GEOLOGIC HISTORY OF SKAGIT VALLEY

Years Ago	Volcano	Event
6,000,000		Cascade Mountain range began to uplift.[8]
2,000,000		Northern Washington was buried by several continental ice sheets.8
14,000	GP	Oldest known deposits are in the White Chuck River Valley.[1] Glaciers began retreating.[10]

SOURCES:

1. Postglacial Volcanic Deposits at Glacier Peak, Washington, and Potential Hazards from Future Eruptions, by James E. Beget, (1982, Open File Report 82-830
2. Soil survey TransMountain pipeline (1989).
3. Prehistoric Settlement Changes in the Southern Northwest Coast: A Functional Approach, by Gail Thompson, Ph.D.., (1978), Geological Survey Professional Paper 1022C
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8. Northwest Volcanoes, A Roadside Geologic Guide, Lanny Ream, (1983)
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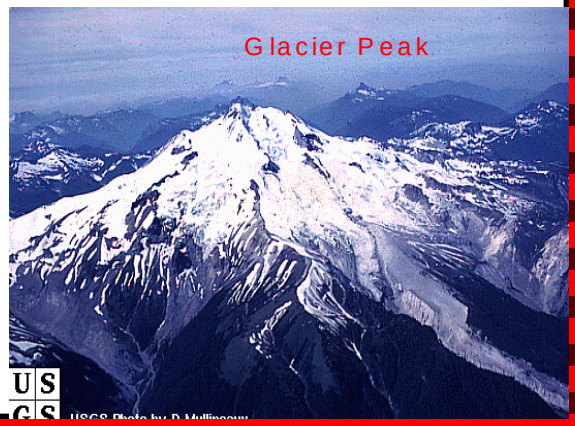

GEOLOGIC HISTORY OF SKAGIT VALLEY

Years Ago	Volcano	Event
13,000		Sea level was 600 ft above present location. Deposition of estuarine and deltaic sediments began. Discharge of sediment materials would have begun around Hamilton.[3]
12,000	GP	Violent eruption depositing widespread layers of ash.[7]
12-11,000		Sea level drops rapidly and becomes relatively stable.[3]

SOURCES:

1. Postglacial Volcanic Deposits at Glacier Peak, Washington, and Potential Hazards from Future Eruptions, by James E. Beget, (1982, Open File Report 82-830
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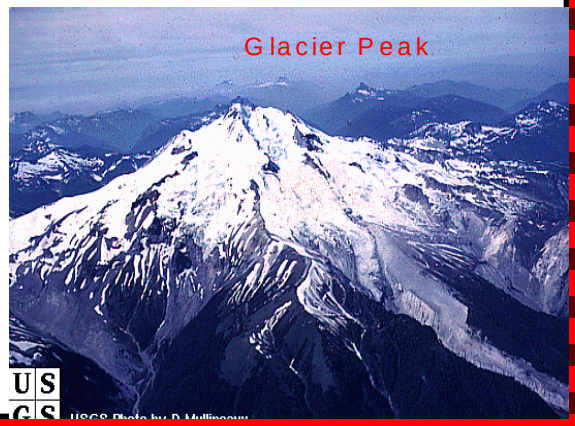

GEOLOGIC HISTORY OF SKAGIT VALLEY

Years Ago	Volcano	Event
11,500	GP	White Chuck assemblage Lahar travels 100 km (62 miles) down Stillaguamish River Valley to Arlington. Changed the flow of the Sauk River near Darrington from the Stillaguamish River to the Skagit River. Lahar can be observed 1.8 miles west of Arlington.[1] Volcano remains dormant for approximately 5,700 years.
10,350	BAKER	Mount Baker erupts. Grayish brown to black ash. Prior to eruption large mudflow moves down Sulphur Creek Valley.[4]
10,000	BAKER	Boulder Creek valley was free of ice below 4,000 ft.[4]

SOURCES:

1. Postglacial Volcanic Deposits at Glacier Peak, Washington, and Potential Hazards from Future Eruptions, by James E. Beget, (1982, Open File Report 82-830
2. Soil survey TransMountain pipeline (1989).
3. Prehistoric Settlement Changes in the Southern Northwest Coast: A Functional Approach, by Gail Thompson, Ph.D.., (1978), Geological Survey Professional Paper 1022C
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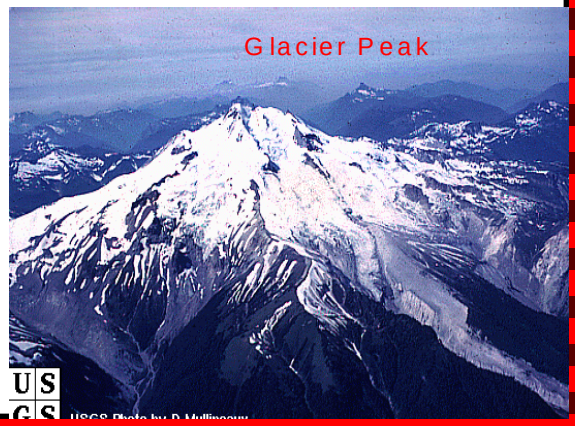

GEOLOGIC HISTORY OF SKAGIT VALLEY

Years Ago	Volcano	**Event**
9,000-5,000		Sea level lowers 30 to 60 feet. The Skagit Delta builds out first into Samish Bay.3 This area is referred to as the Northern Lobe and has been inactive for 5,000 years.[6]
8,700	BAKER	Pyroclastic flows, mudflows, and two lava flows moved down Boulder Creek valley. Some of the flows reached Baker River.[4,8]
8,400	GP	Trees grew at elevation 5,700 feet. Charcoal deposits carbon dated. Sub-alpine fir trees grow today up to a few hundred feet above this level.[1]

SOURCES:

1. Postglacial Volcanic Deposits at Glacier Peak, Washington, and Potential Hazards from Future Eruptions, by James E. Beget, (1982, Open File Report 82-830
2. Soil survey TransMountain pipeline (1989).
3. Prehistoric Settlement Changes in the Southern Northwest Coast: A Functional Approach, by Gail Thompson, Ph.D.., (1978), Geological Survey Professional Paper 1022C
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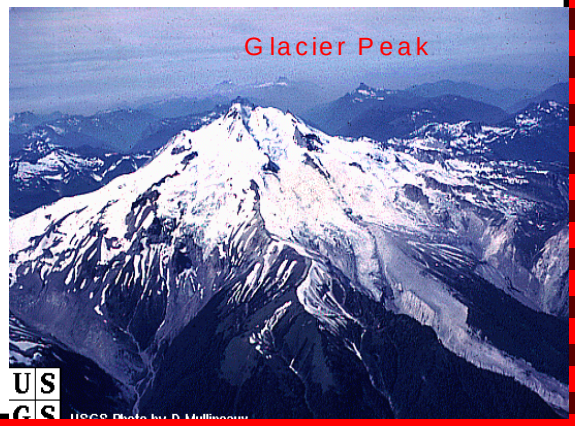

GEOLOGIC HISTORY OF SKAGIT VALLEY

Years Ago	Volcano	Event
6,000	BAKER	Very large mudflow moved 17.5 miles down the Nooksack Valley, large mudflow (lava) moved at least 7.2 miles down Sulphur Creek valley.4 The lava (Sulphur Creek) reached Baker River and forced it against its east bank.[8]
5,500-5,100	GP	Lahar from Kennedy Creek assemblage travels 100 km (62 miles) down the Skagit. Lahar also located in Dusty Creek assemblage which also traveled down the Skagit. Very possible both lahar assemblages were affected by damning of both the White Chuck and Suiattle Rivers. Lake created on the Suiattle was at least 45' deep.[1]

SOURCES:

1. Postglacial Volcanic Deposits at Glacier Peak, Washington, and Potential Hazards from Future Eruptions, by James E. Beget, (1982, Open File Report 82-830
2. Soil survey TransMountain pipeline (1989).
3. Prehistoric Settlement Changes in the Southern Northwest Coast: A Functional Approach, by Gail Thompson, Ph.D.., (1978), Geological Survey Professional Paper 1022C
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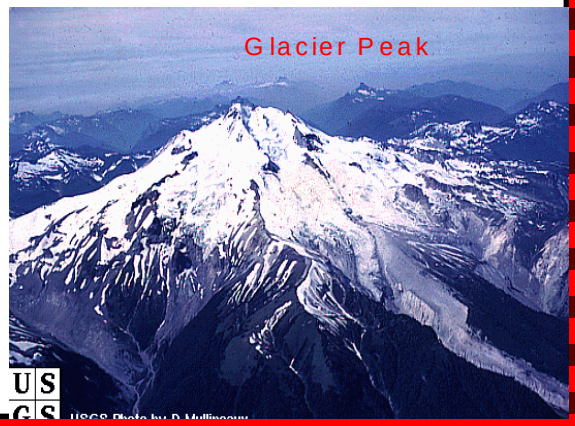

GEOLOGIC HISTORY OF SKAGIT VALLEY

Years Ago	Volcano	**Event**
3,000		Western (Burlington & West Mt. Vernon) and Southern (South Mt. Vernon & Fir Island) lobes of Skagit Delta were created within last 3,000 years, first to Padilla Bay and then to Skagit Bay. The delta engulfed several islands, Burlington Hill, Bay View Ridge, & finally Pleasant Ridge.[3]
2,000-1,500		Anthropologist suggest Indian settlements began along Skagit River tributaries. One such site has been identified along Dry Slough on Fir Island.[3]
1,800	GP	Lahar reaches Sauk River down White Chuck. Believed to have been triggered by large landslide high on Glacier Peak. Clay Lahar 100 m (328 ft) thick travels down Dusty Creek Valley.[1]

SOURCES:

1. Postglacial Volcanic Deposits at Glacier Peak, Washington, and Potential Hazards from Future Eruptions, by James E. Beget, (1982, Open File Report 82-830
2. Soil survey TransMountain pipeline (1989).
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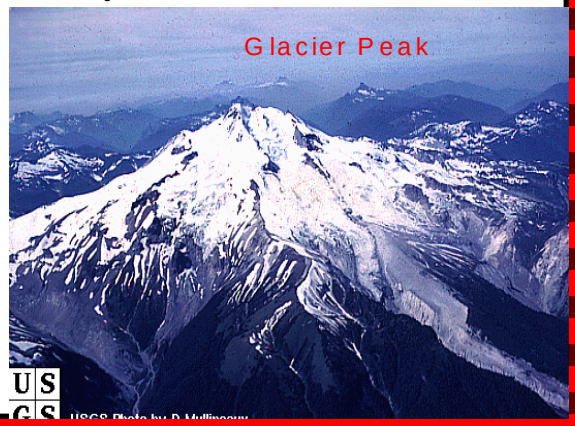

GEOLOGIC HISTORY OF SKAGIT VALLEY

Years Ago	Volcano	**Event**
1,750	GP	"Red" Lahar travels down White Chuck River near Crystal Creek carrying dacite-rich alluvium which underlies the town of Burlington which contains charcoal about 1,800 years old. Estimated that lahar was caused by violent eruption of Glacier Peak which produced 100 million cubic meters (130,000,000 cubic yards) of material.[1] The depth of volcanic material is between 3-30 feet thick.[2] Several small towns in the lower Skagit River valley are built on volcanogenic sedimentary deposits of this age.[10]

SOURCES:

1. Postglacial Volcanic Deposits at Glacier Peak, Washington, and Potential Hazards from Future Eruptions, by James E. Beget, (1982, Open File Report 82-830
2. Soil survey TransMountain pipeline (1989).
3. Prehistoric Settlement Changes in the Southern Northwest Coast: A Functional Approach, by Gail Thompson, Ph.D.., (1978), Geological Survey Professional Paper 1022C
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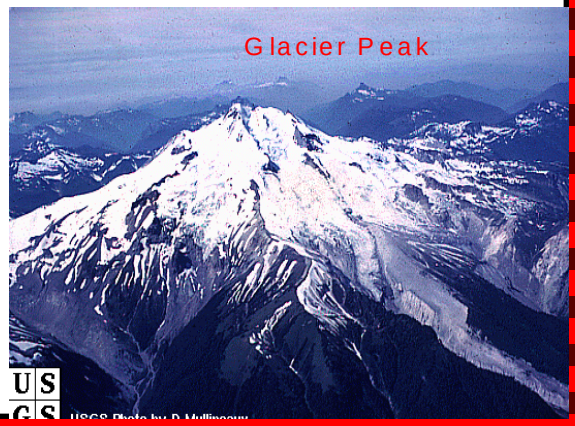

GEOLOGIC HISTORY OF SKAGIT VALLEY

Years Ago	Volcano	Event
1,100	GP	"Remarkable" flood travels down White Chuck River creating large flood plain deposits down the Sauk River. Flood believed to have been caused by glacier-outburst. Two clay light-gray lahars travel down Dusty Creek. Lahars also travel down Chocolate Creek. Possible large flood was related to eruption but no "unequivocal evidence" to support theory.[1]
600	BAKER	Gray and rusty brown mudflow travels down Park Creek to Baker River. Estimated volume of 2 million cubic meters (2,600,000 cubic yards). Probably caused by avalanches of hydrothermally altered rock. No fewer than four avalanches and mudflows have occurred at Baker during the last 600 years.4 Flow can be viewed where Baker Lake Road crosses Park Creek.8

SOURCES:

1. Postglacial Volcanic Deposits at Glacier Peak, Washington, and Potential Hazards from Future Eruptions, by James E. Beget, (1982, Open File Report 82-830
2. Soil survey TransMountain pipeline (1989).
3. Prehistoric Settlement Changes in the Southern Northwest Coast: A Functional Approach, by Gail Thompson, Ph.D.., (1978), Geological Survey Professional Paper 1022C
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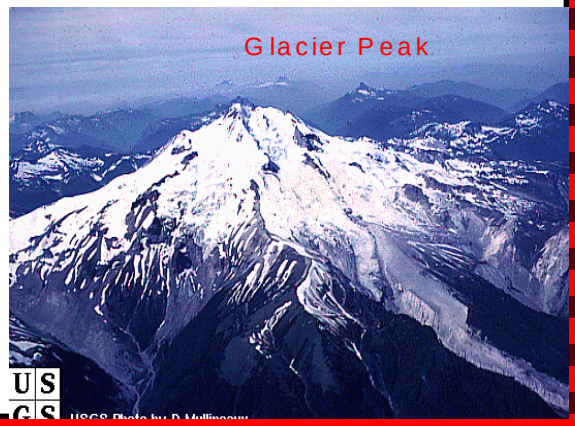

GEOLOGIC HISTORY OF SKAGIT VALLEY

Years Ago	Volcano	Event
450-150	BAKER	Rock debris erupts from Baker, two large mudflows moved 6.5 miles down Boulder Creek valley, large avalanche of rock debris moved at least 5.4 miles down Rainbow Creek valley.[4]
300-200	GP	Small eruptions. Indians reported to pioneers of seeing mountain smoking.[1] Evidence of a very large flood taking place in this time frame.[10]
>200	GP	Two small lahars in Chocolate Creek.[1]
64	GP	In 1938 a lahar buried and destroyed forests as much as 6 miles down Chocolate Creek from Chocolate Glacier. Flooding was observed far down the Suiattle and Sauk Rivers. Caused by glacier-outburst flood.[1]

SOURCES:

1. Postglacial Volcanic Deposits at Glacier Peak, Washington, and Potential Hazards from Future Eruptions, by James E. Beget, (1982, Open File Report 82-830
2. Soil survey TransMountain pipeline (1989).
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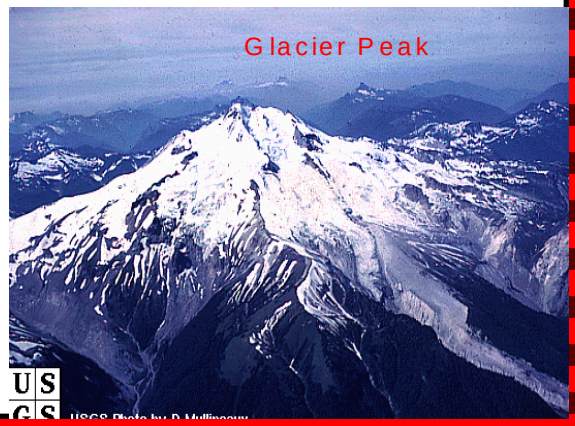

GEOLOGIC HISTORY OF SKAGIT VALLEY

Years Ago	Volcano	Event
29	BAKER	In 1975 increased steam vent activity at Sherman Crater.[4]
24	GP	On June 20, 1980 a small lahar traveled down Dusty Creek to the Suiattle River. Bark was stripped from the trees and mud was deposited on trees and the valley walls of Dusty Creek as much as 3.3 feet above the lahar. It buried about 220,000 sq ft of riverbank and adjacent forest. The volume of material was estimated at 10,000 cubic meters (13,000 cubic yards).[1]
11	GP	On August 17, 1993 the Skagit River ran chocolate brown. The cause, a small glacier outburst flood and resulting mudflow down Chocolate and Dusty Creek's.

SOURCES:

1. Postglacial Volcanic Deposits at Glacier Peak, Washington, and Potential Hazards from Future Eruptions, by James E. Beget, (1982, Open File Report 82-830
2. Soil survey TransMountain pipeline (1989).
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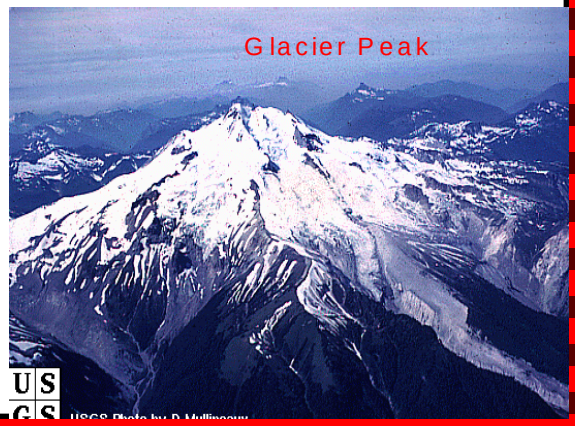

GEOLOGIC HISTORY OF SKAGIT VALLEY

In 1792 Spanish explorers in Bellingham Bay reported "illumination and rumblings emanating from Mount Baker" and left as quickly as they possibly could.

Ed Coleman, who first climbed Baker in 1866 quoted an old Indian who recalled when he was a boy the mountain burst out with a terrible fire and great smoke poisoning the fish in the Skagit River (approx. 1810).

John Hiaton, Pacific Northwest Indian, claimed to have witnessed eruptions of Mt. Baker "about 1820". In 1843 Indians reported stories of an eruption that resulted in a massive fish kill in Baker River, volcanic ash, and a large forest fire east of the volcano.

In 1858 local miners reported lava and apparent lahar reaching Baker River.[5] Accepted dates of volcanic activity at Mt. Baker are 1843, 1854, 1858, 1859, and 1870.

SOURCES:

1. Postglacial Volcanic Deposits at Glacier Peak, Washington, and Potential Hazards from Future Eruptions, by James E. Beget, (1982, Open File Report 82-830
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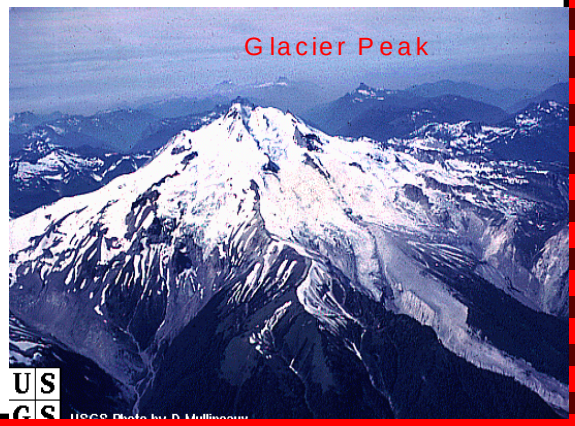


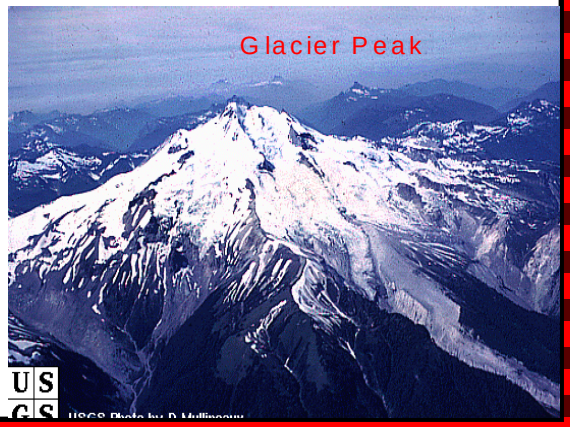
WHAT DOES IT ALL MEAN??

Volcanic-Hazards Assessment

Future eruptions of large volume are likely to form thick fills of lahars and pyroclastic-flow deposits in the upper parts of valleys that head on the volcano. Subsequent incision of these deposits would aggrade valley floors farther downstream with sediment for many years after the eruption, thereby affecting the capacity of stream channels and locally increasing heights of floods.

THESE EFFECTS WOULD BE ESPECIALLY SIGNIFICANT FOR THE EXTENSIVE LOW-LYING AREAS OF THE SKAGIT RIVER FLOOD PLAIN AND DELTA.

SOURCE: *Volcanic Hazards With Respect To Siting Nuclear Power Plants In The Pacific Northwest*, USGS Open File Report 87-297 (1987)



Skagit River Basic Facts

- Drainage Basin = 3,140 Sq.. Miles = 2,009,600 Acres
- 100 Year Flood = 236,000 C.F.S. At Sedro-Woolley
- 1 C.F.S. = 7.5 Gallons = 1,770,000 Gallons Per Second - 106,200,000 Gallons Per Minute = 6,372,000,000 Gallons Per Hour
- One C.F.S. flowing for 24 hours will cover 2 acres to a depth of one foot
- There are 68,000 acres in the Lower Skagit River Valley
- One Acre Foot = One acre to a depth of one foot = 325,000 Gallons

Source: U.S. Army Corps of Engineers

Skagit River Basic Facts

- **Skagit River is potentially the most damaging river in the Pacific Northwest.**
- **November 1995 Flood - Skagit County had 25% of all FEMA Public Assistance costs statewide, 24% of Emergency Housing, 33% Individual Grants, 29% SBA loans, 22% Flood Insurance claims.**
- **1990 Flood: Skagit County had 47% of all damages in the State of Washington (COE).**
- **AT LEAST 30% OF ALL SKAGIT COUNTY RESIDENTS ARE IN THE FLOODPLAIN VS. 6% STATEWIDE; GREATER PERCENTAGE IN THE DELTA.**

Source: Federal Emergency Management Agency (FEMA)

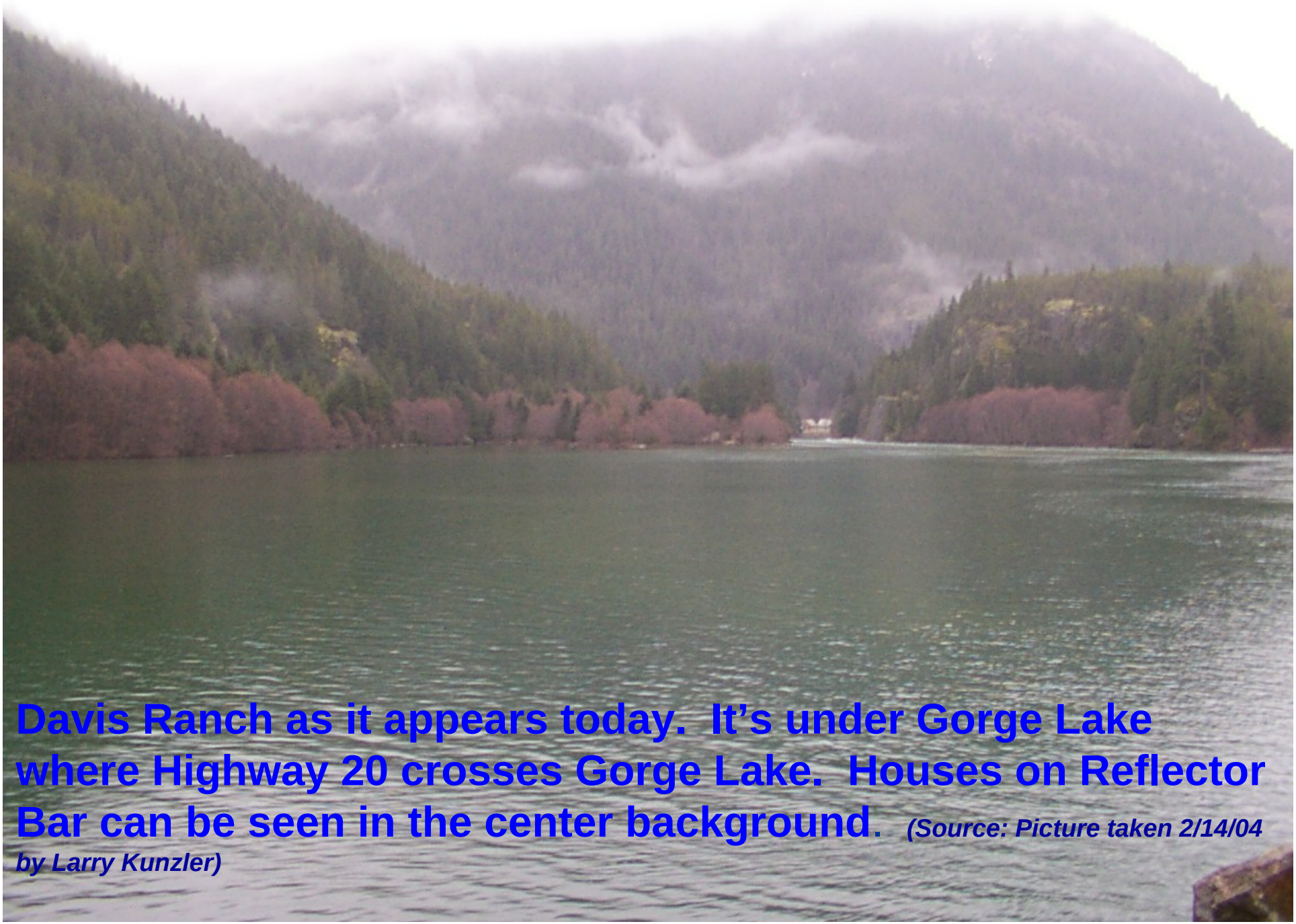
Major Flood History

Year	Flow in Cubic Feet Per Second (C.F.S)
About 1815	400,000 at Sedro Woolley
About 1856	300,000 at Sedro Woolley
1897	190,000 at Sedro Woolley
1909	220,000 at Sedro Woolley
1921	210,000 at Sedro Woolley
1951	144,000 at Mount Vernon
1975	130,000 at Mount Vernon
1990	152,000 at Mount Vernon 146,000 Concrete
1995	145,000 at Mount Vernon 160,000 Concrete
2003	129,000 at Mount Vernon 166,000 Concrete

Source: U.S. Army Corps of Engineers

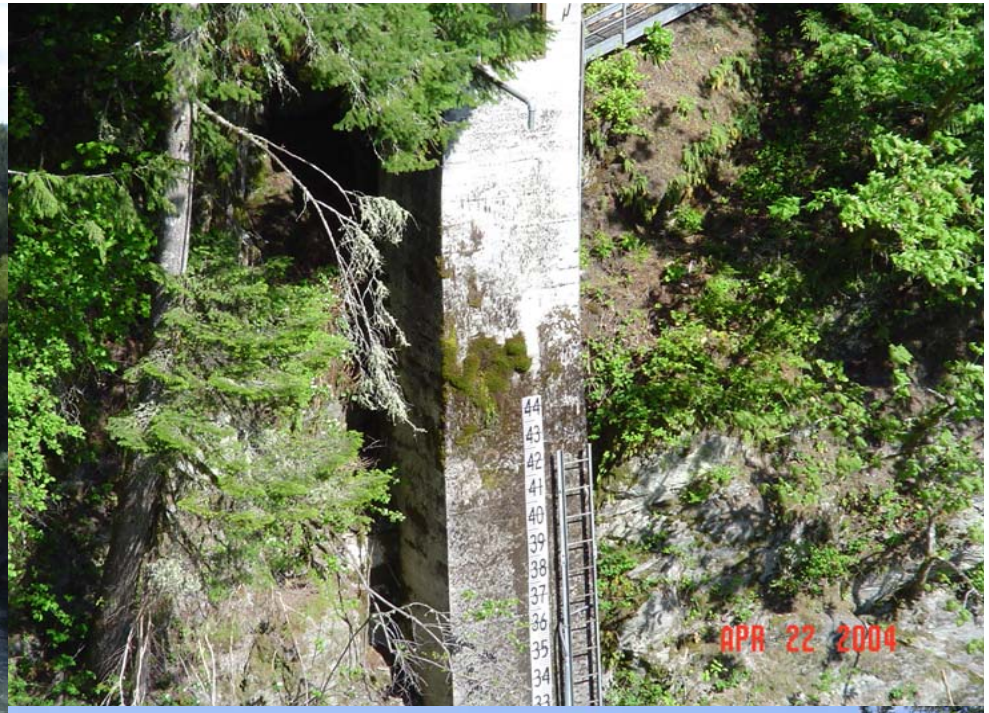
Description: General view of Reflector Bar
Date: Dec 16, 1954

Description: Skagit Damage, Davis Ranch Range Station
Date: Mar 29, 1927



Davis Ranch as it appears today. It's under Gorge Lake where Highway 20 crosses Gorge Lake. Houses on Reflector Bar can be seen in the center background. ***(Source: Picture taken 2/14/04 by Larry Kunzler)***


APR 22 2004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JAMES E. STEWART 1923 PRELIMINARY REPORT – FIELD JOURNAL NOTES

Page 23 Leonard Everett says 1897 flood about 9 inches lower than 1909. **Says that log jam in The Dalles raised water 10 feet in 2 hours.** Considerable distance and slope between 1897 and 1909 and 1921 marks. 1897 1.4 feet higher.

Page 62 Measuring the lengths of rope in Dalles. Found first 100 feet only 95 feet due to shrinkage in rope. Rope probably about okay for the two Dalles sections, as it was graduated while dry but not stretched, while it was used wet and stretched.

Page 69 Checks on rope graduation were made while rope was still stretched across river. It is not certain that these checks are applicable to the lower cross sections also but probably will have to be **assumed so**.

Page 100 Ed Presentine says 1897 flood 6 inches higher than 1909 at Rockport. Says **Indians claim 1897 flood highest on Sauk of all times.**

(Source: James E. Stewart "Field Journal", beginning entry November 24, 1922)

Place	Date	Difference	Other data
Rockport	[illegible]	2.2	[illegible]
Sauk	[illegible]	2.2	[illegible]
R. Larsen [illegible]	[illegible]		[illegible]
Fabre Ferry	[illegible]	2.2	1921: 255
Lake Larsen	[illegible]	1.2	[illegible]
Robertson [illegible]	[illegible]	1.3	[illegible]
Watts	[illegible]	1.2	[illegible]
Just above Dalles	[illegible]	1.3	[illegible]
At the head of the Dalles	[illegible]	[illegible]	[illegible]
At lower end of the Dalles	[illegible]	1.3	[illegible]
At upper end of slope section	[illegible]	1.6	[illegible]
At lower end of slope section	[illegible]	2.0	[illegible]
At BM #6	[illegible]		
At [illegible] Road	[illegible]	1.3 / 1.2	[illegible]
At [illegible] Ferry	[illegible]	1.2	[illegible]
Savage Ranch	[illegible]	[illegible]	[illegible]
Hammerich Ranch	[illegible]	3.3	[illegible]
Old Cedar tree	[illegible]	[illegible]	[illegible]
US Army #14			
Old Cary Ranch	[illegible]	[illegible]	[illegible]
New Cary Ranch	[illegible]		
Hamilton	[illegible]	1.7	[illegible]
Old Maple above Cockreham	[illegible]	0.8	[illegible]
Cockreham	[illegible]	0.9	[illegible]

James E. Stewart Handwritten Notes
APPENDIX E

Place	Date	Difference btwn w/s at date and high-water
Rockport	1/28/23	1897 = 18.1 1909 = 17.6 1917 = 17.5 1921 = 17.6
Sauk	1/28/23	1897 = 19.2 1909 = 18.1 1917 = 16.2 1921 = 19.0
Faber Ferry	1/28/23	1921 = 25.5
John Larson's Place	11/27/22	1894 = 15.5 1896 = 21.6 1897 = 21.8 1909 = 22.2 1921 = 21.9
1400 feet Above The Dalles	11/24/22	1856 = 38.2 1909 = 31.0 1921 = 29.6
The Dalles at the Head of the Dalles	11/25/22	1820 = 53.2 1856 = 42.1 1897 = 36.5 1909 = 33.3 (Est) 1921 = 32.0
At Lower End of The Dalles	11/25/22	1820 = 43.1 1856 = 38.9 (Est) 1897 = 30.0 1909 = 28.6 1921 = 27.1
At Upper End of Slope Section	1/31/23	1820 = 45.0 (Est) 1856 = 36.6 (Est) 1921 = 21.2
At Lower End of Slope Section	1/29/23	1820 = 39.8 (Est) 1856 = 32.3 1921 = 24.8

James E. Stewart Handwritten Notes
APPENDIX E

Fessler's Ranch	11/28/22	1820 = 40.7 (Est) 1856 = 33.3 (Est) 1909 = 26.6 1921 = 25.9
Presentine Ferry	11/28/22	1897 = 24.0 1909 = 22.5 (Est) 1921 = 21.2
Hamilton	11/27/22	1897 = 15.8 1909 = 16.1 1917 = 15.5 1921 = 16.4
Cockerham Island	12/12/22	1894 = 14.4 1897 = 17.9 1909 & 1917 = 17.4 1921 = 16.2
Sedro-Woolley	12/12/22	1820 = 30.0 1856 = 26.4 1897 = 21.2 1906 = 21.1 1909 = 22.9 1917 = 20.5 1921 = 20.7

JAMES E. STEWART 1923 REPORT

Comparison of 1918 and 1923 Flood Flows Concrete WA.		
Flood year	1918 Report	1923 Report
1897	205,000 cfs	275,000
1909	185,000 cfs	260,000
1917	175,000 cfs	220,000

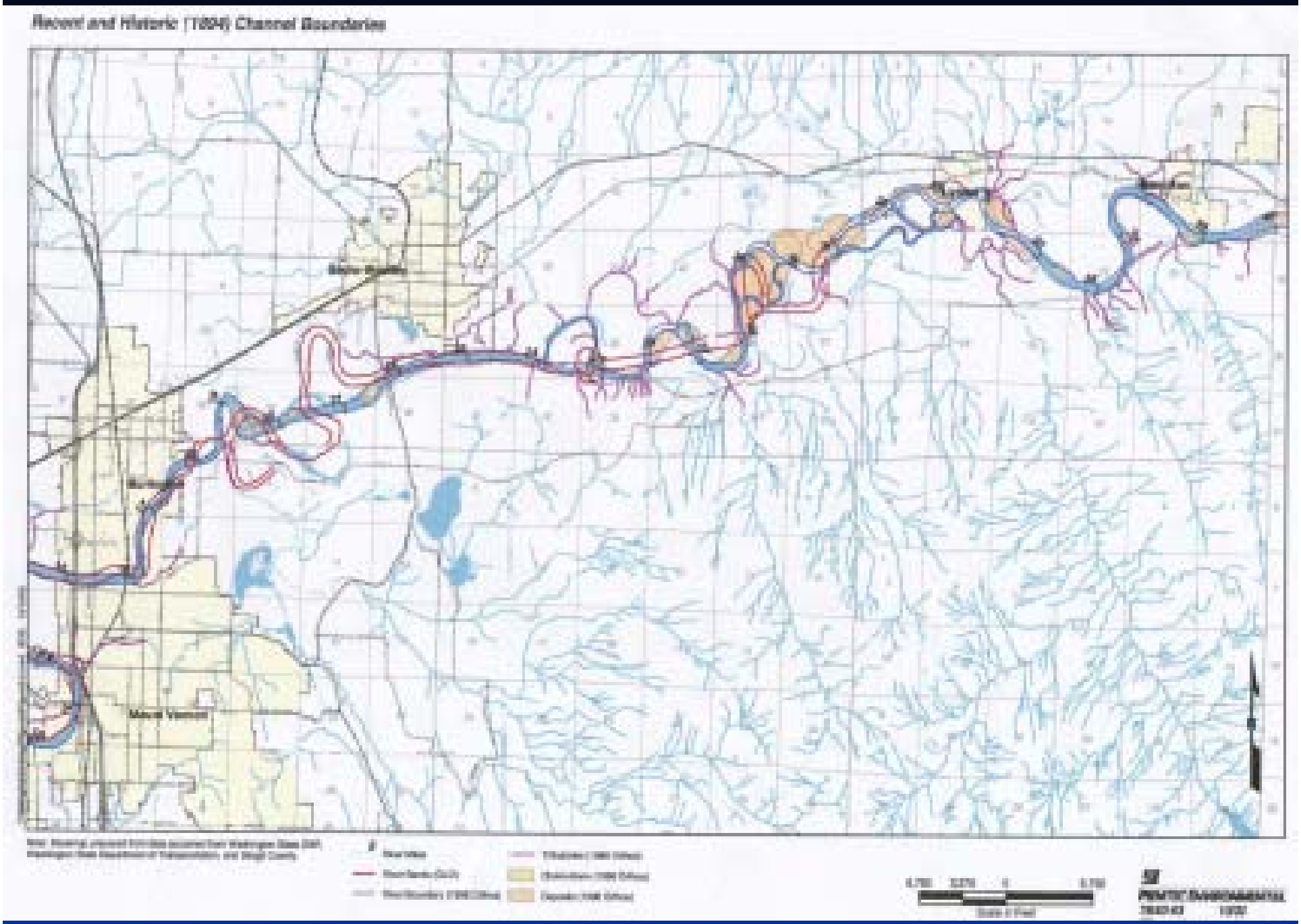
(Source: 1918 and 1923 Stewart Reports)

H.C. Riggs & W. H. Robinson 1950 Report

"*Proposed Revision of Skagit River Flood Peaks*"

Revision for Concrete The Dalles		
Year	Stewart 1923	Revision 1950
1815	500,000	400,000
1856	350,000	280,000
1897	275,000	230,000
1909	260,000	220,000
1921	240,000	210,000
1917	220,000	190,000

Revision for Sedro-Woolley		
Year	Stewart 1923	Revisions 1950
1815	400,000	330,000
1856	300,000	230,000
1896	185,000	170,000
1897	190,000	170,000
1906	180,000	160,000
1909	220,000	190,000
1917	195,000	160,000
1921	210,000	170,000

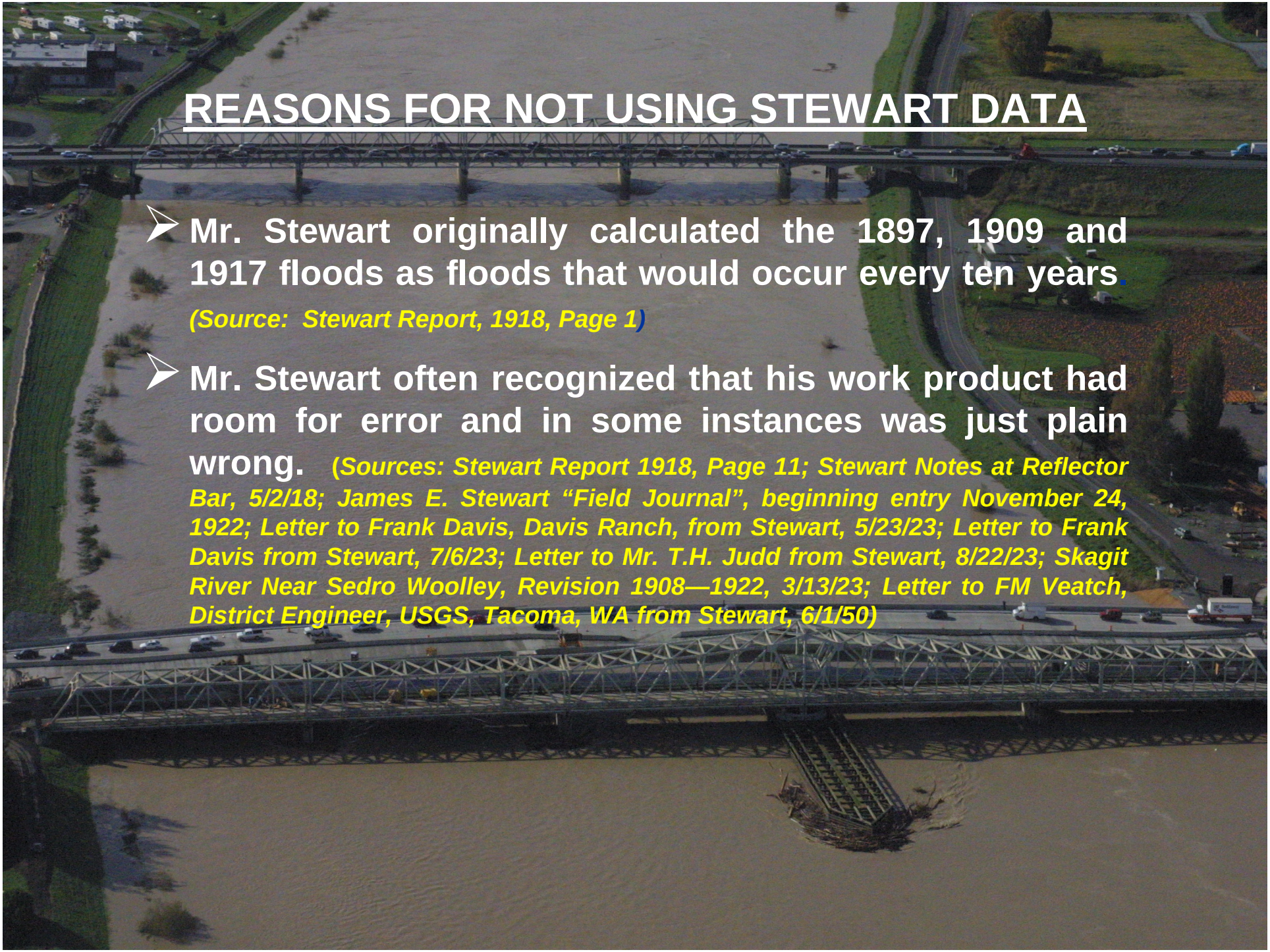

Recent and Historic (1924) Channel Boundaries

FLOOD FLOW CFS RECURRENCE LEVELS[1]

	WITH STEWART		WITHOUT STEWART		WITH STEWART 1918	
FLOOD EVENT	UNREG.	REG.	UNREG.	REG.	UNREG.	REG.
10	163,000	124,000	147,000	112,000	153,000	116,000
50	248,000	185,000	210,000	157,000	222,000	165,000
75	274,000	205,000	228,000	171,000	242,000	181,000
100	293,000	221,000	241,000	182,000	257,000	194,000
250	362,000	279,000	288,000	222,000	308,000	237,000
500	423,000	348,000	327,000	269,000	353,000	290,000

(Source: Unregulated columns and Regulated With Stewart column, Corps of Engineers, Seattle District, 2003, all other regulated columns interpolated estimates)

[1] All figures rounded to the nearest 1,000.



REASONS FOR NOT USING STEWART DATA

- **Mr. Stewart originally calculated the 1897, 1909 and 1917 floods as floods that would occur every ten years.**

  (Source: Stewart Report, 1918, Page 1)

- **Mr. Stewart often recognized that his work product had room for error and in some instances was just plain wrong.** ***(Sources: Stewart Report 1918, Page 11; Stewart Notes at Reflector Bar, 5/2/18; James E. Stewart "Field Journal", beginning entry November 24, 1922; Letter to Frank Davis, Davis Ranch, from Stewart, 5/23/23; Letter to Frank Davis from Stewart, 7/6/23; Letter to Mr. T.H. Judd from Stewart, 8/22/23; Skagit River Near Sedro Woolley, Revision 1908—1922, 3/13/23; Letter to FM Veatch, District Engineer, USGS, Tacoma, WA from Stewart, 6/1/50)***

REASONS FOR NOT USING STEWART DATA

- **The Corps of Engineers has questioned the accuracy of Mr. Stewart's data.** **(Source: Appendix to Report on Survey for Flood Control of Skagit River and Tributaries, Corps of Engineers, 2/21/52, Not For Public Release, Page 17 ¶31)**
- **The discrepancies between calculated flows from Mr. Stewarts 1918 and 1923 Report are never addressed.** **(Source: 1918 and 1923 Stewart Reports; See page 17 of Whitepaper)**
- **His flood elevation marks are not consistent and do not support his flow calculations.** **(Source: James E. Stewart Field Log and Hand Written Notes)**

REASONS FOR NOT USING STEWART DATA

- **No one from USGS was ever able to reproduce Mr. Stewarts flood flows using Stewart's assumptions and data.** **(Sources: Stewart 1918 & 1923 Reports; Proposed Revision of Skagit River Flood Peaks, H.C. Riggs & W.H. Robinson, 11/16/50; Skagit River near Concrete, Wash. – Verification Study by F.J. Flynn and M.A. Benson, 8/52; Skagit River near Sedro-Woolley, Wash., Proposed revisions of historical flood peaks, F. L. Hidaka, 1/12/54; Skagit River Flood Peaks, Memorandum of Review by G. L. Bodhaine, USGS, 5/13/54)**

- **At no time did Mr. Stewart nor USGS ever take into consideration the log jam which Stewart documented at The Dalles which would have greatly influenced the "flood marks" located by Mr. Stewart.** **(Sources: James E. Stewart "Field Journal", beginning entry November 24, 1922; Proposed Revision of Skagit River Flood Peaks, H.C. Riggs & W.H. Robinson, 11/16/50)**

REASONS FOR NOT USING STEWART DATA

- During the November 21 through 25, 1990 flood event 6 inches of rain fell at Marblemount, **15.5 inches of rain fell at Reflector Bar**, 11 inches of rain fell at Glacier on the Baker River side and 11.3 inches of rain fell at Darrington on the Sauk River. The regulated peaks of 146,000 cfs and 152,000 cfs at Concrete and Mount Vernon respectively would have been 182,000 cfs and 180,000 cfs if left unregulated. One has to ask that if Stewart and USGS computations of the 1921 flood are to be believed, how did we end up with only 180,000 cfs unregulated flow with 15.5 inches of rain at Reflector Bar, and Stewart and USGS end up with 240,000 cfs and 225,000 cfs respectfully with only **10.21 inches of rain falling at Reflector Bar**? *(Sources: Flood Summary Report, Nooksack, Skagit and Snohomish River Basins, November 1990 Events, Corps of Engineers, 7/18/91; (Stewart/Bodhaine Report, Geological Survey Water-Supply Paper 1527, 1961)*

HOW CAN WE RESOLVE THIS ISSUE?

1. WE CAN ELIMINATE THE STEWART FLOOD DATA AND USE THE LAST 82 YEARS WORTH OF GAGE DATA TO DETERMINE THE 100 YEAR FLOOD FLOWS.
2. WE CAN TAKE OUR STATE OF THE ART HYDRAULIC MODEL WE PAID 1.5 MILLION DOLLARS FOR, MOVE BACK THE LEVEES TO WHERE THEY WERE IN 1921, TAKE OUT THE LAND FILL AND THE FREEWAY, SIMULATE THE BREAKING OF THE LEVEES AND SEE IF THE 1990 AND 1995 FLOODS WOULD BE AS DEEP IN BURLINGTON AND CLEAR LAKE AS THEY WERE IN 1921.