Little Tonsina & Alyeska Access Road
MP 74.2 Richardson Highway
Culvert Replacement Assessment

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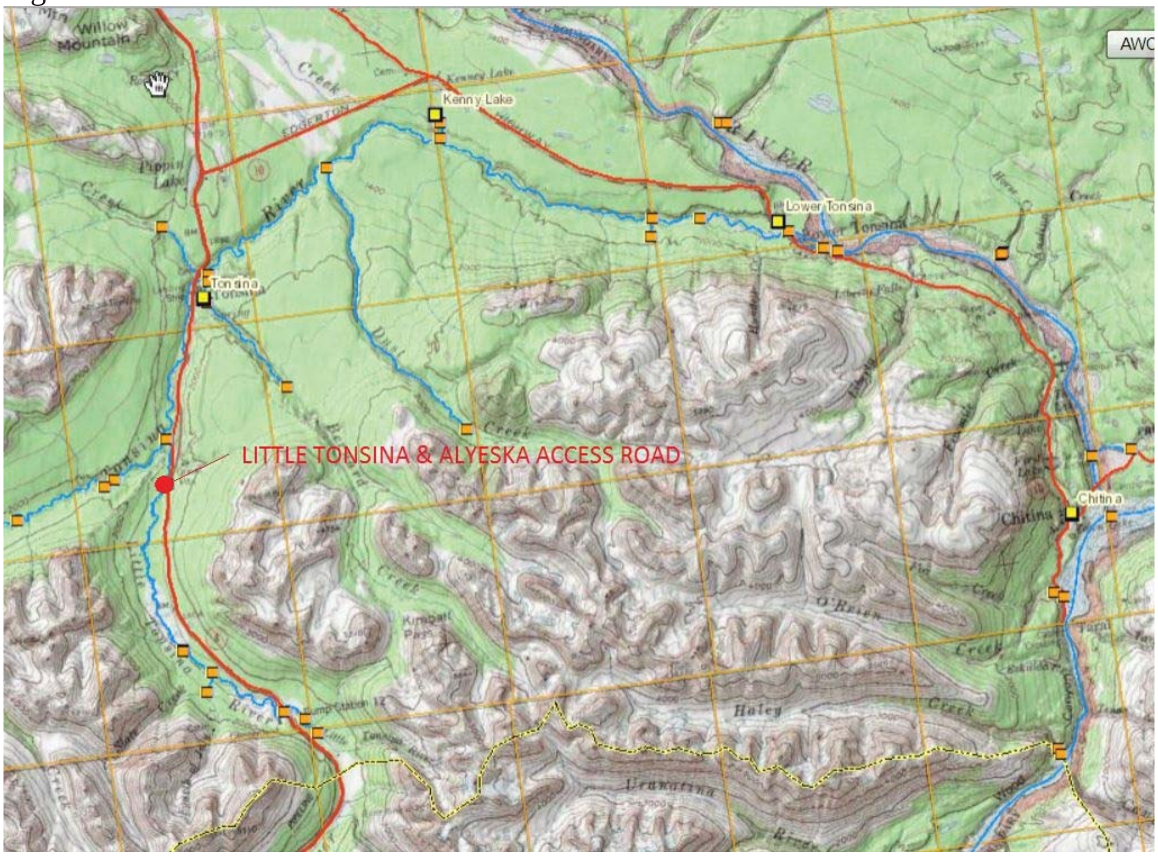
1.0 INTRODUCTION

This assessment evaluates the hydrology, design and specifications for a culvert replacement for the Little Tonsina and Alyeska Access road crossing near mile point 74 of the Richardson Highway in Alaska for fish passage and flood flow. Figure 1 shows the location of the culvert.

Figure 1. Culvert location



1.1 Problem Description

The Little Tonsina is an anadromous river near Tonsina, Alaska. The Little Tonsina flows into the main fork of the Tonsina which is a tributary of the Copper River. The Copper River outlets into Prince William Sound near Cordova, Alaska. The crossing is comprised of two seven foot tall by eleven foot wide CMP squashed arch culverts. The culverts have been determined to be a likely fish passage barrier by the ADF&G for excessive gradient, constriction ratio, and outlet and inlet perch.

1.2 Objectives

The objectives of the project are to:

- Create viable fish passage for salmonid species at the crossing
- Create better flood passage
- Form a more natural stream

1.3 Project Constraints

The project area is relatively constrained by topography and road alignment. The crossing is just a few hundred feet off of the paved Richardson Highway. The crossing is a gravel road and the alignment and elevation of this road could be modified. Currently, it is a difficult grade and tight radius. The road is used by the Alyeska Pipeline Corporation to access the pipeline, by ADOT to access a gravel pit, and by homeowners in the area. From aerial photos, it appears prior to construction of the highway the confluence of the Little Tonsina with the main fork of the Tonsina was 1.5 miles to the north. The original highway construction likely cut off about 1 mile of river length, straightening the river and causing a headcut to travel upstream. Although evidence of this headcut was observed, the river gradient appears to have adjusted at this time and is not continuing to incise. Removal of the culvert may allow additional headcut to happen in the future and should be considered in the design.

Utilities:
No utility locates were completed.

Ownership:
The culvert is on an Alaska DOT owned right of way (ROW). Outside of the ROW, the land is owned by Chugach Native Corporation.

Local Design Guidelines or Requirements:
The minimum design requirements for this crossing would be the ADF&G and ADOT MOA dated August 3, 2001. In addition to meeting the MOA requirements, the USFWS recommends the attached guidelines be used to design this crossing because of the high ecological value of this river (see appendix A).

Flood Hazards or Floodplain Management Requirements:
Flood hazards will need to be evaluated as part of the final project design. The goal of this culvert replacement is to significantly increase the conveyance and reduce flood hazards.

Geotechnical:
Geotechnical investigations were not performed as part of this assessment.

Salvage:
The existing culverts will be removed and are unlikely to be salvageable. There is a section of old culvert 600 feet downstream in the river that should be removed as part of this project.

2.0 CULVERT ANALYSIS

The existing and new culvert was designed by analyzing hydraulic capacity with an HY-8 model of the crossing and a reference reach was identified to assist in sizing the culvert and channel. While the stream simulation method does not require a low or high fish passage flow analysis, a 55mm coho salmon is the design fish for this site.

2.1 Culvert Characterization

The current culvert was evaluated based on field measurements and a survey performed by USFWS in September, 2017. Table 1 shows the existing culvert details.

Table 1. Existing Culvert Characterization

Culvert	Lat/Long	Diameter (ft)	Slope (%)	Length (ft)
Little Tonsina River @ Alyeska Access Road	**Lat: 61.59437, Long: -145.22308**	(2) 7'x11' Squashed Arch CMP Culverts	Left= .9% Right =2.18%	Left =39' Right=45.6'

2.2 Hydrologic Analysis

Table 2 shows results of the hydrologic analysis. Table 3 shows the reference reach stream characteristics for the design effort. The full hydrologic analysis and discussion is attached in Appendix B.

Table 2. Peak Flood Flows

Return interval (yrs)	Peak Flow (cfs)
2	1,030
5	1,590
10	2,000
25	2,550
50	2,970
100	**3,410**
200	3,850

Table 3. Reference Reach Stream Characterization

Stream	Slope (%)	Bankfull Width (ft)	Bankfull Mean Depth (ft)	Comments
Little Tonsina at Alyeska Access Road	.6%	45 ft.	3.06 ft.	Rosgen C4 Stream type Q(BKF) = 551 cfs

Fish passage design is based on a reference riffle cross section surveyed 750 feet upstream of the culvert. The cross section was part of the 1600 feet long culvert profile. The cross section was selected in a riffle in a straight, stable, single channel section of the creek. The historic channelization and headcut in this section of the stream has likely resulted in a higher width/depth ratio than the pre-impact channel. One mile upstream of the channelization, this stream changes to an E4 stream type which would have a lower width to depth ratio. Slope, bankfull width and depth, and substrate were captured at the reference cross section. Information obtained is found in Appendix C.

Figure 2 and 3 show the existing stream, culvert and road profile and section at 100 year flood flows; flows overtop the road.

Figure 2. Existing Culvert Profile

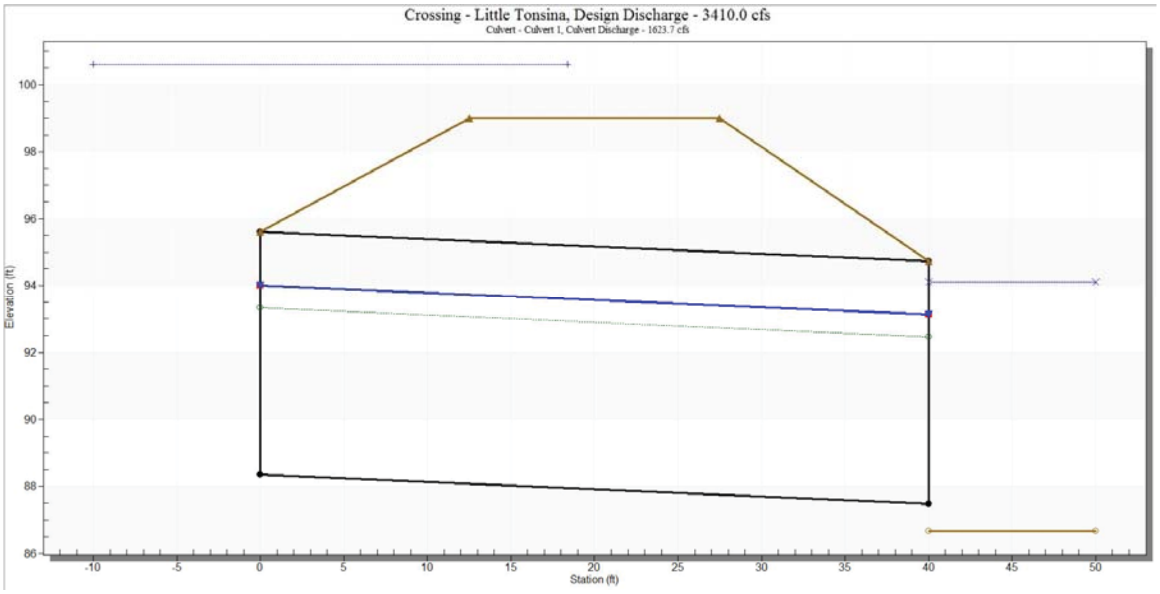
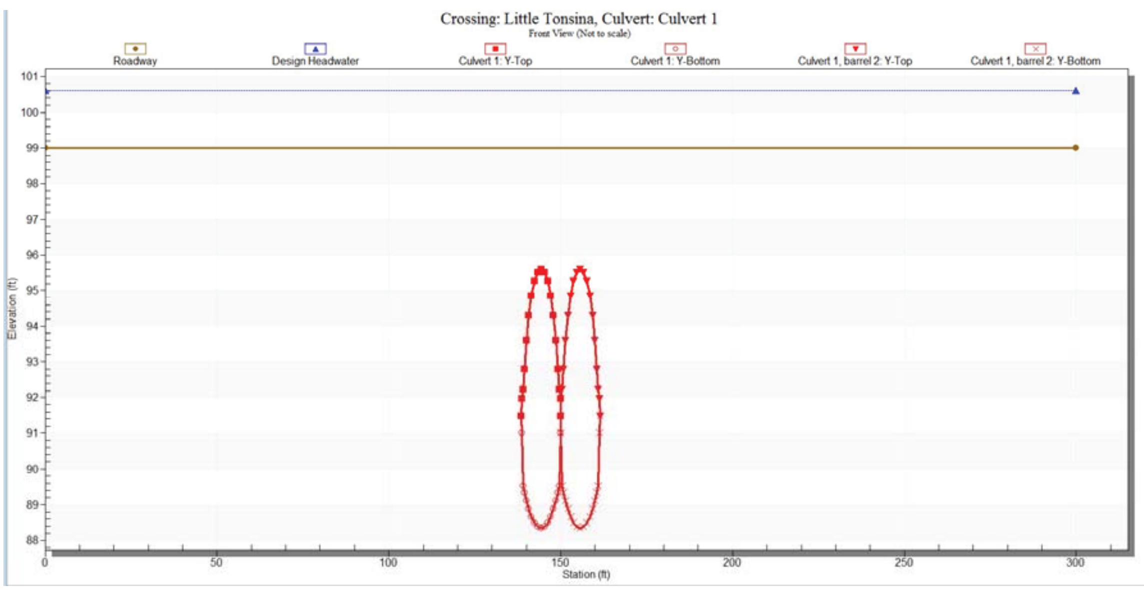


Figure 3. Existing Culvert Section



3.0 NEW CROSSING DESIGN

Two configurations of new crossings were examined to accommodate the 100-year flow event and maximize fish passage, based on an HY-8 analysis and the USFS stream simulation method. An 85 foot span x 16 foot wide bridge is recommended for this crossing.

It is also possible to adequately pass the flood flows at this crossing with a 35’-4” span by 20 foot rise high profile arch with a10 foot diameter overflow culvert. However, this culvert configuration requires the road elevation to be raised 6 feet at the crossing; this makes a culvert likely more expensive than a bridge. The culvert configuration is not as optimal for fish passage as the bridge so it was not selected for this crossing.

The parameters for the recommended crossing configuration are listed in Table 4 and the profile and cross section are shown in Figures 3 and 4. The road would be raised three to four feet under this crossing configuration depending on the bridge girder depth.

Table 4. Recommended New Crossing Dimensions

Crossing	Size	Slope (%)	HW/D Ratio @ Q100
Little Tonsina River @ Alyeska Access Road	85' span x 16' wide bridge	.67	.8 (2.5 feet freeboard)

Figure 3. Proposed Profile – Bridge

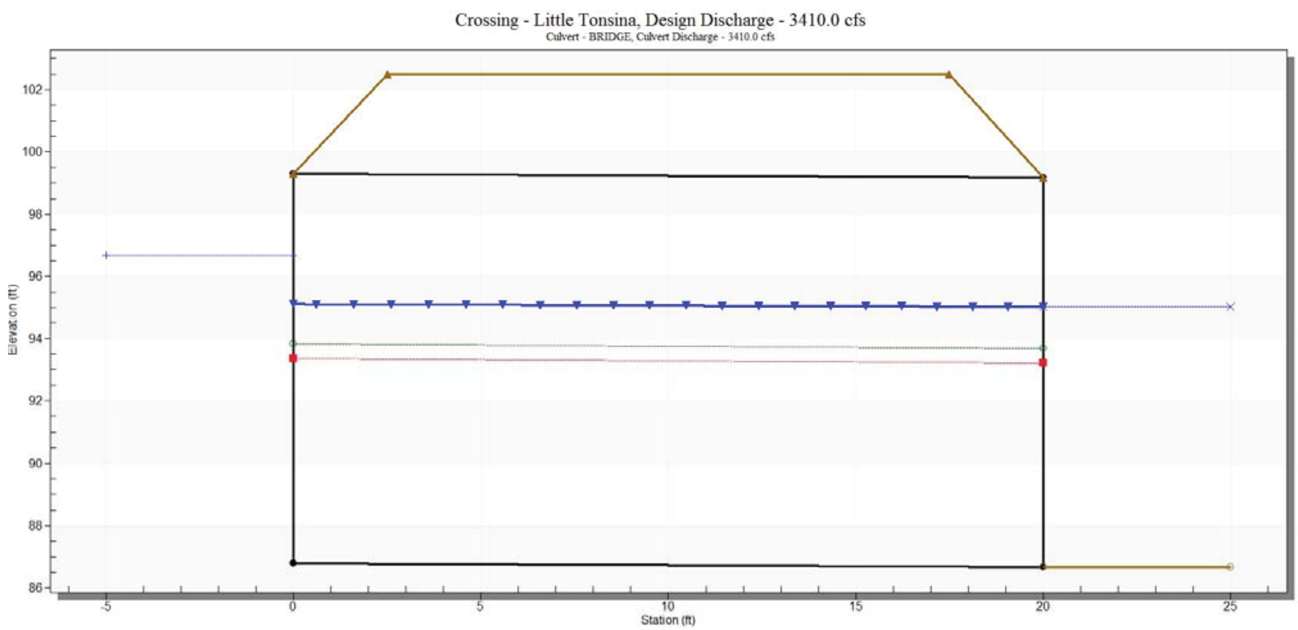
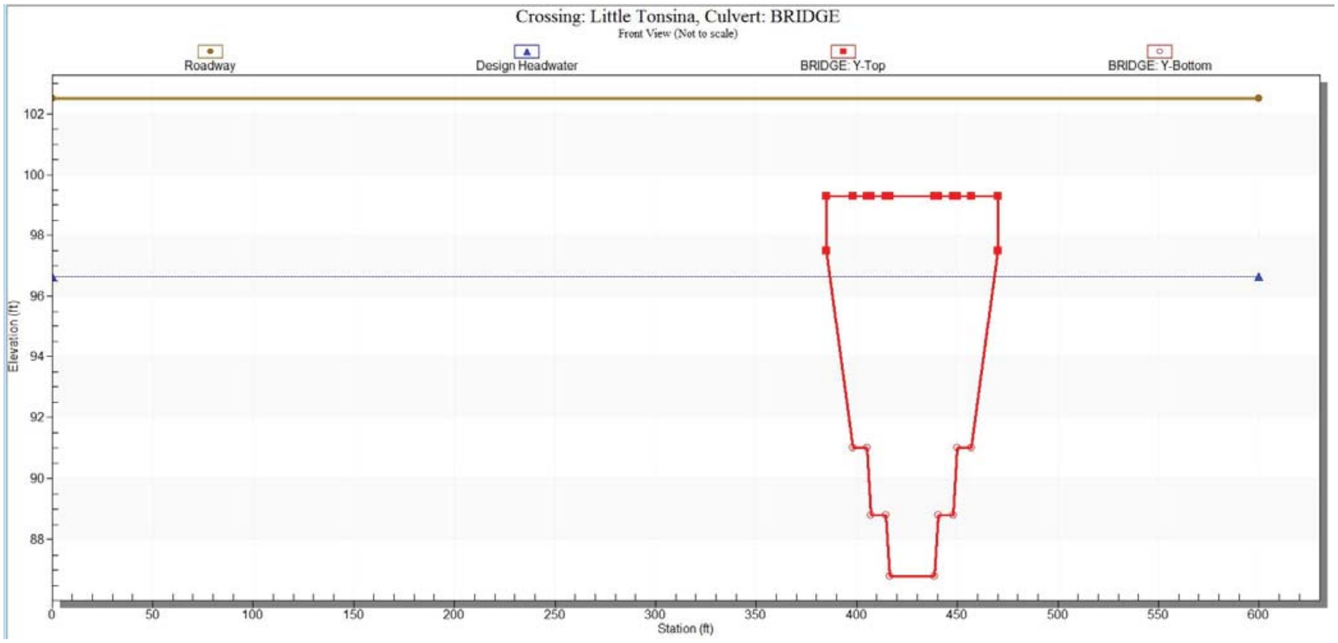


Figure 4. Proposed Cross Section – Bridge



A conceptual layout of the new bridge and road is shown in Appendix D. The new layout would allow for construction of the bridge adjacent and just downstream of the existing crossing. A new ROW will likely be required for this alignment and the overhead utilities will need to be realigned.

A geotechnical investigation will be needed for foundation design of the bridge at this site. In addition, utility locates and full topographic survey will need to be completed prior to further design work. Conceptually, a typical pipeline road bridge as shown in Figure 5 could work at this site.

Figure 5. Existing 85'Span Pipeline Road Bridge over the Little Tonsina

4.0 References

Stream Simulation: An Ecological Approach to Providing Passage for Aquatic Organisms at Road-Stream Crossings, U.S. Department of Agriculture Forest Service National Technology and Development Program; 7700—Transportation Management; 0877 1801—SDTDC; May 2008

U.S. Fish and Wildlife Service

DESIGN GUIDELINES FOR STREAM CROSSINGS

It is the USFWS mission to work with others to conserve, protect and enhance fish, wildlife, and plants and their habitats for the continuing benefit of the American people. The Service strives to maintain riparian connectivity and the Service's Ecological Services and Habitat Restoration Branches work with project sponsors to identify project alternatives that avoid and minimize impacts to aquatic and riparian habitats.

The purpose of this document is to share current Best Management Practices for fish passage crossing design in the state of Alaska. The Fish Passage Memorandum of Agreement (MOA) between Alaska Department of Fish and Game and Alaska Department of Transportation & Public Facilities is often used as the default design criteria however, the MOA was signed in 2001 and the MOA design criteria are now over 15 years old. In the intervening years, the Kenai Peninsula Borough, Municipality of Anchorage, and Mat-Su Borough have all passed ordinances that require crossing structures to have 100-yr flood capacity and the latter two require stream simulation as the primary design criteria for fish passage crossings. These boroughs have adopted a policy of no new barriers or road failures due to flooding. Stream simulation designed crossings have shown to provide better flood and debris conveyance, and fish passage than traditional hydraulically *designed crossings. The USFWS supports stream simulation as the primary crossing design method in most cases with the criteria provided below.*

Applying To All Crossings

1. Stream crossing structures should be designed, constructed, and maintained so as to provide for the full hydrologic functioning of the water body they are crossing.

2. All stream crossing structures in alluvial systems should be designed using the stream simulation method to the greatest extent possible.[1] In instances where stream gradient exceed 6% or site specific conditions do not allow complete stream simulation design, then a hybrid of stream simulation and hydraulic methods can be applied. Stream simulation means that the crossing is designed using reference data from a representative section (reference reach) of the specific water body being crossed. Stream simulation is a crossing design technique that attempts to replicate the natural stream channel conditions found upstream and downstream of the crossing. Sediment transport, flood and debris conveyance, and fish passage function as they do in the natural channel if designed correctly. Stream simulation uses bankfull channel dimensions to size the crossing structure and channel.

   If there are no suitable reference reaches on the specific body of water being crossed, a reference reach may be chosen from another water body with similar geomorphic and hydrologic characteristics. The reference reach characteristics should meet the following criteria in comparison to the water body being crossed:
   - The reference reach bankfull width should be at least one half and no more than two times the water body being crossed
   - The reference reach bankfull discharge should be at least one half and no more than one and one half times the bankfull discharge of the water body being crossed
   - The stream order of the reference reach should be within one stream order of the water body being crossed

   The crossing design channel width, area and other features shall be scaled to the reference reach using ratios to the bankfull conditions.

3. Reference data shall include at a minimum: channel width at bankfull, bankfull cross-sectional area, gradient, substrate grain sizekey pieces, stream type, bankfull average depth, flood prone width, stream order, and watershed area. The reference reach bankfull dimensions should be determined in the field by surveying a detailed cross section at the upper 1/3 of a representative riffle. Bankfull dimensions should not be calculated hydraulically from a hydrology flow estimate.

4. Under normal flow conditions, the channel in the crossing structure shall not substantially differ from the reference reach condition in regards to the channel width at bankfull, bankfull cross-sectional area, gradient, substrate grain size, key pieces, stream type, and bankfull average depth.

5. The width of the primary crossing structure shall not be less than 1.0 times the bankfull width. Culverts shall have a minimum diameter of four feet (4’);

6. Crossing structures shall not interfere with the functioning of floodplains and shall be designed to accommodate at least the 100-year flood flow. If the crossing structure is not designed to accommodate the one hundred-year flow, a route must be established to safely convey flows exceeding the design flow without causing damage to property, endangering human life or public health, or causing significant environmental damage. In cases of crossings within high entrenchment ratio environments (flood prone width/Bankfull width >2) then floodplain overflow culverts may be beneficial to floodplain connectivity and can be used to pass the Q100, but minimum width requirements for the primary culvert still apply.

7. Crossing structures shall maintain the connectivity of wetlands adjacent to stream channels. Additional floodplain culverts may be required to minimize alteration of wetland hydrology upstream and downstream of the crossing.

8. Crossing structures should be placed within/over the pre-existing channel alignment when possible. Road alignment should be as close to perpendicular to the channel as possible.

9. Substrate material within/under the crossing structure shall remain dynamically stable at all flood discharges up to and including a 50-year flood. Dynamic stability means that substrate material mobilized at higher flows will be replace by bed material from the natural channel upstream of the crossing at the same flow. For culverted crossings without an adequate upstream sediment supply, the substrate material within the crossing shall be designed to resist the predicted critical shear forces up to the 100 year flood. For culverts in sand bed channels sediment retention sills may be used if necessary. For culverts with slopes 6% or greater steps and cascade features should be sized and keyed in so not to move, but if necessary sills can be used to keep footer rock in place.

10. Substrate material within/under the crossing structure shall incorporate a low flow channel. The low flow channel should mimic the reference reach where possible. If the low flow channel dimensions are not discernable from the reference reach, the low flow channel should have a cross section sectional area of 15-30% of the bankfull cross sectional area and a minimum depth of four inches (4”) for small streams up to twelve inches (12”) for larger streams. The low flow channel should be defined by rock features that will resist critical shear forces up to the 100 year flood;

11. Streambank are recommended inside of culverts to protect the culvert from abrasion, provide resting areas for fish, and provide for small mammal crossing at low flows. If streambanks are constructed through a crossing, the streambanks shall be constructed of rock substrate designed to be stable at the 100 year flood. The streambank width shall be a minimum of 2.0 times the maximum sieve size of the streambed material (D100). The crossing width shall be increased to allow for the channel width plus the streambanks;

Additional Practices Applying To Culvert Crossings

12. Round culvert pipes shall have a minimum invert burial depth of forty percent (40%) of the culvert diameter into the substrate and. Arch culvert pipes (i.e., “squash” pipes), shall have a minimum invert burial depth of twenty percent (20%) of the culvert’s rise into the substrate, unless vertical adjustment potential (VAP) analysis shows less fill is acceptable.

13. The gradation of the substrate material within a culvert shall be designed to be a dense, well graded mixture with adequate fines to ensure that the majority of the stream flows on the surface and the minimum water depth is maintained;

14. If substrate retention sills must be used, they shall have a maximum weir height of one half (0.5) of the culvert invert burial depth (i.e. 20% of diameter for round pipes and 10% of rise for arch pipes). Substrate retention sills shall be spaced so that the maximum drop between weirs is four inches (4”). The use of sills without substrate is not allowed;

15. Culvert pipes and arches shall be constructed of metal. The use of smooth wall culverts is prohibited. The use of trash racks or debris interceptors is prohibited;

16. Culvert slope shall be within 25% of the natural stream slope of the selected reference reach. For example, if a reference reach is 1.0% slope, the minimum design slope of the stream simulation culvert would be .75% and the maximum design slope would be 1.25%.

DEFINITIONS

100-Year Flood Flow: The stream discharge that has a reoccurrence interval of 100 years, or a 1 in 100 chance of occurring in a given year.

Bankfull Cross sectional Area: The sum of products of unit width and depth at the bankfull stage elevation in a riffle cross section.

Bankfull discharge: A frequently occurring peak flow whose stage represents the incipient point of flooding. It is often associated with a return period of 1-2 years, with an average of 1.5 years.

Bankfull width: The surface width of the stream measured at the bankfull stage.

Flood-prone Area: The area adjacent to the watercourse constructed by the watercourse in the present climate and inundated during periods of high flow. The flood-prone width is the width of the flood plain at an elevation two times (2X) the bankfull depth.

Ordinary High Water Mark (OHWM): The mark along the bank or shore up to which the presence and action of tidal or non-tidal water are so common and usual, and so long continued in all ordinary years, as to leave a natural line impressed on the bank or shore and indicated by erosion, shelving, changes in soil characteristics, destruction of terrestrial vegetation, or other distinctive physical characteristics.

Reference Reach: A portion of a stream that represents a stable channel (dimension, pattern, profile) within the geomorphic context that exists in that segment and can represent a natural or a stable, modified condition.

Slope ratio: The ration of the culvert bed slope to the upstream reach or reference reach channel slope.

Substrate Grain Size: A particle size distribution based on a particle count taken in the reference reach of at least 100 particles. Refer to Bunte and Abt (2001) for recommended sampling methods.[2]

REFERENCES

[1] U.S. Forest Service. 2008. Stream Simulation: An Ecological Approach to Providing Passage for Aquatic Organisms at Road-Stream Crossings. https://www.fs.fed.us/biology/nsaec/fishxing/aop_pdfs.html

[2] Bunte, K.; Abt, S. R. 2001. Sampling surface and subsurface particle-size distributions in wadable gravel-and cobble-bed streams for analyses in sediment transport, hydraulics, and streambed monitoring. Gen. Tech. Rep. RMRS-GTR-74. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station. 428 p.

HYDROLOGY ASSESEMENT for Little Tonsina River at Alyeska Pipeline Access Road
Franklin Dekker – USFWS, 10/31/2017

Summary
Several regression equations and gaged stream discharge per unit area methods were applied to the Little Tonsina River at Alyeska Pipeline Access Road watershed to determine the ideal flood frequency estimate. The 2016 and 2003 regression equations show relative close agreement (within 8%) for the Little Tonsina design Q100. However, based on nearby gaged streams the 2016 regression equation likely overestimates Q100, possibly by 43% (Tonsina River gage overestimate was 43%). Also discharge per unit area methods from two gages that have partial coverage of the design watershed, the Tonsina River at Tonsina (#15208000) and the Little Tonsina near Tonsina (#15207800) both suggest that the 2016 regression Q100 estimate is larger than the true Q100. Unfortunately, the proportion of watershed areas shared by the design watershed and the gages is less than 50% so there is poor confidence in using an estimation method that weights gage and regression estimates. **The 2016 regression method is recommended for the design discharge (Q100=3,410 cfs & 40% Q2=412), but the 2016 regression equation estimate for the Tonsina River gage, discharge per area methods, and the bankfull discharge all indicate that the 2016 regression estimate could be safely adjusted down by up to 30%.**

Regression Equation Inputs
2003 Equation: Region 6
Area: 85.49 mi^2
Precipitation: 24.5 in (PRISM, Gibson 2009)
Percent Forest: 44.9%
Percent lakes: 0.1%

Regression Equation Performance
The 2003 and 2016 regional regression equations estimates have similar magnitudes for the Little Tonsina River, both are within 270cfs or 8% for the 2016 Q100. Another check for the regional regression equations is the performance of the equation at nearby gaged streams. The closest gages with peak flow records used in regional regression equations are Tonsina River at Tonsina (#15208000) and Squirrel Creek at Tonsina (#15208100). The 2016 regression equation results for these two gages overestimated the Q100 discharge by 43% for the Tonsina River and 91% for Squirrel Creek. However, two other gaged streams Stuart (#15213400) and Boulder (#15212500) Creeks to the south of the Little Tonsina watershed were both within 15% of the gage Q100 (Figure 1). Within this subset of gaged systems there is a trend of increasing overestimation of Q100 with decreasing average annual precipitation, however this relationship breaks down if slightly more distant gages are included. The regression equations likely overestimates Q100 at Little Tonsina, especially given the result of discharge per area methods shown below, but the Stuart and Boulder Creek gages reduce confidence in that conclusion.

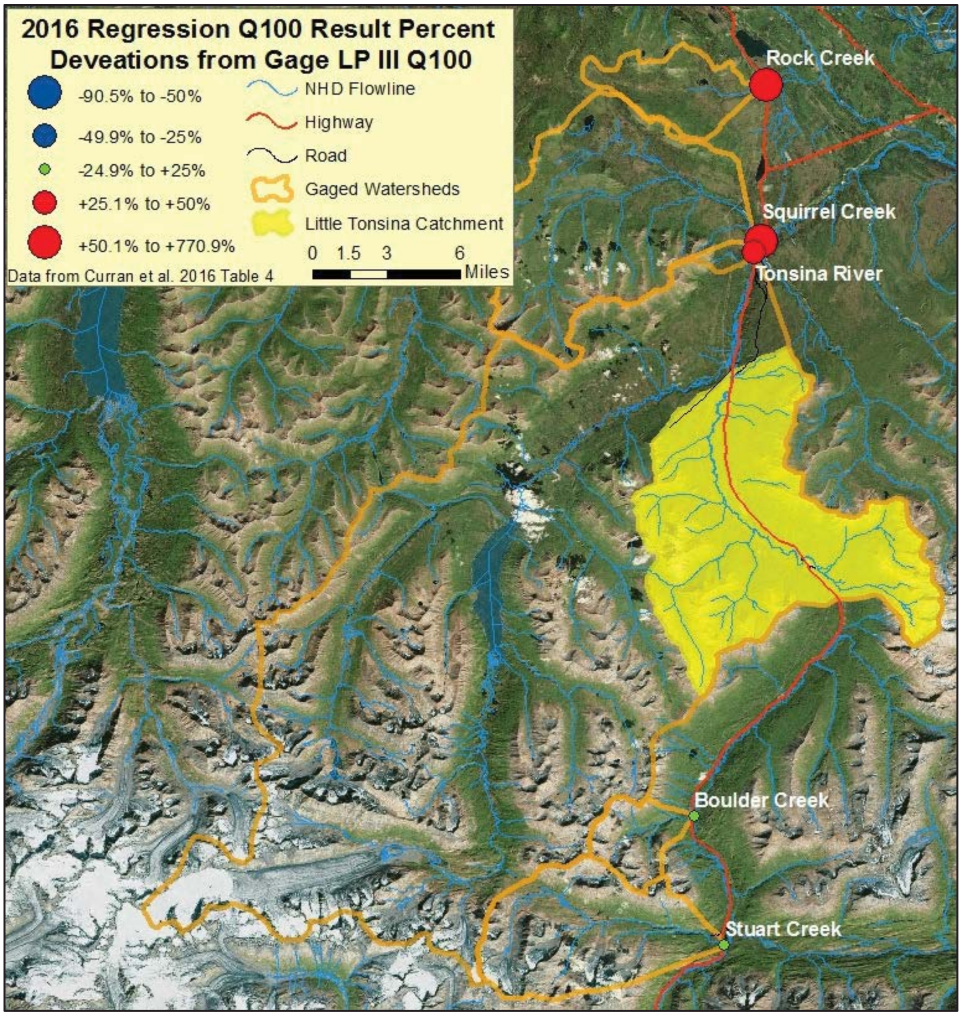


Figure 1. Gaged watersheds in the 2016 Regression Equation near Little Tonsina design watershed.

<u>Tonsina River Gage 15208000</u>

A discharge per unit area correlation with Tonsina River gage yields a Q100 estimate less than the 2016 regression equation but is not an ideal method due to watershed area, precipitation and glaciation differences. The Little Tonsina River design watershed area is 85.4 mi^2, which is 20.2% of the Tonsina River gage watershed area (421 mi^2). The Little Tonsina design watershed area is outside the 50 – 150% range recommended for using a weighted flood frequency estimate method (Curran et al. 2016 p28). The average annual precipitation for the Little Tonsina River design watershed is also considerably less, 24.5 in, compared to 47 in for the Tonsina River gage watershed. Total annual precipitation from the Little Tonsina River watershed constitutes 10.2% of the Tonsina River gage watershed's annual precipitation. The small precipitation contribution may indicate the discharge per unit area method provides high estimates, but the Tonsina River watershed likely has more precipitation in the form of snow on glaciers.

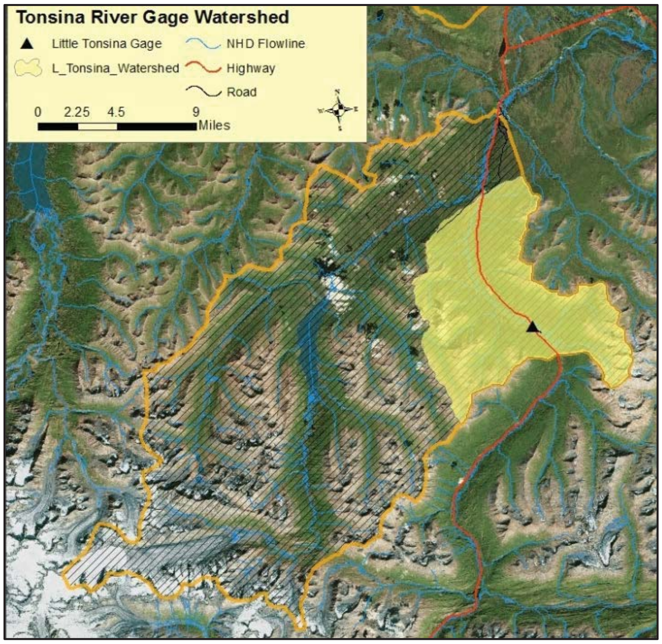


Figure 2. Tonsina River Gage 15208000 watershed with Little Tonsina design watershed.

Little Tonsina River Gage 15207800

The Little Tonsina River has a gage record further upstream at the Richardson Highway crossing that presents similar correlation issues to the Tonsina River gage. The gaged watershed is small, only 23.2 mi^2 which is 27% of the Little Tonsina River design watershed. The station has a short record of 7 peak flows, which is why it was not included in 2016 Regression Equation statistics. Using a plain discharge per area correlation this gage provides the lowest Q100 estimate of all methods tried, but has a Q2 most similar to the discharge derived from the bankfull cross section. The gaged section of the watershed is 27% by area, and contributes 26% of annual precipitation, so its precipitation is likely a fair representation of the larger design watershed.

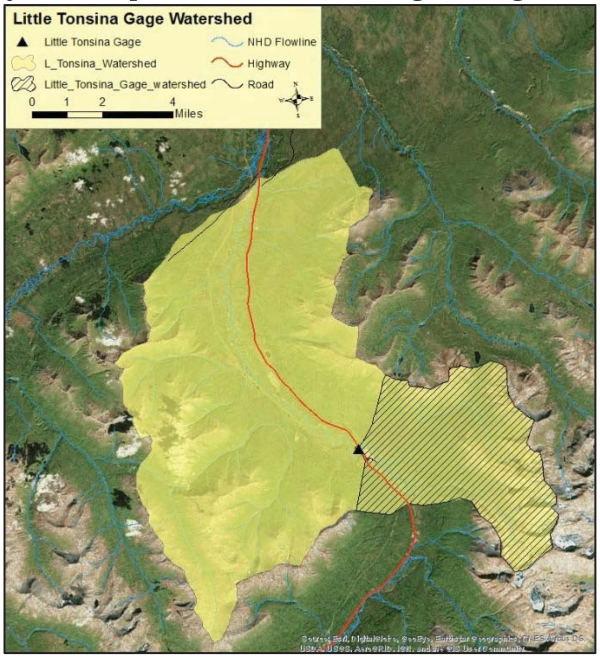


Figure 3. Little Tonsina River Gage 15207800 watershed with Little Tonsina design watershed.

Little Tonsina River Bankfull Discharge

The Little Tonsina River representative design cross section yielded bankfull discharge estimates between 551 and 610 cfs (Worksheet 2-2). The bankfull discharge correlates to a Q1.5 – Q2 so this is another indicator that the regression equation estimates are higher than actual. A 30% reduction of the 2016 regression equation yields a Q2 equal to 721cfs, which is fairly close to the bankfull derived estimates.

Table 1. Flood frequency estimates for the Little Tonsina River at Alyeska Pipeline Access Road design watershed. The 2016 regression method is recommended for the design discharge (3,410 cfs), but the 2016 regression equation estimate for the Tonsina River gage, discharge per area methods, and the bankfull discharge all indicate that the 2016 regression estimate could be safely adjusted down by up to 30%.

			2003 Regional Regression Method			**2016 Regional Regression Method**				
RI	**Q/ A Method Little Tonsina Gage 15207800**	**Q/ A Method Main Tonsina Gage 15208000**	2003 Regression Method	2003 Regression 5% Lower Confid.	2003 Regression 95% Upper Confid.	2016 Regression Method	2016 Regression 5% Lower Confid.	2016 Regression 95% Upper Confid.	2016 Regression Method 30% Reduction	2016 Regression Method 43%* Reduction
yr	cfs	cfs	cfs	cfs	cfs	cfs	cfs	cfs	cfs	
2	371	922	845	440	1620	1,030	359	2,930	721	587
5	462	1275	1360	697	2650	1,590	567	4,450	1,113	906
10	595	1539	1750	867	3520	2,000	716	5,610	1,400	1,140
25	883	1906	2280	1070	4840	2,550	893	7,300	1,785	1,454
50	1226	2213	2700	1220	6000	2,970	1,020	8,670	2,079	1,693
100	**1729**	**2538**	**3140**	**1350**	**7300**	**3,410**	**1,140**	**10,200**	**2,387**	**1,944**
200	2468	2883	3600	1480	8780	3,850	1,250	11,900	2,695	2,195
500	4006	3390	4250	1640	11000	4,460	1,380	14,400	3,122	2,542

*

Table 2. Discharge per unit area method for Little Tonsina River Gage Site 15207800, 23.2 mi2. LPIII input parameters used for gage statistics can be found in the appendix.

RI	LP III 15207800 Q (cfs)	Q/A (cfs/mi^2)
2	101	4.3
5	126	5.4
10	162	7.0
25	240	10.3
50	333	14.3
100	**469**	**20.2**
200	670	28.9
500	1087	46.9

Table 3. Discharge per unit area method for Tonsina River Gage 15208000, 421 mi2. The station with weighted skew coefficient (Sta) values for discharge estimates based on Tonsina River gage data.

RI	Sta 15208000 (Curran et al. 2016 Table 4)	Q/A
yr	cfs	(cfs/mi^2)
2	4540	10.8
5	6280	14.9
10	7580	18.0
25	9390	22.3
50	10900	25.9
100	**12500**	**29.7**
200	14200	33.7
500	16700	39.7

References

Curran, J.H., Meyer, D.F., and 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, 101 p. http://pubs.usgs.gov/wri/wri034188/.

Curran, J.H., Barth, N.A., Veilleux, A.G., and Ourso, R.T. 2016. Estimating flood magnitude and frequency at gaged and ungaged sites on streams in Alaska and conterminous basins in Canada, based on data through water year 2012: U.S. Geological Survey Scientific Investigations Report 2016-5024, 47 p., http://dx.doi.org/10.3133/sir20165024.

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Appendix

LP III Input data for gage 15207800

Station ID	Analysis Option	Beginning Year	Ending Year	Record Length	Inc Hist Peaks	Skew Option	Generalized Skew	Gen Skew Std Error	Mean Sqr Err	Low Hist Peak	PILF (LO) Threshold	PILF (LO) Test	High Sys Peak	Hi-Outlier Threshold	Gage Base Discharge	Urban/Reg Peaks	Latitude	Longitude
15207800	B17B	1973	2007	35	Yes	Station	0.7	0.55	0.3025	570	0	Multiple	214	0	0	No	61.48028	145.1514

Included 2007 historic peak.

Worksheet 2-2. Computations of velocity and bankfull discharge using various methods (Rosgen, 2006b; Rosgen and Silvey, 2007).

Bankfull VELOCITY & DISCHARGE Estimates

Stream:	LITTLE TONSINA	Location:	Reach - ALYESKA ACCESS ROAD
Date:	10/16/2017 — Stream Type: C4	Valley Type:	U-AL-FD
Observers:	Dekker & Hanson	HUC:	

INPUT VARIABLES			OUTPUT VARIABLES		
Bankfull Riffle Cross-Sectional AREA	138.79	A_{bkf} (ft^2)	Bankfull Riffle Mean DEPTH	3.06	d_{bkf} (ft)
Bankfull Riffle WIDTH	45.32	W_{bkf} (ft)	Wetted PERMIMETER ~ $(2 * d_{bkf}) + W_{bkf}$	49.11	W_p (ft)
D_{84} at Riffle	123.78	Dia. (mm)	D_{84} (mm) / 304.8	0.41	D_{84} (ft)
Bankfull SLOPE	0.0030	S_{bkf} (ft / ft)	Hydraulic RADIUS A_{bkf} / W_p	2.83	R (ft)
Gravitational Acceleration	32.2	g (ft / sec^2)	Relative Roughness R(ft) / D_{84} (ft)	6.97	R / D_{84}
Drainage Area	85.5	DA (mi^2)	Shear Velocity $u^* = (gRS)^{½}$	0.523	u* (ft/sec)

ESTIMATION METHODS	Bankfull VELOCITY		Bankfull DISCHARGE	
1. Friction Factor / Relative Roughness — $u = [2.83 + 5.66 * Log\{R / D_{84}\}] u^*$	3.97	ft / sec	551.04	cfs
2. Roughness Coefficient: a) Manning's *n* from Friction Factor / Relative Roughness (Figs. 2-18, 2-19) — $u = 1.49*R^{2/3}*S^{1/2}/n$; $n =$ 0.037	4.40	ft / sec	610.54	cfs
2. Roughness Coefficient: b) Manning's *n* from Stream Type (Fig. 2-20) — $u = 1.49*R^{2/3}*S^{1/2}/n$; $n =$ 0.04	4.07	ft / sec	564.74	cfs
2. Roughness Coefficient: c) Manning's *n* from Jarrett (USGS): $u = 1.49*R^{2/3}*S^{1/2}/n$; $n = 0.39*S^{0.38}*R^{-0.16}$; Note: This equation is applicable to steep, step/pool, high boundary roughness, cobble- and boulder-dominated stream systems; i.e., for $n =$ 0.036	4.48	ft / sec	622.20	cfs
3. Other Methods (Hey, Darcy-Weisbach, Chezy C, etc.) Manning's Limerinos n=0.0383	4.25	ft / sec	589.72	cfs
3. Other Methods (Hey, Darcy-Weisbach, Chezy C, etc.) Darcy-Weisbach (Leopold, Wolman and Miller)	4.28	ft / sec	593.50	cfs
4. Continuity Equations: a) Regional Curves $u = Q / A$; Return Period for Bankfull Discharge Q = 0.0 year	0.00	ft / sec	0.00	cfs
4. Continuity Equations: b) USGS Gage Data $u = Q / A$	0.00	ft / sec	0.00	cfs

Protrusion Height Options for the D_{84} Term in the Relative Roughness Relation (R/D_{84}) – Estimation Method 1

Option 1.	For **sand-bed** channels: Measure 100 **"protrusion heights"** of sand dunes from the downstream side of feature to the top of feature. Substitute the D_{84} sand dune protrusion height in ft for the D_{84} term in method 1.
Option 2.	For **boulder-dominated** channels: Measure 100 **"protrusion heights"** of boulders on the sides from the bed elevation to the top of the rock on that side. Substitute the D_{84} boulder protrusion height in ft for the D_{84} term in method 1.
Option 3.	For **bedrock-dominated** channels: Measure 100 **"protrusion heights"** of rock separations, steps, joints or uplifted surfaces above channel bed elevation. Substitute the D_{84} bedrock protrusion height in ft for the D_{84} term in method 1.
Option 4.	For **log-influenced** channels: Measure "**protrusion heights**" proportionate to channel width of log diameters or the height of the log on upstream side if embedded. Substitute the D_{84} protrusion height in ft for the D_{84} term in method 1.

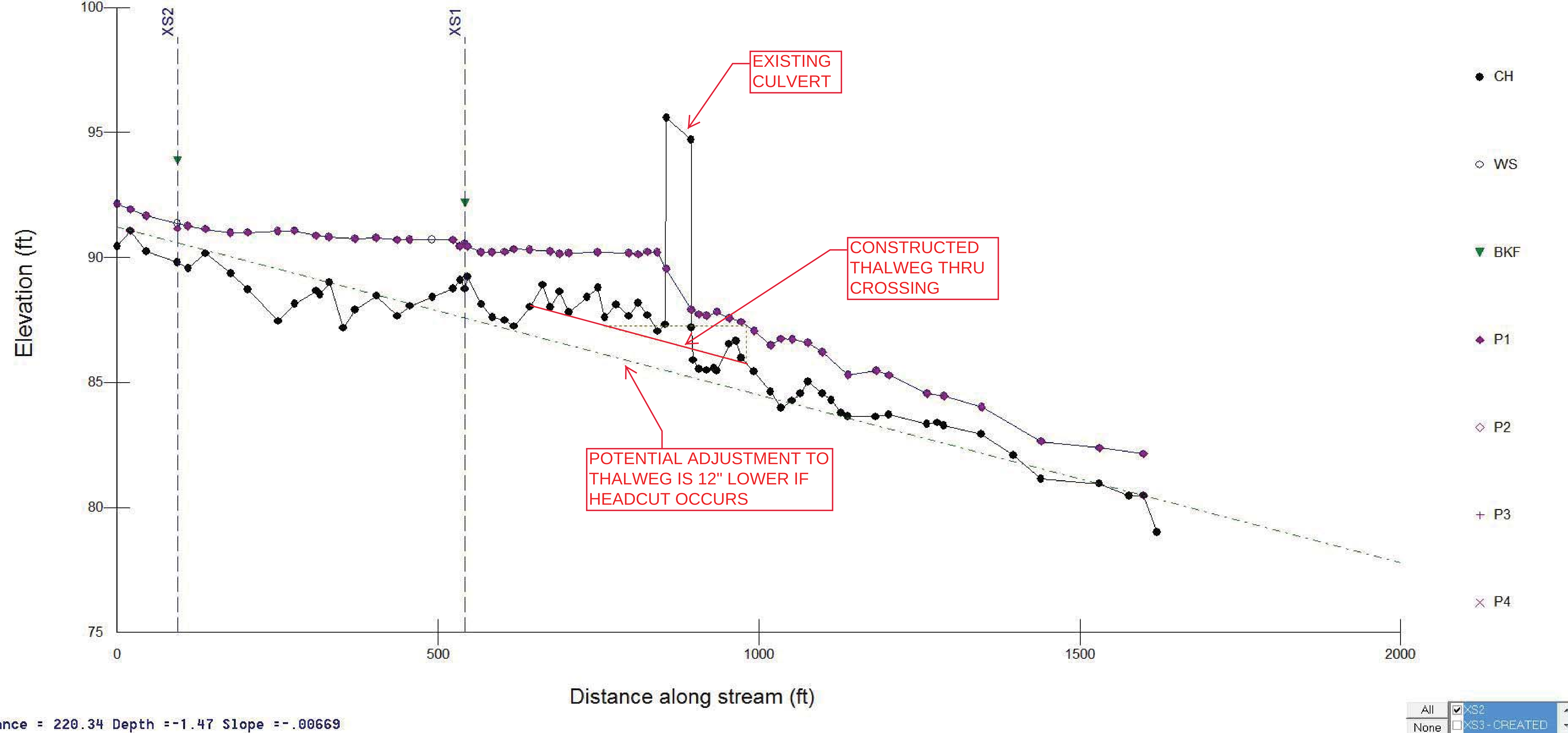
Worksheet 2-3. Field form for Level II stream classification (Rosgen, 1996; Rosgen and Silvey, 2005).

Stream:	**LITTLE TONSINA, Reach - ALYESKA ACCESS ROAD**				
Basin:		Drainage Area: **54720** acres		**85.5**	mi^2
Location:	**ADFG 20103476**				
Twp.&Rge:	**;**	Sec.&Qtr.: **;**			
Cross-Section Monuments (Lat./Long.):	**61.59437 Lat / -145.22308 Long**			Date:	**10/16/17**
Observers:	**Dekker and Hanson**			Valley Type:	U-AL-FD

Parameter	Value	Units
Bankfull WIDTH (W_{bkf}) WIDTH of the stream channel at bankfull stage elevation, in a riffle section.	**45.32**	ft
Bankfull DEPTH (d_{bkf}) Mean DEPTH of the stream channel cross-section, at bankfull stage elevation, in a riffle section ($d_{bkf} = A / W_{bkf}$).	**3.06**	ft
Bankfull X-Section AREA (A_{bkf}) AREA of the stream channel cross-section, at bankfull stage elevation, in a riffle section.	**138.79**	ft^2
Width/Depth Ratio (W_{bkf} / d_{bkf}) Bankfull WIDTH divided by bankfull mean DEPTH, in a riffle section.	**14.81**	ft/ft
Maximum DEPTH (d_{mbkf}) Maximum depth of the bankfull channel cross-section, or distance between the bankfull stage and Thalweg elevations, in a riffle section.	**4.07**	ft
WIDTH of Flood-Prone Area (W_{fpa}) Twice maximum DEPTH, or (2 x d_{mbkf}) = the stage/elevation at which flood-prone area WIDTH is determined in a riffle section.	**233.48**	ft
Entrenchment Ratio (ER) The ratio of flood-prone area WIDTH divided by bankfull channel WIDTH (W_{fpa} / W_{bkf}) (riffle section).	**5.15**	ft/ft
Channel Materials (Particle Size Index) D_{50} The D_{50} particle size index represents the mean diameter of channel materials, as sampled from the channel surface, between the bankfull stage and Thalweg elevations.	**43.14**	mm
Water Surface SLOPE (S) Channel slope = "rise over run" for a reach approximately 20–30 bankfull channel widths in length, with the "riffle-to-riffle" water surface slope representing the gradient at bankfull stage.	**0.006**	ft/ft
Channel SINUOSITY (k) Sinuosity is an index of channel pattern, determined from a ratio of stream length divided by valley length (SL / VL); or estimated from a ratio of valley slope divided by channel slope (VS / S).	**1.23**	

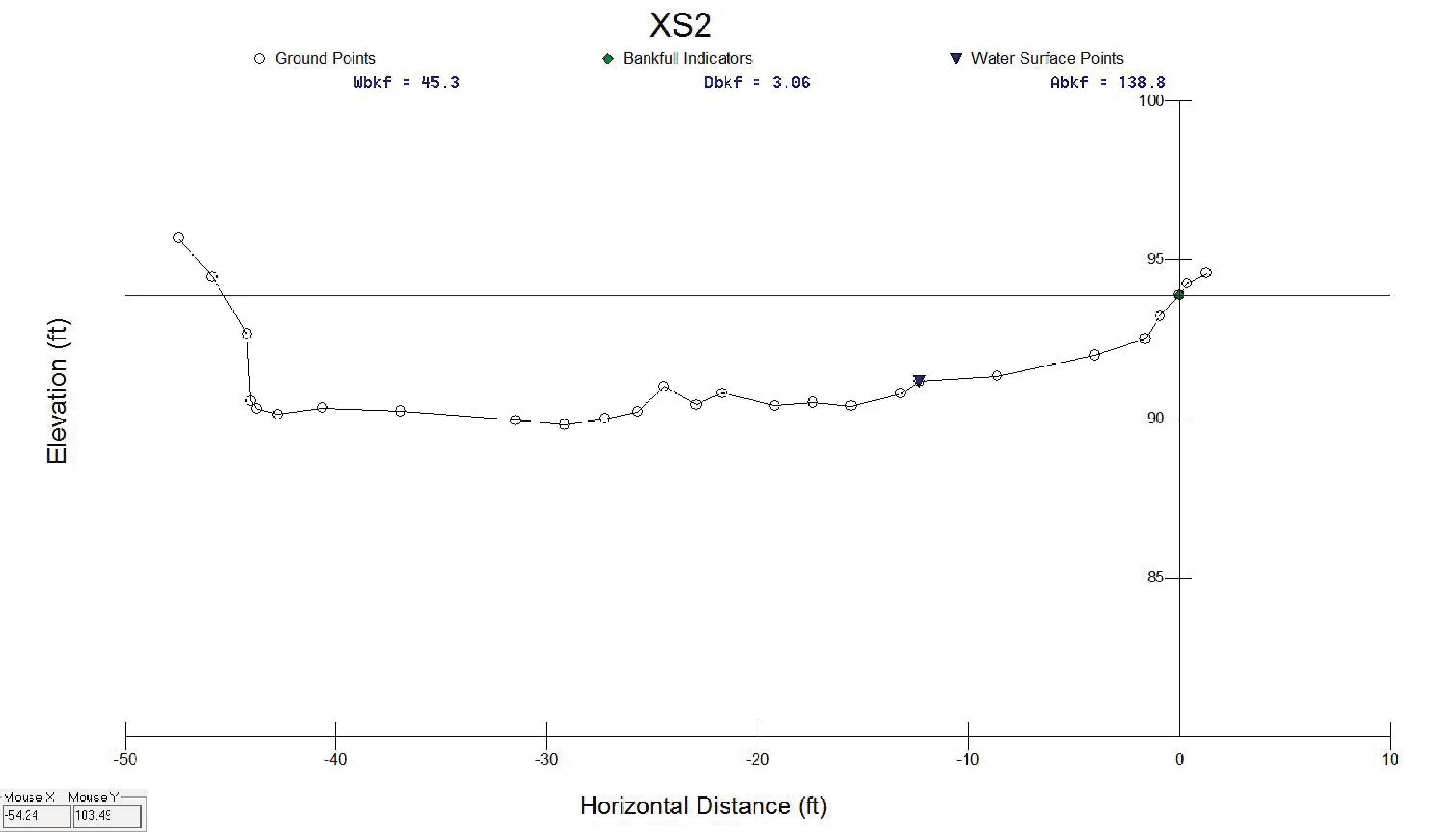
Stream Type **C 4** (See **Figure 2-14**)

LONG PRO



Distance along stream (ft)

Distance = 220.34 Depth =-1.47 Slope =-.00669



XS2
Ground Points
Bankfull Indicators
Water Surface Points
Wbkf = 45.3
Dbkf = 3.06
Abkf = 138.8
100
95
90
85
Elevation (ft)
-50
-40
-30
-20
-10
0
10
Horizontal Distance (ft)
Mouse X
Mouse Y
-54.24
103.49

Sample Type: Riffle

Data | Linear Graph | Bar Graph

Date: 10/16/2017

Size (mm)	TOT #	ITEM %	CUM %
0 - 0.062	14	14.00	14.00
0.062 - 0.125	0	0.00	14.00
0.125 - 0.25	0	0.00	14.00
0.25 - 0.50	0	0.00	14.00
0.50 - 1.0	1	1.00	15.00
1.0 - 2.0	0	0.00	15.00
2.0 - 4.0	3	3.00	18.00
4.0 - 5.7	0	0.00	18.00
5.7 - 8.0	0	0.00	18.00
8.0 - 11.3	2	2.00	20.00
11.3 - 16.0	4	4.00	24.00
16.0 - 22.6	4	4.00	28.00
22.6 - 32.0	10	10.00	38.00
32 - 45	14	14.00	52.00
45 - 64	13	13.00	65.00
64 - 90	11	11.00	76.00
90 - 128	9	9.00	85.00
128 - 180	9	9.00	94.00
180 - 256	6	6.00	100.00
256 - 362	0	0.00	100.00
362 - 512	0	0.00	100.00
512 - 1024	0	0.00	100.00
1024 - 2048	0	0.00	100.00
Bedrock	0	0.00	100.00

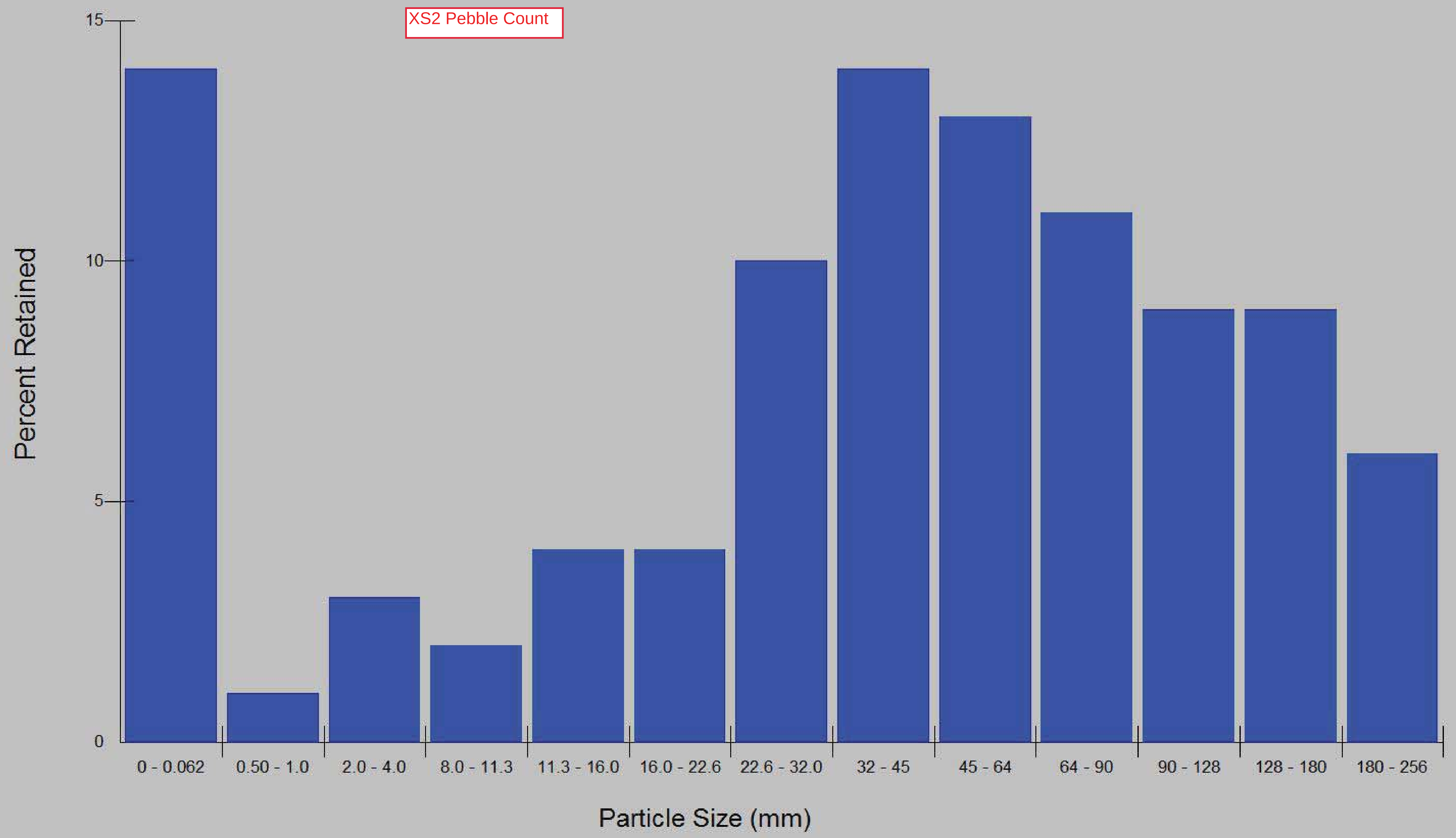
XS2 Pebble Count

Particle Size Analysis

D16 (mm)	2.67
D35 (mm)	29.18
D50 (mm)	43.14
D84 (mm)	123.78
D95 (mm)	192.67
D100 (mm)	256
Silt/Clay (%)	14
Sand (%)	1
Gravel (%)	50
Cobble (%)	35
Boulder (%)	0
Bedrock (%)	0

Total Particles = 100

D50 43.14 mm


XS2 Pebble Count
Percent Retained
15
10
5
0
0 - 0.062
0.50 - 1.0
2.0 - 4.0
8.0 - 11.3
11.3 - 16.0
16.0 - 22.6
22.6 - 32.0
32 - 45
45 - 64
64 - 90
90 - 128
128 - 180
180 - 256
Particle Size (mm)

Culvert Summary Table - BRIDGE

Discharge Names	Total Discharge	Culvert Discharge	Headwate Elevation (ft)	Inlet Control Depth(ft)	Outlet Control Depth(ft)	Flow Type	Normal Depth (ft)	Critical Depth (ft)	Outlet Depth (ft)	Tailwater Depth (ft)	Outlet Velocity (ft/s)	Tailwater Velocity (ft/s)
2 year	1030.00	1030.00	90.32	**3.52~**	0.00	3-M1t	4.21	3.54	4.55	4.55	6.31	6.64
5 year	1590.00	1590.00	93.56	4.61	**6.76**	3-M1t	4.98	4.64	5.70	5.70	6.76	7.74
10 year	2000.00	2000.00	94.37	5.09	**7.57**	3-M1t	5.54	5.12	6.42	6.42	7.07	8.25
25 year	2550.00	2550.00	95.33	5.68	**8.53**	3-M1t	6.12	5.71	7.23	7.23	7.51	8.58
50 year	2970.00	2970.00	96.00	6.09	**9.20**	3-M1t	6.57	6.13	7.80	7.80	7.80	8.81
100 year	3410.00	3410.00	96.66	6.60	**9.86**	3-M1t	7.01	6.54	8.36	8.36	8.08	9.03
200 year	3850.00	3850.00	97.28	7.15	**10.48**	3-M1t	7.39	6.93	8.88	8.88	8.33	9.24
500 year	4460.00	4460.00	98.08	7.91	**11.28**	3-M1t	7.91	7.44	9.57	9.57	8.63	9.49

Summary Table - 85' long bridge

Display

- Crossing Summary Table
- Culvert Summary Tabl — BRIDGE
- Water Surface Profiles
- Tapered Inlet Table
- Customized Table — Options...

Geometry

Inlet Elevation: 86.80 ft
Outlet Elevation: 86.67 ft
Culvert Length: 20.00 ft
Culvert Slope: 0.0067
Inlet Crest: 0.00 ft
Inlet Throat: 0.00 ft

Plot

Crossing Rating Curve
Culvert Performance Curve
Selected Water Profile
Water Surface Profile Data

Outlet Control: Profiles

~ Inlet control is shown, but flow profile is substantially FF.

Help | Flow Types... | Edit Input Data... | Energy Dissipation... | AOP... | Export Report | Adobe PDF (*.pdf) | Close

Culvert Summary Table - Culvert 1

Discharge Names	Total Discharge	Culvert Discharge	Headwater Elevation (ft)	Inlet Control Depth(ft)	Outlet Control Depth(ft)	Flow Type	Normal Depth (ft)	Critical Depth (ft)	Outlet Depth (ft)	Tailwater Depth (ft)	Outlet Velocity (ft/s)	Tailwater Velocity (ft/s)
2 year	1030.00	986.92	92.66	**5.01~**	0.00	3-M1t	3.57	2.93	3.84	4.49	7.36	6.52
5 year	1590.00	1473.01	94.17	**6.52~**	0.00	3-M1t	4.62	3.83	4.85	5.50	8.67	6.51
10 year	2000.00	1818.00	95.15	**7.50~**	0.00	3-M1t	5.32	4.40	5.43	6.08	9.56	5.62
25 year	2550.00	2225.88	96.95	8.69	**9.30**	3-M2t	6.09	5.02	6.05	6.70	10.50	4.57
50 year	2970.00	2565.87	97.88	9.68	**10.23**	3-M2t	6.74	5.52	6.44	7.09	11.37	4.04
100 year	3410.00	2940.89	98.87	10.78	**11.22**	3-M2t	7.46	6.03	6.80	7.45	12.36	3.71
200 year	3850.00	3344.92	99.91	11.96	**12.26**	3-M2t	8.24	6.55	7.11	7.76	13.44	3.55
500 year	4460.00	3826.51	101.11	13.25	**13.46**	3-M2t	9.40	7.14	7.52	8.16	14.58	3.45

Summary Table - 35'-4"x 20' culvert + 10' flood relief culvert

Display

- Crossing Summary Table
- Culvert Summary Table — Culvert 1
- Water Surface Profiles
- Tapered Inlet Table
- Customized Table — Options...

Geometry

Inlet Elevation:	87.65 ft
Outlet Elevation:	87.31 ft
Culvert Length:	50.00 ft
Culvert Slope:	0.0067
Inlet Crest:	0.00 ft
Inlet Throat:	0.00 ft
Outlet Control:	Profiles

Plot

- Crossing Rating Curve
- Culvert Performance Curve
- Selected Water Profile
- Water Surface Profile Data

~ Inlet control is shown, but flow profile is substantially FF.

Help | Flow Types... | Edit Input Data... | Energy Dissipation... | AOP... | Export Report | Adobe PDF (*.pdf) | Close

APPENDIX D

A B C D

1 2 3 4

PLAN VIEW

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Drawing: C:\USERS\HGHANSON\DOCUMENTS\PROJECTS\CRVP\ALYESKA ACCESS ROAD & LITTLE TONSINA\AUTOCAD\LITTLE TONSINA CONCEPT.DWG - Layout: PLAN
Xrefs: FWS-22X34-PLN.DWG LITTLE TONSINA SURVEY.DWG - Images: HEATHER SIGNATURE.JPG HEATHER SIGNATURE.JPG USFWS_LOGO.JPG GOOGLE EARTH LITTLE TONSINA.JPG

U.S. FISH AND WILDLIFE SERVICE
ANCHORAGE CONSERVATION OFFICE
4700 BLM ROAD
ANCHORAGE, AK 99507
907-271-2888

Revision No.	Description	Date	
			Designed H. HANSON
			Drawn H. HANSON
			Checked
			Date 11-1-2017

FISH PASSAGE IMPROVEMENT

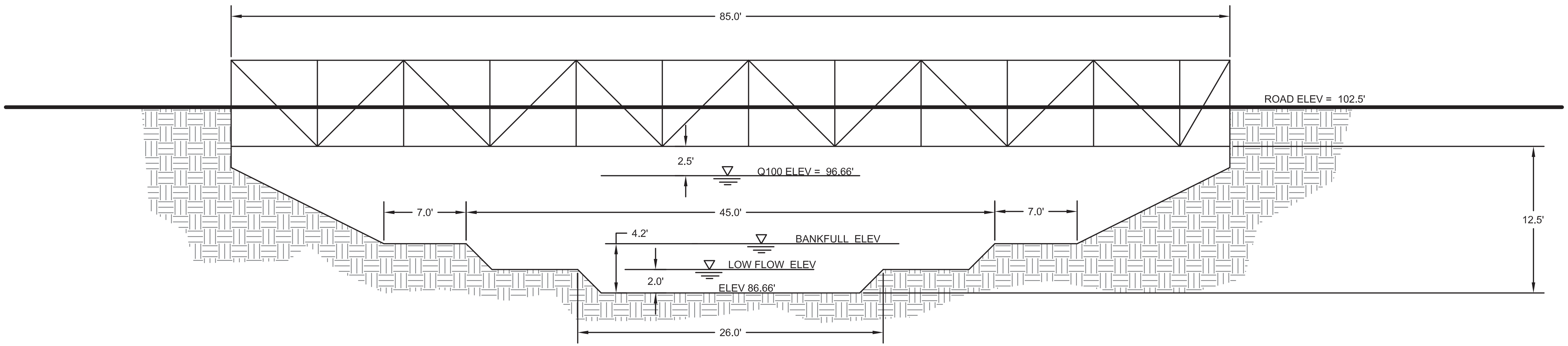
LITTLE TONSINA & ALYESKA ACCESS ROAD, MP 74.2 RICHARDSON HWY

BRIDGE ALIGNMENT CONCEPT

Drawing Number:

C-101

A | B | C | D



CROSS SECTION AT BRIDGE

0 5 10
SCALE IN FEET

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ANCHORAGE, AK 99507
907-271-2888

Revision No.	Description	Date	
			Designed H. HANSON
			Drawn H. HANSON
			Checked
			Date 11-1-2017

FISH PASSAGE IMPROVEMENT

LITTLE TONSINA & ALYESKA ACCESS ROAD, MP 74.2 RICHARDSON HWY

BRIDGE SECTION

Drawing Number: C-102

A | B | C | D

1

2

3

4

PLAN VIEW

N

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Checked:
Date: 10-16-2017

FISH PASSAGE IMPROVEMENT

LITTLE TONSINA & ALYESKA ACCESS ROAD, MP 74.2 RICHARDSON HWY

SURVEY

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User: HGHANSON Oct 16, 2017 - 1:04pm
Drawing: C:\USERS\HGHANSON\DOCUMENTS\PROJECTS\CRVP\ALYESKA ACCESS ROAD & LITTLE TONSINA\AUTOCAD\LITTLE TONSINA CONCEPT.DWG - Layout: PLAN
Xrefs: FWS-22X34-PLN.DWG LITTLE TONSINA SURVEY.DWG - Images: HEATHER SIGNATURE.JPG HEATHER SIGNATURE.JPG HEATHER SIGNATURE.JPG USFWS_LOGO.JPG GOOGLE EARTH LITTLE TONSINA.JPG