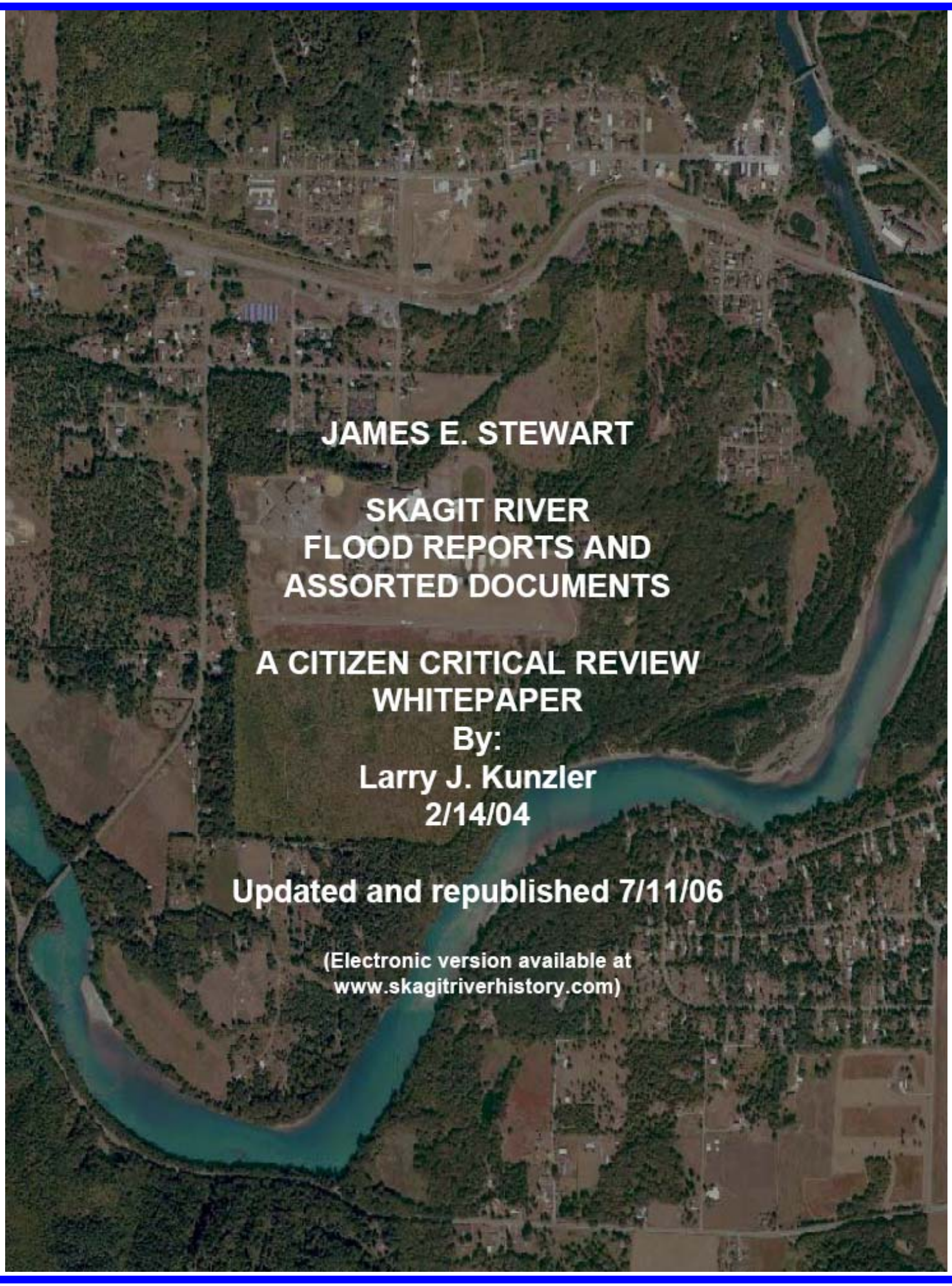

JAMES E. STEWART

SKAGIT RIVER FLOOD REPORTS AND ASSORTED DOCUMENTS

A CITIZEN CRITICAL REVIEW WHITEPAPER

By:
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2/14/04

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(Electronic version available at www.skagitriverhistory.com)

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PREFACE

Since this paper was originally published in 2004 a considerable amount of "new" information has been gathered that in sum supports the original findings of the paper and cast further doubt as to the validity of 1961 USGS Bodhaine/Stewart Report, Water Supply Paper 1527. The original paper was published using Arial 12 point fonts. The "new" material used for this update will be published in Times New Roman 12 point fonts. Also, many of the documents mentioned including both versions of this Whitepaper have been published on the internet at www.skagitriverhistory.com. Those documents will now be followed with the appropriate hyperlinks.

James E. Stewart was an assistant engineer (hydraulic engineer) with the United States Geologic Survey ("USGS"), Water Resources Branch in Tacoma, Washington when he authored his first report on the Skagit River in 1918. ***(Source: Skagit River Flood Report, 8/12/18).*** He left for a few years and was stationed in Hawaii where he was in charge of "water resource investigation". Upon his return he was again assigned to write a report on the historical flooding events on the Skagit River so long as Skagit County would agree to pay for his time. ***(Source: USGS letter to Skagit County 11/16/22)*** Mr. Stewart left USGS for employment with the West Virginia Power and Transmission Company in March 1923, 7 months before his "preliminary" report was completed and given to the Skagit County Commissioners ***(Source: Stewart letter to F.M. Veatch, USGS, 6/1/50)*** in October 1923. ***(Source: Handwritten note contained in USGS files.)***

The significance of this is that Mr. Stewart was paid directly by Skagit County. The information that Skagit County paid for was then prepared by a civilian not a government (USGS) employee and thus Skagit County owns Mr. Stewarts work product and USGS should never have published anything Mr. Stewart authored. The payroll ledger pages from Skagit County can be viewed at **Payment to James E. Stewart** 12/4/22, **Payment to James E. Stewart**, **Second Payment to James E. Stewart** 2/5/23, and **Payment to James E. Stewart** 3/5/23.

Mr. Stewart's 1923 report was never published and there is no evidence contained in the USGS files that anyone from USGS ever went into the field to check his flood elevation measurements. In 1946 there was some renewed interest in publishing Mr. Stewart's work. ***(Source: Letter to William Eisenlohr, Jr., Hydraulic Engineer, USGS, Wash. DC from Stewart re Skagit Report, 4/2/46)*** Significant to note is that this is after Mr. Stewart's supervisor, G. L. Parker retired. Over the next 15 years, several USGS employees looked at Stewart's work which eventually culminated in the Bodhaine/Stewart Report being published in 1961. ***(Source: Geological Survey Water-Supply Paper 1527, 1961)*** However, based on a letter from Mrs. Stewart, located in the USGS files, it is believed that by the time the 1961 report was published, Mr. Stewart had passed away.

In about December, 2002, it became apparent to me that the Corps of Engineers, in their hydraulic analysis was relying entirely on the 1961 Stewart Report to calculate 100 year flood figures for the Skagit River. On January 20, 2003 I wrote a memorandum titled "A Historical Investigation into the Skagit River Flood Levels".

Contained within that memorandum were 12 pages concerning the three "Stewart Reports", which raised questions concerning the conclusions, reached by Stewart and USGS. The Corps of Engineers response to those 12 pages of research was two sentences, which stated:

> *"If there are known errors in the derivation of a peak flow, it is necessary to take these up with the USGS as they are in charge of producing this data. Given that an analysis was done in 1918 by USGS, refined in 1923, looked at again and republished in 1961 and is put on the USGS website tells us that these flows are their best estimate."* ***(Source: Seattle District, U.S. Army Corps of Engineers Response To Larry J. Kunzler's Memorandum dated January 20, 2003, Entitled A Historical Investigation Into the Skagit River Flood Levels, 2/21/03)***

At the time this response was written the Corps of Engineers had not reviewed the Stewart Reports, *"I have not read through the "Stewart" reports nor do I plan to unless it is made clear that a methodology used is incorrect."* ***(Source: Memorandum to Steve Babcock, Project Manager from Ted Perkins, Hydraulic Engineer, Corp of Engineers, 2/5/03)*** Also the Corps statement about the 1918 and 1923 Stewart Reports being published is incorrect. Neither of these two reports was ever "published". Subsequent to writing the above Ted Perkins of the Corps of Engineers has reviewed the Stewart Reports and has helped supply me with information used in this update to the Whitepaper for which I am very grateful.

On January 23, 2004, I had the privilege of reviewing and copying the original Stewart documents, including but not limited to Mr. Stewarts "Field Journal" he used to make handwritten notes concerning his measurements during the winter of 1922, contained in USGS files and maintained by the National Archive Records Administration ("NARA"), at the former Sandpoint Naval Air Station, Seattle, Washington. I also reviewed the papers provided by USGS concerning the subsequent work done on the Stewart information used to publish the 1961 Water Supply Paper, the Bodhaine/Stewart report. The original 12 pages contained in my memorandum on January 20, 2003 were used as the foundation for this Whitepaper. The information was then supplemented with the information I copied from the USGS files at Sandpoint as well as other information obtained from various sources subsequent to that date. An index to the documents copied has been prepared and will be made available to anyone so requesting as well as copies of the documents themselves. (The majority of the documents have now been published at www.skagitriverhistory.com and are hyperlinked herein.)

I would like to take this opportunity to thank USGS for not only making the Stewart files available to me but also for paying the .50 cents per page copying charge that the NARA charges citizens for copying documents. That fee to citizens is something that deserves its own investigation but will not be dealt with in this Whitepaper.

I also would like to thank the U. S. Army, Corps of Engineers, Seattle District, for not only giving me access to their documents but in also providing data needed in the preparation of this paper.

PURPOSE

It is the purpose of this paper, to collect and analyze the evidence which bears on the credibility of the Stewart data and to determine whether reliance on the Stewart data is warranted given the other evidence which has been gathered both before and after 1921. As this Whitepaper will show, the historical flood data, gathered by Mr. James E. Stewart is what is driving the determination of any flood project on the Skagit River. Based on the research contained herein, I have concluded that his work product is questionable and incomplete at best and should not be used at all.

The views expressed herein are entirely my own and are not necessarily those of federal agencies, municipalities, or other individuals. Also, I realize that there are those who will find the paper inflammatory. Hopefully, the majority of reviewers will find it expository. The paper is not meant as a personal attack on any individual or for that matter any federal agency although I am admittedly disappointed in the actions or lack thereof of the federal agencies involved. Hopefully they will read this paper in the sprit it was written, in search of the truth concerning the history of the Skagit River flood events. Admittedly my writing style can be aggressive at times. I attribute that to writing for attorneys over the last 25 years and if it wasn't somewhat aggressive, no one would recognize that I wrote it.

A former newspaper editor here in Skagit County once wrote, *"It takes a lot of time to convince a few stubborn men who don't want to understand, a very short while to convince a lot of common folks."* ***(Chuck Dwelley, Editor, Publisher Concrete Herald 11/4/48 C.H.)*** I'm neither a scientist nor a hydraulic engineer, just a "common folk" in search of the truth.

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I. THE STEWART REPORTS

A. 1918 REPORT

The main premise of this study was to analyze the Skagit River flood flows for the 1897, 1909 and 1917 floods all of which were "large floods". Stewart concluded that, "**Floods closely approaching these three may be expected on an average of once in ten years**. In addition to these floods there are sure indications of a much greater flood at the Reflector Bar and Sedro Woolley gauging stations and also traditions among the Indians." ***(Stewart Report, 1918, Page 1)***

In his 1918 analysis Mr. Stewart based his conclusions primarily on "flood marks" he located at Reflector Bar[1] which is 47 miles upriver from Concrete (***Stewart Report, 1961, Page 6***) and the Davis Ranch[2] (1.5 miles below Reflector Bar) (***Stewart Report, 1918, Page 1***). He also took into consideration flood marks he located at the Skagit River Power Camp near Marblemount, below the Baker River near Concrete (The Dalles[3]) and at Sedro Woolley. He briefly mentioned the Cascade River, Sauk River at Darrington, and the Suiattle River although went into no great detail on those tributaries.

He also talked with a local settler named Mr. Joseph Hart who settled in the Skagit Valley near Sterling (downstream of Sedro Woolley) in 1878 ***(Stewart Report 1918 Page 8)***. Mr. Hart showed Mr. Stewart stains left on trees by previous floods and related stories told to the early settlers by Indians. Stewart wrote that Mr. Hart told him:

> Some of the oldest Indians, judged to be about seventy years of age, told them that when they were small boys a big water came "very quick" and that their tribe did not have time to save their smoked salmon and dried venison; consequently, they nearly starved that winter. Mr. Hart estimated at that time, from the age of the Indians who were able to remember the flood that this flood must have occurred about sixty years previous to 1879. This makes the date of the flood about 1820 and is confirmed by my study at Reflector Bar and by the young spruce trees which did not have the high-water mark on in 1879. ***(Stewart Report 1918, Pages 8 & 9)***

Mr. Stewart concluded his 1918 report by stating:

[1] See Appendix B.

[2] Ibid.

[3] Ibid

> Due to the limited time on this report errors may be found in the plotting of some of the measurements. Unchecked measurements were also plotted. ***(Stewart Report 1918, Page 11)***

He attached an exhibit to his report, which showed the "estimated" discharge for the three floods at below Baker River (The Dalles) and Sedro Woolley. Those figures are as follows:

YEAR	CONCRETE[4]	SEDRO-WOOLLEY
1897	205,000 cfs	171,000 cfs
1909	185,000 cfs	169,000 cfs
1917	175,000 cfs	157,000 cfs

(Stewart Report 1918, Exhibit J)

Located in the USGS files was a transcription of Mr. Stewart's notes taken on May 2, 1918 while at Reflector Bar which is located one-tenth of a mile below the Diablo Dam. ***(Source: Stewart Report, 1961 Page 8)*** Mr. Stewart was using a hand-held "Seattle levelman's level". He measured the December 29, 1917 high-water mark at "6.15 feet above present water surface" and the 1909 high-water at "8.6 feet above present water surface. He stated, "…it can be assumed that the 1909 flood was 2.5 feet higher than 1917." "Estimated fall in water surface .3 per 100 feet or 1.8 feet." ***(Source: Stewart Notes at Reflector Bar, 5/2/18)***

Mr. Stewart wrote "People who have lived in the Skagit Valley since 1888 say floods of 1897, 1909, 1917 are the only big ones of which 1909 was the largest above Marblemount." In talking about a larger flood event he states, "I think the only flaw in the flood flow of this great flood is the possibility of a log jam or snow slide in the canyon below but in a big flood these obstructions would last such a short time that the great amount of sand seen could not have been deposited." ***(Source: Stewart Notes at Reflector Bar, 5/2/18)***

The statement by Mr. Stewart, "…the only flaw in the flood flow of this great flood is the possibility of a log jam or snow slide in the canyon below…" is significant because it is one of the few documentations that Mr. Stewart realized the possibility of log jams or snow slides as having the possibility of impacting his flood reports. The verbiage that was found in his notes was never repeated in his final work product, and only given one line in the USGS 1961 report which stated, "**Higher stages may also have occurred at other points during other floods as a result of log jams**. ***(Source: Bodhaine/Stewart Report, page 22, 1961)***

Since 1966 I have hiked extensively in the Diablo and Ross Lake canyon areas and have observed tremendous amounts of "flood sand" deposited at the base of numerous

[4] The Dalles

streams and tributaries, as well as major landslide areas to Diablo and Ross lakes (i.e. Creek next to the Diablo Lake boat ramp and Greenpoint Campground in Lake Ross). Surely, any flood events in the pre-dam era, would have carried large amounts of that sand down the valley and just as surely, a lot of it would have been deposited in the Reflector Bar and Davis Ranch area.

I have just two final observations concerning the 1918 report. Mr. Stewart stated: "Mrs. Davis states 1897 and 1917 floods just same height, 1 ft over floor in a small bunk house near where they live." ***(Source: Stewart Notes at Reflector Bar, 5/2/18)*** Mrs. Davis was the owner of the Davis Ranch which as previously stated was located 1.5 miles below Reflector Bar. (***Stewart Report, 1918, Page 1***). Also, contained on the front page of the 1918 report is a handwritten note from someone with the initials HEB to GLB (presumed to be G.L. Bodhaine who authored the 1961 report) which states: "Note: I believe all references to 1820 flood in this draft for Sedro Woolley and Concrete are for 1856 flood in later reports." ***(Source: Skagit River Flood Report, 8/12/18)***

The significance of the 1918 report is two fold. First, the figures Mr. Stewart estimated in the table above are considerably lower than in his subsequent work products and will be addressed later in this White Paper. Second, nowhere in either the 1923 report or the 1961 report is this work product even mentioned. This report was given to USGS on August 12, 1918. ***(Source: USGS "Received" stamp on cover page of "Skagit River Flood Report, July 1918)*** That is just 4 years before he began his field measurements for the 1923 report. ***(Source: Stewart Field Journal, 11/24/22 See Appendix A)*** No explanation for the discrepancy is ever mentioned by either Mr. Stewart or USGS.

Further, nowhere in this report is the word "Draft" typed or stamped. This was not a draft report. Mr. Stewart wrote the report and left for Hawaii. I obtained a copy of this report not from USGS files but from Corps of Engineer files several years before this investigation began so evidently the report was circulated between the agencies.

B. 1923 REPORT

1. Preliminary Report

In 1923 Mr. Stewart prepared another report, paid for by Skagit County which consisted of a 28 page Preliminary Report. ***(Source: Preliminary Report – Stage and Volume of Past Floods in Skagit Valley and Advisable Protective Measures Prior to the Construction of Permanent Flood Controlling Works, See also*** **Stewart 1923 Report -- Retyped Version***)* Representatives of Skagit County made arrangements with G.L. Parker, then district engineer of the USGS, Surface Water Branch at Tacoma, to determine the size of the floods. Mr. Parker was Mr. Stewart's supervisor. J. E. Stewart was given the assignment of compiling field data and writing a preliminary report, which was completed in 1923 but not published. ***(Floods in the Skagit River Basin Washington by James E. Stewart and G. Lawrence Bodhaine, Geological Survey Water-Supply Paper 1527, (1961) Pg 3)***.

However, as determined by documents obtained in the USGS files, Mr. Stewart left USGS for employment with the West Virginia Power and Transmission Company in March 1923, 7 months before his "preliminary" report was completed and given to the Skagit County Commissioners ***(Source: Stewart letter to F.M. Veatch, USGS, 6/1/50)*** in October 1923. ***(Source: Handwritten note contained in USGS files.)*** As of the writing of this Whitepaper it is unclear if the "Preliminary Report" obtained from the USGS files is in fact the one which was presented to the Skagit County Commissioners in October 1923 as that Report has a signature page dated 1/28/29.[5] ***(Source: Preliminary Report – Stage and Volume of Past Floods in Skagit Valley and Advisable Protective Measures Prior to the Construction of Permanent Flood Controlling Works, 1/28/29)*** It has now been determined that the 1/28/29 version is not what was sent to the County Commissioners as some of the verbiage, although minor in nature, was changed from the November 16, 1923 version located in Corps of Engineer files. (***See*** **Stewart 1923 Report -- Retyped Version**)

This report was much more comprehensive than the 1918 report although much of the verbiage from the 1918 report was repeated although not referred to. Mr. Stewart began by stating:

> The results of this study are being formed into a report which will not be completed for some time. The data concerning the volume of the floods, which was the basis of the agreement[6] (*between Skagit County and USGS*) was furnished in August of this year. . . Since the arrival of the first white people, about 1869, there have been six Skagit River floods whose discharge has exceeded 175,000 (cfs) at Sedro Woolley. All of those six floods have occurred since November 15, 1869. (***Stewart Report 1923, Page 1***)

2. Field Notes

The basis for Mr. Stewart's 1923 report was found in his "field notes" taken in the winter on 1922. The first such note was dated September 16, 1922 which was actually before his "formal" employment by Skagit County. Mr. Stewart returned to Reflector Bar on 9/15/22. He stated in part:

> "The trip was profitable as faint evidence of the large flood could be traced on the left canyon wall across from where I was. By hand level this was found to be 18.0 feet above water surface of Sept. 15., 18.0 plus 3.3 equals 21.3." "The wave crest of the 1921 flood is about .7 ft below that of 1909 at the 1909 high water mark at Stetattle Creek. The 1921 flood was

[5] In a search of the Skagit County Engineering Departments archive files in the Washington State Archives in Bellingham, no Stewart Reports were located.

[6] No "agreement" was located within USGS files nor Skagit County files other than **Resolution # 1331 re hiring of River Engineer** and a USGS **Letter to Skagit County** 11/16/22.

about .6 or .8 below 1909 flood at the Davis ranch. The 1921 flood came so near that of 1909 in the canyon above Reflector Bar gaging station that they cannot be separated by observation from a distance. The rapid dimming of the 1909 flood marks, the difficulty of finding the early flood mark on the trees where it was bright in 1879, the freshness of the river sand and gravel where the river topped the bank at Reflector Bar, the condition of the Cedar stump at Ruby: all these lead to the assumption that the **great flood** was that of **December 4, 1861**. The old Indian who told Hart and others at Sedro Woolley in 1879 that the flood was when he was a boy either referred to another flood or **they did not understand him**."

(Source: Transcription of Stewart "flood notes" on 9/16/22 by USGS 6/30/23 re Reflector Bar near Marblemount)

There was a "later note" (unknown when) which stated "Data with measurement of May 2, 1918 makes the crest 15.0 ft. use it in preference." (**NOTE:** See "flood notes" 5/2/18 for same location.)

The significance of the highlighted text in the above transcription is that this is the only time "the great flood" was determined to be December 4, 1861. In fact, nowhere in any subsequent publication is this flood, great or otherwise, mentioned. What is also significant is the discounting of the statements made by the "old Indian" as in later versions of the Stewart Report, especially in the 1961 version, the "old Indian" is again quoted as being accurate although it is worth noting that in the Preliminary Report delivered to the Skagit County Commissioners, there was no mention of the "old Indian" statements.

Also noteworthy is that several times in Stewart's 1923 report he mentions and relies upon his work in 1918 (See pages 8, 9, 11, 19, 25, 26 in the 1923 report as well as pages 9 and 14 of his Skagit River at Sedro-Woolley; Revision 1908-1922 dated 3/13/23, **Stewart 1923 Report -- Retyped Version**), however he never addresses the significant differences between the flows he determined for the same flood events in the two reports.

Also located in the USGS files was the original "Field Journal" used by Mr. Stewart in the winter of 1922. A transcription of many of his notes is included in this White Paper as ***Appendix A***. A portion of the appendix which provides anecdotal evidence of Mr. Stewart's research is reprinted here:

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 101 Rockport. Bark and moss point. Possibility 1897 likely wind blown sand. 1.1 feet below this 1921 mark? 1.23 feet below this is 1897 mark. NOTE: Assume 1921 same as 1909. Probably 1909 nail. Ed Presentine says 1897 .5 feet higher then 1909.

January 28, 1923. Old Johnny Towne (Indian) said during 1909 flood that when he was a boy he saw river even higher. He is considered to be 70 years old or more so flood would be that of 1856.

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

The entry on Page 23 is significant because it is now the second time that a "field note" has talked about the influence of log jams on flood flows. A local resident, "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." Depending on how you want to read this statement either the 1897 or the 1909 flood had a log jam in The Dalles so much so that it raised flood waters "10 feet in 2 hours". Was the log jam there in the beginning of the flood or near the crest of the flood? We will perhaps never know, but the significance of the entry in the log clearly points to the distinct probability that The Dalles, a somewhat narrow rock canyon, current location of the "Concrete gage", located downstream of the confluence of the Sauk and Baker rivers, both volcanic in nature and thus subject to carrying huge amounts of debris in all kinds of flood flows, would have been subject to log jams in this area. Thus, any historical "flood marks" observed in this canyon, would have been influenced by log jams backing up the water levels. This is especially significant in that the measurements for the 1897, 1909 and 1917 floods were taken approximately 1 mile upstream of The Dalles. ***(Source: Stewart Report 1923)***

The "approximately 1-mile upstream" statement is also noteworthy because Mr. Stewart says "The most suitable location for a new gaging station is at "The Dalles" one mile below the mouth of Baker River." ***(See page 25 of the 1923 report and the "Preliminary Report" dated 1/28/29.)*** The actual distance in river miles is 2.5 miles (**See Appendix E**). Further, his hand written notes indicate that all the measurements he is relying on took place either at the Baker River vicinity or further upstream of the Baker River all the way to Van Horn (**See Appendix A**). There is no indication he took any measurements between The Dalles and the Baker River, a distance of 2.5 river miles. If Mr. Stewart felt that the difference was only one mile it would infer that he took his measurements for the 1897, 1909 and 1917 floods in the Baker River vicinity to as far upstream as Van Horn which means that his measurements are now further suspect as any measurements in that vicinity of unknown location could have been severely impacted by the flows of The Baker River. In speaking with professional hydraulic engineers, transposing

highwater marks that would be impacted by the inflow from another river from 2.5 to 4 miles upstream of a gage to within one tenth of a foot would be a major accomplishment with today's modern technology let alone in 1923. ***(Source: Preliminary Report 1/28/29)***

Further suggestion that the marks for 1897, 1909 and 1917 floods were taken in Concrete and not "approximately one mile upstream" of The Dalles is supported by comparing what USGS states are Stewart's findings at The Dalles with Stewart's Field Notes reprinted in Appendix A.

Date	Concrete	
11/18/1897	275,000	51.1
11/30/09	260,000	49.1

Town of Concrete…..1909 flood 2 feet above 1921 flood (pg 23). At Everett Ranch **above Concrete** Magnus Miller says 1897 water came to middle of 2nd shake. About 3 feet above beam for rafters. This was shed on side of old barn. Water came to foot of steps to house. Did not get in house. May have came up on step a little. Leonard Everett says 1909 flood came just to bottom of shakes. Makes 1897 flood 2 feet above 1909. (pg 141)

Given the fact that the first statement referencing log jams was made at Reflector Bar ***(Source: Stewart Notes at Reflector Bar, 5/2/18)*** and now this statement at the Dalles, both locations which were key to Stewart's computations of flood flows, it raises the distinct possibility if not probability that all of Stewart's research and observations especially on the "great floods" of 1815 and 1856 as well as all other floods for that matter, could have been impacted by the damming of the Skagit River by log jams, landslides, snow slides, ice dams and/or volcanic debris flows. None of which was ever referenced in any of the Stewart Reports as having an impact on flood measurements.

The entries at page 62 and 69 are particularly disturbing. Not only are Mr. Stewart's measurements made with a hand held level ***(Sources: Stewart Notes at Reflector Bar, 5/2/18 and Transcription of Stewart "flood notes" on 9/16/22 by USGS 6/30/23 re Reflector Bar near Marblemount)*** but now we find that he was using a 95 foot rope and counting it as 100 feet.

3. Additional Work

The report given to the Skagit County Commissioners was "Preliminary". Documents obtained from USGS strongly suggest that the "1923 Stewart Report" was in fact not finished by Mr. Stewart until at least 1949, if at all. The following statements were written by Mr. Stewart:

> "The field work and part of the office work was accomplished in the four months from the middle of November, 1922, to the middle of March, 1923.

> In March 1923, the writer resigned from the USGS. But to fulfill the agreement with Skagit County, the office work was continued at every available opportunity until a preliminary report was issued in September, 1923. … After completing the preliminary report, the writer continued the study, as convenient opportunity offered, up to the present time. The work since March, 1923, has been without financial remuneration, but the writer will feel amply repaid if the study and this more complete report result in the saving of life and property in Skagit Valley, and a material advance in the science of hydraulics." ***(Source: Stewart "Forward" or "Introduction" section to his 1923 Report, 1/27/43)***

The fact of the matter is that three different versions of the 1923 Stewart Report has been located in USGS and Corp of Engineer files. It is unknown which of the three are Mr. Stewart's work and which one was the work of later USGS employees who "worked" on the report. It is known that "some of the work" was done by Mr. William Eisenlohr, Jr. with the USGS Washington DC office.[7] ***(Source: Floods in the Skagit River Basin Washington by James E. Stewart and G. Lawrence Bodhaine, Geological Survey Water-Supply Paper 1527, (1961) Pg 4)*** It is also possible that the three different versions are drafts that Mr. Stewart submitted to USGS at different times although there was no correspondence to substantiate that.

It is also known that Mr. Stewart felt that additional field work was necessary to justify his findings. He stated in part, "The most important field work is checking the "N" for the slope sections used in The Dalles. This checking of the "N" can be done by Mr. Veach's office alone." ***(Source: Stewart letter to Eisenlohr 4/2/46)*** The "N" he is referring to is the "roughness coefficient" of the Kutter's formula (currently referred to as the "Manning Formula") used by hydrologists to determine flood flows. The more debris and/or sediment in the water or trees and brush along the banks of the river the greater the value of "N". The determination of this value can have a significant impact in the final computation of flood flow analysis. This subject will be dealt with in more detail later in this paper.

Even after Mr. Stewart left the employ of USGS he was still trying to gather data from local residents for his paper. He sent a letter to Frank Davis in which he stated:

> ""I have determined the approximate year of that great flood which reached a gage height of 20.8 at Reflector Bar. … The flood, according to the age of the trees, occurred about 1856." "At The Dalles I found traces of still greater flood or floods. These traces mark the maximum flood or floods in the last few thousand years. I am writing you to ask if you would try to obtain evidence of what gage height the maximum flood at Reflector Bar. By comparison of the floods at The Dalles, I would

[7] Subsequent to the original writing of this paragraph another copy of the Stewart Report was located that had date stamps on it indicating when the Corps of Engineers received a copy. There were two dates. The first portion of the report was dated October 5, 1923 which covered the "Chapters" portion of the report and November 16, 1923 which covered the "introduction" or "Preliminary" section of the Report. It is believed to be a copy of Mr. Stewart's original work product.

> estimate that this flood reached a gage height of approximately 25 feet at Reflector Bar. Anyway, it must have been somewhere between 23 and 28 feet." ***(Source: Ltr to Frank Davis, Skagit Power Camp, from Stewart 5/5/23)***

On the same day he wrote a memorandum to a Mr. Judd, (presumably an employee of Seattle City Light) in which he stated:

> As you remember, we did a little flood investigation when I was there last September. We accomplished very little as the bark on the trees seemed to be filled with wind-blown sand instead of flood sand." "Since last Sept. I have determined the approximate date of the great flood that I had found traces of at Reflector Bar. This flood occurred about 1856 instead of 1820, as previously estimated." "Since my visit in September I found at The Dalles near Concrete that there was a larger flood than the 1856 flood – the flood of Indian tradition that occurred about 1820 may have been the one that reached that state." ***(Source: Memorandum to T.N. Judd, from Stewart, 5/5/23)***

Mr. Stewart was having trouble fitting the 1917 flood into his profiles. He writes another letter to Frank Davis asking him for assistance. He stated:

> "The comparison with the 1917 flood does not work out well and I wonder if you can make any suggestion as to the reason." … "**Readings that I have received may be incorrect**…" … "It may be that at some time an enormous snow slide dammed the canyon between Ruby and Reflector Bar, and then broke loose, such an occurrence would check with the old Indian tradition of a flood about 1820 that came unexpectedly in the night and so quick they hardly escaped (Sedro Woolley Indian tradition). … "If the river should stop rising or fall before the temperature fell or before it stopped raining, it would mean there was a snow slide or jam in the canyon and the water would be down a little later carrying everything before it." ***(Source: Letter to Frank Davis, Davis Ranch, from Stewart, 5/23/23)***

Once again, Mr. Stewart acknowledges the possibility of "snow slides" or "jam" impacting his flood results. Once again, no mention of this in any of the Stewart reports.

Subsequent to Mr. Stewart's letter to Frank Davis expressing his concern over a "slide" damming "the canyon between Ruby and Reflector Bar" the Concrete Herald in 1936 published a story in which the "Indian Tradition" flood was discussed. The article stated the following:

> When Mox was ten years old there came a winter of great snow December, January and into February. Then came warm rains and floods. A great slide filled Diablo Canyon full, damming the river. When this broke a great flood raced down the river – ice, logs, and debris—a solid wall of death forty feet high.

> As all the Indian villages were on the lowlands bordering on the river but few escaped. ***(See The Story Of Mox Tatlem, By Dick Buller, 3/5/36 C.H.)***[8]

The irony here is that while this paper is dedicated to showing how Mr. Stewart's work product with respect to the 1897, 1909, 1917 and 1921 floods cannot be relied on, the one flood that Mr. Stewart was so obviously interested in getting his name associated with, he probably got it right. Diablo Canyon is exactly where Mr. Stewart found his "drift bark" and in 1820 Mox Tatlem would have been 10 years old.

Frank Davis answered Mr. Stewart's letter of 5/5/23. Mr. Davis reported that he found:

> "Drift sticks and bark at gulch at 16.3' elevation". … "course wash sand at 19' elevation". … "fine sand, *probably* wash at 22' elevation." "I found no course sand here but there is no doubt about the wash sand at 19." … "Drift at 16.3 does not appear to be very old and was *probably* put there in 1909 though it would seem to be most to high for that." ***(Source: Ltr to Stewart from Frank Davis, Davis Ranch, 5/31/23)***

The measurements were taken with a hand-held level. Davis added a PS to his letter, which stated, "19 is just about the highest point on Reflector Bar flat." ***(Source: Ltr to Stewart from Frank Davis, Davis Ranch, 5/31/23)***

On June 12, 1923 Mr. Stewart solicited the help of local resident, Joseph Hart with whom he had spoke with at length concerning floods in the Sterling area. Mr. Hart responded to Mr. Stewart's letter as follows:

> "The Winter floods previous to the Spring flood of 1894 was about 2 feet higher, but they were never as high or no indications of them being so, excepting the one big flood the Indians tell about. The Winter Floods since that time (1894) were always higher. The more they diked the river close to it, the higher the floods have been." ***(Source: Letter to Stewart from Joe Hart, 6/21/23)***

Joe Hart lived on what is today known as Hart's Island just upstream from Sterling. The island is currently owned by Leonard Halverson.

Mr. Stewart responded to Frank Davis's letter of 7/6/23. He stated that he was at Reflector Bar "last September" in the same "gulch" that Davis made his measurements. However:

> "I determined with a hand level the height of the 1909 and the highest flood. I made them 15.8' and 21.3' which is .5' and .7' respectively lower

[8] I interviewed the daughter of the man who wrote this article. She remembers her father talking about the interview with the Indian (Hiyu Tillicum). She has no recollection of her father ever talking about Mr. Stewart or reviewing his estimates on the Skagit River. The Concrete Herald unlike the Courier Times and the Mt. Vernon Daily Herald did not run stories about the Stewart study in 1923.

> than your results. … "it would seem as though one of our hand levels was out of adjustment or something else was wrong." ***(Source: Letter to Frank Davis from Stewart, 7/6/23)***

Stewart wanted Davis to have his level checked because Stewart had "no way of checking up my data". … "In case your data proves correct in all points, I will probably want to use it instead of mine. For the time being I am averaging our results." ***(Source: Letter to Frank Davis from Stewart, 7/6/23)***

Mr. Stewart wanted to know if Mr. Davis was:

> "confident that the coarse sand at g. ht. 19 marks the crest of some flood? If it is the crest of a flood … it marks the flood of 1856." … "The fine sand is undoubtedly flood sand, and marks the crest of the maximum flood which occurred about 1814 (within 10 years either way). I got the elevation 21.3 from the faint line on the rock wall opposite the small gulch we both worked in. You can plainly see the mark on the same flood on the rock wall opposite the Thunder Creek gage. I found the flood reached to 20.8 at the Reflector Bar gaging station." ***(Source: Letter to Frank Davis from Stewart, 7/6/23)***

In late August, 1923 Mr. Stewart sends another letter to Mr. T.H. Judd at the "Skagit River Camp". He wrote the following:

> "**The data I have previously furnished you are somewhat in error** as to dates and heights of certain floods. It would be well, therefore, to consider all previous data superseded in reading this letter." "The maximum flood, which has occurred in the last few thousand years, had a discharge of about 120,000 second-feet at Reflector Bar. This estimate of discharge may be in error as much as 20 percent. For engineering purposes it would be necessary to plan on handling 145,000 second-feet at that point, and about 155,000 at the Power Camp." "The flood of December 12, 1921 had a discharge of 63,000 second-feet at Reflector Bar. The estimate of discharge is believed to be within 10 percent of correct. The maximum possible estimate for the 1921 flood would, therefore, be 70,000 second-feet at Reflector Bar and 75,000 second-feet at the Power Camp."
>
> "**The discharges that I have given are therefore in excess of what would be computed by using the mean of waves and surges** (the USGS method)." For the 1921 flood, I believe Mr. Parker is expecting to publish 57,000 second-feet or 6,000 second-feet less than I have given. There are certain arguments for both systems of computing flood discharges. Personally, I am of the opinion that the true peak discharge would be very nearly a mean of the discharge obtained by the two different methods of obtaining gage heights. ***(Source: Letter to Mr. T.H. Judd from Stewart, 8/22/23)***

Two years pass and there is no evidence anything was done with the 1923 report. In May, 1925, Mr. Stewart advises Mr. G.L. Parker, USGS District Engineer, Tacoma, Washington of the following:

> "I regret to say that I have no more of the report ready for typing. My family (including myself) had a protracted siege of the influenza just after I asked you for some information concerning Baker River. In my hydrographic studies for the West Penn Power Company, I have had a chance to go into much more detail than was generally possible for any of us in the Survey. As a result of these studies, I have about come to the conclusion that for many, if not practically all, of the steep sloped streams the Survey records for maximum flood discharge are too low, except where they are based on discharge curves, the upper extensions of which were derived from area and mean velocity curves. "…I consider the trouble to be due to extending the rating table by the continued use of the last difference derived from the rating curve. In some cases, I believe a contributory cause has been the use of .2 or surface velocities with reduction coefficients to mean velocities based on measurements made at much lower stages, and consequent coefficients that are too low. Lastly, I believe that in many cases no account has been taken of the over-flow that occurs when the banks have been topped. However, in allowing for such over-flow I believe there is more danger of over-allowance than under-allowance, due to the fact that in many cases there is dead water, a large coefficient of roughness, and other factors tending to reduce the flow much below the figures for the main channel." ***(Source: Letter to G.L. Parker, District Engineer, USGS, from Stewart, 5/4/25)***

The above verbiage seemed to deal with calculations for all rivers in Washington and not just the Skagit as he later references several other river basins. Later he states:

> "I have brought this feature up at this time because I believe that the Skagit River flood discharge at The Dalles can better be determined by an extension of the rating curve with the use of area and mean velocity curves based on the highest convenient .2 and .8 depth measurements than by attempting extreme high flood measurements." … "The highest flood measurements made at The Dalles should be used in checking up the coefficient of roughness that I used in my slope calculations. … One factor that should be remembered in this connection is that the slope cannot be used for 500 feet or more below The Dalles. This is due to the reduction in velocity head in that stretch of the river for high stages. In fact, for extreme high stages there is an upstream slope for some distance below The Dalles." ***(Source: Letter to G.L. Parker, District Engineer, USGS, from Stewart, 5/4/25)***

The above referenced letter is significant from two aspects. First, it shows us that Mr. Stewart is beginning to question his own work product and second, he realizes that the "coefficient of roughness" or the "N" factor could impact his calculations.

4. 1923 Report Analysis

Mr. Stewart devoted large portions of his report to "two great floods" (occurring "about" 1815 and 1856 which he justified by his findings at Reflector Bar which as previously stated is located 47 miles above Concrete and is currently referred to as the town of Diablo).

He included in his report the following computations for flood flows at The Dalles (Concrete):

# in order of magnitude	FLOOD EVENT	GAGE HEIGHT	CFS
1	1815	56.6	500,000
2	1856	44.6	350,000
3	1897	38.4	275,000
4	1909	36.4	260,000
5	1921	34.9	240,000
6	1917	33.0	220,000

Included with the table were footnotes which stated:

> The stages for floods No.'s 3, 4, and 6 have been **estimated** from flood marks **about one mile upstream**. The stage for flood No. 3 was rather uncertain at the upstream point. The stage for flood No. 1 was determined from the maximum height of flood sand opposite the upper Dalles gage. The stage for flood No. 2 was determined from its high water mark left on the Canyon wall in The Dalles. (***Stewart Report 1923, Page 4***) (Emphasis added.)

He also included the following computations for flood flows at Sedro-Woolley:

# in order of magnitude	FLOOD EVENT	GAGE HEIGHT	CFS
1	1815	33.5	400,000
2	1856	30.0	300,000
3	1909	26.5	220,000
4	1921	24.3	210,000
5	1917	24.1	195,000
6	1897	24.9	190,000
7	1896	24.8	185,000
8	1906	24.7	180,000

Included with the computations were footnotes which stated:

> See notes for Reflector Bar concerning the accuracy of dates for floods of 1814 (*sic*) and 1856. The stage for flood No. 6 has been obtained by its relation to the stage of flood No. 7 about one fourth mile upstream. The stage discharge relation is shifting. The discharge for all floods except 3, 4, and 5 are based, to a large extent, therefore, on comparative stages at other points. ***(Source: Stewart Report 1923, Page 5)***

The flood flow computations at Sedro-Woolley were somewhat of an enigma for Mr. Stewart as they are for USGS and the Corps of Engineers today. So much so that Mr. Stewart authored a paper titled "Skagit River at Sedro Woolley: Revision 1908-1922". This is a 15 page document that deals with gage height and rating curve corrections to Stewarts previously reported data. Includes such statements as:

> "…possibly staff gage was re-installed in December 1909 at 1.00 ft higher datum than prior to 1909 flood." "1. Prior to 1911 the river flowed around Sterling Bend in a much longer channel than thereafter. Hence the slope past the gage would be less than for the 1921 flood." "2. Choking effect of the NPRR Bridge was greater during the 1909 flood than during later floods because of the greater discharge." *These two* "causes mentioned would make the slope in 1921 much greater than in 1909. Cause #2 would make the difference between 1909 and 1921 floods greater just above the NPRR embankment than just below it." **NOTE:** NPRR was at the Hwy 9 bridge.
>
> "…no measurements made during the periods November 6, 1908 to August 25, 1910 and September 20, 1919 to November 20, 1922." "…measurements by F.F. Henshaw have been accepted as being as good

as other doubtful features of the measurements warrant. These other features are:

1. Measurements made from ferry. Survey experience is that boat measurements are unsatisfactory. 2. Meter rating unknown. 3. Method and accuracy of obtaining width of river unknown.

The flood of December 30, 1917 caused a large low water shift probably due to deposition of large quantities of sand and gravel at the lower end of Sterling Bend cut off. The lower end of Sterling Bend cut off is the location of the break in gradient between the steep valley gradient and the delta gradient. As a consequence when the stream is loaded with material, to its carrying capacity in the upper section, it is forced to deposit at the break in gradient. It is thought that there are several causes entering in the erratic results at Sedro Woolley as follows: 1. Change in stream bed gradient at lower end of Sterling; 2. The river channel on the delta does not have as much carrying capacity as the river down to Sedro Woolley. The water floods the Nookachamps country, in fact creates a vast reservoir. The backwater from the river channel and reservoir undoubtedly affects the rating at the Sedro Woolley station.

(Source: Skagit River Near Sedro Woolley, Revision 1908—1922, 3/13/23 (See page 67 of 81)

When comparing the above tables with current USGS and Corps of Engineer documents it is evident that at sometime after the 1921 flood USGS recalculated the gage heights that Stewart was using. It is possible that Stewart was using a different set of datum than is currently in use. The first hint of this appears in a USGS 1950 document which states:

> Measurement No. 76 shows the datum then in use (prior to 1923) to be 8.93 ft higher than USGS datum. Then the 1921 flood was higher than the 1949 by 54.3 – 8.9 -41.7 = 3.7 feet. . ***(Source: Proposed Revision of Skagit River Flood Peaks, H.C. Riggs & W.H. Robinson, 11/16/50)***

In a review of the historical record I was unable to determine exactly when or why this happened although the first indication of the new gage heights shows up in the 1961 Stewart Report which will be discussed later.

It is clear that the Corps of Engineers throughout the last 80 years adopted Stewart's computation of flood levels. However those flood levels are highly questionable.

In November 1924, Colonel Barden of the Corps of Engineers held a public hearing in Mt. Vernon to discuss the future of flood control in Skagit County. This is just one year after the Corps had received a copy of the Stewart Report in November 1923. At that public hearing, Colonel Barden stated the following:

> I would like to emphasize the point that Mr. Knapp[9] brought out in his paper, that before any really scientific plan can be prepared for the protection of this valley from floods, it is necessary to have more authoritative information then we now have as to the amount of water carried by the river in time of floods. . . . The information that was collected by Mr. Stewart and given in his report to the committee was excellent so far as the data that he had to work upon permitted, but that data was necessarily more or less inaccurate. ***(Source: Notice and Minutes of Public Hearing, 1924)***

In 1952 the Corps of Engineers while computing flood frequencies wrote the following:

> At the time Mr. Stewart made his report no gaging station had been established on Skagit River at The Dalles, near Concrete. His estimate of 240,000 cfs for the crest discharge at this site is a mean of four calculated discharges, one made by contracted opening method and three by slope section. The 1917 and 1909 discharges were **estimated by comparison of stage heights** with that of the 1921 flood. Determination of gage heights of early floods was made from high-water marks. Mr. Stewart **estimates** the discharge of the discharge of the December 1921 flood to have an accuracy within 5 percent; the 1917, 1909, 1856, and 1815 floods, 10 percent; and the 1897 flood, 20 percent at The Dalles. **These values are also subject to question** because of uncertainty of high-water marks, changing channel conditions tending to alter the rating curves such as clearing the bottom valley lands, erosion and deposition, and excessive extension of rating curves. (Emphasis added) ***(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)***

> Flood records are available in the basin since 1908 but they are not continuous at any single site for the entire period. As described previously, estimates have been made of crest discharges for historical floods occurring in 1815, 1856, 1897, and 1906. However, it was felt that the use of **these flood peaks** not in a continuous series and **of questionable accuracy** would decrease the over-all accuracy of the frequency curve, and so they were omitted from the study. ***(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 ¶33)***

Additionally no verbiage is put forth by Mr. Stewart in his 1923 report as to the discrepancies between his 1918 calculations and his 1922 calculations. They were as follows:

[9] Mr. Knapp was the Skagit County Engineer who worked closely with Mr. Stewart and his comments can be viewed in their entirety at **Robert E.L. Knapp, Skagit County Engineer, Testimony for 11/26/1924 Hearing**.

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)

5. Tree Staining

Mr. Stewart also discussed much more thoroughly in 1923 than he did in 1918 the local phenomenon of tree staining and his conversations with Joseph Hart. He stated the following:

> The old Indian's statement that the trees were stained by flood water agreed with the opinion of the more accurate thinkers among the settlers. The staining of live cedar bark has also been confirmed by the observations of different people after later floods. In the floods since the coming of the white man, however, only a few trees have been stained. The cause of the staining is not known, but whether a tree will be stained or not probably depends on the condition of the tree, the length of time the tree is immersed and the percentage of the staining material, if any, in the water. … It will be proven later that the flood stains seen in 1879 were from a flood of about 1856. … The story of the flood-stained cedar and spruce trees is practically the same as Mr. Hart, of Sedro Woolley, told it in June, 1918. In 1918, Mr. Hart was in excellent health, and had one of the most accurate memories that it has been the writer's privilege to encounter. ***(Stewart Report, 1923,)***

I think it is pretty clear that "tree staining" is associated only with large flood events. During the 1990 second flood event I was privileged to observe a tree stained in the same manner as described by Mr. Stewart. Art Gadbois' residence along Mud Lake Road in Clear Lake has a large spruce tree just outside the back porch which was clearly stained to the height of the flood waters (which were higher then they had ever been in the history of the house being there). The height of the stain lined up exactly with the flood stains on an old cabinet on Mr. Gadbois' back porch.

As to the cause of the tree staining I would agree with Mr. Stewart that it is unknown, however, more likely than not, based on research I have done on the volcanoes which

impact flood flows on the Skagit, I feel it could be attributable to the very high sulphuric acid content of the streams and tributaries flowing into Baker River from Mt. Baker.

What I find most amazing about this section of the 1923 Stewart Report is that he clearly spent a lot of time with Joseph Hart and was just as clearly impressed with the gentleman. I find it utterly impossible to believe that at no time did Mr. Hart ever mention to Mr. Stewart the real cause of the 1856 flood. You see, Mr. Hart was quoted in a local newspaper in 1896 as saying the following:

> Our fellow townsman, Mr. H.L. Devin, was some years ago engaged in surveying in the upper valley in the vicinity of Baker Lake. Being detained over night in an Indian camp, he was told the history of a great flood. They said that about 60 years ago a great slide had choked up the narrow outlet of the Baker valley and that the water accumulated in the basin thus formed until the whole valley was an immense lake, full 80 feet deep. By this time the imprisoned waters had burst through the dam and in a few hours this great volume of water was precipitated into the Skagit flooding the whole valley. The water marks still plainly visible high up the sides of the Baker valley and the great variation in those upon the trees as you come down the Skagit would indicate that this was the real cause of that terrible disaster." ***(Reprinted from the Skagit County Times, Serving Sedro and Woolley, Skagit County Washington, Thursday, November 19, 1896.)*** ***(See 11/19/1896 SCT)***

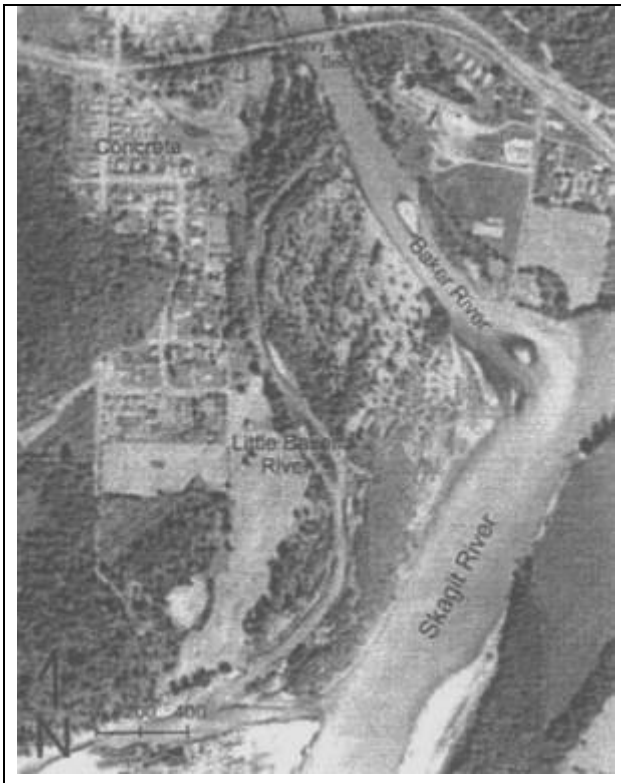
One now has to wonder how Mr. Stewart was able to ascertain the height of the 1856 flood 47 miles upstream of Concrete at Reflector Bar when clearly the majority of the water came from the Baker River. However, Mr. Hart's article does support the premise that the tree stains are caused by large amounts of water coming from the Mt. Baker vicinity. Given the Indian's statement that the water rose "very quick" I think also gives credence to the articles statement concerning the failure of a debris dam bursting.

However, one must also take into consideration that "Harry L. Devin, born in Ottumwa, Ohio, June 16, 1862, came to Sedro in 1889 on a visit and liked the locale so well that the following year he brought his family here an established his home." ***(See 6/29/39 CT)*** This would mean that the statement "some years ago" would have had to be between 1890 and 1894. If Mr. Devin understood the Indians correctly, then "about 60 years ago" would have been between 1830 and 1834 which doesn't fit either the 1820 or the 1856 flood scenario. We of course do not know how well Mr. Devin spoke Lushootseed[10] or how well the Upper Skagit or Chilliwack Indian[11] spoke English. Suppose Mr. Devin didn't translate the story correctly from the Indians or Mr. Hart misstated the quote from Mr. Devin. Suppose instead of 60 years they said 70 years which would put it back to the 1820 flood and suppose Mr. Devin just assumed that due to the

[10] Native language. (See http://www.nps.gov/noca/native1.htm)

[11] The Upper Skagit's and Chilliwack tribes hunted and fished along the Baker River. If the story came from the Upper Skagit's they very well could have been talking about the slide at Diablo instead of Baker. (See http://www.nps.gov/noca/native1.htm)

mud marks on the trees down Baker that the Indian was speaking of the "slide" in Baker when instead the Indian was speaking of the slide in Diablo Canyon. USGS has stated that they can find no evidence of a "slide" in the Baker River Valley or evidence of a debris dam or slide releasing a large amount of water. We will perhaps never know anything other than speculation on the part of geologist and hydrologist whose professions are based on assumptions. All we really know is that an Indian told Mr. Devin, who told Mr. Hart, who told Mr. Stewart, which is hardly an unbroken chain of evidence. We also know that both Diablo and Baker River canyons were extremely narrow before the building of the dams and a slide of any kind would have not only been possible but probable. Earthquakes, snow slides, landslides, log jams, all could have made the conditions described by the Indians. Evidence of the slide in the Baker River could have been removed when the river was diverted from its channel back to its original channel or when the channel was dredged for the building of the dam. (*See **8/6/21 C.H.**, **8/28/24 C.H.**), (**See also Appendix B** pages 70 and 71 for just how narrow the canyons were where they built the dams and how even a minor slide could have caused log jams to build very quickly.) (**See also** the below pictures.)*



Historical view of the Baker River and Little Baker side channel circa 1956, prior to dredging of the Baker River.

Baker River after dredging, circa 1967, showing the dried-up Little Baker former side channel.

Source: http://www.skagitfisheries.org/PastNews/Little%20Baker.htm

6. Glacial History

The 1923 Stewart Report spends a lot verbiage on the glacial history of Skagit County. Mr. Stewart attributes the glaciers to forcing the Skagit River above Concrete and pouring "across the Skagit-Suiattle Divide and thence down the Stillaguamish River." But then he states "The Skagit channel from Sauk to Concrete gradually cleared, after the retreat of the Baker glacier, until a high flood in the Skagit over-topped the remaining material and cut a channel for itself. This final step marked the recapture of the Upper Skagit." [12] ***(Source: Stewart Report 1923)***

What Mr. Stewart did not know was that the "large flood on the Skagit" was actually the result of an eruption of Glacier Peak flooding the Sauk River. The White Chuck assemblage Lahar traveled 100 km (62 miles) down Stillaguamish River Valley to Arlington. That eruption changed the flow of the Sauk River near Darrington from the Stillaguamish River to the Skagit River. . ***(Postglacial Volcanic Deposits at Glacier Peak, Washington, and Potential Hazards from Future Eruptions, by James E. Beget, (1982), Open File Report 82-830)*** In fact nowhere in any of the Stewart Reports including the 1961 report does he even recognize Glacier Peak as a volcano. The importance of this observation is that had Mr. Stewart done any research at all on either the Baker River or the Sauk River he would have recognized the strong probability that the flood "marks" he observed could have been influenced by volcanic activity and/or debris dams. There is no indication in any of his written materials that he made any serious attempts at studying the tributaries to the main stem of the Skagit River.

Do I believe that he located many indicators of large floods on the Skagit River? The answer would be an unequivocal yes. But which flood levels or marks or silt in trees would have been caused by actual rain on snow events and which ones would have been caused by debris dams, log jams, or volcanic mud flows is a question that he never attempted to answer.

C. 1961 REPORT

As previously stated the 1923 Stewart Report was unpublished. Thirty eight years later USGS published the Geological Survey Water-Supply Paper 1527 titled *Floods in the Skagit River Basin Washington* by James E. Stewart and G. Lawrence Bodhaine. It is believed that by the time the 1961 report was published Mr. Stewart had passed away. I base that statement in part on the following and in part on the letter from Mrs. Stewart contained in the USGS files forwarding Mr. Stewarts Skagit files to USGS:

> The pertinent data from the report written by J. E. Stewart are included in this report. Interest in the report was revived in 1942 by F. M. Veatch, who succeeded G. L. Parker as district engineer. As a result, some work on it was done in the Washington office during the next few years, chiefly

[12] We now know that he relied heavily on "The Glaciation of the Puget Sound Region" by J. Harlan Brets, Bulletin No. 8, Washington Geological Survey, See page 35 of 1923 Stewart Report.

> by W. S. Eisenlohr, Jr. In 1949 additional field data were obtained, and work was resumed to evaluate previous data. Most of this report was written by G. L. Bodhaine, Tacoma district. He used the basic data and reports of J. E. Stewart and recent data concerning floods in the Skagit River basin. ***(Stewart Report 1961 Page 4)***

However, several individuals worked on the 1961 report. The last piece of correspondence from Mr. Stewart identified in the USGS files was a letter he wrote in 1950. He wrote in part the following:

> "In April and May 1946 we had some correspondence regarding the possibility of slope measurements below "The Dalles" on Skagit River near Concrete." "…the proposed slope measurements would be made so as to check (using the gaging station rating) the accuracy of the value of "N" used in my 1923 computations for previous large floods at "The Dalles. In March 1923 … I had to leave Tacoma before I had completed the Skagit River Preliminary Flood Report (which contains all of the material previously promised to Skagit County). The most important work not accomplished at that time, due to lack of a gaging station at "The Dalles", was checking the value of "N" used for the slope sections."

Attached to the letter was a memorandum in which Stewart made recommendations for the "slope section". He stated in part,

> "To counteract the uncertainties involved in velocity head gain or loss, it is advisable to take several sections and average the results obtained from them. …In 1922-1923 cross-sections were taken at 618—2,749 and 4,655 feet downstream from the mouth of "The Dalles". It is suggested that for this important check-work five cross-sections be taken, say about 700—1,700—2,700—3,700 and 4,700 feet downstream from the mouth of "The Dalles". It is important that the first one of these below The Dalles be far enough below so that all of the velocity head gained in The Dalles is lost; i.e. that the water has at least reached its maximum level resulting from the loss in velocity head. Another feature of some importance, although how much is uncertain, is the amount of surging in the stream at the ends of the sections during the crest of the flood. Manifestly the only elevations available, when the flood crest is based on high water marks, is the crest of the surges, whereas what is needed is the mean level of the water at the time of the flood crest. ***(Source: Letter to FM Veatch, District Engineer, USGS, Tacoma, WA from Stewart, 6/1/50)***

On June 1, 1950 Mr. Veatch responded to Mr. Stewart's letter. He stated in part:

> "Thank you for your letter of June 1 relative to verification of the value n for the slope-area reach below "The Dalles" on Skagit River near Concrete

and for your suggestions for making the determination." ***(Source: Letter to Stewart from Veatch, 6/7/50)***

1. The "N-Factor"

At this point a more thorough discussion of the "N-Factor" is appropriate. The "N-Factor" is a roughness coefficient that's used to determine the hydraulic properties of a cross section of the river. The formula is:

Q=1.49/n(AR^(2/3)S^(1/2))

where

Q is the stream discharge

n is Manning roughness coefficient

A is the channel wetted cross sectional area

R is the hydraulic radius = A/wetted perimeter
S is the water slope

Manning's n for "natural" waterways ranges from 0.015 to 0.050. It could be higher for steep streams with large boulders, and smaller for a very flat sand bed river, but the above range is usually a good starting point. To determine the n value for natural streams takes experience, there are some reference books but most everything was done for the Southeast US and doesn't work for the Northwest. The best way to determine the n value is to find a cross section and measure the area, slope, discharge and back calculate the n value. The n value doesn't have to remain the same for the entire length of the river, it usually changes when the river changes, slope changes, bed material changes etc. ***(Source: Corps of Engineers, Portland District)***

If any specific discharge varies by 5 percent, the corresponding stage could vary significantly depending on the stream slope and geometry. Instantaneous peak discharges presumably would be less accurate. Thus, a potentially significant accuracy problem exists with the basic data. ***(Source: Corps' Engineering Manual EM 1110-2-1416, Page 3-7)***

Unfortunately, Manning's *n* can seldom be calculated directly with a great deal of accuracy. Gage records offer the best source of information from which to calculate *n* for a reach of channel near a gage. . . . Determination of overbank *n* values requires a detailed field inspection, reference to observed flood profiles, use of appropriate technical references, consultation with other hydraulic engineers, and engineering judgment. ***(Source: Corps' Engineering Manual EM 1110-2-1416, Page 3-7)***

The engineer must evaluate the significance of other factors influencing *n*, including bed form changes, channel alignment, cross-sectional area changes, and bank vegetation. Field inspection of the study stream at varying states of flow is imperative for attaining appropriate estimates of *n* for ranges of discharge. It is not beyond reason to expect the hydraulic engineer to walk or float the entire reach of stream to determine friction values. ***(Source: Corps' Engineering Manual EM 1110-2-1416, Page 3-9)***

Important to note at this point is that all of Stewart's "estimates" were before a gage was installed at "The Dalles" and there is no indication that he consulted with other engineers with respect to determining the flood elevation (flood marks of historical floods) estimates. All of his work in the field was never substantiated or observed by other engineers. All subsequent work performed by USGS engineers "assumed" that Stewart's observations were correct.

Conceptually, there are two major features in any reach: the channel and the floodplain. The friction force in the channel stems primarily from the bed sediment grains and bedforms, whereas the friction forces in the floodplain stem primarily from vegetation and, perhaps, structures. Decidedly different values of *n* can be expected for these regions and they should be differentiated. ***(Source: Corps' Engineering Manual EM 1110-2-1416, Appendix D Page D-17)***

The significance of this discussion is that by "tweaking" the "N-Factor" you can alter the estimated flood flows by a substantial amount as will be shown later in this White Paper. Stewart determined the "N-Factor" near Sedro-Woolley as follows:

> "Kutter's "n" (*now referred to as Manning's "n"*) was taken at 0.035 for section 4; 0.04 for section 2, 3, and 5; and 0.050 for sections 1 and 6. Considerable allowance (up to 100%) was made for increased wetted perimeter, when trees, piles, stumps, building, or other obstructions hindered the flow. Slope was taken as the same as found in 1200 feet of river section between bridges. ***(Source: Skagit River Near Sedro Woolley, Revision 1908—1922, 3/13/23 Page 80 of 81)***

However, for "The Dalles", the single most important measurements of flood levels and flow that Mr. Stewart calculated, the location where the Corps of Engineers is currently using to justify its multi-million dollar flood study, the following is known: "In the original computations an n of .033 was assumed for all sections on the basis of computed n's at Sedro Woolley." ***(Source: "Skagit River near Concrete, WA., Verification Study, M.A. Benson, USGS, 8/52)***

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

In 1950, two engineers working for USGS, evaluated Stewart's work product and authored a document titled "*Proposed Revision of Skagit River Flood Peaks".* For "The Dalles" area they stated the following:

> "On the basis of a slope-area study made in the reach below the gage for the flood of November 27, 1949[13], it appears that the value of "n" used by Stewart in his 1921 flood flow computation was too low for his upper reach. It was also noted that Stewart did not take into account changes in velocity head in his computations. A recomputation of the 1921 peak by present methods using Stewart's values of A, P, and f, and "N" = .040 for the upper reach and "N" = .033 for the lower reach gives 209,000 cfs." … "I can find no data on which to base an estimate of the percentage of energy recovery for various conditions, but it might be that much of this

[13] The gage in The Dalles was installed in 1924, three years after the last flood "estimated" by Stewart.

energy is lost in moving the gravel bottom of the stream." … "The need for revision of the historic flood peaks is supported by the logarithmic extension of the present rating curve. … at those times the overflow area was heavily timbered and would carry little water. In addition, the possibility of a reduction in slope **due to log jams** downstream is to be considered. The recomputed value of 209,000 cfs mentioned above checks this logarithmic extension within 2%. The flood frequency curve shows a sharp offset to the right between recorded and historic floods and **casts further doubt on the published values for the historic floods.** ***(Source: Proposed Revision of Skagit River Flood Peaks, H.C. Riggs & W.H. Robinson, 11/16/50)***

This report is significant because it documents the first time that anyone from USGS ever checked Stewart's work. Twenty-eight years after Stewart's "field work". Nowhere in this or subsequent work products is it documented that anyone ever went into the field and tried to find Stewart's "flood marks" which as previously stated, in the case of "The Dalles" is approximately one mile upstream. ***(Source: Stewart Report 1923, Page 4, See also previous discussion Page 11 herein.)*** It is the first time that the "N-Factor" is adjusted. It is the first and only time that USGS recognizes the probable impact that log jams can have on flood flows.

For the Sedro-Woolley area Riggs and Robinson wrote in part the following:

"There was little basis for the original extension of the rating curves at Sedro Woolley. … The extension of the rating curve for the 1921 flood is **based on measurements made during 1922-23**. … The flood of Nov. 28, 1949 reached a stage of 41.7 ft (USGS datum) at Sedro Woolley. Measurement No. 76 shows the datum then in use (prior to 1923) to be 8.93 ft higher than USGS datum. Then the 1921 flood was higher than the 1949 by 54.3 – 8.9 -41.7 = 3.7 feet. … The great difference between the 1897 peak near Concrete and near Sedro Woolley must be due to the extreme sharpness of the peak. ***(Source: Proposed Revision of Skagit River Flood Peaks, H.C. Riggs & W.H. Robinson, 11/16/50)***

The proposed revisions to the flood peaks by Riggs & Robinson are as follows:

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

Revision for Sedro-Woolley		
Year	Stewart 1923	Revisions 1950
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

Needless to say, the above proposed revisions were substantial. The Dalles ranging from 30,000 cfs reduction for the 1917 and 1921 floods to 100,000 cfs for the 1815 flood. Sedro-Woolley reductions in flow ranging from 15,000 cfs for the 1896 flood to 70,000 cfs for the 1815 and 1856 floods. What is important to note is that all of the proposed revisions are based on changing the components of the mathematical equation used to calculate flood flows while still using Stewart's flood elevation marks.

3. F. J. Flynn Report

Two months later another USGS employee named F. J. Flynn wrote a paper further analyzing the Stewart data at Sedro-Woolley. He stated in part:

> "Control conditions are such that an extension of the rating at Sedro Woolley is subject to much greater doubt than the extension of the rating at Concrete. The assumptions made in the analysis by Riggs and Robinson appear generally reasonable and the proposed revisions should be better than the originally published figures. **However, it is possible that the proposed figures for 1909, 1906, 1897, 1896 are still too high."** . . . "This cut-off about a mile downstream from the station cut more than two miles of river channel around the bend. …it appears that the 1909 peak at Sedro Woolley could be as low as 165,000 cfs. If a curve over to left is logical for 1909, it probably should be used for the 1906 flood too, and maybe all the prior floods." ***(Source: Skagit River near Sedro-Woolley, Revision of historic flood peaks, F.J. Flynn, 1/25/51)***

Mr. Flynn was concerned about the impacts of the Sterling Bend cutoff which occurred in the 1911 flood which according to USGS records only carried 66,600 cfs. Stewart included in his "1923" report that this cut-off was "sided by dynamite" which strongly suggest this was not a natural occurrence.

4. M. A. Benson 1921 Flood Report

In May of 1952, Mr. M. A. Benson, another USGS employee, made some calculations for the flood of December 13, 1921. He determined that the flood flow for that flood at The Dalles should be 225,000 cfs. He based that determination on using an "N-Factor" of .030 (lower than what Stewart used) and data from the flood of November 27, 1949. The notes on the computation are as follows:

> "Only reach B-C used. Reach A-B is expanding and "n" for that portion of the channel is not well verified. Value of "n" for reach B-C is from verification using data from flood of November 27, 1949. ***(Source: Slope area measurement of Skagit River near Concrete for the flood of December 13, 1921, M. A. Benson, 5/5/52)*** ***Note: See Appendix C.***

In August, 1952, Mr. Benson and presumably Mr. Flynn co-authored a "Verification Study" for the Skagit River near Concrete, Wash. They stated in part:

> The peak discharge of the flood on Nov. 27, 1949 was 153,000 cfs from rating curve extended above 135,000 cfs. The rating is defined at high stages by a series of measurements made in 1932. "The peak discharge for the flood of Dec. 13, 1921 was originally computed by Mr. J. E. Stewart … as 240,000 cfs. … **Using Stewart's values of fall and area and wetted perimeter** of the sections the peak discharge of the flood of Dec. 13, 1921, was recomputed as 209,000 cfs with values of "N" assigned on the basis of those determined for the flood of Nov. 27, 1949. … Stewart's section 1 was about 300 feet upstream from sect. A of the 1949 flood; his section 2 was between sections B and C; and his section 3 was about 700 feet downstream from section D. There appears from the stereo-realist slides to be very little likelihood of much change in conditions in the reach since 1921. … After adjusting the areas for the difference in stage between the two floods, there appears to be practically no change between 1921 and 1949. … The writers believe that there is little basis for using a higher "N" in the upper part of the reach than in the lower part. They feel that an "N" computed for the reach B-C-D is more logical. They also feel that only the reach 2-3 of Stewart's 1921 determination should be used in computing the discharge because reach 1-2 is expanding and the "N" for that reach may be questionable. **Using Stewart's values of Fall**, A and r and the 2-section formula, the writers have computed (unchecked) a discharge of 225,000 cfs using an n of .030 (as determined by the 3-section formula for verification study). In memorandum by Riggs and Robinson dated 11-14-50, there is listed proposed revisions for historic floods. These revisions are based on a straight line extension of the rating curve on log-log paper. However, some of the proposed revised figures actually fall to the left of the straight line extension (those for 1856 and 1897). The writers do not have any data upon which to judge the reasonableness of the straight line extension. However, it should be realized that a wide overflow section many miles downstream from the gage could cause the rating to bend to the right. Furthermore, if the discharge for the 1921 is plotted at gage height 47.6 feet and 225,000 cfs it indicates a break to the right. On the basis that the peak for the 1921 flood as computed by Stewart (240,000 cfs) is too high and that the rating now in effect and also in 1921 was the same all the way back to 1815, then the published values for all the historic floods are also a little too high but the highest flood (1815) may be correct. It is felt that the proposed revised figures as listed in the memorandum are too low. After the computation of the 1921 flood is checked, we would favor extending the rating exactly through that point. ***(Source: Skagit River near Concrete, Wash. – Verification Study by F.J. Flynn and M.A. Benson, 8/52)***

The statement, "There appears from the stereo-realist slides to be very little likelihood of much change in conditions in the reach since 1921" would appear to be in direct conflict not only with verbiage contained in this report but with the note contained in the 5/5/52 slope area measurement, "Only reach B-C used. Reach A-B is expanding

and “n” for that portion of the channel is not well verified.” (*See Appendix C*) So based on a “belief” (i.e. an assumption); “without any data in which to judge the reasonableness of the straight line extension”; and using Stewart’s figures they recomputed the flow to be 225,000 cfs.

It has been documented that more likely than not that the 1856 flood was a debris flood coming out of the Baker River. Since The Dalles is over two miles below both the Baker River and the Sauk River, both volcanic in nature, and a very narrow rock canyon as compared to upstream and downstream conditions it is also more likely than not that several log jams occurred in this area. Contained in Stewart’s Field Notes is the following notation: *“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.”* Depending on how you want to read the notation either the 1897 flood or the 1909 flood had a major log jam at the Dalles. There is no indication that Benson or anyone else at USGS ever reviewed the Stewart field notes. There also is no indication that Benson or anyone else at USGS ever discussed the possibility that log jams occurred at The Dalles.

5. F. L. Hidaka 1954 Sedro-Woolley Report

In January, 1954, yet another USGS employee, Mr. F.L. Hidaka looked at the Stewart Report and made recommendations for revisions to the flood figures for Sedro-Woolley. There is evidence in the file through later cited documents that he also authored a report for Concrete at The Dalles however that report was not located in the USGS files. Mr. Hidaka stated in part:

> “Measurements 4-10 were used in the definition of the rating tables dated March 17, 1923, which was the only curve which was defined in the upper end before Sterling Bend was cut-off by the river in 1911. A definite change is believed to have taken place after the bend was cut-off causing the rating curve to plot to the right. … Based somewhat on the discharges which were determined for Skagit River near Concrete and upon the elevations of the flood as determined by Stewart, a tentative curve has been drawn. This curve shows less water then obtained at Concrete because of the short duration and the intensity of the flood which due to channel storage reduced the peak at Sedro Woolley. There is actually no basis for this extension except that it is not believed that the rating curve should break to the right and then back to the left. … On the basis of the tentative curve … new estimates of discharges were made for all the floods which occurred before the Sterling Bend cut-off. … It is believed that the discharge estimates for the 1917 flood is correct and it checks the statement made by Stewart that this flood was remarkable for the length of time that it stayed up high. The discharge obtained for this flood at Concrete was 200,000 cfs while that at Sedro Woolley is 195,000 cfs. Due to the long duration of the flood, the peak discharge for this should be very nearly the same at the two stations because all the channel storage has had an opportunity to fill up and therefore, allowing the peak to proceed down the river without any reductions. The peak for 1921 should be revised on this basis to 200,000 cfs from 210,000 cfs. It is believed

that the cutoff of Sterling Bend had enough effect to cause the entire rating to shift to the right and it is on this assumption that the ratings have been extended. ***(Source: Skagit River near Sedro-Woolley, Wash., Proposed revisions of historical flood peaks, F. L. Hidaka, 1/12/54)***

The revisions to the Stewart figures for Sedro-Woolley as proposed by Mr. Hidaka were as follows:

HIDAKA REVISIONS TO SEDRO-WOOLLEY STEWART FIGURES		
YEAR	STEWART 1923	REVISIONS 1954
1815	400,000	370,000
1856	300,000	260,000
1896	185,000	145,000
1897	190,000	145,000
1906	180,000	140,000
1909	220,000	175,000

(Source: Skagit River near Sedro-Woolley, Wash., Proposed revisions of historical flood peaks, F. L. Hidaka, 1/12/54)

The above revisions represented a change of 7.5% to 23.7% in the Stewart figures. There are handwritten notes on the Hidaka report, signed by G.L. Bodhaine on 5/11/54 which changed all of Hidaka's recommended revisions.

6. G.L. Bodhaine, 1954 Memorandum of Review

Finally, thirty one years after the 1923 Stewart Report was begun, in February, 1954, Mr. G.L. Bodhaine, Area Engineer with USGS in Tacoma, began work on the final work product of publishing, for the first time, the Stewart Report. ***(Source: Letter to JVB Wells, Chief, Surface Water Branch, USGS, Washington DC from F.M. Veatch, District Engineer, USGS Tacoma, 3/23/54.)*** In March of 1954, Mr. Bodhaine authored a Memorandum of Review in which he stated in part:

> "A decision must be made soon concerning the revision of the flood peaks determined by J.E. Stewart at the gaging stations on Skagit River near Concrete and near Sedro Woolley." **Concrete:** "The 1921 flood peak near Concrete seems to be the logical point through which to extend the rating curve for this station. Benson's computed discharge of 225,000 cfs has been checked and seems to be a reliable figure. A logical extension of the rating curve passes through this point and the 1815 flood peak of 500,000 cfs. … The newly suggested values all differ from those of Stewart by less than 10% so perhaps they should not be revised."

Sedro Woolley: There is no firm basis for extending the rating curve for this gaging station because of dike breakage and the lack of good high water measurements. Measurement 1-10 was made before Sterling Bend was cut off in November 1911. During the next few years considerable changes took place and by 1917 the low water rating had changed by about 3 feet. The effect on the high water rating is unknown because it was not well defined before Sterling Bend was cut off. … Scour is an unknown factor. A small piece of evidence that the river did shift considerably after Sterling Bend was cut off lies in a letter Mr. Veatch received from Mr. Nordmark … in June 1944. Mr. Nordmark stated, "As you know the floor of the river dropped several feet and the water table as measured in wells in the vicinity dropped about 6 feet." *This statement was made in reference to the elimination of Sterling Bend.* … "The writer questions the theory that the peak discharges near Sedro Woolley will always be less than those near Concrete. This factor is dependent upon channel storage, **duration of flood peak,** and intermediate inflow. In November 1949 the peak discharge near Concrete was 154,000 cfs while that near Mt. Vernon was 114,000 cfs which shows quite a reduction. However, in February 1951 the peak discharge near Concrete was 139,000 cfs while that near Mt. Vernon was 144,000 cfs which shows a slight increase. It is not known how many Skagit River floods may have been affected similarly. … The 1951 flood just reached the top of the dikes just downstream from Sedro Woolley but did not break through them. This point, then, should represent main channel flow. These same dikes broke in 1917 and in 1921 so the discharge could easily have increased to 200,000 cfs with little additional change in gage height as is indicated on the rating curve. The writer believes the 1917 and 1921 peak discharges suggested by Stewart to be quite reliable based on the above discussion. … The writer recommends that Stewart's values be used. A maximum change of 10.8% seems small when all of the possible errors are considered. ***(Source: Skagit River Flood Peaks, Memorandum of Review by G. L. Bodhaine, USGS, 5/13/54)***

The new suggested values assigned to the historical flood flows for Concrete were as follows:

G.L. Bodhaine Flood Flow Curve Figures for Concrete, 1954			
YEAR	STEWART Discharges in cfs	NEW CURVE Discharges in cfs	Percent Difference
1815	500,000	500,000	0
1856	350,000	340,000	2.9
1897	275,000	265,000	3.6

G.L. Bodhaine Flood Flow Curve Figures for Concrete, 1954			
YEAR	STEWART Discharges in cfs	NEW CURVE Discharges in cfs	Percent Difference
1909	260,000	240,000	7.7
1917	220,000	205,000	6.8
1921	240,000	225,000	6.2

(Source: Skagit River Flood Peaks, Memorandum of Review by G. L. Bodhaine, USGS, 5/13/54)

The new suggested values assigned to the historical flood flows for Sedro-Woolley were as follows:

G.L. Bodhaine Flood Flow Curve Figures for Sedro-Woolley, 1954			
YEAR	STEWART Discharges in cfs	NEW CURVE Discharges in cfs	Percent Difference
1815	400,000	400,000	0
1856	300,000	290,000	3.3
1896	185,000	165,000	10.8
1897	190,000	170,000	10.5
1906	180,000	165,000	8.3
1909	220,000	200,000	9.1
1917	195,000	195,000	0
1921	210,000	210,000	0

(Source: Skagit River Flood Peaks, Memorandum of Review by G. L. Bodhaine, USGS, 5/13/54)

What is amazing about Mr. Bodhaine's suggestions is that there was no work product in the files to justify his findings in his memorandum. There was nothing to suggest that he ever traveled to Skagit County at any point in time. There is nothing to suggest that he took into consideration the possibility that Stewart's flood elevation

figures were impacted by log jams or other obstructions in the river. In fact, there is nothing in the record to suggest that he even reviewed Stewart's field notes.

What is known is that the Tacoma USGS office was under extreme pressure from their Washington DC office to complete the report. ***(Source: Letter to JVB Wells, Chief, Surface Water Branch, USGS, Washington DC from F.M. Veatch, District Engineer, USGS Tacoma, 3/23/54.)*** What is known is that Mr. Bodhaine only began work on the report in February of 1954 and by May 15, 1954 he had totally disregarded all the suggested flood flows from other USGS hydrologist who had looked at Stewart's work product since 1950 (with the exception of the Benson Report), one as recent as January 1954. ***(Source: Skagit River near Sedro-Woolley, Wash., Proposed revisions of historical flood peaks, F. L. Hidaka, 1/12/54)***

What is strongly suggested is that Mr. Bodhaine, took Benson's 1921 flood calculations which computed a discharge of 225,000 cfs which has been previously identified as being based on "*a series of measurements made in 1932*" and "*data from the flood of November 27, 1949*" because it "seems to be the logical point through which to extend the rating curve for this station"; accepted the Stewart calculations of the 1815 flood, and then made all the other figures fit his new curve. Admittedly this statement is speculative in nature, however, given the fact that even the Corps of Engineers doesn't use the 1815 or for that matter the 1856 flood events for anything in their calculations, it would appear that Mr. Bodhaine's work product is highly suspect.

In July of 1954, Mr. Bodhaine sent around for review a draft copy of the "Floods in the Skagit River Basin". He attached a cover memorandum. The memorandum had 9 "Notes for reviewers". Among them were:

> (3) We do not have funds (see letter to JVB Wells, dtd July 2) to do any additional work on the flood frequency study. That study is complicated by storage in the reservoirs so perhaps **the most simple study is desirable**; (5) The high-water profile is not very complete but it seemed that some sort of profile should be presented. ***(Source: Cover memorandum attached to a draft of the Stewart/Bodhaine report from GL Bodhaine, 7/2/54)***

Further evidence that the flood flows at Sedro-Woolley were speculative in nature is found in a paper authored by F.J. Flynn in July, 1954, commenting on Mr. Bodhaine's memorandum of 5/13/54. He states in part:

> "The ratings are complicated by lack of definition, building of dikes and breaking and overtopping of dikes and the unknown effect at high stages of the Sterling Bend cut-off made in 1911. The assumptions and analysis made by Mr. Bodhaine **appears reasonable** and we agree with his recommendation to leave unrevised the figures of discharge for historic flood peaks. ***(Source: Memorandum titled Skagit River at Sedro Woolley, Wash., Historic Flood Peaks, F.J. Flynn, 7/15/54)***

The very next day Mr. Flynn authored another memorandum concerning Bodhaine's work for The Dalles near Concrete. He stated in part:

"This gives a logical looking curve." . . ."…the gage site and datum should be looked into and corrected if necessary in the compilation report. It appears the "Gage" paragraph of the annual reports 1951 is incorrect." "…it would appear that the flood heights…for the historic floods are at site 200 ft upstream and at same datum used Dec. 10, 1924, to Oct. 27, 1937. (*He suggested that the statement in the report be changed to read)*, "Prior to Dec. 10, 1924, staff gage at site 200 ft upstream at datum 12.7 ft higher." "When we wrote our memorandum of 12/21/45[14] we had no idea of the slopes involved. However from the falls measured in the slope-area determination, the fall between the two gage sites is probably on the order of 0.2 ft. … Even though the error due to neglecting fall between the two gage sites would tend to increase the percentage differences between Stewart's figures and the present curve, no changes in the published figures of discharge are warranted." ***(Source: Skagit River near Concrete, Wash., Historic Flood Peaks, F.J. Flynn, 7/16/54)***

7. 1961 Report Analysis

Seven more years go by and finally, in 1961, the Bodhaine/Stewart Report is published. An interesting table was contained in the report, which is partly reproduced here only to show locations above the mouth of the Skagit River for clarity purposes to reference where Mr. Stewart conducted some of his research:

LOCATION	MILES ABOVE MOUTH
Mouth of Skagit Bay	0.0
Mt. Vernon	10.2
Nookachamps Creek	17.4
Gages near Sedro Woolley	21.1
Day Creek	34.1
Alder Creek	40.2
Birdsview	44.3
Gage near Concrete (Dalles)	52.0[15]
Baker River	55.0

[14] The memorandum referenced was not located in the USGS files.

[15] According to this chart, The Dalles is 3 miles below Concrete. Mr. Stewart repeatedly stated that distance was one mile. Maps being utilized today show the difference to be 2.5 miles.

LOCATION	MILES ABOVE MOUTH
Sauk River	68.7
Gorge Dam	95.2
Reflector Bar	99.8
Diablo Dam	99.9
Ross Dam	103.8
Canadian Border	134

(Source: Stewart Report, 1961 Page 8)

Since the writing of the 1923 Stewart report to the publication of the 1961 report the Skagit River experienced no less than 30 documented flood events (***See Appendix D***). The 1961 report while incorporating much of what Mr. Stewart said in his 1923 report supplemented the information with additional flood information most notably the 1949 and 1951 flood events. Pertinent sections to this memorandum of the 1961 Report follow with specific page number references as well as "Comments" on each section:

GEOLOGY –The Skagit River was blocked not only by this tremendous glacier near its mouth, but also further upstream near the town of Concrete where a large local glacier came down the Baker River Valley. The dam formed by one of the glaciers forced the Skagit River to cross a pass, now occupied by the lower Sauk valley, into the Suiattle River Basin. During a portion of this glacial epoch, while the ice dam held, the entire Skagit River above Concrete poured across the Skagit-Suiattle divide and thence down the Stillaguamish River. The ice dam probably held for many thousands of years and during this time the Skagit-Suiattle pass was rapidly cut down to form a regular river channel. After the glacial epoch, the Skagit River returned to its old lower valley and was able to capture the Suiattle and Sauk Rivers from the Stillaguamish River through the new channel cut through the Skagit-Suiattle divide. … It may be nearly 1,000 feet to bedrock in the old river channel on the Skagit delta. ***(Page 8)***

Comment: Again no mention of the volcanic activity of Glacier Peak or even any mention that Glacier Peak is a volcano.

WINTER FLOODS – A rainfall-runoff study for the Skagit River, based on discharge records at Sedro Woolley and precipitation records in the upper part of the basin, at and near Reflector Bar, was made by J. E. Stewart. This study shows that during the years 1909-23 the average yearly runoff in inches at Sedro Woolley was very nearly equal to the average precipitation at the upper basin sites. This indicates that a much heavier precipitation must have occurred at higher altitudes in order to provide the additional amount of water lost through evaporation, transpiration, retention, and ground water. For example, the precipitation in November 1909 was 27.7 inches and the runoff was 12.5 inches; in December 1917 the precipitation was 29.8 inches (7.4 inches occurring

December 27-29) with a runoff of 14.1 inches; and in December 1921, 12.8 inches of precipitation (10.21 inches occurring December 10-12) ***(Page 10)***

Comment: 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 Glaicer 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. **(Flood Summary Report, Nooksack, Skagit and Snohomish River Basins, November 1990 Events, Corps of Engineers, 7/18/91)** The significance of these figures is huge. One has to ask oneself 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?

DURATION OF PEAKS – The duration of the flood peaks in the upper part of Skagit River is an important factor in determining whether the flood will be destructive in the lower reaches. **This may be especially true of the large floods that do not quite reach the stages and discharges of the known great floods**. The peaks of the floods of November 1949 and February 1951 were selected to demonstrate this point. **The peaks would have been considerably higher had there been no storage in the power reservoirs upstream**. ***(Page 11)***

SHORT-DURATION FLOOD OF NOVEMBER 1949 – The flood of November 1949 is a good example of the flattening of a flood crest as it moves downstream. Channel storage had a marked effect on the sharpness of the peak by the time the crest reached Mt. Vernon. The peak discharge of 153,000 cfs near Concrete was reduced to 114,000 near Mt. Vernon. The Sedro Woolley precipitation gage indicates that very little rainfall occurred in the lower part of the basin. ***(Page 11)***

LONG-DURATION FLOOD OF FEBRUARY 1951 – The peak near Concrete lasted many hours longer than the peak of November 1949 although it did not reach as great a discharge. **(T)he duration of the peak reduced the effect of channel storage and that the peak downstream was increased by a large contribution from the low elevations. The large amount of precipitation in the lower reaches of the basin accounts for a part of the increase in peak discharge as the flood progresses downstream.** ***(Page 13)***

EFFECT OF RESERVOIRS – The reservoirs in the upper Skagit River basin have had a material effect on the peak discharge of the river occurring since the dams were constructed. The dam on Baker River (lower Baker) at Concrete was constructed in 1926 and has had an effect on many peak flows in the Skagit River. Diablo Dam was constructed in 1930, and practically all peaks since that date have been reduced somewhat by storage in Diablo Reservoir. The first level in the construction of Ross Dam was completed in 1940, and all peaks since that date have been affected to some degree by storage in Ross Reservoir. By August 1949, Ross Dam had been raised two

more levels and was capable of reducing the peak to a great extent on all but the largest floods at that point. ***(Page 14)***

During the floods of November 1949 and February 1951, Lake Shannon was held at practically a constant level at the time of the peaks, so the Baker River peaks were not appreciably reduced by storage. However, during both floods Diablo and Ross Reservoirs stored large volumes of flow, and the peak discharges on the Skagit River at the gaging station near Concrete were substantially reduced. It has been estimated that the peak flow of the November 1949 flood at the gage near Concrete was reduced by 45,000 cfs owing to storage in the two main-stem reservoirs. This indicates a natural peak discharge of 200,000 cfs near Concrete which probably would have been of disastrous proportions in the lower valley even if the effect of channel storage on the sharp peak was considered. An estimate has been made that the peak discharge of the February 1951 flood at the gage near Concrete was reduced 13,000 cfs by upstream storage. If this flow had not been stored, it probably would have increased the peak at Sedro Woolley and at Mt. Vernon to about 158,000 cfs as a result of the long peak, which also might have proved disastrous to the lower valley. ***(Page 15)***

According to historic newspaper articles the above data would seem to be only partially correct for the 1949 flood event. The flood peaked at The Dalles on Sunday, November 27, 1949. According to the below articles no water was allowed to flow out of Ross Dam. The Lower Baker Dam held back flood waters until late Saturday evening when water was released "at a minimum rate". Hamilton did not begin to flood until 2 a.m. Sunday morning the day the river crested. So the Baker River did contribute to the peak of the flood however, one could surmise that the "short duration" of the flood event was greatly impacted by the storage provided by Lower Baker Dam. Also important to remember is that Upper Baker had yet to be constructed.

> Seattle City Light's Ross Dam on the upper Skagit played a large part in keeping the serious flood from being even worse, E. R. Hoffman, Lighting Superintendent, said today. The valves in the big dam were closed Wednesday, November 23, and no water from the entire upper river was allowed to pass. From Thursday midnight until Sunday midnight enough water was held behind the dam to cover 116,000 acres of land to a depth of one foot. At the crest of the flood approximately **42,600 cubic feet** of water were impounded every second. Elevation of Ross Lake, nearly 20 miles long, came up ten feet, and is now forty feet higher than anticipated for this time of year. On November 28 there was still enough storage space to impound another 200,000 acre feet of water behind Ross Dam.[16] The valves were still closed and no water was getting past the dam. The flood crest at Concrete, first large town below Ross Dam, reached 149,000 cubic feet per second on Sunday, November 27. This would have been disastrously worse except for the water held behind Ross Dam. The crest passed Mt. Vernon early Monday morning, November 28, and the entire river was reported to be receding.

[16] If this statement is true, and they indeed did provide 116,000 acre feet of storage and still had another 200,000 acre feet available, then why is it that they currently only provide 120,000 acre feet of flood control storage?

"Ross Dam does a great deal to keep floods on the Skagit from being much worse", Hoffman said. "However, it cannot be expected that a dam so far up the river will prevent floods altogether. "Only about one-fourth of the river lies above Ross Dam, and the tributary streams feeding the upper fourth are a good deal smaller than the streams below the dam." ***(Source: 12/1/49 B.J.)***

Heavy rains and unseasonably warm temperatures combined with other factors over the week end in causing the first serious flood on the Skagit river in many years. Although the river was high for several days, the rapid rise of the river Saturday night and Sunday morning caught most residents living near the river by surprise. The real cause of the flood was the unusually heavy rainfall during the week, when **11 inches fell on the upper Skagit between Tuesday and Sunday**. During the storm that hit here Saturday, **four inches of rain fell in 24 hours**. This, combined with a Chinook wind and the already bank-full river, brought the water up at a rapid rate starting early Saturday evening. By 2:00 a.m. Sunday water had started to enter the town of Hamilton and by morning there was from two to four feet of water over the entire town. . . . All traffic to the upper valley was closed Sunday by water over the road at Lyman. Before that a few cars had been able to get thru by detouring Hamilton by way of the Lyman Timber Co. road to Grandy Lake. . . . The fact that **water was low behind Ross dam** kept the flood from being much worse. The valves of the dam were closed Wednesday and the **dam was able to hold back all water here until the flood crest had passed**. At the crest of the flood 42,600 cubic feet of water were impounded every second. The **lake**, over 20 miles long, **came up ten and is now forty feet higher than anticipated for this time of the year**. Monday there was still enough storage space to impound another 200,000 acre feet of water. No water is being released. **. . .** The **Baker River dam here held back the rising Baker River until late Saturday evening, when storage capacity was reached.** The water was then released at a minimum rate, keeping the lake level at full height. The Sauk River, uncontrolled, was a big factor in the rapid rise of the river here. The flood crest here Sunday reached 149,000 cubic feet per second. ***(Source: 12/1/49 C.H.)***

HISTORY OF FLOODS – The flood of November 1909 was the largest flood on the Skagit River since the coming of the white man in 1878, except for the reach from Cascade River to a short distance below Birdsview where it was surpassed by the flood of November 1897. **Higher stages may also have occurred at other points during other floods as a result of log jams**. … It has been estimated that the natural discharge of the February 27, 1932 flood near Concrete (corrected for effect of upstream storage) would have been about the same as the discharge of the floods of 1896 and 1906 (U.S. Congress, 1933). It has been estimated that the natural discharge of the November 27, 1949 flood near Concrete (corrected for effect of upstream storage) would have been about the same as the discharge of the 1917 flood. ***(Page 22)***

Comment: This highlighted statement is significant and raises further doubt as to the credibility of Stewart's work. First it is an admission by USGS that log jams could have impacted stages of the river which ultimately could have an impact on "observed" flood marks. Second, there were hand-written notes by Mr. Stewart contained in the USGS files which show where he took his measurements and observed "flood marks". It is clear from a reading of those notes that Mr. Stewart determined a height of all the historic floods and then followed them all the way down the Skagit River. The heights of the floods remained constant. This raises the distinct probability that some of Mr. Stewarts "observed flood marks" were assigned to the wrong flood year.

HISTORIC FLOOD DATA –

SKAGIT RIVER NEAR CONCRETE – The floods of 1897 and 1917 have been dated on the assumption that the floods occurred shortly after midnight. The stages for the floods of 1897, 1909, and 1917 **have been estimated from flood marks about 1 mile upstream.** The stage of the 1897 flood is not as certain as the stages for the other two floods. ***(Page 24)***

Comment: The significance of the highlighted statement is that any debris dam or log jam concentrated in The Dalles would have impacted "flood marks" 1 mile upstream.

As previously stated, it is now believed that Stewart took his measurements in and upstream of Concrete which is 2.5 to 4 miles above The Dalles given Stewart's statements that The Dalles was one mile below Baker River. See earlier discussion herein and Appendix E of this report.

SKAGIT RIVER NEAR SEDRO WOOLLEY – The discharges for all floods except those in 1909, 1917, and 1921 are, to a large extent, based on comparative stages and discharges at other points. ***(Page 25)***

FREQUENCY OF FLOODS – Studies made by Benson (1960) and others, indicate that a long record is necessary before a reliable flood-frequency curve can be drawn. In order to come within 10 percent of the correct value 95 percent of the time for a 50-year flood, a length of record of about 110 years is required. In fact, to obtain this accuracy for even a 10-year flood required 90 years of record. However, to come within 25 percent of the correct value 95 percent of the time only about 39 years are required. To obtain this accuracy for a 10-year flood required only 18 years. . . . For this reason historic data have been included whenever possible to lengthen the record. By using certain floods back to 1815, a synthetic 143 record was obtained. ***(Page 53)***

Comment: In order for the highlighted text to be assumed correct one has to assume that the historical data collected was correct. Based on the document review performed in this Whitepaper and the questions now raised, I would submit that we can no longer make that assumption. We now have gage records for the past 82 years. Surely by using that data we can come very close to the 95 percentile and a lot closer then the 25 percent of the correct value.

The one mistake that the entire hydrologist community who have studied the Skagit River have made is the assumption that Stewart "got it right" with respect to the flows and heights and

order of the individual flood events. At the end of Stewart's field notebook there was a long list of people he wanted to contact and a "Things To Do" list. *(See Appendix A.)* The majority of which it appears Mr. Stewart never got around to accomplishing which would indicate that at best his 1923 report was incomplete. A couple of those things are worth mentioning here.

There is a long list of people he wanted to interview. Evidence in the field notebook suggests that at best he only interviewed one or two of these people. One of the people he wanted to interview was Charlie Moses who according to Stewart's notes was an Indian and "a good man".

In the "Things To Do" list, at #18 it included a notation to, "Get all data concerning floods and damages from newspapers." This is clearly something that Mr. Stewart never got around to doing. Had he done so he would have found the following article:

BIGGEST FLOOD IN SKAGIT HISTORY SAY OLD-TIMERS

The flood of 1921 is the biggest flood in the history of the Skagit, according to old timers, who recall the floods of 1879, 1888, 1897 and on up to the big flood of 1909 and the 1917 freshet.

Mrs. Dreyer, who lives west of town, tells of the big flood of 1888, when in some places the river backed up higher than this year. She says that not so much damage was done then because there were practically no dikes and the water spread over the lowlands more gradually.

Measurements at the Dalles, near Concrete, show that the flood water this year reached a point two feet higher than at any previous time in the memory of the oldest settler. Charley Moses says that it was the biggest flood, with the biggest volume of water ever carried in the Skagit.

At Van Horn the water was 14½ inches higher than it had ever been. In 1909 the river in the upper valley was only about two-thirds as wide as it is now. Hundreds of acres of land are being washed away every year, by both Skagit and Sauk rivers. W. A. Ellison says he has been on the upper river for 21 years and this is the biggest flood he has seen or heard old timers tell about.

Source: Courier Times 12/22/21 (12/22/21 CT)

Not only does the article document from several sources that the 1921 flood was higher than the other historic floods but they interviewed Charlie Moses, the man Mr. Stewart had on his list of things to do. There is no reason to believe that had Mr. Stewart interviewed Mr. Moses that Mr. Moses would have told Mr. Stewart anything different in 1923 then he told the newspaper just ten days after the flood occurred.

If that was the only local news article that came to that conclusion perhaps it would not carry the weight that it does. However, a week later the Concrete Herald ran the following story:

FLOOD WAS HIGHEST IN SKAGIT COUNTY HISTORY

> **Old timers in the Skagit valley, who have seen all the floods in the Skagit valley since the early 80's say that the recent flood carried a greater volume of water than any previous flood since the county was settled, surpassing even the famous high water of 1897.** The fact that the river did not reach marks set in former years at some points in the upper valley is accounted for by the widening of the river since that time. In all places where the banks of the river have remained unchanged the **1921 mark is considerably above that of any previous flood known to settlers.** ***(Source: Concrete Herald 12/31/21 C.H.)***

Further, when one reviews the newspaper articles concerning the 1909 flood in Burlington and compares it to the 1921 flood it is clear that the 1921 flood was more damaging even in the lower valley than the 1909 flood was:

> Burlington had about one foot of water in some of the streets, and there were many buildings over the town that were not even surrounded by water. ***(Source: 12/3/09 B.J.)*** Thursday was a great day in Burlington and many talked of camping on the heights Tuesday night, but the change came about noon, the water went down rapidly and Burlington has perhaps received less damage then any other town on the Skagit. ***(Source: 12/3/09 The Journal)***

> Monday night, December 12, the dikes east and southeast of Burlington broke. Tuesday morning at six o'clock the flood water covered Fairhaven Avenue, and in part the residence districts of the city. At this time the entire lowlands lying east, west, south and in part northwest of Burlington were inundated. The depth of water is on relative, the lamentable fact being that the area of low lands covered with water was wide-spread. ***(Source: 12/16/21 B.J.)***

Had Mr. Stewart ever gotten around to completing his long list of "things to do" his report might have had a degree of creditability. At best, his report is incomplete and never should have been published 40 years after the fact by USGS and blindly accepted by the Corps of Engineers and FEMA as "best available scientific information".

FREQUENCY SERIES – Two types of floods series are the partial-duration series, based upon the floods above a selected base discharge without regard to the number of floods that occur in any one year, and the annual-flood series, based upon the highest flood that occurs each year. There are objections to both types. The partial duration series may include floods that are not independent events, that is, the first flood sets the stage of the one closely following. The annual-flood series however, may omit a second independent flood in a year that may be greater than many annual floods of other years. Both series give essentially the same results for recurrence intervals greater than 10 years. . . . The annual-flood series has been used in this study. ***(Page 54)***

Comment: In Skagit County, the back to back floods are referred to as the "double-pump effect". The second flood is almost always larger than the first as was observed in 1990, 1995 (which experienced 5 flood events in 21 days), and 2003 (***See*** Appendix D).

What is missing from Mr. Bodhaine's equation is the most important factor, the duration of the flood events. The largest floods, with respect to the lower valley, as discussed in this White Paper, are always the floods of long duration. Surely, somewhere in the flood frequency analysis, that should be factored in.

II. SIGNIFICANCE OF STEWART CALCULATIONS

By this stage of the White Paper it is probably not a surprise that I have arrived at the conclusion that the Stewart calculations are highly questionable at best and overstated at worst. The impacts of using the Stewart figures to calculate flood frequencies and flood flows can best be demonstrated by the table below. The current 100 year flood as computed by the U.S. Army Corps of Engineers is 293,000 cfs without the dams (unregulated), and 221,000 cfs with the dams in place (regulated). Those figures were calculated using the James E. Stewart flood measurements in 1923. Without using those historical flood estimates the 100 year flood drops to 241,000 cfs unregulated, and 182,000 cfs regulated. 182,000 cfs is only 16,000 cfs more than we had at Concrete during the October 2003 flood event the largest flood of record since 1922.

Did the historical flood events happen? Sure they did. But did they happen to the magnitude described by Mr. Stewart and later calculated by USGS? Based on the document review used to write this paper I feel that it is very unlikely.

FLOOD FLOW CFS RECURRENCE LEVELS[17]						
	WITH STEWART		WITHOUT STEWART		WITH STEWART 1918	
Recurrence	Unregulated	Regulated	Unregulated	Regulated	Unregulated	Regulated
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)

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

III. CONCLUSIONS

On February 14, 2004 I authored the original 52 page report which was the result of many dedicated hours of research. Subsequent to the issuance of the original paper substantial more research has been conducted and is contained herein which further substantiates the original conclusions.

On February 17, 2004 I sent a copy of the Whitepaper to the major stakeholders in Skagit County. Subsequently, PSE and Skagit County asked USGS to respond to the Whitepaper.

On May 3, 2004, I defended the paper before the Skagit County Flood Control Advisory Committee. Many local elected officials, residents, representatives from federal and state agencies, and USGS were in attendance. My presentation was immediately followed by USGS which in essence stated that they were not going to change the Stewart figures because the flows calculated fit on a frequency curve. Many individuals left the meeting questioning the response by USGS. (*SVH, 5/5/04*, http://www.skagitvalleyherald.com/articles/2004/05/05/news/news02.txt)

On June 7, 2004 I received a letter from USGS in response to the Whitepaper. ***(See USGS Response To Whitepaper)*** I have incorporated their responses to the Whitepaper as well as my rebuttal to their responses in this update to the Whitepaper.

Based on the document review contained herein, the Stewart Reports "estimated flood flows" should be discounted for the following reasons:

1. Mr. Stewart originally calculated the 1897, 1909 and 1917 floods as floods that would occur every ten years. ***(Source: Stewart Report, 1918, Page 1)*** The flow of the floods Mr. Stewart calculated for those years has not repeated themselves in the last 83 years.

USGS RESPONSE: *Estimates of flood frequency can change over time as more data are collected. This may be the case in the Skagit River. In 1918, Stewart estimated that floods approaching the magnitude of the 1897, 1909, and 1917 floods—which ranged from 220,000 to 275,000 cubic feet per second (cfs) in the Skagit River near Concrete—could be expected on an average of once in 10 years. However, using the current (2004) flood frequency analysis computed by the U. S. Army Corps of Engineers for unregulated flows at Concrete (Ted Perkins, USACE, written communication), the same magnitude of floods would have a recurrence interval ranging from 30 to 75 years. The current flood-frequency analysis includes an additional 59 flood peaks that have been recorded since 1918, when Mr. Stewart derived his estimates. The occurrence of flooding of a given magnitude is affected by several processes, including changes in climate, land use, and streamflow regulation. Streamflow in the Skagit River Basin, including peak flood flows, has been affected by regulation since 1926, when a dam was constructed on the Baker River. On the main-stem Skagit River, Diablo Dam has been in place since 1930 and Ross Dam since 1940.*

LJK REBUTTAL: First, USGS has misstated the values assigned by Stewart in 1918 for the 1897, 1909, and 1917 flood events. As stated in this Whitepaper those values were as follows:

YEAR	CONCRETE[18]	SEDRO-WOOLLEY
1897	205,000 cfs	171,000 cfs
1909	185,000 cfs	169,000 cfs
1917	175,000 cfs	157,000 cfs

The difference between the 1918 values and the 1923 values at The Dalles represent an increase of 34%, 41% and 26% respectively. Nowhere did Mr. Stewart, USGS, the Corps or FEMA ever address this increase in flows.

If one is to take USGS's response literally then either Stewart was wrong in his flood estimates or the dams have had a far greater impact on flood flows than the Corps of Engineers has been reporting. Amazing that we experienced 4 (5 if you count 1896) 30 to 75 year flood events in a 25 year period of time and they don't repeat themselves for another 83 years. The fact remains that the flood flows as determined by Mr. Stewart have not reoccurred for 83 years. Further, the Skagit River has reached flood stage 67 times since 1918. If the current flood-frequency analysis includes only 59 flood events then it is in error. There is nothing in USGS's response that justifies Stewart's findings.

2. 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—See Appendix A; 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 (See 1923 re-typed version); Letter to FM Veatch, District Engineer, USGS, Tacoma, WA from Stewart, 6/1/50)***

USGS RESPONSE: *Flood hydrology is not an exact science and results cannot be viewed as absolute numbers. Precise solutions for individual flood peaks, or flood frequencies, are not possible because it is impossible to measure all the variables that contribute to peak discharge in natural systems. These variables include estimates of flow roughness, lateral variations in velocity head, stability of cross sections, surges in unsteady flows, occurrence and non-occurrence of debris dams, and the presence and accuracy of high-water marks. All directly measured and computed flood peaks have error bars associated with them, which reflect the uncertainty in the data. A difference of 30,000 cfs in a flood peak that is estimated or measured to be 200,000 cfs is about 15 percent. In the USGS all flow measurements and computations are assigned an estimated accuracy rating, depending on how difficult the field conditions or uncertain the assumptions (Benson and Dalrymple, 1967). Those estimated ratings are:*

Good – reported value expected to be within 10 percent of the real value
Fair – reported value expected to be within 15 percent of the real value
Poor – reported value may be a least 25 percent different than the real value

[18] The Dalles

A rating of poor does not reflect the quality of work done but is simply a descriptive term that we use to describe estimates that have a 25 percent uncertainty or greater. We do not refrain from reporting flood data because the measurement is difficult or has uncertainty–we try to provide the best number possible under existing conditions, within a probable error.

LJK REBUTTAL: *"Flood hydrology is not an exact science and results cannot be viewed as absolute numbers."* Based on my experience with flood hydrologist I think USGS's response is right on point. Perhaps a more apt statement would be that flood hydrology is the science of assumption which is based on a mathematical statistical analysis of a set of assumed data. It is those "assumptions" that are at issue in this paper. As was observed in the Whitepaper discussion on the "N-factor" (roughness coefficient) even a slight "tweaking" of the figure from .030 to .040 can result in a 30 to 45,000 cfs difference in flows. Unfortunately, this tweaking has a tremendous impact on the taxpayer in the form of the size of the flood control project required, (i.e. amount of storage required to lessen damages, the size of levees and/or bypass requirements). A difference of 30,000 cfs may mean nothing to USGS hydrologist but to the homeowner it is the difference between staying dry and total disaster.

Further, as is documented in the Stewart Reports, it was Stewart who assigned his own "estimated ratings" to his work product. There is no evidence in the files that anyone from USGS ever went into the field or reviewed Stewart's methodology and checked the estimated ratings Mr. Stewart assigned to his work. There is also no evidence in the files as to the methodology used to assign the "estimated ratings" by Mr. Stewart. As mentioned herein, the Corps of Engineers wrote in 1952: "***These values are also subject to question*** *because of uncertainty of high-water marks, changing channel conditions tending to alter the rating curves such as clearing the bottom valley lands, erosion and deposition, and excessive extension of rating curves*."

3. 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, See also Notice of Public Hearing Colonel Barden comments11/26/24)***

USGS RESPONSE: *The flood frequency for different locations along the Skagit River is computed by the U.S. Army Corps of Engineers with data from the USGS. Their most recent frequency curves do not use the USGS peaks for 1815 and 1856, so much of your concern about those peaks seems moot. But we will say that the USGS rating curve for the Skagit River at Concrete reflects a very stable bedrock channel in which extrapolation of the rating to Stewart's reported stages of the earliest floods would produce discharge estimates very close to the reported values in WSP 1527.*

LJK REBUTTAL: The USGS response is non-responsive. As has been shown in the updated version of the Whitepaper, the Corps of Engineers not only questioned the accuracy of Mr. Stewart's data in 1952 but had previously rejected it in its entirety in 1924 as did Skagit County at the same public hearing. The 1815 and 1856 floods were raised simply to show the questionable nature of Mr. Stewart's work product and the data he relied upon for the rest of his report.

4. The discrepancies between calculated flows from Mr. Stewart's 1918 and 1923 Report are never addressed. ***(Source: 1918 and 1923 Stewart Reports; See also page 17 of Whitepaper)***

USGS RESPONSE: Please see the third paragraph of this letter. (Note: The third paragraph in the letter stated the following in its entirety:

"The "Stewart Reports" of 1918, 1923, and any others prior to U.S. Geological Survey Water-Supply Paper (WSP) 1527 (Stewart and Bodhaine, 1961) are drafts of the final Skagit River floods report. As such they reflect the changing thoughts, ideas, and interpretations of a hydrologist as new data and evidence became available. This is the life history of any USGS report–drafts, colleague review, revisions, reinterpretations, final reviews, then publication. It is not unusual for interpretative data, such as flood magnitudes, to evolve throughout this process. As drafts, these documents are not subject to FOIA and should not have been included in the archived materials. First and second drafts of reports are rarely saved. USGS WSP 1527 is the official USGS document concerning the flood history of the Skagit River and states the USGS position as understood in 1961. Data in this document are the only data which the USGS supports.")(Emphasis added.)

LJK REBUTTAL: The position that all of the Stewart Reports are "drafts" is ludicrous. If this statement were true then any document prepared within the auspices of USGS unless published would be considered a "draft" and not subject to FOIA. This statement should be alarming to all taxpayers and elected government officials alike for it is nothing short of a clear and convincing effort to keep relevant information from the public. The question the public needs an answer to, and has a right to know, is what new data and evidence became available that would make a man change his figures by 34%, 41% and 26% respectively for the 1897, 1909 and 1917 flood events? If the USGS Tacoma office is in the habit of destroying all of the work product of its engineers and scientist then the public has no way of checking if what those employees did is in fact keeping with the "*highest standards of effort, commitment, and creativity that define the U.S. Geological Survey*". The director of USGS should immediately direct the Tacoma District USGS office to preserve all materials contained in their archives concerning the Stewart Reports.

The first Stewart Report was written 5 years before the second and was turned in to USGS on July 1918 before Mr. Stewart went to Hawaii. Nowhere in the report is it either stamped or typed the word DRAFT. Had Mr. Stewart not returned from Hawaii or was stationed elsewhere one has to wonder if USGS would now be defending the 1918 report instead of the 1923 report. Further, by Stewart's own writings, he forwarded a "Preliminary Report" to Skagit County. The irony here is that the Preliminary Report is the only one I copied from USGS files and that one is dated January 25, 1929. All other Stewart Reports came from Corps of Engineer files obtained during a litigation subpoena in 1995 (July 1918, August 12, 1918 Appendix, two versions of the 1923 report, probably drafts, one allegedly by Stewart and one allegedly by Eisenlohr which appeared to incorporate the "Preliminary Report" with other Stewart data, and WSP 1527).

Further, I recently obtained a copy of USGS Water Supply Paper 612. It was authored by G.L. Parker, Mr. Stewart's supervisor, who held the position until sometime in the early 1940's. WSP 612 was based on gage heights and river flows in 1925 and was published in 1929 at a cost

of .25 cents per copy. While never mentioning Mr. Stewart, Mr. Parker uses Stewart's figures for The Dalles for the main flood events:

1897 275,000 cfs
1909 260,000 cfs
1917 220,000 cfs
1921 240,000 cfs

He states at page 62:

> Since December 10, 1924 , Stevens continuous recorder in concrete shelter on right bank at The Dalles. Gage used prior to December 10, 1924, was vertical staff on right bank about 200 feet above present gage. Both gage readings refer to same datum, 163 feet above sea level.

For the Sauk River at Darrington he states at page 66:

> 1914-1925: Maximum stage, 15.0 feet at 9 a.m. December 29, 1917 and 4 p.m. December 12, 1921, determined by levels to high-water mark (discharge **36,000 cfs**).

> For the Baker River he states at page 68:

> 1910-1925: Maximum stage recorded, 13.7 feet at 12:30 p.m. December 29, 1917 (discharge, **36,800 cfs**).

So from the above we can surmise that the 1921 flood was lower on the Baker then the 1917 flood at least at the location of the Anderson Creek gage which is upstream of the Upper Baker dam. Now compare what WSP 612 said to what WSP 1527 (1961 Bodhaine/Stewart Report) says at the same locations.

WSP 1527 1961

Sauk River at Darrington, Wash.
[Gaging station 19, page 44.]

Date of flood	*Elevation (feet)*	*Discharge (cfs)*
1815……..	18.0	48,000
1897……..	17.0	44,000
November 1909..……..	**16.0**	**40,000**
December 29, 1917……..	**15.0**	**36,000**

> Studies of river banks, including bars left from old channels, indicate that stages from 2 to 3 feet higher than 1917 have occurred. The flood of 1815 probably was not more than 1 foot higher than the 1897 flood.

The flood of 1897 was higher than the 1909 flood on the Cascade River to the north and the South Fork Skykomish River to the south, so it probably was higher on the Sauk.

The crest of the 1909 flood was obtained from a comparison by the gage observer of the relative stages of the 1909 and 1917 floods in his garden.

Baker River below Anderson Creek, near Concrete, Wash.
[Gaging station 22, page 47.]

Date of flood	*Elevation (feet)*	*Discharge (cfs)*
1815…….....	16.0	50,000
1897……..	13.5	36,700
1909..……	15.3	46,200
December 29, 1917……..	**13.7**	**36,800**
December 12, 1921……..	10.8	23,600

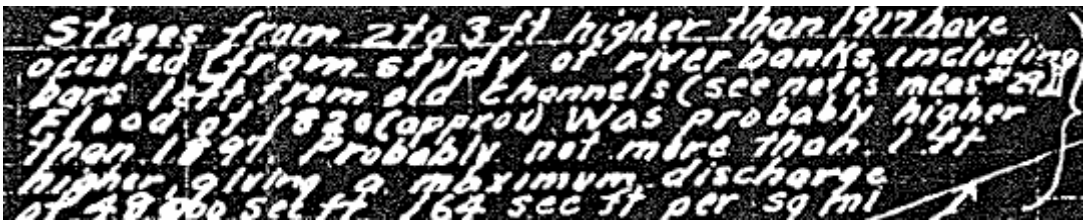
The great flood of 1815 probably reached a gage height of 16.0 feet.

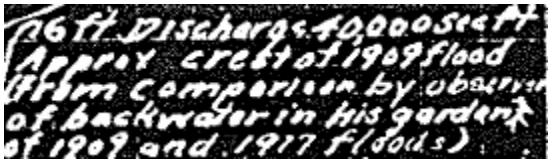
The flood of 1897 probably was about the same height as the 1917 flood, or possibly slightly lower.

The crest of the 1909 flood was obtained from drift marks on trees and from the high water beach line.

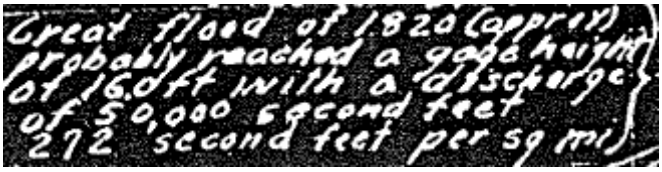
As you can see, with respect to the discharges, they say the same thing. But where did the extra verbiage come from? There is nothing in the record that supports Mr. Bodhaine ever traveling to Skagit County just like there is no evidence Mr. Parker ever came to Skagit County. If one reviews the handwritten notes in the appendix to the Stewart 1918 alleged "draft" report I think that question can be answered. Please review the following:

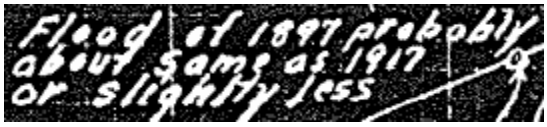
Flood flows at Darrington:





Flows on the Baker River:





This should dispel any reference to Mr. Stewart's work product as being a draft, unless of course, USGS is admitting that they use draft, unchecked work in its' Water Supply Papers. For as the record herein clearly shows, no one from USGS ever checked Mr. Stewart's work product until the 1950's, and then, as number 5 below states, no one was ever able to duplicate his work. I feel very strongly that for reasons stated herein, the reason was because he overestimated the flows at The Dalles.

Mr. Parker used Stewart's 1923 estimated flows at The Dalles but relied on his 1918 report for the Sauk and Baker Rivers for WSP 612. Similarly, Mr. Bodhaine did the same thing in WSP 1527 in 1961. If one assigns Mr. Stewarts cfs flows per square mile to the 1917 flood (137 cfs per square mile) that would mean that the Sauk River carried 97,818 cfs (137 cfs per sq mi x 714 sq miles) during that flood event at the current Sauk River gage which is 5.4 miles upstream of the Skagit River[19], which is 14,000 cfs less then what we just experienced in 2003. Again, using Mr. Stewart's figures, the 1897 flood would have produced the exact flow (107,000 cfs) on the Sauk as the 2003 flood event (150 cfs per sq mi x 714 sq mi). Likewise, using Mr. Stewart's figures, the 1815 flood of Indian Legend would have only produced 10,000 cfs more then the 2003 flood event on the Sauk.

I believe this also would explain how the Corps of Engineers, that rejected Stewart's work in 1924, began using it again in subsequent reports because it was "published" by USGS in 1929.

[19] http://waterdata.usgs.gov/usa/nwis/uv?site_no=12189500

The first flood of 1990 the Sauk crested on November 10th, 2 p.m. at **69,800 cfs**. 2 hours later the Concrete gage crested at 149,000 cfs. During the second flood event, the Sauk crested on November 24th, 6 p.m. at **81,600 cfs**. One hour later the Concrete gage crested at 146,000 cfs.

During the November 29th 1995 flood event the Sauk crested at 6 p.m. at **73,597 cfs**. At 10 p.m. the Concrete gage crested at 159,000 cfs.

During the October 21st 2003 flood event the Sauk crested at 2:15 a.m. at **107,000 cfs**. At 6:15 a.m. the Concrete gage crested at 166,000 cfs.

What does it all mean? First, it is important for the reviewer to realize that the Anderson Creek gage does not pick up any flows into what we call Lake Shannon today, so the amount of water flowing into the Skagit would have been a few thousand cfs greater. Likewise, the Darrington gage does not pick up flows from the Suiattle River which drains just a little over the amount that the Upper Sauk and Whitechuck rivers drain at Darrington, so once again the flows that reached the Skagit would have been greater as described in the paragraphs above. I believe that using Stewart's figures quoted by Mr. Parker and Mr. Bodhaine in USGS Water Supply Papers 612 and 1527, we certainly just experienced a flood in 2003 that was identical to the 1897 flood event, at least on the Sauk River, and slightly lower (10,000 cfs) than the infamous Indian Legend flood had in 1815. I also believe that given the fact that it takes 10 hours for the flows from Diablo to reach The Dalles that the only way Stewart's flows could have happened is if all the water from the Sauk, Baker, Cascade and Diablo would have reached The Dalles at the same time. Didn't anyone at USGS ever consider this when looking at the Stewart flows? Since the Skagit in 1909, 1917 and 1921 was completely unregulated, and the Baker and Sauk crest would have passed The Dalles before the flows from Reflector Bar would have arrived, **HOW DID WE END UP WITH 260,000. 220,000, AND 240,000 cfs flows at The Dalles.** Or were those flood events more comparable to the October 2003 flood event which as stated, unregulated would have carried 209,000 cfs. It's a shame Mr. Stewart didn't keep his 1918 work product or ever explain why he changed his flow figures. ***(Source: Stewart Exhibit J July 1918)***

Location	Drainage area	1897 Maximum discharge	1909 Maximum discharge	1917 Maximum discharge
	sq. mi.	sec.-ft.	sec.-ft.	sec.-ft.
Skagit River Power Camp	1,090	47,400	63,500	47,400
Cascade R. Power Camp	222	40,000	26,000	52,000
Sauk River at Darrington	293	44,000	40,000	36,000
Suiattle River at mouth	345	55,000	38,000	45,000
Baker R. below Anderson Cr.	184	36,700	46,200	36,700
Total		222,000	214,000	197,000
Skagit R. below Baker River (i.e. The Dalles)		205,000	185,000	175,000
Skagit River nr. Sedro-Woolley	2,930	171,000	169,000	157,000

5. No one from USGS was ever able to reproduce Mr. Stewart's flood flows:

CONCRETE FLOOD FLOW CALCULATIONS						
	STEWART		USGS[20]			
Year	1918	1923	Riggs	Benson	Hidaka[21]	Bodhaine
1815		500,000	400,000		?	500,000
1856		350,000	280,000		?	340,000
1897	205,000	275,000	230,000		?	265,000
1909	185,000	260,000	220,000		?	240,000
1917	175,000	220,000	210,000		200,000	205,000
1921		240,000	190,000	225,000	?	225,000

(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)

SEDRO-WOOLLEY FLOOD FLOW CALCULATIONS						
	STEWART		USGS[22]			
Year	1918	1923	Riggs	Benson[23]	Hidaka	Bodhaine
1815		400,000	330,000		370,000	400,000
1856		300,000	230,000		260,000	290,000
1896		185,000	170,000		145,000	165,000
1897	171,000	190,000	170,000		145,000	170,000
1906		180,000	160,000		140,000	165,000
1909	169,000	220,000	190,000		175,000	200,000
1917	157,000	195,000	160,000			195,000
1921		210,000	170,000			210,000

(Sources: Stewart 1918 & 1923 Reports; Proposed Revision of Skagit River Flood Peaks, H.C. Riggs & W.H. Robinson, 11/16/50; 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)

[20] All USGS calculations are based on Stewart's estimated flood heights.

[21] Given Mr. Hidaka's computations for Sedro-Woolley it is assumed all his flows for Concrete would have been less than Stewart's 1923 calculations.

[22] All USGS calculations are based on Stewart's estimated flood heights.

[23] Mr. Benson did not calculate anything other than the 1921 flood at The Dalles, Concrete, WA.

USGS RESPONSE: *If one looks at the historical flood series for the Skagit River near Concrete, WA, there are six historical floods (1815, 1856, 1897, 1909, 1917, 1921) prior to systematic streamgaging that began in 1924.*

Based on uncertainty in the timing of the 1815 and 1856 flood events and the fact that neither settlers nor USGS employees were present to document these events shortly after their occurrence, all discharges for the 1815 and 1856 events in WSP 1527 are now rated poor and indicated as estimates in the USGS Peak Flow File.

The basis for the remaining flood peaks at Concrete–1897, 1909, 1917, and 1921—are recounted here. From reading some of the memoranda at the time that WSP 1527 was written and from looking at the current rating for Skagit River near Concrete, it appears that the discharges for the 1897, 1909, and 1917 floods were determined by extending the current rating at the time through the 1921 measurement computed by Stewart using standard practices of indirect-discharge measurements: the contracted-opening method and the slope-area method. In 1952, an n-verification computation for the same flood computed a discharge that was 6.2 percent less than the discharge computed by Stewart. The n-verification value adds credibility to Stewart's computation, that it is a good computation of discharge. Revisions of peak flows are made when a proposed revised discharge is more than 10 percent different from the original value; therefore, no revision was made based on the n-verification study nor is there now a good reason to revise it or the other peaks. The current rating for the Skagit River near Concrete is based on more recent discharge measurements and extended by a straight-line. One could argue that the current rating should go through the 1921 measurement or the revised n-verification computation. However, since the current rating has been constructed, the highest flow has only reached 166,000 cfs, with recent current-meter measurements as high as 138,000 cfs; therefore, a straight-line extension of the current rating is a reasonable method to determine peak flows. Using the current rating, the 1921 peak discharge is 10.4 percent less than the published value, and the other peaks have nearly the same percent differences (differences range from 9.5 to 11.9 percent less).

LJK REBUTTAL: I could not disagree with the USGS answer more based on the discussion in #4 above and the below computations. While I was completing my newspaper research I noticed that by comparing the 1949 flood to the 2003 flood that there was only a 1.4 foot difference or 12,000 cfs which I believe equates to 8,571 cfs per foot of rise. Applying that figure to the 5.4 foot difference between the 2003 flood and the USGS Stewart 1921 flood I come up with a figure of 212,285 cfs flow for the 1921 flood. I decided to see how this would pan out with other floods using the 2003 flood as the constant. Now I realize that I am not a hydrologist, and that hydrology *"is anything but an exact science"*, and the calculations depend on a lot of things (slope, rise, roughness coefficient, etc.) HOWEVER, in each event below all the figures are a lot closer to what **Riggs & Robinson** did in 1950 (209,000 cfs for the Dalles) than what Stewart allegedly did in 1923 (240,000 cfs at the Dalles).

1921 FLOOD 240,000 cfs STEWART 209,000 cfs RIGGS & ROBINSON

2003 Flood

2003 42.2 166,000
1949 40.8 154,000
1.4 12,000 cfs or 12,000 ÷ 1.4 = 8,571 cfs per foot of rise

1921 47.6
2003 42.2
5.4 x 8,571 = 46,285 + 166,000 = 212,285 for 1921 flood

++

1951 Flood

2003 166,000 42.2
1951 139,000 38.99
27,000 3.3 27,000 ÷ 3.3 = 8,181 cfs per foot of rise

1921 47.6
1951 38.9
8.7 x 8,181 = 71,175 cfs + 139,000 = 210,175 cfs for 1921 flood

++

1975 flood

2003 166,000 42.2
1975 122,000 36.88
44,000 5.32 44,000 ÷ 5.32 = 8,270 cfs cfs per foot of rise
1921 47.6
1975 36.88
10.8 x 8,270 cfs per foot = 89,316 cfs + 122,000 = 211,316 cfs for 1921 flood

++

1990 Flood

2003 166,000 42.2
1990 146,000 39.89
20,000 2.31 or (20,000 ÷ 2.31) = 8,658 cfs per foot of rise

1921 47.6
1990 39.89
7.71 x 8,658 cfs per foot of rise = 66,753 cfs + 146,000 = 212,753 cfs for 1921 flood

++

1995 Flood

2003 166,000 42.2
1995 160,000 41.57
6,000 .63 or (6,000 ¸ .63) 9,523 cfs per foot or rise

1921 47.6
1995 41.5
6.1 x 9,523 cfs per foot of rise = 58,090 cfs + 160,000 = 218,090 cfs for 1921 flood

Per Cent differences between Stewart 1923 and the above figures:

PERCENT DIFFERENCES

STEWART 1921	**2003**	**% DIFFERENCE**
240,000	212,285	11.5
	1951	
240,000	210,175	12.4
	1975	
240,000	211,316	11.9
	1990	
240,000	212,753	11.3
	1995	
240,000	218,090	9.1

6. At no time did Mr. Stewart nor USGS ever take into consideration the log jams which were 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 – See Appendix A; Proposed Revision of Skagit River Flood Peaks, H.C. Riggs & W.H. Robinson, 11/16/50)***

USGS RESPONSE: *The occurrence of log jams during large floods along the upper Skagit River is certainly possible. Even if debris jams impact the reported peak discharges, they are considered a recurring natural process uncontrolled by humans and regularly reflected in the size of floods downstream. You can't subtract the impacts of events that may or may not occur from flood to flood. The USGS integrates the impacts of upstream recurring natural processes by reporting the actual stages and related discharges that are recorded at streamgaging stations.*

LJK REBUTTAL: Stewart's entire observations were based on flood marks, not gages. As USGS so aptly stated in their response to #2 "*These variables include estimates of flow roughness, lateral variations in velocity head, stability of cross sections, surges in unsteady flows, occurrence and non-occurrence of debris dams, and the presence and accuracy of high-water marks*." If those flood marks are influenced by log jams, Stewart's entire report will be skewed by the impacts of those log jams on flood flows, thus the demise of the paleohydrologist assumptions and conclusions. As the Whitepaper showed, the presence of log jams at The Dalles was documented by Stewart but ignored as any part of his analysis. ***(See Appendix A)*** The last sentence in the USGS response is particularly disturbing. They know very well that any flow computed either at The Dalles or upstream of The Dalles would be directly impacted by log jams. A log jam artificially inflates the flow values and would thus give the paleohydrologist false readings.

7. At no time did Mr. Stewart or USGS take into consideration the fact that both the Sauk River and the Baker River are volcanic in nature and volcanic activity such as debris flows or glacier outburst flows could have impacted the "flood marks" located at "The Dalles". ***(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)***

USGS RESPONSE: *We have long recognized that tributaries of the Skagit River drain Glacier Peak and Mount Baker, two Cascade Range volcanoes. We actively monitor and study the Cascade Range volcanoes at the USGS Cascades Volcano Observatory in Vancouver, WA. There is no record of volcano-generated flows from Glacier Peak reaching the Skagit River in the last 5,000 years (Waitt and others, 1995; Beget, 1982). Kevin Scott, a research scientist at the Cascades Volcano Observatory, presented a paper at the annual meeting of the Geological Society of America last fall (Scott and Tucker, 2003). In this abstract, he reports that Sherman Crater, an active vent below the summit of Mt. Baker, generated small hydrovolcanic eruptions in 1843, 1858, and 1859. Highly altered rock from the crater rim failed and generated volcanic debris flows (lahars) that inundated the Baker River valley. Kevin Scott believes these lahars may have temporarily dammed the Baker River; however, he does not believe the lahars could have caused the magnitude of flooding suggested by high marks found downstream along the Skagit River.*

LJK REBUTTAL: It's nice that USGS as an agency has "*long recognized that tributaries of the Skagit River drain Glacier Peak and Mount Baker, two Cascade Range volcanoes"*, however Mr. Stewart never mentioned either volcano and he never mentioned that the probability of debris flows putting massive amounts of material into the Baker/Sauk river systems that could have dammed up the Skagit River especially at the Dalles as was documented in Stewart's own handwritten field notes ***(See Appendix A)***. It is important to note at this juncture that debris flows can be created without a volcanic eruption. Glacier outburst floods, earthquakes, landslides, flooding events after large forest fires all can create debris flows not associated with volcanic lahars that would have put massive amounts of timber into the river systems at different times,

all of which could have taken years to accumulated at the narrow canyon passages on the Baker, Sauk or Skagit systems.

When the first settlers first came to Skagit County they remarked about the massive amounts of "very large cedar stumps strewn across the floodplain as if they were ripped out of the side of the mountains" ***(Source: History of Skagit and Snohomish Counties, Washington, The Interstate Publishing Company, 1905)***. Those massive cedar stumps clearly got there by floating in during flood events. In fact, Stewart never mentioned the two well documented massive log jams at Mt. Vernon that early settlers estimated had eighty year old trees growing out of them. The majority of the material contained in those log jams would have had to flow through The Dalles and very well could have impacted "flood marks" that he attributed to flood events 122 years prior to his discovering them.

Having met with Mr. Kevin Scott, USGS, a gentleman and a scientist that I hold in deep regard, he appears to base his comments solely on volcanic eruptions and lahars. As has been documented through historical documents and newspaper articles the mouth of Baker River to Lower Baker Dam was not only dredged of material but was moved to its current location ***(See Page 25 herein)***. Further, a landslide happened in the Baker River just downstream of the dam in 1965, proving that landslides, debris flows and log jams can and do happen in the narrow canyons. ***(Source: 5/19/65 SVH, 5/20/65 C.H.)***

There is soon to be published data that massive flood deposits near Burlington are the result of the 1,800 year old eruption of Glacier Peak. Further, it is the interpretation of WADNR geologist (and interpretation of Dethier, Beget, Pessl and others) that lahar products (either lahar runout in modern terminology and/or volcanic alluvium) did reach the lower Skagit from Glacier Peak and they were probably quite voluminous (although not as voluminous as the 1800 yr event). All of that material would have had to flow through The Dalles. ***(Source: Personal conversation with WADNR.)***

It is also worth noting that Mr. Scott's determination of the eruptive period of Mt. Baker is within just two years of Mr. Stewart's "estimate" of the 1856 flood. As Mr. Stewart's writings confirm this estimate is based on the age of trees just upstream of "The Dalles" and the assumption that it takes a fir tree four years to grow two and half feet. Mr. Stewart even wrote, "Variations in the possibilities of time it took the tree to reach stump height might vary the year of the flood from the fall of 1854 to the fall of 1857." Given the historical timeline it is highly probable that either Mr. Stewart or Mr. Scott is off by just two years. Additionally, while the science of dendrochronology[24] is a fascinating one its application in river floodways and islands is highly speculative at best. The stripping of vegetation from river islands and the accumulation thereof, seems to have more to do with how much debris is in the river system than the flows of the river. Even in small flood events whole islands can disappear and new islands can form.

In Stewarts 1923 report he wrote the following:

[24] The study of tree rings

> The year of the occurrence of the 1856 flood was determined at the "Dalles". There is a sand bar bench on the north side of the head of the canyon. The highest of floods since the arrival of the white men have not covered this bar to a depth of more than two feet. On this bench are a number of young fir trees apparently of the same age, and all, very apparently, of a much younger age than the surrounding trees. The undoubted explanation of the uniform and youthful age of the trees, is that the sand bar was cleared of all trees by heavy drift, or a jam, during the flood of 1856. One of the trees was cut down in February, 1923, and found to have 62 rings at a stump height of 2.5 feet. A United States Forest Service official judged that it would have taken the tree four years to grow 2.5 feet. The assumed four years of growth plus the 62 years indicated by the rings, would give the tree an age of 66 years, with 1922 as the last year of its growth. If the tree started growing the first year after the flood and took four years to grow 2.5 feet, the flood must have occurred in 1856. Variations in the possibilities of time it took the tree to reach stump height might vary the year of the flood from the fall of 1854 to the fall of 1857. If a flood or floods as high or higher than the floods of 1897 and 1909 had occurred a few years after the tree staining flood, then the young trees would have been destroyed by this second flood, and a new crop of them started. (*Emphasis added*) ***(Source: Stewart Report 1923 pages 12-13)***

Although Mr. Stewart believed that he had discovered the "*undoubted explanation*" there is another possible if not probable explanation. The location of this "*sand bar bench*" is not only located just upstream of The Dalles Canyon, it is also just downstream of the natural overflow area of a historical channel. Another explanation could be that the sand bar bench was not formed before 1856 and therefore trees had no place to grow.

It is also noteworthy to address Mr. Stewart's comments concerning the depth of the water on this bench. "*The highest of floods since the arrival of the white men have not covered this bar to a depth of more than two feet.*" Immediately following the flood of 2003 I walked this sand bar bench. Flood marks left by that flood event clearly put several feet of water on this bench; far in excess of 2 feet as did the 1990 and 1995 flood events. If Mr. Stewart's comment was accurate then clearly the 1897, 1909, 1917 and 1921 flood events did not carry the amount of water Mr. Stewart "*estimated*" that they carried. It is also important to recognize that investigation of the overflow channel (i.e. "*the saddle*") is one of the things Mr. Stewart had left to investigate on his "Things To Do" list (***See #12 Appendix A***). Clearly, Mr. Stewart's conclusions are anything but an "*undoubted explanation*".

8. There is absolutely no evidence in the files that anyone from USGS ever verified the "flood marks" obtained by Stewart nor that Stewart himself ever verified the discrepancies between his observations and those of local residents. ***(Sources: Letter to Frank Davis, Davis Ranch, from Stewart, 5/23/23; Ltr to Stewart from Frank Davis, Davis Ranch, 5/31/23; Letter to Frank Davis from Stewart, 7/6/23; Letter to Mr. T.H. Judd from Stewart, 8/22/23)***

USGS RESPONSE: *It is not common practice for qualified hydrologists and engineers to have another person follow them into the field and verify routine measurements. This would make*

much of surface-water hydrology prohibitively expensive. That said, the lack of documentation does not mean that it was not done. Field trips with colleagues to show progress and results are the rule in the USGS, and these trips are not logged or documented anywhere where they would be archived.

LJK REBUTTAL: This response does nothing to bolster the faith of the American public in the work of government scientist. Documentation of one's work product is paramount to science. Even Mr. Stewart took a camera with him into the field in 1918. Why he decided to leave it at home in 1922-23 is beyond comprehension. What is known is that there are many discrepancies between Mr. Stewart's field notebook and handwritten notes located within Mr. Stewart's files. ***(See Appendix A and Page 1 of notations taken from field notes regarding Skagit River Flood Level and Page 2 of notations taken from field notes regarding Skagit River Flood Level.)***

Stewart used a field notebook **("FN")** to record his observations while in Skagit County. His handwritten notes have been transcribed and are included in this paper in Appendix A. Sometime between March 17, 1923 and his submittal of his preliminary findings in September 1923 he put together handwritten notes regarding his rough computations **("HWN")** of his observations presumably from his field notebook. The two are often in conflict with each other. For instance:

a. The FN records the level of the Skagit in the 1921 flood at the Sauk as being 2.8 feet above the 1909 flood. The HWN shows the 1921 flood as being only 10.8 inches higher than the 1909 flood.

b. The FN records the level of the 1921 flood at the Larson Ranch as being 1.9 inches above the 1897 flood and 2.8 inches below the 1909 flood. The HWN records the level of the 1921 flood at the Larson Ranch as being 1.2 inches above the 1897 flood and 3.6 inches below the 1909 flood.

c. The FN records the level of the 1921 flood at The Dalles as being 2 feet lower than the 1909 flood. The HWN "estimates" that the 1921 flood was one foot 3.6 inches lower than the 1909 flood. Also noteworthy is that the FN documents a log jam in The Dalles for the 1897 flood event that "raised water 10 feet in 2 hours". Clearly this would have impacted flood flows as well as flood marks both upstream and downstream for the 1897 flood event. There is no mention in Mr. Stewart's final report or USGS's 1961 report of this phenomenon.

d. At Hamilton the FN records a notation taken from a local newspaper article which stated that the 1909 flood was 4" higher than the 1897 flood. The HWN comes very close to documenting this having the difference between the 1909 and 1897 flood as 3.6 inches with the 1909 flood being the higher of the two. The HWN further state that the **1921 flood** was 3.6 inches **higher than** the **1909 flood and** 7.2 inches **higher than** the **1897 flood**. Although probably accurate based on local newspaper accounts of the 1921 flood it would appear to contradict all his other estimates.

e. The next entry in the FN is at Cockreham Island and is significant because it shows that Stewart took whatever information a local settler gave him as the gospel and put it in his work product. Mr. Cockreham told Stewart that the 1897 flood was "the highest on his place", and that the 1909 and 1917 floods were about the same height. The HWN show the following computations: The 1897 flood was 6 inches above the 1909 and 1917 floods which were the same height and that the 1921 flood was 1 foot 2.6 inches below the 1909 flood. Cockreham Island is just downstream of Hamilton. How did the 1921 flood go from being 7.2 inches higher than the 1897 flood to being 8.2 inches lower than the 1897 flood in such a short distance?

f. Finally, at Sedro-Woolley the FN documents a conversation between Stewart and a local resident named Mr. Hart. Hart tells Stewart that the 1896 flood was about 2 inches below the 1897 flood. Amazing in the final printed 1961 study which was as much Bodhaines work product as Stewarts the final computation is 1896 1.2 inches below 1897. The HWN's which was clearly Stewart's computations doesn't even compare the two at this location. Captain Harry Taylor of the Corps of Engineers observed the flood flows on the Skagit River both in 1896 and 1897. Just 24 days after the 1897 flood he publishes a report that the level of the Skagit River at Sedro Woolley was 1 foot 6 inches above the 1896 flood event. James E. Stewart and Mr. Bodhaine who saw neither the 1896 nor the 1897 flood events has the difference between the two floods at Sedro-Woolley at only 1.2 inches. Who would have more creditability, a Captain in the U.S. Army who saw the flood events or an engineer who saw none of the flood events and could only "estimate" the flood flows?

The discrepancies listed above have never been addressed by Mr. Stewart, Mr. Bodhaine or USGS, the Corps, or FEMA.

9. The Benson 1921 Flood Report which was relied on heavily by Mr. Bodhaine, relied on some undetermined measurements taken in 1932 and the height of the 1949 flood event to calculate the cfs for the 1921 flood event and used an "N-Factor" lower than Mr. Stewart used which was lower than what other USGS employees used. ***(Source: Skagit River near Concrete, Wash. – Verification Study by F.J. Flynn and M.A. Benson, 8/52; Proposed Revision of Skagit River Flood Peaks, H.C. Riggs & W.H. Robinson, 11/16/50)***

USGS RESPONSE: *The field estimation of Manning's n is very important for indirect discharge calculations and one of the largest sources of uncertainty. In the review of flood records, it is not unusual for other reviewing hydrologists to adjust or alter a roughness coefficient based on their own experiences. As large floods are measured directly by current meter, as was done at the Skagit River near Concrete gage in 1932, the n-values for the channel can be further refined.*

LJK REBUTTAL: As stated herein, Manning's n was determined to be .033 ("*In the original computations an n of .033 was assumed for all sections on the basis of computed n's at Sedro Woolley.*" ***(Source: "Skagit River near Concrete, WA., Verification Study, M.A. Benson, USGS, 8/52)*** The Corps of Engineers is currently using .04 to determine the 100 year flood flows. Two of the elements used in evaluating the Manning's n are vegetation and size of cobbles. Having walked on gravel bars just below The Dalles and Sterling near Sedro-Woolley, I can personally testify that the cobbles in The Dalles area are more like small boulders than the pebbles in Sedro-Woolley. Also based on an aerial photograph of The Dalles area taken in 1937 it is more likely than not that the vegetation along the shore line was very concentrated although the river was clearly wider downstream of The Dalles as the island currently there was clearly not there in 1921. What is most disturbing about the USGS answer is that it appears that the Manning's n is determined by the assumptions of the reviewing hydrologist at the time, thus any "refinement" could be changed to meet the pre-conceived assumptions of the reviewer. This doesn't sound a lot like documented science to me.

10. Riggs & Robinson calculated the 1949 flood heights at Sedro-Woolley to be 41.7 feet. USGS is currently reporting the flood heights of the 1949 flood at The Dalles at 40.8 feet and a flow of 149,000 cfs at Sedro-Woolley. Mr. Bodhaine used the 1949 flood, as an example of a "short-duration" flood event meaning there was less water at Sedro-Woolley than The Dalles. This discrepancy is not addressed in any of the USGS reports. ***(Sources: Proposed Revision of Skagit River Flood Peaks, H.C. Riggs & W.H. Robinson, 11/16/50; Whitepaper Appendix D; Skagit River Flood Peaks, Memorandum of Review by G. L. Bodhaine, USGS, 5/13/54)***

USGS RESPONSE: *In WSP 1527, the November 1949 flood is used as an example of a "short-duration" flood event where the flood crest or peak discharge is reduced as it moves downstream. During the November 1949 flood, the peak discharge at Concrete was 154,000 cfs, and further downstream at Mount Vernon the peak was only 114,000 cfs. The USGS has never reported a November 1949 flood peak discharge for Sedro Woolley, located between Concrete and Mount Vernon, most likely because the gage was not in operation in 1949.*

LJK REBUTTAL: This response is a great example of "bureaucratic non-speak". USGS the agency has never reported (i.e. published) a figure for Sedro-Woolley of 41.7 feet. However, that does not change the fact that two of their hydrologist did in fact compute the flow at that level on 11/16/50 as documented by USGS files referenced above, which would have meant that there was more water at Sedro-Woolley than Concrete changing the flood from one of short duration to long duration. Either the two hydrologists were wrong or reported figures by USGS are wrong. In any event, this discrepancy was not addressed either by Mr. Bodhaine or in the USGS response to the Whitepaper.

11. 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, 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)***

USGS RESPONSE: *We do not think there is any dilemma concerning the rainfall data for the November 1990 floods. The reported rainfall data are point data, but floods integrate rainfall from the entire basin plus any snowmelt. It could well have rained much harder in the hills around Reflector Bar in 1921 than at the point where the rain was recorded. This would not be unusual.*

LJK REBUTTAL: In this response USGS again fails to address the discrepancy with any scientific data or historical research. A difference of 60,000 cfs between the 1921 estimated flow and the 1990 gage flows at the Dalles with over 5 inches of rain difference between the two events at a minimum calls into question the Stewart estimated flows. What other flood event in the history of gage flows on the Skagit River has produced this kind of result? If it is "not unusual" then it shouldn't be all that hard for them to produce some kind of research to justify their answer. Again, they offer no scientific or research data to support their position. The below table strongly suggest that during large flood events the rainfall is pretty evenly distributed throughout the Skagit Basin:

4 Day Rainfall In Skagit River Basin				
Flood Event	**Diablo**	**Upper Baker**	**Sauk**	**CFS The Dalles**
11/30/09	**8.45 inches*[25]**			**260,000 (e, ur)**
12/30/17	**7.48 inches*[26]**		**4.6 inches****	**220,000 (e, ur)**
12/12/21	**10.51 inches***		**10.6 inches ****	**240,000 (e, ur)**
11/11/90	**12.63 inches****	**5.95 inches**LB**	**6.43 inches**[27]**	**142,000 (r)**
11/24/90	**12.26 inches****	**6.7 inches**LB**	**9.73 inches**[28]**	**146,000 (r)** **182,000 (ur)**
11/8/95	**8.39 inches*****	**7.2 inches*****	**7.04 inches**[29]**	**143,000 (r)**

[25] However, 6.99 additional inches fell between November 22nd and November 24th, making the 1909 flood a double-pump event.

[26] However, an additional inch fell in the preceding 24 hours and between December 15th and December 18th an additional 6.76 inches of rain fell, making the 1917 flood a double-pump event.

[27] Important to note here is that the day of the flood, November 11th the rain gage was not working. However the day after the flood November 12th it rained an additional 2.8 inches.

[28] Important to note is that the gage was not working on November 23rd and November 22nd.

[29] This figure represents only 3 days as the gage was not working on November 5th.

4 Day Rainfall In Skagit River Basin				
Flood Event	**Diablo**	**Upper Baker**	**Sauk**	**CFS The Dalles**
11/29/95	**7.94 inches*[30]**	**8.4 inches***	**9.03 inches**[31]**	**160,000 (r)** **180,000 (ur)**
10/17/2003	**8.15 inches***	**7.97 inches***	**7.15 inches****	**94,200 (r)**
10/21/2003	**8.92 inches*[32]**	**8.22 inches*[33]**	**9.28 inches**[34]**	**166,000 (r)** **209,000 (ur)**

e = estimated, r = regulated ur = unregulated Corps of Engineers *= Stewart 1923 Report

****= Corps of Engineer Records ****LB** **= Corps of Engineers Lower Baker**

***** **= USGS Records**

I believe that the above table strongly suggests that during large flood events the rainfall is more often then not more evenly distributed then what USGS would have us believe. I also believe that given the data we have to work with (in all fairness I have to admit that sometimes the Corps data and the USGS data for rainfall gages conflicts with each other. Sometimes USGS reported no rain and the Corps reported several inches and vice versa) that in all likelihood the 1921 flood was the largest flood event in the 20th century, not 1909, just like the local newspaper articles reported from herein stated it was.

Another interesting observation has come out of this research.

UNREGULATED FLOWS ON THE SKAGIT RIVER		
Flood Event	The Dalles	Sedro-Woolley
Stewart 1897	275,000	190,000
Stewart 1909	260,000	220,000
Stewart 1917	220,000	195,000
Stewart 1921	240,000	210,000
1990	195,000	195,000
1995	182,000	186,000
2003	209,000	202,000
100 yr flood est.	297,100	298,600

[30] On November 24th and November 25th and additional 4.78 inches of rain fell for a cumulative 6 day total of 12.72 inches.

[31] The gage was not working on November 26th.

[32] The cumulative impact for the 8 days would be 17.07 inches.

[33] The cumulative impact for the 8 days would be 16.19 inches.

[34] The cumulative impact for the 8 days would be 16.43 inches.

(Sources: 1923 Stewart Report, COE Hydrology Report and 7/10/2006 e-mail from Ted Perkins, Corps of Engineers)

We know from the discussion herein that the 1909 and 1917 flood events were long double-pump floods just like the 1990, 1995 and 2003 flood events were. Query: Where did the water go in the 1909, 1917 flood events? Stewart was a lot closer in 1918 then he was in 1923. I believe that the table further shows us that Stewart's measurements at The Dalles are over-estimated and should be discounted.

12. Mr. Stewart used a hand-held level to obtain the heights of all his observed flood-marks, the accuracy of which could not be verified. ***(Source: Letter to Frank Davis from Stewart, 7/6/23)***

USGS RESPONSE: *Hand levels were a common instrument of the day; and, even if Stewart's readings were in error by 6 inches (a very large error, even for a hand level), a stage of 56.6 or 56 feet for the Skagit River at Concrete would not change the flood peak discharge significantly. He was not leveling a building but was trying to measure the height of flood stains on trees. He is very likely correct to a few inches; certainly within 6 inches. Remember there is an error bar around all flood estimates, which could be as large as 25 percent or more.*

LJK REBUTTAL: I would submit that the last sentence, *"Remember there is an error bar around all flood estimates, which could be as large as 25 percent or more"* is more than enough justification for not using the Stewart data. I guess this would explain the discrepancies of Mr. Stewart's measurements up and down the Skagit which do not correlate with each other (i.e. higher floods on Cockerham Island than just upstream in Hamilton). Perhaps this is why USGS only relies on one flood measurement taken at The Dalles (1921) to calculate their flows ("1897, 1909 and 1917 were taken 1 mile upstream"[35]). One questionable measurement with an admitted "twenty-five percent or more" possibility that it could have been wrong is hardly worth using when trying to formulate a flood control plan for the Skagit River. The taxpayers deserve, and I would think the scientific community would demand, a little more accuracy. If your auto mechanic fixes your car to within 25% of getting it to run is that good enough for you? If your airplane pilot lands the plane within 25% of the runway is that good enough? If your doctor prescribes medicine that gets you to within 25% of being well is that good enough? If not, then why is getting a flood estimate to within 25% good enough to determine base flood elevations or multi-million dollar flood control projects?

13. USGS, specifically Mr. Bodhaine, was under tremendous pressure from their Washington, D.C. office to complete the report. So much so that Mr. Bodhaine even recommended that **the most simple study is desirable.** ***(Sources: Letter to JVB Wells, Chief, Surface Water Branch, USGS, Washington DC from F.M. Veatch, District Engineer, USGS Tacoma, 3/23/54; Cover memorandum attached to a draft of the Stewart/Bodhaine report from GL Bodhaine, 7/2/54)***

[35] See discussion herein which shows that the "approximately one mile" is more likely than not 2.5 to 4 miles upstream.

USGS RESPONSE: *Given that there is a limitation to fiscal and technical resources for any scientific investigation, it is common practice for USGS scientists to try and complete reports within set deadlines. In order to complete a report limited by fiscal and time restraints, the USGS may reduce the scope of a report, but it does not condone the lowering of research standards in order to stay within deadlines. The high quality of USGS data, analysis, and publications is paramount and must be upheld.*

LJK REBUTTAL: The statement "The high quality of USGS data, analysis, and publications is paramount and must be upheld" is very interesting especially in lieu of the following comment:

> "Stewart's study of historical floods in the Skagit River basin had, by today's standards short-comings, simplifications, incomplete documentation, no known photographic documentation, and took decades to review and complete the evaluation of flood hydrology for the Skagit River near Concrete." *(Source: **Review & Comments of "Draft Evaluation of Flood Peaks Estimated by USGS" by Robert D. Jarrett, Ph.D., USGS, National Research Program)***

If that is an example of the high quality of USGS data that is being relied on by federal agencies for determination of multi-million dollar flood control projects and base flood elevations then flood plains across this nation are not being properly managed. I submit that given the list of "Things To Do" attached herein as ***Appendix A*** that Mr. Stewart never had the opportunity to complete as well as the observation by Dr. Jarrett above, that Mr. Stewart's report in 1923 can best be described as incomplete and should not be considered as part of any hydraulic analysis to determine historic flood flows of the Skagit River and thus should be abandoned.

14. Subsequent to the writing of this Whitepaper I reviewed the following newspaper article:

> Almost universal housecleaning has been the rule in Hamilton this week. **Only a few houses in the main part of town escaped** the muddy waters of the flood, which **reached its highest point about midnight Monday**. **At one o'clock Tuesday morning the waters began to recede**, and by nine o'clock all houses except a few on the exceptionally low ground were clear of water, but the mud remained. … Old residents here tell of three former big floods in the history of the town, in 1897, 1909, and 1917, and it is said that this flood was one of the highest, though probably not quite as high as that of 1897. … The Van Horn Shingle Company at Van Horn lost heavily. The shingle sheds were ruined, the filing room of the mill was carried away, and two dry kilns collapsed and the shingles which they contained floated away on the flood. Residents of the houses by the mill, including Mr. And Mrs. W.A. Ellison, took refuge in the mill, putting a stove in the filing room, stove and all, but the main part of the mill remained standing. Mr. Ellison telephoned to Hamilton every hour, giving reports on the rise of the water until the telephone line to his station across the river went out, then Mr. Shields reported from the Van Horn side of the river until the water rose to the telephone and it had to be taken from the wall. These reports enabled the Hamilton people to estimate the rise here and to prepare for it. *(Source: **12/24/21 C.H.**)*

The statement "Only a few houses in Hamilton in the main part of town escaped the muddy waters of the flood" was very significant as I had always thought every house in Hamilton always got flood waters in them especially in 1909 and 1921 given Stewart's estimates of those flood events. I interviewed several individuals and property owners in Hamilton including but not limited to the Mayor, current and former residents.

One house was identified as "the Smith House" located at 307 Maple Street. According to Skagit County Assessor records the house was constructed in 1908. According to all of the individuals interviewed the house had never had floodwater inside the house until the 1995 flood event and then it only had about 2 inches of water. This is highly significant because the 1995 flood carried 160,000 cfs ***(See Appendix D)***. According to the 1923 Stewart Report the 1909 flood was estimated to carry 260,000 cfs and the 1921 flood 240,000 cfs. If the house had only two inches of water in it in 1995 it should have had several feet of water in it in both the 1909 and 1921 flood events. It reportedly had none.

Another residence of interest was "the Slipper House" located at 584 Maple. For the history of this house I interviewed one of its original residents. Fred Slipper was born in that house in 1917. ***(See Appendix F for Mr. Slipper's Declaration)*** According to Mr. Slipper, the house was originally constructed in 1887 and was moved to the 584 Maple location in 1902. Before 1990 the only time the house had water in it was in 1921 and then it only had 2 inches of water in it. During the second 1990 flood event the house had 16 inches of water in it. The house has subsequent to the 1990 flood been raised several feet and during the 1995 and 2003 flood event it again had no water in it. The 1990 flood carried only 146,000 cfs at The Dalles. The obvious question is how did a house in 1921 only have 2 inches of water in it with an estimated flow of 240,000 cfs but ended up with 16 inches of water in 1990 with a flow of only 146,000 cfs?

The answer to that question is that the estimated flows contained in the Stewart Report are overestimated and for that reason alone should not be relied upon for computing the 100 year flood flows for the Skagit River.

What did all the early floods have in common and why did they stop? The answer to the first half of the question is that one man determined how deep the early floods were and based on the document review contained herein, the second half of the answer is strongly suggestive that they never happened to the magnitude that Mr. Stewart said they did. That's why they not only did not repeat themselves once every ten years like Mr. Stewart suggested that they would, but why they also have not repeated themselves in 82 years. Section II "Significance of the Stewart Calculations" shows the impact on flood computations for frequency analysis that Mr. Stewart's work has had on the Skagit River flood control issue. Based on the document review and discussion contained in this Whitepaper, we simply cannot rely on his work product any longer.

APPENDIX A

Subsequent to the initial publication of this paper I obtained a complete copy of Mr. Stewart's field journal. Mr. Stewart visited several of the same sites on different dates. For ease of reading and following what he did I transcribed his notes from his field journal arranged in the most upriver location downstream. The field journal consisted mostly of Mr. Stewarts flood elevation measurements taken with a handheld level in the winter of 1922. Mr. Stewart used the notes contained in the journal in preparation of his report delivered to the Skagit County Commissioners in October 1923.

JAMES E. STEWART FIELD JOURNAL
Beginning date November 24, 1922

Rockport…….1897 flood 6 inches higher then 1909. Assumed 1909 & 1897 same height.(pg 101)

Sauk……1921 flood 2.8 feet above 1909 (pg 100)

John Larson Ranch….1896 flood 3.6 inches below 1921 flood (pg 20)
(Upstream Concrete) 1897 flood 1.9 inches below 1921 flood (pg 20)
1909 flood 2.8 inches above 1921 flood (pg 20)

Town of Concrete…..1909 flood 2 feet above 1921 flood (pg 23) At Everett Ranch above Concrete Magnus Miller says 1897 water came to middle of 2nd shake. About 3 feet above beam for rafters. This was shed on side of old barn. Water came to foot of steps to house. Did not get in house. May have came up on step a little. Leonard Everett says 1909 flood came just to bottom of shakes. Makes 1897 flood 2 feet above 1909. (pg 141)

Dalles…….1897 flood 3.6 feet above 1921 flood (pg 23)
1909 flood 2 feet above 1921 flood (pg 23)
Leonard Everett says 1897 flood about 9" lower than 1909. Says that **log jam in Dalles** raised water 10 feet in 2 hours. (pg 23)
He is wrong probably see bottom half of page 141.[36] See bottom of pg 18 for true comparison of 1909 & 1921[37] (pg 23 note written 3/24/23)

[36] Bottom of page 141 says 1897 flood 2 feet above 1909 at Everett Ranch.

[37] Bottom of page 18 has 1909 flood 1.27 feet above 1921. Appears to have been written on Dec 20, 1922. However this measurement was taken at Washington Cement Plant above and adjacent to Baker River. Mark found is questionable because prior to the building of Baker Dam an earthen dam was placed upstream to generate electricity for the cement plant. It never withstood any flood event. Marks at

(**NOTE**: This is significant because Stewart was in Pittsburg, PA at least by March 17th. See **Page 1 of notations taken from field notes regarding Skagit River Flood Level)**

Hamilton……1909 flood 4" higher then 1897 (quoting fm Hamilton Record-pg 98. The Hamilton Record was the forerunner to the Concrete Herald.)

Cockraham Is…… Mr. Cockraham (sic) farm was about 1,000 feet above the Lyman Ferry. (pg 135) 1897 flood was the highest at his place. 1909 and 1917 about the same. (pg 135) Mr. Cockraham (sic) says old Indian about 90 does not remember flood that drowned Indians but remembers flood several feet higher than 1909 and 1921. 1856 flood probably made HWM seen by Hart. (pg 135)

Upriver……M. Costello (logger who came after 1909 flood) told Stewart 1909 flood at least 22 inches higher than any flood in 22 years. (pg 122)

Skiyou Ferry…….. Anderson says 1917 and 1921 highwater practically the same. He thinks 1909 about 6 inches higher than 1921 at his place and 1897 about 1 foot higher. (pg 131)

Sedro-Woolley……Hart saw 1896 about 2" below 1897. (pg 125)
Hart says 1896 nearly same height as 1917 and not over 2" below 1897. 1909 flood 16 inches above 1917. 1921 flood .075 feet below 1917 (pg 127)
Note: Sto descrip 9-197 12/11/16 GLP gives 1909 flood 56.1; Nov 1896 54.79; Nov 1906 54.7 (pg 128)

Beatty Slough…….Beatty says he came in 1878. 200 or 300 feet above County highway bridge. 1909 highest water he has ever seen. One spring freshet about 1882 the water was red and made the people sick. Possibly this was clay or something that would stain bark like the old extreme flood. (pg 137)

Hart Island……..Hart says he tried to dig out large stump of old cedar tree. He dug down 5 feet and didn't reach the roots of the tree. A Cedar grows on the surface of the ground therefore, the 5 feet of soil was accumulation of river silt after tree started growing. (pg 139)

Mt. Vernon…….1894 Mt. Vernon went underwater in May (pg 98)
Assessor says 1897 flood about 1 foot higher than 1896. (pg 122)
1906 flood 1 ft below dikes. (pg 122)

Cement Plant could have been any number of flood events prior to 1909. *See 1951-06-21 Baker Water Power.pdf.*

Oldtimers stated that 1897 only time waters reached downtown Mt. Vernon. (pg 123) ***NOTE:*** *See Stewart comment on pg 98*
Mt. Vernon gage 1896 23.0; 1897 23.2; 1906 23.9; 1909 25.1; 1917 23.6; 1921 25.0 (pg 125)
1896 flood did not top dikes while 1897 did. (pg 125)

Stewart writes in his notebook beginning at page 140 the following:

Possible sources of information as to flood marks:

Concrete: See Otto Presentine near Grassmere. Kauhman on left side of River may have 1897 mark. Mr. Bratton at old Bratton Ferry marked old floods. Possibly was not there in 1897. See Magnus Miller again about 1897 flood. Mrs. Hamilton on Bensons Slough would know possibly where 1897 marks were. Ask Magnus Miller when cabin was built at Dalles. Examine cabin at Dalles for mud in walls. (pg 140)

Indians: Napoleon. A. Shaker at VanHorn medicine man on Suiattle. Joe Camel Broke a Toe at Concrete. Jimmy Sius on Suiattle. Dan Dillard can tell about where Indians are. Jasper Gates at Mt. Vernon knows about Indians. Eugene English also knows about Indians. (pg 140)

Hamilton: Old log house in lower edge at Hamilton below school house just across creek. Possibly 1897 mark in crevices. Henry Carey 1½ miles above Hamilton can give 1897 flood probably. Considered very intelligent man by others also said to have good memory. (pg 141)

Concrete: At Everett Ranch above Concrete Magnus Miller says 1897 water came to middle of 2nd shake. About 3 feet above beam for rafters. This was shed on side of old barn. Water came to foot of steps to house. Did not get in house. May have came up on step a little. Leonard Everett says 1909 flood came just to bottom of shakes. Makes 1897 flood 2 feet above 1909. (pg 141)

Sauk and Vicinity: S. B. Ellison and E.G. Ellison on Sauk River 1½ miles above mouth have all floods. Probably E.G. best and marks at his place. These marks indicate Sauk alone probably-possibly some backwater from Skagit. Hank Stafford at Sauk can possibly give 1897 flood. Algy Parker ½ mile downstream from Sauk left side can probably give 1897 flood. Old Mrs. Wainright or Harry Wainright may have 1897 HW. City of Seattle J.B. Dodge 1400 Alaska, Skagit River Development. J.M. Waters box 102 Rockport. Ed O'Brien Marblemount RFP 2 miles this side of Marblemount. Alec Stafford Hamilton. Stafford in town Rockport ranch on other side of river. Martin Rockport 5 miles up. Lyman Martin Indian Bacon Creek. Charlie Moses Indian Bacon Creek, good man.[38] William Nubey ½ way Rockport Marblemount. Ed Presentine Rockport. Harry Wainright Sauk. Jimmy Jones 2 miles below Rockport Indian. Johnny

[38] It was Charlie Moses who was quoted in the 1921 Courier Times article saying the water in 1921 flood at The Dalles was 2 feet above all the other floods. *See* **12/22/21 CT.** This is good indication Stewart never talked to Charlie Moses.

Towne Bennet Bros Store, 6 miles not Darrington. Skagit Boom at Van Horn Indian with Napoleon. (pgs 142 & 143)

Skagit County History: Ross was clerk at Astor Co. at Okanogan Post established fall of 1811. Pacific Fur Trading Co. headed by John Jacob Astor started in 1810. Northwest Fur Trading Co. had no posts south of 52º North and west of Rockies in 1810. Toriquin (sic) Astors ship arrived at mouth of Columbia March 22, 1811. Details of voyage in Irving's Astories and Franchores narrative. Ross Cox author of Adventures of Columbia River. Fort Vancouver on the Columbia established in 1824. Fraser River gold excitement in 1858. (pg 143)

Things To Do:[39]

1. Get dredge data. Probably about .80 cents per cubic yard.
2. Study Baker Lake storage.[40]
3. Get exact date NP was built through Sedro. 1890 per Hart.
4. Get exact date NP trestle was replaced by fill. 1900 or 1901 per Hart.
5. Get grade of stream bed Sedro Woolley to mouth probably can obtain from Army Engineers report.
6. Enlarge 1909, 1914, 1917 and 1921 flood crests to 1861 size and find discharge acreage at Concrete.
7. See jomv (sic) about rights to riverbeds. Roberts says law was passed for Puyallup so that bed reverts to reclamation project.
8. Go to Seattle libraries and look-over old histories for floods.
9. Find when Canadian Pacific Ry was put through. Possibly get flood data from them on Fraser River.
10. Examine Bench (marks) downstream from Power Camp to see if any indication of flood that left them and if there has occurred a higher flood than 1856 in recent history.
11. See Charlie Presentine again and see if there is any virgin ground where we can dig to find leaves that he said had been covered up by extreme flood.
12. Investigate saddle at Concrete to see if any indication that recent flood passed through there.
13. Get soundings where USGS topo and Army maps do not cover bays.
14. Find head at old delta prior to present delta.
15. Define limits of floods of 1856, 1897, 1909, 1917, 1921.
16. Run level line from Sterling bend to coast.
17. Get loss suffered by flood districts.
18. Get all data concerning floods and damages from newspapers.

[39] The page numbering stopped. Also no date indication as to when Stewart wrote these notes. Could have been things he wanted to do when study began OR things he wanted to do after January 1923. **In any event it shows that his "study" was incomplete as many of these things were not done for his final "preliminary" report in September 1923 and certainly not done subsequent to his leaving Washington State in March 1923.**

[40] Unclear if Stewart meant water in Baker Lake before dams or if he had knowledge that dam was going to be built. Dam construction did not begin until April 1, 1924 but was being talked about in local press since 1917. Very likely he knew dam on Baker was proposed given second #10 note.

19. Cost of dikes to protect old channel.
20. Salvage value at old channel.
21. Put in slope stations possibly Sedro, just above Hamilton and from Concrete Ferry to bend above Dalles.
22. Get flows at tributaries at time of great flood, possibly at narrowed sections. Consult map.
23. Study possibility of River Control by dams.
29.[41] Cost of moving all people out above detention reservoir at The Dalles.
30. Study plan for detention reservoir and necessary additional dikes.
31. Get coast and geodetic soundings in Skagit and Padilla Bay and dates. Be sure and get oldest soundings.
32. Get HW levels above and below NP grade at Sedro. Get HW 1921 at Mt. Vernon gage.
33. Get 1921 HW above ws at BM #7 US Army.
34. Get distance from BM #6 to Fesszers Ranch.
35. Examine sand in tree at BM #6 to check 1921 HW at that place.

1.[42] Find out earliest settlement in BC, also earliest fur trading posts on rivers in BC.
2. Find oldest and largest solid cedar stump. Find depth of roots and count rings for age. Get rate of deposition per century.
3. Study possibility of diverting part of flood flows from new constructed channel to old channels and sloughs to fill them up.
4. Possibility of tidal gates to keep down stage of mouth of stream at high water.
5. Dam below Concrete to store total flow of Skagit River. Raise water to about elev. 450 feet probably depending on bedrock at Darrington. Dam at low water point of about 145 feet. This to be reduced to 100 feet by new channel net 350 feet. Dam probably 400 feet high.
6. Drift barrier at The Dalles to reduce flow and hold back drift until new channel below Hamilton reduces low water about 40 or 50 feet at The Dalles.
7. New channel below Hamilton to Padilla to carry 100,000 sec feet. 8 feet in 10,000. Dredge cut side trenches, start upper end and build levees. Place concrete facings to embankment to below cutting of stream.
8. Channel Sterling Bend to Padilla. Encircle Sedro so as to later cut channel from Hamilton to connect north of Sedro.
9. Ship channel sea to storage dam.
10. Dam on Skagit above Baker and below Sauk. Diversion dam on Baker to storage dam. . . .[43] Storage in Ruby dam. Study . . .[44]

The following notes were not numbered.

Get BM elevations Army Seattle.

[41] No indication of why Stewart skipped numbering.

[42] No indication why Stewart re-started numbering or when he wrote this list.

[43] Unreadable text.

[44] Ibid.

Get Sacramento flood reports Army.
See Unden (sic).
Get rating table.
See Landes Skagit diversion to Stillaguamish.
Get BM's for Wickersham sheet.
See Roberts and Puyallup.
Write for Hudson Bay company records.
Get good stop watch.
Take along my flood report.
Get Army maps for Gilkey.[45]
Send for Taylors flood report.[46]

The next 14 final pages in the notebook are not the same handwriting as contained in the rest of the notebook. Names that appear at the top of the pages dated March 3rd through March 8th, 1923, are Wright, Theret and H.O. Stiles. The Washington State Archives, located in Bellingham Washington has confirmed that Mr. Wright was the Skagit County Assistant Engineer and Mr. Theret was also a County employee and an assistant to Mr. Wright. H.O. Stiles was a Concrete resident who sometimes assisted County survey crews. Measurements were taken on these days at Sedro-Woolley and The Dalles. What this shows us is that Mr. Stewart was not in Skagit County to observe the work of the County employees. We have no way of knowing if the marks located or the work performed by those employees was correct for the 1921 flood event.

One of the last items on the list was the notation "Channel Sterling Bend to Padilla Bay." Mr. Stewart's journal was located in a red well file folder with a cover letter from Mr. Stewarts wife stating, "Here are all my husbands papers on the Skagit Report." Contained in the folder was a carbon copy of the 1922 Robert E. Herzog GNRR report recommending the "Diversion Channel" to Padilla Bay.

[45] Frank Gilkey was the Skagit County engineer who retired in March 1923. Ironically the same month Stewart quit USGS. See 1923-3-10 Frank Gilkey.pdf)

[46] This is very likely Capt. Harry Taylor's 1897 flood report. Capt. Taylor says flood of 1897 at Sedro-Woolley was 1.6 feet above 1896 flood event. Stewart says the difference was only 1.2 inches above 1896 so he clearly never reviewed Taylor's report.

APPENDIX B

Description: General view of Reflector Bar. Date: Oct 21, 1954 ***(Source: Seattle City Light.)***

Description: Davis Ranch Date: Mar 29, 1927 ***(Source: Seattle City Light)***

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)***

Mouth of The Dalles, Concrete, Wa. Note rock walls on both sides of the canyon and the heavy timber and brush along the banks as well as the increase in the velocity of the river as it is compressed through the canyon. ***(Source: Picture taken by Larry Kunzler, 2/14/04)***

View of The Dalles looking downstream. ***(Source: Picture taken by Larry Kunzler, 2/14/04)***

Example of log jams and woody debris coming from tributary streams and creeks into the Skagit River. ***(Source: Picture taken by Larry Kunzler 2/14/04)***

Log jam on BNSF bridge, 1995 flood event. ***(Source: Corps of Engineers, Seattle District, 1995)***

Diablo Canyon, June 30, 1919.

Property of Special Collections, University of Washington Libraries.

Ross Dam Site October 19, 1919

Lower Baker River Canyon (note rockslide)
Picture taken by Larry J. Kunzler

Upper Baker Canyon
(Picture taken 4/7/2006)

APPENDIX C

9-193
Slope-area measurement
(Experimental, October 1947)
31909

UNITED STATES DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY
WATER RESOURCES BRANCH

File .....

Slope-area measurement of Skagit River near Concrete, Wash. for flood of Dec. 13, 1921

Reach between sections	A–B	B–C	C–D
Length of reach, feet,		2190'	
Fall in reach (F), feet,		2.62'	

Gage height at gaging station, ... feet.
Discharge, ... second-feet.
Drainage area, ... square miles.

SECTION PROPERTIES

Section	n	$\frac{1.486}{n}$	a	r	$r^{2/3}$	$K=\frac{1.486}{n}ar^{2/3}$	$\frac{K^2}{a}$	C_m	Verification: $K S^{1/2}$	Verification: v
B	.030	49.5	19,000	24.35	8.40	7890,000				
C	.030	49.5	16,900	23.80	8.27	6,920,000				
Q = 6,920,000				2.62			= 2,125,000			

Weighted conveyance $^4(K_w)$: A–B ..... B–C ..... C–D .....

COMPUTATION OF DISCHARGE

Section	Assumed Q	$\frac{C_m V^2}{2g}$	$^5\Delta\frac{C_m V^2}{2g}$	$^6 h_f$	$^7 S$	$S^{1/2}$	^{8}Computed Q $= K_w S^{1/2}$	Weight
A								
B								
B								
C								
C								
D								

^{1}DISCHARGE (the weighted average of computed discharges)

Summary of factors influencing measuring conditions (floodmarks, surge, scour, fill, channel configuration, angle of flow, selection of n, etc.):

Only reach B-C used. Reach A-B is expanding and "n" for that portion of the channel is not well verified. Value of "n" for reach B-C is from verification using data from flood of Nov. 27, 1949.

Sheet ..... of ..... sheets. Computed by WRB Date 6/15/52 Checked by F.T.H. Date 11/7/52

FORMULAS

$^2 C_m = \frac{\Sigma v^2 a}{V^2 A} = \frac{\Sigma(K^2/a)}{K^2_{Total}/A_{Total}}$

^{3} $S^{1/2}$ at any section is final discharge divided by K for that section.

$^4 K_w = \sqrt{K_{upstr.} K_{downstr.}}$

$^5 \Delta\frac{C_m V^2}{2g} = \frac{C_m V^2}{2g}_{Upstr.} - \frac{C_m V^2}{2g}_{Downstr.}$

$^6 h_f = F + \Delta\frac{C_m V^2}{2g} - h_i$

$V_{Upstr.} > V_{Downstr.}: h_i = \frac{1}{2}\Delta\frac{C_m V^2}{2g}$

$V_{Upstr.} < V_{Downstr.}: h_i = 0$

$^7 S = \frac{h_f}{\text{Length of reach}}$

^{8} Computed Q must equal assumed Q.

APPENDIX D

HISTORICAL FLOOD FLOWS OF THE SKAGIT RIVER[47]

DATE	C.F.S. CONCRETE	RIVER LEVEL	C.F.S. S-W	C.F.S. M.V.	RIVER LEVEL M.V.[48]
1815	500,000	69.3	400,000	54.56 (Sedro Woolley ("S-W")Gage)	
1856	350,000	57.3	300,000	51.06 (S-W Gage)	
11/16/1896			185,000	45.86 (S-W Gage)	
11/18/1897	275,000	51.1	190,000	45.96 (S-W Gage)	
11/16/06			180,000	180,000[49]	37.00
11/18/08			97,000	N/A	N/A
11/30/09	260,000	49.1	220,000	47.56 (S-W Gage)	
11/21/10			114,000	N/A[50]	N/A
12/30/17	220,000	45.7	195,000	N/A	N/A
12/12/21	240,000	47.6	210,000	140,000[51]	N/A
12/12/24	92,500	32.44	N\A	N/A	N/A
10/16/26	88,900	32.03			
1/12/28	95,500	32.90			
10/9/28	74,300	29.94			
02/27/32	147,000	39.99	157,000	N/A	N/A
11/13/32	116,000		125,000	N/A	N/A
12/22/33	101,000	33.60	110,000	N/A	N/A
01/25/35	131,000	37.90		N/A	N/A
06/19/37	68,300	28.97			
10/28/37	89,600	32.16			
5/29/39	79,600	30.70			
12/2/41	76,300	30.17		65,300	25.99
12/3/43	65,200	28.49			
02/8/45	70,800			59,800	25.77
10/25/46	82,200	31.14		64,900	27.80
10/26/45	102,000	34.00	N/A	94,300	30.25
10/19/47	95,200	32.99	N/A	69,400	28.68
11/28/49	154,000	40.8	149,000	114,000	34.21

[47] . Pool levels are suppose to be at 1592.1 at Ross and 707.9 ft at Upper Baker Reservoir before the simulation begins.

[48] Authors Note: Flood stage is at 28.0 feet.

[49] This figure is incorrect. The levees in 1906 could not have held 180,000 cfs. The figure is a typo contained in the 1965 COE report.

[50] N/A = Not Available.

[51] Extreme difference between Sedro Woolley and Mt. Vernon was due to break in dikes upriver on Burlington side of river. Source: COE report 1/31/25.

DATE	C.F.S. CONCRETE	RIVER LEVEL	C.F.S. S-W	C.F.S. M.V.	RIVER LEVEL M.V.[48]
11/26/50			N/A	68,400	28.19
12/25/50			N/A	74,000	29.08
02/11/51	139,000	38.99	150,000	144,000	36.85
02/1/53	66,000	28.61		65,700	27.76
10/26/55			N/A	84,900	30.69
11/04/55	106,000	34.48	113,000	107,000	33.52
04/30/59	90,700	32.36	92,000	92,300	31.68
11/24/59	89,300	32.17	91,000	91,600	31.58
11/21/60			N/A	70,200	28.51
12/16/60			N/A	70,200	28.51
01/16/61	79,000	30.61	N/A	76,000	29.40
11/20/62	114,000	35.73	N/A	83,200	30.44
10/22/63	73,800	29.80	N/A	N/A	N/A
11/27/63	84,200	31.41	N/A	72,100	28.80
06/22/67	72,300	29.59	N/A	72,000	28.78
10/28/67			N/A	72,700	28.89
01/21/68			N/A	70,900	28.43
06/03/68			N/A	68,800	28.09
01/31/71			N/A	70,300	28.52
07/13/72	91,900	32.54	N/A	80,600	30.07
01/16/74	79,900	30.75	N/A	77,600	29.64
12/4/75	122,000	36.88	N/A	130,000	35.66
12/2/77	70,300	29.27		65,600	27.59
12/19/79	135,000	38.57	N/A	112,000	33.99
12/27/80	148,700	40.19	N/A	114,000	34.16
12/04/82	100,000	33.82	N/A	71,600	28.65
01/05/84	109,000	34.94	N/A	88,200	31.14
01/19/86	93,400	32.75	N/A	72,800	28.84
11/24/86	83,500	31.30	N/A	70,700	28.49
10/16/88	74,100	29.86	N/A	56,700	25.77
11/11/89	119,000	36.39	N/A	88,220	31.14
12/05/89			N/A	95,480	32.39
11/11/90	142,000	40.20	N/A	142,000	36.60
11/24/90	146,000	39.89[52]	196,000[53]	152,000	37.37
11/08/95	143,000	39.45	N/A	89,900	31.62[54]
11/11/95	72,900	29.67	N/A	59,200	26.60

[52] Flooding in Western Washington from 21 to 26 November 1990, COE MFR, 11/29/90

[53] INFO OBTAINED FROM COE 1993 RECON STUDY FAX DATED 3/29/93.

[54] Info obtained from USGS

DATE	C.F.S. CONCRETE	RIVER LEVEL	C.F.S. S-W	C.F.S. M.V.	RIVER LEVEL M.V.[48]
11/14/95	67,700	28.86	N/A	57,100	26.18
11/25/95	63,200	28.11	N/A	61,500	27.03
11/29/95	160,000	41.57	N/A	133,000[55] 141,000[56]	37.32
02/09/96	88,900	32.11	N/A	81,800	29.27
03/20/97	74,740	29.96	N/A	74,980	29.52[57]
11/13/99	101,000	33.80	39.20	78,600	29.88[58]
11/15/01	65,100	28.4	N/A	67,400	28.0[59]
01/08/02	95,600	33.06	38.5	78,700	29.9[60]
06/29/02	63,900	28.23	35.02	58,100	26.25
10/17/03	94,200	33.04		73,400	29.03
10/21/03	166,000[61]	42.21	42.02	129,000	36.19
11/19/03	79,323	30.82	37.31	70,129	28.48

As of November 13, 1999, the Skagit River reached flood stage 66 times since 1900 for an average of once every 1.5 years.

[55] First reported by the COE.

[56] Currently being reported by USGS (10/27/02)

[57] Info obtained from COE Internet Web Site

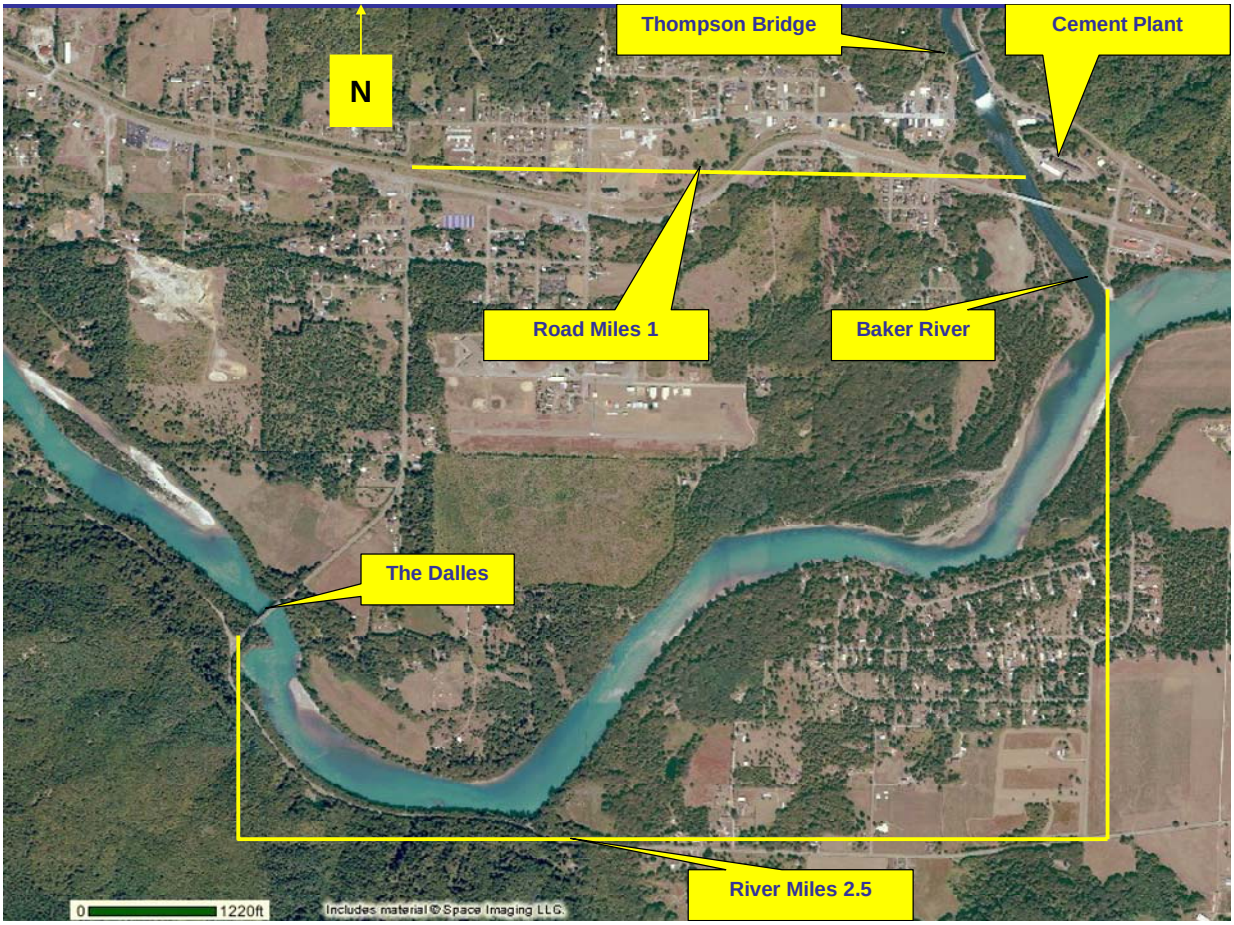
[58] Info obtained from USGS Internet Web Site

[59] Ibid

[60] Ibid

[61] Sauk River crested 107,000 cfs 18.89, 100 yr flood per USGS 11/10/03 Skagit Flood Control Meeting

APPENDIX E


N
Thompson Bridge
Cement Plant
Road Miles 1
Baker River
The Dalles
River Miles 2.5
0
1220ft
Includes material © Space Imaging LLC.

APPENDIX F

IN RE THE MATTER OF THE HISTORY OF THE SKAGIT RIVER	DECLARATION OF FRED W. SLIPPER

I, Fred W. Slipper, under penalty of perjury under the laws of the State of Washington, declare as follows:

1. I was born on May 14, 1917 in my mother and fathers house in Hamilton, Washington. A picture of the house is shown below as it appears today.

2. The house was originally built in 1887 and moved to this location, 584 Maple Street, in 1902. At this location it only had floodwater in it during the December 1921 flood. At no time previous nor subsequent to that date did it have floodwaters in it until the November, 1990 floods.

3. The reason I remember this is because my mother and father had just installed hardwood floors the year before and they were very worried that the 2 inches of floodwater were going to hurt the floors. Because the floodwater was only in the house for a little over an hour or two, the hardwood floors were not damaged. They talked about this from time to time during my childhood.

4. Before 1990 the first floor of the living quarters sat approximately 2 to 3 feet off the ground. The house was raised after the second November 1990 flood when it again had floodwater inside, this time I am told it had 16 inches of water in it.

5. For over 9 years I worked as a weekly columnist for the local Courier Times. On January 7, 1981 I reminisced about my boyhood days in Hamilton and wrote about the infamous December 1921 flood. A copy of that article is attached hereto as Exhibit A.

6. There were a handful of other homes in Hamilton that never had water in them during any flood event until the decade of the 1990's. One of them was called "The Smith House" which is situated at the east end of town at 307 Maple Street. The Smith House was built in 1908 as determined by Skagit County Tax Assessor Records.

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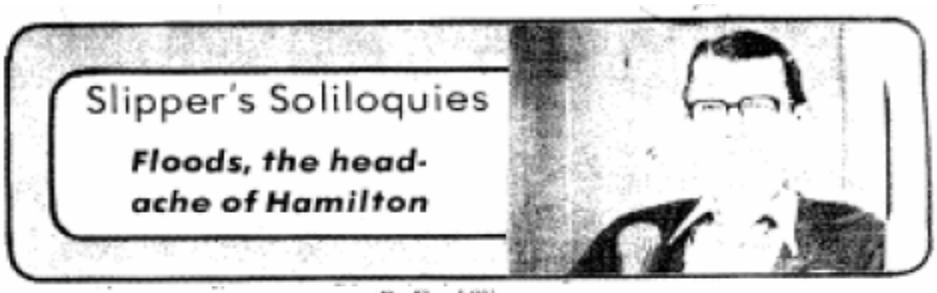
Fred W. Slipper

April 29, 2006 Sedro-Woolley, Washington
Date and Place of Execution

EXHIBIT A



By Fred Slipper

Sitting at home last night (Dec. 26th) listening to the radio flood reports brought back a lot of memories. I may have reminisced on this subject in the past but that would have been in 1980, and this is a new year, so repetition doesn't count....

I thought when all the dams were built up river our floods were supposed to be controlled. At least that is what they told us in the old days. It seems the floods are worse than ever. The radio said Hamilton had been completely evacuated. Back in my childhood I don't remember anyone leaving town. Our house was built quite a bit above the ground, about four feet, and altho water did come in and cover the floor, my folks didn't leave. They did put all the furniture up on blocks dad had stored in a shed just for flood emergencies, and they rolled up the rugs and put me upstairs so I would be out of the way. Many of the other houses were built the same way-two that come to mind are the Jim Smith house and the house that was owned by Great Northern station agent, Mr. Belfry. Nick and Ella Brando are the present owners. Since I have lived there, many of the new houses are the type built on a slab so they are very susceptible to flood conditions.

Our flood gauge was a stick put in the ground down by Sam Morrell's and when the water got to a certain level everyone knew the water was coming. It used to cover the road first down past the school buildings, near the cheese plant owned and operated by Louie Castrilli. (I wonder how many of the present day residents of Hamilton know the cheeses produced by Louie won many blue ribbon awards at various World Fairs?)

When the flood waters finally receded the clean up began. We would find everything in our yard-fence posts, firewood, dog houses, anything that would float was moved to a new location. I could tell just how high the water on each preceding flood had risen by the mud rings around all of the out buildings. There was no way out of town, as the only road out was the old highway, and down near Val Adams (about half way to Lyman) the water got about two feet above the road level.

Then when the water finally receded the work began. In my younger days the houses didn't have wall to wall carpet and the rugs weren't fastened down so they could be rolled up and put on tables, etc. But the mud was still there. The first flood I can remember that covered the floor of our home was 1921. The summer before my folks had put hardwood floors in, and mom was afraid they would be ruined, but apparently they survived.