



Sonoran Blvd. over I-17, M. Smith

Flood Control District of Maricopa County

Engineering Division, Flood Warning Branch

Storm Report : July 31, 2012

Revision 1 : 9/12/2012



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METEOROLOGY

A very moist and unstable atmosphere aided by local mesoscale weather features led to the development of a slow moving severe thunderstorm that produced heavy rainfall in and around the Anthem area on the evening of July 31st, 2012.

Synopsis:

On the day of the event the large scale pattern was characterized by the Monsoon ridge centered over the southern Great Plains, while to the west an upper level inverted trough remained nearly stationary over the lower Colorado River Valley (Fig. 1). As a result, winds were out of south/southeast through much of the atmosphere. Moist southerly flow aided in above-average precipitable water values which were running 1.60"-1.75". The most favorable area for organized t-storm development was to the west and north of Maricopa County where stronger upper-level forcing (divergence) associated with the inverted trough resided. Local lifting mechanisms were necessary in order to initiate t-storm development over the lower deserts of central AZ.

Late afternoon on July 31st became increasing favorable for isolated severe t-storms capable of producing strong wind gusts and potentially heavy rain across northcentral Maricopa County. The hourly District's Convective Quantitative Precipitation Forecast at 5:06pm MST (Table I) was generated before the development of the Anthem Storm. Of note are the high CAPE/ low CIN values, negative Lifted/Showalter Indices, and surface based 1-hr and 30-min potential rainfall values at Desert Mountain School (located 5mi SE of Anthem). Also worth noting were the winds upstream of Anthem. Very moist low-level winds out of the southwest were moving upslope over the lower Bradshaw Range with steering-level winds out of the southeast. This wind profile made for a favorable setup for slow moving surface based t-storms able to tap into the ample low-level moisture unlike earlier pulse convection farther south.

Storm Summary and Radar Analysis:

Severe downdraft winds (Table II, 2nd storm report) from earlier elevated convection around the Deer Valley Municipal Airport kicked off a northward propagating outflow boundary. This gust front initiated a t-storm north of the Cave Buttes Dam area at approximately 4:50pm. The storm intensified into a severe t-storm as it moved north of Carefree Hwy paralleling Interstate 17 into Anthem by around 5:30pm MST. Storm motion continued toward the north/northwest at 10-15mph. However, favorable moist upslope winds aided in continual updraft redevelopment on the southern flank of the t-storm. Thus, the heaviest rain core of the storm was able to remain nearly stationary over the Anthem area for approximately 70 minutes (imagery not shown).

Radar analysis of the t-storm at 6:10pm MST is shown in Figure 2. Image A highlights the Base Reflectivity values of around 60dbz over the Anthem area signifying the severe nature of the t-storm and likely heavy rainfall/hail. Looking at the Base Velocity, Image B, weak storm rotation is further evident indicating a severe t-storm. Image C shows Correlation Coefficient (CC) values, i.e. hydrometeor distribution, within the storm core. High CC values coupled with the high Specific Differential Phase (Kdp) values around 2.5

deg/km seen in Image D signify heavy rainfall (radar estimated rainfall rates of 3-4"/hr.) within the main core of the storm. The lower CC values coupled with large Kdp values are representative of hail within the rain core, which matches well with local storm reports shown in Table II.

By 6:45pm MST the storm had weakened considerably and began to move north of the Anthem/New River area. This storm produced measured wind gusts over 60mph and small hail leading to local storm damage in and around the Anthem area (Table II).

4-Panel 12Z Synoptic Setup 07/31/2012

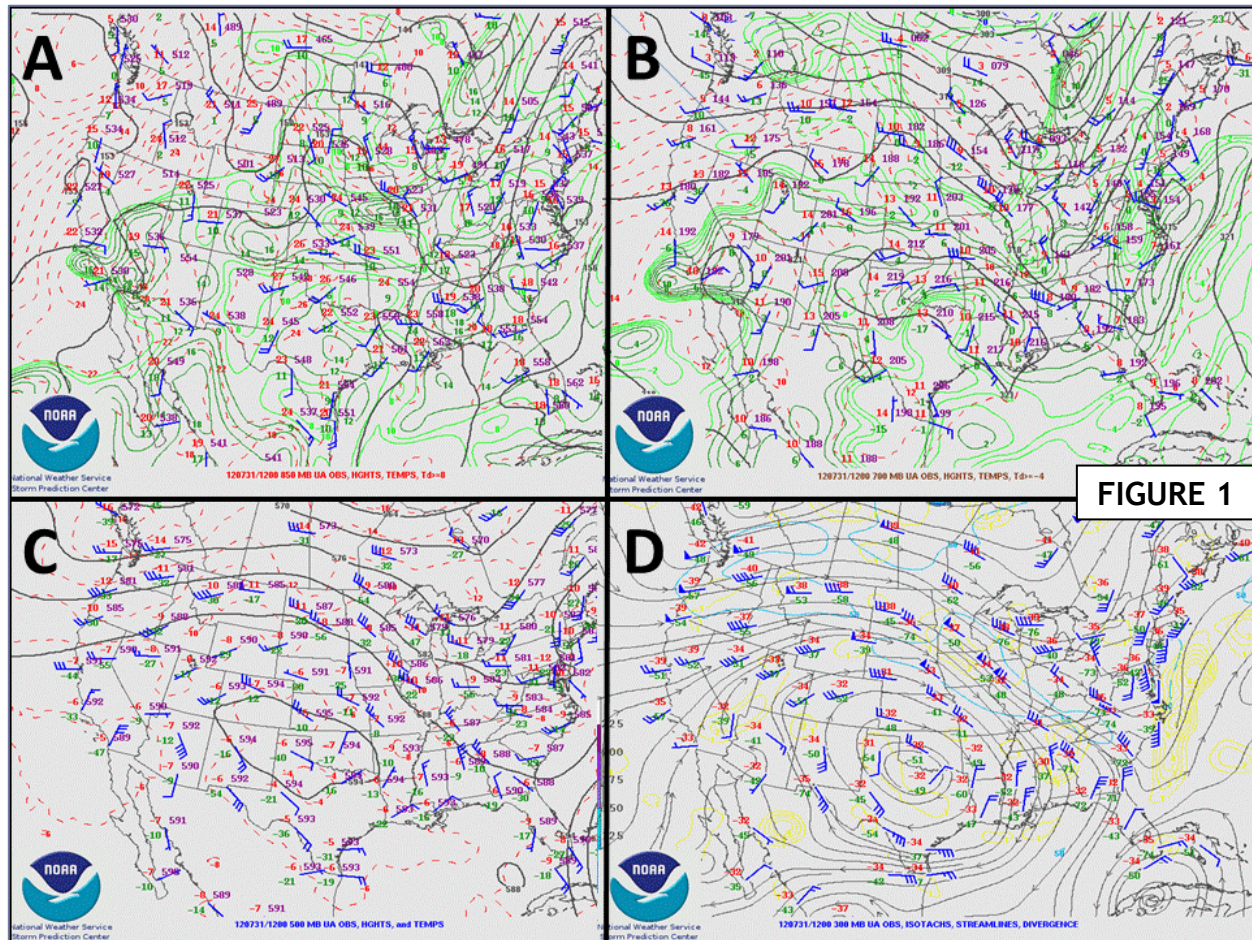


Figure 1 above depicts the synoptic setup at 12Z (5:00 AM MST) on July 31st 2012. The images are from the Storm Prediction Center upper air maps archive. **A)** is the 850mb map: the black lines are heights, the red dashed lines are isotherms, the green lines are isodrosotherms, blue barbs are wind speed, and station observations are plotted at each available location. **B)** is the 700mb map: variables colored the same as A. **C)** is the 500mb map: variables colored the same as in A. **D)** is the 300mb map: the black lines are streamlines, the yellow lines are divergence, and station obs. are plotted at each available location.

Flood Control District of Maricopa County ALERT System
**Current Air Parcel Attributes and
Convective Quantitative Precipitation Forecast**
Tue Jul 31 17:06:09 MST 2012

TABLE I

ELEVATED BASED PARCEL ATTRIBUTES AND QPF																
Weather Station	Station	Air	Dewp.	Wind	Wind	Parcel	LCL	LCL	Warm		Convect. QPF			QPF W/Multiplier		
Name	Elev.	Temp.	Temp.	dir.	spd.	Sfc Pres	Pres	Temp.	Layer	MALR	1hr.	30m.	10m.	1hr.	30m.	10m.
	(ft)	(F)	(F)		(mph)	(mb)	(mb)	(C)	(Km)	(C/Km)	(in)	(in)	(in)	(in)	(in)	(in)
850mb Terrain Storm	*****	74.6	59.6	SW	9.1	846.9	748.8	13.4	3.1	4.3	1.02	0.72	0.43	0.00	0.00	0.00
700mb Terrain Storm	*****	50.3	41.7	SSE	18.1	700.8	651.5	4.4	0.9	5.1	0.28	0.20	0.12	0.00	0.00	0.00

SURFACE BASED PARCEL ATTRIBUTES AND QPF																
Weather Station	Station	Air	Dewp.	Wind	Wind	Parcel	LCL	LCL	Warm		Convect. QPF			QPF W/Multiplier		
Name	Elev.	Temp.	Temp.	dir.	Gust	Sfc Pres	Pres	Temp.	Layer	MALR	1hr.	30m.	10m.	1hr.	30m.	10m.
	(ft)	(F)	(F)		(mph)	(mb)	(mb)	(C)	(Km)	(C/Km)	(in)	(in)	(in)	(in)	(in)	(in)
Desert Mtn. School	1810.0	92.0	72.8	SSW	21.0	959.1	822.0	20.1	5.2	3.9	2.29	1.61	0.96	4.59	3.21	1.93
Lake Pleasant	1815.0	97.6	62.6	WSW	19.0	952.0	719.5	12.7	2.9	4.3	1.29	0.90	0.54	0.00	0.00	0.00
Lake Pleasant North	1750.0	96.2	66.3	WSW	12.0	954.0	750.9	15.3	3.7	4.2	1.62	1.13	0.68	3.24	2.27	1.36
Humboldt Mtn.	5205.0	84.0	48.3	***	0.0	837.0	625.7	4.8	1.0	5.0	0.32	0.23	0.14	0.00	0.00	0.00
Rackensack Canyon	4520.0	89.1	59.2	SW	12.0	871.4	684.3	11.4	2.6	4.4	1.15	0.80	0.48	0.00	0.00	0.00
Carefree	2960.0	89.2	61.0	SSW	12.0	909.0	723.8	12.6	2.9	4.4	1.27	0.89	0.54	0.00	0.00	0.00
Pima @ Jomax Rd	2180.0	96.9	65.0	S	6.0	940.3	728.4	14.3	3.4	4.2	1.51	1.05	0.63	0.00	0.00	0.00
Mount Union	7495.0	66.6	68.6	***	0.0	767.0	779.8	20.6	5.5	3.8	1.82	1.27	0.76	3.63	2.54	1.53

MSP FORECAST ZONE AVERAGEGED SURFACE BASED QPF											
MSP Forecast Zone	Air	Dewp.	Convect. QPF			QPF W/Multiplier			Antecedent Rainfall		
Weather Station	Temp.	Temp.	1hr.	30m.	10m.	1hr.	30m.	10m.	1day	2day	3day
Name	(F)	(F)	(in)	(in)	(in)	(in)	(in)	(in)	(in)	(in)	(in)
New River/Cave Creek	88.6	60.3	1.26	0.88	0.53	0.00	0.00	0.00	0.00	0.27	0.30
Northwest Valley	96.9	65.6	1.54	1.08	0.65	0.00	0.00	0.00	0.00	0.20	0.20
Phoenix North	93.9	66.4	1.67	1.17	0.70	0.00	0.00	0.00	0.04	0.13	0.18
Scottsdale North	93.6	60.2	1.17	0.82	0.49	0.00	0.00	0.00	0.00	0.10	0.69
Far North *No Zone*	70.1	61.3	1.27	0.89	0.53	0.00	0.00	0.00	0.00	0.00	0.00

CURRENT THERMODYNAMIC VARIABLES AND INDICES (RAP MODEL)

Precipitable Water (inches) =	1.55	:	Total atmospheric column water, GPS based from SUOMINET at PHX SRP Location, updated hourly
PW Time Stamp (Julian Day) =	213.91	:	Total atmospheric column water, GPS based from SUOMINET at PHX SRP Location, updated hourly
CAPE (J/Kg) =	1068.83	:	Surface based CAPE value, measures convective instability
CIN (J/kg) =	-2.11	:	Surface based CIN value, measures convective inhibition
Lifted Index =	-3.05	:	>2 no convection, 2-0 showers & iso. t-storms, 0-(-2) t-storms probable, <-2 severe storms
Showalter Index =	-2.91	:	>3 no convection, 3-1 showers & iso. t-storms, 1-(-2) t-storms probable, <-2 severe storms
K-Index =	39.93	:	<15 0%, 15-20 <20%, 21-25 20-40%, 26-30 40-60%, 31-35 60-80%, 36-40 80-90%, >40 >90%
SWEAT Index =	236.06	:	<300 non-severe t-storms, 300-400 severe t-storms possible, >400 severe t-storms probable
Totals Total (CT+VT) =	50.13	:	44-47 light to mod., 48-51 mod. & few heavy, 52-55 heavy & few severe, >55 numerous heavy

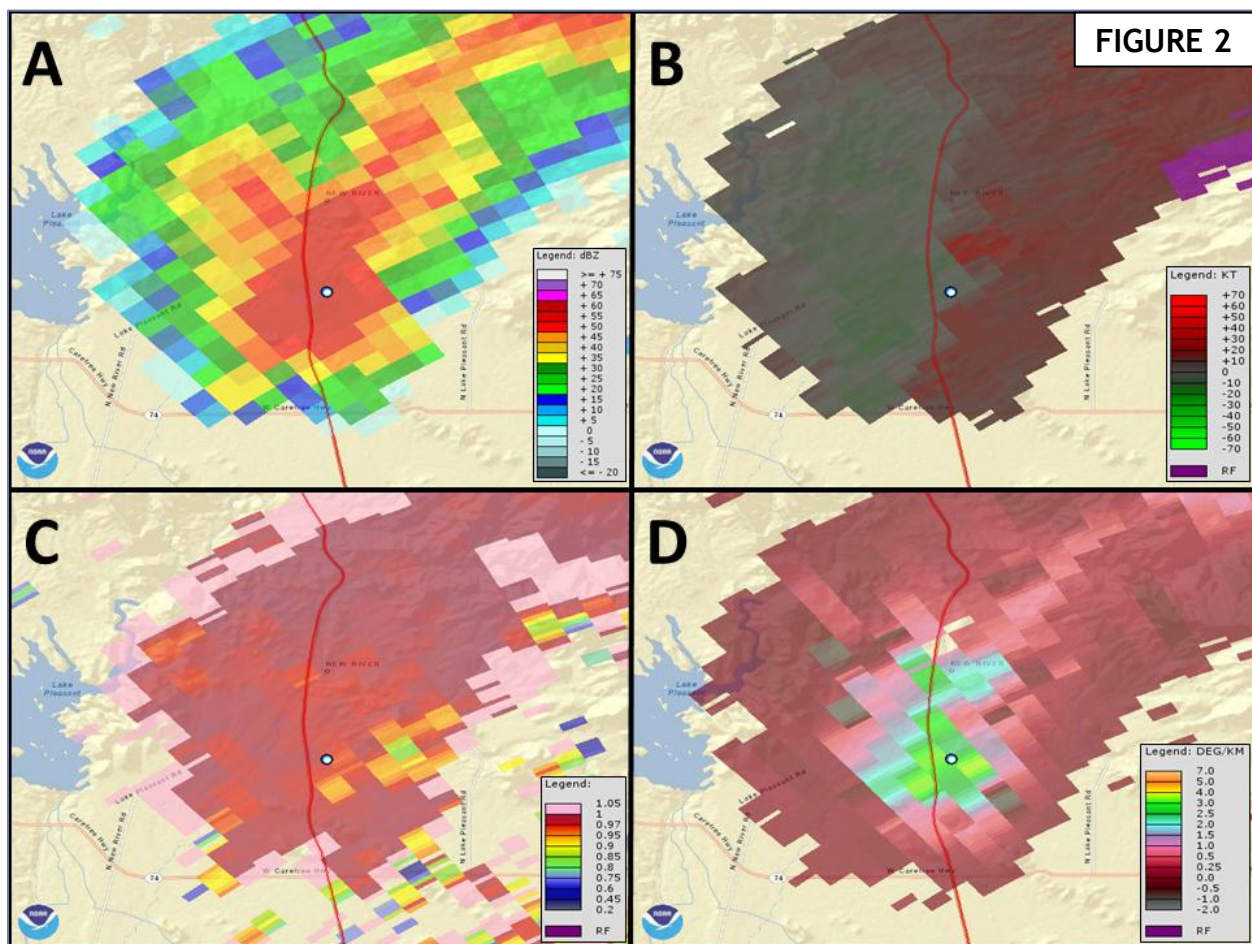
MONSOON CHECKLIST PARAMETERS: ADVECTION section Not Operational in code yet COMING SOON

Moisture	=	100.00	:	normal values 40-90, if t-storms develop >30% chance Flash Flooding if moist tot is >150
Stability	=	180.00	:	normal values 70-90, if t-storms develop >30% chance wind gusts >50mph if Stab tot is >150
Advection	=	0.00	:	normal values 40-90
Monsoon Checklist Total	=	280.00	:	Areal Coverage of rain <80 0%, 81-180 <10%, 181-305 10-20%, 306-395 30-50%, >395 >50%

Local Storm Reports recorded by the NWS the evening of 7/31/2012

Location	Time (MST)	Report	TABLE II
9mi E Peoria	4:45pm	64 mph wind gust by ASOS station	
2mi NNW Anthem	5:57pm	67 mph wind gust by local mesonet	
1mi N Anthem	6:00pm	5.01" of rain in 90min by CoCoRaHS observer	
3mi E Anthem	6:10pm	0.50" hail, 50mph winds, & curb-to-curb street flooding by trained spotter	
Anthem	6:12pm	1.50" of rain in 45min and 0.25" hail by trained spotter	
2mi ENE Anthem	6:20pm	1.00" of rain, pea sized hail, and est. 50mph wind gusts by trained spotter	
2mi N Anthem	6:30pm	Damage to trees from wind, hail, and heavy rain by trained spotter	

4-Panel Radar Analysis at 6:10pm MST 07/31/2012



This Figure displays four radar products from the KIWA WSR-88D at 6:10pm MST on July 31st 2012. Each image was taken at the same vertical radar level of 1.3km. The images were produced using the Weather and Climate Toolkit from NOAA and the Level-3 data was provided from NCDC archive. The white dot in each of the images is intersection of Gavin Peak Parkway and Anthem Way. The red lines on the base map of each image are roads (I-17 is highlighted for reference). **A)** shows the Base Reflectivity in dbz. **B)** shows the Base Velocity in kts. **C)** shows the Correlation Coefficient in percent. **D)** shows the Specific Differential Phase in deg/km.

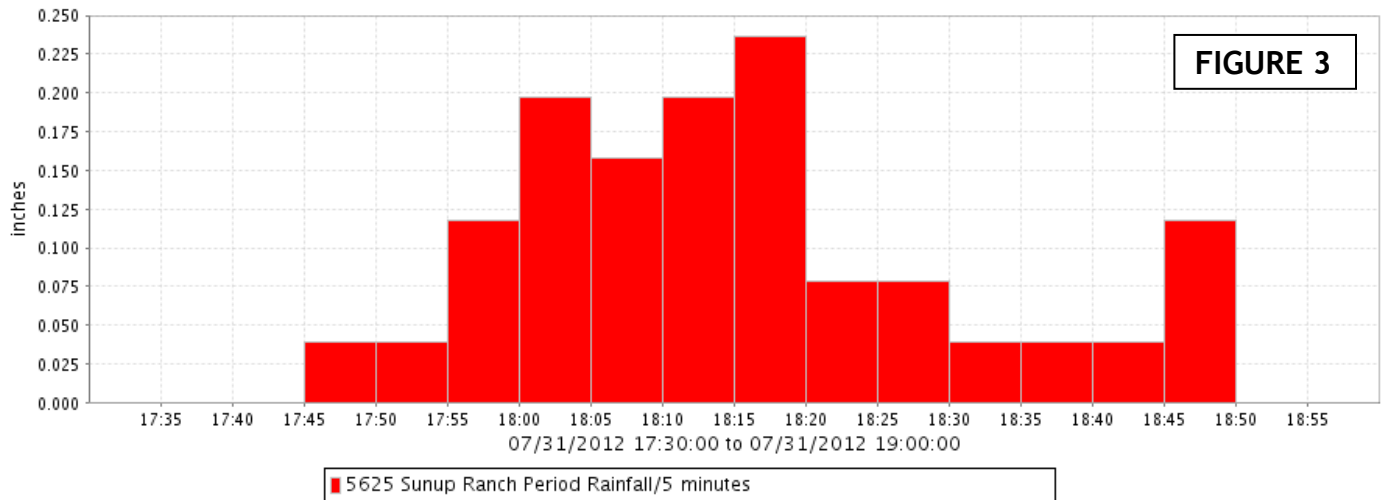
PRECIPITATION

There are two FCDMC automated rain gages near Anthem/Deadman Wash:

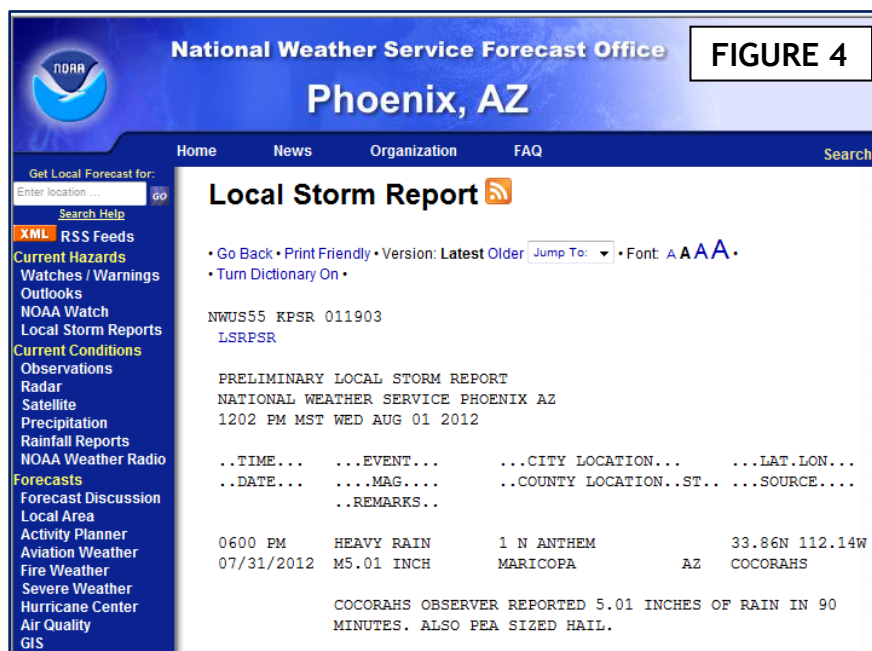
5630 New River Landfill ≈3 miles to the west - 0.16 inch storm total

5625 Sunup Ranch ≈3 miles to the north - 1.38 inch storm total

The 5-minute time distribution for gage 5625 is shown in Figure 3 below:



Several point-rain values were reported from the Anthem area to internet rainfall collection points: 1 from [CoCoRAHS](#), 3 from [RainLog](#) and 1 from [WeatherBug®](#) (Fig. 4). The observation from the CoCoRAHS station, 5.02 inches in 90 minutes, was verified by National Weather Service Phoenix staff and published online.



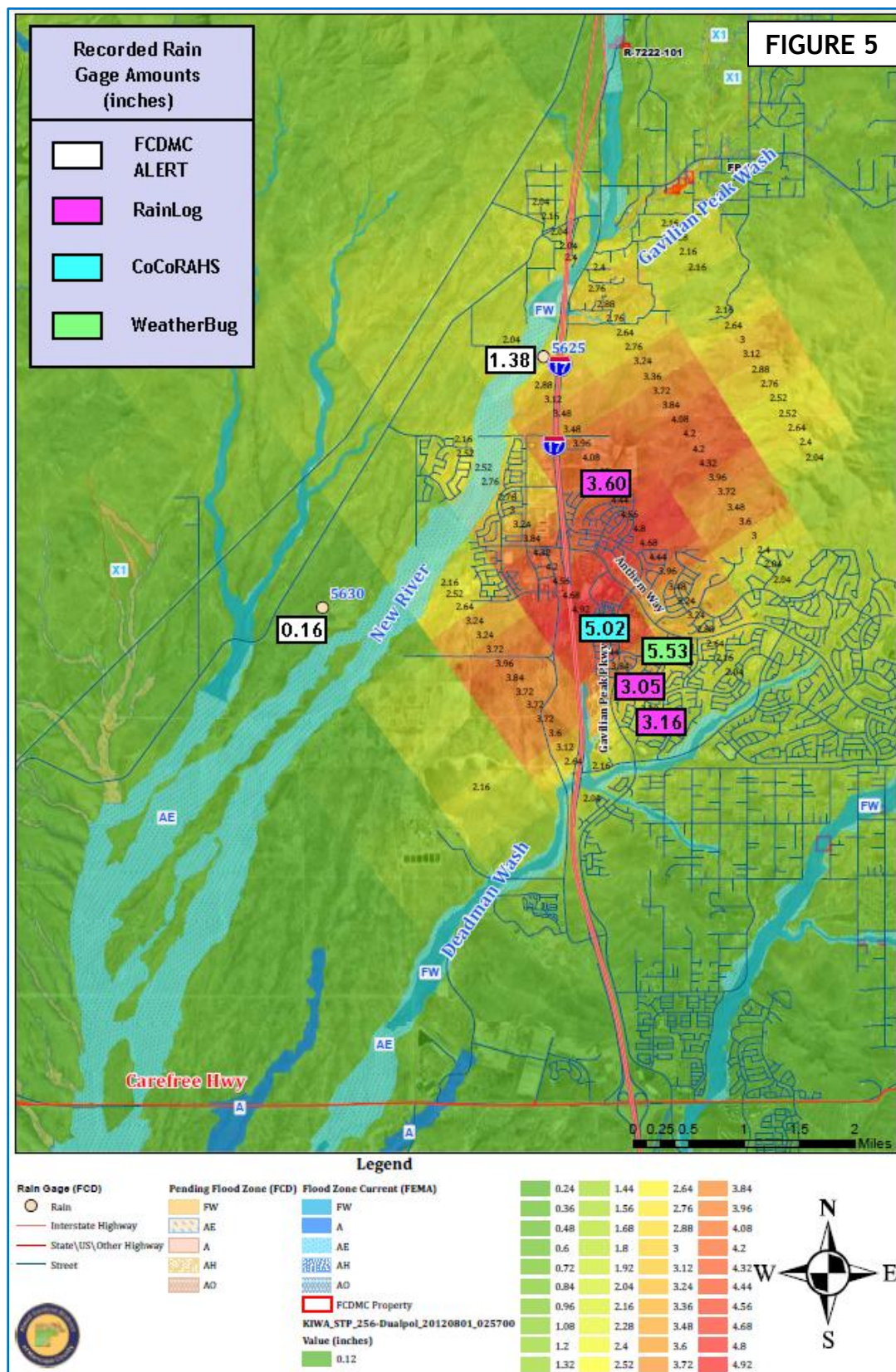



Figure 5 above was created with ESRI ARCMAP®. The colored background represents NWS Dual Polarization storm-total rainfall estimates for July 31st 2012 from 5:00 through 8:00 PM MST. Also shown are the point-rainfall storm-total gage readings from various networks as identified in the legend at upper-left.

Precipitation Frequency Estimates (inches) for 33.86N 112.14W
Annual Maximum Series
From NOAA Atlas 14, Volume I, Version 5

TABLE III

AEP (1- in-Y)	5 min	10 min	15 min	30 min	60 min	90* min	2 hr	3 hr	
2	0.27	0.41	0.51	0.69	0.85	0.93	0.98	1.05	
5	0.40	0.60	0.75	1.01	1.25	1.36	1.42	1.48	
10	0.48	0.73	0.91	1.23	1.52	1.64	1.71	1.78	
25	0.59	0.90	1.12	1.51	1.87	2.01	2.10	2.18	
50	0.68	1.03	1.28	1.72	2.13	2.31	2.40	2.50	
100	0.77	1.17	1.45	1.95	2.41	2.60	2.71	2.84	
200	0.85	1.30	1.61	2.17	2.69	2.89	3.01	3.19	
500	0.97	1.48	1.83	2.46	3.05	3.28	3.42	3.66	
1000	1.06	1.61	2.00	2.69	3.33	3.60	3.74	4.05	

* 90-minute values interpolated, not provided in NOAA 14. AEP is Annual Exceedance Probability.

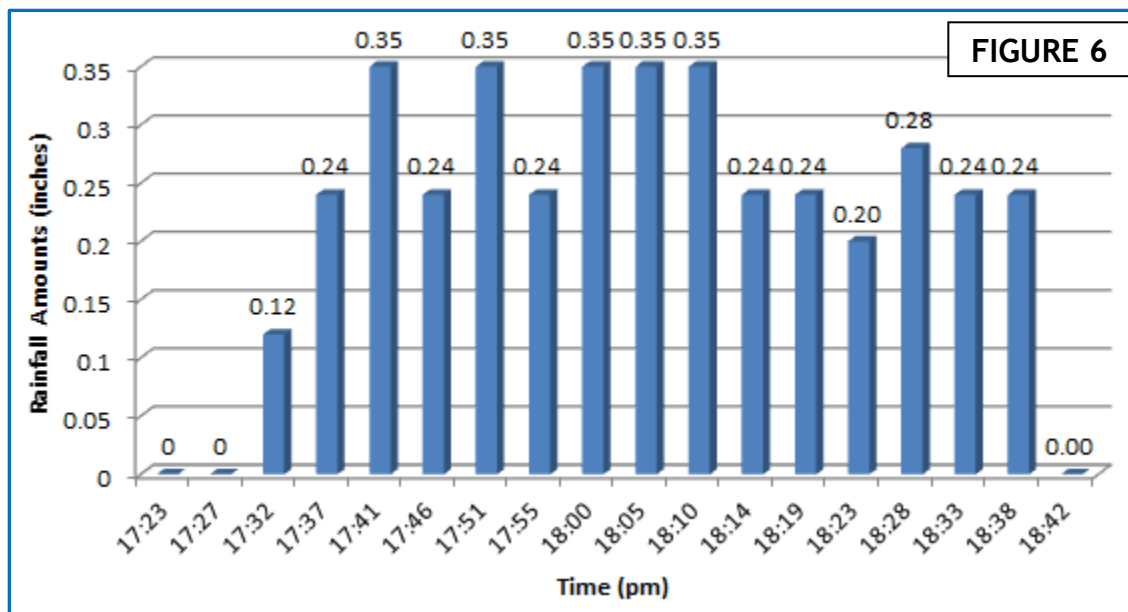
1	0.28	0.47	0.63	1.02	1.34	1.38			Recorded period rainfall from Gage No. 5625
	2	3	3	5	6	5			Return periods (years)
2	0.35	0.71	1.06	1.89	3.66	4.02			Depths and distribution from NWS Dual-Pol radar estimates at the storm core
	4	9	19	84	>1,000	>1,000			Return periods (years)
3	0.44	0.88	1.32	2.36	4.56	5.02			NWS Dual-Pole time distribution applied to 5.01" rainfall from CoCoRAHS Rain Gage
	7	22	59	365	>1,000	>1,000			Return periods (years)

Precipitation Synopsis

Table III presents precipitation frequency statistical estimates from NOAA Atlas 14 at the point in Anthem where the CoCoRAHS station is located. Return periods were estimated for durations up to 90 minutes for Gage 5625, for the rainfall distribution from the NWS Dual-Pol rainfall estimates, and for the Dual-Pol time distribution applied to the rainfall depth recorded at the CoCoRAHS station. This is the first time that we at the District have had the capability to reconstruct a reasonable time distribution (Fig. 6) from radar data at a point, which considerably expands our rainfall reconstruction toolkit. The NWS Dual-Polarization radar measures airborne objects not just in the horizontal, but also in the vertical, which theoretically leads to more accurate precipitation estimates.

This storm was quite unusual for a couple of reasons. First was the sheer volume of rain that fell. Whether looking at line 2 or 3 at the bottom half of Table III, it is evident that for durations of 60 and 90 minutes that this was an extreme storm. The 1-hour total exceeds the District's highest recorded 1-hour total of 3.58 inches at Vulture Mine Road near Wickenburg on 7/21/1986. Second, the storm maintained a very heavy intensity for nearly its entire duration. In Figure 6 below we see that it dropped from 0.20 - 0.35 inches per 4 or 5 minutes for a 66-minute period.

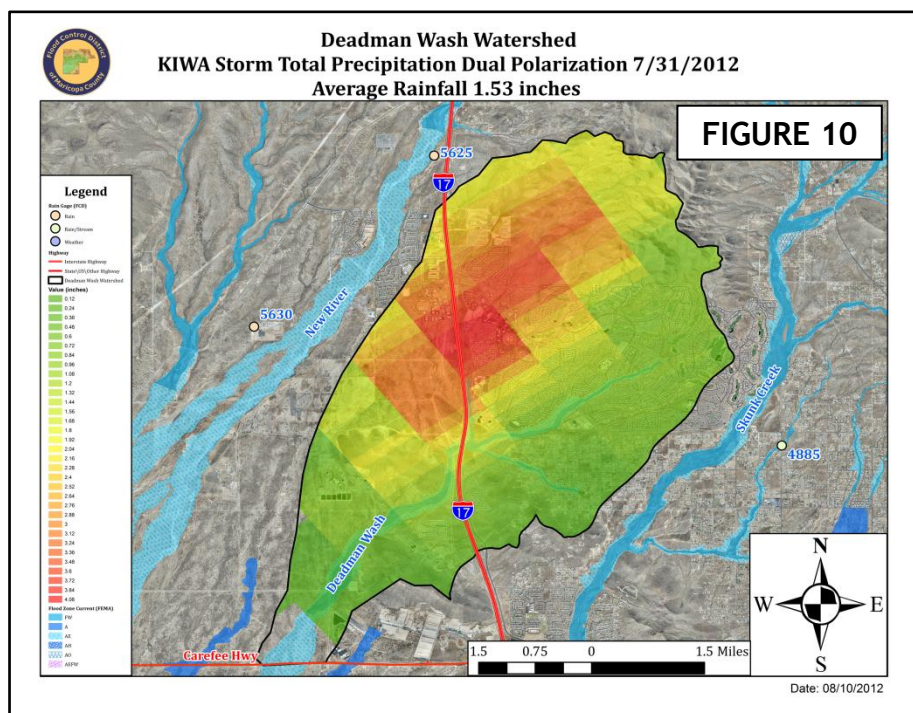
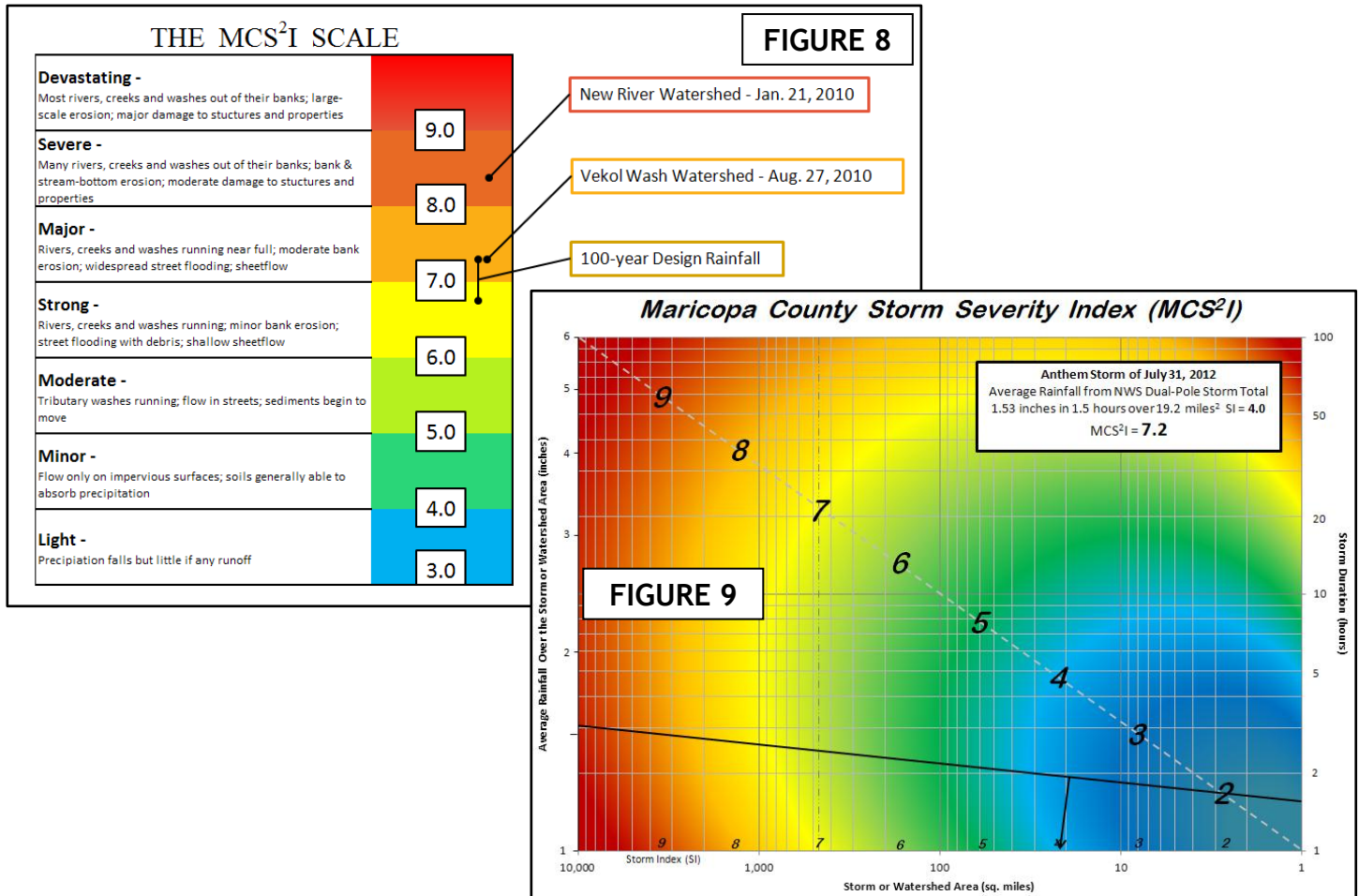
Rainfall distribution from NWS Dual-Polarization Rainfall Estimates at the Core of the Storm



Rain in Anthem, 7/31/2012. From a [YouTube® video](#) submitted by “Irdapollo”.

Maricopa County Storm Severity Index (MCS²I, developed by FCDMC)

MCS²I is an index that classifies the severity of a storm based on the area covered, the average rainfall over that area, and the storm duration. For this storm, we chose the area of Deadman Wash above Carefree Highway - 19.2 square miles, and the average rainfall value from the NWS Dual-Pol rainfall estimates. The storm scores an MCS²I of 7.2, keeping in mind that the very severe rainfall covered only about half of the watershed.



RUNOFF



Deadman Wash east of I-17, 7/31/2012. From a [YouTube® video](#) submitted by “kpho5”.

There are no streamgages in the Deadman Wash watershed east of I-17. There was a USGS crest-stage gage just west of I-17 ([09513820](#)), but it was destroyed by this flood. Prior to this event, the highest discharge recorded was 2,010 cfs on January 21, 2010. The period of record is water-years 1960-79 and 1991-current year. The USGS Phoenix Office will be publishing an indirect measurement for this event - it will be included in a revision of this report when available. Floodwaters in Deadman Wash continued south to Carefree Highway, overtaking the culverts, flowing over the roadway across a wide area (see floodplain at the bottom of Figure 10) and causing closure through the next morning.

A rough estimate of the discharge was made by the author from field data collected on 8/8/2012. A Manning's calculation was made for the area between the I-17 bridges using a flow depth of 10 feet, bottom width of 60 feet, 1:1 side slopes, $n=.040$ and a slope of 0.01 ft/ft. The computed discharge was 13,300 cfs, with a velocity of approximately 16 feet/second. The calculated 100-year discharge published in the 9/30/2005 FEMA Flood Insurance Study for unincorporated Maricopa County is 9,437 cfs for Deadman Wash @ I-17.

A preliminary discharge computation was surveyed and calculated by the USGS Phoenix office on 9/10/2012. Their estimate was 6,500 cfs, with a Gage Height of 13.2 feet and a velocity of approximately 8 feet per second. The difference in the two estimates comes mainly from the calculated channel slope. The author used a slope of 1% while the USGS used a slope of 0.3%, which gives a lower velocity and therefore a lower discharge.

SELECTED DATA SOURCES

1. National Weather Service, Warning Decision Training Branch, Norman, OK - Dual-Polarization Radar Training module Heavy Rain:
<http://www.wdtb.noaa.gov/courses/dualpol/>
2. National Weather Service, Weather Forecast Office, Phoenix, AZ - Local Storm Reports archive: <http://www.wrh.noaa.gov/psr/>
3. National Atmospheric and Oceanic Administration, National Climatic Data Center, Asheville, NC - Radar Data Archive and Climate and Weather Toolkit:
<http://www.ncdc.noaa.gov/oa/radar/radardata.html>
4. National Weather Service, Storm Prediction Center, Norman, OK:
<http://www.spc.noaa.gov/obswx/maps/>
5. Flood Control District of Maricopa County, Phoenix, AZ, Rainfall & Weather Page:
<http://www.flood.maricopa.gov/Rainfall/rainfall.aspx>
6. USGS Arizona:
<http://az.water.usgs.gov>
7. Flood Insurance Study, Maricopa County, Arizona and Incorporated Areas
Volume 1 of 17
Federal Emergency Management Agency, revised 9/30/2005
FIS No. 04013CV001A
8. NOAA Precipitation Frequency Data Server
National Weather Service - Hydrometeorological Design Studies Center
http://hdsc.nws.noaa.gov/hdsc/pfds/pfds_map_cont.html?bkmrk=az