Kearny Mesa

Project Title: San Diego County Hydrograph Modification Plan   Project No: 133904

Date: February 2, 2009

Background

In consideration of other state and regional hydromodification management planning efforts, the County of San Diego has endeavored to compact at least 35 years of historical hourly rainfall data into several .wdm files toward the use of hydrologic modeling in the San Diego region. The hydrologic modeling software HSPF utilizes the .wdm files for both an input and output time series data (precipitation values over time). Each .wdm file is a binary, direct-access file that is organized into discrete data sets associated with either an ALERT or CCDA rainfall station. The ALERT stations are maintained by the County of San Diego; whereas, the CCDA stations are maintained by the Western Regional Climate Center and Scripps Institution of Oceanography's California Climate Change Center, thru funding by the California Energy Commission as part of the CalClim project. A total of eighteen ALERT stations and two CCDA stations were chosen to provide an adequate geographic coverage of the major watersheds within County. This report will describe the methodology used toward the creation of the Kearny Mesa ALERT station input .wdm file.

Alert Data – Framework and Data Gaps

The ALERT station at Kearny Mesa (Sensor ID 28) is still in operation and has provided data between September 1964 and June 2008. The data set for any ALERT station is a series of line by line recordings which reflect the various wet or dry weather events logged by the gauge station. Each data set consists of the recorded sensor data as well as other "attributes" to describe the data (e.g. units).

During a wet event, the mechanical sampler within the gauge station would usually capture the amount of precipitation through the use of a tip bucket. Each time the bucket fills with rain, it tips see-saw like. The total rainfall is measured by counting how many times the bucket tips. However, this recording process was not uniformly done. The data within each ALERT station usually contains an assortment of logging periods at either a 5-minute, 15-minute, hourly or even daily interval. So while the mechanical sampling device is constantly recording the amount of precipitation, the line by line recordings within the time series data are exclusively subject to the whatever logging period was programmed. Additionally, these logging periods are used as the "Source" description in order to properly delineate each recorded event within the time series.

An example of the non-uniform data is provided in Table 1 below:

Table 1 – Kearny Mesa Springs County Data - RAW

Date	Time	Data Value	TipBucketCount	Units	Code	Source
3/2/1985	1800	1		in/100		Kearny Mesa 15-min 1971-84
3/2/1985	1930	2		in/100		Kearny Mesa 15-min 1971-84
3/3/1985	15	1		in/100		Kearny Mesa 15-min 1971-84
3/4/1985 12:01:00 AM		0	10	in	S	Kearny Mesa ALERT 1984-97
3/26/1985 10:36:00 PM		0	10	in	S	Kearny Mesa ALERT 1984-97

However, a uniform dataset is necessary for use within the hydrologic modeling software. As such, the following standards were applied toward a uniform hourly dataset:

- If the ALERT data uses an hr 0, it is reflected in the final dataset as hr 24 of the previous day.
- If the ALERT data recorded rainfall precipitation in hundredths of an inch (in/100) or millimeters (mm), the precipitation value was corrected to inches and a "hundredths to inches" or "millimeters to inches" tagline is used within the source description.
- Aggregation – If an ALERT station recorded multiple rainfall entries within a distinct hour, such as when the logging program was set to 5-minute periods, the precipitation values of each entry are added together to reflect a final cumulative precipitation value for the hour. Regardless if multiple rainfall entries occurred or not, this aggregation process was used across all ALERT data entries due to such a large dataset. Once the aggregation process was applied, an "aggregated" tagline is inserted at the end of the source description.
- Disaggregation – If an ALERT station recorded a single daily rainfall entry, the data value provided is broken down into an hourly rainfall distribution. To accomplish this, a unit hyetograph was created following the direction of the County of San Diego Hydrology Manual, Section 4.3.2. The unit hyetograph uses a log-log interpolated value between the 5-year, 6-hr and 24-hr isopulvial graphs, which are also provided by the San Diego Hydrology Manual. Importantly, the disaggregation process generates a group of 24-hr precipitation distribution values which is often less than the initial cumulative daily data value provided due to rounding. If the disaggregation process was applied, a "disaggregated" tagline is inserted within the source description. The disaggregation table is included within Appendix A – Construction of Hyetograph.

Possible Inherent Errors – Data gaps

When creating the initial input .wdm, it is assumed that the recorded sensor data inherently contains errors or data gaps. After recording data for over three decades in a harsh outdoor environment, machinery can fail, sensors can be damaged or perhaps the electronic data was scrambled. Thankfully, the logging program which recorded the precipitation values would usually apply an error attribute alert during the two main data gap situations: an accumulation period or a missing period. An accumulation period is an error scenario where the amount of precipitation is known, but only as a single cumulative amount over a time frame beyond an hour. Basically the distribution of precipitation is unknown, rendering the data unproductive. (e.g. a faulty tip bucket). A missing period is an error scenario where the amount of precipitation is unknown over any time period. This occurred if something affected the logging apparatus directly (e.g. dead battery).

The identifier codes of an accumulation period are (but not limited to) the following: ***, C SA, SA A, A**

They are grouped together to display when the error period begins and ends. Occasionally, an error period would be followed by a subsequent error period resulting in back to back codes: **SA, SA, SA**

The identifier codes of a missing period are (but not limited to) the following: **M, - SM, SM**

Possible Inherent Errors – Identify Outliers

Unfortunately, not all of these data gaps were so easily identified. Indeed, possible data gaps were at times given a 'passing' code, creating a scenario even more difficult to locate on record characteristics alone. As such, the outlier method of identifying errors was used. The general assumption for any time series data analysis is that it contains (1) a systematic pattern and (2) random event outliers (very high or very low data values) which will make the pattern difficult to identify. Unfortunately, a broad filter of all of these random events in order to make the pattern more salient cannot be implemented as many of these events were concretely observed. This is particularly true for all low data values, with the single exception of any possible negative precipitation events which would obviously be an error. However, some of the very high value outliers do indicate a data gap error. For example, an accumulation event will result in higher than normal precipitation values within a single hour.

An example of the various errors discovered by the outlier method is shown in Table 2 below.

Table 2 - La Mesa County Data

Code	DateMOD	HourMOD	Amount	Source	Units
S	12/21/1989	17	0.08	La Mesa ALERT hrly 1983-97	in
*	12/21/1989	12	0	La Mesa ALERT hrly 1983-97	in
	12/26/1989	23	0.04	La Mesa ALERT hrly 1983-97	in
S	12/28/1989	7	0	La Mesa ALERT hrly 1983-97	in
SA	12/31/1989	24	0.12	La Mesa ALERT hrly 1983-97	in
S	1/31/1990	23	2.91	La Mesa ALERT hrly 1983-97	in
S	2/1/1990	15	0	La Mesa ALERT hrly 1983-97	in
S	2/4/1990	10	0.12	La Mesa ALERT hrly 1983-97	in
S	2/5/1990	10	0.54	La Mesa ALERT hrly 1983-97	in
S	2/6/1990	10	0.85	La Mesa ALERT hrly 1983-97	in
S	2/10/1990	10	0.22	La Mesa ALERT hrly 1983-97	in
S	2/25/1990	25	-0.02	La Mesa ALERT hrly 1983-97	in
SM	3/2/1990	4	0	La Mesa ALERT hrly 1983-97	in

Missing Code: C

Hidden Daily Data, not hourly

Negative event

Too large, SA event

Data Gap Analysis table

Trying to identify each data gap separately would be a time consuming process. Instead, the primary step toward the reestablishment of these data gap errors was to gather them together into a Data Gap Analysis table. As mentioned previously, data gaps occasionally occurred across a successive timeframe which became readily apparent once the gaps are grouped together. Conversely, a flagged data gap would occasionally occur within the same hour or subsequent hour. If the precipitation of the data gap is known (i.e. accumulation event), then the data gap warning can be ignored as the event either occurs within the same hour or subsequent hour. Unfortunately, such a straightforward scenario did not usually occur; as such, the time frame for each data gap is properly identified and then supplemented with verifiable data from a separate source. In order to provide a complete representation of this ALERT station, two historical online datasets were used to supplement any such data gaps. An appropriate supplemental gauge station from either of these historical datasets would be chosen on the basis of location proximity and similarity between the gauge and station elevations. However, a disparity between precipitation values recorded by the ALERT and NNDC publications will potentially exist no matter how precise the location/elevation similarity due to the disordered nature of a stormwater event. A listing of this numerical disparity and the selected supplemental gauge station per data gap is included within the Data Gap Analysis. The Data Gap Analysis table is included as Attachment B.

Filling in the Data Gaps - Supplemental Rainfall Record

NOAA

The first historical online dataset is freely available from the National Weather Service (NWS) at the following website: http://www.wrh.noaa.gov/sgx/obs/rtp/rtpmap.php?wfo=sgx. This link only provides recent daily precipitation data from Regional Temperature and Precipitation (RTP) stations within San Diego. Although not all of these stations reside in the same location as the ALERT stations, they cover some of the same general areas. In this case, the local RTP station at Station ID 420, Montgomery Field. If a data gap occurred within a recent timeframe (May 1998 or later), it would be supplemented by the daily data provided by NWS. Whenever a data gap is supplemented in such a fashion, a “NOAA” tagline is used within the source description as the NWS is operated by the National Oceanic Atmospheric Administration (NOAA).

- Disaggregation – The daily data provided by *NOAA* is broken down into an hourly rainfall distribution to fit the time framework of the hydromodification plan. No matter the actual location of the NOAA station, the disaggregation table and unit hyetograph previously created for the Alert station is used. This unit hyetograph was created by following the direction of the County of San Diego Hydrology Manual, Section 4.3.2. It uses a log-log interpolated value between the 5-year, 6-hr and 24-hr isopulvial graphs, which are also provided by the San Diego Hydrology Manual. Importantly, the disaggregation process generates a total 24-hr precipitation distribution value which is less than the initial daily data value provided by NOAA due to rounding. If the disaggregation process was applied, a "disaggregated" tagline is inserted within the source description. The disaggreation table is included within Appendix A – Construction of Hyetograph.

NNDC

The second historical online dataset must be purchased from the National Climatic Data Center (NCDC), specifically thru the Image and Publications System at the following website: http://www7.ncdc.noaa.gov/IPS/hpd/hpd.html?_page=0&jsessionid=7F8ED28E1BD0C792DFBD4BA7FAC08E51&state=CA&_target1=Next+%3E. This link provides a large volume of hourly precipitation data in PDF format from October 1951 through April 2008. A single PDF purchase yields the recorded hourly data of all NCDC stations within California for one month of a specific year. However, only database gaps up until May 1998 were supplemented in such a fashion. Any data gaps from May 1998 until the present were supplemented with the freely available daily data provided by NWS. Whenever a data gap is supplemented in such a fashion, a "NNDC" tagline is used within the source description to reflect the final data dissemination entity operated by the NOAA National Data Centers (NNDC).

Supplemental ALERT or CCDA stations

Whether thru design or coincidence, an occasional data gap would be found across all three historical datasets (ALERT, NOAA and NNDC). During such an unusual event, the supplemental information will be drawn from the various CCDA rainfall stations as each contains very minimal data gaps.

- The final source of supplemental information will be drawn from the nearest ALERT station. In this case, no additional ALERT stations were used.

QA/QC process

While the current goal is to gather together an input .wdm file, the final goal is to create an output .wdm time series analysis to forecast or predict future precipitation values. This predictive process depends upon identifying a sequence of observations (or pattern) within the observed time series data (i.e. input .wdm). Once the pattern is established, the data can be extrapolated to predict future events. As such, the focus of the QA/QC process for the input .wdm file is the filtering or removal of any errors which will interfere with the pattern, while forgiving any lesser errors which have little to no interference. Once the supplemental information was introduced, the primary QA/QC methods used were (1) a script to identify duplicate event times and (2) a repeat of the Outlier method.

Summary of Kearny Mesa ALERT Station and .wdm Data Set

Watershed: **San Diego River (near ridge with San Clemente Canyon watershed)**
Latitude/Longitude of Kearny Mesa ALERT station: **32.5003, -117.0744**
Elevation of Kearny Mesa ALERT Station: **425 feet**
Data available from: **09/08/1964 to 06/30/2008**
Highest Precipitation recorded within an hour: **1.40 inch**
Lowest Precipitation recorded within an hour: **0.00 inch**
Historical Dataset Resources: **Kearny Mesa ALERT Data, NNDC San Diego WSO AP, NOAA Montgomery Field**

APPENDIX A

Construction of Hyetograph

6-hr Storm

Hour #	Minutes (D)	Intensity	Total Rainfall	Rainfall by Hour
1	60	0.32841631	0.32841631	0.32841631
2	120	0.2099681	0.4199362	0.09151989
3	180	0.16162623	0.48487869	0.06494248
4	240	0.13423999	0.53695997	0.05208129
5	300	0.11623596	0.58117979	0.04421982
6	360	0.10333333	0.62	0.03882021
	Sum			0.62

Kearny Mesa	5-yr	6hr storm	24hr storm
		1.4	2.25

Assumptions: The relationship between a 6hr and 24hr storm is 1:1.61 and that there are no rainfall depth-area adjustments.

The San Diego County Manual, Section 4.3.2 was used to create the below rainfall distribution.

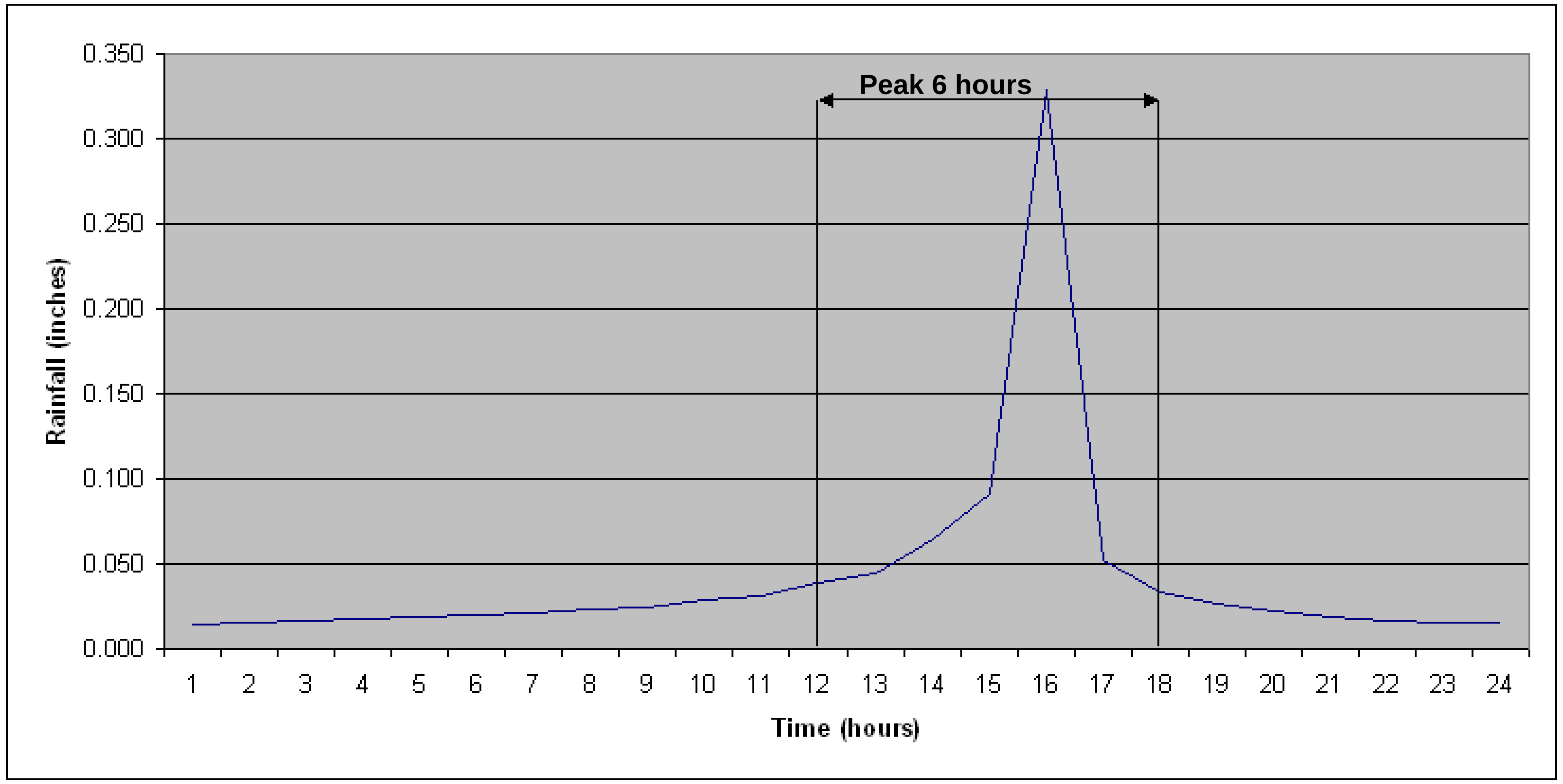
For Hours 1-6; use I = 7.44 * (P6hr) * D^(-0.645) and P=I * (D/60) where P6=0.62 inches and D is in minutes.
For Hours 6-24; use P(x)hr = (x^0.345) * (10^-0.47607) where x equals a particular time in hours

m-slope = 0.345
b-intercept = -0.47607

for hours 6-24 use the formula:
log [f(x)] = mlog(x) + b OR f(x)=x^m) * (10^b)

Nested Storm

Hour #	Minutes (D)	Intensity	Total Rainfall	Rainfall by Hour	Distribution
1	60	0.32841631	0.32841631	0.328	0.015
2	120	0.2099681	0.4199362	0.092	0.016
3	180	0.16162623	0.48487869	0.065	0.016
4	240	0.13423999	0.53695997	0.052	0.018
5	300	0.11623596	0.58117979	0.044	0.018
6	360	0.10333333	0.62	0.039	0.020
7	420		0.65386536	0.034	0.021
8	480		0.68469247	0.031	0.023
9	540		0.71308808	0.028	0.025
10	600		0.73948524	0.026	0.028
11	660		0.76420519	0.025	0.031
12	720		0.78749361	0.023	0.039
13	780		0.80954308	0.022	0.044
14	840		0.83050773	0.021	0.065
15	900		0.85051307	0.020	0.092
16	960		0.86966282	0.019	0.328
17	1020		0.8880438	0.018	0.052
18	1080		0.90572952	0.018	0.034
19	1140		0.92278282	0.017	0.026
20	1200		0.9392579	0.016	0.022
21	1260		0.95520187	0.016	0.019
22	1320		0.97065598	0.015	0.017
23	1380		0.98565655	0.015	0.015
24	1440		1.00023578	0.015	0.015



APPENDIX B

Data Gap Analysis Table

DateMOD	HourMOD	Amount	Code	Units	Filler Data Source	Value Comparison
4/1/1965	8	0	*	in	NNDC San Diego WSO AP	-0.09
4/1/1965	18	0.16	C	in		
4/8/1965	11	0	*	in	NNDC San Diego WSO AP	-0.01
4/8/1965	14	0.26	C	in		
9/16/1965	14	0	*	in	All nearby stations record no event	-0.02
9/16/1965	16	0.02	C	in		
11/15/1965	9	0	*	in	NNDC San Diego WSO AP	0.02
11/15/1965	14	0.15	C	in		
10/10/1966	1	0	*	in	Disaggregate Data	0.00
10/10/1966	24	1.42	C	in		
12/5/1966	23	0	*	in	NNDC San Diego WSO AP	-0.31
12/6/1966	9	0.37	C	in		
3/3/1967	1	0	*	in	NNDC San Diego WSO AP	-0.15
3/4/1967	24	0.26	C	in		
5/23/1967	9	0	*	in	NNDC San Diego WSO AP	-0.02
5/24/1967	8	0.06	C	in		
1/18/1969	22	0	*	in	NNDC San Diego WSO AP	0.09
1/20/1969	8	0.23	C	in		
2/16/1969	8	0	*	in	NNDC San Diego WSO AP	-0.49
2/18/1969	16	0.82	C	in		
4/25/1971	10	0	*	in	NNDC San Diego WSO AP	0.10
4/26/1971	17	0.05	C	in		
12/4/1972	9	0	*	in	NNDC San Diego WSO AP	-0.02
12/4/1972	24	1	C	in		
10/9/1973	1	0	*	in	Disaggregate Data	0.00
10/9/1973	24	0.1	C	in		
1/6/1974	3	0.1	M	in	NNDC San Diego WSO AP	M
1/7/1974	12	0	-			
4/1/1975	1	0	*	in	NNDC San Diego WSO AP	-1.97
4/10/1975	24	3.8	C	in		
11/12/1976	1	0	*	in	NNDC San Diego WSO AP	-0.68
11/13/1976	1	1.02	C	in		
1/10/1978	1	0.02	*	in	NNDC San Diego WSO AP	-1.32
1/10/1978	24	2.25	C	in		
1/11/1978	1	0	*	in	All nearby stations record no event	-0.71
1/11/1978	24	0.71	C	in		
9/5/1978	13	0	*	in	NNDC San Diego WSO AP	-0.23
9/6/1978	10	0.7	C	in		
7/22/1986	24	0	SA	in	All nearby stations record no event	-0.35
7/23/1986	15	0.35	SA	in		
8/10/1986	22	0	SA	in	All nearby stations record no event	-0.08
8/18/1986	13	0.08	SA	in		
2/27/1987	4	0	SA	in	All nearby stations record no event	-0.59
3/1/1987	2	0.59	SA	in		
11/4/1987	17	0.04	SA	in	NNDC San Diego WSO AP	0.35
11/5/1987	11	0.47	SA	in		
3/24/1989	23	0	SA	in	NNDC San Diego WSO AP	-0.79
3/26/1989	23	0.94	SA	in		
12/31/1989	24	0	SM	in	NNDC San Diego WSO AP	M
1/31/1990	23	0	SM	in		
2/12/1992	19	0.12	SA	in	NNDC San Diego WSO AP	0.37
2/13/1992	11	0.63	SA	in		

DateMOD	HourMOD	Amount	Code	Units	Filler Data Source	Value Comparison
3/2/1992	7	0.16	SA	in	NNDC San Diego WSO AP	-0.03
3/2/1992	9	0.2	SA	in		
3/2/1992	13	0.32	SA	in	Ignore SA code	0.00
3/2/1992	14	0.52	SA	in		
1/15/1993	12	0.12	SA	in	Ignore SA code	0.00
1/15/1993	13	0.16	SA	in		
12/31/1993	24	0	SM	in	NNDC San Diego WSO AP	M
1/31/1994	23	0	SM	in		
10/31/1994	24	0	SM	in	NNDC San Diego WSO AP	M
1/15/1997	17	0	SM	in		
10/1/1999	0	0	SM	in	NOAA Montgomery Field	M
3/9/2000	2	0	SM	in		
1/31/2001	24	0	SM	in	NOAA Montgomery Field	M
4/20/2001	9	0	SM	in		
6/18/2001	22	0	SM	in	All nearby stations record no event	M
7/3/2001	12	0	SM	in		
8/9/2001	1	0	SM	in	NOAA Montgomery Field	M
1/5/2002	12	0	SM	in		
2/15/2002	12	0	SA	in	NOAA Montgomery Field	-0.06
2/19/2002	12	0.16	SA	in		
3/17/2002	24	0.04	SM	in	NOAA Montgomery Field	M
3/18/2002	14	0	SM	in		
10/18/2004	12	0.12	SA	in	NOAA Montgomery Field	0.05
10/18/2004	18	0.2	SA	in		
10/27/2004	4	0.72	SA	in	NOAA Montgomery Field	1.86
10/27/2004	7	0.55	SA	in		
12/28/2004	9	0.6	SA	in	NOAA Montgomery Field	-1.13
12/29/2004	5	2.05	SA	in		
1/2/2006	12	0.04	SA	in	NOAA Montgomery Field	0.29
1/2/2006	16	0.28	SA	in		
10/14/2006	2	0.28	SA	in	Ignore SA code, same hour	0.00
2/26/2007	23	0	SA	in	NOAA Montgomery Field	0.03
2/27/2007	23	0.24	SA	in		