ANALYSIS OF SAN LUIS OBISPO HISTORIC PRECIPITATION DATA AND CALIBRATION OF THE CAL POLY WEATHER STATION

by

Hilary Olsen

BioResource and Agricultural Engineering

BioResource and Agricultural Engineering Department

California Polytechnic State University

San Luis Obispo

2014

TITLE	:	Analysis of San Luis Obispo Historic Precipitation Data and Calibration of the Cal Poly Weather Station
AUTHOR	:	Hilary Olsen
DATE SUBMITTED	:	December 8, 2014

Dr. Stuart Styles
Senior Project Advisor

Signature

3 Dec 2014
Date

Dr. Art MacCarley
Department Head

Signature

2/11/2015
Date

ACKNOWLEDGEMENTS

I would like to first thank Jesus Christ, my Lord and Savior, for giving me strength to do all things, including this senior project.

Second, I would like to thank my family for supporting me through my college career and for helping me stay on track with this project.

Third, I would like to give thanks for my advisor, Dr. Stuart Styles, who was always willing to give me guidance, and always pushed me to do my best.

Lastly, I would like to thank the Irrigation Training and Research Center for giving me the opportunity, as well as the funding for this project.

ABSTRACT

Precipitation and temperature data has been measured and recorded for San Luis Obispo, California since 1870. The primary station used in collecting and recording this data has been the COOP 04-7851 station. Due to the various location changes of the COOP station over the past 144 years, discrepancies have been found in the accuracy of recorded and published precipitation data for San Luis Obispo. In 2010, the Irrigation Training and Research Center (ITRC) took over the management of the COOP station, and used information from other ITRC weather stations as well as stations throughout San Luis Obispo to analyze and correct the inaccurate data. This was done using sites like the CIMIS station, Adcon station, San Luis Obispo County gage, and other Cal Poly rain gages.

These corrections allowed water regulation entities to make proper decisions on water allotments and fines for unreasonable and over use. The data will also aid in future weather pattern predictions for the greater San Luis Obispo area as well as provide a quality control method for the Cal Poly weather stations. This report will discuss the steps used in collecting, correcting, and quality control on weather data as well as some background information of the stations and their functions.

DISCLAIMER STATEMENT

The university makes it clear that the information forwarded herewith is a project resulting from a class assignment and has been graded and accepted only as a fulfillment of a course requirement. Acceptance by the university does not imply technical accuracy or reliability. Any use of the information in this report is made by the user(s) at his/her own risk, which may include catastrophic failure of the device or infringement of patent or copyright laws.

Therefore, the recipient and/or user(s) of the information contained in this report agrees to indemnify, defend and save harmless the State, its officers, agents and employees from any and all claims and losses accruing or resulting to any person, firm, or corporation who may be injured or damaged as a result of the use of this report.

TABLE OF CONTENTS

Page

LIST OF FIGURES

Page

LIST OF TABLES

Page

INTRODUCTION

With California's on-going dry spell, the one item that is on every one's mind is: California needs rain. While precipitation is a critical necessity California is currently lacking, the accurate gathering and recording of precipitation amounts is just as important. The lack of rain in California over the past several years (along with other clean water shortage factors) has been a cause for stricter regulation of water allocation. One of the ways that regulation entities can determine proper allocation for different parties is based on the amount of precipitation in the region that occurred the previous water year (July through the following June).

Background

The weather station at Cal Poly, maintained and operated by the Irrigation Training and Research Center (ITRC), is home of three different weather data collection systems. Two of these systems are automated, while two are manually operated.

NOAA Manual Station for San Luis Obispo. This COOP 04-7851 station is nationally recognized by the National Oceanic and Atmospheric Administration (NOAA) and collects both precipitation and temperature data manually using two separate devices. The first is the cotton region thermometer shelter as shown below in Figure 1. This device houses both a minimum and maximum temperature thermometer. These thermometers are checked on a daily basis, and the temperatures are recorded.

Figure 1. COOP cotton region thermometer shelter which houses maximum and minimum temperature thermometers (itrc.org).

The second device is the manual rain gage (shown in Figure 2 below). This device collects precipitation in a rain tube, and then a calibrated rain meter is used to

measure the depth of the water in the tube. The measurements on the rain meter are calibrated to read the amount of rainfall in inches. The data received from this station (both the cotton region thermometer shelter and the COOP manual precipitation collector) is sent to the National Weather Services (NSW) at the end of every month. NWS recognizes this station as an official weather station, and the data collected is used as the official data for the city of San Luis Obispo.

Figure 2. COOP manual precipitation collector uses a calibrated rain meter to measure the amount of rain in inches collected in the tube (itrc.org).

Adcon Telemetry Station. Along with the manual COOP station, the ITRC also manages three other weather monitoring devices. The first is the Adcon Telemetry precipitation gage and monitoring station (shown in Figure 3). This device collects data for several different pieces of information, including precipitation and temperature, on a fifteen minute interval and sends the information to the ITRC Weather Database (http://www.itrc.org/databases/precip/). This station is sustainably operated by a solar powered battery.

Figure 3. Adcon Telemetry station using a tipping bucket to collect precipitation data (itrc.org).

California Irrigation Monitoring Information System. The second device is the California Irrigation Monitoring Information System (CIMIS) station, which is shown in Figure 4.

Figure 4. CIMIS station also uses a tipping bucket to measure rainfall amounts (itrc.org).

This device also has a precipitation gage and thermometers as two of the many pieces of information that it can provide. Like the Adcon station, the CIMIS station is fully automated, and the data collected is sent the ITRC Weather Database on an hourly interval. This device also uses solar energy to operate.

Fisher Porter Rain Gage. The third device in the station is the Fisher Porter Rain Gage (shown in Figure 5). This is a precipitation only device that collects rainfall in a large scale.

Figure 5. Fisher Porter rain gage uses a scale to weigh the amount of rain collected through the top of the port (itrc.org).

It then computes the rainfall amount in inches based on the weight of the water in the scale. This data is stored on a computer in the device which is also powered by solar, and then collected manually using a Secure Digital Card.

Justification

Since 1870, San Luis Obispo has been collecting temperature and precipitation data with the COOP station 04-7851 and recording it for official records. In the late 1920s, the station was moved onto Cal Poly's campus, and in 2010 the ITRC took over the station (Slayton, 2012). Due to the several location changes, the COOP station has been exposed to opportunity for inaccurate data collection. In fact, for a period of approximately 5 years, inaccurate precipitation data was being used by regulation entities to determine water allocation for local farmers. This created a huge issue due to the fact that farmers were being fined for unreasonable use of water, when in fact these fines were based on inaccurate precipitation data. The possibility of inaccurate-based fines only increased the need for an analysis and correction of the data collected from the station over the past 144 years, and calibration of the station to ensure accurate data in the future.

Objectives

The main goals of this senior project are to analyze the historical weather data, make proper corrections to the inaccurate data, and create a method for continual calibration of the ITRC Cal Poly weather station so as to provide concise, accurate weather data. The milestones of this project are as follows:

1. Collect historical data from the COOP station via San Luis Obispo County,
2. Collect data from other stations in the area for comparison against the COOP station and the County data,
3. Analyze the COOP data and make necessary corrections,
4. Monitor all the devices in the weather station to check for either collection or transmittal error,
5. Create a systematic procedure for quality control methods of all the weather gages at the Cal Poly weather station.

LITERATURE REVIEW

While the average American can simply turn on their television or log on to the internet to get a hold of a 5 to 10 day weather forecast for any city in the world, the systems that make this luxury possible are not so simple. There are many different methods currently being used to collect precipitation data.

Department of Water Resources: CIMIS

One of the most popular models being used in California is the California Irrigation Management Information System, or CIMIS, which is run by the California Department of Water Resources (DWR). The 120 plus automated weather stations throughout the state collect data on a "minute-by-minute basis, calculate hourly and daily values, and store them in dataloggers" which are attached to the stations (State of California CIMIS, 2009). From here, the data is retrieved by the computer at the DWR headquarters on a daily basis. Once stored in the computer, the data can be accessed by the public.

Automated Stations. As stated above, CIMIS has 120 automated stations distributed throughout California. These sites were randomly chosen as "microclimates [that represent] the [larger] area of interest" (State of California CIMIS, 2009). These automated stations (shown in Figure 6) collect a vast variety of data such as solar radiation, air temperature, relative humidity, wind speed, and precipitation.

Figure 6. Five Points CIMIS station surrounded by open grass field (State of California CIMIS, 2009).

Other pieces of data are then calculated by the computer such as ETo, net radiation, and dew point temperature. The computer also performs quality control checks on all the data received from the dataloggers and makes note of which pieces of data may be inaccurate.

Spatial Data. CIMIS also uses spatial data reports which provide information about ETo and solar radiation based on remote sensing applications. This data is accurate to within "2 kilometers of spatial resolution" (State of California CIMIS, 2009). As opposed to the automated stations, the spatial data is retrieved via satellite.

Telemetry Data. An issue with using real-time telemetry data records is that to get accurate data there needs to be good station management and upkeep. If the station is not properly set up and maintained, the data may not be accurately read or transferred to the server. Some of the recommendations by the National Weather Service (NWS) in setting up a proper weather station include setting the thermometers approximately 5 feet off the ground, on a level surface that is located in an area the represents the terrain of the area represented, and at least 100 feet away from any pavement or vertical obstructions (NOAA NWS, 2014).

Tree Ring Evaluation and Precipitation

While automated weather stations are extremely useful in collecting and recording weather data, these stations have only been around so long. Scientists are trying to find ways to get historical weather data from before weather stations were available or in use. One of the most looked at methods is dendroclimatology. This is "the science that uses tree rings to study present climate and reconstruct past climate" (Grissino-Mayer, 2014).

In a study done by Suárez, Butler, and Baillie published in 2009, different species of trees in Ireland were observed to find climate signal. The species observed were oak, beech, ash and Scots pine. These species were used in the experiment because of their location close to the Armagh Observatory in Northern Ireland (García-Suárez et al., 2009). The experiment measured the widths of tree rings in different species based on several climate factors such as "temperature series, rainfall, sunshine hours, soil temperatures at 30 and 100 centimeter depth[s], barometric pressure, humidity, cloud cover and wind speed and direction" (García-Suárez et al., 2009). After several tests, the team concluded that the parameters with the greatest affect on the four different species were rainfall and maximum temperature.

The variability in the correlation between tree ring width and precipitation amounts is still an area that is being studied and tested, but there is in fact a correlation observed that can be used as general knowledge.

PROCEDURES AND METHODS

This section of the report provides details of the various measures taken in order to complete this project. These measures include gathering and comparing of historical data from various sites, relating the tree ring widths to rainfall events, creating a system for future calibration and quality assurance, and corresponding with national organizations.

Gathering and Comparing Historical Precipitation Data

When the ITRC took over the COOP station in 2010, some discrepancies were found throughout the previous five years in the data posted on the San Luis Obispo County website. These inaccurate values were found by comparing data from various sites. The sites used in the comparison were the San Luis Obispo County precipitation records, CIMIS station 52, and SLO Reservoir.

San Luis Obispo County Precipitation Records. The County published precipitation data that was collected from the COOP 04-7851 station from all locations over time. This station is labeled as *Cal Poly #1* on the County's online published record. Precipitation data from the County's website was acquired in the following manner.

1. SLO County Water's website was accessed at www.slocountywater.org,
2. The *Water Resources* drop-down menu at the top of the page was clicked,
3. The *Data* tab was clicked,
4. The *Rainfall* tab was selected,
5. Under the *Station* drop-down menu, the *Cal Poly* site was selected,
6. And a download of the monthly and daily precipitation data from 1870 through 2012 appeared as a PDF file.

CIMIS Station 52. Precipitation and other weather related data is published daily on the CIMIS webpage. CIMIS station 52 data was collected via the link on the ITRC webpage in the following manner.

1. CIMIS webpage was accessed at http://www.cimis.water.ca.gov/,
2. A username and password were used to access historical data,
3. The *Data* tab at the top of the page was selected,
4. Station *ID 052* was selected from the *Station Selection*,
5. The report style and date range were selected to be CSV Report and July 2003 to June 2012,

6. And a download of the monthly and daily precipitation data from 2003 through 2012 appeared as a CSV file.

SLO Reservoir. Precipitation data was collected from SLO Reservoir via the County of San Luis Obispo. This station is labeled as *SLO Reservoir* on the County's online published record. Precipitation data from the County's website was acquired in the following manner.

1. SLO County Water's website was accessed at www.slocountywater.org,
2. The *Water Resources* drop-down menu at the top of the page was clicked,
3. The *Data* tab was clicked,
4. The *Rainfall* tab was selected,
5. Under the *Station* drop-down menu, the *SLO Reservoir* site was selected,
6. A table of a fifteen day precipitation record is made available to the public via the website, so in order to have access to historical data, a Data Request Form was completed and sent to the County (see Appendix B for a copy of the completed form),
7. And an Excel spreadsheet of the data was provided upon approval of the Data Request Form.

Once all of the historical data was collected from the three sites, a spreadsheet was complied to compare the data side by side. An example of this is shown below in Table 1 for the data from July of 2007 through June of 2008.

Table 1. Example of precipitation comparison spreadsheet for the 2007/2008 water year.

Beginning Year	Month	SLO County	CIMIS 52	SLO Reservoir
2007	Jul	0.00	0.00	0.00
	Aug	0.13	0.10	0.08
	Sep	0.07	0.00	0.04
	Oct	0.57	0.15	0.98
	Nov	0.06	0.01	0.08
	Dec	2.92	3.72	4.45
	Jan	1.23	8.70	9.84
	Feb	1.36	3.71	3.58
	Mar	0.14	0.12	0.12
	Apr	0.29	0.48	0.71
	May	0.03	0.05	0.00
	Jun	0.00	0.00	0.00
Totals		6.80	17.04	19.88

It is clear from the data that the SLO County recorded almost one-third of the precipitation caught by the other gages.

Creation of Calibration Methods

Quality control plays a very important role in data collection and analysis. Because there are so many weather gages monitored by the ITRC, a method of calibration and quality control needed to be established. The NWS official manual gage was decided on to be the standard gage, since it is the official data recognized by National Weather Service.

The process of quality control checks and calibration of each gage relies on the manual process of comparing and contrasting precipitation data from various gages after each rainfall event, and then a comparison on the accumulated rainfall after each month. Two spreadsheets were created in order to track precipitation amounts between the different gages. The first sheet as seen in Table 2 shows the comparison of three precipitation gages by rainfall event. This event specific method helps track large changes to the gages that affected the previous rainfall event as well as future events (i.e. fecal matter from birds, dead bugs, leaves, etc.). The process used in monitoring the data was using the standard deviation of the three precipitation amounts for each rainfall event. If the standard deviation was less than 0.1 then the data that may have varied from the NOAA manual gage was considered correct. Also, if the difference from the Adcon and CIMIS 52 stations from the manual gage was less than the standard deviation (for deviations greater than 0.1), then the data was considered correct. All instances that did not correlate with these constraints were marked as not compliant (or No on the Table 2 spreadsheet below), and further investigations were made for these dates by the ITRC. The gages were checked for plugging, and adjustments were made to the data if appropriate.

Table 2. Quality control spreadsheet for a per event basis.

Rainfall Event	***Station (Rainfall in inches)***							
Date	NOAA Manual Gage	Stnd. Dev. of Three Stations	Adcon	Diff. from Manual	Compliant	CIMIS 52	Diff. from Manual	Compliant
1/5/13 to 1/6/13	**0.93**	0.04	**0.85**	0.08	Yes	**0.9**	0.03	Yes
1/24/13 to 1/25/13	**0.4**	0.03	**0.34**	0.06	Yes	**0.35**	0.05	Yes
2/8/13 to 2/9/13	**0.47**	0.05	**0.38**	0.09	Yes	**0.41**	0.06	Yes
3/6/13 to 3/8/13	**0.65**	0.10	**0.49**	0.16	Yes	**0.48**	0.17	Yes
3/19/2013	**0.03**	0.02	**0.00**	0.03	Yes	**0.04**	-0.01	Yes
3/30/13 to 3/31/13	**0.22**	0.04	**0.14**	0.08	Yes	**0.19**	0.03	Yes

The second spreadsheet (as shown in Table 3) denotes the comparison of eight weather stations on a monthly basis. This method also helps track the accuracy of

the Cal Poly gages, but on a more long-term level. Please note that not all the gages read the same precipitation amount, due to differences in location and collection procedures. This spreadsheet is used to track the long-term difference between the gages to make sure that they stay relatively constant.

Table 3. Monthly quality control check with eight total local stations.

	Primary Gauges (Rainfall in inches)				Secondary Gauges (Rainfall in inches)			
Date	NOAA Manual Gage	Fisher Porter Gage	Adcon Gage	CIMIS Station 52	Building 70 Manual Gage	Arboretum Gage	Crops Unit Gage	Chorro Creek Station
Jul 2012	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Aug 2012	0.03	0.00	0.00	0.01	0.00	0.00	0.00	0.00
Sep 2012	0.00	0.02	0.00	0.00	0.00	0.00	0.00	0.00
Oct 2012	1.35	1.22	1.22	1.19	1.26	-	-	1.01
Nov 2012	3.07	2.75	2.66	2.66	2.35	-	-	1.86
Dec 2012	6.42	6.10	6.15	5.65	6.50	-	3.78	6.51
Jan 2013	1.35	1.30	1.27	1.20	1.78	-	1.12	1.16
Feb 2013	0.89	0.72	0.77	0.71	0.81	-	0.75	0.62
Mar 2013	0.90	0.65	0.68	0.65	0.88	-	0.52	0.37
Apr 2013	0.00	0.07	0.13	0.11	0.00	-	0.09	0.15
May 2013	0.31	0.22	0.22	0.22	0.00	-	0.21	0.10
Jun 2013	0.01	0.01	0.02	0.02	0.00	-	0.01	0.00
Total	**14.33**	**13.06**	**13.12**	**12.42**	**13.58**	**0.00**	**6.48**	**11.78**

Correspondence with NWS

Throughout the entirety of the project, correspondence with NWS has been a key role in the project's success. Bonnie Bartling is the contact for the National Weather Service. She is a weather specialist at the Oxnard branch, and is in charge of overseeing all voluntary weather stations along the Central Coast.

Two times a year, Bonnie makes a trip to Cal Poly where she evaluates the condition of the two NWS affiliated stations (Fisher Porter Gage and the NOAA Manual Station). She cleans out the Fisher Porter gage by draining and refilling the evaporation-prevention oil on top of the scale, as well as tests the thermometers in the Cotton Region Shelter for accuracy.

At the beginning of every month, the previous month's data sets that were collected from both the manual station and the Fisher Porter Gage are sent to Bonnie at NWS for analysis and publication. Continual training and modifications have been made by Bonnie's request to ensure that the Cal Poly weather station remains an official station recognized by NWS.

RESULTS

The analysis of several weather stations resulted in the use of the COOP 04-7851 station data for the water years starting in 1870 through 2005, and the SLO Reservoir Station #1 data was used from 2006 through 2010, and the COOP 04-7851 station (relocated to the Irrigation Practice Field and managed by the ITRC) data was used again from 2011 until now. The comparison of the data can be found below in Table 4.

As shown in the table above, the data provided by SLO County is significantly lower than the data provided by both the CIMIS station 52 and SLO Reservoir for every year except July 2008 through June 2009. For this reason, and after the analysis of the various stations, the data from SLO Reservoir was decided to be the official data from 2006 through 2010. This can be seen in the tables and graphs provided in Appendix C of this report.

Once the accurate data was properly compiled, a graph was created for the National Weather Service to show a long term average, a 10 year running average, a cumulative departure, as well as the actual data for the past 143 (shown below in Figure 7). This information provided to the NWS allows the historical data to be used in weather forecasting and other precipitation evaluations. One piece of information from that graph that can be extremely helpful in quickly observing long term data is the cumulative departure from average (the orange line). From the graph below, it shows that the majority of the rainfall in the 143 year time frame occurred during the latter part of the twentieth century. This is apparent from the drastic incline in the data starting in the mid 1960s. This graph is a clear and concise way of presenting data that can be used for quality control as well. NWS also creates similar graphs for other weather stations around the country; therefore with a consistent format it is easier to recognize errors and is also aesthetically pleasing.

Figure 8 also shows the comparison of the three ITRC stations used in the quality control calibration. It is clear from the chart that the NOAA manual gage continually reads highest, CIMIS 52 reads second highest, while Adcon usually reads the lowest value of the three stations.

Table 4. Comparison of precipitation values from July 2007 through June 2011.

Beginning Year	Month	SLO County	CIMIS 52	SLO Reservoir
2010	Jul	0.04	0.06	0.00
	Aug	0.00	0.04	0.00
	Sep	0.00	0.13	0.00
	Oct	1.70	2.13	2.20
	Nov	1.81	2.32	2.24
	Dec	9.62	11.98	12.09
	Jan	2.58	3.44	0.47
	Feb	0.96	3.78	4.33
	Mar	0.17	6.48	7.20
	Apr	0.01	0.21	0.16
	May	1.07	1.33	1.42
	Jun	1.33	1.28	1.38
Totals		**19.29**	**33.18**	**31.50**
2009	Jul	0.00	0.00	0.00
	Aug	0.00	0.00	0.00
	Sep	0.00	0.00	0.08
	Oct	0.57	5.90	7.36
	Nov	0.00	0.00	0.08
	Dec	3.39	3.77	4.80
	Jan	6.29	6.96	8.94
	Feb	3.58	5.18	5.75
	Mar	1.32	1.72	1.81
	Apr	2.41	2.74	2.40
	May	0.16	0.27	0.51
	Jun	0.00	0.00	0.00
Totals		**17.72**	**26.54**	**31.73**
2008	Jul	0.00	0.00	0.00
	Aug	0.07	0.00	0.16
	Sep	0.00	0.00	0.00
	Oct	0.33	0.00	0.19
	Nov	1.50	0.69	1.58
	Dec	1.90	2.09	1.89
	Jan	0.91	0.96	0.87
	Feb	5.83	5.40	3.11
	Mar	1.35	1.38	1.49
	Apr	0.49	0.49	0.51
	May	0.22	0.28	0.20
	Jun	0.40	0.00	0.35
Totals		**13.00**	**11.29**	**10.35**
2007	Jul	0.00	0.00	0.00
	Aug	0.13	0.10	0.08
	Sep	0.07	0.00	0.04
	Oct	0.57	0.15	0.98
	Nov	0.06	0.01	0.08
	Dec	2.92	3.72	4.45
	Jan	1.23	8.70	9.84
	Feb	1.36	3.71	3.58
	Mar	0.14	0.12	0.12
	Apr	0.29	0.48	0.71
	May	0.03	0.05	0.00
	Jun	0.00	0.00	0.00
Totals		**6.80**	**17.04**	**19.88**

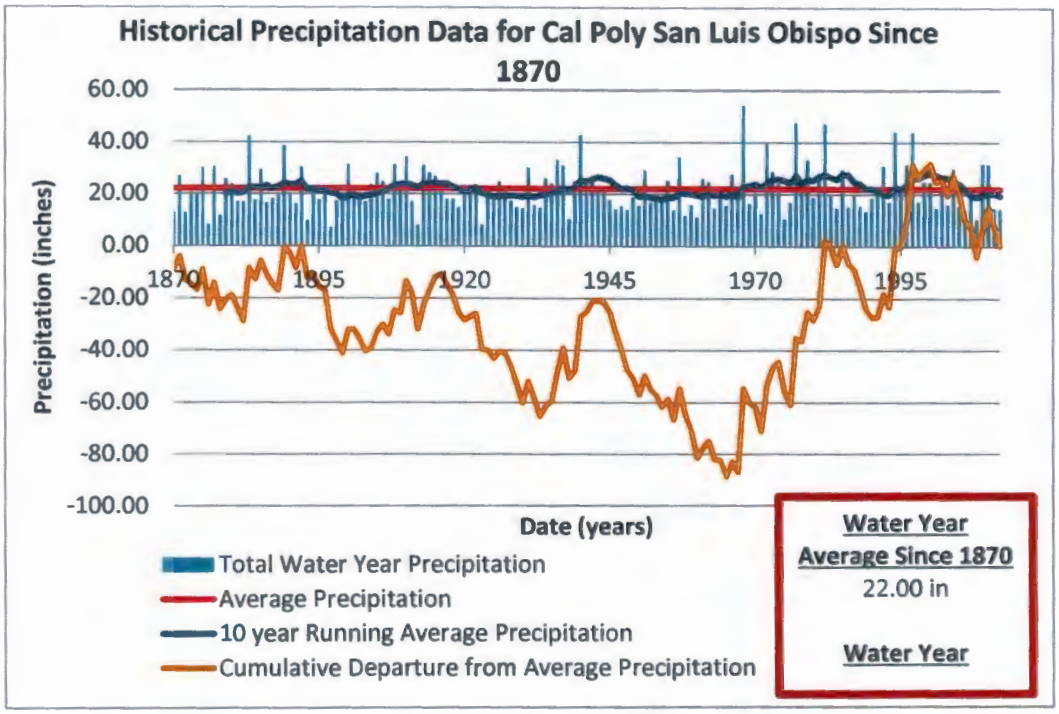


Figure 7. Historical graph of official Cal Poly precipitation data from 1870 to 2012

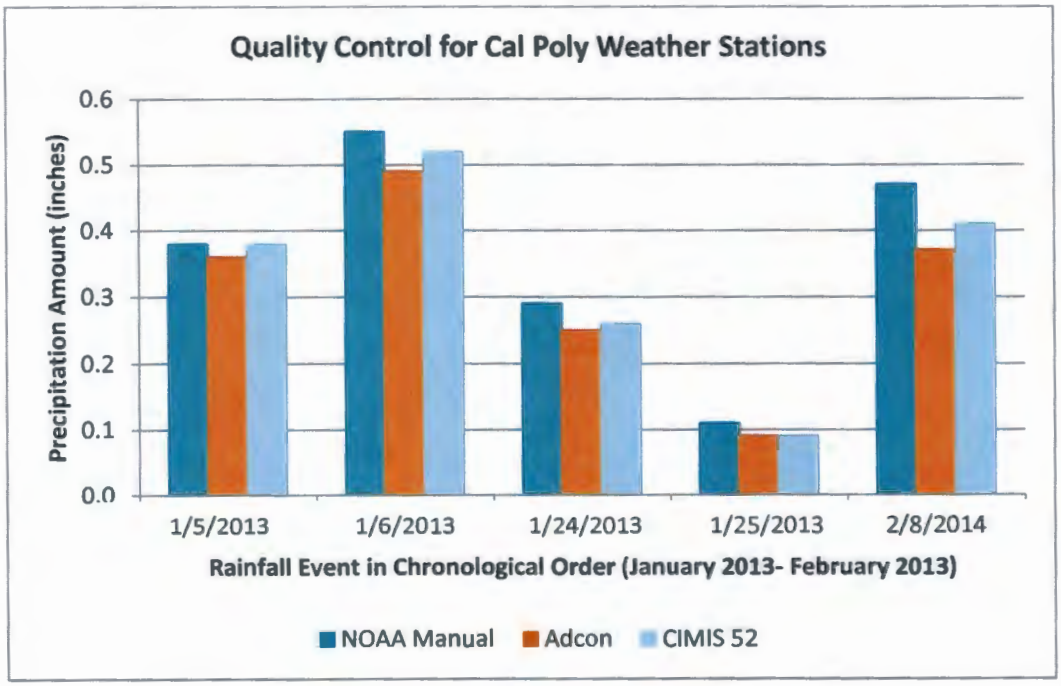


Figure 8. Quality control for each day of rain at the Cal Poly stations by comparing long run difference.

DISCUSSION

The most difficult part of this project was creating a method of quality control and a method of recording future data in a way that is easy for future ITRC staff to use and interpret. The quality control spreadsheet is set up in a way that there are only four pieces of information that need to be entered: the date of the rainfall event (dry day to dry day), and the amount of rain in inches from the NOAA manual gage, the CIMIS 52 gage, and the Adcon gage. The reason that the data was collected from dry day to dry day is because the NOAA manual gage is collected once a day at four o'clock in the afternoon, while the two automated gages record the day's precipitation at midnight. While there was no cost associated with the project, a generous donation by the family of Ernie Righetti and several others will allow this project to continue on into the future by ITRC staff.

The collection of the precipitation data from both the manual gage and the Fisher Porter gage were the only instances that created safety concerns. Due to the possibly muddy and slippery terrain after a rainfall event, it was important to dress in the proper boots/shoes when collecting data. Because historical data was a main focus of this project, a majority of the data was collected from old electronic files or through the internet.

Another difficulty that was resolved with further investigation was understanding the fact that all the gages read different values (for a majority of readings). This is due to the fact that each gage records data in a different fashion, as well as the fact that each gage is in a slightly different location. As shown in Table 3 from the Procedures and Methods section and Figure 8 from the Results section, it is clear that each gage used in the San Luis Obispo area recorded a different amount of precipitation. Once this idea was fully understood, it was easier to create a spreadsheet that monitored quality control of the ITRC weather station gages. Because each station reads a slightly different value for each rainfall event, the spreadsheet monitors the difference between the gages over time to help determine if one gage is reading incorrectly.

RECOMMENDATIONS

Below is a list of recommendations for any further improvements to the collection and recording process of precipitation as well as improvements to the quality control methods currently being used.

- First, for more accuracy in data collection, it would be recommended that all automated precipitation gages base their 24 hour recording cycle starting and stopping at four o'clock in the afternoon. This would allow for all the automated systems to follow the manual recording time (set in place by NWS), and would make quality control of the stations more straight forward.

- Second, the quality control spreadsheet should continue to be applied to other stations in the area, including the Fisher Porter gage. While there are greater discrepancies between stations that are not within the same fifty foot radius, it would still be useful to monitor how those stations differ within the greater San Luis Obispo area.

CONCLUSION

Over the course of three years, historical precipitation data from the Cal Poly Coop 04-7851 station, as well as several other weather stations, was collected. The data pertaining to the years 2005 through 2010 for the Coop station were found to be incorrectly recorded, and therefore the inaccurate data was corrected based on data from surrounding stations.

A quality control spreadsheet was created in order to monitor the accuracy of the gages at the Cal Poly weather station. This spreadsheet uses standard deviations of the NOAA manual gage, Adcon gage, and CIMIS 52 gage and monitors the difference in precipitation for each rainfall event.

With the proper collection methods, as well as tools to aid in the quality control process, regulation entities will be better informed when making decisions regarding water regulation, and monitoring groups will be better suited in making claims and theories related to climate and precipitation.

REFERENCES

California Irrigation Management Information System. 2009. State of California. <http://wwwcimis.water.ca.gov/WSNReportCriteria.aspx>.

García-Suárez, A.M., C.J Butler, M.G.L. Baillie. Climate Signal in Tree-ring Chronologies in a Temperate Climate. 2009. Science Direct. <http://climate.arm.ac.uk/publications/tree_rings.pdf>.

Grissino-Mayer, Dr. Henri D. Principles of Dendrochronology. 2014. <http://web.utk.edu/~grissino/principles.htm>.

Irrigation Training and Research Center. 2014. <http://www.itrc.org/databases/precip/>.

National Oceanic and Atmospheric Administration's National Weather Service. 2014. Cooperative Observer Program. <http://www.nws.noaa.gov/os/coop/standard.htm>.

San Luis Obispo County. 2014. SLO Reservoir. SLO County Water. <http://www.slocountywater.org/weather/alert/precipitation/sloreservoir.htm>.

Slayton, John. COOP Weather Station 047854 "San Luis Obispo Polytech" Narrative History. 2012. Draft.

APPENDIX A

BRAE SENIOR PROJECT CONTRACT

California Polytechnic State University

November 5, 2014

BioResource and Agricultural Engineering Department

Olsen, Hilary S

BRAE Senior Project Contract

00558
9905

Project Title

Analysis of the San Luis Obispo Historic Precipitation Data and Calibration of the Cal Poly Weather Station

Background Information

In 2010 the Irrigation Training and Research Center (ITRC) took over the management of the Cal Poly weather station. Once this transition was complete, it was noticed that there was some discrepancies in the data with other nearby stations. The Cal Poly station was evaluated against several other stations in order to recognize the correct, accurate data, and replace the inaccurate values with the correct ones.

Statement of Work

This project will be done in three phases, the first phase being a data collection phase. Precipitation data will be collected from the Cal Poly weather station (including the NOAA manual gage, the CIMIS station 52 gage, the Adcon gage, and the Fisher Porter gage) as well as the SLO Reservoir, Cal Poly #1 station and the Atascadero rain gage. Once all of the historical data is collected, phase two will consist of analysis. The data will be analyzed to compare and contrast values being recorded by different entities, and then a decision will be made on what values are the most accurate. The third phase will be creating a method for quality control and calibration. A system will be set up for ITRC employees to be able to properly monitor the values being collected and reported by all gages in the Cal Poly weather station to ensure correct and accurate data.

How Project Meets Requirements for the BRAE Major

Major Design Experience – This project consists of mostly analysis related constraints. These constraints can be found below, as well as constraints relating to the management of the station to ensure accurate data is being collected and recorded.

Establishment of objectives and criteria	The main objective of this project is to establish what data is accurate, correct the inaccurate data values with accurate ones, and create a method of quality control to ensure future accurate records.
Synthesis and	This project will require a lot of analysis. Historical data that

analysis	dates back over 100 years will be analyzed for several stations in order to obtain the most accurate values possible.
Construction, testing and evaluation	There is no physical construction aspect of this project. A spreadsheet and evaluation system will be constructed via computer software to provide future employees a method of quality control on the Cal Poly weather station.
Incorporation of applicable engineering standards	The standards used in this project will be in regards to engineering ethics. The accuracy of this data will not only effect the legitimacy of the Cal Poly weather station is the eyes of the National Weather Service, but it will also affect local farmers and other entities that rely on accurate data on which they base business decisions.
Capstone Design Experience – Below is a list of BRAE and other required courses that are applicable to this analysis project.	
Incorporates knowledge/skills from earlier coursework	BRAE 236 – Principles of Irrigation, BRAE 331 – Irrigation Theory, 403 – Agricultural Systems Engineering, SS 121 – Soil Science, ENG 149 – Technical Writing for Engineers, STAT 312 – Statistical Methods for Engineers
Design Parameters and Constraints – Below are a list of project constraints that will be faced during the process and completion of this project.	
Physical	This analysis will involve some physical collection methods. The manual gages at the Cal Poly weather station involve manual collection of data on a daily basis. Historical data will be collected via the internet and historical files.
Economic	This analysis does not include any economical aspects due to the fact that it is the correction of inaccurate data, and the creation of a quality control method has no cost. Economics would become a major factor if this project involved the installation of a new weather station and rain gage.
Environmental	The accurate collection and publication of precipitation amounts has a large impact on the environment, even though it is indirectly related. When businesses are making decisions that could affect the environment based on precipitation records, the accuracy of these records becomes immensely important in assuring environmental considerations are being met with precipitation based decisions.

Sustainability	While the analysis of the station does not directly have any sustainable facets, the Cal Poly weather station itself is sustainable. The manual gages are mechanical only, while the automated stations are solar operated.
Manufacturability	N/A
Health and Safety	Health and safety play a part in this project in relation to the manual collection of the precipitation data. Safety practices must be in use during all methods of data collection to ensure positive health of the collector.
Ethical	This project requires accuracy and honesty. Many business entities rely on the precipitation data being provided by the Cal Poly weather station. If this data is not accurately represented, or the inaccurate data properly corrected, businesses and other local entities could be negatively impacted.
Social	This project, as stated in several constraint sections above, incorporates the well being of the local public. This issue is a very large constraint that must be taken into account during the entirety of the project.
Political	Because this project affects the public, it also has the possibility of effecting political bodies.
Aesthetic	The only aesthetical aspect of this project is related to the representation of the corrected data, and the representation of the method of quality control devices.
List of Tasks and Time Estimate	
TASK	Hours
Collection of historical data for the Cal Poly stations	20
Collection of historical data for other local stations	20
Analysis of the data	50
Correspondence with	20

NWS	
Creation of a quality control method	30
Correspondence with ITRC	20
Writing project report	
Project presentation preparation	20
	10
TOTAL	170

Financial Responsibility	

Preliminary estimate of project costs: $ 0

Finances approved by (signature of Project Sponsor): _____

Final Report Due: Fall 2014 **Number of Copies**: 3

Approval Signatures **Date**

Student: _____ _____

Project Supervisor: _____ _____

Department Head: _____ _____

APPENDIX B

PROJECT TIMELINE

Project Timeline		Week Number									
Key	C= Complete	1	2	3	4	5	6	7	8	9	10
BRAE 460											
	Brainstorm ideas		C								
	Project justification			C							
	Consult with project sponsor				C						
	Consult project advisor				C						
	Correspond with NWS				C			C			C
	Initial lit review							C			
	Draft contract and schedule							C			
	Final contract and schedule due										C
BRAE 461											
	Weekly meetings with advisor	C	C	C	C	C	C	C	C	C	C
	Correspond with NWS	C			C			C			C
	Collect Cal Poly station data		C	C							
	Collect other station data				C	C					
	Write introduction						C				
	Write lit review							C			
	Make corrections								C		
	Make project poster									C	
	Project poster presentation										C
	Final intro and lit review due										C
BRAE 462											
	Weekly meetings with advisor	C	C	C	C	C	C	C	C	C	C
	Analyze historical data		C								
	Brainstorm quality control method			C							
	Create a method for quality control				C						
	Correspond with NWS	C			C			C			
	Write procedures and methods				C						
	Write results					C					
	Write discussion					C					
	Write recommendations						C				
	Decide on proper appendices						C				
	Update table of contents, list of tables, and list of figures							C			
	Write abstract							C			
	Submit to advisor for editting							C			
	Make corrections								C		
	Complete project poster									C	
	Project poster presentation										C
	Final completed report due										C

APPENDIX C

CAL POLY WEATHER STATION HISTORICAL DATA

Data Source: SLO County Reservoir #1 ITRC Manual Data

Monthly Precipitation Data (inches):

Begin Year (July to June)	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	Jun.	TOTAL
1870	0.00	0.00	0.00	0.68	0.38	2.90	1.51	4.43	0.00	2.79	0.28	0.00	12.97
1871	0.00	0.00	0.00	0.00	2.40	13.93	5.16	3.45	0.71	1.37	0.00	0.00	27.02
1872	0.00	0.00	0.00	0.00	0.00	6.00	5.00	1.79	0.00	0.00	0.00	0.00	12.79
1873	0.00	0.00	0.00	0.00	0.00	7.96	4.29	4.04	3.23	1.00	0.00	0.00	20.52
1874	0.00	0.00	0.00	4.28	2.05	0.48	12.10	0.28	0.50	0.00	0.00	0.00	19.69
1875	0.00	0.00	0.00	0.00	6.20	2.20	9.87	5.29	5.30	1.26	0.00	0.00	30.12
1876	0.00	0.00	0.00	1.16	0.00	0.00	4.83	0.42	1.74	0.00	0.00	0.00	8.15
1877	0.00	0.00	0.00	0.00	1.42	3.90	7.88	11.91	2.74	2.75	0.00	0.00	30.60
1878	0.00	0.00	0.00	0.00	1.50	2.58	1.78	2.15	1.60	1.80	0.25	0.00	11.66
1879	0.00	0.00	0.00	0.75	1.40	3.03	1.75	7.23	2.36	8.78	0.52	0.00	25.82
1880	0.00	0.00	0.00	0.00	0.48	13.35	4.71	1.90	1.40	1.85	0.00	0.00	23.69
1881	0.00	0.00	0.40	1.65	0.25	2.00	0.85	3.40	6.75	1.73	0.00	0.00	17.03
1882	0.00	0.00	0.00	0.69	2.95	0.44	1.50	1.60	4.88	1.10	3.85	0.00	17.01
1883	0.00	0.00	0.00	0.00	0.00	3.56	10.57	10.21	12.41	3.39	0.00	2.26	42.40
1884	0.00	0.00	0.00	2.17	0.13	8.85	2.25	0.00	0.94	3.15	0.10	0.00	17.59
1885	0.00	0.00	0.00	0.04	12.90	3.67	5.78	0.79	2.37	3.75	0.00	0.00	29.30
1886	0.00	0.00	0.00	0.25	1.25	1.06	1.10	9.60	1.29	1.56	0.36	0.07	16.54
1887	0.02	0.00	2.05	0.25	1.40	3.15	7.02	0.28	3.84	0.14	0.16	0.04	18.35
1888	0.00	0.00	0.00	0.00	4.48	3.36	1.50	2.08	7.51	0.61	0.00	0.00	19.54
1889	0.00	0.00	0.00	9.19	2.46	11.37	7.27	4.67	3.07	0.29	0.41	0.00	38.73
1890	0.00	0.00	0.82	0.00	0.42	6.04	0.88	7.14	1.97	1.96	0.13	0.15	19.51
1891	0.00	0.00	0.27	0.00	0.20	5.15	0.70	2.88	4.25	0.60	2.23	0.05	16.33
1892	0.00	0.00	0.00	0.15	2.76	6.57	4.02	6.35	9.33	1.14	0.08	0.00	30.40
1893	0.00	0.00	0.03	0.82	0.45	1.64	1.83	2.31	0.79	0.41	1.32	0.21	9.81
1894	0.05	0.00	1.81	1.71	0.35	5.45	8.05	1.82	2.44	0.67	0.47	0.00	22.82
1895	0.00	0.00	0.00	1.80	1.56	0.68	8.23	0.00	3.16	2.22	0.10	0.00	17.75
1896	0.04	0.20	0.00	1.44	3.02	3.04	5.22	4.40	3.17	0.18	0.04	0.00	20.75
1897	0.00	0.00	0.07	0.79	0.07	0.65	1.37	2.20	0.91	0.06	1.04	0.04	7.20
1898	0.00	0.00	0.20	0.39	0.08	0.64	5.56	0.28	7.62	1.54	0.10	0.92	17.33
1899	0.00	0.00	0.00	3.92	1.94	4.51	2.13	0.16	2.18	0.98	1.38	0.01	17.21
1900	0.00	0.00	0.00	1.93	8.01	0.26	11.21	5.89	0.58	2.83	0.69	0.00	31.40
1901	0.00	0.18	0.10	2.58	1.58	0.12	1.46	8.79	4.68	2.44	0.03	0.00	21.96
1902	0.00	0.00	0.00	2.00	1.52	1.48	3.67	3.18	4.98	1.66	0.00	0.00	18.49
1903	0.00	0.00	0.00	0.02	0.48	0.32	1.08	6.79	5.13	2.97	0.20	0.00	16.99
1904	0.00	0.06	3.54	1.00	0.13	1.72	2.35	7.51	4.19	0.77	2.26	0.03	23.56

Begin Year (July to June)	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	Jun.	TOTAL
1905	0.03	0.00	0.00	0.00	1.97	0.32	6.37	3.48	10.86	0.71	4.22	0.16	28.12
1906	0.00	0.03	0.04	0.00	1.08	5.14	8.78	2.45	6.79	0.34	0.11	0.02	24.78
1907	0.00	0.00	0.07	3.23	0.01	3.33	6.69	3.59	0.79	0.14	0.21	0.00	18.06
1908	0.00	0.00	0.84	0.59	0.73	1.70	17.00	6.44	4.04	0.03	0.00	0.00	31.37
1909	0.00	0.00	0.02	0.54	2.24	10.09	3.48	0.43	3.81	0.23	0.00	0.00	20.84
1910	0.00	0.00	0.41	0.30	0.27	0.95	14.31	4.86	11.92	1.32	0.08	0.00	34.42
1911	0.00	0.00	0.02	0.12	0.46	3.72	2.80	0.02	5.65	2.27	2.09	0.00	17.15
1912	0.00	0.00	0.04	0.00	0.79	0.24	3.48	1.66	0.96	0.52	0.30	0.09	8.08
1913	0.00	0.91	0.07	0.00	3.97	5.73	15.03	3.31	1.24	0.68	0.06	0.22	31.22
1914	0.00	0.00	0.00	0.08	0.12	6.01	7.11	9.51	0.95	2.47	1.91	0.01	28.17
1915	0.01	0.00	0.00	0.00	0.34	3.58	18.25	2.38	2.12	0.21	0.04	0.00	26.93
1916	0.00	0.00	1.94	1.82	0.38	9.26	1.59	7.01	0.44	0.11	0.49	0.00	23.04
1917	0.01	0.00	0.00	0.09	0.47	0.14	0.55	9.63	7.12	0.04	0.01	0.00	18.06
1918	0.00	0.01	0.73	0.81	4.00	1.92	1.51	5.48	3.35	0.09	0.19	0.00	18.09
1919	0.00	0.00	0.42	0.12	0.14	4.52	0.82	2.36	4.78	1.65	0.00	0.05	14.86
1920	0.00	0.03	0.00	1.23	1.64	3.85	6.18	2.16	2.29	0.57	1.32	0.00	19.27
1921	0.00	0.00	0.40	0.16	0.16	7.22	4.48	6.49	3.46	0.27	0.72	0.00	23.36
1922	0.00	0.00	0.00	0.47	5.30	6.64	4.51	1.36	0.38	4.57	0.01	0.04	23.28
1923	0.00	0.00	0.70	0.16	0.32	0.73	1.46	0.44	4.05	0.33	0.00	0.00	8.19
1924	0.00	0.04	0.00	0.94	0.89	2.04	2.78	4.32	4.21	2.68	3.58	0.15	21.63
1925	0.00	0.03	0.06	0.37	0.05	3.00	3.32	7.29	0.33	4.31	0.06	0.00	18.82
1926	0.00	0.00	0.00	0.66	8.24	1.41	2.78	7.78	2.10	1.54	0.05	0.12	24.68
1927	0.00	0.00	0.00	2.54	3.04	4.93	0.34	3.89	5.65	0.51	0.43	0.00	21.33
1928	0.00	0.00	0.00	0.00	3.51	5.42	1.96	2.90	1.78	1.39	0.00	0.34	17.30
1929	0.00	0.00	0.05	0.00	0.00	0.33	6.07	3.32	3.15	0.67	1.21	0.17	14.97
1930	0.00	0.00	0.14	0.04	1.98	0.63	6.22	1.92	0.54	0.48	2.52	0.16	14.63
1931	0.00	0.06	0.00	0.09	2.88	14.99	4.95	5.92	0.88	0.40	0.18	0.00	30.35
1932	0.04	0.02	0.05	0.33	0.31	1.81	8.87	0.33	1.03	0.17	0.93	1.88	15.77
1933	0.00	0.00	0.00	0.95	0.00	7.11	0.05	4.80	0.07	0.00	0.38	1.61	14.97
1934	0.00	0.00	0.07	2.28	3.91	2.84	6.01	0.93	4.59	5.35	0.01	0.00	25.99
1935	0.00	0.71	0.00	0.74	1.94	2.72	2.53	12.00	1.49	1.55	0.14	0.20	24.02
1936	0.14	0.00	0.11	1.69	0.00	8.29	7.98	9.25	5.56	0.22	0.00	0.05	33.29
1937	0.00	0.00	0.00	0.09	0.78	7.51	2.70	11.96	6.79	1.12	0.09	0.00	31.04
1938	0.00	0.00	0.54	0.53	0.48	1.08	3.39	1.97	1.92	0.26	0.13	0.00	10.30
1939	0.02	0.00	0.59	1.34	1.07	1.92	9.29	6.41	1.89	2.37	0.01	0.00	24.91
1940	0.00	0.00	0.00	0.78	0.25	9.68	7.80	9.85	8.60	5.23	0.73	0.00	42.92
1941	0.02	0.02	0.00	1.14	0.95	10.18	2.80	1.93	2.33	3.94	0.30	0.00	23.61
1942	0.00	0.01	0.00	0.54	1.34	3.35	10.83	2.01	6.94	1.04	0.00	0.00	26.06

Begin Year (July to June)	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	Jun.	TOTAL
1943	0.00	0.00	0.00	1.15	0.42	4.57	1.77	9.45	2.61	2.22	0.24	0.01	22.44
1944	0.00	0.00	0.00	0.14	6.10	2.18	0.16	6.48	5.91	0.12	0.10	0.09	21.28
1945	0.00	0.03	0.11	1.14	0.83	7.36	0.63	2.26	4.20	1.24	0.19	0.00	17.99
1946	0.04	0.02	0.00	0.55	6.64	2.68	0.44	1.15	2.04	0.20	0.27	0.24	14.27
1947	0.00	0.04	0.00	1.40	0.12	1.47	0.06	2.17	5.25	4.14	0.89	0.00	15.54
1948	0.00	0.00	0.00	0.39	0.02	3.50	1.94	2.41	5.68	0.11	0.00	0.00	14.05
1949	0.00	0.00	0.00	0.00	2.23	3.85	4.89	3.88	1.41	2.53	0.17	0.00	18.96
1950	0.46	0.00	0.03	2.12	2.38	3.25	3.42	1.31	1.03	1.48	0.13	0.00	15.61
1951	0.00	0.04	0.05	0.93	1.96	8.39	9.53	0.63	6.65	1.05	0.04	0.03	29.30
1952	0.05	0.00	0.00	0.00	3.55	7.28	2.37	0.00	1.40	1.99	0.15	0.04	16.83
1953	0.00	0.00	0.00	0.00	3.45	0.42	6.10	3.50	4.90	1.28	0.09	0.03	19.77
1954	0.00	0.00	0.00	0.00	2.77	3.10	5.60	1.96	0.18	2.67	1.00	0.00	17.28
1955	0.00	0.01	0.00	0.00	1.93	10.88	6.51	1.46	0.01	3.47	0.90	0.00	25.17
1956	0.00	0.00	0.00	0.65	0.00	0.49	3.01	3.88	1.17	3.11	1.57	0.00	13.88
1957	0.00	0.00	0.00	1.68	0.55	4.23	3.78	8.99	8.40	6.51	0.23	0.00	34.37
1958	0.00	0.00	0.95	0.00	0.32	0.18	2.69	6.60	0.00	0.95	0.07	0.00	11.76
1959	0.00	0.00	0.73	0.00	0.00	0.60	4.23	6.85	1.52	1.94	0.04	0.00	15.91
1960	0.00	0.00	0.00	0.22	3.76	1.67	1.97	0.91	1.74	0.49	0.33	0.04	11.13
1961	0.01	0.00	0.01	0.00	4.60	2.14	2.88	13.96	2.16	0.13	0.04	0.06	25.99
1962	0.00	0.00	0.00	1.52	0.04	2.73	3.56	8.08	4.61	3.84	0.33	0.09	24.80
1963	0.00	0.00	0.19	1.94	4.08	0.15	3.01	0.12	2.10	1.69	1.03	0.37	14.68
1964	0.02	0.00	0.10	1.43	3.79	5.78	4.10	0.42	2.29	3.91	0.00	0.00	21.84
1965	0.00	0.00	0.00	0.00	7.80	4.12	2.13	1.15	0.29	0.12	0.00	0.01	15.62
1966	0.15	0.00	1.11	0.00	4.40	7.70	0.00	0.58	6.38	6.90	0.36	0.13	27.71
1967	0.00	0.00	1.20	0.00	3.83	3.05	2.43	2.07	3.70	1.31	0.35	0.00	17.94
1968	0.00	0.00	0.01	3.08	2.10	3.92	24.63	15.16	1.88	3.72	0.00	0.03	54.53
1969	0.00	0.00	0.10	0.62	0.89	1.73	7.28	1.42	4.11	0.18	0.00	0.07	16.40
1970	0.00	0.00	0.00	0.11	6.02	8.51	1.89	0.42	0.73	1.56	1.22	0.00	20.46
1971	0.00	0.00	0.19	0.36	2.00	7.03	1.03	0.86	0.00	0.89	0.06	0.00	12.42
1972	0.04	0.00	0.00	2.72	6.79	2.00	13.84	9.67	4.94	0.00	0.02	0.00	40.02
1973	0.00	0.00	0.07	2.18	4.18	4.90	5.17	0.43	8.97	2.81	0.00	0.02	28.73
1974	0.02	0.00	0.00	1.96	0.74	4.93	0.26	8.35	5.90	2.00	0.00	0.00	24.16
1975	0.00	0.00	0.02	2.23	0.36	0.18	0.01	4.17	2.54	0.88	0.00	0.03	10.42
1976	0.00	1.41	3.87	0.50	1.03	2.49	2.01	0.08	2.13	0.06	3.29	0.00	16.87
1977	0.00	0.00	0.03	0.05	0.28	8.49	15.76	10.71	8.09	4.37	0.00	0.07	47.85
1978	0.00	0.00	1.18	0.00	2.46	2.24	4.62	5.99	4.03	0.24	0.00	0.00	20.76
1979	0.00	0.00	0.20	1.28	1.21	4.84	9.22	11.91	3.47	0.70	0.43	0.00	33.26
1980	0.29	0.00	0.00	0.00	0.01	2.10	6.40	2.15	7.48	0.34	0.00	0.00	18.77

Begin Year (July to June)	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	Jun.	TOTAL
1981	0.00	0.00	0.00	1.59	2.97	1.97	5.87	1.65	8.89	4.12	0.01	0.17	27.24
1982	0.00	0.11	1.19	1.74	6.28	4.97	10.05	10.53	8.61	3.30	0.61	0.00	47.39
1983	0.00	0.91	0.15	2.47	6.54	6.72	0.18	0.97	1.02	0.82	0.00	0.00	19.78
1984	0.00	0.08	0.00	1.27	3.61	3.76	0.72	1.94	3.07	0.30	0.02	0.00	14.77
1985	0.04	0.02	0.04	1.05	4.39	2.03	2.65	11.79	7.26	0.16	0.00	0.00	29.43
1986	0.01	0.00	1.14	0.00	0.28	1.51	2.48	2.90	6.62	0.19	0.06	0.00	15.19
1987	0.00	0.00	0.00	2.76	1.49	4.95	2.87	2.67	1.29	3.44	0.20	0.18	19.85
1988	0.02	0.00	0.00	0.00	1.85	8.08	0.98	1.66	1.99	0.76	0.12	0.00	15.46
1989	0.00	0.00	1.70	1.62	0.55	0.00	3.91	2.98	0.70	0.48	1.42	0.00	13.36
1990	0.00	0.00	0.56	0.00	0.36	0.43	0.81	2.39	12.82	0.43	0.00	0.80	18.60
1991	0.00	0.07	0.00	0.44	0.58	4.49	3.43	9.84	3.15	0.10	0.00	0.04	22.14
1992	0.44	0.00	0.00	1.29	0.00	5.45	10.51	8.61	4.03	0.25	0.23	0.09	30.90
1993	0.00	0.00	0.00	0.22	1.89	2.20	2.93	5.97	1.43	1.46	0.86	0.00	16.96
1994	0.00	0.00	2.38	0.89	2.51	1.15	16.03	2.25	16.48	1.12	0.74	0.76	44.31
1995	0.00	0.00	0.00	0.02	0.40	3.55	4.68	9.73	1.78	1.90	1.05	0.00	23.11
1996	0.00	0.00	0.00	2.23	4.43	10.88	13.31	0.46	0.00	0.05	0.00	0.00	31.36
1997	0.05	0.01	0.00	0.00	5.84	5.32	6.86	15.07	3.79	3.58	3.41	0.05	43.98
1998	0.00	0.00	0.35	0.37	1.88	1.22	3.62	2.37	5.19	2.07	0.00	0.00	17.07
1999	0.00	0.00	0.13	0.00	1.69	0.08	4.33	13.17	1.92	2.97	0.21	0.34	24.84
2000	0.00	0.00	0.02	2.22	0.03	0.19	8.10	7.17	4.94	1.87	0.00	0.00	24.54
2001	0.00	0.00	0.00	0.49	5.47	3.03	1.31	0.84	2.14	1.33	0.18	0.00	14.79
2002	0.00	0.00	0.05	0.00	4.42	8.07	0.38	3.16	3.51	1.92	1.39	0.00	22.90
2003	0.03	0.00	0.00	0.00	2.71	3.25	1.13	8.29	0.61	0.00	0.00	0.00	16.02
2004	0.00	0.00	0.00	0.83	3.96	6.21	6.78	5.54	4.29	0.68	1.46	0.01	29.76
2005	0.00	0.00	0.05	0.01	1.17	0.83	4.32	1.34	3.38	2.88	1.33	0.00	15.31
2006	0.20	0.00	0.00	0.08	0.63	3.03	1.61	4.14	0.51	0.75	0.08	0.00	11.03
2007	0.00	0.08	0.04	0.98	0.08	4.45	9.84	3.58	0.12	0.71	0.00	0.00	19.88
2008	0.00	0.16	0.00	0.19	1.58	1.89	0.87	3.11	1.49	0.51	0.20	0.35	10.35
2009	0.00	0.00	0.08	7.36	0.08	4.80	8.94	5.75	1.81	2.40	0.51	0.00	31.73
2010	0.00	0.00	0.00	2.20	2.24	12.09	0.47	4.33	7.20	0.16	1.42	1.38	31.49
2011	0.01	0.00	0.00	0.51	3.20	0.26	3.27	0.73	2.95	3.69	0.00	0.00	14.62
2012	0.01	0.03	0.00	1.35	3.07	6.42	1.35	0.89	0.90	0.00	0.31	0.01	14.34
Average	0.02	0.04	0.24	0.90	2.03	3.95	4.78	4.37	3.54	1.56	0.47	0.10	22.00

APPENDIX D

DATA REQUEST FORM

Print Form

Water Resources Unit Data Request Form

SAN LUIS OBISPO COUNTY
Department of Public Works

County Government Center, Room 207 • San Luis Obispo CA 93408
Phone: (805) 781-5252 • Fax: (805) 788-2182

Please submit this form via email attachment, by mailing a hard copy to the address above, or by fax to (805) 788-2182.

Date: September 19, 2012

PERSONAL INFORMATION

Name of Individual Submitting Request: Hilary Olsen
Company or Agency (If applicable): Irrigation Training and Research Center
Address: California Polytechnic State University

City: San Luis Obispo State: CA Zip Code: 93407-0730
Phone Number: 530-613-6627 Ext:
Fax Number: Email: holsen@calpoly.edu

DESCRIPTION OF DATA

Data Type: Precipitation Data Interval: hourly, daily, 15min Monthly
Data from: May 1, 2005 Data to: Jun 30, 2010
Specific Project Area:
Purpose of Data: Use as a check for other rainfall data collected during this time period
Preferred Data Format: Text File (CSV Format)
Provide any additional notes or detailed information:

Requesting rainfall data from the Reservoir #1 weather station from 2005-2010.

Note: Most data requests will be processed within ten days. Non-standard requests may take additional time.

If you are an investigator, attorney, or agent, acting on the behalf of any other person, please provide their contact information below.

Name of Individual:
Company or Agency (If applicable):
Address:
City: State: Zip Code:
Phone Number: Ext:
Fax Number: Email:

I certify that the foregoing is true and correct.

Theft, destruction, falsification, or removal of any of the requested records is a crime. Government code section 6201

Hilary Olsen 9/19/12
Signature (or name) of Applicant

revised Dec. 3, 2008

APPENDIX E

ANALYSIS OF THE HISTORICAL PRECIPITATION DATA POWERPOINT PRESENTATION

Cal Poly Weather Station

Analysis of the Historical Precipitation Data

Prepared by: Hilary Olsen
Advisor: Dr. Stuart Styles
Completed: Fall 2014

Project Objectives

- Analyze historical data from Cal Poly station
- Analyze historical data from other stations around San Luis Obispo
- Correct inaccurate data published from 2006-2010
- Create a method for quality control of future data

NOAA Manual Station

Cotton Region Thermometer Shelter

Manual Precipitation Gage

Fisher Porter Station

- Uses weigh bucket to calculated amount of precipitation in inches based on weight in pounds
- Manual collected via an SD card at the end of each month
- Data sent to NWS

CIMIS Station 52

- Uses a tipping bucket to measure the amount of precipitation on a 15 minute interval
- Data is collected through the CIMIS webpage
- Collects various types of weather data

Adcon Station

- Uses a tipping bucket to measure the amount of precipitation on a 15 minute interval
- Data is collected through the Advantage Pro webpage
- Real-Time data is posted on ITRC webpage

Reservoir Station – Cal Poly #1

- Maintained by San Luis Obispo County
- Data obtained to correct data from 2006 through 2010 for the COOP 04-7851 station

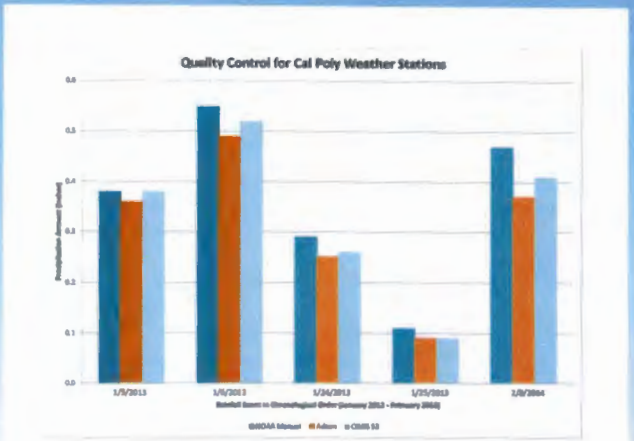
Quality Control Comparison

- Comparison of three stations
- Each gage displays a different reading; this is expected
- Quality control based on if the Adcon or CIMIS 52 station data is less than the standard deviation of all three stations, or if the standard deviation is less than 0.1

Quality Control for Cal Poly Weather Station Gauges								
Rainfall Event	*Station (Rainfall in inches)*							
Date	NOAA Manual Gage	Stnd. Dev. of Three Stations	Adcon	Diff. from Manual	Compliant	CIMIS 52	Diff. from Manual	Compliant
1/3/13 to 1/6/13	0.93	0.04	0.85	0.08	Yes	0.9	0.03	Yes
1/24/13 to 1/25/13	0.4	0.03	0.34	0.06	Yes	0.35	0.05	Yes
2/8/13 to 2/9/13	0.47	0.05	0.39	0.08	Yes	0.41	0.06	Yes
2/6/13 to 2/8/13	0.65	0.10	0.49	0.16	Yes	0.48	0.17	Yes
3/10/2013	0.03	0.02	0.00	0.03	Yes	0.04	-0.01	Yes
3/30/13 to 3/31/13	0.23	0.06	0.14	0.09	Yes	0.19	0.03	Yes

Example of quality control for 2013.

Quality Control Comparison



Precipitation Data Comparison

- Comparison of three stations
- SLO Reservoir and CIMIS 52 are very different from SLO County
- SLO County data changed to match SLO Reservoir data from 2006-2010

Beginning Year	Month	SLO County	CIMIS 52	SLO Reservoir
2010	Jul	0.04	0.06	0.20
	Aug	0.00	0.04	0.00
	Sep	0.00	0.13	0.00
	Oct	1.70	2.13	0.08
	Nov	1.81	2.32	0.63
	Dec	9.62	11.98	3.03
	Jan	2.58	3.44	1.62
	Feb	0.96	3.78	4.13
	Mar	0.17	6.48	0.51
	Apr	0.01	0.21	0.75
	May	1.07	1.33	0.08
	Jun	1.33	1.28	0.00
Totals		19.29	33.18	11.03

Example of comparison for July 2010 through June 2011.
The table displays precipitation amounts in inches.

Completed Cal Poly Historical Data

Further Questions?

Visit itrc.org/databases/precip
for more information

APPENDIX F

HISTORY OF THE COOP 04-7851 STATION – DRAFT REPORT

DRAFT 9 OCT 2012

COOP WEATHER STATION 047854
"SAN LUIS OBISPO POLYTECH"
NARRATIVE HISTORY

John Slayton
260 Sundance Ct
Azusa CA 91702

NARRATIVE HISTORY

Grass Roots Beginnings

In 1866 Dr. W. W. Hayes moved to San Luis Obispo.[1] He had previously served as a weather observer in San Francisco and Santa Barbara.[2] Old habits die hard, and "...this frontier doctor kept daily records of temperature and rainfall and sent his reports back to the Smithsonian Institution, where he had worked as a young man."[3] In 1882 he published a record of rainfall from 1869 to 1882.[4] In 1885 the Army Signal Corps received 'meteorological information' from Dr. Hayes and the Sinsheimer brothers by the hand of a Corporal Thomas Gibson.[5] Perhaps that information was included in the 16 year record of precipitation referred to in that year's report of the State Agricultural Society.[6] (The following year a table in the Signal Corps annual report showed the existence of a 17 year record of precipitation for San Luis Obispo.)[7]

Dr. Hayes' efforts were apparently augmented by a local paper, *The Republic*.[8] Other citizens may have also contributed; Lt. Robert Craig of the Signal Corps reported using the press to invite public participation.[9] During this time it's hard to say who was actually taking measurements, or where, or with what instruments.

Federal Funding!

By 1885, it was time for the Signal Corps to get serious. On February 12, the army sent Lt. Craig from San Francisco to San Luis Obispo. He returned on the 16th with a recommendation that San Luis Obispo would be the best location for a new Signal Service Corps weather station.[10] This recommendation was promptly accepted, and the new second order station was reported established on January 27, going into service on June 1 with 5 observations daily.[11,12]

The station coordinates were given as 35d 18m N, 120d 39m W. It was located at the Andrews Hotel. (See historical picture in the surfacestations.org gallery. Look for the Stevenson screen peeking over the top of the roof.) A later Smithsonian report gave the thermometer elevation as 69 feet, and the rain gauge as 42 feet AGL.[13] This may or may not be correct; the Smithsonian gives this figure for the whole period from 1885 to 1893. But for most of this period, the station was non-existent or in parts unknown, as we shall see. An 1886 report showed barometric pressure, wind, dew point, humidity, precipitation, cloudiness and temperature, from June to December 1885.[14]

Up in Smoke...

Unfortunately the report stopped there, perhaps because the hotel had burned down on April 10, 1886. *The Republic* estimated the loss to the Signal Corps at $1000, a tidy

sum in those days. And the event left the author of the 1886 Signal Corps report in the uncomfortable position of recommending that the station not be reopened, but replaced with a new one at Port Harford.[15] This recommendation was apparently never implemented, but it would be years before the paid station was officially reopened.

In the meantime, weather data was collected from various sources. In 1887, Jesse E. Lewis reported precipitation from July to December to the California Agricultural Society.[16] Some observations for the year ending June 30, 1888 were arranged by M. H. DeYoung of the *San Francisco Chronicle*. Mr. DeYoung's stations were not official Signal Service stations, but the service provided the instruments.[17]

Dr. Hayes apparently was still active; a blurb in the *Republic* on January 10, 1888, reported temperatures for 7:00 AM, 2:00 PM, and 9:00 PM at the county hospital "directed by W. W. Hayes." This, even though Jesse Lewis was the hospital superintendent at the time. By 1889 the hospital location appears to be the settled site. NOAA's MMS location tab remarks: "as of 1/1/89...at hospital where signal service station is located. Early records also from 'Daily Republic'."

It is not clear to me that anyone from the *Daily Republic* was actually making observations. The California State Agricultural report for 1888 contains a lengthy report for 1888 ***compiled*** by J. E. Lewis ***for*** the *Republic*. On page 345 we are told that the Signal Service station was at the hospital. The report included wind velocity, high and low temperatures, rain, and barometric pressure. A 'self-registering' thermometer was in use, at least in January. From all this, it is clear that serious observations were being made, even though the station had been officially closed and was not yet reopened. But the *Republic* appears to be receiving the observations, rather than making them.

The station location was reported as 35d 22m N, 120d 38m W, elevation 366 feet. We learn elsewhere that it was near Bishop and Johnson Avenue, in what was then known as 'the thermal belt' because of its mild weather. Precipitation is again reported in 1888, with no indication of the observer.[18] Jesse E. Lewis continued as hospital superintendent until 1896. In 1889, Mr. Lewis reported the monthly temperatures and precipitation for 1888.[19] He also appears as an observer in the 1890 annual Signal Corps report.[20]

Temperatures are reported for 1889 from January through July, but with no specific indication of their source.[21] Two sources are shown for 1890 precipitation records. They are identified only by '(1)' and '(2)'. The first gives numbers only for January through July; the second reports the entire year.[22]

By 1892-93, the informal local sources may have been drying up. The annual report for 1891 lists SLO in the temperature table, but the line is blank for the year, and it is

not listed in the precipitation table at all. The precipitation table for '92 shows only October through December. SLO doesn't appear in the station list or on the temperature chart in the 1893 report.[23]

Funding Restored...

On August 1, 1894, the station was finally restored to official paid status, now under the management of the Department of Agriculture.[24] NOAA has posted on-line digitized copies of the station's monthly paper reports.[25] There are reports from February of 1893 (before the official reopening) to January of 1896, but these reports are of precipitation only. This may be due to the loss of regional records in the 1906 San Francisco earthquake. All the precipitation records are signed by Jesse Lewis, which makes perfect sense if the station is indeed at the hospital, but becomes a bit puzzling when the station is moved to the Andrews bank building and the reports continue with his name. The digitized voluntary observer's record for September of 1894 carries the note, "This station is near San Luis Obispo and is at the County Hospital."

I suggest that Mr. Lewis continued submitting his own reports even after the station was re-established, so that "This station" on his form refers to his own site and not the newly reopened station. And there are again indications of other sources. The temperature record for 1894 shows the newly activated station as a paid weather service station, and gives readings from August to the end of the year.[26] But it also shows another station, using Southern Pacific data formulas, giving readings from July to the end of the year. A footnote seems to indicate that those readings came from the Pacific Railway system.[27] (See further discussion of railroad involvement below.)

Yet another source appears when we look at the 1894 precipitation record.[28] Three stations are shown. One is the paid station, with data starting in August. Another, starting in June, is our friend the Pacific Railway System. And the third, with monthly readings for the whole year, is the *San Luis Obispo Tribune*. NOAA does not currently cite the *Tribune* in the MMS files.

In 1894 the station was indeed moved to the top of the new Andrews bank building. Coordinates are 35d 18m N, 120d 39m W. Elevations are: [dated 1 June 1885: barometer - 234 feet MSL, thermometer - 50 feet AGL, rain gauge - 42 feet AGL, anemometer - 54 feet AGL], [dated 1 June 1895: barometer - 201 feet MSL, thermometer - 10 feet AGL, rain gauge - 3 feet AGL, anemometer - 46 feet AGL]. The station is now a paid weather service station.[29] While Mr. Lewis' comment above might suggest that these were elevations from the preceding county hospital site, I think that unlikely. A picture from 1894 gives a splendid view of the new station. (See weatherstations.org gallery photo.) The station was now officially reopened, but would move again the following year.

In 1910 an aerial picture of downtown San Luis Obispo was taken from a balloon. This picture shows the next 3 locations of the weather station, and one of these locations shows the station itself as it appeared in 1910. This picture is the property of the History Center of San Luis Obispo County as is the picture of the original Andrews Hotel mentioned above. I have marked the successive locations in order from 1 to 3 (little yellow numbers....).

On June 1, 1895, the station had been moved from the top of the Andrews building to the yard of a residence on the northwest corner of Chorro and Marsh streets. The residence was called the Rackliffe house. This is site number 1. The Stevenson screen was still on a 10 foot tall support structure, but this now rested on the ground, rather than on a building roof. The 1895 report had given station elevation as 201 feet MSL, the thermometer as 10 feet AGL, the rain gauge as 3 feet AGL, and the anemometer as 46 feet AGL (mentioned above). These figures remain unchanged through June, 1902. Temperatures for 1895 are attributed only to the paid station, but precipitation is again sourced from both the paid station and the *Tribune*.[30] In the 1902-03 annual report, the Weather Bureau is getting concerned about the cost of paying rent, which in this case is running $300. (The record doesn't specify, but I suppose that would be per year.) They are proposing to build their own facility.[31] Nevertheless the station remains here until 1902. (Googled coordinates: 35.279, -120.6625)

On June 30 of that year the station was moved to the roof of the Crocker building. (See "2" in the photo.)[32] The Stevenson screen was still on a ten-foot-tall support structure. The new AGL elevations were: thermometer - 46 feet; rain gauge - 39 feet; anemometer - 48 feet. But changes were soon made; on January 12, 1904 the new numbers were 47 feet, 40 feet, and 54 feet AGL, respectively.[33] The station would remain here and these numbers would be reported unchanged until June 30, 1914. (Googled coordinates: 35.2792, -120.6635)

In January of 1896 we had seen the last of the monthly reports submitted by J. E. Lewis. That last form contains the partially decipherable: "Station discontinued on account of Mr. Lewis's _____." NOAA shows no other digitized reports until April of 1906, at which point the monthly reports resume, and include high and low daily temperatures as well as precipitation. Again, the 1906 San Francisco earthquake may be responsible for the gap in records. These new reports are generally signed by the observers, but many of the signatures are indecipherable. So this list should be taken with a good dose of orthographic skepticism....

Apr 1906 - Dec 1908	J. C. James
Feb 1909 - May 1909	W. A. Bowden
Jun 1909, Nov 1909	E. B. Green
Sep 1909 - Oct 1909	W. A. Bowden

Jan 1910 - Mar 1911	T. F. Delaney / H. B. Little
May 1911 - Jul 1911	John S. Osborne
Oct 1911 - Mar 1912	E. F. McFadden
Jul 1912	Dan Ruebask
Sep 1912	J. Sorabaray
Oct 1912 - Mar 1913	C. O. Clifford
Apr 1913	A Cassini
Mar 1913 - Mar 1916	O. P. Gunderson
Apr 1913 - Sep 1913	G. J. Walters
Oct 1913 - Dec 1913	O. P. Gunderson
Jan 1914	M. T. Walsch
Feb 1914	Wm F. Pedego
Mar 1914 - Apr 1917	N. L Maddock
May 1917 - Oct 1917	G. J. Walters

NOAA has posted no digitized forms from this point until the station is moved to the Cal Poly campus in 1927. One can speculate that entry into World War I caused a change in reporting that remained unchanged after the war, but I really don't know.

Back to the first decade...

A complicating question for these years: Did any of the SLO observations originate with a railroad? The roads, especially Southern Pacific, had invested heavily in weather reporting in the 1800s. In 1890, there were 188 railroad stations reporting to the Signal Corps from the Pacific Railway System.[34] Several of the digitized monthly reports mentioned above bear a railroad stamp: April 1906, January 1907, January 1910. And we have commented above on the indications from Agriculture Department records that there was railroad involvement in data sourcing.

And on to the second.

On July 1, 1914 the station was moved to Chorro Street. NOAA gives the address as 1131. (Number "3" in the 1910 photo) The MMS location tab describes the location: "in town. On roof of brick bldg; SS 32' above grd". We are also informed that the new site is "adj. to location 4". I have posted a part of a Sanborn map for 1926 in the surfacestations.org gallery. (SLO 1926) It shows a weather service office still at the corner building (probably the Rackliffe residence). Address 1131 Chorro is in the building immediately to the north. (Googled coordinates: 35.27929, -120.6625)

The annual reports of the weather bureau chief show the instrument AGL elevations here as: temperature - 32 feet, rain gauge - 23 feet, anemometer - 40 feet. These numbers remain unchanged on the annual reports from June 30, 1914 to 1927. The

station remained at this location until it was closed on September 23, 1927. It was reopened on October 1 of that year on the Cal Poly campus.

Moving to Academia

The published NOAA coordinates do not have enough precision to directly pinpoint the new campus location. However *The Rodeo*, Cal Poly's yearbook, has pictures in the 1929, 1930, and 1931 editions showing the station between the administration building and the Crandall Gymnasium. I have reproduced them in the surfacestations.org photo gallery as 1929a..., 1929b..., 1930..., and 1931... . NOAA's MMS location tab currently (as of 7 July 2012) indicates that the station was at this initial location from October 1, 1927 to June 1, 1932. According to that record, it was then moved to the next location, where it remained until 1962.

Unfortunately, that record is incorrect. We know this because there is a Weather Bureau form 531-1 in the surfacestations.org gallery apparently from before 1962 that gives directions to the site. The location is right at the southern boundary of the campus. Yet *The Rodeo* has pictures from the 1937 and 1938 editions that show the station at a different, unreported position just south of the gymnasium but nowhere near the southern edge of campus. These pictures are posted in the gallery as 1937a..., 1937b..., and 1938.... There is also an aerial shot in the 1936 yearbook (1936...) which I have marked to show what I think to be the successive station locations. (little yellow numbers again) The middle location (#2) lacks detail to show what you are looking at, but the other pictures leave no doubt that the station was there during the 1936-37 and 1937-38 school years.

The MMS location tab informs us that the station was ultimately moved 200 yards SSE to get to the south edge of the campus. The Kennedy Library Special Collections has 3 aerial photographs showing the station at this site.[35] Sorry, we do not presently have permission to post these pictures. They appear to cover a span of several years. (You can see the growing bushes/trees to the south of the Stevenson screen.) By backtracking 200 yards NNW, we should reach the location of the previous site. I walked the area with my GPS, and it looks to me like 200 yards NNW will indeed put you just about where we see the station in the 1937-38 pictures, but considerably short of the 1927 site.

Although the MMS files only show two locations, they do show dates for two moves. Using those dates, my guess at the chronology is:

Oct 1, 1927 - Jun 1, 1932: 35.29985, -120.66439
Jun 1, 1932 - Feb 1, 1942: 35.29866, -120.6640
Feb 1, 1942 - Jun 22, 1962: 35.297, -120.6626

It is unclear just what class of station COOP 047851 was when it landed on campus on October 1, 1927. But it was established as a rainfall station on March1 of 1928.[36] About this time, the Guggenheim Foundation set up a demonstration network of weather stations between Los Angeles and San Francisco to support regularly scheduled air passenger service. This demonstration was successful and the Weather Service liked it. So on July 1, 1929, the foundation turned the whole network over to the Feds. And on that same date the Cal Poly COOP station was designated an Airway Station.[37] The airway designation did not last long; it was discontinued on May 15, 1930.[38]

Cal Poly's Kennedy Library has preserved original copies of the monthly observation records. These show the following observers:

Oct 1927 - May 1932 Agosti
Jun 1932 - Jan 1942 J. C. Deuel
Feb 1942 - Oct 1945 M. C. Martinsen

(In 1942, Professor Deuel had been called up to active military duty.)

Friends and Neighbors...?

Draft notices during the war reportedly began with the expression, "Your friends and neighbors have chosen you...." But it was not just individual citizens whose services were commandeered; whole institutions were, as well. The record suggests that COOP 047851 was one of these. A question arises: *What was the relationship of the COOP station with reported neighboring stations?*

We have noted that on July 1, 1929, the Guggenheim network was turned over to the weather bureau and the COOP station gained airway status. The school paper had carried this information in 1928:

> *San Luis Obispo's weather bureau at the Poly office is strategically located in the chain of stations being established along the great airlines of California, under the auspices of the United States Government and financed by funds furnished by the Guggenheim foundation...California now has the best equipped weather-reporting system in the United States...The system consists of 35 Guggenheim stations and seven weather bureaus stations ranged along the great airways between Sacramento and Los Angeles...One of the Guggenheimer stations in this system is located in the Administration at the California Polytechnic. The station is equipped with all of the latest instruments, including an anometer and a Paulin precision barometer. Lynn Broughton has been acting as operator under the Guggenheim system since the first of May, and, on October first, was officially appointed as special observer by the*

U.S. Department of Agriculture. He is assisted by Mr. Thompson. The system is said to have proven satisfactory, and materially increases the safety and economy of aviation on the Pacific Coast...[39]

So we are ostensibly dealing with two Cal Poly weather stations at this time. But it is actually more complicated than that. Because on the same date, July 1, 1929, yet another new station was created: SAN LOUIS OBISPO NAAF.[40] That station is described as "AVIATION, LAND SURFACE, NAAF." The coordinates are the same as those of the COOP station, though they lack enough precision to show the exact location of either station. The question now takes the form: *Were there three physically distinct weather stations at Cal Poly during this time period?*

I believe there was only one, the COOP station, and that this furnished any data that was attributed to the other (virtual?) stations. My reasons:

1. The COOP station shows continuous monthly reporting by signed observers (mostly professors Agosti and Deuel) during this period. Thus there was an existing station available, and no particular reason for the Guggenheim Foundation to spend their limited money to establish a new one.
2. Although Lynn Broughton is named as observer for Guggenheim, assisted by Mr. Thompson, this is probably merely an administrative title. Mr. Broughton at the time was the college accountant and Mr. Thompson was the business manager. It seems improbable that these gentlemen would be personally running outside several times a day to make weather observations. (Remember that one aspect of the aviation network was three daily observations, later raised to six.) Much more credible would be the supposition that Professor Deuel (or, more likely, his students) would be doing this grunt work for both the COOP and Guggenheim networks.
3. The NAAF station appears to be an empty shell. These MMS tabs show no records: Files, Related, Remarks, Phenomena, Equipment, Data Programs, Data Products, or Other Party.
4. Preliminary Googling seems to show that NAAF stations appear during or just prior to WWII. I have found none as early as 1929. This suggest that the NAAF station may have been created by the Navy during the war using a fictional date of origin. If this is the case, then there was no separate physical station at the beginning.

Peace at Last...

By 1945 the war is over and Professor Deuel returns:

Nov 1945 - Sep 1949	J. C. Deuel
(Oct 49)[41] Mar 1950 - May 1950	Fred G. Gertz
Jun 1950 - Jan 1953	E. A. Steiner
Feb 1953	Ralph W. Miller
Mar 1953 - Oct 1957	J. Perozzi
Nov 1957 - Jul 1973	George W. Cockriel

Aug 1973	Forms have been unsigned for months although writing has matched earlier Cockriel submissions, but this month the handwriting changes.
Jul 1977 - Apr 1984	No signatures. Oct 1, 1977 shows "Univ Police".
Apr 1984	Leroy M. Whitmer

In 1962 the station had been moved to the school's airport. We have posted a 1970 aerial photo of the site, again from the Kennedy Library. This location remains unchanged until 2011. Recent satellite and ground photos are readily available of this site.

The following observers are from NOAA's digitized monthly reports.[42]

Apr 1986 - Jul 1990 No signatures during this period.
Aug 1990 - Nov 1990 Mary Viegas
Dec 1990 - Mar 1992 Jennifer K. Cox
Apr 1992 - Mar 1994 Melanie A. Martin
Apr 1994 - Sep 1995 Rebecca Ramsey
Nov 1995 - Jun 1996 Estelle
Aug 1996 B. Mills?
Sep 1995 - Feb 1999 J MacDonald
Mar 1999 - May 2005 During this period, observer duties seem to have been passed around within a small group. Names are not always decipherable, but they include, J. MacDonald, Carey Mills, Mark Anselm, Patricia Cast..., P. Cash Henning (Herring?), Jeff Keyes, Carla Randall.

Ghost Writers in the Sky...?

Suddenly, material attributed to COOP 047851 was coming from somewhere else. From June, 2005, to September, 2011, the data seems to have originated in Weather Underground station KCASANLU4. GISS data files[43] from this period carry some strange source flags[44], including:

Flag 'H': Means 'High Plains Regional Climate Center (Real Time Data)'
6/1/05 to 11/31/05
1/1/06 to 3/31/06
6/1/06 to 6/30/06
9/1/06 to 10/31/06
12/1/06 to 12/31/06
12/1/07 to 1/31/08
6/1/08 to 7/31/08

Flag 'K': Meaning unknown, K is a data flag but not a source flag.
1/1/11 to 11/31/11

Flag '7': Meaning unknown, no such flag listed.
12/1/11 to 12/31/11

End of Identity Theft

Since October 2011, data has once again come from the COOP station, as shown on current B-91 forms. Since 2007 considerable effort has been made to upgrade the station. In 2011 the instruments were moved to 35.30532, -120.662051, so that four weather stations could be consolidated in a single location. Curator Dr. Stuart Styles reports expenditures in the neighborhood of $15K for these efforts.

But Wait, There's More...

I have marked this as a draft; it is improbable that it will ever be finished. Looking forward, the station continues its mission of reporting local weather and training future observers. As to the past, there are many loose threads to unravel. The history museum has an entertaining account by Wilmar Tognazzini of an attempt to use flags to inform people of predicted weather. It would be fun to to incorporate that anecdote into this paper. I still have hope that somewhere there exists a picture of the county hospital that takes in the station instruments. Perhaps some easing of the restrictions on the Kennedy library permissions will one day make it practical to publish the south campus aerials showing the growth of vegetation around the station over a period of years. And there are the mysterious weather stations "San Luis Obispo RS" and "San Luis Obispo NAAF", which seem to be empty shells with no real existence. Plenty of work here for some inquisitive person with more time than I have....

I want to acknowledge and thank Ms. Laura Sorvetti at the Kennedy Library, along with the volunteers at the History Museum of San Luis Obispo County for their considerable assistance in discovering and preparing this material.

ENDNOTES

[1] http://www.cagenweb.com/slo/bios/TW1883.html
[2] *Annual Report of the Smithsonian Institution for the Year 1868*, pp. 69, 70
[3] Landwehr, Lynne, "Medical History of San Luis Obispo County 1860-1900" http://historyinslocounty.org/Early%20Champions%20in%20Health.htm
[4] *Monthly Weather Review*, May 1882 p. 13
[5] *Annual Report of the Chief Signal Officer, 1885* part 1 p. 59-60
[6] *Transactions of the California State Agricultural Society*, 1885 p. 262
[7] *Annual Report of the Chief Signal Officer, 1886* p. 145
[8] ftp://ftp.ncdc.noaa.gov/pub/data/ushcn/v1/metadata
[9] *Annual Report of the Chief Signal Officer, 1885* part 1 p. 59
[10] *op. cit.* p. 58
[11] *op. cit.* pp 536, 545, 576
[12] *Annual Report of the Chief of the Weather Bureau* 1894 pp. 12-13
[13] Smithsonian Miscellaneous Collections Vol 79, 1927 p. 80
[14] *Annual Report of the Chief Signal Officer, 1886* pp. 388-389
[15] *op. cit.* p 139
[16] *Transactions of the California State Agricultural Society*, 1887 p. 434
[17] *Annual Report of the Chief Signal Officer 1888* pp. 11, 63
[18] *Transactions of the California State Agricultural Society*, 1888 p. 388
[19] *Annual Report of the Chief Signal Officer of the Army*, 1889 pp. 262, 298-299, 343
[20] 1890 p. 626
[21] *op. cit.* p. 406
[22] *op. cit.* p. 525
[23] *Annual Report of the Chief of the Weather Bureau* 1893 pp. 14, 163
[24] *Annual Report of the Chief of the Weather Bureau* 1894 pp. 12-13
[25] http://www7.ncdc.noaa.gov/IPS/coop/coop.html
[26] *Annual Report of the Chief of the Weather Bureau* 1894, p. 130-131
[27] *op. cit.* p. 153
[28] *op cit.* p. 190
[29] *Annual Report of the Chief of the Weather Bureau* 1895, pp. 5
[30] *op. cit.* pp. 124-125, 144, 181
[31] *Annual Report of the Chief of the Weather Bureau* 1902-03 p. xxxix
[32] *op. cit.* p. 6
[33] *Annual Report of the Chief of the Weather Bureau* 1904-05 p. 6
[34] *Annual Report of the Chief Signal Officer 1890*, p. 264
[35] UA-CampusAerials-1940-1971-04
UA-CampusAerials-1940-1971-05
UA-CampusAerials-1940-1971-06

[36] *Annual Report of the Chief of the Weather Bureau* 1928-29 p. 39
[37] *Annual Report of the Chief of the Weather Bureau* 1929-30 p. 47
[38] *Annual Report of the Chief of the Weather Bureau* 1930-31 p. 38
[39] *The Polygram* November 16, 1928, front page
[40] NOAA MMS site, San Luis Obispo Poly file, location tab
[41] This date taken from ftp://ftp.ncdc.noaa.gov/pub/data/ushcn/v1/metadata/
[42] http://www7.ncdc.noaa.gov/IPS/coop/coop.html
[43] http://cdiac.ornl.gov/ftp/ushcn daily
[44] http://cdiac.ornl.gov/ftp/ushcn daily/data format.txt

	Previous Data	New Data
First Name:	Hilary	Hilary
Last Name:	Olsen	Olsen
Personal Email:	hilarysolsen@gmail.com	hilarysolsen@gmail.com
Major:	BioResource and Agricultural E	BioResource and Agricultural E
Share Data:	opt_in	opt_in
Principal Activity:	Employed Full-Time	Employed Full-Time
Employer or Institution:	North Coast Engineering	North Coast Engineering
Job title or Concentration:	Engineering Technician	Engineering Technician
Location:	Paso Robles, California	Paso Robles, California
Starting Salary (if applicable):	*Confidential*	41000
Degree Type (if applicable):		
Employed by a non-profit organization:	No	No