

IS THERE AN ECHO? Dr. Snell's 1861-62 Sonora Rainfall Measurements ARE VALID!

INTRODUCTION: About five years ago Dr. Claude Curran and I decided to look into the seemingly outrageous rainfall measurements that Dr. Perez Snell reported in Sonora during the record floods of December 1861- January 1862. After checking his background, using information we had obtained from the Tuolumne County Historical Society, we decided he was a responsible and respected member of the community certainly qualified to make accurate rainfall measurements. Based upon the additional evidence presented in this report, we are convinced more than ever that his measurements are valid and should receive proper recognition from the scientific community.

The rainy season began around November 10 or 11, 1861. Between then and up to January 14, 1862 he measured 72 inches of precipitation. This was followed by another news report of 102 inches for the season ending on January 23, 1862. In other words 30 inches of rain fell during a 10 day period (January 14th through January 23rd)---only 2.4 inches shy of Sonora's long term annual average of over 100 years. In addition to verifying the 30 inches of rain in 10 days, this investigation will go a long way toward establishing the validity of all of Snell's measurements made during the 1861-62 season. *Sources: Nevada Democrat (Nevada City) Thursday, January 23, 1862 and Tuesday, February 4, 1862.*

SOME DETAILS OF THE INVESTIGATION: Precipitation records for the 1861-62 season are limited. We have daily observations for Sacramento and Grass Valley during the months of December and January along with a couple of daily measurements (January 10 and 11) made at Red Dog located ~ 7 miles east southeast of Nevada City. This information combined with Dr. Snell's Sonora observations, as reported in various newspapers, is all the precipitation data that were available for our analyses.

After months of (off and on) trial and error, we finally decided to follow Dr. Snell's lead and divide the January 1862 precipitation at both Sacramento and Grass Valley into two 10 day periods. The First 10 Days covers January 2 through January 11, 1862. The Second 10 Days extends from January 14 through January 23, 1862 --- the same time frame in which Dr. Snell reported 30 inches of rain in Sonora. These two 10 day periods account for over 95% of the precipitation that fell during the month of January 1862 at

both Grass Valley and Sacramento. Another item of interest: There were two major storms or storm periods in each 10 day period. In each case the heaviest consecutive three days of precipitation that fell at or near the end of the 10 days was from heavy warm storm activity.

In the process of comparing the magnitudes of the two 10 day periods, we began to realize we had discovered a method of analysis with the potential to prove the validity of Dr. Snell's 1861-62 rainfall measurements. According to data, from the Sacramento – Grass Valley region, the precipitation was uniformly widespread and the amounts were proportional. If we divide the 10 day precipitation for the Second Storm Period into the 10 day amount for the First Storm Period, at both Sacramento and Grass Valley the results are surprisingly uniform – 79.6% in Sacramento, 79.9% in Grass Valley. Assuming these same conditions prevailed as far south as Sonora, suggests that reasonably accurate estimates can be made for the missing data at Sonora. For example: We have no measurement of how much precipitation fell in Sonora during the first 10 days (January 2 through January 11, 1862). Using Sacramento daily precipitation as a guide, if we multiply Dr. Snell's precipitation measurement for the Second 10 Day Period (30 inches x 79.6%) we get an estimate of **23.88 inches** for the First 10 Day Period of January 1862 at Sonora.

Following a similar procedure, we can estimate how much precipitation each three day warm storm produced in Sonora. If we divide the first 10 day total for Sacramento (6.55 inches) into the three day warm storm total of 3.16 inches **the result is 48%**. The percentage of the precipitation produced by warm storm activity during the second 10 days **was 38%**. Using these percentages gives the following three day estimates for Sonora: **11.46 inches** for the 9,10 and 11 January 1862 storm and **11.40 inches** for the three day January 20-22, 1862 storm.

An examination of the Grass Valley rainfall record suggests that a minor disturbance produced 1.42 inches of precipitation before the major storm in the 2nd 10 day period (January 15 – 18) got underway. Because this disturbance was a cold northerly type it produced 4 inches of snow in Nevada City. This type of weather pattern extended farther south can produce a similar amount of precipitation in Sonora. A comparison of the precipitation amounts that fell at Grass Valley and Sonora during the transition into the December 1972 cold spell, provides an example.

In Grass Valley during the three day period (December 6-8, 1972), 1.75 inches of precipitation fell compared with 1.69 inches at Sonora. Between the 7th and the 8th the minimum temperature at Sacramento dropped 10 degrees followed by an eight degree decrease in the maximum temperature. A similar but a bit slower trend occurred in Sacramento between January 12th and the 14th, 1862 and January 22nd and the 24th, 1862. *Sources: Climatological Data for California, U.S. Department of Commerce and Microfilm Roll "B" of Dr. Logan's weather observations for Sacramento.*

SERIES OF CROSS-CHECKS: Next, using these estimates we will conduct a series of Cross-Checks to test their validity. *See Exhibit A*

Example No. 1: The First Major Storm of Second 10 Day Period

Step No. 1: 30 inches (measured by Dr. Snell) minus 11.40 inches (estimated warm storm total for January 20, 21 and 22) equals 18.6 inches.

Note: The 1.32 inches recorded under the date of the 23rd does not qualify to be included as part of the warm storm. The guideline that is followed specifies that the warm storm is defined by the 3 heaviest consecutive days of rain. Therefore our analysis will treat 1.32 inches separately and in the same manner as the 1.42 inches of rain that fell on the 14th before the main storm got underway.

Step No. 2: Estimate the amount of rain that fell in Sonora during the period (15th through the 18th).

$$18.6 \text{ inches} - (1.42 \text{ inches} + 1.32 \text{ inches}) = \mathbf{15.86 \text{ inches}}$$

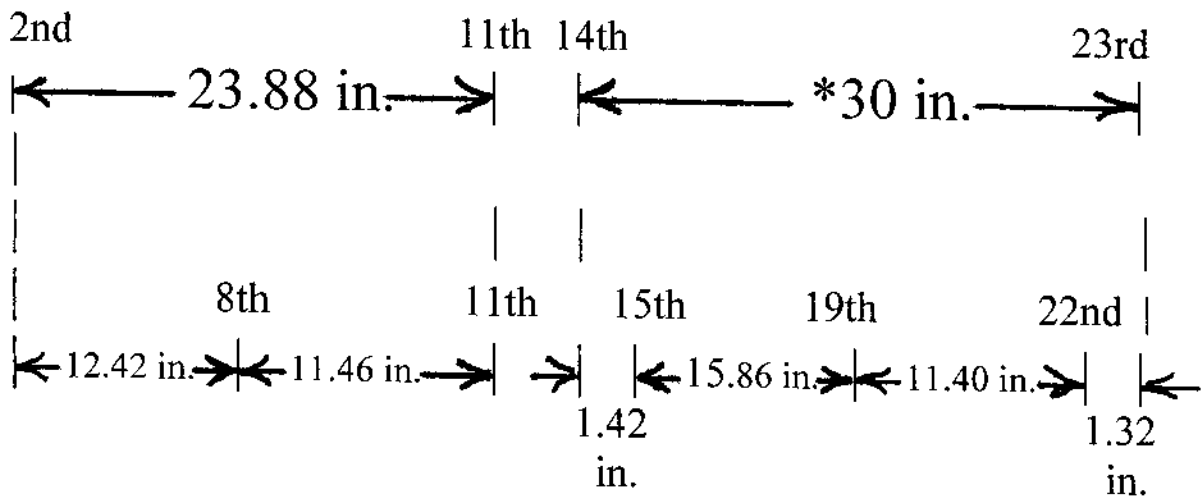
As a result the question that needs to be addressed: **Was the storm beginning late the 15th and lasting through the 18th of January 1862 potent enough to produce ~ 16 inches of rain in Sonora?** A statement on page 7 of the Taylor Brother's book "The Great California Flood of 1862" strongly suggests that the first major storm of the Second 10 Day Period began forming in Southern California on Wednesday the 15th with some rain extending as far north as Folsom and Antioch by the afternoon of the 15th. The statement in the Taylor Brother's book reads as follows: "A nice pleasant rain continued on through the holiday season. It then rained continuously for 15 days and nights. This was followed by a downpour for 24 hours or longer." According to David J. West's diary, on the 16th it

EXHIBIT A

JANUARY 1862 SONORA PRECIPITATION ESTIMATES

First 10 Days

Second 10 Days



Example
No. 4

Example
No. 3

Example
No. 1

Example
No. 2

*Note: Actual amount of precipitation observed by Dr. Perez Snell.

“rained hard all day” at Antioch, and the winds were from out of the Northeast. The Sacramento Union also reported Northeast winds on the 16th in Sacramento. Northeast winds were blowing in response to the developing storm over Southern California. Almost continuous heavy rain was reported at both Antioch and Sacramento on through the evening of the 16th with heavy rain most of the 17th in Antioch. On the *17th, 3.46 inches of rain fell in Sacramento—the heaviest 24 hour total in Sacramento during both December 1861 and January 1862.

*Note: The official state of California record shows a total of 3.15 inches for the 16th and 1.25 inches for the 17th. Hayes Scapbook has .95 of an inch for the 16th and 3.46 inches for the 17th. The two day totals are essentially the same, but other storm information indicates the daily distribution shown in Hayes Scapbook is correct.

According to a gentleman that spent most of the afternoon of the 16th in Folsom, telegraph reports from the mountains 30 minutes before he left to return to Sacramento said it was snowing from Placerville to Strawberry (near the summit). As he was about to leave the telegraph reports had changed and were reporting rain from Placerville to the summit. This development along with the heavy rain and an extended period of falling barometric pressure readings made by Dr. Thomas Logan in Sacramento, indicate that a weather front was being forced northward by a storm center moving in a northerly direction---up the Central Valley of California. Dr. Logan’s barometer was reading 30.04 inches at 7AM on the 15th of January 1862. From there it continued to drop until it reached a low point of 29.45 inches at 9PM on the 17th of January 1862. It is interesting to note that the lowest barometric pressure Mr. Attwood recorded in Grass Valley during the month of January 1862, occurred on the 17th at 4 PM. Snow was reported in the foothills around Oroville and at Laporte late the 17th. *Sources: The Laporte Messenger and the Weekly Butte Record of January 18, 1862, Grass Valley National February 6, 1862, page 2 and Microrfilm Roll "B" of Dr. Logan’s weather observations for Sacramento.*

After a slight rising trend on the 18th Sacramento’s barometric pressure remained almost steady on the 19th. An examination of the rainfall records for Grass Valley and Sacramento indicate that the rain ended in Sacramento on the 17th but it kept pouring in Grass Valley with a 24 hour total ending at noon the 18th of 3.75 inches. By noon the 19th another .43 of an inch had fallen in Grass Valley---still dry in Sacramento. This suggests, along with

the reports of snow at Laporte and in the foothills around Oroville late the 17th, that the weather front had *stalled in the Northern Sierra of California. From there it extended southward along the west side of the Central Sierra into a wave (or low pressure center) forming on the front somewhere in Southern California--- possibly in the vicinity of Santa Barbara. A development of this type along with the mountainous terrain would have halted the eastward progress of the front. Considering the tropical and subtropical origin of the stalled air mass along with the moderate to strong South-Southeast winds blowing at Antioch on the 17th and in Sacramento late the 17th and the morning of the 18th, substantial amounts of rain would have continued to fall in foothill locations such as Sonora. *See figure 1.*

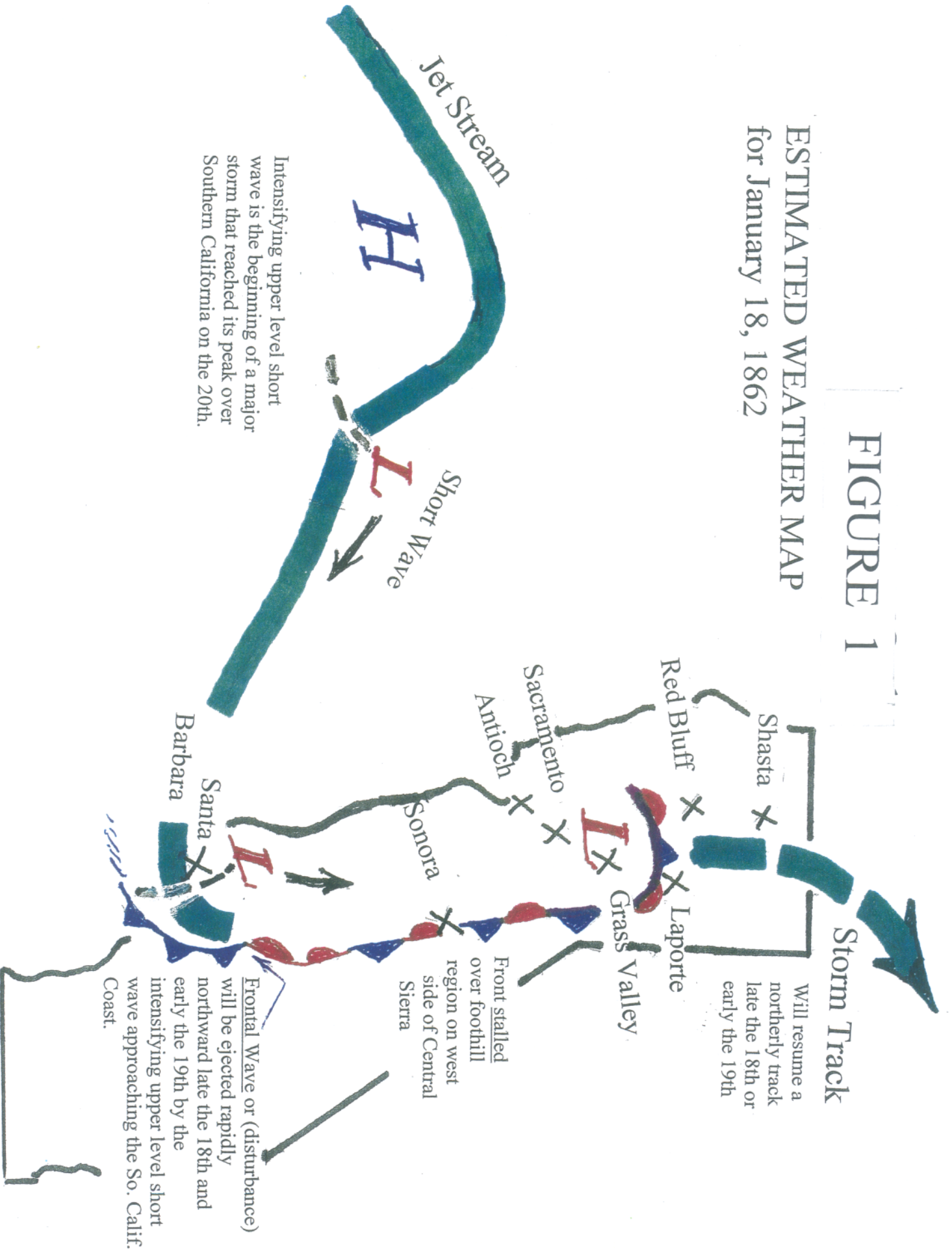
**Note: This conclusion is strongly supported by the following article that appeared in the Weekly Butte Record of Saturday January 18, 1862.*
WEATHER—It has rained incessantly during the past week and at this time—6 o' clock Friday afternoon, continues with unabated vigor. It has been snowing steadily in the mountains and foothills, consequently Feather River is about on a stand. Should the snow melt etc.--.

To bolster this scenario, is there any evidence that a wave was actually forming on the weather front in Southern California on the 18th? We are confident a wave (or relatively small low pressure center) was developing on the 18th because a blustery disturbance moved into Northern California late the 19th. Heavy rain was reported in Antioch, Sacramento, Grass Valley and Red Bluff. From the evening of January 19th through the morning of the 20th in Sacramento, Dr. Logan reported one of the strongest periods of wind during the entire flood series of December 1861 and January 1862. In addition there was an overnight barometric pressure drop of .07 of an inch in Sacramento.

If this storm was developing in Southern California on the 18th what caused it to move so rapidly into Northern California on the 19th? Records show that a major storm had engulfed Southern California around the 20th. The small time interval separating these events is consistent with an intensifying surge of upper level energy approaching the Southern California coast from a West-Northwest to Northwesterly direction early the 19th. Without a doubt this would have driven a frontal wave (say in the vicinity of Santa Barbara) rapidly northward into Northern California by late the 19th. More on this later.

FIGURE 1

ESTIMATED WEATHER MAP
for January 18, 1862



We need to examine the big picture in more detail. How do you explain the huge difference (~ 8 inches) in three day rainfall amounts (late the 15th through the 18th) between the Grass Valley observed amount and the Sonora estimate of ~ 16 inches. *Refer to figure 1.* When the storm that developed in Southern California on the 15th moved northward up the Central Valley of California on the 16th and 17th the winds aloft in the vicinity of Grass Valley and Nevada City were undoubtedly from the Northeast. The downslope heating caused by this scenario would substantially reduce the amount of rain that would have fallen in the Grass Valley area. There is also evidence that the storm's northward progress was decreasing as it entered the Sacramento-Grass Valley region. This would have extended the period of Northeast flow. Being that Sonora is ~ 80 air miles south of Grass Valley it was not subjected to as long a period of Northerly winds. Another comparison suggests that the geographical location of Grass Valley makes it more susceptible to the effects of downslope heating. In our opinion one reason this occurs is because the Sierra ridgeline (just east of the Nevada City-Grass Valley area) makes a significant bend toward the northwest.

ADDITIONAL EVIDENCE SUPPORTING DR. SNELL'S 1861-62 SONORA RAINFALL MEASUREMENTS: At the California Extreme Precipitation Symposium held at Davis in June 2012, Dr. David Curtis cast doubt on the veracity of Snell's measurements and then added that he didn't think there was any streamflow information that would support such high rainfall values. The following news reports from the Sacramento Union sheds some light on the issue raised by Dr. Curtis:

WEBSTER'S STATION, January 16, 1862 -- 8 PM: It has, rained hard all day, and the snow is melting. The river is raising fast. The ravines from the mountains are like swollen rivers.

Note: As near as we can determine Webster's Station was located at or near Kyburz ~ 35 miles east of Placerville at an elevation of ~ 4000 feet.

PLACERVILLE, January 16, 1862 -- 8 PM: It has been raining here with out intermission all day. The river is rising very fast. *So. Fork American Riv.*

FOLSOM, January 16, 1862 -- 8 PM: It has rained here all day. Willow Creek and Alder Creek are now higher than they were ever known to be before. The first bridge on Willow Springs was carried away this evening.

The water did not, come up to the bridge at the late freshet. American River at this point raised 5 feet since morning and is still rising fast.

FOREST HILL, January 17, 1862 (Source: Forest Hill Courier January 22, 1862): The river on Friday afternoon -- January 17 -- was 12 feet higher than any previous flood and 40 feet above low-water mark. *Refers to Middle Fork of American River. News reports verify that many homes were flooded.*

Note: In evaluating the above reports remember this was the general area where gold was discovered in 1848. This suggests that some of the 1862 residents were present during the epic floods of 1849-50 and the early 1850s.

SONORA, January 17, 1862 (Source: Sonora's Union Democrat, January 18, 1862 edition): According to Dr. Snell's gauge, 81.564 inches of water had fallen up to 9AM yesterday morning, since the 10th of November. *This means that 9.564 inches had fallen in Sonora since the 13th of January.*

CONCLUSIONS: There is good reason to believe that upwards of 16 inches of rain fell in Sonora on the 15th through the 18th. The report from Sonora suggests that over 8.0 inches of rain had fallen by 9AM January 17th and there was still about 36 hours to go until late the 18th. We are confident that the weather front (of tropical and subtropical origin) which stalled in the foothill region of the Central Sierra during this period of time would have produced enough additional rain to bring the Sonora total **close to 16 inches.**

Example No. 2: The Second Major Storm of The Second 10 Day Period

As indicated in *Exhibit A* of this report the estimated precipitation that this storm pattern produced in Sonora was **11.40 inches**. Our analysis of this storm indicates that the precipitation came in two main surges. The first surge came when a disturbance located over Southern California on the 18th, was forced rapidly northward late the 19th and early the 20th by an intensifying upper level short wave from the Pacific. *See figure 1.* By midday the 20th the warm front associated with this development had produced 3.6 inches of rain in Grass Valley along with a three degree rise in temperature at Sacramento capping a three day warmup of 10-12 degrees. After ~ 24 hours in which the rain had noticeably tapered off, a very active cold front approached from the west. Early the morning of the 22nd David

J. West reported a South wind with some rain in Antioch. **A short time later* there was a very hard gale from the west--- indicating a frontal passage.

*Note: *A short time later* is supposition on our part and is based upon the wind shift from Southeast toward the Southwest observed by Dr. Logan in Sacramento during the morning and at noon by a gentleman traveling the ridge leading from Nevada City to Washington. He also said it was six to eight degrees cooler the following day.

In Sacramento the barometer dipped to the low point of the three regular daily readings with a *2 PM value of 30.17 inches. The rainfall in Grass Valley ended shortly after dark on the 22nd. Since noon the 21st, 4.62 inches of rain had fallen in Grass Valley. **This was the end of the most devastating series of flood producing storms known to have occurred in California!** Sources: *Nevada Democrat Thursday evening, January 23, 1862*, *Grass Valley National (Thursday, January 23, 1862)*, Figures 1, 2 and 3 in *Lake Sacramento, David J. West's Diary and Microfilm Roll "B" of Dr. Logan's observations.*

*Note: Undoubtedly the barometric pressure fell to its lowest point during the frontal passage that occurred in Sacramento before noon.

DISCUSSION OF RESULTS: During the first surge of storm activity, Grass Valley received 3.6 inches of rain. This storm had moved rapidly out of Southern California following a path similar to its predecessor of the 15th through the 18th. This indicates that a comparison of the precipitation amounts produced by this storm at Grass Valley and Sonora should also have similarities traceable to its immediate predecessor. In other words there was more downslope heating. A news report from Sonora's Union Democrat, January 18, 1862 edition, said that Dr. Snell measured 9.564 inches of rain between January 13th and 9AM January 17th. Using this report, estimate and compare the amount of rain that fell in Grass Valley and Sonora during the period January 15th through 9AM the 17th.

Estimate how much rain fell in Grass Valley from January 13th through January 17th at 9AM:

Step No. 1: Estimate the amount of rain that fell in Grass Valley during the period January 15th through January 17th at 9AM.

Jan. 15: .03 in.-----observation time: Noon
 " 16: 1.28 in.
 " 17: 2.01 in. (2.30 in.- .29 in.) 2.30 in. divided by 8 = .29 in.
 3.32 in.

Step No. 2: Add 3.32 in. and 1.42 in. (Jan. 14th) = **4.74 in.**

Step No. 3: What percentage of the total amount of rain (4.74 in.) that fell in Grass Valley, fell during the period January 15th through January 17th at 9AM ?

3.32 in. divided by 4.74 in. = **70 %**

Step No. 4: Assuming the rainfall amounts at Grass Valley and Sonora were proportional, estimate the amount of rain that fell in Sonora during the period January 15th and January 17th at 9AM:

9.56 in. x .70 = **6.69 in.**

Step No. 5: Compared with Sonora what percentage of the rain during this period fell in Grass Valley ?

3.32 in. divided by 6.69 in. = **50%**

As we pointed out earlier downslope heating was occurring in the Grass Valley-Nevada City area due to two successive storms moving out of Southern California up the Central Valley and into Northern California. Because of this development it is assumed that during the period controlled by this weather pattern (January 15th through January 20th) Grass Valley will receive ~ 50% as much rain as Sonora. It will also be assumed that during the remainder of the Second 10 Day Period the comparative rainfall amounts of Grass Valley and Sonora will be equal.

Using the above criteria, we will conduct the following tests:

Test No.1: Compare the results of this test with the Second 10 Day total of 30 inches observed by Dr. Snell during the period January 14-23, 1862.

Step No. 1: Using the Grass Valley precipitation record, calculate how much rain fell in Grass Valley from the 15th through the 20th: **11.39 inches**

Step No. 2: Determine the total amount of precipitation remaining in the 10 day period: **6.74 inches**

Step No. 3: Using the Grass Valley rainfall information from Steps No. 1 and 2, follow the guidelines listed above and estimate the total 10 day precipitation that fell in Sonora:

$11.39 \times 2 = 22.78 \text{ in.}$ --- Because of the downslope winds in Grass Valley, it is estimated that twice as much rain fell in Sonora.

Total 10 Day Estimate : $22.78 \text{ in.} + 6.74 \text{ in.} = 29.52 \text{ inches.}$
Dr. Snell's 10 Day observation from *Exhibit A*: **30.00 inches**

Test No. 2: Calculate the amount of rain that fell in Grass Valley during the period January 15th through January 18th. Then using the criteria outlined above, estimate how much rain fell in Sonora. Compare these results with the Second 10 Day Period estimate for late January 15th *through January 18th. We also included the .43 of an inch listed under the 19th because evidence indicates it was part of the storm ending late the 18th.

**Note: The end of the period shown on Exhibit A is the 19th. It represents the midday beginning of the rainfall amount included in the three day total for the warm storm of the 20th and 21st ending at noon on the 22nd.*

Step No. 1: Rainfall in Grass Valley (15th through Jan. 18th): **7.79**

Step No. 2: Estimated rainfall in Sonora (' ') = $2 \times 7.79 \text{ in.} = 15.58 \text{ in.}$

Step No. 3: Compare results of *Exhibit A* and Cross-Check Series

Exhibit A Value: **15.86 inches**
Cross-Check Series: **15.58 inches**

Test No. 3: Using Grass Valley data estimate the three day rainfall at Sonora for the 20th, 21st and 22nd. Then compare the results with the *Second Major Storm of the Second 10 Days in Exhibit A.*

Step No. 1: Calculate Cross-Check value: *Because downslope winds were blowing in the Grass Valley-Nevada City area late the 19th and the morning of the 20th* you need to double the value of the Grass Valley rainfall amount listed under the 20th:

$$3.6 \text{ in.} \times 2 = 7.2 \text{ in.} + 4.0 \text{ in. (total for 21st \& 22nd)} = \mathbf{11.2 \text{ inches}}$$

Step No. 2: Compare results with the estimate contained in *Exhibit A*

Exhibit A Value: **11.4 inches**

Cross-Check Series: **11.2 inches**

Heavy rain falling late the 19th and the forenoon of the 20th in Sonora is consistent with the flood damage reported in Placerville the night of the 20th. The Sacramento Daily Union, Monday January 27, 1862 had this to say about Placerville: The freshet which visited this place on Monday night (the 20th) is described as being very severe and disastrous. A portion of the Main Street was flooded, the foot bridge at Bedford Avenue was destroyed, and much damage was done to stores. Much injury to property in upper Placerville was also occasioned.

Note: This incident occurred at almost the end of this record breaking series of floods. The fact that it caused so much damage suggests that it may have been the largest to occur in Placerville, during the 1861-62 series.

DISCUSSION OF RESULTS: The test results strongly supports the preliminary conclusions listed in *Exhibit A*. However the assumption indicating that the remainder of the precipitation, not associated with storm activity from Southern California, fell in equal quantities at both Sonora and Grass Valley needs more explanation and review.

An investigation of the relationship between the comparative amounts of precipitation that fall at Grass Valley and Sonora show a broad range of possibilities. So far we have identified two weather patterns or sequence of events that produce similar amounts of precipitation at both Grass Valley and Sonora. A cold frontal passage with enough moisture to produce up to 2 inches of precipitation at both Grass Valley and Sonora along with a Northerly wind shift at Sacramento and a two day cooling trend of 8-12

degrees describes the first weather pattern. The description of the beginning of the December 1972 cold wave meets most of these requirements. *See top of page three of this report.*

The second weather pattern requires locating the *center of the extreme oscillations that defines the relationship between the comparative amounts of rain that fall at Grass Valley and Sonora during heavy warm storm activity.

*Note: The center is defined as the storm pattern that produces similar amounts of rain at both Grass Valley and Sonora.

The following case histories give a rough idea of how much the comparative rainfall amounts between Grass Valley and Sonora can vary depending on the weather pattern:

Case No. 1: Flood Producing Storm of January 30 – February 1, 1963. A Jet Stream from the Pacific loaded with subtropical air *broke through underneath a blocking high pressure area over Alaska bringing widespread heavy rain to most of the northern half of California. The heaviest three-day amount recorded at Grass Valley was 10.59 inches with 8.59 inches in Sonora. **Result: 81% as much rain fell in Sonora.**

*Note: The official weather maps show the breakthrough of the Jet Stream occurring only several hundred miles west of the Oregon-California border.

Case No. 2: On January 15 through January 20, 1862, a persistent Jet Stream (storm track) extended northward out of Southern California into the Central Valley. A pair of potent storms (one after the other) moved into Northern California. Heavy rain eventually spread to the Oregon border. From the 15th through midday the 20th, 11.39 inches of rain fell in Grass Valley compared with an estimated 22.78 inches in Sonora. **Result: 50% as much rain fell in Grass Valley.**

Case No. 3: So far our research has not identified any of the major flood producing storms of the 20th century with similar amounts of rain at both Grass Valley and Sonora. A sample of 10 cases comparing 10 day amounts overwhelmingly favored Grass Valley. We checked a half dozen cases with three day amounts and the results were the same. At the present time the only case we know of is the Super Flood producing storm of January 9, 10

and 11, 1862. **Results: It is estimated that similar amounts of rain fell at both Grass Valley and Sonora.**

There is ample evidence to show that a westerly Jet Stream broke through, underneath a blocking Alaskan high pressure area, into California. By the afternoon of January 8, 1862, Southerly winds at both Antioch and Sacramento showed a sharp increase in speed. In addition: The temperatures in Sacramento were on the rise, the barometric pressure was beginning to fall and by then it was raining hard in both Sacramento and Antioch. But the breakthrough occurred at a significantly lower latitude. This suggests that the difference in rainfall amounts between Grass Valley and Sonora would be less when compared with the January 30, 1963-February 1, 1963 case described above. A comparison of our estimated three day amount (**11.46 inches**) for Sonora taken from *Example No. 3, Exhibit A*, matches up quite well with the heaviest three day amount of **12.2 inches** actually observed at Grass Valley during the same period of time.

TABLE 1

SUMMARY OF COMPARISON OF ESTIMATED SONORA
PRECIPITATION TOTALS: Cross-Check Series VS. Exhibit A

Second 10 Day Total (January 14th through January 23rd)

Exhibit A: **30.00 inches** (as measured by Dr. Snell)
Cross-Check Series : **29.52 inches**

Comparison For Period (January 15th through January 18th)

Exhibit A: **15.86 inches**
Cross-Check Series: **15.58 inches**

Comparison For Three Day Period (noon the 19th through noon 22nd)

Exhibit A: **11.4 inches**
Cross-Check Series : **11.2 inches**

CONCLUSIONS:

1. The results of our detailed analyses of the weather patterns that prevailed up and down California during the 10 Day Period (January 14 through January 23, 1862) are supportive of the 30 inches of rain Dr. Snell observed in Sonora during this same period of time. Confidence in our results is high because two valid methods of analysis yielded similar answers. *See Table 1 for a summary of the estimated rainfall comparisons for Sonora.* Added support came from various weather reports and reports on streamflow conditions in the general area---usually found in area newspapers.
2. Even though the quantity of data was limited, we do not feel that it was a factor that would have altered our conclusions. Supplements No.1, 2 and 3 combined are a testament of the good quality of the precipitation data available for these analyses. Considering the distances involved and the variations in the terrain, we think our findings are remarkably consistent.

Note: Without the Grass Valley data this type of analysis would not have been possible. I found a copy of the Grass Valley precipitation record in the California State library over 50 years ago while doing historical storm research on the December 1955 flood in the Yuba City area. This information became available to other researchers when our book Lake Sacramento was published in late 2005.

3. As you can see by looking at Exhibit A, there is only one Major Storm segment left to analyze. This has been completed and has been labeled Supplement No. 4: Evidence Supporting **12.42 inches** of Precipitation Reported in **Example No. 4 of Exhibit A.** **The conclusions reached in Supplement No. 4 are supportive of the results obtained from our examination of the other three major storms or storm periods.**
4. Two unique and specialized predictive models are largely responsible for the consistency of the comparative Sonora precipitation estimates shown in **Table 1.**
 - a. **Model No. 1: The main contribution of this model can be traced to the remarkable uniformity and proportionality of the widespread precipitation patterns that were the hallmark of the Major Storms or Storm Periods of January 1862. The rainfall values for the**

month of January at Sonora were derived from this model. *See Exhibit A.*

- b. **Model No. 2:** The results, of the interaction of a pair of rare flood producing storms moving northward out of Southern California, with the unique geographic features of Northern and Central California, were beneficial. It has enabled us to develop a valid relationship between Grass Valley and Sonora rainfall during heavy warm storms in which heating from downslope winds reduced the rainfall in Grass Valley to ~ 50% of what would have fallen in Sonora.

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and
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June 1, 2014

Updated and Expanded to Include
Supplements 3, 4, 5 and 6.
May 28, 2015

SUPPLEMENTS

No.1: Revising Jan. 9-11, 1862 Rainfall Estimate For Red Dog

No. 2 : Correlation Between Red Dog and Sonora Rainfall
(Jan.9-11, 1862)---Using February 1986 Storm Data

No. 3: Correlation Between Red Dog and Sonora Rainfall
(Jan. 9-11, 1862)---Using Estimated Jan. 1862 Data

No. 4: Evidence Supporting The Estimated 12.42 inches of
Precipitation listed under Example No. 4 in Exhibit A

No. 5: Atmospheric Rivers Impact On Record Jan. 1862
Floods in No. California ---LIKELY OVERBLOWN

No. 6: Almost Simultaneous Record Floods On Two Major
California Rivers Approximately 500 Miles Apart