HALFF TPBE #312

TRAVIS COUNTY
FLOOD MITIGATION STUDY

Arroyo Doble, Bluff Springs, Onion Creek Meadows,
Thoroughbred Farms, and Twin Creeks Neighborhoods

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Executive Summary

Central Texas is no stranger to flooding. In recent years the severity and frequency of extreme storm events seems to have increased. In response to recent extreme flooding within the county, Travis County retained Halff Associates, Inc. (Halff) to develop a comprehensive watershed study simulating the October 2015 flooding events and to evaluate flood mitigation alternatives improving public safety and well-being. This Travis study was focused in five neighborhoods: Thoroughbred Farms, Arroyo Doble, Onion Creek Meadows, Twin Creeks, and Bluff Springs. These five neighborhoods reside within two watersheds, Dry Creek East and Onion Creek. Dry Creek East watershed begins within southern Travis County and drains into the Colorado River in Bastrop County. Onion Creek begins in Blanco County, flows through Hays County, and finally drains into the Colorado River within Travis County.

Travis County desired to evaluate flooding in the specific neighborhoods because they experience severe repeated flooding. Specifically, the Thoroughbred Farms neighborhood in the Dry Creek East watershed experienced two flooding events above the 0.2% (500-year) annual chance exceedance (ACE) within a period of seven months. The Bluff Springs, Arroyo Doble, and Onion Creek Meadows neighborhoods in the Onion Creek watershed experienced have experienced two flooding events similar to the 1% (100-year) ACE within the last five years. These historical events are unprecedented yet validate the accuracy of existing riverine models. Once validated, the models were used to evaluate mitigation solutions. The flood mitigation concepts evaluated for this study are conceptual evaluations of potential flood mitigation solutions. Structural drainage improvement projects (detention, channel improvements, floodwalls, etc.) are preferred when a cost effective, viable alternative can be identified. When water surface elevation reduction is not feasible structural alternatives, non-structural (buyouts or structural elevation) alternatives could be utilized to reduce or remove structures from risk of flooding. Highlights of the viable alternatives are displayed in the project fact sheets located in Appendix G.

In order to aid the County in making effective, consistent flood mitigation decisions, a project prioritization assessment was developed through this study. The resulting Travis County Project Prioritization Assessment considers public safety, economic impact, environmental impact, social impact, and project timing of each alternative to select the recommended projects. The results of the project scoring indicated that the recommended flood mitigation projects for each of the study areas are as follows:

- Dry Creek East/ Thoroughbred Farms Neighborhood: Riverine Buyouts
- Onion Creek / Arroyo Doble and Onion Creek Meadows Neighborhoods: Riverine Structural Elevation
- Onion Creek / Onion Creek Meadows: Local Structural Elevation
- Onion Creek / Twin Creeks: Local Buyout
- Onion Creek / Bluff Springs: Riverine Structural Elevation

The neighborhoods in this study are located in watersheds with significant drainage areas. Additionally, these neighborhoods are adjacent to creeks that do not have the capacity to convey flood waters within their banks. Due to these circumstances, it is difficult to identify viable, cost effective structural solutions in the study neighborhoods. These circumstances are not representative of all Travis County neighborhoods that experience flooding.

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Introduction

A comprehensive watershed study was conducted to evaluate the October 2015 flooding event, evaluate flood mitigation alternatives to improve public safety and well-being, and develop a flood mitigation assessment methodology that could be applied across Travis County. Five neighborhoods within Travis County were selected for analysis: Thoroughbred Farms, Arroyo Doble, Onion Creek Meadows, Twin Creeks, and Bluff Springs. All five communities are located within two watersheds, Dry Creek East and Onion Creek. Figure 1 below displays the proximity and extent of each respective watershed.

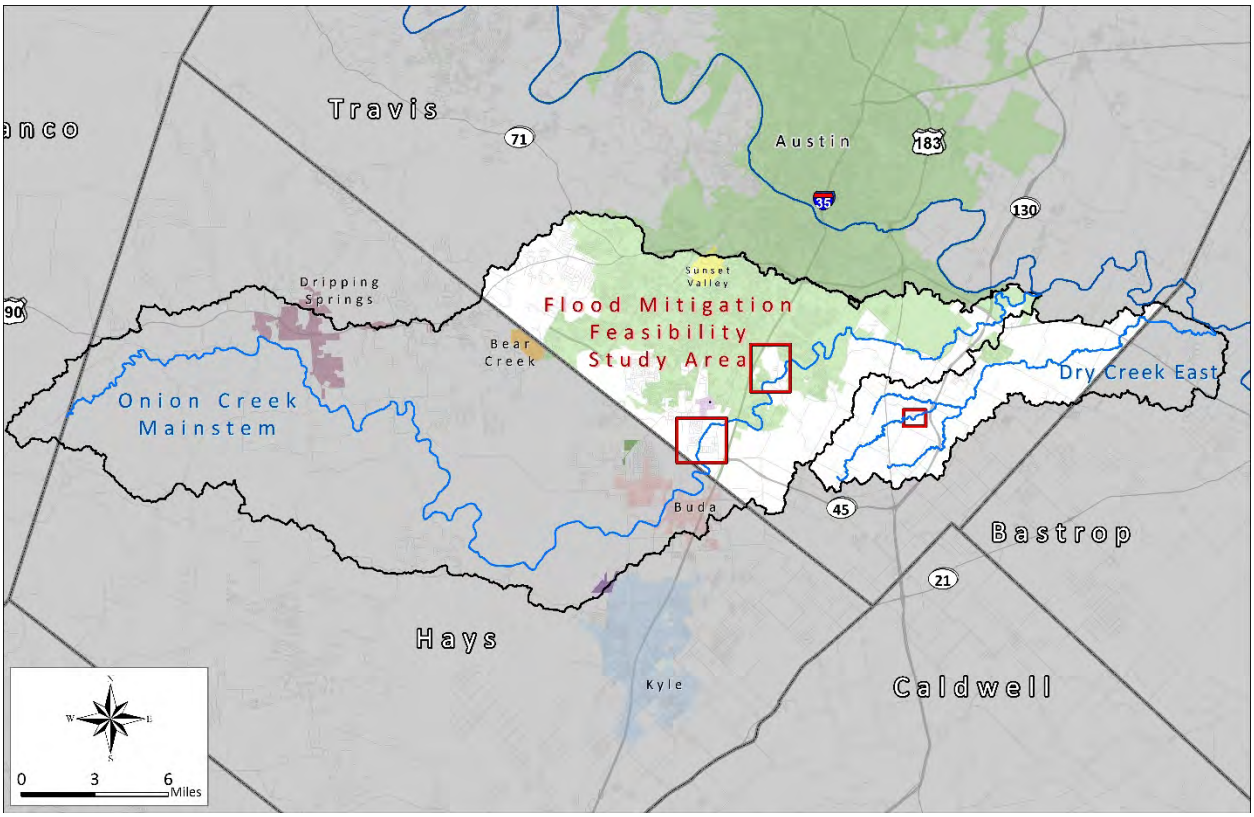


Figure 1: Travis County Flood Mitigation Study Area

This report provides an overview of the Travis County Flood Mitigation Study. The five neighborhoods within the two watersheds of interest are grouped into three distinct areas for the purpose of this investigation: the Thoroughbred Farms Area, the Bear Creek – Onion Creek Confluence Area, and the Bluff Springs Area. Appendices A-C provide additional details regarding each of the respective study areas.

Dry Creek East

The Dry Creek East watershed is approximately 56 square miles and begins within Travis County and drains into the Colorado River in Bastrop County. Dry Creek East is composed of three subwatersheds: North Fork Dry Creek East, South Fork Dry Creek East, and Dry Creek East. Both of the North and South

Forks cross Highway 183 and converge near State Highway 130 (SH 130). The North and South Fork subwatersheds are also completely contained within Travis County. The main stem of Dry Creek East crosses Highway 71, through Bastrop County, and finally drains into the Colorado River. This study evaluated one neighborhood in the Dry Creek East watershed.

- Thoroughbred Farms Area: The Thoroughbred Farms neighborhood is located within the South Fork portion of Dry Creek East just south of the intersection of McKenzie Drive and Farm to Market Road (FM) 973. The neighborhood sits on the left bank of Dry Creek East downstream of the FM 973 bridge but upstream of SH 130. FM 973 provides the only access point to the neighborhood. Neighborhood meetings revealed that this neighborhood is impacted by both riverine and local drainage flooding.

Onion Creek

Onion Creek is approximately 344 square miles beginning in Blanco County, flows through Hays County, and drains into the Colorado River within Travis County. This study focuses on two areas along Onion Creek: the Bear Creek – Onion Creek Confluence area and the Bluff Springs area. Three neighborhoods of interest are located at the Bear Creek – Onion Creek Confluence: Arroyo Doble, Onion Creek Meadows, and Twin Creeks. The Bluff Springs area includes portions of Onion Creek between East Slaughter Lane and the Boggy Creek confluence. One neighborhood of interest (Bluff Springs) is in this area.

- Bear Creek – Onion Creek Confluence Area: Arroyo Doble is located just upstream of the Bear Creek – Onion Creek confluence. The neighborhood is bounded by the Railroad to the west, Bear Creek to the north, Horsethief Trail to the south, and Onion Creek to the east. Twin Creeks Road provides the only access point to the neighborhood. Neighborhood meetings revealed that this neighborhood is impacted by both riverine and local drainage flooding.

  Onion Creek Meadows is located within Upper Onion Creek subwatershed, west of Interstate Highway 35 (IH-35) and east of the Hays-Travis County Boundary. It sits directly adjacent to the main stem of Onion Creek. The neighborhood is bounded by Onion Creek to the west and Old San Antonio Road to the east. Twin Creeks Road and Old San Antonio Road provide two access points into the neighborhood. Neighborhood meetings revealed that this neighborhood is impacted by both riverine and local drainage flooding.

  The Twin Creek Park neighborhood is located to the north of the Bear Creek – Onion Creek confluence. The neighborhood is bounded by Twin Creeks Road to the west and Onion Creek to the east. Twin Creeks Road provides the only access point to the neighborhood. Neighborhood meetings revealed that a few properties are impacted by local drainage flooding.

- Bluff Springs Area: The Bluff Springs neighborhood is located along Bluff Springs Road east of IH-35 and downstream of the East Slaughter Lane Bridge. South Boggy Creek is located along the northern boundary of the neighborhood. Neighborhood meetings revealed that this neighborhood is impacted by both riverine and local drainage flooding.

Study Process

The Travis County Flood Mitigation Analysis was a step-by-step process, where each step was influenced by the preceding analysis. Figure 2 below outlines the steps that were taken during the analysis. Data collection included the collection of technical data (previous studies, rainfall data, field survey, and field reconnaissance) and resident data (testimony, concerns, and validation of historical simulation). Model development included hydrologic and hydraulic analyses. The flood mitigation analysis consisted of the evaluation of riverine and local flooding solutions, project assessment, and recommendations. The primary goals of this study were to evaluate potential solutions to address flooding caused by the riverine systems for each of the three areas of interest and to identify at least one feasible alternative to eliminate 1% (100-year) Annual Chance Exceedance (ACE) flood risk of homes for each neighborhood. This report provides an overview of the study. The appendices provide a more in-depth discussion of the specific details for each study area.

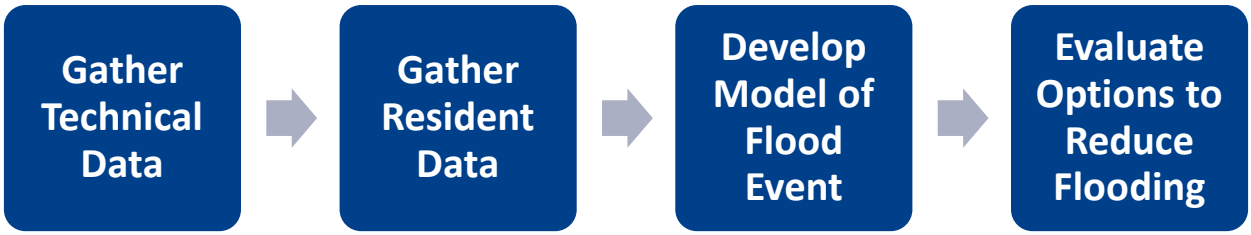


Figure 2: Travis County Mitigation Analysis Process

Data Collection

Halff obtained the most recent hydrologic and hydraulic simulations and supporting data for the Dry Creek East and Onion Creek watersheds. Once the technical data was compiled and a preliminary historical simulation of the October 2015 flood event was developed, the study team held multiple public meetings to gather resident data.

Technical Data

Previous Studies

The main goal of data collection was to obtain the best available data. The hydrologic and hydraulic models for both Dry Creek East and Onion Creek watersheds were obtained for this analysis. The 2013 Dry Creek East current effective FEMA regulatory models and the 2017 Onion Creek preliminary FEMA models served as the starting point for this investigation. Although the 2017 Onion Creek hydrology and hydraulic models are in the preliminary phase of the FEMA approval process, the conceptual level of this study deems them appropriate for use. Table 1 displays the data sources of these models.

Table 1: Technical Data

Watershed	Model Type	Source	Details
Dry Creek East	2013 FEMA Effective	City of Austin/ FEMA/ Halff Associates	2013 Effective Regulatory model developed for City of Austin.
Onion Creek	2017 FEMA Preliminary	City of Austin/ FEMA/ Halff Associates	2017 Preliminary FEMA Hydrologic and Hydraulic models developed for the City of Austin

The Dry Creek East watershed was modeled using Light Detection and Ranging (LiDAR) data flown in 2007 and published by the Sanborn Map Company, Inc. in 2008 for the Capital Area Council of Governments (CAPCOG). The 2017 Onion Creek Floodplain Modeling and Mapping Study utilized the 2013 City of Austin LiDAR flown in 2012 to evaluate flood risk along the Travis County portions of Onion Creek.

Halff also tested the continued validity of using the Dry Creek East regulatory models to simulate the October 2015 event by subtracting the 2013 LiDAR from the 2008 LiDAR within the Travis County portions of Dry Creek East Watershed. The results illustrated negligible development and elevation change within the South Fork portion of Dry Creek East. The only significant land development resulting in elevation changes within Dry Creek East Watershed occurred downstream of the Thoroughbred Farms neighborhood at the Circuit of the Americas, which broke ground in December 2010. Since there was little to no change in topography in the South Fork portion of Dry Creek East, the 2013 effective model was deemed acceptable for use in this evaluation.

Survey and Field Reconnaissance

Finished floor elevations were collected by Zamora, LLC to supplement and validate LiDAR data used within the hydrologic and hydraulic models. Finished floor elevations were defined based on survey where possible. Where survey was not available, LiDAR elevation data was utilized. When water surface elevations exceed the finish floor elevation, interior or structural flooding is likely to occur. Multiple field reconnaissance visits were conducted for this analysis. The first visit was conducted in the Thoroughbred Farms neighborhood on May 27, 2016 to record high water marks from the May 26, 2015 rain event. The study team returned to the Thoroughbred Farms neighborhood on October 5, 2016 to further investigate resident concerns regarding Texas Department of Transportation (TxDOT) improvements. Field reconnaissance for the Onion Creek neighborhoods was conducted on April 3, 2017 to observe drainage patterns and verify existing storm drainage infrastructure.

Table 2: Field Reconnaissance Dates

Date	Watershed	Location	Details
May 27, 2016	Dry Creek East	Thoroughbred Farms	• Document high mater marks • Document flow directions
October 5, 2016	Dry Creek East	Thoroughbred Farms	• Confirmed culvert dimensions • Confirm flow directions
April 3, 2017	Onion Creek	Onion Creek Meadows, Arroyo Doble, Twin Creek Parks, and Bluff Springs.	• Verify storm drainage infrastructure in Onion Creek Meadows • Observe where the railroad failed • Confirm flow directions in Twin Creeks Park • Verify storm drainage infrastructure in Bluff Springs.

Resident Data

Public Meetings

A series of public meetings were held to gather any relevant resident data that could be used to calibrate and validate the watershed models and the simulated October 2015 flood mapping extents. Residents provided first hand testimony of flooding extents and damages. Photos documenting high water marks and damages were collected and copied before being returned to residents. Often, resident testimony confirmed and complimented the simulated preliminary water surface elevations and mapping extents from the October 2015 event. Resident concerns were also recorded and investigated to ensure flooding events, like the destructive October 2015 event, were accurately portrayed in the hydraulic models. The goal of the first round of neighborhood meetings was to inform residents of the status of the project, gain valuable input regarding their flood risks, and validate the results of the historical simulations. The goal of the second round of neighborhood meetings was to inform residents of the status of the project, discuss their existing condition flood risk, and discuss preliminary flood mitigation solutions. Table 3 and Table 4 below display the meeting date, location, and brief agenda covered during each meeting.

Table 3: Dry Creek East Public Meetings

Date	Location	Agenda
August 31, 2016	Del Valle High School	• Introduced study parameters to residents • Discussed recent October 2015 and May 2016 events • Collected TBF resident observations and concerns
September 22, 2016	Commissioners Court	• Presented preliminary Dry Creek East and Onion Creek results to court • Heard additional TBF resident observations and concerns
November 10, 2016	Del Valle High School	• Presented preliminary Dry Creek East results to TBF residents • Directly addressed primary concerns stated by TBF residents at Commissioners Court

Table 4: Onion Creek Public Meetings

Date	Location	Agenda
September 22, 2016	Commissioners Court	• Presented preliminary Dry Creek East and Onion Creek results to court
February 09, 2017	Manchaca Elementary School Cafeteria	• Introduced study parameters to residents in Bear-Onion Creek confluence. • Collected Twin Creeks, Arroyo Doble, and Onion Creek Meadows resident concerns and observations
February 21, 2017	Blazier Elementary School Cafeteria	• Introduced study parameters to Bluff Springs Road residents • Collected Bluff Springs Road resident concerns and observations
June 20, 2017	Manchaca United Methodist Church	• Presented 2016 FEMA Preliminary Floodplains developed during City of Austin Study results to Bear-Onion Creek confluence residents • Addressed primary concerns reported by residents at previous meeting
July 18, 2017	First Independent Baptist Church	• Presented 2016 FEMA Preliminary Floodplains developed during City of Austin Study results to Bluff Springs Residents

Model Development/ Validation

The frequency event nomenclature in this report uses the percent annual chance exceedance (ACE) terminology and is related to the classic annual recurrence interval terminology in Table 5 below.

Table 5: Frequency Event Nomenclature

Frequency Event (Classic Terminology)	Probability of Occurrence in ANY Given Year	Percent Chance of Occurrence in ANY Given Year
500 Year	1 in 500	0.2%
100 Year	1 in 100	01%
50 Year	1 in 50	02%
25 Year	1 in 25	04%
10 Year	1 in 10	10%
5 Year	1 in 5	20%
2 Year	1 in 2	50%

As noted above, this study utilized available technical data for the Dry Creek East and Onion Creek watersheds. Hydrologic analysis is the computation of how much water (flow) enters a creek at specified locations of interest. Once the flow is established in the hydrologic model, the flow is entered into the hydraulic model. Hydraulic analysis is the computation of how water (flow) travels down a creek system. Hydraulic analysis allows for the estimation of water elevations, speed, and floodplain extents along a creek. The Hydrologic Engineering Center- Hydrologic Modeling System (HEC-HMS) version 3.5 was used to simulate peak runoff based on subbasin parameters including drainage area, rainfall, soil infiltration

losses, and channel and detention routing. Peak flows were determined for the standard annual chance rainfall events (50%, 20%, 10%, 04%, 02%, 01%, and 0.2% ACE) and the historical events of interest for each neighborhood. The Hydrologic Engineering Center-River Analysis System (HEC-RAS) version 4.1 was used to estimate water surface elevations and floodplain extents along the neighborhoods of interest using the peak flows determined from the HEC-HMS models.

Dry Creek East

The 2013 current effective FEMA regulatory hydrologic and hydraulic models for the Dry Creek East served as the starting point for this investigation. Following the October 2015 event, the City of Austin obtained and applied historical rainfall event data to the hydrologic simulations. The results of the historical hydrologic simulation were then applied in the hydraulic simulation. The resulting water surface elevations and floodplain extents were presented to the residents during the first public meeting for the community on August 31, 2016. The community engagement process was used to validate that the simulation adequately replicated the historical event. High water marks and resident testimony validated the extents of the simulated historical events as well as the 1% and 0.2% floodplains. Resident testimony about the floodplain extent near a duplex along Man O War Avenue confirmed the modeling accuracy and validity for this evaluation.

As mentioned previously, the City of Austin obtained and provided gage-adjusted radar rainfall data for the October 2015 and May 2016 storm events. Table 6 displays the rainfall estimates for South Fork of Dry Creek East near the Thoroughbred Farms neighborhood. Upon review of the data, it was found that both the October 2015 and May 2016 rainfall events within Thoroughbred Farms neighborhood exceeded the 0.2% (500-year) ACE rainfall totals. Table 7 displays the simulated frequency event flows in comparison to the computed historical event simulations. These flows were than applied in the hydraulic model to evaluate water surface elevations and floodplain extents.

Table 6: Estimated Rainfall for South Fork of Dry Creek East

Location	Rainfall (inches)			
	1% ACE	0.2% ACE	Oct. 30, 2015	May 26, 2016
South Fork of Dry Creek East at Thoroughbred Farms	6.5 (4 hr)	9.0 (4 hr)	11-14 (2 hr)	8-11 (4 hr)

Table 7: Thoroughbred Farms Flow Comparison

Location	Flow (Cubic Feet per Second)			
	1% ACE	0.2% ACE	Oct. 30, 2015	May 26, 2016
South Fork of Dry Creek East at Thoroughbred Farms	11,800 cfs	16,200 cfs	18,000 cfs	16,200 cfs

Inundated structures are identified based on the computed water surface elevations in comparison to the finished floor elevations. Based on the simulation it was found that 20 of the properties are expected to flood during a 1% ACE event and 20 of the properties are expected to flood during a 0.2% ACE event.

Onion Creek

This Travis County study builds upon the modeling and results of the City of Austin's Onion Creek Floodplain Modeling and Mapping Study. The 2017 preliminary FEMA regulatory hydrologic and hydraulic models for Onion Creek served as the starting point for this investigation. Following the October 2013 and 2015 events, the City of Austin obtained and applied historical rainfall event data to the hydrologic simulations. The results of the historical hydrologic simulation were then applied in the hydraulic simulation. The resulting water surface elevations and floodplain extents were presented to the residents during the first public meeting for the community on February 9 and 21, 2016. The community engagement process was used to validate that the simulation adequately replicated the historical event. High water marks and resident testimonies validated the extents of the simulated historical events as well as the 1% and 0.2% floodplains.

As mentioned previously, the City of Austin obtained and provided gage-adjusted radar rainfall data for the October 2013 and October 2015 storm events. Table 8 displays the rainfall estimates for Onion Creek near the Bear Creek confluence area. Upon review of the data, it was found that both the October 2013 and October 2015 rainfall within Onion Creek watershed are similar to the 1% (100-year) ACE rainfall totals. Table 9 displays the simulated frequency event flows in comparison to the computed historical event simulated flows. These flows were than applied in the hydraulic model to evaluate water surface elevations and floodplain extents.

Table 8: Estimated Rainfall for Onion Creek

Location	Rainfall (inches)			
	1% ACE	0.2% ACE	Oct. 31, 2013	Oct. 30, 2015
Onion Creek near confluence with Bear Creek	6.9 (6 hr)	9.5 (6 hr)	9-12 (6 hr)	11-15 (6 hr)

Table 9: Onion Creek Flow Comparison

Location	Flow (Cubic Feet per Second)			
	1% ACE	0.2% ACE	Oct. 31, 2013	Oct. 30, 2015
Onion Creek near confluence with Bear Creek	90,200 cfs	134,100 cfs	60,100 cfs	78,900 cfs
Onion Creek at US 183	121,900 cfs	179,500 cfs	135,000 cfs	120,000 cfs

Inundated structures are identified based on the computed water surface elevations in comparison to the finished floor elevations. Based on the Onion Creek simulations it was found that 15 of the properties are expected to flood during a 1% ACE event and 20 of the properties are expected to flood during a 0.2% ACE event along Onion Creek.

Flood Mitigation Analysis

The flood mitigation concepts are high-level feasibility concepts that may be refined through subsequent engineering analysis and coordination with project stakeholders. Travis County had previously conducted a flood mitigation study that focused on flooding caused by localized systems. This report is titled *Travis County Drainage Basin Study – Volume 1 & 2* and can be found on the Texas Water

Development Board's website. The primary goal of this study was to evaluate potential solutions to address flooding caused by the riverine systems for each of the five neighborhoods of interest. The ultimate objective of this study was to identify at least one feasible alternative to eliminate 1% ACE flood risk of homes for each neighborhood. Potential solutions can be either structural or non-structural in nature.

Structural Alternatives

There are two types of structural alternatives, hydrologic and hydraulic. Water surface elevation reductions can be accomplished using hydrologic, hydraulic, or a combination of hydrologic and hydraulic alternatives. Hydrologic alternatives include detention and retention ponds. Hydraulic alternatives include but are not limited to diversions, floodwalls, and channel improvements. The majority of the structural alternatives considered for this study are hydraulic in nature.

Non-Structural Alternatives

Non-structural flood mitigation alternatives include floodplain management, construction and design regulations, and buyouts. Considering the County is already implementing floodplain management via construction and design regulations, the only non-structural alternatives left are buyouts and structural elevation. Property acquisition is the most effective means of reducing flood damages and improving public safety in at risk neighborhoods indefinitely. The two non-structural solutions considered for Thoroughbred Farms are buyouts and structural elevation within the 1% ACE Floodplain.

Viable Mitigation Solutions

Potential alternatives that best reduce neighborhood structural flooding are described below. This section provides a description of the potential mitigation alternatives including preliminary opinions of probable costs. It should be noted that these flood mitigation concepts were simulated to remove the majority of the structural flooding within the neighborhood of concern. Should any of these mitigation concepts be selected for implementation, the concepts will be refined through subsequent preliminary engineering analysis and coordination with project Stakeholders.

Dry Creek East / Thoroughbred Farms Area

Evaluation of the October 2015 and May 2015 events revealed that the main cause of flooding in the Thoroughbred Farms neighborhood is riverine flooding from the South Fork of Dry Creek East. Since the *Travis County Drainage Basin Study* evaluated and identified potential flood mitigation solutions for local systems, this study only evaluated riverine system flood mitigation concepts for the Thoroughbred Farms neighborhood. The viable flood mitigation solutions for the Thoroughbred Farms neighborhood are listed below.

- Channel Improvements: Channel benching can be used to increase the cross-sectional area (conveyance) of a channel. Channel benching in the Thoroughbred Farms area includes a large benched section on the both sides of South Fork of Dry Creek East from FM 973 to SH 130. These improvements result in high velocities that could potentially be erosive and therefore should be further evaluated in the subsequent analysis. Additionally, this alternative would require significant efforts to maintain the "cleared" channel and would negatively impact the riparian corridor along the South Fork of Dry Creek East, negatively effecting water quality, creek

stability, wildlife, and trees. This flood mitigation project protects 15 homes from the 1% ACE and reduces flood risk for all properties in the Thoroughbred Farms neighborhood. The estimated project cost for this flood mitigation alternative is **$9,062,979**.

- Buyouts: The flood mitigation buyout option includes buyouts to homes within this study area that are estimated to experience structural flooding during the 1% ACE. The estimated cost of buyouts includes real estate services, appraisals, acquisition costs, relocation and moving expenses, asbestos testing and abatement, demolition, and property management. The estimated project cost for buyouts of 20 homes is **$3,812,443**.

- Structural Elevation: The structural elevation option considered in this study is based on the elevation of homes within the study area that are expected to experience structural flooding during the 1% ACE. The estimated cost of structural elevation is based on the square footage of the living areas based on the County's appraisal district information. Although this alternative reduces risk associated with structural damage, public safety is still a concern with this alternative. The estimated project cost for structural elevation of 20 homes is **$2,443,590**.

Onion Creek / Bear Creek – Onion Creek Confluence Area

Evaluation of the October 2013 and October 2015 events revealed that riverine flooding from the Onion Creek impacts the Arroyo Doble and Onion Creek Meadows neighborhoods and localized flooding impacts the all three neighborhoods in this study area. The *Travis County Drainage Basin Study* evaluated and identified potential flood mitigation solutions for local systems in the Arroyo Doble and Twin Creeks neighborhoods, but did not include localized analysis of the Onion Creek Meadows neighborhood. This study evaluated riverine system flood mitigation concepts for the Arroyo Doble and Onion Creek Meadows neighborhoods, as well as local system flood mitigation concepts for the Arroyo Doble, Onion Creek Meadows, and Twin Creeks neighborhoods. The viable flood mitigation solutions for the Bear Creek – Onion Creek Confluence area are listed below.

- Riverine/Floodwalls: Flood protection walls could be effective flood protection solutions as they prevent flood waters from reaching flood prone areas. FEMA criteria require the floodwall to have a minimum freeboard (height above the 1% ACE water level) of at least 3 feet for the entire length of the wall and 3.5 feet of freeboard at the upstream and downstream tie-in locations. Floodwalls were analyzed in both the Arroyo Doble and Onion Creek Meadows neighborhoods. Floodwalls require internal drainage systems to accommodate localized rainfall and associated stormwater run-off behind the wall. Standard internal drainage systems include storm drainage networks combined with a storage facility. These systems allow for the storage of internal drainage until the water could be released to the creek. This flood mitigation project protects 15 homes from the 1% ACE. The estimated project cost for this flood mitigation alternative is **$18,862,502**.

- Riverine/Buyouts: The buyouts option considered in this study is based on the offer of flood mitigation buyouts to homes within the study area that are expected to experience structural flooding during the 1% ACE. The estimated cost of buyouts includes real estate services,

appraisals, acquisition costs, relocation and moving expenses, asbestos testing and abatement, demolition, and property management. The estimated project cost for buyouts of 15 homes in the Arroyo Doble and Onion Creek Meadows neighborhoods is **$10,237,424**.

- Riverine/Structural Elevation: The structural elevation option considered in this study is based on the elevation of homes within the study area that are expected to experience structural flooding during the 1% ACE. The estimated cost of structural elevation is based on the square footage of the living areas based on the County's appraisal district information. Although this alternative reduces risk associated with structural damage, public safety is still a concern with this alternative. The estimated project cost for structural elevation of 15 homes in the Arroyo Doble and Onion Creek Meadows neighborhoods is **$2,637,720**.

- Local/Onion Creek Meadows/Drainage Improvements: The central portion of the Onion Creek Meadows neighborhood experiences localized flooding where residential structures were placed in an area where water naturally flows toward Onion Creek. The *Travis County Drainage Basin Study* did not include localized analysis of the Onion Creek Meadows neighborhood; therefore, this area was included in this study. Underground storm drainage improvements can be used to reduce overland flow and convey storm water underground. Storm drainage improvements in the Onion Creek Meadows neighborhood includes the installation of three 10-feet by 5-feet concrete box culverts along Vinyard Drive. The proposed improvements concentrate flow at the outlet of the storm drainage improvements that may cause erosion or minor downstream impacts. These potential adverse impacts should be further evaluated and mitigated in the subsequent analysis. Additionally, this alternative would require right of way acquisition negotiations with property owners. This flood mitigation project protects 6 homes from the 1% ACE and reduces flood risk for all properties in the Onion Creek Meadows neighborhood. The estimated project cost for this flood mitigation alternative is **$9,613,867.**

- Local/Onion Creek Meadows/Buyouts: The buyouts option considered in this study is based on the offer of flood mitigation buyouts to homes within the study area that are expected to experience structural flooding during the 1% ACE. The estimated cost of buyouts includes real estate services, appraisals, acquisition costs, relocation and moving expenses, asbestos testing and abatement, demolition, and property management. The estimated project cost for buyouts of 6 homes in the Onion Creek Meadows neighborhood that are impacted by localized flooding is **$3,440,430**.

- Local/Onion Creek Meadows/Structural Elevation: The structural elevation option considered in this study is based on the elevation of homes within the study area that are expected to experience structural flooding during the 1% ACE. The estimated cost of structural elevation is based on the square footage of the living areas based on the County's appraisal district information. Although this alternative reduces risk associated with structural damage, public safety is still a concern with this alternative. The estimated project cost for structural elevation

of 6 homes in the Onion Creek Meadows neighborhood that are impacted by localized flooding is **$845,100**.

- Local/Twin Creeks/Buyouts: A single home in the Twin Creeks neighborhood is subject to repetitive flooding as a result of being located in a naturally low area where water tends to gather. The *Travis County Drainage Basin Study* did not include a localized analysis of this portion of the Twin Creeks neighborhood; therefore, this area was included in this study. The buyouts option considered in this study is based on the offer of flood mitigation buyouts to homes within the study area that are expected to experience structural flooding during the 1% ACE. The estimated cost of buyouts includes real estate services, appraisals, acquisition costs, relocation and moving expenses, asbestos testing and abatement, demolition, and property management. The estimated project cost for buyout of one (1) home in the Twin Creek neighborhoods that is impacted by localized flooding is **$200,000**.

Onion Creek / Bluff Springs Area

Evaluation of the October 2013 and October 2015 events revealed that the main cause of flooding in the Bluff Springs neighborhood is riverine flooding from Onion Creek. Since the Travis County has previously evaluated and implemented flood mitigation solutions for local systems, this study only evaluated riverine flood mitigation concepts for the Bluff Springs neighborhood. The viable flood mitigation solutions for the Bluff Springs neighborhood are listed below.

- Channel Improvements: Channel benching can be used to increase the cross-sectional area (conveyance) of a channel. Channel benching in the Bluff Springs area includes a large benched section on the western bank of Onion Creek from Slaughter Lane to the confluence of Boggy Creek. These improvements result in high velocities that could potentially be very erosive and therefore should be further evaluated in the subsequent analysis. Additionally, this alternative would require significant efforts to maintain the "cleared" channel and would negatively impact the riparian corridor along Onion Creek, negatively effecting water quality, creek stability, wildlife, and trees. This flood mitigation project protects 26 homes from the 1% ACE and reduces flood risk for all properties in the Bluff Springs neighborhood. The estimated project cost for this flood mitigation alternative is **$64,881,167**.

- Buyouts: The buyouts option considered in this study is based on the offer of flood mitigation buyouts to homes within the study area that are expected to experience structural flooding during the 1% ACE. The estimated cost of buyouts includes real estate services, appraisals, acquisition costs, relocation and moving expenses, asbestos testing and abatement, demolition, and property management. The estimated project cost for buyouts of 39 homes is **$12,141,723**.

- Structural Elevation: The structural elevation option considered in this study is based on the elevation of homes within the study area that are expected to experience structural flooding during the 1% ACE. The estimated cost of structural elevation is based on the square footage of the living areas based on the County's appraisal district information. Although this alternative

reduces risk associated with structural damage, public safety is still a concern with this alternative. The estimated project cost for structural elevation of 39 homes is **$6,599,430**.

Environmental Investigation

A cursory desktop environmental high-level constraint assessment was conducted on the National Environmental Policy Act (NEPA) and other applicable laws, statues, executive orders, and regulations. A specific NEPA document was not prepared as a part of this study effort, likewise, field investigations were not be performed. This effort was based only on review of existing available documents to identify critical environmental features that should be considered during the development of flood mitigation alternatives analysis. The cursory environmental investigation included the identification of various environmental constraints related to the evaluation of project mitigation alternatives. All efforts were made to avoid and minimize environmental impacts of the proposed flood mitigation alternatives. Appendix F provides a summary of the environmental investigations related to each study area of this project.

Project Prioritization Assessment

County decision makers are required to prioritize flood mitigation projects due to limited available funds. In order to aid the County in making effective flood mitigation decisions consistently, a Project Prioritization Assessment was developed using Multi-Objective Utility Theory. Utility functions are ideal for flood mitigation decision making because of their ability to compare different types of alternatives in a fair and objective manner. Once the utility (score) of each potential risk-reducing alternative is calculated, the alternatives can be rank-ordered to suggest projects for implementation.

Objectives and Attributes

After several interactions and meetings with residents and county officials, it was apparent that safety and the general wellbeing of residents was highly valued amongst all project stakeholders. Therefore, the following objectives were identified for the Travis County Project Prioritization Assessment: Public Safety, Economic Impact, Environmental Impact, Social Impact, and Project Timing. The objectives and their respective attributes are described below.

Table 10: Project Prioritization Assessment Objectives and Attributes

"Objective" Category / Weight		Sub Category Weight	"Attribute" Sub Category	Scoring
Public Safety	***30***	3	Road Flooding and Mobility (pre-project conditions)	1: Isolated Local Roadway Flooding 2: Collector Roadway Flooding 3: Moving water is likely to wash car off road*
		5	Emergency Access (pre-project conditions)	1: Passable 2: Passable but response time increased 3: Impassable
		9	Number of Structures within 1% ACE Footprint (pre-project conditions)	1: 0-15 flooded 2: 15-50 flooded 3: 50+ flooded or critical facility effected
		3	Frequency Event of Structural Flooding (pre-project conditions)	1: ≥ 1% ACE 2: 4%- 1% ACE 3: ≤ 4% ACE
		5	Level of Service (post-project conditions)	1: ≤ 4 % ACE 2: 4% - 1 % ACE 3: ≥ 1 % ACE
		3	Project Risk Reduction (post-project conditions)	1: Public Risk Remains 2: Public Risk Reduced 3: Public Risk Removed
		2	Downstream Mitigation (estimated mitigation cost)	1: 15%+ of project costs 2: 1-15% of project cost 3: No mitigation need for downstream impacts
Economic	***25***	3	Project Cost	1: ≥ 15 Million 2: $5 - 15 Million 3: ≤ $5 Million
		5	Engineering Economics (benefit/cost relationship)	1: B/C < 1.0 2: 1.0-2.0 B/C 3: B/C > 2
		7	Protection Economics (cost/removed structures relationship)	1: C/S > $400K 2: $200K - $400K C/S 3: C/S < $200K
		3	Sustainability O&M Schedule (operation & maintenance)	1: Monthly maintenance 2: Bi-Annual maintenance 3: Annual + maintenance
		3	Sustainability O&M Cost (estimated annual cost)	1: O&M > $4K 2: $2K - $4K O&M 3: O&M Costs < $2K
		2	Impact to County Tax Rolls	1: Decrease 2: No Impact 3: Increase
		2	Funding Source	1: County Funded 3: Grant Funded
Environmental	***20***	10	Water Quality Significance (MS4)	1: Negative Impact 2: No impact 3: Positive Impact
		10	Impact to Existing Environmental Features (i.e. riparian corridor, habitat, etc.)	1: Significant Negative Impact 2: Moderate Negative Impact 3: No Impact / Positive Impact

"Objective" Category / Weight		Sub Category Weight	"Attribute" Sub Category	Scoring
Social	***15***	5	Public Opinion (neighborhood surveys from public meetings)	1: Least Favorable 2: Neutral 3: Most Favorable
		10	Element of a Comprehensive Plan (parks, transportation, planning, HMGP, etc.)	1: No elements in other plans 2: Related to elements in other plans 3: Multiple elements other plan
Project Timing	***10***	4	Ease of Permitting	1: Multi-jurisdiction more permits 2: Local permit with variances/Nationwide 3: Limited local permits
		2	Time for Implementation	1: ≥ 2 Years 2: 1 - 2 Years 3: 0 - 1 Years
		4	Land and Easement Acquisition	1: Condemnation required 2: Purchase necessary 3: No additional acquisition required

– Public Safety: The public safety objective is evaluated based on seven attributes: Road Flooding and Mobility, Emergency Access, Structures in the Floodplain, Frequency of Flooding, Level of Service, Risk Reduction, and Downstream Mitigation.

- *Road Flooding and Mobility:* The pre-project roadway flooding condition is considered in this attribute. Scoring this attribute considers the classification (arterial, collector, local) of the roadway and the magnitude of pre-project roadway flooding. Highest priority is given to the roadways where water is likely to wash vehicles off the roadway. Roadway safety can be estimated using the assumption that depths greater than 1.5 feet and/or velocities greater than 7 feet per second are likely to wash a car off the road.
- *Emergency Access:* This attribute considers the pre-project emergency access to the neighborhood. Emergency access during a flood event is a significant safety concern; therefore, greater priority is given to areas of interest that are cut off from emergency access during a flood event.
- *Structures within 1% ACE Floodplain Footprint:* The pre-project number of structures located in the 1% ACE floodplain footprint is considered in this attribute. This attribute provides insight on the quantity of structures impacted by 1% ACE water surface elevation. It should be noted that not all structures in the floodplain footprint are estimated to encounter flooding inside the structure. Priority was given to areas of interest where more than 50 structures or a critical facility are anticipated to flood during the 1% ACE.
- *Frequency Event of Structural Flooding:* This attribute provides insight into the simulated frequency event that an area of interest first experiences structural flooding. The pre-project anticipated frequency where flooding above a structure's estimated finished floor is considered in this attribute. Greater priority was given to the areas where structural flooding is expected in the more frequent events such as the 4% ACE.

- *Level of Service:* The level of service is the simulated flood exceedance frequency where majority of the structures are removed from the floodplain. The goal of this study was to protect all structures from the 1% ACE. In some cases, this level of service is not feasible. Flood mitigation solutions that protect properties from the 1% ACE or less frequent events are given priority.
- *Project Risk Reduction:* The post-project roadway, structure, mobility, and public flooding risk conditions are considered in this attribute. Scoring this attribute considers the post-project public risk. Highest priority is given to projects that eliminate public risk such as buyouts. When people and property are removed from the floodplain, that risk is eliminated indefinitely. Other projects such as elevation of structures reduce risk of property damages, but do not remove the public from areas of risk.
- *Downstream Mitigation:* This attribute considers post-project estimations of downstream mitigation costs. Since this is a feasibility study with conceptual mitigation evaluations, it is likely that structural projects will require some form of mitigation to ensure the project does not cause adverse impacts to other properties. Flood mitigation alternatives such as buyouts and structural elevations are anticipated to not require additional downstream mitigation measures and therefore are given priority.

– Economic Impact: The economic impact objective is evaluated based on seven attributes: Project Costs, Engineering Economics, Protection Economics, Sustainability, Impact to County Tax Rolls, and Funding Source.

- *Project Cost:* An opinion of probable cost was developed for each alternative. Unit prices for probable costs were developed using the Texas Department of Transportation (TxDOT) bid tabulations from projects within the Austin District within the last calendar year. For specific elements that were not listed within the TxDOT tabulation, unit prices were derived using recent land development and drainage projects in the Central Texas region. It should be noted that these opinions of cost use standard practice and are only considered an estimate. These estimates should be refined should any of the projects mentioned in this analysis be recommended for further evaluation. Opinions of probable cost for each alternative can be found in Appendix D. Projects that are estimated to cost $5 million or less are given priority in this attribute.
- *Engineering Economics:* A FEMA compliant Benefit-Cost Analysis (BCA) was performed for the 13 viable flood mitigation alternatives. The FEMA BCA was established as the standard in order to provide technical and financial assistance for implementation of flood hazard mitigation undertakings and potential federal and state funding eligibility. A neutral priority was given to alternatives with a benefit to cost ratio between 1.0 and 2.0. Greater priority was given to projects with a benefit to cost ratio greater than 2.0.
- *Protection Economics:* Similar to a benefit to cost ratio, this attribute considers the estimated cost relative to the number of protected structures. This equates to a mitigation cost per structure that can be used to compare against multiple mitigation alternatives throughout Travis County. Alternatives with a flood mitigation cost per structure less than $200,000 are given priority.

- *Sustainability O&M Schedule:* Operations and Maintenance (O&M) schedules were estimated in coordination with Travis County based on the County's current O&M schedules for each type of alternative. It is anticipated that that no maintenance is required for structural elevation projects, because the property owner will maintain their own property. It is estimated that annual inspection is required for storm drainage projects, bi-annual maintenance is required for channel improvement projects, and monthly maintenance is required for buyout projects to maintain the lot. Priority was given to the projects that require no maintenance.
- *Sustainability O&M Cost:* O&M annual operating estimates of probable cost are considered in the attribute. The County may estimate budget for project implementation, but they must also consider the long-term O&M costs associated with each project. The O&M costs were estimated in coordination with Travis County based on the County's current O&M costs for each type of alternative. O&M costs associated with this study consider the costs associated with mowing, lot maintenance, and inspection. Similar to the O&M schedule, it is anticipated that that no maintenance is required for structural elevation projects, because the property owner will maintain their own lot. Priority was given to the projects that require no maintenance.
- *Impact to County Tax Rolls:* This alternative considers the project's impact to the County Tax Rolls. An example of a loss of tax base would be a buyout program where Travis County residents relocated to another community. The impact to the County Tax Rolls is estimated by evaluating the number of structure removed and average cost of the structure. Greater priority was given to the projects that potentially increase the County Tax Rolls by keeping residence and improving the property values.
- *Funding Source:* This attribute is based on what could be the project's funding source. The alternative's potential to be funded through grant programs is considered in this attribute. Through evaluation of the alternatives, it was found that some alternatives are likely eligible for grant funding while others would need to seek alternative funding sources. The projects that can be funded though grant programs were given priority.

– Environmental Impact: The environmental impact objective is evaluated based on two attributes: Water Quality Significance and Impact to Existing Environmental Features.

- *Water Quality Significance:* Water quality can potentially be impacted by flood mitigation alternatives. This attribute considers the potential impact to municipal separate storm sewer systems (MS4) that enter waterways within the County's jurisdiction. It is anticipated that a buyout project will have a positive impact on water quality since impervious cover will be removed. Channel improvement projects alter the natural channel but if designed appropriately, should not have an impact on water quality. Other alternatives that confine the creek or concentrate flows may have a negative impact on water quality. Projects with an estimated positive impact are given priority.
- *Impact to Existing Environmental Features:* Any type of stormwater discharged into a natural channel has the ability to impact the characteristics of the channel. The estimate of environmental impact is generally based on whether the environmental impact would

be negligible, moderate or significant. The environmental impact considers the impact to environmental features such as riparian corridors and habitat. Similar to the water quality impact, it is anticipated that a buyout project will have a positive impact since impervious cover will be removed and natural areas will be increased. Channel improvement projects alter the natural channel resulting in significant negative impacts to the riparian corridor and habitat. Alternatives that anticipate no impact or potentially a positive impact are given greater priority.

– Social Impact: The social impact objective is evaluated based on two attributes: Public Opinion and Element of Comprehensive Plan. The social impact objective serves as a placeholder for future Travis County flood mitigation evaluations. No public surveys or detailed review of comprehensive plans were conducted for this study, but future evaluations should include these considerations.
  - *Public Opinion:* The neighborhood surveys from the public meetings and coordination with County staff are considered in this attribute. Public survey questions may be conducted to gain input regarding the neighborhood's most favorable and least favorable flood mitigation alternative project, as well as, most important and least important project constraint. Greater priority is given to the projects that are most favored by the public.
  - *Element of Comprehensive Plan:* In many cases, flood mitigation projects may be funded in combination with or in advance of other county projects. Projects that are listed in multiple County planning documents are more likely to be implemented. Project areas should be cross referenced with the County's planning documents such the bond and capital improvement programs; Land, Water and Transportation Plan; hazard mitigation plan; parks and natural areas plan; corridor plans, etc. Flood mitigation projects that are identified in multiple County planning documents are given greater priority.

– Project Timing: The project objective is evaluated based on three attributes: Ease of Permitting Time for Implementation, and Land and Easement Acquisition.
  - *Ease of Permitting:* Every jurisdiction has its own permitting requirements. Therefore, the location of a proposed risk-reducing project must be considered. Depending on where the proposed project is located, Travis County multi-jurisdiction permits may be required. Some national permits may also be necessary. Delaying one or more permits can deter the projected completion timeline. Projects that only require local permits were given priority in this attribute.
  - *Time for Implementation:* The time of implementation attribute considers the time it takes to design, permit, and construct each alternative. This attribute does not include the time required to obtain funding. In coordination with Travis County, timeline estimates were established for each alternative. These timeline estimates would be refined should any of the projects be recommended for further evaluation. Greater priority is given to projects that could be implemented within a short duration.
  - *Land and Easement Acquisition:* Ideally, a proposed risk-reducing alternative would not require land acquisition. However, this is usually not the case. A portion of a lot or

several lots may need to be purchased to implement the project. In a worst case scenario, condemnation may be required to obtain the required property to advance the project. No additional land or easement acquisition is required for a buyout project or structural elevation project. In a buyout project, the land is included in the acquisition of a residential property. All other structural alternatives require property acquisition. Projects that do not require additional property acquisition are given priority.

Results

The final flood mitigation alternatives were given a score or either 1, 2, or 3 for each attribute as displayed in Table 10 above. The scores represent the level which the project meets the criteria, where 3 is the best and 1 is the worse. Therefore, the highest total score indicates the highest ranked project. The table below summarizes the project prioritization assessments conducted through this study.

Table 11: Project Prioritization Assessment

Viable Alternatives	Public Safety	Social	Economic	Environ-mental	Project Timing	Total Weighted Score*	Rank
Dry Creek East / Thoroughbred Farms Area							
Thoroughbred Farms Channel Improvements	66	20	33	30	18	**167**	**11**
Thoroughbred Farms Buyouts	81	20	57	60	30	**248**	**1**
Thoroughbred Farms Elevations	78	20	68	50	28	**244**	**2**
Bear Creek – Onion Creek Confluence Area							
Arroyo Doble & Onion Creek Meadows Floodwall	66	20	30	30	10	**156**	**13**
Arroyo Doble & Onion Creek Meadows Buyouts	78	20	28	60	30	**216**	**9**
Arroyo Doble & Onion Creek Meadows Elevations	75	20	59	50	28	**232**	**5**
Onion Creek Meadows Storm Drainage Improvements	56	20	36	30	26	**168**	**10**
Onion Creek Meadows Storm Local Buyouts	61	20	49	60	30	**220**	**7**
Onion Creek Meadows Storm Local Elevations	58	20	68	50	28	**224**	**6**
Twin Creeks Buyouts	52	20	54	60	30	**216**	**8**
Onion Creek / Bluff Springs Area							
Bluff Springs Channel Improvements	67	20	30	30	18	**165**	**12**
Bluff Springs Buyouts	76	30	40	60	30	**236**	**4**
Bluff Springs Elevations	73	20	68	50	28	**239**	**3**
*Note: The greatest total weighted score is the first ranked priority project.							

Conclusion & Recommendations

In light of recent extreme flooding events, the *Travis County Flood Mitigation Study Analysis* allowed the County to re-evaluate the flood risk within the Dry Creek East, Bear Creek – Onion Creek Confluence, and Bluff Springs areas to evaluate potential flood mitigation alternatives. There are 20 homes within the Thoroughbred Farms neighborhood, 22 within the Bear Creek – Onion Creek Confluence, and 39 within the Bluff Springs neighborhood where the estimated 1% ACE water surface elevation exceeds the finished floor elevations. The ultimate flood mitigation objective of this study is to identify at least one feasible alternative capable of eliminating the interior flooding risk of homes during the 1% ACE in the five neighborhoods.

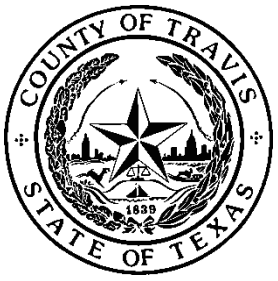
Structural drainage improvement projects are preferred when a cost effective, viable alternative can be identified. When water surface elevation reduction is not feasible through the use of hydrologic or hydraulic alternatives, non-structural (buyouts or structural elevation) alternatives could be utilized to reduce or remove at-risk homes from the floodplain.

The large drainage basins and corresponding volume of flood water along the South Fork of Dry Creek East and Onion Creek significantly impact the viability of cost effective structural solutions in these Travis County neighborhoods. Buyouts and structural elevation provide the best public safety and are more cost effective than other structural alternatives. Additionally, these non-structural alternatives have less environmental impact and the shortest time of implementation. The results of the project scoring indicated that the recommended short-term projects for each of the study areas are as follows:

- Dry Creek East/ Thoroughbred Farms Neighborhood: Riverine Buyouts
- Onion Creek / Arroyo Doble and Onion Creek Meadows Neighborhoods: Riverine Structural Elevation
- Onion Creek / Onion Creek Meadows: Local Structural Elevation
- Onion Creek / Twin Creeks: Local Buyout
- Onion Creek / Bluff Springs: Riverine Structural Elevation

As identified in the *City of Austin's Onion Creek Flood Mitigation Analysis* study, regional detention could also be considered as a flood mitigation alternative for long-term and comprehensive planning. However high project cost, lack of funding, complex permitting, property acquisition, and environmental impact could all be obstacles that would need to be overcome if regional detention was ever implemented. Regional detention would also require regional partnerships between multiple jurisdictions, including coordination between Travis and Hays Counties through their recent Interlocal Agreement (ILA).

This Travis County Flood Mitigation Analysis is a feasibility study. Any results from this study, including post-project flood risk, would be refined should any of the structural projects mentioned in this analysis be recommended for further evaluation.



Travis County Flood Mitigation Study

Appendix A: Dry Creek East

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Introduction

The Dry Creek East watershed is approximately 56 square miles and begins within Travis County and drains into the Colorado River in Bastrop County. Dry Creek East is composed of three subwatersheds: North Fork Dry Creek East, South Fork Dry Creek East, and Dry Creek East. The North and South Forks cross Highway 183 and converge near State Highway 130 (SH 130). Both the North and South Fork subwatersheds are completely contained within Travis County. The main stem of Dry Creek East crosses Highway 71, through Bastrop County and finally drains into the Colorado River. This study evaluated one neighborhood in the Dry Creek East watershed. **Figure A – 1** displays the location of the Thoroughbred Farms neighborhood within Dry Creek East and other landmarks.

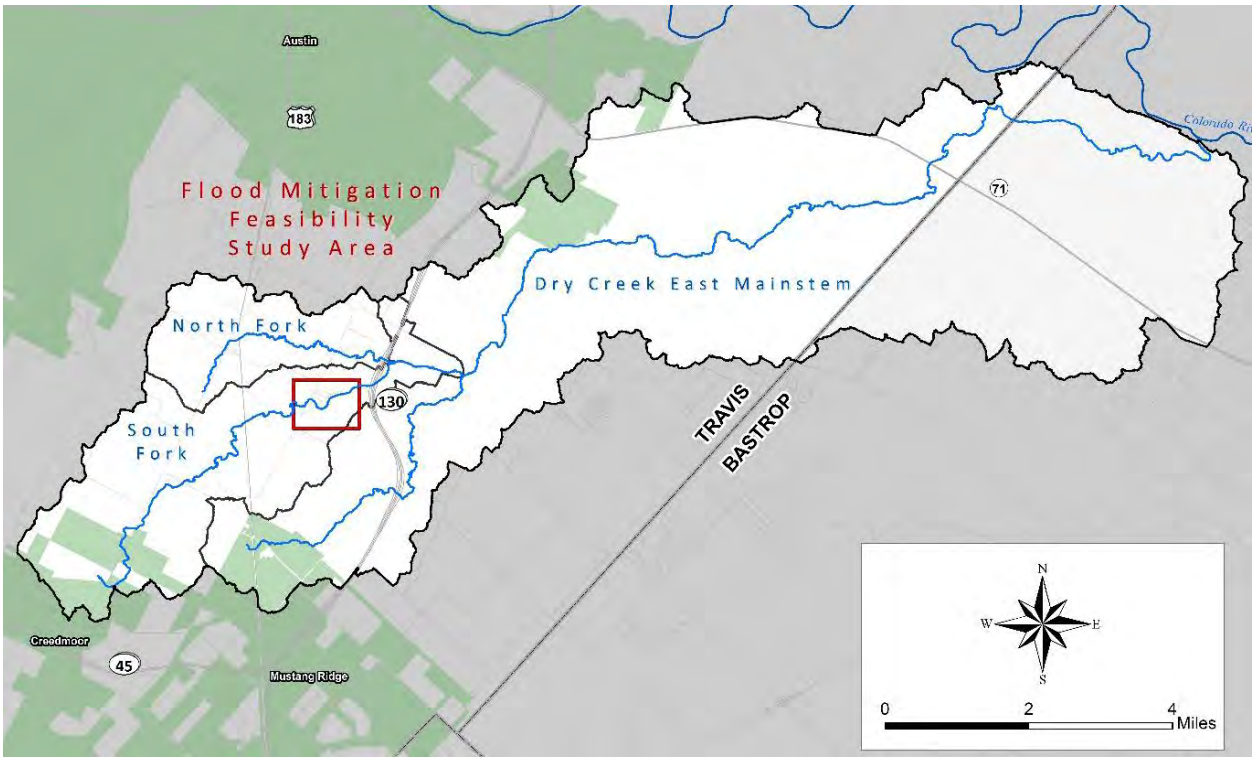

Figure A - 1: Travis County Dry Creek East Watershed Flood Mitigation Study Area Location Map

– Thoroughbred Farms Neighborhood: The Thoroughbred Farms neighborhood is located within the South Fork portion of the Dry Creek East Watershed just south of the intersection of McKenzie Drive and Farm to Market Road (FM) 973. The neighborhood sits on the left bank of Dry Creek East downstream of the FM 973 bridge but upstream of SH 130. FM 973 provides the only access point to the neighborhood. Public meetings with the neighborhood revealed that this neighborhood is impacted by both riverine and local drainage flooding.

The neighborhood experienced extensive flooding including one fatality during the October 30, 2015 event. Due to the limited access to the neighborhood, emergency response was difficult during the 2015 event. The Thoroughbred Farms neighborhood experienced extensive flooding again in May of 2016. Prior to these two extreme weather events, residents in this neighborhood experienced other significant weather events in 2001, 1990s and 1980s. In

response to prior flooding, Travis County purchased several severe repetitive loss structures along Citation Avenue. Overall the neighborhood has a history of being prone to flooding.

Study Process

The Travis County Flood Mitigation Analysis was a step-by-step process, where each step was influenced by the preceding analysis. **Figure A – 2** below outlines the steps that were taken during the analysis. Data collection included the collection of technical data (previous studies, rainfall data, field survey, and field reconnaissance) and resident data (testimony, concerns, and validation of historical simulation). Model development included hydrologic and hydraulic analyses. The flood mitigation analysis consisted of the evaluation of riverine and local flooding solutions, project assessment, and recommendations. The primary goals of this study were to evaluate potential solutions to address flooding caused by the riverine systems for each of the three areas of interest and to identify at least one feasible alternative to eliminate 1% (100-year) Annual Chance Exceedance (ACE) flood risk of homes for each neighborhood. This report describes the Thoroughbred Farms area.

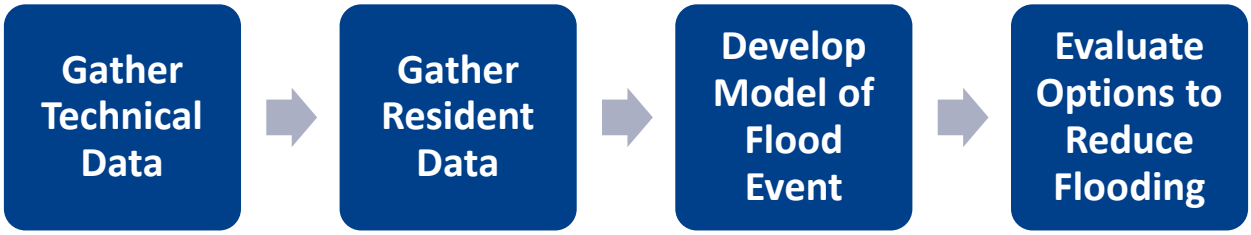

Figure A - 2: Travis County Mitigation Analysis Process

Data Collection

The main goal of data collection was to obtain the best available data. Once the technical data was compiled and a preliminary historical simulation of the October 2015 flood event was developed, the study team held multiple public meetings to gather resident data. **Table A – 1** lists the data collected for this study.

Table A - 1: Data Types Collected for Thoroughbred Farms

Gather Data	
Technical Data	**Resident Data**
• Regulatory Effective Models	• High Water Marks
• LiDAR (ground surface data)	• Flow Direction
• Historical Rainfall	• Floodplain Extents
• Field Survey & Reconnaissance	• General Testimony
• TxDOT Plans	

The 2013 current effective FEMA regulatory hydrologic and hydraulic models for the Dry Creek East served as the starting point for this investigation. The 2013 hydrologic and hydraulic models were developed using Light Detection and Ranging (LiDAR) data flown in 2007 and published in 2008 for the Capital Area Council of Governments (CAPCOG). The 2013 LiDAR was obtained from the City of Austin. Halff tested the continued validity of using the Dry Creek East regulatory models by subtracting the 2013 LiDAR from the 2008 LiDAR within the Travis County portions of Dry Creek East Watershed. The results illustrated negligible development and elevation change within the South Fork portion of the Dry Creek East Watershed. Residents also voiced concerns about recent residential development in the surrounding areas. The only significant land development resulting in elevation changes within Dry Creek East Watershed occurred downstream of the Thoroughbred Farms neighborhood at the Circuit of the Americas, which broke ground in December 2010. The housing developments residents were concerned about were not within the Dry Creek East Watershed, were not part of the Dry Creek East Hydrologic system, and therefore could not be contributing stormwater runoff into the watershed. A few of these developments that were discussed in the meeting are displayed in **Figure A – 3**. Following review of the technical data and public concerns, it was found that the 2013 current effective FEMA hydrologic and hydraulic models were acceptable for this study without updating the models with more recent LiDAR.

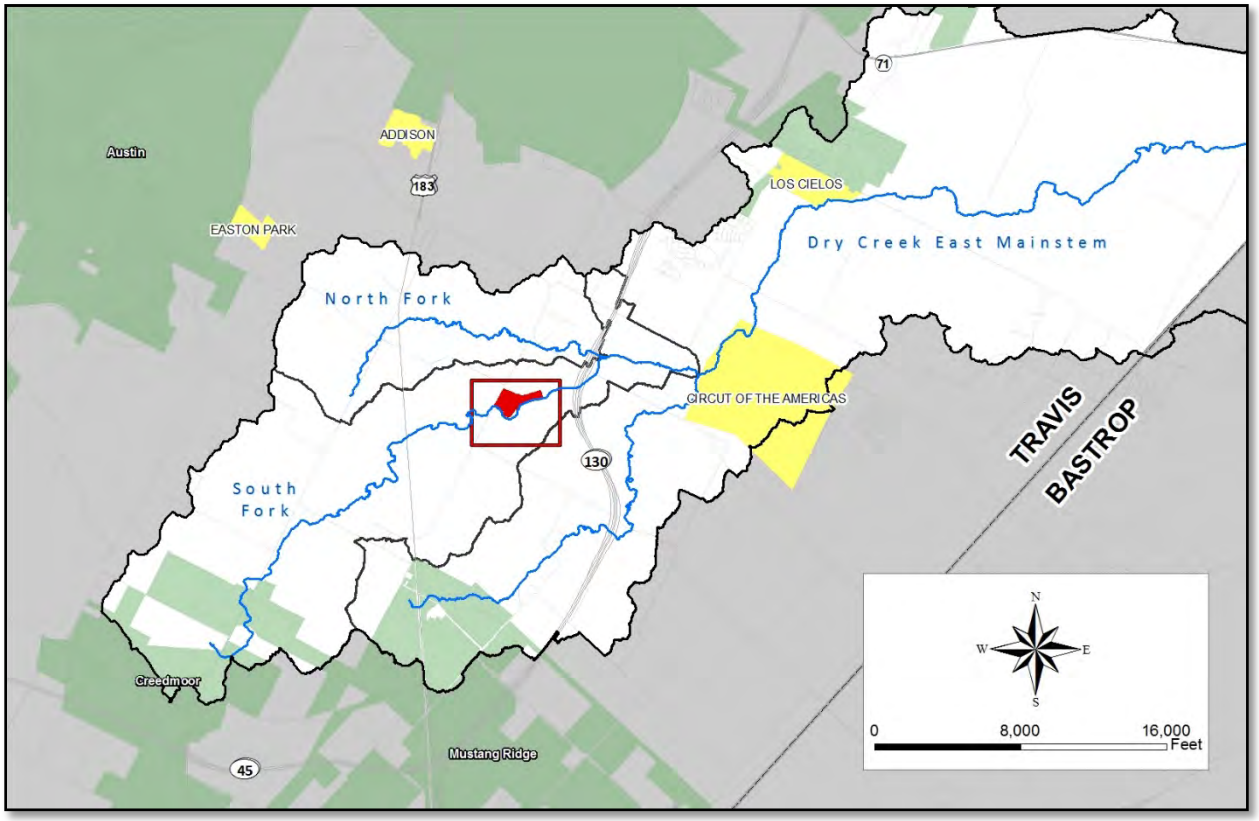

Figure A - 3: Resident Reported Concerns

The City of Austin provided the gage-adjusted radar rainfall for the October 2015 and May 2016 storm events. Upon review of the data, it was found that both the October 2015 and May 2016 rainfalls within Thoroughbred Farms neighborhood exceed the 0.2% (500-year) ACE rainfall totals.

Finished floor elevations were collected by Zamora, LLC to supplement and validate LiDAR data used within the hydrologic and hydraulic models. Where survey was not available, LiDAR elevation data was utilized. When water surface elevations exceed the finish floor elevation, interior or structural flooding is likely to occur.

A series of public meetings were held to gather any relevant resident data that could be used to calibrate and validate watershed models and the simulated October 2015 flood mapping extents. Residents provided first hand testimony of flooding extents and damages. Photos documenting high water marks and damages were collected and copied before being returned to residents. Often, resident testimony confirmed and complimented the simulated preliminary water surface elevations and mapping extents from the October 2015 event. Resident concerns were also recorded and investigated to ensure flooding events, including the destructive October 2015 event, and were accurately portrayed in the hydraulic models. The goal of the first round of neighborhood meetings was to inform residents of the status of the project, gain valuable input regarding their flood risks, and validate the result of the historical simulations. The goal of the second round of neighborhood meetings was to inform residents of the status of the project, discuss their existing condition flood risk, and discuss preliminary flood mitigation solutions.

Multiple field reconnaissance visits were conducted for this analysis. The first visit was conducted in the Thoroughbred Farms neighborhood on May 27, 2016 to record high water marks from the May 26, 2015 rain event. The study team returned to the neighborhood on October 5, 2016 to further investigate resident concerns regarding Texas Department of Transportation (TxDOT) improvements near the FM 973 crossing of the South Fork of Dry Creek East. TxDOT improvement plans were obtained and evaluated for potential adverse impacts to the Thoroughbred Farms neighborhood. **Figure A – 4** illustrates the TxDOT improvements along FM 973.

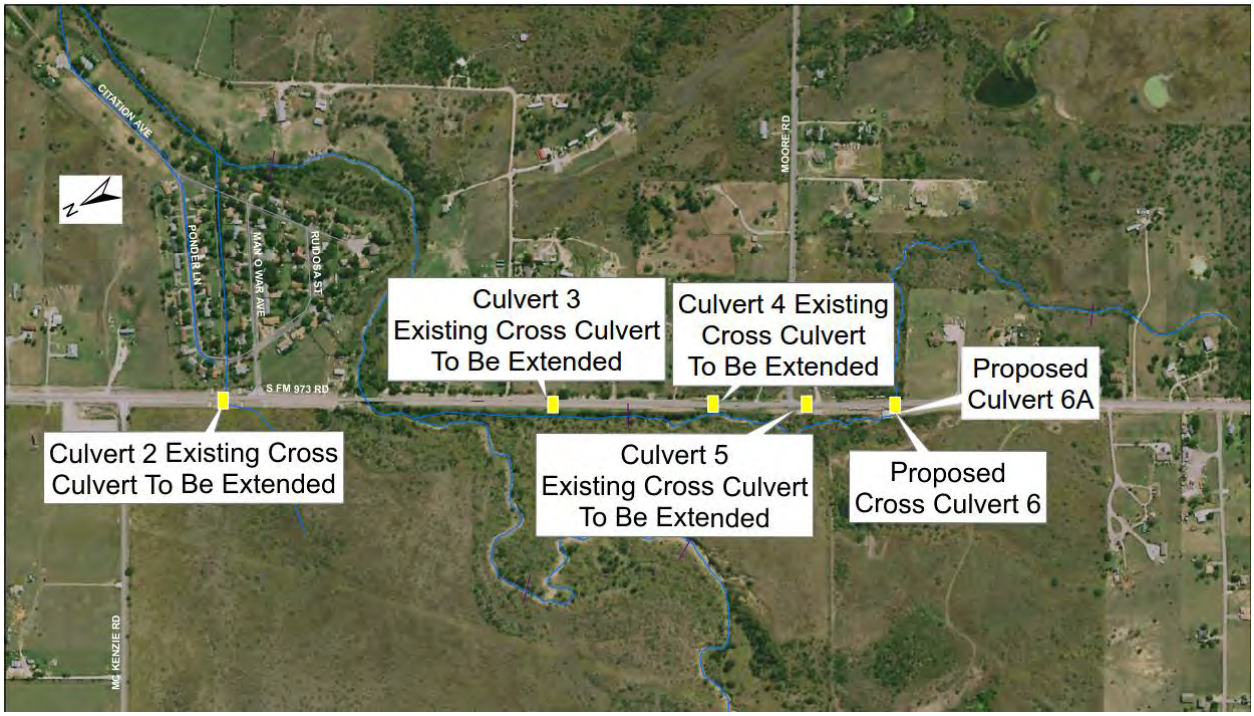

Figure A - 4: TxDOT FM973 Culvert Improvements of Interest

The improvements of FM 973 did not alter the existing drainage pattern. The TxDOT improvements were implemented to increase safety, stability, and minimize erosion. **Figure A – 5** and **Figure A – 6** illustrate how the previous unsafe steep slopes were modified. As evident in **Figure A – 5**, a safety grate was also added to the upstream side of the culvert to prevent debris from being swept into the culvert.

Original **Improvements**

Figure A - 5: TxDOT Culvert 2 Upstream Views

Original **Improvements**

Figure A - 6: TxDOT Culvert 2 Downstream Views

Four culverts along FM 973 were extended to facilitate the widened roadway. The culvert capacities of these crossings were unaltered from the prior capacities. As evident in **Figure A – 7**, one culvert system was modified to provide a uniform crossing rather than the prior crossing that included different sized culverts with unsafe side slopes.

Original **Improvements**

Figure A - 7: TxDOT Culvert 6 & 6A

Model Development / Validation

The hydrologic and hydraulic models were used to simulate the October 2015 flood event and develop flood mitigation alternatives for the Thoroughbred Farms neighborhood within the Dry Creek East watershed. This comprehensive watershed study began by utilizing the City of Austin's most recent FEMA current effective (regulatory) models. The Dry Creek East hydrologic analysis utilizes Natural Resource Conservation Service (NRCS) curve number losses and the NRCS unit hydrograph transform

method. The existing regulatory hydrologic and hydraulic models were used to model seven design storm frequencies. The frequency event nomenclature in this report uses the percent annual chance exceedance (ACE) terminology and is related to the classic annual recurrence interval terminology in **Table A – 2** below.

Table A - 2: Frequency Event Nomenclature

Frequency Event (Classic Terminology)	Probability of Occurrence in ANY Given Year	Percent Chance of Occurrence in ANY Given Year
500 Year	1 in 500	0.2%
100 Year	1 in 100	01%
50 Year	1 in 50	02%
25 Year	1 in 25	04%
10 Year	1 in 10	10%
5 Year	1 in 5	20%
2 Year	1 in 2	50%

Following the October 2015 event, the City of Austin obtained and applied historical rainfall event data to the hydrologic simulations. **Figure A – 8** displays the National Weather Service (NWS) reported rainfall totals for the October 2015 event. The red and orange colors indicate areas where the heaviest rainfall occurred. The results of the historical hydrologic simulation were then applied in the hydraulic simulation to estimate water surface elevations and floodplain extents. The resulting water surface elevations and floodplain extents were presented to the residents during the first public meeting for the community on August 31, 2016. The community engagement process was used to validate that the simulation adequately replicated the historical event. High water marks and resident testimony validated the extents of the simulated historical events as well as the 1% and 0.2% ACE floodplains. Resident testimony about the floodplain extent near a duplex on Man O War Avenue confirmed the modeling accuracy and validity for this evaluation.

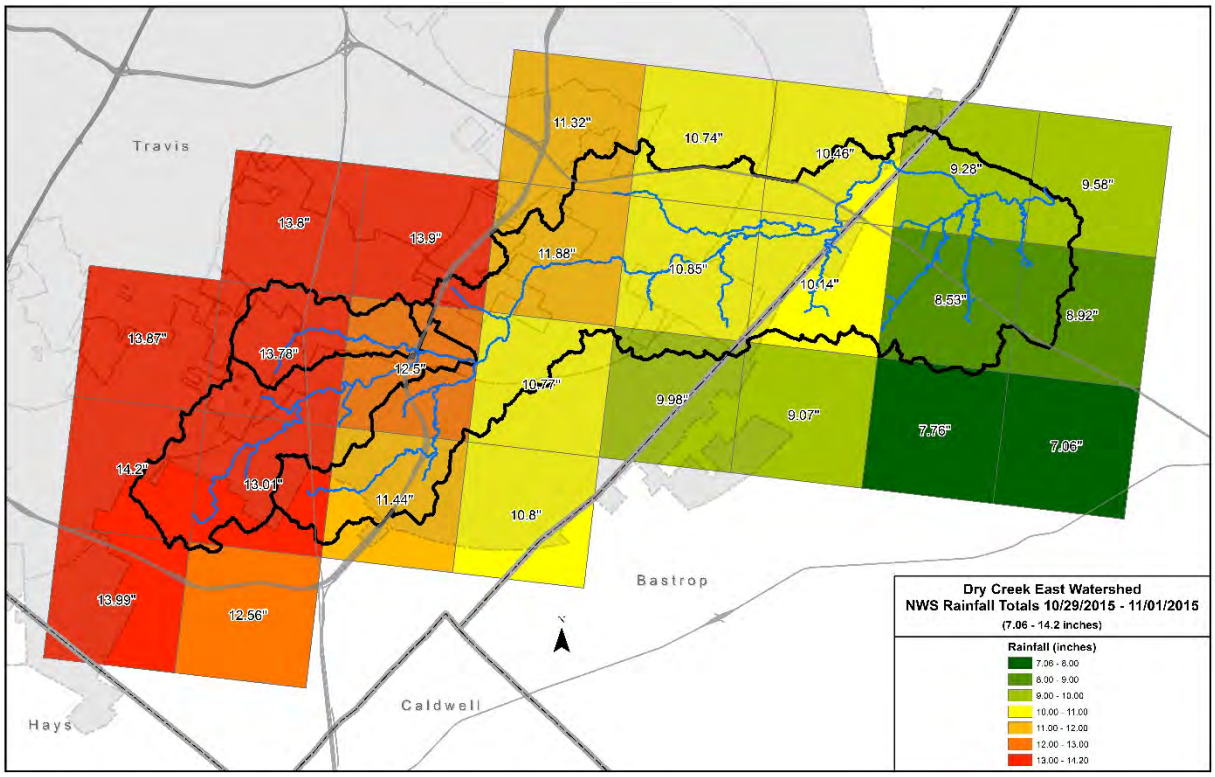

Figure A - 8: Dry Creek East October 2015 National Weather Service Precipitation Totals

As mentioned previously, the City of Austin obtained and provided gage-adjusted radar rainfall data for the October 2015 and May 2016 storm events. This rainfall data was used to generate a meteorological model in the hydrologic HEC-HMS model. **Table A – 3** displays the rainfall estimates for South Fork of Dry Creek East at Thoroughbred Farms. The rainfall patterns leading up to the 2015 and 2016 events were not similar. The soil was already saturated prior to the May 2016 event. The soil was dry prior to the October 2015 event. Therefore, the October 2015 event simulation was assigned Antecedent Runoff Condition II (ARC II) while the May 2016 event simulation was assigned ARC III to account for the saturated soil. As a reference, the frequency storm simulations utilized ARC II conditions. **Table A – 3** displays a comparison of frequency and historical flows. HEC-HMS flow results for both historical events were applied to the HEC-RAS hydraulic model. Upon review of the data, it was found that both the October 2015 and May 2016 rainfall within Thoroughbred Farms neighborhood exceeded the 0.2% (500-year) ACE rainfall totals.

Table A - 3: Thoroughbred Farms Rainfall Comparison

Location	Rainfall (inches)			
	1% ACE	0.2% ACE	Oct. 30, 2015	May 26, 2016
South Fork of Dry Creek East at Thoroughbred Farms	6.5 (4 hr)	9.0 (4 hr)	11-14 (2 hr)	8-11 (4 hr)

Table A - 4: Thoroughbred Farms Calculated Flow Comparison

Location	Flow (Cubic Feet per Second)			
	1% ACE	0.2% ACE	Oct. 30, 2015	May 26, 2016
South Fork of Dry Creek East at Thoroughbred Farms	11,800 cfs	16,200 cfs	18,000 cfs	16,200 cfs

The HEC-RAS hydraulic model utilized the simulated October 2015 and May 2016 hydrologic flows to define historical water surface elevations, floodplain extents and other hydraulic computations. The resulting water surface elevation combined with a 3 ft by 3 ft digital elevation model derived from the 2013 LIDAR data set were used to delineate flood inundation extents. The October 2015 event floodplain extent and simulated depths were also verified against resident testimony and available high water marks.

Many Thoroughbred Farms residents testified that the October 2015 and May 2016 rainfall events produced the largest volume of water to pass through the creek and the highest water surface elevations along their portion of Dry Creek East. Evaluation of the rainfall and stream flow statistics confirm this testimony. **Table A – 5** illustrates the expected depth of flooding for three simulated events: the 1% ACE, the 0.2% ACE, and the October 2015 event. Inundated structures are identified based on the computed water surface elevations in comparison to the Finished Floor Elevations. The negative values indicate how many feet the computed water surface elevation is below the estimated Finished Floor Elevation of a property and positive values indicate how many feet the computed water surface is above the estimated Finished Floor Elevation. For example, 8321 Citation Avenue has a Finished Floor elevation of 512.9 Feet. It is expected to flood approximately 0.3 feet during the 1% ACE event and 1.5 feet during the 0.2% ACE event. Based on the simulation it was found that 20 of the properties are expected to flood during a 1% ACE event and 20 of the properties are expected to flood during a 0.2% ACE event.

Table A - 5: Thoroughbred Farms Neighborhood – Computed Risk Under Current Conditions

	Property ID	Address		Finished Floor Elevation (ft)*	Computed Water Surface Elevation in Feet			Approximate Depth of Flooding in Feet		
					1%	0.2%	Oct-15	1%	0.2%	Oct-15
1	299367	8202	Citation Avenue	504.6	508.8	510.7	511.5	4.2	6.1	6.9
2	299361	8205	Citation Avenue	503.8	509	510.8	511.6	5.2	6.9	7.8
3	299353	8221	Citation Avenue	506.9	510.4	511.7	512.3	3.5	4.7	5.4
4	299352	8301	Citation Avenue	507.6	510.6	511.8	512.5	3	4.2	4.9
5	299351	8303	Citation Avenue	508.9	510.7	511.9	512.6	1.8	3	3.7
6	299350	8305	Citation Avenue	508.8	510.8	512	512.7	2.1	3.3	3.9
7	299349	8307	Citation Avenue	510.2	511.1	512.2	512.8	0.9	2	2.6
8	299348	8309	Citation Avenue	510.5	511.3	512.4	513	0.8	1.9	2.5
9	299347	8311	Citation Avenue	511.2	511.7	512.8	513.4	0.5	1.6	2.2
10	299346	8313	Citation Avenue	512.1	512.2	513.3	513.9	0	1.2	1.7
11	299341	8315	Citation Avenue	511.9	512.7	513.9	514.4	0.7	1.9	2.5
12	299340	8317	Citation Avenue	512.1	513	514.2	514.7	0.8	2	2.6
13	299339	8319	Citation Avenue	512.3	513.1	514.3	514.8	0.8	2	2.5
14	299338	8321	Citation Avenue	512.9	513.1	514.3	514.9	0.3	1.5	2
15	299337	8322	Citation Avenue	512.6	514	515.3	515.9	1.5	2.7	3.3
16	299336	8320	Citation Avenue	516.5	514	515.3	515.9	-2.5	-1.2	-0.6
17	299389	10602	Man O War Avenue	510.9	511.1	512.2	512.8	0.1	1.3	1.9
18	299388	10604	Man O War Avenue	510.1	511.1	512.2	512.8	1	2.2	2.7
19	299387	10606	Man O War Avenue	509.3	510.9	512.1	512.7	1.7	2.8	3.4
20	299391	10607	Ponder Lane	510	511.2	512.3	512.9	1.2	2.4	2.9
21	299377	10608	Ponder Lane	513.8	510.5	511.8	512.4	-3.3	-2.1	-1.4
22	299386	10609	Ponder Lane	511.9	510.7	511.9	512.5	-1.3	-0.1	0.6
23	299376	10610	Ponder Lane	509.3	510.3	511.6	512.3	1.1	2.4	3

* Finished floor elevation was surveyed for all structures.

Flood Mitigation Analysis

The flood mitigation concepts discussed within this report are conceptual evaluations of potential flood mitigation solutions. They are high-level feasibility concepts that may be refined through subsequent preliminary engineering analysis and coordination with project stakeholders. The ultimate objective of this study was to identify at least one feasible alternative for each neighborhood. Buyouts are considered a feasible alternative once all other possibilities have been evaluated and ruled out.

The overall flood mitigation objective is to eliminate the risk of interior flooding of structures during the 1% ACE and to reduce the extent of roadway flooding to meet the County's development requirements. In order to significantly reduce structure flooding in the Thoroughbred Farms neighborhood along the South Fork of Dry Creek East, the flood elevations from the 1% ACE need to be reduced to levels comparable to a flood event with a frequency near the 10% (10-year) ACE. This reduction can be accomplished using hydrologic alternatives (detention/retention ponds), hydraulic alternatives (diversions, floodwalls, channel improvements, etc.), or a combination of these alternatives. The goal of this conceptual analysis was to identify alternatives that would either reduce the 1% ACE peak discharges by approximately 30% or produce equivalent water surface elevation reductions ranging from 2 to 5 feet through the study area.

Hydrologic Mitigation Alternatives

Hydrologic detention temporarily holds waters. The goal of hydrologic detention is to shift the timing of the volume of water passing through the stream. The goal is to alter the peak flow rates and timing of peak flow to reduce the flow impacts downstream. In order to take the frequency peak discharge from the 1% to 10% ACE approximately 1,700 acre-feet would need to be detained. The proposed pond should ideally be placed where existing topography was favorable for significant detention and feasible construction. There are some undeveloped areas upstream of the Thoroughbred Farms neighborhood that were evaluated as a potential location for detention. Unfortunately, none of these locations were large enough to store the required to provide a significant benefit to the Thoroughbred Farms neighborhood. Additionally, high project cost, lack of available funding, complex permitting, property acquisition, and environmental impacts prolong the estimated timeline for implementation. Due to these constraints, detention was not further analyzed as a viable alternative during this neighborhood.

Hydraulic Mitigation Alternatives

For flood mitigation, reductions in water surface elevation in the Thoroughbred Farms neighborhood along the South Fork of Dry Creek East could be achieved by increasing the flow area or conveyance of the channel within the study area. The results from the current effective 1% ACE simulation were used as the baseline for the hydraulic flood mitigation alternative evaluation. The hydraulic analysis revealed that the 1% ACE and other water surface elevation profiles display one major localized increase in water surface elevation, head loss, just upstream of the FM 973 Bridge. Increases like the water surface elevation illustrated in **Figure A – 9** are generally caused by inflow from large tributaries or channel constrictions where the cross-sectional area and therefore conveyance of a channel is reduced. Although there is an existing tributary confluence directly upstream of FM 973, there is also a channel constriction downstream of the FM 973 Bridge.

A broad range of conceptual hydraulic alternatives were evaluated to mitigate flooding in the Thoroughbred Farms neighborhood. These hydraulic alternatives include the construction of floodwalls, diversion channels, and channel modifications in order to reduce the computed 1% ACE water surface elevation. Any downstream adverse impacts or increases in water surface elevation associated with hydraulic alternative options would be evaluated and mitigated should any of the projects mentioned in this analysis be recommended for further evaluation. Diversion channels were not considered a viable alternative due to the large extent of the South Fork of Dry Creek East floodplain and lack of County owned property in the area. Similarly, floodwalls were not considered a viable alternative due to the existence of a local tributary through the neighborhood and existing topography that prohibits construction of a FEMA compliant floodwall. Therefore, the hydraulic mitigation flood mitigation alternatives were concentrated on channel modifications.

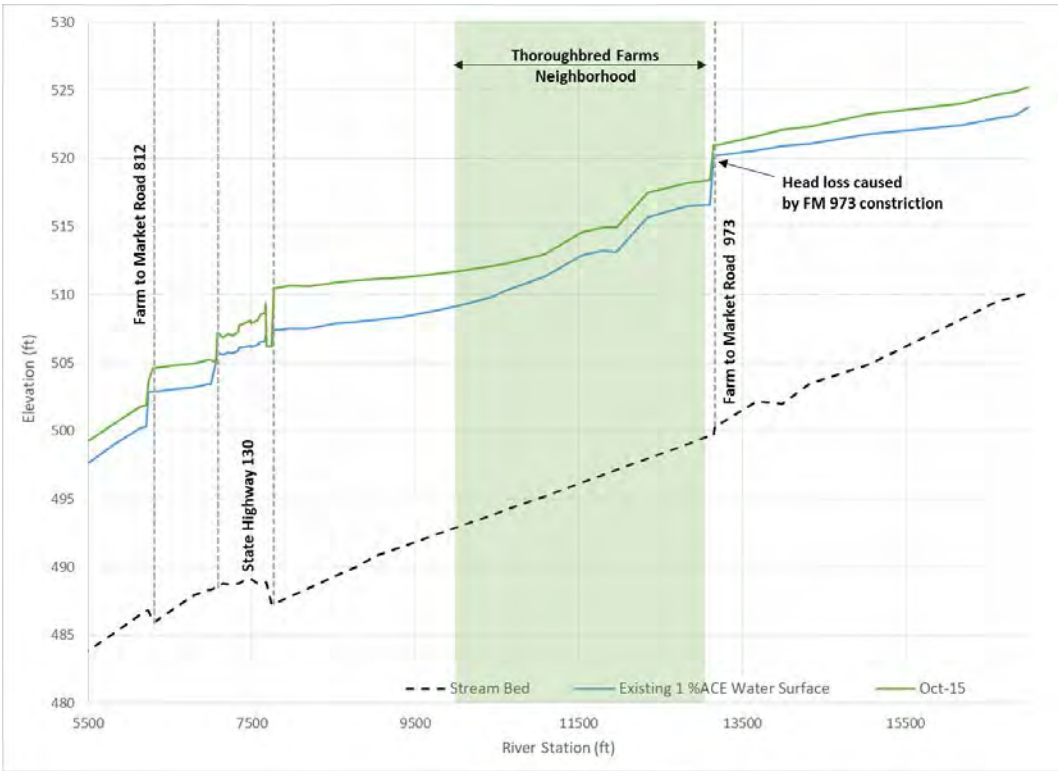

Figure A - 9: South Fork Water Surface Elevation Profile

Viable Mitigation Solutions

Potential alternatives that best reduce Thoroughbred Farms neighborhood structure flooding are described below. This section documents the potential mitigation alternatives including high-level conceptual illustrations and preliminary opinions of probable costs. It should be noted that these conceptual mitigation concepts were simulated to remove the majority of the structural flooding within the neighborhood of concern. These mitigation concepts will be refined through subsequent preliminary engineering analysis and coordination of project Stakeholders.

Existing conditions and proposed flood mitigation improvements were analyzed on their ability to convey floodwaters. Ultimately, this analysis aimed to identify which alternatives could reduce the 1% ACE peak flows or produce equivalent water surface elevation reductions throughout the areas of interests. Non-structural solutions were also considered. If water surface elevations cannot feasibly be reduced through structural alternatives, buyouts could be used to completely remove at-risk homes and their occupants permanently from the floodplain. When people and homes are removed from the floodplain, risk is eliminated indefinitely.

An opinion of probable cost was developed for each alternative. Unit prices for probable costs were developed using the Texas Department of Transportation (TxDOT) bid tabulations from projects within the Austin District within the last calendar year. For specific elements that were not listed within the TxDOT tabulation, unit prices were derived using recent land development and drainage projects in the Central Texas region. It should be noted that these opinions of cost use standard practice and are only

considered an estimate. These estimates should be refined should any of the projects mentioned in this analysis be recommended for further evaluation. Cost ranges of Operations and Maintenance (O&M) estimates were also estimated and considered for each of the final alternatives.

Project benefits are computed using FEMA's Flood Module version 5.2.1. This Flood Module is used to generate project benefit representing a present value of future damages that are estimated to occur over the useful life of the project. FEMA's "full flood" data module was used to calculate the structural replacement flood damage reduction.

Evaluation of the October 2015 and May 2016 events revealed that riverine flooding from Dry Creek East impacts the neighborhood and localized flooding impacts may have also been a factor during these extreme events. The *Travis County Drainage Basin Study* evaluated and identified potential flood mitigation solutions for local systems in the Thoroughbred Farms neighborhood; therefore, this study only evaluated riverine system flood mitigation concepts in this area. The viable flood mitigation solutions for the Thoroughbred Farms neighborhood are described below. These selected alternatives were chosen considering their technical feasibility, cost, and input from project stakeholders.

Structural Alternatives

As discussed above, structural alternatives generally include the construction of detention facilities, floodwalls, diversion channels, and channel modifications in order to reduce the computed 1% ACE water surface elevation. Since detention, floodwalls, and diversion channels were deemed infeasible, the only structural alternatives evaluated for the Thoroughbred Farms neighborhood was channel modifications.

- Channel Improvements: Channel benching can be used to increase the cross-sectional area (conveyance) of a channel. To minimize US Army Corps of Engineers Clean Water 404 Permitting requirements, channel benching was evaluated above South Fork of Dry Creek East's estimated ordinary high water elevations. Channel benching in the Thoroughbred Farms area includes a large benched section on the both sides of South Fork of Dry Creek East. Available open space limited the proposed channel improvements to a 200-foot bench placed 3 feet above the channel invert with 4-foot horizontal to 1-foot vertical slopes back to the natural topography. These improvements result in high velocities that could potentially be very erosive and therefore should be further evaluated in the subsequent analysis. Additionally, this alternative would require significant efforts to maintain the "cleared" channel and would negatively impact the riparian corridor along the South Fork of Dry Creek East, negatively effecting water quality, creek stability, wildlife, and trees. A map of the proposed channel improvements alternative is displayed in **Figure A – 10**. Stand-alone channel benching in the Thoroughbred Farms neighborhood would result in an approximate removal of approximately 15 structures from flooding during the computed 1% ACE. These channel modifications would need to be combined with an additional alternative to provide significant reductions in water surface elevations and removal of all structures from the 1% ACE.

  The channel improvement costs are significantly impacted by the high volume of excavation required to bench the channel. The estimated project cost for this flood mitigation alternative is **$9,062,979**. Due to the limited flood mitigation benefits and potential negative environmental

impacts this channel benching in the Thoroughbred Farms neighborhood was not recommended as the most viable solution for this neighborhood.

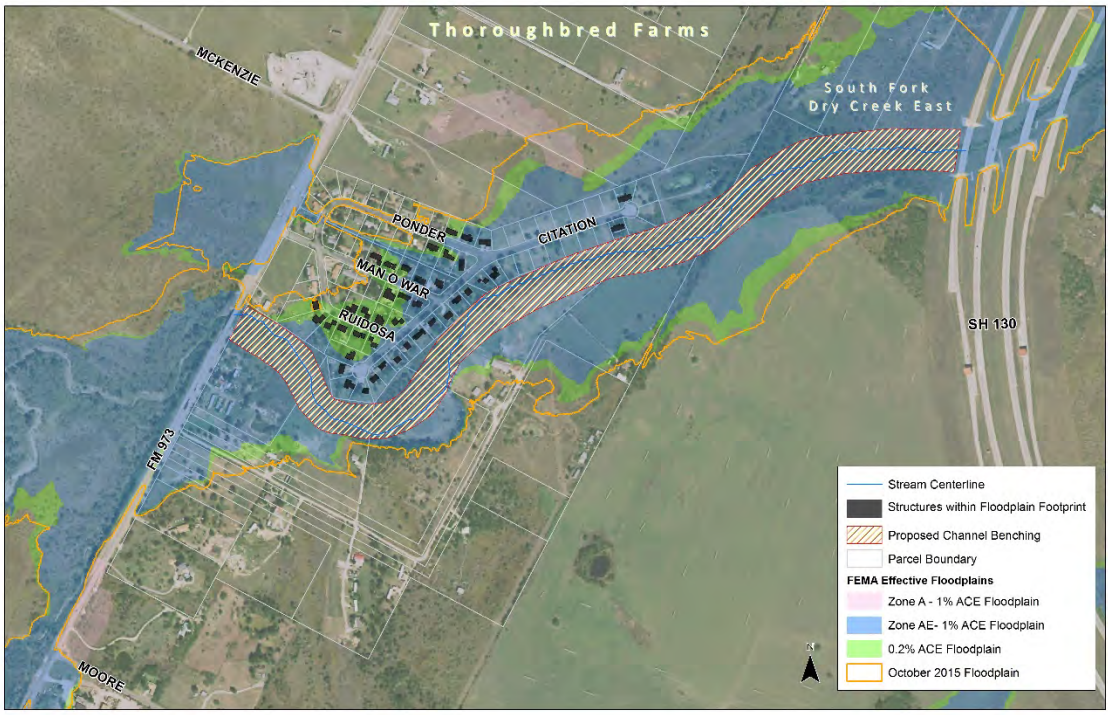

Figure A - 10: Thoroughbred Farms Proposed Channel Improvements

Non-Structural Alternatives

Non-structural flood mitigation alternatives include floodplain management, construction and design regulations, buyouts, and structural elevation. Considering the County is already implementing floodplain management via construction and design regulations, the only Non-Structural alternatives left are buyouts and structural elevation. Buyouts are the most effective means of reducing flood damages and improving public safety in at risk neighborhoods indefinitely. The two non-structural solutions considered for Thoroughbred Farms are buyouts and structure elevation within the 1% ACE Floodplain.

- Buyouts: The buyout option considered in this study is based on the offer of flood mitigation buyouts to homes within the study area that are expected to experience structural flooding during the 1% ACE. Such buyouts should be prioritized based on the expected depth of flooding and should proceed from the highest risk homes to the lowest risk as funding becomes available. The estimated cost of buyouts includes real estate services, appraisals, acquisition costs, relocation and moving expenses, asbestos testing and abatement, demolition, and property management. A map of the proposed buyout properties is displayed in **Figure A – 11**. The effectiveness of this alternative is dependent on successful acquisition of at risk homes. If property owners decline to sell, the home could remain at risk. This flood mitigation project protects 20 homes from the 1% ACE, if acquired. The estimated project cost for this flood mitigation alternative is **$3,812,443**.

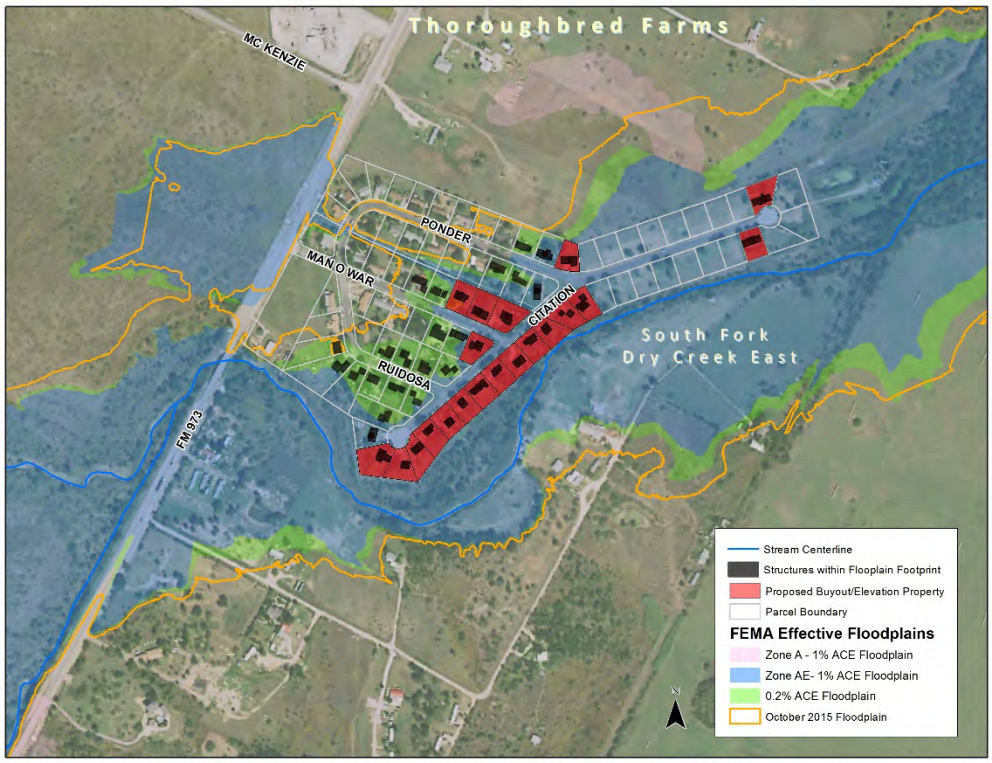

Figure A - 11: Thoroughbred Farms Proposed Buyout and Structural Elevation Properties

– Structural Elevation: The structural elevation option considered in this study is based on the elevation of homes within the study area that are expected to experience structural flooding during the 1% ACE. Similar to the buyout alternative, such elevations should be prioritized based on the expected depth of flooding and should proceed from the highest risk homes to the lowest risk as funding becomes available. The estimated cost of structural elevation is based on the square footage of the living areas based on the County's appraisal district information. The proposed properties for structural elevation are consistent with **Figure A – 11** above. The effectiveness of this alternative is dependent on successful elevation of at risk homes. Although this alternative reduces risk associated with structural damage, public safety is still a concern with this alternative due to potential high velocities associated with flood waters. If implemented, this flood mitigation project reduces structural damages of 20 homes from the 1% ACE. The estimated project cost for this flood mitigation alternative is **$2,443,590.**

Conclusion & Recommendations

In light of recent extreme flooding events, the Travis County Flood Mitigation Study Analysis allowed the County to re-evaluate the flood risk within the Thoroughbred Farms. There are 20 homes within the Thoroughbred Farms neighborhood where the estimated 1% ACE water surface elevation exceeds the finished floor elevations. The ultimate flood mitigation objective of this study is to identify at least one

feasible alternative capable of eliminating the interior flooding risk of homes during the 1% ACE in Thoroughbred Farms.

Cost Effectiveness:

A FEMA compliant Benefit-Cost Analysis (BCA) was performed for the 3 final flood mitigation alternatives. The FEMA BCA was established as the standard in order to provide technical and financial assistance for implementation of flood or hazard mitigation undertakings and potential federal and state funding eligibility. **Table A – 6** below displays the results of this calculated benefits.

Table A - 6: Benefit-Cost Analysis Results

Viable Alternatives	Project Benefits (Avoided Damages)	Estimated Project Cost	Benefit Cost Ratio
Thoroughbred Farms Channel Improvements	$920,174	$9,062,979	**0.10**
Thoroughbred Farms Buyouts	$5,628,898	$3,812,443	**1.48**
Thoroughbred Farms Elevations	$3,652,278	$2,443,590	**1.49**

Recommendation:

After the finalization of the engineering analysis for the viable flood mitigation alternatives, each were evaluated using a project scoring assessment established for the County. The flood mitigation benefits of each of these alternatives were evaluated based on the benefits provided relative to the 2016 current effective FEMA, existing condition 1% ACE. The buyout alternative is less expensive than the channel improvement alternative for the Thoroughbred Farms neighborhood. Although elevation costs are potentially less expensive than voluntary buyouts, elevation does not completely eliminate a home's exposure to flooding hazards. An elevated home can still be surrounded by high velocity flood waters capable of sweeping away people and assets. The only way to completely eliminate a structure's exposure to the 1% ACE risk is to remove the structure from the floodplain via buyouts. The recommended solution for the Thoroughbred Farms neighborhood is buyouts.

This Travis County Flood Mitigation Analysis is a feasibility study. Any results from this study, including post-project flood risk, would be refined should any of the structural projects mentioned in this analysis be recommended for further evaluation.

Appendix 1: Dry Creek East Digital Data

Travis County Flood Mitigation Study

Appendix B: Bear Creek – Onion Creek Confluence

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Introduction

Onion Creek is approximately 344 square miles beginning in Blanco County, flows through Hays County, and drains into the Colorado River within Travis County. This section focuses on the Bear Creek – Onion Creek Confluence Area. Three neighborhoods of interest are located at the Bear Creek – Onion Creek Confluence: Arroyo Doble, Onion Creek Meadows, and Twin Creeks. **Figure B – 1** illustrates the location of this area along the Onion Creek main stem.

- Arroyo Doble: Arroyo Doble is located just upstream of the Bear Creek – Onion Creek confluence. The neighborhood is bounded by the Railroad to the west, Bear Creek to the north, Horsethief Trail to the south, and Onion Creek to the east. Twin Creeks Road provides the only access point to the neighborhood. Neighborhood meetings revealed that this neighborhood is impacted by both riverine and local drainage flooding.

- Onion Creek Meadows: Onion Creek Meadows is located within Upper Onion Creek subwatershed, west of interstate highway 35 (IH-35) and east of the Hays-Travis County Boundary. It sits directly adjacent to the main stem of Onion Creek. The neighborhood is bounded by Onion Creek to the west and Old San Antonio Road to the east. Twin Creeks Road and Old San Antonio Road provide two access points into the neighborhood. Neighborhood meetings revealed that this neighborhood is impacted by both riverine and local drainage flooding.

- Twin Creek Park: The Twin Creek Park neighborhood is located to the north of the Bear Creek – Onion Creek confluence. The neighborhood is bounded by Twin Creeks Road to the west and Onion Creek to the east Twin Creeks Road provides the only access point to the neighborhood. Neighborhood meetings revealed that a few properties are impacted by local drainage flooding.

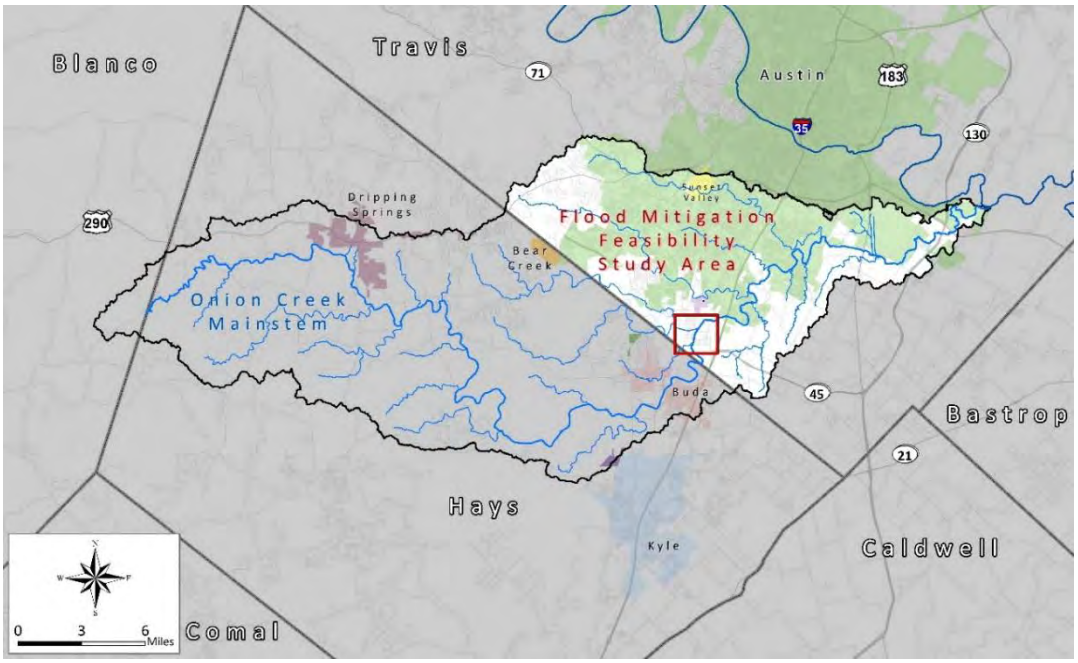

Figure B - 1: Onion Creek Flood Mitigation Study Area Location Map

Study Process

The Travis County Flood Mitigation Analysis was a step-by-step process, where each step was influenced by the preceding analysis. **Figure B – 2** below outlines the steps that were taken during the analysis. Data collection included the collection of technical data (previous studies, rainfall data, field survey, and field reconnaissance) and resident data (testimony, concerns, and validation of historical simulation). Model development included hydrologic and hydraulic analyses. The flood mitigation analysis consisted of the evaluation of riverine and local flooding solutions, project assessment, and recommendations. The primary goals of this study were to evaluate potential solutions to address flooding caused by the riverine systems for each of the three areas of interest and to identify at least one feasible alternative to eliminate 1% (100-year) Annual Chance Exceedance (ACE) flood risk of homes for each neighborhood. This report describes the Bear Creek – Onion Creek Confluence area.

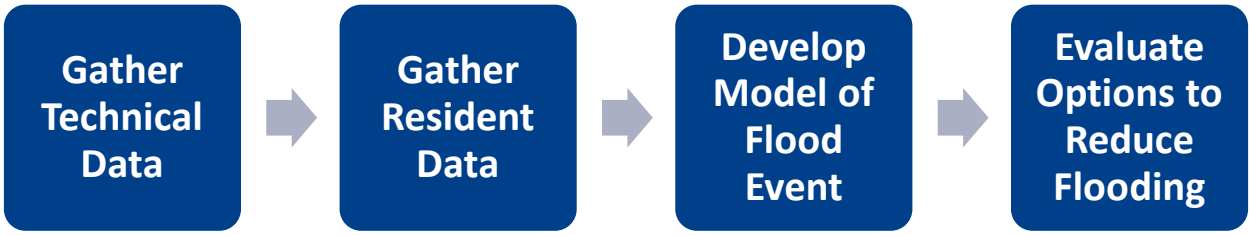

Figure B - 2: Travis County Mitigation Analysis Process

Data Collection

The main goal of data collection was to obtain the best available data. Once the technical data was compiled and a preliminary historical simulation of the October 2015 flood event was developed, the study team held multiple public meetings to gather resident data. **Table B – 1** lists the data collected for this study.

Table B - 1: Data Types Collected for Onion Creek Watershed

Gather Data	
Technical Data	**Resident Data**
• Regulatory Effective Models	• High Water Marks
• LiDAR (ground surface data)	• Flow Direction
• Historical Rainfall	• Floodplain Extents
• Field Survey & Reconnaissance	• General Testimony

The 2017 preliminary FEMA regulatory hydrologic and hydraulic models for Onion Creek served as the starting point for this investigation. Although the 2017 Onion Creek hydrology and hydraulic models are in the preliminary phase of the FEMA approval process, the conceptual level of this study deems them appropriate for use. The 2017 Onion Creek Floodplain Modeling and Mapping Study utilized the 2013 City of Austin Light Detection and Ranging (LiDAR) flown in 2012 to update and evaluate flood risk along the Travis County portions of Onion Creek.

The City of Austin provided the gage-adjusted radar rainfall for the October 2013 and October 2015 storm events. Upon review of the data, it was found that both the October 2013 and 2015 rainfall within Onion Creek watershed are similar to the 1% (100-year) ACE rainfall totals.

Finished floor elevations were collected by Zamora, LLC to supplement and validate LiDAR data used within the hydrologic and hydraulic models. Where survey was not available, LiDAR elevation data was utilized. When water surface elevations exceed the finish floor elevation, interior or structural flooding is likely to occur. A field reconnaissance visit was conducted on April 3, 2017 to observe drainage patterns and verify existing storm drainage infrastructure.

A series of public meetings were held to gather any relevant resident data that could be used to calibrate and validate watershed models and simulated riverine, October 2015 flood mapping extents. Residents provided first hand testimony of flooding extents and damages. Photos documenting high water marks and damages were collected and copied before being returned to residents. Often, resident testimony confirmed and complimented the simulated preliminary water surface elevations and mapping extents from the October 2015 event. Resident concerns were also recorded and investigated to ensure flooding events, including the destructive October 2015 event, were accurately portrayed in the hydraulic models. The goal of the first round of neighborhood meetings was to inform residents of the status of the project, gain valuable input regarding their flood risks, and validate the result of the historical simulations. The goal of the second round of neighborhood meetings was to inform residents of the status of the project, discuss their existing condition flood risk, and discuss preliminary flood mitigation solutions.

During the meetings, residents of Arroyo Doble and Onion Creek Meadows confirmed the validity of the October 2015 riverine simulations but also voiced concerns about localized flooding from a railroad failure in the Arroyo Doble neighborhood and lack of sufficient drainage infrastructure in the Onion Creek Meadows neighborhood. Although localized flooding was not a focus of this study, both of these concerns were conceptually evaluated to better understand the October 2015 flood impact and identify potential mitigation solutions. These items are discussed in the *Flood Mitigation Analysis* sections of this report.

Model Development / Validation

This section describes the hydrologic and hydraulic models used to simulate the October 2015 flood event and develop flood mitigation alternatives for the Onion Creek Meadows and Arroyo Doble neighborhoods within the Onion Creek watershed. The Onion Creek hydrologic analysis utilizes Natural Resource Conservation Service (NRCS) curve number losses and the Snyder's unit hydrograph transform method. The 2017 preliminary hydrologic and hydraulic models were used to model seven design storm frequencies. The frequency event nomenclature in this report uses the percent annual chance exceedance (ACE) terminology and is related to the classic annual recurrence interval terminology in **Table B – 2** below.

Table B - 2: Frequency Event Nomenclature

Frequency Event (Classic Terminology)	Probability of Occurrence in ANY Given Year	Percent Chance of Occurrence in ANY Given Year
500 Year	1 in 500	0.2%
100 Year	1 in 100	01%
50 Year	1 in 50	02%
25 Year	1 in 25	04%
10 Year	1 in 10	10%
5 Year	1 in 5	20%
2 Year	1 in 2	50%

Following the October 2013 and 2015 events, the City of Austin obtained and applied historical rainfall event data to the hydrologic simulations. **Figure B – 3** displays the National Weather Service (NWS) reported rainfall totals for the October 2015 event. The red and orange colors indicate areas where the heaviest rainfall occurred. The results of the historical hydrologic simulation were then applied in the hydraulic simulation. The resulting water surface elevations and floodplain extents were presented to the residents during the first public meeting for the community on February 9, 2016. The community engagement process was used to validate that the simulation adequately replicated the historical event. High water marks and resident testimony validated the extents of the simulated historical events as well as the 1% and 0.2% floodplains.

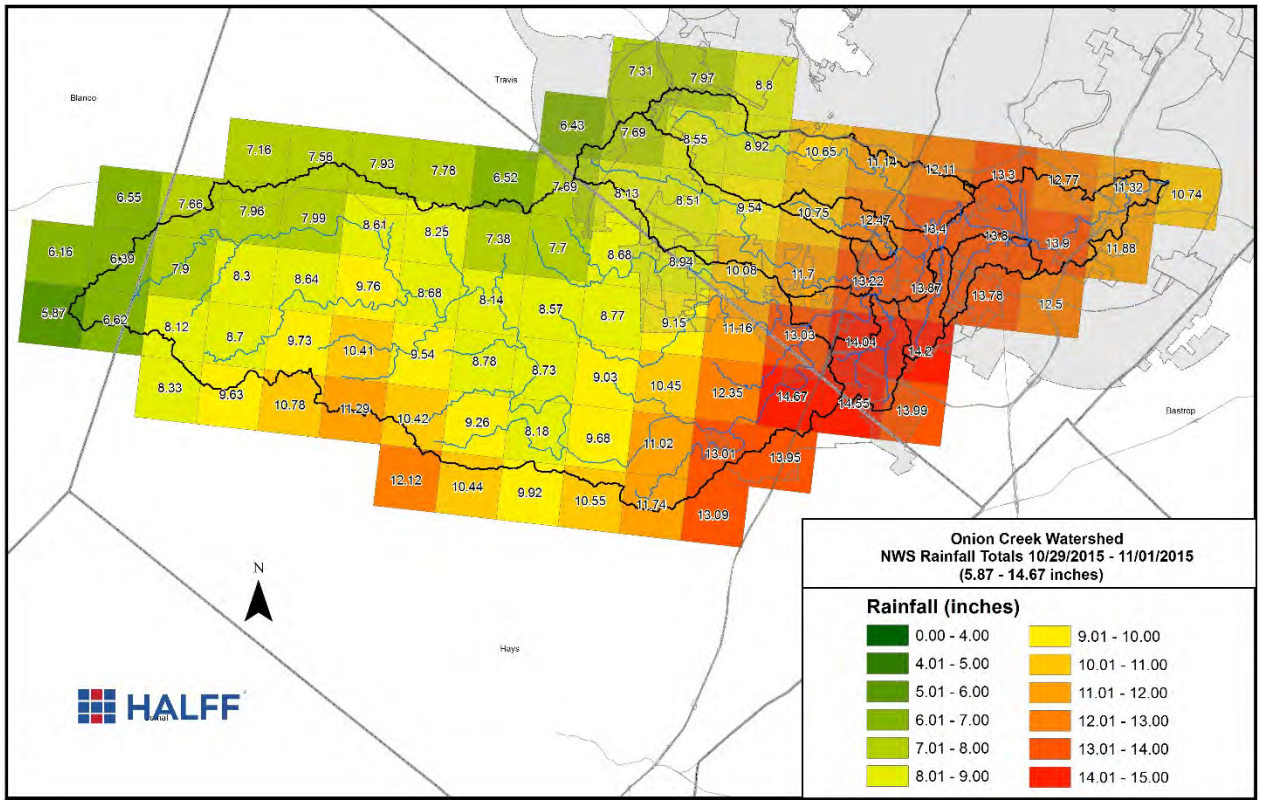

Figure B - 3: Onion Creek October 2015 National Weather Service Precipitation Totals

As mentioned previously, the City of Austin obtained and provided gage-adjusted radar rainfall data for the October 2013 and October 2015 storm events. **Table B – 3** displays the rainfall estimates for Onion Creek near the Bear Creek confluence area. The rainfall patterns leading up to the 2013 and 2015 events were not similar. The soil was already saturated prior to the October 2013 event. The soil was dry prior to the October 2015 event. Therefore, the October 2015 event simulation was assigned Antecedent Runoff Condition (ARC) II while the October 2013 event simulation was assigned ARC III to account for the saturated soil prior to the rainfall event. As a reference, the frequency storm simulations utilized ARC II conditions. Upon review of the data, it was found that both the October 2013 and October 2015 rainfall within Onion Creek watershed are similar the 1% (100-year) ACE rainfall totals. **Table B – 4** displays the simulated frequency event flows in comparison to the computed historical event simulations. These flows were than applied in the hydraulic model to evaluate water surface elevations and floodplain extents.

Table B - 3: Estimated Rainfall for Onion Creek

Location	Rainfall (inches)			
	1% ACE	0.2% ACE	Oct. 31, 2013	Oct. 30, 2015
Onion Creek near confluence with Bear Creek	6.9 (6 hr)	9.5 (6 hr)	9-12 (6 hr)	11-15 (6 hr)

Table B - 4: Onion Creek Flow Comparison

Location	Flow (Cubic Feet per Second)			
	1% ACE	0.2% ACE	Oct. 31, 2013	Oct. 30, 2015
Onion Creek near confluence with Bear Creek	90,200 cfs	134,100 cfs	60,100 cfs	78,900 cfs
Onion Creek at US 183	121,900 cfs	179,500 cfs	135,000 cfs	120,000 cfs

The HEC-RAS hydraulic model utilized the simulated October 2013 and October 2015 hydrologic flows to define historical water surface elevations, floodplain extents and other hydraulic computations. The resulting water surface elevation combined with a 3 ft by 3 ft digital elevation model derived from the 2013 LIDAR data set were used to delineate flood inundation extents. The October 2015 event floodplain extent and simulated depths were also verified against resident testimony and available high water marks.

Many Arroyo Doble and Onion Creek Meadows residents testified that the October 2015 rainfall event produced the largest volume of water to pass through the neighborhood and the highest water surface elevations they have ever experienced. Evaluation of the rainfall and stream flow statistics confirm both events were very significant and local flooding was a problem. **Table B – 5** illustrates the expected depth of riverine flooding for three simulated events: the 1% ACE, the 0.2% ACE, and the October 2015 event. Inundated structures are identified based on the computed water surface elevations in comparison to the Finished Floor Elevations. The negative values indicate how many feet the computed water surface elevation is below the estimated Finished Floor Elevation of a property and positive values indicate how many feet the computed water surface is above the estimated Finished Floor Elevation. For example, 12704 Arroyo Doble Drive has a Finished Floor Elevation of 617.9 Feet. It is expected to flood approximately 3.6 feet during the 1% ACE event and 8.7 feet during the 0.2% ACE event. Based on the Onion Creek simulations it was found that 15 of the properties are expected to flood during a 1% ACE

event and 37 of the properties are expected to flood during a 0.2% ACE event along Onion Creek in the Arroyo Doble and Onion Creek Meadows neighborhoods.

Table B - 5: Bear Creek – Onion Creek Confluence Riverine Computed Risk Under Current Conditions

	Property ID	Address		Finished Floor Elevation (ft)*	Computed Water Surface Elevation in Feet			Approximate Depth of Flooding in Feet		
					1%	0.20%	15-Oct	1%	0.20%	15-Oct
1	140704	12704	Arroyo Doble Drive	617.9	621.5	626.6	622.5	3.6	8.7	4.6
2	141075	12706	Arroyo Doble Drive	618.7*	621.5	626.6	622.5	2.8	7.9	3.8
3	141075	12708	Arroyo Doble Drive	616.6*	621.6	626.7	622.6	5.0	10.1	6.0
4	141075	12710	Arroyo Doble Drive	623.1*	621.6	626.7	622.6	-1.5	3.6	-0.5
5	141075	12800	Arroyo Doble Drive	625.6	621.7	626.8	622.7	-3.9	1.2	-2.9
6	141075	12805	Arroyo Doble Drive	621.2	621.5	626.6	622.9	0.3	5.4	1.7
7	141075	12805	Arroyo Doble Drive	624.3	622.2	627.3	623.1	-2.1	3.0	-1.2
8	141753	12805	Arroyo Doble Drive	620.6	621.5	626.6	623.2	0.9	6.0	2.6
9	141753	12805	Arroyo Doble Drive	623.5	622.5	627.6	623.3	-1.0	4.1	-0.2
10	141753	12901	Arroyo Doble Drive	623.8	622.8	627.9	623.5	-1.0	4.1	-0.3
11	142221	12907	Arroyo Doble Drive	625.2	623.6	628.8	624.2	-1.6	3.6	-1.0
12	142221	12907	Arroyo Doble Drive	624.9	623.4	628.6	624.0	-1.5	3.7	-0.9
13	142438	13007	Arroyo Doble Drive	628.7	624.7	630.0	625.1	-4.0	1.3	-3.6
14	142730	13007	Arroyo Doble Drive	630.8	625.0	630.4	625.3	-5.8	-0.4	-5.5
15	142730	13009	Arroyo Doble Drive	630.8	625.4	630.8	625.7	-5.4	0.0	-5.1
16	141075	300	Bear Canyon Drive	628.3	621.7	626.8	622.7	-6.6	-1.5	-5.6
17	142730	13010	Onion Creek Drive	621.0*	625.7	631.0	625.9	4.7	10.0	4.9
18	142730	13011	Onion Creek Drive	629.1	625.3	630.7	625.6	-3.8	1.6	-3.5
19	143036	13100	Onion Creek Drive	623.4	626.2	631.5	626.3	2.8	8.1	2.9
20	143036	13101	Onion Creek Drive	635.7	626.0	631.3	626.1	-9.7	-4.4	-9.6
21	143111	13106	Onion Creek Drive	631.1	627.2	632.5	627.2	-3.9	1.4	-3.9
22	143650	13200	Onion Creek Drive	629.2	627.6	632.9	627.5	-1.6	3.7	-1.7
23	143650	13204	Onion Creek Drive	626.6*	627.9	633.2	627.8	1.3	6.6	1.2
24	144040	13204	Onion Creek Drive	627.9*	628.1	633.4	628.0	0.2	5.5	0.1
25	144040	13206	Onion Creek Drive	630.9*	628.5	633.7	628.3	-2.4	2.8	-2.6
26	144040	13300	Onion Creek Drive	632.4	629.0	634.6	628.7	-3.4	2.2	-3.7
27	144659	13302	Onion Creek Drive	622.8*	629.2	635.0	628.9	6.4	12.2	6.1
28	144659	13304	Onion Creek Drive	630.6	629.4	635.4	629.1	-1.2	4.8	-1.5
29	144659	13306	Onion Creek Drive	630.3	629.6	635.8	629.3	-0.7	5.5	-1.0
30	144659	13308	Onion Creek Drive	635.6	630.6	636.5	630.3	-5.0	0.9	-5.3
31	142438	13006	Stagecoach Way	624.7*	624.4	629.6	624.8	-0.3	4.9	0.1
32	142438	13009	Stagecoach Way	616.6	624.5	629.8	624.9	7.9	13.2	8.3
33	142730	13010	Stagecoach Way	624.8*	624.9	630.2	625.2	0.1	5.4	0.4
34	142438	13011	Stagecoach Way	621.3	624.9	630.2	625.2	3.6	8.9	3.9
35	142730	13015	Stagecoach Way	621.3*	625.4	630.8	625.6	4.1	9.5	4.3
36	142730	13018	Stagecoach Way	626.2*	625.7	631.1	625.9	-0.5	4.9	-0.3
37	143036	13019	Stagecoach Way	622.5	626.5	631.8	626.6	4.0	9.3	4.1
38	143111	13021	Stagecoach Way	630.1	626.7	632.0	626.8	-3.4	1.9	-3.3
39	140704	N/A	Twin Creeks Drive	624.5	621.5	626.6	622.5	-3.0	2.1	-2.0
40	141075	12732	Twin Creeks Road	626.2	621.5	626.6	622.9	-4.7	0.4	-3.3

*Finished Floor Elevation was surveyed.

Table B – 6 illustrates the expected depth of localized flooding in the Onion Creek Meadows neighborhood for two simulated events: the 1% ACE and 0.2% ACE. The negative values indicate how many feet the computed water surface elevation is below the estimated Finished Floor Elevation of a property and positive values indicate how many feet the computed water surface is above the estimated Finished Floor Elevation. Based on the localized flooding simulations it was found that 6 of the properties are expected to flood during a 1% ACE event and 9 of the properties are expected to flood during a 0.2% ACE event.

Table B - 6 : Bear Creek – Onion Creek Localized Computed Risk Under Current Conditions

	Property ID	Address		Finished Floor Elevation (ft)*	Computed Water Surface Elevation in Feet		Approximate Depth of Flooding in Feet	
					1%	0.20%	1%	0.20%
1	352158	12900	Ben Milam Drive	651.4	651.2	651.6	-0.2	0.2
2	513765	12902	Ben Milam Drive	654	652.7	653	-1.3	-1
3	352461	12903	Ben Milam Drive	654.4*	654.9	655.2	0.5	0.8
4	352362	13444	Onion Creek Drive	671.7	670.7	671.1	-1	-0.6
5	352137	304	Turley Drive	649.6	648.3	648.6	-1.3	-1
6	352135	306	Turley Drive	651.8*	650	650.4	-1.8	-1.4
7	352159	401	Turley Drive	654	653.5	653.8	-0.5	-0.2
8	513766	12902	Vinyard Drive	659.0*	655.9	656.3	-3.1	-2.7
9	352445	12904	Vinyard Drive	657.6*	657.5	657.9	-0.1	0.3
10	352446	12906	Vinyard Drive	658.1	658.9	659.3	0.8	1.2
11	352468	12907	Vinyard Drive	660.6	658.9	659.3	-1.7	-1.3
12	352447	12908	Vinyard Drive	659.5	659.1	659.4	-0.4	-0.1
13	352467	12909	Vinyard Drive	661.4	660.7	661.1	-0.7	-0.3
14	352448	13000	Vinyard Drive	663.0*	661.7	662.1	-1.3	-0.9
15	352466	13001	Vinyard Drive	662.6*	662.5	662.9	-0.1	0.3
16	352449	13002	Vinyard Drive	664.9	664.3	664.7	-0.6	-0.2
17	352465	13003	Vinyard Drive	663.1*	664	664.5	0.9	1.4
18	352450	13004	Vinyard Drive	667.2	665.9	666.3	-1.3	-0.9
19	352464	13005	Vinyard Drive	664.8*	665.8	666.2	1	1.4
20	352463	13007	Vinyard Drive	666.7*	667.3	667.8	0.6	1.1
21	352462	13009	Vinyard Drive	667.8*	668.8	669.3	1	1.5

*Finished Floor Elevation was surveyed.

Flood Mitigation Analysis

The flood mitigation concepts discussed within this report are conceptual evaluations of potential flood mitigation solutions. They are high-level feasibility concepts that may be refined through subsequent preliminary engineering analysis and coordination with project stakeholders. The ultimate objective of this study was to identify at least one feasible alternative for each neighborhood. Property acquisitions are considered a feasible alternative once all other possibilities have been evaluated and ruled out.

The overall flood mitigation objective is to eliminate the risk of interior flooding of structures during the 1% ACE and to reduce the extent of roadway flooding to meet the County's development requirements. In order to significantly reduce structure flooding in the Bear Creek – Onion Creek Confluence area, the flood elevations from the 1% ACE need to be reduced to levels comparable to a flood event with a frequency near the 2% (50-year) ACE. This reduction can be accomplished using hydrologic alternatives

(detention/retention ponds), hydraulic alternatives (diversions, floodwalls, channel improvements, etc.), or a combination of these alternatives. The goal of this conceptual analysis was to identify alternatives that would either reduce the 1% ACE peak discharges by approximately 30% or produce equivalent water surface elevation reductions ranging from 2 to 6 feet through the study area.

Hydrologic Mitigation Alternatives

Hydrologic detention temporarily holds waters. The goal of hydrologic detention is to shift the timing of the volume of water passing through the stream. The goal is to alter the peak flow rates and timing of peak flow to reduce the flow impacts downstream. The proposed pond should ideally be placed where existing topography was favorable for significant detention and feasible construction. There are some undeveloped areas upstream of the Bear Creek – Onion Creek Confluence that were evaluated as a potential location for detention. Unfortunately, none of these locations were large enough to retain enough flood waters to provide a significant benefit to the study area. Additionally, high project cost, lack of available funding, complex permitting, property acquisition, and environmental impacts prolong the estimated timeline for implementation. Due to these constraints, detention was not further analyzed as a viable alternative for this neighborhood.

Regional detention could also be considered as a flood mitigation alternative for long-term and comprehensive planning. Although high project cost, lack of funding, complex permitting, property acquisition, and environmental impact could all be obstacles that would need to be overcome if regional detention was ever implemented. Regional detention would also require regional partnerships between multiple jurisdictions, including coordination between Travis and Hays Counties through their recent Interlocal Agreement (ILA).

Hydraulic Mitigation Alternatives

For flood mitigation, reductions in water surface elevation in the Onion Creek Meadows and Arroyo Doble neighborhoods along Onion Creek could be achieved by increasing the flow area or conveyance of the channel within the study area. The preliminary results from the updated 1% ACE simulation were used as the baseline for the hydraulic flood mitigation alternative evaluation. The water surface elevation within these neighborhoods is illustrated in **Figure B – 4**. Increases in the water surface elevation are generally caused by inflow from large tributaries or channel constrictions where the cross-sectional area and therefore conveyance of a channel is reduced. Except for the location at Twin Creeks Drive there are no other locations were the channel is constricted enough to raise the water surface elevation. Unfortunately, the removal of the constriction at Twin Creeks Drive would not lower the water surface elevation enough to provide a significant benefit to the Arroyo Doble or Onion Creek Meadows neighborhoods. Therefore, constriction removal was not considered a viable alternative.

A broad range of conceptual hydraulic alternatives were evaluated to mitigate flooding in the Bear Creek – Onion Creek study area. These hydraulic alternatives include the construction of floodwalls, diversion channels, and channel modifications in order to reduce the computed 1% ACE water surface elevation. Any downstream adverse impacts or increases in water surface elevation associated with hydraulic alternative options would be evaluated and mitigated should any of the projects mentioned in this analysis be recommended for further evaluation. Diversion channels were not considered a viable alternative due to the large extent of the Onion Creek floodplain and lack of County owned property in

the area. Therefore, the hydraulic mitigation flood mitigation alternatives were concentrated on flood protection walls.

Flood protection walls could be effective flood protection solutions as they prevent flood waters from reaching flood prone areas. FEMA criteria require the floodwall to have a minimum freeboard (height above the 1% ACE water level) of at least 3 feet for the entire length of the wall and 3.5 feet of freeboard at the upstream and downstream tie-in locations. Floodwalls were analyzed in both the Arroyo Doble and Onion Creek Meadows neighborhoods.

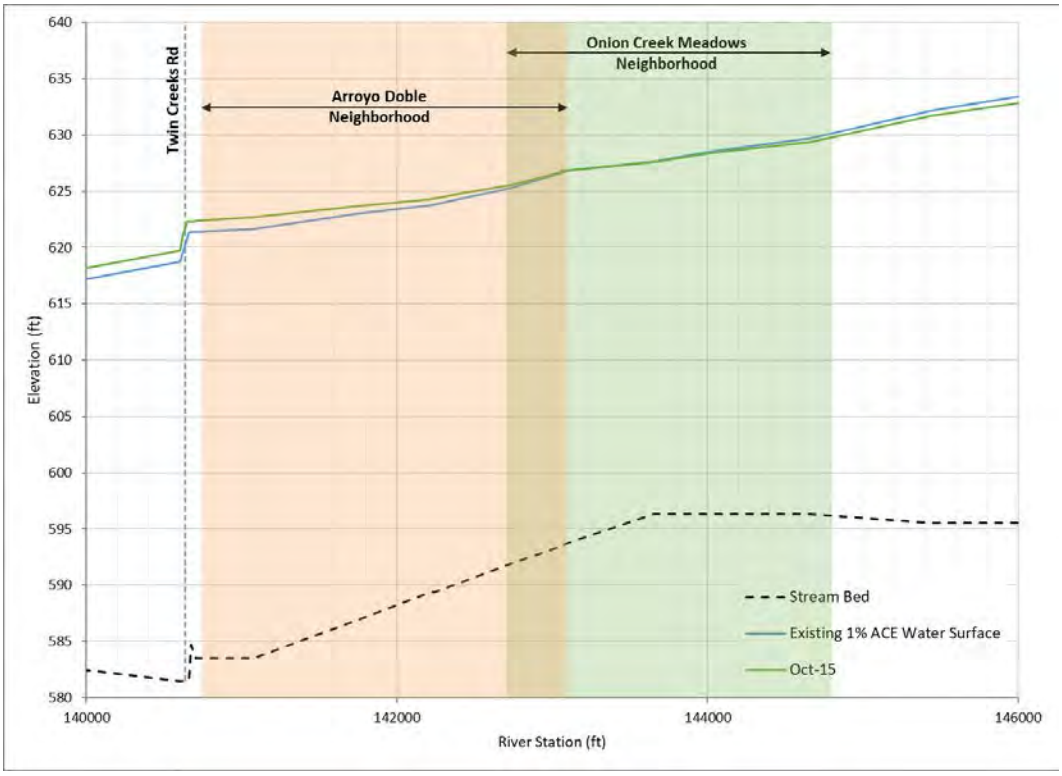

Figure B - 4: Bear Creek – Onion Creek Confluence Area Water Surface Elevation Profile

Viable Mitigations Solutions

Potential alternatives that best reduce the structure flooding in the neighborhoods within the Bear Creek – Onion Creek confluence area are described below. This section documents the potential mitigation alternatives including high-level conceptual illustrations and preliminary opinions of probable costs. It should be noted that these conceptual mitigation concepts were simulated to remove the majority of the structural flooding within the neighborhood of concern. These mitigation concepts will be refined through subsequent preliminary engineering analysis and coordination project Stakeholders.

Existing conditions and proposed flood mitigation improvements were analyzed on their ability to convey floodwaters. Ultimately, this analysis aimed to identify which alternatives could reduce the 1% ACE peak flows or produce equivalent water surface elevation reductions throughout the areas of interests. Non-structural solutions were also considered. If water surface elevations cannot feasibly be reduced through structural alternatives, buyouts could be used to completely remove at-risk homes and

their occupants permanently from the floodplain. When people and homes are removed from the floodplain, risk is eliminated indefinitely.

An opinion of probable cost was developed for each alternative. Unit prices for probable costs were developed using the Texas Department of Transportation (TxDOT) bid tabulations from projects within the Austin District within the last calendar year. For specific elements that were not listed within the TxDOT tabulation, unit prices were derived using recent land development and drainage projects in the Central Texas region. It should be noted that these opinions of cost use standard practice and are only considered an estimate. These estimates should be refined should any of the projects mentioned in this analysis be recommended for further evaluation. Cost ranges of Operations and Maintenance (O&M) estimates were also estimated and considered for each of the final alternatives.

Project benefits are computed using FEMA's Flood Module version 5.2.1. This Flood Module is used to generate project benefit representing a present value of future damages that are estimated to occur over the useful life of the project. FEMA's "full flood" data module was used to calculate the structural replacement flood damage reduction.

Evaluation of the October 2013 and October 2015 events revealed that riverine flooding from Onion Creek impacts the Arroyo Doble and Onion Creek Meadows neighborhoods and localized flooding impacts the all three neighborhoods in this study area. During the public meetings, resident validated the results of the historical simulations but also expressed concern with the localized flooding from a railroad failure in the Arroyo Doble neighborhood and lack of sufficient drainage infrastructure in the Onion Creek Meadows neighborhood. Following a site visit to confirm drainage infrastructure and patterns including coordination with Travis County, it was found that the *Travis County Drainage Basin Study* evaluated and identified potential flood mitigation solutions for local drainage systems in the Arroyo Doble and Twin Creeks neighborhoods, but did not include localized analysis of the Onion Creek Meadows neighborhood. Since the Travis County has previously evaluated flood mitigation solutions for local drainage systems the Arroyo Doble and Twin Creeks neighborhoods, this study did not re-evaluate mitigation solutions for these areas. It should be noted that localized flood risk from the Arroyo Doble railroad failure was not included in the *Travis County Drainage Basin Study,* therefore the study team evaluated conceptual mitigation solutions to reduce that risk.

The Arroyo Doble neighborhood localized flood risk associated with the railroad embankment occurs when local drainage flows to a low area in existing topography on the western side of the railroad. The lowest elevation of this low area is located between Horsethief Trail and Bear Creek. Currently, water ponds in the low area, slowly draining to Bear Creek. There is approximately 210 acres of area that drain to this area combined with some overflow from Garlic Creek. Cutting a channel from the low area to Bear Creek is a potential option to reduce flood risk associated with the railroad embankment. A channel along the western edge of the railroad will allow water to drain rather than holding water and threatening the railroad embankment. The proposed channel improvements include a 20-foot bottom with 3-foot horizontal to 1-foot vertical slopes back to the natural topography. Construction of a channel in this location would require extensive negotiations with property owners and the railroad owners. Since this localized flooding was not the focus of the study cost estimation and coordination with property owners was not conducted.

Since the Travis County did not previously evaluate flood mitigation solutions for local drainage systems the Onion Creek Meadows neighborhood, this study evaluated localized mitigation solutions to reduce risk in the Onion Creek Meadows neighborhood. The viable flood mitigation solutions for the Bear Creek – Onion Creek Confluence area are described below. These selected alternatives were chosen considering their technical feasibility, cost, and input from project stakeholders.

Structural Alternatives

As discussed above, structural alternatives generally include the construction of detention facilities, floodwalls, diversion channels, and channel modifications in order to reduce the computed 1% ACE water surface elevation. Since detention, floodwalls, and diversion channels were deemed infeasible, the only structural alternatives evaluated for the Arroyo Doble and Onion Creek Meadows neighborhoods was flood protection walls.

- Riverine/Floodwalls: Flood protection walls could be effective flood protection solutions as they prevent flood waters from reaching flood prone areas. FEMA criteria require the floodwall to have a minimum freeboard (height above the 1% ACE water level) of at least 3 feet for the entire length of the wall and 3.5 feet of freeboard at the upstream and downstream tie-in locations. Floodwalls were analyzed in both the Arroyo Doble and Onion Creek Meadows neighborhoods. The potential alignment of these floodwalls can be seen in **Figure B – 5**. The flood protection wall located in the Arroyo Doble neighborhood is 3,300 feet long. The average height is 14 feet with a maximum height of 17 feet. The flood protection wall located in the Onion Creek Meadows neighborhood is 3,100 feet long. The average height is 23 feet with a maximum height of 26 feet. Floodwalls require internal drainage systems to accommodate localized rainfall and associated stormwater run-off behind the wall. Standard internal drainage systems include storm drainage networks combined with a storage facility. These systems allow for the storage of internal drainage until the water could be released to the creek. Stand-alone floodwalls in this area would result in an approximate removal of approximately 11 structures from flooding during the computed 1% ACE. These floodwalls would need to be combined with an additional alternative to provide significant reductions in water surface elevations and removal of all structures from the 1% ACE.

  The floodwall costs are significantly impacted by the wall construction and required internal drainage systems. The estimated project cost for this flood mitigation alternative is **$18,862,502**. Due to the limited flood mitigation benefits and potential negative environmental impacts, floodwalls along Onion Creek were not recommended as the most viable solution for this neighborhood.

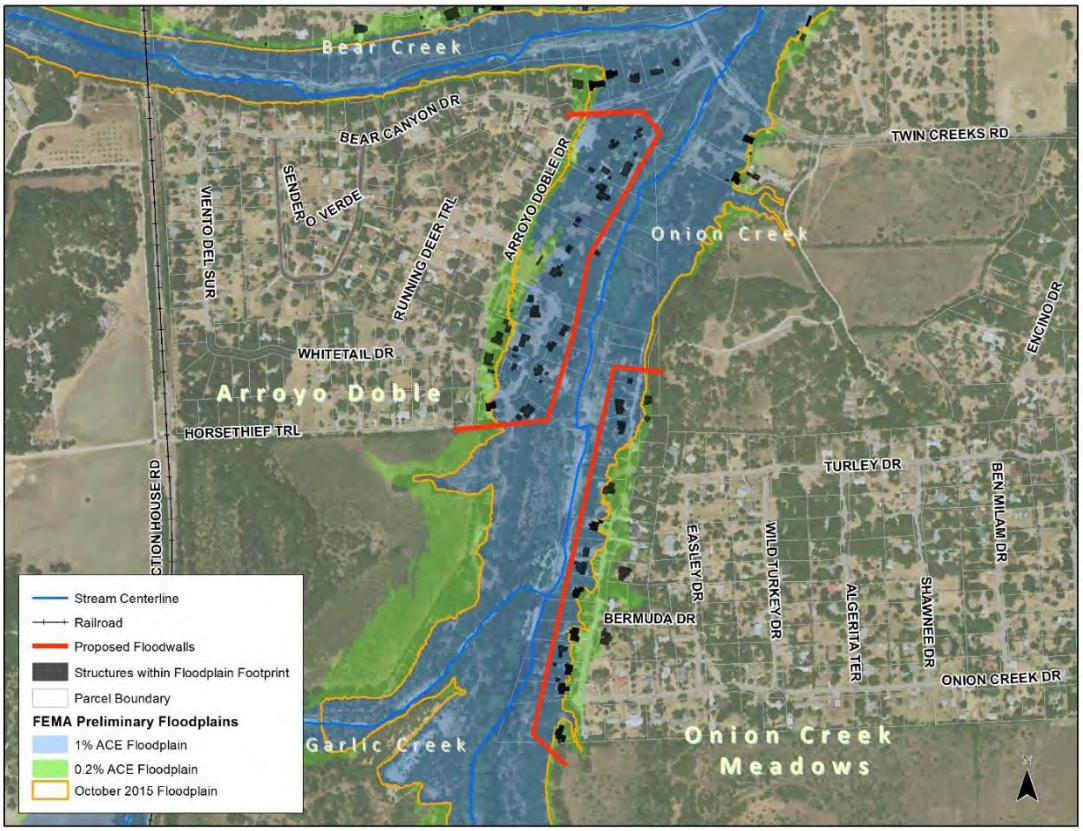

Figure B - 5: Arroyo Doble and Onion Creek Meadows Proposed Floodwall Improvements

– Local/Onion Creek Meadows/Drainage Improvements: The central portion of the Onion Creek Meadows neighborhood experiences localized flooding in a location were residential structures were placed in an area where water naturally flows toward Onion Creek. The *Travis County Drainage Basin Study* did not include localized analysis of the Onion Creek Meadows neighborhood; therefore, this area was included in this study. Underground storm drainage improvements can be used to reduce overland flow and convey storm water underground. Storm drainage improvements in the Onion Creek Meadows neighborhood includes the installation of three 10-feet by 5-feet concrete box culverts along Vinyard Drive. The proposed improvements concentrate flow at the outlet of the storm drainage improvements that may cause erosion or minor downstream impacts. These potential adverse impacts should be further evaluated and mitigated in the subsequent analysis. Additionally, this alternative would require right of way acquisition negotiations with property owners. This flood mitigation project protects 6 homes from the 1% ACE and reduces flood risk for several properties in the Onion Creek Meadows neighborhood. The estimated project cost for this flood mitigation alternative is **$9,613,867.**

Non-Structural Alternatives

Non-structural flood mitigation alternatives include floodplain management, construction and design regulations, buyouts, and structural elevation. Considering the County is already implementing floodplain management via construction and design regulations, the only non-structural alternatives left are buyouts and structural elevation. Buyouts are the most effective means of reducing flood damages

and improving public safety in at risk neighborhoods indefinitely. The two non-structural solutions considered for Arroyo Doble, Onion Creek Meadows, and Twin Creek neighborhoods are buyouts and structure elevation within the 1% ACE Floodplain.

- Riverine/Buyouts: The buyouts option considered in this study is based on the offer of flood mitigation buyouts to homes within the study area that are expected to experience structural flooding during the 1% ACE. Such buyouts should be prioritized based on the expected depth of flooding and should proceed from the highest risk homes to the lowest risk as funding becomes available. The estimated cost of buyouts includes real estate services, appraisals, acquisition costs, relocation and moving expenses, asbestos testing and abatement, demolition, and property management. A map of the proposed buyout properties is displayed in **Figure B – 6**. The effectiveness of this alternative is dependent on successful acquisition of at risk homes. If property owners decline to sell, the home could remain at risk. This flood mitigation project protects 15 homes from the 1% ACE, if acquired. The estimated project cost for buyouts in the Arroyo Doble and Onion Creek Meadows neighborhoods is **$10,237,424**.

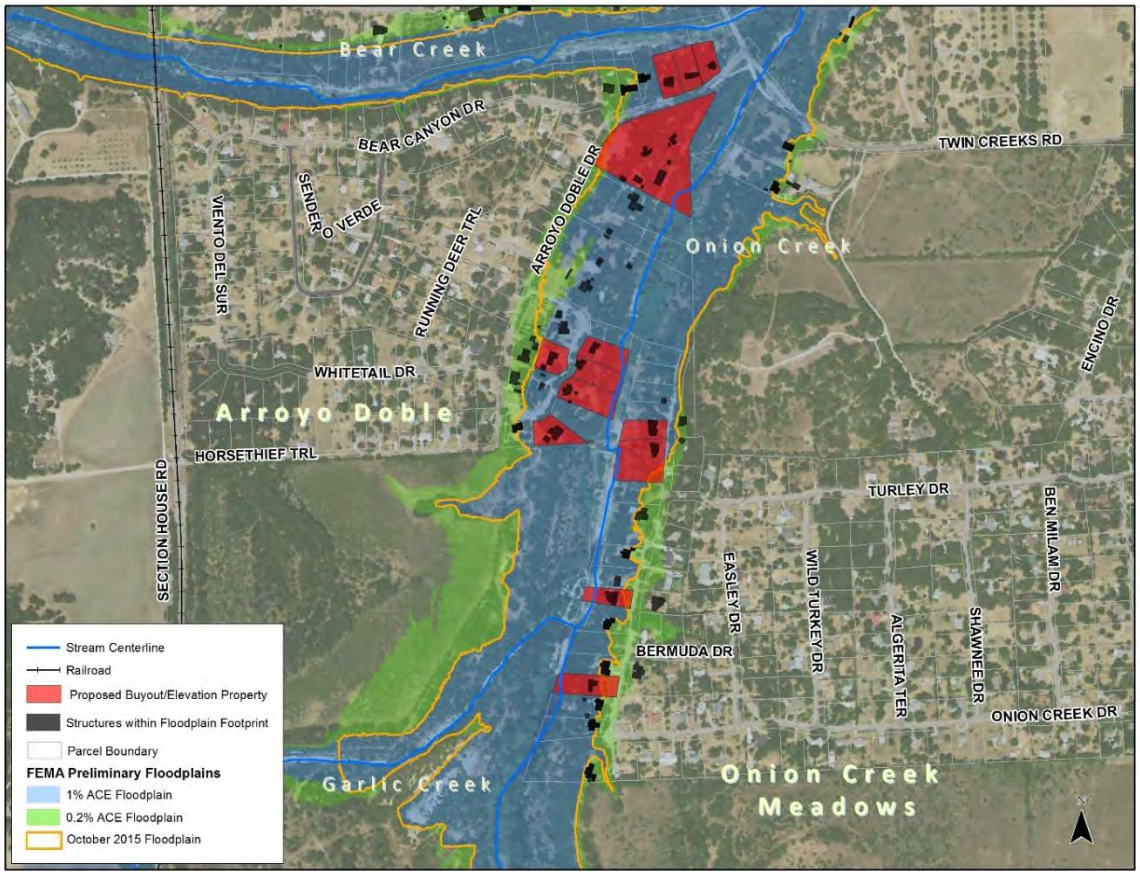

Figure B - 6: Arroyo Doble and Onion Creek Meadows Proposed Buyout and Structural Elevation Properties

- Riverine/Structural Elevation: The structural elevation option considered in this study is based on the elevation of homes within the study area that are expected to experience structural flooding during the 1% ACE. Similar to the buyout alternative, such elevations should be prioritized based on the expected depth of flooding and should proceed from the highest risk homes to the

lowest risk as funding becomes available. The estimated cost of structural elevation is based on the square footage of the living areas based on the County's appraisal district information. The proposed properties for structural elevation are consistent with **Figure B – 6**. The effectiveness of this alternative is dependent on successful elevation of at risk homes. Although this alternative reduces risk associated with structural damage, public safety is still a concern with this alternative due to potential high velocities associated with flood waters. If implemented, this flood mitigation project reduces structural damages of 15 homes from the 1% ACE. The estimated project cost for structural elevation in the Arroyo Doble and Onion Creek Meadows neighborhoods is **$2,637,720**.

– Local/Onion Creek Meadows/Buyouts: The buyouts option considered in this study is based on the offer of flood mitigation buyouts to homes within the study area that are expected to experience structural flooding during the 1% ACE. Such buyouts should be prioritized based on the expected depth of flooding and should proceed from the highest risk homes to the lowest risk as funding becomes available. The estimated cost of buyouts includes real estate services, appraisals, acquisition costs, relocation and moving expenses, asbestos testing and abatement, demolition, and property management. A map of the proposed buyout properties is displayed in **Figure B – 7**. The effectiveness of this alternative is dependent on successful acquisition of at risk homes. If property owners decline to sell, the home could remain at risk. This flood mitigation project protects 6 homes from the 1% ACE, if acquired. The estimated project cost for buyouts in the Onion Creek Meadows neighborhood that are impacted by localized flooding is **$3,440,430**.

– Local/Onion Creek Meadows/Structural Elevation: The structural elevation option considered in this study is based on the elevation of homes within the study area that are expected to experience structural flooding during the 1% ACE. Similar to the buyout alternative, such elevations should be prioritized based on the expected depth of flooding and should proceed from the highest risk homes to the lowest risk as funding becomes available. The estimated cost of structural elevation is based on the square footage of the living areas based on the County's appraisal district information. The proposed properties for structural elevation are consistent with **Figure B – 7**. The effectiveness of this alternative is dependent on successful elevation of at risk homes. Although this alternative reduces risk associated with structural damage, public safety is still a concern with this alternative due to potential high velocities associated with flood waters. If implemented, this flood mitigation project reduces structural damages of 6 homes from the 1% ACE. The estimated project cost for structural elevation in the Onion Creek Meadows neighborhood that are impacted by localized flooding is **$845,100**.

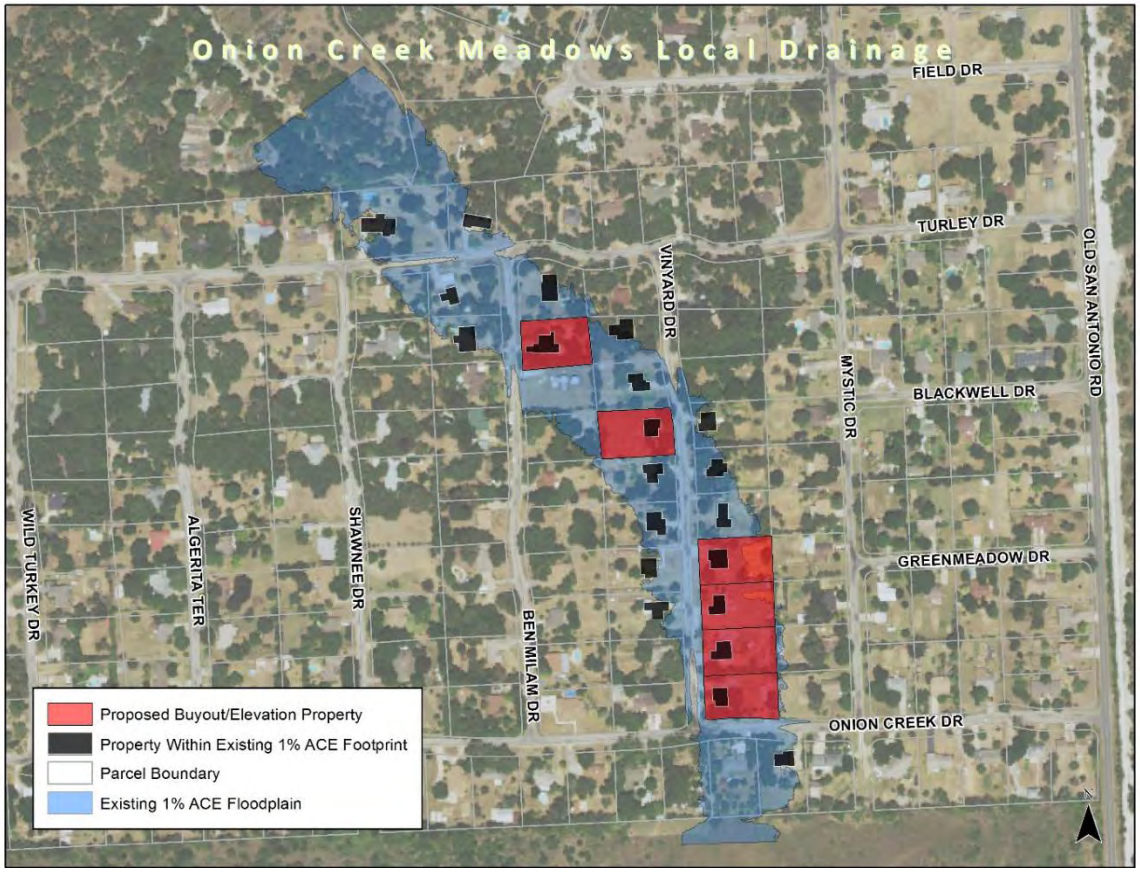

Figure B - 7: Onion Creek Meadows Local Flooding Buyout and Structural Elevation Properties

– Local/Twin Creeks/Buyouts: A single home in the Twin Creeks neighborhood is subject to repetitive flooding as a result of being located in a naturally low area where water tends to gather. This location is displayed in **Figure B – 8**. The *Travis County Drainage Basin Study* did not include localized analysis of this portion of the Twin Creeks neighborhood; therefore, this area was included in this study. The buyouts option considered in this study is based on the offer of flood mitigation buyouts to homes within the study area that are expected to experience structural flooding during the 1% ACE. The estimated cost of buyouts includes real estate services, appraisals, acquisition costs, relocation and moving expenses, asbestos testing and abatement, demolition, and property management. The effectiveness of this alternative is dependent on successful acquisition of at risk homes. If property owners decline to sell, the home could remain at risk. This flood mitigation project protects one (1) home from the 1% ACE, if acquired. The estimated project cost for buyout of one (1) home in the Twin Creek neighborhoods that is impacted by localized flooding is **$200,000**.

Figure B - 8: Twin Creek Park Proposed Buyout Property

Conclusion & Recommendations

In light of recent extreme flooding events, the Travis County Flood Mitigation Study Analysis allowed the County to re-evaluate the flood risk within the Bear Creek- Onion Creek Confluence. There are 15 homes within the Arroyo Doble and Onion Creek Meadows Floodwall Project Area where the estimated 1% ACE water surface elevation exceeds the finished floor elevations. The ultimate flood mitigation objective of this study is to identify at least one feasible alternative capable of eliminating the interior flooding risk of homes during the 1% ACE in Arroyo Doble and Onion Creek Meadows.

Cost Effectiveness:

A FEMA compliant Benefit-Cost Analysis (BCA) was performed for the 3 final flood mitigation alternatives. The FEMA BCA was established as the standard in order to provide technical and financial assistance for implementation of flood or hazard mitigation undertakings and potential federal and state funding eligibility. **Table B – 7** below displays the results of these calculated benefits.

Table B - 6: Bear Creek - Onion Creek Confluence Benefit-Cost Analysis Results

Viable Alternatives	Project Benefits (Avoided Damages)	Estimated Project Cost	Benefit Cost Ratio
Arroyo Doble & Onion Creek Meadows Floodwall	$277,772	$18,862,502	**0.01**
Arroyo Doble & Onion Creek Meadows Buyouts	$4,140,000	$10,237,242	**0.40**
Arroyo Doble & Onion Creek Meadows Elevations	$2,625,000	$2,637,720	**1.00**
Onion Creek Meadows Storm Drainage Improvements	$1,166,549	$9,613,867	**0.12**
Onion Creek Meadows Storm Local Buyouts	$1,714,684	$3,440,430	**0.50**
Onion Creek Meadows Storm Local Elevations	$1,273,034	$845,100	**1.51**
Twin Creeks Buyouts	$276,000	$200,000	**1.38**

Recommendation:

After the finalization of the engineering analysis for the viable flood mitigation alternatives, each were evaluated using a project scoring assessment established for the County. The flood mitigation benefits of each of these alternatives were evaluated based on the benefits provided relative to the 2017 preliminary FEMA, existing condition 1% ACE. The non-structural alternatives are significantly less expensive than the floodwalls or drainage improvement alternatives and structural elevations are the only cost effective solutions for the Arroyo Doble and Onion Creek Meadows neighborhoods. Although an elevated home can still be surrounded by high velocity flood waters capable of sweeping away people and assets, this alternative is more viable than buyouts and homes require elevation of an average 3.5 feet. The recommended riverine solution for Arroyo Doble and Onion Creek Meadows neighborhoods is structural elevation. The recommended localized solution for the Onion Creek Meadows neighborhood is structural elevation, and the recommended localized solution for the Twin Creeks neighborhood is a buyout.

This Travis County Flood Mitigation Analysis is a feasibility study. Any results from this study, including post-project flood risk, would be refined should any of the structural projects mentioned in this analysis be recommended for further evaluation.

Appendix 1: Bear Creek – Onion Creek Confluence Digital Data

Travis County Flood Mitigation Study

Appendix C: Onion Creek Bluff Springs

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Introduction

Onion Creek is approximately 344 square miles beginning in Blanco County, flows through Hays County, and drains into the Colorado River within Travis County. This section focuses on the Bluff Springs Area within Onion Creek. The Bluff Springs area includes portions of Onion Creek between East Slaughter Lane and the Boggy Creek confluence. **Figure C – 1** illustrates the location of each of these areas along Onion Creek main stem.

- Bluff Springs Area: The Bluff Springs neighborhood is located along Bluff Springs Road east of IH-35 and downstream of the East Slaughter Lane Bridge. South Boggy Creek is located along the northern boundary of the neighborhood. Neighborhood meetings revealed that this neighborhood is impacted by both riverine and local drainage flooding.

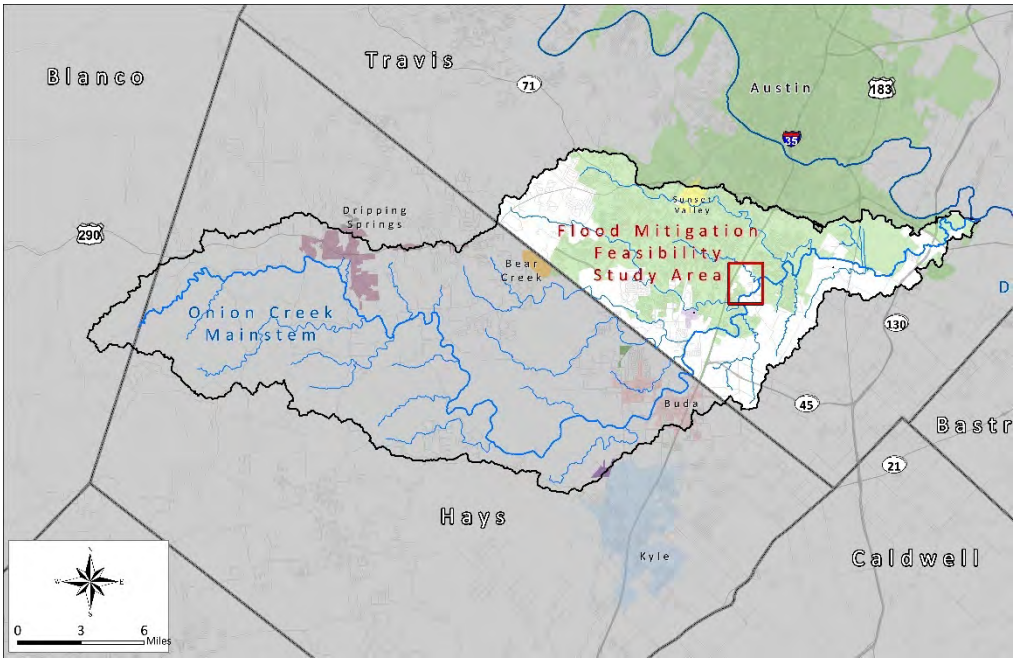

Figure C - 1: Travis County Onion Creek Flood Mitigation Buff Springs Study Area Location Map

Study Process

The Travis County Flood Mitigation Analysis was a step-by-step process, where each step was influenced by the preceding analysis. **Figure C – 2** below outlines the steps that were taken during the analysis. Data collection included the collection of technical data (previous studies, rainfall data, field survey, and field reconnaissance) and resident data (testimony, concerns, and validation of historical simulation). Model development included hydrologic and hydraulic analyses. The flood mitigation analysis consisted of the evaluation of riverine and local flooding solutions, project assessment, and recommendations. The primary goals of this study were to evaluate potential solutions to address flooding caused by the riverine systems for each of the three areas of interest and to identify at least one feasible alternative to

eliminate 1% (100-year) Annual Chance Exceedance (ACE) flood risk of homes for each neighborhood. This report describes the Bluff Springs area.

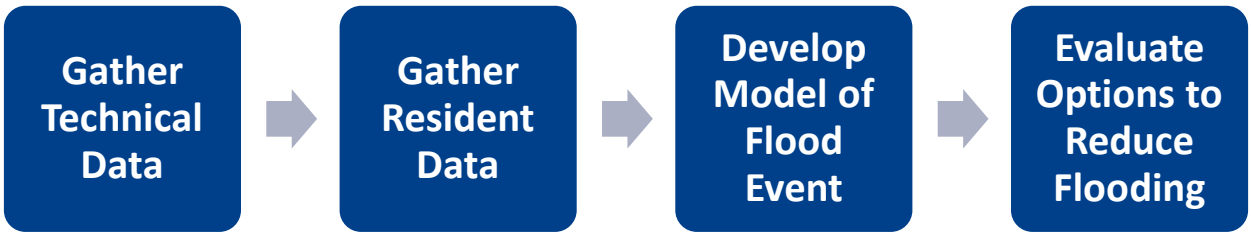

Figure C - 2: Travis County Mitigation Analysis Process

Data Collection

The main goal of data collection was to obtain the best available data. Once the technical data was compiled and a preliminary historical simulation of the October 2015 flood event was developed, the study team held multiple public meetings to gather resident data. **Table C – 1** lists the data collected for this study.

Table C - 1: Data Types Collected for Onion Creek Watershed

Gather Data	
Technical Data	**Resident Data**
• Regulatory Effective Models	• High Water Marks
• LiDAR (ground surface data)	• Flow Direction
• Historical Rainfall	• Floodplain Extents
• Field Survey & Reconnaissance	• General Testimony

The 2017 preliminary FEMA regulatory hydrologic and hydraulic models for Onion Creek served as the starting point for this investigation. Although the 2017 Onion Creek hydrology and hydraulic models are in the preliminary phase of the FEMA approval process, the conceptual level of this study deems them appropriate for use. The 2017 Onion Creek Floodplain Modeling and Mapping Study utilized the 2013 City of Austin Light Detection and Ranging (LiDAR) flown in 2012 to update and evaluate flood risk along the Travis County portions of Onion Creek.

The City of Austin provided the gage-adjusted radar rainfall for the October 2013 and October 2015 storm events. Upon review of the data, it was found that both the October 2013 and 2015 rainfall within Onion Creek watershed are similar to the 1% (100-year) ACE rainfall totals.

Finished floor elevations were collected by Zamora, LLC to supplement and validate LiDAR data used within the hydrologic and hydraulic models. Where survey was not available, LiDAR elevation data was utilized. When water surface elevations exceed the finish floor elevation, interior or structural flooding is likely to occur. A field reconnaissance visit was conducted on April 3, 2017 to observe drainage patterns and verify existing storm drainage infrastructure.

A series of public meetings were held to gather any relevant resident data that could be used to calibrate and validate watershed models and simulated riverine, October 2015 flood mapping extents. Residents provided first hand testimony of flooding extents and damages. Photos documenting high water marks and damages were collected and copied before being returned to residents. Often, resident testimony confirmed and complimented the simulated preliminary water surface elevations and mapping extents from the October 2015 event. Resident concerns were also recorded and investigated to ensure flooding events, including the destructive October 2015 event, and were accurately portrayed in the hydraulic models. The goal of the first round of neighborhood meetings was to inform residents of the status of the project, gain valuable input regarding their flood risks, and validate the result of the historical simulations. The goal of the second round of neighborhood meetings was to inform residents of the status of the project, discuss their existing condition flood risk, and discuss preliminary flood mitigation solutions.

During the meetings, residents confirmed the validity of the October 2015 simulations but also voiced concerns about recent residential development in the surrounding areas. New development to the north of the Bluff Springs neighborhood drain to South Boggy Creek entering Onion Creek downstream of the neighborhood. Runoff from this development is not expected to increase flooding through the Bluff Springs neighborhood. New development near Slaughter Lane drains to Onion Creek just upstream of the Bluff Springs neighborhoods. These new developments were required to ensure their development did not cause adverse impacts or increased flooding along Onion Creek. Additionally, in such a large watershed as Onion Creek the runoff from these nearby developments enter Onion Creek and travel downstream well before the simulated flood wave approaches the neighborhood.

Model Development / Validation

This section describes the hydrologic and hydraulic models used to simulate the October 2015 flood event and develop flood mitigation alternatives for the Bluff Springs Area within the Onion Creek watershed. This comprehensive watershed study began by utilizing the City of Austin's most recent 2017 preliminary FEMA models. The Onion Creek hydrologic analysis utilizes Natural Resource Conservation Service (NRCS) curve number losses and the Snyder's unit hydrograph transform method. The 2017 preliminary hydrologic and hydraulic models were used to model seven design storm frequencies. The frequency event nomenclature in this report uses the percent annual chance exceedance (ACE) terminology and is related to the classic annual recurrence interval terminology in **Table C – 2** below.

Table C - 2: Frequency Event Nomenclature

Frequency Event (Classic Terminology)	Probability of Occurrence in ANY Given Year	Percent Chance of Occurrence in ANY Given Year
500 Year	1 in 500	0.2%
100 Year	1 in 100	01%
50 Year	1 in 50	02%
25 Year	1 in 25	04%
10 Year	1 in 10	10%
5 Year	1 in 5	20%
2 Year	1 in 2	50%

Following the October 2013 and 2015 events, the City of Austin obtained and applied historical rainfall event data to the hydrologic simulations. **Figure C – 3** displays the National Weather Service (NWS) reported rainfall totals for the October 2015 event. The red and orange colors indicate areas where the heaviest rainfall occurred. The results of the historical hydrologic simulation were then applied in the hydraulic simulation. The resulting water surface elevations and floodplain extents were presented to the residents during the first public meeting for the community on February 21, 2016. The community engagement process was used to validate that the simulation adequately replicated the historical event. High water marks and resident testimony validated the extents of the simulated historical events as well as the 1% and 0.2% floodplains.

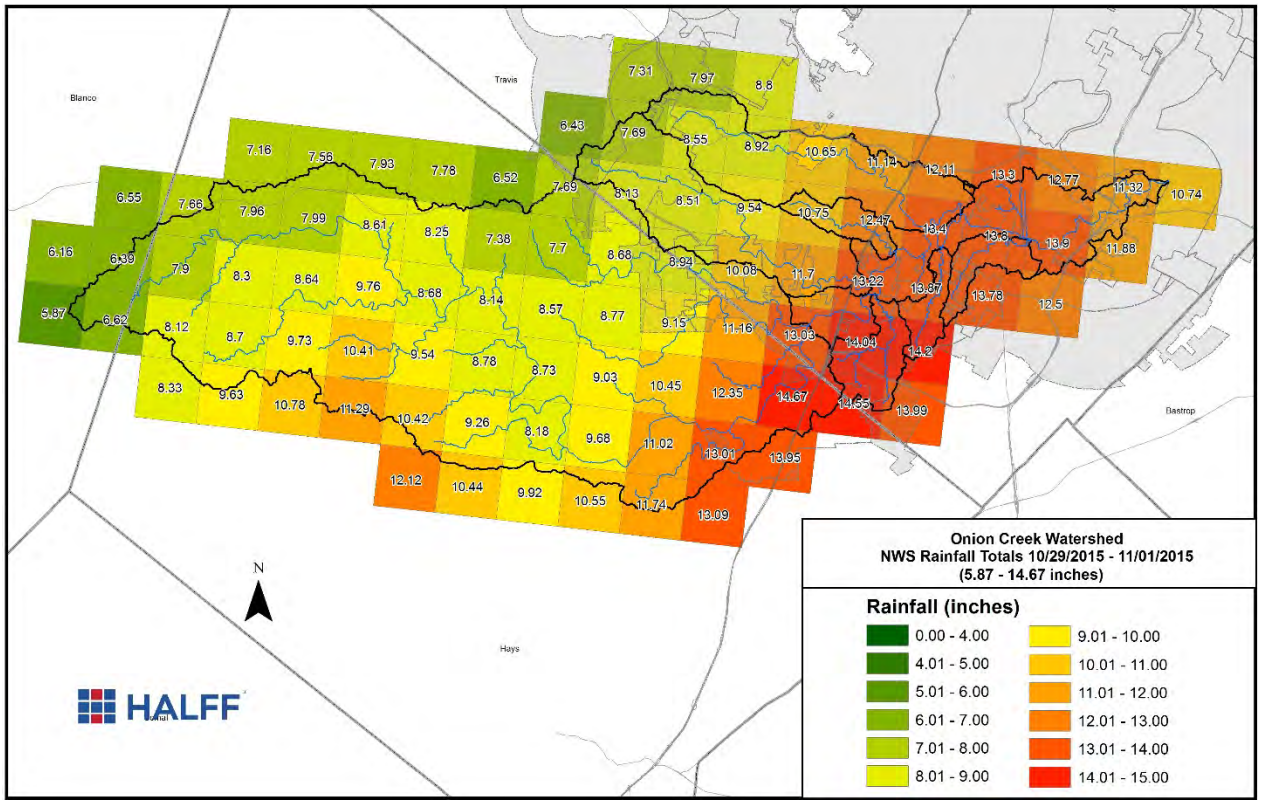

Figure C - 3: Onion Creek October 2015 National Weather Service Precipitation Totals

As mentioned previously, the City of Austin obtained and provided gage-adjusted radar rainfall data for the October 2013 and October 2015 storm events. **Table C – 3** displays the rainfall estimates for Onion Creek near the Bear Creek confluence area. The rainfall patterns leading up to the 2013 and 2015 events were not similar. The soil was already saturated prior to the October 2013 event. The soil was dry prior to the October 2015 event. Therefore, the October 2015 event simulation was assigned Antecedent Runoff Condition (ARC) II while the October 2013 event simulation was assigned ARC III to account for the saturated soil prior to the rainfall event. As a reference, the frequency storm simulations utilized ARC II conditions. Upon review of the data, it was found that both the October 2013 and October 2015 rainfall within Onion Creek watershed are similar the 1% (100-year) ACE rainfall totals. **Table C – 4** displays the simulated frequency event flows in comparison to the computed historical event

simulations. These flows were then applied in the hydraulic model to evaluate water surface elevations and floodplain extents.

Table C - 3: Estimated Rainfall for Onion Creek

Location	Rainfall (inches)			
	1% ACE	0.2% ACE	Oct. 31, 2013	Oct. 30, 2015
Onion Creek near confluence with Bear Creek	6.9 (6 hr)	9.5 (6 hr)	9-12 (6 hr)	11-15 (6 hr)

Table C - 4: Onion Creek Flow Comparison

Location	Flow (Cubic Feet per Second)			
	1% ACE	0.2% ACE	Oct. 31, 2013	Oct. 30, 2015
Onion Creek near confluence with Bear Creek	90,200 cfs	134,100 cfs	60,100 cfs	78,900 cfs
Onion Creek at US 183	121,900 cfs	179,500 cfs	135,000 cfs	120,000 cfs

The HEC-RAS hydraulic model utilized the simulated October 2013 and October 2015 hydrologic flows to define historical water surface elevations, floodplain extents and other hydraulic computations. The resulting water surface elevation combined with a 3 ft by 3 ft digital elevation model derived from the 2013 LIDAR data set were used to delineate flood inundation extents. The October 2015 event floodplain extent and simulated depths were also verified against resident testimony and available high water marks.

Many Bluff Springs neighborhood residents testified that the October 2015 rainfall event produced the largest volume of water to pass through the neighborhood and the highest water surface elevations they have ever experienced. Evaluation of the rainfall and stream flow statistics confirm both events were very significant and local flooding was a problem. **Table C – 5** illustrates the expected depth of riverine flooding for three simulated events: the 1% ACE, the 0.2% ACE, and the October 2015 event. Inundated structures are identified based on the computed water surface elevations in comparison to the finished floor elevations. The negative values indicate how many feet the computed water surface elevation is below the estimated Finished Floor Elevation of a property and positive values indicate how many feet the computed water surface is above the estimated Finished Floor Elevation. For example, 8209 Bluff Springs Road has a Finished Floor Elevation of 558.9 Feet. It is expected to flood approximately 1.4 feet during the 1% ACE event and 2.3 feet below the Finished Floor Elevation during the 0.2% ACE event. Based on the Onion Creek simulations it was found that 39 of the properties are expected to flood during a 1% ACE event and 75 of the properties are expected to flood during a 0.2% ACE event along Onion Creek within the Bluff Springs neighborhood.

Table C - 5: Bluff Springs Neighborhood – Computed Risk Under Current Conditions

	Property ID	Address		Finished Floor Elevation (ft)*	Computed Water Surface Elevation in Feet			Approximate Depth of Flooding in Feet		
					1%	0.20%	15-Oct	1%	0.20%	15-Oct
1	430732	8209	Bluff Springs Road	558.9	557.6	561.2	557.5	-1.3	2.3	-1.4
2	430731	8301	Bluff Springs Road	552.6	557.5	561.2	557.4	4.9	8.6	4.8

	Property ID	Address		Finished Floor Elevation (ft)*	Computed Water Surface Elevation in Feet			Approximate Depth of Flooding in Feet		
					1%	0.20%	15-Oct	1%	0.20%	15-Oct
3	430731	8301	Bluff Springs Road	555.2	557.6	561.2	557.5	2.4	6	2.3
4	430731	8301	Bluff Springs Road	562.7	557.7	561.4	557.6	-5.0	-1.3	-5.1
5	430730	8303	Bluff Springs Road	562.2	557.8	561.5	557.6	-4.4	-0.7	-4.6
6	430728	8305	Bluff Springs Road	557.0	557.8	561.6	557.7	0.8	4.6	0.7
7	430728	8305	Bluff Springs Road	560.2	557.8	561.6	557.7	-2.4	1.4	-2.5
8	430728	8305	Bluff Springs Road	560.7	557.8	561.5	557.7	-2.9	0.8	-3
9	430728	8305	Bluff Springs Road	561.3	557.9	561.6	557.7	-3.4	0.3	-3.6
10	430726	8401	Bluff Springs Road	555.2	558.0	561.8	557.9	2.8	6.6	2.7
11	430782	8402	Bluff Springs Road	557.7*	558.1	562.0	558.0	0.4	4.3	0.3
12	430725	8403	Bluff Springs Road	552.8	558.0	561.8	557.9	5.2	9	5.1
13	430783	8404	Bluff Springs Road	556.7	558.2	562.1	558.1	1.5	5.4	1.4
14	430724	8405	Bluff Springs Road	551.7	558.1	561.9	558.0	6.4	10.2	6.3
15	430784	8406	Bluff Springs Road	556.4	558.4	562.3	558.3	2.0	5.9	1.9
16	430723	8407	Bluff Springs Road	556.9	558.2	562.1	558.1	1.3	5.2	1.2
17	430803	8500	Bluff Springs Road	557.0*	558.6	562.5	558.5	1.6	5.5	1.5
18	430722	8501	Bluff Springs Road	557.7	558.3	562.2	558.2	0.6	4.5	0.5
19	430804	8502	Bluff Springs Road	557.0	558.8	562.7	558.7	1.8	5.7	1.7
20	430805	8504	Bluff Springs Road	557.7	558.9	562.8	558.8	1.2	5.1	1.1
21	430806	8506	Bluff Springs Road	557.7	559.0	562.9	558.9	1.3	5.2	1.2
22	430719	8507	Bluff Springs Road	553.9	558.0	561.9	557.9	4.1	8	4
23	430719	8507	Bluff Springs Road	565.1	558.6	562.5	558.5	-6.5	-2.6	-6.6
24	430715	8511	Bluff Springs Road	559.1	558.9	562.8	558.8	-0.2	3.7	-0.3
25	430714	8601	Bluff Springs Road	556.2	559.0	562.9	558.9	2.8	6.7	2.7
26	430834	8602	Bluff Springs Road	559.2*	559.4	563.3	559.3	0.2	4.1	0.1
27	430836	8606	Bluff Springs Road	559.5	559.6	563.5	559.5	0.1	4	0
28	430712	8607	Bluff Springs Road	556.3	559.3	563.2	559.2	3.0	6.9	2.9
29	430856	8610	Bluff Springs Road	559.5*	560.0	563.8	559.9	0.5	4.3	0.4
30	430857	8612	Bluff Springs Road	559.0*	560.1	563.9	560.0	1.1	4.9	1
31	430710	8701	Bluff Springs Road	555.9	560.0	563.9	560.0	4.1	8	4.1
32	430710	8701	Bluff Springs Road	556.6	559.9	563.8	559.8	3.3	7.2	3.2
33	430711	8701	Bluff Springs Road	557.8	559.9	563.7	559.8	2.1	5.9	2
34	431124	8800	Bluff Springs Road	559.3	561.9	565.6	561.8	2.6	6.3	2.5
35	431123	8902	Bluff Springs Road	559.8	563.3	566.8	563.3	3.5	7	3.5
36	431140	8905	Bluff Springs Road	555.5*	560.9	564.8	560.9	5.4	9.3	5.4
37	808440	9100	Bluff Springs Road	567.9	564.7	568.3	564.6	-3.2	0.4	-3.3
38	431115	4402	Brandt Road	568.3	564.9	568.6	564.9	-3.4	0.3	-3.4
39	431116	4412	Brandt Road	560.1	565.1	568.8	565.1	5.0	8.7	5
40	431117	4414	Brandt Road	562.9	564.6	568.3	564.6	1.7	5.4	1.7
41	431119	4424	Brandt Road	560.4*	564.3	567.8	564.2	3.9	7.4	3.8
42	431120	4424	Brandt Road	555.9*	564.6	568.2	564.5	8.7	12.3	8.6
43	431122	4506	Brandt Road	556.5	564.3	567.9	564.3	7.8	11.4	7.8
44	557072	N/A	Brandt Road	558.9	565.6	569.4	565.6	6.7	10.5	6.7
45	431114	N/A	Brandt Road	568.4	565.3	569.0	565.2	-3.1	0.6	-3.2
46	430814	2408	Cecil Drive	563.1	560.1	563.9	560.0	-3.0	0.8	-3.1
47	430824	2409	Cecil Drive	564.1	560.4	564.2	560.3	-3.7	0.1	-3.8
48	430813	2410	Cecil Drive	562.5	560.0	563.8	559.9	-2.5	1.3	-2.6
49	430825	2411	Cecil Drive	563.1	560.2	564.0	560.1	-2.9	0.9	-3
50	430812	2412	Cecil Drive	561.5	559.8	563.7	559.7	-1.7	2.2	-1.8
51	430826	2413	Cecil Drive	561.9	560.1	563.9	560.0	-1.8	2	-1.9

	Property ID	Address		Finished Floor Elevation (ft)*	Computed Water Surface Elevation in Feet			Approximate Depth of Flooding in Feet		
					1%	0.20%	15-Oct	1%	0.20%	15-Oct
52	430811	2500	Cecil Drive	560.7	559.7	563.6	559.6	-1.0	2.9	-1.1
53	430827	2501	Cecil Drive	561.1	559.9	563.8	559.8	-1.2	2.7	-1.3
54	430810	2502	Cecil Drive	559.9	559.6	563.5	559.5	-0.3	3.6	-0.4
55	430828	2503	Cecil Drive	560.4	559.9	563.7	559.8	-0.5	3.3	-0.6
56	430830	2505	Cecil Drive	559.7	559.6	563.5	559.5	-0.1	3.8	-0.2
57	430808	2506	Cecil Drive	558.7	559.3	563.2	559.2	0.6	4.5	0.5
58	430832	2507	Cecil Drive	559.3	559.5	563.4	559.4	0.2	4.1	0.1
59	430807	2508	Cecil Drive	558.1	559.1	563.1	559.0	1.0	5	0.9
60	430833	2509	Cecil Drive	558.7*	559.3	563.2	559.2	0.6	4.5	0.5
61	430799	2409	Mozelle Lane	561.9	559.3	563.2	559.2	-2.6	1.3	-2.7
62	430787	2410	Mozelle Lane	562.1	558.9	562.9	558.8	-3.2	0.8	-3.3
63	430786	2500	Mozelle Lane	559.4*	558.7	562.7	558.6	-0.7	3.3	-0.8
64	430785	2502	Mozelle Lane	558.0	558.5	562.5	558.4	0.5	4.5	0.4
65	430844	2408	Perkins Drive	565.7	562.0	565.6	561.9	-3.7	-0.1	-3.8
66	430847	2409	Perkins Drive	564.8	562.4	566.1	562.4	-2.4	1.3	-2.4
67	430843	2410	Perkins Drive	564.8	561.5	565.3	561.5	-3.3	0.5	-3.3
68	430848	2411	Perkins Drive	564.0	561.9	565.6	561.8	-2.1	1.6	-2.2
69	430842	2412	Perkins Drive	563.7	560.9	564.8	560.9	-2.8	1.1	-2.8
70	430849	2413	Perkins Drive	563.1	561.4	565.1	561.3	-1.7	2	-1.8
71	430841	2414	Perkins Drive	563.1	560.5	564.4	560.5	-2.6	1.3	-2.6
72	430840	2500	Perkins Drive	562.4	560.3	564.2	560.2	-2.1	1.8	-2.2
73	430850	2501	Perkins Drive	562.7	560.9	564.7	560.8	-1.8	2	-1.9
74	430839	2502	Perkins Drive	561.8	560.2	564.0	560.1	-1.6	2.2	-1.7
75	430851	2503	Perkins Drive	562.1	560.5	564.4	560.4	-1.6	2.3	-1.7
76	430838	2504	Perkins Drive	560.8*	559.9	563.8	559.8	-0.9	3	-1
77	430852	2505	Perkins Drive	561.0	560.2	564.0	560.1	-0.8	3	-0.9
78	430854	2509	Perkins Drive	560.7*	560.0	563.9	559.9	-0.7	3.2	-0.8
79	430855	2511	Perkins Drive	560.3*	559.9	563.7	559.8	-0.4	3.4	-0.5

*Finished Floor Elevations were surveyed.

Flood Mitigation Analysis

The flood mitigation concepts discussed within this report are conceptual evaluations of potential flood mitigation solutions. They are high-level feasibility concepts that may be refined through subsequent preliminary engineering analysis and coordination with project stakeholders. The ultimate objective of this study was to identify at least one feasible alternative for each neighborhood. Property acquisitions are considered a feasible alternative once all other possibilities have been evaluated and ruled out.

The overall flood mitigation objective is to eliminate the risk of interior flooding of structures during the 1% ACE and to reduce the extent of roadway flooding to meet the County's development requirements. In order to significantly reduce structure flooding in the Bluff Springs area, the flood elevations from the 1% ACE need to be reduced to levels comparable to a flood event with a frequency near the 2% (50-year) ACE. This reduction can be accomplished using hydrologic alternatives (detention/retention ponds), hydraulic alternatives (diversions, floodwalls, channel improvements, etc.), or a combination of these alternatives. The goal of this conceptual analysis was to identify alternatives that would either

reduce the 1% ACE peak discharges by approximately 30% or produce equivalent water surface elevation reductions ranging from 2 to 6 feet through the study area.

Hydrologic Mitigation Alternatives

Hydrologic detention temporarily holds waters. The goal of hydrologic detention is to shift the timing of the volume of water passing thru the stream. The goal is to alter the peak flow rates and timing of peak flow to reduce the flow impacts downstream. The proposed pond should ideally be placed where existing topography was favorable for significant detention and feasible construction. There are some undeveloped areas upstream of the Onion Creek Bluff Springs Area that were evaluated as a potential location for detention. Unfortunately, none of these locations were large enough to store the required to provide a significant benefit to the study area. Additionally, high project cost, lack of available funding, complex permitting, property acquisition, and environmental impacts prolong the estimated timeline for implementation. Due to these constraints, detention was not further analyzed as a viable alternative for this neighborhood.

Regional detention could also be considered as a flood mitigation alternative for long-term and comprehensive planning. Although high project cost, lack of funding, complex permitting, property acquisition, and environmental impact could all be obstacles that would need to be overcome if regional detention was ever implemented. Regional detention would also require regional partnerships between multiple jurisdictions, including coordination between Travis and Hays Counties through their recent Interlocal Agreement (ILA).

Hydraulic Mitigation Alternatives

For flood mitigation, reductions in water surface elevation in the Bluff Springs neighborhood along Onion Creek could be achieved by increasing the flow area or conveyance of the channel within the study area. The preliminary results from the updated 1% ACE simulation were used as the baseline for the hydraulic flood mitigation alternative evaluation. The water surface elevation within these neighborhoods is illustrated in **Figure C – 4**. Increases in the water surface elevation are generally caused by inflow from large tributaries or channel constrictions where the cross-sectional area and therefore conveyance of a channel is reduced. There are no specific locations were the channel is constricted enough to raise the water surface elevation therefore, channel modifications were considered as an alternative for the reach across the Bluff Springs neighborhood.

A broad range of conceptual hydraulic alternatives were evaluated to mitigate flooding in the Bluff Springs neighborhood. These hydraulic alternatives include the construction of floodwalls, diversion channels, and channel modifications in order to reduce the computed 1% ACE water surface elevation. Any downstream adverse impacts or increases in water surface elevation associated with hydraulic alternative options would be evaluated and mitigated should any of the projects mentioned in this analysis be recommended for further evaluation. Diversion channels were not considered a viable alternative due to the large extent of the Onion Creek floodplain and lack of County owned property in the area. Similarly, floodwalls were not considered a viable alternative due to the existence of a local tributary through the neighborhood and existing topography that prohibits construction of a FEMA compliant floodwall. Therefore, the hydraulic mitigation flood mitigation alternatives were concentrated on channel modifications.

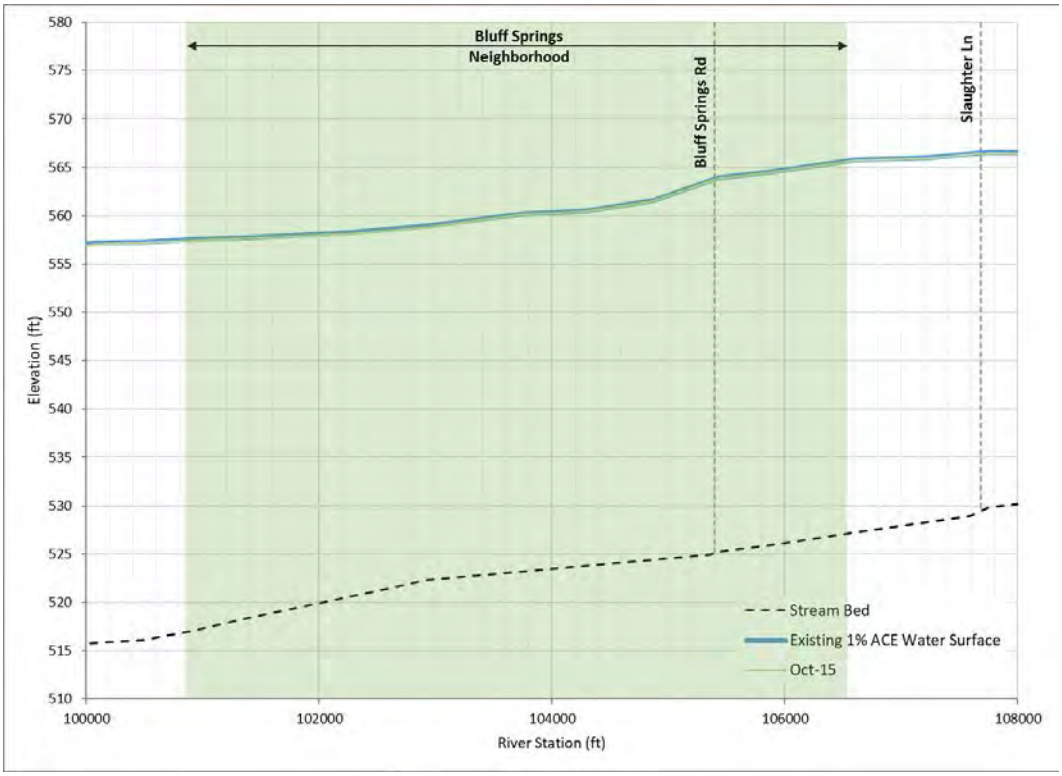

Figure C - 4: Bluff Springs Water Surface Elevation Profile

Viable Mitigations Solutions

Potential alternatives that best reduce Bluff Springs neighborhood structure flooding are described below. This section documents the potential mitigation alternatives including high-level conceptual illustrations and preliminary opinions of probable costs. It should be noted that these conceptual mitigation concepts were simulated to remove the majority of the structural flooding within the neighborhood of concern. These mitigation concepts will be refined through subsequent preliminary engineering analysis and coordination of project Stakeholders.

Existing conditions and proposed flood mitigation improvements were analyzed on their ability to convey floodwaters. Ultimately, this analysis aimed to identify which alternatives could reduce the 1% ACE peak flows or produce equivalent water surface elevation reductions throughout the areas of interests. Non-structural solutions were also considered. If water surface elevations cannot feasibly be reduced through structural alternatives, buyouts could be used to completely remove at-risk homes and their occupants permanently from the floodplain. When people and homes are removed from the floodplain, risk is eliminated indefinitely.

An opinion of probable cost was developed for each alternative. Unit prices for probable costs were developed using the Texas Department of Transportation (TxDOT) bid tabulations from projects within the Austin District within the last calendar year. For specific elements that were not listed within the TxDOT tabulation, unit prices were derived using recent land development and drainage projects in the Central Texas region. It should be noted that these opinions of cost use standard practice and are only considered an estimate. These estimates should be refined should any of the projects mentioned in this

analysis be recommended for further evaluation. Cost ranges of Operations and Maintenance (O&M) estimates were also estimated and considered for each of the final alternatives.

Project benefits are computed using FEMA's Flood Module version 5.2.1. This Flood Module is used to generate project benefit representing a present value of future damages that are estimated to occur over the useful life of the project. FEMA's "full flood" data module was used to calculate the structural replacement flood damage reduction.

Evaluation of the October 2013 and October 2015 events revealed that the main cause of flooding in the Bluff Springs neighborhood is riverine flooding from the Onion Creek. Residents expressed concern with the existing local systems. Following a site visit to confirm drainage infrastructure and patterns including coordination with Travis County, it was found that the *Travis County Drainage Basin Study* evaluated and identified potential flood mitigation solutions for local systems in the Bluff Springs neighborhood. Since the Travis County has previously evaluated and implemented flood mitigation solutions for local systems, this study only evaluated riverine system flood mitigation concepts for the Bluff Springs neighborhood. The viable flood mitigation solutions for the Bluff Springs neighborhood are described below. These selected alternatives were chosen considering their technical feasibility, cost, and input from project stakeholders.

Structural Alternatives

As discussed above, structural alternatives generally include the construction of detention facilities, floodwalls, diversion channels, and channel modifications in order to reduce the computed 1% ACE water surface elevation. Since detention, floodwalls, and diversion channels were deemed infeasible, the only structural alternatives evaluated for the Bluff Springs neighborhood was channel modifications.

- Channel Improvements: Channel benching can be used to increase the cross-sectional area (conveyance) of a channel. To minimize US Army Corps of Engineers Clean Water 404 Permitting requirements, channel benching was evaluated above Onion Creek's estimated ordinary high water elevations. Channel benching in the Bluff Springs area includes a large benched section on the western bank of Onion Creek from Slaughter Lane to the confluence of Boggy Creek. The proposed channel improvements include a 500-foot bench placed 3 feet above the channel invert with 3-foot horizontal to 1-foot vertical slopes back to the natural topography. These improvements result in high velocities that could potentially be very erosive and therefore should be further evaluated in the subsequent analysis. Additionally, this alternative would require significant efforts to maintain the "cleared" channel and would negatively impact the riparian corridor along Onion Creek, negatively effecting water quality, creek stability, wildlife, and trees. A map of the proposed channel improvements alternative is displayed in **Figure C – 5**. Stand-alone channel benching in the Bluff Springs neighborhood would result in an approximate removal of approximately 26 structures from flooding during the computed 1% ACE. These channel modifications would need to be combined with an additional alternative to provide significant reductions in water surface elevations and removal of all structures from the 1% ACE.

  The channel improvement costs are significantly impacted by the high volume of excavation required to bench the channel. The estimated project cost for this flood mitigation alternative is **$64,881,167**. Due to the limited flood mitigation benefits and potential negative

environmental impacts this channel benching in the Bluff Springs neighborhood was not recommended as the most viable solution for this neighborhood.

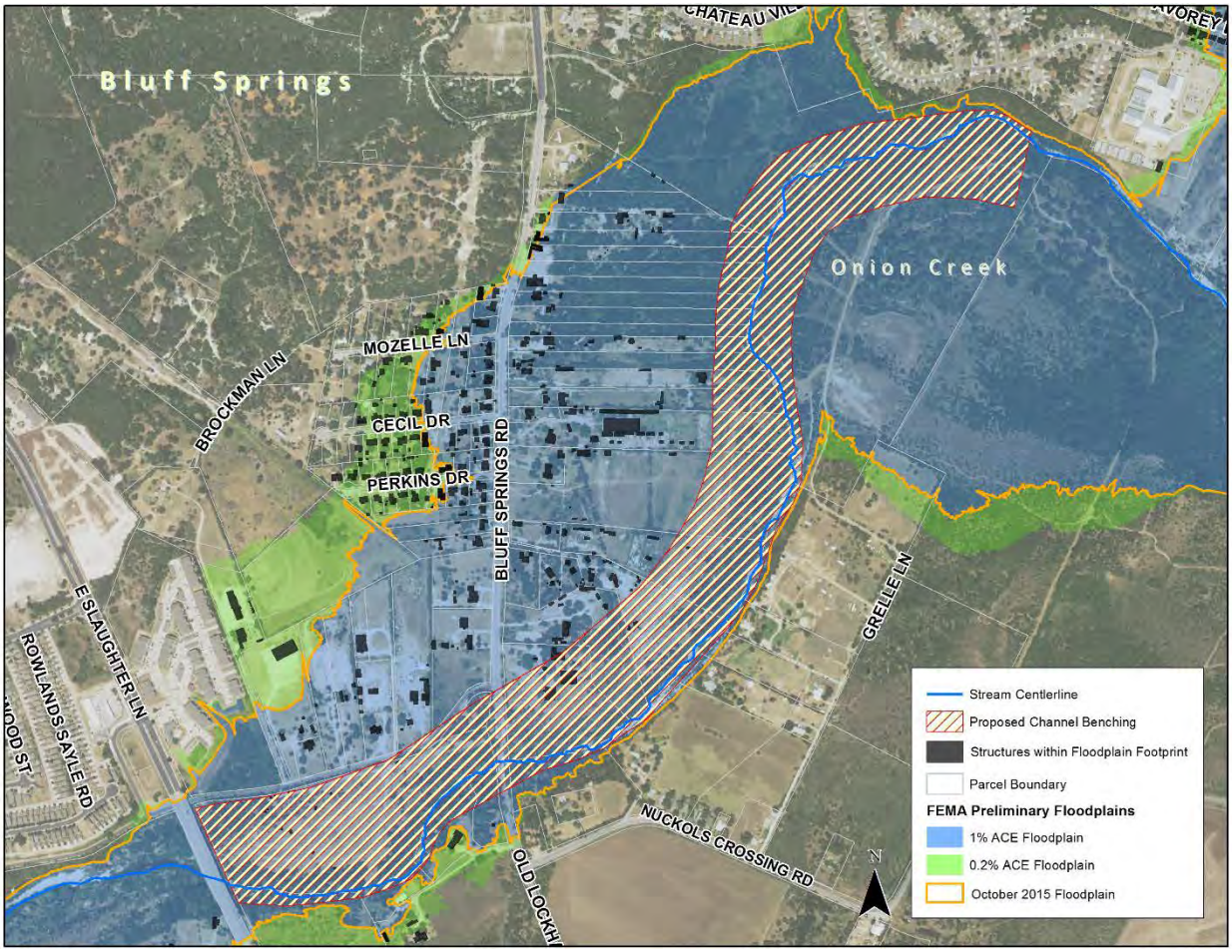

Figure C - 5: Bluff Springs Proposed Channel Improvements

Non-Structural Alternatives

Non-structural flood mitigation alternatives include floodplain management, construction and design regulations, buyouts, and structural elevation. Considering the County is already implementing floodplain management via construction and design regulations, the only Non-Structural alternatives left are buyouts and structural elevation. Buyouts are the most effective means of reducing flood damages and improving public safety in at risk neighborhoods indefinitely. The two non-structural solutions considered for Bluff Springs are buyouts and structure elevation within the 1% ACE Floodplain.

- Buyouts: The buyouts option considered in this study is based on the offer of flood mitigation buyouts to homes within the study area that are expected to experience structural flooding during the 1% ACE. Such buyouts should be prioritized based on the expected depth of flooding and should proceed from the highest risk homes to the lowest risk as funding becomes available. The estimated cost of buyouts includes real estate services, appraisals, acquisition costs, relocation and moving expenses, asbestos testing and abatement, demolition, and property management. A map of the proposed buyout properties is displayed in **Figure C – 6**.

The effectiveness of this alternative is dependent on successful acquisition of at risk homes. If property owners decline to sell, the home could remain at risk. This flood mitigation project protects 39 homes from the 1% ACE, if acquired. The estimated project cost for buyouts of 39 homes is **$12,141,723**.

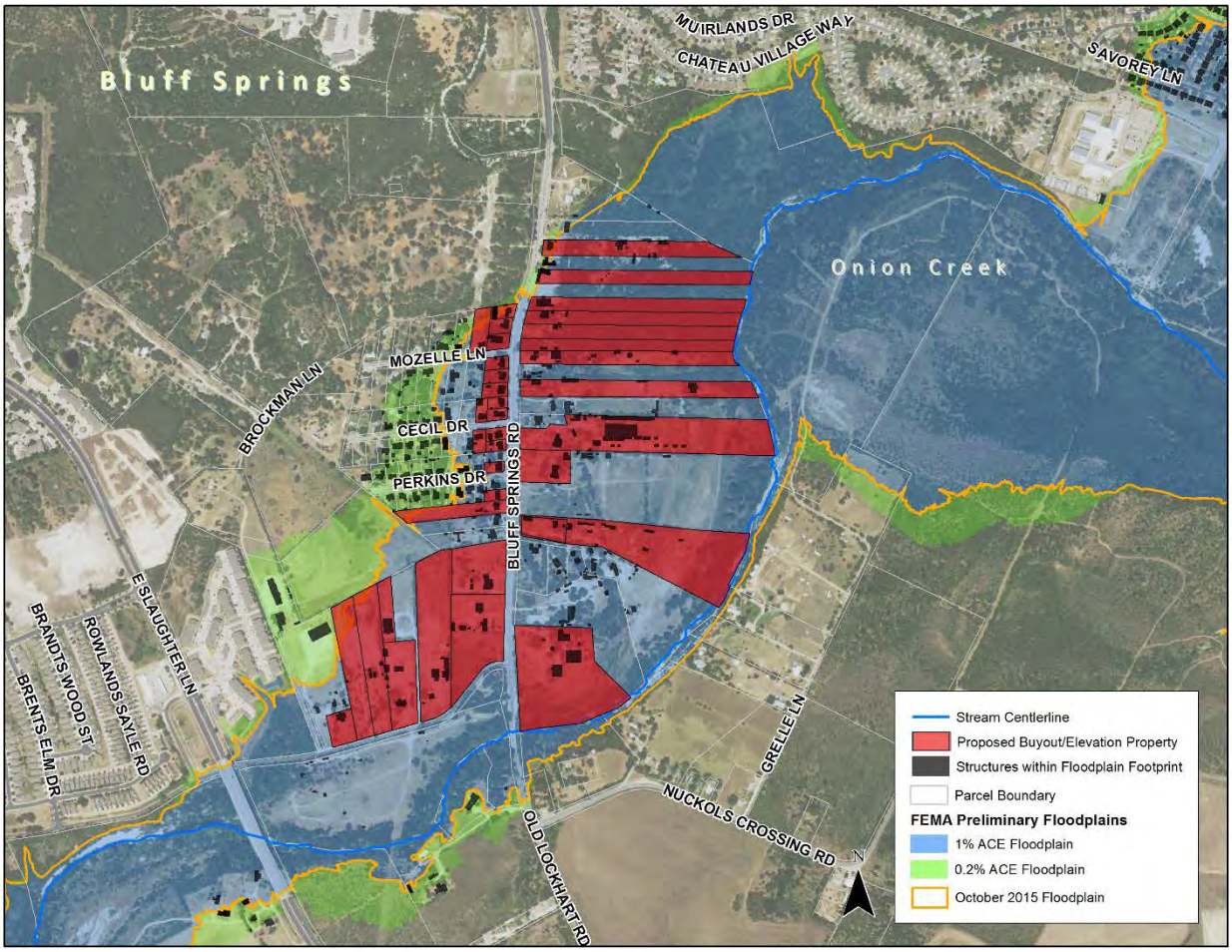

Figure C - 6: Bluff Springs Proposed Buyout and Structural Elevation Properties

– Structural Elevation: The structural elevation option considered in this study is based on the elevation of homes within the study area that are expected to experience structural flooding during the 1% ACE. Similar to the buyout alternative, such elevations should be prioritized based on the expected depth of flooding and should proceed from the highest risk homes to the lowest risk as funding becomes available. The estimated cost of structural elevation is based on the square footage of the living areas based on the County's appraisal district information. The proposed properties for structural elevation are consistent with **Figure C – 6** above. The effectiveness of this alternative is dependent on successful elevation of at risk homes. Although this alternative reduces risk associated with structural damage, public safety is still a concern with this alternative due to potential high velocities associated with flood waters. If implemented, this flood mitigation project reduces structural damages of 39 homes from the 1% ACE. The estimated project cost for structural elevation of 39 homes is **$6,599,430**.

Conclusion & Recommendations

In light of recent extreme flooding events, the Travis County Flood Mitigation Study Analysis allowed the County to re-evaluate the flood risk within the Bluff Springs area. There are 39 homes within the Bluff Springs Area where the estimated 1% ACE water surface elevation exceeds the finished floor elevations. The ultimate flood mitigation objective of this study is to identify at least one feasible alternative capable of eliminating the interior flooding risk of homes during the 1% ACE in Bluff Springs.

Cost Effectiveness:

A FEMA compliant Benefit-Cost Analysis (BCA) was performed for the 3 final flood mitigation alternatives. The FEMA BCA was established as the standard in order to provide technical and financial assistance for implementation of flood or hazard mitigation undertakings and potential federal and state funding eligibility. **Table C – 6** below displays the results of this calculated benefits.

Table C - 6: Benefit-Cost Analysis Results

Viable Alternatives	Project Benefits (Avoided Damages)	Estimated Project Cost	Benefit Cost Ratio
Bluff Springs Channel Improvements	$642,067	$64,881,167	**0.01**
Bluff Springs Buyouts	$10,630,550	$12,141,723	**0.88**
Bluff Springs Elevations	$6,767,394	$6,599,430	**1.03**

Recommendation:

After the finalization of the engineering analysis for the viable flood mitigation alternatives, each were evaluated using a project scoring assessment established for the County. The flood mitigation benefits of each of these alternatives were evaluated based on the benefits provided relative to the 2017 preliminary FEMA existing condition 1% ACE. The non-structural alternatives are significantly less expensive than the channel improvement alternative. Structural elevation is the most cost effective solution for the Bluff Springs neighborhood. Although an elevated home can still be surrounded by high velocity flood waters capable of sweeping away people and assets, this alternative is more viable for the neighborhood than buyouts. Due to the location of the at risk structures in proximity to Onion Creek, velocities are lower in these flood fringe areas than areas immediately adjacent to the creek. The large residential lots and large number of at risk structures make structural elevation the more viable alternative. The recommended solution for the Bluff Springs neighborhood is structural elevation.

This Travis County Flood Mitigation Analysis is a feasibility study. Any results from this study, including post-project flood risk, would be refined should any of the structural projects mentioned in this analysis be recommended for further evaluation.

Appendix 1: Onion Creek Bluff Springs Area Digital Data

Travis County Flood Mitigation Study

Appendix D: Opinion of Probable Cost

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List of Tables

Dry Creek East / Thoroughbred Farms Area

Channel Improvement

Table D - 1: Thoroughbred Farms Channel Modifications

PAY ITEM NO.	DESCRIPTION	UNITS	UNIT PRICE	QUANTITY	SUB-TOTALS
1	Clearing and grubbing	STA	$ 1,000	60	$ 60,000
2	Channel Excavation and Haul Off	CY	$ 11	558,000	$ 6,138,000
3	Hydro mulch Seeding	SY	$ 0.40	151,000	$ 60,400
4	Soil Retention Blankets (10%)	SY	$ 2	15,100	$ 30,200
5	Temporary Erosion and Sediment Control (3%)	LS	$ 188,658	1	$ 188,658
6	Mobilization (10%)	LS	$ 647,726	1	$ 647,726
				SUBTOTAL	**$ 7,124,984**
				CONTINGENCY (20%)	**$ 1,424,997**
				TOTAL PROJECT COST	**$ 8,549,981**
7	Engineering and Survey Fees (5%)	LS	$ 427,499	1	$ 427,499
8	Regulatory Permitting (1%)	LS	$ 85,500	1	$ 85,500
				PROJECT GRAND TOTAL	**$ 9,062,979**

Note: Estimate excludes cost of protection, relocation, reconstruction of utilities. Also excludes property acquisition costs.

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Buyouts

Table D - 2: Thoroughbred Farms Buyouts Estimate

PAY ITEM NO	DESCRIPTION	UNITS	UNIT PRICE	QUANTITY	SUB-TOTALS
1	Buyouts, Thoroughbred Farms Area	LS	$ 3,812,443	1	$ 3,812,443
				PROJECT GRAND TOTAL	$ 3,812,443

Note: Estimates include all costs associated with property acquisition (including real estate services, appraisals, acquisition costs, relocation/moving expenses, asbestos testing/abatement, demolition, and property management during the entire process).

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Structural Elevation

Table D - 3: Thoroughbred Farms Elevation Estimate

PAY ITEM NO	DESCRIPTION	UNITS	UNIT PRICE	QUANTITY	SUB-TOTALS
1	Elevations, Thoroughbred Farms Area	LS	$ 2,443,590	1	$ 2,443,590
				PROJECT GRAND TOTAL	$ 2,443,590

Note: Estimates are based on Travis County Appraisal District recorded livable square footage values.

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Onion Creek / Bear Creek – Onion Creek Confluence Area

Riverine

Floodwalls

Table D - 4: Arroyo Doble Flood Protection Wall

PAY ITEM NO	DESCRIPTION	UNITS	UNIT PRICE	QUANTITY	SUB-TOTALS
1	Clearing and Grubbing	STA	$ 1,000	33	$ 33,000
2	Flood protection wall	SF	$ 100	45,900	$ 4,590,000
3	Detention Pond	LS	$ 750,000	1	$ 750,000
4	Internal Drainage Infrastructure	LS	$ 350,000	1	$ 350,000
5	Hydromulch Seeding	SY	$ 0.40	43,800	$ 17,520
6	Temporary Erosion and Sediment Control (5%)	LS	$ 57,526	1	$ 57,526
7	Mobilization (5%)	LS	$ 289,902	1	$ 289,902
				SUBTOTAL	**$ 6,087,948**
				CONTINGENCY (20%)	**$ 1,217,590**
				TOTAL PROJECT COST	**$ 7,305,538**
8	Engineering and Survey Fees (5%)	LS	$ 365,277	1	$ 365,277
9	Regulatory Permitting (1%)	LS	$ 73,055	1	$ 73,055
				PROJECT GRAND TOTAL	**$ 7,743,870**

Note: Estimate excludes cost of protection, relocation, reconstruction of utilities. Also excludes property acquisition costs.

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Table D - 5: Onion Creek Meadows Flood Protection Wall

PAY ITEM NO	DESCRIPTION	UNITS	UNIT PRICE	QUANTITY	SUB-TOTALS
1	Clearing and Grubbing	STA	$ 1,000	31	$ 31,000
2	Flood protection wall	SF	$ 100	70,400	$ 7,040,000
3	Detention Pond	LS	$ 750,000	1	$ 750,000
4	Internal Drainage Infrastructure	LS	$ 350,000	1	$ 350,000
5	Hydromulch Seeding	SY	$ 0.40	231,600	$ 92,640
6	Temporary Erosion and Sediment Control (5%)	LS	$ 61,182	1	$ 61,182
7	Mobilization (5%)	LS	$ 416,241	1	$ 416,241
				SUBTOTAL	**$ 8,741,063**
				CONTINGENCY (20%)	**$ 1,748,213**
				TOTAL PROJECT COST	**$ 10,489,276**
8	Engineering and Survey Fees (5%)	LS	$ 524,464	1	$ 524,464
9	Regulatory Permitting (1%)	LS	$ 104,893	1	$ 104,893
				PROJECT GRAND TOTAL	**$ 11,118,632**

Note: Estimate excludes cost of protection, relocation, reconstruction of utilities. Also excludes property acquisition costs.

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Buyouts

Table D - 6: Estimated Buyout Costs Arroyo Doble and Onion Creek Meadows Structures along Onion Creek

PAY ITEM NO	DESCRIPTION	UNITS	UNIT PRICE	QUANTITY	SUB-TOTALS
1	Buyouts, Arroyo Doble and Onion Creek Meadows	LS	$ 10,237,242	1	$ 10,237,242
				PROJECT GRAND TOTAL	**$ 10,237,242**

Note: Estimates include all costs associated with property acquisition (including real estate services, appraisals, acquisition costs, relocation/moving expenses, asbestos testing/abatement, demolition, and property management during the entire process).

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Structural Elevation

Table D - 7: Estimated Elevation cost for Arroyo Doble and Onion Creek Meadows Structures along Onion Creek

PAY ITEM NO	DESCRIPTION	UNITS	UNIT PRICE	QUANTITY	SUB-TOTALS
1	Elevations, Arroyo Doble and Onion Creek Meadows	LS	$ 2,637,720	1	$ 2,637,720
				PROJECT GRAND TOTAL	**$ 2,637,720**

Note: Estimates are based on Travis County Appraisal District recorded livable square footage values.

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Local

Onion Creek Meadows Drainage Improvement

Table D - 8: Onion Creek Meadows Storm Drainage Improvements

PAY ITEM NO	DESCRIPTION	UNITS	UNIT PRICE	QUANTITY	SUB-TOTALS
1	Concrete Box Culvert 10 FT X 5 FT	LF	$ 605	6,000	$ 3,630,000
2	10' X 5' Safety End Treatment	EA	$ 20,000	4	$ 80,000
3	Cut & Restoring Pavement (Asphalt)	SY	$ 250	9,000	$ 2,250,000
4	Excavation	CY	$ 11	17,700	$ 194,700
5	Traffic Control	MONTH	$ 7,000	4	$ 28,000
6	Demolition of Existing Storm Sewer	LF	$ 4	4,000	$ 16,000
7	Hydromulch	SY	$ 0.40	800	$ 320
8	Curb Inlets	EA	$ 5,000	10	$ 50,000
9	Temporary Erosion and Sediment Control (5%)	LS	$ 312,451	1	$ 312,451
10	Mobilization (10%)	LS	$ 656,147	1	$ 656,147
				SUBTOTAL	**$ 7,217,618**
				CONTINGENCY (20%)	**$ 1,443,524**
				TOTAL PROJECT COST	**$ 8,661,142**
11	Engineering and Survey Fees (10%)	LS	$ 866,114	1	$ 866,114
12	Regulatory Permitting (1%)	LS	$ 86,611	1	$ 86,611
				PROJECT GRAND TOTAL	**$ 9,613,867**

Note: Estimate excludes cost of protection, relocation, reconstruction of utilities. Also excludes property acquisition costs.

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Onion Creek Meadows Buyouts

Table D - 9: Onion Creek Meadows Local Drainage Buyouts Estimated Costs

PAY ITEM NO	DESCRIPTION	UNITS	UNIT PRICE	QUANTITY	SUB-TOTALS
1	Buyouts, Onion Creek Meadows Storm Drainage Improvements	LS	$ 3,440,430	1	$ 3,440,430
				PROJECT GRAND TOTAL	**$ 3,440,430**

Note: Estimates include all costs associated with property acquisition (including real estate services, appraisals, acquisition costs, relocation/moving expenses, asbestos testing/abatement, demolition, and property management during the entire process).

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Onion Creek Meadows Structural Elevation

Table D - 10: Onion Creek Meadows Local Drainage Structural Elevation

PAY ITEM NO	DESCRIPTION	UNITS	UNIT PRICE	QUANTITY	SUB-TOTALS
1	Elevations, Onion Creek Meadows Storm Drainage Improvements	LS	$ 845,100	1	$ 845,100
				PROJECT GRAND TOTAL	**$ 845,100**

Note: Estimates are based on Travis County Appraisal District recorded livable square footage values.

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Twin Creeks Buyouts

Table D - 11: Twin Creeks Buyout Estimate

PAY ITEM NO	DESCRIPTION	UNITS	UNIT PRICE	QUANTITY	SUB-TOTALS
1	Buyouts, Twin Creeks	LS	$ 276,000	1	$ 276,000
				PROJECT GRAND TOTAL	**$ 276,000**

Note: Estimates include all costs associated with property acquisition (including real estate services, appraisals, acquisition costs, relocation/moving expenses, asbestos testing/abatement, demolition, and property management during the entire process).

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Bluff Springs

Channel Improvement

Table D - 12: Bluff Springs Channel Modifications

PAY ITEM NO	DESCRIPTION	UNITS	UNIT PRICE	QUANTITY	SUB-TOTALS
1	Clearing and grubbing	STA	$ 1,000	90	$ 90,000
2	Channel Excavation and Haul Off	CY	$ 11	4,052,000	$ 44,572,000
3	Hydromulch Seeding	SY	$ 0.40	596,000	$ 238,400
4	Soil Retention Blankets (10%)	SY	$ 2	59,600	$ 119,200
5	Temporary Erosion and Sediment Control (3%)	LS	$ 1,350,588	1	$ 1,350,588
6	Mobilization (10%)	LS	$ 4,637,019	1	$ 4,637,019
				SUBTOTAL	**$ 51,007,207**
				CONTINGENCY (20%)	**$ 10,201,441**
				TOTAL PROJECT COST	**$ 61,208,648**
8	Engineering and Survey Fees (5%)	LS	$ 3,060,432	1	$ 3,060,432
9	Regulatory Permitting (1%)	LS	$ 612,086	1	$ 612,086
				PROJECT GRAND TOTAL	**$ 64,881,167**

Note: Estimate excludes cost of protection, relocation, reconstruction of utilities. Also excludes property acquisition costs.

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Buyout

Table D - 13: Bluff Springs Buyouts Estimate

PAY ITEM NO	DESCRIPTION	UNITS	UNIT PRICE	QUANTITY	SUB-TOTALS
1	Buyouts, Bluff Springs Area	LS	$ 12,141,723	1	$ 12,141,723
				PROJECT GRAND TOTAL	$ 12,141,723

Note: Estimates include all costs associated with property acquisition (including real estate services, appraisals, acquisition costs, relocation/moving expenses, asbestos testing/abatement, demolition, and property management during the entire process).

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Structural Elevation

Table D - 14: Bluff Springs Elevations Estimate

PAY ITEM NO	DESCRIPTION	UNITS	UNIT PRICE	QUANTITY	SUB-TOTALS
1	Elevations, Bluff Springs Area	LS	$ 6,599,430	1	$ 6,599,430
				PROJECT GRAND TOTAL	$ 6,599,430

Note: Estimates are based on Travis County Appraisal District recorded livable square footage values.

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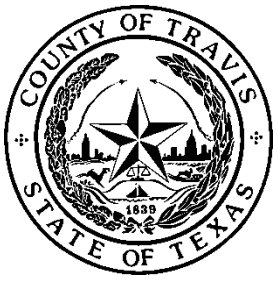

Travis County Flood Mitigation Study

Appendix E: Benefit - Cost Analysis Technical Report

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Introduction

The benefit-cost analysis (BCA) considers monetary risk to structures and their associated contents located within the immediate project areas. Risk is evaluated using the existing (pre-project) conditions in relation to the mitigated (post-project) conditions. The difference between the two conditions is called the project benefits. This BCA report provides additional details about the analysis.

Structure Damages

The benefit/cost ratios for the structures were determined by use of FEMA's Flood Module (5.2.1), which calculates a present value of future damages that are estimated to occur over the useful life of the project and divides that figure into the cost of the project. Project lifetime is assumed 50 years for drainage improvement projects, 30 years for structural elevation projects, and 100 years buyout projects. The estimated future damages are based on varying flood depth scenarios for different storm events and flood flows.

In the course of the benefit/cost (B/C) calculation, LiDAR data was obtained which was then used to determine finished floor elevation (FFE) by the addition of a value based on foundation type. The FFE assumptions were validated using a few field surveys. The B/C results include a list of properties and the calculated benefits from this project in all the areas of interest. The spreadsheets include the FFEs, and pre- and post-mitigation project results for the 2-, 5-, 10-, 25-, 50-, 100-, and 500-year frequency events. In completing the B/C runs, we used the FEMA flood models for buyout projects, drainage improvement projects, and structural elevation projects to assess possible benefits for each type of project.

In order to complete the analysis, the FEMA defaults were utilized for a Flood Model Riverine analysis. Halff Associates, Inc. provided supporting tables that included the structure inventory, estimated or surveyed FFEs, appraisal district living area square footage, stream bed elevations, and 14 sets of water surface elevations (WSE) for the pre- and post-project conditions for the 2-, 5-, 10-, 25-, 50-, 100-, and 500-year frequency events.

I addition to using of FEMA's Flood Module (5.2.1) to calculate benefits, benefits using FEMA provided pre-calculated benefits were analyzed. In a memo from 2013, and subsequent FEMA guidance, FEMA states "Based on extensive analysis, pre-calculated benefits have been determined for acquisition and elevation projects located in SFHAs. This analysis demonstrates a national average for benefits of $276,000 for acquisition projects and of $175,000 for elevation projects. Therefore, FEMA has determined that the acquisition or elevation of a structure located in the 100-year floodplain for which costs are equal to or less than the amount of benefits noted above is cost effective. For projects that contain multiple structures, the average cost of all structures in the project must meet the stated criterion."

Structure Depth-Damage Functions

Structural damage functions for all residential buildings utilized FEMA Flood Module defaults. The structures in the analysis were identified as one-story or two-story and assumed no basement. The Building Replacement Value was determined using the supplied living areas, identified type of construction, and assuming average quality of construction. The *Marshall and Swift Cost Estimation Guide* dated 12/2016 was used to determine the full Building Replacement Value.

Contents Depth-Damage Functions

Contents damage functions for all residential buildings utilize FEMA Full-Data Riverine module defaults. Default contents functions and values were used for all commercial structures as well.

Contents Replacement Value Determinations

For all structures in the project, the BCA used the FEMA default value.

Displacement Times and Values

In the FEMA BCA methodology, displacement times and values account for certain additional costs of flooding other than direct damages to structures and contents. These include renting alternative living or work space, extra commuting timing, storage, etc. Current FEMA guidance provides recommended values for these costs, and the Flood Module software provides defaults for displacement times for all use types.

For the residential uses, this BCA uses the FEMA Default Value. The default values for each non-residential use type were also used.

Results of the Structure Analysis

The results were reported individually in spreadsheets for documentation. Table 1 below provides a summary the computed structural analysis for each proposed project.

Cost Analysis

Halff Associates, Inc. provided cost estimates for the drainage improvement project. JSWA estimated costs for structural elevation and acquisition/demolition (buyout) was also evaluated used the following cost estimation assumptions / methodology:

Acquisition/demolition

1. Total appraisal district value (building and land) was multiplied by 2.5 for an estimate of market value. This multiplier includes the assume cost for supplemental housing and demolition costs.
2. Benefits for buyouts are higher than those for drainage improvement projects and structural elevation projects as acquisition permanently removes the properties from harm's way, with no residual risk.

Structure Elevation

1. The appraisal district livable square footage of the home was multiplied by $90/sqft as an estimated cost of elevation.

Benefit Cost Analysis Results

The table below provides a summary of the benefit cost analysis and the resulting benefit/cost ratios for each of the evaluated Travis County viable alternatives.

Table 1. Benefit Cost Analysis Results

Viable Alternatives	Project Benefits (Avoided Damages)	Estimated Project Cost	Benefit Cost Ratio
Dry Creek East / Thoroughbred Farms Area			
Thoroughbred Farms Channel Improvements	$920,174	$9,062,979	**0.10**
Thoroughbred Farms Buyouts	$5,628,898	$3,812,443	**1.48**
Thoroughbred Farms Elevations	$3,652,278	$2,443,590	**1.49**
Bear Creek – Onion Creek Confluence Area			
Arroyo Doble & Onion Creek Meadows Floodwall	$277,772	$18,862,502	**0.01**
Arroyo Doble & Onion Creek Meadows Buyouts	$4,140,000	$10,237,242	**0.40**
Arroyo Doble & Onion Creek Meadows Elevations	$2,625,000	$2,637,720	**1.00**
Onion Creek Meadows Storm Drainage Improvements	$1,166,549	$9,613,867	**0.12**
Onion Creek Meadows Storm Local Buyouts	$1,714,684	$3,440,430	**0.50**
Onion Creek Meadows Storm Local Elevations	$1,273,034	$845,100	**1.51**
Twin Creeks Buyouts	$276,000	$200,000	**1.38**
Onion Creek / Bluff Springs Area			
Bluff Springs Channel Improvements	$642,067	$64,881,167	**0.01**
Bluff Springs Buyouts	$10,630,550	$12,141,723	**0.88**
Bluff Springs Elevations	$6,767,394	$6,599,430	**1.03**

Travis County Flood Mitigation Study

Appendix F: Environmental Investigation

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Introduction

The project area is in the Blackland Prairies Ecoregion, between both the Edwards Plateau Ecoregion and the Post Oak Savanah Ecoregion, as described by Gould (1960). Historically, it was a native prairie, but the project area has experienced significant residential and commercial development. All five project sites are located within residential development areas that are characterized by single-family homes, as well as community centers (such as schools, parks, and churches) and neighborhood commercial development (Figure F- 1 thru Figure F- 5, attached).

Water Resources

All five proposed projects are in the Colorado River Basin. The major waterways within the project areas are Onion Creek and Dry Creek, as well as their associated tributaries. Onion Creek drains to the Colorado River in Travis County, while Dry Creek East drains to the Colorado River in Bastrop County.

Section 404 of the Clean Water Act: Waters of the U.S.

Section 404 of the Clean Water Act (CWA) addresses the discharge of dredge and fill materials into waters of the U.S. Based on 33 Code of Federal Regulations 328.3(a) and joint U.S. Army Corps of Engineers (USACE) -Environmental Protection Agency (EPA) guidance following the U.S. Supreme Court's 2006 decision in *Rapanos v. United States* and *Carabell v. United States* (USACE 2007). The USACE and EPA assert CWA jurisdiction over (1) traditional navigable waters (TNW) and all wetlands adjacent to TNWs; (2) relatively permanent waters (RPW), which include non-navigable tributaries of TNWs that typically flow year-round or have continuous flow at least seasonally, and all abutting wetlands to RPWs; and (3) other water bodies (such as non-RPWs, wetlands adjacent to non-RPWs, and wetlands adjacent to but not directly abutting an RPW) that are analyzed and determined to have a significant nexus with a TNW. A significant nexus exists if the tributary, in combination with all its adjacent wetlands, has more than a speculative or an insubstantial effect on the chemical, physical, and/or biological integrity of a TNW.

Investigations to identify wetlands and other potential waters of the U.S. within the project area included a review of background information such as aerial photography, topographic maps, U.S. Fish and Wildlife Service (USFWS) National Wetland Inventory (NWI) maps, National Hydrography Dataset (NHD), and Federal Emergency Management Agency (FEMA) floodplain maps. Additionally, the *Navigable Waters of the United States in the Fort Worth, Albuquerque, and Tulsa Districts Within the State of Texas* was reviewed to conclude that no navigable waters are listed within the project area.

Dry Creek East / Thoroughbred Farms Area

Based on a review of aerial photography, topographic maps, NHD, FEMA floodplain maps, and the USFWS NWI maps, the proposed project is located within Dry Creek and a potential NWI feature (Figure I). Dry Creek would likely be considered a waters of the U.S., subject to confirmation by the USACE after field work is completed. Any placement of temporary or permanent dredge or fill material into these potential waters of the U.S., including wetlands or other special aquatic sites, would require a Section 404 permit.

A wetland determination/delineation would be required to identify any potential waters of the U.S. within the footprint of the proposed project. A field survey and impact assessment would be needed to determine whether a Section 404 permit is required and which permit type would apply.

Onion Creek / Bear Creek – Onion Creek Confluence Area

Based on a review of aerial photography, topographic maps, NHD, FEMA floodplain maps, and the USFWS NWI maps, the proposed project is located adjacent to Onion Creek and a potential NWI feature (Figure F- 7). Based on desktop review only, Onion Creek would likely be considered a waters of the U.S., subject to confirmation by the USACE after field work is completed. Any placement of temporary or permanent dredge or fill material into these potential waters of the U.S., including wetlands or other special aquatic sites, would likely require a Section 404 permit.

A wetland determination/delineation would be required to identify any potential waters of the U.S. within the footprint of the proposed project. A field survey and impact assessment would be needed to determine whether a Section 404 permit is required and which permit type would apply.

Onion Creek / Onion Creek Meadows Local Drainage Area

Based on a review of aerial photography, topographic maps, NHD, FEMA floodplain maps, and the USFWS NWI maps, the headwaters of an unnamed tributary to Onion Creek crosses the project area on the north side of the project in the area of the proposed culvert (Figure F- 8). Onion Creek would likely be considered a waters of the U.S., subject to confirmation by the USACE after field work is completed. The unnamed tributary to Onion Creek may also be a potential waters of the U.S. depending on if it exhibits an ordinary high water mark and has a nexus with Onion Creek. Any placement of temporary or permanent dredge or fill material into these potential waters of the U.S., including wetlands or other special aquatic sites, would require a Section 404 permit.

A wetland determination/delineation would be required to identify any potential waters of the U.S. within the footprint of the proposed project. A field survey and impact assessment would be needed to determine whether a Section 404 permit is required and which permit type would apply.

Onion Creek / Twin Creeks Area

Based on a review of aerial photography, topographic maps, NHD, FEMA floodplain maps, and the USFWS NWI maps, the proposed project is not located within or adjacent to a potential waters of the U.S. (Figure F- 9). A field survey would be needed to confirm this assessment. A wetland determination/delineation would also be required to identify any potential wetlands within the footprint of the proposed project. If the proposed project is determined to not impact a waters of the U.S., including any wetlands or special aquatic features, no Section 404 permit would be required.

Onion Creek / Bluff Springs Area

Based on a review of aerial photography, topographic maps, NHD, FEMA floodplain maps, and the USFWS NWI maps, the proposed project is located within Onion Creek and a potential NWI feature (Figure F- 10). Based on desktop review only, Onion Creek would likely be considered a waters of the U.S., subject to confirmation by the USACE after field work is completed. Any placement of temporary or permanent dredge or fill material into these potential waters of the U.S., including wetlands or other special aquatic sites, would require a Section 404 permit.

A wetland determination/delineation would be required to identify any potential waters of the U.S. within the footprint of the proposed project. A field survey and impact assessment would be needed to determine whether a Section 404 permit is required and which permit type would apply.

Edwards Aquifer

Based on the Texas Commission on Environmental Quality's (TCEQ) Edwards Aquifer Viewer v3.8 (accessed in October 2017), all of the proposed projects are located outside of the areas that are subject to regulation by the TCEQ under the Edwards Aquifer Protection Program.

Endangered Species

Table F- 1 and Table F- 2 provide lists and regulatory status of the threatened and endangered species that the U.S. Fish and Wildlife Service (USFWS) and Texas Parks and Wildlife Department (TPWD) consider as having the potential to occur in Travis County. Also included in these tables are the regulatory status, habitat description, and the potential for species habitat to occur within the project area based on a desktop review. A review of the Texas Natural Diversity Database (NDD) in October 2017 showed no documented element of occurrence of federal or state-listed threatened or endangered species within 5 miles of any of the proposed project sites. Also, no critical habitat for federally or state-listed threatened or endangered species is located within any of the proposed project sites.

Table F- 1: Federally Threatened, Endangered, or Candidate Species of Potential Occurrence in Travis County

Species	Listing	Description of Suitable Habitat	Potential Habitat in Vicinity?
Black-capped Vireo (*Vireo atricapilla*)	E	Oak-juniper woodlands with distinctive patchy, two-layered aspect; shrubs and trees with open, grassy spaces; requires foliage-reaching to ground level for nesting cover; deciduous and broad-leaved shrubs and trees provide insects for feeding.	Unlikely
Golden-cheeked Warbler (*Dendroica chrysoparia*)	E	Oak-juniper woodlands; dependent on Ashe juniper for long, fine bark strips, only available from mature trees, used in nest construction; nests are placed in various trees other than Ashe juniper; forage for insects in broad-leaved trees and shrubs; nesting late March-early summer.	Unlikely
Whooping Crane (*Grus americana*)	E	Potential migrant via plains throughout most of state to coast; winters in coastal marshes of Aransas, Calhoun, & Refugio Counties.	Unlikely
Austin Blind Salamander (*Eurycea waterlooensis*)	E	Mostly restricted to subterranean cavities of the Edwards Aquifer; only known from the outlets of Barton Springs.	No

Species	Listing	Description of Suitable Habitat	Potential Habitat in Vicinity?
Jollyville Plateau Salamander (*Eurycea tonkawae*)	T	Known from springs and waters of some caves located north of the Colorado River.	No
Barton Springs Salamander (*Eurycea sosorum*)	E	Known from the outlets of Barton Springs and subterranean water-filled caverns.	No
Golden Orb (*Quadrula aurea*)	C	Sand and gravel in some locations and mud at others; intolerant of impoundment in most instances; Guadalupe, San Antonio, and Nueces River basins.	Unlikely
Smooth Pimpleback (*Quadrula houstonensis*)	C	Small to moderate streams and rivers as well as moderate sized reservoirs; mixed mud, sand, and fine gravel; tolerates very slow to moderate flow rates, appears not to tolerate dramatic water level fluctuations, scoured bedrock substrates, or shifting sand bottoms; lower Trinity, Brazos and Colorado River basins.	Yes
Texas Fatmucket (*Lampsilis bracteata*)	C	Streams and rivers on sand, mud, and gravel substrates; intolerant of impoundment; broken bedrock and course gravel or sand in moderately flowing water; Colorado and Guadalupe River basins.	Yes
Texas Pimpleback (*Quadrula petrina*)	C	Mud, gravel and sand substrates, generally in areas with slow flow rates; Colorado and Guadalupe River basins.	Yes
Texas Fawnsfoot (*Truncilla macrodon*)	C	Possibly rivers and small streams, and intolerant of impoundment; flowing rice irrigation canals, possibly sand, gravel, and perhaps sandy-mud bottoms in moderate flows; Brazos and Colorado River basins.	Yes
Bee Creek Cave Harvestman (*Texella reddelli*)	E	Small, blind, cave-adapted harvestman endemic to a few caves in Travis and Williamson Counties.	No
Bone Cave Harvestman (*Texella reyesi*)	E	Endemic to a few caves in Travis and Williamson Counties.	No
Tooth Cave Pseudoscorpion (*Tartarocreagris texana*)	E	Cave-adapted pseudoscorpion known from small limestone caves of the Edwards plateau.	No
Tooth Cave Spider (*Neoleptoneta myopica*)	E	Very small, cave-adapted, sedentary spider.	No

Species	Listing	Description of Suitable Habitat	Potential Habitat in Vicinity?
Kretschmarr Cave Mold Beetle (*Texamaurops reddelli*)	E	Found in the Edwards Plateau, Travis County; found in total darkness under and among rocks and organic debris and buried in silt.	No
Tooth Cave Ground Beetle (*Rhadine persephone*)	E	Resident, small, cave-adapted beetle found in small Edwards Limestone caves in Travis and Williamson Counties.	No
Bracted Twistflower (*Streptanthus bracteatus*)	C	Texas endemic; shallow, well-drained gravelly clays and clay loams over limestone in oak juniper woodlands and associated openings, on steep to moderate slopes and in canyon bottoms; several known soils include Tarrant, Brackett, or Speck over Edwards, Glen Rose, and Walnut geologic formations.	Unlikely

Source: USFWS IPaC (Accessed October 2017); E – Endangered; T – Threatened; C- Candidate

Table F- 2: State-listed Threatened, Endangered, or Candidate Species of Potential Occurrence in Travis County

Species	Listing	Description of Suitable Habitat	Potential Habitat in Vicinity?
Red Wolf (*Canus rufus*)	E	Extirpated; formerly known throughout eastern half of Texas in brushy and forested areas, as well as coastal prairies.	No
Bald Eagle (*Haliaeetus leucocephalus*)	T	Found primarily near rivers & large lakes; nests in tall trees or on cliffs near water; communally roosts especially in winter	Unlikely
Black-capped Vireo (*Vireo atricapilla*)	E	Same as **Table 1**.	Unlikely
Golden-cheeked Warbler (*Dendroica chrysoparia*)	E	Same as **Table 1**.	Unlikely
Interior Least Tern (*Sterna antillarum athalassos*)	E	Subspecies is listed only when inland (more than 50 miles from a coastline); nests along sand and gravel bars within braided streams, rivers; also know to nest on man-made structures (inland beaches, wastewater treatment plants, gravel mines, etc); eats small fish and crustaceans, when breeding forages within a few hundred feet of colony.	Unlikely

Species	Listing	Description of Suitable Habitat	Potential Habitat in Vicinity?
Peregrine Falcon (*Falco peregrinus*)	T	Both subspecies migrate across the state from more northern breeding areas in US and Canada to winter along coast and farther south; subspecies (*F. p. anatum*) is also a resident breeder in west Texas; the two subspecies' listing statuses differ, *F.p. tundrius* is no longer listed in Texas; but because the subspecies are not easily distinguishable at a distance, reference is generally made only to the species level; see subspecies for habitat.	Unlikely
Whooping Crane (*Grus americana*)	E	Same as **Table 1**.	Unlikely
False Spike Mussel (*Quincuncina mitchelli)*	T	Possibly extirpated in Texas; probably medium to large rivers; substrates varying from mud through mixtures of sand, gravel and cobble; Rio Grande, Brazos, Colorado, and Guadalupe (historic) River basins	Yes
Smooth Pimpleback (*Quadrula houstonensis*)	T	Same as **Table 1**.	Yes
Texas Fatmucket (*Lampsilis bracteata*)	T	Same as **Table 1**.	Yes
Texas Pimpleback (*Quadrula petrina*)	T	Same as **Table 1**.	Yes
Austin Blind Salamander (*Eurycea waterlooensis*)	E	Same as **Table 1**.	No
Texas Horned Lizard (*Phrynosoma cornutum*)	T	Open, arid and semi-arid regions with sparse vegetation, including grass, cactus, scattered brush or scrubby trees; soil may vary in texture from sandy to rocky; burrows into soil, enters rodent burrows, or hides under rock when inactive.	Unlikely

Source: TPWD, Rare, Threatened, and Endangered Species of Texas by County, Travis County (accessed October 2017); E – Endangered; T – Threatened

Dry Creek East / Thoroughbred Farms Area

The Dry Creek East / Thoroughbred Farms Area project site is located within an urbanized area, with residential neighborhood communities surrounding the proposed project site. Based on the residential development in the vicinity of the project, it is unlikely that any intact habitat for most of the listed threatened and endangered species in Table F- 1 and Table F- 2 are present. However, the proposed project is located within the vicinity of a potential waters of the U.S., which may contain habitat for mussel species. A habitat assessment would be required to verify the presence/absence of appropriate habitat.

The proposed project is located less than 10 miles from known populations of the Barton Springs salamander. However, the proposed project is not located within the Edwards Aquifer zone or within a mapped karst zone (Figure F- 11). Also, the proposed project is not located within the vicinity of any Barton Springs outlets and there are no known caves within the proposed project limits. Therefore, it is unlikely for the proposed project to effect cave dwelling threatened and endangered species.

Onion Creek / Bear Creek – Onion Creek Confluence Area

The Onion Creek / Bear Creek – Onion Creek Confluence Area project site is located within an urbanized area, with residential neighborhood communities surrounding the proposed project site. Based on the residential development in the vicinity of the project, it is unlikely that any intact habitat for most of the listed threatened and endangered species in Table F- 1 and Table F- 2 are present. However, the proposed project is located within the vicinity of a potential waters of the U.S., which may contain habitat for mussel species. A habitat assessment would be required to verify the presence/absence of appropriate habitat.

The proposed project is located less than 10 miles from known populations of the Barton Springs salamander. However, the proposed project is not located within the Edwards Aquifer zone and is located in Karst Zone 4, which is defined as an area which does not contain endangered cave fauna (Figure F- 11). Also, the proposed project is not located within the vicinity of any Barton Springs outlets and there are no known caves within the proposed project limits. Therefore, it is unlikely for the proposed project to effect cave dwelling threatened and endangered species.

Onion Creek / Onion Creek Meadows Local Drainage Area

The Onion Creek / Onion Creek Meadows Area project site is located within an urbanized area, with residential neighborhood communities surrounding the proposed project site. Based on the residential development near the project, it is unlikely that any intact habitat for most of the listed threatened and endangered species in Table F- 1 and Table F- 2 are present. However, the proposed project is located within the vicinity of a potential waters of the U.S., which may contain habitat for mussel species. A habitat assessment would be required to verify the presence/absence of appropriate habitat.

The proposed project is located less than 10 miles from known populations of the Barton Springs salamander. However, the proposed project is not located within the Edwards Aquifer zone or within a mapped karst zone (Figure F- 11). Also, the proposed project is not located within the vicinity of any Barton Springs outlets and there are no known caves within the proposed project limits. Therefore, it is unlikely for the proposed project to effect cave dwelling threatened and endangered species.

Onion Creek / Twin Creeks Area

Based on a desktop review of the Onion Creek / Twin Creeks Area project area, no habitat for any federally or state-listed threatened or endangered species or candidate species is assumed to be located within the vicinity of the project. The proposed project site footprint is limited and is located in the middle of a residential development. However, a habitat assessment would be required to verify the presence/absence of habitat.

The proposed project is located less than 10 miles from known populations of the Barton Springs salamander. However, the proposed project is not located within the Edwards Aquifer zone and is located in Karst Zone 4, which is defined as an area which does not contain endangered cave fauna

(Figure F- 11). Also, the proposed project is not located within the vicinity of any Barton Springs outlets and there are no known caves within the proposed project limits. Therefore, it is unlikely for the proposed project to effect cave dwelling threatened and endangered species.

Onion Creek / Bluff Springs Area

The Onion Creek / Bluff Springs Area project site is located within an urbanized area, with residential neighborhood communities and other development surrounding the proposed project site. Based on the residential development in the vicinity of the project, it is unlikely that any intact habitat for most of the listed threatened and endangered species in Table F- 1 and Table F- 2 are present. However, the proposed project is located within the vicinity of a potential waters of the U.S., which may contain habitat for mussel species. A habitat assessment would be required to verify the presence/absence of appropriate habitat.

The proposed project is located less than 10 miles from known populations of the Barton Springs salamander. However, the proposed project is not located within the Edwards Aquifer zone and is located in Karst Zone 4, which is defined as an area which does not contain endangered cave fauna (Figure F- 11). Also, the proposed project is not located within the vicinity of any Barton Springs outlets and there are no known caves within the proposed project limits. Therefore, it is unlikely for the proposed project to effect cave dwelling threatened and endangered species.

Bald and Golden Eagle Protection Act

Within the U.S. or anywhere within its jurisdiction, bald eagles (*Haliaeetus leucocephalus*) and golden eagles (*Aquila chrysaetos*) are protected by the Bald and Golden Eagle Protection Act (BGEPA) of 1940. No observations have been recorded in the project area. Based on desktop review, it is unlikely that any appropriate habitat would be impacted by the proposed projects.

Cultural Resources

Cultural resources are structures, buildings, archeological sites, districts (a collection of related structures, buildings, and/or archeological sites), cemeteries, and objects. Both federal and state laws require consideration of cultural resources during project planning. The following constraints analysis assumes that the project does not have a federal nexus and would only be subject to the Antiquities Code of Texas (ACT) regarding cultural resources.

Historic Resources

In order to comply with the ACT for standing structure historic resources, Blanton & Associates, Inc. (B&A) review was limited to the footprint of each proposed project site. Standing structure historic resources that are subject to review under the ACT include any properties that are listed in the National Register of Historic Places (NRHP) and listed as standing structure State Antiquities Landmarks (SALs).

Dry Creek East / Thoroughbred Farms Area

A review of the THC's Texas Historic Sites Atlas did not reveal the presence of any NRHP-listed properties or standing structure SALs within the APE. Therefore, as a result of this review, it appears that no standing structure historic resources protected by the ACT are located within the footprint of the proposed project site and no standing historic resources would be adversely affected by the project.

Since the project would not pose effects to SAL or NRHP-listed properties under the ACT, it is anticipated that the project would be allowed to proceed as planned without further historic resource investigations.

Onion Creek / Bear Creek – Onion Creek Confluence Area

A review of the Texas Historical Commission's (THC) Texas Historic Sites Atlas did not reveal the presence of any NRHP-listed properties or standing structure SALs within the APE. Therefore, as a result of this review, it appears that no standing structure historic resources protected by the ACT are located within the footprint of the proposed project site and no standing historic resources would be adversely affected by the project. Since the project would not pose effects to SAL or NRHP-listed properties under the ACT, it is anticipated that the project would be allowed to proceed as planned without further historic resource investigations.

Onion Creek / Onion Creek Meadows Local Drainage Area

A review of the THC's Texas Historic Sites Atlas did not reveal the presence of any NRHP-listed properties or standing structure SALs within the APE. Therefore, as a result of this review, it appears that no standing structure historic resources protected by the ACT are located within the footprint of the proposed project site and no standing historic resources would be adversely affected by the project. Since the project would not pose effects to SAL or NRHP-listed properties under the ACT, it is anticipated that the project would be allowed to proceed as planned without further historic resource investigations.

Onion Creek / Twin Creeks Area

A review of the THC's Texas Historic Sites Atlas did not reveal the presence of any NRHP-listed properties or standing structure SALs within the APE. Therefore, as a result of this review, it appears that no standing structure historic resources protected by the ACT are located within the footprint of the proposed project site and no standing historic resources would be adversely affected by the project. Since the project would not pose effects to SAL or NRHP-listed properties under the ACT, it is anticipated that the project would be allowed to proceed as planned without further historic resource investigations.

Onion Creek / Bluff Springs Area

A review of the THC's Texas Historic Sites Atlas did not reveal the presence of any NRHP-listed properties or standing structure SALs within the APE. Therefore, because of this review, it appears that no standing structure historic resources protected by the ACT are located within the footprint of the proposed project site and no standing historic resources would be adversely affected by the project. Since the project would not pose effects to SAL or NRHP-listed properties under the ACT, it is anticipated that the project would be allowed to proceed as planned without further historic resource investigations.

Archeological Resources

B&A conducted a background review of previous archeological surveys and locations of recorded archeological sites within one kilometer (km) (0.6 mile) of the project area by consulting the THC's restricted-access Online Archeological Sites Atlas. In addition to identifying recorded archeological sites,

the review included the following types of information on the Archeological Sites Atlas: NRHP properties, SALs, Official Texas Historical Markers, Registered Texas Historic Landmarks, and cemeteries.

Dry Creek East / Thoroughbred Farms Area

Results of the background review indicate that eight previously recorded sites occur within one km of the project area (Figure F- 1). One of the eight sites is the San Jose Avenue Cemetery (41TV2026). Six of the previously recorded archeological sites (41TV2132 and 41TV2163–41TV2167) were identified during the 2005 Hicks & Company, Inc. SH 130 survey. Each of these sites are recorded as prehistoric lithic scatters, one of which, 41TV2164, overlaps the eastern boundary of the project area. All six of these sites were determined not eligible for inclusion to the NRHP by the THC in 2007. Site 41TV2326 is recorded as a historic artifact scatter and was determined not eligible for inclusion on the NRHP in 2008. In 1993, Espy, Huston & Associates, Inc. conducted a survey of a 26.5 km transmission line replacement for LCRA. This survey area overlaps the eastern half of the project area. No previously recorded sites were identified within one km of the proposed project area during this survey. Since the project area has not been subjected to archeological survey, it is anticipated that an archeological survey will be required under the ACT.

Onion Creek / Bear Creek – Onion Creek Confluence Area

Results of the background review indicate that five previously recorded archeological sites or cemeteries occur within one km of the proposed project area (Figure F- 2). No previous archeological investigations were identified during the review as occurring within the project area or within one km. Sites 41TV186 and 41TV255 were recorded as house structures. 41TV186 was a frame house with a chimney on the south end. The site form does not any other information nor does it provide recommendations. Site 41TV255 was recorded as a structure that had undergone renovation and been sold to a developer. The eligibility status of these sites is unknown. The remaining three sites are all cemeteries, McCuistion Cemetery (41TV1662), the Live Oak Cemetery (41TV1683), and 41TV1688 (the Brown Cemetery). No site form or other information was found for any of the cemeteries. None are listed on the THC's Historic Cemetery list. Since the project area has not been subjected to archeological survey, it is anticipated that an archeological survey will be required under the ACT.

Onion Creek / Onion Creek Meadows Area

Eight archeological sites were identified during the desktop review for the Onion Creek / Onion Creek Meadows Area project (Figure F- 3). Three of the eight sites are cemeteries. These are 41TV1682 (McCuistion Cemetery), 41TV1683 (Live Oak Cemetery), and 41TV1688 (Brown Cemetery), none of which are listed on the THC's Historic Cemetery list. Sites 41TV1425, 41TV1426, and 41HY214 were recorded during a pedestrian survey conducted by the State Department of Highways and Public Transportation (SDHPT) in 1989 for the then proposed Outer Parkway project. Sites 41TV1425 and 41HY214 are prehistoric occupations and site 41TV1426 is an early 20-century house foundation. No report or eligibility recommendations were found for these sites. Site 41TV255 was recorded as a historic house that had undergone renovation and been sold to a developer. The only information available for site 41TV188 is a TARL note card stating that a private landowner donated one prehistoric artifact from the site in 1957 and then another in 1960. The type of artifact is not identified. Since the

project area has not been subjected to archeological survey, it is anticipated that an archeological survey will be required under the ACT.

Onion Creek / Twin Creeks Area

Results of the background review indicate that three previously recorded archeological sites are within one km of the project area (Figure F- 4). All three are recorded as cemeteries, the Live Oak Cemetery (41TV1683), the Brown Cemetery (41TV1688), and the Chapel Hill Memorial Cemetery (41TV1689). No site form or other information was found for any of the cemeteries. None are listed on the THC's Historic Cemetery list.

Two previous archeological surveys have been conducted within one km of the project area. In 2001, a survey was conducted for the U.S. Army Corp of Engineers, Fort Worth District. No other information is available for this survey. In 2014 Horizon Environmental Services, Inc. conducted a survey for the proposed expansion of 1.3 miles of Farm-to-Market Road (FM) 1626 near Manchaca in southwestern Travis County. No archeological resources were identified within the APE that would meet the criteria for listing on the NRHP according to 36 CFR 60.4 or for designation as SALs according to 13 TAC 26, and no further archeological work was recommended. Since the project area has not been subjected to archeological survey, it is anticipated that an archeological survey will be required under the ACT

Onion Creek / Bluff Springs Area

Results of the background review indicate that eleven previously recorded archeological sites or cemeteries occur within one km of the project area (Figure F- 5). None are located within the footprint of the project boundaries. Four of the previously recorded archeological sites (41TV1827 – 41TV1830) were identified during the Lower Colorado River Authority's (LCRA) HiCross Transmission Line rebuild in 1997. All four of the sites have been determined not eligible for inclusion on the NRHP list. Lone Star Archeological Services recorded site 41TV1581 during a survey for the East Slaughter Lane Extension in 1991. No report is on file with the THC for this project and the eligibility of the site is unknown.

The most recent cultural resource investigations within the one-km boundary was an intensive cultural resources survey of a 20.9-acre tract for a proposed real estate development. During the intensive survey of the APE one site, 41TV2538, was recorded. Site 41TV2538 represents the remnants of a mid-20th century dairy and cattle ranch complex (the Carrington Dairy Farm/Goodnight Ranch). The site was determined not eligible for inclusion to the NRHP by the THC.

Sites 41TV109, 41TV683, 41TV1687, and 41TV1942 are also within the one-km radius boundaries. Sites 41TV1582 and 41TV1687 are both identified as the Smith Family Cemetery. No additional information was found for these sites. No site form exists for site 41TV109, the only information available is a 1930 TARL site card that mentions artifacts being donated by R.C. Wilson. Site 41TV683 was recorded in 1983 and revisited in 1994 by the TASN/TCAS but no information concerning its NRHP/SAL eligibility was found. Site 41TV1942 was recorded in 2001 by what appears to be the landowner. Since the project area has not been subjected to archeological survey, it is anticipated that an archeological survey will be required under the ACT.

FIGURES

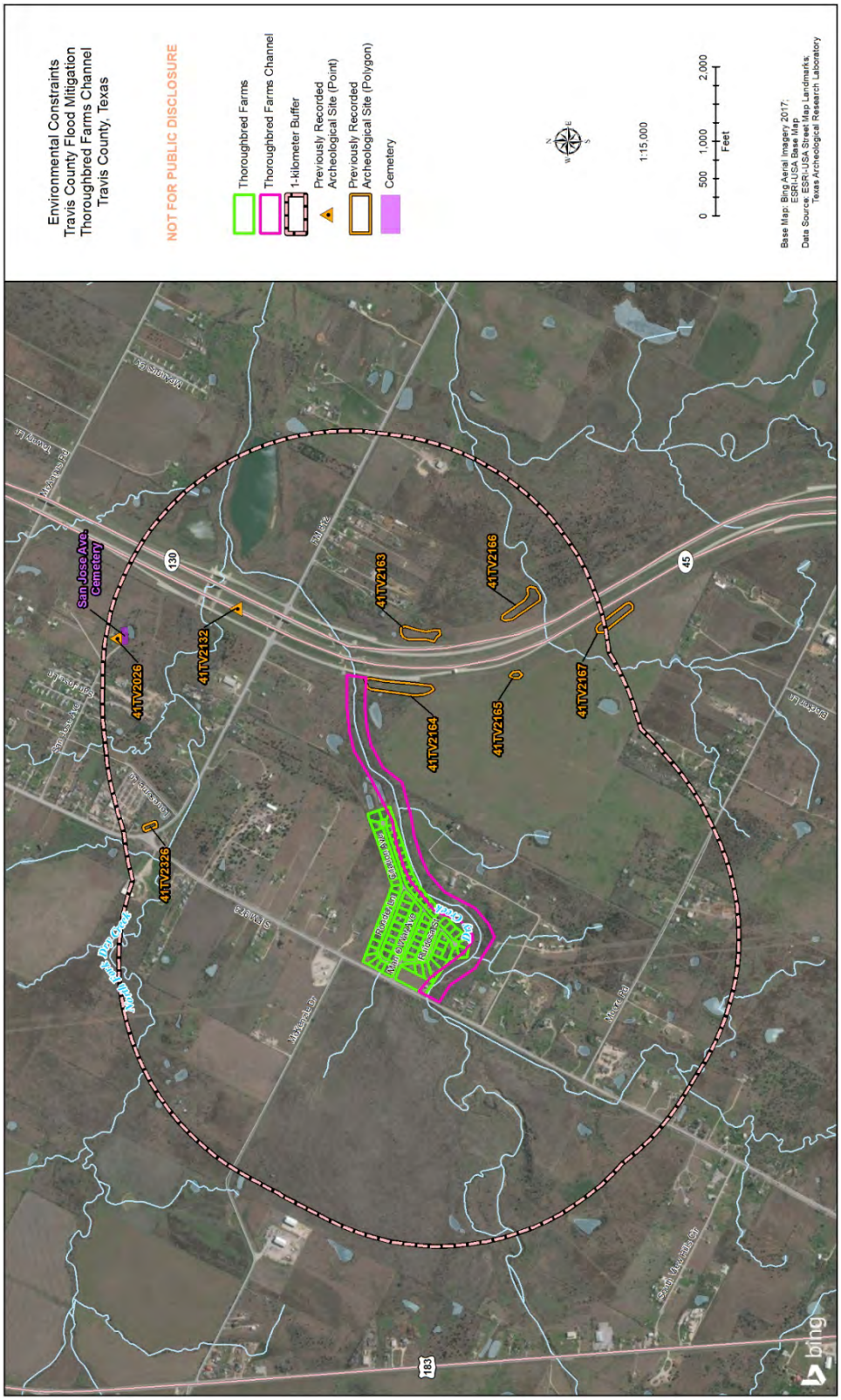


Figure F- 1: Environmental Constraints for Thoroughbred Farms Area

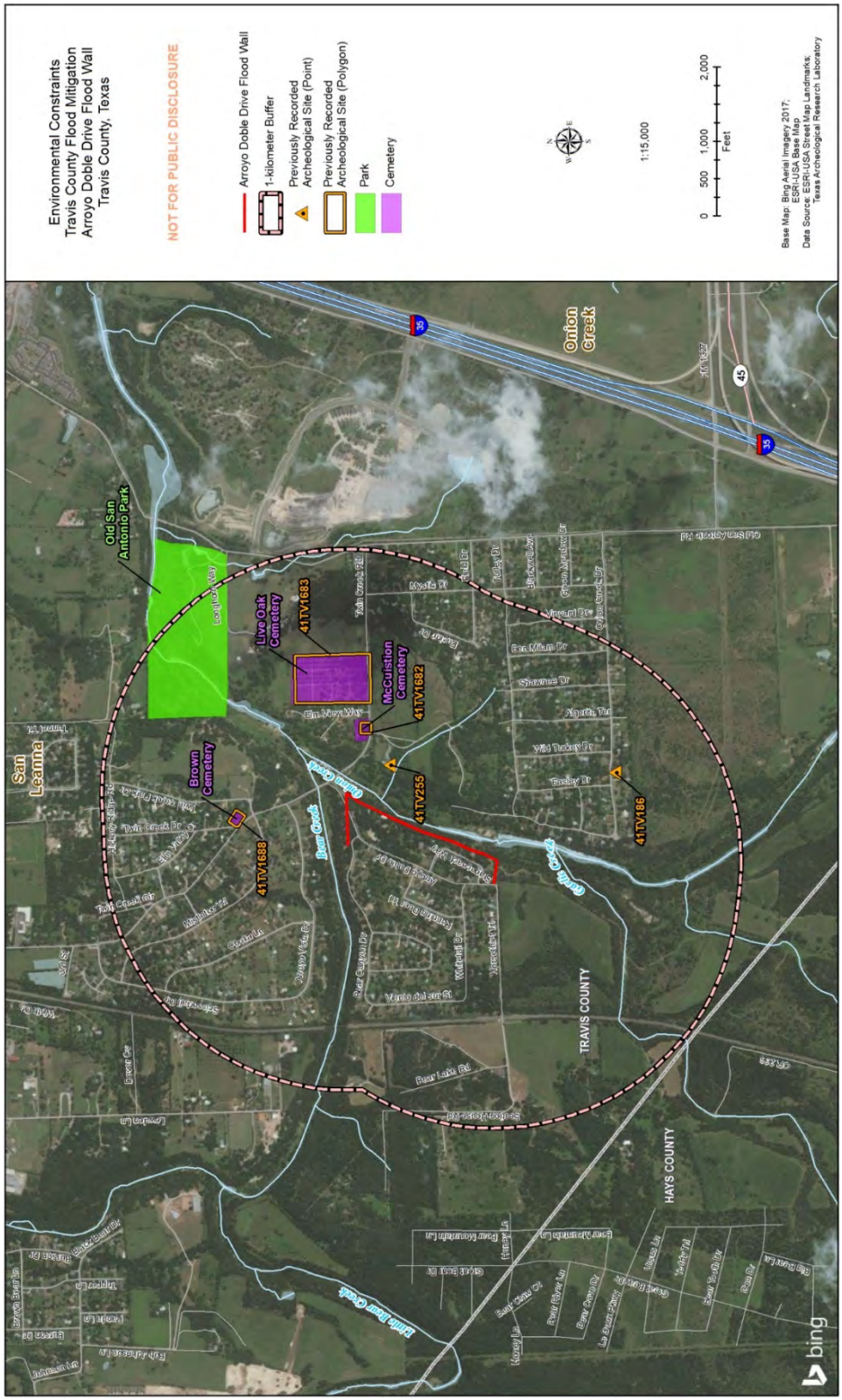


Figure F- 2: Environmental Constraints for Arroyo Doble Area

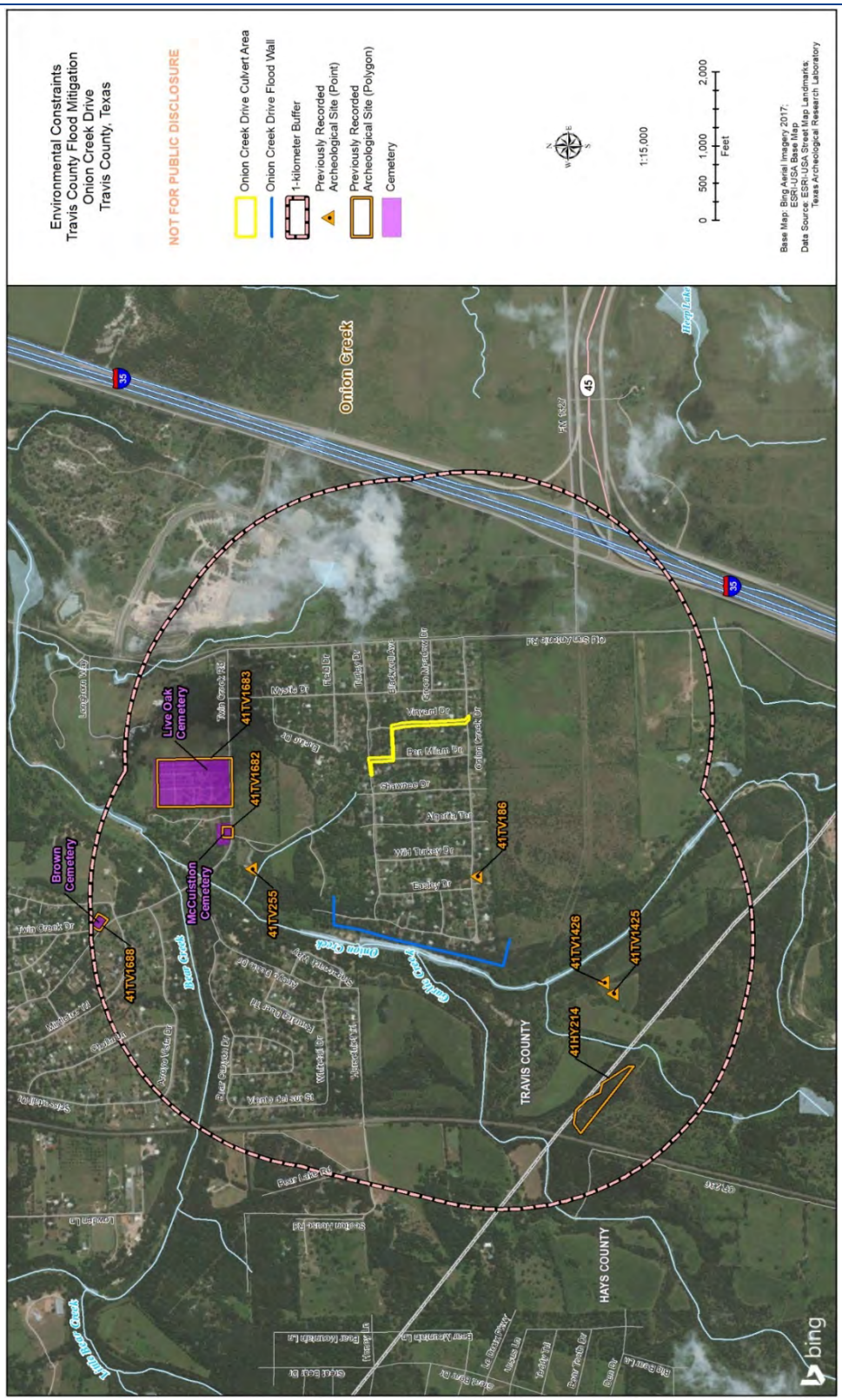


Figure F- 3: Environmental Constraints for Onion Creek Meadows Area

Figure F- 4: Environmental Constraints for Twin Creeks Area

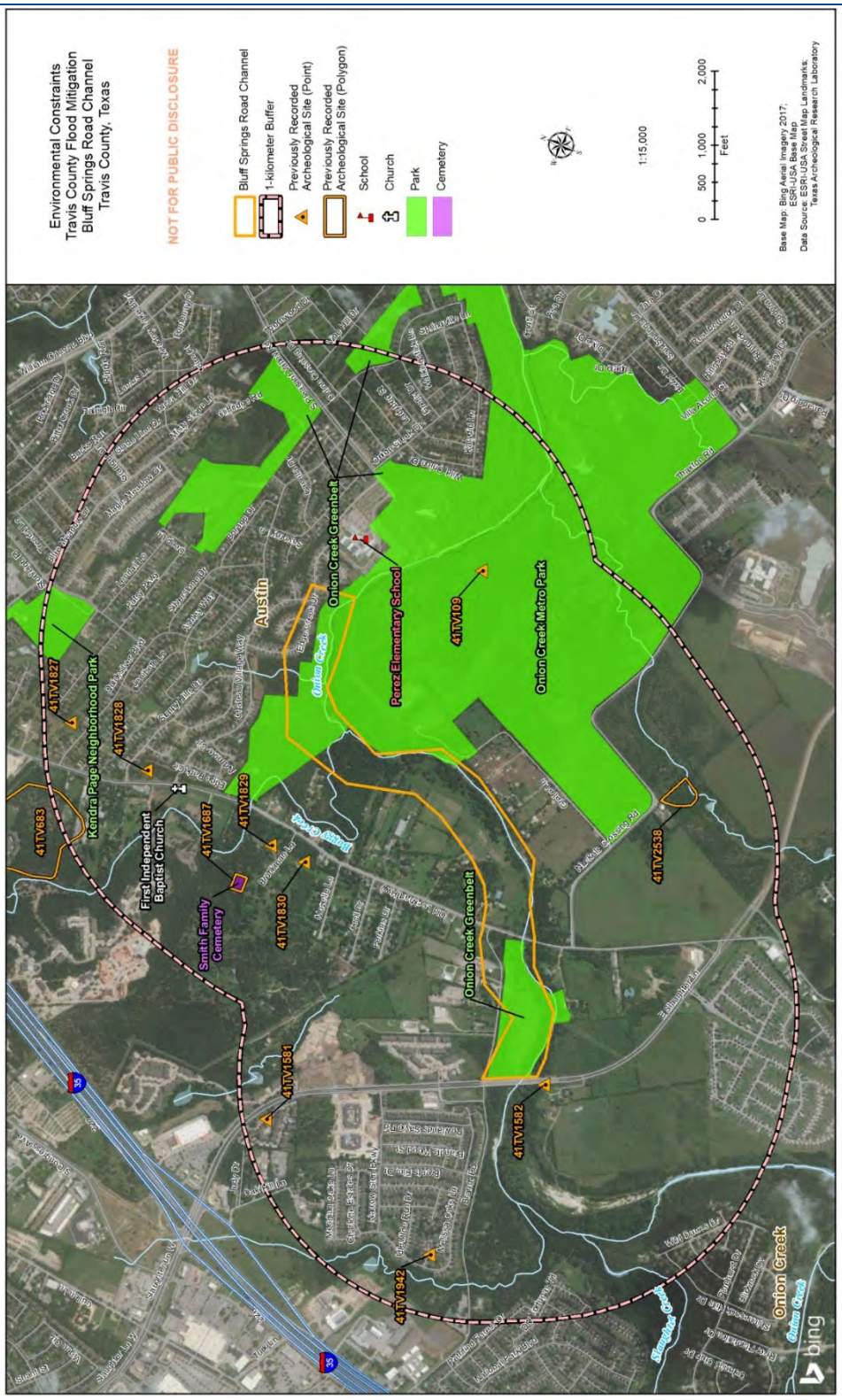


Figure F- 5: Environmental Constraints for Bluff Springs Area

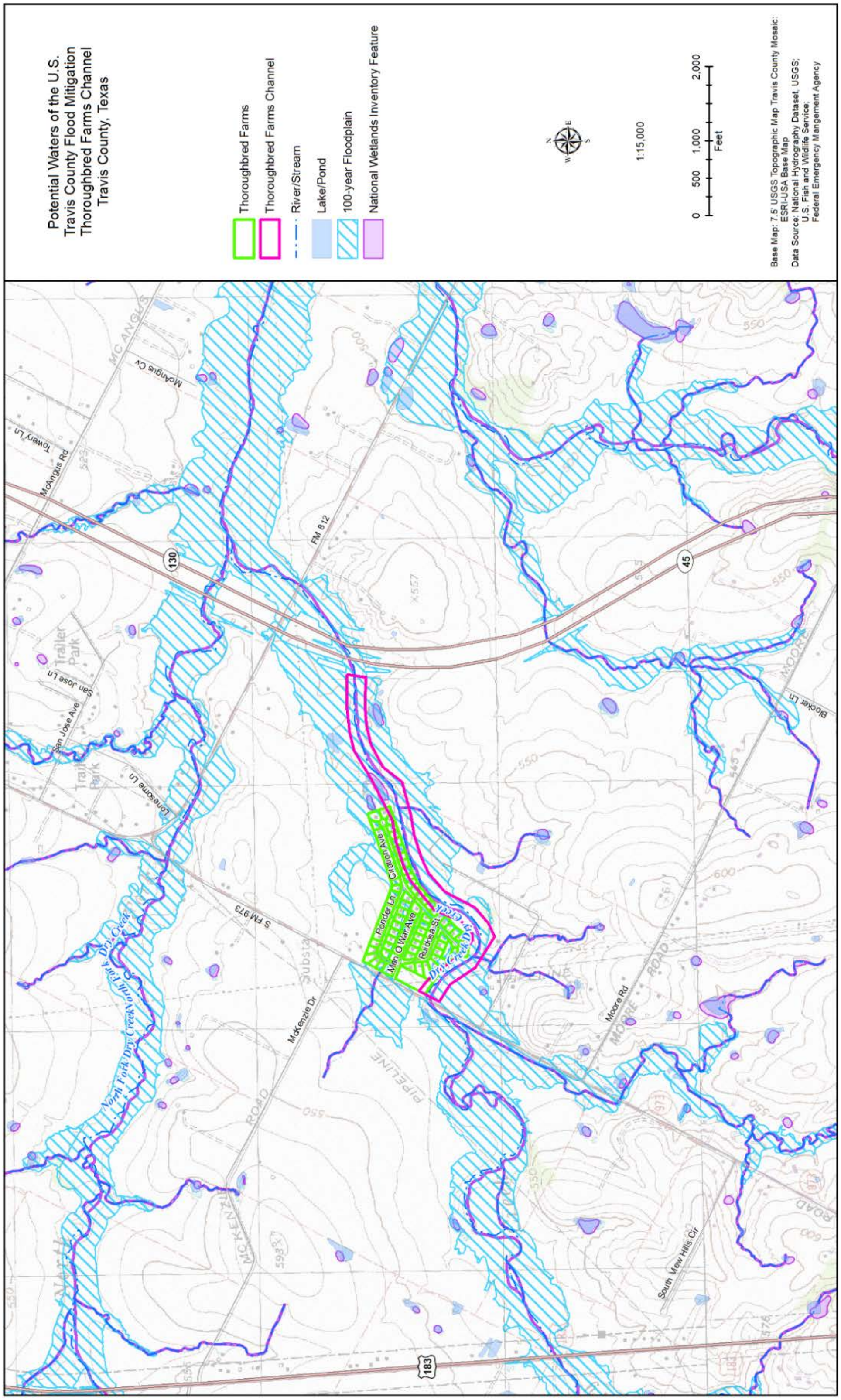


Figure F- 6: Potential Waters of the U.S. Thoroughbred Farms Area

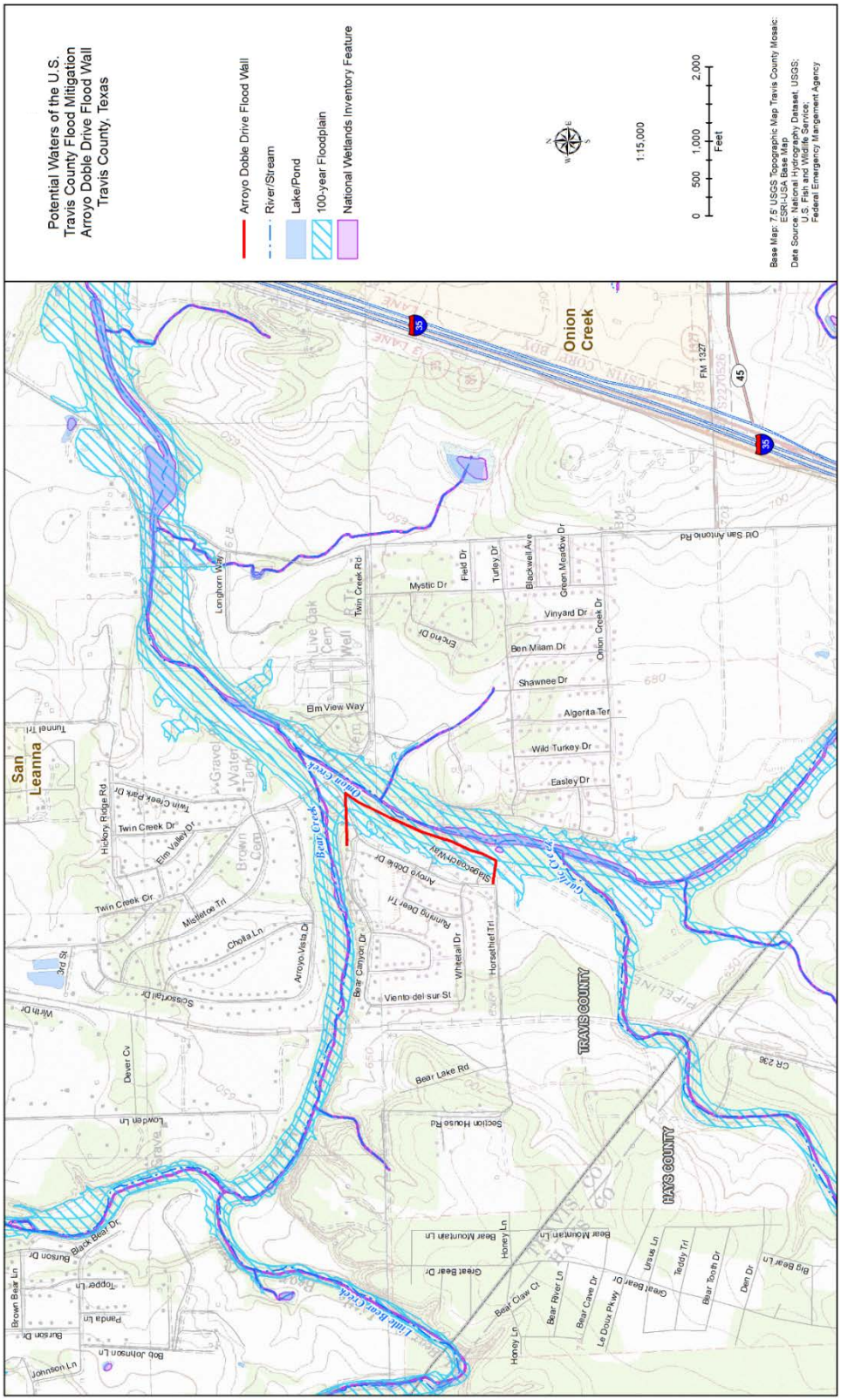


Figure F- 7: Potential Waters of the U.S. Arroyo Doble Area

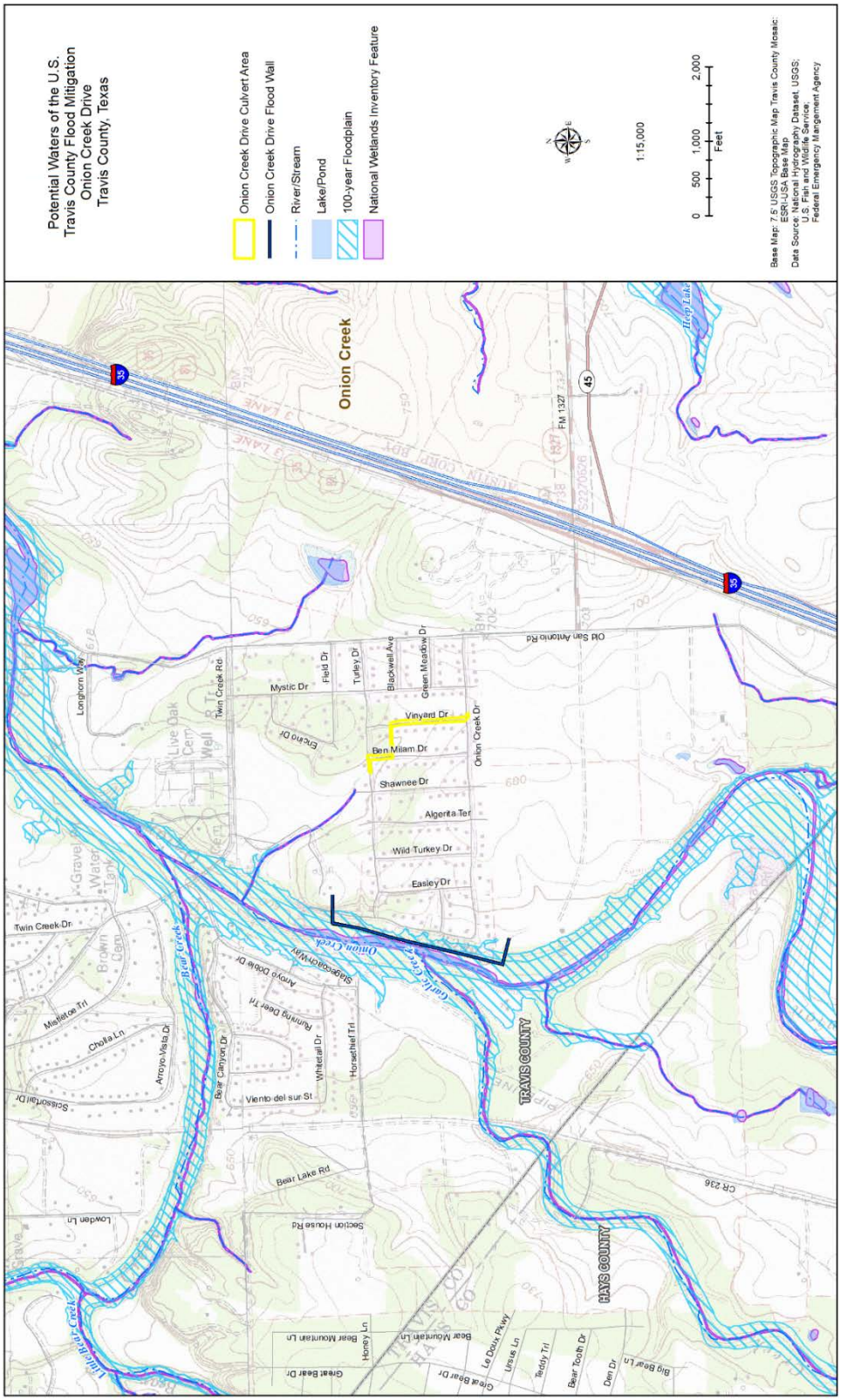


Figure F- 8: Potential Waters of the U.S. Onion Creek Meadows

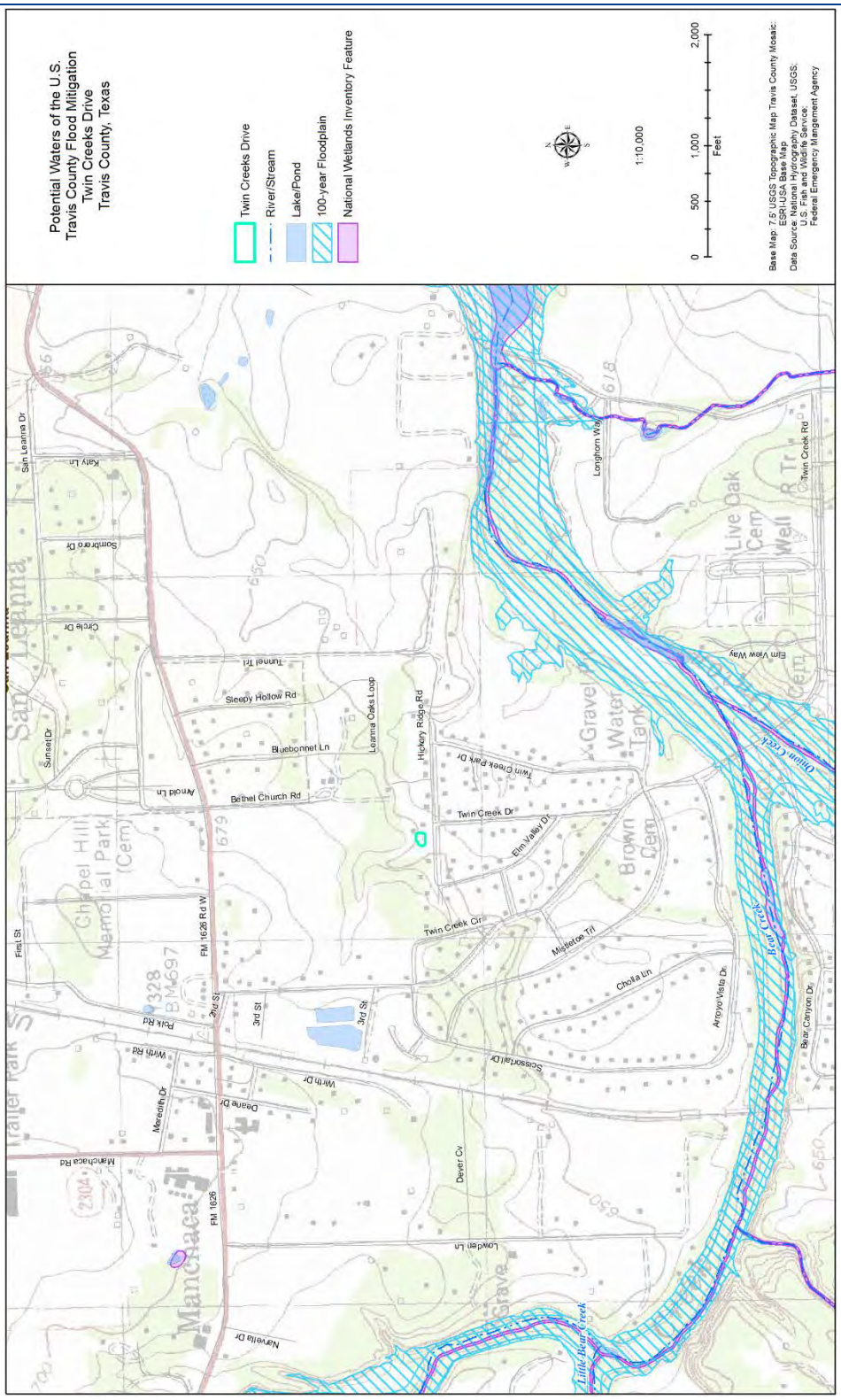


Figure F- 9: Potential Waters of the U.S. Twin Creeks Area

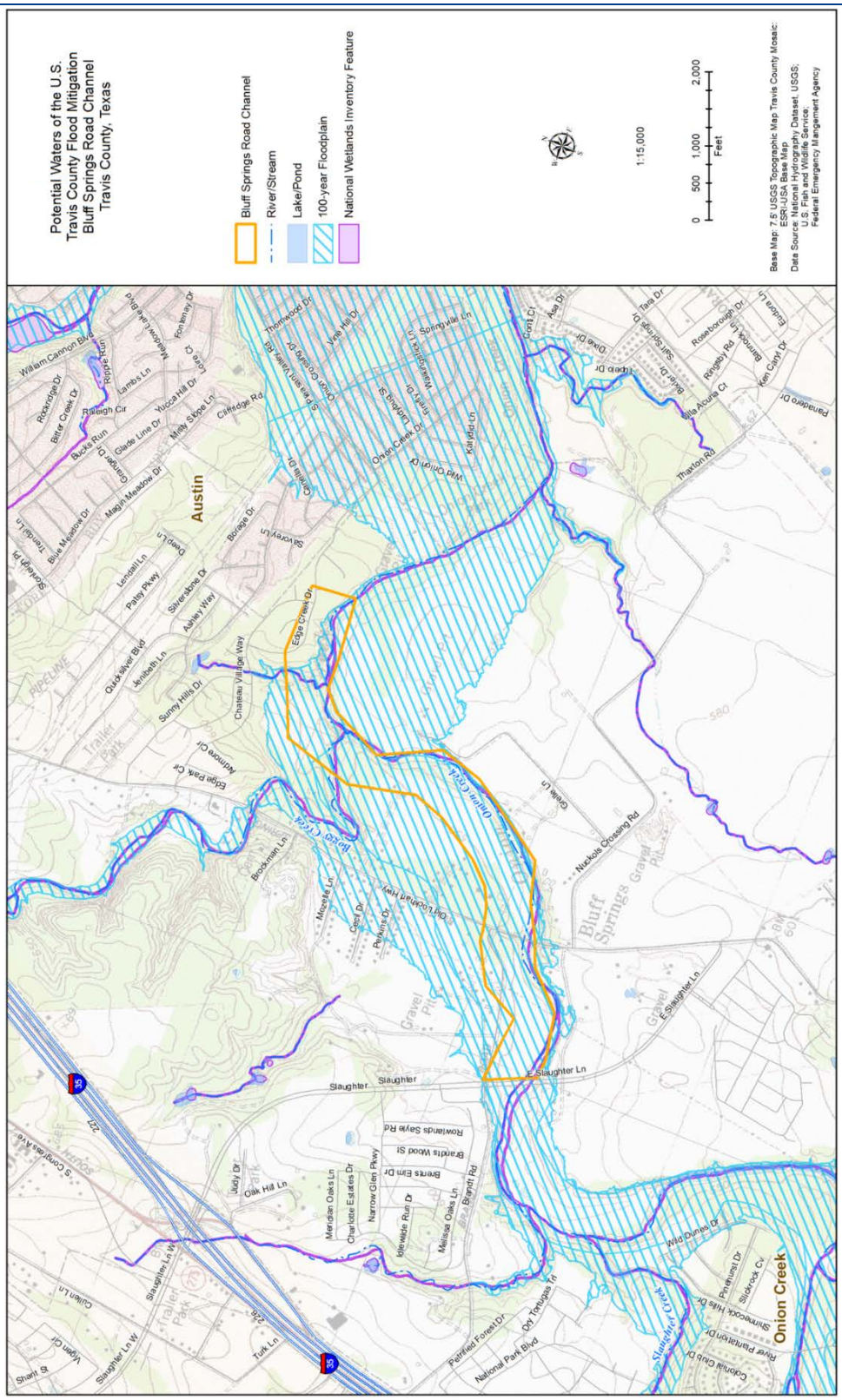


Figure F- 10: Potential Waters of the U.S Bluff Springs Channel Area

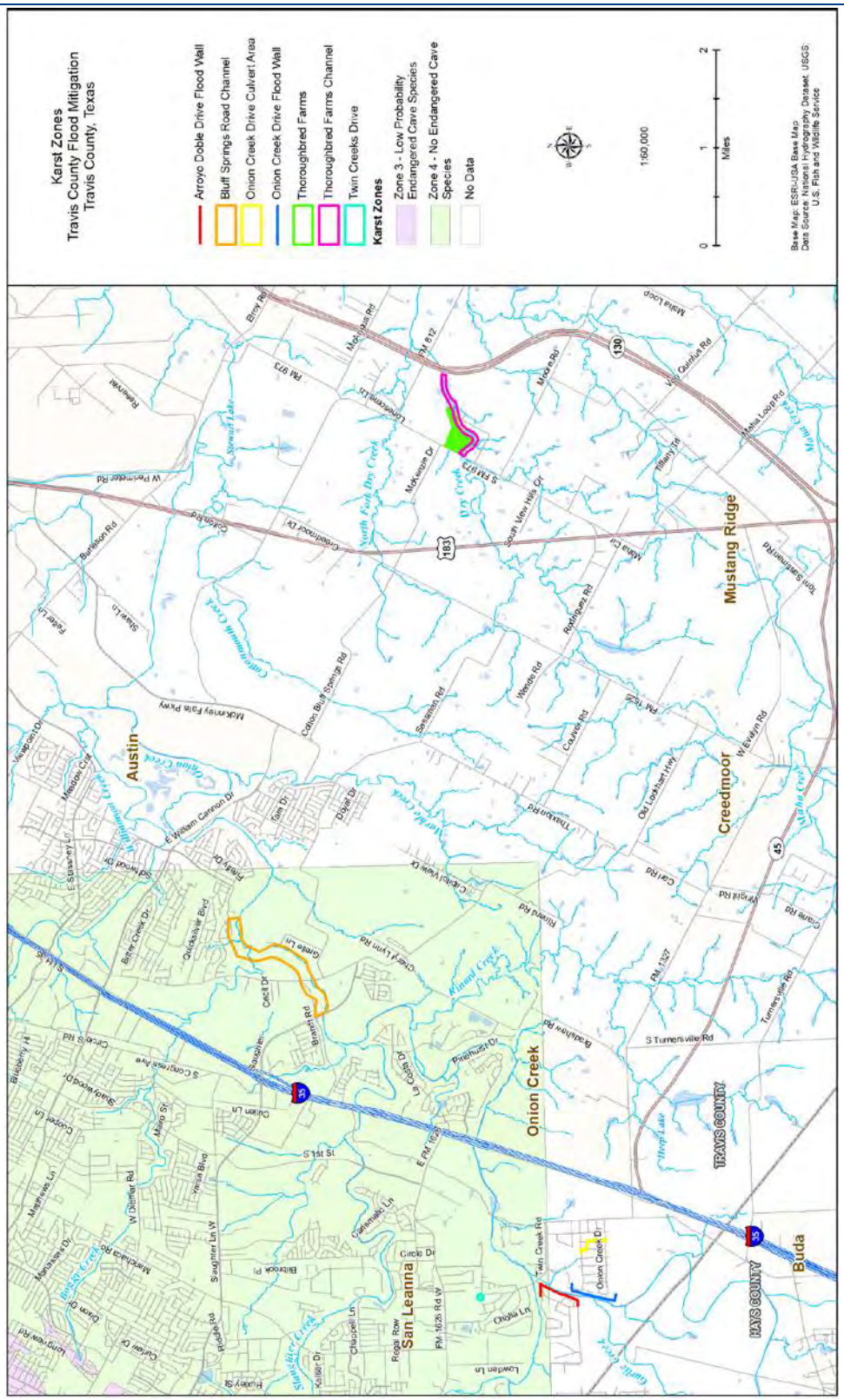
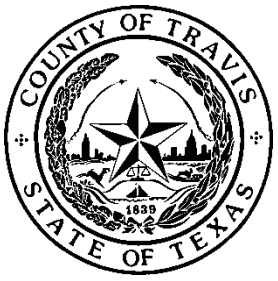


Figure F- 11: Karst Zones for All Areas of Study



Travis County Flood Mitigation Study

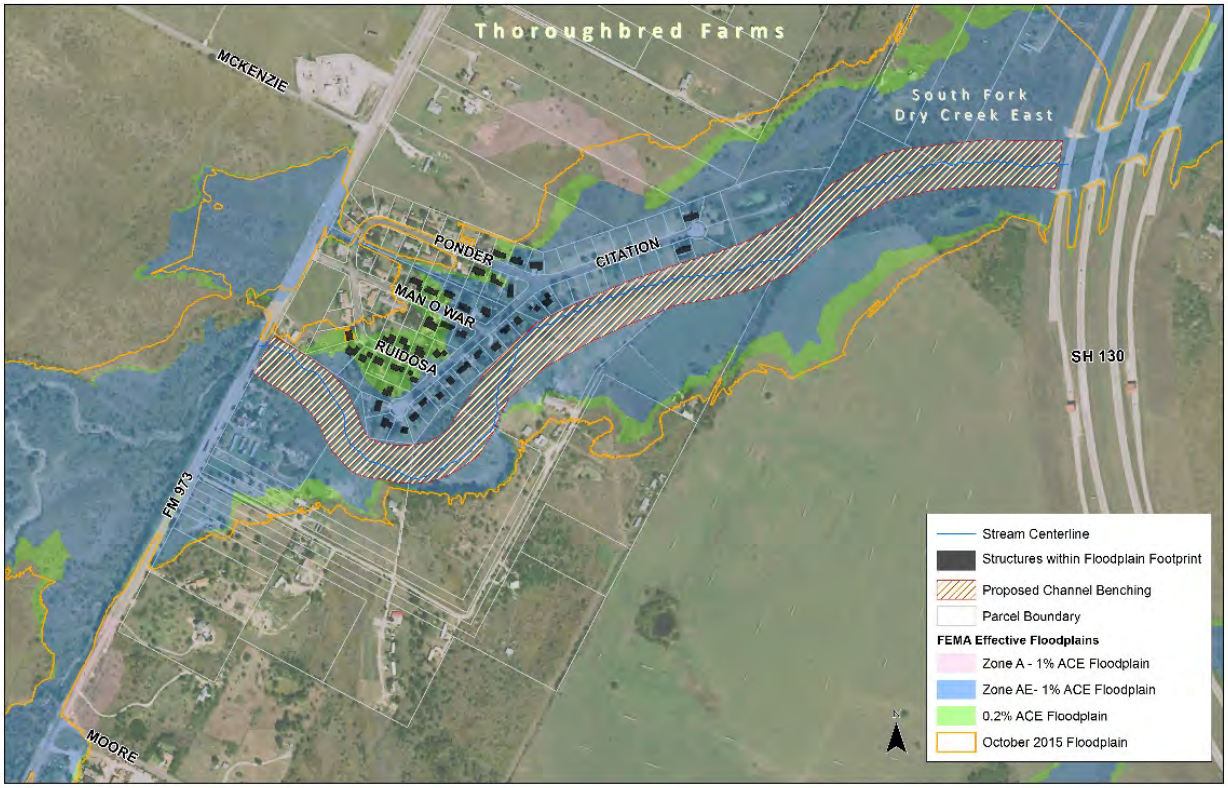
Appendix G: Project Fact Sheets and Scoring

TRAVIS COUNTY FLOOD MITIGATION PROJECTS

Thoroughbred Farms Channel Improvements

PROJECT
Watershed: Dry Creek East
Stream: South Fork Dry Creek East
Flooding Type: Riverine

LOCATION
Neighborhood: Thoroughbred Farms
Precinct: 4



PUBLIC SAFETY
Road Flooding and Mobility: All roadways considered unsafe
Emergency Access: No emergency access during Oct 2015 event
Number of Structures within 1% ACE Footprint: 23 Structures
Frequency Event of Structural Flooding: 4 Structures in the 20% ACE
Level of Service: Protects 15 of 20 from 1% ACE
Project Risk Reduction: Risk reduced
Downstream Mitigation: Channel improvements require mitigation

ECONOMIC IMPACT
Project Cost: Estimated $9.1M
Engineering Economics: Benefit to Cost Ratio = 0.1
Protection Economics: $600,000 per Structure
Sustainability O&M Schedule: Minimum of Bi-Annual Maintenance
Sustainability O&M Cost: Estimated $10,075 annual cost
Impact to County Tax Rolls: No impact
Funding Source: High cost and not grant eligible

PROJECT TIMING
Ease of Permitting: USACE 404 Nationwide expected
Time for Implementation: 3+ years
Land and Easement Acquisition: Requires property acquisition

SOCIAL IMPACT
Public Opinion: NA
Element of a Comprehensive Plan: NA

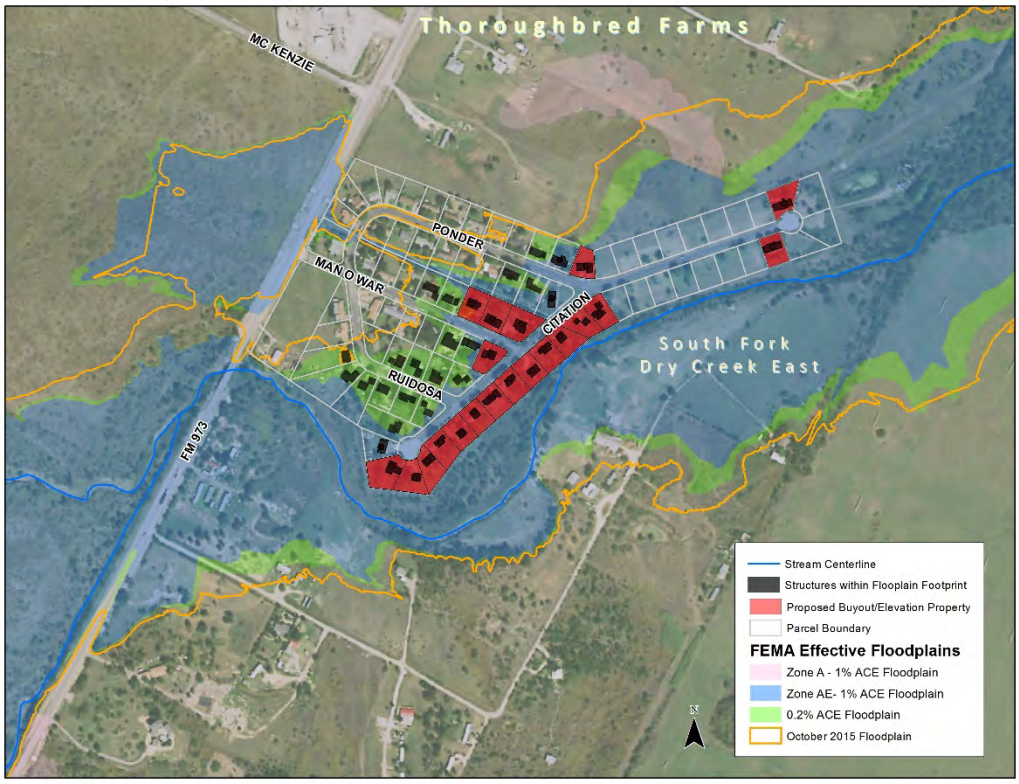
ENVIRONMENTAL IMPACT
Water Quality Significance: Potential stability issues when alter a natural system
Impact to Existing Environmental Features: Negative impact to riparian corridor and natural stability

TRAVIS COUNTY FLOOD MITIGATION PROJECTS

Thoroughbred Farms Buyout

PROJECT
Watershed: Dry Creek East
Stream: South Fork Dry Creek East
Flooding Type: Riverine

LOCATION
Neighborhood: Thoroughbred Farms
Precinct: 4



PUBLIC SAFETY
Road Flooding and Mobility: All roadways considered unsafe
Emergency Access: No emergency access during Oct 2015 event
Number of Structures within 1% ACE Footprint: 23 Structures
Frequency Event of Structural Flooding: 4 Structures in the 20% ACE
Level of Service: Protects 20 of 20 from 1% ACE
Project Risk Reduction: Risk removed
Downstream Mitigation: No mitigation

ECONOMIC IMPACT
Project Cost: Estimated $3.8M
Engineering Economics: Benefit to Cost Ratio = 1.48
Protection Economics: $190,000 per Structure
Sustainability O&M Schedule: Monthly Maintenance
Sustainability O&M Cost: Estimated $2,015 annual cost
Impact to County Tax Rolls: Loss of 20 Properties
Funding Source: Grant Eligible

PROJECT TIMING
Ease of Permitting: County permits only
Time for Implementation: 0-1 years
Land and Easement Acquisition: No acquisition

SOCIAL IMPACT
Public Opinion: NA
Element of a Comprehensive Plan: NA

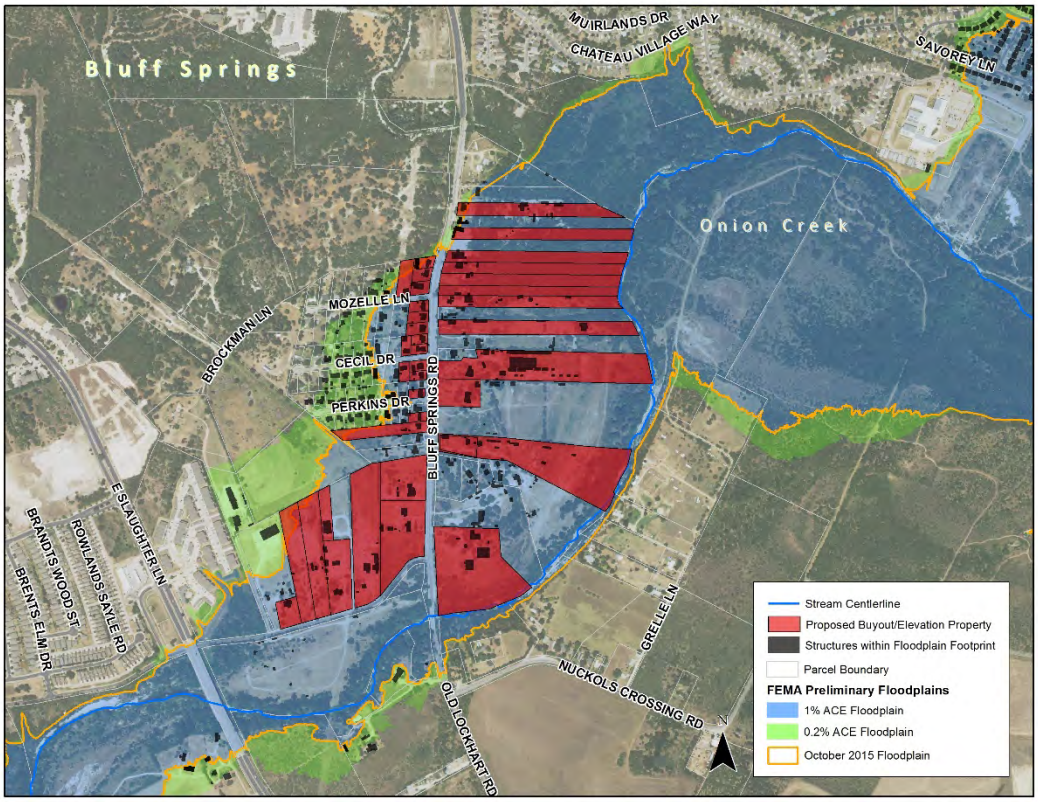
ENVIRONMENTAL IMPACT
Water Quality Significance: Positive impact with removal of impervious cover
Impact to Existing Environmental Features: Positive impact with added green space and no riparian impact

TRAVIS COUNTY FLOOD MITIGATION PROJECTS

Thoroughbred Farms Structural Elevation

PROJECT
Watershed: Dry Creek East
Stream: South Fork Dry Creek East
Flooding Type: Riverine

LOCATION
Neighborhood: Thoroughbred Farms
Precinct: 4



PUBLIC SAFETY
Road Flooding and Mobility: All roadways considered unsafe
Emergency Access: No emergency access during Oct 2015 event
Number of Structures within 1% ACE Footprint: 23 Structures
Frequency Event of Structural Flooding: 4 Structures in the 20% ACE
Level of Service: Protects 20 of 20 from 1% ACE
Project Risk Reduction: Risk reduced
Downstream Mitigation: No mitigation

ECONOMIC IMPACT
Project Cost: Estimated $2.4M
Engineering Economics: Benefit to Cost Ratio = 1.49
Protection Economics: $120,000 per Structure
Sustainability O&M Schedule: No O&M
Sustainability O&M Cost: No O&M
Impact to County Tax Rolls: No residential loss
Funding Source: Grant Eligible

PROJECT TIMING
Ease of Permitting: County permits only
Time for Implementation: 1-2 years
Land and Easement Acquisition: No acquisition

SOCIAL IMPACT
Public Opinion: NA
Element of a Comprehensive Plan: NA

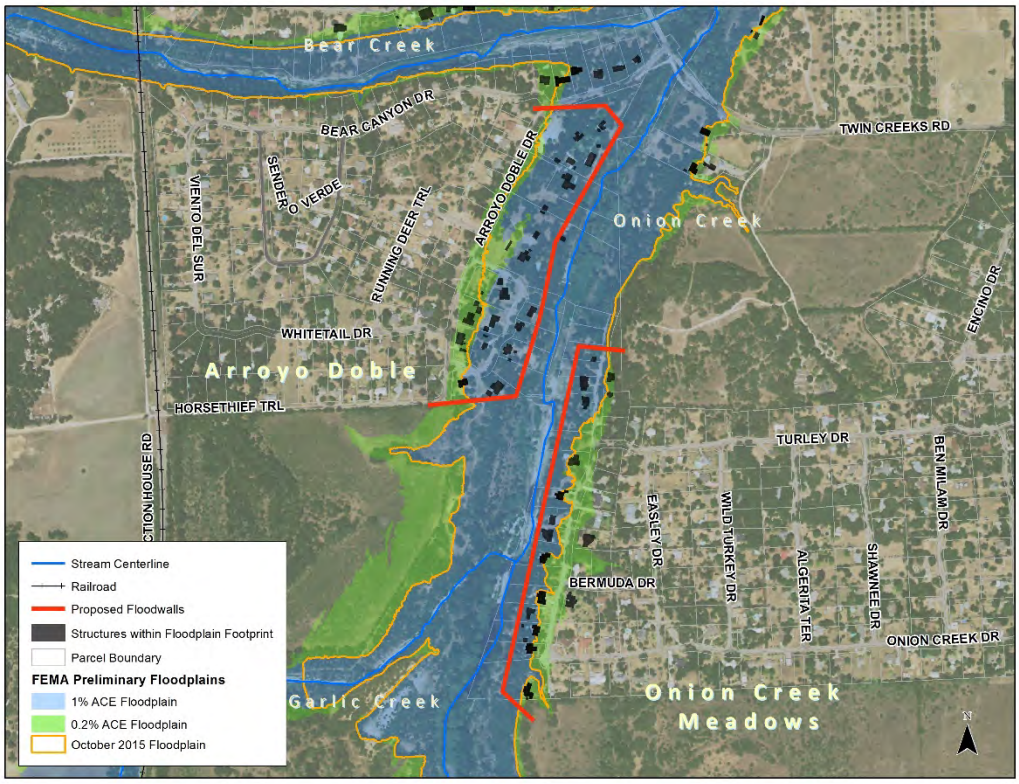
ENVIRONMENTAL IMPACT
Water Quality Significance: No impact
Impact to Existing Environmental Features: No impact

TRAVIS COUNTY FLOOD MITIGATION PROJECTS

Arroyo Doble & Onion Creek Meadows Floodwalls

PROJECT
Watershed: Onion Creek
Stream: Onion Creek
Flooding Type: Riverine

LOCATION
Neighborhood: Arroyo Doble & Onion Creek Meadows
Precinct: 3



PUBLIC SAFETY
Road Flooding and Mobility: Main roadways considered unsafe
Emergency Access: No access to AD, limited access to OCM
Number of Structures within 1% ACE Footprint: 27 Structures
Frequency Event of Structural Flooding: 8 Structures in the 2% ACE
Level of Service: Protects 11 of 15 from 1% ACE
Project Risk Reduction: Risk reduced
Downstream Mitigation: Floodwalls require mitigation

ECONOMIC IMPACT
Project Cost: Estimated $18.8M
Engineering Economics: Benefit to Cost Ratio = 0.01
Protection Economics: $1,709,090 per Structure
Sustainability O&M Schedule: Minimum of Bi-Annual Maintenance
Sustainability O&M Cost: Estimated $34,000 annual cost
Impact to County Tax Rolls: No impact
Funding Source: High cost and not grant eligible

PROJECT TIMING
Ease of Permitting: Requires floodwall accreditation
Time for Implementation: 5+ years
Land and Easement Acquisition: Requires condemnation

SOCIAL IMPACT
Public Opinion: NA
Element of a Comprehensive Plan: NA

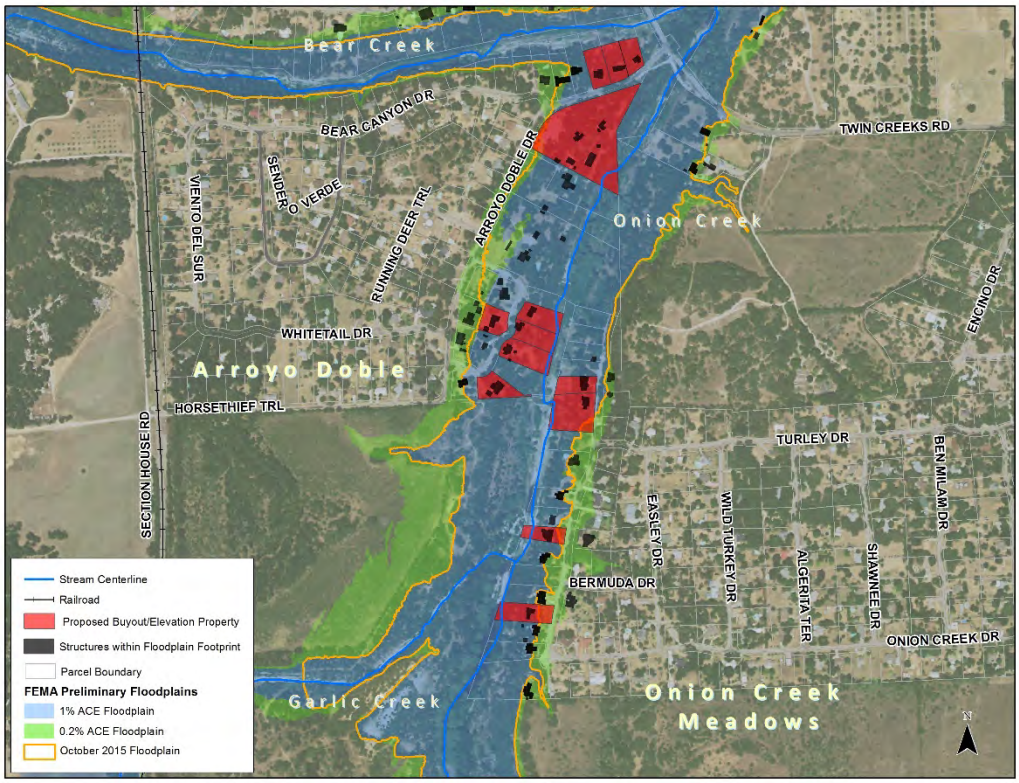
ENVIRONMENTAL IMPACT
Water Quality Significance: Confines channel and increases sediment loads
Impact to Existing Environmental Features: Moderate negative impact

TRAVIS COUNTY FLOOD MITIGATION PROJECTS

Arroyo Doble & Onion Creek Meadows Buyout

PROJECT
Watershed: Onion Creek
Stream: Onion Creek
Flooding Type: Riverine

LOCATION
Neighborhood: Arroyo Doble & Onion Creek Meadows
Precinct: 3



PUBLIC SAFETY
Road Flooding and Mobility: Main roadways are considered unsafe
Emergency Access: No access to AD, limited access to OCM
Number of Structures within 1% ACE Footprint: 27 Structures
Frequency Event of Structural Flooding: 8 Structures in the 2% ACE
Level of Service: Protects 15 of 15 from 1% ACE
Project Risk Reduction: Risk removed
Downstream Mitigation: No mitigation

ECONOMIC IMPACT
Project Cost: Estimated $10.2M
Engineering Economics: Benefit to Cost Ratio = 0.40
Protection Economics: $680,000 per Structure
Sustainability O&M Schedule: Monthly Maintenance
Sustainability O&M Cost: Estimated $28,000 annual cost
Impact to County Tax Rolls: Loss of 15 Properties
Funding Source: Not Grant Eligible

PROJECT TIMING
Ease of Permitting: County permits only
Time for Implementation: 0-1 years
Land and Easement Acquisition: No acquisition

SOCIAL IMPACT
Public Opinion: NA
Element of a Comprehensive Plan: NA

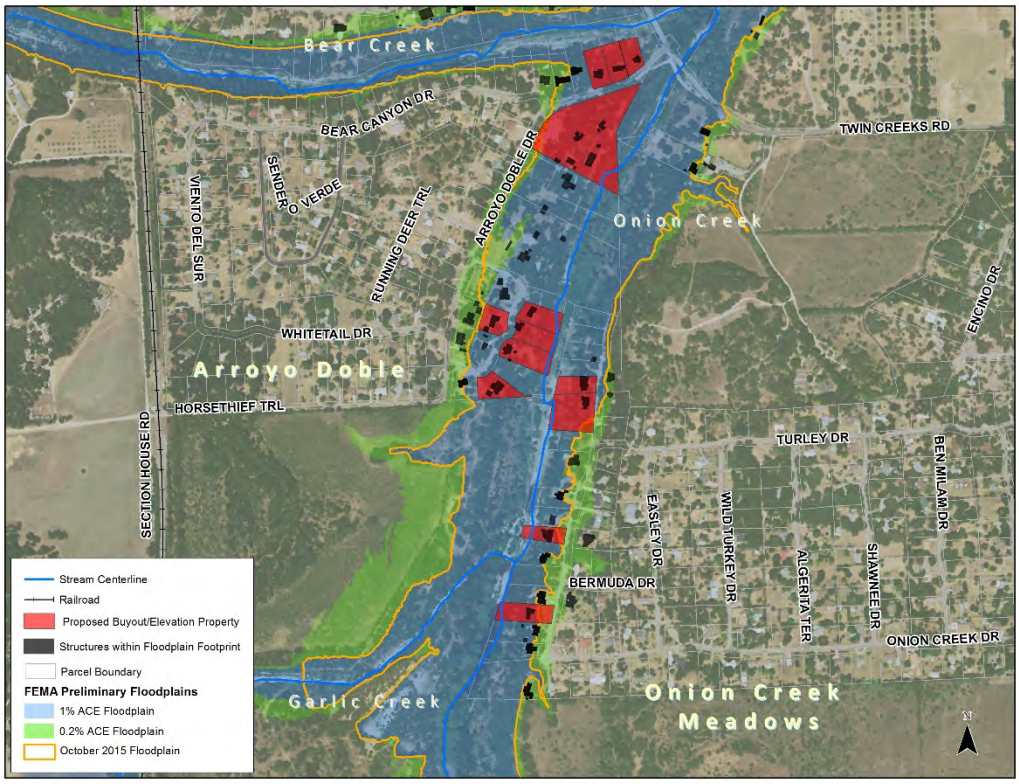
ENVIRONMENTAL IMPACT
Water Quality Significance: Positive impact with removal of impervious cover
Impact to Existing Environmental Features: Positive impact with added green space and no riparian impact

TRAVIS COUNTY FLOOD MITIGATION PROJECTS

Arroyo Doble & Onion Creek Meadows Elevation

PROJECT
Watershed: Onion Creek
Stream: Onion Creek
Flooding Type: Riverine

LOCATION
Neighborhood: Arroyo Doble & Onion Creek Meadows
Precinct: 3



PUBLIC SAFETY
Road Flooding and Mobility: Main roadways considered unsafe
Emergency Access: No access to south, limited to north
Number of Structures within 1% ACE Footprint: 27 Structures
Frequency Event of Structural Flooding: 8 Structures in the 2% ACE
Level of Service: Protects 15 of 15 from 1% ACE
Project Risk Reduction: Risk reduced
Downstream Mitigation: No mitigation

ECONOMIC IMPACT
Project Cost: Estimated $2.6M
Engineering Economics: Benefit to Cost Ratio = 0.1
Protection Economics: $173,333 per Structure
Sustainability O&M Schedule: No O&M
Sustainability O&M Cost: No O&M
Impact to County Tax Rolls: No residential loss
Funding Source: Not Grant Eligible

PROJECT TIMING
Ease of Permitting: County permits only
Time for Implementation: 1-2 years
Land and Easement Acquisition: No acquisition

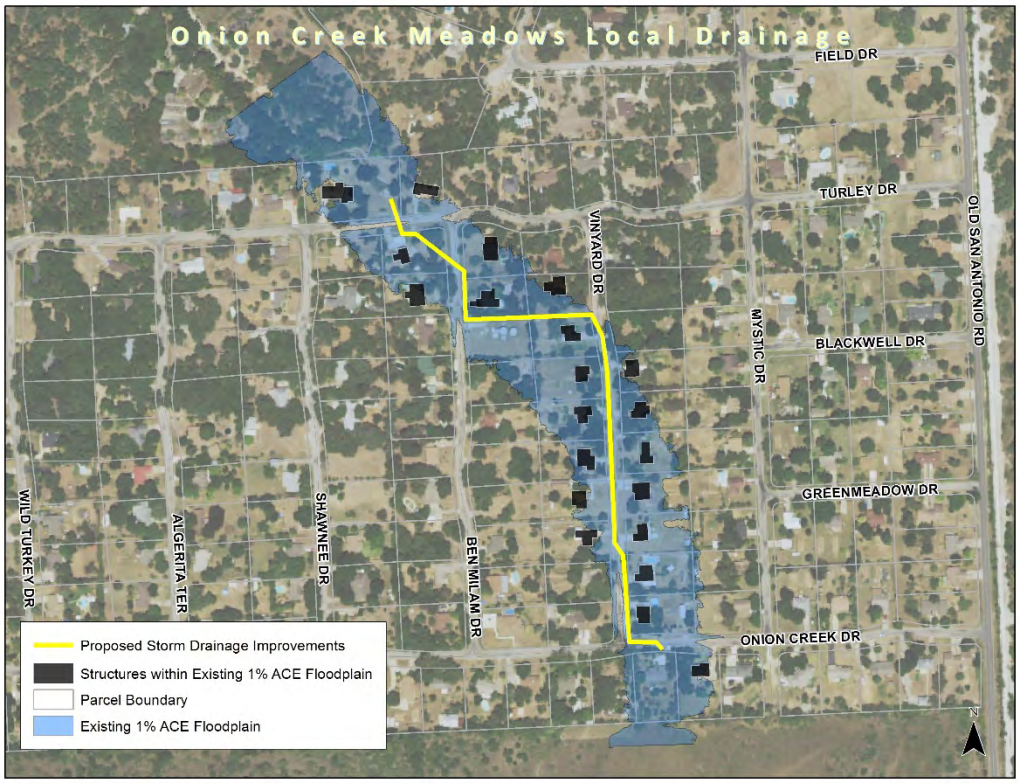
SOCIAL IMPACT
Public Opinion: NA
Element of a Comprehensive Plan: NA

ENVIRONMENTAL IMPACT
Water Quality Significance: No impact
Impact to Existing Environmental Features: No impact

Onion Creek Meadows Storm Drainage Improvements

PROJECT
Watershed: Onion Creek
Stream: Unnamed Tributary to Onion Creek
Flooding Type: Local

LOCATION
Neighborhood: Onion Creek Meadows
Precinct: 4



PUBLIC SAFETY
Road Flooding and Mobility: Local Roadway Flooding
Emergency Access: Multiple access points
Number of Structures within 1% ACE Footprint: 14 Structures
Frequency Event of Structural Flooding: 5 Structures in the 4% ACE
Level of Service: Protects 6 of 6 from 1% ACE
Project Risk Reduction: Risk reduced
Downstream Mitigation: Drainage improvements require mitigation

ECONOMIC IMPACT
Project Cost: Estimated $9.6M
Engineering Economics: Benefit to Cost Ratio = 0.12
Protection Economics: $1.6M per Structure
Sustainability O&M Schedule: Annual Inspection
Sustainability O&M Cost: Estimated $20,000 annual cost
Impact to County Tax Rolls: No impact
Funding Source: High cost and not grant eligible

PROJECT TIMING
Ease of Permitting: USACE 404 Nationwide expected
Time for Implementation: 3+ years
Land and Easement Acquisition: Requires property acquisition

SOCIAL IMPACT
Public Opinion: NA
Element of a Comprehensive Plan: NA

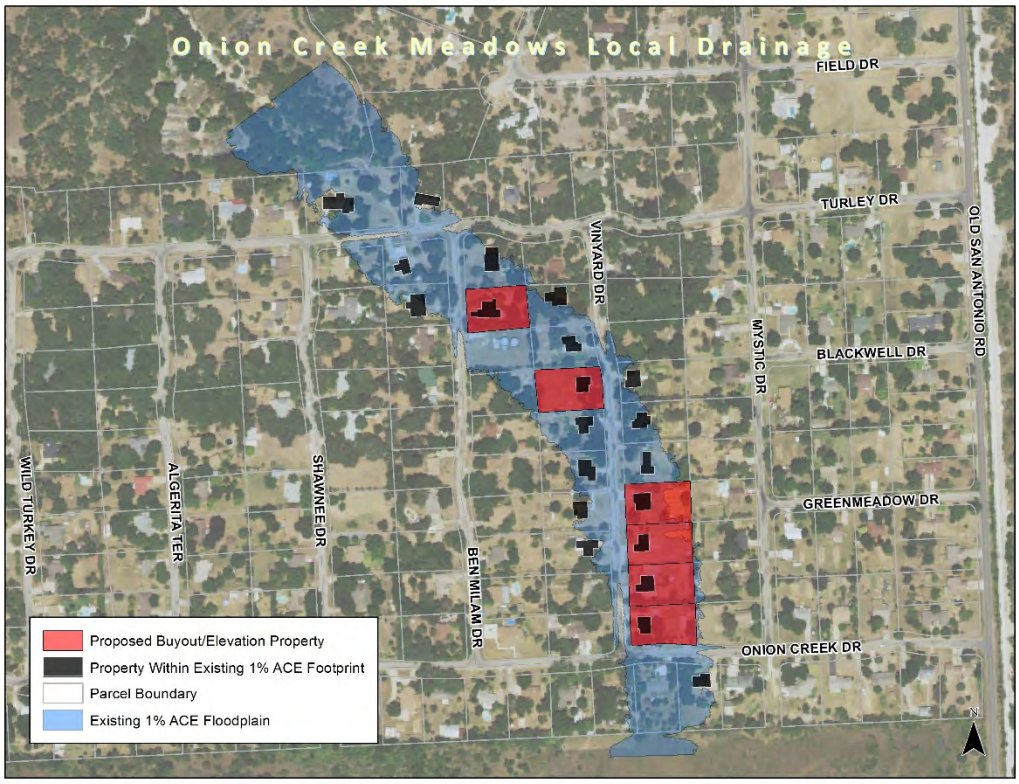
ENVIRONMENTAL IMPACT
Water Quality Significance: Minimal Negative Impact
Impact to Existing Environmental Features: Minimal Negative Impact

TRAVIS COUNTY FLOOD MITIGATION PROJECTS

Onion Creek Meadows Storm Local Buyouts

PROJECT
Watershed: Onion Creek
Stream: Unnamed Tributary to Onion Creek
Flooding Type: Local

LOCATION
Neighborhood: Onion Creek Meadows
Precinct: 4



PUBLIC SAFETY
Road Flooding and Mobility: Local roadway flooding
Emergency Access: Multiple access points
Number of Structures within 1% ACE Footprint: 14 Structures
Frequency Event of Structural Flooding: 5 Structures in the 4% ACE
Level of Service: Protects 6 of 6 from 1% ACE
Project Risk Reduction: Risk removed
Downstream Mitigation: No mitigation

ECONOMIC IMPACT
Project Cost: Estimated $3.4M
Engineering Economics: Benefit to Cost Ratio = 0.5
Protection Economics: $570,000 per Structure
Sustainability O&M Schedule: Monthly Maintenance
Sustainability O&M Cost: Estimated $1,100 annual cost
Impact to County Tax Rolls: Loss of 6 Properties
Funding Source: Not Grant Eligible

PROJECT TIMING
Ease of Permitting: County permits only
Time for Implementation: 0-1 years
Land and Easement Acquisition: No acquisition

SOCIAL IMPACT
Public Opinion: NA
Element of a Comprehensive Plan: NA

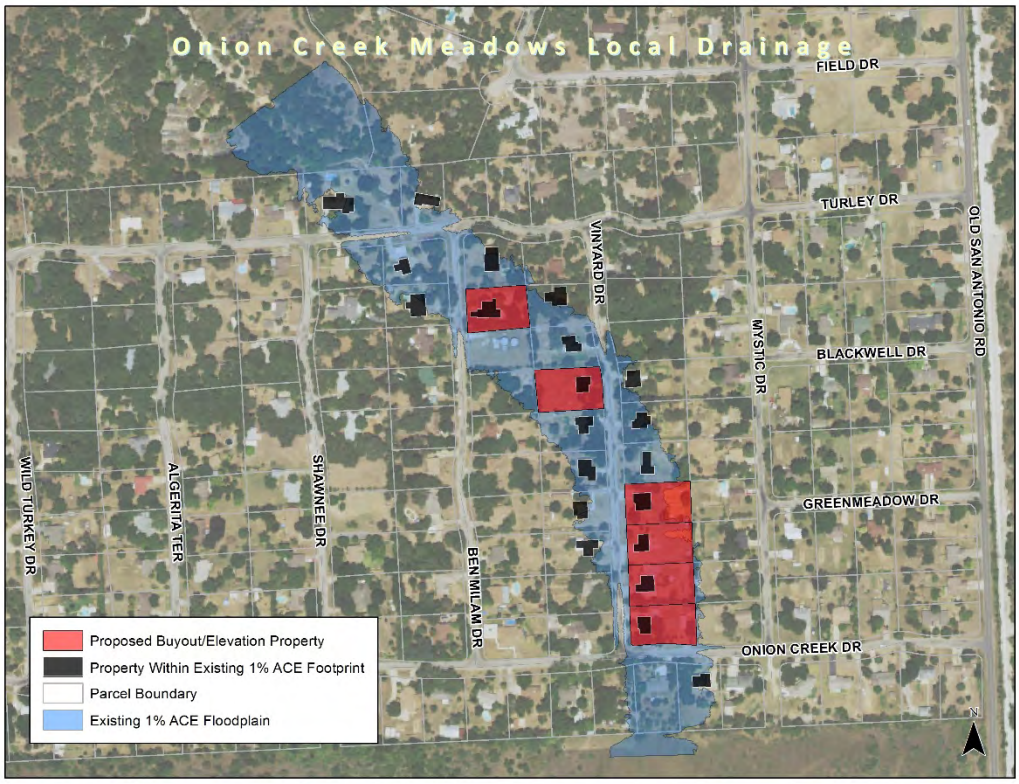
ENVIRONMENTAL IMPACT
Water Quality Significance: Positive impact with removal of impervious cover
Impact to Existing Environmental Features: Positive impact with added green space and no riparian impact

TRAVIS COUNTY FLOOD MITIGATION PROJECTS

Onion Creek Meadows Storm Local Elevation

PROJECT
Watershed: Onion Creek
Stream: Unnamed Tributary to Onion Creek
Flooding Type: Local

LOCATION
Neighborhood: Onion Creek Meadows
Precinct: 4



PUBLIC SAFETY
Road Flooding and Mobility: Local roadway flooding
Emergency Access: Multiple access points
Number of Structures within 1% ACE Footprint: 14 Structures
Frequency Event of Structural Flooding: 5 Structures in the 4% ACE
Level of Service: Protects 6 of 6 from 1% ACE
Project Risk Reduction: Risk reduced
Downstream Mitigation: No mitigation

ECONOMIC IMPACT
Project Cost: Estimated $845,100
Engineering Economics: Benefit to Cost Ratio = 1.51
Protection Economics: $141,000 per Structure
Sustainability O&M Schedule: No O&M
Sustainability O&M Cost: No O&M
Impact to County Tax Rolls: No residential loss
Funding Source: Grant Eligible

PROJECT TIMING
Ease of Permitting: County permits only
Time for Implementation: 1-2 years
Land and Easement Acquisition: No acquisition

SOCIAL IMPACT
Public Opinion: NA
Element of a Comprehensive Plan: NA

ENVIRONMENTAL IMPACT
Water Quality Significance: No impact
Impact to Existing Environmental Features: No impact

TRAVIS COUNTY FLOOD MITIGATION PROJECTS

Twin Creeks Buyout

PROJECT
Watershed: Onion Creek
Stream: Unnamed Tributary to Onion Creek
Flooding Type: Local

LOCATION
Neighborhood: Twin Creeks
Precinct: 3

PUBLIC SAFETY
Road Flooding and Mobility: Local roadway flooding
Emergency Access: Multiple access points
Number of Structures within 1% ACE Footprint: 1 Structure
Frequency Event of Structural Flooding: 1 Structure in the 2% ACE
Level of Service: Protects 1 of 1 from 1% ACE
Project Risk Reduction: Risk removed
Downstream Mitigation: No mitigation

ECONOMIC IMPACT
Project Cost: Estimated $200,000
Engineering Economics: Benefit to Cost Ratio = 1.0
Protection Economics: $200,000
Sustainability O&M Schedule: Monthly Maintenance
Sustainability O&M Cost: Estimated $325 annual cost
Impact to County Tax Rolls: Loss of 1 Property
Funding Source: Grant Eligible

PROJECT TIMING
Ease of Permitting: County permits only
Time for Implementation: 0-1 years
Land and Easement Acquisition: No acquisition

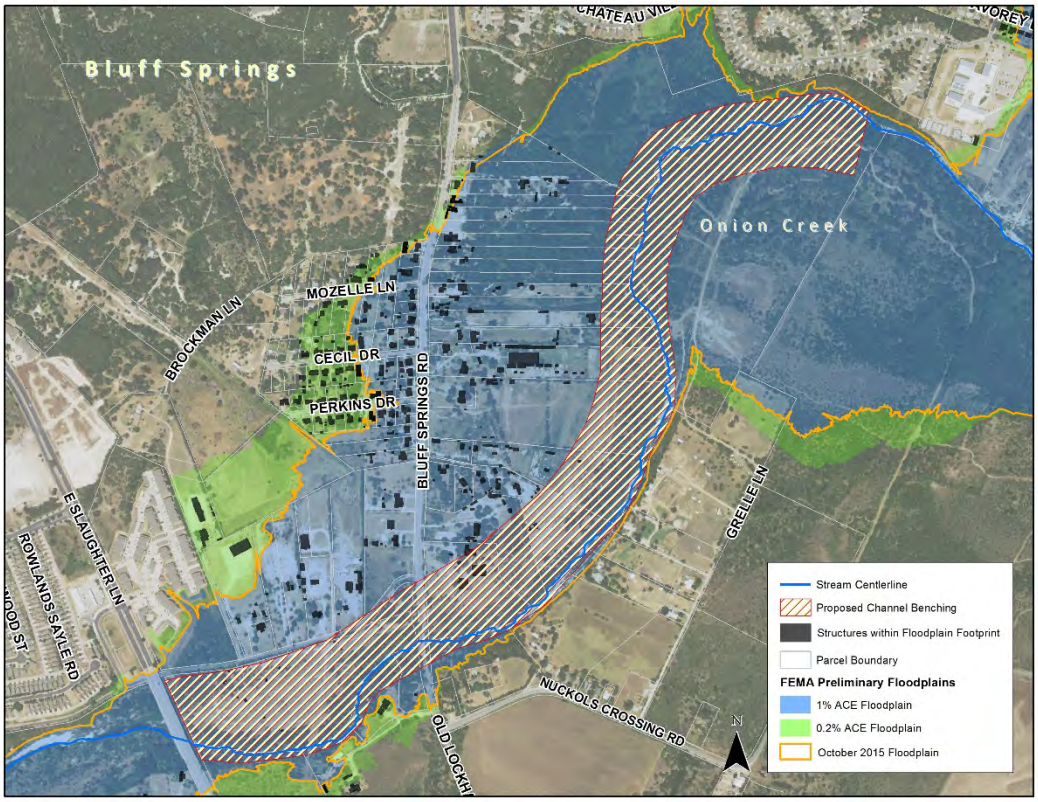
SOCIAL IMPACT
Public Opinion: NA
Element of a Comprehensive Plan: NA

ENVIRONMENTAL IMPACT
Water Quality Significance: Positive impact with removal of impervious cover
Impact to Existing Environmental Features: Positive impact with added green space and no riparian impact

Bluff Springs Channel Improvements

PROJECT
Watershed: Onion Creek
Stream: Onion Creek
Flooding Type: Riverine

LOCATION
Neighborhood: Bluff Springs
Precinct: 4



PUBLIC SAFETY
Road Flooding and Mobility: Main roadways considered unsafe
Emergency Access: No access to south, limited to north
Number of Structures within 1% ACE Footprint: 48 Structures
Frequency Event of Structural Flooding: 6 Structures in the 4% ACE
Level of Service: Protects 26 of 39 from 1% ACE
Project Risk Reduction: Risk reduced
Downstream Mitigation: Channel improvements require mitigation

ECONOMIC IMPACT
Project Cost: Estimated $64.8M
Engineering Economics: Benefit to Cost Ratio = 0.01
Protection Economics: $2,492,308 per Structure
Sustainability O&M Schedule: Minimum of Bi-Annual maintenance
Sustainability O&M Cost: Estimated $40,000 annual cost
Impact to County Tax Rolls: No impact
Funding Source: High cost and not grant eligible

PROJECT TIMING
Ease of Permitting: USACE 404 Nationwide expected
Time for Implementation: 3+ years
Land and Easement Acquisition: Requires property acquisition

SOCIAL IMPACT
Public Opinion: NA
Element of a Comprehensive Plan: NA

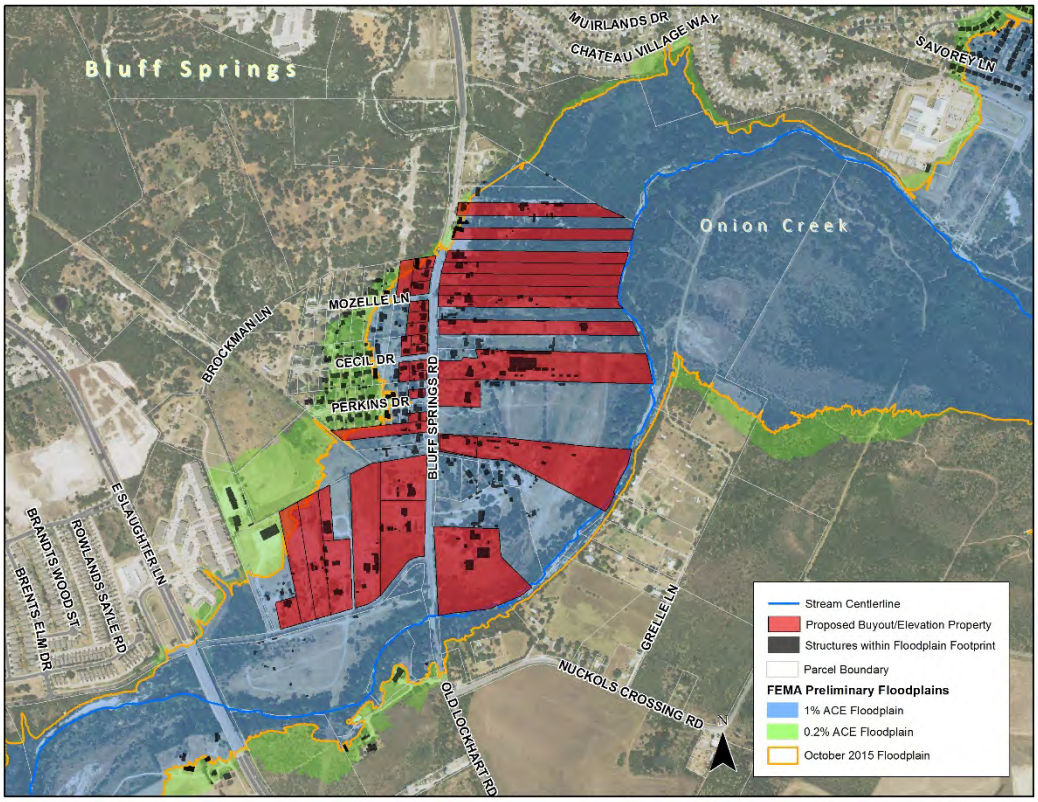
ENVIRONMENTAL IMPACT
Water Quality Significance: Potential stability issues when alter a natural system
Impact to Existing Environmental Features: Negative impact to riparian corridor and natural stability

TRAVIS COUNTY FLOOD MITIGATION PROJECTS

Bluff Springs Buyout

PROJECT
Watershed: Onion Creek
Stream: Onion Creek
Flooding Type: Riverine

LOCATION
Neighborhood: Bluff Springs
Precinct: 4



PUBLIC SAFETY
Road Flooding and Mobility: Main roadways considered unsafe
Emergency Access: No access to south, limited to north
Number of Structures within 1% ACE Footprint: 48 Structures
Frequency Event of Structural Flooding: 6 Structures in the 4% ACE
Level of Service: Protects 39 of 39 from 1% ACE
Project Risk Reduction: Risk removed
Downstream Mitigation: No mitigation

ECONOMIC IMPACT
Project Cost: Estimated $12.1M
Engineering Economics: Benefit to Cost Ratio = 0.88
Protection Economics: $320,512 per Structure
Sustainability O&M Schedule: Monthly Maintenance
Sustainability O&M Cost: Estimated $30,200 annual cost
Impact to County Tax Rolls: Loss of 26 Properties
Funding Source: Not Grant Eligible

PROJECT TIMING
Ease of Permitting: County permits only
Time for Implementation: 0-1 years
Land and Easement Acquisition: No acquisition

SOCIAL IMPACT
Public Opinion: NA
Element of a Comprehensive Plan: NA

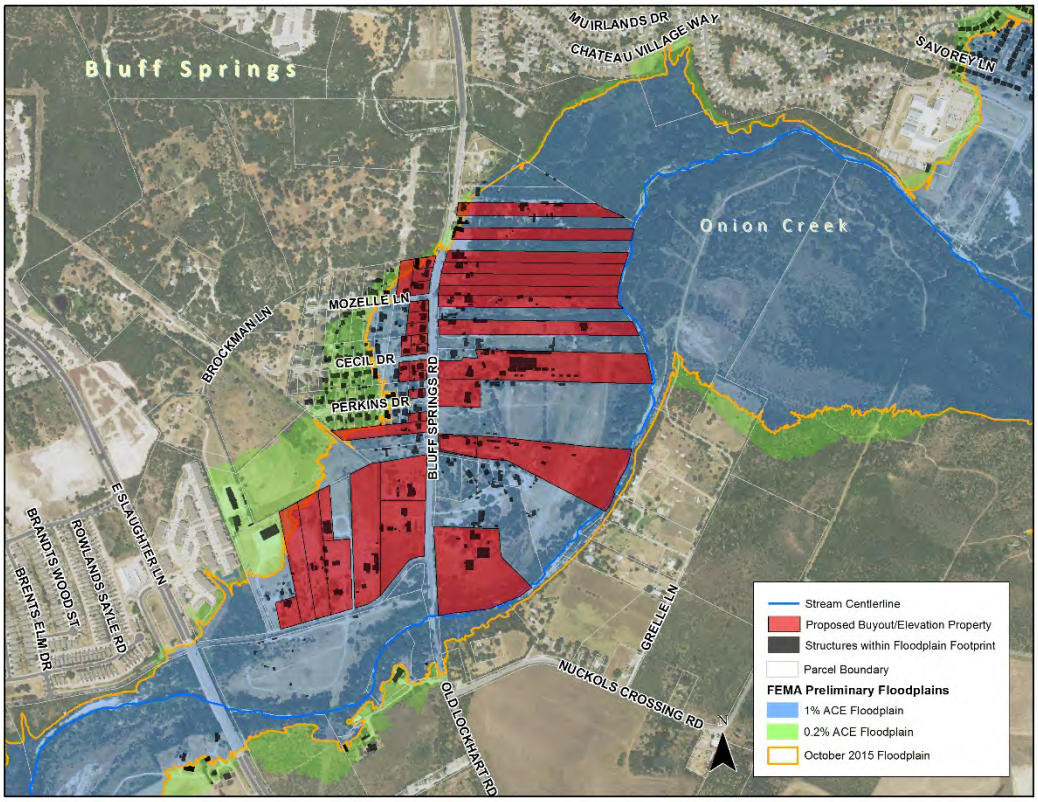
ENVIRONMENTAL IMPACT
Water Quality Significance: Positive impact with removal of impervious cover
Impact to Existing Environmental Features: Positive impact with added green space and no riparian impact

TRAVIS COUNTY FLOOD MITIGATION PROJECTS

Bluff Springs Elevation

PROJECT
Watershed: Onion Creek
Stream: Onion Creek
Flooding Type: Riverine

LOCATION
Neighborhood: Bluff Springs
Precinct: 4



PUBLIC SAFETY
Road Flooding and Mobility: Main roadways considered unsafe
Emergency Access: No access to south, limited to north
Number of Structures within 1% ACE Footprint: 48 Structures
Frequency Event of Structural Flooding: 6 Structures in the 4% ACE
Level of Service: Protects 39 of 39 from 1% ACE
Project Risk Reduction: Risk reduced
Downstream Mitigation: No mitigation

ECONOMIC IMPACT
Project Cost: Estimated $6.6M
Engineering Economics: Benefit to Cost Ratio = 1.03
Protection Economics: $170,000 per Structure
Sustainability O&M Schedule: No O&M
Sustainability O&M Cost: No O&M
Impact to County Tax Rolls: No residential loss
Funding Source: Grant Eligible

PROJECT TIMING
Ease of Permitting: County permits only
Time for Implementation: 1-2 years
Land and Easement Acquisition: No acquisition

SOCIAL IMPACT
Public Opinion: NA
Element of a Comprehensive Plan: NA

ENVIRONMENTAL IMPACT
Water Quality Significance: No impact
Impact to Existing Environmental Features: No impact

	"Objective" Category Weight	Sub Category Weight	"Attribute" Sub Category	Scoring	Thoroughbred Farms Channel Improvements	Thoroughbred Farms Channel Improvements Notes	Thoroughbred Farms Buyouts	Thoroughbred Farms Buyouts Notes	Thoroughbred Farms Elevations	Thoroughbred Farms Elevation Notes
Public Safety	***30***	3	Road Flooding and Mobility (Pre-Project Conditions)	1: Isolated Local Roadway Flooding 2: Collector Roadway Flooding 3: Moving water is likely to wash car off road*	3	FM 973 1% ACE is 1 ft over road = unsafe Citation 1% ACE is 3 ft over road = unsafe	3	FM 973 1% ACE is 1 ft over road = unsafe Citation 1% ACE is 3 ft over road = unsafe	3	FM 973 1% ACE is 1 ft over road = unsafe Citation 1% ACE is 3 ft over road = unsafe
		5	Emergency Access (Pre-Project Conditions)	1: Passable 2: Passable but response time increased 3: Impassable	3	Emergency responders were not able to access during Oct 2015 event	3	Emergency responders were not able to access during Oct 2015 event	3	Emergency responders were not able to access during Oct 2015 event
		9	Number of Structures within 1% ACE Footprint (Pre-Project Condition)	1: 0-15 flooded 2: 15-50 flooded 3: 50+ flooded or critical facility effected	2	23 Structures in the 1% ACE floodplain footprint	2	23 Structures in the 1% ACE floodplain footprint	2	23 Structures in the 1% ACE floodplain footprint
		3	Frequency Event of Structural Flooding (Pre-Project Condition)	1: ≥ 1% ACE 2: 4%- 1% ACE 3: ≤ 4% ACE	3	4 Structures in the 20% ACE floodplain by FFE	3	4 Structures in the 20% ACE floodplain by FFE	3	4 Structures in the 20% ACE floodplain by FFE
		5	Level of Service (Post-Project Protection)	1: ≤ 4 % ACE 2: 4% - 1 % ACE 3: ≥ 1 % ACE	1	Pulls 15 of 20 from 1% ACE floodplain by FFE 0.75 removal efficiency Pulls 4 of 5 from the 10% ACE floodplain by FFE	3	Pulls 20 of 20 from 1% ACE floodplain by FFE 1.0 removal efficiency Only structures in 0.2% ACE floodplain at risk	3	Pulls 20 of 20 from 1% ACE floodplain by FFE 1.0 removal efficiency Structures are still vulnerable to high velocity flood waters
		3	Project Risk Reduction (Post-Project Conditions)	1: Public Risk Remains 2: Public Risk Reduced 3: Public Risk Removed	2	Public Risk Reduced	3	Public Risk Removed	2	Public Risk Reduced
		2	Downstream Mitigation (estimated mitigation cost)	1: 15%+ of project costs 2: 1-15% of project cost 3: No mitigation need for downstream impacts	2	Channel improvements increase downstream WSEL and Volume. Requires mitigation.	3	No mitigation	3	No mitigation
			Category Total Score		***66***		***81***		***78***	
Social	***15***	5	Public Opinion (Neighborhood Surveys from Public Meetings)	1: Least Favorable 2: Neutral 3: Most Favorable	2	No survey for this project, but will be used in future projects.	2	No survey for this project, but will be used in future projects.	2	No survey for this project, but will be used in future projects.
		10	Element of a Comprehensive Plan (Parks, Transportation, Planning, HMGP etc.)	1: No elements in other plans 2: Related to elements in other plans 3: Multiple elements other plan	1	Not currently related to a comprehensive plan	1	Not currently related to a comprehensive plan	1	Not currently related to a comprehensive plan
			Category Total Score		***20***		***20***		***20***	
Economic	***25***	3	Project Cost	1: ≥ 15 Million 2: $5 - 15 Million 3: ≤ $5 Million	2	Estimated $9.1M	3	Estimated $3.8M	3	Estimated $2.4M
		5	Engineering Economics (benefit/cost relationship)	1: B/C < 1.0 2: 1.0-2.0 B/C 3: B/C > 2	1	BCR = 0.1	2	BCR = 1.48	2	BCR = 1.49
		7	Protection Economics (cost/removed structures relationship)	1: C/S >$400K 2: $200K - $400K C/S 3: C/S < $200K	1	$9M / 15 structures = $600,000/ Structure	3	$3.8 / 20 structures = $190,000/structure	3	$2.4M/ 20 Structures= $120,000/Structure
		3	Sustainability O&M Schedule (operation & maintenance)	1: Monthly maintenance 2: Bi-Annual maintenance 3: Annual + maintenance	2	Minimum of Bi Annual Maintenance	1	Lot maintenance of purchased land	3	No county O&M required
		3	Sustainability O&M Cost (estimated annual cost)	1: O&M > $4K 2: $2K - $4K O&M 3: O&M Costs < $2K	1	Mowing of ~31 Acres of channel improvements Medium Terrain Mowing estimated at $325 per Acre per year Cost=31 Acres * $325 = $10,075	2	Lot maintenance of 6.2 Acres of purchased land Medium Terrain Mowing estimated at $325 per Acre per year Cost=6.2 Acres * $325 = $2,015	3	No O&M Costs to County. Responsibility of Property Owner.
		2	Impact to County Tax Rolls	1: Decrease 2: No Impact 3: Increase	2	No loss of residential properties. Minor ROW losses	1	Removal of 20 residential structures. LMI	2	No impact
		2	Funding Source	1: County Funded 3: Grant Funded	1	High cost and not grant eligible	3	Positive BCA is grant eligible.	3	Positive BCA is grant eligible.
			Category Total Score		***33***		***57***		***68***	
Environmental	***20***	10	Water Quality Significance (MS4)	1: Negative Impact 2: No impact 3: Positive Impact	2	Potential stability issues when adjust a natural system.	3	Positive Impact - Removal of impervious cover	2	No Impact
		10	Impact to Existing Environmental Features (i.e. Riparian Corridor, Habitat, etc.)	1: Significant Negative Impact 2: Moderate Negative Impact 3: No Impact / Positive Impact	1	Negative impact to riparian corridor and natural stability	3	Structures will be removed	3	No impact
			Category Total Score		***30***		***60***		***50***	
Project Timing	***10***	4	Ease of Permitting	1: Multi-jurisdiction more permits 2: Local permit with variances/Nationwide 3: Limited local permits	2	Nationwide b/c channel improvements are above OHWM. Do not think wetland issue here.	3	County Level Demolition permits	3	County Level Building Permits
		2	Time for Implementation	1: ≥ 2 Years 2: 1 - 2 Years 3: 0 - 1 Years	1	Design, Permitting and Construction expected to be 3+ years	3	0-1 year	2	1-2 year
		4	Land and Easement Acquisition	1: Condemnation required 2: Purchase necessary 3: No additional acquisition required	2	County does not own easement or ROW	3	Voluntary Buyouts but no other land necessary	3	No purchase
			Category Total Score		***18***		***30***		***28***	
				Score	**167**		**248**		**244**	

	"Objective" Category Weight	Sub Category Weight	"Attribute" Sub Category	Scoring	Arroyo Doble & Onion Creek Meadows Floodwall	Arroyo Doble & Onion Creek Meadows Floodwall Notes	Arroyo Doble & Onion Creek Meadows Buyouts	Arroyo Doble & Onion Creek Meadows Buyouts Notes	Arroyo Doble & Onion Creek Meadows Elevations	Arroyo Doble & Onion Creek Meadows Elevation Notes
Public Safety	***30***	3	Road Flooding and Mobility (Pre-Project Conditions)	1: Isolated Local Roadway Flooding 2: Collector Roadway Flooding 3: Moving water is likely to wash car off road*	3	Twin Creeks Road 1% ACE is 4.6 ft over road = unsafe	3	Twin Creeks Road 1% ACE is 4.6 ft over road = unsafe	3	Twin Creeks Road 1% ACE is 4.6 ft over road = unsafe
		5	Emergency Access (Pre-Project Conditions)	1: Passable 2: Passable but response time increased 3: Impassable	3	Arroyo Doble cut off; Onion Creek Meadows may be accessed from another spot	3	Arroyo Doble cut off; Onion Creek Meadows may be accessed from another spot	3	Arroyo Doble cut off; Onion Creek Meadows may be accessed from another spot
		9	Number of Structures within 1% ACE Footprint (Pre-Project Condition)	1: 0-15 flooded 2: 15-50 flooded 3: 50+ flooded or critical facility effected	2	27 Structures in the 1% ACE floodplain footprint	2	27 Structures in the 1% ACE floodplain footprint	2	27 Structures in the 1% ACE floodplain footprint
		3	Frequency Event of Structural Flooding (Pre-Project Condition)	1: ≥ 1% ACE 2: 4%- 1% ACE 3: ≤ 4% ACE	2	8 Structures in the 2% ACE floodplain by FFE	2	8 Structures in the 2% ACE floodplain by FFE	2	8 Structures in the 2% ACE floodplain by FFE
		5	Level of Service (Post-Project Protection)	1: ≤ 4 % ACE 2: 4% - 1 % ACE 3: ≥ 1 % ACE	2	Pulls 11 of 15 from 1% ACE floodplain by FFE 0.73 removal efficiency 0.2% ACE overtops walls	3	Pulls 15 of 15 from 1% ACE floodplain footprint 1.0 removal efficiency Only structures in 0.2% ACE floodplain at risk	3	Pulls 15 of 15 from 1% ACE floodplain footprint 1.0 removal efficiency Only structures in 0.2% ACE floodplain at risk
		3	Project Risk Reduction (Post-Project Conditions)	1: Public Risk Remains 2: Public Risk Reduced 3: Public Risk Removed	2	Public Risk Reduced	3	Public Risk Removed	2	Public Risk Reduced
		2	Downstream Mitigation (estimated mitigation cost)	1: 15%+ of project costs 2: 1-15% of project cost 3: No mitigation need for downstream impacts	1	WSE rises downstream of walls	3	No mitigation	3	No mitigation
			Category Total Score		***66***		***78***		***75***	
Social	***15***	5	Public Opinion (Neighborhood Surveys from Public Meetings)	1: Least Favorable 2: Neutral 3: Most Favorable	2	No survey for this project, but will be used in future projects.	2	No survey for this project, but will be used in future projects.	2	No survey for this project, but will be used in future projects.
		10	Element of a Comprehensive Plan (Parks, Transportation, Planning, HMGP etc.)	1: No elements in other plans 2: Related to elements in other plans 3: Multiple elements other plan	1	Not currently related to a comprehensive plan	1	Not currently related to a comprehensive plan	1	Not currently related to a comprehensive plan
			Category Total Score		***20***		***20***		***20***	
Economic	***25***	3	Project Cost	1: ≥ 15 Million 2: $5 - 15 Million 3: ≤ $5 Million	1	Estimated $18.8M	2	Estimated $10.2M	3	Estimated $2.6M
		5	Engineering Economics (benefit/cost relationship)	1: B/C < 1.0 2: 1.0-2.0 B/C 3: B/C > 2	1	Combined BCR = 0.01	1	BCR = 0.40	1	BCR = 0.995
		7	Protection Economics (cost/removed structures relationship)	1: C/S >$400K 2: $200K - $400K C/S 3: C/S < $200K	1	$18.8M / 11 structures = $1,709,090/ Structure	1	$10.2M / 15 structures = $680,000/ Structure	3	$2.6M / 15 structures = $173,333 per structure
		3	Sustainability O&M Schedule (operation & maintenance)	1: Monthly maintenance 2: Bi-Annual maintenance 3: Annual + maintenance	2	Minimum of Bi Annual Maintenance	1	Lot maintenance of purchased land	3	No county O&M required
		3	Sustainability O&M Cost (estimated annual cost)	1: O&M > $4K 2: $2K - $4K O&M 3: O&M Costs < $2K	1	Mowing and Annual inspection and maintenance Mowing estimated at $325 per Acre per year+ LS inspection Cost= 43Acres * $325 + $20K = $34K	1	Lot maintenance of ~25 Acres of purchased land Medium Terrain Mowing estimated at $325 per Acre per year Cost= 25Acres * $325 = $28K	3	No O&M Costs to County. Responsibility of Property Owner.
		2	Impact to County Tax Rolls	1: Decrease 2: No Impact 3: Increase	2	No Impact. Blocked river views negative impact on tax value but no floodplain offsets.	1	Removal of 15 residential structures. More expensive structures	2	No impact
		2	Funding Source	1: County Funded 3: Grant Funded	1	High cost and not grant eligible	1	Not grant eligible	1	Not grant eligible
			Category Total Score		***30***		***28***		***59***	
Environmental	***20***	10	Water Quality Significance (MS4)	1: Negative Impact 2: No impact 3: Positive Impact	1	Confines channel increases sediment loads.	3	Positive Impact - Removal of impervious cover	2	No impact
		10	Impact to Existing Environmental Features (i.e. Riparian Corridor, Habitat, etc.)	1: Significant Negative Impact 2: Moderate Negative Impact 3: No Impact / Positive Impact	2	Less impact to riparian corridor	3	Structures will be removed	3	No impact
			Category Total Score		***30***		***60***		***50***	
Project Timing	***10***	4	Ease of Permitting	1: Multi-jurisdiction more permits 2: Local permit with variances/Nationwide 3: Limited local permits	1	Floodwall accreditation	3	County Level Demolition permits	3	County Level Building Permits
		2	Time for Implementation	1: ≥ 2 Years 2: 1 - 2 Years 3: 0 - 1 Years	1	Design, Permitting and Construction expected to be 5+ years	3	0-1 years	2	1-2 year
		4	Land and Easement Acquisition	1: Condemnation required 2: Purchase necessary 3: No additional acquisition required	1	Construction of a wall will require condemnation.	3	Voluntary Buyouts but no other land necessary	3	No purchase
			Category Total Score		***10***		***30***		***28***	
				Score	**156**		**216**		**232**	

	"Objective" Category Weight	Sub Category Weight	"Attribute" Sub Category	Scoring	Onion Creek Meadows Storm Drainage Improvements	Onion Creek Meadows Storm Drainage Improvements Notes	Onion Creek Meadows Storm Local Buyouts	Onion Creek Meadows Storm Local Buyouts Notes	Onion Creek Meadows Storm Local Elevations	Onion Creek Meadows Storm Local Elevation Notes
Public Safety	***30***	3	Road Flooding and Mobility (Pre-Project Conditions)	1: Isolated Local Roadway Flooding 2: Collector Roadway Flooding 3: Moving water is likely to wash car off road*	1	Roadway is mostly dry at 650 ft but homes on both sides of street experience flooding	1	Roadway is mostly dry at 650 ft but homes on both sides of street experience flooding	1	Roadway is mostly dry at 650 ft but homes on both sides of street experience flooding
		5	Emergency Access (Pre-Project Conditions)	1: Passable 2: Passable but response time increased 3: Impassable	2	Multiple access points to the neighborhood	2	Multiple access points to the neighborhood	2	Multiple access points to the neighborhood
		9	Number of Structures within 1% ACE Footprint (Pre-Project Condition)	1: 0-15 flooded 2: 15-50 flooded 3: 50+ flooded or critical facility effected	1	14 Structures in the 1% ACE floodplain footprint	1	14 Structures in the 1% ACE floodplain footprint	1	14 Structures in the 1% ACE floodplain footprint
		3	Frequency Event of Structural Flooding (Pre-Project Condition)	1: ≥ 1% ACE 2: 4%- 1% ACE 3: ≤ 4% ACE	3	5 Structures in the 4% ACE floodplain by FFE	3	5 Structures in the 4% ACE floodplain by FFE	3	5 Structures in the 4% ACE floodplain by FFE
		5	Level of Service (Post-Project Protection)	1: ≤ 4 % ACE 2: 4% - 1 % ACE 3: ≥ 1 % ACE	3	Pulls 6 of 6 from 1% ACE floodplain by FFE 1.0 removal efficiency Pulls 4 of 9 from the 0.2% ACE floodplain by FFE	3	Pulls 6 of 6 from 1% ACE floodplain by FFE 1.0 removal efficiency Structures permanently removed from risk; Only structures in 0.2% ACE floodplain and beyond at risk	3	Pulls 6 of 6 from 1% ACE floodplain by FFE 1.0 removal efficiency
		3	Project Risk Reduction (Post-Project Conditions)	1: Public Risk Remains 2: Public Risk Reduced 3: Public Risk Removed	2	Public Risk Reduced	3	Public Risk Removed	2	Public Risk Reduced
		2	Downstream Mitigation (estimated mitigation cost)	1: 15%+ of project costs 2: 1-15% of project cost 3: No mitigation need for downstream impacts	2	Need to evaluate further but may slightly increase runoff locally but not in Onion Creek.	3	No mitigation	3	No mitigation
			Category Total Score		***56***		***61***		***58***	
Social	***15***	5	Public Opinion (Neighborhood Surveys from Public Meetings)	1: Least Favorable 2: Neutral 3: Most Favorable	2	No survey for this project, but will be used in future projects.	2	No survey for this project, but will be used in future projects.	2	No survey for this project, but will be used in future projects.
		10	Element of a Comprehensive Plan (Parks, Transportation, Planning, HMGP etc.)	1: No elements in other plans 2: Related to elements in other plans 3: Multiple elements other plan	1	Not currently related to a comprehensive plan	1	Not currently related to a comprehensive plan	1	Not currently related to a comprehensive plan
			Category Total Score		***20***		***20***		***20***	
Economic	***25***	3	Project Cost	1: ≥ 15 Million 2: $5 - 15 Million 3: ≤ $5 Million	2	Estimated $9.6M	3	Estimated $3.4M	3	Estimate $845,100
		5	Engineering Economics (benefit/cost relationship)	1: B/C < 1.0 2: 1.0-2.0 B/C 3: B/C > 2	1	BCR = 0.12	3	BCR = 0.50	2	BCR = 1.51
		7	Protection Economics (cost/removed structures relationship)	1: C/S >$400K 2: $200K - $400K C/S 3: C/S < $200K	1	$9.6M / 6 structures = $1.6M	1	$3.4M / 6 structures = $570,000	3	$845,100 / 6 structures = $141,000
		3	Sustainability O&M Schedule (operation & maintenance)	1: Monthly maintenance 2: Bi-Annual maintenance 3: Annual + maintenance	3	Annual Inspection	1	Lot maintenance of purchased land	3	No county O&M required
		3	Sustainability O&M Cost (estimated annual cost)	1: O&M > $4K 2: $2K - $4K O&M 3: O&M Costs < $2K	1	Annual Inspection of Improvements Estimated Lump Sum Amount Cost=$20K	3	Lot maintenance of ~3.4Acres of purchased land Medium Terrain Mowing estimated at $325 per Acre per year Cost=3.4 Acres * $325 = $1,100	3	No O&M Costs to County. Responsibility of Property Owner.
		2	Impact to County Tax Rolls	1: Decrease 2: No Impact 3: Increase	2	No loss of residential properties. Minor ROW losses	2	Removal of 6 residential structures	2	No impact
		2	Funding Source	1: County Funded 3: Grant Funded	1	High cost and not grant eligible	1	Not grant eligible	3	Positive BCA is grant eligible.
			Category Total Score		***36***		***49***		***68***	
Environmental	***20***	10	Water Quality Significance (MS4)	1: Negative Impact 2: No impact 3: Positive Impact	1	Currently project does not include WQ BMPs. Current system provides WQ through open systems.	3	Positive Impact - Removal of impervious cover	2	No Impact
		10	Impact to Existing Environmental Features (i.e. Riparian Corridor, Habitat, etc.)	1: Significant Negative Impact 2: Moderate Negative Impact 3: No Impact / Positive Impact	2	Less environmental impact	3	Structures will be removed	3	No impact
			Category Total Score		***30***		***60***		***50***	
Project Timing	***10***	4	Ease of Permitting	1: Multi-jurisdiction more permits 2: Local permit with variances/Nationwide 3: Limited local permits	3	County Level permits as long as not wetlands in area.	3	County Level Demolition permits	3	County Level Building Permits
		2	Time for Implementation	1: ≥ 2 Years 2: 1 - 2 Years 3: 0 - 1 Years	3	Design, Permitting and Construction expected to be 3+ years	3	0-1 years	2	1-2 year
		4	Land and Easement Acquisition	1: Condemnation required 2: Purchase necessary 3: No additional acquisition required	2	County does not own easement or ROW	3	Voluntary Buyouts but no other land necessary	3	No purchase
			Category Total Score		***26***		***30***		***28***	
				Score	**168**		**220**		**224**	

	"Objective" Category Weight	Sub Category Weight	"Attribute" Sub Category	Scoring	Twin Creeks Buyouts	Twin Creeks Buyouts Notes
Public Safety	***30***	3	Road Flooding and Mobility (Pre-Project Conditions)	1: Isolated Local Roadway Flooding 2: Collector Roadway Flooding 3: Moving water is likely to wash car off road*	1	Flooding of Hickory Ridge Road
		5	Emergency Access (Pre-Project Conditions)	1: Passable 2: Passable but response time increased 3: Impassable	2	Multiple access points to the neighborhood
		9	Number of Structures within 1% ACE Footprint (Pre-Project Condition)	1: 0-15 flooded 2: 15-50 flooded 3: 50+ flooded or critical facility effected	1	1 Structures in the 1% ACE floodplain footprint
		3	Frequency Event of Structural Flooding (Pre-Project Condition)	1: ≥ 1% ACE 2: 4%- 1% ACE 3: ≤ 4% ACE	2	1 Structures in the 2% ACE floodplain by FFE
		5	Level of Service (Post-Project Protection)	1: ≤ 4 % ACE 2: 4% - 1 % ACE 3: ≥ 1 % ACE	3	Pulls 1 of 1 from 1% ACE floodplain by FFE 1.0 removal efficiency
		3	Project Risk Reduction (Post-Project Conditions)	1: Public Risk Remains 2: Public Risk Reduced 3: Public Risk Removed	1	Public Risk Remains
		2	Downstream Mitigation (estimated mitigation cost)	1: 15%+ of project costs 2: 1-15% of project cost 3: No mitigation need for downstream impacts	3	No mitigation
			Category Total Score		***52***	
Social	***15***	5	Public Opinion (Neighborhood Surveys from Public Meetings)	1: Least Favorable 2: Neutral 3: Most Favorable	2	No survey for this project, but will be used in future projects.
		10	Element of a Comprehensive Plan (Parks, Transportation, Planning, HMGP etc.)	1: No elements in other plans 2: Related to elements in other plans 3: Multiple elements other plan	1	Not related to other comprehensive plan but could be connected to existing parks
			Category Total Score		***20***	
Economic	***25***	3	Project Cost	1: ≥ 15 Million 2: $5 - 15 Million 3: ≤ $5 Million	3	Estimated $200,000
		5	Engineering Economics (benefit/cost relationship)	1: B/C < 1.0 2: 1.0-2.0 B/C 3: B/C > 2	2	BCR = 1.38
		7	Protection Economics (cost/removed structures relationship)	1: C/S >$400K 2: $200K - $400K C/S 3: C/S < $200K	3	$200,000 / 1 structures = $200,000
		3	Sustainability O&M Schedule (operation & maintenance)	1: Monthly maintenance 2: Bi-Annual maintenance 3: Annual + maintenance	1	Lot maintenance of purchased land
		3	Sustainability O&M Cost (estimated annual cost)	1: O&M > $4K 2: $2K - $4K O&M 3: O&M Costs < $2K	1	Lot maintenance of ~1 Acres of purchased land Medium Terrain Mowing estimated at $325 per Acre per year Cost= 1 Acres * $325 = $325
		2	Impact to County Tax Rolls	1: Decrease 2: No Impact 3: Increase	1	Removal of 26 residential structures based on FFE
		2	Funding Source	1: County Funded 3: Grant Funded	3	Grant Eligible
			Category Total Score		***54***	
Environmental	***20***	10	Water Quality Significance (MS4)	1: Negative Impact 2: No impact 3: Positive Impact	3	Positive Impact - Removal of impervious cover
		10	Impact to Existing Environmental Features (i.e. Riparian Corridor, Habitat, etc.)	1: Significant Negative Impact 2: Moderate Negative Impact 3: No Impact / Positive Impact	3	Structures will be removed
			Category Total Score		***60***	
Project Timing	***10***	4	Ease of Permitting	1: Multi-jurisdiction more permits 2: Local permit with variances/Nationwide 3: Limited local permits	3	County Level Demolition permits
		2	Time for Implementation	1: ≥ 2 Years 2: 1 - 2 Years 3: 0 - 1 Years	3	0-1 years
		4	Land and Easement Acquisition	1: Condemnation required 2: Purchase necessary 3: No additional acquisition required	3	Voluntary Buyouts but no other land necessary
			Category Total Score		***30***	
				Score	**216**	

	"Objective" Category Weight	Sub Category Weight	"Attribute" Sub Category	Scoring	Bluff Springs Channel Improvements	Bluff Springs Channel Improvements Notes	Bluff Springs Buyouts	Bluff Springs Buyouts Notes	Bluff Springs Elevations	Bluff Springs Elevation Notes
Public Safety	***30***	3	Road Flooding and Mobility (Pre-Project Conditions)	1: Isolated Local Roadway Flooding 2: Collector Roadway Flooding 3: Moving water is likely to wash car off road*	3	Bluff Springs 1% ACE is 7 ft over road = unsafe	3	Bluff Springs 1% ACE is 7 ft over road = unsafe	3	Bluff Springs 1% ACE is 7 ft over road = unsafe
		5	Emergency Access (Pre-Project Conditions)	1: Passable 2: Passable but response time increased 3: Impassable	2	No access south on Bluff Springs but can travel North.	2	No access south on Bluff Springs but can travel North.	2	No access south on Bluff Springs but can travel North.
		9	Number of Structures within 1% ACE Footprint (Pre-Project Condition)	1: 0-15 flooded 2: 15-50 flooded 3: 50+ flooded or critical facility effected	2	48 Structures in the 1% ACE floodplain footprint	2	48 Structures in the 1% ACE floodplain footprint	2	48 Structures in the 1% ACE floodplain footprint
		3	Frequency Event of Structural Flooding (Pre-Project Condition)	1: ≥ 1% ACE 2: 4%- 1% ACE 3: ≤ 4% ACE	3	6 Structures in the 4% ACE floodplain by FFE	3	6 Structures in the 4% ACE floodplain by FFE	3	6 Structures in the 4% ACE floodplain by FFE
		5	Level of Service (Post-Project Protection)	1: ≤ 4 % ACE 2: 4% - 1 % ACE 3: ≥ 1 % ACE	2	Pulls 26 of 39 from 1% ACE floodplain by FFE 0.67 removal efficiency Pulls 12 of 18 from the 2% ACE floodplain by FFE	3	Pulls 39 of 39 from 1% ACE floodplain by FFE 1.0 removal efficiency Only structures in 0.2% ACE floodplain and beyond at risk	3	Pulls 39 of 39 from 1% ACE floodplain by FFE 1.0 removal efficiency Only structures in 0.2% ACE floodplain and beyond at risk
		3	Project Risk Reduction (Post-Project Conditions)	1: Public Risk Remains 2: Public Risk Reduced 3: Public Risk Removed	3	Public Risk Remains	3	Public Risk Removed	2	Public Risk Reduced
		2	Downstream Mitigation (estimated mitigation cost)	1: 15%+ of project costs 2: 1-15% of project cost 3: No mitigation need for downstream impacts	1	Channel improvements increase downstream WSEL and Volume. Requires mitigation.	3	No mitigation	3	No mitigation
			Category Total Score		***67***		***76***		***73***	
Social	***15***	5	Public Opinion (Neighborhood Surveys from Public Meetings)	1: Least Favorable 2: Neutral 3: Most Favorable	2	No survey for this project, but will be used in future projects.	2	No survey for this project, but will be used in future projects.	2	No survey for this project, but will be used in future projects.
		10	Element of a Comprehensive Plan (Parks, Transportation, Planning, HMGP etc.)	1: No elements in other plans 2: Related to elements in other plans 3: Multiple elements other plan	1	Not related to other comprehensive plan but could be connected to existing parks	2	Not related to other comprehensive plan but could be connected to existing parks	1	Not currently related to a comprehensive plan
			Category Total Score		***20***		***30***		***20***	
Economic	***25***	3	Project Cost	1: ≥ 15 Million 2: $5 - 15 Million 3: ≤ $5 Million	1	Estimated $64.8M	2	Estimated $12.1M	3	Estimated $6.6M
		5	Engineering Economics (benefit/cost relationship)	1: B/C < 1.0 2: 1.0-2.0 B/C 3: B/C > 2	1	BCR = 0.01	2	BCR = 0.88	2	BCR = 1.03
		7	Protection Economics (cost/removed structures relationship)	1: C/S >$400K 2: $200K - $400K C/S 3: C/S < $200K	1	$64.8M / 26 structures = $2,492,308	2	$12.5M / 39 structures = $320,512	3	$6.6M / 39 structures = $170,000 per structure
		3	Sustainability O&M Schedule (operation & maintenance)	1: Monthly maintenance 2: Bi-Annual maintenance 3: Annual + maintenance	2	Minimum of Bi Annual Maintenance	1	Lot maintenance of purchased land	3	No county O&M required
		3	Sustainability O&M Cost (estimated annual cost)	1: O&M > $4K 2: $2K - $4K O&M 3: O&M Costs < $2K	1	Mowing of ~123 Acres of channel improvements Medium Terrain Mowing estimated at $325 per Acre per year Cost=123 Acres * $325 = $40K	1	Lot maintenance of ~93 Acres of purchased land Medium Terrain Mowing estimated at $325 per Acre per year Cost= 93 Acres * $325 = $30,200	3	No O&M Costs to County. Responsibility of Property Owner.
		2	Impact to County Tax Rolls	1: Decrease 2: No Impact 3: Increase	2	Mostly acquiring open land and not impacting the structure.	1	Removal of 26 residential structures based on FFE	2	No impact
		2	Funding Source	1: County Funded 3: Grant Funded	1	High cost and not grant eligible	1	Not grant eligible	3	Positive BCA is grant eligible.
			Category Total Score		***30***		***40***		***68***	
Environmental	***20***	10	Water Quality Significance (MS4)	1: Negative Impact 2: No impact 3: Positive Impact	2	Potential stability issues when adjust a natural system.	3	Positive Impact - Removal of impervious cover	2	No Impact
		10	Impact to Existing Environmental Features (i.e. Riparian Corridor, Habitat, etc.)	1: Significant Negative Impact 2: Moderate Negative Impact 3: No Impact / Positive Impact	1	Big impact to riparian corridor and natural stability	3	Structures will be removed	3	No impact
			Category Total Score		***30***		***60***		***50***	
Project Timing	***10***	4	Ease of Permitting	1: Multi-jurisdiction more permits 2: Local permit with variances/Nationwide 3: Limited local permits	2	Nationwide b/c channel improvements are above OHWM. Do not think wetland issue here.	3	County Level Demolition permits	3	County Level Demolition permits
		2	Time for Implementation	1: ≥ 2 Years 2: 1 - 2 Years 3: 0 - 1 Years	1	Design, Permitting and Construction expected to be 3+ years	3	0-1 years	2	1-2 year
		4	Land and Easement Acquisition	1: Condemnation required 2: Purchase necessary 3: No additional acquisition required	2	County does not own easement or ROW	3	Voluntary Buyouts but no other land necessary	3	No purchase
			Category Total Score		***18***		***30***		***28***	
			Score		**165**		**236**		**239**	

Table G - 1: Project Prioritization Assessment

Viable Alternatives	Public Safety	Social	Economic	Environ-mental	Project Timing	Total Weighted Score*	Rank
Dry Creek East / Thoroughbred Farms Area							
Thoroughbred Farms Channel Improvements	66	20	33	30	18	**167**	**11**
Thoroughbred Farms Buyouts	81	20	57	60	30	**248**	**1**
Thoroughbred Farms Elevations	78	20	68	50	28	**244**	**2**
Bear Creek – Onion Creek Confluence Area							
Arroyo Doble & Onion Creek Meadows Floodwall	66	20	30	30	10	**156**	**13**
Arroyo Doble & Onion Creek Meadows Buyouts	78	20	28	60	30	**216**	**9**
Arroyo Doble & Onion Creek Meadows Elevations	75	20	59	50	28	**232**	**5**
Onion Creek Meadows Storm Drainage Improvements	56	20	36	30	26	**168**	**10**
Onion Creek Meadows Storm Local Buyouts	61	20	49	60	30	**220**	**7**
Onion Creek Meadows Storm Local Elevations	58	20	68	50	28	**224**	**6**
Twin Creeks Buyouts	52	20	54	60	30	**216**	**8**
Onion Creek / Bluff Springs Area							
Bluff Springs Channel Improvements	67	20	30	30	18	**165**	**12**
Bluff Springs Buyouts	76	30	40	60	30	**236**	**4**
Bluff Springs Elevations	73	20	68	50	28	**239**	**3**

*Note: The greatest total weighted score is the first ranked priority project.