2000

UDFCD FLASH FLOOD PREDICTION PROGRAM ANNUAL REPORT

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

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 forecasts of a Private Meteorological Service (PMS) to augment the traditional forecast services of the National Weather Service (NWS) for the six-county District region.

The District forecast area supported 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. 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 ~20 percent in the period of 1990 to 1999 and prediction service requests have increased noticeably in the past three years in Boulder, Douglas and Arapahoe Counties.

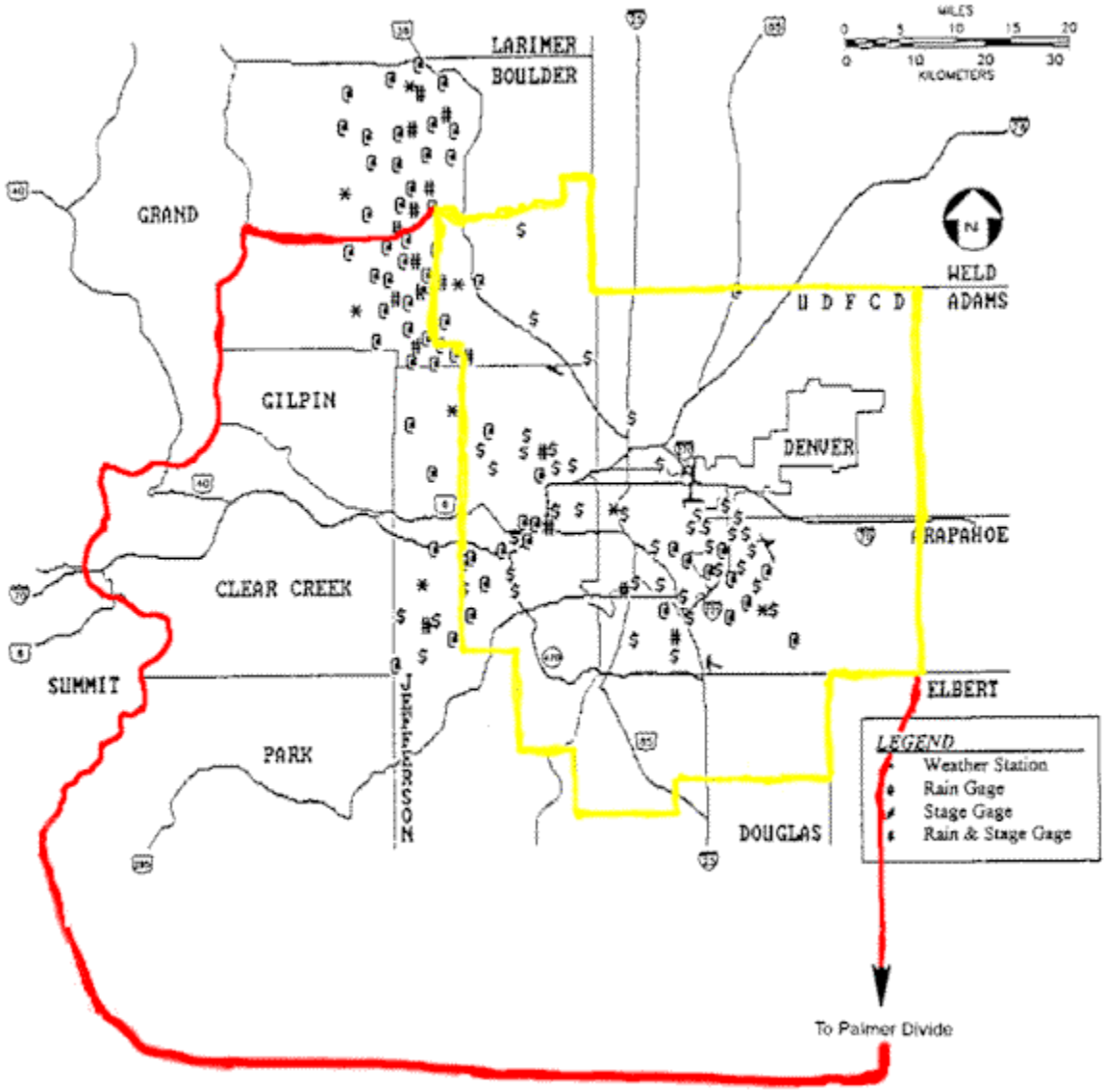
Henz Meteorological Services (HMS) of Denver was selected as the 2000 F2P2 Private Meteorological Service. HMS provided similar services for the 1990 to 1999 F2P2's. HMS forecast meteorologists John Henz, Bryan Rappolt and William Badini provided services.

2.0 2000 Operational Season

The F2P2 season began on 15 April 2000 and continued through 15 September 2000 for **154 operational days**. Normal operational hours were from 0700L to 2200L and covered **2,322 hours**. During the period from 1000PM to 0200AM HMS meteorologists added an **additional 64 hours** of support time as storms in eastern Adams, eastern Arapahoe and northern Douglas Counties persisted over newly populated areas near Denver International Airport, Parker and eastern Aurora. Overnight forecasting from midnight to 700 AM added an **additional 72 hours** for a total of **2,458 hours of F2P2 activity**. This five per cent increase in operational hours past 1000PM is due to population increase in eastern and southern portions of the District in Adams, Arapahoe and Douglas Counties.

The F2P2 required a continuous **Metwatch** of the District for the entire period using the NWS WSR-88D Doppler radar, satellite, conventional surface and upper air observations and local ALERT and weather station networks. These observations were used by HMS meteorologists to prepare in-house analyses, predictions and specialized F2P2 products. These products included daily **Heavy Precipitation Outlooks (HPO), MESSAGE 1, 2, 3 and 4's, Message updates, Quantitative Precipitation Forecasts (QPF) and StormTraks.** The HPO's were issued at least once daily to describe the potential for heavy precipitation in each of the District counties. Messages were issued on those days when the potential of heavy rainfall capable of producing some form of flooding in the District or a portion of the District was deemed possible. QPF's and Storm Traks were issued on Message days to provide additional weather support to the F2P2 user community.

Figure 1 The District and F2P2 Forecast Area



3.0 2000 F2P2 Operational Product Production

The F2P2 is designed to offer a unique, basin-specific weather information source concerning heavy precipitation, urban flooding and flash flooding threats to the six participating District Counties and the cities within those counties. Direct support is rendered to the District basin-specific 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.
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 southcentral Denver.
4. **Westerly Creek Flood Warning Plan**, which impacts eastern Denver and western Aurora.
5. **Toll Gate Creeks Flood Warning Plan**, which impacts central and southern Aurora.
6. **Ralston Creek Flood Warning Plan**, which impacts central Arvada.
7. **Bear Creek Flood Warning Plan**, which impacts Jefferson County and southern Lakewood.

Five specific F2P2 products exist as expert-to-user support. These products are **Heavy Precipitation Outlooks (HPO), Messages, Internal Message Status's (IMS), Quantitative Precipitation Forecasts (QPF) and HMS Storm Trak predictions.** During the 2000 season HMS delivered the following quantities of the identified F2P2 Fax Products:

Table 1 2000 F2P2 Production Summary

Product	Number issued*
Heavy Precipitation Outlook (HPO)	***327***
Message Forms and Updates	***136***
Internal Message Status (IMS) statements	***92***
Basin-Specific Quantitative Precipitation Forecasts	***7***
StormTraks	***57***
Total	***619***

- NOTE: In order to compare to previous years take number issued times the number of Broadcast Fax recipients

These products were delivered via fax and Broadcast Fax to participating agencies. The majority of the faxes were sent on the US West Broadcast Fax service network. Broadcast fax was used to send high impact products with a short “shelf life” such as HPO's, Messages, StormTraks and IMS’s.

While fax service dominated the “hard copy” F2P2 products, significant electronic copy service was provided to the F2P2 via **the Internet**. All HPO, IMS and QPF products were sent to the HMS F2P2 Web Page. The District F2P2 Web Page is subsequently linked to those products. HMS sent **327 HPO products, 62 IMS and 7 QPF** products through the District’s Web Page.

The on-demand access of the Web Page products to decision-makers using office and home computer systems is a desirable asset of the Web Page service. HMS logged over **1,000 storm-related telephone interactions** during the program, emphasizing the **strong technical "touch"** of the program in the local community. HMS used three dedicated telephone lines: two for voice and one for fax products. These three lines were adequate to handle the volume of communications generated during peak storm periods. User input indicates that the quality of the faxed Storm Traks has improved sufficiently to supplant event verbal “hand-holding” to some degree.

4.0 2000 F2P2 Operational Verification

The **primary service rendered by the F2P2** to participating local governments and associated emergency response agencies **is the issuance of value-added weather forecasts of flash flooding potential, urban and stream flooding, and locally heavy rainfall**. HMS indicates the potential for these events in a series of Messages issued directly to the users by phone, fax and Web Page. The definition of each Message is given below in **Table 2**.

Table 2 Message Definitions used in the District Flash Flood Prediction Program (F2P2)

MESSAGE 1 (*Internal Alert*)

A Message 1 is an advisory message meant to inform key people in local emergency response community that weather conditions are such that flood producing storms could develop later in the day. It is issued after forecast discussions between HMS and National Weather Service (NWS). The advisory is preceded by the statement, “ THIS IS A RED FLAG MESSAGE”, when HMS deems priority handling by communications dispatchers is required.

MESSAGE 2 (*Flash Flood Watch*)

This Message indicates that a Flash Flood Watch has been issued by the NWS **and/or** HMS feels that the risk is high that a life-threatening flood may occur later in the day. This Message requires priority handling by communications dispatchers.

MESSAGE 3 (*Flash Flood Warning*)

This Message indicates that a Flash Flood Warning has been issued by the NWS **and/or** HMS feels that the risk is high that a life-threatening flood is imminent. This Message requires priority handling by communications dispatchers.

MESSAGE UPDATE

This Message is used by HMS to provide additional information to any of the above Messages on the developing weather situation. For example, this Message has been used to narrow a NWS Watch or Warning area, as more information becomes available or to provide more site-specific information during an event. If HMS feels that this Message requires priority handling by a communications dispatcher, it is preceded by the statement, “ THIS IS A **RED FLAG** MESSAGE ”.

MESSAGE 4 (*All Clear*)

This Message cancels the flood potential status. HMS issues it after consultation with NWS and other entities involved with direct HMS communications.

The issuance of F2P2 Messages is quantitatively linked to both the rainfall potential of the weather events and the response of the District basins to the rainfall. **Table 3** shows the criteria for Message issuance based on both the rainfall potential and the anticipated response of the District basin.

Table 3 UDFCD Flash Flood Prediction Program Message Criteria

UDFCD FLASH FLOOD PREDICTION PROGRAM
MESSAGE CRITERIA

Message 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 a significant problem. 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 a significant impact on street runoff. Rainfall rates are predicted or observed to **exceed 1.00"/30** minutes **and** the storm is considered **imminent**.

Message 2:	Issued to local governments when the threat of potential life threatening flooding is predicted or the NWS issues a Flash Flood Watch. A HMS-generated M-2 is the equivalent of a Flash Flood Watch. M-2 lead-times of several hours are desirable.
M-2 Rainfall intensity criteria:	**>3.00"/hour or a lower value based on mutual discussion between NWS, District and HMS due to antecedent rainfall impacts on soil saturation and/or runoff characteristics.**

Message 3:	Issued to local governments whenever 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.

4.1 Message Verification

The verification of the messages issued by the District's F2P2 is presented in **Table 4**. This year's verification is presented in a simplified verification scheme that embodies common sense. A message day is defined as any day from 15 April to 15 September on which a Message 1 or Message 2 is issued based on the criteria presented in **Table 3**. Messages were issued on 23 days during the 2000 F2P2. The next column shows the number of message days on which rainfall events were observed which met or exceeded the message criteria described in **Table 3**. In 2000 there were 20 days on which events met the criteria. Thus the F2P2 forecasts of a message day were correct 87 percent of the time.

Individual messages are issued to counties, cities and flood warning plan basins. Typically, more than one message is issued on a message day. The next column shows the number of messages issued on the message days. A total of 143 messages were issued on message days or an average of about 6 messages per message day. The next column shows the number of messages that verified with a rainfall event meeting the criteria in **Table 3**. Approximately 57 percent of the messages verified. This value is just about average for the 22-year F2P2 statistics.

Message issuance is used to alert the District users that the potential exists for street flooding or flash flooding rainfall. The operational period runs 154 days from 15 April to 15 September. The F2P2 correctly identified that heavy rainfall would not fall on 85 percent of the days during that operational period. On the days a message was issued heavy rainfall was observed over 50 percent of the time. Thus, the 57% message verification rate has proven to be effective for users because of the significant number of days on which messages are not issued.

Table 4: Monthly Message Verification for the 2000 F2P2 Operational Season

Month	Message Days in District	Message Days That Verified	Number of Messages Issued	Number of Messages That Verified	Percent of Messages Vefifying
April	0	0	0	0	
May	2	2	13	11	85%
June	1	0	6	0	0
July	6	6	39	22	56%
August	13	12	80	50	63%
September	1	0	5	0	0
Total	**23**	**20**	**143**	**81**	**57%**

Message 1's were issued on a **total of only 23 days, the lowest number of days in the 22-year history of the F2P2**. The **20 observed M-1 days were the lowest observed in the past 22 years**. In 2000 **57 percent of the 136 M1's verified which was slightly above the 22-year average**. ***The 81 verified message events were the lowest recorded since the F2P2 began.***

If storm rainfall intensities are sufficient to create serious street flooding or flash flooding, the District PMS issues either a Message Red Flag or Message 3, Flash Flood Warning. A Red Flag was issued 25 times and verified 25 times for the third straight 100 percent verification rate. The improvement in Red Flag (RF) verification marks the fifth straight year of 98 percent verification or better. This consistent effort reverses the past concern that RF issuance was over-stimulated by the NWS WSR-88D Doppler radar and that customer RF expectations were not being met.

Message 3's (***Flash Flood Warning or Flood Warning***) were issued by the National Weather Service for **3 storm events and one verified. HMS did not concur with the Message 3 issuance on July 16 and for the "District-wide" Message 3 on August 17. HMS believes that the NWS over-reacted on July 16th and on the second M-3 of August 17 due to a variety of operational reasons related to radar-rainfall estimates.** In each case, HMS called affected communities and informed them of weather factors. Close coordination between NWS and HMS meteorologists on storm days kept both organizations "on the same page" most days to the public's benefit.

4.2 County Message Verification and Service Evaluation

Each of the messages issued in the F2P2 is released to a specific county dispatcher in which the flooding potential has been forecast. Some of the Messages are issued for a portion of a county while others are issued for a specific basin supported by a Flood Detection Network (FDN). A County message is verified as a **"hit"** only if a rain/flooding event meeting the message criteria in **Table 3** occurs in the **District portion of that county or in the drainage area of a stream flowing into the District**. **Table 5** below summarizes the results of the 2000 F2P2 verification by county.

Table 5: County Message Verification for the 2000 F2P2 Operational Season

Group	Messages	Message Hits	% M Hits	Red Flags	RF Hits	% RF Hits	% RF M-1's	Events Missed	Event<10 min Lead
County									
ARAP	23	18	82	4	4	100	18	0	1
ADM	20	13	68	4	4	100	21	0	0
DUG	21	14	65	2	2	100	10	1	1
BOU	17	7	38	1	1	100	07	**0**	**0**
JEF	20	10	47	1	1	100	05	1	1
AUR	21	11	55	3	3	100	15	**0**	**0**
DEN	21	9	45	4	4	100	20	0	0
TOTAL	**143**	**82**	**57**	**19**	**19**	**100**	**14**	**2**	**3**
FDN/FWRP									
ARV				2	2	100	100		
LAK				2	2	100	100		
WHT				2	2	100	100		
TOTAL	0	0	0	6	6	100	100		

Verification for the City of Aurora was added to the County statistics. The same criteria apply for a Message issued for a basin-specific FDN. Messages are designed to support both the unique District flood-warning plans associated with Flood Detection Networks (FDN) and other portions of the counties and cities in the District, which do not have a FDN. Verification of each message by county provides a means of assessing the accuracy of the support given to these areas. **Consistency** was noted in the accuracy of the County messages issued during 2000.

Table 5 shows the County and City M1 and Red Flag verification. Most county verifications dropped to just above average levels for 2000. The primary reason for this change was the added degree of forecast difficulty offered faced in 2000. Most messages are issued on days with clearly defined weather causes for the locally heavy rainfall. In 2000 gust front collisions were the primary weather cause of message event occurrence on 16 of the 24 days or 68 per cent. In 1999 by comparison only 8 of 47 message days, 17 per cent, had gust front collision as the primary cause of the locally heavy rainfall. Typically, HMS meteorologists had to adjust to the rapid influx of boundary layer moisture in the outflows from storms outside the District, which mixed with hot District air and produced strong storms within 20-30minutes of gust front collision. **Outflow boundaries from Weld County were the culprits on 11 of the 16 days and HMS suffered by having only the Brighton and Louisville mesonet stations available to quantify the moisture content of the outflow air. Weather stations in southern Weld County would have helped.**

Improvement was also evident in **Message Red Flag** issuance as evidenced in **Table 5**. A **message indicates** to the user that **the potential exists for a flooding event** later during the day. A **Red Flagged Message indicates that a flooding event is imminent**. In other words the Red Flag means rapid information dissemination and response action is needed. **One hundred percent of the 2000 Message Red Flags verified compared to 100 percent in 1999 and 1998 and 99 percent in 1997**. The Red Flag verification has rebounded to pre-1994 levels for the fifth straight year indicating **users can rely on F2P2 Red Flags. Each Red Flag had a 30-60 minute leadtime.**

Two events occurred on August 13 without a prior message being issued. One of the events occurred over Morrison in the Jefferson County foothills where a rain gauge was hit by two peak 10-minute rainfalls in a "train-echo" effect lasting 30 minutes. One hour later a gust front collision into a storm just south of the District in Douglas County caused a brief 20-minute heavy rain of just over an inch near Castle Pines.

Both events covered areas of less than 2 square miles on radar and no flooding events were noted. In both cases the atmosphere increased low-level moisture rapidly with dew points climbing from 35-40F to 50-55F in less than 15-minutes as mid-level moisture surfaced. **HMS is evaluating the predictability of each event.**

No lead-time was given for these two events and only a 5-15 minute lead-time was given to western Arapahoe County on August 17. A Denver Cyclone over Littleton "spun up" a strong thunderstorm in only 15 minutes. The HMS meteorologist immediately issued a message for the storms and additional messages for downstream areas. The rest of the District received 30-75 minute lead-times. The weather factors producing this day are worthy of re-evaluation.

5.0 Significant 2000 Storms and Heat Records

The 2000 F2P2 set records for being the "most storm-free" summer in 22 years and also the summer with the most days, 61, that the high temperature equaled or exceeded 90F. **Only 20 days were observed with message level events** (19 forecast, 1 un-forecast). Only 20 message days were also observed in 1979 but the lack of flood detection networks and poor radar coverage probably missed an additional 2-3 days. The 22 year average number of message days is 29. In most cases only half as many events were noted in the District this year as compared to last year's record setting summer. As they say all things tend to balance out in nature.

The following F2P2 records were observed in 2000:

1. **Fewest days with messages issued: 23 days**
2. **Fewest number of verified message days: 20 days (ties 1979)**
3. **Fewest number of June verified message days: 0 days**
4. **Fewest number of July message days: 6 days**
5. ***The 81 verified message events were the lowest recorded since the F2P2 began.***

These records under-score the lack of storm opportunities that occurred this past summer season. The storm track remained well north of Colorado in June and July causing a "power shortage" for local storm formation. Additionally, the Arizona monsoon came later than normal, debuting mid-August instead of mid-July, and departing early in September. In short, the big story in 2000 was less rather than more.

Only six M1 event days stand out as extraordinary storm days in the 2000 F2P2:

1. **May 17: South Arapahoe/ Northwest Douglas County 1-2 feet of 1 inch hail and heavy rain**
2. **July 16: Sub-tropical circulation crosses the District and hits all counties with heavy rain of 1.00" to 2.50" in 1-3 hours.**
3. **August 17 and 18: Multiple street and flash flooding events with one death on the 17th**
4. **August 28 and 29: Dual Littleton "thunder-gushers" produced significant street flooding and a two-storm total of over 4.00 inches of rain in less than 30 hours.**

The May 17th event produced the most severe weather damage recorded in the District this past summer. Over 3 million dollars of hail damage was reported in portions of south Littleton and northwestern Highlands Ranch. The July 16th event produced the most widespread rainfall of the summer with all counties reporting at least one 2.00-inch storm. The tragic death of a fireman attempting a water rescue of a women trapped in a car underscored the intensity of the August 17th event. The two 2.00"+ rainfalls were recorded by John Henz in a standard NWS gauge at his home located 1 mile west of Broadway and 1 mile north of Mineral Avenue. Significant street flooding was noted in Littleton on both days.

6.0 Concerns and Recommendations

HMS utilizes this portion of the report to identify important operational developments, operational problem areas and matters of concern, which became apparent during the operational season.

Mesonet

HMS meteorologists have been very pleased with continued upgrading of weather station coverage by the District during the 2000 F2P2. The addition of weather station site on Squaw Peak vastly improved HMS capability to issue basin-specific products such as QPF and StormTraks. HMS supports new weather stations at DIA and Aurora Reservoir in the eastern District to address the expanding population base and a new flood detection network in the southwestern corner of the District where a "data-void area" has existed. Additional stations in Weld County would help with outflow boundary forecasting.

Use of the Internet

HMS recommends that the District aggressively pursue an inventory of F2P2 users to determine if Internet delivery of most F2P2 products would satisfy user needs and offer new venues of user support. Increasing costs of Broadcast fax services and "the paper bound format" of QPF, Message and StormTrak products could be released into a more graphic user-friendly context. Initial response to the use of the Internet for HPO and QPF products should be expended in 2001.

Flood Warning Plans

HMS suggests that the District consider assisting local communities without flood detection networks to develop and exercise community-specific flood warning response plans. The need would appear most acute in the Jefferson and Boulder County foothills where many new communities are developing. Additional need areas may be located in rapidly developing and previously rural land around DIA and in unincorporated portions of Douglas, Arapahoe and Adams Counties.

Recommendations

HMS offers the following recommendations for consideration by the District in 2000:

- **HMS recommends that the District consider the evaluation and enhancement of flood warning response plans for urban and foothills areas of Jefferson, Douglas, Boulder, Adams and Arapahoe Counties where rapidly growing communities have formed**

- **HMS recommends the continued effort to expand the District ALERT Mesonet to assist in the production of basin-specific Message, StormTrak and QPF products.**

- **HMS recommends an inventory of F2P2 users to identify the potential of using the Internet for F2P2 delivery of F2P2 forecast products, including QPF, Messages and StormTraks in graphic formats.**

APPENDIX A

2000

COUNTY AND CITY

DAILY MESSAGE VERIFICATION

2000 F2P2 Verification of Message and Red Flag Message-Days

#	Date	Arapco	Adco	Boco	Denco	Dougco	Jeffco	Aurora	Red Flags	Wht Rg	Lak	Arv	Arapco	Adco	Boco	Denco	Dougco	Jeffco	Aurora
1	5-17	Hit	Hit	Hit	Hit	Hit	Hit	Miss											
2	5-25	Hit	Hit		Miss	Hit	Miss	Hit											
3	6-27	Miss	Miss	Miss	Miss	Miss	Miss												
4	7-10	Hit						Hit											
5	7-12	Hit	Hit	Miss	Hit	Hit	Miss	Hit											
6	7-14	Hit			Miss	Hit		Miss											
7	7-16	Hit	Hit	Hit	Hit	Hit	Hit	Hit		Hit	Hit	Hit	Hit	Hit	Hit	Hit		Hit	
8	7-17	Hit	Miss	Miss	Hit-DIA	Hit	Miss	Miss											
9	7-20	Miss	Miss		Miss	Miss		Miss											
10	8-15	Hit	Miss	Miss	Miss	Hit	Miss	Hit											
11	8-16	Hit	Hit	Hit	Hit	Hit	Hit	Hit											
12	8-17	Hit	Hit	Hit	Hit	Hit	Hit	Hit		Hit	Hit	Hit	Hit	Hit		Hit	Hit		Hit
13	8-18	Hit	Hit	Miss	Miss	Hit	Hit	Miss					Hit	Hit			Hit		
14	8-21			Miss		Miss	Miss												
	8-22	?	?	?	?	?	?	?											
15	8-24	Hit																	
16	8-25	Hit	Hit	Miss	Miss	Hit	Miss	Hit											
17	8-26	Hit	Miss	Miss	Miss	Hit	Miss	Miss											
18	8-27	Hit	Hit		Miss	Miss	Hit	Miss											
19	8-28	Hit	Hit	Miss	Hit	Hit	Hit	Hit					Hit			Hit			Hit
20	8-29	Hit	Hit	Hit	Hit	Miss	Hit	Hit						Hit		Hit			Hit
21	8-30	Miss	Hit	Hit	Miss	Miss	Miss	Miss											
22	8-31	Hit	Hit	Miss	Hit	Miss	Hit	Hit											
23	9-01	Miss	Miss		Miss		Miss	Miss											
% Hit		**82**	**68**	**38**	**45**	**65**	**47**	**55**		**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**

M-1 days: 20 of 23 message days verified: 87% 4 “bust days”: 19 County M-1 misses

County M-1’s: Verified 79 of 136 or 58%; on non-bust days verified 79 of 117 or 67% County Red Flag M-1’s: Verified 100%

2000 F2P2 Verification of Message 2 and 3

#	Date	M-2	Arapco	Adco	Boco	Denco	Dougco	Jeffco	Aurora	M-3	Arapco	Adco	Boco	Denco	Dougco	Jeffco	Aurora
1	7-16												N/C			N/C	
2	7-17		Miss	Miss	Hit	Miss	Hit	Hit	Miss								
3	8-17										MISS	MISS		MISS	MISS	MISS	MISS
3	8-17											N/C		N/C			
% Hit			**0**	**100**	**100**	**0**	**100**	**100**	**0**		**0**	**50**	**100**	**50**	**0**	**50**	**0**

N/C-Non concurrence with NWS issued watch or warning.

APPENDIX B

SUPPLEMENTARY ANNUAL VERIFICATIONS

Table B-1

UDFCD F2P2 DISTRICT-WIDE MESSAGE 1 DAY ONLY VERIFICATION

1979 - 2000

	Year	Message 1 Days	Verified Hits	Verified Misses	Not Forecasted	Percent Accuracy	False Alarm %	Probability of Detection
GRD District Era	1979	26	17	9	3	65%	35%	85%
	1980	35	23	12	0	66%	34%	100%
	1981	40	31	9	0	78%	23%	100%
	1982	42	34	8	0	81%	19%	100%
HKA County Era	1983	37	32	5	0	86%	14%	100%
	1984	38	32	6	0	84%	16%	100%
	1985	28	25	3	0	89%	11%	100%
	1986	35	30	5	1	86%	14%	97%
	1987	47	40	7	0	85%	15%	100%
	1988	28	24	4	0	86%	14%	100%
	1989	31	26	5	0	84%	16%	100%
HMS Red Flag Era	1990	30	26	4	2	87%	13%	93%
	1991	42	31	11	0	74%	26%	100%
	1992	29	25	4	0	86%	14%	100%
	1993	28	25	3	0	89%	11%	100%
	1994	26	24	2	0	92%	8%	100%
	1995	43	35	8	1	81%	19%	97%
	1996	52	41	11	0	79%	21%	100%
	1997	40	38	2	1	95%	5%	97%
	1998	34	28	6	0	82%	18%	100%
	1999	45	37	8	0	82%	18%	100%
	2000	23	19	4	1	83%	17%	95%
	Total District Era	143	105	38	3	73%	27%	97.2%
	Total County Era	244	209	35	1	86%	14%	99.5%
	Total Red Flag Era	391	330	61	5	85%	15%	98.5%
	Total	778	644	134	9	83%	17%	98.6%
	22 Year Average	35	29	6	1.4	83%	17%	98.6%

Message 1 Day = Forecast potential of urban/stream flooding due to predicted rain rates of >1.00'/hr

Hit = Observation of flooding or >1.00"/hr rains

Miss = Non-bservation of flooding or >1.00"/hr rains