Fish Passage Barrier and Surface Water Diversion Screening Assessment and Prioritization Manual

WASHINGTON DEPARTMENT OF FISH & WILDLIFE
HABITAT PROGRAM
ENVIRONMENTAL RESTORATION DIVISION

Salmonid Screening, Habitat Enhancement, and Restoration (SSHEAR) Section

August 2000

Washington Department of FISH and WILDLIFE

TABLE OF CONTENTS

LIST OF APPENDICES

LIST OF FIGURES

LIST OF TABLES

1. Introduction

Fish Passage Features (Culverts, Dams, and Fishways)

The primary purpose of the manual sections pertaining to fish passage barriers is to provide guidance on how to identify and prioritize culverts, dams, and fishways that impede fish passage. This manual provides guidance on making a barrier assessment of culverts and dams. For fishways, complete the necessary field forms and forward them to WDFW. WDFW staff will then evaluate the fishway and enter it into the database as either a fish passage barrier or a durable and efficient fishway. The barrier assessment process is described in the text but the actual data that must be collected and the format for storage are contained in tables. An overview of the process, using a culvert as an example, is shown in Figure 1. Depending on the goal of an individual inventory, only some of the steps in Figure 1 may be completed. Some inventories are designed to only locate the culverts, others to determine the barrier status of the culverts, and the goal of some inventories is to go all the way through prioritization. For each culvert to be evaluated, the location must be determined by obtaining its global positioning system (GPS) coordinates. A determination must be made as to whether the stream is fish bearing or not; if the stream is non-fish bearing, then limited information is collected on the culvert. On fish bearing streams, detailed physical measurements of the culvert and stream are taken to describe the site and allow for the barrier analysis. The amount of information collected depends upon whether the barrier status can be determined in the Level A analysis. If the culvert is determined to be a barrier or a non-barrier in the Level A analysis, no further culvert data collection is required. If the barrier status is still unknown, then a Level B analysis must be completed. The Level B analysis involves collecting more detailed information required to run a hydraulic model to determine the barrier status of the culvert.

Once a culvert has been identified as a barrier, it is necessary to assess the potential habitat gain that would be achieved if the barrier was corrected. A downstream check is first conducted to determine if the barrier culvert is physically accessible to anadromous salmonids or if a significant quantity of resident salmonid habitat exists immediately downstream. For resident salmonids, a significant habitat reach must be at least 200 meters in length, have a gradient < 20%, and be free of other natural point barriers. If there is no anadromous salmonid access or significant resident salmonid habitat below the culvert, no further evaluation would be conducted. In anadromous waters the habitat gain will always be upstream of the barrier culvert, but in resident waters the habitat gain is the smaller piece of habitat whether it is upstream or downstream of the barrier culvert. For instance, if there are 600 meters of habitat downstream of a barrier culvert and there are 2,200 meters of habitat upstream, the downstream habitat would be quantified and used to prioritize the project for repair.

Three methodologies are described to estimate the potential habitat gain that would be realized if the culvert were repaired. The first is to complete a full physical survey. The second involves using the same methodology as the full survey except that the sampling frequency is reduced. The third method requires sampling a smaller section of the stream and using those data along with additional information to estimate the potential habitat gain. In the full survey, approximately a 20% sampling rate is achieved by sampling 30 meters out of every 160 meters of stream or 60 meters out of every 320 meters of stream, depending upon the stream length. When

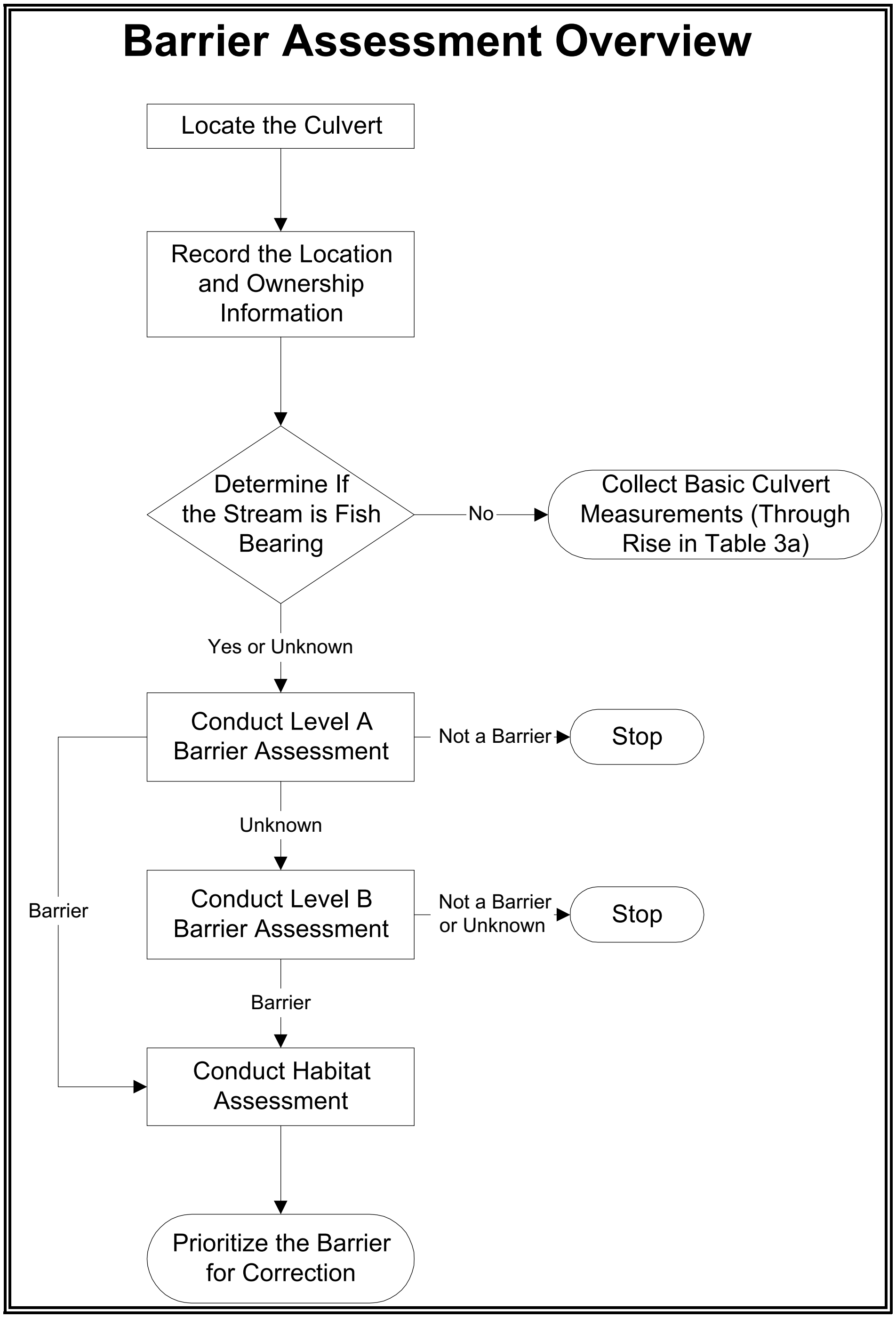

Figure 1. Overview of the barrier assessment protocol.

complete physical habitat surveys are not practical an expanded threshold determination (ETD) is conducted to estimate the amount of habitat upstream or downstream of a barrier. In this methodology, measurements are taken in the first 200 meters and expanded to estimate the total habitat gain.

Once the potential habitat gain has been quantified, then it is possible to prioritize the project.

The Priority Index (PI) takes into account the habitat gain, the mobility and health status of the fish stocks that would benefit from increased access to the habitat, and the projected cost of the project. The PI is a valuable tool to be used with other relevant factors to select projects for correction.

The final section of this manual describes the database (SSHEARBase) that functions as a central repository for information resulting from inventories conducted throughout the state. This information is used to locate, prioritize, select, and implement fish passage and screening projects vital to the recovery of Washington's salmonids. This database is designed to house data collected in accordance with this manual.

Surface Water Diversions

The manual sections pertaining to surface water diversions are intended to provide guidance on procedures for identifying, describing and prioritizing gravity and pump diversions. Information collected using the water diversion inventory protocols can be used to: 1) initiate development of a fish screen conceptual design for a specific diversion, or 2) develop a fish screening "action plan" for all surface diversions in a watershed. The objective in both cases is to achieve compliance with current state and federal fish screening biological protection criteria. The goal of screening water diversions is to provide complete protection (approaching 100 percent of the individuals in a population) from mortality, injury and delay for all life stages (juveniles and adults) and species of concern. All water diversions must be properly screened under state and federal law; the presence of one or more species requiring protection from mortality/injury/delay is assumed without the burden of proof that fish are actually entrained in the diversion.

The inventory process is described in the text, but the actual data that must be collected and the format for storage are contained in tables. Figure 2 gives an overview of the entire process from locating the diversion through prioritizing for correction. Depending on the goal of an individual inventory, only some of the steps in Figure 2 may need to be completed. Regardless of the purpose of the inventory, the location of the point-of-diversion (POD) must be determined by obtaining its global positioning system (GPS) coordinates.

Fish presence information is entered by the inventory group based on data supplied by WDFW, Yakima Screen Shop (YSS) fish screening technical assistance staff or from other resource agency sources (WDFW district fish or habitat biologists, US Forest Service fish biologists, etc.). Fish species presence information is necessary to generate the Screening Priority Index (SPI) numerical value for each diversion, which is a valuable tool to prioritize corrective actions within and between watersheds. The SPI takes into account the size of the diversion (amount of water diverted), the probability of an individual of a given species encountering the screen, and additional "modifiers" for: 1) species mobility (anadromous vs. resident life history), 2) stock status, and 3) estimated screening cost. Design flow is the critical variable used to assess the relative impact (between diversions) on fish mortality/injury and to estimate project cost. Construction and operation/maintenance costs are directly proportional to design flow. The greater the flow, the higher the likelihood that fish will be entrained in the diversion. If available, the Relative Design Flow, the percentage of streamflow diverted by month, provides

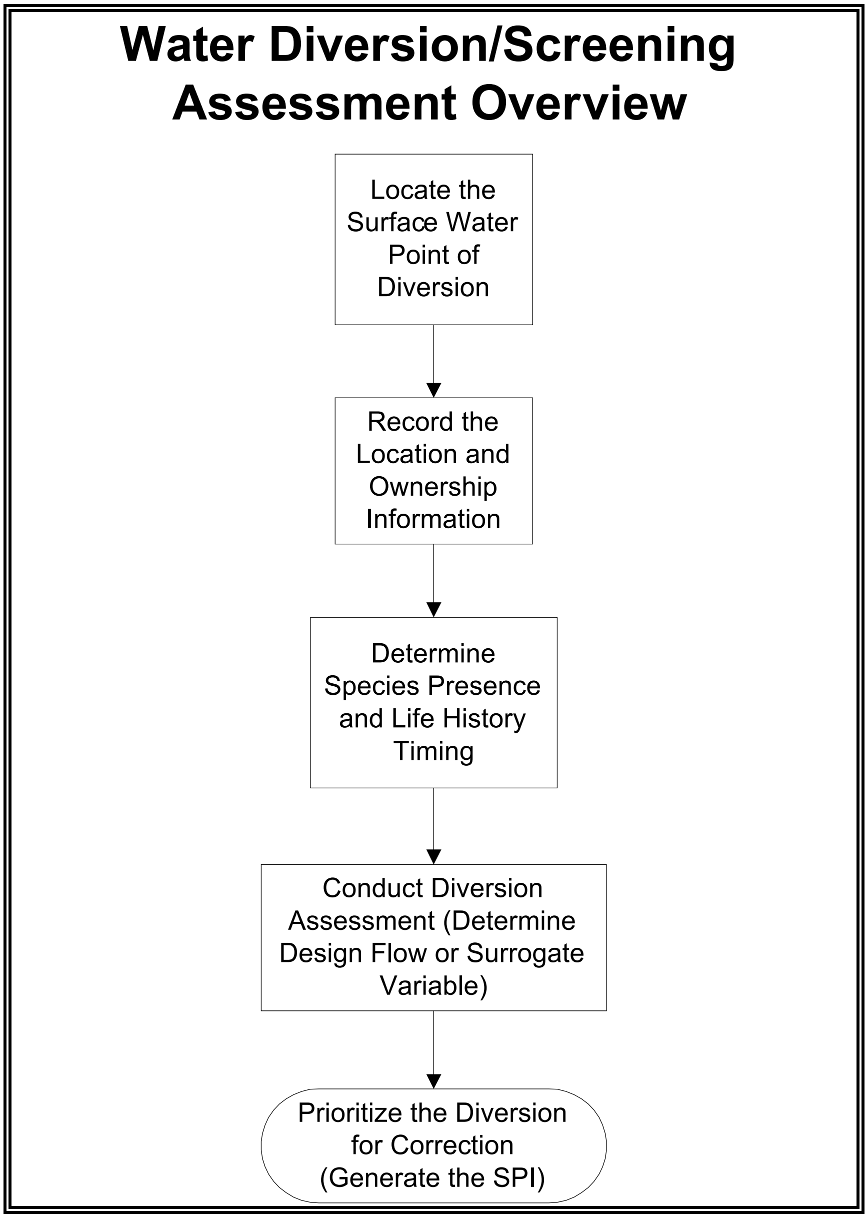

Figure 2. Overview of the water diversion/screening assessment protocol.

greater insight into the relative impacts when comparing diversions. Where design flow or relative design flow cannot be directly measured or determined from water right documentation, a surrogate variable, intake cross sectional area, may be used. Intake area is easily measured by field inventory crews.

2. Fish Passage and Screening Assessments

There are two basic types of inventories available: the stream-based approach and the road-based approach. In the stream-based approach, it is preferred that all human-made features (*e.g.*, culverts, water diversions, dams and fishways) are recorded and evaluated. A stream-based inventory can be watershed-based or jurisdictional. In a watershed-based inventory, the entire fish bearing zone within the watershed would be walked. In a jurisdictional inventory, the section(s) of stream within a given ownership would be walked. In the road-based approach, only the features that are encountered at road crossings (usually culverts) are recorded and evaluated. Road-based inventories can also be watershed-based or jurisdictional. Road-based jurisdictional inventories include inventories on county or state highways where the goal is for a jurisdiction to identify fish passage problems associated with their road system. A road-based watershed approach has been employed by some groups to inventory all culverts in a watershed by driving all the roads encountered. This method results in a fairly complete culvert inventory but invariably some roads, and therefore, some culverts and other features, are missed. The only way to ensure that all human-made features are encountered, is to walk the stream.

Table 1 outlines the 5 options that are available to individuals considering inventories. In the previous version of this manual there were 6 options. For this version, Options 4 and 5 were dropped and Option 6 was divided into Options 6a and 6b. Option 1 is a road-based, jurisdictional inventory that involves assessing culverts only. In this option, only verification of a significant reach above and below barrier culverts is conducted (see Threshold Determination, section 3.3). The barriers are not prioritized. Inventories utilizing Option 1 generate an unranked list of barrier culverts. Option 2 is similar to Option 1, except that all other road crossings of the stream would be assessed regardless of ownership. In Option 3, the culverts are assessed and the potential habitat gain upstream of barriers is derived by an expanded threshold determination (ETD, see section 3.5). This option is available to groups wishing to conduct a road-based culvert inventory with prioritization without walking the entire stream. Since using the ETD to prioritize projects requires that only a small portion of the stream be surveyed, the priority index generated with this methodology will be discounted relative to barriers prioritized using Option 6a or 6b. Anadromous access, the amount of useable habitat, the habitat quality throughout all reaches, and additional barriers (human-made and natural) should be verified via downstream and upstream checks to provide a higher level of data confidence. In Option 6a, a full physical survey is conducted (see section 3.4). This option provides the best estimate of habitat availability and the highest level of certainty that all human-made features and natural barriers have been located. Option 6b is similar to 6a except that the sample frequency is reduced. When the goal of an inventory is to assess *and* prioritize barriers for correction, Option 6a is preferred followed by Option 6b. If the need for expediency overrides accuracy, then Option 3 may be used with caution and acknowledgment of shortcomings through the "confidence factor".

2.1 Location, Identification of Fish Bearing Streams, and Other Basic Site Information

For all features collect the information in Table 2. This information describes the location, ownership, fish utilization, and feature type. For road-based inventories, this is the only

Table 1. Fish passage barrier and water diversion/screening assessment and inventory options.

Options for Fish Passage Barrier Assessment and Prioritization					
Critical Elements	**Full Physical Survey Option 6a**	**Reduced Sample Physical Survey Option 6b**	**ETD Option 3**	**Option 2**	**Option 1**
Stream-based or Road-based inventory	Both	Both	Both[1]	Road	Road
Prioritization of barriers[2] for correction is possible	Yes	Yes	Yes	No	No
Provides for locating and assessing all human-made features (culverts, dams, fishways, and water diversions) located in the stream	Yes	Yes	No	Road culverts only	No
20% sample frequency	Yes	No	No	No	No
One sample per reach	No (One or more)	Yes	No	No	No
Entire habitat walked to verify end point (12' falls, gradient barrier), OHW, HQM's, reach breaks, *etc.*	Yes	Yes	No	No	No
Reach breaks assigned	Yes	Yes	Yes	No	No
Rearing based on 60 DLF/ spawning on OHW	Yes	Yes	Yes	No	No
Species specific (PI calculated for individual species)	Yes	Yes	Yes	No	No
Significant reach assessment	Yes	Yes	Yes	Yes	Yes
Confidence factor[3]	1.0	0.9	0.7		
Options for Water Diversion/Screening Assessment and Prioritization					
Gravity Diversion	Flow Derived from Water Right	Flow Estimated Using a Flow Meter	Flow Estimated Using Diversion Ditch Area and Constant Velocity of 0.75		
Pump Diversion	Flow Derived from Water Right	Flow Recorded from a Meter[4]	Flow Calculated from Irrigation System Components		
Confidence factor[3]	1.0	0.9	0.7		

[1] It is not recommended that the ETD be used when a stream-based inventory is being conducted. Since the entire stream is being walked, options 6a or 6b would provide a better estimate of habitat availability while allowing for additional barriers to be prioritized.
[2] Prioritization of water diversions does not require a habitat assessment. Water diversions are prioritized based upon the size of the diversion, the species impacted by the diversion, and other factors.
[3]The "confidence factor" is a multiplier that is applied to PI's when ranking potential projects for funding
[4]If the irrigation system is metered

information that need be collected for washes (channels that lack any semblance of a riparian zone, *e.g.*, a sage brush lined ravine) in Eastern Washington and for culverts on non-fish bearing streams that have a diameter less than 0.6 meters for single culverts or 0.45 meters for multiple culverts. For all other culverts on non-fish bearing streams, record the information through "Rise" in Table 3a. If a culvert inventory is all that is being conducted, this would be the extent of the information collected on all culverts. If the goal of the inventory is to conduct a barrier assessment of culverts on fish bearing streams, then collect all the information in Tables 2, 3a, and, if necessary, 3b. For stream-based inventories, where the fish bearing status has already been determined, collect the information in Table 2 for all features and Table 3a and if necessary 3b for culverts, Table 4 for fishways, Table 5 for dams, Table 6 for gravity diversions, Table 7 for pump diversions, and Table 8 for other features.

The latitude and longitude of the feature site must be identified in decimal degrees and based upon the World Geodetic Survey 1984 datum (WGS84). It is preferred that this be obtained using a differentially correctable GPS unit. If the latitude and longitude are obtained off of a USGS 7.5 minute (1:24,000) quadrangle map, then the coordinates must be converted from the North American Datum 1927 (NAD27) to the WGS84 datum.

Satisfaction of any one or more of the following criteria qualifies a water as fish bearing. If none of the criteria are met, the water is considered non-fish bearing. Don't hesitate to put the stream in the unknown category until it is investigated further.

Fish Bearing Criteria

- Water courses having average ordinary high-water widths in excess of 0.6 meters (2 feet) in Western Washington and 0.9 meters (3 feet) in Eastern Washington provided the stream gradient is less than 20 percent.
- Water courses identified in WDFW's Priority Habitats and Species (PHS) database as fish bearing.
- Water courses listed as Type 1, 2, 3 or 4 on the Department of Natural Resources Water Type Maps.
- Water courses listed as fish bearing in *"A Catalog of Washington Streams and Salmon Utilization"* (Williams, *et al.* 1975 and Phinney and Bucknell 1975).
- Water courses listed as fish bearing on *StreamNet (http://www.streamnet.org/).*
- Water courses with documented salmonid use determined by visual observation, electrofishing, or verification by local biologists.

2.2 Culverts

2.2.1 Physical Measurements

Due to safety considerations, do not enter the culvert to collect this information. When measuring the water depth inside the culvert, stand at the downstream end of the culvert and measure the depth an arms length inside of the culvert. Always use extreme caution when working in and around the stream due to the instability of stream banks and the slippery nature of the stream bed. Safety considerations always override the data collection protocol outlined in this manual. It is recommended that eye protection be worn by field personnel due to the risk of eye injury from streamside vegetation.

If barrier assessment is a goal of the inventory then the information in Table 3a must be collected for a Level A analysis and the information in Tables 3a *and* 3b must be collected for a Level B analysis (See section 2.2.2 for information on the Level A and B analysis). It is advisable to initially collect only the information in Table 3a and do the Level A analysis while at the site. This will often determine the barrier status without using the parameters needed for a Level B analysis. If the barrier status of the culvert is not determined by the Level A analysis, proceed with the data collection for the Level B analysis (Table 3b). The attributes are described in the tables, and Figure 3 gives examples of some of the culvert descriptors and physical measurements. An example of a culvert evaluation field form can be found in Appendix A.

Culverts with Associated Fishways
If a culvert is encountered that has a fishway associated with it to facilitate fish passage then proceed to section 2.3 and evaluate it as a fishway. Do not collect the information in Tables 3a and 3b. Types of fishways that are commonly associated with culverts are: log controls, rock controls, plank controls, concrete controls, gabion controls, baffles, pool and chute fishways, and pool and weir fishways.

Units
Previous to July 1, 1999 the fish passage database contained culvert information in English units and habitat information in metric units. In an attempt to standardize the database, most of the culvert data has been converted to metric units. The following are the only fields that will remain in English units:

River Mile - Table 2,
Basin Area - Table 2,
Precipitation - Table 2, and
Corrugations - Table 3b.

All other data must be input in metric units as outlined it Tables 2, 3a, and 3b.

Survey Techniques
Establish a benchmark at a location that is stable and easy to relocate. Select a location for the level that has good visibility upstream and downstream of the culvert. If such a location cannot be found then the level will have to be moved to obtain all the desired readings. Set up the level, place the stadia rod on the benchmark, and backsight to the benchmark. Normally the elevation of the benchmark is arbitrarily set at 100.00 meters. If a standard level attached to a tripod is being used, take the reading off the stadia rod, add it to the benchmark elevation to get the instrument height. If a laser level is being used, read the vertical distance to the reflector. If the vertical distance is positive, subtract it from the reflector height and add the difference to the benchmark elevation to get the instrument height. If the vertical distance is negative, add it to the reflector height and add the sum to the benchmark elevation to obtain the instrument height. When taking streambed or culvert elevation readings using a standard level, subtract the reading from the stadia rod from the instrument height to get the elevation. When taking streambed or culvert elevations using the laser level, if the vertical distance is positive, subtract it from the reflector height and subtract the difference from the instrument height. If the vertical distance is negative, subtract it and the reflector height from the instrument height to get the desired elevation. If the reflector is mounted to an adjustable stadia rod, be sure to record the height of the reflector if it is being moved up or down between measurements. Mounting the reflector to an adjustable rod can facilitate taking readings by moving the reflector up or down to avoid obstacles.

In some instances, it will not be possible to get all the elevations necessary without moving the level. If it is necessary to move the level, have the rod holder position the rod in a stable location (turning point) that is visible from the present location of the level and the location the level is to be moved. Get the elevation of the point at which the rod is located. Move the instrument to the

Table 2. WDFW fish passage and screening database (SSHEARBase) attribute descriptions for location, ownership, fish utilization, and feature type. Attribute values indicated in bold text are mandatory choices. Shaded attributes are required of WDFW field crews only.

Attribute	Description
Site ID	Unique identifier for each stream crossing. Format is open, may contain both alpha and numeric characters. For example: XXYYYY format, where XX = inventory code assigned to WSDOT (99), YYYY = crossing number, arbitrarily assigned (*e.g.* 990023). Field is used as a table key and to create links to associated tables and data.
Latitude	Northerly geographic position of feature in decimal degrees using 9 decimal places. Latitude should be expressed as a positive number without the sign (*e.g.* 48.873459247). Do not include N. Used to map the location of the feature.
Longitude	Westerly geographic position of feature in decimal degrees using 9 decimal places. Longitude should be expressed as a negative number (*e.g.* -122.098217359). Do not include W. Used to map the location of the feature.
East	Geographic position of feature in State Plane coordinates (Washington South, NAD27). Used to map the location of the feature.
North	Geographic position of feature in State Plane coordinates (Washington South, NAD27). Used to map the location of the feature.
Project	Specifies WDFW project responsible for the data. Also identifies origin of legacy data. Current projects include **WSDOT, WLARETRO, THURSTON, JEFFCO, UFPP, FPDB** (fishways)**, FPGRANT, NCOAST, NSOUND.**
Reported By	Name of group, agency, or individual reporting the feature data.
Road Name	Name of road, includes WSDOT Highway numbers (*e.g.* I-5, I-405 *etc.*)
Mile Post	Highway mile post (to 0.01 mile) where feature is located, where applicable.
County	Proper name only of county where feature is located (*e.g.*. Thurston, Jefferson).
WDFW Region	WDFW region. Values are **1- 6**.
WSDOT District	WSDOT district. Values are **1 - 6**. Applies to WSDOT owned features only.
WSDOT Schedule	Applies to WSDOT owned features only.
WSDOT Funding	Applies to WSDOT owned features only.
Wildlife Area	WDFW wildlife area name. Applies to Wildlife Area Inventory only.
Wildlife Area Unit	WDFW wildlife area unit name. Applies to Wildlife Area Inventory only.
Quarter Section	Quarter section where feature is located. Enter as **NW, NE, SW**, or **SE.**
Section	Section where feature is located.
Township	Township where feature is located. Enter as **XXN**, where XX is the Township number, include leading zeros.
Range	Range where feature is located. Enter as **XXE** or **XXW**, where XX is the range number and E is east and W is west. Include leading zeros.
Location/ Directions	Location of feature relative to landmarks or driving directions. 250 character limit.
Stream	Name of the stream where the feature is located. If the stream is unnamed, enter unnamed.
WRIA	Water Resource Inventory Area number for STREAM (above), 8 character maximum consisting of 6 digits, 1 decimal point, and 1 upper case letter (00.0000A). The first two digits are the WRIA number (1-62), the remaining 4 digits and alpha character are the stream number. If the stream has no number enter at least the WRIA number.
Tributary To	Name of the water body to which STREAM (above) is connected. If unnamed, enter unnamed. May include WRIA & stream number.

Table 2. (Cont.)

Attribute	Description
River Mile	Distance from mouth of stream to the feature location. Reported in miles to the nearest 0.01.
Basin Area	Required only if conducting a Level B (hydraulic) analysis. Total drainage area above feature. Reported in square miles to the nearest 0.1. Calculate from 7.5 minute USGS quadrangles.
Basin Precipitation	Required only if conducting a Level B (hydraulic) analysis. Average annual or 2-year 24-hour precipitation dependant on region. See Powers and Saunders 1996 (Appendix C)
Fish Use	Indicator of fish use in stream where the feature is located. Determines level of feature evaluation. Values are; **yes, no, unknown**.
Decision Criteria	Basis for FISH USE determination: "**mapped**" indicates that stream is typed as 1 - 4 on DNR water type maps, "**physical**" means the stream meets the minimum physical dimensions specified in the Forest Practice Regulations, "**biological**" means fish have been directly observed, and "**other**" means criteria other than those listed was used (explain in comments). A "yes" FISH USE determination may be based on mapped, physical, biological or other criteria. A "no"determination is made when the stream does not meet any of the above criteria. If unknown leave blank.
Species	The species (from the following list) expected or known to utilize the stream where the feature is located. These species are used in the WDFW priority index model. Multiple entries are allowed, separated by /. Use the two character code for each species. **SO** = sockeye (including kokanee), **CH** = chum, **PK** = pink, **CO** = coho, **CK** = chinook, **SH** = steelhead, **SCT** = searun cutthroat, **RT** = resident cutthroat/rainbow trout complex, **DB** = dolly/bull trout, **EB** = eastern brook trout, **BT** = brown trout
Feature Type	Record the type of human-made fish passage or water diversion feature encountered. Use one of the following values: **culvert, fishway, dam, gravity diversion, pump diversion** or **other**. If a culvert has any formal structure (*e.g.* log, plank, or rock controls, internal baffles, fish ladder) associated with it to aid fish passage it is considered a fishway. Features that are not culverts, dams, fishways or diversions are recorded as other. Complete the appropriate field evaluation form for the feature (Appendix A).
Site Comments	Concise comments (255 character limit) pertinent to the site.
Evaluation Level	Level/type of feature and habitat evaluation conducted and completed at site. Check all that apply. **RL** = report logged (no field assessment); **FR** = field review; **DC** = downstream check; **PS** = physical survey; **TD** = threshold determination; **ETD** = expanded threshold determination. This field is used to track progress of inventory efforts. It is critical to keep it updated.
Owner Type	General category of ownership. Values are: **private, state, federal, tribal, county, city, unknown**.
Name	Name of owner, include organizational subdivision (*e.g.* district, region) separated by hyphen.
Address	Street address of feature owner.
Address2	Mailing address of feature owner if different from street address.
City	Name of city.
State	Two character abbreviation for state (*e.g.* WA).
Zipcode	Standard Zipcode or zip+4.
Phone	Include area code in phone number. Format (123)456-7890.
Contact&Phone	Name and phone number of specific contact if other than the owner. Include area code in phone number.

Table 3a. WDFW fish passage database (SSHEARBase) attribute descriptions for culvert descriptors and core physical measurements required for a Level A analysis. Attribute values indicated in bold text are mandatory choices. Shaded attributes are required of WDFW field crews only.

Attribute	Description
Sequencer	Identifies individual culverts at multiple culvert stream crossings. Format X.Y, where X = specific culvert number and Y = total number of culverts in crossing. For example at a triple culvert crossing the first pipe would be 1.3, the second 2.3 and the third 3.3. Used in conjunction with Site ID to create a unique record ID.
Field Review Crew	Last names of individuals responsible for collecting field data on culverts. Separate names with /.
Field Review Date	Date of the field review. MM/DD/YYYY format.
Shape	Specify the shape of the culvert using one of the following codes: **RND** = round, **BOX** = rectangular, **ARCH** = bottomless arch, **SQSH** = squash (pipe arch), **ELL** = ellipse, **OTH** = other.
Material	Specify the material of which the culvert is constructed using one of the following codes: **PCC** = precast concrete, **CPC** = cast in place concrete, **CST** = corrugated steel, **SST** = smooth steel, **CAL** = corrugated aluminum, **SPS** = structural plate steel, **SPA** = structural plate aluminum, **PVC** = plastic, **TMB** = timber, **MRY** = masonry, **OTH** = other.
Span	The horizontal dimension of the culvert. Expressed in meters to the nearest 0.01. Used in conjunction with Average Streambed Width to calculate Culvert Span to Streambed Width Ratio.
Rise	The vertical dimension of the culvert. Expressed in meters to the nearest 0.01. For round culverts this value will be the same as the span.
Water Depth Inside Culvert	Depth of water inside the culvert, measured at the downstream end away from the influence of outlet conditions. Expressed in meters to the nearest 0.01.
Outfall Drop	Distance from the water surface at the downstream end of the culvert to the water surface of the plunge pool. If the stream is dry, the outfall drop is the difference between the downstream invert elevation and the elevation of the plunge pool control. Expressed in meters to the nearest 0.01.
Length	The length of the culvert measured to the nearest 0.1 meters. Include aprons if present.
Culvert Slope	Slope of the culvert, reported in percent (*e.g.* 4.3). May be a positive or negative number. May be shot directly with laser or derived from invert elevations and culvert length. Slope readings taken with a clinometer are not acceptable.
Streambed Material in Culvert	Specifies the presence of streambed material ***throughout*** the length of the culvert. Values are; yes or no.
Water Velocity Inside Culvert	Field estimate of water velocity through the culvert in meters per second. Use flow meter or 3 chip method. Informational. Optional.
Apron	Indicates presence and location of an apron. Values are: **none, upstream, downstream, both** (both ends).
Tidegate	Indicates presence of a tidegate. Values are: **yes** or **no**.
Fill Depth	Depth of road fill over culvert. Measured to the nearest meter.
Plunge Pool Length	Distance from the outlet of the culvert to the downstream control. Measured in meters to the nearest 0.01.
Plunge Pool Maximum Depth	Maximum depth of plunge pool. Expressed in meters to the nearest 0.01. Informational.
Plunge Pool OHW Width	Width of the plunge pool at its widest point measured at Ordinary High Water. Expressed in meters to the nearest 0.1. Informational.

Table 3a. (Cont.)

Attribute	Description
Average Streambed Width	The average width of the streambed (toe width). Measured at the second riffle downstream of the culvert. Used in conjunction with culvert span to calculate Culvert Span to Streambed Width Ratio.
Culvert Span to Streambed Width Ratio	The ratio of culvert width (span or diameter) to streambed (toe) width. Derived by dividing culvert span by average streambed width. Expressed as a decimal fraction.
Maintenance Required	Indicates if culvert is in need of maintenance, valid entries include: **no** = no maintenance needed, **yes/fp** = maintenance needed to improve fish passage (culvert not a barrier otherwise), **yes/om** = maintenance needed, fish passage not an issue.
Recheck	Need/reason to re-visit the site. Field values are not rigid but please use the following for consistency. Maximum number of characters is 10. Use the comment field if necessary. Once the recheck has been done, the field value needs to be toggled to **no** and comments cleared to avoid future confusion. **no** = no need, **GPS** = gps position, **photo** = photo, **pass HF** = evaluate passability at high flow, **pass LF** = evaluate passability at low flow, **LB** = Level B data required.
Barrier	Results of fish passage evaluation. Values are; **yes** = culvert is a barrier, **no** = culvert is not a barrier, **unknown** = culvert beyond Level B analysis. If the stream is non-fish bearing the field is left blank.
Passability	Percent passability based on field crews professional judgement. Values are 0, 33, 67, 100. This value is used in the PI model to derive B (proportion of fish passage improvement). Make sure values in the Passability and Barrier fields are consistent. If the stream is non-fish bearing the field is left blank. For non WDFW crews the passability is assumed to be 0.33 unless the individuals making the assessment have an advanced level of expertise.
Problem	Factor that determined barrier status. Applies only to barrier culverts. Entries include **outfall drop, slope, velocity,** and **depth.** Enter outfall drop if the measured outfall drop is > 0.24 meters or enter slope if the slope is > 1% (Level A Analysis). The results of the hydraulic analysis (Level B) will indicate either water depth or velocity. Enter all that apply, separate each entry with a /.
Repair Status	Indicates the need for barrier repair. If the culvert is not a barrier enter **OK**. If there is insufficient habitat gain to warrant repair (see Threshold Determination, Section 3.3) the entry would be **NG** (no gain). If sufficient habitat is present enter **RR** (repair required). If the barrier has been fixed enter **FX** (fixed). If the fix involves conversion to a fishway enter **FX/FW.** If a threshold determination has not been made enter **UD** (undetermined). If the stream is non-fish bearing the field is left blank.
Comments	Concise description of culvert problem and explanation of any attribute where OTHER was selected.

Table 3b. WDFW fish passage database (SSHEARBase) attribute descriptions for physical measurements required to conduct a Level B (hydraulic) analysis. Attribute values indicated in bold text are mandatory choices.

Attribute	Description
Reference Point Datum	Specify the datum of the reference point (benchmark). Expressed in meters to the nearest 0.01. May be an established datum or a local assumed datum.
Reference Point Location	Describe the location of the survey reference point (benchmark).
Culvert Elevation - Upstream	Elevation of the culvert bottom (invert) at the upstream end. Expressed in meters to the nearest 0.01
Culvert Streambed Elevation - Upstream	The surface elevation of ***any*** streambed material inside the culvert at the upstream end. Expressed in meters to the nearest 0.01. Used to determine streambed slope through the culvert and actual flow area for the hydraulic model. If streambed material is not present throughout the length of the culvert leave blank.
Corrugation	For corrugated pipes record the dimensions of the corrugations. These are used in the hydraulic model to determine roughness coefficient. Dimensions are depth by width (peak to peak), measured in inches. The following three corrugations will cover 95% of corrugated pipes: **0.5 x 2.66, 1 x 3,** and **2 x 6**. If different specify using the same format. For non-corrugated pipes enter **smooth**. For culverts with concrete or asphalt covering the corrugations on the invert, enter **paved.**
Culvert Elevation - Downstream	Elevation of the culvert bottom (invert) at the downstream end. Expressed in meters to the nearest 0.01
Culvert Streambed Elevation - Downstream	The surface elevation of ***any*** streambed material inside the culvert at the downstream end. Expressed in meters to the nearest 0.01. Used to determine streambed slope through the culvert and actual flow area for the hydraulic model. If streambed material is not present throughout the length of the culvert leave blank.
Downstream Control Cross Section ST0..ST6 EL0..EL6	The downstream control is typically the head of the first riffle below the culvert (5-10 meters downstream). The cross section is derived from at least 7 points across the channel. Data is recorded as station (ST0..6) and elevation (EL0..6). Start at the top of the left bank (ST0 & EL0), looking downstream, and work to the right. Measure elevations at the top of each bank, each toe, the thalweg, and other grade breaks. Value for ST0 will always be 0, values for ST1..6 will be the distance in meters measured to the nearest 0.01 from ST0. Elevations are measured in meters to the nearest 0.01. Used in the hydraulic model. Each station and elevation is a separate field in the database.
DS Control Water Surface Elevation	Elevation of the water surface at the downstream control. Measured in meters to the nearest 0.01. Derived by adding water depth to the bed elevations at the control. Used in conjunction with the downstream culvert elevation and WDIC to determine hydraulic drop.
DS Control OHW Elevation	Elevation of Ordinary High Water at the downstream control. Measured in meters to the nearest 0.01.
Water Surface Elevation 15 meters Downstream of DS Control	Water surface elevation at the channel centerline, 15 meters downstream of the downstream control. Measured in meters to the nearest 0.01. Derived by adding Downstream Bed Elevation and water depth. Used in hydraulic model. Also used in conjunction with upstream water surface elevation to estimate stream gradient through the reach.
Channel Dominant Substrate	Best description of the dominant substrate in the channel between the culvert and the point 15 meters downstream of the downstream control. Select one of the following: **riprap, boulder, cobble, gravel, sand, mud, bedrock** Needed for the hydraulic model.

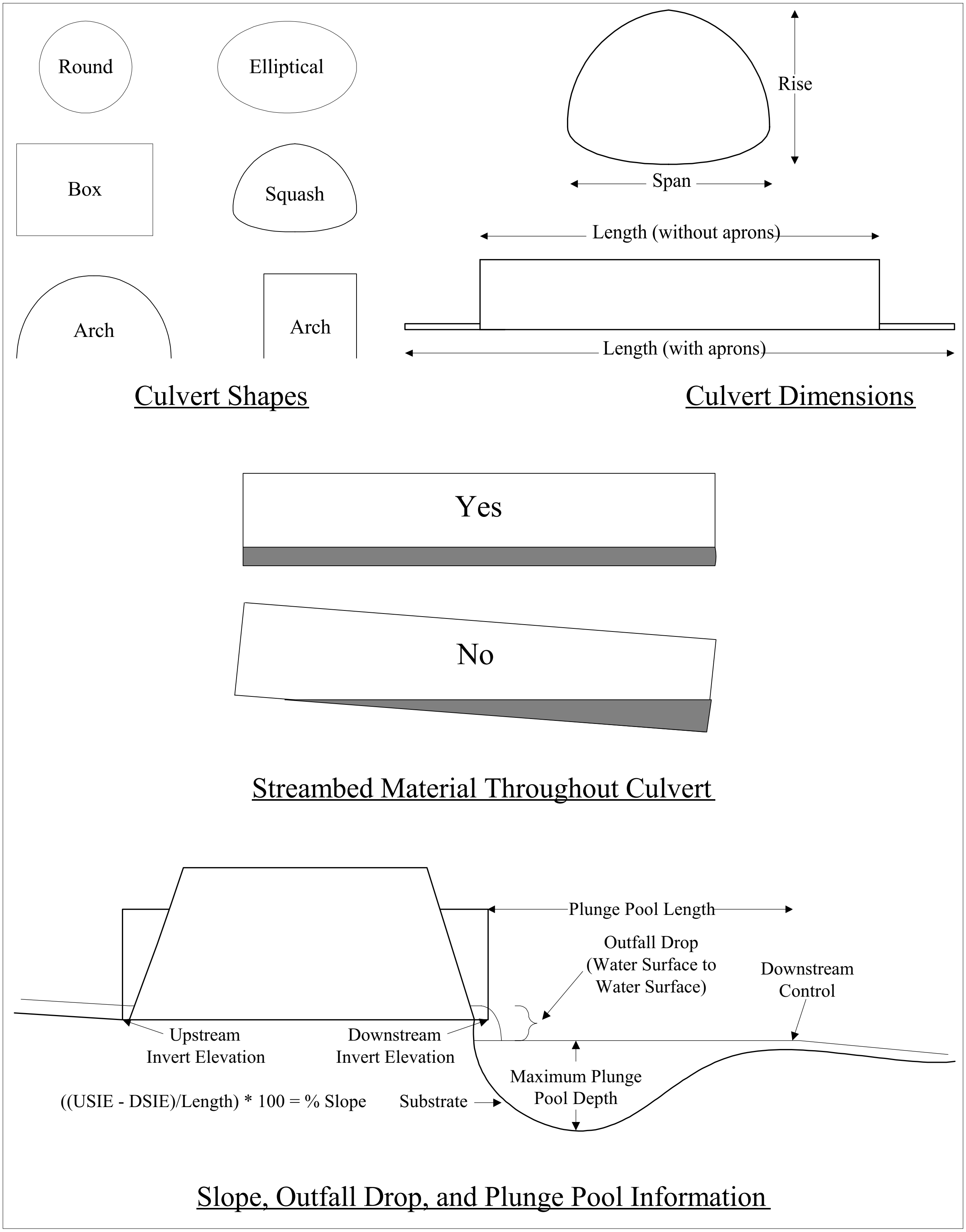

Figure 3. Examples of culvert descriptors and physical measurements.

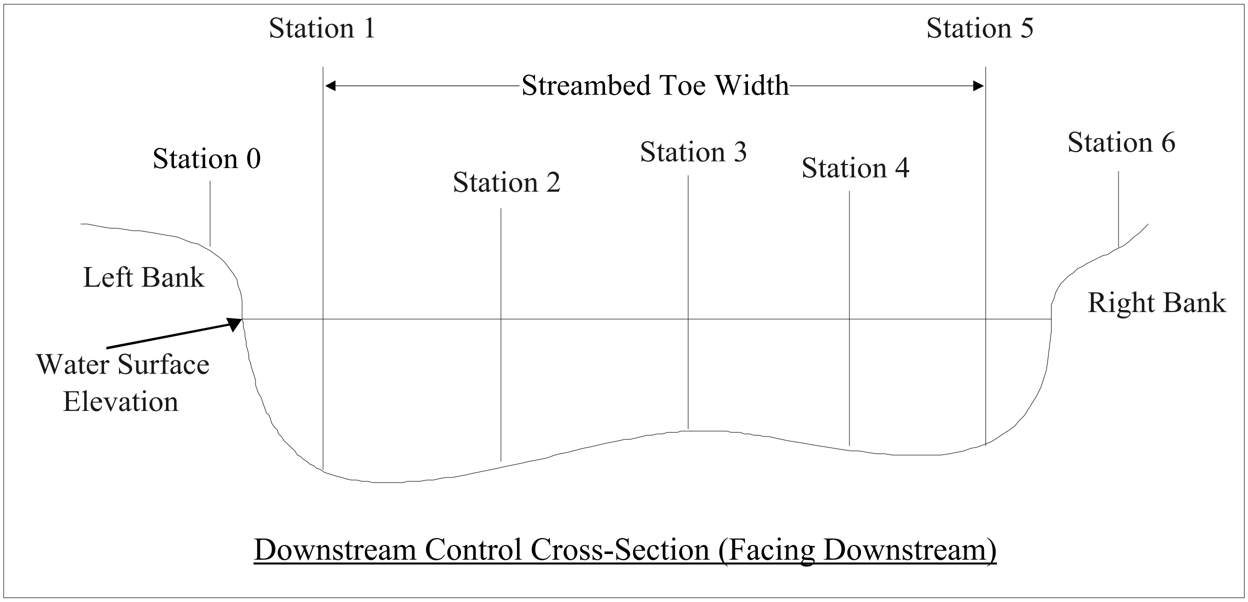

Figure 3. (Cont.)

new location and backsight to the rod to determine the new instrument height. Proceed with taking the necessary elevations. When all elevations have been taken, reverse the procedure that was followed to move the instrument and move it back to a location near its original location. Check the elevation of the benchmark; it should be 100.00 meters. If it's not, then an error was made and the whole process should be repeated since the elevations are erroneous. In some locations, it may be necessary to have more than one turning point. Make sure to check for errors.

Multiple Culverts

When multiple culverts are encountered at a single site, complete one site form (Table 2) and complete culvert forms (Tables 3a and 3b) for each non-overflow culvert using the sequencer to distinguish between culverts. If the culverts are set at approximately the same elevation and slope, then add their widths together to calculate the culvert span to streambed width ratio. If one or more culverts are set significantly higher[1] than the other culvert(s), then only use the lower culvert(s) in the barrier assessment. The higher elevation culvert is considered an overflow culvert and should only be noted in the comments.

2.2.2 Barrier Analysis

Barrier culvert determination is a step-wise process of data collection and analysis. The process is outlined below.

1. Locate culvert and record positional information (section 2.1, Table 2).

[1]"Significantly higher" is defined as when the upstream invert elevation is greater than the upstream invert elevation of the lower culvert plus 50% of the lower culverts rise.

2. Determine and record whether or not the stream is fish bearing (section 2.1).
   a. If no, collect the information through "rise" in Table 3a.
   b. If yes or unknown, continue with evaluation, go to 3.

3. Collect and record descriptive information and core physical measurements (section 2.2.1, Table 3a), go to 4.

4. Barrier Analysis - Level A (Figure 4)
   a. Is there natural streambed material throughout the culvert?
      i. If yes, is the culvert width (span) at least 75% of the average streambed toe width at the second riffle downstream of the culvert?
         (1) If yes, the culvert is *not a barrier*, additional measurements not required.
         (2) If no, Level B analysis is required, go to 5.
      ii. If no; is there an outfall drop > 0.24 meters?
         (1) If yes, the culvert is a *barrier*, additional measurements not required.
         (2) If no, is the culvert slope greater than or equal to 1%?
            (a) If yes, the culvert is a *barrier*, additional measurements not required.
            (b) If no, Level B analysis is required, go to 5.

5. Is there a grade break in the culvert?[2]
   a. If yes, then a Level B analysis is not possible and the barrier status is unknown.[3]
   b. If no, go to 6.

6. Is the culvert tidally influenced[4] or is there a large pond or wetland downstream of the culvert making it difficult or impossible to obtain the downstream control cross-section information?
   a. If yes, then a Level B analysis is not possible and the barrier status is unknown.
   b. If no, go to 7.

7. Barrier Analysis - Level B (hydraulic) (Figure 5.)

---

[2]This is sometimes the case where a culvert has been extended and the new section is installed at a different elevation or slope than the old culvert. This can also occur when a section of the culvert settles or a joint fails.

[3]In cases where the slope of any portion of the culvert exceeds 1% or the drop inside the culvert exceeds 0.24 meters, then it can be categorized as a barrier. If the slope does not exceed 1% and the drop does not exceed 0.24 meters, or if these parameters cannot be measured, then the barrier status of the culvert is unknown and a higher level of analysis is required.

[4]For tidally influenced culverts, an independent analysis of tidal influence and streamflow is needed. For the tidal data, the hydraulic criteria must be met at least six daylight hours on 90% of the days during the migration season for a culvert to be considered passable.

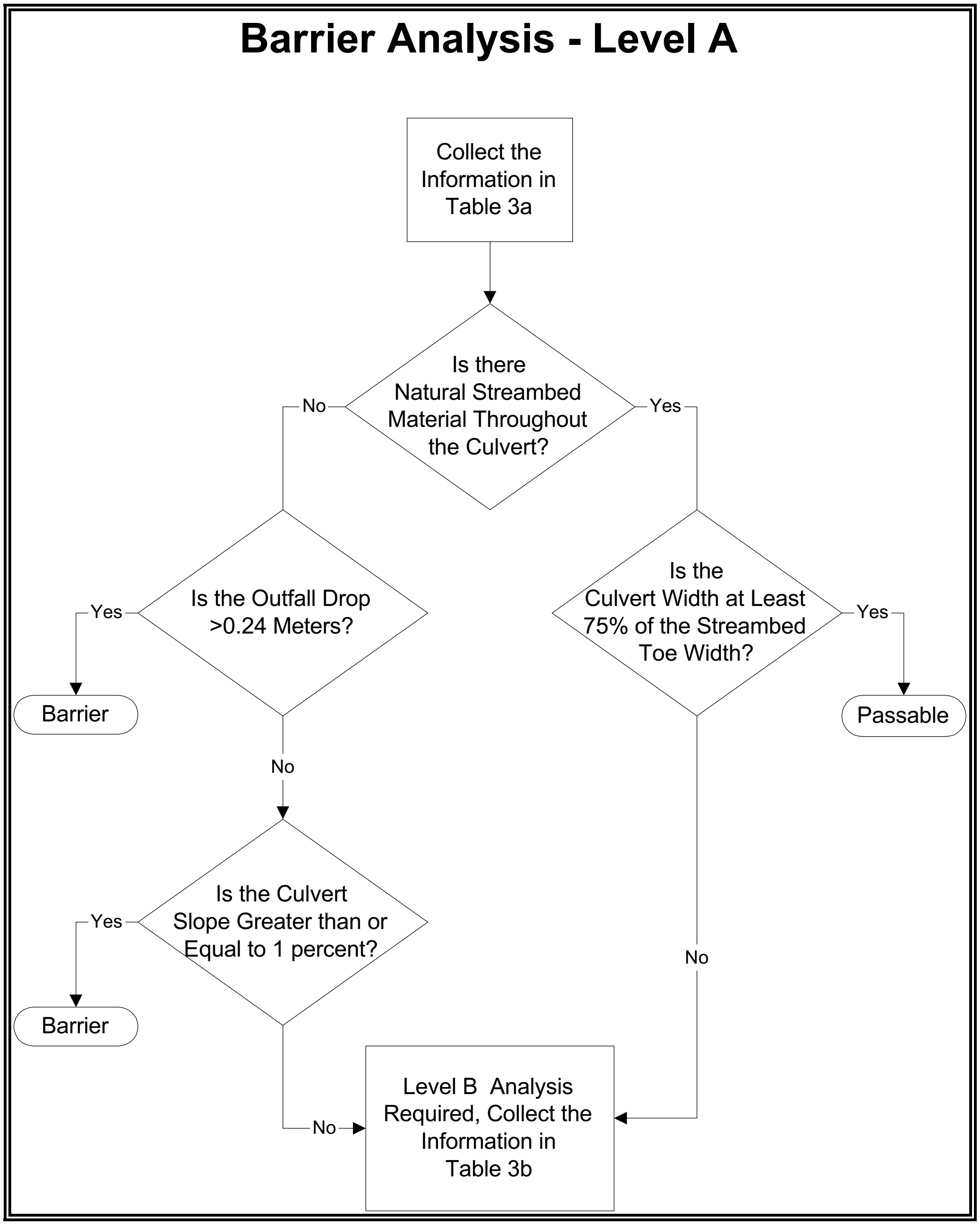

Figure 4. Flow chart of the Level A culvert analysis.

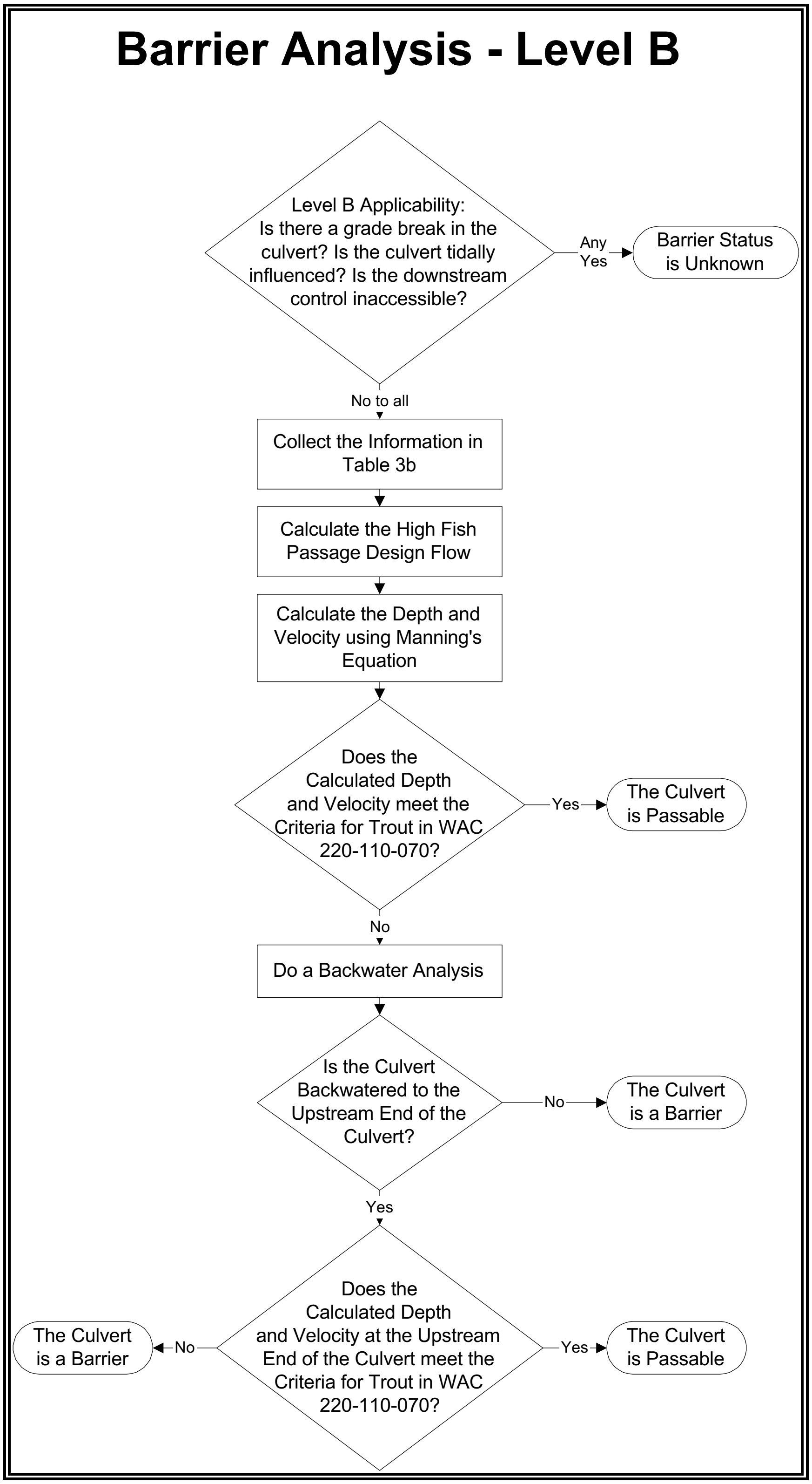

Figure 5. Flow chart of the Level B culvert analysis.

The purpose of the Level B hydraulic analysis is to calculate the maximum velocity and corresponding depth in the culvert at the high fish passage design flow and compare the values to Table 1 in WAC 220-110-070 section 3(b)(ii) for Adult Trout (Appendix B). The values shown for velocity in Table 1 is the maximum Q/A velocity in the culvert. If the culvert is not backwatered, the calculation can be done using Manning's equation for normal depth. Using normal depth assures the maximum velocity will be calculated. If the culvert is backwatered, then a backwater analysis must be done to find the maximum velocity. There are five basic steps to follow for a Level B analysis:

Step 1) Collect field data for a Level B Analysis (Table 3b).

Step 2) Calculate the high fish passage design flow.

Step 3) Calculate the flow characteristics of the stream channel at the high fish passage design flow.

Step 4) Evaluate flow in the culvert, without backwater.
Using Manning's equation calculate flow velocity and depth, and compare to the allowable velocity and depth from Table 1 in the WAC (Appendix B).

Note: If the calculated velocity is less than the allowable velocity from Table 1, and the depth greater than or equal to the required depth from Table 1, then the culvert is considered passable. If the calculated velocity is greater than the allowable velocity or the depth is less than required, then the culvert needs to be checked for backwater.

Step 5) Evaluate flow in the culvert, with backwater (if applicable).
If the culvert is backwatered (i.e. the depth at the outlet is greater than the depth calculated from Step 4 -Manning's Equation), then proceed with the backwater calculation. Perform the backwater analysis computation starting at the culvert outlet and proceeding upstream in increments until normal depth or the culvert inlet is reached. If the normal depth is reached before the backwater analysis reaches the culvert inlet (fully backwatered), then the maximum velocity and corresponding depth would be the same as calculated from Step 4 (Manning's Equation). If the culvert is fully backwatered, then select the velocity and depth at the station nearest the upstream end of the culvert.

The velocity and depth values in Steps 2 through 5 can be calculated by hand or using commercially available software. WDFW has prepared a spreadsheet for making these calculations. This spreadsheet can be accessed at: www.wa.gov/wdfw. The following files are available for use:

LvlBEng.wb2	Quattro Pro 6 for Windows, English Version
LvlBMet.wb2	Quattro Pro 6 for Windows, Metric Version

LvlBEng.xls	Excel 97, English Version
LvlBMet.xls	Excel 97, Metric Version

ExampleOneLvlBEng.wb2	Example 1, Quattro Pro 6.0 - Windows, English Version
ExampleTwoLvlBEng.wb2	Example 2, Quattro Pro 6.0 - Windows, English Version

The spreadsheet has step by step directions, beginning on the Instruction page. The spreadsheet may provide inaccurate results if the instructions are not followed.

The spreadsheet cannot complete the calculations for zero or negative sloped culverts, culverts with a grade break, or culverts with streambed material throughout. For culverts with zero or negative slopes, set the downstream invert elevation 0.01 lower than the upstream invert elevation and the calculations will work. The spreadsheet is capable of calculations for round, box and pipearch culvert shapes. Backwater is analyzed with the Direct Step method (distance calculated from depth) from Chow (1959). The calculation starts at a control point (culvert outlet) and proceeds upstream until the normal depth calculated by Manning's equation is reached. A detailed description of how to use the spreadsheets is in Appendix D.

2.3 Fishways

A fishway is any human-made structure that facilitates the passage of fish through or over a barrier. The barrier can be human-made such as a culvert, low head dam, or concrete flume. The barrier can also be natural in origin such as a falls or cascade. If an instream structure, such as a log control, plank control, rock control, or gabion control, is encountered do not report it as a fishway unless its function is to pass fish above or through a barrier. Throughout the state, many streams have undergone habitat enhancement work including the placement of streambed controls in order to develop spawning areas and/or plunge pools for rearing habitat. If you come across such structures, evaluate them as dams (section 2.4).

Culverts and dams with associated fishways are considered fishways. Collect the site information in Table 2 and fishway information in Table 4, but do not collect the information in Tables 3a or 3b for culverts or Table 5 for dams.

Many attempts have been made by barrier owners and others to construct fishways to improve fish passage. Some of these efforts have been successful but many have been failures. In order for a fish passage facility to be legally recognized as a fishway, it must be both durable and efficient. In other words, it must be able to withstand extreme flow events along with the associated bedload and woody debris that accompany these events and be able to efficiently pass fish over a wide range of flows. The evaluation of a fishway to determine if it is durable and efficient requires an advanced level of expertise. For this reason, collect the information in Tables 2 and 4 and forward it to WDFW for evaluation.

Table 4. WDFW fish passage database (SSHEARBase) attribute descriptions for fishway descriptors. Attribute values indicated in bold text are mandatory choices. Shaded attributes are required of WDFW field crews only.

Attribute	Description
Field Crew	Last name(s) of the field review team responsible for data, individuals separated by / (e.g. Gower/Cox).
Field Review Date	The date the fishway was first reviewed. **MM/DD/YYYY**
Barrier	Results of fish passage evaluation. Values are; **yes** = fishway is a barrier, **no** = fishway is not a barrier, **unknown** = fishway passability unknown, **NLE** = fishway no longer exists.
Passability	Percent passability based on field crews professional judgement. Values are: **0, 33, 67, 100**. This value is used in the PI model to derive B (proportion of fish passage improvement).
Inspection Frequency	Schedule of fishway inspections, select from list: **A** = annual, **B** = biennial, **C** = triennial, **D** = scheduled inspections not required, **E** = no inspections (fishway requires reconstruction), **F** = ad hoc inspections.
Fishway Type	Select from list: **BC** = baffled culvert, **BF** = baffled flume, **CC** = concrete control, **SP** = steep pass, **GC** = gabion control, **LC** = log control, **RC** = rock control, **SCC** = sacrete control, **TH** = trap and haul, **WP** = weir pool, **VS** = vertical slot, **PC** = pool chute, **BL** = blasted falls, **PLC** = plank control, **RCC** = roughened channel culvert.
Modifies	Structure fishway modified for fish passage: **culvert, dam, falls** (natural)**, habitat** (offchannel/over-wintering).
Construction Year	Year fishway was built. **YYYY**
Number of Pools	The number of pools or steps within the fishway structure.
Entrance Pool Depth	The depth measured outside of the fishway structure at the downstream end. Meters (0.01)
Pool Head Difference	The hydraulic drop measured at each weir or baffle from water surface to water surface. Meters (0.01)
Number of Baffles	The number of baffles within a baffled culvert or flume, not to be confused with weirs.
Baffle Type	Material of which the baffles are composed, select from list: **concrete, metal, plastic, wood, rock, other.**
Number of Weirs	The number of weirs utilized within a formal fishway, not be confused with baffles.
Weir Type	Material of which the weirs are composed, select from list: **concrete, metal, plastic, wood, other.**
Grade Control Location	Presence and location of streambed grade controls, select from list: **none, upstream, downstream, both.**
Description	Brief description of the fishway, 255 character limit.
Habitat Gain	Potential habitat gain expressed in lineal meters. Equals length of physical survey upstream of fishway.
Comments	Additional description or comments, 255 character limit.

2.4 Dams

A dam is any human-made structure that results in an abrupt change in water surface elevation. For example, a concrete water diversion structure resulting in a 1 meter drop in water is a dam. Another example of a dam is where one of a series of log controls fails, resulting in a 0.5 meter waterfall over the next upstream control.

When a dam is encountered, collect the information in Tables 2 and 5 and make a barrier determination based upon the difference in the water surface elevations above and below the dam. If the stream is used by chum salmon and the water surface difference at the dam is greater that 0.24 meters, then it is a barrier. If the stream is not utilized by chum salmon and the water surface difference is greater than 0.3 meters, then it is a barrier. In some cases a dam will be equipped with a standpipe and there will be no flow over the crest of the dam; these are always barriers.

If a dam is encountered with an associated fishway to facilitate fish passage then evaluate it as a fishway as outlined is section 2.3. Do not collect the information in Table 5.

2.5 Surface Water Diversion/Screen Evaluation

2.5.1 Physical Measurements

Table 6 describes the information and physical measurements needed to characterize gravity diversions (ditches and canals) and associated fish screens. Table 7 describes the parameters used to characterize surface pump diversions. As with all other features, collect the site information in Table 2 for all gravity and pump diversions. The screening requirements for water diversions can be found in Appendix B.

Units

Data in the water diversion portion of the inventory must be input in English units since screen dimensions, pump volume, and water rights are all in English units.

2.5.2 Gravity Diversions

Most of the parameters in the inventory protocol found in Table 6 are self-explanatory, but "Flow", "Flow Derivation", "Diversion Ditch Area" and "ScFunction" (Screen Function) warrant additional clarification.

Flow; Flow Derivation

Determining maximum, legal diverted flow is a critical piece of information used by WDFW to prioritize the diversion for screening, determine the size and type of fish screen needed, and estimate construction cost. The preferred method to obtain the design flow is from the diversion owner's water right documentation if the owner is willing to provide the information to the inventory crew. This is particularly true if the diversion was authorized after 1917 or if pre-1917 water right claims have been adjudicated by a Superior Court. If this is the case, the owner should possess a Certificate of Water Right issued by the State of Washington which defines the legal, maximum instantaneous flow in cfs. Unadjudicated claims may be of use in determining design flow, but are not sufficient alone in the absence of "actual use" measurements.

Table 5. WDFW fish passage database (SSHEARBase) attribute descriptions for dam descriptors. Attribute values indicated in bold text are mandatory choices. Shaded attributes are required of WDFW field crews only.

Attribute	Description
Field Review Crew	Last name(s) of the field review team responsible for data, individuals separated by / (e.g. Gower/Cox).
Field Review Date	Field review date. **MM/DD/YYYY**
Dam Name	Recorded legal name, or local name.
Reservoir Name	Recorded legal name, or local name.
Type	Type of dam, select from list: **CN** = concrete, **RE** = earthfill, **MS** = masonry, **MT** = metal, **ER**= rockfill, **TB** = timber, and **OT** = other.
Span	Does the structure span completely or only partially across the stream, select from list: **full, partial**.
Length	Length of the dam in meters (0.1).
Height	The height from the front base of the dam, to the crest in meters (0.01).
Water Surface Difference	If water is flowing over the crest of the dam, give the difference between the water surface elevations above and below the dam in meters (0.01). If the dam is equipped with a standpipe, leave blank.
Plunge Pool Depth	Depth of plunge pool below the dam in meters (0.01).
Description	Description of the dam and any problems associated with it. 255 character limit.
Primary Purpose	Primary purpose of dam, select from list: **D** = debris control, **C** = flood control, **H** = hydroelectric, **I** = irrigation, **N** = navigation, **P** = stock or farm pond, **Q** = water quality, **R** = recreation, **S** = water supply, **T** = tailings, **O** = other.
Recheck	Need/reason to re-visit the site. Field values are not rigid but please use the following for consistency. Maximum number of characters is 10. Use the comment field if necessary. Once the recheck has been done, the field value needs to be toggled to **no** and comments cleared to avoid future confusion. **no** = no need, **GPS** = gps position, **photo** = photo, **pass HF** = evaluate passability at high flow, **pass LF** = evaluate passability at low flow.
Barrier	Results of fish passage evaluation. Values are: **yes** = dam is a barrier; **no** = dam is not a barrier; **unknown** = dam is of unknown barrier status. If the stream is non-fish bearing the field is left blank.
Passability	Percent passability based on field crews professional judgement. Values are: **0, 33, 67, 100**. This value is used in the PI model to derive B (proportion of fish passage improvement). Make sure values in the Passability and Barrier fields are consistent. If the stream is non-fish bearing the field is left blank.
Repair Status	Indicates the need for barrier repair. If the dam is not a barrier enter **OK**. If there is insufficient habitat gain to warrant repair (see significant reach determination) the entry would be **NG** (no gain). If a threshold determination has not been made enter **UD** (undetermined). If sufficient habitat is present enter **RR** (repair required). If the barrier has been fixed after its initial discovery enter **FX** (fixed). If the fix involves conversion to a fishway enter **FX/FW.** If the stream is non-fish bearing the field is left blank.
Comments	Additional comment space. 255 character limit.

Table 6. WDFW fish passage database (SSHEARBase) attribute descriptions for gravity diversion descriptors. Attribute values indicated in bold text are mandatory choices. Shaded attributes are required of WDFW field crews only.

Attribute	Description
Field Review Crew	Last name(s) of the field review team responsible for data, individuals separated by / (e.g. Gower/Cox).
Field Review Date	Field review date. **MM/DD/YYYY**
Access	Type of transportation capable of accessing site: **vehicle, ORV, foot, other**.
Point Of Diversion	Point of diversion (POD): **LB** = left bank, **RB** = right bank, referenced looking downstream.
Diversion Dam	Presence of instream diversion structure: **yes** or **no**.
Headgate	Presence of headgate: **yes** or **no**.
Diversion Ditch Area	Bank full, cross-sectional area of the diversion ditch, canal, flume, or pipe in square feet (0.1).
Flow	Flow of diversion in gallons per minute (gpm).
Derivation	How flow was determined: **measured** = gauge/flow meter, **water right** = legal documentation, **derived** = calculated from irrigation system components.
Screened	Reports the presence of some type of screening device whether or not it meets WDFW screening criteria: **yes** or **no**.
Screen Function	Descriptor of screen function and/or maintenance requirements: **OK** = functioning properly, **MN** = maintenance needed.
Problems/Comments	Description of problems associated with screen, bypass, etc.
Water Right	Water right number associated with diversion.

The next best way to determine the flow is by direct measurement. If the survey can be scheduled to coincide with peak spring/summer diversions, then a valid flow measurement can be obtained utilizing a flow meter. Standard hydrological procedures for measuring open channel flow in the ditch or canal should be followed to yield flow in cubic feet/second (cfs) rounded to the nearest 0.1 cfs. The database requires that flow in cfs units be converted and entered into the tables in gallons/minute (gpm), where 1.0 cfs = 449 gpm.

The last, and least reliable way to estimate the flow is by using diversion ditch area (see below) multiplied by a velocity of 0.75 ft/s to obtain a flow in cfs. Multiply the flow in cfs by 449 to obtain a flow in gpm. The constant of 0.75 ft/s is a mean, calculated from measured velocities in a number of diversion ditches by WDFW crews. Since water velocity varies from diversion ditch to diversion ditch, the flow generated by this method is not as accurate as using the two methods above. Because of the lower confidence in PI's calculated using this approach, a multiplier of 0.7 will be applied them.

Diversion Ditch Area
If accurate design flow measurement is not feasible (wrong time of year, no diversion occurring, no velocity meter, etc.), then a surrogate parameter must be measured that is an approximate indicator of the diversion size (flow). The **bank full, cross-sectional area of the ditch**, measured a short distance (100-300 feet) downstream of the POD, has been selected as the flow surrogate. The inventory crew should select a location where the normal waterline is readily apparent on the bank. Measure the width of the ditch in feet at the waterline elevation to the nearest 0.1 foot using a cloth tape, tape measure or survey stadia rod. Then use another tape measure to measure the vertical distance (depth) from the horizontal "waterline" to the ditch bottom. Width x depth = cross-sectional bank full area. If the ditch cross-section is not rectangular, calculate area as accurately as possible by using the area formula for a trapezoid (Area = ½ (width $_{waterline}$ + width $_{bottom}$) x depth). Area should be entered in square feet, rounded to the nearest 0.1 ft^2.

Screen Function (ScFuntion)/Problems
If the diversion is equipped with a fish screen, indicate if the screen appears to be functioning properly from a *fish protection perspective*. A screen may be functioning to adequately pass water down the ditch or canal, but not provide fish protection from "entrainment" (passage of fish through, around or under the screen) or "impingement" (involuntary contact and immobilization of fish on the screen surface). Obvious defects to look for are:

1. Holes or dents in the screen surface or frame from impact damage (floating debris) or normal deterioration from weather, oxidation, etc. that would allow small fish to pass through the screen or be injured by contact with the screen surface. Also, screen mesh openings that are obviously "over-sized" (greater than 3/32 inch) as measured with a tape measure, ruler, or rod (probe) at the widest point (diagonal is square mesh cloth).

2. Gaps and spaces between the screen structural frame and the ditch bottom or screen civil works structure (wood, metal or concrete section in the ditch that the screen fits in to). Spaces greater than 3/32 inches between the sides or bottom of the screen frame and structure allow small fish to swim around or under the screen and continue down the diversion. Side and bottom rubber seals are intact and in continuous contact with the drum screen.

3. Is the drum screen submergence within 65% (minimum) to 85% (maximum)?

4. For screen lengths greater than 4 feet, the screen to flow angle must be less than or equal to 45 degrees.

5. If equipped with a fish bypass, is the bypass entrance or return pipe blocked with debris? Is there sufficient flow to allow fish to find, enter the bypass and return to the river?

2.5.3 Pump Diversions
Many of the parameters in the inventory protocol found in Table 7 are self-explanatory, but "Bypass", "Screen Type", "Screen Mat", "ScCondition"(Screen Condition), "Capacity", and "Derivation" warrant additional clarification.

Bypass
This attribute applies only where the pump diversion is withdrawing water from a "lagoon" that is connected to the river, creek or other water body by a narrow intake channel or a pipe. If the lagoon is configured with: 1) both an *intake* channel (or pipe) and an *outlet* channel (or pipe), and 2) sufficient outflow away from the pump intake through the outlet to carry fish back to the parent waterbody, then indicate "Yes" in the "Bypass" attribute field. If the lagoon is a "dead-end" with only an intake channel or pipe which requires fish to swim back upstream to get back to the parent waterbody, mark the field "No".

Screen Type
See Figure 6 for illustrations of the various types of pump intake screens. Select the screen type that most closely matches the actual shape and style of the screen in the field.

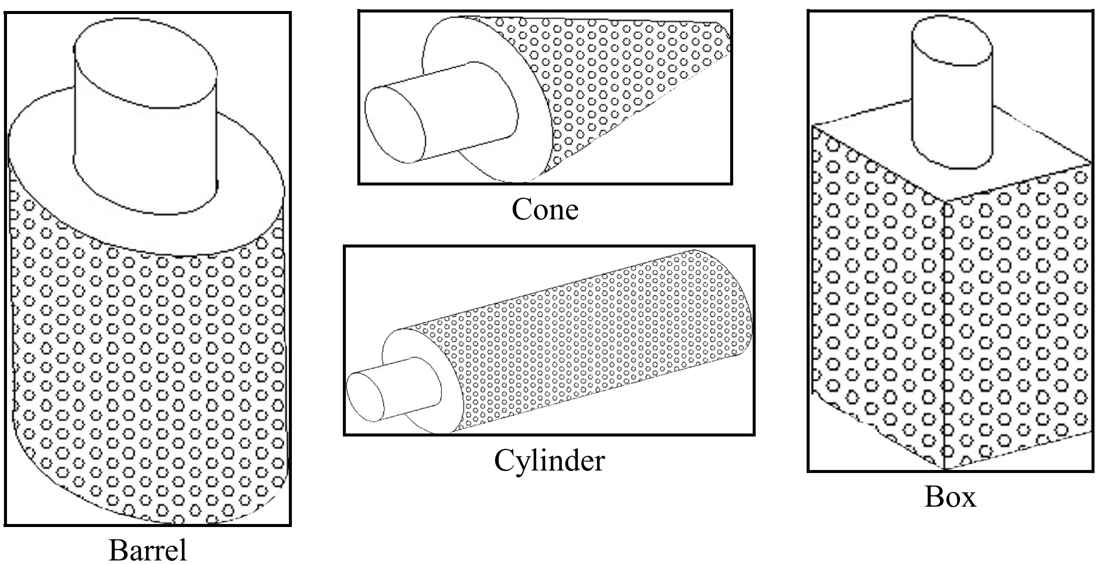

Figure 6. Common types of pump screens.

Screen Mat(erial)
Designate: "wm" for woven, metal wire mesh; "pp" for perforated plate (stainless steel, aluminum or brass strainer with round or slotted holes); "pb" for stainless steel profile bar - also called "wedge wire" or "well screen". Designate other("ot") for diversions screened with perforated (slots or holes) polyvinyl chloride (PVC) pipe and make a note indicating this type of material.

Sc (Screen) Condition
See discussion of screen function defects for gravity diversions above. Check for over-sized screen openings, gaps and spaces greater than 3/32 inch, damage to the screen surface from impact or corrosion, and structural damage to the screen frame from impact or collapse caused by failure to remove floating debris.

Table 7. WDFW fish passage database (SSHEARBase) attribute descriptions for pump diversion descriptors. Attribute values indicated in bold text are mandatory choices. Shaded attributes are required of WDFW field crews only.

Attribute	Description
Field Review Crew	Last name(s) of the field review team responsible for data, individuals separated by / (e.g. Gower/Cox).
Field Review Date	Field review date. **MM/DD/YYYY**
Access	Type of transportation capable of accessing site: **vehicle, ORV, foot, other.**
Point Of Diversion	Point of diversion (POD): **LB** = left bank, **RB** = right bank, referenced looking downstream.
Intake Location	Location of pump intake: **RB** = river bank, **OS** = off shore, **LN** = lagoon, **CV** = cove. A lagoon is separated from river by pipe or channel. A cove is open to the river.
Fish Bypass	Presence of fish bypass. Select **yes** or **no** if POD location is a lagoon, **na** if otherwise.
Diversion Dam	Presence of instream diversion structure: **yes** or **no** (If yes complete dam protocol).
Screened	Reports whether the diversion is screened for fish protection: **yes** or **no**.
Screen Type	Type of screening device: **BX** = box, **BR** = barrel, **CY** = cylinder, **CN** = cone, **OT** = other, **XX** = none.
Screen Material	Material screen is constructed of: **WM** = wire mesh, **PM** = plastic mesh, **PP** = perf plate, **PB** = profile bar, **EM** = expanded metal, **OT** = other.
Diameter	Diameter of barrel, cylinder or cone screen in feet (0.1).
Height	Height of barrel, box or cone screen in feet (0.1).
Length	Length of box or cylinder screen in feet (0.1).
Area	Area of screen in square feet (0.1).
Opening Dimension	Smallest dimension of the screen material opening.
Screen Condition	Descriptor of screen condition and/or maintenance requirements: **OK** = clean and intact, **MN** = minor maintenance needed.
Compliance	Does screen meet WDFW criteria: **yes** or **no**.
Problem/Comments	Description of problems associated with screen, bypass, etc.
Intake Pipe Outside Diameter	Measured outside diameter of the intake pipe in inches (0.1).
Pump Type	Type of pump design: **centrifugal** or **turbine**.
Meter No	Meter or power pole identification number nearest to pump.
Capacity	Volume of water, measured or calculated in ***gpm.***
Derivation	How flow was determined: **measured** = gauge present, **derived** =calculated from irrigation system components, **water right** = legal documentation.
Water Right	Water right number associated with diversion.

Capacity & Derivation
The preferred method of determining capacity (flow) is from the water right (see *Flow; Flow Derivation* in section 2.5.2). If the there is no water right or it is not available, measure or estimate the screen design flow for the pump diversion and report in gallons/minute. If the diversion has an in-line flow meter and is running, simply read the meter and record the instantaneous flow in gpm (not the total volume pumped in acre-feet). Most diversions will not have a flow meter. A design flow estimate, suitable for properly sizing for a screen that complies with all WDFW and NMFS screening criteria, can be derived by estimating irrigation system output. For a closed, pressurized system that delivers water via sprinkler head, contact the diversion owner and ask for the manufacturer, type (model no.), number and size of sprinkler heads, nozzles, etc. that can be supplied water when operating normally with full pump output. Also ask for the operating pressure (pounds/sq. in. or P.S.I.). Obtain technical specification sheets for the appropriate make, type and size of sprinkler from local irrigation supply companies. The flow output in gpm per nozzle at various operating pressures can be obtained from the specification charts. The flow per sprinkler nozzle multiplied by the maximum number of sprinkler heads that can be operated yields an accurate, derived estimate of pump intake design flow for closed, pressurized systems.

2.6 Other
For features that are not culverts, fishways, dams, or water diversions collect the information in Tables 2 and 8. Describe the feature in as much detail as possible.

Table 8. WDFW fish passage database (SSHEARBase) attribute descriptions for “other” descriptors. Attribute values indicated in bold text are mandatory choices. Shaded attributes are required of WDFW field crews only.

Field Name	Description
Field Review Crew	Last name(s) of the field review team responsible for data, individuals separated by / (e.g. Gower/Cox).
Field Review Date	Field review date. **MM/DD/YYYY**
Description	Description of this feature
Barrier	Results of fish passage evaluation. Values are: **yes** = feature is a barrier; **no** = feature is not a barrier; **unknown**. If the stream is non-fish bearing the field is left blank.
Passability	Percent passability based on field crews professional judgement. Values are **0, 33, 67, 100**. This value is used in the PI model to derive B (proportion of fish passage improvement). Make sure values in the Passability and Barrier fields are consistent. If the stream is non-fish bearing the field is left blank.
RepairStatus	Indicates the need for barrier repair. If the feature is not a barrier enter **OK**. If there is insufficient habitat gain to warrant repair (see significant reach determination) the entry would be **NG** (no gain). If a threshold determination has not been made enter **UD** (undetermined). If sufficient habitat is present enter **RR** (repair required). If the barrier has been fixed after its initial discovery enter **FX** (fixed). If the fix involves conversion to a fishway enter **FX/FW.** If the stream is non-fish bearing the field is left blank.

3. Habitat Assessment

Respect private property. Prior to conducting fieldwork, always obtain landowners' permission to enter private property.

Habitat assessments can range from a simple threshold determination (section 3.3) to a full physical survey (section 3.4). If the scope of the inventory is to simply identify human-made barriers to fish passage, then a threshold determination would be appropriate and provide an unranked list of barriers to fix. If the goal of the inventory is to identify and prioritize barriers for correction, then some type of physical habitat assessment is necessary to quantify the amount of habitat that would become available should the barrier be fixed. Three physical survey options are available. The most reliable is the full physical survey (section 3.4), followed by the reduced sampling physical survey (section 3.4). The least desirable method of quantifying habitat is the expanded threshold determination (section 3.5), however, this method may be the only practical solution if time and/or funding do not allow for one of the more reliable methodologies.

In watersheds that can provide habitat for anadromous salmonids, potential habitat gain is always calculated from the human-made barrier upstream to the first natural barrier. The net gain is represented by the connection of the smaller (upstream) piece of habitat with the larger (ocean access downstream). In those portions of a watershed that only support resident salmonids, barrier removal may not result in a net gain of habitat upstream because resident fish populations can exist both up and downstream of a human-made barrier. Resident fish populations and habitat become fragmented and isolated by the human-made barriers because downstream migration is possible but upstream is not. This reduces genetic interchange and makes fish populations susceptible to extinction within isolated reaches. Overall habitat quality from a fish standpoint is diminished as some habitat components are isolated from segments of the population. In addition, some reaches may not have all the habitat components necessary to sustain independent populations. What is gained by barrier removal is the reconnecting of fragmented fish populations and habitat by re-establishing the ability of fish to migrate upstream. For the purposes of calculating a PI value, the benefit to the resident fish population is represented by the habitat segment between the human-made barrier and the closest natural barrier, whether it be upstream or downstream. For example, if an impassable waterfall exists 500 linear meters downstream of a barrier and there is more than 500 linear meters of useable habitat upstream, the downstream habitat would be used to calculate habitat gain as it is the smallest. In this case the real benefit is to the smaller population segment provided by the access to the larger population/habitat component. Conversely, if there is an impassable cascade eight kilometers downstream of a barrier and there is less than eight kilometers of habitat upstream, the upstream habitat would be used to prioritize for barrier resolution. In this case the real benefit is to the larger population segment provided by the access to the smaller population/habitat component.

3.1 Downstream Check

The purpose of the downstream check is to determine if the human-made barrier is physically accessible to anadromous salmonids or if a significant quantity of resident salmonid habitat exists immediately downstream. Anadromous salmonid access is verified by walking downstream to a point known to be free of barriers or until a natural barrier is encountered. Human-made barriers are considered repairable and documented, and the survey is continued. If a permanent natural point barrier (waterfall > 3.7 vertical meters) is present, or the stream gradient exceeds 20% for 160 meters (continuous), the human-made barrier is considered to be inaccessible to anadromous species. Measure the length of the downstream check with a hip chain and keep detailed notes. For each additional feature (including culverts, dams, fishways, water diversion, *etc*.) encountered (barrier and non-barrier) document, evaluate, and record the hip chain distance. Assign site identification numbers, collect GPS readings, and fill out appropriate site and feature forms. Record the hip chain distance for natural and partial barriers encountered. Also, make note of habitat quality, land use, canopy, cover, fish observations (species, number, and size.). Measure and record the gradient periodically and note the stopping point (*e.g*., at the confluence with the Skykomish River, or at a 5 meter falls). The downstream check notes should be entered onto the comments sheet as described in section 3.4.1.1.

3.2 Physical Habitat Survey

The physical habitat survey is a means to quantify the habitat available upstream or downstream of a barrier and allows for the prioritization of projects. Three methodologies are described below that can be used to quantify habitat - the full physical survey, the reduced sampling physical survey, and the expanded threshold determination. An example of a physical survey field form that can be used for each methodology can be found in Appendix A. Table 9 includes the information from the physical habitat survey that resides in the fish passage database. The definitions, habitat measurements, and habitat descriptions found in this section apply to each of the methodologies.

Reach
A section of stream with a similar gradient, bed form, channel size, streamflow, land use characteristics, and having a length of at least 160 meters (except for pond reaches which can be less that 160 meters in length).

Natural Point Barrier
A waterfall greater than 3.7 meters in vertical height**.**

Gradient Barrier
A sustained gradient >20% for a distance ≥160 meters, or when the channel has a sustained gradient >16% for a distance ≥160 meters *and* a channel width <0.6 meters in Western Washington or <0.9 meters in Eastern Washington *as measured at the ordinary high water width.*

Ordinary High Water Width
The width of the stream, measured perpendicular to the flow, as measured from the line on the bank where the presence and action of waters are so common and usual and so long continued in ordinary years, as to mark upon the soil or vegetation a character distinct from that of the abutting upland.

Table 9. WDFW fish passage and screening database (SSHEARBase) attribute descriptions for summarizing habitat assessments. Attribute values in bold text are mandatory choices.

Attribute	Description
Habitat Assessment Method	Habitat assessment methodology used to generate Priority Index. **FS =** Full Physical Survey, **RSFS** = Reduced Sampling Full Survey, or **ETD** = expanded threshold determination.
Quattro File	Name of the Quattro Pro spreadsheet file where habitat assessment data resides.
Downstream Check Date	Date (MM/DD/YYYY format) when downstream check was completed.
Downstream Check Length	Length of downstream check in meters.
Number of Downstream Barriers	Number of artificial barriers downstream of the barrier.
Physical Survey Date	Date (MM/DD/YYYY format) of the physical habitat survey.
Physical Survey Length	Length of physical habitat survey upstream of barrier, measured in meters.
Number of Upstream Barriers	Number of artificial barriers upstream, between barrier and end of physical habitat survey.
Spawning Area	Amount of spawning habitat available upstream of barrier, in square meters.
Rearing Area	Amount of rearing habitat available upstream of barrier, in square meters.

Stream Length

Measured to the nearest meter using a belt chain with a 3 strand, biodegradable thread. For an upstream survey, begin the measurement at the human-made barrier and continue upstream until a natural point barrier or gradient barrier is reached, or until the stream is no longer fish bearing. For a downstream survey, begin the measurement at the human-made barrier and continue downstream until a natural point barrier or gradient barrier is reached.

Pool, Riffle, and Rapid Physical Measurements

The stream is divided into three habitat types - pool, riffle, and rapid. Rapids are high gradient riffles with large substrate and generally contain "white water". Runs and glides must be broken into riffles or pools. Surface flow characteristics and depth should be used to distinguish whether a run or glide is characterized as a riffle or pool.

For each pool, riffle, and rapid, record the length, to the nearest 0.1 meter, within the sample section. (See section 3.4 for discussion of a sample section for the full physical and reduced sampling surveys and section 3.5.1 for the ETD.) Record, to the nearest 0.1 meter, the stream wetted width and the ordinary high water (OHW) width at the first two pools, riffles, and rapids found within the sample section that are representative of the conditions within the section if conducting a full or reduced sampling physical survey. If conducting an ETD, then record the wetted and OHW width for the first pool, riffle, and rapid found within the sample section that is representative of the conditions within the section. The width measurements should be taken in an area representative of the average width of the habitat type, not in an area where the stream is wider or narrower. A staff marked for metric lengths or meter tape are used. Record the average water depth to the nearest 0.01 meter at the cross section where each of the wetted width measurements were taken. Take a minimum of three measurements that are representative of the range of depths found in the cross section and average.

Substrate Composition

Substrate composition for pools, riffles, and rapids are visually estimated in each sample pool, riffle, and rapid measured. The method estimates the percent of total area of each sample pool, riffle, and rapid measured that is occupied by each substrate category listed Table 10. The process should be completed by both observers independently and then the estimates combined into one sample estimate in a collaborative process. For example, to estimate substrate composition for a sample pool, each surveyor would visually observe the most abundant substrate type and estimate the percent of the total pool area it occupies. Repeat the process for estimates of the second most abundant substrate type then the third and finally the fourth or least abundant. Substrate particles are sorted by stream channel hydraulic forces that tend to group substrate particles of similar size categories. Once all four substrate categories have been estimated they should be totaled and equal 100%.

Substrate composition estimates are very important because the production estimates for spawning-limited species such as Chum, Pink and Sockeye salmon are calculated using the estimated percent gravel by pool/riffle/rapid area.

Table 10. Substrate size classes used to characterize substrate composition.

MEAN PARTICLE DIAMETER SIZE CLASS RANGES		
CATEGORY NAME	**SIZE CLASS RANGE (in)**	**SIZE CLASS RANGE (mm)**
Boulder	>12 in	>305 mm
Rubble/Cobble	3 to 12 in	76 to 305 mm
Gravel	0.20 to 3 in	5 to 76 mm
Sand/Fines	<0.20 in	< 5 mm

Habitat Quality Modifiers

Two Habitat Quality Modifiers (HQM) are assigned to each survey reach to identify the productive capability of the habitat as described in Table 11. The HQM rating is used as a multiplier of the habitat area to obtain H in the Priority Index (PI) model (H= habitat quality modifier x habitat in square meters). Since a separate production rate is used for each species present in the PI model and the production rate is calculated using square meters of spawning habitat for species that normally do not rear in streams (chum, sockeye and pink salmon), and square meters of rearing habitat for species dependant upon stream rearing habitat, *the habitat* *quality modifier must be applied independently to spawning and rearing habitat*. Often the habitat quality modifier will be the same for both. But in some situations, for example silt bottom creeks, rearing habitat may be excellent (rearing HQM = 1) but, due to a high percentage of fines (grain size <0.85 mm) mixed in with spawning size gravel, spawning habitat would be of reduced quality.

The spawning habitat quality modifier is determined visually by estimating the percent fine particle (<0.85mm) composition of the substrate area/patches that are classified as "gravel" (5 to 76 mm (0.20 to 3 inches) diameter particles). The estimating procedure combines subjective evaluations of the surface composition, silt plume characteristics as a boot heel is dug 8 - 10 inches into a "gravel" patch substrate, and the composition of several handfuls of the underlying substrate. The procedure should be repeated several times at each site to estimate the percent fines (<0.85 mm) in the "gravel" for each reach.

The rearing habitat components or function to be considered when assigning a habitat quality modifier are riparian vegetation (shade, cover), channel morphology (pool:riffle ratio), undercut banks, instream cover (LWD, boulder matrix), seasonal flow, and temperature. Components are to be evaluated within the context of expected normal density, occurrence and function given the stream gradient, elevation, and geographical location.

Without formal training it may be difficult to assign the habitat quality modifiers. If training has not been received, use a habitat quality modifier of ⅔ as a default.

Table 11. Criteria used to assign Habitat Quality Modifiers to rearing and spawning habitat.

HABITAT QUALITY MODIFIER (HQM)			
HABITAT CONDITION	**HQM VALUE**	**REARING HABITAT CRITERIA[2]**	**SPAWNING HABITAT CRITERIA**
GOOD TO EXCELLENT	1	Rearing habitat is stable and in a normal productive state with all components functional	Spawning gravel patches have ≤16% fine particle sizes that are <0.85mm in diameter
FAIR	2/3	Rearing habitat shows moderate/widespread signs of instability and/or disturbance known to reduce productive capability (one or more habitat components missing or significantly reduced presence)	Spawning gravel patches/riffles show moderate/widespread signs of instability (scour/filling) and/or >16% and ≤21% fine particle sizes <0.85mm in diameter
POOR	1/3	Rearing habitat shows signs of major/widespread disturbance likely to cause major reductions in its production capabilities (two or more habitat components missing or severely reduced presence)	Spawning gravel patches/riffles show major/widespread signs of instability (scour/filling) and/or >21% and ≤26% fine particle sizes <0.85mm in diameter
NO VALUE	0	Rearing habitat severely disturbed so that production capabilities are with out value to salmonids at this time	Spawning gravel patches with >26% fine particle sizes <0.85mm in diameter

Limiting Factors

If a habitat quality modifier other than 1 is assigned to a reach indicate why. A simple note will suffice (dairy waste, unstable channel, >16% fines, lacking riparian vegetation, lacking instream cover, irrigation return water, stream dry, high summer temperatures, stormwater, urban development, *etc*.).

Spring Influence
Calculation of the 60 day summer low flow requires identification of the degree of "spring influence" as described in the 60 day summer low flow methodology (Appendix E). The spring influence factor (Table 12) is used to *minimize the reduction of measured wetted area in streams that have springs contributing a substantial part of the flow during the summer low flow period.* The influence the spring factor has on the 60 day low flow calculated area ranges from no influence (spring factor = 0), to completely canceling the reduction of measured wetted area for the summer flow period and effectively saying that the stream runs at a constant flow perpetually with no summer low flow area reduction (spring influence = 3). Few streams are unaffected by summer drought, so it is important to use good judgement when applying the spring factor. Use the guidelines found in Table 12 to assign the spring factor to each reach surveyed.

Table 12. Criteria used to assign a spring influence factor.

SPRING INFLUENCE FACTOR (SPRING FACTOR)		
SPRING INFLUENCE	**SPRING FACTOR**	**CRITERIA**
ABSENT	0	normal channel morphology with evidence of a range of flows (scoured pool riffle sequence)
SLIGHT	1	rectangular cross section with minor variations in depth (less evidence of scour and bed transport than above) ***(Summer low flow width = 1/3 OHW width)***
MODERATE	2	as above but even less sediment transport and scour with low flat flood plains and little evidence of freshet activity ***(Summer low flow width = 2/3 OHW width)***
PRONOUNCED	3	bank vegetation established with a distinct line a small distance above the water surface during summer flow period, heavy moss growth on the exposed stream rocks can indicate freshet activity is very weak. *Must flow at nearly constant flow level year around* ***(Summer low flow width = OHW width)***

Pond Habitat
Pond habitat shall be defined as a zero gradient reach having an average width at least five times that of the average pool width and five times the average pool length in the downstream reach. Pond reaches do not need to be 160 meters in length to qualify as a reach. In the event short, high quality riffles exist between a series of high quality rearing ponds, exceptions to reach lengths can be made (<160 meters) to capture these high quality areas in the survey.

Flow
A flow measurement should be taken at the beginning of each survey and periodically while proceeding upstream as flow conditions change at tributary or groundwater input areas (use of the chip method is acceptable). Measure flows at a culvert, sharp crested weir, riffle area, or other uniform cross section when possible. The average width and average depth of the selected cross section is determined with at least 3 measurements of each. Flow velocity measurements

are taken using a stop watch and meter tape to time a chip traveling over the length of the sample riffle or a distance up to 10 meters. At a minimum, divide the stream into thirds (left, center, and right) and take a measurement in each third.

Water Temperature

Water temperature is normally taken at the same general time as the flow using a hand-held mercury thermometer calibrated for Celsius readings. Temperature is recorded to the nearest degree.

Gradient

Take at least one gradient measurement per sample section. Gradient may be measured using a clinometer or hand or tripod mounted level and stadia rod. Take the gradient over as long a stream section as visibility allows, being careful to not shoot across meanders. Take back sights when possible as a double check.

Canopy Composition

Visually estimate the percent of the wetted stream area shaded by the riparian vegetation while assuming a full leaf out condition. Note the dominant tree and shrub species within the stream corridor. One canopy composition estimate should be made for each reach. Periodic use of a densiometer is advised to calibrate survey observations and to train new survey teams.

Additional Barriers

Frequently, additional human-made barriers and water diversions exist which may need to be corrected to realize the potential habitat gain above or below the primary barrier. When encountered, record the barrier or diversion location into the "additional barriers" space in the field data notebook as the distance in meters above or below the target barrier. Identify the method of measurement (belt chain, stream catalog, aerial photo, USGS quadrangle). Record the type of structure (*e.g.*, water diversion, lake outlet screen, culvert, dam, or fishway) and record the location (preferably the GPS position). Collect the site information as required in Table 2 and complete the appropriate field form(s) for the type of feature encountered. Each secondary human-made barrier will appear as an additional record in the WDFW fish passage database. A reach break is made at each human-made barrier encountered.

Instream Cover

Instream cover density such as large woody debris (LWD), undercut banks, large boulders, close overhanging vegetation, *etc.* is visually estimated as high, medium or low. The instream cover rating should be reflected in the rearing habitat modifier. One estimate of instream cover density should be made for each reach.

Juvenile Abundance

A subjective visual estimate (none, low, medium, or high) of fry densities is noted by species (if possible) for each stream reach.

Comments

Note principal stream features, road crossings, and other human-made features, *etc.* (in meters from the beginning of the survey) as they are encountered. Note natural features such as beaver dams, log jams, cascades, falls, *etc*. The end of the survey and the reason for ending the survey are recorded.

3.3 Threshold Determination

A threshold determination is the verification that a significant reach of habitat exists upstream and downstream of a human-made barrier. A significant reach is defined as a section of stream having at least 200 linear meters of useable habitat without a gradient or natural point barrier. In the case where a culvert falls within the 200 meters, do not count the length of the culvert as part of the significant reach since the culverted section of stream is not considered useable habitat. If an additional human-made barrier is found, then make the determination as to whether it has a reasonable likelihood of correction (small dams and road culverts are likely to be corrected, large dams may not be). If not, then there is not a significant reach present. If there is not a significant reach of habitat upstream and downstream of a barrier, the barrier would not warrant correction. An exception to the significant reach threshold may occur if high quality, limiting habitat exists upstream of the barrier in anadromous waters or upstream or downstream in resident waters. For instance, 100 meters upstream of a human-made barrier there is a 16 foot high falls. The stream reach below the falls contains high quality spawning habitat that is not found downstream of the human-made barrier. In this case, the correction of the barrier may be justified since the existence of the barrier is limiting the entire stream's production potential.

3.4 Full Physical Survey and Reduced Sampling Physical Survey

A full physical survey is the preferred option for assessing the habitat above or below a human-made barrier. This method gives the most reliable estimate of the available habitat and allows for the identification of natural and human-made barriers as well as evaluation of the habitat quality throughout the survey.

Sample Section

When conducting a full survey, the length of the stream is estimated from USGS quadrangle maps (1:24,000), to determine the appropriate sampling frequency. For streams less than 1.6 kilometers in length, 30 meters of habitat is sampled for every 160 meters of stream length. For streams greater than 1.6 kilometers in length, sample the first 60 meters of every 320 meters of stream. This method results in approximately a 20% sampling level. Habitat surveys proceed from the human-made barrier and continue upstream or downstream until a gradient or natural point barrier is reached. All of the information described in section 3.2 is collected.

If a reduced sampling physical survey is being conducted, the only departure from the full physical survey is that only one 60 meter sample is collected for each stream reach rather than collecting a sample every 160 or 320 meters. Everything else is identical between the two methodologies.

Reach Breaks

The stream is broken out into reaches with similar streamflow, gradient, and bed form. A reach break is assigned at each tributary contributing ≥20% of parent stream flow. Reach breaks are also assigned at 1, 3, 5, 7, 12, and 16% gradient. Table 13 shows the expected species utilization in each gradient strata and the gradient strata that each species may ascend, even though they may not reside in that strata. For instance, coho salmon are generally found in stream reaches having gradients of 7% or less, however, they may ascend stream reaches up to16% and reproduce and rear in lower gradient reaches upstream. In this case, you would include coho salmon in all reaches having a gradient of 7% or less even if there are intermediate reaches up to 16%. Table 13 should be used to assign species utilization to reaches unless additional information is available for the stream. The reach breaks do not necessarily correspond with changes in species utilization because some reach breaks are established to account for habitat differences at different stream gradients.

A gradient strata must be sustained for at least 160 meters. The survey is terminated at a natural point barrier (waterfall >3.7 meters vertical height) or when a sustained gradient >20% is encountered for a distance ≥ 160 meters (>16% for a channel width <0.6 meters in Western Washington and <0.9 meters in Eastern Washington *measured at the ordinary high water width*).

Since it will not always be known how long the stream continues at a particular gradient, it is necessary to measure the first 160 meters by belt chain to verify the need to create a new reach when a new gradient reach stratum is encountered. Sample frequency should continue uninterrupted across gradient reaches, to avoid unnecessary sampling should the gradient change occur in less than 160 meters. This is an exception to the way other types of reach breaks (bed form change, land-use change, secondary human-made barriers, *etc.*) are handled, where a new sampling frequency will begin at the reach break point.

Table 13. Expected species utilization (shaded) and passability (vertical lines) for each gradient strata.

	Gradient Strata (%)						
Species	0-1	1-3	3-5	5-7	7-12	12-16	16-20
Chum Salmon							
Pink Salmon							
Coho Salmon							
Sockeye Salmon							
Chinook Salmon							
Steelhead Trout							
Searun Cutthroat							
Bull Trout[1]							
Trout[2]							

[1]Includes resident and anadromous bull trout/Dolly Varden
[2]Includes resident rainbow and cutthroat trout

Changes in bed form that require a reach break are any change which significantly affects pool:riffle:rapid ratio, substrate composition, or channel width. Bed form strata need not be 160 meters long to qualify as a reach. An example is a stream which has a significant gravel source (feeder bluff) which provides good spawning gravel in riffle areas downstream but has boulder and bed rock (gravel poor) upstream from this point. In this case a reach break at the feeder bluff is necessary to keep from biasing the gravel composition assessments regardless of the length of riffle and bedrock areas above and below the feeder bluff. For another example, if a sediment source is a sand bluff which shifts bed composition to a high percentage sand (low percentage spawning gravel) downstream and low sand (high percentage spawning gravel) upstream - a reach break is also required.

Other bed form shifts which require a reach break are a change from a forested high quality channel (high level of LWD) which emerges into a highly impacted dairy or cattle grazing reach of lower productivity (cattle waste, low LWD, or lack of stream bank vegetation and hiding cover).

As a rule of thumb a reach break is made wherever a change in stream characteristic will affect one of the measured parameters used to calculate species-specific production potential (gradient, channel width, riffle area, pool area, bed composition, or habitat quality modifier). In addition, a reach break is made at each human-made feature encountered during the survey.

3.4.1 Data Analysis

Physical habitat survey data are used to estimate habitat gains in terms of fish production potential. Habitat gain is expressed in square meters (m^2) of either spawning or summer rearing habitat. These values are a key variable (H) in the Priority Index Model which is used to prioritize barrier correction. Spawning area is used for those species (chum, pink, and sockeye salmon) whose production is limited by spawning habitat. Rearing area is used for those species (coho and chinook salmon, steelhead, cutthroat, rainbow, bull, brook, and brown trout) whose production is limited by rearing habitat.

Physical habitat survey and expanded threshold determination data are processed in a customized spreadsheet developed in Quattro Pro. The spreadsheet generates a detailed report for each stream surveyed which contains the total habitat gain per species, habitat measurements for each stream reach and the total survey, habitat quality information, and other fundamental survey data.

Spawning area is calculated as the sum of the areas of each habitat type, measured at ordinary high water, multiplied by the gravel percentage in each habitat type. Widths at ordinary high water are determined during the survey using the bank vegetation line and other hydrologic evidence.

Pond and lake habitat are included in rearing habitat. When large ponds and lakes are present in a watershed, the calculated rearing areas are extremely large, yielding unreasonably high production values. To adjust this, a lake adjustment factor was developed that reduces the rearing area for lakes and ponds larger than 2000 square meters through the formula:

$$(((\text{Area} - 2000)/2000)^{1/2}\,2000) + 2000.$$

This reduces the rearing area to an number that approximates the littoral area which more accurately describes the rearing potential for a large pond or lake.

Rearing area is calculated using a projected 60-day low flow that is calculated using basin area, spring influence, and a regional constant (Figure 7). Sixty-day low flow is defined as the lowest average flow occurring over any period of 60 consecutive days during the year. The entire stream area calculated using the 60-day low flow is considered rearing area. This methodology allows comparison of rearing areas regardless of the season in which the stream was surveyed. Both the spawning and rearing areas can be adjusted by a Habitat Quality Modifier, which is a subjective estimate of habitat quality. It has a value which ranges in increments of ⅓ from zero to one. A separate modifier is assigned to rearing and spawning habitat within each stream reach. This modifier serves to decrease the habitat areas in degraded streams to reflect the lower production potential.

Gains in spawning or rearing area are calculated for each species (potential presence) for each sample reach within a survey. Reach values are then subjected to an analysis of species

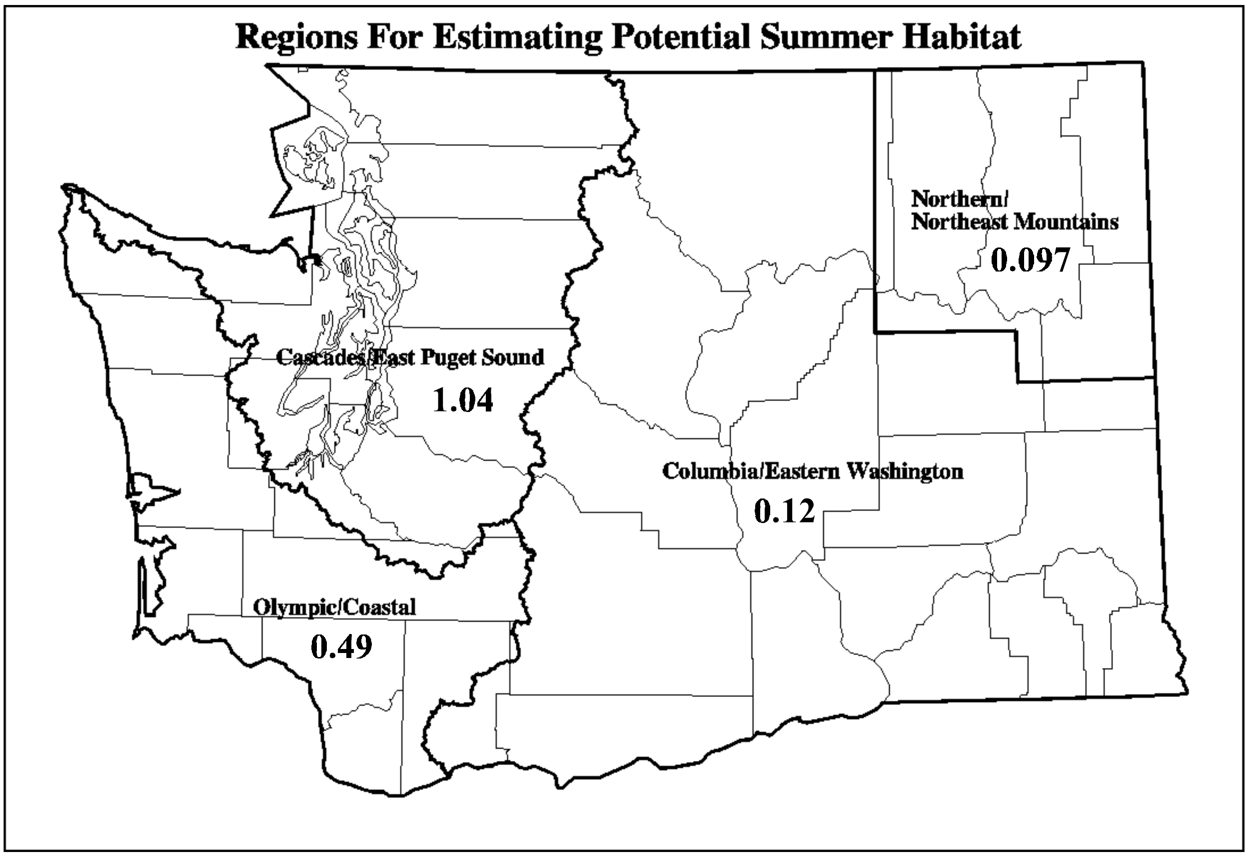

Figure 7. Regions and their associated constants for estimating the 60-day low flow.

interaction. Competition between species with similar freshwater life histories[5] tends to reduce

---

[5]Species complexes are determined by similarities in life history and are as follows: sockeye, chum, and pink salmon; coho salmon, searun cutthroat trout, chinook salmon, and steelhead; resident cutthroat/rainbow trout and bull trout/Dolly Varden; and brook and brown trout.

the production rate below single species production values. For example, optimum single species productivity for two species within the same complex (coho and steelhead) is estimated at 0.05 and 0.0021 adults/m^2 respectively. If the single species values are added, a total production value of 0.0521 is the result. To adjust for competition within species complexes, the species complex factor was developed to reduce multiple species production values below the simple total of individual values.

If there are 3 species in the species complex then:

Species Complex Factor (CF) = production value species 1 + 0.67 (production value species 2) + 0.33 (production value species 3) / production value species 1 + production value species 2 + production value species 3

If there are 4 species in the species complex then:

Species Complex Factor (CF) = production value species 1 + 0.75 (production value species 2) + 0.5 (production value species 3) + 0.25 (production value species 4)/ production value species 1 + production value species 2 + production value species 3 + production value species 4

In the case of coho and steelhead the species complex production value would be reduced from 0.0521 to 0.0516 or [*0.0521 x (0.05+0.75(0.0021)/0.05+0.0021)*].

In practice, the species complex factor is used to reduce the habitat area (H) used in the Priority Index formula. The habitat area value is adjusted on a reach by reach basis for each species present. In the case where coho and steelhead utilize the same stream reach the total rearing area available would be multiplied by the species complex factor [H = habitat gain (m^2) x *(0.05+0.67(0.0021)/0.05+0.0021)*]. The adjusted habitat values for each reach are summed and used to calculate single species PI values using the full single species adult production value. The result is the same as adjusting the adult production value.

3.4.1.1 Data Entry

A customized spreadsheet is used to process field data collected using the full physical survey or expanded threshold determination methods described earlier. The primary output from the spreadsheet is species specific adjusted production area values which represent the H variable in the Priority Index equation.

The spreadsheet template is named SurveyV4.wb1. Once it has been completed it must be saved under a different file name in order to maintain the template. A separate file is created for each stream surveyed. Multiple surveys and thus files may be necessary for some human-made barriers. Combining the output from multiple files is described below in the summary section. The spreadsheet consists of four sheets, an input sheet where all the physical habitat measurements are entered, an output sheet which contains the results of the analysis, and two comments sheets which contain field observations associated with the downstream check and the physical survey.

Sample field data can be found in Appendix F. These sample data are used in the examples for data input and output in the following sections.

Input

The input sheet has a header section containing the following fields: Survey Method, Stream Name, Tributary To, WRIA #, Sample Frequency, Date, Observer(s), Section Surveyed, and File (electronic file name). This information is automatically inserted into the Output and Comments sheets. The header is followed by ten reach sections, each containing information on location, habitat quality, flow, species presence, 60-day low-flow parameters, and habitat measurements (samples). Each reach can accommodate 79 samples. Between the sample input area and the next reach are a series of fields containing formulas for calculating sample averages. Data entry is restricted to the gray cells on the spreadsheet. White cells contain either labels or display results of underlying formulas. An example of the input sheet (single reach), with the sample data, is presented in Appendix G and each data field and its appropriate inputs are described in Table 14.

In cases where a reach has more than 79 samples, additional input lines may be added to the reach using the insert line function. Surveys with more than 10 reaches require a new file with Reach 11 data entered under Reach 1 of the second file, Reach 12 data under Reach 2 of the second file, and so on. Actual reach numbers should be explained in the comments section. Combining the output from the two files is described below in the summary section.

Output

The output sheet displays the results and summaries of the survey. It contains most of the formulas used to process the data. As such, it is a read-only sheet, so do not attempt to enter or edit data. Any corrections must be made on the input sheet. Altering or deleting any of the formulas will result in erroneous or missing data. The output sheet is formatted into 11 printable pages (see printing instructions below), one survey summary page and ten reach summary pages. An example is presented in Appendix H with the sample data.

The survey summary page contains the header information, total lengths for the survey, samples, additional human-made barriers, area totals and ratios for pool, riffle, rapid, and pond habitats, total stream area measured, and total spawning and rearing area. Two production area tables are presented, one with areas adjusted for species interaction, the other not. The total adjusted production area for a given species is the value for the H variable in the Priority Index equation for that species.

The reach pages summarize survey information on a reach by reach basis. This includes the locational, habitat quality, species presence, flow, temperature, and substrate composition information from the input sheet. Lengths, average widths and depths, areas, ratios, and gravel

Table 14. Instructions for data entry into the Input spreadsheet. Required data entry fields and values are in bold.

Field Name	Field Type	Instructions for Data Entry
HEADER INFORMATION		
Survey Method:	Character	Survey methodology used. Valid entries include: **FS** for full physical survey **RSFS** for reduced sampling full survey, and **ETD** for expanded threshold determination.
Stream Name:	Character	Name of the stream being surveyed. If the stream is an unnamed tributary, then enter unnamed stream.
Tributary To:	Character	Name of the water body the surveyed stream is tributary to.
WRIA # :	Character	Water Resource Inventory Area (WRIA) and stream number assigned to the surveyed stream. In cases where unnamed tributaries do not have an assigned stream number, or the stream number is unknown, then include only the WRIA. Refer to the following publications to find WRIAs and stream numbers: Williams *et al.* (1975), Phinney and Bucknell (1975), and WDOE (1972). WDOE's Internet website <http://www.wa.gov/ecology/wr/wrias.html> contains a map of all WRIA's.
Sample Frequency:	Character	Survey sample frequency. Either 60 m / 322 m, 30 m / 161 m, or 60 m/reach. *Leave blank for ETD.*
Date:	Date	Date of PS, RPS or ETD. If the stream survey took more than one day to complete, then enter the date when survey began. Format MM/DD/YYYY.
Observer(s):	Character	Last names of the stream surveyors.
Section surveyed:	Character	Enter text describing the stream section surveyed, from beginning to ending point. (e.g. -mouth to 1000 m upstream, or, highway 101 milepost 10.90 to 1000 m upstream)
File:	Character	Filename the stream survey is saved as. (e.g. 991754.wb1)
LOCATION INFORMATION Note: All of the following fields are repeated for each reach within the survey.		
Begin (m):	Numeric	Hip-chain reading at the beginning of the reach (e.g. Reach 1 should begin at zero, Reach 2 should begin where Reach 1 ends, Reach 3 begins where Reach 2 ends, and so on). Units in meters.
End (m):	Numeric	Hip-chain reading at the end of each reach. Units in meters.
Reach Length (m):	Numeric	Total length of the surveyed reach, in meters, based on beginning and ending positions. *Calculated field, do not edit.*
Position:	Character	Describe the beginning position of the survey reach (e.g. 250 m upstream Highway 101 Milepost 10.90; or; immediately upstream of confluence with main stem; or; immediately upstream of culvert under 223rd St).

Table 14. (Cont.)

Field Name	Field Type	Instructions for Data Entry
HABITAT QUALITY		
Instream Cover:	Character	Describe the amount and type of instream cover. Instream cover density is visually estimated as high, medium, or low. Types include large woody debris (LWD), undercut banks, large boulders, close overhanging vegetation, etc (e.g. high, mostly large woody debris; or; medium, primarily boulder; or; low, tall grasses and other rooted macrophytes). *A low instream cover rating should be reflected in the rearing habitat quality modifier.*
Juv. Abundance:	Character	A subjective visual estimate of fry densities, by species if possible, within the reach. Valid entries include: low, moderate, high, or none observed.
Canopy:	Character	Canopy composition, in percent, noting major tree and shrub species within stream corridor (e.g. 85% canopy, primarily second growth alder and other deciduous species; or; 100% second growth, primarily cedar and douglas fir; or; 10% very sparse canopy, some deciduous shrubs present).
Limiting Factors:	Character	If a habitat quality modifier other than 1 was assigned, explain why (e.g. dairy waste, unstable bed, lacking riparian vegetation, lacking instream cover, irrigation return water, stream dries in summer, high summer temperatures, gravels heavily silted, etc.).
Add. Barriers:	Character	Number of additional barriers upstream of the initial barrier, both human-made and natural, including partial and total fish barriers.
Total culverted length:	Numeric	Total length of all culverts.
Spawning:	Numeric	Habitat quality modifier for spawning habitat. Valid entries include: Good to Excellent = **1**; Fair = **0.67**; Poor = **0.33**; No Value = **0**.
Rearing:	Numeric	Habitat quality modifier for rearing habitat. Valid entries include: Good to Excellent = **1**; Fair = **0.67**; Poor = **0.33**; No Value = **0**.
T (C):	Numeric	Stream temperature, measured in degrees Celsius.
T @ trib:	Numeric	Stream temperature measured at the confluence with a tributary entering the survey reach. Leave blank if there are none.
REACH SPECIES USE		
Species Presence	Character	Enter an 'x' under each species that is expected to utilize the habitat. If species utilization is unknown, contact area fish biologists, habitat biologists, or consult publications including the *Stream Catalog* (Williams *et al.* 1975 and Phinney and Bucknell 1975); SASSI (WDFW *et al.* 1993 and WDFW 1997). Species known to be present in the main stem, are assumed to be present in the tributaries, providing the tributaries are accessible (or can be made accessible if all barriers are removed) and do not exceed the normal upper gradient limits for the species.

Table 14. (Cont.)

Field Name	Field Type	Instructions for Data Entry
FLOW CALCULATION The three chip method is commonly used for flow calculation. Field data are entered in metric units and automatically converted to cubic feet per second (CFS).		
D(ft)	Numeric	Average water depth (in feet) of cross section used in the three chip method flow calculation. *Calculated field, do not edit.*
L(ft)	Numeric	Length (in feet) of the stream segment used for the three chip method flow calculation. *Calculated field, do not edit.*
W(ft)	Numeric	Average wetted width (in feet) of cross section used for the three chip flow calculation. *Calculated field, do not edit.*
D(m)	Numeric	Average water depth of the cross section, used for three chip method flow calculation, measured in meters to the nearest hundredth.
L(m)	Numeric	Length of stream segment used for three chip method flow calculation, measured in meters to the nearest hundredth.
W(m)	Numeric	Average wetted width of cross section used for the three chip method flow calculation, measured in meters to the nearest hundredth.
1-	Numeric	First time recorded (in seconds) for three chip method flow calculation.
2-	Numeric	Second time recorded (in seconds) for three chip method flow calculation.
3-	Numeric	Third time recorded (in seconds) for three chip method flow calculation.
FLOW=	Numeric	Flow through a cross-section of the stream, in CFS. Equation used: Q = W x D x V x C, where Q is the flow in CFS, W is the average width of the cross-section, D is the average depth of the cross-section, V is the velocity (distance in feet divided by the average time in seconds), and C is the constant (0.8) representing the bed roughness factor. *Calculated field, do not edit.*
ave.	Numeric	Average amount of time (in seconds) for the chip to travel from the beginning to the end of the measured stream segment (for chip method flow calculation) *Calculated field, do not edit.*
60 DAY LOW FLOW		
Est. Drainage Area:	Numeric	Estimated drainage area for the reach, measured off a USGS quadrangle map, using a planimeter or GIS software. Units in square miles, measured to the nearest hundredth.
Spring influences are (see below):	Numeric	Spring influences (absent - **0**, slight - **1**, moderate - **2**, pronounced - **3**).
Reg. Constant (for 60-d low flow calc.):	Numeric	Regional constant (Figure 7) for 60- day low flow calculation (Olympic / Coastal region = **0.49**; Cascade / Puget = **1.04**; Columbia / Eastern WA = **0.12**; Northern / NE mountains = **0.097**).

Table 14. (Cont.)

Field Name	Field Type	Instructions for Data Entry
HABITAT MEASUREMENTS		
Type	Character	Under the heading 'Type', enter the habitat type measured for each sample. Valid entries include: '**p**' for pool, '**r**' for riffle, '**rap**' for rapid, and '**pond**' for pond. Pond habitat should be broken out as a separate reach that does not contain pool, riffle or rapid data.. Ponds, wetlands and lakes will be considered "pond" habitat for data entry purposes.
L	Numeric	Under the heading 'L', enter the length (in meters) of the habitat type measured for each sample. For pond habitat, enter the length (in meters) walked in the field or measured off of an aerial photo.
W	Numeric	Under the heading 'W', enter the wetted width (in meters) of the habitat type measured for each sample.
OHW	Numeric	Under the heading 'OHW', enter the ordinary high water width (in meters) of the habitat type measured for each sample.
D	Numeric	Under the heading 'D', enter the depth (in meters) of the habitat type measured for each sample.
Grad.	Numeric	Under the heading 'Grad.', enter the percent stream gradient for each sample section, expressed as a decimal. (e.g. a 5% stream gradient would be entered as 0.05).
B	Numeric	Under the heading 'B', enter the percentage of boulder that is present within each habitat type measured, expressed as an integer.
R	Numeric	Under the heading 'R', enter the percentage of rubble that is present within each habitat type measured, expressed as an integer.
G	Numeric	Under the heading 'G', enter the percentage of gravel that is present within each habitat type measured, expressed as an integer.
S	Numeric	Under the heading 'S', enter the percentage of sand/silt that is present within each habitat type measured, expressed as an integer.

percentages are calculated for pools, riffles, rapids, and ponds. Pool, riffle, rapid, and pond areas are calculated for wetted measures, ordinary highwater (OHW) measures, and 60-day low flow equations. Wetted areas represent conditions at the time of the survey, OHW areas represent conditions expected during the spawning season, and 60-day low flow areas represent summer low flow conditions. Spawning area is based on OHW area and rearing area is based on 60-day low flow area as described above.

Comments

Downstream check and upstream survey comments are recorded on the appropriate comments sheet. Each sheet contains the heading information from the input sheet. Do not change the heading. If there are any errors in the heading correct them on the input sheet. Below the heading there is a column (A) for the hip-chain reading and a column (B) for the comments associated with that reading. When text reaches column J, continue entering comments on the line below. Upstream comments should be divided by reaches. Highlighting additional barriers or instream activities (*e.g.*, bank stabilization, stream dredging, *etc.*) with bold text is recommended. The comments may be printed after proofing, see Printing instructions. An example is presented in Appendix H using the sample data from Appendix F.

Summary

The summary spreadsheet (Summary.wb1) is used to calculate the total survey length, rearing area, spawning area, and adjusted production areas from multiple stream surveys associated with a single fish passage barrier. The output represents the total potential habitat gain upstream of the target barrier. The spreadsheet will accommodate 10 surveys and the 11 species. The survey length, rearing area, spawning area, and adjusted production areas from each stream survey (output sheet-survey summary page) are entered into the appropriate cells in the Summary spreadsheet where they are summed and totals presented. Table 15 describes the cells and the data entry protocol. A sample is provided in Appendix I. Data entry is restricted to the shaded cells.

Saving/File Naming

To maintain template integrity both the SurveyV4 and Summary spreadsheets are distributed as read-only files. Once data are entered the files must be saved under new names. Save files as Quattro Pro Version 5.0 (wb1) to ensure compatibility with older versions of Quattro Pro. The unique site identification (SITE ID) number assigned to the target barrier is used in naming all associated survey files. For the primary stream surveyed the name consists of the SITE ID and the file extension (*e.g.* 991754.wb1). For tributaries to the primary stream the name consists of the SITE ID plus a lower case letter ('a' for the first tributary encountered upstream, 'b' to the second, and so on) and the file extension (*e.g.* 991754a.wb1). For tributaries to the secondary streams the name consists of the SITE ID , the lower case letter for the secondary tributary, a number ('1' for the first tertiary stream, '2' for the second, and so on), and the file extension (*e.g.* 991754a1.wb1). For Summary spreadsheets the name consists of the SITE ID number plus the characters 'su' and the file extension (*e.g.* 991754su.wb1).

Printing

The SurveyV4 output and comments sheets are printable. The input sheet is solely for entering data. The output sheet is formatted into 11 printable pages: one survey summary page and ten reach summary pages. In the print dialog box, select “current sheet” and specify the range of pages to print based on one survey summary page and the number of reaches (*e.g.* for a survey with 5 reaches, pages 1 through 6 must be specified). To print the comment sheets, select the desired sheet, initiate the print function, and select “current sheet” in the print dialog box. To confirm that all the text will be printed, view the comments with “print preview” prior to printing. To print the Summary spreadsheet, block select all of the text to print, then initiate the print function.

Table 15. Instruction for data entry into the Summary spreadsheet.

Field Name	Field Type	Instructions for Data Entry
Stream Name:	Character	Name of the primary stream surveyed, which flows through the target fish passage barrier.
WRIA:	Character	WRIA and stream number for primary stream surveyed.
Tributary To:	Character	Water body for which the primary stream is a tributary to.
Site ID:	Character	SITE ID number assigned to the target fish passage barrier during the inventory process.
Filenames:	Character	Enter the filenames of all stream surveys associated with the barrier. Accommodates up to ten stream surveys, the primary stream and nine tributaries.
Species Present:	Character	Species names for all salmonids present in the streams surveyed. Include all species that were selected during data entry into the physical survey spreadsheet. These species names will automatically be inserted into the appropriate cells for the Adjusted Production Area headings.
Length Surveyed (m):	Numeric	Length (in meters) of each survey (for primary stream, 1st tributary, 2nd tributary, 3rd tributary, and so on), taken from the survey summary report, use the "Total Length Surveyed:" cell on the first page of the Output sheet.
Total Length Surveyed (m):	Numeric	Total length (in meters) surveyed, upstream or downstream of the target fish passage barrier. *Calculated field, do not edit.*
Rearing Area (m^2):	Numeric	Amount of rearing area (in square meters) for each survey, from the survey summary report, use the "Total Rearing Area:" cell found on the first page of the Output sheet.
Total Rearing Area (m^2):	Numeric	Total rearing area (in square meters) available above the target fish passage barrier. *Calculated field, do not edit.*
Spawning Area (m^2):	Numeric	Amount of spawning area (in square meters) for each survey, from the survey summary report, use the "Total Spawning Area:" cell found on the first page of the Output sheet.
Total Spawning Area (m^2):	Numeric	Total spawning area (in square meters) available above the target fish passage barrier. *Calculated field, do not edit.*
Adjusted Production Area:	Numeric	Next to each species listed, enter the adjusted production area for that species for each survey, taken from the survey summary report, found at the bottom of the first page of the Output sheet in the Adjusted Production Areas table.
Total Adjusted Production Area:	Numeric	Total adjusted production area, for each species. These values will be used in the PI formula. *Calculated fields, do not edit.*

3.5 Expanded Threshold Determination (ETD)

When full physical habitat surveys are not practical an ETD is conducted to estimate the amount of habitat upstream or downstream of a barrier. This methodology requires a physical habitat survey within the first 200 meters upstream or downstream of the barrier depending on where the habitat gain lies. Stream widths and depths measured in the survey are extrapolated throughout the watershed via map derived reaches. The pool, riffle, and rapid ratios and substrate composition assigned to each reach are taken from tables of averages derived from historical WDFW physical survey data. Values are assigned based on reach gradient and general location (Eastern vs Western Washington). These derived habitat measures are then used to calculate potential habitat gain in the same fashion as full physical survey data.

This method allows prioritization of fish passage projects using the Priority Index (PI) Model. Anadromous access, the amount of useable habitat, the habitat quality throughout all reaches, and additional barriers (human-made and natural) should be verified via downstream and upstream checks to provide a higher level of data confidence. When applying for grant funding to correct human-made barriers, more credit will be given to projects with a higher level of habitat and barrier evaluation. Drawbacks of using this method include: 1) high risk of missing other human-made or natural barriers in system that do not show up on the topographic map; 2) risk of prematurely ending a survey based upon a barrier that is indicated on the map but is in reality not a barrier; 3) substrate composition, channel width, and pool/riffle ratios may not conform to the table of averages; 4) land-use practices may vary from reach to reach; 5) habitat quality may vary from reach to reach; and 6) because of 1 through 5 above, there is a high potential to underestimate or overestimate the amount of available habitat.

3.5.1 ETD Field Survey

Once it has been determined that a significant reach of useable habitat is present, determine whether the potential habitat gain is upstream or downstream of the barrier. In anadromous waters the gain is always upstream, in resident waters the gain is the lesser of the upstream or downstream habitat.

Measure and record the stream gradient immediately above or below the barrier (depending on the direction of travel). Begin sampling 40 meters from the barrier to minimize culvert or dam influences. Collect standard physical survey data (see section 3.2) for the next 160 meters, sampling every 40 meters. Measure length, wetted width, OHW width, and depth for the first of each habitat type (pool, riffle, rapid) encountered in each 40 meter section that are representative of the habitat in the reach. Measure the lengths for each additional habitat type encountered and measure the stream gradient within each 40 meter sample section. Record the average substrate composition for each habitat type encountered (percent boulder, rubble, gravel, sand). Assign habitat quality modifiers to spawning and rearing habitat. Record species observations, area land-use, reasons for downgrading habitat quality, *etc*. Note the amount and type of canopy cover, instream cover, and amount of spring influence. Describe and record the location of any human-made or natural barriers encountered.

The objective is to sample at least 2 representative pools and riffles for ETD extrapolation. If the sampling objective is not met within the first 200 meters continue until at least 2 pools and 2 riffles are sampled, until 500 meters have been surveyed, or until the first reach break above a pond, lake, or wetland is encountered, whichever comes first. If the sample needs are still not met, use the data collected. Since it may be necessary to get out of the stream to access the next distinct reach, be sure to record the location of habitat measured beyond the first 200 meters.

3.5.2 ETD Reach Determination

After conducting field work, the stream and watershed needs to be divided into reaches and associated sub-basins. Described below are the procedures for delineating reach breaks and basin areas from maps based on gradient changes, tributaries, and pond habitat. Map generated reach breaks can be modified using field data on additional barriers, bed form changes, tributaries, land use changes, additional human-made barriers, *etc*. These procedures require the use of one or more of the following tools to measures lengths and areas; map wheel, planimeter, ruler, GIS software, or other instrument.

An ETD survey planning form can be found in Appendix J. Fill out the shaded sections and place a check next to the species that are present. An example of a completed ETD survey can also be found in Appendix J.

Gradient based reach breaks are calculated from USGS quadrangle maps (1:24,000). Measure the length of stream segments containing contour lines of similar spacing. Count the number of contour lines that fall within the measured distance and multiply this number by the contour interval to get the elevation difference. Divide the elevation difference by the length of the stream segment and multiply the product by 100 to get the gradient in percent. For example, if within 5,280 ft. of stream length, there are six 40 ft. contour lines that are approximately equal distance apart, the elevation difference within the section is 240 ft. The resulting stream gradient is 4.5% ([240 ft. / 5,280 ft.] x 100). Reach breaks are established based on the gradient strata defined in section 3.4. A gradient change (to a different strata) must be sustained over a stream segment of at least 160 meters to justify a new reach. See Figure 8, for an example of stream reaches delineated from a map.

During full physical habitat surveys, reach breaks are also made at each tributary contributing ≥20% of the receiving stream flow. Since flow cannot be measured from a map, basin area is used as a surrogate for flow. For an ETD, reach breaks are established at tributaries whose basin area accounts for more than 20% of the parent stream basin area (upstream of the confluence). When measuring the basin area of a reach, only include the area that is contributing flow to that particular reach. See Figure 9, for an example of where to measure the basin area. Reach breaks are also made at each additional fish bearing tributary shown on the USGS map, regardless of flow contribution. In addition, reach breaks are made at ponds, wetlands and lakes that show on the map. The mapped ETD survey ends at a natural point barrier, gradient barrier, or the source of flow.

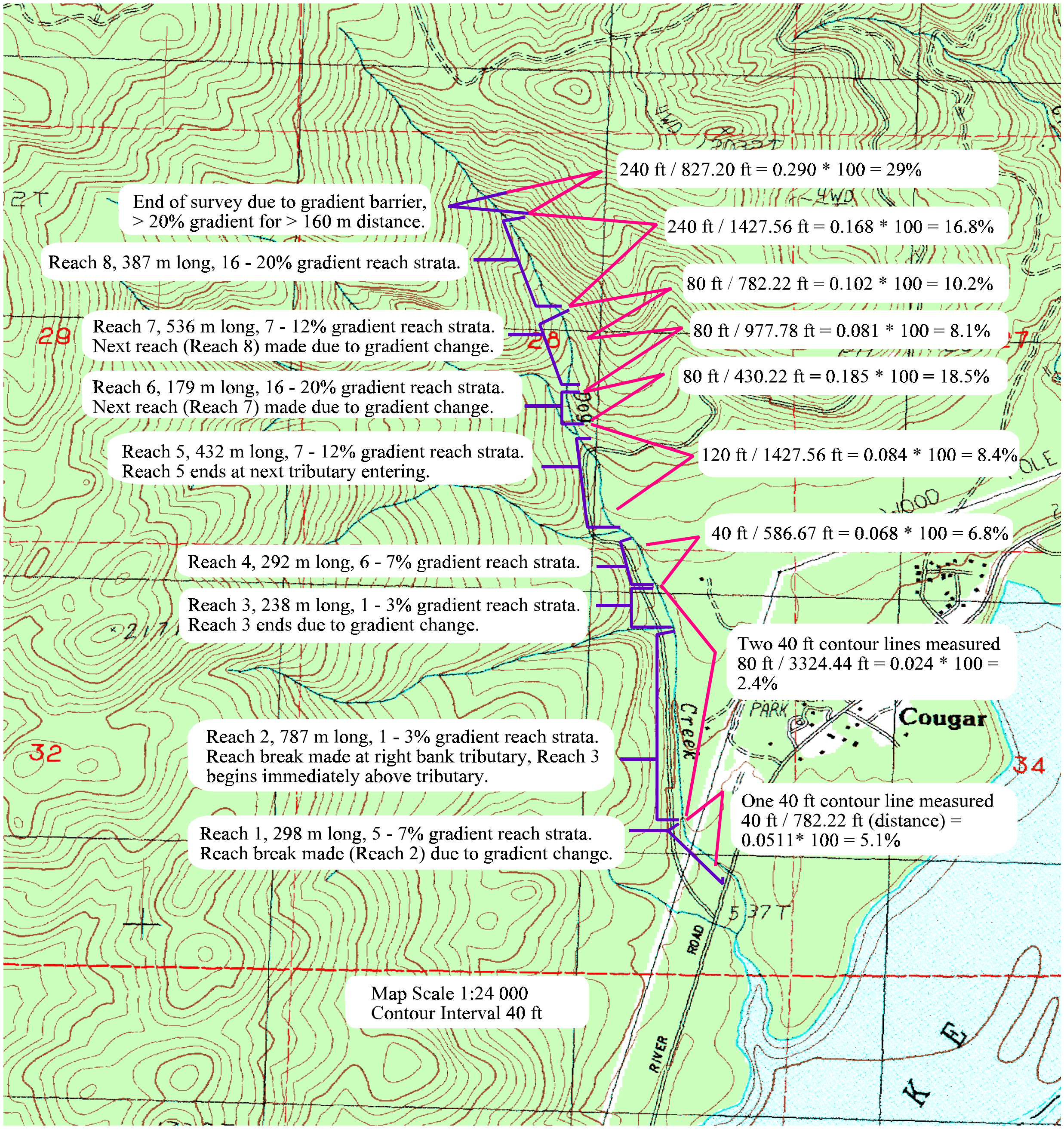

Figure 8. Example of stream reaches delineated from a map.

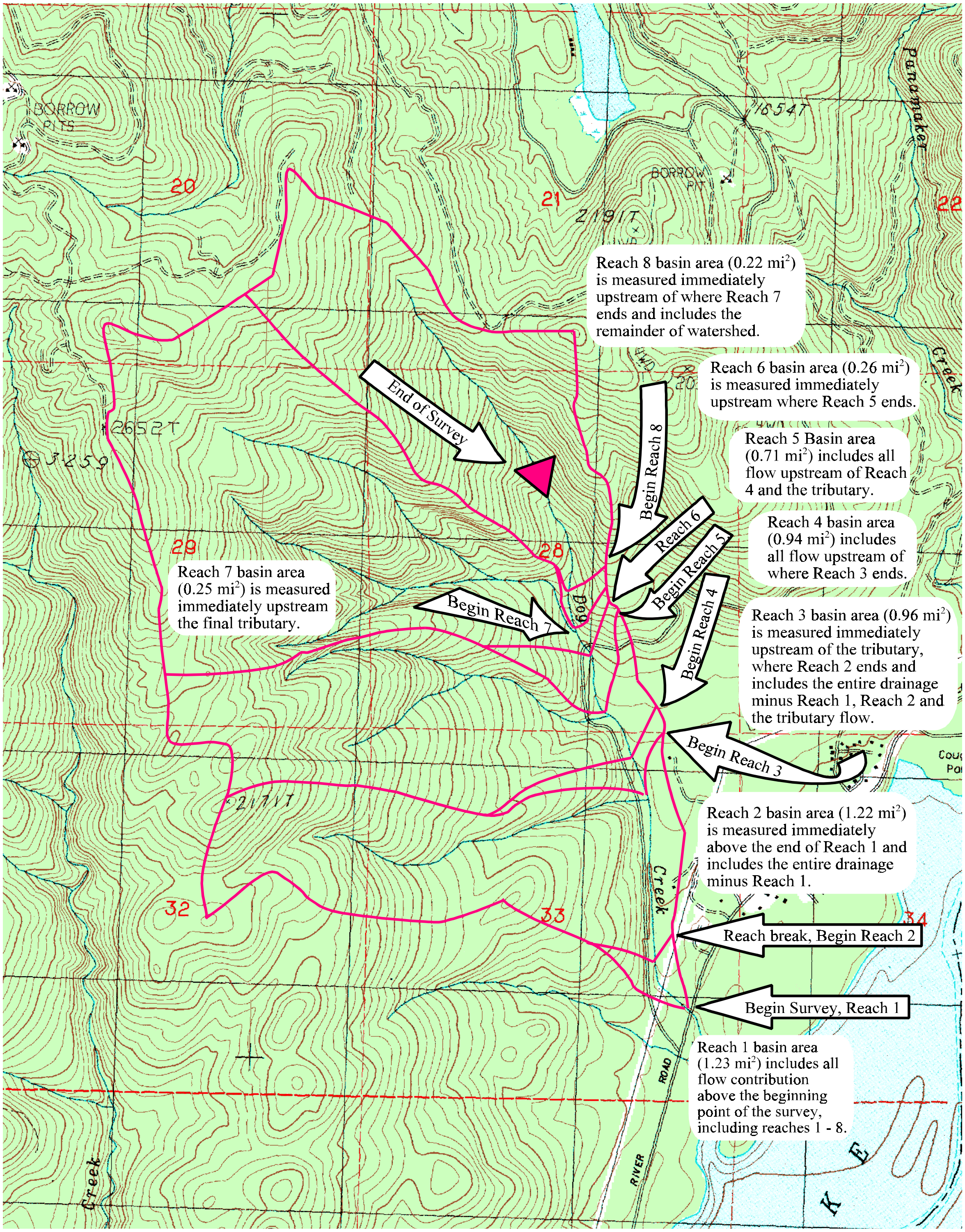

Figure 9. Example of how to measure basin area.

If upstream and/or downstream checks are conducted, field data can be used to add reach breaks or modify those delineated from the map, provided positional data is collected (GPS, hip chain, *etc*.). Reach breaks can be added for significant land-use changes (*e.g.*, forested to open pasture), channel bed form changes, additional barriers, and field verified gradient changes and tributary contributions.

3.5.3 Data Extrapolation

Stream widths and depths measured in the survey are extrapolated throughout the watershed via map derived reaches. The pool, riffle, and rapid ratios and substrate composition assigned to each reach are taken from tables of averages derived from historical WDFW physical survey data. Values are assigned based on reach gradient and general location (Eastern vs Western Washington). These derived habitat measures are then used to calculate potential habitat gain in the same fashion as full physical survey data.

Channel Measurements

Field data are assigned to Reach 1. Channel measurements are *estimated* for each subsequent reach using an expansion factor. This factor is based on the ratio of the basin area to the mean values for wetted width, ordinary high water (OHW) width, and depths for each habitat type from Reach 1. The reach basin area is divided by the factor to obtain the estimated channel measurement. For example, to get the wetted width expansion factor for riffles, Reach 1 basin area is divided by the mean riffle wetted width (1.00 mi^2 / 3.5 m = 0.29); the Reach 2 riffle wetted width is the Reach 2 basin area divided by the expansion factor (0.75 mi^2 / 0.29 = 2.58 m) and so forth. If there were no measurements taken for rapid habitat within Reach 1, then estimates for rapids are made using the riffle data.

Habitat Types

The lengths of each habitat type within each reach is estimated by multiplying the total reach length by the habitat type constants in Table 16. The constant is the average proportion of a given habitat type within a gradient strata. Considering the following Western Washington example, Reach 2 is 400 m long, and falls into the 0 - 1% gradient stratum. This stratum in Western Washington is generally 78% pool and 22% riffle. Multiply Reach 2 length (400) by the pool constant (0.78) to estimate the length of the reach that is pool (400 x 0.78 = 312 m of pool). To estimate the length of Reach 2 that is riffle, multiply the reach length by the riffle constant (400 x 0.22 = 88 m of riffle).

Ponds, wetlands and lakes are not extrapolated with the pool, riffle and rapid data. Ponds, wetlands, or lakes are considered separate reaches and their actual dimensions are used. Ponds, wetlands, and lakes are all considered pond habitat for data entry purposes. Measure and record length and mean width for the pond habitat and measure the basin area (mi^2) for the reach. Use a DNR orthophoto or aerial photograph to measure the length and mean width of pond habitat, since photos will likely be more accurate than a map. Use a USGS quadrangle map (1:24,000) to measure the basin area for the pond habitat reach. If the first habitat type upstream of the human-made barrier is a pond the spreadsheet will not perform the data extrapolation correctly. Enter the pond in reach 2 and enter the first non-pond reach into reach 1 and note this in the comments.

Table 16. Estimates of pool, riffle, and rapid ratios and percent gravel estimates for Western and Eastern Washington.

Western Washington

Gradient Strata	Estimated % pool	Estimated % riffle	Estimated % rapid	Estimated % pool gravel	Estimated % riffle gravel	Estimated % rapid gravel
0 - 1	78	22	0	15	26	—
1 - 3	48	52	0	36	53	—
3 - 5	38	62	0	33	52	—
5 - 7	27	69	4	34	44	10
7 - 12	27	64	9	30	42	13
12 - 16	19	44	36	28	33	13
16 - 20	18	39	43	29	19	13

Eastern Washington

Gradient Strata	Estimated % pool	Estimated % riffle	Estimated % rapid	Estimated % pool gravel	Estimated % riffle gravel	Estimated % rapid gravel
0 - 1	50	50	0	17	24	—
1 - 3	50	50	0	26	57	—
3 - 5	31	68	1	23	45	17
5 - 7	19	80	1	25	36	19
7 - 12	39	56	5	18	39	15
12 - 16	*19	*44	*36	*28	*33	*13
16 - 20	*18	*39	*43	*29	*19	*13

* Since data for Eastern Washington streams were not available, data for Western Washington streams were used.

Substrate Composition

Average percent gravel composition for each gradient strata are found in Table 16. These averages are based on historical WDFW physical survey data for Western and Eastern Washington. These gravel percentages are applied to each reach based on the reach gradient. The *actual data* collected within the first 200 m of the ETD survey are manually entered into the appropriate shaded cells of Reach 1 in the spreadsheet template, ETD2000.wb1. Follow the same data entry conventions outlined in section 3.4.1.1 (SurveyV4.wb1 protocol), for the input sheet heading and Reach 1 data. Enter the Washington Region (E = eastern, W = western) into the shaded cell of the heading.

Mandatory data entry for reaches 2 - 10 include basin area, habitat quality modifiers, spring influence, regional constant, species present, stream gradient, and the beginning and ending point of reach (in meters from the target barrier). Habitat quality modifiers, spring influence, and other unmeasured data are assumed to be the same as Reach 1, unless field verified. Enter additional reach data for temperature, flow calculations, and comments, if available. The channel dimensions are automatically calculated after the reach beginning and ending points, basin area, and stream gradient are entered. If the reach is comprised of pond habitat, enter the dimensions and the gradient into the "pond" row only.

Enter upstream and downstream comments into the comments sheets. Spawning and rearing habitat area calculations are generated in the output sheet of ETD2000.wb1. The output and comments pages are used to report survey results and to generate the 'H' value for the PI model. The output and comments sheets can be printed as described in section 3.4.1.1 for SurveyV4.wb1.

ETD2000.wb1 is also used for tributaries to the parent stream. However, the estimated channel dimensions for the tributary Reach 1 must first be calculated, unless tributary data is collected in the field. Retrieve the parent stream average channel dimensions (wetted width, OHW width, depth) for each habitat type (pool, riffle, rapid) and the basin area for the reach immediately upstream of the tributary (found in the output sheets of the parent stream survey). Then divide the basin area by each channel dimension for each habitat type. Divide the tributary Reach 1 basin area by the numbers resulting from the previous calculation to get the estimated tributary channel dimensions for the tributary Reach 1. For example, if the tributary enters into Reach 3 of the parent stream, you will use the Reach 4 data to extrapolate the tributary. To find the pool wetted width, divide the parent stream Reach 4 basin area by the Reach 4 wetted pool width ($1.50 \text{ mi}^2 / 1.62 \text{ m} = 0.92$). Next divide the tributary Reach 1 basin area by 0.92 to find the estimated tributary Reach 1 pool wetted width ($1.00 \text{ mi}^2 / 0.92 = 1.08 \text{ m}$). After generating the tributary Reach 1 channel dimensions for all habitat types (pool, riffle, and rapid), enter those estimates into the appropriate shaded cells for Reach 1 in the ETD2000.wb1 spreadsheet. Follow the same data entry protocol for tributary reaches 2 - 10 as for the parent stream reaches 2 - 10.

As in SurveyV4.wb1, ETD2000.wb1 accommodates data entry for up to 10 reaches. Surveys with more than 10 reaches require a new file with Reach 11 data entered under Reach 1 of the second file, Reach 12 entered under Reach 2 of the second file, and so on. Actual reach numbers should be explained in the comments section. Use Summary.wb1 to sum all of the habitat areas for multiple ETD surveys (see section 3.4.1.1).

4. Prioritization

4.1 Fish Passage Priority Index

The variety in costs, amounts of habitat gain, and species utilizing potential project sites throughout Washington State can make the characterization and prioritization of corrections to fish passage barriers complex. The WDFW Fish Passage Inventory process uses a Priority Index model to consolidate the many factors which affect a project's feasibility (expected passage improvement, production potential of the blocked stream, fish stock health, *etc.*) into a manageable framework for developing prioritized lists of projects. The result is a numeric indicator giving each project's relative priority that includes production benefits to both anadromous and resident salmonid species adjusted for sympatric species interactions (species complexes). The Priority Index (PI) for each barrier is calculated as follows:

$$PI\ '\ \sum_{all\ species} \sqrt[4]{[(BPH\ )\ x\ \ MDC\ ]}$$

Where:

PI = Fish Passage Priority Index

- Relative project benefit considering cost.
- The PI is actually the sum ($\sum_{all\ species}$) of individual PI values, one of which is calculated for each species present in a stream (*e.g.*, PI_{coho} is added to PI_{chum} to obtain $PI_{all\ species}$).
- The quadratic root in the equation is used because it provides a more manageable number and represents a geometric mean of factors used.

B = Proportion of passage improvement

- Proportion of fish run expected to gain access due to the project (passability after project minus passability before project); gives greater weight to projects providing a greater margin of improvement in passage.
- Barriers are assumed to be partial and have a value of 0.67. Modifications to this approach can be applied with advanced levels of expertise.

P = Annual adult equivalent production potential per m^2

- Estimated number of adult salmonids that can potentially be produced by each m^2 of habitat annually.
- The values (adults/m^2) are species specific; chinook salmon = 0.016, chum salmon = 1.25, coho salmon = 0.05, pink salmon = 1.25, sockeye salmon = 3.00, steelhead =

0.0021, bull trout/Dolly Varden = 0.0007, searun cutthroat trout = 0.037, resident cutthroat/rainbow trout = 0.04, brook trout = 0.04, and brown trout = 0.0019.

H = Habitat gain in m^2

- Measured/calculated from physical survey; gives greater weight to projects which will make greater amounts of habitat available.

- Spawning area values used for species complexes normally limited by spawning habitat (sockeye, chum, and pink salmon) and rearing area values used for species complexes normally limited by rearing habitat [(coho salmon, searun cutthroat, chinook salmon, and steelhead) and (resident cutthroat/rainbow trout and bull trout/Dolly Varden) and (brook and brown trout)].

- When more than one species within a species complex is present H is modified to reflect sympatric interactions among species with similar freshwater life histories. The result is a reduction of single species habitat area values when competing species coexist.

M = Mobility Modifier

- Accounts for benefits to each fish stock for increased mobility (access to habitat being evaluated); gives greater weight to projects that increase productivity of species that are highly mobile and subject to geographically diverse recreational and commercial fisheries by providing access to habitat currently limiting productivity.

  2 = Highly mobile stock subject to geographically diverse recreational and commercial fisheries (anadromous species).

  1 = Moderately mobile stock subject to local recreational fisheries (resident species).

  0 = Increased mobility of stock would have negative or undesirable impacts on productivity or would be contrary to fish management policy. By default, exotic salmonid species such as brook trout and brown trout are assigned a 0 value unless they are the only salmonid species present in the system.

D = Species Condition Modifier

- Representation of status of species present; gives greater weight to less healthy species as listed in the *Washington State Salmon and Steelhead Stock Inventory (SASSI)* report (WDF *et al.* 1993) and *Washington Salmonid Stock Inventory, Bull Trout/Dolly Varden* (WDFW 1997). In the absence of a SASSI assignment, stock condition should be estimated using the best available information.

  3 = Condition of species considered critical.

2 = Condition of species considered depressed or stock of concern.

1 = species not meeting the conditions for 2 or 3.

C = Cost Modifier

- Representation of projected cost of project; gives greater weight to less costly projects.

  3 = incremental funds needed ≤ $100,000.

  2 = incremental funds needed >$100,000 and ≤$500,000.

  1 = incremental funds needed >$500,000.

- All barriers receive a cost modifier value of 2 until engineering evaluations are completed.

The information from the fish passage priority index that resides in the fish passage and screening database is shown in Table 17.

Table 17. WDFW fish passage and screening database (SSHEARBase) attribute descriptions for the fish passage priority index. Attribute values in bold text are mandatory choices.

Attribute	Description
B	B = Proportion of passage improvement. Values can range between 0.1 and 1.0. This value is based on the % Passability estimate made for barrier features. A total barrier would have a value of 1 indicating a 100% improvement in fish passage if the barrier were corrected. Based on current barrier assessment methodologies input values should be; 0% passable = **1.0**, 33% passable = **0.67**, 67% passable = **0.33**. These values can vary between species for a given barrier reflecting different swimming strengths.
P	P= annual adult equivalent production potential per m^2. Values are species specific. This is a read only field with the values being programed into the form.
H	H = gain in production habitat (m^2) above a barrier. This value is taken from the adjusted production area table in the habitat assessment spreadsheet.
M	M = mobility modifier. Values include; **2** (anadromous species), **1** (resident species), and **0** (species whose increased mobility would have negative impacts to native species such as brook trout and brown trout). Default values have been programed into the form. They can be changed if conditions require.
D	D = stock condition modifier. Valid entries include; **3** (stock status critical), **2** (stock status depressed or of concern), or **1** (stock status not meeting the conditions for 2 or 3).
C	C = cost modifier. Valid entries include; **3** (estimated project cost ≤ $100,000), **2** (estimated project cost >$100,000 and ≤ $500,000, or **1** (estimated project cost >$500,000).
PI Species	Species specific PI value. Read only, calculated by form.
PI Total	Sum of all species specific PI values. Read only, calculated by form.

4.2 Screening Priority Index

The Screening Priority Index Model is a hybrid of the quadratic formula used in prioritizing fish passage barriers. The SPI was created to consolidate the many variables relevant to water diversions into a manageable framework for developing prioritized lists of projects. The SPI for each unscreened or ineffectively screened diversion is calculated as follows:

$$SPI \quad \sum_{all\ species} \sqrt[4]{[(QP)\ x\ \ MDC\ ]}$$

Where:

SPI = Screening Priority Index

- Relative project benefit considering cost.
- The SPI is actually the sum ($S_{\text{all species}}$) of individual SPI values, one of which is calculated for each species present in a stream (*e.g.*, SPI $_{\text{coho}}$ is added to SPI $_{\text{chum}}$ to obtain SPI $_{\text{all species}}$).

Q = Flow in gallons per minute

- Flow through the diversion is used as a surrogate for the number of adult equivalent salmonids potentially killed by an unscreened diversion.
- For gravity diversions, flow is determined from the water right, directly measured, or is estimated from the diversion ditch area multiplied by 0.75. For pump diversions, flow is determined from the water right, or if the system is metered, flow can be taken from the meter, or it is the maximum volume of water that could be diverted based upon irrigation system components.

P = Annual adult equivalent production potential per m^2

- Estimated number of adult salmonids that can potentially be produced by each m^2 of habitat annually. Used as a surrogate for the probability of an individual fish of a given species encountering a diversion.
- The values (adults/m^2) are species specific; chinook salmon = 0.016, chum salmon = 1.25, coho salmon = 0.05, pink salmon = 1.25, sockeye salmon = 3.00, steelhead = 0.0021, bull trout/Dolly Varden = 0.0007, searun cutthroat trout = 0.037, resident cutthroat/rainbow trout = 0.04, brook trout = 0.04, and brown trout = 0.0019.

M = Mobility Modifier

- Gives greater weight to projects that increase productivity of species that are highly mobile and subject to geographically diverse recreational and commercial fisheries by providing increased survival through screening.

  2 = Highly mobile stock subject to geographically diverse recreational and commercial fisheries (anadromous species)

  1 = Moderately mobile stock subject to local recreational and commercial fisheries (anadromous species)

  0 = Increased survival of stock would have negative or undesirable impacts on productivity of native species or would be contrary to fish management policy. By default, exotic salmonid species such as brook trout, brown trout and Atlantic salmon will be assigned a 0 value unless they are the only salmonid species present in the system.

D = Species Condition Modifier

- Representation of status of species present; gives greater weight to less healthy species as listed in the Washington State Salmon and Steelhead Stock Inventory (SASSI) report (WDF *et.al*. 1993) and *Washington Salmonid Stock Inventory, Bull Trout/Dolly Varden* (WDFW 1997). In the absence of SASSI assignment, stock condition should be estimated using the best available information.

  3 = Condition of species considered critical

  2 = Condition of species considered depressed or stock of concern

  1 = Species not meeting the conditions for 2 or 3

C = Cost Modifier

- Representation of projected cost of project; gives greater weight to less costly projects.

  3 = incremental funds needed ≤ $1,000…

  2 = incremental funds needed > $1,000 and ≤ $5,000…

  1 = incremental funds needed > $5,000

The information from the screening priority index that resides in the fish passage and screening database is shown in Table 18.

Table 18. WDFW fish passage and screening database (SSHEARBase) attribute descriptions for the screening priority index. Attribute values in bold text are mandatory choices.

Attribute	Description
Q	Q = diversion flow in gallons per minute.
P	P= annual adult equivalent production potential per m^2. Values are species specific. This is a read only field with the values being programed into the form.
M	M = mobility modifier. Values include; **2** (anadromous species), **1** (resident species), and **0** (species whose increased mobility would have negative impacts to native species such as brook trout and brown trout). Default values have been programed into the form. They can be changed if conditions require.
D	D = stock condition modifier. Valid entries include; **3** (stock status critical), **2** (stock status depressed or of concern), or **1** (stock status not meeting the conditions for 2 or 3).
C	C = cost modifier. Valid entries include; **3** (estimated project cost ≤ \$1000), **2** (estimated project cost >\$1000 and ≤ \$5000, or **1** (estimated project cost >\$5000).
PI Species	Species specific PI value. Read only, calculated by form.
PI Total	Sum of all species specific PI values. Read only, calculated by form.

5. Fish Passage and Screening Database

The 1998 Legislature enabled a grants program to provide funding for fish passage barrier culvert inventories and repair. The Salmonid Screening, Habitat Enhancement and Restoration Section (SSHEAR) of WDFW was tasked to develop a database to provide a central repository for barrier culvert information resulting from the statewide inventories. This information is used to locate, prioritize, select, and implement fish passage improvement projects vital to the recovery of Washington's salmonids. This database has been expanded to include information on fishways, dams, water diversions, and other features that impact fish. This database is designed to house data collected in accordance with this manual. In order for this database to operate effectively and provide consistent accurate output we ask that contributors follow the protocols, conventions, and formats prescribed in this document. WDFW has developed a distributable copy of this database application and it is available upon request.

5.1 Data Requirements

The level of inventory and assessment undertaken will determine which data are collected and submitted for inclusion in the state-wide data set. For inventories focusing on culvert location only, provide the data presented in Table 2. For inventories locating and assessing culverts for fish passage, provide the data presented in Tables 2, 3a, and 3b. For inventories locating culverts, assessing fish passage, and prioritizing barrier repairs, provide the data presented in Tables 2, 3a, 3b, and 9 and 17. For inventories that also involve assessing fishways, dams, water diversions, and other features, provide the data presented in Tables 4, 5, 6, 7, 8, and 18. Table 2 defines the information specifying the location, ownership, fish utilization, and barrier type of each stream crossing. Table 3a defines the culvert descriptors and core physical measurements required for Level A fish passage barrier assessment. Table 3b describes the physical measurements required for Level B fish passage barrier assessment. Table 4 shows the data necessary for fishways, Table 5 for dams, Table 6 for gravity diversions, Table 7 for pump diversions, and Table 8 for other features. Table 9 describes the habitat summary information from the physical habitat surveys. The Priority Index Model is described in Table 17 for fish passage barriers, and Table 18 for unscreened or ineffectively screened water diversions. Within these tables the attribute values in **BOLD** text are mandatory choices, and should not be deviated from. Groups using different values in their databases are responsible for converting them to the specified values prior to submitting data for inclusion in the WDFW database. Suggested additions or changes may be submitted with a written explanation to WDFW for review.

5.2 Site/Culvert Identification

Each stream crossing may contain single or multiple culverts. WDFW protocol requires that each culvert be measured individually and treated as a separate record in the database. In order for the database to function properly each stream crossing and culvert must have a unique identifier. This is accomplished using two fields as a compound key. The fields are SiteID and Sequencer (format described in Tables 2 and 3a) and their relationship is as follows. Each stream crossing is assigned a unique SiteID value which differentiates it from other crossings. Each culvert within a crossing is assigned a Sequencer value. Culvert records in multiple culvert crossings are related to each other by the common SiteID and differentiated by the Sequencer. Once SiteID's are established they should not be changed. They are used to track, link, and update records. Changing ID's may lead to duplicate records resulting in erroneous analyses. If ID's are changed it is imperative to supply a key to update existing values.

This form of record keeping may lead to repetition of data since some of the data are specific to the crossing while others are specific to the culverts therein. For Tables 3a and 3b it is not necessary to repeat site specific data in each record associated with a multi-culvert crossing. It is critical that all the site specific data be present in at least one of the records associated with the crossing, preferably the first in the sequence.

5.3 Latitude/Longitude

The inclusion of *accurate* latitude and longitude based upon the World Geodetic Survey 1984 datum (WGS84) is critical to the mapping functionality of this database. Please supply this information in decimal degrees (DDD.dddddddd), *not* in degrees-minutes-seconds (DDD MM SS). If the Global Positioning System (GPS) is being used to obtain the geographic coordinates it is preferable to use a receiver capable of providing differentially corrected coordinates (either real-time or post processed). If coordinates are being derived from maps, use USGS 7.5 minute quadrangles (1:24,000) and convert from the North American Datum 1927 (NAD27) to the WGS84 datum.

5.4 Data Exchange

WDFW has developed a distributable copy of the fish passage and screening database application. The export function from the database application will generate the output files necessary for data exchange. If the WDFW database application is not being used, any database application and design (flat file vs relational) may be used to store and manipulate data. However, for data exchange, standard comma and quote delimited ASCII files are used. The structure for these files are presented in Tables 19, 20a, 20b, 21, 22, 23, 24, 25, 26, 27, and 28. These file formats correspond with the data described in Tables 2, 3a, 3b, 4, 5, 6, 7, 8, 9, 17, and 18, respectively. Again, the level of inventory effort will determine which files are used. Data from Table 2 must be submitted using the format presented in Table 19 with the resultant ASCII file named SITE.TXT. Data from Table 3a must be submitted using the format presented in Table 20a with the resultant ASCII file named CULVERT.TXT. Data from Table 3b must be submitted using the format presented in Table 20b with the resultant ASCII file named LEVELB.TXT. Data from Table 4 must be submitted using the format presented in Table 21 with the resultant ASCII file named FISHWAY.TXT. Data from Table 5 must be submitted using the format presented in Table 22 with the resultant ASCII file named DAM.TXT. Data from Table 6 must be submitted using the format presented in Table 23 with the resultant ASCII file named GRAVITY.TXT. Data from Table 7 must be submitted using the format presented in Table 24 with the resultant ASCII file named PUMP.TXT. Data from Table 8 must be submitted using the format presented in Table 25 with the resultant ASCII file named OTHER.TXT. Data from Table 9 must be submitted using the format presented in Table 26 with the resultant ASCII file named HABSUM.TXT. Data from Table 17 must be submitted using the format presented in Table 27 with the resultant ASCII file named BARRIERPI.TXT. Data from Table 18 must be submitted using the format presented in Table 28 with the resultant ASCII file named SCREENPI.TXT. Please note that the P value described in the Priority Index is not included in the ASCII file. This value is constant for each species and thus does not need to be supplied. Do not deviate from these formats as errors will result. Please submit only completed records which have been thoroughly checked for errors and format.

5.5 General Data Entry Conventions

- DO NOT include unit symbols in numeric fields, they are assumed.
- Percentage fields are reported in values between 0 and 100. DO NOT include % symbol, it is assumed.
- Coded entries are to be in UPPERCASE.
- General text entries are to be in lowercase.
- Capitalize the first letter of proper nouns.
- For entries involving water bodies (stream, trib to fields) use the following abbreviations without punctuation:

River - R	Middle Fork - MF
Creek - Cr	Lake - Lk
North Fork - NF	Slough - Sl
South Fork - SF	

•

For entries involving road names (road name, address fields) use the following abbreviations without punctuation:

Avenue - Ave	Place - Pl
Road - Rd	Highway - Hwy
Street - St	State Route - SR
Court - Ct	Interstate - I
Lane - Ln	

- Leave fields blank if there is no data.

Table 19. Table structure used to generate ASCII file for exchange of location, ownership, fish utilization, and feature type (SITE) data. Field types include A - alphanumeric and N - numeric. Field size indicates the required and/or maximum number of characters allowed in each field. Mandatory values and/or formats are also indicated.

Attribute	Field Name	Type	Size	Values or Formats
Site ID	SiteID	A	20	
Latitude	Lat	A	30	DD.dddddddd
Longitude	Long	A	30	-DDD.dddddddd
Reported By	Idby	A	25	
Road Name	Road Name	A	25	
County	County	A	15	
Quarter Section	Qsec	A	2	NE, NW, SE, SW
Section	Section	N		

Table 19. (Cont.)

Attribute	Field Name	Type	Size	Values or Formats
Township	Township	A	3	XXN
Range	Range	A	3	XXE or XXW
Location/Directions	Location	A	255	
Stream	Stream	A	25	
WRIA	WRIA	A	10	
Tributary To	Trib To	A	25	
River Mile	RM	N		
Basin Area	Basin Area	N		
Basin Precipitation	Precip	N		
Fish Use	Fish Use	A	7	yes, no, unknown
Decision Criteria	FU Criteria	A	20	mapped, physical, biological, other
Species	Species	A	35	SO/CH/PK/CO/CK/SH/CT/RB/DB/EB/BT
Feature Type	FeaType	A	10	culvert, dam , fishway, gravity diversion, pump diversion, other
Site Comments	STComment	A	255	
Report Logged	RL	L		T(rue) or F(alse)
Field Review	FR	L		T(rue) or F(alse)
Threshold Determination	TD	L		T(rue) or F(alse)
Downstream Check	DC	L		T(rue) or F(alse)
Physical Survey	PS	L		T(rue) or F(alse)
Expanded Threshold Determination	ETD	L		T(rue) or F(alse)
Owner Type	OwnerType	A	25	
Name	OwnName	A	30	
Address	Address	A	30	
Address2	Address2	A	30	
City	City	A	15	
State	State	A	2	
Zipcode	Zipcode	A	10	
Phone	Phone	A	12	
Contact&Phone	Contact	A	20	

Table 20a. Table structure used to generate ASCII file for exchange of culvert descriptors and core physical measurement (CULVERT) data. Field names corresponds to those used for a Level A culvert analysis. Field types include A - alphanumeric and N - numeric. Field size indicates the required and/or maximum number of characters allowed in each field. Mandatory values and/or formats are also indicated.

Attribute	**Field Name**	**Type**	**Size**	**Values or Formats**
Site Identifier	SiteID	A	20	
Sequencer	Sequencer	A	3	
Field Review Crew	FR Crew	A	25	
Field Review Date	FR Date	A	10	MM/DD/YYYY
Shape	Shape	A	3	RND, BOX, ARCH, SQSH, ELL, OTH
Material	Material	A	3	PCC, CPC, CST, SST, CAL, SPS, SPA, TMP, MRY, PVC, OTH
Span	Span/Dia	N		
Rise	Rise	N		
Water Depth Inside Culvert	WDIC	N		
Outfall Drop	Outfalldrp	N		
Length	Length	N		
Slope	CulvSlope	N		
Streambed Material in Culvert	BedMat	A	3	yes, no
Water Velocity Inside Culvert	Velocity	N		
Apron	Apron	A	10	upstream, downstream, both, none
Tidegate	Tidegate	A	3	yes, no
Plunge Pool Length	Pplength	N		
Plunge Pool Maximum Depth	Ppmaxdepth	N		
Plunge Pool OHW Width	Ppohwwidth	N		
Average Streambed Width	AvBedWidth	N		
Culvert Span to Streambed Width Ratio	CulToeRa	N		
Barrier	Barrier	A	7	yes, no, unknown
Problem	Problem	A	30	outfall drop, velocity, depth, slope
Repair Status	RepairStat	A	5	blank, OK, NG,UD, RR, FX, FX/FW
Comments	FcComments	A	255	

Table 20b. Table structure used to generate ASCII file for exchange of Level B physical measurement (LEVELB) data. Field names corresponds to those used to conduct a Level B culvert analysis. Field types include A - alphanumeric and N - numeric. Field size indicates the required and/or maximum number of characters allowed in each field. Mandatory values and/or formats are also indicated.

Attribute	Field Name	Type	Size	Values or Formats
Site Identifier	SiteID	A	20	
Sequencer	Sequencer	A	3	
Reference Point Datum	Datum	N		
Reference Point Location	DatumLoc	A	10	
Culvert Invert Elevation - Upstream	USIE	N		
Culvert Streambed Elevation-Upstream	USCBE	N		
Corrugation	Corrug	A	8	smooth, 0.5X2.66, 1X3, 2X6, paved
Culvert Invert Elevation - Downstream	DSIE	N		
Culvert Streambed Elevation-Downstream	DSCBE	N		
DS Control X-Section - Station 0	DSST0	N		
Downstream Control - Elevation 0	DSEL0	N		
DS Control X-Section - Station 1	DSST1	N		
DS Control X-Section - Elevation 1	DSEL1	N		
DS Control X-Section - Station 2	DSST2	N		
DS Control X-Section - Elevation 2	DSEL2	N		
DS Control X-Section - Station 3	DSST3	N		
DS Control X-Section - Elevation 3	DSEL3	N		
DS Control X-Section - Station 4	DSST4	N		
DS Control X-Section - Elevation 4	DSEL4	N		
DS Control X-Section - Station 5	DSST5	N		
DS Control X-Section - Elevation 5	DSEL5	N		
DS Control X-Section - Station 6	DSST6	N		
DS Control X-Section - Elevation 6	DSEL6	N		
DS Control Water Surface Elevation	DSCWSE	N		
DS Control OHW Elevation	DSCOHWElv	N		
Water Surface Elevation 15m downstream of DS Control	DSWSElv	N		
Channel Dominant Substrate	CHDomSub	A	7	riprap, boulder, cobble, gravel, sand mud, bedrock

Table 21. Table structure used to generate ASCII file for exchange of fishway data. Field types include A - alphanumeric, N - numeric, S - short integer, and D - Date. Field size indicates the required and/or maximum number of characters allowed in each field. Mandatory values and/or formats are also indicated.

Attribute	Field Name	Type	Size	Values or Formats
Site Identifier	SiteID	A	20	
Field Review Crew	FRCrew	A	25	
Field Review Date	FRDate	D		MM/DD/YYYY
Fishway Type	FWType	A	12	BC, BF, CC, SP, GC, LC, RC, SCC, TH, WP, VS, PC, BL, PLC, RCC
Modifies	Modify	A	10	culvert, dam, falls, habitat
Construction Year	Consyr	S		YYYY
Number of Pools	NoPools	S		
Entrance Pool Depth	EntDepth	N		
Pool Head Difference	HeadDiff	A	25	
Number of Baffles	BaffleNo	S		
Baffle Type	Baffletype	A	25	concrete, rock, metal, plastic, wood, other
Number of Weirs	Weir No	S		
Weir Type	Weirtype	A	25	concrete, rock, metal, plastic, wood, other
Grade Control Location	BedContLoc	A	10	none, upstream, downstream, both
Description	Descrip	A	255	
Habitat Gain	Habitat	N		
Comments	Fwcomment	A	255	

Table 22. Table structure used to generate ASCII file for exchange of dam data. Field types include A - alphanumeric, N - numeric, and D - Date. Field size indicates the required and/or maximum number of characters allowed in each field. Mandatory values and/or formats are also indicated.

Attribute	Field Name	Type	Size	Values or Formats
Site Identifier	SiteID	A	20	
Field Review Crew	FRCrew	A	25	
Field Review Date	FRDate	D		MM/DD/YYY
Dam Name	DamName	A	30	
Reservoir Name	ResvName	A	30	
Type	Type	A	15	CN, RE, MS, MT, ER, TB, OT
Span	Span	A	7	full, partial
Length	Length	N		
Height	Height	N		
Water Surface Difference	WaterSurfDiff	N		
Plunge Pool Depth	PPDepth	N		
Description/Problem	Problem	A	200	
Primary Purpose	PrimePurp	A	15	D, C, H, I, N, P, Q, R, S, T, O
Barrier	Barrier	A	7	yes, no, unknown
Repair Status	RepairStatus	A	5	blank, OK, NG, UD, RR, FX, FX/FW
Comments	DComments	A	200	

Table 23. Table structure used to generate ASCII file for exchange of gravity diversion data. Field types include A - alphanumeric, N - numeric, and D - Date. Field size indicates the required and/or maximum number of characters allowed in each field. Mandatory values and/or formats are also indicated.

Attribute	Field Name	Type	Size	Values or Formats
Site Identifier	SiteID	A	20	
Field Review Crew	FRCrew	A	25	
Field Review Date	FRDate	D		MM/DD/YYYY
Access	Access	A	10	vehicle, foot, ORV, other
Point of Diversion	POD	A	2	LB, RB, IS
Diversion Dam	DvsnDam	A	3	yes, no
Headgate	Headgate	A	3	yes, no
Diversion Ditch Area	DivDitchArea	N		
Flow	Flow	N		gallons per minute
Derivation	Derivation	A	12	measured, verbal, water right, calculated, other
Screened	Screened	A	7	yes, no, unknown
Screen Condition	ScFunction	A	7	OK, MN
Problems	Problems	A	200	

Table 24. Table structure used to generate ASCII file for exchange of pump diversion data. Field types include A - alphanumeric, N - numeric, and D - Date. Field size indicates the required and/or maximum number of characters allowed in each field. Mandatory values and/or formats are also indicated.

Attributes	Field Name	Type	Size	Values or Formats
Site Identifier	SiteID	A	20	
Field Review Crew	FRCrew	A	25	
Field Review Date	FRDate	D		MM/DD/YYYY
Access	Access	A	10	vehicle, foot, ORV, other
Point of Diversion	POD	A	2	LB, RB, IS
Intake Location	Location	A	2	RB, OS, LN, CV
Fish Bypass	Bypass	A	3	yes, no
Diversion Dam	DvsnDam	A	3	yes, no
Screened	Screened	A	7	yes, no, unknown
Screen Type	ScreenType	A	3	BX, BR, CY, CN, OTH, XX
Screen Material	ScreenMat	A	3	WM, PB, PM, PP, EM, OTH
Diameter	Diameter	N		
Height	Height	N		
Length	Length	N		
Area	Area	N		
Opening Dimension	OpenDmnsn	A	20	(should this be numeric)
Screen Condition	ScFunction	A	7	OK, MN
Problem	Problem	A	200	
Intake Pipe Outside Diameter	PipeODia	N		
Pump Type	PumpType	A	15	centrifugal, turbine
Meter/Pole Number	Meter No	A	15	

Table 25. Table structure used to generate ASCII file for exchange of data on features identifies as "other". Field types include A - alphanumeric, N - numeric, and D - Date. Field size indicates the required and/or maximum number of characters allowed in each field. Mandatory values and/or formats are also indicated.

Attribute	Field Name	Type	Size	Values or Formats
Site Identifier	SiteID	A	20	
Field Review Crew	FRCrew	A	25	
Field Review Date	FRDate	D		MM/DD/YYYY
Description	Description	A	255	
Barrier	Barrier	A	7	yes, no, unknown
Repair Status	RepairStatus	A	5	blank, OK, NG, UD, RR, FX, FX/FW

Table 26. Table structure used to generate ASCII file for exchange of habitat summary (HABSUM) data. Field types include A - alphanumeric and N - numeric. Field size indicates the required and/or maximum number of characters allowed in each field. Mandatory values and/or formats are also indicated.

Attribute	Field Name	Type	Size	Value or Format
Site Identifier	SiteID	A	20	
Habitat Assessment Method	SurveyType	A	5	FS, RSFS, ETD
Downstream Check Date	Dsck Date	A	10	MM/DD/YYYY
Downstream Check Length	Ds Length	N		
Number of Downstream Barriers	No Ds Barr	N		
Physical Survey Date	Ps Date	A	10	MM/DD/YYYY
Physical Survey Length	Ps Length	N		
Number of Upstream Barriers	No Us Barr	N		
Spawning Area	Spawn Area	N		
Rearing Area	Rear Area	N		

Table 27. Table structure used to generate ASCII file for exchange of priority index model variables and results (BARRIERPI) data. Field types include A - alphanumeric and N - numeric. Field size indicates the required and/or maximum number of characters allowed in each field. Mandatory values, for species present, are also indicated.

Attribute	Field Name	Type	Size	Value or Format
Site Identifier	SiteID	A	20	
Type of feature associated with this information.	Feature	A	15	**barrier**
Proportion of Fish Passage Improvement - Sockeye Salmon	Bso	N		0.67
Production Habitat Gain - Sockeye Salmon	Hso	N		
Mobility Modifier - Sockeye Salmon	Mso	N		2
Species Condition Modifier - Sockeye Salmon	Dso	N		1, 2, 3
Cost Modifier - Sockeye Salmon	Cso	N		1, 2, 3
Priority Index - Sockeye Salmon	PIso	N		
Proportion of Fish Passage Improvement - Chum Salmon	Bch	N		0.67
Production Habitat Gain - Chum Salmon	Hch	N		
Mobility Modifier - Chum Salmon	Mch	N		2
Species Condition Modifier - Chum Salmon	Dch	N		1, 2, 3
Cost Modifier - Chum Salmon	Cch	N		1, 2, 3
Priority Index - Chum Salmon	PIch	N		
Proportion of Fish Passage Improvement - Pink Salmon	Bpk	N		0.67
Production Habitat Gain - Pink Salmon	Hpk	N		
Mobility Modifier - Pink Salmon	Mpk	N		2
Species Condition Modifier - Pink Salmon	Dpk	N		1, 2, 3
Cost Modifier - Pink Salmon	Cpk	N		1, 2, 3
Priority Index - Pink Salmon	PIpk	N		
Proportion of Fish Passage Improvement - Coho Salmon	Bco	N		0.67
Production Habitat Gain - Coho Salmon	Hco	N		
Mobility Modifier - Coho Salmon	Mco	N		2
Species Condition Modifier - Coho Salmon	Dco	N		1, 2, 3
Cost Modifier - Coho Salmon	Cco	N		1, 2, 3
Priority Index - Coho Salmon	PIco	N		
Proportion of Fish Passage Improvement - Chinook Salmon	Bck	N		0.67

Table 27. (Cont.)

Attribute	Field Name	Type	Size	Value or Format
Production Habitat Gain - Chinook Salmon	Hck	N		
Mobility Modifier - Chinook Salmon	Mck	N		2
Species Condition Modifier - Chinook Salmon	Dck	N		1, 2, 3
Cost Modifier - Chinook Salmon	Cck	N		1, 2, 3
Priority Index - Chinook Salmon	PIck	N		
Proportion of Fish Passage Improvement - Steelhead	Bsh	N		0.67
Production Habitat Gain - Steelhead	Hsh	N		
Mobility Modifier - Steelhead	Msh	N		2
Species Condition Modifier - Steelhead	Dsh	N		1, 2, 3
Cost Modifier - Steelhead	Csh	N		1, 2, 3
Priority Index - Steelhead	PIsh	N		
Proportion of Fish Passage Improvement - Searun Cutthroat Trout	Bct	N		0.67
Production Habitat Gain - Searun Cutthroat Trout	Hct	N		
Mobility Modifier - Searun Cutthroat Trout	Mct	N		2
Species Condition Modifier - Searun Cutthroat Trout	Dct	N		1, 2, 3
Cost Modifier - Searun Cutthroat Trout	Cct	N		1, 2, 3
Priority Index - Searun Cutthroat Trout	PIct	N		
Proportion of Fish Passage Improvement - Resident Cutthroat/Rainbow Trout	Brb	N		0.67
Production Habitat Gain - Resident Cutthroat/Rainbow Trout	Hrb	N		
Mobility Modifier - Resident Cutthroat/Rainbow Trout	Mrb	N		1
Species Condition Modifier - Resident Cutthroat/Rainbow Trout	Drb	N		1, 2, 3
Cost Modifier - Resident Cutthroat/Rainbow Trout	Crb	N		1, 2, 3
Priority Index - Resident Cutthroat/Rainbow Trout	PIrb	N		
Proportion of Fish Passage Improvement - Dolly Varden/Bull Trout	Bdb	N		0.67
Production Habitat Gain - Dolly Varden/Bull Trout	Hdb	N		
Mobility Modifier - Dolly Varden/Bull Trout	Mdb	N		1, 2

Table 27. (Cont.)

Attribute	Field Name	Type	Size	Value or Format
Species Condition Modifier - Dolly Varden/Bull Trout	Ddb	N		1, 2, 3
Cost Modifier - Dolly Varden/Bull Trout	Cdb	N		1, 2, 3
Priority Index - Dolly Varden/Bull Trout	PIdb	N		
Proportion of Fish Passage Improvement - Brook Trout	Beb	N		0.67
Production Habitat Gain - Brook Trout	Heb	N		
Mobility Modifier - Brook Trout	Meb	N		0, 1
Species Condition Modifier - Brook Trout	Deb	N		1, 2, 3
Cost Modifier - Brook Trout	Ceb	N		1, 2, 3
Priority Index - Brook Trout	PIeb	N		
Proportion of Fish Passage Improvement - Brown Trout	Bbt	N		0.67
Production Habitat Gain - Brown Trout	Hbt	N		
Mobility Modifier - Brown Trout	Mbt	N		0, 1
Species Condition Modifier - Brown Trout	Dbt	N		1, 2, 3
Cost Modifier - Brown Trout	Cbt	N		1, 2, 3
Priority Index - Brown Trout	PIbt	N		
Total Priority Index Value for all the species.	PI TOTAL	N		

Table 28. Table structure used to generate ASCII file for exchange of priority index model variables and results (SCREENPI) data. Field types include A - alphanumeric and N - numeric. Field size indicates the required and/or maximum number of characters allowed in each field. Mandatory values, for species present, are also indicated.

Attribute	Field Name	Type	Size	Value or Format
Site Identifier	SiteID	A	20	
Type of feature associated with this information.	Feature	A	15	**screen**
Flow - Sockeye Salmon	Qso	N		
Mobility Modifier - Sockeye Salmon	Mso	N		2
Species Condition Modifier - Sockeye Salmon	Dso	N		1, 2, 3
Cost Modifier - Sockeye Salmon	Cso	N		1, 2, 3
Priority Index - Sockeye Salmon	PIso	N		
Flow - Chum Salmon	Qch	N		
Mobility Modifier - Chum Salmon	Mch	N		2
Species Condition Modifier - Chum Salmon	Dch	N		1, 2, 3
Cost Modifier - Chum Salmon	Cch	N		1, 2, 3
Priority Index - Chum Salmon	PIch	N		
Flow - Pink Salmon	Qpk	N		
Mobility Modifier - Pink Salmon	Mpk	N		2
Species Condition Modifier - Pink Salmon	Dpk	N		1, 2, 3
Cost Modifier - Pink Salmon	Cpk	N		1, 2, 3
Priority Index - Pink Salmon	PIpk	N		
Flow - Coho Salmon	Qco	N		
Mobility Modifier - Coho Salmon	Mco	N		2
Species Condition Modifier - Coho Salmon	Dco	N		1, 2, 3
Cost Modifier - Coho Salmon	Cco	N		1, 2, 3
Priority Index - Coho Salmon	PIco	N		
Flow - Chinook Salmon	Qck	N		
Mobility Modifier - Chinook Salmon	Mck	N		2
Species Condition Modifier - Chinook Salmon	Dck	N		1, 2, 3
Cost Modifier - Chinook Salmon	Cck	N		1, 2, 3

Table 28. (Cont.)

Attribute	Field Name	Type	Size	Value or Format
Priority Index - Chinook Salmon	PIck	N		
Flow - Steelhead	Qsh	N		
Mobility Modifier - Steelhead	Msh	N		2
Species Condition Modifier - Steelhead	Dsh	N		1, 2, 3
Cost Modifier - Steelhead	Csh	N		1, 2, 3
Priority Index - Steelhead	PIsh	N		
Flow - Searun Cutthroat Trout	Qct	N		
Mobility Modifier - Searun Cutthroat Trout	Mct	N		2
Species Condition Modifier - Searun Cutthroat Trout	Dct	N		1, 2, 3
Cost Modifier - Searun Cutthroat Trout	Cct	N		1, 2, 3
Priority Index - Searun Cutthroat Trout	PIct	N		
Flow - Resident Cutthroat/Rainbow Trout	Qrb	N		
Mobility Modifier - Resident Cutthroat/Rainbow Trout	Mrb	N		1
Species Condition Modifier - Resident Cutthroat/Rainbow Trout	Drb	N		1, 2, 3
Cost Modifier - Resident Cutthroat/Rainbow Trout	Crb	N		1, 2, 3
Priority Index - Resident Cutthroat/Rainbow Trout	PIrb	N		
Flow - Dolly Varden/Bull Trout	Qdb	N		
Mobility Modifier - Dolly Varden/Bull Trout	Mdb	N		1, 2
Species Condition Modifier - Dolly Varden/Bull Trout	Ddb	N		1, 2, 3
Cost Modifier - Dolly Varden/Bull Trout	Cdb	N		1, 2, 3
Priority Index - Dolly Varden/Bull Trout	PIdb	N		
Flow - Brook Trout	Qeb	N		
Mobility Modifier - Brook Trout	Meb	N		0, 1
Species Condition Modifier - Brook Trout	Deb	N		1, 2, 3
Cost Modifier - Brook Trout	Ceb	N		1, 2, 3
Priority Index - Brook Trout	PIeb	N		
Flow - Brown Trout	Qbt	N		
Mobility Modifier - Brown Trout	Mbt	N		0, 1

Table 28. (Cont.)

Attribute	Field Name	Type	Size	Value or Format
Species Condition Modifier - Brown Trout	Dbt	N		1, 2, 3
Cost Modifier - Brown Trout	Cbt	N		1, 2, 3
Priority Index - Brown Trout	PIbt	N		
Total Priority Index Value for all the species.	PI TOTAL	N		

6. Technical Assistance

For technical assistance involving field surveys, please contact Mike Barber at (360) 902-2555 or Jim Lenzi at (360) 902-2556. For technical assistance regarding database structure and content please contact Brian Benson at (360) 902-2570.

7. Literature Cited

Chow, V.T. 1959. Open Channel Hydraulics. McGraw-Hill Book Company, Inc. 680 pp.

Phinney, L.A., and P. Bucknell. 1975. A catalog of Washington streams and salmon utilization. Vol. 2 - Coastal Region. Wash. Dept. Fish. Olympia, WA.

Washington Department of Ecology. 1972. River Mile Index Mainstem Columbia River.

Washington Department of Fisheries, Washington Department of Wildlife, and Western Washington treaty Indian Tribes. 1993. 1992 Washington State Salmon and Steelhead Stock Inventory. Olympia. 212 pp.

Washington Department of Fish and Wildlife. 1997. Washington State Salmonid Stock Inventory Appendix Bull Trout/Dolly Varden. Washington Department of Fish and Wildlife. Olympia, WA. 437 pp.

Williams, R.W., R.M. Laramie, and J.J. Ames. 1975. A catalog of Washington streams and salmon utilization. Vol. 1 - Puget Sound. Wash. Dept. Fish. Olympia, WA.

APPENDIX A

Field Forms

SITE IDENTIFICATION FIELD FORM (6/22/00)

[1]Site ID:________________________ GPS Position Taken: ☐Yes ☐No

[2]Identifying Group:_______________ [3]Road Name:___________________

[4]Milepost:_______________________ [5]County:________________________

[6]¼ Sec:________ Section:________ Township:______ Range:_________

[7]Location/Directions:____

____

____

[8]Stream Name:_________________________ [9]WRIA #:_______________

[10]Tributary To:_________________________ [11]River Mile:_____________

[12]Fish Use: ☐Yes ☐No ☐Unknown

[13]Fish Use Criteria: ☐Mapped ☐Physical ☐Biological ☐Other

[14]Species: ☐Chinook ☐Chum ☐Sockeye ☐Coho ☐Pink
☐Steelhead ☐Resident Cutthroat/Rainbow Trout
☐Searun Cutthroat ☐Bull/Dolly Varden Trout
☐Brook Trout ☐Brown Trout

[15]Feature Type: ☐Culvert ☐Fishway ☐Dam ☐Gravity Diversion
☐Pump Diversion ☐Other

[16]Site Comments:____

____

____

[17]Evaluation Level: ☐RL ☐FR ☐DC ☐PS ☐TD ☐ETD

[18]OWNER INFORMATION

Type: ☐Federal ☐State ☐County ☐City ☐Tribal ☐Private ☐Other

Name:____

Street Address:____

Mailing Address:____

City:___________________________ State:______ Zip:________________

Phone #:________________________

Contact Name & Phone#:____

____

SITE FORM INSTRUCTIONS

1.) Site ID number (unique site identifier).

2.) Group or agency making report.

3.) Road name - name of road (if any) on which the barrier resides.

4.) Road milepost to the nearest 1/10. **WDFW crews only.**

5.) County name.

6.) Legal description.

7.) Directions to the site.

8.) Name of stream associated with the site.

9.) Watershed Resource Inventory Area number.

10.) Name of stream at first major confluence.

11.) River mile to the nearest 1/10 from first major confluence.

12.) Indicate whether or not the stream is fish bearing.

13.) How was fish bearing determination made?

14.) Fish species known to be present in the stream or fish species that would be expected to benefit from the correction of the barrier.

15.) Type of feature encountered.

16.) Any comments relating to the operation or characteristics of the structure identified above.

17.) Completed level of evaluation (multiple entries allowed). Codes: RL - report logged, FR - field review, DC - downstream check, PS - physical survey, TD - threshold determination, ETD - expanded threshold determination.

18.) Owner information (if known).

CULVERT EVALUATION FIELD FORM (Level A Anal.) (6/22/00)

[1]Site ID:______________________

[2]Sequencer:____________________

[3]Field Review Team

Crew:__________________

Date:__________________

CULVERT DESCRIPTION

[4]Shape: ☐RND ☐BOX ☐ARCH ☐SQSH ☐ELL ☐OTH

[5]Material: ☐PCC ☐CPC ☐CST ☐SST ☐CAL ☐SPS ☐SPA ☐PVC ☐TMB ☐MRY ☐OTH

[6]Span/Dia:_________ [7]Rise__________ [8]H_2O Depth in Culv:_________

[9]Outfall Drop:__________ [10]Length___________ [11]Slope:___________

[12]Streambed Material Throughout Culvert: ☐Yes ☐No ☐Unknown

[13]Velocity:_________ [14]Apron: ☐None ☐US ☐DS ☐Both

[15]Tidegate: ☐Yes ☐No [16]Fill Depth:________________________

PLUNGE POOL DESCRIPTION

[17]Length:_________________ [18]Maximum Depth:_________________

[19]OHW Width:_____________________

CHANNEL DESCRIPTION

[20]Average Streambed Toe Width:______________________________

[21]Culvert Span/Streambed Toe Width Ratio:______________________

SUMMARY INFORMATION

[22]Maintenance Required: ☐No ☐Yes/FP ☐Yes/OM

[23]Recheck: ☐No ☐GPS ☐Photo ☐Pass HF ☐Pass LF ☐LB

[24]Barrier: ☐Yes ☐No ☐Unknown

[25]%Passability: ☐0 ☐33 ☐67 ☐100

[26]Problem w/Culvert: ☐Outfall Drop ☐Slope ☐Velocity ☐Depth

[27]Repair Status: ☐OK ☐NG ☐RR ☐FX ☐FX/FW ☐UD

[28]Comments:____

____

____

____

LEVEL A FORM INSTRUCTIONS

1.) Site ID number (Unique site identifier)
2.) Sequencer - If 1 culvert at site then 1.1, if 2 then 1.2 or 2.2
3.) Field review team information
4.) Cross-sectional shape of the culvert. RND - round, BOX - square or rectangular, ARCH - bottomless, SQSH - squash (pipe arch), ELL - elliptical, OTH - other
5.) Material Pipe is composed of. PCC - pre-cast concrete, CPC - cast-in-place concrete, CST - corrugated steel, SST - smooth steel, CAL - corrugated aluminum, SPS - structural plate steel, SPA - structural plate aluminum, PVC - polyvinylchloride, TMB - timber, MRY - masonry, OTH - other
6.) Maximum width of the culvert to the nearest 0.01 meter.
7.) Height of the culvert to the nearest 0.01 meter.
8.) Water depth in culvert to the nearest 0.01 meter.
9.) Difference between the water surface in the culvert at the DS end and the water surface immediately DS of the culvert.
10.) Length of the culvert to the nearest 0.1 meter.
11.) % slope of the culvert (USIE-DSIE/Length)*100
12.) Is there streambed material throughout the culvert?
13.) Water velocity inside the culvert in meters per second.
14.) Is there an apron attached to either or both ends of the culvert?
15.) Is there a tidegate associated with the culvert?
16.) Estimated height of the road fill. **WDFW crews only.**
17.) Length of the plunge pool to the 0.01 meters.
18.) Maximum depth of the plunge pool to the nearest 0.01 meters.
19.) Ordinary high water width of the plunge pool to the nearest 0.01 meters.
20.) The average streambed toe width outside of the influence of the culvert to the nearest 0.01 meters.
21.) The ratio of the width of the culvert to the toe width of the stream.
22.) Does the culvert require maintenance? If yes, does the need for maintenance affect fish passage? If so, check the yes/fp block. **WDFW crews only.**
23.) Is there a need to recheck the culvert in the future? No - no need, GPS - GPS position needed, Photo - photo needed, Pass HF - evaluate passage at high flow, Pass LF - evaluate passage at low flow, LB - Level B data required. **WDFW crews only.**
24.) Barrier status of the culvert.
25.) Estimated percent passability of the culvert. **WDFW crews only.**
26.) If the culvert is a barrier, what is the problem? Check all that apply.
27.) The current repair status of the culvert. OK - non-barrier, NG - no gain, RR - repair required, FX - fixed, FX/FW - repaired and converted to a fishway, UD - undetermined, habitat assessment incomplete.
28.) Comments regarding the culvert.

CULVERT EVALUATION FIELD FORM (Level B Analysis) (6/22/00)

[1]Site ID:______________________

[2]Sequencer:___________________

[4]Datum:________________________

[5]Datum Location:_______________

____

____

____

[3]Field Review Team

Crew:____________________

Date:____________________

UPSTREAM MEASUREMENTS

[6]Invert Elevation:___________ [7]Culvert Bed Elevation:______________

[8]Corrugation: □Smooth □0.5"x2.66" □1"x3" □2"x6" □Paved Invert □Other____________

DOWNSTREAM MEASUREMENTS

[9]Invert Elevation:___________ [10]Culvert Bed Elevation:_____________

[11]DOWNSTREAM CONTROL CROSS-SECTION

	Top LB	Toe LB	Bed 1	Bed 2	Bed 3	Toe RB	Top RB
Station	0						
Bed Elevation							

[12]Water Surface Elevation at DS Control:_________________________

[13]OHW Elevation at DS Control:________________________________

[14]Water Surface Elevation 15m DS of DS Control:__________________

[15]Dominant Channel Substrate Composition: □Bedrock □Boulder □Riprap □Cobble □Gravel □Sand □Mud

LEVEL B FORM INSTRUCTIONS

1.) Site ID number (Unique site identifier)
2.) Sequencer - If 1 culvert at site then 1.1, if 2 then 1.2 (meaning culvert 1 of 2) or 2.2 (meaning culvert 2 of 2).
3.) Field review team information.
4.) What is the datum (benchmark) elevation?
5.) Location of the datum.
6.) Elevation of the invert (bottom) of the culvert at the upstream end to the nearest 0.01 meter.
7.) The elevation of the streambed, if any, at the upstream end of the culvert.
8.) Corrugation dimensions in inches, measured valley to peak and peak to peak. If the corrugations at the culvert invert are completely covered with asphalt or concrete, enter paved.
9.) Elevation of the invert (bottom) of the culvert at the downstream end to the nearest 0.01 meter.
10.) The elevation of the streambed, if any, at the downstream end of the culvert.
11.) The downstream control is the normally head of the first riffle downstream of the culvert. Start at the top of left bank (station 0, facing downstream) and proceed to the right taking up to 7 elevations, to the nearest 0.01 meters, to describe the cross-sectional profile of the stream. The station is the distance, to the nearest 0.01 meters, from station 0 to the location the bed elevation was taken.
12.) Water surface elevation at the downstream control.
13.) Ordinary high water elevation at the downstream control.
14.) Water surface elevation 15 meters downstream of the downstream control to the nearest 0.01 meter.
15.) Dominant channel substrate between the downstream end of the culvert and the point 15 meters downstream of the downstream control.

Level B Analysis Elevations Worksheet (6/22/00)

Site ID:_________________________

Datum Elevation (Benchmark):________________________________

Datum Location:____

____

	BS	HI	RH	FS	ELEV	DEPTH	WSE
Benchmark							
US Invert Elev							
US Culvert Bed Elev							
DS Invert Elev							
DS Culvert Bed Elev							
DS Water Surf. Elev							
Downstream Control Cross-Section							
	STA						
Top LB ST0	0						
Toe LB ST1							
Bed 1 ST2							
Bed 2 ST3							
Bed 3 ST4							
Toe RB ST5							
Top RB ST6							
OHW Elev.							

Average Water Surface Elevation at Downstream Control (WSE):_____

Elevation calculations:

1) Laser Reading (+): Subtract the laser reading from the rod height (RH) then subtract the remainder from the instrument height (HI).

2) Laser Reading (-): Subtract both the laser reading and the rod height (RH) from the Instrument height (HI).

FISHWAY EVALUATION FORM (6/22/00)

[2]Field Review Team
Crew:________________
Date:________________

[1]Site ID:______________________

[3]Barrier: ☐Yes ☐No ☐Unk ☐NLE

[4]%Passability: ☐0 ☐33 ☐67 ☐100

[5]Inspection Frequency: ☐A ☐B ☐C ☐D ☐E

[6]Fishway Type: ☐BC ☐BF ☐BL☐CC ☐GC ☐LC ☐PC ☐PLC ☐RC ☐SCC ☐SP ☐T&H ☐VS ☐WP ☐RCC

[7]Modifies: ☐Culvert ☐Dam ☐Falls ☐Habitat

[8]Construction Year:_________

[9]Number of Pools:____________ [10]Entrance Pool Depth:__________

[11]Pool Head Difference:_____________________________________

[12]Number or Baffles: ____________

[13]Baffle Type: ☐Concrete ☐Rock ☐Metal ☐Plastic ☐Wood ☐Other

[14]Number of Weirs:_____________

[15]Weir Type: ☐Concrete ☐Rock ☐Metal ☐Plastic ☐Wood ☐Other

[16]Grade Control Location: ☐None ☐Upstream ☐Downstream ☐Both

[17]Description (Form must be accompanied by slides or color photos):___

____

____

____

____

____

[18]Habitat Gain:_________________

[19]Comments (Driving directions):______________________________

____

____

____

FISHWAY FORM INSTRUCTIONS

1.) Site ID number (Unique site identifier).
2.) Field review team information.
3.) Is the fishway a barrier to fish passage? **WDFW fishway staff only**.
4.) Estimated percent passability of the fishway. **WDFW crews only.**
5.) Inspection frequency. A - annual, B - biennial, C - triennial, D - scheduled inspections not required, E - no inspections (fishway requires reconstruction) **WDFW fishway staff only**.
6.) Type of fishway: BC - baffled culvert, BF - baffled flume, BL - blasted falls/cascade, CC - concrete control, GC - gabion control, LC - log control, PC - pool chute, PLC - plank control, RC - rock control, SCC - saccrete controls, SP - steep pass, T&H - trap & haul, VS - vertical slot, WP - weir pool, RCC - roughened channel culvert
7.) The structure the fishway modified for fish passage.
8.) Year of fishway construction.
9.) Number of pools in the fishway (include last pool below the last downstream weir).
10.) Depth of the fishway entrance pool (nearest 0.01 meter)
11.) Measured distance between water surfaces in adjacent pools (listed in ascending order separated by "/", nearest 0.01 meter)
12.) Number of baffles in a baffled culvert or flume.
13.) Material from which baffles are constructed.
14.) Number of weirs present in the fishway.
15.) Material from which the weirs are constructed.
16.) Presence and position of bed controls relative to other fixed structures.
17.) Description of the fishway. **WDFW staff must include photos with the form**.
18.) Habitat gain, in linear meters, upstream of the fishway.
19.) Driving directions and additional comments.

DAM FIELD FORM (6/22/00)

[1]Site ID:______________________

[3]Dam Name:____________________

[4]Reservoir Name:_______________

____

[2]Field Review Team

Crew:__________________

Date:__________________

[5]Type: ☐CN ☐RE ☐MS ☐MT ☐ER ☐TB ☐OT

[6]Span: ☐Full ☐Partial

[7]Length:______________________ [8]Height:______________________

[9]Water Surface Difference:___________ [10]Plunge Pool Depth:________

[11]Description:____

____

____

____

____

____

[12]Primary Purpose: ☐D ☐C ☐H ☐I ☐N ☐P ☐Q ☐R ☐S ☐T ☐O

[13]Recheck: ☐No ☐GPS ☐Photo ☐Pass HF ☐Pass LF

[14]Barrier: ☐Yes ☐No ☐Unknown

[15]%Passability: ☐0 ☐33 ☐67 ☐100

[16]Repair Status: ☐OK ☐NG ☐RR ☐FX ☐FX/FW ☐UD

[17]Comments:____

____

____

____

____

____

DAM FORM INSTRUCTIONS

1.) Site ID number (Unique site identifier)
2.) Field review team information
3.) Legal or local name of the dam.
4.) Legal or local name of the reservoir.
5.) The material from which the dam is constructced. CN - concrete, RE - earthfill, MS - masonry, MT - metal, ER - rockfill, TB - timber, and OT - other.
6.) Does the dam completely or partially span the stream channel?
7.) Length of the dam in meters (0.01).
8.) The height of the dam from the front base to the crest to the nearest 0.01 meters.
9.) If water is flowing over the crest of the dam, give the difference between the water surface elevations above and below the dam in meters (0.01). If the dam is equipped with a standpipe, leave blank.
10.) Maximum depth of the plunge pool to the nearest 0.01 meters.
11.) Description of the dam and any problems associated with it.
12.) The purpose of the dam. D - debris control, C - flood control, H - hydroelectric, I - irrigation, N - navigation, P - stock or farm pond, Q - water quality, R - recreation, S - water supply, T - tailings, O - other.
13.) Is there a need to recheck the dam in the future? No - no need, GPS - GPS position needed, Photo - photo needed, Pass HF - evaluate passage at high flow, Pass LF - evaluate passage at low flow. **WDFW crews only.**
14.) Barrier status of the dam.
15.) Estimated percent passability of the dam. **WDFW crews only.**
16.) The current repair status of the dam. OK - non-barrier, NG - no gain, RR - repair required, FX - fixed, FX/FW - repaired and converted to a fishway, UD - undetermined, habitat assessment incomplete..
17.) Comments regarding the dam.

GRAVITY DIVERSION EVALUATION FORM (6/22/00)

[1]Site ID:________________________

[3]Access: ☐Vehicle ☐ORV ☐Foot

[4]Point of Diversion: ☐LB ☐RB

[5]Diversion Dam: ☐Yes ☐No

[6]Headgate: ☐Yes ☐No

[7]Diversion Ditch Area:____________

[8]Flow:____________________gpm

[9]Flow Derivation: ☐Measured ☐From Water Right ☐Derived

[10]Screened: ☐Yes ☐No ☐Unknown

[11]Screen Function: ☐OK ☐MN

[12]Problems/Comments:____

____

____

____

____

____

____

____

____

____

[13]Water Right #:____

[2]Field Review Team

Crew:____________________

Date:____________________

GRAVITY DIV. FORM INSTRUCTIONS

1.) Site ID number (Unique site identifier).
2.) Field review team information.
3.) How can the site be accessed? By on-road vehicle, off-road vehicle, or by foot?
4.) Is the point of diversion on the left bank or right bank looking downstream?
5.) Is there a dam associated with the diversion?
6.) Is there a headgate associated with the diversion?
7.) Bank full, cross-sectional area of the diversion ditch, canal, flume, or pipe in square feet to the nearest 0.1.
8.) The volume of flow diverted in gallons per minute (gpm).
9.) How was the flow calculated? Was it measured using a gauge or flow meter, was it taken off a water right, or was it derived from the irrigation system components?
10.) Does the diversion have any type of fish screening device regardless of whether it meets WDFW criteria?
11.) If a screen is present, does it appear to be functioning or is it in need of maintenance?
12.) Comments regarding the diversion.
13.) The water right number associated with the diversion. **WDFW crews only**.

PUMP DIVERSION EVALUATION FORM (6/22/00)

1Site ID:________________________

2Field Review Team
Crew:____________________
Date:____________________

3Access: ☐Vehicle ☐ORV ☐Foot

4Point of Diversion: ☐LB ☐RB

5Intake Loc.: ☐RB ☐OS ☐LN ☐CV

6Fish Bypass :☐Yes ☐No ☐NA

7Diversion Dam: ☐Yes ☐No 8Screened:☐Yes ☐No

9Screen Type: ☐BX ☐BR ☐CY ☐CN ☐ST ☐OT ☐ XX

10Screen Material: ☐WM ☐PM ☐PP ☐PB ☐EM ☐OT

11Diameter: ___________________ 12Height________________________

13Length:______________________ 14Area:_________________________

15Opening Dimension:___________ 16Screen Condition: ☐OK ☐MN

17Compliance: ☐Yes ☐No

18Problem/Comments:____

____

____

____

____

____

____

____

____

____

19Pipe Outside Diameter:____

20Pump Type: ☐Centrifugal ☐Turbine

21Meter Number:_________________ 22Capacity:___________________

23Derivation: ☐Measured ☐Derived ☐Water Right

24Water Right #:____

PUMP DIV. FORM INSTRUCTIONS

1.) Site ID number (Unique site identifier).
2.) Field review team information.
3.) How can the site be accessed? By on-road vehicle, off-road vehicle, or by foot?
4.) Is the point of diversion on the left bank or right bank looking downstream?
5.) Location of the pump intake. RB - river bank, OS - off shore, LN - lagoon, CV - cove. A lagoon is separated from river by pipe or channel. A cove is open to the river.
6.) Presence of fish bypass. Select yes or no if POD location is a lagoon, na if otherwise.
7.) Is there a dam associated with the diversion?
8.) Is the diversion screened for fish protection?
9.) Type of screening device: BX - box, BR - barrel, CY - cylinder, CN - cone, ST - strainer, OT - other, XX - none.
10.) Material screen is constructed of: WM - wire mesh, PM - plastic mesh, PP - perf plate, PB - profile bar, EM - expanded metal, OT - other.
11.) Diameter of the barrel, cylinder or cone in feet (0.1).
12.) Height of barrel, box, or cone screen in feet (0.1).
13.) Length of box or cylinder screen in feet (0.1).
14.) Area of screen in square feet (0.1).
15.) The smallest demension of the sceen material opening.
16.) Screen condition and/or maintenance requirements: OK - clean and intact, MN - minor maintenance needed.
17.) Does the screen meet WDFW criteria? **WDFW crews only**.
18.) Description of the problems associated with the screen, bypass, *etc*.
19.) Measured outside diameter of the intake pipe in inches (0.1).
20.) Type of pump.
21.) Meter or power pole identification number nearest the pump.
22.) Volume of water, measured or calculated in gpm. **WDFW crews only**.
23.) How flow was determined: measured - gauge present, derived - calculated from irrigation system components, water right - legal documentation. **WDFW crews only**.
24.) Water right number associated with diversion. **WDFW crews only**.

"OTHER" EVALUATION FORM (6/2200)

[1]Site ID:______________________

[3]Description:____________________

____

____

____

____

____

____

[2]Field Review Team

Crew:__________________

Date:__________________

____

____

____

____

____

____

[4]Barrier: ☐Yes ☐No ☐Unknown

[5]%Passability: ☐0 ☐33 ☐67 ☐100

[6]Repair Status: ☐OK ☐NG ☐RR ☐FX ☐FX/FW ☐UD

OTHER FORM INSTRUCTIONS

1.) Site ID number (Unique site identifier).
2.) Field review team information.
3.) Description of the feature.
4.) Barrier status of the feature.
5.) Estimated percent passability of the feature. **WDFW crews only.**
6.) The current repair status of the feature. OK - non-barrier, NG - no gain, RR - repair required, FX - fixed, FX/FW - repaired and converted to a fishway, UD - undetermined, habitat assessment incomplete.

PHYSICAL HABITAT SURVEY FIELD FORM (3/1/00)

[1]Survey ID:____________ [2]Date:_________ [3]Observers:_____________

[4]Stream Name:________________ [5]Road/MP:______________________

[6]Trib. To:______________ [7]WRIA:________ [8]Position:________________

[9]Section Surveyed:_____________________ [10]Survey Method:_________

[11]Reach #:__________ [12]Begin CR:________ [13]End CR:_________

[14]Spawning HQM:___ [15]Rearing HQM:_____ [16]Spring Influence:________

[17]Instream Cover:_______ [18]Juvenile Abundance:_______ [19]Temp.:_____

[20]Canopy:_____________________ [21]Additional Barriers:_____________

[22]Limiting Factors:_____________________ [23]Culverted Length:________

[24]Sampling Frequency: □30/160 □60/320

[25]Flow Measurement: Depth:_______ Length:_________ Width:_______

Time 1:______ Time 2:_________ Time 3:_______

Chain Reading	Habitat Type	Length	Wetted Width	OHW Width	Depth	Gradient	% Boulder/Rubble/Gravel/ Sand

HABITAT FORM INSTRUCTIONS

1.) Should be the same as the barrier site ID.
2.) Date of survey.
3.) Names of field crew conducting the survey.
4.) Name of stream being surveyed.
5.) Road name and milepost (if known).
6.) Name of stream at first major confluence.
7.) Watershed Resource Inventory Area number.
8.) Location of the beginning of the reach (*e.g.*, at barrier culvert on Jones Road; at left bank tributary at 1543 meters).
9.) Starting and ending point of the survey
10.) Type of survey being conducted. PS - Full Physical Survey, RSPS - Reduced Sample Physical Survey, ETD - Expanded Threshold Determination
11.) Number of reach being sampled.
12.) Hip chain reading at the beginning of the reach in meters.
13.) Hip chain reading at the end of the reach in meters.
14.) Habitat Quality modifier assigned to spawning habitat for the reach. Appropriate values: Good - 1, Fair - 0.67, Poor - 0.33, Very poor with no habitat value - 0.
15.) Habitat Quality modifier assigned to rearing habitat for the reach. Appropriate values: Good - 1, Fair - 0.67, Poor - 0.33, Very poor with no habitat value - 0.
16.) Estimate of the spring contribution to the flow of the stream. Absent - 0, Slight - 1, Moderate - 2, Pronounced - 3.
17.) Characterize the amount of instream cover using low, medium, high.
18.) A visual estimate of fry abundance using low, medium, high.
19.) Temperature in degrees Celsius.
20.) Percent canopy cover. Note dominant species.
21.) The number of barriers encountered including human-made and natural.
22.) If a habitat quality modifier of less the 1 was assessed, explain why.
23.) Total length of all culverts in the reach in meters.
24.) Either 30 meters out of 160 meters or 60 out of 320.
25.) Record the information, in meters and seconds, necessary to calculate the flow using the 3-chip method. A flow meter may be used if available.

Chain Reading: Distance on hip chain at beginning of a habitat type in meters.
Habitat Type: Pool - P, Riffle - R, Rapid - Rap, Pond - Pond.
Length: Length of the habitat type in meters.
Wetted Width: The wetted width of the habitat type in meters.
OHW Width: The width at the ordinary high water line in meters.
Depth: Average depth of the habitat type in meters.
Gradient: The percent gradient for each sample section.
% Boulder/Rubble/Gravel/Sand: Visual estimate of the percent composition of each substrate type in each habitat type (*e.g.*, 15/35/40/10).

APPENDIX B

WAC 220-110-070 Water Crossing Structures
and
Screening Requirements For Water Diversions

WAC 220-110-070 Water crossing structures.

In fish bearing waters, bridges are preferred as water crossing structures by the department in order to ensure free and unimpeded fish passage for adult and juvenile fishes and preserve spawning and rearing habitat. Pier placement waterward of the ordinary high water line shall be avoided, where practicable. Other structures which may be approved, in descending order of preference, include: Temporary culverts, bottomless arch culverts, arch culverts, and round culverts. Corrugated metal culverts are generally preferred over smooth surfaced culverts. Culvert baffles and downstream control weirs are discouraged except to correct fish passage problems at existing structures.

An HPA is required for construction or structural work associated with any bridge structure waterward of or across the ordinary high water line of state waters. An HPA is also required for bridge painting and other maintenance where there is potential for wastage of paint, sandblasting material, sediments, or bridge parts into the water, or where the work, including equipment operation, occurs waterward of the ordinary high water line. Exemptions/5-year permits will be considered if an applicant submits a plan to adhere to practices that meet or exceed the provisions otherwise required by the department.

Water crossing structure projects shall incorporate mitigation measures as necessary to achieve no-net-loss of productive capacity of fish and shellfish habitat. The following technical provisions shall apply to water crossing structures:

(1) Bridge construction.

(a) Excavation for and placement of the foundation and superstructure shall be outside the ordinary high water line unless the construction site is separated from waters of the state by use of an approved dike, cofferdam, or similar structure.
(b) The bridge structure or stringers shall be placed in a manner to minimize damage to the bed.
(c) Alteration or disturbance of bank or bank vegetation shall be limited to that necessary to construct the project. All disturbed areas shall be protected from erosion, within seven calendar days of completion of the project, using vegetation or other means. The banks shall be revegetated within one year with native or other approved woody species. Vegetative cuttings shall be planted at a maximum interval of three feet (on center), and maintained as necessary for three years to ensure eighty percent survival. Where proposed, planting densities and maintenance requirements for rooted stock will be determined on a site-specific basis. The requirement to plant woody vegetation may be waived for areas where the potential for natural revegetation is adequate, or where other engineering or safety factors preclude them.
(d) Removal of existing or temporary structures shall be accomplished so that the structure and associated material does not enter the watercourse.
(e) The bridge shall be constructed, according to the approved design, to pass the 100-year peak flow with consideration of debris likely to be encountered. Exception shall be granted if applicant provides hydrologic or other information that supports alternative design criteria.

(f) Wastewater from project activities and water removed from within the work area shall be routed to an area landward of the ordinary high water line to allow removal of fine sediment and other contaminants prior to being discharged to state waters.
(g) Structures containing concrete shall be sufficiently cured prior to contact with water to avoid leaching.
(h) Abutments, piers, piling, sills, approach fills, etc., shall not constrict the flow so as to cause any appreciable increase (not to exceed .2 feet) in backwater elevation (calculated at the 100-year flood) or channel wide scour and shall be aligned to cause the least effect on the hydraulics of the watercourse.
(i) Riprap materials used for structure protection shall be angular rock and the placement shall be installed according to an approved design to withstand the 100-year peak flow.

(2) Temporary culvert installation.

The allowable placement of temporary culverts and time limitations shall be determined by the department, based on the specific fish resources of concern at the proposed location of the culvert.
(a) Where fish passage is a concern, temporary culverts shall be installed according to an approved design to provide adequate fish passage. In these cases, the temporary culvert installation shall meet the fish passage design criteria in Table 1 in subsection (3) of this section.
(b) Where culverts are left in place during the period of September 30 to June 15, the culvert shall be designed to maintain structural integrity to the 100-year peak flow with consideration of the debris loading likely to be encountered.
(c) Where culverts are left in place during the period June 16 to September 30, the culvert shall be designed to maintain structural integrity at a peak flow expected to occur once in 100 years during the season of installation.
(d) Disturbance of the bed and banks shall be limited to that necessary to place the culvert and any required channel modification associated with it. Affected bed and bank areas outside the culvert shall be restored to preproject condition following installation of the culvert.
(e) The culvert shall be installed in the dry, or in isolation from stream flow by the installation of a bypass flume or culvert, or by pumping the stream flow around the work area. Exception may be granted if siltation or turbidity is reduced by installing the culvert in the flowing stream. The bypass reach shall be limited to the minimum distance necessary to complete the project. Fish stranded in the bypass reach shall be safely removed to the flowing stream.
(f) Wastewater, from project activities and dewatering, shall be routed to an area outside the ordinary high water line to allow removal of fine sediment and other contaminants prior to being discharged to state waters.
(g) Imported fill which will remain in the stream after culvert removal shall consist of clean rounded gravel ranging in size from one-quarter to three inches in diameter. The use of angular rock may be approved from June 16 to September 30, where rounded rock is unavailable. Angular rock shall be removed from the watercourse and the site restored to preproject conditions upon removal of the temporary culvert.

(h) The culvert and fill shall be removed, and the disturbed bed and bank areas shall be reshaped to preproject configuration. All disturbed areas shall be protected from erosion, within seven days of completion of the project, using vegetation or other means. The banks shall be revegetated within one year with native or other approved woody species. Vegetative cuttings shall be planted at a maximum interval of three feet (on center), and maintained as necessary for three years to ensure eighty percent survival. Where proposed, planting densities and maintenance requirements for rooted stock will be determined on a site-specific basis. The requirement to plant woody vegetation may be waived for areas where the potential for natural revegetation is adequate, or where other engineering or safety factors need to be considered.

(i) The temporary culvert shall be removed and the approaches shall be blocked to vehicular traffic prior to the expiration of the HPA.

(j) Temporary culverts may not be left in place for more than two years from the date of issuance of the HPA.

(3) Permanent culvert installation.

(a) In fish bearing waters or waters upstream of a fish passage barrier (which can reasonably be expected to be corrected, and if corrected, fish presence would be reestablished), culverts shall be designed and installed so as not to impede fish passage. Culverts shall only be approved for installation in spawning areas where full replacement of impacted habitat is provided by the applicant.

(b) To facilitate fish passage, culverts shall be designed to the following standards:

(i) Culverts may be approved for placement in small streams if placed on a flat gradient with the bottom of the culvert placed below the level of the streambed a minimum of twenty percent of the culvert diameter for round culverts, or twenty percent of the vertical rise for elliptical culverts (this depth consideration does not apply within bottomless culverts). Footings of bottomless culverts shall be buried sufficiently deep so they will not become exposed by scour within the culvert. The twenty percent placement below the streambed shall be measured at the culvert outlet. The culvert width at the bed, or footing width, shall be equal to or greater than the average width of the bed of the stream.

(ii) Where culvert placement is not feasible as described in (b)(i) of this subsection, the culvert design shall include the elements in (b)(ii)(A) through (E) of this subsection:

(A) Water depth at any location within culverts as installed and without a natural bed shall not be less than that identified in Table 1. The low flow design, to be used to determine the minimum depth of flow in the culvert, is the two-year seven-day low flow discharge for the subject basin or ninety-five percent exceedance flow for migration months of the fish species of concern. Where flow information is unavailable for the drainage in which the project will be conducted, calibrated flows from comparable gauged drainages may be used, or the depth may be determined using the installed no-flow condition.

(B) The high flow design discharge, used to determine maximum velocity in the culvert (see Table 1), is the flow that is not exceeded more than ten percent of the time during the months of adult fish migration. The two-year peak flood flow may be used where stream flow data are unavailable.

(C) The hydraulic drop is the abrupt drop in water surface measured at any point within or at the outlet of a culvert. The maximum hydraulic drop criteria must be satisfied at all flows between the low and high flow design criteria.
(D) The bottom of the culvert shall be placed below the natural channel grade a minimum of twenty percent of the culvert diameter for round culverts, or twenty percent of the vertical rise for elliptical culverts (this depth consideration does not apply within bottomless culverts). The downstream bed elevation, used for hydraulic calculations and culvert placement in relation to bed elevation, shall be taken at a point downstream at least four times the average width of the stream (this point need not exceed twenty-five feet from the downstream end of the culvert). The culvert capacity for flood design flow shall be determined by using the remaining capacity of the culvert.

Table 1. Fish Passage Design Criteria for Culvert Installation

Criteria	Adult Trout >6 in.(150mm)	Adult Pink, Chum Salmon	Adult Chinook, Coho, Sockeye, Steelhead
1. Velocity, Maximum (fps)			
Culvert Length (ft)			
a. 10 - 60	4.0	5.0	6.0
b. 60 - 100	4.0	4.0	5.0
c. 100 - 200	3.0	3.0	4.0
d. >200	2.0	2.0	3.0
2. Flow Depth Minimum (ft)	0.8	0.8	1.0
3. Hydraulic Drop, Maximum (ft)	0.8	0.8	1.0

(E) Appropriate statistical or hydraulic methods must be applied for the determination of flows in (b)(ii)(A) and (B) of this subsection. These design flow criteria may be modified for specific proposals as necessary to address unusual fish passage requirements, where other approved methods of empirical analysis are provided, or where the fish passage provisions of other special facilities are approved by the department.
(F) Culvert design shall include consideration of flood capacity for current conditions and future changes likely to be encountered within the stream channel, and debris and bedload passage.
(c) Culverts shall be installed according to an approved design to maintain structural integrity to the 100-year peak flow with consideration of the debris loading likely to be encountered. Exception may be granted if the applicant provides justification for a different level or a design that routes that flow past the culvert without jeopardizing the culvert or associated fill.
(d) Disturbance of the bed and banks shall be limited to that necessary to place the culvert and any required channel modification associated with it. Affected bed and bank areas outside the culvert and associated fill shall be restored to preproject configuration following

installation of the culvert, and the banks shall be revegetated within one year with native or other approved woody species. Vegetative cuttings shall be planted at a maximum interval of three feet (on center), and maintained as necessary for three years to ensure eighty percent survival. Where proposed, planting densities and maintenance requirements for rooted stock will be determined on a site-specific basis. The requirement to plant woody vegetation may be waived for areas where the potential for natural revegetation is adequate, or where other engineering or safety factors preclude them.

(e) Fill associated with the culvert installation shall be protected from erosion to the 100-year peak flow.

(f) Culverts shall be designed and installed to avoid inlet scouring and shall be designed in a manner to prevent erosion of streambanks downstream of the project.

(g) Where fish passage criteria are required, the culvert facility shall be maintained by the owner(s), such that fish passage design criteria in Table 1 are not exceeded. If the structure becomes a hindrance to fish passage, the owner shall be responsible for obtaining a HPA and providing prompt repair.

(h) The culvert shall be installed in the dry or in isolation from the stream flow by the installation of a bypass flume or culvert, or by pumping the stream flow around the work area. Exception may be granted if siltation or turbidity is reduced by installing the culvert in the flowing stream. The bypass reach shall be limited to the minimum distance necessary to complete the project. Fish stranded in the bypass reach shall be safely removed to the flowing stream.

(i) Wastewater, from project activities and dewatering, shall be routed to an area outside the ordinary high water line to allow removal of fine sediment and other contaminants prior to being discharged to state waters.

[Statutory Authority: RCW 75.08.080. 94-23-058 (Order 94-160), § 220-110-070, filed 11/14/94, effective 12/15/94. Statutory Authority: RCW 75.20.100 and 75.08.080. 83-09-019 (Order 83-25), § 220-110-070, filed 4/13/83.]

Screening Requirements For Water Diversions

Washington State Laws (RCW 77.16.220; RCW 75.20.040, RCW 75.20.061) require all diversions from waters of the state to be screened to protect fish.

These laws and the following design criteria are essential for the protection of fish at surface water diversions. Fish drawn into hydropower, irrigation, water supply, and other diversions are usually lost from the fish resources of the state of Washington.

The following criteria are based on the philosophy of physically excluding fish from being entrained in water diverted without becoming impinged on the diversion screen. The approach velocity and screen mesh opening criteria are based upon the swimming stamina of emergent size fry in low water temperature conditions. It is recognized that there may be locations at which design for these conditions may not be warranted. Unless conclusive data from studies acceptable to Washington Department of Fish and Wildlife indicate otherwise, it is assumed that these extreme conditions exist at some time of the year at all screen sites.
Additional criteria may be required for unique situations, large facilities or intakes within marine waters.

I. Screen Location and Orientation

A. Fish screens in rivers and streams shall be constructed within the flowing stream at the point of diversion and parallel to the stream flow. The screen face shall be continuous with the adjacent bankline. A smooth transition between the screen and bankline shall be provided to prevent eddies in front, upstream and downstream of the screen.

Where it can be thoroughly demonstrated that flow characteristics or site conditions make construction or operation of fish screens at the diversion entrance impractical, the screens may be installed in the canal downstream of the diversion.

B. Diversion intakes in lakes and reservoirs shall be located offshore in deep water to minimize the exposure of juvenile fish to the screen. Salmon and trout fry generally inhabit shallow water areas near shore.

C. Screens constructed in canals and ditches shall be located as close as practical to the diversion. They shall be oriented so the angle between the face of the screen and the approaching flow is no more than 45. All screens constructed downstream of the diversion shall be provided with an efficient bypass system.

II. Approach Velocity

The approach velocity is defined as the component of the local water velocity vector perpendicular to the face of the screen. Juvenile fish must be able to swim at a speed equal or greater than the approach velocity for an extended length of time to avoid impingement on the screen. The following approach velocity criteria are maximum velocities that shall not be exceeded anywhere on the face of the screen. A maximum approach velocity of 0.4 feet per second is allowed.

The approach velocity is calculated based on the gross screen area not the net open area of the screen mesh.

The intake structure and/or fish screen shall be designed to assure that the diverted flow is uniformly distributed through the screen so the maximum approach velocity is not exceeded.

III. Minimum Screen Area

The minimum required screen area is determined by dividing the maximum diverted flow by the maximum allowable approach velocity. To find the screen area in square feet, divide the diverted flow in cubic feet per second (450 gpm = 1.0 cubic foot per second) by the approach velocity 0.4 feet per second):

$$MinimumScreenArea = DivertedFlow(cfs) \,/\, ApproachVelocity(f \,/\, s)$$

The minimum required screen area must be submerged during lowest stream flows and may not include any area that is blocked by screen guides or structural members.

Diversions less than or equal to 180 gallons/minute (0.4 cfs) require a minimum submerged screen area of 1.0 square foot, which is the smallest practical screening device.

IV. Sweeping Velocity

The sweeping velocity is defined as the component of the water velocity vector parallel to and immediately upstream of the screen surface. The sweeping velocity shall equal or exceed the maximum allowable approach velocity. The sweeping velocity requirement is satisfied by a combination of proper orientation (angle of screen 45 to the approaching flow) of the screen relative to the approaching flow and adequate bypass flow.

Screen bay piers or walls adjacent to the screen face shall be flush with screen surfaces so the sweeping velocity is not impeded.

V. Screen Mesh Size, Shape, and Type of Material

Screen openings may be round, square, rectangular, or any combination thereof, provided structural integrity and cleaning operations are not impaired.

Screen mesh criteria is based on the assumption that steelhead and/or resident trout fry are ubiquitous in the state of Washington and will be present at all diversion sites.

Following are the maximum screen openings allowable for emergent salmonid fry. The maximum opening applies to the entire screen structure including the screen mesh, guides, and seals. The profile bar criteria is applied to the narrow dimension of rectangular slots or mesh.

Woven Wire Mesh	Profile Bar	Perforated Plate
0.087 inch	1.75 mm	0.094 inch
(6-14 mesh)	(0.069 inch)	(3/32 inch)

The allowable woven wire mesh openings is the greatest open space distance between mesh wires. An example allowable mesh specifications is provided; there are other standard allowable openings available. The mesh specification gives the number of mesh openings per lineal inch followed by the gauge of the wires. For example, 6-14 mesh has six mesh openings per inch of screen. It is constructed with 6, 14-gauge (0.080 inch diameter) wires per inch.

The profile bar openings are the maximum allowable space between bars. The allowable perforated plate openings are the diameter of circular perforations. Perforated slots are treated as profile bars.

Screens may be constructed of any durable material; woven, welded, or perforated. The screen material must be resistant to corrosion and ultraviolet damage.

For longevity and durability, minimum wire diameter for woven mesh shall be 0.060 inch (18 gauge) on fixed panel screens, where they are not subjected to impact of debris. Minimum wire diameter for woven mesh shall be 0.080 inch (14 gauge) for rotary drum screens, traveling belt screens, and in areas where there is a potential for damage from floating debris or cleaning operations.

VI. Bypass

All screens constructed downstream of the diversion shall be provided with an efficient bypass system to rapidly collect juvenile fish and safely transport them back to the river. The downstream end of the screen shall terminate at the entrance to the bypass system. It is the water diversion owner's responsibility to obtain necessary water rights to operate the fish bypass; failure to do so may be considered failure to meet state screening law requirements.

VII. Cleaning

Fish screens shall be cleaned as frequently as necessary to prevent obstruction of flow and violation of the approach velocity criterion. Automatic cleaning devices will be required on large screen facilities.

Additional detailed information is available explaining the background and justification of these criteria and showing standard details of flow distributors, acceptable bypass designs, and screen areas required for various flows.

For further information contact:

Pat Schille (primary)
Wash. Dept. of Fish and Wildlife
3705 W. Washington Ave.
Yakima, WA 98903-1137
(509) 575-2735 Fax: 454-4139
email: schilpcs@dfw.wa.gov

Ken Bates (secondary)
Wash. Dept. of Fish and Wildlife
600 Capitol Way North
Olympia, WA 98501-1091
(360) 902-2545 Fax: 902-2946
email: bateskmb@dfw.wa.gov

APPENDIX C

Fish Passage Design Flows for Ungaged Catchments in Washington

FISH PASSAGE DESIGN FLOWS FOR UNGAGED CATCHMENTS IN WASHINGTON

Patrick D. Powers, P.E.
Caleb S. Saunders

Washington Department of FISH and WILDLIFE

LANDS AND RESTORATION SERVICES PROGRAM
Environmental Engineering Services

December 23, 1996
Revised March 16, 1998

Prepared in Cooperation with the Washington State Department of Transportation

Introduction

Successful upstream passage of adult and juvenile fish through artificial structures (channels, culverts, fishways) depends on the selection of appropriate passage design flows. It is recognized that fish passage through artificial structures cannot practically be provided at all flows. A high design flow is selected to be the upper limit of the range through which upstream fish passage criteria are satisfied. The limitation of passage above the passage design flow may be due to velocity, drop height or turbulence. Structural design flows are also important, especially in terms of passage of debris and bed material. WAC 220-110-070 (Water Crossing Structures) requires that the high flow design discharge be the flow that is not exceeded more than 10 percent of the time during the months of migration. This report provides regional regression equations for ungaged catchments to estimate this flow.

For gaged catchments the 10 percent exceedance flow for any month can be easily determined by developing a flow duration curve. For ungaged catchments, the two-year peak flood can be used to estimate this flow (Cummans, 1975). The two-year peak flow is often much higher (300 to 400 percent) than the 10 percent exceedence flow. Bates (1988), reviewed current agency criteria and developed two regression equations relating basin parameters to the 10 percent exceedence flow.

The U.S. Geological Survey (USGS) are in the process of updating regional regression equations for flood frequencies in Washington. This report utilizes the same regions and basin parameters to develop regression equations for the 10 percent exceedence flow for the months of January and May. These months were selected to represent the high fish passage design flow (Q_{FP}) for two periods when upstream passage has been observed (Peterson, 1982) and (Cederholm, 1982). January represents the month of highest flow when adult salmonids are passing upstream, and May represents the most critical month for upstream passage of juvenile salmonids. Other months are also important, but January and May represent the two extreme combinations for design considerations. Equations were developed for three regions of Western Washington (Figure 1). Data was also analyzed for Eastern Washington, but no correlation between design flows and basin parameters could be found.

Description of Regions

The state of Washington was divided into subsections based on their drainage flow characteristics. These regions were derived from "The Catalog of Information on Water Resources Data" (1972), "Water Resources Regions and Subregions for the National Assessment of Water and Related Land Resources" by the U.S. Water Resources Council (1970), "River Basins of the United States" by the Inter-Agency Committee on Water Resources, Subcommittee on Hydrology (1961), and State planning maps. The regions defined are those regularly employed by the U.S. Water Resources Council and USGS for water resources planning.

The Coastal Lowland Region (Region 1) includes parts of Clallam, Jefferson, Mason, Thurston, Pacific, Lewis, and all of Grays Harbor counties and consists of streams that drain directly into the Pacific Ocean.

The Puget Sound Region (Region 2) includes sections of Clallam, Jefferson, Mason, Thurston, Pierce, and all of King, Snohomish, Whatcom, and Skagit counties. Region two consists of streams that drain into the Puget Sound. In order to find the best correlation, the Region 2 data was divided into highland and lowland streams. The division was defined at gage elevations of 1000 feet. In addition, Region 2 had a high percentage of urbanized streams (defined arbitrarily as greater than 20 percent impervious surfaces). Separate regression equations were run for this data.

The Lower Columbia Region (Region 3) is based on rivers that flow west of the Cascade Mountain Range and drain into the Columbia River. This region includes Wahkiakum, Cowlitz, Clark, and sections of Skamania, Pacific, and Lewis Counties. Again the best correlation was found when the region was divided into highland and lowland subregions. Again, the classification was based on the gage elevation.

Region four (Eastern Washington) is defined as the rivers in counties east of the Cascade Mountain Range. As defined by the USGS and U.S. Water Resources Council, Eastern Washington is divided into six regions. Too few fluvial systems fit the required criteria however to analyze any one region as a whole. Therefore, it was necessary to condense all of Eastern Washington into one region. No correlation was found amongst the small, unrepresentative data pool gathered within this large, diverse region.

Methodology

To create a usable model for estimating fish passage design flows, a data selection process was necessary. Parameters selected required the drainage areas to be less than 50 square miles with at least five years of data compiled by the USGS for January and May. All selected data were reported by USGS as either fair, good or excellent. Sites where the measured data was reported poor or had large periods of estimation during the months of interest were excluded from the analysis. Certain sites were also rejected because of major upstream diversions, lakes or reservoirs acting as stream controls. Data was compiled from USGS Hydrodata (Daily Values) and USGS Open File Reports 84-144-A, 84-144-B, 84-145-A, and 84-145-B. Basin drainage areas were gathered from the USGS Hydrodata. Mean annual precipitation and precipitation intensity were gathered from the USGS Open File Reports. When figures were not available in the Open File Reports, values were determined by locating the latitudinal and longitudinal coordinates of the gage stations on Plates 1 and 2. The 10 percent exceedence flow values were calculated using the Hydrodata software via the Weibul formula;

$$P = M/(N+1)$$

where N is the number of values and M is the ascendant number in the pool of values.

Regression Analysis

A least squares multiple regression analysis was run on a logarithmic transformation of the data. Drainage area and mean annual precipitation (precipitation intensity for Region 1) were the independent values. The independent variables used were those specified in the 1996 USGS report.

Reasonable correlations were found within the Western Washington regions. Correlation improved upon further division of the individual regions. Gage less than 1000 feet were classified lowland, gages more than 1000 feet were classified highland. Separate analyses were run for the high passage flows during January and May migration periods for each region/subregion defined. Percent standard error (Tasker 1978), was derived from the formula;

$$SE_{percent} = 100(e^{\text{mean squared}} - 1)^{1/2},$$

where the units of the mean are natural log units. A table was included in the paper by Tasker that allowed for simple derivation of standard error in percent from logarithmic units.

The user is reminded of the non-symmetrical nature of the log-normal distribution. The higher the calculated design flow, the greater probability that the upper design flow will fall higher than one standard error above the regression line and less than one standard error below the regression line. It is, however, correct to assume an equal probability within one standard error above or below the regression line when the calculated flow and the standard error are expressed in logarithmic (base 10) units. However, the imprecise nature of accurately predicting high passage design flows would more often than not influence the user to add the standard error, making the probability distribution somewhat unimportant. The above statement remains to maintain scientific accuracy.

Results and Applications

Table 1 is a summary of the regression equations that were developed. Region one stations were all lowland (elevation <1000 ft), Region 2 had lowland, highland (elevation > 1000 ft) and urbanized stations, and Region 3 has lowland and highland stations.

Computation of a fish passage design flow at an ungaged site is made as follows:

1. From the map showing hydrologic regions (Figure 1), select the region in which the site is located.

2. From Table 1 select the appropriate equation from the region, elevation or land use condition and month.

3. From a USGS topographic map measure the drainage area above the site, latitude and longitude and estimate the basin parameters from plates 1 and 2.

4. Substitute the values determined from step three into the equation from step two and solve for the fish passage design flow.

5. Apply the percent standard error as appropriate. In most cases the standard error is added to the result because the high end of the passage flow is desired, but in some cases if depth is a concern it may be subtracted.

Example 1: Lake Creek Tributary (Lake Cavanaugh Road)
From Table 1: Region 2, Elev <1000 ft, January
A = 1.82 sq mi
Latitude: 48°22' Longitude: 122°11'
From Plate 2: P = 80 in/yr

$Q_{fp} = 0.125(A)^{.93}(P)^{1.15}$

$Q_{fp} = 0.125(1.82)^{.93}(80)^{1.15}$

Q_{fp} = 34 cfs, Standard Error is 48.6%

Q_{fp} = 18 to 50 cfs ....Answer

Example 2: S. Branch Big Creek (SR 101)
From Table 1: Region 1, May
A = 0.87 sq mi
Latitude: 47°09' Longitude: 123°53'
From Plate 1: $I_{24,2}$= 4.5 in/24 hours

$Q_{fp} = 2.25(A)^{.85}(I_{24,2})^{0.95}$

$Q_{fp} = 2.25(0.87)^{.85}(4.5)^{0.95}$

Q_{fp} = 8.3 cfs, Standard Error is 30.6%

Q_{fp} = 6 to 11 cfs..Answer

Table 1. - Regional regression equations for fish passage design flows in Washington. Q_{fp}, fish passage design flow; A, drainage area, square miles; I, 2-year, 24-hour precipitation, in inches; P, mean annual precipitation, in inches.

	Equation	Constant a	Coefficients b	c	Standard error of prediction (%)
REGION 1					
January	$Q_{fp}=aA^bI^c$	6.99	0.95	1.01	25.7
May	$Q_{fp}=aA^bI^c$	2.25	0.85	0.95	30.6
REGION 2					
Lowland Streams < 1000 feet Elevation					
January	$Q_{fp}=aA^bP^c$	.125	0.93	1.15	48.6
May	$Q_{fp}=aA^bP^c$	.001	1.09	2.07	75
Highland Streams > 1000 feet Elevation					
January	$Q_{fp}=aA^b$	141	0.72		59.8
May	$Q_{fp}=aA^bP^c$	3.25	0.76	0.48	56.9
Urban Streams > 20% Effective Impervious Area					
January	$Q_{fp}=aA^bP^c$	.052	0.96	1.28	40.7
May	$Q_{fp}=aA^bP^c$	.003	1.10	1.60	43.3
REGION 3					
Lowland Streams < 1000 feet Elevation					
January	$Q_{fp}=aA^bP^c$	.666	0.95	0.82	38.1
May	$Q_{fp}=aA^bP^c$	.014	0.87	1.42	38.1
Highland Streams > 1000 feet Elevation					
January	$Q_{fp}=aA^bP^c$	.278	1.41	0.55	59.8
May	$Q_{fp}=aA^bP^c$	3.478	0.85	0.38	28.2

Table 2. - Maximum and minimum values of basin characteristics and R squared values used in the regression analysis, by region and land type.

	Drainage Area (sq mi)	Mean Annual Precipitation (inches)	2-year 24-hour Precipitation (inches)	R^2 (January/ May)
REGION 1				
Maximum	48	--	7.5	(0.91/0.84)
Minimum	2.72	--	2.5	
REGION 2				
Lowland Streams < 1000 ft Elevation				
Maximum	48.6	160	--	(0.81/0.77)
Minimum	1	28	--	
Highland Streams > 1000 ft Elevation				
Maximum	45.8	170	--	(0.68/0.76)
Minimum	.19	60	--	
Urban Streams > 20% Effective Impervious Area				
Maximum	24.6	47	--	(0.74/0.76)
Minimum	3.67	35	--	
REGION 3				
Lowland Streams < 1000 ft Elevation				
Maximum	40.8	130	--	(0.84/0.86)
Minimum	3.29	56	--	
Highland Streams > 1000 ft Elevation				
Maximum	37.4	132	--	(0.73/0.81)
Minimum	5.87	70	–	

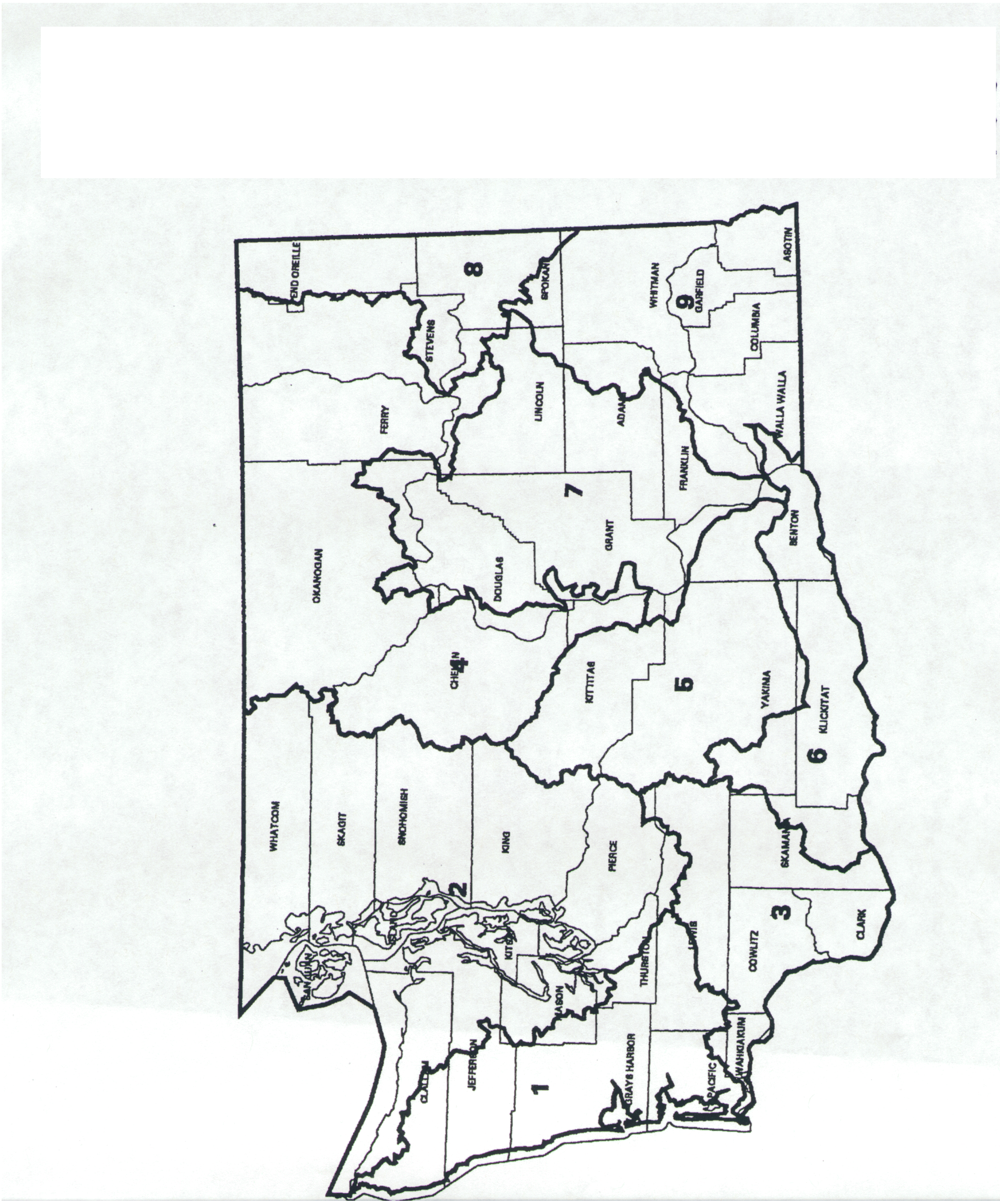

Figure 1. Regions in Washington State used for development of regression equations (USGS 1996)

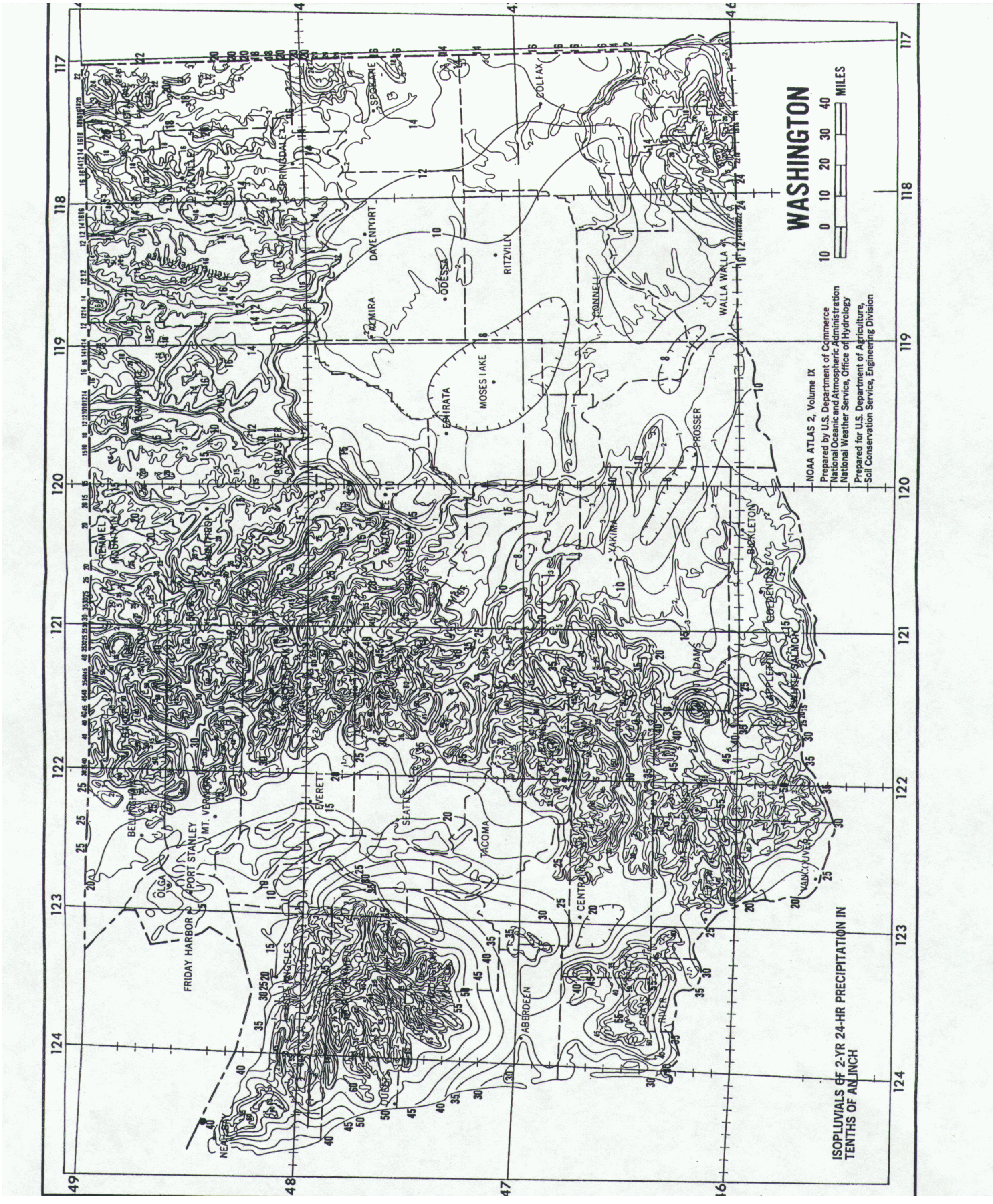

Plate 1. For an electronic copy go to http://www.wsdot.wa.gov/eesc/cae/hydraulics/app222a.pdf.

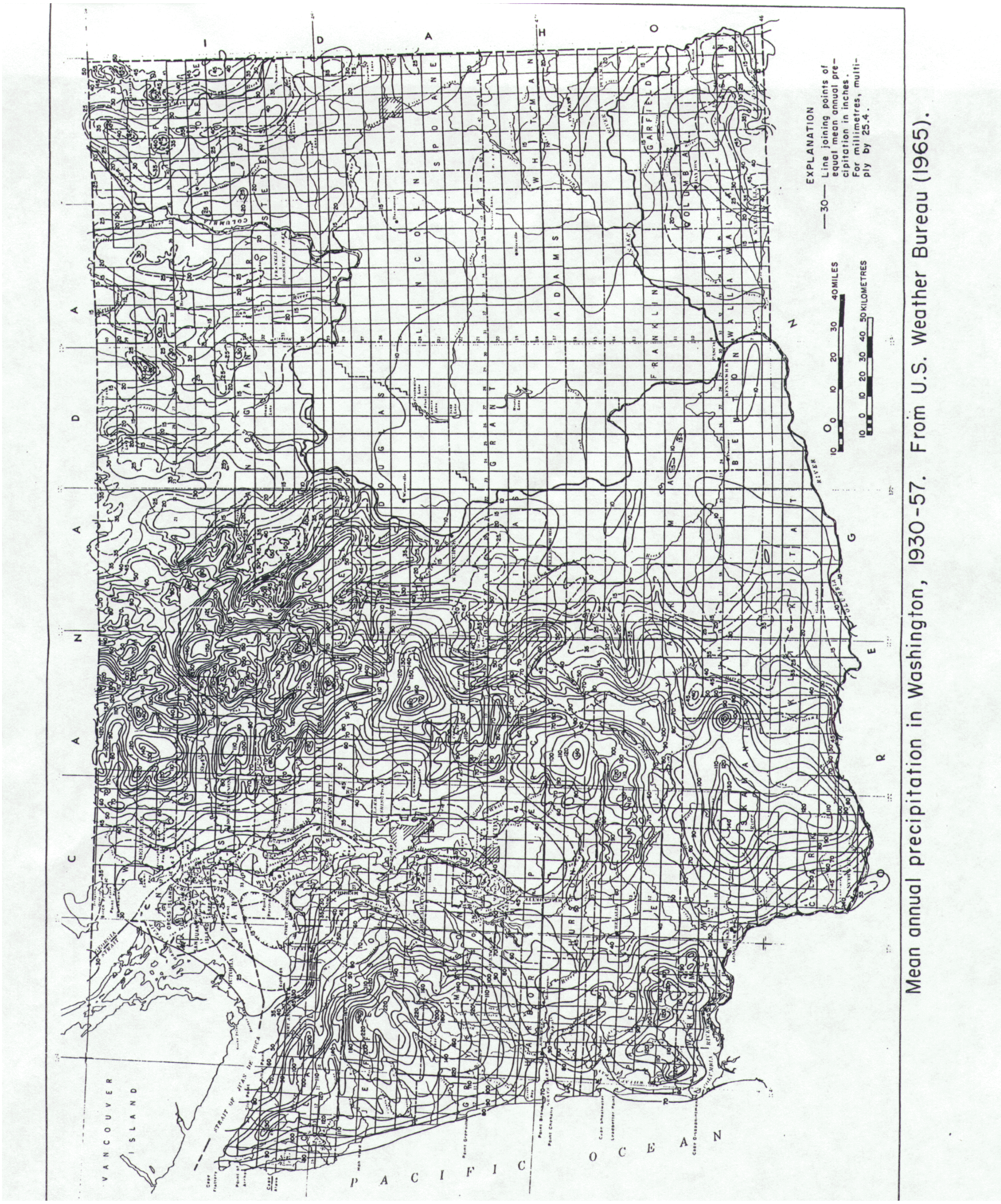

Plate 2. For an electronic copy go to http://www.wsdot.wa.gov/eesc/cae/hydraulics/app222c.pdf.

References

Bates, K. and P.D. Powers. 1988. Design flows for adult salmon passage. Washington Department of Fisheries. Unpublished.

Cederholm, C.J., W.J. Scarlett. 1982. Seasonal immigration of juvenile coho salmonids into four small tributaries of the Clearwater River, Washington. University of Washington Press. Seattle.

Cummans, J.E., M.R. Collins and E.G. Nassar. 1975. Magnitude and frequency of floods in Washington. United States Geological Survey. Open-file report 74-336.

Peterson, N.P. 1982. Immigration of juvenile coho salmon into riverine ponds. Canadian Journal of Fisheries Aquatic Sciences. 39:1308-1310.

USGS, 1996. Flood frequencies in Washington. United States Geological survey. In preparation.

Tasker, Gary D. 1978. Relation between Standard Errors in Log Units and Standard Errors in Percent. WRD Bulletin.

Williams, J.R., and Pearson, H.E. 1985. Streamflow statistics and drainage basin characteristics for the South Western and Eastern Regions, Washington. Volume I. USGS. Open-file report 84-145-A. Volume II Open-file report 84-145-B.

Williams, J.R., and Pearson, H.E. and Wilson J.D. 1985. Streamflow statistics and drainage basin characteristics for the Puget Sound Region, Washington. Volume I. USGS. Open-file report 84-144-A. Volume II. Open-file report 84-144-B.

APPENDIX D

Instructions for Using Level B Spreadsheet

Using this spreadsheet requires one to input data from Table 3b and to input values by trial and error to perform calculations. In places, the user is asked to compare design and calculated values. When doing so, the design and calculated values need to be equal or within 5% of one another for the equations to function properly.

The units for the English version are feet, feet per second and cubic feet per second. For the metric version the units are meters, meters per second and cubic meters per second. The basin area and precipitation values are in English units for all versions.

Step 1) Open the spreadsheet for the desired units and software version.

- LvlBEng.wb2 Quattro Pro 6 for Windows, English Units
- LvlBMet.wb2 Quattro Pro 6 for Windows, Metric Units
- LvlBEng.xls Excel 97, English Units
- LvlBMet.xls Excel 97, Metric Units

Step 2) Go to the Introduction Page to begin.

- Instruction text throughout the spreadsheet is in red.

Step 3) Go to the Hydrology Page.

- Follow the step-by-step instructions (red text) on the left side of the page.
- On the Hydrology Page the user is asked to input the following:
  1. Stream name
  2. Site ID
  3. Sequencer
  4. Hydrologic Region from Appendix C, Figure 1
  5. Drainage area
  6. Precipitation (2yr./24-hr. for region 1, or mean annual for all other regions)

  Note: If multiple culverts are being analyzed for one site, the calculated design flow must be distributed for each culvert and hand entered here. It is recommended to distribute the flow equally unless one culvert elevation at the upstream end is significantly lower than the other(s). If so, use the lower culvert for the entire flow, or the culvert with the steepest slope. Also, if the design flow is calculated using other methods, this value can be hand entered.

Step 4) Go to the X Section Page.

- Follow the step-by-step instructions (red text) on the left side of the page.
- On the X Section Page the user is asked to input the following:
  1. Downstream control water surface elevation.
  2. Water surface elevation 50 feet further downstream.
  3. Station and elevations of the downstream control channel cross section.
  4. The *estimated* water surface elevation at the fish passage design flow. Repeat until the calculated flow equals or is within 5% of the design flow.
  5. The type of culvert: Round, Box or Pipearch.

Step 5) Go to the appropriate culvert page: Round, Box, or *Pipearch.

- Follow the step-by-step instructions (red text) on the left side of the page.
- On the Round, Box or *Pipearch page, the user is asked to input the following:
  1. Diameter, or Span and Rise of the culvert.
  2. Manning's n for the culvert.
  3. Length of the culvert.
  4. The elevation of the upstream invert.
  5. The elevation of the downstream invert.
  6. The *estimated* normal flow depth. Repeat until the calculated flow equals the design flow.

     *Note: A table of common pipearch sizes is provided on the Pipearch Table page of the spreadsheet. A copy of the table is attached as Table 1.

Step 6) Go to the Summary Page.

- On the Summary Page all input data as well as the results of calculations are summarized in one table.
- Review all input values and resulting output.
- Return to the appropriate sheet to make any necessary corrections.
- When you are satisfied the analysis is complete, print this page for the report.

Table 1. Full-flow data for pipe arch (squash) culverts in English and metric units.

English						Metric			
Span (in.)	Rise (in.)	Span (ft)	Rise (ft)	Waterway Area (ft^2)	Hydraulic Radius (ft)	Span (m)	Rise (m)	Waterway Area (m^2)	Hydraulic Radius (m)
Corrugations 2 2/3 x 1/2 in.									
17	13	1.42	1.08	1.1	0.280	0.43	0.33	0.10	0.085
21	15	1.75	1.25	1.6	0.340	0.53	0.38	0.15	0.104
24	18	2.00	1.50	2.2	0.400	0.61	0.46	0.20	0.122
28	20	2.33	1.67	2.9	0.462	0.71	0.51	0.27	0.141
35	24	2.92	2.00	4.5	0.573	0.89	0.61	0.42	0.175
42	29	3.50	2.42	6.5	0.690	1.07	0.74	0.60	0.210
49	33	4.08	2.75	8.9	0.810	1.24	0.84	0.83	0.247
57	38	4.75	3.17	11.6	0.924	1.45	0.97	1.08	0.282
64	43	5.33	3.58	14.7	1.040	1.63	1.09	1.37	0.317
71	47	5.92	3.92	18.1	1.153	1.80	1.19	1.68	0.351
77	52	6.42	4.33	21.9	1.268	1.96	1.32	2.03	0.386
83	57	6.92	4.75	26.0	1.380	2.11	1.45	2.42	0.421
Corrugations 3 x 1 in.									
60	46	5.00	3.83	15.6	1.104	1.52	1.17	1.45	0.337
66	51	5.50	4.25	19.3	1.230	1.68	1.30	1.79	0.375
73	55	6.08	4.58	23.2	1.343	1.85	1.40	2.16	0.409
81	59	6.75	4.92	27.4	1.454	2.06	1.50	2.55	0.443
87	63	7.25	5.25	32.1	1.573	2.21	1.60	2.98	0.479
95	67	7.92	5.58	37.0	1.683	2.41	1.70	3.44	0.513
103	71	8.58	5.92	42.4	1.800	2.62	1.80	3.94	0.549
112	75	9.33	6.25	48.0	1.911	2.84	1.91	4.46	0.582
117	79	9.75	6.58	54.2	2.031	2.97	2.01	5.04	0.619
128	83	10.67	6.92	60.5	2.141	3.25	2.11	5.62	0.653
137	87	11.42	7.25	67.4	2.259	3.48	2.21	6.26	0.689
142	91	11.83	7.58	74.5	2.373	3.61	2.31	6.92	0.723
Corrugations 6 x 2 in.									
73	55	6.08	4.58	22	1.29	1.85	1.40	2.0	0.393
76	57	6.33	4.75	24	1.35	1.93	1.45	2.2	0.411
81	59	6.75	4.92	26	1.39	2.06	1.50	2.4	0.424
84	61	7.00	5.08	28	1.45	2.13	1.55	2.6	0.442
87	63	7.25	5.25	30	1.51	2.21	1.60	2.8	0.460
92	65	7.67	5.42	33	1.55	2.34	1.65	3.1	0.472
95	67	7.92	5.58	35	1.61	2.41	1.70	3.3	0.491
98	69	8.17	5.75	38	1.67	2.49	1.75	3.5	0.509
103	71	8.58	5.92	40	1.71	2.62	1.80	3.7	0.521
106	73	8.83	6.08	43	1.77	2.69	1.85	4.0	0.540
112	75	9.33	6.25	45	1.81	2.84	1.91	4.2	0.552
114	77	9.50	6.42	48	1.87	2.90	1.96	4.5	0.570
117	79	9.75	6.58	51	1.93	2.97	2.01	4.7	0.588
123	81	10.25	6.75	54	1.97	3.12	2.06	5.0	0.600
128	83	10.67	6.92	57	2.01	3.25	2.11	5.3	0.613
131	85	10.92	7.08	60	2.07	3.33	2.16	5.6	0.631
137	87	11.42	7.25	63	2.11	3.48	2.21	5.9	0.643
139	89	11.58	7.42	66	2.17	3.53	2.26	6.1	0.661
142	91	11.83	7.58	70	2.23	3.61	2.31	6.5	0.680
148	93	12.33	7.75	73	2.26	3.76	2.36	6.8	0.689
150	95	12.50	7.92	77	2.32	3.81	2.41	7.2	0.707
152	97	12.67	8.08	81	2.38	3.86	2.46	7.5	0.725
154	100	12.83	8.33	85	2.44	3.91	2.54	7.9	0.744
161	101	13.42	8.42	88	2.48	4.09	2.57	8.2	0.756
167	103	13.92	8.58	91	2.52	4.24	2.62	8.5	0.768
169	105	14.08	8.75	95	2.57	4.29	2.67	8.8	0.783
171	107	14.25	8.92	100	2.63	4.34	2.72	9.3	0.802
178	109	14.83	9.08	103	2.67	4.52	2.77	9.6	0.814
184	111	15.33	9.25	107	2.71	4.67	2.82	9.9	0.826
186	113	15.50	9.42	111	2.77	4.72	2.87	10.3	0.844
188	115	15.67	9.58	116	2.83	4.78	2.92	10.8	0.863
190	118	15.83	9.83	121	2.89	4.83	3.00	11.2	0.881
197	119	16.42	9.92	125	2.92	5.00	3.02	11.6	0.890
199	121	16.58	10.08	130	2.98	5.05	3.07	12.1	0.908

APPENDIX E

Estimate of Potential Summer Habitat
60 Day Low Flow Methodology

October 17, 1994

ESTIMATE OF POTENTIAL SUMMER HABITAT

Objective

The objective of this study is to estimate, from channel characteristics which are measurable throughout the field season, the relative areas of summer low flow rearing habitat in streams across the state.

Method

This method for estimating relative potential aquatic habitat is based on regional estimates of 60-dy low flow per unit watershed area (i.e., cubic feet per second per square mile) combined with channel characteristics measured in the physical survey.

The physical survey distinguishes four geomorphic stream features: riffles, rapids, pools, and ponds. These features are generally categorized into two habitat types: pools (i.e., pools and ponds), and riffles (i.e., all other habitat types). Pools are characterized by low gradients (<1%), reduced flow velocities, and often greater water depths than in surrounding areas. Ponds are pools which have average widths and lengths at least five times the average widths and lengths of pools in the downstream reach. Riffle habitat types are characterized by shallow, swift, turbulent flow over completely or partially submerged obstructions.

Regional stream gage data were used to generate regression equations of the form:

$$Q_{60} = (CA) / 35.3 \qquad \text{(Eq. 1)}$$

where Q_{60} = 60-day low flow (cubic meters per second),
A = watershed area (square miles), and
C = a regional constant.

From this equation, Q_{60} can be estimated for each stream in the survey. In this preliminary study, Washington was divided into four hydrologic regions: 1) Olympic Peninsula/south coast, 2) Cascade (east Puget Sound), 3) Columbia/Eastern Washington, and 4) Northern/North-eastern mountains. These divisions are based on evaluation of USGS analyses of low flow characteristics of streams in Washington rather than on direct statistical analysis of low flow data. Due to scarcity of 60-day low flow data, regression relationships for the Olympic/south coast and the Northern/north-eastern mountain regions were developed from 7-day low flow data and increased by a factor representing the regional relationship between 60-day low flow and 7-day low flow. The Cascade/east Puget Sound 60-day low flow values were interpolated from 30-day and 90-day low flow data. Regional constants are shown in Table 1.

Table 1. Regional constants for 60-day low flow per square mile of watershed area.

Region	Constant	Standard Error	R^2	Observations
Olympic/coastal	0.49	0.023	0.36	168
Cascade/east Puget Sound	1.04	0.140	0.28	46
Columbia/Eastern Washington	0.12	0.021	0.22	17
Northern/N-E mountains	0.097	0.011	0.22	70

Water surface area at 60-day low flow conditions was used to estimate relative potential habitat. Two hydraulic equations were used to estimate average flow geometry in the riffles:

$$Q = AV, \qquad \text{(Eq. 2)}$$

where Q = flow, in cubic meters per second,
A = cross-sectional area of flow, in square meters,
V = average velocity of flow, in meters per second;

and Manning's equation,

$$V = (1/n)\, R^{2/3} S^{1/2}, \qquad \text{(Eq. 3)}$$

where n = Manning's roughness factor,
R = the hydraulic radius (in m) = flow area/wetted perimeter,
S = the gradient.

Certain simplifying assumptions were made in order to estimate the low flow riffle area:

1) the riffles are wide in relation to their depth (i.e., width/depth > 10) during the period of measurement and at low flow;

2) the width/depth ratio (W/D) remains constant between the time of the stream survey and summer low-flow conditions,

3) the cross-sectional shape of the riffle bottom is approximately triangular, i.e., the depth increases gradually from the banks to the thalweg so that

$$A = (WD) / 2 \quad \text{(Eq. 4)}$$

4) the surface area of rapids changes, in response to changes in flow, by the same factor as that of the riffles;

5) the roughness factor, n, is approximately 0.1 under low-flow conditions.

By combining equations 2, 3, and 4, average 60-day low-flow riffle depth (D_{60}) and width (W_{60}) were calculated as

$$D_{60} = [(0.318\ Q_{60} D_s) / (S^{0.5} W_s)]^{0.375} \quad \text{(Eq. 5)}$$

where D_s = the average riffle depth (in m) measured during the survey,
W_s = the average riffle width (in m) measured during the survey, and

$$W_{60} = (W_s\ D_{60}) / D_s \quad \text{(Eq. 6)}$$

The ratio W_{60}/W_s is the factor used in calculating riffle and rapid surface areas at Q_{60}, i.e.,

$$A_{60}\ (\text{riffle}) = A_s\ (\text{riffle})\ {*}W_{60}/W_s, \text{ and} \quad \text{(Eq. 7)}$$
$$A_{60}\ (\text{rapid}) = A_s\ (\text{rapid})\ {*}W_{60}/W_s \quad \text{(Eq. 8).}$$

Pool depth is assumed to change by an amount equal to the change in the riffle depth. Pool area is assumed to change by a factor equal to the square of the ratio of the low-flow depth to the average measured depth, i.e.,

$$A_{60}\ (\text{pool}) = A_s\ (\text{pool}){*}[D_s(\text{pool})-(D_s-D_{60})]^2/D_s(\text{pool}). \quad \text{(Eq. 9)}$$

Pond depth and surface area is assumed to be relatively insensitive to changes in flow. It is suggested that a factor of 1.0 be assigned to pond area, i.e.,

$$A_{60}\ (\text{pond}) = A_s\ (\text{pond}). \quad \text{(Eq. 10)}$$

Discussion

Individual stream systems may vary substantially in their low-flow characteristics from the regional averages developed for use in this habitat estimate. One particularly important aspect of streams which will cause them to deviate from regional low-flow estimates is contributions to base flow by springs; the habitat offered by these streams will be seriously underestimated by this method.

It is suggested that the physical survey of streams include a checklist designed to identify spring-fed systems. Indicators of spring-dominated hydrology include:

1) a relatively regular, rectangular cross-section, with minor variations in depth,

2) very low, flat floodplains, and

3) bank vegetation established along a distinct line, at a small distance above the water surface; moss on the exposed surfaces of rocks in the channel is a strong indicator of spring-fed flow.

The presence of these indicators could be noted in the physical survey on a scale of zero to three as: absent (0), slight (1), moderate (2), and pronounced (3).

The low-flow habitat factors estimated by this method should be increased according to the degree of spring influence, as identified in the physical survey, i.e.,

$$F_{sp} = 1.0 - \frac{(1-F)\ (3-N)}{3} \qquad \text{(Eq. 11)}$$

where F_{sp} = the low flow habitat factor, modified for spring influence,
F = the previously calculated low flow habitat factor, and
N = the degree of indicators of spring influence identified during the physical survey.

Thus, where the indicators are identified as pronounced, the habitat factors will be 1.0; where no spring-fed indicators are evident the habitat factors will be as previously calculated.

Several other possibilities exist for the improvement of the estimates yielded by this method. For example, the regional low-flow constants (C) could be improved by subdividing the regions, by the inclusion of a larger number of stream gages, and by considering climatic and watershed factors such as precipitation and elevation.

Additionally, this method assumes that the resistance offered to flow by the streambed is constant. Resistance is represented by the roughness factor, n, in Manning's equation. Manning's n becomes highly variable when the average substrate particle is more than 10% of flow depth. The Manning's n assumed for this analysis (i.e., 0.1) would occur throughout a range of depths and substrate textures, for instance, at an average depth of 1 foot and an average particle size (by weight) of 6.2 inches, at an average depth of 8 inches and an average particle size of 4.5 inches, and at an average depth of 4 inches and an average particle size of 2.5 inches. The effect of assuming this constant value for Manning's n is that the low-flow surface areas of streams with fine-textured, smooth substrates may be overestimated. Thus, the hydraulic calculations could be refined by varying the roughness factor according to the substrate texture and the Q_{60}.

APPENDIX F

Sample Field Notes

Downstream Check Comments Site ID#: 161030

Date: 12/9/1997

Chain Reading	Comments
0	Begin survey, 4% grad.
62	4% grad.
345	LB trib, 30% of mainstem flow
550	log jam
756	passable falls 2 ½ ‘ drop, deep plunge pool- GPS
935	log jam, 2' drop, 12'' deep plunge pool- GPS taken
1232 to 1250	series of passable log jam- GPS taken
1524	stream enters side channel of Hoh R downstream access for anadromous species verified

PHYSICAL HABITAT SURVEY FIELD FORM (11/22/'99)

[1]Survey ID: 161030 [2]Date: 12/10/97 [3]Observers: Till and Cox

[4]Stream Name: Unnamed Stream [5]Road/MP: Oil City Rd/5.98

[6]Trib. To: Hoh River [7]WRIA: 20.0149 [8]Position: Oil City Road

[9]Section Surveyed: Oil City Rd to Headwaters [10]Survey Method: PS

[11]Reach #: 1 [12]Begin CR: 0 [13]End CR: 625

[14]Spawning HQM: 1 [15]Rearing HQM: 1 [16]Spring Influence: 3

[17]Instream Cover: High [18]Juvenile Abundance: Low [19]Temp.: 7

[20]Canopy: 95%, 2nd growth alder, fir [21]Additional Barriers: None

[22]Limiting Factors: None [23]Culverted Length: 0

[24]Sampling Frequency: □30/160 ■60/320

[25]Flow Measurement: Depth: 0.2 Length: 4.4 Width: 4.0

Time 1: 11.08 Time 2: 12.39 Time 3: 10.52

Chain Reading	Habitat Type	Length	Wetted Width	OHW Width	Depth	Gradient	% Boulder/Rubble/Gravel/Sand
0	r	17	4.8	7.0	0.15	4	20/60/20/0
17	p	14	4.7	8.1	0.25		20/30/30/20
31	r	3	2.0	5.2	0.15		5/45/20/30
34	p	5	3.0	4.4	0.25		5/45/25/25
39	r	7	2.9	4.2	0.1		0/50/50/0
46	p	3	2.2	3.1	0.45		0/50/50/0
49	r	2	5.9	8	0.15		10/60/30/0

Upstream Survey Comments   Survey ID#: 161030
Date: 12/10/1997

Chain Reading	Comments
0	Reach 1 - Begin survey immediately upstream Oil City Rd 4% stream gradient
93	LB trib. < 20% mainstem flow
148	RB spring influence
160	minor log jam
216	big log jam, water flows under jam making it passable- lot's of LWD in stream due to logging - GPS taken
275	RB spring influence
358	log jam, stream flows around and under, 100% passable- GPS taken
423	log jam 100% passable
479	log bridge over stream- GPS taken
597	log jam, stream flows under, presently a barrier to adults, but could blow out- GPS taken
625	reach break due to RB trib > 20% parent flow, will survey tributary later
Reach 2	
666	log jam, stream flows under, barrier to adults, GPS taken
701	RB trib enters from marsh - stream braids here
705	log / LWD jam- GPS taken
723	LB trib < 20% of flow
819	Log / LWD jam
950	Log / LWD jam
960	LB trib < 20% , 0.50 m to log road w/ 2' cc rnd culvert w/ 6" outfall drop, 100% passable- GPS
1037	Log / LWD jam- GPS taken
1047	RB spring influence
1057	5 ft x 40 ft long, steel RND culvert 100% passable, gravel in bottom, 0.35 m water depth in culvert
1084	old log bridge - GPS taken
1182	LWD jam
1298	RB trib > 20% parent flow, Reach Break

APPENDIX G

Input Page with Sample Data

WDFW - SSHEAR
PHYSICAL HABITAT SURVEY - INPUT FILE (Ver. 4)

Survey Method :	PS	Date:	12/10/1997
Stream Name:	Unnamed	Observer(s):	Till & Cox
Tributary To:	Hoh R	Section surveyed:	from culvert on Oil City Rd at milepost 5.98 to headwaters
WRIA #:	20.0429		
Sample Frequency:	60 m / 322 m	File:	161030.wb1

REACH #1		Begin(m):	0	End(m): 625	Reach Length(m): 625
Quality		Position:	begin at culvert on Oil City Rd		
spawning:	1.00	Instream Cover:	high; boulders and LWD		
rearing:	1.00	Juv. Abundance:	low		
		Canopy:	0.95; 2nd growth; primarily alder and fir		
T (C):	7	Limiting Factors:	many log debris jams from cedar logging		
		Add. Barriers:	none		
T @trib:		Total culverted length:	0	m	Est. Drainage Area: 0.81 mi²

REACH #1 FIELD DATA

		FLOW		
D(ft)	L(ft)	W(ft)	Time	
0.65	14.43	13.12	1-	11.08
D(m)	L(m)	W(m)	2-	12.39
0.2	4.4	4	3-	10.52
FLOW=	8.78	cfs	ave.	11.33

Species Presence (x =Yes, blank = No)

Sockeye	Chum	Pink	
Coho	**Cutthroat**	**Chinook**	**Steelhead**
x	x		x
Res CT/RB	**Bull**		
x	x		
Brook	**Brown**		

Spring influences are (see below): 3
(absent-0, slight-1, mod.-2, pronounced-3)
1.) relatively regular, rectangular cross-section, minor variations in depth
2.) Poorly defined bars and thalweg / very low, flat floodplain
3.) bank vegetation along a distinct line, at a small distance above the H2O surface; moss on exposed surfaces of rocks

Reg. Constant (for 60-d low flow calc.): 0.49
Olympic/Coastal = 0.49
Cascade/E. Puget = 1.04
Columbia/E. WA=0.12
Northern/NE Mts.=0.097

REACH #1 HABITAT MEASUREMENT

Type	L	W	OHW	D	Grad.	B	R	G	S
r	17	4.8	7	0.15	0.04	20	60	20	0
p	14	4.7	8.1	0.25		20	30	30	20
r	3	2	5.2	0.15		5	45	25	25
p	5	3	4.4	0.25		5	45	25	25
r	7	2.9	4.2	0.1		0	50	50	0
p	3	2.2	3	0.45	0.04	0	50	50	0
r	2	5.9	8	0.15		10	60	30	0
p	3	5.5	5.9	0.35		20	60	30	0
r	19								

APPENDIX H

Output Page with Comments using Sample Data

WDFW - SSHEAR
PHYSICAL SURVEY OF POTENTIAL HABITAT (Ver. 4)

Stream Name: Unnamed
Tributary To: Hoh R
WRIA #: 20.0429
Sample Frequency: 60 m / 322 m
Survey Method: PS

Date: 12/10/1997
Observer(s): Till & Cox
Section surveyed: from culvert on Oil City Rd at milepost 5.98 to headwaters
File: 161030.wb1

Summary of Information - Total Stream Length

Total Length Surveyed:	1714.00	m	Tot. Length Culverted:	34.00	m
Total Length Sampled:	303.00	m	Percent of Stream Length		
Percent Sampled:	17.68	%	Culverted:	1.98	%

Measured Pool Area:	2266.38	m²
Measured Riffle Area	2022.54	m²
Measured Rapid Area:	0.00	m²
Measured Pond Area:	0.00	m²
Total Measured Stream Area:	**4288.93**	**m²**

Total Spawning Area:	**1338.26m²**
Total Rearing Area:	**4201.14m²**

POOL : RIFFLE : RAPID : POND RATIO (%)

Pool= 52.84 Riffle= 47.16 Rapid= 0.00 Pond= 0.00

PRODUCTION AREA CALCULATIONS

	Sockeye	Chum	Pink	Coho	Cutthroat	Chinook	Steelhead	Res CT/RB	Bull	Brook	Brown
Reach 1	0.00	0.00	0.00	2426.80	2426.80	0.00	2426.80	2426.80	2426.80	0.00	0.00
Reach 2	0.00	0.00	0.00	1364.69	1364.69	0.00	1364.69	1364.69	1364.69	0.00	0.00
Reach 3	0.00	0.00	0.00	372.22	372.22	0.00	372.22	372.22	372.22	0.00	0.00
Reach 4	0.00	0.00	0.00	37.43	37.43	0.00	37.43	37.43	37.43	0.00	0.00
Reach 5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Reach 6	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Reach 7	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Reach 8	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Reach 9	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Reach 10	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total area*	0.00	0.00	0.00	4201.14	4201.14	0.00	4201.14	4201.14	4201.14	0.00	0.00

** Spawning habitat used for sockeye, chum and pink, rearing used for all other species.*

ADJUSTED PRODUCTION AREAS

	Sockeye	Chum	Pink	Coho	Cutthroat	Chinook	Steelhead	Res CT/RB	Bull	Brook	Brown
Reach 1	0.00	0.00	0.00	2146.26	2146.26	0.00	2146.26	2413.94	2413.94	0.00	0.00
Reach 2	0.00	0.00	0.00	1206.94	1206.94	0.00	1206.94	1357.46	1357.46	0.00	0.00
Reach 3	0.00	0.00	0.00	329.19	329.19	0.00	329.19	370.24	370.24	0.00	0.00
Reach 4	0.00	0.00	0.00	33.10	33.10	0.00	33.10	37.23	37.23	0.00	0.00
Reach 5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Reach 6	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Reach 7	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Reach 8	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Reach 9	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Reach 10	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total area*	0.00	0.00	0.00	3715.49	3715.49	0.00	3715.49	4178.87	4178.87	0.00	0.00

Summary of Information - Reach #1

Starting Position:	begin at culvert on Oil City Rd	Length of Reach Culverted:	0.00 m
Length of Reach:	625.00 m	Percent of Reach Culverted:	0.0 %
Length Sampled:	73.00 m	Estimated drainage area:	0.81 mi²

Canopy: 0.95; 2nd growth; primarily alder and fir
Instream Cover: high; boulders and LWD
Juv. Abundance: low
Limiting Factors: many log debris jams from cedar logging
Additional Barriers: none

Spring influences are (see below): 3

(absent-0, slight-1, mod.-2, pronounced-3)

1.) relatively regular, rectangular cross-section, minor variations in depth
2.) Poorly defined bars and thalweg / very low, flat floodplain
3.) bank vegetation along a distinct line, at a small distance above the H2O surface; moss on exposed surfaces of rocks

Reg. Constant (for 60-d low flow calc.): 0.49

Olympic/Coastal = 0.49

Cascade/E. Puget = 1.04
Columbia/E. WA=0.12
Northern/NE Mts.=0.097

Species Present

Sockeye	no	Coho	yes	Steelhead	yes	Res CT/RB	yes	Brook	no
Chum	no	Cutthroat	yes			Bull	yes	Brown	no
Pink	no	Chinook	no						

Pool : Riffle : Rapid : Pond Ratio (%)

Pool= 33.96 Riffle= 66.04 Rapid= 0.00 Pond= 0.00

Pool L sampled:	25.00 m	Pool Gravel %:	33.75
Riffle L sampled:	48.00 m	Riffle Gravel %:	31.25
Rapid L sampled:	0.00 m	Rapid Gravel %:	0.00
Pond L sampled:	0.00 m	Pond Gravel %:	0.00
Ave. Pool Depth:	0.33 m	Flow:	8.78 cfs
Ave. Riffle Depth:	0.138 m	Ave. Grad.:	4.00 %
Ave. Rapid Depth:	0.00 m	Ave. Temp:	7.0 ˚C
Ave. Pond Depth:	0.00 m	T @ trib.:	0.0 ˚C

Substrate Composition (%): Boulder= 10.00 Rubble= 50.00 Gravel= 32.50 Sand= 8.75

Wetted (Measured) Area

Ave. Pool Width:	3.85 m	Pool Area (W)	824.06 m²
Ave. Riffle Width:	3.900 m	Riffle Area (W):	1602.74 m²
Ave. Rapid Width:	0.00 m	Rapid Area (W):	0.00 m²
Ave. Pond Width:	0.00 m	Pond Area (W):	0.00 m²
		Total Reach Area(W):	**2426.80 m²**

Ordinary High Water Area

Ave. Pool W(OHW):	5.35 m	Pool Area (OHW):	1145.12 m²
Ave. Riffle W(OHW):	6.10 m	Riffle Area (OHW):	2506.85 m²
Ave. Rapid W(OHW):	0.00 m	Rapid Area (OHW):	0.00 m²
Ave. Pond W(OHW):	0.00 m	Pond Area (OHW):	0.00 m² m²
		Total Reach Area(OHW):	**3651.97 m²**

60-day Low Flow Area

60-day Low Flow:	0.011 cfs	Pool Area (60dLF):	824.06 m²
Low-Flow Depth:	0.058	Riffle Area (60dLF):	1602.74 m²
Low-Flow Width:	1.65	Rapid Area (60dLF):	0.00 m²
		Pond Area (60dLF):	0.00 m²
Pool Factor:	0.76		
Riffle/Rapid Factor:	0.42	**Total Reach Area (60dLF):**	**2426.80 m²**
Pond Factor:	1.00		

QUALITY MODIFIERS:

spawning:	1.00	**Spawning Area:**	**1169.87 m²**
rearing:	1.00	**Rearing Area:**	**2426.80 m²**

::

WDFW-SSHEAR   PHYSICAL SURVEY OF POTENTIAL HABITAT
DOWNSTREAM CHECK COMMENTS

Stream Name: Unnamed
Tributary To: Hoh R
WRIA #: 20.0429

Date: 12/10/1997
Observer(s): Till & Cox
Section surveyed: cuvlert on Oil City Rd at milepost 5.98 to Hoh R

Hip Chain	Comment
0	Begin Survey
62	Gradient 4%
345	LB tributary; 30% of mainstem flow.
550	Log Jam
786	Log falls; passable 0.76 m drop, deep plunge pool. GPS taken.
935	Log falls; passable 0.76 m drop, 0.30 m deep plunge pool. GPS taken.
1232	18 m of log jams. Log jam w/ 0.91 m drop, 0.90 m deep pool. GPS taken.
1524	Tributary braids and enters side channel of Hoh River.

WDFW-SSHEAR PHYSICAL SURVEY OF POTENTIAL HABITAT
UPSTREAM SURVEY COMMENTS

Stream Name:	Unnamed	**Date:**	12/10/1997
Tributary To:	Hoh R	**Observer(s):**	Till & Cox
WRIA # :	20.0429	**Section surveyed:**	from culvert on Oil City Rd
Sample Frequency:	60 m / 322 m		at milepost 5.98 to headwaters

Hip Chain	Comment
0	REACH 1, Begin Survey Gradient 4%
9	Roadside drainage ditch on LB; <20% of mainstem flow.
93	LB tributary; <20% of mainstem flow.
148	RB spring influence.
160	Minor log jam.
216	LB tributary; <20% of mainstem flow. 17% gradient
244	Big log/debris jam; water flows under jam. GPS taken.
320	REACH 1, SAMPLE 2 Gradient 3%
358	Stream runs under and around log jam;100% passable. GPS taken.
479	Log Bridge; 100% passable GPS taken for bridge.
597	Stream flows under log jam; possibly not passable to adults. GPS taken.
625	RB tributary; >20% of mainstem flow. Reach break due to tributary (see file 161030a.wb1).
625	REACH 2, SAMPLE 1 Gradient 2.5%
666	Stream flows under log jam; barrier to adults. GPS taken.
684	Heavily embedded gravel.
705	Log/debris jam. GPS taken.
719	US end of log/debris jam.
723	LB tributary; < 20% of mainstem flow.
819	Log/debris jam.
953	REACH 2, SAMPLE 2 Gradient 1%
960	LB tributary; < 20% of mainstem flow. Tributary runs about 5 m to logging road with a 0.60 m CMP RND; 0.15 m outfall drop; 100% passable (Site 170001).
1057	CST RND 1.52 m diameter; 12.19 m long; 100% passable; streambed material throughout (Site 170002). Roadside ditch enters at downstream end of CMP. Ditch <20% of main flow.
1084	Old log bridge, 100% passable. GPS taken for bridge.
1274	REACH 2, SAMPLE 3
1284	Log/debris jam.
1298	RB tributary; >20% of main flow. Reach break due to tributary (see file 161030b.wb1).
1298	REACH 3, SAMPLE 1 Gradient 1%
1403	Canopy cover - 40%. Instream cover - 100%. Abundant debris in stream making many small pools and causing some water to flow above ground and some underground.
1545	Barrier culvert under old logging road; 0.91 m CMP RND; 9.14 m long (Site 170003). Downstream end is crushed inward on one side. Upstream end choked with logging debris causing stream to run underground for about 20 m before entering culvert.
1554	Reach break upstream of barrier culvert.
1554	REACH 4, SAMPLE 1
	Upper end of culvert is buried. Channel has no definite boundaries; flow is intermittent.
1559	Stream above ground again.
1564	Stream briefly re-emerges and then moves under gravel / rubble again. No definite channel.
1568	Stream re-appears with gravel and rubble streambed.
1577	100% passable culvert; 0.61 m CMP RND 12.19 m long; completely backwatered (Site 170004).
1600	Abundant debris. Stream is underground and flows mostly under debris. Heavy salal understory.
1626	Stream has been intermittent until here, where it temporarily is emergent and has a definite channel.
1628	Ground here is somewhat marshy -- can see some emergent skunk cabbage. Area has been heavily disturbed due to logging and is possibly drier now than it once was.
1654	Stream is underground again.
1714	Stream still underground, cannot sample.
1765	No more flow or channel. End of survey at source of flow.

APPENDIX I

Summary Spreadsheet

WDFW - SSHEAR

Physical Survey Summary of Information

Stream Name:	Unnamed
Tributary To:	Hoh R
WRIA #:	20.0429
Site ID:	161030

Filename(s):

1	161030.WB1	6	
2	161030a.WB1	7	
3	161030b.WB1	8	
4	161030b1.WB1	9	
5		10	

Species present:

1	coho	7	
2	steelhead	8	
3	searun cutthroat	9	
4	resident rainbow/ cutthroat	10	
5	bull trout	11	
6			

Length Surveyed (m):

Primary Stream:	1714.00	m
1st tributary:	72.00	m
2nd tributary:	700.00	m
3rd tributary:	183.00	m
4th tributary:		m
5th tributary:		m
6th tributary:		m
7th tributary:		m
8th tributary:		m
9th tributary:		m
Total Length Surveyed (m):	**2669.00**	**m**

Spawning area (m²):

Primary Stream:	1338.26	m²
1st tributary:	6.43	m²
2nd tributary:	163.37	m²
3rd tributary:	51.44	m²
4th tributary:		m²
5th tributary:		m²
6th tributary:		m²
7th tributary:		m²
8th tributary:		m²
9th tributary:		m²
Total Rearing Area (m²):	**1559.50**	**m²**

Rearing area (m²):

Primary Stream:	4201.14	m²
1st tributary:	38.04	m²
2nd tributary:	788.73	m²
3rd tributary:	207.20	m²
4th tributary:		m²
5th tributary:		m²
6th tributary:		m²
7th tributary:		m²
8th tributary:		m²
9th tributary:		m²
Total Rearing Area (m²):	**5235.11**	**m²**

coho	Primary Stream:	4143.58	m²
Adjusted Production Area:	1st tributary:	0.00	m²
	2nd tributary:	463.97	m²
	3rd tributary:	204.36	m²
	4th tributary:		m²
	5th tributary:		m²
	6th tributary:		m²
	7th tributary:		m²
	8th tributary:		m²
	9th tributary:		m²
	Total Adjusted Production Area:	**4811.91**	**m²**

steelhead	Primary Stream:	4143.58	m²
Adjusted Production Area:	1st tributary:	38.04	m²
	2nd tributary:	782.29	m²
	3rd tributary:	204.36	m²
	4th tributary:		m²
	5th tributary:		m²
	6th tributary:		m²
	7th tributary:		m²
	8th tributary:		m²
	9th tributary:		m²
	Total Adjusted Production Area:	**5168.27**	**m²**

searun cutthroat	Primary Stream:	3993.60	m²
Adjusted Production Area:	1st tributary:	36.16	m²
	2nd tributary:	749.77	m²
	3rd tributary:	196.96	m²
	4th tributary:		m²
	5th tributary:		m²
	6th tributary:		m²
	7th tributary:		m²
	8th tributary:		m²
	9th tributary:		m²
	Total Adjusted Production Area:	**4976.49**	**m²**

resident rainbow / cutthroat	Primary Stream:	3993.60	m²
Adjusted Production Area:	1st tributary:	36.16	m²
	2nd tributary:	749.77	m²
	3rd tributary:	196.96	m²
	4th tributary:		m²
	5th tributary:		m²
	6th tributary:		m²
	7th tributary:		m²
	8th tributary:		m²
	9th tributary:		m²
	Total Adjusted Production Area:	**4976.49**	**m²**

bull trout	Primary Stream:	3993.60	m²
Adjusted Production Area:	1st tributary:	36.16	m²
	2nd tributary:	749.77	m²
	3rd tributary:	196.96	m²
	4th tributary:		m²
	5th tributary:		m²
	6th tributary:		m²
	7th tributary:		m²
	8th tributary:		m²
	9th tributary:		m²
	Total Adjusted Production Area:	**4976.49**	m²

APPENDIX J

ETD Survey Planning Form
with an Example of a Completed ETD

ETD Survey Planning

Site ID # : ____

Stream Name: ____

Tributary To: ____

Is this the Primary Stream or Tributary?: ____

Location of tributary entering into primary, measured in meters upstream or downstream of project site: ____

Tributary Entering in RB or LB?: ____

Check Mark Species Present and List Verification Source

Species	Check	Verification Source	Species	Check	Verification Source
Sockeye			Searun Cutthroat		
Chum			Resident Rainbow/ Cutthroat		
Pink			Bull / Dolly		
Coho			Brook		
Chinook			Brown		
Steelhead					

Is this the Upstream or Downstream ETD: ____

REACH BREAKS BY GRADIENT AND TRIBUTARIES

Reach	Reach Begin	Reach End	Reach Length (m)	Average Gradient	Reach Break due to Gradient or Tributary?	Basin Area (mi²):
1						
2						
3						
4						
5						
6						
7						
8						
9						
10						
TOTAL:						

Are there potential natural (point) barriers downstream or upstream? (Y / N / Unknown): ____

Distance from crossing downstream or upstream to point barrier (m): ____

Describe type of point barrier (e.g. falls, cascade, etc.): ____

Source of point barrier identification: (e.g. stream catalog, map, WDFW personnel, etc.) ____

Number of road crossings shown on a map, upstream or downstream the initial crossing, or, on tributary: ____

ETD Survey Planning

Site ID #: 990120

Stream Name: Dog Cr

Tributary To: Yale Reservoir

Is this the Primary Stream or Tributary?: Primary

Location of tributary entering into primary, measured in meters upstream or downstream of project site: ------

Tributary Entering in RB or LB?: ------

Check Mark Species Present and List Verification Source

Species	Present	Verification Source	Species	Present	Verification Source
Sockeye			Searun Cutthroat		
Chum			Resident Rainbow/ Cutthroat	√	visual observation by WDFW Biologist, John Long
Pink			Bull / Dolly		
Coho			Brook		
Chinook			Brown		
Steelhead					

Is this the Upstream or Downstream ETD: upstream ETD

REACH BREAKS BY GRADIENT AND TRIBUTARIES

Reach	Reach Begin	Reach End	Reach Length (m)	Average Gradient	Reach Break due to Gradient or Tributary?	Basin Area (mi²):
1	0	298	298	5%	gradient	1.23
2	298	1085	787	2.4%	tributary	1.22
3	1085	1323	238	2.4%	gradient	0.96
4	1323	1615	292	6.8%	tributary	0.94
5	1615	2047	432	8%	tributary	0.71
6	2047	2226	179	18.5%	gradient	0.26
7	2226	2762	536	9%	gradient	0.25
8	2762	3149	387	16%	gradient	0.22
9						
10						
TOTAL:			3149			

Are there potential natural (point) barriers downstream or upstream? (Y / N / Unknown): unknown

Distance from crossing downstream or upstream to point barrier (m): --------

Describe type of point barrier (e.g. falls, cascade, etc.): --------

Source of point barrier identification: (e.g. stream catalog, map, WDFW personnel, etc.) --------

Number of road crossings shown on a map, upstream or downstream the initial crossing, or, on tributary: 1

ETD Survey Planning

Site ID # : 990120
Stream Name: Unnamed
Tributary To: Dog Cr

Is this the Primary Stream or Tributary?: Tributary

Location of tributary entering into primary, measured in meters upstream or downstream of project site: 1085 m

Tributary Entering in RB or LB?: RB

Check Mark Species Present and List Verification Source

Species	Check	Source	Species	Check	Source
Sockeye			Searun Cutthroat		
Chum			Resident Rainbow/ Cutthroat	√	observed in Dog Cr
Pink			Bull / Dolly		
Coho			Brook		
Chinook			Brown		
Steelhead					

Is this the Upstream or Downstream ETD: upstream ETD

REACH BREAKS BY GRADIENT AND TRIBUTARIES

Reach	Reach Begin	Reach End	Reach Length (m)	Average Gradient	Reach Break due to Gradient or Tributary?	Basin Area (mi²):
1	0	370	370	16%	gradient	0.18
2	370	918	548	10%	gradient	0.16
3	918	1088	170	12%	gradient	0.10
4						
5						
6						
7						
8						
9						
10						
TOTAL:			1088			

Are there potential natural (point) barriers downstream or upstream? (Y / N / Unknown): unknown, but suspected

Distance from crossing downstream or upstream to point barrier (m): unknown

Describe type of point barrier (e.g. falls, cascade, etc.): falls or cascades; high gradient upstream

Source of point barrier identification: (e.g. stream catalog, map, WDFW personnel, etc.) USGS quad map shows high gradients

Number of road crossings shown on a map, upstream or downstream the initial crossing, or, on tributary: 0

WDFW - SSHEAR
Expanded Threshold Determination - INPUT FILE (Ver. 4)

Survey Method :	ETD	Date:	9/09/1999
Stream Name:	Dog Cr	Observer(s):	Lonu & McLeaf
Tributary To:	Yale Reservoir	Section surveyed:	upstream River Rd milepost 35.80
WRIA #:	27		
Sample Frequency:		File:	990120.wb1
Washington Region (E = eastern, W = western):	W		

REACH #1	Begin(m):	0.00	End(m):	298.00	Reach Length(m):	298.00
Quality	Position:	begin sampling 40 m upstream River Rd at milepost 35.80 abundant				
spawning: 1.00	Instream Cover:					
rearing: 1.00	Juv. Abundance:	high; numberous cutthroat observed				
	Canopy:	80%, mixed 2nd growth				
T (C): 12.00	Limiting Factors:	low summer flows				
	Add. Barriers:	none within 200 m surveyed				
T @trib:	Total culverted length:		m	Est.Drainage Area:	1.230	mi²

REACH #1 FIELD DATA

FLOW				
D(ft)	L(ft)	W(ft)	Time	
0.33	9.84	6.23	1-	12.00
D(m)	L(m)	W(m)	2-	13.00
0.10	3.00	1.90	3-	12.00
FLOW=	1.31	cfs	ave.	12.33

Species Presence (x =Yes, blank = No)

Sockeye	Chum	Pink		
Coho	Cutthroat	Chinook	Steelhead	
Res CT/RB	Bull			
x				
Brook	Brown			

Spring influences are (see below): 1
(absent-0, slight-1, mod.-2, pronounced-3)

1.) relatively regular, rectangular cross-section, minor variations in depth

2.) Poorly defined bars and thalweg / very low, flat floodplain

3.) bank vegetation along a distinct line, at a small distance

above the H2O surface; moss on exposed surfaces of rocks

Reg. Constant (for 60-d low flow calc.): 0.490
Olympic/Coastal = 0.49

Cascade/E. Puget = 1.04

Columbia/E. WA=0.12

Northern/NE Mts.=0.097

REACH #1 HABITAT MEASUREMENT

Type	L	W	OHW	D	Gradient	B	R	G	S
p	3	1.7	3.5	0.27	0.06	50	40	10	
r	7.4	0.8	6.4	0.1	0.06	40	40	20	
p	24	1.4	5.1	0.08		40	30	20	10
r	36	1.3	5	0.07		40	30	20	10
r	7.5	1.6	11.2	0.05		50	30	15	5
p	12.3	1.8	5.7	0.18	0.06	50	30	10	10
r	18.8	1.7	6.3	0.1	0.06	60	30	10	
p	14.4	2.9	9.6	0.32	0.06	20	30	40	10
r	22								
r	10.8	1.8	7.9	0.1	0.05	40	20	30	10
p	14.4	2.8	7.9	0.32	0.05	30	30	30	10
r	8.1	1.9	4.1	0.1	0.05	40	30	25	5
p	8.3	1.8	3.2	0.22	0.05	30	30	20	20
r	16.5								
	samp L				Grad ave	B ave	R ave	G ave	S ave
	203.50	W	OHW	D	0.056	40.83	30.83	20.83	10.00
	p L	p ave	p ave	p ave		pB ave	pR ave	pG ave	pS ave
	76.40	2.07	5.83	0.23		36.67	31.67	21.67	12.00

	r L	r ave	r ave	r ave		rB ave	rR ave	rG ave	rS ave
	127.10	1.52	6.82	0.09		45.00	30.00	20.00	7.50
	rap L	rap ave	rap ave	rap ave		rapB ave	rapR ave	rapG ave	rapS ave
	0.00	ERR	ERR	ERR		ERR	ERR	ERR	ERR
	pond L	pond ave	pond ave	pond ave		pondB ave	pondR ave	pondG ave	pondS ave
	0.00	ERR	ERR	ERR		ERR	ERR	ERR	ERR

REACH #2		Begin(m):	298.00	End(m):	1085.00	Reach Length(m):	787.00
Quality		Position:					
spawning:	1.00	Instream Cover:					
rearing:	1.00	Juv. Abundance:					
		Canopy:					
T (C):		Limiting Factors:					
		Add. Barriers:					
T @trib:		Total culverted length:				Est. Drainage Area:	1.220 mi²

REACH #2
FIELD DATA

		FLOW		
D(ft)	L(ft)	W(ft)	Time	
0.00	0.00	0.00	1-	
D(m)	L(m)	W(m)	2-	
			3-	
FLOW=	ERR	cfs	ave.	ERR

Species Presence (x =Yes, blank = No)

Sockeye	Chum	Pink		
Coho	Cutthroat	Chinook	Steelhead	
Res CT/RB	Bull			
x				
Brook	Brown			

Spring influences are (see below): 1
(absent-0, slight-1, mod.-2, pronounced-3)

1.) relatively regular, rectangular cross-section, minor variations in depth

2.) Poorly defined bars and thalweg / very low, flat floodplain

3.) bank vegetation along a distinct line, at a small distance

above the H2O surface; moss on exposed surfaces of rocks

Reg. Constant (for 60-d low flow calc.): 0.490
Olympic/Coastal = 0.49

Cascade/E. Puget = 1.04

Columbia/E. WA=0.12

Northern/NE Mts.=0.097

REACH #2 HABITAT MEASUREMENT

Type	L	W	OHW	D	Gradient	B	R	G	S
p	377.76	2.05	5.79	0.23	0.024			36.00	
r	409.24	1.50	6.76	0.09				53.00	
rap	0.00	1.50	6.76	0.09				0.00	
pond									
	samp L				Grad ave	B ave	R ave	G ave	S ave
	787.00	W	OHW	D	0.024	ERR	ERR	29.67	ERR
	p L	p ave	p ave	p ave		pB ave	pR ave	pG ave	pS ave
	377.76	2.05	5.79	0.23		ERR	ERR	36.00	ERR
	r L	r ave	r ave	r ave		rB ave	rR ave	rG ave	rS ave
	409.24	1.50	6.76	0.09		ERR	ERR	53.00	ERR
	rap L	rap ave	rap ave	rap ave		rapB ave	rapR ave	rapG ave	rapS ave
	0.00	1.50	6.76	0.09		ERR	ERR	0.00	ERR
	pond L	pond ave	pond ave	pond ave		pondB ave	pondR ave	pondG ave	pondS ave
	0.00	ERR	ERR	ERR		ERR	ERR	ERR	ERR