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# **Culvert Inventory and Assessment for Fish Passage in the State of Alaska: A Guide to the Procedures and Techniques used to Inventory and Assess Stream Crossings 2009-2014**

by

**Mark Eisenman**

and

**Gillian O'Doherty**



April 2014

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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.

<b>Weights and measures (metric)</b>		<b>General</b>		<b>Mathematics, statistics</b>	
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, $\chi^2$ , 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
<b>Weights and measures (English)</b>		Company	Co.	degree (angular)	$^\circ$
cubic feet per second	ft <sup>3</sup> /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	≥
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	e.g.	less than or equal to	≤
pound	lb	(for example)		logarithm (natural)	ln
quart	qt	Federal Information Code	FIC	logarithm (base 10)	log
yard	yd	id est (that is)	i.e.	logarithm (specify base)	log <sub>2</sub> , etc.
		latitude or longitude	lat or long	minute (angular)	'
<b>Time and temperature</b>		monetary symbols (U.S.)	\$, ¢	not significant	NS
day	d	months (tables and figures): first three letters	Jan, ..., Dec	null hypothesis	$H_0$
degrees Celsius	°C	registered trademark	®	percent	%
degrees Fahrenheit	°F	trademark	™	probability	P
degrees kelvin	K	United States (adjective)	U.S.	probability of a type I error (rejection of the null hypothesis when true)	$\alpha$
hour	h	United States of America (noun)	USA	probability of a type II error (acceptance of the null hypothesis when false)	$\beta$
minute	min	U.S.C.	United States Code	second (angular)	"
second	s	U.S. state	use two-letter abbreviations (e.g., AK, WA)	standard deviation	SD
<b>Physics and chemistry</b>				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				

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# TABLE OF CONTENTS

	Page
LIST OF TABLES.....	ii
LIST OF FIGURES.....	ii
ABSTRACT.....	1
INTRODUCTION.....	1
<b>SECTION ONE: OVERVIEW</b> .....	<b>2</b>
SAFETY.....	2
SITE NAMING CONVENTIONS.....	2
Sites.....	2
Projects.....	2
Assessments.....	3
EQUIPMENT.....	3
CREW DUTIES.....	4
ASSESSMENTS.....	4
Site Sketch and Photographs.....	4
Culvert Data Sheet.....	4
Fish Data.....	4
Longitudinal Profile.....	4
<b>SECTION TWO: METHODS</b> .....	<b>5</b>
CULVERT DATA SHEET.....	5
Location Section.....	5
Culvert Description.....	8
Culvert Types.....	8
Culvert Materials.....	12
Structure Type.....	12
Culvert Measurements.....	13
Inlet and Outlet Type.....	14
Outfall Type.....	14
Inlet or Outlet Aprons.....	18
Rust Line.....	18
Corrugations.....	19
Culvert Length.....	19
Embedded Culverts.....	20
Culvert Condition.....	22
Habitat Elements.....	23
Stream Measurements.....	27
Stream Width.....	27
Ordinary High Water.....	27
Constriction Ratio.....	29
Stream Stage.....	29
Stream Approach Angle.....	30
Site Codes.....	31
Backwatered Sites.....	33

## TABLE OF CONTENTS (Continued)

Baffles .....	34
Step Pools .....	34
FIELD NOTEBOOK .....	37
Site Photographs .....	39
Photograph Log page .....	39
Site Sketch .....	47
Longitudinal Profile.....	47
Survey Stations .....	49
Surveying a Step Pool Complex .....	52
Calculating Outfall Height and Culvert Gradient .....	54
PHOTO-ONLY DATA SHEET .....	55
FISH DATA SHEET .....	56
<b>SECTION THREE: RATING</b> .....	<b>58</b>
GLOSSARY .....	60

## LIST OF TABLES

<b>Table</b>	<b>Page</b>
1. Culvert Type table on the Culvert Data Sheet .....	8
2. Culvert Material table on Culvert Data Sheet .....	12
3. Inlet and outlet types .....	14
4. Culvert outfall type.....	14
5. Substrate types used in the Habitat Elements section of the Culvert Data Sheet .....	23
6. Site codes from the Culvert Data Sheet.....	31
7. Fish passage decision matrix .....	59

## LIST OF FIGURES

<b>Figure</b>	<b>Page</b>
1. Example of site/survey nomenclature for a site with more than one survey .....	3
2. Sample header information for Culvert Data Sheet.....	5
3. Culvert Data Sheet, front .....	6
4. Culvert Data Sheet, back .....	7
5. Culvert Data Sheet: culvert description section.....	8
6. Example culvert type, material, and structure class from Culvert Data Sheet.....	8
7. Illustration of culvert types.....	9
8. Photographs of culvert types: examples of open-bottom arches and embedded circular culverts.....	10
9. Photographs of culvert types: ovals, arches, and box culverts .....	11
10. Structure types from the back of the Culvert Data Sheet .....	12
11. Culvert invert dimensions at a round pipe and a damaged pipe .....	13
12. Culvert inlet/outlet types .....	15
13. Classification of culvert outfall types.....	17
14. Culvert rust line height and patterns.....	19
15. Illustration showing corrugation dimensions .....	19
16. Illustration of total culvert length and top of miter length for a mitered culvert .....	20
17. Classification of embedded culverts .....	22
18. Habitat Elements section of the Culvert Data Sheet.....	23
19. Substrate types used in the Habitat Elements Section of the Culvert Data Sheet.....	26

## LIST OF FIGURES (Continued)

Figure	Page
20. Stream measurement, stream stage, and approach angle on the Culvert Data Sheet.....	27
21. Recording ordinary high-water mark. ....	29
22. Illustrated example of an approach angle of 45 degrees.....	30
23. Illustration showing a site considered backwatered because the tailwater control grade point is higher than the culvert's inlet invert. ....	34
24. Baffles inside culverts. ....	34
25. Step pools within a culvert. ....	36
26. Photograph showing constructed rock weirs downstream of culvert. ....	36
27. Field notebook.....	37
28. Cover page in field notebook. ....	38
29. Department of Transportation placard on culvert marker. ....	38
30. Sample photograph log page from field notebook. ....	39
31. Photograph site marker for the start of a site photograph sequence. ....	41
32. Photograph of road surface.....	41
33. Photograph of inverts from road looking upstream.....	42
34. Photograph of outlet from downstream, showing outfall type and condition.....	42
35. Photograph of outlet with a measuring rod for reference. ....	43
36. Photograph of inlets from upstream. ....	43
37. Photograph of the inside of a culvert.....	44
38. Photograph of stream channel outside the influence of the culvert.....	44
39. Photograph of representative substrate.....	45
40. Sample photographs of conditions that may be negatively affecting fish passage. ....	46
41. Sample site sketch. ....	47
42. Overhead view of typical extent of longitudinal profile during a fish passage assessment.....	48
43. Surveyed points longitudinal view. ....	49
44. Example of a longitudinal profile of a crossing. ....	49
45. Sample of survey data and calculation in a field notebook. ....	51
46. Illustration showing grade control points in a manufactured step pool complex. ....	52
47. Overhead view of a manufactured step pool complex.....	53
48. Illustration showing where outfall height is measured on a freefall-into-pool outfall type.....	54
49. Illustration showing the outfall height measurement for a freefall onto riprap and cascade over riprap.....	54
50. Fish Passage Assessment Photo-only Data Sheet.....	55
51. Fish Data Sheet.....	56
52. Example of the Fish Data Sheet and notes section of the Culvert Data Sheet.....	57
53. Representative photograph showing the species and size class of fish caught at a culvert site.....	57
54. Site classification and codes.....	58





## ABSTRACT

In 2011, a field manual was prepared that describes Alaska Department of Fish and Game standard forms and procedures to be used when performing a Level 1 assessment of fish passage during culvert inventories. This manual, as described in this guide, describes and explains the process for assessing crossings on borough, municipality, private, and federal roads, as well as on the Alaska Railroad, from 2009-2014. Survey methods, with focus on required photographic and written records, are detailed. These include culvert type and material, substrate types, site observation codes, and stream and culvert measurements. A matrix is presented for rating each structure by its ability to support unimpeded passage of juvenile salmonid fish.

Key words: culverts, culvert inventory, classification, survey data, photographic records, rating, culvert type, habitat elements, site codes, fish passage

## INTRODUCTION

The Alaska Department of Fish and Game (ADF&G) Fish Passage Assessment Program was created in 2000 and charged with assessing state-owned road crossings for impacts to fish passage. Since that time ADF&G has also assessed crossings on borough, municipality, private, and federal roads and on the Alaska Railroad. Salmon and other fish move throughout the watershed year round, and unobstructed access to habitat is critical to helping maintain a healthy fish population. Properly designed bridges and culverts have little or no adverse effect on fish, aquatic organisms, and other riverine animals, but when culverts are too small, too steep, or incorrectly placed relative to the natural stream, they impede both up- and downstream fish movement.

This manual will cover ADF&G Level 1 assessments. Level 1 or rapid assessments are based on physical measurements of the culvert and stream channel and focus on juvenile salmonid fish passage. The culvert is surveyed for type, slope, outfall height, constriction, and other physical parameters and then classified as green, gray, or red using a decision matrix.

Culvert classifications:

Green: Conditions at the crossing are likely to be adequate for fish passage.

Gray: Conditions at the crossing may be inadequate for fish passage.

Red: Conditions at the crossing are likely to be inadequate for fish passage.

The decision matrix was developed in 2001 by an interagency group consisting of representatives from ADF&G, the United States Forest Service (USFS), and Alaska Department of Transportation (AKDOT) using the best available information to predict the ability of a juvenile coho (55 mm) to pass through a variety of culvert types. A 55 mm coho salmon (*Oncorhynchus kisutch*) was chosen as the model fish because coho are believed to be the weakest swimmers among the juvenile salmonids. Therefore, culverts that are passable by a 55 mm coho should be passable by all other fish.

Level 2 assessments use computer modeling software to further evaluate selected sites. Level 2 assessments are not covered in this manual.

# **SECTION ONE: OVERVIEW**

---

This manual was created in 2011 to record the standardized techniques and protocols used to inventory and assess fish passage at stream crossings by the ADF&G Fish Passage Improvement Program. It was originally created for internal use by field staff but was revised and updated for publication in 2014.

## **SAFETY**

Surveying culverts carries a unique set of risks, and many Alaskan sites are remote and far from hospital and emergency services. Crews should take all measures to ensure safety during each assessment. If conditions appear unsafe due to high flows, traffic conditions, weather, or any other factors, crews should not attempt an assessment.

Assessments on the railroad will only take place in cooperation with the Alaska Railroad Corporation, and Railroad staff must be onsite for all railroad assessment work. When working at a road crossing, the crew must place traffic warning signs at least 200 ft from the culvert in both directions to alert traffic that there are surveyors in the area. Survey equipment must be set up in a place that is out of the way of traffic. Crew members must wear brightly colored safety vests at all times, and vehicles must be parked in a safe location.

In compliance with ADF&G regulations designed to prevent the spread of invasive species and disease, crews will not wear felt-bottom wader boots.

## **SITE NAMING CONVENTIONS**

### **SITES**

Each road or railroad crossing known to ADF&G is assigned a permanent Site ID (Figure 1). The site ID is an 8-digit number in which the first 3 digits indicate the 3rd level Hydrologic Unit Code (HUC), such as 20101840. Site IDs are not assigned in the field; instead, they are created and assigned to new sites after the field season. In-the-field Site IDs are primarily used when an existing site is being reassessed.

### **PROJECTS**

Most assessments are carried out as part of a regional project, and each project is assigned a Project Code. Project codes are alphanumeric with 3 letters and 2 numbers, typically denoting the location and year of a project. For example, the project KOD05 took place on Kodiak Island in 2005. Project codes are assigned before fieldwork begins and should be recorded on all data sheets.

Assessments that are not part of a regional project are instead assigned the prefix “UPDATE” to indicate they belong to miscellaneous ongoing updates to the dataset.

## ASSESSMENTS

Each time an assessment is carried out, it is given a SurveyID in the field. The SurveyID consists of the Project Code and a 5-to-7 character identifier (Visit ID), which is created and assigned by the field crew at the time of assessment. The Visit ID can be any combination of numbers or letters as long as it is unique within a project. Visits IDs are typically an abbreviation of the road name combined with a number. Examples of Survey IDs include the following:

- KOD05CHI01 (Kodiak Island Project, 2005, Chiniak Highway, Survey #1);
- EDS10STS10 (Elliott, Dalton, and Steese Project, 2010 Steese Highway, Survey #10).

Where a full assessment cannot be carried out, a crossing is still assigned a SurveyID, but it will have a PS (Photo-only Site) prefix (e.g., PSENG01).

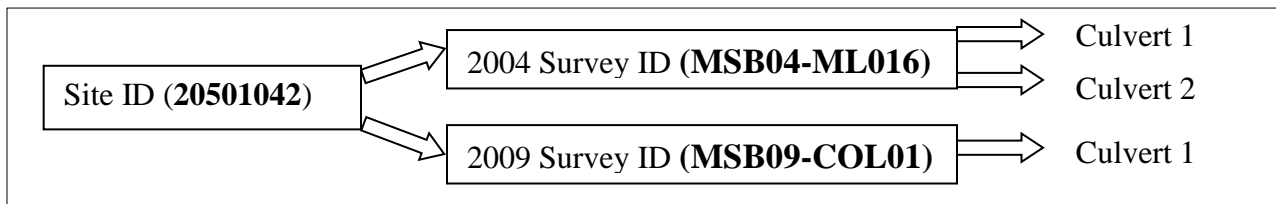


Figure 1.–Example of site/survey nomenclature for a site with more than one survey.

## EQUIPMENT

A standard list of equipment used at a culvert assessment follows:

Quantity	Item
1	Auto level and tripod
1	16' survey rod (hundredths of feet)
1	25' survey rod (hundredths of feet)
2	300' surveying tapes in tenths of feet
1	100' surveying tape in tenths of feet
1	Waterproof digital camera
1	Laser range finder
2	Compasses
1	Survey notebook
1	Culvert Data Sheet
1	Metal clipboard
1	25' tape measure (tenths of feet and inches)
1	3' folding tape measure (tenths of feet and inches)
2	Calculators
1	Small dry-erase board (or comparable)
1	Flashlight or headlamp
1	Axe or safety brush axe for clearing brush
2	Utility clips
1	Roll of flagging tape
1	Set of 2-way radios for communicating in noisy conditions
2	Minnow traps and bait
2	5-gallon buckets
1	Fish measuring tube or board

## **CREW DUTIES**

A typical crew consists of 2 people. One crew member is primarily responsible for taking site photographs, drawing the site sketch, and directing the survey. The other crew member is primarily responsible for filling out the Culvert Data Sheet and collecting fish data. Duties should be alternated regularly so that both crew members are familiar with the entire set of duties.

## **ASSESSMENTS**

### **SITE SKETCH AND PHOTOGRAPHS**

A site sketch is completed in the field notebook, and a series of photographs are taken at each site with a digital camera.

### **CULVERT DATA SHEET**

The location, type, dimensions, condition, and design of the structure are recorded on this sheet (Figure 2), as well as information on the stream size and flow, substrate type, and any other factors that may affect fish passage.

When conditions make it impossible to collect data, the Photo-only Data Sheet is used to record the location and existence of a crossing and to assign an ID. The Photo-only Data Sheet should **only** be used if **no** data can be recorded. If some measurements or basic data can be collected, all information should be recorded on a Culvert Data Sheet.

### **FISH DATA**

At every site that is not already included in the Anadromous Waters Catalog (AWC), baited traps should be set upstream and downstream of the culvert in a quiet pool or other suitable trapping area where they are unlikely to be disturbed during the assessment. The fish data sheet is used to record the results of any trapping or other fish-identification effort. Trapping-effort data is also logged on the Culvert Data Sheet. When time allows, AWC streams should also be trapped to help supplement, expand, and back-up existing fish data at those streams.

### **LONGITUDINAL PROFILE**

The longitudinal profile (LP) is a surveyed profile of the stream through the reach containing the crossing. At a minimum the longitudinal profile should run from a point downstream of the outlet pool tailwater control (TWC) to the first resting area upstream of the crossing. Wherever possible, the profile is extended or a second survey performed to determine stream gradient. Site conditions and stream morphology will determine the exact length of the longitudinal profile at each site.

## SECTION TWO: METHODS

---

This section covers the methods used during a standard Level 1 culvert assessment. Each element of the assessment is explained. This manual covers the most commonly encountered conditions, but crews frequently encounter atypical structures or site conditions that are not covered in the manual. Taking detailed notes and clear photographs is therefore very important. If there are any questions about the assessment, detailed notes will be useful.

The following section is organized as follows:

- Culvert Data Sheet,
- Field Notebook,
- Photo-only Data Sheet,
- Fish Data Sheet.

### CULVERT DATA SHEET

A culvert data sheet is filled out at every site except Photo-only Sites (Figures 2 and 3).

#### LOCATION SECTION

The Survey ID is created by the field crew as described above. Fill out this section in as much detail as possible. If this site has been assessed in the past, it will already have an assigned Site ID, which may be entered if it is known. New sites will have a Site ID assigned after the field season, so this field on the form should be left blank at the time of assessment. Road name is taken from either a map or road sign, and if there is a discrepancy, include both names. When assessing a private drive, turnout, bike trail, or driveway, label it as such and include information on the location in the notes. If a stream does not have a name on the map, label it as either Unnamed Stream or as a tributary to a larger known stream into which it flows into (e.g., Wasilla Creek Tributary). Time is the 24-hour system, or military time. Book # refers to the corresponding field notebook. Crew members are listed by initials; include all crew who are present at the site. Latitude and longitude should be recorded from the GPS to at least 5 decimal places; do not round.

Survey ID	ABCL10 ABCL01	Date	7/21/10
Site ID		Time	1800
Road Name	Alaska Rd	Book #	4
Milepost	2	Crew	ME, JL
Watershed	SUSITNA	Lat.	68.68723
Stream Name	WALLBASH Cr	Long.	-149.0967

Figure 2.—Sample header information for Culvert Data Sheet.

<b>Survey ID</b>	<input style="width: 90%;" type="text"/>	<b>Date</b>	<input style="width: 90%;" type="text"/>	
<b>Site ID</b>	<input style="width: 90%;" type="text"/>	<b>Time</b>	<input style="width: 90%;" type="text"/>	
<b>Road Name</b>	<input style="width: 90%;" type="text"/>	<b>Book #</b>	<input style="width: 90%;" type="text"/>	
<b>Milepost</b>	<input style="width: 90%;" type="text"/>	<b>Crew</b>	<input style="width: 90%;" type="text"/>	
<b>Watershed</b>	<input style="width: 90%;" type="text"/>	<b>Lat.</b>	<input style="width: 90%;" type="text"/>	
<b>Stream Name</b>	<input style="width: 90%;" type="text"/>	<b>Long.</b>	<input style="width: 90%;" type="text"/>	

**Culvert Description: pipes numbered left to right facing downstream**

	Units	1	2	3	4	5
Culvert Type (CIR, PA, etc.)						
Culvert Material (CSP, SSP, etc.)						
Structure Type (from matrix)	1 to 5					
Inlet Type (PRO, 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 (PRO, 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					
<b>Outfall Height</b>	ft					
<b>Pipe Gradient</b>	%					
<b>Water Depth at Outlet</b>	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				

**Site Classification (Red/Gray/Græn)** \_\_\_\_\_  
(Complete all applicable sections of this form before leaving survey site!)

Site Codes	1	2	3	4	5	6
from table						

<b>Resurvey? (Y/N)</b>	<input style="width: 90%;" type="text"/>	Old Survey ID (if known) _____
<b>Backwatered? (Y/N)</b>	<input style="width: 90%;" type="text"/>	Step Pools <input type="checkbox"/> Baffles <input type="checkbox"/> Tidal <input type="checkbox"/>

**Stream Measurements**

	Dist.	OHW
Upstream width		
Upstream width		
Upstream width		
Upstream width		
Downstream width		
Downstream width		
Downstream width		
	Avg u/s width	
	Avg d/s width	
	<b>Constriction Ratio</b>	

**Stream Stage** (High, Med, or Low) \_\_\_\_\_

**Stream Approach Angle** \_\_\_\_\_

Fish data:	Sheet #	Line #s		
Trap	Loc/Dist	Time In	Time out	Soak Time
<b>A</b>				
<b>B</b>				

**Notes:** (Fish observations, damage, oddities, ect)

Figure 3.-Culvert Data Sheet (front).

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
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
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
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 span to OHW width ratio less than 0.5
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 1.0%, 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.
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.
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.

- 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.
- Ordinary high water (OHW) is the mean stream width measured either upstream or downstream of the culvert beyond the hydraulic influence of the culvert.
- 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.
- 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.
- Outfall height is the difference between the water surface elevation at the outlet and in the outlet pool (or the equivalent tailwater surface).

**Culvert Material**

SSP	Structural steel plate (bolted)
SAP	Structural aluminum plate (bolted)
CSP	Corrugated steel
CAP	Corrugated aluminum
WOD	Wood
RCP	Reinforced concrete
CPP	Corrugated plastic
NCP	Non-corrugated metal
UNK	Unknown/Other

**Culvert Type**

CIR	Circular pipe
OVL	Oval
AO	Open-bottom arch
BOX	Box culvert
PA	Pipe-arch
BR	Bridge
OT	Other
RM	Removed structure
FBO	Flat-bottom Oval

**Substrate Types**

Code	Descriptio	Size Guidelines
SCL	Silt/ Clay	0.08mm to less than 2mm
SA	Sand	2mm to less than 5mm
GRV	Gravel	5mm to less than 80mm
CBL	Cobble	80mm to less than 250mm
BO	Boulder	250mm to less than 1 meter
BD	Bedrock	1 meter or greater
OR	Organics	n/a
NON	None	n/a

**Site Observations Codes**

OHG	Outfall height gray
OHR	Outfall height red
GRDG	Culvert gradient gray
GRDR	Culvert gradient red
CRG	Constriction ratio gray
CRR	Constriction ratio red
AL	Culvert is poorly aligned
BV	Beaver Activity
CG	Compound gradient in pipe
CS	Cut-slope sliding into culvert
DF	Debris Flow
EC	Hydraulic flows 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:

Figure 4.-Culvert Data Sheet (back).

Note: The back of the data sheet contains the rating matrix, some instructions, and all the codes.

## CULVERT DESCRIPTION

The culvert's physical dimensions, material, and structure type of the culvert(s) are recorded under the Culvert Description section (Figure 5). The appropriate codes can be found on the back of the data sheet (Figure 3). If there are multiple culverts, culverts are numbered from left to right facing downstream. Enter the data for each culvert in the appropriate column.

**Culvert Description: pipes numbered left to right facing downstream**

	Units	1	2	3	4	5
Culvert Type (CIR, PA, etc.)		CIR				
Culvert Material (CSP, SSP, etc.)		CSP				
Structure Type (from matrix)	1 to 5	3				
Inlet Type (PRO, HDW, ect)		PRO				
Inlet Apron Length	ft	/				
Inlet Width	ft	3.0				
Inlet Height	ft	2.7				
Substrate Depth Inlet	ft	.3				
Rust Line Height Inlet	ft	2				
Sedimentation at Inlet?	Y/N	N				
Outlet Type (PRO, HDW, ect)		PRO				
Outlet Apron Length	ft	/				
Outlet Width	ft	3.0				
Outlet Height	ft	2.6				
Outfall Type (AG, F, C, etc.)		F				
Substrate Depth Outlet	ft	.4				
Corrugation Depth	in	2				
Corrugation Width	in	6				
Culvert Length	ft	146.2				
Embedded?	Y/N	N				
Embedded Depth	ft	/				
Condition Rating (5=best)	1 to 5	3				

Figure 5.—Culvert Data Sheet: culvert description section.

## Culvert Types

Culvert types are listed on the back of the Culvert Data Sheet. Types are circular (CIR), oval pipe (OVL), open-bottom arch (AO), box culvert (BOX), pipe arch (PA), flat-bottomed oval (FBO; “underpasses”), other (OT), or a removed structure (RM) (Table 1; Figure 6).

Table 1.—Culvert Type table on the Culvert Data Sheet.

Designation	Culvert type
CIR	Circular pipe
OVL	Oval
AO	Open-bottom arch
BOX	Box culvert
PA	Pipe-arch
BR	Bridge
OT	Other
RM	Removed structure
FBO	Flat-bottom Oval

	Units	1	
Culvert Type (CIR, PA, etc.)		CIR	
Culvert Material (CSP, SSP, etc.)		CSP	
Structure Type (from matrix)	1 to 5	3	

Figure 6.—Example culvert type, material, and structure class from Culvert Data Sheet.



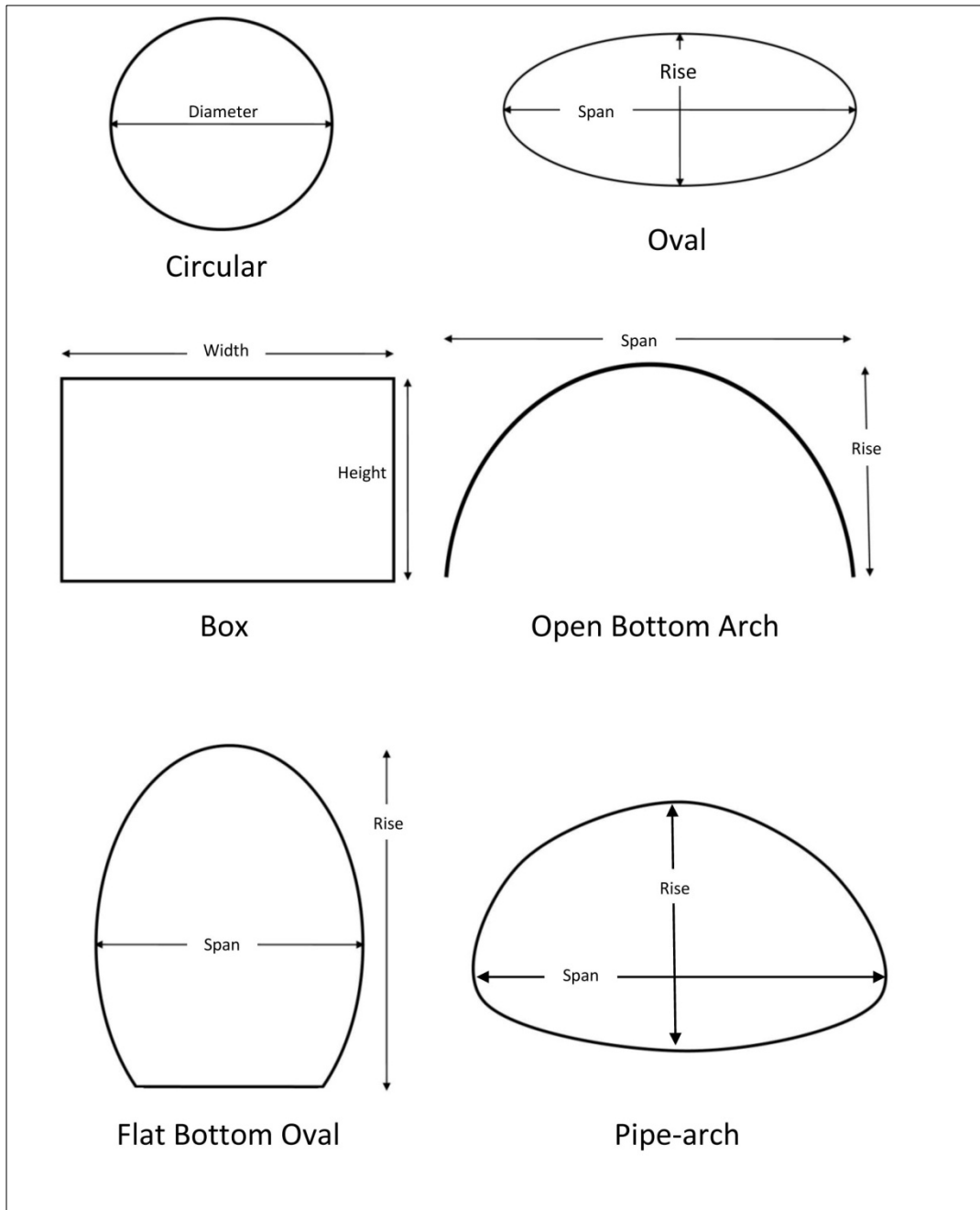


Figure 7.—Illustration of culvert types.



Open-Bottom Arches



Embedded Circular Culverts

Figure 8.—Photographs of culvert types: examples of open-bottom arches and embedded circular culverts.

*Note:* It can be difficult to tell an embedded circular pipe from an open-bottom arch with correctly buried footers. The top two pictures are both open-bottom arches, and the lower photographs show embedded circular pipes. If there is any question about a site, make a note.



Flat Bottom Ovals



Pipe Arches



Box Culverts

Figure 9.—Photographs of culvert types: ovals, arches, and box culverts. Flat-bottom oval culverts are typically as tall as or taller than they are wide, in contrast to pipe arches, which are wider than they are tall. Flat-bottom oval culverts are generally used for bicycle and ski underpasses but are occasionally found in streams.

## Culvert Materials

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) (Table 2). Culvert types and materials are listed on the back of the data sheet for reference.

Structural steel and aluminum plate is recognized by the large bolts used to fasten plates together.

Table 2.–Culvert Material table on Culvert Data Sheet.

Designation	Culvert Material
SSP	Structural steel plate (bolted)
SAP	Structural aluminum plate (bolted)
CSP	Corrugated steel
CAP	Corrugated aluminum
WOD	Wood
RCP	Reinforced concrete
CPP	Corrugated plastic
NCP	Non-corrugated metal
UNK	Unknown/Other

## Structure Type

Structure types are determined by the culvert type, size, and material and cannot be completed until all of the culvert measurements have been collected. Use the table on the back of the data sheet to determine structure type (Figure 10).

Structure Type	
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.
2	Culverts (all span widths) with 2 X 6 inch corrugations or greater, not embedded.
3	Pipe arch or circular CMP (span width greater than 4 feet), less than 2 X 6 inch corrugations, not embedded
4	Pipe arch or circular CMP (span width less than or equal to 4 feet), less than 2 X 6 inch corrugations, not embedded
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
6	Multiple Structure Installations

Figure 10.–Structure types from the back of the Culvert Data Sheet.

## Culvert Measurements

All measurements in this section are in tenths of feet *except for corrugation measurements, which are in inches in accordance with manufacturer specifications.*

Inlet and outlet heights are measured from the top to the bottom of the culvert and from the smallest inside dimensions of the opening from the tops of the corrugations. If there is substrate at the invert, the height should be measured from the top of the culvert to the substrate in the thalweg. Figure 11 illustrates inlet and outlet dimensions for a round pipe and a damaged pipe.

Substrate depth is determined by pounding a known length of rebar into the substrate until it reaches the culvert and subtracting the measured length of the rebar remaining above substrate from the known length. Inlet and outlet widths should be measured to the smallest inside diameter at the culvert's widest point, measuring from the tops of the corrugations.

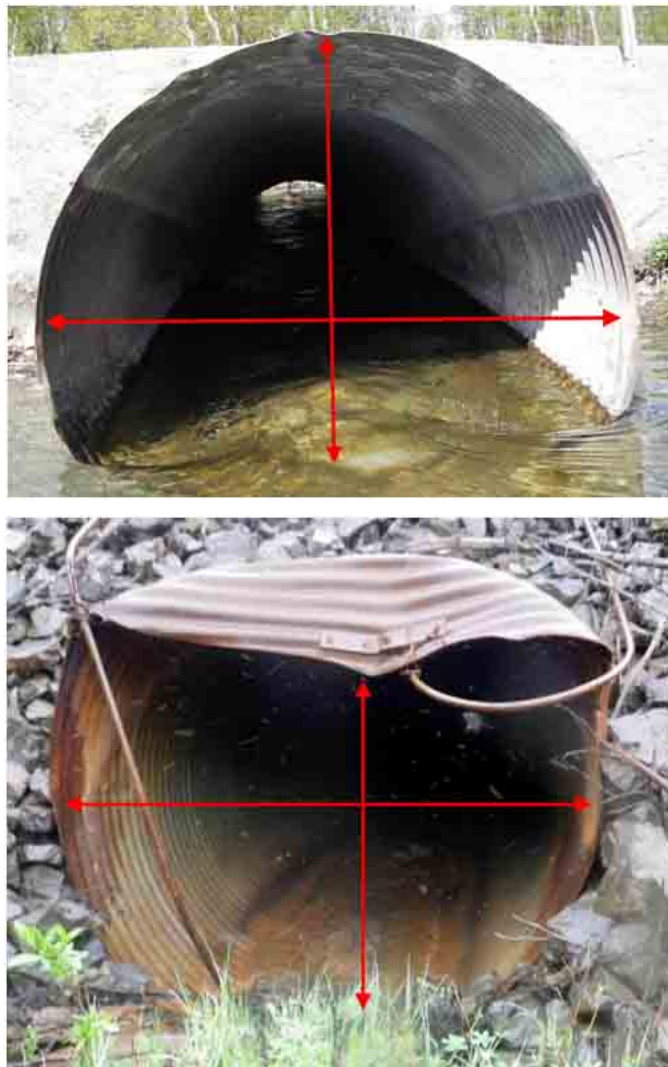


Figure 11.—Culvert invert dimensions at a round pipe and a damaged pipe.

## Inlet and Outlet Type

Inlet and outlet types are listed on the back of the Culvert Data Sheet (Table 3; Figure 12). Projecting inlets extend beyond the face of the fill gradient. Mitered inlets are cut at an angle so that the culvert is flush with the road. A headwall is a retaining structure flush with the culvert invert and may be constructed of concrete, metal or wood. Flared outlets are metal structures bolted onto the inverts of a culvert. Aprons are usually concrete pads constructed directly at the outlet and sometime inlets of culverts, but these are uncommon in Alaska. Wing Wall Culverts have a structure, usually made of the same material as the headwall, that angles off of the main headwall and helps funnel flow into the culvert(s).

Table 3.–Inlet and outlet types.

Designation	Outlet type
PRO	Projecting
MIT	Mitered
HDW	Headwall
FLA	Flared
APR	Apron
WIN	Wing Wall

## Outfall Type

Each culvert outfall is categorized as either set at stream grade, free-fall into the outlet pool, free-fall onto riprap, cascade over riprap, fish passage structure, smooth flow over an apron, an overflow culvert, or a hydraulic jump (Table 4; Figure 13 a-d). All classifications are made at the time of assessment.

Table 4.–Culvert outfall type.

Designation	Outfall type
AG	At stream grade
F	Free fall in to pool
C	Cascade over riprap
SF	Smooth flow over apron
OP	Overflow pipe
HJ	Hydraulic jump
FR	Free fall on to riprap
PS	Fish passage structure



Projecting Culvert



Mitered Culvert



Headwall Culvert



Wing Wall Culvert



Flared Metal Apron Culvert



Concrete Apron Culvert

Figure 12.-Culvert inlet/outlet types.



Figure 13a.—Projecting culvert outlet with an outfall type: at stream grade.



Figure 13b.—Projecting culvert with an outfall type: free-fall onto riprap.

-continued-





Figure 13c.–Projecting culvert with an outfall type: free-fall into pool.

*Note:* The cement footer is supposed to be buried below the surface, not exposed, and is not a headwall.



Figure 13d.–Culvert outfall type of fish passage structure (fish ladder).

Figure 13.–Classification of culvert outfall types.

## **Inlet or Outlet Aprons**

If an inlet or outlet apron exists, the construction material is noted and the length measured (as described above). An apron is considered a structure added to the end of a culvert to prevent scour of the stream channel. This includes concrete structures added to disperse water. In Alaska, aprons are uncommon, and where they do exist, they are typically constructed of riprap.

Mitered outlets are not considered aprons. The miter is considered part of the culvert and is included for overall culvert length.

## **Rust Line**

Rust line height is defined as the upper limit of rust inside the culvert and indicates the depth of ordinary high water flow through the culvert. 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. If the culvert is embedded, the rust line is measured from the top of the bed material. Culvert width, height, and rust line height are measured using a steel tape or level rod to the nearest tenth of a foot (Figure 14a). Aluminum culverts will not have rust lines but may have other markings from tannin staining or algae growth. Sometimes a culvert is moved or reset after a flood and may have multiple rust lines from being turned; these should not be measured (Figure 14b).



Figure 14a.—Photograph illustration of rust line height.

-continued-



Figure 14b. Culvert showing multiple rust lines due to reuse.

Figure 14.–Culvert rust line height and patterns.

### Corrugations

Corrugations are measured from crest to crest for width and from trough to crest for depth (Figure 15). *Corrugations are measured in inches and fractions, not tenths of feet or tenths of inches.*

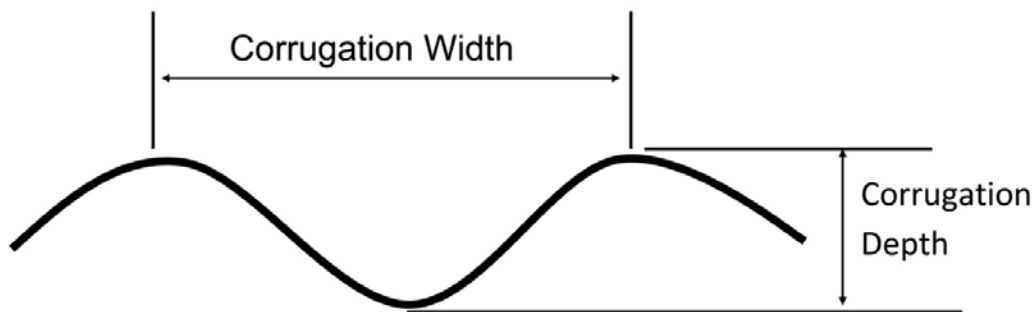


Figure 15.–Illustration showing corrugation dimensions.

### Culvert Length

Culvert length should be measured through the culvert with a laser range finder to the nearest tenth of a foot. It is important that the culvert length is measured accurately so that the gradient is correct. Measure exactly to the end of the culvert and do not measure diagonally or at an angle. The length of aprons or other inlet or outlet structures are also measured, generally using a tape. When measuring mitered culverts, the total culvert length should be recorded as culvert length unless the miters are buried or damaged, in which case the top of the pipe is measured and used to calculate gradient (Figure 16).

If the laser range finder cannot be used because there is no line of sight through the culvert, estimate the length using another method by shooting over the road with the laser or measuring through the culvert or over the road with a tape measure. If it is not possible to obtain a length due to high road fill, culvert damage, or other considerations and the culvert is labeled with a DOT placard and length (Figure 29), the length on the placard can be used. If any of these methods are used, note the method used in the notes and that the calculated culvert gradient is an approximation.

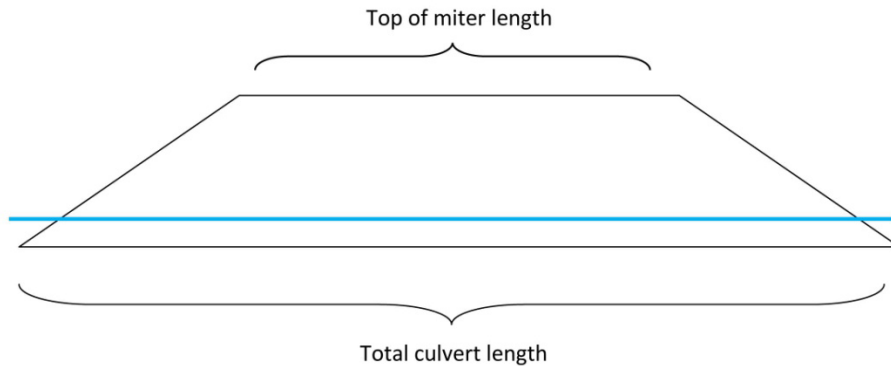


Figure 16.—Illustration of total culvert length and top of miter length for a mitered culvert.

### Embedded Culverts

**For a culvert to be considered embedded, it must have 100% bedload coverage through the length of the culvert, and both inverts must be lower than the streambed elevation.** 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 culvert to the point of maximum horizontal dimension of the culvert (haunch height) or is 1 foot deep, **whichever is greater** (Figure 17). Embedded depth will be the measurement of substrate at the inlet or outlet, **whichever one is the least**.

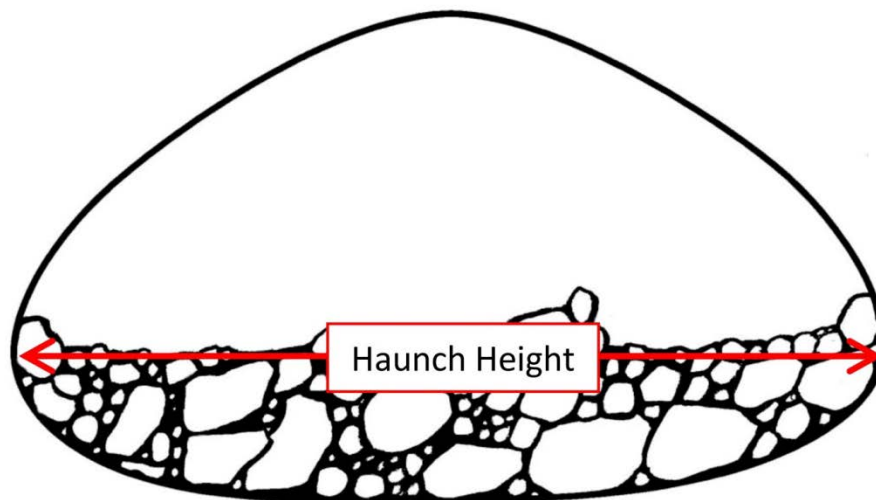


Figure 17a.—Illustration showing an embedded pipe arch and maximum horizontal dimension or haunch height.

-continued-

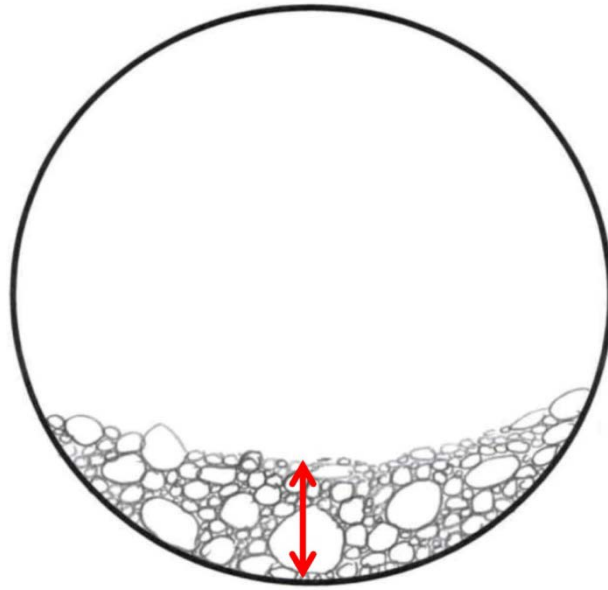


Figure 17b.—Illustration showing a round culvert embedded to 20% of its height.

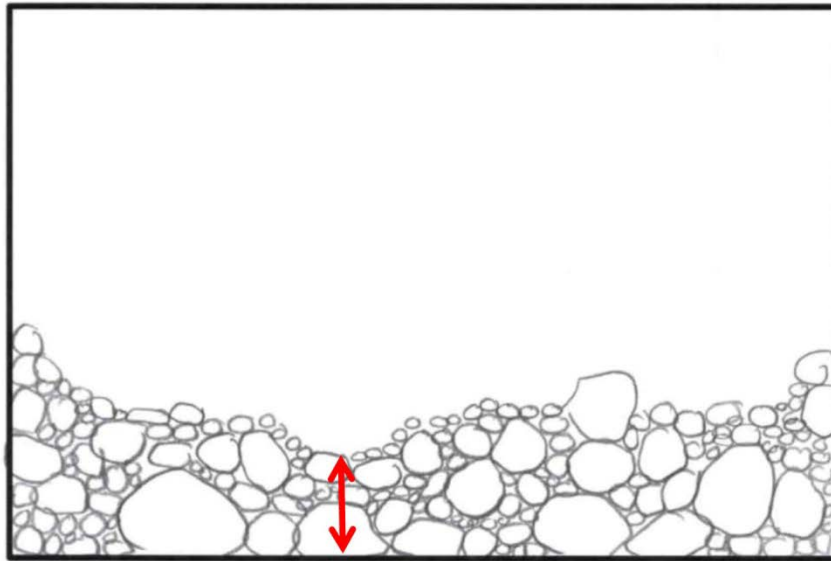


Figure 17c. Illustration showing a box culvert embedded to 20% of its height.

-continued-

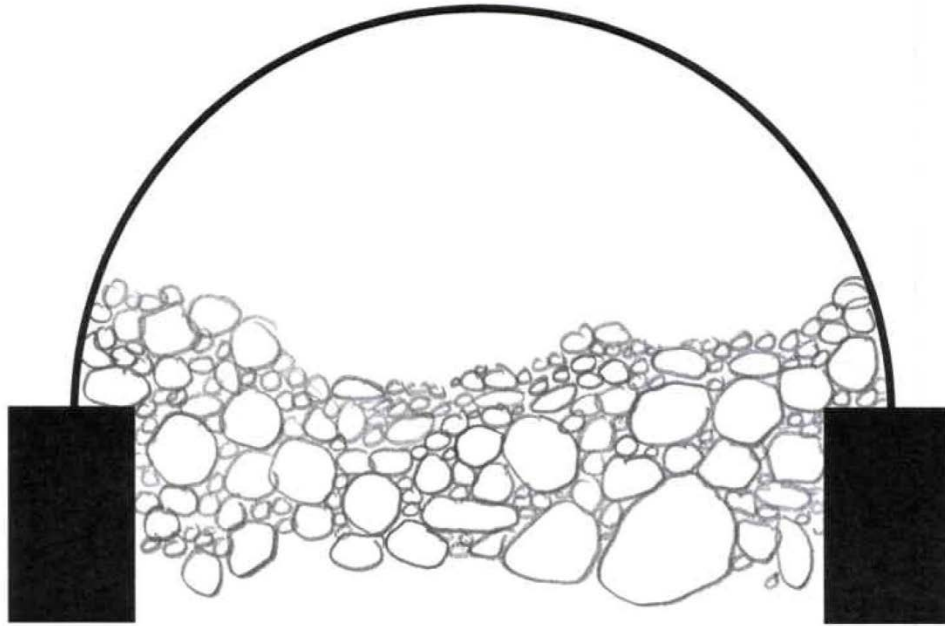


Figure 17d. Illustration showing an embedded bottomless pipe arch with concrete footers, a low flow channel, and constructed banks.

Figure 17.—Classification of embedded culverts.

Where substrate is greater than approximately 0.5 feet deep, substrate depth is determined 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 of the rod.

### **Culvert Condition**

The condition of each culvert is ranked 1 through 5 according to the following AKDOT 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 culvert should be trouble free.
- (5) *Excellent*: culvert shows no signs of problems or rust; could allow flow at full capacity without disrupting fish passage.

The lower part of the culvert measurements section (outfall height, water depth at outlet, gradient, etc.) is filled out later after the survey is complete because most of the values are determined from elevations collected during the longitudinal profile. This part of the process will be discussed further in the Longitudinal Profile section.

## HABITAT ELEMENTS

The next portion of the Culvert Data Sheet is used to record substrate (Figures 18 and 19). Dominant and subdominant substrate types are determined visually and should reflect the naturally occurring substrate in the creek, not roadbed material that has sloughed into the creek bed. Move as far up or downstream as needed to determine the naturally occurring streambed material. Use the size categories on the back of the sheet to classify the substrate (Table 5).

The inlet and outlet section should only be filled if there is substrate at the inverts and in the culvert. Substrate in the inverts is often not naturally occurring and may include roadbed material or other nonnative materials such as riprap. If these are present, record them.

Habitat Elements	Upstream	Downstream	Inlet	Outlet
Dominant substrate	CBL	CBL	GRV	CBL
Subdominant substrate	GRV	GRV		

Figure 18.—Habitat Elements section of the Culvert Data Sheet.

Table 5.—Substrate types used in the Habitat Elements section of the Culvert Data Sheet.

Designation	Description	Size Guidelines
SCL	Silt/Clay	0.08 mm to less than 2 mm
SA	Sand	2 mm to less than 5 mm
GRV	Gravel	5 mm to less than 80 mm
CBL	Cobble	80 mm to less than 250 mm
BO	Boulder	250 mm to less than 1 meter
BD	Bedrock	1 meter or greater
OR	Organics	n/a
NON	None	n/a

Figure 19 (a-f) provides photographic illustrations of representative substrate types.



Figure 19a.-Silt/clay.



Figure 19b.-Silt/clay.

-continued-





Figure 19c.–Gravel with sand.



Figure 19d.–Organic.

-continued-



Figure 19e.—Sand with gravel.



Figure 19f.—Gravel with cobbles.

Figure 19.—Substrate types used in the Habitat Elements Section of the Culvert Data Sheet.

## STREAM MEASUREMENTS

This section of the Culvert Data Sheet is completed as follows (Figure 20).


Stream Measurements		
	Dist.	OHW
Upstream width	50	7.0
Upstream width	75	12.3
Upstream width	135	8.9
Upstream width		
Downstream width		
Downstream width		
Downstream width		
	Avg u/s width	9.4
	Avg d/s width	
	Constriction Ratio	.32
Stream Stage (High, Med, or Low)		MED
Stream Approach Angle		20°

Figure 20.—Stream measurement, stream stage, and approach angle on the Culvert Data Sheet.

### Stream Width

Stream widths are used to calculate the culvert's constriction ratio, which is the ratio of the stream width to the culvert width. The constriction ratio is used to determine whether the culvert is undersized relative to the stream.

Stream widths should be taken outside the influence of the culvert and, if possible, upstream of the crossing. If this is not possible due to ponding or other factors, measure the width downstream, below the tailwater crest and indicators of incision, such as eroding streambanks. If there is a known history of road failure, do not measure widths downstream. If both up- and downstream water bodies are ponds, lakes, or sloughs, average widths cannot be recorded and a constriction ratio is not calculated, unless there is a natural channel a short distance above the upstream water body

### Ordinary High Water

Stream width is measured at ordinary high water (OHW) along 3 straight runs or heads of riffles at locations up- or downstream of any obvious influence of the crossing structure (Figure 21 a and b). All channel widths are measured perpendicular to streamflow and to the nearest tenth of a foot using a fiberglass tape. The distance upstream of the inlet to the location of each width measurement is also recorded. Take at least 3 measurements at each site. Take the average of the measurements to calculate average stream width.

OHW is defined by the State of Alaska as:

- (A) In the non-tidal portion of a river, lake or stream: the portion of the bed(s) and banks up to which the presence and action of the non-tidal water is so common and usual, and so long continued in all ordinary years, as to leave a natural line or "mark" impressed on the bank or shore as indicated by erosion, shelving, changes in soil characteristics, destruction of terrestrial vegetation, or other distinctive physical characteristics;

- (B) In a braided river, lake, or stream: the area delimited by the natural line or “mark,” as defined in Part A above, impressed on the bank or shore of the outside margin of the most distant channels; or
- (C) In the tidally influenced portion of a river, lake, or stream: the portion of the bed(s) and banks below the
  - a. OHW as described in A or B above, or
  - b. mean high water elevation; whichever is higher at the project site.

Please note that ordinary high water is not the same as a bankfull. Bankfull width is the lateral extent of the water surface at bankfull depth; bankfull depth is the water surface elevation required to completely fill the channel to a point above which water would spill out onto the floodplain.



Figure 21a.—Photograph showing example of ordinary high-water mark (OHW).

-continued-



Figure 21b.–Photograph showing example of ordinary high-water mark (OHW).

Figure 21.–Recording ordinary high-water mark.

### Constriction Ratio

The constriction ratio (CR) for one culvert is calculated as the culvert width (CW) divided by the average channel width at OHW. Culvert width is the widest point at the inlet invert.

$$(CW/OHW):1$$

For more than one circular culvert, use this formula.

$$CR = \sqrt{(r_1^2 + r_2^2 + r_{x,\dots}^2) * 2} / OHW$$

Where  $r$  is the radius of the culverts.

Constriction ratio is not calculated in the field for sites that have more than one pipe arch or a battery of multiple types of culverts.

### Stream Stage

Stream stage is recorded to document stream conditions at the time of the assessment. We use 4 stream stages for our assessment: high, medium, low, and dry. These are defined as follows:

- High: Stream is at or above ordinary high water (OHW).
- Medium: Stream is below OHW but above low flow (described below). Flow is sufficient to allow fish passage upstream and downstream of culvert.
- Low: Flow is confined to the middle of the thalweg leaving significant portions of the active streambed dry, water is only present in isolated pools, or flow is not sufficient to allow fish passage upstream and downstream of the culvert.
- Dry: Stream is without water.

Most streams assessed during the summer field season in Alaska will fall into the medium category. If they do not, note or photograph evidence of high or low stream stage.

### Stream Approach Angle

Stream Approach Angle is the angle between the stream and culvert, as illustrated below, where the approach angle is 45 degrees (Figure 22). Stream approach angle is measured using a compass to sight down the middle of the culvert and the stream channel and should be a positive number between 0 (no deviation) and 90 degrees (stream approaches culvert at right angles).

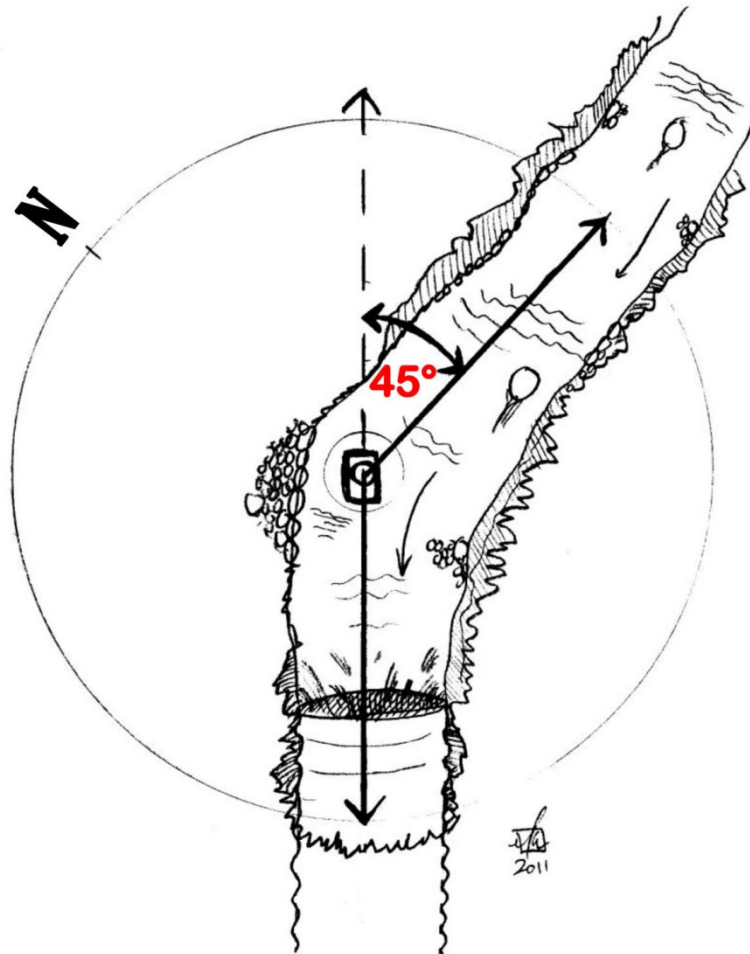


Figure 22.—Illustrated example of an approach angle of 45 degrees.

## SITE CODES

Site codes are used to standardize observations at the culvert (Table 6). Record the appropriate codes in the box at the top of the sheet.

Table 6.–Site codes from the Culvert Data Sheet.

### Site Observations

OHG	Outfall height gray
OHR	Outfall height red
GRDG	Culvert gradient gray
GRDR	Culvert gradient red
CRG	Construction ratio gray
CRR	Construction ratio red
AL	Culvert is poorly aligned
BV	Beaver activity
CG	Compound gradient in pipe
CS	Cut-slope sliding into culvert
DF	Debris Flow
EC	Hydraulic flows 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

- OHG – Outfall Height Gray – Culverts with an outfall greater than zero and less than 4 inches receive this code.
- OHR – Outfall Height Red – Culverts with an outfall over 4 inches receive this code.
- GRDG – Culvert Gradient Gray – Depending on structure class, the culvert slope, determined from the longitudinal profile, will be used to assess whether the culvert has a gray gradient.
- GRDR – Culvert Gradient Red – Depending on structure class, the culvert slope, determined from the longitudinal profile, will be used to assess if the culvert has a red gradient.

- CRG – Constriction Ratio Gray – Sites determined to have a constriction ratio between 0.5 and .75 will be labels CRG.
- CRR – Constriction Ratio Red – Any site determined to have a constriction ratio under 0.50 will receive this code.

### **Other site codes**

These describe conditions at the site.

- AL – Alignment – Culvert is poorly aligned. This code is used for culverts that have an approach angle over 45 degrees or where the alignment is causing erosion, debris clogging, or other observed problems.
- BV – Beaver Activity – Sites that show signs of being influenced by beaver activity. This can refer to dams upstream and downstream of the culvert(s) or culverts plugged by beavers.
- CG – Compound Gradient – Any culvert that has a noticeable change in the gradient (a gradient break) within the crossing structure.
- CS – Cut-Slope Sliding into Culvert – This code refers to the cut slope of the road sliding into the stream channel or culvert.
- DF – Debris Flow – This code is used when a site shows signs of a large amount of debris and/or sediment movement at the site; typically, the culverts with this code will be partially filled with debris.
- EC – Hydraulic Flows Exceed Capacity – This code is used when the culvert(s) are visually observed to be undersized for the stream size at the site. Examples include culverts that are more than half full at medium stream flows, culverts that are entirely submerged, any location where it is possible to observe that the stream regularly overtops the road, and high rust lines and erosional scour around inlet.
- IAS – Inlet Apron Too Steep – An apron, bolted on metal or concrete, has a gradient steeper than the culvert.
- IB – Improper Bedding – The substrate underneath the culvert was not installed properly. Examples include the culvert sinking in wetland areas, bowing down in the center or heaving up or rocks being forced up through the culvert from thaw/freezing actions.
- IC – Damage Associated With Icing Problems – Typical ice damage is inverts being bent upward, pressure damage in the barrel of the culvert, and other invert damage.
- IP – Inlet Perch – Sediment or debris creates a perch at the inlet so that the stream drops down into the culvert at the inlet. Typically associated with undersized culverts that have upstream ponding at higher flows.
- MP – Mechanical Damage or Parting Joints – This code is used if a culvert shows signs of damage or sections coming apart.
- MT – Material Inadequate for Designed Use – This code is used if the culvert at a crossing is obviously not suited for the site. Examples are plastic or smooth concrete culverts on salmon streams and steel culverts used in a tidal zone.
- OAS – Outlet Apron Too Steep – An apron, bolted on metal or concrete, has a gradient steeper than the culvert.
- OT – Other – This is a catch-all code used to describe some other issue that is not covered in any of the other codes. Examples have included sinkholes in the road, water



diversion dams in the outlet pool, and culverts that have been deliberately blocked to keep livestock in. If this code is used, it should be explained in the notes section.

- RD – Road Bank Erosion – This code is used if the road bank is eroding around the culvert. This can be caused by the stream eroding the road prism or by runoff from the road.
- RF – Road Fill – This code is used if road fill is being pushed off the road prism by grading and substrate is filling the culvert.
- SD – Sediment Accumulation – This code is used if the culvert or some part of the crossing structure is causing sediment accumulation in the upstream channel, typically observed where an undersized structure causes ponding at high flows.
- SF – Shallow Fill Above Culvert – This code is used if there is not enough road fill over the top of the culvert(s). There should be a minimum of 12 to 18 inches of fill over most culverts. Insufficient fill can result in the culvert collapsing from heavy loads being driven over it.
- SG – Culvert Sagging– This code is used if there is a visible sagging of the culvert inside the barrel. These sags are usually caused by insufficient fill or improper bedding and are more common on longer culverts.
- SS – Subsidence – This code is used when a culvert has started to sink or the roadbed is sinking at the crossing.
- ST – Structural Problem – This code is used when the culvert has some other structural issue or damage such as headwalls failing or scoured footers.
- TS – Too Short – This code is used when the culvert is too short for the road prism. Culverts that are too short do not extend past the end of the road bank and can cause road bank erosion.
- WD – Woody Debris – This code is used when there are large amounts of wood debris plugging the culvert or causing other problems at the crossing site.
- NO – None of this type – If a culvert crossing has no site codes associated with it, this code is entered to show that none of the above conditions exist at the site.

## **BACKWATERED SITES**

A site is considered backwatered if one of two criteria is met. Record this information under the culvert description section of the Culvert Data Sheet (front) and follow the instructions below for coding the site classification.

- 1) A site is backwatered if the elevations of the tailwater control exceeds the elevation of the invert at both the inlet and outlet and any apron structures (Figure 23), or
- 2) The culvert is located in a pond, slough, or other area with slow moving or still water and tailwater and headwater surfaces are equivalent *and* water surface is continuous throughout the entire structure with at least 0.1 feet of depth at the shallowest point.

If the culvert is backwatered, this supersedes the critical values, and the culvert will be rated as Green. For example, a backwatered culvert is considered green even if it has a red culvert gradient and constriction ratio. In this case, mark on the data sheet in the space provided that the site is backwatered and classify it as green, remembering to list all relevant codes despite the Green rating.

## Site Backwatered by Tailwater Control

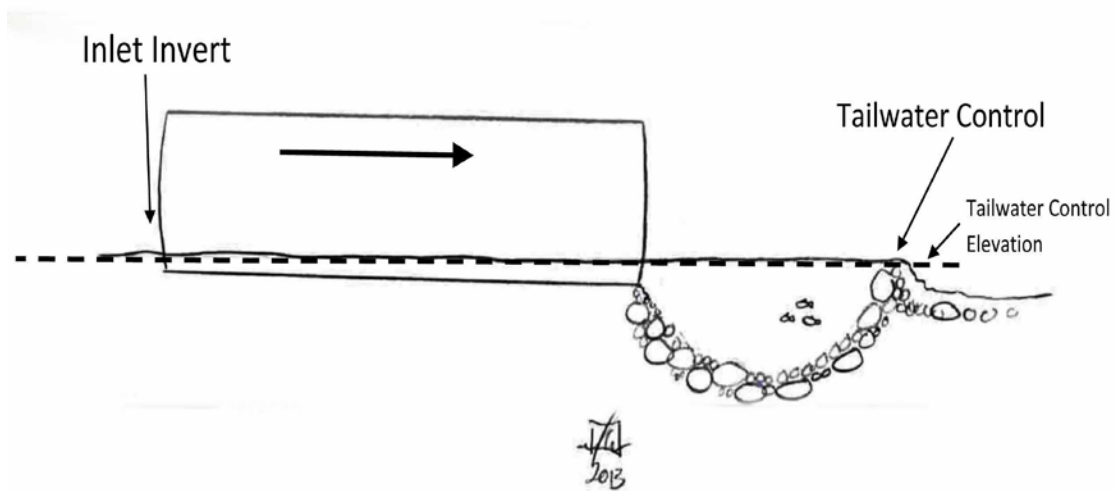


Figure 23.—Illustration showing a site considered backwatered because the tailwater control grade point is higher than the culvert's inlet invert.

### **BAFFLES**

Baffles are sometimes installed inside culverts to slow water movement and to help create resting areas inside the culvert (Figure 24). Baffles can be made of different materials and differ in number and size. If the culvert has baffles, check the appropriate box. If only one culvert at a multi-culvert crossing has baffles, make a note in the notes section which culvert has baffles.

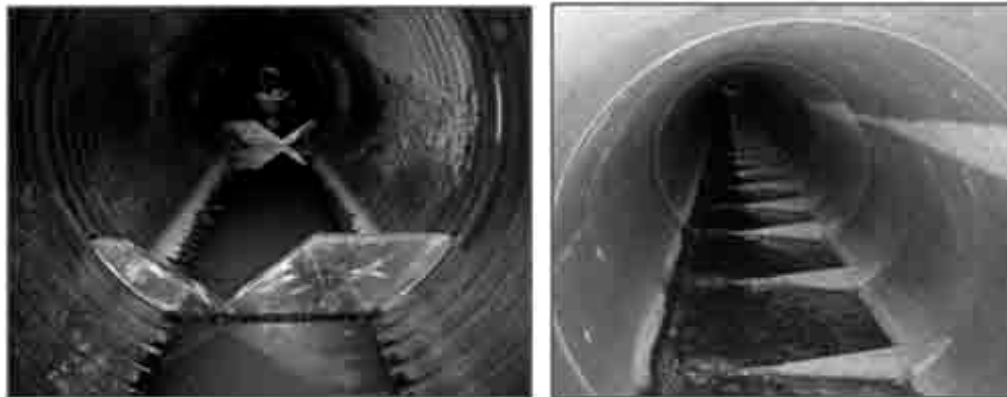


Figure 24.—Baffles inside culverts.

### **STEP POOLS**

Step pools occur naturally on high-gradient streams and are also used as a constructed habitat feature in stream simulation culverts or to backwater the outlet of a perched culvert to facilitate fish passage. Step pools may be constructed throughout the culvert or in the upstream or downstream channel. They may be constructed at a gradient close to the overall stream grade or

they may be constructed at a much steeper gradient in an effort to allow fish to enter a perched culvert (Figures 25 a-c; Figure 26). If there is a constructed step pool complex, mark the box labeled “step pools” on the culvert data sheet. **Do not check the box if the step pools are a natural feature of the stream and not constructed.**



Figure 25a.—Looking upstream at a series of step pools constructed as part of a replacement project.



Figure 25b.—Looking downstream at a series of step pools constructed as part of a culvert replacement project.

-continued-



Figure 25c.–Constructed step pools running through an embedded culvert.

Figure 25.–Step pools within a culvert.

Figure 26 shows a constructed step pool complex that backwaters the outlet of a formerly perched culvert. Because these step pools closely resemble the adjacent natural stream channel, they were not initially noted as step pools by the assessment crew. Closer examination shows that the channel is somewhat steeper through this stretch and that the steps are more evenly spaced than naturally occurring steps would be. Also notice the rock weirs exposed on the right bank; these are the ends of the constructed steps and should be visible below OHW wherever manmade step pools have been constructed.



Figure 26.–Photograph showing constructed rock weirs downstream of culvert.

## FIELD NOTEBOOK

Notebooks are used to record survey data, calculations of gradient and outfall height, a site sketch and the photograph log. Books are labeled with the project name, book number, and month and year on the front cover (Figure 27). Notebooks are numbered sequentially throughout the project as shown below.

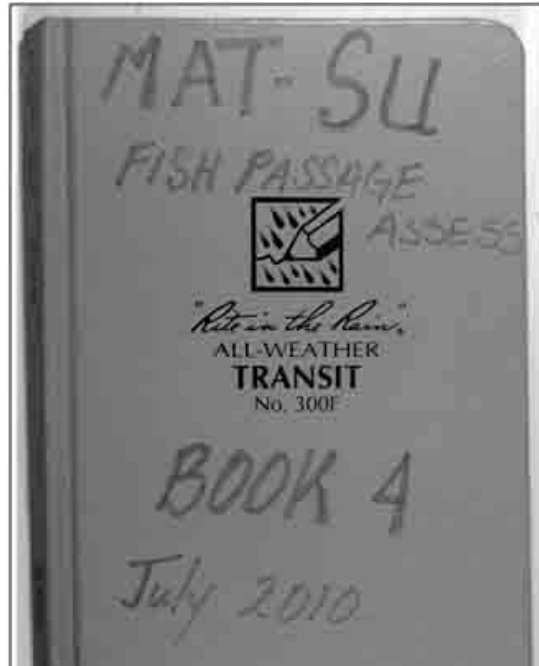


Figure 27.–Field notebook

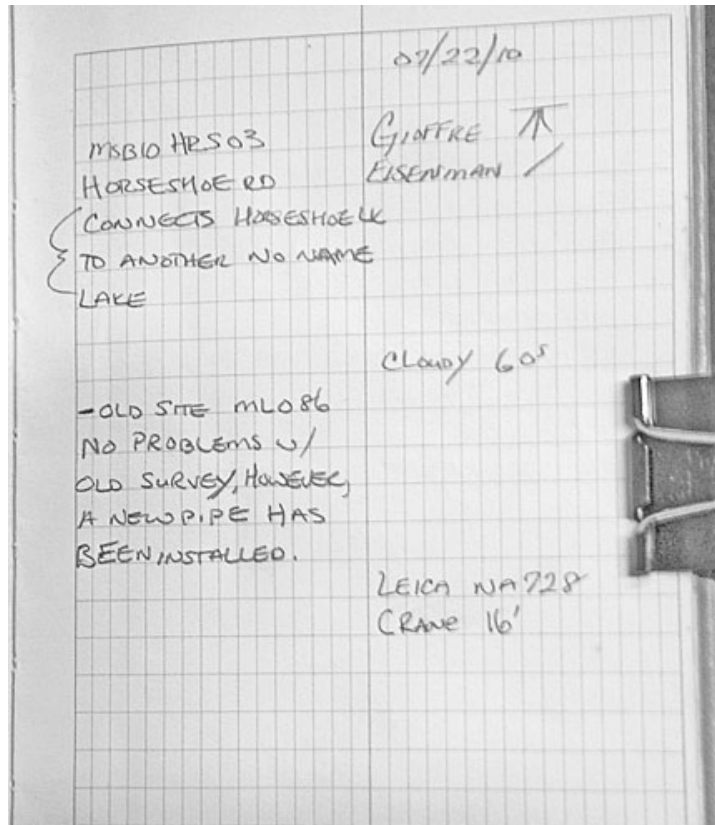


Figure 28.—Cover page in field notebook.

The date, Project and Survey ID, crew names and roles, road and stream name (if known), general weather observations, and the equipment used at this site are all recorded on the cover page. Record both the level model and the survey rod size and type.

If the site has already been assigned a permanent Site ID, it should be recorded. If the site is a re-assessment, the reason it is being re-assessed should be recorded here (e.g., the culvert has been replaced since a previous assessment or conditions at the site have changed) (Figure 28).

Many culverts on state-owned roads have DOT placards mounted on culvert markers (Figure 29).



Figure 29.—Department of Transportation placard on culvert marker.

The top number is typically the unique identifying number for that culvert. The bottom number is the approximate culvert size. The unique identifier for the culvert shown in Figure 29 is 1427+50, and it is approximately 36 inches in diameter and 224 feet in length. This information should be recorded on the cover page.

## SITE PHOTOGRAPHS

A series of photographs are taken at each site with a digital camera. A short description of each photograph is recorded in the field notebook in the order in which the photographs are taken (Figure 30).

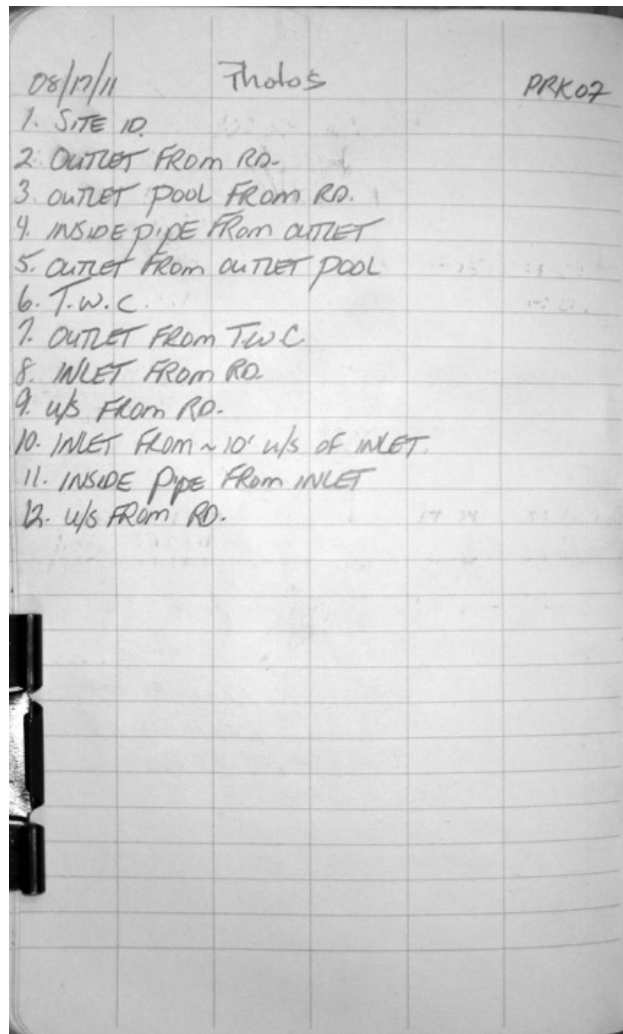


Figure 30.—Sample photograph log page from field notebook.

## PHOTOGRAPH LOG PAGE

The photograph log page is a log of all photographs in the order they were taken. It is also helpful to record the numbers the camera assigns each photograph.

Move obstructions like tree branches out of the way to allow a clear, unobstructed view of the culvert. Make sure the lens is clean, is not fogged, and does not have water droplets on it. Check photographs after taking them to be sure they are in focus and clear of obstructions and contain all the information intended.

Required photographs include:

- Site Marker. The Survey ID, road name, and date are written on a whiteboard and photographed. This is the *first* photograph taken at each site.
- View of the road surface at the crossing site.
- View from the culvert looking downstream at the tail crest and beyond.
- View from downstream of the tailwater control (or about 50 feet downstream if there is no tailwater), looking upstream at the culvert(s). The photograph should show the culvert outlet type, condition, road embankment, and the tailwater control if present.
- If the site has more than one culvert, take pictures of the culverts as a group and each inlet and outlet separately. If there is a large outlet perch, photograph this with the survey rod included for scale.
- 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.
- Photographs from the inlet and outlet showing the interior of the culvert. These photographs are used to show rust line height, and, if present, culvert damage, multiple grades, and/or obstructions.
- Photographs of the inlet and outlet at close range showing detail of perches, rust lines, and anything else interesting to the site.
- Views from the culvert looking upstream and downstream. These photographs should show vegetation and general channel type directly upstream and downstream of the culvert but outside of the culvert's influence.
- A photograph of typical stream substrate and other channel roughness elements upstream of the culvert's influence. An object of known size, such as a measuring stick or field notebook, should be used as a reference.
- Additional photographs of conditions, if any, that may be negatively affecting fish passage (e.g., damage, debris, bedload deposition at the inlet).

If fish are captured, representative photographs should be taken of the different species for documentation.

Figures 31 through 39 are example photographs for the Photograph Log Page, by photograph type.



1. Site Marker. The Survey ID, date, road name, and (if known) stream name are written on a piece of paper or dry-erase board and photographed with the field notebook (Figure 31).

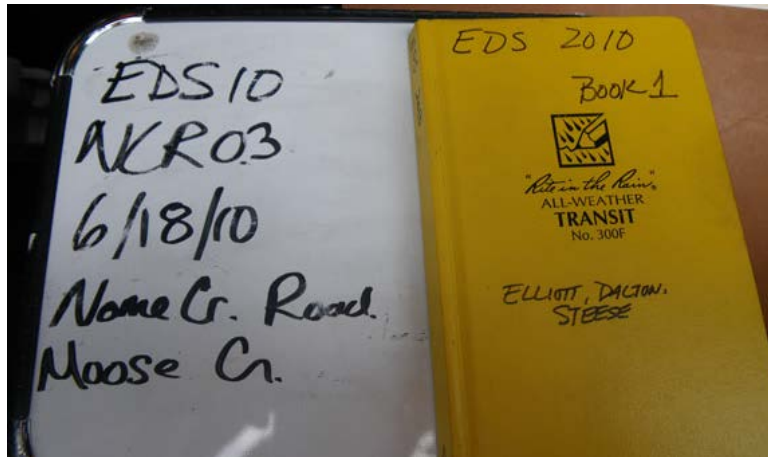


Figure 31.–Photograph site marker for the start of a site photograph sequence.

*Note:* This photograph includes the Project ID (EDS10), the Survey ID (NCR03), the date, road name, stream name, the field notebook used to record the survey data, and other pertinent information about the site, such as whether it is a re-assessment or a pre- or post-replacement assessment.

2. View of the road surface at the crossing site (Figure 32).



Figure 32.–Photograph of road surface.

*Note:* If possible, this photograph should include a reference marker, such as a milepost, road sign, or intersection. The photograph should show the surface material of the road.

3. Photographs of the inlet(s) and outlet(s) from the road above the culvert (Figure 33).



Figure 33.–Photograph of inverts from road looking upstream.

4. View from downstream of the crossing looking upstream showing the culvert outlet type, condition, and road embankment (Figure 34). This photograph should show the culvert outlet height above the tailwater. If the site has more than one culvert, take pictures of the culverts as a group and a photograph of each one separately. If there is a large outlet perch, take a photograph with the survey rod included for scale (Figure 35).



Figure 34.–Photograph of outlet from downstream, showing outfall type and condition.



Figure 35.–Photograph of outlet with a measuring rod for reference.

5. View from an upstream location (looking downstream) showing the culvert inlet type, condition, and road embankment (Figure 36). This photograph should show channel roughness (substrate, debris, vegetation, etc.) and culvert inlet conditions.



Figure 36.–Photograph of inlets from upstream.

6. Photographs from the inlet and outlet showing the interior of the culvert (Figure 37). These photographs are used to show rust line height, and, if present, culvert damage and obstructions.



Figure 37.–Photograph of the inside of a culvert.

7. Views from the culvert looking upstream and downstream. These photographs should show vegetation and general channel type directly upstream and downstream of the culvert but outside the influence of the culvert (Figure 38).



Figure 38.–Photograph of stream channel outside the influence of the culvert.

8. A photograph of typical stream substrate and other channel roughness elements outside the culvert's influence (Figure 39).

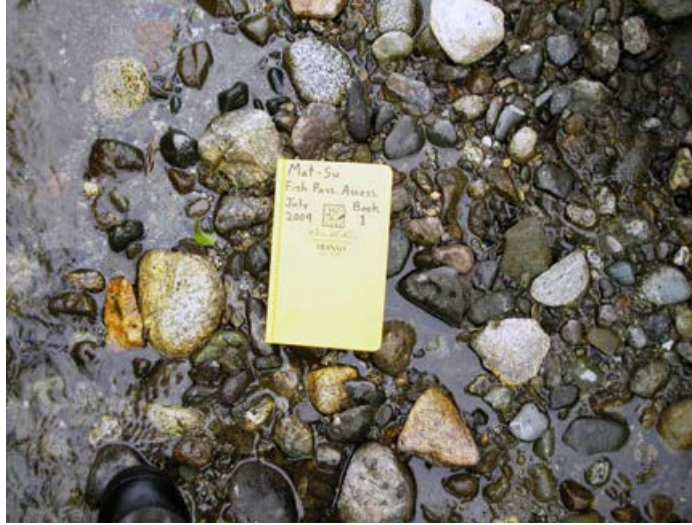


Figure 39.–Photograph of representative substrate.

*Note:* An object of known size, such as a measuring stick or notebook, should be used as a reference.

9. Additional photographs of conditions, if any, that may be negatively affecting fish passage (e.g., damage, debris, bedload deposition at the inlet, beaver dams, manmade barriers, etc.; Figure 40 a-c).



Figure 40a.–Photograph of an upstream beaver dam.

-continued-



Figure 40b.–Photograph of a nearby water control structure.



Figure 40c.–Photograph of a passage barrier downstream of culvert.

Figure 40.–Sample photographs of conditions that may be negatively affecting fish passage.

Take as many photographs as needed to convey site conditions. Photographs taken from different angles and distances can better help illustrate site conditions, local features, and potential problems.

## SITE SKETCH

The site sketch is recorded in the field notebook (Figure 41).

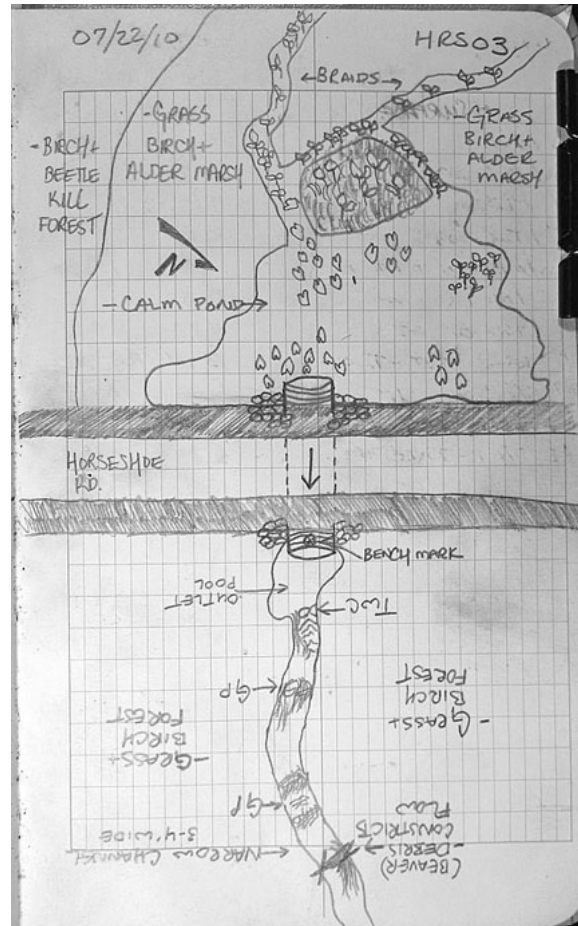


Figure 41.-Sample site sketch.

The site sketch should include all notable stream and site features, such as pools, glides, runs, rapids, gravel bars, log jams, and surrounding vegetation. The site sketch should also include the date and Survey ID at the top of the page, along with the road name, a north arrow, the angle of skew of the culvert and road, the direction of flow, the location of the temporary benchmark, nearby buildings, identifying road signs, beaver dams, ponds, fences, etc.

## LONGITUDINAL PROFILE

To assess culverts, we take a longitudinal section of the stream through the reach that crosses the road (Figure 42). The length of the longitudinal profile depends on the conditions at the site but is typically at least 100' and includes any reaches of the stream that are obviously influenced by the road crossing. Where a stream gradient is to be calculated, it must be done outside the influence of the culvert on the stream; typically, a separate profile is surveyed up or downstream of the site.

In addition to being used to create a longitudinal profile, the elevations calculated from the survey are used to calculate 2 of the 3 critical values for the site evaluation: culvert gradient and outfall height (Figures 43 and 44). Elevations are also used to calculate water depth at outlet,

road fill depth, and elevations at the invert and tailwater control to determine whether the site is backwatered.

Survey data collected during the longitudinal profile is recorded in the notebook, as are the calculations made to determine culvert gradient and outfall height.

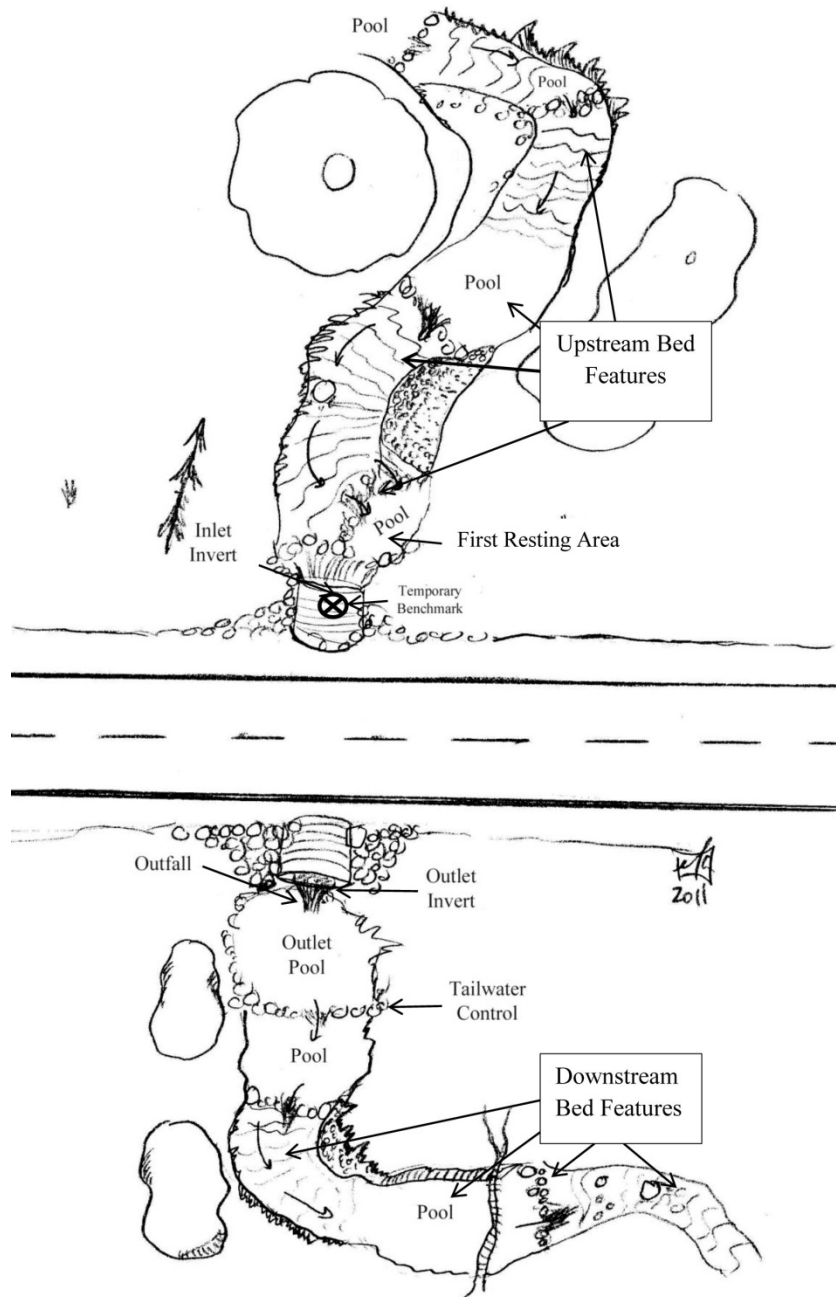


Figure 42.—Overhead view of typical extent of longitudinal profile during a fish passage assessment.



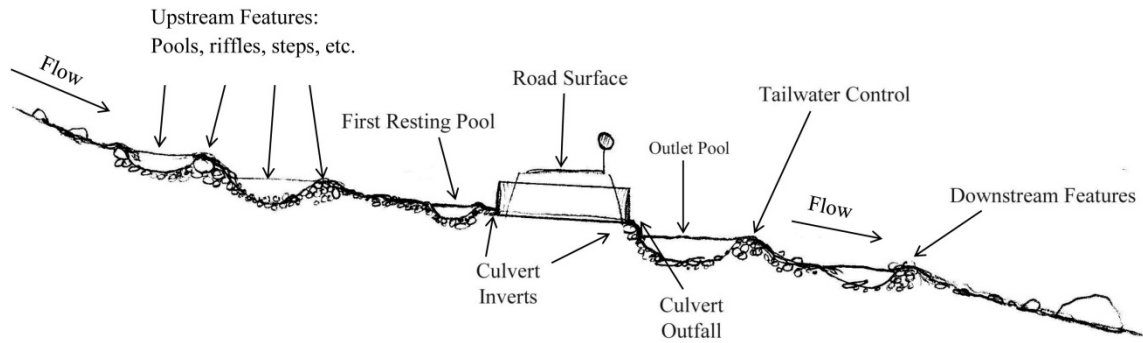


Figure 43.—Surveyed points longitudinal view.

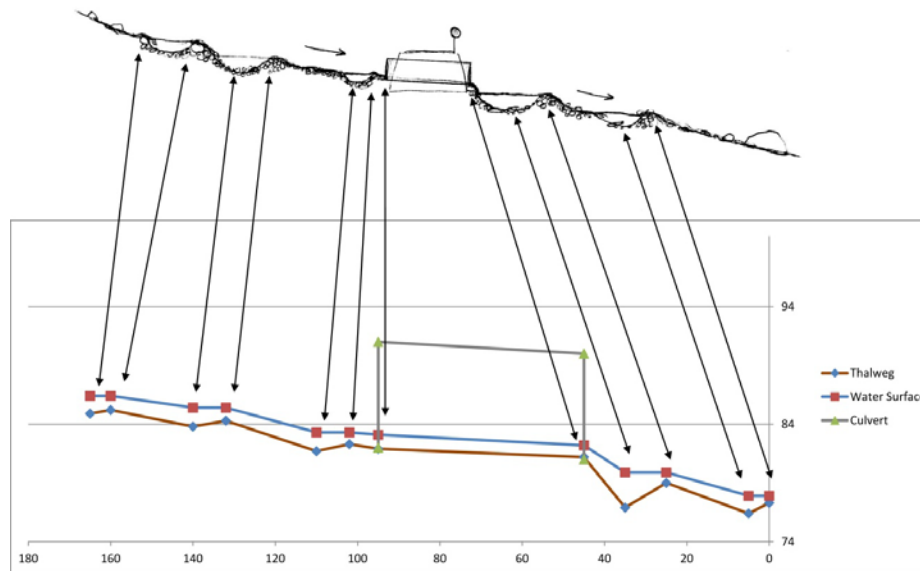


Figure 44.—Example of a longitudinal profile of a crossing.

### Survey Stations

Stations are the locations at which elevations are taken. Each station is assigned a curvilinear distance determined by running a measuring tape down the center of the channel. The tape can be secured using clamps, pins, or rocks. Once the tape has been set up, a temporary benchmark is established and the streambed and water surface are surveyed through the reach as shown in Figure 43. Survey data is recorded in the field notebook.

At each of these standard stations, measure the elevation of the streambed and the water surface (where applicable). Not all of these stations will be present at all sites, and some sites may require additional survey stations to capture the influence of the culvert on the streams. The profile should extend from the crossing up- and downstream far enough to capture any impacts the culvert has on the channel.

1. **Invert elevation at the inlet and outlet.** Place the base of the rod at the lowest point in the inlet and outlet. If the structure is a corrugated metal culvert, the base of the rod should be placed on top of the corrugations. If the culvert contains a small amount of streambed material, the material should be removed and the base of the rod placed directly on the bottom of the culvert. If the culvert is fully embedded or the invert cannot be readily exposed, the 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 are also recorded. In all cases, the water surface elevation at inlet and outlet should be recorded. To do this, hold the level rod so that the bottom of the rod is flush with the water surface at inlet and outlet.
2. **Top of culvert.** The elevation of the highest point of the inlet and outlet (recorded as top of culvert). This is measured on top of any corrugations.
3. **Gradient breaks within the culvert.** Where a gradient break is noted and the size of the culvert allows it, the elevation of gradient breaks within the structure should be measured. Record the elevation of the top and bottom of the break or, in the case of gradual gradient changes, at regular intervals throughout the length of the structure.
4. **Upstream channel.** Survey a longitudinal profile of the streambed and water surface surveyed upstream from the inlet to the point that provides resting habitat for fish moving upstream, usually a pool. This profile will include aprons or other extensions of the culvert inlet. This profile represents channel conditions that fish moving upstream will encounter as they exit the culvert.
5. **Headwater elevation.** Measure the headwater elevation by placing the bottom of the level rod 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.
6. **Road surface elevation.** This should be taken on top of the culvert near the edge of the road.
7. **Tailwater elevation.** The tailwater is the water surface immediately downstream of the culvert outlet. To determine the tailwater elevation, place the level rod 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.
8. **Downstream channel.** A longitudinal profile of the streambed and water surface is surveyed downstream from the culvert outlet. The number of stations required is determined by site conditions. At a minimum the downstream profile should include the tailwater pool depth and the bed elevation at the tailwater crest (tailwater control). Outlet pools, aprons, fish passage structures or other extensions of the culvert outlet should also be surveyed. 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 stream feature or gradient break (e.g., riffle or step) 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. 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.

9. **Channel gradient calculation for comparison to the gradient of embedded culverts.** Embedded culverts have some additional data collection requirements related to the need to compare the culvert and culvert streambed gradient to the natural channel gradient. 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 10x the OHW width, preferably 20x or greater, 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. Sites that connect ponds or sloughs and have a level water surface should have a stream slope entered as zero and not left blank.
10. **Channel gradient.** Wherever time and conditions allow, a channel gradient should be measured even at non-embedded culverts. Indicate the method used to collect channel gradient if it is different from the method used to survey the crossing (for example, a hand-held inclinometer).

After the survey is complete, the elevations are calculated by the crew leader and checked by the second crew member before leaving the site so any errors can be corrected or a new survey carried out if necessary. Once the data has been checked, this check is indicated by a tick mark or set of initials at the end of the long profile. All calculations should be recorded in the notebook with the work shown (Figure 45).



Figure 45.—Sample of survey data and calculation in a field notebook.

## Surveying a Step Pool Complex

When surveying the site of a constructed step pool complex, all the steps should be surveyed. If the culvert is large enough and conditions are safe, survey the steps inside the culvert as well (Figures 46 and 47). Note the width of each step and substrate type.

For analysis, step height is calculated similar to determining outfall height, and pool depths are calculated for evaluation of sufficient depth to initiate jumping by selected fish species. The difference in water surface elevation between each step is the step height. Pool depth is calculated by the difference between water surface elevation and max pool depth.

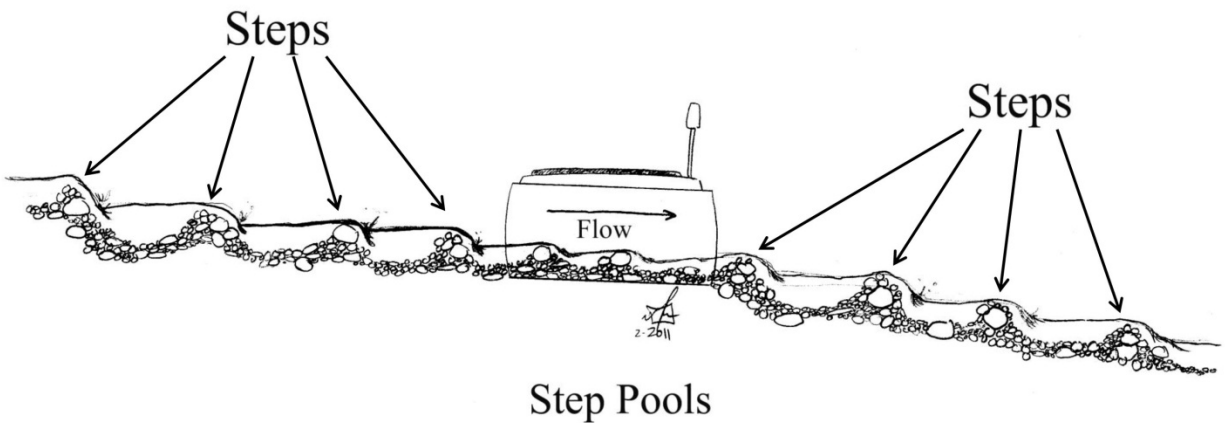


Figure 46.—Illustration showing grade control points in a manufactured step pool complex.

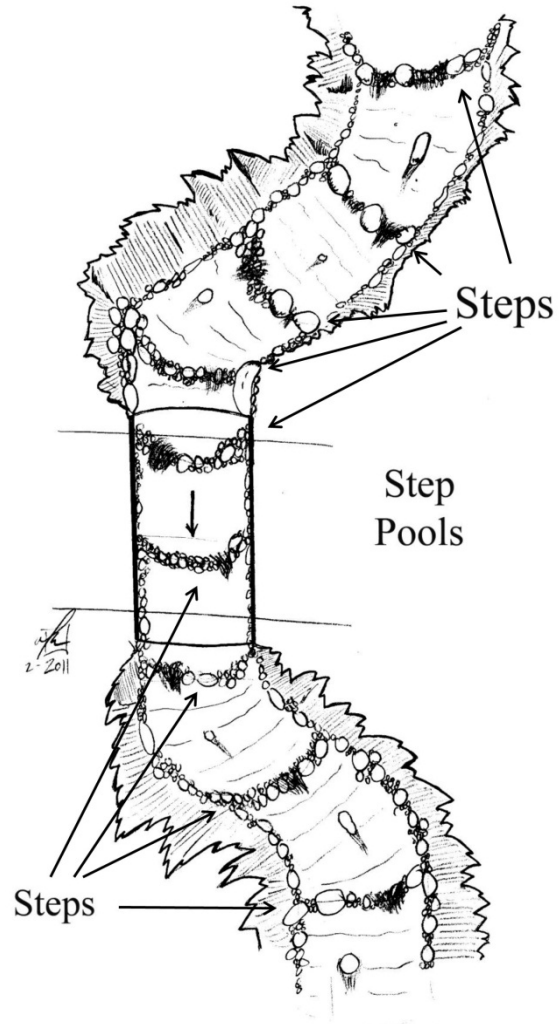


Figure 47.—Overhead view of a manufactured step pool complex.

## Calculating Outfall Height and Culvert Gradient

Outfall height (OH) is calculated from survey data collected as described above and is the distance from the water surface at outlet (OWS) to the outlet pool surface or tailwater surface (TWS).

$$OH = OWS - TWS$$

The outfall height for a freefall-into-pool outfall type is the outlet water surface elevation subtracted from the outlet pool surface elevation (Figure 48). When calculating outfall height for freefall-onto-riprap and cascade-over-riprap outfall types, take the difference between the outlet water surface elevation and the water surface elevation at the end of the riprap (Figure 49).

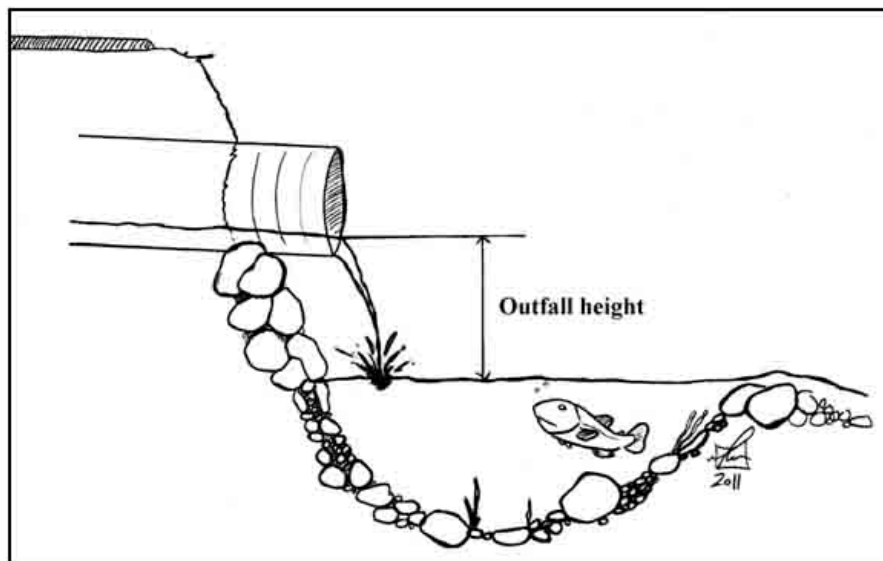


Figure 48.—Illustration showing where outfall height is measured on a freefall-into-pool outfall type.

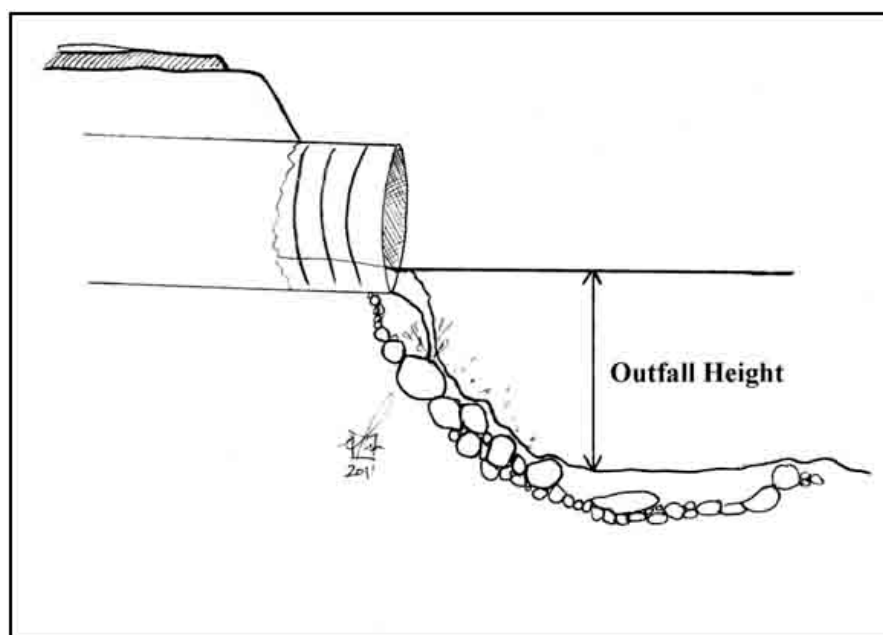


Figure 49.—Illustration showing the outfall height measurement for a freefall onto riprap and cascade over riprap.

Culvert gradient is calculated as the difference in elevations between inlet invert and outlet invert, divided by the length of the culvert and multiplied by 100. In the case of an embedded culvert, or a culvert with damaged inverts or sediment at inlet and/or outlet, use top of culvert elevations instead of invert elevations:

$$\frac{(Inlet\ elevation - Outlet\ elevation)}{Culvert\ length} * 100 = Pipe\ Gradient$$

Maximum gradients are calculated when there is a gradient break within a culvert. Max Gradient may also be calculated for aprons or artificial riffles where they are significantly steeper than the culvert itself and may impede fish passage.

## PHOTO-ONLY DATA SHEET

When conditions make it impossible to collect any data, the Photo-only Data Sheet is used to record the location and to assign a Survey ID to the site (Figure 50). If it is possible to take some measurements related to the culverts, basic data should be entered on the Culvert Data Sheet instead (see the section below on completing this data sheet). A good guideline is to record as much data as is safely possible.



<b>Fish Passage Survey Photo Site Only Form</b>			
<small>(Remember to fill out a section in the Survey Notebook for this site as well)</small>			
Survey ID:	<input type="text"/>	Date:	<input type="text"/>
Site ID:	<input type="text"/>	Time:	<input type="text"/>
Road Name:	<input type="text"/>	Book #	<input type="text"/>
Milepost	<input type="text"/>	Crew:	<input type="text"/>
Watershed	<input type="text"/>	Latitude	<input type="text"/>
Stream Name	<input type="text"/>	Longitude:	<input type="text"/>
<b>Photo Log</b>	<b>Comments:</b> (include why this is a photo site only: bridge, safety concern, ect.)		
1	<input type="text"/>		
2	<input type="text"/>		
3	<input type="text"/>		
4	<input type="text"/>		
5	<input type="text"/>		
6	<input type="text"/>		
7	<input type="text"/>		
8	<input type="text"/>		
9	<input type="text"/>		
10	<input type="text"/>		
	<p><small>*All Site ID's for Photo Sites should begin with the prefix PS to denote a photosite. ( Example:PSARD01)</small></p> <p><small>**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.</small></p>		

Figure 50.–Fish Passage Assessment Photo-only Data Sheet.

## FISH DATA SHEET

Each crew should have 2 or more minnow traps. Traps are baited with salmon roe and should be placed in pools or slow-moving water both upstream and downstream from the culvert. Traps should be set out upon arrival at a site, in order to maximize the time they are in the water.

On the Culvert Data Sheet, under the Fish Data section, note (1) the location (upstream or downstream), (2) the distance from the culvert, (3) the time that traps are placed in the water and the time they are taken out, and (4) soak time (Figures 51 and 52). Soak time is the time the traps are in the water, measured in hours and tenths of hours (i.e., an hour and a half is 1.5 hours; an hour and forty-five minutes is 1.75 hours).

The Fish Data Sheet is used to record data on any fish captured (Figure 51). It is not necessary to photograph every fish measured, but representative photographs of species and size classes should be taken (Figure 53). Log photographs on the photograph log in the field notebook, as discussed earlier. If adults are observed, record as much information as possible, such as number of fish observed, approximate size, and location, and take photographs and video if possible.

All captured salmonids should be identified to species and have their snout-fork length measurement taken to the nearest mm. All other fish should be identified, counted, and recorded. Once each fish is identified and measured, place it in a recovery bucket of fresh stream water. When all fish have recovered, release them at the trapping site.

**Fish Passage Culvert Assessment** Sheet 1 of       
**Fish Sampling Form**  
 Date 7/6/2010 Project EDS 10

Site ID	Trap #	Distance		Species	Size category	Number	Comments
		from culvert	US or DS				
1	B	100	DS	Coho	65	1	Healthy looking fish
2	B	100	T	Coho	70	1	
3	B	100	DS	Coho	80	1	
4							
5							
6							
7							
8							
9							
10							
11							
12							
13							
14							
15							
16							
17							
18							
19							

Figure 51.–Fish Data Sheet.



Fish data:	Sheet #	Line #s	Trap	Loc/Dist	Time In	Time out	Soak Time
	1	1-3	A	0/20'	1600	1730	1.5
			B	2/100'	1600	1735	1.5

Notes: 3 Fish Caught on D/S Trap

Figure 52.—Example of the Fish Data Sheet and notes section of the Culvert Data Sheet.

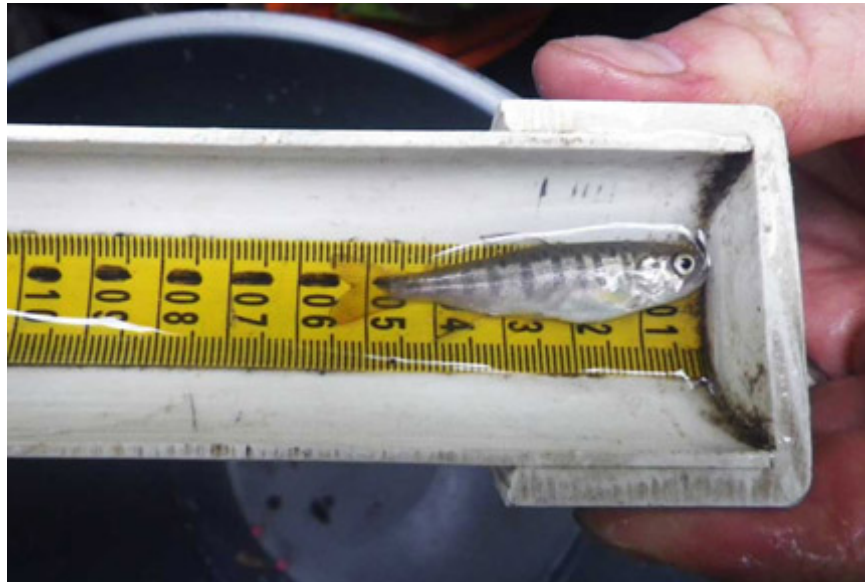


Figure 53.—Representative photograph showing the species and size class of fish caught at a culvert site.

## SECTION THREE: RATING

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After completing the assessment and calculating the gradient, outfall height, and constriction ratio, the culvert can be rated as Red, Gray, or Green with relation to fish passage. This is recorded on the Culvert Data Sheet. Determine the structure type and then use the three Critical Values to locate the culvert in the decision matrix (Table 7). At sites with more than one culvert, culverts are rated both individually and as part of the site as a whole.

Where factors other than the Critical Values affect fish passage at the site (e.g., a beaver or debris grate that is permanently affixed to the culvert that fish cannot swim through), a site can be field-rated as Red or Gray. All ratings are reviewed by program staff using photographs and notes, so collect thorough documentation. If there is not enough information to assign any kind of rating, the “Black” rating is used.

While rating the culvert, remember to fill in all of the applicable Site Codes (Figure 54).

**Site Classification (Red/Gray/Green)** RED

(Complete all applicable sections of this form before leaving survey site!)

Site Codes	1	2	3	4	5	6
from table	LRZ	CHZ	GADR	MP	CG	BV

<b>Resurvey? (Y/N)</b>	N	Old Survey ID (if known) _____
<b>Backwatered? (Y/N)</b>	N	Step Pools <input type="checkbox"/> Baffles <input type="checkbox"/> Tidal <input type="checkbox"/>

Figure 54.—Site classification and codes.

Remember that more information is always better. Many crossings will only be assessed for fish passage once and revisiting the site may be difficult, especially in remote areas. At some sites the crew will not be able to complete all sections of the Culvert Data Sheet due to safety concerns, high water, culvert damage, or other factors. In these cases, the crew should take good notes and explain why some information could not be collected. If conditions at a site do not allow for even the most basic information to be collected, take photographs, draw a site sketch, and collect location information.

Table 7.–Fish passage decision matrix.

	Structure Type	Green <i>Conditions may be adequate to pass juvenile fish</i>	Gray <i>Conditions unlikely to pass juvenile fish; additional analysis required</i>	Red <i>Conditions assumed inadequate to pass juvenile fish; additional analysis required</i>
1	Bottomless pipe arch, embedded pipe arch, CMP or box culvert or other embedded structure that functions in a similar fashion.	Installed at channel gradient (+/- 1% gradient), AND construction ratio greater than or equal to 0.75 OR fully backwatered	Structure not installed at channel gradient (+/- 1%), OR construction ratio of 0.5 to 0.75	Culvert span to OHW width ratio less than 0.5
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 construction 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 construction ratio of 0.5 to 0.75	Culvert gradient greater than 2.0%, OR outfall hgt. greater than 4 inches, OR construction ratio less than 0.5
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 construction 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 construction width ratio of 0.5 to 0.75	Culvert gradient greater than 2.0%, OR outfall hgt. greater than 4 inches, OR construction ratio less than 0.5
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 construction ratio greater than 0.75 OR fully backwatered	Culvert gradient 0.5 to 1.0%, OR less than or equal to 4-inch outfall hgt., OR construction width ratio of 0.5 to 0.75	Culvert gradient greater than 1.0%, OR outfall hgt. greater than 4 inches, OR construction ratio less than 0.5.
5	Non-embedded box culverts, tidally influenced culverts, culverts with non-standard configurations or materials, culverts with baffles or downstream weirs or step pools, fish ladders, bridges with aprons, and 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.
6	Multiple Structure Installations	Individual culverts all classified as Green as above	Individual culverts all classified as Gray or as some mix of Gray or Red as above.	Individual culverts all classified as Red as above.

## GLOSSARY

Anadromous Waters Catalog: *The Catalog of Waters Important for the Spawning, Rearing or Migration of Anadromous Fishes* specifies which Alaskan streams, rivers and lakes are important to anadromous fish species and therefore afforded protection under AS 16.05.871. Water bodies that are not “specified” within the Catalog are not afforded that protection. To be protected under AS 16.05.871, water bodies must be documented as supporting some life function of an anadromous fish species (salmon, trout, char, whitefish, sturgeon, etc.).

Approach Angle: The angle at which the stream flows into the culvert inlet.

Apron: A length of non-erosive material designed to prevent scour holes developing at the outlet ends of culverts, outlet pipes, grade stabilization structures, and other water-control devices.

Arch Culvert: Corrugated steel pipe formed in an arch shape that spans the stream and sits on footers of concrete, bedrock, or wood. A bottomless arch culvert is built across the natural streambed.

Azimuth: A horizontal angle measured clockwise from any fixed reference plane or easily established base direction line.

Bankfull Flow: A condition in which flow completely fills the stream channel to the top of the bank but does not spill over into the floodplain.

Baffle: Structures, usually metal plates, installed inside a culvert to deflect and/or slow the flow of water to aid upstream fish passage.

Bedload: Sediment moving on or near the streambed and frequently in contact with it.

Benchmark: A marked point of known elevation from which other elevations may be established.

Box Culvert: An enclosed culvert, mainly rectangular in cross-section, typically made of corrugated steel or aluminum (wood or concrete box culverts are also found).

Channel: A natural or artificial waterway of perceptible extent that periodically or continuously contains moving water. It has a definite bed and banks, which serve to confine the water.

Channelization: Straightening of a stream or the dredging of a new channel to which the stream is diverted.

Culvert: A closed conduit used for the passage of surface water under or through a road or other embankment.

Diameter: Inside diameter, measured between inside crests of corrugations.

Drainage Area: Total land area draining to any point in a stream, as measured on a map, aerial photograph, or other horizontal plane. Also called catchment area, watershed, and basin.

Embedded Culvert: Any culvert that has substrate throughout its length, typically with an invert lower than the streambed elevation. Embedded culverts include geomorphic, stream simulation, and other types of embedment design methodologies or design standards to meet fish passage criteria.

Fish Migration: The movement of individual fish and/or fish populations for any purpose, including feeding, spawning, etc.

## **GLOSSARY (Continued)**

**Flood:** Any flow that exceeds the bankfull capacity of a stream or channel and flows out on the floodplain; greater-than-bankfull discharge.

**Floodplain:** Any flat or nearly flat lowland that borders a stream and is covered by its waters at flood stage. Land immediately adjoining a stream that is inundated when the discharge exceeds the conveyance of the normal channel. The channel proper and the areas adjoining the channel which have been or hereafter may be covered by the regulatory or 100-year flood. Any normally dry land area that is susceptible to being inundated by water from any natural source.

**Ford:** A road crossing a stream where a hard causeway is provided or naturally occurs in the bed of the stream.

**Fry:** Juvenile salmon and trout in their first few months of life.

**Gabion:** A patented woven or welded wire basket filled with rocks of such a size that they do not pass through the openings in the basket. Individual baskets are stacked in place like building blocks and filled with rock to form erosion resistant structures.

**Glide:** A stream facet feature that is commonly indicated by smooth, relatively fast-flowing water and is the transition zone of a pool to a riffle as water moves downstream. Stretch of stream that typically separates pools from riffles. The stream bed of a glide has an adverse slope.

**Gradient (slope):** The rate of rise or fall of a slope, expressed as a percentage or ratio as determined by a change in elevation to the length.

**Head of riffle:** The upstream end of a riffle and downstream end of a glide.

**Headwall:** A retaining wall located at either the inlet or outlet of a culvert.

**Headwater:** The height of water at the inlet of a culvert.

**Headwater Elevation:** The water surface elevation upstream from a culvert entrance invert, typically measured relative to the benchmark.

**Hydraulic Capacity:** The effective carrying ability of a drainage structure. Measured as volume per time period.

**Hydraulic Unit Code (HUC):** A geographic area representing part of all of a surface drainage basin, a combination of drainage basins, or a distinct hydrologic feature.

**Inlet:** Point where water enters a culvert.

**Invert:** The lowest internal point of any cross section in a culvert.

**Level 1 Culvert Assessment:** Rapid assessments based on physical measurements of the culvert and stream channel and focused on juvenile salmonid fish passage. The culvert is assessed for type, slope, outfall height, constriction, and other physical parameters and then classified as green, gray, or red using a decision matrix.

**Longitudinal Profile:** A survey taken down the length of a stream that is used to illustrate the gradient and other features of that stream.

## **GLOSSARY (Continued)**

**Ordinary High Water:** This is the line between upland and bottomland that persists through successive changes in water levels, below which the presence of water is so common or recurrent that the character of the soil and vegetation is markedly different from the upland.

**Outfall height:** The difference between the culvert outlet water surface and the tailwater surface when a perch exists at a culvert's outlet.

**Outfall types:** The conditions that exist at the outlet of a culvert as water exits.

**Outlet:** Point of culvert at which water exits the structure after passing through a structure.

**Perch:** The development of a fall or cascade at a culvert outlet due to the erosion of the stream channel downstream from a culvert barrel, bridge, apron, or ford.

**Pipe Arch:** A corrugated metal pipe that is shaped so that it is wider than it is tall with the widest part being located near the bottom of the culvert.

**Pool:** Deeper stream feature characterized by still or slow-moving water and a smooth surface. Pools can typically be 2-3 times the depth of a riffle.

**Resident Fish:** Fish that spend their entire life cycle in freshwater. In Alaska, resident fish include landlocked anadromous fish (e.g., kokanee and coho), as well as traditionally defined resident fish species such as arctic grayling or rainbow trout.

**Riffle:** Stream feature characterized by shallow, fast-moving water broken by the presence of rocks and boulders. Typically the steepest part of a stream.

**Rise:** The maximum vertical height inside a culvert, usually measured at the centerline.

**Roughness:** A measure of the friction exerted on the moving water by the channel bed and banks, as well as other elements such as vegetation and woody debris.

**Run:** Stream feature characterized by fast-moving water that is not broken by the presence of rocks or boulders and is the transition zone of a riffle to a pool. A run deeper than a riffle will often have a well-defined thalweg.

**Rust Line:** A well-defined line separating rusted and unrusted metal inside the barrel of a metal culvert that marks the extent of ordinary high water.

**Salmonid:** Fish belonging to the family Salmonidae, such as salmon and trout.

**Scour:** Channel degradation, typically at the culvert outlet resulting from erosive velocities.

**Skew:** The angle formed by the intersection of the line normal to the centerline of the road with the centerline of a culvert.

**Snout-fork measurement:** The length from the tip of the snout to the end of the middle caudal fin rays. Also known as Fork Length.

**Soak Time:** The amount of time a baited trap is left in the water to capture fish.

**Streamflow:** The rate at which water passes a given point in a stream, usually expressed in cubic feet per second (cfs).

**Stream gradient:** The overall gradient of the stream through a reach.

## **GLOSSARY (Continued)**

**Stream Stage:** Stage is the water level above some arbitrary point in the river.

**Structural Multi-Plate:** Multi-plate or structural plate culverts assembled on a treated timber or concrete foundation. Because of their size (normally in excess of 2 m in diameter) and the fact that they are placed on a foundation, they are normally assembled on site. A series of interlocking steel plates are bolted together to make the required shape and length.

**Substrate:** Bed material in a stream channel or culvert.

**Tailwater Control (tailcrest):** A geomorphic feature that controls the elevation of the tailwater, which is the water immediately downstream of the culvert.

**Tailwater Depth:** The depth of water immediately downstream from a culvert, measured from the culvert outlet invert.

**Tailwater Elevation:** The water surface elevation at the downstream side of a hydraulic structure (i.e., culvert or bridge), usually measured from a datum.

**Thalweg:** The deepest continuous channel in a stream, generally marking the line of fastest flow.

**Trash Rack:** A structural device used to prevent debris from entering a culvert or other hydraulic structure.

**Water Surface Profile:** A profile plot of water surface elevation through a culvert or open channel.

**Watershed:** The region drained by or contributing water to a specific point that could be along a stream, lake or other stormwater facilities.

**Weir:** Small dam in a stream that causes water to back up behind it, and flow over or through it. (a) A notch or depression in a levee, dam, embankment, or other barrier across or bordering a stream, through which the flow of water is measured or regulated. (b) A barrier constructed across a stream to divert fish into a trap. (c) A dam (usually small) in a stream to raise the water level or divert its flow.

**Wingwall:** The retaining wall that provides a transition from the culvert headwall to the channel.