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National Hydrologic Warning Council 2015 Operational Excellence Award Nomination Harris County Flood Warning System

Nominator

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Nominee

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The Harris County Flood Control District's Executive Director, Mike Talbott, is aware of the nomination for this award.

Operational Excellence Summary

Below is a summary of the steps the Harris County Flood District (HCFCD) has taken since 2007 to turn the incapacitated Harris County Flood Warning System back into a reliable and accurate source of real-time hydrological data for the HCFCD, local officials, National Weather Service, and public to facilitate better decisions before, during, and after storm events.

1. In 2008, there were tens of thousands of unknown gage reports being received every day. This was contributing to corruption of good data reports and general system capacity overload. Now there are less than 225 unknown gage reports on the HCFCD portion of the gage network.
2. In 2008, on average as much as 45% of the gages were not reporting and/or inaccurately reporting on a weekly/monthly/event basis. Through extensive training and diligence of the staff there are now less than 2% of gages that are not reporting regularly and accurately. An example of the incredible improvements in sensor data reporting is clearly shown on March 9, 2015. Out of 280 rainfall and stage sensors in the HCFCD network only two water level sensors did not report correctly or .007% of the total sensor network. On average less than 2% of the total 280 sensors do not report correctly during events.

3. In 2008, as much as 60% of the HCFCD gage data transmissions were being lost during flooding rainfall events when the data was most critical. This was a result of the extensive overloading of the radio frequencies transmitting the data due to poor maintenance practices, inappropriate sensor reporting times, and unregulated system expansion. Today less than 3% of the data is lost during flooding events. Significant steps were taken by HCFCD management to establish strict system expansion guidelines, appropriate sensor reporting times, and most important moving all HCFCD gages to their own dedicated radio frequency which protected HCFCD data from regional partner data competition on the radio frequency. Additionally, a third primary repeater was established to directly relay sensor data reports to the primary and backup base station receive locations helping to reduce loading on the two legacy primary repeaters.
4. In 2008, the accuracy of rainfall and stage data was fair and poor, respectively. Now it is extraordinary and excellent. Standards have been established to assess gage data quality during and after heavy rainfall to determine the number of sensors that did not report accurately and is based on the categories of poor, marginal, fair, excellent, extraordinary. The extraordinary rating allows only 7 sensors either stage or rainfall to be inaccurate out of 280 total sensors in the HCFCD network.
5. Since 2010, all of the HCFCD gauges have received semi-annual preventative maintenance visits where every sensor is tested for proper calibration and operational readiness. A preventative maintenance form was established to track critical site calibrations and information, whereas before there was no formal preventative maintenance procedures. Additionally, FWS management developed pass and fail percentages for the reporting sensors calibration tests which is enforced across the network. This focused effort has resulted in an enormous improvement in the data quality being received and made available to the HCFCD and the many others that use this data. HCFWS technicians have been instrumental in the overall data quality gains of the system. The vast improvement in the data quality has been recognized by both the local National Weather Service Office and the West Gulf River Forecast Center which ingest the HCFCD FWS data into their workstations to utilize during rainfall and flooding.
6. In 2013 the entire HCFCD FWS system was surveyed for the first time since 2005. Every gage location has an installed benchmark with an established elevation that is utilized to survey all aspects of the FWS equipment at each site. This includes: measuring plates for accurate verification of water levels, water level sensor reporting devices, crest stage gage, bottom of channel, bankfull elevation, and bottom of gage housing. The current operating procedure is the re-survey the entire network every 3 years and each of the listed equipment is survey immediately if it is replaced or move.
7. In 2010 HCFCD launched a new public website and mobile version to view the FWS gage data. Both of these applications are used extensively by decision makers, other agencies, and TV media during flooding events as well as on a daily basis by numerous engineering

firms and universities to obtain historical rainfall and water level data dating back to the mid 1980's. HCFCD has an outstanding working relationship with the local media outlets, local National Weather Service Office, and numerous county emergency management personnel and is part of the local National Weather Service Integrated Warning team which brings all these partners together to discuss operational severe weather topics and procedures. The HCFCD FWS website is one of the most used resources for flooding and rainfall information in the region and is frequently broadcast on local media, its data on rainfall rates are released via social media, and maps published on numerous agencies websites. An ongoing study by Rice University has discovered that the utilization of the HCFCD FWS data on a public weather risk calculator website for Harris County is the top information source requested and used on this website.

8. In the past year, in conjunction with consultants, the HCFCD developed a comprehensive top-to-bottom training program for field personnel and supervisors that include written material, classroom instruction, and hands-on work, field work at actual gage stations, written tests, and hands-on testing. The objectives were to be able to assess the abilities of individual techs, create a comprehensive training program for future employees, develop a comprehensive procedure manual for the techs and supervisors for reference, and significantly reduce reliance of consultants and vendors. Additionally, this training is to develop troubleshooting and critical thinking skills required to successfully maintain a system of this magnitude and develop a base line skills requirement to assess staff progress.
9. Since 2009, the HCFCD FWS staff (management and technicians) worked closely with the ten partner agencies to improve the quality of their specific gage data while providing the infrastructure for receiving, processing and disseminating data reports from gauges. In fact, the vast improvements in the HCFCD system have been noticed by all of the regional partners and currently two inter-local agreements have been established where HCFCD technicians operate and maintain these partners' networks.
10. The HCFCD is in the process of transitioning all of the Harris County Flood Warning System to ALERT2 to eliminate the chance of data loss, and to allow the ten regional partners to continue to use ALERT until they are ready to convert. The goal is to have all 140 of the HCFCD gauging stations converted to ALERT2 by the end of January 2016.
11. The HCFCD operates a robust repeater network and data collection, processing, and dissemination software that is available to all of the partner agencies at no cost. Once the HCFCD gages are converted to ALERT2, the current ALERT radio frequency will become available for partner agencies to begin their conversion to ALERT2, if they so desire.



Harris County Flood Control District Background

The Harris County Flood Control District (HCFCD) is a special purpose district created by the Texas Legislature in 1937 in response to devastating floods that struck the region in 1929 and 1935. The HCFCD's boundaries are coincident with Harris County (1,756 square miles) which is the 3rd most populous in the U.S., 4.3 million that includes 32 cities including Houston. The HCFCD's flood control infrastructure is extensive, including more than 1,500 channels totaling about 2,500 miles in length (about the distance from Los Angeles to New York); and more than 160 stormwater detention basins (15,200 acres) ranging in size from 1 to 1,000+ acres. Nature also challenges us with relatively flat terrain, clay soils that do not absorb water well, and very intense rainfall (1% probability 4.3"/hour and 13.2"/24 hours). The flooding problems in the community are severe with over 19,500 homes and businesses flooded since 1989 in 18 events and 72,500 homes flooded during Tropical Storm Allison in 2001.

With such potential, severe flooding problems, the Harris County Flood Warning System information is critical to minimizing the impact of floods on people's homes, families, emotions, work place, and finances. By providing real-time information based on the real-time quality data to local officials and the media, governments, companies, schools, and individuals can make decisions to minimize flood damages and impacts to people. In addition, the hydrological data collected during floods and near-floods is used to model existing and future conditions for watershed master planning and identifying structural and nonstructural flood damage reduction projects.

Description of the Harris County Flood Warning System

Harris County Flood Warning System Goal

Provide accurate and consistent rainfall, stage, and other data on a reliable real-time basis in a useful form to the Harris County Flood Control District, National Weather Service (NWS), Harris County Office of Emergency Management (HCOEM), other Harris County officials, and the public to facilitate making decisions before, during and after storm events to reduce the risk of property damage, injuries, and loss of life.

History

The Harris County Flood ALERT System installation began in 1982 at the HCFCD office on North Main Street (now referred to as the Harris County Flood Warning System) after Tropical Storm Claudette caused extensive flooding and damage in Harris County in 1979. (Maximum rainfall 43 inches in 24 hours just south of Harris County.) One of the first real tests of the 12 gage locations in 5 watersheds was Hurricane Alicia in August 1983. The hardware could not handle graphics yet, and it took 45 minutes to read the values from 24 rain and water level sensors and plot them manually. In 1984, the Harris County Flood ALERT System was named as one of the nation's ten outstanding engineering achievements by the National Society of Professional Engineers.

From 1983 to 1996, the number of stations increased from 13 to approximately 80. The number of personnel required for operating and maintaining the system increased as well. In 1996, responsibility for personnel, operation, and maintenance shifted to the new HCOEM. From 1996 to 2007, the number of gage locations grew from 80 to 138. During this same timeframe, rainfall, stage, weather, and road sensors from ten other government entities in the region were incorporated into the data receiving and reporting network. A table showing the number of stations and sensors in 2007 is shown below. The Harris County Regional Flood Warning System had grown to one of the largest in the U.S. However, the addition of sensors both within and outside Harris County occurred with little restriction or evaluation on the quality and reliability of the entire FWS.

As of 2007	Harris County Flood Warning System	Regional Flood Warning System
Stations	137	249
Sensors	301	636

2007-2008 Self-Evaluation

Starting in about 2000, the HCFCD flood watch engineers began noticing problems with the quality of the rainfall and stage data itself, as well as an increasing number of real-time data gaps during storm events. In 2004, the HCFCD hired their first full time flood watch employee and on staff meteorologist, Jeff Lindner, to focus on improving the collection, evaluation, forecasting, and dissemination of real-time flood information. In June 2007, a review and evaluation of the FWS was initiated from the HCFCD, HCOEM, and the Harris County Public Infrastructure Department to identify problems and develop recommendations for improvements. In order to thoroughly research and understand the details of operating and maintaining a flood warning system, the work team relied heavily on the HCOEM Flood ALERT staff as well as the flood warning community in the U.S. An owners/operators questionnaire was developed and distributed to 36 ALERT operators/owners in the U.S. Fifteen responses were received and the results characterized into four major categories: General, Operations, Funding, and Future Improvements. Upon receipt of the survey results, discussion of the responses led to further investigation through team conference calls with Charlotte Mecklenburg Storm Water Services and site visits with the Denver Urban Drainage District, City of Overland Park, City of Dallas, Tarrant County Regional Water District, and the Lower Colorado River Authority. Besides the invaluable information provided by the ALERT owners and operators, professional relationships were established with many superb and dedicated individuals.

A comprehensive report of the condition of the FWS was completed in November 2008 that identified six problems and proposed 15 recommendations. In summary, the problems identified include the flood ALERT system was stressed, data collection capacity from the stations was inadequate leading to significant loss of data through “collisions”, the equipment and components were aging, and the ALERT staff was inexperienced and diverted to other tasks.

In November 2007, a moratorium on adding gages was adopted to prevent a worsening of the data loss problem. Based on the first recommendation in the report, the maintenance and operations of the Harris County Flood Warning System was transferred back to the HCFCD in March 2009. Since then, thanks to Jeff Lindner, many dedicated HCFCD staff, and support from senior leaders and Harris County Commissioners Court, all 15 of the near term and long term recommendations have been implemented except one.

Hurricane Ike to Present

In September 2008, Hurricane Ike caused extensive damage in Harris County including to the Flood Warning System. Within days, HCFCD hired One Rain using an emergency contract to help repair the gage stations that were damaged and assess the entire Flood ALERT system. Besides One Rain staff, several other experts were employed to assist the HCOEM ALERT technicians with the repair of gage stations and then evaluate and make recommendations to improve the entire ALERT system. Evaluating and restoring the 16 damaged gage stations was an excellent first step in evaluating the rest of the system and the staff responsible for maintaining it. The team included Ilse Gayl, Mike Zucosky, David Haynes, Don Van Wie, and Chris Roark. The May 2009 Report stated “The combined performance, maintainability and sustainability of gage sites, repeater/concentrator locations, base station tools and overall system architecture are all required components for providing reliable, high quality data.” The following recommendations from the consultant team have been completed or are in progress:

- HCFCD gages put on separate frequency from regional partners to reduce collisions
- Located and stopped data reports from unknown sources and malfunctioning sensors and equipment
- Developed gage station expansion protocol for new gage station requests and preventative maintenance guidelines with sensor calibration procedures
- ALERT2 concentrators installed at the repeaters
- Replaced DataWise base station software with Contrail to support maintenance and performance tracking
- Began monitoring impact of regional partners' gages on system functionality. HCFCD now works closely with each regional partner for benefit of everyone
- Gage station improvements and standardization include changing from stand pipes to NEMA boxes and upgrading transmitters
- Daily data quality assessment and management using Contrail tools and diligent staff reviews
- Since 2009, field personnel and managers have participated in 12 training sessions over multiple days learning all aspects of the flood warning system. In addition, the consultants and equipment suppliers provide invaluable service on an as needed basis.
- Improved preventative maintenance twice per year to reduce problems during events.

The results in data quality and reduction in loss of data during an event has been dramatic. From just April 2009 to October 2011, data loss was reduced by about one-half and it has improved significantly since then.

ALERT2 and the Future

In 2015, the HCFCD is focusing on completing the conversion to ALERT2. It has not been easy because initial implementation of a major technological change is always a challenge. Fortunately, members of the collaborative ALERT2 work group are leading the implementation for HCFCD and a few other agencies are participating in this initial launch, as well. Refinements are being made and coordinated among the various parties so the ALERT2 protocol, software, equipment, etc. will be consistent and predictable among the support consultants, equipment providers, and software options. Below is a table showing what has been completed so far and what is to do.

Completed Through 2014

- Repeaters and base stations upgraded to receive ALERT2 transmissions
- ALERT2 ID's created and submitted to National Database
- ALERT2 slot assignment plan
- ALERT2 sensor integration plan (incorporating existing sensors)
- Established Beta test sites at gages 510 (HCFCD) and 580 (USGS/HCFCD combo)

2015 Tasks

- Bid and award gage transmitters (backplate mounted)
- Install GPS antenna at gage stations
- Deploy ALERT2 transmitters at gage stations
- Standardize gage station setups for maximum consistency
- Extensive technician and manager training on ALERT2 fundamentals and applications

Since 2008, system wide improvements were accomplished through hard work and dedication of the Flood ALERT staff, support from senior leaders and Harris County Commissioners Court, and committed and experienced consultants and contractors in the ALERT systems field. Ongoing improvements and upgrades such as ALERT2 are needed to maintain reliability and accuracy of the data and to incorporate new technologies with respect to software and data collection devices. HCFCD has and continues to be committed to the success and improvement of both the Harris County and Regional Flood ALERT System.



Acknowledgments

Even though we talk about flood warning systems in dry and technical terms, the bottom line is it's really about people. The people in the community we serve and provide information to help them make better decisions, the people who work to operate and maintain the flood warning systems every day, the people who provide the support and funding, and the people who use the data and information on a real-time basis to advise officials and the public or use and analyze the data to reduce the flood risk from the next storm. The following people have directly contributed to the successes realized thus far on the effort to accomplish the HCFCD's goal for the Harris County Flood Warning System. Thanks to the many people not listed as well.

HCFCD

Jeff Lindner, Flood Watch Manager, Meteorologists
Jim Greeson, Flood Warning System Supervisor
Rene Mireles, Hydrologic Technician
Richard Velasco, Hydrologic Technician
Ronnie Havran, Hydrologic Technician
Jeremy Justice, Hydrologic Analyst
Valerie Lomas, Data Specialist
Many Information Services Staff (Computer Support)
Mike Talbott, Executive Director

Consultants

Don Van Wie, Telos Services, Inc.
David Haynes, Distinctive AFWS Designs, Inc.

Equipment/Software Providers

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Hach
OneRain
Campbell Scientific
Blue Water Design

Others with Flood Warning Systems

Jeff East, USGS
Kevin Stewart, Urban Drainage and Flood Control District
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