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March 29, 2011

Chal A. Martin, PE
Public Works Director
City of Burlington
833 South Spruce Street
Burlington, WA 98233

RE: Professional Opinion of Methodology and Results of Upper Dalles Gauge Calibration Survey Performed by James E. Stewart (1922-1923)

Dear Mr. Martin,

At your request, I have reviewed the various documents and survey field note copies provided by the City of Burlington (List Attached) with regard to the vertical datum used by James Stewart, US Geological Survey (USGS) Hydrologist, to calibrate the Upper Dalles flood gauge along the Skagit River near Concrete, Washington from November 1922 through March 1923. During his survey, Mr. Stewart documented High Water Marks (HWM) from the December 1921 flood, established a water level gauge and performed cross sections of the Skagit River.

As the basis for his work in this vicinity, Mr. Stewart used USGS Benchmark 231 T.U.L., from "Spirit Leveling in the State of Washington 1896 to 1917, Inclusive", page 78, with a published elevation of 230.506 feet. In Stewart's notes, pages 22 and 30, the survey crew began the level run from 231 T.U.L using a rounded elevation of 230.51 feet. Stewart makes no mention of this benchmark being disturbed or damaged in his notes (Stewart tends to document anomalies and disturbed benchmarks with impressive detail in his field notes). According to the Stewart field notes, two level runs were made to establish high water marks in this vicinity. Although both of these level runs were open ended, they checked within 0.02 feet at the 1921 Flood Mark at the "Wolf Residence" (elevation being 184.55 and

184.53, respectively). Although not technically a closed loop, I would consider this methodology to be procedurally equivalent, as the Stewart survey crew ran open level lines two times to the same points even though they were completed nearly a month apart. The adjusted elevation for the Wolf Residence 1921 Flood Mark would be 184.54 feet.

The level run that began on page 30 of the survey notes continues on page 32, establishing the water level gauge elevation of the lower gauge board at 171.02 feet. One turn before the end of the level line, Stewart took a "side shot" reading onto a Benchmark (BM) described as "Top of 60 penny bent spike...". It can be assumed from the notes that this BM apparently existed from previous survey work based upon the description on page 33, which reads, "BM is marked 187.24'. This was from unchecked level notes. True figure is 188.22." Without the supporting documentation of how the original elevations were established, simple subtraction creates a potential elevation difference at the upper gauge of 0.98 feet. It is unknown what, if anything, this benchmark may have been used for prior to or subsequent to Stewarts 1923 survey.

I also reviewed the response letter by USGS dated May 6, 2010, which provides a limited background into the apparent decision to discount Stewart's original survey work in this area. Per this letter, it appears that the USGS established a "1.8 feet higher datum" as the basis for their hydraulic analysis. From the USGS field notes, it can be concluded that the horizontal position of the "Original" gauge station and the "New" gauge Station are in different places- the "Original" Station was further upstream. At the establishment of the new gauge, in subsequent USGS Discharge Measurement Field Notes, the field crew observed very consistent gauge to top-of-water readings (see page 5 of 13, September 16, 1924). These notes indicate that the gauge is working correctly and is in harmony with the water elevations at the time of the survey, but do not indicate that the survey crew leveled to any original Stewart Benchmarks or Gauges. Stewart did level between the Lower Dalles and the Upper Dalles gauges (reference pages 84-87, January 27, 1922 field notes). This level line was only run in one direction. Without any additional supporting field notes or documentation from USGS, it cannot be concluded that there is a direct connection between the Stewart data and subsequent USGS survey data in this vicinity. The "1.8 foot" vertical difference conclusion therefore appears to be speculative and inconclusive.

It is our understanding that the most recent USGS sponsored hydraulic analysis and flood prediction mapping may have used elevation information for the 1921 flood from Stewart's survey. It is also our understanding that the USGS may have disqualified Stewart's datum in favor of more recent and different elevation monuments or data. It is our determination that the two related yet not equal datum planes are not interchangeable, and that any downstream predictions resulting from the use of both of these cannot, as a result, be deemed reliable.

In conclusion, based on a full review of the information provided to me by the City of Burlington for this analysis, and without additional field notes or records from USGS regarding these early surveys, I find no reason to disagree with Stewart's 1923 HWM elevation at the Wolf Residence as 184.54' (1917 USGS datum). Without supporting documentation to the contrary, there is a strong likelihood that the disqualification of the basis for Stewart's 1923 work could cause discrepancy in the mathematics behind the flood analysis used to prepare the most recent FIRM map(s) in this region. The differences between the "Original" gauge elevation and the "New" gauge elevation alone provide enough uncertainty to warrant a new or modified analysis and certainly disclose apparent weaknesses and gaps in the processes, methodologies, and results of the flood predictions in the Skagit River basin.

Sincerely,

Pacific Surveying and Engineering

Peter K. Brands, PLS, CFedS

Principal

Enclosures

DOCUMENTS SUPPLIED BY THE CITY OF BURLINGTON

1. Stewart's Field Notes, 1922-23, pp. 0-147

2. Station Gage Notes, September 1924, pp. 1-13

3. Station Gage Notes, February 15, 1926 by D.J.F. Calkins (2 pages, stamped "12-1940" on top right corner)

4. Level Notes, Skagit River at the Dalles Near Concrete, April 6, 1932, pp. 1-6

5. Station Analysis, 1927, Skagit River Near Concrete, annotated "910" in upper right corner

6. Station Description 1931, 1 page.

7. Station Description 1938, 2 pages.

8. USGS Bulletin 674, Spirit Leveling in the State of Washington 1896 – 1917 Inclusive, selected pages

9. USGS Letter dated May 6, 2010, re: "USGS responses to issues raised by the Technical Memorandum, "Review and reevaluation of Skagit River 1921 flood peak discharge"

10. USGS Letter dated November 5, 2008 re: response to datum issue

11. Meeting Notes, May 10, 2010 meeting between USGS Tacoma staff, Skagit County, Burlington, and County/City technical consultants re: Skagit Historic Floods

12. FEMA memo, February 26, 2010, revised May 19, 2010