HISTORY OF WEATHER OBSERVATIONS
Sonoma, California
1850 – 1911

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Prepared By
Glen Conner
9216 Holland Road
Scottsville, Kentucky

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Several people contributed to the research for this study. Among them was Diane Smith of the Depot Park Museum of the Sonoma Valley Historical Society who readily gave of her knowledge of Sonoma history. She was most helpful in providing photographic records.

Most of all there must be acknowledgement of the efforts of the observers who produced the climate record that we now treasure as a key to understanding the climate. Those who preserved those records were important as well.

To you who are reading this, thanks for your interest in preserving the history of weather observations.

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HISTORY OF WEATHER OBSERVATIONS
Sonoma, California
1851 —1911

Glen Conner
Kentucky State Climatologist Emeritus

INTRODUCTION

When Dr John Campbell arrived in Sonoma, the town had already experienced several historic events. Its Mission San Francisco Solano de Sonoma was established in 1823. General Vallejo, the military commander of the northern area of Mexico, founded Sonoma in 1835 as a buffer against the Russian colony at Fort Ross, located a few miles away. In 1846, the flag of the California Republic was first raised over Sonoma as a result of the Bear Flag Revolution.

In July 1846, the first United States Flag was raised at Sonoma by an officer who came ashore from a U.S. Frigate, the Portsmouth, that was anchored in the harbor.

> I have the pleasure to announce, that the Flag of the United States, was, on the 7th inst hoisted at Monterey, and will I expect this day, be substituted for the revolutionary flag recently hoisted at Sonoma.

The U.S. Army subsequently occupied the town. The Post's Return dated April 1847 reported the arrival of the 7th Regiment of the New York Volunteers commanded by Capt J. E. Brackett.

> The company (C) arrived at Sonoma April 4 1847 from San Francisco and took post at the public Barracks as the Garrison of the place.

The Return reported that the organization included two officers and 59 enlisted men.

The Post's Return[1] for Sonoma for September 1849 was the first to mention the presence of a surgeon. That first surgeon in Sonoma was Dr John S. Griffin who arrived on 18 September 1849 as a member of the staff of the U.S. Army's 1st Dragoons. He had accompanied the unit on its march from Santa Fe, through the desert landscape of Arizona, to California. He was on the battlefields tending to the wounds and other medical needs of the Dragoons. He had other duties as well. On 5 June 1847, he had made the first weather observations in Los Angeles while

[1] The term "Returns" was the title of monthly reports from the Post that accounted for its personnel by rank and included remarks about their illness or absence.

assigned to the same 1st Dragoons. However, so far as is known, he did not record the weather after they moved to Sonoma.

In November 1850, Dr John Campbell was added to the staff as an Assistant Surgeon. The primary responsibility of the surgeon was the physical welfare of the troops but he also was responsible for making weather observations. To the long list of historic firsts in Sonoma, Dr Campbell added another — the first weather observations in Sonoma. He entered his observations on the U.S. Army Form 2 Meteorological Register and, at the end of the November 1850, he forwarded it (Figure 1) to the Surgeon General's Office in Washington.

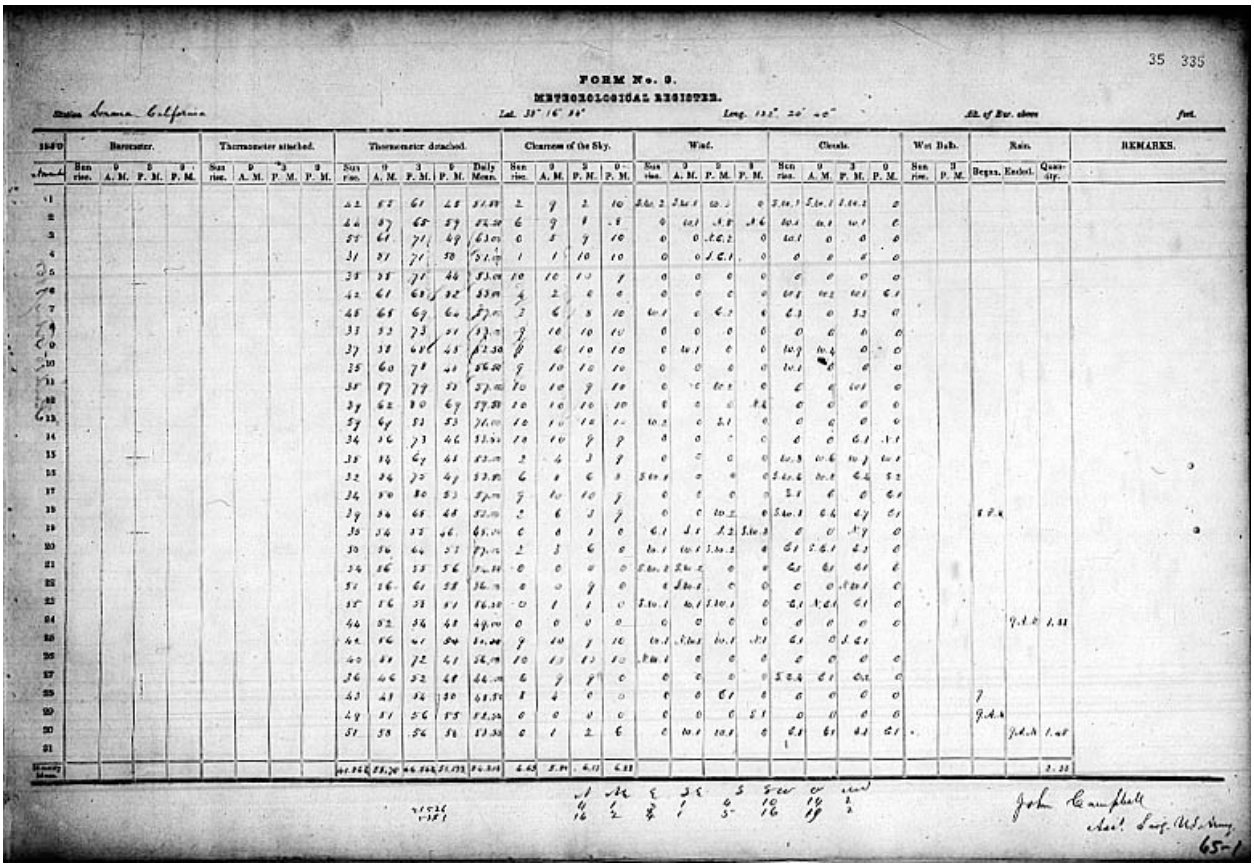


Figure 1. First Weather Observations from Sonoma, November 1850
Source: National Climatic Data Center

Weather observation made by the Post Surgeon was not a new idea. The Army Surgeon General, Joseph Lovell, had initiated efforts to create a climate network in 1817. By 1819, the network was collecting daily weather observations from Army Posts located in the then 22 states. The observers in that network were the Surgeons at the Posts. Their reports were forwarded to the Surgeon General's office in Washington. Surgeon General Lovell stated clearly that the purpose of the network was to determine if climate change was then occurring.

> On the question whether in a series of years there be any material change in the climate of a given district of country; and if so, how far it depends upon cultivation of the soil, density of population, &c, the most contradictory opinions have been advanced. While one contends, that as population increases and cultivation extends the climate becomes warmer, another is equally convinced that it becomes colder and a third, that there is no change in this respect.

Before any determination about climate change could be made, a base line of data had to be collected. It was essential that those data be collected before the "natural" climate was altered by the intrusion of human activities. Surgeon General Lawson noted in 1840 that the place to do that was on the frontier.

> ….the hope is indulged that the medical corps of the army, more especially as many of the military posts afford an opportunity of making observations in regions still in a state of nature, will ere long be furnished with the means of prosecuting more extensive researches, and of keeping pace with the progress of Science.

Location

Sonoma was incorporated in 1850 and was the original county seat of Sonoma County. The first location for all observations made by the Army in 1850 and 1851 was at the Sonoma Barracks on the Plaza in Sonoma. The second location was at the residence and ranch of Robert Hall beginning from 1882 and continuing to 1911. The Hall Ranch was primarily orchards located along the Sonoma Creek (Figure 2).

Figure 2. Looking North along Sonoma Creek
Source: Depot Park Museum, Sonoma

In addition to Robert Hall's observations, rainfall measurements were made at the Gundlach-Brundshu Winery from September 1909 through March 1911. The disposition of those records is unknown.

After 1911, observations were not resumed until 1951 when Lawrence W. Dickey became the observer at his home in Sonoma for the Weather Bureau.

Record

The Army's weather record at Sonoma continued until they abandoned the location. There followed an eleven-year period of time without weather observations being taken in any official network. In October 1862, observations resumed for a five-month period. Almost twenty years followed after that with no observational record.

When observations were resumed in July 1882, the location of the observation site had changed only slightly. The recipient of the data had changed. The U.S. Army's Signal Service

was created in 1871 by Congress to organize and operate a climate network. It began with fifty-two weather stations but by 1884 received data from 458 weather stations, one of which was a Voluntary Observer Station at Sonoma.

The Sonoma station contributed to contribute to the climate record until 1911. The observations ended and were not begun again until 1951.

During the entire period of record, the growth of the town did not spawn the urbanization that would have contaminated the record with the heat that large cities generate. Even with the breaks in the record, it represents an important location for studies of long-term climate variability.

Goal of the Study

The goal of this study was to document the weather observational history of Sonoma, California. The climatic data, and information from the observations made there, are readily available for the entire period of record. They may be accessed through the National Climatic Data Center, the Western Regional Climate Center, and the State Climatologist of California. The challenge of this study was to identify the role of Sonoma in the development of a federal weather observational program and where it fit in the route that followed from the Army Surgeons, the Signal Service Observers, and the Weather Bureau meteorologists, to the current National Weather Service Forecasters and their extensive observational and forecast network of today.

LOCATION OF OBSERVATIONS

Surgeon General Years 1850-1851

The first observations were made at Sonoma Barracks. The barracks (Figures 3 and 4) was located on the northwest corner of the intersection of 1st and Spain Streets facing the Sonoma Plaza.

Figure 3. Sonoma Barracks, 2006
Source: Author

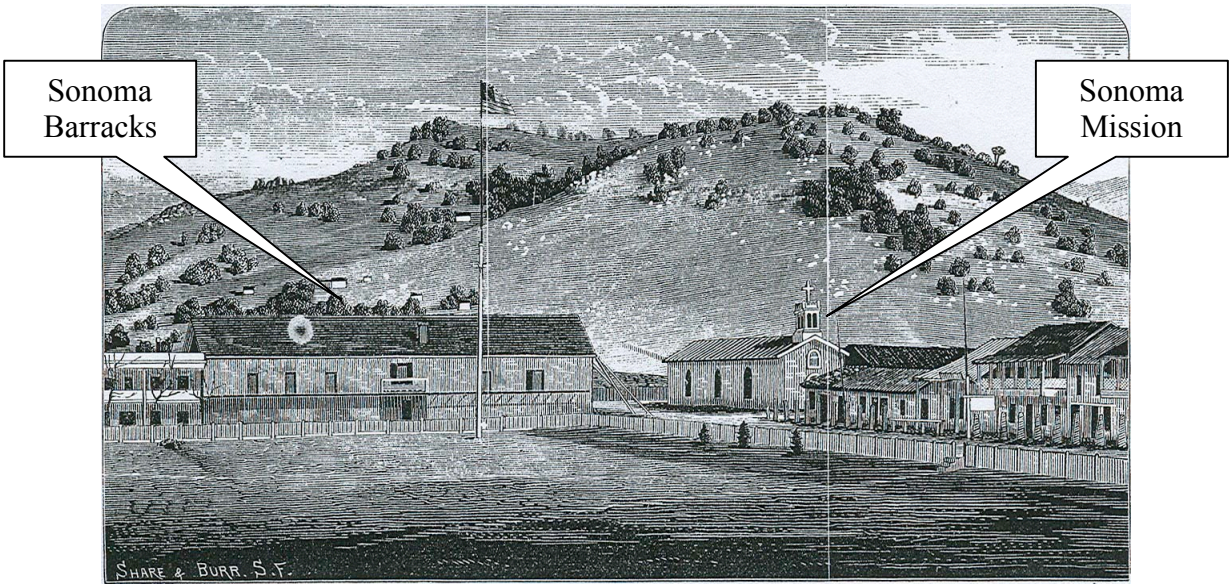


Figure 4. Sonoma Barracks 1873
Source: Menefee, 1873

The original Barracks was constructed to house Mexican soldiers under General Vallejo in 1840-1841. It was used for that purpose until 1844. Tays included a description of the Barracks and the other structures on the north side of the Plaza.

> Vallejo's building and premises which occupied an entire block of almost six hundred feet facing the plaza on its north side. At the east end of the block was the two-story adobe barracks, 110 feet long and 50 feet wide. The eastern half of the barracks, contained a large assembly hall 52 feet long and 45 feet wide; and along the front of the second story was a five –foot balcony extending the full length of the building. A high adobe wall about 25 feet long, with a wide gate, connected the western end of the barracks with the eastern end of the General's home. Vallejo's mansion was also a two-story adobe, in the form of an L. The main wing, about 130 feet long, faced south and, like the barracks, had a balcony along the front. The other wing projected from the west end toward the north, and was about 100 feet long, both wings being 50 feet wide. At the western corner formed by the intersection of the wings, rose a square tower four stories high, and around each of the three upper stories was a narrow balcony used by the sentries on guard. Another high adobe wall, 150 feet long,, in which was a wide gate, connected the west side of the tower with the east end of Salvador Vallejo's home, which stood at the western end of the block.
>
> Across the street, east of the barracks, stood the church and mission buildings of San Francisco Solano.

A part of the U.S. Army's 7th New York Volunteers[2] were the first U.S. Army unit to be stationed in Sonoma. About 1,000 men of that unit came to California from New York by ship on a trip that took them around the Horn. A small company of them reported, in their Return for the month, that they had arrived in Sonoma from San Francisco on 4 April 1847 and had occupied the Barracks.

When they arrived, they had a hospital steward but did not have a surgeon assigned. The responsibility for making weather observations was assigned by the Army Surgeon General to the surgeons. Because no surgeon was present, the presumption is that no meteorological instruments were available to the steward who was a Private.

[2] Known as Stephenson's Regiment

The 1st Dragoons, who had endured Kearney's trek from Santa Fe to California, moved into Sonoma on 3 May 1849 and replaced the New York men. This replacement unit was commanded by Captain Andrew. J. Smith[3]. They did not make weather observations.

Dr Campbell of the 1st Dragoons arrived in November 1850 with his weather instruments and immediately began to make observations. The location of the meteorological instruments was recorded as 38˚ 16' 54" N and 122˚ 20' 40" W. The method for determining the location was not recorded. Even so, one can estimate their location because the instructions required the thermometer to be mounted on the north side of a building, preferably in continual shade under an overhanging roof. The Barracks had an overhanging roof (Figure 5) that sheltered the north side of the building It seems likely the thermometer would have been hanging on the first floor wall that faced the courtyard.

Figure 5. Courtyard in Read of Sonoma Barracks
Source: Author, 2006

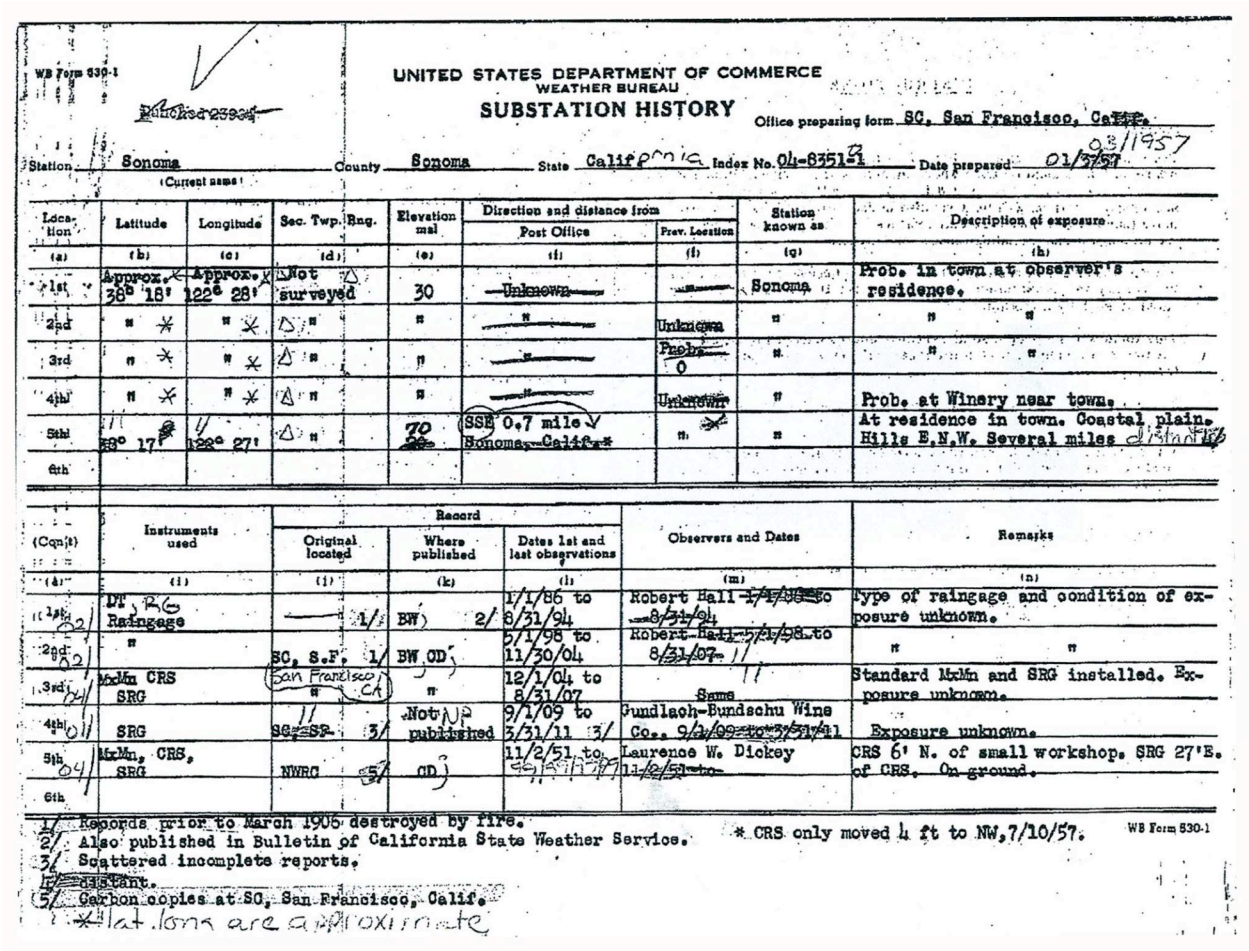
The Global Positioning System (GPS) location of the estimated location was 38˚ 17' 40" N and 122˚ 27' 24" W at an elevation of about 84 feet above mean sea level (MSL).

The Army Post in Sonoma was closed in January 1852 according to Parmelee. He stated that the surplus blankets, leather goods, furniture and uniforms were sold to the local citizens.

[3] A. J. Smith would become a Major General in the Confederate Army during the Civil War

The Signal Service Years 1882-1892

The observations resumed in 1882. As in the previous description of location, this one's precise location was not recorded. It was just given as being at Sonoma. The Form 530-1 Substation History for Sonoma prepared by the Weather Bureau on 1 January 1957[4] (Figure 6) approximates the location as 38˚ 18' N and 122˚ 28' W at an elevation of 30 feet MSL There was the caveat that it was not a surveyed position and was probably at the observer's residence.[5]



WB Form 530-1

UNITED STATES DEPARTMENT OF COMMERCE
WEATHER BUREAU
SUBSTATION HISTORY

Office preparing form SC, San Francisco, Calif.

Station Sonoma (Current name) County Sonoma State California Index No. 04-8351-1 Date prepared 01/3/57

Location (a)	Latitude (b)	Longitude (c)	Sec. Twp. Rng. (d)	Elevation msl (e)	Direction and distance from Post Office (f)	Prev. Location (f)	Station known as (g)	Description of exposure (h)
1st	Approx. 38° 18'	Approx. 122° 28'	Not surveyed	30	Unknown	—	Sonoma	Prob. in town at observer's residence.
2nd	"	"	"	"	"	Unknown	"	" "
3rd	"	"	"	"	—	Prob. 0	"	" "
4th	"	"	"	"	—	Unknown	"	Prob. at Winery near town.
5th	38° 17'	122° 27'	"	70	SSE 0.7 mile Sonoma, Calif.*	"	"	At residence in town. Coastal plain. Hills E.N.W. Several miles distant
6th								

(Con't) (a)	Instruments used (i)	Record: Original located (j)	Record: Where published (k)	Record: Dates 1st and last observations (l)	Observers and Dates (m)	Remarks (n)
1st 02	DT, RG Raingage	— 1/	BW 2/	1/1/86 to 8/31/94	Robert Hall ~~1/1/86 to 8/31/94~~	Type of raingage and condition of exposure unknown.
2nd 02	"	SC, S.F. 1/	BW OD	5/1/98 to 11/30/04	Robert Hall ~~5/1/98 to 8/31/07~~	" "
3rd 04	MxMn CRS SRG	San Francisco Ca	"	12/1/04 to 8/31/07	Same	Standard MxMn and SRG installed. Exposure unknown.
4th 01	SRG	SC, SF 3/	Not published	9/1/09 to 3/31/11 3/	Gundlach-Bundschu Wine Co. ~~9/1/09 to 3/31/11~~	Exposure unknown.
5th 04	MxMn, CRS, SRG	NWRC 5/	CD	11/2/51 to 99/99/9999	Laurence W. Dickey ~~11/2/51 to~~	CRS 6' N. of small workshop. SRG 27'E. of CRS. On ground.
6th						

1/ Records prior to March 1905 destroyed by fire.
2/ Also published in Bulletin of California State Weather Service.
3/ Scattered incomplete reports.
4/ distant.
5/ Carbon copies at SC, San Francisco, Calif.
* lat. long are approximate

* CRS only moved 4 ft to NW, 7/10/57.

WB Form 530-1

Figure 6. Substation History Form 530 for Sonoma, 1957
Source: National Climatic Data Center

[4] Note that the handwritten entries on the form were editorial comments made three months after the original. No substantive changes were made.
[5] This residence may be the one Mr. Hall used while his home on the ranch was being built.

The second series of observations were made at Hall's Ranch. The Ranch lay in the floodplain of Sonoma Creek (Figure 7) with little variation in altitude from the previous observations site.

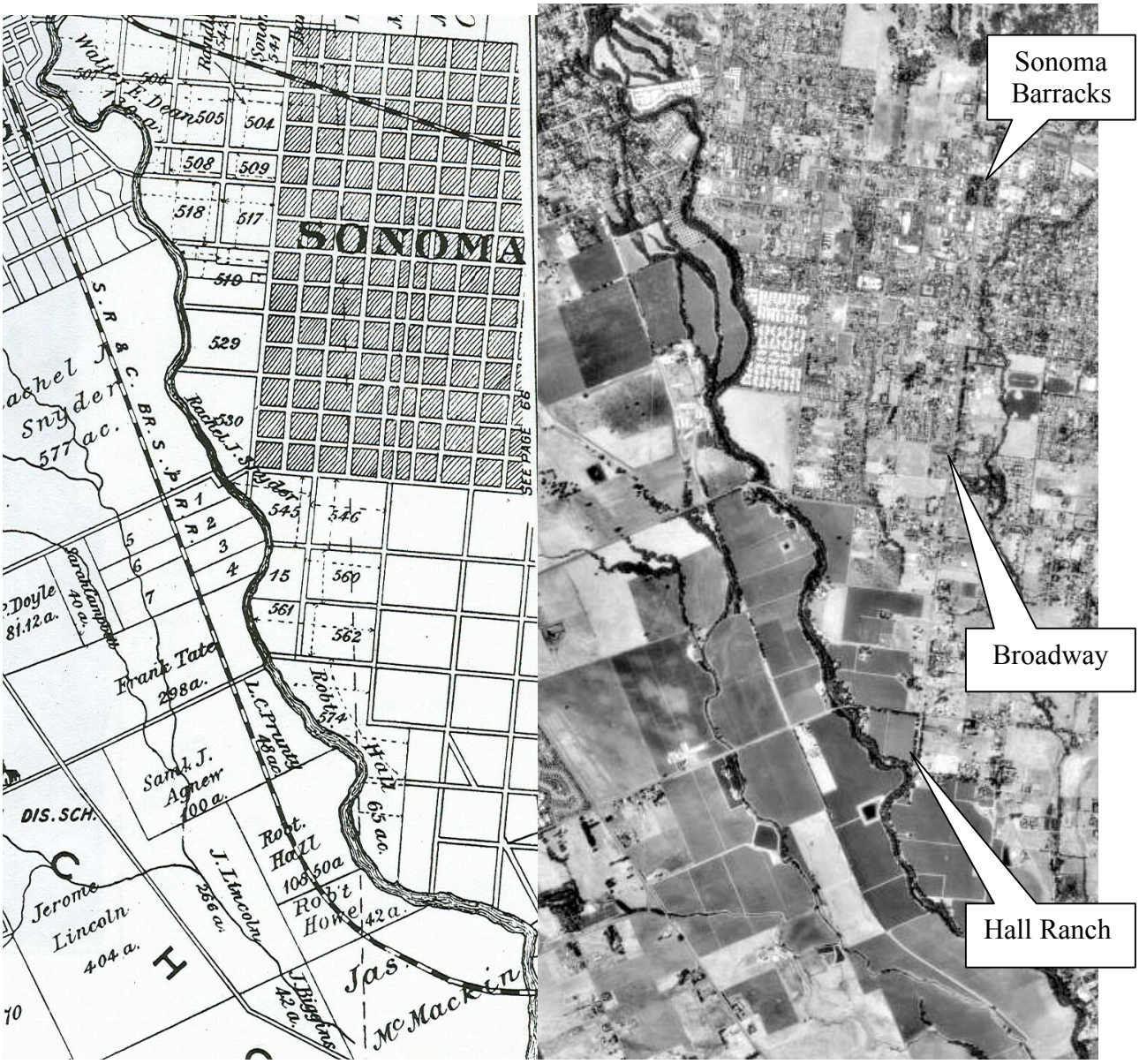


Figure 7. Hall Ranch Location
Source: On left, Historical Map of Sonoma County California, 1877.
On Right, USGS Orthophoto Image, 1998

At the ranch, the home (Figure 8) was one possible location of the observations.

Figure 8. Robert Hall's Residence
Source: Depot Park Museum, Sonoma Valley Historical Society

The area in the foreground of Figure 8 may be the courtyard mentioned as the observation location.

The observer noted temperatures six times on the morning of the 30th in his March 1884 report. The temperature had reached 32˚ at 2 o'clock that morning and smoke was being generated in his orchard because the trees were in bloom. Perhaps, the orchard (Figure 9) was another place for temperature observations during the frost potential time of the year.

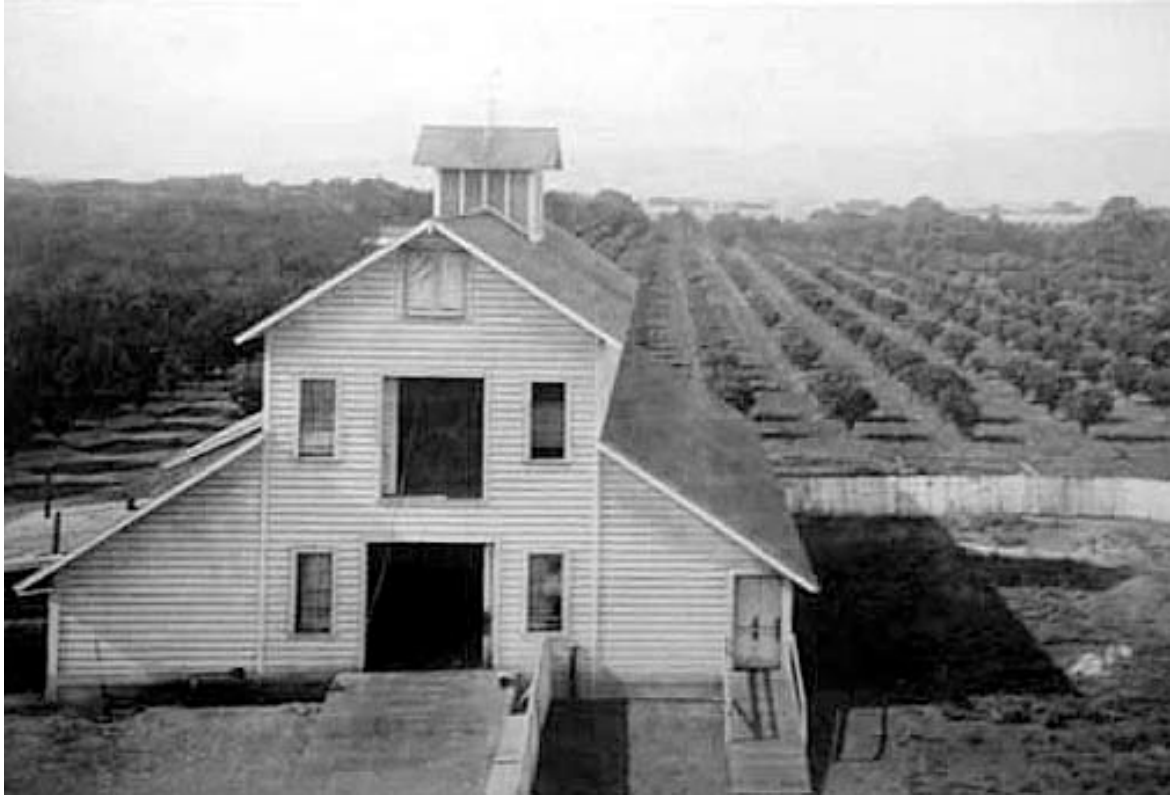


Figure 9. Robert Hall's Barn and Orchard, looking south
Source: Depot Park Museum, Sonoma Valley Historical Society

In April 1886, the location was reported at as 38˚ 17 2/3' N and 122˚ 26 1/2' W. Again, there was no comment on how that location was determined.

Weather Bureau Years 1892—1911

The weather network was removed from the Signal Service and incorporated into the newly created Weather Bureau in 1892. The only change at Sonoma was that data were then forwarded to the Weather Bureau in Sacramento.

In a 1906 inspection report (Figure 10), the location was given more precisely at 38˚ 17' 40" N and 122˚ 26' 30" W. There is the note that it was two miles south of Sonoma in a level valley of Sonoma Creek. That location was on the observer's ranch "200 feet from residence" and in the "N. E. Cor. Open court under veranda." Compare that description to the photograph in shown Figure 8.

Form No. 4029—Mis.

U. S. DEPARTMENT OF AGRICULTURE, WEATHER BUREAU.

Description of Cooperative Observer's Station and Instruments.

Station: Sonoma; County: Sonoma; State: Cal.

Latitude: 38° 17' 40" N Authority: U.S.Weather Bureau

Longitude: 122° 26' 30" W Authority: do

Elevation of ground above sea level: 30ft Authority: C.G.Smith, Boston.

EQUIPMENT.

Kind of thermometers in use: U.S. Weather Bureau Max #1559 Min # 7964

Kind of shelter in use: " " "

Kind of rain gage in use: " " "

Location of shelter [Describe position, whether over sod or cultivated ground, or upon a building, etc.; distance from nearest high objects; direction toward which door opens; height of floor above ground] → 4ft.)

Location N.E. Cor. open court under veranda, 10 ft. wide; distance above ground 7 ft.

Location of rain gage [On ground ~~or building~~; distance from nearest high objects; height of top of gage above ground] 3 ft. 40 ft.

General description of station [Is country generally level, rolling, or mountainous; if forest or bodies of water in vicinity, give distance from shelter, approximately; if station is in town, give street and number of house]: Station ½ mile S. of Sonoma - Level valley with low mts. either side - San Pablo Bay on the south - Sonoma Creek central portion valley, 210 ft. from residences

Time of observation [local]: 5 pm.

Name of observer: Robert Hall

Postoffice address: Sonoma, Cal.

Date: 2/8/06.

10,000—12, 1905.

SCANNED OAKLAND

Figure 10. Description of Sonoma Station in 1906
Source: National Climatic Data Center

The confusion about the location was partially explained by a note the observer made on his January 1883 report.

> Having a city residence and a country home my report is irregular — being in San Francisco in the winter mostly

According to the Substation History (Figure 6), there were rainfall measurements taken at the Gundlach-Bundschu Winery (Figure 11) near Sonoma from September 1909 through March 1911. It did not have the latitude or longitude for the observation site. Officials currently at the Winery were unaware of these observations and had no record on where they might have been taken. Assuming that the primary interest was the amount of rainfall that the vineyard received and that it would not be far removed from the residence, a location was estimated by the author and measured by GPS as 38˚ 16' 41" N and 122˚ 25' 08" W at approximately 94 feet MSL.

Figure 11. Gundlach-Bundschu Vineyard
Source: Author, 2006

The observations in Sonoma ended in August 1907 and did not resume until after the end of the period for this paper. In November 1951, Lawrence W. Dickey established a station at his residence at 394 East McArthur in Sonoma.

INSTRUMENTATION

Thermometer

The only instruments that accompanied the surgeons to Sonoma in 1850 were a thermometer to measure temperature, a weather vane to determine wind direction, and a rain gauge to measure precipitation. Those were the standard instruments provided in the Surgeon General's climate network.

A detached thermometer used from 1886 through 1894 but its type was not recorded. The maximum thermometer was number 10559 and the minimum was number 7964. Their use began on 1 December 1904. The types of thermometers used at Sonoma were not recorded but they probably were Green thermometers on Townsend mounts, the common equipment for the period. An example of them is shown in Figure 11. They were mounted inside a shelter.

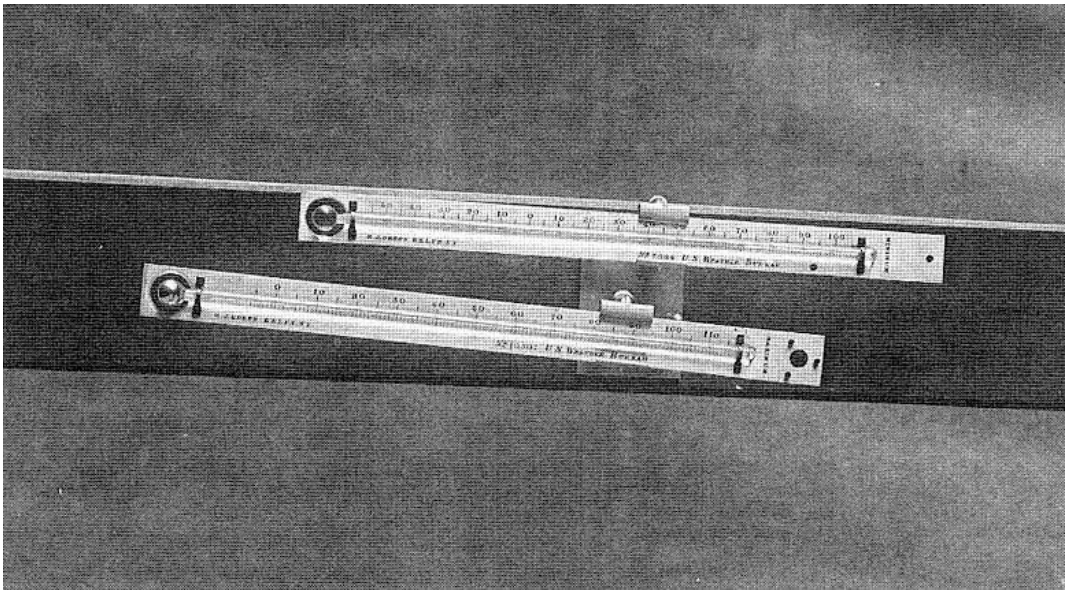


Figure 11. Green Maximum and Minimum Thermometers
Source: National Archives and Records Administration

Hygrometer

The first relative humidity entries were made for few days in November 1882. No mention was made of the type of instrument being used.

The observer reported receiving wet and dry bulb thermometers and began reporting their data in September 1885.

Rain Gauge

The type of rain gauge used by the Army in Sonoma in 1850 was not recorded. However, the Surgeon General's instructions from 1855 gave a fairly vivid description.

> The instrument used to measure the quantity of rain which falls is the conical rain gauge.
>
> I will be kept remote from all elevated structures, at a distance of at least equal to their height, and still further off, where it can be conveniently done. It is to be suspended in a circular opening made in a board, which is to be fixed to a post, eight feet from the ground; the opening to be five inches in diameter, and beveled so as to fit the side of the gauge, into which the cap is to be fixed, base downwards, to prevent evaporation. The measurement is made by putting down perpendicularly to the bottom of the gauge the measuring stick, and applying it, from its point to the water mark, on the scale, which will express the quantity in inches, or their decimals. The graduation of the scale is by hundredths of an inch for the first three tenths of an inch, and above that by tenths and half tenths. Parts of degrees will be measured by the eye, and set down in decimals. If a rain continue for any length of time, the quantity on the gauge will be measured at suitable intervals, before the water rises high in it, and the measurements summed us at the close.

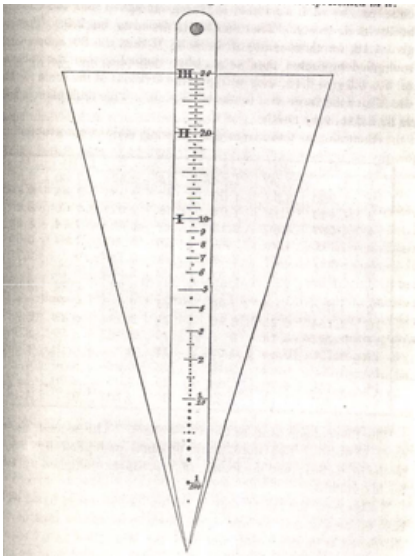


Figure 12. DeWitt Conical Rain Gauge
Source: Silliman's American Journal of Science and Art, 1832

When the second observer began his record, he did not have a rain gauge. In his November 1882 report, the observer noted. " I have no rain gauge but want one."

He did not have his wish granted until much later. He occasionally made comments about rainfall events but did not enter quantities. His first entries of rainfall amounts were on the form he submitted for November 1885. That month gave him frequent opportunities with 13.40 inches of rain that fell on twenty of November's days.

There was no mention of the type of rain gauge that made those measurements. No doubt that the U.S. Signal Service furnished it. The conical rain gauge that was in standard use for many years was probably the type used in Sonoma. That type is shown in Figure 13.

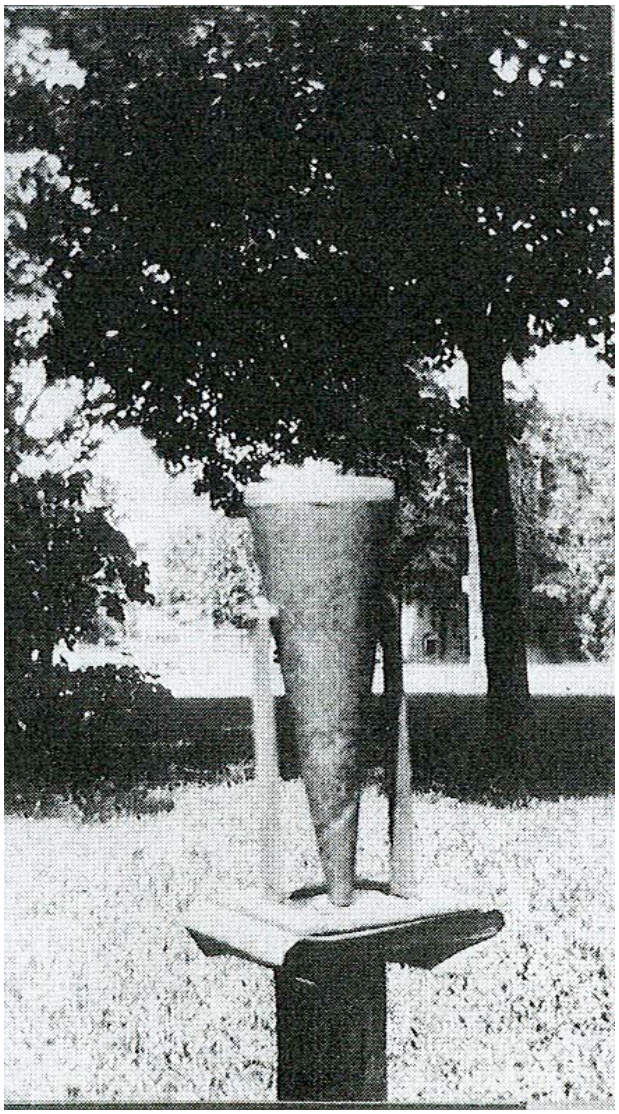


Figure 13. Conical Rain Gauge
Source: National Archives and Records Administration

The standard U.S. Weather Bureau rain gauge (Figure 14) was in use in 1906.

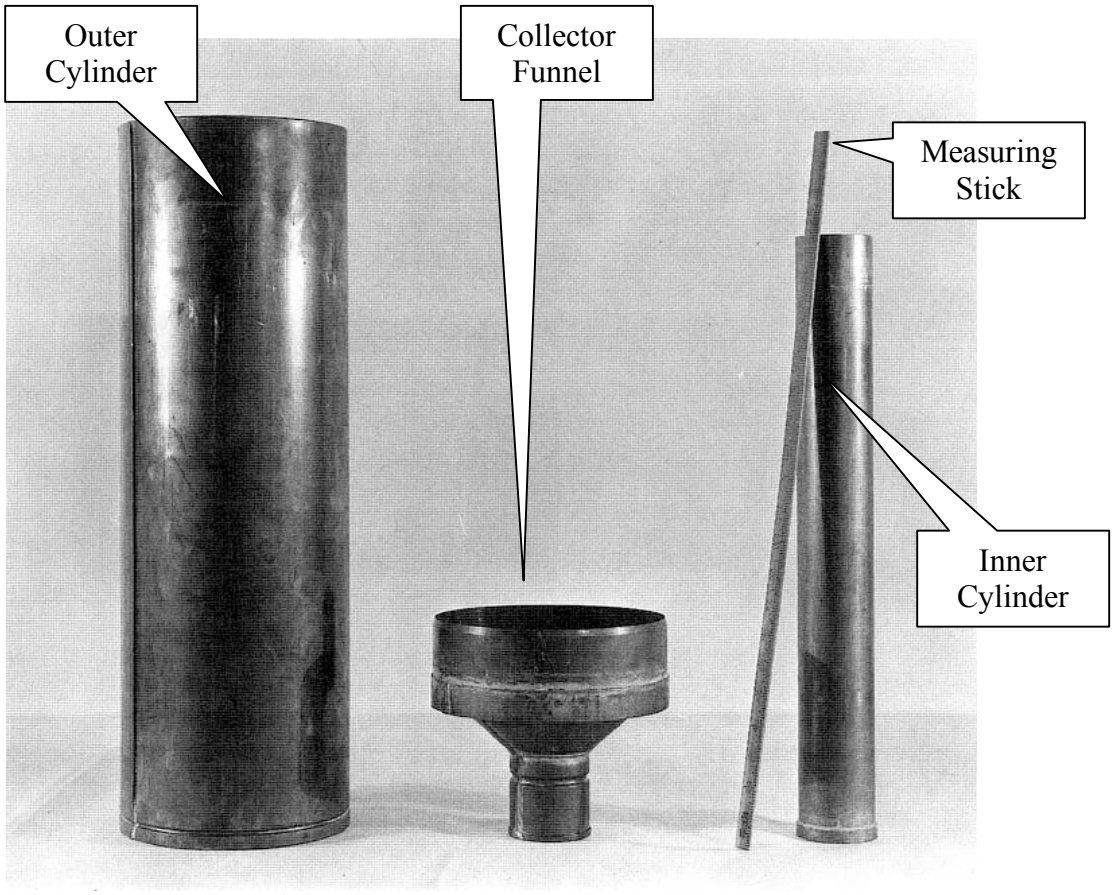


Figure 14. Standard Eight Inch Rain Gauge
Source: National Archives and Records Administration

The funnel of standard rain gage was placed over the inner cylinder and directed the water into it. The area of the top of the funnel was ten times the area of the top of the inner cylinder. Therefore, an inch of rainfall would stand ten inches deep in the inner cylinder. The measuring stick was magnified (in effect) ten times, to an actual length of twenty inches, and was marked in rainfall inches and hundredths of an inch. The inner cylinder and funnel were placed into the outer cylinder. The outer cylinder caught the overflow when the amount was greater than two inches and could be used to catch snowfall in the winter.

Barometer

The first barometer entries were made on 1 February 1883 with no indication of the type of barometer being used. The barometer had an “attached thermometer” that measured the room temperature so that a correction could be made for the expansion of the mercury due to temperature. That temperature was entered on the observation form.

The Green Barometer was in widespread use by the Signal Service. It is probable that the one in Sonoma was like the one shown in Figure 15.

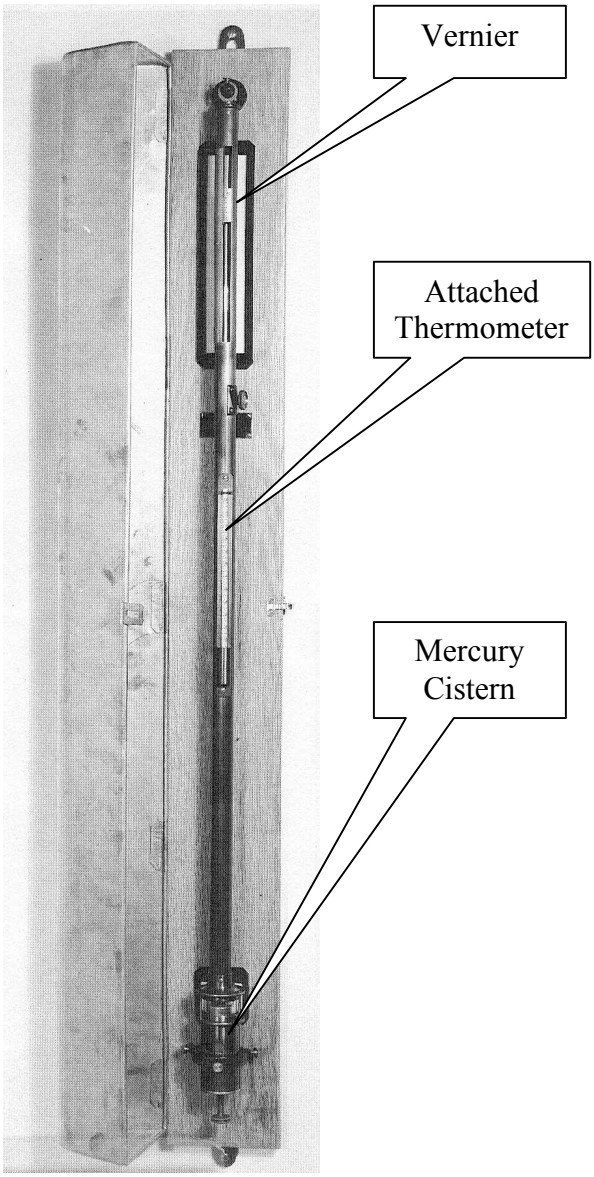


Figure 15. Mercury Barometer
Source: National Archives and Records Administration

Shelter

The thermometers were mounted inside an instrument shelter at the Hall Ranch. In 1906, the shelter was located at the northeast corner of an open court under the veranda, ten feet wide,

at about seven feet above ground. The door of the shelter faced west and the floor of the shelter was four feet above ground level. The shelter was located 200 feet from the residence. The shelter that was provided by the Weather Bureau to observers like Hall is shown in Figure 16.

Figure 16. Cotton Region Instrument Shelter was the Type Used in Sonoma
Source: National Archives and Records Administration

Wind Instruments

Weather vanes[6] were provided to some observers by the U.S. Signal Service. Direction of the wind was observed in the sixteen points of the compass. The vane was to be mounted on a roof and oriented to true north. It was to be mounted at least eight to ten feet higher than surrounding obstacles. Figure 17 is one vane from that era.

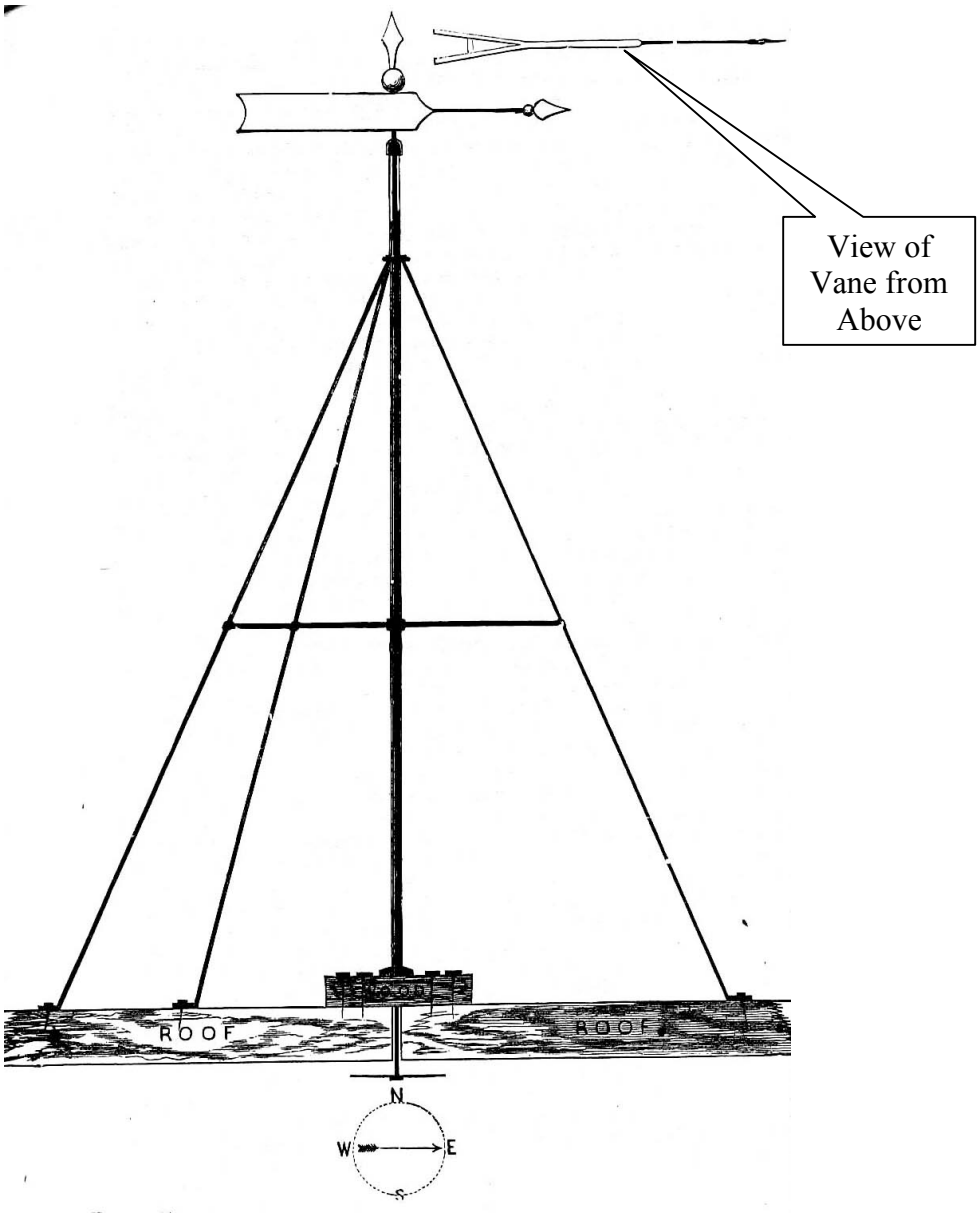


Figure 17. Weather Vane used by Signal Service Volunteer Observers
Source: Instructions to Volunteer Observers, 1882

[6] Vanes were also called "weather cocks."

OBSERVERS

Surgeon General Years

Nov 1850 —Apr 1851
Dr John Campbell

John Campbell was the first weather observer in Sonoma. He was born in New York and joined the Army on 13 December 1847 as an Assistant Surgeon. He arrived in Sonoma on 24 October 1850 for duty with the U.S. Army's 1st Dragoons who were stationed there. His career in the Army continued until his retirement on 16 September 1885 in the rank of Colonel.

Dr Campbell was also the second Army physician[7] in Sonoma. He had been preceded by Dr John S. Griffin who was with the Army in Los Angeles but also served at Sonoma as the surgeon in Kearney's 1st Dragoons.

According to Warren, the Surgeon General wrote to Dr Griffin on 11 September 1849.

> …I may now add that Assistant Surgeon John Campbell and Abbott (a late appointment) have been detailed for duty in California and will proceed thither via Chagres[8]…

Warren also recounts a second letter from the Surgeon General on 6 June 1850, indicating that he thought that Dr Campbell had arrived in California.

> Dr Campbell reported his arrival in Panama on the 24th March and doubtless reached California in April …

Regardless of that belief, Dr Campbell had not yet arrived at the time of the letter.

In July 1850, Dr Griffin was granted a "conditional leave of absence." Dr Campbell arrived in October.

Signal Service Years

Jul 1882—May 1892
Robert Hall

Robert Hall was a native of Massachusetts who came to San Francisco, California in 1863. He, along with his partner Robert Howe, developed an orchard just south of Sonoma in

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[7] The first physician in Sonoma was Dr Charles Van Geldern who arrived in 1849 according to Veronda

[8] The Chagres River was a river in Panama part of the route across the Isthmus from the Caribbean to the Pacific

1872. They expanded their land holding until it was divided between the two in 1885. The Hall Ranch by 1889 was described by Lewis as having 180 acres. His 80 acres of orchard grew a variety of fruits including peach, apricot, pear, quince, plum, cherry, apples, prunes, nectarines, figs, almonds, and walnuts. He also had 56 acres of wine grapes and five acres of table grapes. The Santa Rosa and Carquinez Railroad passed through his ranch.

It may have been that his interest in weather derived from concern for the productivity of his extensive orchards. In any case, he became a Voluntary Observer for the U.S. Signal Service in July 1882.

Weather Bureau Years

Jun 1892— Aug 1907
Robert Hall

Robert Hall continued to observe and record the weather when the responsibilities of the Signal Service were transferred to the Weather Bureau created within the Department of Agriculture.

OBSERVATIONS

Observations 1850-1851

The surgeon at Sonoma Barracks made observations at the times prescribed in the Surgeon General's directions for taking meteorological observations. They directed observations of temperature, clearness of the sky, the direction and force of the wind, and the direction and velocity of the clouds. They were to record the time of commencement and end of precipitation with the amount rainfall as measured by the rain gauge.

The observations were made at "a little before sunrise," 9 a.m., 3 p.m., and 9 p.m. The observations made at sunrise and 3 p.m. were added and the sum was halved to determine the mean daily temperature. That approximates the current method of adding the maximum and minimum temperatures and halving them to determine the daily mean. The daily minimum usually occurs just before sunrise and the maximum usually about 2 p.m. or so.

The cloud movement entries were restricted to the lowest layer of clouds. Directions were recorded as the direction from which the clouds were moving. The velocity was estimated and recorded as a number that represented a range of velocities.

Observations 1862-1863

There was a reference by the observer, Robert Hall, in his May 1883 report of the rainfall was "unprecedented. The nearest approach to it was in May 1860 when it amounted to 2. 86 inches." There is not an indication of who made the older observations but it may well have been Hall.

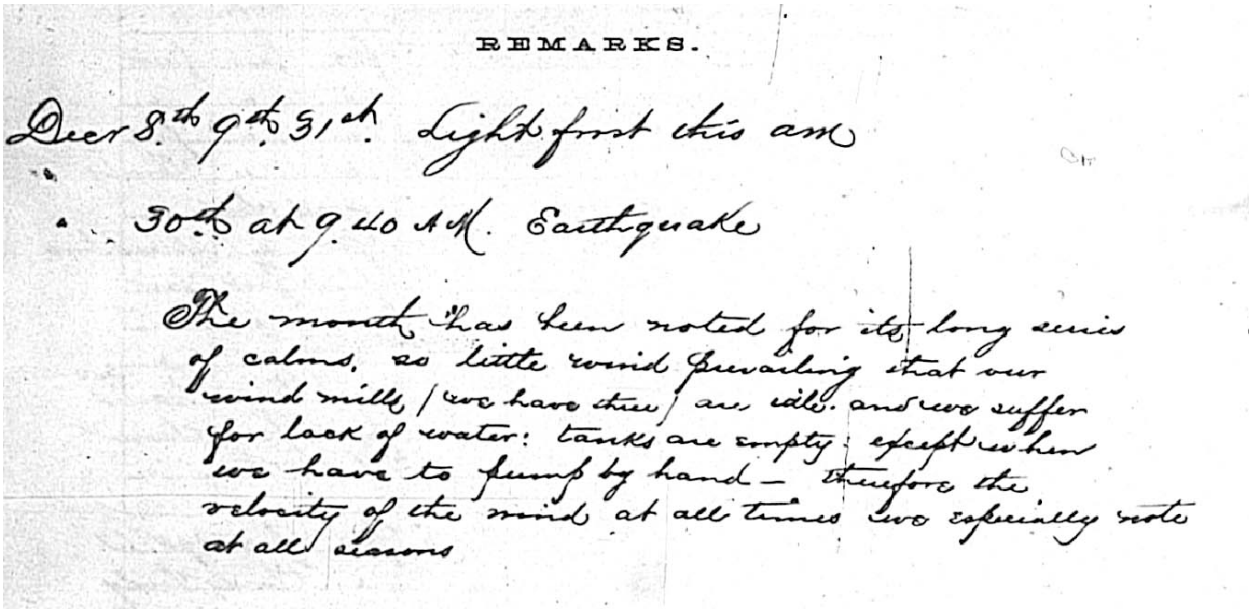
Observations 1882-1892

The early observation forms submitted by observer Robert Hall were seldom complete. He remarked about his absences, his business apparently required him to be away frequently. Beginning in 1884, his forms were mostly complete, fewer missing days than previous forms.

There were still absences though. For example, he commented about these missing weeks.

> Nov 6/84 Left Sonoma and remained at S.F. until March 2d/85.
> During that interval no observations taken. // Hall

When not absent, his forms were generally complete and contained remarks that were informative about the weather. These remarks (Figure 18) discuss the unusually calm conditions that prevailed through December 1885 and the effect that had on his orchard.



REMARKS.

Decr 8th 9th 31st Light frost this am

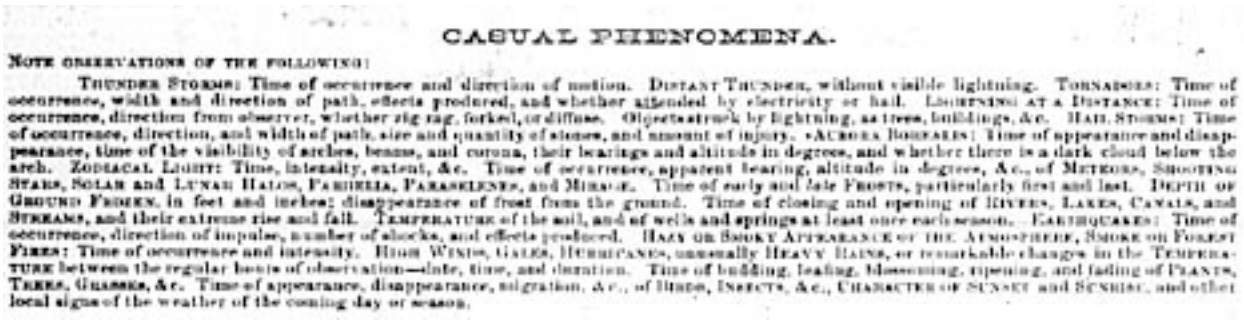
30th at 9.40 AM. Earthquake

The month has been noted for its long series of calms, so little wind prevailing that our wind mill (we have three) are idle. and we suffer for lack of water: tanks are empty, except when we have to pump by hand — therefore the velocity of the wind at all times we especially note at all seasons

Figure 18. Robert Hall's Remarks, December 1885
Source: National Climatic Data Center

Dry bulb and wet bulb temperatures were reported for the first time at 9 p.m, in September 1885. The dew point and relative humidity entries were not made perhaps he did not have the tables necessary for that determination. The data were not entered again after March 1886.

The Signal Service form had ample space for remarks and instructions for what elements deserved comments. In 1886, data were being collected on a variety of topics. We find some of those topics to be far removed from meteorology. For example, the requirement to report aurora borealis and earthquakes eventually disappeared from the topics. Others requirements are related to weather and climate but may seem strange at first glance. One of those was the requirement to report the temperature of well and spring water at least once each season. It turns out that ground water temperature mimics the mean annual temperature and, although wasn't the reason the data were collected, is now a valuable artifact of climate. Other requirements such as the time of budding, leafing, etc. were more directly related to what we understand weather to be. The list (Figure 19) of the casual phenomena had a much wider scope of remarks than that solicited today but still makes reading the old weather reports interesting.



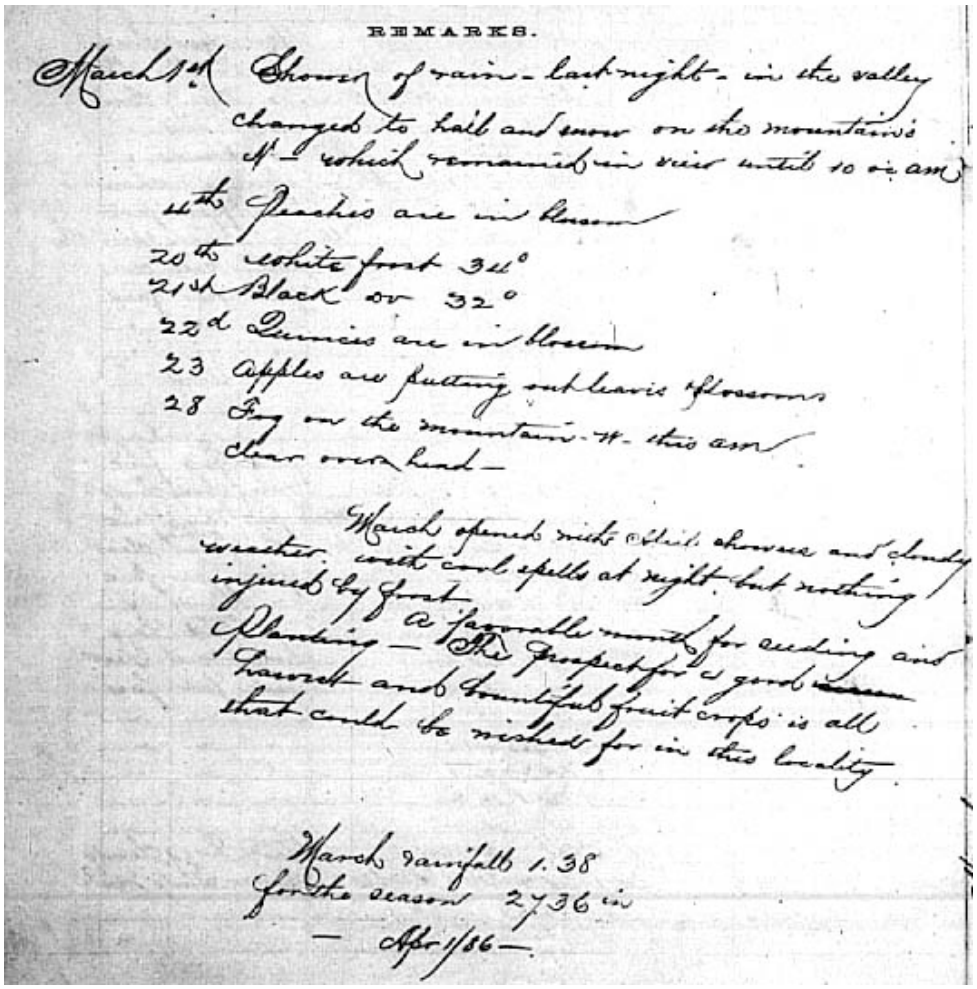
CASUAL PHENOMENA.

NOTE OBSERVATIONS OF THE FOLLOWING:

THUNDER STORMS: Time of occurrence and direction of motion. DISTANT THUNDER, without visible lightning. TORNADOES: Time of occurrence, width and direction of path, effects produced, and whether attended by electricity or hail. LIGHTNING AT A DISTANCE: Time of occurrence, direction from observer, whether zig zag, forked, or diffuse. Objects struck by lightning, as trees, buildings, &c. HAIL STORMS: Time of occurrence, direction, and width of path, size and quantity of stones, and amount of injury. AURORA BOREALIS: Time of appearance and disappearance, time of the visibility of arches, beams, and corona, their bearings and altitude in degrees, and whether there is a dark cloud below the arch. ZODIACAL LIGHT: Time, intensity, extent, &c. Time of occurrence, apparent bearing, altitude in degrees, &c., of METEORS, SHOOTING STARS, SOLAR and LUNAR HALOS, PARHELIA, PARASELENES, and MIRAGE. Time of early and late FROSTS, particularly first and last. DEPTH OF GROUND FROZEN, in feet and inches; disappearance of frost from the ground. Time of closing and opening of RIVERS, LAKES, CANALS, and STREAMS, and their extreme rise and fall. TEMPERATURE of the soil, and of wells and springs at least once each season. EARTHQUAKES: Time of occurrence, direction of impulse, number of shocks, and effects produced. HAZY OR SMOKY APPEARANCE OF THE ATMOSPHERE, SMOKE OR FOREST FIRES: Time of occurrence and intensity. HIGH WINDS, GALES, HURRICANES, unusually HEAVY RAINS, or remarkable changes in the TEMPERATURE between the regular hours of observation—date, time, and duration. Time of budding, leafing, blossoming, ripening, and fading of PLANTS, TREES, GRASSES, &c. Time of appearance, disappearance, migration, &c., of BIRDS, INSECTS, &c., CHARACTER OF SUNSET and SUNRISE, and other local signs of the weather of the coming day or season.

Figure 19. Instructions for Casual Phenomena from Observation Form
Source: National Climatic Data Center

The remarks from observer Hall (Figure 20) were confined, for the most part, to phenomena that directly affected his orchard.



REMARKS.

March 1st Shower of rain - last night - in the valley changed to hail and snow on the mountains N - which remained in view until 10 o'c am

4th Peaches are in blossom

20th White frost 34°

21st Black do 32°

22d Quinces are in blossom

23 Apples are putting out leaves & blossoms

28 Fog on the mountain - W - this am clear over head -

March opened with slight showers and cloudy weather with cool spells at night but nothing injured by frost

A favorable month for seeding and planting - The prospect for a good ~~season~~ harvest and bountiful fruit crops is all that could be wished for in this locality.

March rainfall 1.38
for the season 27.36 in
- Apr 1/86 -

Figure 20. Robert Hall's Remarks March 1886
Source: National Climatic Data Center

Observations 1892—1911

The observer commented in May 1892 on having difficulty completing the Weather Bureau's Form 1005.

The Weather Bureau form required the wind velocity to be entered as a "Force Number." Instructions for ascertaining velocity were printed on the form. The wind velocity was estimated using words that had been assigned meanings in miles per hour.

Calm	0 mph
Very Gentle Breeze	2 mph
Gentle Breeze	4 mph
Fresh Breeze	12 mph
Strong Wind	25 mph
High Wind	35 mph
Gale	45 mph
Strong Gale	60 mph
Violent Gale	75 mph
Hurricane[9]	90 mph

In October 1892, the observer changed the observation hours from 7 a.m., 2 p.m. and 9 p.m. to 6 a.m., noon, and 6 p.m. He explained, "Am now rushed with clerical work during vintage season, will furnish better report next month if you will provide me Blank Form No 1008..." The following month, his time of observations changed to 7 a.m., noon, and 5 p.m.

Digital Record

The National Climatic Data Center assigned station numbers to each of the climate stations to facilitate the use of their data in digital from. The number assigned to Sonoma is 048351. The same number is used with the observations made from November 1951 to the present.

[9] The word "Hurricane" referred only to wind speed, not to the tropical cyclone we now associate with it.

CLIMATOLOGY

The Sonoma Democrat on 6 December 1873 published a letter to the editor about a snow storm in Healdsburg.

> Yesterday we had the heaviest snow storm that was ever known in this part of the country, covering the whole face of the earth with snow to a depth of five or six inches; rain setting in this morning and rained all day, melting the snow and flooding the ground with water, making the rainfall for the season six and forty-five hundredths inches. The snow did more or less damage, the roofs of houses falling in, trees falling on fences and breaking the telegraph wires, but no lives were lost as far as heard from.

On the same day, the Sonoma Democrat also reported that professor William B. Hardy of the Pacific Methodist College in Santa Rosa would begin to provide weather summaries at the end of each month. The great storm mentioned in the article was the snow storm that had just occurred.

> They should be carefully preserved for future reference. The full series for the year will be invaluable to those interested in keeping a record of the weather. This report is fuller than is ordinarily published and will on that account be more acceptable, owing to the great interest manifested in everything relating to the great storm.

Professor Hardy was a professor of physics and an observer for the Smithsonian Institution's climate network. He had submitted his first observations to them for the November 1873 and the following month had recorded the snow depth in Santa Rosa from the great storm as 12 inches. He added a comment (Figure 21) to verify the unusual nature of the storm.

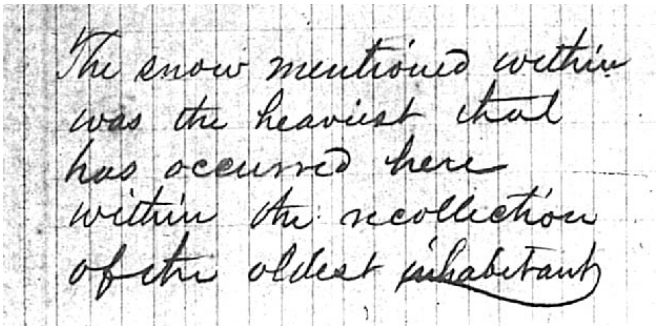

The snow mentioned within
was the heaviest that
has occurred here
within the recollection
of the oldest inhabitants

Figure 21. Hardy's Comments about the Great Snow Storm 1873
Source: National Climatic Data Center

Professor Hardy's first monthly report to the newspaper was for January 1874 and included the barometer, thermometer, and rain gauge readings for each day. It was published on 7 February 1874 (Figure 22).

METEOROLOGICAL.

Abstract of meteorological record of Prof. Wm. B. Hardy, Pacific Methodist College, reported under the direction of the Smithsonian Institute, Washington, D. C., for the month of January, 1874.

Day of the month.	BAROMETER (Reduced to 32° Fahrenheit)				THERMOMETER (in open air.)				Rain fall inches.
	7 A.M.	1 P.M.	9 P.M.	D'LY M'N	7 A.M.	1 P.M.	9 P.M.	D'LY M'N	
1	29 80	29 73	29 65	29 73	55 0	57 0	55 0	56 0	0 69
2	29 61	29 61	29 84	29 69	48 0	49 0	41 0	46 0	1 00
3	30 03	30 02	30 09	30 05	35 0	50 0	42 0	42 0	.....
4	30 01	30 09	30 09	30 06	36 0	50 0	44 0	43 0	.....
5	30 08	30 01	29 85	29 98	33 0	50 0	42 0	42 0	.....
6	29 92	29 92	29 90	29 91	35 0	55 0	42 0	42 0	.....
7	29 97	29 92	29 82	29 90	32 0	56 0	44 0	44 0	.....
8	29 93	29 91	29 90	29 91	33 0	48 0	42 0	41 0	.....
9	29 97	29 93	29 90	29 93	40 0	44 0	45 0	43 0	.....
10	29 86	29 83	29 83	29 84	40 0	42 0	42 0	41 0	.....
11	29 83	29 77	29 81	29 80	42 0	47 0	45 0	45 0	.....
12	29 88	29 85	29 86	29 85	41 0	42 0	41 0	41 0	.....
13	29 87	29 83	29 79	29 83	39 0	45 0	41 0	42 0	.....
14	29 73	29 64	29 61	29 66	40 0	48 0	48 0	45 0	.....
15	29 51	29 41	29 32	29 41	56 0	57 0	58 0	57 0	0 81
16	29 36	29 48	29 49	29 44	55 0	60 0	53 0	56 0	2 01
17	29 33	29 36	29 49	29 39	54 0	51 0	53 0	53 0	0 93
18	29 77	29 80	29 81	29 79	38 0	51 0	48 0	46 0	0 04
19	29 61	29 57	29 80	29 66	50 0	46 0	37 0	44 0	0 35
20	29 84	29 83	29 84	29 84	34 0	45 0	37 0	39 0	0 01
21	29 85	29 82	29 81	29 84	36 0	45 0	48 0	41 0	.....
22	29 95	30 00	30 10	29 98	33 0	46 0	37 0	39 0	.....
23	30 13	30 13	30 12	30 18	30 0	50 0	41 0	40 0	.....
24	30 13	30 08	30 05	30 08	33 0	52 0	43 0	42 0	.....
25	29 97	29 91	29 99	29 96	42 0	47 0	47 0	45 0	.....
26	30 02	30 05	30 09	30 05	47 0	54 0	48 0	50 0	0 50
27	30 05	30 04	30 07	30 05	47 0	54 0	50 0	50 0	0 05
28	30 00	29 99	30 12	30 04	53 0	57 0	52 0	54 0	1 40
29	30 17	30 15	30 10	30 14	48 0	54 0	49 0	50 0	0 67
30	30 03	29 99	29 97	30 00	41 0	50 0	51 0	47 0	.....
31	30 01	29 99	30 01	30 00	48 0	56 0	46 0	50 0	86
MEANS	29 88	29 87	29 88		41 7	50 1	45 4	45 7	.....
REDUCED TO SEA LEVEL.									
Max.	30 35	30 33	30 30		56 0	60 0	58 0	57 0	.....
Min.	29 51	29 54	29 50		30 0	42 0	37 0	39 3	.....
Me'n	30 03	30 05	29 93		.....	.....	.....	.....	.....
R'nge	0 84	0 79	0 80		26 0	18 0	21 0	18 0	.....
Mean of month.....				30 05	.....			46 0	.....
Extreme range.....				0 85	.....			30 0	.....

Rain of the month in inches.....8 32
Amount of rain previously reported.....15 22
Total rain of season to date.....23 54 in.

WINDS—From some point between N. and E., 1 day; E. and S., 5 days; S. and W., 8 days; W. and N., 7 days.

WEATHER—Clear, 5 days; Variable and cloudy, 13 days. Rain fell on 13.

Figure 22. Hardy's First Report to the Sonoma Democrat, 7 February 1874
Source: Sonoma Democrat

Hardy provided reports to the Smithsonian Institution from November 1873 through April 1874.

Thompson's 1877 book on Sonoma County contained several pages of climate information, He had annual precipitation totals from 1853-1876 but did not identify the source. 1889 Lewis Illustrated History of Sonoma County had a summary of climate for the period 1853-1886. The source of the data and its specific location was not recorded. It included annual rainfall for Sonoma County that were identical to those of comparable years in Thompson's book. The data in both books were from the rainy season rather than for the calendar year. The early years' data appear to be from Santa Rosa, the later years from Petaluma. Those data are shown in Table 1.

Table 1. Annual Precipitation Sonoma County 1853-1886

Santa Rosa			Petaluma	
1853-54	29"		1876-77	13.15"
1854-55	30"		1877-78	39.24"
1855-56	25"		1878-79	20.83"
1856-57	25		1879-80	26.83"
1857-58	23"		1880-81	24.55"
1858-59	23"		1881-82	17.04"
1859-60	21"		1882-83	19.15"
1860-61	17"		1883+84	24.55"
1861-62	46"		1884-85	14.96"
1862-63	17"		1885-86	28.89"
1863-64	12"			
1864-65	26"			
1865-66	30"			
1866-67	40"			
1867-68	50"			
1868-69	26"			
1869-70	25"			
1870-71	17			
1871-72	40"			
1872-73	21.58"			
1873-74	29.54			
1874-75	23.30"			
1875-76	>32"			
1875-76	>32"			

The U.S. Signal Service had replaced the Smithsonian as the climate network by the time May Howard of Healdsburg began observing the weather for several months in 1878 beginning in April. The record is short but good.

The 1880 History of Sonoma County by Munro-Frazer detailed a discussion of Sonoma County's climate of each month quoted from the work of R. A. Thompson. It mentions the very dry years of 1863-4 and 1864-5.

After a gap in the record, observations resumed in Santa Rosa in June 1885 by L. M. King. He submitted his observations to the U.S. Signal Service. King's contributions ended in August 1885. After a short gap in the record, A. C. McMeans was the Voluntary Observer for the Signal Service in October 1887, but for that month only.

Extensive climatologies of California were prepared by James A. Barwick each year from 1887 through 1896. They were titled "Annual Meteorological Review of the State of California." Barwick was the meteorologist in charge of the Weather Bureau Office in Sacramento and was hear of the Meteorological Department of the State Agricultural Society, also located in Sacramento. He included temperature and precipitation tables that were provided by Robert Hall, the observer in Sonoma.

The 1889 Lewis Illustrated History of Sonoma County had a summary of climate (pages 218-219) for the period 1853-1886. The source of the data and its specific location was not recorded. It included annual rainfall for Sonoma County was included. The data were from the rainy season rather than for the calendar year.

McAdie's Climatology of California in 1903, included Sonoma's monthly precipitation data from 1886 through 1900.

Elford's Climate of Sonoma County summarized the data from 1954 to 1964 for Sonoma and gave the location as 38˚ 17' N and 122 ˚7' W at an elevation of 20 feet. Pages 2 through 5 are narrative summaries of the county's climate. It also listed the climate stations in the county with Pt Arena having a 50 year temperature record, several stations with 30 year records including Santa Rosa, and Sonoma with a 10 year record. The narrative description of the southeastern portion of the County includes a mention of Sonoma Creek that flows through the valley into San Pablo Bay.

APPENDIX 1

Methodology

The primary sources of information for this study were the Sonoma observers' daily weather records themselves. Copies of their monthly reports and the data digitized from those reports were available from the Western Regional Climate Center in Reno, Nevada, or the National Climatic Data Center in Asheville, North Carolina. The monthly reports can be considered original sources because they were written by the observers and not altered by subsequent readers.

There were a variety of secondary sources that held information about Sonoma, its history, and its people. The author visited and collected information from the holdings of the Sonoma Public Library and the Depot Park Museum in Sonoma; Sacramento Public Library, California State Library; California State Archives, California Military Museum, and the National Weather Service Office, Sacramento;. National Climatic Data Center at Asheville, North Carolina; the National Archives and Records Administration, the National Medical Library, and the Smithsonian Institution Archives in Washington, D.C.

The tertiary sources were reference materials that are available on-line. Among those were the metadata prepared by the Office of the State Climatologist of California, the Western Regional Climate Center, the National Climatic Data Center substation histories, and the Office of Medical History in the Office of the Surgeon General, U.S. Army. Two genealogical research sources, Ancestry.com and Genealogy.com were used to provide some of the personal information about the observers. For location analysis, the interactive maps available from TopoZone.com were used.

There was an attempt to glean information from all these sources that would allow a glimpse into the lives of the observers, the location of the observation site, and the historical environment that produced the climatic history of Sonoma. Maps, drawings, and photographs were included when appropriate to illustrate the information.

Throughout the research for and preparation of this study, the objective was to produce a document that future studies can use to evaluate the validity of the data that were collected here, judge the trustworthiness of the observers who collected them, and determine the climatological significance of the whatever variability may be discerned.

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