



**Alaska Department of Transportation & Public Facilities
Seward Highway MP 75-90**

**Final
Hydrologic and Hydraulic Assessment**

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Prepared by

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1.0 Introduction

This Hydrologic and Hydraulic Assessment presents the findings of the 2006 hydrologic reconnaissance effort conducted for the Seward Highway Milepost (MP) 75-90 Project (Project). The purpose of this work was to document the existing conveyance structures, evaluate their condition and hydraulic capacity, and develop preliminary recommendations for replacement structures. The accompanying plan set, *Preliminary Drainage Plan Set* (Plan Set), should be used as a visual aid to the discussion in this Assessment.

2.0 Study Objectives

This study documents the type, size, and condition of existing conveyance structures within the project area. Structures were evaluated based on condition, capacity, and ability to meet fish passage requirements. Recommendations are made for replacement structures as required. Per the scope of work, evaluation of existing or proposed bridge sites was done only on a qualitative basis. Sizing of bridge openings and scour depths is not part of the current scope of work.

3.0 Scope of Work

The scope of work for this memorandum consists of the following tasks:

- Conduct field reconnaissance to review and document the existing conveyance structures along the route. Collect basic field data at each site.
- Obtain existing data including mapping, aerial photography, record drawings, and available data on anadromous and resident fish use.
- Perform interviews with ADOT&PF and Alaska Railroad Corporation (ARRC) operations and maintenance personnel to document existing flooding, icing, debris accumulation, erosion, or other hydrologic issues.
- Delineate drainage basins and determine drainage basin characteristics.
- Calculate design flows for each conveyance structure.
- Evaluate fish passage at each site.
- Prepare report to include information necessary to support Section 404 and ADNR OHMP Title 41 permitting for all culverts, morphological analysis for bridge sites, and fish passage preliminary designs.

4.0 Project Area

The project area is located at the southern boundary of the Municipality of Anchorage, approximately 30 to 40 miles south of the Anchorage Bowl. The Seward Highway parallels the coastline of Turnagain Arm and crosses Ingram Creek, Placer River, Portage Creek, Twentymile River, Peterson Creek, Kern Creek, Virgin Creek, Glacier Creek, and many unnamed streams and drainages between MP 75 and 90 (**Plan Set** title sheet).

Mileposts used throughout this report are the mileposts of the existing highway. Milepost 0 is in Seward, MP 75 is approximately Ingram Creek and MP 90 is approximately the Alyeska Highway Intersection (Girdwood). For reference, Potter Marsh near Anchorage is at MP 117. All elevations, including tidal, are based on NAVD 1988 datum.

5.0 History

The project area was originally a tidal mudflat similar to what can be observed on the undeveloped south side of Turnagain Arm. The rivers that flowed into Turnagain Arm were free to meander. Construction of the Alaska Railroad through a portion of the project area in the early 1900s served to fix in place the locations of the drainages that it crossed. Later construction and reconstruction of the roadway fixed in place the locations of the remainder of the drainages within the project area.

The earthquake of March 27, 1964 severely damaged the Seward Highway within the project area. The entire area subsided from the earthquake. This entire section of roadway was reconstructed following the earthquake. This reconstruction began in May 1966 and was completed in May 1968. The pre-1964 conveyance structures were timber pile supported bridges or metal culvert. The majority of these were replaced. At major rivers steel pile-supported steel bridges were installed. Steel culverts were installed at smaller drainages. In some cases a fill section was constructed where there was a prior conveyance structure. All of these changes influenced the hydrology of the project area. The conveyance structures shown on the 1966/68 record drawings are the structures that exist to this day, with the exception of Ingram Creek where a new bridge was installed in 1985.

A major manmade change within the project area was that the construction of the highway (and the adjacent railroad) which resulted in the creation of numerous wetlands and ponds on former mudflat areas on the inland side of the highway. These areas now provide fish and wildlife habitat.

A major natural change within the project area is the migration of the main channel of Turnagain Arm. Review of historic aerial photography showed that the main channel of Turnagain Arm was on the south side of the inlet in 1951 for the entire project area from Ingram Creek to Girdwood. By 1973 the channel had migrated to the north side of the inlet from just west of Peterson Creek (MP 84.6) to MP 88. By 2005 it had migrated to the north side from just west of Twentymile River (MP 82) to MP 88. When the existing culverts were placed in 1966/68 it is likely that there was an extensive tide flat on the north side between Twenty-Mile River and MP 88. This has now been scoured away and the culvert outlets in this segment are now perched at the top of a steep rip rap slope. In this segment of the project, fish access to these culverts is only possible during high tides.

6.0 Data Collection

Data collected for this report includes:

Historic aerial photography for project area from:

- 1950/51, USGS, 1"=3300 feet
- 1973, Portage to Bird at Low Tide, 1"=2000'

The 1993 Tidal Report for Seward Highway Bird Point to Girdwood and tidal data collected by Skip Barber at the Twentymile River bridge..

LIDAR ground survey of project corridor performed by Aero-Metric, Inc on September 20 & 21, 2005, and May 19, 2006. This survey was certified by independent ground survey provided by AADOT&PF that was conducted between September 15, 2005 and April 19, 2006.

Fish reports completed for this project.

Record drawings for project area including:

- State of Alaska, Department of Highways, Seward Highway Emergency Grading and Drainage, 1964. (Post earthquake temporary trestle and profile grade).
- State of Alaska, Department of Highways, Seward Highway Grading, Drainage, Bridges and Surfacing, March 22, 1966. (Post earthquake reconstruction)
- Alaska Department of Transportation, Ingram Creek Bridge, July 28, 1983.
- ARRC 2002 Track Charts. (Schematic plan and profile of track with conveyance structure locations and size.)

Memorandum on culverts in project area including:

- Culvert and Tide Elevations Spreadsheet, Paul Janke, AADOT&PF, September 15, 2006.
- Spreadsheet summary of the culverts in Project area, Ed Weiss, ADNR OHMP. July 19, 2006.
- Summary of an August 17 and August 26 inspection of culverts under the Seward Highway between Portage and Girdwood, Paul Janke, AADOT&PF, August 15, 2005.

7.0 Reconnaissance Surveys

The field reconnaissance and data collection was done on September 13, 2006, September 18, 2006, November 7, 2006 and October 4, 2007. Each of the existing culverts and bridges within the project corridor were visited and conveyance structure milepost, type, size condition, and drainage basin characteristics were noted. Photographs were taken at each site, general hydrologic observations were made and preliminary drainage recommendations developed.

An additional reconnaissance focusing specifically on the mile 81.9 culvert near Twentymile River was done on July 2, 2007 to document how the tides affects the water level upstream from this culvert. This was done in response to public comment about flooding in this area.

Additional data collection on fish streams was done as part of the fisheries work for this project. This included measurement of channel slopes, cross sections, ordinary high water widths, and observation of substrate type.

8.0 Existing Problem Areas

Interviews with ADOT&PF and ARRC operations and maintenance personnel were conducted to document existing flooding, icing, debris accumulation, erosion or other hydrologic issues. Meeting records are included as an appendix. In general the people interviewed reported no flooding or icing issues that affect the roadway within the project corridor.

The major problem is the extremely poor condition of the existing culverts. These culverts are corrugated steel pipe that was installed over 40 years ago in a saline environment. Some of these pipes are so corroded that they do not have any bottom. With the bottom of a culvert gone, water flowing through the culvert could wash the fill material out from below and around the culvert. This can cause the formation of a sink hole in the roadway. Such a sinkhole was observed at a drainage culvert and in the road shoulder at the Kern Creek culvert crossing.

9.0 Hydrology and Hydraulics

The following is a description of each drainage basin along the project corridor, a discussion of the existing conveyance structure, the recommended conveyance structure, and any other items of note. Sizing of replacement bridges was not done for this project. Descriptions are provided from MP 75 to 90, Ingram Creek to Girdwood. All descriptions of left or right side of a channel are looking downstream. Table 1 provides a summary of all the existing and proposed conveyance structures. Table 2 provides details of all the existing and proposed conveyance structures. The *Preliminary Drainage Plan Set (Plan Set)* provides aerial photo mapping and ground photography of each existing culvert and shows locations of proposed culverts.

Drainage areas are based on USGS topographic mapping supplemented by aerial photography and ground surveys to delineate drainage basins.

Design flows are as recommended by the Alaska Preconstruction Manual Section 1120.5. For culverts on primary highways the design flow is the 50-year frequency flood. For bridges on primary highways the design flow is the 50-year frequency flood. For bridges in designated flood hazard areas the design flow is the 100-year frequency flood. All of the bridges within the project area except for Peterson Creek (Ingram Creek undetermined) are in FEMA designated flood areas (FEMA panel numbers 02005-0510, 0520B and 0600B). In addition, all culverts were evaluated for their ability to pass the 100 year frequency flood.

The existing conveyance structures, with the exception of the Ingram Creek Bridge, were designed in 1966 without hydrologic data. Review of the bridge drawings indicated the bridges were installed with the same length as the bridges destroyed in the 1964 earthquake, were all considered intertidal and the low chord elevation was based on extreme high tide elevation.

Table 1 summarizes the number of existing and proposed conveyance structures within the project area.

Table 1 Summary of Existing and Proposed Conveyance Structures

	Existing	Proposed	Comments
Bridges	9	10	
Culverts	26	12	1 of 12 is located on ARRC

There is no stream flow data for any of the drainages within the project area except Glacier Creek where a gauge was operated by USGS at the ARRC Bridge from 1965 to 1978. With the exception of Glacier Creek, design flows were calculated using the methodology contained in “Estimating the Magnitude and Frequency of Peak Streamflows for Ungaged Sites on Streams in Alaska and Conterminous Basins in Canada” (USGS Water Resources Investigations Report 03-4188, 2003). Parameters for each proposed conveyance structure are included in Table 2.

Table 2 Parameters used for USGS Regression Analysis

Mile-post	Stream Name	Drainage Basin Area (sq. mi.)	Precipitation (in/yr)	Lake Area (square miles)	Lake Area (%)	50-YR ¹ Design Flow (cfs)	100-YR ¹ Design Flow (cfs)
75.2	Ingram Creek	21.7	70	0.00	0.00%		2,600
77.9	Placer River (Overflow)	126	111	0.04	0.03%		19,000
78.4	Placer River	126	111	0.04	0.03%		19,000
79.0	Portage Creek #1	56.7	143	2.00	3.52%		13,000
79.6	Portage Creek #2	56.7	143	2.00	3.52%		13,000
81	Twentymile River	168	113	1.40	0.83%		25,000
81.9	NONE	1.75	70	0.30	16.9%	250	300
82.8	NONE	0.08	70	0.00	0.00%	19	23
83.3	Pipe 1	0.45	70	0.03	7.77%	80	96
83.31	Pipe 2	0.41	70	0.01	3.52%	75	90
83.8	NONE	0.86	70	0.05	5.74%	140	170
84.15	Peterson Creek	4.18	70	0.02	0.40%		650
84.6	NONE	0.24	70	0.00	0.00%	47	57
85.2	NONE	0.51	70	0.03	6.73%	92	110
85.99	NONE	0.02	70	0.00	0.00%	6	7
86.17	NONE	0.01	70	0.00	0.00%	3	4
86.3	Kern Creek	7.80	70	0.00	0.00%	940	1,100
86.7	NONE	0.01	70	0.00	0.00%	2	3
87.1	Kern Slide area	1.17	70	0.05	4.51%	180	220
87.7	NONE	0.12	70	0.00	0.00%	27	33
88.15	NONE	0.67	70	0.02	2.93%	120	140
88.6	NONE	0.10	70	0.00	0.00%	23	28

Mile-post	Stream Name	Drainage Basin Area (sq. mi.)	Precipitation (in/yr)	Lake Area (square miles)	Lake Area (%)	50-YR ¹ Design Flow (cfs)	100-YR ¹ Design Flow (cfs)
88.7	NONE	0.13	70	0.00	0.00%	29	35
89.2	Virgin Creek	4.38	70	0.00	0.00%	580	670
89.6	NONE	0.29	70	0.00	0.00%	57	68
89.7	Glacier Creek	58.2	70	0.00	0.00%		16,000 ²
89.8	Old Girdwood Drainage	0.05	70	0.00	0.00%	12	14

¹ Per regression equations and procedures of *Estimating the Magnitude and Frequency of Peak Streamflows for Ungaged Sites on Streams in Alaska and Conterminous Basins in Canada*, USGS Water-Resources Investigations Report 03-4188

² Determined by gage record analysis.

Table 3 Existing and Proposed Conveyance Structures

Mile Post	Drainage Name	Drainage Area (mi ²)	Glacier Area ¹ (mi ²)	Design Flow ² (cfs)	Fish Stream	Existing Conveyance Structure			Proposed Work						
						Type	Size	Length (ft)	Type	Size (in)	Length (ft)	Inlet Elevation	Outlet Elevation	Slope	Comments
75.2	Ingram Creek	21.7	0.67	2,600	Yes	bridge, 2 span	204 ft	n/a	replace (typ) bridge	n/a	n/a	n/a	n/a	n/a	
77.9	Placer River (Overflow)	126	47	19,000	Yes	bridge, 4 span	324 ft	n/a	replace (typ) bridge	n/a	n/a	n/a	n/a	n/a	
78.4	Placer River	126	47	19,000	Yes	bridge, 5 span	456 ft	n/a	replace (typ) bridge	n/a	n/a	n/a	n/a	n/a	
79.0	Portage Creek #1	56.7	22	13,000	Yes	bridge, 3 span	203 ft	n/a	replace (typ) bridge	n/a	n/a	n/a	n/a	n/a	
79.6	Portage Creek #2	56.7	22	13,000	Yes	bridge, 3 span	243 ft	n/a	replace (typ) bridge	n/a	n/a	n/a	n/a	n/a	
81.0	Twentymile River	168	40	25,000	Yes	bridge, 7 span	568 ft	n/a	replace (typ) bridge	n/a	n/a	n/a	n/a	n/a	
81.9	Unnamed	1.75	0	250	Yes	cmp, beveled edges	72 in	135	replace	72	135	18.9	18.2	0.50 percent	
82.8	Unnamed	0.08	0	19	Yes	cmp	36 in	96	replace	36	96	22.8	22.4	0.50 percent	
83.3	Unnamed	0.45	0	80	Yes	cmp	36 in	98	remove	n/a	n/a	n/a	n/a	n/a	drainage conveyed to new RR culvert near MP 83.8
83.31	Unnamed	0.41	0	75	Yes	cmp	36 in	118	remove	n/a	n/a	n/a	n/a	n/a	
83.5	Unnamed	n/a	0	n/a	No	cmp	unknown	unknown	remove	n/a	n/a	n/a	n/a	n/a	
83.8	Unnamed	0.86	0	140	Yes	ARRC cmp	36 in	40	install new RR culvert	see text	45	24.4	24.3	0.30 percent	Construct outlet channel
84.1	Unnamed	n/a	0	n/a	No	cmp	48 in	98	remove	n/a	n/a	n/a	n/a	n/a	drainage conveyed to Peterson Creek
84.15	Peterson Creek	4.18	0.46	650	Yes	bridge, 2 span	123 ft	n/a	replace (typ) bridge	n/a	n/a	n/a	n/a	n/a	
84.2	Unnamed	n/a	0	n/a	No	cmp	48 in	94	remove	n/a	n/a	n/a	n/a	n/a	drainage conveyed to Peterson Creek
84.6	Unnamed	0.24	0	47	No	cmp	36 in	108	replace	36	108	24.0	22.9	1.00 percent	raise to match existing ground level
85.2	Unnamed	0.51	0	92	Yes	cmp	36 in	106	replace	48	106	19.6	19.1	0.50 percent	match existing inlet elevation
85.6	Unnamed	n/a	0	n/a	No	cmp	48 in	89	remove	n/a	n/a	n/a	n/a	n/a	drainage conveyed to MP 85.2 culvert
85.7	Unnamed	n/a	0	n/a	No	cmp	24 in	108	remove	n/a	n/a	n/a	n/a	n/a	drainage conveyed to MP 85.99 culvert
85.84	Unnamed	n/a	0	n/a	No	cmp	24 in	87	remove	n/a	n/a	n/a	n/a	n/a	drainage conveyed to MP 85.99 culvert
85.87	Unnamed	n/a	0	n/a	No	cmp	24 in	100	remove	n/a	n/a	n/a	n/a	n/a	drainage conveyed to MP 85.99 culvert
85.95	Unnamed	n/a	0	n/a	No	cmp	24 in	unknown	remove	n/a	n/a	n/a	n/a	n/a	drainage conveyed to MP 85.99 culvert
85.99	Unnamed	0.02	0	6	No	cmp	36 in	120	replace	36	120	24.0	22.8	1.00 percent	raise to match existing ground level
86.17	Unnamed	0.01	0	3	No	cmp	36 in	97	remove or replace	36	97	25.0	24.0	1.00 percent	remove if Kern Creek bridge is constructed
86.3	Kern Creek	7.80	0	1,100	Yes	cmp	120 in (x2)	139, 110	replace with bridge	n/a	n/a	n/a	n/a	n/a	
86.4	Unnamed	n/a	0	n/a	No	cmp	24 in	104	remove	n/a	n/a	n/a	n/a	n/a	
86.6	Unnamed	n/a	0	n/a	No	cmp	36 in	104	remove	n/a	n/a	n/a	n/a	n/a	
86.7	Unnamed	0.01	0	2	No	cmp	36 in	78	remove or replace	36	78	28.0	27.2	1.00 percent	remove if Kern Creek bridge is constructed
87.1	Kern Slide	1.17	0	180	Yes	cmp	42 in	102	replace	66	102	22.2	21.7	0.50 percent	

Table 3 Existing and Proposed Conveyance Structures

Mile Post	Drainage Name	Drainage Area (mi ²)	Glacier Area ¹ (mi ²)	Design Flow ² (cfs)	Fish Stream	Existing Conveyance Structure			Proposed Work						
						Type	Size	Length (ft)	Type	Size (in)	Length (ft)	Inlet Elevation	Outlet Elevation	Slope	Comments
87.7	Unnamed	0.12	0	27	No	cmp	24 in	134	replace	36	134	24.0	23.3	0.50 percent	
88.15	Unnamed	0.67	0	120	Yes	cmp	60 in	83	replace	60	83	24.0	23.6	0.50 percent	inlet set to hold existing pond water level
88.6	Unnamed	0.10	0	23	No	cmp	24 in	84	replace	30	84	26.0	25.2	1.00 percent	
88.7	Unnamed	0.13	0	29	No	cmp	24 in	126	replace	30	126	25.2	23.9	1.00 percent	
89.2	Virgin Creek	4.38	0.06	670	Yes	bridge, 2 span	123 ft	n/a	replace (typ) bridge	n/a	n/a	n/a	n/a	n/a	
89.6	Unnamed	0.29	0	57	Yes	cmp	60 in	76	replace	60	76	23.1	22.9	0.33 percent	slope as required to meet existing elevation
89.7	Glacier Creek	58.2	5.2	16,000	Yes	bridge, 2 span	163 ft	n/a	replace (typ) bridge	n/a	n/a	n/a	n/a	n/a	
89.8	Old Girdwood Townsite	0.05	0	12	Yes	cmp	36 in	122	replace	36	122	21.1	21.1	0.00 percent	construct 400 ft long outlet channel

¹ Glacier areas calculated as shown on USGS 63,360 scale maps, 1951

² Design flows for all culverts are based on 50-year return period events; all bridges, including Kern Creek, are based on 100-year return period events.

³ The elevations given are approximate, for analysis purposes only, final elevations need to be field set to meet habitat and fish passage needs.

In addition to streamflow, the majority of the conveyance structures within the project area are also subject to the ebb and flow of the tide. Elevations of tidal fluctuations have been measured for the Girdwood and Twentymile River areas. These are listed in Table 4 using NAVD 1988 vertical datum.

Table 4 – Project Area Tidal Fluctuations

Tidal Datum	Elevation, ft (NAVD 1988 datum)	
	Girdwood ¹	Twentymile ²
Extreme High Water (EHW)	25.9	28.7
Mean Higher High Water (MHHW)	20.4	21.9
Mean High Water (MHW)	19.7	21.2
Mean Tide Level (MTL)	6.6*	15.8*
Mean Low Water (MLW)	2.6*	13.5*
Mean Lower Low Water (MLLW)	2.6*	13.4*
Extreme Low Water (ELW)	2.6*	12.5*

¹ Girdwood tidal elevations based on 1993 Tidal Report for the Seward Highway Bird Point to Girdwood project

² Twentymile tidal elevations determined statistically from data collected by Skip Barber from March 24th to December 31st, 1988

* These elevations are influenced by river flows.

There is scant research on storm surges in Turnagain Arm. The 1993 Tidal Report for the Bird-to-Gird project, stated that likely storms would decrease tide elevations. Still, this does not prohibit extreme tides from exceeding the reverse flow capacity of a culvert in a tidal zone. However, there is no research to quantify such flows and more importantly, there is no evidence that such circumstances have negatively impacted the roadway or conveyance structures, nor natural habitat. Design for tidal surges is addressed if replacement culverts are constructed with at least existing capacity and elevation.

The ebb and flow of the tide have had an interesting affect on ponds and wetlands that have been created in former mudflat areas on the inland side of the highway. The average inlet elevation of the culverts with fish passage to these areas is 0.4 feet above MHHW. When these culverts were installed the main channel of the inlet was on the opposite side of the inlet and these culverts were placed on the tidal flats. Forty years of tidal action have deposited silt in the former mudflats inland of the highway raising the ground elevation.

In locations where there is sufficient outflow (significant drainage basin) a channel has been maintained through the deposited silts. A levee has formed along both sides of these channels due to deposition of silt (examples at MP 81.9, 82.8, 85.2 and 87.1). These leveed channels progress upstream and are subsequently reinforced with

vegetation. In some cases these levees limit the drainage from the surrounding area. These levees have a direct influence on the presence and type of habitat in these areas.

In locations where there is insufficient outflow there is no channel through the deposited silts and the ground elevation has been raised. In these locations, the inlet to the culvert has been buried and will need to be raised to allow drainage (examples at MP 84.6, 85.99 and 87.7). This change of invert elevation will not likely affect the existing habitat in these areas.

Bridges are proposed in all locations where necessary to accommodate flood flows or debris and ice. Culverts are proposed where bridges are not required. Sizing of proposed bridges was not in this scope of work.

Preliminary design of proposed culverts was done based on the following criteria:

1. A design frequency of exceedance probability of 50 years. In addition to the exceedance probability used for design, each culvert was evaluated for its ability to pass an event with an exceedance probability of 100 years.
2. Assuming MHHW as back water for flow calculations of tidally affected conveyance structures (Alaska DOT&PF Design Criteria 9.3.3)
3. A minimum culvert size of 24 inches (36 inches if greater than 100 feet in length) or the size of the existing culvert, whichever is larger.
4. An allowable headwater (depth of water that that can be ponded at the upstream end of the culvert) that is non-damaging to upstream property, no greater than the low point in the road grade, and no greater than an HW/D of 1.5 (A HW/D greater than 1.5 was allowed for exceedance probability of 100 years but road overtopping or flooding of upstream property was not acceptable. In those cases the culvert size was increased.)
5. If tidally affected, a backwater equal to the mean higher high tide elevation was assumed during design flood events.
6. The storage capacity upstream of highway embankment was ignored as this provided a conservatively sized structure.
7. Culverts in salt water environments should be constructed of aluminum to minimize corrosion. Culvert corrugations in fish streams should be as large as commonly available and at least 3-inch x 1-inch to aid juvenile fish passage..
8. Tier 3 design criteria of the Memorandum of Agreement (MOA) dated August 29, 2001 between ADF&G and the ADOT&PF should be used for all culverts that are tidally affected. These culverts have fish access due to reversed flow during high tides.

Fish-bearing streams listed in Tables 1 were determined by Ed Weiss, ADNR OHMP and from the results of a previous fisheries investigation, conducted by HDR fish scientists, summarized in a memorandum titled 2006 Freshwater Fish Assessment dated March 1, 2007. All 9 of the streams with bridges are fish bearing streams. The alignment also contains 9 fish-bearing streams that flow through culverts.

Many of the streams outfall directly to Turnagain Arm and the slope of the channel (road embankment) downstream of the culvert outlet is too steep (14 percent to 38 percent) to pass fish. Furthermore, most of these streams do not flow in a channel down the riprap embankment. Rather they flow through the rocks down the slope. Fish passage in these cases is only possible when the tide is higher than the inlet elevation of the culvert. Fish passage is provided according to Tier 3 criteria since flow is reversed during these times. Culvert size at these locations was dictated by the design flow and placement of gravel or rock substrate in the culvert is not recommended.

This steep slope between the culvert outlet and Turnagain Arm is typically faced with coarse riprap. It has been observed on a few of the very small drainages within the project area, that where the water spills down the slope during low tide, outmigrant fish can be trapped within the coarse rock as the low streamflow percolates into the ground. Seagulls have been noted feeding at the outlet of some of these streams at low tide. Reconstruction of the slope downstream of the outlet should be considered to limit outmigrant mortality at low tide. This reconstruction would consist of creating a smooth channel by filling the voids in the rocks.

Following are discussions of each individual conveyance structure along the project corridor. A set of drawings showing the plan location of existing and proposed conveyance structures and photos of each is shown in the accompanying Plan Set.

MP 75.2 - Ingram Creek (Bridge #620), (shown on Plan Set sheet 3)

Drainage Area	21.7 square miles including Muddy Creek (This drainage area, including Muddy Creek, was noted as 23.4 square miles on 1985 drawings).
Design Flood Frequency	100-year
Design Discharge	2,600 cfs (5,300 cfs on 1985 drawings)
Existing Structure	2 span, 204' long bridge, constructed 1966
Proposed Structure	Bridge
Fish Presence	Yes

Ingram Creek has its headwater at the top of Turnagain Pass and approximately 3 percent of its drainage area is glaciated. It has a steep gradient to about 1 mile upstream of where it is crossed by the Seward Highway. Just upstream of the Seward Highway bridge, Ingram Creek is joined by Muddy Creek. Prior to 1966, there was a separate Seward Highway bridge for Muddy Creek. When the highway was reconstructed in 1966 the Muddy Creek Bridge was removed and Muddy Creek diverted into Ingram Creek. In 1985 a new bridge was constructed approximately 200 feet downstream of the 1966 bridge as part of a road reconstruction project. The concrete foundations from the 1966 bridge were not removed and are visible today. The western bridge span has filled in with sediment due to one of the upstream former bridge foundations acting similar to a spur dike.

MP 77.9 & MP 78.4 – Placer River Overflow (Bridge #627) & Placer River (Bridge #629), (shown on Plan Set sheets 8 & 9)

Drainage Area	126 square miles (both channels)
Design Flood Frequency	100-year
Design Discharge	19,000 cfs
Existing Structure	4 span, 324' long bridge and 5 span, 456' long bridge, respectively, constructed 1966
Proposed Structure	Bridges
Fish Presence	Yes

Approximately 30 percent of the drainage basin of the Placer River is glaciated and includes the Spencer Glacier and the Skookum Glacier. Comparison of 1951 to 1973 and present day aerial photos shows that the Spencer Glacier has receded and there is now a lake at the toe of the glacier. Also observed is that the river is incising which is directly related to the loss of sediment from Spencer Glacier. The Skookum Glacier is further downstream in the basin and still contributes significant sediment to the portion of the river downstream of its confluence.

When these bridges were constructed, the Placer River Overflow was the less dominant channel of Placer River. Due to upstream channel migration Placer River Overflow is now the main channel of Placer River. Because there is possibility of a future shift, both bridges must be designed to carry the entire future flow of the river.

The road fill in this area was constructed across the broad floodplain of the Placer River. In 1964 there were five bridges (Bridges #622 to 626) between the west end of the flood plain and the Placer River Overflow Bridge. These bridges were not reconstructed following the 1964 earthquake. The Placer River floodplain has been disconnected from the ebb and flow of the Turnagain Arm by the road embankment. It is now primarily a freshwater marsh. A small amount of the freshwater drainage that formerly went through these five bridges flows west to Ingram Creek via a narrow channel between the road and a rock bluff. The majority of this drainage flows east to Placer River Overflow. Where this drainage connects to the Placer River Overflow a substantial channel has formed that is now head cutting upstream to the west. As this channels head cuts the marsh around it will be drained (see Plan Set sheet 8).

At the Placer River Overflow Bridge the river is incised into the extensive surrounding floodplain. The existing bridge is located on an inflexion point of the channel meanders and spans the entire channel. The river has migrated slightly to the left just upstream of bridge. Additional riprap and perhaps a guide bank are recommended at this location. Deposition is occurring on the right bank.

At the Placer River Bridge the river is incised into the extensive surrounding floodplain. The existing bridge is located on a straight channel reach and spans the entire channel.

MP 79.0 & MP 79.6 – Portage Creek #1 (Bridge #630) & Portage Creek #2 (Bridge #631), (shown on Plan Set sheets 10 & 11)

Drainage Area	56.7 square miles (both channels)
Design Flood Frequency	100-year
Design Discharge	13,000 cfs
Existing Structure	3 span, 203' long bridge and 3 span, 243' long bridge, respectively, constructed 1966
Proposed Structure	Bridges
Fish Presence	Yes

Approximately 30 percent of the drainage basin of Portage Creek is glaciated, including the Burns, Portage, and Byron Glaciers. All of these glaciers have receded and there is now a lake at their toe. This condition has existed for a long enough period of time that Portage Creek has now reached a new equilibrium with its sediment supply. It is no longer a braided stream.

From review of aerial photography, in 1951 Portage Creek #1 was the main channel of Portage Creek. By 1973 lateral migration of an upstream channel had shifted most of the flow to Portage Creek #2. This shift has continued up until the present and Portage Creek #2 is now the main channel of Portage Creek. Portage Creek is very active and future migration could cause a shift back to the Portage Creek #1 channel. Because there is possibility of a future shift, both bridges must be designed to carry the entire future flow of Portage Creek.

At the Portage Creek #1 Bridge the river is incised into the surrounding floodplain. The existing bridge is located on a straight reach of the channel and spans the entire channel. The ARRC Bridge is immediately upstream of the highway bridge and will provide protection to the highway bridge from future meanders.

At the Portage Creek #2 Bridge the river is incised into the surrounding floodplain. The ARRC Bridge is immediately upstream of the highway bridge and will provide protection to the highway bridge from future meanders. The river is migrating extensively upstream of the ARRC Bridge and is threatening approximately 700 feet of the ARRC embankment to the left of the bridge. The ARRC will need to stabilize this area.

Approximately 1500 feet upstream of the bridges and located between the two channels, there are a few houses and some farmland. The elevation of this property will need to be considered during bridge design.

MP 81.0 – Twentymile River (Bridge #634), (shown on Plan Set sheet 14)

Drainage Area	168 square miles
Design Flood Frequency	100-year
Design Discharge	25,000 cfs
Existing Structure	7 span, 568' long bridge, constructed 1969
Proposed Structure	Bridge
Fish Presence	Yes

Approximately 20 percent of the drainage basin of the Twentymile River is glaciated. This includes the Twentymile Glacier and a smaller unnamed glacier that feeds into Carmen Creek. The Carmen Creek glacier has receded and there is now a lake at its toe. The Twentymile Glacier still feeds directly into the Twentymile River.

Approximately 300 to 400 feet upstream of the Seward Highway is an ARRC bridge. Both the ARRC and the Seward Highway bridges span the incised channel of this river. The segment of channel between the ARRC Bridge and the Seward Highway Bridge has dikes on both sides and is heavily armored with riprap. Upstream of the ARRC Bridge the river has migrated approximately 400 feet to the left from 1973 to 2005. The Seward Highway Bridge is currently protected by the ARRC Bridge. The ARRC will likely need to install additional riprap and a guide bank at this location. The overall conveyance through both structures is limited by old piling remaining in the river on right side of channel upstream of the ARRC Bridge.

MP 81.9 – Unnamed (shown on Plan Set sheet 16)

Drainage Area	1.75 square miles
Design Flood Frequency	50-year
Design Discharge	250 cfs
Existing Structure	72" x 135' CMP, constructed 1966 Inlet El.- 19.76 (top substrate), 18.93 (est, culvert invert) Outlet El. - 17.43 Slope – 1.1 percent
Proposed Structure	72" Corrugated Aluminum Pipe Inlet El. – 18.9± (match existing control elevation) Slope – 0.5 percent
Fish Presence	Yes

This culvert has a drainage area that includes both steep forested slopes and an undefined portion of the Twentymile River floodplain. The portion of the drainage area that is undefined was not included in flood flow calculations. The ARRC rail line is upstream of this culvert and along with the roadway they form a dike around approximately 0.17 square miles of area. Surface drainage enters this diked area through three ARRC culverts. ARRC culvert 66.1 is a 60-inch culvert that conveys drainage from the Twentymile River floodplain. It was submerged 46 inches when observed on July 2, 2007. ARRC culvert 66.4 is a 36-inch culvert that drains a small pond. ARRC culvert 66.45 is a 36-inch culvert that conveys a hill slope stream.

Prior to the 1964 earthquake there was a 200 foot long wooden trestle at this location. The existing 72-inch culvert was installed in 1966/68. It is badly corroded and the bottom is completely gone for much of its length. There are boulders at the culvert inlet and the present upstream water surface elevation is set by these boulders and not by the culvert invert. The slope of this culvert based on the record drawings is 1.1 percent. The 2006 survey shows a steeper slope but this is potentially because the survey rod was not accurately placed on the upstream culvert invert.

This culvert also conveys the flow and ebb of the tide at tidal ranges above approximately 19 feet (NAVD 1988 Datum). This is two feet below mean high water in this area, so this area experiences the flow and ebb of the tide for a portion of most tidal cycles. Forty years of this tidal action have caused the channel upstream of this culvert to form a levee along both sides due to deposition of silt. The leveed channel progresses upstream and is subsequently reinforced with vegetation. This levee limits the drainage from the area between the highway and the tracks. A landowner who uses the ARRC right of way to access his land has reported that this restricted drainage may be causing some access issues but a field inspection noted that drainage from the hill slope and a poorly constructed trail likely contribute to this situation. Removal of this levee would improve the drainage in this area but would also greatly alter the present habitat value. This alteration of habitat should be considered in any decision of whether the levee is to be removed or breached.

This culvert outfalls into Turnagain Arm. The slope of the channel between the culvert outlet and the inlet is 14 percent. This steep slope limits fish passage to those periods of time when the tide is higher than the culvert inlet. This slope may become steeper in the future as the main channel of Turnagain Arm appears to be migrating closer to this culvert outfall.

It is proposed that this culvert be replaced with a 72-inch corrugated aluminum pipe. This pipe will pass the 50-year design flow without exceeding the extreme high water tidal elevation. Limiting the headwater during an extreme flood event to the headwater during an extreme tide event limits potential issues with the access concerns discussed above.

Any change to inlet elevation will change the upstream hydrology and habitat. Thus, the invert elevation at the inlet should match the elevations of the existing culvert and the existing rock sill should not be disturbed. If the rock sill will be disturbed the invert elevation should match the elevation of the rock sill. The culvert slope should be 0.5 percent to prevent sediment buildup in the culvert barrel. Substrate material for fish passage should not be installed in this pipe as it will not aid in fish passage, since passage is only possible during tides above 19 feet.

MP 82.8 – Unnamed (shown on Plan Set sheet 18)

Drainage Area	0.08 square miles
Design Flood Frequency	50-year
Design Discharge	19 cfs
Existing Structure	36" x 96' CMP, constructed pre-1964 Inlet El. – 22.33 Outlet El. – 22.83 (outlet higher than inlet) Slope – 0.5 percent
Proposed Structure	36" Corrugated Aluminum Pipe Inlet El. – 22.83 (match existing outlet elevation) Slope – 0.5 percent Reconstruct outlet channel
Fish Presence	Yes

The drainage basin for this culvert is steep mountain slopes with a small pond at their base that was formed by the highway embankment. A 36-inch ARRC culvert (ARRC CUL 67.05) conveys water across the embankment to this pond. The ARRC embankment also separates this pond from another larger pond to the north. At the time of the survey, the water surface elevation of the north pond was 0.4 feet higher than the south pond.

The existing 36-inch culvert existed prior to the 1964 earthquake and was extended in 1966/68. It is extremely corroded, the bottom is completely gone for much of its length and the downstream 10 foot extension installed in 1966/68 has been eroded away.

Like the MP 81.7 culvert, this culvert conveys the ebb and flow of the tide and this tidal action has caused the channel upstream of this culvert to form a levee along each stream bank due to deposition of silt. This levee plays a critical role in the present open-water and marsh habitat of this area. The culvert inlet at this location is lower than the culvert outlet, effectively making the inlet elevation the same as the outlet elevation.

This culvert outfalls into Turnagain Arm. The slope of this outlet channel is 20 percent. This steep slope limits fish passage to those periods of time when the tide is higher than the effective culvert inlet elevation of 22.83 or approximately MHHW.

It is proposed that this culvert be replaced with a 36-inch corrugated aluminum pipe. This pipe will pass the 50-year design flow without exceeding the extreme high water tidal elevation. The invert elevation at the inlet should match the record elevations of the existing pipe. Substrate material for fish passage should not be installed in this pipe as it will not aid in fish passage, since passage is only possible on high tides.

Reconstruction of the slope downstream of the outlet should be considered to limit out-migrant mortality at low tide. This reconstruction would consist of creating a smooth channel by filling the voids in the rocks.

MP 83.3 & 83.31 – Unnamed (shown on Plan Set sheet 19)

	MP 83.3	MP 83.31
Drainage Area	0.45 square miles	0.41 square miles
Design Flood Frequency	50-year	50-year
Design Discharge	80 cfs	75 cfs
Existing Structure	36" x 98' CMP constructed pre-1966 Inlet El. – 22.15 Outlet El. – 22.12 Slope – 0.0 percent	36" x 118' CMP constructed pre-1966 Inlet El. –23.29 Outlet El. –22.82 Slope – 0.4 percent
Proposed Structure 1	None	None
Fish Presence	Yes	Yes

ARRC MP 67.61 (SW MP 83.31) – Unnamed (shown on Plan Set sheet 19)

Drainage Area	Not applicable
Design Flood Frequency	Not applicable
Design Discharge	Provides conveyance if primary culverts blocked by avalanche
Existing Structure	36" x unknown length Inlet El. – unknown, Outlet EL. - 22.00 Slope - unknown
Proposed Structure	36" Corrugated Aluminum Pipe Inlet EL. - 26.0 Slope - 0.5%

ARRC MP 68.01 (SH MP 83.8) – Proposed ARRC Culvert north of Two Ponds (shown on Plan Set sheet 20)

	ARRC MP 68.01 (SH MP 83.8)
Drainage Area	0.86 square miles
Design Flood Frequency	50-year
Design Discharge	140 cfs
Existing Structure	36" CMP.
Proposed Structure 1	8' wide x 6' tall concrete box culvert, approximately 45 ft long. Located at ARRC tracks. 20 percent substrate fill. Inlet El. – 24.4' (Top of substrate) Slope – 0.3 percent
Fish Presence	Yes

The drainage basins for the two culverts at MP 83.3 and MP 83.31 are steep mountain slopes with large ponds at their base that were formed by the ARRC embankment. The two ponds are not connected and are separated by a narrow fill section that provided access to a now abandoned gravel pit. The primary stream in this drainage basin presently flows into the north pond. This outlet location may vary from year to year depending on disposition of the avalanche debris that comes down the stream channel.

The two 36-inch highway culverts provide the outlets for each of these ponds. There are also similar 36-inch culverts through the adjacent ARRC embankment. The ARRC culvert controls the elevation of the south pond. The highway culvert controls the elevation of the north pond. The north pond also has an additional outlet at its north end. This outlet structure is a 36-inch ARRC culvert (ARRC culvert 68.01, approximately Seward Highway MP 83.8) that drains to a channel that connects to Peterson Creek. The invert of this culvert was 0.9 feet higher than the pond surface when observed. The water surface in the north pond was approximately one foot higher than the south pond when surveyed.

Both existing 36-inch highway culverts existed prior to the 1964 earthquake and were extended in 1966/68. They are both corroded. The two ARRC culverts at MP 83.3 and MP 83.31 are in similar decrepit condition.

These culverts convey the ebb and flow of the tide and this tidal action has caused the channel upstream of the ARRC culverts to form a levee along both sides due to deposition of silt.

Both culverts outfall into Turnagain Arm. The slope of the outlet channels are 31 percent and 36 percent respectively. This steep slope limits fish passage to those periods of time when the tide is higher than the culvert inlet.

It is proposed that these two highway culverts be eliminated (along with the ARRC culvert at the south pond) and replaced with a concrete box culvert that would be located through the ARRC embankment at the location of the present ARRC culvert 68.01 (approximately Seward Highway MP 83.8). This culvert will pass the 50-year design

flow with a headwater that is 3.5 feet lower than the top of tracks. This culvert will be designed for fish passage and the invert will be filled with substrate material. The inlet invert elevation of the substrate material will be set to maintain the surveyed water surface elevation of the north lake. A channel will be constructed from the downstream end of this culvert to the existing tidal slough that connects to Peterson Creek.

A connection channel between the two ponds will also be constructed. The water surface of the south lake would raise 1 foot to match the north lake. This water surface elevation will result in the best match with the existing channel to Peterson Creek.

The ARRC culvert at the north pond (ARRC MP 67.61 / SH MP 83.31) should be replaced and maintained to allow conveyance if passage to the primary conveyance (proposed box culvert at ARRC MP 68.01 / SH MP 83.8) becomes temporarily blocked by avalanches that are common in this area. This culvert will allow runoff in these situations to flow northwest between the highway and the railroad to reconnect to the above mentioned channel downstream of the proposed box culvert. A 36-inch corrugated aluminum pipe should be installed with the inlet invert elevation of 26.0 feet so that it only conveys flow if the primary conveyance is blocked or during peak events.

The relocated culvert at ARRC MP 68.01 (SH MP 83.8) will provide all tide fish access to both ponds via an existing tidal slough that connects to Peterson Creek. It will eliminate the potential for juvenile mortality caused by the steep slope downstream of the culvert outlets to Turnagain Arm. It will also eliminate maintenance of two highway and one ARRC culverts.

Drainage for the area between the ARRC and the Seward Highway will flow to Peterson Creek. To aid this drainage the fill section between the ARRC and the highway at MP 83.3 will be removed.

MP 84.15 – Peterson Creek (Bridge #636) (shown on Plan Set sheet 20)

Drainage Area	4.18 square miles
Design Flood Frequency	100-year
Design Discharge	650 cfs
Existing Structure	2 span, 123' long bridge, constructed 1969
Proposed Structure	Bridge
Fish Presence	Yes

Approximately 11 percent of the drainage basin of Peterson Creek is glaciated. The creek is very steep upstream of the highway. Downstream of the highway there is a large alluvial fan that extends out into Turnagain Arm. The present channel of the creek through this fan is to the south.

Approximately 200 feet upstream of the Seward Highway is an ARRC bridge. The ARRC Bridge is 50 feet wide with vertical abutments.

Reconnaissance of this creek upstream of the ARRC Bridge shows that it is aggrading and has the potential to shift course to the north. A training structure may be needed in this area. The ARRC embankment will provide some protection to the highway from this potential channel shift.

MP 84.6 – Unnamed (shown on Plan Set sheet 21)

Drainage Area	0.24 square miles
Design Flood Frequency	50-year
Design Discharge	47 cfs
Existing Structure	36" x 108' CMP, constructed pre-1964 Inlet El. – 21.85 Outlet El. – 21.44 Slope –0.4 percent
Proposed Structure	36" Corrugated Aluminum Pipe Inlet El. – 24 ft (raised to match existing ground level) Slope –1 percent
Fish Presence	No

This culvert has a drainage area that that is predominantly steep mountain slopes. There is an ARRC culvert directly across from the highway culvert and a pond between the base of the mountain and the ARRC embankment. When observed, the inlet to this ARRC culvert was perched 1.3 feet above the pond water surface. Because of this the pond will provide detention storage for rainfall events and limit flow out of the highway culvert.

This culvert conveys the ebb and flow of the tide above MHHW and this tidal action has caused deposition in the area upstream of this culvert. This deposition has raised the ground level, and there does not appear to be enough flow from this area to maintain a channel in this area.

The existing 36-inch. culvert existed prior to the 1964 earthquake and was extended in 1966/68. It is extremely corroded and the bottom is completely gone for much of its length.

It is proposed that this culvert be replaced with a 36-inch corrugated aluminum pipe. This pipe will pass the 50-year design flow without exceeding the extreme high water tidal elevation. The ground level at the inlet has raised and there is not sufficient flow to keep this channel open. There are two options for replacement. The pipe could either be relocated to a new position at the same invert elevation or it could remain at the same location and the invert raised to accommodate the new ground level in this area. This latter alternative will limit the frequency of tides into this area, raise the ponded water level, and create more of a freshwater marsh in this area. This latter alternative is proposed, pending discussions with resource agency staff.

MP 85.2 – Unnamed (shown on Plan Set sheet 23)

Drainage Area	0.51 square miles
Design Flood Frequency	50-year
Design Discharge	92 cfs
Existing Structure	36" x 106' CMP, constructed pre-1964 Inlet El. – 19.59 Outlet El. – 18.42 Slope – 1.1 percent
Proposed Structure	48" Corrugated Aluminum Pipe Inlet El. – 19.59 (match existing inlet elevation) Slope – 0.5 percent Reconstruct outlet channel
Fish Presence	Yes

The drainage basin for this culvert is steep mountain slopes with a large pond at their base that was formed by the highway embankment. An 18-inch ARRC culvert (ARRC CUL 69.4) conveys water across the embankment to this pond.

This culvert also conveys the ebb and flow of the tide above MHW and this tidal action has caused the channel upstream of this culvert to form a levee along both sides due to deposition of silt. This levee plays a critical role in the present open-water and marsh habitat of this area.

The existing 36-inch culvert existed prior to the 1964 earthquake and was extended in 1966/68. It is extremely corroded. The inlet is collapsed and buried. The outlet is collapsed and partially buried.

It is proposed that this culvert be replaced with a 48-inch corrugated aluminum pipe. This pipe will pass the 50-year design flow without exceeding the extreme high water tidal elevation. The invert elevation at the inlet and outlet should match the record elevations of the existing pipe. Although the ground level in this ponded area is rising due to deposition of silt, it is likely that the amount of flow through this culvert will maintain an adequate channel.

This culvert outfalls into Turnagain Arm. The slope of the outlet channels is 27 percent. This steep slope limits fish passage to those periods of time when the tide is higher than the culvert inlet. Reconstruction of the slope downstream of the outlet should be considered to limit out-migrant mortality at low tide. This reconstruction would consist of creating a smooth channel by filling the voids in the rocks.

MP 85.99 – Unnamed (shown on Plan Set sheet 24)

Drainage Area	0.02 square miles
Design Flood Frequency	50-year
Design Discharge	6 cfs
Existing Structure	36" x 120' CMP, constructed pre-1964 Inlet El. – unknown (buried) Outlet El. – unknown (corroded) Slope -Unknown
Proposed Structure	36" Corrugated Aluminum Pipe. Inlet El. – 24' (raised to match existing ground level) Slope –1 percent
Fish Presence	No

The drainage basin for this culvert is the area between MP 85.7 and MP 86.0. There are no ARRC culverts that contribute flow to this area.

There are four culverts that are located within this area (MP 85.84, 85.87, 85.95 and 85.99). All of these are buried in the fill and, except for 85.99, do not convey flow. MP 85.99 is nearly entirely buried but still conveys flow.

This culvert conveys the ebb and flow of the tide above MHHW and this tidal action has caused deposition in the area upstream of this culvert. This deposition has raised the ground level, and there does not appear to be enough flow from this area to maintain a channel in this area.

The existing 36-inch culvert existed prior to the 1964 earthquake and was extended in 1966/68. It is extremely corroded and very little is left of this culvert.

It is proposed that this culvert be replaced with a 36-inch corrugated aluminum pipe. This pipe will pass the 50-year design flow without exceeding the extreme high water tidal elevation. The ground level at the inlet has raised and there is not sufficient flow to keep this channel open. There are two options for replacement. The pipe could either be relocated to a new position at the same invert elevation or it could remain at the same location and the invert raised to accommodate the new ground level in this area. This latter alternative will limit the frequency of tides into this area, raise the ponded water level, and create more of a freshwater marsh in this area. This latter alternative is proposed, pending discussions with resource agency staff.

MP 86.17 – Unnamed (shown on Plan Set sheet 24)

Drainage Area	0.01 square miles
Design Flood Frequency	50-years
Design Discharge	3 cfs
Existing Structure	36" x 97' CMP, constructed pre-1964 Inlet El. – 22.75 Outlet El. – 22.11 Slope –unknown
Proposed Structure	None if Kern Creek Bridge constructed. 36" Corrugated Aluminum Pipe otherwise Inlet El. – 25' (raised to match existing ground level) Slope –1 percent
Fish Presence	No

The drainage basin for this culvert is the area between MP 86.0 and MP 86.3. There are no ARRC culverts that contribute flow to this area.

This culvert conveys the ebb and flow of the tide above MHHW and this tidal action has caused deposition in the area upstream of this culvert. This deposition has raised the ground level, and there does not appear to be enough flow from this area to maintain a channel in this area.

The existing 36-inch culvert existed prior to the 1964 earthquake and was extended in 1966/68. It is extremely corroded and the pipe is half full of sediment.

If a bridge is constructed at Kern Creek this pipe can be removed and not replaced as this area will drain towards Kern Creek. If a bridge is not constructed at Kern Creek it is proposed that this culvert be replaced with a 36-inch corrugated aluminum pipe.

MP 86.3 – Kern Creek (shown on Plan Set sheet 25)

Drainage Area	7.8 square miles
Design Flood Frequency	100-year
Design Discharge	1,100 cfs
Existing Structure	120" x 139 and 120" x 110' CMP, constructed 1966-68. Later extended on upstream end by ARRC. Total length approximately 230'. Inlet El. –21' (south pipe), 20' (north pipe) Outlet El. – 12' (south pipe), 15' (north pipe) Slope – 4 percent (south pipe), 2 percent (north pipe)
Proposed Structure	Bridge
Fish Presence	Yes

Approximately three percent of the drainage basin of Kern Creek is glaciated. Downstream of the highway there is an alluvial fan that extends out into Turnagain Arm. Approximately 100 feet upstream of the Seward Highway are the ARRC tracks.

In 1962 the Seward Highway crossed Kern Creek with a 150 foot bridge. The ARRC also had a bridge across this creek. When the Seward Highway was reconstructed in 1964 the bridge was replaced with twin 10 foot diameter culverts. At some later date the ARRC extended these culverts upstream. Debris jams at these culverts have caused significant aggradation upstream of the culverts. This aggradation has changed the morphology of the creek and has locally steepened the channel at the culvert inlets potentially creating fish passage problems.

The debris and sediment load in Kern Creek is too high for a culvert to function and a bridge is recommended for this site.

The existing culverts at this location are severely degraded, to the extent that they are completely missing their inverts at the downstream segments. There is a slump in the shoulder of the roadway above the south culvert indicating a loss of fill material.

MP 86.7 – Unnamed (shown on Plan Set sheet 26)

Drainage Area	0.01 square miles
Design Flood Frequency	50-years
Design Discharge	2 cfs
Existing Structure	36" x 78' CMP, constructed pre-1964 Inlet El. – 25.9 Outlet El. – 23.43 Slope –unknown
Proposed Structure	None if Kern Creek Bridge constructed. 36" Corrugated Aluminum Pipe otherwise Inlet El. – 28.0' (raised to match existing ground level) Slope –1 percent
Fish Presence	No

The drainage basin for this culvert is the area between MP 86.3 (Kern Creek) and MP 86.8. There are no ARRC culverts that contribute flow to this area.

The existing 36-inch culvert existed prior to the 1964 earthquake and was extended in 1966/68. It is corroded.

If a bridge is constructed at Kern Creek this pipe can be removed and not replaced as this area will drain towards Kern Creek. If a bridge is not constructed at Kern Creek it is proposed that this culvert be replaced with a 36-inch corrugated aluminum pipe.

MP 87.1 – Unnamed (shown on Plan Set sheet 26)

Drainage Area	1.17 square miles
Design Flood Frequency	50-year
Design Discharge	180 cfs
Existing Structure	42" x 102' CMP, constructed 1966-68 Inlet El. – 21.19 Outlet El. – 20.19 Slope – 1 percent
Proposed Structure	66" Corrugated Aluminum Pipe Inlet El. – 21.19 (match existing inlet elevation) Slope – 0.5 percent Reconstruct outlet channel
Fish Presence	Yes

This culvert has a significant stream that enters a freshwater pond located between the ARRC tracks and the roadway. The existing 42-inch culvert was installed in 1966/68. This culvert is corroded and failing and is displaced at the last downstream joint.

This culvert outfalls into Turnagain Arm. The slope of this outlet channel is 26 percent. This steep slope limits fish passage to those periods of time when the tide is higher than the culvert inlet elevation of 21.2 or approximately MHHW. This culvert conveys the ebb and flow of the tide and this tidal action has caused the channel upstream of this culvert to form a levee along both sides due to deposition of silt. The levee created the large freshwater pond and maintains the pond water surface elevation.

It is proposed that this culvert be replaced with a 60-inch corrugated aluminum pipe. This pipe will pass the 50-year design flow. The inlet invert elevation should match the record elevations of the existing pipe. Substrate material for fish passage should not be installed in this pipe as it will not aid in fish passage, since passage is only possible at high tide.

Reconstruction of the slope downstream of the outlet should be considered to limit out-migrant mortality at low tide. This reconstruction would consist of creating a smooth channel by filling the voids in the rocks.

MP 87.7 – Unnamed (shown on Plan Set sheet 28)

Drainage Area	0.12 square miles
Design Flood Frequency	50-year
Design Discharge	27 cfs
Existing Structure	24" x 134' CMP, constructed pre-1964 Inlet El. –19.52 Outlet El. – 17.01 Slope – 3 percent
Proposed Structure	36" Corrugated Aluminum Pipe Inlet El. – 24' (match existing ground level) Slope – 0.5 percent
Fish Presence	No

The drainage basin for this culvert is a small but steep section of mountain slope and an area between the ARRC tracks and the highway. There are three ARRC culverts that contribute flow to this area.

This culvert is nearly completely buried in the fill at the upstream and downstream ends, but still conveys flow.

This culvert also conveys the ebb and flow of the tide above MHHW and this tidal action has caused deposition in the area upstream of this culvert. This deposition has raised the ground level, and there does not appear to be enough flow from this area to maintain a channel in this area.

The existing 24-inch culvert existed prior to the 1964 earthquake and was extended in 1966/68. It is extremely corroded and very little is left of this culvert.

It is proposed that this culvert be replaced with a 36-inch corrugated aluminum pipe. This pipe will pass the 50-year design flow. The ground level at the inlet has raised and there is not sufficient flow to keep this channel open. There are two options for replacement. The pipe could either be relocated to a new position at the same invert elevation or it could remain at the same location and the invert raised to accommodate the new ground level in this area. This latter alternative will limit the frequency of tides into this area, may raise the pond water level, and create more of a freshwater marsh in this area. This latter alternative is proposed, pending discussions with resource agency staff.

MP 88.15 – Unnamed (Girdwood Swimming Pond), (shown on Plan Set sheet 28)

Drainage Area	0.67 square miles
Design Flood Frequency	50-year
Design Discharge	120 cfs
Existing Structure	60" x 83' CMP, constructed 1966-68 Inlet El. – 22.21' Outlet El. – 21.87' Slope – 0.4 percent
Proposed Structure	60" Corrugated Aluminum Pipe Inlet El. – 24.0' (set to hold existing pond level) Slope – 0.5 percent
Fish Presence	Yes

The drainage basin for this culvert is steep mountain slopes with a large pond at their base that was formed by the highway embankment. This pond is frequently used as a swimming pond by Girdwood residents. Two ARRC culverts (ARRC CUL 72.59 and CUL 72.69) convey water across the embankment to an area between the ARRC tracks and an old roadbed. The culvert across this old road bed is nonfunctional.

This culvert also conveys the ebb and flow of the tide above MHW and this tidal action deposits silt beneath the pond water surface.

This culvert outfalls into Turnagain Arm. The slope of the outlet channels is 26 percent. This steep slope limits fish passage to those periods of time when the tide is higher than the culvert inlet.

The existing 60-inch culvert was constructed in 1966/68. It is extremely corroded and the bottom is gone.

It is proposed that this culvert be replaced with a 60-inch corrugated aluminum pipe. This pipe will pass the 50-year design flow. The water surface elevation in the pond is controlled by a rock weir. The invert elevation at the inlet should be set to maintain the existing pond elevation. Substrate material for fish passage should not be installed in this pipe as it will not aid in fish passage, since passage is only possible at high tide.

MP 88.6 – Unnamed (shown on Plan Set sheet 29)

Drainage Area	0.10 square miles
Design Flood Frequency	50-year
Design Discharge	23 cfs
Existing Structure	24" x 84' CMP, constructed pre-1964 Inlet El. – 26.04 Outlet El. – 23.77 Slope –3 percent
Proposed Structure	30" Corrugated Aluminum Pipe Inlet El. – 26.04 (match existing ditch line) Slope – 1 percent
Fish Presence	No

The drainage basin for this culvert is steep mountain slopes with a small pond at their base that was formed by the ARRC embankment. Invert of ARRC culvert was two feet above pond water surface at time of inspection. Water was percolating through ARRC embankment to ditch between ARRC and highway which are very close at this location. The highway culvert is submerged at its outlet.

This culvert outfalls into a tidal marsh and to Turnagain Arm via a 250 foot long channel. The channel has grown in with vegetation and is difficult to find.

The existing 24-inch culvert was constructed prior to 1964. Its condition is unknown.

It is proposed that this culvert be replaced with a 42-inch corrugated aluminum pipe. This pipe will pass the 50-year design flow. The invert elevation at the inlet should be set to match the existing ditch line. The outlet invert will be set by the minimum slope and will be partially submerged.

MP 88.7 – Unnamed (shown on Plan Set sheet 30)

Drainage Area	0.13 square miles
Design Flood Frequency	50-year
Design Discharge	29 cfs
Existing Structure	24" x 126' CMP, constructed pre-1964 Inlet El. – 25.23 Outlet El. – 23.14 Slope –1.6 percent
Proposed Structure	30" x 126' Corrugated Aluminum Pipe Inlet El. – 25.2 (match existing) Slope – 1 percent
Fish Presence	No

The drainage basin for this culvert is steep mountain slope upstream of the ARRC embankment. The existing 24-inch culvert was constructed prior to 1964. Its condition is unknown. It is proposed that this culvert be replaced.

MP 89.15 – Virgin Creek (Bridge #638), (shown on Plan Set sheet 30)

Drainage Area	4.38 square miles
Design Flood Frequency	100-year
Design Discharge	670 cfs
Existing Structure	2 span, 123' long bridge, constructed 1969
Proposed Structure	Bridge
Fish Presence	Yes

Approximately one percent of the drainage basin of Virgin Creek is glaciated. Virgin Creek exits the mountains into the floodplain of Glacier Creek. Virgin Creek maintains a separate channel through the Glacier Creek floodplain although connections to Glacier Creek may exist.

Approximately 1500 feet upstream of the Seward Highway are the ARRC tracks. The ARRC has three 5 foot diameter culverts for Virgin Creek. The invert elevation of the north culvert is lower and carries the base flow. All three culverts are perched three to four feet at their downstream end. Extreme high tides reach to three feet above culvert inverts as evidenced by ice marks on culverts noted during reconnaissance. The top elevation of the ARRC embankment within the Glacier Creek valley is lowest for an 1800 foot segment at Virgin Creek. Because of these culverts and the sag in the ARRC embankment, the Virgin Creek Bridge may carry a portion of the over bank flow from Glacier Creek during peak events.

Because of the extremely flat ground surface at the mouth of the Glacier Creek valley, the Seward Highway and ARRC embankments are essentially low dams across the valley. Overtopping of the railroad and road may occur if the capacities of the bridges or culverts are exceeded during flood events.

A comprehensive analysis of the flood risks in the Glacier Creek valley, including Glacier and Virgin Creeks, is recommended to understand how much of the design event flows through the Seward Highway Glacier Creek and Virgin Creek bridges. That analysis was not part of this study. The flood flow information will be needed to evaluate abutment and pier scour potential for these bridges as well as determine the bridge length required to meet FEMA flood hazard permitting requirements.

The left span of the Virgin Creek Bridge is completely filled in with sediment. Downstream of the highway bridge the Virgin Creek channel parallels the highway embankment for 700 feet before turning 90 degrees towards the inlet. This section of the creek was relocated in 1966/68 and a hardened slope constructed to protect the road embankment.

MP 89.6 – Unnamed (shown on Plan Set sheet 31)

Drainage Area	0.29 square miles (Culvert also has direct connection to Glacier Creek over bank flow)
Design Flood Frequency	50-year
Design Discharge	57 cfs
Existing Structure	60" x 76' CMP, constructed pre-1964 Inlet El. – 23.11 (Approx) Outlet El. – 22.86 (Approx)
Proposed Structure	60" Corrugated Aluminum Pipe Inlet El. – Match existing Outlet El. – Match existing Slope –as required
Fish Presence	Yes

The drainage basin for this culvert is the marsh of the Glacier Creek floodplain. There is a channel through the marsh upstream of the highway embankment. This channel runs approximately 1200 feet upstream to the ARRC embankment. The ARRC has a three feet diameter culvert at this location. The highway culvert may carry a portion of the over bank flow from Glacier Creek during peak events.

This culvert outfalls into a 1000-foot long linear pond along the highway embankment that appears to be manmade. This pond drains to Glacier Creek via two separate channels. Vegetative growth and beaver activity in these channels controls the pond elevation which in turn controls the water surface elevation upstream of the highway embankment. Because of this the existing culvert is submerged at both ends.

The existing 60-inch culvert was constructed prior to 1964. Its condition is unknown.

It is proposed that this culvert be replaced with a 60-inch corrugated aluminum pipe. This pipe will pass the 50-year design flow. The inlet and outlet elevations should be set to match the existing culvert. As the culvert will be submerged no substrate will be necessary

MP 89.7 – Glacier Creek (Bridge #639), (shown on Plan Set sheet 32)

Drainage Area	58 square miles
Design Flood Frequency	100-year
Design Discharge	The 100-year event flow is 14,042 by the FEMA flood study hydrologic analysis and 16,000 by gage record analysis
Existing Structure	2 span, 163' long bridge, constructed 1969
Proposed Structure	Bridge
Fish Presence	Yes

The drainage basin of Glacier Creek includes Crow Creek, Winner Creek, Alyeska Creek and California Creek. Approximately nine percent of the drainage basin of Glacier Creek is glaciated.

Approximately 1200 feet upstream of the Seward Highway are the ARRC tracks. The ARRC has a 67-foot wide bridge with vertical abutments.

Because of the extremely flat ground surface at the mouth of the Glacier Creek valley, the Seward Highway and ARRC embankments are essentially low dams across the valley. Overtopping of the railroad and road may occur if the capacities of the bridges or culverts are exceeded during flood events.

A comprehensive analysis of the flood risks in the Glacier Creek valley, including Glacier and Virgin Creeks, should be done to understand how much of the design event flows through the Seward Highway Glacier Creek and Virgin Creek bridges. That analysis was not part of this study. The flood flow information will be needed to evaluate abutment and pier scour potential for these bridges as well as determine the bridge length required to meet FEMA flood hazard requirements.

MP 89.8 – Old Girdwood Town Site (shown on Plan Set sheet 32)

Drainage Area	0.05 square miles
Design Flood Frequency	50-year
Design Discharge	12 cfs
Existing Structure	24" x 122' CMP on 1966 record drawings. Surveyed as 36" CMP. Inlet El. – 21.09 Outlet El. – 19.43 Slope –1 percent
Proposed Structure	36" Corrugated Aluminum Pipe Inlet El. – 21.09 Outlet El. – 21.09 Slope –0 percent Construct 400' long outlet channel
Fish Presence	Yes

The drainage basin for this culvert is the Old Girdwood town site. This area was formerly the floodplain of Glacier Creek but the ARRC embankment on the east, a dike on the south and the highway embankment on the west have isolated this area. The only drainage out of this area is this highway culvert.

This culvert outfalls into a 500-foot long ditch that leads to Turnagain Arm. Vegetative growth in this channel controls the water surface elevation at the culvert outlet and upstream of the highway embankment in Old Girdwood. Because of this, the existing culvert is submerged at both ends and this backwater is causing flooding problems in Old Girdwood. During a previous attempt to resolve this flooding, an agency meeting sponsored by the Girdwood Board of Supervisors was held in Girdwood on August 31, 2005 to discuss this issue and possible solutions. At this meeting there was agreement that opening up this ditch and the consequent lowering of the water surface in the wetland

on the upstream side of the Seward Highway in the Old Girdwood town site would be acceptable.

The installation date of the existing 36-inch culvert is unknown. Its condition is unknown.

It is proposed that this culvert be replaced with a 36-inch corrugated aluminum pipe. The inlet and outlet elevations should be set to match the existing culvert.

Recent surveys show that the existing ditch downstream of the highway may be on private property. Because of this it is recommended that this ditch be relocated to the western toe of the highway embankment. A 400-foot long ditch in this area will connect to Glacier Creek. The ditch should be constructed at a shallow slope for the majority of its length and designed to hold a 1 foot backwater at the culvert entrance. With this slight backwater no substrate will be required in the culvert.

10.0 Location Hydraulic Study

A location hydraulic study (LHS) documents how the project will interact with mapped regulatory floodplains. A separate LHS will be prepared as part of a later phase of the project. As part of this investigation, the project team met with the Municipality of Anchorage Flood Hazard Program Administrator to review the flood hazard program and flood hazard areas. Flood hazard areas are mapped along the project corridor within the Municipality of Anchorage boundaries except for an area around and including Peterson Creek (reason for this gap in the mapping is unknown). Two types of flood hazard areas are mapped: riverine and tidal. Within the riverine flood hazard areas, mapped regulatory floodplains with base flood elevations have been established for Glacier Creek, Placer River, Portage Creek, Twentymile River, and Virgin Creek. A tidal flood hazard zone has been mapped for all of Turnagain Arm to extreme high tide levels. These are shown on FEMA panel numbers 02005-0510, 0520B and 0600B.

The Municipality of Anchorage Flood Hazard Program Administrator oversees the flood hazard program in the Municipality of Anchorage. To work within the mapped flood zones a Flood Hazard Permit will be required from the Municipality of Anchorage. All of Turnagain Arm and the major streams (except Peterson Creek) within the project area have mapped flood zones. Work proposed in these areas, including rip rap or fill placement, culvert replacement, and bridge reconstruction, will need to be coordinated with the Municipality of Anchorage Flood Hazard Program Administrator and will need a flood hazard permit before construction. To issue the permit, the Municipality of Anchorage Flood Hazard Program Administrator will require an evaluation that demonstrates that the proposed work will not impact the base flood elevations, where established, or will not increase flood risks. Required analyses will vary depending on the proposed action.