A MIRACULOUS DISCOVERY

PREFACE
written by Dr. Claude Curran

"Eureka! I have found it!" was the cry of every miner who struck it rich in the Mother Lode of California. The miners were people who came from all walks of life, mainly from the United States of America but, also from many other countries. These were people in the U.S. who dropped what they were doing to be lured west by the prospect of riches. Most of these folks did not know what it was like to endure copious rain in the winter rather than the interminable cold, snow, and ice typical to the eastern two-thirds of the country.

What these folks found, instead, was drought, with very hot summers in the diggings, and cool, rainy winters. For many miners, the weather was a reversal from what they were used to experiencing. They were hard at labor searching for gold, literally turning over every stone in search of "easy yellow wealth." Little did they know winter could bring torturously intense storms.

When we think of these miners it reminds us of the black turnstone (Avenaria melanocephala). This beautiful bird frequents ocean shores along the Pacific Coast where, with its oddly shaped bill, it flips over stones in search of aquatic invertebrates on which to dine. There is not a meal under every stone; The birds must flip a lot of stones to sustain themselves. And so, too, it was with the miners; There wasn't gold under each stone, however, they relentlessly continued to search for the precious metal.

Inevitably, the benign winter weather of the early gold rush took a turn for much worse in late fall of 1861 and early winter of 1862. There were devastating floods the magnitude of which few people had ever witnessed. The flood water probably came as a shock to most people, especially to miners in the mountains, and farmers on flood plains who were "mining" agricultural wealth in the Great Central Valley. Much of these activities were directly affected, along with the entire state of California's economy, a phenomenon from which it took many years to recover.

This is where we come in. The management of water in the Golden State is paramount to its economy and indispensable to its residents, even reaching far beyond the state's borders. As researchers, we (Leon Hunsaker and Claude Curran) ask ourselves: How did this happen? What was the magnitude of the storms? And what can we learn from thoroughly studying these weather events and their effects? We are weather turnstones seeking answers to some vexing and perplexing questions. We see ourselves as weather detectives, having thoroughly uncovered weather tidbits from a variety of historical sources that have enabled us to reconstruct those horrendous events.

Our objective is to translate all this into a narrative which everyone will understand and take seriously. As with all of science, many of our questions have been answered however, some have not, and we will continue to turn weather stones as long as we live. It has taken a decade of hard work and personal financial commitment (endorsed by our respective wives) to prepare this presentation.

Here is what we ask of you: Please commit to reading and studying these few pages representing thousands of hours of work driven by our concern for the fine people of California and the rest of the nation. Read this through, then spend a couple hours studying it, and we are certain you will recognize the MIRACLES we have discovered. Eureka, WE have found it!

INTRODUCTION:
written by Leon Hunsaker

The <u>risk</u> of Sacramento being flooded again by a record January 10th, 1862-type flood is much greater than Sacramento flood officials are expecting. This is because the peak flow that occurred during that record flood has been underestimated by at least 50%. Our evidence is presented in the following report.

The Swamp Commissioner's estimate of 509,000 cubic feet per second (CFS) from the record January 10, 1862 peak flow on the American River at Folsom/Fair Oaks **is essentially correct**! During our many years of debate with the Water Establishment (Army Corps of Engineers, California Department of Water Resources, and the USGS) it has become abundantly clear they are overlooking three key factors when they calculate the record January 10, 1862 peak flow on the American River at Folsom. They continue to overlook a well-above average amount of **snowmelt** from a storm that deposited heavy amounts of snow as low as the foothill region of the Sacramento Valley just prior to the record-breaking flood of January 10th. The next two factors: a **collapsing snowpack** and a **frozen watershed**, can have a dramatic effect on the peak flow, especially when you have a heavy warm storm situation in which both factors are in play.

OVERLOOKED FACTORS' IMPACT ON PEAK FLOW

Low Level Snowmelt: I was given an opportunity at the end of the June 2010 California Extreme Precipitation Symposium to make a few remarks about the preliminary research Dr. Claude Curran and I had conducted on the record breaking December 1861 - January 1862 flood series. One of my comments registered with Robert Collins, the district hydrologist for the Sacramento District of the Army Corp of Engineers. My comment: "It appears to us that the **snowmelt** from the heavy, low elevation snow storm just prior to the record flood (of January 10th) has been <u>missed</u> in your peak flow calculations."

When I finished, Mr. Collins took over and stated that he had made some snowmelt calculations. Assuming the rainfall amounts were similar, the low-level snowmelt made the average maximum 3-day runoff in 1862 on the American River at Folsom/Fair Oaks 30% greater than the 3-day runoff during the floods of either February 1986 or January 1997. This is important because the Water Establishment continues to insist that the magnitude of the January 10, 1862 flood is in the same category as the February 1986 and January 1997 floods.

The next step was made relatively easy by the Army Corps of Engineers when they published estimates of the maximum average (unregulated) 3-day flow at various locations for each water season. To obtain an average (unregulated) 3-day flow, according to Collin's estimate, you simply increase the 1997 flood's (unregulated) maximum 3-day flow (164,252 CFS) at Fair Oaks by 30%.

1997 (3-day flow) - *164,000 CFS x .30 = 49,200 CFS

Collin's estimated 3-day: 164,000 CFS + *49,000 CFS = **213,000 CFS flow** at Folsom (1862)

**rounded off to the nearest 1,000 CFS*

TRANSITION: We need to find an acceptable method of estimating the peak flow that would have likely occurred during an average 3-day flow period of 213,000 CFS.

Developing a Method of Estimating Peak Flows for the Larger 1862 Floods: We started with a copy of *figure 3.1* from the National Research Council's 1999 report *Improving American River Flood Frequency Analyses.* It was in the right format and contained the kind of information we needed to make the 1862 peak flow estimates. But the scale was too small! Since river flow data were not available for the 1862 floods we searched for any 3-day flow estimates that might have been made by the Water Establishment. This search located a report by the California Department of Water Resources dated February 23, 1999 entitled *DWR Analysis of 1862 Precipitation and Runoff*. On page 2 of this report they calculated a 3-day average flow in January 1862 of around 200,000 CFS on the American River at Folsom/Fair Oaks. *Holger Sommers used red ink when he added this information to *figure 3.1* (It now becomes part of our report and is identified as *Modified figure 3.1*). We also asked Sommers to add enough information to cover flows that were 10-15% larger than 200,00 CFS. We requested the additional information because of the following statement made by the author(s) at the end of the DWR report: "The 3-day precipitation estimates imply that the 1862 storm was not larger than the 1997 and 1986 storms, **what is not known is the size of the snowpack."**

**Sommers taught fluid mechanics at Carnegie Melon University in Pittsburgh.*

Now we have a modified version of *figure 3.1* that allows us to estimate the peak flows of the larger 1862 floods. First, we locate the Collin's 3-day flow estimate of 213,000 CFS on the "y" axis. Then we trace it across our modified *figure 3.1* until we reach the extended regression line. Then we drop downward to the "x" axis. This gives us an **estimated peak flow of ~414,000 CFS.**

(Remember, our peak flow estimate of ~414,000 CFS was based upon Collin's 3-day average flow estimate of 213,000 CFS. This information was published in an article (The Weatherman) in the Sacramento News and Review June 12, 2012 edition. This shows that our 414,000 CFS peak flow estimate was made public at least several days ahead of when the Swamp Commissioner's report was made public at the 2012 June Extreme Precipitation Symposium.)

TRANSITION: So far, we have only been dealing with the first of three factors: low-level snowmelt, which the Water Establishment overlooked when estimating the maximum average 3-day flow at Folsom/Fair Oaks for the record-breaking flood of January 10, 1862. The Water Establishment also overlooked the role that a **collapsing snowpack** and a **frozen watershed** can play in determining the magnitude of peak flows. When both factors work together the results can be well beyond the expected. **Our research clearly shows that this is what was happening during the record flood of January 10th.**

List of Observations, Watershed Conditions, and Weather Event Sequences that Support the Above Conclusion:

1. Refer to Diagram –B: Chart of the Oscillations of the Sacramento River at Sacramento *(Note: This data was collected by Thomas M. Logan, M.D. at the location where the American River joins the Sacramento.)*

We say the ~3 foot rise in water level shown on January 10, 1862, when the water level across the entire region was already well above flood stage, was **nothing short of spectacular!** We also say it was due to a collapsing snowpack on top of frozen ground. It was mainly an American River event because the peak flow on the Sacramento River didn't reach Sacramento until ~24 hours later (the evening of the 11th.)

2. Modified arctic air quickly settled in over Northern California right after New Year's Day 1862. By the morning of January 4th the minimum temperature at Webber's station one mile east of the summit on Henness Pass was -18 Fahrenheit (F). Farther south along the summit at Strawberry, above Placerville, the minimum temperature the morning of the 4th was -16 degrees F. That same morning, the ground around Placerville was frozen hard, and the temperature at Nevada City was +17 degrees F with ice one half inch thick. *(See Afterthoughts section for source of temperatures.)*

Note: David West in Antioch reported a cool north wind blowing on the 3rd of January, followed by what he described as a **cold, raw day on January 4th.** This indicates that a widespread and well-defined cold northerly breeze was still blowing on the 4th. The wind chill factor made the +17 F in Nevada City that morning feel noticeably colder. A cold, dry, northerly wind on the 4th at Henness Pass (elevation ~7,000 feet) with a downslope component would warm up at the rate of 5 ½ degrees F per 1,000 feet of descent. The warm-up for a 3,000 foot descent, toward the northern boundary of the American River watershed, would be almost 17 degrees F *(refer to Diagram C).* Even with this warm-up, the minimum temperatures at an elevation of 4,000 feet would probably range from about zero to 5 degrees above zero. The -16 degrees F minimum temperature reading at Strawberry, and the hard frozen ground reported at Placerville on January 4th, indicate that numerous minimum temperature estimates could have been made across the American River watershed with similar results.

3. Condition of Watershed Before Arrival of Warm, Flood Producing Storm

After the first major flood event in early December there was very little, if any, snow left on the American River watershed, even in the higher elevations *(see Item #6 in Afterthoughts).* When the storm track returned in mid-December there were three significant storms between then and the end of the month. The snowline on the first two storms was ~4,500 feet. But the snowline on the third storm was closer to 6,000 feet. This suggests there was an elevational band of snow ~1,200 feet wide that was being rained on by the last storm in the series. The ~3 to 4 inches of rain that fell on this band of snow would have likely turned most of the lower half (~600 feet) to slush. When the cold spell arrived right after New Year's the slush would have been subjected to a hard freeze. This scenario strongly suggests there was a layer of ice approximately 600 feet wide (beginning at an elevation of 4,600 to 4,700 feet) underneath the fresh snow that had fallen just prior to the arrival of the warm, flood producing storm. Because of the lack of penetration of the watershed surface by the rain and the snowmelt, the amount and speed of the runoff would have increased substantially. The rest of the watershed below about 4,600 to 4,700 feet had been soaked by rain from the December storms. This section of the watershed was still void of snow until the arrival of the heavy, low-level snowstorm of January 5th.

a. Conclusion: The quick freeze that occurred the night of the 3rd and morning of the January 4th was hard enough to prevent water (rain or snowmelt) from soaking into the top layer of the watershed soil. We also believe this was the case for the entire American River watershed above ~2,000 feet.

4. <u>Significance of a Collapsing Snowpack on Top of a Frozen Watershed</u>

a. The 1855 Ninth Annual Report of the Smithsonian Institution, page 55, says it best: "The presence of a few inches of snow, with the subjacent earth frozen so as to prevent it from imbibing, will greatly enhance the diluvial effects of even a moderate rain. The snow first absorbs the water and retains it until fully saturated. Then the entire mass rapidly liquefies and flows off."

b. Special Weather Summary from December 1964 Oregon Climatological Data Publication: "This same pattern of snow followed by heavy rains was occurring over the entire state. The top layer of earth had been frozen by the very low temperatures just preceding this storm. When the snowpack collapsed, the normal infiltration of significant amounts of water couldn't take place. The result was immediate runoff into drainage streams of all stored snow and rainwater, plus that being added by the very heavy rain in progress. Rivers rose rapidly. In most tributary streams to the middle and lower Willamette, with very long period of observations, new record-high stages were set. Some peak discharges were over 150% of any previously measured. The same general situation prevailed in the rivers and creeks along the coast, in the southwestern valleys, and south-central and northeastern Oregon."

<u>*Note:*</u> *The same sequence of weather events responsible for the record December 1964 flooding in Oregon also prevailed during the record flood of January 10, 1862 on the American River at Folsom/Fair Oaks. In both cases, the time span between the beginning of the cold snap and the beginning of the warmer flood-producing rain was ~5 to 6 days.*

Calculating the January 10, 1862 Peak Flow at Folsom/Fair Oaks Taking into Account all Three Factors Overlooked by the Water Establishment

Remember that so far, we have only dealt with the increase in flow caused by the low-level snowmelt. Now, we're going to tackle the problem of numerically assessing the combined effect a collapsing snowpack and a frozen watershed can have on the magnitude of the peak flow. Both these factors were active when the warm, flood producing storm of January 9, 10, and 11, 1862 swept across the American River watershed.

We decided to attempt a peak streamflow comparison between two storms of similar magnitude. The first storm situation (late January 1963) had both a collapsing snowpack and a frozen watershed (above 5,000 feet). The second storm situation (early January 1997) had neither (above 5,000 feet). For a peak streamflow comparison, we chose the approximate 51 square mile South Yuba River watershed near Cisco. It extended from near Cisco (~5,200 feet) to the summit (~7,000 feet) and shares a portion of the American River watershed's northern boundary *(see Diagram C)*.

1. Peak Flow Comparison

   January 1963: 18,400 CFS

   January 1997: 15,000 CFS

   - **A difference of 3,400 CFS**

   a. Rounding off to the nearest 1%, how much larger was the January 1963 peak flow?

$$3{,}400 \div 15{,}000 = .226 = 22.6\% = 23\%$$

2. Now, by increasing Collin's estimated peak flow of ~414,000 CFS by 23% we get a numerical estimate of 509,200 CFS for peak flow that occurred on the American River at Folsom/Fair Oaks during the record flood of January 10, 1862.

   a. By rounding off 509,200 CFS to the nearest 1,000 CFS, we get our final answer of **509,000 CFS.**

3. <u>Comments:</u>

   a. 509,000 CFS is exactly the same answer the Swamp Commissioners came up with when they made their estimate of the record peak flow for the above location in May of 1862.

   b. The fact that our numbers match theirs **boggles** the mind when you consider all the "rounding off", potential "data extraction errors" and "assumptions" different people made while developing the diagrams, tables and figures that are part of the frame work that made it possible to solve this complex problem.

   c. Leon says: "The results of this research are the closest thing to a miracle I have observed in my lifetime."

   d. Claude says: "[It's] a miracle since our research was accomplished without knowledge of the Swamp Commission report written in the spring of 1862. We arrived at our approximation by examining anecdotal information as well as records produced by a hydrograph and on-site temperature, precipitation, and wind information."

   e. We have grave concerns that when a flood (or floods) such as occurred in December 1861 and January 1862 occurs in the future:

1.) The prospect of loss of life, limb, and property in Sacramento and the Delta regions could be significant

2.) Liability for such a prospect, and the impact that will surely be felt by insuring agencies as well as the public sector, could be staggering

Perhaps legislation limiting liability in the more flood prone areas is the most equitable approach. Some kind of a sliding scale in which the public's liability decreases as the risk of flooding increases. Generally speaking, under current liability law, flood victims can collect for damages if it can be proven that the responsible government entity was negligent. *From now on, we will assume that the entity we are referring to is a member of the Water Establishment.*

Considering only Sacramento: The upgrades in recent years to Folsom Dam and the levee system protecting Sacramento have changed the picture. However, are the changes enough? In our opinion, it comes down to this: **Which January 10, 1862 peak flow estimate on the American River at Folsom/Fair Oaks do you agree with?**

To our knowledge, the latest revised Water Establishment peak flow estimate on the American River at Folsom/Fair Oaks for January 10th is **320,000 CFS.** The 1997 flood peak at Folsom/Fair Oaks of ~300,000 CFS pushed Folsom Dam's spillway to the limit. However, recent improvements that enlarged the spillway and increased the capacity of Folsom Lake *may* have been enough to enable the dam to handle a peak flow of 320,000 CFS. A close examination of Diagram B (Logan's Hydrograph) has prompted us to insert the word "may" because of the widespread flooding that occurred during December 1861. On the other hand, if **we *and* the Swamp Commissioners** are right, with a peak flow estimate of around **500,000 CFS**, there will be no "may" about it; Sacramento will be flooded **unless** a rather bold operating plan is adopted, *a plan that we understand is currently in the Water Establishment's arsenal of options.* The plan would draw down the level of Folsom Lake ahead of the arrival of floodwaters from the anticipated record flood. If this procedure is successful, there will likely be ~400,000 Acre Feet of water left in Folsom Lake after the drawdown is complete. That would leave well over 600,000 Acre Feet of storage space for floodwaters.

The success of this procedure not only depends upon the accuracy of the weather forecast but how well the drawdown plan is executed**. If weather computer models are reasonably accurate and the drawdown is successful, we are cautiously optimistic that most of Sacramento could survive a January 10, 1862-type flood with a peak flow in the neighborhood of 500,000 CFS.** *(We say "most" because West Sacramento is a good example of rapid growth without adequate flood protection.)*

If you feel the above plan is **too risky**, the other alternative is to build the Auburn Dam. We are of the opinion that water from an Auburn Dam will eventually be needed to meet the combination of challenges caused by rapid growth and drought. If you agree, let's build the dam sooner rather than later. (Of course, the arrival on the scene of another habitable planet or a financially feasible method of desalination could change everything.)

ACKNOWLEDGEMENTS

This incredible discovery would never have seen the light of day without the compassion of Gary Estes. Less than two weeks before the June 2010 California Extreme Precipitation Symposium was to take place I asked Gary, the director, for a spot on the program. When I answered his

question, “Why not next year?” with “I just turned 87!”, the conversation changed back to the current year. He already had a copy of our book “Lake Sacramento” so he knew we probably had something worthwhile to say about the December 1861 - January 1862 series of floods in California. Toward the end of our telephone conversation Gary said I could have 10-15 minutes at the conclusion of their scheduled program. Then he added that attendance would be voluntary. Gary also knew that I was hurting because my wonderful wife of 63 years had passed away only a week or so earlier. I later learned that I was about the same age as his father. THANK YOU, GARY, FOR YOUR COMPASSION AND YOUR SUPPORT.

Late in the afternoon on the day of the Symposium I was introduced to a surprisingly large holdover crowd of, I’d estimate at, somewhere between 200-250 people. In spite of a warm round of applause and my many years on television, I was nervous. During my short presentation, there were several blank spots due to “senior moments” but my concerns vanished during the discussion period following my remarks. It was almost as if Robert Collins, Corp of Engineers Hydrologist for the Sacramento District, sensed my uneasiness. When he indicated that his investigation showed the low-level snowmelt had been overlooked in the record peak flow calculations, I was elated! Finally, someone had agreed with us! The result of Robert Collins’s work is the foundation that made this discovery possible. ROBERT, PLEASE ACCEPT OUR SINCERE THANKS!

Other individuals and organizations also provided valuable information and support. Sincere thanks to:

1. The two USGS hydrologists who estimated the peak flow of the late January 1963 flood on the South Yuba River near Cisco after the flood waters had overwhelmed the measurement gauge

2. David Madruga, my assistant, for locating in the state library, and making a copy of, Dr. Logan's 1861-1862 Sacramento River hydrograph
3. Don Bradshaw, PG&E Co. law case coordinator, for making arrangements for me to keep the weather records of a flood lawsuit I'd worked on while employed by PG&E
4. Jim Goodridge, California State climatologist, for willingly filling our requests for weather data
5. John Torrens, PG&E Co. employee, for providing all-around assistance in finding key information about 1861-1862 flooding in Sacramento
6. Cosmo Garvin, reporter for the Sacramento News and Review, for documenting our denial of having any knowledge of the Swamp Commissioner's work ahead of time, in his excellent story, "The Weatherman"
7. Corp of Engineers, for providing maximum 3-day average unregulated flow calculations for each water year at various locations including the American River at Folsom/Fair Oaks
8. California Department of Water Resources, for their 3-day average 1862 flow estimate of around 200,00 CFS on the American River at Folsom/Fair Oaks
9. National Research Council, for the use of their modified *figure 3.1* to help determine peak flows of 1862 floods
10. My daughter, Claudia Roskelley, for her many errands, phone calls, regular mailings, emails, and shopping for supplies. *Much of this was accomplished while doctors were struggling to save her kidneys.*
11. Bryce Hunsaker, for upgrading my computer by installing a larger screen and making several other improvements that allowed me to produce this report

12. Mark Hastings, for locating several precipitation stations with data for both storms used in the peak flow comparison. A comparison of the heaviest 3-day totals for each storm supports our claim that the 3-day totals for both storms were similar.

13. Kent Brown, a good Hugo neighbor, for keeping us posted on the latest news articles relating to floods in California

14. Shannon Young, for suggestions that improved key format items

AFTERTHOUGHTS

The background material for many of the estimated precipitation amounts and snowlines comes from our book: LAKE SACRAMENTO. For example:

1. Snowline estimates for the first two storms that occurred in the latter part of December 1861:

- Sacramento mean temperature for both storms 50 degrees F
- Estimated temperature at snowline 34 degrees F
- During the storm assume a wet adiabatic lapse rate of 3 ½ degrees F per 1,000 feet

(50 – 34 = 16) ÷ 3.5 = 4.57 (*See figure 3 in LAKE SACRAMENTO*)
- estimated snowline: 4,500 to 4,600 feet

2.Verification of above snowline: *Nevada Democrat,* January 7, 1862 ---- The stage lines to Omega and Moore's Flat (about 4,000 feet elevation) have substituted sleighs for stages. This indicates that the lower tip of the main snowpack remained above 4,000 feet until the low-level snowstorm of January 5th.

3. For estimates of mountain precipitation amounts, daily record for Grass Valley was usually the starting point (*See figure 1 in LAKE SACRAMENTO*)

4. *Sacramento Daily Union*, January 5, 1862, 8:00 p.m., Placerville: "It has been raining here all day and turned to snowing tonight. It is snowing hard at Strawberry and Carson Valley. It was very cold here yesterday, the ground being frozen hard. At Strawberry (near the summit) the thermometer stood at 16 below zero."

5. *Sacramento Daily Union*, February 11, 1862, page 2, column 3: Webber's Station, one mile east of the summit on Henness Pass, reported a minimum temperature on the morning of January 4, 1862 of -18 degrees F.

6. *Grass Valley National*, Thursday, December 12, 1861: "The Henness Pass: Mr. Powers, who came down from Orleans Flat this morning, informs us that the rains extended to the summit of the mountains, carrying off the snow on the Henness Pass."

Leon Hunsaker, MS (MIT)
and
Claude Curran, PhD (University of Oklahoma)
September 10, 2018

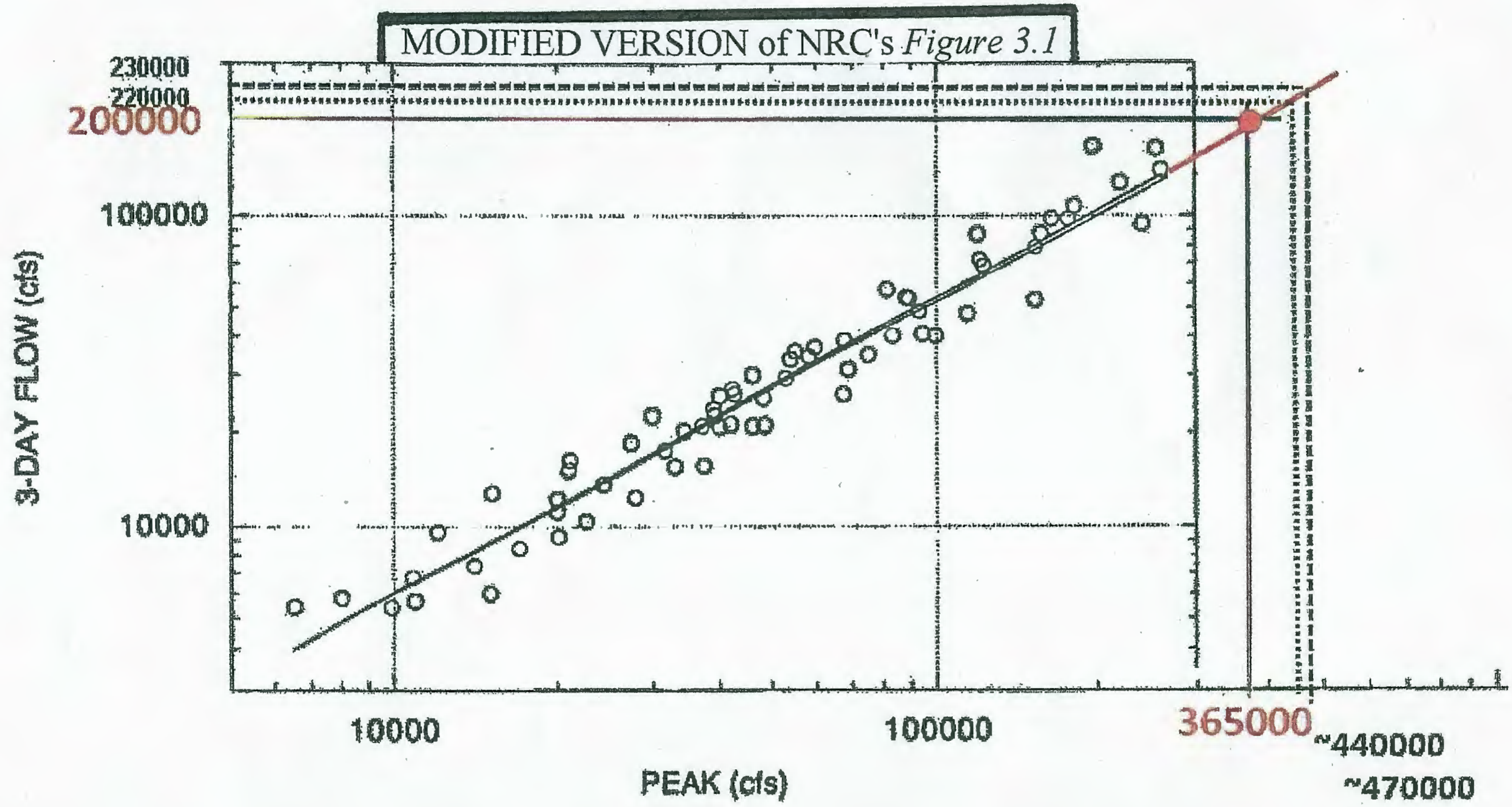

FIGURE 3.1 Log-log relationships of three-day flow on peak flow, American River. Both regressions are based on data from the unregulated period of record (1905-1955); the regression line with the larger slope is also based on flow estimates for the period 1956-1997.

(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)

NRC
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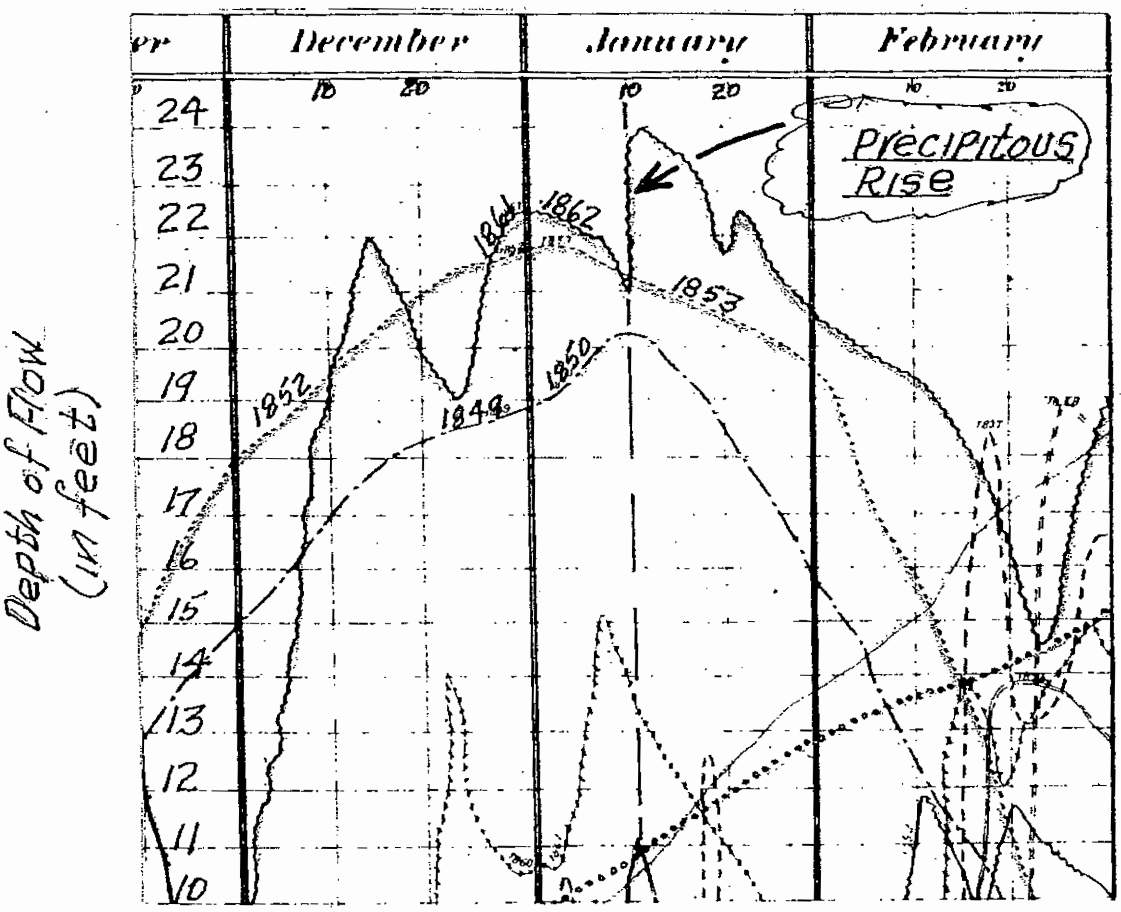
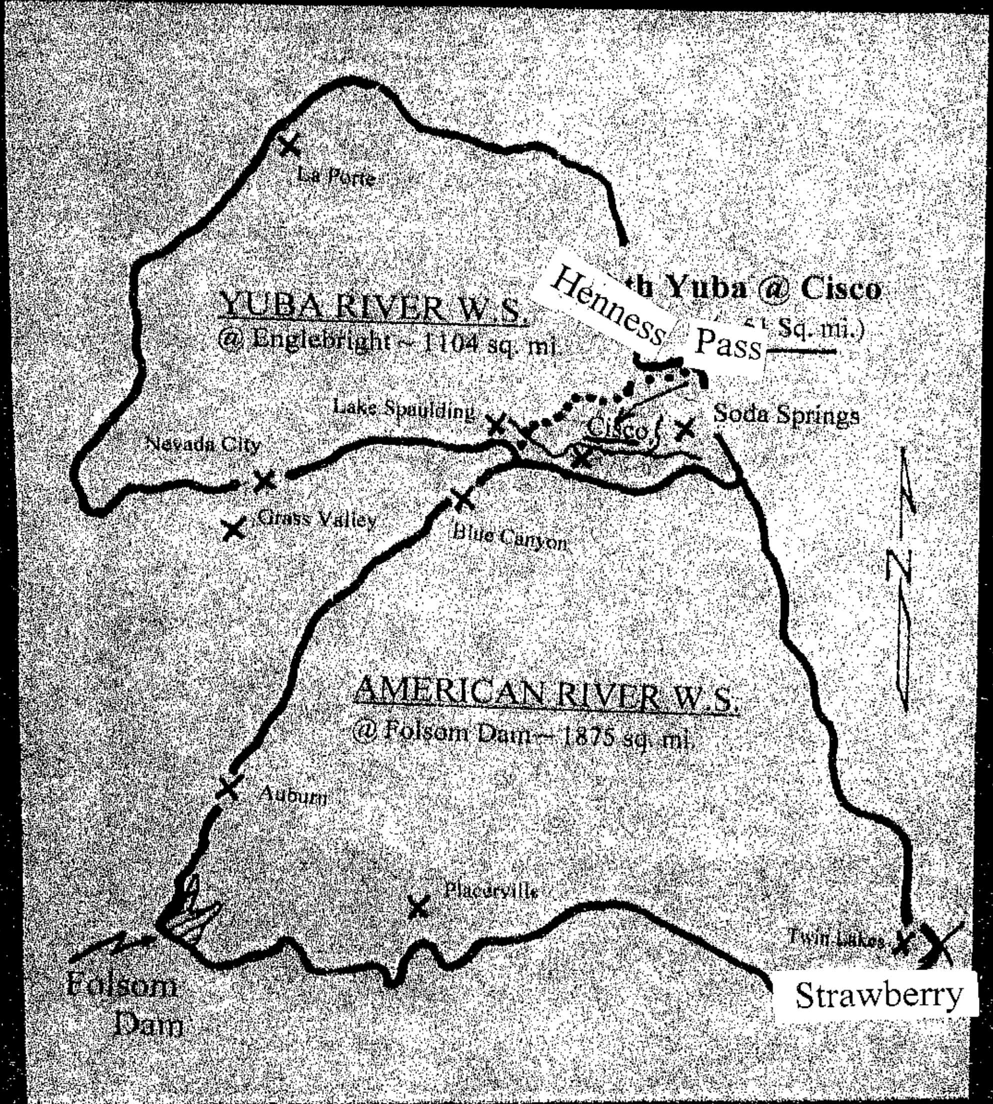
DIAGRAM-B

* ***CHART of THE OSCILLATIONS of THE SACRAMENTO RIVER***
(@ Sacramento) - 1849 through 1862



* **A Segment from the *Chart of the Oscillations of the Sacramento River* by THOMAS M. LOGAN, M.D.**

Comparing Peak Flows--Jan. 1963 with Jan. 1997 on
South Yuba River @ Cisco



Peak Flow 1963: 18,400 cfs
Peak Flow 1997: 15,000 cfs

Note: Difference 3,400 cfs which makes the 1963 peak 23% larger than 1997!

DIAGRAM C