Step by Step Development of Peak Flow Estimate on the American River @ Folsom for Record Flood: 1/10/1862

A. INTRODUCTION

In 2005, after Dr. Claude Curran and I had finished our book: " Lake Sacramento " Can It Happen Again?, we began to appreciate the enormity and extent of the December 1861- January 1862 flood series. When compared with the major floods of the 20th-century it became clear to us that it was in a class by itself. W.T. Ellis, longtime levee boss in Marysville, had this to say way back in 1920: " This flood is not generally taken into account in flood planning simply because to have done so, the expense would of been prohibitive."

During the summer of 2006, we decided if our results were going to be conclusive we needed to demonstrate numerically that the flood peaks of January 1862 were greater than any that occurred in the 20th century. We chose the American River because of its early history of flooding the city of Sacramento. Then it was decided that a peak flow estimate would be made for January 10, 1862 at Folsom--the recognized date of the all-time record high flow on the American River at Folsom (Fair Oaks).

Of course this is easier said than done because of the lack of adequate streamflow data for 19th century floods. The debris being washed into the rivers and streams by gold miners not only changed the depth of the flow at a given location, it also changed the cross-section of the river bed. Without river stage and river-bed cross-section information it makes a direct comparison of 19th century and 20th-century floods very difficult, if not impossible. So the search to find a credible method that could be used to estimate the magnitude of the record January 10, 1862 flow at Folsom became our number one priority.

Before tackling this problem we decided to see if we could find any previous peak flow estimates for January 10, 1862 on the American River at Folsom. Oregon State climatologist George Taylor suggested we contact Gary Estes (Coordinator of California's Annual Extreme Precipitation Symposium). Gary referred us to an engineer in the state of Washington who had done some work on flood problems in the Sacramento area. This gentleman stated that the information we were looking for would most likely be found in the National Research Council report: *Improving American River Flood Frequency Analyses* published by the National Academy Press, Washington D.C. 1999.

On page 37 of this report, Table 2.2-Maximum Peak Discharge on the American River at Fair Oaks (unregulated conditions) gives an 1862 Peak discharge of 265,000 CFS. This estimate was made by Bossen in 1941. *(affiliation- not given)*

On page 45 of this same report under the heading, Analysis of American River Data (second item)-estimated peak of the 1862 flood (265,000 CFS) assumed to be the largest instantaneous peak discharge since 1848.

On page 19 of the Taylor brothers' book: "The Great California Flood of 1862" published on March 2, 2006, they refer to data tabulated in Geological Survey, 1953: "Extrapolating the data given, we estimate the peak flow in 1862 to be no less than 250,000 CFS."

Note: These were the only references we found pertaining to peak flow estimates on the the American River at Folsom for the January 1862 flood. Apparently we were not the only ones looking for 1862 peak flow estimates on the American River. Also on page 19 of the Taylor brothers' book it states: "It is not clear why an estimate was not made for peak flow for the 1862 flood on this river" *(referring to the American River).*

B. EVENTS PRIOR TO PLACING AD IN FOLSOM TELEGRAPH

After reviewing the above report, a product of the NRC's Committee on American River Flood Frequencies, we decided to challenge Bossen's January 1862 peak flow estimate of 265,000 CFS on the American River at

Folsom. We have wondered why the Roos' estimate of a peak flow of 295,000 CFS for the major flood of January 1997 at Folsom wasn't given precedence over the Bossen estimate of 265,000 CFS. A cross-check of the Roos' estimate was made. Using ratio and proportion we adjusted the December 1964 peak flow data from Englebright Dam (171,700 CFS) for the difference in area between the Yuba (1104 square miles) and American River (1875 square miles) watersheds and came within 1.2% of replicating the Roos' estimate. The assumptions that were made are: 1) the intensity of each storm (1964 and 1997) was similar on both watersheds and 2) the peak flows on the Yuba at Englebright were similar for both the December 1964 and January 1997 flood producing storms. Therefore, it is our conclusion that the Roos' estimate is a valid indicator of the January 1997 peak flow at Folsom. Comparative peak flow data for the Yuba at Englebright during the major flood of January 1997 are unavailable. This is due to regulation of the flow on the middle fork of the Yuba River following the construction of the New Bullards Bar Dam in 1969.

A comparison of the watershed conditions prior to the onset of the flood producing storms of January 1862 and January 1997, reveals two significant differences. There was significantly more snow melt below 5,000 feet in January 1862, (s*ee figure 8* in "Lake Sacramento"). In January 1862, about the bottom 13% of the watershed was void of snow compared with ~37% before the warm storm of January 1997. Besides the snow factor, there was also frozen ground in January 1862 which impeded the infiltration of the rain and melted snow--further increasing the amount of runoff.

Summary: According to the comparative storm information, presented in *figure 5* of "Lake Sacramento", the 3 day burst precipitation amounts at Grass Valley and Lake Spaulding were about equal for both storms (1862 & 1997). However, the above comparison of the watershed conditions, prior to the January 1862 and January 1997 flood producing storms, clearly indicates that river flows were higher in January 1862.

Initially we were estimating that the 1862 flood peak on the Yuba at Englebright was approximately 10 to 20% larger than December 1964. An examination of *figures 6, 8 & 9* in "Lake Sacramento" supports this estimate. By using the technique described above, we get the following preliminary estimate of the peak flow on the American River at Folsom for January 10, 1862:

STEP N0. 1: Assume that the January 10,1862 peak flow on the Yuba River at Englebright Dam was 10% larger than the peak flow for December 1964.

171,700 cfs (December 1964 peak) + 10% = **188,870 cfs**

STEP N0. 2: (using ratio & proportion) Adjust the above January 1862 estimate at Englebright for the difference in watershed area between the Yuba and the American River.

X = Estimated peak flow for January 10, 1862 on the American River at Folsom.

X	• •	1875 (sq. mi.)	=	**320,000 cfs**
188,870 cfs	• •	1104 (sq. mi.)		(rounded off)

At this point we were not ready to decide on a numerical estimate for the peak flow that occurred January 10, 1862 on the American River at Folsom. We simply felt there were too many loose ends that needed further investigation. But we were confident that our work would allow us to raise the bar and state that the peak flow on January 10, 1862 was in excess of 300,000 CFS.

In the late summer and early fall of 2006 we made several unsuccessful attempts to share this information. Finally we placed the following advertisement in the *Folsom Telegraph*:

We Respectfully DISAGREE

A 1998 flood frequency analysis for the American River at Folsom (Fair Oaks) by the National Research Council used An instantaneous peak flow for the record Flood of January 10, 1862 of 265,000 cfs.

This estimate was made by L.E. Bossen in 1941. New evidence uncovered during our recent research indicates the peak flow was much larger >300,000 cfs. See our web page for details: www.leonhunsaker.net

Leon Hunsaker & Claude Curran
(M.S.—MIT) (Ph.D. – U. of Okla.)

Note: This ad was placed in the Folsom Telegraph 11/22/06

C. PRESENTATION AT NATIONAL GEOGRAPHERS' CONFERENCE

Our next attempt to be heard was at the annual meeting of the Association of American Geographers (AAG). This meeting was held in San Francisco April 2007. The title of our paper: "Would a Repeat of The Legendary Flood of 1862 Overtop Folsom Dam?" The main conclusions reached in this presentation are as follows:

1. We feel confident that the L. E. Bossen estimate of the peak flow for January 10, 1862 (of 265,000 CFS) on the American River at Folsom (or Fair Oaks) **is at least 20% too low**! **Our estimate (rounded off): 320,000 CFS--is conservative!**

Note: A comparative study of peak flows and watershed conditions for five major high water events between the years (1950-2000) on the ~51 square mile South Yuba River Watershed above Cisco **supports this view**. Frozen ground underneath a fresh snow pack were the conditions that existed on much of the Yuba and American River Watersheds just prior to the major flood producing storm of January 10, 1862. An examination of the January 1963 storm, that produced a record peak flow of **18,400 CFS** on the South Yuba River at Cisco, illustrates the huge impact this combination of watershed factors can have on peak flows.

At the 33rd Annual Western Snow Conference held in Colorado Springs, Colorado, April, 1965, Frederick A. Bertle (Hydraulic Engineer -- Bureau of Reclamation) had this to say about the impact a fresh snow pack can have on peak flows: "In many areas of the western United States, the maximum floods occur as the result of an extreme rain falling on a relatively fresh snow cover. The snow pack will absorb the rainfall from the early part of the storm and release it later. As a result of the release of stored water from the snow pack, in addition to the melting of the snow and the rainfall itself, the runoff peak flow may be considerably more severe than would occur from the rainfall alone." *This statement can be found on page 11 of the conference proceedings.*

2. We believe a series of major floods similar to 1861-62, **when considered as a unit**, has the potential to overwhelm storage facilities because of the small time interval between flood events. This would be

followed by free flowing rivers and widespread levee failures in the valleys--**a catastrophic event!**

Note: Folsom Dam would have surely been overtopped by an 1861-62 type flood before the recent upgrades were in place. Now that the size of the spillgates have been increased, the excess water from a major flood can be released and hopefully pass by without incident.

D. ANOTHER LOOK AT OUR 320,000 CFS ESTIMATE

As we have already stated we had good reason to believe that our 320,000 CFS peak flow estimate for the American River at Folsom on January 10, 1862 was conservative. Sometime later the USGS decided to toss their hat in the ring and also posted a peak flow estimate of 320,000 CFS for January 10, 1862 at Folsom. *As recently as January 2011, this estimate was still on their website.*

From the summer of 2007 until the Fall of 2008, our research on California floods had slowed to a snails pace. However, once in a while in a telephone conversation, we would review the reasons why we felt our peak flow estimate for January 10, 1862 was conservative. Then in the Fall of 2008 we decided to take another look at the record breaking peak flow on the South Yuba River at Cisco, produced by the heavy warm storm of January 1963. As pointed out earlier, conditions on the South Yuba River watershed above Cisco, prior to the January 1963 warm storm, were similar to the conditions that existed on the Yuba and American River watersheds just ahead of the major flood producing storm of January 10, 1862.

Then we decided to see if a comparison of the January 1997 and January 1963 peak flows on the South Yuba River at Cisco would shed some light on the record peak flow that occurred on the American River at Folsom, January 10, 1862. This comparison indicated that the peak flow during the January 1963 high water event was **23% higher.** Therefore, if we increase Roos' January 1997 peak flow estimate, of 295,000 CFS at Folsom by 23%, our peak flow estimate for January 10, 1862 is **365,000 CFS.** *Estimate has been rounded off to nearest 5,000 CFS.*

E. TWO PEAK FLOW ESTIMATES: **320,000 CFS** vs. **365,000 CFS**

The obvious question: Which estimate is most representative of what actually occurred at Folsom on January 10, 1862? We think the arguments presented in section "C" clearly favor the 365,000 CFS peak flow estimate. However, in an attempt to strengthen our case we began searching for another method of estimating the January 10, 1862 peak flow at Folsom. This time we decided to look for bits of useful information that might be gleaned from "official reports and publications".

This effort turned out to be a surprising success. Two main items came to our attention. *Figure 3.1* from the 1999 NRC report: Improving American River Flood Frequency Analyses and the DWR report: Analysis of 1862 Precipitation and Runoff *(on the American River watershed- dated February 23, 1999).* On page 2 of the DWR report it states: "Because the 1862 event had antecedent conditions like the 1997 event, an estimated runoff volume for 1862 was made using the 1997 precipitation/runoff ratio of 1.7. The calculated runoff volume was around 200,000 CFS (3-day)." *Figure 9* in "Lake Sacramento" supports these ideas. *Figure 3.1* shows the log-log relationships of three-day flow on peak flow, American River.

However, before we could make an estimate, *figure 3.1* needed to be modified to include 1862 flood data. We asked an expert (Holger Sommer) in fluid mechanics to make the necessary modifications. We have included our modified version of *figure 3.1* as part of this report. You now have the information you need to make another independent estimate of the peak flow on the American River at Folsom for January 10, 1862.

Note: *Holger taught fluid mechanics at Carnegie Melon University in Pittsburgh, PA.*

STEP N0. 1: Locate the 200,000 cfs value on the "Y" axis.

STEP N0. 2: Then move in a horizontal direction to the right until you intersect the extended regression line.

STEP N0. 3: At this point you drop vertically downward to the "X" axis. This gives an estimated peak flow of **365,000 CFS.**

COMMENT N0. 1: The DWR (3-day flow) of 200,000 CFS along with our modified version of *figure 3.1* from the 1999 NRC report, confirms the consistency of our peak flow prediction of **365,000 CFS.**

COMMENT N0. 2: Holger thought it would be a good idea to cross-check the data upon which *figure 3.1* is based. Our request for information was turned down by the Chairman of the Committee On American River Flood Frequencies. Rather than trying to obtain the data through the "Freedom of Information Act", we decided not to pursue the matter any further.

F. LINGERING DOUBTS AND SHARING OUR RESULTS

After a thorough review of the big picture, we added a plus sign to our 365,000+ CFS estimate. Our reasons: According to Brewer, in January 1862 there was a Lake in the Central Valley 250 to 300 mi. long with an average width of ~20 mi. Paraphrasing what William Ellis had to say on page 18 of the Taylor brothers' book, an 18-20 ft. thick layer of brownish-looking fresh water riding on top of the more dense saltwater was flowing through the Golden Gate and out to sea at least as far as the Farallon Islands. A heavily laden freighter reportedly foundered when it sailed into this layer of fresh water in the vicinity of the Farallons. The outflow was so pronouced it stopped the tide at the Golden Gate for a week. These facts left us feeling that our estimate of 365,000 CFS still wasn't high enough but we lacked the evidence we needed to change it. As a result the plus sign on our estimate remained **just a hunch**.

In the meantime we sent along a copy of our work to Joe Countryman (president of a consulting firm) working on the proposed upgrade of Folsom Dam and the American River levee system. Joe's courteous, but lukewarm, response along with a footnote* on page 13 of the 1999 NRC report, started us off in a new direction. We changed from estimating peak flows to estimating volumes. This is when we decided to to take another look at Dr. Snell's much maligned rainfall measurements made in Sonora during the floods of December 1861 and January 1862.

***Note:** The footnote at the bottom of page 13 states: "Daily rather than instantaneous flows are critical to flood management decision on the American River because of the significant volume of upstream flood storage at Folsom Dam."

G. SNELL's 1861-62 SONORA RAINFALL DATA--A GAME CHANGER

We launched an investigation to establish the validity of Dr. Snell's Sonora rainfall measurements made during the 1861-62 flood period. First we checked into his background using information we had obtained from the Tuolomne County Historical Society. He is known as Tuolomne County's pioneer scientist and was certainly capable of making accurate rainfall measurements.

Then in a paper prepared for the 2010 California Maximum Precipitation Symposium, we made the argument that Snell's supposedly outrageous 1861-62 rainfall measurements were valid. The title of our report: Dr. Snell's Rainfall Measurements Taken In Sonora During The December 1861-January 1862 Floods **Are Valid**. *This report has been made part of the proceedings of the 2010 Symposium and appears on the Symposium's website.*

TRANSITION: Our conclusion that Dr. Snell's 1861-62 Sonora rainfall measurements are a game changer is based upon the following list of facts and information:

1. Quoting from page 2 of the above report: " From the beginning of the wet season (on or about November 11, 1861 until January 14, 1862) 72 in. of rain fell in Sonora. Then, 10 days later (from January 14th until the 23rd) he recorded another 30 in.--raising the seasonal total to a whopping 102 in. We say whopping because Sonora's normal annual rainfall is approximately 32 in."

2. Now, turning to Exhibit A in this report and once again quoting from page 2: "*Exhibit A* compares ten consecutive days of rainfall at Grass Valley and Sonora for seven major floods of the 20th Century on the American River watershed. In all cases the 10 day total for Grass Valley exceeded the 10 day total for Sonora by a substantial margin. However, the same rainfall comparison for the 10 day period from January 14, 1862 through January 23, 1862 was reversed --30 in. in Sonora compared with a little more than 18 in. in Grass Valley." **This indicates that the Jet Stream (or storm track if you prefer) had shifted toward the south.**

3. When did this shift toward the south occur? On page 6, section 3c of our report establishing the validity of Snell's 1861-62 rainfall measurements it states**:** "However, as the Christmas holidays approached, the Jet Stream (storm track) began to shift southward, as evidenced by a report of rain starting to fall in the Los Angeles basin on Christmas Day. This report also stated that a "nice pleasant rain" continued on through the holiday season. <u>It then rained continuously for 15 days and nights.</u> This was followed by a downpour for 24 hours, or longer." *Source:* "The Great California Flood of 1862", page 7, by the Taylor Brothers.

4. Referring to the quote from the report on Dr. Snell's 1861-62 rainfall measurements, on page 7: The statement underlined above indicates that the intensity of the rain increased in the Los Angeles basin on or about January 2, 1862. It is also our opinion that the seasonal rainfall totals for Grass Valley and Sonora were about equal at this point--approximately 42 in. If you add 30 in., the total comes to 72 in.* which is equal to the seasonal total that Dr. Snell reported for Sonora up to January 14, 1862. **Therefore, we propose that approximately 30 inches of rain fell in Sonora during the 10 day period from January 2, 1862 to January 11, 1862, matching the January 14, 1862 to January 23, 1862 total of 30 inches.**

5. *During this same time period (November 11, 1861-January 14, 1862) 56.19 in. of precipitation fell in Grass Valley.

6. **<u>CONCLUSION:</u> In January 1862, there were two super-floods on the American River watershed. The peak flows produced by these floods at Folsom, were only 12 days apart--one on January 10th followed by another on January 22nd.**

7. On page 2 of the February 23, 1999 DWR report: Analysis of 1862 runoff assumed an average American River basin January precipitation depth of 50 in. This method also assumed wet antecedent conditions and a 1997 precipitation /runoff ratio of 1.7. The calculated runoff was around 200,000 CFS (3-day).

8. **<u>COMMENTS and CONCLUSIONS:</u>**

By way of review, if we refer to our modified version of NRC's *figure 3.1,* we see that the **200,000 CFS** (3-day) lines up with the

365,000 CFS peak flow. This was our peak flow estimate for January 10, 1862 on the American River at Folsom before the acceptance of Snell's 1861-62 Sonora rainfall measurements. Based upon the information in the first seven items of this section, there is little doubt in our minds that the estimated 50 in. average precipitation depth for the American River basin in January 1862 is substantially shy of the mark.

This is why we call the validation of the Snell 1862 rainfall data **a game changer**. All past estimates of **volume** as well as **peak flow** on the American River should be revisited --including our January 10, 1862 peak flow estimate of 365,000 CFS at Folsom.

H. REVISING OUR 365,000 CFS PEAK FLOW ESTIMATE AT FOLSOM

Using Dr. Snell's Sonora data as a guide, a conservative estimate of the average precipitation depth on the American River basin for January 1862 would be the total of the precipitation that fell at Sonora during the two almost back to back 10 day wet periods--*which adds up to ~60 in.* Sonora is situated at a relatively low elevation(~1800 ft.). Now let us assume that a broad and relatively deep current of air in the vicinity of Sonora moves in a north-northwesterly direction parallel to the Sierra toward Placerville (Elev. 1890 ft.). Placerville is located on the southern edge of the American River watershed. Up to this point any increase in precipitation due to cooling by orograghic lift would likely be minor. Leaving Placerville it appears that the air current would be traveling in a more northerly direction parallel to the Northern Sierra. As a result the observed increases in precipitation would be due mainly to the increase in elevation (orographic lift) as the air travels in a northerly direction. A good example of this is a comparison of the 10 day precipitation totals for five select reporting stations in the American River basin during the major flood producing storms of December 1964, February 1986 and January 1997. *See page 4, Section "A" of the Snell report.*

Note: To get a better idea of what we are describing, refer to our estimate of the Jet Stream weather pattern associated with the Super Flood of January 10, 1862. The heavy dark green line, outlined in red, is our revised location of the Jet Stream (storm track) after taking into account how the "Snell Effect" would alter its path.

Why do we think this Jet Stream weather pattern produced significantly more precipitation on the American River basin than any of the Jet Stream patterns associated with the major floods of the 20th Century? Our estimate shows the Jet Stream (storm track) coming from right out of the south-southeast loaded with extra moisture from the subtropics. This is demonstrated conclusively by a review of the statewide peak stream flow data associated with the second Super Flood of January 22, 1862--***also of subtropical origin.*** *See page 3 of the Snell report*. We also believe that the bend of the Sierra, that begins near the southern boundary of the American River watershed, enhances the orographic lift especially when flood producing Jet Stream flow patterns originate in the subtropics.

There are several reports which support our contention that the rainfall was unusually heavy *and most likely of subtropical origin*. The following reports appeared in the *Sacramento Union:*

1. (January 9, 1862) The Flood in Mariposa: Property damage along the Merced to an amount not dreamed of by men who have for a long time lived in the localities.

2. (January 14, 1862) Placerville, Jan. 10th, 9PM--Editors Union: Rain, Rain, Rain! There seems to be no let-up to it; for three days it has poured down upon us, and at this writing it seems to be coming down in torrents----rivulets are turned into rivers which sweeps everything before them.

3. (January 14, 1862) The Flood in Georgetown: A correspondent of the Union, writing from Georgetown, Eldorado County, January 10th says: The hardest rain ever known in the mountains by any of the old settlers has been falling here for the last three days and nights, and it has been impossible to cross any of the small streams.

Note: These reports are relevant to the first Super Flood of January 1862. The chaotic runoff situation described in both the Placerville and Georgetown reports suggest that frozen ground was a contributing factor.

Following the first Super Flood of January 10th, the southerly Jet Stream from the subtropics was interrupted by northerly flow cold enough to produce snow at low elevations. This snow episode wasn't nearly as heavy in the lower elevations, as the one prior to the first Super Flood but it

did leave behind 4 in. in Nevada City and 2 in.* in Cacheville on the 14th and 15th respectively.

*__Note:__ As matter of interest, a correspondent of the *Sacramento Union* wrote that the snowflakes falling in Cacheville (near the foothills that line the southwestern portion of the Sacramento Valley) on the 15th were as large as the palm of your hand.

The following reports are evidence that a strong southerly Jet Stream from the subtropics was about to be reestablished over California:

1. Refer to section "G" statement N0. 3

2. (January 22, 1862) Forest Hill Courier: The river on Friday afternoon --January 17th --was 12 feet higher than any previous flood and 40 feet above low water mark. *Refers to middle fork of American River*.

3. Refer to *figure 2* in "Lake Sacramento": It shows that ~3.5 in. of rain fell in Sacramento on January 17th. By over an inch, this is the heaviest single day of rainfall recorded in Sacramento during the entire months of December 1861 and January 1862.

After examining the facts we believe that the 24 hour downpour, referred to in item N0.1, most likely commenced on the 16th. It is also our belief that the events listed above were caused by the same upper level disturbance that originally formed in the subtropics. From the subtropics this disturbance was forced in a north-northwesterly direction and moved across the length of the Central Valley of California on January 17th. The end result was a well defined Jet Stream (storm track) extending from the subtropics in a north-northwesterly direction along a path that kept it centered west of the California Sierra summit all the way to the Oregon border.

This Jet Stream weather pattern provided a platform for the development of the second Super Flood of January 1862 on the American River watershed. *Figure 3* in "Lake Sacramento" shows a mean temperature reading in Sacramento on the 15th of 41 degrees (F). By the 18th and 19th the mean daily temperature in Sacramento had risen to 52 degrees (F) and was followed by a 3-day precipitation burst temperature of 55.5 degrees (F). *See figure 10* in "Lake Sacramento". This information combined with the daily precipitation amounts for Sacramento and Grass Valley in *figures 1*

and 2, also in "Lake Sacramento", tells the story. On or about January 22, 1862, either record flooding or near record flooding occurred from Southern California to the Oregon border. *See page 3 of the Snell report.*

In our opinion assuming an average precipitation depth for January 1862 on the American River basin of ~60 in., **is conservative**. When compared with the DWR estimate of 50 in. our estimate is 20% higher. This increase refers to precipitation not runoff. It is also our understanding from the comments made at the Maximum Precipitation Symposium last June, that runoff calculations, based upon an average precipitation depth of 55 to 60 in. on the American River basin, would be forthcoming. In the absence of this information, we will make what we consider several reasonable estimates.

DWR's estimate of an average 50 in precipitation depth on the American River basin for January 1862, was calculated to produce a 3-day flow at Folsom (Fair Oaks) of 200,000 CFS. Referring to our modified version of the NRC's *figure 3.1*, if we assume a 10% increase in flow due to the "Snell Factor" we get a 3-day flow of 220,000 CFS. This corresponds to a peak flow of (~440,000 CFS). If you increase the flow 15% (230,000 CFS), the resulting peak flow increases to (~470,000 CFS).

I. COMMENTS AND CONCLUSIONS

1. **COMMENT:** In the summer of 2009 I had a brief telephone conversation with Joe Countryman. I was told that the basic upgrades on Folsom Dam were being designed to handle a flood peak of ~450,000 CFS. I also asked Joe how they arrived at this figure. In fairness to Joe, I am not a statistician, but the way I understood it, they* used a statistical technique hat involved ranking the peak flows of the individual years of record. I tried to explain it to our expert (Holger Sommer) and he said: "Sounds like they are after the one in a thousand year flood."

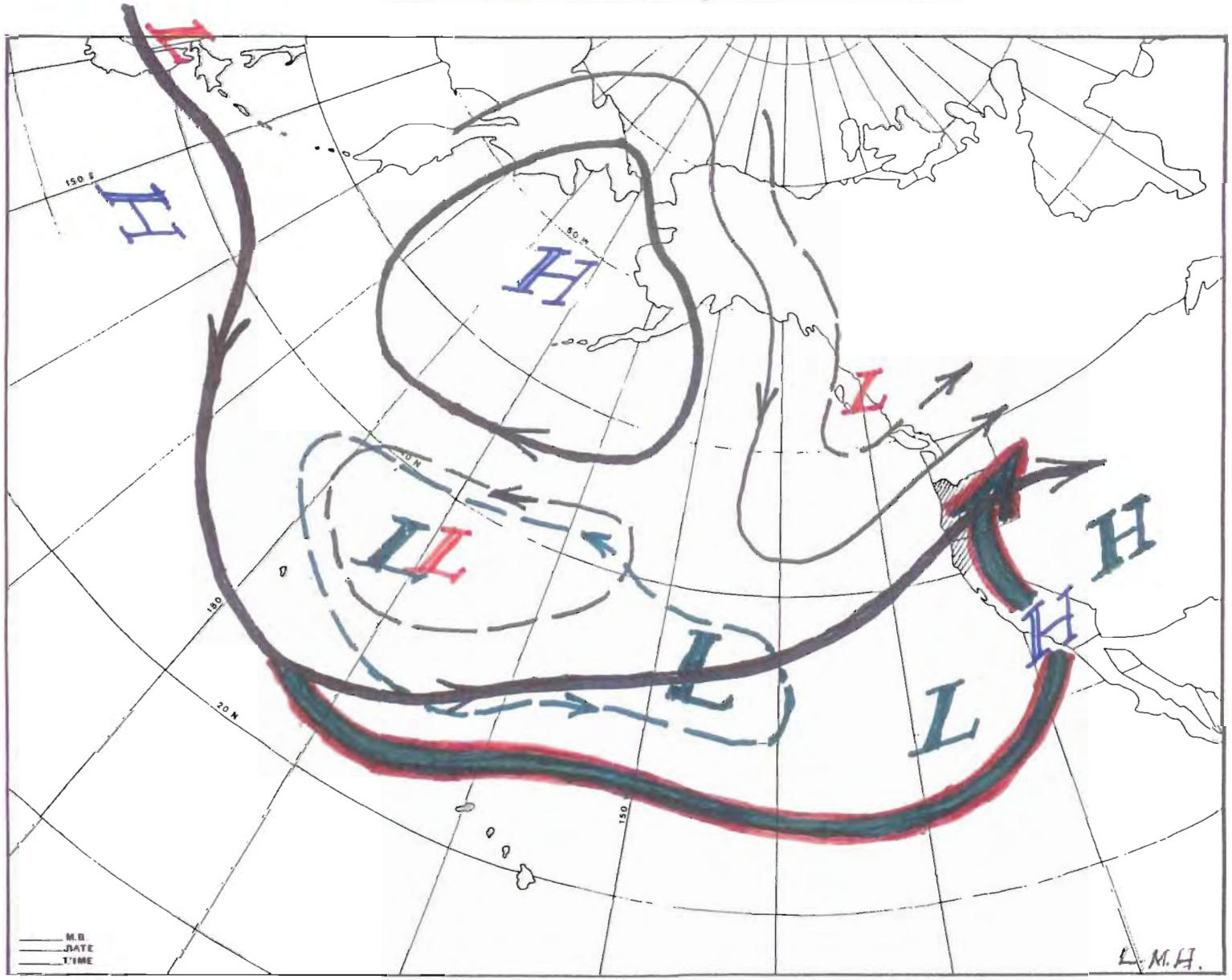
*__Note:__ I don't remember asking who they were.

2. **CONCLUSION:** By taking the "Snell Factor" into consideration we are increasing our peak flow estimate on the American River at Folsom (Fair Oaks) for January 10, 1862 from **365,000 CFS** up to between ***440,000 CFS** and ***470,000 CFS**.

*__Note:__ These peak flow estimates may increase when 3-day runoff values for the American River at Folsom have been calculated using an average January 1862 watershed precipitation depth of 55 to 60 in.

Leon Hunsaker, MS (MIT)
with
Claude Curran, Ph. D. (U of Oklahoma)
June 10, 2011

SUPER FLOOD



JAN. 9 & 10, 1862

MODIFIED VERSION of NRC's *Figure 3.1*

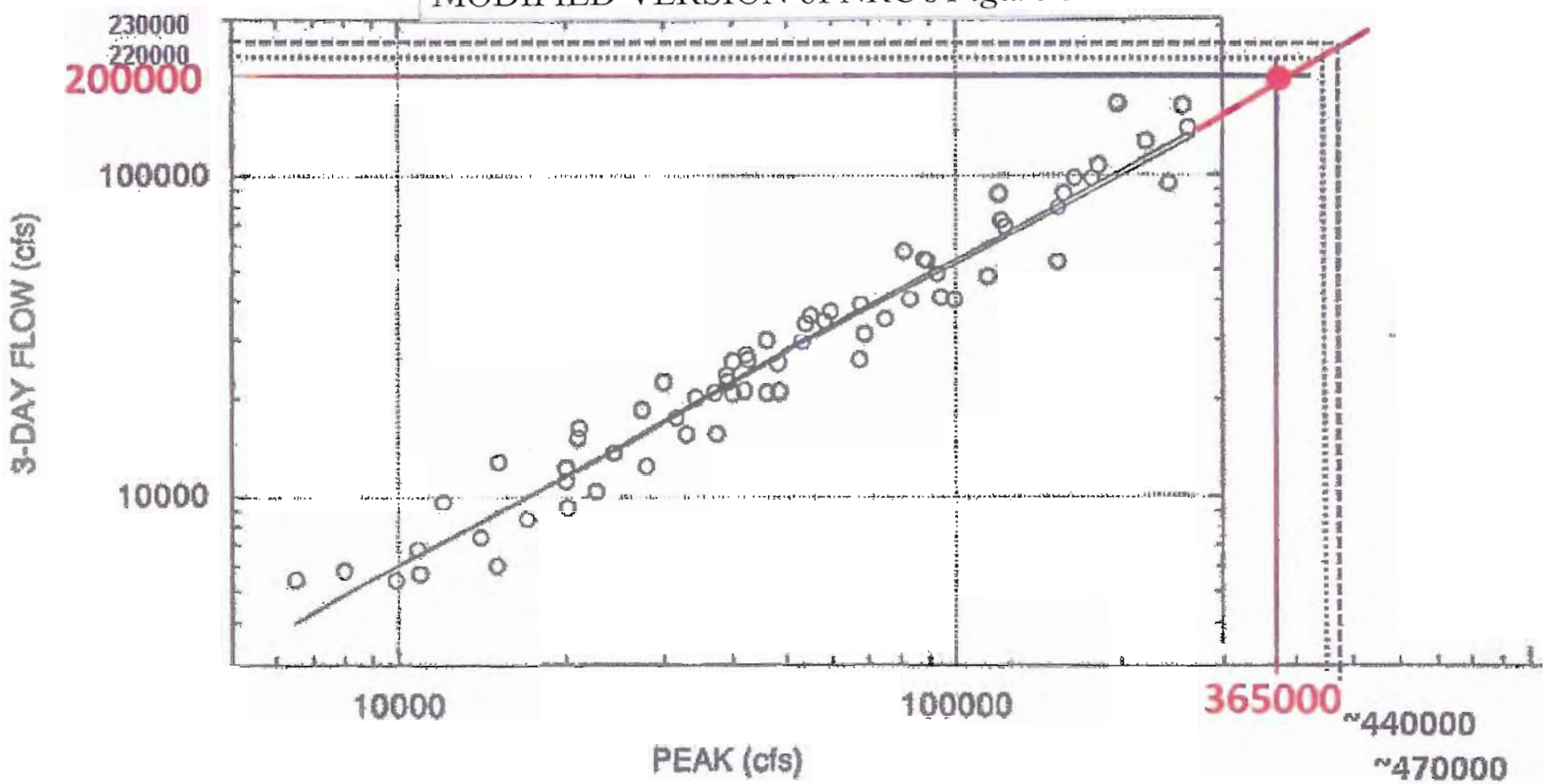


FIGURE 3.1 Log-log relationships of three-day flow on peak flow, American River. Both regressions are based on data from the unregulated period of record (1905-1955); the regression line with the larger slope is also based on flow estimates for the period 1956-1997.

(modified with 1862 flood data)

A 10% increase of the 3-DAY FLOW (220,000 cfs)
results in a 20.5% increase in the PEAK (~440,000 cfs)
A 15% increase of the 3-DAY FLOW (230,000 cfs)
results in a 28.7% increase in the PEAK (~470,000 cfs)