

Cypress Creek Floods:
Knowing the Enemy and the Consequences of Ignorance
Timothy W. Gibson
Cypress Creek Fire Department, Cypress, Texas

CERTIFICATION STATEMENT

I hereby certify that this paper constitutes my own product, that where the language of others is set forth, quotation marks so indicate, and that appropriate credit is given where I have used the language, ideas, expressions, or writings of another.

Signed: 

Abstract

The problem is the Cypress Creek watershed continues to flood the community. The purpose is to identify the hazards of flooding to the community along the Cypress Creek watershed within the fire department district. The method applied to this research is descriptive. The research questions to study this problem are: a) what areas within the district are most susceptible to flooding, b) how many citizens are at risk of flooding during a 1% event, c) how are these citizens notified of imminent flooding, d) are these citizens able to avoid risks associated with this flooding? The community lives, recreates, and travels in the area of Cypress Creek waterway. This waterway has been flooding increasingly with development. The citizens are at increased risks associated with flooding, both on the roadways and in the structures along the creek. The community, emergency responders, and county agencies must partner to help the community be better prepared for flooding when it occurs. A thorough review of past flooding events, surveys of homeowners, interviews with county officials, review of relevant literature from other locations with similar events, and a review of current science on this subject was conducted. The survey result of homeowners is limited to a very small percentage of the affected neighborhoods due to a lack of organizational resources to distribute those surveys. Flooding is occurring more often, but some efforts to mitigate over the last few years by Harris County Flood Control District have shown some results. Improved science and technology can provide better warnings thus saving more lives, both civilian and responders.

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Introduction

The problem is the Cypress Creek watershed continues to flood the community. The purpose is to identify the hazards of flooding to the community along the Cypress Creek watershed within the fire department district. The creek is known to flood frequently, but not always at a level that is dangerous, but possibly more frequently than past decades. It is theorized that, once identified, the hazards of flooding will better inform the district and department the methods needed to reduce the risks that both citizens and responders encounter.

1. What areas within the district are most susceptible to flooding?
2. How many citizens are at risk of flooding during a 1% event?
3. How are these citizens notified of imminent flooding?
4. Are these citizens able to avoid risks associated with this flooding?

This research will benefit the community through the identification of and increased awareness of local risks from flooding, and increased prevention of citizen exposure to the risks from this flooding. This research will attempt to identify at risk locations, where citizens are exposed to the highest probability of flooding dangers, and work to mitigate as much of that risk as possible. The method applied to this research is descriptive.

Background and Significance

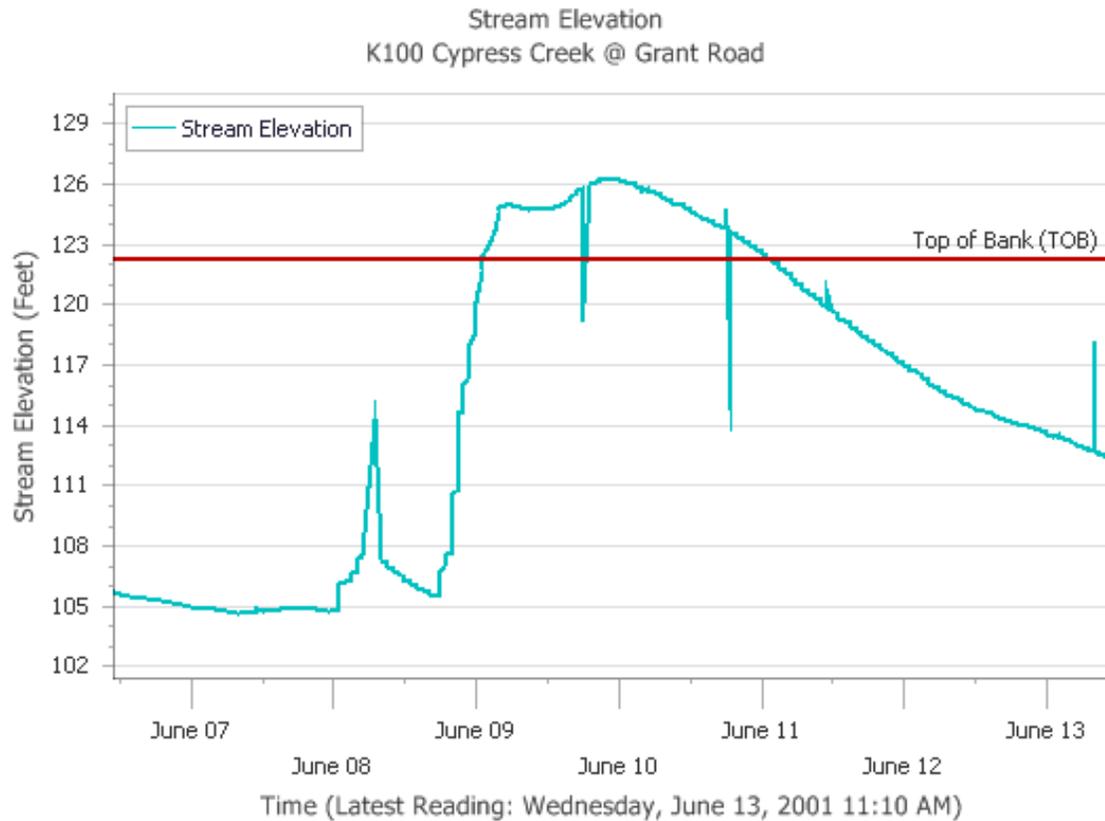
Cypress Creek Fire Department is a combination department that was founded in 1976 as a volunteer fire department in the Northwest Harris County, Texas suburbs of Houston. The department services the area that is within the legal limits of Harris County Emergency Services District 13. The first immigrant, John H. Callihan, to settle in the area was given a Mexican Land Grant as part of what is called Austin's Fifth Colony in 1835. This tract was set directly

over much of the length of Little Cypress Creek, and to include the confluence of Little Cypress Creek and Big Cypress Creek, squarely in the middle of the fire district. The great-great-grandson still holds a small section of this original tract. The district is 25 square miles, down from the original 35 due to annexation by Houston, with a residential population of 79,900. The district has a growing warehouse/industrial concentration that has many locations exceeding 200,000 square feet under one roof. The latest construction includes a 1.9 million square feet complex and a 20-story high-rise tower that is the new home to a growing leader in petroleum drilling and exploration. The department's name is derived from the waterway that dissects the district from west to east, including a major tributary that comes from the northwest to intersect the larger creek. Cypress Creek is one of the largest watersheds in Harris County, covering roughly 300 square miles. The Cypress Creek watershed is home to more than 340,000 residents (Harris County Watersheds: Cypress Creek, 2015). The main body of Cypress Creek, sometimes referred to as Big Cypress Creek, enters the district at Huffmeister Road and extends to the west and leaves the district after crossing the railroad tracks just west of Cutten Road. This is approximately 7.2 miles in length. Little Cypress Creek enters the district at Telge Road and ends at its confluence with Cypress Creek near the Lake Cypress Estates/Saracen Park neighborhoods. This confluence is now located at a county park where homes once stood that were all bought out after repetitive severe flooding events over the years.

Figure 1 Confluence of Creeks at Maxwell Park



Little Cypress Creek covers approximately 3.18 miles in our district. These two creeks are fed by countless storm water control ditches, retention basins, and detention basins all engineered and required by county, state, and federal mandates. Flooding along the Cypress Creek watershed, within the Cypress Creek Fire Department district, has put citizens at risk and required responders to enter flood waters, both still and moving, to facilitate their extrication. This flooding has been documented for more than 100 years and, due to the nature of our topography, hydrology, and geography, will continue to occur for years to come. The flooding can also be much worse. In 2001 Tropical Storm Allison dropped 37 inches of rain in some parts of Houston, while the highest total on Cypress Creek was 28 inches near Spring, Texas, where the creek crosses IH-45. The following charts the rain and stream levels the days leading up to and just after Tropical Storm Allison crossed, turned and crossed back over Harris County.



This storm was responsible for 70,000 flooded homes, more than 2,000 of them completely destroyed and 28 deaths. 1,000 homes on Cypress Creek flooded. Southeast Texas and the Greater Houston area has seen higher: the United States record for 24 hour rainfall occurred just south of Houston when Tropical Storm Claudette stalled and dropped 43 inches in 24 hours. There are several risks: first, exposure to water borne pathogens (CDC, 2015) that are found in flood waters; second, extrication from flood waters presents risks to citizens and responders due to the technical nature of rescue operations via a variety of methods; lastly, the department relies upon volunteer responders that are a part of the community and, if flooding comes on fast, are cut off from their station and decrease the ability to respond to the community's needs thus increasing the risk of loss of life. This is related to Executive Analysis of Community Risk Reduction through the risk to both residents of the community and transients traveling through

the area that are not aware of the hazards of routine flooding, thus reducing the chances that citizens would be in harm's way requiring emergency response from the fire department. This research is related to the United States Fire Administration (USFA) Goal #1 by reducing citizen risk through identification and increased awareness of local flooding. This is furthermore related to USFA Goal #2 through better identification, thus better planning and preparedness, for the fire department

Literature Review

A review of current literature to find relevant research on the topic was conducted. The literature review was used to seek relevant research and publications referencing the research questions. Question One asks what areas within the district are most susceptible to flooding. A floodplain is the low lands adjoining the channel, river, stream, watercourse, or lake that have been or may be inundated by flood water (Bedient, Huber, & Vieux, 2013). The Cypress Creek watershed is home to more than 340,000 residents, up from approximately 70,000 in the 1960s (Harris County Watersheds: Cypress Creek, 2015). The conclusions drawn from a study of 60 years of historical data up to 1969, was that continued urbanization would lead to increasing the magnitude of the two year flood by nine times and the 50 year flood by five times (Johnson & Sayre, 1973). In 1988 USACE was slated for a survey of the floodplain along Cypress Creek, this survey was delayed and ultimately was not accomplished until 1997. At that time USACE estimated 1,500 homes were inside the 100 year floodplain of Cypress Creek according to Cypress Creek Flood Control Coalition website, however; references to a study from 1985 state that as many as 2,400 homes are in the 100-year, 1% event, flood plain (Wilson & Pudlewski, 1987). This number seemed low, a subsequent survey was sponsored by CCFCC, the data and survey were shared with HCFCD and USACE as it reflected over 5,000 homes along the entire

length of the creek resided in the floodplain. The fact that a significant flood, such as those in July 1979, October 1994, October 1998, or June 2001 (Weather Research Center, 2015), could create devastation requiring FEMA buyouts and local impact of loss of tax revenue and decrease of citizen quality of life. The area found to be of highest concerns are also the area that HCFCD, with and without FEMA programs, have bought the bulk of properties (HCAD, 2015). The post Tropical Storm Allison (HCFCD, 2015) floodplain revisions shifted the flood channel and practically all of the floodplain boundaries from 500 to 1 year. This shift put the many newer homes with very high home values well into or along the 100 year floodplain (HCFCD, 2015). The 100 year floodplain is based on the one-in-one hundred chance (1 percent) of occurrence in any given year, however; this is not to say that the chance of an one hundred year event, can be linked to the one hundred year storm or one hundred year flood or even one hundred year peak flow event in a given waterway (The Shodor Education Foundation, Inc., 1998). A University of Texas studies for the period of 1959-2008, excluding Hurricane Katrina, Texas recorded 840 flood deaths, nearly three times that of Pennsylvania just behind Texas (Sharif). Urban development, addition of paved surfaces and rooftops, can increase runoff rates of up to 10 times faster than some unpaved lands (Rosen, 2015). The flooding of roadways results in rapid runoff into storm drains, flood control channels, basins, and waterways. This is supported by a publication from Pennsylvania State University (Cotrone, 2015); 1 acre of paved surface has the same amount of annual runoff as 36 acres of forested land or 20 acres of grassland. The roadways in and around the community become floodways for storm water running off of paved areas, structures, and other hard scape. Over half of flood related drownings occur in vehicles, with one study showing the statistic in Texas as high as 77% (Flash Flood Alley , 2015) (Sharif). According to Jim Blackburn, prominent environmental law professor at Rice University, the

frequency of our large storms has increased significantly. Professor Blackburn, co-director of the Severe Storm Prediction, Education and Evacuation from Disasters (SSPEED) Center at Rice University, states that in the past 40 years we have had eight storms that exceeded our 100-year flood standard of 13 inches in 24 hours and three storms that have exceeded 19 inches in 24 hours, our official 500-year flood standard (Blackburn, 2015). An article in an Environmental Protection Agency (EPA) publication cited Rhode Island Department of Environmental Management in stating that developed watersheds collect about 500% more runoff than undeveloped and it leads to streams to be bank full twice as often each year (Miller, 1996).

The Harris County Flood Control District estimated, in 2013, that proposed major flood control projects for Cypress Creek would cost around \$325 million dollars (Arrajj, 2013). Flooding in urban areas poses substantial risks to residents. While Cypress Creek drops slowly, rather mildly in comparison to other parts of the country, during flooding the various channels, storm channels, basins, or the creek itself will be moving quite quickly. Force as slow as three miles per hour can sweep you off your feet in as little as six inches of water according to National Oceanic and Atmospheric Administration (NOAA, 2015). In the thirty years from 1977-2006 flood deaths is more than 33% higher than lightning, over 40% higher than tornadoes, and around 50% higher than hurricanes (NOAA, 2015). Further research found that many find the warnings to be ignored, or just not comprehensive enough, and therefore not heeded (Handmer, 2000) (Holeywell, 2015) (Maxwell, 2014). Often the warnings take too long to reach residents, or require a resident to sign up or register to get the warnings.

The earliest water level gauges along Cypress Creek were installed in 1945, only one at the Highway 75 (IH-45 current) crossing until much later into the 1960s and 1970s. The first rainfall gauge in the general area was off of Jones Road and Louetta Road just north of the creek

and in our department's district. Even as late as 1973, Cypress Creek data was not considered essential in considerations of floods in Houston as evidenced by the lack of data usage in the USGS report on historical flooding in Houston (Johnson & Sayre, 1973). The only warnings received directly would be from local news media via Harris County Office of Emergency Management or via direct notification at their website (Harris County, 2015).

In many communities, even in Harris County, the only notification is when local jurisdictions get National Weather Service reports and activate archaic disaster alert sirens or klaxons. Here in Texas even some of the more advanced warning systems can fail as seen in Austin, Texas in 2014 (Maxwell, 2014). Warning systems have been more and more documented, especially technology driven warning systems (Basha, Ravela, & Rus, 2008) (Fehling, 2015) (Keatts, 2015).

Procedures

The purpose is to identify the hazards of flooding to the community along the Cypress Creek watershed within the fire department district. To answer research question one the flood plain maps in the district were researched. The data helped develop a list of streets that are now in or adjacent to the 100 year flood plain, as revised during the Tropical Storm Allison Recovery Project (TSARP). This list was compiled using the Harris County Flood Control Website Flood Education Mapping Tool (Flood Education Mapping Tool, 2015). This showed what down to street level where the lines are now established. This map was compared to the Harris County Appraisal District's website HCAD Parcel Viewer (HCAD Parcel Viewer, 2015). From this it was determined that 377 homes were completely within the new 100 year flood plain. There were limitations in reaching out to the entire breath of affected homes by department leadership.

Attempts to contact home owners associations, listed in Appendix 6, and management companies to reach these homeowners without going door to door. Several were open to an electronic survey they could share a link with the residents. Neither Longwood Subdivision owners nor Management Company would answer requests for information. This decreased the total home owners by 80, but the sample size was increased by including residents that were close to those areas. The lack of conventional resources to go residence by residence in the affected areas created very low results. Despite this a Survey Monkey survey was developed to assess which homeowners/residents had been affected by flooding and to what degree. Those results were collected electronically. During the flooding of July 2012 and again in May of 2015, in person surveys of the flooded areas of the district were conducted. These surveys involved driving out to observe the streets that are in the flood plain and note them in a list of affected areas.

Research was conducted of the district incident report software and a tally of the total numbers of calls for rescue boats, high profile evacuation vehicles, and call types. Due to the multiple call types, these were tallied along with just bulk calls and dates of calls. These calls were then compared to statistical data about rainfall and stream levels available from HCFCD, USACE, and USGS for those time frames to determine the rate of rainfall, the rate of stream rise and the timing of the events. This provided the approximate data needed to also answer research question 2. This type of data has never been previously gathered nor had any efforts toward attention to it. This presented a limitation of data collection that was potentially overcome by sifting through all of the notes on the various calls that possibly revolved around the dates and times of known flooding events. The data on the rain and flood events, compared with the response times of the calls for help, allowed me to determine the time frames and isolate where the greatest risk were and the types of risks for those citizens most affected. The community

action group, Cypress Creek Flood Control Coalition, was contacted for assistance. This coalition was formed by residents within our district in 1999, in direct response to the floods of 1994 and 1998. A personal interview, found in Appendix 10, with the coalition president, Richard “Dick” Smith was conducted. This interview was also cut short by other leadership within the organization for various reasons. Mr. Smith is retired and lives on Texas Army Trail in Saracen Park, one of the most routinely flooded streets in our district. After an invitation from Mr. Smith, attendance at a full meeting of the coalition board of directors helped generate resources on more data about flooding history in the area. Mr. Smith further pointed towards the coalition website for relevant links, dates, times, milestones, and meetings that have influenced the actions of organizations along Cypress Creek in relation to flooding. One of the items found in this research of the coalition website was the fact that mitigation of flooding by regulating construction has been ineffective recently (Cypress Creek Flood Control Coalition, 2015). The group provided information of two excellent resources that are local and experts in their fields. First was Dr. Phil Bedient, hydrologist and professor of hydrology at Rice University. Dr. Bedient was contacted and allowed a phone interview, found in Appendix 9, and reviewed much of his literature including multiple journal articles and his text book on flood plain hydrology and management. In reviewing literature found in the National Library of Medicine, one very severe limitation in the available data on flooding, as well as the impact of flooding, found is the inconsistency of the data classification and reporting. This article (Doocy, Daniels, Murray, & Kirsch, 2013) used the 2007 Asian tsunami as an example where one set of statistics listed this data as a flooding event, whereas the Emergency Events Database EM-DAT from the Centre for Research on the Epidemiology of Disasters (CRED) did not include it as a flooding event. Just

as the National Fire Incident Reporting System (NFIRS) has multiple response or incident types that an incident can be typed as, so can national and international typing of incidents.

Research question 3 was answered using interviews with a representative from HCFCD, Appendix 8, as well as the county Emergency Management Coordinator, Appendix 7. These provided the answers to the question for my department and community. Further the information was compared to research about alerting systems in other communities. To help compare this to other areas around Harris County a second survey with similar questions as those used in the interviews of the two county representatives was generated. This survey was sent to fire chiefs in areas south, west and north of Harris County that have been affected by flooding as well. This survey can be found in Appendix 4. These responses, obtained in the interviews, were reviewed to determine if they represented the only capabilities available to the area. This data was compared with material from Dr. Bedient and his work at the Severe Storm Prediction, Education and Evacuation from Disasters (SSPEED) Center at Rice University near the Texas Medical Center south of Downtown Houston. Dr. Bedient helped design the Flood Alert System 1, also called FAS1, now updated and upgraded to FAS3 (Rice University and Texas Medical Center, 2015) (Rice University, 2015). This system protects the high value, high target hazard area of the Texas Medical Center in Houston from repetitive flooding along Brays Bayou through downtown Houston. During the phone interview with Dr. Bedient he helped review the process of building an integrated flood warning systems using current technology for communities like those along Cypress Creek. This information was used, as well as reviews of online media about flood warning systems (Holeywell, 2015) (Basha, Ravela, & Rus, 2008) (Krzhizhanovskaya, et al., 2011), what works and what doesn't, as well as new systems being built or used since flooding disasters in communities. Research question 4 was answered

through research online for articles, research, and discussions about the habits of citizens and the risk taking that occurs during flooding events; this included adherence to advance warnings, barriers, and repetitive flood events (Handmer, 2000) (Beavin, 2015) (Basha, Ravela, & Rus, 2008) (Mioc, et al., 2008) (Marin-Perez, Garcia-Pintado, & Gomez, 2012).

The lack of organizational support for the subject of community risk reduction resulted in a severe lack of time and resources allocated to this project. This cascaded into a limitation on reaching residents with surveys and a complete restriction from contacting businesses in the district. Despite the value of the topic, and its obvious impact on the community, leadership within the organization felt there wasn't a return on this topic that would warrant the commitment of further resources. Some of these restrictions included limited time for conducting one on one interviews with subject matter experts, requiring a reliance on email interviews and/or posted generalized surveys with home owners associations or neighborhood management organizations. The preferred method of reaching residents and businesses would have been individual surveys left at each residence and/or business with the ability to send in the data and/or complete a provided online link to the survey. Further, more time for in person interviews would have facilitated more thorough information and a broader scope of the body of knowledge available to use for this project.

Results

Results show the volatility and fast response of the creek to runoff from a small rain storm over the developed area the district. When this is taken in context of the rainfall that has fallen over the same district in the last 15 years, this has led to major responses by the department to help move stranded citizens, as shown in Appendix 3, from flood water that has

risen faster than current warnings are issued. According to Harris County Flood Control District's Flood Watch Manager/Meteorologist Jeffrey Lindner, Cypress Creek has 16 gauges to measure stream level, rainfall, or both that it utilizes to watch the conditions of the stream. The flood control district maintains that television media is the best avenue to reach most residents the fastest by providing the data about conditions and/or flooding to the television meteorologists. The district is notified by email or text when a station reports 1 inch of rainfall or a stream level is three feet below its bank full stage (Lindner, 2015). As evidenced in the sudden heavy rainfall July 11-13 of 2012, the speed at which the water enters the runs off into the creek, thereby raising the level and volume of water in the creek is very sudden. This water must flow through the streets, ditches, and basins to enter the creek. This date showed a rainfall of nearly two inches the morning of the 11th followed by nearly 4.5 inches in the overnight and morning of the 12th. The resulting runoff flooded many roadways requiring sixteen separate responses to evacuate, rescue, or locate flooding victims in vehicles, homes, and businesses. When compared to the two inch rainfall, previously quoted from September 11th, this flooding event in July of 2012 pushed the flow of Cypress Creek at Grant Road to over 4,000,000 gallons per minute. The creek stayed over bank full for more than 48 hours, demonstrating the slow fall after the sudden build up requiring the basins, ditches, and often the roadways to hold water longer and expose citizens to further hazards. This flooding was higher than either the Tropical Storm Allison in 2001 or Hurricane Ike in 2008, but less than the benchmark event of October 1994 (Gage Detail 1160, 2015). The 1994, 1998, and Tropical Storm Allison of 2001 were the storms and flooding that resulted in the greatest buy out of homes along Cypress Creek, Spring Creek, and White Oak Bayou all in Northwest Harris County. The creek is heavily affected by the amount of sediment that is carried in and deposited along the creek. It was noted in a 2000

study by Brown & Root Services, on behalf of the joint partnership of the City of Houston, HCFCD, Montgomery County, San Jacinto River Authority, and the Texas Water Development Board, that the “sugar sand” found in Cypress Creek amounted to 42% of the total sedimentation found in the West Fork of the San Jacinto River and subsequently Lake Houston, the reservoir for much of the surface water used in the Greater Houston Metroplex (Brown & Root Services, 2000). It should be noted that this study was conducted in 1999, and the final report developed in June of 2000, one year prior to Tropical Storm Allison which triggered a complete overhaul of all flood plain maps throughout the entire region.

According to Harris County Emergency Management Coordinator Mark Sloan, Harris County relies on National Weather Service to notify both local citizens and officials supplemented by the USACE warnings as readings come in from the waterways and basins that they monitor. ALERT, Automated Level Evaluation in Real Time systems were developed by the National Weather Service in the 1970’s intended to be a flood warning system for local agencies’ (ALERT Systems, 2015). This was later updated by OneRain to the ALERT2 updated standard protocol in the mid-2000’s (ALERT2 Real-time Monitoring for Automated Flood Warning, 2015), this is the third implementation of these systems from this company to the Harris County Flood Control District monitoring system. The system is not automated and requires the Office of Emergency Management and Homeland Security to monitor both rain fall and watershed levels to make any additional notifications. Further the office stated the county does utilize the Texas Department of Transportation (TxDOT) electronic signs on the highways and interstates to warn of high water or flooding along those roadways, however; the county currently has no automated signs or barriers on smaller roadways and has no plans to implement them in the foreseeable future. In a recent development, directly related to the repetitive

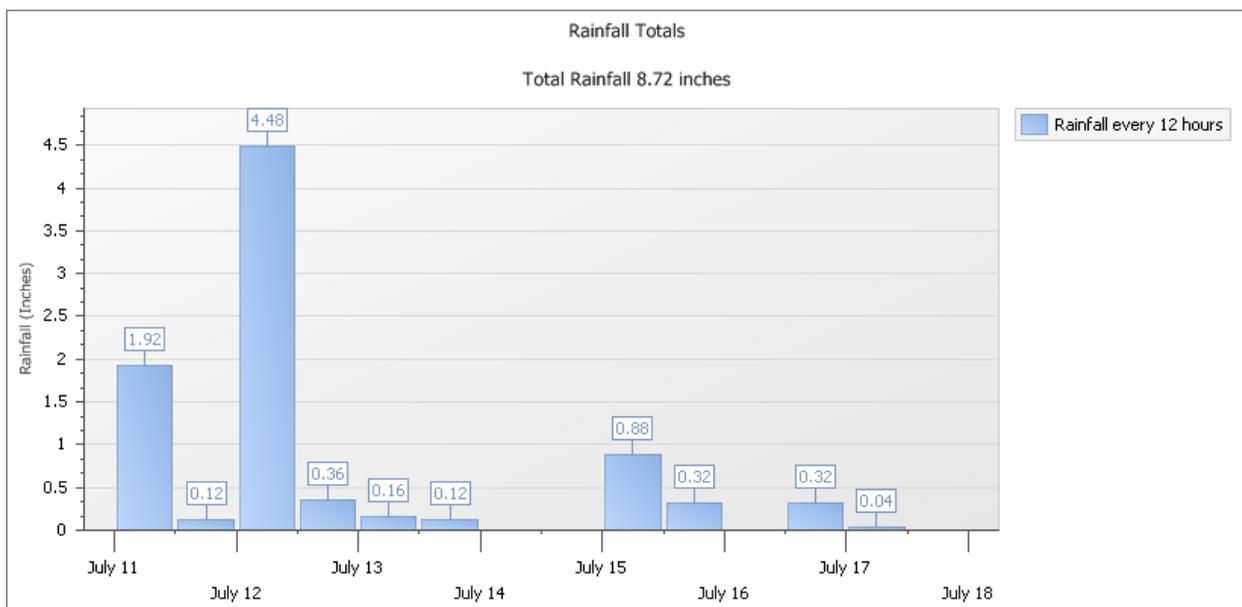
flooding fatalities in Houston at more than two dozen underpasses, the City of Houston has decided to build flood gates that will close when water levels begin rising in these underpasses and thereby limiting access to the hazards (Fehling, 2015).

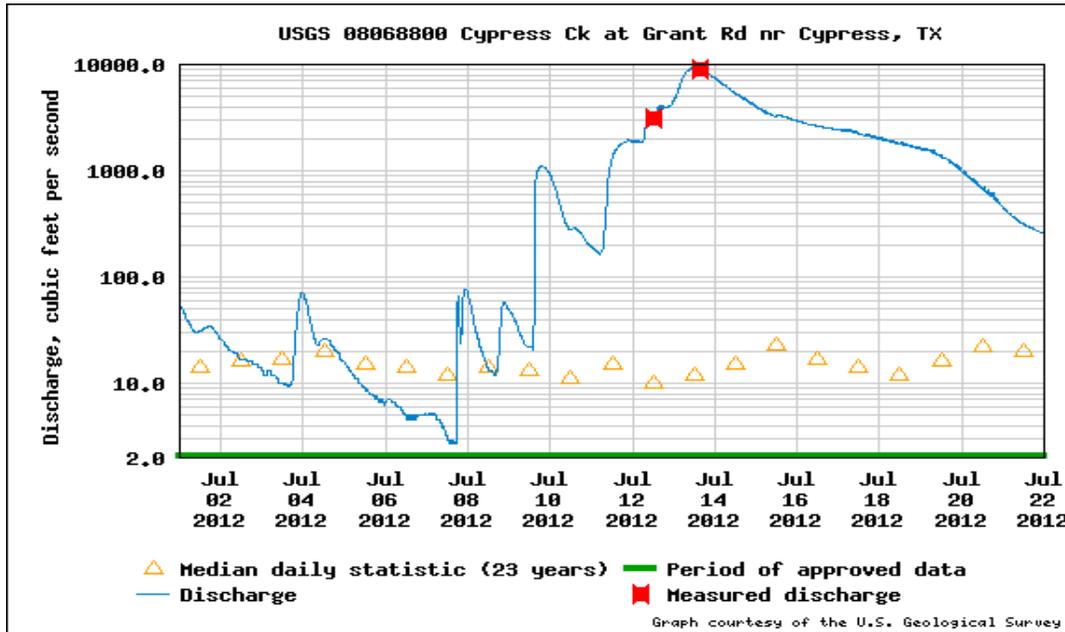
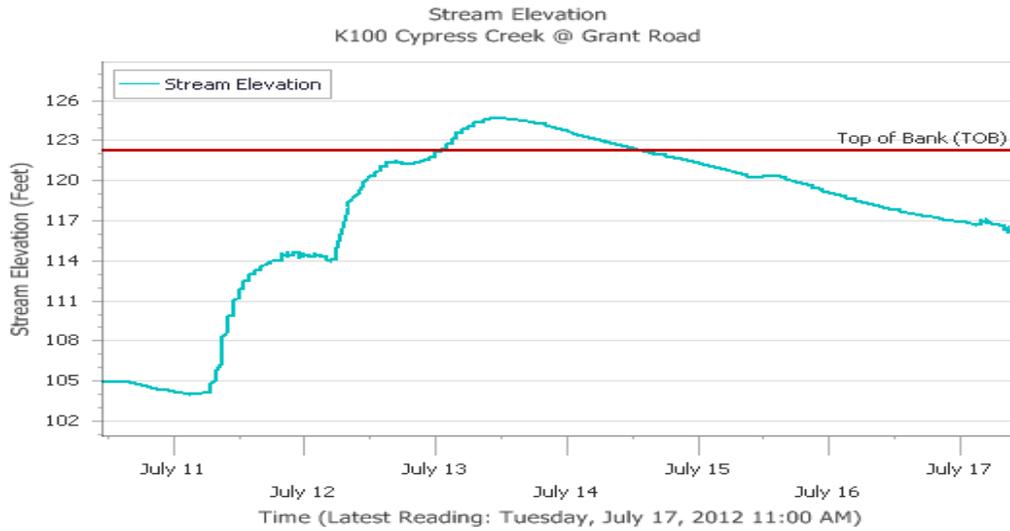
Survey #1, sent to residents in the most affected neighborhoods, generated four dozen responses. This represents close to 10% of the estimated sample size of 500 residences that are situated along the creek, within, or close to the 100 year flood plain. When asked if their residence had been affected by flooding from the creek or its adjoining waterways, 17% stated they have been affected. These respondents reported the effects being as little as delays entering or leaving their residence to four feet of water throughout their home. Flooding of this nature often requires assistance. July of 2012 flooding, previously shown, created the need for evacuation by boat or high profile vehicles of over 80 individuals from both residences and vehicles (Leonard, 2012). As referenced in the article, these areas are represented in the following images including (in order) Norchester subdivision, Kluge Road, and Grantwood subdivision. All pictures were taken from the department's water evacuation boats while assisting residents.



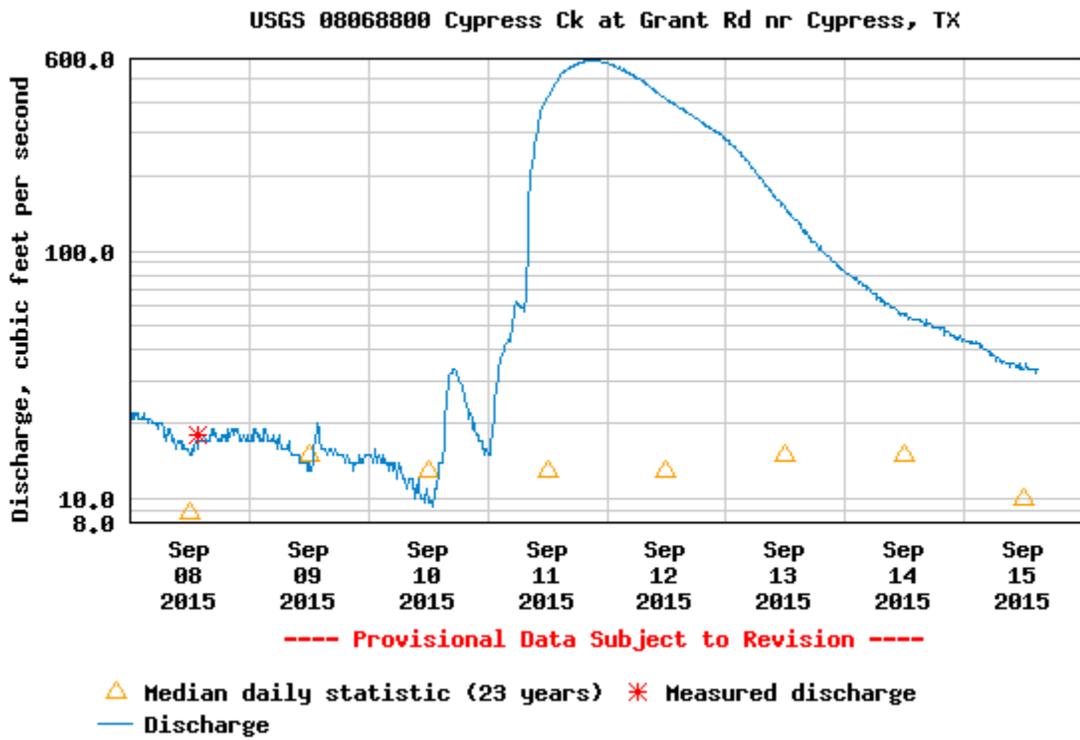
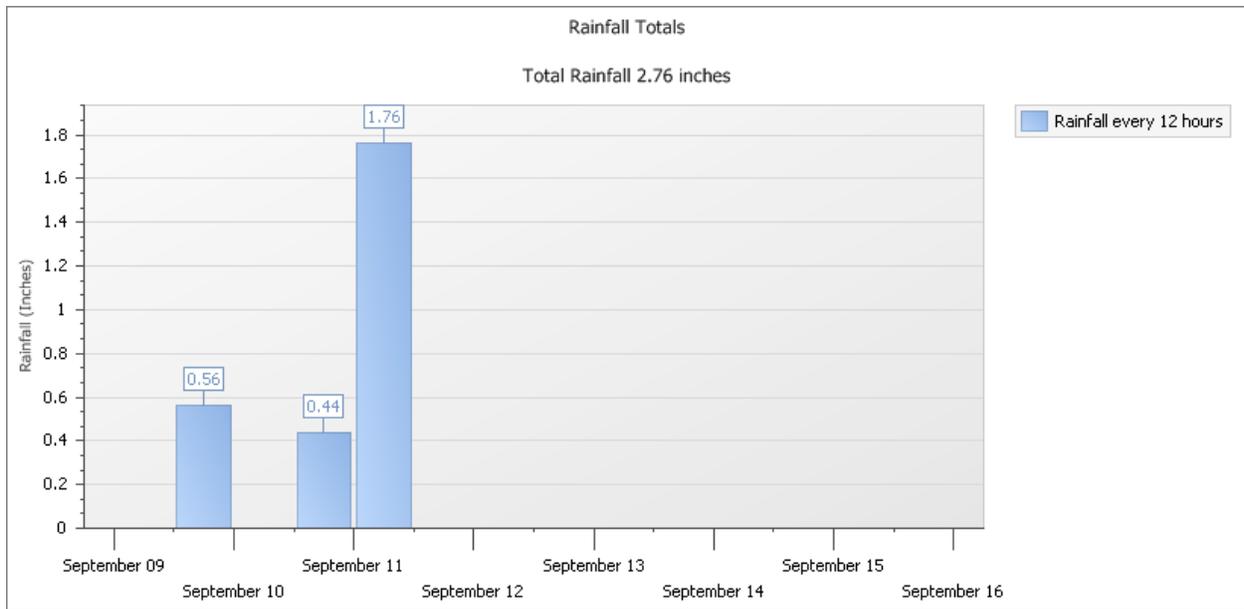
Discussion

Development along Cypress Creek continues, primarily upstream near the creek’s origins, in far western Harris County and eastern Waller County. According to one estimate, nearly 30,000 acres of rural farm and pasture land have been developed in this area. This part of the creek is very low, very flat, and would allow for flooding to spread out and slowly make its way down stream. Texas Forest Service (TFS) estimates that paving over one acre of land will increase runoff by 162%. The estimates by Harris County Flood Control District (HCFCD), US Army Corps of Engineers (USACE), and Cypress Creek Flood Control Coalition (CCFCC) show the overflow from this developed land has increased the runoff from the Cypress Creek headwaters to 13,500 cubic feet per second or 100,980 gallons per second. Cypress Creek crosses Grant Road at a very vulnerable area. The roadway is low and the creek depth is relatively shallow causing the enormous flow to spread up and out of the banks into the surrounding roads and community. The July 2012 charts clearly demonstrate the massive storm water runoff that surges Cypress Creek to capacity and out of its banks with moderate rainfall. It does not take these levels to surge the creek, but when it happens, homes and roadways become inundated and hazardous conditions put residents and rescuers in danger.





History shows a modest rainfall of less than two inches, as seen the first week of September 2015 in the following figures, is enough to increase the flow from a mere 4,400 gallons per minute (10 cubic feet per second) to nearly 300,000 gallons per minute (600 cubic feet per second) and increase the waters depth by over six feet.



Since 1990 the western most portion of Harris County, between Interstate 10 and Highway 290, has tripled its population. This includes the upper end, and overflows, of Cypress Creek. The portion of Harris County that has doubled its population in that same time, this includes the

portions of Cypress Creek east of Highway 290 to Interstate 45, including our fire department district (Harris County, 2015). Harris County population is estimated to grow by more than 2 million by 2025, according to a study conducted in 2003 by the Houston-Galveston Area Council (Houston-Galveston Area Council, 2003).

There has been flooding with a few homes affected, however we have not seen the repetitive flooding or flood damage due to the extensive work by the flood control district to develop new retention and detention for storm water. This has not stopped the flooding, access to the flooded areas, or prevented development or residents from desiring to live in these areas as they are highly sought after neighborhoods. The fact that we now have so many residents living around these creeks and channels that are so prone to flooding has increased the numbers of citizens that are exposed to and required to travel through flood waters on a routine basis. This growth is taking place in the previously undeveloped areas in far west Harris County that will decrease the amount of land available to slow the run off while increasing the total runoff from storms that must be carried by the streams, creeks, and waterways southeast into the bays and ultimately the gulf. Bridgeland, a master planned community south of Highway 290, is being built along Cypress Creek. This 11,400 acre development was a source of controversy as it is developing along the very locations that are considered vital to the storm water runoff retention at the upper basin of the creek. In 2012 Howard Hughes Development took over the project and has dedicated 3,000 acres of development lakes and green space (Bridgeland, 2015). This green space is the primary mover behind a massive undertaking that is being spearheaded by the group Cypress Creek Flood Control Coalition. The Cypress Creek Greenway Project is a multi-faceted approach to acquire, restore, and utilize green space to mitigate flooding. This approach is being combined with the county parks and trails system to join the county parks and trails along

Cypress Creek, Little Cypress Creek and Spring Creek from Waller County to the confluence of the creeks and the San Jacinto River. This reclamation project has resulted in major investments from developers to help the coalition, flood control district, and county precinct parks departments to provide quality of life land use for the citizens while at the same time providing required green space back to the creeks that has historically flooded (Cypress Creek Flood Control Coalition, 2015). Flood watches, meaning flooding is possible in your area or flood warning, meaning flooding is already occurring or will occur soon in your area have become routine and quite common place in Harris County. The fact that these warnings are issued for counties and will often say a given jurisdiction or creek area, but when you have a 50 mile long creek that has nearly 300 square miles of watershed citizens and responders may be less than certain about flooding in their areas. In an interview for the Urban Edge blog, operated by Kinder Institute for Urban Research, Dr. Phil Bedient, director for the SSPEED Center and a professor of hydrology at Rice University gave this statement: “The problem is the public gets flood alerts for the whole county. That doesn’t tell them anything. It’s a bunch of numbers. Nobody understands what 6 inches of rainfall in 3 hours means. You need a simplified system that’s communicating to the public whether their area is in trouble. People get all these county-wide alerts, and they quit paying attention. Harris County is 1,700 square miles. We’re giving people the same alerts in Tomball that we’re giving people in Clear Lake 50 miles away. I don’t want that kind of prediction” (Keatts, 2015). Along Cypress Creek citizens rely on radio, television, email, cell phone based messaging services, or the internet to notify them of emergencies. The notifications are much generalized for the areas and not neighborhood or community specific. As noted in a multitude of news articles, even some more automated warning systems such as reverse911, where the system sends a recorded message to residents in

selected areas, neighborhoods, or other geographically selected area and calls them to give them the message, can and will be either ignored, not answered, or simply disregarded as not applying to them (Keatts, 2015) (Maxwell, 2014) (Beavin, 2015). Despite advances warnings are often disregarded. As stated before, most flood fatalities occur in vehicles on flooded roadway. The flooding in the roadways was reported as one of major concern in the survey conducted with residents around the flood plain.



Figure 2 Rescue boat operations on Kluge Road, launch in middle of road with stranded cars whose drivers were rescued in the very early morning hours after driving into an already flooded roadway

The area that has had absolutely no buy outs is the Longwood subdivision in the northern end of our territory. This area is dissected by the major tributary Little Cypress Creek. To accommodate the previously existing floodplain, the developers put a golf course along and around the creek. The growth has been upper end neighborhoods, both master planned communities and, a newly coined term of, pocket neighborhoods. These are those small compact neighborhoods with high end builders and large homes crammed into smaller parcels such as 30-50 acres. Currently in the Cypress Creek Fire Department district, there are 84 single family homes that have been redistricted into the 100 year (1%) flood plain. (Harris County, 2015) These homes have an average value of approximately \$18,260,000. (HCAD, 2015) According to

an article published in ScienceDaily, a location within a floodplain will lower estimated home sales value by 7.3%. (Wiley-Blackwell, 2008) This represents a loss of value to those homes of \$1,332,980. The affect this has on the capabilities of Cypress Creek Fire Department as seen in the reduced ad valorem taxes collected by Harris County Emergency Services District (ESD) #13 that collects property tax to fund the operations of Cypress Creek FD within this district. The district currently collects \$0.0872 per \$100 value of all property in the district. This is proposed to go up to \$0.09 to support increased needs in the district. Taking into consideration the new rate this reduction in value relates to a loss of \$1199.68 annually to the districts funds. The flooding has also resulted in flood buy outs by, or through, the Harris County Flood Control District. When this happens the property is assigned a \$0 value and taxes are no longer levied against the property. In the past two decades approximately 180 single family homes, of the 376 listed as repetitive loss or severe repetitive loss by the National Flood Insurance Program (HCFCD , 2011) were bought out as a result of severe or repeated flooding damage. These buy outs represent a total property valuation loss to the area of \$39,133,000 and net loss to the ESD of \$35,219.70 annually. When budgeting for equipment upgrades, facility improvements, equipment maintenance and training, these budgetary numbers have a real impact in what can and cannot be accomplished annually. The Harris County Public Infrastructure Division is responsible for construction plans reviews and permitting to insure compliance with county building codes. According to their website, between 2003 and 2012, total flood insurance claims *averaged* nearly \$4 billion per year across the county. Furthermore, they state that in the last 52 years nearly 1,000 flood events have been federally declared disasters (Flood Facts, 2015). The July 2012 flood was not one of those, it was merely a heavy storm that trained along the Cypress Creek watershed. The urbanization, as discovered in the literature review, shows that creeks and

streams will fill quicker and flood more often due to development. 61% of Texas lives in 11 counties with populations greater than 500,000. This represents 4.3% of all Texas counties. If you were to include the counties greater than 250,000 it would total nearly 70% in less than 8% of the 254 counties in Texas (Annual Estimates of the Resident Population: April 1, 2010 to July 1, 2014, 2015). Part of HCFCD's mission is to mitigate flooding through working with the various floodplain administrators. These are the representatives from the various authorities having jurisdiction (AHJ). The idea is to regulate construction and mitigate flooding through impact studies that must be completed for all major construction. This is spelled out in The Criteria Manual for the Design of Flood Control and Drainage Facilities in Harris County, all of these can be found in the document library of the HCFCD website (HCFCD , 2011). The 2004 revision of this document, despite the constantly increasing out of banks flooding along the creek, was allowed to maintain the allowable regulatory release rate to remain unchanged from the values found in the manual from 1984.

Recommendations

The department can, and should, partner with the various county agencies, the flood control coalition, and home owners associations in a public-private partnership. The current relationship with Harris County Parks Department exists, but can be fostered over the coming year to help build this relationship into a very useable tool. The relationship with the Harris County Precinct 4 Constables Park Division is very well developed and should be leveraged to allow the department and park deputies to crosswalk information for the sake of the community. The lines of communication that were opened during the development of this research should be cultivated into a worthy relationship to use the power of a very well established grass roots activism to help reach out to better prepare the community as a whole. This partnership can then

develop lists of roadways, residences, businesses, parks, and trails that are most at risk of flooding. The thresholds of when water rises in these areas can be observed over the coming months, even years, using simple off the shelf technology that can provide date/time stamped digital images to correspond with rainfall, stream level, and flow gages along the creek. From there the community can build a set of solid warning benchmarks for the creek area to better prepare for the inevitable risks that are associated with living along Cypress Creek. The growth, the development of land, and the sedimentation of the channel have not remained constant since 1984. The district, as well as a consortium of all first responder organizations in the watershed, must reach out to the legislators in the county and state to rectify this as soon as possible. The failure of our AHJ decision makers to better manage runoff, development, and stream improvements has resulted in many more flooding events. There is a total of 34 floodplain administrators within Harris County. Each of these represents a different and unique AHJ with a total of 250 elected officials for the 34 floodplain administrators to report to. Each of these then has a wide array of priorities, interests, and constituents they are accountable to. Each of these events not only puts the community at risk, but it necessitates the increased need of the district. The district must develop new approaches, expensive capital investment in resources, increased training demands, and operating in a very deadly environment that is ever changing. Further, this creates a demand of an increased mutually agreed upon approach to responses along the creek across approximately 10 different emergency response organizations. To complicate matters, each of these organizations is an independent emergency services district or county agency that has no obligation cooperate or work together. Developing a greater sense of the acceptable risk for the community requires more research. The district board of commissioners is elected by the community, but we rarely find more than 0.5% of the total population in the

district vote on these commissioners. This lack of civic involvement could indicate a lack of understanding in what the community's needs truly are. Acceptable risk from businesses and residents should be assessed and used to help develop a more thorough set of operational mission and goals. Then perhaps a more accurate direction and needs assessment can be developed.

During the Executive Analysis of Community Risk Reduction, each student presented a slideshow about their research. A good motto for the community could be: it rains in Texas (Weather Research Center, 2015), nobody can stop the water, nobody can stop all of the development, but a community can be prepared for the reality of flooding. By the way, it's raining in Texas today.

References

- ALERT Systems*. (2015, 11 1). Retrieved from National Weather Service National Oceanic and Atmospheric Administration : www.nws.noaa.gov/os/hod/SHManual/SHMan001_alert.htm
- ALERT2 Real-time Monitoring for Automated Flood Warning*. (2015, November 15). Retrieved from OneRain: <https://www.onerain.com/solutions/alert2>
- Annual Estimates of the Resident Population: April 1, 2010 to July 1, 2014*. (2015, March). Retrieved from U.S. Census Bureau, Population Division: <http://factfinder.census.gov/faces/tableservices/jsf/pages/productview.xhtml?src=bkmk>
- Arraji, S. (2013, December 17). *Proposals emerge to manage overflow at Cypress Creek and Addicks Reservoir*. Retrieved from Community Impact: <http://communityimpact.com/2013/12/17/proposals-emerge-to-manage-overflow-at-cypress-creek-and-addicks-reservoir/>
- Basha, E., Ravela, S., & Rus, D. (2008, November 5). *Model-Based Monitoring for Early Warning Flood Detection*. Retrieved November 12, 2015, from Massachusetts Institute of Technology: <https://groups.csail.mit.edu/drl/wiki/images/a/a1/BashaSenSys08.pdf>
- Beavin, A. (2015, June 10). *Multiple weather warnings sent to residents along Blanco River*. Retrieved from KXAN: <http://kxan.com/2015/06/10/multiple-weather-warnings-sent-to-residents-along-blanco-river/>
- Bedient, P., Huber, W., & Vieux, B. (2013). *Hydrology and Floodplain Analysis* (Fifth ed.). Essex, England: Pearson Education Limited.
- Blackburn, J. (2015, June 5). *Houston must embrace its flooding reality*. Retrieved from Houston Chronicle: <http://www.chron.com/opinion/outlook/article/Blackburn-Houston-must-embrace-its-flooding-6310545.php>
- Bridgeland*. (2015, September 3). Retrieved from Howardhughes.com: <http://www.howardhughes.com/properties/master-planned-communities/bridgeland.html>
- Brown & Root Services. (2000, June 30). *Regional Flood Protection Study For Lake Houston Watershed Flood Program*. Retrieved from Texas Water Development Board: www.twdb.texas.gov/publications/reports/contracted_reports/doc/97483219.pdf
- CDC. (2015, September 10). *Storm, flood, and hurricane response*. Retrieved from Centers for Disease Control and Prevention: <http://www.cdc.gov/niosh/topics/emres/pre-workers.html>
- Cotrone, V. (2015, November 14). *The Role of Trees and Forests in Healthy Watersheds*. Retrieved from <http://extension.psu.edu/plants/green-industry/landscaping/culture/the-role-of-trees-forests-in-healthy-watersheds>

- Cypress Creek Flood Control Coalition. (2015, September 10). *Greenway Project*. Retrieved from Cypress Creek Flood Control Coalition: http://www.cfcc.org/greenway_project/index.html
- Doocy, S., Daniels, A., Murray, S., & Kirsch, T. D. (2013, April 16). *The Human Impact of Floods: a Historical Review of Events 1980-2009 and Systematic Literature Review*. Retrieved from National Center for Biotechnology Information: http://www.ncbi.nlm.nih.gov/pmc/articles/PMC3644291/#__articleid1149620aff-info
- Fehling, D. (2015, August 19). City of Houston Installing Warning Gates at Flood-Prone Underpasses . *Houston Public Media*. Houston, Texas, United States of America. Retrieved September 9, 2015, from <http://www.houstonpublicmedia.org/news/city-of-houston-installing-warning-gates-at-floodprone-underpasses/>
- Flash Flood Alley . (2015, August 20). *Flood Damage and Fatality Statistics*. Retrieved from Flood Safety: <http://www.floodsafety.com/national/life/statistics.htm#biblio>
- Flood Education Mapping Tool*. (2015, June 10). Retrieved from Harris County Flood Control District: <http://www.harriscountyfemt.org/>
- Flood Facts*. (2015, September 14). Retrieved from Harris County Public Infrastructure Division: http://hcpid.org/permits/fp_information.html
- Gage Detail 1160*. (2015, September 15). Retrieved from Harris County Flood Control District: <http://www.harriscountyfws.org/GageDetail/Index/1160?From=9/15/2015%2011:14%20AM>
- Handmer, J. (2000, October 18). Are flood warnings futile? Risk communication in emergencies. *The Australasian Journal of Disaster and Trauma Studies*. Retrieved from The Australian Journal of Disaster and Trauma Studies.
- Harris County. (2015, Septemberr 10). *2012-2014 Population Study*. Retrieved from Harris County Texas: [http://www.harriscountytexas.gov/CmpDocuments/74/2012-2014 Population Study.pdf](http://www.harriscountytexas.gov/CmpDocuments/74/2012-2014%20Population%20Study.pdf)
- Harris County. (2015, August 20). *Glossary*. Retrieved from Harris County Flood Control District: <https://www.hcfcd.org/glossary/>
- Harris County. (2015, Novmeber 15). *Harris County Alerts*. Retrieved from Harris County Homeland Security and Emergency Management: <http://www.readyharris.org/go/maillinglist/1829/>
- Harris County Watersheds: Cypress Creek*. (2015, March 20). Retrieved from Harris County Flood Control District: <https://www.hcfcd.org/bayous-watersheds/harris-county-watersheds/cypress-creek/>
- HCAD. (2015, August 15). Retrieved from Harris County Appraisal District: <http://www.hcad.org/default.asp>
- HCAD Parcel Viewer*. (2015, June 10). Retrieved from Harris County Appraisal District: <http://arcweb.hcad.org/parcelviewer/>

- HCFCF . (2011). *Technical Document Library*. Retrieved from Harris County Flood Control District: <https://www.hcfcf.org/technical-area/technical-document-library/>
- HCFCF. (2015, August 30). *Tropical Storm Allison Recovery Project*. Retrieved from Harris County Flood Control District Tropical Storm Allison: <https://www.hcfcf.org/storm-center/tropical-storm-allison-2001/tropical-storm-allison-recovery-project/>
- Holeywell, R. (2015, June 2). Could better flood warnings save lives? *Houston Chronicle*. Retrieved from <http://www.houstonchronicle.com/local/gray-matters/article/Better-more-targeted-flood-warnings-6299915.php>
- Houston-Galveston Area Council. (2003). *2025 Regional Growth Forecast*. Houston: HGAC.
- Johnson, S. L., & Sayre, D. M. (1973). *Effects of Urbanization on Floods in the Houston, Texas Metropolitan Area*. Austin: United States Geological Survey.
- Keatts, A. (2015, September 3). As Cities Faces Climate Change, Competing Models For Flood Warnings Emerge. Houston, Texas, United States of America. Retrieved from <http://urbanedge.blogs.rice.edu/2015/09/03/as-cities-faces-climate-change-competing-models-for-flood-warnings-emerge/#.VfcNV5cbkUM>
- Krzyszhanovskaya, V. V., Shirshov, G. S., Melnikova, N. B., Belleman, R. G., Rusadi, F. I., Broekhuijsen, B. J., . . . Meijer, R. J. (2011). Flood early warning system: design, implementation and. *Procedia Computer Science*, 106-115. Retrieved from ScienceDirect: http://ac.els-cdn.com/S1877050911000706/1-s2.0-S1877050911000706-main.pdf?_tid=a73bf032-8cd6-11e5-9ae2-0000aabb0f01&acdnat=1447729106_b7e7605dc856f172bce7d7716d16b96d
- Leonard, M. (2012, July 19). Recent Northwest Harris County flooding causes estimated \$1 million in damage. *Community Impact*.
- Lindner, J. (2015, June 10). Flood Watch Manager/Meteorologist. (T. Gibson, Interviewer)
- Marin-Perez, R., Garcia-Pintado, J., & Gomez, A. S. (2012, March 28). *A Real-Time Measurement System for Long-Life Flood Monitoring and Warning Applications*. doi:<http://dx.doi.org/10.3390%2Fs120404213>
- Maxwell, R. (2014, January 28). Flood reveals major gaps in city's response. *KXAN*. Austin, Texas, United States of America. Retrieved from <http://kxan.com/2014/01/28/flood-reveals-major-gaps-in-citys-response/>
- Miller, S. (1996). Maintenance . *Nonpoint Source News*(April/May), 8-9. Retrieved from <http://water.epa.gov/polwaste/nps/archives/upload/44issue.pdf>
- Mioc, D., Nickerson, B., MacGillivray, E., Morton, A., Anton, F., Fraser, D., . . . Liang, G. (2008). *Early warning and mapping for flood disasters*. Retrieved from International Society for

Photogrammetry and Remote Sensing:

http://www.isprs.org/proceedings/XXXVII/congress/4_pdf/263.pdf

NOAA. (2015, September 12). *Turn around don't drown*. Retrieved from Southern Region Headquarters National Weather Service: <http://www.srh.noaa.gov/tadd/>

Rice University. (2015, August 19). *Flood Alert System 3*. Retrieved from Phillip B. Bedient: <http://bedient.rice.edu/fas3.html>

Rice University and Texas Medical Center. (2015, August 20). *Flood Alert*. Retrieved from Texas Medical Center Flood Alert System: <http://www.flood-alert.org/#Home:Home>

Rosen, R. A. (2015, September 1). *Water: The Ultimate Recyclable*. Retrieved from Texas Aquatic Science: <http://www.texasaquaticscience.org/water-ultimate-recyclable-aquatic-science-texas/>

Sharif, H. (n.d.). *Flood Fatalities in Texas*. Retrieved from South Regional Headquarters NOAA: http://www.srh.noaa.gov/images/bro/news/pdf/Flood_Fatalities_in_Texas.pdf

The Shodor Education Foundation, Inc. (1998). *Application: The Science of Water Runoff*. Retrieved from Surface Water Runoff Modeling: <http://www.shodor.org/master/environmental/water/runoff/RunoffApplication.html>

Weather Research Center. (2015, August 12). *Significant Houston Area Floods*. Retrieved from Weather Research Center: <http://www.wxresearch.com/almanac/houflood.html>

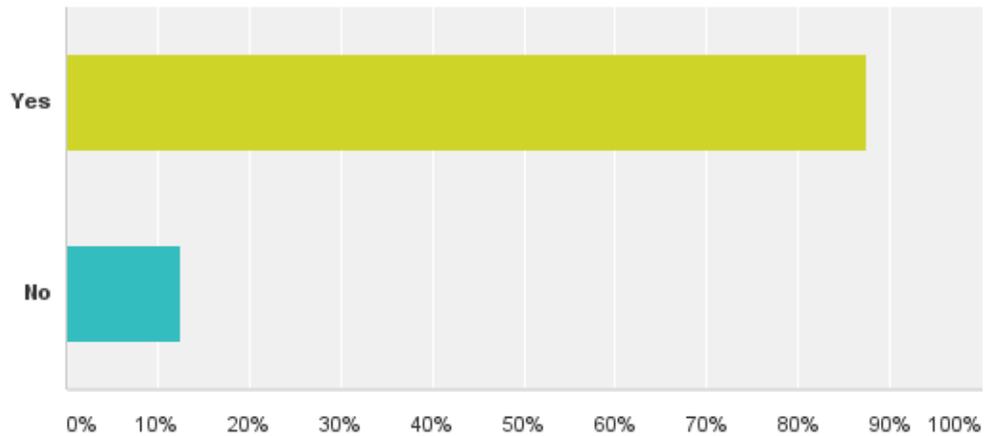
Wiley-Blackwell. (2008, April 3). *Proximity To A Flood Zone Lowers Property Values*. Retrieved from ScienceDaily: <http://www.sciencedaily.com/releases/2008/04/080403152742.htm>

Wilson, P. C., & Pudlewski, R. (1987). Optimizing Flood Protection for Cypress Creek, Harris County, Texas. In L. S. University, & V. Singh (Ed.), *Flood Hydrology: Proceeding of the International Symposium on Flood Frequency and Risk Analysis, 14-17 May 1986, Louisiana State University, Baton Rouge, USA* (pp. 281-282). Baton Rouge: Springer Netherlands. doi:10.1007/978-94-009-3957-8

Appendix 1 Survey

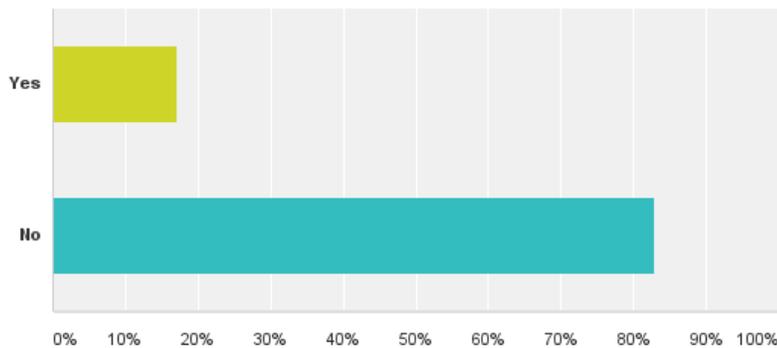
Q1 Do you live in a neighborhood that borders Cypress Creek watershed or its tributaries? (this includes Little Cypress Creek, Mound Creek, Turkey Creek, Dry Gully, Faulkey Gully, Seals Gully, Bond Gully)

Answered: 48 Skipped: 0



Q2 Has your residence and/or business been affected as a result of flooding along the Cypress Creek watershed or one of its tributaries?

Answered: 47 Skipped: 1



Q3 If you answered yes to the last question, please describe any damage or the impact this flooding had on your residence and/or business.

Answered: 8 Skipped: 40

Responses Date

1 We have significant street flooding in heavy quick rains. Our back yard (and pool) isn't able to drain given the street flooding. We've come very close to having water in our home on numerous occasions. If we're not home, we have to park down the street to gain access to our home (or any home in the cul de sac)

5/26/2015 8:11 AM

2 Lost time due to flooded entrance to neighborhood. 5/25/2015 6:59 PM

3 Flooding street are becoming an increasing problem. Causing dangerous conditions. 5/24/2015 8:53 PM

4 Every time we get a extremely hard rain lasting 30-45 or longer, the water in the street in front of our residence gets high enough to flood an automobile and our driveway is inaccessible.

5/22/2015 9:47 PM

5 Three feet of water in the house 5/22/2015 6:26 PM

6 Street flooding many times during heavy rains. 5/22/2015 5:13 PM

7 Our Home flooded on 2012. 4 ft throughout the house/garage had to be torn out and replaced. Flood ins did not cover much. Huge \$ loss. Now the new subdivision Alden woods is behind us, 4 ft higher then when we flooded. We are very scared.

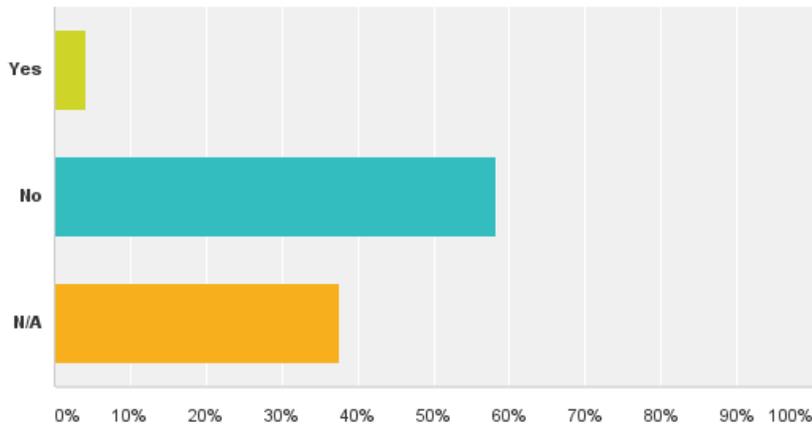
5/22/2015 3:40 PM

8 BACKYARD WATER HAS REACHED WITHIN 1-2 INCHES OF BACK DOOR/HOUSE AND FRONT STREET WATER HAS GONE OVER CURB AND 1/3 OF WAY UP FRONT LAWN WITH HEAVY RAINS(HURRICAINES)

5/22/2015 1:31 PM

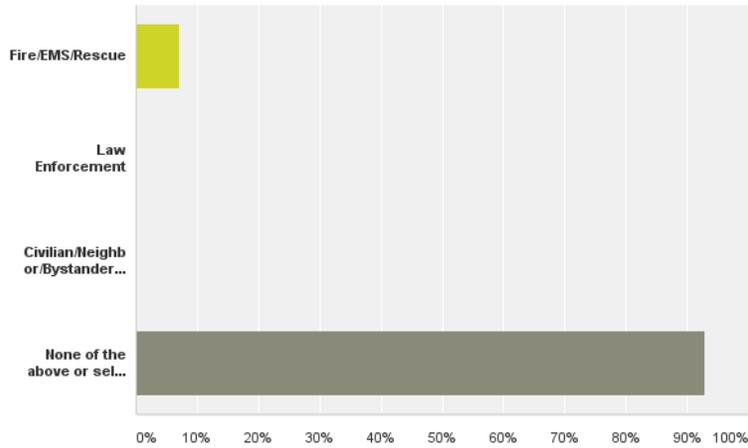
Q4 Did anyone require assistance in evacuating as a result of the flooding in your residence and/or business?

Answered: 48 Skipped: 0



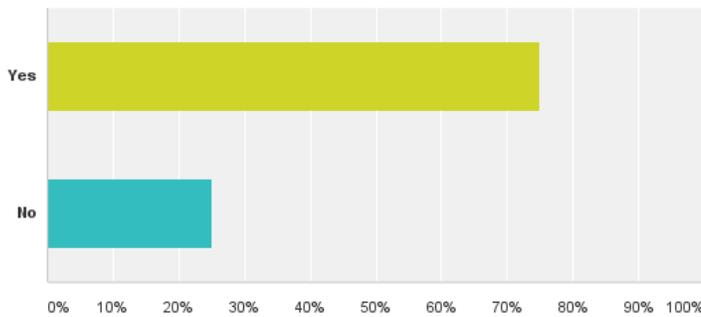
Q5 If you answered yes to the last question, what type of assistance was required to assist the evacuation during the flooding of your residence and/or business?

Answered: 14 Skipped: 34



Q6 Do you know of roadways in your area that have high water or flood during heavy rains or flooding along the Cypress Creek watershed?

Answered: 48 Skipped: 0



Q7 If you answered yes to the last question, please list the roadways you have seen with high water.

Answered: 36 Skipped: 12

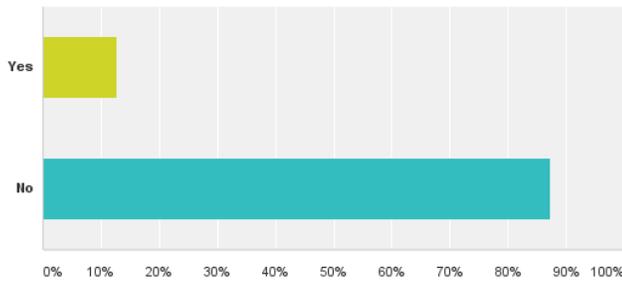
Responses Date

- 1 Texas Army Raven Creek Drive Lakecrest Drive 6/2/2015 11:49 AM
- 2 Eldridge, Grant, Kulge, Telge & Louetta 5/27/2015 4:22 PM
- 3 N Eldridge, Misty Hills, Autumn Valley Drive 5/26/2015 8:11 AM
- 4 Entrance to Quail Forest. 5/25/2015 6:59 PM
- 5 Grant Road at Cypress Creek... Spring Cypress at Telge... Cypresswood Drive at Jones Road... 5/24/2015 10:30 PM
- 6 Grant Rd 5/24/2015 8:53 PM
- 7 Grant Road, Jones Road, Longwood Trace, Eldridge, Kluge, Jarvis 5/24/2015 6:07 PM
- 8 Finch Brook Dr 5/24/2015 4:12 PM
- 9 Autumn Valley Drive 5/23/2015 5:27 PM
- 10 Misty Hills Drive 5/23/2015 4:30 PM
- 11 Longwood trace 5/23/2015 9:35 AM
- 12 All of the streets on our side of Louetta in Lakewood Glen (i.e., Misty Hills, Finchbrook, etc.) 5/22/2015 9:47 PM
- 13 Maxwell road 5/22/2015 8:46 PM

- 14 Huffmeister near the bridge on Cypress Creek, Maxwell Road, 5/22/2015 6:26 PM
- 15 Grant, cypresswood 5/22/2015 5:20 PM
- 16 Autumn Valley, Golden Valley, April Mist all in Lakewood Glen. 5/22/2015 5:13 PM
- 17 Golden valley drive. Finchbrook. April mist 5/22/2015 5:03 PM
- 18 Grant rd 5/22/2015 4:35 PM
- 19 Eldridge near Grant 5/22/2015 4:25 PM
- 20 Huffmeister, grant road 5/22/2015 3:40 PM
- 21 Autumn Valley, N. Eldridge just south of Grant Rd 5/22/2015 3:26 PM
- 22 Jarvis, Telge, Spring Cypress 5/22/2015 2:45 PM
- 23 Grant near Lakewood Forest. cypresswood near jones 5/22/2015 2:33 PM
- 24 Longwood Trace in Longwood when Little Cypress Creek has overflowed. It has happened at least 4-5 times since we moved here in 1996.
5/22/2015 2:24 PM
- 25 Misty Hills Dr. 5/22/2015 1:56 PM
- 26 LOUETTA, FINCHBROOK, AUTUMN VALLEY, ODDOM COURT 5/22/2015 1:31 PM
- 27 Grant 5/22/2015 12:51 PM
- 28 Eldridge south of Grant at the Walmart shopping center 5/22/2015 12:00 PM
- 29 Eldridge parkway 5/22/2015 11:59 AM
- 30 Telge Road - north of future Louetta Road 5/22/2015 11:54 AM
- 31 Of course the historic flooding of Grant Rd in the 90's , especially where the road goes over the creek, was the biggest event by far. Many neighborhoods had houses had to be abandoned . Many homes were lost or damaged along the creek at that time all the way back to Huffmeister. Currently Louetta going over the creek in Longwood subdivision has flooded to the point of the road being blocked a few times and cars getting stuck or having to turn around.
5/22/2015 11:52 AM
- 32 Autumn Valley, in Lakewood Glen 5/22/2015 11:47 AM
- 33 Eldridge just west of Grant Rd Autumn Court April Mist Court 5/22/2015 11:38 AM
- 34 13211 Autumn Valley 77429 5/22/2015 11:21 AM
- 35 Grant rd at cypress creek, cypress wood and Jones 5/22/2015 10:35 AM
- 36 Jones and cypresswood. Huffmeister at maxwell 5/22/2015 10:35 AM

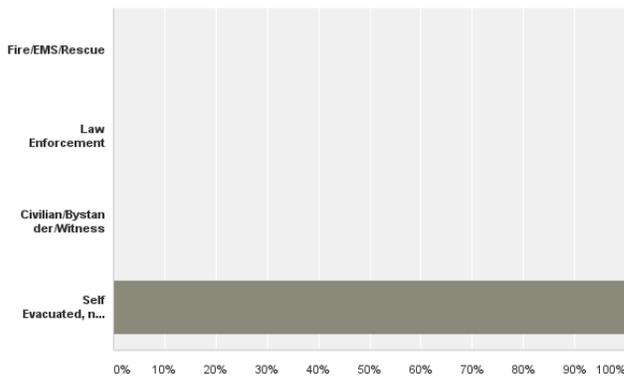
Q8 Have you ever been stranded in high water in your vehicle?

Answered: 47 Skipped: 1



Q9 If you answered yes to the last question, what type of assistance did you require to reach a safe location?

Answered: 11 Skipped: 37



Q10 Please provide us with your community/neighborhood name and a street name where your residence and/or business is located so we may better use the data to help improve the safety of our community. Thank you!

Answered: 44 Skipped: 4

Responses Date

- 1 Prestonwood Forest Brinkworth Lane 6/2/2015 12:55 PM
- 2 Ravensway Saracen Park HOA 12719 Ravensway Drive, Cypress, Texas 6/2/2015 11:49 AM
- 3 Lakewood Glen 13202 Finch Brook Dr. 6/1/2015 8:22 AM
- 4 LAKEWOOD GLEN 5/31/2015 9:41 AM
- 5 Lakewood Glen on Peach Meadow Drive 5/27/2015 4:22 PM
- 6 Lakewood Glen 5/26/2015 6:31 PM
- 7 LAKEWOOD GLEN 5/26/2015 4:13 PM
- 8 Lakewood Glen - 13202 Misty Hills Drive, Cypress, Texas 77429 5/26/2015 9:26 AM
- 9 Lakewood Glen 13211 Autumn Valley Drive 5/26/2015 8:11 AM
- 10 Quail Forest, Peach Meadow Drive 5/25/2015 6:59 PM
- 11 Lakewood Glen neighborhood, Bristol Berry 5/25/2015 2:59 PM
- 12 Dave Lockwood, Lakewood Forest (35+ years) , Realtor(R)... We are trying to make sure HC Pct. 4 and Pct. 3 get the flood control issues under control. They are making dumb decisions, and the proposed taking of the Shaw's property at Grant / Becker Cemetery was one - which has fortunately - apparently - been reversed. The flood control underground culverts need to be properly sized, and the existing flood control drainage easements - including L-103 on Grant Road - need to be improved to take excess water away from Grant Road down to Little Cypress Creek and beyond... 5/24/2015 10:30 PM
- 13 Lakewood Glen 5/24/2015 8:53 PM
- 14 Lakewood Glen April Mist Ct. 5/24/2015 6:07 PM
- 15 Lakewood Glen 5/24/2015 4:12 PM
- 16 Lakewood Glen Finch Brook 5/23/2015 5:27 PM
- 17 Lakewood Glen Misty Hills Drive 5/23/2015 4:30 PM
- 18 Windsdowne lane 5/23/2015 9:35 AM
- 19 David & Rikki Vaughan 13226 Autumn Valley Dr. (Lakewood Glen) 5/22/2015 9:47 PM
- 20 Lakewood Glen 5/22/2015 8:47 PM
- 21 Lake Cypress Estates, Maxwell Road 5/22/2015 8:46 PM
- 22 Lake Cypress Estates Maxwell Road 5/22/2015 6:26 PM
- 23 Lakewood Glen. Golden Valley Drive. 5/22/2015 5:13 PM
- 24 Lakewood glen. Golden valley drive 5/22/2015 5:03 PM
- 25 Lakewood Glen Trails, Post Oak Glen Lane 5/22/2015 4:51 PM
- 26 Lakewood Glen. Youngfield 5/22/2015 4:35 PM
- 27 Lakewood Glen 5/22/2015 4:25 PM
- 28 Lake Cypress Estates Corner of Huffmeister & Maxwell Rd. 5/22/2015 3:40 PM
- 29 Lakewood Glen, April Mist Ct 5/22/2015 3:26 PM
- 30 Coles Crossing, Jarvis 5/22/2015 2:45 PM
- 31 Lakewood Glen Lemur Lane 5/22/2015 2:29 PM
- 32 Longwood Village Traceton Circle Cypress, TX 77429 5/22/2015 2:24 PM
- 33 Lakewood Glenn- Misty Hills Dr. 5/22/2015 1:56 PM
- 34 LAKEWOOD GLEN, FINCH BROOK DRIVE(13231) 5/22/2015 1:31 PM
- 35 LWG YOUNGFIELD DR 5/22/2015 12:51 PM
- 36 Lakewood Glen Lake Mist Ct. 5/22/2015 12:20 PM
- 37 Lakewood Glen on Allysum Ct. 5/22/2015 12:00 PM
- 38 Lakewood Glen Finch Brook drive 5/22/2015 11:59 AM
- 39 Thank you for your interest. One of our concerns is that as new development continues, our area will be subject to more drainage and flooding problems, which this survey is not able to address. 5/22/2015 11:52 AM
- 40 Lakewood Glen Section 1 13123 Bristolberry Dr 5/22/2015 11:47 AM
- 41 Lakewood Glen April Mist Court 5/22/2015 11:38 AM
- 42 Lakewood Glen, Pallwood Lane 5/22/2015 11:21 AM
- 43 Lakewood Trails 5/22/2015 10:35 AM
- 44Lakewoodforest.5/22/201510:35AM

Appendix 2 List of Roads with Flooding from Survey 1

List of Roads with Reported Flooding			
Cypress Creek FD Flooding Survey			
Road Name	Crossstreet	Neighborhoods Responding	Street
North Eldridge		Lakewood Glen	Misty Hills
Misty Hills		Lakewood Forest	
Autumn Valley Drive		Quail Forest	Peach Meadow
Entrance to Quail Forest		Lakewood Glen	Autumn Valley
Grant Road	Cypress Creek	Lakewood Glen	Bristol Berry
Spring Cypress	Telge	Lakewood Forest	
Cypresswood Dr	Jones Rd	Lakewood Glen	April Mist
Grant Road		Lakewood Glen	Finch Brook
Jones Road			Windsdowne Lane
Longwood Trace		Lake Cypress Estates	Maxwell Rd
Eldridge		Lakewood Glen	Golden Valley
Kluge		Lakewood Glen Trails	Post Oak Glen Ln
Jarvis		Lakewood Glen	Youngfield
Finch Brook Dr		Lakewood Glen	April Mist

Autumn Valley Drive			
Misty Hills			
Longwood Trace			
Maxwell			
Huffmeister	Cypress Creek		
Maxwell			
Grant Road			
Cypresswood Dr			
Golden Valley			
April Mist			
Finchbrook			
Grant Road			
Eldridge	Grant		
Huffmeister			
Grant Road			
North Eldridge			
Autumn Valley Drive			
Jarvis			
Telge			
Spring Cypress			
Grant Road	Lakewood Forest		

Cypresswood Dr	Jones Rd		
Misty Hills			
Louetta			
Finchbrook			
Autumn Valley Drive			
Oddom Court			
Telge	Louetta		
Autumn Valley Drive			
April Mist			
Autumn Court			
Grant Road	Cypress Creek		
Huffmeister	Maxwell		
Jones Road	Cypresswood Dr		

521	7/13/2012	
521	7/13/2012	
521	7/13/2012	
521	7/13/2012	
521	7/13/2012	

Appendix 4 Flooding Alerts or Notifications Sent to Area Fire Chiefs

Q1: Does your department have a waterway in your district that floods?

Yes

Q2: If you selected YES, has this waterway caused flooding on roadways or occupied structures?

Yes

Q3: If you selected YES to Question 2, which of the choices below have been affected by this flooding? Select all that apply.

Residential structures, Residential roadways

Q4: Does your community have a form of notification or warning for periods of imminent flooding?

Yes

Q5: If you answered YES to Question 4, what type of warning or notification is given or transmitted to the community at risk?

Text Alert to mobile phones or devices, Reverse 9-1-1 Phone Message

Q6: Does your community have routine town hall meetings or information sessions about the dangers of flooding in the at risk areas?

No

Q7: Does your community have posted warnings about the dangers of flooding: (Select all that apply)

Respondent skipped this question

Q8: Please help us by allowing us to collect a few demographics to help us with our data.

What is the waterway name? Clear Creek

What is your agency name? Pearland Fire Department

What is your zip code 77581

Q9: Please feel free to add any other information that you feel may be of use to this research:

Respondent skipped this question

Flooding Alerts or Notifications SurveyMonkey

Q1: Does your department have a waterway in your district that floods?

Yes

Q2: If you selected YES, has this waterway caused flooding on roadways or occupied structures?

Yes

Q3: If you selected YES to Question 2, which of the choices below have been affected by this flooding? Select all that apply.

Residential roadways

Q4: Does your community have a form of notification or warning for periods of imminent flooding?

No

Q5: If you answered YES to Question 4, what type of warning or notification is given or transmitted to the community at risk?

Respondent skipped this question

Q6: Does your community have routine town hall meetings or information sessions about the dangers of flooding in the at risk areas?

No

Q7: Does your community have posted warnings about the dangers of flooding: (Select all that apply)

Respondent skipped this question

Q8: Please help us by allowing us to collect a few demographics to help us with our data.

What is the waterway name? Cypress Creek

What is your agency name? Champions ESD

What is your zip code 77069

Q9: Please feel free to add any other information that you feel may be of use to this research:

Respondent skipped this question

2 / 7

Flooding Alerts or Notifications SurveyMonkey

Q1: Does your department have a waterway in your district that floods?

Yes

Q2: If you selected YES, has this waterway caused flooding on roadways or occupied structures?

Yes

Q3: If you selected YES to Question 2, which of the choices below have been affected by this flooding? Select all that apply.

Commercial structures, Residential structures, Residential roadways

Q4: Does your community have a form of notification or warning for periods of imminent flooding?

Yes

Q5: If you answered YES to Question 4, what type of warning or notification is given or transmitted to the community at risk?

Text Alert to mobile phones or devices, Reverse 9-1-1 Phone Message, Door to Door notifications , Television or Radio Broadcasts

Q6: Does your community have routine town hall meetings or information sessions about the dangers of flooding in the at risk areas?

Yes

Q7: Does your community have posted warnings about the dangers of flooding: (Select all that apply)

In areas or districts that have had high water events in the past?

,

On roadways that frequently have high water?

Q8: Please help us by allowing us to collect a few demographics to help us with our data.

Respondent skipped this question

Q9: Please feel free to add any other information that you feel may be of use to this research:

Respondent skipped this question

3 / 7

Flooding Alerts or Notifications SurveyMonkey

Q1: Does your department have a waterway in your district that floods?

Yes

Q2: If you selected YES, has this waterway caused flooding on roadways or occupied structures?

Yes

Q3: If you selected YES to Question 2, which of the choices below have been affected by this flooding? Select all that apply.

Residential roadways, Business or Industrial district roadways, Residential structures,
Commercial structures

Q4: Does your community have a form of notification or warning for periods of imminent flooding?

Yes

Q5: If you answered YES to Question 4, what type of warning or notification is given or transmitted to the community at risk?

Text Alert to mobile phones or devices, Reverse 9-1-1 Phone Message, Television or Radio Broadcasts,

Other, please comment below

Code Red weather warning system

Q6: Does your community have routine town hall meetings or information sessions about the dangers of flooding in the at risk areas?

Yes

Q7: Does your community have posted warnings about the dangers of flooding: (Select all that apply)

Respondent skipped this question

Q8: Please help us by allowing us to collect a few demographics to help us with our data.

What is the waterway name? Numerous creeks, San Jacinto River, Spring Creek

What is your agency name? Magnolia Volunteer Fire Department

What is your zip code 77356

Q9: Please feel free to add any other information that you feel may be of use to this research:

Respondent skipped this question

4 / 7

Flooding Alerts or Notifications SurveyMonkey

Q1: Does your department have a waterway in your district that floods?

Yes

Q2: If you selected YES, has this waterway caused flooding on roadways or occupied structures?

Yes

Q3: If you selected YES to Question 2, which of the choices below have been affected by this flooding? Select all that apply.

Residential roadways, Residential structures

Q4: Does your community have a form of notification or warning for periods of imminent flooding?

Yes

Q5: If you answered YES to Question 4, what type of warning or notification is given or transmitted to the community at risk?

Text Alert to mobile phones or devices, Reverse 9-1-1 Phone Message, Door to Door notifications,

Other, please comment below

We also use NIXLE, which is subscriber based so the coverage is limited.

Q6: Does your community have routine town hall meetings or information sessions about the dangers of flooding in the at risk areas?

No

Q7: Does your community have posted warnings about the dangers of flooding:

(Select all that apply)

Other (please specify) No

Q8: Please help us by allowing us to collect a few demographics to help us with our data.

What is the waterway name? West Fork of the San Jacinto River, Lake Houston

What is your agency name? HCESD #46/Atascocita VFD

What is your zip code 77346

Q9: Please feel free to add any other information that you feel may be of use to this research:

Good luck!

5 / 7

Flooding Alerts or Notifications SurveyMonkey

Q1: Does your department have a waterway in your district that floods?

Yes

Q2: If you selected YES, has this waterway caused flooding on roadways or occupied structures?

Yes

Q3: If you selected YES to Question 2, which of the choices below have been affected by this flooding? Select all that apply.

Business or Industrial district roadways, Residential roadways

Q4: Does your community have a form of notification or warning for periods of imminent flooding?

Yes

Q5: If you answered YES to Question 4, what type of warning or notification is given or transmitted to the community at risk?

Text Alert to mobile phones or devices

Q6: Does your community have routine town hall meetings or information sessions about the dangers of flooding in the at risk areas?

No

Q7: Does your community have posted warnings about the dangers of flooding: (Select all that apply)

Near the waterway?,

On roadways that frequently have high water? ,

In areas or districts that have had high water events in the past?

Q8: Please help us by allowing us to collect a few demographics to help us with our data.

What is the waterway name? SJRA

What is your agency name? The Woodlands Township

What is your zip code 77380

Q9: Please feel free to add any other information that you feel may be of use to this research:

Respondent skipped this question

6 / 7

Flooding Alerts or Notifications SurveyMonkey

Q1: Does your department have a waterway in your district that floods?

Yes

Q2: If you selected YES, has this waterway caused flooding on roadways or occupied structures?

Yes

Q3: If you selected YES to Question 2, which of the choices below have been affected by this flooding? Select all that apply.

Residential structures, Residential roadways

Q4: Does your community have a form of notification or warning for periods of imminent flooding?

Yes

Q5: If you answered YES to Question 4, what type of warning or notification is given or transmitted to the community at risk?

Television or Radio Broadcasts

Q6: Does your community have routine town hall meetings or information sessions about the dangers of flooding in the at risk areas?

No

Q7: Does your community have posted warnings about the dangers of flooding: (Select all that apply)

Respondent skipped this question

Q8: Please help us by allowing us to collect a few demographics to help us with our data.

What is the waterway name? Little Cypress Creek, Spring Creek, Willow Creek

What is your agency name? Rosehill Fire Department

What is your zip code 77377

Q9: Please feel free to add any other information that you feel may be of use to this research:

Respondent skipped this question

Appendix 5 Significant Houston Area Floods

Weather Research Center

TM
5090 Richmond #467 Houston, Texas 77056 Phone: 713-529-3076 E-mail: wrc@wxresearch.org

Significant Houston Area Floods

Year Date Description

1837		APR	Lashing Flood in Houston, Texas (2)
1837	OCT		Hurricane caused Buffalo Bayou to cause a 4' Flood on Main Street in Houston (2)
1839	FEB		Five months after opening the Milam Street Bridge over Buffalo Bayou was severely damage by a storm and flood.(1)
1841	FEB		Two day storm caused flooding that washed out two bridges on Buffalo Bayou. Building and Homes were destroyed along Buffalo and White Oak Bayou. (1)
1843	OCT		Downtown Houston streets turned into raging rivers. All bridges leading into the city were underwater. Flooding occurs on Buffalo, White Oak, and Brays Bayou. (1)
1845	----		First Flood of Consequence was in 1845. (6)
1853	----		Buffalo Bayou over flows its banks and causes the first major flood in the city. (7)
1854	----		Significant Flood. Flood Discharge on Buffalo Bayou. Major flood on Greens and Halls Bayou. (4) (6) (14)
1875	SEP 18-19		A hurricane made landfall at Indianola. White Oak and Buffalo Bayou were 30 to 40 feet above normal. All bridges over Buffalo Bayou were swept away except one. Major flood on Greens and Halls Bayou. (1)(14)
1879	FEB		Flood stage 34.3 feet on Buffalo Bayou.
1879	AUG		Devastating flood on Buffalo Bayou. Downtown Houston had 2 to 6 inches of rain in a few hours. Major Storm hits the White Oak and Buffalo Bayou areas, flooding downtown Houston. Major flood on Greens and Halls Bayou. (1)(12)
1887	AUG 29		Buffalo Bayou became a raging torrent and swept houses and bridges away. A family of 9 drowned before they could escape. 11 deaths (10)
1899	JUN 29		Stalled tropical moisture. Rained for the previous 36 hours straight in Houston, Texas. (4)
1900	SEP 9		Major hurricane makes landfall in Galveston. Harris County experiences widespread flooding. (1)
1902	JUN 26-28		14.22" at Nacogdoches, Texas and 8 inches of rain in southwest Houston.(4)(3)
1902	JUL 20-30		16.90" at Temple, Texas and 8" North Houston, Texas. (4)
1903	JUL 1-5		12.45" of rain at Beeville, TX - 6 to 7 inches of rain in South Houston. (4)
1907	MAY 28-31		12.71" Sugar Land, Tx causing flooding in southeastern Texas. Greens and Halls Bayou out of their banks (4)(3)
1913	OCT 1-4		14.79" of in Boerne, TX - 7.5 inches in south Houston. October 1 7.17" of rain fell in 32 hours at the Houston City Office (11)
1913	DEC		Brazos River flood spread to Harris County, Buffalo, White Oak, Brays and Greens Bayou were all out of their banks. Downtown Houston was flooded. San Jacinto River out of its banks in Conroe 25.2'.(1)(6)
1914	MAY 26-30		11.92" in Beaumont, Texas - 8 inches in north Houston. (4)

- 1915** AUG 18-20 Hurricane landfall in Galveston (Category 4) - 20 inches of rain over Houston causing widespread heavy flooding(1)(4)
- 1919** JUN 15 Brays Bayou at Main Street 1.6 Miles upstream from Harris Gully. Flood was the maximum since at least 1911. 8.39" of rain fell at the Houston City office. Brays Bayou gage height 56 feet. White Oak Bayou out of its banks. (16)(1) (11) (6)
- 1919** SEP 14-17 Hurricane landfall near Corpus Christi in South Texas (Category 4) - 7 inches of rain over Houston. Brays Bayou one of the hardest hit. Small boats were the only transportation near Rice off of Brays Bayou. (1)(4)
- 1922** MAY San Jacinto River at Conroe out of its banks 24.2'. (6) (4)
- 1924** MAY 29-30 Conroe 13.85". Heavy rainfall in north Houston. (4)(6)
- 1929** APR Storm moved in from the Gulf causing rain for 14 hours. Much of the county had 10 inches or more. All bayous were over their banks. 9.5" of rain along the Brays Bayou. (1)
- 1929** MAY 12-18 11.37" Houston City Office had 8.07" on the 15th.
- 1929** MAY 24-31 Flooding May 31. Houston Central Water Plant was flooded. San Jacinto River was reported to be 30 feet above normal. May 31 White Oak Bayou is out of its banks. May 30 Spring Creek near Spring highest flood since at least 1879 according to local residents. Gage Height was 48.9' Cypress Creek near Humble, Texas the gage height was 32.7'. (6)(1)
- 1930** MAY 12 Stationary Storm over Harris County for 3 days causing 12.5 inches of rain over the area. 2.6" of rain on May 12 in 21 hours (11) (5) (1)
- 1932** FEB Flooding in Pearland, TX. Clear Creek gage was at 17.8'. (1)(6).
- 1932** AUG 14 Hurricane made landfall in Freeport and caused widespread flooding on all of the bayous. Downtown Houston was flooded. (1)
- 1933** JUL 22-27 E Houston had 12" of rain due to a Tropical Storm which made landfall near Freeport and moved slowly across eastern Texas. Flooding reported along all of Harris County bayous. (1)
- 1935** DEC 6-9 20.6" in 35 hours over Westfield, TX. Houston reported 5.52" of rain. Satsuma in northwest Harris County had 16.49" of rain. Bayous were 52 feet above normal. The city's pumping station was unable to supply water for a few days and the city had no protection against fire. Buffalo Bayou at Houston 54.4 feet with 40,000cfs. Buffalo Bayou at Addicks 85.6'. 2/3 of rural Harris County was flooded. Halls Bayou was over its banks. Spring and Cypress Creeks were out of their banks. (1)(4)(3)(6)
- 1936** MAY 22-29 12" of rain over west Houston. May 24 3.96" of rain fell in 7 hours at the Houston City Office (11) (4)
- 1936** DEC 10 Brays out of its banks. December 9 1.68" of rain fell in 3.4 hours at the Houston City Office (11) (6)
- 1938** MAY 7 White Oak Bayou out of its banks. May 6 5.91" of rain fell in 1.9 hours at the Houston City Office (11) (5)
- 1938** MAY 16 One day storm centered over Buffalo Bayou. Katy, Texas Almost all the rain fell in 12 hour period. (4)
- 1938** MAY 19 Buffalo Bayou out of its banks 3.5' above flood stage. (5) (6)
- 1939** JUL 13-15 Buffalo and White Oak Bayou peak flows. July 11 8.27" of rain fell in 27 hours at the Houston City Office. JUL 14 Flooding in Alvin, Texas. Chocolate Bayou gage height 19.9'. (1) (11) (5) (6)
- 1940** JUN 18 Buffalo Bayou out of its banks. 3.02" of rain fell in 1.7 hours at the Houston City Office. (11)(5)

- 1940** NOV 24-25 Hempstead had 16" in 24 hours; Conroe. 5 days of rain over northeast Houston. 4.70" of rain fell in 18 hours at the Houston City Office. Heavy rains lasted for 5 days in northeast Harris County. Nov 25 San Jacinto at Conroe the gage height was 25.85'. Nov 25 Spring Creek at I45 flooded (14) (1) (11)
- 1941** APR 24 I45 flooded at Spring Creek. (14)
- 1941** JUN 11 Buffalo and White Oak Bayou out of its banks. 3.29" of rain fell in 1.3 hours at the Houston City Office. Buffalo Bayou is 4.83' above flood stage. (11)(5)(6)
- 1941** SEP 17-24 Hurricane makes landfall near Freeport and moves inland over Houston. Flooding throughout the City. 4 killed. (1)
- 1941** NOV 1 White Oak Bayou out of its banks. October 30 4.59" of rain fell in 20 hours at the Houston City Office (11)(6)
- 1942** JUL 6-7 Buffalo and White Oak Bayou out of its banks. 3.32" of rain fell in 7.5 hours at the Houston City Office. Buffalo Bayou 4.75' above flood stage. Many bayous and creeks overflowed their banks. (11)(5)(6)
- 1943** JUL 28-AUG 1 Hurricane makes landfall near Galveston and flooded parts of Houston. July 27 7.26" of rain fell in 27 hours at the Houston City Office. (11)(1)(5)(3)
- 1943** OCT Hurricane makes landfall near Freeport. 11,000 homes are flooded in Harris County.(1)
- 1943** NOV 2 Buffalo and White Oak Bayou out of its banks. Nov 1 10.83" of rain fell in 7 hours at the Houston City Office. Buffalo Bayou 3.95' above flood stage. (11)(5)(6)(16)
- 1944** MAR 19 White Oak Bayou out of its banks. May 21 5.38" of rain fell in 4 hours at the Houston City Office.(11)(6)
- 1945** AUG 27-30 Slow moving Tropical disturbance [Hurricane made landfall near Port Aransas] produced heavy rains on the Texas Coast. Hockley in Harris County had 19.6" from 7am Aug 26 to 1PM Aug 29 Anahuac had 15.87" in 24 hours, Hobby had 15.65" in 24 hours-Storm made landfall near Port Aransas. Buffalo Bayou out of its banks. Aug 27 9.28" of rain fell in 15 hours at the Houston City Office. Buffalo Bayou at Addicks gage height 81.23' flowing 11,200cfs. Aug 30 Buffalo Bayou at Houston flowing 10,900cfs. Major flooding on all bayous and streams. Hurricane landfall near Port Aransas. (1)(11)(3)(5)(6)
- 1946** MAY 20-21 Buffalo Bayou out of its banks. May 19 4.48" of rain fell in 1.2 hours. 3.75' above flood stage. Buffalo Bayou at Addicks gage height 79.61'. Buffalo Bayou at Waugh out of its banks. (16)(1)(11)(5)(6)
- 1946** NOV 7 Buffalo Bayou out of its banks. 4.57' above flood stage. (5)
- 1949** OCT 8 Thunderstorm caused flooding over Brays and Greens Bayou. 10" of rain fell in 24 hours. Over 100 homes were flooded. October 7 7.64" of rain fell in 12 hours at the Houston City Office. Flooding in Alvin, Tx Oct 8. Oct 8 Chocolate Bayou gage height 18.8'. Buffalo Bayou at Piney Point out of its banks. (16)(11)(1)(6)
- 1950** FEB Thunderstorms ahead of a cold front caused rainfall over Greens Bayou. Baytown Flooded. (1)
- 1953** MAY 18 Buffalo and White Oak Bayou out of its banks. 2.58" of rain in 3 hours. Buffalo Bayou was 3 feet above flood stage. Halls Bayou had a maximum flood. (1)(11)(5)(6)(14)
- 1954** JUL 30-AUG 2 Buffalo and White Oak Bayou out of its banks. July 29 5.59" of rain fell in 23 hours. Buffalo Bayou was 1.28' feet above flood stage. Greens Bayou gage 64.75' on Jul 30. Halls Bayou gage height 60.65' on Jul 30. (1)(11)(5)(6)(16)

- 1955** MAY Thunderstorm over north Harris County caused 10 inches of rain in less than 24 hours flooding homes.(1)
- 1957** MAR 17-18 White Oak Bayou out of its banks. Flooding in Pearland, TX. Clear Creek flooded. (1)(5)
- 1957** JUN 27-28 Hurricane Audrey made landfall close the Texas/Louisiana border. Flooding reported throughout Harris County.(1)
- 1957** OCT 15-18 2" of rain in 2 hours. Buffalo and White Oak and Greens Bayou out of its banks. 3.00" of rain fell in 1.7 hours at the Houston City Office on Oct 15. (11)(1)(5)
- 1959** APR 10-12 Buffalo and White Oak Bayou out of its banks.(6)(5)
- 1959** OCT Thunderstorms caused flooding of 100 homes along the Brays Bayou and Kegans Bayou. 7" of rain was reported.
- 1960** JUN 24-28 Tropical Low 5-15" of rain. Cypress and Spring Creeks and San Jacinto River and Sims Bayou were out of their banks. White Oak out of its banks. Jun 24 7.29" of rain fell in 29 hours at the Houston City Office. June 25 14.25" in 42 hours. Jun 26 6.96" of rain fell in 6 hours at the Houston City Office. Brays Bayou gage height 49.72' on June 26. Sims Bayou gage height 29.76'. 11.88" of rain on Spring Creek (14)(11)(1)
- 1960** OCT White Oak Bayou out of its banks.
- 1961** FEB 17 Greens and Halls Bayous out of their banks. White Oak Bayou out of its banks. (16)
- 1961** Jun 19-21 White Oak Bayou out of its banks. Jun 18 4.75" of rain fell in 2 hours at the Houston City Office. Buffalo Bayou at Addicks out of its banks. (16)(11)(6)
- 1961** SEP 11-12 Hurricane Carla caused heavy flooding in southern Harris County. Rainfall amounts of 8 to 10 inches. Greens and Halls Bayous out of their banks. Buffalo Bayou at Waugh out of its banks. (14)(1)
- 1961** SEP 21 Greens Bayou at 59 was 4.75' above flood stage.
- 1961** NOV 13 Greens and Halls Bayou out of their banks. (16)
- 1962** NOV 27 Greens and Halls Bayou out of their banks. (16)
- 1964** MAR 7 Buffalo Bayou at Piney Point out of its banks.
- 1964** MAY 31-JUN 1 Thunderstorms caused 5" of rain in 4 hours causing 235 homes to flood along the Greens and Hall Bayous. (1)
- 1966** APR 14 Thunderstorms caused 5" of rain over Greens Bayou and Cypress Creek. Several homes were flooded. 3.52" of rain in 7 hours at the Houston City Office. (11)(1)(14)
- 1968** MAY 13 Thunderstorms caused flooding over the Vince and Sims Bayous. 6 inches of rain fell in 24 hours. 2.74" of rain fell in 1.6 hours at the Houston City Office. (11)(1)
- 1968** JUN 15-25 Ten days of rain
- 1968** JUL 3 Buffalo Bayou at Piney Point out of its banks. (16)
- 1969** FEB 19-22 Thunderstorms ahead of a cold front flooded 200 homes and businesses in south and southeast Harris County. 1.89" of rain fell in 28 hours at the Houston City Office. Greens and Halls Bayou out of their banks. (14)(16)(11)(1)
- 1970** OCT 9.09" of rain fell in 24 hours causing flooding. (14)
- 1971** OCT 12 Buffalo Bayou at Piney Point was 1.56' above Flood Stage.(18)
- 1972** MAR 20-21 7.47" rain IAH, 7.01" in 3 hours; Independent Heights 7.65" Halls Bayou 9.5" Thunderstorms ahead of a cold front. Buffalo Bayou at Piney Point out of its banks. (14)(18)(1)

- 1973** JUN 12-13 Harris County had 10-15" of rain; 10 drowned in Alvin, 16.01; Coldspring 16.71". Sims and Greens Bayous were out of their banks. Buffalo Bayou at Piney Point 4.98' out its banks. (18) (1)
- 1975** JUN 9-10 Extensive flooding in Harris County. Deer Park 15.65"; Hobby 7.15"; Westbury 10.34". Thunderstorms over southern Harris County. 550 homes - 50 apartments and 4 businesses were flooded. There was 9 inches of rain in 7 hours. Sims Bayou out of its banks. (17)(1)
- 1976** JUN 15 Texas Medical Center Flood 10.47"; 8 drowned; Westbury 10.12". Hunting Bayou at Loop 610. 10.2" of rain in 6 hours. 13" of rain impacted the Brays Bayou. (1)(3)
- 1978** NOV Strong thunderstorm caused flooding along the Brays Bayou. (1)(3)
- 1979** JAN 19 Cypress Creek at Katy Hockley out of its banks. (17)
- 1979** APR 18 16" of rain over Harris County. Flooding wide spread over many Harris County Bayous and streams. Conroe 12-14" of rain, 3 deaths. (1)(3)
- 1979** JUL 24-25 Tropical Storm Claudette - 43" of rain in Alvin in 24 hours. (1)
- 1979** SEP 1 Tropical Storm Elena, flooding downtown, 1 death
- 1979** SEP 19 13" of rain Brazoria County, 4 deaths. Three days of rain totals of 8 to 27". (3)
- 1980** JAN 22 3" of rain in a short period caused flooding 1981 MAY 3 10" of rain, 1 death. Hobby 9.48" of rain. (3)
- 1981** MAY 21 Cypress Creek at Katy Hockely out of its banks. (17)
- 1981** JUN 5 Tropical Depression, 12" of rain, 1 death
- 1981** AUG 31 Remnants of tropical depression, 2" to 10". Flooding along Brays Bayou. Buffalo Bayou at Piney Point 7.20' above flood stage. (17) (1)
- 1981** OCT 5 Sims Bayou out of its banks. (17)
- 1983** MAY 21 Strong thunderstorms caused flooding along several Harris County creeks and bayous. Brays and White Oak and Cypress and Spring Creek were out of their banks. Montgomery County flooded. (1)
- 1983** Aug 17-19 Hurricane Alicia. Flooding along all the bayous. Extensive flooding reported along all area bayous and streams. Greens Bayou at 59 3.68' above flood stage. Sims Bayou at Telephone was out of its banks. (17) (1)
- 1983** SEP 19-20 Heavy rains 4 people killed. 9" of rain from thunderstorms south of downtown Houston. 1000 homes flooded along Brays Bayou. Buffalo Bayou at Piney Point 5.6' above flood stage. (17)(1)
- 1984** SEP 18-22 Low pressure system caused flooding
- 1984** OCT 25-26 9" of rain in one day in northern Harris County. More than 200 homes flooded. 10" of rain at IAH with 650 homes flooded in western Harris County and northern Fort Bend Counties. Cypress Creek and Greens and White Oak Bayous out of their banks. Greens Bayou at 59 was 5' above flood state. (17)(1)(3)
- 1985** NOV 11 Sims Bayou out of its banks. 5.5" of rain fell in southeast Houston. (17)(8)
- 1985** NOV 24-25 11" of rain SW Montgomery County.(8)
- 1986** NOV 11 Buffalo Bayou at Piney Point out of its banks. (18)
- 1987** JUN 11-12 10.4" of rain fell over eastern Harris County, 1 death.(8)
- 1987** NOV 25 Heavy rains, 4".

- 1989** JAN 18 Thunderstorm flooded streets and stores. (8)
- 1989** MAY 16-19 10.28" of rain at IAH. 15" of rain in Spring, Texas in 24 hours. 1400 homes flooded. 7-14" of rain over much of Harris County. Buffalo Bayou at Piney Point 7.39' above flood stage. Greens Bayou at 59 was 5.04' above flood stage. (17)(1)(3)
- 1989** JUN 25-JUL 7 The remnants of TS Allison produced heavy rain. 1100 homes flooded 6-12 inches of rain. Greens Bayou at 59 5.04' above flood stage. (1)(17)
- 1989** AUG 1 Sims Bayou out of its banks. (17)
- 1991** JAN 10 Liberty River overflowed
- 1991** DEC 19-31 Fort Bend County Homes Flooded.(3)
- 1992** MAR 4-5 White Oak Bayou flowed into IH10 causing flooding, 1drowned. 1500 homes flooded. Much of I-10 was underwater. Buffalo Bayou out of its banks. Record floods on upper Brays Bayou. Over 300 homes flooded along Brays Bayou. White Oak Bayou 4.10' above flood stage. Buffalo Bayou at Piney Point 11.23' above flood stage. (14)(1)(8)
- 1993** MAR 1-2 Halls Bayou near Jensen over its banks and bank full conditions on Greens Bayou. One home flooded along Greens Bayou; 2"-3" rain, 4"-5" in some scattered locations. (5)(9)
- 1993** MAR 23 5"-7" across the northern portion of Houston. Flooding at underpass of Holman and Louisiana. (9)
- 1993** JUN 20 Buffalo Bayou at Piney Point 3.01' above flood stage. (18)
- 1993** OCT 6" of rain fell over southern Houston
- 1994** FEB 20 Heavy rain, 6.1" on the Waller/Ft. Bend County Line. 6" in Katy.(9)
- 1994** AUG 15 Flooded cars on West Sam Houston Tollway.
- 1994** OCT 17-18 29" of rain fell in 3 days over Harris County. October 18 Spring Creek gages was at 224'. Along Brays Bayou 100 homes flooded. 90 subdivisions were flooded with 3400 homes flooded. 19 deaths. Buffalo Bayou at Piney Point 4.11' above flood stage. (17)
- 1995** JUN 30 3"-6" of rain fell causing street flooding.(8)
- 1995** OCT 18 Buffalo Bayou was 3.85' above flood stage. (6)
- 1995** NOV 2 Street flooding in Clear Lake.(8)
- 1995** DEC 17-18 Widespread flooding on the 17th. Flooding on 290 on the 18th.(8)(9)
- 1996** SEP 18 Widespread street flooding in downtown Houston and Pasadena. Water made its way into homes and businesses in Pasadena. (8)(9)
- 1996** SEP 27 Street flooding NE Houston.(8)
- 1997** JAN 27 Widespread street flooding.(9)
- 1997** MAR 12 Training rains caused significant flooding in Houston. Many bayous over banks for much of the day. I-10 was closed due to high water. Buffalo Bayou was 2.14' above flood stage. (6)(8)(9)
- 1997** APR 4 Street flooding in Houston
- 1997** APR 25 5"-7" of rain caused street, bayou and creek flooding.(8)
- 1997** MAR 12 Early morning flooding. Heavy rains stalled over Houston.
- 1997** MAY 21- 22 Street flooding in west Houston 6"-8" of rain. Elderly man drowned as he drove into a flooded underpass. Buffalo Bayou at Piney Point 4.69' above flood stage. (17)(8)
- 1997** MAY 24 Severe flooding in Houston; 50-75 homes flooded. Creeks and Bayous out of their banks.(8)
- 1997** MAY 30 3"-5" of rain; 6 homes flooded in northern Harris County.(9)
- 1997** NOV 28 High water on feeder at I-45 and Nasa Road 1. (9)
- 1997** DEC 20 Street flooding in Humble and SW Houston.(9)

- 1998** JAN 4 Red Bluff in Pasadena flooded; also roads near Alameda Mall.(8)
- 1998** JAN 6 Street flooding in Bellaire.(9)
- 1998** JAN 21 Street flooding across Harris County; flooding in Pasadena.(9)
- 1998** SEP 11 Tropical Storm Frances 7"-12" of rain over Houston. Homes in Jersey Village were flooded. Buffalo Bayou was 13.33' above flood stage. Along White Oak Bayou 1300 homes were flooded. Buffalo Bayou at Milam was 8.77' above flood stage. White Oak Bayou at Heights was over its banks. (14)(1)(8)
- 1998** SEP 14 High water on Desse Rd, and Main St. in Baytown. (9)
- 1998** OCT 4 Heavy rains stalled over Harris County and northern Galveston County. Feeder Roads flooded on I-45 in southern Harris County.(8)
- 1998** OCT 17-19 Pacific/Gulf moisture caused flooding in northern Harris County and Montgomery County. Spring and Cypress Creeks flooded. 1200 Homes were flooded in Harris County. 12 to 14 inches of rain. Spring Creek at Heger the gage height was 219.9'on October 19. Bear Creek at FM 529 out of its banks. Cypress Creek at Katy Hockley out of its banks. (18) (19) (1) (8) (9)
- 1998** NOV 12-14 Numerous roads closed due to flooding. Heavy rainfall over southeast Texas 5" to 7" inches of rain fell. 200 Homes flooded along Cypress and Spring Creek. Nov 14 Cypress Creek at Katy Hockley out of its banks. (14)(8)
- 1999** MAR 19 Heavy rains over west Houston. Buffalo Bayou at Piney Point 2.76' above flood stage. (18)(8)
- 1999** NOV 13 Buffalo Bayou 1.93' above flood stage.(6)
- 2000** MAY 19 Major Flooding on Greens Road, Aldine Westfield; 1 foot of water in the approach control tower; 4 Feet of standing water on streets in Kingwood. Flooding in Bellaire, Alief. US 59, Loop 610 US 90 flooded. Beltway 8 and I-10 impassable. 6.5" of rain near Bellaire and Beltway 8.
- 2000** SEP 13 Foot of standing water in League City stalled cars - 7" of rainfall.(9)
- 2000** OCT 22 Flooding Liberty County.(8)
- 2001** MAR 28 Flooding on Interstate 10 between Washington and Loop 610. Flooding on Milam and Travis Street. Buffalo Bayou at Piney Point 4.24' above flood stage. (17)(18)(8)(9)
- 2001** JUN 6-9 Tropical Storm Allison, widespread flooding, >35" of rain. White Oak Bayou was above flood stage and Buffalo Bayou was 3.05' above flood stage. More than 6000 homes were flooded along Brays Bayou. Greens Bayou at 59 was 6.81' above flood stage. Greens Bayou out of its banks. White Oak at Heights 9.5' above flood stage. (17)(14) (6)(1)(3)
- 2002** AUG 15 Tropical Moisture associated with upper level low dumped rainfall over Southeast Texas Coast. Galveston had 11.46" in 24 hours. Buffalo Bayou at Piney Point out of its banks. (17)(8)
- 2002** OCT 28-NOV Strong thunderstorms streamed across west and north Houston dumping 5 to 8 inches of rain in a short time. Flooded homes in Jersey Village and many roads. 9 straight days of rain over northeast Harris County. White Oak, Greens and Halls Bayou were out of their banks. 2000 homes are flooded. Buffalo Bayou at Piney Point 4.4' above flood stage. (18)(1)(8)
- 2003** AUG 31 Flooding in Pasadena
- 2003** NOV 16-18 Flooding in Aldine. 24 tornadoes touched down during 15 hour period of severe weather in southeastern Texas on November 17th. 300 homes were flooded in Harris County and hundreds of vehicles were flooded. 1 death of 17 year girl in Sharpstown. Buffalo Bayou at Piney Point 7' above flood stage. Greens Bayou at Beltway 8 out of its banks. Greens Bayou at 59 3.61' above flood stage. (18)(8)

- 2004** MAY 1 Southbound feeder of I45 flooded at West Bank and Memorial Village and Pasadena.(9)
- 2004** MAY 13 Street Flooding in and around Kingwood.(9)
- 2004** JUN 13 Street Flooding in downtown Houston and the Medical Center area.(8)
- 2004** NOV 17 Buffalo Bayou was 6.09' above flood stage.
- 2004** NOV 22-23 Flooding between I45 northbound feeder and FM 1960. Clay road covered with a foot and a half of water. Water covered road at I10 feeder and Hwy 6. Buffalo Bayou at Piney Point 1.35' above flood stage. (18)(9)
- 2005** MAY 29 Flooding in Aldine. (9)
- 2005** JUL 14 Flooding along I10 East, Downtown Houston and U of H area. 3.31" in 1 hour at Buffalo Bayou and Shepherd. Buffalo Bayou at Piney Point out of its banks. (17) (8)
- 2005** DEC 14 Strong thunderstorms streamed across west and north Houston causing 4 to 6 inches of rainfall causing street flooding. (8)
- 2006** JUN 19 Upper Level low remains over Houston causing flooding. 11" of rain fell south and east of Harris County. 3000 homes were flooded. (1)(8)
- 2006** OCT 16 Tropical low and upper level disturbance combined with a warm front which caused training rains that moved over Houston on Sunday and Monday. Several bayous were close to bank full or over the banks causing street flooding. Buffalo Bayou at Piney Point 4.46' above flood stage. (18) (8)
- 2006** OCT 26-27 Storms ahead of an advancing cold front trained across the Tomball and southeast regions causing flooding.(10)
- 2007** JUN Several days of rain. (8)
- 2012** JUL 12-13 71 homes in Harris County and 334 homes flooded by training thunderstorms. (9)
- 2013** MAY 10 Many freeways flooded and Homes flooded from training thunderstorms. (9)
- 2015** MAY 27-28 Large thunderstorm complex stalls over Houston causing most freeways to be flooded. Homes in Meyerland area flooded.

REFERENCES

- (1) <http://www.hcfcd.org/hcfloodhistory.html>
- (2) Johnston, Marguerite, 1991: Houston The Unknown City, 1836, Texas A&M University Press
- (3) <http://floodsafety.com/texas/USGdemo/>
- (4) "US Corps of Engineers, 1935 Flood
- (5) <http://nwis.waterdata.usgs.gov/nwis>
- (6) Texas Water Commission Bulletin 6311, December 1963, Floods in Texas - Magnitude and frequency of Peak Flows
- (7) <http://www.houstonhistory.com>
- (8) Houston Chronicle
- (9) <http://www.ncdc.noaa.gov>
- (10) Department of Interior, Major Floods of 1936
- (11) US Geological Survey, Water Resources Investigations 3-73, "Effects of Urbanization on Floods in the Houston, Texas, Metropolitan Area

(12) <http://www.buffalobayou.org/history.html>

(13) <http://www.hcoem.org>

(14) US Army Corps of Engineers, June 1972, Flood Plain Information - Spring Creek, Greens & Halls

Bayou

(15) <http://water.usgs.gov/waterwatch>

(16) US Dept. of Interior Geological Survey, Surface Water Records of Texas: 1961

(17) <http://ahps.srh.noaa.gov/ahps2/>

(18) <http://www.nws.noaa.gov>

Weather Research Center

5090 Richmond #467 Houston, Texas 77056

(713) 529-3076

E-mail wrc@wxresearch.org

Appendix 6 Homeowners Associations and Management Groups

1. Longwood Village HOA: Principal Management Company of Houston, 713-329-7182
2. Norchester HOA: Chaparral Management, AAMC, 281-537-0957
cmc@chaparralmanagement.com
3. Lakewood Grove, Lakewood Glen, Lakewood Forest North, Mandolin Village,
Ravensway, Saracen Park, Turtle Lake, Ravensway Lakes: SCS Management, 281-463-
1777, info@scsmgmt.com
4. Lakewood Forest: Lakewood Forest Fund, 281-370-8943, gm@lakewoodforestfund.com

Appendix 7 Interview Questions with Mark Sloan, Harris County Emergency Management Coordinator, Office of Homeland Security and Emergency Management

8/12/2015

1. Who decides when to notify the community about imminent flooding?
 - a. NWS notifies Locals and Public, HCFCFD to locals and public, ACE to Locals and Public
2. How is the decision made?
 - a. Thresholds? No, we use rain fall versus watershed levels
 - b. Waterway or locality specific? No
3. Does the county utilize any advanced flood warning? Automated warning?
 - a. Radar(NEXRAD) integrations? Yes, 6 streams
 - b. Automatic signals or barriers? TxDOT signs yes, barriers no, only manual
4. Does Cypress Creek area, watershed, have any significant areas of concern for OHSEM? Yes, but can't be specific

Appendix 8 Email Questionnaire with Jeffrey Lindner, Flood Watch Department
Manager/Meteorologist, Harris County Flood Control District

Question #1: How are citizens that reside, or work, along Cypress Creek notified of imminent flooding? The main notification of flooding conditions in Harris County is TV media, NWS warnings, and more recently social media feeds. Additionally, citizens are encouraged to visit www.harriscountyfws.org to view the rainfall and stream gage data that HCFCD provides. While social media is becoming the increasing tool of choice by some, TV media remains the best avenue to reach the most residents the fastest. HCFCD has a good working relationship with the TV meteorologists which we rely on heavily during flooding to get out critical information on the location of where we think flooding is going to happen as well as which watersheds and subdivisions may be impacted.

Question #2: What are the triggers to initiate the notifications? How closely are these monitored, in other words, when these triggers are reached, does this become a priority to monitor the creek?

HCFCD maintains and operates 140 stream and rainfall gage stations in Harris County of which 16 are on Cypress and Little Cypress Creeks. HCFCD, NWS, and HCOEM staff are notified via e-mail or text message any time one of these gages reports the following:

- a. 1 inch of rainfall in 15 minutes
- b. Stream level is 3.0' below bank full.

The stream level alarm is usually the trigger for constant monitoring of a particular watershed. Flood warnings for individual watersheds are issued by the NWS usually in coordination with HCFCD staff when it is likely that overbank flooding will occur. River Forecast center forecasts

are provided for Cypress Creek at I-45, Grant Rd, and Katy Hockley Rd which also assist in the flooding threat and warning issuance for the watershed.

Question #3: Knowing that over 50% of all drownings during flooding events are motorists in vehicles, how are motorists warned about flood prone roadways during flooding events? Street flooding in the Houston area is generally different than “low water crossing” flooding in central TX which usually results in many flash flood event fatalities. Given our flat terrain in this region the flow of water is usually not great enough to sweep vehicles away...instead our sunken underpasses tend to fill up with water and at times motorist either drive into those flood waters or become trapped. Many of the historically flood prone underpasses have some flood gage height markings posted somewhere to warn motorists how deep the water is. Some heavily flood prone locations have flashing lights to add more warning. However in a significant and widespread flooding event like the Memorial Day flooding...many streets, even those that normally do not flood in heavy rainfall flood and become impassable and it is nearly impossible to close are of the street that may have flooding or post any type of warning information along those streets.

The NWS developed the “Turn Around Don’t Drown” slogan which is now widely used and which we (HCFCD and HCOEM) strongly stress during flooding situations. During significant flooding when many roadways and freeways are under water HCFCD usually will make the recommendation that residents should shelter in place and avoid travel until the water recedes.

Question #4: Does the county have any plans to improve the prediction and warnings with a system similar to the one currently in use in the Texas Medical Center, the City of Sugarland or proposed for Clear Creek/Clear Lake area? (As researched and developed through Rice University’s SSPEED lab) HCFCD is currently investigating the concept of a county-wide flood

forecasting system which would include various methods to forecast water levels along many if not all of the bayous in the county. Brays Bayou is a fairly easy watershed to model and forecast since it is nearly 95% urban and has few changes in the watershed and the channel. Other watersheds are more difficult due to ongoing development and changes within the watershed. We are currently looking into several options that will meet our fast response times in an urban setting and capture the complex hydrology in Harris County.

Question #5: Are there plans to remediate or buy out any more properties along the Cypress Creek watershed in light of recent (July 2012, March 2015 and May 2015) flooding events? I will defer this question to James Wade our buyout manager. (Mr. Wade never responded to repeated attempts to contact and get these answers)

Appendix 9 Telephone Interview with Dr. Philip Bedient, Professor of Hydrology and Director of Severe Storm Prediction, Education, and Evacuation from Disasters (SSPEED) Center at Rice University, Houston, Texas (<http://sspeed.rice.edu/sspeed/index.html>)

1. Dr. Bedient how does the FAS3 system used in the Texas Medical Center (TMC) work?
 - a. The system takes all the physical gages, such as rainfall, stream level, stream flow, and cameras with the NEXRAD radar data on rainfall in the watershed and submits it through a complicated software program that predicts rise and flooding. The data is then given to the AHJ to make a decision on local flooding alerts and actions.
2. The system has been in place for a long time, has it been successful?
 - a. The system has protected TMC literally through dozens of flooding events. TMC has used the data to not only close flood doors in tunnels under the facilities, but it has also been used to evacuate the structures with predictions that the roads themselves would also be impassable.
3. Could a system like this be used along an unimproved stream such as Cypress Creek?
 - a. The system is now working in Sugarland and also along Clear Creek, it would require more work to install, but it has been proposed in the past.
 - b. So the system has been considered for Cypress Creek?
 - c. Working with HCFCD and CCFCC we built data that would indicate that it could work along Cypress Creek.
4. Why has it not been considered or installed along Cypress Creek to better warn the citizens?

- a. I'm not really sure what decisions went into not choosing the system, but it couldn't be cost. It would be less than the cost of a new work truck or pick up truck.
5. Harris County has meteorologist and an entire flood control district as well as emergency management staff; do they get all of this data?
 - a. The SSPEED Center can predict much of the flooding in the area but it is up to the county to select the data that tells them when, and then they must act to warn citizens about flooding in the areas that are likely to be affected.

Appendix 10 Interview with Richard “Dick” Smith, President Cypress Creek Flood Control Coalition

1. Mr. Smith how long have you lived here along Cypress Creek?
 - a. Since 1981
2. When was the first major flood that made you concerned about the situation along Cypress Creek?
 - a. Twice the summer of 1983 and again in 1984. One was Hurricane Alicia, but rests were just storms. Then in September 1998 and again a month later, that is when we started the idea for the Coalition. We had three separate floods summer of 1999.
3. They were becoming more frequent?
 - a. When we moved out here there wasn't much West of this part of Cypress, just farms and a few small neighborhoods. In the late 1980s and again in the early 2000's construction of huge neighborhoods, some 5000 or more homes have been built in the upper end of the watershed. This includes the newly constructed Grand Parkway.
 - b. The county says they conducted “No Adverse Impact” studies for all of this construction, but it is hard to believe. So we contacted our own hydrology engineer to survey and review the pertinent data. Our belief is that the impact studies were conducted using old data, prior to the Tropical Storm Allison Recover Project revised flood plain maps. When our engineers reviewed the construction impacts using the revised flood plain and runoff information, we are certain that the impact is much greater than that approved by the county.

4. Has this been presented to Harris County?
 - a. Yes it has. We first became involved with HCFCD to request engineering studies that had previously been conducted by the USACE. These predicted very low numbers in the floodplain and we worked with Harris County to conduct more accurate studies and found that the numbers were nearly 300% higher (homes inside the 100 year floodplain).
 - b. Changes and personnel shifts impeded our progress, but we still have reviewed and worked with HCFCD and USACE to present the problems. HCFCD has finally taken the data and problem seriously and is working on projects to slow or prevent future flooding.
5. You mentioned working with attorneys to press the issue, why has that been necessary?
 - a. We reached out to Jim Blackburn, an environmental lawyer, who has experience in other lawsuits about flooding, wetlands, and waterways.

