FINAL

SNOHOMISH RIVER POLLUTANT DIAGNOSIS AND IMPLEMENTATION PROJECT

PHYSICAL HABITAT SURVEY AND MONITORING PROTOCOL FOR LARGE RIVERS
VERSION 1.2

July 20, 2004

Prepared by

Snohomish County Public Works
Surface Water Management Division
2731 Wetmore Avenue, Suite 300
Everett Washington 98201

Aquatic Habitat Sampling Plan

Snohomish River Pollutant Diagnosis and Implementation Project

Approvals:

Bill Leif, Water Quality Section Supervisor Snohomish County Surface Water Management	Date
Joan M. Lee, Director Snohomish County Surface Water Management	Date
David Pater, Project Manager Washington State Department of Ecology	Date

Table of Contents

Title Page with Approvals ii

Table of Contents and Distribution List iii

Introduction 1

Methods 1

Bank Condition Survey 9

Geomorphic Habitat Survey 13

Post-Survey Data Processing and Quality Assurance/Control 20

Literature Cited 21

Appendix A - Data dictionary for Bank Condition survey 23

Appendix B - Data dictionary for Geomorphic Habitat survey 26

Attachments

Haas, A.H., F.E. Leonetti, L.T. Parker, M.D. Purser, and M.D. Rustay. 2003. Stillaguamish River bank and physical habitat conditions survey 2002 summary report. Snohomish County Public Works, Surface Water Management, Everett, WA.

Leonetti, F.E., A.H. Haas, L.T. Parker, M.D. Purser, and M.D. Rustay. 2002. Precision and repeatability of wadeable stream habitat survey methods. Snohomish County Public Works, Surface Water Management, Everett, WA.

List of Tables

Table 1. Study area Snohomish basin reach identification and geomorphic characteristics. Sampling effort is 100% for bank conditions and 50% for habitat conditions.. 7
Table 2. LWD Decay Class Criteria 18

List of Figures

Figure 1. Snohomish River Pollutant Diagnosis and Implementation Project Study Area and River Segments 2
Figure 2. Skykomish River Segments 3
Figure 3 Snohomish River-Snoqualmie River Segments. 4
Figure 4 Snohomish Estuary-Quilceda Creek Segments 5
Figure 5. Example data entry for geomorphic reach header sheet 8
Figure 6. Example data entry for pools. 17
Figure 7. Example data entry for LWD. 18
Figure 8. Example data entry for LWD jams. 19

Distribution List

David Pater, Washington State Department of Ecology

Jamie Bails, Snohomish Conservation District

Introduction

Background

In 1999, Snohomish County Public Works Surface Water Management (SWM) initiated a multi-year stream habitat inventory of fish bearing streams in Snohomish County. A quantitative, rapid and repeatable survey protocol for wadable streams was developed (SWM, 2000, SWM, 2001a). To fill aquatic habitat condition data gaps in large, non-wadable rivers in Snohomish County, SWM developed this physical habitat survey protocol. Non-wadable rivers provide some of the most critical habitat for Endangered Species Act-listed Chinook salmon (*Oncorhynchus tshawytscha*) and native char (*Salvelinus spp*.), and thus data on current conditions in these areas provide an important foundation for salmon conservation plan actions and monitoring. Furthermore, physical habitat data from large rivers, including streambank conditions data are valuable for flood modeling and management. Also, identification of surface water discharge (outfalls) points is valuable information for tracking water quality conditions. When physical habitat conditions are analyzed alongside water quality and flooding data, they provide information as a basis for an integrated river restoration and management strategy.

The goals of this survey are to:

- Provide supporting data and analysis for salmon conservation, water quality evaluations, flood modeling and management, and capital project design and permitting;
- Collect data on current conditions as a benchmark for future trend monitoring, analysis and adaptive management;
- Systematically characterize and document the location of previously unknown outfalls, and;
- Identify restoration needs and potential projects based on watershed, reach and site-specific analysis.

The expected products from this survey are:

- an updated Geographic Information System (GIS) layer showing the location and stability of all dikes, levees, berms, revetments, deflectors and other anthropogenic modifications including points of surface water discharge from outfalls;
- an updated GIS hydrography layer including better coverage of secondary channel habitat (i.e. side-channels and off-channel habitat); and
- a report summarizing current aquatic habitat conditions in large rivers, examining relationships among parameters and comparing results to habitat performance criteria such that restoration projects can be developed.

Methods

Approach

The physical habitat survey and monitoring protocol for large rivers consists of two surveys, a Bank Condition survey and a Geomorphic Habitat survey. The Bank Condition survey is implemented prior to the Geomorphic Habitat survey. Data are gathered continuously on bank conditions along the right and left banks. Parameters include bank modifications, toe class material, instability, and point discharges. The Bank Condition survey is also used to reconnoiter for the Geomorphic Habitat survey, and thus Global Positioning System (GPS) points are collected at pools and LWD jams. The Geomorphic Habitat survey is conducted along unit reaches that comprise approximately fifty percent of geomorphic reach length. Data are gathered on the dimensions and characteristics of pools, LWD pieces, and LWD jams. All field work is conducted within waters of the State.

Study Area

The Snohomish River basin (WRIA 7) encompasses 1,856 square miles and is the second largest basin in Washington State that drains to Puget Sound. In Snohomish County, the three primary rivers in the basin flowing from the west slope of the Cascade Mountains are the Skykomish, Snoqualmie, and Snohomish (see Figures 1-4). These mainstem rivers and many smaller Snohomish County rivers in the basin such as the Pilchuck, Sultan and Wallace provide significant habitat for five salmon species, three trout species and one char species. This project will sample the non-wadeable portions of mainstem rivers and larger tributaries, particularly those river segments in the study area influenced by adjacent urban, rural and agricultural land uses. Non-wadeable rivers include those where water depth during low flow periods commonly exceeds 0.5 meters in riffles, 1-meter depth in glides, and 2-meter depth in pools and where flow velocities limit wading and hence access for habitat measurement. In the Snohomish River basin, this includes the Snohomish River estuary, Snohomish River mainstem, Skykomish River mainstem, Snoqualmie River mainstem, Wallace River, Sultan River, and the lower portion of other major tributaries.

Figure 1. Snohomish River Pollutant Diagnosis and Implementation Project Study Area and River Segments. The dashed lines delineate County boundaries.

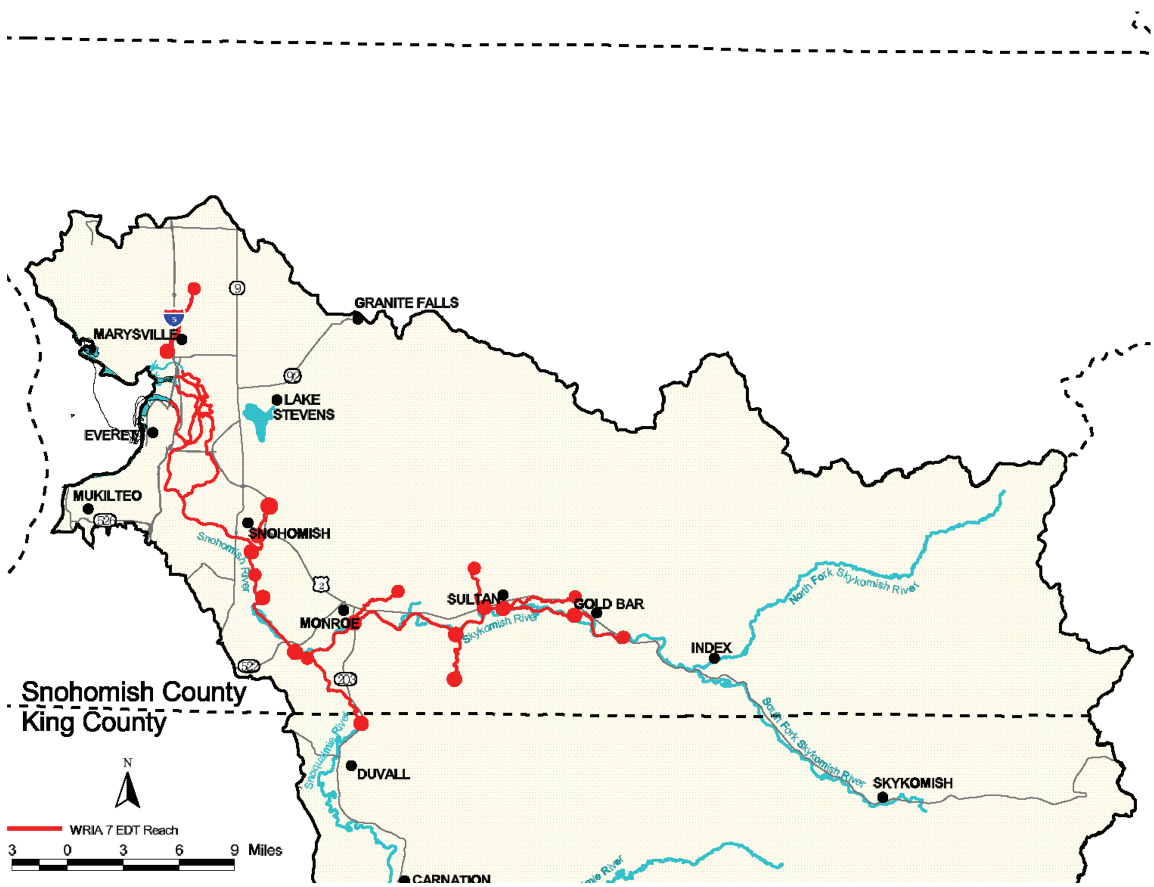


Figure 2. Skykomish River survey segments.

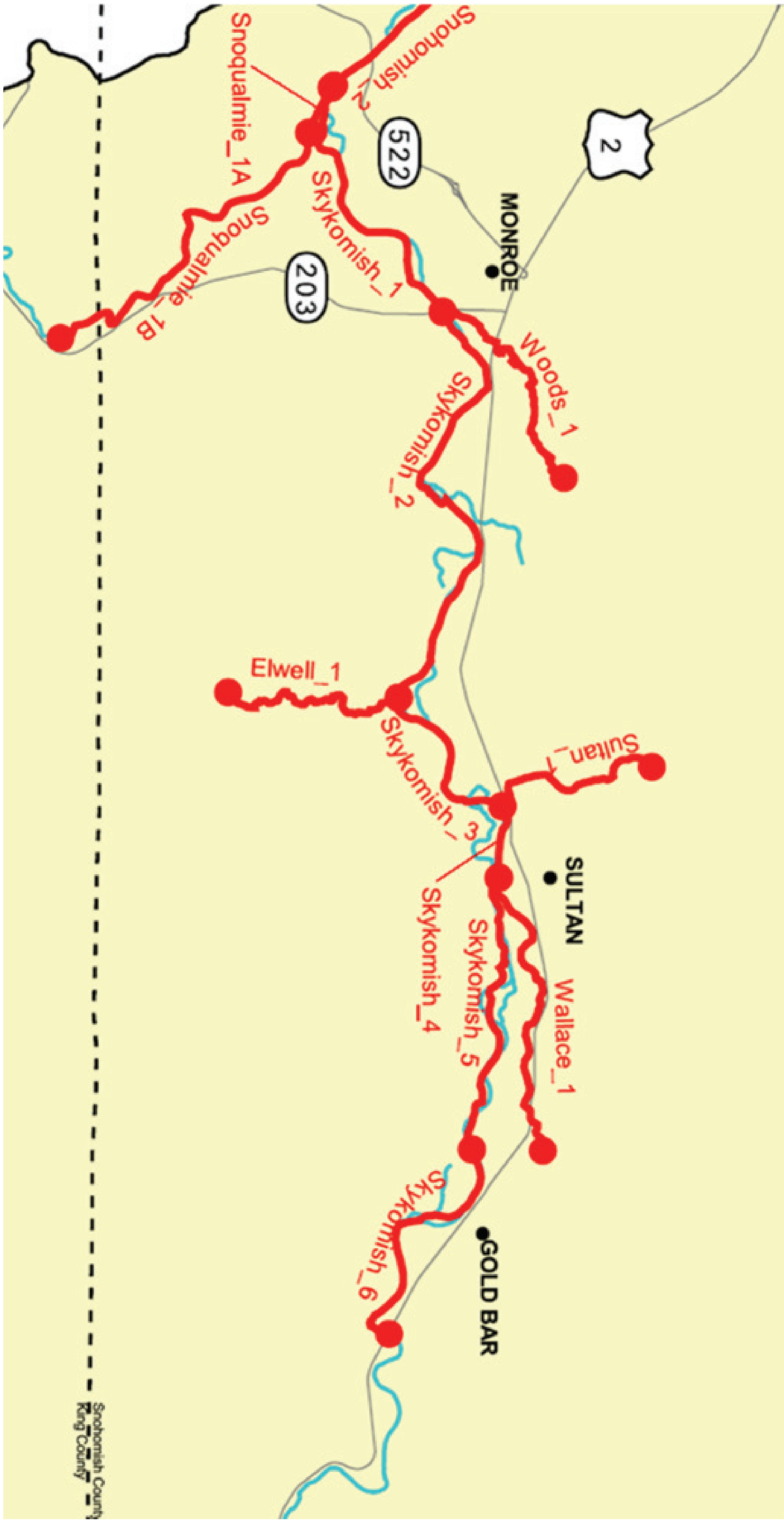
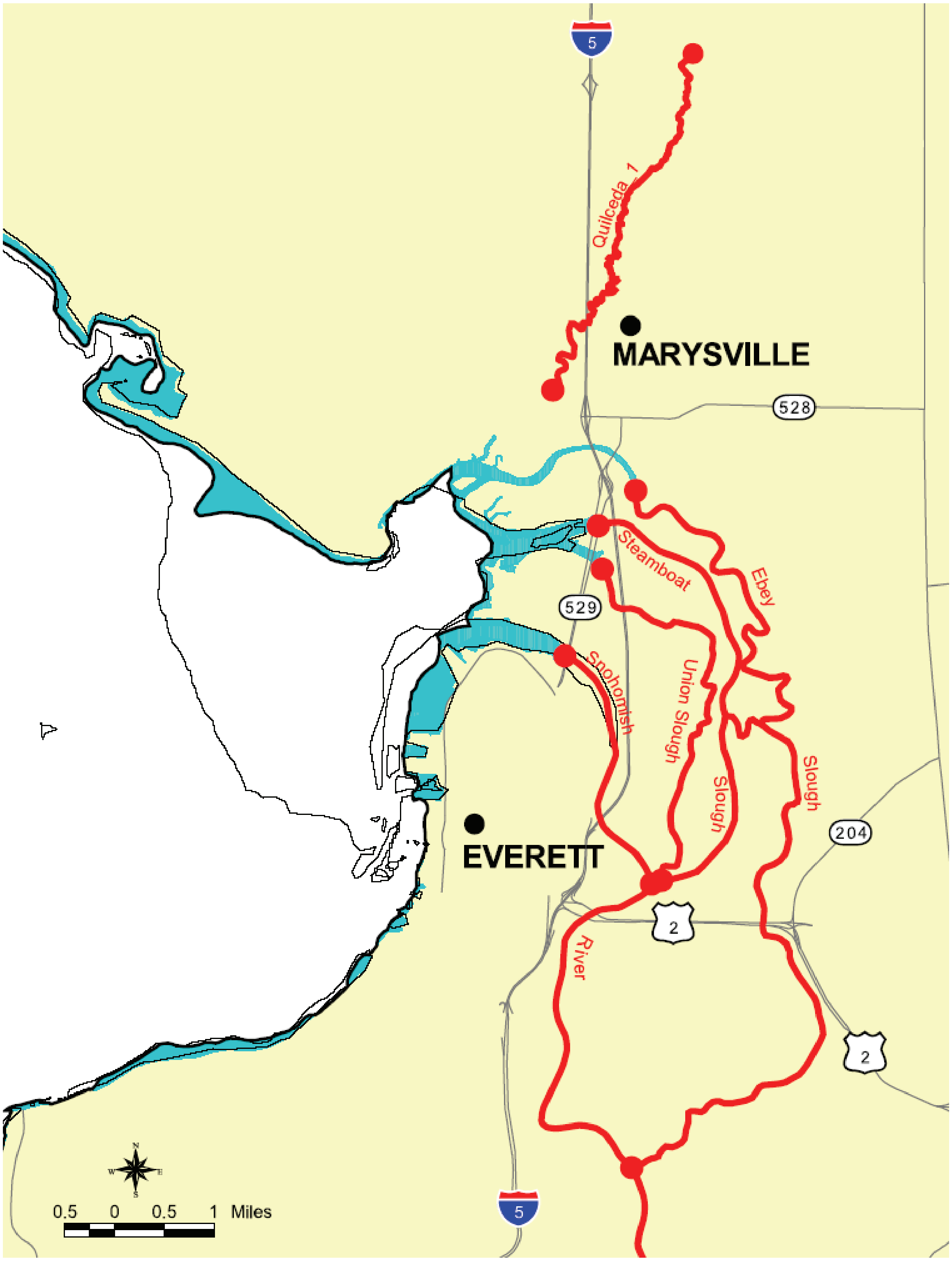


Figure 3. Snohomish-Snoqualmie River survey segments.

Figure 4. Snohomish River estuary survey segments.



Reach Delineation and Selection

The delineation of geomorphic stream reaches for this project uses existing reach databases as the foundation. Boundaries are adjusted for consistency with Snohomish County's Endangered Species Act (ESA) subbasins coverage. County staff classify geomorphic reaches based on gradient and entrenchment in accordance with Rosgen Level I stream classification methods (Rosgen, 1996). Reach demarcations, as currently identified (Table 1), were used by the Snohomish Basin Salmonid Recovery Technical Committee to conduct Ecosystem Diagnosis and Treatment (EDT, Mobrand Biometrics, Inc.) modeling. For this project, each geomorphic reach is divided into quarters. Half the reach (upper, middle two quarters, or lower) is randomly selected for the Geomorphic Habitat survey. As a quality control (QC) measure, a subset (approximately 10%) of surveyed reaches is resurveyed by different team members for data quality and assurance purposes (also see attachments).

Field Equipment

Field computer (2)
Measuring tape
Range Finder
Flagging tape
First aid kit safety gear
Hand-held calculator
Two inflatable boats
Trimble GPS units (2)
Stadia rod
Field map and clipboard
Hand-held sonar
Logger's diameter tape
Two-way radios

Table 1. Study area Snohomish basin reach identification and geomorphic characteristics. Sampling effort is 100% for bank conditions and 50% for habitat conditions.

						Reach width (ft)		
Watershed	**Subbasin**	**Reach ID #**	**EDT REACH**	**Rosgen Channel Type**	**Length (km)**	**Max**	**Min**	**Gradient (%)**
Snohomish	Estuary	EST	Estuary_1	DA	22.33	1080	260	0.01
Snohomish	Estuary	SNO_E	Snohomish River	DA	22.33	680	300	0.01
Snohomish	Estuary	UNS	Union Slough	DA	7.05	470	90	0.01
Snohomish	Estuary	SBS	Steamboat Slough	DA	8.08	730	200	0.01
Snohomish	Estuary	EBS	Ebey Slough	DA	17.46	670	110	0.01
Snohomish	Cathcart Drainages	SNH1	Snohomish_1	D	2.38	513	471	0.04
Snohomish	Cathcart Drainages	SNH2	Snohomish_2	D	6.82	370	366	0.04
Snoqualmie	Snoqualmie Mouth	SNQ1	Snoqualmie_1A	D	1.16	280	180	0.05
Snoqualmie	Snoqualmie Mouth	SNQ2	Snoqualmie_1B	E	9.03	280	180	0.05
Skykomish	Lower Mainstem Sky	SKY1	Skykomish_1	D	6.92	370	366	0.06
Skykomish	Lower Mainstem Sky	SKY2	Skykomish_2	D	11.18	370	366	0.06
Skykomish	Lower Mainstem Sky	SKY3	Skykomish_3	D	4.25	370	366	0.06
Skykomish	Lower Mainstem Sky	SKY4	Skykomish_4	D	1.71	370	366	0.06
Skykomish	Upper Mainstem Sky	SKY5	Skykomish_5	D	6.92	635	460	0.06
Skykomish	Upper Mainstem Sky	SKY6	Skykomish_6	C	6.21	250	300	0.06
Snohomish	Quilceda	QUA1	Quilceda_1	E	3.28	23	10	0.20
Pilchuck	Lower Pilchuck	PCK1	Pilchuck_1	C	2.72	60	35	0.10
PIlchuck	Lower Pilchuck	PCK2	Pilchuck_2	C	2.83	80	50	0.20
Woods	Lower Woods	WDS1	Woods_1	C	6.08	35	15	0.09
Elwell	Lower Mainstem Sky	EWL1	Elwell_1	C	5.19	15	7	0.50
Sultan	Lower Sultan River	STN1	Sultan_1	C	4.55	150	130	0.60
Wallace	Lower Wallace	WAL1	Wallace_1	C	7.25	83	40	0.40

Field Computers and File Management

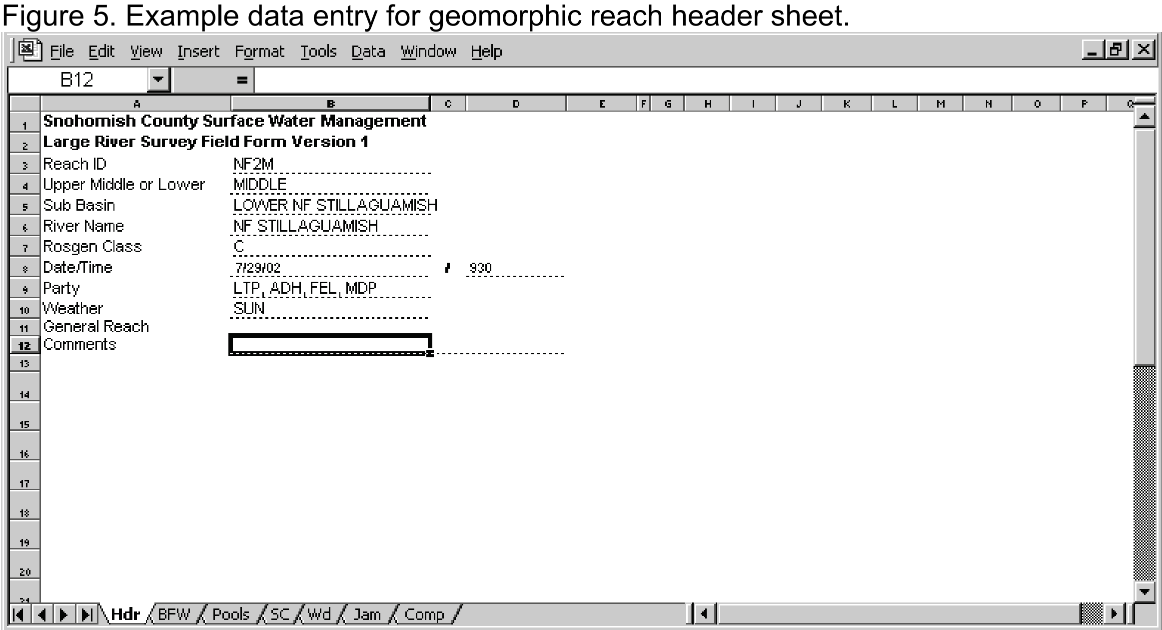
The Bank Condition survey employs a Trimble Geoexplorer GPS receiver and data collector to record locations and attributes of riverbanks. The Geoexplorer's horizontal accuracy is sub-meter on a second-by-second basis. Two GPS bank condition files are associated with each reach – one for each bank. All files are stored with a unique name created by combining letter values assigned to each reach and riverbank surveyed.

During the Geomorphic Habitat survey, data are entered into a spreadsheet contained on a Juniper Systems' Allegro Field PC ™, a hand-held field computer. The following section describes the procedure each survey team follows to ensure data are stored in a useful and organized format.

At the beginning of each unit reach, the file **BRSFS.pt** (the main spreadsheet) is opened. The file contains seven worksheets: one header sheet containing the information about the reach to be surveyed, five sheets for habitat parameter data entry and a compilation sheet that organizes data from each of the previous sheets into a single spreadsheet (for data management purposes only). Before entering any data, the file is saved after the designated reach identification number.

Once the file is saved as the reach identification number, the caps lock is engaged and all known reach information is entered into the spaces provided in the header sheet (Figure 5). Habitat information is entered into the habitat parameter sheets which are found by tapping on the tabs at the bottom of the screen. The file is saved periodically to ensure a minimal loss of data in the event of a computer lockup. At no time should data be entered into the compilation sheet (while the sheet is protected, some data entries are still possible). Completed reach files are transferred to an office computer after each day of survey and checked for invalid or missing data. Any anomalies are flagged and reported to the data manager.

Figure 5. Example data entry for geomorphic reach header sheet.



Bank Condition Survey

The objectives of the Bank Condition survey are to classify, characterize and map linear and single point features in one integrated survey. Linear features include hydromodifications, streambank instability, edge habitat, and secondary (including floodplain) habitat features. Single point instream and floodplain features include outfalls, culverts, deflectors, and other features (see definitions below). The survey involves both aerial orthophoto interpretation and field sampling techniques. Edge and secondary habitat units are delineated through orthophoto interpretation.

Secondary objectives of the Bank Condition survey are 1) to gather GPS locations of outfalls to develop an outfall sampling scheme based on the known population, in support of water quality sampling (other locations of outfalls and water quality sampling points will be acquired from Department of Ecology data layers; EIM Database), and 2) to gather GPS locations of pools and LWD jams (see definitions below) to better quantify pool and LWD jam frequency along the entire geomorphic reach in support of the Geomorphic Habitat survey.

Definitions:

Hydromodifications: human-made alterations to the stream channel, shoreline, and banks, which functionally act to limit channel and floodplain response to watershed processes, such as the delivery and routing of water, sediment, and large woody debris.

***Natural Streambank Instability*:** banks are unstable if they show indications of any of the following features at or above bankfull (Bauer and Burton 1993):

Breakdown: obvious blocks of bank broken away and lying adjacent to the bank breakage.
Slumping or False bank: the bank has obviously slipped down, cracks may or may not be obvious, but the slump feature is obvious.
Fracture: a crack is visibly obvious on the bank indicating that the block of bank is about to slump or move into the stream.
Vertical & Eroding: the bank is mostly uncovered as defined below *and* the bank angle is steeper than 80^{o} from the horizontal.

Hydromodified Streambank Instability: a failing hydromodification (riprap bank, levee/dike, armoring of any kind, deflectors, groins, etc.) is one that shows visible signs of sloughing, erosion, undercutting, slumping, erosion beside or behind the structure at either the upstream or downstream end, exposure of underlying material, tension cracks (long cracks running parallel to the river on top of bank), leaning trees, or armor material (e.g., riprap) that has been relocated by the river such that it no longer prevents migration.

Stable Streambanks: natural streambanks covered with any of the following features are considered stable:

- perennial vegetation ground cover > 50%, including if bank is undercut (>90° from the horizontal).
- roots of vegetation cover > 50% of the bank, including if bank is undercut (>90° from the horizontal).

- ≥ rocks of cobble size protect 50% of the bank surfaces or larger (Very uncommon except from talus slopes from inner gorges on naturally valley-confined reaches of non-wadeable rivers).
- ≥ 50% of the bank surfaces are protected by logs of ≥10-cm diameter.
- the bank is mostly covered as defined above *and* the bank angle is less than 80^{o} from the horizontal.
- otherwise, banks are considered uncovered.

Edge Habitat*:* edge habitat is characterized as to type based on the following definitions from Hayman, et al. (1996):

Bank edge: vertical, or nearly vertical shore.
Bar edge: shallow, low gradient interface with the shore.
Backwater edge: enclosed, low-velocity areas separated from the main channel. See backwater pool definition below for additional criteria.

Secondary Channel Habitat: aquatic floodplain features such as oxbows, side-channel sloughs, side-channels, beaver ponds and tributary streams.

Procedure:
Office Preparation
Map production is the first step in the Bank Condition survey. Maps displaying hydrography (water courses, shorelines or water boundary), reach breaks, river miles, previously known hydromodifications and fish blockages, boat put-in/take-out locations and the 100-year floodplain over recent orthophotos are produced for each reach. These maps act as a template for orthophoto interpretation, a field guide and a backup to GPS data collection. If previous survey points were recorded upstream or downstream of the area scheduled for survey, these data are also included on the field map to provide reference for start and/or end points and to facilitate seamless data collection. Maps (including the orthophoto layer) are reviewed and potential hydromodifications that do not appear in existing GIS spatial datasets are noted for field verification.

Field Survey
The field survey focuses on characterizing streambank stability and hydromodifications and identifying instream and floodplain points. Edge habitat and secondary channel habitat is not ground-truthed as part of this survey. The position of stormwater outfalls, pools and LWD jams are recorded as point data to facilitate the subsequent water quality investigation and geomorphic inventory. Bank instability and hydromodifications are continuously recorded using a Trimble Geoexplorer GPS and data collector. Surveys are conducted from two separate boats, one on each bank. In addition, one crew collects GPS locations for pools, and one crew collects GPS locations for LWD jams. If the channel is bifurcated, then hydromodifications and bank instability are measured along the outer banks only.

Hydromodification data are collected in two point feature classes: continuous bank modifications, which will be converted to lines, and floodplain and instream modifications, such as outfalls, tide gates and deflectors, which will remain as points. Specific data input and a copy of the data dictionary are found in Appendix A.

Bank Modifications:
To simplify data collection, bank modifications are recorded as point features along a continuous riverbank. At a change in any of the descriptive attribute fields listed below, a GPS point is recorded as near the location of change as possible. The attributes given to a point characterize the bank between this point and the next downstream modification point on the same bank. Survey teams will collect data points at the beginning of attribute changes while surveying in a downstream direction, or at the end of attribute changes if surveying in an upstream direction. Attributes are collected for the bank condition point feature, BNKCNDPT, in the following fields:

RIVER_BANK is collected as describing the left or right bank (facing downstream).

CONDITION categorizes the bank as being either "natural" or "modified".

STABILITY is recorded for both natural and hydromodified banks, describes whether or not the bank is intact or failing based on criteria listed above.

CONTINUITY clarifies the organization of bank modification points within a file and aids in the subsequent joining of multiple files. The furthest upstream point on each riverbank is labeled *start* and attributed to describe the bank downstream. The most downstream bank modification point recorded for each bank is labeled *end* and should only contain information in the *River Bank* and *Continuity* fields. This point is a terminus for attributes assigned to the bank at the point immediately upstream. All bank modification points recorded between the start and end points are assigned *serial* with one exception. If for any reason a section of bank between the start and end points is not surveyed, the continuity field for the point at the upstream end of the section is labeled *break*. When survey is resumed the first bank modification point recorded is again assigned *serial* continuity.

HMOD_TYPE describes the type of bank modification. Types include *dike/levee, berm, revetment, bulkhead, and grade*. If the type of bank modification is unclear, it is classified as a revetment. Banks whether natural or modified are identified as *stable or unstable* based on whether or not they meet the bank instability definitions (natural and hydromodified).

HMOD_TOE is determined for the toe class type by visually examining primary bank material below the ordinary high water mark. Toe classes include *Riprap, Rubble, Structural, and Earth*. Bank material greater than 256 mm (10 in) is considered *Riprap*. Bank material less than 256 mm is considered *Rubble* (Beamer & Henderson, 1998). Other classes such as wood, concrete, and gabion are lumped into *Structural* toe class. *Earth* includes soil as well as "natural" toe material. Non-modified banks and banks with setback modifications receive a *N/A* HMOD_TOE value by default.

CONFIDENCE labels each GPS point as being recorded on, near or significantly away from a change in bank condition. *High*, *Moderate*, or *See Photo* confidences are recorded depending on how the surveyor feels the resulting point represents the actual location of the bank condition change. This information is used during post-survey data processing to identify points needing adjustment. *See Photo* confidence values indicate the GPS position is not reliable and points/notes recorded on the aerial photograph should be used to place the point during post processing. When unfavorable satellite positions, topography, vegetation or swift currents prevent point collection using GPS, bank condition, pool and jam points are recorded solely on field maps. These points are integrated with the GPS-collected points during post-survey data processing.

Instream and Floodplain Modifications:

Instream modifications are features that are located within or protrude into the channel. They include surface water outfalls, bridge footings, deflectors, weirs, docks/pilings, and subsurface utility crossings. These modifications are recorded as point features. The positions of pools and LWD jams may also be recorded as instream (habitat) points for those portions of reaches not surveyed during the Geomorphic Habitat survey to obtain a more complete inventory of pools and LWD jams to develop whole river summary statistics.

Floodplain modifications are features that interact with or impact secondary channel habitats and are collected as point features. Floodplain modifications include culverts, tide/flood gates, pump stations, plugs, and diversion structures that impede or block natural flow and connectivity between secondary habitats such as tributaries, sloughs, lakes, ponds, or side channels and the mainstem.

Attributes for the instream and floodplain modifications feature, INSTFPPT, are collected in the following fields:

RIVER_BANK is collected as describing the left or right bank or center channel (facing downstream).

MOD_TYPE categorizes the instream modification type as occurring either in the stream channel or on the floodplain.

INSTR_TYPE includes surfacewater outfalls, bridge footings, deflectors, weirs, docks/pilings, and subsurface utility crossings. As mentioned above, during portions of the survey, pools and log jams may also be included as instream points. Where instream modifications co-occur with (or form) pools or LWD jams, this forming function is denoted as the pool forming factor or LWD jam type (see below). A value of N/A is selected for floodplain points.

FLDPL_TYPE includes the type of floodplain modifications as culverts, tide/floodgates, pump stations, Plug dikes, diversion structures and outfalls. A value of N/A is entered for instream points.

FLPL_BLOCK describes the floodplain feature blocked by one of the floodplain modifications above. Features include: tributary, side channel, distributary slough, blind tidal slough, pond and unknown. N/A is selected for instream modifications.

CONFIDENCE see above.

Geomorphic Habitat Survey

The primary objective of the Geomorphic Habitat survey is to characterize habitat conditions for salmonids, focusing on pools and LWD in rivers and secondary channel habitats. It is implemented in approximately 50% of each geomorphic reach and approximately 50% of the delineated side channels. The survey involves both aerial photo interpretation and field sampling.

Definitions:

Bankfull width (BFW) is the width of a stream channel measured at riffle crossover locations and at the point where overbank flow begins during a flood event that is typically observed every 1-2 years. In channels with disconnected or undeveloped floodplains, bankfull indicators may include: the top of deposited bedload (gravel bars), stain lines on banks, the lower limit of perennial vegetation, moss on streamside trees or lichen on rocks, a change in slope or particle size on the stream bank, or undercut banks (USFS, 1999). Large flood events may obscure signs of bankfull dimensions associated with floods recurring every 1-2 years. However, in general, even large floods will not disrupt well established lower limits of perennial vegetation and multiple measurements of bankfull flow dimensions will tend toward a measure associated with frequent (1-2 years) channel forming flows.

Wetted width is the width dimension at the low-flow channel margin at the time of survey as measured downstream from qualifying pools at the riffle crossover point.

Riffles are swift flowing (broken surface water) / steep habitat units and can be composed of high gradient riffles (> 4%), where the amount of exposed substrate or broken water is high; and low gradient riffles (< 4%), where flow may cover completely or partially submerge obstructions. Riffles are also characterized by substrate size as:

- Boulder (> 302 mm)
- Large Cobble (127 mm – 302 mm)
- Small Cobble (73.7 mm – 127 mm)
- Gravel (5.1 mm – 73.7 mm)

Glides, as defined for this survey, have slow-moving water of uniform depth and in Snohomish County's large rivers is typically 1 m in depth (+/- 0.5 m) at low flow.

Pools are sections of a river channel where water is impounded within a closed topographical depression (Abbe and Montgomery, 1996). For a habitat unit to qualify as a pool in this survey it must meet minimum area and depth requirements based on bankfull width dimensions and as indicated by habitat suitability criteria (e.g. NMFS, 1996). Because all bankfull width dimensions in large rivers are likely to be > 20 m, the minimum area and residual pool depth requirements are 5.0 m^2 and 0.4 m, respectively (after Pleus, et al., 1999). Additionally, pools must be ≥ 1 m at maximum depth.

Pool Tailouts are the downstream portion of pools where streambed gradient increases in a downstream direction and where fluvial hydraulics create substrate and flow conditions highly suitable for spawning. Because the hydraulic gradient steepens beyond the riffle crest, stream flow is forced downward into the gravel in advance of and over the riffle crest. Water that infiltrates is highly oxygenated for salmonid embryo incubation. Additionally, because pools in advance of tailout areas are depositional, tailout areas have a reduced probability of fine sediment deposition, and, as flow accelerates over the riffle crest, fine sediments remain in suspension. Pool tailouts measured in this study have suitable spawning gravel size (8-128 mm), are identified by flow acceleration, and are in advance of the riffle crest.

Backwater Pools are a pool type formed by an eddy along the channel margin downstream from obstructions such as bars, rootwads, or boulders, or resulting from back watering upstream from a downstream obstruction. Often backwater pools are the downstream remainder of a secondary side channel. Backwater pools are not associated with the thalweg and are sometimes separated from the channel by gravel bars. These pools may or may not have a downstream riffle crest forming a closed topographical depression and so only the maximum depth and area criteria for pools apply. Edge habitat associated with backwater pool area is classified as backwater edge.

Woody debris refers to both large and small woody debris, stumps and jams as defined below.

Large woody debris (LWD) is defined as downed wood that intercepts bankfull flow (trunk not branches) in a substantial fashion and is large enough to influence the formation of habitats (USFS, 1999).

Jams are defined as 3 or more touching pieces of LWD (defined above) together producing a single structure significantly intercepting bankfull flow. Report Y or N if piece is part of a jam. Using orthophotos, we have classified jams as fitting three general types (after Abbe and Montgomery, 1996): bar top jams, bar apex jams and meander jams.

Bar Top Jams (BTJs) are random accumulations of loosely organized debris on top of a bar with little vertical stacking. BTJs have little influence on channel morphology, are not contained within the low flow channel, and may be short-lived in location as wood floats on to and off of these locations with the rise and fall of rivers. BTJs would be least likely to provide direct habitat value for salmonids and least likely to form suitable habitats as a result of influencing channel morphology.

Bar Apex Jams (BAJs) are typically more stable LWD accumulations anchored by large pieces (60-90 cm minimum diameter dependent on bankfull depth) with root wads showing vertical stacking of orthogonal and oblique members located at the upstream end of a gravel bar or forested island. BAJs influence river channel morphology, local habitat formation (as crescentic pools or direct habitat cover during higher flows) and riparian forest development.

Meander Jams (MJs) are typically more stable LWD jams located at and often stabilizing the concave surface of meanders or outer stream bank with key members and vertical stacking. MJs can influence channel morphology by altering river radius of curvature and among all LWD jam types has the greatest degree of association with the river thalweg and low flow conditions.

Secondary Channel Habitat is composed of side-channel (within the bankfull width) and off-channel (outside the bankfull width) habitat. Side channels are defined as channels that contain the smaller portion of the total bankfull flow (may be dry during low flow periods) and are separated from the main channel by a stable island. A stable island in a forested stream is defined by USFS (1999) as supporting woody vegetation (excluding willow), which is estimated to be at least 5 years old (and covers at least 50% of the island surface). Off-channel habitat includes marshes, ponds and oxbow lakes that are outside the bankfull channel and are not field surveyed.

Procedure:

Office Preparation

Fifty percent of each geomorphic reach (upper half, middle half, or lower half) is randomly selected for detailed survey. Exceptions are made when the lower half of one reach and the upper half of the next reach are selected for logistical reasons rather than randomly.

For each survey reach maps are produced which include orthophotos, reach breaks, boat put-in and take-out locations, the delineation of waterbodies and water courses, and data gathered during the Bank Condition survey, including bank characteristics and the location of pools and LWD jams for sub-sampling purposes (see below). Aerial photo interpretation and use of LIDAR (LIght Distance And Ranging) topographic imagery are used to assist in the identification and delineation of side channels and off-channel habitats. All side channel and off channel areas identified using LIDAR imagery must still be ground-truthed to determine accessibility (for fish). Areas where additional ground-truthing is necessary to verify the accuracy of the Bank Condition survey data, side- and off-channel areas or the waterbody boundary (as it may change with flood events) are flagged with a question mark to be resolved during the field survey.

Field Survey

Because each reach surveyed varies in complexity, the division of labor between surveyors within and between watercraft is varied. Generally, surveyors in one craft are responsible for enumerating and characterizing single pieces of LWD on one bank as well as identifying and measuring pools. Surveyors in the second craft collect LWD data on the opposite bank and are responsible for measuring and sampling jams. However, side channels, long pools and large jams require coordination and flexibility in the division of labor. Specific data input and a copy of the data dictionary is found in Appendix B. Field survey training with all survey participants is crucial for making consistent and definition-based measurements with instrumentation that may be new or unfamiliar to users. This especially important when data are categorized based on observations.

Bankfull Width
Bankfull width is measured once for each reach surveyed at the crest of the first riffle in order to calibrate BFW estimates made using orthophotos in Arcview®. A GPS point is collected at the location of the measurement. Data are entered in the field computer in the appropriate worksheet. BFW measurements of the Stillaguamish River were highly correlated (r^2=0.85, p<0.01, n=20) with those measured using orthophotos in Arcview®. BFW is a precisely measured habitat parameter and will not be included as part of QC surveys (see attached report on precision and repeatability).

Riffles
All riffles will be identified by dominant substrate size (boulder, large cobble, small cobble, or gravel) based on a visual inspection. For each riffle, the up- and down-stream unit boundaries will be identified by GPS and the length will be measured, where possible, with a laser rangefinder. If the riffle wetted width (RWW) is uniform, only one width measurement will be taken. If the riffle wetted width is visually estimated to be irregular by up to 30%, three RWW measurements will be taken at the beginning, middle and end of the riffle. Riffle area will be calculated. As an office exercise and to estimate riffle area in the 50% of each reach not surveyed, RWW and length will be measured using year 2003 orthophotos in Arcview®. Data points and riffle dimensions measured in 2004 will be used to calibrate riffle measurements of 2003 photos to estimate total riffle area and evaluate the need for QC measurements of riffle length. RWW measures for replicate samples were found to be very precise and will not be included in QC surveys (see attached report on precision and repeatability).

Glides
The amount of glide habitat will be estimated as the difference between the sum of measured pool and riffle areas and the total wetted area, as estimated by GIS analysis. In order to develop good estimates of glide area, the objective is to minimize error variance associated with pool and riffle measurements. One way of doing this is by way of habitat unit delineation for which definitions are provided. Additionally, pools and riffles will be identified spatially based on their downstream end point and multiple measurements of unit length and widths will reduce error variance.

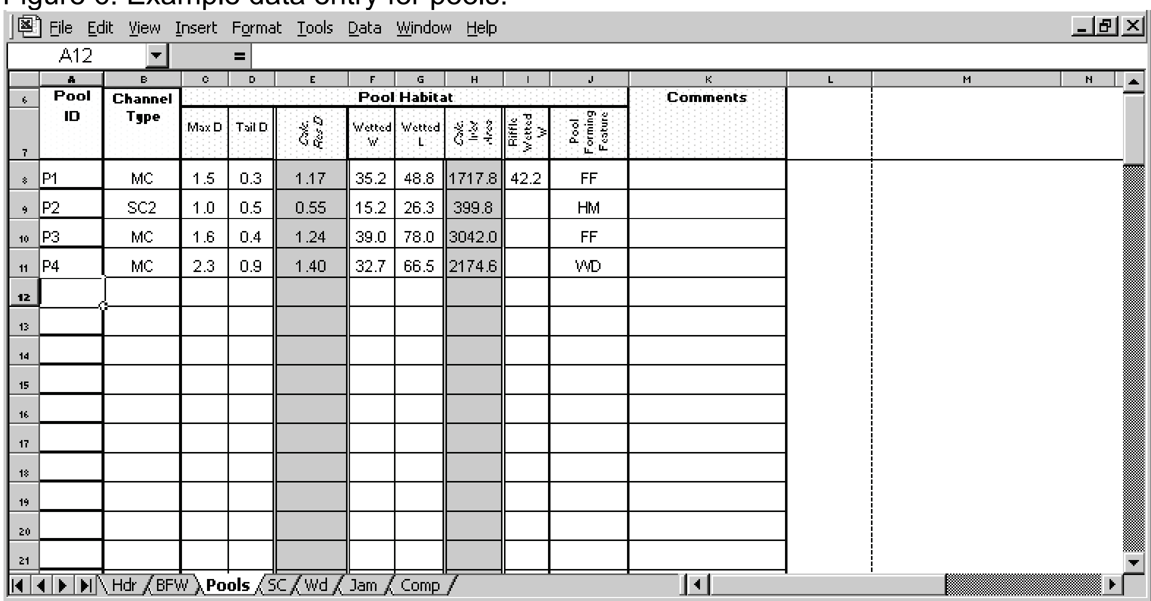
Pools
Pools within each surveyed reach are recorded by reach name, abbreviation and pool number (Figure 6). This pool number is cross-referenced with GPS data previously collected during the Bank Condition survey. A minimum residual depth (maximum pool depth minus tailout depth) of 0.4 meter and a minimum of 1 meter maximum depth are required to qualify as a primary pool type, but not for the backwater pool type. The pool GPS position is entered and labeled.

For each pool, average pool width is measured using a laser rangefinder and maximum and tailout depths are measured with a handheld digital sonar gun or stadia rod. Pool lengths are measured in the field with a laser rangefinder or identified on field maps and measured using Arcview® with aerial orthophotos. It is important to note that, in contrast with SWM's protocol for wadable streams, only total pool area is measured, not "functional area." This deviation from the wadable stream survey protocol is based on the assumption that the functional area is equal to the total area at the scale of large rivers.

For each pool, the primary pool-forming feature is recorded as hydromodification (e.g., riprap, structural or pilings), wood (LWD with or without a rootwad or jam), free formed or bedrock. Data are entered for each pool in the appropriate field computer spreadsheet (Figure 6).

For each pool, the pool tailout area will be coded as having spawnable size gravel (8-128 mm, enter Y/N). For every 3rd pool with spawnable size gravel, the pool tailout area will be measured (length and width) and identified with a single GPS point. For reporting purposes, spawnable pool tailout area as a percent of total pool area will be estimated and correlated with total pool area. In cases where a pool is followed downstream by a glide, the tailout of the pool is delineated at the beginning of the glide rather than at the downstream riffle crest.

Figure 6. Example data entry for pools.



Pool ID	Channel Type	Pool Habitat								Comments
		Max D	Tail D	Calc Res D	Wetted W	Wetted L	Calc Int Area	Riffle Wetted W	Pool Forming Feature	
P1	MC	1.5	0.3	1.17	35.2	48.8	1717.8	42.2	FF	
P2	SC2	1.0	0.5	0.55	15.2	26.3	399.8		HM	
P3	MC	1.6	0.4	1.24	39.0	78.0	3042.0		FF	
P4	MC	2.3	0.9	1.40	32.7	66.5	2174.6		WD	

<u>Woody Debris</u>
Data are gathered on single pieces of LWD and on LWD jams according to the following protocol for each parameter and entered (see Figures 7 and 8 on following pages).

Single pieces

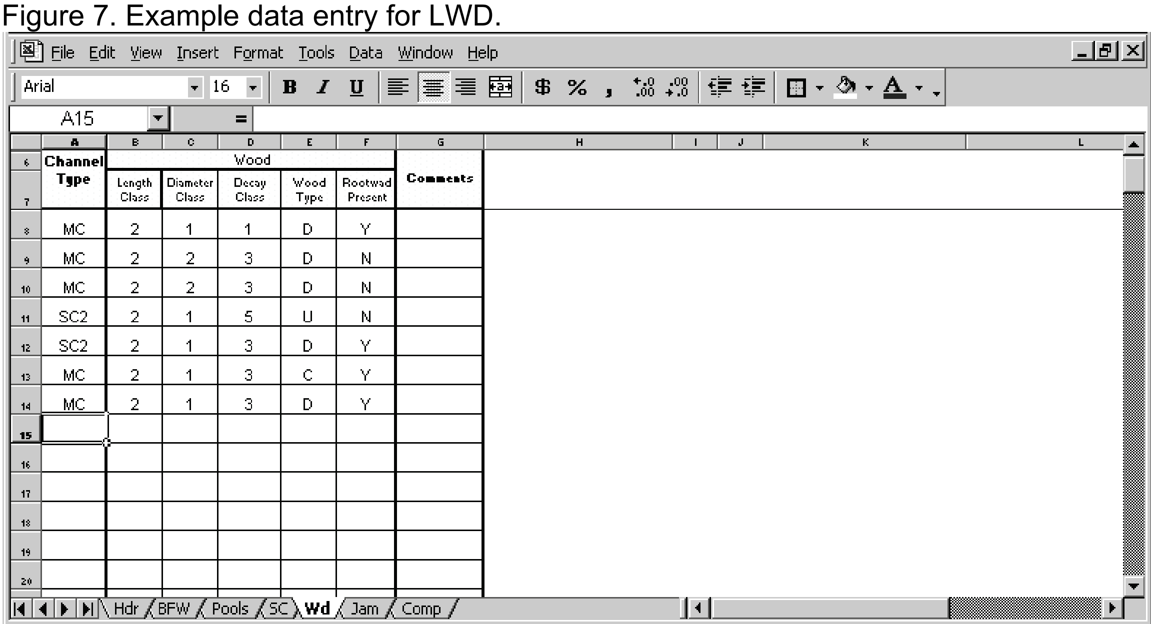
Abundance - all pieces which are greater than 7.6 m in length and 30 cm in diameter at 7.6 meters from the base are recorded.
Length class - log length is measured or visually estimated and recorded in the field computer in three length classes: 7.6-15 m; >15 m; and <7.6 m with a rootwad only. The first five pieces each day are measured and every 10th piece thereafter is also measured to stay calibrated.
Diameter class - log diameter is measured or visually estimated and recorded in four diameter classes; 30-60 cm, 60-90 cm, >90 cm, and <30 cm with a rootwad only. The first five pieces each day are measured and every 10th piece thereafter is also measured to stay calibrated. Log diameter is measured at 7.6 meters from the base of the log.

Rootwad presence/absence - for a rootwad to be counted on a piece of woody debris, the mean rootwad diameter must be ≥ one meter. Y or N is reported for rootwad presence.
Decay class **-** each piece is characterized based on the condition of the wood from natural decay. Table 2 lists the criteria for decay class. The five classes of Schuett-Hames, et al. (1994) have been simplified into three: “recent” (1), “intermediate” (3) and “old” (5) (Collins, et al., 2002; Table 2). Pieces within decay class 5 will automatically be classified as wood type unknown.

Table 2: LWD Decay Class Criteria

Decay Class (Collins, *et al.,* 2002)	Decay Class (Schuett-Hames *et al.* 1994)	Bark	Twigs	Texture	Shape	Wood Color
1	1	Intact	Present	Intact	Round	Original Color
1	2	Intact	Absent	Intact	Round	Original Color
3	3	Trace	Absent	Smooth	Round	Darkening
5	4	Absent	Absent	Abrasion	Round/Oval	Dark
5	5	Absent	Absent	Vesicular	Irregular	Dark

Figure 7. Example data entry for LWD.



Channel Type	Wood: Length Class	Diameter Class	Decay Class	Wood Type	Rootwad Present	Comments
MC	2	1	1	D	Y	
MC	2	2	3	D	N	
MC	2	2	3	D	N	
SC2	2	1	5	U	N	
SC2	2	1	3	D	Y	
MC	2	1	3	C	Y	
MC	2	1	3	D	Y	

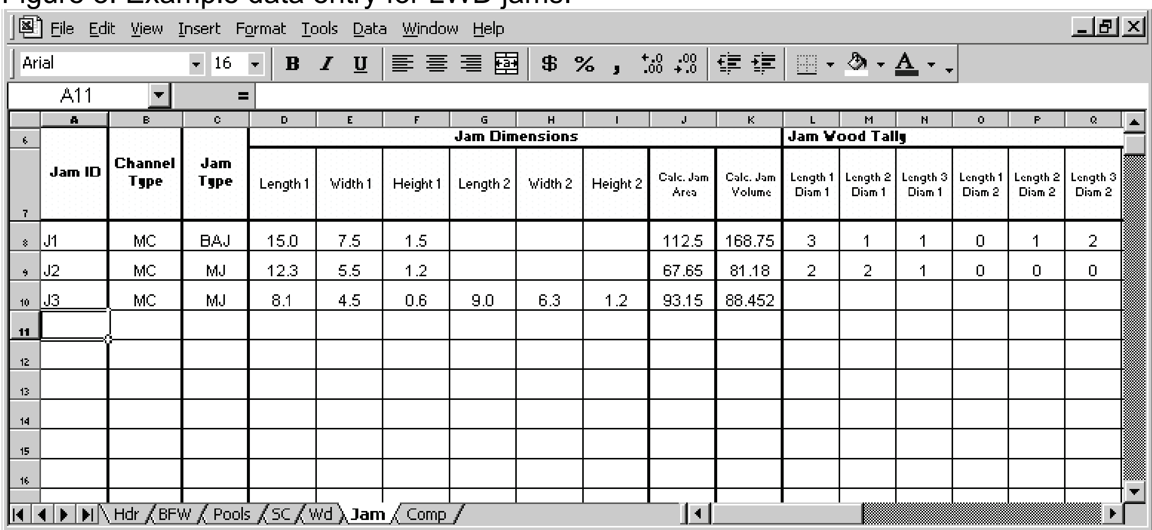
LWD Jams

Jam location - The location recorded, using GPS, of all jams wholly or partially (at least 3 pieces) contained within the bankfull width, including side channels, during the Bank Condition Survey.
Jam type - The jam type is recorded based on the three general classes defined above.

Jam dimensions - The cubic volume of each jam is estimated by measuring and recording an average jam height, length and width. For irregularly shaped jams, the area is an additive estimate of two or more cubic volume measurements.

LWD dimensions within jams - Approximately one-third of the jams are identified and marked on aerial photos prior to field survey, then sampled for piece data during the Geomorphic Unit survey. If new jams are encountered during the geomorphic surveys that were not enumerated during the Bank Condition surveys, every third jam is sampled. Within these jams, all LWD pieces are tallied based on length/diameter classes, wood type, rootwad presence/absence, and decay class.

Figure 8. Example data entry for LWD jams.



Jam ID	Channel Type	Jam Type	Jam Dimensions								Jam Wood Tally					
			Length 1	Width 1	Height 1	Length 2	Width 2	Height 2	Calc. Jam Area	Calc. Jam Volume	Length 1 Diam 1	Length 2 Diam 1	Length 3 Diam 1	Length 1 Diam 2	Length 2 Diam 2	Length 3 Diam 2
J1	MC	BAJ	15.0	7.5	1.5				112.5	168.75	3	1	1	0	1	2
J2	MC	MJ	12.3	5.5	1.2				67.65	81.18	2	2	1	0	0	0
J3	MC	MJ	8.1	4.5	0.6	9.0	6.3	1.2	93.15	88.452						

<u>Secondary Channel Habitats</u>

Prior to the Bank Condition or Geomorphic Habitat surveys, aerial photos and LIDAR topographic imagery are interpreted to identify potential secondary channel features based on the definition above. If a stable island does not separate the feature from the main channel, it should be combined with the main channel measurements. If the feature is located outside the bankfull channel, it should be marked on field maps and described in the comments based on the definition provided above.

For all secondary channels identified, a GPS position is obtained at the first point encountered where the channel connects to the main channel. A determination is made as to whether the secondary channel is dry but within the bankfull channel, connected at one end (channel type SC1), or connected at both ends (channel type SC2) at the time of the survey, and the corresponding code is recorded in the spreadsheet. The secondary channel is surveyed using the same protocol as for mainstem channels, collecting data on pools, LWD, jams, and bank conditions (outer streambank only), if not previously collected. The wetted and total widths are measured and recorded (length can be measured off of photos in the office) and significant off-channel habitat features, which are outside the bankfull flow, should be noted in the comments but not measured.

Post-Survey Data Processing and Quality Assurance/Control

GPS data collected during the Bank Condition survey is downloaded from the Trimble data collector into Pathfinder Office®, which creates shapefiles for Arcview®, identified by reach location and type (bank condition points, pool and jam location points). Pools and LWD jam positions collected as point data during the Bank Condition survey are incorporated into Geomorphic Habitat survey shapefiles to integrate with data collected during the Geomorphic Habitat survey.

Point locations and attributes are checked by the person who collected the field data using aerial photos, comments, and other information to ensure that all necessary values have been entered and that data and coding are consistent with other information. Bank condition points are adjusted to an updated, routed streambank or shoreline theme in GIS. Continuous line data are generated from primary data points, each segment representing a particular combination of bank condition attributes. This post-processing exercise generates segment lengths for individual or combined attributes. Individual segments also represent sample points for statistical analysis of individual or combined attributes to answer specific questions.

Geomorphic habitat data on pools, LWD, jams, and cross-sectional measurements are checked for missing or invalid values. Data are compared with shapefiles of location information collected during Bank Condition survey. Point locations and attributes are checked by the person who collected the field data using aerial photos, comments, and other information to ensure that all necessary values have been entered and that data and coding are consistent with other information. Areas of pools and active channels are calculated and proportions are calculated. Pools are counted and frequencies are calculated at different scales. Class information on LWD is counted and combined at various scales to answer specific questions.

For the purposes of quality control, it is recommended that the survey be repeated, using different staff, in at least 10% of the reaches surveyed. This should generally be accomplished close in time (and thus in flow conditions) to the original survey. Quality control efforts will focus on sampling pools, LWD, and bank stability/instability. Data from the quality control survey should be checked against the original survey data immediately to determine whether the different teams are properly implementing the protocol.

Finally, Snohomish County SWM will transmit all data collected to Ecology for its inclusion in Ecology's Environmental Information Management (EIM) system database. Snohomish County SWM will coordinate the data transmission with Ecology's EIM Manager and will submit all data in accordance with Ecology's Data Submittal Guide. The most recent Data Submittal Guide will be consulted via the Internet just prior to the data transfer.

Literature Cited

Abbe, T.B, and D.R. Montgomery. 1996. Large woody debris jams, channel hydraulics and habitat formation in large rivers. Regulated Rivers: Research & Management, Vol. 12, 201-221.

Bauer, S.B., and T.A. Burton. 1993. Monitoring protocols to evaluate water quality effects of grazing management on western rangeland streams. U.S. Environmental Protection Agency Region 10, Seattle, WA.

Beamer, E.M., and R.A. Henderson. 1998. Juvenile salmonid use of natural and hydromodified stream bank habitat in the mainstem Skagit River, Northwest Washington. Skagit System Cooperative. La Conner, WA. 51 p.

Collins, B. D., D.R. Montgomery, and A. D. Haas. 2002. Historic changes in the distribution and functions of large woody debris in Puget Lowland rivers. Canadian Journal of Fisheries and Aquatic Science 59:66-76.

Haas, A.H., F.E. Leonetti, L.T. Parker, M.D. Purser, and M.D. Rustay. 2003. Stillaguamish River bank and physical habitat conditions survey 2002 summary report. Snohomish County Public Works, Surface Water Management, Everett, WA.

Hayman, R.A., E.M. Beamer, and R.E. McClure, 1996. FY 1995 Skagit River Chinook – Restoration Research Progress Report No. 1. Skagit System Cooperative , LaConner, WA. 113 p.

Leonetti, F.E., A.H. Haas, L.T. Parker, M.D. Purser, and M.D. Rustay. 2003. Precision and repeatability of wadeable stream habitat survey methods. Snohomish County Public Works, Surface Water Management, Everett, WA.

National Marine Fisheries Service. 1996. Coastal salmon conservation: working guidance for comprehensive salmon restoration initiatives on the Pacific Coast. USDC-NOAA, NMFS, Portland, OR. Report dated September 15, 1996.

Pleus, A. E., D. Schuett-Hames, and L. Bullchild. 1999. TFW Monitoring Program method manual for the habitat unit survey. Prepared for the Washington State Dept. of Natural Resources under the Timber, Fish, and Wildlife Agreement. TFW-AM9-99-003. DNR #105. June.

Rosgen, D. L. 1996. Applied river morphology. Wildland Hydrology Books, Pagosa Springs, CO.

Schuett-Hames, D., A. Pleas, L. Bullchild, S. Hall. [eds.] 1994. Ambient monitoring program manual. Timber-Fish-Wildlife, TFW-AM9-94-001. Northwest Indian Fisheries Commission, Olympia, WA.

Snohomish County SWM. 2000. Physical habitat survey and monitoring protocol for wadable streams. Snohomish County, Public Works, Surface Water Management, Version 5.0.

Snohomish County SWM. 2001. Physical habitat survey and monitoring protocol for wadable streams. Snohomish County, Public Works, Surface Water Management, Version 6.0 (06/01).

USDA-Forest Service. 1999. Stream inventory handbook: Level I & II. USDA, Region 6, Version 9.9.

Appendix A

Data dictionary for Bank Condition survey

```
"Bank Condition", Dictionary, "MRUSTAY 2004"
"BNKCNDPT", point, "Channel Edge Modifications", 1, seconds, 5, Code
   "NAME", text, 16, normal, "Reach/record identifier", normal, 1,
Label1
   "RIVER_BANK", menu, required, required, Label2
      "Right"

      "Left"
   "CONDITION", menu, normal, normal
      "Natural"
      "Modified"
   "STABILITY", menu, normal, normal
      "Stable"
      "Unstable"
   "CONTINUITY", menu, required, required
      "Start"
      "Serial", default
      "Break"
      "End"
   "HMOD_TYPE", menu, normal, "Enter N/A for Natural, Set Back", normal
      "Dike/Levee"
      "Berm"
      "Revetment"
      "Bulkhead"
      "Grade"
      "N/A", default
   "HMOD_TOE", menu, normal, "Describe bank material at bankfull toe",
normal
      "Rip Rap (GT 256 mm)"
      "Rubble (LT 256 mm)"
      "Structural"
      "Earth/Natural", default
   "CONFIDENCE", menu, normal, "Location confidence", normal
      "High", default
      "Moderate"
      "See Photo"
   "COMMENT", text, 30, normal, "Description, Misc.", normal
   "COMMENT_2", text, 30, normal, normal
   "COMMENT_3", text, 30, normal, normal

"INSTFPPT", point, "Instream and Floodplain points", 1, seconds, 5,
Code
   "NAME", text, 16, normal, "Reach/record identifier", normal, 1,
Label1
   "RIVER_BANK", menu, required, "Location of Feature Bank or Mid-
channel", required, Label2
      "Right"
      "Left"
      "Mid-Channel"
   "MOD_TYPE", menu, required, "Mod effects are in or out of channel",
required
      "Instream"
```

```
      "Floodplain"
   "INSTR_TYPE", menu, required, "Type of In Stream Modification",
required
      "Pool"
      "LWD Jam"
      "Bridge Footing"
      "Dock/Marina"
      "Deflector"
      "Log Raft"
      "Pilings"
      "Utility Cross Under"
      "Weir"
      "Other"
      "N/A", default
   "FLDPL_TYPE", menu, normal, "Type of Tributary Modification", normal
      "Culvert"
      "Tide/Flood Gate"
      "Pump Station"
      "Plug Levee/Dike"
      "Diversion Structure"
      "Outfall"
      "N/A", default
   "FLPL_BLOCK", menu, normal, normal
      "Unknown"
      "Tributary"
      "Side channel"
      "Distributary Slough"
      "Blind Tidal Slough"
      "Pond"
      "N/A", default
   "CONFIDENCE", menu, normal, "Used for post processing of points",
normal
      "High", default
      "Moderate"
      "See Photo"
   "COMMENT", text, 30, normal, normal
   "COMMENT_2", text, 30, normal, normal
   "COMMENT_3", text, 30, normal, normal

"ACCESSPT", point, "", 1, seconds, 5, Code
   "River_Bank", menu, normal, normal, Label2
      "Right"
      "Left"
   "User", menu, required, normal, Label1
      "Human Foot"
      "Human Boat"
      "Human Vehicle"
      "Cattle"
   "Condition", menu, normal, normal
      "Good"
      "Moderate"
      "Severe"
   "PhotoID", text, 30, normal, normal
   "Comment1", text, 30, normal, normal
   "Comment2", text, 30, normal, normal

"OUTFALLS", point, "", 1, seconds, 5, Code
```

```
"Flow", menu, normal, normal, Label1
   "No", default
   "Yes"
"Material", menu, normal, normal, Label2
   "Concrete"
   "CMP"
   "CMP Coated"
   "Packed Soil"
   "Ductal Iron"
   "GrassVeg"
   "Gravel"
   "HDPE Smooth"
   "HDPE Corrugated"
   "N/A"
"Structure", menu, normal, normal
   "Pipe"
   "CB"
   "Detention"
   "Ditch"
   "Stream"
   "Tile Drain"
   "Tide Gate"
   "Other"
"Comment 1", text, 30, normal, normal
"Comment 2", text, 30, normal, normal
```

Appendix B

Data dictionary for Geomorphic Habitat survey

```
"DraftLarge_River_Hab", Dictionary, "MDR"
"Pool", point, "Records location, type and dimensions", 1, seconds, 5,
Code
   "Pool_ID", text, 10, not_permitted, normal, 1, PoolA1, Label1
   "Pool_Type", menu, normal, normal
      "Primary"
      "Backwater"
   "Pool_Form", menu, required, "Choose Pool Forming Factor", normal,
Label2
      "Free form"
      "Rip rap"
      "Bed rock"
      "Wood"
   "Max_Depth (m)", numeric, 2, 0.99, 10.00, 1.00, required, "meters",
normal
   "Width (m)", numeric, 2, 0.00, 200.00, 0.00, required, "Meters",
normal
   "Length (m)", numeric, 2, 0.00, 500.00, 0.00, normal, "Meters",
normal
   "Tailout_Depth (m)", numeric, 2, 0.00, 10.00, 0.00, required,
"Meters", normal
   "Spawnable", menu, required, normal
      "Y"
      "N"
   "Tailout_Width", numeric, 1, 0.0, 300.0, 0.0, normal, normal
   "Tailout_Length", numeric, 1, 0.0, 300.0, 0.0, normal, normal
   "Comment1", text, 30, normal, normal
   "Comment2", text, 30, normal, normal

"Riffle", point, "", 1, seconds, 3, Code
   "Riffle_ID", text, 12, not_permitted, normal, 1, RiffleA1
   "Riffle_Type", menu, normal, normal, Label1
      "Boulder"
      "Large_Cobble"
      "Small_Cobble"
      "Gravel"
   "Wetted_W(m)", numeric, 2, 0.00, 200.00, 0.00, normal, "m", normal
   "BFW(m)", numeric, 2, 0.00, 200.00, 0.00, normal, "m", normal
   "Length (m)", numeric, 2, 0.00, 500.00, 0.00, normal, "Meters",
normal
   "Comment1", text, 30, normal, normal
   "Comment2", text, 30, normal, normal

"Jam", point, "", 1, seconds, 15, Code
   "Jam_ID", text, 30, not_permitted, normal, 1, JamA1, Label1
   "Jam_Type", menu, required, "Bar top, bar apex, meander", normal,
Label2
      "BTJ"
      "BAJ"
      "MJ"
```

```
   "Jam_length (m)", numeric, 2, 0.00, 100.00, 0.00, required, "m",
normal
   "Jam_width (m)", numeric, 2, 0.00, 100.00, 0.00, required, "m",
normal
   "Jam_height (m)", numeric, 2, 0.00, 20.00, 0.00, required, "m",
normal
   "2Jam_length (m)", numeric, 2, 0.00, 100.00, 0.00, normal, "m",
normal
   "2Jam_width (m)", numeric, 2, 0.00, 100.00, 0.00, normal, "m",
normal
   "2Jam_height (m)", numeric, 2, 0.00, 20.00, 0.00, normal, "m",
normal
   "Comment1", text, 30, normal, normal
   "Comment2", text, 30, normal, normal
   "D1L1", numeric, 0, 0, 100, 0, normal, normal
   "D1L2", numeric, 0, 0, 100, 0, normal, normal
   "D1L3", numeric, 0, 0, 100, 0, normal, normal
   "D2L1", numeric, 0, 0, 100, 0, normal, normal
   "D2L2", numeric, 0, 0, 100, 0, normal, normal
   "D2L3", numeric, 0, 0, 100, 0, normal, normal
   "D3L1", numeric, 0, 0, 100, 0, normal, normal
   "D3L2", numeric, 0, 0, 100, 0, normal, normal
   "D3L3", numeric, 0, 0, 100, 0, normal, normal
   "D4L1", numeric, 0, 0, 100, 0, normal, normal
   "D4L2", numeric, 0, 0, 100, 0, normal, normal
   "D4L3", numeric, 0, 0, 100, 0, normal, normal
   "Rootwad", numeric, 0, 0, 100, 0, normal, normal
   "Decay_Class1", numeric, 0, 0, 1000, 0, normal, normal
   "Decay_Class2", numeric, 0, 0, 1000, 0, normal, normal
   "Decay_Class3", numeric, 0, 0, 1000, 0, normal, normal

"LWD", point, "Single Pieces", 1, seconds, 1, Code
   "LWD_ID", text, 30, not_permitted, normal, 1, LWDA1, Label1
   "Length_Class", menu, required, "7.6-15, >15, <7.6m", normal
      "1"
      "2"
      "3"
   "Diameter_Class", menu, required, "30-60, 60-90, >90, <30cm",
normal, Label2
      "1"
      "2"
      "3"
      "4"
   "Wood_Type", menu, required, "Conifer, Deciduous, Unknown", normal
      "C"
      "D"
      "U"
   "Decay_Class", menu, required, "1,3,5", normal
      "1"
      "3"
      "5"
   "Rootwad", menu, required, "y or n", normal
      "Y"
      "N"

"Side_Chan", point, "", 1, seconds, 5, Code
   "SC_ID", text, 12, not_permitted, normal, 1, SCA1
```

```
   "Wetted_W(m)", numeric, 2, 0.00, 200.00, 0.00, normal, "m", normal
   "BFW(m)", numeric, 2, 0.00, 200.00, 0.00, normal, "m", normal
   "Length (m)", numeric, 2, 0.00, 500.00, 0.00, normal, "Meters",
normal
   "Comment1", text, 30, normal, normal
   "Comment2", text, 30, normal, normal
```