Restoration Evaluation—Fish Passage

Final Report

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Summary

Fish passage assessment methods, including physical and biotic measures, were applied at 13 crossing locations located within the Matanuska-Susitna Borough. Nine of the sites were at locations of previous fish passage restoration. Two levels of fish passage assessment methods were used at each location. Level 1 assessment methods included measures of channel and culvert physical characteristics to evaluate the influence of crossing structures on stream channel geometry and slope. These measures were accompanied by fish surveys and short-term fish trapping. Level 2 assessment methods included more detailed stream channel and culvert characteristics in order to assess passage using the FishXing V3 model. We measured stream discharge, water velocity within the culvert and at the culvert inlet and outlet, and flow times using dissolved solutes. Level 2 biotic measure included summation removal estimates of fish abundance and community composition above and below the crossing structures.

We concluded that Level 1 measures used for comparisons between channel and stream crossing physical characteristics combined with direct measures of water velocity and flow times was the best method for evaluating fish passage. Physical measures allowed for the identification of those locations where stream characteristics were not modified to construct the stream crossing and unaltered fish passage could be assumed. Comparisons between water velocities at the crossings with published values of target fish swimming speeds were used to evaluate those crossings where stream physical characteristics were modified. The FishXing program did not accurately model water velocity at the crossing sites. Water velocities within crossing structures using a velocity meter were closest to the maximum velocities obtained from flow times using dissolved solutes. Minimum water velocity based upon the flow time of dissolved solutes may be a better measure of velocities used by juvenile salmon. Juvenile fish likely use low velocity areas for resting and migrating through potential velocity barriers. Biotic measures comparing the abundance of fish above and below the crossing supported the physical evaluation in some cases.

Three crossing locations were determined to be barriers to juvenile fish migration, two un-restored and one a site of previous restoration efforts. We found differences in the number of juvenile coho salmon at two of these three sites. The lack of differences in fish abundance at one of the barrier sites likely was due either to the large number of young-of-the-year coho within the samples preventing us from capturing enough one-year-old fish, or due to minimal outmigration because of abundant upstream rearing habitat. Additional fish community sampling at crossing locations is necessary to refine sampling methods and evaluate the usefulness of biotic measures in assessments and restoration prioritization.

Introduction

Roads, railroads, and other transportation structures often cause barriers to fish migration at stream crossing locations. Stream crossing structures affect the movement of fish and other aquatic life by altering the stream physical characteristics. There are multiple different types of stream crossing structures from fords to bridges. Stream channels are often straightened or narrowed or both to accommodate a certain sized bridge or culvert. Reducing channel length by straightening can increase the energy slope and water velocities. Similarly, narrowing the channel can increase water velocity and depth. Increases in water velocity and depth can result in a scour pool downstream of the crossing structure where channel materials are no longer held in place by culvert walls or bridge abutments. The lowering of the stream bed at scour pools can create a height difference between culvert outlets and the outlet pool surface. Modification of stream substrate during construction or replaced with culvert material can alter water velocities at the crossing. Alternately, extremely wide crossing structures, particularly those with large porous substrate can reduce water depths or cause subsurface water flow. All of these conditions can create barriers to fish passage.

The construction of migration barriers can have significant effects to fish production as access to large areas of spawning or rearing habitat can be eliminated or reduced. For this reason considerable work has been done to assess fish passage and restore migration barriers. Fish passage assessment has focused on comparisons between laboratory measures of fish swimming ability and the physical conditions at crossing locations, primarily water velocity and depth. Fish swimming ability, both prolonged and burst, has been assessed under varying conditions of velocity, buoyant forces, and water temperature (summaries and equations within the FishXing V3 2006) which affect physical water properties and fish physiology. Water velocity can be measured at multiple longitudinal and vertical locations and at crossing locations and compared to fish swimming ability along with leap heights at culvert outlets to evaluate fish passage. However, multiple site visits are necessary to determine how water velocity and leap heights change under variable flow conditions. Velocity measures can be augmented with measures of those channel physical characteristics at reference and crossing locations that have an influence on water velocity and fish passage. Physical measures generally include channel width, slope, substrate, and perch height. The difference in physical conditions can then be used to predict fish passage (Rich 2003). Stream and crossing physical characteristics can also be used to mathematically model water velocity and depth at crossing structures under variable flow conditions (FishXing). The amount of information necessary to obtain the input parameters for fish passage models is much greater than direct velocity measures and simple measures of channel and culvert geometry. Therefore, the benefits of more detailed measures must be balanced against the costs associated with data collection and analyses.

The accurate assessment of fish passage is the ultimate objective of any evaluation methodology. That is, the difference between passage predicted by the assessment method and actual passage of the target fish species. Actual fish passage, however, is rarely known, but can be assumed in some situations. Unrestricted fish passage can be

assumed when the crossing structure does not modify stream channel physical characteristics. The presence or absence of anadromous Pacific salmon provides another measure of fish passage barriers. For those situations where there is complete blockage to adult and juvenile salmon movement, Pacific salmon will be absent upstream of the crossing structure. These two conditions, unhindered fish passage, and complete blockages can be used to test assessment methods. Fish passage models, like FishXing, are used to calculate water velocities within a crossing structure under certain flow conditions. Accurately determining the ability of a fish to pass through a culvert or other crossing depends then, in part, on accurately predicting water velocities. Different methods also can be compared to see if they provide the same results.

While considerable work has been done modeling fish passage based upon stream physical characteristics and fish swimming ability, we are not aware of any work comparing the fish community composition above and below crossing structures as a method for evaluating fish passage or augmenting model derived results. The life history of Pacific salmon provides a biological method of fish passage assessment. Coho and Chinook salmon migrate from the ocean to spawning locations in streams and rivers where juveniles may spend up to 3 or more years rearing, prior to outmigrating to the ocean. Juvenile Chinook and coho salmon have been shown to move extensively from spawning locations during their fresh water residency (Irvine and Johnston 1992, Kahler et al. 2001); however, our understanding of juvenile salmon movement is limited. Pacific salmon are absent upstream from adult migration barriers. Pacific salmon also will be absent from stream reaches upstream of barriers to juvenile fish movement when these reaches do not contain spawning habitat. There also may be partial barriers to adult salmon migration due to the variability in fish swimming ability or stream physical conditions at different flows. Assessment of these types of barriers should be possible by comparing fish numbers and sizes above and below crossings. There should also be differences in the juvenile fish abundance or size distribution above and below complete or partial juvenile barriers as fish disperse to rearing and overwintering locations.

The objective of this study was to evaluate fish passage, compare fish passage assessment methods, and to determine method accuracy at calculating model results and fish migration. In addition, we qualitatively and quantitatively compared the fish community above and below crossing structures to determine if biotic measures could augment physical measures.

Methods

We distinguished passage assessment methods by assigning them to two different levels based upon the amount of information and time necessary for data collection and analyses. Level 1 provided simple field measurements of channel and culvert physical characteristics and qualitative surveys for fish presence or absence above and below crossings similar to initial screening used by the Alaska Department of Fish and Game (Rich 2003 as cited by Karle 2005). Physical measures included channel width, slope, substrate particle size, culvert width, culvert slope, culvert substrate, and culvert perch height. Channel width was measured at 5 locations upstream and downstream from the crossing locations above or below any obvious area of culvert influence. Widths were

measures on straight channel sections, at ordinary high water (vegetation line), and separated longitudinally by approximately 3 channel widths. Water surface and bed slopes were measured using a hand level and leveling rod. We measured bed and water surface heights between two riffles and the distance between riffles. Substrate particle size was determined qualitatively. Maximum culvert widths and culvert width at the rust line were measured. Culvert slope was determined from the length of the pipe and the height at the inlet and outlet inverts. Culvert perch height was determined as the distance from the height of the water surface at the culvert outlet, and outlet pool. The presence or absence of adult or juvenile fish was determined through visually surveys of the stream channel and short-term fish trapping upstream and downstream from the crossing. Traps (one to three) were fished for approximately 2 hours.

We used ratios of culvert width to stream width, culvert slope to stream slope, presence of substrate within the culvert, and culvert perch height to determine whether the culvert allowed unimpeded fish passage. If culvert width to stream width was greater than 0.9, culvert slope was within 1% or less than the stream slope, there was substrate within the culvert, and the culvert perch height was less than or equal to 0.1 m, then the pipe was considered to allow unhindered fish passage. We did not consider crossings that did not meet these criteria as blockages, necessarily, but could not categorize them as allowing free passage. That is, sites that did not simulate stream physical conditions were not assumed to be fish migration barriers. The presence of anadromous salmon adults or juveniles was an indication of some upstream spawning or the ability of some juvenile fish to pass through the culverts, and the crossing was categorized as a partial blockage.

Level 2 evaluations provide more quantitative physical and biological data. Level 2 physical evaluations included the measurements necessary to use the FishXing V3 model. At this level, we surveyed the culvert inlet and outlet heights using a laser level and leveling rod. The channel cross-section at the outlet control was surveyed as well as the outlet pool bottom and water surface height. Channel slope downstream from the culvert was measured using the laser level and leveling rod. Stream discharge was measured as the sum of individual component flows (Rantz et al. 1982). Water velocity at the culvert inlet and outlet were measured using a Price AA pygmy meter. Water velocity was measured within the culvert using the Price meter if the pipe was large enough, or using a General Oceanics flow meter suspended from the end of a leveling rod extended into the culvert 3 to 4 meters. We also measured water velocity by injecting a bolus of concentrated MgCl solution into the upstream end of the culvert and timing the passage of the solution by measuring conductivity and time since injection, at 5 second intervals, at the culvert outlet. Maximum velocity was the time at which specific conductivity began to increase at the culvert outlet, mean velocity was the peak in specific conductivity, and minimum velocity was the time when conductivity returned to pre-injection concentrations.

The physical characteristics were used to estimate water velocity within the culvert using the FishXing V3 model. Fish passage design flows were selected to bracket measured stream discharge. Target fish species were 55 mm coho salmon for all locations. We

also used adult coho salmon for those locations where physical conditions suggested a potential adult barrier.

Intensive fish trapping was conducted upstream and downstream from the crossing locations to obtain summation removal population estimates (Bryant 2000). Fish were captured and removed from the stream in four sets of 9 minnow traps fished for 90 minute intervals. All fish from each trapping set were retained in separate buckets until all four trapping sets were complete. Nine traps were baited with commercially cured salmon roe and placed within slow moving pool habitats within approximately 20 to 30-m sampling sections. If the total number of fish captured in the first set either upstream or downstream was less than 5 fish, sampling was terminated for that location. Captured fish from each set were identified and measured to fork length. After all trapping sets were completed; fish from each set were identified, counted, and measured to fork length and returned to the stream. Fish data were separated into two different size classes based upon fork length. Fish less that 55 mm were considered young-of-the-year (YOY), and fish greater than 55 mm were considered at least 1 year old. The 55 mm size distinction also was used because this is the fish length used to evaluate passage using the FishXing model.

Table 1. Stream crossing locations and restoration status.

Crossing Name	Stream Name	Road Location	Latitude	Longitude	Restored (Date)
Cottonwood Slough at Surrey	Cottonwood Slough	Surrey Road	61 31' 23.7"	149 31' 24.9"	No
Government Creek	Government Creek	Edgerton Park	61 41' 35.2"	149 18' 27.3"	No
Colter Creek at North Sitze Road	Colter Creek	North Sitze Road	61 39' 12.7"	149 29' 55.6"	No
Wasilla Creek at Lower Road	Wasilla Creek	Lower Road	61 34' 37.3"	149 16' 55.4"	No
Cottonwood Creek at Settlement	Cottonwood Creek	Settlement Avenue	61.6324	149.24189	Yes (2004)
Crocker Creek Lower	Crocker Creek	Mile 2 Settlers Bay (2nd crossing)	61 30' 2.9"	149 36' 59.6"	Yes*(2005)
Lucy Creek 1 (upstream)	Lucy Creek	Cardif at Bromley	61 31' 32"	149 34' 9"	Yes (2004)
Lucy Creek 2	Lucy Creek	Cardif Lane	61 31' 25.8"	149 34' 8.9"	Yes (2004)
Lucy Creek 3	Lucy Creek	Lupine	61 31' 21.5"	149 34' 10"	Yes (2004)
Lucy Creek 4 (downstream)	Lucy Creek	Larkspur	61 31' 19.6"	149 34' 9.3"	Yes (2004)
Meadow Creek at Meadow Lakes	Little Meadow Creek	Meadow Lakes Loop	61 35' 31.3"	149 39' 49.5"	Yes (2004)
Papoose 1	Crooked Lake Creek	Mile 1 Papoose Drive	61 30' 50.3"	150 4' 2.7"	Yes (2004)
Papoose 2	Crooked Lake Creek	Mile 2 Papoose Drive	61 30' 54.6"	150 5' 11.1"	Yes (2004)

* Culvert retrofitted with outlet control structure not restored by replacement.

The fish passage evaluation methodology was implemented at 13 crossing locations in 2006 and 2007 (Table 1). Nine of these sites were locations of previous fish passage restoration projects. Level 1 data collection was conducted at all sites in September and October of 2006 and July of 2007. Crossing site locations and descriptions are following. Level 2 physical measures were conducted at all 13 sites in June of 2007, and juvenile fish were captured in baited minnow traps on July 11 through July 20, 2007.

Results

Level 1 Physical and Biotic Assessment

Stream and culvert physical characteristics are shown in Table 2 and fish passage criteria are shown in Table 3. For the majority of the sites, there was no difference in the evaluation when we used upstream or downstream channel widths. The only exception to this was at the upper Crooked Lake Creek site, where upstream channel width was much smaller than downstream. However, the stream is primarily within ponds upstream of the crossing and the upstream width was based upon one measurement as the channel flowed between ponds. We considered the downstream channel widths to be more representative. The data in Table 2 are based upon maximum culvert width to stream width. Using culvert width at ordinary high water would have altered the results for some sites.

For channel slope we used bed slope rather that water surface slope. We used bed slope because of the difficulty in measuring the water surface within culverts. Channel slope often varied from upstream to downstream. In this case we used the maximum channel slope for comparisons. We based this on the assumption that if fish can navigate the steeper channel slope they should be able to navigate the steeper culvert, if all other characteristics are equal. The Lucy 2 culvert is located on a section of stream with very shallow slopes, and while the bed slope within the culvert was greater, water was backed up into the culvert and water surface slope appeared to be close to 0.

Based upon the Level 1 physical measures, only five crossings could be assumed to allow unhindered fish passage; Cottonwood Creek at Settlement Avenue and the culverts along Lucy Creek. The Cottonwood Creek crossing at Settlement Avenue is located at the upper end of the drainage. There are no additional upstream crossings. There are an estimated ten additional culvert crossings downstream. This channel of Cottonwood Creek provides unique physical characteristics not found elsewhere within the drainage (Davis and Davis 2006). The current crossing is over a bottomless arch culvert that replaced a metal pipe in the early spring of 2004. Adult and juvenile coho salmon and resident Dolly Varden have been observed above and below the culvert crossing. The physical characteristics of the culverts along Lucy Creek did not differ from the channel characteristics with one exception. The culverts and stream channel were reconstructed in 2005. Channel slope within the constructed sections of Lucy Creek is quite steep, up to 12%. We saw one Dolly Varden upstream of culvert 3 and fish were captured below culvert 4 and upstream of culvert 3.

Table 2. Stream and culvert physical characteristics from Level 1 data collection. Channel substrate is classified as sand or silt (s), gravel (g), or cobble (c).

	Channel Width (m)		Channel Slope		Channel Substrate		Culvert				
	Up	Down	Up	Down	Up	Down	W (m)	OHW (m)	Slope	Subs	Perch (m)
Colter Creek	3.48	4.08	0.009	0.040	g/c	g/c	1.5	1.4	0.050	None	None
Cottonwood Creek	2.94	3.28	0.001	0.014	S	c	3.0	3.0	0.009	c	None
Cottonwood Slough	Pond	1.28	0.000	0.002	S	s	1.2	0.6	0.009	None	None
Crocker Creek	6.98	6.50	0.003	0.030	s	g/c	1.2	1.0	0.007	None	0.12
Crooked Lake Creek (lower)	1.76	1.58	0.019	0.020	c	c	1.2	1.2	0.010	g	None
Crooked Lake Creek (upper)	1.05	2.21	0.000	0.001	g/c	g/c	1.2	1.2	0.040	g/c	None
Government Creek	5.15		0.040	0.020	c	c	1.6	1.2	0.030	None	0.4
Little Meadow Creek	2.57	2.74	0.012	0.008	c	c	3.7	3.7	0.030	c	None
Lucy Creek 1 (upstream)	1.50	1.03	0.007	0.120	s/g/c	s/g/c	1.3	1.3	0.030	g/c	None
Lucy Creek 2*	1.08	1.40		0.006	s/g/c	s/g/c	1.3	1.3	0.015	g/c	None
Lucy Creek 3	1.40	0.80	0.006	0.030	s/g/c	c	1.3	1.3	0.017	c	None
Lucy Creek 4 (downstream)	0.80	1.70	0.030	0.050	c	c	1.3	1.3	0.010	c	None
Wasilla Creek	4.66	5.20	0.005	0.005	g/c	g/c	2.5	2.3	0.020	g/c	None

* water surface slope within culvert much less than bed slope due to backwater.

Table 3. Summary of comparison between culvert and stream physical characteristics. Characteristics that differ are indicated with an "X" and when the same are indicated with an "O". Sites without any differences were assumed to allow unhindered passage.

Culvert	Culvert to Average Stream Width < 0.9	Slope + 1% of Stream Slope	No Substrate within Culvert	Perched > 0.1 m
Colter Creek	X	X	X	O
Cottonwood Creek	O	O	O	O
Cottonwood Slough	O	X	X	O
Crocker Creek	X	O	X	X
Crooked Lake Creek (lower)	X	O	O	O
Crooked Lake Creek (upper)	X	X	O	O
Government Creek	X	O	X	X
Little Meadow Creek	O	X	O	O
Lucy Creek 1 (upstream)	O	O	O	O
Lucy Creek 2	O	O	O	O
Lucy Creek 3	O	O	O	O
Lucy Creek 4 (downstream)	O	O	O	O
Wasilla Creek	X	X	O	O

Four of the nine restored sites had physical characteristics at the crossing site that differed from stream reference conditions. At Crocker Creek, fish passage restoration was attempted through construction of an outlet control structure rather than culvert replacement. At both of the Crooked Lake Creek sites, culvert width was less than stream width. Culvert slope was over 1% steeper than channel slope at the lower Crooked Lake Creek and Little Meadow Creek sites. Changes in the physical characteristics at the crossing locations indicate that the crossing can influence water velocity and fish passage but can not be assumed to cause an adult or juvenile fish migration barrier.

Stream surveys and short-term fish trapping documented Pacific salmon or Dolly Varden upstream of all but the upper two crossings of Lucy Creek (Table 4). At Government Creek, and Crocker Creek adult salmon were holding in the culvert outlet pool. Some adult salmon were seen upstream of the crossing on Government Creek, but not on Crocker Creek. Adult salmon carcasses were seen upstream of the Colter Creek culvert. Based upon the fish surveys, none of the crossings could be considered complete blockages to fish migration.

Table 4. Presence (X) or absence (O) of adult and juvenile salmon from Level 1 biotic surveys.

	Upstream		Downstream		Notes
	Adult	Juv	Adult	Juv	
Colter Creek	X	X	X	X	Adult carcasses upstream.
Cottonwood Creek	X	X	X	X	
Cottonwood Slough	X	X	O	X	
Crocker Creek	O	X	X	X	Adults at culvert outlet
Crooked Lake Creek (lower)	O	X	O	X	
Crooked Lake Creek (upper)	O	X	O	X	Juvenile rainbow trout swam through culvert
Government Creek	X	X	X	X	
Little Meadow Creek	O	X	O	X	
Lucy Creek 1 (upstream)	O	O	O	O	
Lucy Creek 2	O	O	O	X	One Dolly Varden between 2 and 3
Lucy Creek 3	O	X	O	O	
Lucy Creek 4 (downstream)	O	O	O	X	
Wasilla Creek	X	X	X	X	

Level 2 Physical and Biotic Assessment

The physical channel and culvert measures, as well as data input into FishXing are shown in Appendix A. Fish passage assessment results using FishXing (version 3.0) are shown in Table 5. Model results determined that all sites except Meadow Creek were barriers to the passage of 60 mm juvenile coho salmon. Flows for low and high passage were selected to bracket flows measured on site (June 2007). Water levels during discharge measurements were below the upland vegetation line at all sites. Variations in stream flow did not affect model estimates of fish passage at sites which were barriers at the low passage flow. That is, these sites were barriers at all flows greater than the low passage

flow. Little Meadow Creek was estimated to be a barrier at all flows greater than 2.44 cfs.

Measures of velocities within the culverts using a velocity meter and solute flow times are shown in Table 6. Measured water velocities using a velocity meter were generally higher than water velocities based upon flow times. Measured velocities were most closely related to maximum flow time velocities. Maximum sustained swimming speed for a 60 mm coho salmon is near 1.0 ft/s (FishXing V3). Water velocity measured within the culvert using a velocity meter was greater than 1 ft/s at all sites except for Cottonwood Creek at Settlement Avenue (0.56 ft/s) and Little Meadow Creek (1.0 ft/s). However, using minimum flow time (maximum velocity), velocities within Cottonwood Creek remained below 1.0 ft/s while velocities within Little Meadow Creek exceeded 1.0 ft/s. Cottonwood Slough, Lucy Creek at Cardif, and both Crooked Lake Creek sites had maximum and average flow time velocities below 1.0 ft/s. Using maximum flow time (minimum velocities), 1.0 ft/s is exceeded at Crocker Creek, Colter Creek and presumably Government Creek.

FishXing did not accurately predict water velocity at most locations. FishXing V3 velocity accuracy is shown in Table 7. FishXing accurately (accuracy from 80 to 120%) predicted water velocities within the culvert at 6 of the 13 sites. FishXing was less accurate at the culvert inlet and outlet where accurate velocities were modeled at 3 and 2 of the crossings, respectively.

Table 5. Summary output from FishXing. All sites except Little Meadow Creek were evaluated as barriers to juvenile salmon migration. V is a velocity barrier, EB is exhausting during bursting speeds, and Leap is a barrier due to perch height. QLP and QHP are low and high passage flows, respectively.

Crossing Name	Culvert	Length	QLP	QHP	Barriers
Cottonwood Creek at Settlement	Cottonwood Creek	63.65 ft	4.5 cfs	10 cfs	V
Cottonwood Slough at Surrey	Cottonwood Slough	39.4 ft	1 cfs	3 cfs	V
Crocker Creek Lower	Crocker Creek	73.16 ft	3 cfs	8 cfs	V
Government Creek	Government Creek	49.2 ft	9 cfs	15 cfs	Leap; V
Lucy Creek 1	Lucy Creek	51 ft	1 cfs	3 cfs	EB
Lucy Creek 2	Lucy Creek	64 ft	1 cfs	3 cfs	EB
Lucy Creek 3	Lucy Creek	59.7 ft	1 cfs	3 cfs	EB
Lucy Creek 4	Lucy Creek	46 ft	1 cfs	3 cfs	EB
Meadow Creek at Meadow Lakes	Little Meadow Creek	69.55 ft	2 cfs	8 cfs	NONE
Papoose 1	Crooked Lake Creek	32.15 ft	.5 cfs	3 cfs	Depth; EB
Papoose 2	Crooked Lake Creek	48 ft	1 cfs	5 cfs	EB
N. Sitze Road	Colter Creek	33.46 ft	5 cfs	10 cfs	V
Wasilla Creek at Lower Road	Wasilla Creek	39.4 ft	14 cfs	20 cfs	V

Table 6. Culvert water velocities using a price pygmy meter and solute flow times. Inlet is the culvert inlet and Out is the culvert outlet.

			Measured Velocity (ft/s)			Flow Time Velocity (ft/s)		
Stream	**Road**	**Flow (cfs)**	**Inlet**	**Out**	**Mid**	**Max**	**Min**	**Ave**
Cottonwood Slough	Surrey Road	0.8	0.38	1.97	1.89	0.98	0.52	0.79
Government Creek	Edgerton Park	9.2	6.20	7.63	6.64	N/A	N/A	N/A
Colter Creek	N. Seitze Road	5.0	5.80	4.57	5.79	6.69	6.69	6.69
Wasilla Creek	Lower Road	14.0	2.62	1.35	1.42	N/A	N/A	N/A
Cottonwood Creek	Settlement Avenue	4.7	1.20	1.77	0.56	0.85	0.47	0.64
Crocker Creek	Settlers Bay	3.4	1.45	2.65	2.60	2.93	1.05	1.83
Lucy Creek 1	Cardif at Bromley	1.0	2.82	1.50	1.08	1.7	0.57	1.13
Lucy Creek 2	Cardif Lane	1.0	1.47	0.65	1.18	0.81	0.27	0.56
Lucy Creek 3	Lupine	1.0	3.34	2.94	2.27	1.49	0.60	1.09
Lucy Creek 4	Larkspur	1.0	0.95	1.42	2.32	1.85	0.62	1.16
Little Meadow Creek	Meadow Lakes Loop	2.8	2.17	1.17	1.00	1.54	0.73	1.07
Crooked Lake Creek	Papoose Drive Mile 1	0.5	1.45	0.70	2.10	0.80	0.23	0.46
Crooked Lake Creek	Papoose Drive Mile 2	1.3	1.88	0.79	1.36	0.64	0.25	0.38

Table 7. Percent accuracy (modeled value/measured value*100) of velocity estimates using FishXing. Accuracy between 80 and 120% are highlighted.

Stream	Road	Inlet	Outlet	Middle
Cottonwood Slough	Surrey Road	669	**118**	**97**
Government Creek	Edgerton Park	**112**	72	**83**
Colter Creek	N. Seitze Road	**117**	122	71
Wasilla Creek	Lower Road	56	248	**105**
Cottonwood Creek	Settlement Avenue	69	142	132
Crocker Creek	Settlers Bay	173	130	**87**
Lucy Creek 1	Cardif at Bromley	**102**	139	194
Lucy Creek 2	Cardif Lane	157	65	150
Lucy Creek 3	Lupine	63	32	72
Lucy Creek 4	Larkspur	217	**116**	72
Little Meadow Creek	Meadow Lakes Loop	73	43	**114**
Crooked Lake Creek	Papoose Drive Mile 1	162	27	**81**
Crooked Lake Creek	Papoose Drive Mile 2	387	75	254

Fish sampling results are shown in Table 8. We used the total catch data for comparisons. The 90% confidence interval for most sites was exceedingly large, the exceptions being Little Meadow Creek and Government Creek. Large confidence intervals were due to the inability to adequately deplete the fish population. The more intensive fish sampling provided additional information in the assessment of passage barriers. Differences in the catch of resident fish abundance or age classes of anadromous salmon were observed at Crocker Creek, Government Creek and Crooked Lake Creek.

Juvenile fish were abundant below the culvert at Crocker Creek, with 31 fish caught during the first trap set, containing coho salmon, sockeye salmon, and Dolly Varden. Only 5 fish were captured upstream of the crossing during the first trap set, and contained only larger coho salmon juveniles. These results suggest that the culvert presents a barrier to the migration of young-of-the year coho salmon, with limited or no upstream coho spawning. Dolly Varden were captured below the crossing but not upstream.

At Government Creek, there also were differences in the number of Dolly Varden and coho salmon caught above and below the stream crossing. Differences were greatest for Dolly Varden and one year old coho salmon. For coho salmon, these results support the qualitative and quantitative physical data and biotic observations. Water velocities of over 6 ft/s were measured in the Government Creek culvert which exceeds the maximum swimming velocity of juvenile coho salmon. However, adult coho were observed upstream of the crossing. Upstream coho salmon spawning explains the presence of juvenile fish upstream. Emigration explains the difference in numbers of YOY and to a greater extent one year old fish.

Table 8. Fish sampling results showing total capture and population estimates from summation removal.

	Total Captured				Population Estimate		
	<55 mm	> 55 mm	Total Salmonids	Total DV	<55 mm	>55 mm	Total
Crocker Creek	Sample contained coho salmon, sockeye salmon, and Dolly Varden						
Upstream	0	3	3	0	NA	NA	NA
Downstream	3	23	26	5	NA	NA	NA
Colter Creek	Sample contained coho salmon						
Upstream	158	19	177	0	298	21	288
Downstream	108	3	111	0	401	2.5	438
Government Creek	Sample contained coho salmon and Dolly Varden						
Upstream	46	3	48	5	133	5.25	137
Downstream	116	22	138	22	182	31	181
Lucy Creek	Sample contained Dolly Varden						
Upstream	0	1	1	1	NA	NA	NA
Downstream	1	2	3	3	NA	NA	NA
Crooked Lake Creek Lower Crossing	Sample contained coho salmon and lampreys						
Upstream	19	16	35	0	90	17	97
Downstream	56	25	81	0	2032	42	250
Meadow Creek	Sample contained coho salmon, sticklebacks, and lampreys						
Upstream	46	41	87	0	46	45	91
Downstream	10	28	38	0	18	41	74
Cottonwood at Settlement Ave.	Sample contained coho salmon						
Upstream	2	0	2	0	NA	NA	NA
Downstream	3	1	4	0	NA	NA	NA

There were differences in the juvenile coho salmon catches above and below the lower Crooked Lake Creek culvert. The culvert width was less than 0.9 times stream width at this location; however, other physical stream conditions were maintained at the crossing location. Stream water velocities within the culvert ranged from 0.53 to 1.25 ft/second, within values passable to juvenile salmon. Velocities based upon MgCl flow times demonstrated a larger range of flows. Therefore, biotic differences appear to contradict the physical data. Catch rates may not have adequately represent fish abundance or community composition or else, differences in other physical or biotic factors influenced fish distribution. There were no differences in fish community or age class distribution at Colter Creek; however, the location was clearly a blockage to juvenile fish migration based upon physical measures of water velocity greater than 4 ft/s.

Discussion

Changes to stream physical characteristics can lead to migration barriers. These can be changes in water surface elevations that exceed the fish leaping ability or velocities that exceed fish swimming ability. Among the culverts we investigated, only two had perched outlets. Karle (2005) provided a discussion of the different approaches used to measure perch height and the different heights used to assume blockage. We measured perched culverts as the difference between water surface elevation at the culvert outlet and the water surface at the outlet pool. We believe that perched culverts are commonly associated with other factors influencing fish passage and rarely occur as the only potential cause of a fish barrier. We measured perch heights of 0.12 m at Crocker Creek and 0.4 m at Government Creek. However, these crossing locations also lacked substrate within the culvert, constricted the channel, and had excessive water velocities. Therefore, an assessment of fish passage using our Level 1 measures would not be based upon perch height alone. A review of the larger data sets obtained through surveys conducted by the Alaska Department of Fish and Game and others could test this hypothesis.

We did not get consistent results between the different assessment methods. All of the five restored locations determined to allow unhindered fish passage through the Level 1 evaluation were not supported using FishXing. The determination of unhindered fish passage through Level 1 was based upon maintenance of stream channel characteristics at the crossing location. The stream slope, channel area, and discharge within the reference channel may have resulted in estimates of water velocities exceeding fish passage using FishXing. Therefore, excessive velocities would have been predicted within the culvert even if reference channel characteristics were maintained.

The FishXing model was a poor predictor of water velocities within crossing structures and, therefore, provided inaccurate assessments of fish passage. Karle (2005) also found that FishXing did not accurately predict water velocities, and suggests that the model should be calibrated from at least two measures of stream discharge. However, this may negate the usefulness of the model because water velocities could be measured directly at two different flows, which would likely bracket fish passage flows, avoiding the need to use the model.

Level 1 physical measures, accompanied by measures of water velocity within the culvert and discharge, appear to be the best tools available for evaluating fish passage. The maintenance of reference channel characteristics at the crossing location can identify those sites where fish passage can be presumed to be unaffected by the crossing structure. At locations where the crossing structure modifies channel conditions, direct measures of velocity can be used to further evaluate passage based upon the target species.

Evaluating water velocity using the flow time of a solute through the crossing may provide a measure more applicable to the passage of juvenile salmon. Direct measures of water velocity using a flow meter at 0.6 depth does not represent the range of velocities created by substrate within the culvert and available for fish. Solute injections have been used to measure the transient storage areas within stream substrates (Webster and Valett 2006). Solutes retained within the boundary layers surrounding and within the substrate and low velocity areas in eddies caused by the substrate increase the time for stream conductivity to return to pre-injection levels. If juvenile fish can use these same areas while passing through a culvert, then these minimum flow time velocities may be more applicable to assessments of fish passage. Direct measures of velocity using the flow time of dissolved solutes does not provide information on the variability in velocities at the inlet or outlet or other locations throughout the culvert. Velocities at these discrete locations can be obtained from meter measurements or models. However, if these direct or modeled measures are inaccurate or do not reflect velocities experienced by passing fish, then they provide no useful information for fish passage assessment.

Using the minimum flow time velocities in Table 7, and a sustained swimming speed for juvenile coho salmon of 1.0 ft/second, we estimate that fish passage was maintained at all of the crossings except Crocker Creek and Colter Creek. Although we did not obtain flow time velocities for Government Creek, the high direct measures and lack of substrate suggest including Government Creek within this group. This result is supported, at least in part, by the difference in fish community composition.

The utility of Level 2 measures of fish community composition in assessing fish passage appear to be limited to those situations where there is limited spawning or rearing habitat upstream of the crossing structure. The crossing structures at Government Creek and Colter Creek were both obvious barriers to juvenile fish migration. However, differences in juvenile fish densities were documented at Government Creek but not at Colter Creek. These differences could be explained by the extent of upstream rearing habitat. The Edgerton Road crossing of Government Creek is at approximately 800 ft elevation and near the base of Government Peak. The stream slope changes rapidly upstream of the crossing, providing very little spawning and rearing habitat. Alternatively, Colter Creek is at 400 ft elevation with slightly more (approximately 1.5 km) upstream spawning and rearing habitat. Another possibility is that there were differences in one-year-old coho salmon above and below the Colter Creek crossing but we were unable to measure these differences. Sampling was conducted in July, and the samples were dominated by young-of-the-year fish. Increasing the number of one-year-old fish could be accomplished by sampling earlier in the spring before juvenile emergence or when young-of-the-year fish are two small to be captured with conventional minnow traps.

The lack of upstream spawning may explain the differences in the fish community above and below Crocker Creek. Adult coho salmon were observed downstream from the Crocker Creek crossing and the crossing was not determined to be a velocity or depth barrier to adult salmon. However, there is very little available spawning habitat upstream of the crossing. We also captured sockeye salmon juveniles below the crossing but did not see any sockeye salmon above or below the crossing. Given these results we also should have seen differences in Chinook salmon juveniles above and below the Colter Creek and Government Creek crossings. These two streams are tributaries to the Little Susitna River, which supports Chinook salmon spawning, but Chinook salmon spawning has not been documented within these tributaries and no adults were observed during this study. Chinook salmon juveniles are numerous in the mainstem of the Little Susitna River near the mouth of Colter Creek (Davis and Davis 2007). It may be that juvenile Chinook salmon do not migrate into these tributaries, they were excluded from samples due to the high number of young-of-the-year coho, or we did not sample at the correct time. Additional sampling will be necessary to further evaluate the usefulness of measures of anadromous fish distribution in evaluating fish passage barriers.

Measures of anadromous fish distribution also may be useful in prioritizing fish passage restoration projects. Stream crossing barriers that result in differences in the community composition or abundance of age classes of juvenile fish may have an increased restoration priority. Within the Susitna and Little Susitna River drainages these sites would include small wetland streams with substrate composed of fine sediment and organic material that do not support salmon spawning but are likely important rearing areas. Other sites could include smaller tributaries to streams that support mainstem Chinook salmon spawning. Small wetland stream systems are abundant throughout the Susitna River drainage. While these streams provide little spawning habitat, they may be critical for the rearing of juvenile salmon, particularly coho and Chinook salmon. For example, the Indian River, Portage Creek, and Gold Creek, located in the upper Susitna Drainage, all provide Chinook salmon spawning habitat (Hoffman 1985) but very little rearing habitat. Research on juvenile salmon movement and rearing suggests that small non-natal wetland streams may provide critical rearing and overwintering habitat for juvenile salmonids.

In the glacial Taku River, juvenile fish move from upstream spawning areas to rearing areas in the lower river (Murphy et al. 1997). Other studies have shown the importance of off channel and tributary habitats for juvenile salmonid rearing (Ebersole et al. 2006). The movement of juvenile salmon from spawning areas has been documented in the Susitna River, as well as other glacial rivers. Juvenile fish capture rates decreased in the semi-glacial Little Susitna River in 2007 following increasing fall flows and a reduction in water temperature (ARRI unpublished). Changes in temperature and flow have been shown to be associated with juvenile salmonid migration in southeast Alaska streams (Bramblett 2002). Therefore, access to these rearing and overwintering sites may be critical for species survival.

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Appendix A—Culvert and Stream Physical Data and FishXing Input

Fish Xing V3 Output Summary

Crossing Name	Culvert		QLP	QHP	Barriers
Cottonwood Creek at Settlement	Cottonwood Creek	63.65 ft	4.5 cfs	10 cfs	V
Cottonwood Slough at Surrey	Cottonwood Slough	39.4 ft	1 cfs	3 cfs	V
Crocker Creek Lower	Crocker Creek	73.16 ft	3 cfs	8 cfs	V
Government Creek	Government Creek	49.2 ft	9 cfs	15 cfs	Leap; V
Lucy Creek 1	Lucy Creek	51 ft	1 cfs	3 cfs	EB
Lucy Creek 2	Lucy Creek	64 ft	1 cfs	3 cfs	EB
Lucy Creek 3	Lucy Creek	59.7 ft	1 cfs	3 cfs	EB
Lucy Creek 4	Lucy Creek	46 ft	1 cfs	3 cfs	EB
Meadow Creek at Meadow Lakes	Little Meadow Creek	69.55 ft	2 cfs	8 cfs	NONE
Papoose 1	Crooked Lake Creek	32.15 ft	.5 cfs	3 cfs	Depth; EB
Papoose 2	Crooked Lake Creek	48 ft	1 cfs	5 cfs	EB
Softwind Road	Colter Creek	33.46 ft	5 cfs	10 cfs	V
Wasilla Creek at Lower Road	Wasilla Creek	39.4 ft	14 cfs	20 cfs	V

Culvert Survey Data Sheet page 1

Surveyors jcd/nick Date 6/7/2007

Latitude: 61 31 32.0 Longitude: 149 34 09.0

Road: Cardif at Bromley Intersection Mile Post:

Stream Name: Lucy Creek Watershed: Cottonwood Creek

Culvert Type:

Circular	x	Pipe Arch	Box	Open Arch	Other

	Ht (m)	Width (m)	Rustline Ht.(m)	Ht (m)	Width (m)	Rustline Ht.(m)
Inlet:			Outlet:	1.15	1.38	0.11

Material:

SSP	CSP	Aluminum	Plastic	Concrete	Log/wood	Other

Corrugations (width x depth) (in): 3 x 1

Pipe Conditions:	good	abraided	rust-through	Other

Inlet Type:	projecting	headwall	wingwalls	mitered

Outlet Config.	At Grade	Freefall to Pool	Cascade over riprap

Outlet Apron	Other

Inlet	Middle	Outlet

Embeded:

Substrate Size: Cobble to large gravel throughout

Culvert Velocities:

	water depth (m)	Vel (m/s) or Counts/40s
Inlet	0.25 ft	112 /40s
Outlet	0.35 ft	59 /40s
Middle		

Flow Time:		#1	#2	#3	#4	#5
Begin		13812	14527			
End		14527	15283			
Time	Min	0	0			
	Sec	58.46	58			

For General Oceanics flow meter use Flow time section. Flow time for solute additions or bouyant objects.

Upstream Channel Widths (m)

1.1	1.18	1.2	2.45	1.88

Downstream Channel Widths (m)

0.97	0.99	1.25	1.1	0.88

Downstream channel widths and first three upstream are of the constructed channel.

Culvert Survey Data Sheet page 2

Road:	Cardif at Bromley Intersection
Stream Name:	Lucy Creek

Tailwater Control: Pool Tailout log-weir Boulder weir

concrete weir channel x-section

Tailwater Cross-sections:

Station (m)	0.4	1.15	1.43	1.8	2.1	2.5	3.1
Elevation (m)	2.432	2.622	2.881	2.96	2.89	2.506	2.521
water depth (m)			0.02	0.11	0.03		
Notes	Lt		LWE		RWE		
Station (m)							
Elevation (m)							
water depth (m)							
Notes							

Channel Slope:

	Ht 1 (m)	Ht. 2 (m)	wd 1 (m)	wd 2 (m)	Dist 1 (m)	Dist 2 (m)
Upstream:	2.775	2.96	0.06	0.11	0	1.46
Downstream:						

Discharge:

SEE LUPINE

Dist (m)	Elev. (m)	Vel or Cnts/40s	

Culvert Elevations:

	Elev (m)	wd (m)
Inlet Invert:	2.217	0.11
Outlet Invert:	2.775	0.06
Pool Bottom:	N/A	
Pool Depth:	N/A	
OHW at Control:		

Culvert Length (m) 15.6

Fish Species Observations:
No fish seen.

Notes:

Data for Fish Xing Entry

Lucy Creek at Cardif and Bromley

Discharge Measurement	Measured at Lucy 3, Lupine Crossing
Date	6/7/2007
Flowing Channel Width (m)	1.22
Flowing Channel Area (m2)	0.08
Averaage Depth (m)	0.07
Discharge (m3/s)	0.03
Ave Velocity (cm/s)	33.43
Discharge (cfs)	1.00
Area (ft2)	0.91
Average Velocity (ft/s)	1.10

Culvert Data		
Shape	Circular	Culvert Slope
Construction	3 x 1 corregated pipe	0.0357692
Sunkent Depth (ft)	0.754593	
Diameter (in)	54.33071	
Culvert Length (ft)	51.1811	
Inlet Bottom Elev (ft)	92.72638	
Outlet Bottom Elev (ft)	90.89567	

Outlet Channel Characteristics

Station	Dist (m)	Elev (m)	Dist (ft)	Elev (ft)	Channel Slope
	0.4	2.432	1.312336	92.021	0.1267123
	1.15	2.622	3.772966	91.39764	
	1.43	2.881	4.691601	90.5479	
	1.8	2.96	5.905512	90.28871	
	2.1	2.89	6.889764	90.51837	
	2.5	2.506	8.2021	91.77822	
	3.1	2.521	10.1706	91.729	

Data Check		**Measured Values**		**Fish Xing v2**		**Fish Xing V3**	
	Vel (m/s)	Vel (cm/s)	Vel (ft/s)	Vel (ft/s)	Accuracy	Vel (ft/s)	Accuracy
Inlet	0.86	85.94	2.82	2.64	93.63	2.87	101.79
Outlet	0.46	45.68	1.50	2.93	195.52	2.08	138.80
Middle	0.33	32.87	1.08	1.94	179.91	2.08	192.89
	0.35	35.03	1.15	1.94	168.81	2.08	181.00

Culvert Survey Data Sheet page 1

Surveyors JCD/NE Date 6/7/2007

Latitude: 61 31 25.8 Longitude: 149 34 08.9

Road: Cardif Lane Mile Post:

Stream Name: Lucy Creek Watershed: Cottonwod Creek

Culvert Type:

Circular x Pipe Arch Box Open Arch Other

	Ht (m)	Width (m)	Rustline Ht.(m)		Ht (m)	Width (m)	Rustline Ht.(m)
Inlet:	1.09	1.32	0.13	Outlet:	1.32	1.33	0.33

Material:

SSP CSP Aluminum Plastic Concrete Log/wood Other

Corrugations (width x depth) (in): 3 x 1

Pipe Conditions: good abraided rust-through Other

Inlet Type: projecting headwall wingwalls mitered

Outlet Config. At Grade Freefall to Pool Cascade over riprap

Outlet Apron Other

	Inlet	Middle	Outlet
Embeded:	0.23		0.01
Substrate Size:	Silt small grave and some cobble		Same as upstream

Culvert Velocities:

	water depth (m)	Vel (m/s) or Counts/40s
Inlet	0.35 ft	58 cnts/40
Outlet	1 ft	25
Middle		

General Oceanics Flow meter

Flow Time:	#1	#2	#3	#4	#5
Begin	12015	12798			
End	12798	13806			
Time					
	58.26	60.95			

For General Oceanics flow meter use Flow time section. Flow time for solute additions or bouyant objects.

Upstream Channel Widths (m)

1.15	1.25	1.05	2.18	3.38

Downstream Channel Widths (m)

0.7	2.2	1.7	1.25	1.15

Culvert Survey Data Sheet page 2

Road:	Cardif Lane
Stream Name:	Lucy Creek

Tailwater Control: Pool Tailout log-weir Boulder weir

concrete weir channel x-section

Tailwater Cross-sections:

Station (m)	3.9	3.3	2.8	2.1	1.25	0.95	0.35
Elevation (m)	2.68	2.74	3.059	3.091	2.99	2.634	0.325
water depth (m)			0.06	0.14	0.06		
Notes	LT		LWE		RWE		
Station (m)							
Elevation (m)							
water depth (m)							
Notes							

Channel Slope:

	Ht 1 (m)	Ht. 2 (m)	wd 1 (m)	wd 2 (m)	Dist 1 (m)	Dist 2 (m)
Upstream:						
Downstream:	3.321	3.091	0.31	0.14	0	9.4

Discharge:

Dist (m)	wd (m)	Vel or Cnts/40s	
SEE LUPINE			

Culvert Elevations:

	Elev (m)	wd (m)
Inlet Invert:	2.906	0.11
Outlet Invert:	3.213	0.31
Pool Bottom:		
Pool Depth:		
OHW at Control:		

Culvert Length (m) 19.7

Fish Species Observations:
None

Notes:

Natural channel above and below culvert

Lucy Creek at Cardif Lane

Discharge Measurement	
Date	6/7/2007
Flowing Channel Width (m)	1.22
Flowing Channel Area (m2)	0.08
Averaage Depth (m)	0.07
Discharge (m3/s)	0.03
Ave Velocity (cm/s)	33.43
Discharge (cfs)	1.00
Area (ft2)	0.91
Average Velocity (ft/s)	1.10

Culvert Data		
Shape	Circular	Culvert Slope
Construction	3 x 1 corregated pipe	0.0155838
Sunkent Depth (ft)	0.754593	
Diameter (in)	52.3622	
Culvert Length (ft)	64.63255	
Inlet Bottom Elev (ft)	90.46588	
Outlet Bottom Elev (ft)	89.45866	

Outlet Channel Characteristics

Station	Dist (m)	Elev (m)	Dist (ft)	Elev (ft)	Channel Slope
	3.9	2.68	12.79528	91.20735	-0.006383
	3.3	2.74	10.82677	91.0105	
	2.8	3.059	9.186352	89.96391	
	2.1	3.091	6.889764	89.85892	
	1.25	2.99	4.10105	90.19029	
	0.95	2.634	3.116798	91.35827	
	0.35	0.325	1.148294	98.93373	

Data Check		**Measured Values**		**Fish Xing v2**		**Fish Xing V3**	
	Vel (m/s)	Vel (cm/s)	Vel (ft/s)	Vel (ft/s)	Accuracy	Vel (ft/s)	Accuracy
Inlet	0.45	44.92	1.47	3.04	206.29	2.32	157.43
Outlet	0.20	19.85	0.65	0.65	99.83	0.41	62.97
Middle	0.36	36.12	1.18	2.21	186.51	1.78	150.22
	0.44	44.44	1.46	2.21	151.57	1.78	122.08

Culvert Survey Data Sheet

Surveyors JCD/NE Date 6/7/2007

Latitude: 61 31 21.5 Longitude: 149 34 10.0

Road: Lupine Mile Post:

Stream Name: Lucy Cr. Watershed: Cottonwood Creek

Culvert Type:

Circular x Pipe Arch Box Open Arch Other

	Ht (m)	Width (m)	Rustline Ht.(m)		Ht (m)	Width (m)	Rustline Ht.(m)
Inlet:	1.1	1.34	0.14	Outlet:	1.14	1.4	0.14

Material:

SSP CSP Aluminum Plastic Concrete Log/wood Other

Corrugations (width x depth) (in): 3 x 1

Pipe Conditions: good abraided rust-through Other

Inlet Type: projecting headwall wingwalls mitered

Outlet Config. At Grade Freefall to Pool Cascade over riprap

Outlet Apron Other

	Inlet	Middle	Outlet
Embeded:	0.24		0.26

Substrate Size: Large gravel to cobble

Culvert Velocities:

	water depth (m)	Vel (m/s) or Counts/40s
Inlet	0.2 ft	133 cnts/40
Outlet	0.25 ft	117 cnts/40
Middle		

Flow Time:	#1	#2	#3	#4	#5
Begin	5026	6584			
End	6584	8126			
Time					
	60.62	58.61			

For General Oceanics flow meter use Flow time section. Flow time for solute additions or bouyant objects.

Upstream Channel Widths (m)				
0.7	2.2	1.7	1.25	1.15
Downstream Channel Widths (m)				
0.97	0.88	0.93	0.65	0.7

Culvert Survey Data Sheet page 2

Road:	Lupine
Stream Name:	Lucy Cr.

Tailwater Control: Pool Tailout log-weir Boulder weir

concrete weir channel x-section

Tailwater Cross-sections:

Station (m)	3.5	2.5	2.63	2.1	1.5	1.25	0.5
Elevation (m)	2.845	3.01	3.222	3.328	3.25	3.052	2.87
water depth (m)			0	0.1	0.02		
Notes	Lt bank	top of bank	LWE		RWE	Top Bank	Rt
Station (m)							
Elevation (m)							
water depth (m)							
Notes							

Channel Slope:

	Ht 1 (m)	Ht. 2 (m)	wd 1 (m)	wd 2 (m)	Dist 1 (m)	Dist 2 (m)
Upstream:						
Downstream:	3.328	3.625	0.1	0.15	0	9.1

Discharge:

Dist (m)	wd (**ft**)	Vel or Cnts/40s	
2.7	0	0	
2.38	0.3	25	
2	0.3	81	
1.75	0.25	43	
1.48	0.1	0	

Culvert Elevations:

	Elev (m)	wd (m)
Inlet Invert:	3.002	0.12
Outlet Invert:	3.316	0.1
Pool Bottom:		
Pool Depth:		
OHW at Control:		

Culvert Length (m) 18.2

Fish Species Observations:
None

Notes:
Downstream channel widths of constructed channel. Slope measured downstream.
Local resident remembers adult Dolly Varden, but no salmon.

Lucy Creek at Lupine

Discharge Measurement	
Date	6/7/2007
Flowing Channel Width (m)	1.22
Flowing Channel Area (m2)	0.08
Averaage Depth (m)	0.07
Discharge (m3/s)	0.03
Ave Velocity (cm/s)	33.43
Discharge (cfs)	1.00
Area (ft2)	0.91
Average Velocity (ft/s)	1.10

Culvert Data		
Shape	Circular	Culvert Slope
Construction	3 x 1 corregated pipe	0.017253
Sunkent Depth (ft)	0.8530184	
Diameter (in)	55.11811	
Culvert Length (ft)	59.711286	
Inlet Bottom Elev (ft)	90.150919	
Outlet Bottom Elev (ft)	89.120735	

Outlet Channel Characteristics

Station	Dist (m)	Elev (m)	Dist (ft)	Elev (ft)	Channel Slope
	3.5	2.845	11.48294	90.66601	0.032637
	2.5	3.01	8.2021	90.12467	
	2.63	3.222	8.628609	89.42913	
	2.1	3.328	6.889764	89.08136	
	1.5	3.25	4.92126	89.33727	
	1.25	3.052	4.10105	89.98688	
	0.5	2.87	1.64042	90.58399	

Data Check		**Measured Values**		**Fish Xing v2**		**Fish Xing V3**	
	Vel (m/s)	Vel (cm/s)	Vel (ft/s)	Vel (ft/s)	Accuracy	Vel (ft/s)	Accuracy
Inlet	1.02	101.90	3.34	2.27	67.90	2.25	67.30
Outlet	0.90	89.74	2.94	0.92	31.25	1.08	36.68
Middle	0.69	69.07	2.27	1.65	72.82	1.63	71.93
	0.71	70.70	2.32	1.65	71.13	1.63	70.27

Culvert Survey Data Sheet page 1

Surveyors JCD/NE Date 5/7/2007

Latitude: 61 31 19.6 Longitude: 149 34 9.3

Road: Larkspur Mile Post:

Stream Name: Lucy Creek Watershed: Cottonwood Creek

Culvert Type:

Circular x Pipe Arch Box Open Arch Other

	Ht (m)	Width (m)	Rustline Ht.(m)		Ht (m)	Width (m)	Rustline Ht.(m)
Inlet:	1.03	1.28	0.18	Outlet:	0.97	1.32	0.14

Material:

SSP CSP Aluminum Plastic Concrete Log/wood Other

Corrugations (width x depth) (in): 3 x 1

Pipe Conditions: good abraided rust-through Other

Inlet Type: projecting headwall wingwalls mitered

Outlet Config. At Grade Freefall to Pool Cascade over riprap

Outlet Apron Other

	Inlet	Middle	Outlet
Embeded:	0.25		0.35
Substrate Size:	Large Cobble		

Culvert Velocities:

	depth (m)	Vel (m/s) or Counts/40s
Inlet	0.25 ft	37 cnts/40s
Outlet	0.3 ft	56 cnts/40s
Middle		

Flow Time:	#1	#2	#3	#4	#5
Begin	8387	9929			
End	9929	11998			
Time					
	58.57	59.4			

For General Oceanics flow meter use Flow time section. Flow time for solute additions or bouyant objects.

Upstream Channel Widths (m)

0.97	0.88	0.93	0.65	0.7

Downstream Channel Widths (m)

0.87 2.1	2.35 2.06	1.25			

Culvert Survey Data Sheet page 2

Road:	Larkspur
Stream Name:	Lucy Creek

Tailwater Control: Pool Tailout log-weir Boulder weir

concrete weir channel x-section

Tailwater Cross-sections:

Station (m)	0.4	1.3	1.6	2	2.48	2.8	3.5
Elevation (m)	2.906	2.927	3.075	3.18	3.07	2.949	3.019
water depth (m)			0	0.12	0		
Notes			LWE		RWE		
Station (m)							
Elevation (m)							
water depth (m)							
Notes							

Channel Slope:

	Ht 1 (m)	Ht. 2 (m)	wd 1 (m)	wd 2 (m)	Dist 1 (m)	Dist 2 (m)
Upstream:						
Downstream:	3.18	3.483	0.12	0	0	5.5

Discharge:

Dist (m)	wd (m)	Vel or Cnts/40s	
SEE Lupine			

Culvert Elevations:

	Elev (m)	wd (m)
Inlet Invert:	2.869	0.13
Outlet Invert:	3.138	0.11
Pool Bottom:		
Pool Depth:		
OHW at Control:		

Culvert Length (m) 14.1

Fish Species Observations:
None

Notes:

Lucy Creek at Larkspur

Discharge Measurement	
Date	5/7/2007
Flowing Channel Width (m)	1.22
Flowing Channel Area (m2)	0.08
Averaage Depth (m)	0.07
Discharge (m3/s)	0.03
Ave Velocity (cm/s)	33.43
Discharge (cfs)	1.00
Area (ft2)	0.91
Average Velocity (ft/s)	1.10

Culvert Data		
Shape	Circular	Culvert Slope
Construction	3 x 1 corregated pipe	0.019078
Sunkent Depth (ft)	0.984252	
Diameter (in)	51.9685	
Culvert Length (ft)	46.25984	
Inlet Bottom Elev (ft)	90.58727	
Outlet Bottom Elev (ft)	89.70472	

Outlet Channel Characteristics

Station	Dist (m)	Elev (m)	Dist (ft)	Elev (ft)	Channel Slope
	0.4	2.906	1.312336	90.46588	0.055091
	1.3	2.927	4.265092	90.39698	
	1.6	3.075	5.249344	89.91142	
	2	3.18	6.56168	89.56693	
	2.48	3.07	8.136483	89.92782	
	2.8	2.949	9.186352	90.3248	
	3.5	3.019	11.48294	90.09514	

Data Check		**Measured Values**		**Fish Xing v2**		**Fish Xing V3**	
	Vel (m/s)	Vel (cm/s)	Vel (ft/s)	Vel (ft/s)	Accuracy	Vel (ft/s)	Accuracy
Inlet	0.289629	28.96286	0.950225	2.2	231.52	2.06	216.79
Outlet	0.433974	43.39742	1.4238	1.6	112.38	1.65	115.89
Middle	0.707499	70.74988	2.32119	1.6	68.93	1.68	72.38
	0.936032	93.60319	3.070971	1.6	52.10	1.68	54.71

Culvert Survey Data Sheet

Surveyors JCD/NE Date 6/13/2007

Latitude: 61 30 02.9 Longitude: 149 36 59.6

Road: Settlers Bay Mile Post:

Stream Name: Crocker Creek Watershed: Crocker Cr.

Culvert Type:

Circular	Pipe Arch	Box	Open Arch	Other
x				

	Ht (m)	Width (m)	Rustline Ht.(m)		Ht (m)	Width (m)	Rustline Ht.(m)
Inlet:	1.15	1.2		Outlet:	1.18	1.17	0.27

Material:

SSP	CSP	Aluminum	Plastic	Concrete	Log/wood	Other
	x					

Corrugations (width x depth) (in): 3 x 1

Pipe Conditions:	good	abraided	rust-through	Other
	x			

Inlet Type:	projecting	headwall	wingwalls	mitered
		x		

Outlet Config.	At Grade	Freefall to Pool	Cascade over riprap	
		x		
	Outlet Apron		Other	

	Inlet	Middle	Outlet
Embeded:	0.05		
Substrate Size:	Cobble/gravel	None	None

Culvert Velocities:

	depth (m)	Vel (m/s) or Counts/40s
Inlet	0.88 ft	57 cnts
Outlet	0.7 ft	105 cnts
Middle		

Flow Time:	#1	#2	#3	#4	#5
Begin	57415				
End	59186				
Time					
	60				

For General Oceanics flow meter use Flow time section. Flow time for solute additions or bouyant objects.

Upstream Channel Widths (m)

4.9	5.1	6.8	8.1	10

Downstream Channel Widths (m)

7	4.7	6.4	7.5	7

Culvert Survey Data Sheet page 2

Road:	Settlers Bay
Stream Name:	Crocker Creek

Tailwater Control: Pool Tailout log-weir Boulder weir

concrete weir channel x-section

Tailwater Cross-sections:

Station (m)	1	4.2	4.4	6.2	7.4	7.6	11.1
Elevation (m)	2.412	2.755	2.912	2.9	2.905	2.897	2.866
water depth (m)			0.03	0.09	0.03	0.06	0
Notes			RWE				LWE
Station (m)	12.2	12.7					
Elevation (m)	2.791	2.453					
water depth (m)							
Notes							

Channel Slope:

	Ht 1 (m)	Ht. 2 (m)	wd 1 (m)	wd 2 (m)	Dist 1 (m)	Dist 2 (m)
Upstream:						
Downstream:	2.905	3.009	0.03	0.05	0	7.7

Discharge:

Dist (m)	wd (m)	Vel or Cnts/40s	
0.6	1	0	RWE
1	1.5	0	
1.3	1.51	18	
1.6	1.55	11	
2	1.55	18	
2.4	1.51	15	
2.7	1.35	8	
3.45	0.5	0	LWE

Culvert Elevations:

	Elev (m)	wd (m)
Inlet Invert:	2.836	0.28
Outlet Invert:	2.947	0.19
Pool Bottom:	3.407	0.55
Pool Depth:		0.55
OHW at Control:		
Culvert Length (m)	22.3	

Fish Species Observations:
Dolly Varden Observed Upstream

Notes:
Outlet is boulder wall @ pool end. Step pools from rock. Some foam.

Crocker Creek at Settler's Bay

Discharge Measurement	
Date	6/13/2007
Flowing Channel Width (m)	2.85
Flowing Channel Area (m2)	1.15
Averaage Depth (m)	0.40
Discharge (m3/s)	0.10
Ave Velocity (cm/s)	8.42
Discharge (cfs)	3.41
Area (ft2)	12.35
Average Velocity (ft/s)	0.28

Culvert Data			
Shape	Circular		Culvert Slope
Construction			0.004978
Sunkent Depth (ft)	-0.032808		
Diameter (in)	46.06299		
Culvert Length (ft)	73.16273		
Inlet Bottom Elev (ft)	90.69554	Pool Bottom (ft)	88.82218
Outlet Bottom Elev (ft)	90.33136		

Outlet Channel Characteristics

Station	Dist (m)	Elev (m)	Dist (ft)	Elev (ft)	Channel Slope
	1	2.412	3.28084	92.08661	0.013506
	4.2	2.755	13.77953	90.96129	
	4.4	2.912	14.4357	90.44619	
	6.2	2.9	20.34121	90.48556	
	7.4	2.905	24.27822	90.46916	
	7.6	2.897	24.93438	90.49541	
	11.1	2.866	36.41732	90.59711	
	12.2	2.791	40.02625	90.84318	
	12.7	2.453	41.66667	91.9521	
			0	100	
			0	100	

							Barrier Type:	
Data Check		**Measured Values**		**Fish Xing v2**			**Fish Xing V3**	
	Vel (m/s)	Vel (cm/s)	Vel (ft/s)	Vel (ft/s)	Accuracy	Reduc. Fac	Vel (ft/s)	Accuracy
Inlet	0.441571	44.15714	1.448725	3.43	236.7599	0.422369	2.67	184.3
Outlet	0.806234	80.62341	2.645125	2.63	99.42819	1.005751	4.7	177.6854
Middle	0.793202	79.32022	2.602369	2.49	95.68204	1.045128	2.18	83.76982

Flow Time Velocity			
	Max	Min	Average
Vel (cm/s)	89.2	31.86	55.75
Vel (ft/s)	2.93	1.05	1.83

Culvert Survey Data Sheet

Surveyors JCD/NE Date 6/13/2007

Latitude: 61 39 16.6 Longitude: 149 29 48.4

Road: Softwind Road Mile Post: 3

Stream Name: Colter Creek Watershed: Little Susitna

Culvert Type:

Circular x Pipe Arch Box Open Arch Other

	Ht (m)	Width (m)	Rustline Ht.(m)		Ht (m)	Width (m)	Rustline Ht.(m)
Inlet:	1.46	1.49	0.45	Outlet:	1.45	1.5	

Material:

SSP CSP Aluminum Plastic Concrete Log/wood Other

Corrugations (width x depth) (in): 3 x 1

Pipe Conditions: good abraided rust-through Other

Inlet Type: projecting headwall wingwalls mitered

Outlet Config. At Grade Freefall to Pool Cascade over riprap

Outlet Apron Other

	Inlet	Middle	Outlet
Embeded:	0	0	0
Substrate Size:	None	None	None

Culvert Velocities:

	depth (m)	Vel (m/s) or Counts/40s
Inlet		
Outlet		
Middle		

General Oceanics Flow Meter

Flow Time:	Inlet	Inlet	Middle	Outlet	#5
Begin	41015	44962	48900	54228	
End	44962	48900	54227	57337	
Time					
	60	60	60	60	

For General Oceanics flow meter use Flow time section. Flow time for solute additions or bouyant objects.

Upstream Channel Widths (m)

3.4	3.4	4.1	3	3.5			

Downstream Channel Widths (m)

4.3	4	2.9	4.3	4.9			

Culvert Survey Data Sheet page 2

Road: Softwind Road
Stream Name: Colter Creek

Tailwater Control: Pool Tailout log-weir Boulder weir

concrete weir channel x-section

Tailwater Cross-sections:

Station (m)	1	2	3	3.8	4.3	5.2	5.7
Elevation (m)	2.499	2.732	2.932	3.307	3.782	3.637	3.595
water depth (m)					0.28	0.14	0.09
Notes					LWE		
Station (m)	6.8	8	8.8	10	13.1	14.2	
Elevation (m)	3.546	3.515	3.479	3.509	3.756	3.28	
water depth (m)	0.1	0.07	0.02	0	0.13		
Notes					RWE		

Channel Slope:

	Ht 1 (m)	Ht. 2 (m)	wd 1 (m)	wd 2 (m)	Dist 1 (m)	Dist 2 (m)
Upstream:						
Downstream:	3.546	3.917	0.1	0.14	6.2	14.8

Discharge:

Dist (m)	wd (m)	Vel or Cnts/40s	
3.82	0	0	
4.1	0.4	32	
4.5	0.5	53	
4.8	0.4	80	
5	0.5	103	
5.3	0.5	106	
5.6	0.35	78	
5.9	0.4	29	
6.35	0	0	

Culvert Elevations:

	Elev (m)	wd (m)
Inlet Invert:	3.12	0.26
Outlet Invert:	3.657	
Pool Bottom:	4.225	0.78
Pool Depth:		0.78
OHW at Control:		
Culvert Length (m)	10.2	

Fish Species Observations:

YOY coho above and below culvert. Many more seen below culvert in outlet pool.

Notes:

Colter Creek at Softwind Road

Discharge Measurement	
Date	6/13/2007
Flowing Channel Width (m)	2.53
Flowing Channel Area (m2)	0.29
Averaage Depth (m)	0.11
Discharge (m3/s)	0.14
Ave Velocity (cm/s)	49.69
Discharge (cfs)	5.03
Area (ft2)	3.09
Average Velocity (ft/s)	1.63

Culvert Data			
Shape	Circular		Culvert Slope
Construction			0.0526471
Sunkent Depth (ft)	0.164042		
Diameter (in)	59.055118		
Culvert Length (ft)	33.464567		
Inlet Bottom Elev (ft)	89.76378	Pool Bottom (ft)	86.138451
Outlet Bottom Elev (ft)	88.001969		

Outlet Channel Characteristics

Station	Dist (m)	Elev (m)	Dist (ft)	Elev (ft)	Channel Slope
	1	2.499	3.28084	91.80118	0.0431395
	2	2.732	6.56168	91.03675	
	3	2.932	9.84252	90.38058	
	3.8	3.307	12.46719	89.15026	
	4.3	3.782	14.10761	87.59186	
	5.2	3.637	17.06037	88.06759	
	5.7	3.595	18.70079	88.20538	
	6.8	3.546	22.30971	88.36614	
	8	3.515	26.24672	88.46785	
	8.8	3.479	28.87139	88.58596	
	10	3.509	32.8084	88.48753	
	13.1	3.756	42.979	87.67717	
	14.2	3.28	46.58793	89.23885	

Data Check	**Measured Values**		**Fish Xing v2**			Barrier Typ Velocity Fish Xing V3	
	Vel (m/s)	Vel (cm/s)	Vel (ft/s)	Vel (ft/s)	Accuracy	Red. Fac.	Vel (ft/s)	Accuracy
Inlet	1.77	176.78	5.80	5.05	87.07	1.15	6.76	116.55
Outlet	1.39	139.25	4.57	5.57	121.92	0.82	5.58	122.14
Middle	2.39	238.59	7.83	5.57	71.16	1.41	5.58	71.29
Inlet 2	1.76	176.38	5.79	5.05	87.27	1.15	5.58	96.43

Flow Time Velocity

	Max	Min	Average
Vel (cm/s)	204	204	204
Vel (ft/s)	6.69	6.69	6.69

Culvert Survey Data Sheet

Surveyors JCD/NE Date 6/13/2007

Latitude: 61 31 23.7 Longitude: 149 31 24.9

Road: Surrey Road Mile Post: approx. 2.5

Stream Name: Cottonwood Slough Watershed: Cottonwood Cr.

Culvert Type:

Circular x Pipe Arch Box Open Arch Other

	Ht (m)	Width (m)	Rustline Ht.(m)		Ht (m)	Width (m)	Rustline Ht.(m)
Inlet:	0.94	1.12	0.34	Outlet:	1.2	1.2	

Material:

SSP CSP Aluminum Plastic Concrete Log/wood Other

Corrugations (width x depth) (in): 3 x 1

Pipe Conditions: good abraided rust-through Other

Inlet Type: projecting headwall wingwalls mitered

Outlet Config. At Grade Freefall to Pool Cascade over riprap

Outlet Apron Other

	Inlet	Middle	Outlet
Embeded:	0.18		
Substrate Size:	gravel/cobble/wood	None	None

Culvert Velocities:

	depth (m)	Vel (m/s) or Counts/40s
Inlet	0.5 ft	14 40s
Outlet	0.2 ft	78 40s
Middle		

Flow Time:		#1	#2	#3	#4	#5
Begin		59189				
End		60475				
Time	Min					
	Sec	60				

For General Oceanics flow meter use Flow time section. Flow time for solute additions or bouyant objects.

Upstream Channel Widths (m)

Downstream Channel Widths (m)

2	1.4	1.1	1	0.9			

Culvert Survey Data Sheet page 2

Road: Surrey Road
Stream Name: Cottonwood Slough

Tailwater Control: Pool Tailout log-weir Boulder weir

concrete weir channel x-section

Tailwater Cross-sections:

Station (m)	1.1	1.9	2.25	2.8	3.6	4	5.3
Elevation (m)	2.6	2.625	2.818	2.921	2.903	2.615	2.715
water depth (m)				0.13	0.09		
Notes							
Station (m)							
Elevation (m)							
water depth (m)							
Notes							

Channel Slope:

	Ht 1 (m)	Ht. 2 (m)	wd 1 (m)	wd 2 (m)	Dist 1 (m)	Dist 2 (m)
Upstream:						
Downstream:	2.911	2.921	0.05	0.13	0	4.2

Discharge:

Dist (m)	wd (ft)	Vel or Cnts/40s	
2.2	0	0	RWE
2.65	0.15	35	
2.8	0.3	31	
3.1	0.4	33	
3.4	0.35	21	
3.65	0.2	0	LWE

Culvert Elevations:

	Elev (m)	wd (m)
Inlet Invert:	2.705	0.2
Outlet Invert:	2.824	0.05
Pool Bottom:	2.96	0.14
Pool Depth:		
OHW at Control:		
Culvert Length (m)	12	

Fish Species Observations:

Notes:
Pond upstream. Foam accumulations <1.0 ft2

Cottonwood Slough at Surrey Road

Discharge Measurement	
Date	6/13/2007
Flowing Channel Width (m)	1.45
Flowing Channel Area (m2)	0.11
Averaage Depth (m)	0.07
Discharge (m3/s)	0.02
Ave Velocity (cm/s)	19.80
Discharge (cfs)	0.75
Area (ft2)	1.16
Average Velocity (ft/s)	0.65

Culvert Data			
Shape	Circular		Culvert Slope
Construction			0.0099167
Sunkent Depth (ft)	0		
Diameter (in)	47.24409		
Culvert Length (ft)	39.37008		
Inlet Bottom Elev (ft)	91.12533	Pool Bottom (ft)	90.288714
Outlet Bottom Elev (ft)	90.73491		

Outlet Channel Characteristics

Station	Dist (m)	Elev (m)	Dist (ft)	Elev (ft)	Channel Slope
	1.1	2.6	3.608924	91.46982	0.002381
	1.9	2.625	6.233596	91.3878	
	2.25	2.818	7.38189	90.75459	
	2.8	2.921	9.186352	90.41667	
	3.6	2.903	11.81102	90.47572	
	4	2.615	13.12336	91.4206	
	5.3	2.715	17.38845	91.09252	
			0	100	
			0	100	
			0	100	
			0	100	

							Barrier Type:	
Data Check		**Measured Values**		**Fish Xing v2**			**Fish Xing V3**	
	Vel (m/s)	Vel (cm/s)	Vel (ft/s)	Vel (ft/s)	Accuracy	Red. Fac	Vel (ft/s)	Accuracy
Inlet	0.11	11.49	0.38	2.44	647.30	0.15	2.75	729.54
Outlet	0.60	60.11	1.97	3.52	178.49	0.56	3.53	178.99
Middle	0.58	57.60	1.89	1.99	105.31	0.95	1.99	105.31

Flow Time Velocity

	Max	Min	Average
Vel (cm/s)	30	16	24
Vel (ft/s)	0.98	0.52	0.79

Culvert Survey Data Sheet page 1

Surveyors JCD/NE Date 6/7/2007

Latitude: 61 30 50.3 Longitude: 150 04 02.7

Road:	Papoose Road	Mile Post:	Approx. 1.0
Stream Name:	Crooked Lake Creek	Watershed:	Little Susitna

Culvert Type:

Circular x Pipe Arch Box Open Arch Other

	Ht (m)	Width (m)	Rustline Ht.(m)		Ht (m)	Width (m)	Rustline Ht.(m)
Inlet:	0.89	1.17	0.19	Outlet:	1.03	1.22	0.26

Material:

SSP CSP Aluminum Plastic Concrete Log/wood Other

Corrugations (width x depth) (in): 3 x 1

Pipe Conditions: good abraided rust-through Other

Inlet Type: projecting headwall wingwalls mitered

Outlet Config. At Grade Freefall to Pool Cascade over riprap

Outlet Apron Other

	Inlet	Middle	Outlet
Embeded:	0.28		0.19

Substrate Size: gravel to cobble

Culvert Velocities:

	depth (m)	Vel (m/s) or Counts/40s
Inlet	0.3 ft	57 cnts/40s
Outlet	0.45	27 cnts/40s
Middle		

Flow Time:	#1	#2	#3	#4	#5
Begin	1737	2962	4217		
End	2962	4217	5026		
Time					
	51.47	55.98	48.8		

For General Oceanics flow meter use Flow time section. Flow time for solute additions or bouyant objects.

Upstream Channel Widths (m)

1.05				

Downstream Channel Widths (m)

1.95	2.1	2.5	2.1	2.4

Culvert Survey Data Sheet page 2

Road:	Little Susitna
Stream Name:	Crooked Lake Creek

Tailwater Control: Pool Tailout log-weir Boulder weir

concrete weir channel x-section

Tailwater Cross-sections:

Station (m)	1.9	2.7	3.1	3.6	4.1	4.75	5.4
Elevation (m)	2.076	2.08	2.14	2.326	2.379	2.379	2.359
water depth (m)				0	0.055	0.05	0
Notes							
Station (m)	5.5	7.2					
Elevation (m)	2.176	2.149					
water depth (m)							
Notes							

Channel Slope:

	Ht 1 (m)	Ht. 2 (m)	wd 1 (m)	wd 2 (m)	Dist 1 (m)	Dist 2 (m)
Upstream:						
Downstream:	2.379	2.376	0.05	0.01	0	4.9

Discharge:

Dist (m)	wd (m)	Vel or Cnts/40s	
3.6	0	0	
4.1	0.15	13	
4.35	0.25	27	
4.75	0.15	30	
5.07	0.2	29	
5.25	0	0	

Culvert Elevations:

	Elev (m)	wd (m)
Inlet Invert:	2.066	0.09
Outlet Invert:	2.506	0.2
Pool Bottom:	2.44	0.12
Pool Depth:		
OHW at Control:		
Culvert Length (m)	9.8	

Fish Species Observations:
Juvenile coho above and below, frogs.

Notes:

Crooked Lake Creek at Papoose Road Upstream Culvert

Discharge Measurement	
Date	6/7/2007
Flowing Channel Width (m)	1.65
Flowing Channel Area (m2)	-72.71
Averaage Depth (m)	-44.07
Discharge (m3/s)	0.01
Ave Velocity (cm/s)	-0.02
Discharge (cfs)	0.47
Area (ft2)	-782.62
Average Velocity (ft/s)	0.00

Culvert Data			
Shape	Circular	Culvert Slope	
Construction		0.044897959	
Sunkent Depth (ft)	0.77099738	Culvert Water Surface Slope	
Diameter (in)	48.0314961	-0.03367347	
Culvert Length (ft)	32.152231		
Inlet Bottom Elev (ft)	93.2217848	Pool Bottom (ft)	91.994751
Outlet Bottom Elev (ft)	91.7782152		

Outlet Channel Characteristics

Station	Dist (m)	Elev (m)	Dist (ft)	Elev (ft)	Channel Slope
	1.9	2.076	6.2335958	93.188976	-0.00061224
	2.7	2.08	8.8582677	93.175853	
	3.1	2.14	10.170604	92.979003	
	3.6	2.326	11.811024	92.368766	
	4.1	2.379	13.451444	92.194882	
	4.75	2.379	15.58399	92.194882	
	5.4	2.359	17.716535	92.260499	
	5.5	2.176	18.044619	92.860892	
	7.2	2.149	23.622047	92.949475	
			0	100	
			0	100	

							Barrier Type:	
Data Check	**Measured Values**		**Fish Xing v2**				**Fish Xing V3**	
	Vel (m/s)	Vel (cm/s)	Vel (ft/s)	Vel (ft/s)	Accuracy	Red. Fac.	Vel (ft/s)	Accuracy
Inlet	0.44	44.16	1.45	2.34	161.52	0.62	2.34	161.52
Outlet	0.21	21.37	0.70	1.76	251.08	0.40	0.19	27.11
Middle	0.64	63.96	2.10	1.76	83.87	1.19	1.70	81.01
	0.60	60.25	1.98	1.76	89.04	1.12	1.70	86.01

Culvert Survey Data Sheet page 1

Surveyors JCD/NE Date 6/7/2007

Latitude: 61 30 54.6 Longitude: 150 05 11.1

Road: Papoose Drive Mile Post: 2

Stream Name: Crooked Lake Creek Watershed: Little Susitna

Culvert Type:

Circular x Pipe Arch Box Open Arch Other

	Ht (m)	Width (m)	Rustline Ht.(m)		Ht (m)	Width (m)	Rustline Ht.(m)
Inlet:	0.91	1.2		Outlet:	0.7	1.2	0.3

Material:

SSP CSP Aluminum Plastic Concrete Log/wood Other

Corrugations (width x depth) (in): 3 x 1

Pipe Conditions: good abraided rust-through Other

Inlet Type: projecting headwall wingwalls mitered

Outlet Config. At Grade Freefall to Pool Cascade over riprap

Outlet Apron Other

	Inlet	Middle	Outlet
Embeded:	0.29		0.5

Substrate Size: small gravel (32mm)

Culvert Velocities:

	depth (m)	Vel (m/s) or Counts/40s
Inlet	0.45 ft	20
Outlet	0.35 ft	49
Middle		

Flow Time:	#1	#2	#3	#4	#5
Begin	827	1236			
End	1236	1728			
Time					
	61.88	61.94			

For General Oceanics flow meter use Flow time section. Flow time for solute additions or bouyant objects.

Upstream Channel Widths (m)

1.65	1.53	1.46	2.09	2.1

Downstream Channel Widths (m)

0.95	1.04	1.96	2.05	1.9

Culvert Survey Data Sheet page 2

Road:	Papoose Drive
Stream Name:	Crooked Lake Creek

Tailwater Control: Pool Tailout log-weir Boulder weir

concrete weir channel x-section

Tailwater Cross-sections:

Station (m)	1	2	2.5	2.7	3.15	3.55	3.92
Elevation (m)	3.165	3.215	3.184	3.55	3.477	3.477	3.445
water depth (m)				0.18	0.11	0.1	0.007
Notes							
Station (m)	4.2	5.15	6.05				
Elevation (m)	3.19	3.143	3.207				
water depth (m)							
Notes							

Channel Slope:

	Ht 1 (m)	Ht. 2 (m)	wd 1 (m)	wd 2 (m)	Dist 1 (m)	Dist 2 (m)
Upstream:						
Downstream:	3.477	3.746	0.1	0.22	0	13.3

Discharge:

Dist (m)	wd (ft)	Vel or Cnts/40s	
2.83	4	19	
3	0.32	21	
3.2	0.3	31	
3.4	0.3	35	
3.6	0.3	38	
3.8	0.22	21	

Culvert Elevations:

	Elev (m)	wd (m)
Inlet Invert:	3.386	
Outlet Invert:	3.54	
Pool Bottom:	3.7005	
Pool Depth:		
OHW at Control:	3.37	
Culvert Length (m)	14.6	

Fish Species Observations:
Rainbow at outlet, spawning lamprey, coho juv.
YOY coho above and below pipe.

Notes:

Crooked Lake Creek at Papoose Drive

Discharge Measurement	
Date	6/7/2007
Flowing Channel Width (m)	0.97
Flowing Channel Area (m2)	0.18
Averaage Depth (m)	0.19
Discharge (m3/s)	0.04
Ave Velocity (cm/s)	19.38
Discharge (cfs)	1.25
Area (ft2)	1.97
Average Velocity (ft/s)	0.64

Culvert Data			
Shape	Circular	Culvert Slope	
Construction	3x1	0.010548	
Sunkent Depth (ft)	1.64042		
Diameter (in)	47.24409		
Culvert Length (ft)	47.90026		
Inlet Bottom Elev (ft)	88.89108	Pool Bottom (ft)	87.85925
Outlet Bottom Elev (ft)	88.38583		

Outlet Channel Characteristics

Station	Dist (m)	Elev (m)	Dist (ft)	Elev (ft)	Channel Slope
	1	3.165	3.28084	89.61614	0.020226
	2	3.215	6.56168	89.4521	
	2.5	3.184	8.2021	89.55381	
	2.7	3.55	8.858268	88.35302	
	3.15	3.477	10.33465	88.59252	
	3.55	3.477	11.64698	88.59252	
	3.92	3.445	12.86089	88.69751	
	4.2	3.19	13.77953	89.53412	
	5.15	3.143	16.89633	89.68832	
	6.05	3.207	19.84908	89.47835	
			0	100	

							Barrier Typ	Velocity
Data Check		**Measured Values**		**Fish Xing v2**			**Fish Xing V3**	
	Vel (m/s)	Vel (cm/s)	Vel (ft/s)	Vel (ft/s)	Accuracy	Red. Fac	Vel (ft/s)	Accuracy
Inlet	0.16	16.05	0.53	1.88	357.08	0.28	1.87	355.18
Outlet	0.38	38.08	1.25	0.79	63.23	1.58	0.8	64.03
Middle	0.18	17.76	0.58	1.36	233.38	0.43	1.36	233.38
	0.21	21.35	0.70	1.36	194.20	0.51	1.36	194.20

Culvert Survey Data Sheet

Surveyors JCD/NE Date 6/8/2007

Latitude: 61 41 35.2 Longitude: 149 18 27.3

Road:	Edgerton Park	Mile Post:	
Stream Name:	Government Creek	Watershed:	Little Susitna

Culvert Type:

Circular	Pipe Arch	Box	Open Arch	Other
x				

	Ht (m)	Width (m)	Rustline Ht.(m)		Ht (m)	Width (m)	Rustline Ht.(m)
Inlet:	1.66	1.61		Outlet:			

Material:

SSP	CSP	Aluminum	Plastic	Concrete	Log/wood	Other
	Plastic extesion					

Corrugations (width x depth) (in): 3 x 2

Pipe Conditions:	good	abraided	rust-through	Other

Inlet Type:	projecting	headwall	wingwalls	mitered

Outlet Config.	At Grade	Freefall to Pool	Cascade over riprap	
	Outlet Apron		Other	

	Inlet	Middle	Outlet
Embeded:	0		0

Substrate Size: Large Gravel and Cobble

Culvert Velocities:

	depth (m)	Vel (m/s) or Counts/40	Begin	End	Time
Inlet			15536	19718	59.77
Outlet			19718	24135	62.59
Middle			33062	36513	33.64
			36513	40086	38.53

Flow Time:	#1	#2	#3	#4	#5
Begin	24135	28540			
End	28540	33068			
Time					
	58.47	59.09			

For General Oceanics flow meter use Flow time section. Flow time for solute additions or bouyant objects.

Upstream Channel Widths (m)

5.5	4.7	5.5	5.3	4.7	5.1		

Downstream Channel Widths (m)

Culvert Survey Data Sheet page 2

Road:	Edgerton Park
Stream Name:	Government Creek

Tailwater Control: Pool Tailout log-weir Boulder weir

concrete weir channel x-section

Tailwater Cross-sections:

Station (m)	1.5	2.25	2.35	4.2	5.5	6.5	8.2
Elevation (m)	2.715	3.16	3.505	3.562	3.49	3.4	3.367
water depth (m)			0.18	0.23	0.21	0.13	0.07
Notes							
Station (m)	9.3	12.8	15.3				
Elevation (m)	3.36	3.29	2.971				
water depth (m)	0.07						
Notes							

Channel Slope:

	Ht 1 (m)	Ht. 2 (m)	wd 1 (m)	wd 2 (m)	Dist 1 (m)	Dist 2 (m)
Upstream:	1.76	2	0.24	0.26	0	12
Downstream:						

Discharge:

Dist (m)	wd (ft)	Vel or Cnts/40s	
2	0.95	21	
2.4	0.7	54	
2.8	0.7	135	
3.2	0.45	144	
3.8	0.25	55	
4.4	0.2	47	
5.1	0.1	10	
6	0.4	54	
6.33	0	0	

Culvert Elevations:

	Elev (m)	wd (m)
Inlet Invert:	2.692	0.38
Outlet Invert:	3.15	0.22
Pool Bottom:	4.205	0.92
Pool Depth:	0.92	
OHW at Control:		
Culvert Length (m)	15	

Fish Species Observations:

Notes:

Government Creek at Edgerton Park Road

Discharge Measurement	
Date	6/8/2007
Flowing Channel Width (m)	4.33
Flowing Channel Area (m2)	0.48
Averaage Depth (m)	0.11
Discharge (m3/s)	0.26
Ave Velocity (cm/s)	54.04
Discharge (cfs)	9.20
Area (ft2)	5.19
Ave Velocity (ft/s)	1.77

Culvert Data			
Shape	Circular		Culvert Slope
Construction	3 x 1		0.030533
Sunkent Depth (ft)	0		
Diameter (in)	63.385827		
Culvert Length (ft)	49.212598	Pool Bottom	86.20407
Inlet Bottom Elev (ft)	91.167979		
Outlet Bottom Elev (ft)	89.665354		

Outlet Channel Characteristics

Station	Dist (m)	Elev (m)	Dist (ft)	Elev (ft)	Channel Slope
	1.5	2.715	4.92126	91.09252	0.02
	2.25	3.16	7.38189	89.63255	
	2.35	3.505	7.709974	88.50066	
	4.2	3.562	13.77953	88.31365	
	5.5	3.49	18.04462	88.54987	
	6.5	3.4	21.32546	88.84514	
	8.2	3.367	26.90289	88.95341	
	9.3	3.36	30.51181	88.97638	
	12.8	3.29	41.99475	89.20604	
	15.3	2.971	50.19685	90.25262	
			0	100	

Data Check	**Measured Values**		**Fish Xing v2**			Leap, Velocity **Fish Xing V3**	
	Vel (m/s)	Vel (cm/s)	Vel (ft/s)	Vel (ft/s)	Accuracy	Reduc.	Vel (ft/s)	Accuracy
Inlet	1.89	188.83	6.20	5.97	96.36	1.04	6.91	111.53
Outlet	2.33	232.66	7.63	5.55	72.71	1.38	5.45	71.40
Middle	2.02	202.46	6.64	5.55	83.56	1.20	5.45	82.05
	2.06	205.92	6.76	5.55	82.15	1.22	5.45	80.67

Culvert Survey Data Sheet

Surveyors JCD/NE Date 6/7/2007

Latitude: 61 35 31.3 Longitude: 149 39 49.5

Road: Meadow Lakes Mile Post:

Stream Name: Little Meadow Creek Watershed: Big Lake

Culvert Type:

Circular ____ Pipe Arch x Box ____ Open Arch ____ Other ____

	Ht (m)	Width (m)	Rustline Ht.(m)	Ht (m)	Width (m)	Rustline Ht.(m)
Inlet:	3.7	1.5	Outlet:	1.6	3.75	

Material:

SSP | CSP | Aluminum | Plastic | Concrete | Log/wood | Other

Corrugations (width x depth) (in): 6 x 2

Pipe Conditions: good | abraided | rust-through | Other

Inlet Type: projecting | headwall | wingwalls | mitered

Outlet Config. At Grade | Freefall to Pool | Cascade over riprap

Outlet Apron Other

Inlet Middle Outlet

Embeded: N/A

Substrate Size: Small to large gravel.

Culvert Velocities:

	depth (m)	Vel (m/s) or Counts/40s
Inlet	0.3 ft	86 cnts/40s
Outlet	0.52 ft	46 cnts/40s
Middle	0.72 ft	39 cnts/40s

Flow Time:	#1	#2	#3	#4	#5
Begin					
End					
Time					

For General Oceanics flow meter use Flow time section. Flow time for solute additions or bouyant objects.

Upstream Channel Widths (m)

3.3	2.3	2.5	2.1	2.4	2.8		

Downstream Channel Widths (m)

2.9	3	3.5	2.3	2			

Culvert Survey Data Sheet page 2

Road: Meadow Lakes
Stream Name: Little Meadow Creek

Tailwater Control: Pool Tailout log-weir Boulder weir

concrete weir channel x-section

Tailwater Cross-sections:

Station (m)	6.4	5.67	5.05	4.4	3.7	2.9	2.3
Elevation (m)	2.141	2.109	2.897	2.96	2.991	3.03	2.954
water depth (m)			0	0.11	0.14	0.19	0.1
Notes							

Station (m)	2.1	0.5					
Elevation (m)	2.109	2.141					
water depth (m)							
Notes							

Channel Slope:

	Ht 1 (m)	Ht. 2 (m)	wd 1 (m)	wd 2 (m)	Dist 1 (m)	Dist 2 (m)
Upstream:						
Downstream:	3.042	3.147	0.2	0.22	0	13

Discharge:

Dist (m)	wd (ft)	Vel or Cnts/40s	
2.2	0.29	0	
2.7	0.41	33	
3.2	0.5	43	
3.6	0.45	41	
4	0.35	33	
4.4	0.3	29	
4.75	0.4	13	
5.06	0	0	

Culvert Elevations:

	Elev (m)	wd (m)
Inlet Invert:	2.861	0.09
Outlet Invert:	3.042	0.2
Pool Bottom:		
Pool Depth:		
OHW at Control:	2.731	

Culvert Length (m) 21.2

Fish Species Observations:
Lamprey spaning upstream and downstream of culvert. Juvenile salmon observed above and belo culvert

Notes:

Little Meadow Creek at Meadow Lakes Raod

Discharge Measurement	
Date	6/7/2007
Flowing Channel Width (m)	2.86
Flowing Channel Area (m2)	0.33
Averaage Depth (m)	0.11
Discharge (m3/s)	0.08
Ave Velocity (cm/s)	23.95
Discharge (cfs)	2.75
Area (ft2)	3.50
Average Velocity (ft/s)	0.79

Culvert Data		
Shape	Pipe Arch	Culvert Slope
Construction	6 x 1	0.0085377
Rise (ft)	5.249344	
Span (ft)	12.30315	
Culvert Length (ft)	69.55381	
Inlet Bottom Elev (ft)	90.61352	
Outlet Bottom Elev (ft)	90.01969	

Outlet Channel Characteristics

Station	Dist (m)	Elev (m)	Dist (ft)	Elev (ft)	Channel Slope
	6.4	2.141	20.99738	92.97572	0.0080769
	5.67	2.109	18.60236	93.08071	
	5.05	2.897	16.56824	90.49541	
	4.4	2.96	14.4357	90.28871	
	3.7	2.991	12.13911	90.18701	
	2.9	3.03	9.514436	90.05906	
	2.3	2.954	7.545932	90.3084	
	2.1	2.109	6.889764	93.08071	
	0.5	2.141	1.64042	92.97572	

Data Check		**Measured Values**		**Fish Xing v2**			Velocity Barrier **Fish Xing V3**	
	Vel (m/s)	Vel (cm/s)	Vel (ft/s)	Vel (ft/s)	Accuracy	Red. Fac.	Vel (ft/s)	Accuracy
Inlet	0.66	66.19	2.17	1.54	70.92	1.41	1.56	71.84
Outlet	0.36	35.80	1.17	0.52	44.27	2.26	0.53	45.12
Middle	0.30	30.48	1.00	1.12	111.99	0.89	1.13	112.99

Culvert Survey Data Sheet

Surveyors JCD/NE Date 6/8/2007

Latitude: Longitude:

Road: Settlement Avenue Mile Post:

Stream Name: Cottonwood Creek Watershed: Cottonwood Creek

Culvert Type:

Circular ____ Pipe Arch x Box Open Arch ____ Other ____

	Ht (m)	Width (m)	Rustline Ht.(m)		Ht (m)	Width (m)	Rustline Ht.(m)
Inlet:	1.45	3		Outlet:	1.45	3	

Material:

SSP | CSP | Aluminum | Plastic | Concrete | Log/wood | Other

Corrugations (width x depth) (in): 6 x 2

Pipe Conditions: good | abraided | rust-through | Other

Inlet Type: projecting | headwall | wingwalls | mitered

Outlet Config. At Grade | Freefall to Pool | Cascade over riprap

Outlet Apron | Other

Inlet | Middle | Outlet

Embeded: NA Bottomless Arch

Substrate Size: Cobble and large to small gravel

Culvert Velocities:

	depth (m)	Vel (m/s) or Counts/40s
Inlet	1 ft	47
Outlet	0.35 ft	70
Middle		

Flow Time:	#1	#2	#3	#4	#5
Begin	40163	40486			
End	40486	40895			
Time					
	51.31	54.35			

For General Oceanics flow meter use Flow time section. Flow time for solute additions or bouyant objects.

Upstream Channel Widths (m)

2.7	3.4	2.7	2.9	3			

Downstream Channel Widths (m)

3	3.4	3.2	2.9	4.2			

Culvert Survey Data Sheet page 2

Road:	Settlement Avenue
Stream Name:	Cottonwood Creek

Tailwater Control: Pool Tailout log-weir Boulder weir

concrete weir channel x-section

Tailwater Cross-sections:

Station (m)	0.5	1.3	2	2.8	3.5	4.4	4.2
Elevation (m)	2.41	2.617	2.901	2.809	2.895	2.812	2.7
water depth (m)			0.27	0.19	0.27	0.19	0.07
Notes							
Station (m)	5.6	6					
Elevation (m)	2.47	2.465					
water depth (m)							
Notes							

Channel Slope:

	Ht 1 (m)	Ht. 2 (m)	wd 1 (m)	wd 2 (m)	Dist 1 (m)	Dist 2 (m)
Upstream:						
Downstream:	2.751	2.895	0.16	0.27	0	10.2

Discharge:

Dist (m)	wd (ft)	Vel or Cnts/40s	
1	0	0	
1.4	0.3	59	
1.8	0.4	85	
2	0.4	75	
2.6	0.45	78	
3	0.4	64	
3.5	0.15	36	
3.65	0	0	

Culvert Elevations:

	Elev (m)	wd (m)
Inlet Invert:	2.882	0.32
Outlet Invert:	2.751	0.16
Pool Bottom:		
Pool Depth:		
OHW at Control:		

Culvert Length (m) 19.4

Fish Species Observations:

Juvenile coho (yoy) above and below culvert.

Notes:

Discharge Measurement	Cottonwood at Settlement
Date	6/8/2007
Flowing Channel Width (m)	3.65
Flowing Channel Area (m2)	0.80
Averaage Depth (m)	0.22
Discharge (m3/s)	0.13
Ave Velocity (cm/s)	16.70
Discharge (cfs)	4.73
Area (ft2)	8.64
Average Velocity (ft/s)	0.55

Culvert Data

Shape	Pipe-Arch	Culvert Slope
Construction	6 x 2	-0.006753
Rise (ft)	4.757218	
Span (ft)	9.84252	
Culvert Length (ft)	63.64829	
Inlet Bottom Elev (ft)	90.54462	
Outlet Bottom Elev (ft)	90.97441	

Outlet Channel Characteristics

Station	Dist (m)	Elev (m)	Dist (ft)	Elev (ft)	Channel Slope
	0.5	2.41	1.64042	92.09318	0.014118
	1.3	2.617	4.265092	91.41404	
	2	2.901	6.56168	90.48228	
	2.8	2.809	9.186352	90.78412	
	3.5	2.895	11.48294	90.50197	
	4.4	2.812	14.4357	90.77428	
	4.2	2.7	13.77953	91.14173	
	5.6	2.47	18.3727	91.89633	
	6	2.465	19.68504	91.91273	
			0	100	
			0	100	

Data Check	**Measured Values**		**Fish Xing v2**			Barrier Type: **Fish Xing V3**	
	Vel (m/s)	Vel (cm/s)	Vel (ft/s)	Vel (ft/s)	Accuracy	Red. Fac	Vel (ft/s)	Accuracy
Inlet	0.37	36.56	1.20	1.24	103.38	0.97	0.80	66.70
Outlet	0.54	54.03	1.77	1.21	68.26	1.47	3.48	196.31
Middle	0.17	16.92	0.56	1.00	180.18	0.56	0.82	147.74
	0.20	20.22	0.66	1.00	150.72	0.66	0.82	123.59

Culvert Survey Data Sheet

Surveyors JCD/NE Date 6/8/2007

Latitude: 61 34 37.3 Longitude: 149 16 55.4

Road:	Lower Road	Mile Post:	
Stream Name:	Wasilla Creek	Watershed:	Wasilla Creek

Culvert Type:

Circular	Pipe Arch	Box	Open Arch	Other
x				

	Ht (m)	Width (m)	Rustline Ht.(m)		Ht (m)	Width (m)	Rustline Ht.(m)
Inlet:	2.1	2.5		Outlet:	2.1	2.5	

Material:

SSP	CSP	Aluminum	Plastic	Concrete	Log/wood	Other
	x					

Corrugations (width x depth) (in): 6 x 2

Pipe Conditions:	good	abraided	rust-through	Other
	x			

Inlet Type:	projecting	headwall	wingwalls	mitered
			x	

Outlet Config.	At Grade	Freefall to Pool	Cascade over riprap
	x		

	Outlet Apron	Other

	Inlet	Middle	Outlet
Embeded:	0.4		0.4
Substrate Size:	Cobble, large gravel, silt		

Culvert Velocities:

	depth (m)	Vel (m/s) or Counts/40s
Inlet	1.75 ft	104
Outlet	From Discharge	
Middle	0.9 ft	56

Flow Time:	#1	#2	#3	#4	#5
Begin					
End					
Time					

For General Oceanics flow meter use Flow time section. Flow time for solute additions or bouyant objects.

Upstream Channel Widths (m)

4.7	4.2	5.1	4.9	4.4			

Downstream Channel Widths (m)

6.2	4.2	5.3	5.1				

Culvert Survey Data Sheet page 2

Road:	Lower Road
Stream Name:	Wasilla Creek

Tailwater Control: Pool Tailout log-weir Boulder weir

concrete weir channel x-section

Tailwater Cross-sections:

Station (m)	0.35	0.9	1.3	1.55	2.6	3.8	4.8
Elevation (m)	1.99	2.46	2.62	3.166	3.233	3.211	3.165
water depth (m)							
Notes							
Station (m)	5.95	6.9	7.6				
Elevation (m)	2.953	2.739	2.492				
water depth (m)							
Notes							

Channel Slope:

	Ht 1 (m)	Ht. 2 (m)	wd 1 (m)	wd 2 (m)	Dist 1 (m)	Dist 2 (m)
Upstream:						
Downstream:	3.181	3.211	0.28	0.28	0	5.1

Discharge:

Dist (m)	wd (ft)	Vel or Cnts/40s	
0.6	1	61	
1	1	58	
1.5	1	35	
2	0.8	57	
2.5	0.8	47	
3	0.9	58	
3.5	0.9	91	
4	0.75	24	
4.25	0	0	

Culvert Elevations:

	Elev (m)	wd (m)
Inlet Invert:	3.417	0.58
Outlet Invert:	3.181	0.28
Pool Bottom:		
Pool Depth:		
OHW at Control:		

Culvert Length (m) 12

Fish Species Observations:

Notes:

Wasilla Creek at Lower Road

Discharge Measurement	
Date	6/8/2007
Flowing Channel Width (m)	4.25
Flowing Channel Area (m2)	0.95
Averaage Depth (m)	0.22
Discharge (m3/s)	0.40
Ave Velocity (cm/s)	41.91
Discharge (cfs)	14.13
Area (ft2)	10.27
Average Velocity (ft/s)	1.38

Culvert Data		
Shape	Circular	Culvert Slope
Construction	6 x 2 Pipe Arch	-0.019667
Rise (ft)	6.889764	
Span (ft)	8.2021	
Culvert Length (ft)	39.37008	
Inlet Bottom Elev (ft)	88.78937	
Outlet Bottom Elev (ft)	89.56365	

Outlet Channel Characteristics

Station	Dist (m)	Elev (m)	Dist (ft)	Elev (ft)	Channel Slope
	0.35	1.99	1.148294	93.47113	0.0058824
	0.9	2.46	2.952756	91.92913	
	1.3	2.62	4.265092	91.4042	
	1.55	3.166	5.085302	89.61286	
	2.6	3.233	8.530184	89.39304	
	3.8	3.211	12.46719	89.46522	
	4.8	3.165	15.74803	89.61614	
	5.95	2.953	19.521	90.31168	
	6.9	2.739	22.6378	91.01378	
	7.6	2.492	24.93438	91.82415	
			0	100	

						Barrier Type: Velocity	
Data Check		**Measured Values**		**Fish Xing v2**		**Fish Xing V3**	
	Vel (m/s)	Vel (cm/s)	Vel (ft/s)	Vel (ft/s)	Accuracy	Vel (ft/s)	Accuracy
Inlet	0.80	79.86	2.62	2.04	77.86	1.46	55.72
Outlet	0.41	41.00	1.35	1.57	116.72	3.33	247.56
Middle	0.43	43.40	1.42	1.57	110.27	1.50	105.35

Appendix B—Site Location Photographs

Photograph 1. Colter Creek upstream of N. Seitze Road Crossing.

Photograph 2. Colter Creek outlet.

Photograph 3. Outlet of Crocker Creek at mile 2, Settler's Bay Road showing constructed outlet control structure.

Photograph 4. Upstream of Crooked Lake Creek (upstream crossing).

Photograph 5. Outlet of Crooked Lake Creek (upstream crossing).

Photograph 6. Inlet of Lower Crooked Lake Creek culvert.

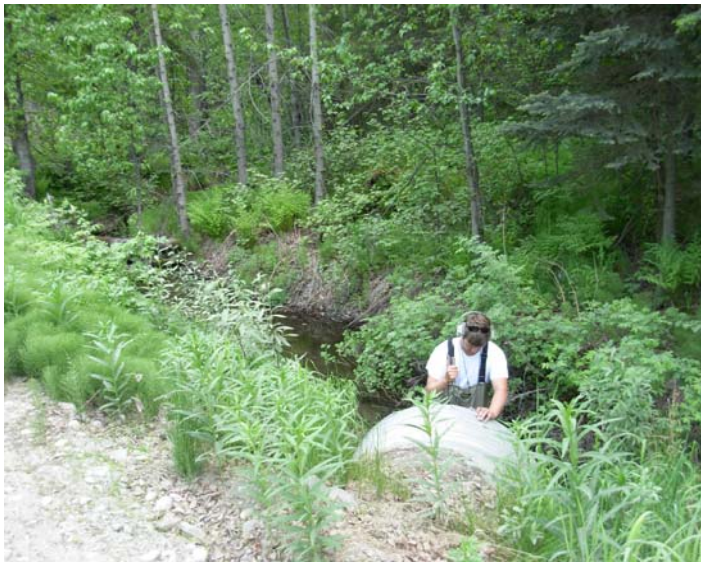
Photograph 7. Outlet of second Crooked Lake Creek culvert.

Photograph 8. Outlet of Government Creek crossing.

Photograph 9. Measuring discharge at outlet of Lucy Creek 3 crossing.

Photograph 10. Constructed Lucy Creek channel downstream from crossing number 3.

Photograph 11. Lucy Creek upstream from crossing number 3.



Photograph 12. Lucy Creek at the outlet of crossing number 2.

Photograph 13. Outlet of Little Meadow Creek at Meadow Lakes Loop road.

Photograph 14. Inlet of Little Meadow Creek crossing of Meadow Lakes Loop Road.