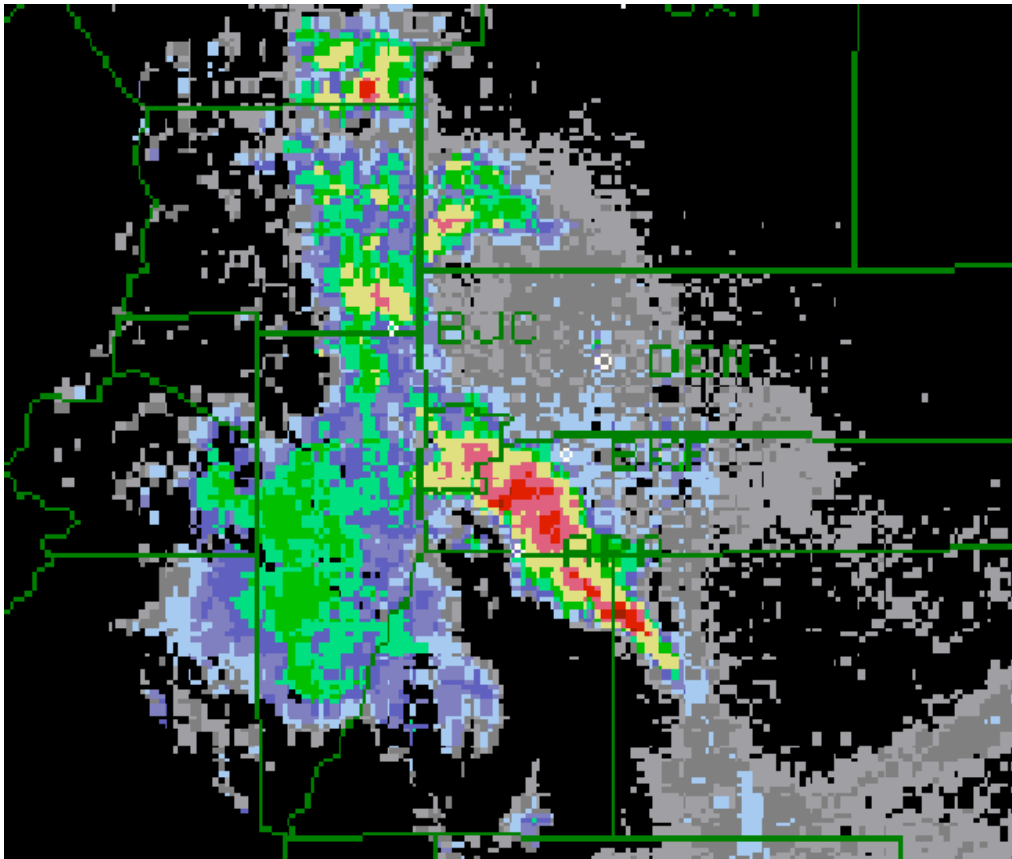


2003 UDFCD FLASH FLOOD PREDICTION PROGRAM ANNUAL REPORT



Nexrad 88-D Image of heavy rainfall event over the District at approximately 10:05 PM on July 18th, 2003.

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Appendix A: 2003 F2P2 Verification of Messages

Appendix B: UDFCD F2P2 District-wide Message Day Statistics

1.0 Introduction

Urban Drainage & Flood Control District (UDFCD or District) has funded a Flash Flood Prediction Program (F2P2) since May 1979. The F2P2 was established as a response to the disastrous Big Thompson Flash Flood of July 31, 1976 in Larimer County. The District contracts the unique, basin/storm-specific weather prediction services of a Private Meteorological Service (PMS) to augment the traditional forecast and warning services of the National Weather Service (NWS) for the seven-county District area.

The District forecast area supported by the PMS is shown in Figure 1 and includes over 60 percent of Colorado's population. The District is approximately 1,600 square miles and the forecast area is about 3,000 square miles that includes the upper basin areas of streams that flow into the District. Terrain in the forecast area varies from the rolling populated prairies of Arapahoe and Adams Counties to highly urbanized Denver County to the rugged plains-foothills-mountain interfaces of Jefferson, Boulder and Douglas Counties. The population in this area has increased dramatically over the last few years with most notable increases occurring within the city of Aurora and Douglas County. Douglas County has been one of the fastest growing Counties in the United States over the last four years.

HDR Hydro-Meteorological Services of Denver was selected as the 2003 F2P2 PMS. HDR operational meteorologists Robert Rahrs, John Henz, Bryan Rappolt and William Badini provided the F2P2 forecast services with the assistance of meteorological technician Daniel Henz. William Badini acted as Project Manager with Bryan Rappolt and John Henz providing quality control and quality assurance on F2P2 products. Mr. Rappolt and Mr. Henz also provided guidance to the on-duty operational meteorologist, based on their vast experience with the F2P2.

This season marked the 2nd for Robert Rahrs working within the F2P2. William Badini worked his 5th and Daniel Henz his 3rd as a Meteorological Technician working in support of the meteorologist. John Henz's participation in the program this season marked his 25th year being involved with the F2P2 along with Bryan Rappolt's 12th. In addition, this year marked the 1st year in which the project involved Skyview Weather of Castle Rock, Colorado in the program.

2.0 2003 Operational Season

The 2003 F2P2 season began on April 15th and concluded on September 15th for a total of 154 operational days. Normal operational hours were defined as from 700 AM to 1000 PM. There were a number of days where significant operations and support extended outside of this time frame, which is typical for the history of the program.

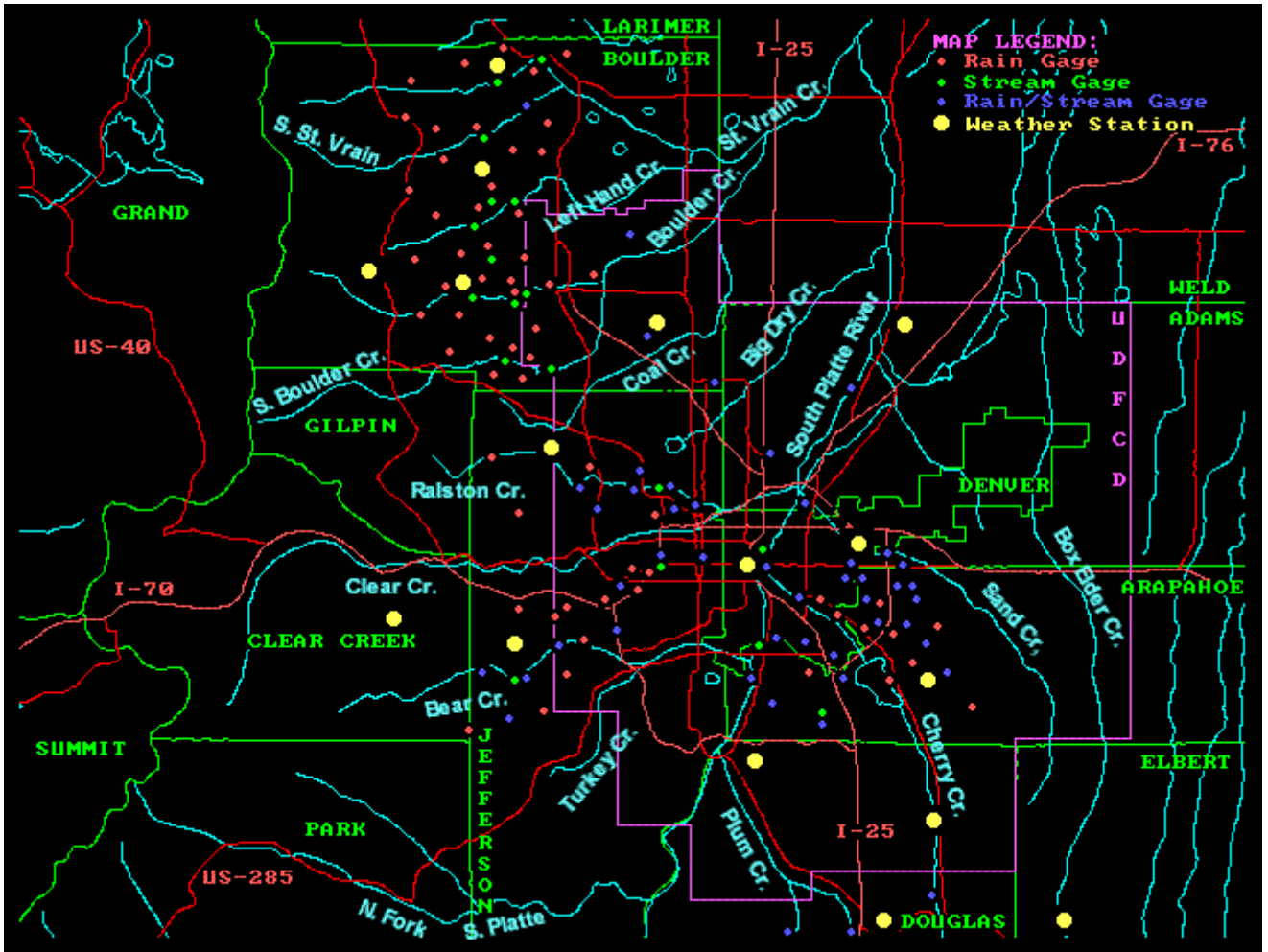


Figure 1. The UDFCD and the flood detection network.

The 2003 F2P2 season marked the first year that Skyview Weather participated in the F2P2 program. HDR was responsible for all products and services from April 15th through May 14th. Skyview was utilized in the program from May 15th through September 15th. In summary, Skyview’s role was to issue the initial morning HPO (with a handful of exceptions) after conducting a technical discussion with an HDR meteorologist. After the morning HPO was issued, Skyview was tasked with monitoring the meteorological conditions (or “metwatch”) for the remainder of the operational day on a regional and local basis. Skyview was tasked with contacting the designated HDR meteorologist should the observed/forecasted conditions evolve to a status of concern for potential Message-level storms. In addition, Skyview was also tasked with updating the initial HPO given HDR-defined criteria.

3.0 2003 F2P2 Operational Products

The F2P2 provides a unique, urban flooding and flash flooding prediction and warning service to the seven District counties and the cities and towns within those counties and inside of the District. Direct support is rendered to the District basin-specific flood warning plans identified below:

1. **Boulder Creek Flood Warning Plan**, which serves Boulder/South Boulder Creeks in Boulder County, which impacts the City of Boulder and portions of un-incorporated Boulder County.
2. **Lena Gulch Flood Warning Plan**, which serves the Lena Gulch Basin and impacts Jefferson County, Golden, Lakewood and Wheat Ridge.
3. **Goldsmith/Harvard Gulch Flood Warning Plan** which impacts south-central Denver.
4. **Westerly Creek Flood Warning Plan**, which impacts eastern Denver and western Aurora.
5. **Toll Gate Creek Flood Warning Plan**, which impacts central and southern Aurora.
6. **Ralston Creek Flood Warning Plan**, which impacts Arvada and Jefferson County.
7. **Bear Creek Flood Warning Plan**, which impacts western Lakewood, the town of Morrison and portions of central Jefferson County.

Five specific F2P2 products were produced within the F2P2. These products included the Heavy Precipitation Outlook (HPO), Messages (1-4), Internal Message Status (IMS), Quantitative Precipitation Forecasts (QPF) and StormTrak. During the 2003 F2P2 season HDR produced the following number of F2P2 products:

Table 1: 2003 F2P2 Product Summary

Product	Number issued
Heavy Precipitation Outlook (HPO)	197
Message and Message Updates	333
Internal Message Status (IMS) reports	71
Basin-Specific Quantitative Precipitation Forecasts	27
StormTraks	62
Total	792

All products were delivered to F2P2 participants using Xpedite Internet-based broadcast fax service and were also uploaded and available from UDFCD's ALERT web site, <http://alert.udfcd.org/udebb.html>. Message forms were the only F2P2 product not available on the UDFCD's ALERT web site due to the fact that Messages (internal alerts) are only intended to be utilized by F2P2 participants and are not intended for the public.

Voice communication continued to be the primary form of communication within the F2P2. Four hundred fifty-eight (**458**) telephone interactions were logged by HDR, between HDR meteorologists/meteorological technicians and F2P2 participants. This statistic indicates that verbal communications remains a key component of the F2P2 to ensure proper communications of products and maintaining a 'personal touch' to the program.

Denver Office of Emergency Management and Denver Wastewater received notification of the issuance of Messages and StormTraks through pagers. InfoRad software was

used to disseminate the text information to the pagers. There were a total of one hundred and two (**102**) information disseminations to the Denver F2P2 pager network.

4.0 2003 F2P2 Operational Verification

The primary service rendered by the F2P2 to participants is the issuance of forecasts and warnings of flash flooding potential, urban and stream flooding, and locally heavy rainfall events that cause nuisance flooding. HDR indicates the potential for these events in a series of products issued directly to the users by phone, fax and Internet. The definition and criteria associated with each Message is given in Table 2.

The issuance of F2P2 Messages is quantitatively linked to rainfall criteria established by the District.

Table 2: UDFCD Flash Flood Prediction Program Message Criteria

Message 1: M-1	Issued primarily to alert local governments to the threat of nuisance flooding of streets and low lying areas due to thunderstorm rainfall when storm total rainfall is 0.50" - 1.00" in one hour or less. When rainfall is 1.00" to < 3.00" in one to three hours, urban street and stream flooding becomes significant. M-1 lead-times of >1 hour are desirable.
Message 1 Rainfall Intensity Criteria:	Any of the forecast rainfall intensities below prompt a Message 1 issuance
	1.00"/ 60 minutes
	0.75"/ 30 minutes
	0.50"/ 10 minutes
Message 1: RED FLAG RED FLAG Rainfall intensity:	Issued to identify storm events, which fall just short of producing life-threatening rainfall, but produce significant runoff. Rainfall rates are predicted or observed to equal or exceed Message 1 criteria and the storm is considered imminent . <i>(This criteria was changed during this seasons to ANY event that may produce a Message-level rainfall.)</i>
Message 2: M-2 M-2 Rainfall intensity criteria:	Issued when the threat of potential life threatening flooding is predicted or the NWS issues a Flash Flood Watch. An HDR-generated M-2 is the equivalent of a Flash Flood Watch. M-2 lead-times of several hours are desirable. >3.00"/hour or a lower value based on mutual discussion between NWS, District and HDR due to antecedent rainfall impacts on soil saturation and/or runoff characteristics.
Message 3: M-3	Issued when a life-threatening flash flood is imminent or the NWS issues a Flash Flood Warning. M-3's are issued in accordance with basin-specific warning plans if available or at the discretion of the meteorologist.
Message 4:	Issued when the flooding threat has passed.

4.1 2003 F2P2 Message Day, Count and Verification

The verification of the Messages issued by HDR meteorologists is presented in Table 3. A Message day is defined as any day from April 15 to September 15 on which a Message 1, Message 2 or Message 3 is issued based on the criteria presented in Table 2. Messages were valid on **30** days during the 2003 F2P2. There were **24** days, of the 30 that Message-level rainfall verified, based on the established criteria listed in Table 2. The result was an **80%** verification of messages days on a District-wide basis.

Table 3: Monthly Message Verification for the 2003 F2P2 Operational Season

Month	District-Wide Message Days	District-Wide Message Days Verified	Percent of Message Days Verifying	County Messages Issued	Messages Verified
April	1	1	100%	7	3
May	9	5	56%	41	7
June	4*	4	100%	31	21
July	6	6	100%	41	19
August	10	8	80%	65	20
September	0	0	N/A	0	0
Total	30	24	80%	185	70

* There were 2 distinct heavy-rain events that occurred on June 17th, one in the early morning hours and a second in the afternoon/evening hours.

Message 1's were issued on 30 days with one event encompassing a significant portion of two calendar days (May 9th-10th) and one day (June 17th) in which there were two distinct periods of Message-level rainfall. Depending on how one accounts for "Message Days" in the period, there were 30 separate 'calendar' days in which Messages were valid with 31 distinct periods of Message-level rainfall or potential rainfall. This number is slightly below the long-term average of 35 Message Days during the 25-year history of the F2P2 and ranks as being tied for 15th (out of 25) in terms of the number of Message days during the program.

There were 3 days when Message 2's were issued for any portion of the district during the 2003 operational season. This is considered to be a near normal number when compared to the long-term average. In addition, there were 4 days in which Message 3's were issued for various portions of the District. There was one day, (July 27th) in which both a Message 2 and Message 3 were issued on the same day.

4.2 County Message Verification and Comparison Statistics

Each Message issued in the F2P2 is disseminated to a specific county or to the City of Aurora in which flooding potential has been forecast. For the purposes of verification, Messages will be verified on only a county-by-county basis. Verifying Messages at the city level can be considered difficult given the relatively small scale that most individual cities present. These counties are listed in Table 4. A Message indicates to the user that the potential exists for a flooding event later during the day.

A county Message is verified as a "hit" only if a rainfall event meeting the Message criteria in Table 2 occurs in the District-portion of that city/county or in the drainage area of a stream that flows into the District. Table 4 below summarizes the results of the 2003 F2P2 verification by jurisdiction.

On a county-by-county basis, the percentage of verifying hits varied from 62% in Arapahoe County to 15% in Broomfield County. It should be noted that the advent of Broomfield County a year-and-a-half ago created a fairly small county from a spatial standpoint. In addition, there are very few observations points that record rainfall, which is an important component in the verification process. If one takes out the statistics for Broomfield County in this county cumulative verification, then the cumulative county 'hit' ratio increases to 44% from 39%. Over the previous 24 years of the F2P2, the average verification rate has been 55%, or 11% better than this years' program. The other counties with territory inside of the UDFCD have been well established since the programs inception and have an adequate to excellent coverage of precipitation reporting stations from both the ALERT (Automated Local Evaluation in Real Time) and CoCoRahs (Community Collaborative Rain and Hail Study) observers. The ALERT system is operated by the UDFCD and the CoCoRahs is based on volunteers taking daily precipitation observations and is coordinated by Colorado State University.

Table 4: County Message Verification for the 2003 F2P2 Operational Season

Primary Contacts	Messages Issued	Message Hits	% Message Hits	Events Missed	Event < 10min Lead Time
Adams	28	12	45	0	1
Arapahoe	28	18	62	0	2
Boulder	24	6	26	1	1
Broomfield	27	4	15	0	0
Denver	28	13	48	0	2
Douglas	27	11	61	0	0
Jefferson	27	10	56	0	1
TOTAL	189	74	39%	1	7

Here is a sampling of how the 2003 F2P2 season ranks against the prior 24 F2P2 seasons:

1. **Ranked tied for 15th with respect to the number of message days that occurred.**
2. **Average amount of Message 2's and National Weather Service Flash Flood Watches (3).**
3. **Above average amount of Message 3's and National Weather Service Flash Flood Warnings (4).**

A chart depicting all of the county-by-county Message issuances and the verification of those Messages are depicted in Appendix A. Message statistics for all 25 F2P2 seasons can be found in a table located in Appendix B.

5.0 Synopsis: 2003 Season

The 2003 season could easily be described as the “year of recovery” for much of the Front Range of Colorado from a precipitation perspective. The 2002-2003 winter and spring brought about a near seasonal amount of precipitation to both the Denver Metro area and the nearby foothills. This helped keep the fire danger in the Front Range foothills to a minimum, which was a secondary concern in the 2002 program. From a monthly perspective, conditions were most active (as measured by the number of Message Days) in mid/late May and August while relatively ‘quiet’ conditions (vs. normal), as a whole, were experienced in June and especially July with the exception of a few days as noted below. The “half-months” of the program (Apr. 15th - Apr. 30th and

Sept. 1st - Sept. 15th) were relatively quiet as only 1 Message day (Apr. 23rd) occurred and that was mainly due to a “general stratiform” rainfall that did not involve short duration-high intensity rainfall that can accompany thunderstorm-based activity.

5.1 Message 2/Message 3 Events

Given the importance of the threat of Flash Flooding as a focal point of the F2P2, a detailed account of days where Message 2 and/or Message 3s’ were issued is provided below. Each event day has a synopsis of the meteorological conditions that occurred and a general description of HDR operations for that day. The first section describes the conditions for days where Message 2’s were issued.

5.1.1 Message 2 Events

May 30th: (Message 2)

The first Message 2 day of the F2P2 season was on May 30th. This type of event was somewhat unusual in that Message 2’s were issued in part due to a combination of both hydrological and meteorological factors. As of late May, an above average quantity of snowpack still remained at the higher elevations of basins east of the Continental Divide. In the 5 to 6 days leading up to the 30th, a very strong upper-level ‘ridge’ of high pressure established itself over the Central Rocky Mountains. This led to sustained, unseasonably warm temperatures at high elevations leading to exceptionally high streamflow on basins such as Boulder, South Boulder, Bear and Clear Creeks. These high flows effectively reduced the amount of rain required to produce substantial flooding on these basins with the greatest concerns focused on Boulder Creek. The Message 2s were valid only for Jefferson and Boulder Counties given the risk, while Message 1s’ were valid for the remainder of the District. In summary, low-level moisture on the Eastern Plains were unable to move into the area and generate substantial thunderstorm activity as anticipated earlier in the day.

July 27th-28th: (Message 2 & 3 – 27th; Message 2 - 28th)

The other two Message 2 days were back-to-back on Sunday and Monday, July 27th and 28th. A prolonged period of very robust low-level moisture (surface dewpoints in the upper 50s/lower 60s) was prevalent over the District on both days along with very high moisture content through the depth of the atmosphere. On the 27th, a sequence of storms on the western sections of the District produced relatively low amounts of precipitation (considering the conditions) with low-grade Message 1 level rainfall amounts in 10-15 minute time scales. The lone exception to this was a sequence of thunderstorms that were ‘training’ over the same area in the far southwestern portions of the UDFCD in Douglas County near Sedalia. The National Weather Service issued a Flash Flood Warning for this area given rainfall estimates in the 3-4” range and HDR concurred with this given the atmospheric potential and a lack of high-density rainfall gauges that were in the vicinity of these storms. Various reports from the area indicated significant street flooding and some swollen tributaries to Plum Creek. However, no reports of flooding of a devastating or damaging level were reported.

On the 28th, similar conditions from a temperature/moisture standpoint persisted across the District as a ‘refreshing’ surge of very moist low-level air moved into the area during the mid-morning hours. This helped in maintaining conditions favorable for thunderstorms capable of producing rainfall amounts that would exceed flash flood guidance. Scattered thunderstorms eventually developed over the western and

southern portions of the District however, the impact of this activity was limited in terms of intensity and duration. Recorded precipitation amounts were limited to what could be characterized as just meeting Message 1 rainfall criteria. No significant rainfall that would be categorized as Message 3 criteria appeared to have fallen this day in the District.

5.1.2 Message 3 (only) Events

Four (4) Message 3's (Flash Flood Warnings) were issued by HDR and the National Weather Service (respectively) during the 2003 operational season. These days were on Thursday May 15th, Friday July 18th, Sunday July 27th and Tuesday July 29th. The events on July 27th have been detailed in the sections above with the remainder detailed below.

May 15th: (Message 3)

In summary, a very moist low-level airmass was entrenched over the Plains with a strong convergence line/Denver Cyclone in place just to the east of the District. It is surmised that a weak low-level circulation developed over N. Adams/SW Weld Co. and essentially 'wrapped around' the circulation westward into the Boulder vicinity, bringing a rapid increase in moisture to the immediate vicinity. Observations from the NCAR Foothills Lab clearly indicated this rapid change in airmass in a very short period of time. During this period, a modest line of thunderstorms appeared to be moving along the foothills of Larimer Co. southward into Boulder Co. The apparent convergence of these two features resulted in a strong line of thunderstorms that developed in a fairly narrow north-south orientation a few miles west of the foothills/plains interface in Boulder Co. This line of thunderstorms produced extremely heavy rainfall in the near vicinity with rain gauges registering over 1.50" of rain in 30 minutes with storm totals just exceeding 3.00" in a location northwest of Boulder (CoCoRahs observer-see Figure 3). The greatest amount of precipitation in the ALERT gauge system was 2.56" of storm total rainfall at Batasso (gauge #4110) in the Boulder Creek Basin. Maps that depict the intense but relatively narrow area of precipitation can be seen in Figures 2 and 3.

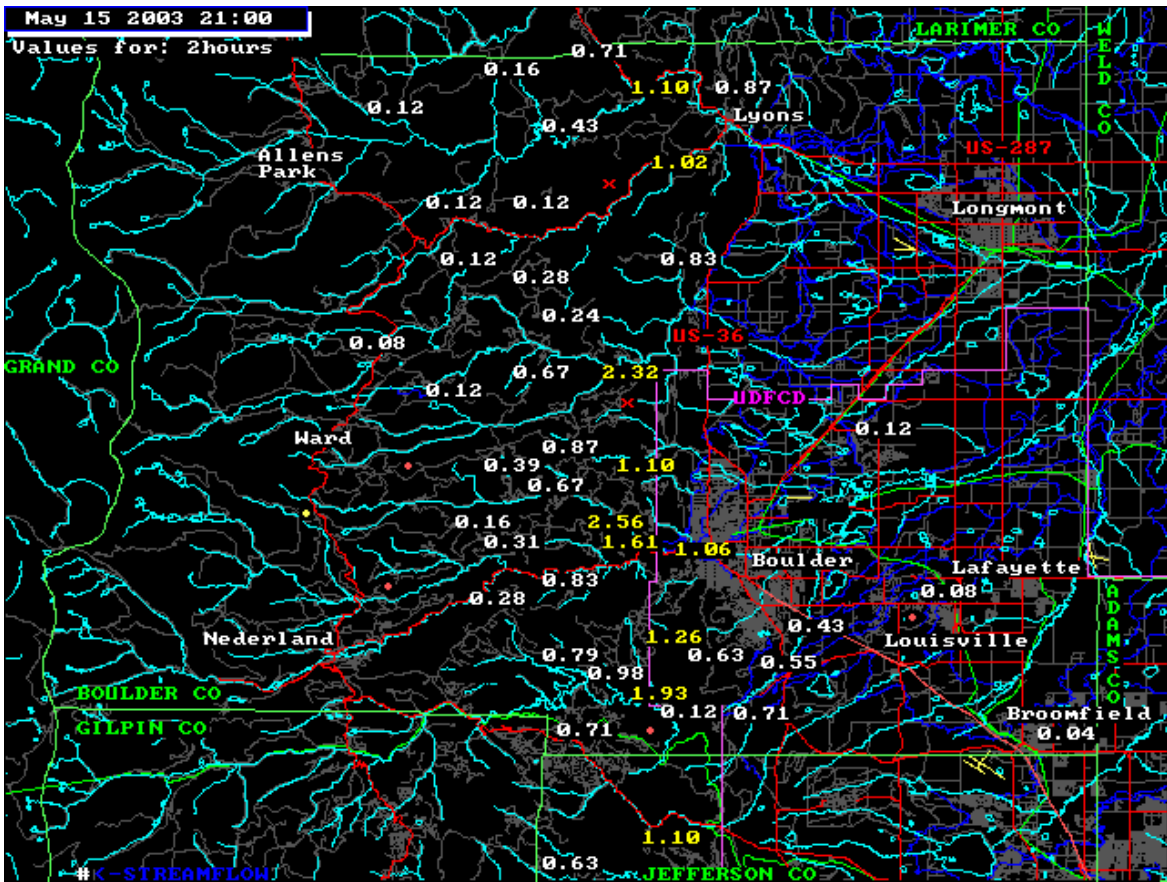


Figure 2. Precipitation recorded by ALERT gauges from 700PM to 900PM on May 15th, 2003

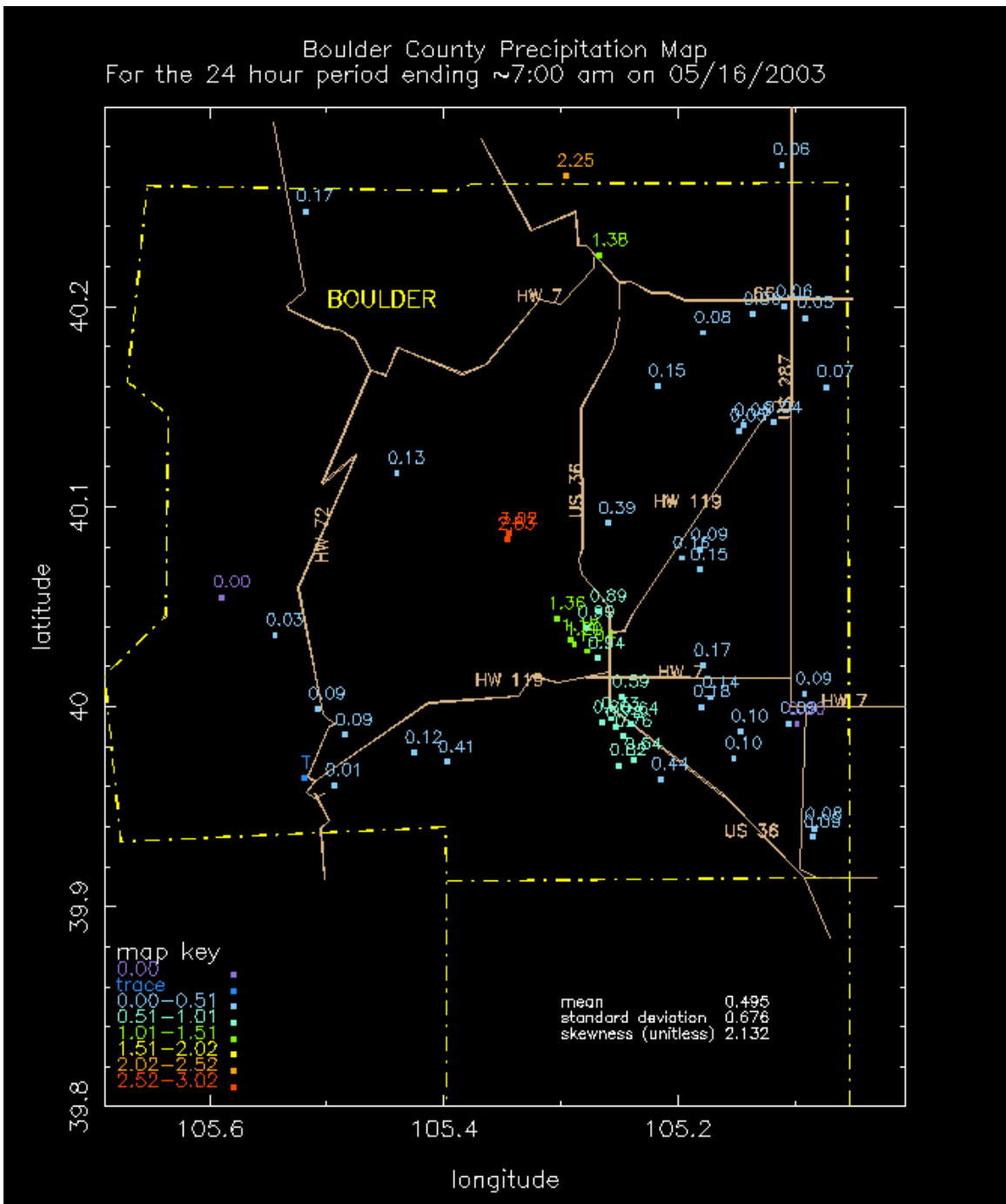


Figure 3. CoCoRahs map of 24-hour rainfall totals from 600 AM May 15th to 600 AM May 16th.

The intense amount of precipitation that fell in the Boulder Co. foothills spurred the National Weather Service to issue a Flash Flood Warning (Message 3) for the Boulder area. Message 1's were issued for Boulder Co. after observing a 0.50" rainfall in a 10-minute period concurrent with the observed heavy rainfall. The Message 3's were issued approximately 35 minutes later, due in part to the Flash Flood Warning issued by the National Weather Service. However, in this instance the actual threat of a 'major' flooding event in the City of Boulder along Boulder Creek was not apparent due

to the fact that this intense rain fell over a relatively small portion of the basin upstream of the City of Boulder. However, there were significant reports of rockslides and flooded structures on a local basis in areas directly underneath and near the heaviest rainfall.

July 18th: (Message 3)

A complex set of meteorological factors occurred on this day, even for July, as conditions across the area were quite docile for most of the afternoon and early evening with early evening temperatures in the upper 80s and dewpoints in the mid/upper 40s around 700 PM. Around 800 PM a sequence of thunderstorms in Weld County and near the Wyoming border assisted in generating a strong gust front moving towards the south. Observations taken near 900 PM indicated that the airmass behind this front was exceptionally moist with surface dewpoints in the mid-to-upper 50s (occasionally at/near 60 F). After this boundary proceeded through much of the District in the 8:00-9:00 PM time frame, a line of intense thunderstorms developed on a line from Parker to the Denver Tech Center to Western Aurora near 9:45 PM. This line of storms formed in the post-frontal airmass along what appeared to be a pre-existing boundary that was previously undetected before the frontal passage. Due to the extremely humid airmass in the wake of this system this line of storms produced exceptionally heavy amounts of rain in its' wake. Measured rainfall intensities near 2.00"/hour occurred in sections of SE Denver causing numerous flooding problems in the Goldsmith Gulch basin. The observed rainfall intensities during the peak of the event triggered the National Weather Service to issue a Flash Flood Warning (Message 3) for much of the area detailed above near 10:15-10:30 PM. Given the actual observed rainfall rates at the time and the extremely moist low-level conditions in place at that time, HDR concurred with the Flash Flood Warning with Message 3's given that the thunderstorm complex indicated little movement at the time of peak intensity and the uncertainty of substantial movement or weakening. Fortunately, these storms did dissipate after 60 to 90 minutes and did weaken some during that time period. In terms of F2P2 operations HDR had issued Message 1s' for Denver Co. around 9:45 PM but these messages were issued at nearly the same time that heavy rainfall began to fall in the vicinity and lead-time was minimal.

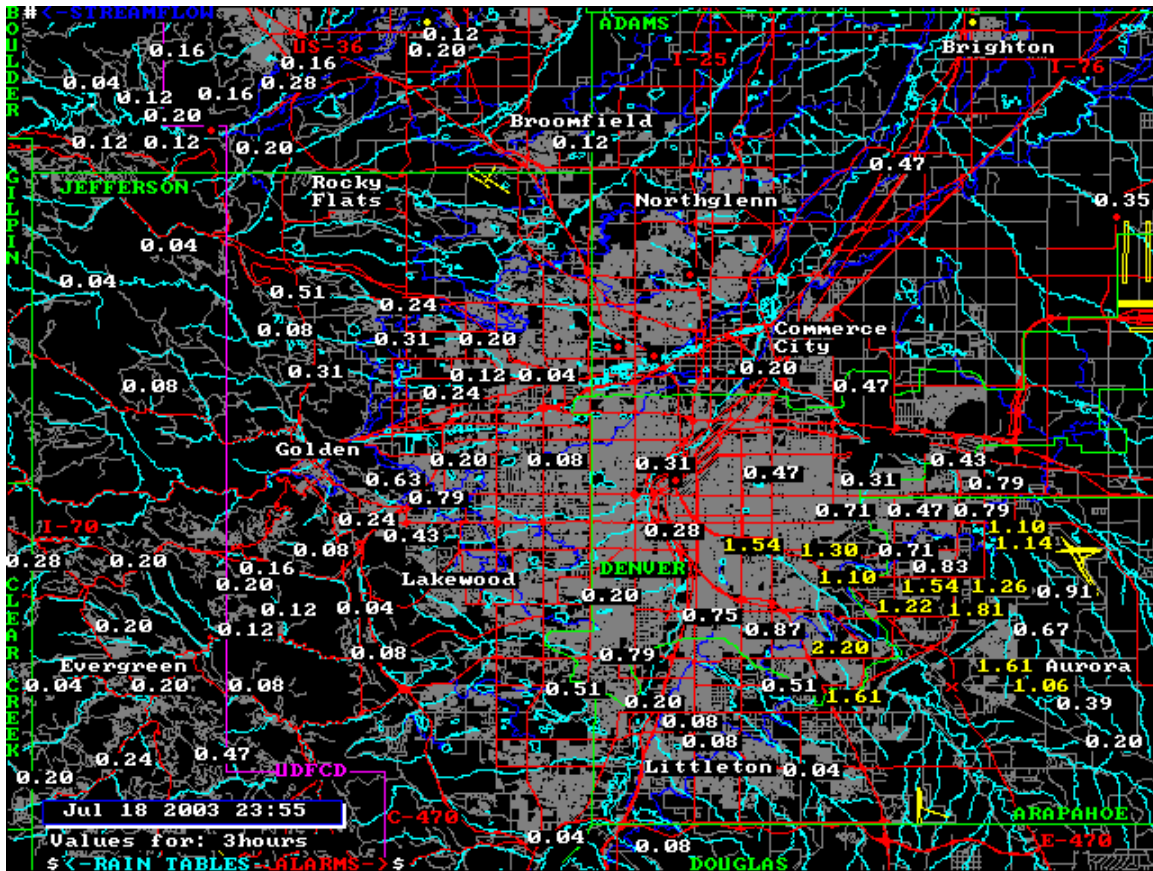


Figure 4. ALERT 3-hour total rainfall (i.e. storm totals) from 855PM to 1155 PM July 18th, 2003.

July 29th: (Message 3)

This day was the end of a 4-day stretch of active weather, which encompassed Messages 1's from the 26th through the 29th (note: the two days with Message 2's immediately before it). The vertical and low-level moisture conditions had decreased some from the prior two days but were still ripe for Message 1's. Another exacerbating factor for strong thunderstorm development on this day was that the mid/upper-level winds (from 10-20,000' above sea-level) had shifted to a more favorable position to allow foothills-based storms to propagate onto the Plains. Also, morning analysis indicated a series of well-defined upper-level disturbances forecast to move through the District, which was also a feature that had been somewhat 'lacking' in the prior two days. A strong line of storms began to move through the District in the 100 to 300 PM time frame. As storms formed in the Boulder Co. foothills and moved southward into Jefferson Co., they reached what appeared to be their maximum rainfall intensity along/near the foothills/plains interface. The Van Bibber at Colorado 93 gauge (#330) recorded a fairly impressive storm total of 1.34" with an embedded 0.91" in 15 minutes. Reports of a substantial water flow over Colorado 93 to the National Weather Service in Boulder along with the heavy rainfall mentioned above prompted them to issue a Flash Flood Warning for Jefferson County. This prompted a Message 3 to be issued by HDR however, it was not believed to be necessary due 1) the total rainfall amounts that were forecast to fall and 2) individual storms were moving at a modest speed and not remaining over any particular area for a prolonged period of time. Message 1's and appropriate StormTraks were issued with appropriate lead times. Other measured

storms total amounts also registered in the 1.00" to 1.40" in a concentrated area north and south of gauge #330 from the Boulder County line down towards western Lakewood.

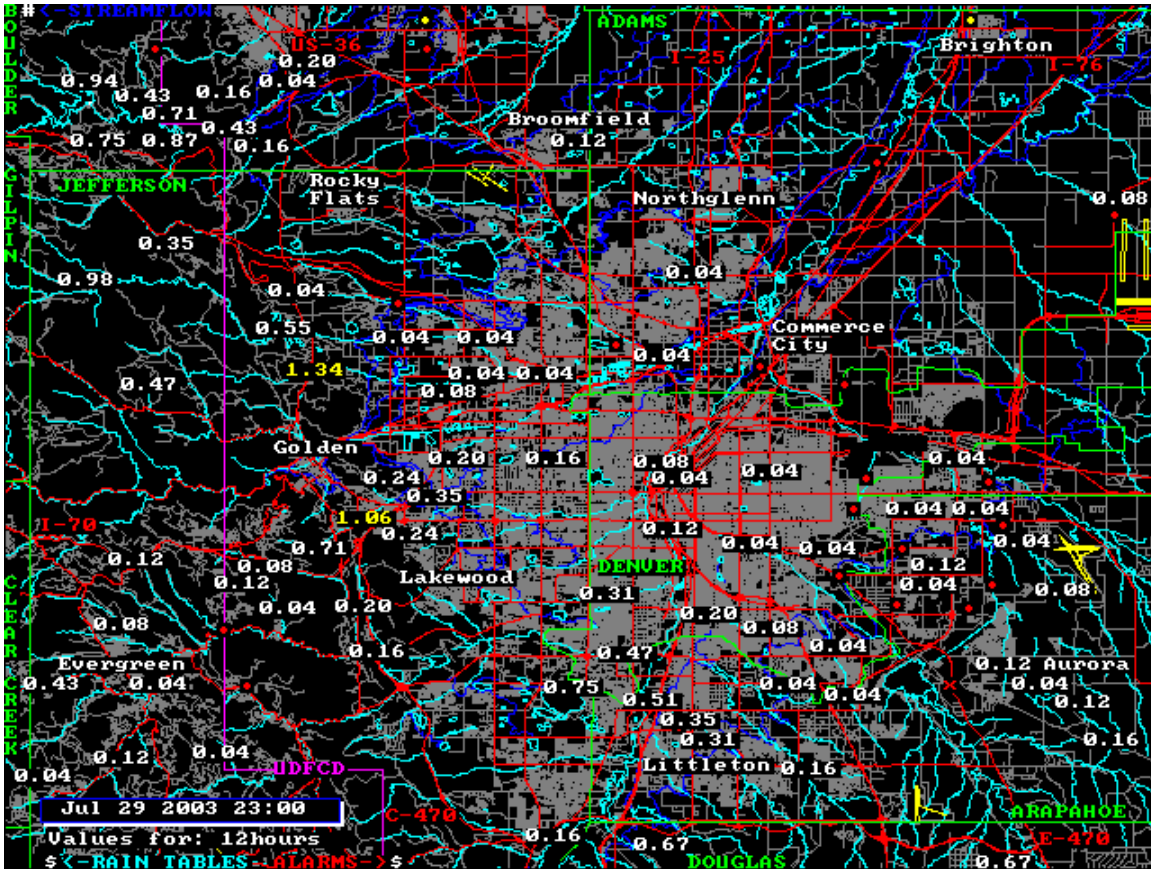


Figure 5. ALERT storm total rainfall for July 29th, 2003 (Period is from 1100 AM to 1100 PM).

5.2 Significant Storms of 2003

The five most significant “storm events” in the 2003 F2P2 are listed below in the order of severity of impact in the District:

- 1) July 18th: Please see section 5.1.2 above.
- 2) May 15th: Please see section 5.1.2 above.
- 3) July 29th: Please see section 5.1.2 above
- 4) August 8th:

The conditions for this day were on the nearing the proverbial ‘borderline’ in terms of initial Message issuance in the late afternoon hours with surface dewpoints in the upper 40s with some indications that Messages would be required later in the day. In the 6:00 to 6:30 PM time frame a cluster of storms began to migrate south southeastward over the foothills of Boulder County. The ALERT Mesonet detected a

notable shift in the surface winds over the eastern and central portions of the District from weak southerlies to modest easterlies, with increasing low-level moisture. This cluster of storms began to indicate some notable intensification over southern Boulder County. As these storms moved off of the foothills and across the plains, some notable intensification occurred while proceeding southeastward. The result was the production of some, intense rainfall over the central portions of the District, mainly in Denver and Arapahoe Counties. Peak storm-total rainfall amounts were in the 1.00"-1.35" range with numerous reports in Denver Co. between the ALERT and CoCoRaHS measurement networks. The peak 15-minute rainfall in the ALERT network was 1.02" at the Cherry Creek @ Steele gauge (#1720) with a storm total of 1.34", which was the highest amount of all gauges in the area. Given the mesoscale conditions around 630-645 PM, HDR was concerned that Message-level rainfall was appearing more imminent across the plains portions of the District and not necessarily the foothills. From an operational standpoint, HDR was in the midst of issuing Message 1's for most of the remainder of the District when the activity over Boulder Co. intensified. The Message-level rainfall recorded in Boulder Co. was detected but due to the current position and movement of the storm-responsible for the rainfall, near the Boulder/Jefferson County line, a decision was made to not issue a Message A in order to properly notify the other counties that were to be affected by the storm in the near future.

5) June 17th:

This day could be considered quite prolific in terms of a 24-hour period. A small but very robust storm formed in the 230-300 AM time frame in the vicinity of US-36 and Federal Blvd. This storm began to move south southeastward over extreme western Adams Co. and eventually through northwestern and central Denver. This storm produced some very localized and brief but heavy rainfall of approximately 0.50" in 10 minutes in Adams and Denver Counties. An interesting characteristic of this storm was the nocturnal nature of its development. A post-event analysis surmises that this storm developed on the intersection of a stalled outflow boundary, from thunderstorms that occurred that previous evening, and a rather 'ordinary' surge of air moving south across the plains. The robust nature of this activity began to dissipate around 4:30 AM and completed by 5:00 AM.

After the nocturnal event described above, skies cleared in the morning and early afternoon hours and a second round of storms fired up along the Front Range in the 200-500 PM range across the District producing Message-level rainfall over portions of the District. After a respite of about 4 to 5 hours, another surge of air moved across the plains entered the district from the north. This helped to trigger yet another round of storms across the southern and eastern sections of the District. Although actual depth/duration amounts bordered on the lower end of Message 1 level criteria, storm total amounts from the afternoon and late-evening activity produced some fairly robust amounts. There were numerous reports of >1.00" amounts across the District. The highest recorded amount was 1.93" in extreme southeastern Denver County, (near JF Kennedy Golf Course/Cherry Creek Dam). There were also reports of 1.34" and 1.50" of storm total rainfall nearby in extreme western Aurora.

6.0 Recommendations and Comments

ALERT Mesonet

In general, the ALERT Mesonet was again deemed a reliable source of data in determining the rainfall threat in the District this year. The loss of the Urban Farm weather station on June 26th 2003 F2P2 season was considered a disappointing loss to the network especially with respect to detecting real-time conditions over the northeastern section of the District. Current efforts to restore the Urban Farm site to the old Stapleton site are proceeding and HDR would like to encourage this process to continue with site installation before the 2004 F2P2 season.

Another concern with the ALERT Mesonet is over the Quincy Reservoir site in the southeastern portions of the District. Many times during the peak portions of the season, this station registered readings that could have been deemed unreasonable when comparing data to neighboring sites. These discrepancies were the most notable during the 'peak' summer months of the program, from June to August.

Xpedite Internet-based broadcast fax service

The Xpedite fax delivery service performed optimally a majority of the time during the program. There were 2 instances this season where the service was not functioning during non-scheduled maintenance and those are difficulties that must be dealt with on a case-by-case basis. In addition, there is the 'nuisance' of the alternating weekly maintenance that Xpedite performs on Saturday evenings. It is suggested that if Xpedite continues to serve as the program broadcast fax service, a brief SOP be drafted between the PMS and UDFCD to address the protocol and priority of communications in these cases.

Internet Access/Computing Facilities:

HDR was pleased with the Internet and computing capabilities provided by the UDFCD at the Flood Prediction Center. No recommendations or alterations are to be made here.

Flood Warning Plans

HDR suggests that a preliminary evaluation study be undertaken to assess the potential need and feasibility for enhancing existing Flood Warning Plans (FWP) listed in section 3.0 or upgrading the existing FWP's to Flood Response Plans (FRP). Such upgrades and enhancements could assist affected counties and communities in maximizing the information provided by the F2P2, the UDFCD ALERT system, and incorporate new technologies including GIS. FRP's would provide pro-active response actions for emergency response agencies in these communities.

Such an evaluation would encompass such tasks as interviewing and information gathering of various agencies involved with flood response and flood related activities. This information would be utilized in generating recommendations for enhancements and cost estimates to enhance the FWP's and upgrade FWP's to FRP's. In addition, the

role and utility of the F2P2 to the response organizations will be assessed along with a recommendation for future enhancements to that program.

Additional Meteorological Data Sets

HDR would like to suggest the following in regards to two particular data sets in regards to operational forecasting and real-time analysis.

1) Colorado-Department of Transportation (C-DOT) surface weather data stations

HDR is pleased that this data set is now available to the public after many years. This data stream has the potential to effectively double, if not triple the amount of real-time surface data in Eastern/Central Colorado. Currently, the only portal to view this data is through MADIS at NCAR. Although this data set is very thorough in nature, it is deemed somewhat cumbersome from an operational standpoint. HDR would recommend that other delivery methods of receiving or viewing the data be made available to the PMS next year.

2) ACARS (Aircraft Communications Addressing and Reporting System)

The NCAR Forecast Systems Lab (FSL) has developed what could be described as a useful web-based application to view ACARS data in real-time. A consistent source of uncertainty during the course of operations this season was assessing the 'representativeness' of the temperature/wind profile of the sub-cloud layer by use of surface-based observations stations. Although the use of the ALERT (and potentially the C-DOT sites) in the elevated terrain of the foothills may provide some guidance, HDR suggests that the UDFCD continue to pursue ACARS availability from FSL. If this request is not deemed possible by FSL, or other entities with the authority to deny access, then HDR would request that archived ACARS data be made available to the PMS for post-event assessment in future seasons.

GIS-Based Products

1) STORMTRAK

The production of the Stormtrak product was altered in June of 2003 with the arrival of the MxAnalyst server from Meteorologix. After some initial alterations after implementation, the product performed at an optimal level. HDR is generally pleased with the current product.

2) QCP2 and QRPM

The development of the QCP2 and QRPM product was not implemented in the 2003 F2P2. At a post-F2P2 meeting, the actions needed to implement this system were addressed. Actions will be taken before next year to ensure that this system will be implemented and operational for the 2004 program for the PMS and UDFCD to utilize.

3) Other GIS-Information

The use of the Meteorologix MxAnalyst for the display of radar data was deemed very useful in terms of identifying precise storm location with respect to certain geographical boundaries. Identification of UDFCD District boundaries, county boundaries and major and minor highways assisted the HDR meteorologists in ensuring storm location and in Stormtrak issuance. HDR would like to encourage the District to develop more layers GIS-based information in radar-based products. Such information would include the delineation of drainage basins that are of prime concern to the District both in the foothills and the plains. Also, the development of GIS-based files depicting the ALERT rain gauge sites with naming references might be deemed useful for real-time radar-rainfall verification to the PMS in future operations as well.

7.0 Summary

The 2003 UDFCD F2P2 operated from April 15th to September 15th for the 25th consecutive year. This years' program was conducted by HDR Engineering Inc. with Skyview Weather acting as a subcontractor from May 15th through September 15th, which was the first time two entities operated the program. Overall, there were 30 official Message days in the F2P2, which is below the long-term average of 35 while there were 4 days with Message 3s' and 3 days with Message 2's. These numbers are above average in terms of Message 3's and near normal for Message 2's.

The overall statistics indicate that the verification of Message Day 'hits', as scored on a District-wide basis, registered at 80%, which is lower than the longer-term average of 83%. When the verification statistics are calculated on a county-by-county basis, the statistics indicate a relatively low number of hits (39%), which is lower than the long-term average of 55% and the lowest in the history of the program. HDR considered this 'dual-operation' of the program a challenging situation in terms of providing the same-level of service that had been provided to the District and other end-users in the program in past seasons. Other service alternatives in the future could encompass greater use of internal personnel and/or 'contract' personnel under the direct supervision of HDR staff will be explored if HDR is selected as the PMS for next years' program. A reason for the lower county cumulative verification rates for Messages could stem from the separation of the "metwatch" and the forecast/Message-support components of the program.

Appendix A: Message Issuance and Verification Grid for the 2003 F2P2 Season

#	Day	Date	Counties						Broomfield
			Arapahoe	Adams	Boulder	Denver	Douglas	Jefferson	
1	Wed	4/23	HIT	HIT	MISS	HIT	MISS	MISS	MISS
2	Fri-Sat	5/9-10	HIT	MISS	MISS	HIT	MISS	HIT	MISS
3	Thur	5/15			HIT			MISS	
4	Sun	5/18	MISS	HIT		MISS			MISS
5	Fri	5/23	MISS	MISS		MISS	MISS		MISS
6	Sat	5/24	HIT	MISS	MISS	MISS	HIT	MISS	MISS
7	Sun	5/25	MISS	MISS	MISS	MISS	MISS	MISS	MISS
8	Fri	5/30	MISS	MISS	MISS	MISS	MISS	MISS	MISS
9	Sat	5/31	MISS	MISS		MISS	MISS		MISS
10	Tue	6/17		HIT		HIT		HIT	
11	Tue	6/17	HIT	HIT	HIT	HIT	HIT	HIT	HIT
12	Wed	6/18	HIT	HIT	MISS	HIT	HIT	MISS	HIT
13	Thur	6/19	HIT	HIT	MISS	HIT	MISS	HIT	MISS
14	Sun	6/29	HIT	MISS	MISS	MISS	HIT	MISS	MISS
15	Fri	7/18	HIT	MISS		HIT	MISS	MISS	MISS
16	Sat	7/19	HIT	MISS	MISS	MISS	HIT	MISS	MISS
17	Sat	7/26	HIT	MISS	MISS	HIT	MISS	MISS	MISS
18	Sun	7/27	HIT	MISS	MISS	HIT	HIT	HIT	MISS
19	Mon	7/28	HIT	MISS	MISS	MISS	HIT	HIT	MISS
20	Tue	7/29	HIT	MISS	MISS	HIT	HIT	HIT	MISS
21	Tue	8/2	MISS				MISS	MISS	
22	Wed	8/3	HIT	MISS	HIT	HIT	HIT	HIT	MISS
23	Fri	8/8	HIT	HIT	MISS*	HIT	MISS	MISS	MISS
24	Sat	8/9	MISS	MISS	MISS	MISS	MISS	MISS	MISS
25	Mon	8/11	HIT	MISS	MISS	MISS	HIT	MISS	MISS
26	Mon	8/18	HIT	HIT	HIT	MISS	HIT	MISS	HIT
27	Sat	8/23	HIT	HIT	MISS	MISS	MISS	MISS	MISS
28	Sun	8/24	MISS	HIT	MISS	MISS	MISS	MISS	MISS
29	Fri	8/29	MISS	MISS	MISS	MISS	MISS	HIT	MISS
30	Sat	8/30	MISS	HIT	MISS	HIT	MISS	MISS	MISS
			HIT	Message issued with <10 minutes of lead time					
			MISS*	Message level rainfall observed with no Message issued					

**Appendix B:
UDFCD F2P2 DISTRICT-WIDE MESSAGE DAY STATISTICS
1979 - 2003**

	Message 1	Verified	Verified	Not	Percent	False	Probability
Year	Days	Hits	Misses	Forecasted	Accuracy	Alarm %	of Detection
GRD "District" Era	1979	26	17	9	3	65%	85%
	1980	35	23	12	0	66%	100%
	1981	40	31	9	0	78%	100%
	1982	42	34	8	0	81%	100%
HKA "County" Era	1983	37	32	5	0	86%	100%
	1984	38	32	6	0	84%	100%
	1985	28	25	3	0	89%	100%
	1986	35	30	5	1	86%	97%
	1987	47	40	7	0	85%	100%
	1988	28	24	4	0	86%	100%
	1989	31	26	5	0	84%	100%
HMS "Basin" Era	1990	30	26	4	2	87%	93%
	1991	42	31	11	0	74%	100%
	1992	29	25	4	0	86%	100%
	1993	28	25	3	0	89%	100%
	1994	26	24	2	0	92%	100%
	1995	43	35	8	1	81%	97%
	1996	52	41	11	0	79%	100%
	1997	40	38	2	1	95%	97%
	1998	34	28	6	0	82%	100%
	1999	45	37	8	0	82%	100%
	2000	23	19	4	1	83%	95%
HDR	2001	42	39	3	0	93%	100%
	2002	23	16	7	0	70%	100%
	2003	30	24	6	1	80%	97%
Total District Era	143	105	38	3	73%	97.2%	
Total County Era	244	209	35	1	86%	99.5%	
Total Basin Era	433	369	64	5	85%	98.5%	
Total HDR Era	65	55	10	0	83%	100%	
Total	874	722	153	10	83%	98.8%	
25 Year Average	35	29	6.1	0.4	84%	98.8%	