Hydrology and Hydraulics Report
Haines Highway Milepost 3.5 to 25.3
Study for Preliminary Engineering Report

ADOT&PF Project No. 68606 / SHAK-095-6(28)

Prepared for:
DOWL Engineers
4040 B Street
Anchorage, AK 99503

Prepared by:
Inter-Fluve, Inc.
1020 Wasco Street, Suite I
Hood River, OR 97031
541.386.9003
www.interfluve.com
October 3, 2006

(Intentionally blank)

1. Table of Contents

1.1 Table of Tables

1.2 Table of Figures

2. Executive summary

This report presents design concepts for roadway embankment erosion protection along the Chilkat River; and, flood conveyance, and fish passage at a number of culverts along tributary streams. Design features are in support of the Preliminary Engineering Report and are based on May 23, 2006 alignments provided by DOWL with adjustments to alignment and profile provide September 2006. The alignment is similar to that shown in the companion Stream and Habitat Inventory (S&HI) prepared by Inter-Fluve, Inc. (Inter-Fluve, July, 2006)

The proposed Haines Highway realignment project between mileposts 3.5 and 25.3 follows the Chilkat River and crosses 106 culvert locations. The highway embankment along the Chilkat River was conceptually designed for erosion and depth of scour protection. The analysis and design follow methods in the Highway Preconstruction Manual and Highway Drainage Manual and are presented in Section 4.

All culverts located in the field were evaluated in the field by rapid assessment methods and are summarized in tabular format in the appendices. A total of 28 culverts are discussed in greater detail in this report. Of these culvert crossings, ten are either 48-inch diameter or larger, or of approximately equivalent size, along fish bearing streams with desirable upstream habitats. Four large culverts are located on the two active debris flows at MP 19 and 23, plus one culvert at the occasionally active debris flow at Station 670+00. Geotechnical recommendations by DOWL to accommodate debris flows and review by Alaska Department of Transportation and Public Facilities are in progress. Analysis and design of large culverts and culverts along fish bearing streams follow methods in the Highway Preconstruction Manual and Highway Drainage Manual and are presented in Sections 5 through 19. Thirteen smaller pipes were identified that had fish presence and will require fish passage for the replacement culverts. Analysis and design of the smaller fish pipes are discussed in Section 20.

3. Introduction

The Haines Highway realignment study involves the 3R construction of the highway between mileposts 3.5 and 25.3. This work is necessary to bring the highway into compliance with current design standards. Completion of this stretch will connect with previously constructed improvements for an improved highway between Haines and the Canadian border.

This study is a preliminary level hydrologic and hydraulic evaluation of the Chilkat River and tributary drainages that cross the Haines Highway between mileposts 3.5 and 25.3. Conceptual level designs and drawings for erosion protection along the highway embankment and preliminary design of fish passage and flood conveyance at larger culverts are included in this study. This report is submitted in support of the Preliminary Engineering Report (PER). This report was prepared in accordance with the Highway Preconstruction Manual (HPM) 1120.5 and the Alaska Highway Drainage Manual (HDM). Final designs will require detailed survey for each stream crossing and will be prepared and documented in a final design report to be submitted with Plans-in-Hand. This report provides information for preliminary design and environmental/permitting actions.

A companion Stream and Habitat Inventory Study (S&HI) was prepared by Inter-Fluve, Inc. (July, 2006).

3.1 Objective

The objective of this report is to characterize hydrologic and hydraulic conditions of the Chilkat River and tributary crossings of the highway. Further, conceptual level designs for typical erosion protection and passage of flood flows and fish through larger culverts were prepared for environmental/permitting actions. Full designs will be prepared at a later phase for submittal with the Plans-in-Hand.

3.1.1 Objective - Chilkat River

The Chilkat River is a large, dynamic, glacially fed river. There is a complex network of side channels between mileposts 10 and 19. Further, the Chilkat River discharges to the Lynn Canal which experiences 16.5-ft tidal fluctuations. No Federal Emergency Management Agency (FEMA) Flood Insurance Study for the project reach was identified. The Haines Highway follows the northeast bank of the river, with river flows along the embankment toe for long stretches of highway. In a number of locations, side channels impinge directly into the highway embankment then turn downstream at sharp angles.

The objective of this study along the Chilkat River and its side channels was to estimate the erosive forces acting on the proposed road embankment for conceptual design of bank revetments. Depths and locations of scour were investigated in the field and conceptually analyzed to aid in estimating depth of scour along the toe of the proposed embankment.

The impacts on flood water surface elevations by the proposed project are approximately evaluated.

These objectives were approached through field investigations, interviews with Alaska Department of Transportation and Public Facilities (ADOT&PF) maintenance personnel and long time residents, and conceptual level analysis and design. Design level analysis and modeling will be completed and documented at a later phase for the Plans-in-Hand submittal.

3.1.2 Objective - Tributaries

Between mileposts 3.5 and 25.3, 106 existing culvert crossings were located in the field. Eight culverts listed in the as-built drawings were not found in the field. An inventory of pipe size and general site conditions was made through a rapid assessment and tabulated (see Appendix Section 22.1).

Of the culverts found, fifteen crossings were identified for this Summary Hydraulic Report. Ten of these crossings are comprised of either 48-inch or larger diameter pipes, or fish bearing streams with ample upstream habitats. In addition, five large culverts are located along debris fans - flood runoff and fish passage design will be coordinated with geotechnical design in progress by DOWL Engineers (DOWL) for passage of debris torrent sediments. Thirteen additional, smaller pipes are included in the anadromous waters catalog (AWC) or were identified by Inter-Fluve or Alaska Department of Natural Resources, Office of Habitat Management and Permitting (OHMP) staff to have fish present. A brief narrative of each of these smaller pipes is included in this report. The associated analysis, designs and drawings were prepared to a conceptual level for inclusion in the Preliminary Engineering Report for environmental/permitting actions. Final designs and hydraulic reports will be prepared for submittal with the Plans-in-Hand.

3.2 Field Investigations

On October 5 through 10, 2005, Inter-Fluve conducted field investigations of the hydrologic and hydraulic conditions of the Chilkat River and tributary crossings. The field investigation included: 1) investigation of Chilkat River main stem and side channel scour and bank erosion conditions; 2) inventory and rapid assessment of existing culverts; 3) identification of culverts requiring more detailed study; and 4) cursory total station survey for conceptual design of a number of larger/fish bearing culverts. Conditions immediately following the flood of November 2005 were observed by Inter-Fluve staff and incorporated into the S&HI and this study. In response to design refinements and adjustments of the highway alignment, the present crossing location near Station 917+00 was viewed and hand measurements taken in the spring of 2006, though ground survey has not yet been conducted.

Details of the field investigation along the Chilkat River are provided in Section 4.2.

All culverts shown on the 1980 as-built drawings were searched for. A total of 106 crossings, including multiple pipes, were located. Of the crossings shown on the as-built drawings, eight were not found. A rapid assessment of all found culverts was conducted. The rapid assessment included: size and condition of culvert, inlet/outlet conditions, height to stain line, degree of sedimentation/debris, and photo documentation of inlet/outlet conditions. An inventory of the culverts found in the field with a summary of rapid assessment results is included in a table in Appendix Section 22.1, along with those culverts listed on the as-built drawings that were not found. Based on height to stain line, the majority of the surveyed pipes appeared to be adequately sized. Further, interviews with ADOT&PF maintenance personnel indicated that no problem culverts were recalled. Thus, the anecdotal record indicates that to date there has been satisfactory conveyance through the existing pipes. A large magnitude flood occurred during November 2005 and was reported to be as large a flood as recalled. Observations by Mark Sogge (Inter-Fluve, Haines) and Roger Ingledue (ADOT&PF Haines maintenance supervisor) indicate that all occurrences of road overtopping were the result of culverts plugged with sediment and debris (personal communication, March 8, 2006). No evidence of unobstructed pipes having insufficient conveyance capacity was reported.

In preparation for environmental and permitting actions, preliminary designs for flood conveyance and fish passage were prepared for ten of the larger crossings and thirteen smaller fish bearing pipes identified for more intensive analysis. As noted above, study and design efforts at the four large culverts located along the two debris flows at MP 19 and 23, plus a fifth culvert at the occasionally active debris flow at station 670+00, will be coordinated with geotechnical design by DOWL for passage of debris torrent sediments. The geotechnical recommendations are currently in review by ADOT&PF. Detailed site topographic survey, design and final Summary Hydraulic Report for each pipe will be prepared during a later phase and submitted with Plans-in-Hand.

Basic site survey data were collected at the fifteen large culverts identified for more detailed study. As survey coverage was unknown at the time and results of ongoing survey efforts would not be available within the timeframe of the preliminary phase of this study (October-November, 2005), Inter-Fluve used a total station to collect cursory stream profile, typical cross section, culvert invert and crown elevations at the inlet and outlet and typical roadway elevations. The purpose of this data collection was to provide the essential site topographic data required to develop conceptual designs. Final design will require site-specific detailed topographic, cross section and profile survey data. The thirteen smaller fish pipes were identified after the field investigations and subsequently added to this study. Survey data from the additional thirteen smaller fish pipes were obtained from the ground based survey of the road embankment by ADOT&PF or Toner-Nordling or from the project LIDAR.

3.3 Hydrology - General Methods

3.3.1 Chilkat River

Hydrologic analysis methods for the Chilkat River are covered in Section 4.4.

3.3.2 Tributary Basins

Hydrologic analysis methods conducted in common for the tributary basins are included here, with tributary-specific information included in the individual tributary summaries.

3.3.2.1 Hydrology

Hydrologic analyses were performed for eleven streams with major crossings of the Haines Highway between mileposts 3.5 and 25.3. All streams flow through culverts under the Haines Highway shortly before entering the main stem of the Chilkat River or major Chilkat side channels. These streams have culverts at least 48 inches in diameter and/or contain significant fish habitat. Peak flow estimates for various return periods were estimated in order to analyze flood conveyance and fish passage conditions. According to the Alaska Department of Fish and Game (ADF&G) and ADOT&PF Fish Passage MOA (2001), fish passage design flow is 40 percent of the 2-year peak flow. At this time, hydrologic analysis was not performed for the four streams that are located on debris fans. For these streams, flood runoff and fish passage design will be coordinated with geotechnical recommendations for passage of debris flow sediments.

The thirteen smaller fish pipes all drain areas ranging from 0.05- to 0.49-sq. mi. All are smaller than the 0.72-sq mi lower limit for the USGS regional regression estimates for flood runoff flows. Estimates of flows along the additional thirteen smaller fish pipe streams were extrapolated based on area weighting from neighboring larger basins. However, the high degree of variance in hydrologic predictions was suspected to incur unacceptable error. Therefore, an alternate approach was taken: while providing fish passage to meet Tier 1 or Tier 2 criteria, the flood conveyance of the proposed structures was verified to be either equal or greater to existing conditions. Details of this analysis are covered in Section 20 – Small Fish Culverts.

The eleven streams for which hydrologic analyses were performed originate in the Takshanuk Mountains northwest of Haines, AK. A map of the basin locations can be found in Figure 1. Basin sizes range from 0.47 mi^2 to 2.26 mi^2. Basin elevations range from sea level to over 5,000 feet. The watersheds are steep, with average watershed slopes ranging between 44 and 64 percent. Spruce-dominated forests with poorly-drained soils reach up to approximately 3,000 feet. Unforested alpine slopes characterize the higher elevations. Annual precipitation is approximately 60 inches, with most of the precipitation falling as snow in the winter months (Western Regional Climate Center). Seasonal hydrographs are unavailable for these basins; however, based on elevation and precipitation regimes, peak stream flows would be expected to result from spring and summer snowmelt with occasional peaks generated by rain and rain-on-snow events. Debris flows dominate channel and valley morphology for some streams in this area; however, the eleven streams addressed in this section do not exhibit frequent debris flows.

Peak flows for various return periods were estimated for each of the eleven basins using USGS regional regression equations (Curran et al. 2003), the SCS Unit Hydrograph Method (SCS 1984), and the Rational Method. For the reasons discussed below, peak flow estimates generated from the regional regression equations are believed to be the most appropriate for stream crossing design purposes.

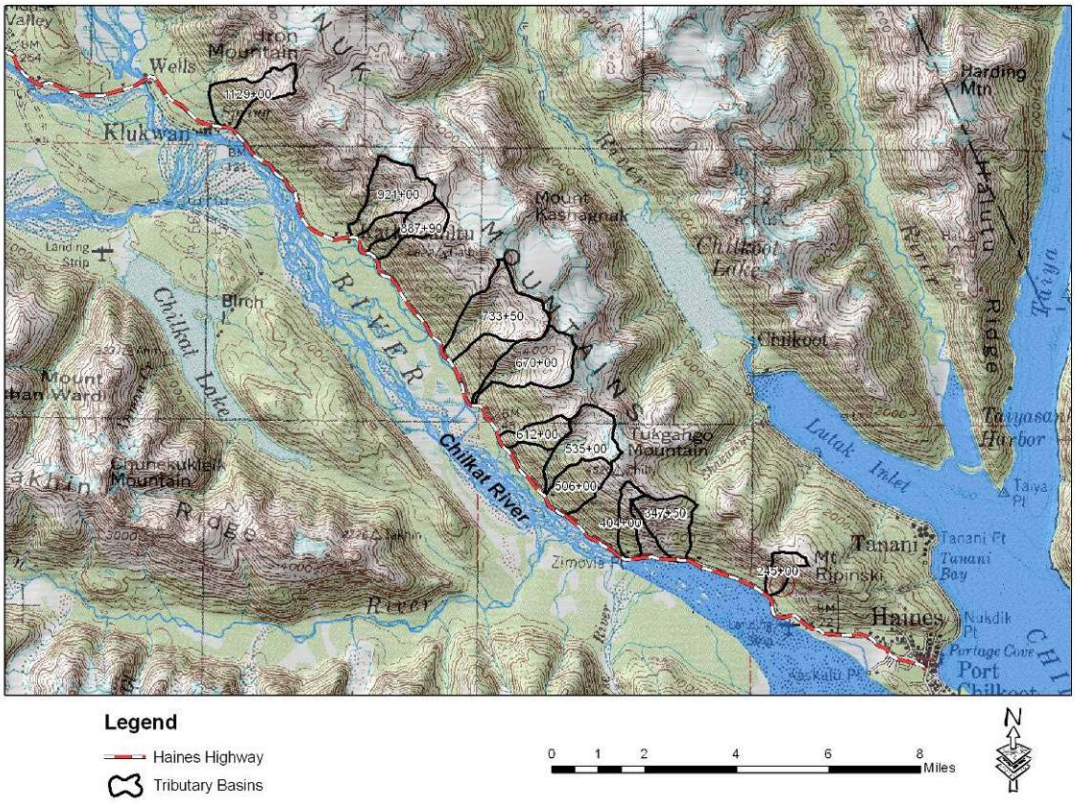


Figure 1. Map of Tributary Basins.

3.3.2.2 Regional Regression Analysis

The regression equations for southeast Alaska utilize drainage area (A), storage (ST), mean annual precipitation (P), and mean minimum January temperature (J) as predictor variables. Curran et al. (2003) used stream flow data from a total of 93 gaging stations to develop the regression equations. The equations and accuracy information are displayed in Table 3-1. Drainage area for each tributary basin was obtained by manually digitizing watershed boundaries on USGS 1:24,000 (7.5 minute) topographic maps in a Geographic Information System (GIS). Percent storage for each basin was obtained in GIS by digitizing surface water areas on the topographic maps. Mean minimum January temperature was obtained from values mapped by Jones and Fahl (1994). Values for basins located between isothermal lines were estimated through visual interpolation. Mean annual precipitation values were obtained in GIS using a digitized version of the Jones and Fahl (1994) annual precipitation map - all of the basins fall within the 60 inch annual precipitation zone. **It should be noted, however, that this precipitation value**

may be higher than actual annual precipitation measurements at Haines of 47.7 inches (Western Regional Climate Center).

Table 3-1. USGS Regional Regression equations for estimating flood magnitude for various recurrence intervals. Equations are applicable to southeast Alaska (Curran et al. 2003).

Regression Equation for Specified Recurrence Interval (93 gaging stations)	Average standard error of prediction (percent)	Average equivalent years of record*
$Q_2 = 0.004119\ A^{0.8361}\ (ST+1)^{-0.3590}\ P^{0.9110}\ (J+32)^{1.635}$	38	0.88
$Q_5 = 0.009024\ A^{0.8322}\ (ST+1)^{-0.3670}\ P^{0.8128}\ (J+32)^{1.640}$	37	1.3
$Q_{10} = 0.01450\ A^{0.8306}\ (ST+1)^{-0.3691}\ P^{0.7655}\ (J+32)^{1.622}$	37	1.8
$Q_{25} = 0.02522\ A^{0.8292}\ (ST+1)^{-0.3697}\ P^{0.7165}\ (J+32)^{1.588}$	38	2.4
$Q_{50} = 0.03711\ A^{0.8286}\ (ST+1)^{-0.3693}\ P^{0.6847}\ (J+32)^{1.559}$	40	2.8
$Q_{100} = 0.05364\ A^{0.8281}\ (ST+1)^{-0.3683}\ P^{0.6556}\ (J+32)^{1.527}$	41	3.1
$Q_{200} = 0.07658\ A^{0.8276}\ (ST+1)^{-0.3669}\ P^{0.6284}\ (J+32)^{1.495}$	43	3.4
$Q_{500} = 0.1209\ A^{0.8272}\ (ST+1)^{-0.3646}\ P^{0.5948}\ (J+32)^{1.449}$	45	3.6

A=drainage area, in square miles; ST= area of lakes and ponds (storage), in percent; P=mean annual precipitation, in inches; J=mean minimum January temperature, in degrees Fahrenheit
Applicable range of variables: A: 0.720-571; ST: 0-26; P: 70-300; J: 0-32
**The number of years of systematic stream flow data that would have to be collected for a given site to estimate the stream flow statistic with accuracy equivalent to the estimate from the regression equation*

Basin characteristics for the eleven basins were within the range of values used to develop the regression equations with a number of exceptions. Three of the basins had drainage areas below the range; the smallest of which has a drainage area of 0.466 mi^2 compared to the range of 0.720 – 571 mi^2. According to the Jones and Fahl (1994) precipitation map, all of the basins have a mean annual precipitation of 60 inches, compared to the range of 70 – 300 inches. The violation of these criteria will affect the accuracy of the flow predictions. In general, the 11 tributary basins are smaller, lower elevation, drier, and warmer than the basins used to generate the regression equations. The study basins may exhibit proportionally larger peak flows than the basins used to generate the regression equations because of quicker times of concentration (less attenuation) due to high gradient and small size. Actual peak flow volumes could also be lower than those reported if precipitation levels are closer to the 47.7 inches measured at Haines, compared to the 60 inches reported by Jones and Fahl (1994).

Compared to the SCS Unit Hydrograph Method and the Rational Method, the regional regression equations are believed to represent the most appropriate flow estimates for design purposes. The regression estimates are included in Table 3-2. Estimates from the SCS and Rational Method are presented in Appendix, Section 22.2.

Table 3-2. Flow estimates for tributary basins using USGS Regional Regression Equations (Curran et al. 2003).

Station ID	Drainage Area (mi^2)	40% of 2-year flood[1]	Flow Estimate for Indicated Return Period (ft^3/second)							
			2	5	10	25	50	100	200	500
245 + 00	0.47	17	42	64	79	99	114	130	147	171
342 + 00	0.60	20	50	75	93	117	135	154	175	202
347 + 50	1.23	37	92	137	169	212	246	280	317	368
506 + 00	1.07	30	76	113	139	175	203	232	263	305
535 + 00	1.46	29	73	107	130	166	193	220	250	290
612 + 00	0.65	21	52	78	96	121	140	160	181	210
670 + 00	1.75	38	96	142	174	220	255	291	331	384
733 + 50	2.26	50	125	186	228	288	334	381	432	502
887 + 90	0.80	22	55	82	101	127	148	169	192	224
921 + 00	1.55	38	95	141	175	219	255	291	331	385
1129 + 00	1.26	29	73	109	135	170	198	227	258	301

[1] *Interim fish passage design flow (ADFG/ADOT&PF Memorandum of Agreement 2001)*

3.3.2.3 SCS Unit Hydrograph Method

The SCS (now NRCS-Natural Resources Conservation Service) Unit Hydrograph Method (SCS 1984) was also applied to these 11 basins. The SCS Method calculates the volume of runoff per area of the basin according to soil and land use conditions. Information on time of concentration of stream flow and initial abstraction of storm precipitation are then used to calculate a unit hydrograph, which is applied to the runoff volume to calculate peak flow rates (SCS 1984). The hydrologic soil group was obtained in GIS using the NRCS State Soil Geographic (STATSGO) layer (NRCS 1979). The hydrologic soil group and land use conditions were then used to determine runoff curve numbers, which for all the basins were estimated at a value of 79. Time of concentration was obtained using flow length and average watershed slope, according to the procedures described for the method. Flow lengths were obtained in GIS by measuring the flow path from the stream outlet to the watershed divide using digitized versions of the USGS 7.5 minute topographic maps. Average watershed slopes were obtained by performing map calculations on the 30-meter Digital Elevation Models (DEMs) for the basins.

Basin characteristics yielded values outside the range for the initial abstraction to precipitation ratio that is used in the model. This is due to high intensity storms and low permeability soils. These results suggest that conditions in the study basins are outside the range of basin characteristics used to develop the SCS Method, which is primarily geared towards lowland agricultural basins. Final runoff volumes were substantially higher than those predicted with the regional regression equations. For these reasons, the SCS Method values were considered unreasonable estimates and were not incorporated into the final estimates for design flow. SCS Method flow estimates can be found in Appendix, Section 22.2.

3.3.2.4 Rational Method

The Rational Method was also applied to the study basins. The rational method simply uses rainfall intensity, watershed area, and a runoff coefficient to predict peak flow

levels. Rainfall intensities for the 1-hour storm were used due to the short times of concentration of the basins. A runoff coefficient of 0.25 was selected based on watershed slopes and hydrologic soil groups. The Rational Method is best suited for small urban catchments and results for larger, rural basins should be viewed with caution. Nevertheless, the peak flow estimates are similar to the regional regression estimates, though slightly lower on average. These values are not used as recommended design flows because of the violation of basin size criteria specified in the Alaska Highway Drainage Manual (ADOT&PF, 1995), but they do increase confidence in the regional regression estimates because of their similar magnitude. Rational Method flow estimates can be found in Appendix, Section 22.2.

4. Chilkat River

4.1 Introduction

The project reach extends from highway milepost 3.5 to 25.3. The highway runs roughly parallel with the river, crossing at the Wells Bridge near milepost 25.

The Chilkat River is a large, glacial fed river. Drainage area at the Wells Bridge is 791-square miles. Near the Haines airport the drainage area increases to 1,602-square miles. The Chilkat River varies in width from about 1,000-ft up to 1.1-miles near the airport. Bed materials range from silt/sand at the mouth to gravel/cobble near the upstream end of the study area. The active river channels shift dramatically over a short time period. From the mouth to milepost 10 the main stem parallels and fronts much of the highway. From milepost 10 to 19 there are a number of side channels and back water sloughs near the highway. A map of the Chilkat River watershed is included in Figure 2.

This study addresses, at a conceptual level, erosion protection of the highway embankment adjacent to the Chilkat River or its side channels. Included are estimates of depths of scour through field investigations and analysis. Further, incorporation of habitat while providing engineered stability to the highway is addressed.

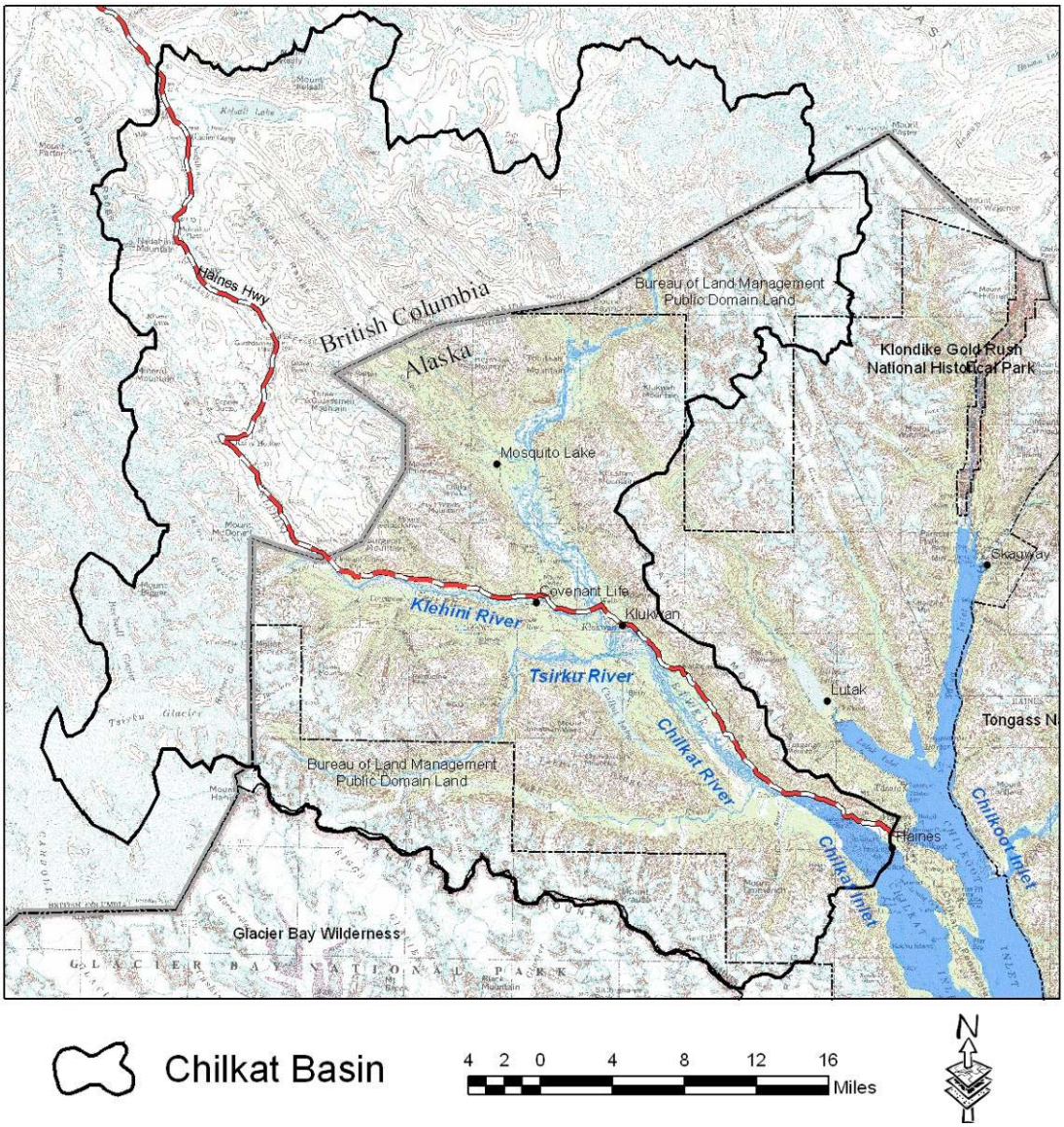


Figure 2. Map of the Chilkat Basin.

4.2 Chilkat River Field Investigations

Field investigations of the Chilkat River included visual inspection of existing roadway embankments, revetment and vegetation conditions, and estimates of existing scour depth conditions. Main areas of concern along the Chilkat River included reaches where the Chilkat River makes moderate to sharp bends, where points of land jut into the river and side channels of the Chilkat River impinge directly on the highway embankment.

4.2.1 Chilkat River Main Stem

Scour investigations were based on depth sounder measurements of scour holes along the main stem and side channels: An 18.5-ft jet boat was used to access portions of the main

stem of the Chilkat River. An Eagle, SuperPro ID portable depth sounder was attached to the boat to estimate depths to bottom. The depth sounder readings were periodically compared against depths manually probed with a rod to develop a correction factor. Typical areas where river scour were expected to occur were investigated by slowly ferrying across the river, depth sounder readings were called out and noted on site aerial photos. These depth readings are likely accurate to no better than 1- to 2-ft. Reading distance from shore was visually estimated and likely accurate to no better than 5- to 10-ft. The objective was to gain an understanding of relative magnitude of scour at different river conditions.

ADF&G maintains a staff gage near highway Station 418+00 as noted in Section 4.3.1. At the time of the boat based investigations, the staff gage read approximately 29.03-ft elevation. No river flow information is associated with elevation readings.

Depths measured on October 7, 2005 ranged from 2- to 3-ft along straight wide sections to as deep as 15.5-ft in areas of bends and obstructions. Specific areas noted to have deep scour holes include:

- Off a point of land near Station 338+00 scour depths range from 9- to 15.5-ft approximately 25-ft from shore.
- Near Station 417+00, scour depths range from 8- to 14-ft with maximum depth about 30-ft from shore.
- Near Station 477+00 (above the lower ADF&G fish wheel) flow depths are between 4.5 and 6.0-ft deep, evidence of little scouring along this locally straight reach.
- Near Station 485+00 (above the upper ADF&G fish wheel) flow depths range from 6.0- to 9.5-ft. Flows impinge on the road embankment at the outside of a bend.

Scour conditions appeared to be localized at predictable locations, yet extend for several hundred feet in an upstream-downstream direction. It is anticipated that the location of scour holes will change dramatically in response to flood conditions and changes in channel plan form. It must be noted that scour holes typically reach their greatest depth at or shortly before a flood peak. As the flood recedes, bed load begins to deposit in the scour hole, reducing the depth observed following the flood. Thus, the maximum depth of scour during floods is typically greater than those observed following the flood. Maximum depths of scour during flooding vary dependent on a number of factors including magnitude of flood, rate of flow increase/decrease, debris, sediment and water temperature.

During the boat based investigations, visual observations were made of the existing riprap revetment and adjacent vegetative condition. In general, the existing rock along the main stem of the Chilkat River appeared to be performing satisfactorily for erosion protection. Woody vegetation growth was typically vigorous above a well-defined elevation on the bank and sporadic or absent below this elevation.

4.2.2 Chilkat River Side Channel

Side channels impinge directly on the highway and turn away at sharp angles; notably near stations: 663+00, 724+00, 772+00, 837+00 and 851+00. Depth of scour at sharp bends along side channels impinging on the highway were also investigated by jet boat, where accessible, using the portable depth sounder. Areas inaccessible to the jet boat were investigated with the portable depth sounder attached to the end of a floating boom. The transducer was taped to a crab pot buoy which was attached to the end of a 14-ft long aluminum pruning saw handle. The 15-ft long depth sounder cable allowed readings to be taken from a wadeable depth along shore to a distance of about 15-ft into the channel. A guy line attached to the buoy was held from an upstream location to maintain the boom in position in areas of higher flow velocities. The boom was manually extended out from the bank and depth soundings read off and recorded. These depth readings are likely accurate to no better than 1- to 2-ft. Distance from shore was estimated in relation to reference marks along the pole and likely accurate to 1- to 3-ft. The objective was to gain an understanding of relative magnitude of scour at sharp bends.

Depths measured along the side channels on October 7 and 8, 2005 ranged from 4-ft along straight sections to as deep as 12-ft at sharp bends. Specific areas noted to have deep scour holes include:

- At a bend in the side channel near Station 646+00 depths range from 4- to 9.5-ft.
- At a sharp bend in the side channel near Station 663+00 depths range from 6- to 11-ft.
- Along a straight reach of the side channel from Station 693+00 to 720+00 depths range from 4- to 9.5-ft. Average depths appear to range from 5- to 6-ft.
- At a bend in the side channel near Station 724+00 depths range from 6.5- to 11-ft. Deepest scour appears to occur approximately 10- to 15-ft off shore.
- At a bend in the side channel near Station 772+00 depths range from 6- to 9-ft.
- At bends in a minor side channel near Stations 837+00 and 851+00 scour depths range from 6- to 11-ft deep.

Scour conditions appeared to be localized at predictable locations yet extend for a few hundred feet in the upstream-downstream direction. Commonly, vegetated banks opposite the highway dropped vertically 7- to 8-ft below water level to the stream bottom. Trees toppled into the channel are not uncommon along these locations. As noted earlier, scour holes typically reach their greatest depth at or shortly before a flood peak. As the flood recedes, bed load begins to deposit in the scour hole, reducing the depth observed following the flood. Depths of scour during floods are expected to be greater than those observed following the flood event.

Visual observations of riprap conditions along the side channels indicated that the majority of the existing rock was in satisfactory condition. Some erosion was noted along the bank where the rock was small, banks were steep, and flow impingement most likely. These areas were located at: 721+50-725+00, 771+00-773+00, and 798+00-800+00. Areas of vegetated riprap generally appeared to be in satisfactory condition for erosion protection. Typically there is a distinct elevation of persistent vegetation with vigorous

plant growth above and little to no plant growth below. These observable conditions provide useful guidelines for what is feasible for bioengineering solutions.

4.3 Hydraulic History

4.3.1 Tidal and Non-Tidal

Tidal range of the Lynn Canal at the Chilkat Inlet gage (6.9-miles southeast (true) of the Haines airport) is 16.5-ft between mean lower low water (MLLW) and mean higher high water (MHHW) (http://www.co-ops.nos.noaa.gov/benchmarks/9452421.html).

An inquiry was submitted to ADOT&PF surveyors regarding conversion from the tidal datum to land based elevation datum. The following response was provided (T. Reed, personal communication May 22, 2006):

> "ADOT&PF has benchmark ties to the NAVD 88 datum in the Haines area for the subject project. Based on other ADOT&PF survey work (specifically GPS ties to tidal benchmarks at Taiyasanka Harbor, AK station 9452434) in the area a conversion from tidal to NAVD 88 datum was determined to be NAVD 88 + 7.4-ft = MLLW tidal datum. MHHW tide elevation along the Chilkat Inlet is 16.76-ft (MLLW). This elevation converted to NAVD 88 is approximately 9.4-ft (NAVD 88). Based on existing conditions LIDAR topographic mapping, elevation 14.7-ft (NAVD 88) occurs along the Chilkat River sand flats at the downstream end of the Haines Airport, downstream of the project beginning. The lowest LIDAR elevation observed at the upper end of the runway is 17.3-ft NAVD88."

The extent of tidal influence along the Chilkat River was approximately estimated by extrapolating the HEC-RAS model developed for the scour hole at station 417+00 to downstream from the airport. The most downstream cross section synthesized for the Station 417+00 outcropping was copied downstream to the airport and also copied to 14,045-ft downstream of the airport to the end of the flats indicated on the USGS topographic map. The elevations of these cross sections were adjusted based on the LIDAR contour elevation (14-ft) at the airport and at the downstream end of the flats based on extrapolation of the lower LIDAR coverage. Though extremely approximate in nature, this provided a rough approximation of the back water (M1 curve) caused by the MHHW. From this modeling it was seen that high tide will not have a hydraulic affect on river during the 2-year or higher flows that were considered in the model. Results of the approximate HEC-RAS model are shown in Appendix 22.5.1.

Fluctuations in the Chilkat River discharge and associated water elevations will affect the project and backwater many of the tributary crossings of the highway. Typical summer water level fluctuations are observed at a staff gage maintained and monitored by ADF&G near station 418+00. The gage has been read for a period of record from 1994 through 2005 from June through September or October. The gage readings include only water surface elevation. The top of the piling elevation, 36.185-ft, was surveyed by ADOT&PF in 2005 with the associated staff gage elevations subsequently tied to that temporary bench mark elevation (Sogge personal communication, Sept 2006). River

water surface levels range from about 31.0- to 33.0-ft for June through July. Levels begin to decrease starting in August. In September the river levels range from an average low of about 29.0- to 31.5-ft. September minimum water levels are about 28.5-ft while maximum values are about 33.5-ft. These levels reflect the impact of fall rains. No river discharge measurements or calculations are associated with these stage data. A chart of these data are provided in Figure 3

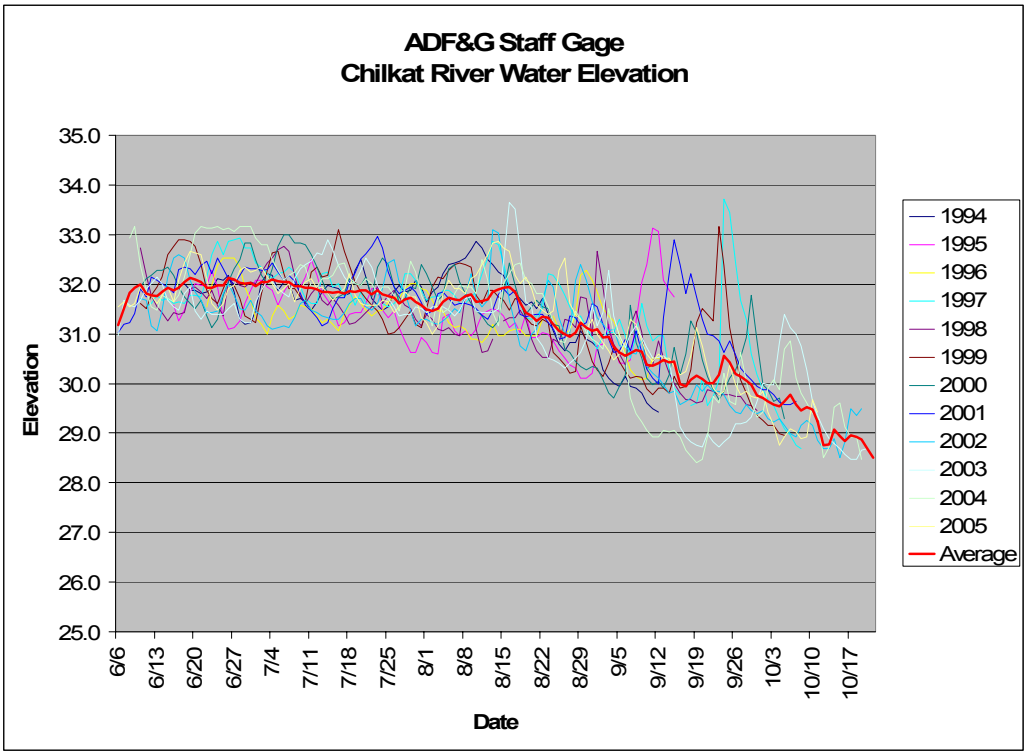


Figure 3. ADF&G staff gage readings near Sta 418+00

4.3.2 Navigation

Navigation is limited to recreational, commercial tour and ADF&G research jet boat use along the length of the project. In addition, commercial raft float trips are conducted from the Tsirku River through the Chilkat Bald Eagle Preserve to about milepost 15. Recreational canoes, kayaks and rafts are also used along the river. The Chilkat River dynamically shifts its course with extensive gravel bars, shallow flow depths over riffles and extensive sand and silt flats. Other than tourism and sport and subsistence fishing, little commercial activity presently occurs along the Chilkat River. Therefore, no other navigational use is anticipated.

4.3.3 Confluence

The Chilkat River discharges to the Chilkat Inlet of Lynn Canal. Within the project reach, the Chilkat River has confluences with the Kicking Horse River, the Tahkin River, the Tsirku River and the Klehini River. All these rivers discharge into the Chilkat River

from the southwest side, opposite the highway. No impact is foreseen to these confluences by the proposed action.

4.3.4 Mining

Approximately 500,000-cy of gravel was mined from the river near the Haines airport runway during the winter of 1990-91 for construction of the Haines airport. Otherwise, mining activity within the Chilkat River has not been identified to exist. No mining of gravel material is reportedly planned for this project.

Iron, gold, copper, platinum and palladium deposits exist within the Chilkat River watershed along the project length. However, economics have not justified mining these deposits. No plans for mining these deposits are publicly available. (Sogge, personal communication)

4.3.5 Debris and Icing Problems

Debris load along the Chilkat River consists of large woody debris load typical of this scale of southeast Alaskan glacial rivers. This debris forms occasional logjams but has not been observed to have a significant impact on the Haines Highway.

The timing of ice-up of the Chilkat River depends on the severity of the winter. In general, there is a section of the river near the Tsirku River alluvial fan that remains open at least through November, but more often December. There have been many times around Christmas when the river has been observed to be open between 19 mile and the Wells Bridge. It is not uncommon for most of the river to freeze over in January and February. Channels of the river can open up in March, but the main breakup does not typically occur until the beginning of April. (Sogge, personal communication)

Glaciers occupy approximately 20 percent of the upper watershed (based on the 1:250,000 USGS map). Glaciers do not directly encroach into the project area. No glacial outburst flooding was recalled in the anecdotal record. USGS Atlas HA-455 (Post and Mayo, 1971) indicates no significant glacial outburst floods in the Chilkat River Basin. Glacial outburst flooding from the headwaters of the Tsirku River is implied by hatch pattern on Sheet 1 in the Post and Mayo report. However, there is no discussion of the Tsirku River in the report. The Tsirku River discharges into the Chilkat River opposite the village of Klukwan. Based on the anecdotal record and cursory reference in the Post and Mayo report, it is assumed that glacial outburst flooding has insignificant influence on the Chilkat River.

4.3.6 Geomorphology

Geomorphology of the Chilkat River can be characterized as a large dynamic glacially fed river. The river is braided throughout the project length and the active flow path shifts significantly and dramatically over short time periods; typically in response to higher magnitude and longer duration flows. As an anecdotal example, along a side

channel adjacent to the road near milepost 14, an exposed sand bar observed in 1999 by Inter-Fluve was absent and found to be replaced by a 12-ft deep scour hole during the October 2005 field investigation. The braided main stem is adjacent to the road from the Haines airport to milepost 10. From milepost 10 to 19, there is a complex system of side channels close to the road with the main river further from the road. Along the project length, the Klehini, Tsirku, Tahkin and Kicking Horse Rivers are tributary to the Chilkat River.

4.3.7 Bed Load

Based on ocular investigation, bed load varies in size from sands and silts near the downstream end, transitioning to gravels and cobbles near the Wells Bridge. Above the Wells Bridge, the Chilkat River widens with extensive sand bars noted.

4.3.8 Environmental

Environmental considerations along the Chilkat River include the presence of Chinook, coho, pink, chum and sockeye salmon, eulachon and bald eagles. Proposed bank revetments strive to maximize the use of habitat elements while maintaining engineered stability.

4.4 Hydrology

The Chilkat River originates in the Datlasaka and Kusawak Mountains of northwest coastal British Columbia, flows into northern southeast Alaska, and empties into the Chilkat Inlet branch of the Lynn Canal near Haines, AK. Total basin size is approximately 1,600 square miles; just over half (54 percent) lying within the United States. Major tributaries include the Kelsall River, the Klehini River, the Tsirku River, and the Takhin River. Elevations in the basin range from sea level at the mouth to approximately 9,000 feet in the headwaters of the Tsirku Basin. Precipitation is snow-dominated with summer rains common in the lower elevations. The higher elevations are covered with expansive glaciers. The main stem and major tributaries exhibit a glacial melt water hydrologic regime, with peak flows typically occurring in the early summer (snowmelt) or in late summer/early fall (rain plus snowmelt). Low flows typically occur during winter months. Occasional large peak flows result from rain-on-snow events.

Flood frequency analysis was conducted for five locations along the main stem Chilkat River. Flow estimates were made for various return periods in support of channel hydraulic assessments at various locations where the main stem Chilkat or major side channels flow adjacent to the Haines Highway. Flow estimates are for the entire Chilkat River and do not account for flow separation into branching channels.

Peak flow estimates for various return periods were estimated using a combination of USGS regional regression equations (Curran et al. 2003) and watershed expansion of nearby available gage data. Nearby gages used in the watershed expansion include the

Klehini Gage (USGS Station #15056560) and the Upper Chilkat Gage (USGS #15056400).

4.4.1 Regional Regression Analysis

The regression equations for southeast Alaska utilize drainage area (A), storage (ST), mean annual precipitation (P), and mean minimum January temperature (J) as predictor variables. Curran et al. (2003) used stream flow data from a total of 93 gaging stations to develop the equations. The equations and accuracy information are displayed in Table 3-1. Basin delineations were performed manually in a Geographic Information System (GIS) using the USGS 1:250,000 topographical map (Skagway) and shaded relief images derived from 30-meter Digital Elevation Models (DEMs). Percent storage for each basin was obtained in GIS by digitizing surface water areas on topographic maps. Mean annual precipitation values were obtained in GIS using a digitized version of the Jones and Fahl (1994) annual precipitation map. Average precipitation values for each basin were weighted by the amount of area in each precipitation zone. Precipitation zones were not available for the Canadian portions of the basins; US data was therefore proportionally expanded into the Canadian portion. Mean minimum January temperature was obtained by geo-referencing and digitizing the temperature isothermal map in Jones and Fahl (1994). Average temperature values for each basin were weighted by the amount of area in each temperature zone. The regression estimates for the main stem Chilkat are included in Table 4-2.

4.4.2 Watershed Expansion Using Gage Data

Flow records are available for several years at two locations in the Chilkat Basin. These include the Upper Chilkat Gage (1962-1968) and the Klehini Gage (1982-1993). Curran et al. (2003) recommend a procedure for estimating peak flows where gage data is available. The method involves conducting Log Pearson III analysis on the gage data and weighting these results with those obtained using regional regression equations. Weighting is conducted according to the number of years of record of gage data and the Equivalent Years of Record (EYR) of the regression equation. This analysis was conducted by Curran et al. (2003) for many streams in Alaska, including the Klehini. The values for the Klehini included in Table 4-2 were obtained by expanding the reported Klehini values to the basins of interest.

Curran et al. (2003) performed stream flow analysis for stations with at least eight years of record and therefore did not perform analysis for the Upper Chilkat Gage, which has seven years of peak flow records. The procedure they describe, however, is suitable for stations with as few as five years of record due to the weighting with regression equations. Their procedure was therefore performed for the Upper Chilkat Gage location in order to obtain additional data points for final peak flow estimates.

A Log Pearson Type III analysis was first performed on the gage data following the methods described in Bulletin 17B of the IACW (1982). Instantaneous peaks were used for all years except one, where only the average daily peak was available. A weighted skew coefficient was obtained by weighting the derived station skew with the generalized

skew for southeast Alaska using the procedures described in Curran et al. (2003). The values obtained through Log Pearson III analysis are included in Table 4-1. Regional regression analysis was then performed for the station location. The Log Pearson III values and the regression values were weighted using the following equation from Curran et al. (2003):

$$\log Q_{Twtd} = \frac{\log Q_{Tsta} N + \log Q_{Treg} EYR}{N + EYR}$$

where Q_{Twtd} is the weighted peak flow estimate, Q_{Tsta} is the value obtained from the Log Pearson III analysis with weighted skew, Q_{Treg} is the value obtained using the regional regression equation, N is the number of years of record of station data, and EYR is the Equivalent Years of Record for the regional regression equation. The weighted flow estimates for the Chilkat Gage location are included in Table 4-1.

Table 4-1. Results of flow calculations for the Upper Chilkat Gage location using Log Pearson Type III Analysis and USGS regional regression equations.

	Log Pearson III		Regional Regression		
Return Period	Q (ft^3/second)	Years of Record (Gage)	Q (ft^3/second)	Equivalent Years of Record[1]	Weighted Q (ft^3/second)
2	8,985	7	6,521	0.88	8,669
5	12,712	7	8,880	1.30	12,017
10	15,649	7	10,485	1.80	14,418
25	19,949	7	12,922	2.40	17,856
50	23,610	7	14,766	2.80	20,647
100	27,697	7	16,633	3.10	23,684
200	32,269	7	18,678	3.40	26,987

[1] *From Curran et al. (2003)*

4.4.3 Final Flow Estimates

In order to obtain final flood flow estimates, values from the following analyses were averaged: 1) regional regression, 2) watershed expansion using Klehini Gage, and 3) watershed expansion using Upper Chilkat Gage. All of these results are included in Table 4-2.

Table 4-2. Final flow estimates for locations along the lower mainstem Chilkat River. Values in cubic feet per second.

Return Period	Chilkat at Mouth (1,602 mi^2)	Chilkat below Tahkin River (1,526 mi^2)	Chilkat below Tsirku River (1,364 mi^2)	Chilkat below Klehini River (1,080 mi^2)	Chilkat above Klehini River (791 mi^2)
2-Year					
Regional Regression	32,837	30,932	25,465	18,327	12,375
Klehini Expansion	40,106	38,204	34,148	27,038	19,803
Upper Chilkat Expansion	57,869	55,123	49,272	39,013	28,573
Average	43,604	41,420	36,295	28,126	20,250
5-Year					
Regional Regression	45,167	42,552	35,173	25,506	17,260
Klehini Expansion	47,327	45,081	40,296	31,906	23,368
Upper Chilkat Expansion	80,213	76,408	68,297	54,076	39,606
Average	57,569	54,681	47,922	37,163	26,745
10-Year					
Regional Regression	53,375	50,300	41,637	30,368	20,523
Klehini Expansion	51,839	49,380	44,138	34,948	25,596
Upper Chilkat Expansion	96,242	91,677	81,944	64,882	47,520
Average	67,152	63,786	55,906	43,399	31,213
25-Year					
Regional Regression	66,004	62,231	51,731	37,896	25,763
Klehini Expansion	57,537	54,807	48,989	38,789	28,409
Upper Chilkat Expansion	119,186	113,532	101,479	80,350	58,849
Average	80,909	76,856	67,399	52,345	37,674
50-Year					
Regional Regression	75,469	71,180	59,301	43,610	29,708
Klehini Expansion	61,485	58,568	52,351	41,451	30,359
Upper Chilkat Expansion	137,818	131,280	117,343	92,911	68,049
Average	91,591	87,010	76,332	59,324	42,705
100-Year					
Regional Regression	85,007	80,209	66,969	49,436	33,748
Klehini Expansion	65,434	62,330	55,713	44,113	32,308
Upper Chilkat Expansion	158,093	150,593	134,606	106,579	78,060
Average	102,845	97,710	85,763	66,710	48,039
200-Year					
Regional Regression	95,425	90,074	75,366	55,839	38,200
Klehini Expansion	69,382	66,091	59,075	46,775	34,258
Upper Chilkat Expansion	180,138	171,592	153,376	121,441	88,944
Average	114,982	109,252	95,939	74,685	53,801

4.5 Local input

The Haines area ADOT&PF maintenance supervisor, Roger Ingledue, was interviewed about existing conditions, past performance and areas of concern. In general, the existing Chilkat River and Haines Highway system was reported to be functioning satisfactorily. No flood overtopping of the road either by the Chilkat River main stem or side channels or tributary crossings along the project reach was reported. Overtopping of the road by some tributaries during the November 2005 flood was reported in cases where the

culverts were blocked by debris or sediment. No problems with icing were recalled. And no problem areas of revetment erosion were noted.

A flood occurred in November, 2005 that caused sediment and debris accumulations in some tributaries that blocked culverts. Mr. Ingledue reported that flows overtopping the road during the November 2005 flood were a result of debris and sediment plugging the culvert. No overtopping was reported at culverts that were not obstructed. (Personal communication to Mark Sogge, Inter-Fluve, March 8, 2006)

4.6 Backwater

4.6.1 Main stem

No FEMA Flood Insurance Studies were located for the Chilkat River. Anecdotal information indicates that this stretch of highway has not been overtopped during the period of record, since about 1980. Reports of overtopping of the highway during the November 2005 flood were determined to be mountainside flows blocked by sediment and debris accumulations at culverts and subsequently overtopping the road.

The hydraulic and geomorphic conditions of this river and system of side channels are extremely dynamic and complex. The Chilkat River is a braided sand, gravel and cobble bed river with rapidly changing active channels. An extensive sand flats area is located at the mouth where the sediment load deposits as the Chilkat River enters the tidal Lynn Canal. Existing data consists of LIDAR coverage along the highway corridor extending up to approximately one-third, but no more than 1,000-ft, across the active river. The LIDAR does not capture below water topography (bathymetry). The active river ranges from 1,000-ft to over a mile in width. USGS maps have a contour interval of 100-ft and are inadequate to extend the topographic coverage for the hydraulic analysis. Further, the USGS 1:63,360 topographic maps were created in 1954 and revised/inspected in 1977. In addition to the coarse resolution of the topography, it is impacted by isostatic rebound anecdotally reported to be approximately 0.9-inches/year as noted in Section 4.9. There is extremely limited availability of river flow-water surface elevation data for calibration of a hydraulic model.

Given the dynamic nature and complexity of the Chilkat River system and scale of the several miles of river paralleling the road; determination of a jurisdictional 100-year water surface elevation along the length of the project is beyond the scope of this study.

Therefore, an alternate approach was adopted for this conceptual level evaluation. This approximate approach is site specific to enable a semi-quantitative modeling approach for design values. In addition, the relative impact of the proposed action on water surface elevations can be approximated. For preliminary design of bank erosion protection and depth of scour, areas of greatest concern were considered. The area selected for this simplified approach was near Station 417+00. A scour hole with depths to 15.5-ft is located at the outside of a bend in the river off a point of land. ADF&G maintains a seasonal staff gage near this location.

Model cross sections were approximately synthesized from the dearth of available data. The LIDAR surface topographic information was used in conjunction with depth sounder readings to approximate bathymetry. Active river width was approximated from the USGS topographic map with a southwest flood plain elevation assumed. Distance between sections was measured from the respective location of the sections superimposed on the LIDAR topography. Downstream boundary conditions were determined by normal depth calculations using a slope of 0.00066-ft/ft determined from the portion of LIDAR topography for the river. For this conceptual phase, values of Manning's n roughness coefficient were estimated based on engineering judgment. Values for the channel and overbank areas were 0.038 and 0.055, respectively.

The existing conditions model was copied and modified to reflect a 2H:1V bank. Comparison of the existing and proposed conditions models indicates 0.02-ft of increase in elevation. However, it must be noted that the Chilkat River is dynamically changing location and bed form with corresponding changes in water surface elevations. Further, the model did not account for changes in cross sectional shape as silts/sands/gravels will transport and deposit in response to river flows.

As noted in Section 4.3.1, this model was used to approximately estimate the upstream limit of tidal influence. The downstream most cross section near station 417+00 was copied to near the airport and the limit of the sand flats indicated on the USGS topographic map. Cross section elevations were adjusted based on LIDAR elevations at the airport and extrapolation to the edge of the sand flats. Low tide conditions were modeled using a normal depth as a downstream boundary condition. High tide conditions were modeled using MHHW converted to NAVD 88 project datum as a constant downstream water surface elevation boundary condition. The results of this approximate model indicated that high tide elevations did not create a back water condition (hydraulic M1 curve) on river flows at the downstream end of the model below the Haines airport.

Summary results from the modeling effort are included in Appendix 22.5.1.

4.6.2 Side Channels

A modeling approach similar to the main stem was taken for the side channels. Representative sites near Stations 663+00, 693+00 to 730+00, 770+00 and 813+00 were selected for evaluation. The LIDAR topographic data included the full side channel width at these locations. Boat and wading based depth sounding readings were used to synthesize below water portions of the cross section. Wading based depth soundings extended only partially across the side channel. Depths across the un-sounded width were extrapolated by assumption.

A range of flows were included in the model in an effort to determine the worst case condition for design of revetment and scour depth protection. As described in the preceding section, the river system is extremely dynamic and complex. The percent of flow diverting from the main Chilkat River along the side channel and flood plains is not

known. Therefore, it is not possible to determine a return period event for the various flows.

Summary results from the modeling effort are included in Appendix 22.5.1.

4.7 Scour

As described in Section 4.2, areas where scour would be expected to occur were investigated using a portable depth sounder. These areas were accessed with a jet boat or by wading. These readings provide the scour conditions at the time of the field investigation; October 7 and 8, 2005. Floods typically form the deepest scour at or near the peak of the flood hydrograph. As the flood recedes, the scour hole begins to fill in with bed load. Therefore, maximum scour depth would be expected to be deeper than that measured in October.

4.7.1 Main Stem

Scour depths were observed using the jet boat and depth sounder. Locations of depth readings from the bank were noted by landmarks and visual estimates of distance from the bank. Readings and location were noted onto the project air photo. Main stem depths ranged from 2- to 3- feet in shallow straight riffles to scour holes with depths of 14- to 15.5-ft. Scour holes typically occurred at bends or points of land extending into the active flow path. Scour holes extended for several hundred feet in the upstream-downstream direction.

The Chilkat River system is highly dynamic with flow paths and channel geometry changing quickly and dramatically. As a result, the location, depth and mechanism of scour should be expected to change with scour depths in excess of observed values potentially occurring at nearly any location along the embankment.

4.7.2 Side Channels

Locations of scour holes along the side channels are likely to be more static in their location than those occurring within the main river channel. The scour holes were typically located at bends or local scour at obstructions. Observed scour depths ranged from 8- to 12-ft or more.

4.8 Hydraulic Design

4.8.1 Main Stem

Field observations and the results of the hydraulic modeling were used for conceptual design of road embankment protection. In the field it was noted that there was a distinct elevation on the bank of persistent woody vegetation. Woody vegetation was generally robust above this elevation. Below this elevation, the vegetation was either altogether absent or sporadic. This very obvious field indicator provides a guideline about the

applicability of bioengineering techniques for erosion protection. Below this elevation rock is the most suitable material to provide the level of erosion protection required for the highway. Above this elevation, vegetation may provide a satisfactory measure for erosion protection. Non-living vegetation may be incorporated into the lower bank if properly designed for scour and stability of the road, road embankment, and materials. Concepts are shown in the drawings. Final design of these features will be completed at a later stage for submittal with Plans-in-Hand.

Rock to protect the lower bank was sized for flows up to the 100-year event based on bed tractive force, adjusted for increases if along a bend, using the moment stability method (Julien, 1995). The moment stability method accounts for the angularity and specific gravity of rock and provides results that compare well against conditions observed in the field. For relatively straight reaches an average rock size of 18-inches (sound and angular rock with a minimum specific gravity equal to 2.65) laid at a 2H:1V slope will be required. A layer of filter gravel (or fabric) will be required between the rock and the bank slope.

Scour depth is most accurately estimated from field observations. As noted in the preceding section, scour at bends and points of land jutting into the channel were observed in early October, 2005 to have depths to 15.5-ft. These depths will be greater during flood peaks. The observed scour holes occur in predictable isolated locations and tend to extend for several hundred feet in the upstream – downstream direction. Areas at higher risk of erosion include places where the river impinges the road embankment with flows turning at an angle or where land juts into the flow. Straight flow paths were observed to have flow depths of 3- to 6-ft deep with a relatively flat bed surface. However, the river is dynamic and continually changing flow path. Any portion of the road embankment may become subject to aggressive scour from river flows. Following project completion, monitoring and adaptive management is highly recommended.

From the hydraulic analysis, bed shears appear low enough that vegetation may perform satisfactorily for bank erosion protection above the field observed elevation of persistent woody vegetation. Basic concepts are included in the concept drawings. Details will be prepared at final design.

4.8.2 Side Channels

Similar to the main stem, field observations and the results of the hydraulic modeling were used for conceptual design of road embankment protection along the side channels of the Chilkat River. A distinct elevation of persistent woody vegetation was noted for side channels as well.

The side channels represent a complex network of flow paths. It was not possible without extensive topographic data and modeling efforts to determine the percentage of each flood that is conveyed along the side channels or flood plains. Therefore, a worst case condition, corresponding to bank full flow, was used as the design condition along the side channels. Flows greater than bank full are expected to spill onto the flood plain

and dissipate the energy associated with the additional flow. Rock to protect the lower bank was sized for flows up to the worst case condition based on bed tractive force, and the moment stability method (Julien, 1995). A bend coefficient was used to account for greater shear forces along bends (FHWA, 1988). For sharp bends (e.g. Station 663+00) the coefficient doubles the bed tractive force. The moment stability method accounts for the angularity of rock and provides results that compare well against conditions observed in the field. Average rock size of about 18-inch diameter will be required along straight reaches, below the tangent of bends. At moderate bends average rock size will need to be between 21- and 27-inches. At sharp bends with high tractive forces and turbulence, average rock size may need to be 30-inches and laid at 2.5H:1V or flatter. All rock is to be sound and angular with sizes based on a minimum specific gravity equal to 2.65. A layer of filter gravel (or fabric) will be required between the rock and the bank slope.

Scour depth is based on observations in the field. As noted in the preceding section, scour at bends and points of land jutting into the Chilkat side channels were observed in early October, 2005 to have depths to 11.5-ft. These depths will be greater during flood peaks. The scour holes occur in predictable isolated locations and tend to extend for a few hundred feet in the upstream – downstream direction. Areas at higher risk of erosion include outsides of bends. The severity of scour increases with tighter bends. Straight flow paths were observed to have flow depths of 4- to 6-ft deep with a relatively flat bed surface. Locations of scour are not expected to change from current locations. Fallen trees or debris accumulations will also initiate local scour to occur. Following project completion, an ongoing monitoring and adaptive management is highly recommended.

From the hydraulic analysis, bed shears appear low enough that vegetation may perform satisfactorily for bank erosion protection above the field observed elevation of persistent woody vegetation. Basic concepts are included in the concept drawings. Details will be prepared at final design.

4.9 23 CFR

An internet search turned up no indication that a FEMA Flood Insurance Study exists for the Chilkat River. Communication with Haines Borough Planner Scott Hansen indicated that no FEMA Flood Insurance Study (FIS) is known to exist for the Chilkat River system. An FIS for the immediate Haines area dating back to the 1970's is available but is likely obsolete as isostatic rebound is anecdotally reported to be approximately 0.9-inches/year (S. Hansen, email communication).

As described in Section 4.6, representative conditions at Station 417+00 were modeled. The existing conditions run was copied and modified to represent bank conditions. There is 0.02-ft of increase in water surface elevation. It must be noted that the river changes dynamically with shifting bed forms. Changes in cross section and flow roughness by these natural processes are anticipated to cause greater changes in water surface elevations. Further, the dynamic shifting of the river bed and bar forms will likely adjust in response to roadway encroachment. A detailed analysis of this bed shifting is beyond the scope of this study.

Risks associated with the proposed action are considered to be similar in scale to those of the existing roadway. The road embankment is subject to forces of the Chilkat River and changes in channel form, such as scour depths and locations. The existing road is subject to much the same forces. Through field observations and design calculations similar or greater levels of protection are an objective. Following project implementation monitoring and maintenance are recommended.

4.10 Conclusion

The hydraulic features of the proposed action have been developed to a conceptual level in support of permitting and environmental activities. At final, the design features will be revised as appropriate and final designs and report will be prepared for the Plans-in-Hand submittal.

Conceptual designs follow industry standard methods. Bioengineering has no nationally established engineering design methods. Design of vegetation features is based on current knowledge in the industry and Inter-Fluve's experience from 1983 to the present in this field. Further, reference reach conditions are used as a design template.

4.11 Riprap

Existing riprap was observed to be mostly stable and reported to be performing satisfactorily. Hydraulic analysis was used to preliminarily size rock for road embankment erosion protection as described in Section 4.8.

4.12 Flood Hazard Area

The project is not located within a defined flood hazard area.

5. Culvert Replacement at Station 245+50

5.1 Introduction

The unnamed tributary crossing the highway at station 245+50 is comprised of an existing circular 48-inch corrugated metal pipe (CMP). The bottom of the pipe is rusted and should be replaced. At this Preliminary Engineering Report phase, the pipe was preliminarily designed based on Tier 1 (stream simulation) methods outlined in the ADOT&PF and ADF&G MOA. Tier 1 methods were selected based on the high quality of upstream habitats. This project will replace the existing pipe with a larger 6'-9" by 4'-11" pipe arch to convey flood flows and provide fish passage.

5.2 Hydraulic History

This unnamed tributary crosses the Haines Highway at about elevation 21-ft. As described in Section 4.3.1, MHHW is at elevation 9.4-ft (NAVD 88) and based on approximate modeling tidal backwater will not extend to this location.

Field indicators of Chilkat River backwater (i.e. deposition of fine sediments) were not seen to extend upstream along the tributary to the location of the existing culvert. Therefore, it is not likely that the culvert is impacted by backwater effects from frequently occurring Chilkat River flows. Large Chilkat River floods would be expected to have a backwater influence extending to the culvert.

No historical flood data are available for this tributary. Magnitude and water surface elevations for the flood of record are not known. High water marks for large flood events were not evident. No Flood Insurance Studies were identified for the Chilkat River or its tributaries, including this one.

A site visit was conducted on October 7, 2005. A rapid assessment and cursory site survey were conducted for this phase as described in Section 3.2. The existing culvert is a 48-inch CMP with no stream substrate material in the bottom of the pipe. The bottom of the pipe is rusted and should be replaced for longevity. From the site survey, the existing pipe is approximately 72-ft long at approximately 0.0326-ft/ft slope. A small amount of flow was observed. No problems with the existing culvert were reported in the anecdotal record or indicators observed in the field.

The creek is too small for navigation. This project will not impact navigation. The confluence with the Chilkat River is more than 1,000-ft downstream. No upstream confluences were observed in the vicinity. Therefore, no impacts to confluences are expected. This stream runs through a portion of the Southeast Road builder gravel pit.

Geomorphic conditions were summarized in the Stream and Habitat Inventory (S&HI). From observations and simple tape measurements by hand, upstream of the culvert the stream is a 3-6' wide, E type channel with a substrate of mixed sand and organics. There is a small pool at the culvert inlet. Downstream of the culvert the stream winds along the

toe of the road fill slope back to station 234+50. The upstream half of this 1050' section is also an E type channel 3-6' wide with a sandy/organic substrate. Stream banks are grassy, woody debris is present and alder often overhangs the stream. The lower half of this section is influenced by the river backwater, wider (6-10'), more open and 6-18" deep. Substrate is silt, sand, fine gravels and organic matter. Aquatic weeds shape the stream meander and banks are grassy or vegetated with alder and willow.

The S&HI indicates that this stream is used by coho as spawning and rearing habitat. Dolly Varden use this stream for rearing. The stream is listed in the Anadromous Waters Catalog as catalog number: 115-32-10250-2004.

5.3 Hydrology

The contributing basin has a drainage area of approximately 0.47 square miles and extends up to near the summit of Mount Ripinski (3,679 feet). The watershed is steep, with an average watershed slope of 63 percent. There is no perennial channel depicted on the USGS 7.5 minute topographical map. The perennial flow present on the valley floor may be largely contributed by seeps at the toe of the hill slope. There is very little storage in the basin and there are no glaciers. The watershed is largely undeveloped, with slight industrial encroachment in the lower portion of the basin.

There is no known gage information for this stream. Peak flow estimates using regional regression equations ranged from 42 cfs for the 2-year event to 130 cfs for the 100-year flood. The fish passage design flow, which is 40 percent of the 2-year event, is 17 cfs. There is no local input to report for this basin.

5.4 Hydraulic Design

At this phase, preliminary design was completed in support of the Preliminary Engineering Report. Final designs will require detailed stream cross section and profile survey. Final culvert designs will be prepared and documented for submittal with the Plans-in-Hand.

A 6'-9" by 4'-11" pipe arch is recommended as the replacement at this crossing. This size pipe will satisfy requirements of the Tier 1 (stream simulation) design method for fish passage as stated in the *Memorandum of Agreement between the Alaska Department of Fish and Game and the Alaska Department of Transportation and Public Facilities for the Design Permitting and Construction of Culverts for Fish Passage* (ADOT&PF and ADF&G, 2001). This culvert will provide sufficient span to accommodate the 6.7-ft wide reference stream channel width measured by the Inter-Fluve survey (October, 2005). The culvert would be set at a slope to match the existing stream system. Concepts are shown in Section 22.3.

Stream substrate will be placed in the bottom of the pipe to fill a minimum of 20 percent of the rise. Through engineering methods, the size of stream substrate will be designed to be dynamically stable for flows up to a 50-year flood. The gradation of the stream substrate will be designed using methods first published as guidelines by Washington

Department of Fish and Wildlife (WDFW) to replicate gradations of naturally occurring substrates.

Existing and proposed conditions were modeled with HEC-RAS. Results of modeling indicate that the proposed culvert will pass the 50-year flood with headwater elevation to culvert rise ratio equal to 1.02.

Table 5-1. 245+50 Hydrologic and Hydraulic Summary

Drainage Area = 0.47-square miles

Exceedance probability	10%	2%	1%
Return period	10-year (Q10)	50-year (Q50)	100-year (Q100)
Design discharge (cfs)	79	114	130
Flow depth at inlet (ft)	2.82	3.98	4.59
Hw/D	0.72	1.02	1.17

Note: Design was completed to preliminary level in support of the Preliminary Engineering Report based on cursory survey data collected by Inter-Fluve based on a relative horizontal and vertical datum. Final design will include site topographic survey.

5.5 23 CFR

There is no known FEMA Flood Insurance Study for the existing culvert. The proposed action includes a culvert larger in size and more hydraulically efficient than the existing culvert. Hydraulic analysis indicates that the upstream water surface elevations will be lower with the proposed culvert than currently exist.

Risks of the proposed culvert are considered minimal. There is a reduction in upstream backwater effects and more efficient conveyance of flows through the pipe. There is less likelihood of debris blocking the culvert.

5.6 Conclusion

The hydraulic features of the proposed action are developed to a preliminary level at this phase in support of the Preliminary Engineering Report. Design will be completed for submittal with Plans-in-Hand. The proposed culvert is not expected to impact the flood plain or environment. The proposed culvert meets ADOT&PF's requirements for conveyance of the 50-year event. The proposed culvert was designed for fish passage using the Tier 1 method to simulate adjacent stream conditions. This provides favorable continuity of stream processes and passage of fish through the culvert from adjacent stream reaches.

The hydrologic and hydraulic summary for the proposed culvert are presented in Table 5-1.

5.7 Riprap

The culvert was designed to provide fish passage using Tier 1 stream simulation to maintain continuity of flow of water and sediment. No riprap is proposed at this time.

5.8 Station 245+50 – Existing conditions photos

Existing Culvert: 48-inch cmp
Catalog Number: 115-32-10250-2004
Fish Use: Rearing coho and Dolly Varden. Spawning coho
Description: Based on hand measurements, upstream of the culvert the stream is a 3-6' wide, E type channel with a substrate of mixed sand and organics. There is a small pool at the culvert inlet. Downstream of the culvert the stream winds along the toe of the road fill slope back to station 234+50. The upstream half of this 1050' section is also an E type channel 3-6' wide with a sandy/organic substrate. Stream banks are grassy, woody debris is present and alder often overhangs the stream. The lower ½ of this section is influenced by the river backwater, wider (6-10'), more open and 6-18" deep. Substrate is silt, sand, fine gravels and organic matter. Aquatic weeds shape the stream meander and banks are grassy or vegetated with alder and willow.

6. Culvert Replacement at Station 342+00

6.1 Introduction

The unnamed tributary crossing the highway at station 342+00 is comprised of an existing circular 36-inch corrugated metal pipe (CMP). The bottom of the pipe is rusted with the outlet unraveled; the pipe should be replaced. At this Preliminary Engineering Report phase, the pipe was preliminarily designed based on Tier 1 (stream simulation) methods outlined in the ADOT&PF and ADF&G MOA. Tier 1 methods were selected based on the high quality of upstream habitats. This project will replace the existing pipe with a larger 6'-9" by 4'-11" pipe arch to convey flood flows and provide fish passage.

6.2 Hydraulic History

This unnamed tributary crosses the Haines Highway at about elevation 26.5-ft. As described in Section 4.3.1, MHHW is at elevation 9.4-ft (NAVD 88 and based on approximate modeling tidal backwater will not extend to this location.

Field indicators of Chilkat River backwater (i.e. deposition of fine sediments) extend upstream along the tributary to the location of the existing culvert. Therefore, the culvert is impacted by Chilkat River backwater effects.

No historical flood data are available for this tributary. Magnitude and water surface elevations for the flood of record are not known. High water marks for large flood events were not evident. No Flood Insurance Studies were identified for the Chilkat River or its tributaries, including this one.

A site visit was conducted on October 7, 2005. A rapid assessment and cursory site survey were conducted for this phase as described in Section 3.2. The existing culvert is a 36-inch CMP with no sediment in the bottom of the pipe. The bottom of the pipe is rusted with a section of the outlet unraveled and should be replaced for longevity. From the site survey, the existing pipe is approximately 54-ft long at approximately 0.0067-ft/ft slope. The outlet is perched approximately 0.25- to 0.6-ft above the scour pool water surface. The pool is about 1.1-ft deep. A small amount of flow was observed. No problems with conveyance through the existing culvert were reported in the anecdotal record or indicators observed in the field.

The creek is too small for navigation. This project will not impact navigation. The confluence with the Chilkat River is approximately 250-ft downstream. No upstream confluences were observed in the vicinity. No impacts to confluences are expected. No mining occurs on this stream.

Geomorphic conditions were summarized in the Stream and Habitat Inventory (S&HI). From observations and simple tape measurements by hand, upstream of the culvert the complex channel of the stream meanders among alder roots and downfall. The stream is

1-3’ wide with a substrate of gravel and organics. Depth is 6-8” and overhanging cover is dense. The downstream end of the culvert is perched 3-4” and unraveled. The stream meanders along the road back to station 339+75 before entering the Chilkat River. The river backwaters the stream and deposits silt over the gravel bed. The stream is 4-6’ wide and 3-4” deep. It lies in an old flood channel of the river. Stream banks are grass covered.

The S&HI indicates that this stream is used by coho and Dolly Varden as rearing habitat. The stream is not listed in the Anadromous Waters Catalog.

6.3 Hydrology

The contributing basin has a drainage area of approximately 0.6 square miles. The basin extends up to Seven Mile Saddle, which connects into the Shakasevi drainage on the east side of the divide. The high point of the basin is at 3,904 feet at the summit of an unnamed peak. The watershed has an average slope of 42 percent. The USGS 7.5 minute topographical map depicts a perennial stream channel that is believed to be within the contributing area for the culvert. The bulk of the perennial flow present on the valley floor may be largely contributed by seeps at the toe of the hill slope and possibly by hyporheic flow from the main stem Chilkat. There is virtually no storage in the basin and there are no glaciers. The watershed is undeveloped.

There is no known gage information for this stream. Peak flow estimates using regional regression equations ranged from 50 cfs for the 2-year event to 154 cfs for the 100-year flood. The fish passage design flow, which is 40 percent of the 2-year event, is 20 cfs. There is no local input to report for this basin.

6.4 Hydraulic Design

At this phase, preliminary design was completed in support of the Preliminary Engineering Report. Final designs will require detailed stream cross section and profile survey. Final culvert designs will be prepared and documented for submittal with the Plans-in-Hand.

A 6’-9” by 4’-11” pipe arch is recommended as the replacement at this crossing. This size pipe will satisfy requirements of the Tier 1 (stream simulation) design method for fish passage as stated in the *Memorandum of Agreement between the Alaska Department of Fish and Game and the Alaska Department of Transportation and Public Facilities for the Design Permitting and Construction of Culverts for Fish Passage* (ADOT&PF and ADF&G, 2001). This culvert will provide sufficient span to accommodate the 5.1-ft wide reference stream channel width measured by the Inter-Fluve survey (October, 2005). The culvert would be set at a slope to match the existing stream system. Concepts are shown in Section 22.3.

Stream substrate will be placed in the bottom of the pipe to fill a minimum of 20-percent of the rise. Through engineering methods, the size of stream substrate will be designed to be dynamically stable for flows up to a 50-year flood. The gradation of the stream

substrate will be designed using methods first published as guidelines by Washington Department of Fish and Wildlife (WDFW) to replicate gradations of naturally occurring substrates.

Existing and proposed conditions were modeled with HEC-RAS. Results of modeling indicate that the proposed culvert will pass the 50-year flood with headwater elevation to culvert rise ratio equal to 1.16.

Table 6-1. 342+00 Hydrologic and Hydraulic Summary

Drainage Area = 0.60-square miles

Exceedance probability	10%	2%	1%
Return period	10-year (Q10)	50-year (Q50)	100-year (Q100)
Design discharge (cfs)	93	135	154
Flow depth at inlet (ft)	3.36	4.54	5.09
Hw/D	0.86	1.16	1.30

Note: Design was completed to preliminary level in support of the Preliminary Engineering Report based on cursory survey data collected by Inter-Fluve based on a relative horizontal and vertical datum. Final design will include site topographic survey.

6.5 23 CFR

There is no known FEMA Flood Insurance Study for the existing culvert. The proposed action includes a culvert larger in size and more hydraulically efficient than the existing culvert. Hydraulic analysis indicates that the upstream water surface elevations will be lower with the proposed culvert than currently exist.

Risks of the proposed culvert are considered minimal. There is a reduction in upstream backwater effects and more efficient conveyance of flows through the pipe. There is less likelihood of debris blocking the culvert.

6.6 Conclusion

The hydraulic features of the proposed action are developed to a preliminary level at this phase in support of the Preliminary Engineering Report. Design will be completed for submittal with Plans-in-Hand. The proposed culvert is not expected to impact the flood plain or environment. The proposed culvert was designed for fish passage using the Tier 1 method to simulate adjacent stream conditions. This provides favorable continuity of stream processes and passage of fish through the culvert from adjacent stream reaches.

The hydrologic and hydraulic summary for the proposed culvert are presented in Table 6-1.

6.7 Riprap

The culvert was designed using Tier 1 stream simulation to maintain continuity of flow of water and sediment. No riprap is proposed at this time.

6.8 Station 342+00 – Existing conditions photos

Existing Culvert: 36-inch cmp
Fish Use: Rearing coho and Dolly Varden
Description: Based on hand measurements, upstream of the culvert the complex channel of the stream meanders among alder roots and downfall. The stream is 1-3' wide with a substrate of gravel and organics. Depth is 6-8" and overhanging cover is dense. The downstream end of the culvert is perched 3-4" and unraveled. The stream meanders along the road back to station 339+75 before entering the Chilkat River. The river backwaters the stream and deposits silt over the gravel bed. The stream is 4-6' wide and 3-4" deep. It lies in an old flood channel of the river. Stream banks are grass covered.

7. Culvert Replacement at Station 347+50

7.1 Introduction

The unnamed tributary crossing the highway at station 347+50 is comprised of an existing circular 48-inch corrugated metal pipe (CMP). The pipe bottom is rusted and the inlet is damaged; the pipe should be replaced. At this Preliminary Engineering Report phase, the pipe was conceptually designed based on Tier 1 (stream simulation) methods outlined in the ADOT&PF and ADF&G MOA. Tier 1 methods were selected based on the high quality of upstream habitats. This project will replace the existing pipe with a larger 7'-3" by 5'-3" pipe arch to convey flood flows without overtopping the road and provide fish passage.

7.2 Hydraulic History

This unnamed tributary crosses the Haines Highway at about elevation 28-ft. As described in Section 4.3.1, MHHW is at elevation 9.4-ft (NAVD 88 and based on approximate modeling tidal backwater will not extend to this location.

Field indicators of Chilkat River backwater (i.e. deposition of fine sediments) extend upstream along the tributary to the location of the existing culvert. Therefore, the culvert is impacted by Chilkat River backwater effects.

No historical flood data are available for this tributary. Water surface elevations for flood of record are not known. High water marks for large flood events were not evident. No Flood Insurance Studies were identified for the Chilkat River or its tributaries, including this one.

A site visit was conducted on October 7, 2005. A rapid assessment and cursory site survey were conducted for this phase as described in Section 3.2. The existing culvert is a 48-inch CMP with no stream substrate material observed in the bottom of the pipe. The pipe bottom is rusted and the inlet is damaged and should be replaced for longevity. From the site survey, the existing pipe is approximately 60-ft long laid at approximately 0.0194-ft/ft slope. The rim of the downstream scour pool is 1.2-ft higher than the culvert outlet invert and 0.03-ft lower than the culvert inlet effectively backwatering most of the pipe length. No flow was observed. No problems with the existing culvert were reported in the anecdotal record or indicators observed in the field.

The creek is too small for navigation. This project will not impact navigation. The confluence with the Chilkat River is approximately 350-ft downstream. No upstream confluences were observed in the vicinity. No impacts to confluences are expected. No mining occurs on this stream.

Geomorphic conditions were summarized in the Stream and Habitat Inventory (S&HI). The culvert appears to be fairly recently replaced yet the bottom of the pipe is rusted. From observations and simple tape measurements by hand, upstream of the culvert the stream is a 1-2' wide E type channel with a fine silt and gravel substrate. The stream

drains a swamp fed by numerous springs along the toe of the mountain. The culvert outlet empties into a short section of gravel bottomed stream with a width of 2-3' and grassy banks. The stream then turns into a 3-6' wide backwatered slough with a silt substrate. Springs feed this section of the stream.

The S&HI indicates that this stream is used by coho and Dolly Varden as rearing habitat. The stream is listed in the Anadromous Waters Catalog as catalog number: 115-32-10250-2014.

7.3 Hydrology

The contributing basin has a drainage area of approximately 1.23 square miles. The basin extends up to Seven mile Saddle, which connects into the Shakasevi drainage on the east side of the divide. The high point of the basin is at 4,088 feet on the ridge leading north to Tukgahgo Mountain. The watershed has an average slope of 55 percent. The USGS 7.5 minute topographical map depicts two perennial stream channels that have their confluence 150 meters upstream of the culvert. Some of the perennial flow present on the valley floor may possibly be from hyporheic flow from the main stem Chilkat. There is virtually no storage in the basin and no glaciers. A pack trail heading to Seven mile Saddle follows the eastern edge of the basin; otherwise, the watershed is undeveloped.

There is no known gage information for this stream. Peak flow estimates using regional regression equations ranged from 92 cfs for the 2-year event to 280 cfs for the 100-year flood. The fish passage design flow, which is 40 percent of the 2-year event, is 37 cfs. Hydraulic analysis for the existing pipe indicates that the 2-year event will over top the road. Given that the anecdotal record of culverts along the Haines Highway has not identified this culvert to be a problem, the flows from the hydrology estimates are suspected to be too large and in error. This is the only tributary with estimated flows being suspiciously high. Therefore, an alternate approach was taken where the hydraulic capacity of the existing culvert was used to back calculate the flow that meets design criteria (HW/D < 1.5). In addition, the culvert configuration required to provide fish passage was analyzed to confirm that the flood conveyance was equal to or greater than existing conditions.

For existing conditions the flow corresponding to a HW/D ~ 1.5 is approximately 169-cfs (10-year event predicted flow). Prorating the predicted flows to the ADOT&PF criteria of HW/D < 1.5 for the 50-year design event would approximate the Q2-yr ~ 63-cfs, Q10-yr ~ 116-cfs, Q50-yr ~ 169-cfs and Q100-yr ~ 192-cfs. The corresponding fish passage flow is roughly 25-cfs. Through the hydraulic analysis a 7'-3"x5'-3" pipe arch is required to prevent overtopping of the road. This is a significantly larger pipe than the existing structure which has not been reported in the anecdotal record to be a problem. The hydrology remains suspect and will be further scrutinized during final design.

There is no local input to report for this basin.

7.4 Hydraulic Design

At this phase, preliminary design was completed in support of the Preliminary Engineering Report. Final designs will require detailed stream cross section and profile survey. Final culvert designs will be prepared and documented for submittal with the Plans-in-Hand.

Though a 6'-9"x4'-11" meets Tier 1 fish passage requirements and provides greater conveyance than the existing culvert, hydraulic analysis indicates that the flow estimated through the existing pipe that meets current ADOT&PF criteria for HW/D for the 50-year event will overtop the road. Therefore, a 7'-3" by 5'-3" pipe arch is recommended as the replacement at this crossing to prevent overtopping of the road by the estimated 50-year flow. This size pipe will satisfy requirements of the Tier 1 (stream simulation) design method for fish passage as stated in the *Memorandum of Agreement between the Alaska Department of Fish and Game and the Alaska Department of Transportation and Public Facilities for the Design Permitting and Construction of Culverts for Fish Passage* (ADOT&PF and ADF&G, 2001). This culvert will provide sufficient span to accommodate the 6.9-ft wide reference stream channel width measured by the Inter-Fluve survey (October, 2005). The culvert would be set at a slope to match the existing stream system. Concepts are shown in Section 22.3.

Stream substrate will be placed in the bottom of the pipe to fill a minimum of 20-percent of the rise. Through engineering methods, the size of stream substrate will be designed to be dynamically stable for flows up to a 50-year flood. The gradation of the stream substrate will be designed using methods first published as guidelines by Washington Department of Fish and Wildlife (WDFW) to replicate gradations of naturally occurring substrates.

Existing and proposed conditions were modeled with HEC-RAS. Results of modeling indicate that the proposed culvert will provide greater conveyance capacity than currently exists.

Table 7-1. 347+50 Hydrologic and Hydraulic Summary

Drainage Area = 1.23-square miles

Exceedance probability	10%	2%	1%
Return period	10-year (Q10)	50-year (Q50)	100-year (Q100)
Design discharge (cfs)	116	169	192
Flow depth at inlet (ft)	3.34	4.22	5.09
Hw/D	0.85	1.08	1.30

Notes:

1. Design was completed to preliminary level in support of the Preliminary Engineering Report based on cursory survey data collected by Inter-Fluve based on a relative horizontal and vertical datum. Final design will include site topographic survey.
2. Through the hydraulic analysis a 7.25'x5.25' pipe arch is required to prevent the roughly estimated 50-year flood from overtopping the road. This is a significantly larger pipe than the

existing structure which has not been reported in the anecdotal record to be a problem. The hydrology remains suspect and will be further scrutinized during final design.

7.5 23 CFR

There is no known FEMA Flood Insurance Study for the existing culvert. The proposed action includes a culvert larger in size and more hydraulically efficient than the existing culvert. Hydraulic analysis indicates that the upstream water surface elevations will be lower with the proposed culvert than currently exist.

Risks of the proposed culvert are considered minimal. There is a reduction in upstream backwater effects and more efficient conveyance of flows through the pipe. There is less likelihood of debris blocking the culvert.

7.6 Conclusion

The hydraulic features of the proposed action are developed to a preliminary level at this phase in support of the Preliminary Engineering Report. Design will be completed for submittal with Plans-in-Hand. The proposed culvert is not expected to impact the flood plain or environment. The proposed culvert meets ADOT&PF's requirements for conveyance of the 50-year event. The proposed culvert was designed for fish passage using the Tier 1 method to simulate adjacent stream conditions. This provides favorable continuity of stream processes and passage of fish through the culvert from adjacent stream reaches.

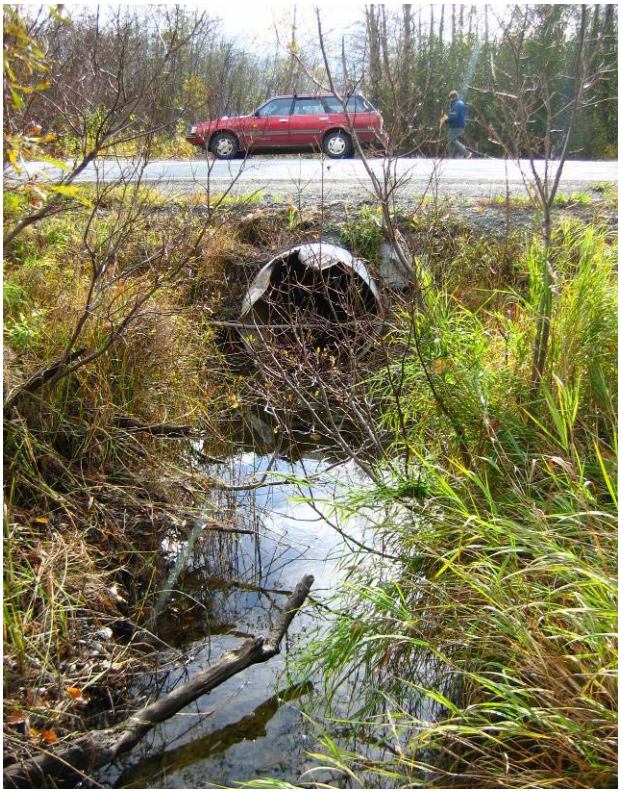
The hydrologic and hydraulic summary for the proposed culvert are presented in Table 7-1.

7.7 Riprap

The culvert was designed using Tier 1 stream simulation to maintain continuity of flow of water and sediment. No riprap is proposed at this time.

7.8 Station 347+50 – Existing conditions photos

Existing Culvert: 48-inch cmp
Catalog Number: 115-32-10250-2014
Fish Use: Rearing coho and Dolly Varden
Description: The culvert appears to be fairly recently replaced. Based on hand measurements, upstream of the culvert the stream is a 1-2' wide E type channel with a fine silt and gravel substrate. The stream drains a swamp fed by numerous springs along the toe of the mountain. The culvert outlet empties into a short section of gravel bottomed stream with a width of 2-3' and grassy banks. The stream then turns into a 3-6' wide backwatered slough with a silt substrate. Springs feed this section of the stream.



8. Culvert Replacement at Station 506+25

8.1 Introduction

The unnamed tributary crossing the highway at station 506+25 is comprised of an existing circular 48-inch corrugated metal pipe (CMP) with a rusted bottom and outlet apron. At this Preliminary Engineering Report phase, the pipe was preliminarily designed based on Tier 1 (stream simulation) methods outlined in the ADOT&PF and ADF&G MOA. Tier 1 methods were selected based on the high quality of upstream habitats. The stream is an average of 8-ft wide. A 7'-4" by 5'-4" pipe arch is proposed based on Tier 1 fish passage methods.

8.2 Hydraulic History

This unnamed tributary crosses the Haines Highway at about elevation 35-ft. As described in Section 4.3.1, MHHW is at elevation 9.4-ft (NAVD 88) and based on approximate modeling tidal backwater will not extend to this location.

Field indicators of Chilkat River backwater (i.e. deposition of fine sediments) extend upstream along the tributary to the location of the existing culvert. Therefore, the culvert is impacted by Chilkat River backwater effects.

No historical flood data are available for this tributary. Water surface elevations for the flood of record are not known. High water marks for large flood events were not evident. No Flood Insurance Studies were identified for the Chilkat River or its tributaries, including this one.

A site visit was conducted on October 7, 2005. A rapid assessment and cursory site survey were conducted for this phase as described in Section 3.2. The existing culvert is a 48-inch CMP with no stream substrate material observed in the bottom of the pipe. The bottom of the pipe and outlet apron is rusted and should be replaced for longevity. From the site survey, the existing pipe is approximately 65-ft long laid at approximately 0.0091-ft/ft slope. The rim of the downstream scour pool is 0.13-ft lower than the culvert outlet invert. Low flows appear able to backwater the culvert outlet invert. No problems with the existing culvert were reported in the anecdotal record or indicators observed in the field.

The creek is too small for navigation. This project will not impact navigation. The confluence with the Chilkat River is approximately 125-ft downstream. No upstream confluences were observed in the vicinity. No impacts to confluences are expected. No mining occurs on this stream.

Geomorphic conditions were summarized in the Stream and Habitat Inventory (S&HI). From observations and simple tape measurements by hand, upstream of the culvert the stream is about 8' wide and flows over a silt/organic substrate. The stream is backwatered by the Chilkat River and had a depth of 6-8" at the time of the survey.

Banks are muddy and grassy, with willow and alder growing close to the water on one side. The culvert empties into a 30' diameter pool with a depth of 3'. Banks are silty up to the level of frequent river backwater and then formed of grass and young willow/alder. Substrate is silt. Downstream of the pool the channel is 10' wide but terminates abruptly at a sandbar about 125' from the road. A small trickle flows over the sandbar and into an isolated pool. Fish access is dependent on the river water level.

The S&HI indicates that this stream is used by coho and Dolly Varden as rearing habitat. The stream is listed in the Anadromous Waters Catalog as catalog number: 115-32-10250-2024.

8.3 Hydrology

The contributing basin has a drainage area of approximately 1.07 square miles. The basin extends up to a ridge leading northeast toward Tukgahgo Mountain. The high point of the basin is at 4,490 feet. The watershed has an average slope of 57 percent. The USGS 7.5 minute topographical map depicts a single perennial stream channel with its headwaters at a small lake. A portion of the perennial flow present on the valley floor may be contributed by seeps at the toe of the hill slope and possibly by hyporheic flow from the main stem Chilkat. There is very little storage in the basin and there are no glaciers. The watershed is undeveloped.

There is no known gage information for this stream. Peak flow estimates using regional regression equations ranged from 76 cfs for the 2-year event to 232 cfs for the 100-year flood. The fish passage design flow, which is 40 percent of the 2-year event, is 30 cfs. There is no local input to report for this basin.

8.4 Hydraulic Design

At this phase, preliminary design was completed in support of the Preliminary Engineering Report. Final designs will require detailed stream cross section and profile survey. Final culvert designs will be prepared and documented for submittal with the Plans-in-Hand.

By Tier 1 methods, a 7'-4" by 5'-4" pipe arch would be required to accommodate stream width at this crossing. This size pipe will satisfy requirements of the Tier 1 (stream simulation) design method for fish passage as stated in the *Memorandum of Agreement between the Alaska Department of Fish and Game and the Alaska Department of Transportation and Public Facilities for the Design Permitting and Construction of Culverts for Fish Passage* (ADOT&PF and ADF&G, 2001). This culvert will provide sufficient span to accommodate the 8-ft wide reference stream channel width measured by the Inter-Fluve survey (October, 2005). The culvert would be set at a slope to match the existing stream system. Concepts are shown in Section 22.3.

The culvert would have stream substrate placed in the bottom of the pipe arch to fill a minimum of 20-percent of the rise. Through engineering methods, the size of stream substrate will be dynamically designed to be stable for flows up to a 50-year flood. The

gradation of the stream substrate will be designed using methods first published as guidelines by Washington Department of Fish and Wildlife (WDFW) to replicate gradations of naturally occurring substrates.

Existing and proposed conditions were modeled with HEC-RAS. Results of modeling indicate that the proposed culvert will provide greater conveyance capacity than currently exists.

Existing and proposed conditions were modeled with HEC-RAS. Results of modeling indicate that the proposed culvert will pass the 50-year flood with headwater elevation to culvert rise ratio equal to 1.29.

Table 8-1. 506+25 Hydrologic and Hydraulic Summary

Drainage Area = 1.07-square miles

Exceedance probability	10%	2%	1%
Return period	10-year (Q10)	50-year (Q50)	100-year (Q100)
Design discharge (cfs)	139	203	232
Flow depth at inlet (ft)	3.92	5.49	6.41
Hw/D	0.92	1.29	1.51

Note: Design was completed to preliminary level in support of the Preliminary Engineering Report based on cursory survey data collected by Inter-Fluve based on a relative horizontal and vertical datum. Final design will include site topographic survey.

8.5 23 CFR

There is no known FEMA Flood Insurance Study for the existing culvert. The proposed action includes a culvert larger in size and more hydraulically efficient than the existing culvert. Hydraulic analysis indicates that the upstream water surface elevations will be lower with the proposed culvert than currently exist.

Risks of the proposed culvert are considered minimal. There is a reduction in upstream backwater effects and more efficient conveyance of flows through the pipe. There is less likelihood of debris blocking the culvert.

8.6 Conclusion

The hydraulic features of the proposed action are developed to a preliminary level at this phase in support of the Preliminary Engineering Report. Design will be completed for submittal with Plans-in-Hand. The proposed culvert is not expected to impact the flood plain or environment.

The hydrologic and hydraulic summary for the proposed culvert are presented in Table 8-1.

8.7 Riprap

The culvert was designed using Tier 1 stream simulation to maintain continuity of flow of water and sediment. No riprap is proposed at this time.

8.8 Station 506+25 – Existing conditions photos

Existing Culvert: 48-inch cmp
Catalog Number: 115-32-10250-2024
Fish Use: Rearing coho and Dolly Varden
Description: Based on hand measurements, upstream of the culvert the stream is about 8' wide and flows over a silt/organic substrate. The stream is backwatered by the Chilkat River and had a depth of 6-8" at the time of the survey. Banks are muddy and grassy, with willow and alder growing close to the water on one side. The culvert empties into a 30' diameter pool with a depth of 3'. Banks are silty up to the level of frequent river backwater and then formed of grass and young willow/alder. Substrate is silt. Downstream of the pool the channel is 10' wide but terminates abruptly at a sandbar about 125' from the road. A small trickle flows over the sandbar and into an isolated pool. Fish access is dependent on the river water level.

9. Culvert Replacement at Station 535+50

9.1 Introduction

This tributary is referred to locally as 10-Mile Creek. The tributary crosses the highway at station 535+50 near a hydroelectric plant. The crossing is comprised of one 24-inch and one 36-inch circular corrugated metal pipes (CMP). At this Preliminary Engineering Report phase, the pipe was preliminarily designed to meet Tier 1 fish passage requirements. Tier 1 methods were selected based on the high quality of upstream habitats. The stream is an average of 15.3-ft wide. A 14'-1" by 6'-2" aluminum box culvert will satisfy Tier 1 methods for fish passage and meet site cover restrictions.

9.2 Hydraulic History

10-Mile Creek crosses the Haines Highway at about elevation 37-ft. As described in Section 4.3.1, MHHW is at elevation 9.4-ft (NAVD 88) and based on approximate modeling tidal backwater will not extend to this location.

10-Mile Creek discharges into 10-Mile Slough, then enters the main stem of the Chilkat River approximately 800-ft downstream of the culverts. Field indicators of Chilkat River backwater (i.e. deposition of fine sediments) extend upstream along 10-Mile Slough to the location of the existing culvert. Therefore, the culvert is impacted by Chilkat River backwater effects.

No historical flood data are available for this tributary. Magnitude and water surface elevations for the flood of record are not known. High water marks for large flood events were not evident. No Flood Insurance Studies were identified for the Chilkat River or its tributaries, including this one.

A site visit was conducted on October 7, 2005. A rapid assessment and cursory site survey were conducted for this phase as described in Section 3.2. The existing culverts are one 24-inch and one-36-inch diameter circular CMP. The majority of the flows pass through the 36-inch pipe. No perching of the pipe or formation of a scour pool was observed. Approximately 0.6-ft of material was measured in the bottom of the 36-inch pipe. From survey measurements on the 36-inch CMP, the length is approximately 73-ft long at approximately 0.0087-ft/ft slope. The majority of the flows pass through the 36-inch pipe. No problems with the existing culvert were reported in the anecdotal record or indicators observed in the field.

The creek is too small for navigation. This project will not impact navigation. The confluence with the Chilkat River is approximately 800-ft downstream of the culverts. The confluence with 10-Mile Slough is approximately 100-ft downstream. No upstream confluences were observed in the vicinity. No impacts to confluences are expected. No mining occurs on this stream.

Geomorphic conditions were summarized in the Stream and Habitat Inventory (S&HI). From observations and simple tape measurements by hand, upstream of the culverts the stream is about 15' wide and flows in riffles over ideal spawning gravels. The banks are well vegetated and overhang the stream. A hydroelectric plant is upstream. Downstream of the culverts the stream varies in width from 15-20', the bottom is gravel and the stream is heavily utilized by spawning salmon. Stream banks are fully vegetated with grasses. Further downstream the stream meanders through a wide, old river channel that is frequently backwatered by the river.

The S&HI indicates that this stream is used by coho and Dolly Varden as rearing habitat. Pink and chum use this stream for spawning habitat. The stream is listed in the Anadromous Waters Catalog as catalog number: 115-32-10250-2028-3002.

9.3 Hydrology

10-Mile Creek has a drainage area of approximately 1.46 square miles. The high point of the basin is at 4,441 feet at the summit of Tukgahgo Mountain. The watershed has an average slope of 44 percent. The USGS 7.5 minute topographical map depicts a perennial stream channel that is fed by several lakes in the upper basin. This storage comprises just under 2 percent of the basin area. Glaciers on the north side of Tukgahgo Mountain lie within the basin but comprise less than 5 percent of the basin area. The basin is narrow at the outlet, with little more than 500 hundred feet of stream channel between the culvert and the toe of the hill slope. A small hydroelectric operation is located on the stream at the hill slope toe and a small staging area is located on the north side of the stream upstream of the culvert. The hydropower plant is a run-of-the-river facility and does not impact the flow hydrograph (J. Floreski, personal communication to M. Sogge, March 2006). The remainder of the watershed is undeveloped.

There is no known gage information for this stream. Peak flow estimates using regional regression equations ranged from 73 cfs for the 2-year event to 220 cfs for the 100-year flood. The fish passage design flow, which is 40 percent of the 2-year event, is 29 cfs. There is no local input to report for this basin.

9.4 Hydraulic Design

At this phase, preliminary design was completed in support of the Preliminary Engineering Report. Final designs will require detailed stream cross section and profile survey. Final culvert designs will be prepared and documented for submittal with the Plans-in-Hand.

By Tier 1 methods, a 14'-1" by 6'-2" aluminum box culvert would be required to accommodate stream width at this crossing and to meet site cover restrictions. This size pipe will satisfy requirements of the Tier 1 (stream simulation) design method for fish passage as stated in the *Memorandum of Agreement between the Alaska Department of Fish and Game and the Alaska Department of Transportation and Public Facilities for the Design Permitting and Construction of Culverts for Fish Passage* (ADOT&PF and ADF&G, 2001). This culvert will provide sufficient span to accommodate the 15.3-ft

wide reference stream channel width measured by the Inter-Fluve survey (October, 2005). The culvert would be set at a slope to match the existing stream system. Concepts are shown in Section 22.3.

The culvert is proposed to have stream substrate placed in the bottom to fill a minimum of 20-percent of the rise. Through engineering methods, the size of stream substrate will be designed to be dynamically stable for flows up to a 50-year flood. The gradation of the stream substrate will be designed using methods first published as guidelines by Washington Department of Fish and Wildlife (WDFW) to replicate gradations of naturally occurring substrates.

Existing and proposed conditions were modeled with HEC-RAS. Results of modeling indicate that the proposed culvert will pass the 50-year flood with headwater elevation to culvert rise ratio equal to 1.11.

Table 9-1. 535+50 Hydrologic and Hydraulic Summary

Drainage Area = 1.46-square miles

Exceedance probability	10%	2%	1%
Return period	10-year (Q10)	50-year (Q50)	100-year (Q100)
Design discharge (cfs)	130	193	220
Flow depth at inlet (ft)	2.78	3.51	3.77
Hw/D	0.88	1.11	1.19

Note: Design was completed to preliminary level in support of the Preliminary Engineering Report based on cursory survey data collected by Inter-Fluve based on a relative horizontal and vertical datum. Final design will include site topographic survey.

9.5 23 CFR

There is no known FEMA Flood Insurance Study for the existing culvert. The proposed action includes a culvert larger in size and more hydraulically efficient than the existing culvert. Hydraulic analysis indicates that the upstream water surface elevations will be lower with the proposed culvert than currently exist.

Risks of the proposed culvert are considered minimal. There is a reduction in upstream backwater effects and more efficient conveyance of flows through the pipe. There is less likelihood of debris blocking the culvert.

9.6 Conclusion

The hydraulic features of the proposed action are developed to a preliminary level at this phase in support of the Preliminary Engineering Report. Design will be completed for submittal with Plans-in-Hand. The proposed culvert is not expected to impact the flood plain or environment. The proposed culvert meets ADOT&PF's requirements for conveyance of the 50-year event. The proposed culvert was designed for fish passage using the Tier 1 method to simulate adjacent stream conditions. This provides favorable

continuity of stream processes and passage of fish through the culvert from adjacent stream reaches.

The hydrologic and hydraulic summary for the proposed culvert are presented in Table 9-1.

9.7 Riprap

No riprap is proposed at this time.

9.8 Station 535+50 – Existing conditions photos

Existing Culverts: 30-inch cmp, 24-inch cmp
Catalog Number: 115-32-10250-2028-3002
Fish Use: Rearing coho and Dolly Varden. Spawning pink and chum
Description: Based on hand measurements, upstream of the culverts the stream is about 15' wide and flows in riffles over ideal spawning gravels. The banks are well vegetated and overhang the stream. A hydroelectric plant is upstream. Downstream of the culverts the stream varies in width from 15-20', the bottom is gravel and the stream is heavily utilized by spawning salmon. Stream banks are fully vegetated with grasses. Further downstream the stream meanders through a wide, old river channel that is frequently backwatered by the river.

10. Culvert Replacement at Station 612+40

10.1 Introduction

The unnamed tributary crossing the highway at station 612+40 is comprised of two existing circular 24-inch corrugated metal pipes (CMP). The bottoms of the pipes are rusted and should be replaced. At this Preliminary Engineering Report phase, the pipe was preliminarily designed based on Tier 1 (stream simulation) methods outlined in the ADOT&PF and ADF&G MOA. Tier 1 methods were selected based on the high quality of upstream habitats. This project will replace the existing pipe with a larger 7'-3" by 5'-3" pipe arch to convey flood flows and provide fish passage.

10.2 Hydraulic History

This unnamed tributary crosses the Haines Highway at about elevation 44-ft. As described in Section 4.3.1, MHHW is at elevation 9.4-ft (NAVD 88) and based on approximate modeling tidal backwater will not extend to this location.

Field indicators of Chilkat River backwater (i.e. deposition of fine sediments) extend upstream along the tributary to the location of the existing culvert. The culvert is impacted by Chilkat River backwater effects.

No historical flood data are available for this tributary. Magnitude and water surface elevations for the flood of record are not known. High water marks for large flood events were not evident. No Flood Insurance Studies were identified for the Chilkat River or its tributaries, including this one.

A site visit was conducted on October 7, 2005. A rapid assessment and cursory site survey were conducted for this phase as described in Section 3.2. The existing culverts are two 24-inch CMPs with no stream substrate material observed in the bottom of the pipes. The bottoms of the pipes are rusted and should be replaced for longevity. From the site survey, the two pipes are approximately 63-ft long at an adverse slope. The pipe is higher than the adjacent streambed. No flow was observed. No problems with the existing culvert were reported in the anecdotal record or indicators observed in the field.

The creek is too small for navigation. This project will not impact navigation. The confluence with a side channel of the Chilkat River is immediately downstream. No upstream confluences were observed in the vicinity. Therefore, no impacts to confluences are expected. No mining occurs on this stream.

Geomorphic conditions were summarized in the Stream and Habitat Inventory (S&HI). From observations and simple tape measurements by hand, upstream of the culverts the stream is a 2' wide E type channel with a very low gradient. It is infrequently backwatered by the Chilkat River. The banks are thickly vegetated with grasses and the substrate is a blend of organics and silt. The stream leads into a broad wetland.

Downstream of the culvert the stream banks are bare sand and the stream is heavily backwatered by the river. The substrate is silt/gravel and there is no cover.

The S&HI indicates that this stream is used by coho, Dolly Varden and cutthroat as rearing habitat. The stream is listed as catalog number: 115-32-10250-2032.

10.3 Hydrology

The contributing basin has a drainage area of approximately 0.65 square miles. The basin extends up to 4,035 feet. The watershed has an average slope of 49 percent. The USGS 7.5 minute topographical map does not depict a perennial stream channel. The perennial flow present on the valley floor is likely contributed by seeps at the toe of the hillslope as well as by hyporheic flow from a side channel of the mainstem Chilkat. There is virtually no storage in the basin and there are no glaciers. The watershed is undeveloped.

There is no known gage information for this stream. Peak flow estimates using regional regression equations ranged from 52 cfs for the 2-year event to 160 cfs for the 100-year flood. The fish passage design flow, which is 40 percent of the 2-year event, is 21 cfs. There is no local input to report for this basin.

10.4 Hydraulic Design

At this phase, preliminary design was completed in support of the Preliminary Engineering Report. Final designs will require detailed stream cross section and profile survey. Final culvert designs will be prepared and documented for submittal with the Plans-in-Hand.

A 6'-9 by 4'-11" pipe arch is recommended as the replacement at this crossing. This size pipe will satisfy requirements of the Tier 1 (stream simulation) design method for fish passage as stated in the *Memorandum of Agreement between the Alaska Department of Fish and Game and the Alaska Department of Transportation and Public Facilities for the Design Permitting and Construction of Culverts for Fish Passage* (ADOT&PF and ADF&G, 2001). This culvert will provide sufficient span to accommodate the 5.9-ft wide reference stream channel width measured by the Inter-Fluve survey (October, 2005). The culvert would be set at a slope to match the existing stream system. Concepts are shown in Section 22.3.

Stream substrate will be placed in the bottom of the pipe to fill a minimum of 20-percent of the rise. Through engineering methods, the size of stream substrate will be designed to be dynamically stable for flows up to a 50-year flood. The gradation of the stream substrate will be designed using methods first published as guidelines by Washington Department of Fish and Wildlife (WDFW) to replicate gradations of naturally occurring substrates.

Existing and proposed conditions were modeled with HEC-RAS. Results of modeling indicate that the proposed culvert will pass the 50-year flood with headwater elevation to culvert rise ratio equal to 1.05.

Table 10-1. 612+40 Hydrologic and Hydraulic Summary

Drainage Area = 0.65-square miles

Exceedance probability	10%	2%	1%
Return period	10-year (Q10)	50-year (Q50)	100-year (Q100)
Design discharge (cfs)	96	140	160
Flow depth at inlet (ft)	3.36	4.40	4.92
Hw/D	0.80	1.05	1.17

Note: Design was completed to preliminary level in support of the Preliminary Engineering Report based on cursory survey data collected by Inter-Fluve based on a relative horizontal and vertical datum. Final design will include site topographic survey.

10.5 23 CFR

There is no known FEMA Flood Insurance Study for the existing culvert. The proposed action includes a culvert larger in size and more hydraulically efficient than the existing culvert. Hydraulic analysis indicates that the upstream water surface elevations will be lower with the proposed culvert than currently exist.

Risks of the proposed culvert are considered minimal. There is a reduction in upstream backwater effects and more efficient conveyance of flows through the pipe. There is less likelihood of debris blocking the culvert.

10.6 Conclusion

The hydraulic features of the proposed action are developed to a preliminary level at this phase in support of the Preliminary Engineering Report. Design will be completed for submittal with Plans-in-Hand. The proposed culvert is not expected to impact the flood plain or environment. The proposed culvert was designed for fish passage using the Tier 1 method to simulate adjacent stream conditions. This provides favorable continuity of stream processes and passage of fish through the culvert from adjacent stream reaches.

The hydrologic and hydraulic summary for the proposed culvert are presented in Table 10-1.

10.7 Riprap

The culvert was designed using Tier 1 stream simulation to maintain continuity of flow of water and sediment. No riprap is proposed at this time.

10.8 Station 612+40 – Existing conditions photos

Existing Culverts: 2 - 24-inch cmps
Catalog Number: 115-32-10250-2032
Fish Use: Rearing coho, Dolly Varden and cutthroat
Description: Based on hand measurements, upstream of the culverts the stream is a 2' wide E type channel with a very low gradient. It is infrequently backwatered by the Chilkat River. The banks are thickly vegetated with grasses and the substrate is a blend of organics and silt. The stream leads into a broad swamp. Downstream of the culvert the stream banks are bare sand and the stream is heavily backwatered by the river. The substrate is silt/gravel and there is no cover.

11. Culvert Replacement at Station 670+00

This site is pending ADOT&PF review of DOWL geotechnical recommendations for debris flows

11.1 Introduction

The unnamed tributary crossing the highway at station 670+00 is comprised of two existing circular 36-inch corrugated metal pipes (CMP). The realignment is currently under evaluation to best meet local site conditions. A recommendation for passing sediment delivered by debris torrents has been proposed by DOWL geotechnical engineers and is currently in review at ADOT&PF

11.2 Hydraulic History

This unnamed tributary currently crosses the Haines Highway at about elevation 48-ft As described in Section 4.3.1, MHHW is at elevation 9.4-ft (NAVD) 88 and based on approximate modeling tidal backwater will not extend to this location.

Field indicators of Chilkat River backwater (deposition of fine sediments) extend upstream along the tributary to the location of the existing culvert. The culvert is impacted by Chilkat River backwater effects.

No historical flood data are available for this tributary. Water surface elevations for flood of record are not known. High water marks for large flood events were not evident. No Flood Insurance Studies were identified for the Chilkat River or its tributaries, including this one.

A site visit was conducted on October 7, 2005. A rapid assessment and cursory site survey of the existing culverts were conducted for this phase as described in Section 3.2. The existing culverts are two 36-inch CMP with no material in the bottom of the pipes. Measurements on one pipe, as a typical condition, indicates a length of approximately 59-ft long at approximately 0.016-ft/ft slope. Flow was observed along the creek. No problems with the existing culvert were reported in the anecdotal record or indicators observed in the field. The new alignment for the highway is currently under review but is anticipated to abandon this crossing for a location further up the hill.

The creek is too small for navigation. This project will not impact navigation. The confluence with the Chilkat River is more than 600-ft downstream. No upstream confluences were observed in the vicinity. Therefore, no impacts to confluences are expected. No mining occurs on this stream.

Geomorphic conditions were summarized in the Stream and Habitat Inventory (SH&I). Upstream of the culverts the stream splits almost immediately. The minor branch runs in a roadside ditch up to near station 675+00 where it turns away from the road. The section along the road is an E type channel 2’ wide and +1’ deep. The banks are vegetated with grasses that frequently overhang the full width of the stream. Substrate is gravel. Where

it cuts away from the road, this section of the stream broadens and winds through established forest. The major branch of the stream is gravel bottomed and meanders away from the road in a stable bed with well forested banks. The culverts empty into a broad 15' by 20' pool that leads into a 4-8' wide E-channel backwatered at times by a beaver dam and the influence of a side channel of the river. The stream dumps into the river near station 664+25. The stream banks are predominantly grass, with some willow. At times, the stream flows directly along the toe of the road fill. The lower section of the stream is much less well vegetated that the upper portion.

The Habitat Inventory indicates that this stream is used by coho and Dolly Varden as rearing habitat. This stream is used by pink salmon as spawning habitat. The stream is listed as catalog number: 115-32-10250-2040.

11.3 Hydrology

This stream has a drainage area of approximately 1.75 square miles. The high point of the basin is at 5,265 feet at the summit of an unnamed peak. The watershed has an average slope of 53 percent. The USGS 7.5 minute topographical map depicts a perennial stream channel with several branches midway up the basin. The southern branch is fed by lakes in the upper basin. This storage comprises less than 1 percent of the basin area. A small glacier is depicted on the southeast side of the basin (map data is circa 1991) but the current status of this glacier is unknown. The basin is narrow at the outlet, with only a couple of hundred feet of stream channel between the culvert and the toe of the hill slope. The watershed is undeveloped.

There is no known gage information for this stream. Peak flow estimates using regional regression equations ranged from 96 cfs for the 2-year event to 291 cfs for the 100-year flood. The fish passage design flow, which is 40 percent of the 2-year event, is 38 cfs. There is no local input to report for this basin.

11.4 Hydraulic Design

The new alignment for the highway is currently under review but is anticipated to abandon this crossing for a location further up the hill. This stream occasionally experiences debris flows. Hydraulic design will be completed pending resolution of the alignment and debris flow considerations.

Table 11-1. 670+00 Hydrologic and Hydraulic Summary

Drainage Area = 1.75-square miles

Exceedance probability	10%	2%	1%
Return period	10-year (Q10)	50-year (Q50)	100-year (Q100)
Design discharge (cfs)	174	255	291
Flow depth at inlet (ft)	Pending Geotechnical design recommendations		

Note: Design is pending ADOT&PF approval of DOWL geotechnical recommendations to accommodate debris flow conditions. Final design will require site topographic survey.

11.5 23 CFR

There is no known FEMA Flood Insurance Study for the existing culvert. This section will be completed pending resolution of the alignment and debris flow considerations.

11.6 Conclusion

This section will be completed pending resolution of the alignment and debris flow considerations.

The hydrologic and hydraulic summary for the proposed culvert are presented in Table 11-1.

11.7 Riprap

This section will be completed pending resolution of the alignment and debris flow considerations.

11.8 Station 670+00 – Existing conditions photos

Existing Culverts: 2 – 36-inch cmp
Catalog Number: 115-32-10250-2040
Fish Use: Rearing coho and Dolly Varden. Spawning pink salmon
Description: Based on hand measurements, upstream of the culverts the stream splits almost immediately. The minor branch runs in a roadside ditch up to near station 675+00 where it turns away from the road. The section along the road it an E type channel 2' wide and +1' deep. The banks are vegetated with grasses that frequently overhang the full width of the stream. Substrate is gravel. Where it cuts away from the road, this section of the stream broadens and winds through established forest. The major branch of the stream is gravel bottomed and meanders away from the road in a stable bed with well forested banks. The culverts empty into a broad 15' by 20' pool that leads into a 4-8' wide E-channel backwatered at times by a beaver dam and the influence of a side channel of the river. The stream joins the river near station 664+25. The stream banks are predominantly grass, with some willow. At times, the stream flows directly along the toe of the road fill. The lower section of the stream is much less well vegetated that the upper portion.

12. Culvert Replacement at Station 731+00

12.1 Introduction

This tributary is referred to locally as 14-Mile Creek. The tributary crosses the highway at station 731+00 near a local unimproved boat ramp. The crossing is comprised of two 36-inch circular corrugated metal pipes (CMP). The bottoms of the pipes are rusted and should be replaced. At this Preliminary Engineering Report phase, the pipe was preliminarily designed to meet Tier 1 fish passage methods and site cover restrictions. Tier 1 methods were selected based on the high quality of upstream habitats. The stream was surveyed near the culverts to be about 14-ft wide. A 12'-7" by 8'-4" pipe arch is proposed.

12.2 Hydraulic History

14-Mile Creek crosses the Haines Highway at about elevation 49.5-ft. As described in Section 4.3.1, MHHW is at elevation 9.4-ft (NAVD 88) and based on approximate modeling tidal backwater will not extend to this location.

14-Mile Creek flows 150-ft from the culvert outlet before entering a side channel of the Chilkat River. The culvert is actively backwatered by flows along this side channel

No historical flood data are available for this tributary. Magnitude and water surface elevations for the flood of record are not known. High water marks for large flood events were not evident. No Flood Insurance Studies were identified for the Chilkat River or its tributaries, including this one.

A site visit was conducted on October 8, 2005. A rapid assessment and cursory site survey were conducted for this phase as described in Section 3.2. The existing culverts are two 36-inch diameter circular CMP. Both culverts are at similar elevations and at the time of the survey were nearly submerged by backwater from the Chilkat River side channel. The pipes were clear of debris. The bottoms of the pipes are rusted and should be replaced for longevity. From the site survey, the pipes are approximately 94-ft long laid at approximately 0.0118-ft/ft slope. The culverts were observed to be nearly submerged by backwater. No problems with the existing culvert were reported in the anecdotal record or indicators observed in the field.

The creek at the culverts and upstream is too small for navigation. The culvert replacement will not impact navigation at the culverts and upstream. No upstream confluences were observed in the vicinity. The confluence with a side channel of the Chilkat River is approximately 150-ft downstream of the culverts. An unimproved boat launch ramp is located immediately downstream of the culverts to provide access to the side channel of the Chilkat River. Maintaining the existing launch conditions, removal of the launch and restoration of the stream and relocation or improvement of the launch facilities are currently under consideration. No other impacts to confluences are expected. No mining occurs on this stream.

Geomorphic conditions were summarized in the Stream and Habitat Inventory (S&HI). From observations and simple tape measurements by hand, upstream of the culverts the stream is 8-10' wide and leads into a vegetated meadow. Stream banks are stable and vegetated with grasses and willow. The substrate is loose silt and organic matter. There is some backwatering by the river. The outlets of the culverts are nearly submerged even at low river levels and empty into a large, deep pool that acts as both a rearing area for fish and a boat launch site. The pool empties into the river via a short channel. There is some overhanging vegetation on one side of the pool. Substrate is sand and silt.

The S&HI indicates that this stream is used by coho and Dolly Varden as spawning and rearing habitat. Pink and chum use this stream for spawning habitat. The stream is listed in the Anadromous Waters Catalog as catalog number: 115-32-10250-2044.

12.3 Hydrology

14-Mile Creek has a drainage area of approximately 2.26 square miles, the largest of the tributary basins. The high point of the basin is at 5,664 feet at the summit of an unnamed peak. The watershed has an average slope of 51 percent. The USGS 7.5 minute topographical map depicts a perennial stream with two major forks extending to the headwaters. Each branch is fed by lakes in the upper basin. Lake storage comprises less than 1 percent of the basin area. Expansive glaciers cover the east side of the divide, but no glaciers are located on the west side in the basin area. The stream enters the Chilkat side channel further south than depicted on the USGS map. Flow on the valley floor is likely supplemented by hill slope seeps and possibly by hyporheic flow from the Chilkat side channel. The watershed is undeveloped.

There is no known gage information for this stream. Peak flow estimates using regional regression equations ranged from 125 cfs for the 2-year event to 381 cfs for the 100-year flood. The fish passage design flow, which is 40 percent of the 2-year event, is 50 cfs. There is no local input to report for this basin.

12.4 Hydraulic Design

At this phase, preliminary design was completed in support of the Preliminary Engineering Report. Final designs will require detailed stream cross section and profile survey. Final culvert designs will be prepared and documented for submittal with the Plans-in-Hand.

By Tier 1 methods, a 12'-7" by 8'-4" pipe arch would be required to accommodate stream width at this crossing and to meet site cover restrictions. This size pipe will satisfy requirements of the Tier 1 (stream simulation) design method for fish passage as stated in the *Memorandum of Agreement between the Alaska Department of Fish and Game and the Alaska Department of Transportation and Public Facilities for the Design Permitting and Construction of Culverts for Fish Passage* (ADOT&PF and ADF&G, 2001). This culvert will provide sufficient span to accommodate the 14-ft wide reference stream channel width measured by the Inter-Fluve survey (October, 2005). The culvert

would be set at a slope to match the existing stream system. Concepts are shown in Section 22.3.

Stream substrate will be placed in the bottom of the pipe arch to fill a minimum of 20-percent of the rise. Through engineering methods, the size of stream substrate will be designed to be dynamically stable for flows up to a 50-year flood. The gradation of the stream substrate will be designed using methods first published as guidelines by Washington Department of Fish and Wildlife (WDFW) to replicate gradations of naturally occurring substrates.

Existing and proposed conditions were modeled with HEC-RAS. Results of modeling indicate that the proposed culvert will pass the 50-year flood with headwater elevation to culvert rise ratio equal to 0.71.

Table 12-1. 731+00 Hydrologic and Hydraulic Summary

Drainage Area = 2.26-square miles

Exceedance probability	10%	2%	1%
Return period	10-year (Q10)	50-year (Q50)	100-year (Q100)
Design discharge (cfs)	228	334	381
Flow depth at inlet (ft)	3.09	4.76	5.34
Hw/D	0.46	0.71	0.80

Note: Design was completed to preliminary level in support of the Preliminary Engineering Report based on cursory survey data collected by Inter-Fluve based on a relative horizontal and vertical datum. Final design will include site topographic survey.

12.5 23 CFR

There is no known FEMA Flood Insurance Study for the existing culvert. The proposed action includes a culvert larger in size and more hydraulically efficient than the existing culvert. Hydraulic analysis indicates that the upstream water surface elevations will be lower with the proposed culvert than currently exist.

Risks of the proposed culvert are considered minimal. There is a reduction in upstream backwater effects and more efficient conveyance of flows through the pipe. There is less likelihood of debris blocking the culvert.

12.6 Conclusion

The hydraulic features of the proposed action are developed to a preliminary level at this phase in support of the Preliminary Engineering Report. Design will be completed for submittal with Plans-in-Hand. The proposed culvert is not expected to impact the flood plain or environment. The proposed culvert meets ADOT&PF's requirements for conveyance of the 50-year event. The proposed culvert was designed for fish passage using the Tier 1 method to simulate adjacent stream conditions. Tier 1 methods were

selected based on the high quality of upstream habitats. This provides favorable continuity of stream processes and passage of fish through the culvert from adjacent stream reaches.

The hydrologic and hydraulic summary for the proposed culvert are presented in Table 12-1.

12.7 Riprap

The culvert was designed using Tier 1 stream simulation to maintain continuity of flow of water and sediment. No riprap is proposed at this time.

12.8 Station 731+00 – Existing conditions photos

Existing Culverts: 2 – 36-inch cmp
Catalog Number: 115-32-10250-2044
Fish Use: Rearing and spawning coho and Dolly Varden
Description: Based on hand measurements, upstream of the culverts the stream is 8-10' wide and leads into a vegetated meadow. Stream banks are stable and vegetated with grasses and willow. The substrate is loose silt and organic matter. There is some backwatering by the river. The outlets of the culverts are nearly submerged even at low river levels and empty into a large, deep pool that acts as both a rearing area for fish and a boat launch site. The pool empties into the river via a short channel. There is some overhanging vegetation on one side of the pool. Substrate is sand and silt.

13. Culvert Replacement at Station 886+00

13.1 Introduction

This tributary, locally referred to as 17-Mile Creek, crosses the highway at station 886+00. The crossing is comprised of one 6'-1"x4'7" pipe arch. The bottoms of the pipes are stained and have rust and should be replaced for longevity. At this Preliminary Engineering Report phase, the pipe was preliminarily designed to meet Tier 1 fish passage methods and site cover restrictions. Tier 1 methods were selected based on the high quality of upstream habitats and ground water source. The stream immediately above the road is ponded with a free flowing reach immediately upstream that is an average of 12.6-ft wide. An 11'-7" by 7'-5" pipe arch is proposed to meet Tier 1 methods based on the free flowing reach and site cover restrictions. At this Preliminary Engineering Report phase, the pipe was preliminarily designed.

13.2 Hydraulic History

17-Mile Creek crosses the Haines Highway at about elevation 68-ft. As described in Section 4.3.1, MHHW is at elevation 9.4-ft (NAVD 88) and based on approximate modeling tidal backwater will not extend to this location. This tributary flows approximately 480-ft to a minor side channel of the Chilkat River. The culvert may experience some backwater by flows along this side channel

No historical flood data are available for this tributary. Magnitude and water surface elevations for the flood of record are not known. High water marks for large flood events were not evident. No Flood Insurance Studies were identified for the Chilkat River or its tributaries, including this one.

A site visit was conducted on October 8, 2005. A rapid assessment and cursory site survey were conducted for this phase as described in Section 3.2. The existing culvert is a 6'-1"x4'7" pipe arch. The outlet is perched about 0.25-ft above the water surface elevation in the downstream scour pool. The pipe appears to have no accumulated sediment in the bottom. The pipe is approximately 72-ft long laid at approximately 0.0209-ft/ft slope. No problems with the existing culvert were reported in the anecdotal record or indicators observed in the field.

The creek is too small for navigation. This project will not impact navigation. The confluence with a side channel of the Chilkat River is approximately 480-ft downstream. No upstream confluences were observed in the vicinity. No impacts to confluences are expected. No mining occurs on this stream.

Geomorphic conditions were summarized in the Stream and Habitat Inventory (S&HI). The stream upstream of the culvert is a man-made complex consisting of two distinct branches. The main branch is a spring fed channel that runs up to station 895+00 where it ends in a beaver dam or man-made berm. From observations and simple tape measurements by hand, the lower half of this channel is consistently 8-10' wide and

forms a slow moving pool 1-2' deep. The steep banks are vegetated with overhanging grasses. Several springs feed into the channel from under the bank on the mountain side The upper half of the channel is a 2-3' wide riffle winding through boulders and thickly vegetated with grasses. The second branch of the complex feeds into the main branch about 100' upstream of the culvert inlet. This branch is fed by a series of springs, as well as a mountain stream, and rises in a series of pools and riffles up to a chum salmon incubation box facility operated by the Northern Southeast Regional Aquaculture Association. The stream substrate is gravel/cobble and the banks are well vegetated. Downstream the culvert outlet empties into a large pool used as a holding area for adult chum salmon. Pool substrate is silt covered gravel. A short channel connects the pool to the Chilkat River.

The S&HI indicates that this stream is used by coho and Dolly Varden as rearing habitat. Chum and coho use this stream as spawning habitat. The stream is listed in the Anadromous Waters Catalog as catalog number: 115-32-10250-2060-3002.

13.3 Hydrology

This stream has a drainage area of approximately 0.8 square miles. The high point of the basin is at 5,608 feet at the summit of an unnamed peak. The watershed has an average slope of 57 percent. The USGS 7.5 minute topographical map depicts a perennial stream that branches midway up the basin. There is virtually no storage in the basin and there are no glaciers. The man-made channel running along the road is fed by hill slope seeps and possibly by hyporheic flow from the Chilkat side channel. The watershed is undeveloped.

There is no known gage information for this stream. Peak flow estimates using regional regression equations ranged from 55 cfs for the 2-year event to 169 cfs for the 100-year flood. The fish passage design flow, which is 40 percent of the 2-year event, is 22 cfs. There is no local input to report for this basin.

13.4 Hydraulic Design

At this phase, preliminary design was completed in support of the Preliminary Engineering Report. Final designs will require detailed stream cross section and profile survey. Final culvert designs will be prepared and documented for submittal with the Plans-in-Hand.

By Tier 1 methods, an 11'-7" by 7'-5" pipe arch would be required to accommodate stream width at this crossing and site cover restrictions. This size pipe will satisfy site cover restrictions and requirements of the Tier 1 (stream simulation) design method for fish passage as stated in the *Memorandum of Agreement between the Alaska Department of Fish and Game and the Alaska Department of Transportation and Public Facilities for the Design Permitting and Construction of Culverts for Fish Passage* (ADOT&PF and ADF&G, 2001). This culvert will provide sufficient span to accommodate the 12.6-ft wide reference stream channel width measured by the Inter-Fluve survey (October, 2005). The culvert would be set at a slope to match the existing stream system. Concepts are shown in Section 22.3.

Stream substrate will be placed in the bottom of the pipe arch to fill a minimum of 20-percent of the rise. Through engineering methods, the size of stream substrate will be designed to be dynamically stable for flows up to a 50-year flood. The gradation of the stream substrate will be designed using methods first published as guidelines by Washington Department of Fish and Wildlife (WDFW) to replicate gradations of naturally occurring substrates.

Existing and proposed conditions were modeled with HEC-RAS. Results of modeling indicate that the proposed culvert will pass the 50-year flood with headwater elevation to culvert rise equal to 0.44.

Table 13-1. 886+00 Hydrologic and Hydraulic Summary

Drainage Area = 0.80-square miles

Exceedance probability	10%	2%	1%
Return period	10-year (Q10)	50-year (Q50)	100-year (Q100)
Design discharge (cfs)	101	148	169
Flow depth at inlet (ft)	1.83	2.60	2.98
HW/D	0.31	0.44	0.5

Note: Design was completed to preliminary level in support of the Preliminary Engineering Report based on cursory survey data collected by Inter-Fluve based on a relative horizontal and vertical datum. Final design will include site topographic survey.

13.5 23 CFR

There is no known FEMA Flood Insurance Study for the existing culvert. The proposed action includes a culvert larger in size and more hydraulically efficient than the existing culvert. Hydraulic analysis indicates that the upstream water surface elevations will be lower with the proposed culvert than currently exist.

Risks of the proposed culvert are considered minimal. There is a reduction in upstream backwater effects and more efficient conveyance of flows through the pipe. There is less likelihood of debris blocking the culvert.

13.6 Conclusion

The hydraulic features of the proposed action are developed to a preliminary level at this phase in support of the Preliminary Engineering Report. Design will be completed for submittal with Plans-in-Hand. The proposed culvert is not expected to impact the flood plain or environment. The proposed culvert meets ADOT&PF's requirements for conveyance of the 50-year event. The proposed culvert was designed for fish passage using the Tier 1 method to simulate adjacent stream conditions. This provides favorable continuity of stream processes and passage of fish through the culvert from adjacent stream reaches.

The hydrologic and hydraulic summary for the proposed culvert are presented in Table 13-1.

13.7 Riprap

The culvert was designed to provide fish passage using Tier 1 stream simulation to maintain continuity of flow of water and sediment. No riprap is proposed at this time.

13.8 Station 886+00 – Existing conditions photos

Existing Culvert: 6’-1” x 4’-7” pipe arch
Catalog Number: 115-32-10250-3002
Fish Use: Rearing coho and Dolly Varden. Spawning chum and coho
Description: The stream upstream of the culvert is a man-made complex consisting of two distinct branches. The main branch is a spring fed channel that runs up to station 895+00 where it ends in a beaver dam or man-made berm. Based on hand measurements, The lower half of this channel is consistently 8-10’ wide and forms a slow moving pool 1-2’ deep. The steep banks are vegetated with overhanging grasses. Several springs feed into the channel from under the bank on the mountain side The upper half of the channel is a 2-3’ wide riffle winding through boulders and thickly vegetated with grasses. The second branch of the complex feeds into the main branch about 100’ upstream of the culvert inlet. This branch is fed by a series of springs, as well as a mountain stream, and rises in a series of pools and riffles up to a chum salmon incubation box facility operated by the Northern Southeast Regional Aquaculture Association. The stream substrate is gravel/cobble and the banks are well vegetated. Downstream the culvert outlet empties into a large pool used as a holding area for adult chum salmon. The pipe is perched 4”. Pool substrate is silt covered gravel. A short channel connects the pool to the Chilkat River.

14. Culvert Replacement at Station 917+00

14.1 Introduction

This tributary, locally known as Horse Farm Creek, crosses the new highway at station 917+00 near a private grass airstrip. The existing crossing is comprised of two 36-inch circular corrugated metal pipes (CMP) along a stream averaging 4- to 6-ft wide. The highway will be realigned with the new crossing approximately 800-ft downstream of the existing crossing. The stream at the new location is approximately 15-ft wide along a section that is backwatered by Eighteen Mile Slough, a side channel of the Chilkat River. Given that Horse Farm Creeks expands from a 4- to 6-ft wide channel along a free flowing section to nearly three times that width along a back watered section at the new crossing, Tier 2 fish passage methods were selected for design. A Tier 2 design will provide flow depth and velocities that are passable for fish while avoiding an overly large conveyance structure associated with a Tier 1 design approach. An 8'-2" by 5'-9" pipe arch will meet Tier 2 fish passage methods and site cover restrictions. At this Preliminary Engineering Report phase, the pipe was preliminarily designed.

14.2 Hydraulic History

Horse Farm Creek crosses the Haines Highway at about elevation 77-ft. As described in Section 4.3.1, MHHW is at elevation 9.4-ft (NAVD 88) and based on approximate modeling tidal backwater will not extend to this location. The new highway alignment is immediately upstream of the confluence and is backwatered by Eighteen Mile Slough.

No historical flood data are available for this tributary. Magnitude and water surface elevations for the flood of record are not known. High water marks for large flood events were not evident. This reach of Horse Farm Creek is directly backwatered by Eighteen Mile Slough. No Flood Insurance Studies were identified for the Chilkat River or its tributaries, including this one.

A site visit of the existing culverts was conducted on October 8, 2005. A rapid assessment and cursory site survey of the existing culverts were conducted for this phase as described in Section 3.2. The existing culverts are two 36-inch diameter circular CMP. Both culverts are at similar elevations and at the time of the survey were nearly submerged. Approximately 0.8- to 1.4-ft of material was measured in the bottom of the 36-inch pipes. The bottom of the pipe is rusted and - should this road be kept in service for access to private property - should be replaced for longevity. A replacement pipe to provide access has not been designed at this time. From the site survey, the pipes are approximately 59-ft long laid at approximately 0.0241-ft/ft slope. The culverts were observed to have no scour pool or be perched. No problems with the existing culvert were reported in the anecdotal record or indicators observed in the field. After the field investigation was completed, the proposed highway alignment was shifted downstream approximately 800-ft. The following analysis is based on the new alignment currently proposed and shown in the companion Stream and Habitat Inventory (S&HI).

The creek is too small for navigation. This project will not impact navigation. The confluence with Eighteen Mile Slough, a side channel of the Chilkat River, is immediately downstream. No upstream confluences were observed in the vicinity. No impacts to confluences are expected. No mining occurs on this stream.

Geomorphic conditions were summarized in the Stream and Habitat Inventory (S&HI). From observations and simple tape measurements by hand, upstream of the existing culverts the stream is a fast 4-6% continuous riffle with a rocky substrate. The stream is 4-6' wide and meanders through a young forest. Downstream of the culverts the stream meanders along the existing road, intersecting the new alignment centerline at station 908+50. The roughly 1300' of stream between the culvert outlet and the confluence with Eighteen Mile Slough can be approximately divided by habitat type into three reaches. The first 400' section, measured from the culvert outlet downstream, is a 4-6' wide E-channel composed primarily of riffles, with a substrate of gravel. Although it is of similar width, the second 400' section is flatter in gradient and more complex, composed of riffles combined with numerous deep pools associated with the root structures of well established vegetation. The substrate of this reach is more silt/organic, although the November 2005 flood did deposit a good deal of gravel. The downstream reach connecting to the slough widens to a maximum width of 15' and is subject to backwatering when the Chilkat River is high. The stream substrate is silt, and the banks are steep and well vegetated. Two small streams draining the wetlands enter Horse Farm Creek from the west.

The S&HI indicates that this stream is used by coho and Dolly Varden as spawning and rearing habitat. Pink and coho use this stream for spawning habitat. The stream is listed in the Anadromous Waters Catalog as catalog number: 115-32-10250-2060-3001.

14.3 Hydrology

This stream has a drainage area of approximately 1.55 square miles. The high point of the basin is at 5,621 feet at the summit of an unnamed peak. The watershed is steep, with an average slope of 64 percent. The USGS 7.5 minute topographical map depicts a perennial stream with 3 branches midway up the basin. There is virtually no storage and there are no glaciers. The lower 500 meters of stream channel flows along the eastern edge of the large Nineteen-Mile Debris Fan and possibly loses flow to this feature. There is a small airstrip adjacent to the lower portion of the stream downstream of the culvert, but no development within the drainage area contributing to the culvert itself.

There is no known gage information for this stream. Peak flow estimates using regional regression equations ranged from 95 cfs for the 2-year event to 291 cfs for the 100-year flood. The fish passage design flow, which is 40 percent of the 2-year event, is 38 cfs. There is no local input to report for this basin.

14.4 Hydraulic Design

At this phase, preliminary design was completed in support of the Preliminary Engineering Report. Topographic data was limited to the project LIDAR. Visual and approximate measurements were made of the stream cross section at the new crossing. Final designs will require detailed stream cross section and profile survey. Final culvert designs will be prepared and documented for submittal with the Plans-in-Hand.

The new culvert is located along a section of stream backwatered by Eighteen Mile Slough. The stream is approximately three times wider than along freely flowing sections. Therefore, Tier 2 methods were selected to provide fish passage. An 8'-2" by 5'-9" pipe arch culvert would be required to provide fish passage and flood conveyance . This size pipe will satisfy requirements of the Tier 2 (hydraulic) design method for fish passage as stated in the *Memorandum of Agreement between the Alaska Department of Fish and Game and the Alaska Department of Transportation and Public Facilities for the Design Permitting and Construction of Culverts for Fish Passage* (ADOT&PF and ADF&G, 2001). Concepts are shown in Section 22.3.

Stream substrate is not required but may be placed in the bottom of the culvert to improve fish passage conditions. Through engineering methods, the size of stream substrate will be designed to be dynamically stable for flows up to a 50-year flood. The gradation of the stream substrate will be designed using methods first published as guidelines by Washington Department of Fish and Wildlife (WDFW) to replicate gradations of naturally occurring substrates.

Existing and proposed conditions were modeled with HEC-RAS. Results of modeling indicate that the proposed culvert will pass the 50-year flood with headwater elevation to culvert rise ratio equal to 1.01.

Table 14-1. 917+00 Hydrologic and Hydraulic Summary

Drainage Area = 1.55-square miles

Exceedance probability	10%	2%	1%
Return period	10-year (Q10)	50-year (Q50)	100-year (Q100)
Design discharge (cfs)	175	255	291
Flow depth at inlet (ft)	4.04	5.39	6.01
Hw/D	0.77	1.01	1.11

Note: Design was completed to preliminary level in support of the Preliminary Engineering Report based on cursory survey data collected by Inter-Fluve based on a relative horizontal and vertical datum. Final design will include site topographic survey.

14.5 23 CFR

There is no known FEMA Flood Insurance Study for the existing culvert. The proposed action includes a culvert to be placed where none currently exist. Hydraulic modeling based on project LIDAR and assumptions of bathymetry indicate that water surface

elevations for the 50- and 100-year events will increase by nearly 2-ft. The site topography (LIDAR) and aerial photography indicates that adjacent land uses is undeveloped forest. It is anticipated that increases in water surface elevations will not encroach on the adjacent private lands (e.g. air strip). Final design will include detailed cross section and profile survey to more accurately quantify hydraulic conditions and associated impacts. A larger structure with less impact on upstream water surface elevations may be required.

Risks of the proposed culvert are considered minimal.

14.6 Conclusion

The hydraulic features of the proposed action are developed to a preliminary level at this phase in support of the Preliminary Engineering Report. Design will be completed for submittal with Plans-in-Hand. The proposed culvert is not expected to impact the flood plain or environment.

The hydrologic and hydraulic summary for the proposed culvert are presented in Table 14-1.

14.7 Riprap

No riprap is proposed at this time.

14.8 Station 917+00 – Existing conditions photos

Existing Culverts: 2 – 36-inch cmp
Catalog Number: 115-32-10250-2060-3001
Fish Use: Rearing coho and Dolly Varden. Spawning pink and coho
Description: Upstream of the culverts the stream is a fast 4-6% continuous riffle with a rocky substrate. The stream is 4-6' wide and meanders through a young forest. Downstream of the culverts the stream meanders along the existing road, intersecting the new alignment centerline at station 908+50. The roughly 1300' of stream between the culvert outlet and the confluence with Eighteen Mile Slough can be approximately divided by habitat type into three reaches. The first 400' section, measured from the culvert outlet downstream, is a 4-6' wide E-channel composed primarily of riffles, with a substrate of gravel. Although it is of similar width, the second 400' section is flatter in gradient and more complex, composed of riffles combined with numerous deep pools associated with the root structures of well established vegetation. The substrate of this reach is more silt/organic, although the 11/05 flood did deposit a good deal of gravel.

Station 917+00 – Existing conditions photos (cont'd)

The downstream reach connecting to the slough widens to a maximum width of 15' and is subject to backwatering when the Chilkat River is high. The stream substrate is silt, and the banks are steep and well vegetated. Two small streams draining the wetlands enter Horse Farm Creek from the west.

15. Culvert Replacement at Station 983+25

This site is pending ADOT&PF review of DOWL geotechnical recommendations for debris flows

15.1 Introduction

This tributary is located along a debris flow at highway station 983+25. The crossing is comprised of an 8'-2" by 5'-9" pipe arch. A recommendation for passing sediment delivered by debris torrents has been proposed by DOWL geotechnical engineers and is currently in review at ADOT&PF. The crossing requirements for passage of debris torrent sediments are anticipated to govern the size and type of structure. Hydrology and Hydraulic design for flood conveyance and fish passage will be coordinated with geotechnical considerations for debris torrents to be completed during a later phase.

15.2 Hydraulic History

This section will be completed pending resolution of debris flow considerations.

15.3 Hydrology

This section will be completed pending resolution of debris flow considerations.

15.4 Hydraulic Design

This section will be completed pending resolution of debris flow considerations.

Table 15-1. 983+25 Hydrologic and Hydraulic Summary

This section will be completed pending resolution of debris flow considerations.

15.5 23 CFR

This section will be completed pending resolution of debris flow considerations.

15.6 Conclusion

This section will be completed pending resolution of debris flow considerations.

15.7 Riprap

This section will be completed pending resolution of debris flow considerations.

15.8 Station 983+25 – Existing conditions photos

Existing Culvert: 8'– 2" x 5'– 9" pipe arch
Fish Use: Rearing coho and Dolly Varden
Description: This stream is part of the 19 mile slide area and is subject to alteration by the periodic influx and mechanical removal of large quantities of slide material. This material consists of fine decomposed rock and gravels mixed with cobbles. The stream above the culvert runs in an open ditch along the road back to station 979+00. No vegetation is present yet numerous juvenile fish were seen in the stream. The stream turns away from the road and runs toward the mountain for about 75' before any upstream movement of fish is prevented by a barrier falls. Downstream of the culvert the stream is braided and open until it intersects the woods several hundred feet below the pipe. The substrate is slide material and initially there is little vegetation. Once the stream enters the woods it is a 2-3' wide fast riffle until it empties into a series of riverside pools fed by upwelling water.

16. Culvert Replacement at Station 994+50

This site is pending ADOT&PF review of DOWL geotechnical recommendations for debris flows

16.1 Introduction

This tributary is located along a debris flow at highway station 994+50. The crossing is comprised of a 9'-9" by 6'-9" pipe arch. A recommendation for passing sediment delivered by debris torrents has been proposed by DOWL geotechnical engineers and is currently in review at ADOT&PF. The crossing requirements for passage of debris torrent sediments are anticipated to govern the size and type of structure. Hydrology and Hydraulic design for flood conveyance and fish passage will be coordinated with geotechnical considerations for debris torrents to be completed during a later phase.

16.2 Hydraulic History

This section will be completed pending resolution of debris flow considerations.

16.3 Hydrology

This section will be completed pending resolution of debris flow considerations.

16.4 Hydraulic Design

This section will be completed pending resolution of debris flow considerations.

Table 16-1. 994+50 Hydrologic and Hydraulic Summary

This section will be completed pending resolution of debris flow considerations.

16.5 23 CFR

This section will be completed pending resolution of debris flow considerations.

16.6 Conclusion

This section will be completed pending resolution of debris flow considerations.

16.7 Riprap

This section will be completed pending resolution of debris flow considerations.

16.8 Station 994+50 – Existing conditions photos

Existing Culvert: 9'– 9" x 5'– 9" pipe arch
Fish Use: Unknown
Description: The stream above the culvert of this 19 mile slide stream is very unstable and often excavated by heavy equipment. Substrate is mobile slide material. Some vegetation is beginning to be established on the banks. Fish passage above the culvert is blocked by a headcut upstream 200'. Downstream of the culvert the stream is initially a braided riffle with little sign of viable fish habitat. Two hundred feet downstream of the culvert outlet the stream becomes a steep cascade through boulders until it enters the river.

17. Culvert Replacement at Station 1123+25

17.1 Introduction

The unnamed tributary crossing the highway at station 1123+25, near the turn off to the village of Klukwan, is comprised of an existing circular 36-inch corrugated metal pipe (CMP). At this Preliminary Engineering Report phase, the pipe was preliminarily designed based on Tier 1 (stream simulation) methods outlined in the ADOT&PF and ADF&G MOA. Tier 1 methods were selected based on fair to good upstream habitats and to provide continuity of flow, sediment and debris through the pipe. This project will replace the existing pipe with a larger 7'-3" by 5'-3" pipe arch to convey flood flows and provide fish passage.

17.2 Hydraulic History

This unnamed tributary crosses the Haines Highway at about elevation 117-ft. As described in Section 4.3.1, MHHW is at elevation 9.4-ft (NAVD 88) and based on approximate modeling tidal backwater will not extend to this location. The low flow water level in adjacent reaches of the Chilkat River are at approximately elevation 108-ft. It is unlikely that Chilkat River flows will have a backwater impact extending to the culvert location.

No historical flood data are available for this tributary. Magnitude and water surface elevations for the flood of record are not known. High water marks for large flood events were not evident. No Flood Insurance Studies were identified for the Chilkat River or its tributaries, including this one.

A site visit was conducted on October 8, 2005. A rapid assessment and cursory site survey were conducted for this phase as described in Section 3.2. The existing culvert is a 36-inch CMP with no material in the bottom of the pipe. From the site survey, the existing pipe is approximately 66-ft long at approximately 0.057-ft/ft slope. The tributary streambed slope is 0.038-ft/ft and 0.007-ft/ft upstream and downstream, respectively, of the culvert. A small amount of flow was observed. No problems with the existing culvert were reported in the anecdotal record or indicators observed in the field.

The creek is too small for navigation. This project will not impact navigation. The confluence with the Chilkat River is more than 1,500-ft downstream. No upstream confluences were observed in the vicinity. Therefore, no impacts to confluences are expected. No mining occurs on this stream.

Geomorphic conditions were summarized in the Stream and Habitat Inventory (S&HI). From observations and simple tape measurements by hand, upstream of the culverts the stream is 1-2' wide and composed of riffle habitat. The stream runs alongside the road up to station 1134+00 before the channel turns away from the road. For the first 150' above the culvert the stream lies away from the toe of the road fill slope and cover is provided by adjacent willow and alder. The stream then runs tight along the toe and the

banks are vegetated with grasses. Downstream of the culvert the stream flows through a manipulated habitat with patches of willow and grasses beginning to be established. For both portions of the stream the substrate is small gravel.

The S&HI indicates that this stream is used by coho and Dolly Varden as rearing habitat. Chum and coho use this stream for spawning habitat. The stream is listed as catalog number: 115-32-10250-2070.

17.3 Hydrology

This stream has a drainage area of approximately 1.26 square miles. The high point of the basin is at 5,477 feet on a ridge leading north toward Iron Mountain. The watershed has an average slope of 54 percent. The USGS 7.5 minute topographical map depicts a single perennial stream channel extending only one third of the way up the basin. There is no storage and there are no glaciers. The lower 1,000 yards of stream flows along the eastern edge of the large Twenty-three mile debris fan and likely loses flow to this feature. There is a water tank in the lower portion of the basin that supplies the village of Klukwan. Otherwise, the watershed is undeveloped.

There is no known gage information for this stream. Peak flow estimates using regional regression equations ranged from 73 cfs for the 2-year event to 227 cfs for the 100-year flood. The fish passage design flow, which is 40 percent of the 2-year event, is 29 cfs. There is no local input to report for this basin.

17.4 Hydraulic Design

At this phase, preliminary design was completed in support of the Preliminary Engineering Report. Final designs will require detailed stream cross section and profile survey. Final culvert designs will be prepared and documented for submittal with the Plans-in-Hand.

A 7'-3" by 5'-3" pipe arch is recommended as the replacement at this crossing. This size pipe will satisfy requirements of the Tier 1 (stream simulation) design method for fish passage as stated in the *Memorandum of Agreement between the Alaska Department of Fish and Game and the Alaska Department of Transportation and Public Facilities for the Design Permitting and Construction of Culverts for Fish Passage* (ADOT&PF and ADF&G, 2001). This culvert will provide sufficient span to accommodate the 6.6-ft wide reference stream channel width measured by the Inter-Fluve survey (October, 2005). The culvert would be set at a slope to match the existing stream system. Concepts are shown in Section 22.3.

Stream substrate will be placed in the bottom of the pipe to fill a minimum of 20-percent of the rise. Through engineering methods, the size of stream substrate will be designed to be dynamically stable for flows up to a 50-year flood. The gradation of the stream substrate will be designed using methods first published as guidelines by Washington Department of Fish and Wildlife (WDFW) to replicate gradations of naturally occurring substrates.

Existing and proposed conditions were modeled with HEC-RAS. Results of modeling indicate that the proposed culvert will pass the 50-year flood with headwater elevation to culvert rise ratio equal to 1.37.

Table 17-1. 1123+25 Hydrologic and Hydraulic Summary

Drainage Area = 1.26-square miles

Exceedance probability	10%	2%	1%
Return period	10-year (Q10)	50-year (Q50)	100-year (Q100)
Design discharge (cfs)	135	198	227
Flow depth at inlet (ft)	2.00	2.45	2.63
Hw/D	1.07	1.37	1.5

Note: Design was completed to preliminary level in support of the Preliminary Engineering Report based on cursory survey data collected by Inter-Fluve based on a relative horizontal and vertical datum. Final design will include site topographic survey.

17.5 23 CFR

There is no known FEMA Flood Insurance Study for the existing culvert. The proposed action includes a culvert larger in size and more hydraulically efficient than the existing culvert than currently exist.

Risks of the proposed culvert are considered minimal. There is a reduction in upstream backwater effects and more efficient conveyance of flows through the pipe. There is less likelihood of debris blocking the culvert.

17.6 Conclusion

The hydraulic features of the proposed action are developed to a preliminary level at this phase in support of the Preliminary Engineering Report. Design will be completed for submittal with Plans-in-Hand. The proposed culvert is not expected to impact the flood plain or environment. The proposed culvert meets ADOT&PF's requirements for conveyance of the 50-year event. The proposed culvert was designed for fish passage using the Tier 1 method to simulate adjacent stream conditions. This provides favorable continuity of stream processes and passage of fish through the culvert from adjacent stream reaches.

The hydrologic and hydraulic summary for the proposed culvert are presented in Table 17-1.

17.7 Riprap

The culvert was designed using Tier 1 stream simulation to maintain continuity of flow of water and sediment. No riprap is proposed at this time.

17.8 Station 1123+25 – Existing conditions photos

Existing Culvert: 36-inch cmp
Catalog Number: 115-32-10250-2070
Fish Use: Rearing coho and Dolly Varden. Spawning chum and coho
Description: Based on hand measurements, upstream of the culverts the stream is 1-2' wide and composed of riffle habitat. The stream runs alongside the road up to station 1134+00 before the channel turns away from the road. For the first 150' above the culvert the stream lies away from the toe of the road fill slope and cover is provided by adjacent willow and alder. The stream then runs tight along the toe and the banks are vegetated with grasses. Downstream of the culvert the stream flows through a manipulated habitat with patches of willow and grasses beginning to be established. For both portions of the stream the substrate is small gravel.

18. Culvert Replacement at Station 1200+60

This site is pending ADOT&PF review of DOWL geotechnical recommendations for debris flows

18.1 Introduction

This tributary is located along a debris flow at highway station 1200+60. The crossing is comprised of a corrugated metal pipe (CMP) about 13-ft in diameter. A recommendation for passing sediment delivered by debris torrents has been proposed by DOWL geotechnical engineers and is currently in review at ADOT&PF. The crossing requirements for passage of debris torrent sediments are anticipated to govern the size and type of structure. Hydrology and Hydraulic design for flood conveyance and fish passage will be coordinated with geotechnical considerations for debris torrents to be completed during a later phase.

18.2 Hydraulic History

This section will be completed pending resolution of debris flow considerations.

18.3 Hydrology

This section will be completed pending resolution of debris flow considerations.

18.4 Hydraulic Design

This section will be completed pending resolution of debris flow considerations.

Table 18-1. 1200+60 Hydrologic and Hydraulic Summary

This section will be completed pending resolution of debris flow considerations.

18.5 23 CFR

This section will be completed pending resolution of debris flow considerations.

18.6 Conclusion

This section will be completed pending resolution of debris flow considerations.

18.7 Riprap

This section will be completed pending resolution of debris flow considerations.

19. Culvert Replacement at Station 1208+20

This site is pending ADOT&PF review of DOWL geotechnical recommendations for debris flows

19.1 Introduction

This tributary is located along a debris flow at highway station 1208+20. The crossing is comprised of an 8'-2" by 5'-9" pipe arch. A recommendation for passing sediment delivered by debris torrents has been proposed by DOWL geotechnical engineers and is currently in review at ADOT&PF. The crossing requirements for passage of debris torrent sediments are anticipated to govern the size and type of structure. Hydrology and Hydraulic design for flood conveyance and fish passage will be coordinated with geotechnical considerations for debris torrents to be completed during a later phase.

19.2 Hydraulic History

This section will be completed pending resolution of debris flow considerations.

19.3 Hydrology

This section will be completed pending resolution of debris flow considerations.

19.4 Hydraulic Design

This section will be completed pending resolution of debris flow considerations.

Table 19-1. 1208+20 Hydrologic and Hydraulic Summary

This section will be completed pending resolution of debris flow considerations.

19.5 23 CFR

This section will be completed pending resolution of debris flow considerations.

19.6 Conclusion

This section will be completed pending resolution of debris flow considerations.

19.7 Riprap

This section will be completed pending resolution of debris flow considerations.

19.8 Station 1208+20 – Existing conditions photos

Existing Culvert: 8’-2” x 5’-9” pipe arch

20. Small Fish Culverts

20.1 Introduction

Following completion of the field investigations and submittal of the preliminary draft H&H report (November 2005), a number of smaller pipes with fish present were identified. These pipes were included in the Anadromous Waters Catalog or seen to have fish present by Inter-Fluve or OHMP staff. These pipes are all 36-inches or less in diameter, two sites have double 24-inch CMPs, and are not required to have a hydraulic summary report. However, culvert replacements will require a hydraulic project permit. At the request of ADOT&PF, discussion of these culverts and recommendation of design method and culvert size were subsequently added to this report. Therefore, each of these smaller pipes with fish present are identified, existing conditions discussed, H&H analysis/preliminary design presented and size of pipe to meet fish passage and flood conveyance requirements discussed. This section describes methods for providing fish passage and providing flood conveyance equal or greater to the existing culverts.

20.2 Hydraulic History

Through the anecdotal record and interviews with ADOT&PF maintenance personnel no culverts were identified that had problems with icing or conveyance of flood flows through unobstructed pipes. Therefore, it is assumed that existing conditions of each pipe discussed below are performing satisfactorily.

20.3 Hydrology

To the investigators' knowledge, there are no stream gaging data available for these streams. Furthermore, the basins range in size from 0.05- to 0.49-sq. mi, all of which fall below the 0.72 sq. mi. threshold to be reliably evaluated using USGS regression equations for this region. Initially, peak flow estimates were obtained by applying flow per unit area values from neighboring basins. Subsequent hydraulic analysis suggested that these flow estimates were unrealistically large in comparison to the size of the culverts and anecdotal reports of satisfactory flood conveyance. An alternate approach was therefore applied, whereby Tier 1 or Tier 2 fish passage designs were developed and the culvert hydraulic capacity was checked to ensure that flood conveyance equaled or exceeded existing conditions.

20.4 Hydraulic Design

Existing hydraulic capacity was calculated using Federal Highway Administration's or HY-8 culvert hydraulic analysis software.

Fish passage Tier 1 or Tier 2 based on recommendations and discussion with ADOT&PF and agency personnel. Tier 2 calculations utilized ADF&G's FISHPASS program for baffled and unbaffled pipes. Design fish were either adults or juvenile Coho or Cutthroat through prior discussion and agreement with ADOT&PF and Agency personnel. A

summary of design method and design fish for Tier 2 applications is included in the culvert summary shown in Appendix 22.4.

A new culvert that would meet fish passage criteria was identified and then resized if necessary to provide equal or greater conveyance capacity than the existing structure. Hydraulic analysis was completed using FHWA HY-8. A comparison of hydraulic capacity for the existing and proposed culverts at each site is presented in Appendix 22.5.3.

Four of the smaller fish pipes are recommended to be integrated with stream improvements during a later mitigation phase. These improvements will improve fish passage and aquatic habitat (e.g. spawning and rearing). At station 757+50 an additional benefit of channel modification will be improvement to stream process and recreational access along the side channel of the Chilkat River. Fish passage and hydraulics of these culverts will be revised at the mitigation phase to incorporate these stream enhancements.

A summary discussion of each site follows.

Station 252+00. Tier 2 no baffles
The existing pipe is a 24-inch CMP with a rusted bottom. Elevation is approximately 22-ft. Upstream and downstream conditions are described in the companion Stream and Habitat Inventory (S&HI) and summarized in the following paragraph. Fish passage is designed using Tier 2 methods given the relatively flat gradient and observed ability of fish to pass the existing culvert. FishPass analysis indicates that juvenile Coho are able to pass the existing culvert. Therefore, the culvert replacement can be of similar type and elevation as the existing culvert - hydraulic capacity would remain unchanged.

As stated in the S&HI:

> Catalog Number: 115-32-10250-2006
> Stream Name: Schnabel Creek
> Fish Use: Rearing coho, Dolly Varden and cutthroat
> Description: Based on observations and hand measurements, upstream of the culvert the stream is 1-2' wide and 1' deep. The stream banks are thickly vegetated with grasses that tend to grow over most of the stream surface. Substrate is organic matter over gravel. The stream runs along the toe of the Southeast Road builders' fill, crossing the access driveway at station 255+00 and then connecting to the artificial ponds near 256+00. The downstream end of the culvert is submerged in a small pool, with a 2-3' wide E type channel forming almost immediately at the outlet and meandering through the wetlands to connect to another stream. The outlet channel has a very low gradient, a silty bottom and low, vertical banks vegetated with marigolds, sedges and willows.

Station 263+50. Tier 2 no baffles
The existing pipe is a 24-inch CMP with a rusted bottom. Elevation is approximately 22-ft. Upstream and downstream conditions are described in the companion S&HI and

summarized in the following paragraph. Fish passage is designed using Tier 2 methods given the relatively flat gradient and observed ability of fish to pass the existing culvert. FishPass analysis indicates that juvenile Coho are able to pass the existing culvert. Therefore, the culvert replacement can be of similar type and elevation as the existing culvert - hydraulic capacity would remain unchanged.

As stated in the S&HI:

Catalog Number: 115-32-10250-2006-3003
Stream Name: none, listed as tributary to Schnabel Creek
Fish Use: Rearing coho, Dolly Varden and cutthroat
Description: Although the ADFG Catalog lists this stream as a tributary to Schnabel Creek, it is actually a separate system fed by a wetland and spring complex cut off from the upper reaches of Schnabel Creek by the driveway at station 259+25. Upstream of the culvert the inlet stream flows from both directions along the toe of the road embankment. Flow is dispersed through a broad wetland area with little in the way of a defined channel. Based on observations and hand measurements, depth is usually less than 0.5' over a saturated organic base. Downstream of the culvert outlet is a 10' by 15' pool, with a depth of 3'. The pool leads into a 2' wide, 1' deep silt bottomed channel that meanders through willow and alder root systems. This channel winds roughly parallel to the road, swinging tight to the existing embankment toe between 260+50 and 261+00.

Station 268+90. Tier 1

The existing pipe is a 36-inch CMP with a rusted bottom. Elevation is approximately 23-ft. Upstream and downstream conditions are described in the companion S&HI and summarized in the following paragraph. Fish passage is designed using Tier 1 methods given good upstream habitats which include wetlands. Based on hand measurements of the existing stream, the representative channel is approximately 2-ft wide. In order to incorporate stream substrate material to Tier 1 standards and provide equal or greater conveyance to what exists, a 4-ft diameter CMP will be required.

As stated in the S&HI:

Catalog Number: 115-32-10250-2008
Stream Name: Waterfall Creek
Fish Use: Rearing coho, Chinook and Dolly Varden. Coho Spawning
Description: The ADFG catalog lists this pipe as the primary conduit of Waterfall Creek. This is no longer the case. The culvert at station 271+40 now passes the majority of the flow that leads from the waterfall the creek is named for. Based on observations and hand measurements, upstream of the inlet there is a short, 2'wide, shallow stream segment leading into an emergent marsh. The stream substrate is organic matter over gravel. The outlet stream is a short, 2' wide, 0.7' deep section leading into the main stream that flows from the 271+40 culvert. The stream banks are well vegetated with grasses.

Station 271+40. Tier 1

The existing pipe is a 24-inch CMP with a rusted bottom. Elevation is approximately 22-ft. Upstream and downstream conditions are described in the companion S&HI and summarized in the following paragraph. Fish passage is designed using Tier 1 methods given excellent upstream habitats which include wetlands. Based on hand measurements of the existing stream the representative channel is approximately 3-ft wide. In order to incorporate stream substrate material to Tier 1 standards and provide equal or greater conveyance to what exists, a 3-ft diameter CMP will be required.

As stated in the S&HI:

Catalog Number: 115-32-10250-2008-3005
Stream Name: none listed, tributary to Waterfall Creek
Fish Use: Rearing coho, Dolly Varden, Chinook and cutthroat
Description: Upstream of the culvert the stream disperses immediately into thickly vegetated marsh in a broad remnant channel. Based on observations and hand measurements, there are a number of pools with depth of up to 3'. The pools are fed in part by a small mountain stream about 100' from the road. However, the majority of the flow comes from the stream and wetland complex that stretches ahead on line up to the waterfall near station 301+00. Downstream of the culvert the stream meanders along the road to station 269+00 before turning toward the river. The stream flows through a marsh in a defined channel, with the banks composed of thick vegetation. Substrate is organic; depth is 0.5 - 1'.

Station 316+00. Tier 2 baffles

The existing crossing is two 24-inch CMPs with rusted bottoms. Elevation is approximately 26-ft. Upstream and downstream conditions are described in the companion S&HI and summarized in the following paragraph. Of note, upstream of the culverts is a gravel lined pool that was excavated following heavy sedimentation during the November 2005 flood. The pool is approximately 15-ft by 35-ft, and presently bare of vegetation. A few redds were observed during the October field investigations, prior to the November 2005 flood, thus fish have been seen to utilize upstream habitats and passage is to be provided. Fish passage was designed by Tier 2 methods using FishPass given the poor quality of upstream habitats. The Tier 2 culvert was then analyzed for conveyance capacity using HY-8 to exceed existing conditions. A 4-ft diameter CMP is required with baffles to a height of 0.6-ft.

As stated in the S&HI:

Fish Use: Rearing coho, cutthroat, Chinook and Dolly Varden. Spawning redds present
Description: Upstream of the culvert there is a large, shallow, gravel bottomed pool excavated after the November 2005 flood. Based on observations and hand measurements, this pool is fed primarily by a 4' wide cascade that passes through a culvert in the adjacent driveway. Another mountain stream near station 317+00 provides another 10% of the flow. All fish habitat above the culvert has been scoured to gravel. Redds were present in this section in October 2005. This stream is used for

a small hydropower system. Downstream of the culvert is a 10' wide gravel bottomed plunge pool with redds present (October 2005) at the tailout. The stream then flows directly to the river in a 6-10' wide, rocky cascade channel, the lower end of which is influenced by the river backwater.

Station 337+70. Tier 2 no baffles

The existing pipe is a 24-inch CMP with rusted bottoms. Elevation is approximately 28-ft. Upstream and downstream conditions are described in the companion S&HI and summarized in the following paragraph. Of note, upstream of the culverts is a gravel lined pool that was excavated following heavy sedimentation during the November 2005 flood. The pool is approximately 10- by 30-ft, and presently bare of vegetation. Some habitat value was noted during the October field investigations, prior to the November 2005 flood, thus fish passage is to be provided. Fish passage was designed by Tier 2 methods using FishPass given the limited value of upstream habitats. The Tier 2 culvert was then analyzed for conveyance capacity using HY-8 to exceed existing conditions. A 3-ft diameter CMP is required to meet Tier 2 criteria using FishPass.

As stated in the S&HI:

Fish Use: Rearing coho and Dolly Varden below culvert outlet

Description: Based on observations and hand measurements, upstream of the culvert there is a 10' by 30' pool created by ditch cleaning activity in the spring of 2006. This shallow pool is fed by a stream cascading down the cut slope adjacent to the pool. The inlet stream averages 4' wide and 0.1' deep and is well defined further upstream. Downstream of the culvert is an 8' diameter plunge pool 1.5' deep. The culvert was not perched in late May of 2006. The stream meanders the 140' to the Chilkat River through an 8' wide, high banked channel. The channel banks are thickly vegetated with alder and cottonwood. The stream meanders within this channel, with width varying from 1-3', and depth 0.2' to 0.8'. It is composed of pools and riffles over gravel.

Station 405+00. Tier 1 or 2 pending decision on mitigation channel recommendation.

The existing pipe is a 36-inch CMP with rusted bottoms. Elevation is approximately 30-ft. Upstream of the culvert is an extensive wetland that could provide excellent rearing habitat. The outlet of the existing culvert is perched, discharging directly to the Chilkat River. Periodic fish passage is enabled when the Chilkat River levels are sufficiently high. The proposed replacement culvert is recommended to be integrated into a fish passage channel – recommended as mitigation and to be design during a later phase - to connect the pipe to the Chilkat River for a greater range of flows. The downstream passage channel will be developed during a mitigation phase to follow. A 4-ft diameter CMP is likely to be required.

As stated in the S&HI:

Catalog Number: 115-32-10250-2016

Stream Name: Lily Pad Creek

Fish Use: Rearing coho and Dolly Varden
Description: Based on observations and hand measurements, upstream of the culvert the first 50' of the stream consists of a 2' wide E type channel. The stream then disperses into a swamp and loses any defined channel. At the downstream end of the culvert the stream plunges directly onto a sandbar. There is an intermittent pool and shallow exit stream over the sandbar. Rearing fish access to the swamp is controlled by the river water level.

Station 443+00. Tier 2 baffles
The existing pipe is two 24-inch CMPs with rusted bottoms. Elevation is approximately 39-ft. Upstream and downstream conditions are described in the companion S&HI and summarized in the following paragraph. Of note, upstream of the culverts is a gravel lined pool at the toe of a steep cascade. Fish passage was designed by Tier 2 methods using FishPass given the poor quality of upstream habitats. The Tier 2 culvert was then analyzed for conveyance capacity using HY-8 to exceed existing conditions. A 3.5-ft diameter CMP is required with baffles to a height of 0.6-ft.

As stated in the S&HI:
Fish Use: Rearing coho, cutthroat, steelhead and Dolly Varden. Possible spawning
Description: Based on observations and hand measurements, upstream of the culverts there is a 20' diameter gravel lined pool fed by a quickly steepening, 3-5' wide, rocky cascade/step pool section of stream. The culverts empty into a 6-8' diameter plunge pool. The active culvert is perched 4-6". The stream below the outlet pool is composed of riffles interspersed with step pools and is 3-6' wide. Substrate is small rocks and gravel. Mature vegetation overhangs the stream.

Station 554+00. Tier 1
The existing pipe is a 24-inch CMP with a rusted bottom. Elevation is approximately 40-ft. Upstream of the culvert is 10-1/2 Mile Pond that could provide excellent rearing habitat. Fish passage is designed using Tier 1 methods given excellent upstream habitats. Based on hand measurements of existing stream the representative channel is approximately 2-ft wide. In order to incorporate stream substrate material to Tier 1 standards and provide equal or greater conveyance to what exists, a 3-ft diameter CMP will be required.

As stated in the S&HI:
Catalog Number:115-32-10250-2028-0010 (Pond is catalogued, stream not identified)
Stream Name: 10 1/2 Mile Pond, outlet stream
Fish Use: Coho and steelhead rearing
Description: Although this creek is not specifically shown on the ADF&G catalogue maps, it is directly connected to the 10 ½ Mile Pond. Based on observations and hand measurements, upstream of the culvert is a 15' stream that then disperses into the pond. The stream is 2-3' wide and 0.3'deep. Stream substrate is organic, and vegetation grows throughout. Below the culvert outlet the stream runs for 6' in a 2'

wide, 0.2’ deep channel, then disperses into a 10-20’ wide wetland full of grasses and willows. Flow in this wetland is visible, depth is 0.8 to 1.3’. There are some open water areas. This wetland continues along the road for about 175’, then becomes more channelized (3’ wide, 0.3’ deep) and turns away from the road. Near station 551+00 the stream broadens to 8-10’ wide. Many fish were noted to be present (June 2006).

Station 630+00. Tier 2
The existing pipe is a 24-inch CMP with a rusted bottom. Elevation is approximately 45-ft. The outlet of the existing culvert is perched, discharging directly to the Chilkat River. Periodic fish passage is enabled when the Chilkat River levels are sufficiently high. The existing pipe meets Tier 2 fish passage requirements when the tailwater is 0.6-ft or greater over the outlet invert. The proposed replacement culvert is recommended to be integrated into a fish passage channel – recommended as mitigation and to be design during a later phase - to maintain this tailwater requirement and to connect the pipe to the Chilkat River for a greater range of flows. The downstream passage channel will be developed during a mitigation phase to follow.

As stated in the S&HI:

Fish Use: Rearing cutthroat and Dolly Varden

Description: The flood of November 2005 directed approximately two-thirds of the flow from the waterfall at station 629+50 towards this culvert. The rest of the flow exits through the culvert at 612+50. Based on observations and hand measurements, above the culvert inlet the stream divides into a 6-8’ wide, 1-2’ riffle, pool, glide complex running through an established alder and birch forest. The stream substrate is silt and organics for the first 100’, then changes to recently deposited alluvial material. The culvert empties directly into the Chilkat River and is perched at low water.

Station 757+50. Options - Tier 1 or 2
The existing pipe is a 24-inch CMP with rusted bottoms. Elevation is approximately 57-ft. Upstream of the culvert is a pool and stream system that could provide excellent rearing habitat. The outlet of the existing culvert is perched, and discharges to a side channel of the Chilkat River surveyed by ADOT&PF or T-N to average about 8-ft wide – possibly a result of human disturbance. Based on preliminary methods either a 7’-4” by 5’4” pipe arch for Tier 1 design methods or 3-ft diameter CMP for Tier 2 design methods is likely to be required. This area is recommended for mitigation opportunities. The proposed replacement culvert will be integrated into a fish passage channel to connect the pipe to the Chilkat River for a greater range of flows. Design method and size of pipe will be integrated with the mitigation channel to be completed at a later phase.

As stated in the S&HI:

Fish Use: Rearing coho, Chinook and Dolly Varden

Description: Based on observations and hand measurements, upstream of the culvert there is a small waterfall fed pool that extends about 50’ back on line. The stream

branch leading to north is 5-8' wide and 0.3' deep for the first 35', where the main flow enters as a waterfall. This 35' riffle section is shallow, littered with organic debris, and has a gravel substrate. The water extends in a roadside ditch up to station 759+00 where there is another small waterfall. This reach is an 8' wide, 0.8' deep pool. Standing water with little flow extends another 100' ahead on line. Fish are present throughout. Downstream, the perched culvert empties into a silty channel backwatered by the river. Grass grows on the banks above the river level, but bare silt is exposed lower down. There is no cover. The river gravel bars near the outlet are actively used for spawning.

Station 787+50. Tier 2 baffles
The existing pipe is one 36-inch CMP with rusted bottoms. Elevation is approximately 56-ft. Upstream and downstream conditions are described in the companion S&HI and summarized in the following paragraph. Of note, upstream of the culverts is small stream that drains from the hill side. The outlet of the pipe is perched to a side channel of the Chilkat River and may require a fish passage channel constructed as mitigation to gain access to the pipe during low stage. Fish passage was designed by Tier 2 methods using FishPass given the poor quality of upstream habitats. The Tier 2 culvert was then analyzed for conveyance capacity using HY-8 to exceed existing conditions. A 3.5-ft diameter CMP is required with baffles to a height of 0.6-ft.

As stated in the S&HI:

Fish Use: Rearing coho, Chinook and Dolly Varden
Description: Based on observations and hand measurements, upstream of the culvert there is a small waterfall fed pool that extends about 50' back on line. The stream branch leading to north is 5-8' wide and 0.3' deep for the first 35', where the main flow enters as a waterfall. This 35' riffle section is shallow, littered with organic debris, and has a gravel substrate. The water extends in a roadside ditch up to station 759+00 where there is another small waterfall. This reach is an 8' wide, 0.8' deep pool. Standing water with little flow extends another 100' ahead on line. Fish are present throughout. Downstream, the perched culvert empties into a silty channel backwatered by the river. Grass grows on the banks above the river level, but bare silt is exposed lower down. There is no cover. The river gravel bars near the outlet are actively used for spawning.

20.5 23 CFR

There is no known FEMA Flood Insurance Study for any of these existing culverts. The proposed action for each site includes replacement with a culvert that provides fish passage to Tier 1 or Tier 2 requirements and has flow capacity equal to or greater than the existing pipe.

Risks of the proposed culverts are considered less than the existing structures. There is a reduction in upstream backwater effects and more efficient conveyance of flows through the pipes. There is less likelihood of sediment or debris blocking the culverts.

20.6 Conclusion

The hydraulic features of the proposed action are developed to a preliminary level at this phase in support of the Preliminary Engineering Report. Design will be completed for submittal with Plans-in-Hand. The proposed culverts were designed for fish passage using the Tier 1 or Tier 2 method based on prior discussion and agreement with ADOT&PF and agency personnel. This provides favorable continuity of stream processes and passage of fish through the culvert from adjacent stream reaches. The proposed culverts will meet or exceed the conveyance of existing structures. The proposed culverts are not expected to impact the flood plain or environment.

The hydraulic summary for the proposed culvert are presented in Appendix 22.5.3.

20.7 Riprap

The culverts were designed using Tier 1 or Tier 2 stream simulation to maintain continuity of flow of water and sediment. Each culvert was designed to provide equal or greater flood capacity than currently exists. At this preliminary phase, the reduction in flow restriction is assumed to reduce any scour potential that may exist. Therefore, no riprap is proposed at this time.

21. References:

Alaska Department of Fish and Game and Alaska Department of Transportation and Public Facilities. 2001. *Memorandum of Agreement between the Alaska Department of Fish and Game and the Alaska Department of Transportation and Public Facilities for the Design Permitting and Construction of Culverts for Fish Passage*.

Behlke, C. et. al., 1991. FISHPASS culvert design sofware.

Behlke, C. et. al., 1991. Fundamentals of Culvert Design for Passage of Weak-Swimming Fish. FHWA-AK-RD-90-10.

Alaska Department of Transportation and Public Facilities. 1995. *Alaska Highway Drainage Manual*.

Alaska Department of Transportation and Public Facilities. 2003. *Alaska Highway Preconstruction Manual*.

Arcement, G. J. and V. R. Schneider. 1989. Guide for Selecting Manning's Roughness Coefficients for Natural Channels and Flood Plaines. U.S. Geological Survey Water-Supply Paper 2339.

American Iron and Steel Institute. 1983. Handbook of Steel Drainage & Highway Construction Products, third ed.

Big R Manufacturing LLC. Corrugated Steel Pipe (brochure). www.bigrmfg.com

Curran, J.H., Meyer, D.F., Tasker, G.D., 2003, Estimating the Magnitude and Frequency of Peak Streamflows for Ungaged Sites on Streams in Alaska and Conterminous Basins in Canada: U.S. Geological Survey Water-Resources Investigations Report 03-4188

Federal Highways Administration (FHWA), 1989. HEC-11, Design of Riprap Revetment. FHWA-IP-89-016

FHWA, 1988. HEC-15, Design of Roadside Channels with Flexible Linings. FHWA-IP-87-7

FHWA, HY-8, Culvert analysis, version 6.1.

Hansen, Scott Borough of Haines email communication

Ingledue, Roger, personal communication, October 2005

Inter-Fluve, Inc. July 2006. Haines Highway MP 3.5-25.3, Stream and Habitat Inventory.

Inter-Fluve, Inc. 1999. Guidelines for Bank Stabilization on the Mendenhall River. ADF&G. Habitat Restoration Division, Technical Report 99-3.

Jones, S.H. and Fahl, C.B., 1994, Magnitude and frequency of floods in Alaska and conterminous basins of Canada: U.S. Geological Survey Water-Resources Investigations Report 93-4179.

Maynord, Stephen T., August 1996. "Toe-scour estimation in stabilized bendways". J of Hydraulic Engineering, pg 460-464

NOAA National Ocean Service, Center for Operational Oceanographic Products and Services (tidal data) http://www.co-ops.nos.noaa.gov/benchmarks/9452421.html

Post, Austin and Larry Mayo. 1971. "Glacier Dammed Lakes and Outburst Floods in Alaska". Department of the Interior United States Geological Survey Hydrologic Investigations Atlas HA-455.

Interagency Advisory Committee on Water Data (IACW). 1982. Guidelines for determining flood flow frequency: Bulletin 17B of the Hydrology Subcommittee. Office of Water Data Coordination. U.S. Geological Survey. Reston, Virginia, 183 p.

Natural Resources Conservation Service (NRCS). 1979. Digitized version of the Exploratory Soil Survey of Alaska; STATSGO Publication. U.S. Dept of Agriculture – NRCS. Fort Worth, TX.

Soil Conservation Service (SCS). 1984. Natural Resources Conservation Service (formerly the Soil Conservation Service) Engineering Field Handbook – Chapter 2: Estimating Runoff and Peak Discharges. US Dept of Agriculture – NRCS.

U.S. Army Corps of Engineer's HEC-RAS version 3.1.2, 2004

USGS gage data http://nwis.waterdata.usgs.gov/ak/nwis/sw

22. Appendices:

22.1 Culvert Inventory Table

Insert 5-page (landscape) excel culvert table: “App .1 - rapid assessment table.pdf”

22.2 Hydrology - Table of flow estimates for tributary basins.

Flow estimates include those obtained by: 1) USGS regional regression equations, 2) SCS Unit Hydrograph Method, and 3) the Rational Method. The estimates from the USGS regional regression estimates are the recommended flow estimates for flood conveyance and fish passage design assessments.

	Culvert Station										
Return Period	**245+00** (0.47mi^2)	**342+00** (0.6 mi^2)	**347+50** (1.23mi^2)	**506+00** (1.07 mi^2)	**535+00** (1.46 mi^2)	**612+00** (0.65 mi^2)	**670+00** (1.75 mi^2)	**733+50** 92.26 mi^2)	**887+90** (0.8 mi^2)	**921+00** (1.55 mi^2)	**1129+00** (1.26 mi^2)
2-Year											
Regional Regression	42	50	92	76	73	52	96	125	55	95	73
SCS Unit Hydrograph Method	119	141	304	333	397	196	471	637	294	558	496
Rational Method	37	48	98	86	117	52	140	181	64	124	101
5-Year											
Regional Regression	64	75	137	113	107	78	142	186	82	141	109
SCS Unit Hydrograph Method	250	295	628	603	714	358	851	1,137	451	857	693
Rational Method	47	60	124	108	147	66	177	228	81	156	127
10-Year											
Regional Regression	79	93	169	139	130	96	174	228	101	175	135
SCS Unit Hydrograph Method	274	323	689	670	793	398	946	1,263	531	1,009	817
Rational Method	56	71	147	129	175	78	210	272	96	186	152
25-Year											
Regional Regression	99	117	212	175	166	121	220	288	127	219	170
SCS Unit Hydrograph Method	357	422	898	905	1,070	537	1,276	1,704	677	1,286	1,041
Rational Method	64	82	169	147	201	90	241	312	110	213	174
50-Year											
Regional Regression	114	135	246	203	193	140	255	334	148	255	198
SCS Unit Hydrograph Method	429	507	1,079	1,003	1,187	596	1,416	1,890	760	1,445	1,169
Rational Method	69	88	180	158	215	96	258	333	118	228	186
100-Year											
Regional Regression	130	154	280	232	220	160	291	381	169	291	227
SCS Unit Hydrograph Method	471	556	1,183	1,120	1,325	665	1,580	2,109	833	1,583	1,281
Rational Method	74	95	196	171	234	104	280	362	128	247	202

22.3 Drawings

Insert twelve drawings of culvert

22.4 Culvert Summary

Insert excel file: “App.4 - culvert recommendation summary.pdf”
One 11x17 sheet with culvert summary info

22.5 Hydraulic Output

22.5.1 Hydraulic Output – Chilkat River

Insert PDF file: App.5a - Hydraulics Chilkat HEC-RAS.pdf

22.5.2 Hydraulic Output – Tributaries

Conversion from relative datum: As described in Section 3.2 cursory survey was collected as part of Inter-Fluve's October 2005 field investigations. These survey data were used for the preliminary HEC-RAS hydraulic modeling shown in this appendix. Approximate conversions to ADOT&PF datum was obtained by comparing elevations of features at each site surveyed by Inter-Fluve and ADOT&PF or Toner-Nordling. The approximate datum conversion is noted below. Subtract the elevation difference noted in the table from the Inter-Fluve survey and models for stations noted in the table to obtain approximate ADOT&PF elevations. Elevations for culverts not noted in the table are based on ADOT&PF datum. Design level survey of stream cross sections, topography, bathymetry and profiles – based on ADOT&PF project datum - will be required at all culverts to finalize designs for submittal at Plans-in-Hand.

Culvert	Datum conversion elevation difference (IFI interim datum) – (elevation difference) ~ (ADOT&PF datum)
245+50	74.42-ft
342+00	68.83-ft
347+50	69.17-ft
506+25	57.63-ft
535+25	57.88-ft

Insert PDF file: App.5b - Hydraulics tributaries HEC-RAS.pdf

22.5.3 Hydraulic Output – Small Fish Pipes

Insert PDF file: App.5c - Hydraulics small fish pipes.pdf