

A decorative horizontal bar with a dark red top section and a light gray bottom section.

## 2019 MHFD Heavy Rainfall Threat Analysis Tool

### FINAL REPORT

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Submitted by:

**Dewberry**

8100 East Maplewood Avenue, Suite 150  
Greenwood Village, CO 80111

Submitted to:

**Kevin Stewart**

**Mile High Flood District**  
2480 W 26<sup>th</sup> Ave, #156B  
Denver, CO 80211

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### Submitted to:



### Contributors

**Dana McGlone**  
Hydrometeorologist  
dmcglone@dewberry.com  
720.943.5923

**Danny Elsner, PE**  
Project Manager  
eelsner@dewberry.com  
303.951.0639

**Ken Cecil, P.E.**  
Principle-in-Charge  
kcecil@dewberry.com  
720.463.2661

## OVERVIEW

In early 2015, Dewberry designed and developed a Heavy Rainfall Threat Analysis (formally known as the Heavy Rainfall Guidance Tool and hereafter, Tool) for the Mile High Flood District (hereafter, MHFD or District) to address four crucial questions regarding the summertime daily heavy rainfall threat across the District area: (i) timing, (ii) location, (iii) intensity and (iv) confidence. The Tool is based on an ensemble of high-resolution weather models that are able to directly simulate convective rainfall. The original 2015 operational version of the Tool was based on raw model data. In 2016, a Technical Memo documenting the 2015 Tool performance noted, among other things, a noticeable “overconfidence” bias where heavy rainfall was being predicted with higher frequency and higher probability than was being observed. Thus, a significant processing step was added for the 2016 operational season to reduce this bias. After the 2016 operational season, further research on bias correction was undertaken, and flow dependent biases were noted and corrections applied to the Tool from 2017 and onward. Prior to the start of the 2018 operational season, the Tool was reduced from six to five forecast zones with the existing zones trimmed from south to north and east to west. This was done in hopes to reduce the rainfall influence of the climatological active regions of the eastern plains and southern half of the Palmer Divide, whose rainfall had no effect on runoff over the District. At the beginning of 2018, the NCAR and NSSL ensembles used in the previous three seasons were discontinued due to research projects ending. To replace these 18 models, the 9 member High-Resolution Rapid Refresh Ensemble (hereafter, HRRRE) was added to the Tool.

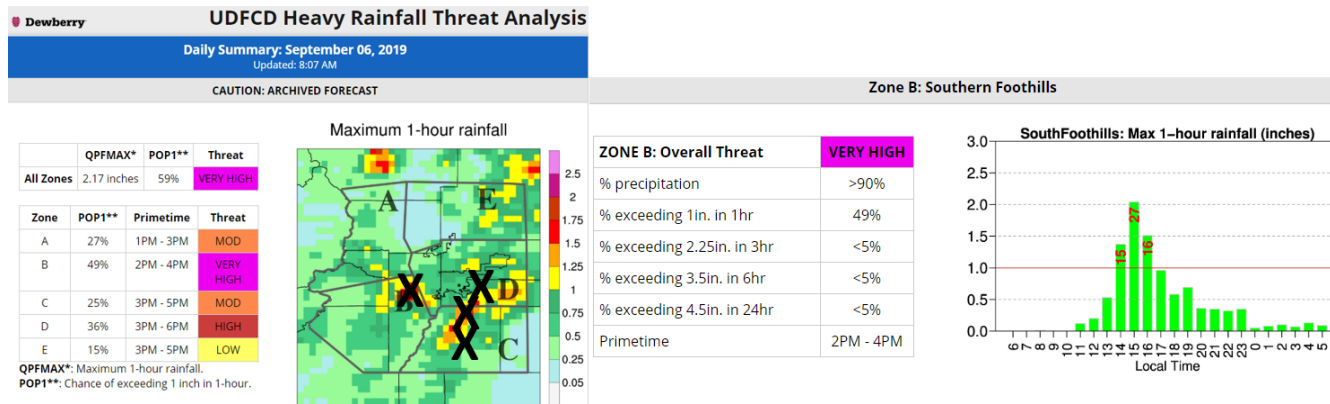
Upgrades to the model continued for the 2019 operational season with eight more model members added from the 4km Texas Tech University WRF Ensemble (hereafter, TTU-WRFens). The HRRR 00Z, 06Z and 12Z runs were also extended out to 24-hours (previously 18-hours). Updates also occurred on the website. The Primetime (the best estimate of timing for heavy precipitation) was implemented to indicate when POP-1hr (Probability of Precipitation exceeding 1 inch in 1-hour) was possible for the next 24-hour period, and Quantitative Precipitation Forecast (QPF) language was simplified with rollover definitions added on the main analysis page. To maximize the hit rate, the All Zone “High” threat threshold was reduced (POP-1hr  $\geq$  78 from POP-1hr  $\geq$  84). Lastly, a social media campaign was executed to disseminate flood threat information to the user community on High and Very High flood threat days. During the 2019 season, Dewberry prepared images and tweets for five events (7/20, 8/8, 8/21, 9/6, 9/8) for the District. Review of the social media campaign is outside the scope of this report, but more information can be found in the monthly progress reports delivered to the MHFD F2P2 manager, Kevin Stewart. This report will provide an analysis of the Tool’s performance during 2019 operational season.

## Tool description

The Tool accesses hourly Quantitative Precipitation Forecast (QPF) data from up to 63 high resolution weather model simulations from the National Severe Storms Laboratory (NSSL), the National Centers for Environmental Prediction (NCEP), Texas Tech University (TTU) and the National Center for Atmospheric Research (NCAR). All models have horizontal resolution of 4 km (2.4 miles) or less allowing for a more realistic representation of thunderstorm-based rainfall compared to weather models with coarser resolution. QPF data from the model “ensemble” is re-gridded to a common ~3.9 km grid across an area centered on the MHFD, after which maximum hourly QPF (hereafter, QPF-Max) and Probability of Exceedance (POE; for example, chance of exceeding 1 inch per hour) are computed for each of five forecast Zones (see Figure 1). Although MHFD’s area is about 1,600 sq. miles, the Tool’s area covers about 5,700 sq. miles for two main reasons. First, to ensure that rainfall is captured within contributing watershed boundaries that extend outside of the official MHFD boundary, and second, due to the imperfect (but improving) nature of heavy rainfall forecasts.

Tool output is displayed on a web-based user interface, and is publicly available at: <http://qpf.udfd.org>. Snapshots of the “Daily Summary” and “Zone Forecasts” sections of the Tool’s web interface are shown in Figure 1 from September 6th, when rainfall exceeding 1 inch in 1 hour was observed over areas marked with the black “X” (11 ALERT stations). During 2017, a notable upgrade in the Tool’s operations allowed for three updates per day compared to two daily updates during 2015 and

2016. In the 2019 season, this upgrade greatly improved the visual for the Tool on the September 6<sup>th</sup> 4PM update by dropping the QPF-Max area over Zone B (timing had passed). This, in turn, made the forecast easier for the end-user to interpret.



**Figure 1:** Snapshot of the "Daily Summary" and "Zone-Specific Forecasts" of the Tool's website for the 8AM update of September 6<sup>th</sup>, 2019. Heavy rainfall was observed in four of the five Forecast Zones during the afternoon and evening hours.

An archive of the Tool's output is available by clicking on the "Archives" link at the top right of the website. This Final Report represents an official validation of the Tool's performance during the 2019 operational season spanning May 1 to September 30. For the month of May, a hindcast was performed to include the upgrades (added models, post-processing equations, bias correction, etc.) that were not implemented into the Tool until June 1<sup>st</sup>. In this report, we first discuss the methodology for the validation effort and present Tool validation statistics, as well as an example of a noteworthy and highly-accurate heavy rainfall event. Finally, we provide conclusions and recommendations for future operation.

## METHODOLOGY

Validating the performance of rainfall forecasts is notoriously difficult due to the large spectrum of possible metrics. This is especially relevant when data from multiple weather models are involved, as is the case with the Tool. For the purposes of this report, we must recall that the Tool was designed to predict the *maximum* rainfall potential on any given day. While it is possible and potentially useful to investigate other aspects of rainfall statistics (for example, distribution across the domain, relation to climatology, etc.), the primary focus of this report will be on analyzing maximum rainfall amounts in (i) each of the five Forecast Zones individually and (ii) across the five Zones collectively. Furthermore, since we are interested in relatively short-term rainfall capable of producing flash flooding, **the focus of the validation will be on the 1-hour time period for the morning run (produced at 8AM MDT) over the 153 day operational season.**

### Rainfall Observations

We used MHFD's roughly 200 active ALERT rainfall gages as one of the primary inputs to the validation. Raw tipping bucket data was obtained from TriLynx (special thanks to Steve Malers) and processed maximum 30-minute and hourly accumulations with a sliding window. Note that this is an important upgrade beginning in 2017, where ALERT data in 2015-2016 was binned into hourly increments before a maximum value was calculated. The 2015-2016 method was found to underestimate maximum rainfall by up to 40%. To supplement the ALERT data, we use two additional products: (i) gridded gauge-adjusted radar estimates provided by the National Oceanic and Atmospheric Administration's Stage IV product at roughly 4 km resolution and (ii) volunteer-based observations from the Community Collaborative Rain, Hail & Snow Network (CoCoRaHS) network. The benefit of Stage IV is that it has full coverage in space and is especially useful due to MHFD's

proximity to the Denver NEXRAD Doppler radar. However, Stage IV’s limitations are that (i) because it is first derived from radar reflectivity (and then gage corrected) it does not always accurately reflect the true rainfall, (ii) because the Stage IV product is on a 4-km grid, this may act to smooth out rainfall amounts, especially for spatially explicit storms, and (iii) the data is produced in hourly increments, which causes Stage IV maximum hourly rainfall to be *lower* than corresponding ALERT data during most heavy rainfall events. CoCoRaHS observations were used mainly for quality control especially during cases where only one or two ALERT gages measured heavy rainfall or when Stage IV two hour rainfall totals were over 1 inch.

For our validation, ***we use the maximum hourly rainfall from either processed ALERT data or Stage IV.*** This represents the best readily available estimate of maximum rainfall, which is what the Tool is designed to forecast. For All Zones in 2019, the daily maximum rainfall was measured by ALERT 54% of the time when POP-1hr was realized. Daily summaries of zone-aggregated and zone-specific precipitation amounts are shown in Appendices A and B, respectively.

Table 1 describes the characteristics of the five forecast zones. All five zones are between 1,000 and 1,100 square miles, while Zone B (Southern Foothills) is the exception at about 1,300 square miles due to its extension to the Continental Divide. The roughly equal area size of the new five zones (as opposed to the prior zones) makes post-processing of the QPF data more consistent and validation between the zones more comparable. Table 1 also shows that each Zone had a widely varying number of gages within it (note that not all gages may be active at all times), ranging from 16 in Zone E (North Metro) to 100 in Zone D (Central Metro). The right two columns of Table 1 show rainfall statistics for the 2019 season. The number of days where maximum hourly rainfall exceeded 0.5 inches ranged from 19 in Zone A (Northern Foothills) to 38 in Zone C (Palmer Divide). There were 63 days during the 153 day operational season when at least one Zone measured 0.5 inches in 1 hour, which was up from 49 during the 2018 season and on par with the 2017 season (64 days). While it was believed that the zone cutbacks may have help decrease the number of 0.5 inches in 1 hour days, 2018 may have just been an anomalously low count due to the blocking ridge pattern creating drier than normal conditions. More operational seasons with the new zones will help lead to further clarification of the data. Regarding the more important threshold of 1 inch over 1 hour, there were 26 such days, which was up 4 from the 2018 season and up 7 from the 2017 season. All Zones had at least 1 day of 1 inch over 1 hour with the climatologically active region of the Palmer Divide (Zone C) reaching the highest number of days (15 days). To be brief, **2019 can be described as relatively active across the adjacent plains (C, D, E) but more quiet across the mountain zones (A, B).** The greater coverage of ALERT gages in Zone D (Central Metro) may also help capture the more spatially explicit storms. Finally, note that in the two right columns of Table 1, the sum of the values across each Zone do not equal the total: this occurs because there are often instances when multiple zones record rainfall accumulations exceeding these thresholds *simultaneously*.

**Table 1:** Summary of Forecast Zones and 2019 statistics. Note that there are 153 days in the 2019 operational season.

Forecast Zone	Area (sq. mi.)	# of ALERT gages	# of days with rainfall >= 0.5 in/hr	# of days with rainfall >= 1.0 in/hr
(A) Northern Foothills	1,034	68 gages	19 days	7 days
(B) Southern Foothills	1,317	27	23	8
(C) Palmer Divide	1,131	47	38	15
(D) Central Metro	1,151	100	34	10
(E) Northern Metro	1,130	16	29	11
<b>All Zones</b>	<b>5,763</b>	<b>258</b>	<b>63 (2017 – 64; 2018 - 49)</b>	<b>26 (2017 – 19; 2018 - 22)</b>

## Threat Classification System

Although the Tool outputs forecasted rainfall amounts, its broader purpose is to act as a decision support tool. Accordingly, a translation between rainfall intensity and probability into a threat level(s) is required. As in 2015 through 2018, five threat levels were used: No Threat, Low, Moderate, High and Very High. The Threat Level is based on two considerations: rainfall intensity and probability of exceedance. The following four rainfall duration thresholds are used to identify a possible threat: **1 inch per 1 hour, 2.25 inches per 3 hours, 3.5 inches per 6 hours and 4.5 inches per 24 hours**. Using multiple durations captures the wide array of rainfall events, ranging from very intense, short-duration events (e.g. 1 hour) to low-to-moderate intensity, long-duration events (e.g. 6+ hours). In addition to the threshold itself, the probabilistic capabilities of the Tool were leveraged to quantify the confidence of a threshold being exceeded. Intuitively, assuming atmospheric model QPF has some skill, a higher POE warrants a higher threat level (as was shown to be true during 2015 through 2018). The classifications are determined using the protocol in Table 2. Note that in addition to the Zone-Specific thresholds, an “All Zones” threshold was also used to assign a single threat across the entire Tool domain. As can be expected, the thresholds for the All Zones threat levels were significantly higher than Zone-Specific ones, due to the increased skill that exists as a larger area is considered. For 2019 season, the All Zones “High” threat threshold was decreased from 84% to 78%, which based on 2016-2018 historical data would allow for a 75% hit rate.

**Table 2:** Threat classification system.

Threat	Zone-Specific Threshold	All Zones Threshold
LOW	POE $\geq$ 8%	POE $\geq$ 25%
MODERATE	POE $\geq$ 19%	POE $\geq$ 39%
HIGH	POE $\geq$ 29%	POE $\geq$ 78%
VERY HIGH	POE $\geq$ 45%	POE $\geq$ 90%

Table 3 is the culmination of three years’ worth of operational experience, although it is important to realize that as the science continues to evolve, updates to Table 3 can be expected. Table 3 shows the number of threats identified for each Zone, categorized by threat level. Of the 153 days in the 2019 operational season, there were 13 days where at least a Low threat was present for All Zones. Table 4 shows the 2019 All Zones threat summary next to the 2017 and 2018 All Zone summary for reference, although the area size (2017), number of days in the operational season (2018) and High threat threshold was different (2017, 2018). Though not an apples to apples comparison, the number of All Zone threat days decreased more than 50% from the 2017 to 2018 season, but slightly rebounded from 2018 to 2019. There are also zero Very High threat days during 2019 season with little to no change in Low threats. Compared to 2018, 2019 was a much more active season, which is shown by the increase in the number of Moderate threats issued. Even if the High threat threshold used the metrics from 2017 (>64%), there would only be two additional All Zones High threat for the season. Also included in Table 4 is the F2P2 Heavy Precipitation Outlook (HPO) provided each morning by Skyview Weather. The HPO issued 44 more threats days than the Tool with 16 more high-end threat days and 26 more low-end threat days.

**Table 3: 2019 Threat Level Summary, by Zone**

Zone	None	Low	Mod	High	Very	Threats Issued
(A) Northern Foothills	133	10	5	4	1	20
(B) Southern Foothills	127	17	7	1	1	26
(C) Palmer Divide	129	15	4	5	0	24
(D) Central Metro	129	10	5	9	0	24
(E) Northern Metro	133	10	5	4	1	20
All Zones	120	13	19	1	0	33

**Table 4: All Zones Threat Comparison between 2019, 2018, 2017 and 2019 HPOs for reference. Note the 2017 season had a different All Zone domain and 2018 had a shorter operational season, so use caution when comparing the data.**

All Zones	None	Low	Mod	High	Very	Threats Issued
2019	120	13	19	1	0	33
2018	115	15	9	0	1	25
2017	87	13	28	24	1	66
2019 HPO	76	39	21	17	--	77

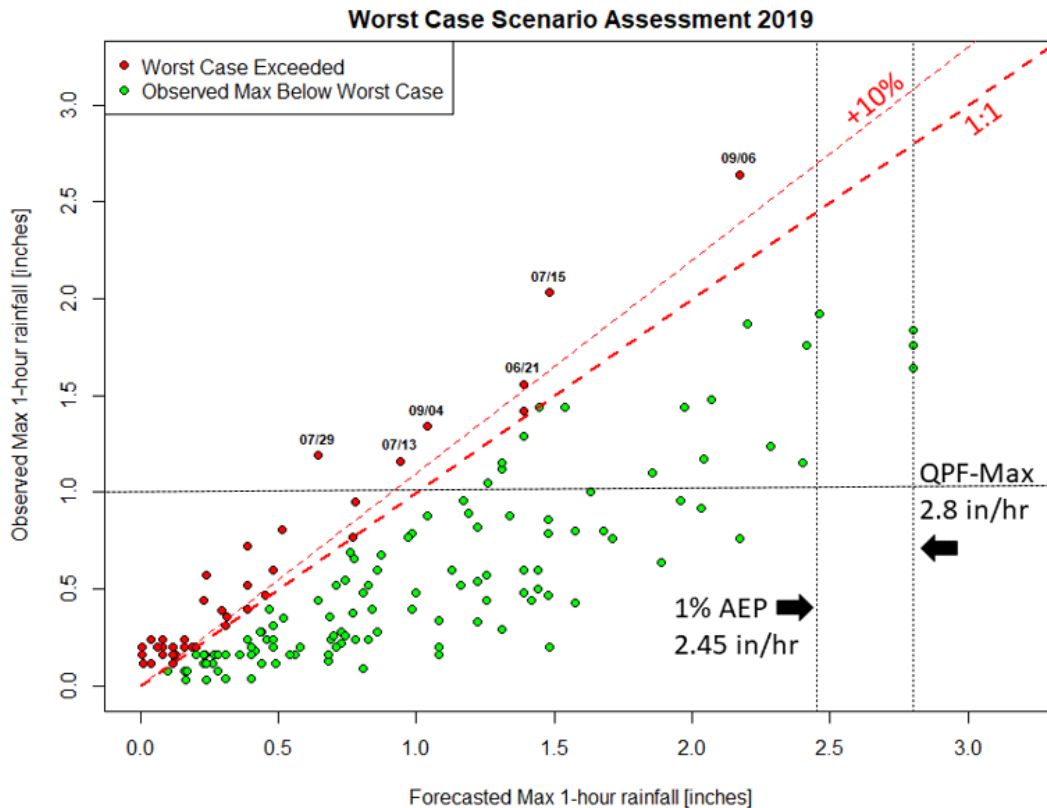
## VALIDATION

### Worst-case scenario analysis

A key output of the Tool is the daily 1-hour QPF-Max, which is analogous to the *realistic* worst-case scenario estimate. It is important to appreciate the significance of the term “realistic”. From a simple theoretical standpoint, one can assign a maximum potential rainfall intensity (i.e. worst-case scenario) based on historical rainfall climatology such as NOAA Atlas 14. For example, the 1-in-100 year hourly point rainfall in the Denver area is 2.34 inches, while the 1-in-1000 year amount is 3.67 inches. Unfortunately, these values will drastically overestimate observed maximum rainfall the vast majority of the time, decreasing their utility in operations. To add realism, consideration of factors such as Precipitable Water content, atmospheric flow, and seasonality, will allow for a better estimate of the daily worst-case scenario. The Tool accomplishes this by considering the simulations from many weather models, in order to capture the variety of outcomes that are possible given an initial atmospheric state.

In a perfect system, the worst-case scenario intensity will be higher than observed maximum rainfall, though occasionally the worst-case scenario will be realized. Figure 2 shows this worst-case scenario assessment during the 2019 season. Note that the vast majority of the time, the QPF-Max is indeed higher than, or equal to the observed maximum (hereafter, QPE-Max) rainfall. Of the 63 days when hourly rainfall intensity exceeded 0.5 inches, QPF-Max was higher 78% of the time (79% of the time if a 10% margin is added), which is much higher than 2018 (61%) and more on par with the 2016 and 2017 operational seasons (81% and 83%, respectively). Concentrating only on days when hourly intensity exceeds 1 inch, QPF-Max is higher or equal to observed intensity 76% of the time. This is the highest percentage in program history, which translates to a decrease in the worst-case scenario being realized. Furthermore, the correlation between QPF-Max and QPE-Max remains strong (0.79), implying that as the worst-case scenario increases, so does the observed intensity. The presence of a correlation reiterates the “realistic” aspect of the QPF-Max, making it more useful for operations.

Prior to the start of the 2018 operational season, the max 1-hour QPF bias correction was increased from 2.45 inches (~1% AEP) to 2.8 inches to ensure the worst-case scenario was captured for the higher end threats (see vertical lines in Figure 2). This value was determined by averaging the top two QPE values from the ALERT gages starting in 2015. For reference, the QPE-Max record is from August 30, 2016 where 2.96 inches was observed. During the 2018 season, the max 1-hour ALERT value observed was 2.76 inches on July 23<sup>rd</sup> near Buckley Air Force Base. Thus, the 2.8 inch max 1-hour QPF bias correction seemed reasonable to use for the 2019 operational season. Taking into account the 2019 season, the average of the top 4 max 1-hour ALERT QPE (2.63 inches, 2.64 inches, 2.76 inches, 2.96 inches) remains under 2.8 inches; therefore, it is recommended that this max threshold is reasonable for use in the upcoming 2020 season. The worst-case scenario was realized seven times during the 2019 season when QPE was greater than 1 inch in 1 hour, which can be seen in Figure 2. Two of these events fell within the ~10% margin of error (6/21, 8/7; note: the event on 6/21 was within a 12% margin of error).



**Figure 2:** Comparison of bias-corrected daily 1-hour QPF-Max (i.e. “Realistic Worst-Case Scenario”) and highest observed 1-hour rainfall across all Forecast Zones. Green dots show instances where QPF-Max was higher than observed, while red dots show where observed rainfall exceeded QPF-Max. The thick red dashed line shows a one-to-one relationship (while the light-dashed line shows a 10% buffer, for reference). Note that the highest allowable QPF-Max increased from 2.45 inches in 1 hour (~1% Annual Exceedance Probability) to 2.8 inches in 1 hour prior to the 2018 season based on the two highest QPE values from prior seasons (see 2016 Technical Memo for further explanation). This was still the recommended cap (based on the highest three QPE values) after the 2018 season, so no changes were made for the 2019 season.



Table 5 shows the number of days per month when moderate (0.75 inch in 1 hour) and heavy (1 inch in 1 hour) rainfall rates were observed, compared to climatology. Of the 44 days when moderate and heavy rainfall intensity were observed, 23 occurred during July and August, but 29 occurred during June and July. While the highest count in July is consistent with climatology, June was slightly higher than normal. This was likely due to the active pattern in place at the beginning June from the 1<sup>st</sup> to the 5<sup>th</sup>. Of the 26 days with heavy rainfall intensity, 9 (34%) occurred during July, which is in line with climatology but higher than expected.

**Table 5:** Monthly statistics of heavy rainfall occurrence during the 2019 season.

Month	# of days with rainfall exceeding		Climatological daily probability of exceeding	
	0.75 inch / hour	1 inch / hour	0.75 inch / hour	1 inch / hour
May	4	2	5%	3%
June	13	8	7%	4%
July	16	9	20%	14%
August	7	3	13%	7%
September	4	4	4%	4%
<b>Total</b>	<b>44</b>	<b>26</b>	N/A	N/A

Table 6 shows the days when QPF-Max underestimated the observed rainfall in instances where QPE was over 1 inch and not within the 10% error. Of the six remaining days, QPF-Max was within ~12% of the observed max rainfall intensity during the June 21<sup>st</sup> event. Four of the six events also had only one zone (of the five zones) reach the 1 inch per hour threshold, which indicates local heavy rainfall rather than a large-scale event capable of producing widespread flooding. While models are improving, these more isolated events remain harder for models to predict. Thankfully hourly QPF-Max, an important value to end-users, was only under an inch per hour during two of the six events, which were also isolated in nature as they only occurred only in one zone. On September 6<sup>th</sup>, a Very High threat was issued with QPF-Max at 2.17 inches, but the QPE-Max reached 2.64 inches. While this was still a worst-case scenario, it is promising that the QPF-Max was on the higher end as large QPE events such as these are far and few between. They play a crucial role in the quantile mapping analysis (bias correction tables) completed at the beginning of each season, so it is likely the prior seasons' larger QPE-Max events helped increase the QPF-Max value on September 6<sup>th</sup>. Thus, implementation of these high QPE-Max events, and all data from Table 6, into the quantile mapping analysis is expected help reduce future instances where the 1-hour QPF-Max is underestimated.

**Table 6:** Summary of days when 1-hour QPF-Max underestimated rainfall intensity with 10% margin of error (only shown when QPE exceeded 1 inch in 1 hour).

Date	Max hourly observed	Hourly QPF-Max	# of Zones with > 1 in per hour
June 21	1.56 inches	1.39 inches	1
July 13	1.16	0.94	1
July 15	2.03	1.48	2
July 29	1.19	0.64	1
September 4	1.34	1.04	1
September 6	2.64	2.17	4

## Case Study

Every once and awhile, the Tool's output can be extremely accurate, which was the case on September 6<sup>th</sup>, 2019. After the morning update at 8AM, the Tool indicated a very active rainfall period from 3PM to 6PM (Figure 1). On the synoptic scale that day, a cold front had pushed south and returned high moisture to the area. Precipitable Water (PW) was measured at 1.06 inches in the morning sounding at Denver. For reference, this placed PW in the 95<sup>th</sup> percentile for that time of year and broke a daily maximum record, so this could be considered a late season event. It is well know that when PW values are greater than 1 inch, POP-1hr will likely be realized if all other atmospheric ingredients are available for convection (lift and instability). On top of high atmospheric moisture, storm motion was forecast to be under 10mph with back-building storms possible due the continuous westerly component of the wind field (upslope flow). Thus, it was not surprising that the Tool indicated a high probability for 1 hour rainfall to exceed 1 inch.

What was noteworthy from the output were the individual zone POP-1hr, discrete nature of the maximum 1-hour QPF and the QPF-Max value. It is not often individual zones exceeded 40% reliability. Thus, the 49% POP1 in Zone B and Very High threat was notable. There was also a very small window for Primetime (2PM to 4PM) in Zone B with a 3PM POP-1hr at 29%, which is exceptionally high. Not to be outdone, Zone D also had a high POP-1hr at 36%, which categorized the threat as High. There was less agreement in regards to Primetime; however, the window for the heavy rainfall threat was only 3-hours in length. Additionally, the discrete nature of the maximum 1-hour QPF indicated agreement by models in respect to the location of storms. Lastly, QPF-Max, that represents the worst-case scenario, was forecast to be 2.17 inches (00Z run of the NSSL-WRF). It is not often that this value exceeds 2 inches, and when paired with high POP1-hr and well-defined storm location, there was high confidence this QPF value could be achieved.

Sure enough, the Tool verified with incredible accuracy in timing, location and magnitude. Areas receiving over 1 inch in 1 hour are marked with a black "X" in Figure 1. QPE exceeded 1 inch in 1 hour at nine ALERT stations in Zones B, C and D, and the QPE-Max reached 2.64 inches at the Big Dry Creek at Heritage Regional Park gage (located on the boundary between Zone C and D). While QPF was underestimated, it is possible there was a limitation with the model data as it is aggregated on the hour. Looking at the 3-hour QPF-Max from the NSSL-WRF 00Z run, QPF was 2.95 inches. This may have been a better estimation of the worst-case scenario as it would have caught rain falling across the hour. As expected, there were several flood reports associated with these two storms. In the mountains near Floyd Hill, there were reports of mud flows, debris slides and high water running down I-70, which temporarily closed the highway. In the Denver Metro area, two people had to be rescued from a vehicle that was stranded from flooding at C-470 and Yosemite. This event builds confidence that the Tool's performance continues to increase due to improvements in high-resolution QPF and/or with the post-processing techniques that are refined each season.

## Contingency Table

The Contingency Table is a useful metric for evaluating the effectiveness of the Tool's forecasts; Table 7 summarizes the information that can be obtained from such a table. A day is categorized as a Flood Day when the Tool forecasts a non-zero threat level. In turn, a Flood Day is observed when maximum 1-hour rainfall across all the Forecast Zones exceeds 1 inch (note that this does not actually indicate that flooding occurred, but acting as a proxy for flooding).

**Table 7:** Flood Day Contingency Table.

		Flood Day Forecasted	
		YES	NO
Flood Day Observed	YES	HIT	MISS
	NO	FALSE ALARM	HIT

By adding up all of the total Hits and dividing by the number of total days (153), we find the “Accuracy” rate. Meanwhile, we are also interested in the quantifying the occurrence of Misses and False Alarms; these statistics are essential for guiding future refinement of the Tool. We run these calculations for each zone separately. For completeness and a reference point, we also calculate a contingency table across All Zones to answer the broader question: “if a threat was forecast anywhere in the domain, did it verify anywhere in the domain?” Such a domain-wide contingency table is likely to yield higher Accuracy numbers than each Zone since there is more leniency in the spatial dimension. However, it is still a useful metric given the imperfect nature of heavy rainfall prediction. A HPO Contingency Table was also created to quantify the performance of the Tool (objective forecast) to a more subjective forecast.

Overall, the 2019 operational season was more active than 2018, providing a larger sample size from which to determine zone-specific statistics, which in turn, means more weight can be placed on the 2019 results. Table 8 indicates the Tool’s performance showed slight variation across the Forecast Zones, with accuracy ranging from 85.6% in Zone B (South Foothills) to 90.2% in Forecast Zone A and E (North Foothills and North Metro, respectively). Compared to the 2018 season, the False Alarm Rate either remained the same or slightly increased. While the increase is not optimal, this value remained under the goal and industry standard of 20%. When compared to the 2018 season, the Miss Rate decreased drastically for Zones A, D and E (as much as ~40%) along with a reduction in the bias.

Zones B and C had Miss Rates of 25% and 40%, respectively, which is an increase from last season. Looking further into the increase of the Miss Rate for Zone B, it seems this may be a sample size issue. With only eight Flood Days this season, the Miss Rate can jump +/-12.5% for each event, which could easily push the Miss Rate above or below the 15% goal. Further analysis of the missed events for Zone C indicate that the high-resolution models sometimes either have trouble initiating convection over Palmer Divide or with storm motion/available surface moisture. Prior to the start of the 2020 season, it would be beneficial to research whether Zone C should have its own bias correction or zone-specific post-processing equation. Currently, Zone C is lumped together with Zone D and E due to the drastically higher elevations found in Zone A and B (North and South Foothills).

Across all Forecast Zones (Table 8, panel f) Accuracy was 85% with a 12% False Alarm Rate and a 31% Miss Rate. The Tool’s Accuracy continued to remain high after a successful 2018 season (2017: 72.7%; 2018: 86.4%). This implies that the changes made prior to the start of the 2018 season may have increased the Accuracy of the Tool. The False Alarm Rate did increase slightly (2017: 32%; 2018: 9%), but this remains well-below the goal of 25%. Lack of data was not an issue for producing False Alarms as all hours from the models were available on average 97% of the time on those days. Additionally, the Miss Rate decreased by a larger margin with no changes made to the All Zone Low threat threshold indicating improvement in the post-processing procedures (2017: 7%; 2018: 36%). Once again, the optimal tradeoff between the False Alarm Rate and Miss Rate will be reassessed prior to the start of the 2020 season with the data from 2019 included, which will create a larger sample size. Further conversations will continue to be held with MHFD as minimizing the Miss Rate is more of a priority than decreasing the False Alarm Rate. A general rule by the forecast community is that the False Alarm Rate should remain under 20% and the Miss Rate remain under 15%.

**Table 8:** Contingency Tables of the Tool's performance for each zone separately and for all zones together. Bottom image has the number of Flood Days for reference.

		Flood Day Forecasted			
		YES	NO		
Flood Day Observed	a)Zone A				
	YES	6	1	Accuracy: 90.2 %	False Alarm: 9.6%
	NO	14	132	Misses: 14.3%	
Flood Day Observed	b)Zone B				
	YES	6	2	Accuracy: 85.6%	False Alarm: 13.8%
	NO	20	125	Misses: 25.0%	
Flood Day Observed	c)Zone C				
	YES	9	6	Accuracy: 86.3%	False Alarm: 10.9%
	NO	15	123	Misses: 40.0%	
Flood Day Observed	d)Zone D				
	YES	8	2	Accuracy: 88.2%	False Alarm: 11.2%
	NO	16	127	Misses: 20.0%	
Flood Day Observed	e)Zone E				
	YES	8	3	Accuracy: 90.2%	False Alarm: 8.5%
	NO	12	130	Misses: 27.3%	

		YES	NO		
Flood Day Observed	f)All zones			Accuracy: 85.0%	
	YES	18	8	False Alarm: 11.8%	
	NO	15	112	Miss: 30.8%	

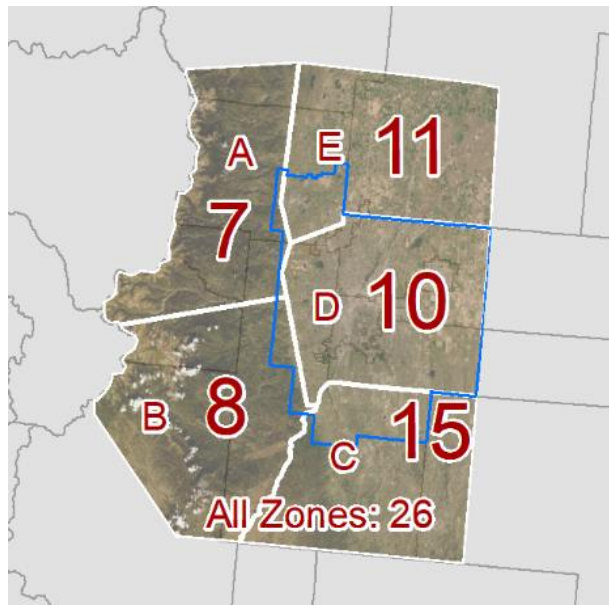


Table 9 shows Contingency Tables for All Zones without the addition of the new TTU-WRF ensemble and for the HPOs delivered by Skyview each morning, for reference. Panel A indicates that there would have been a slight improvement in all metrics without the addition of the TTU-WRFens. Accuracy would have increased by 2.6% with the False Alarm and Miss Rate decreasing by 2.4% and 3.8%, respectively. Of the 15 days there was a difference in classified flood category (hindcast), only four would have been in favor of increasing the Tools' metrics. A quick additional Mean Absolute Error analysis of the individual TTU-WRFens members (not shown) implies uniform performance between the members. Supplementary analysis will be performed prior to the start of the 2020 season to further determine the value of the ensemble members before incorporating the QPF into the Tool. It may also be possible to obtain older data from TTU to train the models with a larger data set. When compared to the HPOs, the Tool had a much lower False Alarm Rate and superior Accuracy. While heavy rainfall prediction is still imperfect (although improving), it is worth looking into lowering the All-Zones Low threat threshold. While this may increase the False Alarm Rate, it may reduce the Miss Rate by a larger magnitude.

**Table 9:** (a) Contingency Table without TTU-WRFens. (b) Contingency Table for HPO.

		Flood Day Forecasted		
		YES	NO	
<b>(a)</b>	<b>All zones</b>			Accuracy: 87.6% False Alarm: 9.4% Miss: 26.9%
	<b>Flood Day Observed</b>			
	<b>YES</b>	19	7	
	<b>NO</b>	12	115	

		Flood Day Forecasted		
		YES	NO	
<b>(b)</b>	<b>All zones</b>			Accuracy: 65.4% False Alarm: 40.9% Miss: 3.8%
	<b>Flood Day Observed</b>			
	<b>YES</b>	25	1	
	<b>NO</b>	52	75	

Table 10 shows the Hit Rate (Accuracy) and False Alarm Rate as a function of the Tool threat level (for All Zones). An important feature of a good forecast system is the ability to discriminate between the lower and higher threat days. Indeed, Table 10 shows that the Hit Rate climbs from 30.8% for the Low threat to 68.4% and 100% for the Moderate and High threat. It should be noted that there were no All Zones Very High threats issued this season, and only one day had a High threat (July 20<sup>th</sup>). Therefore, conclusions about the accuracy of the High Threat should be interpreted with caution. Using the High threat threshold from 2017 (64%), there would have been two additional High threat days and both would have verified for a 100% Hit Rate. This result implies it may be possible to lower the High threat threshold once again and maintain the 80% Hit Rate goal for next season. This will again be evaluated in the off season.

Another finding in Table 10 is that the number of threats does not decrease as one moves to a higher threat level, which may be expected. It is possible this season that many days had particularly threatening atmospheric ingredients for heavy rainfall, which is why the number of (high-end) Moderate threat days forecast (19) exceeded the number of Low threat days (13) forecast. However, it is also feasible that the post-processing techniques or POE thresholds were better adjusted for 2017 through 2018 seasons with intentions of properly proportioning the threat level system. It also seems decreasing the southern and western extent of the Tool's domain helped hone in the Tool's capability for more reliable and accurate District probabilistic forecast for a second year in a row.

**Table 10:** Hit and False Alarm Rate as a function of threat level across All Zones (compare with **Table 8**, panel f).

Threat Level	# Cases	Hit Rate	False Alarm
Low	13	30.8%	69.2%
Moderate	19	68.4%	31.6%
High	1	100%	100%
Very High	0	N/A	N/A
Total	33	54.5%	45.5%

## CONCLUSIONS

The MHFD Heavy Rainfall Threat Analysis Tool concluded its fifth season of operation on September 30<sup>th</sup>, 2019. The Tool incorporates a large number of state-of-the-art high-resolution weather models to objectively estimate the chances of seeing heavy rainfall across the District. The Tool's methodology has undergone two major upgrades since the inaugural 2015 season. In 2016, model bias correction and post-processing was included, which resulted in a notable drop in the False Alarm Rate but a rise in the Miss Rate. In 2017, flow dependent post-processing was included, as well as an estimate of the threat level across all Forecast Zones. While this improved the Miss Rate, the False Alarm Rate increased. For the 2018 season, the southern and western edge of the domain were cutback (climatologically more active and don't affect the District), and the remaining 5 forecast zones were adjusted to be more equal in area and fall on county boundaries. Results from 2018 and 2019 indicate this may have helped improve the Accuracy of the Tool as well as helped drop the Miss Rate. Overall, 2019 was a more active season in regards to 1 inch in 1 hour events (26 events), which suggests more confidence can be placed on the results presented in this report.

Similar to 2018, the Northern and Southern Foothills had the fewest number of flood days. In addition, the Northern Metro area was quiet when compared to the more active adjacent zones (Central Metro and Palmer Divide). The number of events greater than 0.75 inches decreased across All Zones from 49 to 44 days. Of the 44 days, 29 occurred in June/July vs. 23 in July/August. While the highest count in July is consistent with climatology, June was slightly higher than normal likely due to the active pattern in place at the beginning of the month. As for threats forecast, the greatest number of threats issued were located over the southern half of the District (B, C, D) with the Northern Foothills and Northern Metro only having 20 threats forecast. Each zone, except the Central Metro, had the number of threats properly proportioned (decreasing as one moves to a higher threat). However with accuracy measured at 88% and a False Alarm rate of 11%, it indicates that the nine High threats forecast in Zone D were likely warranted.

The Tool continued to provide a good estimate of the *realistic* worst-case scenario of the daily heavy rainfall threat, one of the key metrics that it was designed to forecast. This was manifested by its forecasted 1-hour maximum rainfall rates (QPF-Max) being at or above those that were observed 78% of the time (79% with allowance of a 10% error margin) during situations where observed 1-hour rainfall intensity exceeded 0.5 inches. This percentage was still at 76% (an all-time Tool high) when limiting to days when at least 1 inch in 1 hour accumulations were observed. Of the seven events where the Tool underestimated observed rainfall intensity, two of the events the forecast max intensity was within ~12%. Overall, this translates to a decrease in the worst-case scenario being realized. Once again, heavy rainfall (1 inch in 1 hour or more) occurrence was seasonally distributed in a way that was mostly consistent with climatology, with 9 of the 26 days occurring during July. June remained above normal when compared to climatology (8 days), and August was right around the expected daily probability (3 days).

Contingency tables monitoring Hits, False Alarms and Misses showed that the Hit rate (or Accuracy rate) for All Zones was 85%, which is on par with 2018 (86%) and up from 73% in 2017, 80% in 2016 and 69% in 2015. The most notable reason for this is the processing algorithms (post 2016), changes in the threshold of the Probability of Exceedance (see Table 2) and decrease in area size of the Tool. The All Zone Miss Rate decreased by 6% to 31%, so the False Alarm Rate increased by 2%. This trade-off between False Alarm Rate and Miss Rate can be expected. However, the False Alarm Rate remains below industry standards and decreased in greater magnitude than the increase of the Miss Rate. Of course the Tool's performance is highest when more events occur, so there can be more confidence placed in high performing results from the last two years. Performance is expected to continue to increase as more data is ingested into the post-processing equations (increase from 3 to 4 years), so the active 2019 season should add value to next year's operational season. The addition of the TTU-WRFens into

the Tool will be further analyzed in the off-season as metrics looked to decrease when the model members were not included in a hindcast analysis.

In conclusion, the findings of this Final Report suggest the Heavy Rainfall Threat Analysis Tool continues to show value in increasing lead time and accuracy of heavy rainfall forecasts for the District. The improved metrics during the 2018 operational season and high performance during the 2019 season are encouraging results. Utility of the Tool continues to improve each season and updates to methodology to include the latest data are a large part of the Tool's success. Incorporating the latest science and data in the Tool will continue to be a priority as preparation for next operational season.

## RECOMMENDATIONS

It is recommended that post-processing methods be re-assessed before 2020 operations in order to (i) incorporate 2019 observations, (ii) investigate significantly decreasing the Miss Rate while only slightly increasing the False Alarm Rate by testing the POE thresholds (individual and all zones), and (iii) assess whether Zone C should have its own bias correction or zone-specific post-processing equation. It is also recommended to further analyze the usefulness of the TTU-WRFens as all metrics improved when the model members were not used in the Tool's hindcast. Bias corrections for the TTU-WRFens will also be completed, as well as for the HRRRE, to see the effects on the Tool's performance. Prior to 2018, work had begun to do an evening update (N4) in hopes to capture the end of the diurnal convection cycle during the monsoon season. This update would also alert the end-user if the heavy rainfall threat continued overnight, which sometimes occurs with post-frontal upslope flow. It is suggested that this update be completed before the start of next operational season.



## REFERENCES

Dewberry, 2016: UDFCD Heavy Rainfall Guidance Tool – Upgrades for 2016 Operational Season. Submitted to the Urban Drainage and Flood Control District on May 27, 2016, revised on July 26, 2016.

Perica et al., 2013: Precipitation-Frequency Atlas of the United States, Volume 8. National Oceanic and Atmospheric Administration, United States Department of Commerce, Silver Spring, MD.

## APPENDIX A – DISTRICT-WIDE FORECASTS AND OBSERVATIONS

The table below show daily summary of observations and forecasts for all zones. See Appendix B for zone-specific information. Column names are described below:

Column	Units	Description
A	N/A	Date
B	Inches	Max 24-hour from CoCoRaHS gages.
C	#	Number of CoCoRaHS gages exceeding 1 inch.
D	#	Number of CoCoRaHS gages with measurable precipitation.
E	Inches	ALERT max 30 minute precipitation.
F	Inches	ALERT max 1-hour precipitation.
G	Inches	ALERT max 2-hour precipitation.
H	Inches	ALERT second highest 1-hour precipitation.
I	Inches	ALERT max 24-hour precipitation.
J	#	Number of ALERT gages exceeding 1 inch in 1 hour.
K	Inches	NOAA Stage IV max 1-hour precipitation.
L	Inches	NOAA Stage IV max 2-hour precipitation.
M	Inches	NOAA Stage IV max 24-hour precipitation. Note that this can be lower than column (L) because more gages are used during the 24-hour gage adjustment.
N	Yes/No	First guess at whether or not a Flood Day (QPE exceeding 1 inch in 1 hour) is observed.
O	Yes/No	Reassessment of (N) after manual quality control.
NZones	#	Number of zones where a Flood Day was observed.
P	Threat, %	Tool threat level (color), and probability of exceeding 1 inch in 1 hour.

**APPENDIX A – DISTRICT-WIDE FORECASTS AND OBSERVATIONS**

A	CoCoRaHS			ALERT						NOAA Stage IV			Flood Day Classification			Threat
	B	C	D	E	F	G	H	I	J	K	L	M	N	O	Nzones	P
5/1	0.38	0	189	0.25	0.31	0.4	0.28	0.56	0	0.25	0.49	0.62				3
5/2	0.05	0	12	0.16	0.16	0.16	0.16	0.2	0	0.12	0.23	0.17				2
5/3	0	0	0	0.04	0.04	0.04	0	0.04	0	0.08	0.14	0.08				1
5/4	0	0	0	0	0	0	0	0	0	0.03	0.36	0.03				2
5/5	0	0	0	0	0	0	0	0	0	0.03	0.04	0.05				2
5/6	0.75	0	262	0.6	0.68	0.72	0.28	0.76	0	0.66	1.01	0.8	YES			9
5/7	0.78	0	263	1.1	1.1	1.1	0.52	0.8	1	0.55	1.03	0.8	YES			41
5/8	1.4	24	248	0.2	0.28	0.44	0.24	0.8	0	0.21	0.45	1.35				6
5/9	0.61	0	230	0.24	0.4	0.44	0.32	0.72	0	0.23	0.46	0.9				3
5/10	0.27	0	50	0.35	0.52	0.6	0.32	0.92	0	0.15	0.29	0.5				3
5/11	0.13	0	65	0.16	0.28	0.36	0.2	0.55	0	0.12	0.21	0.32				3
5/12	0	0	0	0.04	0.04	0.04	0.04	0.04	0	0	0.01	0.02				2
5/13	0.01	0	3	0.48	0.48	0.48	0.16	0.48	0	0.12	0.19	0.13				6
5/14	0.05	0	14	0.04	0.04	0.04	0.04	0.04	0	0.09	0.2	0.1				5
5/15	0.01	0	2	0.24	0.4	0.72	0.12	2.28	0	0.04	0.15	0.07				2
5/16	0.09	0	14	0.16	0.16	0.2	0.16	0.24	0	0.06	0.13	0.08				3
5/17	0.42	0	195	0.16	0.2	0.2	0.16	0.2	0	0.22	0.44	0.52				4
5/18	0.18	0	126	0.16	0.2	0.2	0.12	0.2	0	0.16	0.31	0.2				6
5/19	0.49	0	247	0.12	0.16	0.2	0.12	0.36	0	0.18	0.35	0.51				4
5/20	2.1	66	267	0.16	0.2	0.32	0.2	0.64	0	0.47	0.92	2.55				15
5/21	1	0	150	0.36	0.6	0.72	0.52	0.92	0	0.72	1.42	0.76	YES			3
5/22	1.01	1	223	0.2	0.24	0.32	0.2	0.8	0	0.15	0.28	1.19				3
5/23	0.32	0	159	0.2	0.2	0.24	0.12	0.56	0	0.15	0.29	0.61				4
5/24	0.02	0	2	0.32	0.36	0.68	0.32	1.16	0	0.05	0.13	0.04				2
5/25	0.3	0	8	0.04	0.04	0.04	0	0.04	0	0.04	0.07	0.04				2
5/26	0.69	0	183	0.48	0.48	0.48	0.44	0.72	0	1.17	2.11	1.55	YES	YES	2	49
5/27	1.1	3	255	0.68	0.68	0.72	0.68	0.88	0	0.8	1.57	1.51	YES	YES	1	42
5/28	0.89	0	264	0.76	0.88	0.88	0.44	0.96	0	0.58	1.06	0.94	YES			29
5/29	0.26	0	34	0.12	0.12	0.12	0.08	0.28	0	0.13	0.23	0.79				5
5/30	0.07	0	45	0.4	0.4	0.4	0.16	0.4	0	0.18	0.35	0.3				15
5/31	0.16	0	110	0.16	0.2	0.2	0.12	0.2	0	NA	NA	NA	YES			6
6/1	1.31	1	160	0.8	0.92	0.92	0.8	0.92	0	1.12	2.23	1.21	YES	YES	1	37
6/2	0.67	0	120	0.32	0.36	0.36	0.32	0.36	0	0.96	1.82	1.03	YES	YES	1	19
6/3	0.74	0	156	0.68	0.68	0.72	0.48	0.72	0	0.82	1.32	1.28	YES			11
6/4	0.24	0	119	0.2	0.2	0.2	0.16	0.24	0	0.33	0.58	0.51				13
6/5	1.47	2	201	0.8	1.29	1.43	0.48	1.44	1	0.91	1.81	1.59	YES	YES	2	48
6/6	0.42	0	66	0.78	0.79	0.79	0.24	0.8	0	0.36	0.65	0.5				12
6/7	0.67	0	170	0.4	0.44	0.44	0.4	0.44	0	0.44	0.87	0.8				14
6/8	0.59	0	249	0.2	0.2	0.2	0.2	0.28	0	0.69	1.32	0.85	YES			15
6/9	0.1	0	20	0.2	0.2	0.2	0.04	0.2	0	0	0	0				1

**APPENDIX A – DISTRICT-WIDE FORECASTS AND OBSERVATIONS**

A	CoCoRaHS			ALERT						NOAA Stage IV			Flood Day Classification			Threat
	B	C	D	E	F	G	H	I	J	K	L	M	N	O	Nzones	P
6/10	0.04	0	1	0.16	0.24	0.24	0.16	0.2	0	0.04	0.08	0.06				1
6/11	0.03	0	13	0.16	0.2	0.2	0.08	0.2	0	0.05	0.09	0.05				1
6/12	0.04	0	6	0.16	0.24	0.24	0.12	0.64	0	0.14	0.23	0.14				5
6/13	0.36	0	66	0.24	0.24	0.24	0.24	0.24	0	0.38	0.62	0.43				5
6/14	0.18	0	88	0.24	0.24	0.24	0.16	0.24	0	0.23	0.46	0.29				6
6/15	0.55	0	127	0.56	0.64	0.68	0.36	0.68	0	0.37	0.71	1.24				41
6/16	1.06	1	233	0.72	0.8	0.8	0.64	0.84	0	0.74	1.41	1.06	YES			27
6/17	1.41	6	278	1.32	1.48	1.48	1.4	1.48	7	1.34	2.61	2.52	YES	YES	5	67
6/18	0.9	0	250	0.84	0.84	0.84	0.48	0.88	0	1.24	2.46	1.76	YES	YES	1	62
6/19	0.12	0	31	0.47	0.47	0.47	0.12	0.47	0	0.15	0.26	0.27				4
6/20	0.3	0	48	0.43	0.43	0.59	0.16	0.75	0	0.81	1.56	0.81	YES			5
6/21	1.94	25	266	1.32	1.56	1.76	0.76	1.96	1	0.95	1.85	1.42	YES	YES	1	38
6/22	1.42	2	271	1.28	1.44	1.48	0.96	1.64	1	0.82	1.41	1.14	YES	YES	1	42
6/23	0.27	0	94	0.16	0.16	0.16	0.12	0.2	0	0.77	1.29	1	YES			7
6/24	0.1	0	5	0.12	0.16	0.16	0.12	0.24	0	0.15	0.27	0.72				2
6/25	0.3	0	32	0.28	0.28	0.28	0.16	0.28	0	0.57	1.02	0.57	YES			2
6/26	0.02	0	2	0.28	0.28	0.28	0.16	0.28	0	0.03	0.04	0.03				2
6/27	0.55	0	15	0.28	0.28	0.28	0.2	0.28	0	0.31	0.52	0.35				3
6/28	0.33	0	93	0.55	0.55	0.55	0.35	0.55	0	0.41	0.71	0.62				7
6/29	0.15	0	31	0.2	0.2	0.2	0.08	0.2	0	0.34	0.59	0.47				10
6/30	1.83	3	260	1.08	1.44	1.44	0.88	1.44	2	1.18	2.31	1.96	YES	YES	3	38
7/1	1.87	19	258	1.24	1.92	2.16	1.32	2.16	5	0.82	1.48	1.91	YES	YES	4	61
7/2	1.22	1	106	1	1	1	0.64	1	0	0.59	1.12	0.7	YES			35
7/3	0.14	0	15	0.2	0.2	0.2	0.16	0.2	0	0.26	0.52	0.77				3
7/4	0.82	0	254	0.6	0.68	0.68	0.52	0.92	0	0.88	1.7	1.42	YES			4
7/5	1.61	11	240	1.63	1.76	2	1.04	2.08	3	1.08	2.14	1.57	YES	YES	4	37
7/6	0.3	0	40	0.28	0.32	0.36	0.24	0.36	0	0.43	0.82	0.52				33
7/7	1	0	151	0.6	0.64	0.64	0.44	0.68	0	1.05	1.98	1.68	YES	YES	1	23
7/8	0.33	0	136	0.71	0.95	0.95	0.16	0.95	0	0.35	0.65	0.36				12
7/9	0.01	0	1	0.08	0.08	0.08	0.08	0.08	0	0	0	0				1
7/10	0.01	0	1	0.12	0.16	0.16	0.08	0.24	0	0.12	0.21	0.12				8
7/11	0.23	0	51	0.24	0.24	0.24	0.12	0.12	0	0.44	0.78	0.44				2
7/12	3.2	1	36	0.6	0.6	0.6	0.24	0.6	0	0.57	1.13	0.82	YES			5
7/13	1.45	7	163	0.88	1.16	1.2	1.08	1.24	2	0.81	1.49	1.27	YES	YES	1	13
7/14	0.94	0	92	0.56	0.6	0.68	0.32	0.68	0	0.27	0.52	0.48				25
7/15	1.21	4	200	2.03	2.03	2.03	1.76	2.07	2	0.97	1.91	1.24	YES	YES	2	22
7/16	0.29	0	73	0.36	0.36	0.36	0.08	0.36	0	0.25	0.45	0.27				7
7/17	0.18	0	25	0.12	0.16	0.16	0.16	0.24	0	0.12	0.25	0.17				1
7/18	0	0	0	0.12	0.12	0.12	0.08	0.16	0	0	0	0.02				1
7/19	0.52	0	1	0.12	0.16	0.16	0.08	0.24	0	0.02	0.03	0.02				1

**APPENDIX A – DISTRICT-WIDE FORECASTS AND OBSERVATIONS**

A	CoCoRaHS			ALERT						NOAA Stage IV			Flood Day Classification			Threat
	B	C	D	E	F	G	H	I	J	K	L	M	N	O	Nzones	P
7/20	1.61	12	292	1.68	1.76	1.8	1.72	2.32	16	1.67	3.13	3.38	YES	YES	5	78
7/21	2.39	7	226	1.16	1.64	1.64	1	1.64	3	1.22	2.38	1.76	YES	YES	4	64
7/22	1.34	3	114	1.32	1.44	1.44	1.32	1.44	3	0.87	1.63	1.32	YES	YES	1	63
7/23	0.25	0	28	0.2	0.2	0.2	0.12	0.2	0	0.5	0.97	0.62				37
7/24	0.79	0	133	0.52	0.52	0.52	0.2	0.52	0	0.86	1.28	0.9	YES			30
7/25	0.84	0	172	0.88	0.96	0.96	0.76	0.96	0	0.72	1.1	0.77	YES			48
7/26	0.4	0	65	0.36	0.52	0.56	0.28	0.56	0	0.31	0.6	0.5				7
7/27	0.96	0	152	0.76	0.76	0.76	0.68	0.8	0	0.76	1.41	0.85	YES			44
7/28	0.1	0	7	0.16	0.24	0.24	0.12	0.4	0	0.12	0.24	0.24				3
7/29	1.14	1	44	0.92	1.12	1.32	0.8	1.4	1	1.19	2.26	1.78	YES	YES	1	7
7/30	0.38	0	121	0.2	0.24	0.24	0.2	0.44	0	0.24	0.44	0.44				9
7/31	0.67	0	189	0.36	0.44	0.48	0.4	0.48	0	0.79	1.57	0.98	YES			8
8/1	1.12	1	253	0.84	0.92	0.92	0.68	1.04	0	0.8	1.54	1.12	YES			54
8/2	0.71	0	74	0.32	0.48	0.52	0.24	0.68	0	0.6	1.13	0.7	YES			15
8/3	0.1	0	2	0.2	0.2	0.2	0.16	0.36	0	0.52	1.02	0.67	YES			12
8/4	0.94	0	87	0.52	0.6	0.6	0.44	0.64	0	0.43	1.08	0.65	YES			13
8/5	0.69	0	119	0.44	0.48	0.52	0.28	0.64	0	0.31	0.61	0.77				12
8/6	0.02	0	9	0.16	0.16	0.16	0.04	0.16	0	0.13	0.25	0.14				2
8/7	0.67	0	158	1.42	1.42	1.42	1.34	1.42	2	0.42	0.83	0.68	YES			14
8/8	3.3	16	255	0.96	1.16	1.32	0.96	1.72	1	1.87	3.71	3.56	YES	YES	1	63
8/9	0.89	0	77	0.56	0.72	0.96	0.16	0.96	0	1.15	2.29	2.27	YES	YES	1	19
8/10	0.15	0	59	0.12	0.16	0.16	0.12	0.2	0	0.48	0.81	0.65				26
8/11	1.12	1	144	0.64	0.64	0.64	0.44	0.64	0	0.76	1.49	1.16	YES			56
8/12	0.12	0	18	0.24	0.28	0.28	0.2	0.28	0	0.35	0.7	0.35				2
8/13	0.84	0	74	0.48	0.5	0.5	0.2	0.51	0	0.89	1.79	0.91	YES			18
8/14	0.04	0	2	0.16	0.16	0.16	0.12	0.32	0	0.03	0.06	0.03				1
8/15	0.02	0	2	0.12	0.12	0.12	0.08	0.16	0	0.03	0.1	0.04				1
8/16	0.14	0	16	0.16	0.16	0.16	0.08	0.24	0	0.39	0.72	0.66				2
8/17	0.19	0	45	0.12	0.12	0.12	0.12	0.12	0	0.4	0.8	0.46				2
8/18	0	0	0	0.2	0.24	0.24	0.12	0.4	0	0	0	0				1
8/19	0	0	0	0.16	0.2	0.2	0.12	0.2	0	0	0.37	0				1
8/20	0.26	0	79	0.2	0.24	0.24	0.16	0.24	0	0.54	1.02	0.54	YES			5
8/21	1.88	9	203	1.64	1.84	1.92	1.8	1.92	11	0.9	1.55	1.38	YES	YES	1	62
8/22	0.27	0	83	0.18	0.18	0.18	0.16	0.18	0	0.44	0.77	0.56				30
8/23	0.12	0	29	0.12	0.12	0.12	0.08	0.12	0	0.26	0.79	0.28				5
8/24	0.03	0	2	0.12	0.12	0.12	0.04	0.12	0	0	0.06	0				1
8/25	0	0	0	0.12	0.12	0.12	0.04	0.12	0	0	0	0				1
8/26	0	0	0	0.12	0.12	0.12	0.12	0.2	0	0	0	0				1
8/27	0.01	0	1	0.16	0.16	0.16	0.04	0.24	0	0	0.12	0				1
8/28	0.97	0	1	0.16	0.24	0.24	0.12	0.44	0	0	0	0				1

**APPENDIX A – DISTRICT-WIDE FORECASTS AND OBSERVATIONS**

A	CoCoRaHS			ALERT						NOAA Stage IV			Flood Day Classification			Threat
	B	C	D	E	F	G	H	I	J	K	L	M	N	O	Nzones	P
8/29	0	0	0	0.12	0.12	0.12	0.04	0.12	0	0.01	0.02	0.02				2
8/30	0.19	0	59	0.24	0.28	0.28	0.16	0.4	0	0.29	0.93	0.29				24
8/31	0.03	0	3	0.2	0.2	0.2	0.08	0.2	0	0.08	0.15	0.1				3
9/1	0	0	0	0.16	0.2	0.2	0.08	0.4	0	0.02	0.04	0.03				1
9/2	0	0	0	0.16	0.16	0.16	0.12	0.28	0	0	0.05	0				1
9/3	0.1	0	8	0.2	0.24	0.28	0.16	0.32	0	0.77	1.39	1.44	YES	YES	1	7
9/4	0.6	0	79	0.64	0.76	0.76	0.36	0.76	0	1.34	2.16	2.1	YES	YES	1	11
9/5	0.29	0	53	0.52	0.52	0.53	0.24	0.53	0	0.47	0.79	0.61				7
9/6	2.73	15	268	1.96	2.64	2.68	1.88	2.76	9	0.93	1.84	1.42	YES	YES	4	60
9/7	1.46	1	63	0.2	0.24	0.24	0.16	0.28	0	0.57	1.07	0.83	YES			18
9/8	1.41	2	281	0.72	0.84	0.84	0.48	0.88	0	1.15	2.16	1.46	YES	YES	1	55
9/9	0.34	0	42	0.16	0.16	0.16	0.16	0.12	0	0.6	1.05	0.67	YES			1
9/10	0.55	0	55	0.24	0.24	0.24	0.2	0.24	0	0.44	0.79	0.44				11
9/11	0.49	0	187	0.32	0.32	0.32	0.2	0.32	0	0.66	1.29	0.81	YES			7
9/12	0.01	0	5	0.12	0.12	0.12	0.12	0.12	0	0.01	0.01	0				1
9/13	0	0	0	0.12	0.16	0.16	0.08	0.28	0	0	0	0.03				1
9/14	0	0	0	0.12	0.12	0.12	0.12	0.2	0	0	0	0.01				1
9/15	0	0	0	0.16	0.2	0.2	0.12	0.36	0	0.02	0.03	0.03				1
9/16	0.28	0	29	0.12	0.16	0.16	0.12	0.16	0	0.2	0.3	0.2				2
9/17	0.06	0	3	0.16	0.2	0.2	0.16	0.2	0	0.03	0.05	0.03				2
9/18	0.25	0	32	0.16	0.16	0.16	0.12	0.24	0	0.15	0.23	0.23				3
9/19	0	0	0	0.28	0.28	0.28	0.12	0.28	0	0.05	0.19	0.11				3
9/20	0.04	0	1	0.12	0.16	0.16	0.08	0.24	0	0.05	0.07	0.07				1
9/21	0.2	0	118	0.16	0.16	0.16	0.12	0.28	0	0.11	0.64	0.29				3
9/22	0	0	0	0.12	0.2	0.2	0.12	0.36	0	0	0	0				1
9/23	0	0	0	0.16	0.16	0.16	0.12	0.24	0	0	0	0				1
9/24	0	0	0	0.16	0.2	0.2	0.12	0.24	0	0	0	0				1
9/25	0	0	0	0.16	0.2	0.2	0.12	0.24	0	0	0	0				1
9/26	0	0	0	0.12	0.12	0.12	0	0.12	0	0	0	0				2
9/27	0.4	0	126	0.16	0.24	0.32	0.2	0.4	0	0.23	0.45	0.56				4
9/28	0.02	0	9	0.08	0.08	0.08	0.08	0.12	0	0	0.01	0.03				2
9/29	0.03	0	1	0.08	0.08	0.08	0	0.16	0	0.01	0.04	0				1
9/30	0.18	0	165	0.12	0.16	0.16	0.12	0.2	0	0.02	0.29	0.03				1

## APPENDIX B – ZONE SPECIFIC FORECASTS AND OBSERVATIONS

The tables below show daily summaries of observations and forecasts for each of the five forecast zones (i.e. analogous to Appendix A, but for each forecast zone separately). Column names are described below:

Column	Units	Description			
A	N/A	Date		K	Inches NOAA Stage IV max 1-hour precipitation.
B	Inches	Max 24-hour from CoCoRaHS gages.		L	Inches NOAA Stage IV max 2-hour precipitation.
C	#	Number of CoCoRaHS gages exceeding 1 inch.		M	Inches NOAA Stage IV max 24-hour precipitation. Note that this can be lower than column (L) because more gages are used during the gage adjustment of radar estimates.
D	#	Number of CoCoRaHS gages with measurable precipitation.		N	Yes/No First guess at whether or not a Flood Day (QPE exceeding 1 inch in 1 hour) is observed.
E	Inches	ALERT max 30 minute precipitation.		O	Yes/No Reassessment of (N) after manual quality control.
F	Inches	ALERT max 1-hour precipitation.		P	Threat, % Tool threat level (color), and probability of exceeding 1 inch in 1 hour.
G	Inches	ALERT max 2-hour precipitation.			
H	Inches	ALERT second highest 1 hour precipitation.			
I	Inches	ALERT max 24-hour precipitation.			
J	#	Number of ALERT gages exceeding 1 inch in 1 hour.			

**APPENDIX B –ZONE A SPECIFIC FORECASTS AND OBSERVATIONS**

**a) Forecast Zone A: North Foothills**

A	CoCoRaHS			ALERT						NOAA Stage IV			Flood Day Classification		Threat
	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P
5/1	0.21	0	17	0.25	0.31	0.4	0.28	0.56	0	0.16	0.27	0.62			0
5/2	0	0	0	0.16	0.16	0.16	0.16	0.2	0	0.04	0.07	0.08			1
5/3	0	0	0	0.04	0.04	0.04	0	0.04	0	0.05	0.05	0.05			0
5/4	0	0	0	0	0	0	0	0	0	0.03	0.05	0.03			1
5/5	0	0	0	0	0	0	0	0	0	0.03	0.04	0.05			1
5/6	0.28	0	24	0.2	0.24	0.24	0.16	0.28	0	0.45	0.79	0.54			3
5/7	0.24	0	25	0.16	0.16	0.16	0.12	0.2	0	0.16	0.26	0.30			11
5/8	1.4	7	25	0.2	0.24	0.32	0.16	0.76	0	0.18	0.45	1.35			4
5/9	0.38	0	26	0.2	0.32	0.4	0.28	0.6	0	0.14	0.28	0.80			1
5/10	0.05	0	10	0.35	0.35	0.47	0.32	0.92	0	0.11	0.22	0.50			1
5/11	0.04	0	6	0.16	0.28	0.36	0.2	0.55	0	0.07	0.14	0.20			1
5/12	0	0	0	0.04	0.04	0.04	0.04	0.04	0	0.00	0.00	0.02			0
5/13	0	0	0	0	0	0	0	0	0	0.07	0.07	0.08			2
5/14	0	0	0	0	0	0	0	0	0	0.03	0.05	0.04			4
5/15	0	0	0	0	0	0	0	0	0	0.03	0.05	0.07			2
5/16	0.09	0	6	0	0	0	0	0	0	0.06	0.13	0.08			2
5/17	0.31	0	16	0.12	0.16	0.2	0.12	0.2	0	0.19	0.37	0.44			2
5/18	0.02	0	5	0.04	0.04	0.04	0	0.04	0	0.04	0.08	0.10			1
5/19	0.46	0	24	0.12	0.12	0.16	0.12	0.36	0	0.12	0.23	0.51			2
5/20	0.81	0	23	0.08	0.12	0.16	0.12	0.28	0	0.17	0.41	0.91			2
5/21	0.2	0	23	0.28	0.4	0.52	0.32	0.68	0	0.72	1.42	0.48	YES		1
5/22	0.41	0	21	0.2	0.2	0.24	0.16	0.8	0	0.10	0.18	0.57			1
5/23	0.17	0	18	0.2	0.2	0.24	0.12	0.56	0	0.13	0.28	0.56			1
5/24	0	0	0	0.24	0.36	0.68	0.32	1.16	0	0.05	0.11	0.04			0
5/25	0.05	0	4	0.01	0.01	0.01	0	0.03	0	0.02	0.04	0.03			1
5/26	0.21	0	8	0.24	0.28	0.28	0.28	0.28	0	0.31	0.57	0.31			4
5/27	0.73	0	24	0.28	0.36	0.4	0.32	0.52	0	0.32	0.55	0.85			6
5/28	0.3	0	22	0.2	0.28	0.28	0.24	0.44	0	0.13	0.22	0.33			7
5/29	0.1	0	8	0.08	0.08	0.12	0.08	0.28	0	0.11	0.20	0.48			2
5/30	0.04	0	6	0.04	0.04	0.04	0.04	0.04	0	0.04	0.10	0.10			3
5/31	0.13	0	7	0.12	0.12	0.12	0.08	0.04	0	0.18	0.34	0.18			2
6/1	0.13	0	14	0.08	0.08	0.08	0.08	0.08	0	0.23	0.42	0.29			6
6/2	0.09	0	15	0.24	0.24	0.24	0.16	0.24	0	0.22	0.41	0.29			5
6/3	0.03	0	6	0.2	0.2	0.2	0.08	0.2	0	0.16	0.29	0.16			8
6/4	0.14	0	11	0.2	0.2	0.2	0.16	0.2	0	0.21	0.40	0.28			7
6/5	0.83	0	24	0.24	0.28	0.28	0.24	0.4	0	0.39	0.66	0.95			48
6/6	0.42	0	25	0.78	0.79	0.79	0.24	0.8	0	0.28	0.51	0.41			6
6/7	0.27	0	14	0.28	0.28	0.32	0.2	0.4	0	0.35	0.62	0.40			5



**APPENDIX B –ZONE A SPECIFIC FORECASTS AND OBSERVATIONS**

A	CoCoRaHS			ALERT						NOAA Stage IV			Flood Day Classification		Threat
	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P
6/8	0.11	0	26	0.2	0.2	0.2	0.2	0.24	0	0.32	0.60	0.61			2
6/9	0.02	0	2	0.04	0.04	0.04	0.04	0.04	0	0.00	0.00	0.00			0
6/10	0.04	0	1	0	0	0	0	0	0	0.00	0.00	0.00			0
6/11	0.01	0	3	0	0	0	0	0	0	0.02	0.03	0.02			0
6/12	0	0	0	0	0	0	0	0	0	0.00	0.01	0.00			1
6/13	0.03	0	7	0.04	0.04	0.04	0.02	0.04	0	0.17	0.35	0.32			1
6/14	0.03	0	12	0.08	0.08	0.08	0.08	0.08	0	0.23	0.43	0.23			2
6/15	0.26	0	21	0.24	0.24	0.24	0.16	0.24	0	0.22	0.38	0.29			14
6/16	0.38	0	23	0.36	0.36	0.36	0.32	0.48	0	0.61	1.08	0.67	YES		7
6/17	1.31	4	30	1.32	1.44	1.44	1.4	1.44	5	0.95	1.79	1.32	YES	YES	32
6/18	0.23	0	23	0.16	0.16	0.16	0.16	0.16	0	0.39	0.52	0.54			20
6/19	0.12	0	18	0.08	0.08	0.12	0.08	0.12	0	0.15	0.26	0.27			1
6/20	0.11	0	16	0.04	0.04	0.04	0.04	0.04	0	0.09	0.18	0.20			2
6/21	1.1	1	23	0.32	0.32	0.44	0.32	1.08	0	0.26	0.50	1.04			2
6/22	0.55	0	24	0.24	0.32	0.36	0.24	0.6	0	0.16	0.31	0.56			6
6/23	0.04	0	12	0.16	0.16	0.16	0.12	0.2	0	0.06	0.16	0.47			1
6/24	0.03	0	4	0	0	0	0	0	0	0.05	0.14	0.72			1
6/25	0.03	0	2	0.04	0.04	0.08	0	0.08	0	0.17	0.33	0.21			0
6/26	0	0	0	0.01	0.01	0.01	0	0.01	0	0.03	0.04	0.03			0
6/27	0	0	0	0	0	0	0	0	0	0.00	0.00	0.00			0
6/28	0.16	0	8	0.12	0.12	0.16	0.12	0.16	0	0.36	0.65	0.56			1
6/29	0.01	0	1	0	0	0	0	0	0	0.10	0.19	0.21			3
6/30	1.16	2	28	0.68	0.72	0.72	0.44	0.8	0	1.18	2.31	1.69	YES	YES	11
7/1	1.49	3	29	1.24	1.92	2.16	1.32	2.16	3	0.82	1.41	1.91	YES	YES	19
7/2	0.23	0	24	0.32	0.32	0.32	0.24	0.36	0	0.43	0.86	0.61			6
7/3	0.13	0	3	0.2	0.2	0.2	0	0.2	0	0.26	0.43	0.29			1
7/4	0.55	0	13	0.48	0.48	0.56	0.44	0.56	0	0.30	0.40	0.35			1
7/5	0.15	0	6	0.12	0.12	0.12	0.08	0.12	0	0.30	0.51	0.38			2
7/6	0.18	0	6	0.04	0.04	0.04	0.04	0.08	0	0.32	0.59	0.36			5
7/7	0.9	0	20	0.6	0.64	0.64	0.44	0.68	0	0.39	0.71	0.50			5
7/8	0.09	0	7	0.08	0.12	0.12	0.04	0.2	0	0.11	0.19	0.12			2
7/9	0	0	0	0	0	0	0	0	0	0.00	0.00	0.00			0
7/10	0	0	0	0	0	0	0	0	0	0.00	0.00	0.00			1
7/11	0.16	0	17	0.24	0.24	0.24	0.12	0.12	0	0.21	0.36	0.22			1
7/12	0.33	0	8	0.6	0.6	0.6	0.24	0.6	0	0.33	0.58	0.37			4
7/13	0.14	0	9	0.04	0.04	0.04	0.04	0.04	0	0.23	0.60	0.22			6
7/14	0.25	0	17	0.56	0.6	0.68	0.32	0.68	0	0.18	0.34	0.34			4
7/15	1.05	2	30	0.52	0.52	0.56	0.44	0.64	0	0.70	1.34	1.24	YES	YES	7
7/16	0.29	0	18	0.12	0.12	0.12	0.08	0.12	0	0.19	0.38	0.22			1
7/17	0	0	0	0	0	0	0	0	0	0.00	0.00	0.00			0

**APPENDIX B –ZONE A SPECIFIC FORECASTS AND OBSERVATIONS**

A	CoCoRaHS			ALERT						NOAA Stage IV			Flood Day Classification		Threat
	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P
7/18	0	0	0	0.08	0.08	0.08	0.08	0.08	0	0.00	0.00	0.00			0
7/19	0.52	0	1	0.08	0.08	0.08	0.08	0.08	0	0.00	0.00	0.00			0
7/20	1.16	1	31	0.96	1.12	1.36	1.08	1.64	3	1.67	2.96	3.38	YES	YES	39
7/21	0.61	0	30	0.88	1.04	1.04	0.92	1.04	1	0.43	0.85	0.70	YES	YES	26
7/22	0.71	0	25	0.36	0.36	0.36	0.32	0.44	0	0.41	0.72	0.64			9
7/23	0.22	0	15	0.08	0.08	0.08	0.04	0.08	0	0.50	0.97	0.62			8
7/24	0.44	0	17	0.24	0.24	0.24	0.2	0.24	0	0.66	1.20	0.84	YES		6
7/25	0.84	0	29	0.75	0.77	0.77	0.64	0.77	0	0.72	1.10	0.77	YES		21
7/26	0.1	0	9	0	0	0	0	0	0	0.11	0.20	0.19			1
7/27	0.41	0	24	0.24	0.24	0.24	0.2	0.24	0	0.36	0.69	0.45			8
7/28	0	0	0	0	0	0	0	0	0	0.00	0.00	0.00			1
7/29	0.03	0	1	0	0	0	0	0	0	0.02	0.04	0.02			0
7/30	0.06	0	7	0.2	0.24	0.24	0.12	0.24	0	0.20	0.36	0.38			1
7/31	0.16	0	14	0.12	0.12	0.12	0.08	0.12	0	0.14	0.25	0.19			3
8/1	0.67	0	29	0.36	0.48	0.48	0.32	0.76	0	0.66	1.10	0.85	YES		15
8/2	0.28	0	18	0.2	0.24	0.32	0.2	0.32	0	0.29	0.56	0.30			3
8/3	0.1	0	1	0	0	0	0	0	0	0.01	0.02	0.03			3
8/4	0.29	0	25	0.2	0.2	0.2	0.11	0.24	0	0.29	0.54	0.58			9
8/5	0.69	0	19	0.44	0.48	0.52	0.28	0.64	0	0.31	0.61	0.77			2
8/6	0.02	0	3	0.04	0.04	0.04	0	0.04	0	0.08	0.09	0.08			0
8/7	0.35	0	19	0.24	0.24	0.24	0.2	0.28	0	0.24	0.41	0.35			4
8/8	0.69	0	29	0.36	0.4	0.56	0.32	0.64	0	0.41	0.81	0.86			11
8/9	0.04	0	6	0.12	0.16	0.2	0.12	0.16	0	0.15	0.22	0.29			1
8/10	0.15	0	18	0.08	0.12	0.12	0.12	0.16	0	0.25	0.45	0.65			4
8/11	0.39	0	23	0.24	0.32	0.36	0.24	0.4	0	0.41	0.77	0.55			5
8/12	0	0	0	0.12	0.12	0.12	0.12	0.12	0	0.00	0.01	0.00			0
8/13	0.02	0	2	0.12	0.12	0.12	0.08	0.12	0	0.05	0.07	0.12			1
8/14	0	0	0	0	0	0	0	0	0	0.00	0.00	0.00			0
8/15	0	0	0	0	0	0	0	0	0	0.01	0.02	0.02			0
8/16	0.02	0	2	0	0	0	0	0	0	0.17	0.33	0.22			0
8/17	0.19	0	9	0.04	0.04	0.04	0.04	0.04	0	0.26	0.52	0.40			0
8/18	0	0	0	0	0	0	0	0	0	0.00	0.00	0.00			0
8/19	0	0	0	0	0	0	0	0	0	0.00	0.00	0.00			0
8/20	0.01	0	2	0	0	0	0	0	0	0.07	0.08	0.07			2
8/21	0.57	0	27	0.6	0.76	0.76	0.36	0.8	0	0.77	1.45	0.96	YES		29
8/22	0.05	0	5	0.18	0.18	0.18	0.12	0.18	0	0.24	0.47	0.24			4
8/23	0.01	0	1	0	0	0	0	0	0	0.04	0.08	0.05			2
8/24	0	0	0	0	0	0	0	0	0	0.00	0.00	0.00			0
8/25	0	0	0	0	0	0	0	0	0	0.00	0.00	0.00			0
8/26	0	0	0	0	0	0	0	0	0	0.00	0.00	0.00			0

**APPENDIX B –ZONE A SPECIFIC FORECASTS AND OBSERVATIONS**

A	CoCoRaHS			ALERT						NOAA Stage IV			Flood Day Classification		Threat
	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P
8/27	0	0	0	0	0	0	0	0	0	0.00	0.00	0.00			0
8/28	0	0	0	0	0	0	0	0	0	0.00	0.00	0.00			0
8/29	0	0	0	0	0	0	0	0	0	0.01	0.02	0.02			1
8/30	0.02	0	4	0.01	0.01	0.01	0	0.01	0	0.08	0.15	0.15			2
8/31	0.03	0	1	0	0	0	0	0	0	0.08	0.15	0.08			0
9/1	0	0	0	0	0	0	0	0	0	0.01	0.01	0.01			0
9/2	0	0	0	0	0	0	0	0	0	0.00	0.00	0.00			0
9/3	0.05	0	2	0.01	0.01	0.01	0	0.01	0	0.27	0.54	0.41			1
9/4	0.31	0	2	0.04	0.04	0.04	0	0.04	0	0.36	0.65	0.39			2
9/5	0.29	0	11	0.52	0.52	0.53	0.24	0.53	0	0.38	0.58	0.44			4
9/6	0.7	0	23	0.88	0.92	0.92	0.88	1	0	0.75	1.41	1.41	YES	YES	31
9/7	0.1	0	3	0	0	0	0	0	0	0.02	0.04	0.13			1
9/8	0.57	0	23	0.46	0.48	0.48	0.46	0.6	0	0.43	0.79	0.98			24
9/9	0.02	0	4	0.04	0.04	0.04	0.04	0.04	0	0.03	0.10	0.04			0
9/10	0.08	0	13	0.08	0.08	0.08	0.08	0.08	0	0.18	0.33	0.24			2
9/11	0.29	0	17	0.16	0.32	0.32	0.16	0.32	0	0.23	0.40	0.44			1
9/12	0.01	0	1	0	0	0	0	0	0	0.01	0.01	0.00			0
9/13	0	0	0	0	0	0	0	0	0	0.00	0.00	0.03			0
9/14	0	0	0	0	0	0	0	0	0	0.00	0.00	0.01			0
9/15	0	0	0	0	0	0	0	0	0	0.00	0.00	0.02			1
9/16	0	0	0	0	0	0	0	0	0	0.03	0.05	0.05			1
9/17	0	0	0	0	0	0	0	0	0	0.01	0.01	0.01			1
9/18	0.03	0	7	0	0	0	0	0	0	0.07	0.13	0.12			1
9/19	0	0	0	0	0	0	0	0	0	0.05	0.09	0.11			1
9/20	0	0	0	0.04	0.04	0.04	0	0.08	0	0.05	0.07	0.07			1
9/21	0.01	0	1	0	0	0	0	0	0	0.05	0.09	0.06			0
9/22	0	0	0	0	0	0	0	0	0	0.00	0.00	0.00			0
9/23	0	0	0	0	0	0	0	0	0	0.00	0.00	0.00			0
9/24	0	0	0	0.12	0.12	0.12	0	0.12	0	0.00	0.00	0.00			0
9/25	0	0	0	0	0	0	0	0	0	0.00	0.00	0.00			0
9/26	0	0	0	0	0	0	0	0	0	0.00	0.00	0.00			1
9/27	0.4	0	21	0.16	0.24	0.32	0.2	0.4	0	0.14	0.28	0.41			1
9/28	0.02	0	2	0.04	0.04	0.04	0.04	0.04	0	0.00	0.01	0.03			1
9/29	0	0	0	0	0	0	0	0	0	0.00	0.00	0.00			0
9/30	0.06	0	12	0.04	0.04	0.08	0.04	0.08	0	0.02	0.06	0.03			0

**APPENDIX B –ZONE B SPECIFIC FORECASTS AND OBSERVATIONS**

**b) Forecast Zone B: South Foothills**

A	CoCoRaHS			ALERT						NOAA Stage IV			Flood Day Classification		Threat
	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P
5/1	0.38	0	17	0.12	0.16	0.16	0.12	0.16	0	0.06	0.12	0.23			0
5/2	0.04	0	1	0.04	0.04	0.04	0.04	0.04	0	0.01	0.03	0.02			1
5/3	0	0	0	0	0	0	0	0	0	0.02	0.03	0.02			0
5/4	0	0	0	0	0	0	0	0	0	0.02	0.03	0.02			1
5/5	0	0	0	0	0	0	0	0	0	0	0.01	0.02			1
5/6	0.25	0	21	0.16	0.16	0.16	0.12	0.24	0	0.34	0.66	0.35			2
5/7	0.64	0	23	0.28	0.28	0.28	0.24	0.4	0	0.39	0.61	0.65			9
5/8	1.2	2	20	0.2	0.28	0.44	0.24	0.8	0	0.17	0.42	0.91			3
5/9	0.3	0	21	0.12	0.12	0.2	0.12	0.36	0	0.23	0.43	0.49			1
5/10	0.27	0	17	0.2	0.28	0.4	0.24	0.76	0	0.15	0.29	0.38			1
5/11	0.05	0	11	0.08	0.08	0.12	0.08	0.2	0	0.06	0.11	0.19			0
5/12	0	0	0	0	0	0	0	0	0	0	0	0.02			0
5/13	0.01	0	1	0	0	0	0	0	0	0.04	0.08	0.05			2
5/14	0.05	0	8	0	0	0	0	0	0	0.09	0.17	0.1			3
5/15	0.01	0	2	0	0	0	0	0	0	0.04	0.07	0.07			1
5/16	0	0	0	0	0	0	0	0	0	0.02	0.05	0.05			2
5/17	0.16	0	2	0.04	0.08	0.08	0.04	0.08	0	0.14	0.21	0.19			2
5/18	0.01	0	1	0	0	0	0	0	0	0.06	0.11	0.12			1
5/19	0.19	0	20	0.04	0.08	0.08	0.04	0.08	0	0.12	0.22	0.47			1
5/20	1.6	2	24	0.12	0.16	0.2	0.12	0.32	0	0.2	0.38	1.1			4
5/21	0.11	0	17	0.28	0.44	0.56	0.36	0.64	0	0.25	0.48	0.69			1
5/22	1.01	1	23	0.08	0.08	0.12	0.08	0.56	0	0.15	0.28	1.19			1
5/23	0.32	0	20	0.08	0.12	0.2	0.08	0.4	0	0.15	0.29	0.61			1
5/24	0	0	0	0.16	0.2	0.4	0.2	0.84	0	0.04	0.13	0			0
5/25	0	0	0	0	0	0	0	0	0	0	0	0			1
5/26	0.06	0	15	0	0	0	0	0	0	0.14	0.26	0.14			1
5/27	0.9	0	19	0.28	0.28	0.28	0.12	0.44	0	0.19	0.33	0.3			4
5/28	0.38	0	26	0.16	0.24	0.32	0.12	0.68	0	0.07	0.14	0.2			4
5/29	0.26	0	12	0.12	0.12	0.12	0.08	0.12	0	0.13	0.23	0.79			2
5/30	0.07	0	13	0.08	0.16	0.24	0.12	0.24	0	0.18	0.35	0.3			7
5/31	0.05	0	12	0.04	0.04	0.04	0.04	0.04	0	0.04	0.08	0.05			2
6/1	0.54	0	20	0.12	0.16	0.16	0.12	0.16	0	0.42	0.83	0.61			11
6/2	0.14	0	9	0	0	0	0	0	0	0.35	0.54	0.61			8
6/3	0.54	0	16	0.52	0.52	0.52	0.24	0.52	0	0.51	0.87	0.53			4
6/4	0.14	0	20	0.08	0.08	0.08	0.08	0.08	0	0.23	0.36	0.26			6
6/5	0.95	0	25	0.8	1	1	0.44	1.08	0	0.6	0.99	1.09	YES	YES	41
6/6	0.07	0	10	0.04	0.04	0.04	0.04	0.04	0	0.21	0.41	0.22			8
6/7	0.27	0	21	0.24	0.24	0.24	0.12	0.24	0	0.4	0.75	0.47			5

**APPENDIX B –ZONE B SPECIFIC FORECASTS AND OBSERVATIONS**

A	CoCoRaHS			ALERT						NOAA Stage IV			Flood Day Classification		Threat
	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P
6/8	0.11	0	22	0.04	0.04	0.08	0.04	0.08	0	0.14	0.17	0.15			3
6/9	0.07	0	11	0.04	0.04	0.04	0.04	0.04	0	0	0	0			0
6/10	0	0	0	0	0	0	0	0	0	0	0	0			0
6/11	0.01	0	1	0	0	0	0	0	0	0	0	0			0
6/12	0	0	0	0.08	0.12	0.12	0	0.12	0	0.14	0.23	0.14			1
6/13	0.15	0	5	0	0	0	0	0	0	0.19	0.37	0.3			1
6/14	0	0	0	0.04	0.04	0.04	0	0.04	0	0.04	0.06	0.05			1
6/15	0.49	0	20	0.56	0.64	0.68	0.28	0.68	0	0.22	0.41	1.1			10
6/16	0.66	0	19	0.48	0.48	0.48	0.28	0.52	0	0.69	0.92	0.85			8
6/17	0.99	0	24	0.56	0.56	0.56	0.48	0.56	0	1.34	2.08	2.19	YES	YES	20
6/18	0.65	0	23	0.28	0.32	0.36	0.32	0.4	0	0.4	0.77	0.8			10
6/19	0.02	0	1	0	0	0	0	0	0	0.01	0.02	0.01			1
6/20	0.02	0	1	0.16	0.16	0.16	0.08	0.16	0	0.06	0.12	0.16			1
6/21	0.86	0	22	0.24	0.28	0.32	0.24	0.72	0	0.48	0.91	0.87			1
6/22	0.42	0	26	0.2	0.36	0.48	0.24	0.64	0	0.29	0.55	0.98			5
6/23	0.01	0	2	0.04	0.04	0.04	0	0.04	0	0.03	0.09	0.13			1
6/24	0	0	0	0	0	0	0	0	0	0.01	0.06	0.1			0
6/25	0.09	0	6	0.04	0.04	0.04	0	0.04	0	0.1	0.2	0.14			1
6/26	0	0	0	0	0	0	0	0	0	0.01	0.03	0.02			1
6/27	0	0	0	0	0	0	0	0	0	0.02	0.04	0.02			1
6/28	0.01	0	1	0	0	0	0	0	0	0.1	0.18	0.16			2
6/29	0.07	0	15	0.12	0.12	0.12	0.04	0.12	0	0.34	0.59	0.47			3
6/30	0.62	0	25	0.4	0.52	0.64	0.4	0.64	0	0.57	0.93	0.93			13
7/1	1.31	2	23	0.68	0.68	0.68	0.64	0.72	0	0.75	1.31	1.13	YES	YES	21
7/2	1.22	1	14	0.04	0.04	0.04	0.04	0.2	0	0.44	0.79	0.7			4
7/3	0.02	0	2	0.04	0.04	0.04	0	0.04	0	0.26	0.52	0.68			1
7/4	0.14	0	7	0.12	0.12	0.12	0	0.12	0	0.36	0.56	0.51			1
7/5	0.68	0	21	0.56	0.56	0.56	0.44	0.64	0	0.79	1.51	1.17	YES	YES	2
7/6	0.3	0	15	0.28	0.32	0.36	0.16	0.36	0	0.38	0.7	0.51			23
7/7	0.1	0	7	0	0	0	0	0	0	0.07	0.13	0.1			7
7/8	0.33	0	26	0.16	0.16	0.16	0.12	0.24	0	0.2	0.39	0.22			3
7/9	0	0	0	0	0	0	0	0	0	0	0	0			0
7/10	0.01	0	1	0	0	0	0	0	0	0.12	0.21	0.12			2
7/11	0	0	0	0	0	0	0	0	0	0.19	0.37	0.2			0
7/12	0.04	0	1	0.04	0.04	0.04	0	0.08	0	0.07	0.11	0.11			2
7/13	0.91	0	22	0.56	0.6	0.64	0.52	0.64	0	0.45	0.88	0.78			5
7/14	0.35	0	21	0.12	0.12	0.12	0.04	0.12	0	0.2	0.48	0.41			8
7/15	0.97	0	21	0.64	0.68	0.68	0.36	0.72	0	0.62	1.08	0.77	YES		5
7/16	0.09	0	4	0.04	0.04	0.04	0	0.04	0	0.11	0.19	0.17			2
7/17	0.01	0	1	0.04	0.04	0.04	0	0.04	0	0.04	0.06	0.04			0

**APPENDIX B –ZONE B SPECIFIC FORECASTS AND OBSERVATIONS**

A	CoCoRaHS			ALERT						NOAA Stage IV			Flood Day Classification		Threat
	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P
7/18	0	0	0	0	0	0	0	0	0	0	0	0.02			0
7/19	0	0	0	0	0	0	0	0	0	0.02	0.03	0.02			0
7/20	0.87	0	25	0.56	0.56	0.56	0.44	0.64	0	0.79	1.34	2.26	YES	YES	20
7/21	0.45	0	22	0.44	0.44	0.48	0.4	0.48	0	1.2	2.11	1.76	YES	YES	15
7/22	0.2	0	15	0.48	0.48	0.48	0.28	0.48	0	0.75	1.44	0.79	YES		20
7/23	0.17	0	3	0	0	0	0	0	0	0.34	0.65	0.47			12
7/24	0.32	0	8	0.08	0.08	0.08	0.08	0.08	0	0.25	0.48	0.36			5
7/25	0.82	0	20	0.24	0.24	0.28	0.2	0.28	0	0.32	0.55	0.58			22
7/26	0.06	0	5	0.04	0.04	0.04	0	0.04	0	0.11	0.16	0.16			2
7/27	0.96	0	23	0.2	0.2	0.2	0.2	0.4	0	0.34	0.67	0.52			8
7/28	0.05	0	1	0	0	0	0	0	0	0.12	0.24	0.24			0
7/29	0.17	0	12	0.32	0.36	0.36	0.08	0.36	0	0.34	0.51	0.35			1
7/30	0.07	0	12	0.08	0.08	0.08	0.04	0.08	0	0.13	0.25	0.17			3
7/31	0.35	0	23	0.16	0.16	0.16	0.12	0.2	0	0.57	1.08	0.6	YES		3
8/1	0.6	0	21	0.4	0.48	0.48	0.32	0.72	0	0.23	0.45	0.5			10
8/2	0.71	0	18	0.32	0.48	0.52	0.16	0.68	0	0.46	0.84	0.7			4
8/3	0	0	0	0.04	0.04	0.04	0	0.04	0	0.13	0.24	0.13			7
8/4	0.94	0	20	0.52	0.6	0.6	0.44	0.64	0	0.43	0.77	0.65			12
8/5	0.11	0	17	0.04	0.04	0.04	0.04	0.04	0	0.14	0.26	0.3			2
8/6	0	0	0	0	0	0	0	0	0	0.1	0.16	0.12			0
8/7	0.03	0	6	0.04	0.04	0.04	0	0.04	0	0.11	0.23	0.36			5
8/8	0.98	0	21	0.68	0.68	0.8	0.52	1	0	0.72	1.24	1.45	YES		15
8/9	0.1	0	2	0.04	0.04	0.04	0	0.04	0	0.31	0.45	0.56			2
8/10	0.14	0	16	0.08	0.08	0.08	0.04	0.08	0	0.48	0.81	0.65			9
8/11	0.17	0	17	0.08	0.12	0.12	0.08	0.12	0	0.65	1.17	0.86	YES		6
8/12	0.03	0	3	0.24	0.28	0.28	0	0.28	0	0.35	0.7	0.35			0
8/13	0.04	0	4	0	0	0	0	0	0	0.04	0.07	0.04			1
8/14	0	0	0	0	0	0	0	0	0	0.02	0.03	0.03			0
8/15	0	0	0	0	0	0	0	0	0	0	0	0			0
8/16	0	0	0	0	0	0	0	0	0	0	0.01	0			0
8/17	0.07	0	6	0	0	0	0	0	0	0.07	0.14	0.12			0
8/18	0	0	0	0	0	0	0	0	0	0	0	0			0
8/19	0	0	0	0	0	0	0	0	0	0	0	0			0
8/20	0.26	0	12	0.08	0.08	0.08	0.08	0.08	0	0.13	0.22	0.15			1
8/21	0.54	0	17	0.6	0.64	0.68	0.44	0.68	0	0.48	0.92	0.76			13
8/22	0.27	0	15	0.04	0.04	0.04	0.04	0.04	0	0.14	0.24	0.17			3
8/23	0.02	0	2	0	0	0	0	0	0	0.05	0.09	0.05			2
8/24	0	0	0	0	0	0	0	0	0	0	0	0			0
8/25	0	0	0	0	0	0	0	0	0	0	0	0			0
8/26	0	0	0	0	0	0	0	0	0	0	0	0			0

**APPENDIX B –ZONE B SPECIFIC FORECASTS AND OBSERVATIONS**

A	CoCoRaHS			ALERT						NOAA Stage IV			Flood Day Classification		Threat
	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P
8/27	0	0	0	0	0	0	0	0	0	0	0	0			0
8/28	0	0	0	0	0	0	0	0	0	0	0	0			0
8/29	0	0	0	0	0	0	0	0	0	0	0.01	0			1
8/30	0.15	0	12	0.12	0.12	0.12	0.12	0.12	0	0.14	0.24	0.18			2
8/31	0	0	0	0	0	0	0	0	0	0.03	0.05	0.1			0
9/1	0	0	0	0	0	0	0	0	0	0.02	0.04	0.03			0
9/2	0	0	0	0	0	0	0	0	0	0	0	0			0
9/3	0.1	0	6	0.12	0.16	0.16	0.12	0.2	0	0.77	1.39	1.44	YES	YES	3
9/4	0.31	0	20	0.2	0.24	0.24	0.04	0.24	0	0.56	0.99	0.67			3
9/5	0.04	0	4	0.04	0.04	0.04	0.04	0.08	0	0.47	0.79	0.61			3
9/6	1.52	1	24	1	1.04	1.08	1	1.16	1	0.93	1.84	1.15	YES	YES	53
9/7	1.46	1	8	0.08	0.08	0.08	0.04	0.12	0	0.51	0.93	0.83			2
9/8	0.83	0	27	0.32	0.4	0.56	0.36	0.6	0	0.61	1.08	1.24	YES		19
9/9	0.01	0	5	0.04	0.04	0.04	0.04	0.04	0	0.01	0.04	0			0
9/10	0.01	0	1	0	0	0	0	0	0	0.01	0.03	0.01			1
9/11	0.04	0	9	0.32	0.32	0.32	0.2	0.32	0	0.07	0.11	0.09			0
9/12	0	0	0	0	0	0	0	0	0	0	0	0			0
9/13	0	0	0	0	0	0	0	0	0	0	0	0			0
9/14	0	0	0	0	0	0	0	0	0	0	0	0.01			0
9/15	0	0	0	0	0	0	0	0	0	0.02	0.03	0.03			1
9/16	0.04	0	3	0	0	0	0	0	0	0.08	0.15	0.09			1
9/17	0.06	0	1	0	0	0	0	0	0	0	0	0			0
9/18	0.07	0	5	0.04	0.04	0.04	0	0.04	0	0.1	0.17	0.15			1
9/19	0	0	0	0	0	0	0	0	0	0.04	0.07	0.09			1
9/20	0	0	0	0	0	0	0	0	0	0	0	0			0
9/21	0.11	0	20	0.04	0.04	0.04	0.04	0.04	0	0.07	0.14	0.14			0
9/22	0	0	0	0.04	0.04	0.04	0	0.04	0	0	0	0			0
9/23	0	0	0	0	0	0	0	0	0	0	0	0			0
9/24	0	0	0	0	0	0	0	0	0	0	0	0			0
9/25	0	0	0	0	0	0	0	0	0	0	0	0			0
9/26	0	0	0	0	0	0	0	0	0	0	0	0			0
9/27	0.01	0	3	0	0	0	0	0	0	0.07	0.13	0.1			1
9/28	0.02	0	2	0	0	0	0	0	0	0	0	0.01			0
9/29	0	0	0	0	0	0	0	0	0	0.01	0.04	0			0
9/30	0.03	0	6	0	0	0	0	0	0	0.01	0.03	0.02			0

**APPENDIX B –ZONE C SPECIFIC FORECASTS AND OBSERVATIONS**

**c) Forecast Zone C: Palmer Divide**

A	CoCoRaHS			ALERT						NOAA Stage IV			Flood Day Classification		Threat
	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P
5/1	0.2	0	38	0.08	0.12	0.12	0.08	0.16	0	0.25	0.49	0.61			0
5/2	0.02	0	1	0.04	0.08	0.08	0.04	0.08	0	0.1	0.17	0.17			1
5/3	0	0	0	0	0	0	0	0	0	0.03	0.03	0.03			0
5/4	0	0	0	0	0	0	0	0	0	0	0	0			1
5/5	0	0	0	0	0	0	0	0	0	0	0	0			1
5/6	0.27	0	31	0.16	0.16	0.16	0.12	0.16	0	0.44	0.8	0.78			3
5/7	0.53	0	35	0.28	0.32	0.32	0.32	0.44	0	0.3	0.68	0.6			7
5/8	0.89	0	38	0.12	0.16	0.24	0.12	0.6	0	0.2	0.4	0.94			1
5/9	0.16	0	30	0.2	0.28	0.32	0.24	0.48	0	0.23	0.46	0.69			1
5/10	0.12	0	17	0.32	0.52	0.6	0.32	0.64	0	0.09	0.18	0.28			1
5/11	0.03	0	9	0.08	0.08	0.12	0.04	0.16	0	0.07	0.13	0.13			1
5/12	0	0	0	0.04	0.04	0.04	0.04	0.04	0	0	0	0			0
5/13	0.01	0	2	0	0	0	0	0	0	0.04	0.05	0.04			1
5/14	0.01	0	1	0	0	0	0	0	0	0.04	0.08	0.06			2
5/15	0	0	0	0	0	0	0	0	0	0.03	0.07	0.07			1
5/16	0.03	0	6	0	0	0	0	0	0	0.04	0.07	0.05			1
5/17	0.07	0	8	0.04	0.04	0.04	0	0.04	0	0.21	0.34	0.21			1
5/18	0.09	0	7	0.04	0.04	0.04	0	0.08	0	0.09	0.18	0.13			2
5/19	0.06	0	32	0	0	0	0	0	0	0.07	0.12	0.11			1
5/20	2.1	24	42	0.16	0.2	0.32	0.2	0.64	0	0.21	0.41	1.8			8
5/21	1	0	8	0.28	0.4	0.64	0.4	0.92	0	0.25	0.51	0.76			1
5/22	0.31	0	21	0.2	0.24	0.32	0.2	0.68	0	0.09	0.18	0.26			1
5/23	0.02	0	3	0.12	0.12	0.12	0.08	0.16	0	0.07	0.14	0.12			0
5/24	0	0	0	0	0	0	0	0	0	0	0	0			0
5/25	0.3	0	1	0	0	0	0	0	0	0	0	0			0
5/26	0.64	0	28	0.4	0.44	0.44	0.4	0.44	0	1.17	2.11	1.55	YES	YES	2
5/27	0.26	0	31	0.16	0.16	0.2	0.12	0.16	0	0.21	0.39	0.22			3
5/28	0.36	0	36	0.24	0.36	0.44	0.2	0.56	0	0.37	0.65	0.46			6
5/29	0.06	0	3	0.04	0.04	0.04	0.04	0.08	0	0.03	0.06	0.39			1
5/30	0.03	0	6	0.24	0.28	0.28	0.16	0.28	0	0.14	0.32	0.26			11
5/31	0.16	0	26	0.16	0.16	0.16	0.12	0.16	0	0.2	0.39	0.25			1
6/1	0.45	0	36	0.4	0.44	0.44	0.4	0.44	0	0.58	1.1	0.68	YES		5
6/2	0.01	0	3	0.28	0.28	0.28	0.08	0.28	0	0.26	0.5	0.26			7
6/3	0.54	0	18	0.36	0.36	0.4	0.16	0.4	0	0.82	1.32	1.1	YES		3
6/4	0.19	0	23	0.2	0.2	0.2	0.16	0.2	0	0.33	0.58	0.51			4
6/5	0.63	0	11	0.68	0.88	0.92	0.48	0.92	0	0.64	1.25	0.82	YES		41
6/6	0.02	0	1	0	0	0	0	0	0	0.02	0.06	0.03			3
6/7	0.48	0	18	0.08	0.16	0.16	0.04	0.16	0	0.42	0.78	0.8			5



**APPENDIX B –ZONE C SPECIFIC FORECASTS AND OBSERVATIONS**

A	CoCoRaHS			ALERT						NOAA Stage IV			Flood Day Classification		Threat
	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P
6/8	0.12	0	33	0.08	0.08	0.08	0.04	0.12	0	0.61	1.22	0.62	YES		3
6/9	0	0	0	0	0	0	0	0	0	0	0	0			0
6/10	0	0	0	0.04	0.04	0.04	0.04	0.04	0	0.04	0.08	0.06			0
6/11	0	0	0	0	0	0	0	0	0	0	0	0			0
6/12	0.04	0	5	0.08	0.08	0.08	0.04	0.08	0	0.08	0.19	0.08			1
6/13	0.36	0	28	0.24	0.24	0.24	0.24	0.24	0	0.38	0.62	0.43			1
6/14	0.13	0	15	0.24	0.24	0.24	0.04	0.24	0	0.18	0.32	0.22			1
6/15	0.55	0	23	0.36	0.4	0.4	0.36	0.44	0	0.37	0.71	1.24			15
6/16	1.06	1	28	0.72	0.8	0.8	0.64	0.84	0	0.74	1.41	1.06	YES		10
6/17	1.41	1	40	1.28	1.48	1.48	1.24	1.48	2	1.3	2.61	2.52	YES	YES	42
6/18	0.33	0	40	0.84	0.84	0.84	0.48	0.88	0	0.44	0.78	0.59			30
6/19	0.01	0	2	0.47	0.47	0.47	0.04	0.47	0	0	0	0			1
6/20	0.08	0	5	0.43	0.43	0.59	0.04	0.75	0	0.18	0.28	0.2			0
6/21	1.94	3	42	1.32	1.56	1.76	0.76	1.96	1	0.95	1.85	1.42	YES	YES	3
6/22	1.42	2	41	1.28	1.44	1.48	0.96	1.64	1	0.82	1.41	1.14	YES	YES	16
6/23	0.04	0	7	0.04	0.04	0.04	0.04	0.04	0	0.05	0.1	0.08			1
6/24	0.1	0	1	0	0	0	0	0	0	0.15	0.27	0.15			0
6/25	0.15	0	8	0.12	0.12	0.12	0.08	0.12	0	0.35	0.66	0.45			0
6/26	0.01	0	1	0.04	0.04	0.04	0	0.04	0	0.02	0.03	0.02			0
6/27	0.09	0	1	0.04	0.04	0.04	0	0.04	0	0.31	0.52	0.32			1
6/28	0.33	0	31	0.28	0.28	0.28	0.16	0.32	0	0.41	0.71	0.62			1
6/29	0.15	0	10	0.2	0.2	0.2	0.08	0.2	0	0.33	0.59	0.44			1
6/30	1.83	1	38	0.88	1.24	1.28	0.88	1.28	1	1.17	2.21	1.96	YES	YES	10
7/1	0.27	0	19	0.6	0.6	0.64	0.2	0.68	0	0.34	0.66	1.29			25
7/2	0.59	0	16	1	1	1	0.32	1	0	0.59	1.12	0.67	YES		11
7/3	0.14	0	5	0.04	0.04	0.04	0.04	0.04	0	0.22	0.35	0.77			1
7/4	0.64	0	40	0.52	0.68	0.68	0.52	0.68	0	0.88	1.7	1.04	YES		1
7/5	1.03	1	30	1.16	1.4	2	0.68	2.08	1	0.78	1.49	1.57	YES	YES	8
7/6	0.28	0	12	0.28	0.28	0.28	0.24	0.28	0	0.43	0.82	0.52			13
7/7	0.44	0	16	0.32	0.32	0.32	0.24	0.32	0	0.41	0.76	0.65			3
7/8	0.16	0	23	0.71	0.95	0.95	0.16	0.95	0	0.25	0.47	0.32			3
7/9	0.01	0	1	0	0	0	0	0	0	0	0	0			0
7/10	0	0	0	0	0	0	0	0	0	0	0	0			1
7/11	0.03	0	2	0	0	0	0	0	0	0.11	0.19	0.12			0
7/12	0.24	0	10	0.08	0.08	0.08	0.04	0.08	0	0.32	0.57	0.42			2
7/13	0.1	0	7	0.24	0.24	0.28	0.16	0.4	0	0.64	1.19	1	YES		4
7/14	0.05	0	5	0.12	0.12	0.12	0.08	0.12	0	0.05	0.1	0.18			4
7/15	1.03	1	31	2.03	2.03	2.03	1.76	2.07	2	0.97	1.91	1.09	YES	YES	2
7/16	0.18	0	10	0.04	0.04	0.04	0.04	0.04	0	0.23	0.42	0.23			2
7/17	0.1	0	11	0	0	0	0	0	0	0.12	0.23	0.17			0

**APPENDIX B –ZONE C SPECIFIC FORECASTS AND OBSERVATIONS**

A	CoCoRaHS			ALERT						NOAA Stage IV			Flood Day Classification		Threat
	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P
7/18	0	0	0	0	0	0	0	0	0	0	0	0			0
7/19	0	0	0	0	0	0	0	0	0	0	0	0			0
7/20	1.01	1	41	1.64	1.76	1.76	1.72	2.32	5	1.66	3.13	2.58	YES	YES	25
7/21	1.14	3	40	1.16	1.52	1.6	0.56	1.6	1	1.22	2.38	1.73	YES	YES	30
7/22	1.34	3	37	1.32	1.44	1.44	1.32	1.44	3	0.86	1.58	1.32	YES	YES	13
7/23	0.11	0	7	0.2	0.2	0.2	0.12	0.2	0	0.35	0.64	0.35			2
7/24	0.19	0	14	0.52	0.52	0.52	0.16	0.52	0	0.86	1.28	0.9	YES		3
7/25	0.5	0	35	0.88	0.96	0.96	0.76	0.96	0	0.43	0.77	0.75			8
7/26	0.35	0	21	0.32	0.36	0.36	0.28	0.36	0	0.31	0.6	0.5			1
7/27	0.67	0	34	0.76	0.76	0.76	0.68	0.8	0	0.76	1.41	0.85	YES		12
7/28	0.01	0	1	0.04	0.04	0.04	0	0.04	0	0.05	0.08	0.05			0
7/29	1.14	1	21	0.92	1.12	1.32	0.8	1.4	1	1.19	2.26	1.78	YES	YES	2
7/30	0.11	0	5	0.04	0.04	0.04	0.04	0.04	0	0.12	0.19	0.12			1
7/31	0.67	0	22	0.36	0.4	0.4	0.2	0.4	0	0.29	0.79	0.39			2
8/1	1.12	1	38	0.84	0.92	0.92	0.68	1.04	0	0.8	1.54	1.12	YES		16
8/2	0.01	0	3	0.24	0.4	0.4	0.24	0.6	0	0.6	1.13	0.64	YES		1
8/3	0	0	0	0.04	0.04	0.04	0	0.04	0	0.52	1.02	0.67	YES		2
8/4	0.03	0	3	0	0	0	0	0	0	0.17	0.31	0.19			4
8/5	0.25	0	22	0.32	0.32	0.32	0.2	0.32	0	0.18	0.33	0.32			1
8/6	0.02	0	1	0	0	0	0	0	0	0.09	0.19	0.12			0
8/7	0.4	0	22	1.42	1.42	1.42	1.34	1.42	2	0.38	0.66	0.64	YES		3
8/8	3.3	15	45	0.96	1.16	1.32	0.96	1.72	1	1.87	3.71	3.56	YES	YES	32
8/9	0.68	0	15	0.56	0.72	0.96	0.16	0.96	0	1.15	2.29	2.27	YES	YES	7
8/10	0.13	0	15	0.08	0.16	0.16	0.08	0.2	0	0.14	0.26	0.35			6
8/11	1.12	1	41	0.6	0.6	0.6	0.44	0.6	0	0.76	1.49	1.16	YES		15
8/12	0.12	0	9	0.12	0.12	0.12	0.08	0.12	0	0.25	0.49	0.3			1
8/13	0.03	0	9	0	0	0	0	0	0	0.19	0.36	0.19			0
8/14	0	0	0	0	0	0	0	0	0	0.03	0.06	0.03			0
8/15	0.02	0	1	0	0	0	0	0	0	0.03	0.06	0.04			0
8/16	0.14	0	8	0.08	0.12	0.16	0.08	0.24	0	0.39	0.72	0.66			0
8/17	0.1	0	4	0	0	0	0	0	0	0.06	0.12	0.09			0
8/18	0	0	0	0	0	0	0	0	0	0	0	0			0
8/19	0	0	0	0	0	0	0	0	0	0	0	0			0
8/20	0.17	0	30	0.12	0.12	0.12	0.12	0.16	0	0.37	0.72	0.42			2
8/21	0.55	0	30	0.44	0.48	0.48	0.32	0.52	0	0.55	1.04	0.71	YES		20
8/22	0.22	0	23	0.16	0.16	0.16	0.16	0.16	0	0.44	0.77	0.56			4
8/23	0.12	0	10	0.12	0.12	0.12	0.08	0.12	0	0.26	0.5	0.28			1
8/24	0	0	0	0	0	0	0	0	0	0	0	0			0
8/25	0	0	0	0	0	0	0	0	0	0	0	0			0
8/26	0	0	0	0	0	0	0	0	0	0	0	0			0

**APPENDIX B –ZONE C SPECIFIC FORECASTS AND OBSERVATIONS**

A	CoCoRaHS			ALERT						NOAA Stage IV			Flood Day Classification		Threat
	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P
8/27	0.01	0	1	0	0	0	0	0	0	0	0	0			0
8/28	0	0	0	0	0	0	0	0	0	0	0	0			0
8/29	0	0	0	0	0	0	0	0	0	0	0	0			0
8/30	0.12	0	6	0.24	0.28	0.28	0.04	0.32	0	0.19	0.38	0.24			3
8/31	0	0	0	0	0	0	0	0	0	0.05	0.08	0.1			0
9/1	0	0	0	0	0	0	0	0	0	0.01	0.02	0.01			0
9/2	0	0	0	0	0	0	0	0	0	0	0	0			0
9/3	0	0	0	0.12	0.16	0.28	0.16	0.32	0	0.39	0.7	0.78			1
9/4	0.6	0	15	0.64	0.76	0.76	0.36	0.76	0	1.34	2.16	2.1	YES	YES	5
9/5	0.07	0	10	0.08	0.12	0.12	0.04	0.12	0	0.05	0.09	0.14			1
9/6	2.7	8	43	1.68	1.92	1.96	1.64	2.08	4	0.78	1.5	1.42	YES	YES	25
9/7	0.24	0	20	0.2	0.24	0.24	0.12	0.28	0	0.57	1.07	0.64	YES		3
9/8	0.68	0	41	0.48	0.48	0.48	0.48	0.52	0	0.65	1.2	0.78	YES		15
9/9	0.01	0	4	0.08	0.08	0.08	0.04	0.08	0	0	0	0			0
9/10	0	0	0	0	0	0	0	0	0	0	0	0			0
9/11	0.01	0	1	0	0	0	0	0	0	0.04	0.09	0.08			0
9/12	0	0	0	0	0	0	0	0	0	0	0	0			0
9/13	0	0	0	0	0	0	0	0	0	0	0	0			0
9/14	0	0	0	0	0	0	0	0	0	0	0	0			0
9/15	0	0	0	0	0	0	0	0	0	0	0	0			1
9/16	0.28	0	20	0.04	0.04	0.04	0.04	0.04	0	0.2	0.3	0.2			1
9/17	0.01	0	1	0	0	0	0	0	0	0.03	0.05	0.03			0
9/18	0.25	0	8	0.04	0.04	0.04	0.04	0.04	0	0.15	0.23	0.23			1
9/19	0	0	0	0	0	0	0	0	0	0	0	0			1
9/20	0	0	0	0	0	0	0	0	0	0	0	0			0
9/21	0.01	0	1	0.04	0.04	0.04	0	0.04	0	0.11	0.15	0.11			1
9/22	0	0	0	0	0	0	0	0	0	0	0	0			0
9/23	0	0	0	0	0	0	0	0	0	0	0	0			0
9/24	0	0	0	0	0	0	0	0	0	0	0	0			0
9/25	0	0	0	0	0	0	0	0	0	0	0	0			0
9/26	0	0	0	0	0	0	0	0	0	0	0	0			0
9/27	0.07	0	13	0.04	0.04	0.08	0	0.08	0	0.08	0.14	0.13			1
9/28	0	0	0	0.04	0.04	0.04	0	0.04	0	0	0	0			0
9/29	0	0	0	0	0	0	0	0	0	0	0	0			0
9/30	0.06	0	17	0	0	0	0	0	0	0	0	0			0

**APPENDIX B –ZONE D SPECIFIC FORECASTS AND OBSERVATIONS**

**d) Forecast Zone D: Central Metro**

A	CoCoRaHS			ALERT						NOAA Stage IV			Flood Day Classification		Threat
	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P
5/1	0.09	0	65	0.08	0.08	0.08	0.08	0.12	0	0.23	0.46	0.5			0
5/2	0.05	0	8	0.04	0.04	0.04	0	0.04	0	0.12	0.23	0.14			0
5/3	0	0	0	0.04	0.04	0.04	0	0.04	0	0.08	0.14	0.08			0
5/4	0	0	0	0	0	0	0	0	0	0	0.36	0			0
5/5	0	0	0	0	0	0	0	0	0	0	0	0			1
5/6	0.75	0	93	0.6	0.68	0.72	0.28	0.76	0	0.66	1.01	0.8	YES		3
5/7	0.78	0	95	1.1	1.1	1.1	0.52	0.8	1	0.43	0.84	0.71	YES		21
5/8	1.35	4	86	0.16	0.24	0.4	0.2	0.8	0	0.21	0.36	1.12			1
5/9	0.61	0	81	0.16	0.24	0.36	0.24	0.48	0	0.15	0.27	0.9			1
5/10	0.03	0	5	0.04	0.04	0.04	0.04	0.04	0	0.06	0.11	0.3			0
5/11	0.04	0	15	0.04	0.04	0.04	0.04	0.04	0	0.08	0.15	0.16			1
5/12	0	0	0	0	0	0	0	0	0	0	0	0			0
5/13	0	0	0	0.48	0.48	0.48	0.16	0.48	0	0.12	0.19	0.13			1
5/14	0	0	0	0.04	0.04	0.04	0.04	0.04	0	0.04	0.14	0.04			2
5/15	0	0	0	0.24	0.4	0.72	0.12	2.28	0	0.02	0.08	0.04			1
5/16	0.01	0	1	0.16	0.16	0.2	0.16	0.24	0	0.01	0.02	0.02			1
5/17	0.27	0	88	0.16	0.16	0.16	0.16	0.16	0	0.21	0.4	0.41			1
5/18	0.18	0	83	0.16	0.2	0.2	0.12	0.2	0	0.16	0.31	0.2			2
5/19	0.17	0	82	0.08	0.12	0.12	0.04	0.2	0	0.06	0.12	0.15			1
5/20	2.05	20	91	0.12	0.16	0.24	0.16	0.44	0	0.47	0.92	2.55			4
5/21	0.75	0	40	0.36	0.6	0.72	0.48	0.84	0	0.25	0.46	0.59			1
5/22	0.3	0	77	0.08	0.12	0.16	0.08	0.32	0	0.14	0.28	0.34			1
5/23	0.06	0	42	0.04	0.04	0.04	0.04	0.08	0	0.07	0.15	0.21			0
5/24	0.02	0	2	0.04	0.04	0.04	0.04	0.04	0	0	0	0			0
5/25	0.02	0	1	0	0	0	0	0	0	0	0	0			0
5/26	0.64	0	81	0.48	0.48	0.48	0.44	0.72	0	0.56	1.1	1	YES		7
5/27	1.1	2	94	0.68	0.68	0.72	0.68	0.88	0	0.8	1.57	1.16	YES		18
5/28	0.3	0	95	0.2	0.24	0.32	0.2	0.6	0	0.31	0.61	0.67			9
5/29	0.01	0	5	0.04	0.04	0.04	0.04	0.04	0	0.01	0.02	0.04			1
5/30	0.04	0	19	0.4	0.4	0.4	0.12	0.4	0	0.01	0.02	0.01			6
5/31	0.08	0	23	0.16	0.2	0.2	0.08	0.2	0	2.58	4.03	2.59	YES		1
6/1	1.31	1	75	0.8	0.92	0.92	0.8	0.92	0	1.12	2.23	1.21	YES	YES	18
6/2	0.32	0	56	0.32	0.36	0.36	0.32	0.36	0	0.51	0.98	0.63			9
6/3	0.74	0	80	0.68	0.68	0.72	0.48	0.72	0	0.66	1.22	1.28	YES		6
6/4	0.24	0	24	0.16	0.2	0.2	0.08	0.24	0	0.16	0.35	0.29			3
6/5	1	0	64	0.28	0.32	0.32	0.28	0.52	0	0.5	0.93	0.87			33
6/6	0.26	0	18	0.32	0.32	0.32	0.16	0.32	0	0.36	0.65	0.5			2
6/7	0.67	0	64	0.4	0.44	0.44	0.4	0.44	0	0.44	0.81	0.72			6

**APPENDIX B –ZONE D SPECIFIC FORECASTS AND OBSERVATIONS**

A	CoCoRaHS			ALERT						NOAA Stage IV			Flood Day Classification		Threat
	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P
6/8	0.59	0	85	0.2	0.2	0.2	0.16	0.28	0	0.63	1.32	0.85	YES		3
6/9	0.1	0	3	0.2	0.2	0.2	0.04	0.2	0	0	0	0			0
6/10	0	0	0	0.16	0.24	0.24	0.16	0.2	0	0	0	0			0
6/11	0	0	0	0.16	0.2	0.2	0.08	0.2	0	0	0.02	0			0
6/12	0	0	0	0.16	0.24	0.24	0.12	0.64	0	0	0	0			0
6/13	0.07	0	16	0.24	0.24	0.24	0.12	0.24	0	0.17	0.35	0.18			1
6/14	0.18	0	18	0.24	0.24	0.24	0.16	0.24	0	0.22	0.4	0.29			1
6/15	0.55	0	36	0.2	0.2	0.24	0.12	0.24	0	0.16	0.29	0.21			4
6/16	0.36	0	80	0.48	0.52	0.52	0.48	0.56	0	0.67	1.19	0.7	YES		7
6/17	0.8	0	95	0.76	0.88	0.92	0.76	1.2	0	1.12	2.11	1.47	YES	YES	39
6/18	0.5	0	81	0.2	0.2	0.2	0.2	0.2	0	1.24	2.46	1.76	YES	YES	31
6/19	0.02	0	3	0.2	0.2	0.2	0.12	0.32	0	0.12	0.19	0.12			1
6/20	0.3	0	11	0.2	0.2	0.2	0.16	0.2	0	0.81	1.56	0.81	YES		1
6/21	1.03	1	94	0.28	0.36	0.36	0.28	0.8	0	0.46	0.85	0.84			5
6/22	0.83	0	93	0.44	0.44	0.48	0.4	0.72	0	0.43	0.84	0.79			13
6/23	0.02	0	18	0.08	0.08	0.08	0.04	0.08	0	0.1	0.25	0.17			1
6/24	0	0	0	0.12	0.16	0.16	0.12	0.24	0	0	0	0			0
6/25	0.3	0	14	0.28	0.28	0.28	0.16	0.28	0	0.57	1.02	0.57	YES		0
6/26	0.02	0	1	0.28	0.28	0.28	0.16	0.28	0	0	0	0			0
6/27	0.55	0	14	0.28	0.28	0.28	0.2	0.28	0	0.29	0.5	0.35			1
6/28	0.22	0	37	0.2	0.2	0.24	0.2	0.28	0	0.18	0.32	0.26			0
6/29	0.07	0	4	0.2	0.2	0.2	0.08	0.2	0	0.03	0.05	0.08			1
6/30	0.47	0	90	0.44	0.44	0.44	0.2	0.44	0	0.79	1.42	0.9	YES		4
7/1	1.73	6	90	1	1.12	1.12	1.04	1.16	2	0.72	1.28	1.51	YES	YES	31
7/2	0.89	0	33	0.84	0.96	0.96	0.64	0.96	0	0.55	1	0.61	YES		8
7/3	0.01	0	2	0.16	0.16	0.16	0.16	0.16	0	0.11	0.17	0.14			0
7/4	0.82	0	102	0.6	0.64	0.64	0.52	0.76	0	0.7	1.26	1.31	YES		1
7/5	1.18	4	95	0.92	0.92	0.92	0.92	0.96	0	0.92	1.74	1.19	YES	YES	4
7/6	0.02	0	2	0.12	0.12	0.12	0.08	0.12	0	0.03	0.07	0.04			9
7/7	0.42	0	45	0.32	0.32	0.36	0.2	0.36	0	0.67	1.44	0.83	YES		3
7/8	0.12	0	51	0.16	0.2	0.2	0.12	0.2	0	0.23	0.34	0.23			2
7/9	0	0	0	0.08	0.08	0.08	0.08	0.08	0	0	0	0			0
7/10	0	0	0	0.12	0.16	0.16	0.08	0.24	0	0	0	0			1
7/11	0.13	0	19	0.08	0.08	0.08	0.08	0.12	0	0.2	0.41	0.2			0
7/12	3.2	1	9	0.2	0.2	0.2	0.2	0.28	0	0.57	1.13	0.61	YES		1
7/13	1.45	7	99	0.88	1.16	1.2	1.08	1.24	2	0.81	1.49	1.27	YES	YES	1
7/14	0.02	0	2	0.08	0.08	0.08	0.08	0.12	0	0.06	0.11	0.08			1
7/15	0.54	0	40	0.32	0.32	0.32	0.2	0.32	0	0.28	0.61	0.47			2
7/16	0.13	0	20	0.12	0.12	0.12	0.08	0.12	0	0.25	0.45	0.27			1
7/17	0.18	0	13	0.12	0.16	0.16	0.16	0.24	0	0.12	0.25	0.12			0

**APPENDIX B –ZONE D SPECIFIC FORECASTS AND OBSERVATIONS**

A	CoCoRaHS			ALERT						NOAA Stage IV			Flood Day Classification		Threat
	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P
7/18	0	0	0	0.12	0.12	0.12	0.08	0.16	0	0	0	0			0
7/19	0	0	0	0.12	0.16	0.16	0.08	0.24	0	0	0	0			0
7/20	1.61	10	103	1.68	1.76	1.8	1.68	1.8	8	0.97	1.87	1.49	YES	YES	39
7/21	2.39	4	73	1.08	1.64	1.64	1	1.64	1	1.21	2.21	1.54	YES	YES	36
7/22	0.77	0	26	0.6	0.64	0.64	0.4	0.64	0	0.87	1.63	0.92	YES		25
7/23	0.25	0	1	0.16	0.16	0.2	0.08	0.2	0	0	0	0			1
7/24	0.79	0	44	0.36	0.36	0.36	0.2	0.36	0	0.4	0.68	0.51			2
7/25	0.38	0	70	0.2	0.2	0.2	0.2	0.24	0	0.21	0.39	0.23			8
7/26	0.4	0	30	0.36	0.52	0.56	0.24	0.56	0	0.11	0.19	0.25			1
7/27	0.76	0	41	0.24	0.28	0.32	0.28	0.4	0	0.2	0.34	0.32			9
7/28	0.1	0	2	0.16	0.24	0.24	0.12	0.4	0	0.02	0.02	0.02			0
7/29	0.18	0	10	0.16	0.16	0.16	0.16	0.32	0	0.44	0.87	0.47			0
7/30	0.38	0	46	0.2	0.2	0.2	0.16	0.44	0	0.21	0.41	0.44			0
7/31	0.63	0	101	0.36	0.44	0.48	0.4	0.48	0	0.48	0.91	0.59			2
8/1	0.35	0	80	0.16	0.16	0.2	0.16	0.28	0	0.26	0.51	0.34			19
8/2	0.04	0	1	0.16	0.16	0.2	0.16	0.36	0	0.01	0.06	0.04			1
8/3	0	0	0	0.2	0.2	0.2	0.16	0.36	0	0	0	0			1
8/4	0.33	0	39	0.32	0.32	0.32	0.24	0.56	0	0.41	1.08	0.43	YES		3
8/5	0.06	0	9	0.2	0.2	0.2	0.2	0.32	0	0.08	0.11	0.08			2
8/6	0	0	0	0.16	0.16	0.16	0.04	0.16	0	0	0.02	0			0
8/7	0.56	0	35	0.44	0.44	0.48	0.4	0.52	0	0.41	0.71	0.44			3
8/8	0.73	0	76	0.36	0.4	0.56	0.36	0.6	0	0.69	1.34	0.76	YES		19
8/9	0.45	0	10	0.28	0.28	0.28	0.12	0.28	0	0.35	0.57	0.41			4
8/10	0.01	0	1	0.12	0.12	0.12	0.12	0.16	0	0.01	0.01	0.01			2
8/11	0.84	0	39	0.64	0.64	0.64	0.24	0.64	0	0.53	1.1	0.65	YES		19
8/12	0	0	0	0.2	0.2	0.2	0.2	0.28	0	0	0.02	0.04			0
8/13	0.14	0	22	0.39	0.39	0.39	0.2	0.24	0	0.37	0.72	0.37			1
8/14	0.04	0	2	0.16	0.16	0.16	0.12	0.32	0	0	0.03	0			0
8/15	0	0	0	0.12	0.12	0.12	0.08	0.16	0	0	0.1	0			0
8/16	0.01	0	1	0.16	0.16	0.16	0.08	0.24	0	0.01	0.04	0.01			0
8/17	0.05	0	12	0.12	0.12	0.12	0.12	0.12	0	0.14	0.64	0.17			0
8/18	0	0	0	0.2	0.24	0.24	0.12	0.4	0	0	0	0			0
8/19	0	0	0	0.16	0.2	0.2	0.12	0.2	0	0	0.37	0			0
8/20	0.1	0	26	0.2	0.24	0.24	0.16	0.24	0	0.54	1.02	0.54	YES		4
8/21	1.88	9	101	1.64	1.84	1.92	1.8	1.92	11	0.9	1.55	1.38	YES	YES	33
8/22	0.17	0	24	0.12	0.12	0.12	0.08	0.16	0	0.27	0.68	0.27			15
8/23	0.1	0	14	0.04	0.04	0.04	0.04	0.04	0	0.14	0.79	0.2			3
8/24	0.03	0	1	0.12	0.12	0.12	0.04	0.12	0	0	0	0			0
8/25	0	0	0	0.12	0.12	0.12	0.04	0.12	0	0	0	0			0
8/26	0	0	0	0.12	0.12	0.12	0.12	0.2	0	0	0	0			0

**APPENDIX B –ZONE D SPECIFIC FORECASTS AND OBSERVATIONS**

A	CoCoRaHS			ALERT						NOAA Stage IV			Flood Day Classification		Threat
	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P
8/27	0	0	0	0.16	0.16	0.16	0.04	0.24	0	0	0.12	0			0
8/28	0.97	0	1	0.16	0.24	0.24	0.12	0.44	0	0	0	0			0
8/29	0	0	0	0.12	0.12	0.12	0.04	0.12	0	0	0	0			0
8/30	0.19	0	32	0.16	0.24	0.24	0.16	0.4	0	0.29	0.88	0.29			3
8/31	0.01	0	1	0.2	0.2	0.2	0.08	0.2	0	0	0	0			0
9/1	0	0	0	0.16	0.2	0.2	0.08	0.4	0	0	0	0			0
9/2	0	0	0	0.16	0.16	0.16	0.12	0.28	0	0	0.05	0			0
9/3	0	0	0	0.2	0.24	0.24	0.12	0.24	0	0.01	0.01	0.01			0
9/4	0.18	0	25	0.16	0.2	0.2	0.16	0.4	0	0.18	0.38	0.32			1
9/5	0.1	0	9	0.16	0.2	0.2	0.12	0.2	0	0.07	0.09	0.1			1
9/6	2.73	6	105	1.96	2.64	2.68	1.88	2.76	4	0.7	1.26	1.19	YES	YES	36
9/7	0.34	0	32	0.2	0.2	0.2	0.16	0.2	0	0.16	0.29	0.2			1
9/8	1.41	2	101	0.72	0.84	0.84	0.48	0.88	0	0.65	1.24	0.82	YES		40
9/9	0.05	0	3	0.16	0.16	0.16	0.16	0.12	0	0	0	0			0
9/10	0.01	0	1	0.2	0.2	0.2	0.16	0.2	0	0.01	0.01	0.01			1
9/11	0.3	0	78	0.24	0.24	0.24	0.16	0.32	0	0.29	0.43	0.35			1
9/12	0.01	0	2	0.12	0.12	0.12	0.12	0.12	0	0	0	0			0
9/13	0	0	0	0.12	0.16	0.16	0.08	0.28	0	0	0	0			0
9/14	0	0	0	0.12	0.12	0.12	0.12	0.2	0	0	0	0			0
9/15	0	0	0	0.16	0.2	0.2	0.12	0.36	0	0	0	0			1
9/16	0.08	0	6	0.12	0.16	0.16	0.12	0.16	0	0.15	0.2	0.15			0
9/17	0.01	0	1	0.16	0.2	0.2	0.16	0.2	0	0.01	0.01	0.01			0
9/18	0.02	0	6	0.16	0.16	0.16	0.12	0.24	0	0.04	0.06	0.04			1
9/19	0	0	0	0.28	0.28	0.28	0.12	0.28	0	0	0.19	0			0
9/20	0.04	0	1	0.12	0.16	0.16	0.08	0.24	0	0	0	0			0
9/21	0.2	0	76	0.16	0.16	0.16	0.12	0.28	0	0.07	0.64	0.08			1
9/22	0	0	0	0.12	0.2	0.2	0.12	0.36	0	0	0	0			0
9/23	0	0	0	0.16	0.16	0.16	0.12	0.24	0	0	0	0			0
9/24	0	0	0	0.12	0.2	0.2	0.12	0.24	0	0	0	0			0
9/25	0	0	0	0.16	0.2	0.2	0.12	0.24	0	0	0	0			0
9/26	0	0	0	0.12	0.12	0.12	0	0.12	0	0	0	0			0
9/27	0.02	0	8	0.12	0.12	0.12	0.08	0.16	0	0.01	0.03	0.05			1
9/28	0	0	0	0.08	0.08	0.08	0.08	0.12	0	0	0	0			0
9/29	0.03	0	1	0.08	0.08	0.08	0	0.16	0	0	0	0			0
9/30	0.12	0	56	0.12	0.16	0.16	0.12	0.2	0	0	0.04	0			0

**APPENDIX B –ZONE E SPECIFIC FORECASTS AND OBSERVATIONS**

**e) Forecast Zone E: North Metro**

A	CoCoRaHS			ALERT						NOAA Stage IV			Flood Day Classification		Threat
	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P
5/1	0.23	0	52	0.16	0.24	0.36	0.12	0.4	0	0.09	0.19	0.34			0
5/2	0.01	0	2	0	0	0	0	0	0	0	0.08	0			0
5/3	0	0	0	0	0	0	0	0	0	0.01	0.02	0.01			0
5/4	0	0	0	0	0	0	0	0	0	0	0.29	0			0
5/5	0	0	0	0	0	0	0	0	0	0	0	0			1
5/6	0.33	0	93	0.36	0.36	0.36	0.16	0.44	0	0.35	0.66	0.54			2
5/7	0.29	0	85	0.28	0.28	0.28	0.28	0.36	0	0.55	1.03	0.8	YES		19
5/8	1.32	11	79	0.12	0.16	0.24	0.12	0.76	0	0.08	0.16	0.97			1
5/9	0.44	0	72	0.24	0.4	0.44	0.32	0.72	0	0.08	0.16	0.43			1
5/10	0.01	0	1	0.08	0.12	0.24	0.08	0.48	0	0.04	0.08	0.08			0
5/11	0.13	0	24	0.04	0.04	0.04	0.04	0.04	0	0.12	0.21	0.32			1
5/12	0	0	0	0	0	0	0	0	0	0	0.01	0			0
5/13	0	0	0	0	0	0	0	0	0	0.04	0.06	0.04			1
5/14	0.02	0	5	0	0	0	0	0	0	0.05	0.2	0.09			2
5/15	0	0	0	0	0	0	0	0	0	0.02	0.15	0.04			1
5/16	0.03	0	1	0	0	0	0	0	0	0	0.09	0			1
5/17	0.42	0	81	0.16	0.2	0.2	0.12	0.2	0	0.22	0.44	0.52			2
5/18	0.07	0	30	0.04	0.04	0.04	0.04	0.04	0	0.09	0.25	0.09			1
5/19	0.49	0	89	0.12	0.16	0.2	0.08	0.32	0	0.18	0.35	0.4			2
5/20	1.24	20	87	0.12	0.16	0.16	0.12	0.4	0	0.16	0.31	1.2			3
5/21	0.78	0	62	0.36	0.52	0.62	0.52	0.76	0	0.11	0.43	0.35			1
5/22	0.36	0	81	0.08	0.12	0.12	0.08	0.24	0	0.09	0.18	0.33			1
5/23	0.19	0	76	0.04	0.08	0.08	0.04	0.2	0	0.08	0.16	0.17			0
5/24	0	0	0	0.32	0.32	0.32	0.08	0	0	0	0	0			0
5/25	0.08	0	2	0.04	0.04	0.04	0	0.04	0	0.04	0.07	0.04			0
5/26	0.69	0	51	0.28	0.28	0.28	0.08	0.28	0	0.94	1.83	1.17	YES	YES	17
5/27	1.06	1	87	0.44	0.44	0.48	0.4	0.6	0	0.66	1.25	1.51	YES	YES	28
5/28	0.89	0	85	0.76	0.88	0.88	0.44	0.96	0	0.58	1.06	0.94	YES		20
5/29	0.11	0	6	0.04	0.04	0.04	0.04	0.04	0	0	0	0			1
5/30	0.01	0	1	0	0	0	0	0	0	0	0	0			2
5/31	0.06	0	42	0.05	0.05	0.05	0.04	0.05	0	0.13	0.3	0.13			1
6/1	0.07	0	15	0.04	0.04	0.04	0	0.04	0	0.15	0.27	0.2			2
6/2	0.67	0	37	0.08	0.08	0.08	0.04	0.08	0	0.96	1.82	1.03	YES	YES	12
6/3	0.25	0	36	0.12	0.12	0.12	0.08	0.12	0	0.25	0.49	0.3			4
6/4	0.15	0	41	0.08	0.08	0.08	0.08	0.08	0	0.19	0.38	0.24			4
6/5	1.47	2	77	0.8	1.29	1.43	0.36	1.44	1	0.91	1.81	1.59	YES	YES	32
6/6	0.03	0	12	0	0	0	0	0	0	0.11	0.15	0.13			1
6/7	0.32	0	53	0.12	0.12	0.2	0.12	0.24	0	0.15	0.87	0.27			3



**APPENDIX B –ZONE E SPECIFIC FORECASTS AND OBSERVATIONS**

A	CoCoRaHS			ALERT						NOAA Stage IV			Flood Day Classification		Threat P
	B	C	D	E	F	G	H	I	J	K	L	M	N	O	
6/8	0.42	0	83	0.2	0.2	0.2	0.16	0.24	0	0.69	1.24	0.83	YES		3
6/9	0.02	0	4	0	0	0	0	0	0	0	0	0			0
6/10	0	0	0	0	0	0	0	0	0	0	0	0			0
6/11	0.03	0	9	0	0	0	0	0	0	0.05	0.09	0.05			0
6/12	0.01	0	1	0	0	0	0	0	0	0	0	0			0
6/13	0.11	0	10	0.08	0.08	0.08	0	0.12	0	0.29	0.53	0.35			1
6/14	0.09	0	43	0.08	0.08	0.08	0.08	0.08	0	0.22	0.46	0.23			1
6/15	0.41	0	27	0.4	0.4	0.44	0.14	0.44	0	0.36	0.56	0.5			3
6/16	0.77	0	83	0.6	0.64	0.64	0.24	0.64	0	0.64	1.19	0.69	YES		11
6/17	1.1	1	89	0.92	0.96	0.96	0.76	0.96	0	1.05	2.07	1.44	YES	YES	63
6/18	0.9	0	83	0.48	0.48	0.48	0.23	0.56	0	0.57	1.07	0.84	YES		35
6/19	0.03	0	7	0	0	0	0	0	0	0.02	0.04	0.02			1
6/20	0.05	0	15	0	0	0	0	0	0	0.06	0.76	0.06			1
6/21	1.21	20	85	0.36	0.4	0.48	0.4	1.04	0	0.26	0.49	1.13			2
6/22	0.61	0	87	0.24	0.28	0.32	0.24	0.4	0	0.32	0.54	0.74			6
6/23	0.27	0	55	0.04	0.04	0.04	0.02	0.04	0	0.77	1.29	1	YES		1
6/24	0	0	0	0	0	0	0	0	0	0.04	0.06	0.06			0
6/25	0.01	0	2	0	0	0	0	0	0	0.05	0.12	0.09			0
6/26	0	0	0	0	0	0	0	0	0	0.01	0.01	0.01			0
6/27	0	0	0	0	0	0	0	0	0	0.03	0.03	0.03			0
6/28	0.04	0	16	0.55	0.55	0.55	0.35	0.55	0	0.08	0.14	0.17			0
6/29	0.01	0	1	0	0	0	0	0	0	0.04	0.08	0.04			0
6/30	0.5	0	79	1.08	1.44	1.44	0.24	1.44	1	0.92	1.6	1.09	YES	YES	3
7/1	1.87	8	97	0.72	0.76	1.04	0.4	1.16	0	0.63	1.48	1.29	YES	YES	24
7/2	0.13	0	19	0.04	0.04	0.04	0	0.04	0	0.06	0.17	0.13			3
7/3	0.03	0	3	0	0	0	0	0	0	0.06	0.1	0.06			0
7/4	0.46	0	92	0.4	0.4	0.48	0.2	0.92	0	0.74	1.34	1.42	YES		1
7/5	1.61	6	88	1.63	1.76	1.79	1.04	1.79	2	1.08	2.14	1.39	YES	YES	6
7/6	0.02	0	5	0.08	0.08	0.08	0.04	0.08	0	0.02	0.04	0.05			5
7/7	1	0	63	0.43	0.43	0.45	0.32	0.45	0	1.05	1.98	1.68	YES	YES	6
7/8	0.19	0	29	0.08	0.08	0.08	0.04	0.08	0	0.35	0.65	0.36			3
7/9	0	0	0	0	0	0	0	0	0	0	0	0			0
7/10	0	0	0	0	0	0	0	0	0	0	0	0			0
7/11	0.23	0	13	0	0	0	0	0	0	0.44	0.78	0.44			0
7/12	0.51	0	8	0	0	0	0	0	0	0.57	1.06	0.82	YES		1
7/13	0.19	0	26	0.04	0.04	0.04	0.04	0.04	0	0.33	0.64	0.34			1
7/14	0.94	0	47	0.04	0.04	0.04	0.04	0.04	0	0.27	0.52	0.48			2
7/15	1.21	1	78	0.84	0.84	0.84	0.24	0.88	0	0.54	1.07	0.8	YES		2
7/16	0.17	0	21	0.36	0.36	0.36	0.04	0.36	0	0.16	0.31	0.18			1
7/17	0	0	0	0	0	0	0	0	0	0.02	0.04	0.02			0

**APPENDIX B –ZONE E SPECIFIC FORECASTS AND OBSERVATIONS**

A	CoCoRaHS			ALERT						NOAA Stage IV			Flood Day Classification		Threat P
	B	C	D	E	F	G	H	I	J	K	L	M	N	O	
7/18	0	0	0	0	0	0	0	0	0	0	0	0			0
7/19	0	0	0	0.08	0.08	0.08	0.08	0.08	0	0	0	0			0
7/20	0.93	0	92	0.64	0.64	0.64	0.4	0.72	0	1.04	1.99	2.22	YES	YES	35
7/21	0.93	0	61	0.28	0.28	0.28	0.28	0.28	0	0.81	1.55	0.94	YES		16
7/22	0.5	0	11	0.04	0.04	0.04	0	0.04	0	0.47	0.84	0.47			11
7/23	0.1	0	2	0	0	0	0	0	0	0	0	0.02			0
7/24	0.29	0	50	0.08	0.08	0.08	0.04	0.08	0	0.34	0.84	0.39			2
7/25	0.08	0	18	0	0	0	0	0	0	0.05	0.15	0.05			5
7/26	0	0	0	0	0	0	0	0	0	0	0	0			1
7/27	0.18	0	30	0.08	0.08	0.08	0.04	0.08	0	0.08	0.17	0.12			7
7/28	0.02	0	3	0	0	0	0	0	0	0.07	0.11	0.12			0
7/29	0	0	0	0	0	0	0	0	0	0	0.36	0			0
7/30	0.27	0	51	0.2	0.24	0.24	0.2	0.24	0	0.24	0.44	0.26			1
7/31	0.62	0	29	0.24	0.28	0.28	0.08	0.28	0	0.79	1.57	0.98	YES		2
8/1	0.6	0	85	0.12	0.16	0.16	0.08	0.2	0	0.09	0.18	0.2			14
8/2	0.18	0	34	0.04	0.04	0.04	0	0.04	0	0.41	0.77	0.42			1
8/3	0.01	0	1	0	0	0	0	0	0	0	0	0			1
8/4	0	0	0	0	0	0	0	0	0	0.26	1.08	0.3	YES		1
8/5	0.37	0	52	0.04	0.04	0.04	0	0.04	0	0.26	0.47	0.5			2
8/6	0.02	0	5	0.04	0.04	0.04	0	0	0	0.13	0.25	0.14			1
8/7	0.67	0	76	0.2	0.2	0.2	0.2	0.2	0	0.42	0.83	0.68			4
8/8	1.14	1	84	0.12	0.12	0.12	0.04	0.2	0	0.61	1.12	1.06	YES		16
8/9	0.89	0	44	0.34	0.34	0.34	0.12	0.34	0	0.52	0.99	0.74			2
8/10	0.12	0	9	0.04	0.04	0.08	0	0.12	0	0.09	0.27	0.27			1
8/11	0.02	0	24	0	0	0	0	0	0	0.06	1.17	0.09	YES		10
8/12	0.04	0	6	0.16	0.16	0.16	0	0.16	0	0.15	0.3	0.15			0
8/13	0.84	0	37	0.48	0.5	0.5	0.2	0.51	0	0.89	1.79	0.91	YES		2
8/14	0	0	0	0	0	0	0	0	0	0.01	0.02	0.01			0
8/15	0.01	0	1	0	0	0	0	0	0	0	0.06	0			0
8/16	0.09	0	5	0	0	0	0	0	0	0.13	0.23	0.15			0
8/17	0.07	0	14	0.04	0.04	0.04	0	0.04	0	0.4	0.8	0.46			0
8/18	0	0	0	0	0	0	0	0	0	0	0	0			0
8/19	0	0	0	0.04	0.04	0.04	0	0.04	0	0	0.18	0			0
8/20	0.07	0	9	0	0	0	0	0	0	0.44	0.83	0.47			3
8/21	0.05	0	28	0	0	0	0	0	0	0.14	0.36	0.23			21
8/22	0.14	0	16	0.03	0.03	0.03	0	0.03	0	0.08	0.16	0.09			9
8/23	0.02	0	2	0	0	0	0	0	0	0.19	0.26	0.19			3
8/24	0.02	0	1	0	0	0	0	0	0	0	0.06	0			0
8/25	0	0	0	0	0	0	0	0	0	0	0	0			0
8/26	0	0	0	0	0	0	0	0	0	0	0	0			0

**APPENDIX B –ZONE E SPECIFIC FORECASTS AND OBSERVATIONS**

A	CoCoRaHS			ALERT						NOAA Stage IV			Flood Day Classification		Threat P
	B	C	D	E	F	G	H	I	J	K	L	M	N	O	
8/27	0	0	0	0	0	0	0	0	0	0	0.01	0			0
8/28	0	0	0	0	0	0	0	0	0	0	0	0			0
8/29	0	0	0	0	0	0	0	0	0	0	0	0			0
8/30	0.08	0	5	0	0	0	0	0	0	0.18	0.93	0.18			5
8/31	0.01	0	1	0	0	0	0	0	0	0.08	0.13	0.08			0
9/1	0	0	0	0	0	0	0	0	0	0.01	0.03	0.01			0
9/2	0	0	0	0	0	0	0	0	0	0	0.02	0			0
9/3	0	0	0	0	0	0	0	0	0	0.02	0.02	0.02			0
9/4	0.08	0	17	0	0	0	0	0	0	0.07	0.14	0.09			2
9/5	0.24	0	19	0.04	0.04	0.04	0	0.04	0	0.17	0.46	0.27			1
9/6	0.22	0	73	0.08	0.12	0.12	0.08	0.12	0	0.33	0.55	0.34			15
9/7	0	0	0	0	0	0	0	0	0	0	0	0			1
9/8	0.94	0	89	0.4	0.48	0.48	0.32	0.56	0	1.15	2.16	1.46	YES	YES	43
9/9	0.34	0	26	0.04	0.04	0.04	0	0.04	0	0.6	1.05	0.67	YES		0
9/10	0.55	0	40	0.24	0.24	0.24	0.2	0.24	0	0.44	0.79	0.44			4
9/11	0.49	0	82	0.21	0.27	0.27	0.2	0.28	0	0.66	1.29	0.81	YES		1
9/12	0.01	0	2	0	0	0	0	0	0	0	0	0			0
9/13	0	0	0	0	0	0	0	0	0	0	0	0			0
9/14	0	0	0	0	0	0	0	0	0	0	0	0			0
9/15	0	0	0	0	0	0	0	0	0	0	0	0			1
9/16	0	0	0	0	0	0	0	0	0	0	0.17	0			0
9/17	0	0	0	0	0	0	0	0	0	0.01	0.03	0.01			0
9/18	0.03	0	6	0	0	0	0	0	0	0.02	0.06	0.02			0
9/19	0	0	0	0	0	0	0	0	0	0.01	0.07	0.01			1
9/20	0	0	0	0	0	0	0	0	0	0	0.01	0			0
9/21	0.06	0	20	0.04	0.04	0.04	0	0.04	0	0.1	0.19	0.29			0
9/22	0	0	0	0	0	0	0	0	0	0	0	0			0
9/23	0	0	0	0	0	0	0	0	0	0	0	0			0
9/24	0	0	0	0.16	0.16	0.16	0.08	0.16	0	0	0	0			0
9/25	0	0	0	0	0	0	0	0	0	0	0	0			0
9/26	0	0	0	0	0	0	0	0	0	0	0	0			0
9/27	0.36	0	81	0.08	0.12	0.2	0.12	0.2	0	0.23	0.45	0.56			1
9/28	0.02	0	5	0.04	0.04	0.04	0	0.04	0	0	0	0			0
9/29	0	0	0	0	0	0	0	0	0	0	0	0			0
9/30	0.18	0	74	0.03	0.05	0.08	0	0.03	0	0	0.29	0			0