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Salmon Passage Restoration Cost – Benefit Prioritization for the Matanuska-Susitna Basin, Alaska

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Salmon Passage Restoration Cost-Benefit Prioritization for the Matanuska Susitna Basin, Alaska, 2016

Franklin Dekker and William Rice, PE

Abstract

The Matanuska-Susitna (Mat-Su) basin in Southcentral Alaska is home to five species of Pacific salmon (*Oncorhynchus* spp.) and is the fastest developing region in Alaska. Since 2000, the Alaska Department of Fish and Game (ADF&G) has documented a total of 573 manmade stream crossings, typically culverts at stream crossings in the Mat-Su. This is estimated to be over 95% of all Mat-Su crossings in fish-bearing waters. The U.S. Fish and Wildlife Service (USFWS), ADF&G and the Mat-Su Basin Salmon Habitat Partnership (Partnership) have worked since 2000 to restore fish passage at sites that do not provide adequate salmon passage. To optimize barrier replacement efforts the Partnership identified the need for a cost-benefit prioritization of salmon barriers at road-stream crossings. This was done by developing a barrier replacement cost estimate and measuring the length of habitat upstream of each barrier. From measurements of distance upstream of each barrier and an estimated cost based on a nonlinear regression of past replacement costs and stream width, we calculated an estimated replacement cost per mile. Top barriers were selected based on miles of upstream habitat and then ranked by their cost-benefit value. Barriers replaced for salmon passage were also identified because no comprehensive list existed since replacement projects began in 2000 and an analysis of past replacements was used to inform this report. As of 2015, 476 of the 573 inventoried fish passage sites were located on salmon bearing streams, and 287 were classified by ADF&G as likely or potential passage barriers for 55 mm juvenile Coho Salmon *O. kisutch*. These barriers may affect juvenile salmon access to an estimated 455 miles of habitat. Of the 287 classified barriers, 55 accounted for 75% of the total miles of habitat upstream of barriers and were selected for the cost-benefit analysis. Results of the cost-benefit analysis indicate that 15 of the 55 barriers with the lowest cost per mile value should be given priority for restoration over the next 5 years. The 15 barriers selected account for 184.5 miles and would cost approximately $4.8 million to replace. Future prioritizations could include additional factors such as upstream habitat quality, lake acreage, culvert perch height, improved stream network miles, improved cost estimates, presence of invasive Northern Pike (*Esox Lucius*) or Partnership-defined priority water bodies.

Introduction

Each year in the Matanuska-Susitna (Mat-Su) basin in Southcentral Alaska, five species of Pacific salmon (*Oncorhynchus spp*.) return to spawn in the basin's numerous watersheds. Salmon are an integral part of life for Mat-Su residents who value open spaces, a rural lifestyle and wish to live in close proximity to job centers in Anchorage, Alaska. The basin has been the fastest developing region in Alaska for the past two decades. The human population is projected to increase from 74,000 in 2005 to 100,000 by 2020 (Fried 2007). Although other salmon barriers exist such as small dams, culverts at road crossings are the most prevalent anthropogenic fish migration barrier feature in the Mat-Su basin. Current culvert construction typically provides adequate size, slope and natural substrate for salmon passage. However, many culverts installed prior to 2000 were installed without consideration for maintaining salmon passage and pose partial or full barriers to the migration of Pacific salmon at one or more life stages.

Author: Franklin Dekker is a hydrologist and William Rice is an engineer with the U.S. Fish and Wildlife Service. The authors can be contacted at Anchorage Fish and Wildlife Field Office, 4700 BLM Road, Anchorage, Alaska 99507 or at Franklin_Dekker@fws.gov and William_Rice@fws.gov.

Restoring fish passage in the Mat-Su basin typically requires replacing undersized or perched culverts with similar structures designed for flood flows and fish passage. Costs for culvert replacements, including design, engineering, construction and re-vegetation can vary from $50,000 to over $500,000, which necessitates careful prioritization of restoration funding to maximize benefits to salmon.

Damaged or older culverts in the Mat-Su basin can act as barriers to juvenile salmon movement by creating conditions where salmon are unable to move freely upstream or downstream to important habitats. Culverts that are undersized, placed above stream grade, or angled too steeply can result in flows with high velocity, internal turbulence, or inadequate flow depth that may create conditions inadequate for salmon passage (Kane and Wellen 1985; Hotchkiss and Frei 2007). Juvenile salmon especially have limited ability for sustained-burst swimming required to pass through culverts with high velocity flows. Culverts may also be barriers if they are perched above the downstream water surface and create a drop such that juvenile salmon or in some cases adult salmon are prevented from entering (Powers and Orsborn 1985). Other culverts that are long or lack natural substrate may cause behavioral changes and delay movements (Hotchkiss and Frei 2007). When adult salmon are impeded from traveling upstream to spawn, access to spawning habitat is effectively lost. Juvenile salmon may experience increased competition, predation and other stressors if unable to move freely between rearing and overwintering habitats (Lang et al. 2004). Barriers likely reduce overall potential salmon production in a system due to habitat fragmentation and these additional stressors.

The U.S. Fish and Wildlife Service (USFWS), Alaska Department of Fish and Game (ADF&G) and other partners have removed salmon barriers in the Mat-Su basin since 2000, but many barriers still exist and work will continue for many years. The Mat-Su Basin Salmon Habitat Partnership (Partnership) is a group of federal, state and local government agencies, NGOs, commercial entities, and private citizens, organized under the National Fish Habitat Partnership Program working collaboratively with the goal to ensure quality salmon habitat via protection and restoration. The Partnership has identified barrier replacements as a high priority for salmon conservation. Barrier replacements have the potential to reopen miles of habitat, and compared to other habitat restoration techniques, barrier removals can result in large increases in fish production with high cost-effectiveness (Scully et al 1990; Roni et al 2002). One Partnership goal is to replace salmon barriers with ‘stream simulated’ crossings that maintain natural substrate and processes through a culvert by providing adequate passage for aquatic organisms, organic matter, sediment, and floods (McKinnon and Hnytka 1985; Mat-Su Basin Salmon Habitat Partnership 2013). To help accomplish this goal and maximize the amount of habitat reopened, in 2013 the Partnership created Strategic Action 4.2.2 to “Develop and Implement Fish Passage Prioritization and Improvement Plan” based on an analysis of benefits to salmon versus cost of replacement (Mat-Su Basin Salmon Habitat Partnership 2013). This study completes a cost-benefit analysis as identified for the Partnership.

Priority lists of barriers have guided past replacement efforts in the Mat-Su, but they have not been comprehensive and have been hindered by a lack of complete assessment data and quantified benefits. An initial barrier removal prioritization was adopted by the Partnership in 2011 (Mat-Su Salmon Partnership 2011). The Mat-Su Salmon Passage Improvement Plan utilized ADF&G Level 1 culvert assessment information to identify culverts that were classified

as severe barriers to salmon based on culvert perch height, amount undersized, and slope (O'Doherty 2010). However, this prioritization did not consider replacement cost or the amount of potential upstream habitat. In addition, only half of the culverts in the Mat-Su had been assessed in 2011. In 2015, over 95% of all known barriers in the Mat-Su had been assessed and a cost-benefit analysis could be implemented that contained nearly all barriers. Although most barriers have been identified, verification of salmon presence and the ownership of barriers have not been cataloged for all sites.

This study complements other active prioritization efforts by the Partnership. ADF&G is developing a prioritization of barrier culverts based on an optimization model that analyzes the network of culverts located in a watershed to more accurately quantify the benefits of replacement in the context of other barriers located up- or downstream (G. O'Doherty, ADF&G, personal communication). The USFWS is developing a barrier selection optimization model from fish distribution and habitat quality information collected in the Big Lake watershed (Gerken and Sethi 2013). This model will determine the effectiveness of using biological data from both adult and juvenile salmon life stages to inform culvert replacements throughout the Mat-Su. Optimization models have been used successfully in the contiguous U.S. to inform restoration efforts (O'Hanley and Tomberlin 2005; O'Hanley 2011).

The goal is to prioritize barrier replacement on salmon bearing streams in the Mat-Su basin using a cost-benefit ranking where cost is estimated from past replacements and the benefit is quantified by upstream habitat measured in miles. In the process we will identify past barrier replacements, remaining barriers to salmon, and the entities that own them. Results include an analysis of past replacements and remaining barriers by ownership, a ranking of barriers according to cost-benefit value and short-term replacement targets.

Study Area

The Mat-Su basin encompasses an area of 63,000 km^2 including the watersheds of the Matanuska and Susitna rivers (Figure 1). The basin contains over 38,000 km of streams and thousands of lakes (Mat-Su Basin Salmon Habitat Partnership 2013). Glaciers located near the drainage divide in the Alaska Range and Chugach and Talkeetna mountains feed larger rivers, whereas streams that originate lower in the basin are primarily groundwater or wetland fed systems. The majority of development is located in the southern part of the basin around population centers of Palmer, Wasilla and Houston. Major roads extend from the core developed area north along the Parks Highway, east along the Glenn Highway and west on Petersville Road. Additional minor roads form a dense network in the core area. The Alaska Railroad also extends north and parallels the Parks Highway. The majority of fish passage sites are culverts located within this infrastructure.

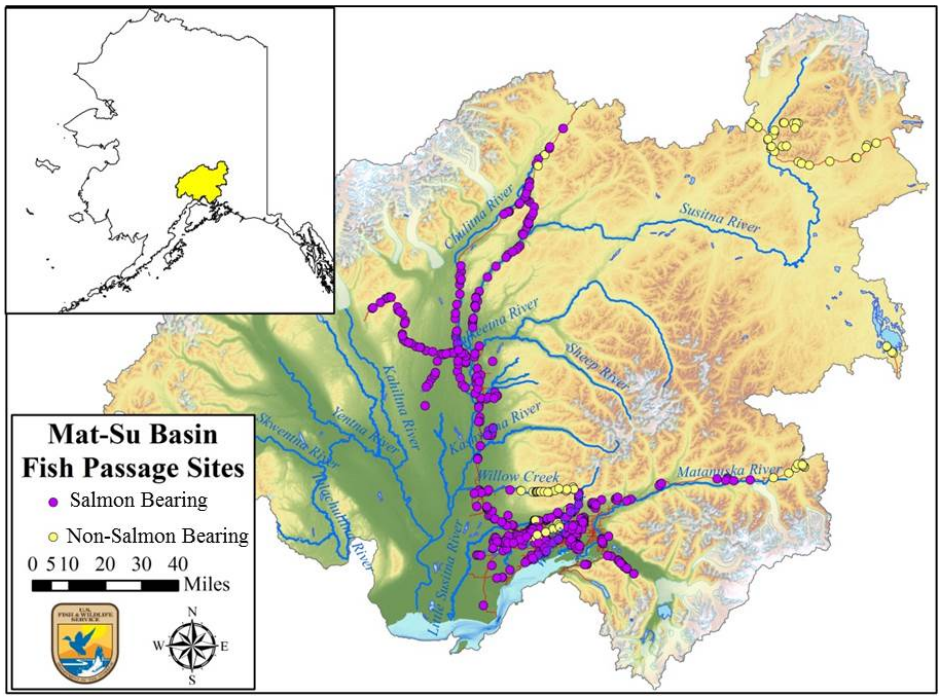

Figure 1. The location of assessed fish passage sites in the Mat-Su basin. Only fish passage sites on salmon bearing streams were analyzed for prioritization, but non-salmon bearing sites are also shown. Many of the fish passage sites are concentrated in the developed southern part of the basin, but they also extend north and east along the Parks, Glenn and Denali highways and railroad system. Of the total 573 fish passage sites 476 were identified as salmon bearing for this prioritization.

Methods

Data for each fish passage site were collected to create the final prioritization, including salmon presence, barrier rating, upstream stream miles, ownership and estimated replacement cost. Other potential prioritization metrics and methods that were considered, but not included are shown in Appendix A.

Fish Passage Site Selection

The ADF&G fish passage site database and USFWS records were used to identify fish passage sites in the Mat-Su. The fish passage sites were selected from the ADF&G GIS (Geographic Information System, ArcMap 10.3, ESRI) database of all fish passage sites in Alaska. The ADF&G database includes primarily culverts, but also some dams, fish ladders and low water crossings. Bridges are generally not included in the database unless they were formerly culverts and have been replaced since 2000. A total of 573 fish passage sites were identified, including 564 from the ADF&G database. An additional 8 sites from USFWS records, not found in the ADF&G database, were also identified. A subset of these 573 sites was identified as barriers and salmon bearing for prioritization.

Only Mat-Su fish passage sites on salmon bearing water bodies were selected. Non-salmon bearing sites were identified opportunistically based on locations in the basin where natural barriers are known to exclude salmon; for example sites along upper Willow Creek are upstream

of a natural slope barrier. Additional non-salmon bearing sites were identified from independent field surveys (ABR Inc. 2014). Sites were given one of three classifications**,** *Non-Salmon Bearing*, Anadromous Waters Catalog (AWC) *Salmon Bearing*, or *Likely Salmon Bearing*. A non-salmon bearing designation was defined as occurring within water bodies where salmon have not been documented. A salmon bearing designation was defined as occurring within water bodies in the AWC, which is an atlas of salmon bearing streams maintained by ADF&G. The remaining waterways with unknown or incomplete status in AWC, were designated as *likely salmon bearing* based on 1) under 12% stream slope and 2) occurring in watersheds with AWC listed waters that appear hydrologically connected based on laser derived elevation models (LiDAR) and aerial photo observations and an absence of natural barriers.

Barrier Selection

Barriers were selected from the salmon bearing fish passage sites based on ADF&G ratings. The ADF&G Level 1 assessment provides a rating of Green, Red, Gray or Black for fish passage sites on fish bearing streams in the Mat-Su basin. Ratings are classified based on the swimming ability of a 55 mm (fork length) juvenile Coho Salmon (*O. kisutch*) to successfully swim upstream through a barrier (O'Doherty 2010). Green rated sites are likely adequate for fish passage, whereas Red rated sites are assumed inadequate to pass juvenile fish (O'Doherty 2010). Gray sites may be inadequate for fish passage but additional analysis, such as use of FishXing or other hydraulic software are necessary to determine if a site should be rated as Green or Red. Sites with a Black rating require field surveys for assessment data. For the prioritization, only Red, Gray and Black rated fish passage sites were selected. Red and Gray sites were selected because they are most likely barriers to juvenile salmon. Black sites were included because their status is unknown and assumed to be barriers. The group of salmon bearing fish passage sites with Red, Gray, or Black ratings is referred to as "barriers", and when referring to all fish passage sites, "sites" is used.

Miles Upstream of Fish Passage Sites

The number of stream miles located upstream of fish passage sites is the most basic means of quantifying habitat where connectivity is potentially affected. All upstream miles used in this report were measured in GIS using existing streamlines in the National Hydrography Dataset, U.S. Geological Survey (USGS) 7.5-minute quadrangle topographic maps, and 1-foot aerial photo and LiDAR datasets. USFWS hydrologists completed measurements of upstream miles for all salmon bearing sites using methods applied by ADF&G (G. O'Doherty, personal communication). Miles were measured on all salmon bearing fish passage sites so analysis of barriers, non-barriers and replaced barriers could inform future replacement efforts. The metric of upstream miles could not be accurately enumerated on 52 fish passage sites because the streamlines were too small to measure using aerial photos or LiDAR. As a result, these sites were given a place holder value of 0.01 mile.

Two methods were used to delineate stream length upstream from each salmon bearing site. Both protocols measured miles upstream until the stream ended, or stream slope exceeded 12%, as measured manually from USGS topographic maps, which was considered the upper limit for salmon. The protocols, termed Non-Barrier Termination and Barrier Termination, differed where additional fish passage sites were encountered upstream as follows:

The Non-Barrier Termination Method: This method ceased delineation of stream miles when any upstream fish passage site (barrier or non-barrier) was encountered. These Non-Barrier Termination miles were used to present miles reopened from past barrier replacement projects to avoid recounting miles.

The Barrier Termination Method: This method continued delineation of stream miles upstream through non-barriers recorded as of the end of 2015, but ceased delineation at existing barriers. Barrier Termination miles were used for all prioritization of future barrier replacements.

Fish Passage Site Ownership

Fish passage site ownership was determined using GIS and data layers of railroads, and state and municipal roads. Sites were labeled; DOT for Department of Transportation, MSB for Mat-Su Borough, Railroad for Alaska Railroad, Private for private driveways, Houston for City of Houston, Wasilla for City of Wasilla, DNR for Department of Natural Resources, UAA for University of Alaska Anchorage, and BLM for Bureau of Land Management.

Barrier Replacement Estimated Cost

An estimate of the cost to restore each barrier was calculated using a nonlinear power function regression of past project costs and replaced culvert size. The relationship between cost and replaced culvert size was determined from a subset of 42 culverts replaced on Mat-Su Borough owned roads by USFWS, Mat-Su Borough and other partners between 2008 and 2014. The replacement costs included design, permitting and construction.

Before the regression analysis, design costs of the 42 replaced culverts were adjusted to represent the higher design costs in 2015 due to an increase in design complexity. Design cost was adjusted based on culvert width. Culverts less than 8 feet wide were adjusted to $50,000 for design and for culverts greater than 8 feet wide, design cost were adjusted to $75,000. Construction costs of the 42 replaced culverts were not adjusted. Based on USFWS project experience, construction costs were considered representative of current competitive construction costs for 2015 even though they were constructed in previous years (W. Rice, personal communication). The total cost of construction, permitting and adjusted design was used in the regression along with culvert width.

The replacement cost estimate for the remaining barriers was calculated using stream width as a substitute for culvert width in the regression equation. Stream width at upstream ordinary high water was collected for all barriers from ADF&G Level 1 assessment reports. Stream width was assumed to be a good approximation of minimum culvert width to estimate cost. The resulting regression equation was used to generate a cost estimate for sites with MSB, Private, Houston, Wasilla, DNR, and UAA ownership. For Railroad and DOT owned barriers, the regression equation was also used, but a correction factor of 200% was applied to regression results to approximate the consistently higher costs for Railroad and DOT projects (W. Rice, personal communication). In USFWS experience, DOT roads are larger and more costly to design and construct than the MSB roads used in the regression analysis. Railroad owned barriers are approximately twice as expensive as similar sized MSB owned crossings. All estimates were rounded up the nearest $1,000. For 14 barriers with more complex and expensive replacement

issues, a separate cost estimate was manually applied based on preliminary USFWS engineering estimates.

Replaced Barrier Selection
USFWS records of culvert replacement projects were compiled to determine which fish passage barriers had been replaced in the Mat-Su basin since 2000. A restored label was assigned to the sites that were replaced between 2000 and 2015. Restored sites were identified to characterize fish passage sites in the Mat-Su and ensure no restored barriers were mistakenly included in the prioritization.

Replaced Barrier Analysis
Replaced and remaining barriers were analyzed according to miles reopened and ownership to document progress and inform replacement strategies. Non-Barrier Termination miles were used for tables and figures in this section to avoid counting miles upstream of replaced barriers more than once. First, replacement progress was summarized by year to understand the rate of barrier replacement in the Mat-Su basin. Barrier replacement progress was then put in context of all salmon bearing fish passage sites in the Mat-Su with four pie charts grouped by ADF&G ratings between 2000 and 2015. The number of sites and miles upstream were summed according to each rating category (Red, Grey, Black, Green and Replaced). A second set of four pie charts grouped barriers by ownership and differentiated progress made by each owner between 2000 and 2015.

The comparison of fish passage site status between 2000 and 2015 was slightly problematic because only a small percentage of fish passage sites had been assessed as of 2000. The set of 2015 known sites, with replaced barriers and pre-replacement ratings, was used to approximate sites as they were in 2000. Less than an estimated 10 new crossings were installed between 2000 and 2015, therefore the comparison is considered a valid representation of barriers and upstream miles for this time.

Barrier Prioritization
Miles of stream length upstream of each barrier was used as the first prioritization factor. Barriers were ranked by Barrier Termination miles from largest to smallest. The barriers were then plotted on a curve to graphically analyze remaining barriers for replacement. The barrier rank according to miles upstream was used for the horizontal axis and the percentage of total miles upstream for the vertical axis. Each quartile of the chart was colored so high ranking barriers were shown in red and low ranking barriers in blue. The curve was used to select a subset of approximately 50 barriers that together constituted 75% of upstream miles for further cost-benefit analysis. Using the same method, the number of barriers that accounted for 75% of upstream miles was individually determined for the DOT, MSB, Railroad and Private ownership categories.

Cost-benefit analysis was conducted by dividing the estimated barrier replacement cost by upstream miles of habitat to create a cost per mile value. For the final prioritization, the subset of barriers that accounted for 75% of the remaining miles upstream was ranked by their cost-benefit values. The top 15 sites in this cost-benefit ranking were recommended for barrier replacements over the next 5 years.

Results

Fish Passage Site Selection

A total of 573 fish passage sites were assessed for salmon presence in the Mat-Su. Of 573 sites, 97 were located on non-salmon bearing streams, and 476 sites were located on salmon bearing streams or were presumed salmon bearing streams. The AWC confirmed salmon presence at 215 sites and an additional 261 were likely or presumably salmon bearing. The 476 salmon bearing sites were used for analysis of replaced barriers and prioritization of future replacements.

Barrier Selection

Of the 476 salmon bearing sites, 287 barriers were identified for prioritization according to the Red, Gray and Black ADF&G Level 1 ratings.

Miles Upstream of Fish Passage Sites

Upstream habitats measured in miles were collected for 424 fish passage sites and 52 sites were given a placeholder of 0.01 miles because they could not be enumerated from remote sensing data. Using the Non-Barrier Termination measurement method, 773 miles of habitat were located upstream of all fish passage sites versus 1,118 miles based on the Barrier Termination measurement method. For the 287 barriers in the Mat-Su, there were 345 miles of upstream habitat using the Non-Barrier method and 455 miles using Barrier Termination. The Non-Barriers method accounted for 44% and the Barrier Termination 40% of the total miles of habitat upstream of fish passage sites.

Fish Passage Site Ownership

Four ownership categories accounted for the majority of fish passage sites; MSB with 209, DOT with 207, Railroad with 72 and Private with 50. The other five ownership categories, BLM, DNR, Houston, Wasilla, and UAA collectively own 35 sites with each owner having less than 14 sites each. Barriers were found in all ownership categories except BLM, which has no fish passage sites on salmon bearing streams. Complete tables of barriers, grouped by owner, are located in Appendix B (Tables B3 – B10).

Barrier Replacement Estimated Cost

The power function regression of cost and culvert width although significant was not a strong fit (R^2 =0.38, $p < 0.001$) overall, but was used to provide a consistent, conceptual cost estimate for comparison purposes (Figure 2). The low correlation is likely caused by confounding factors such as variations in remoteness, road type, fill sources, depth of road fill, presence of utilities, size and experience of bidding contractors or other factors. Based on the power function and cost adjustments for DOT and Railroad barriers, replacement cost estimates range from $44,000 to $661,000. The 14 sites that were separately assigned cost estimates from USFWS assessments vary between $200,000 and $2,000,000 based on known complexities. Overall the mean cost estimate for each barrier is $233,000, but the mean cost for DOT and Railroad owned barriers is higher at $310,000. The total spent on past replacements between 2000 and 2015 is estimated to be approximately $17.9 million. The total replacement cost estimate for all remaining barriers in the Mat-Su basin is $66.9 million.

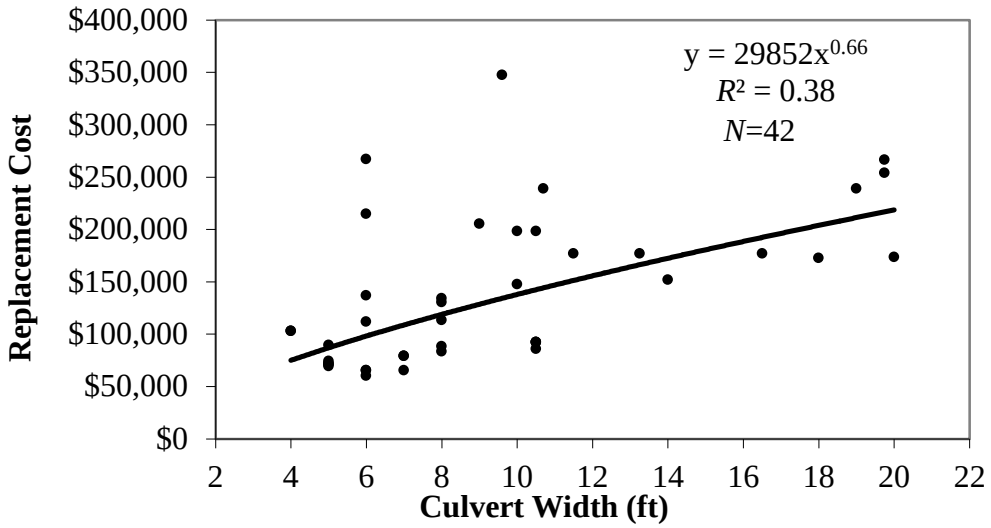

Figure 2. Barrier replacement cost and culvert width fit with a power function regression (R^2 =0.38, $p < 0.001$) for 42 culvert replacements conducted with USFWS involvement from 2008-2014.

Replaced Barrier Selection

Between 2000 and 2015, 105 barrier replacements on salmon bearing streams were completed in the Mat-Su basin, accounting for 21% of the 476 salmon bearing fish passage sites (Table 1). There were 8 replaced barriers not in the ADF&G fish passage database, but were included from USFWS records.

Table 1. Summary values for replaced barriers by year in the Mat-Su.

Year	Number of Barriers Replaced	Upstream Miles
2001	3	4
2002	1	0.2
2003	5	3.1
2004	8	15.7
2005	6	32.3
2006	3	1.3
2007	5	5.9
2008	13	17.1
2009	13	36.4
2010	14	31.5
2011	9	22.7
2012	11	15
2013	2	8.7
2014	8	9.6
2015	4	19.2
Total	**105**	**222.7**

Replaced Barrier Analysis

Analysis of past replacements and the remaining barriers was meant to inform strategies for future replacements. The rate of progress in the Mat-Su basin between 2000 and 2015 averaged 7 barriers removed and 14.8 miles of habitat reopened annually (Table 1). In 2000, the distribution of ADF&G ratings for salmon bearing fish passage sites was 63% Red, 17% Gray, 18% Green and 2% Black (Figure 3 Top). Miles upstream of barriers showed similar distributions by ratings (Figure 3). By 2015, 22% of the fish passage sites were restored and sites rated Red were reduced from 63% to 42% and 222 miles of streams were reopened (Figure 3 Bottom).

Analysis by ownership show MSB barriers have been reduced by almost half in the past 15 years and privately owned barriers by approximately a third (Figure 4). Barriers owned by the Railroad and DOT have collectively been reduced by 12, 4% of Railroad barriers and 8% of DOT barriers. DOT was responsible for approximately 50% of upstream habitat miles in 2000, but with a MSB restoration rate of 5 per year versus the DOT rate of 0.67 per year, DOT is now responsible for 67% of all current upstream miles above barriers. The barrier restorations included construction of 5 bridges, 2 rocky ramp grade elevations, 1 in-stream barrier removal and 97 culvert replacements. A complete list of replaced barriers is located in the Appendix B (Table B1).

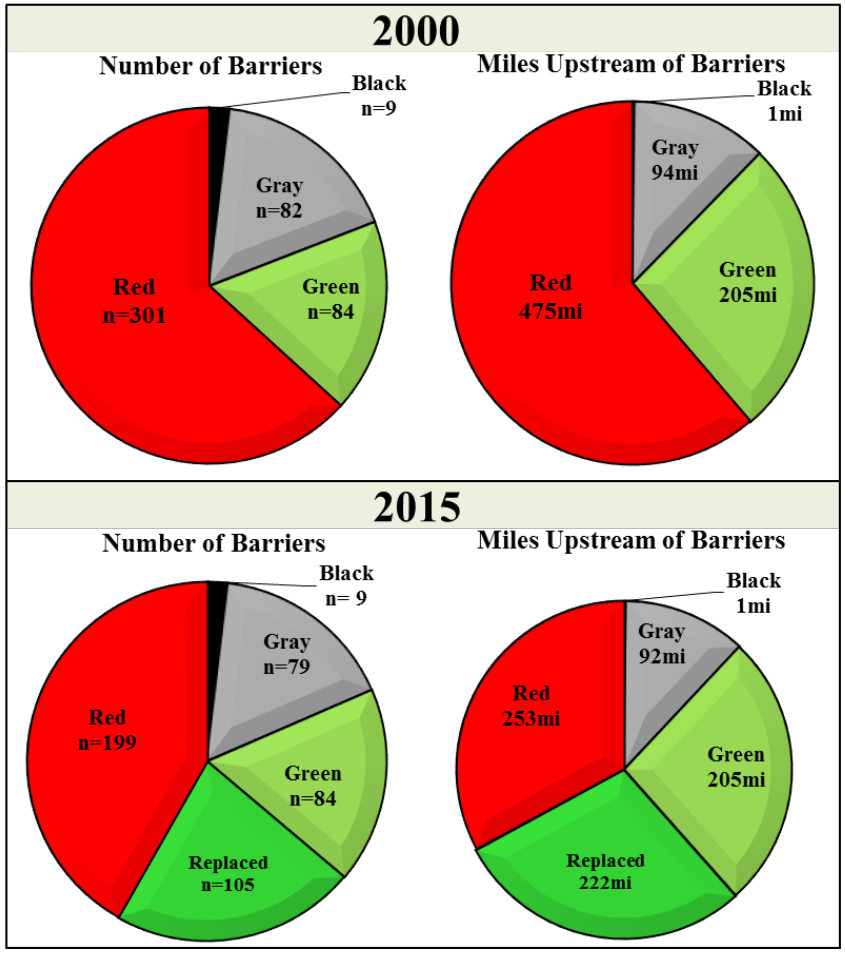

Figure 3. The pie charts on the left display the number of salmon bearing fish passage sites grouped by fish passage site rating in years 2000 and 2015. Note: the 2015 number of assessed salmon bearing fish passage sites was also used for 2000. Less than 10 new sites were installed between 2000 and 2015, therefore for comparison purposes this is considered a valid representation of barriers and upstream miles. The charts on the right display miles upstream. While most fish passage sites and miles are still rated Red, Gray or Black in 2015, indicating inadequate salmon passage, the growing number of restored barriers shows progress toward a transportation network with better salmon passage.

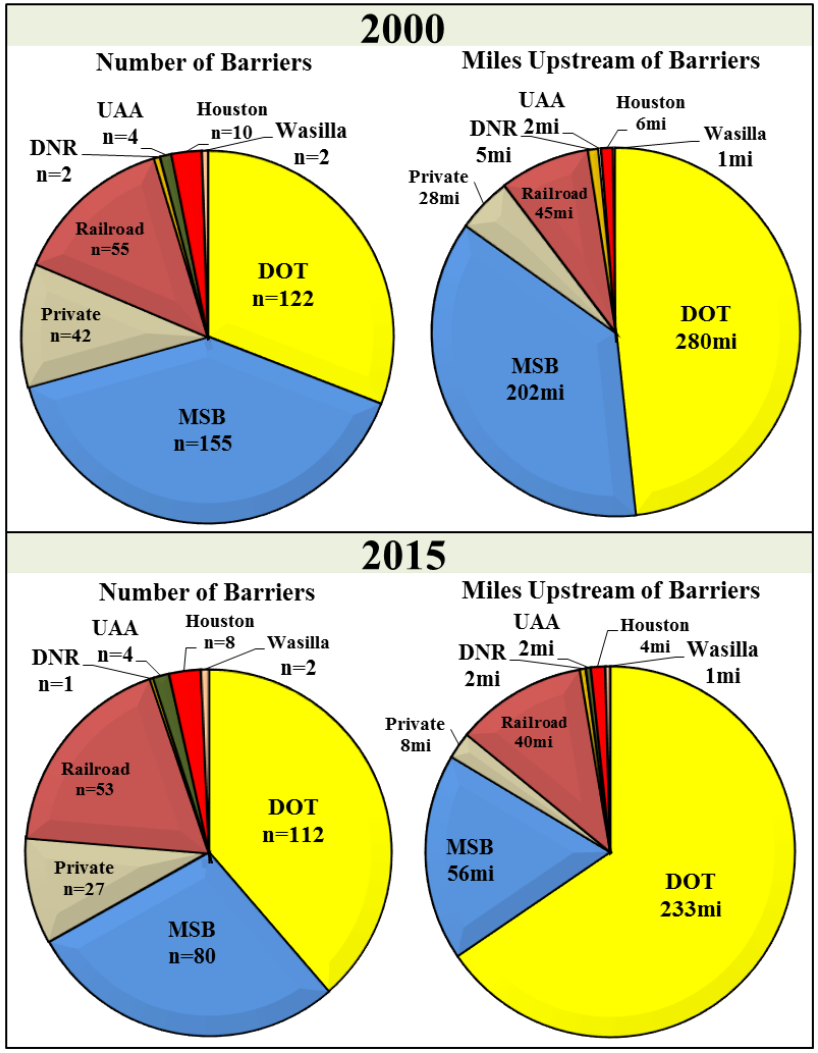

Figure 4. Charts display the number of barriers and upstream miles of habitat grouped by ownership: Alaska Department of Transportation (DOT), Mat-Su Borough (MSB) Alaska Railroad, Private, University of Alaska Anchorage (UAA), Alaska Department of Natural Resources (DNR), City of Houston and City of Wasilla. The upper pie charts display the status of barriers and miles in 2000 before restorations and the lower charts display the current status. The MSB and Privately owned barriers have reduced the most.

Barrier Prioritization

For 2016 and beyond the 287 remaining fish passage barriers were ranked and graphed by miles of upstream habitat to identify top barriers for prioritization (Figure 5). There are 55 barriers that account for 75% of remaining miles of upstream habitat (Appendix Table B2), but represent only 19% of the remaining barriers (Figure 5, Red, Orange and Yellow Quartiles). The 55 barriers were selected for further cost-benefit analysis and the top 4 barriers accounted for 25% (112.5 miles) of the total remaining upstream miles of habitat (Figure 5, Red Quartile). The 26 DOT and 23 MSB owned barriers account for 75% of remaining upstream miles of habitat by owner (Figure 6).

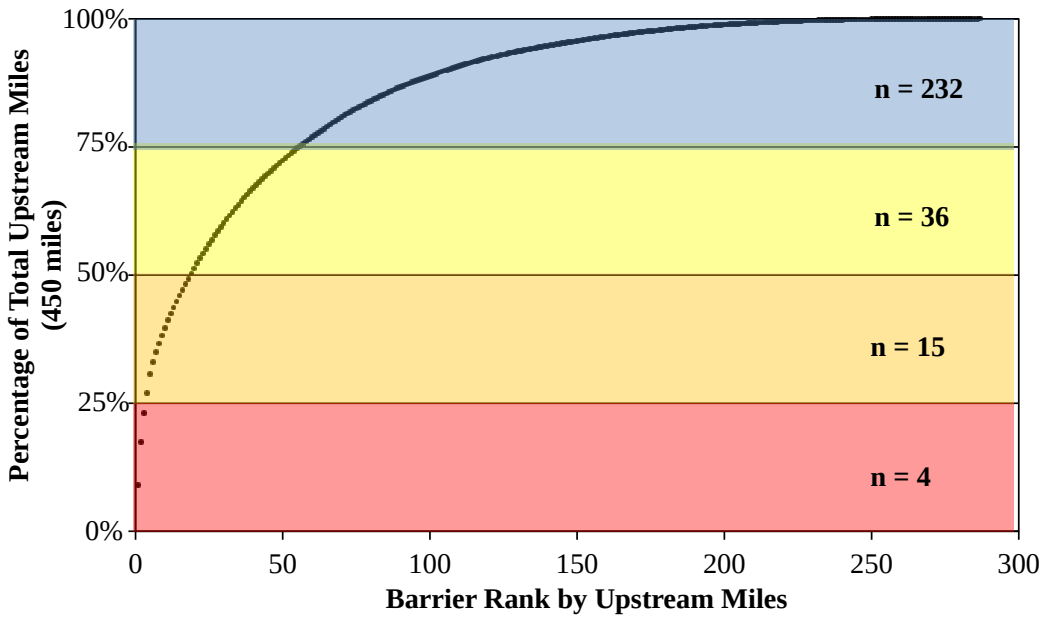

Figure 5. The curve displays the number of 287 remaining salmon barriers in order of upstream miles (horizontal axis) at the end of 2015, where the vertical axis is the percentage of total upstream miles. Each quartile accounts for 112.5 miles of upstream habitat (*n* = the number of barriers). To highlight barriers that will yield the most benefits, each quartile is color coded with highest ranking barriers in red and the lowest ranking in blue.

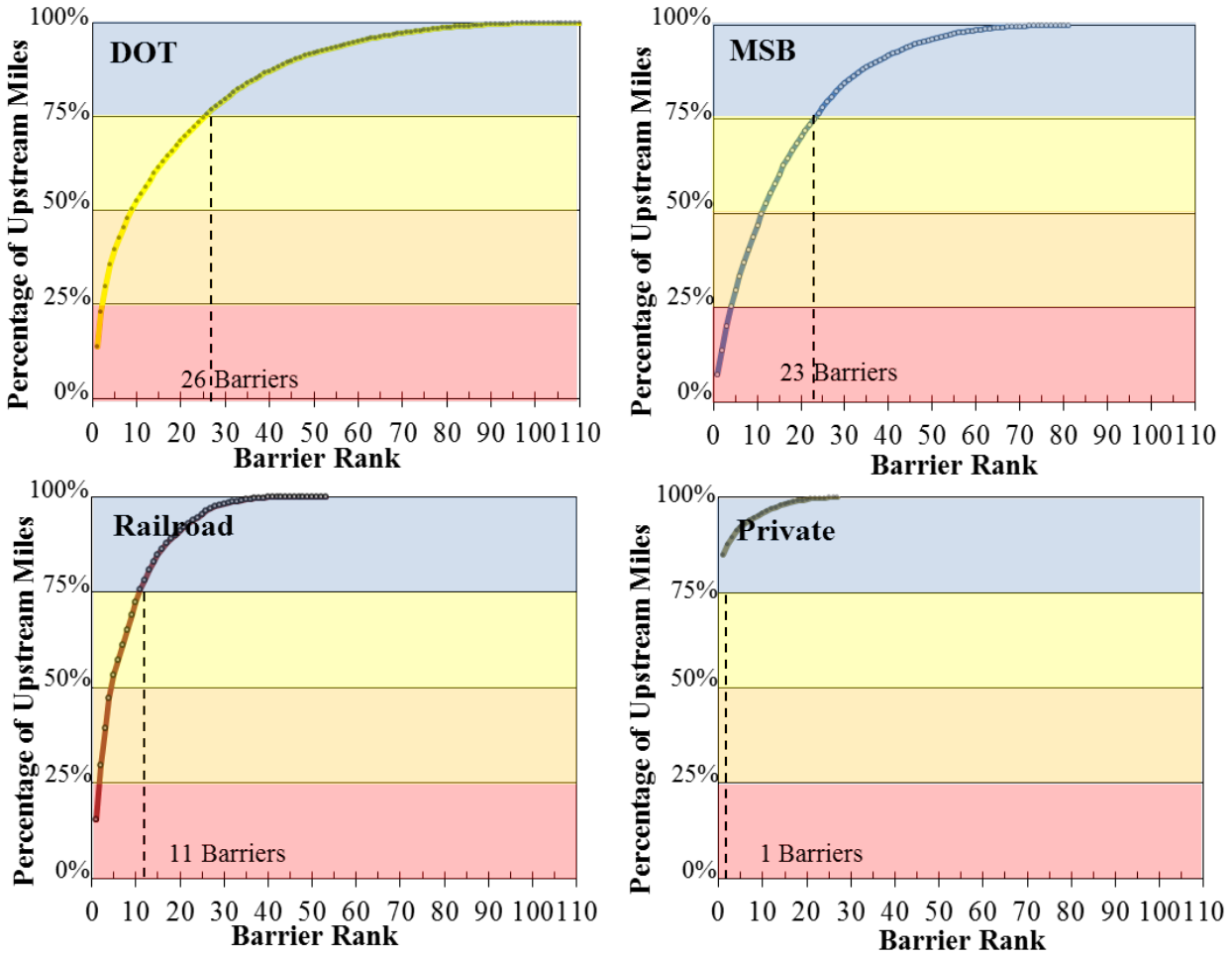

Figure 6. These graphs represent the percentage of habitat in miles upstream of barriers grouped by the four main ownership categories. The dashed line in each graph corresponds to the number of barrier replacements required for each owner to restore 75% of their remaining upstream miles. The 75% of remaining upstream miles of habitat include 277 miles for DOT, 65.7 miles for MSB, 53 miles for the Railroad, and 47.8 miles for privately owned.

The top 55 barriers determined by overall miles of upstream habitat were ranked by their cost-benefit value for the final prioritization (Table 2). To replace all 55 barriers the estimated cost is $23 million. On average the estimated cost for each replacement is $430,000, but costs range from $85,000 to $2,000,000. The average cost per mile of stream reopened is $102,000 per mile. A subset of 15 barriers with the best cost-benefit values were assessed for a 5-year replacement strategy. The top 15 according to cost-benefit are estimated to cost $4.7 million and would open 184 miles of streams (Table 3).

Table 2. A cost-benefit prioritization of top 55 salmon barriers from the top three, Red, Orange and Yellow upstream miles quartiles (Figure 6). Note that field verification is required before any replacement decisions because the ranking is based on best estimates of upstream miles and cost.

Fish Pass. Site #	Road Name	Stream Name	Owner	ADFG rating	Creek Width (ft)	Estimated Cost	Non-Barrier Termination Miles	Barrier Termination Miles	**Upstream Mile Ranking**	Cost-Benefit ($ per mi)	**Cost Benefit Ranking**
20401335	Private Drive	Wasilla Creek	Private	Gray	37.8	$377,000	1.4	40.7	**1**	$9,273	**1**
20501394	Parks Highway	Trapper Creek	DOT	Red	23.4	$549,000	37.5	37.5	**2**	$14,654	**2**
20501092	Birch Road	Unnamed	Houston	Red	6.0	$111,000	3.1	4.5	**21**	$24,809	**3**
20501379	Parks Highway	Pass Creek	DOT	Gray	30.8	$659,000	7.9	25.6	**3**	$25,773	**4**
20501417	Talkeetna Spur Rd	Answer Creek	DOT	Red	20.8	$507,000	18.0	18.0	**4**	$28,236	**5**
20501410	Parks Highway	Unnamed	DOT	Gray	11.8	$175,000	6.0	6.0	**13**	$29,177	**6**
20401844	Fish Lake Road	Fish Lake tributary	MSB	Red	4.0	$85,000	2.7	2.7	**42**	$31,335	**7**
20501466	Hidden Hills Road	Caswell Creek	MSB	Red	12.0	$200,000	2.3	5.4	**14**	$37,199	**8**
20501429	Parks Highway	Unnamed	DOT	Red	5.4	$206,000	5.0	5.0	**18**	$41,491	**9**
20501514	Shaman Road	Caswell Creek	MSB	Red	15.4	$208,000	4.7	4.7	**19**	$44,107	**10**
20401279	Parks Highway	Cottonwood Creek	DOT	Gray	9.0	$291,000	0.8	6.6	**12**	$44,410	**11**
20501442	Old Parks Highway	Lilly Creek	DOT	Gray	15.3	$207,000	4.5	4.5	**22**	$46,484	**12**
20502150	Parks Highway	Chulitna River Trib	DOT	Red	17.8	$458,000	9.0	9.0	**7**	$51,151	**13**
20501387	Parks Highway	Unnamed	DOT	Gray	22.8	$539,000	10.2	10.2	**6**	$52,652	**14**
20501798	Alaska Railroad	Susitna River tributary	Railroad	Red	5.7	$215,000	0.7	4.1	**25**	$52,810	**15**
20401288	Home Built Circle	Neklason, unnamed	MSB	Gray	16.0	$213,000	1.3	3.9	**28**	$54,797	**16**
20401290	Fairview Loop Road	Cottonwood Slough	DOT	Red	3.4	$152,000	2.8	2.8	**40**	$54,970	**17**
20400590	Glenn Highway	Unnamed	DOT	Red	9.0	$291,000	5.2	5.2	**16**	$56,355	**18**
20501461	Caswell Lakes Road	Unnamed	MSB	Red	10.0	$156,000	2.6	2.6	**43**	$59,014	**19**
20501480	Petersville Road	Ninemile Creek	DOT	Red	8.8	$286,000	4.6	4.6	**20**	$62,405	**20**
20501807	Alaska Railroad	Susitna River tributary	Railroad	Red	10.4	$321,000	5.1	5.1	**17**	$62,675	**21**
20501398	Petersville Road	Seventeen Mile Creek	DOT	Red	7.7	$262,000	4.2	4.2	**24**	$62,690	**22**
20501232	Sushana Road	Coal Creek	MSB	Red	8.6	$142,000	2.2	2.2	**52**	$65,772	**23**
20401312	Glenn Highway	Rabbit Slough	DOT	Gray	21.2	$514,000	1.2	7.1	**10**	$72,654	**24**
20501139	Alaska Railroad	Little Meadow Creek	Railroad	Gray	7.6	$600,000	0.4	8.2	**8**	$73,439	**25**
20501428	Parks Highway	Lake Creek tributary	DOT	Red	6.9	$243,000	3.2	3.2	**36**	$77,094	**26**
20501392	Parks Highway	Chulitna River Trib	DOT	Red	12.0	$353,000	4.4	4.4	**23**	$79,773	**27**
20501388	Parks Highway	Chulitna River Trib	DOT	Red	10.8	$327,000	4.0	4.0	**27**	$82,372	**28**
Fish Pass.	Road Name	Stream Name	Owner	ADFG	Creek	Estimated	Non-Barrier	Barrier	**Upstream**	Cost-	**Cost**

Site #				rating	Width (ft)	Cost	Termination Miles	Termination Miles	**Mile Ranking**	Benefit ($ per mi)	**Benefit Ranking**
20501154	Foothills Boulevard	Lucille Creek	MSB	Red	8.0	$200,000	2.4	2.4	**45**	$83,388	**29**
20501383	Parks Highway	Horsehoe Creek	DOT	Red	24.6	$566,000	6.6	6.6	**11**	$85,247	**30**
20502151	Parks Highway	Chulitna River Trib	DOT	Gray	19.2	$480,000	5.3	5.3	**15**	$91,268	**31**
20501799	Alaska Railroad	Question Creek	Railroad	Gray	10.0	$312,000	3.2	3.2	**34**	$96,630	**32**
20502094	Alaska Railroad	Indian Creek tributary	Railroad	Red	6.0	$222,000	2.1	2.1	**55**	$108,159	**33**
20502088	Alaska Railroad	Indian River tributary	Railroad	Gray	7.0	$247,000	2.2	2.2	**51**	$112,091	**34**
20400589	Glenn Highway	Unnamed	DOT	Red	14.0	$390,000	3.4	3.4	**31**	$114,521	**35**
20501381	Parks Highway	Unnamed	DOT	Red	13.0	$371,000	3.2	3.2	**35**	$116,453	**36**
20400585	Glenn Highway	Unnamed	DOT	Gray	8.0	$269,000	2.3	2.3	**49**	$117,740	**37**
20501418	Talkeetna Spur Road	Question Creek Trib	DOT	Red	8.3	$275,000	2.3	2.3	**48**	$118,230	**38**
20501434	Big Lake Road	Lucille Creek	DOT	Red	8.8	$2,000,000	6.4	16.4	**5**	$121,674	**39**
20501374	Parks Highway	Fourth of July Creek	DOT	Gray	20.0	$494,000	3.9	3.9	**29**	$127,461	**40**
20501413	Parks Highway	Rabideux Creek Trib	DOT	Red	12.1	$354,000	2.8	2.8	**39**	$127,605	**41**
20501436	Beaver Lake Road	Lynda Lake Portage	MSB	Gray	2.4	$400,000	3.1	3.1	**38**	$128,739	**42**
20501422	Parks Highway	Susitna River tributary	DOT	Red	10.0	$312,000	2.4	2.4	**46**	$130,769	**43**
20501081	Alaska Railroad	Meadow Creek Trib	Railroad	Red	6.3	$1,000,000	5.6	7.6	**9**	$131,579	**44**
20401326	Palmer Wasilla Hwy	Wasilla Creek	DOT	Gray	17.7	$455,000	1.2	3.4	**32**	$135,492	**45**
20501378	Parks Highway	Granite Creek	DOT	Red	18.8	$475,000	3.5	3.5	**30**	$136,440	**46**
20501489	Petersville Road	Peters Creek tributary	DOT	Gray	12.1	$355,000	2.4	2.4	**47**	$149,314	**47**
20401304	Fern	Cottonwood Creek	Wasilla	Gray	37.7	$377,000	1.3	2.1	**53**	$180,946	**48**
20501156	Settler Bay Drive	Crocker Creek	MSB	Red	5.0	$400,000	2.2	2.2	**50**	$181,171	**49**
20401307	Bogard Road	Cottonwood Creek	DOT	Red	27.0	$603,000	2.2	3.3	**33**	$185,365	**50**
20501419	Talkeetna Spur Road	Question Creek	DOT	Red	31.0	$661,000	3.1	3.1	**37**	$212,090	**51**
20501375	Parks Highway	Hardage Creek	DOT	Red	27.8	$615,000	2.7	2.7	**41**	$224,974	**52**
20501071	Pittman Road	Fuller Lake Drainage	DOT	Red	4.0	$600,000	2.5	2.5	**44**	$237,459	**53**
20501152	Alaska Railroad	Unnamed	Railroad	Red	3.7	$600,000	2.1	2.1	**54**	$290,092	**54**
20501432	Parks Highway	Little Meadow Creek	DOT	Red	29.2	$2,000,000	4.0	4.0	**26**	$496,924	**55**

Table 3. Summary of the top 15 salmon barriers by owner.

Ownership	Number of Barriers	Total Miles Upstream (Barrier Termination)	Total Estimated Cost	Average Cost-Benefit ($/mile)
DOT	9	122.4	$359,1000	$37,114
MSB	3	12.8	$493,000	$37,547
Houston	1	4.5	$111,000	$24,809
Railroad	1	4.1	$215,000	$52,810
Private	1	40.7	$377,000	$9,273
Total	**15**	**184.5**	**$4,787,000**	**$35,571**

Discussion and Conclusion

Progress has been made to remove salmon passage barriers to critical spawning, rearing and overwintering habitats in the Mat-Su basin over the past 15 years. This is evident in the 222 miles of stream reopened to salmon as a result of removing 105 barriers. The MSB owned barriers had the highest proportion of barrier replaced compared to other barrier-owning entities. While work should continue on MSB owned barriers, additional emphasis should be placed on Railroad and DOT owned barriers, which are responsible for the bulk of the remaining upstream miles of inaccessible habitat and should be identified as targets for future replacement efforts. While the remaining miles of salmon stream habitat above barriers in the Mat-Su is greater than what has been restored to date, only 55 barriers account for 75% of the miles that remain.

The upstream mile and cost-benefit analysis provides an opportunity to make informed decisions about replacing the top ranked barriers. To optimize near-term restoration funding, one strategy would be to assess and pursue replacement of the top 15 salmon barriers identified in the cost-benefit ranking. This cohort blocks access to 184.5 miles of stream with an estimated cost to restore of $4.8 million, or $320,000 per barrier. For comparison, an estimated $10 million to $17.9 million was spent on the 105 barriers restored between 2000 and 2015. Replacing the top 15 barriers would cost-effectively reopen the most miles of habitat for salmon, and would involve partnering with 5 different barrier owners including DOT, MSB, Railroad, Private and the City of Houston.

In practice, other factors will affect the order of barrier replacements in the Mat-Su. The road work priorities of DOT and Mat-Su Borough Operations and Maintenance Department will affect the order of barrier replacements. Invasive Northern Pike (*Esox lucius*) are another factor that affects barrier removal decision making, as barriers in watersheds without pike typically receive priority over those where pike are present. Where information on the quality of habitat is available, it is also considered in the decision making process. In the context of invasive species, habitat quality, priorities of partners and other factors, this prioritization should be used to help frame discussions and weigh options with tangible benefits and costs.

The cost of Mat-Su basin culvert projects is comparable to restoration projects for salmon in other regions. A synthesis of culvert replacement costs in California range between $13,000 and $380,000, but most projects are greater than $150,000 (Thomson and Pinkerton 2008). Cost-benefit comparisons are more difficult to find, but the Elwha Dam removal project in Washington cost $26.9 million and reopened 70 miles to Chinook Salmon (National Park Service

2015). The cost-benefit for this large dam removal was $384,000 per mile; however, stream restoration costs added millions of dollars more. The average cost per mile for the top 55 remaining barriers in the Mat-Su is estimated at $102,000 per mile.

Prioritizing fish barrier removals in other regions include many more factors, but this initial prioritization will be useful to inform Mat-Su basin efforts and future prioritizations. The State of Washington prioritizations use a suite of habitat quality measurements including the number of salmon species benefitted, the severity of the barrier, and cost (Washington Department of Fish and Wildlife 2009). A more advanced prioritization could be conducted for the Mat-Su basin once goals for salmon passage improvement are refined and more specific field and remote sensing data are collected relative to fish habitat quality. Estimates of replacement costs can also be improved using multivariate regressions with factors such as height of road fill or road surface. Future prioritizations could address specific conservation targets of the Partnership including priority ecosystems. For the purposes of the Mat-Su Salmon Habitat Partnership, this cost-benefit analysis achieves the research need outlined in the strategic plan and can be updated and utilized in future efforts.

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Appendix A

Other Factors Considered

Upstream Habitat Quality
Although habitat quality factors were not used for prioritization in this study, two efforts in Alaska, one by the U.S. Forest Service in Southeast and another by the Copper River Watershed Project (CRWP) in the Copper River Basin collected habitat quality data for their prioritizations (Copper River Watershed Project 2011; Schultz et al. 2014). The Biological Significance Index (unpublished), developed by the U.S. Forest Service uses habitat quality data such as stream gradient and pool frequency among several other factors with a published assessment protocol to numerically score habitats associated with potential fish passage projects. The CRWP uses methods modified from the U.S. Forest Service to score fish passage sites based on four categories of habitat suitability (Table 1).

Table 1. The Copper River Watershed Project Upstream Habitat Quality Scoring, with elements modified from US Forest Service assessment criteria from Southeast Alaska (Copper River Watershed Project 2011).

Classification (score)	Habitat description (outside influence of culvert and road)
Unsuitable (0)	The reach upstream of the culvert has excessive gradient (>25%), excessive stream velocities, lacks spawning substrate, or has other hydrological and geomorphological characteristics (i.e., is stagnant, or ephemeral) that would preclude its capability of supporting fish (USFS Class IV).
Low Suitability (2)	Habitat may be suitable for some resident fish and/or anadromous species and life history stages, low in mesohabitat diversity (pools, riffles, runs). May be steep in gradient, >10%, but accessible to fish (most similar to USFS Class II).
Moderate Suitability (5)	Habitat is relatively good for one or several species, resident and/or anadromous, moderately diverse (pools, riffles, runs) mesohabitat (between USFS Class I and II).
High Suitability (10)	Fish habitat favorable for spawning and rearing, for anadromous and resident species, clean and abundant spawning gravels but also a range of substrates; has a diversity of mesohabitat types and channel complexity (USFS Class 1).

This type of habitat quality information has not been collected for the Mat-Su basin fish passage sites so a habitat quality factor cannot be included in a basin-wide prioritization effort at this time.

Upstream Lake Acreage
Lakes are important habitat for spawning Sockeye Salmon (*O. nerka*) and indicate good habitat complexity that other salmon species need for juvenile overwintering. Lake area upstream of fish passage sites was measured and recorded in total acres similar methods used to measure upstream miles. Lake area upstream from barriers was collected, but not used in this prioritization.

Culvert Perch
Culvert outfall height was documented for barriers based on records from ADF&G Level 1 surveys or from additional studies by USFWS. In future prioritizations, outfall height is one important factor that could be used to rate barrier severity or assess for adult-only barriers.

Updated Stream Miles
An updated stream network will be completed for the Mat-Su basin in early 2016. This updated network will give a more accurate accounting of upstream miles to provide a future revision of the model presented here.

Appendix B

Table B.1. Salmon passage barriers in the Mat-Su basin restored between 2001 and 2015.

Site	Road Name	Stream Name	Lat.	Long.	Owner-ship	Lake Area (acres)	Upstream Miles Non-Barrier Termination	Upstream Miles Barrier Termination	Year Restored
20401308	Trail near Palmer Elks	Cottonwood Creek	61.60934	-149.29179	Private	0	0.4	0.4	2001
20501439	Lakes Boulevard	Meadow Creek Trib	61.566085	-149.89239	MSB	107	2.7	2.7	2001
99999998	Anaconda Ave	Buddy Creek	62.133855	-150.00601	MSB	0	0.9	11.7	2001
20401354	Lower Road	Wasilla Creek tributary	61.5793	-149.29231	MSB	0	0.2	0.2	2002
20401267	Settlement Road	Cottonwood Creek	61.631849	-149.24325	MSB	0	1.9	1.9	2003
20401295	Cardiff Road	Lucy Creek tributary	61.524905	-149.57124	MSB	0	0.3	0.3	2003
20401355	Lower Road	Wasilla Creek tributary	61.57845	-149.28668	MSB	0	0.2	0.2	2003
99999992	E. Back Acres Ave	Bodenburg Creek	61.5562	-149.0353	MSB	0	0.1	0.7	2003
99999993	E. Elk Rd	Bodenburg Creek	61.5575	-149.036	MSB	0	0.6	0.6	2003
20401296	Cardiff Road	Lucy Creek tributary	61.522902	-149.5712	MSB	0	0.1	0.5	2004
20401297	South Starflower Drive	Lucy Creek tributary	61.521581	-149.57146	MSB	0	0.0	0.5	2004
20401298	Lupine Lane	Lucy Creek tributary	61.52206	-149.57157	MSB	0	0.1	0.5	2004
20501136	Papoose Twins Road	Unnamed	61.514167	-150.08558	MSB	0	0.9	2.2	2004
20501137	Papoose Twins Road	Crooked Lake outlet	61.51365	-150.06941	MSB	284	1.3	1.3	2004
20501138	Papoose Twins Road	Crooked Lake outlet	61.513056	-150.05131	MSB	0	1.0	1.0	2004
20501444	Meadow Lakes Loop Rd	Little Meadow Creek Trib	61.59164	-149.66653	MSB	10	4.9	7.7	2004
99999994	private driveway	Parks Creek	61.633	-149.79	Private	0	7.4	7.4	2004
20401310	Alaska Railroad	Rabbit Slough	61.535008	-149.23474	Railroad	0	2.5	2.5	2005
20401351	South Grantham Road	Wasilla Creek	61.572544	-149.30899	MSB	0	1.0	5.6	2005
20401885	Trapline Drive	Cottonwood Slough	61.52641	-149.51387	MSB	0	0.0	0.0	2005
20501045	Sitze Road	Swiftwater Creek	61.64996	-149.5119	MSB	0	3.7	3.7	2005
99999995	Buffalo Mine Road	Moose Creek	61.69761	-149.09506	DNR	0	3.4	3.4	2005
99999996	S. Big Lake Rd	Fish Creek outlet Big Lake	61.5393	-149.8336	MSB	3403	21.7	34.4	2005
20401230	Surrey Road	Cottonwood Creek tributary	61.52448	-149.52934	MSB	0	0.1	0.1	2006
20501101	Wolf Road	Unnamed	61.576389	-149.84028	MSB	166	1.1	1.1	2006
20501883	Tamarack Road	Unnamed	61.53111	-149.86607	MSB	7	0.1	0.1	2006
20401231	Surrey Road	Cottonwood Creek	61.52498	-149.52989	MSB	0	0.2	0.9	2007
20401291	Surrey Road	Cottonwood Slough	61.52233	-149.52652	MSB	0	0.9	0.9	2007
20401343	Murphy Road	Wasilla Creek tributary	61.71077	-149.11888	MSB	0	1.3	3.5	2007
20401356	Lower Road	Wasilla Creek	61.576443	-149.28456	MSB	0	3.0	4.1	2007
20501224	Settler Bay Drive	Crocker Creek	61.49608	-149.61229	MSB	0	0.5	1.9	2007
20401344	Murphy Road	Wasilla Creek tributary	61.71796	-149.12068	MSB	0	0.2	2.2	2008
20401347	ATV Trail	Wasilla Creek tributary	61.720183	-149.11839	Private	0	2.0	2.0	2008
20401348	Falk Road	Wasilla Creek	61.655249	-149.20056	MSB	0	1.0	34.7	2008
20501037	Welch Way	Unnamed	61.663611	-149.33506	MSB	0	0.3	0.3	2008
20501039	Schwald Road	Government Creek	61.659167	-149.43278	MSB	0	1.0	1.0	2008
20501041	Coles Road	Unnamed	61.664444	-149.38547	MSB	0	0.1	0.1	2008
20501042	Coles Road	Little Susitna River tributary	61.664444	-149.38194	MSB	0	0.1	0.1	2008
20501046	Sitze Road	Moon Princess Creek	61.653333	-149.49861	MSB	0	0.2	3.4	2008
20501068	Driveway off Sitze Road	Moon Princess Creek	61.6564	-149.49915	Private	0	0.1	3.2	2008
20501069	Driveway off Sitze Road	Moon Princess Creek	61.65712	-149.49825	Private	0	0.1	3.2	2008

Site	Road Name	Stream Name	Lat.	Long.	Owner-ship	Lake Area (acres)	Upstream Miles Non-Barrier Termination	Upstream Miles Barrier Termination	Year Restored
20501189	Kime Lane	Nancy Lake and unnamed pond	61.69695	-149.99681	MSB	8	0.0	0.0	2008
20501819	Edgerton Parks Road	Government Creek	61.69323	-149.30983	MSB	0	8.9	8.9	2008
20501876	Driveway off Sitze Road	Moon Princess Creek	61.65833	-149.49677	Private	0	3.1	3.1	2008
20401349	Crabb Circle	Spring Creek	61.661229	-149.19296	MSB	0	1.0	1.0	2009
20401350	Crabb Circle	Wasilla Creek	61.661301	-149.18846	MSB	0	29.2	32.7	2009
20401810	Babcock Drive	Carniege Creek tributary	61.63786	-149.19386	MSB	0	0.1	0.1	2009
20501032	North Russett Road	Unnamed	61.68363	-149.29979	MSB	0	0.2	0.2	2009
20501060	Karen Street	Rainbow Lake inlet	61.598889	-149.62194	MSB	0	2.1	2.1	2009
20501112	Horseshoe Lake Road	Horshshoe Lake Inlet	61.568917	-149.9475	MSB	132	1.5	2.2	2009
20501183	Driveway	Little Susitna River Trib	61.68193	-149.28561	Private	0	0.2	6.8	2009
20501184	Private road on Elk Ranch	Unnamed	61.68557	-149.29788	Private	0	0.3	2.9	2009
20501817	East Alberta Circle	Moose Lick Creek	61.69336	-149.29895	MSB	0	0.0	1.9	2009
20501818	East Alberta Circle	Little Susitna River Trib	61.69345	-149.29468	MSB	0	0.0	0.2	2009
20501841	Moose Lick Circle	Moose Lick creek	61.69363	-149.29964	MSB	0	0.4	1.9	2009
20501878	Runyon Circle	Little Susitna River Trib	61.69377	-149.29529	MSB	0	0.1	0.1	2009
99999989	Private road on Elk Farm	Unnamed	61.683967	-149.28391	Private	0	1.3	6.5	2009
20400591	Jonesville Mine Road	Eska Creek	61.727912	-148.91054	DOT	0	1.2	14.0	2010
20401268	Engstrom Road	Cornelius & Nekleson Lakes	61.62885	-149.26083	MSB	40	0.7	2.6	2010
20501034	Edgerton Parks Road	Unnamed	61.69004	-149.29552	MSB	0	0.5	2.5	2010
20501035	Edgerton Parks Road	Unnamed	61.69125	-149.27878	MSB	0	5.1	5.1	2010
20501036	Edgerton Parks Road	Unnamed	61.69342	-149.26294	MSB	0	0.2	0.2	2010
20501113	Horseshoe Lake Road	Horseshoe Lake Outlet	61.561944	-149.94389	MSB	412	3.0	5.8	2010
20501192	Bryant Road	Connects two Lakes	61.47303	-149.9593	MSB	98	0.0	0.0	2010
20501426	Parks Highway	Grey's Creek	61.895766	-150.0779	DOT	0	11.1	11.1	2010
20502072	Private Drive	Little Creek	61.68013	-149.30107	Private	0	0.3	3.4	2010
20502073	Private Drive	Little Creek	61.67922	-149.3013	Private	0	0.1	3.5	2010
20502074	North Waldo Reed Rd	Unnamed	61.69886	-149.30252	MSB	0	0.1	1.4	2010
20502075	North Waldo Reed Rd	Unnamed	61.6997	-149.30302	Private	0	1.4	1.4	2010
20502126	Nancy Lake Circle	Nancy Creek	61.68623	-149.97345	MSB	0	0.1	0.6	2010
20502136	Parks Highway	Grey's Creek	61.89806	-150.07678	DOT	0	7.7	7.7	2010
20400592	Jonesville Mine Road	Eska Creek	61.73861	-148.90591	DOT	0	12.7	12.7	2011
20501047	West Sunrise Road	Poddle Creek	61.64993	-149.5645	MSB	0	3.4	3.4	2011
20501049	West Sunrise Road	Little Susitna River Trib	61.65078	-149.5854	MSB	0	1.0	1.0	2011
20501050	West Sunrise Road	Coyote Creek	61.64995	-149.56772	MSB	0	4.6	4.6	2011
20501052	West Dean Road	Unnamed	61.6135	-149.64656	MSB	89	0.1	0.1	2011
20501053	North Meadow Lakes Rd	Unnamed	61.61118	-149.64053	MSB	0	0.1	0.1	2011
20501054	North Meadow Lakes Rd	Unnamed	61.61229	-149.64629	MSB	0	0.1	0.2	2011
20501520	South Silver Salmon Dr	Caswell Creek tributary	61.99387	-149.96294	MSB	25	0.7	0.7	2011
99999990	Private Driveway	Little Creek	61.678661	-149.30217	Private	0	0.0	3.5	2011
20401292	Redoubt	Cottonwood Creek Trib	61.530349	-149.52456	MSB	0	0.2	0.2	2012
20401327	Bogard Road	Wasilla Creek	61.613889	-149.24219	DOT	0	2.2	2.2	2012
20401328	Colony School Drive	Walby Creek	61.612589	-149.23594	DOT	0	1.3	1.3	2012
20401329	Private Drive	Wasilla Creek tributary	61.611721	-149.23756	Private	0	0.1	1.4	2012

Site	Road Name	Stream Name	Lat.	Long.	Owner-ship	Lake Area (acres)	Upstream Miles Non-Barrier Termination	Upstream Miles Barrier Termination	Year Restored
20401336	Fishhook Road	Carnegie Creek	61.636075	-149.19144	DOT	0	2.1	2.1	2012
20401337	Fishhook Road	Wasilla Creek	61.643084	-149.19789	DOT	0	2.2	36.9	2012
20401338	Fishhook Road	Wasilla Creek tributary	61.642027	-149.19631	DOT	0	0.1	0.1	2012
20401358	Abandoned Homestead Rd	Wasilla Creek	61.551901	-149.29947	Private	0	2.4	8.0	2012
20501143	Settler Bay Drive	Crocker Creek	61.501056	-149.62028	MSB	0	1.3	1.3	2012
20501464	Hidden Hills Road	Caswell Creek tributary	61.98937	-149.96042	MSB	57	0.4	1.1	2012
20501800	Alaska Railroad	Sunshine Creek	62.17595	-150.07674	Railroad	57	2.7	2.7	2012
20501173	Cameo Road	Goose Creek	61.42235	-149.91904	MSB	400	1.7	9.8	2013
20501471	Katahdan Road	Buddy Creek	62.13629	-149.94032	MSB	0	7.0	7.0	2013
20501095	Hawk Lane	Unnamed	61.585333	-149.78111	MSB	14	1.4	1.4	2014
20501096	Hawk Lane	Unnamed	61.585722	-149.79694	MSB	0	0.0	0.0	2014
20501403	Oil Well Road	Moose Creek tributary	62.28352	-150.42371	MSB	0	2.1	2.1	2014
20501404	Oil Well Road	Moose Creek tributary	62.237866	-150.43933	MSB	12	0.6	0.6	2014
20501445	Vine Road	Lucille Creek	61.562441	-149.60146	MSB	0	1.1	1.1	2014
20501462	Caswell Lakes Road	Caswell Creek	62.00833	-149.98599	MSB	147	3.1	3.1	2014
20501472	Oil Well Road	Kroto Creek tributary	62.10631	-150.52565	MSB	38	1.0	1.0	2014
20501473	Oil Well Road	Unnamed	62.18156	-150.51703	MSB	0	0.3	0.3	2014
20501182	Crystal Lake Road	Rainbow to Long Lake	61.70733	-150.08525	MSB	146	0.6	0.6	2015
20501238	Willow Creek Parkway	Shirley Lake outlet	61.75812	-150.10677	DOT	371	6.9	7.4	2015
20501435	Beaver Lake Road	Meadow Creek	61.562688	-149.82533	MSB	128	7.8	10.0	2015
20501526	Unknown	Buddy Creek	62.14034	-149.9866	MSB	0	3.9	10.8	2015
					Sum:	6152.4	222.4		

Table B2. Upstream miles ranking of the top 63 salmon barrier sites from the top three, red, orange and yellow upstream miles quartiles. Note that field verification is required before any replacement decisions because the ranking is based on best estimates of upstream miles and cost.

Fish Pass. Site #	Road Name	Stream Name	Owner	ADFG rating	Creek Width (ft)	Estimated Cost	Upstream Miles Non-Barrier Termination	Upstream Miles Barrier Termination	**Upstream Mile Ranking**	Cost-Benefit ($ per mi)	**Cost Benefit Ranking**
20401335	Private Drive	Wasilla Creek	Private	Gray	37.8	$377,000	1.4	40.7	**1**	$9,273	**1**
20501394	Parks Highway	Trapper Creek	DOT	Red	23.4	$549,000	37.5	37.5	**2**	$14,654	**2**
20501379	Parks Highway	Pass Creek	DOT	Gray	30.8	$659,000	7.9	25.6	**3**	$25,773	**4**
20501417	Talkeetna Spur Road	Answer Creek	DOT	Red	20.8	$507,000	18.0	18.0	**4**	$28,236	**5**
20501434	Big Lake Road	Lucille Creek	DOT	Red	8.8	$2,000,000	6.4	16.4	**5**	$121,674	**59**
20501387	Parks Highway	Unnamed	DOT	Gray	22.8	$539,000	10.2	10.2	**6**	$52,652	**15**
20502150	Parks Highway	Chulitna River tributary	DOT	Red	17.8	$458,000	9.0	9.0	**7**	$51,151	**13**
20501139	Alaska Railroad	Little Meadow Creek	Railroad	Gray	7.6	$600,000	0.4	8.2	**8**	$73,439	**32**
20501081	Alaska Railroad	Meadow Creek tributary	Railroad	Red	6.3	$1,000,000	5.6	7.6	**9**	$131,579	**68**
20401312	Glenn Highway	Rabbit Slough	DOT	Gray	21.2	$514,000	1.2	7.1	**10**	$72,654	**30**
20501383	Parks Highway	Horsehoe Creek	DOT	Red	24.6	$566,000	6.6	6.6	**11**	$85,247	**37**
20401279	Parks Highway	Cottonwood Creek	DOT	Gray	9.0	$291,000	0.8	6.6	**12**	$44,410	**11**
20501410	Parks Highway	Unnamed	DOT	Gray	11.8	$175,000	6.0	6.0	**13**	$29,177	**6**
20501466	Hidden Hills Road	Caswell Creek	MSB	Red	12.0	$200,000	2.3	5.4	**14**	$37,199	**8**
20502151	Parks Highway	Chulitna River tributary	DOT	Gray	19.2	$480,000	5.3	5.3	**15**	$91,268	**40**
20400590	Glenn Highway	Unnamed	DOT	Red	9.0	$291,000	5.2	5.2	**16**	$56,355	**19**
20501807	Alaska Railroad	Susitna River tributary	Railroad	Red	10.4	$321,000	5.1	5.1	**17**	$62,675	**23**
20501429	Parks Highway	Unnamed	DOT	Red	5.4	$206,000	5.0	5.0	**18**	$41,491	**9**
20501514	Shaman Road	Caswell Creek	MSB	Red	15.4	$208,000	4.7	4.7	**19**	$44,107	**10**
20501480	Petersville Road	Ninemile Creek	DOT	Red	8.8	$286,000	4.6	4.6	**20**	$62,405	**22**
20501092	Birch Road	Unnamed	Houston	Red	6.0	$111,000	3.1	4.5	**21**	$24,809	**3**
20501442	Old Parks Highway	Lilly Creek	DOT	Gray	15.3	$207,000	4.5	4.5	**22**	$46,484	**12**
20501392	Parks Highway	Chulitna River tributary	DOT	Red	12.0	$353,000	4.4	4.4	**23**	$79,773	**34**
20501398	Petersville Road	Seventeen Mile Creek	DOT	Red	7.7	$262,000	4.2	4.2	**24**	$62,690	**24**
20501798	Alaska Railroad	Susitna River tributary	Railroad	Red	5.7	$215,000	0.7	4.1	**25**	$52,810	**16**
20501432	Parks Highway	Little Meadow Creek	DOT	Red	29.2	$2,000,000	4.0	4.0	**26**	$496,924	**167**
20501388	Parks Highway	Chulitna River tributary	DOT	Red	10.8	$327,000	4.0	4.0	**27**	$82,372	**35**
20401288	Home Built Circle	Neklason, unnamed lakes	MSB	Gray	16.0	$213,000	1.3	3.9	**28**	$54,797	**17**
20501374	Parks Highway	Fourth of July Creek	DOT	Gray	20.0	$494,000	3.9	3.9	**29**	$127,461	**61**
20501378	Parks Highway	Granite Creek	DOT	Red	18.8	$475,000	3.5	3.5	**30**	$136,440	**71**
20400589	Glenn Highway	Unnamed	DOT	Red	14.0	$390,000	3.4	3.4	**31**	$114,521	**54**
20401326	Palmer Wasilla Hwy	Wasilla Creek	DOT	Gray	17.7	$455,000	1.2	3.4	**32**	$135,492	**70**
20401307	Bogard Road	Cottonwood Creek	DOT	Red	27.0	$603,000	2.2	3.3	**33**	$185,365	**92**
20501799	Alaska Railroad	Question Creek	Railroad	Gray	10.0	$312,000	3.2	3.2	**34**	$96,630	**43**
20501381	Parks Highway	Unnamed	DOT	Red	13.0	$371,000	3.2	3.2	**35**	$116,453	**56**
20501428	Parks Highway	Lake Creek tributary	DOT	Red	6.9	$243,000	3.2	3.2	**36**	$77,094	**33**
20501419	Talkeetna Spur Road	Question Creek	DOT	Red	31.0	$661,000	3.1	3.1	**37**	$212,090	**106**
20501436	Beaver Lake Road	Lynda Lake Portage	MSB	Gray	2.4	$400,000	3.1	3.1	**38**	$128,739	**64**
20501413	Parks Highway	Rabideux Creek tributary	DOT	Red	12.1	$354,000	2.8	2.8	**39**	$127,605	**62**
20401290	Fairview Loop Road	Cottonwood Slough	DOT	Red	3.4	$152,000	2.8	2.8	**40**	$54,970	**18**
20501375	Parks Highway	Hardage Creek	DOT	Red	27.8	$615,000	2.7	2.7	**41**	$224,974	**114**

Fish Pass. Site #	Road Name	Stream Name	Owner	ADFG rating	Creek Width (ft)	Estimated Cost	Upstream Miles Non-Barrier Termination	Upstream Miles Barrier Termination	**Upstream Mile Ranking**	Cost-Benefit ($ per mi)	**Cost Benefit Ranking**
20401844	Fish Lake Road	Fish Lake tributary	MSB	Red	4.0	$85,000	2.7	2.7	**42**	$31,335	**7**
20501461	Caswell Lakes Road	Unnamed	MSB	Red	10.0	$156,000	2.6	2.6	**43**	$59,014	**21**
20501071	Pittman Road	Fuller Lake Drainage	DOT	Red	4.0	$600,000	2.5	2.5	**44**	$237,459	**120**
20501154	Foothills Boulevard	Lucille Creek	MSB	Red	8.0	$200,000	2.4	2.4	**45**	$83,388	**36**
20501422	Parks Highway	Susitna River tributary	DOT	Red	10.0	$312,000	2.4	2.4	**46**	$130,769	**66**
20501489	Petersville Road	Peters Creek tributary	DOT	Gray	12.1	$355,000	2.4	2.4	**47**	$149,314	**75**
20501418	Talkeetna Spur Road	Question Creek tributary	DOT	Red	8.3	$275,000	2.3	2.3	**48**	$118,230	**58**
20400585	Glenn Highway	Unnamed	DOT	Gray	8.0	$269,000	2.3	2.3	**49**	$117,740	**57**
20501156	Settler Bay Drive	Crocker Creek	MSB	Red	5.0	$400,000	2.2	2.2	**50**	$181,171	**90**
20502088	Alaska Railroad	Indian River tributary	Railroad	Gray	7.0	$247,000	2.2	2.2	**51**	$112,091	**52**
20501232	Sushana Road	Coal Creek	MSB	Red	8.6	$142,000	2.2	2.2	**52**	$65,772	**27**
20401304	Fern	Cottonwood Creek	Wasilla	Gray	37.7	$377,000	1.3	2.1	**53**	$180,946	**89**
20501152	Alaska Railroad	Unnamed	Railroad	Red	3.7	$600,000	2.1	2.1	**54**	$290,092	**130**
20502094	Alaska Railroad	Indian Creek tributary	Railroad	Red	6.0	$222,000	2.1	2.1	**55**	$108,159	**48**

Table B3. DOT owned fish passage sites ranked according to upstream miles. Note that field verification is required before any replacement decisions because the ranking is based on best estimates of upstream miles and cost.

Fish Pass. Site #	ADFG rating	Road Name	Stream Name	Lat	Long	Lake Area (acres)	Upstream Miles Non-Barrier Termination	Upstream Miles Barrier Termination	Estimated Cost	Cost-Benefit ($ per mi)	DOT Upstream Mile Ranking	DOT Cost Benefit Ranking
20501394	Red	Parks Highway	Trapper Creek	62.328013	-150.24063	154	37.46	37.46	$549,000	$14,654	1	1
20501379	Gray	Parks Highway	Pass Creek	62.91069	-149.71436	52	7.86	25.57	$659,000	$25,773	2	2
20501417	Red	Talkeetna Spur Road	Answer Creek	62.202338	-150.06689	74	17.96	17.96	$507,000	$28,236	3	3
20501434	Red	Big Lake Road	Lucille Creek	61.56113	-149.77858	0	6.44	16.44	$2,000,000	$121,674	4	28
20501387	Gray	Parks Highway	Unnamed	62.508638	-150.25858	272	10.24	10.24	$539,000	$52,652	5	9
20502150	Red	Parks Highway	Chulitna River tributary	62.3534	-150.25304	0	8.95	8.95	$458,000	$51,151	6	8
20401312	Gray	Glenn Highway	Rabbit Slough	61.53579	-149.25305	0	1.17	7.07	$514,000	$72,654	7	14
20501383	Red	Parks Highway	Horsehoe Creek	62.867382	-149.85261	0	6.64	6.64	$566,000	$85,247	8	18
20401279	Gray	Parks Highway	Cottonwood Creek	61.575344	-149.40413	0	0.82	6.55	$291,000	$44,410	9	6
20501410	Gray	Parks Highway	Unnamed	62.28541	-150.24777	14	6.00	6.00	$175,000	$29,177	10	4
20502151	Gray	Parks Highway	Chulitna River tributary	62.40329	-150.25931	0	5.26	5.26	$480,000	$91,268	11	19
20400590	Red	Glenn Highway	Unnamed	61.723581	-148.82971	0	5.16	5.16	$291,000	$56,355	12	11
20501429	Red	Parks Highway	Unnamed	61.645597	-149.8763	78	4.96	4.96	$206,000	$41,491	13	5
20501480	Red	Petersville Road	Ninemile Creek	62.31267	-150.34764	219	4.58	4.58	$286,000	$62,405	14	12
20501442	Gray	Old Parks Highway	Lilly Creek	61.706599	-149.99987	13	4.45	4.45	$207,000	$46,484	15	7
20501392	Red	Parks Highway	Chulitna River tributary	62.453785	-150.27282	69	4.43	4.43	$353,000	$79,773	16	16
20501398	Red	Petersville Road	Seventeen Mile Creek	62.337282	-150.57411	63	4.18	4.18	$262,000	$62,690	17	13
20501432	Red	Parks Highway	Little Meadow Creek	61.575655	-149.72457	0	4.02	4.02	$2,000,000	$496,924	18	71
20501388	Red	Parks Highway	Chulitna River tributary	62.474435	-150.27147	15	3.97	3.97	$327,000	$82,372	19	17
20501374	Gray	Parks Highway	Fourth of July Creek	63.205634	-149.32846	0	3.88	3.88	$494,000	$127,461	20	29
20501378	Red	Parks Highway	Granite Creek	62.976873	-149.63153	0	3.48	3.48	$475,000	$136,440	21	33
20400589	Red	Glenn Highway	Unnamed	61.803313	-148.07039	0	3.41	3.41	$390,000	$114,521	22	23
20401326	Gray	Palmer Wasilla Hwy	Wasilla Creek	61.599417	-149.25122	0	1.18	3.36	$455,000	$135,492	23	32
20401307	Red	Bogard Road	Cottonwood Creek	61.613869	-149.29059	29	2.20	3.25	$603,000	$185,365	24	42
20501381	Red	Parks Highway	Unnamed	62.876313	-149.8176	0	3.19	3.19	$371,000	$116,453	25	25
20501428	Red	Parks Highway	Lake Creek tributary	61.658857	-149.9353	0	3.15	3.15	$243,000	$77,094	26	15
20501419	Red	Talkeetna Spur Road	Question Creek	62.221769	-150.08706	128	3.12	3.12	$661,000	$212,090	27	47
20501413	Red	Parks Highway	Rabideux Creek tributary	62.217327	-150.22977	8.3	2.77	2.77	$354,000	$127,605	28	30
20401290	Red	Fairview Loop Road	Cottonwood Slough	61.528299	-149.50711	0	2.77	2.77	$152,000	$54,970	29	10
20501375	Red	Parks Highway	Hardage Creek	63.133726	-149.44814	0	2.73	2.73	$615,000	$224,974	30	50
20501071	Red	Pittman Road	Fuller Lake Drainage	61.604722	-149.63194	36	2.53	2.53	$600,000	$237,459	31	52
20501422	Red	Parks Highway	Susitna River tributary	62.15563	-150.09995	48	2.39	2.39	$312,000	$130,769	32	31
20501489	Gray	Petersville Road	Peters Creek tributary	62.47121	-150.7227	0	2.38	2.38	$355,000	$149,314	33	35
20501418	Red	Talkeetna Spur Road	Question Creek tributary	62.211389	-150.07844	49	2.33	2.33	$275,000	$118,230	34	27
20400585	Gray	Glenn Highway	Unnamed	61.793657	-147.92993	17	2.28	2.28	$269,000	$117,740	35	26
20400587	Red	Glenn Highway	Muddy Creek	61.796315	-147.9974	0	1.91	1.91	$312,000	$163,573	36	37
20401334	Gray	Trunk Road	Wasilla Creek tributary	61.608073	-149.24377	0	0.48	1.90	$209,000	$110,256	37	22
20501424	Red	Parks Highway	Susitna River tributary	62.044431	-150.05978	0	1.87	1.87	$335,000	$179,071	38	41
20501393	Gray	Parks Highway	Unnamed	62.393131	-150.26302	22	1.86	1.86	$362,000	$194,282	39	44
20501239	Red	Willow Fishhook Rd	Willow Creek tributary	61.77201	-149.80711	0	1.82	1.82	$197,000	$108,426	40	21

20501478	Gray	Petersville Road	Rabideux Creek tributary	62.31664	-150.28952	0	1.63	1.63	$163,000	$100,187	41	20
20501490	Gray	Petersville Road	Peters Creek tributary	62.47888	-150.74722	0	1.62	1.62	$269,000	$166,498	42	38
20501062	Red	Pittman Road	Unnamed	61.616389	-149.61972	30	1.47	1.47	$500,000	$339,124	43	60
20501851	Red	Parks Highway	Chulitna River E Fork Trib	63.12758	-149.45355	0	1.46	1.46	$260,000	$178,660	44	40
20501512	Red	Petersville Road	Peters Creek tributary	62.38356	-150.72408	0	1.42	1.42	$374,000	$264,236	45	53
20501492	Red	Petersville Road	Rambler Creek	62.49235	-150.97867	0	1.33	1.33	$255,000	$191,847	46	43
20502149	Gray	Parks Highway	Chulitna River tributary	62.34004	-150.24846	0	1.32	1.32	$152,000	$115,366	47	24
20501391	Red	Parks Highway	Chulitna River tributary	62.60844	-150.22281	0	1.24	1.24	$246,000	$198,157	48	45
20501498	Red	Petersville Road	Peters Creek tributary	62.53489	-150.82375	0	1.11	1.11	$227,000	$203,852	49	46
20501502	Gray	Petersville Road	Deep Creek tributary	62.4321	-150.70341	0	1.08	1.08	$184,000	$171,061	50	39
20501416	Gray	Parks Highway	Montana Lakes	62.138672	-150.05098	77	0.99	0.99	$222,000	$224,040	51	49
20502148	Red	Parks Highway	Chulitna River tributary	62.61988	-150.23604	0	0.96	0.96	$135,000	$139,949	52	34
20400602	Red	Knik River Road	Unnamed	61.507841	-148.99832	0	0.91	0.91	$262,000	$287,177	53	56
20501504	Red	Petersville Road	Peters Creek tributary	62.38988	-150.72342	0	0.90	0.90	$141,000	$155,840	54	36
20501083	Red	West Parks Highway	Little Meadow Creek Trib	61.57855	-149.72969	0	0.89	0.89	$500,000	$564,632	55	73
20501411	Gray	Parks Highway	Unnamed	62.269569	-150.2433	0	0.86	0.86	$253,000	$294,212	56	58
20502120	Red	Parks Highway	Susitna River tributary	61.6317	-149.83406	0	0.84	0.84	$187,000	$222,341	57	48
20501384	Red	Parks Highway	Pass Creek tributary	62.907647	-149.71901	0	0.84	0.84	$411,000	$489,683	58	70
20401171	Red	Buffalo Mine Road	Premier Creek	61.71059	-149.0901	0	0.83	0.83	$253,000	$306,452	59	59
20400597	Red	Knik River Road	Unnamed	61.488314	-148.90327	0	0.78	0.78	$519,000	$664,189	60	75
20502135	Red	Parks Highway	Willow Creek tributary	61.77043	-150.06857	0	0.31	0.76	$527,000	$694,477	61	77
20401325	Gray	Glenn Highway	Spring Creek	61.55226	-149.25021	0	0.72	0.72	$352,000	$485,993	62	69
20402070	Gray	South Glenn Hwy	Unnamed	61.55384	-149.24358	0	0.63	0.63	$170,000	$270,120	63	54
20400588	Gray	Glenn Highway	Matanuska River tributary	61.73055	-148.79634	0	0.62	0.62	$297,000	$477,001	64	68
20400595	Gray	Knik River Road	Knik River tributary	61.505742	-148.96939	7	0.61	0.61	$286,000	$468,997	65	67
20400601	Red	Knik River Road	Unnamed	61.456765	-148.84028	0	0.60	0.60	$170,000	$281,187	66	55
20501493	Red	Petersville Road	Cache Creek tributary	62.49026	-150.9852	0	0.58	0.58	$170,000	$291,194	67	57
20501386	Red	Parks Highway	Unnamed	62.638894	-150.22352	0	0.55	0.55	$222,000	$403,786	68	62
20501483	Red	Petersville Road	Ninemile Creek tributary	62.31097	-150.37393	0	0.54	0.54	$289,000	$532,434	69	72
20501402	Red	Petersville Road	Seventeen Mile Creek Trib	62.336828	-150.56422	0	0.47	0.47	$338,000	$726,263	70	79
20400599	Red	Knik River Road	Unnamed	61.468754	-148.86878	0	0.45	0.45	$305,000	$678,933	71	76
20501485	Red	Petersville Road	Moose Creek tributary	62.31997	-150.46295	0	0.45	0.45	$258,000	$575,930	72	74
20501385	Gray	Denali Highway	Lily Creek tributary	62.662479	-150.22593	0	0.44	0.44	$518,000	$1,166,964	73	91
20501503	Red	Petersville Road	Deep Creek tributary	62.43077	-150.70657	0	0.42	0.42	$99,000	$235,155	74	51
20500567	Red	Palmer Fishhook Rd	Unnamed	61.713226	-149.23389	0	0.41	0.41	$140,000	$341,663	75	61
20501497	Red	Petersville Road	Peters Creek tributary	62.53714	-150.84134	0	0.40	0.40	$163,000	$407,027	76	63
20501479	Red	Petersville Road	Rabideux Creek tributary	62.31733	-150.30853	0	0.40	0.40	$183,000	$457,711	77	66
20400600	Red	Knik River Road	Unnamed	61.462725	-148.86016	0	0.39	0.39	$283,000	$725,142	78	78
20501390	Red	Parks Highway	Chulitna River tributary	62.60528	-150.22652	0	0.38	0.38	$323,000	$845,582	79	87
20501481	Red	Petersville Road	Ninemile Creek tributary	62.31047	-150.36227	0	0.38	0.38	$163,000	$431,720	80	65
20501396	Red	Petersville Road	Ninemile Creek tributary	62.311913	-150.3922	0	0.29	0.29	$215,000	$729,173	81	80
20401455	Black	Parks Highway	Spring Creek	61.555913	-149.24984	0	0.29	0.29	$312,000	$1,070,637	82	90
20401169	Red	Buffalo Mine Road	Moose Creek tributary	61.71027	-149.09184	0	0.27	0.27	$206,000	$761,451	83	82
20501494	Red	Petersville Road	Cache Creek tributary	62.51407	-150.91388	0	0.26	0.26	$197,000	$761,589	84	83
20502152	Red	Parks Highway	Chulitna River tributary	62.37938	-150.26729	0	0.25	0.25	$197,000	$775,540	85	85
20501499	Red	Petersville Road	Peters Creek tributary	62.49765	-150.76802	0	0.25	0.25	$370,000	$1,493,217	86	95

20401170	Gray	Buffalo Mine Road	Moose Creek tributary	61.73028	-149.04044	0	0.25	0.25	$201,000	$812,578	87	86
20501496	Red	Petersville Road	Long Creek	62.53283	-150.84973	0	0.22	0.22	$95,000	$427,152	88	64
20400586	Red	Glenn Highway	Unnamed	61.798195	-147.99051	0	0.21	0.21	$319,000	$1,496,266	89	96
20400596	Red	Knik River Road	Unnamed	61.489623	-148.91206	0	0.19	0.19	$141,000	$756,709	90	81
20400598	Red	Knik River Road	Unnamed	61.479474	-148.88895	0	0.19	0.19	$160,000	$863,296	91	88
20400627	Red	Old Glenn Highway	Unnamed	61.47402	-149.17479	0	0.18	0.18	$140,000	$765,866	92	84
20500569	Gray	Palmer Fishhook Rd	Fishhook Creek	61.758358	-149.22752	0	0.15	0.15	$573,000	$3,855,334	93	101
20501085	Red	Parks Highway	Unnamed	61.577222	-149.72778	0	0.09	0.15	$500,000	$3,433,582	94	100
20400628	Red	Old Glenn Highway	Unnamed	61.47402	-149.17015	0	0.14	0.14	$130,000	$949,925	95	89
20501491	Red	Petersville Road	Peters Creek tributary	62.48464	-150.7643	0	0.13	0.13	$192,000	$1,436,193	96	92
20400594	Red	Jonesville Mine Road	Eska Creek tributary	61.733072	-148.91504	0	0.13	0.13	$193,000	$1,477,464	97	94
20500568	Red	Palmer Fishhook Rd	Little Susitna River Trib	61.751338	-149.23256	0	0.13	0.13	$399,000	$3,102,307	98	99
20400626	Red	Old Glenn Highway	Unnamed	61.473731	-149.18927	0	0.09	0.09	$254,000	$2,854,027	99	98
20501500	Gray	Petersville Road	Peters Creek tributary	62.48615	-150.76562	0	0.07	0.07	$169,000	$2,362,625	100	97
20401319	Black	Glenn Highway	Spring Creek tributary	61.543956	-149.25141	0	0.05	0.05	$72,000	$1,440,000	101	93
20501207	Red	Palmer Fishhook Rd	Little Susitna River Trib	61.74695	-149.23218	0	0.05	0.05	$272,000	$5,558,131	102	103
20501067	Red	Pittman Road	Unnamed	61.620278	-149.62361	79	0.04	0.04	$500,000	$13,033,344	103	105
20501206	Red	Palmer Fishhook Rd	Little Susitna River Trib	61.73625	-149.23341	0	0.04	0.04	$169,000	$4,747,892	104	102
20401191	Red	Knik River Road	Friday Creek tributary	61.43481	-148.78177	0	0.01	0.01	$209,000	$20,900,000	105	108
20401313	Gray	Alaska Railroad	Rabbit Slough tributary	61.54244	-149.23131	0	0.01	0.01	$222,000	$22,200,000	106	109
20501380	Red	Parks Highway	Unnamed	62.877824	-149.80453	0	0.01	0.01	$130,000	$13,000,000	107	104
20501382	Red	Parks Highway	Coal Creek tributary	62.876534	-149.81442	0	0.01	0.01	$466,000	$46,600,000	108	112
20501389	Red	Parks Highway	Chulitna River tributary	62.58795	-150.23599	0	0.01	0.01	$250,000	$25,000,000	109	110
20501415	Red	Parks Highway	Unnamed	62.179672	-150.18733	2	0.01	0.01	$192,000	$19,200,000	110	107
20501508	Gray	Petersville Road	Twentymile Creek Trib	62.35535	-150.66945	0	0.01	0.01	$160,000	$16,000,000	111	106
20502147	Red	Parks Highway	Chulitna River tributary	62.55037	-150.23428	0	0.01	0.01	$312,000	$31,200,000	112	111

Table B4. MSB owned fish passage sites ranked according to upstream miles. Note that field verification is required before any replacement decisions because the ranking is based on best estimates of upstream miles and cost.

Fish Pass. Site #	ADFG rating	Road Name	Stream Name	Lat	Long	Lake Area (acres)	Upstream Miles Non-Barrier Termination	Upstream Miles Barrier Termination	Estimated Cost	Cost-Benefit ($ per mi)	MSB Upstream Mile Ranking	MSB Cost Benefit Ranking
20501466	Red	Hidden Hills Road	Caswell Creek	61.98929	-149.997	0	2.31	5.38	$200,000	$31,335	1	2
20501514	Red	Shaman Road	Caswell Creek	62.01782	-149.948	0	4.72	4.72	$208,000	$37,199	2	3
20401288	Gray	Home Built Circle	Neklason & unnamed lakes	61.62735	-149.283	102	1.31	3.89	$213,000	$44,107	3	5
20501436	Gray	Beaver Lake Road	Lynda Lake Portage	61.56963	-149.841	169	3.11	3.11	$400,000	$52,547	4	22
20401844	Red	Fish Lake Road	Fish Lake tributary	61.79082	-148.537	0	2.71	2.71	$85,000	$54,797	5	1
20501461	Red	Caswell Lakes Road	Unnamed	62.00057	-149.956	0	2.64	2.64	$156,000	$58,668	6	7
20501154	Red	Foothills Boulevard	Lucille Creek	61.56167	-149.571	0	2.4	2.4	$200,000	$59,014	7	14
20501156	Red	Settler Bay Drive	Crocker Creek	61.51222	-149.629	0	2.21	2.21	$400,000	$64,921	8	29
20501232	Red	Sushana Road	Coal Creek	61.66169	-149.467	0	2.16	2.16	$142,000	$65,091	9	10
20501409	Red	Susitna River Road	Trapper Creek	62.3155	-150.219	0	2.04	2.04	$461,000	$65,772	10	38
20401303	Red	Edlund	Cottonwood Creek	61.55449	-149.488	0	1.97	1.97	$368,000	$66,776	11	30
20501055	Red	Meadow Lakes Drive	Seymore Lake Drainage	61.5975	-149.678	83	1.89	1.89	$111,000	$67,896	12	6
20401302	Red	Marble Way	Cottonwood Creek	61.5416	-149.523	0	1.78	1.78	$355,000	$73,240	13	31
20401299	Gray	Lucy Lake Road	Lucy Creek tributary	61.51441	-149.574	27	1.14	1.69	$145,000	$83,388	14	15
20501130	Gray	Private Access Drive	Unnamed	61.57306	-149.839	0	0.39	1.46	$99,000	$85,936	15	12
20501448	Gray	Horseshoe Lake Rd	Unnamed	61.56709	-149.917	45	1.42	1.42	$104,000	$87,534	16	13
20501077	Red	Ridgecrest Road	Little Meadow Creek	61.5725	-149.693	70	1.34	1.34	$272,000	$96,021	17	32
20401315	Red	Old Matanuska Road	Spring Creek	61.54821	-149.229	0	0.01	1.31	$85,000	$96,524	18	8
20501515	Red	Shaman Road	Caswell Creek Tributary	62.01909	-149.948	0	1.25	1.25	$109,000	$109,708	19	16
20401272	Gray	Sierra Street	King Lake outlet	61.62141	-149.344	115	1.17	1.17	$76,000	$126,648	20	9
20501223	Red	Royal Lane	O'Brian Creek	61.48391	-149.683	0	0.54	1.14	$200,000	$127,717	21	28
20401331	Gray	North 49th State St	Wasilla Creek tributary	61.61438	-149.209	0	1.11	1.11	$74,000	$128,739	22	11
20501075	Red	Beverly Lake Road	Unnamed	61.61611	-149.565	0	1.08	1.08	$57,000	$129,548	23	4
20501465	Gray	Hidden Hills Road	Unnamed	61.98934	-149.979	0	1.07	1.07	$135,000	$131,010	24	20
20401301	Red	Riverdell	Cottonwood Creek	61.53214	-149.528	0	0.96	0.96	$317,000	$138,864	25	43
20501051	Gray	Phillips Drive	Unnamed	61.61139	-149.639	32	0.9	0.9	$99,000	$151,069	26	19
20501467	Red	Makuskin	Unnamed	62.14681	-149.913	2	0.89	0.89	$117,000	$171,004	27	24
20501076	Gray	Kalmbach Lake Dr	Unnamed	61.61472	-149.588	52	0.79	0.79	$110,000	$175,483	28	25
20401176	Red	Clare Way	Knik River tributary	61.47771	-148.892	0	0.69	0.69	$90,000	$181,171.35	29	23
20401271	Red	Unnamed	Anderson Lake outlet	61.62339	-149.324	99	0.68	0.68	$102,000	$187,264	30	26
20501258	Red	Zero Lakes Road	Lake Creek tributary	61.67188	-149.824	0	0.63	0.63	$80,000	$199,412	31	21
20401845	Red	Fish Lake Road	Fish Lake tributary	61.78276	-148.555	0	0.54	0.54	$52,000	$202,918	32	17
20401340	Red	Bonnie	Wasilla Creek tributary	61.64679	-149.19	0	0.51	0.51	$105,000	$203,922	33	36
20401294	Gray	West Halter Way	Cottonwood Creek tributary	61.52991	-149.52	0	0.07	0.49	$47,000	$204,100	34	18
20501469	Red	Malaspina	Unnamed	62.14444	-149.921	0	0.47	0.47	$106,000	$204,609	35	39
20401879	Red	Victory Road	Packsaddle Creek	61.80069	-147.986	0	0.43	0.43	$111,000	$207,104	36	41
20401339	Red	North Bonnie Dr.	Wasilla Creek tributary	61.64275	-149.194	0	0.42	0.42	$85,000	$224,575	37	34
20501516	Red	Susitna River Road	Trapper Creek tributary	62.31506	-150.198	0	0.42	0.42	$410,000	$225,741	38	62
20401881	Red	Samovar Way	Wasilla Creek tributary	61.71913	-149.103	0	0.4	0.4	$82,000	$226,359	39	35
20501479	Gray	Mastodon Road	Unnamed	62.28277	-149.951	0	0.4	0.4	$143,000	$239,658	40	46
20501513	Red	Saunders Road	Susitna River tributary	62.30718	-150.185	0	0.4	0.4	$95,000	$260,608	41	40

20501456	Red	Bradley	Susitna River tributary	62.30309	-150.179	0	0.38	0.38	$85,000	$278,441	42	37
20501459	Red	Bradley	Susitna River tributary	62.28135	-150.179	0	0.34	0.34	$70,000	$329,228	43	33
20401322	Gray	Nelson Road	Spring Creek	61.54779	-149.264	0	0.28	0.28	$111,000	$341,781	44	47
20501222	Red	Rubacaba Road	O'Brian Creek	61.49331	-149.66	0	0.27	0.27	$107,000	$346,854	45	48
20400593	Red	Jone Village Road	Unnamed	61.73291	-148.919	13	0.26	0.26	$45,000	$357,665	46	27
20401341	Red	Falk Road	Wasilla Creek tributary	61.65719	-149.217	0	0.25	0.25	$87,000	$389,587	47	45
20501193	Red	Lewis Loop	Fish Creek tributary	61.45493	-149.809	0	0.25	0.25	$99,000	$397,134	48	49
20501468	Red	Malaspina	Unnamed	62.16042	-149.933	0	0.24	0.24	$68,000	$401,531	49	42
20502071	Gray	North Solid Rock Cir	Unnamed	61.69472	-149.261	39	0.2	0.2	$89,000	$435,098	50	50
20401330	Red	Seagull Drive	Wasilla Creek tributary	61.61601	-149.212	48	0.19	0.19	$103,000	$461,072	51	53
20501190	Red	Kenny Boulevard	Willow Creek tributary	61.77268	-149.987	0	0.19	0.19	$170,000	$535,240	52	61
20501433	Red	Buckingham Palace	Lilly Creek	61.7044	-150.003	0	0.18	0.18	$137,000	$541,229	53	58
20401269	Red	Twin Lakes Drive	Neklason Lake Tributary	61.63196	-149.264	0	0.16	0.16	$75,000	$602,155	54	51
20501120	Red	Lakes Boulevard	Unnamed	61.56306	-149.848	0	0.14	0.14	$88,000	$650,000	55	56
20501460	Red	Barge Road	Question Creek	62.22772	-150.052	0	0.13	0.13	$45,000	$650,391	56	44
20401342	Red	Bush Road	Wasilla Creek tributary	61.65705	-149.215	0	0.13	0.13	$92,000	$705,976	57	57
20401234	Red	Unknown	Knik River tributary	61.4551	-148.838	0	0.13	0.13	$111,000	$755,042	58	60
20501463	Red	Cummings	Talkeetna River tributary	62.34392	-150.066	0	0.13	0.13	$287,000	$854,698	59	71
20401289	Red	East Larch Drive	Cottonwood Creek Trib	61.6008	-149.342	0	0.12	0.12	$73,000	$869,535	60	54
20501065	Gray	Jolly Roger Drive	Unnamed	61.63306	-149.611	0	0.1	0.1	$54,000	$908,958	61	52
20501099	Red	Victor Road	Unnamed	61.58972	-149.819	94	0.1	0.1	$65,000	$984,906	62	55
20401333	Red	North 49th State St	Wasilla Creek tributary	61.61578	-149.209	1	0.03	0.07	$123,000	$1,117,122	63	66
20401357	Red	Bains Jordan	Wasilla Creek tributary	61.65298	-149.189	0	0.07	0.07	$85,000	$1,303,171	64	64
20501073	Red	Wyoming Drive	Unnamed	61.62528	-149.587	0	0.06	0.06	$70,000	$1,351,339	65	63
20501100	Red	Shoreline Court	Unnamed	61.58944	-149.821	0	0.06	0.06	$53,000	$1,720,624	66	59
20401880	Red	Victory Road	Packsaddle Creek	61.79988	-147.986	0	0.06	0.06	$126,000	$1,980,462	67	68
20502076	Red	North Waldo Reed	Unnamed	61.69907	-149.303	0	0.05	0.05	$62,000	$2,114,751	68	65
20501405	Gray	Oil Well Road	Moose Creek tributary	62.22848	-150.445	0	0.04	0.04	$85,000	$2,170,476	69	67
20401359	Red	Fireweed Road	Wasilla Creek tributary	61.56652	-149.313	0	0.04	0.04	$85,000	$2,221,352	70	69
20401286	Gray	Trapline Drive	Cottonwood Slough	61.52564	-149.515	0	0.01	0.04	$113,000	$2,249,357	71	72
20401886	Red	Unknown	Eska Creek tributary	61.73244	-148.926	0	0.03	0.03	$74,000	$2,900,797	72	70
20401346	Red	East Oceanview Rd	Wasilla Creek tributary	61.71812	-149.104	0	0.02	0.02	$76,000	$3,467,333	73	73
20501131	Red	Unknown	Unnamed	61.58917	-149.821	0	0.02	0.02	$105,000	$5,304,675	74	74
20401235	Red	Buffalo Mine Rd	Moose Creek tributary	61.70985	-149.093	0	0.01	0.01	$99,000	$7,000,000	75	79
20401311	Black	Unknown	Spring Creek	61.54383	-149.252	0	0.01	0.01	$121,000	$7,100,000	76	80
20401345	Red	Unknown	Wasilla Creek tributary	61.71911	-149.103	0	0.01	0.01	$74,000	$7,400,000	77	77
20501064	Gray	Cove Drive	Unnamed	61.63361	-149.613	13	0.01	0.01	$85,000	$8,500,000	78	78
20501074	Red	Beverly Lake Road	Unnamed	61.61611	-149.566	0	0.01	0.01	$71,000	$9,900,000	79	76
20501181	Red	Creekside Road	Willow Creek side slough	61.76626	-149.995	0	0.01	0.01	$70,000	$12,100,000	80	75

Table B5. Railroad owned fish passage sites ranked according to upstream miles. Note that field verification is required before any replacement decisions because the ranking is based on best estimates of upstream miles and cost.

Fish Pass. Site #	ADFG rating	Road Name	Stream Name	Lat	Long	Lake Area (acres)	Upstream Miles Non-Barrier Termination	Upstream Miles Barrier Termination	Estimated Cost	Cost-Benefit ($ per mi)	Railroad Upstream Mile Ranking	Railroad Cost Benefit Ranking
20501139	Gray	Alaska Railroad	Little Meadow Creek	61.58586	-149.67	0	0.43	8.17	$600,000	$73,439	1	3
20501081	Red	Alaska Railroad	Meadow Creek tributary	61.58802	-149.722	72	5.61	7.60	$1,000,000	$131,579	2	7
20501807	Red	Alaska Railroad	Susitna River tributary	62.45379	-150.118	0	5.12	5.12	$321,000	$62,675	3	2
20501798	Red	Alaska Railroad	Susitna River tributary	62.30142	-150.108	0	0.74	4.07	$215,000	$52,810	4	1
20501799	Gray	Alaska Railroad	Question Creek	62.19553	-150.088	0	3.23	3.23	$312,000	$96,630	5	4
20502088	Gray	Alaska Railroad	Indian River tributary	62.83105	-149.637	135	2.20	2.20	$247,000	$112,091	6	6
20501152	Red	Alaska Railroad	Unnamed	61.59139	-149.741	137	2.07	2.07	$600,000	$290,092	7	16
20502094	Red	Alaska Railroad	Indian Creek tributary	62.8348	-149.65	0	2.05	2.05	$222,000	$108,159	8	5
20502078	Red	Alaska Railroad	Salmon Creek tributary	62.87123	-149.598	0	1.99	1.99	$312,000	$156,718	9	9
20501809	Red	Alaska Railroad	Susitna River tributary	62.50445	-150.104	21	1.82	1.82	$286,000	$157,255	10	10
20502133	Gray	Alaska Railroad	Unnamed	61.7611	-150.049	19	1.74	1.74	$231,000	$132,855	11	8
20502121	Gray	Alaska Railroad	Unnamed	62.69556	-149.835	4	1.38	1.38	$222,000	$160,948	12	11
20501808	Red	Alaska Railroad	Susitna River tributary	62.5027	-150.102	0	1.36	1.36	$312,000	$228,814	13	14
20502118	Red	Alaska Railroad	Susitna River tributary	62.71832	-149.778	0	1.18	1.18	$222,000	$187,967	14	12
20502134	Red	Alaska Railroad	Susitna River tributary	62.56136	-150.068	58	0.93	0.93	$312,000	$335,826	15	18
20502101	Red	Alaska Railroad	Unnamed	62.94857	-149.658	0	0.79	0.79	$170,000	$214,226	16	13
20501802	Red	Alaska Railroad	Susitna River tributary	62.10044	-150.069	0	0.76	0.76	$197,000	$260,160	17	15
20501162	Gray	Alaska Railroad	Unnamed	61.59507	-149.756	107	0.68	0.68	$600,000	$888,187	18	28
20502115	Red	Alaska Railroad	Unnamed	62.72756	-149.745	0	0.58	0.58	$170,000	$290,982	19	17
20502081	Gray	Alaska Railroad	Susitna River tributary	62.85891	-149.613	0	0.54	0.54	$254,000	$472,440	20	23
20501866	Black	Alaska Railroad	Unnamed	62.21251	-150.095	0	0.49	0.49	$222,000	$452,207	21	21
20502107	Red	Alaska Railroad	Unnamed	62.78555	-149.684	0	0.49	0.49	$222,000	$456,586	22	22
20502083	Red	Alaska Railroad	Susitna River tributary	62.85552	-149.622	0	0.45	0.45	$226,000	$500,817	23	25
20501803	Gray	Alaska Railroad	Susitna River tributary	62.04448	-150.071	0	0.45	0.45	$222,000	$497,816	24	24
20502119	Red	Alaska Railroad	Susitna River tributary	62.70676	-149.818	0	0.43	0.43	$170,000	$392,966	25	19
20501793	Red	Alaska Railroad	Susitna River tributary	62.44993	-150.12	0	0.39	0.39	$236,000	$602,122	26	26
20502141	Red	Alaska Railroad	Susitna River tributary	62.53811	-150.095	0	0.35	0.35	$517,000	$1,463,739	27	32
20502114	Red	Alaska Railroad	Unnamed	62.73495	-149.729	0	0.30	0.30	$120,000	$401,093	28	20
20502142	Black	Alaska Railroad	Susitna River tributary	62.49593	-150.097	0	0.26	0.26	$197,000	$769,159	29	27
20502143	Gray	Alaska Railroad	Susitna River tributary	62.53502	-150.097	0	0.17	0.17	$170,000	$1,028,031	30	30
20501865	Black	Alaska Railroad	Twister Creek	62.31321	-150.104	0	0.12	0.12	$107,000	$904,707	31	29
20501164	Black	Alaska Railroad	Unnamed	61.63005	-149.834	0	0.12	0.12	$124,000	$1,065,323	32	31
20501796	Gray	Alaska Railroad	4th of July Creek	63.20616	-149.332	0	0.11	0.11	$361,000	$3,324,600	33	37
20501165	Red	Alaska Railroad	Lake Creek tributary	61.6577	-149.937	0	0.11	0.11	$267,000	$2,473,333	34	36
20502122	Gray	Alaska Railroad	Lake Creek tributary	61.64408	-149.874	0	0.11	0.11	$222,000	$2,058,101	35	35
20502128	Black	Alaska Railroad	Susitna River tributary	62.61812	-149.996	0	0.09	0.09	$140,000	$1,482,174	36	33

20501166	Red	Alaska Railroad	Unnamed	61.67381	-149.964	0	0.09	0.09	$161,000	$1,735,907	37	34
20502130	Gray	Alaska Railroad	Unnamed	61.69884	-149.998	0	0.05	0.05	$237,000	$4,812,132	38	39
20501804	Gray	Alaska Railroad	Susitna River tributary	62.41718	-150.122	0	0.04	0.04	$165,000	$3,824,480	39	38
20401360	Black	Alaska Railroad	Wasilla Creek tributary	61.56646	-149.313	0	0.01	0.01	$107,000	$7,769,911	40	40
20501795	Red	Alaska Railroad	Unnamed	62.99057	-149.63	0	0.01	0.01	$294,000	$29,400,000	41	51
20501864	Gray	Alaska Railroad	Unnamed	63.06721	-149.569	0	0.01	0.01	$222,000	$22,200,000	42	49
20502077	Red	Alaska Railroad	Salmon Creek tributary	62.89515	-149.589	0	0.01	0.01	$170,000	$17,000,000	43	47
20502085	Red	Alaska Railroad	Indian River tributary	62.84637	-149.634	0	0.01	0.01	$368,000	$36,800,000	44	53
20502087	Gray	Alaska Railroad	Indian River tributary	62.8295	-149.637	0	0.01	0.01	$168,000	$16,800,000	45	46
20502093	Gray	Alaska Railroad	Susitna River tributary	62.96744	-149.647	0	0.01	0.01	$204,000	$20,400,000	46	48
20502096	Gray	Alaska Railroad	Susitna River tributary	62.96044	-149.653	0	0.01	0.01	$138,000	$13,800,000	47	41
20502098	Red	Alaska Railroad	Susitna River tributary	62.92512	-149.655	0	0.01	0.01	$156,000	$15,600,000	48	43
20502105	Red	Alaska Railroad	Susitna River tributary	62.933	-149.663	0	0.01	0.01	$159,000	$15,900,000	49	44
20502106	Red	Alaska Railroad	Susitna River tributary	62.93616	-149.666	0	0.01	0.01	$230,000	$23,000,000	50	50
20502109	Red	Alaska Railroad	Unnamed	62.78926	-149.696	0	0.01	0.01	$346,000	$34,600,000	51	52
20502110	Red	Alaska Railroad	Susitna River tributary	62.74159	-149.714	0	0.01	0.01	$140,000	$14,000,000	52	42
20502138	Red	Alaska Railroad	Susitna River tributary	62.5224	-150.08	0	0.01	0.01	$166,000	$16,600,000	53	45

Table B6. Privately owned fish passage sites ranked according to upstream miles. Note that field verification is required before any replacement decisions because the ranking is based on best estimates of upstream miles and cost.

Fish Pass. Site #	ADFG rating	Road Name	Stream Name	Lat	Long	Lake Area (acres)	Upstream Miles Non-Barrier Termination	Upstream Miles Barrier Termination	Estimated Cost	Cost-Benefit ($ per mi)	Private Upstream Mile Ranking	Private Cost Benefit Ranking
20401335	Gray	Private Drive	Wasilla Creek	61.63222	-149.2	0	1.45	40.66	$377,000	$9,273	1	1
20401262	Gray	Private Drive	Bodenberg Creek	61.56409	-149.041	0	1.19	1.19	$135,000	$113,249	2	3
20501155	Gray	Bailey Ave	Lucille Creek	61.57028	-149.51	374	0.97	0.97	$200,000	$207,227	3	4
20501116	Red	Private Dr Lakes Blv	Unnamed	61.54167	-149.949	47.1	0.81	0.81	$85,000	$105,276	4	2
20401275	Gray	Private Camp Challenge Christ	Wolf Lake outlet stream	61.62844	-149.309	0	0.50	0.50	$175,000	$347,673	5	9
20401260	Red	Private Drive	Bodenberg Creek Trib	61.56648	-149.043	0	0.39	0.39	$85,000	$218,447	6	5
20401264	Red	private drive - Goodrich	Bodenberg Creek	61.57038	-149.039	0	0.38	0.38	$278,000	$728,788	7	15
20401270	Red	Private- Camp Challenge Christ	Neklason Lake Tributary	61.63292	-149.274	0	0.32	0.32	$72,000	$226,502	8	7
20501070	Red	Private off Double Brother	Cloudy Lake Drainage	61.61639	-149.626	0	0.31	0.31	$69,000	$221,889	9	6
20401266	Gray	Driveway Off Bodenberg	Bodenberg Creek	61.57262	-149.036	0	0.29	0.29	$85,000	$296,651	10	8
20401282	Gray	driveway - Trapline Drive	Cottonwood Slough	61.52648	-149.512	0	0.03	0.27	$116,000	$425,950	11	11
20401265	Red	private drive	Bodenberg Creek Trib	61.57234	-149.042	0	0.27	0.27	$179,000	$661,685	12	13
20501117	Red	Private Dr Lakes Blv	Unnamed	61.54028	-149.951	5	0.25	0.25	$93,000	$371,756	13	10
20401274	Red	Driveway	Wolf Lake outlet stream	61.62593	-149.312	0	0.22	0.22	$96,000	$442,553	14	12
20401261	Gray	private drive	Bodenberg Creek	61.56419	-149.043	0	0.16	0.16	$135,000	$850,908	15	16
20502113	Red	Private Gravel ATV	Little Meadow Creek	61.57636	-149.728	0	0.14	0.14	$235,000	$1,666,467	16	20
20401273	Red	Driveway	Cottonwood Creek Trib	61.62455	-149.314	0	0.13	0.13	$85,000	$667,763	17	14
20401887	Red	Lee Drive	Packsaddle Creek	61.80521	-147.982	0	0.12	0.12	$151,000	$1,299,380	18	19
20401259	Red	Private off Old Glenn Hwy	Bodenberg Creek	61.57624	-149.042	0	0.11	0.11	$186,000	$1,696,323	19	21
20401263	Red	Private Drive - Goodrich	Bodenberg Creek Trib	61.57037	-149.04	0	0.11	0.11	$119,000	$1,133,220	20	17
20401283	Gray	driveway off Trapline Drive	Cottonwood Slough	61.52631	-149.514	0	0.01	0.05	$62,000	$1,160,296	21	18
20501153	Red	Trail	Unnamed	61.59083	-149.741	0	0.04	0.04	$79,000	$1,854,068	22	23
20401848	Red	Driveway off Oceanview Rd	Wasilla Creek tributary	61.71852	-149.104	0	0.04	0.04	$76,000	$1,839,740	23	22
20401284	Gray	driveway - Trapline Drive	Cottonwood Slough	61.52595	-149.515	0	0.04	0.04	$85,000	$2,325,763	24	24
20401363	Red	private drive near Hyer Road	Wasilla Creek tributary	61.57566	-149.295	0	0.02	0.02	$111,000	$4,631,182	25	25
20501063	Gray	Driveway off Pittman	Unnamed	61.61611	-149.62	0	0.01	0.01	$70,000	$4,820,573	26	26
20501221	Red	Driveway	Nancy Creek tributary	61.68859	-149.957	0	0.01	0.01	$54,000	$5,400,000	27	27

Table B7. City of Houston owned barriers ranked according to upstream miles. Note that field verification is required before any replacement decisions because the ranking is based on best estimates of upstream miles and cost.

Fish Pass. Site #	ADFG rating	Road Name	Stream Name	Lat	Long	Lake Area (acres)	Upstream Miles Non-Barrier Termination	Upstream Miles Barrier Termination	Estimated Cost	Cost-Benefit ($ per mi)	Houston Upstream Mile Ranking	Houston Cost Benefit Ranking
20501092	Red	Birch Road	Unnamed	61.57556	-149.775	38.4	3.06	4.47	$111,000	$24,809	1	1
20501094	Red	Larae Road	Unnamed	61.57972	-149.746	0	0.31	0.97	$102,000	$105,311	2	2
20501082	Red	Airolo Drive	Unnamed	61.58222	-149.725	0	0.46	0.46	$67,000	$146,449	3	3
20501438	Gray	Kenlar Road	Unnamed	61.57825	-149.753	0	0.25	0.25	$74,000	$293,712	4	4
20501090	Gray	Little Meadow Creek Rd	Unnamed	61.57528	-149.736	0	0.17	0.17	$85,000	$513,604	5	5
20501080	Red	Cannon Drive	Unnamed	61.58778	-149.723	0	0.05	0.05	$156,000	$3,359,887	6	6
20501086	Red	Brittany Drive	Unnamed	61.57694	-149.729	0	0.04	0.04	$85,000	$2,074,879	7	7
20501084	Gray	Brittany Drive	Little Meadow Creek	61.57806	-149.73	0	0.03	0.03	$146,000	$5,254,451	8	8

Table B8. UAA owned fish passage sites ranked according to upstream miles. Note that field verification is required before any replacement decisions because the ranking is based on best estimates of upstream miles and cost.

Fish Pass. Site #	ADFG rating	Road Name	Stream Name	Lat	Long	Lake Area (acres)	Upstream Miles Non-Barrier Termination	Upstream Miles Barrier Termination	Estimated Cost	Cost-Benefit ($ per mi)	UAA Upstream Mile Ranking	UAA Cost Benefit Ranking
20501148	Red	Moose Meadows Road	Unnamed	61.67806	-149.405	0	0.64	0.64	$138,000	$214,785	1	3
20501150	Red	Moose Meadows Road	Unnamed	61.67333	-149.418	0	0.40	0.40	$69,000	$173,155	2	1
20501147	Red	Moose Meadows Road	Unnamed	61.6825	-149.409	0	0.31	0.31	$58,000	$185,333	3	2
20501149	Red	Moose Meadows Road	Unnamed	61.67528	-149.413	0	0.16	0.16	$44,000	$280,012	4	4

Table B9. City of Wasilla owned fish passage sites ranked according to upstream miles. Note that field verification is required before any replacement decisions because the ranking is based on best estimates of upstream miles and cost.

Fish Pass. Site #	ADFG rating	Road Name	Stream Name	Lat	Long	Lake Area (acres)	Upstream Miles Non-Barrier Termination	Upstream Miles Barrier Termination	Estimated Cost	Cost-Benefit ($ per mi)	Wasilla Upstream Mile Ranking	Wasilla Cost Benefit Ranking
20401304	Gray	Fern	Cottonwood Creek	61.56313	-149.45	0	1.32	2.08	$377,000	$180,946	1	1
20501197	Red	Mack Road	Wetland connector	61.57662	-149.512	0	0.04	0.04	$99,000	$2,386,507	2	2

Table B10. DNR owned fish passage sites ranked according to upstream miles. Note that field verification is required before any replacement decisions because the ranking is based on best estimates of upstream miles and cost.

Fish Pass. Site #	ADFG rating	Road Name	Stream Name	Lat	Long	Lake Area (acres)	Upstream Miles Non-Barrier Termination	Upstream Miles Barrier Termination	Estimated Cost	Cost-Benefit ($ per mi)	DNR Upstream Mile Ranking	DNR Cost Benefit Ranking
20401198	Gray	Maud Road	McRoberts Creek	61.58475	-148.98727	0.00	1.73	1.73	$173,000	$205,952	1	1