Mill Creek
Alternatives Analysis and Design

UPDATE #4 *March and April 2025*

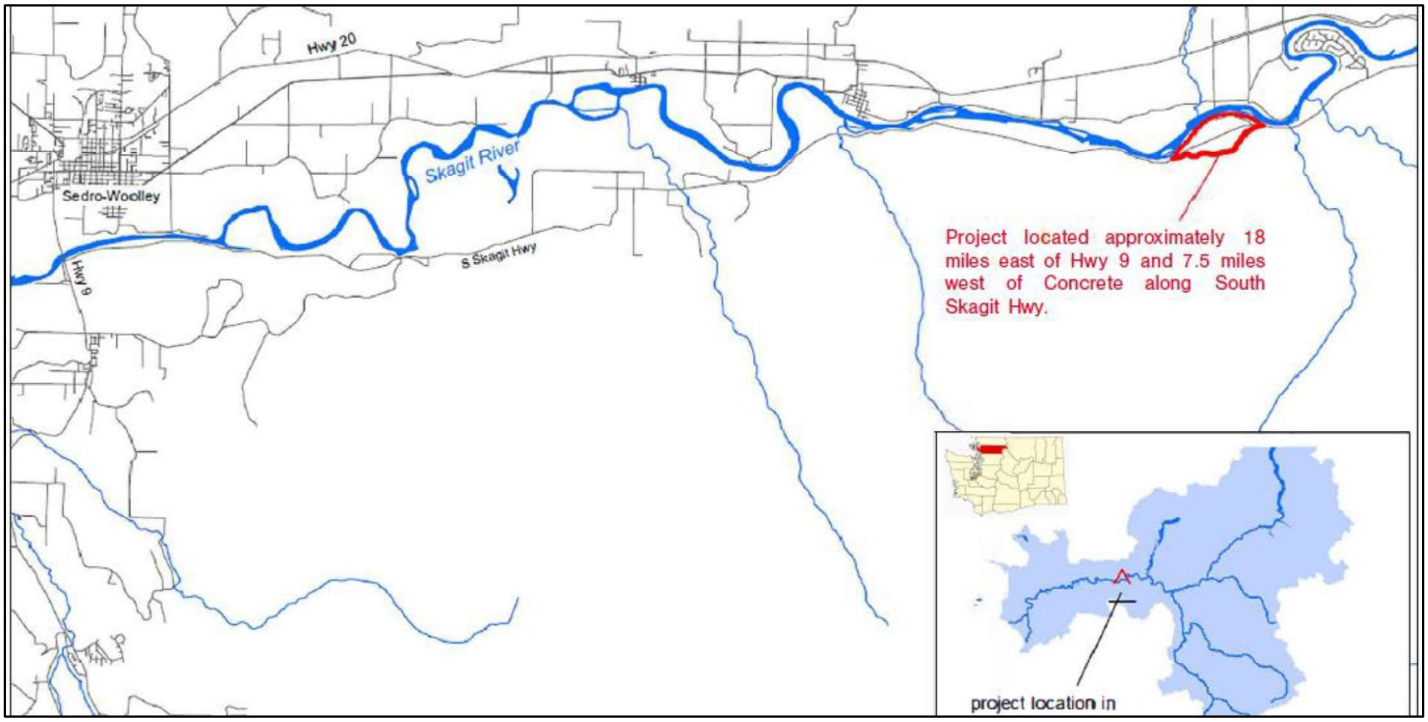
OVERVIEW
South Skagit Highway, a Skagit County owned road, travels along the South side of the Skagit River and crosses over Mill Creek near milepost 18. This section of roadway is within the floodplain of the Skagit River and the alluvial fans of Mill and Savage Creeks resulting in routine flooding and damage to the road. The clearance under the Mill Creek bridge is too small for sediment transport and the Savage Creek culvert is a partial barrier to fish passage. The County began working on this project in 2004 with a sediment and flood management report. In partnership with the Skagit River System Cooperative an alternatives analysis was completed in 2015. The County is currently assessing various alternatives to improve the road and fish passage/habitat in this area. This phase of work is expected to be completed December 2025.

A detailed history of the project and all previous updates can be found on the Mill Creek website which is located at:
https://www.skagitcounty.net/Departments/PublicWorksSurfaceWaterManagement/MillCreekFeasibilityStudy.htm

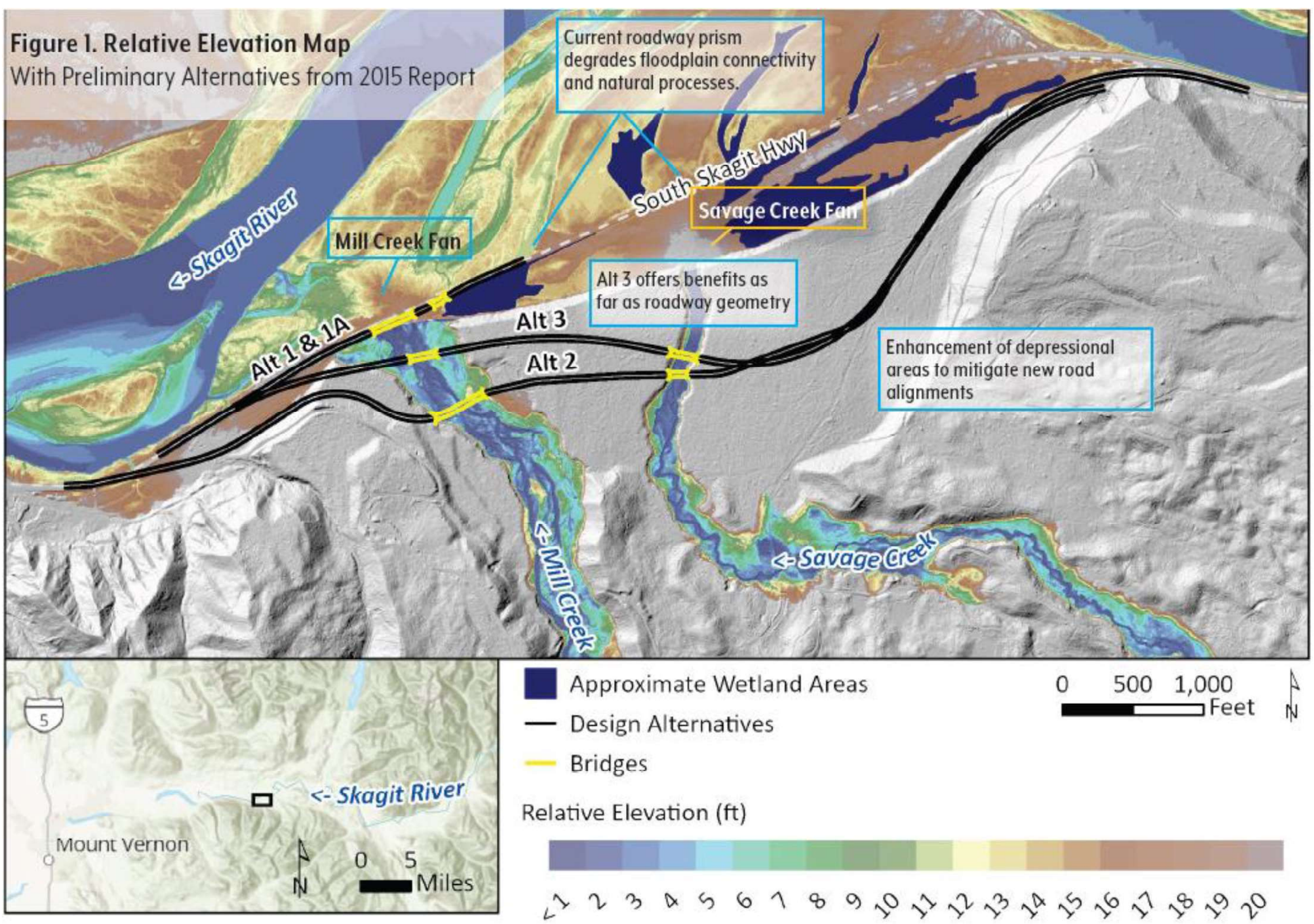
UPDATES

- *Funding –*
  - Skagit County successfully applied to the NOAA's Transformational Habitat grant.
  - We are working on the Federal Local Bridge Program Grant and on the National Fish and Wildlife's National Coastal Resilience Fund
  - We are currently in the ground round for some limited funding through the Salmon Recovery Funding Board to complete geotechnical work and a more detailed topographical survey of the new alignment. Site visits for proposals are next week.
- *Design –*
  - KPFF and their subs have been working on the Type, Size, and Location report required for the grant submittals. This will detail what bridges and alignments have been considered. Once it is finalized, we will upload to the website above.
  - See next page for a portion of the "supporting materials" submitted to both NOAA grants. This shows the alternatives, conceptual levels for cost of the bridges, and the great write-up by NHC explaining why this area is complex.

UPCOMING
Staff will continue discussions with affected and interested parties.
KPFF and subs will work towards completion of the Basis of Design Report (Type, Size, Location report)
County staff will continue to seek design and eventual construction funding.



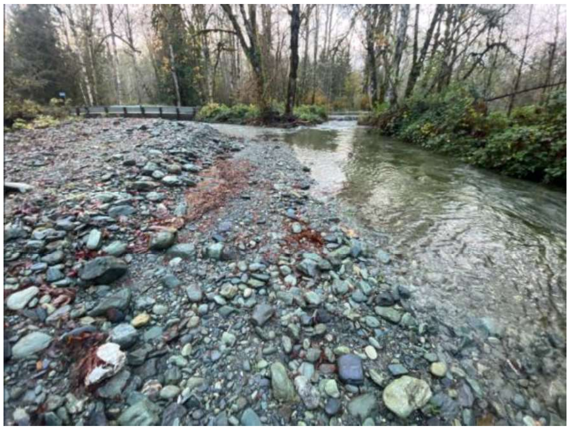
Project Vicinity Map



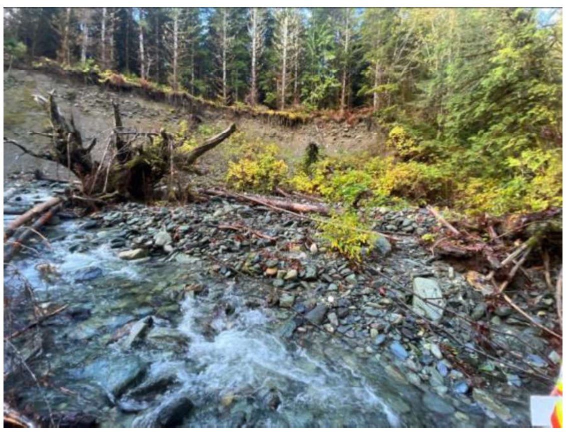
Relative Elevation Model showing previous alternatives. The current preferred alternative closely aligns with Alternative 2 on this map. This REM clearly shows the South Skagit Highway within the Skagit floodplain and Mill Creek alluvial fan.

South Skagit Highway looking east on June 4, 2024. A small rain event caused Mill Creek to overtop the road, causing road shoulder damage, impacting drivers, and impacting fish.

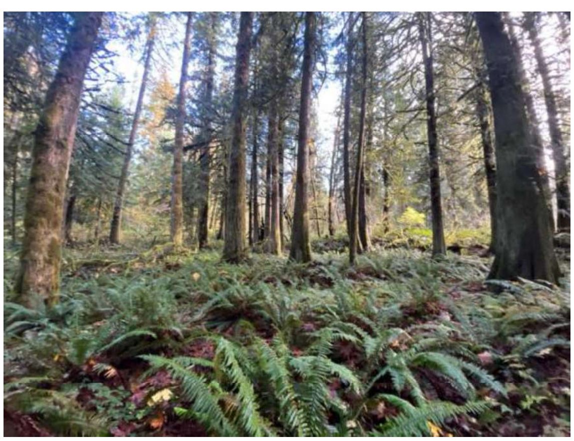
South Skagit Highway looking west on June 4, 2024, same day as above. The majority of Mill Creek is flowing along the highway and into Savage Creek.

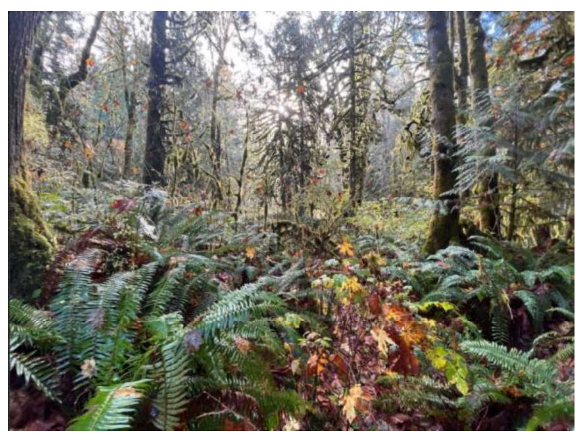


Mill Creek bridge. Picture on the left shows over 50% of the creek avulsing east towards Savage Creek. Picture on the right shows the mostly plugged bridge. This is despite routine dredging. Photos taken October 2024.



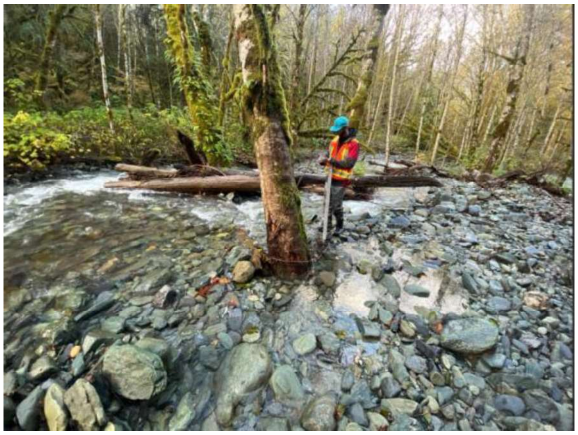
Sediment supply bank approximately 200 feet upstream of the exsiting bridge. Photos taken October 2024.



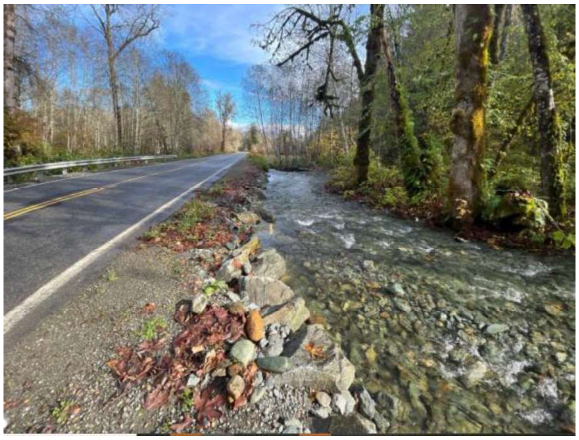


Mill Creek representative riparian areas upstream of the bridge. All of the upstream land is within Timber and there is no development. Photos taken October 2024.

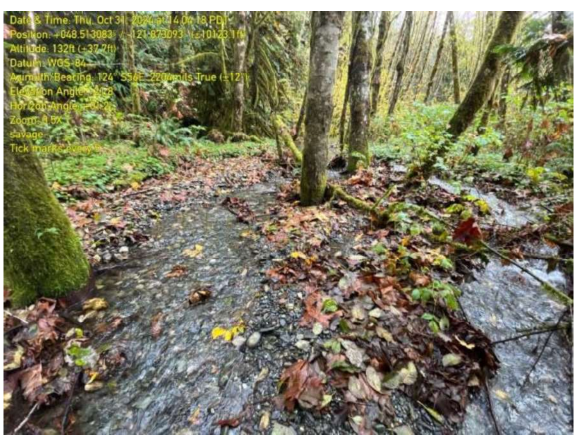
Typical habitat upstream of Mill Creek crossing. Photos taken October 2024.



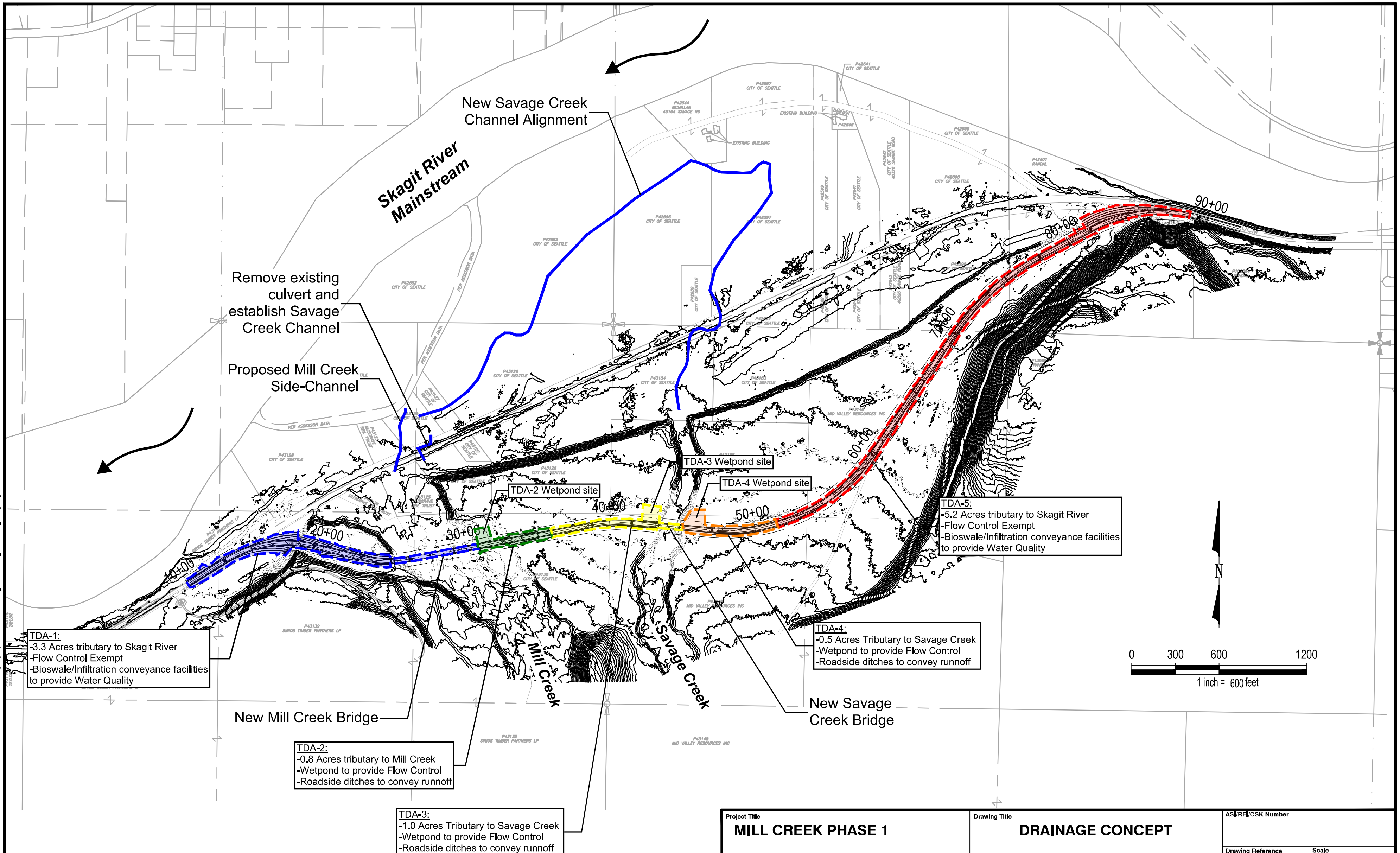
Examples of Mill Creek channel complexity – braided channels, large wood, standing trees, undercut banks, log jams, pools, riffles, and glides. Photos taken throughout 2024.



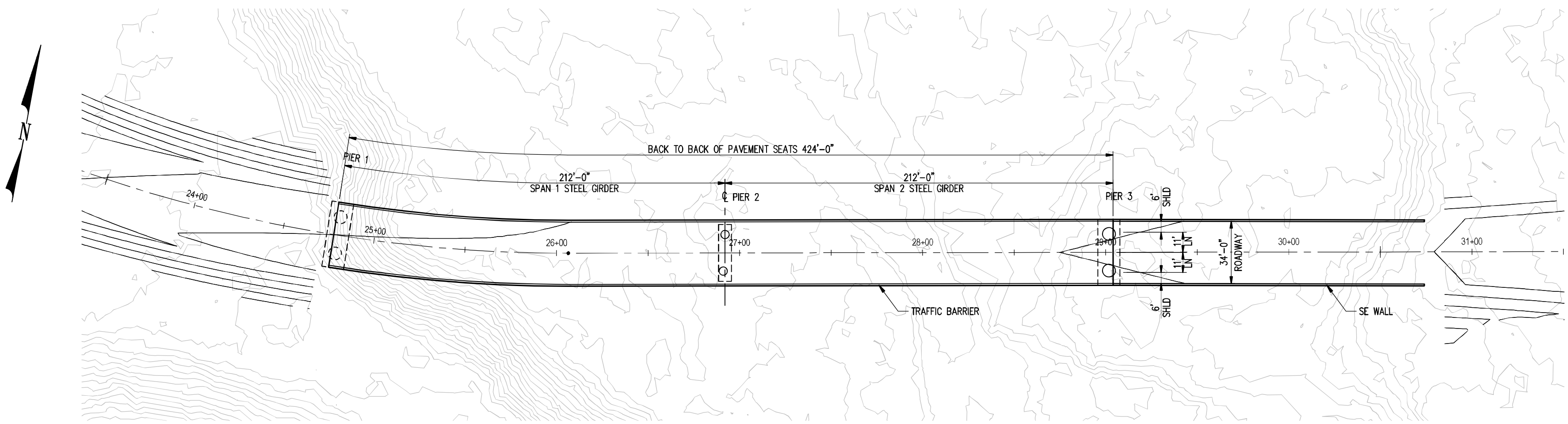
Mill Creek flowing into Savage Creek along the South Skagit Highway. Both photos are looking east from the shoulder of the road. Mill Creek is attempting to deposit sediment upstream of the bridge in any location possible, slowly filling in the Savage Creek wetland. Photos taken September 2024.



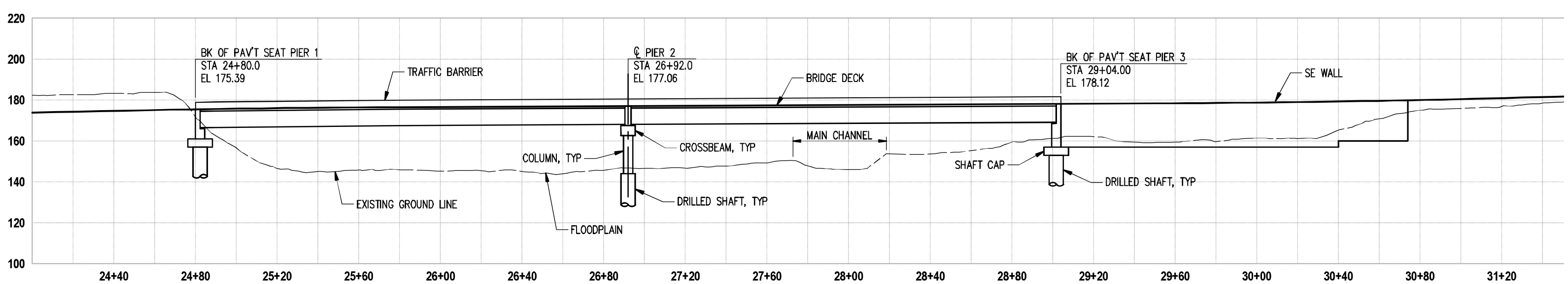
Typical Savage Creek upstream of the crossing and wetland complex. Photos taken October 2024.



Project Title	Drawing Title	ASI/RFI/CSK Number
MILL CREEK PHASE 1	DRAINAGE CONCEPT	
Client: SKAGIT COUNTY	kpff — 1601 5th Avenue, Suite 1600, Seattle, WA 98101, 206.622.5822, www.kpff.com	Drawing Reference / Scale / Date / Drawn/Ck'd By



PLAN
SCALE: 1" = 30'



ELEVATION
SCALE: 1" = 30'

Xrefs:
MCP!_Wall Profiles
MCP!_100-SCALE
xMC-KPFF-2234xtb

CAD USER: RICKT PLOT DATE: Jan 23, 2025-01:12pm
PATH: V:\2400576 (Mill Creek-S Skagit Highway)\02_Design (v2022)\MC-OPT4-S01.dwg

kpff
1601 5th Avenue, Suite 1600
Seattle, WA 98101
206.622.5822
www.kpff.com

NO.	DATE	BY	REVISION

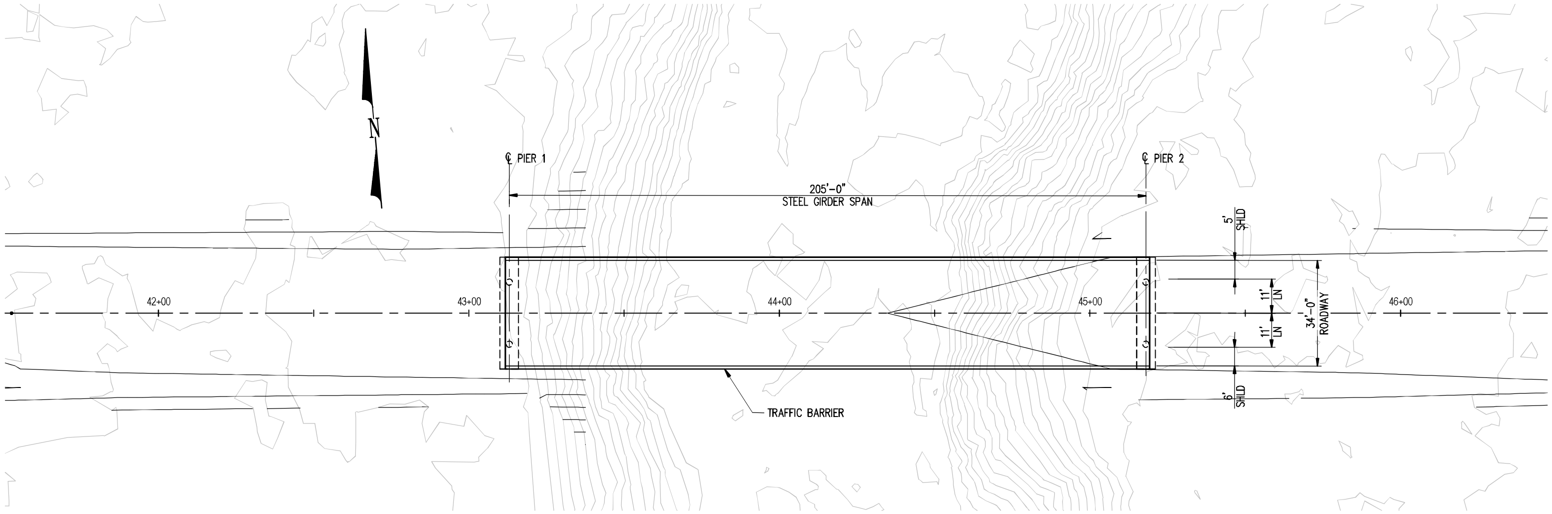
MILL CREEK BRIDGE

--

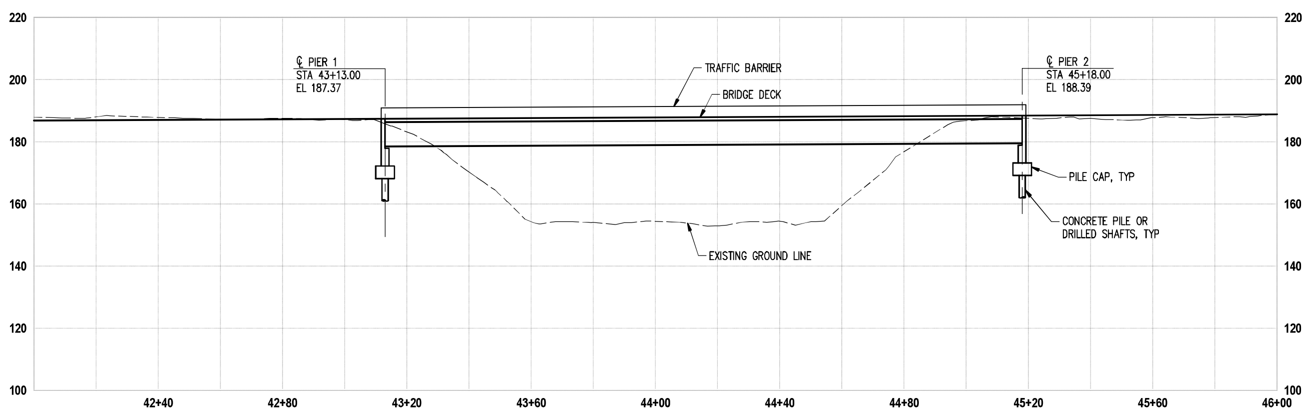
MILL CREEK BRIDGE OPTION 4
TWO SPAN STEEL GIRDER BRIDGE
BRIDGE LAYOUT

DRAWN: HT	PROJECT NO.: 2400576
DESIGN: --	SCALE: AS SHOWN
CHECKED: --	DATE: --
DRAWING NO.	S01
SHEET NO.	- OF -

Xrefs:
MCP!_Wall Profiles
MCP!_100-SCALE
xSC-KPFF-2234xtb



PLAN
SCALE: 1" = 20'



ELEVATION
SCALE: 1" = 20'

CAD USER: RICKT PLOT DATE: Apr 10, 2025-11:15am
PATH: V:\2400576 (Mill Creek-S Skagit Highway)\02_Design (v2022)\SC-OPT5-S01.dwg

kpff
1601 5th Avenue, Suite 1600
Seattle, WA 98101
206.622.5822
www.kpff.com

NO.	DATE	BY	REVISION

SAVAGE CREEK BRIDGE
--

SAVAGE CREEK BRIDGE OPTION 5
SINGLE SPAN STEEL GIRDER BRIDGE
BRIDGE LAYOUT

DRAWN: HT	PROJECT NO.: 2400576
DESIGN: --	SCALE: AS SHOWN
CHECKED: --	DATE: --
DRAWING NO.	S01
SHEET NO.	- OF -

BRIDGE DESIGN ALTERNATIVES

MILL CREEK

Our structural team evaluated different bridge alternatives for Mill Creek; the options considered are:

Option 1: Single span prestressed concrete girder bridge.
Option 2: Single span steel girder bridge
Option 3: Three span prestressed concrete girder bridge
Option 4: Two span steel girder bridge
Option 5: Four span prestressed concrete girder bridge
Option 6: Three span steel girder bridge

Several key factors were considered, including cost estimates, constructability, logistics, long-term maintenance, and environmental impacts.

We developed cost estimates using parametric estimation, WSDOT Unit Bid Analysis, preliminary cost estimating tables and data from recent relative projects. The cost estimates included bridge superstructure cost, substructure cost (e.g SE walls, abutments, columns and shafts), bridge approach slab, fill, mobilization, and contingency.

Our constructability review focused on design feasibility, material availability, and site constraints.

Environmental impacts considerations include the effect of filling and scour protection.

A single span option is cost-effective in terms of the superstructure; however, there are trade-offs to consider. Although the superstructure costs are lower, the need for excessive fill and tall abutment walls may negate these savings, with funding for fill potentially becoming a concern. Additionally, the substructure raises stability concerns, particularly in areas prone to settlement, as the use of tall SE walls and large fill volumes may lead to stability issues.

On the other hand, a multi-span option, which includes intermediate piers, helps address the challenges associated with tall abutment walls and large fill volumes. As the bridge length increases, the amount of fill and the height of the abutment walls decreases, improving stability.

When comparing prestressed concrete to steel, the logistical challenges of prestressed concrete include the potential need for two cranes and accessibility issues that could increase costs and cause delays. Additionally, transporting heavy girders to the site may face difficulties due to road geometry and bridge load restrictions. Steel, however, has logistical advantages. Its lighter weight allows for easier transportation in smaller sections, which are then spliced together on-site. Steel construction is relatively easier than concrete due to launching, which considerably reduces the size of the crane needed for girder erection. The main disadvantage of steel is it requires more maintenance in the long term.

Finally, when considering scour protection, the costs for erosion control appear to be similar across all alternatives, making it a consistent consideration in each option.

The recommended options for Mill Creek are 4 and 6.

SAVAGE CREEK

For Savage Creek, our structural team evaluated four options:

Option 1: Single (175') prestressed concrete girder bridge.
Option 2: Single (175') steel girder bridge.
Option 3: Single (205') prestressed concrete girder bridge.
Option 4: Single (205') steel girder bridge.

The same considerations apply for Savage Creek when comparing the concrete and steel options. The main difference between the options is that the long-span option will have shorter abutment walls. The short span option on the other hand will be more cost effective but will have a narrower hydraulic opening.

The recommended option for Savage Creek is the 205' steel girder bridge.

kpff

By: KPFF
Date: 4/14/2025

ENGINEER'S QUANTITIES ESTIMATE

MILL CREEK BRIDGE ESTIMATE

OPTION 1: SINGLE PRESTESSED CONCRETE SPAN (TOTAL LENGTH = 175')				
	TOTAL=	$	9,946,073	
OPTION 2: SINGLE STEEL SPAN (TOTAL LENGTH = 235')				
	TOTAL=	$	11,161,526	
OPTION 3: 3 - PRESTRESSED CONCRETE SPANS (TOTAL LENGTH = 420')				
	TOTAL=	$	14,924,217	
OPTION 4: 2 STEEL GIRDER SPANS (TOTAL LENGTH = 420')				Prefered Alternative
	TOTAL=	$	15,144,591	
OPTION 5: 4 - PRESTRESSED CONCRETE SPANS (TOTAL LENGTH = 610')				
	TOTAL=	$	18,909,095	
OPTION 6: 3 - STEEL GIRDER SPANS (TOTAL LENGTH = 610')				Prefered Alternative
	TOTAL=	$	20,114,684	

SAVAGE CREEK BRIDGE ESTIMATE

OPTION 1: SINGLE PRESTESSED CONCRETE SPAN (TOTAL LENGTH = 205')				
	TOTAL=	$	5,811,885	
OPTION 2: SINGLE STEEL SPAN (TOTAL LENGTH = 205')				
	TOTAL=	$	6,341,391	Prefered Alternative
OPTION 3: SINGLE PRESTESSED CONCRETE SPAN (TOTAL LENGTH = 175')				
	TOTAL=	$	5,295,729	
OPTION 4: SINGLE STEEL SPAN (TOTAL LENGTH = 175')				
	TOTAL=	$	5,708,064	Prefered Alternative

Note: Estimates include scour protection, mobiliaztion and 40% contingency kpff

ENGINEER'S QUANTITIES ESTIMATE

Project: Mill Creek
By: KPFF
Date: 4/14/2025

ITEM NO.	ITEM NAME	QUANTITY	UNIT	UNIT COST	TOTAL COST	NOTES/ASSUMPTIONS:
OPTION 4: 2 STEEL GIRDER SPANS (TOTAL LENGTH = 420')						
1	STEEL GIRDER	15120	SF	$ 400	$ 6,048,000	BDM APPENDIX 12.3-A1
2	STRUCTURE EXCAVATION CLASS A INCL. HAUL	1037	CY	$ 12	$ 12,444	BDM APPENDIX 12.3-A2
3	ST. REINF. BAR	58800	LB	$ 1	$ 58,800	BDM APPENDIX 12.3-A2
4	CONC. CLASS 4000 (COLUMNS)	1200	CY	$ 250	$ 300,000	BDM APPENDIX 12.3-A2
5	CONC. CLASS 4000 (ABUT. & RET. WALLS)	260	CY	$ 450	$ 117,000	BDM APPENDIX 12.3-A2
6	SE WALL - PRECAST CONC. PANELS OR CONC. BLOCK	8000	SF	$ 60	$ 480,000	BDM APPENDIX 12.3-A1
7	SHAFTS (CONSTRUCTING - FT. DIAM SHAFT (4' TO 6' DIA.)	700	LF	$ 2,500	$ 1,750,000	ASPECT INPUT
8	QA SHAFT TEST	9	EA	$ 1,000	$ 9,000	BDM APPENDIX 12.3-A2
9	REMOVING SHAFT OBSTRUCTION	-	EST	-	$ 87,950	BDM APPENDIX 12.3-A2
10	BRIDGE APPROACH SLAB	1044	SY	$ 350	$ 365,400	BDM APPENDIX 12.3-A1
11	GRAVEL BORROW FOR STRUCTURAL EARTH WALL	5926	CY	$ 60	$ 355,556	WSDOT UBA
12	SCOUR PROTECTION	250000	LS	1	$ 250,000	costs provided by NHC (rounded up)
13	MOBILIZATION	1	LS	1	$ 983,415	
			40 % CONTINGENCY		$ 4,327,026	
				TOTAL=	$ 15,144,591	
OPTION 5: 4 - PRESTRESSED CONCRETE SPANS (TOTAL LENGTH = 610')						
1	PRESTRESSED CONCRETE GIRDERS	21960	SF	$ 350.00	$ 7,686,000	BDM APPENDIX 12.3-A1
2	STRUCTURE EXCAVATION CLASS A INCL. HAUL	444	CY	$ 12	$ 5,333	BDM APPENDIX 12.3-A2
3	ST. REINF. BAR	64800	LB	$ 1	$ 64,800	BDM APPENDIX 12.3-A2
4	CONC. CLASS 4000 (COLUMNS)	3600	CY	$ 250	$ 900,000	BDM APPENDIX 12.3-A2
5	CONC. CLASS 4000 (ABUT. & RET. WALLS)	160	CY	$ 450	$ 72,000	BDM APPENDIX 12.3-A2
6	SHAFTS (CONSTRUCTING - FT. DIAM SHAFT (4' TO 6' DIA.)	1250	LF	$ 2,500	$ 3,125,000	BDM APPENDIX 12.3-A2
7	QA SHAFT TEST	15	EA	$ 1,000	$ 15,000	BDM APPENDIX 12.3-A2
8	REMOVING SHAFT OBSTRUCTION	-	EST	-	$ 157,000	BDM APPENDIX 12.3-A3
9	BRIDGE APPROACH SLAB	210	SY	$ 350	$ 73,500	BDM APPENDIX 12.3-A1
10	SCOUR PROTECTION	180000	LS	1	$ 180,000	costs provided by NHC (rounded up)
11	MOBILIZATION	1	LS	1	$ 1,227,863	
			40 % CONTINGENCY		$ 5,402,599	
				TOTAL=	$ 18,909,095	
OPTION 6: 3 - STEEL GIRDER SPANS (TOTAL LENGTH = 610')						
1	STEEL GIRDER	21960	SF	$ 400.00	$ 8,784,000	BDM APPENDIX 12.3-A1
2	STRUCTURE EXCAVATION CLASS A INCL. HAUL	444	CY	$ 12	$ 5,333	BDM APPENDIX 12.3-A2
3	ST. REINF. BAR	52800	LB	$ 1	$ 52,800	BDM APPENDIX 12.3-A2
4	CONC. CLASS 4000 (COLUMNS)	2400	CY	$ 250	$ 600,000	BDM APPENDIX 12.3-A2
5	CONC. CLASS 4000 (ABUT. & RET. WALLS)	160	CY	$ 450	$ 72,000	BDM APPENDIX 12.3-A3
6	SHAFTS (CONSTRUCTING - FT. DIAM SHAFT (4' TO 6' DIA.)	1250	LF	$ 2,500	$ 3,125,000	BDM APPENDIX 12.3-A2
7	QA SHAFT TEST	12	EA	$ 1,000	$ 12,000	BDM APPENDIX 12.3-A2
8	REMOVING SHAFT OBSTRUCTION	-	EST	-	$ 156,850	BDM APPENDIX 12.3-A2
9	BRIDGE APPROACH SLAB	210	SY	$ 350	$ 73,500	BDM APPENDIX 12.3-A1
10	SCOUR PROTECTION	180000	LS	1	$ 180,000	costs provided by NHC (rounded up)
11	MOBILIZATION	1	LS	1	$ 1,306,148	
			40 % CONTINGENCY		$ 5,747,053	
				TOTAL=	$ 20,114,684	

Project: Savage Creek
By: KPFF
Date: 4/14/2025

ENGINEER'S QUANTITIES ESTIMATE

ITEM NO.	ITEM NAME	QUANTITY	UNIT	UNIT COST	TOTAL COST	NOTES/ASSUMPTIONS:
OPTION 1: SINGLE PRESTESSED CONCRETE SPAN (TOTAL LENGTH = 205')						
1	PRESTRESSED CONCRETE GIRDER	7380	SF	$ 350	$ 2,583,000	BDM APPENDIX 12.3-A1
2	STRUCTURE EXCAVATION CLASS A INCL. HAUL	1000	CY	$ 12	$ 12,000	BDM APPENDIX 12.3-A2
3	CONC. CLASS 4000 (ABUT. & RET. WALLS)	65	CY	$ 450	$ 29,167	BDM APPENDIX 12.3-A2
4	ST. REINF. BAR	11667	LB	$ 1	$ 11,667	BDM APPENDIX 12.3-A2
5	SHAFTS (CONSTRUCTING - FT. DIAM SHAFT (4' TO 6' DIA.)	400	LF	$ 2,500	$ 1,000,000	ASPECT INPUT
6	QA SHAFT TEST	6	EA	$ 1,000	$ 6,000	BDM APPENDIX 12.3-A2
7	REMOVING SHAFT OBSTRUCTION	-	EST	-	$ 50,300	BDM APPENDIX 12.3-A2
8	BRIDGE APPROACH SLAB	220	SY	$ 250	$ 55,000	BDM APPENDIX 12.3-A2
9	SCOUR PROTECTION	35000	LS	1	$ 35,000	costs provided by NHC
10	MOBILIZATION	1	LS	1	$ 369,213	
				40 % CONTINGENCY	$ 1,660,539	
				TOTAL=	$ 5,811,885	
OPTION 2: SINGLE STEEL SPAN (TOTAL LENGTH = 205')						
1	STEEL GIRDER	7380	SF	$ 400	$ 2,952,000	BDM APPENDIX 12.3-A1
2	STRUCTURE EXCAVATION CLASS A INCL. HAUL	1000	CY	$ 12	$ 12,000	BDM APPENDIX 12.3-A2
3	CONC. CLASS 4000 (ABUT. & RET. WALLS)	65	CY	$ 450	$ 29,167	BDM APPENDIX 12.3-A2
4	ST. REINF. BAR	11667	LB	$ 1	$ 11,667	BDM APPENDIX 12.3-A2
5	SHAFTS (CONSTRUCTING - FT. DIAM SHAFT (4' TO 6' DIA.)	400	LF	$ 2,500	$ 1,000,000	ASPECT INPUT
6	QA SHAFT TEST	6	EA	$ 1,000	$ 6,000	BDM APPENDIX 12.3-A2
7	REMOVING SHAFT OBSTRUCTION	-	EST	-	$ 50,883	BDM APPENDIX 12.3-A2
8	BRIDGE APPROACH SLAB	220	SY	$ 250	$ 55,000	BDM APPENDIX 12.3-A2
9	SCOUR PROTECTION	35000	LS	1	$ 35,000	costs provided by NHC
10	MOBILIZATION	1	LS	1	$ 411,672	
				40 % CONTINGENCY	$ 1,825,355	
				TOTAL=	$ 6,388,744	

OPTION 3: SINGLE PRESTESSED CONCRETE SPAN (TOTAL LENGTH = 175')								
1	SAVAGE CREEK SUPERSTRUCTURE	6300	SF	$ 350	$	2,205,000		BDM APPENDIX 12.3-A1
2	STRUCTURE EXCAVATION CLASS A INCL. HAUL	167	CY	$ 12	$	2,000		BDM APPENDIX 12.3-A2
3	CONC. CLASS 4000 (ABUT. & RET. WALLS)	65	CY	$ 450	$	29,167		BDM APPENDIX 12.3-A2
4	ST. REINF. BAR	11667	LB	$ 1	$	11,667		BDM APPENDIX 12.3-A2
5	SE WALL - PRECAST CONC. PANELS OR CONC. BLOCK	750	SF	$ 60	$	45,000		ASPECT INPUT
6	SHAFTS (CONSTRUCTING - FT. DIAM SHAFT (4' TO 6' DIA.)	400	LF	$ 2,500	$	1,000,000		BDM APPENDIX 12.3-A2
7	QA SHAFT TEST	6	EA	$ 1,000	$	6,000		BDM APPENDIX 12.3-A2
8	REMOVING SHAFT OBSTRUCTION	-	EST	-	$	53,133		BDM APPENDIX 12.3-A1
9	BRIDGE APPROACH SLAB	220	SY	$ 250	$	55,000		costs provided by NHC
10	SCOUR PROTECTION	35000	LS	1	$	35,000		
11	MOBILIZATION	1	LS	1	$	340,697		
				40 % CONTINGENCY	$	1,513,065		
				TOTAL=	$	5,295,729		
OPTION 4: SINGLE STEEL SPAN (TOTAL LENGTH = 175')								BDM APPENDIX 12.3-A1
1	SAVAGE CREEK SUPERSTRUCTURE	6300	SF	$ 400	$	2,520,000		BDM APPENDIX 12.3-A2
2	STRUCTURE EXCAVATION CLASS A INCL. HAUL	167	CY	$ 12	$	2,000		BDM APPENDIX 12.3-A2
3	CONC. CLASS 4000 (ABUT. & RET. WALLS)	65	CY	$ 450	$	29,167		BDM APPENDIX 12.3-A2
4	ST. REINF. BAR	11667	LB	$ 1	$	11,667		ASPECT INPUT
5	SE WALL - PRECAST CONC. PANELS OR CONC. BLOCK	750	SF	$ 60	$	45,000		
6	SHAFTS (CONSTRUCTING - FT. DIAM SHAFT (4' TO 6' DIA.)	400	LF	$ 2,500	$	1,000,000		BDM APPENDIX 12.3-A2
7	QA SHAFT TEST	6	EA	$ 1,000	$	6,000		BDM APPENDIX 12.3-A2
8	REMOVING SHAFT OBSTRUCTION	-	EST	-	$	50,300		BDM APPENDIX 12.3-A1
9	BRIDGE APPROACH SLAB	220	SY	$ 250	$	55,000		costs provided by NHC
10	SCOUR PROTECTION	35000	LS	1	$	35,000		
11	MOBILIZATION	1	LS	1	$	375,413		
				40 % CONTINGENCY	$	1,651,819		
				TOTAL=	$	5,781,365		

Northwest Hydraulic Consultants Inc.
301 W Holly St U-3
Bellingham, WA 98225
Tel: 206-241-6000

NHC Reference No. 2009051
January 17, 2025

KPFF Consulting Engineers
1601 5th Ave #1600
Seattle, WA 98101

Attention: Anne Fabrello-Streufert, Project Manager (KPFF)
Via email: Anne.Fabrello-Streufert@kpff.com

Re: Mill Creek at South Skagit Highway Phase 1 Design
Geomorphic Summary

Dear Ms. Fabrello-Streufert:

NHC is assisting KPFF with the preliminary design of a reroute of the South Skagit Highway to cross Mill and Savage Creeks at more favorable locations away from an area of complex alluvial fan-floodplain interaction that has led to a poor level of service and high maintenance burden at those crossings (Figure 1). NHC is providing Hydrologic, Hydraulic, and Geomorphic analysis to support this design. Section 1 of this technical memo outlines key observations supporting the decision to move Mill Creek Bridge out of the zone of aggradation. The realigned road will also result in moving the crossing location over Savage Creek and removal of the South Skagit Highway embankment that affects wetlands and constrains hydraulic and geomorphic processes across approximately 100 acres of Skagit River Floodplain.

1 MILL CREEK SITE GEOMORPHIC HISTORY

Rapid accumulation of sediment in Mill Creek at and downstream of the South Skagit Highway crossing has almost completely filled the bridge opening over the past four decades (Figure 1). This accumulation has resulted from interaction between channel changes in the Skagit River and high sediment supply from Mill Creek. Understanding this history will help guide the prediction of future channel change, understanding of possible future flood scenarios, and determinations about preferred crossing locations.

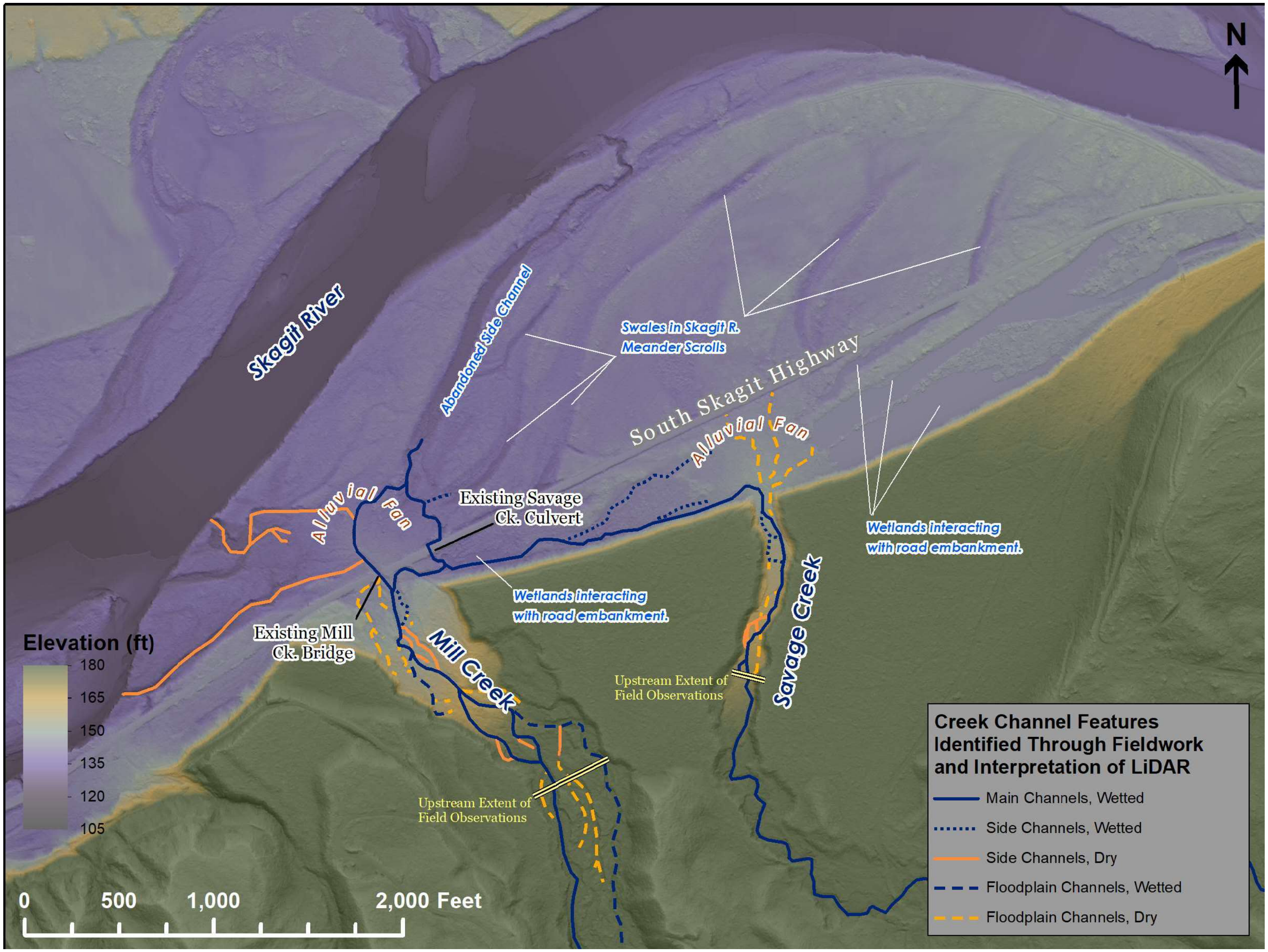


Figure 1: Overview map of Mill and Savage Creeks and Skagit River Floodplain between the creek fans and river

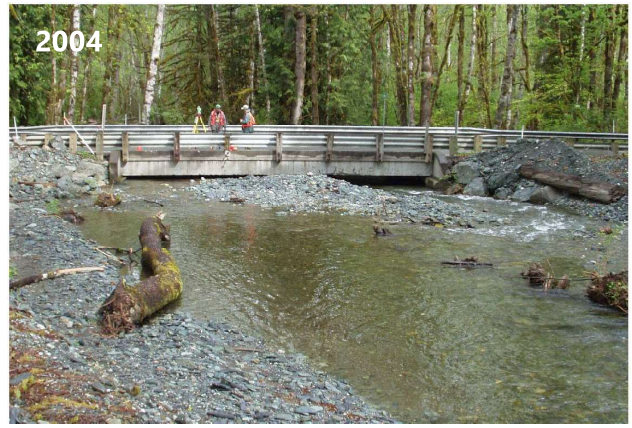


Figure 2: Photos of the Mill Creek Crossing between 1972 and 2024. 1972 to 2004 photos from NHC (2004).

1.1 Mill Creek Interactions with Skagit River

Aerial photos of the site in 1972 (Figure 2) show that a large (~150 ft wide) side channel of the Skagit River meandered to a position about 240 ft northwest of the Mill Creek crossing location and that Mill Creek had built a small delta-fan bar into this side channel. Before this time, periodic high flows in the Skagit River likely transported most of the sediment supplied by Mill Creek out of this side channel, keeping it open. Between 1972 and 1985, however, the slow accumulation of sediment at the mouth of Mill Creek reduced the capacity of flow through the side channel to carry away sediment supplied by Mill Creek, creating a positive feedback cycle where sediment accumulation reduced the amount of flow through the side channel, further driving additional sediment accumulation. By 1985, the Mill Creek delta-fan had prograded completely across the side channel and blocked throughflow from the Skagit River (Figure 2). After this, all the sediment supplied by Mill Creek was deposited locally and Mill Creek began building a larger alluvial fan through a sequence of avulsions downstream of the South Skagit Highway, driving aggradation of the bed at the crossing.

This sequence explains the history of aggradation at the Mill Creek crossing. Substantial aggradation began around 1985, when the side channel closed, and aggradation thereafter proceeded rapidly until the 1990s, after which periodic sediment removals were necessary to maintain flow through the bridge.

Comparison of recent (2017-2023) shows that sediment accumulation remains focused on the Mill Creek fan near and downstream of the crossing, with little channel profile change occurring from above about 600 ft upstream of the current crossing. The proposed Mill Creek bridge will be located upstream of this aggradation zone.

Upstream of this aggradation zone, Mill Creek has an anabranching planform with numerous side channels and floodplain channels. The creek is locally perched above the valley bottom, and avulsions into any of these channel features may occur.

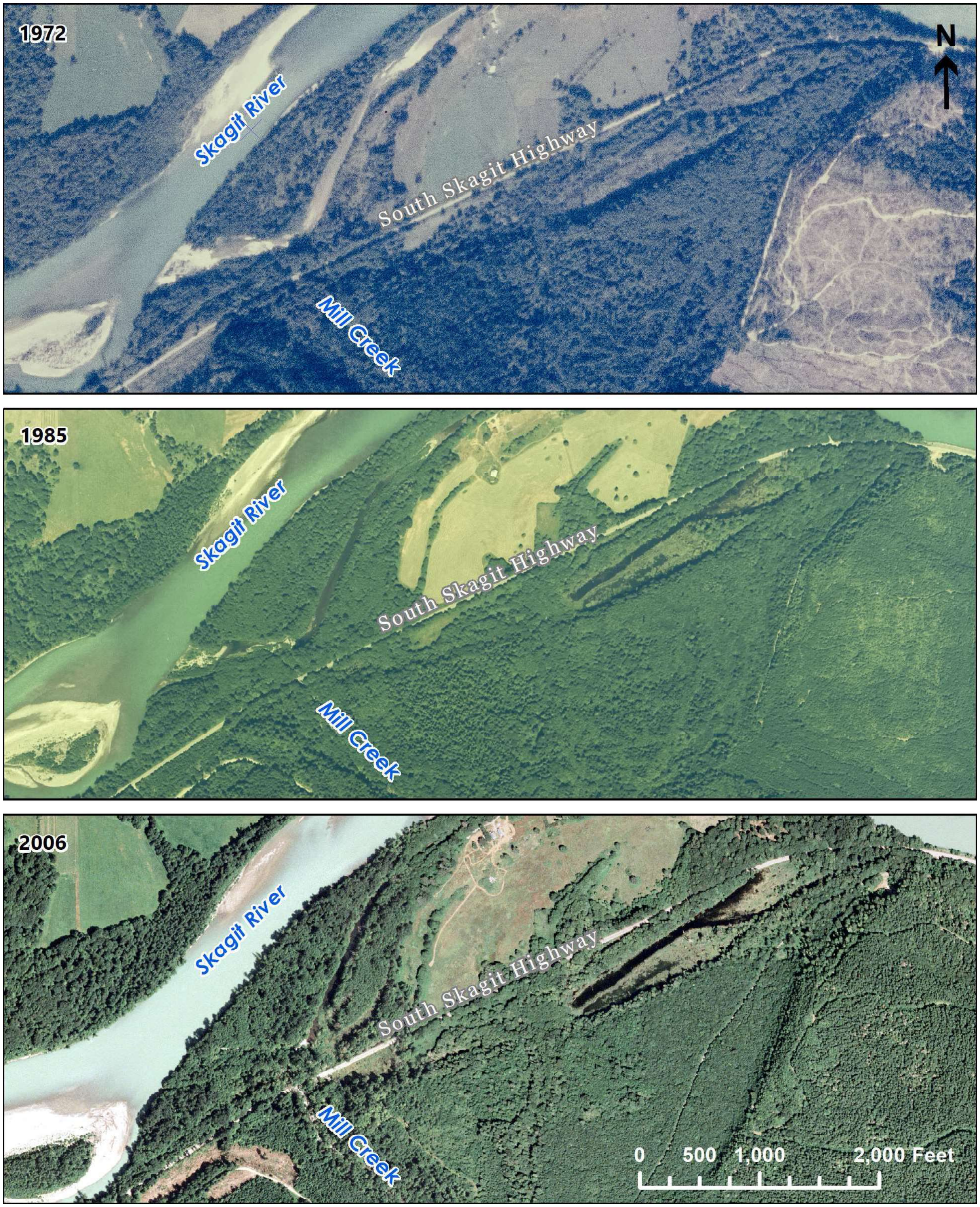


Figure 3: Aerial photos showing closure of the Skagit River side channel at Mill Creek confluence.

1.2 2002 Hydrogeomorphic Flood

A particularly important flood occurred in 2002, when a rain-on-snow flood generated numerous landslides throughout the Mill Creek Basin which introduced a large volume of sediment and large wood to the creek and generated a combined debris flow and bridge-dam failure outburst flood (Grizzel, 2002). In addition to supplying sediment to the South Skagit Highway Crossing over the creek, wood entrained by the flood formed very large jams across the creek upstream of the crossing (Grizzel 2002; Figure 3). Because debris flows move faster than flood waves and entrain material from along their paths, the peak discharges in such events can be much higher than typical hydrometeorological floods (Jakob et al., 2015) and the combined effects of the wood jams and large flood peak raised water levels enough to scour channels through terraces well above the channel elevation (Grizzel, 2002). Preliminary estimates indicate that the peak discharge of the 2002 event was potentially an order of magnitude higher than the estimated 100-year recurrence interval flood generated solely from hydrometeorological processes. Field observations from 2024 and interpretation of LiDAR show this terrace (the T1 terrace on the right bank between RM 0.45 and 0.8 in Figure 3) was located at an elevation of six to eight feet above the channel. Published observations of the event do not include estimates of the debris flow volume or peak instantaneous discharge; however, using a hydraulic model and quantitative calculations, we estimate discharge could have been bout 8,000 cfs ± 5,000 cfs. The proposed bridge will be designed to withstand such a discharge.

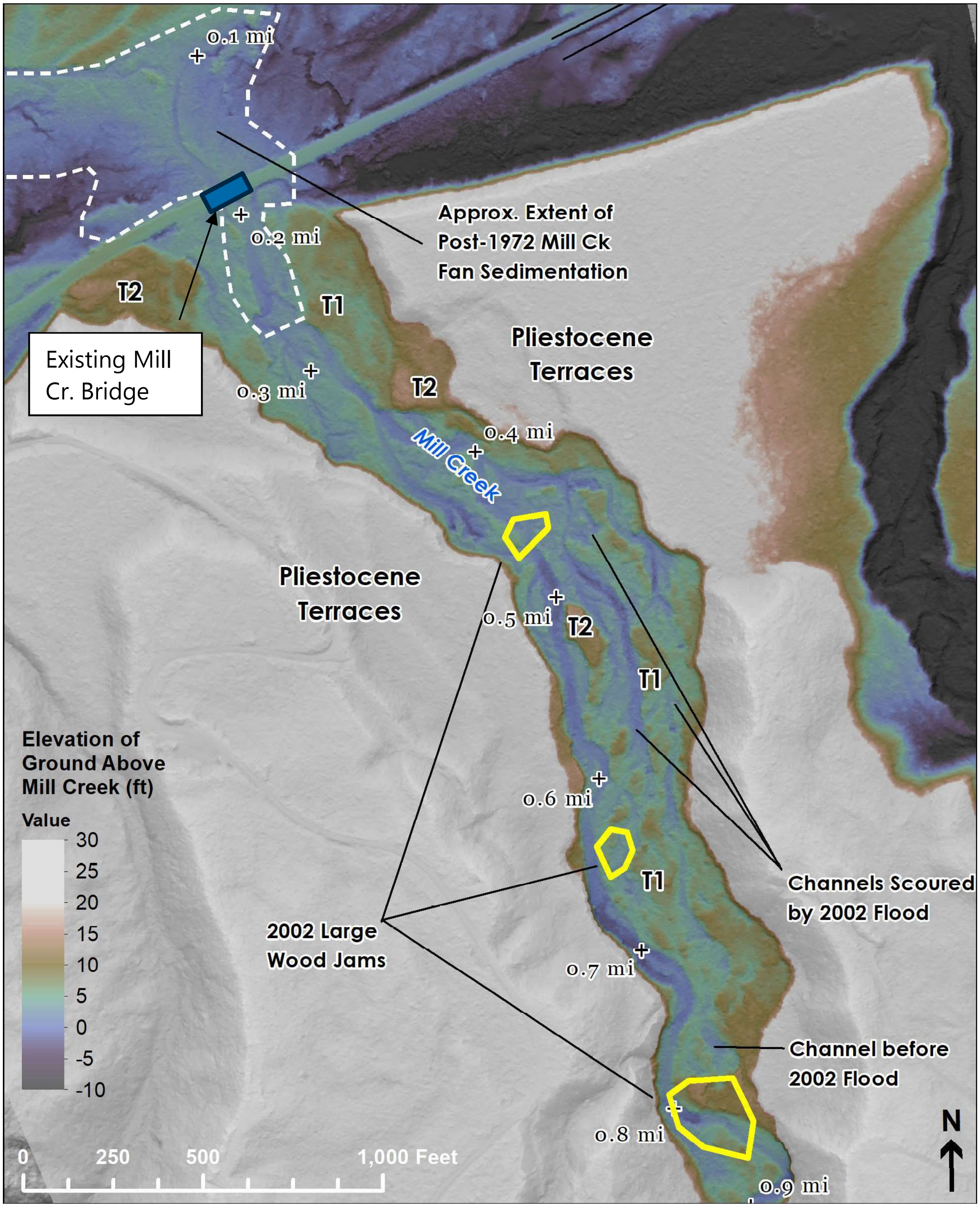


Figure 4: Relative elevation model of mill creek with key features from the 2002 hydrogeomorphic flood, identified by Grizzel (2002), and select other valley bottom geomorphic features annotated.

2 SAVAGE CREEK AND SKAGIT RIVER FLOODPLAIN

Savage Creek debouches from an approximately 300 to 400 ft wide valley that is deeply incised below Pleistocene terraces into the Skagit River Floodplain approximately 2,000 ft upstream of the current Savage Creek culvert under the South Skagit Highway. At this point, it has built up an alluvial fan (Figure 1) that extends to the north. The South Skagit Highway cuts through this fan. In some places the fan was lowered to meet the highway grade, while in others fill was placed blocking potential Savage Creek flow paths and impounding several large ponds and wetlands that lie between the Savage Creek Alluvial fan, terrace escarpment, and South Skagit Highway. Presently, Savage Creek turns abruptly to the west at the fan apex and follows a westerly alignment before entering another pond and wetland that are controlled by interactions between the Mill Creek alluvial fan, South Skagit Highway embankment, and Savage Creek culvert (Figure 1). Given this geomorphic and hydraulic setting, removing the South Skagit Highway embankment opens the possibility of Savage Creek occupying a large area of the Skagit River Floodplain where it may flow between various meander scroll swales across the floodplain.

In the valley upstream of the alluvial fan, the mainstem and side channels of Savage Creek generally anabranch across the entire valley bottom (Figure 1). In many areas, the channel is very wide (on the order of 40-60 ft), poorly defined, and surrounded by very low wet floodplain, while in some areas is slightly more channelized and occupies a 25-35 ft wide channel. Where the main channel abuts the valley wall, cutbanks readily erode into the valley wall toe, indicating the creek is actively expanding the valley bottom.

CLOSURE

We trust this report meets your needs. If you have any questions or requests, please feel free to contact the undersigned.

Sincerely,

Northwest Hydraulic Consultants Ltd.

Report prepared by	**Report under review by**
Unsigned draft by	*Unsigned draft by*
Andrew Nelson, LG Principal Geomorphologist	Derek Stuart, P.E. Principal-in-Charge

NHC File Path: "B:\2009051_Mill_Creek_at_South_Skagit_Highway_Phase_1\03_Geomorphology\GeomorphContextSummary_Edited for NOAA Grant.docx"

REFERENCES

Grizzel, J. (2002 April). *The Mill Creek Debris Torrent: Just Where Did All that Sediment Come From*. [online] Available from: NHC project files.

Jakob, M., Clague, J. J., and Church, M. (2015). Rare and dangerous: Recognizing extra-ordinary events in stream channels. *Canadian Water Resources Journal / Revue canadienne des ressources hydriques*, 1–13. doi:10.1080/07011784.2015.1028451.

NHC (2004). *Mill Creek Bridge 40086 South Skagit Highway Sediment Management / Flood Protection Preliminary Report*. Report Prepared by Northwest Hydraulic Consultants for Skagit County Department of Public Works.

DISCLAIMER

This report has been prepared by Northwest Hydraulic Consultants Ltd. for the benefit of KPFF Consulting Engineers for specific application to the Mill Creek at South Skagit Highway Phase 1 Design. The information and data contained herein represent **Northwest Hydraulic Consultants Inc.'s** best professional judgment in light of the knowledge and information available to **Northwest Hydraulic Consultants Inc's.** at the time of preparation and were prepared in accordance with generally accepted engineering and geoscience practices.

Except as required by law, this report and the information and data contained herein are to be treated as confidential and may be used and relied upon only by KPFF Consulting Engineers, its officers, and employees. **Northwest Hydraulic Consultants Inc's.** denies any liability whatsoever to other parties who may obtain access to this report for any injury, loss, or damage suffered by such parties arising from their use of or reliance upon this report or any of its contents.