75	0.04	0.60	17	1	0	389.00	22.88	0.00
PA0-2	85.77	0.50	0.00	–	–	–	–	–	–	–
PA0-3	74.95	0.95	0.01	–	–	–	–	–	–	–
PA0-4	171.68	1.00	0.02	0.60	0	0	0	0.00	0.00	0.00
PA0-5	586.78	0.77	0.05	0.70	0	0	0	0.00	0.00	0.00
PA0-6	66.82	0.25	0.00	–	–	–	–	–	–	–
PA0-7	196.21	1.00	0.02	–	–	–	–	–	–	–
PA1-1	300.97	1.58	0.05	0.70	1	0	0	21.07	0.00	0.00
PA1-2	2137.43	2.50	0.53	0.30	0	0	0	0.00	0.00	0.00
PA1-3	535.85	1.38	0.07	0.60	0	0	0	0.00	0.00	0.00
PA1-4	478.31	5.79	0.28	1.70	0	0	0	0.00	0.00	0.00
PA1-5	1866.87	2.91	0.54	0.60	119	15	2	219.21	27.63	3.68
PA1-8	481.41	1.47	0.07	0.30	8	1	1	112.88	14.11	14.11
PA2-1	1114.95	20.36	2.27	0.90	3	2	1	1.32	0.88	0.44

[a] Reach labels are identified in the map presented in Figure E.