Skagit River
Historical Flood Elevations and Peak Flow Estimates

to be presented at

Skagit River GI H&H Technical Workshop

Wednesday, June 17, 2009

PACIFIC INTERNATIONAL ENGINEERING

CITY OF Burlington
SKAGIT COUNTY, WASHINGTON INCORPORATED 1902

SKAGIT RIVER BASIN

~

PUGET SOUND, WASHINGTON

Upper Baker Dam

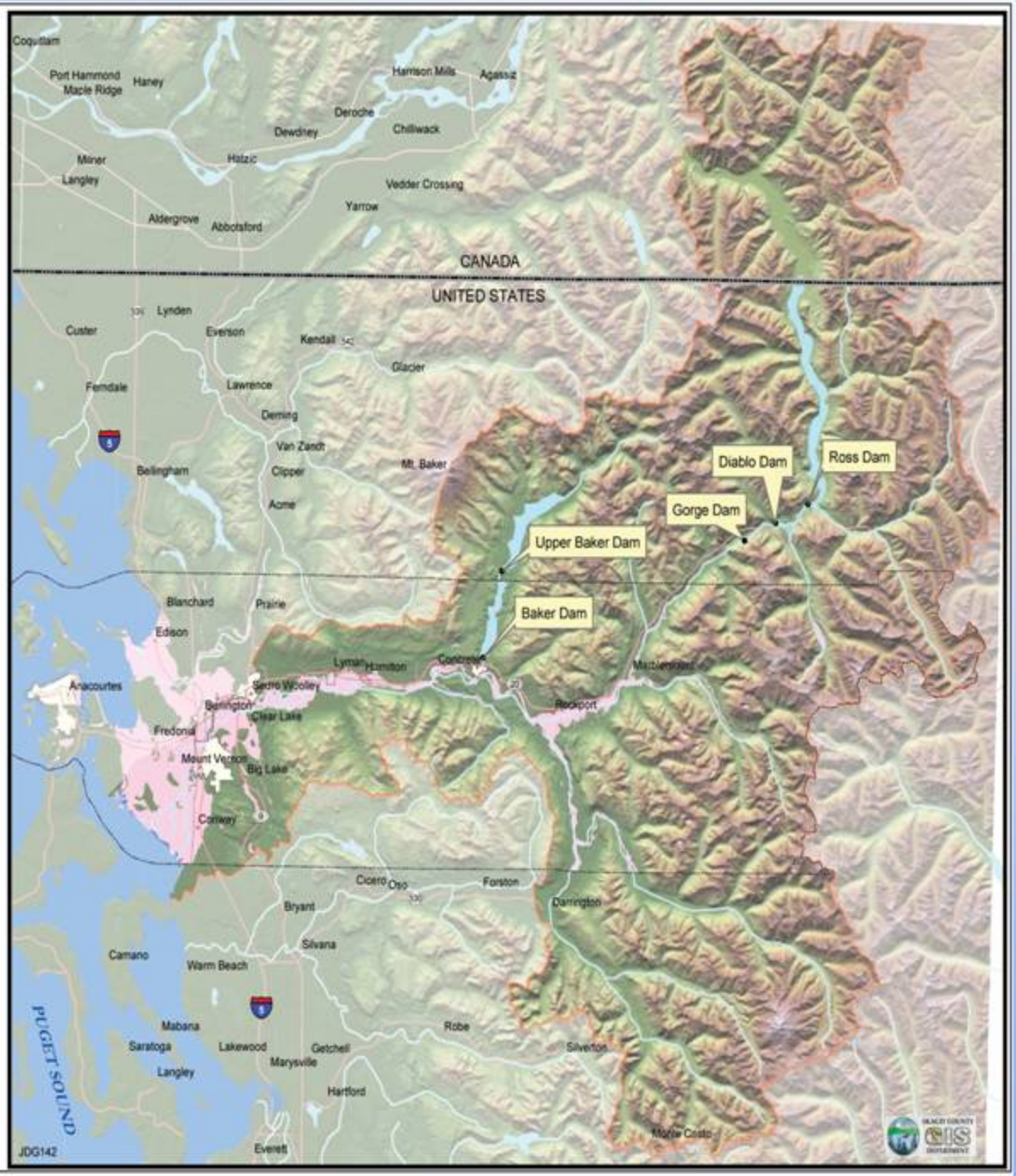
Ross Dam

Lower Baker Dam

N
W E
S

0 25 50 100 150 200
Miles

Map Printed: June 5, 2003



Background

Corps of Engineers began a General Investigation study in 1996

- Skagit County the local sponsor
- Study to be completed maybe 2015
- County hired Pacific International Engineering in 2002 to supplement COE effort
- PI Engineering and Corps could not agree on hydrology
- County made policy decision to terminate PI Engineering contract in 2006

More Background

- FEMA contracted with the Corps to develop revised flood insurance maps in 2003
  - Hydrology was still an issue
- Skagit County contracted with Northwest Hydraulic Consultants in early 2006 to further study the hydrology issue
- Mount Vernon, Burlington and 2 Dike Districts contracted with PI Engineering in late 2006 to further study the hydrology issue
- COE issued revised hydrology report in May 2008
- PI Engineering issued revised hydrology report in October 2008
  - *Topic of this presentation*
- nhc issued revised hydrology report in November 2008

Even More Background

- Following the extensive work of James E. Stewart, a Hydraulic Engineer who studied the Skagit Basin from 1917 – 1923, a gage was installed in 1924 near Concrete and has been continuously recording river stage/discharge information since
  - 84 years of data at a stable gage site
- Stewart's work is extensively documented in his field notes of 1922-23

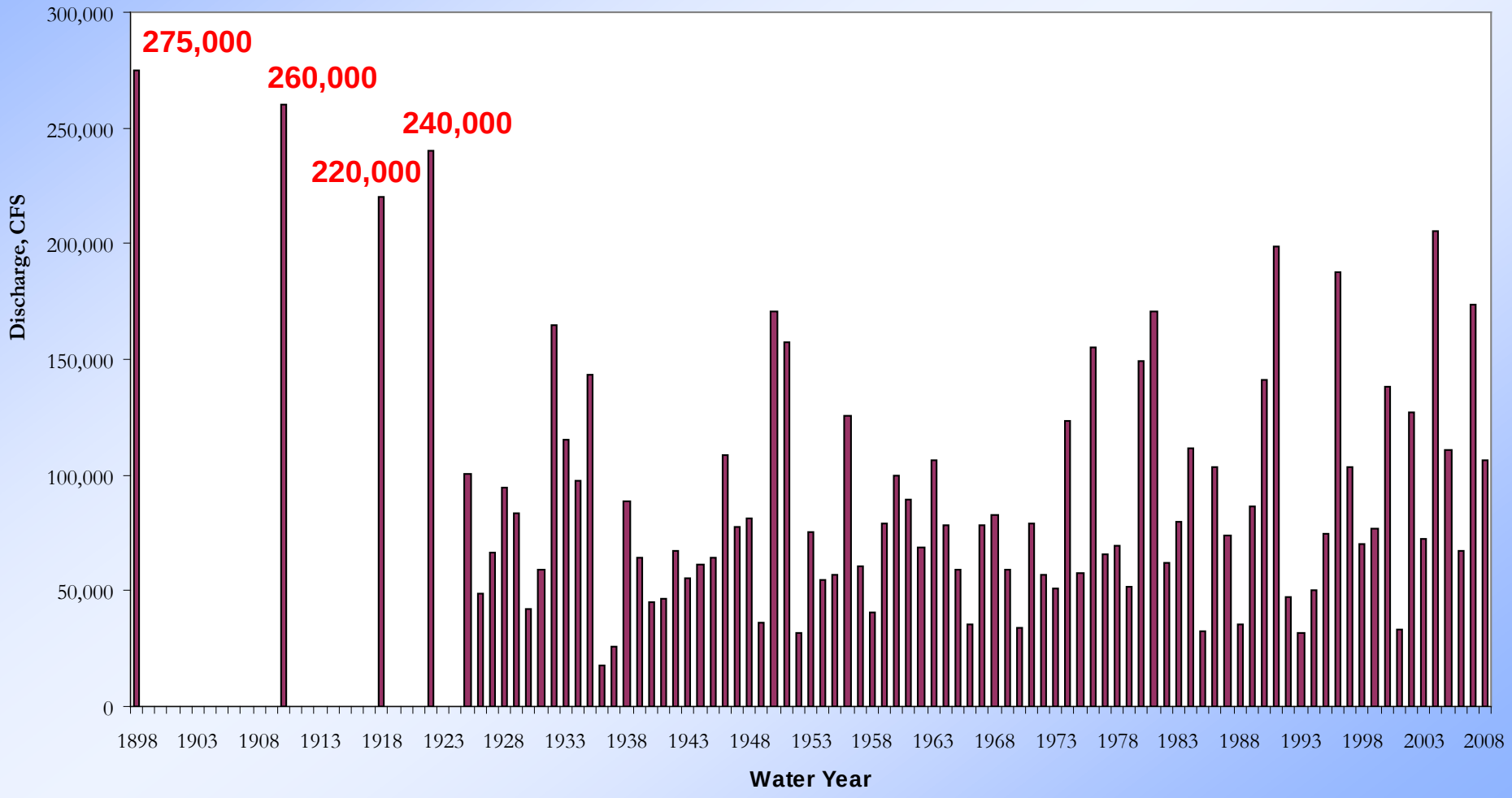

27/08/2006

At Issue

Magnitude of historic floods

SKAGIT RIVER WINTER UNREGULATED ANNUAL PEAK DISCHARGES

Water Year 1898 to 2008 - USGS Gage near Concrete, WA

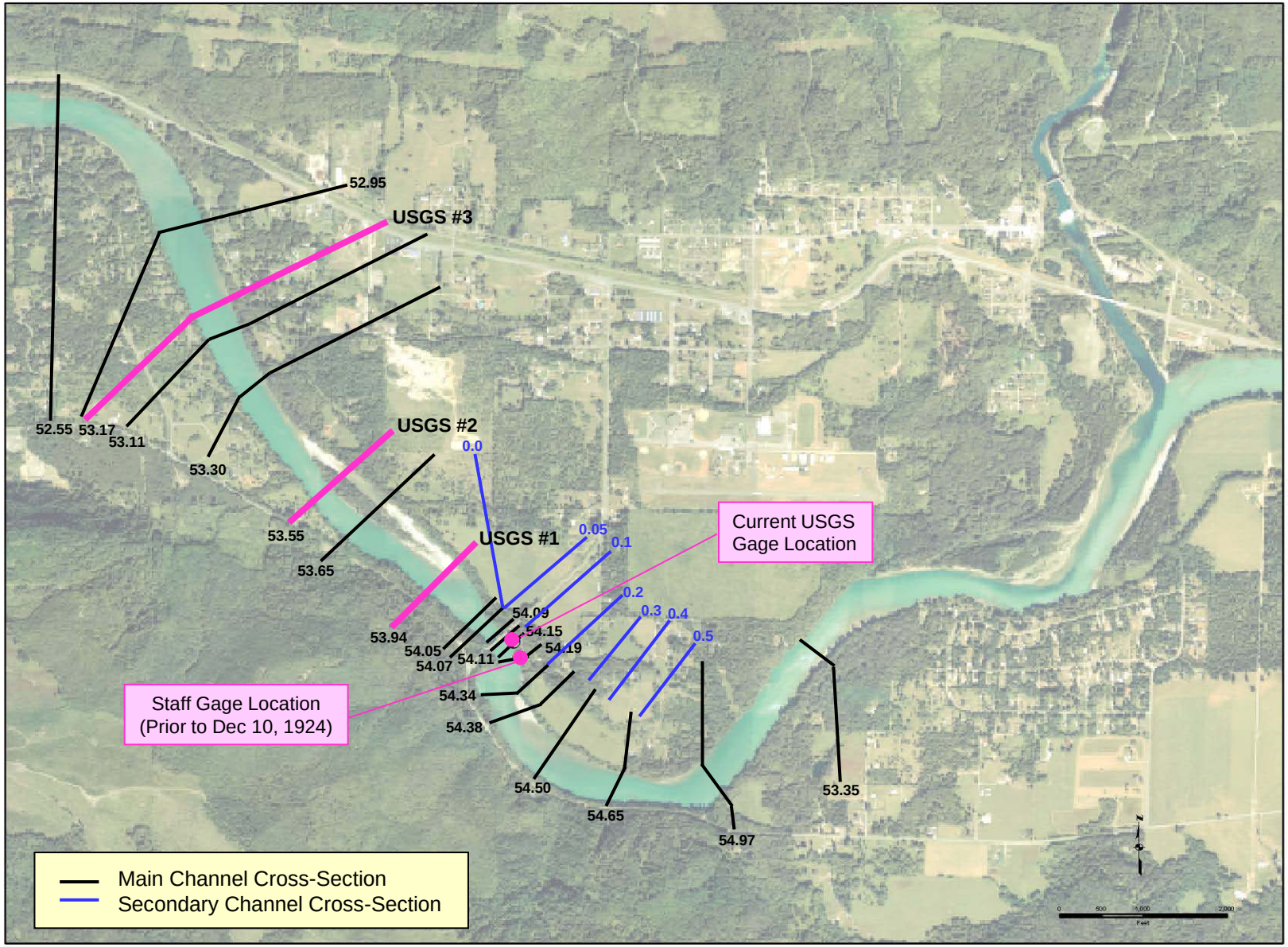


Stewart and USGS Peak Discharge Estimates for Historical Floods at Sedro-Woolley

Flood	Stewart		USGS		
	1918	1923	Rigg & Robinson	Hidaka	Bodhaine
1897	171,000	190,000	170,000	145,000	170,000
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

(Source: Stewart 1918 & 1923 Reports; Proposed Revision of Skagit River 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). Available at www.skagitriverhistory.com

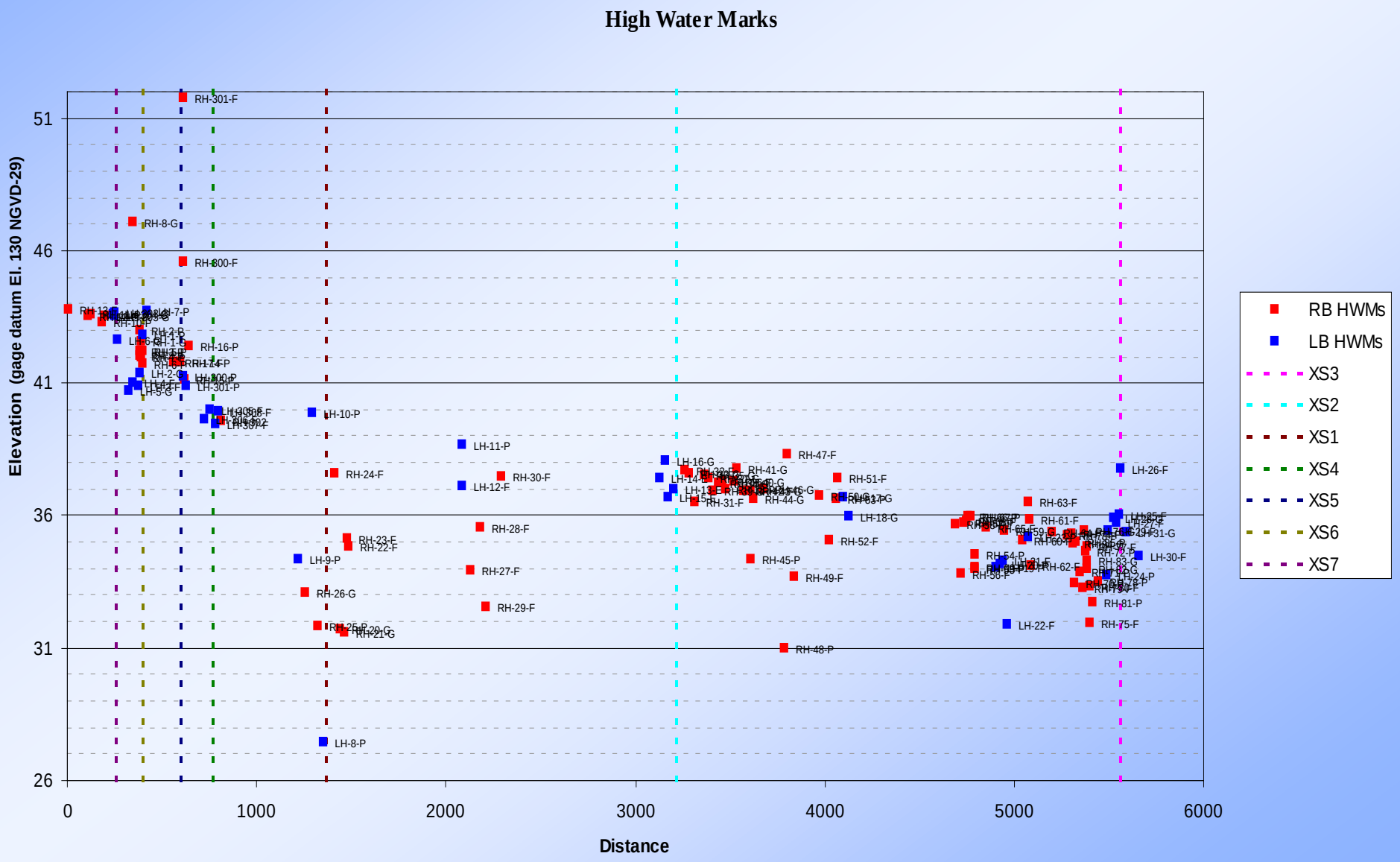

27/08/2006


52.95
USGS #3
52.55
53.17
53.11
53.30
USGS #2
0.0
53.55
53.65
USGS #1
0.05
0.1
0.2
0.3
0.4
0.5
Current USGS Gage Location
54.09
54.15
54.19
53.94
54.05
54.07
54.11
54.34
54.38
Staff Gage Location (Prior to Dec 10, 1924)
54.50
54.65
54.97
53.35
Main Channel Cross-Section
Secondary Channel Cross-Section

2003 Main Channel High Water Marks

Stewart's slope/area reach below the Dalles

Surveyed (in summer 2004) by USGS




09:36

USGS Estimated Peak Stages and Discharges of Skagit River near Concrete for Four Historical Floods (Drainage Area = 2,700 sq. mi.)

Flood	Gage Height at Current Gage* as Published in 1961 (ft)	Gage Height** Estimated by Stewart in 1923*** (ft)	Discharge Estimated by Stewart in 1923*** (cfs)	Discharge Revised by USGS in 2007**** (cfs)
1897	51.1	38.4	275,000	265,000
1909	49.1	36.4	260,000	245,000
1917	45.7	33.0	220,000	210,000
1921	47.6	34.9	240,000	228,000

* Current gage datum El. 130.00 (NGVD29) at RM 54.15.

** At the Upper Dalles gage installed by Stewart for his flood investigation during the winter of 1922-23. Gage Datum El. 140.89 surveyed by Stewart (Stewart's survey notes, pp. 86-87).

*** These unpublished 1923 estimates by James Stewart were documented in the 1961 U.S. Geological Survey Water Supply Paper (WSP) 1527 (USGS 1961).

**** Revised due to Manning's "n" verification in Scientific Investigations Report 2007-5159 (USGS 2007)

PI Engineering Approach:

Use modern hydraulic modeling techniques to assign a discharge estimate to Stewart-surveyed high water marks of the 1921 flood

At Hamilton—

- “Smith” house – constructed in 1908
  - Survived floods of 1909, 1917, and 1921

- Stewart-surveyed high water marks (based on citizen interviews in 1922), and additional information documenting the 1909 flood in County records

At Hamilton

	12.73	12.73		00.00	W S
TP			4.36	8.37	
	10.68	19.05			
			2.77	16.78	RP
	2.94	96.84		93.90	Top of GN rail
TP			2.40	94.44	
	4.21	98.65			
			3.03	95.62	1917 HW
TP			4.95	93.70	
	3.40	97.10			
TP			4.49	92.61	
	5.87	98.48			
			1.59	96.89	R.P. described above

Nov 27 1922

10 AM

nail in 14" maple tree river edge of old levee

Nov 28

in front of Hamilton Depot. { Elev from USGS Bulletin 670?

.55 above = 1909 HW
.84 above = 1921 HW

{At AJ Jacobin cigar store. Bldg may have settled 1 or 2 in. last 15 yrs

95.62
.55
96.17 = 1909

95.62
.84
96.46 = 1921

95.62
80.11
15.51 = 1917 HW above stage 11/27/22

96.17
80.11
16.06 = 1909 HW above stage 11/27/22

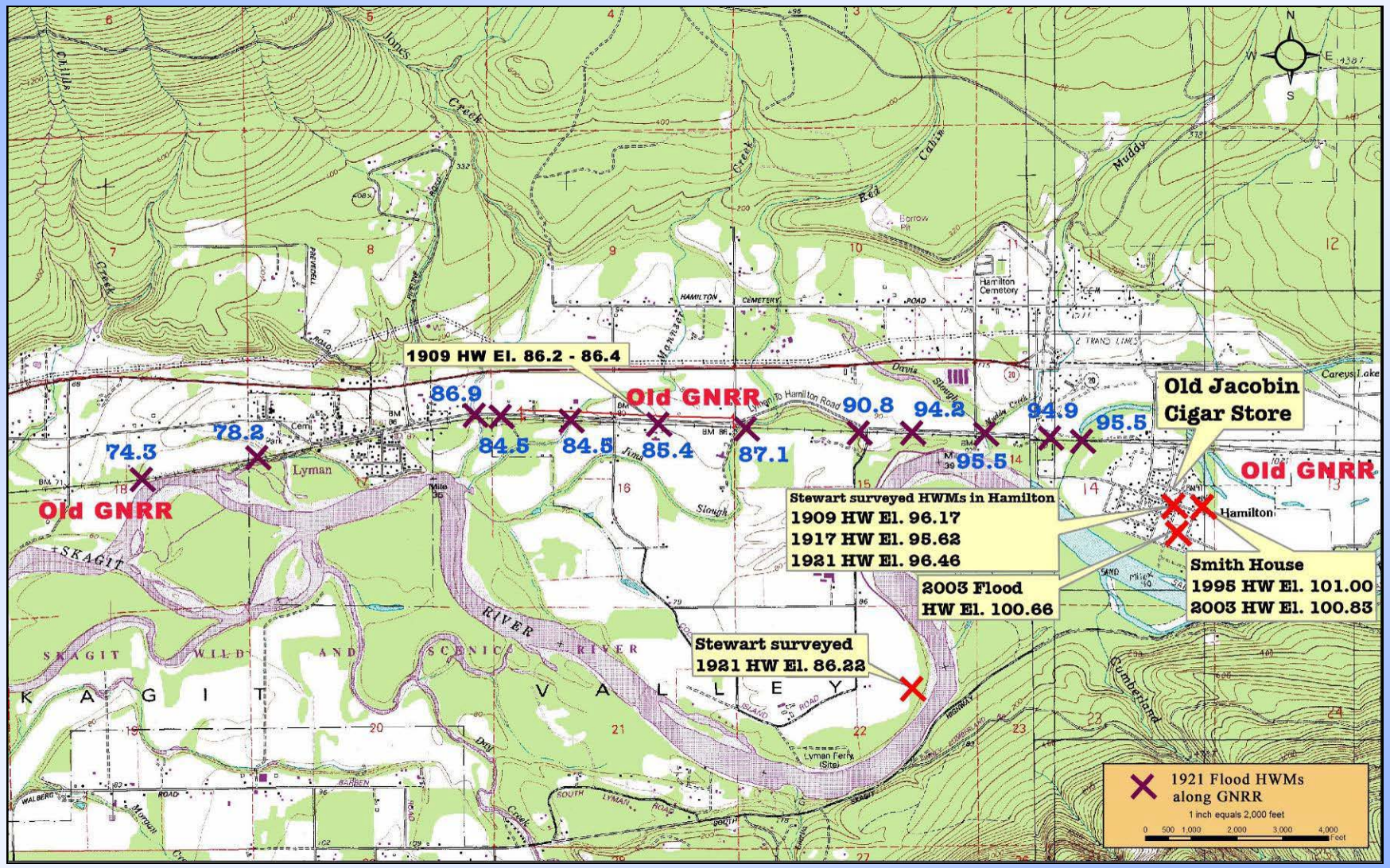
96.46
80.11
16.35 = 1921 HW above 11/27/22 stage

96.89
16.78
80.11 Elev of WS Nov 27

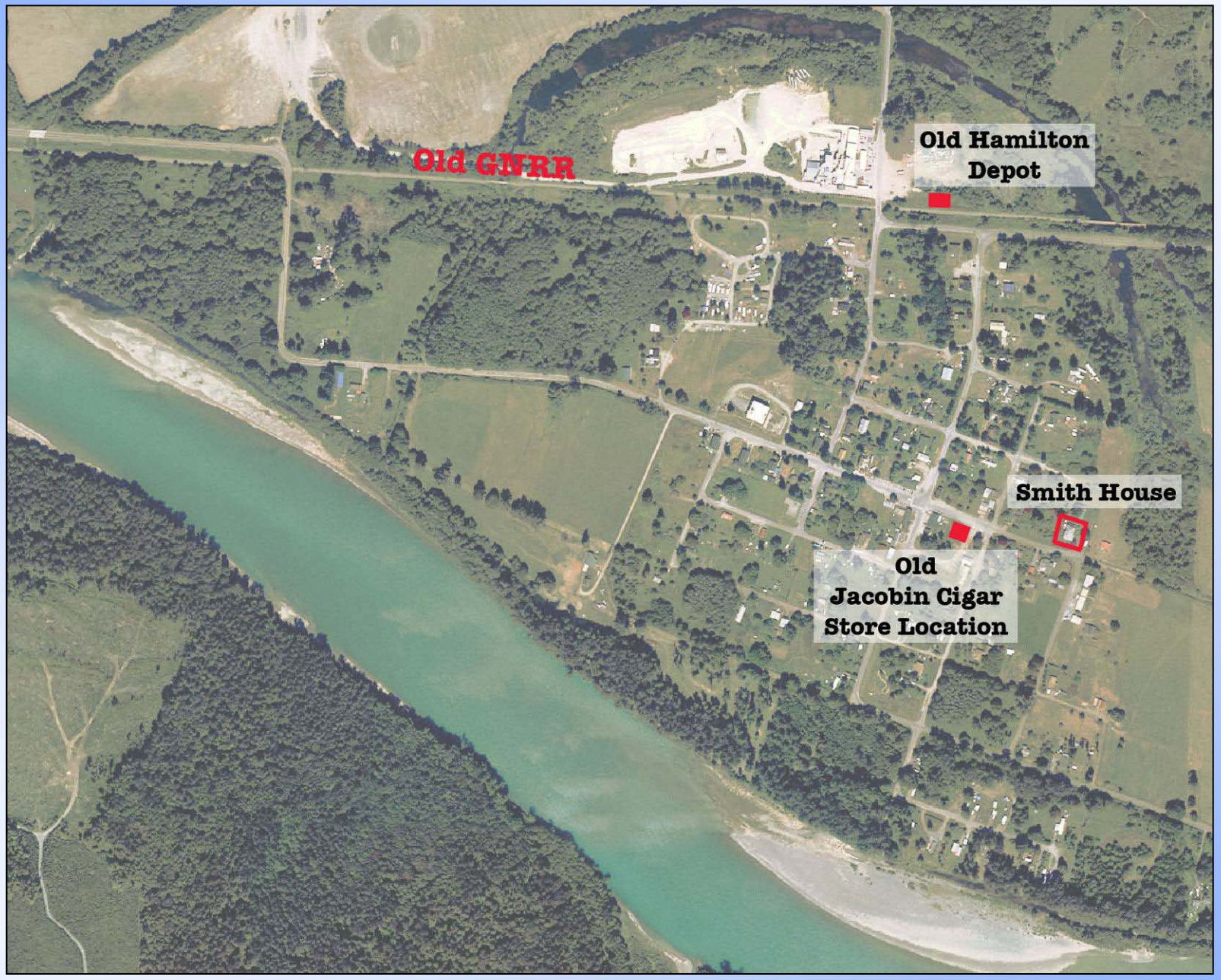
Magnus Miller says 1897 flood came to door knob of James Smiths drug store (door later note drug store raised since then)

Hine across from Hamilton may have 1897 mark

Historical Flood Marks in Lyman-Hamilton Area



Aerial Photo of Hamilton Area



2003 Flood in Hamilton

Photo showing WS El. 98-100, 145,000 cfs

Flood Peak WS El. 99-101, 165,000 cfs at 9:30 am

(photo taken by Skagit County on Oct. 21, 2003, 2:20 pm)

2003 Flood in Hamilton

Photo showing WS El. 98-100, 145,000 cfs

Flood Peak WS El. 99-101, 165,000 cfs at 9:30 am

(photo taken by Skagit County on Oct. 21, 2003, 2:40 pm)

“Smith” House, built in 1908, Hamilton WA

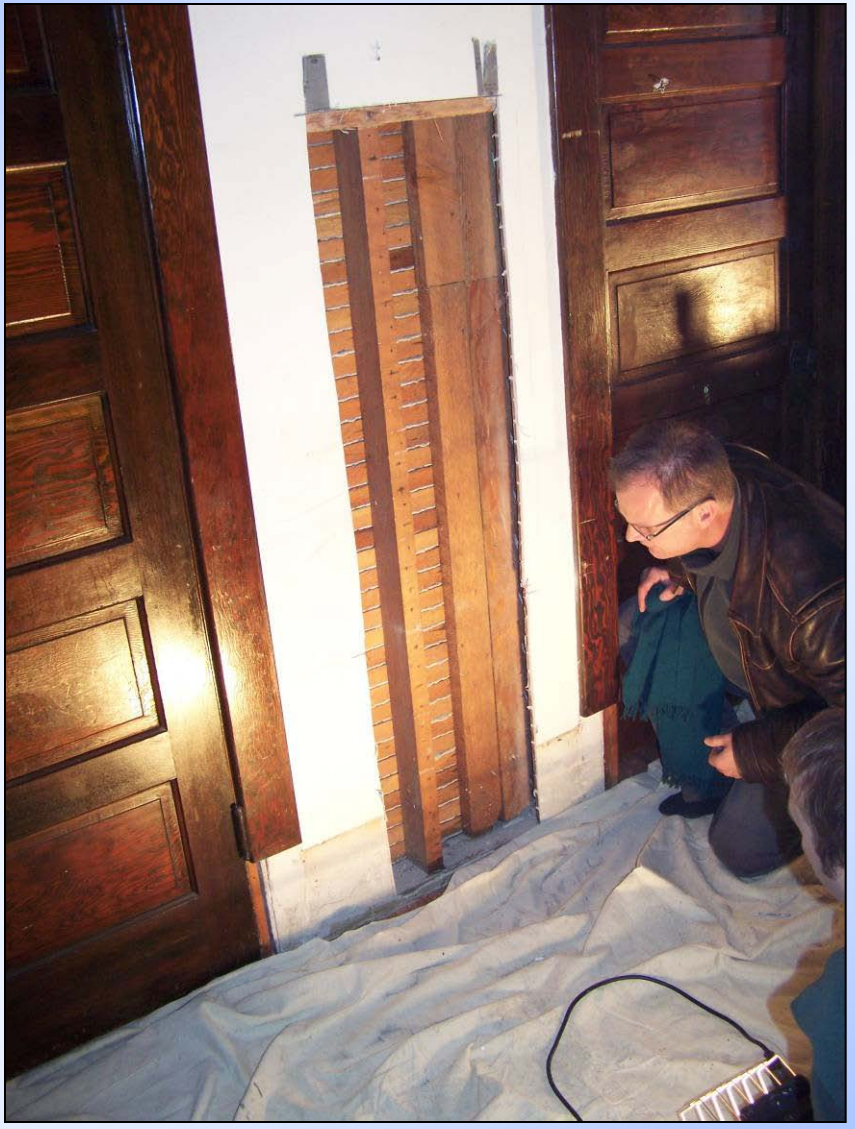
Smith House in Hamilton during Oct. 21, 2003 Flood

Photo showing WS El. 100, 145,000 cfs (2:40 pm)

Flood peak WS El. 101, 165,000 cfs (9:30 am)

Smith House in Hamilton, undated photograph of the 1909, 1917, or 1921 flood event (Hamilton Museum archives)

Smith House, built in 1908, Hamilton WA



“Smith” House, built in 1908, Hamilton WA

Hamilton Flood Elevations
Then and Now

Year	Water Level in Hamilton, A. J. Jacobin Cigar Store And Smith House
1897	(no data)
1909	96.17
1917	95.62
1921	96.46
1995	101.00
2003	100.83

Hamilton Results

- Max historical flood discharge since 1908 at the Smith House was no more than 188,000 cfs

- Historical flood discharges for the 1909, 1917, and 1921 events based on Stewart's HWMs at Jacobin Cigar Store appear much less than 188,000 cfs

At Concrete

- Extension of hydraulic model and comparison to Stewart-surveyed high water marks (based on citizen interview)

- Forensic investigation of houses built prior to 1921 to determine if they had previously been flooded

22/ Levels at Concrete

BS	HI	FS	Elev	
.40	230.91		230.51	BM USGS
			225.57	
		5.34	214.33	
1.31	215.64			
		3.30	207.34	
7.45	214.79			
		0.47	214.32	
2.96	217.28			
		12.82	204.46	
1.92	206.38			
		12.73	193.65	
0.91	194.56			
		12.33	182.23	
4.40	186.63			
		2.08	184.55	

Dec 21 1922

	BS	HI	FS	Elev	
	10.5	20.5		10.00	1897 flood crest on stump at old bridge site Est by Mr. Miller. HW was 3½ below top of stump
TP			11.2 rod 4.6 top 15.8	4.7	
	4.7	9.4			
			3.0	6.4	1921 HW

These are relative figures only for at stump and Washington Cement Plant. The [illegible] are a comparison of stump and [illegible] during [illegible]

23/ Nov 28

See pages 18 and 30 also

Measured down 11.24' from this point on freightcar to rail below (about 300 ft below depot)

Ground surface 4.9 ft below line of sight at this point. Near pt. of zero flow for old channel. Call low pt Elev 210 ft

1921 flood mark at Wolfs Residence

(McDaniels near Washington Cement plant can give 1909 flood)

Leonard Everett says 1897 flood about 9" lower than 1909, says that log jam in Dalles raised water 10 ft in 2 hrs. He says 1897 flood about highest midnight
1909 highest after midnight possibly 12:30
1921 highest about 1 am
considerable distance and some slope between 1897 and 1909 marks. Est max at 0.2 ft [illegible] 1897 1 ft higher than 1909 and 3.4 ft higher than 1921

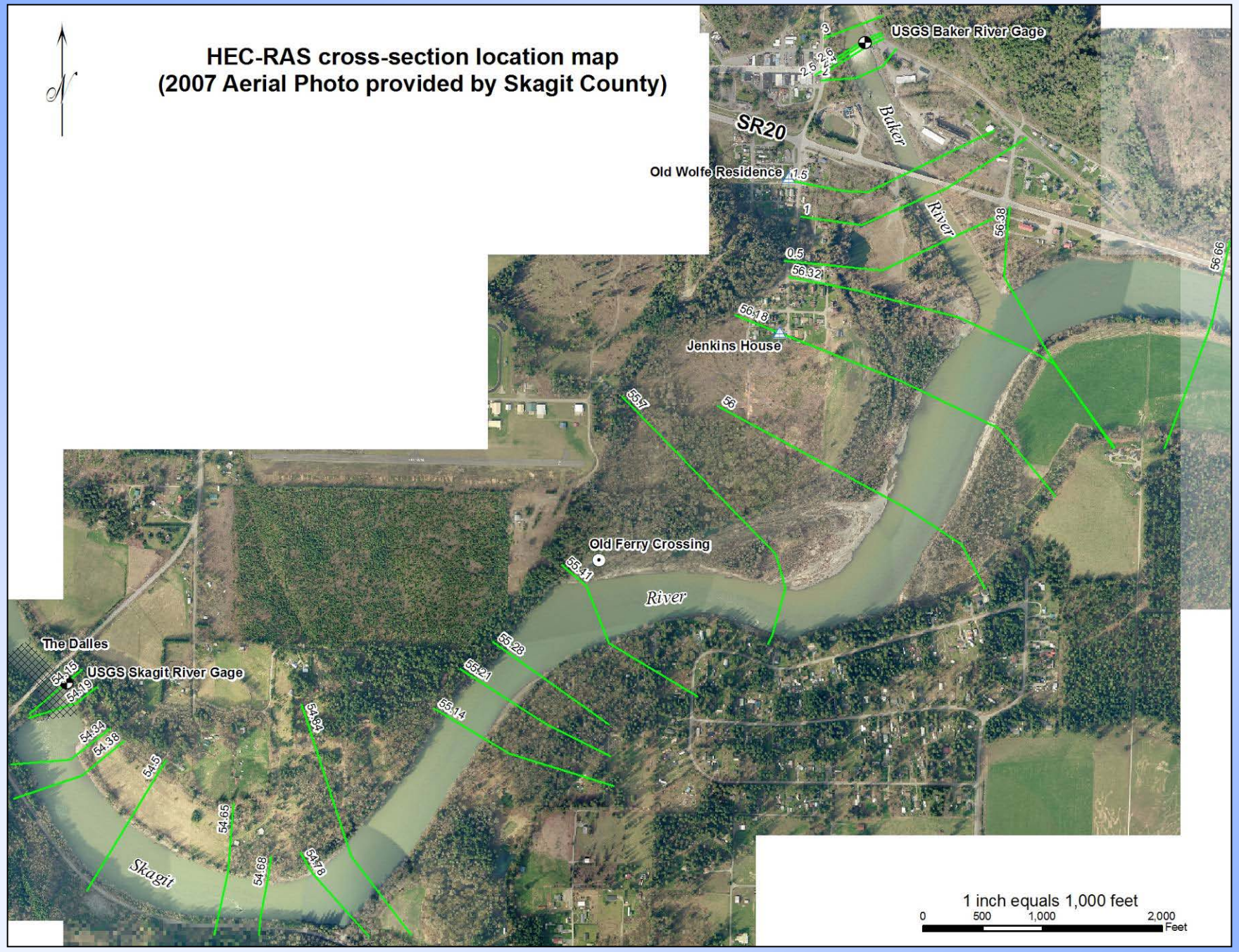
1897	10.00
1909	8.4
1921	6.4

Found line of 1909 HW 2.0' above 1921 at Washington Cement plant machine shop today

He is wrong probably see bottom of page 17 [illegible]

See bottom of page 13 [illegible]

P70645
P70866
Old Wolfe Residence
Crofoot
PARCELS OWNED
BY L.E. WOLFE
1921
Sources
1) 1921 Real Property Tax Roll And Assessment, State Archives, Bellingham
2) Skagit County on-line Assessor Database
3) Assessor Parcel Map Section 11 Township 35 Range 08
Research conducted by Josef Kunzler and Carl Martin
30 Mar 08
P70617
P70771
Off Map
P70613


HEC-RAS cross-section location map
(2007 Aerial Photo provided by Skagit County)
USGS Baker River Gage
SR20
Baker
River
Old Wolfe Residence
Jenkins House
Old Ferry Crossing
River
The Dalles
USGS Skagit River Gage
Skagit
3
2.5
2.6
2.4
2
1.5
1
0.5
56.38
56.66
56.32
56.18
55.7
56
55.41
55.28
55.21
55.14
54.84
54.15
54.19
54.34
54.38
54.5
54.65
54.68
54.78
1 inch equals 1,000 feet
0
500
1,000
2,000
Feet

October 2003 Flood

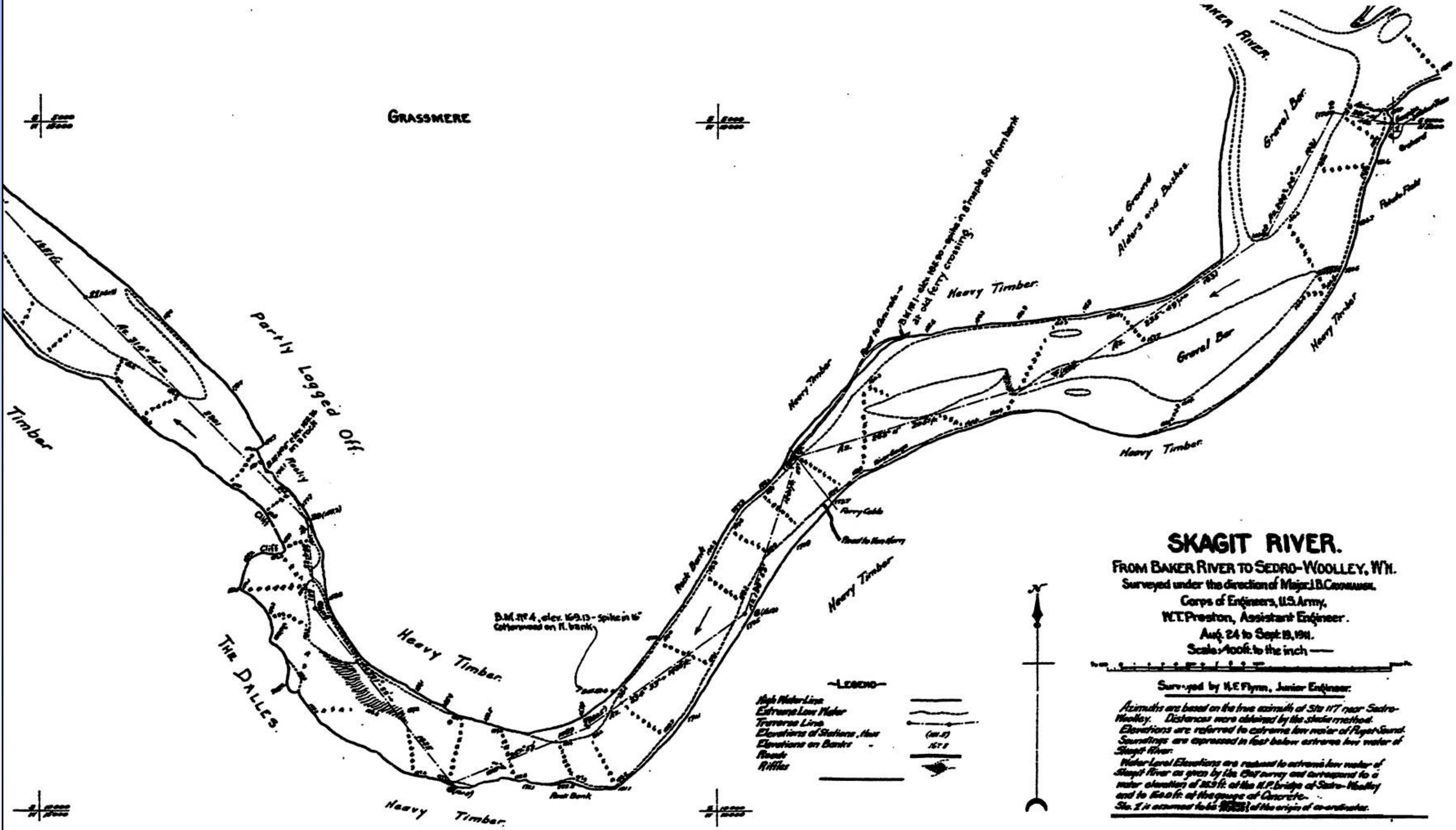
Comparison of Modeled and Observed 2003 Flood Elevations (NGVD-29)

Date of Flood	Time	Skagit River Flow* (cfs)	Baker River Flow** (cfs)	High Water Mark Location	Source of Data	Observed (ft)	Modeled (ft)	Difference (ft) btw. Modeled and observed flood elev.
21-Oct-03	6:15 AM	165,655	4,647	Baker River gage	USGS gage record	183.49	183.70	0.21
21-Oct-03	6:30 AM	164,169	4,655	Baker River gage	USGS gage record	183.48	183.50	0.02
21-Oct-03	7:15 AM	162,602	4,710	Baker River gage	USGS gage record	183.32	183.29	-0.03
21-Oct-03	7:30 AM	162,342	4,747	Baker River gage	USGS gage record	183.22	183.25	0.03
21-Oct-03	9:30 AM	150,956	4,822	Baker River gage	USGS gage record	181.77	181.70	-0.07
21-Oct-03	9:45 AM	151,538	4,822	Baker River gage	USGS gage record	181.54	181.78	0.24
21-Oct-03	6:15 AM	165,655	4,647	Jenkins House	Resident provided photo	182.75	182.78	0.03
21-Oct-03	6:30 AM	164,169	4,655	Jenkins House	Resident provided photo	182.75	182.57	-0.18
21-Oct-03	9:30 AM	150,956	4,822	Jenkins House	Resident provided photo	181.15	180.74	-0.41
21-Oct-03	9:45 AM	151,538	4,822	Jenkins House	Resident provided photo	181.15	180.82	-0.33
21-Oct-03	6:15 AM	165,655	4,647	Old staff gage at the Dalles	USGS 2004 survey	173.30	173.39	0.09
21-Oct-03	6:30 AM	164,169	4,655	Old staff gage at the Dalles	USGS 2004 survey	173.30	173.21	-0.09

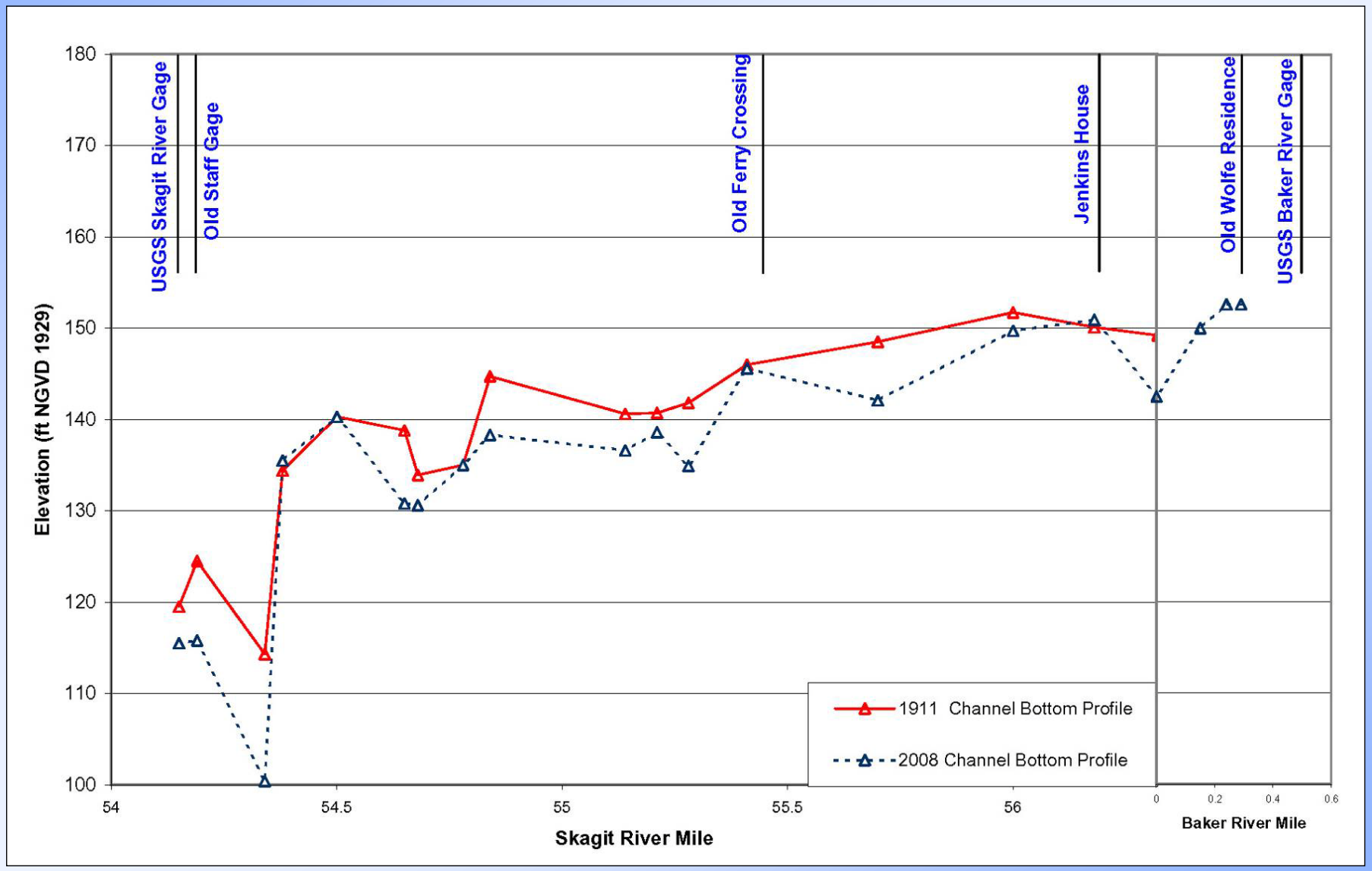
***USGS provided flow data (15-minute interval) at the Skagit River gage near Concrete**

****PSE provided hourly flow data (interpolated for 15-minute interval) below Lower Baker Dam and powerhouse**

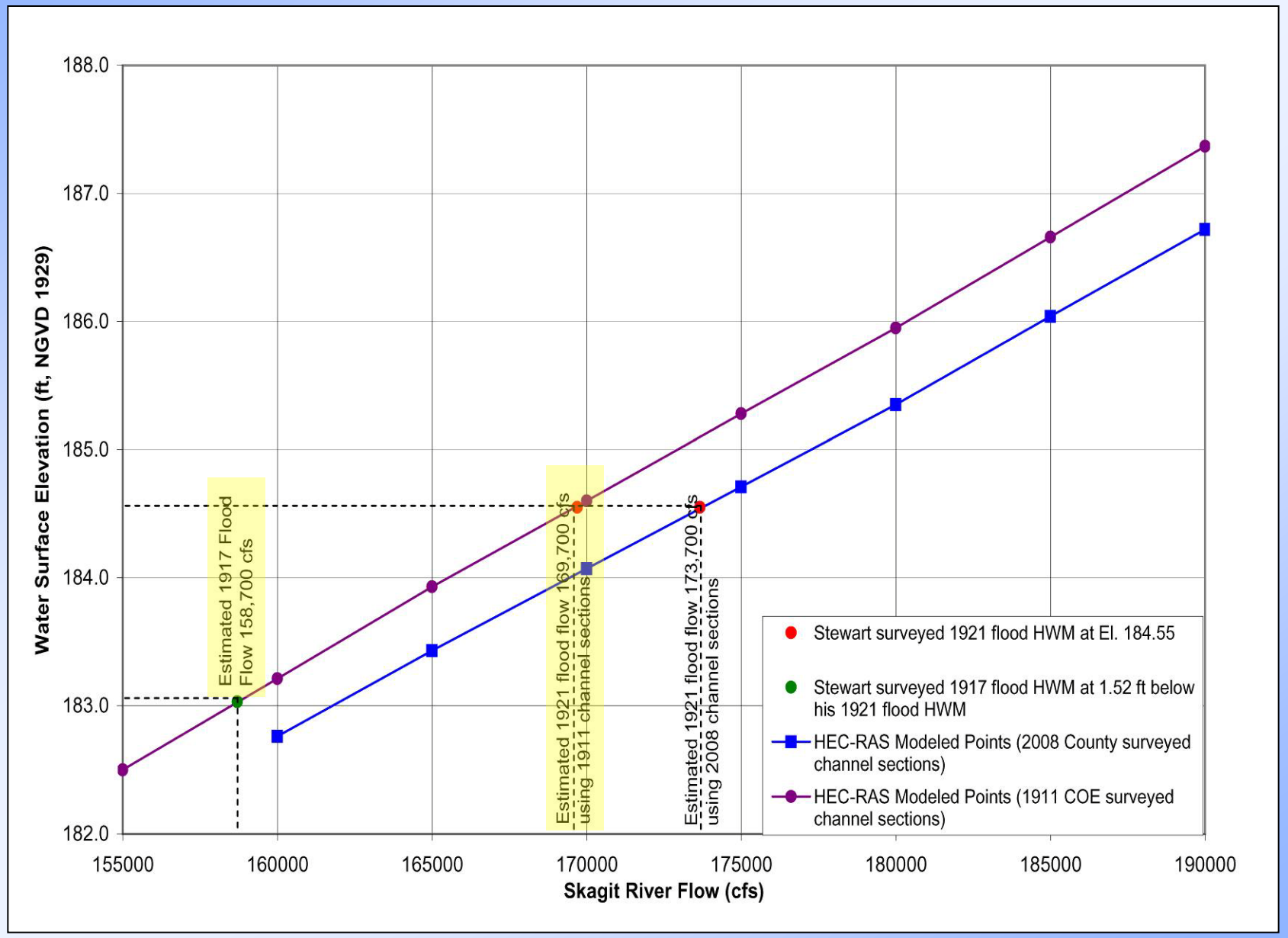
1911 Corps Survey Map



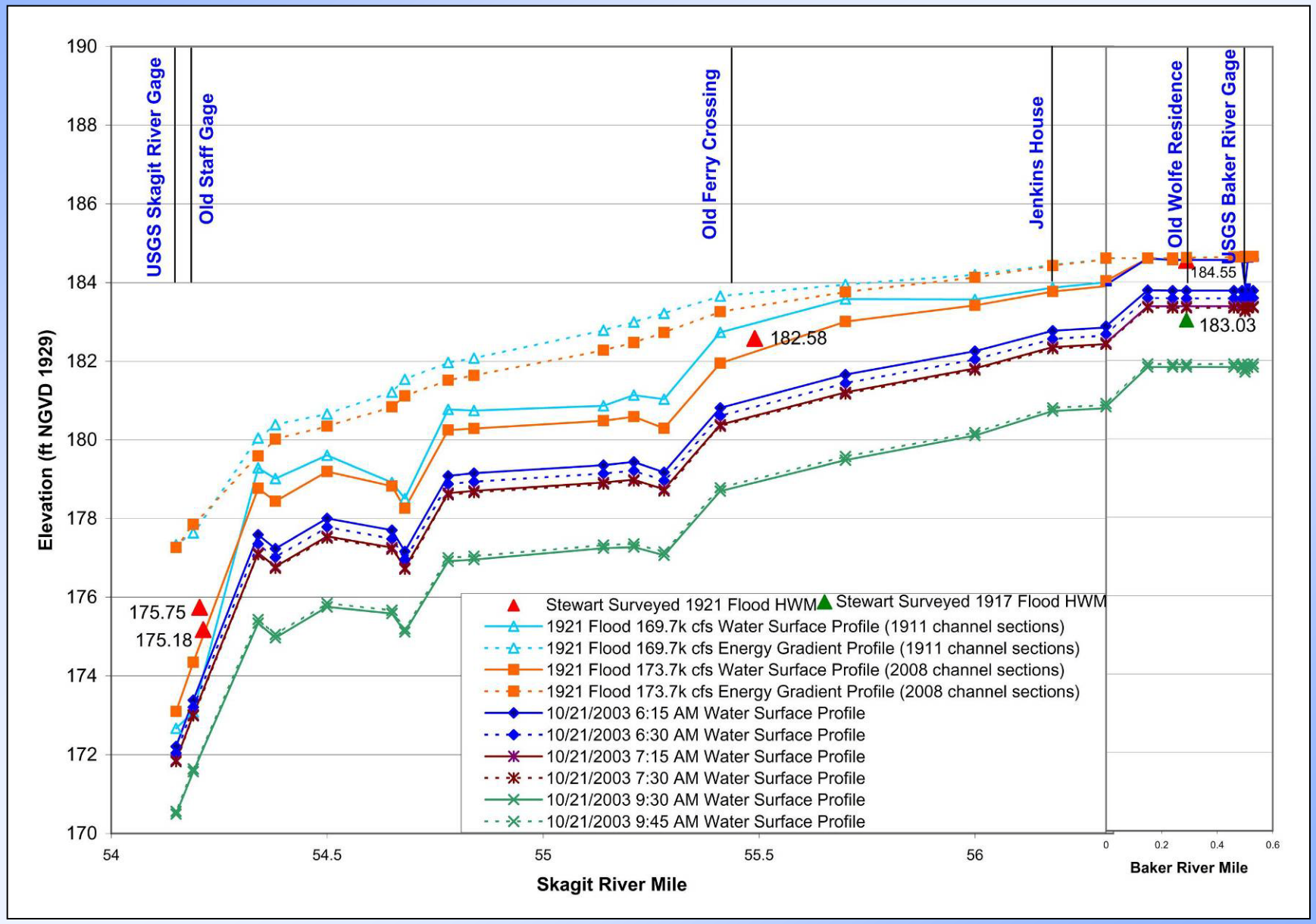
Comparison of 1911 and 2008 Surveyed Skagit River Channel Bottom Profiles in Concrete Reach



Flood Stage-Discharge Curve at Wolfe Residence in Concrete



HEC-RAS Modeled Flood Profiles in Concrete Reach of the Skagit and Baker Rivers



Stewart's Surveyed 1921 High Water Marks in the Dalles

Stewart's surveyed 1921 HW elevations (El.) and elevation differences (h) (quoted from Stewart's survey notes and Exhibit B of his unpublished 1923 report):

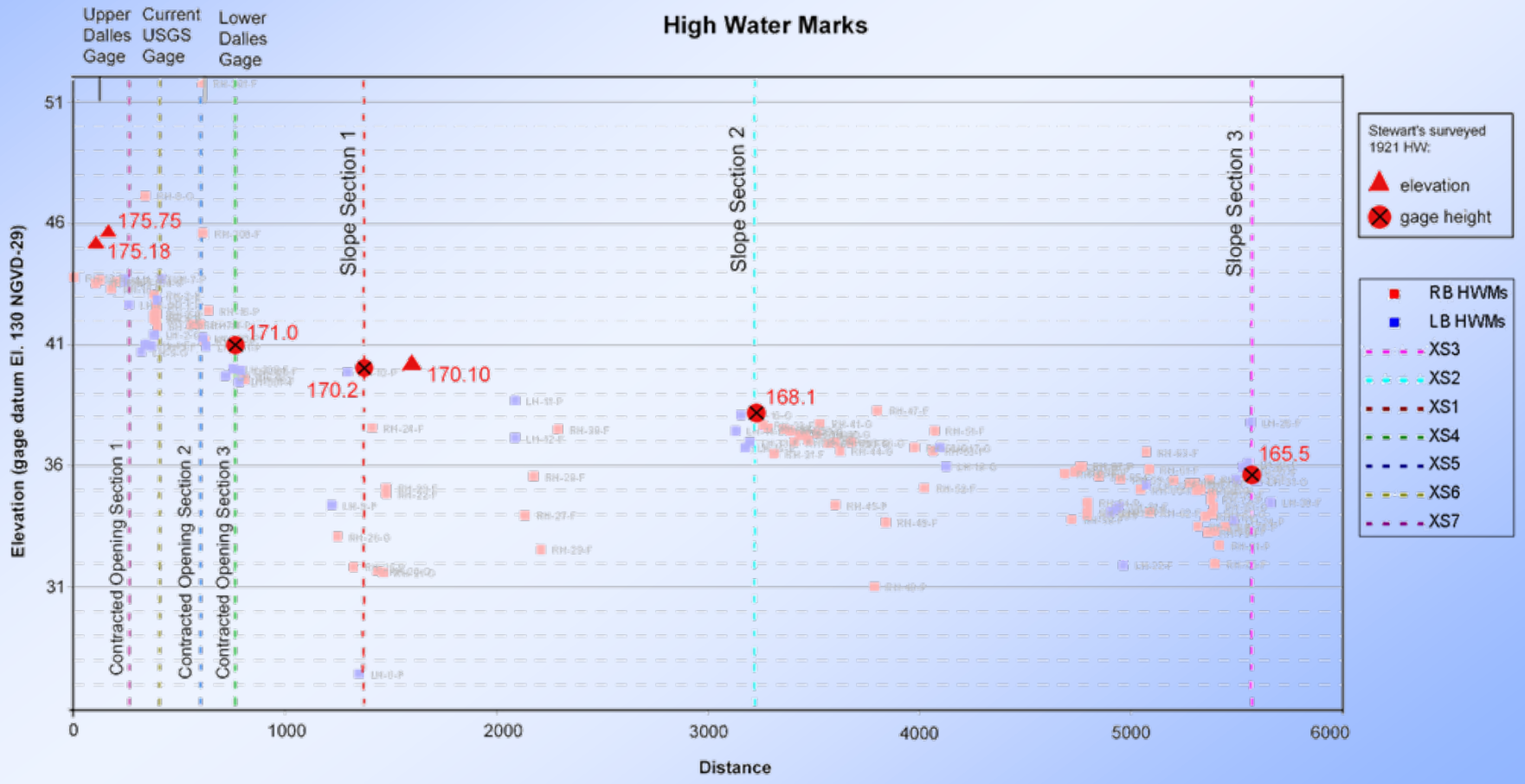
- El. 175.75 and El. 175.18 at the upper Dalles gage (notes, pp. 86-87, gage heights added to gage datum El. 140.89)
- El. 170.10 at 865 ft below the lower Dalles gage (notes, pp. 64-65)
- h = 4.2 ft for the 560 ft distance between his "contracted opening" section 1 (100 ft below the upper Dales gage) and section 3 (the lower Dalles gage) (p. 14, Exhibit B)
- h = 2.11 ft between his "slope" section 1 (618 ft below the lower Dalles gage) and section 2 (2,479 ft below the lower Dalles gage) (p. 2 & p. 9, Exhibit B)
- h = 2.62 ft between his "slope" section 2 and section 3 (4,655 ft below the lower Dalles gage) (p. 2 & p. 10, Exhibit B)
- h = 4.73 ft between his "slope" section 1 and section 3 (p. 11, Exhibit B)

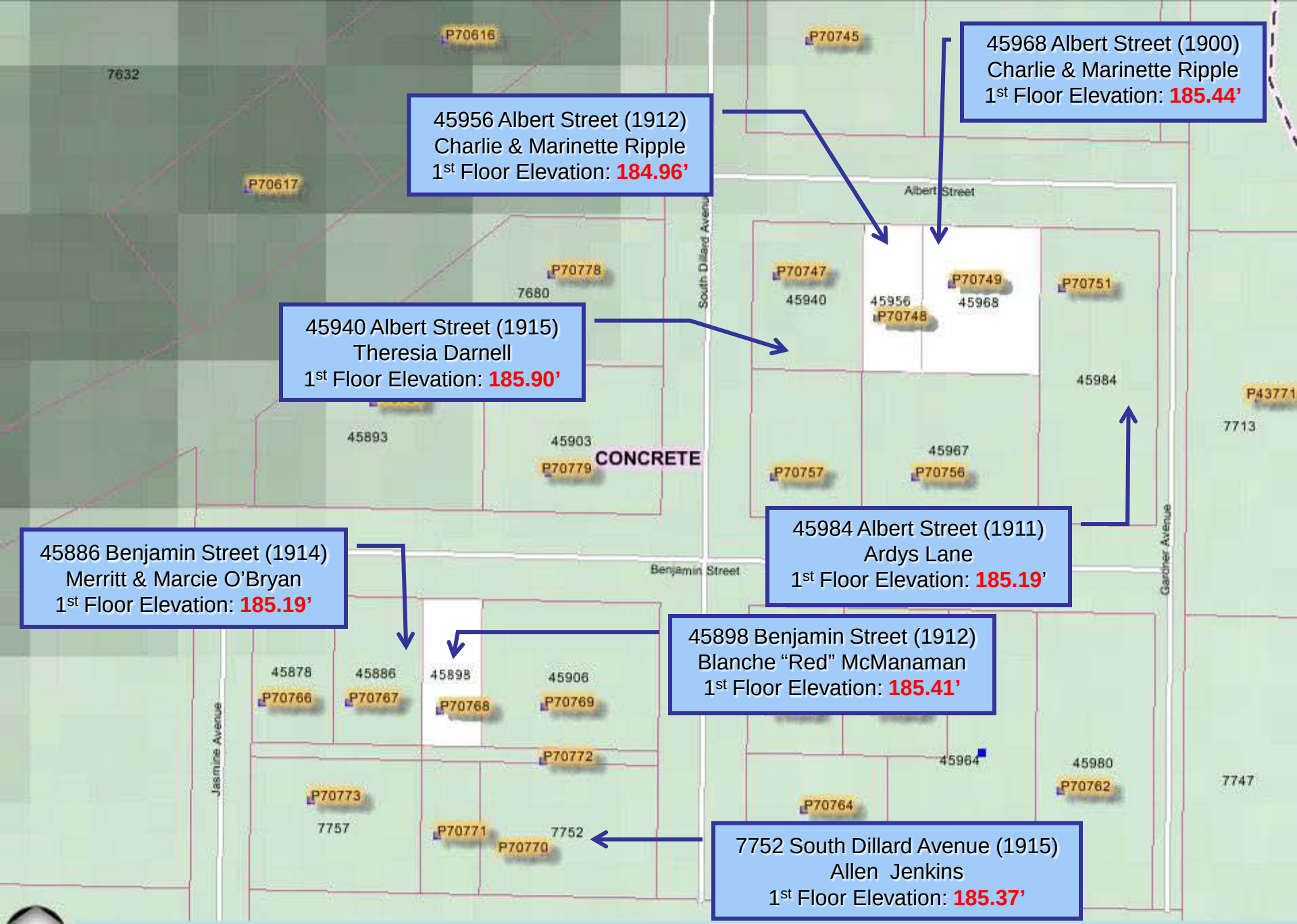
Based on these Stewart's numbers, the following 1921 HW elevations were estimated:

- El. 171.0 at the lower Dalles gage
- El. 170.2 at the "slope" section 1
- El. 168.1 at the "slope" section 2
- El. 165.5 at the "slope" section 3

1921 and 2003 Flood High Water Marks

Surveyed by Stewart (in 1922-23) and USGS (in summer 2004)





Crofoot Parcels and First Floor Elevations (2008 surveyed by County)

Ripple House #1, parcel #70749

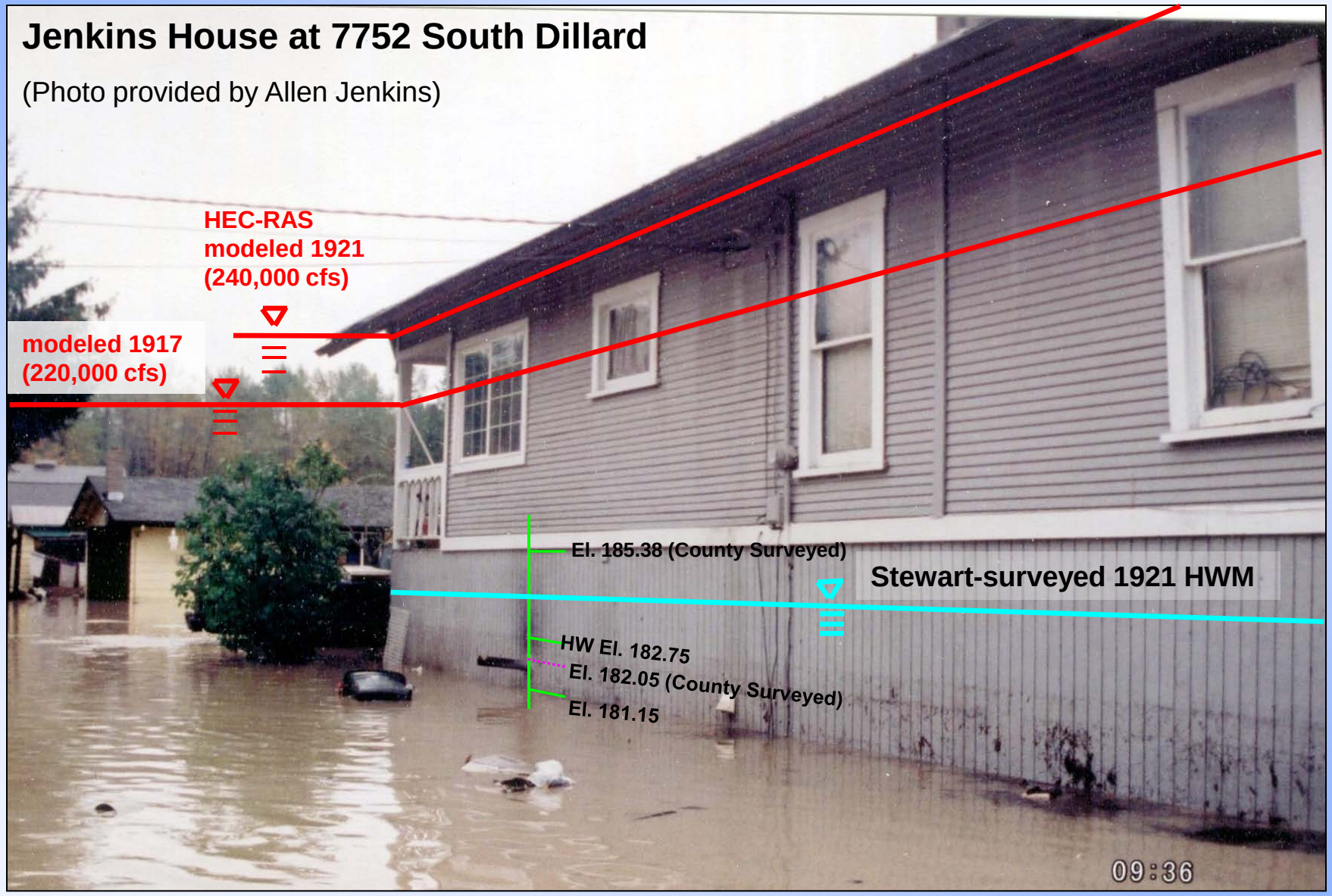
Ripple House #1,
45968 Albert Street,
Crofoot Addition, Concrete

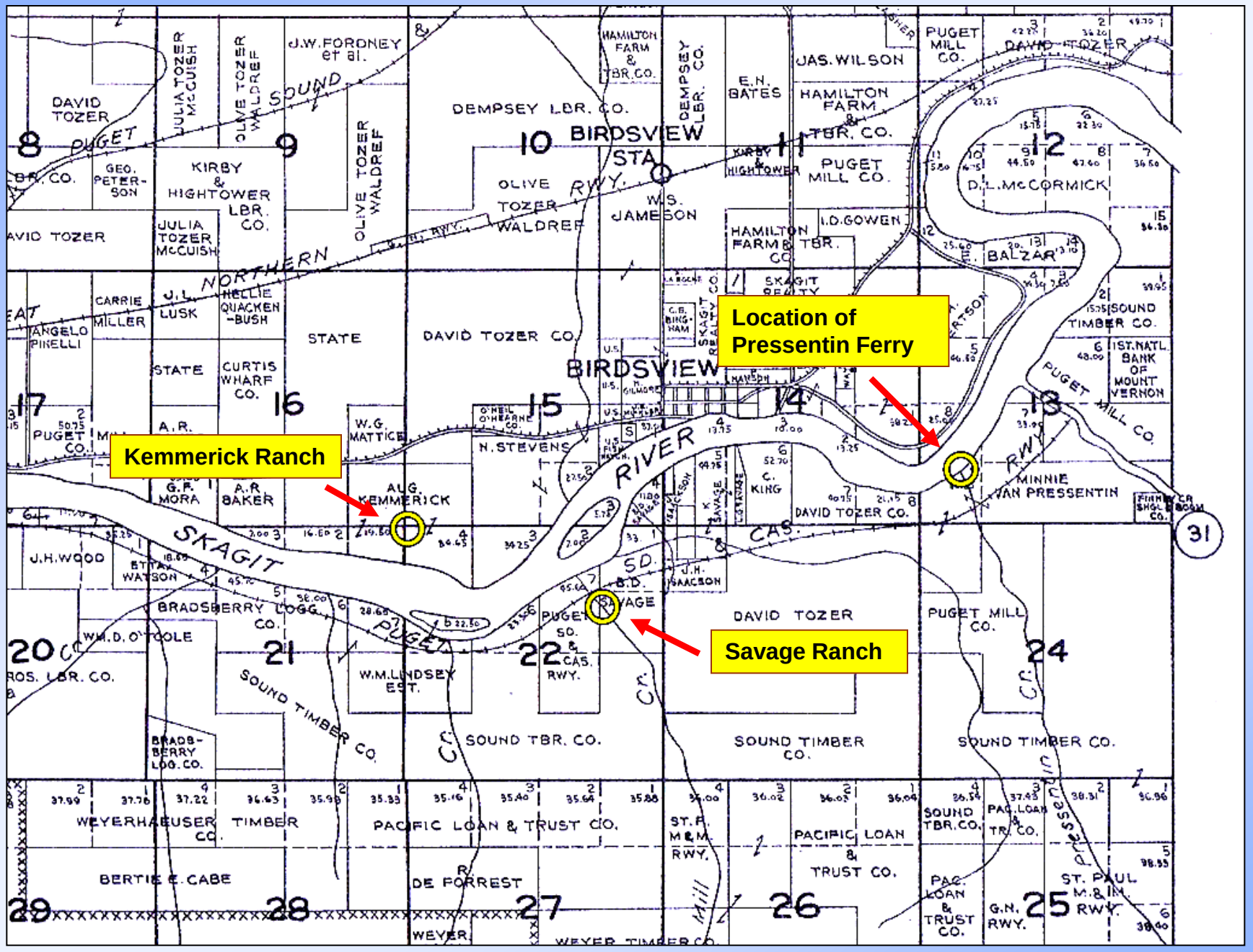
Ripple House #1 with exterior siding removed for inspection of interior wall cavity.
First floor elevation 185.51

Ripple House #2, parcel #P70748

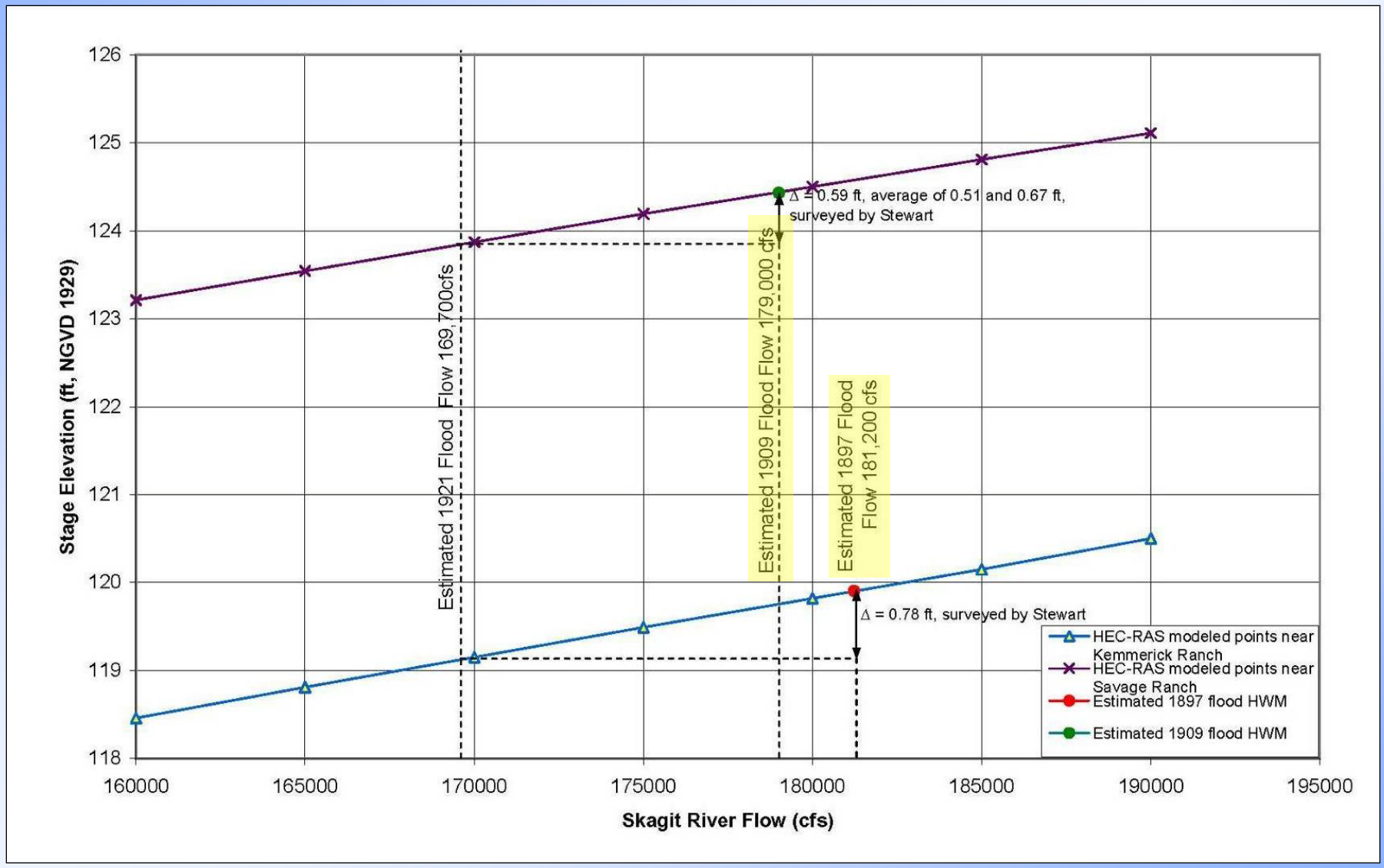
First Floor Elevation 184.96. Annotated photo showing exterior siding removed for inspection of interior wall cavity

October 2003 Flood




Location of Pressentin Ferry
Kemmerick Ranch
Savage Ranch
SKAGIT RIVER
PUGET SOUND
NORTHERN
BIRDSVIEW
DEMPSEY LBR. CO.
DAVID TOZER CO.
PUGET MILL CO.
SOUND TIMBER CO.
SOUND TBR. CO.
PACIFIC LOAN & TRUST CO.
WEYERHAEUSER TIMBER CO.
BERTIE E. CABE
DE FORREST
AUG. KEMMERICK
MINNIE VAN PRESSENTIN
J.W. FORONEY et al.
JAS. WILSON
HAMILTON FARM & TBR. CO.
D.L. McCORMICK
W.S. JAMESON
I.D. GOWEN
BALZAR
W.G. MATTICE
N. STEVENS
C. KING
J.H. WOOD
WM. D. O'TOOLE
W.M. LINDSEY EST.
BRADSBERRY LOG. CO.
1ST. NATL. BANK OF MOUNT VERNON
SOUND TIMBER CO.
ST. P. M. & M. RWY.
G.N. RWY.
ST. PAUL M. & M. RWY.
31

Flood Stage-Discharge Curves at Kemmerick and Savage Ranches near Birdsview

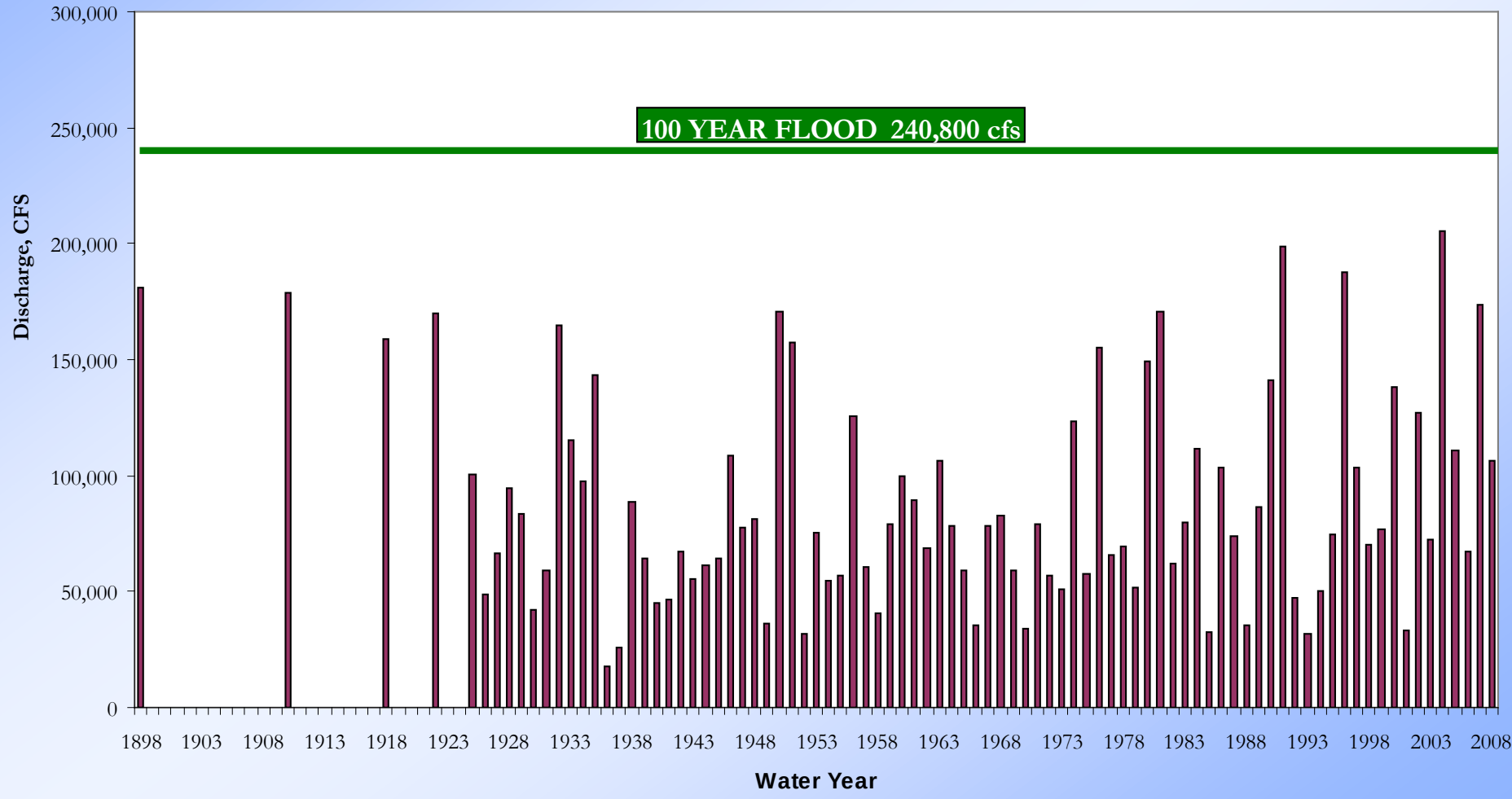


Estimated Peak Discharges of Skagit River near Concrete for Four Historical Floods (Drainage Area = 2,700 sq. mi.)

Flood	Discharge Estimated by Stewart in 1923 (cfs)	Discharge Revised by USGS in 2007 (cfs)	Discharge Modeled by PIE in 2008 (cfs)
1897	275,000	265,000	181,200
1909	260,000	245,000	179,000
1917	220,000	210,000	158,700
1921	240,000	228,000	169,700

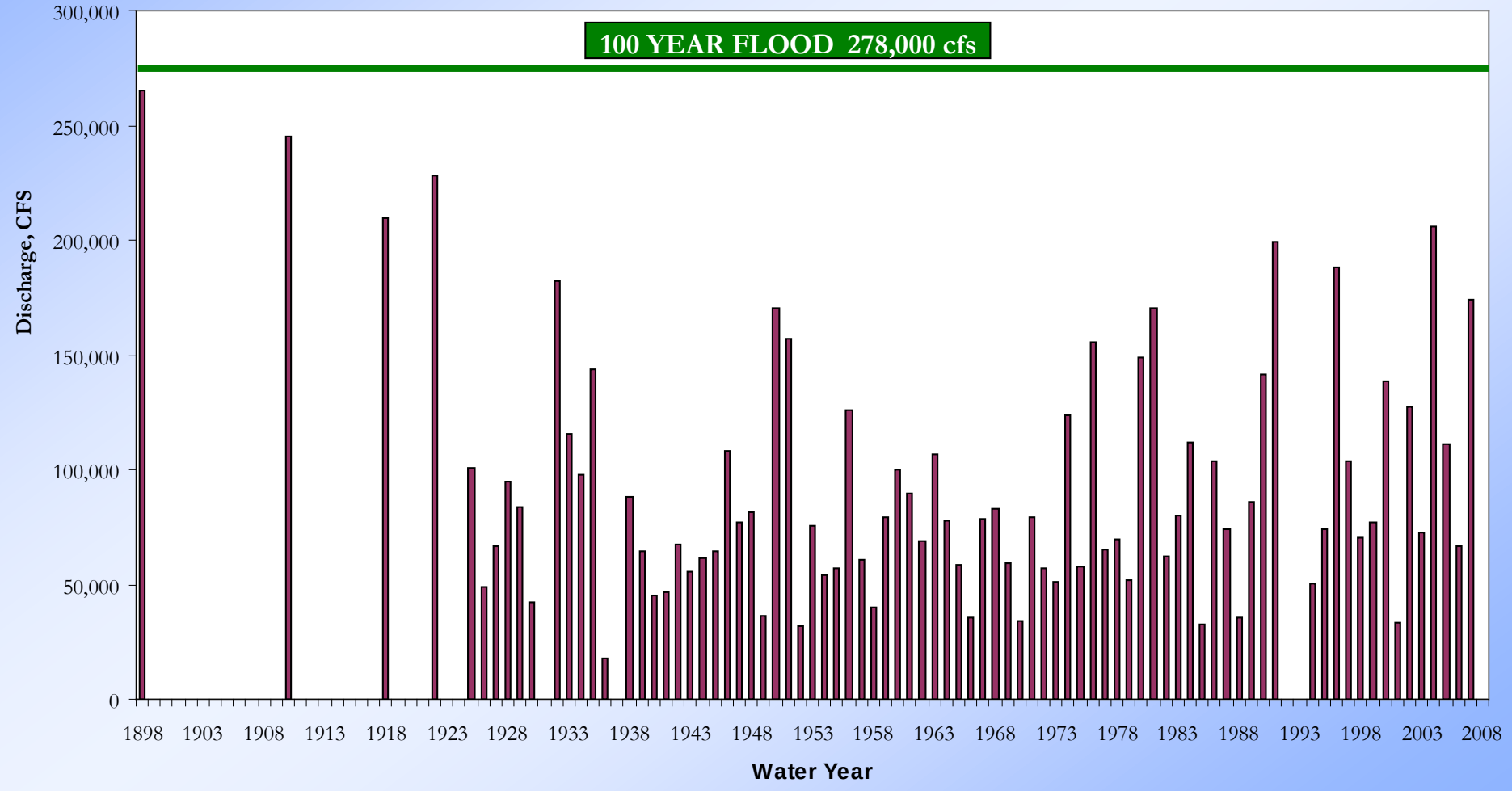
SKAGIT RIVER WINTER UNREGULATED ANNUAL PEAK DISCHARGES (PIE)

Water Year 1898 to 2008 - USGS Gage near Concrete, WA

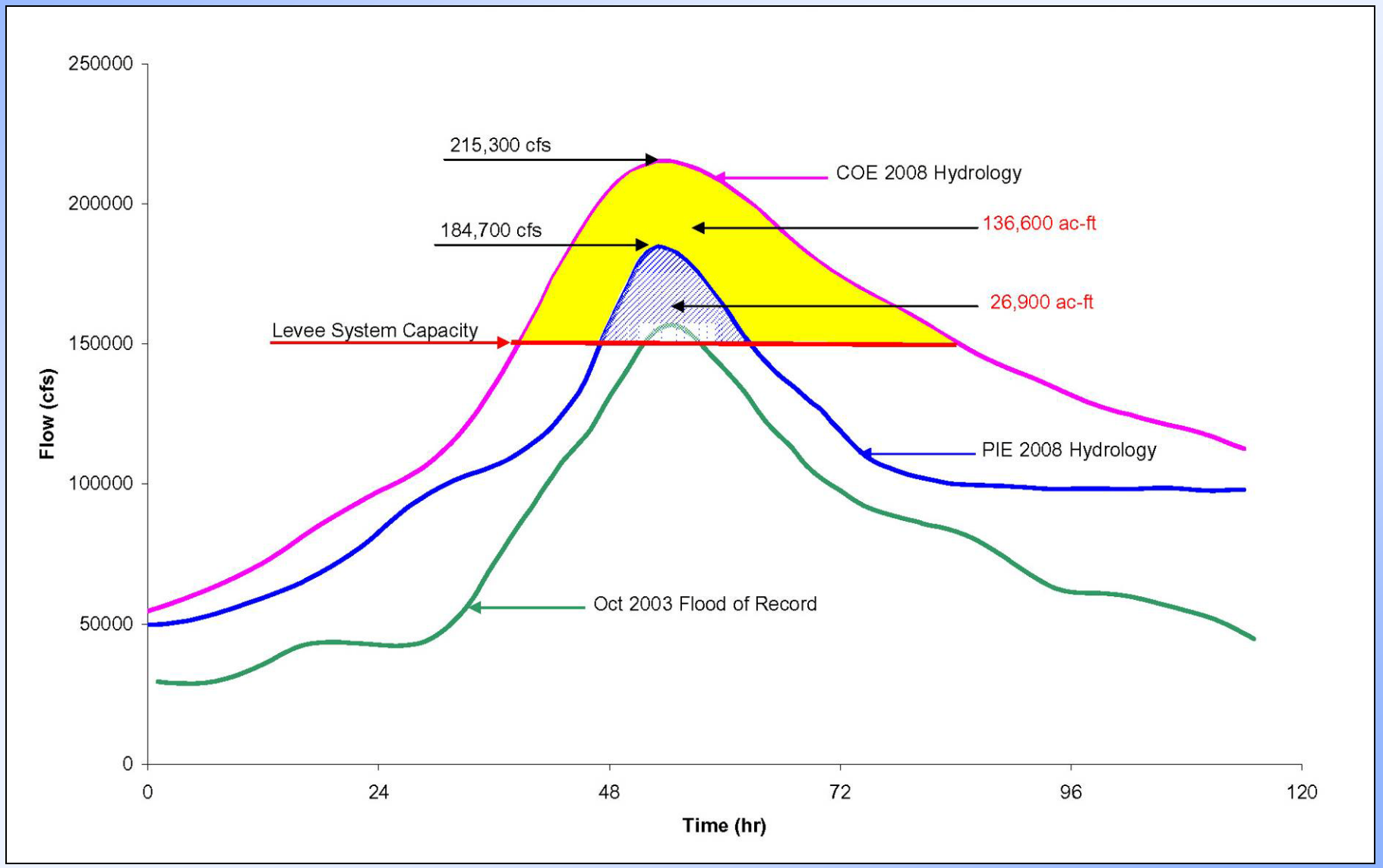


SKAGIT RIVER WINTER UNREGULATED ANNUAL PEAK DISCHARGES (COE)

Water Year 1898 to 2008 - USGS Gage near Concrete, WA



FEMA 100-Year Flood Hydrographs at Sedro Woolley (with existing flood storage)



Questions?