

TFW Monitoring Program

# METHOD MANUAL

for the

# LARGE WOODY DEBRIS SURVEY



by:

Dave Schuett-Hames

Allen E. Pleus

Jim Ward

Martin Fox

Jeff Light



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## Abstract

The TFW Monitoring Program method manual for the Large Woody Debris (LWD) Survey provides a standard method for assessing and monitoring the quantity and quality of large woody debris. The LWD Survey has two methods for measuring the amount of large woody debris at the TFW stream segment scale. The relatively quick Level 1 method quantifies the number of pieces in each of several size class categories and by bankfull channel zone. The Level 2 method collects more detailed information on individual pieces including piece count, volume by bankfull channel zone, whether it is deciduous or conifer, and stability. In addition, LWD jam information is collected for both Level 1 and Level 2 Surveys. The Jam method collects information on jam and piece count, number of jams by bankfull channel zone, and number of pieces per jam in each of several size class categories. Association with a Reference Point Survey provides information on piece and jam distribution. Optional key piece information can be collected for the Level 1 and Jam methods and is calculated in the database for Level 2 pieces. TFW data management services provides basic analysis of LWD data at 100 meter (except Level 1) and stream segment scales. Standard calculations include the number of pieces and jams per channel width and kilometer.

This introduction section describes the purpose of the LWD Survey, reviews scientific background information, and describes the cooperator services provided by the TFW Monitoring Program. Following the introduction, sections are presented in order of survey application including: study design, pre-survey preparation, stream discharge measurement, survey method, post-survey documentation, data management, and references. An extensive appendix is also provided that includes: copy masters of field forms; examples of completed field forms; a field criteria and code sheet; a standard field and vehicle gear checklist; and data management examples.

**TFW Monitoring Program**  
Northwest Indian Fisheries Commission  
6730 Martin Way E.  
Olympia, WA 98516

Ph: (360)438-1180  
Fax: (360)753-8659

Internet:  
<http://www.nwifc.wa.gov>

**Washington Dept. of Natural Resources**  
**Forest Practices Division: CMER Documents**  
P.O. Box 47014  
Olympia, WA 98504-7014

Ph: (360)902-1400

## The Authors

**Dave Schuett-Hames** is the TFW Monitoring Program Coordinator/Biologist at the Northwest Indian Fisheries Commission. He received a B.S. degree in biology (1976) and an M.E.S. (1996) from The Evergreen State College. He worked for 12 years as a fish habitat biologist for the Lummi and the Squaxin Island Tribes. He joined the program in 1992. E-mail: dschuett@nwifc.wa.gov

**Allen E. Pleus** is the Lead Training and Quality Assurance Biologist for the TFW Monitoring Program at the Northwest Indian Fisheries Commission. He received a B.A. degree in communications (1985) and an M.E.S. (Master's degree in Environmental Studies, 1995) from The Evergreen State College. He began working for the program in 1991. E-mail: apleus@nwifc.wa.gov

**Jim Ward** is a Slope Stability Geologist for the Weyerhaeuser Timber Company. Mailing address: Box 420, Centralia, WA 98513. E-mail: jim.ward@weyerhaeuser.com

**Martin Fox** is a Fisheries Biologist for the Muckleshoot Indian Tribe Fisheries Department. He received a B.S. degree in Fisheries Biology from the University of Washington in 1986. Mailing address: 39015 172nd Ave SE, Auburn, WA 98092. E-mail: mfox@muckleshoot.nsn.us

**Jeff Light** is a Forest Hydrologist for the Plum Creek Timber Company - Cascade Region. He received a B.S. degree in Biology from the University of Colorado and a M.S. degree in Fisheries from the University of Washington. He has worked for TFW since 1987 and as a co-chair on the Monitoring Advisory Group since 1992. Mailing address: 999 3rd Ave. Suite 2300, Seattle, WA 98104. E-mail: jlight@plumcreek.com

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## Copying of the Method Manual

All TFW Monitoring Program method manuals are public documents. No permission is required to copy any part. The only requirement is that they be properly cited. Copies of the methods manuals are available from the TFW Monitoring Program at the Northwest Indian Fisheries Commission or from the Washington Dept. of Natural Resources.

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# Large Woody Debris Survey

## 1. Introduction



The TFW Monitoring Program method manual for the Large Woody Debris (LWD) Survey provides a standard method for assessing and monitoring the quantity and quality of large woody debris. The LWD Survey has two methods for measuring the amount of large woody debris at the TFW stream segment scale. The relatively quick Level 1 method quantifies the number of pieces in each of several size class categories and by bankfull channel zone. The Level 2 method collects more detailed information on individual pieces including piece count, volume by bankfull channel zone, whether it is deciduous or conifer, and stability. In addition, LWD jam information is collected for both Level 1 and Level 2 Surveys. The Jam method collects information on jam and piece count, number of jams by bankfull channel zone, and number of pieces per jam in each of several size class categories. Association with a Reference Point Survey provides information on piece and jam distribution. Optional key piece information can be collected for the Level 1 and Jam methods and is calculated in the database for Level 2 pieces. TFW data management services provides basic analysis of LWD data at 100 meter (except Level 1) and stream segment scales. Standard calculations include the number of pieces and jams per channel width and kilometer.

This introduction section describes the purpose of the LWD Survey, reviews scientific background information, and describes the cooperator services provided by the TFW Monitoring Program. Following the introduction, sections are presented in order of survey application including: study design, pre-survey preparation, stream discharge measurement, survey method, post-survey documentation, data management, and ref-

erences. An extensive appendix is also provided that includes: copy masters of field forms; examples of completed field forms; a field criteria and code sheet; a standard field and vehicle gear checklist; and data management examples.

### 1.1 Purpose

The Timber-Fish-Wildlife Monitoring Program (TFW-MP) provides standard methods for monitoring changes and trends in stream channel morphology and habitat characteristics. The Large Woody Debris (LWD) Survey method has been approved by TFW's Cooperative Monitoring, Evaluation and Research Committee (CMER) and is accepted as a standard method for monitoring on forest lands in Washington state by tribal governments, state natural resource agencies, timber companies, environmental organizations, and others. The purpose of the Large Woody Debris Survey method is to:

1. Provide a means of accurately documenting the current abundance, characteristics, and function of large woody debris in stream channels.
2. Provide a repeatable methodology that can be used to monitor changes in the status of large woody debris over time.
3. Provide information on the abundance and characteristics of large woody debris that is suitable for use in the Watershed Analysis Assessment procedure.
4. Improve knowledge of the distribution, characteristics, and function of large woody debris in Pacific Northwest streams.

### 1.2 Background

This section provides a review of the scientific literature used as the basis for the LWD Survey. Background information includes the biological role of large woody

debris, the effects of large woody debris on channel morphology, and the distribution of large woody debris within watersheds and stream segments.

### 1.2.1 *Biological Role of Large Woody Debris*

Large woody debris plays an important biological role in Pacific Northwest streams, creating and enhancing fish habitat through increased channel complexity in streams of most sizes (Bisson et al., 1987). Pools formed in association with LWD often provide deep, low velocity habitat with cover. This habitat is beneficial for a variety of salmonid species and life history stages, particularly those that over-winter in stream channels. Large woody debris also functions to retain spawning gravel in high energy channels and provides thermal and physical cover. Another role is to provide habitat and nutrient sources for macro invertebrates and microorganisms.

### 1.2.2 *Effects of Large Woody Debris on Channel Morphology*

Large woody debris (LWD) is an important factor affecting channel morphology in the Pacific Northwest. LWD influences channel morphology in several ways. Logs and rootwads enter stream channels due to mortality from bank cutting, blowdown, mass wasting, and other processes (Swanson and Lienkamper, 1978).

Large woody debris influences channel morphology in several ways. Pools often form in association with LWD due to adjacent scouring or impoundment of water behind channel-spanning pieces. Large woody debris often traps and stores sediment, having a moderating affect on sediment transport rates. In steeper, smaller channels, it often influences channel processes by forming distinct steps that capture sediment on the upstream side and dissipate energy as the flow drops over the step. The effect of LWD once in the channel is related to its volume, stability, longevity, size of the stream channel, and the tendency for wood to collect in large accumulations known as debris jams.

### 1.2.3 *Distribution of Large Woody Debris Within Watersheds and Stream Segments*

The nature and distribution of large woody debris in a

stream channel reflects past and present recruitment rates, decay, and rate of movement through the channel. This is largely determined by the age and composition of past and present adjacent riparian stands and channel morphology. Current conditions reflect the past history of both natural and management-related channel disturbances including timber removal in riparian areas, flood events, debris flows, splash damming, and stream cleanout.

## 1.3 **Cooperator Services**

The TFW Monitoring Program provides a comprehensive suite of services to support TFW cooperators collecting data consistent with program goals. Services include study design assistance, pre-season training through annual workshops and on-site visits, pre-season quality assurance reviews, data entry systems, summary reports of monitoring results, and database/data archiving services. These services are offered free of charge. Method manuals are available for the following surveys:

- ◆ Stream Segment Identification
- ◆ Reference Point Survey
- ◆ Habitat Unit Survey
- ◆ Large Woody Debris Survey
- ◆ Stream Temperature Survey
- ◆ Spawning Gravel Composition Survey
- ◆ Spawning Habitat Availability Survey
- ◆ Spawning Gravel Scour Survey
- ◆ Wadable Stream Discharge Meas. Method

To find out more about TFW Monitoring Program services and products, contact us or visit our link on the NWIFC homepage. The address is:

TFW Monitoring Program  
Northwest Indian Fisheries Commission  
6730 Martin Way East  
Olympia, WA 98516

Ph: (360) 438-1180  
Fax: (360) 753-8659  
Internet site: [www.nwifc.wa.gov](http://www.nwifc.wa.gov)



## 2. Study Design

A well designed monitoring study identifies changes in channel characteristics over time due to land management or natural disturbances. This is accomplished by establishing either a sound baseline or following the original study design. Poorly designed studies detect changes that are the result of differences in crew method application or changes in sampling location. Effective monitoring study designs require rigorous planning, documentation, and consistency in methods, method application, and data analysis. This ensures that the monitoring data produced meets the objectives of the project and monitoring plan.

Developing a study design involves the identification of monitoring segments, assessing sample method options, timing of surveys, reviewing survey modification options, and planning for pre-season crew training and quality assurance reviews.

### 2.1 Identifying Monitoring Segments

The LWD Survey uses the TFW stream segment as the fundamental unit of analysis for characterizing large woody debris abundance and other characteristics. A basic step in study design development is identifying a group of candidate segments from which to select suitable monitoring segments or sub-segments.

The TFW method identifies stream segments based on gradient, valley confinement, and flow. A USGS 7.5 minute topographic map (photocopy worksheet) with delineated segments is required for this part of the study design development. Many streams have already been segmented through past TFW monitoring projects, Watershed Analysis processes, and the Salmon and Steelhead Habitat Inventory and Assessment Project (SSHIAP). If the stream has not been pre-segmented, or pre-segmented boundaries are not suitable for your monitoring plan, partition the river system into stream segments or sub-segments using the TFW Monitoring Stream Segment Identification method (Pleus and Schuett-Hames, 1998a) before continuing. Segment data documented on Form 1 and USGS topographic maps are required for data tracking and to provide important information for identifying segment boundary locations and access points.

### *Salmon and Steelhead Habitat Inventory and Assessment Project (SSHIAP)*

Contact:

Randy McIntosh, Project Lead  
Northwest Indian Fisheries Commission  
6730 Martin Way E.  
Olympia, WA 98516  
(360)438-1180  
e-mail: mcintos@nwifc.wa.gov

### 2.2 Survey Method Options

The LWD Survey has two options for monitoring large woody debris on a stream segment scale. The Level 1 option is the least time-intensive and is designed to collect a minimum amount of LWD information. This method is used to generate core information on the abundance, size class, and channel location of LWD pieces applicable for Level 1 Watershed Analysis. Procedures are also provided for determining which pieces meet the key piece criteria as defined by the Watershed Analysis resource condition indices (WFPB, 1996). Collection of information on additional zone 3 pieces is optional.

The more intensive Level 2 option involves taking measurements and collecting additional information on characteristics and functions of individual pieces of LWD. This method provides core information including reference point association, mid-point diameter, length by channel zone location, species category, stability, and pool forming function. Length and diameter information is used to calculate volume by channel zone, and to identify key pieces. Procedures are also provided for the collection of supplemental zone 3 pieces, channel orientation, decay class, and sediment storage parameters.

LWD Jam data is required when conducting either the Level 1 or Level 2 survey options. This method generates core information on the abundance, individual piece size class, and channel location of LWD jams applicable for Level 1 or Level 2 Watershed Analysis.

Jam data is combined with individual piece data from either survey level to calculate total pieces in the segment. Procedures are also provided for determining which pieces meet the key piece criteria and collection of information on additional zone 3 pieces.

### **2.3 Channel Length and Width and the TFW Reference Point Survey**

Information on mean segment bankfull width and survey reach length are required to calculate LWD parameters such as number of pieces and jams per channel width and kilometer. This information is automatically provided were the TFW Reference Point Survey has been conducted (Pleus and Schuett-Hames, 1998b). Reference points are also used for associating pieces and jams with 100 meter reaches, and for analysis of their frequency and distribution within the segment in the data summary by reference point report. If no reference point survey is done, data analysis is limited to segment mean characteristics.

### **2.4 Timing of Surveys**

The ideal time to sample is in the late summer/early fall low flow period when discharge conditions are most stable. Sampling should be conducted during moderate to low flow conditions so repeat surveys can be conducted at similar discharges and the data can be used to compare stream reaches and determine trends over time. Surveys can be conducted at higher flows and linked to repeat surveys at similar discharge measurements. However, higher flows generally increase data variability caused by factors such as turbidity obscuring crew identification of, and limiting measurement access to, in-water measurement parameters. If you are unfamiliar with the hydrologic regime of the stream to be sampled, consult with people familiar with the system or refer to USGS streamflow records to determine an appropriate sampling period. Avoid working in the channel during spawning or when there are eggs in the gravel to prevent unnecessary disturbance and mortality to salmonid populations.

### **2.5 Survey Additional Parameter and Modification Options**

Collecting additional parameter data and modifications of the core LWD criteria to meet individual cooperator needs is acceptable if it does not compromise the integrity of the core TFW parameters. Analysis for additional or modified parameter data is the responsibility of the cooperator. Contact the TFW Monitoring Program for assistance to ensure comparability. The TFW-MPLWD survey is designed to produce standard LWD information suitable for entry into the TFW database, and producing TFW data summary reports. Data collected using these methods can be compared with other data collected using the same methods from around the state. Justification of modifications and additional parameters as suitable for monitoring purposes is the responsibility of the cooperator.

There are two levels at which modification documentation is important. The first is to qualify data collected on the field forms and the second is to qualify data entered into the TFW database. Survey modifications are defined as any change to the core criteria and methods as documented in the latest version of the TFW method manual. In other words, data collected using the modified method would not be comparable at some level with data collected using the methods and criteria as stated in the manual.

Documentation of modifications and/or additional parameters in the *Survey Notes* sections of Form 4.0 allows accurate interpretation of the field data from Forms 4.1, 4.2, and 4.3. It is feasible to have the field forms flagged as modified, but not the database where core data has been extracted by the cooperator before data entry. Documentation of modification in the database allows accurate interpretation of affected parameters and calculations on summary reports. However, in most situations modified data cannot be entered into the database due to validation checks.

The field forms provided in the manuals have been designed for consistent and accurate recording of large woody debris information and entry into the TFW database. The forms have been refined based on research and monitoring experience. This design reduces data errors caused by factors such as legibility, calculations, and data association. The field forms have been designed to accommodate the collection of additional

parameter data, thus limiting the necessity of cooperators to modify or create new forms.

## **2.6 Pre-Season Crew Training and Quality Assurance Review**

Appointments should be made with the TFW Monitoring Program for pre-season training and quality assurance reviews. Annual training workshops are provided and on-site training is available. Repeat training is encouraged to learn new methods, techniques, and refresh skills. Pre-season quality assurance reviews provide the highest level of documentation that crews are applying the methods in an accurate and consistent manner *before* collecting project data. QA reviews should be repeated seasonally to maintain documentation and to refresh survey skills.

### 3. Pre-Survey Preparation

Gather, prepare, record, and pack for transportation all necessary survey equipment and materials required for field crews to complete the field portion of the LWD Survey.

#### 3.1 Survey Equipment

Survey equipment are those items necessary for crews to conduct either Level 1 or 2 surveys. This list does not cover all possible equipment that can be useful for Large Woody Debris Survey purposes. The TFW-MP database is designed to use metric units so metric measurement equipment should be used. The basic equipment includes:

##### *Survey Equipment*

- ◆ Measurement tape  
(30 to 50 m; accuracy  $\pm 0.10$  m)
- ◆ Measuring rod  
(5 to 7 m; accuracy  $\pm 0.01$  m)
- ◆ Railroad chalk
- ◆ Log Calipers, Biltmore Stick, or  
Logger's tape  
(accuracy  $\pm 1$  cm or 0.01 m)
- ◆ Standard field and vehicle gear  
(Appendix D)

Check all measurement equipment for damage. TFW-MP recommends that all measurement equipment is calibrated to a known accurate standard both pre- and post-survey to meet quality assurance plan monitoring requirements.

The use of metric measurement equipment complies with standard scientific methods. The cost of purchasing metric equipment is often offset by savings in personnel time and effort required to convert from English to metric units. It also results in the highest quality data due to avoidance of errors during conversion of large data sets. Mixing unit types within a survey is strongly discouraged due to potential for multiple conversion errors. If using English units, all measurements must be converted to metric units before entry into the TFW-MP database.

#### 3.2 Survey Materials

Survey materials are those items necessary for crews to locate and document the stream segment and access points, site conditions, and for recording field data. This list does not cover all possible materials. The basic materials include:

##### *Survey Materials*

- ◆ USGS 7.5 minute topographic map worksheet
- ◆ Road map
- ◆ Copy of segment's Form 1.0 and 2H
- ◆ Copy of LWD Forms 4.0, 4.1, 4.2, and 4.3 (Appendix A)
- ◆ Copy of LWD Criteria and Code Field Sheet (Appendix C)

Start by gathering and organizing stream site access information and working on logistical factors. This includes: obtaining directions and maps; contacting landowners and securing permission to access property; acquiring necessary permits and passes; and determining if the access roads are gated and get gate keys or make necessary arrangements with landowner to open access. Next, begin the survey documentation by preparing and filling-out header and field data forms. Refer to Appendix B for examples of completed field forms.

##### 3.2.1 LWD "HEADER INFORMATION" Form 4.0

Use the Form 4.0 copy master to make one copy on regular white paper for copying purposes (Figure 1). A new Form 4.0 is completed for each stream segment. Primary header information can be copied directly from the segment's completed Form 1. Instruction on filling-out the *Study Design Information*, *Discharge Information*, and *Survey Notes* boxes will be covered in the "Post-Survey Documentation" section. The Water Resource Inventory Area number (WRIA #), unlisted tributary number (Unlisted Trib), segment number (Segment #), Sub-Segment Code, and Begin

Figure 1. LWD Survey "HEADER INFORMATION" Form 4.0

Survey Date are key fields used to identify unique monitoring segments for the TFW-MP database.

### Header Section

**Stream Name:** Record the WRIA-designated stream name. Use "Unnamed" where appropriate.

**WRIA #:** Record the six digit Water Resource Inventory Area (WRIA) number (00.0000).

**Unlisted Trib:** Most streams do not require unlisted tributary numbers and if so, fill this space with three zeros (000). For unlisted tributaries, record a three digit cooperator-designated unlisted tributary number (001 - 999) and mark the appropriate RB/LB circle.

**Segment #:** Record the one to three digit segment number (1 - 999).

**Sub-Segment Code:** Record the number or letter character sub-segment code (1 - 99 or a - zz). Record a "0" if not a sub-segment.

**Date:** Enter the date the form is being filled-out. The date documents the time line of this portion of your monitoring plan. It also is a reference to the manual version used to survey the stream.

### Survey Crew Section

Record the names and affiliations of the lead, recorder, and other field crew involved in data collection for the survey. Affiliations correspond to employers such as a

tribe, government agency, industry, environmental group, consulting company, etc. Record the most recent year that the lead crew person received official TFW Monitoring Program on-site and/or annual workshop LWD training, and/or a QA Review. Note any other relevant training or field experience in the *Survey Notes* section.

### Sample Method Information Section

**Core Survey Coverage:** Fill in the circle corresponding to the survey level applied on the segment during this survey. A modified Level 1 survey using Form 4.2 would still be marked as a Level 1 survey. Mark whether LWD jams were part of the survey even if no jams were found within the segment. Collection of jam data is required for database calculations and producing LWD summary reports. Fill-in the "Non-TFW" circle if the data collected does not meet the minimum TFW core criteria or the core criteria cannot be extracted from the data set.

**Supplemental Survey Coverage:** Fill in the circle corresponding to any additional parameters for which data was collected. If the "Other" circle is marked, list the parameter(s). Collection of "green LWD" piece data would fit in this category.

**Mean Segment BFW:** Record the mean bankfull width of the segment. This parameter corresponds to the criteria used during the survey for identifying LWD pieces and jams with "Key Pieces" and "Pool Forming Function." The mean segment bankfull width can be copied from the Reference Point Survey Report or calculated from Form 2D.

**Pool FF:** Based on the mean segment bankfull width, record the minimum pool surface area and residual pool depth to be used in this survey for estimating piece or jam "Pool Forming Function" (Table 1). Record the criteria in the appropriate blanks. For example, if the segment has a mean bankfull width of 7.5 meters, the minimum unit surface area will be recorded as 2.0 square meters (m<sup>2</sup>) and the minimum residual pool depth will be recorded as 0.25 meters.

### Equipment Section

As equipment is selected for conducting the survey, document the equipment type, size, condition, measurement accuracy, and pre-survey calibration dates as

Table 1. Minimum unit surface area size and residual pool depth criteria by channel bankfull width.

Mean Segment Bankfull Width (m)	Minimum Unit Size (m <sup>2</sup> )	Minimum Residual Pool Depth (m)
> 0 to < 2.5	0.5	0.10
≥ 2.5 to < 5.0	1.0	0.20
≥ 5.0 to < 10.0	2.0	0.25
≥ 10.0 to < 15.0	3.0	0.30
≥ 15.0 to < 20	4.0	0.35
≥ 20	5.0	0.40

indicated. Mark the appropriate circle corresponding to whether equipment is in metric or English units. Document the type of wading gear used (wet/knee/hip/chest/dry/swim/etc.). Document any other measurement equipment used during the survey.

Select wading gear to accommodate stream and survey conditions. On most streams, having one crew with chest waders is important for access to, and taking measurements along the deeper parts of the channels. Having only knee or hip boots for a larger stream can result in under-estimation of unit surface areas and residual pool depths. However, it is important to note that use of chest waders in fast flowing streams can be dangerous. Also consider future repeatability of each option. For example, wading wet or swimming may be acceptable to crews one year, but may not be an option the next time.

### 3.2.2 LWD "FIELD DATA" Forms 4.1, 4.2, and 4.3

Use copy master(s) to make one copy on regular white paper for additional copying purposes (Figure 2).

*All Forms:* Record the *Stream Name/WRIA #/Unlisted Trib/Segment #/Sub-Segment Code* as documented on Form 4.0. Record the initials of the crew lead and other crew in the spaces provided in the upper right-hand corner. Leave the "Page \_\_ of \_\_" and "Date" spaces blank as they are recorded in the field during the survey.

*Level 1 Survey Forms 4.1 and 4.3:* Mark the appropriate circle to identify whether Key Piece and/or Zone 3 information will be collected during the survey.

*Level 2 Survey Forms 4.2 and 4.3:* Mark the appropriate circle to identify whether the measurements on the form are in meters or feet.

Use these copies to make multiple field copies onto waterproof paper such as "Rite in the Rain" brand. This process eliminates the need to fill out all header information on each form. Copies can be made single-sided or duplex.

### 3.2.3 LWD Criteria and Code Field Sheet

Use the copy master to make one copy on waterproof paper. This sheet provides all pertinent survey criteria and documentation codes including a complete key piece volume matrix for quick and easy reference in the field.

## 4. Stream Discharge Measurement

For all LWD Surveys, a pre-survey discharge measurement is required because LWD location relative to the wetted channel is flow dependent. This information can help determine appropriate flows for repeat surveys and whether the discharge at the time of the survey is representative of summer low flows (if part of study design).

Discharge measurements are taken using the TFW Monitoring Program Wadable Stream Discharge Measurement Method (Pleus, 1999). Stream discharge measurements are recorded using Forms 7.0 and 7.1. The results are copied onto LWD Form 4.0. It is important that the rest of the survey be completed as soon after the discharge measurement as possible. If crews note that the discharge is changing substantially, the survey should be suspended until the flows return to starting levels as determined through additional discharge measurements. In general, monitoring value decreases with increasing changes in discharge during a survey. The number of additional discharge measurements taken for a given survey depends upon stream and weather conditions, survey length, study design objectives, and quality assurance plan requirements.

Figure 2. LWD Survey "FIELD DATA" Forms 4.1, 4.2, and 4.3.

## 5. Large Woody Debris Survey Methods

This section provides the criteria and procedures for conducting the LWD Survey. It is organized in a sequential format to facilitate accurate and consistent application of the methods. Both Level 1 and Level 2 Surveys require conducting the Jam Survey. This section can be copied for crews to take out into the field for referencing. Forms 4.1, 4.2, and 4.3 have been designed to record, organize, and track the information gathered using these methods.

The methods section is divided into four sub-sections: 1) Large Woody Debris and Channel Zone Identification; 2) LWD Level 1 Survey Procedure; 3) LWD Level 2 Survey Procedure; and 4) LWD Jam Survey Procedure. The Level 1, Level 2, and Jam sub-sections are further divided into core and supplemental data collection parts. The LWD Survey procedure will be explained as if a crew were conducting the survey for the first time on one stream segment within a watershed. This procedure can be applied on a watershed level by systematically following the same methods segment by segment.

### 5.1 Large Woody Debris and Channel Zone Identification

For the purposes of both Level 1 and 2 methods, there are three types of LWD: 1) logs; 2) rootwads; and 3) jams. Different information is collected for each type, so the first task is to identify the piece type being observed. Channel zone information is also a fundamental part of both survey levels and jams and instructions are provided to help field identification.

#### 5.1.1 LWD Log Identification

A log is defined as a tree or section of tree and may or may not include a root system (Figure 3). To qualify as LWD, a log must meet four criteria:

#### *LWD Log Criteria*

1. Dead;
2. The root system (if present) no longer supports the weight of the stem/bole;
3. Minimum diameter of 0.1 meters (10 centimeters) along 2 meters of its length; and
4. Minimum 0.1 meter of length extending into the bankfull channel (or optional above the

*Dead:* No life evident at time of survey or no chance of survival to the next survey season. Determining chance of survival requires specific knowledge of tree species and their ability to regenerate.

*Root System:* The root system (if present) is wholly or partially detached from the ground to the point where it is no longer capable of supporting the weight of the stem/bole.

*Minimum Length/Diameter:* Length measurements are from the base of the attached root-ball, if present, to the furthest end of the log, even if the end is less than the minimum 0.1 meter diameter, or is jagged.

Diameter is measured to the nearest centimeter at the mid-point along the length of each log. If the diameter cannot be accurately measured, estimate the diameter and note its accuracy (i.e.,  $\pm 2$  cm,  $\pm 5$  cm,  $\pm 10$  cm, etc.) as such in your field notes. In situations where the log is divided into several large branches at the mid-point, measure the diameter immediately below the point where the branches fork. If the piece is round, measure the diameter with the spline of the caliper parallel to the channel substrate or water surface. In situations of irregularly shaped boles, use the average of two measurements taken perpendicular to each other at the widest and narrowest axes, or use a loggers tape.

If a portion of a log is buried and its true length or diameter cannot be determined, measure only the exposed portion of the log where it becomes visually obscured by other debris, sediment, vegetation, or water. Quick excavation by probing or surface debris removal to check for parameter dimensions is acceptable. When



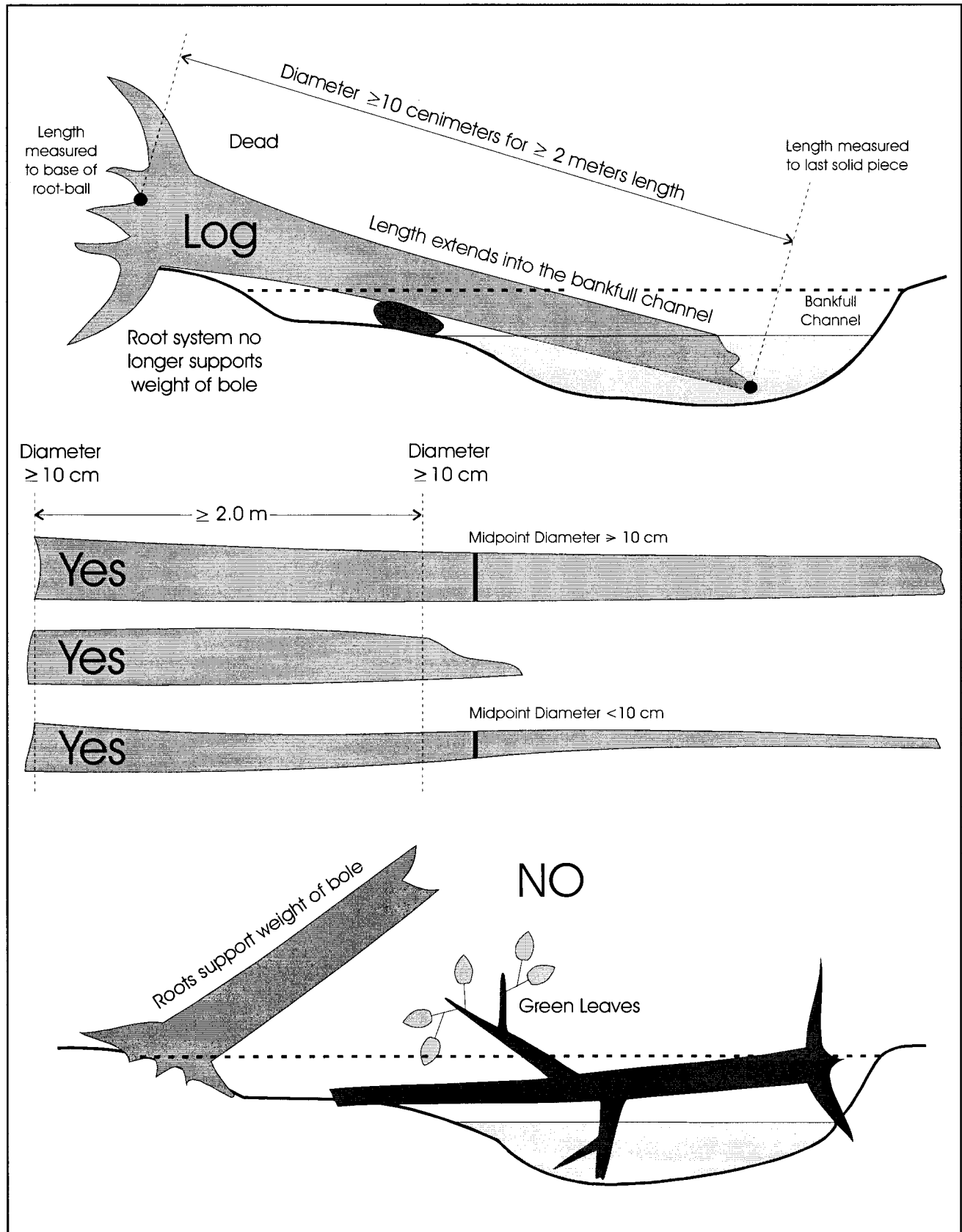


Figure 3. Criteria for large woody debris log identification.

a piece of wood forks into numerous small branches, such as the branches at the top of a tree, measure the length to the point where the main bole is no longer distinctly larger than the branches forking off of it.

*Bankfull channel:* To determine if the piece extends into the bankfull channel, refer to the "Channel Zone Identification" sub-section.

#### *Difficult Situations*

*Green leaves:* The presence of green leaves indicates that the tree or tree section is not fully dead at the time of the survey and therefore is not counted as part of the core TFW-MP LWD data. Green leaves can be an indicator of a tree species' ability to regenerate disturbed or damaged root systems. However, many co-operators have expressed a desire to collect information on these pieces. This can be accomplished by modifying the forms using the following techniques:

- ◆ Form 4.1 and 4.3 - add a new column labeled "G" within each of the four LWD categories to record "green" pieces. If key piece information is not being collected, use that column but make sure to re-label it.
- ◆ Form 4.2 - use the *Piece Cat L - R* column to note whether the piece is a *GL* (green log) or a *GR* (green rootwad).

Note: Data on "green LWD" must be separated out from core TFW-MP data before entering into the database at this time.

*Forks:* A fork is defined as a single bole that becomes two boles above the estimated breast height position (DBH = 4.5 feet or 1.5 meters). Forked LWD are counted as one piece with the diameter taken at its midpoint. Individual boles joined at the base or root system (below DBH) are counted as individual pieces if each piece meets the minimum length and diameter criteria.

*Branches:* Branches that are attached to the bole of the tree are not counted as part of a piece's length or as a separate piece regardless of their individual size.

*Broken and very decayed pieces:* LWD that has been broken into smaller pieces are counted separately if they meet minimum criteria. To determine if pieces are separate, *imagine* a crane picking-up one of the broken pieces. Pieces that would not remain attached

are counted as individual LWD. This technique can also be used to determine the length of an extensively rotted log or rootwad.

#### 5.1.2 *LWD Rootwad Identification*

A rootwad is defined as a dead section of tree with a recognizable bole and root system, but its total length is less than the minimum 2.0 meter log length criteria (Figure 4). LWD rootwads are most often old stumps left over from timber harvests along the banks of streams. Rootwads are typically recruited into the stream channels through bank cutting and erosion. This process gradually exposes the roots of standing stumps until they are detached and all or part of their length are within the bankfull channel. To qualify as a LWD, a rootwad must meet *all four* of the following criteria:

##### *LWD Rootwad Criteria*

1. Dead;
2. Root system detached from original position;
3. Minimum diameter of 0.2 meters (20 centimeters) with total length < 2 meters; and
4. Minimum 0.1 meter of length extending into the bankfull channel (or optional above the bankfull channel).

*Length:* Length is measured from the base of the "root-ball" to the furthest extent of the bole.

*Diameter:* Diameter is measured at the base of the bole where it meets the roots. In situations of irregularly shaped boles, use the average of two measurements taken perpendicularly to each other at the widest and narrowest axes, or use a loggers tape. If a bole is not present, it cannot be identified as a rootwad.

*Root system:* Rootwads must have an identifiable root system and bole. Rootwads become LWD when they have fully detached from their original floodplain or terrace locations. This is an important distinction defining its function as channel debris. Exposed roots that are within the bankfull channel may have an influence on channel morphology and provide habitat for salmonids, but they do not have the ability to move along the length of the channel and hence are not yet "debris."

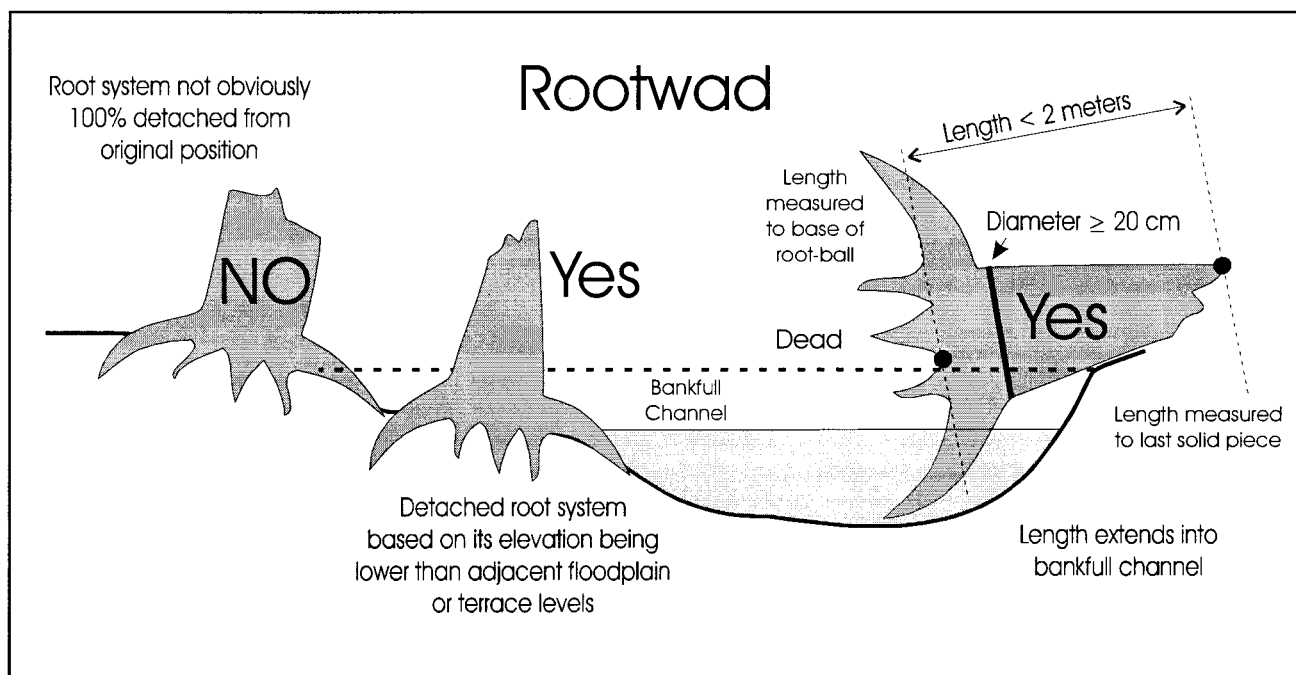


Figure 4. Criteria for large woody debris rootwad identification.

Detachment can be difficult to determine especially if the rootwad is still in an upright position and the root system is buried. Count the piece if it can be determined that it was originally anchored at a higher level or if the bole is lower than the root system. If you are unsure that the rootwad has moved from its original location, do not count it. If the bole has fallen into the bankfull channel, the root system has obviously become detached and the piece is counted.

*Bankfull channel:* To determine if the piece extends into the bankfull channel, refer to the "Channel Zone Identification" sub-section.

### 5.1.3 LWD Jam Identification

Large woody debris jams are defined as channel-influencing structures formed by accumulations of 10 or more qualifying logs and rootwads (Figure 5). Individual jam pieces must meet the LWD criteria as defined above. While smaller accumulations may sometimes function as debris jams, for TFW purposes they are counted as individual pieces. This version of jam identification has changed from the 1994 version in two important ways. First, pieces do not have to be "in contact" or "touching" to be associated with a jam. Second, jam piece counts no longer include those

pieces whose lengths are completely within Zone 4. Refer to the "LWD Jam Survey Procedure" section for information on collecting data comparable with the 1994 version. To qualify as a jam, LWD must meet the following criteria:

#### *LWD Jam Criteria*

1. Minimum 10 qualifying pieces of LWD either physically touching at one or more points, or associated with jam structure;
2. Minimum 0.1 meter of one LWD piece's length extending into the bankfull channel (or optional above the bankfull channel).

On most stream systems, jams are originally formed through in-channel sorting of LWD either randomly, or around key members after the pieces have been recruited (Abbe and Montgomery, 1996). However, jams can also be formed by hillslope processes where trees are blown down in domino fashion, where streamside or hillslope slides enter a stream, or where deposition occurs at the end of a debris torrent track (Swanson and Lienkaemper, 1978). Over time, jam accumulations can be influenced by both in-channel and hillslope processes.

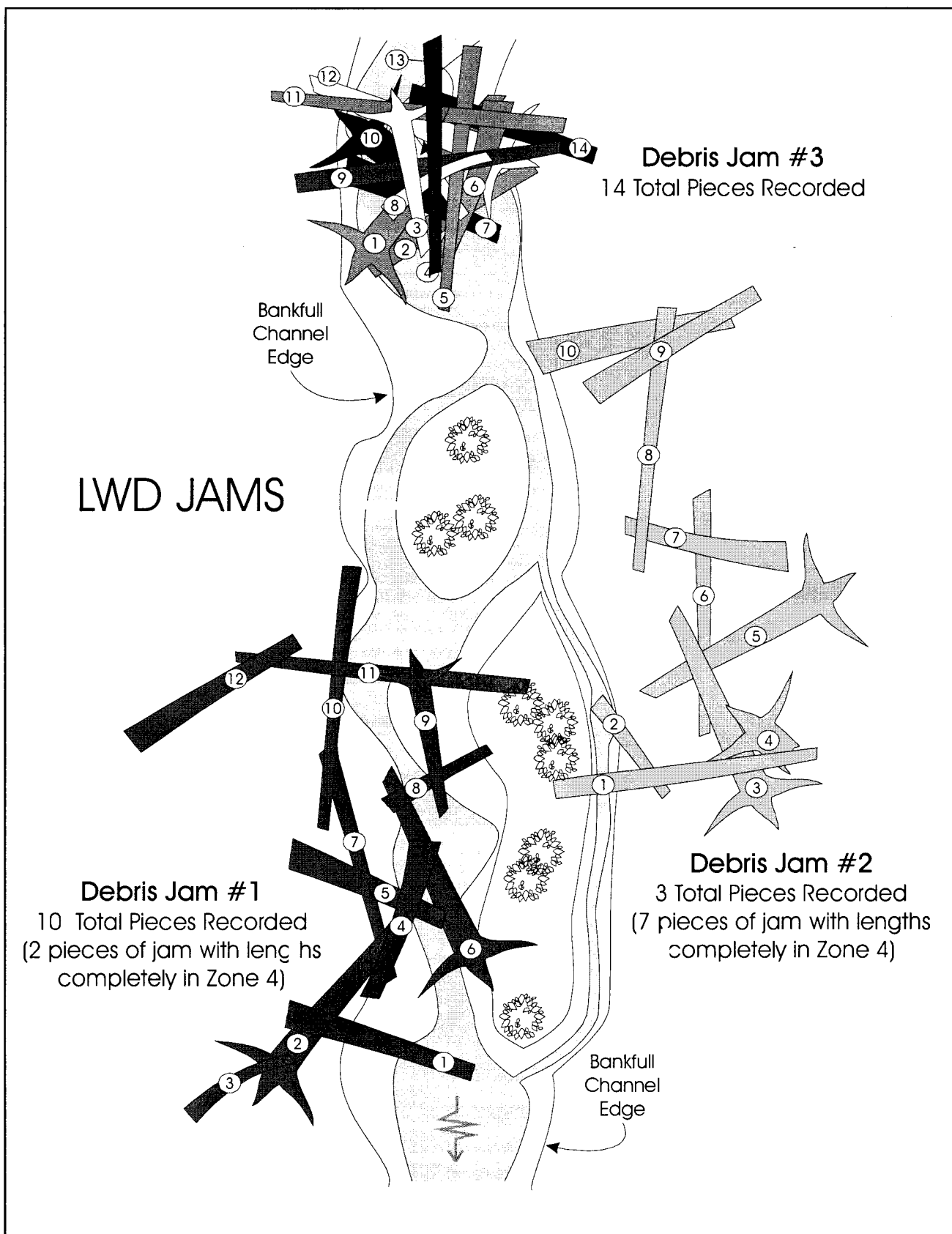


Figure 5. Criteria for large woody debris identification.

Jam structures can range from random accumulations that form a loose mat with little vertical stacking, to densely packed accumulations that result in the vertical stacking of five or more interwoven layers. Some jams may eventually integrate into and help develop the floodplain. Jams formed around key members are considered the most stable and have the greatest ability to alter in-channel morphology, surface textures, water depths, and flow velocities. In these jams, the LWD that otherwise might be flushed through that portion of the channel is deposited, usually by racking up against the key members. This results in jams associated with higher quality aquatic and terrestrial riparian habitats such as pools, sediment storage, and forested islands.

#### 5.1.4 Channel Zone Identification

Four zones are used to characterize LWD channel locations (Figure 6). The application of the channel zone system is discussed separately in the Level 1, Level 2, and Jam survey procedures.

**Zone 1** is defined as the portion of the bankfull channel that is wetted at the time of the survey, regardless of whether the water is flowing or stagnant. Zone 1 is flow dependent and future surveys must be done at

corresponding stream discharge measurements to produce comparable zone 1 data for trend monitoring.

**Zone 2** is defined as the area between the bankfull channel edge (BFCE) on both banks, below an imaginary line that connects those points, above the wetted channel surface, and includes areas such as dry gravel bars. Think of the upper boundary line as a fiberglass tape stretched between the BFCE as if measuring the channel's bankfull width. Use the BFCE identification and confidence/default methods as described in the Reference Point Survey method manual (Pleus and Schuett-Hames, 1998b).

**Zone 3** is defined as the area found directly above Zone 2 (bankfull channel). This zone typically includes pieces that span or extend out over the bankfull channel that provide cover or are considered LWD recruitment candidates.

**Zone 4** is defined as the area outside of the bankfull channel and Zone 3. This zone typically includes the floodplain, terrace, and/or riparian areas. *Pieces that are completely in Zone 4 are never counted - including pieces associated with jams.*

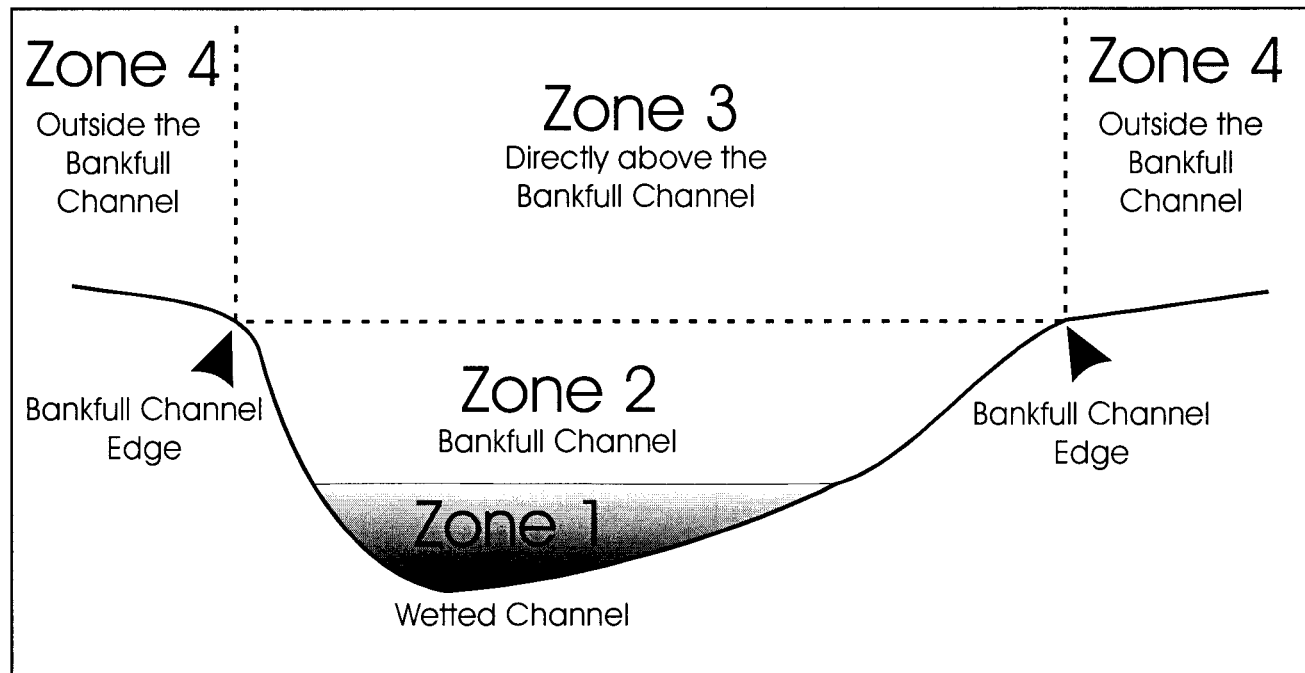


Figure 6. Criteria for channel zone identification.

## 5.2 LWD Level 1 Survey Procedure

This section is divided into core and optional supplemental data collection parts. Data are collected on qualifying individual LWD logs and rootwads during the Level 1 survey. Refer to the LWD Jam Procedure section for recording accumulations of 10 or more pieces. In situations where no individual LWD pieces are found within the segment, a Form 4.1 must still be filled-out. Put a "0" or "NO PIECES" on the form to document that a Level 1 survey was done but no pieces were observed. Enter this information into the database.

### 5.2.1 Level 1 Core Data Collection

Data is collected on all qualifying LWD pieces in the Level 1 survey except those associated with debris jams. In the Level 1 survey, each piece is assigned one tally mark on Form 4.1 in categories based on the LWD size/type category and the lowest zone in which the minimum piece length could be measured. If key pieces are being identified, they are tallied separately from the non-key pieces on the right side of each box in the appropriate column. If key pieces are not distinguished, all pieces are recorded in the column's left-hand box.

**NEW:** Use one Form 4.1 per reference point interval to tally LWD pieces. Record the number of the nearest downstream reference point in the *Downstream RP#* box. The nearest downstream reference point is determined by the location of each piece's mid-point (see Figure 7).

Begin the survey at the downstream end of the stream segment and walk up the channel to avoid turbidity that can obstruct LWD identification or accurate measurements. Systematically work up the channel and identify qualifying LWD pieces. For each piece, determine the category and size class for logs.

### LWD Category Identification

In the LWD Level 1 survey, qualifying pieces are assigned to one of four LWD categories: Rootwad; Small Log; Medium Log; and Large Log (Table 2). Qualifying LWD rootwads are not divided into size classes. Qualifying LWD logs are divided into three size classes based upon their diameter. Small logs have a midpoint diameter of equal to or greater than ( $\geq$ ) 10 centimeters (cm) and less than ( $<$ ) 20 cm. Medium logs have a midpoint diameter of  $\geq$  20 cm and  $<$  50 cm. Large logs have a midpoint diameter of  $\geq$  50 cm.

Table 2. LWD Level 1 survey piece category and size class identification by midpoint diameter criteria.

LWD Category	Diameter
Rootwad	$\geq 20$ cm
Small Log	$\geq 10$ cm to $< 20$ cm
Medium Log	$\geq 20$ cm to $< 50$ cm
Large Log	$\geq 50$ cm

### Lowest Channel Zone Identification

Next, identify the lowest channel zone in which the minimum piece length could be measured. A piece is assigned to Zone 1 if a minimum 0.1 meter of its length is within the water. A piece is assigned to Zone 2 if a minimum 0.1 meter of its length is within the bankfull channel, but does not extend the minimum length into the water.

Each piece must be assigned to only one LWD category/zone combination. Railroad chalk is useful for marking tallied pieces and to help prevent missing or double-counting pieces in complex areas. At the end of the segment survey, add the tally marks together on each page for each category/zone combination and record the number in their corresponding "Tally Totals" boxes.

### 5.2.2 Level 1 Supplemental Data Collection

Collection of supplemental data is optional when conducting the Level 1 Survey. Mark the appropriate circles in the header band if either supplemental Zone 3 or Key Piece information is being collected for the survey. For those interested in collecting information on "Green" LWD, refer to the "Large Woody Debris and Channel Zone Identification" section. Record a "0" in the appropriate columns on the form in situations where a Level 1 survey was done, but no key pieces or Zone 3 pieces were identified. This information is entered into the database.

This section describes the procedures required for recording additional data on qualifying LWD pieces with lowest measurable lengths in Zone 3, and for determining which Zone 1, 2 or 3 pieces also meet "Key Piece" criteria. At this time, the TFW-MP database

does not include Zone 3 piece counts or other information in calculations or reports. The collection of data on qualifying LWD that also meets key piece criteria does *not* add to the total segment piece count. Tally marks are simply moved to the key piece section if they meet the additional criteria. Individual pieces that are entirely within Zone 4 are not counted.

**Zone 3 Tally (Optional ZONE 3 row):** Assign one tally mark for each qualifying Zone 3 LWD piece to one of the four LWD categories. A piece is assigned to Zone 3 if a minimum 0.1 meters of its length extends into the area directly above the bankfull channel, and does not have a measurable length in Zones 2 or 1. Collection of Zone 3 piece information must be consistently applied across the entire segment.

**Key Pieces Tally (Key Pieces columns):** Tally marks for regular LWD pieces that also meet key piece criteria are placed in corresponding "Key Pieces" tally sections on Form 4.1. Record a "0" in the appropriate columns on the form where no pieces were identified for that category. This information is entered into the database. For example, a survey identified five LWD large size logs ( $\geq 50$  cm diameter) in Zone 1. In situations where cooperators chose not to collect supplemental key piece data, all five tally marks would be located in the regular piece section. However, if key piece data is being collected and one of those pieces meets key piece criteria, the tally box for that combination would show four tally marks in the regular piece section and one tally mark in the key piece section.

Table 3 provides the minimum volume by channel bankfull width required to qualify LWD as a key piece. To determine whether LWD meets key piece criteria, its diameter and length are measured to see if it meets the minimum criteria based on volume (Table 4).

To use Table 4, the first step is to select the bankfull width (BFW) category that corresponds with the segment mean bankfull width. Use this column for the entire segment regardless of variation in channel width along the length of the segment. The second step is to measure the diameter of the candidate piece and round the result to the nearest 0.05 meter (5 cm). Locate the diameter in the left-hand column and follow the row across until it intersects with the appropriate bankfull width category. The number on that row is the minimum length required to meet key piece criteria.

Table 3. Key piece criteria based on mean segment bankfull width and volume.

Key Piece Criteria	
Mean Segment Bankfull Width (m)	Minimum Volume (m <sup>3</sup> )
0 to < 5	1.0
$\geq 5$ to < 10	2.5
$\geq 10$ to < 15	6.0
$\geq 15$ to < 20	9.0
$\geq 20$	9.0

Table 4. Partial detail of key piece volume matrix based on Watershed Analysis Fish Habitat Module, Table F-5. See Appendix C for complete matrix.

Min Dia. (m)	BFW 0 to 5	BFW 5 to 10	BFW 10 to 15	BFW 15 to 20
	Min Length (m)			
0.50	6	13	31	
0.55	5	11	26	
0.60	4	9	22	32
0.65	3	8	19	28
0.70	3	7	19	24
0.75	3	6	14	21

#### EXAMPLE

**Step 1:** The stream segment being surveyed has a mean bankfull width of 12.0 meters, and that fits in the 10 - 15 meter category.

**Step 2:** The candidate LWD log has a diameter of 53 centimeters (0.53 meters) and this is rounded to 0.55 meters. The candidate log has a length of 24 meters.

**Step 3:** The intersection of the 0.55 meter diameter row and the 10-15 m BFW column shows that a 0.55 meter diameter piece must be at least 26 meters long before it qualifies as a key piece in a segment with a mean 12 meter bankfull width. The candidate LWD does not meet the key piece criteria and is tallied as regular LWD.

### 5.3 LWD Level 2 Survey Procedure

Data are collected on all qualifying individual LWD logs and rootwads during the Level 2 survey except those associated with debris jams. Fill-out one row on Form 4.2 for each qualifying piece of LWD. Refer to the LWD Jam Procedure section for recording accumulations of 10 or more pieces. Mark the appropriate circles in the header band to document whether measurements are recorded in meters or feet.

Identification of key pieces is not required on Form 4.2 since piece diameters and lengths are recorded and the database will sort out LWD pieces that meet the key piece criteria. In situations where no individual LWD pieces are found within the segment, a Form 4.2 is still required. Put a "0" or "NO PIECES" on the form to document that a Level 2 survey was done but no pieces were observed. This information is entered into the database. Mark the blank row after the last jam record "END OF SURVEY" for documentation.

#### 5.3.1 Level 2 Core Data Collection

**Piece Number** (*Piece #* column): Record the piece number. Assign each qualifying LWD piece a unique number, beginning with "1" and continuing sequentially upstream to the last piece in the stream segment.

**Downstream Reference Point Association** (*Dwn Ref #* column): Record the number of the nearest downstream reference point. Each LWD piece is associated with a 100 meter reach delineated by established reference points. The nearest downstream reference point is determined by the location of each piece's mid-point (Figure 7). This system prevents double counting pieces in two reaches or segments.

**Log/Rootwad Identification** (*Piece Cat L/R* column): Record either (*L*) for Log or (*R*) for Rootwad.

**Diameter Measurement** (*Piece Dia cm* column): Measure and record the diameter at the mid-point of the piece to the nearest centimeter or 0.01 meter. On irregularly shaped pieces where the bole is not round, two measurements should be taken and averaged. Use the Field Notes column to record calculations.

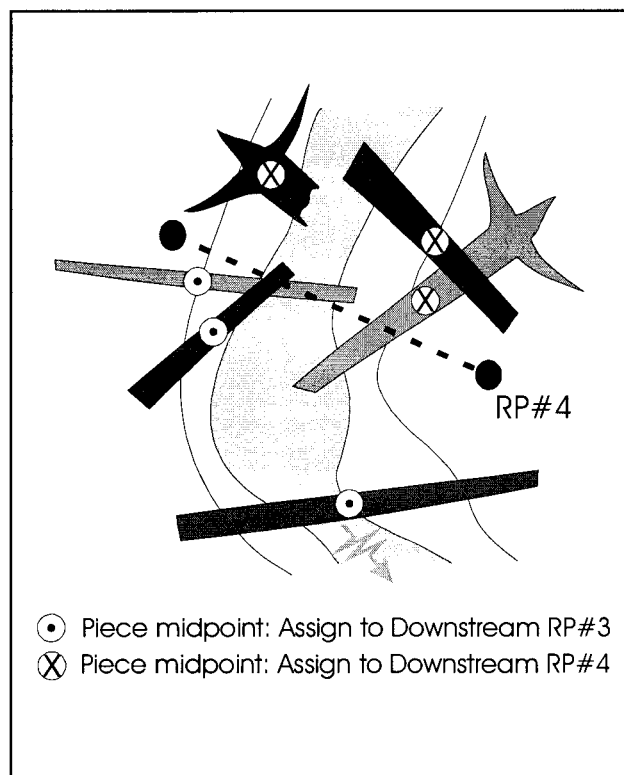


Figure 7. Assign LWD pieces to the nearest downstream reference point based on its midpoint location.

**Piece Length Measurement by Channel Zone Location** (*Piece Length* column): Record the length of each piece by channel zone to the nearest 0.1 meter. Refer to the LWD identification section for piece length measurement criteria. If there is no length in one or more of the zones, place a "0" or diagonal mark in that box. This provides documentation that a measurement was not simply forgotten. Total lengths and volumes are computed during data processing. Form 4.2 has separate columns for each of the channel zone locations. Total length is calculated in the database.

A good technique is to identify all the zone boundaries on the piece before taking the length measurements (Figure 8). A piece of railroad chalk is useful to help mark and remember boundary locations.

◆ **Zone 1 lower boundary:** The lower boundary of Zone 1 is the end of the piece located within the wetted channel. In situations where locating the end of a piece is difficult due to water visibility, water depth, sediment or other obstructions, the end of the piece is the furthest extent of visible or easily verified length.



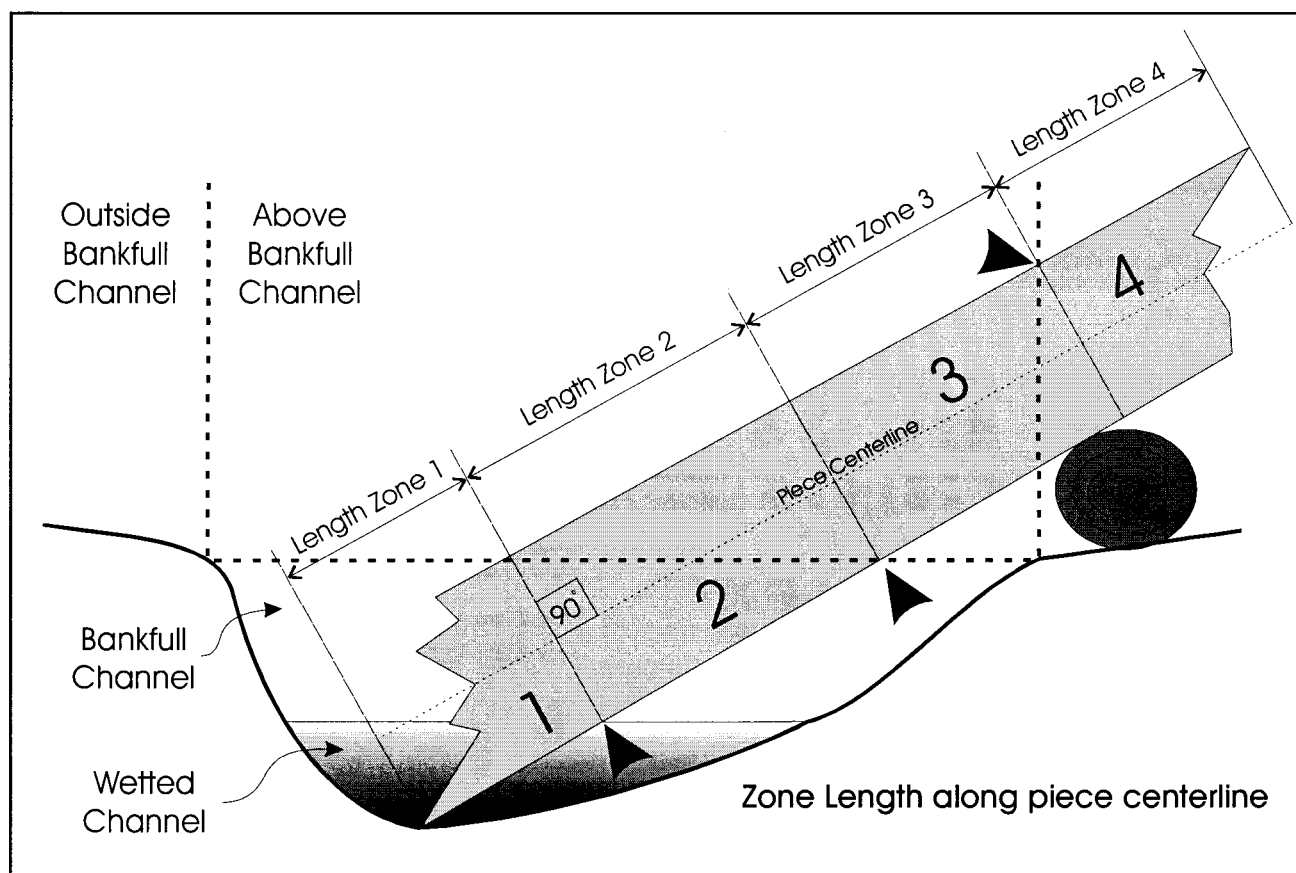


Figure 8. Measuring Zone 1, 2, 3, and 4 lengths along a piece of LWD.

◆ **Zone 1/Zone 2 boundary:** Identify the point along the length of the piece where it leaves the wetted channel. This point is often found where the waterline last touches the underside of the log. Mark the corresponding location with chalk along the top or side of the piece for measurement reference.

◆ **Zone 2/Zone 3 boundary:** Identify the point along the length of the piece where it leaves the bankfull channel. Mark the corresponding location with chalk along the top or side of the piece for measurement reference. Often, this point is found where an estimated bankfull waterline would last touch the underside of the piece.

In situations where a bankfull channel edge is nearby, the zone 2/3 boundary can be identified by using an extend stadia rod and torpedo level. One end of the stadia is placed at the BFCE and then the rod is leveled. Keeping the rod level, swing it upstream or downstream to identify the location of the piece boundary.

In situations where the bankfull channel edge is not

close enough or in complex areas, use the confidence/default technique. Working from inside the channel out or up, identify the point on the piece where 100 % confidence is lost that it is still in Zone 2. Working from outside the channel in or down, identify the point on the piece where 100 % confidence is lost that it is still in Zone 3. Reassess the confidence range and adjust if necessary. The default Zone 2/3 boundary is identified as mid-point within the confidence range.

◆ **Zone 3/Zone 4 boundary:** Identify the point along the length of the piece where it crosses the vertical boundary of the bankfull channel. For this boundary, the furthest extent of influence is often on the top or sides of the piece. Mark the corresponding location with chalk along the top or side of the piece for measurement reference.

Use the BFCE point established by Zone 2 identification and imagine a boundary line from that point straight up along the length of the bank. The stadia rod/torpedo level and confidence/default techniques can also be used to identify this measurement point.

◆ **Zone 4 outer boundary:** The outer boundary of Zone 4 is the end of the piece located on or above the floodplain/terrace/hillslope.

Once the zone boundaries have been determined, begin at the Zone 1 section to measure and record its length on Form 4.2. Progress up the piece to systematically measure and record the piece lengths in Zones 2, 3, and 4 as needed. The sum of the zone lengths equals the total piece length. In situations where an irregular piece intersects the same zone multiple times, it is necessary to measure each length portion and add them together in the Field Notes column. The total length for that zone is then entered. In situations where locating the end of a piece in Zone 4 is too dangerous or inaccessible, measure to the furthest extent possible and put a "+" sign (e.g., 5.0+, 10.0+, etc.) estimate the piece's end and note the accuracy of the estimate (e.g., ± 0.5, 1.0, or 5.0). The signs are not entered into the database, but can be used as shorthand field notes.

**Tree Species Category** (*Species Cat C/D/U* column): Record the tree species category in this column using *C* for Conifer, *D* for Deciduous/Hardwood or *U* for Unknown.

Characteristics of the bark, wood fiber, and branching pattern can often be used to identify the type of wood. A tree identification guide may be useful for identifying species. If not 100% confident about the species category, record "U" for unknown.

**Stability Factors** (*Piece Stability R/B/P or Unstable* column): Record up to three of the applicable stability factors for the piece using *R* for root system, *B* for buried, *P* for pinned or pegged, or *U* for unstable.

A root system is defined as one or more identifiable roots projecting from the root-ball of the piece. Buried stability is defined as the complete burial of either end or lateral burial of 50% or more of the diameter along some portion of the piece's length. Pinned/pegged stability is defined as having another qualifying LWD piece on top of it, or due to being pegged between other logs, standing trees, boulders, or bedrock. A piece can have all three factors recorded if present.

Unstable/Other is defined as having none of the above factors present. This includes very large pieces where the size and weight alone are considered stability

factors. Size and weight stability are calculated from piece length and diameter measurements in the database to determine if their volume meets "Key Piece" criteria.

**Pool Forming Function** (*Pool FF Y/N* column): Record *Y* for Yes and *N* for No if the log or rootwad contributes to the formation of a qualifying pool. Criteria based on TFW Habitat Unit Survey (Pleus et al., 1999).

For a given pool, there may be one or more LWD pieces that directly contribute to its formation. This includes pieces contributing to flow modification during bankfull events that scours out sediment from water plunging over the top, deflecting the flow underneath or to the side, and damming. *Estimate* whether the associated pool qualifies using the minimum surface area and residual pool depth criteria in Tables 5 and 6. The criteria is based on a segment's average bankfull channel width. This includes Zone 2 pieces outside of the summer low-flow wetted perimeter that contributes to pool formation at bankfull flows.

Table 5. LWD pool forming function minimum pool unit surface area and residual pool depth criteria by bankfull channel width - metric units.

Mean Segment Bankfull Width (m)	Minimum Unit Size (m <sup>2</sup> )	Minimum Residual Pool Depth (m)
> 0 to < 2.5	0.5	0.10
≥ 2.5 to < 5.0	1.0	0.20
≥ 5.0 to < 10.0	2.0	0.25
≥ 10.0 to < 15.0	3.0	0.30
≥ 15.0 to < 20	4.0	0.35
≥ 20	5.0	0.40

### 5.3.2 Level 2 Supplemental Data Collection

Collection of supplemental data is optional when conducting the Level 2 Survey. Mark the appropriate circle in the header band if information is being collected on pieces with lowest measurable lengths in Zone 3. For those interested in collecting information on "Green" LWD, refer to the "Large Woody Debris and Channel Zone Identification" section.

Table 6. LWD pool forming function minimum pool unit surface area and residual pool depth criteria by bankfull channel width - English units.

Mean Segment Bankfull Width (feet/tenths)	Minimum Unit Size (feet/tenths <sup>2</sup> )	Minimum Residual Pool Depth (feet/tenths)
> 0 to 8.2	5.4	0.33
≥ 8.2 to 16.4	10.8	0.66
≥ 16.4 to 32.8	21.5	0.82
≥ 32.8 to 49.2	32.3	0.98
≥ 49.2 to 65.6	43.1	1.15
≥ 65.6	53.8	1.31

This section describes the procedures required for recording (a) Zone 3 counts, (b) channel orientation function, (c) decay class, and (d) sediment storage data on qualifying LWD pieces. At this time, the TFW-MP database does not include Zone 3 piece counts or other information in calculations or reports. Information on piece orientation, decay, and sediment storage provides greater characterization of established qualifying LWD and does not affect the total piece count.

#### Zone 3 Piece Count

A piece is counted if a minimum 0.1 meter of its length is within Zone 3 (the area directly above the bankfull channel), but not into the bankfull channel or water. Piece numbering follows the normal sequential count progression. The only difference in collection of piece characteristic data is that there are no length measurements in the Zone 1 or 2 columns. Collection of Zone 3 piece information must be consistently applied across the entire segment.

#### Channel Orientation

*Channel Orient* column: Orientation is measured to represent a piece's horizontal position within the bankfull channel. Option 1 (Bilby and Ward, 1991) - record either *A* for parallel, *B* for perpendicular, *C* for downstream, or *D* for upstream. Option 2 (Robison and Beschta, 1990) - record the orientation degree between 0° and 180°. A compass is used to determine category or actual orientation degrees. Orientation is based both upon the angle of the bole's length axis in relation to the estimated direction of flow at bankfull stage and

the position of the root system and/or direction of the small-diameter end depending upon the option.

*Option 1:* This method is based on eight 45° quadrants (Figure 9). Parallel (*A*) is defined as a piece with its length axis oriented between either 337.5° and 22.5°, or 157.5° and 202.5°. Perpendicular (*B*) is defined as a piece with its length axis oriented between either 67.5° and 112.5°, or 247.5° and 292.5°. Root system or small-diameter end direction is not a factor in category *A* or *B* orientation. Downstream (*C*) is defined as a piece oriented at any other angle with its small-diameter end pointed downstream (root system upstream). Upstream (*D*) is defined as a piece oriented at any other angle with its small-diameter end pointed upstream (root system downstream).

*Option 2:* Pieces with their root system in the upstream direction (small-diameter end downstream) are assigned an orientation angle of between 0 and 89 degrees (Figure 10). Pieces with their root system in the downstream direction (small-diameter end upstream) are assigned an orientation angle of between 91 and 180 degrees. Direction of root system/small diameter end is not a factor for 90 degree oriented pieces.

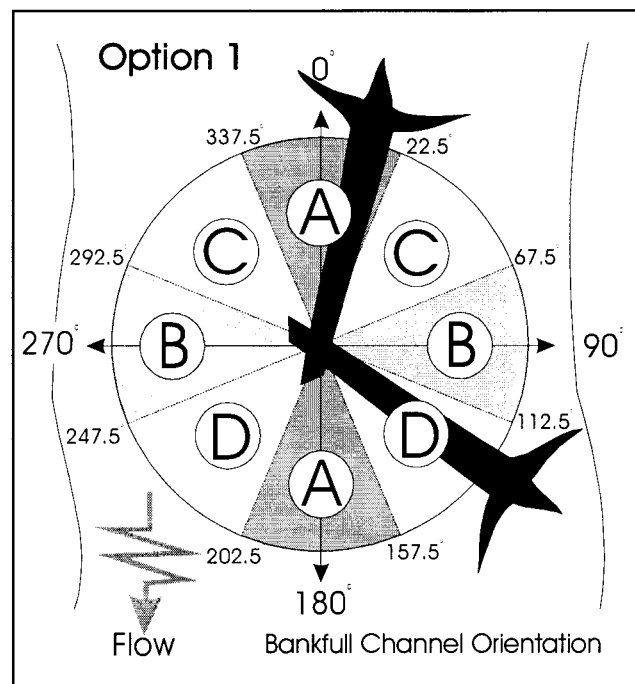


Figure 9. LWD orientation Option 1 system based on Bilby and Ward (1991).

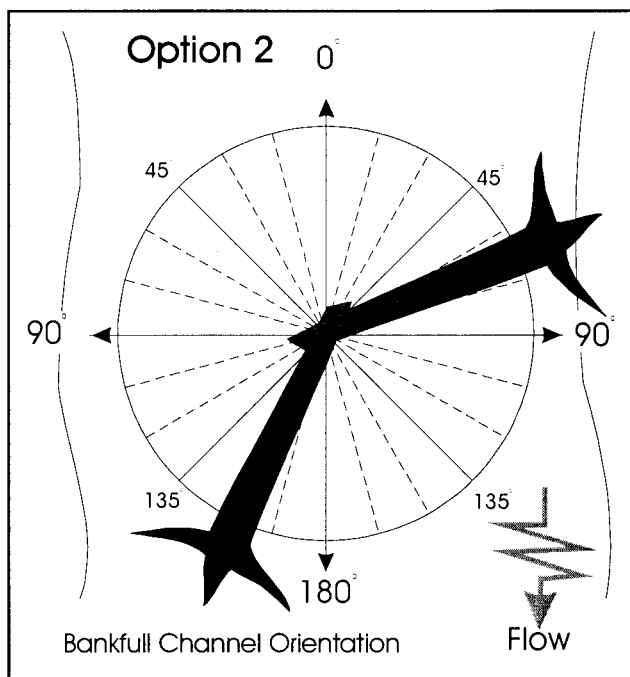


Figure 10. LWD orientation Option 2 based on Robison and Beschta (1990).

### Decay Class

**Piece Decay column:** Option 1 (Robison and Beschta, 1990): Record a single number code between 1 and 5 related to the decay class for each piece. Option 2 (Grette, 1985): Record a single number code between 1 and 7 related to the decay class for each piece.

**Option 1:** This option is provided for those cooperators interested in comparing decay class results to re-

search conducted by Robison and Beschta (1990). Table 7 provides the criteria for determining decay class using this system.

**Option 2:** This option is provided for those cooperators interested in comparing decay class results to research conducted by Grette (1985) and McHenry et al. (1998). Table 8 provides the criteria for determining decay class using this system.

### Definitions of decay indicators

**Bark:** Bark is defined as the tough protective covering around the exterior of tree roots, stems, and branches. Different species produce different thicknesses and textures. Intact bark is that which maintains its integrity with the inner wood surface and cannot be removed by hand. This includes situations where the exterior layer of bark has been severely abraded, but does not expose the inner wood surface. Loose bark no longer adheres to the inner wood surface and can be moved or removed by hand.

**Branches/Limbs/Twigs:** Branches and twigs are the secondary and greater stems extending from the main tree bole. Branches and twigs are present where stem diameters can be measured and absent where they cannot be measured as they do not extend past the stem collar at the main tree bole.

**Surface Texture:** The surface is defined as the outer layer of the tree wood. In less decayed pieces, this surface would contact the inner layer of bark. In pieces with advanced decay, the surface is the outermost layer

Table 7. A five-class decay system for evaluating coniferous and deciduous large woody debris from Robison and Beschta (1990).

Decay Class	Bark	Twigs 3 cm; 1.2 in	Surface Texture	Shape	Wood Color
1	Intact	Present	Intact/Firm	Round	Original
2	Intact	Absent	Intact/Firm	Round	Original
3	Trace	Absent	Smooth to some surface abrasion	Round	Original to darkening
4	Absent	Absent	Abrasion to some holes and openings	Round to oval	Dark
5	Absent	Absent	Vesicular with many holes and openings	Irregular	Dark

Table 8. A seven-class decay system for evaluating coniferous and deciduous large woody debris from Grette (1985).

Decay Class	Bark	Limbs	Surface Texture	Center
1	Intact	Present	Firm	Solid
2	Intact	Absent	Firm	Solid
3	Loose or absent	Absent	Firm	Solid
4	Absent	Absent	Slightly rotted	Solid
5	Absent	Absent	Extensively rotted	Solid
6	Absent	Absent	Completely Rotted	Solid
7	Absent	Absent	Completely Rotted	Rotted

of decomposed wood. A firm surface texture is where the integrity of the wood strength has not been lost. The texture is often smooth to the touch as if the bark has just been removed. A firm surface texture is also identified where abrasion has roughened or gouged the outer wood layer, but the integrity of the wood strength is still intact. Deteriorating or decomposing surface texture is where the wood's chemical and biological structure is breaking down and affecting the integrity of the wood strength. A firm surface would produce wood chips if cut with a knife, and a deteriorating surface would produce multiple wood fibers and parts. Indications of deterioration range from pockets of outer surface softening to rotten where porous surface wood easily crumbles to the touch.

**Center Integrity:** The center is defined as the core of the wood where the first growth rings are located. Solid integrity is where wood strength has not been deteriorated as defined above. Estimation of integrity can be made at observation points such as the piece ends and where holes are available due to deterioration by chemical, biological, or animal factors. Accurate verification requires taking core samples. Pieces with very advanced decay are not included in LWD counts where it is *estimated* that they could break or crumble into non-qualifying LWD pieces if moved.

### Sediment Storage

**Sed Stor Y/N column:** Assign each piece either a "Y" for yes or "N" for no if it is *directly* associated with sediment storage. Sediment storage is defined as meeting all of the following criteria: 1) a minimum 1 square meter surface area deposit of coarse or fine substrate; 2) retained within the bankfull width of the stream channel; and 3) by direct association with the LWD piece. Without the presence of the identified piece, sediment would not likely accumulate in that location, or it would become mobilized if the wood was removed. This means that the stored sediment has to be at a higher elevation than the corresponding general channel sediment level. Sediment sizes in storage deposits are often of a different size class than the predominant bed material. The boundaries of stored sediment are typically defined by breaks in channel gradient and differences in composition of bed materials.

### 5.4 LWD Jam Survey Procedure

Data is collected on qualifying LWD jams for both the Level 1 and Level 2 surveys. Fill-out one row on Form 4.3 for each qualifying LWD jam. Accumulations of less than 10 pieces are recorded as individual LWD pieces according to the level of survey being conducted. Although jams must always contain 10 or more pieces, only pieces with measurable lengths extending into Zones 1, 2, and 3 are recorded on the field form. Therefore, it is possible to record less than 10 pieces on small jams where some of the piece lengths are totally in Zone 4. Review the "LWD Jam Identification" section for resolving complex situations. In situations where no LWD jams are found within the segment, it is still required that a Form 4.3 be filled-out. Put a "0" or "NO JAMS" on the form to document that a jam survey was done but no jams were identified. This information is entered into the database. Mark the blank row after the last jam record "END OF SURVEY" for documentation.

Walking on top of LWD jams can be difficult and dangerous, so jam information is intended to be collected while walking around the outside of the unit and does not necessitate actual measurement of individual pieces of wood.

### 5.4.1 Jam Core Data Collection

**Jam Number** (*Jam #* column): Record the sequential jam number. Assign each qualifying LWD jam a unique number, beginning with "1" and continuing sequentially upstream to the last jam in the stream segment (e.g., 1, 2, 3, 4, etc.).

**Jam Reference Point Association** (*Dwn Ref #* column): Record the number of the nearest downstream reference point. The nearest downstream reference point is determined by the location of the jam's midpoint (Figure 11). This system prevents double counting jams or jam pieces in two reference point reaches. Jam piece numbers can be split at reference points using the percent estimation technique.

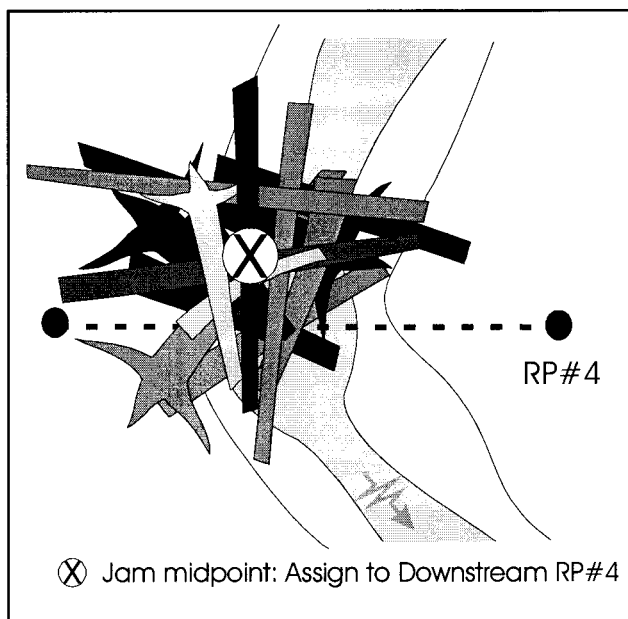


Figure 11. Assign LWD jams to the nearest downstream reference point based on midpoint location.

#### Percent Estimation Technique

One row is filled out for the entire jam's piece count and associated with the downstream reference point based on its midpoint location. In the Field Notes column, record the estimated percentage of pieces whose midpoints are downstream and upstream of the reference point boundary. Percentages can be estimated in 10 percent or 25 percent groupings. The total of the downstream and upstream percentages must equal 100 percent.

**Jam Channel Location** (*Lowest Zone* column): Record either zone number 1, 2, or optional 3.

Record the jam's lowest channel zone. A jam is assigned to Zone 1 if at least one of its lowest LWD pieces extends its length a minimum 0.1 meters into the water. A jam is assigned to Zone 2 if at least one of its LWD pieces extends its length a minimum 0.1 meters into the bankfull channel area, but none of the pieces has a measurable length in Zone 1.

**Jam Pool Forming Function** (*Pool FF* column): Record "Y" for Yes or "N" for No if the jam contributes to the formation of a qualifying pool. For a given pool, there may be one or more individual LWD pieces within a jam that have contributed to its formation through direct or indirect means. This includes flow modification that scours out sediment from water plunging over the top, deflecting the flow underneath or to the side, and damming.

Use the TFW Habitat Unit Survey method manual pool criteria based on a segment's average bankfull channel width for minimum surface area and residual pool depth to estimate whether associated pools qualify (see Tables 5 and 6). This includes Zone 2 jams outside of the summer low-flow wetted perimeter that you determine contribute to associated pool formation at bankfull flows.

**Tally of Visible Pieces by Category** (*Tally of Visible Pieces* column): Record a tally mark representing an individual piece of LWD in the appropriate type and size class column. Associated jam pieces that are completely within Zone 4 are *not* tallied. The percentage of Zone 1, 2, and 3 pieces tallied out of the total estimated jam can be recorded in the Field Notes column. Record a "0" in the appropriate columns on the form where no pieces in that category were identified. This information is entered into the database.

Walk around the debris jam and count the visible pieces that meet the minimum size criteria for rootwads and logs. LWD tallies and diameter size classes are estimated in unsafe conditions. Rootwads are tallied as a single size class. Logs are tallied corresponding to their diameter size class as either small (*S-LOG* 10 to < 20 cm), medium (*M-LOG* 20 to < 50 cm), or large (*L-LOG* 50 cm).

Because it is often not possible to see both ends of logs that go through the middle of large jams, it may be difficult to know if you are missing a piece or counting the same piece twice. Using railroad chalk to mark tallied pieces is helpful to prevent this problem. Estimation of log diameter sizes requires experience with a log caliper to calibrate your eye. The tally marks are added together at the end of the survey and recorded along the *Tally Totals* row under their appropriate LWD type and size class.

### *Splitting Jams at Segment Boundaries*

Single jams with pieces influencing two or more study reaches are split according to the estimated midpoint locations of individual pieces. The overall jam's midpoint location, an estimated percentage of total pieces within the study reach, and a brief description of the jam are documented in the Field Notes column.

For example, Figure 12 represents a sprawling jam with pieces influencing three segment study reaches. The Crazy Creek Segment 3 portion of the jam would record a unique jam number, nearest downstream reference point number for that portion of the jam, the

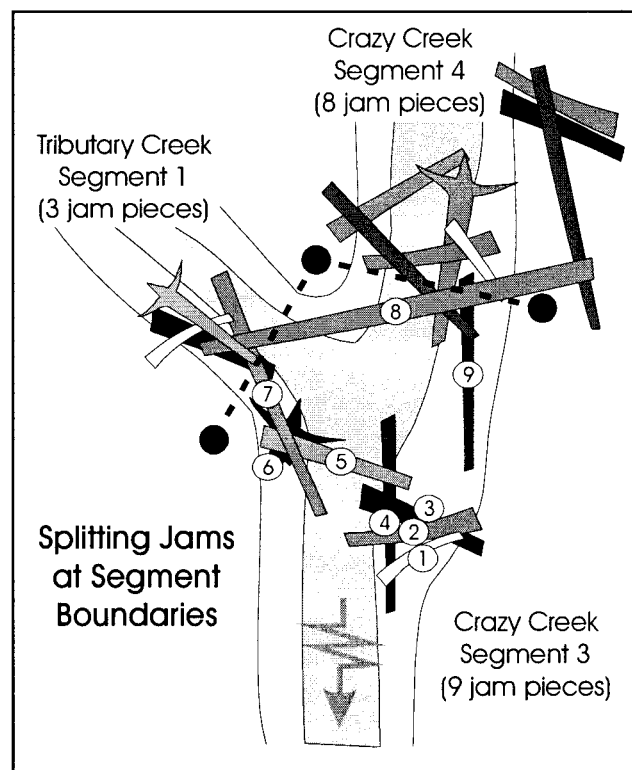


Figure 12. Splitting jam piece counts at segment boundaries.

lowest zone of the overall jam, the pool forming function of the overall jam, and a tally of visible pieces based on piece mid points falling in that segment. The Crazy Creek Segment 4 portion of the jam can record the same number if known or a unique jam number, a different downstream reference point number, the same lowest zone and pool forming function describing the overall jam, and a tally of visible pieces based on piece mid points falling in that segment. The Crazy Creek tributary Segment 1 jam information would follow the same process as Segment 4. In general, only one segment is part of the study plan and other segment information is not collected. If all three segments were surveyed, the sum of the pieces from each segment would reflect the total jam piece count.

### 5.4.2 Jam Supplemental Data Collection

This section describes the procedures required for recording data on additional qualifying LWD jams with lowest zone of 3 and for identifying individual pieces within a qualifying jam that meet key piece criteria. Collection of supplemental data is optional when conducting the Jam survey. Mark the appropriate circles in the header band if either Zone 3 or Key Piece information is being collected for the survey. Jams that are entirely within Zone 4 are not counted. Record a "0" in the appropriate columns on the form in situations where a jam survey was done, but no key pieces or Zone 3 pieces were identified. This information is entered into the database.

This version of the LWD Jam Survey does not include in the total jam piece counts those individual jam pieces with lengths completely within Zone 4. Jam piece count comparisons to 1994 methods can be accomplished by using the next row on Form 4.3 to record Zone 4 piece information (not entered into database). Use the same jam and reference point numbers, but record a "4" in the *Lowest Zone* column. For those interested in collecting information on "Green" LWD, refer to the "Large Woody Debris and Channel Zone Identification" section.

**Zone 3 Jam Count:** A jam is assigned to Zone 3 if at least one of its lowest LWD pieces extends its length a minimum 0.1 meters into the area directly above the bankfull channel, and no jam pieces have measurable lengths in Zones 2 or 1. Jam numbering follows the normal sequential count progression. The only

difference in collection of jam data is that a "3" is recorded in the *Lowest Zone* column. Collection of Zone 3 piece information must be consistently applied across the entire segment. At this time, the TFW-MP database does not include Zone 3 jam or piece information in calculations or reports.

*Key Pieces Tally:* Tally marks for qualifying individual LWD regular pieces that also meet key piece criteria are placed in corresponding *Key Pieces* tally sections. Refer to the "Level 1 Supplemental Data Collection" section for specific information on key piece identification procedures and documentation. The collection of key piece characteristic data on qualifying LWD pieces within an established jam does *not* add to the total segment piece count. Tally marks are simply moved to the key piece section if they meet the additional criteria.



## 6. Post-Survey Documentation

After completion of the field portion of the Large Woody Debris Survey, field forms need to be organized, supplemental information and calculations completed, and all forms and information error checked before the data is ready to be entered into the database. The objective of this section is to organize the data to ensure that this survey can be repeated the same way in the future by different crews.

### 6.1 Finalizing Forms 4.0, 4.1, 4.2 and 4.3

Organize the forms and check for missing sheets. Systematically check each LWD Survey form for completeness. All parameter blanks and boxes should contain information or a "/" to designate that no information is available or needed.

#### 6.1.1 All Forms

The following list provides guidance on some common tasks:

- ◆ Page numbering is related to form type. Count the number of total pages separately for Forms 4.0, 4.1, 4.2, and 4.3.
- ◆ The page number should be filled in as used during the survey (e.g., Page 1 of \_\_, Page 2 of \_\_, Page 3 of \_\_, etc.). Forms that have been copied on both side of one sheet of paper will count as two separate pages.
- ◆ The total number of pages for each type of form is filled in at the end of the survey (e.g., Page 1 of 6, Page 2 of 6, Page 3 of 6, etc.).
- ◆ Organize the field forms by type and then by page number for easy reference. It is common to have different totals for each type.

#### 6.1.2 Form 4.0

##### Study Design Information

*Begin/End Survey Dates:* Record the dates based on Forms 4.1, 4.2, and 4.3 that LWD Survey field data collection began and ended for that segment. The *Begin Survey Date* is a key database field used to track and identify this specific survey.

*Survey Length:* Where the entire segment was surveyed, record the segment length as documented in the "Study Design Information" section on the Reference Point Survey Form 2H or the database report. Where only portions of the segment were surveyed, record the total length of reach actually surveyed within the segment.

*Survey Coverage:* Fill-in the survey's coverage circle and percentage of the survey length that best applies to the survey. Mark *WHL* if the whole or entire segment or sub-segment was inventoried for sample collection (100%). Mark *PRT* if the survey was applied on a consecutive length of a partial segment/sub-segment. For example, where only the first 500 meters of a 2,000-meter-length segment will be inventoried for sample collection (25%). Mark *SUB* if the survey was applied using a random or systematic placement subsampling strategy. For example, where every other 100 meter interval reach will be inventoried for sample collection (50%). Mark *PSB* if a combination of *PRT* and *SUB* was applied. Mark *OTH* if your study design differs from the above.

*Partial/Other Survey Location:* These locations are associated with survey length lower and upper boundaries - that is, the boundaries encompassing the section of stream actually surveyed. Record the WRIA river/stream mile locations to the nearest tenth of a mile (0.0 - 9999.9) and reference point numbers (0 - 9999).

##### Survey Notes

This section is provided to make brief notes related to unique survey conditions and problems encountered.

Note any modifications to the TFW-MP Large Woody Debris Survey criteria used to meet individual cooperator needs. This includes minimum diameter, length, or other identification criteria, channel zone system, jam size, decay class etc. Additional information can be included on the back of the form or on separate sheets of paper. If separate sheets are used, they need to be included in the *Page \_\_\_ of \_\_\_* information and have the key header information listed at the top of each page.

### *Discharge Information*

Record all date and discharge measurements from Forms 7.0 and 7.1 that apply to this survey.

#### *6.1.3 Form 4.1*

Count the tally marks for each LWD category and zone, and record the sum in their respective *Tally Totals* row and box.

#### *6.1.4 Form 4.3*

Count the tally marks for each LWD category, and record the sum in their respective *Tally Totals* row and box.

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## **6.2 Error Checking**

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Error checking of field forms is a very important task and sufficient time should be taken to complete it. It is best done during or immediately after data collection. It becomes more difficult to reconcile discrepancies and track down correct information the more time passes since the survey was completed. Where information cannot be corrected, the data may not be useful for monitoring purposes. Contact the TFW-MP for assistance in determining how to handle missing data fields.

Review Forms 4.0, 4.1, 4.2 and 4.3 plus all other documents compiled during the Large Woody Debris Survey. Have a second person look them over for completeness, legibility and errors. Every page of every form requires error checking for legibility, complete and consistent header information, obvious measurement and transcription errors, and calculation errors. Work systematically through each section and when completed, put your initials and date in the *Error Checked by* box at the bottom of each page. If the person error checking the data is not a crew member, their full name and task should be recorded in the *Survey Notes* section of Form 4.0.

## 7. Data Management

The TFW Monitoring Program offers data management services to help cooperators quickly analyze data collected with the program methods and to produce standard monitoring reports. The heart of the service is a database system housed at the Northwest Indian Fisheries Commission. This database calculates parameters, produces reports and archives electronic versions of the data. The database is also an important archive of monitoring data that can be used for developing study designs and identifying control or reference sites. This section describes the process for data preparation, data processing and archiving, and data analysis.

### 7.1 Data Preparation

Before data entry can occur for the Large Woody Debris Survey, some preparation must be done. The following materials are needed:

- ◆ completed and error-checked Forms 4.0, 4.1, 4.2, and 4.3 as needed for each segment;
- ◆ a data entry system and set of instructions;
- ◆ an "Ambsys" data dictionary;
- ◆ a copy of the completed Stream Segment Identification Form 1.0;
- ◆ and a copy of the completed Reference Point Survey Form 2.H.

Before the data entry process can begin, an entry system must be selected. Choose a data entry system from the list below and request a free copy and user's manual from the TFW Monitoring Program. The database has three entry system options for survey data. These are:

- ◆ Microsoft Excel 4.0 pre-formatted spreadsheets;
- ◆ Lotus 1-2-3 (vers. 3) pre-formatted spreadsheets;
- ◆ Microsoft Access 7.0 pre-formatted entry forms.

Refer to Appendix E for an example of the Excel pre-formatted spreadsheet. Select a spreadsheet format if your data requires conversion from English to metric units. Replace all English unit measurements with metric equivalents. Read the instructions for the data entry system and the Ambsys data dictionary, noting the field types and data constraints (what type of data can be entered into each field).

### 7.2 Data Processing, Products and Archiving

Open the section of the entry system pertaining to the LWD Survey on your computer. You must complete the header, Level 1 or Level 2, and the Debris Jam detail forms. Following the entry system instructions, enter the data from Forms 4.0, 4.1 or 4.2, and 4.3 as directed. After the data has been entered and the session saved, error check the data entry. The most efficient process is to have one person read the data off the screen and another check it with the original field form. Save the file a final time after verifying the accuracy of the entered data.

Data can be sent to the TFW Monitoring Program using several different methods. A few are described here. Gather together:

- ◆ Copies of the field forms;
- ◆ Copy of USGS topographic map section(s) with the stream segment locations marked; and
- ◆ An electronic version of the data.

Copies of all survey field forms and other documentation can be hand delivered, mailed, or faxed to the Northwest Indian Fisheries Commission. Copies of the USGS topographic map sections can be hand delivered, mailed, or faxed and must contain the following information: upstream and downstream segment boundaries along the stream, township, range, section, contour interval, and map name and date. The electronic versions of the data can be sent via e-mail, CD, or on a floppy disk. After the program receives the electronic files, the data is imported into the database by a TFW-MP staff person.

Safe and efficient archiving is also provided through Data Management Services. The data generated by individual cooperators is archived electronically in the database system. Hard copies of the field forms, topographic maps and supplemental information are archived at the TFW-MP facility to meet quality assurance needs and to reduce the chance of loss due to personnel changes or destruction. Access to cooperator data can be limited by request. Call for information on the data access policy.

## 7.3 Data Analysis

LWD reports can be generated for Level 1 or Level 2 surveys. A Level 1 LWD Survey Report uses information from Forms 4.0, 4.1, and 4.3. A Level 2 LWD Survey Report uses information from Forms 4.0, 4.2, and 4.3. Both survey reports use what is entered in the LWD header form to calculate parameters such as number of LWD pieces and jams, per channel width and kilometer.

The results of data analysis are available in three reports: Level 1 Large Woody Debris Survey Report; Level 2 Large Woody Debris Survey Report; and Data Summary by Reference Point Report. Refer to Appendix E for examples.

### 7.3.1 Level 1 Large Woody Debris Survey Report

A Level 1 LWD Survey Report uses information from Forms 4.0, 4.1, and 4.3. The report covers one stream segment and is divided into header information, total in-channel piece summary, individual piece summary, and debris jam summary sections. The following is a brief description of the information provided and data analysis by section.

*Header Information:* includes stream name, WRIA number, survey date beginning and ending time span, segment/sub-segment number, reference point number span, river mile span, discharge dates and flow, survey length and coverage, survey leader name and affiliation, and channel width.

*Total In-Channel Piece Summary (Individual and Debris Jam Pieces):* This table presents information on the total LWD in the segment, combining data from individual pieces (Form 4.1) and jams (Form 4.3). Data is summarized by five piece categories including rootwads, logs  $\geq 10$  and  $<20$  centimeters, logs  $\geq 20$  and  $<50$  centimeters, logs  $\geq 50$  centimeters, and total pieces. Eight parameters are calculated including total number of pieces, percent of total pieces, LWD per channel width, LWD per kilometer, number of key pieces, percent LWD key pieces, key pieces per channel width, and key pieces per kilometer.

*Individual Piece Summary:* This table presents data on individual pieces only (Form 4.1). Data is

summarized by five piece categories including rootwads, logs  $\geq 10$  and  $<20$  centimeters, logs  $\geq 20$  and  $<50$  centimeters, logs  $\geq 50$  centimeters, and total pieces. Seven parameters are calculated including total number of pieces, number of zone 1 pieces, percent zone 1 pieces, number of zone 2 pieces, percent zone 2 pieces, number of key pieces, and percent of key pieces.

*Debris Jam Summary:* This table presents data on jam pieces only (Form 4.3). Nine parameters are calculated including the number of debris jams, debris jams per kilometer, number of logs  $\geq 10$  and  $<20$  centimeters, number of logs  $\geq 20$  and  $<50$  centimeters, number of rootwads, number total pieces, number of key pieces, and percent key pieces.

### 7.3.2 Level 2 Large Woody Debris Survey Report

A Level 2 LWD Survey Report uses information from Forms 4.0, 4.2, and 4.3. The report covers one stream segment and is divided into header information, total in-channel piece summary, debris jam summary, individual in-channel LWD piece summary, individual in-channel LWD volume summary, and individual in-channel piece characteristics summary sections. The following is a brief description of the information provided and data analysis by section.

*Header Information:* includes stream name, WRIA number, survey date beginning and ending time span, segment/sub-segment number, reference point number span, river mile span, discharge dates and flow, survey length and coverage, survey leader name and affiliation, and channel width.

*Total In-Channel Piece Summary (Individual and Debris Jam Pieces):* This table presents data on all pieces in the segment, combining data on individual pieces (Form 4.2) and jam pieces (Form 4.3). Data is summarized by five piece categories including rootwads, logs  $\geq 10$  and  $<20$  centimeters, logs  $\geq 20$  and  $<50$  centimeters, logs  $\geq 50$  centimeters, and total pieces. Sixteen parameters are calculated including number of pieces, percent of total pieces, LWD per channel width, LWD per kilometer, number of key pieces, percent key pieces of total, key pieces per channel width, key pieces per kilometer, mean diameter, mean length, total volume, mean volume, total in-channel volume, mean in-channel volume, in-channel volume per

channel width, and in-channel volume per kilometer. LWD jam volumes are calculated by assigning a mean length and diameter for each size class based on the individual piece data. This assumes that the size distribution of jam pieces is the same as individual pieces.

*Debris Jam Summary:* This table presents data on jam pieces only (Form 4.3). Nine parameters are calculated including the number of debris jams, debris jams per kilometer, number of logs  $\geq 10$  and  $< 20$  centimeters, number of logs  $\geq 20$  and  $< 50$  centimeters, number of logs  $\geq 50$  centimeters, number of rootwads, number total pieces, number of key pieces, and percent key pieces.

*Individual In-Channel LWD Piece Summary:* These tables present data on individual pieces only (Form 4.2). The summary is divided into two parts.

All Pieces by Piece Type - Data is summarized by three piece categories including rootwads, logs, and total pieces. Seven parameters are calculated including number of pieces, pieces per channel width, pieces per kilometer, number of key pieces, percent key pieces, key pieces per channel width, and key pieces per kilometer.

Pieces by Size Category - Data is summarized by four piece categories including rootwads, logs  $\geq 10$  and  $< 20$  centimeters, logs  $\geq 20$  and  $< 50$  centimeters, logs  $\geq 50$  centimeters. Seven parameters are calculated including number of pieces, pieces per channel width, pieces per kilometer, number of key pieces, percent key pieces, key pieces per channel width, and key pieces per kilometer.

*Individual In-Channel LWD Volume Summary:* This summary is divided into two parts.

All Pieces by Piece Type - Data is summarized by three piece categories including rootwads, logs, and total pieces. Eight parameters are calculated including mean diameter, mean length, mean volume, total volume, mean in-channel volume, total in-channel volume, in-channel volume per channel width, and in-channel volume per kilometer.

Pieces by Size Category - Data is summarized by four piece categories including rootwad, logs  $\geq 10$  and  $< 20$  centimeters, logs  $\geq 20$  and  $< 50$  centimeters, logs  $\geq 50$  centimeters. Eight parameters are calculated including mean diameter, mean length, mean volume, total volume, mean in-channel volume, total in-channel volume,

in-channel volume per channel width, and in-channel volume per kilometer.

*Individual In-Channel Piece Characteristics Summary:* Data is summarized by four piece characteristic categories including conifer, deciduous, unknown, and total. Eleven parameters are calculated including number of pieces, percent of total, total volume, in-channel volume, percent volume in-channel, number pieces with stability factors, percent pieces with stability factors, percent with root system stability factors, percent with buried stability factors, percent with pinned stability factors, and percent with pool forming functions.

### 7.3.3 Data Summary by Reference Point Report

The Data Summary by Reference Point Report provides analysis of LWD data by individual 100 meter reaches defined by their downstream and upstream reference point numbers. This report requires that a Reference Point Survey has been completed and entered into the database. The report is divided into header information, reference point, and total piece summary sections. The report will also include analysis of habitat data if the Habitat Unit survey has been completed. The following is a brief description of the data analysis by section.

*Reference Point:* includes the following information by reference point reach - downstream/upstream reference point numbers, distance between the reference points, bankfull width and depth, canopy closure individual and percent measurements.

*Total Piece Summary (Individual and Debris Jam Pieces):* This table presents data on all pieces in the segment, combining data on individual pieces (Form 4.2) and jam pieces (Form 4.3). Data is summarized by five piece categories including rootwad, logs  $\geq 10$  and  $< 20$  centimeters, logs  $\geq 20$  and  $< 50$  centimeters, logs  $\geq 50$  centimeters, and total. Sixteen parameters are calculated including number of pieces, percent of total pieces, LWD per channel width, LWD per kilometer, number of key pieces, percent key pieces of total, key pieces per channel width, key pieces per kilometer, mean diameter, mean length, mean volume, total volume, mean in-channel volume, total in-channel volume, in-channel volume per channel width, and in-channel volume per kilometer.

## 8. References

- 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.
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## **9. Appendixes**

### **Appendix A**

Form 4.0, 4.1, 4.2, and 4.3 Copy Masters

### **Appendix B**

Completed Examples of Forms 4.0, 4.1, 4.2, and 4.3

### **Appendix C**

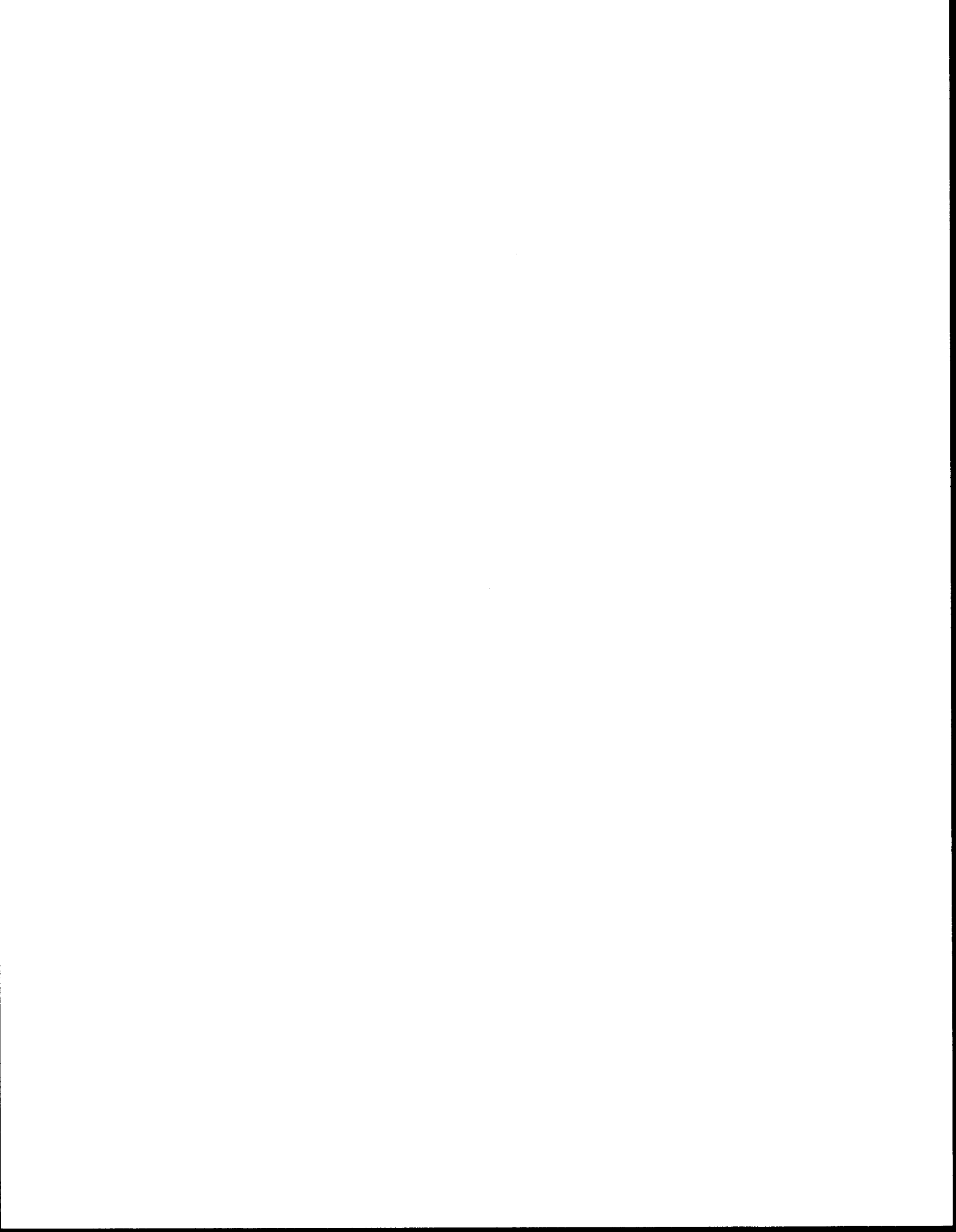
LWD Criteria and Code Field Sheet Copy Master

### **Appendix D**

Standard Field and Vehicle Gear Checklist Copy Master

### **Appendix E**

Data Management Examples

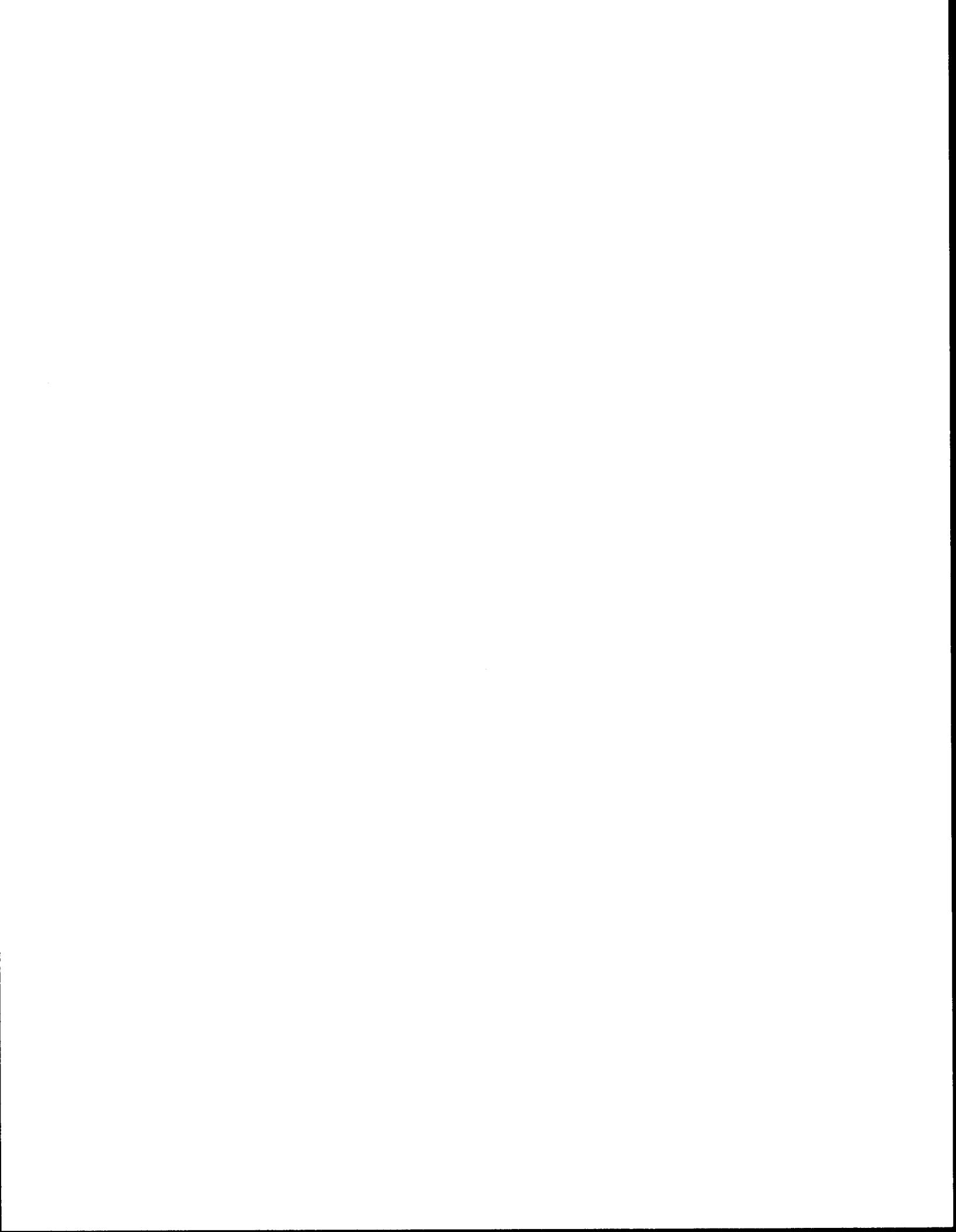




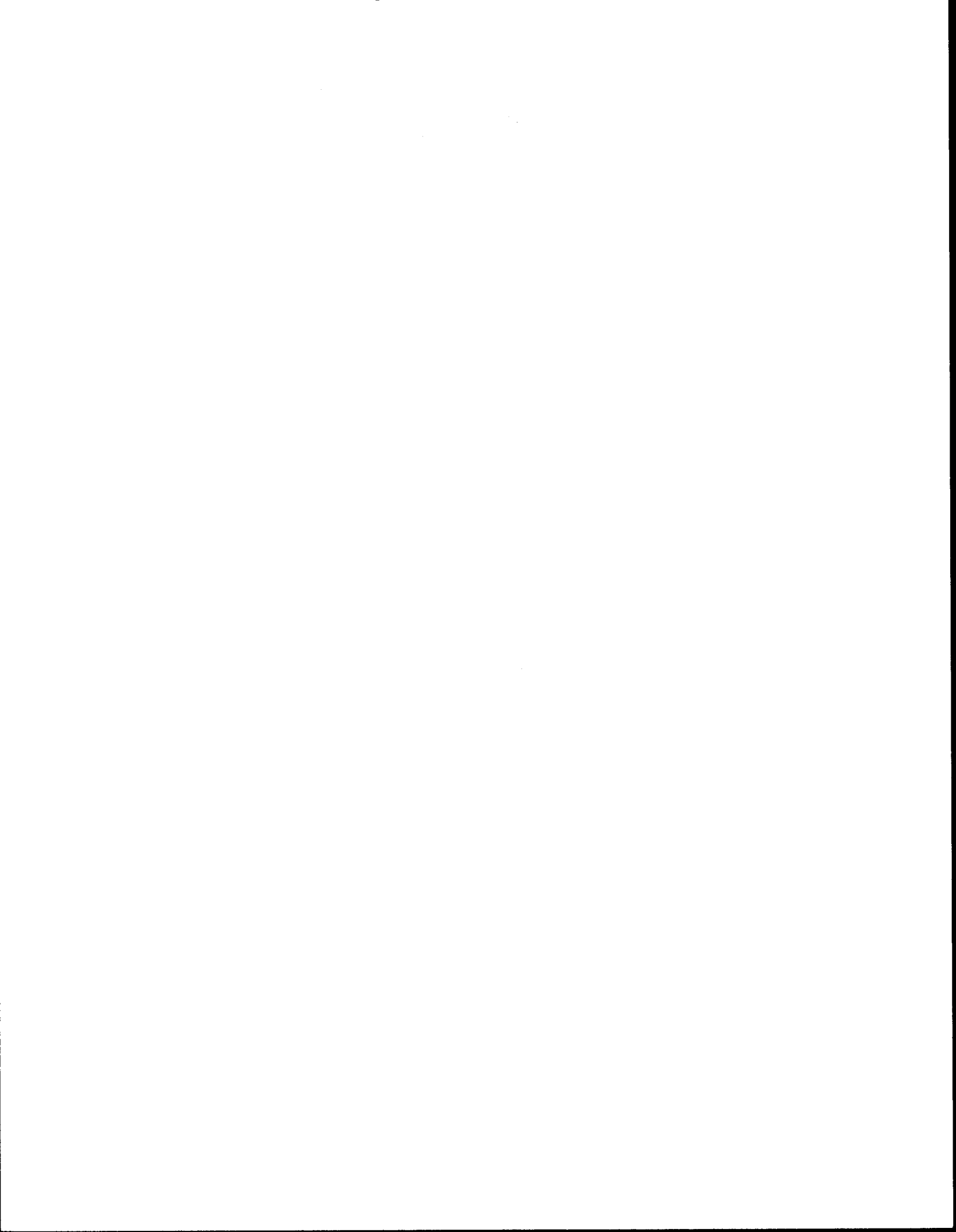
# **Appendix A**

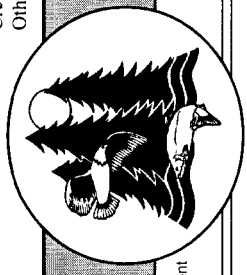
Form 4.0, 4.1, 4.2, and 4.3 Copy Masters

(Keep original copy master with manual)









# FORM 4.1

## FIELD DATA

## LWD LEVEL 1 SURVEY

Stream Name \_\_\_\_\_

KEY PIECES  
 ZONE 3

WRIA # \_\_\_\_\_ Date \_\_\_\_/\_\_\_\_/\_\_\_\_

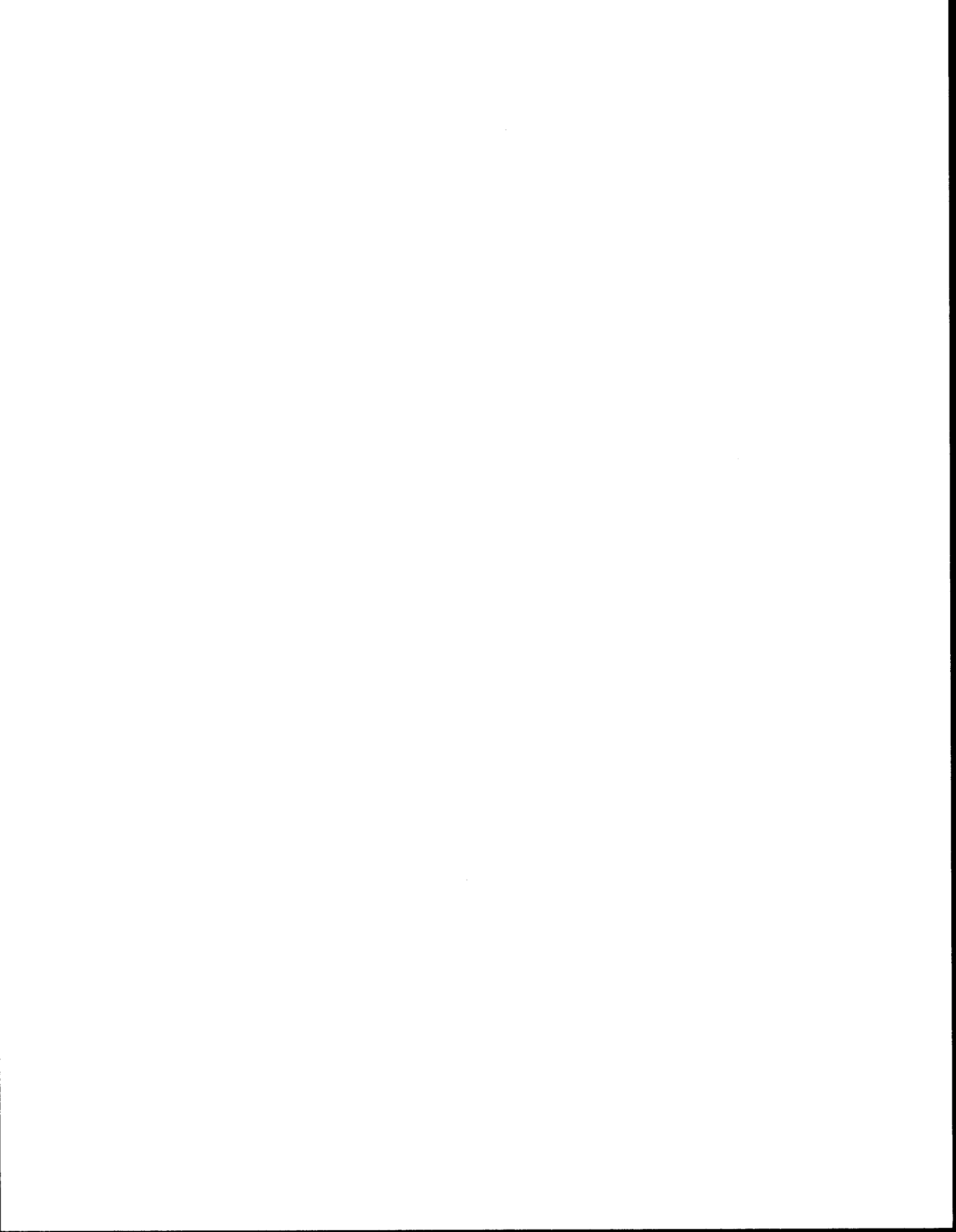
Unlisted Trib  RB  LB

Segment # \_\_\_\_\_

Sub-Segment Code \_\_\_\_\_

Downstream RP #	TALLY OF VISIBLE PIECES				Field Notes
	Rtwd Dia ≥ 20 cm	Small - LOG ≥ 10 cm to < 20 cm	Medium - LOG ≥ 20 cm to < 50 cm	Large - LOG ≥ 50 cm	
	KEY PIECES	KEY PIECES	KEY PIECES	KEY PIECES	
TALLY PIECES W/LOWEST <b>ZONE 1</b>					
TALLY TOTALS					
TALLY PIECES W/LOWEST <b>ZONE 2</b>					
TALLY TOTALS					
Optional <b>ZONE 3</b> (Cross-out if not used)					
TALLY TOTALS					



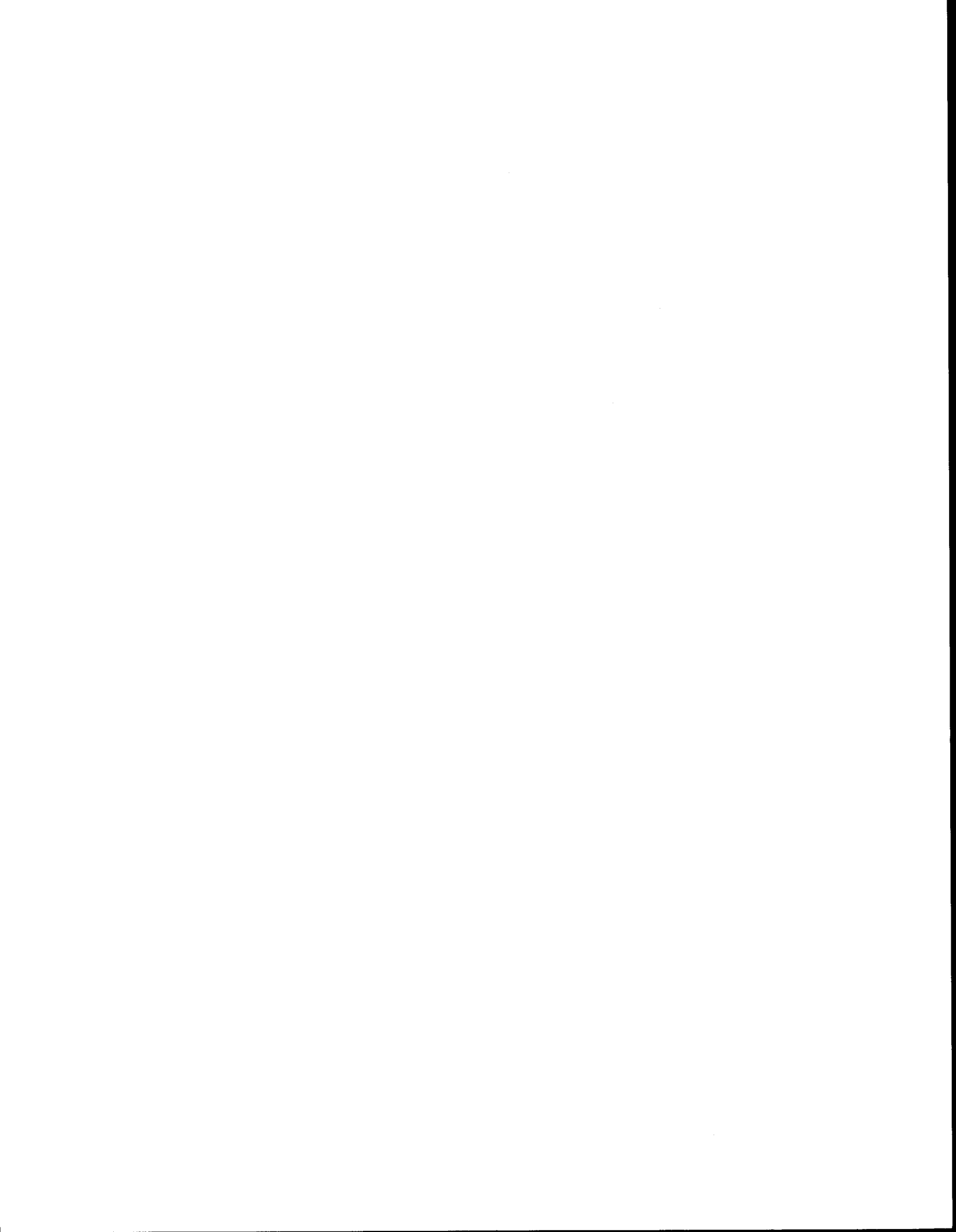












## **Appendix B**

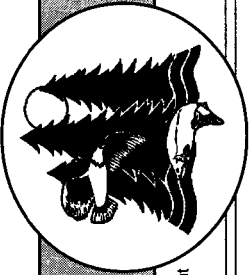
Completed Examples of Forms 4.0, 4.1, 4.2, and 4.3



# LWD SURVEY

## HEADER INFORMATION

# FORM 4.0



WRIA # 30028

Unlisted Tribo  RB  LB

Segment # 12

Sub-Segment Code b

Date 6/19/98

### Study Design Information

Begin Survey Date 6/20/98  
End Survey Date 6/23/98

Survey Length 1750 m

Survey Coverage Percentage  
 WHL (Whole) 100 %  
 SUB (Sub-sample) \_\_\_\_\_ %  
 PRT (Partial) \_\_\_\_\_ %  
 PSB (Partial Sub-sample) \_\_\_\_\_ %  
 OTH (Other) \_\_\_\_\_ %

Partial/Other Survey Location  
 WRIA River Mile: from \_\_\_\_\_ to \_\_\_\_\_  
 Reference Points: from \_\_\_\_\_ to \_\_\_\_\_

TFW  
 Mod. TFW  
 Non-TFW

### Sample Method Information

Core Supplemental  
 Survey Coverage Survey Coverage  
 Level 1  Key Pieces  
 Level 2  Zone 3  
 Jams  Decay Class  
 Sediment Storage  
 Orientation  
 Other  
JAM SED STOR  
 (TFW LEVEL 2)

Mean Segment BFW 19.5 m  
 Pool FF \_\_\_\_\_ surf. area \_\_\_\_\_  
 \_\_\_\_\_ RPD

### Discharge Information

Date 6/20/98 0.53  
 Date 6/22/98 0.52  CMS  CFS  
 Date \_\_\_/\_\_\_/\_\_\_ \_\_\_\_\_

Equipment	Metric <input checked="" type="radio"/> English <input type="radio"/>	Type	Size	Cond	Accuracy	Pre-Calibrated	Post-Calibrated
FIBERGLASS TAPE # 035		KESON	30	GOOD	± 0.01	5/4/98	7/20/98
STADIA ROD # 007		MOUND CITY	5.0	"	"	"	"
LOG CALIPER # 101		SWEDESH	95cm	"	± 0.2cm	"	"
COMPASS # 249		SUNNTO MC-1	POCKET	"	± 2°	"	"
CHEST WADEERS							
RAILROAD CHALK		BLUE					
CAMERA # 004		MINDOLTA WEATHERMATIC	35mm	w/	30mm lens		
FILM		SLIDE	36exp	400EI	ROLL # 007		

### Survey Crew

Name  
DEVIN SMITH  
AMY MORGAN

Affiliation  
TFW MONITORING PROGRAM  
 (Lead) \_\_\_\_\_  
 (Rec.) \_\_\_\_\_

Crew Lead: Year of most recent WSDM Training '98 QA Review '98

### Summary Notes

- ▶ DECAY CLASS OPTION 1: 5 CLASS - ROBISON ; BRESCHTA
- ▶ ORIENTATION OPTION 1: A/B/C/D - BILBY ; WARD
- ▶ SUMMER LOW FLOW CONDITIONS
- ▶ SIDE CHANNEL (LB - RP 6 to 8) MOSTLY SMALL DECID.
- GOOD HABITAT w/ COHO JUVENILE IN POOLS
- ▶ LWD CUTTING ; REMOVAL NEAR RP # 15 -
- SUMMER CABINS NEARBY w/ EASY ACCESS

**X EXAMPLE DATA ONLY X**

① ERROR CHECKING BY ALLEN PLEUS - TFW MONITORING PROG.

○ continued page \_\_\_\_\_

Form 3.0

① Error Checked by: AP Date: 7/22/98

All Field Forms Error Checked by: AP Date: 7/22/98

All Data Entry Error Checked by: AP Date: 7/26/98





Stream Name DESCHUTES RIVER

**LWD LEVEL 1 SURVEY**

**FIELD DATA**



**FORM 4.1**

WRIA # 130028

Segment # 12

Date 6/25/98

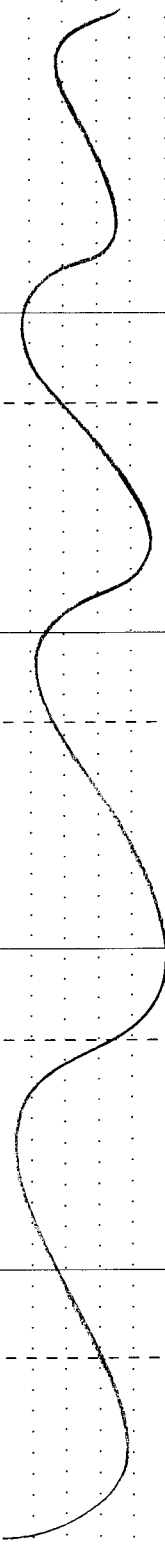
KEY PIECES  
 ZONE 3

Unlisted Trib  RB  
 LB

Sub-Segment Code Q

Downstream RP #	TALLY OF VISIBLE PIECES						Field Notes
	Rtwd Dia ≥ 20 cm	Small - LOG ≥ 10 cm to < 20 cm	KEY PIECES	Medium - LOG ≥ 20 cm to < 50 cm	KEY PIECES	Large - LOG ≥ 50 cm	
<b>ZONE 1</b>	/					/	<ul style="list-style-type: none"> <li>• MOST PIECES HAD LESS THAN 25% OF LENGTH IN ZONE 1</li> <li>• FULL RANGE OF DECAY</li> <li>• MOST SMALL &amp; MED LOGS ARE DECIDUOUS</li> </ul>
TALLY TOTALS	6	17	0	8	0	4	1
<b>ZONE 2</b>							
TALLY TOTALS	3	23	0	13	0	7	2
<b>Optional ZONE 3</b> (Cross-out if not used)							
TALLY TOTALS							

\* EXAMPLE DATA ONLY \*



ERROR CHECKED by: AP Date: 7/25/98





**LWD LEVEL 2 SURVEY**

**FIELD DATA**

METERS  
 FEET

**FORM 4.2**



WRIA # 130028

Unlisted Trib  RB  LB

Segment # 12

Sub-Segment Code 6

Date 6/20/98

DWN RP #	PIECE Cat (L-R)	PIECE Dia (CM)	PIECE LENGTH			SPECIES Cat (C-D-U)	PIECE Stability R B P	Unstable	POOL FF (Y-N)	CHANNEL Orient (opt.#1)	PIECE Decay Storage (opt.#1) (Y-N)	SEDIMENT Storage (Y-N)	Field Notes
			Zone 1	Zone 2	Zone 3								
1	∅	24	4.0	0.5	-	-	P	N	A	3	N	* EXAMPLE	
2	↓	110	-	7.0	-	C	U	N	A	4	Y	DATA	
3	↓	46	6.1	-	-	U	B P	N	B	4	Y	ONLY *	
4	↓	26 <sup>①</sup>	1.2	0.7	-	D	R P	Y <sup>②</sup>	C	2	N	① MEAN: 17 + 35 = 52/2 = 26 ② SMALL POOL ~ 2 X 5 m	
5	↓	19	-	6.4	1.2	D	R	N	B	1	N		
6	↓	37	0.9	8.2	0.4	D	R B P	Y <sup>③</sup>	D	3	Y	③ 3 PIECES ASSOCIATED W/LARGE DEEP POOL	
7	↓	20	4.6	3.2 <sup>④</sup>	1.0	U	R B	Y <sup>④</sup>	A	3	Y	④ MULTIPLE ZONE 1: 2.9 + 0.3 = 3.2	
8	↓	45	7.9	1.2	-	C	R	Y <sup>⑤</sup>	A	2	N		
9	↓	23	-	1.9	-	U	R B	N	D	3	Y <sup>⑥</sup>		
10	↓	33	5.4	-	-	U	B	N	A	4	Y		
11	↓	41 <sup>⑦</sup>	2.0 <sup>†</sup>	0.3	-	U	P	Y	D	3	N	⑦ EST. MIDPOINT-UNDER WATER ⑧ 2+ LENGTH INTO DEEP POOL	
12	↓	29	-	5.7	-	U	U	N	C	5	N		
13	↓	37	6.9	-	-	D	U	N	C	4	N		
14	↓	36	2.9	4.3	10 <sup>⑨</sup>	D	R P	Y <sup>⑨</sup>	A	1	N	⑨ EST. ± 2m ⑩ LARGE SHALLOW POOL * MORE NEXT PAGE	





TFW Monitoring Program Stream Name DESCHUTES RIVER

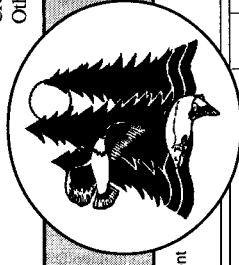
**LWD JAM SURVEY**

**FIELD DATA**

**FORM 4.3**

KEY PIECES  
 ZONE 3

WRIA # 130028 Unlisted Trib  RB  LB Segment # 12 Sub-Segment Code 6 Date 6/20/98



Jam #	DWN RP #	LOWEST Zone (1-3)	POOL FF (Y-N)	Rtwd Dia ≥ 20 cm	TALLY OF VISIBLE PIECES			Large - LOG ≥ 50 cm	KEY PIECES	SEC Stor	Field Notes
					KEY PIECES	Small - LOG ≥ 10 cm to < 20 cm	Medium - LOG ≥ 20 cm to < 50 cm				
1	3	1	Y	1	###	###	1	1	X		① SMALL / DEEP POOL
TALLY TOTALS											
2	5	1	N	1	###	###	1	1	N		• MOSTLY SHORT PIECES • DELAY 3+ • ① PIECE IN ZONE 1
TALLY TOTALS											
3	9	2	N	1	###	###	1	1	N		• LOOSE JAM - MOSTLY WIND-THROW
TALLY TOTALS											
4	12	1	Y	1	###	###	1	1	Y		• ① COMPLEX JAM - MOST PIECES TALKED FROM OUTSIDE JAM • LARGE POOL w/ COHO JUVENILES
TALLY TOTALS											
TALLY TOTALS											
TALLY TOTALS											

6/20 → 6/21 →

END  
 \* EXAMPLE DATA ONLY \*



## **Appendix C**

### **LWD Criteria and Code Field Sheet Copy Master**

(Keep original copy master with manual)



# Large Woody Debris Survey Criteria & Code Sheet

<p><b>Criteria Log (L)</b></p> <ol style="list-style-type: none"> <li>1. Dead - No chance of survival</li> <li>2. Roots no longer support weight of log</li> <li>3. Minimum 10 cm dia. FOR AT LEAST 2 m length</li> <li>4. Enters Zone 1 or 2 (optional Zone 3)</li> </ol>	<p><b>Codes</b></p> <p><b>R</b> Root system is attached to piece  <b>B</b> Greater than 50% diameter buried at some point along length  <b>P</b> Piece is pinned between vertical live or dead structures  <b>U</b> Unstable (if NONE of the above)</p> <p>(choose up to three or unstable)</p>																																										
<p><b>Criteria Rootwad (R)</b></p> <ol style="list-style-type: none"> <li>1. Dead &amp; roots have detached from original location</li> <li>2. Total length less than 2 m</li> <li>3. Minimum 20 cm diameter where bole meets root collar</li> <li>4. Enters Zone 1 or 2 (optional Zone 3)</li> </ol>	<p><b>Codes</b></p> <p><b>C</b> Conifer species (100% confident)  <b>D</b> Deciduous species (100% confident)  <b>U</b> Unknown species (Less than 100% confident)</p> <p>(choose one)</p>																																										
<p><b>Criteria Debris Jam</b></p> <ol style="list-style-type: none"> <li>1. Minimum 10 qualifying pieces LWD touching or assoc. w/jam structure</li> <li>2. Minimum 1 piece enters Zone 1 or 2 (optional Zone 3)</li> </ol>	<p><b>Codes</b></p> <p><b>Y</b> Piece associated with adjacent pool unit formation  <b>N</b> No pool unit or it doesn't meet minimum Habitat criteria (estimated only)</p> <p>(choose one)</p>																																										
<p><b>Criteria Zone system</b></p> <p><b>Zone 1:</b> Within wetted portion of channel  <b>Zone 2:</b> From water surface to a line connecting the bankfull edges  <b>Zone 3:</b> Directly above Zone 2 to infinity  <b>Zone 4:</b> Outside of bankfull channel</p>	<table border="1"> <thead> <tr> <th>Mean Seg BFW (m)</th> <th>Min m<sup>2</sup></th> <th>Min RPD</th> <th>Mean Seg BFW (ft.)</th> <th>Min ft.<sup>2</sup></th> <th>Min RPD (feet/feetths)</th> </tr> </thead> <tbody> <tr> <td>&lt; 2.5</td> <td>0.5</td> <td>0.10</td> <td>&lt; 8.2</td> <td>5.4</td> <td>0.33</td> </tr> <tr> <td>2.5 - 5.0</td> <td>1.0</td> <td>0.20</td> <td>8.2 - 16.4</td> <td>10.8</td> <td>0.66</td> </tr> <tr> <td>5.0 - 10</td> <td>2.0</td> <td>0.25</td> <td>16.4 - 32.8</td> <td>21.5</td> <td>0.82</td> </tr> <tr> <td>10 - 15</td> <td>3.0</td> <td>0.30</td> <td>32.8 - 49.2</td> <td>32.3</td> <td>0.98</td> </tr> <tr> <td>15 - 20</td> <td>4.0</td> <td>0.35</td> <td>49.2 - 65.6</td> <td>43.1</td> <td>1.15</td> </tr> <tr> <td>&gt; 20</td> <td>5.0</td> <td>0.40</td> <td>=/&gt; 65.6</td> <td>53.8</td> <td>1.31</td> </tr> </tbody> </table>	Mean Seg BFW (m)	Min m <sup>2</sup>	Min RPD	Mean Seg BFW (ft.)	Min ft. <sup>2</sup>	Min RPD (feet/feetths)	< 2.5	0.5	0.10	< 8.2	5.4	0.33	2.5 - 5.0	1.0	0.20	8.2 - 16.4	10.8	0.66	5.0 - 10	2.0	0.25	16.4 - 32.8	21.5	0.82	10 - 15	3.0	0.30	32.8 - 49.2	32.3	0.98	15 - 20	4.0	0.35	49.2 - 65.6	43.1	1.15	> 20	5.0	0.40	=/> 65.6	53.8	1.31
Mean Seg BFW (m)	Min m <sup>2</sup>	Min RPD	Mean Seg BFW (ft.)	Min ft. <sup>2</sup>	Min RPD (feet/feetths)																																						
< 2.5	0.5	0.10	< 8.2	5.4	0.33																																						
2.5 - 5.0	1.0	0.20	8.2 - 16.4	10.8	0.66																																						
5.0 - 10	2.0	0.25	16.4 - 32.8	21.5	0.82																																						
10 - 15	3.0	0.30	32.8 - 49.2	32.3	0.98																																						
15 - 20	4.0	0.35	49.2 - 65.6	43.1	1.15																																						
> 20	5.0	0.40	=/> 65.6	53.8	1.31																																						
<p><b>Lumpers &amp; Splitters</b></p> <ul style="list-style-type: none"> <li>&gt; Green leaves: do not count as part of core data</li> <li>&gt; Nurse logs count unless root systems of live growth provide piece stability</li> <li>&gt; Floaters can be part of, but CANNOT make a Jam</li> <li>&gt; Disregard branches</li> <li>&gt; Forks: measure the one with most bankfull influence and/or largest diameter or length - disregard other</li> </ul>	<p>(choose up to three or unstable)</p>																																										

<b>Metric to</b>	10 cm = 0.1 m = 4 inches	2 m =
<b>Feet</b>	20 cm = 0.2 m = 8 inches	6.6 feet
<b>Conversion</b>	50 cm = 0.5 m = 20 inches	

Meter/Feet conversion: meters x 3.281 = feet





# LWD Key Piece Volume Criteria

Based on Watershed Analysis Fish Habitat Module:

Table F-5 (p.F-26, 1995)

BFW		BFW			
		>0 to < 5	5 to < 10	10 to < 15	15 to < 20
Min Dia (m)	Min Len (m)				
0.20	32				
0.25	21				
0.30	15	36			
0.35	11	26			
0.40	8	20			
0.45	7	16	38		
0.50	6	13	31		
0.55	5	11	26		
0.60	4	9	22	32	
0.65	3	8	19	28	
0.70	3	7	19	24	
0.75	3	6	14	21	
0.80	2	5	12	18	
0.85	2	5	11	16	
0.90	2	4	10	15	
0.95	2	4	9	13	
1.00	2	4	8	12	
1.05	2	3	7	11	
1.10	2	3	7	10	
1.15	1	3	6	9	
1.20		3	6	8	
1.25		3	5	8	
1.30		2	5	7	
1.40		2	4	6	
1.55		2	4	5	
1.60		2	3	5	
1.70		2	3	4	
1.80		1	3	4	
2.00			2	3	
2.40			2	2	
2.80			1	2	
3.40				1	

BFW (m)	Volume (m3)
0 to < 5	1
5 to < 10	2.5
10 to < 15	6
15 to < 20	9
> 20	(optional 9 or >)

**Procedure:**

1. Select segment bankfull width (BFW) category; (from Reference Point Survey)
2. Measure diameter of candidate pieces and round to nearest 0.05 m (5 cm);
3. Follow matrix across to find the minimum length requirement.

**Key Log Example:**

1. Segment has an average BFW of 12 m (use BFW column of 10 to < 15 m)
2. Candidate log diameter is measured/estimated to be .53 m (round to .55 m)
3. Log must be a minimum of 26 m long (measure/estimate log length to assess if a Key Piece)

**Key Rootwad Example:**

1. Segment has an average BFW of 4 m (use BFW column of 0 - 5 m)
2. A rootwad Key Piece must have a minimum diameter of 1.15 m and length of 1 m.

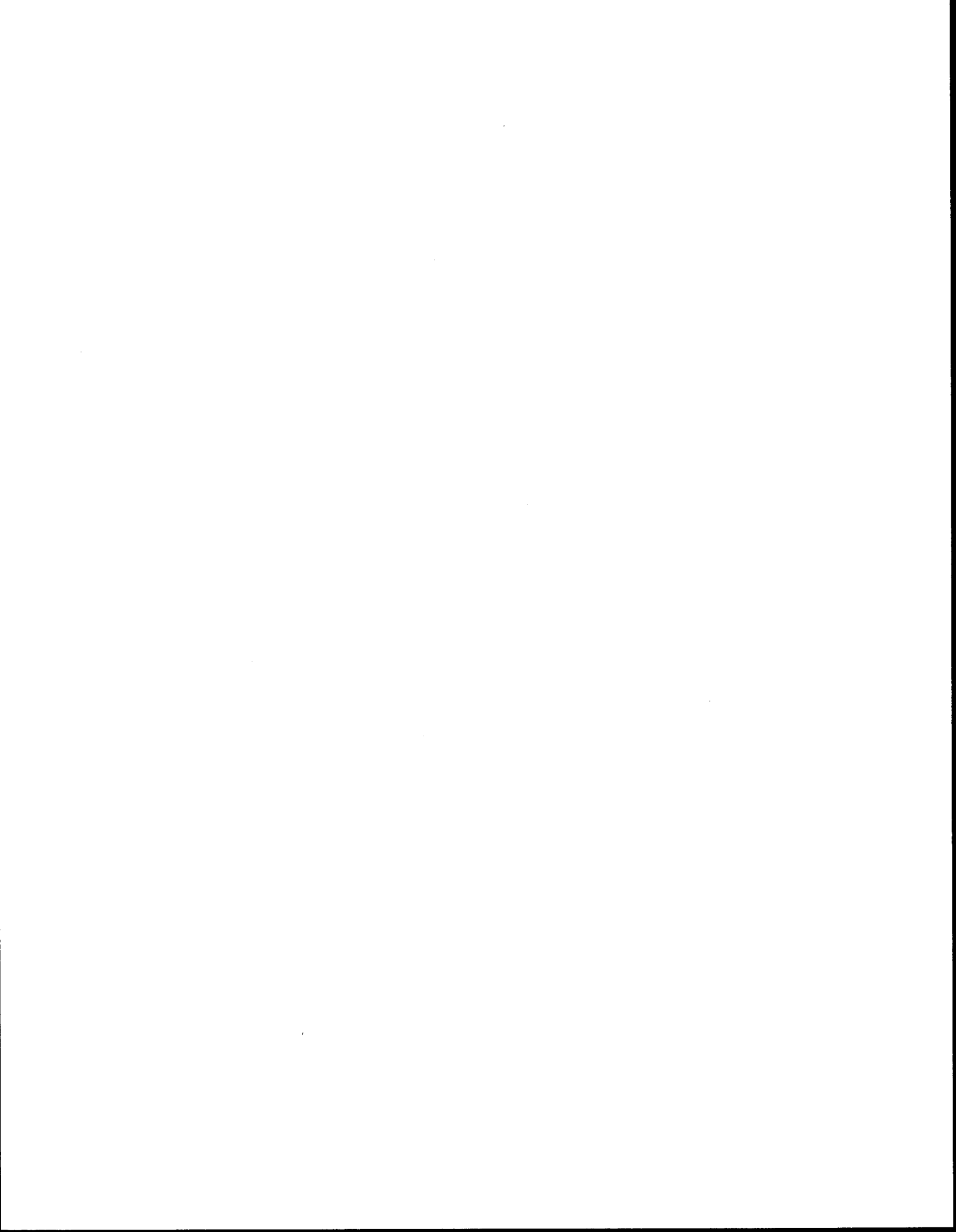
Meter/feet conversion: meters x 3.281 = feet



## **Appendix D**

### **Standard Field and Vehicle Gear Checklist Copy Master**

(Keep original copy master with manual)



✓ **STANDARD FIELD GEAR**

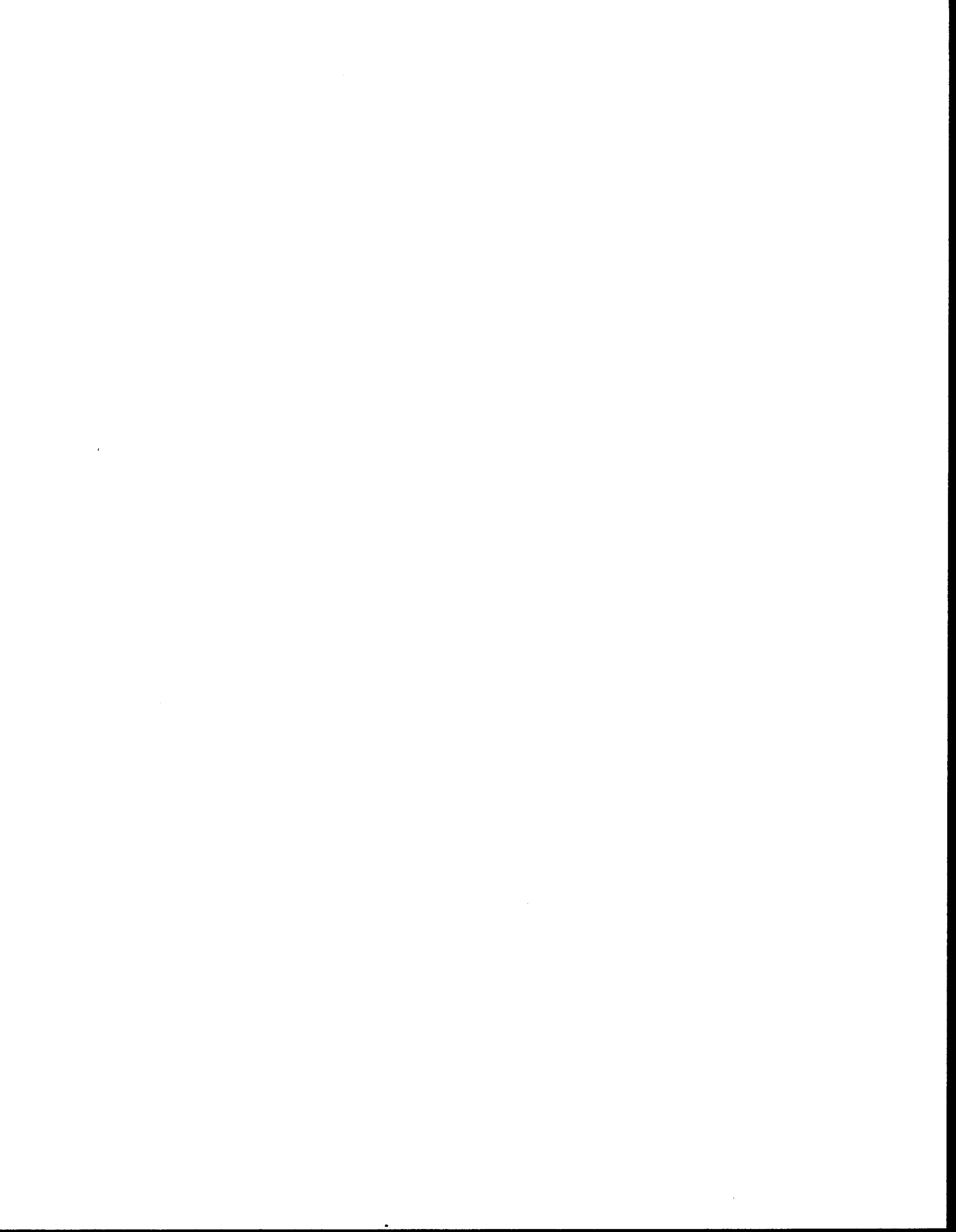
- Field clip board/form holder
- Survey Forms (on waterproof paper)
- Copy of survey methods
- Maps- topographic and road
- Pencils & erasers
- Permanent ink marker
- Calculator
- 150 mm ruler
- Pocket field notebook
  
- Survey Vest
- Compass
- Safety whistle
- Spring clips (2)
- Vinyl flagging
- Pocket knife/multi-purpose tool
  
- Backpack or canvas tote bag
- First aid kit
- Water bottle and/or filtration system
- Food/energy bars
- Rain gear
- Leather gloves
- Safety glasses
- Bug repellent
- Sun screen
- Small flashlight or headlamp
- Matches/fire starter
- Emergency blanket
- Snake bite kit (eastern Washington)

✓ **STANDARD VEHICLE GEAR**

- Waterproof plastic tote box
- Backup fiberglass tape
- Comprehensive first aid kit
- Rain tarp
- Rope (100 ft.)
- Extra water
- Extra food
- Extra dry clothes
- Extra batteries
  
- Spare tire/jack/tire iron
- Tire sealant/inflator
- Tow strap
- Come-along winch
- Fire shovel
- Fire extinguisher
- CB radio (to monitor logging activity)
- Cell phone/VHF radio
- Brush cutter
- Ax/bow saw/chain saw
- Tire chains

✓ For remote work, extra survival & safety gear is recommended.

*This gear list is provided as a guideline for outfitting field crews and is not intended to cover all situations. Local conditions may require additional or different gear.*



# **Appendix E**

## **Data Management Examples**





**EXAMPLE: Excel Data Entry Spreadsheet Fields**

<b>TFW Monitoring</b>															
<b>LWD Survey Header</b>															
wria basin	wria stream	trib	segm	sub segm	begin survey date	end survey date	leader first name	leader last name	leader affiliation	recorder first name	recorder last name	recorder affiliation	begin ref pt	end ref pt	beginning river mile (mi)
>>>>	ending river mile (mi)	discharge date	discharge 1 flow (cms)	disch 1 down ref pt	disch 1 dist above ref pt (m)	discharge 2 date	discharge 2 flow (cms)	disch 2 down ref pt	disch 2 dist above ref pt (m)	discharge 3 date	discharge 3 flow (cms)	disch 3 down ref pt	disch 3 dist above ref pt (m)	survey length (m)	survey coverage
>>>>	survey percentage (%)	field notes													
<b>TFW Monitoring</b>															
<b>LWD Level 1 Survey Data</b>															
wria basin	wria stream	trib	segm	sub segm	beginning survey date	downstr. refpt	zone num	zone rtwads (>20 cm)	zone small logs (10-20 cm)	zone med logs (20-50 cm)	zone large logs (>50 cm)	key rtwads (>20 cm)	key small logs (10-20 cm)	key med logs (20-50 cm)	key large logs (>50 cm)
>>>>	field notes	entry date													
<b>TFW Monitoring</b>															
<b>LWD Level 2 Survey Data</b>															
wria basin	wria stream	trib	segm	sub segm	beginning survey date	piece survey date	piece num	downstr ref pt	piece type (L/R)	piece diam (cm)	zone1 length (m)	zone2 length (m)	zone3 length (m)	zone4 length (m)	wood type (C/D/U)
>>>>	stability code 1 (R/B/P/U)	stability code 2 (R/B/P/U)	stability code 3 (R/B/P/U)	pool form func (Y/N)	orien-tation	decay class	decay subclass	field notes	entry date						
<b>TFW Monitoring</b>															
<b>LWD Jam Survey Data</b>															
wria basin	wria stream	trib	segm	sub segm	begin survey date	jam survey date	jam num	downstr ref pt	rtwads (>20 cm)	small pieces (10-20 cm)	med pieces (20-50 cm)	large pieces (>50 cm)	chan zone	pool form func	key rtwads (>20 cm)
>>>>	key small logs (10-20 cm)	key med logs (20-50 cm)	key large logs (>50 cm)	field notes	entry date										



# TFW Monitoring

## Level 1 Large Woody Debris Survey Report

Stream Name: GOLD CREEK

WRIA: 39.1881 .000

Survey Date: 08/31/1998 to 08/31/1998

Segment: 1 sub: 0

Reference Points: 0 to 7

Svy Length (m)/Coverage: 100 / prt

River Miles: 0.1 to 1.0

Survey Leader: Johnny Grady

Discharge Date Flow (cms)

Affiliation: USFS

1 09/01/1998 0.36  
2  
3

Channel Width: 0.00 meters on 08/31/1998

### Total In-channel Piece Summary (Individual and Debris Jam Pieces)

	Total # of Pieces	Percent of Total Pieces	LWD per Chan Width	LWD per Kilometer	Number of Key Pieces	Percent LWD Key Pieces	Key Pieces per Chan Width	Key Pieces per Kilometer
Rootwads	7	13.2%	0.0	70.0				
Logs 10-20 cm	12	22.6%	0.0	120.0				
Logs 20-50 cm	26	49.1%	0.0	260.0				
Logs >50 cm	8	15.1%	0.0	80.0				
Total	53		0.0	530.0				

### Individual Piece Summary

	Total # of Pieces	Number Zone 1 Pieces	Percent Zone 1 Pieces	Number Zone 2 Pieces	Percent Zone 2 Pieces	Number of Key Pieces	Percent of Key Pieces
Rootwads	7	3	42.9%	3	42.9%		
Logs 10-20 cm	8	5	62.5%	2	25.0%		
Logs 20-50 cm	23	11	47.8%	10	43.5%		
Logs >50 cm	4	0	0.0%	3	75.0%		
Total	42	19	45.2%	18	42.9%		

# TFW Monitoring

## Level 1 Large Woody Debris Survey Report

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### Debris Jam Summary

Number of Debris Jams	Debris Jams per Kilometer	Logs >=10 <20 cm	Logs >=20 <50 cm	Logs >=50 cm	Rootwads	Number Total Pieces	Number Key Pieces	Percent Key Pieces
1	10.00	4	3	4	0	11	0	0.0%

# TFW Monitoring

## Level 2 Large Woody Debris Survey Report

Stream Name: DEEP CREEK

WRIA: 19 .0103 .000

Survey Date: 08/24/1992 to 09/28/1992

Segment: 1 sub: 0

Reference Points: 0 to 41

Svy Length (m)/Coverage: 4100 /

River Miles: 0.1 to 2.6

Survey Leader: RH

Discharge Date      Flow (cms)

Affiliation: Lower Elwha Tribe

- 1
- 2
- 3

Channel Width: 20.95 meters on 08/24/1992

### Total In-channel Piece Summary (Individual and Debris Jam Pieces)

	Number of Pieces	Percent of Total Pcs	LWD per Chan Width	LWD per Kilometer	# of Key Pieces	Prcnt LWD / Key Pieces	Key Pcs per Chan Width	Key Pieces per Kilometer
Rootwads	42	3.0%	0.2	10.2	1	20.0%	0.0	0.2
Logs >=10 <20cm	485	34.1%	2.5	118.3	0	0.0%	0.0	0.0
Logs >=20 <50cm	623	43.8%	3.2	152.0	0	0.0%	0.0	0.0
Logs >= 50cm	274	19.2%	1.4	66.8	4	80.0%	0.0	1.0
<b>Total</b>	<b>1424</b>	<b>100.0%</b>	<b>7.3</b>	<b>347.3</b>	<b>5</b>	<b>0.0</b>	<b>0.0</b>	<b>1.2</b>

	Number of Pieces	Mean Diam (cm)	Mean Len (m)	Total Vol (m3)	Mean Vol (m3)	Total In-Chan Vol (m3)	Mean In-Chan Vol (m3)	In-Chan Vol/CW (m3)	In-Chan Vol/Km
Rootwads	42	62.3	2.0	35.09	0.84	35.09	0.84	0.18	8.56
Logs >= 10 <20 cm	485	15.1	5.9	53.89	0.11	47.62	0.10	0.24	11.62
Logs >= 20 <50 cm	623	32.2	6.4	349.75	0.56	300.98	0.48	1.54	73.41
Logs >= 50 cm	274	70.6	6.3	831.57	3.03	708.40	2.59	3.62	172.78
<b>Total</b>	<b>1424</b>			<b>1270.30</b>	<b>0.89</b>	<b>1092.09</b>	<b>0.77</b>	<b>5.58</b>	<b>266.36</b>

### Debris Jam Summary

Number of Debris Jams	Debris Jams per Kilometer	Logs >=10 <20 cm	Logs >=20 <50 cm	Logs >=50 cm	Rootwads	Number Total Pieces	Number Key Pieces	Percent Key Pieces
45	10.98	369	354	179	18	920	0	0.0%

# TFW Monitoring

## Level 2 Large Woody Debris Survey Report

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### Individual In-channel LWD Piece Summary

#### All Pieces By Piece Type

	Number of Pieces	Pieces per Chan Width	Pieces per Kilometer	Number of Key Pieces	Percent Key Pieces	Key Pieces per Chan Width	Key Pieces per Kilometer
Rootwads	24	0.12	5.9	1	20.0%	0.005	0.2
Logs	480	2.45	117.1	4	80.0%	0.020	1.0
<b>Total</b>	<b>504</b>	<b>2.58</b>	<b>122.9</b>	<b>5</b>	<b>100.0%</b>	<b>0.026</b>	<b>1.2</b>

#### Pieces By Size Category

Piece Category	Number of Pieces	Pieces per Chan Width	Pieces per Kilometer	Number of Key Pieces	Percent Key Pieces	Key Pieces per Chan Width	Key Pieces per Kilometer
Rootwads	24	0.12	5.9	1	20.0%	0.005	0.2
>=10 <20 cm	116	0.59	28.3	0	0.0%	0.000	0.0
>=20 <50 cm	269	1.37	65.6	0	0.0%	0.000	0.0
>=50 cm	95	0.49	23.2	4	80.0%	0.020	1.0

### Individual In-channel LWD Volume Summary

#### All Pieces by Piece Type

	Mean Diam (cm)	Mean Len (m)	Mean Vol (m3)	Total Vol (m3)	Mean In-Chan Vol (m3)	Total In-Chan Vol (m3)	In-Chan Vol/CW (m3)	In-Chan Vol/Km
Rootwads	62.3	2.0	0.84	20.05	0.84	20.05	0.10	4.89
Logs	35.7	6.3	0.94	452.23	0.81	386.96	1.98	94.38
<b>Total</b>				<b>472.28</b>	<b>0.77</b>	<b>407.02</b>	<b>2.08</b>	<b>99.27</b>

#### Pieces By Size Category

Piece Category	Mean Diam (cm)	Mean Len (m)	Mean Vol (m3)	Total Vol (m3)	Mean In-Chan Vol (m3)	Total In-Chan Vol (m3)	In-Chan Vol/CW (m3)	In-Chan Vol/Km
Rootwads	62.3	2.02	0.84	20.05	0.84	20.05	0.10	4.89
>= 10 <20 cm	15.1	5.93	0.11	12.89	0.10	11.39	0.06	2.78
>= 20 <50 cm	32.2	6.39	0.56	151.02	0.48	129.97	0.66	31.70
>= 50 cm	70.6	6.35	3.03	288.32	2.59	245.61	1.26	59.91

# TFW Monitoring

## Level 2 Large Woody Debris Survey Report

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### Individual In-channel Piece Characteristics Summary

	Num of Pieces	Prct of Total	Total Vol (m3)	In-Chan Vol (m3)	% Vol In-Chan	# Pcs / Stab Fact	% with Stab Fact	% total pcs with stability factors			% Form Pools
								% / Root System	% Part Buried	% Pinned	
Conifer	185	36.7%	289.97	245.07	84.5%	100	54.1%	4.3%	36.2%	13.5%	22.7%
Deciduous	192	38.1%	138.08	119.14	86.3%	99	51.6%	13.0%	24.0%	14.6%	8.9%
Unknown	127	25.2%	44.23	42.80	96.8%	62	48.8%	2.4%	33.1%	13.4%	11.8%
Total	504		472.28	407.02	86.2%	261	51.8%	7.1%	30.8%	13.9%	14.7%





# TFW Monitoring

## Data Summary by Reference Point Report

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Stream Name: KENNEDY CREEK	WRIA: 14 .0012 .000
RFP Survey Date: 10/03/1994 to 10/03/1994	Segment: 8 sub: 0
HAB Survey Date: 10/03/1994	
LWD Survey Date: 10/03/1994	Survey Length: 300
River Miles: 4 to 4.2	Survey Coverage:
Survey Leader: MICHELLE STEVIE	Affiliation: SQUAXIN ISLAND TRIBE

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Reference Point	Dist between	Bank		Canopy Closure					
0 - 1	<u>Ref Pts</u>	<u>Width</u>	<u>Depth</u>	<u>Upstr</u>	<u>Rt Bnk</u>	<u>Dnstr</u>	<u>Lft Bnk</u>	<u>% Closure</u>	<u>Multi-Chan</u>
	100 mtrs	7.20	0.250					51	

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### Habitat Unit Summary

Unit Type	Total Number	Percentage of Total	Total Surface Area (sq. meters)	Percentage of Surface Area
Cascades	4	21.10%	31.89	3.90%
Pools	6	31.60%	620.95	75.10%
Riffles	9	47.40%	174.51	21.10%
Tailouts	0	0.00%	0	0.00%

Habitat Units per Kilometer: 190.0

Habitat Units per Bankfull Width: 1.5

### Other Unit Information

Unit Type	Number	Total Length
Obscured Units	0	0
Subsurface Flow U	0	0
Wetland Units	0	0

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### Habitat Unit Location

Unit Category	Number of Units	Total Length
Primary Units	11	109.10
Secondary Units	5	32.10
Side-channel Units	3	11.20

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# TFW Monitoring

## Data Summary by Reference Point Report

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### Total Piece Summary (Individual and Debris Jam Pieces)

	Number of Pieces	Percent of Total Pcs	LWD per Chan Width	LWD per Kilometer	# of Key Pieces	Prct LWD / Key Pieces	Key Pcs per Chan Width	Key Pieces per Kilometer
Rootwads	2	100.0%	0.16	20.0	0	0.00	0	0
Logs >=10 <20cm	12	42.9%	0.98	120.0	0	0.00	0	0
Logs >=20 <50cm	25	47.2%	2.03	250.0	0	0.00	0	0
Logs >= 50cm	13	81.3%	1.06	130.0	1	0.06	0.0813	10
<b>Total</b>	<b>52</b>		<b>4.22</b>	<b>520.0</b>	<b>1</b>	<b>0.06</b>	<b>0.0813</b>	<b>10</b>

	Number of Pieces	Mean Diam (cm)	Mean Len (m)	Total Vol (m3)	Mean Vol (m3)	Total In-Chan Vol (m3)	Mean In-Chan Vol (m3)	In-Chan Vol/CW (m3)	In-Chan Vol/Km
Rootwads	2	0.0	0.0	0.000	0.000	0.000	0.000	0.000	0.0
Logs >= 10 <20 cm	12	14.8	3.6	0.734	0.061	0.424	0.035	0.034	4.2
Logs >= 20 <50 cm	25	30.9	5.4	10.175	0.407	8.925	0.357	0.725	89.2
Logs >= 50 cm	13	64.5	5.9	29.358	2.258	7.489	0.576	0.609	74.9
<b>Total</b>	<b>52</b>			<b>40.267</b>	<b>2.726</b>	<b>16.837</b>	<b>0.968</b>	<b>1.368</b>	<b>168.4</b>

### Debris Jam Summary

Number of Debris Jams	Debris Jams per Kilometer	Logs >=10 <20 cm	Logs >=20 <50 cm	Logs >=50 cm	Rootwads	Number Total Pieces	Number Key Pieces	Percent Key Pieces
2	20	8	17	11	2	38	0	0

