

**Inventory and Assessment of Stream Crossings in the
Fish-Bearing Waters of Southeast Alaska – Phase 2**

by

Gillian O’Doherty

And

Mark Eisenman

November 2013

Alaska Department of Fish and Game

Divisions of Sport Fish and Commercial Fisheries



Symbols and Abbreviations

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

Weights and measures (metric)		General		Mathematics, statistics	
centimeter	cm	Alaska Administrative Code	AAC	<i>all standard mathematical signs, symbols and abbreviations</i>	
deciliter	dL	all commonly accepted abbreviations	e.g., Mr., Mrs., AM, PM, etc.	alternate hypothesis	H_A
gram	g	all commonly accepted professional titles	e.g., Dr., Ph.D., R.N., etc.	base of natural logarithm	e
hectare	ha	at	@	catch per unit effort	CPUE
kilogram	kg	compass directions:		coefficient of variation	CV
kilometer	km	east	E	common test statistics	(F, t, χ^2 , etc.)
liter	L	north	N	confidence interval	CI
meter	m	south	S	correlation coefficient	
milliliter	mL	west	W	(multiple)	R
millimeter	mm	copyright	©	correlation coefficient (simple)	r
		corporate suffixes:		covariance	cov
Weights and measures (English)		Company	Co.	degree (angular)	$^\circ$
cubic feet per second	ft ³ /s	Corporation	Corp.	degrees of freedom	df
foot	ft	Incorporated	Inc.	expected value	E
gallon	gal	Limited	Ltd.	greater than	>
inch	in	District of Columbia	D.C.	greater than or equal to	\geq
mile	mi	et alii (and others)	et al.	harvest per unit effort	HPUE
nautical mile	nmi	et cetera (and so forth)	etc.	less than	<
ounce	oz	exempli gratia (for example)	e.g.	less than or equal to	\leq
pound	lb	Federal Information Code	FIC	logarithm (natural)	ln
quart	qt	id est (that is)	i.e.	logarithm (base 10)	log
yard	yd	latitude or longitude	lat or long	logarithm (specify base)	log ₂ , etc.
		monetary symbols (U.S.)	\$, ¢	minute (angular)	'
Time and temperature		months (tables and figures): first three letters	Jan,...,Dec	not significant	NS
day	d	registered trademark	®	null hypothesis	H_0
degrees Celsius	°C	trademark	™	percent	%
degrees Fahrenheit	°F	United States (adjective)	U.S.	probability	P
degrees kelvin	K	United States of America (noun)	USA	probability of a type I error (rejection of the null hypothesis when true)	α
hour	h	U.S.C.	United States Code	probability of a type II error (acceptance of the null hypothesis when false)	β
minute	min	U.S. state	use two-letter abbreviations (e.g., AK, WA)	second (angular)	"
second	s			standard deviation	SD
Physics and chemistry				standard error	SE
all atomic symbols				variance	
alternating current	AC			population sample	Var
ampere	A			sample	var
calorie	cal				
direct current	DC				
hertz	Hz				
horsepower	hp				
hydrogen ion activity (negative log of)	pH				
parts per million	ppm				
parts per thousand	ppt, ‰				
volts	V				
watts	W				

REGIONAL OPERATIONAL PLAN SF.4A.2013.09

**INVENTORY AND ASSESSMENT OF STREAM CROSSINGS IN THE
FISH-BEARING WATERS OF SOUTHEAST ALASKA – PHASE 2**

by

Gillian O'Doherty

Alaska Department of Fish and Game, Division of Sport Fish, Anchorage

and

Mark Eisenman

Alaska Department of Fish and Game, Division of Sport Fish,, Anchorage

Alaska Department of Fish and Game
Division

November 2013

The Regional Operational Plan Series was established in 2012 to archive and provide public access to operational plans for fisheries projects of the Divisions of Commercial Fisheries and Sport Fish, as per joint-divisional Operational Planning Policy. Documents in this series are planning documents that may contain raw data, preliminary data analyses and results, and describe operational aspects of fisheries projects that may not actually be implemented. All documents in this series are subject to a technical review process and receive varying degrees of regional, divisional, and biometric approval, but do not generally receive editorial review. Results from the implementation of the operational plan described in this series may be subsequently finalized and published in a different department reporting series or in the formal literature. Please contact the author if you have any questions regarding the information provided in this plan. Regional Operational Plans are available on the Internet at: <http://www.adfg.alaska.gov/sf/publications/>

*Gillian O'Doherty,
Alaska Department of Fish and Game, Division of Sport Fish
333 Raspberry Road, Anchorage Alaska*

*Mark Eisenman
Alaska Department of Fish and Game, Division of Sport Fish
333 Raspberry Road, Anchorage, Alaska*

This document should be cited as:

O'Doherty, G. and M. Eisenman. 2013. Inventory and assessment of stream crossings in the fish bearing waters of Southeast Alaska – Phase 2. Alaska Department of Fish and Game, Division of Sport Fish, Regional Operational Plan ROP.SF.4A.2013.09, Anchorage.

The Alaska Department of Fish and Game (ADF&G) administers all programs and activities free from discrimination based on race, color, national origin, age, sex, religion, marital status, pregnancy, parenthood, or disability. The department administers all programs and activities in compliance with Title VI of the Civil Rights Act of 1964, Section 504 of the Rehabilitation Act of 1973, Title II of the Americans with Disabilities Act (ADA) of 1990, the Age Discrimination Act of 1975, and Title IX of the Education Amendments of 1972.

If you believe you have been discriminated against in any program, activity, or facility please write:

ADF&G ADA Coordinator, P.O. Box 115526, Juneau, AK 99811-5526

U.S. Fish and Wildlife Service, 4401 N. Fairfax Drive, MS 2042, Arlington, VA 22203

Office of Equal Opportunity, U.S. Department of the Interior, 1849 C Street NW MS 5230, Washington DC 20240

The department's ADA Coordinator can be reached via phone at the following numbers:

(VOICE) 907-465-6077, (Statewide Telecommunication Device for the Deaf) 1-800-478-3648,

(Juneau TDD) 907-465-3646, or (FAX) 907-465-6078

For information on alternative formats and questions on this publication, please contact:

ADF&G, Division of Sport Fish, Research and Technical Services, 333 Raspberry Rd, Anchorage AK 99518 (907) 267-2375

SIGNATURE PAGE

Project Title: Inventory and Assessment of Stream Crossings in the Fish Bearing Waters of Southeast Alaska – Phase 2

Project leader(s): Gillian O’Doherty

Division, Region, and Area: Division of Sport Fish, Region IV, Anchorage

Project Nomenclature:

Period Covered: May 2013 – November 2014

Field Dates: June 2013 – September 2014

Plan Type: Category I

Approval

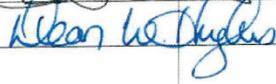
Title	Name	Signature	Date
Project leader	Gillian O’Doherty		11.20.13
Research Coordinator	Dean Hughes		11/21/13

TABLE OF CONTENTS

	Page
LIST OF TABLES.....	iii
LIST OF FIGURES.....	iii
LIST OF APPENDICES.....	iii
ABSTRACT.....	1
PURPOSE.....	1
BACKGROUND.....	2
OBJECTIVES.....	2
METHODS.....	3
Study Area.....	3
Data Collection.....	7
Fish Passage Assessment.....	7
Site Selection and Naming.....	8
Survey Protocol.....	9
Data Reduction.....	17
Data Analysis.....	18
SCHEDULE AND DELIVERABLES.....	21
RESPONSIBILITIES.....	21
REFERENCES CITED.....	23
APPENDIX A - FIELD FORMS.....	25

LIST OF TABLES

Table	Page
Table 1.–Total Road Miles and predicted number of crossings in towns in Southern Southeast Alaska	1
Table 2.–General activity schedule for fish passage inventory and assessment from April 2013 through November 2014.	21

LIST OF FIGURES

Figure	Page
Figure 1.–Overview of the project area showing the road systems of Petersburg, Wrangell, Ketchikan, and Prince of Wales Island.	3
Figure 2.–Predicted sites for the Petersburg area.	4
Figure 3.–Predicted sites for the Wrangell area.	5
Figure 4.–Predicted sites for the Ketchikan area.	6
Figure 5.–Predicted sites for the Prince of Wales Island road system.	7
Figure 6.–Cross-sectional views of most commonly encountered culvert types.	10
Figure 7.–Illustration of the invert design categories.	11
Figure 8.–An illustration of the concept of differential leveling.	14

LIST OF APPENDICES

Appendix	Page
Appendix A1.–Field forms.	26

ABSTRACT

The primary goal of this study is to assess the impacts of culverted crossings on the movement of fish in Petersburg, Wrangell, Ketchikan, and on Prince of Wales Island. All crossings located on state and borough owned roads that cross fish bearing waters will be assessed using the standard ADFG Level 1 assessment methodology. For this project, fish-bearing waters are those streams and water bodies known to support fish through direct sampling or observation, known by local biologists to support fish or are tributaries to a known fish-bearing water body. The data will be used to prioritize the replacement of barriers to fish movement with emphasis on anadromous systems.

Key words: fish passage assessment, culverts, barriers, juvenile salmonids Southeast Alaska, Petersburg, Wrangell, Ketchikan, Prince of Wales Island.

PURPOSE

The purpose of this project is to document the location and of culverts on roads in Southern Southeast Alaska and to classify them with respect to their potential to affect fish passage. Southeast Alaska was ranked as the 3rd most valuable commercial salmon fishery in estimated value in 2010, and second with both total numbers of fish caught and total pounds caught (ADF&G 2010). Most of Southeast Alaska is fairly remote, only being accessible by plane or ferry, and in a few locations by road.

Table 1. Total Road Miles and predicted number of crossings in towns in Southern Southeast Alaska

Road Network	Miles	Predicted Number of Crossings
Petersburg	72	103
Wrangell	55	59
Ketchikan	87	53
Prince of Wales Island	327	682
Totals	541	897

The immediate benefit of this project will be the determination of the number and location of culverts that are likely to be barriers to fish movements. Data from the project will be useful in developing proposals for restoring fish passage at stream crossings classified as barriers as well as providing information to assist their general planning and road maintenance needs. Ultimately, the result will be the removal or replacement of these structures thereby increasing the amount of aquatic habitat available in a given stream. Long-term benefits of this project will be improved protection of important anadromous and resident fish habitats and fishery resources in Southeast Alaska.

Field work will begin in early June 2013 and or as soon as stream conditions are favorable for wading and concluded in mid to late August. Final data analysis and final report writing will take place between October 2014 and May 2015.

BACKGROUND

Culverted road crossings often delay, impeded or block fish movement into and out of stream systems, resulting in habitat fragmentation with the potential to affect fish populations.. Culvert assessments throughout the Pacific Northwest (Botkin et al. 1994; Kahler and Quinn 1998; Mirati 1999) and southeast and southcentral Alaska (Flanders and Cariello 2000; Albert and Beers unpublished; Rich unpublished; Albert and Weiss unpublished) suggest that a majority of existing culverts obstruct fish movements to some degree.

Culverts may be barriers to fish immediately upon installation or develop into barriers over time due to alterations in stream flow and channel morphology up and downstream or poor maintenance and debris jams. Types of barriers include over-steepened reaches, excessive water velocities, impassable jumps at the entry into the culvert, physical blockage due to damaged pipes or debris, inadequate water depth or subsurface flow at damaged structures. Free and efficient movement through culverts is necessary for anadromous and resident fishes of all age classes and life stages to allow unobstructed access to important habitats (Kahler and Quinn 1998). Adult fish must access spawning areas and juvenile anadromous fish such as Chinook (*Oncorhynchus tshawytscha*), coho (*Oncorhynchus kisutch*), and sockeye salmon (*Oncorhynchus nerka*) spend up to two years in fresh water as juveniles, moving to exploit diverse habitats for feeding and over-wintering. Fish passage barriers also prevent free access to essential habitats for resident species such as grayling, which often use specific streams for spawning, juvenile rearing, summer feeding, and over-wintering. Culverts are most likely to have a negative effect on the movements of fish with limited swimming and leaping abilities, such as juvenile salmonids, and on species such as coho salmon, that rely on small streams for spawning and rearing habitat.

OBJECTIVES

The goal is to perform a complete census of all stream crossings, other than bridges, associated with fish-bearing waters or waters that have the potential to be fish-bearing. For this project, fish-bearing waters are those streams and water bodies known to support fish through direct sampling or observation, known by local biologists to support fish or are tributaries to a known fish-bearing water body. A site that does not support fish due to a known downstream anthropogenic barrier (such as a dam) will be treated as a fish-bearing water.

The objectives of this project are to:

1. Determine the number, classification, and location of culverts in fish bearing streams within the project area. This includes all crossings on State, federal, borough and private roads;
2. Assess fish passage conditions utilizing the coarse filter screening criteria;
3. Identify a subset of high priority stream-road crossing sites for future restoration or improvement; and
4. Add all inventoried culvert crossing sites to the ADF&G Fish Passage Improvement Database and make available on the internet along with mapped information through the Internet Mapping Service.

METHODS

STUDY AREA

The bulk of this project in 2013 will be focused in Petersburg which has the most predicted crossings. In 2014, the project will focus entirely on Prince of Wales Island and any other areas not covered in 2013. Prince of Wales Island has over 327 miles of roads to be surveyed and 682 predicted crossings. Work will begin in June 2013 with the project truck and equipment being ferried down to Petersburg. Once surveys are complete in Petersburg the crew will ferry to Wrangell and complete surveys there and then move onto Ketchikan to complete the field season. In June 2014, the crew will transport the project truck and equipment to Prince of Wales Island and work all summer on the island's road system.

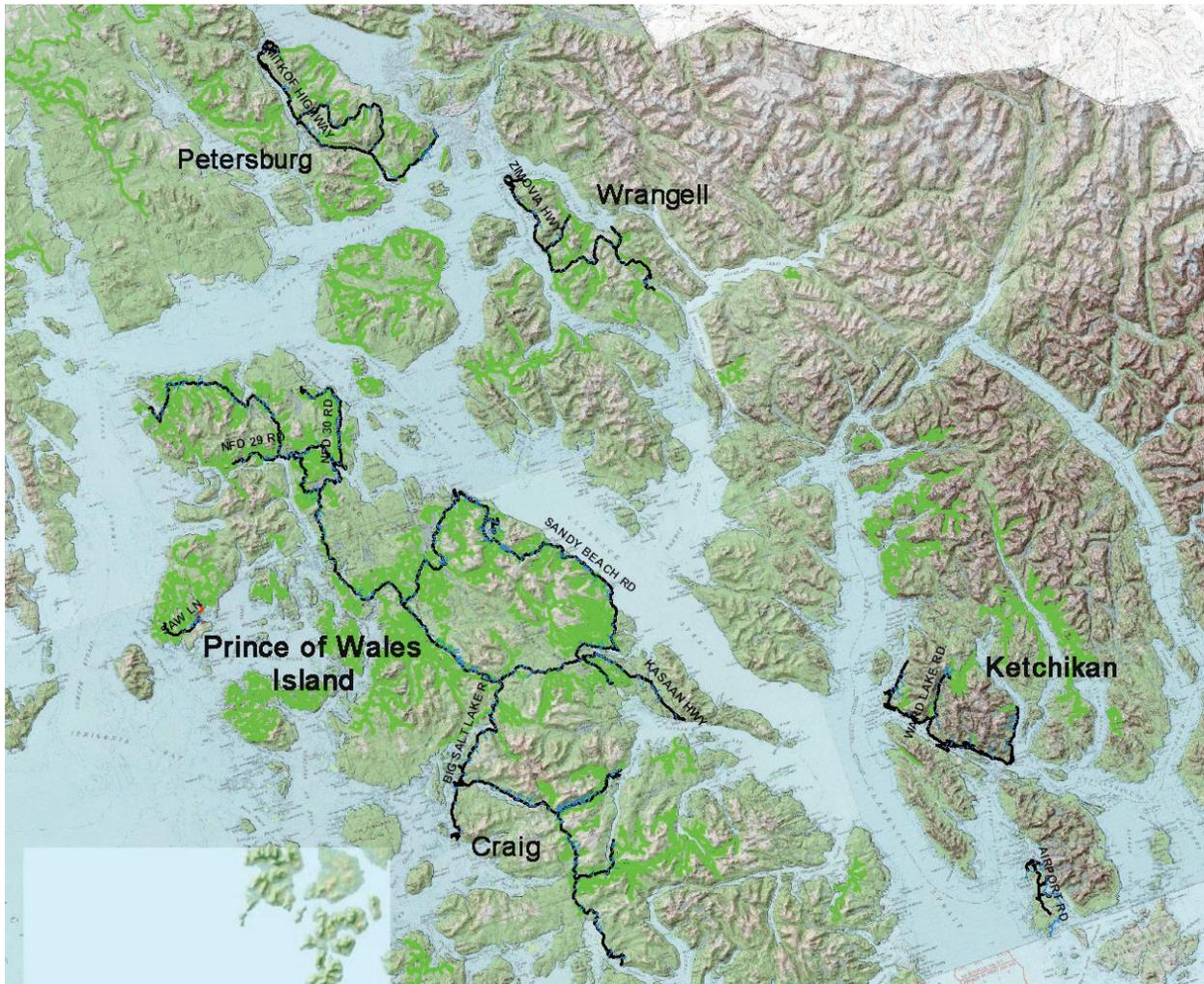


Figure 1.—Overview of the project area showing the road systems of Petersburg, Wrangell, Ketchikan, and Prince of Wales Island. (Black lines are state or borough maintained roads, green lines show known US Forest Service Roads).

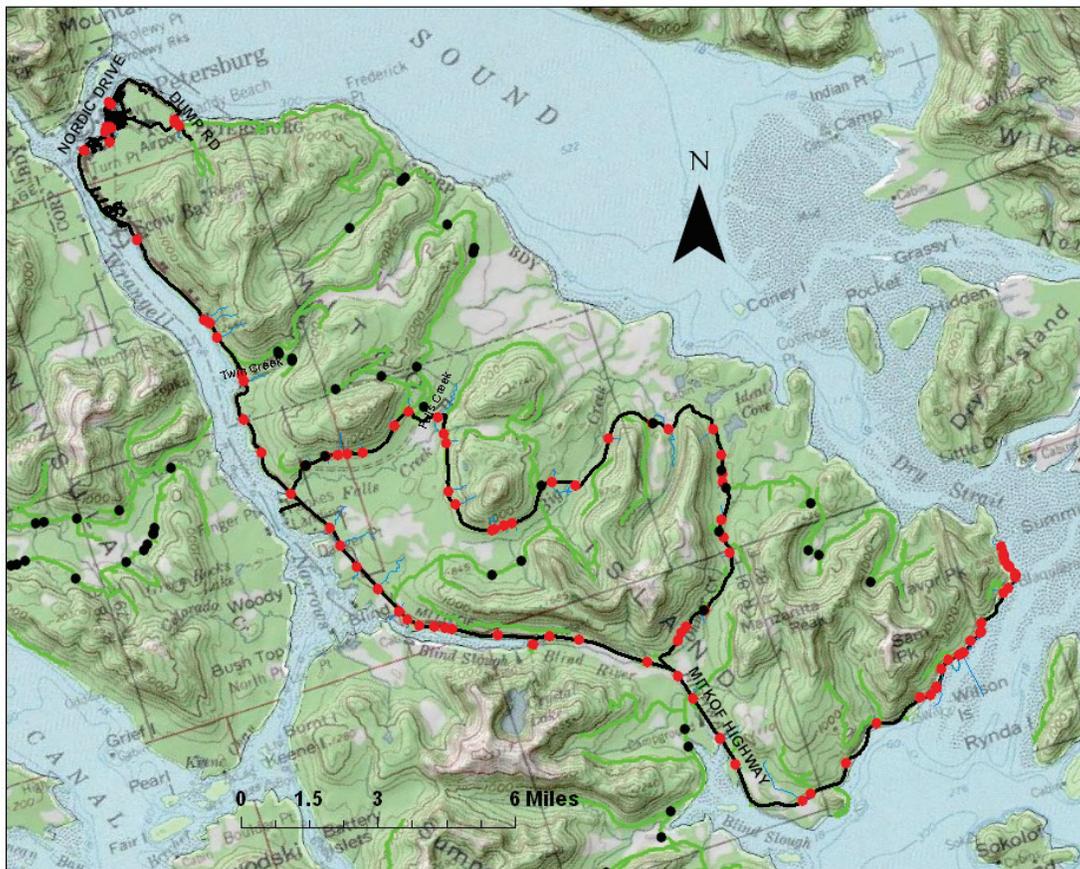


Figure 2.—Predicted sites for the Petersburg area. Red dots indicate a predicted site, black dots denote a previous US Forest Service Road Condition Survey.

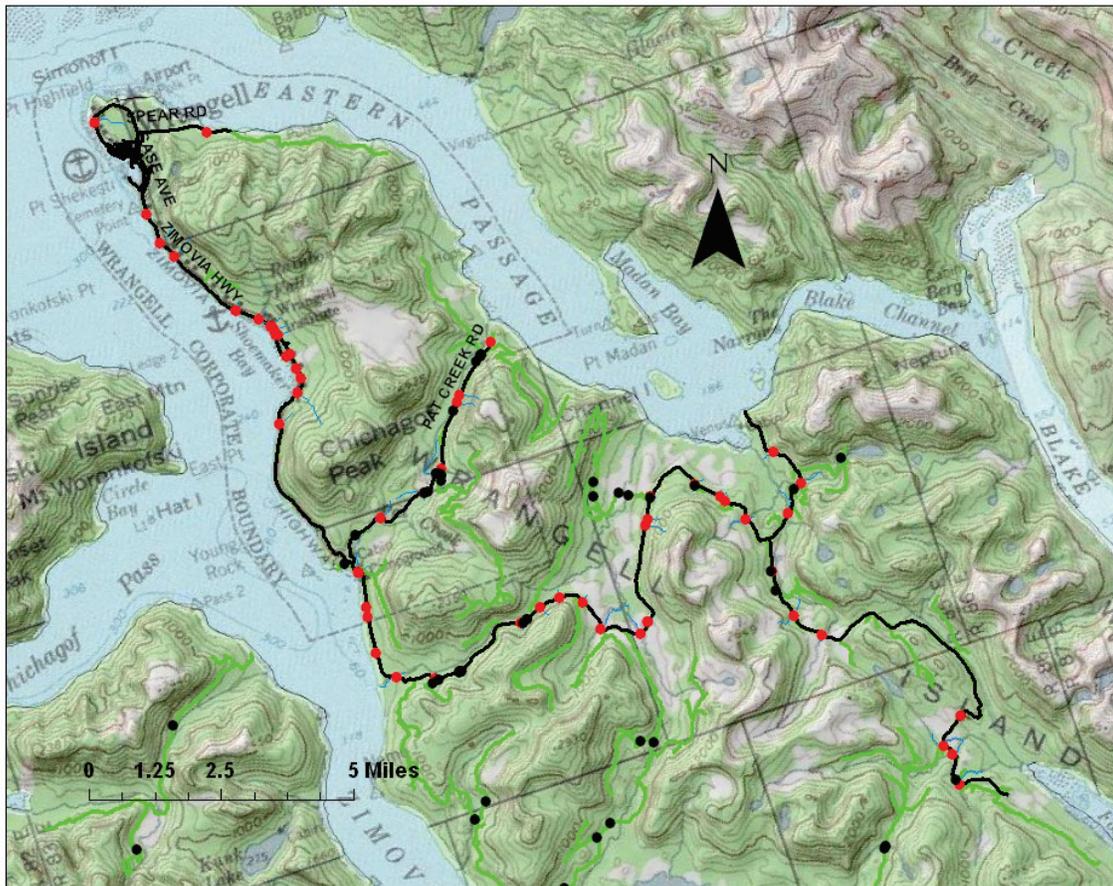


Figure 3.—Predicted sites for the Wrangell area.

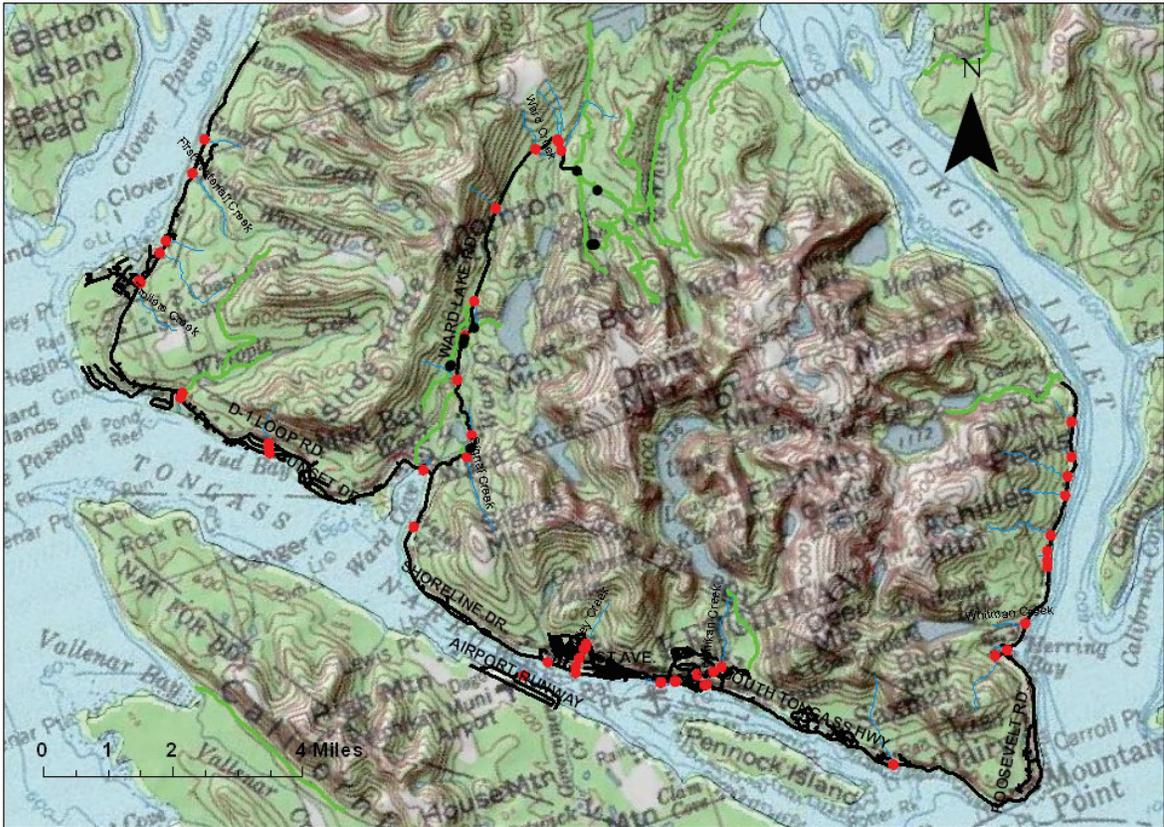


Figure 4.—Predicted sites for the Ketchikan area

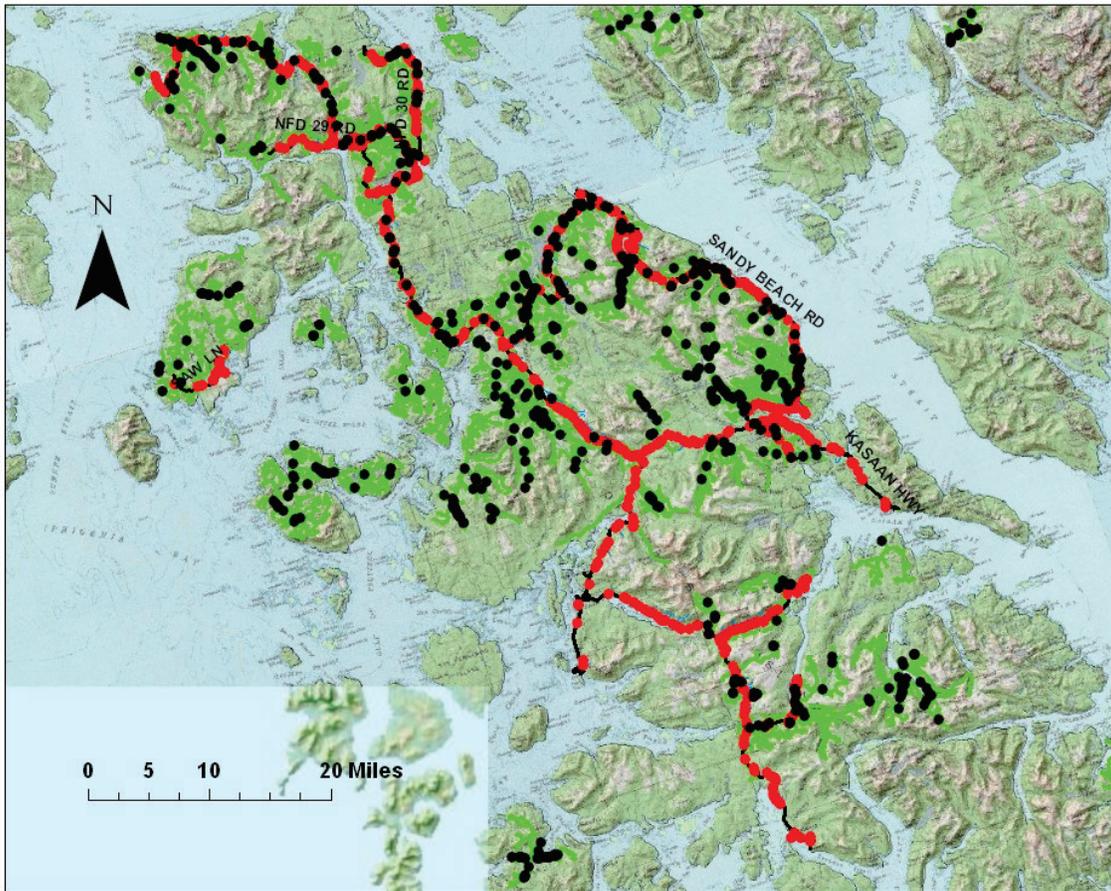


Figure 5.—Predicted sites for the Prince of Wales Island road system.

DATA COLLECTION

Fish Passage Assessment

Fish passage will be assessed at all culverts in fish bearing waters within the study area. Fish passage at each culvert is assessed using a Level 1 Assessment protocol similar to that followed by Flanders and Carriello (2000), Rich (unpublished), and described by Clarkin *et al.* (2005). The method relies on a set of standards developed by an interagency working group (Flanders and Carriello 2000) and is designed to evaluate crossing structures with respect to passage by juvenile salmonids. This procedure utilizes streambed and crossing elevations and observations from the site surveys to classify culverts into one of three categories:

- (1) *Green*, conditions at the culvert assumed to be adequate for the passage of juvenile fish;
- (2) *Red*, conditions at the culvert are assumed to be inadequate for passage of juvenile fish,
and
- (3) *Gray*, further analysis is required to determine if the structure provides passage for juvenile fish.

A subset of sites classified as undetermined (Gray) using the Level 1 Assessment will be modeled using FishXing software once fieldwork is completed. The Level 1 Assessment is designed to assess passability for approximately a 55mm juvenile coho, believed to be the weakest swimming juvenile salmonid, and does not assess culverts for adult fish passability. If an adult barrier is suspected then FishXing may also be used to determine the degree to which the structure is a barrier to adult fish.

The following tasks will be undertaken to carry out the study:

Task 1: Identify known and potential culvert locations and generate a digital map using GIS. Identify locations where streams in the National Hydrography Dataset (NHD) intersect platted MSB or state roads (Parks, Elliott, Dalton, and Steese Highways) and map these locations digitally along with the locations of known culverts. Known culvert locations come from railroad maintenance logs, previous fish passage surveys or habitat surveys.

Task 2: Locate each potential culvert site in the field. We will use digitally generated maps and a GPS to locate sites. Bridges or other structures are noted. Previously surveyed sites are assessed for changes that may warrant a resurvey such as a culvert replacement.

Task 3: Survey each new culvert site as well as any previously surveyed sites that have undergone replacement or other change that warrants a resurvey (e.g. significant damage to structures, significant channel alterations). Survey elements include determining site location using a handheld global positioning system (GPS) unit; photographing each site including upstream and downstream channel; recording structure type and condition, culvert and channel dimensions and geometry; determining critical elevations using differential leveling and recording observations describing the site.

Task 4: Site classification. Calculate critical values and determine fish passage status for each culvert site using the Level 1 Assessment (Table 1) (Red/ Gray/ Green) in the field.

Task 5: Additional hydraulic measurements will be collected at a subset of sites categorized as Grey in Task 4. This will be used to conduct hydrological modeling to help classify sites with respect to fish passage. The methods for selecting these sites are described in the Survey Protocol section of this plan.

Task 6: At sites not included in the AWC, fish trapping will be carried out and fish numbers, species and length recorded.

Task 7: Enter all data into the Fish Passage Improvement Program database.

Site Selection and Naming

Prior to beginning fieldwork known and potential culvert locations are identified and mapped using ArcView. The NHD is overlaid on the most up to date road layer available and all places where the two intersect are marked as potential crossing locations. Additional information on the location of sites was taken from earlier surveys, partner organizations, road managers and previous fisheries surveys and added to the ArcView to create a comprehensive map of known or

suspected crossing sites. The sites are converted to waypoints, which are downloaded to handheld Garmin GPS units and used to find streams in the field. The survey crew will attempt to locate additional culverts on all roads by visual observation and will note culverts that are visible or suspected on unmapped roads (such as driveways and bike trails).

Not all streams appear on existing maps. When the crew finds an unmapped stream they will note the coordinates at the location it crosses the road.

Once a site has been located it will be determined if it is a previously surveyed site or a new site. New sites are assigned a unique identifier. Sites receive a unique Site ID that has a geographic component (the last three digits of the 3rd order Hydrologic Unit Code or HUC in which the site is located) and the following 5 digits are assigned sequentially as sites as surveyed.

Both new and previously surveyed sites receive a Survey ID, which identifies the project, the year and the site location and will follow the previously used alphanumeric conventions for project name, data and location (e.g. MSB10PRK01, where MSB10 refers to the project and year, Mat-Su Borough 2010, and the PRK01 refers to the road the survey was conducted on and survey number on that road, Parks Highway).

Only sites known or reasonably expected to be fish bearing will be included in the assessment project. Sites that are typically classed as non-fish bearing include: ephemeral drainages that do not contain a defined channel, disconnected ponds, extremely steep channels, crossings located above known natural barriers such as waterfalls, drainage swales, drainage ditches, cross drainage culverts, or other artificial water features. Crossings that are located above man-made barriers will be assessed.

All culvert sites selected for the inventory will be surveyed using the protocol described below. All data will be recorded on project data forms (Appendix A) and survey notebooks. Unless noted, all measurements are in decimal feet.

SURVEY PROTOCOL

1. Complete Field Data form.

Site Description

The following information is recorded in the site description section of the field data form (see Appendix A): Site ID (if already assigned, otherwise it is assigned post survey), Survey ID, Date, Time, Road Name, Milepost, Latitude, Longitude, Watershed and Stream Name, Survey Book number and the initials or names of the survey crew.

Culvert Description

When a crossing structure consists of multiple culverts, each individual culvert is numbered according to its position sequentially from left to right as the observer faces downstream.

Culverts will be categorized by design type and type of material used for construction. Culvert design types are: open-bottom arch (AO), closed bottom arch (AR), oval pipe (OVL), pipe arch (PA), box culvert (BOX), circular pipe (CIR) flat-bottomed oval (FBO; “underpasses”) or other (OT) (Figure 3). Material types are corrugated steel (CSP), structural steel (SSP), corrugated aluminum (CAP), structural aluminum (SAP), non-corrugated metal (NCP), plastic (CPP), wood (WOD), concrete (CON) or unknown/other (UNK).

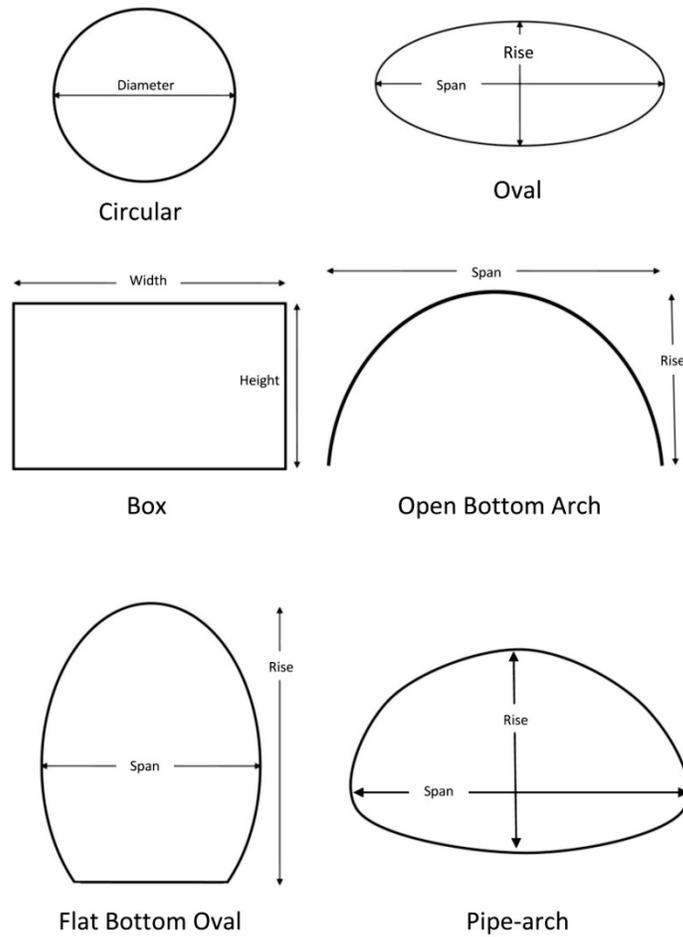


Figure 6.—Cross-sectional views of most commonly encountered culvert types.

The type of inlet and outlet, projecting, mitered or flared, will be noted as will the presence of a headwall, wing walls, or an apron (Figure 4). Projecting inlets extend beyond the face of the fill gradient. Mitered inlets are cut so that the end of the culvert matches the angle of the gradient face and are typically installed flush with the face of the fill gradient.



Figure 7.—Illustration of the invert design categories.

Each culvert outfall is categorized as either set at stream grade, a free-fall into the outlet pool, a free-fall onto riprap, a cascade over rip-rap, a fish passage structure, smooth flow over an apron, an overflow pipe or an hydraulic jump at the time of survey. If an inlet or outlet apron exists, the construction material is noted and the length measured as described above.

Width (span) and height (rise) of the inlet and outlet of each pipe will be measured inside of corrugations at the point of maximum difference. Rust line height is defined as the upper limit of rust inside the culvert and indicates the depth of sustained high water flow through the pipe. The rust line height is measured from the invert of the culvert at the inlet. If the culvert is a corrugated metal pipe, the rust line is measured from the top of the corrugations or bed material in the invert. Culvert width, height, water depth, and rust line height are measured using a steel tape or level rod to the nearest 0.10 ft

Culverts that contain substrate are inspected to determine whether they are embedded by measuring the depth of the substrate at the inlet and outlet to the nearest 0.10-foot. For a culvert to be considered embedded both inverts must be lower than the streambed elevation; the barrel must contain streambed material throughout its length; circular culverts must be buried at least

20 percent of their diameter or 1 foot whichever is greater; pipe-arch culverts must be embedded so that the mean depth of the substrate within the pipe is equal to or greater than the vertical distance from the bottom of the culvert to the point of maximum horizontal dimension or 20 percent of the height, whichever is greater. Where substrate is greater than approximately 0.5 feet deep, substrate depth is estimated by driving a steel rod of known length into the material and subtracting the height of the rod projecting above the substrate from the total length.

Culvert length from inlet to outlet is measured to the nearest 0.10 foot using a Trimble Spectra HD-150 laser distance meter. If this technique is not possible, the end of a fiberglass tape is floated through the culvert and the tape used to measure the length. The length of aprons or other inlet or outlet structures are also measured using the tape.

The condition of each culvert is ranked 1 through 5 according to the following definitions-:

- (1) *Defective*, culvert is in dire need of prompt repair or replacement, flaws threaten to disrupt or are hindering traffic;
- (2) *Poor*, culvert is in need of repair and shows potential for further deterioration;
- (3) *Fair*, culvert is operational but may need maintenance to restore function to full potential, distinct rust line and/or abraded bottom present, adverse conditions could lead to major problems;
- (4) *Good*, culvert shows minor deficiencies, beginning of rust line formation may be visible; with continued maintenance should be trouble free;
- (5) *Excellent*, culvert shows no signs of problems or rust, could allow flow at full capacity without disrupting fish passage.

Stream Measurements

The average width of the stream at Ordinary High Water (OHW) above the culvert is measured along at least three straight runs or heads of riffles at locations upstream of any obvious influence of the crossing structure. All channel widths are measured perpendicular to stream flow and to the nearest 0.10-foot using a fiberglass tape. The distance upstream of the inlet to the location of each width measurement is also recorded. If the upstream channel is a lake, wide slough or braided channel, channel widths of the downstream channel is recorded instead. If both up and downstream water bodies are ponds, lakes or sloughs average widths are not recorded.

Site Observation Codes

Site Observation codes refer to circumstances that affect fish passage at a site; are used to clarify the reasons a site was placed into the Gray or Red categories and also to note problems that are not part of the Level 1 matrix but potentially affect fish passage. The most commonly used codes refer to critical values that are measured at every site such as outfall height, pipe gradient or constriction ratio. These codes indicate the reason(s) for placing the site in the *Gray* or *Red* category. Additional codes are used to record other site conditions that may affect either fish passage or the prioritization of the culvert for replacement or repair. These include poor alignment, significant sedimentation, beaver activity, deliberate blockage by means of a screen or grill, debris blockage or various types of structural damage. The complete list of codes and definitions is in Appendix B.

Stream Approach Angle

The alignment of the inlet with the upstream channel is determined to the nearest one degree using a hand-held sighting compass. The approach angle is calculated by subtracting the back azimuth of the line looking downstream through the culvert, from the azimuth of the channel looking upstream from the culvert inlet.

Habitat Elements

The dominant and subdominant substrate type at the inlet and outlet and in the up and downstream channels outside of the culvert influence will be determined visually and recorded.

2. Complete Site Sketch and Photograph Descriptions in Survey Notebook

Site Sketch

The site sketch is completed in the field notebook and includes the position of the benchmark, angle of skew of the culvert and road, direction of flow, location of fish traps, and other significant geomorphologic or physical features at the site.

Photographs

A series of photographs are taken at each site with a digital camera. The order of photos and a description of each are recorded in the survey notebook. Photographs include the following views:

- ❑ Site Marker. The Site ID, road and date are written on a piece of paper and photographed at the site;
- ❑ View of the road surface at the crossing site;
- ❑ View from the culvert looking downstream at the tailcrest and beyond;
- ❑ View from below the tailcrest looking upstream showing the culvert outlet type, condition, and road embankment. This photograph should show channel roughness (substrate, debris, vegetation etc.) and culvert outlet height above the tailwater;
- ❑ View from an upstream location (looking downstream) showing the culvert inlet type, condition, and road embankment. This photograph should show channel roughness (substrate, debris, vegetation etc.) and culvert inlet conditions;
- ❑ View from the culvert looking upstream;
- ❑ When possible, a photograph of typical stream substrate and other channel roughness elements upstream of the culvert's influence;
- ❑ Additional photographs of conditions, if any, that may be negatively affecting fish passage (e.g., damage, debris, undesirable bedload deposition).

3. Obtain Standard Elevations and Record in Survey Notebook

All elevations are determined by differential leveling. Measurements will be read to the nearest 0.01 foot using a Sokkisha/Lietz model B2C automatic level and a telescoping 15 or 25-foot fiberglass leveling rod graduated in 0.01-foot increments. Differential leveling is a technique by which an optical instrument (automatic level) and graduated rod are used to determine the

elevation of points on the surface of the earth relative to a point of known elevation, commonly called a benchmark (Figure 5). The optical instrument provides a perfectly level line of sight with which to read the level rod. A level rod is graduated upward from the base, zero is at the bottom of the rod, in an appropriate scale. In the US, the scale is usually in feet with a minimum subdivision of 1/100th of a foot.

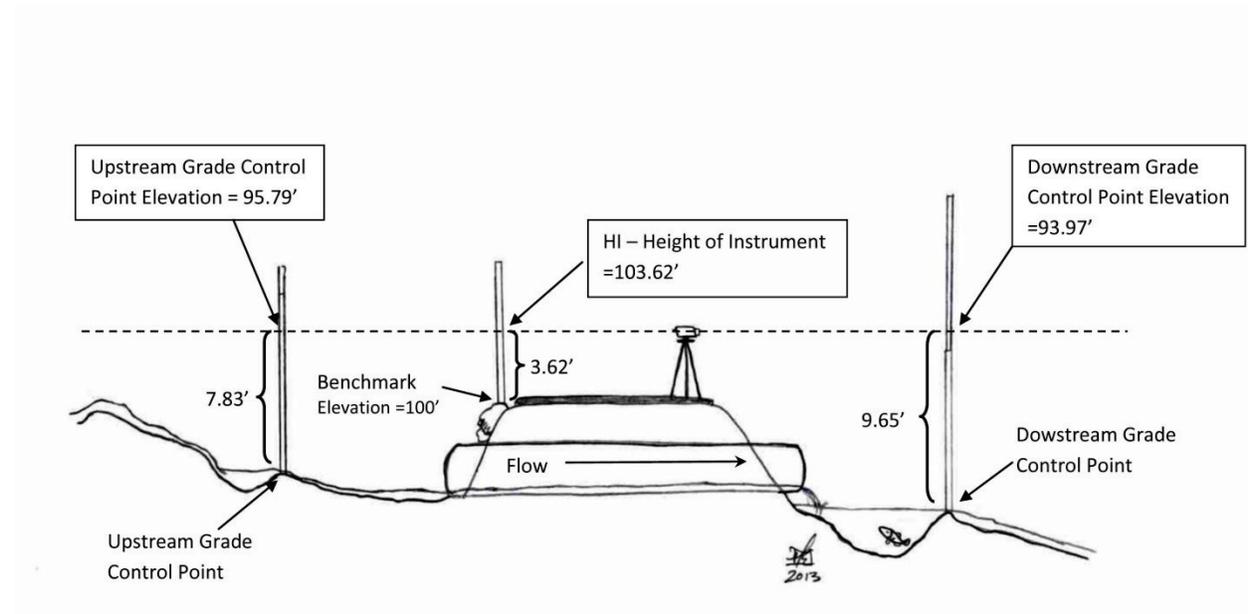


Figure 8.—An illustration of the concept of differential leveling.

The instrument is set up on a tripod and leveled according to a spirit vial incorporated in its base. The level rod is held vertically on a point of known elevation and sighted with the instrument; this is known as taking a backsight (BS) or “plus sight”. The backsight reading is added to the elevation of the benchmark to determine the elevation of the line of sight of the instrument or instrument height (HI). The level rod is then placed on the point of unknown elevation and sighted with the instrument; this is known as taking a foresight (FS) or “minus sight”. The foresight reading is subtracted from the HI to calculate the unknown elevation.

A temporary benchmark (TBM) with an arbitrary elevation of 100.00 feet will be established at each site when practical and all elevations will be relative to the TBM. Each TBM will be established in a protected location if possible to reduce the chance that it will be disturbed. The location and description of each TBM will be entered into the field notebook. A TBM may be a large masonry nail driven into the pavement or a square or X chiseled into a concrete wing wall, headwall or other relatively permanent feature such as a nearby boulder or rock outcropping.

The following elevations are recorded:

Invert elevation at the inlet and outlet. The base of the level rod is placed at the lowest point in the inlet and outlet and read with the level. A water surface reading is also taken at the inlet and outlet. If the structure is a corrugated metal pipe, the base of the level rod is placed on top of the

corrugations. If the culvert contains a small amount of streambed material, the material is removed and the base of the rod placed directly on the bottom of the structure. If the culvert is fully embedded or the invert cannot be readily exposed, the level rod is placed on top of the bed material in the thalweg. If there is an apron or other manmade extension of the culvert inlet or outlet, the elevation of the ends of the apron is determined as well. **For embedded culverts:** The elevation of the highest point of the inlet and outlet is used instead of the lowest point. This is to accurately reflect the angle at which the culvert was installed. Damaged culverts or culverts installed in such a way as to make the inverts inaccessible may also require these elevations to be taken on top of the structure instead of at the invert. In all cases the water surface elevation should still be recorded.

Gradient breaks within the culvert. Where a gradient break is noted and the size of the culvert allows it the elevation at gradient breaks within the structure will also be collected. The level rod is placed at the lowest point the breaks in gradient or, in the case of gradual gradient changes, at regular intervals throughout the length of the structure.

Upstream thalweg profile. A longitudinal profile of the streambed is surveyed upstream from the inlet to the first grade control that provides resting habitat for fish moving upstream, usually the tailcrest of a pool. This profile will include aprons or other extensions of the culvert inlet. The level rod is placed in the thalweg at each gradient break along the profile and read with the level. This profile represents channel conditions that fish moving upstream will encounter as they exit the pipe. Where there is resting habitat immediately upstream of the pipe this step can be omitted.

Headwater elevation. The bottom of the level rod is placed at the edge of the headwater, near the inlet, so that the bottom of the rod is flush with the water surface. The headwater is the water surface immediately upstream of the culvert inlet. The elevation of the thalweg is also taken at this station.

Road surface elevation. The level rod is placed on the surface of the road directly above the center of the structure and read with the level. The road surface elevation may be used to determine headwater depth for flood capacity calculations and when used in conjunction with invert elevations, provide an index of fill removal costs in the prioritization protocol.

Tailwater Elevation. The tailwater is the water surface, often a pool, immediately downstream of the culvert outlet. To determine the tailwater elevation the level rod is placed in still or slow flowing water, often found near the edge of the channel so that the bottom of the rod is flush with the water surface.

Downstream thalweg profile. This profile shows the shape of the stream bed and the elevation change across the water surface immediately downstream of culvert and the number of stations required is determined by site conditions. At a minimum the downstream profile should include the tailwater elevation, the bed elevation at the tailwater and both the bed elevation and water surface elevation at a point 50-100' downstream. Outlet pools, aprons, fish passage structures or other extensions of the culvert outlet should also be included where applicable. Measure the elevation of the outlet pool bottom at the point of maximum depth. At most sites it is appropriate to continue to survey to the second grade control point downstream of the tailwater control or the culvert outlet. To take the profile the level rod is placed in the thalweg at each subsequent grade control point and read with the level. Water surface elevations are also collected at each station. Where there are no downstream riffles or other grade control features the elevation of the

thalweg and water surface should be measured at the tailwater and at a point between 50' and 100' downstream of the culvert.

Channel Gradient Calculation for Comparison to the Gradient of Embedded Culverts. Embedded culverts have some additional data collection requirements, primarily related to the need to compare the culvert gradient to the natural channel gradient. The culvert gradient is calculated as described above for embedded culverts using the top of the culvert inlet and outlet in order to accurately describe the angle that the culvert is installed at. The channel gradient is calculated using the measured elevation of the water surface at straight runs or tops of riffles over a length equivalent to at least 10 x the OHW width far enough up or downstream of the culvert to be outside the influence of the structure. Where the channel gradient is noticeably different up and downstream of the culvert, such as on the edge of a valley floor, the channel gradient may be collected both up and downstream of the structure.

4. Fish Trapping:

At sites not included in the AWC, the crew sets minnow traps to determine whether fish are present above or below the culvert. These sites will be identified in advance using GIS and fisheries information from the AWC and partner organizations.

Traps baited with cured salmon roe are set near the bank far enough up and downstream of the culvert to minimize disturbance from surveying activities on trapping. Traps soak approximately one to two hours and no more than three hours. Fish are removed from the trap and either handled and released immediately or sedated in an anesthetic bath of 2.5 g/L sodium bicarbonate to water. Fish remain in the bath for 3-5 minutes and are observed and removed as soon as they appear sedated. Sedated fish are placed in a length measuring tube measured (fork length to the nearest millimeter), identified to species life stage and life history and removed and placed in a recovery bath of stream water. After recovery, fish are released in pools at or adjacent to capture site.

Fish observed at the site but not trapped or handled are noted on the datasheet.

5. Additional Data Collection for Modeling

Sites with the following characteristics may be selected for modeling using FishXing 3.0:

- Classified as Gray in the Level 1 Assessment Filter, or
- Classified as Gray or Red in the Level 1 Assessment Filter and potentially also a barrier to adult salmonids due to either:
 - Outfall height > 2ft, or
 - Gradient through culvert greater than 3% and no substrate, weirs or baffles inside culvert (Taylor & Love 2003).
 - Adult fish observed attempting to pass through culvert and failing.
- Stream crossings selected for modeling must also meet all of the following criteria:
 - Single pipe or multiple pipe installation with the stream flow distributed equally between pipes.
 - No significant obstructions (boulders, debris jams, baffles etc.) in the pipe that constrict the flow or create a hydraulic jump.

- No significant damage to the pipe or inlet or outlet structures.
- Not in a tidal area.
- No baffles, step pools, grade control structures, fish ladders or other hydraulic control structures.
- No compound gradient (break in gradient) within the pipe.

At sites selected for possible modeling with FishXing, further hydraulic data will be collected. The longitudinal profile will be extended to at least 100 ft or three pool-riffle sequences whichever is greater to allow calculation of the downstream channel gradient. In addition to the longitudinal profile, the crew will survey a cross-sectional profile at the tailwater control. At some sites, there is no outlet pool and culvert discharge is unimpeded. In these cases channel geometry and roughness will influence water depth downstream of the outlet, so the cross-sectional profile is surveyed within 5 feet of the outlet. Size and composition of streambed material along the cross-sectional profile will be described and photographed in order to estimate roughness.

In order to estimate the average velocity at the inlet and outlet the cross sectional area of the water at each will be measured as well as the stream discharge. Cross sectional area will be measured by establishing a cross-section at the inlet or outlet that is on top of the corrugations and taking water depths at regular intervals along the cross section. Water depth will be measured to the nearest 0.1 feet

Stream discharge is estimated at a suitable location either upstream or downstream of the crossing. Discharge will be estimated using an acoustic Doppler velocimeter and wading rod following the velocity-area technique as described by Nolan and Shields (2000) and Gordon *et al.* (2004). To apply this method, the stream channel is divided into cells across the cross-section. The depth and average velocity of the water are recorded in each cell. Velocity is measured at 0.6 depth. The station designating the relative location of each cell is the distance from the initial point on the left bank at the edge of the water to a particular cell. Once the measurements are complete, the discharge of each cell is calculated as:

$$Q_n = d_n \times \left(\frac{b_{n+1} - b_{n-1}}{2} \right) \times v_n$$

Where:
 Q_n = discharge for cell n
 d_n = depth at cell n
 b_n = distance along tape from initial point on left bank to station n
 v_n = mean velocity of cell n

The sum of the cell discharges is the total discharge for the stream.

DATA REDUCTION

All quantitative and qualitative data will be recorded in the field on water resistant paper either on a data form (Appendix A) or in a hardbound field notebook. Before leaving each culvert site,

all elevation data will be checked, relative elevations calculated, and the field notebook and data forms reviewed to ensure that all required data elements have been recorded. The crew leader will also ensure that accurate descriptions for each digital photo are documented and appropriate notes and field diagrams describing the site are recorded. In the majority of cases prior to leaving the site, Level 1 critical values will be calculated and a fish passage classification assigned as described below in the Data Analysis section (Table 1).

Raw data will be entered into a database at the end of each day. The field notebook and data forms will be re-checked for errors prior to entering data into the database. All electronic data files and digital photographs will be backed up each day onto a removable drive in addition to being stored on the computer hard drive. Backup data will be securely stored and transported separately from the laptop computer.

The latitude and longitude of each crossing site will be transformed from WGS84 datum to NAD83 datum and projected for display on digital USGS 1:63,300 scale maps using the ESRI ArcToolbox datum transformation and projection tools.

The project database and GIS project files will be stored on the ADF&G Sport Fish server at O:\DSF\R5\hr_projs\Culverts_Master\Office Database in Anchorage. A final edited copy of the data along with a data map will be provided to ADF&G Division of Sport Fish, Research and Technical Services for archiving.

DATA ANALYSIS

The Level 1 protocol was created to provide a simple procedure for rapid evaluation of stream crossing structures with respect to fish passage for juvenile salmonids. It relies on criteria originally developed by an interagency working group including the US Forest Service, ADF&G, and ADOT/PF (Flanders and Carriello 2000; USDA 2001) (Table 2). The method, previously used in conjunction with culvert inventories on the Kenai Peninsula, in the Copper River Basin, and in the Matanuska-Susitna Borough, was adapted for use in southcentral Alaska by ADF&G and ADOT/PF and (Albert and Weiss unpublished; Rich unpublished; Albert and Beers unpublished).

As subsequent culvert inventories followed the initial work performed by USFS, ADF&G, and others, incremental changes in the assessment criteria were made based on the professional judgment of individual project managers. These changes were discussed in detail during an October 2005 meeting between ADF&G and ADOT&PF. The consensus at that meeting was ADF&G should continue to use the original criteria as agreed upon by the original working group until there is scientific evidence that clearly shows changes are necessary. As a result, the critical values for fish passage assessment used from 2005 through 2010 aligned with the original assessment criteria with the exception of structure type categories, which were combined to simplify data analysis. The original classification scheme included eight structure types and this was reduced to five. Preliminary evaluation of fish passage condition using data from previous culvert inventories (Albert and Weiss in prep; Rich unpublished; Albert and Beers unpublished) indicated there was little or no change in the results of the analyses due to combining structure type categories (Steve Albert, ADF&G, personal communication).

In 2008 the Level 1 Matrix was slightly amended to assess additional structure types; to more clearly define backwatered culverts and to assess multiple pipe installations, which have been

added as a sixth structure type category. These changes reflect the way the Level 1 method has been applied in practice for a number of years. No changes were made to the existing structural types and corresponding critical values.

Critical values. Three critical values are the basis for the Level 1 Assessment: 1) culvert gradient, 2) stream constriction, and 3) outfall height.

1. *Culvert gradient* is the percent gradient of the invert of the culvert and is defined as:

$$((\text{invert elevation at inlet} - \text{invert elevation at outlet}) \div \text{culvert length}) \times 100$$

If a pipe has an apron or other additional structure on either end, the gradients of the pipe itself and each apron will be calculated separately.

2. *Channel constriction ratio* is a comparison of the width of the crossing structure (CW) to the average width of the natural channel at ordinary high water (OHW: as described in the stream measurements section of the survey protocol) and is defined as:

$$(CW \div OHW):1$$

Mean channel width upstream of the crossing structure is used to determine the channel constriction ratio.

Where there are multiple pipe structures, the area of all of the pipes is summed and the diameter of a single structure of the same shape and total summed area is calculated and used to calculate the constriction ratio.

Where there is a slough or pond up or downstream or it is impossible to determine the average width of the active channel for any reason the constriction ratio is left out of the Level 1 classification.

3. *Outfall height* used in the analysis for this project is flow-dependent outfall height, which is defined as the difference in water surface (WS) elevation in the outlet and the surface elevation of the tailwater.

$$WS \text{ elevation in outlet} - WS \text{ elevation of outlet pool or tailwater}$$

Classification. Culverts are first assigned to a structure type based on size and design and then the critical values determined from survey data are compared to specific criteria for each structure type (Table 1). Culverts are classified as follows based on those standards:

Green all critical values, culvert gradient, channel constriction ratio, and outfall height, are within acceptable ranges; these structures are assumed adequate to provide juvenile fish passage;

Red one or more critical values, culvert gradient, channel constriction ratio, or outfall height is in the defined unacceptable range. These structures assumed inadequate for juvenile fish passage.

Gray one or more critical values falls into the range between acceptable and unacceptable or the structure is too complex to be classified using the Level I methodology. A more detailed hydraulic analysis is required to assess fish passage.

The critical values do not apply to stream crossing structures that are fully backwatered. For this project, we assume fully backwatered culverts in palustrine channels are not limiting to fish movement unless physically blocked. Fully backwatered sites are classified as *Green*.

For multiple culvert installations, the gradient and outfall height of each pipe is compared to the appropriate passage criteria for the individual pipe's size and construction. If each pipe is classified as *Green*, the site will be classified as *Green*. If each pipe is classified as *Red*, the site will be classified as *Red*. If not all of the pipes at a site fall into the same category, the site is classified as *Gray*.

Culverts made of materials other than corrugated metal pipe often fall into structure type 5 in the matrix (Table 1), but may be categorized by the field crew as *Green* or *Red* if site conditions clearly either allow or limit juvenile fish passage. For example, a fully backwatered concrete box culvert would be categorized as *Green*, while a wooden pipe with a 0.33 foot or greater outfall height would be categorized as *Red*.

Culverts classified as either *Red* or *Gray* are considered a potential hazard to fish passage and are treated as such when planning fish passage restoration projects. Some culverts classified as *Gray* may pass adult fish or may pass juvenile fish during certain conditions; however, they are not functioning well enough to be considered *Green*.

FishXing 3

Sites that are selected for modeling as described in the methods section will also be assessed using FishXing 3 following the procedures in the FishXing 3 manual (available online at http://www.fsl.orst.edu/geowater/FX3/help/FX3_Help.html). Previous work has shown that establishing the correct Manning's N values (the roughness of the channel and/ or culvert) is important for accurate modeling results and that FishXing often overestimates the average velocities if the provided N-values are used. Karle (2005) developed a method to improve the accuracy of the model results by comparing the modeled average inlet and outlet velocities to the model using measured average inlet and outlet velocities and adjusting the N-values until the two are in agreement. ADF&G is currently completing a study using the Karle method to calibrate FishXing by adjusting the Manning's N values so that the predicted average velocities at a single flow are most similar to the measured average velocities at that flow. The results of that study and consultation with other agency hydrologists and the FishXing model's authors will be used to determine the exact method of calibration used to analyze this data.

SCHEDULE AND DELIVERABLES

General project activities schedule follows:

Table 2.–General activity schedule for fish passage inventory and assessment from April 2013 through November 2014.

Year (CY)	Dates	Activity
2013	April 1 - May 31	Prepare logistics for Southeast Alaska field season, complete Operations Plan.
	June 1 - August 31	Survey stream crossings in Petersburg, Wrangell and Ketchikan.
	Sept. 1 - Dec 31	Compile and enter data into database, quality check all data, write summary report for Southeast Alaska project
2014	Jan 1 - May 31	Finish Reports. Prepare logistics for up coming season. Update database and GIS layers for project and upcoming field season.
	June 1 - August 31	Survey stream crossings on Prince of Wales Island.
	Sept.1- Nov 30	Final Data Analysis and write final report

RESPONSIBILITIES

Gillian O’Doherty, Habitat Biologist III, Project Supervisor

Duties: Project management, general supervision and budgeting. Help prepare operational plan and final reports. Assist in fieldwork as needed.

Mark Eisenman, Habitat Biologist I, Project Leader

Duties: Train and supervise field crew. Prepare operational plan. Acquire, organize, and maintain field equipment. Collect culvert inventory data describing individual culverts and stream conditions according to the protocol. Reduce and analyze raw data to identify and prioritize any culvert barrier sites for fish passage restoration. Complete post-season project review. Prepare and submit to ADF&G nominations of streams for inclusion into the fish distribution database. Prepare data reports and final reports.

Neil Durco: Fish and Wildlife Tech III, Culvert Field Crew

Duties: Assist the crew leader in acquiring, organizing, supplementing, and maintaining field equipment. Collect spatial and field inventory data describing individual culverts according to the described field data collection protocol. Prepare and organize field data for entry in digital format into a project database, ensuring data quality assurance and control.

Pat Hansen, Biometrician III

Duties: Provide guidance on inventory design. Assist with data analysis. Review project operational plan and reports.

Skip Repetto, Analyst Programmer III

Duties: Provide technical assistance for data organization and analysis in ArcGIS.

Develop software tools to display spatial, tabular, and graphic data via the ArcIMS page on the ADF&G website.

Ryan Snow, Analyst Programmer IV

Duties: Design project database. Assist data retrieval and database reporting. Provide technical support for software and hardware development, operations, and maintenance. Develop software tools to integrate GIS and database functions.

REFERENCES CITED

- ADF&G (Alaska Department of Fish and Game). 2010. 2010 Alaska commercial salmon harvests and xxvessel values. <http://www.cf.adfg.state.ak.us/geninfo/finfish/salmon/catchval/blusheet/10exvesl.php> (Accessed Jan. 10, 2011).
- Albert, S.W. and D. Beers. *Unpublished*. Preliminary Inventory and assessment for fish passage of culverts in the Copper River Basin. Alaska Department of Fish and Game, Division of Sport Fish. Anchorage.
- Albert, S.W. and E.W. Weiss. *Unpublished*. Inventory and assessment for Fish Passage of crossing structures under Matanuska-Susitna Valley Roads. Alaska Department of Fish and Game, Division of Sport Fish. Anchorage.
- Botkin, D., K. Cummins, T. Dunne, H. Regier, M. Sobel, and L. Talbot. 1994. Status and future of salmon of Western Oregon and Northern California: Findings and Options. Report No. 8. Center for the Study of the Environment. Santa Barbara, CA.
- Clarkin, K., A. Connor, M.J. Furniss, R. Gubernick, M. Love, K. Moynan, and S. Wilson-Musser. 2005. National inventory and assessment procedure for identifying barriers to aquatic organism passage at road-stream crossings. USDA Forest Service National Technology and Development Program. San Dimas, CA.
- Flanders, L.S. and J. Cariello. 2000. Tongass road condition survey report. Alaska Dept. of Fish and Game, Habitat and Restoration Division. Technical Report No. 00-7.
- Gordon, N.D., T.A. McMahon, B.L. Finlayson, C.J. Gippel, and R.J. Nathan. 2004. Stream hydrology: An introduction for ecologists. 2nd Edition. John Wiley and Sons, England.
- Johnson, J. and K. Klein. 2009 Catalog of waters important for spawning, rearing, or migration of anadromous fishes – Arctic Region, Effective June 1, 2009. Alaska Department of Fish and Game, Special Publication No. 09-01, Anchorage.
- Johnson, J. and K. Klein. 2009 Catalog of waters important for spawning, rearing, or migration of anadromous fishes – Interior Region, Effective June 1, 2009. Alaska Department of Fish and Game, Special Publication No. 09-02, Anchorage
- Kahler, T.H. and T.P. Quinn. 1998. Juvenile and resident salmonid movement and passage through culverts. Research Project T9903, Task 96. Washington State Transportation Center (TRAC), University of Washington, Seattle, WA.
- Karle, K. F. 2005. Analysis of an efficient fish barrier assessment protocol for highway culverts. FHWA-AK-RD-05-02.
- Mirati, A. 1999. Assessment of road culverts for fish passage problems on state and county owned roads. Statewide Summary Report. Oregon Dept. of Fish and Wildlife.
- Nolan, K.M. and R.R. Shields. 2000. Measurement of stream discharge by wading. US Geological Survey Water Resources Investigations Report 00-4036 CD ROM ver. 1.1
- Rich, C.F. *Unpublished*. Fish passage at culverts on the Kenai Peninsula, Alaska. Alaska Dept. of Fish and Game. Division of Sport Fish. Anchorage.
- Sweet, D., S. Ivey, and D. Rutz. 2004. Area Management Report for the recreational fisheries of Northern Cook Inlet, 2003. Alaska Dept. of Fish and Game. Fishery Management Report No. 04-05. Anchorage, AK.
- USDA. 2001. Tongass Monitoring and Evaluation Report. USDA Forest Service. Tongass National Forest.

APPENDIX A- FIELD FORMS

Survey ID		Date		Site Classification (Red/Gray/Green)						
Site ID		Time		<i>(Complete all applicable sections of this form before leaving survey site!)</i>						
Road Name		Book #		Site Codes	1	2	3	4	5	6
Milepost		Crew		from table						
Watershed		Lat.		Resurvey? (Y/N)		Old Survey ID (if known)				
Stream Name		Long.		Backwatered? (Y/N)		Step Pools <input type="checkbox"/> Baffles <input type="checkbox"/> Tidal <input type="checkbox"/>				
Culvert Description: pipes numbered left to right facing downstream				Stream Measurements						
	Units	1	2	3	4	5		Dist.	OHW	
Culvert Type (CR, PA, etc.)										
Culvert Material (CSP, SSP, etc.)										
Structure Type (from matrix)	1 to 5									
Inlet Type (FRD, HDW, ect)										
Inlet Apron Length	ft									
Inlet Width	ft									
Inlet Height	ft									
Substrate Depth Inlet	ft									
Rust Line Height Inlet	ft									
Sedimentation at Inlet?	Y/N									
Outlet Type (FRD, HDW, ect)										
Outlet Apron Length	ft									
Outlet Width	ft									
Outlet Height	ft									
Outfall Type (AG, F, C, etc.)										
Substrate Depth Outlet	ft									
Corrugation Depth	in									
Corrugation Width	in									
Culvert Length	ft									
Embedded?	Y/N									
Embedded Depth	ft									
Condition Rating (5=best)	1 to 5									
Outfall Height	ft									
Pipe Gradient	%									
Water Depth at Outlet	ft									
Max Gradient	%									
Length of Max Gradient	ft									
Stream Gradient	%									
Backwatered?	Y/N									
Individual Culvert Rating (Red, Gray, Green)										
Habitat Elements	Upstream	Downstream	Inlet	Outlet						
Dominant substrate										
Subdominant substrate										

Upstream width				
Downstream width				
Downstream width				
Downstream width				
	Avg u/s width			
	Avg d/s width			
	Constriction Ratio			
Stream Stage (High, Med, or Low)				
Stream Approach Angle				
Fish data	Sheet #	Line #s		
Trap	Loc/Dist	Time In	Time out	Soak Time
A				
B				
Notes: (Fish observations, damage, oddities, ect)				

-continued-

Structure Type	Green Conditions may be adequate to pass juvenile fish	Gray Conditions unlikely to pass juvenile fish, additional analysis required	Red Conditions assumed inadequate to pass juvenile fish, additional analysis required	Site Observations Codes	
				Code	Description
1 Bottomless pipe arch, embedded pipe arch, CMP, box culvert or other embedded structure that functions in a similar fashion to an embedded pipe arch.	Installed at channel gradient (+/- 1% gradient), AND culvert span to OHW width ratio greater than or equal to 0.75 OR fully backwatered	Structure not installed at channel gradient (+/- 1%), OR culvert span to OHW width ratio of 0.5 to 0.75	Culvert span to OHW width ratio less than 0.5	OHG	Outfall height gray
2 Culverts (all span widths) with 2 X 6 inch corrugations or greater, not embedded.	Culvert gradient less than 1.0%, AND outfall hgt. = 0, AND culvert span to OHW width ratio greater than 0.75 OR fully backwatered	Culvert gradient 1.0 to 2.0%, OR less than or equal to 4-inch outfall hgt., OR culvert span to OHW width ratio of 0.5 to 0.75	Culvert gradient greater than 2.0%, OR outfall hgt. greater than 4 inches, OR span to OHW width ratio less than 0.5	OHR	Outfall height red
3 Pipe arch or circular CMP (span width greater than 4 feet), less than 2 X 6 inch corrugations, not embedded	Culvert gradient less than 0.5%, AND outfall hgt. = 0, AND culvert span to OHW width ratio greater than 0.75 OR fully backwatered	Culvert gradient 0.5 to 2.0%, OR less than or equal to 4-inch outfall hgt., OR culvert span to OHW width ratio of 0.5 to 0.75	Culvert gradient greater than 2.0%, OR outfall hgt. greater than 4 inches, OR culvert span to OHW width ratio less than 0.5	GRDG	Culvert gradient gray
4 Pipe arch or circular CMP (span width less than or equal to 4 feet), less than 2 X 6 inch corrugations, not embedded	Culvert gradient less than 0.5%, AND outfall hgt. = 0, AND culvert span to OHW width ratio greater than 0.75 OR fully backwatered	Culvert gradient 0.5 to 2.0%, OR less than or equal to 4-inch outfall hgt., OR culvert span to OHW width ratio of 0.5 to 0.75	Culvert gradient greater than 1.0%, OR outfall hgt. greater than 4 inches, OR span to OHW width ratio less than 0.5.	GRDR	Culvert gradient red
5 Non-embedded box culverts, culverts with non-standard configurations or materials, culverts with baffles or downstream weirs or step pools, fish ladders, bridges with aprons, or tidally influenced culverts	Fully backwatered as described below.	All others and tidally influenced culverts	Outfall height at downstream end of structure greater than 4 inches.	CRG	Constriction ratio gray
6 Multiple Structure Installations	Individual culverts all classified as Green as above	Individual culverts all classified as Gray or as some mix of Green, Gray or Red as above.	Individual culverts all classified as Red as above.	CRR	Constriction ratio red
<p>1. These criteria are not design standards, but rather indicate whether the structure is likely to provide fish passage for juvenile salmonids based on a one-time evaluation.</p> <p>2. Ordinary high water (OHW) is the mean stream width measured either upstream or downstream of the culvert beyond the hydraulic influence of the culvert.</p> <p>3. An embedded culvert must have 100% bedload coverage. Circular and box culverts must be embedded at least 20% of their height. A pipe-arch must be embedded so that the mean bedload depth is greater than or equal to the vertical distance from the bottom of the pipe to the point of maximum horizontal dimension of the culvert (haunch height) or is 1 foot deep, whichever is greater.</p> <p>4. A culvert is considered backwatered if one of the following conditions is met: 1) elevation of the tailwater control exceeds the elevation of the invert at both the outlet and inlet of the culvert and the of any aprons or other inlet or outlet structures 2) the culvert is located in a pond, slough or other area with slow moving or still water and the tailwater and headwaters surface are equivalent and water surface is continuous throughout the entire structure and at least 0.1 feet in depth at the shallowest point. Culvert gradient, span to OHW ratio, and outfall height criteria are not considered in the assessment of fish passage in backwatered culverts. A culvert is not backwatered if a hydraulic jump occurs within the barrel.</p> <p>5. Outfall height is the difference between the water surface elevation at the outlet and in the outlet pool (or the equivalent tailwater surface).</p>				AL	Culvert is poorly aligned
				BV	Beaver Activity
				CG	Compound gradient in pipe
				CS	Cut-slope sliding into culvert
				DF	Debris Flow
				EC	Hydraulic flow s exceeded capacity
				IAS	Inlet apron too steep
				IB	Improper bedding
				IC	Damage associated with ice problems
				IP	Inlet perch
				MP	Mechanical damage or joints parting
				MT	Material inadequate for designed use
				OAS	Outlet apron too steep
				OT	Other - vibrations, cavitation, etc.
				RD	Road bank erosion
				RF	Road Fill (pushed off road by grader)
				SD	Sediment accumulation
				SF	Shallow fill above culvert
				SG	Culvert sagging in middle
				SS	Subsidence
				ST	Structural Problem
				TS	Culvert is too short
				WD	Woody Debris
				NO	None of this type
				Inlet/Outlet Type	
				PRO	Projecting
				MIT	Mitered
				HDW	Headwall
				FLA	Flared
				APR	Apron
				WIN	Wing Wall
				Outfall Type	
				AG	At Stream Grade
				F	Free Fall In To Pool
				C	Cascade Over Rip-Rap
				SF	Smooth Flow Over Apron
				OP	Overflow Pipe
				HJ	Hydraulic Jump
				FR	Free Fall on To Rip Rap
				PS	Fish Passage Structure

Additional Site Notes:

**Fish Passage Culvert Assessment
Fish Sampling Form**

Sheet ____ of ____

Date _____ Project _____

	Site ID	Trap #	Distance from culvert	U/S or D/S	Species	Size category	Number	Comments
1								
2								
3								
4								
5								
6								
7								
8								
9								
10								
11								
12								
13								
14								
15								
16								
17								
18								
19								
20								
21								
22								
23								
24								
25								
26								
27								
28								
29								
30								

Fish Passage Survey Photo Site Only Form

(Remember to fill out a section in the Survey Notebook for this site as well)

Survey ID:	_____	Date:	_____
Site ID:	_____	Time:	_____
Road Name:	_____	Book #	_____
Milepost	_____	Crew:	_____
Watershed	_____	Latitude	_____
Stream Name	_____	Longitude:	_____

Photo Log Comments: (Include why this is a photo site only: bridge, safty concern, ect.)

1	_____
2	_____
3	_____
4	_____
5	_____
6	_____
7	_____
8	_____
9	_____
10	_____



*All Site ID's for Photo Sites should begin with the prefix PS to denote a photosite.
 (Example:PSARD01)

**This Form should only be filled out if you were unable to take any physical measurements at the site or if you are documenting a site as a bridge replacement.

