Project Summary

Figure 1 Photo: Williamson County Sheriff's Office

Williamson County is seeking to reduce the impact of Riverine Flooding and Storms on the life and safety of the 114,451 residents in the project area and the first responders who serve them. This will be accomplished through the installation of a Flood Monitoring System (PROJECT) to warn, notify, and protect citizens from dangerous flooding conditions in areas of high risk. The eligible activities in this project consist of threat and hazard identification, public information and warning and communications infrastructure. Low water crossings (LWC) across the County pose a significant threat to the traveling public during rainfall events. The County's first responders from County Fire, EMS and Sheriff's offices have performed 187 swift water rescues in the last five years alone. This is particularly true after dark, when motorists are more likely to be unaware of flooded crossings. The County's 2019 Hazard Mitigation Plan identified the development of this network as a high priority. This integrated Flood Monitoring System will make Williamson County more resilient through a combination of a Flood Monitoring Network (hardware) that includes gages and warning equipment at the crossings themselves and Flood Monitoring Tools (software) that collect information from the network to analyze immediate repercussions and support emergency response decisions during flood events. The LMI benefit in the project area is equal to 52% of the affected population.

Eligible Activity: Flood Monitoring System

Methodology for Project Selection:

Background & Need

Williamson County covers an area of 1,135 square miles and is located within the aptly known "Flash Flood Alley", where the combination of high intensity rainfall and efficient surface drainage along the Balcones Escarpment combine to result in rapid flooding. If this grant funding is awarded, it will enhance the safety of the County's approximately 590,551 persons and enable Williamson County to make improvements to its roadways that warn residents of flooding at low water crossings. Flashing warning signs will be activated by a network of stream gages at the crossing as they gather data to send into the remote Flood Monitoring System. The Monitoring System communicates with the software to analyze stream level data and display inundation maps to enable EMS to notify populations and risk and prepare for action if necessary. This will include a reverse 911 call system, with the goal of reducing the number of lives lost in the future. All data gathered can be maintained and used as a baseline for future roadway and infrastructure improvements.

While most of the county is relatively rural, it is the fourth fastest growing County in the State of Texas, the ninth fastest growing County in the United States and includes the growing cities of Round Rock, Cedar Park, Georgetown, Leander, Taylor and Hutto among others. Williamson County is also home to the smaller cities of Jarrell, Liberty Hill, Florence, Weir, Granger, Coupland, Thrall, Bartlett, and Thorndale.

Environmental Conditions

The Balcones Escarpment has hilly terrain and thin topsoil that quickly funnels rainfall to the streams and rivers. It is also where warm air from the Gulf combines with cool air from the Pacific which produces intense rainfall events. These events have been witnessed throughout Williamson County history, with this application arising from the effects of the Memorial Day floods of 2015.

In addition to storms along the Balcones Escarpment, the County's location is near enough to the Gulf that it is also at risk of heavy rainfall from Tropical Storms. One such example is Tropical Storm Hermine which dropped over 15 inches of rainfall in certain areas of the County on September 7th and 8th in 2010. During Tropical Storm Hermine, 687 homes were damaged, an estimated $1.5 million in damage was assessed to county roads and one fatality was reported. Subject to the geography and climate of its location, the County will continue to experience flash flooding events in the future.

Previous Disasters

Federal disasters were declared in the County during 1989, 1991,1998, 2005, 2007, 2008 and finally, in 2015. During the 2015 Memorial Day floods, over 450 homes within the County were impacted, an estimated $7 million in damage was assessed to county infrastructure and facilities. Tragically, there was one fatality. After the floodwater receded, crews found a truck downstream of the LWC at CR 143 while surveying flood damage. The body of the 55-year old driver was found 1.5-miles downstream of the location of the truck. Since 2010, County personnel have participated in approximately 375 high water or underwater rescues.

In the last five years, the County has continued to be impacted by isolated flood events caused by heavy rainfall. This has triggered an increasing number of dangerous water and high water rescue efforts by the County's emergency management personnel in order to pull people from harm's way. The County's road network was built to support a much more rural population, with over 200 low water crossings that served a dispersed settlement pattern shaped by farming and ranching operations. As population growth greatly increased, so did the number of people dependent on these crossings. On May 25, 2015 alone, the County's Fire, EMS and Sheriff's offices were called out for 80 high water rescues, located across the County. The table below provides a snapshot of the number and timing of rescues over the last five years.

Table 1: Williamson County High Water Rescue Counts

Year	High Water Rescues	Dates of Peak Calls
2015	102	May 25
2016	27	March 30 and Sept 26
2017	11	May 6
2018	30	Sept 22
2019	17	Jan 2, April 24, and May 8

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These rescues primarily serve county citizens trying to evacuate a flood prone area or just navigate safely back to their family homes. The dates of peak calls above are just of few of the days each year that found many low water crossings underwater, blocking access to escape routes and neighborhoods, and or forcing a motorist to take a long detour to avoid high water.

Although a federal disaster was not declared, 2018 saw a repeat of the 2015 flash flooding on a smaller scale. As just one example of the kind of risk low water crossings represent for the County, on September 22 of that year, the Sheriff's office was called out at approximately 4 a.m. for a water rescue of 10-30 people fleeing high water in the Liberty Hill area. October 2018 saw a repeat event with road overtopping and rescue efforts that included rescuing a school bus washed off the road by high waters in Leander. Although high waters continued in the region for several days, these events did not rise to the level of a Federal Disaster Declaration.

Figure 2: Low Water Crossing, Williamson County Sheriff's Office

Population at Risk

The population benefitting from the Flood Monitoring System is 114,451, with 52.3% of that population meeting the criteria of Low-and-Moderate Income. As the roadways with LWC serve thousands of travelers from Williamson County and the larger region, the secondary benefit of this System is anticipated to be much higher. Some of the communities benefitted include Taylor, Round Rock, Georgetown, Florence, Bartlett and Granger.

One of the primary objectives of mitigating flooding risks is to reduce the of loss of life or injury to the people within the County. With the relatively rural nature of much of the County, there are many roadways where the rivers and streams often overtop, in some locations, as frequently as every time that it rains. It can take as little as 6-inches of water flowing over a roadway surface to carry a car downstream. These low water crossings pose significant risk to the traveling public who may be unaware of the danger of the rapidly moving water. In addition to the risks associated with the LWCs, the county has residents, businesses and recreation areas that are directly adjacent to the rivers and creeks.

Figure 3: Location of Proposed Flasher System at CR 369 near Taylor, Texas

During a flood event, it is imperative to warn residents of the risks to themselves and their property as early as possible to save lives. Because of the large land area of the County, limited staff, and rapid development of flash flooding events, manual road closings are extremely time consuming, and staff may not be able to post a warning sign at every unsafe location in a timely manner. This has resulted in both fatalities as well as the aforementioned water rescues for those locations that were not closed soon enough.

It is therefore the objective of the County to build a comprehensive Flood Monitoring System that is a combination of both hardware and software tools to serve as a means of saving lives by informing residents of the status of LWCs throughout the county and providing a system to warn residents of flooding through various communication methods.

Project Scope & Description: Comprehensive Flood Monitoring System

The combination of the Flood Monitoring Network and customized Flood Monitoring Tools will provide protection for citizens across all of Williamson County. The County has identified a strategic mitigation need through its recent flood mapping, the County's strategic efforts to prepare a Flood Protection Plan and the development of the County's 2019 Road Bond program. To reduce the risk of injury and loss of life, both for citizens and the County's emergency management personnel, Williamson County is seeking to establish a Flood Monitoring System that serves both rural and urbanized areas of the County. Through the implementation of this system, the County would minimize the use of high risk, low water crossings during heavy rainfall and flash flooding events, put in place a monitoring system to support the State's "Turn Around, Don't Drown" campaign and reduce the number of high water rescues performed by the County's emergency operations personnel.

Flood Monitoring Network (Hardware)

The first piece of the proposed Flood Monitoring System is the planning, engineering, and construction of a robust Flood Monitoring Network. The network will be comprised of the following components,

strategically placed throughout the County to optimize County Staff's ability to protect the public from dangerous flooding:

1 Base Station:

Receives and stores data from remote stations, performs data checking, generates notifications, can use data from other sources (USGS, RAWS), serves data for public and private web applications. The base station will reside at the Williamson County Emergency Management Operations Center in Georgetown, TX.

22 Rainfall Gages: (11 stand-alone, 11 combined with Stream Level Gages)

Detects rainfall for early warning of developing flood hazards. To achieve good distribution of rain gages in watershed locations where they will provide early detection of heavy precipitation and flood risk, standalone rain gages are typically vital. Rainfall data will feed into the Flood Monitoring System Tools that notify County staff of flooding risk. Rainfall gages were placed at and upstream of high risk LWC's within the County, along rivers and creeks with high risk for property damage and distributed throughout the County to ensure almost all flood risks could be identified to ensure coverage of the county. To optimize overall system cost, a rain gage was added at each identified stream level gage.

41 Stream Level Gages: (11 with Rainfall Gage, 30 with Automated Flasher)

Measures water level with a pressure transducer or radar. Stream level data is used to alert County staff of developing risks, display information on a web map platform, and provide data for the real-time inundation mapping. Stream level gages were placed at and upstream of high risk LWC's within the County, along rivers and creeks with high risk for property damage and distributed throughout the County to ensure almost all flood risks could be identified.

30 Automated Flasher Systems:

Provides flashing signage when stream level is over the roadway surface. The flasher systems will alert drivers, bikers, walkers, and other users of the roadway network that it is not safe to cross. Flasher systems include one stream level gage and two warning signs/lights (one on each side of the crossing). The automated flasher systems have been proposed at high risk LWCs where the County has experienced frequent and destructive flooding.

4 Remote Cameras:

Allows for observation/verification of flooding in real-time and captures historical footage. The cameras function during both daytime and nighttime hours and can transmit images at least every minute using a cellular telemetry link to upload photos to a cloud server at regular intervals. Remote camera systems have been placed at the County's highest risk crossings for visual monitoring and verification of other sensors.

2 Remote Automated Weather Stations:

Measures wind speed/direction, air temperature, humidity, barometric pressure, soil moisture, precipitation, solar radiation. Serves an additional purpose of wildfire weather monitoring. One weather station will reside at the WCSO Training Center in Hutto, TX and the other will be located at the Emergency Communications Tower in Georgetown, TX.

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Figure 4: Automated Flasher System

A combination of the described devices is proposed and shown in the attached project map. In addition to the devices listed, one additional radio tower will be required in Taylor, TX to extend the signal of the base station to the eastern portions of the County. All systems will be placed within existing Right-Of-Way (ROW) and will not require acquisition of property. The attached project map shows the location of all proposed systems of the flood monitoring network and is summarized in Table 2 below.

Table 2: Summary of Proposed Monitoring Network Systems

ID	Station Type	City	Stream Crossing	Roadway Crossing
0	Flasher System	Unincorporated	Salado Creek	CR 305
1	Flasher System	Unincorporated	San Gabriel River Tributary 17	CR 106
2	Flasher System	Unincorporated	Middle Fork San Gabriel River	Cedar Hollow Rd
3	Flasher System	Unincorporated	North Fork San Gabriel River	CR 258
4	Flasher System	Unincorporated	Unnamed Tributary to North Fork San Gabriel River	CR 258
5	Flasher System	Round Rock	Dry Branch Tributary 1	Greenlawn Blvd
6	Flasher System	Round Rock	Brushy Creek	Summit St
7	Flasher System	Round Rock	Brushy Creek	Chisholm Trail Rd
8	Flasher System	Round Rock	Lake Creek	S Burnet St
9	Flasher System	Round Rock	Unnamed Tributary to Brushy Creek	E Bowman Rd
10	Flasher System	Georgetown	Pecan Branch	Airport Rd
11	Flasher System	Unincorporated	South Salado Creek	CR 232
12	Flasher System	Granger	Willis Creek Tributary 1	E Oak St
13	Flasher System	Unincorporated	Avery Branch	CR 405
14	Flasher System	Unincorporated	Mustang Creek	CR 398
15	Flasher System	Taylor	South Fork Mustang Creek	CR 369
16	Flasher System	Unincorporated	Mileham Branch	CR 121
19	Rainfall Gage	Unincorporated	Pecan Creek	FM 619

ID	Station Type	City	Stream Crossing	Roadway Crossing
21	Stream Level Gage / Rainfall Gage	Unincorporated	Pecan Branch	Shady Hollow Dr
22	Stream Level Gage / Rainfall Gage	Unincorporated	Cobbs Springs Branch	CR 239
23	Stream Level Gage / Rainfall Gage	Unincorporated	Pecan Creek	CR 418
24	Stream Level Gage / Rainfall Gage	Taylor	Bull Branch	Davis St
25	Stream Level Gage / Rainfall Gage	Leander	South Fork San Gabriel River	Ronald W Reagan Blvd
26	Camera / Flasher System	Unincorporated	Opossum Creek	CR 328
27	Stream Level Gage / Rainfall Gage	Unincorporated	Donahoe Creek	CR 384
28	Stream Level Gage / Rainfall Gage	Unincorporated	Willis Creek	CR 326
29	Rainfall Gage	Unincorporated	Middle Fork San Gabriel River	Ronald W Reagan Blvd
30	Stream Level Gage / Rainfall Gage	Unincorporated	Boggy Creek	CR 405
32	Stream Level Gage / Rainfall Gage	Unincorporated	Brushy Creek	CR 434
33	Rainfall Gage	Unincorporated	North Salado Creek	CR 229
34	Rainfall Gage	Unincorporated	Unnamed Tributary to Dog Branch	Shin Oak Ln
35	Rainfall Gage	Unincorporated	Pecan Branch East	CR 337
36	Rainfall Gage	Unincorporated	Brushy Creek	CR 455
37	Rainfall Gage	Unincorporated	Dry Brushy Creek	CR 464
38	Stream Level Gage / Rainfall Gage	Unincorporated	Berry Creek	CR 245
39	Rainfall Gage	Unincorporated	Willis Creek	CR 314
41	Stream Level Gage / Rainfall Gage	Unincorporated	South Fork San Gabriel River	RM 1869
42	Rainfall Gage	Unincorporated	North Fork San Gabriel River	CR 236
43	Rainfall Gage	Unincorporated	Berry Creek	CR 220
44	Rainfall Gage	Unincorporated	Granger Lake	Granger Dam Rd
45	Camera / Flasher System	Unincorporated	Brushy Creek	Brushy Bend Dr
46	Camera / Flasher System	Unincorporated	Brushy Creek	CR 123
47	Camera / Flasher System	Unincorporated	San Gabriel River	CR 100
48	Flasher System	Unincorporated	Unnamed Tributary to San Gabriel River	CR 100
50	Base Station	Georgetown	N/A	N/A
51	Weather Station	Georgetown	N/A	N/A
52	Flasher System	Unincorporated	Dry Berry Creek	CR 143
53	Flasher System	Leander	Brushy Creek	CR 177
54	Flasher System	Unincorporated	Unnamed Tributary to Salado Creek	CR 305
55	Flasher System	Unincorporated	North Salado Creek	CR 232
56	Flasher System	Unincorporated	North Salado Creek	CR 232
57	Flasher System	Unincorporated	Willis Creek	CR 382
58	Flasher System	Unincorporated	Pecan Creek	CR 152
59	Flasher System	Unincorporated	South Berry Creek	CR 251
60	Weather Station	Unincorporated	N/A	N/A
61	Radio Tower	Taylor	N/A	N/A

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A major consideration of system placement was ensuring benefit to LMI areas within the County. While it is straight-forward to see how a system placed within an LMI block would benefit the community by informing them of a direct flood risk, the benefit of the entire system outside of the LMI block will also benefit those residents in two additional ways:

1. Upstream rainfall gages and stream level gages can alert the County to developing flood risks. The County can alert the downstream residents (within or outside of an LMI block) of the imminent flooding and evacuate people as necessary to save lives. This can be used in parallel with the Flood Monitoring Tools outlined in the following section.
2. Most residents within the County live in one area and work in another. To get from home to work, residents utilize the State, County and City roadway networks. Providing the monitoring network throughout the roadways in the County and connecting the Flood Monitoring Tools to the virtual network will keep the public informed of locations that are unsafe at any given time.

As Williamson County residents outside the Project Area become acquainted with the benefits participating in this network, they will have the opportunity to leverage and expand its benefits by partnering with the County to add additional tools to measure rainfall and warn drivers and residents of impending floodwaters.

Flood Monitoring Tools (Software)

In support of the Flood Monitoring Network, Williamson County will create customized Flood Monitoring Tools to help visualize gage readings and notify County staff of potential risk. These monitoring tools utilize real-time data collected from the Flood Monitoring Network to display risk for informed flood response. The system's complementary Flood Monitoring Tools would include:

Base Station Database & Software will minimize the need for swift water rescues and reduce the number of motorists using LWC during flood events using the following methods:

- Alarm checking of incoming rainfall intensity, streamflow/stage and other weather parameter data against programmable criteria that can be system-wide or site-specific, with remote notification on screen, with email or SMS messages.
- Automatic screening of erroneous data to minimize the risk of providing inaccurate data and nuisance "false alarms."
- Computation of stream discharge; management of sensor calibrations and ratings by authorized staff.
- Data integration with geographic information system (GIS) maps; open SQL and ODBC connectivity.
- Automated data export (of formatted data files, reports and plots) to cooperative agencies such as the National Weather Service (NWS).
- Automated data import from outside agency sources such as the United States Geological Survey (USGS) and State water resources agency.
- Automated system metrics export to service provider for system performance analysis.
- Automated backup to local server or service provider.

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Customized Web Map Applications to Provide:

- Visual tools including interactive maps to display sensor values as well as time series plots (accumulated precipitation depths, hydrographs, etc.) and other information including critical elevations of stage.
- Display and custom creation of maps, time series plots, and reports.
- Real-time station data shown on interactive maps that can be accessed on smart phones and tablets.

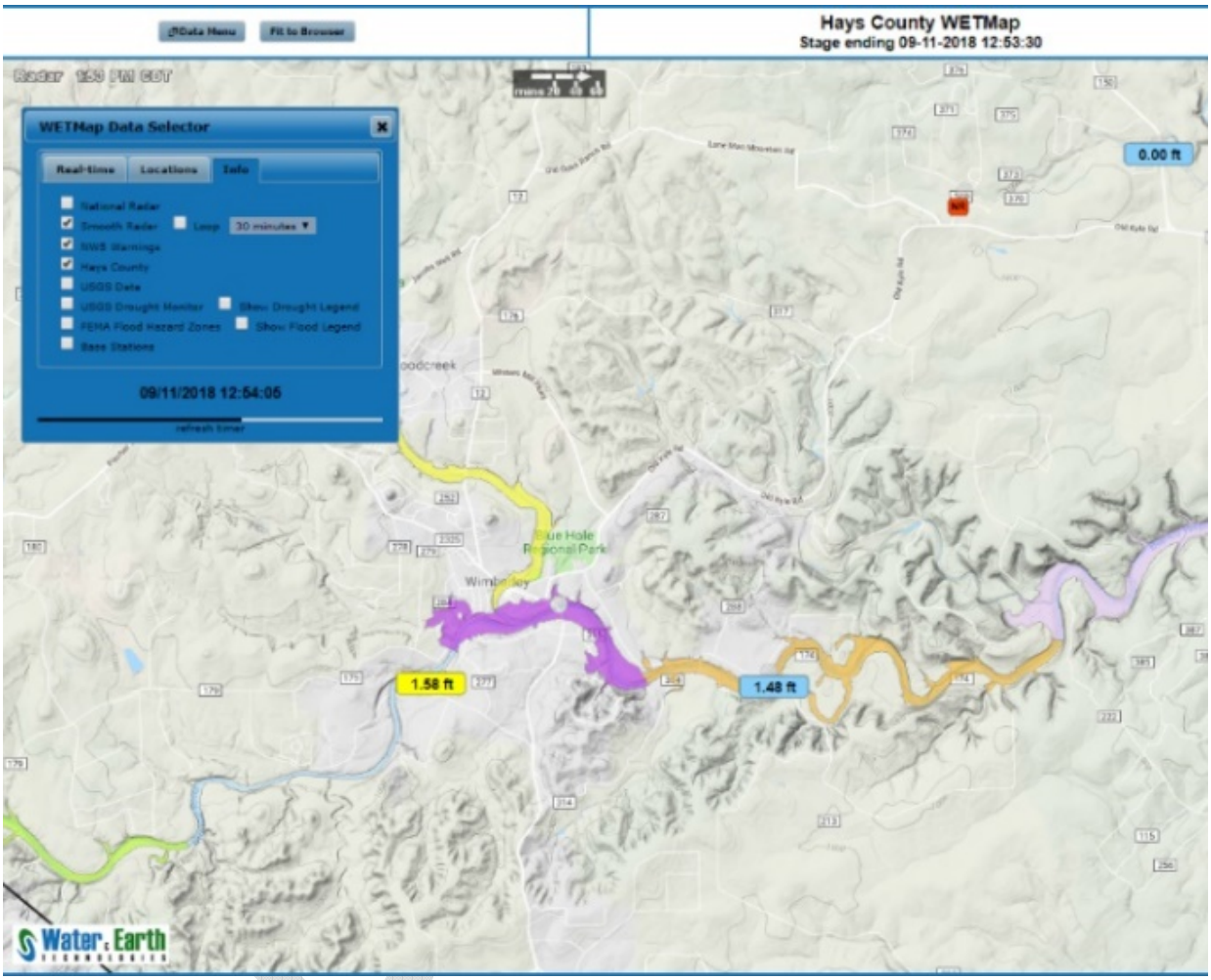

Figure 5: Example 1 of Real-Time Inundation Maps

Real-Time Flood Frequency Inundation Mapping (2-, 5-, 10-, 25-, 50-, 100-, and 500-year event)

- Necessary Hydrologic and Hydraulic modeling will be conducted to support real-time display of inundation mapping.
- Develop flood inundation mapping based on frequency return intervals along the identified creeks to support the 41 stream gages. Existing hydraulic models will be used to generate inundation mapping for the 2-, 5-, 10-, 25-, 50-, 100-, and 500-year frequency events.

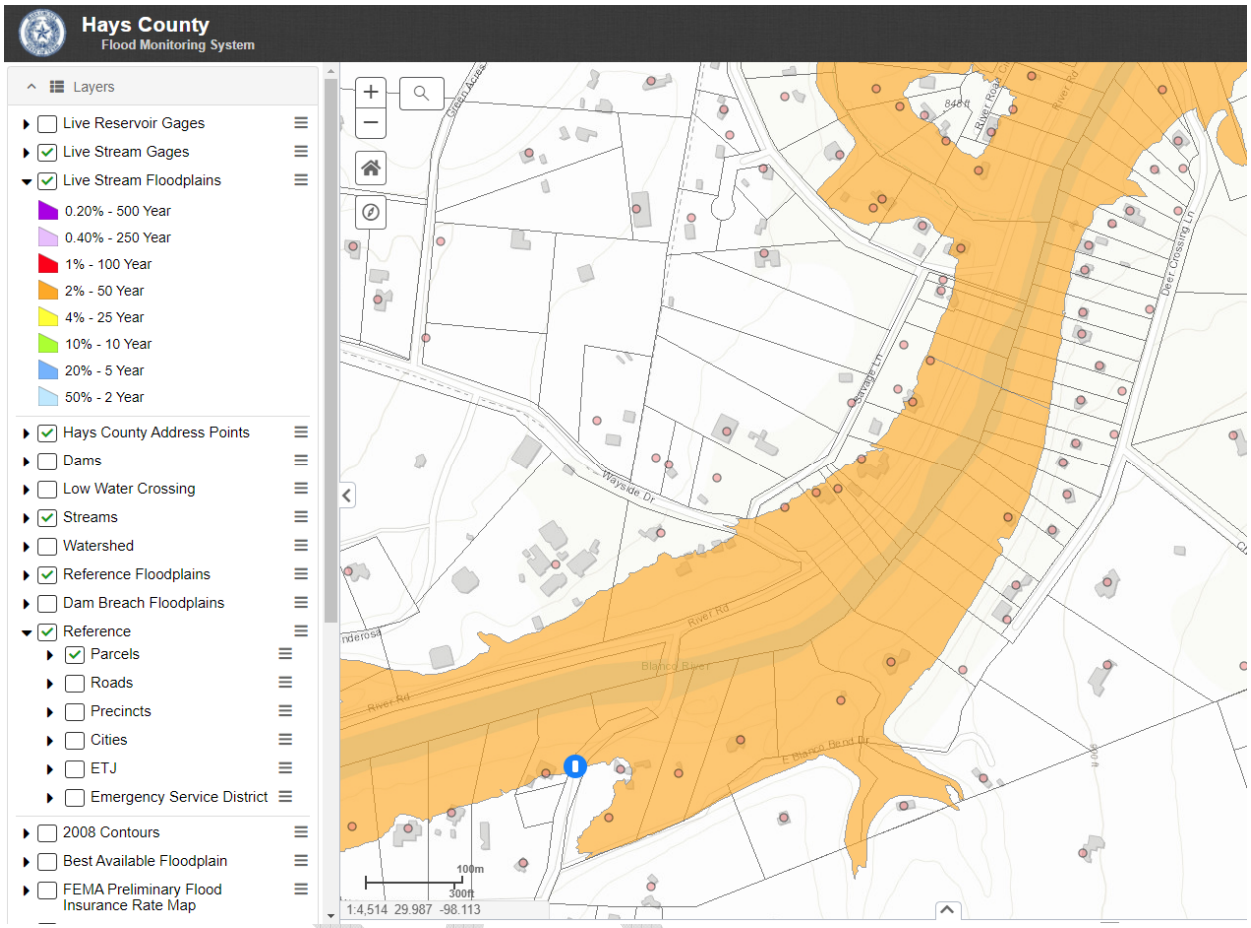

Figure 6: Example 2 of Real-Time Inundation Maps

The Monitoring Tools' web-based application would receive raw gage data and display it to increase accessibility and improve the flood monitoring system. The software features within the Monitoring Tools' could be used by County identify direct risks to structures and properties and be used to trigger a reverse 911 call to the impacted area. This application will include the development of a public site to view current conditions, as well as a secured site to assist with County emergency operations and flood warning.

Project Service Area Detail

The Project Service Area is defined by the locations of the monitoring and warning devices placed at LWCs throughout the County. The majority of these devices are placed within LMI Census Block to benefit the community by informing them of a direct flood risk. Where there is a downstream benefit to vulnerable LMI populations, upstream rainfall gages and stream level gages are selected to provide residents with warnings about developing flood risks. When used in parallel with the Flood Monitoring Tools, this will allow the County to alert citizens to imminent flooding danger and evacuate people as necessary to save lives. As most residents within the County live in one area and work in another, the monitoring system will also benefit even those LMI residents who live adjacent to an area with a gage or warning sign and use the State, County and City roads with LWCs. Installing the monitoring network

throughout the County's roadway system in combination with the Flood Monitoring Tools will keep the general public informed of locations that are not safe at any given time.

The following map shows the boundaries of the Project area by Census Block Group, shown here as hatched areas, color coded to indicate areas with greater than 51% LMI population. The location of the individual monitoring tools, including rainfall gages, flasher systems, cameras, stream level gages and weather stations as point files on the map.

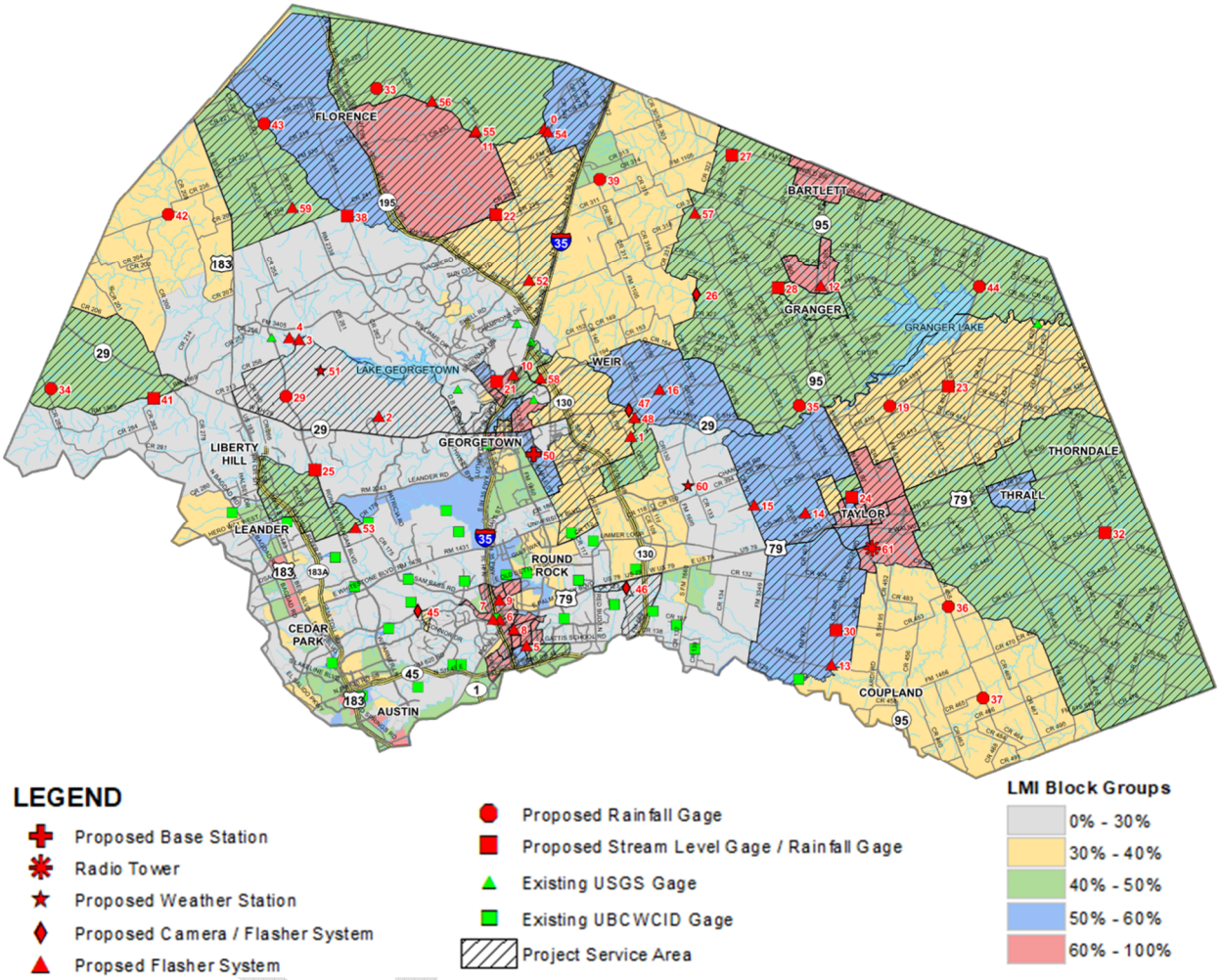

Figure 6: Project Service Area

The criteria for definition of the project area is as follows:

- Benefit to Census Blocks with Low-and-Moderate Income populations
- Proximity to major population centers
- Adjacency and interconnectedness to roadways with LWCs
- Position in the rural areas of the watershed that allow the system to provide warning of downstream impacts to more densely settled population areas.

The project service area is bounded by the following Census Geographic Areas (CGA):

Table 3: Summary of Project Service Areas Census Geographic Areas

Block Group	Census Tract	Population	LMI Percentage	LMI Population	Block Group	Census Tract	Population	LMI Percentage	LMI Population
1	201.12	8,558	18%	1,540	2	209	954	52%	495
1	201.13	1,622	45%	732	3	209	1,908	45%	852
2	201.13	1,425	47%	671	1	210	937	78%	732
1	201.14	2,769	66%	1,829	2	210	1,393	70%	975
2	201.14	2,270	54%	1,221	3	210	1,234	51%	623
3	201.14	768	62%	474	1	211	1,362	61%	835
1	202.01	698	64%	450	2	211	1,452	69%	1,004
2	202.01	1,340	45%	606	1	212.01	2,226	31%	679
1	202.04	1,510	58%	879	2	212.01	748	79%	595
4	202.04	996	47%	472	1	212.02	2,881	41%	1,174
1	203.01	2,420	42%	1,011	2	212.02	1,304	52%	675
1	203.02	5,148	50%	2,550	1	212.03	1,171	79%	921
2	205.04	2,007	70%	1,395	2	212.03	910	54%	492
3	205.04	4,007	75%	2,996	3	212.03	652	64%	418
2	205.09	1,618	31%	496	1	213	1,211	74%	897
2	206.02	848	72%	612	2	213	960	62%	592
1	207.01	1,065	75%	794	3	213	928	41%	378
2	207.01	1,855	71%	1,320	4	213	1,421	43%	617
2	207.03	5,393	41%	2,187	1	214.01	1,695	75%	1,269
3	207.03	1,174	56%	652	4	214.01	4,539	55%	2,480
1	207.04	3,005	66%	1,969	1	214.02	1,300	52%	674
2	207.04	2,117	61%	1,301	2	214.02	2,158	38%	825
3	207.04	1,404	77%	1,081	3	214.02	516	86%	442
2	207.07	2,475	65%	1,597	4	214.02	1,394	98%	1,359
1	208.03	3,454	37%	1,278	1	215.02	4,017	61%	2,468
2	208.03	1,224	50%	609	2	215.02	1,116	87%	971
1	208.04	3,592	24%	854	1	215.03	2,047	62%	1,271
1	208.08	875	54%	470	1	216.02	1,895	57%	1,079
2	208.08	812	57%	467	1	216.03	1,056	34%	363
1	209	1,106	33%	364	2	216.03	1,511	51%	767
Project Area Total Population = 114,451									
Project Area Total LMI Population = 59,797									

Added Resiliency Measures

The County is proactively seeking solutions to mitigate these hazards with its partners including FEMA, the Texas Water Development Board and the Upper Brushy Creek Water Control and Improvement District (UBCWCID). The District recently participated in a substantial update of the County's Flood Insurance Rate Maps (FIRM), encompassing the Brushy Creek Watershed and portions of the San Gabriel Watershed. After an extensive period of public review, the revised FIS and FIRM panels became effective

December 20, 2019. In recognition of the need for further examination of risk and the need to establish strategies that keep its citizens safe, the County is involved in ongoing efforts to pursue a countywide Flood Protection Plan to mitigate existing flooding problems, to properly plan for and guide new development, and to provide prudent floodplain management in the fourth most rapidly growing county in Texas.

Project Funding

The County is seeking grant funding from the General Land Office through the CDBG-MIT competition as a part of the 2015 Floods State MID Competition. Williamson County will fund 10% of the Project cost to expand the reach of the grant awarded to the County through the 2019 Road Bond Program.

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