Feasibility Study

Williamson Creek Flood Risk Reduction Phase 1
(COA 2015 PR2.1)

Evaluation and Alternatives Analysis

City of Austin, Travis County, Texas
July 25, 2022

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1 Introduction

Williamson Creek between Cherry Creek and South Congress Avenue, located in South Austin, has a long history of flooding in certain areas. There are several areas within this reach of Williamson Creek, also referred to as Middle Williamson Creek, with approximately 79 structures in the FEMA regulatory floodplain that have experienced flood damage during more frequent design storms (less than 25-year flood frequency event) according to the Interim Feasibility Report and Integrated Environmental Assessment dated October 2006. This study has identified 183 houses at risk of flooding during the ultimate condition 25-year flood frequency event due to the update of Atlas 14 precipitation data. This area of flooding is highly ranked on the City's FY18 Creek Flood Risk Reduction regional priority list. Four reaches that have experienced flood damages were studied in the Williamson Creek Sediment Impact Analysis completed by HDR in 2007.

The study area encompasses 6.65 square miles of Williamson Creek watershed as shown in Figure 1-1 below. The study limits are along the main stem of Williamson Creek from West Gate Blvd. to South Congress Avenue. The limits of the watershed shown below are from the effective City of Austin hydrologic model.

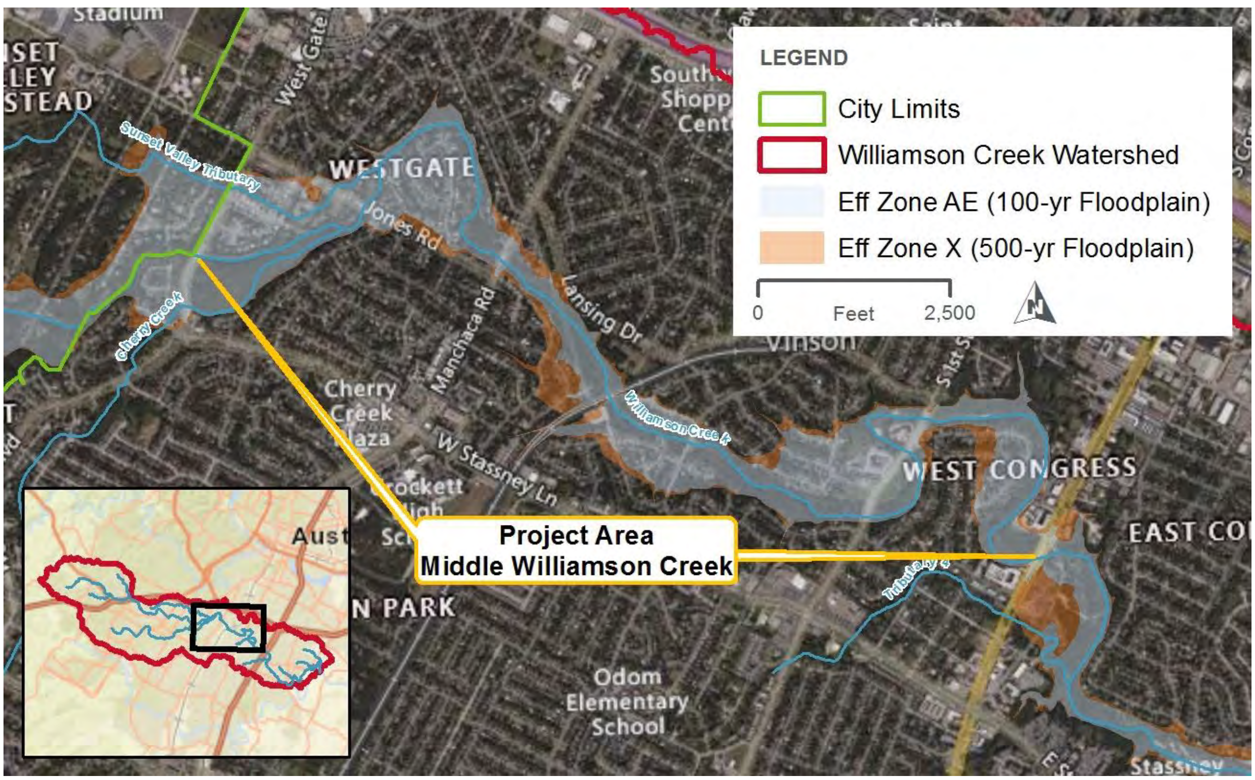

Figure 1-1. Project Location in Williamson Creek Watershed

The primary objectives of Phase 1 of this feasibility study include:

- Update and reassess the extent of existing conditions flooding for the main stem of Williamson Creek between Cherry Creek and South Congress Avenue with new 2017 LiDAR, NOAA Atlas 14 rainfall data, 2-dimentional hydraulic modeling, and updated calibration based on more recent high-water marks;

- Evaluate viability and cost of flood risk reduction alternatives, including a qualitative analysis of the preferred alternative solutions previously identified by the City and USACE for Middle Williamson Creek; and
- Provide recommendations of viable flood risk reduction solutions to further investigate in the next phase.

Section 3 of this report discussed the process and results of updating the effective COA hydrologic models including HEC-HMS model version updates, Atlas 14 precipitation updates, impervious cover updates, curve number updates, Oak Hill Parkway project update, and other model update.

Section 4 of this report discussed the process and results of updating the effective COA hydraulic models. The effective HEC-RAS model version 3.1.2 was updated to HEC-RAS version 5.0.7 to allow for a 1-D and 2-D combined hydraulic model and refined floodplain mapping. In addition, the results of structure inundation for different frequency events were documented at the end.

Section 5 of this report evaluated six (6) flood risk reduction solutions based on previous studies and proposed three (3) additional alternatives. A matrix for scoring and ranking were developed to provide information and recommendation for the City to determine future steps.

2 Data Collection

This section of the report summarizes the data collected in support of this study. A list of data obtained and not obtained is provided as well as summaries of key prior studies, field surveying, and general data gathering efforts.

2.1 Topographic Data

2.1.1 LiDAR and LiDAR Contours

The 2017 Central Texas LiDAR that covers the entire Travis County in 50-cm pixel resolution was obtained from TNRIS DataHub. This LiDAR data was managed by the Texas Strategic Mapping Program and was collected from January 28th, 2017 through March 22nd, 2017.

The downloaded 2017 Central Texas LiDAR digital terrain model (DEM) was clipped to the project extent and converted from meter to feet for modeling purposes. Contours were generated from the 2017 LiDAR DEM in 1-ft and 2-ft intervals for figures and hydrology and hydraulic analyses.

2.1.2 Aerial Photos

The 2020 CapArea & McLennan Imagery was obtained from TNRIS DataHub. This dataset was acquired in January 2020 and covers the entire Travis County area in 1-ft pixel resolution.

2.2 Spatial Data

2.2.1 Soil Data

The Soil Survey Geographic Database (SSURGO) soil data for Travis County was downloaded from the USDA Web Soil Survey. This data includes the digital soil maps and the accompanying soil properties and interpretations database. The soil data was processed to include hydrologic soil group for each soil type and clipped to the Williamson Creek Watershed extent.

2.2.2 Land Use Data

The COA Land Use Inventory Detailed GIS data was obtained from the City's open data portal. By the time of this study, the Land Use Inventory data was updated in 2019. The land use data was used to help determine the percentage of impervious cover for hydrology calculations.

2.2.3 Planimetrics Data

Planimetric features are a complication of features produced for the 2015 Planimetrics/Impervious Cover dataset by the City of Austin. This dataset includes the most updated building footprints, paved and unpaved roads from 2015.

Other available COA planimetrics data used to create the combined impervious cover shapefile include:

- 2013 COA Pools
- 2013 COA Decks

- 2013 COA Double Line Streets
- 2013 COA Paved Areas
- 2013 COA Driveways
- 2013 COA Remaining Pervious Cover

2.2.4 City Easements

City easements dataset represents easements acquired by COA through the office of Real Estate Services and was obtained from the COA open data portal.

2.2.5 Drainage Complaints

2.2.6 Other Geospatial Data

Other spatial data obtained from the COA include:

- Properties buy-out inventory
- Previously surveyed structure finished floor elevations (FFE)
- Large detention pond footprints (total of twenty-nine ponds within the watershed)
- Hydrologic and hydraulic models related geospatial data.
- Rainfall depth grided precipitation data from October 13, 2013 storm event for model calibration purpose.
- Observed high water marks from the October 13, 2013 storm event for model calibration purpose.
- COA buyout project status and update for structures within the project area

2.3 Prior Studies

The following previous reports were obtained in coordination with City staff. These reports provided a history of the studied portion of Williamson Creek watershed and help advance this study by offering useful information such as past flood mitigation alternatives evaluated, properties already bought out by the City, sediment transportation and channel geomorphology analysis, and etc.

2.3.1 The City of Austin Watershed Protection Master Plan Phase I Watersheds Report (2001)

This report was prepared by the COA Watershed Protection Department in 2001. This Master Plan Report investigated existing watershed problems, gauged the impact of future urbanization in seventeen (17) watersheds including Williamson Creek watershed, and provided recommendations to meet future watershed planning goals. The report categorized Williamson Creek watershed as non-urban watershed and documented severe historical flooding within the watershed. The estimated number of flooded structures for the 25-year and 100-year flood frequency events were 295 and 454 respectively according to the report.

2.3.2 USACE Interim Feasibility Studies (2006 and 2008)

The USACE Interim Feasibility Studies is a comprehensive study conducted by the U.S. Army Corps of Engineers Fort Worth District and the Lower Colorado River Authority (LCRA) to investigate the water resources problems, needs and opportunities within the studied river basins including Williamson Creek Watershed. The objective of this study include: reducing flood damages throughout the basin; reducing risk to life, health and welfare of residents; enhancing the quality of life; reducing emergency costs associated to the occurrence of significant flood events within the Basin; reducing overall erosion; stabilizing the geomorphology of the various channels; restoring aquatic ecosystem and riparian zones; increasing recreational opportunities; restoring endangered species habitat; and improving recreational opportunities for residents and visitors to the Basin.

According to the 2006 USACE study, a total of 236 structures on Williamson Creek received damages in a 100-year storm frequency event. These structures were mainly slab-on-grade residences and most of them has less than 1-foot floor correction from ground elevation to finish floor elevation.

This study provided analysis and recommendations for the structural and non-structural alternative plans for Williamson Creek Watershed.

- Structural – diversion structural, regional detentions, levees, floodwalls, and channel modifications
- Non-structural – removal of damageable properties from the flood prone areas. Raising of structures and floodplain evacuation (buyout).

The following options were researched for Williamson Creek:

- Flood damage reduction only plan: One-sided, benched channel modification concept to increase channel conveyance which minimize environmental impacts.
- Non-structural floodplain evacuation in combination with ecosystem restoration, Including removing 58 structures from the 4% ACE floodplain.
- Structural combined plan: One-sided, benched channel modification concept to increase channel conveyance which minimize environmental impacts, plus ecosystem restoration and recreation features to form a complete, multi-objective plan.

The study concluded that the structural combined plan with modifications was preferred. The plan included segmented benching along the four problem areas for a total length of 8,500 feet and acquisition of 114 acres land for habitat restoration and hiking trail construction.

2.3.3 Preliminary Engineering Report for Regional Detention and Culvert Replacements for Williamson Creek Watershed (2000)

This study was conducted by Alan Plummer Associates, Inc. in March 2000. The study evaluated the feasibility of relieving flooding along Williamson Creek through the construction of two alternative regional detention ponds configuration and concluded that either detention pond alternative would not significantly reduce water surface elevation to benefit structure flooding on the overbanks comparing to the cost of the project. In addition, the study evaluated the bridge and culvert replacements on Westgate Boulevard and concluded that such improvements would not eliminate inundation of the roadway due to the constraint of the 25-year event tailwater elevation. The study also recommended further investigation into updating the hydraulic model and downstream channel improvements to reduce tailwater would be rewarding.

2.3.4 Williamson Creek Sediment Field Reconnaissance for Stability Assessment (2007)

HDR conducted a sediment impact analysis in 2007 to present the information collected through field reconnaissance, sediment sampling, analysis of historical channel adjustments, and some initial computations regarding the capability of the stream to transport sediment at specific locations.

2.3.5 Williamson Creek Stability Assessment Technical Memorandum (2009)

This technical memorandum was prepared by HDR in July 2009 to re-evaluate the alternatives to reduce flooding in Williamson Creek as proposed in the 2006 USACE report. This technical memo documented findings that complemented the previous preliminary investigation and field reconnaissance of Williamson Creek documented in July 2007 Sediment Field Reconnaissance report.

2.3.6 Williamson Creek Plan Reformulation Technical Memorandum (2010)

This technical memorandum documented the results and findings of the flood risk management modeling efforts. The study concluded that the mitigation provided by the original NED plan was insufficient and suggested that non-structural buyout program would likely be more economical than extensive structural channel modifications throughout the studied reaches. It also suggested that further investigation into the inter-basin flow between the main stem, Cherry Creek and Sunset Valley Tributary should be considered to provide more accurate hydraulic results for evaluating the flood mitigation alternatives.

2.4 Hydrologic and Hydraulic Models

The following Hydrologic and Hydraulic Models were obtained from the City:

2.4.1 Effective FEMA Hydrologic (2007) and Hydraulic (2006) Models

The effective FEMA hydrologic model was created in HEC-HMS version 2.2.2 in 2007. The model was created for the entire Onion Creek watershed. Four existing condition (4) basin models were created for Williamson Creek watershed with four (4) meteorological models for 10-, 50-, 100-, and 500-year rainfall events.

The effective FEMA hydraulic model was created in 2005 and updated in 2006 in HEC-RAS version 3.1.3. The entire Williamson Creek including upper and lower reaches and part of Sunset Valley Tributary were included in the model geometry. The model included the Existing Conditions (FEMA) plan, Ultimate Conditions plan, and Existing Conditions (City of Austin) plan.

2.4.2 Effective City of Austin Hydrologic (2008) and Hydraulic (2006) Models

The effective City of Austin Hydrologic model were created in HEC-HMS version 2.2.2 in 2008. The model included six (6) basin models and five (5) meteorological models. Eighty-one (81) subbasins were modeled and results were generated for the existing condition 10-, 25-, 50-, 100-, and 500-year storm events, as well as the ultimate condition 25- and 100-year storm events. This effective 2008 COA hydrologic model updated the 2007 FEMA effective Hydrologic model by removing downstream connection from JWCR210B and correcting upstream (JWCR210B) and downstream connection (JWCR220) for WCR210A.

The effective City of Austin Hydraulic Model is essentially the same as the 2006 effective FEMA hydraulic model as described above.

2.4.3 USACE Interim Feasibility Studies models (2006)

The USAC Williamson Creek Feasibility Study HEC-RAS model was created by USACE in 2005 in version 3.1.3 to provide hydraulic model plans for flood mitigation alternatives mentioned in the report.

2.4.4 Oak Hill Parkway Project Hydrologic (2019) and Hydraulic (2019 Models

The Oak Hill Parkway Project HEC-HMS model was received from the City which included the following updates to the 2008 COA effective HEC-HMS model by Freese and Nichols (FNI).

Existing Condition Plan (Revised_Ex*yr_FNI):

- Updated HEC-HMS version 2.2.2 to version 3.5.
- Updated all frequency storms to reflect the Atlas 14 updated precipitation data
- Updated the existing Oakhill detention facility to reflect the dam safety survey from August 2019
- Modified subbasins upstream and downstream of proposed detention sites in order to establish accurate comparison points.

Proposed Condition Plan (OBC_Only_*yr_FNI):

- Adjusted the proposed impervious area for all subbasins affected by the project. Shifted subbasin areas affected by the alignment around the Kitcheon subbasin.
- Added proposed detention at the Old Bee Cave site.

The Oakhill Parkway Project HEC-RAS model was also obtained from the City which revised the flows to reflect the updated HEC-HMS model results as described above, and updated terrain data as well as cross sections and structures to include proposed design.

2.4.5 Approximation of October 13 Flood Inundation Limits Memorandum

This technical memo documented changes made to the effective Williamson Creek HEC-RAS model geometry data, the location and observed values of the high water marks from the October 13, 2013 flood event that were used to calibrate the HEC-RAS model, the development of flows used to match the high water marks, and the summary of the modeling results from this event.

2.5 Survey Data Collection

2.5.1 Field Visit with Photos and Notes

HDR performed a river walk field reconnaissance to inspect the main stem of Williamson Creek to be studied, along with associated hydraulic and hydrologic features, land use and vegetative cover conditions, and identified flood prone areas. Typical and special condition channel and overbank types were photographed and tagged with location. The field visit photos and the geographic locations are included in the geodatabase in the Appendix L. Below are some photos at typical locations.

Figure 2-1. U/S of West Gate Blvd near Bayton Loop

Figure 2-2. Williamson Creek at West Gate Blvd looking D/S

Figure 2-3. Elevated structures on left overbank between Williamson Creek and Sunset Valley Tributary

Figure 2-4. Williamson Creek and Cherry Creek Confluence

Figure 2-5. Williamson Creek at St Johns Ave. looking U/S

Figure 2-6. Sunset Valley Tributary looking U/S

Figure 2-7. Williamson Creek looking D/S at UPRR

Figure 2-8. Williamson Creek at D/S of Emerald Forest Drive

2.5.2 Surveyed Finished Floor Elevations

The lowest finished floor elevations (FFE) of thirty (30) selected habitable structures within the high flood risk areas were surveyed. The FFEs of the surveyed structures were compared with LiDAR data to verify the FFE assumptions made to the nearby structures. The locations of the surveyed structures are shown in Figure 2-9 below.

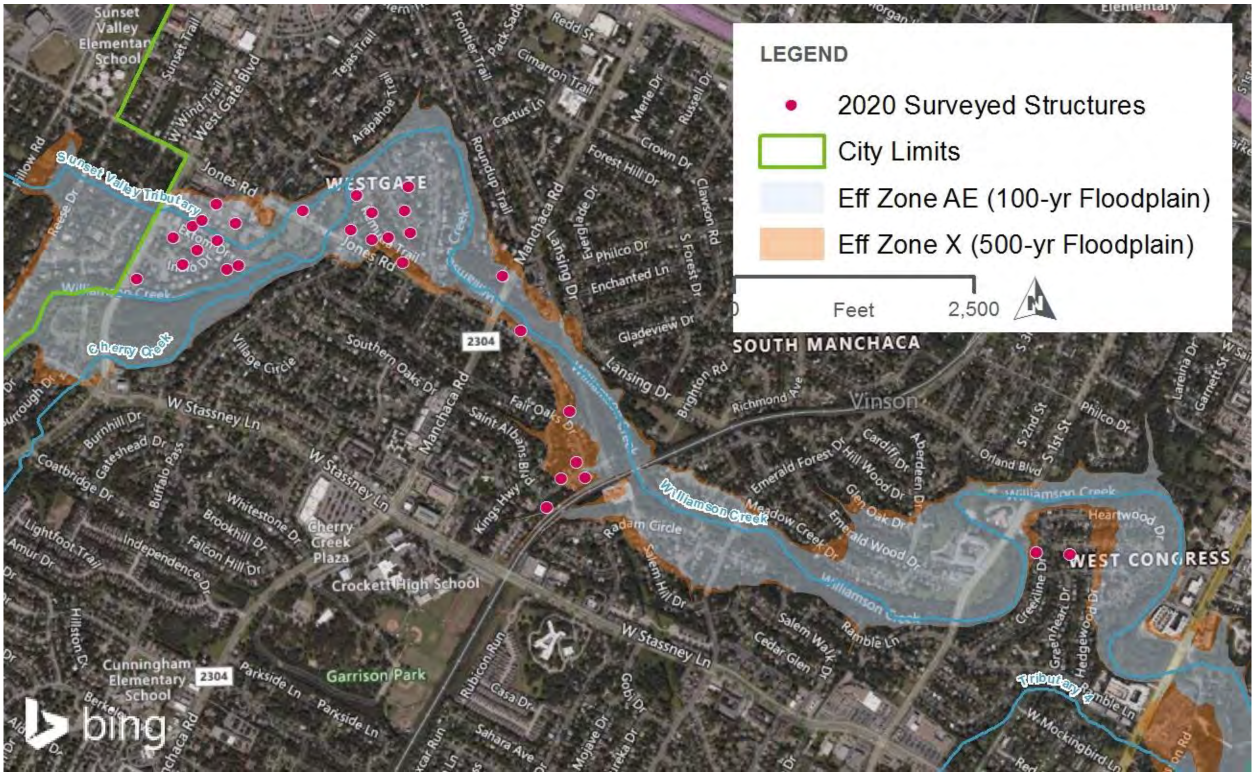

Figure 2-9. 2020 Surveyed Finish Floor Elevation Structures

3 *Effective* Hydrology Model Update

The current *effective* hydrologic model for Williamson Creek was obtained from the City and consists of two land use scenarios – existing land use and ultimate, or fully developed, land use. The model was updated to include the most recent watershed characteristics and Atlas 14 precipitation. The updated model was used to re-evaluate flood inundation extent and the habitable structures being flooded within the project area.

3.1 Effective Hydrologic Model

3.1.1 Watershed Description

The Williamson Creek watershed is located to the south of the Lady Bird Lake in South Central Austin, flowing from west to east. There are 10 tributaries in the current hydrologic model including the four tributaries included in this flood study, namely, Sunset Valley Tributary, Kincheon Branch, Cherry Creek, and Pleasant Hill Tributary. Williamson Creek flows eastward and joins Onion Creek approximately 2,000 feet (ft) upstream of McKinney Falls Parkway just west of Austin-Bergstrom International Airport (AUS).

The total contributing drainage area of the watershed is 30.37 square miles (sq. mi.). The watershed is highly urbanized. The land use in the watershed generally includes residential, commercial, and industrial. Open space such as parks, landscaped areas, and other undeveloped areas are scattered throughout the watershed. There are 81 subbasins delineated in the COA effective model. These subbasins were used for this study and are shown in Appendix A.

3.1.2 Hydrologic Parameters

The current effective hydrologic model for the Williamson Creek watershed was developed with HEC-HMS, Version 2.2.2, and included six basin models: four existing conditions and two ultimate conditions. The existing condition basin models were created for 10-, 50-, 100-, and 500-year storm frequencies. The ultimate condition basin models were created for 25- and 100-year storm frequencies. The rainfall distribution was defined by the Natural Resources Conservation Service's (NRCS's) Type-III, 24-hour duration storm. The total rainfall depths were based on the United States Geological Survey (USGS) Depth-Duration Frequency of Precipitation for Texas, Water Resources Investigations Report 98-4044, by William Asquith (November 2001). These storm depths for the given recurrence frequencies in Travis County, Texas, are summarized in Table 3-1 below.

Table 3-1. Effective Model Storm Precipitation Recurrence Interval and Depths

Recurrence Interval (year)	24-hr Depth of Precipitation (inch)
2	3.44
5	4.99
10	6.10
25	7.64
50	8.87
100	10.20
500	13.50

Rainfall infiltration loss rates were defined using the NRCS Curve Number method which are based on hydrologic soil group and land use type. The excess rainfall was transformed into direct runoff using the Snyder Unit Hydrograph method. Key hydrologic parameters associated with individual subbasins are listed in Table 3-2.

Table 3-2. Hydrologic Parameters for the Effective City of Austin HMS Model

Subbasin Identification (ID)	Area (sq mi)	Curve Number (CN)[1]	Existing IC%[2]	Ultimate IC%[2]	Existing Lag Times (mins)	Ultimate Lag Times (mins)
WCR1000W1060	0.430	70	50	50	0.65	0.61
WCR100W100	0.242	78	45	45	0.48	0.31
WCR1010W1030	0.334	76	60	60	0.53	0.53
WCR1020W1070	0.132	83	65	65	0.27	0.26
WCR1030W1080	0.540	82	60	60	0.73	0.71
WCR1040W1090	0.674	78	45	45	0.82	0.69
WCR1050W1100	0.454	75	40	40	0.87	0.84
WCR10W10	0.726	79	25	30	0.55	0.37
WCR1100W1170	0.416	74	75	75	0.49	0.49
WCR110W110	0.454	81	55	55	1.04	0.98
WCR1110W1180	1.217	75	40	40	1.39	1.34
WCR1120W1190	1.036	76	40	40	0.51	0.42
WCR1160W1210	0.292	70	50	50	0.36	0.28
WCR1180W1200	0.340	75	20	30	0.48	0.37
WCR120W113	0.520	76	60	60	0.71	0.70
WCR140W140A	0.132	77	50	50	0.69	0.65
WCR140W140B	0.149	77	50	50	0.69	0.65

Table 3-2. Hydrologic Parameters for the Effective City of Austin HMS Model

Subbasin Identification (ID)	Area (sq mi)	Curve Number (CN)[1]	Existing IC%[2]	Ultimate IC%[2]	Existing Lag Times (mins)	Ultimate Lag Times (mins)
WCR140W140C	0.180	77	50	50	0.80	0.60
WCR140W140D	0.225	77	50	50	0.61	0.47
WCR140W140E	0.219	77	50	50	0.55	0.55
WCR150W150	1.179	80	50	50	0.69	0.65
WCR160W160	0.180	77	50	50	0.25	0.22
WCR180W180	0.137	80	45	45	0.37	0.36
WCR190W530	0.606	80	40	40	0.64	0.61
WCR200W200	0.062	80	45	45	0.23	0.23
WCR20W20	0.250	78	45	45	0.36	0.29
WCR210W210A	0.818	81	45	45	0.99	0.91
WCR210W210B	1.006	81	45	45	0.87	0.78
WCR210W210C	1.023	81	45	45	0.92	0.92
WCR240W1040	0.870	74	50	50	0.80	0.76
WCR260W260	1.434	75	50	50	0.89	0.82
WCR280W600	0.291	81	25	25	0.41	0.41
WCR290W640	0.037	82	45	45	0.18	0.18
WCR300W300	0.611	83	50	50	0.64	0.60
WCR30W30	0.541	77	25	35	0.53	0.37
WCR310W310	0.278	75	40	50	0.33	0.28
WCR350W890A	0.423	78	15	40	0.70	0.44
WCR350W890B	0.197	78	15	40	0.22	0.14
WCR360W360	0.522	75	40	50	0.50	0.35
WCR380W990A	0.109	76	40	50	0.22	0.16
WCR380W990B	0.203	76	40	60	0.51	0.38
WCR390W370	0.272	70	5	30	0.50	0.39
WCR400W400	0.098	70	5	5	0.33	0.33
WCR40W40	0.337	78	10	30	0.42	0.35
WCR440W560	0.168	79	35	35	0.20	0.12
WCR460W580	0.037	80	5	20	0.10	0.10
WCR470W570	0.129	79	15	40	0.22	0.11
WCR50W50	0.410	77	35	35	0.41	0.29
WCR520W490	0.107	78	15	40	0.24	0.10
WCR530W500	0.207	79	10	35	0.36	0.25
WCR540W520	0.144	79	5	40	0.17	0.16

Table 3-2. Hydrologic Parameters for the Effective City of Austin HMS Model

Subbasin Identification (ID)	Area (sq mi)	Curve Number (CN)[1]	Existing IC%[2]	Ultimate IC%[2]	Existing Lag Times (mins)	Ultimate Lag Times (mins)
WCR560W620	0.087	80	35	35	0.25	0.25
WCR570W590	0.101	80	50	50	0.24	0.24
WCR590W660	0.450	81	40	40	0.40	0.37
WCR600W630	0.124	83	55	55	0.23	0.22
WCR60W60	0.495	76	30	35	0.48	0.40
WCR610W670	0.111	81	40	40	0.23	0.20
WCR620W680	0.649	78	25	35	0.51	0.40
WCR630W720	0.260	79	30	30	0.36	0.29
WCR680W730	0.258	77	55	55	0.43	0.35
WCR690W710	0.095	79	20	45	0.30	0.20
WCR720W740	0.106	80	55	55	0.36	0.35
WCR750W860	0.161	74	55	55	0.22	0.21
WCR780W850	0.066	76	40	40	0.17	0.17
WCR790W810	0.257	77	55	55	0.32	0.26
WCR800W840	0.292	79	45	45	0.25	0.14
WCR80W80	0.755	77	40	40	0.57	0.47
WCR810W870	0.088	77	50	50	0.16	0.14
WCR830W930	0.383	77	35	50	0.57	0.33
WCR840W880	0.134	79	35	60	0.24	0.11
WCR860W950	0.530	78	55	65	0.82	0.73
WCR870W920	0.159	72	15	45	0.36	0.16
WCR880W960A	0.475	73	45	45	0.58	0.50
WCR880W960B	0.816	73	45	45	0.75	0.71
WCR880W960C	0.615	73	45	55	0.66	0.57
WCR90W90A	0.228	80	30	50	0.44	0.26
WCR90W90B	0.337	80	30	40	0.46	0.42
WCR930W970	0.087	78	40	50	0.18	0.14
WCR940W980	0.102	76	55	60	0.20	0.16
WCR950W1010	0.201	76	60	60	0.26	0.25
WCR980W1020	0.600	76	55	55	0.59	0.55

[1] Curve Numbers are the same for existing condition and ultimate condition in the effective HEC-HMS Model.
[2] IC% = percent impervious cover

3.2 Hydrologic Model Updates

The effective hydrologic model was updated to create an existing hydrologic model that reflects existing conditions and current precipitation data standards. The following updates were made:

- Converted HEC-HMS, Version 2.2.2, to Version 4.3.0.
- Adopted National Oceanic and Atmospheric Administration (NOAA) Atlas 14 rainfall depths.
- Updated percentage of impervious cover (IC%) based on 2019 COA Land Use (LU) and 2015 Planimetric geographic information system (GIS) database.
- Updated Curve Number (CN) per LU code.
- Updated to reflect recent development in watershed (Oak Hill Parkway)
- Added additional storm frequency events

3.2.1 HEC-HMS Version Update

The current effective hydrologic model for the Williamson Creek watershed was obtained from the COA and run using HEC-HMS Version 2.2.2 on HDR computers. The model was then converted to the latest version of HEC-HMS, version 4.3.0, and the results were compared and verified to match the effective model results. This model served as the duplicate effective hydrologic model to begin making updates.

3.2.2 Atlas 14 Rainfall Update

In September 2018, the National Weather Service (NWS) published NOAA Atlas 14 – Precipitation Frequency Atlas of the United States, Volume 11, and Version 2.0. Atlas 14 updates the precipitation frequency estimates for Texas based on historical rainfall records through December 2017. To reflect this change, COA amended the Drainage Criteria Manual, Section 2, in 2019. In this amendment, the depth-duration-frequency (DDF) tables are provided for Austin South (Zone 1) and Austin North (Zone 2) to account for the spatial variation of the Atlas 14 precipitation-frequency estimates. Figure 3-1 shows the geographic locations of the two zones.

The entire Williamson Creek watershed is located within Zone 1. Therefore, the DDF values for Zone 1 were utilized. Table 3-3 below shows the DDF values for Zone 1. The 24-hr Atlas 14 precipitation depths are much higher than the pre-atlas 14 data as compared in Table 3-4.

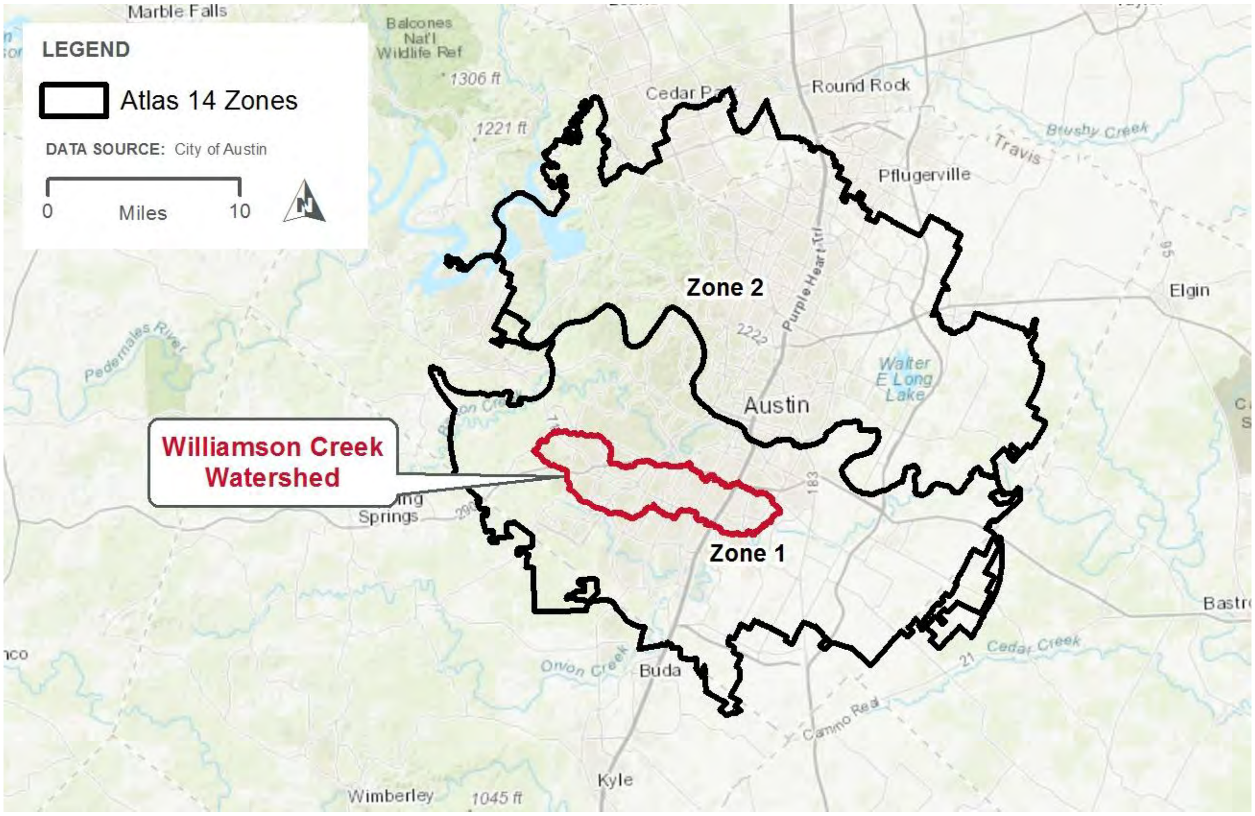

Figure 3-1. Atlas 14 Precipitation Zones for the City of Austin

Table 3-3. Depth-Duration Frequency Values (Zone 1)

Duration	Depth of Precipitation (in) by Recurrence Interval							
	2 yr	5 yr	10 yr	25 yr	50 yr	100 yr	200 yr	500 yr
5-min	0.53	0.67	0.80	0.98	1.12	1.28	1.45	1.68
15-min	1.06	1.35	1.60	1.96	2.24	2.54	2.87	3.34
30-min	1.49	1.90	2.25	2.75	3.13	3.54	4.01	4.69
1-hr	1.96	2.51	2.99	3.66	4.19	4.77	5.45	6.45
2-hr	2.42	3.15	3.82	4.81	5.63	6.57	7.65	9.28
3-hr	2.70	3.54	4.34	5.55	6.60	7.81	9.21	11.31
6-hr	3.17	4.20	5.21	6.78	8.17	9.79	11.65	14.48
12-hr	3.64	4.84	6.02	7.85	9.47	11.37	13.58	16.94
24-hr	4.14	5.51	6.84	8.90	10.69	12.80	15.27	19.05

Table 3-4. Atlas 14 and Pre-Atlas 14 24-hr Precipitation Depths Comparison

Recurrence Interval (year)	Pre-Atlas 14 24-hr Depth of Precipitation (inch)	Atlas 14 24-hr Depth of Precipitation (inch)	% Increase
2	3.44	4.14	20.3%
5	4.99	5.51	10.4%
10	6.10	6.84	12.1%
25	7.64	8.90	16.5%
50	8.87	10.69	20.5%
100	10.20	12.80	25.5%
500	13.50	19.05	41.1%

3.2.3 Existing and Fully Developed Condition Impervious Cover Update

The COA recommends that the existing condition IC% be determined based on the latest planimetric data and checked against the IC% based on the COA's existing land use layer. In addition, the fully developed condition IC% shall be determined based on the COA's fully developed land use layer. The 2015 planimetric data and the 2019 land use layer obtained from the COA GIS data portal were used to update the IC%.

When calculating existing IC% using the 2015 planimetric data, the recommended IC% based on the Origin Feature Class were used to calculate the total existing IC% per subbasin. Table 3-5 below shows the recommended IC% for the planimetric data.

Table 3-5. Impervious Cover Associated with COA Planimetric Data

Origin Feature Class	Feature	Percent Impervious
Building_Footprints_2015	Courtyard	100%
Building_Footprints_2015	Structure	100%
Decks_2015	Covered	100%
Decks_2015	Uncovered	100%
Double_Line_Streets_2015	Edge of Paved Road	100%
Double_Line_Streets_2015	Edge of Unpaved Road	100%
Driveways_2015	Paved	100%
Driveways_2015	Unpaved	100%
Man-Made_Hydrography_2015	Dam	100%
Man-Made_Hydrography_2015	Dock	100%
Man-Made_Hydrography_2015	Paved Ditch	0%
Other_Landmarks_2015	Compacted Soil	0%
Other_Landmarks_2015	Edge of Trail	100%
Other_Landmarks_2015	Golf Course	0%

Table 3-5. Impervious Cover Associated with COA Planimetric Data

Origin Feature Class	Feature	Percent Impervious
Other_Landmarks_2015	Gravel/Sandpit	0%
Other_Landmarks_2015	Landfill	100%
Other_Landmarks_2015	Miscellaneous	0%
Other_Landmarks_2015	Open Space	0%
Other_Landmarks_2015	Open Storage	0%
Other_Landmarks_2015	Other/Landmark	0%
Other_Landmarks_2015	Quarry	0%
Other_Landmarks_2015	Tank	100%
Other_Landmarks_2015	Unpaved Athletic Field	0%
Other_Landmarks_2015	Unpaved Parking	100%
Paved_Areas_2015	Airport Runway/Taxiway	100%
Paved_Areas_2015	Bridge	100%
Paved_Areas_2015	Edge of Paved Alley	100%
Paved_Areas_2015	Edge of Pavement	100%
Paved_Areas_2015	Median > 10 feet (ft)	100%
Paved_Areas_2015	Patio	100%
Paved_Areas_2015	Paved Parking	100%
Paved_Areas_2015	Recreation Court/Ball Field	100%
Paved_Areas_2015	Sidewalk	100%
Pools_2015	Aboveground	0%
Pools_2015	In-Ground	0%
Remaining	Pervious Remaining Pervious Area	0%

When calculating existing IC% using the 2019 land use layer, the recommended Urban Watersheds IC% for existing condition based on land use code was used to calculate the total existing IC% per subbasin. Table 3-6 below shows the recommended IC% for the land use layer.

Table 3-6. Impervious Cover under Existing and Fully Developed Land Use Conditions for Urban Watersheds

Land Use Code	Land Use Description	Impervious Cover Percentage	
		Existing	Fully-Developed
100	Single Family	50	50
113	Mobile Homes	50	50
160	Large Lot Single Family (>= 1 acre [ac]/lot)	12	25
200	Multifamily	70	70
300	Commercial	85	85
330	Mixed Use	80	80
400	Office	80	80
500	Industrial	80	80
560	Quarries	0	0
600	Civic	60	60
700	Open Space	5	5
800	Transportation	100	100
860	Right-of-Way (ROW)	90	90
870	Utilities	50	50
900	Undeveloped	0	0
940	Water	100	100
999	Unknown	5	5

The fully developed condition IC% was also calculated using the 2019 land use layer. The Urban Watersheds IC% for fully developed condition per land use code was used to calculate the total fully developed IC% per subbasin.

The existing and fully developed condition IC% are compared with the IC% in the effective model in Table 3-7 below. The updated IC% based on the 2019 land use layer was eventually used in the existing condition hydrologic model.

Table 3-7. Effective and Revised HEC-HMS Model Parameter Comparison

Subbasin ID	Area (sq mi)	Effective Parameters			Revised Parameters			
		CN[1]	Exist IC%[2]	Ful-Dev IC%[2]	CN[1]	Exist IC%[2] (2019 LU)	Exist IC%[2] (2015 PLM)	Ful-Dev IC%[2]
WCR1000W1060	0.430	70	50	50	72	54	41	54
WCR100W100	0.242	78	45	45	76	22	11	27
WCR1010W1030	0.334	76	60	60	79	58	43	58
WCR1020W1070	0.132	83	65	65	80	78	62	78
WCR1030W1080	0.540	82	60	60	81	50	44	50

Table 3-7. Effective and Revised HEC-HMS Model Parameter Comparison

Subbasin ID	Area (sq mi)	Effective Parameters			Revised Parameters			
		CN[1]	Exist IC%[2]	Ful-Dev IC%[2]	CN[1]	Exist IC%[2] (2019 LU)	Exist IC%[2] (2015 PLM)	Ful-Dev IC%[2]
WCR1040W1090	0.674	78	45	45	77	55	34	55
WCR1050W1100	0.454	75	40	40	75	42	24	42
WCR10W10[3]	0.726	79	25	30	81	33	10	34
WCR1100W1170	0.416	74	75	75	74	63	53	63
WCR110W110	0.454	81	55	55	80	66	55	66
WCR1110W1180	1.217	75	40	40	75	49	39	49
WCR1120W1190	1.036	76	40	40	80	46	14	47
WCR1160W1210	0.292	70	50	50	68	54	43	54
WCR1180W1200	0.340	75	20	30	73	40	31	40
WCR120W113	0.520	76	60	60	78	56	44	56
WCR140W140A	0.132	77	50	50	80	54	38	54
WCR140W140B	0.149	77	50	50	81	59	45	59
WCR140W140C	0.180	77	50	50	79	61	45	61
WCR140W140D	0.225	77	50	50	80	65	54	65
WCR140W140E	0.219	77	50	50	80	57	45	57
WCR150W150	1.179	80	50	50	81	51	36	51
WCR160W160	0.180	77	50	50	68	42	20	43
WCR180W180	0.137	80	45	45	81	44	33	44
WCR190W530	0.606	80	40	40	78	33	15	34
WCR200W200	0.062	80	45	45	81	45	33	45
WCR20W20	0.250	78	45	45	80	54	21	54
WCR210W210A	0.818	81	45	45	80	58	35	58
WCR210W210B	1.006	81	45	45	80	55	35	55
WCR210W210C	1.023	81	45	45	81	51	38	51
WCR240W1040	0.870	74	50	50	76	59	45	59
WCR260W260	1.434	75	50	50	78	56	41	56
WCR280W600	0.291	81	25	25	80	26	19	26
WCR290W640	0.037	82	45	45	81	50	35	50
WCR300W300	0.611	83	50	50	81	47	36	47
WCR30W30[3]	0.541	77	25	35	81	52	24	52
WCR310W310	0.278	75	40	50	80	61	48	61
WCR350W890A	0.423	78	15	40	78	31	14	31
WCR350W890B	0.197	78	15	40	76	31	17	31

Table 3-7. Effective and Revised HEC-HMS Model Parameter Comparison

Subbasin ID	Area (sq mi)	Effective Parameters			Revised Parameters			
		CN[1]	Exist IC%[2]	Ful-Dev IC%[2]	CN[1]	Exist IC%[2] (2019 LU)	Exist IC%[2] (2015 PLM)	Ful-Dev IC%[2]
WCR360W360	0.522	75	40	50	76	62	59	62
WCR380W990A	0.109	76	40	50	79	60	46	60
WCR380W990B	0.203	76	40	60	79	62	47	62
WCR390W370	0.272	70	5	30	66	11	8	11
WCR400W400	0.098	70	5	5	72	6	2	6
WCR40W40	0.337	78	10	30	79	37	15	39
WCR440W560	0.168	79	35	35	80	45	26	45
WCR460W580	0.037	80	5	20	79	33	17	33
WCR470W570	0.129	79	15	40	80	38	11	38
WCR50W50	0.410	77	35	35	78	50	21	50
WCR520W490	0.107	78	15	40	81	76	21	76
WCR530W500	0.207	79	10	35	81	47	30	47
WCR540W520	0.144	79	5	40	80	53	37	53
WCR560W620	0.087	80	35	35	80	33	25	33
WCR570W590	0.101	80	50	50	81	53	39	53
WCR590W660	0.450	81	40	40	81	52	43	52
WCR600W630	0.124	83	55	55	81	58	46	58
WCR60W60	0.495	76	30	35	79	49	21	49
WCR610W670	0.111	81	40	40	81	43	34	43
WCR620W680	0.649	78	25	35	80	43	18	43
WCR630W720	0.260	79	30	30	80	46	24	47
WCR680W730*	0.258	77	55	55	80	37	18	64
WCR690W710	0.095	79	20	45	81	34	15	34
WCR720W740	0.106	80	55	55	81	55	40	55
WCR750W860	0.161	74	55	55	81	56	39	56
WCR780W850	0.066	76	40	40	80	41	21	41
WCR790W810	0.257	77	55	55	82	40	21	40
WCR800W840	0.292	79	45	45	80	49	15	49
WCR80W80*	0.755	77	40	40	79	46	28	42
WCR810W870	0.088	77	50	50	80	56	37	56
WCR830W930	0.383	77	35	50	77	49	26	49
WCR840W880	0.134	79	35	60	81	61	26	61
WCR860W950	0.530	78	55	65	79	72	65	72

Table 3-7. Effective and Revised HEC-HMS Model Parameter Comparison

Subbasin ID	Area (sq mi)	Effective Parameters			Revised Parameters			
		CN[1]	Exist IC%[2]	Ful-Dev IC%[2]	CN[1]	Exist IC%[2] (2019 LU)	Exist IC%[2] (2015 PLM)	Ful-Dev IC%[2]
WCR870W920	0.159	72	15	45	68	69	33	69
WCR880W960A	0.475	73	45	45	70	50	36	50
WCR880W960B	0.816	73	45	45	73	53	35	53
WCR880W960C	0.615	73	45	55	77	72	57	72
WCR90W90A	0.228	80	30	50	75	63	40	63
WCR90W90B	0.337	80	30	40	80	62	29	62
WCR930W970	0.087	78	40	50	81	61	34	61
WCR940W980	0.102	76	55	60	78	72	54	72
WCR950W1010	0.201	76	60	60	81	63	52	63

[1] Curve Numbers are the same for existing condition and ultimate condition in the effective and updated HEC-HMS Model.
[2] IC% = percent impervious cover
[3] Subbasin WCR10W10 and WCR30W30 were later modified to reflect the Oak Hill/71 project HEC-HMS model provided by COA in Dec, 2019

3.2.4 Curve Number Update

The COA recommends that the CN be determined based on pervious area ground surface conditions (soil type and vegetation cover) and the hydrologic condition of the vegetative cover. Table 3-8 below shows the recommended CN per land use and per hydrologic soil group.

Curve numbers for each subbasin were updated based on the 2019 land use layer in the existing HEC-HMS model.

Table 3-8. Curve Number based on Land Use Code

Land Use Code	Description	NRCS CN per Hydrologic Soil Group			
		A	B	C	D
100	Single Family	39	61	74	80
113	Mobile Homes	49	69	79	84
160	Large-Lot Single Family	49	69	79	84
200	Multifamily	39	61	74	80
300	Commercial	39	61	74	80
330	Mixed Use	39	61	74	80
400	Office	49	69	79	84
500	Industrial	30	48	65	73
560	Quarries	39	61	74	80
600	Civic	39	61	74	80
700	Open Space	49	69	79	84
800	Transportation	49	69	79	84
860	ROW	49	69	79	84
870	Utilities	39	61	74	80
900	Undeveloped	49	69	79	84
	Undeveloped (woods)	43	65	76	82
	Undeveloped (brush)	35	56	70	77
	Undeveloped (grass)	49	69	79	84
	Undeveloped (agriculture)	74	85	90	93
940	Water	39	61	74	80
999	Unknown	Review and assign most appropriate value based on similar land use.			

3.2.5 Oak Hill Parkway Project Update

The preliminary hydrologic and hydraulic models from the proposed Oak Hill Parkway project preliminary drainage study were received from the City in December of 2019. From the hydrologic model received, the following updates were incorporated into the Williamson Creek existing and ultimate conditions basin models to reflect approved updates to existing conditions and the proposed changes anticipated by the future Oak Hill Parkway project.

- Updated the existing Oak Hill detention facility to reflect the Freese and Nichols (FNI) dam safety survey from August 2019 for both existing and ultimate conditions
- Updated and renamed subbasin WCR10W10 and WCR30W30 to match FNI's model for both existing and ultimate conditions
- Updated the proposed impervious area for WCR10W10 and WCR30W30 for ultimate conditions to match FNI's model

- Updated subbasin WCR80W80 and WCR680W730 to match FNI's model affected by the proposed alignment change in the Kincheon subbasin for ultimate condition
- Added proposed detention at the Old Bee Cave site for ultimate condition

3.2.6 Other Model Update

Additional flood frequencies were added to the current effective model including 2-, 5-, and 25-year storms for existing conditions and 2-, 5-, 10-, and 50-year storms for ultimate conditions. The SCS curve number method parameters (Tc, CN, and IMP%) and lag time remained unchanged for existing and ultimate conditions except for the initial abstractions for the added flood frequencies. The initial abstraction defines the amount of precipitation that must fall before surface excess results. To be consistent with the effective model, the initial abstractions for all the additional storm events were interpolated from the data points provided in the effective model. Figure 3-2 below shows the fitting curve for the initial abstraction.

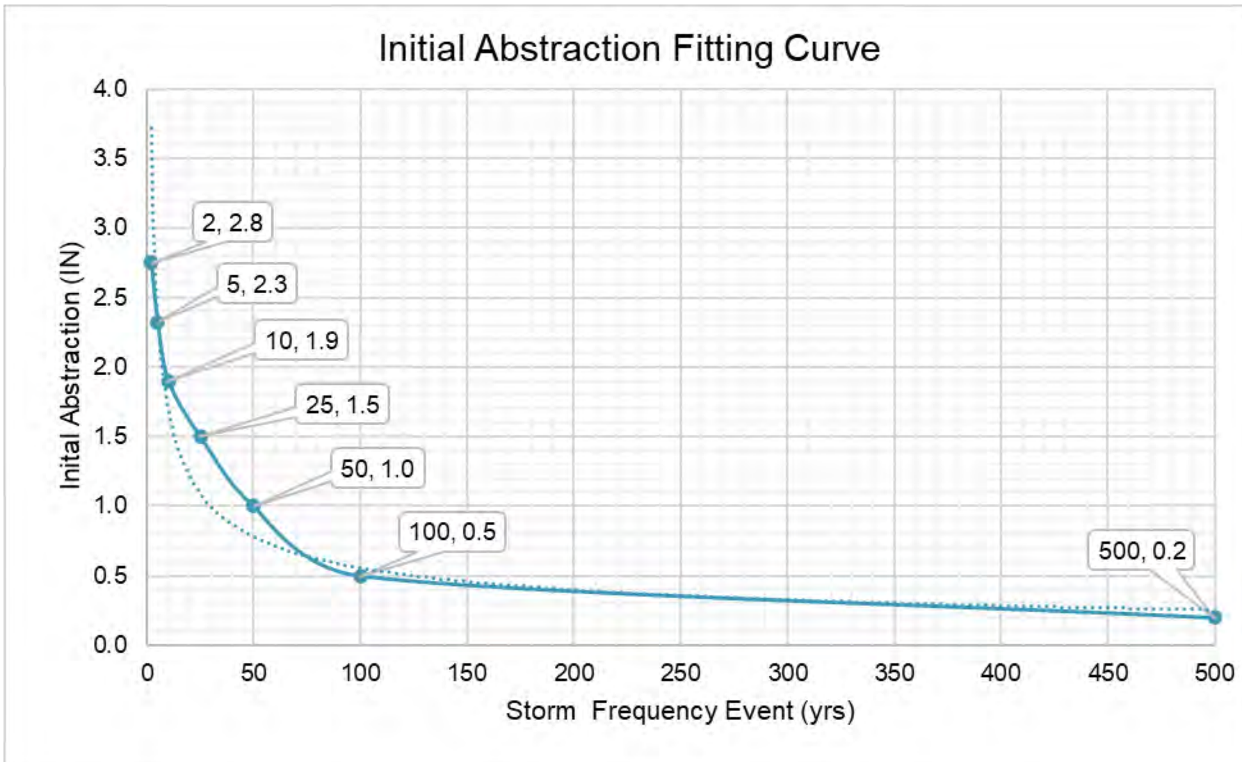

Figure 3-2. Initial Abstraction Fitting Curve

Due to the application of Atlas 14 precipitation data, the simulated 500-year detention volume for the Lantana detention pond exceeded the maximum storage input in the effective model. No survey or as-built data were available to extend the stage-storage-discharge data. To resolve this issue for preliminary modeling purposes, both the storage-discharge curve and elevation-storage curve were extended linearly. This update would not affect hydrologic results for the less frequent storm events. However, the Lantana detention pond geometry should be surveyed and updated for future analyses.

3.3 Updated Hydrologic Results and Summary

Simulations for the existing conditions hydrologic models were run for the 2-, 5-, 10-, 25-, 50-, 100-, and 500-year, 24-hour storm events. These simulation runs incorporated updated Atlas 14 DDF and updated existing conditions CN and IC%. The resulting peak discharges from the simulation runs were compared with the *duplicate effective* model runs in HEC-HMS, Version 4.3.0. In general, an average increase of 18 percent to 35 percent in peak discharges per basin were observed in these updated runs. Table 3-9 below summarizes the results for the major junctions within the study area.

Table 3-9. Effective versus Revised Existing Peak Discharges at Major Junctions

Node	Location along Williamson Creek	10 Year		50 Year		100 Year	
		Effective	Existing	Effective	Existing	Effective	Existing
JWCR120	D/S of Johns Road	11,340	14,230	20,710	25,680	24,880	30,750
JWCR1170	Menchaca Road	11,370	14,270	20,670	25,760	24,850	30,870
JWCR1000	D/S of Rail Road	11,810	14,840	21,300	26,990	25,660	32,430
JWCR103	South First Street	11,880	14,950	21,270	26,670	25,640	32,710
JWCR360	D/S of South Congress Ave	12,020	15,210	21,400	27,120	25,820	33,440

Simulations for the ultimate conditions hydrologic models were run for 2-, 5-, 10-, 25-, 50- and 100-year storm events. These simulation runs incorporated updated Atlas 14 DDF data, updated ultimate conditions CN and IC% values, and preliminary Oak Hill Parkway project updates. The resulting peak discharges from the simulation runs were compared with the *duplicate effective* model runs in HEC-HMS, Version 4.3.0 at major junctions. The average increase in the peak discharges for the updated 25- and 100-year ultimate condition simulation runs are 22 percent and 19 percent, respectively. Table 3-10 below summarizes the results for the major junctions within the study area.

Table 3-10. Effective versus Ultimate Peak Discharges at Major Junctions

Node	Location along Williamson Creek	25-Year		100-Year	
		Effective	Ultimate	Effective	Ultimate
JWCR120	D/S of Johns Road	17,440	20,980	26,200	31,040
JWCR1170	Menchaca Road	17,300	20,730	25,870	30,780
JWCR1000	D/S of Rail Road	17,720	21,460	26,480	32,050
JWCR103	South First Street	17,690	21,440	26,350	32,260
JWCR360	D/S of South Congress Ave	17,710	21,680	26,420	32,840

3.4 Detention Pond Storage Effect Analysis

This section describes the results of an independent study of the detention pond storage effect. The results of the analysis were not reflected in the existing hydrologic model for the purpose of this study, but should be considered for future phase.

In August of 2017, the City of Austin Watershed Protection Department studied the impacts of private stormwater detention facilities to peak flows on the Montopolis Tributary of Carson Creek. As part of the study, the City evaluated changes in peak flow due to detention ponds and explored methodologies that could be applied more generally to reproduce the flow reduction impacts without modeling ponds in detail. One of the methods recommended in the study included adjusting peak rate factor (PRF) in the SCS Unit Hydrograph calculations to mimic influence of ponds on peak flows and hydrographs.

A GIS shapefile of existing detention ponds within the Williamson Creek watershed was obtained from the City, which included a total of 29 ponds. Most of these ponds were constructed as part of private commercial and residential developments and are not included in the hydrologic model. Only three regional COA detention ponds (Oak Hill, Lantana, and Dick Nichols) are modeled in the effective hydrologic model. The effective model used Snyder Unit Hydrograph method. It was converted to use SCS Unit Hydrograph method with default peaking factor (value of 484) and used as base condition to compare effects of detention ponds. The cumulative effect of the ponds, not modeled in the effective hydrologic model, in reducing the peak flow was measured by using SCS Unit Hydrograph transform method and applying an adjusted PRF in the affected subbasins.

The adjusted PRF for the individual subbasin was calculated based on % ratio of available storage volume due to detention ponds to overall area of corresponding subbasin and generally following guidance given in the NRCS Texas Engineering Technical Note No. 210-18-TX5 as described in the draft City memorandum. A summary of the adjusted PRF calculations for individual subbasins are shown in Table 3-11.

The resulting peak discharges at the impacted subbasins and major junctions are compared with the base model using standard PRF in Table 3-12 to evaluate the effect of detention pond storage. It shows that the maximum reduction in peak discharges was <5% for 10-year storm event and <4% for 50- and 100-year storm events.

Table 3-11. Subbasins and Corresponding Pond Peaking Factor Calculations

Subbasin ID	Sum of Pond Volume (ac-ft)	Subbasin Area (ac)	% Ratio of Vol. to Overall Area	Fp	Standard PRF	Standard PRF x Fp	Rounded PRF
WCR10W10	4.28	464.64	0.9%	89%	484	429	400
WCR30W30	2.90	346.65	0.8%	90%	484	433	400
WCR530W500	6.79	132.48	5.1%	72%	484	348	350
WCR750W860	1.71	103.04	1.7%	82%	484	398	400
WCR60W60	0.41	316.80	0.1%	97%	484	471	450
WCR800W840	16.83	186.88	9.0%	72%	484	348	350
WCR470W570	10.73	82.56	13.0%	72%	484	348	350
WCR80W80	12.98	483.20	2.7%	76%	484	367	350
WCR570W590	7.16	64.64	11.1%	72%	484	348	350
WCR150W150	2.88	754.56	0.4%	94%	484	457	450
WCR210W210C	3.46	672.00	0.5%	93%	484	450	450
WCR210W210B	16.31	626.56	2.6%	76%	484	369	350
WCR210W210A	24.44	524.16	4.7%	72%	484	347	350
WCR1030W1080	3.64	345.60	1.1%	87%	484	423	400
WCR1040W1090	2.56	431.36	0.6%	92%	484	445	450
WCR140W140C	0.16	112.64	0.1%	97%	484	470	450
WCR260W260	1.44	917.76	0.2%	97%	484	469	450
WCR590W660	0.18	288.00	0.1%	98%	484	475	450

Table 3-12. Peak Discharges Comparison for Standard PRF and Adjusted PRF

Subbasin ID	10-Year			50-Year			100-Year		
	Base	Base PRF	Diff %	Base	Base PRF	Diff %	Base	Base PRF	Diff %
(REV)WCR10W10	3017	2955	-2.0%	5529	5454	-1.4%	6573	6487	-1.3%
(REV)WCR30W30_DS	957	938	-2.1%	1789	1764	-1.4%	2138	2109	-1.3%
(REV)WCR30W30_US	1192	1167	-2.1%	2227	2196	-1.4%	2661	2626	-1.3%
WCR530W500	992	950	-4.3%	1642	1583	-3.6%	1921	1852	-3.6%
WCR750W860	804	791	-1.6%	1291	1274	-1.3%	1504	1485	-1.3%
WCR60W60	2338	2340	0.1%	3887	3897	0.2%	4559	4571	0.3%
WCR800W840	1397	1338	-4.3%	2310	2227	-3.6%	2705	2607	-3.6%
WCR470W570	583	557	-4.5%	1004	968	-3.7%	1183	1140	-3.6%
WCR80W80	3513	3360	-4.4%	5907	5692	-3.6%	6939	6689	-3.6%
WCR570W590	498	478	-4.2%	808	779	-3.6%	943	909	-3.6%
WCR150W150	5759	5766	0.1%	9401	9424	0.3%	10977	11007	0.3%
WCR210W210C	5019	5025	0.1%	8193	8213	0.3%	9567	9593	0.3%
WCR210W210B	4876	4673	-4.2%	7894	7611	-3.6%	9214	8884	-3.6%
WCR210W210A	4149	3979	-4.1%	6649	6412	-3.6%	7749	7473	-3.6%
WCR1030W1080	2626	2582	-1.7%	4301	4246	-1.3%	5024	4961	-1.3%
WCR1040W1090	3224	3228	0.1%	5290	5303	0.2%	6201	6217	0.3%
WCR140W140C	883	885	0.2%	1407	1411	0.3%	1639	1644	0.3%
WCR260W260	6962	6971	0.1%	11334	11362	0.2%	13259	13295	0.3%
WCR590W660	2207	2209	0.1%	3590	3599	0.3%	4190	4202	0.3%
JWCR120[1]	14582	14649	0.5%	27374	27506	0.5%	34207	34398	0.6%
JWCR1170[1]	14764	14818	0.4%	27194	27281	0.3%	33640	33762	0.4%
JWCR1000[1]	15606	15650	0.3%	28698	28776	0.3%	35339	35441	0.3%
JWCR103[1]	15858	15890	0.2%	28680	28732	0.2%	35599	35674	0.2%
JWCR360[1]	16415	16436	0.1%	29653	29691	0.1%	36756	36799	0.1%

[1] See description in Table 3-10.

4 *Effective* Hydraulic Model Update

Williamson Creek is a FEMA studied stream with a mapped regulatory floodplain. The objective of this task is to update the current effective hydraulic modeling and mapping to re-evaluate the inundation boundaries and flooding depths utilizing revised hydrology, the most recent topographic data and HEC-RAS 1D/2D combined modeling approach.

4.1 *Effective* Hydraulic Model

The current effective hydraulic model for the Williamson Creek watershed was obtained from the City of Austin in HEC-RAS version 3.1.2. It was developed in 2005 and revised in July 2016. This model includes one geometry data ("Upper and Lower Williamson"), three steady flow analysis plans ("Existing Conditions (FEMA)", "Existing Conditions (City of Austin)", and "Ultimate Conditions") and the corresponding flow data. The main stem of Williamson Creek and part of Sunset Valley tributary were modeled. The main stem of Williamson Creek was further divided into upper and lower reaches at Menchaca Road. All structures were modeled using the previously surveyed elevations. The model included lateral structures between Sunset Valley Tributary and Williamson Creek to simulate flow interactions between the two channels. Figure 4-1 shows the effective hydraulic model schematic at the studied extent.

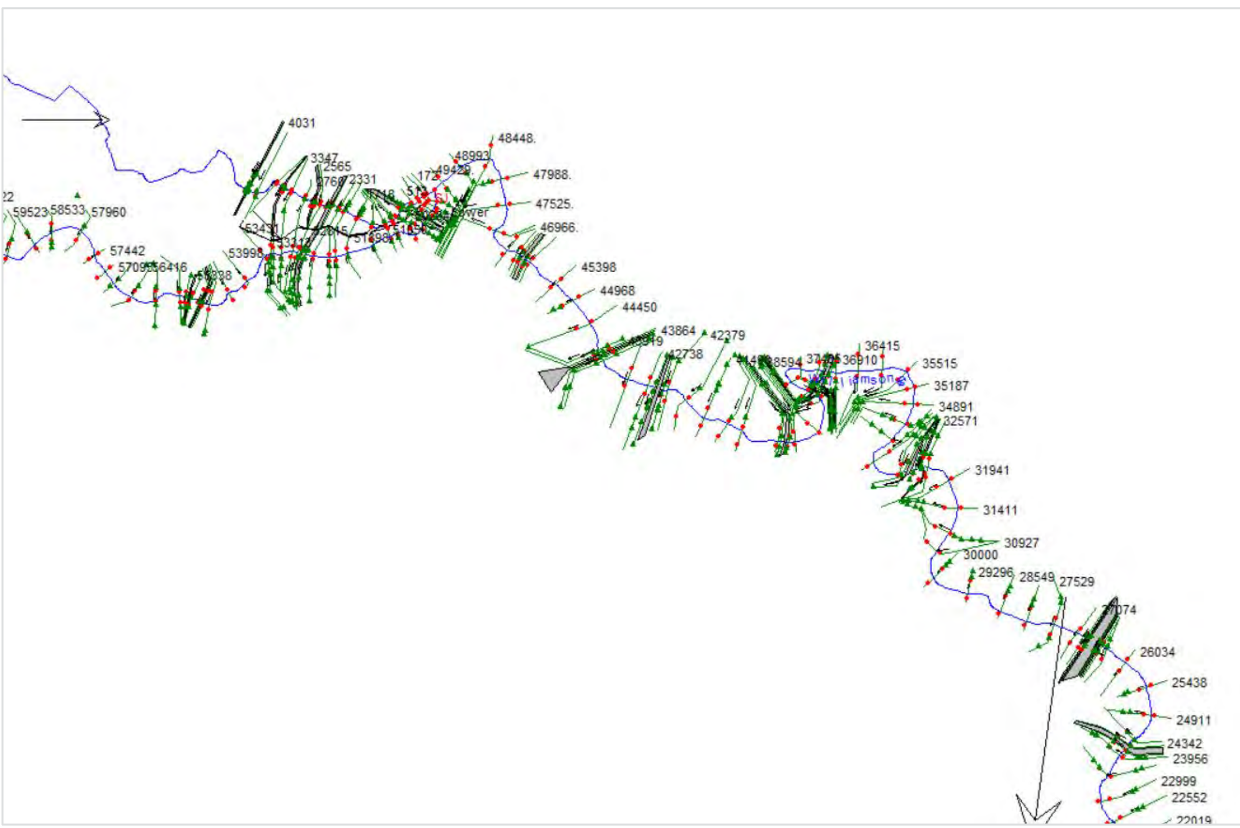

Figure 4-1. City of Austin Effective Hydraulic Model Schematic

4.2 Revised Hydraulic Model Updates

The Williamson Creek meanders multiple times within the project reach and includes complex overland flow patterns where tributaries join the main channel. Overland flow patterns vary during different levels of flood conditions at these meanders and confluences. Flow interactions and bifurcations present at multiple locations where tributaries join the Williamson Creek main channel or water overtops the main channel bank and flows through adjacent overbank areas. One-dimensional hydraulic models have limitations in modeling such complex flooding scenarios. A 1-D and 2-D combined hydraulic model was developed to better simulate these flow patterns using HEC-RAS version 5.0.7. This model would provide updated existing condition hydraulic results as a basis for the analysis of potential creek flood risk reduction alternatives. In the 1-Dimensional (1D) domain, the river stations were kept the same as those in the effective model for the convenience of model results comparison. The 2-Dimensional (2D) storage areas were connected to the 1D domain using lateral weirs. The 2D area can better simulate shallow flooding, complex flow interaction and bifurcations. The above updates are discussed in more detail in the sub-sections below.

4.2.1 Terrain and Model Extent

The terrain data used for the revised hydraulic model was generated from 2017 Central Texas LiDAR obtained from TNRIS. The LiDAR data was in NAD83 datum and was projected to Texas Central State Plane FIPS 4203 coordinate system.

The 1D/2D combined model began just upstream of Williamson Creek at Brodie Lane and extended eastwards to end before Williamson Creek at Interstate Highway 35 (IH-35). The 2D storage areas covered the left and right overbanks of the main stem of Williamson Creek. Figure 4-2 shows the 1D/2D combined hydraulic model schematic.

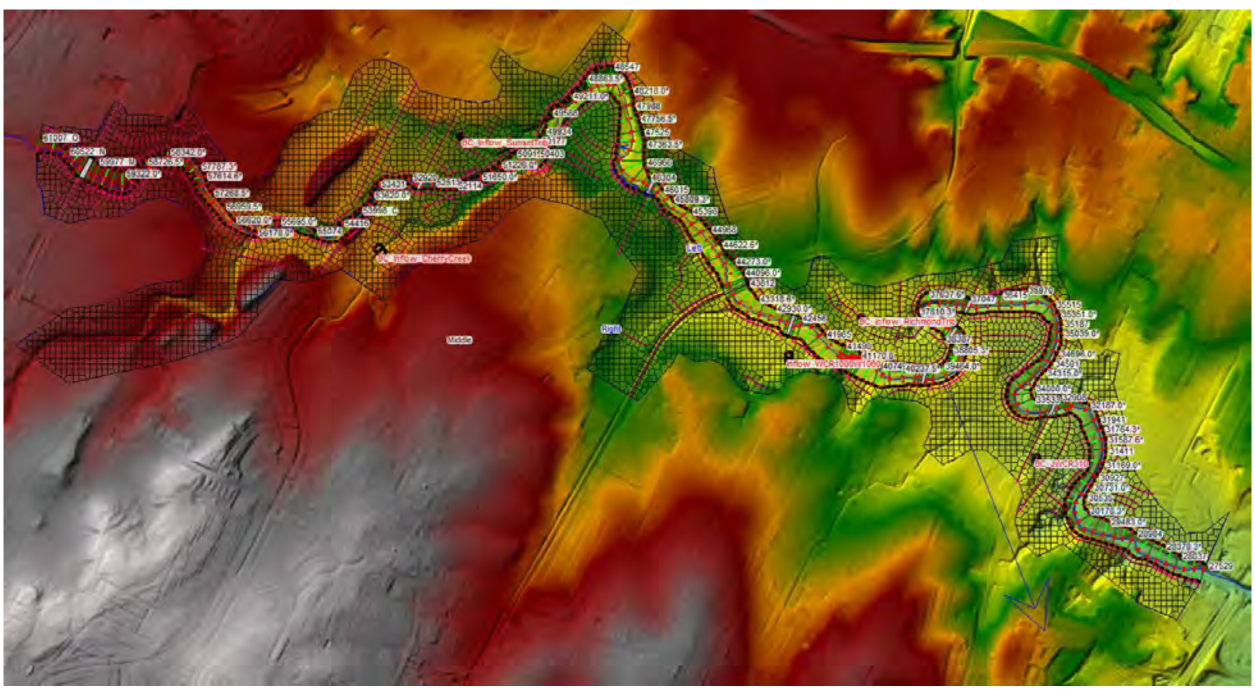

Figure 4-2. Revised Hydraulic Model Schematic

4.2.2 1D Model Geometry

The 1D component of the revised hydraulic model was built off the current effective hydraulic model for the Williamson Creek watershed within the model extent. The cross sections from the current effective model were truncated to near top of bank and in some cases adjusted to align correctly with channel. The station numbers of the truncated cross sections were kept the same as in current effective model. Few cross sections were added, especially near bends, to have 1D extents representing the main channel smoothly. The cross sections geometry was extracted from the 2017 LiDAR data. In addition, the manning's n value of the main channel and overbanks were determined from the effective model and adjusted by visual inspection of aerial photography. Manning's n values for the 1D cross sections range from 0.035 to 0.1.

There are 13 bridge/culvert structures along Williamson Creek within the model extent. Bridge/culvert deck stationing from the effective model were updated as the bounding cross sections were trimmed to top of bank. The bridge/culvert parameters were duplicated from the effective model. No additional survey was scoped to update the geometry of the structures.

A 1-foot wide pilot channel was introduced to assist stabilizing the unsteady state model by smoothing out channel bed irregularities and provide some artificial depth. The pilot channel invert was dropped to follow the slope of the existing channel. The utilization of pilot channel has negligible effect on model results. In addition to the pilot channel, interpolated cross sections were added to the geometry at few places for the same purpose.

4.2.3 2D Model Geometry

A 2D computational mesh with a general cell size of 100 feet by 100 feet was developed for left and right overbanks. Breaklines and refinement regions were used in RAS mapper tools to capture finer resolution features such as regional ponds, bridge/culvert, roads, elevated ground and other obstructions in the underlying geometry. Bridge/culvert structures on the tributaries of Williamson Creek within the 2D domain were not modeled in this study. However, these structures were accounted for using "leaky" cells to allow flow transfer. The underlying manning's n value for the 2D computational mesh were assigned based on the 2019 land use layer obtained from the COA GIS data portal. Manning's n value for each land use type were summarized in below.

Table 4-1. Landuse and Manning's Coefficient

Land Use Description	Manning's n Coefficient
Commercial	0.150
Developing	0.015
Greenbelt	0.080
Open	0.045
Other Structure	0.150
Parking Lot	0.015
Residential_MF	0.100
Residential_SF	0.100
Road	0.015

The 2D areas were connected to 1D cross sections using lateral weirs. Lateral weirs were delineated along the edge of 2D boundary at high ground and were limited to less than 1-mile. Lateral weirs were managed to break at bridge/culvert structures and tributaries with channel depths greater than 6-feet to improve model stability and to allow for appropriate weir coefficient use at confluence. Weir equation was selected as the overflow computation method. Weir coefficient along top of banks and tributaries are 0.5 and 2.0 respectively following HEC-RAS guidelines.

4.2.4 Boundary Conditions

Inflow hydrographs from areas upstream of the model extents were added as external boundary conditions at the upstream most cross section. Direct runoff, calculated in HEC-HMS, for sub-basin areas within the hydraulic model extents was added as an internal boundary condition. These hydrographs were directly applied to and distributed between several cross sections as applicable. There are few areas where major tributaries join the Williamson Creek with complex flow patterns and flooding can extend to 2D areas outside of main channel. For such areas, tributary flows were applied as internal boundary condition to the 2D domain and allowed to flow automatically from 2D domain to 1D main channel and vice versa. Flow from subbasin WCR1000W1060 joins the Williamson Creek mainly through two separate tributaries. Hence, 50% of the flow was added directly at River Station 40749 and remaining 50% of the flow was added to the 2D domain near second tributary confluence. Downstream model extents stop at River Station 27529 where the last few cross sections receive almost half of the flow from subbasin WCR360W360. Hence, 50% of flow from the subbasin was added near River Station 28529. HEC-HMS nodes or junctions used for internal and external boundary conditions are listed in Table 4-2.

Table 4-2. Revised 1D/2D RAS Boundary Conditions

River Station	Boundary Condition	HMS Node ID
61007	External Hydrograph	JWCR100
56416	Uniform Lateral Inflow	WCR100W100
55940	Uniform Lateral Inflow	J160K
54416	Uniform Lateral Inflow	WCR160W160
49429	Uniform Lateral Inflow	WCR110W110
48547	Uniform Lateral Inflow	WCR110W1170
46107	Uniform Lateral Inflow	WCR1100W1170
45398	Uniform Lateral Inflow	WCR120W113
43122	Uniform Lateral Inflow	WCR260W260
40749	Uniform Lateral Inflow	WCR1000W1060
36415	Uniform Lateral Inflow	WCR240W1040
30000	Uniform Lateral Inflow	WCR310W310
28549	Uniform Lateral Inflow	WCR360W360
2D Domain	Flow Hydrograph	WCR1010W1030
2D Domain	Flow Hydrograph	J130SV
2D Domain	Flow Hydrograph	WCR1000W1060
2D Domain	Flow Hydrograph	JWCR140A
2D Domain	Flow Hydrograph	JWCR310

A normal depth boundary condition was used at the downstream end of the model near Williamson Creek at IH-35.

4.2.5 Other Model Parameters

The 1D/2D HEC-RAS model was executed with variable time step controlled by courant condition using diffusion wave equations.

4.3 Revised Hydraulic Model Validation with 2013 Storm

Hydraulic model validation was performed using historical rainfall from the October 2013 storm event. Hyetographs were generated from observed gridded precipitation data and simulated in the existing condition HEC-HMS model as described in Section 3.4. The resulting hydrographs were added as inflow boundary conditions to the revised hydraulic model. The hydraulic model was then validated by comparing model water surface elevation (WSEL) with the observed high water marks. The validated hydraulic model was considered the final revised hydraulic model to be used in the flood mitigation alternative analysis.

4.3.1 Observed Rainfall/Runoff

The rainfall data from the October 2013 storm event obtained from the COA consisted of a gridded shapefile that covered the entire Austin metro area (containing 4,483 grid cells) as shown in Figure 4-3. The dataset also contained 196 CSV files of 15-minute rainfall depths for each one of the shapefile grid cells for the rainfall period from October 12th, 2013 to October 13th, 2013. In order to calculate the rainfall depths for sub-basins of the Williamson Creek watershed, 111 grid cells were extracted from the original shapefile to be used for the targeted area. Figure 4-4 presents the spatial correlations between the selected grid cells and the Williamson Creek sub-basins.

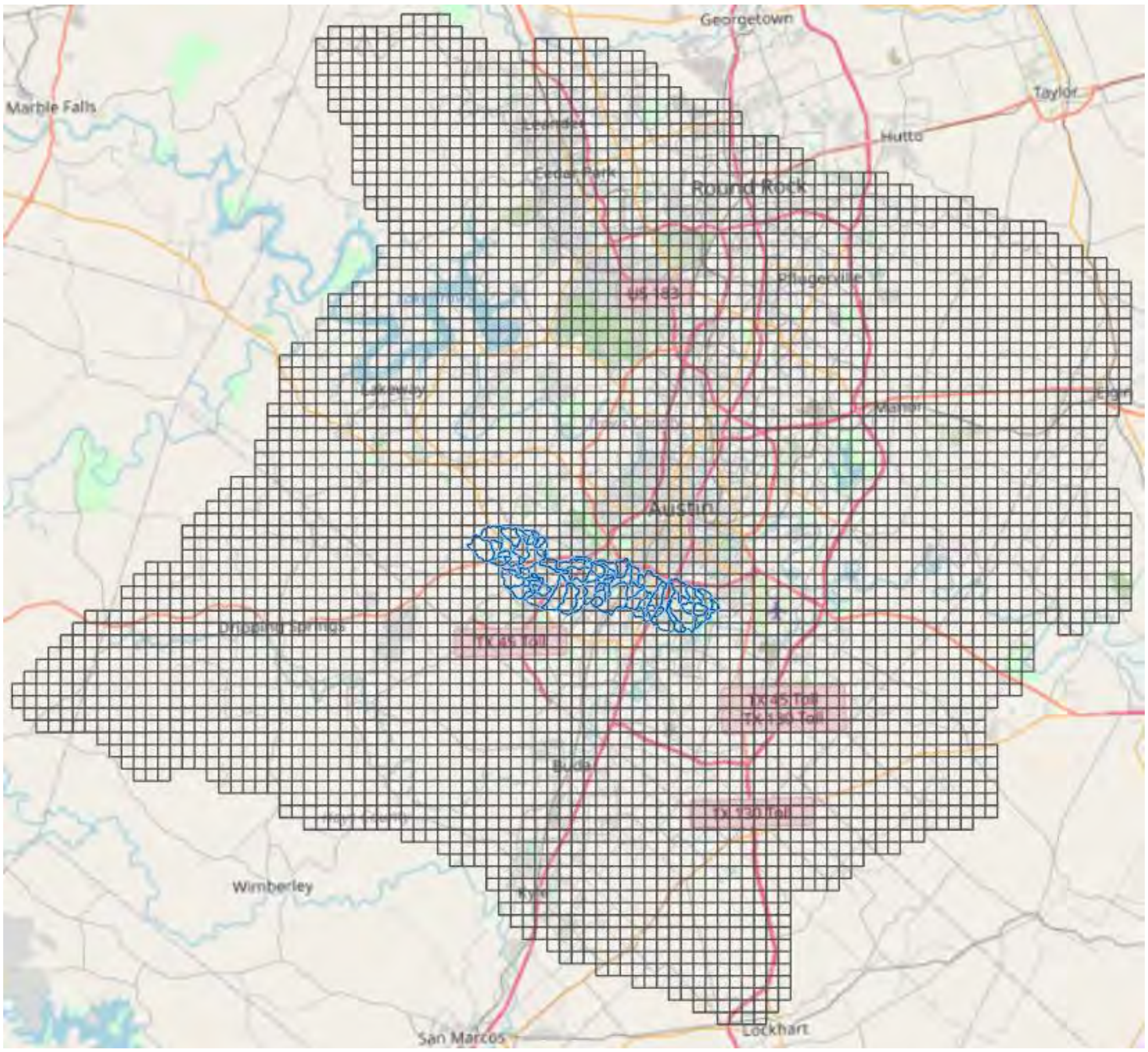

Figure 4-3. Gridded Shapefile with Rainfall Depth Data

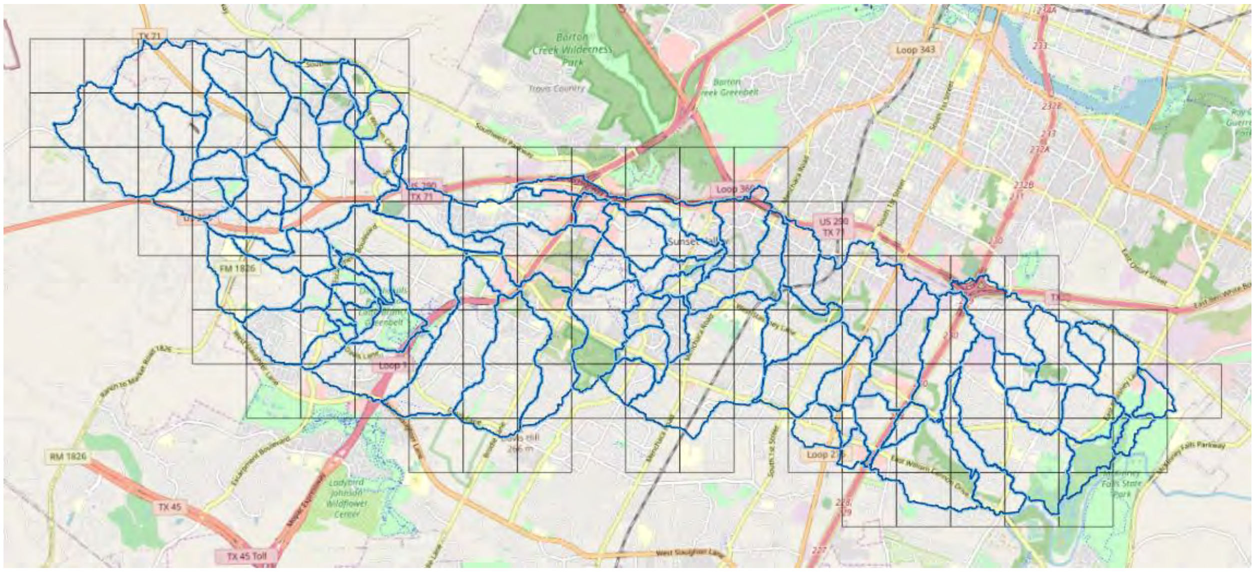

Figure 4-4. Rainfall Grid over Williamson Creek Subbasins

HDR determined that the rainfall period for this portion of the city occurred between 21:15 on 10/12/2013 to 10:45 on 10/13/2013. The time periods before and after this event were removed since they contained no rainfall. The total rainfall depths were mapped in Figure 4-5. It is obvious that the center of the Williamson Creek watershed experienced the greatest rainfall during the October 2013 storm event.

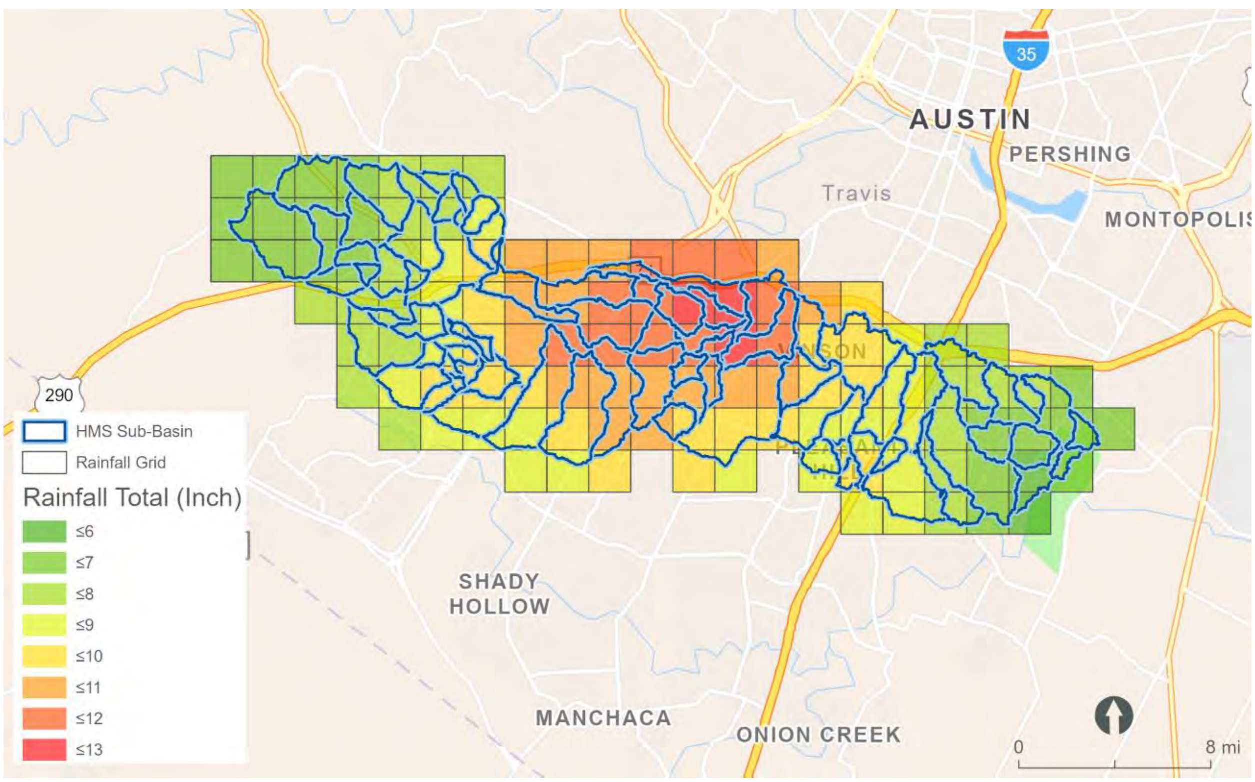

Figure 4-5. Storm Total Rainfall for the Williamson Creek area.

The 15-minute rainfall depths during the selected period were averaged into each subbasin using Zonal Statistic tools in ArcGIS Pro 2.4.2. The resulting 15-min interval hyetographs for the Williamson Creek sub-basins were entered as paired precipitation gages in HEC-HMS model. The resulting peak discharge calculated in HEC-HMS at key locations are shown in Table 4-3. It was assumed that there is no inter-basin transfer of runoff from Williamson Creek watershed to its neighboring watershed.

Table 4-3. October 2013 Storm Event Peak Discharges at Key Locations

Node	Description	Peak Discharge (cfs)
JWCR120	WC @ D/S of Jones Rd	14,978
JWCR1170	WC @ Menchaca Rd	14,930
JWCR1000	WC @ D/S of Rail Road	15,432
JWCR103	WC @ S 1st Street	15,444
JWCR360	WC @ D/S of S Congress	15,575

4.3.2 Model Parameters Adjustment

The City developed a steady state HEC-RAS model in 2016 for the same 2013 storm to match observed high water marks along Williamson Creek. This City model was used as a reference and the revised 1D/2D combined model was adjusted to better match observed water surface elevations. These minor adjustments included tweaking the 2D mesh cell size and shape, refining the manning's roughness coefficients, revising channel invert near Broken Bow area (based on the City model), adding interpolated cross sections, and distributing tributary inflows over multiple cross sections (instead of applying it to just one cross section).

The City model used flows from the City of Austin FEWS post-event runoff simulated Vflo model from the gage-adjusted radar rainfall data. The City model flows were scaled to match the observed high water marks.

HDR estimated HEC-HMS flows were applied to the 1D/2D combined model. Resulting HDR flows in the main channel of Williamson Creek were then compared to the City model flows at corresponding locations. HDR estimated flows were about 30% more than flows used in the City model. The City HMS model used to estimate these flows for 2013 storm event was not calibrated. Hence, estimated flows from the HDR HMS model were reduced by 20% (to be in between HMS estimated flows and the City estimated flows) to best replicate the observed high water marks.

4.3.3 Results/Comparison to Observed High Water Marks

A total of 36 observed high water marks from the October 2013 storm event were obtained from the City of Austin, from which 33 data points lie within the study extent and were used for results comparison. The high water mark data used was based primarily on post-storm observations, photographs and measurements by the City staff. Some observation points were based on direct measurement added to the LiDAR ground elevation while others were based on estimation from photographs. Table 4-4 below summarizes the locations of the observed data, the observed high water marks and confidence level (of the observation as indicated by the City of Austin), and modeled WSELs. The table has few locations with more than one point at same address. These points are actual observation points at same address but at two separate areas within the property (possibly different ends of the structure) that has different ground elevations. Spatial locations of all observed data points are presented in the figures of Appendix B. Effective River Station in Table 4-4 is approximate location based on 1-D cross section numbers for reference. Figure 4-6 shows a profile view of the observed HWM on top of the modeled water profile. The model correlates well with the observation at high confident data points as highlighted in Table 4-4. The average percentage difference between the observed data and the validated model results is 0.08% and modeled water surface elevation generally matched high water marks within 0.5 feet. It is noted that the high water mark water surface elevations were based on 2012 Lidar data while HDR model water surface elevations are based on 2017 Lidar data. Some places near Radam Circle and Bayton Loop have differences in ground elevation in 2012 Lidar and 2017 Lidar as some houses are removed between 2012 and 2017.

Table 4-4. HEC-RAS WSEL vs Observed High Water Marks

ID	Effective River Station	Location	COA Observation			Model WSEL (ft-msl)[1]	Δ (ft)	CL[2]
			2012 LiDAR Elevation (ft-msl)	Depth (ft)	HWM (ft-msl)			
1	53431	5615 Bayton Loop[3]	659.40	3.10	662.50	663.32	0.82	N/A
2	51898	5305 Indio Dr	653.60	2.00	655.60	655.65	0.05	N/A
3	51898	5305 Indio Dr	655.50	0.00	655.50	655.69	0.19	N/A
4	51050	2501 Jones Rd	652.80	0.00	652.80	654.28	1.48	N/A
5	50284	5003 Packsaddle Pass	651.20	0.00	651.20		N/A	N/A
6	50284	5003 Packsaddle Pass	650.80	1.50	652.30	650.27	-2.03	N/A
7	50177	4804 Broken Bow Pass	642.50	1.50	644.00	644.12	0.12	N/A
8	48993	4801 Buckskin Pass	641.60	0.80	642.40	642.99	0.59	N/A
9	48488	5003 Buckskin Pass	639.30	1.30	640.60	640.89	0.29	N/A
10	46966	4806 Pawnee Pathway	636.80	3.50	640.30	640.81	0.51	L
11	46966	4806 Pawnee Pathway	634.10	5.50	639.60	640.83	1.23	L
12	46966	USGS Gage 08158930	618.39	20.62	639.01	639.52	0.51	N/A
13	46232	Menchaca Rd crossing (S)	638.90	0.00	638.90		N/A	M
14	46232	Menchaca Rd crossing (N)	639.30	0.00	639.30	639.68	0.38	M
15	43712	5306 Meadow Creek Cir[3]	624.30	0.80	625.10	624.94	-0.16	H
16	43712	5303 Meadow Creek Cir[3]	622.80	2.40	625.20	625.11	-0.09	H
17	43122	1214 Radam Cir[3]	624.40	0.50	624.90	624.79	-0.11	H
18	43122	1212 Radam Cir[3]	623.70	0.85	624.55	624.48	-0.07	H
19	43122	1210 Radam Cir[3]	624.00	0.65	624.65	624.46	-0.19	H
20	43122	1208 Radam Cir[3]	622.30	1.90	624.20	624.4	0.20	H
21	42738	5231 Meadow Creek Dr	622.60	1.25	623.85	623.99	0.14	H
22	42456	Emerald Forest Dr crossing	622.00	0.00	622.00		N/A	N/A
23	42379	1103 Radam Cir[3]	620.60	0.80	621.40		N/A	H

Table 4-4. HEC-RAS WSEL vs Observed High Water Marks

ID	Effective River Station	Location	COA Observation			Model WSEL (ft-msl)[1]	Δ (ft)	CL[2]
			2012 LiDAR Elevation (ft-msl)	Depth (ft)	HWM (ft-msl)			
24	42379	1104 Radam Cir[3]	618.90	2.50	621.40		N/A	H
25	42379	1104 Radam Cir[3]	621.60	0.00	621.60	619.74	-1.86	H
26	42379	1102 Radam Cir[3]	618.10	2.80	620.90	619.4	-1.50	H
27	41965	1100 Radam Cir[3]	617.80	2.90	620.70	619.23	-1.47	H
28	40749	5103 Aberdeen Dr	613.00	1.00	614.00	613.15	-0.85	L
29	40749	5103 Aberdeen Dr	613.33	0.83	614.16	613.15	-1.01	M
30	35187	320 Heartwood Dr	598.20	0.80	599.00	599.21	0.21	M
31	34891	308 Heartwood Dr	596.90	1.20	598.10	597.97	-0.13	M
32	34129	206 Heartwood Dr	594.40	2.00	596.40	595.82	-0.58	M
33	32433	Wassan Rd crossing	591.70	0.00	591.70		N/A	N/A

[1] Water surface elevations were extracted from point values in the HEC-RAS 1D/2D result and not from nearby cross sections. No value indicates that the point is not inundated.

[2] CL = Confidence Level as noted in COA observation

[3] Location where structures/houses removed between Year 2012 and 2019

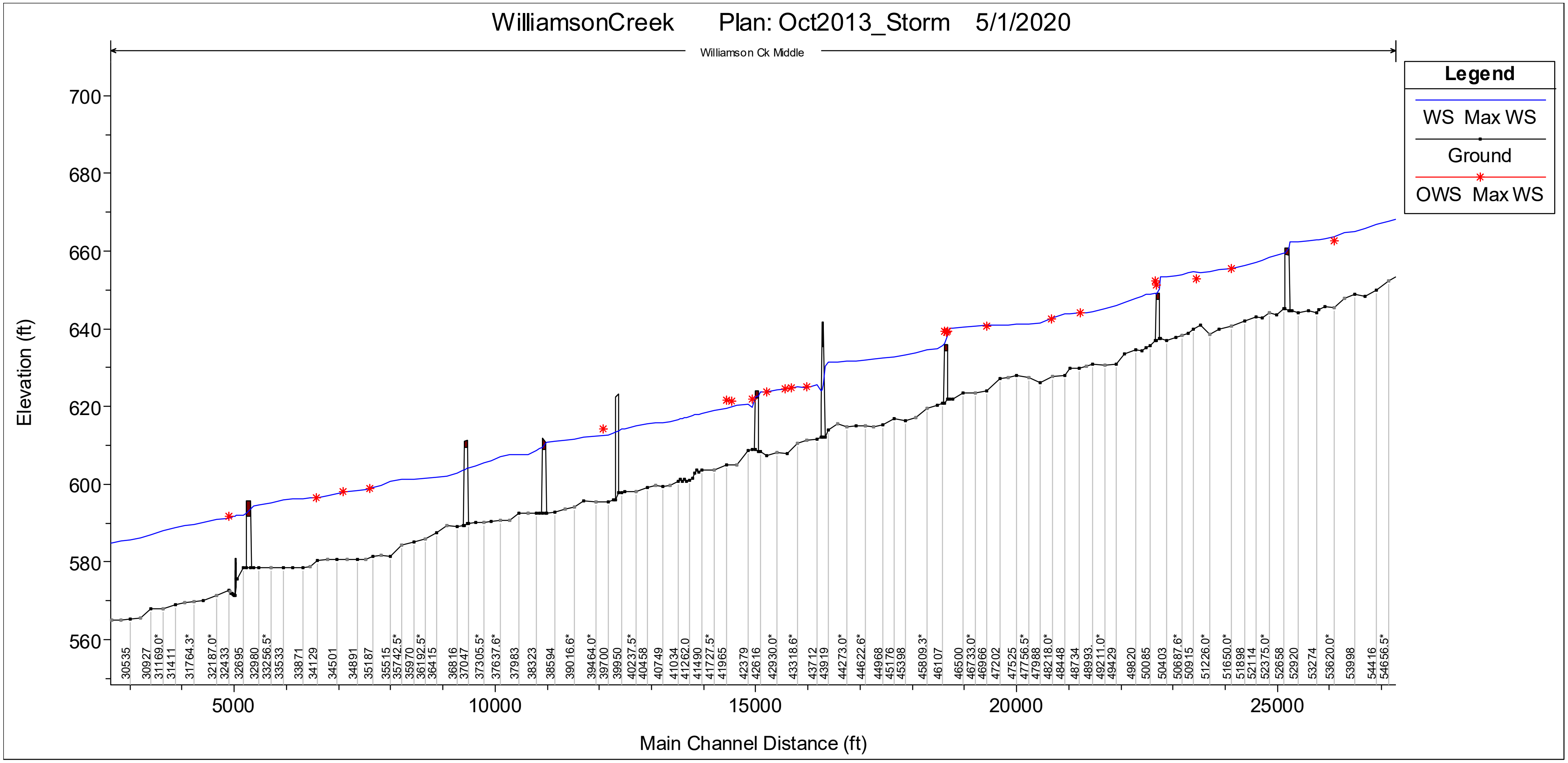

Figure 4-6. Observed HWM vs Validated Model Water Profile

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4.4 Revised Model Results

Once the revised hydraulic model was validated against observed high water marks from the October 2013 storm event, the model geometry was then used to prepare existing and ultimate conditions inundation mapping and to determine the extents of structural inundation. The revised results are summarized and compared against the effective model in the following sections.

4.4.1 Revised Existing and Ultimate Conditions Floodplain Boundaries

The revised existing condition 100-year and 500-year floodplain boundaries and ultimate condition 25-yr and 100-yr floodplain boundaries were compared with the effective floodplain boundaries for the corresponding storm frequency events.

Figure 4-7 shows the floodplain boundary comparison for the existing condition 100-yr storm event. The revised existing 100-year floodplain expands significantly at the upstream of Union Pacific Railroad in the middle of the project area. Along the bend of Heartwood, flood water tends to spill through some shallow areas in the neighborhood.

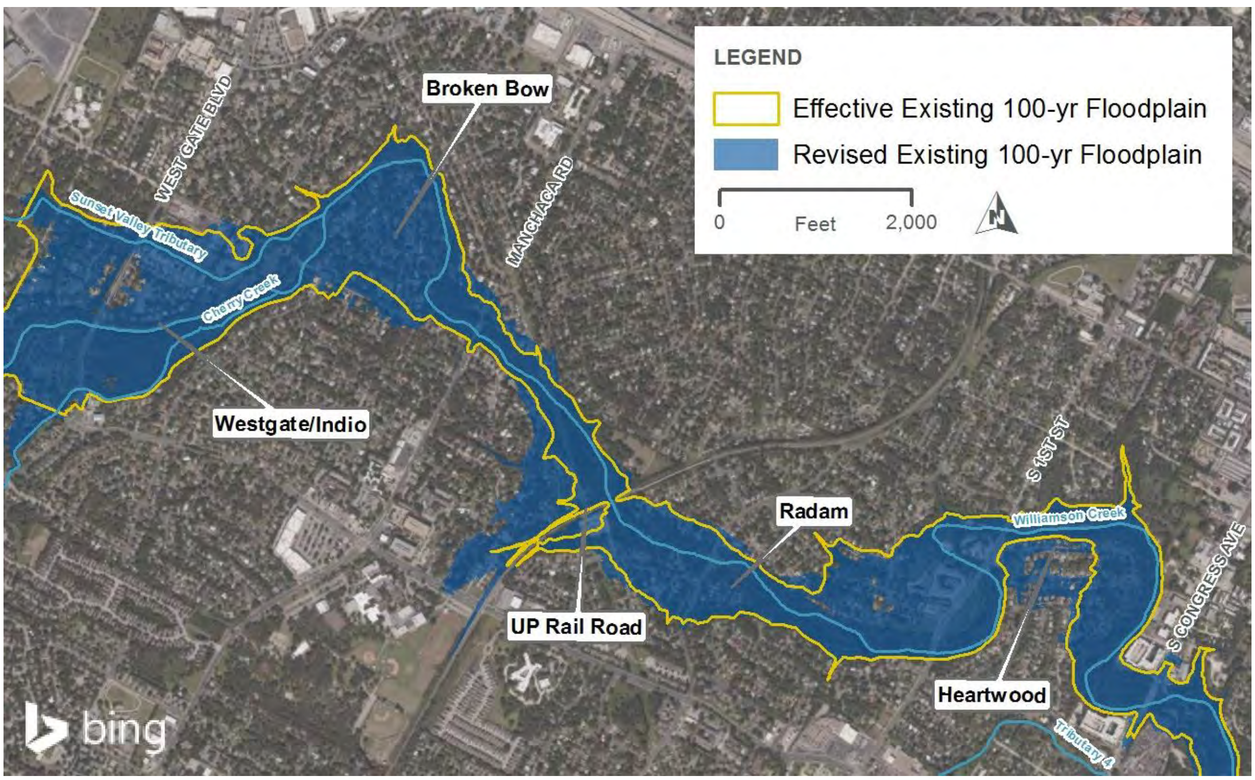

Figure 4-7. Existing Condition 100-YR Floodplain Boundary Comparison

Figure 4-8 shows the floodplain boundary comparison for the existing condition 500-year storm event. Like the existing condition 100-year storm event, the revised existing condition 500-year floodplain boundary is significantly wider at the upstream of the Union Pacific Railroad and in the Heartwood neighborhood.

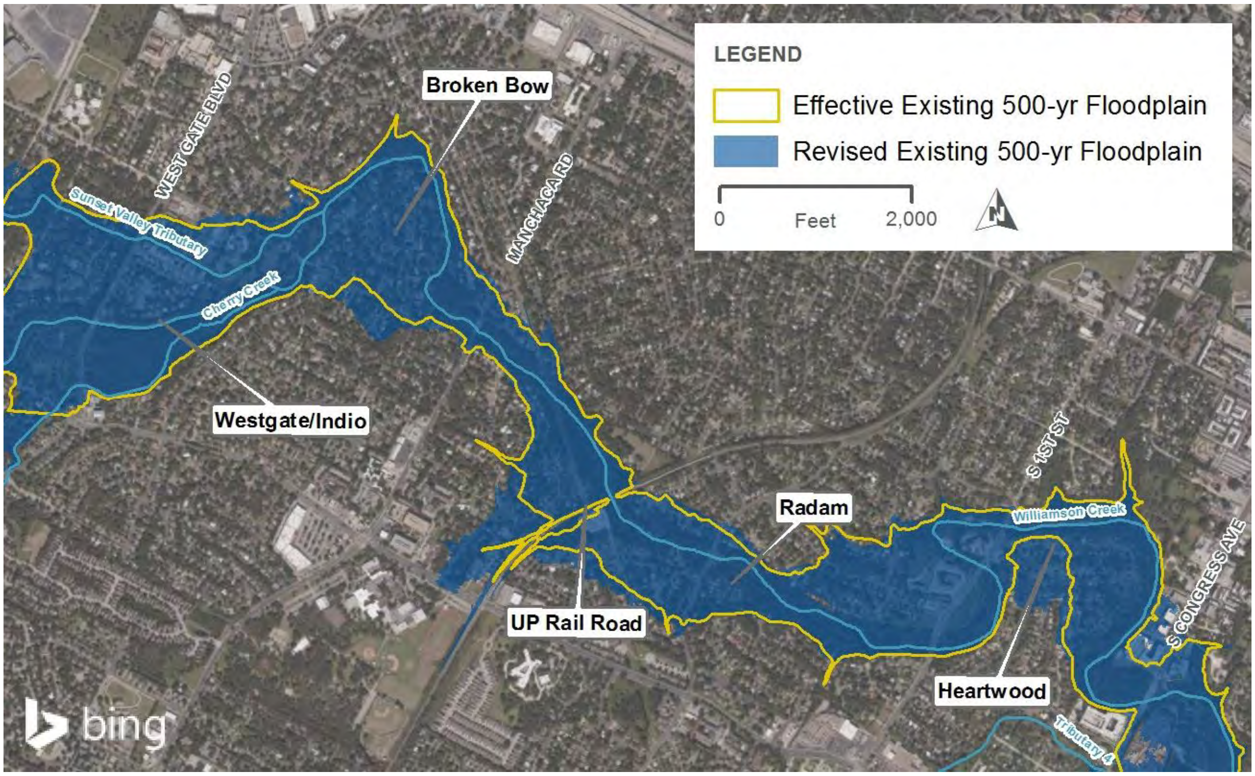

Figure 4-8. Existing Condition 500-YR Floodplain Boundary Comparison

Figure 4-9 below shows the floodplain boundary comparison for the ultimate condition 25-year storm event. In addition to the area at the upstream of Union Pacific Railroad, the revised floodplain boundary is significantly wider at Broken Bow and Radam. At Bayton Loop area where Sunset Valley Tributary and Cherry Creek join Williamson Creek, the HEC-RAS 1D/2D model picks up more detail in the flat area between channels.

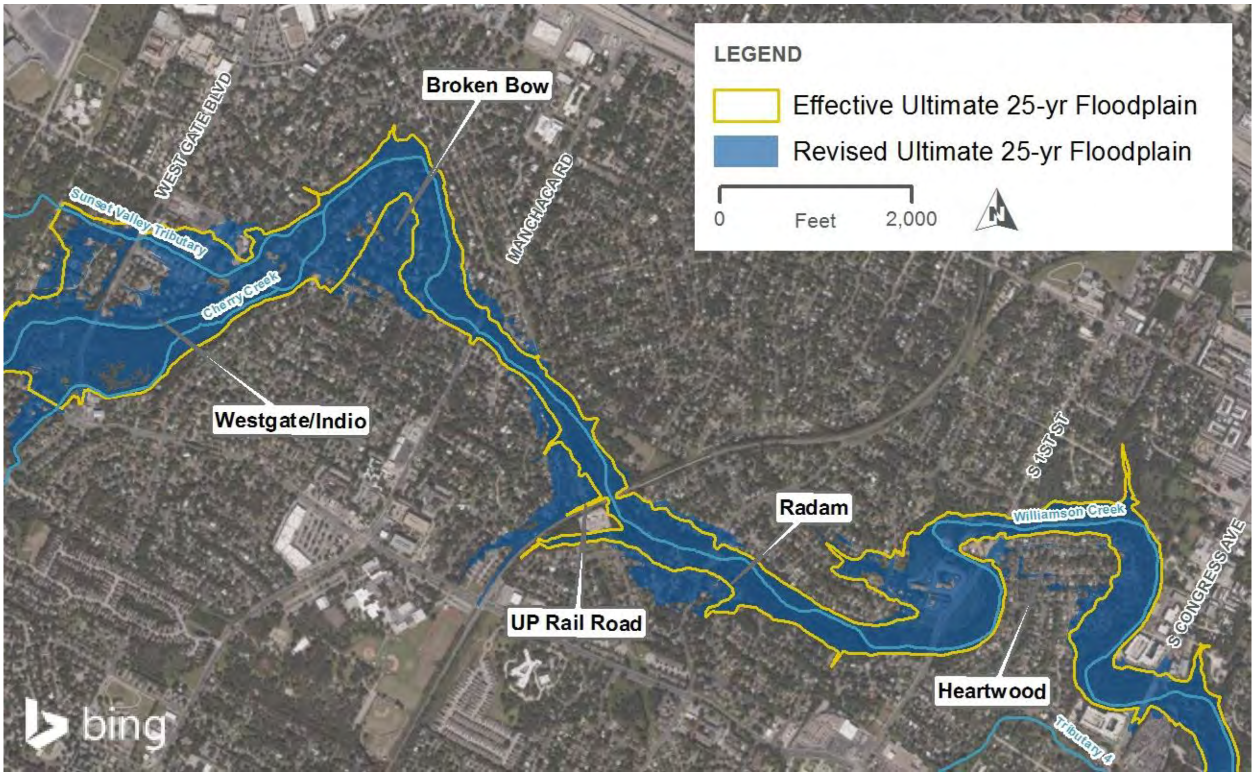

Figure 4-9. Ultimate Condition 25-YR Floodplain Boundary Comparison

Figure 4-10 below shows the floodplain boundary comparison for the ultimate condition 100-year storm event. The revised floodplain boundary generally follows the effective floodplain boundary except for the area at upstream of Union Pacific Railroad. The shortcut through the Heartwood neighborhood area is seen in the ultimate condition 100-year floodplain as well.

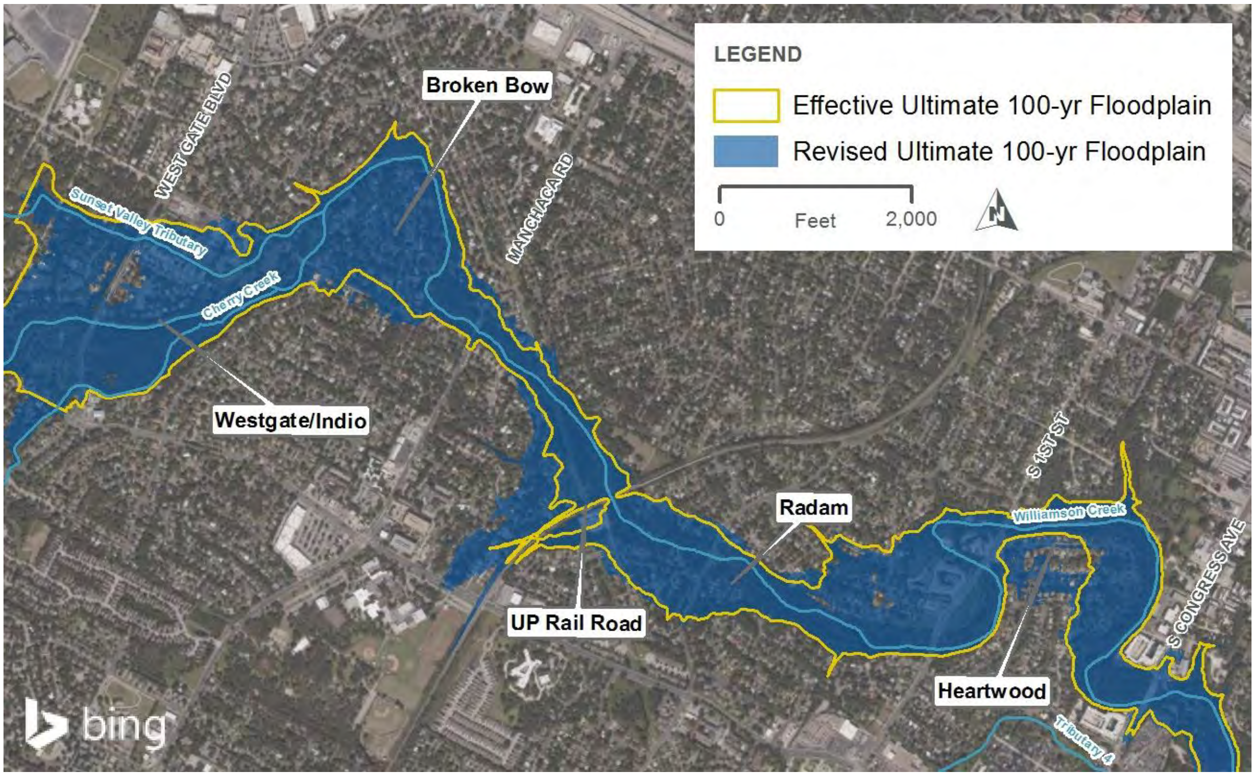

Figure 4-10. Ultimate Condition 100-YR Floodplain Boundary Comparison

4.4.2 Inundation Maps and Structure Flooding

Revised hydraulic model inundation extents were used to determine habitable structures within the studied Williamson Creek watershed that are at risk for flooding. Structural flooding occurs when the water surface elevation is higher than the lowest finished floor elevation (FFE). The finished floor elevation (FFE) were either obtained from previously surveyed FFE or estimated from 2017 LiDAR data and google street view. For elevated structures, the estimated FFEs were calculated by adding 10-ft to the highest ground elevation. For non-elevated structures, FFEs were calculated by adding 6 inches to the highest ground elevation at the structure. HDR also selected thirty (30) representative structures from the estimated FFE for additional survey. This data was not available at the time of the report but will be completed and updated once they become available.

The inundation boundaries and structures inundated for existing and ultimate condition storm events are presented in the figures of Appendix C.

Table 4-5 through Table 4-7 summarize the number of structures inundated for each storm event categorized by the previously identified problem area. These numbers do not include previously bought-out/removed structures. These tables also compare the change of inundated structures between the effective models and the revised hydraulic models. The results indicate that the total number of inundated structures generally increases in the revised hydraulic model.

Table 4-5. Inundated Structures by Problem Area – Existing 100-YR

Problem Area	Existing Condition		
	Eff. 100-YR	Rev. 100-YR	Diff
West Gate/Bayton Loop/Indio	51	51	0
Broken Bow	89	97	8
Radam	106	115	9
Heartwood	31	55	24
Other Areas	3	82	79
Total	**280**	**400**	**120**

Table 4-6. Inundated Structures by Problem Area – Ultimate Condition 25-YR

Problem Area	Ultimate Condition		
	Eff. 25-YR	Rev. 25-YR	Diff
West Gate/Bayton Loop/Indio	30	33	3
Broken Bow	46	76	30
Radam	22	41	19
Heartwood	9	11	2
Other Areas	0	22	22
Total	**107**	**183**	**76**

Table 4-7. Inundated Structures by Problem Area – Ultimate Condition 100-YR

Problem Area	Ultimate Condition		
	Eff. 100-YR	Rev. 100-YR	Diff
West Gate/Bayton Loop/Indio	51	51	0
Broken Bow	89	97	8
Radam	106	112	6
Heartwood	33	54	21
Other Areas	13	82	69
Total	**292**	**396**	**104**

The inundation depths of the identified habitable structures were extracted from the revised hydraulic model at the centroids of the structures. The figures in Appendix D show the flooding depth and inundation depth of the habitable structures for the existing and ultimate condition 25-year and 100-year storm events. The tables in Appendix E document the address, FFE, and inundation depth for each structure.

4.4.3 Water Surface Elevation Comparison at Key Locations

The water surface elevations of the revised hydraulic model were compared to the current effective model at several key locations within the study extent and are summarized in Table 4-8 and Table 4-9. Figure 4-11 shows these comparison locations.

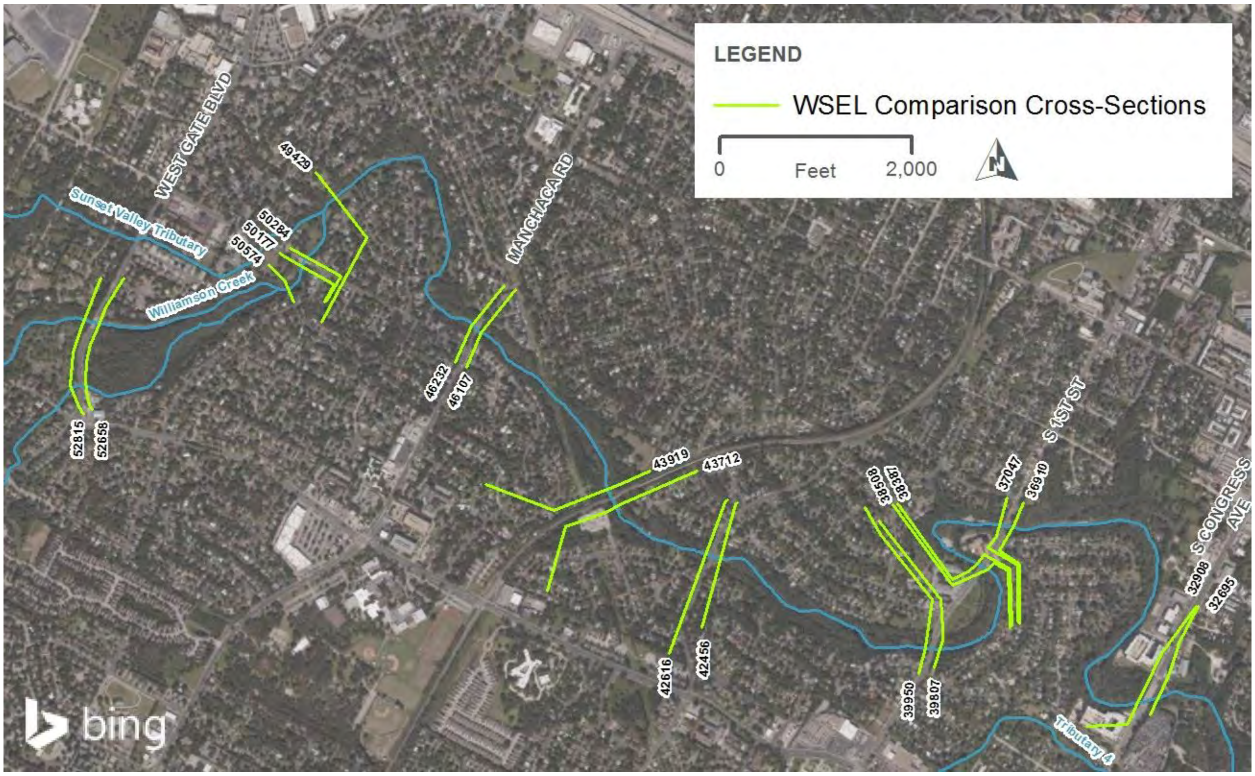

Figure 4-11. Key Locations for Max Water Surface Elevation Comparison

Impacts to the maximum water surface elevations vary significantly depending on the location in the Williamson Creek watershed and the storm events. These changes are due to atlas 14 impact and the dynamic flow routing of the 2D model compared to the previous 1D steady state model. In summary, the revised hydraulic model results in an increase in water surface elevations comparing to the current effective model. The impacts are greater for less frequent storm event.

Table 4-8. Effective vs Revised Existing Max WSEL (ft-msl) at Key Locations

Location Description	River Station	100-YR			500-YR		
		Eff	Rev	Δ	Eff	Rev	Δ
WC at upstream of West Gate Blvd	52815	664.94	667.46	2.52	665.83	670.26	4.43
WC at downstream of West Gate Blvd	52658	663.16	663.39	0.23	664.42	665.62	1.20
Downstream of Cherry Creek Confluence	50574	654.90	656.07	1.17	656.01	659.03	3.02
WC at upstream of Johns Rd	50284	654.44	655.92	1.48	655.39	658.94	3.55
WC at downstream of Johns Rd	50177	652.01	654.31	2.30	653.75	658.16	4.41
Downstream of Sunset Valley Confluence	49429	649.95	650.43	0.48	651.86	653.75	1.89
WC at upstream of Menchaca Rd	46232	643.01	647.16	4.15	646.42	650.82	4.40
WC at downstream of Menchaca Rd	46107	642.11	644.98	2.87	645.75	648.66	2.91
WC at upstream of UPRR	43919	635.43	641.83	6.40	641.24	644.08	2.84
WC at downstream of UPRR	43712	630.95	631.6	0.65	632.65	634.65	2.00
WC at upstream of Emerald Forest Dr	42616	628.22	630.76	2.54	629.18	633.56	4.38
WC at downstream of Emerald Forest Dr	42456	625.22	627.53	2.31	627.76	631.51	3.75
WC at upstream of S 1st St (A)	39950	618.00	621.42	3.42	620.17	625.38	5.21
WC at downstream of S 1st St (A)	39807	617.94	619.77	1.83	620.17	622.94	2.77
WC at upstream of S 1st St (B)	38508	615.27	618.74	3.47	618.29	622.44	4.15
WC at downstream of S 1st St (B)	38387	614.44	617.74	3.30	617.95	622.01	4.06
WC at upstream of S 1st St (C)	37047	610.88	614.54	3.66	615.12	618.72	3.60
WC at downstream of S 1st St (C)	36910	609.60	611.19	1.59	612.45	615.63	3.18

Table 4-9. Effective vs Revised Ultimate Max WSEL (ft-msl) at Key Locations

Location Description	River Station	100-YR			500-YR		
		Eff	Rev	Δ	Eff	Rev	Δ
WC at upstream of West Gate Blvd	52815	664.42	665.66	1.24	664.89	667.61	2.72
WC at downstream of West Gate Blvd	52658	662.21	661.94	-0.27	663.3	663.41	0.11
Downstream of Cherry Creek Confluence	50574	653.90	655.43	1.53	654.98	656.08	1.10
WC at upstream of Johns Rd	50284	653.54	655.33	1.79	654.52	655.93	1.41
WC at downstream of Johns Rd	50177	650.53	651.83	1.30	652.15	654.32	2.17
Downstream of Sunset Valley Confluence	49429	648.07	648.48	0.41	650.09	650.42	0.33
WC at upstream of Menchaca Rd	46232	640.11	644.49	4.38	643.26	647.15	3.89
WC at downstream of Menchaca Rd	46107	638.60	641.08	2.48	642.4	644.96	2.56
WC at upstream of UPRR	43919	630.89	638.07	7.18	635.86	641.82	5.96
WC at downstream of UPRR	43712	628.48	629.48	1.00	631.12	631.56	0.44
WC at upstream of Emerald Forest Dr	42616	624.41	628.64	4.23	628.41	630.73	2.32
WC at downstream of Emerald Forest Dr	42456	622.92	623.68	0.76	625.4	627.48	2.08
WC at upstream of S 1st St (A)	39950	616.09	618.66	2.57	618.15	621.34	3.19
WC at downstream of S 1st St (A)	39807	615.95	617.22	1.27	618.09	619.69	1.60
WC at upstream of S 1st St (B)	38508	613.04	616.00	2.96	615.47	618.64	3.17
WC at downstream of S 1st St (B)	38387	611.42	613.33	1.91	614.68	617.60	2.92
WC at upstream of S 1st St (C)	37047	607.50	608.31	0.81	611.16	614.34	3.18
WC at downstream of S 1st St (C)	36910	606.78	607.61	0.83	609.81	611.07	1.26

5 Evaluation of Flood Risk Reduction Alternatives

In this section, nine flood risk reduction alternatives were evaluated for middle Williamson Creek, six (A through F) that were previously identified and three (G through I) that were developed in this study. The objective of the alternatives is to demonstrate flood risk reduction benefit, including removal, of habitable structures from the 25-year and 100-year ultimate conditions events without creating adverse impacts to Williamson Creek upstream or downstream of the study area. The evaluations were performed at the conceptual level of detail to assist the City of Austin (City) in determining alternatives that are not viable and do not warrant further study. The remaining alternatives that do appear to have viability may be further investigated in Phase 2 of the Williamson Creek Flood Risk Reduction Project.

The nine alternatives that were evaluated are:

- **Alternative A**: Qualitatively evaluated the 2006 USACE "Tentatively Selected Plan" including channel modifications along Heartwood, Radam, Broken Bow, and Bayton Loop areas as described in the Interim Feasibility Report and Integrated Environmental Assessment – Final (USACE, October 2006). This alternative did not include the development of a revised proposed condition hydraulic model.
- **Alternative B**: Evaluated flood walls in a proposed conditions hydraulic model to provide flood protection for 100-year ultimate land use conditions water surface elevation. Location of flood walls along the channel near flood risk areas were based on results from the revised hydraulic model. The proposed condition hydraulic model determined the length and height of floodwall necessary to provide protection from 100-year ultimate land use conditions event.
- **Alternative C**: Evaluated a non-structural permanent evacuation (Voluntary Buyouts) for structures with finished floor elevation below 100-year ultimate land use conditions water surface elevation. Estimated costs were provided by the City.
- **Alternative D**: Evaluated flood proofing (Elevating) single-family homes at least two feet above 100-year ultimate land use conditions water surface elevation. Prior to this evaluation, this alternative was deemed infeasible by the City of Austin Law Department but was included as a point of comparison for other alternatives.
- **Alternative E**: Evaluated a regional detention pond near confluence of Kincheon Creek with Williamson Creek that was previously proposed in a preliminary engineering report by Alan Plummer Associates, Inc. in March 2000.
- **Alternative F**: Evaluated the use of open green space near the confluence of Cherry Creek and Williamson Creek as detention using a proposed conditions hydraulic model.
- **Alternative G**: Evaluated channel modifications using targeted cross sections in each of the five problem areas identified in Section 1 of this report. These were not modeled in a HEC-RAS 1D/2D proposed conditions model, but instead used a hydraulic calculator for each cross-section to estimate flood risk benefit.

- **Alternative H**: Evaluated a 2.5-mile underground bypass using a proposed conditions 1D/2D hydraulic model. The proposed bypass is generally along Stassney Lane. It diverts flood waters from Williamson Creek at Bayton Loop and outfalls at Williamson Creek just downstream of South Congress Avenue and the Tributary 4 confluence.
- **Alternative I**: Evaluated a combination of various alternatives including channel modifications, flood walls, and voluntary buyouts using a proposed conditions 1D/2D hydraulic model.

In addition to detailing the flood risk reduction benefits, unless determined to be infeasible pre-emptively by the City (Alt D) or due to the results of the hydraulic modeling, the evaluation of each alternative included: assessing compliance with City Environmental Criteria Manual (ECM) related to stream stability; assessing compliance with City Drainage Criteria Manual (DCM); anticipating local, state, and national permitting requirements; assessing real estate needs including easements and land acquisitions; determining potential major water and wastewater utility impacts; projecting the time of implementation including design, permitting, and construction; assessing social/community impacts and public input; and qualitatively assessing relative potential operations and maintenance costs. Alternatives which resulted in no net flood risk reduction benefits to habitable structures or less than 50 feet in aggregate reduction of inundation of habitable structures were not included in the evaluation matrix.

5.1 Evaluation Criteria

A high level, semi-quantitative alternatives comparison matrix was developed to assist the City in determining viable solutions from which to move forward with in Phase 2 of the middle Williamson Creek Flood Risk Reduction Project. For this matrix, nine criteria were chosen by the City to represent the evaluation detailed in the previous section. The criteria and the associated weight of each (out of 100), determined by the City, are shown in Table 5-1.

Table 5-1. Alternatives Comparison Matrix Criteria and Weight

Number	Description	Weight
C1	Environmental Constraints and Permitting Efforts	10
C2	Land and Easement Acquisition	5
C3	Potential Major Utility Impacts	5
C4	Time of Implementation	5
C5	Social/Community Impacts and Public Input	10
C6	Percent of Structures at Risk of Interior Flooding (100-yr) with Risk Removed	30
C7	Cost Effectiveness of Flood Risk Reduction for 25-yr Storm ($/ft-home of Flood Reduction)	15
C8	Cost Effectiveness of Flood Risk Reduction for 100-yr Storm ($/ft-home of Flood Reduction)	15
C9	Qualitative Score for O&M	5

The rating for each criterion is on a scale of one to five, with five being the preferable rating. The ratings and associated rate definition for each criterion is defined in the following sections. Unless otherwise stated, the ratings were determined by HDR staff with input from the City during the review process.

5.1.1 C1 – Environmental Constraints and Permitting Efforts

Criteria 1 – Environmental Constraints and Permitting Efforts, weighted 10 out of 100, represents the ability of the alternative to meet ECM and DCM requirements, promote stream stability, and minimize permitting requirements. Impacts to stream stability will be evaluated based on the conclusions of Williamson Creek Sediment Field Reconnaissance for Stability Assessment (HDR, 2007). The rating definitions, shown in Table 5-2, were developed by HDR environmental staff. If an alternative causes adverse impacts to structures, then this would be deemed significant due to the inability to obtain a permit from the City.

Table 5-2. Rating Definition: C1 – Environmental Constraints and Permitting Efforts

Rating	Definition
5	Minimal – Limited to no environmental impact or permitting effort
4	Minimal to Moderate – Short term, moderate environmental impact during construction. Minimal environmental survey and permitting expected. Local site plan permitting, or variances required.
3	Moderate – Short term impacts during construction. Environmental surveys required and local site plan permitting, or variances required. Nationwide or Individual permit likely required.
2	Moderate to Significant – Long term, moderate environmental impact with permits among multiple jurisdictions. More challenging local site plan permitting, and Nationwide or Individual Permit likely required.
1	Significant – Long term, significant environmental impact with significant permits among multiple jurisdictions

5.1.2 C2 – Land and Easement Acquisition

Criteria 2 – Land and Easement Acquisition, weighted 5 out of 100, represents the necessary land and easements acquisition for each alternative. The rating definitions, shown in Table 5-3, are quantitative, but developed to create distinction between each alternative. In some cases, the number of easements and acquisitions is more of an effort than the total acreage. This is accounted for by using total cost of easements and acquisitions, as it includes the additional per property costs of real estate services, survey, appraisal, title, and (for acquisitions) relocation/abatement. This is estimated per property at $15,500 and $130,000 for drainage easements and acquisitions, respectively. Voluntary buyouts are not considered to negatively affect the rating for this criterion.

Table 5-3. Rating Definition: C2 – Land and Easements Acquisition

Rating	Definition
5	None - No additional land/easement acquisition needed in order to implement project
4	Minimal - Less than $10M in land/easement acquisition needed in order to implement project
3	Moderate - Greater than or equal to $10M and less than $50M in land/easement acquisition in order to implement project
2	Significant - Greater than or equal to $50M and less than $100M in land/easement acquisition in order to implement project
1	Substantial - Greater than $100M in land/easement acquisition in order to implement project

5.1.3 C3 – Potential Major Utility Impacts

Criteria 3 – Potential Major Utility Impacts, weighted 5 out of 100, represents the impact the proposed alternative may have on water and wastewater utilities. The rating definitions, shown in Table 5-4, are dependent on type of utility (water vs wastewater), type of impact (relocation vs removal), length of impact, and if the impact necessitates a wastewater lift station. The impacts were evaluated based on a desktop analysis from the water and wastewater utility data on the GIS Open Data Portal as of December 2020.

Table 5-4. Rating Definition: C3 – Potential Major Utility Impacts

Rating	Definition
5	None – No anticipated major water/wastewater utility impacts or only the removal of decommissioned lines.
4	Minimal – Only removal of previously decommissioned utility lines
3	Moderate – Rating 4 and/or less than 1,500 linear feet of water and/or less than 2,000 linear feet of wastewater
2	Significant – Rating 4 and/or greater than 1,500 linear feet of water and/or greater than 2,000 linear feet of wastewater
1	Substantial – Rating 2 and/or the requirement of a wastewater lift station.

5.1.4 C4 – Time of Implementation

Criteria 4 – Time of Implementation, weighted 5 out of 100, represents the length of time to implement the proposed alternative including design, permitting, and construction. The rating definitions are shown in Table 5-5. Estimates for the proposed alternatives are based off similar projects in a similar area.

Table 5-5. Rating Definition: C4 – Time of Implementation

Rating	Definition
5	0-2 years, once funding is available
4	2-5 years, once funding is available
3	5-7 years, once funding is available
2	7-10 years, once funding is available
1	Greater than 10 years, once funding is available

5.1.5 C5 – Social/Community Impacts and Public Input

Criteria 5 – Social/Community Impacts and Public Input, weighted 10 out of 100, represents the alternatives social and community impacts through public input. Public Input on the alternatives was received via a community survey conducted January through March 2022. The results of this community survey and discussion of results from the COA WPD team plus the history of public engagement is in Appendix F. The rating definitions are shown in Table 5-6.

Table 5-6. Rating Definition: C5 – Social/Community Impacts and Public Input

Rating	Definition
5	Greater than 50% approval
3	25% to 50% approval
1	Less than 25% approval

5.1.6 C6 – Percent of Structures with Removed Risk of Interior Flooding (100-yr)

Criteria 6 – Percent of Structures with Removed Risk of Interior Flooding (100-yr), weighted 30 out of 100, represents the ability of the alternative to remove the risk of inundation for structures expected to flood in the 100-year ultimate conditions event. The rating definitions are shown in Table 5-7. If an alternative causes adverse impacts in which a structure is now expected to be inundated where it previously was not, then this would be accounted for in this criterion by cancelling out a removal.

Table 5-7. Rating Definition: C6 – Percent of Structures with Removed Risk of Interior Flooding (100-yr)

Rating	Definition
5	Greater than or equal to 50% of structures with interior flooding removed
4	Greater than or equal to 40% or less than 50% of structures with interior flooding removed
3	Greater than or equal to 30% or less than 40% of structures with interior flooding removed
2	Greater than or equal to 20% or less than 30% of structures with interior flooding removed
1	Less than 20% of structures with interior flooding removed

5.1.7 C7 – Cost Effectiveness of Flood Risk Reduction for 25-yr Event

Criteria 7 – Cost Effectiveness of Flood Risk Reduction for the 25-year Event, weighted 15 out of 100, represents the ability of the alternative to reduce inundation depth within structures expected to flood in the 25-year ultimate conditions event. Cost effectiveness, in this criterion, is determined by dividing the change of inundation of all structures by the total estimated cost of the alternative. Unless otherwise stated, a 30% contingency is used on opinion of probable construction costs (OPCC). The rating definitions are shown in Table 5-8. If an alternative causes adverse impacts in which a structure is now expected to have a higher depth of interior flooding than in pre-project conditions, it would be accounted for in this criteria as it is the total change in inundation, including reductions and increases.

Table 5-8. Rating Definition: C7 – Cost Effectiveness of Flood Risk Reduction for 25-yr Event

Rating	Definition
5	Less than $700k per foot of structural inundation reduction
4	Greater than or equal to $700k and less than $800k per foot of structural inundation reduction
3	Greater than or equal to $800k and less than $900k per foot of structural inundation reduction
2	Greater than or equal to $900k and less than $1M per foot of structural inundation reduction
1	Greater than or equal to $1M per foot of structural inundation reduction

5.1.8 C8 – Cost Effectiveness of Flood Risk Reduction for 100-yr Event

Criteria 8 – Cost Effectiveness of Flood Risk Reduction for the 100-year Event, weighted 15 out of 100, represents the ability of the alternative to reduce inundation depth within structures expected to flood in the 100-year ultimate conditions event. Cost effectiveness, in this criterion, is determined by dividing the change of inundation of all structures by the total cost of the alternative. The rating definitions are shown in Table 5-9. If an alternative causes adverse impacts in which a structure is now expected to have a higher depth of interior flooding than in pre-project conditions, then this would be accounted for in this criteria as it is the total change in inundation, including reductions and increases.

Table 5-9. Rating Definition: C8 – Cost Effectiveness of Flood Risk Reduction for 100-yr Event

Rating	Definition
5	Less than $200k per foot of structural inundation reduction
4	Greater than or equal to $200k and less than $325k per foot of structural inundation reduction
3	Greater than or equal to $325k and less than $450k per foot of structural inundation reduction
2	Greater than or equal to $450k and less than $575k per foot of structural inundation reduction
1	Greater than or equal to $575k per foot of structural inundation reduction

5.1.9 C9 – Qualitative Score for O&M

Criteria 9 – Qualitative Score for O&M, weighted 5 out of 100, represents the expected operations and maintenance necessary for the project after construction. No O&M costs are scoped to be detailed in this study. The rating definitions, shown in Table 5-10, are used to score the alternatives relative to each other. In general, projects may be distinguished from each other using knowledge of similar projects in a similar area through expected level of magnitude of O&M costs.

Table 5-10. Rating Definition: C9 – Qualitative Score for O&M

Rating	Definition
5	No expected O&M Cost
4	Minimal expected O&M Cost
3	Moderate expected O&M Cost
2	Significant expected O&M Cost
1	Substantial expected O&M Cost

5.2 Alternative A – Re-evaluate 2006 USACE "Tentatively Selected Plan"

5.2.1 Alternative Description

The U.S. Army Corps of Engineers Fort Worth District and LCRA conducted a comprehensive study of the lower Colorado River basin in 2006 to investigate the water resources problems, needs, and opportunities within the studied river basins including Williamson Creek Watershed. The problems and needs were identified along the Williamson Creek reaches to develop alternative solutions to the flooding problems. The reach names and description defined in the USACE study are summarized in Table 5-11. The study concluded that the structural combined plan with modifications was preferred as the tentatively selected plan. The plan included segmented benching along the four problem areas for a total length of 8,500 feet.

Table 5-11. Williamson Creek Reach Name and Description from 2006 USACE Study

Reach Name	Description
Heartwood	South Congress Avenue to Jeffburn Cove
Radam	Jeffburn Cove to Menchaca Road
Broken Bow	Menchaca Road to Remuda Trail
Westgate Blvd/Bayton Loop	Remuda Trail to Pillow Road

Alternative A reassessed the feasibility of implementing the tentatively selected plan as recommended in the 2006 USACE study. The reassessment assumes that the modeling and results from this study are still valid. The revised floodplain boundaries and flows as a result of the revised hydraulic model developed in Section 4 of this report were utilized to evaluate the effectiveness of the recommended channel modifications at each problem area.

The projected change in water surface elevation described in the following sections was determined using the 1D HEC-RAS model from the 2006 USACE study. A discharge representative of the area of proposed improvements from the revised 1D/2D hydraulic model was equated to the closest frequency event in the 2006 USACE model. No changes were made to the 2006 model. The resulting water surface elevations from the two different models were then compared.

Heartwood Reach

The 2006 USACE study recommended a 1,200-foot long channel improvement with benching on the right bank between Heartwood Drive and S Congress Ave. The width of the bench would vary from 0' to 160'. Figure 5-1 below represents the location and extents of channel benching.

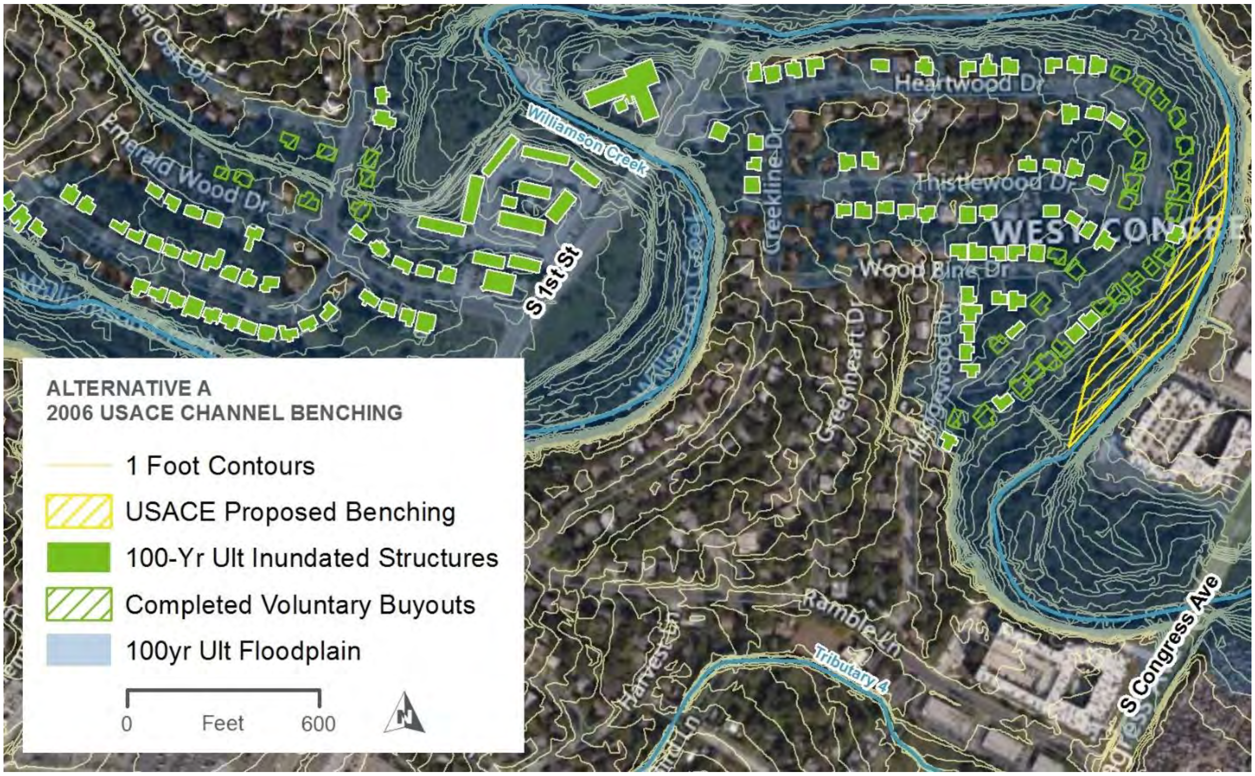

Figure 5-1. 2006 USACE Recommended Channel Benching at Heartwood

According to the 2006 USACE study, the benching would protect houses along Heartwood Drive from being flooded during less frequent flood events (10-year and below). However, 27 structures along Heartwood Drive have been bought out by the City of Austin. In addition, the revised hydraulic model moves the floodplain boundaries much further, resulting in more structures at risks than expected in 2006. Table 5-12 below summarizes the water surface elevation reductions for the 10-year and 100-year 2006 USACE flood events.

Table 5-12. 2006 USACE Tentatively Selected Plan Post-project WSEL Reduction - Heartwood

2006 USACE Storm Event	2006 USACE Flow (cfs)	HDR Updated Equivalent Event	HDR Updated Equivalent Event Flow (cfs)	Δ WSEL (ft)
10-Year	11,390	>5-Year	10,945	-0.09
100-Year	24,120	<25-Year	27,117	-0.48

The 2006 USACE 10-year storm event and 100-year storm event are roughly equivalent to the HDR updated 5-year storm event and 25-year storm event, respectively. Based on the updated hydraulic model results discussed in Section 4 of this study, the inundated structures under the updated 10-year storm event are mostly bought out by the City (19 out of 21). As a result of the recent buyout and the updated hydraulic model results, the 2006 recommended benching will provide less flood risk reduction benefit than previously estimated.

Radam Reach

The 2006 USACE study recommended a 1,400-foot long channel improvement with benching on the right bank between Radam Circle and Meadow Creek Drive. The width of the bench would vary from 0' to 300'. The Emerald Forest Drive bridge crossing the improved channel would not be modified. Figure 5-2 below represents the location and extents of channel benching.

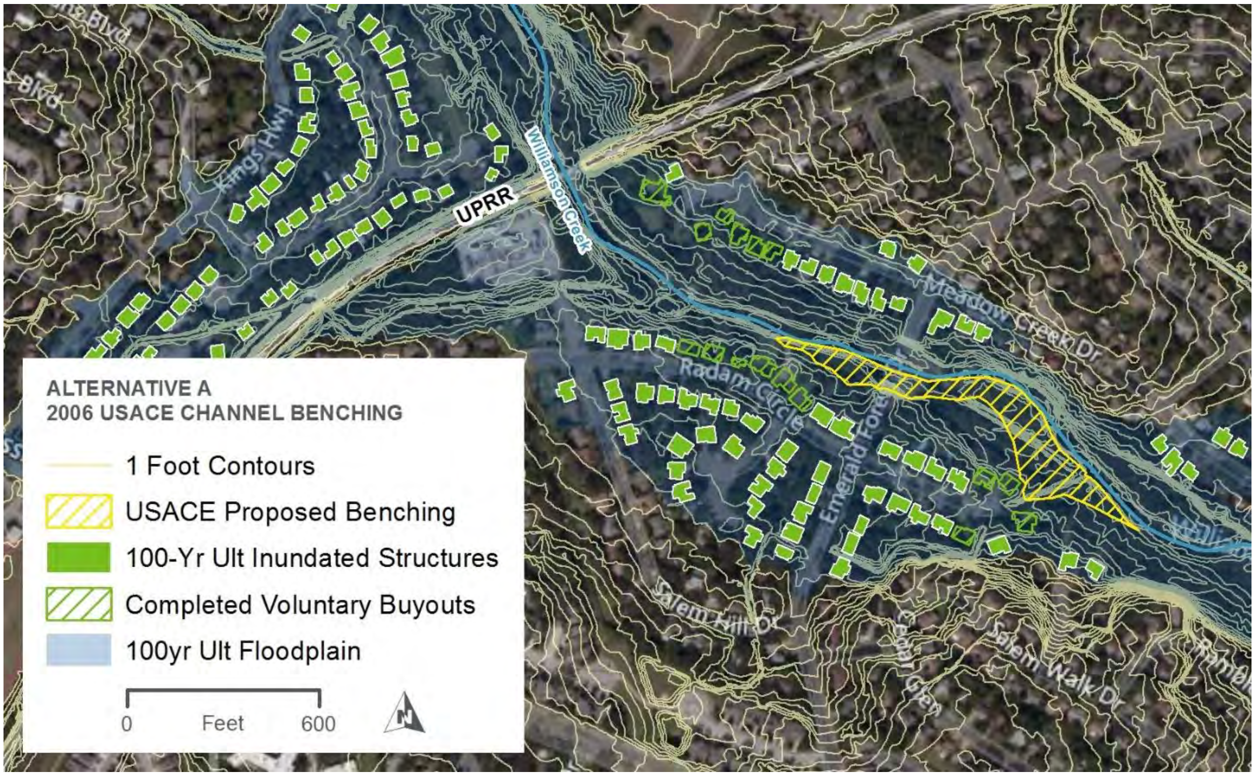

Figure 5-2. 2006 USACE Recommended Channel Benching at Radam

The 2006 recommended benching aimed at reducing houses on both side of Williamson Creek at risks during less frequent storm event (10-year and below). Table 5-13 below summarizes the water surface elevation reductions for the 10-year and 100-year 2006 USACE flood events.

Table 5-13. 2006 USACE Tentatively Selected Plan Post-project WSEL Reduction – Radam

2006 USACE Storm Event	2006 USACE Flow (cfs)	HDR Updated Equivalent Event	HDR Updated Equivalent Event Flow (cfs)	Δ WSEL (ft)
10-Year	11,390	>5-Year	10,863	-0.24
100-Year	23,945	<25-Year	26,987	-0.21

The 2006 USACE 10-year storm event and 100-year storm event are roughly equivalent to the HDR updated 5-year storm event and 25-year storm event, respectively. The City of Austin has recently bought out 16 structures within the Radam reach. Based on the updated hydraulic model results discussed in Section 4 of this study, the inundated structures under the updated 10-year storm event are mostly bought out by the City (16 out of 24). As a result of the recent buyout and the updated hydraulic model results, the 2006 recommended benching will provide less flood risk reduction benefit than previously anticipated.

Broken Bow Reach

The 2006 USACE study recommended a 2,900-foot long channel improvement with 2,000 feet of benching on the right bank and 900 feet on the left bank between Menchaca Road and Jones Road. The width of the bench would vary from 0’ to 130’. Figure 5-3 below represents the location and extents of channel benching.

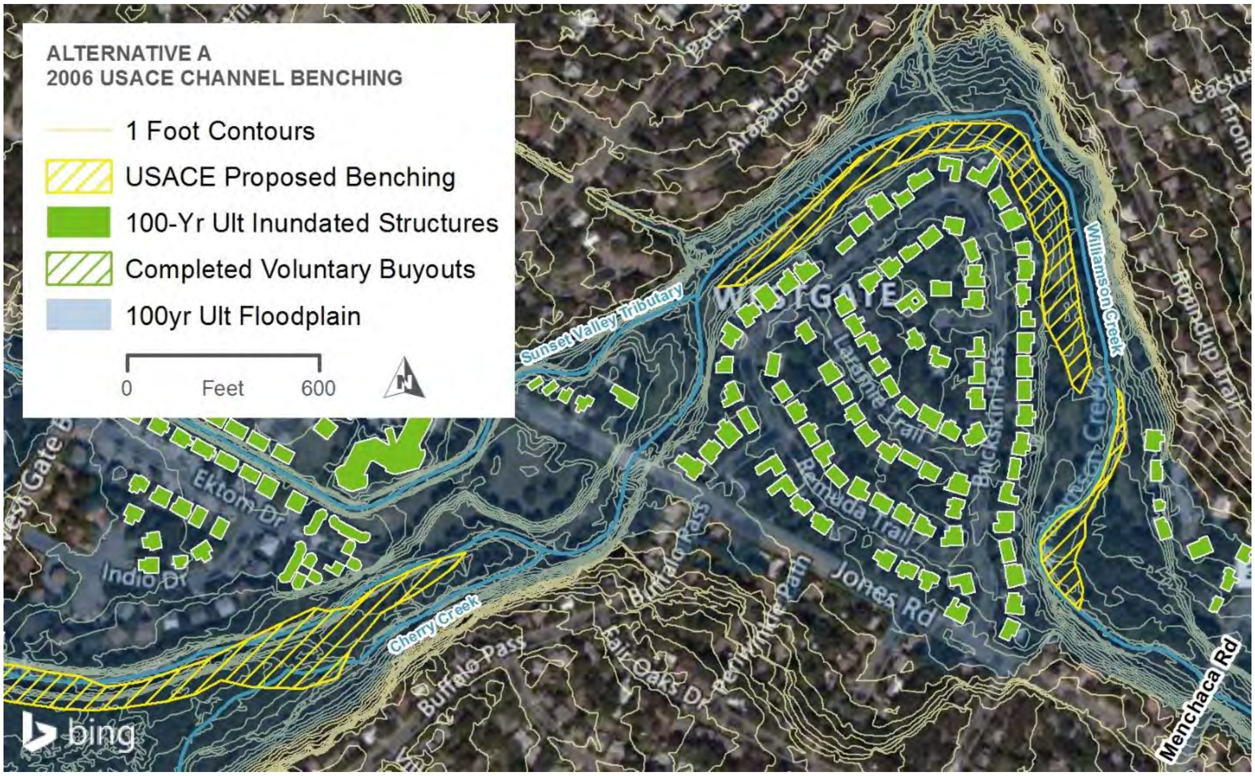

Figure 5-3. 2006 USACE Recommended Channel Benching at Broken Bow

The 2006 study indicates that houses along Broken Bow and Buckskin Pass would experience less flooding after benching with the flood damage only occurring near the 100-year flood event or higher. This conclusion will less likely be valid due to the widened floodplain boundaries as a result of the revised hydraulic model. More houses are being flooded during less frequent flood events. Table 5-14 below summarizes the water surface elevation reduction for the 2006 USACE 100-year flood event.

Table 5-14. 2006 USACE Tentatively Selected Plan Post-project WSEL Reduction – Broken Bow

2006 USACE Storm Event	2006 USACE Flow (cfs)	HDR Updated Equivalent Event	HDR Updated Equivalent Event Flow (cfs)	Δ WSEL (ft)
100-Year	22,943	<25-Year	25,196	-1.16

The 2006 USACE 100-year storm event is roughly equivalent to the HDR updated 25-year storm event. Based on the updated hydraulic model results discussed in Section 4 of this study, there are

76 structures inundated under the updated 25-year storm event. Assuming the 2006 USACE plan will generate the same amount of reduction in water surface elevation for the updated 25-year storm event, only 30 or 39% structures will be removed from the flood risk. The recommended benching at Broken Bow will not provide the same level of flood risk reduction as expected in 2006.

Westgate/Bayton Loop Reach

The 2006 USACE study recommended a 3,000-foot long channel improvement with 1,200 feet benching on both banks upstream of the bridge at Westgate Boulevard and 1,800 feet benching on the right bank downstream of the bridge. The width of the bench would vary from 0' to 250'. Figure 5-4 below represents the location and extends of channel benching.

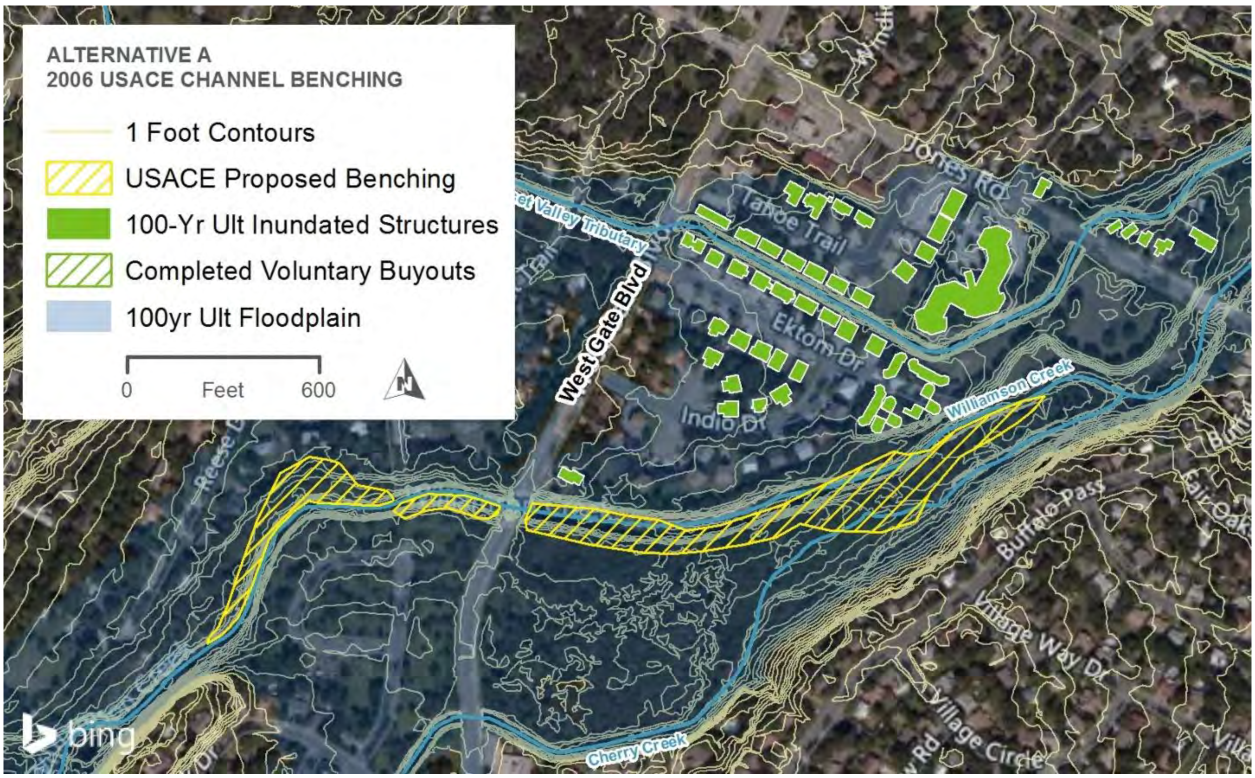

Figure 5-4. 2006 Recommended Channel Benching at Westgate/Bayton Loop

The benching recommended at upstream of Westgate Boulevard is not considered in this study, because most of the houses at Bayton Loop have already been bought out by the City. Many of the houses on the left bank of Williamson Creek are already elevated and most structures at risks are near the Sunset Valley Tributary. According to the 2006 USACE study, the benching would protect houses between Williamson Creek and Sunset Valley Tributary from being flooded during less frequent flood events (5-year and below). Table 5-15 below summarizes the water surface elevation reduction for the 2006 USCE 5-year flood event.

Table 5-15. 2006 USACE Tentatively Selected Plan Post-project WSEL Reduction – Westgate

2006 USACE Storm Event	2006 USACE Flow (cfs)	HDR Updated Equivalent Event	HDR Updated Equivalent Event Flow (cfs)	Δ WSEL (ft)
5-Year	6,960	>2-Year	5,753	-1.8

The 2006 USACE 5-year storm event is roughly equivalent to the HDR updated 2-year storm event. Based on the updated hydraulic model results discussed in Section 4 of this study, there are no structures inundated under the updated 2-year storm event. The recommended benching at Westgate/Bayton Loop reach will not provide the same level of flood risk reduction as expected in 2006.

5.2.2 Summary

Due to the updated flood risk identified from the results in this study and voluntary buyouts that have already occurred within the watershed, the 2006 USACE selected plan, in its current form, is determined to not be a viable or practical option as it failed to provide any measurable reduction in flood risk for structures within the 25-year and 100-year ultimate conditions floodplain for the expected magnitude of capital investment needed to implement the project. This alternative was not pursued any further and will not be included in the final comparison matrix evaluation as it did not meet the minimum total reduction in depth of inundation.

5.3 Alternative B – Flood Walls

5.3.1 Alternative Description

HDR identified four locations for potential flood walls in order to provide flood protection during the 100-year ultimate land use conditions event. These locations were modeled within the HEC-RAS 1D/2D model to determine efficacy and impacts. Location and properties of the proposed flood walls are shown in Figure 5-5 and Table 5-16, respectively. The height of the flood walls includes a 3' freeboard over the modeled 100-year ultimate conditions water surface elevation.

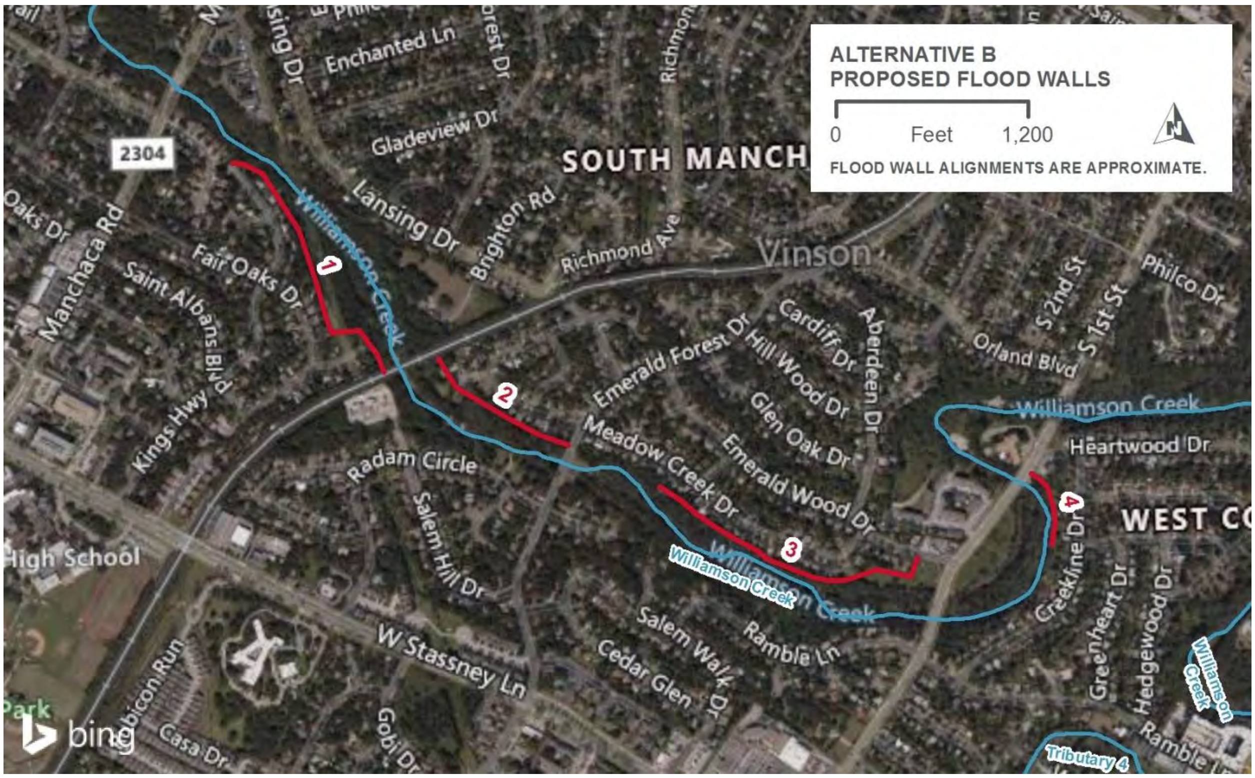

Figure 5-5. Alternative B proposed flood wall segments

Table 5-16. Alternative B flood wall properties

Flood Wall	Length (ft)	Maximum Height (ft)	Average Height (ft)
1	1,800	20.5	10.7
2	1,000	14.5	10.8
3	1,900	11.3	6.8
4	500	7.9	5.9

These alignments proved to reduce risk of inundation to some structures while increasing the risk to others, some who were not previously modeled to be at risk for the 25-year frequency event. This is evident in Figure 5-6 and Figure 5-7 which shows the change to the structural inundation and floodplain for the 25-year and 100-year ultimate conditions, respectively. Table 5-17 summarizes impacts to structural inundation depths. During the 100-year ultimate conditions event, flood walls 2 and 3 are flanked by back water. Flood Wall 1 crosses a minor, but not inconsequential, tributary which may provide challenges for accommodating the local drainage behind the flood wall. While there are adverse impacts to habitable structures, the alternative provides positive net benefits to the project area and will be included in the evaluation matrix.

Table 5-17. Alternative B impact to structure inundation depth

Impact to Structure Inundation Depth	25-Year Ultimate Conditions		100-Year Ultimate Conditions	
	Number of Structures	Avg Change in Depth (ft)	Number of Structures	Avg Change in Depth (ft)
Added	12	0.21	19[a]	-
Increased	38	0.19	142	0.36
No Change	55	-	16	-
Decreased	57	-0.03	108	-0.56
Removed	33	-1.82	130	-2.07

[a] Estimated as finished floor elevations for homes outside of the 100-year ultimate conditions floodplain were not surveyed.

Figure 5-6. Alternative B vs Ultimate Conditions – 25yr: Change to Structural Inundation

Figure 5-7. Alternative B vs Ultimate Conditions – 100yr: Change to Structural Inundation

5.3.2 Environmental Constraints and Permitting Efforts

DCM Compliance

Due to adverse impacts to existing structures, this alternative fails to meet DCM compliance, and it is extremely unlikely that it would be granted a variance.

Stream Stability

This alternative has not anticipated to have an impact on stream stability throughout the project area as the proposed flood walls do not affect the higher frequency events which perform the majority of sediment aggradation and degradation.

Environmental

All four of the proposed Flood Walls would be entirely within the City's suburban critical water quality zone (CWQZ). Development within the CWQZ must conform to the City Code 25-8-261 and should be revegetated and restored within the limits of construction as prescribed by the City Environmental Criteria Manual. It is unlikely that all protected trees can be avoided, and tree mitigation would likely be required.

Two City critical environmental features (CEFs) are located near Alternative B. Spring Horizon is located along Williamson Creek within approximately 115 feet northeast of the western end of Flood Wall 1. Spring 1 is located along Williamson Creek in the Heartwood Reach and is within approximately 300 feet of northeast of the northern end of Flood Wall 4. According to City Code 25-8-281, the width of the CEF buffer should be 150 feet from the edge of the CEF.

Flood Wall 1 and a small portion of Flood Wall 2 are located within the Edwards Aquifer transition zone. No Edwards Aquifer Protection Plan (EAPP) would be required for construction of the Flood Walls since the recharge zone is more than 2,800 feet west of Flood Wall 1 and water would not drain back into the recharge zone.

The Texas Natural Diversity Database (TXNDD) is maintained by the TPWD. The TXNDD contains information on the documented occurrences of threatened, endangered and Species of Greatest Conservation Need (SGCN), in the state of Texas. Species with SGCN designation do not have legal protections due to the risk of extinction, but are those that are declining or rare, and need attention to recover or to prevent the need to list under state or federal regulation. Three species of greatest conservation need (SGCN) have been documented within the project area for this alternative, Heller's marbleseed (*Onosmodium helleri*), Texas fescue (*Festuca versuta*), and the plateau spot-tailed earless lizard (*Holbrookia lacerata*). However, these species have not been observed at these locations since 1943, 1917, and 1953, respectively. No documented occurrences of any state or federally listed threatened or endangered species were reported in the vicinity of the proposed flood walls. A resource list from the U.S. Fish & Wildlife Service's (USFWS) Information for Planning and Consultation (IPaC) and the Travis County Endangered Species List from TPWD were reviewed. While no field visit or species-specific surveys were completed, no impacts to state or federally listed threatened or endangered species would be expected due to the lack of required habitat within the project area.

Based on a preliminary evaluation, it appears there would be no permanent fill in waters of the U.S.: however, it is not currently known if the work can be done without temporary fill. If temporary fill within waters of the U.S. to facilitate construction access is necessary a Clean Water Act, Section

404 permit may be necessary. If fill activities in waters of the U.S. are required, it is anticipated the activities can be configured to meet the conditions of a Nationwide Permit. However, it is not possible at this early stage to determine if notification to the U.S. Army Corps of Engineers, Fort Worth District – Regulatory Division would be required.

There may be temporary impacts to noise and traffic levels from construction equipment during the construction activities, but these impacts would be minimal and would likely be managed through work hour limits.

Cultural Resources

A cultural resources memo was completed for the project on December 3, 2020, which detailed the geologic background, soils, and previously recorded cultural resources within 1 mile of each alternative.

The database results are tabulated in Appendix G. Presented here are the recommendations. The Atlas review indicated that there have been five previous cultural resources surveys conducted within 1 mile (mi; 1.6 kilometers [km]) of Alternative B (Appendix G). None of the previous surveys overlap Alternative B. In addition, the review revealed that three archaeological sites and two cemeteries have been recorded within the 1-mile search radius (see Appendix G) While none of the cultural resources overlap Alternative B, site 41TV1389 is located approximately 336 ft from Alternative B (see Appendix G. Cultural Resources Memo). Site 41TV1389 is recorded as a prehistoric lithic scatter and has not been evaluated for NRHP eligibility.

Recommendations

The Atlas search revealed that there are various cultural resources recorded within one mile of Alternative B and that the alternative has not been previously surveyed. Although Alternative B is located along Williamson Creek which is a high probability setting for cultural resources, the banks of Williamson Creek have been extensively disturbed by residential construction. Due to this previous disturbance and past flooding of the creek, it is highly unlikely that any cultural resources remain intact within the project area.

As discussed in the Cultural Resources Memo, this project would be required to be in compliance with Chapter 191 of the Texas Natural Resources Code (Antiquities Code of Texas) and its accompanying Rules of Practice and Procedure (13 TAC 26). For projects larger than 5 acres or those that disturb more than 5,000 cubic yards of soil, compliance requires either a cultural resources survey of the project Area of Potential Effects or a determination from the Texas Historical Commission that the proposed project will have No Effect on historic properties as defined in Section 106 of the National Historic Preservation Act of 1966, as amended.

5.3.3 Land and Easement Acquisition

There are approximately 1.4 acres across 30 different properties of permanent drainage easement required for construction of the flood walls for an estimated $2.9M. However, adverse impacts for this alternative are substantial and an additional 93 acres across 326 properties of permanent drainage easement is required due to adverse impacts to water surface elevations within the project area at an estimated cost of $164.5M. Total anticipated costs for drainage easements for this alternative is $167.5M. These proposed drainage easements exclude the existing easements, right of way, or city owned property. See Appendix H for detailed exhibits and tables of the proposed drainage easements.

5.3.4 Potential Major Utility Impacts

The proposed flood walls do cross several existing wastewater lines; however, the wastewater lines were greater than 2 feet lower than the anticipated depth of excavation and, therefore, there are no estimated major water or wastewater utility impacts.

5.3.5 Time of Implementation

Accounting for the anticipated time adverse impacts would have on the permitting process, time of implementation, once funding is available, is estimated to be five to seven years.

5.3.6 Social/Community Impacts and Public Inputs

The Nature Conservancy and Community Powered Workshop, along with City Watershed Protection Department (WPD), are in the current process of envisioning the future of the Central Williamson Creek Greenway which includes some of the proposed flood walls. The vision, while yet to be finalized, is favoring a natural environment, but with available public amenities like access to the creek. Flood walls, especially 1, 2, and 3 would prevent public access or exit from the creek for long stretches. This alternative was not included in the 2022 community survey as it was considered not a viable option for flood risk reduction, however, it is likely that the reduction in access to the creek and adverse impacts would have resulted in less than a 25% approval rating from the public.

5.3.7 Percent of Structures at Risk of Interior Flooding (100-year storm) with Risk Removed

As shown in Figure 5-7, for the 100-year ultimate conditions event, the proposed alternative removes 130 structures from the floodplain. This amounts to 266 structures proposed inundations versus 396 existing inundations in the 100-year ultimate conditions event, a 33% reduction. However, the addition of structures is likely underestimated as the finished floor elevations for structures outside of the existing floodplain were not surveyed.

5.3.8 Cost Effectiveness of Flood Risk Reduction

This alternative proposes 5,200 linear feet of flood walls at an average height of 8.9 feet, which amounts to approximately 5,000 cubic yards of cement concrete. The concrete along with the 1.4 acres of permanent drainage easement comprise the bulk of the actual construction of the flood walls, which is estimated to be $10.6M. However, as discussed previously, there are substantial adverse impacts to structures which add an additional estimated $167.5M for a total OPCC of $175.1M. Cost effectiveness for the 25-year and 100-year ultimate conditions events are summarized in Table 5-18. A detailed OPCC can be found in Appendix J.

Table 5-18. Alternative B – Cost Effectiveness Summary

Storm Event	Total Change in Inundation Depth for All Structures (ft)	Cost Effectiveness ($/ft)
25-Year Ultimate	-54.0	$3,243,000
100-Year Ultimate	-278.1	$630,000

5.3.9 Anticipated O&M

This alternative is expected to have moderate O&M requirements associated with the flood walls. FEMA recommends biannual, pre-flood, and post-flood inspections along with mowing to maintain access to the wall and limit vegetation with roots that may disrupt the base of the wall.

5.3.10 Summary

Alternative B – Flood Walls, proposes four flood walls along the middle Williamson Creek in which there is significant flow outside of the channel banks. In general, these flood walls do provide protection for the intended homes, but due to the nature of flood walls and the reduction in conveyance area they create, there are substantial adverse impacts to other structures and the water surface elevation along the creek.

The flood walls are not expected to have measurable impact to stream stability, but are expected to have short term, moderate environmental impact during construction with minimal environmental survey and permitting. There would be City site plan permitting and variances required due to placement in the City CWQZ. It is highly unlikely, that this alternative, as modeled, would obtain City permit approvals given the adverse impacts to structural inundations.

This alternative requires 95 acres of permanent drainage easements across 356 properties for an anticipated cost of $167.5M. There are no anticipated major water or wastewater utility impacts.

This alternative was not included in the 2022 community survey as it was not considered a viable option for flood risk reduction, however, it is likely that the reduction in access to the creek and adverse impacts would have resulted in less than a 25% approval rating from the public.

The project is anticipated to take five to seven years to implement at a total construction cost of $175.1M with moderate O&M costs. The alternative removes 33% of structural inundations and has a cost effectiveness of $3,243k and $630k per foot of inundation reduction for the 25-year and 100-year ultimate conditions events, respectively.

In its current conceptual layout, Alternative B – Flood Walls, is not viable for reducing flood risk reduction in the project area due to its inability to meet DCM compliance, undesirable cost effectiveness, and projected less than 25% approval rating. This conclusion is supported by the resulting comparison matrix at the end of this section. The viability of flood walls in combination with other alternatives is explored in Alternative I.

5.4 Alternative C – Non-structural Permanent Evacuation (Voluntary Buyouts)

5.4.1 Alternative Description

The non-structural permanent evacuation alternative, or voluntary buyouts, eliminates flood risk by removing habitable structures inundated by the selected storm events. The structures qualified for buyout are those with finished floor elevation (FFE) below the selected flood event water surface elevations (see Section 4.4.2 for information about obtaining structure FFE). The number of structures to be removed were categorized by the previously defined five problem areas as mentioned in Section 4 of this report. Table 5-19 and Figure 5-8 summarize these problem areas.

Table 5-19. Williamson Creek Problem Areas

Reach Name	Description
Westgate/Indio	Westgate Boulevard to Sunset Tributary Confluence
Broken Bow	Sunset Tributary Confluence to Menchaca Road
Other	Menchaca Road to Union Pacific Railroad
Radam	Union Pacific Railroad to S 1st Street
Heartwood	S 1st St to South Congress Avenue

Figure 5-8. Middle Williamson Creek Problem Areas

Seven scenarios were analyzed as described below.

- Scenario 1: remove all qualified structures out of the 100-year ultimate condition storm event.
- Scenario 2: remove qualified structures with inundation depth greater than 2-ft out of the 100-year ultimate condition storm event.
- Scenario 3: remove all qualified structures out of the 25-year ultimate condition storm event.
- Scenario 4: remove qualified structures with inundation depth greater than 2-ft out of the 25-year ultimate condition storm event.
- Scenario 5: remove all qualified structures out of the 10-year ultimate condition storm event.
- Scenario 6: remove qualified structures with inundation depth greater than 2-ft out of the 10-year ultimate condition storm event.
- Scenario 7: remove all repetitive loss structures (calculated only for project area).

Scenarios 1 through 6 are shown in Figure 5-9 through Figure 5-11.

For estimating costs, the City provided a study by the City of Austin Office of Real Estate (ORES) regarding acquisition and relocation costs for Middle Williamson Creek. This study estimated the average acquisition and relocation costs for a single-family home to be approximately $630,000. Costs for commercial or large multi-family property acquisitions were based on each individual property. Smaller multi-family duplexes, fourplexes, and condos were costed like single-family homes for simplicity. These numbers will be used to estimate costs below. Further information about this study by ORES can be found in Appendix K. Note, the numbers depicted below, may differ from the study due to rounding differences, but overall magnitude is similar.

Westgate/Indio

The Westgate/Indio problem area is mainly the confluence area of Sunset Valley Tributary, Williamson Creek, and Cherry Creek. Table 5-20 below summarize the number of qualified structures and estimated buyout cost for each scenario.

Table 5-20. Summary of Buyout – Westgate/Indio

Scenario	Selected Event	Inundation Depth	Number of Structures Qualified				Estimated Cost ($M)
			Single Family	Multi-Family	Commercial	Total	
1	100-year	> 0-ft	6	43	2	51	37.7
2	100-year	> 2-ft	6	20	2	28	18.6
3	25-year	> 0-ft	6	25	2	33	30.8
4	25-year	> 2-ft	4	8	0	12	7.6
5	10-year	> 0-ft	4	9	1	14	9.8
6	10-year	> 2-ft	-	-	-	-	-

Broken Bow

The Broken Bow problem area includes only single-family homes. This area is bounded by Menchaca Road, Johns Road, and Williamson Creek centerline. Table 5-21 below summarize the number of qualified structures and estimated buyout cost for each scenario.

Table 5-21. Summary of Buyout – Broken Bow

Scenario	Selected Event	Inundation Depth	Number of Structures Qualified[a]	Estimated Cost ($M)
1	100-year	> 0-ft	97	61.1
2	100-year	> 2-ft	63	42.2
3	25-year	> 0-ft	76	47.9
4	25-year	> 2-ft	32	20.2
5	10-year	> 0-ft	31	19.5
6	10-year	> 2-ft	5	3.2

[a] All structures are single-family homes.

Other

The Other problem area is bounded by Menchaca Road and the Union Pacific Railroad. Table 5-22 below summarize the number of qualified structures and estimated buyout cost for each scenario.

Table 5-22. Summary of Buyout – Other

Scenario	Selected Event	Inundation Depth	Number of Structures Qualified			Estimated Cost ($M)
			Single Family	Multi-Family	Total	
1	100-year	> 0-ft	65	17	82	69.7
2	100-year	> 2-ft	45	12	57	53.9
3	25-year	> 0-ft	18	4	0	13.9
4	25-year	> 2-ft	6	0	0	3.8
5	10-year	> 0-ft	-	-	-	-
6	10-year	> 2-ft	-	-	-	-

Radam

The Radam problem area extends from the downstream of the Union Pacific Railroad to the upstream of South 1st Street. Table 5-23 below summarizes the number of qualified structures and estimated buyout cost for each scenario.

Table 5-23. Summary of Buyout – Radam

Scenario	Selected Event	Inundation Depth	Number of Structures Qualified				Estimated Cost ($M)
			Single Family	Multi-Family	Commercial	Total	
1	100-year	> 0-ft	97	13	2	112	81.1
2	100-year	> 2-ft	29	12	1	42	37.4
3	25-year	> 0-ft	30	10	1	41	37.0
4	25-year	> 2-ft	8	3	0	11	8.6
5	10-year	> 0-ft	7	3	0	10	6.5
6	10-year	> 2-ft	-	-	-	-	-

Heartwood

The Heartwood problem area extends from South 1st Street to South Congress Ave. Table 5-24 below summarize the number of qualified structures and estimated buyout cost for each scenario.

Table 5-24. Summary of Buyout – Heartwood

Scenario	Selected Event	Inundation Depth	Number of Structures Qualified			Estimated Cost ($M)
			Single Family	Commercial	Total	
1	100-year	> 0-ft	52	2	54	34.0
2	100-year	> 2-ft	18	0	18	11.3
3	25-year	> 0-ft	11	0	11	6.9
4	25-year	> 2-ft	6	0	6	3.8
5	10-year	> 0-ft	2	0	2	1.3
6	10-year	> 2-ft	1	0	1	0.6

Summary

The summary of the buyout for the entire project area is shown in Table 5-25.

Table 5-25. Summary of Buyout – All Areas

Scenario	Selected Event	Inundation Depth	Number of Structures Qualified				Estimated Cost ($M)
			Single Family	Multi-Family	Commercial	Total	
1	100-year	> 0-ft	317	73	6	396	283.6
2	100-year	> 2-ft	165	44	3	212	163.4
3	25-year	> 0-ft	141	39	3	183	136.5
4	25-year	> 2-ft	56	11	-	67	43.8
5	10-year	> 0-ft	44	12	1	57	37.0
6	10-year	> 2-ft	6	-	-	6	3.8
7	Repetitive Loss		25	-	-	25	15.8

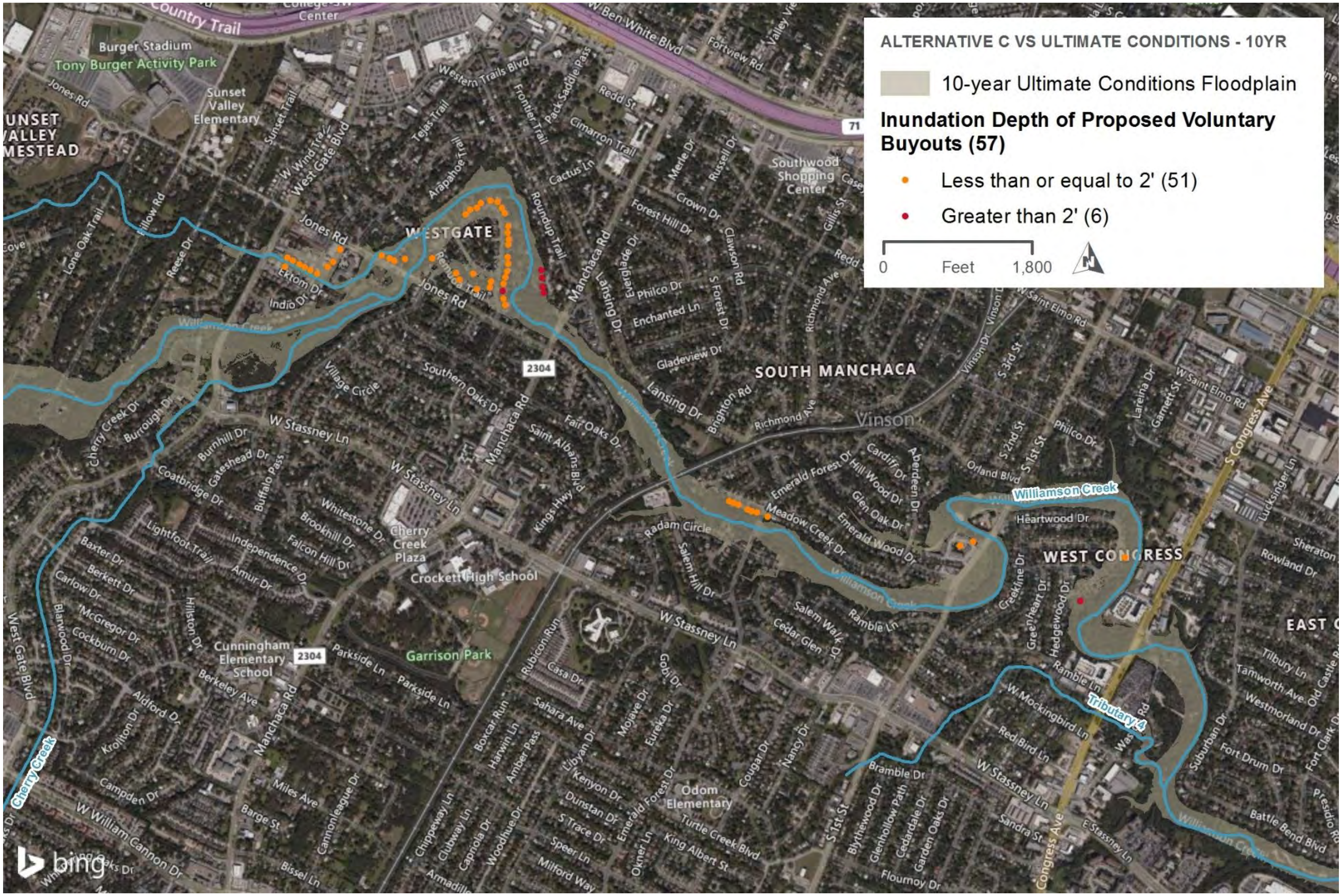

Figure 5-9. Alternative C vs Ultimate Conditions – 10yr: Proposed Voluntary Buyouts

Figure 5-10. Alternative C vs Ultimate Conditions – 25yr: Proposed Voluntary Buyouts

Figure 5-11. Alternative C vs Ultimate Conditions – 100yr: Proposed Voluntary Buyouts

5.4.2 Environmental Constraints and Permitting Efforts

Due to the nature of demolition of existing developed properties acquired during buyouts, the environmental and natural resource impacts are anticipated to be relatively limited. Any potential hazardous materials issues can be managed using qualified demolition contractors applying standard best management practices.

There would be temporary impacts to noise and traffic levels from construction equipment during the construction activities, but these impacts would be minimal. Other than these temporary impacts, this alternative would have no other anticipated adverse environmental impacts.

5.4.3 Land and Easement Acquisition

There is no easement or land acquisition necessary for construction associated with this alternative. Voluntary buyouts are not considered under this criterion.

5.4.4 Potential Major Utility Impacts

No utility impacts are anticipated beyond those associated with abatement for residential or commercial structures. Abatement is included in the estimated cost for acquisition and relocation.

5.4.5 Time of Implementation

Analogous to recent City voluntary buyout efforts in the project area, total estimated time of implementation for this alternative, once funding is available, including abatement and demolition, is 2 to 5 years.

5.4.6 Social/Community Impacts and Public Input

Approximately 48% of survey respondents considered this alternative acceptable to reducing flood risk, however over 54% said only structures that have already experienced flooding should be eligible and 21% said they would consider selling their property given a fair offer. At least 1 multi-family property, Stony Creek Apartments, provides affordable housing for residents below the City median family income (MFI). It was not discernible whether these residents responded to the survey.

5.4.7 Percent of Structures at Risk of Interior Flooding (100-year storm) with Risk Removed

For the 100-year ultimate conditions event, the proposed alternative removes all 396 structures from the floodplain, a 100% reduction.

5.4.8 Cost Effectiveness of Flood Risk Reduction

The opinion of probable cost for this project is estimated to be $284M. Cost effectiveness for the 25-year and 100-year ultimate conditions events are summarized in Table 5-26.

Table 5-26. Alternative C – Cost Effectiveness Summary

Storm Event	Total Change in Inundation Depth for All Structures (ft)	Cost Effectiveness ($/ft)
25-Year Ultimate	-326.9	$868,000
100-Year Ultimate	-1,082.0	$262,000

5.4.9 Anticipated O&M

Anticipated O&M, once demolition and reseeding has been completed, is generally limited to periodic mowing of the acquired land three to six times a year. Currently, in the project area, known as the Middle Williamson Watershed Management Area[a], lots that are adjacent to the creek usually are only mowed near sidewalks and roadways for a six-foot buffer, with natural grasses and vegetation near the creek banks encouraged. Other lots are used for pollinator habitats with the plantings of natural grasses and wildflowers. Generally, in several 2020 surveys, residents of the area support the use of lots acquired for useable public space whether it be a trail to and along the creek, community garden, sitting areas, etc. These uses would likely require more maintenance than the current mowing practices.

5.4.10 Summary

Alternative C – Non-structural Permanent Evacuation, proposes the voluntary buyout of all structures inundated in the 100-year ultimate conditions floodplain. This alternative eliminates flood risk to these structures and has the potential for future green space along the creek.

Environmental constraints and permitting associated with voluntary buyouts are anticipated to be limited, with only traffic and noise interruptions during demolition.

This alternative requires acquisition of 139 acres of land for an anticipated $284M. No permanent easements are anticipated. There are no anticipated water or wastewater utility impacts.

This alternative has moderate social and community impacts and received a 48% approval rating from the 2022 community survey respondents.

The project is anticipated to take 2 to 5 years to implement at a total cost of $284M with minimal O&M.

The alternative removes 100% of structural inundations and has a cost effectiveness of $868k and $262k per foot of inundation reduction for the 25-year and 100-year ultimate conditions events, respectively.

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[a] More details about the current management of this area can be found here.

5.5 Alternative D – Flood Proofing (Elevating Structures)

5.5.1 Alternative Description

This alternative seeks to reduce risk of inundation to structures by elevating a structure so that the livable area is at a tolerable level of risk of inundation. FEMA recommends[b] elevating a structure above the base flood elevation with a minimum of 1-foot of freeboard in order to substantially decrease flood insurance rates. The cost of elevating a structure depends on many factors including square footage, home layout, number of stories, repairs to damaged foundations, height of elevation, and more. For the purposes of this study, several assumptions were made to estimate cost per structure to elevate:

- Only single-family homes would be eligible to be flood proofed. Single family homes were identified using the "Zoning (Small Map Scale)" shapefile from the City Open Data Portal as of December 23, 2020.
- Per the City of Austin, a $25,000 base estimate is applied to each structure to provide temporary relocation and assistance while the structure is being elevated (see Appendix K).
- A Google Street View inspection of various subdivisions concluded that most of the structures eligible for flood proofing are on concrete slab foundations, which is more expensive to elevate than a pier and beam foundation. An estimated $90 per square foot from Dawson Foundation Repair[c] was used to estimate the cost of elevating a structure. From Dawson Foundation Repair, "This [estimation] includes house elevation and all elements of the architectural, engineering, and structural design tasks. It does not include any interior remodeling." It is assumed that this includes testing for lead/asbestos and abatement, if necessary. Square footage of the home is derived from "Building Footprints Year 2013" shapefile from the City of Austin Open Data Portal and includes all roofed areas (home, garage, porches, etc).
- For these preliminary costs, there was no differentiation of cost based on height of elevation needed. Dawson Foundation Repair stated that costs only begin to significantly increase when raising higher than 6 feet, which represents less than 10% of the proposed structures for flood proofing in the 100-year ultimate conditions.

Using these assumptions, the costs were estimated for elevating homes inundated in the 25-year and 100-year ultimate conditions event. These costs shown in Table 5-27 and Table 5-28. The average construction cost to elevate a structure is estimated at $231,000 and $213,000 for the 25-year and 100-year ultimate conditions events, respectively. Another foundation company, Abry Brother's Foundation & Structural Solutions, estimates the average construction cost for elevation of a home in Houston ranges between $80,000 to $150,000[d]. This lends to the conclusion that the estimates below are conservative and appropriate for this level of study.

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[b] US DHS. FEMA. n.d. *Chapter 5: Elevating Your House*. (Homeowner's Guide to Retrofitting). Retrieved from https://www.fema.gov/pdf/rebuild/mat/sec5.pdf

[c] https://www.dawsonfoundationrepair.com/cost-elevating-house/

[d] https://abrybros.com/house-raising-and-home-elevation-by-abry-brothers-in-houston-texas/

Table 5-27. Proposed cost for flood proofing (elevating) structures in the 25-year ultimate conditions floodplain

Problem Area	Number of Structures	Temporary Relocation Cost ($M)	Home Elevation Cost ($M)	Total Estimate Cost ($M)
Westgate	6	0.15	0.98	1.12
Broken Bow	76	1.90	19.94	21.84
Heartwood	11	0.28	2.02	2.30
Other	18	0.45	2.93	3.38
Radam	30	0.75	6.67	7.42
Total	**141**	**3.5**	**32.5**	**36.1**
		Average ($)	**$231k**	**$256k**

Figure 5-12. Zoning of Inundated Structures: 25-Year Ultimate Conditions

Table 5-28. Proposed cost for flood proofing (elevating) structures in the 100-year ultimate conditions floodplain

Problem Area	Number of Structures	Temporary Relocation Cost ($M)	Home Elevation Cost ($M)	Total Estimate Cost ($M)
Westgate	6	0.15	0.97	1.12
Broken Bow	97	2.43	25.19	27.61
Heartwood	52	1.30	9.95	11.25
Other	65	1.63	11.01	12.64
Radam	97	2.43	20.37	22.80
Total	**317**	**7.9**	**67.5**	**75.4**
		Average ($)	**$213k**	**$238k**

Figure 5-13. Zoning of Inundated Structures: 100-Year Ultimate Conditions

5.5.2 Summary

Alternative D – Flood Proofing proposes the elevation of all single-family homes located within the 100-year ultimate conditions floodplain. This alternative does not include estimates for commercial or multi-family structures. This alternative reduces flood risk to these structures up to the 100-year ultimate conditions event for total anticipated cost of $75.4M. Prior to the commencement of this study, the City determined that this option may not be possible for them to implement, but wanted to include it in the report for comparison purposes. At this time, based on the City of Austin's Law Department review and interpretation of state statutes and local government code, it does not appear that the elevation of buildings on private property is an acceptable use of the City's funding sources. This alternative will not appear in the comparison matrix.

5.6 Alternative E – Regional Detention Pond

5.6.1 Alternative Description

In a March 2000, Preliminary Engineering Report for the City of Austin, Alan Plummer Associates, Inc. (Plummer) proposed a regional detention pond between Brodie Lane and West Gate Boulevard near the confluence of Kincheon Branch with Williamson Creek. This regional detention pond had two potential configurations, shown in Figure 5-14. Both configurations involved constructing an earthen dam across Williamson Creek to a height of 690 ft-msl.

Figure 5-14. Alternative E – Regional Detention Conceptual Layout

For the larger configuration, known as Pond 1, Plummer proposed an earthen dam be constructed across Williamson Creek just downstream of the confluence with Kincheon Branch. This dam would be approximately 1,500 feet in length with a maximum height of 32 feet, a 15’ top width, and 3 to 1 side slopes. The principal outlet structure was denoted as 5-10’x10’ box culverts through the dam at the existing creek flowline. An auxiliary spillway structure was mentioned, but not clearly defined. The drainage area for Pond 1 was 15.9 square miles and would create a maximum storage volume of 830 acre-feet while inundating 85 acres and, at the time, 7 residential structures. Recent City 2017 LiDAR estimates actual maximum storage to be approximately 790 ac-ft.

For the smaller configuration, known as Pond 2, Plummer proposed an earthen dam be constructed across Williamson Creek just upstream of the confluence with Kincheon Branch. This dam would be approximately 1,850 feet in length with a maximum height of 26 feet, a 15’ top width, and 3 to 1 side slopes. The principal outlet structure was denoted as 5-10’x10’ box culverts through the dam at the existing creek flowline. An auxiliary spillway structure was mentioned, but not clearly defined. The drainage area for Pond 2 was 8.0 square miles and would create a maximum storage volume of 250 acre-feet while inundating 30 acres and, at the time, no residential structures.

HDR incorporated concepts from Pond 1 into a 1D/2D model for Alternative E. As there was no auxiliary spillway clearly defined, a 130 ft wide spillway set at elevation 686 ft-msl was added to the concept to simulate a conventional earthen dam. As stated above, the concept proposed is more akin to an earthen dam and, given the number of habitable structures downstream and height of the dam, would likely be classified as a small, high-hazard dam requiring that the dam be able to safely pass the 75% Probable Maximum Flood (PMF), according to the Texas Commission on Environmental Quality (TCEQ) dam safety requirements and Chapter 299 of the Texas Administrative Code (TAC). This dam would also be classified as a regional detention pond by the City and must meet criteria for regional detention ponds as described in Section 8.3.3 of the DCM. One of the criteria is 2-foot freeboard on top of the embankment for a 100-year frequency event.

The results from HEC-RAS model of Alternative E showed that the dam would overtop at a frequency event between 50-year and 100-year flood events, a much higher frequency than the 75% PMF. In an attempt to prevent overtopping of the dam crest, the area behind the dam was graded to provide an additional 580 ac-ft of storage than what was originally proposed in the Plummer report, approximately 1,370 ac-ft total, however, this grading did not prevent the dam from overtopping at a frequency of at least the 100-year ultimate conditions and does not meet DCM criteria discussed previously. Model results from this concept are shown in Figure 5-15 and Figure 5-16. Table 5-29 summarizes impacts to structural inundation depths. For this configuration, more properties would need to be acquired (60) than are removed from the floodplain (56). The height of the dam could be raised in order to prevent overtopping of the dam crest and meet DCM criteria but benefit downstream would likely be negated by the increase of properties in the proposed flood pool.

In general, unintended overtopping of the dam crest is to be avoided. However, in some specific cases, overtopping risks are lower if the embankment slopes and dam crest can withstand overtopping without experiencing damage that would cause a breach to form. The ability of a dam to withstand overtopping is dependent on several factors including depth, duration, and velocity of overtopping flows, soil (or armor) type and compaction, embankment geometry, and presence or absence of a tailwater. If built in this configuration, the pond would need extensive overtopping protection, likely a concrete crest and downstream embankment in order to meet TCEQ dam safety requirements and safely pass the 75% PMF. This configuration also causes adverse impacts, namely within the City of Sunset Valley. These visually depicted with the increase in inundation boundary in some areas (shown in red). Acquisition of these properties is included in the number of properties to be acquired discussed previously.

Table 5-29. Alternative E impact to structure inundation depth

Impact to Structure Inundation Depth	25-Year Ultimate Conditions		100-Year Ultimate Conditions	
	Number of Structures	Avg Change in Depth (ft)	Number of Structures	Avg Change in Depth (ft)
Added[a]	0	-	0	-
Increased	0	-	2	0.11
No Change	0	-	0	-
Decreased	52	-2.04	338	-0.30
Removed	131	-1.28	56	-0.73

[a] This table only represents homes within the project area that have known finished floor elevations, but as shown in Figure 5-15 and Figure 5-16, the proposed floodplain does impact an estimated 60 homes and properties (red).

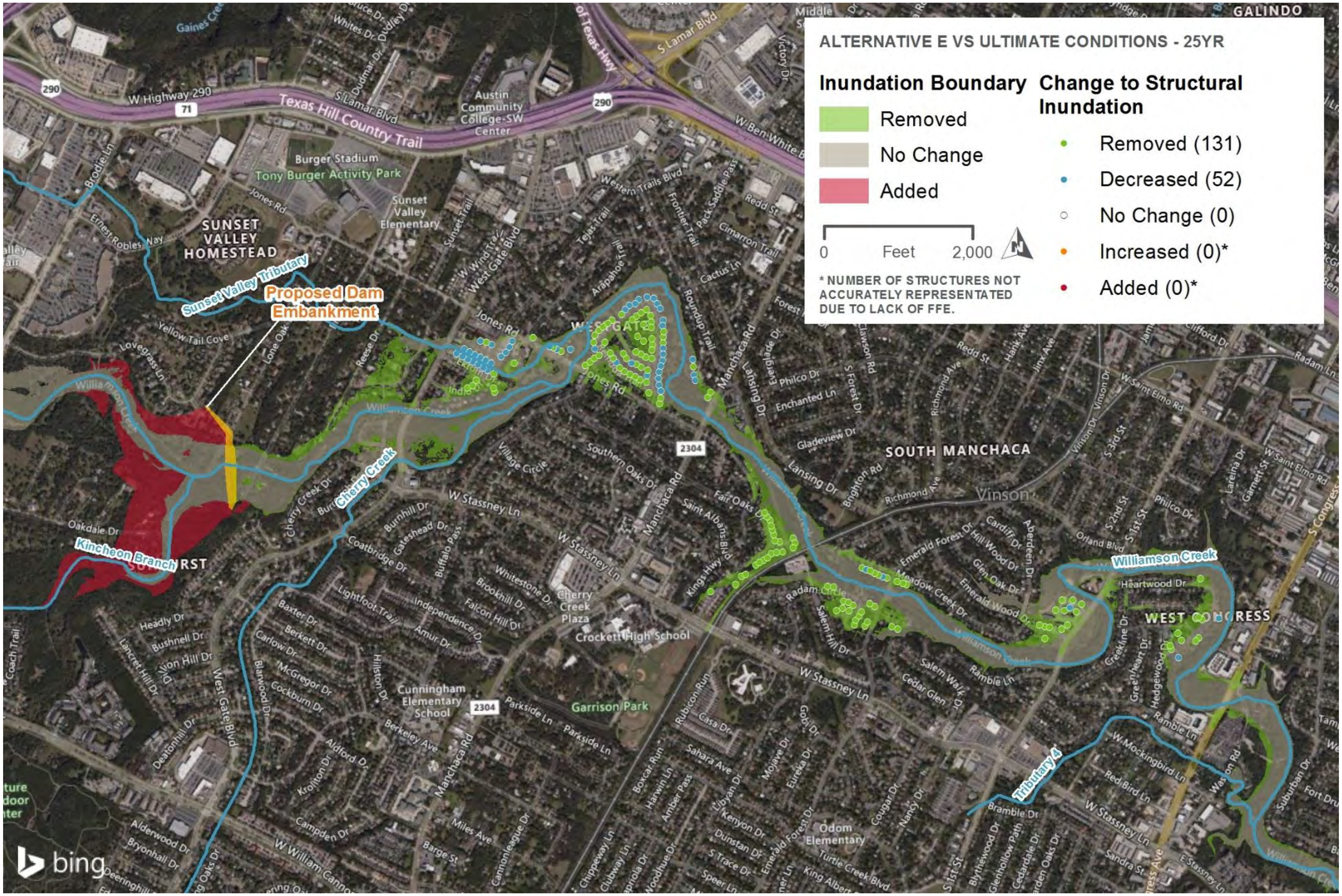

Figure 5-15. Alternative E vs Ultimate Conditions – 25yr: Change to Structural Inundation

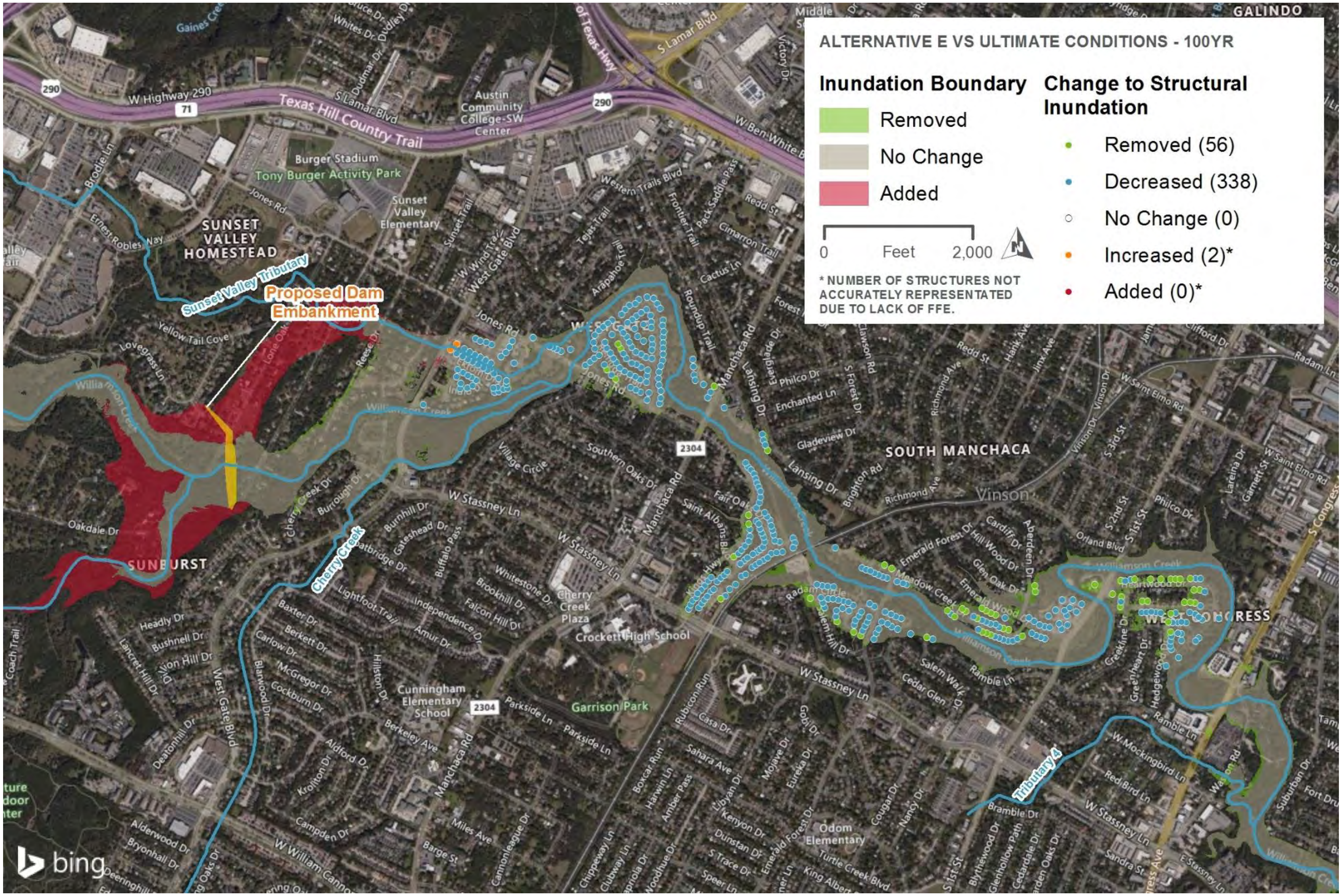

Figure 5-16. Alternative E vs Ultimate Conditions – 100yr: Change to Structural Inundation

5.6.2 Summary

The conceptual layouts for a regional detention dam, previously proposed by Alan Plummer Inc. are unlikely to meet dam safety requirements of safely passing the 75% PMF or DCM requirements of a 2 foot freeboard for the 100-year frequency event as the dam embankment overtops at a frequency between the 50-year and 100-year ultimate conditions. The flood pool was graded in order to provide more flood storage and prevent overtopping, but this was unsuccessful, and still overtopped at a frequency just higher than the 100-year event. In general, unintended overtopping of the dam crest is to be avoided, as it usually increases the likelihood of a dam breach, however the embankment could be protected with concrete armoring to reduce the risk. In the modeled dam configuration, the number of proposed property acquisitions (60) is higher than the number of homes removed from inundation in the 100-year frequency event (56). The lack of net benefits and unlikelihood of receiving permits for a dam estimated to overtop at a frequency just higher than the 100-year ultimate conditions event renders this alternative infeasible and it will not be considered in the final comparison matrix.

5.7 Alternative F – West Gate Detention

5.7.1 Alternative Description

Open green space around the West Gate Boulevard crossings of Williamson Creek and Cherry Creek (Figure 5-17) prompted the desire of the City to evaluate using this space as detention in order to provide flood risk reduction to homes downstream. There were several iterations of various detention and flood bench concepts for this area in order to determine the most effective for flood risk reduction for the project area. These iterations were unsuccessful as they proved to only have very localized benefits, however, they are described below should any future hydraulic studies about this area occur.

Figure 5-17. Alternative F – West Gate Detention

Initial investigations modeled 108 acre-feet of off-channel detention between the confluence of Williamson Creek and Cherry Creek downstream of West Gate Blvd (see "Confluence" in Figure 5-17), but there was minimal flood risk reduction anticipated as West Gate Boulevard is overtopped in both the 25-year and 100-year ultimate conditions events, and, therefore, a significant portion of the detention is utilized before the peak of Williamson Creek.

In an attempt to prevent the overtopping of West Gate Blvd, a 81 acre-feet of off-channel detention was modeled upstream of West Gate Blvd between the confluences of Cherry Creek and Williamson Creek along Bayton Loop where a voluntary home buyout effort had opened up considerable green space (see "Bayton Loop" in Figure 5-17). Like the first detention, the Bayton Loop detention prematurely fills from overland flows from an out-of-bank Cherry Creek before the peak of both the 25-year and 100-year ultimate conditions storm. Reductions in water surface elevations were not prominent and, for the most part, did not extend beyond Jones Road.

The complex flow patterns of the area proved to hinder the proposed detention's ability to reduce flood risk to homes downstream. Channel improvements to Cherry Creek and opening up the crossing could potentially facilitate an effective detention system and provide measurable flood risk reduction, but the lack of available right-of-way due to close proximity of homes to the creek provides another barrier for this concept. Using the option of using the open green spaces as detention was abandoned as it was considered infeasible due to lack of flood risk reduction benefits.

An additional iteration led to modeling the Bayton Loop and Confluence areas as a flood bench for Williamson Creek versus an off-channel detention, which significantly reduces water surface elevations upstream of West Gate Blvd for the 25-year and 100-year ultimate conditions events, however minimal impact is shown downstream of Jones Road to the intended areas of interest. Flood reduction upstream of West Gate Blvd is not an objective of this study as it primarily reduces flooding within the City of Sunset Valley. This iteration is also not feasible concept for the use of the open space to provide flood risk reduction to the project area.

This localized reduction in water surface elevation does show potential for mitigation locations if the West Gate Boulevard crossings of Williamson Creek and its tributaries were brought into DCM compliance which requires non-local streets to have a maximum headwater not exceed 0.5-feet above the roadway crown elevation for the 100-year ultimate conditions event. The 100-year ultimate conditions event produces headwater elevations at West Gate Blvd that are over 6-feet higher than the crossing of Williamson Creek, and over 3-feet higher than the crossing at Cherry Creek.

Preliminary models suggest raising the crossings of Cherry Creek and Williamson Creek to an elevation of 667 ft-msl from the existing elevations of 661.50 ft-msl and 660.74 ft-msl, respectively, and raising Sunset Tributary to an elevation of 662 ft-msl from the existing elevation of 660 ft-msl. Raising the roadway along with replacing the three structures would minimize overtopping of the roadway during the 100-year ultimate conditions event to less than 0.5 feet. Proposed structures for Cherry Creek and Sunset Tributary are standard TxDOT concrete slab and girder (CS&G) bridges with two 30-foot spans and a 2-foot deck thickness. The proposed structure for Williamson Creek is also a CS&G bridge, but with four 30-foot spans and a 2-foot deck thickness. The two open green spaces discussed in this alternative provide the opportunity for mitigation for impacts of these structures. A proposed schematic for this is shown in Figure 5-18 with overtopping depths shown in Table 5-30, and the proposed impact on structures in Table 5-31, Figure 5-19, and, Figure 5-20. Note, that FFE for structures upstream of West Gate Boulevard are not included in this study and impacts to structures there are not accounted for.

As shown in the results figures, there are some adverse impacts upstream of West Gate, but as roadway DCM compliance was not an objective of this study, this alternative was not refined beyond the initial model run and will not be developed further in this study. It is important to note that this could be a potential future study if the City identifies the need to bring these crossings into compliance.

Figure 5-18. West Gate Boulevard DCM compliance proposed schematic

Table 5-30. Existing versus proposed overtopping depths for West Gate Boulevard

Crossing	25-Year Ult Overtopping (ft)			100-Year Ult Overtopping (ft)		
	Existing	Proposed	+/-	Existing	Proposed	+/-
Williamson Creek	3.64	-5.09	-8.73	6.31	-2.16	-8.47
Cherry Creek	1.75	-2.82	-4.57	2.90	-0.15	-3.05
Sunset Tributary	-	-	-	0.56	-0.88	-1.44

Table 5-31. West Gate DCM compliance impact to structure inundation depth

Impact to Structure Inundation Depth	Number of Structures	Avg Change in Depth (ft)	Number of Structures	Avg Change in Depth (ft)
Added	0	-	0	-
Increased	1	0.01	1	0.19
No Change	59	-	1	-
Decreased	121	-0.07	388	-0.06
Removed	2	-0.13	6	-0.64

Figure 5-19. Alternative F versus Ultimate Conditions – 25yr: Change to Structural Inundation

Figure 5-20. Alternative F versus Ultimate Conditions – 100yr: Change to Structural Inundation

5.7.2 Summary

Open green space around the West Gate Boulevard crossing of Williamson and Cherry Creeks lead the City to designate Alternative F of this study for the evaluation of this area as detention. Using as much of the available space as possible, two off-channel detention basins of 108 acre-feet and 81 acre-feet proved to only have minimal benefits to flood risk reduction. Additional iteration of modeling these areas as flood benches versus detention proved to only have localized benefits to flood risk reduction, predominately outside of the project area. Due to lack of flood risk reduction benefits to the project area, this alternative was considered infeasible and will not be included in the comparison matrix. A preliminary model suggests that the West Gate Boulevard crossings of Cherry Creek, Williamson Creek, and Sunset Valley Tributary could be brought into compliance by raising the roadway, increasing the conveyance through the crossings, and using the open green spaces for mitigation of adverse impacts. This alternative was not included in the evaluation matrix, as it did not meet the minimum total reduction in depth of inundation.

5.8 Alternative G – Channel Modifications

5.8.1 Alternative Description

During the past few years, the City has acquired many structures at risk along the studied reaches of Williamson Creek. The acquired land plus the restudied hydrologic and hydraulic characteristics of Williamson Creek may promote new opportunities for channel modifications other than those recommended in the 2006 USACE report. Alternative G evaluated new channel modification opportunities at the five problem areas mentioned above. Two scenarios listed below were analyzed under Alternative G.

- Scenario 1: Excavate channel to the maximum extent that would remove all structures out of the ultimate conditions 25-year and 100-year floodplain. Scenario 1 does not consider existing easements or structures and is infeasible but was included in this study to show the magnitude of channel modifications necessary to provide flood risk reduction up to the 100-year ultimate conditions event at each given location.
- Scenario 2: Excavate channel to more reasonable limits within existing drainage easements or city-owned property. Excavations include a flood bench at a minimum 3:1 slope at selected cross sections to calculate depth reduction and structures removed for the ultimate condition 25-year and 100-year flood events. A two-foot deep pilot channel was retained to allow the channel to retain its form for more of the geomorphically significant flows as recommended in the 2005 Williamson Creek Plan Formulation Technical Memo by HDR.

This alternative was not scoped to be evaluated with a full unsteady 1D/2D proposed conditions model. Instead, select cross sections of each reach were evaluated using a steady-state hydraulic calculator in Bentley FlowMaster. Channel modifications were modeled to have dense riparian vegetation using a Manning's value of 0.65, to meet ECM compliance. Evaluation of this alternative in subsequent sections will use the results of Scenario 2, including costing, utility impacts, easements, time of implementation, etc. Because this alternative was not dynamically modeled, results presented should not be considered to be completed at the same level of effort and detail as other alternatives in this study.

Westgate/Indio

The selected cross sections are located approximately 250 feet and 1,650 feet downstream of Westgate Blvd Bridge as shown in Figure 5-21.

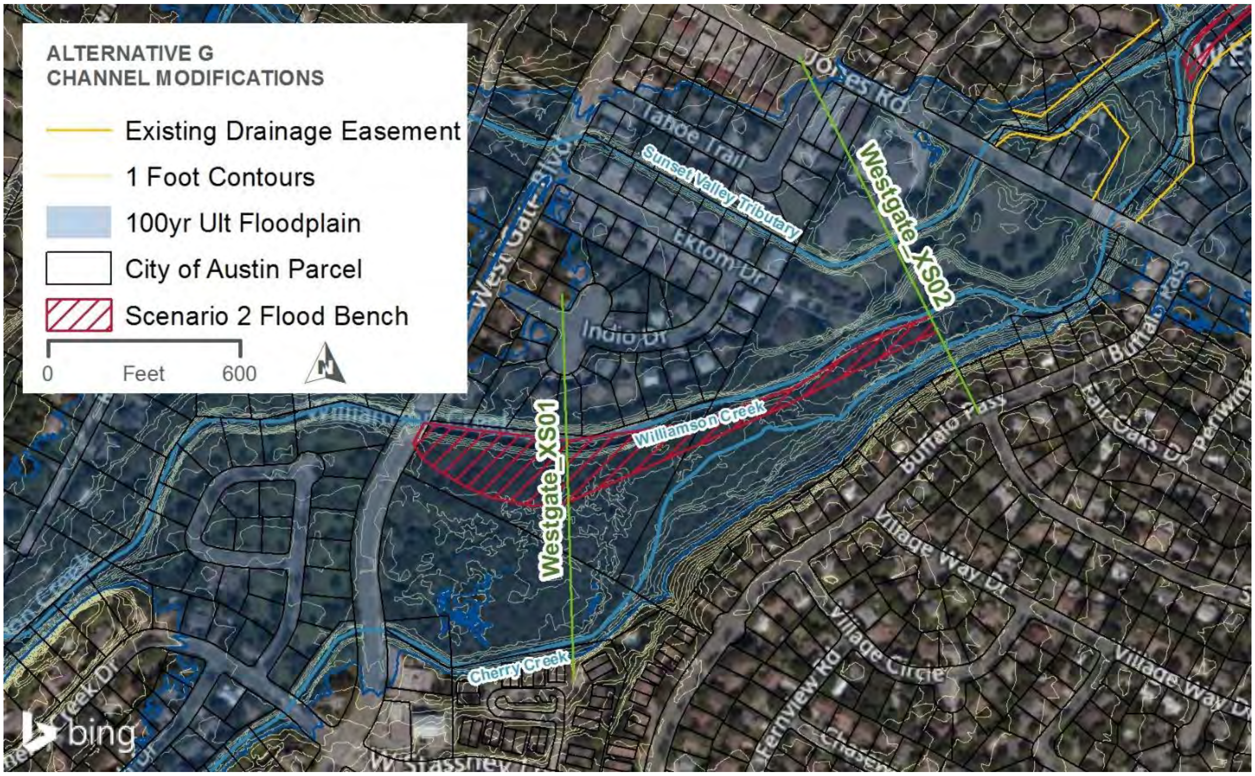

Figure 5-21. Alternative G – West Gate: Location of Selected Cross-Sections

The maximum structure inundation depths for the ultimate 25-year and 100-year storm events and structure addresses are summarized in Table 5-32.

Table 5-32. Alternative G – West Gate: Maximum Structure Inundation Depth Summary

Event	Max Depth	Location	Address
25-yr Ult	3.93	D/S of Johns Road Bridge	2504 Jones Rd
100-yr Ult	6.55	D/S of Johns Road Bridge	2504 Jones Rd

To meet the risk reduction requirement for Scenario 1, the proposed channel excavation would start at 2-ft above the channel bottom elevation on the right overbank in between Williamson Creek and Cherry Creek. For selected cross section 1 (XS01), a 325-ft flat bench is proposed with 3:1 slope back to existing ground. For selected cross section 2 (XS02), a 50-ft flat bench is proposed with 3:1 slope back to existing ground on the right overbank, and a 380-ft flat bench is proposed with 3: slope back to existing ground on the left overbank.

To meet the risk reduction requirement for Scenario 2, the proposed channel excavation would start at 2-ft above the channel bottom elevation on the right overbank in between Williamson Creek and Cherry Creek. For selected cross section 1 (XS01), a 158-ft flat bench is proposed with 3:1 slope back to existing ground on the right overbank. For selected cross section 2 (XS02), a 50-ft flat bench is proposed with 3:1 slope back to existing ground on the right overbank.

Figure 5-22 and Figure 5-23 below show the grading limits at each cross section.

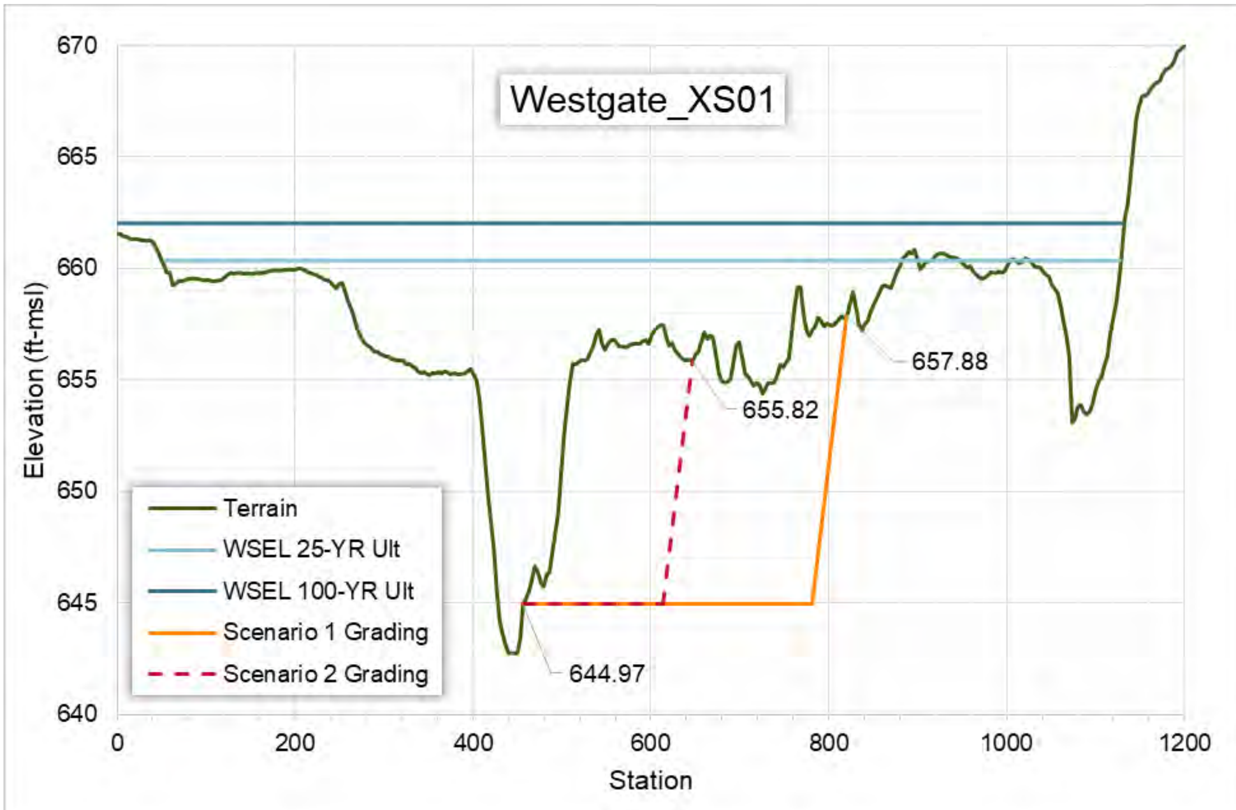

Figure 5-22. Alternative G – Westgate_XS01 Proposed Grading

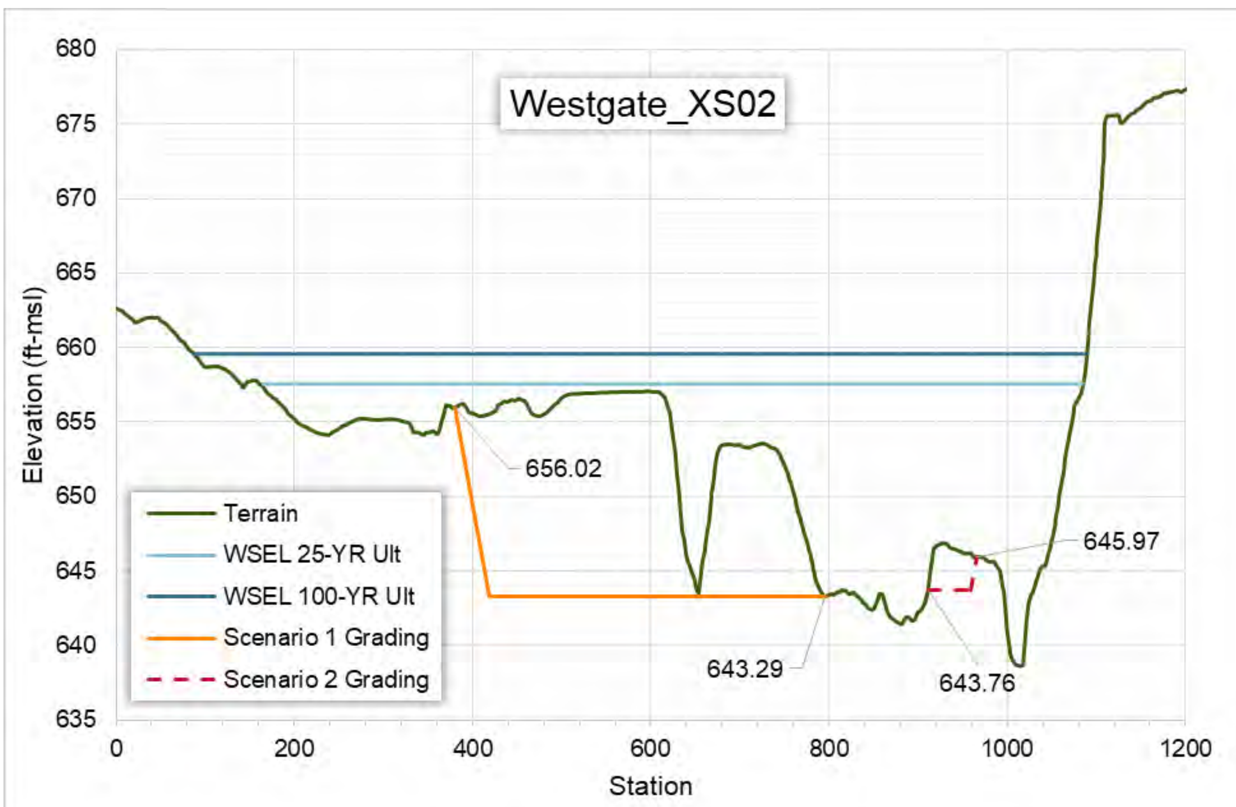

Figure 5-23. Alternative G – Westgate_XS02 Proposed Grading

Table 5-33 below compares the pre-project and post-project water surface elevation for Scenario 2. Scenario 2 will remove 30% to 42% of the structures out of the ultimate condition 25-year and 2% to 12% out of the ultimate 100-year floodplain.

Table 5-33. Alternative G – Westgate/Indio: Pre-Project versus Post Project Results

Westgate XS ID	Channel Bottom Elev.	WSEL 25yrUlt				WSEL 100yrUlt			
		Pre[a]	Post[b]	+/-[c]	%[d,e]	Pre[a]	Post[b]	+/-[c]	%[d,f]
01	642.76	660.36	656.67	-3.69	42%	662.03	660.40	-1.63	2%
02	641.15	657.57	657.05	-0.52	30%	659.62	659.25	-0.37	12%

[a] Pre-Project Conditions
[b] Post-Project Conditions
[c] Change from pre-project to post-project
[d] Percent of structural inundations removed.
[e] Total of 33 habitable structures were inundated under pre-project ultimate condition 25-yr storm event.
[f] Total of 51 habitable structures were inundated under pre-project ultimate condition 100-yr storm event.

Broken Bow

The selected cross sections are located approximately 800-ft downstream of Johns Road and 630-ft and 1100-ft upstream of Menchaca Road Bridge as shown in Figure 5-24.

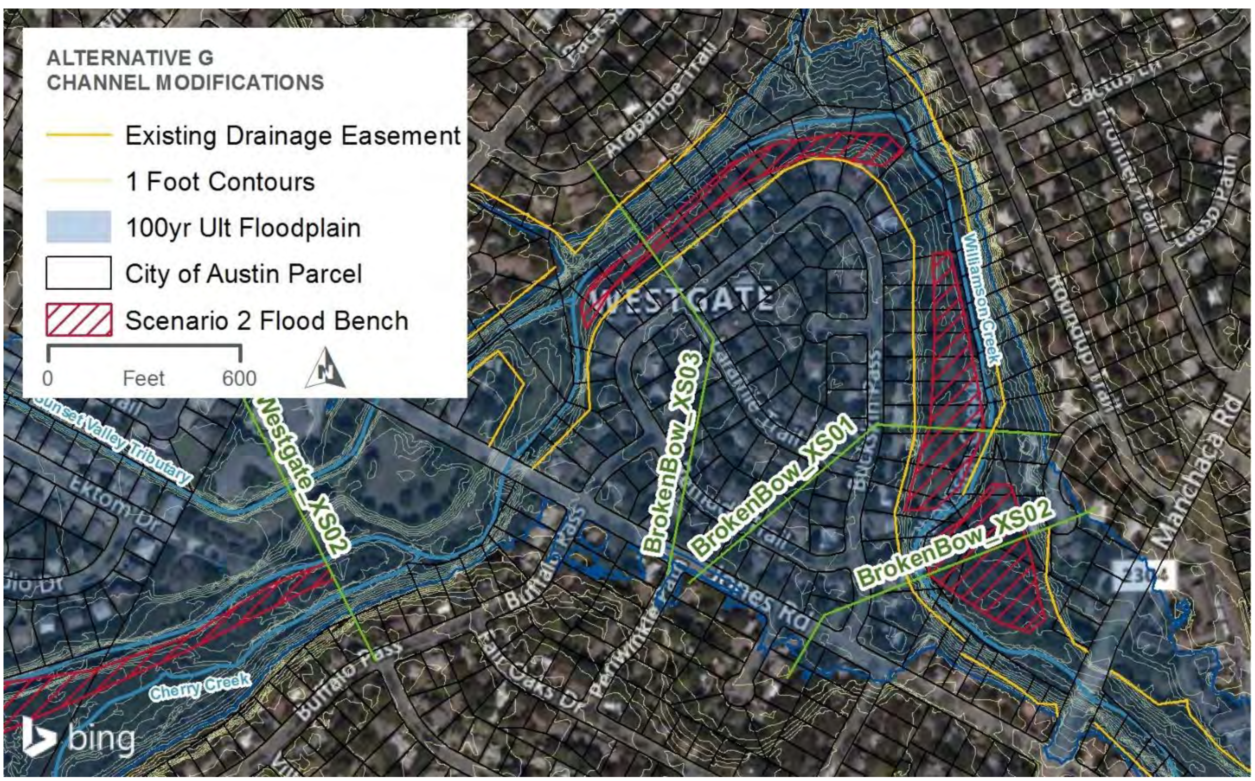

Figure 5-24. Alternative G – Broken Bow: Location of Selected Cross-Sections

The maximum structure inundation depths for the ultimate 25-year and 100-year storm events and structure addresses are summarized in Table 5-34.

Table 5-34. Alternative G – Broken Bow: Maximum Structure Inundation Depth Summary

Event	Max Depth	Location	Address
25-yr Ult	8.62	U/S of Menchaca Rd on the LOB	4808 Pawnee Pathway
100-yr Ult	11.46	U/S of Menchaca Rd on the LOB	4808 Pawnee Pathway

To meet the risk reduction requirement for Scenario 1, the proposed channel excavation would start at 2-ft above the channel bottom elevation on the right or left overbanks. For selected cross section 1 (XS01), a 940-ft flat bench is proposed with 3:1 slope back to existing ground. For selected cross section 2 (XS02), a 400-ft flat bench is proposed with 3:1 slope back to existing ground on the right overbank, and a 300-ft flat bench is proposed with 3:1 slope back to existing ground on the left overbank. For selected cross section 3 (XS03), a 1,064-ft flat bench is proposed with 3:1 slope back to existing ground on the right overbank.

To meet the risk reduction requirement for Scenario 2, the proposed channel excavation would start at 2-ft above the channel bottom elevation on the right or left overbanks. For selected cross section 1 (XS01), a 300-ft flat bench is proposed with 3:1 slope back to existing ground on the right overbank. For selected cross section 2 (XS02), a 300-ft flat bench is proposed with 3:1 slope back to existing ground on the left overbank. For selected cross section 3 (XS03), a 40-ft flat bench is proposed with 3:1 slope back to existing ground on the right overbank.

Figure 5-25 through Figure 5-27 below show the grading limits at each cross section.

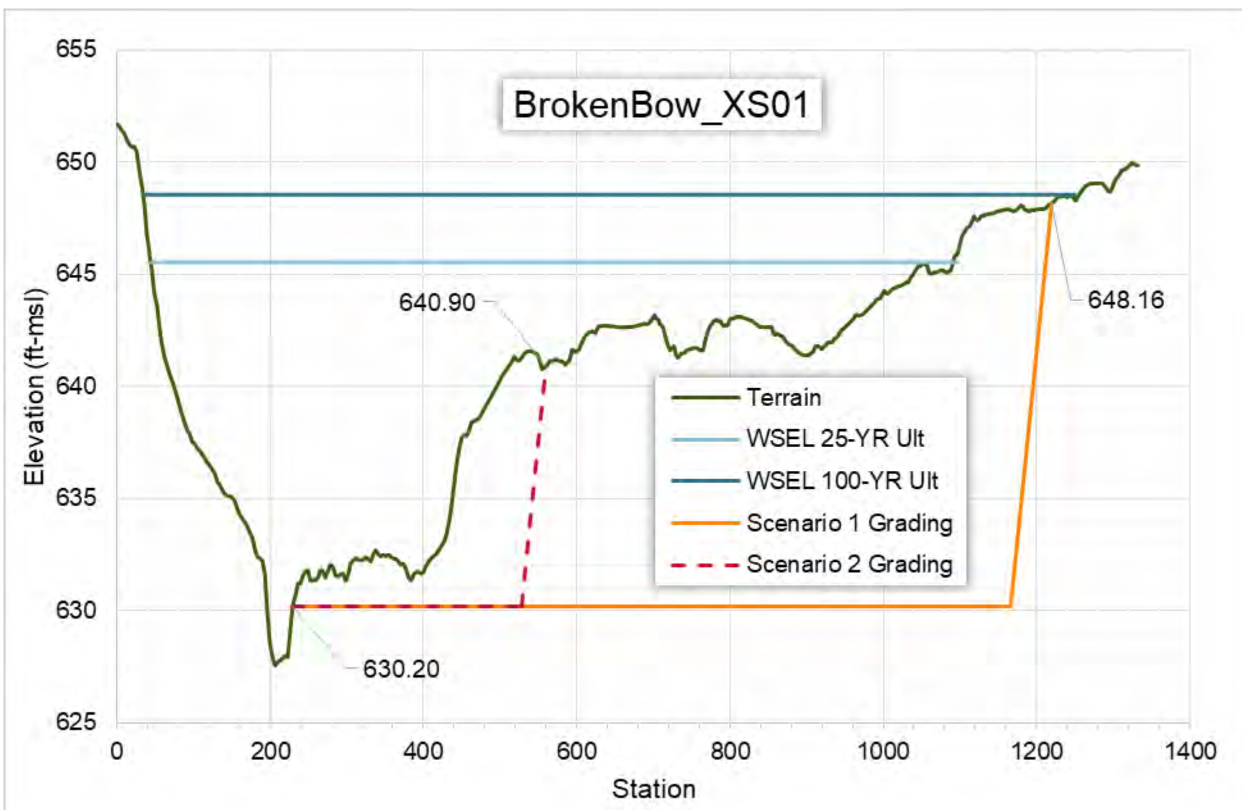

Figure 5-25. Alternative G – BrokenBow_XS01 Proposed Grading

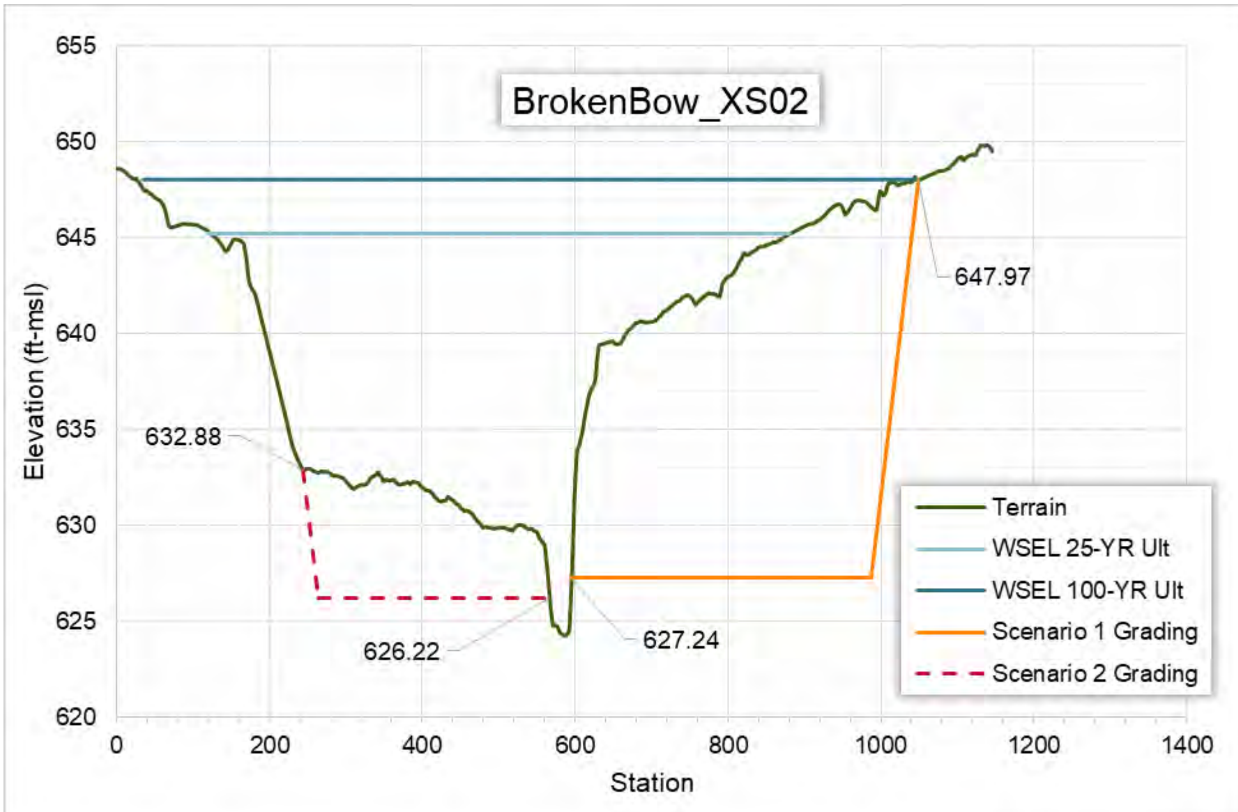

Figure 5-26. Alternative G – BrokenBow_XS02 Proposed Grading

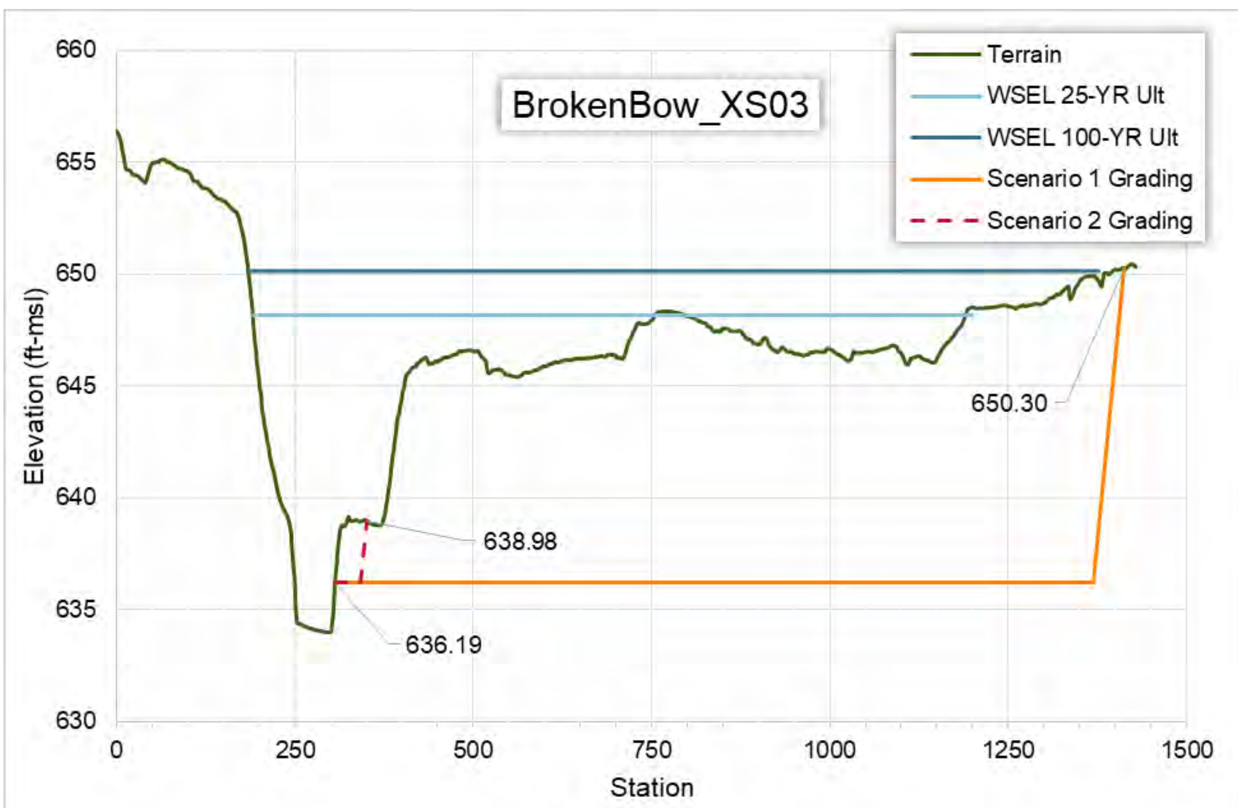

Figure 5-27. Alternative G – BrokenBow_XS03 Proposed Grading

Table 5-35 below compares the pre-project and post-project water surface elevation for Scenario 2. Scenario 2 will remove approximately 57% to 91% of the structures out of the ultimate condition 25-year and 34% to 40% out of the ultimate condition 100-year floodplain.

Table 5-35. Alternative G – Broken Bow: Pre-Project versus Post Project Results

Broken Bow XS ID	Channel Bottom Elev.	WSEL 25yrUlt				WSEL 100yrUlt			
		Pre[a]	Post[b]	+/-[c]	%[d,e]	Pre[a]	Post[b]	+/-[c]	%[d,f]
01	627.56	645.54	643.82	-1.72	57%	648.55	646.74	-1.81	34%
02	624.26	645.22	641.11	-4.11	91%	648.03	645.26	-2.77	46%
03	634.00	648.17	648.15	-0.02	13%	650.14	650.02	-0.12	2%

[a] Pre-Project Conditions
[b] Post-Project Conditions
[c] Change from pre-project to post-project
[d] Percent of structural inundations removed.
[e] Total of 76 habitable structures were inundated under pre-project ultimate condition 25-yr storm event.
[f] Total of 97 habitable structures were inundated under pre-project ultimate condition 100-yr storm event.

Other

The selected cross sections are located approximately 500-ft and 1,200-ft upstream of UPRR Bridge as shown in Figure 5-28.

Figure 5-28. Alternative G – Other: Location of Selected Cross-Sections

The maximum structure inundation depths for the ultimate 25-year and 100-year storm events and structure addresses are summarized in Table 5-36.

Table 5-36. Alternative G – Other: Maximum Structure Inundation Depth Summary

Event	Max Depth	Location	Address
25-yr Ult	2.89	U/S of UPRR on the ROB	5204 Calais Ct
100-yr Ult	6.52	U/S of UPRR on the ROB	5204 Calais Ct

To meet the risk reduction requirement for Scenario 1, the proposed channel excavation would start at 2-ft above the channel bottom elevation on the right or left overbank. For selected cross section 1 (XS01), a 130-ft flat bench is proposed with 3:1 slope back to existing ground on the right overbank, and a 30-ft flat bench is proposed with 3:1 slope back to existing ground on the left overbank. For selected cross section 2 (XS02), a 180-ft flat bench is proposed with 3:1 slope back to existing ground on the right overbank.

To meet the risk reduction requirement for Scenario 2, the proposed channel excavation would start at 2-ft above the channel bottom elevation on the right or left overbank. For selected cross section 1 (XS01), a 30-ft flat bench is proposed with 3:1 slope back to existing ground on both left and right overbanks. For selected cross section 2 (XS02), a 170-ft flat bench is proposed with 3:1 slope back to existing ground on the right overbank.

Figure 5-29 and Figure 5-30 below show the grading limits at each cross section.

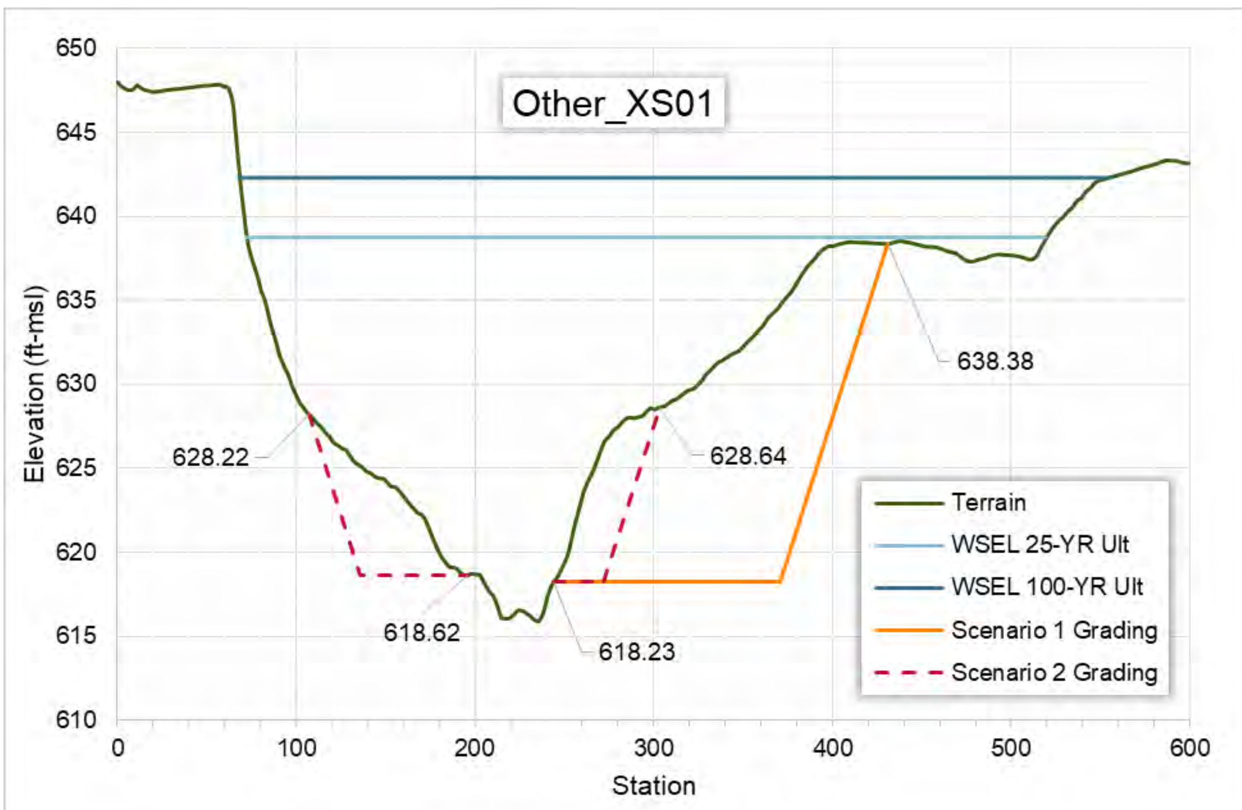

Figure 5-29. Alternative G – Other_XS01 Proposed Grading

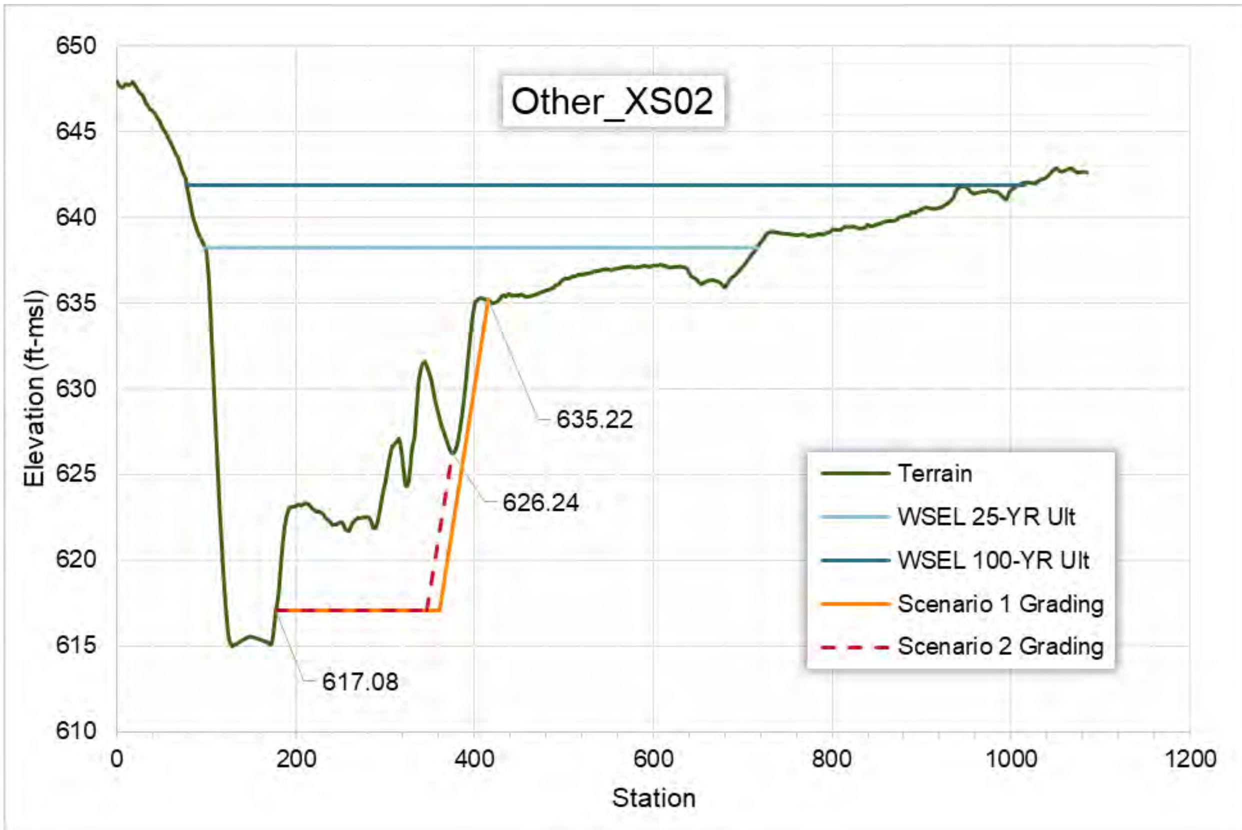

Figure 5-30. Alternative G – Other_XS02 Proposed Grading

Table 5-37 below compares the pre-project and post-project water surface elevation for Scenario 2. Scenario 2 will remove approximately 100% of the structures out of the ultimate condition 25-year and 12% to 71% out of the ultimate condition 100-year floodplain.

Table 5-37. Alternative G – Other: Pre-Project versus Post Project Results

Other XS ID	Channel Bottom Elev.	WSEL 25yrUlt				WSEL 100yrUlt			
		Pre[a]	Post[b]	+/-[c]	%[d,e]	Pre[a]	Post[b]	+/-[c]	%[d,f]
01	615.89	638.76	635.23	-3.53	100%	642.30	640.90	-1.40	12%
02	614.97	638.25	631.13	-7.12	100%	641.90	638.42	-3.48	71%

[a] Pre-Project Conditions
[b] Post-Project Conditions
[c] Change from pre-project to post-project
[d] Percent of structural inundations removed.
[e] Total of 22 habitable structures were inundated under pre-project ultimate condition 25-yr storm event.
[f] Total of 82 habitable structures were inundated under pre-project ultimate condition 100-yr storm event.

Radam

The selected cross sections are located approximately 440-ft upstream and 370-ft downstream of Emerald Forest Drive as shown in Figure 5-31.

Figure 5-31. Alternative G – Radam: Location of Selected Cross-Sections

The maximum structure inundation depths for the ultimate 25-year and 100-year storm events and structure addresses are summarized in Table 5-38.

Table 5-38. Alternative G – Radam: Maximum Structure Inundation Depth Summary

Event	Max Depth	Location	Address
25-yr Ult	3.82	U/S of Emerald Forest Dr on the LOB	5227 Meadow Creek Dr
100-yr Ult	7.00	U/S of S. 1st St	5112 S 1ST St G

To meet the risk reduction requirement for Scenario 1, the proposed channel excavation would start at 2-ft above the channel bottom elevation on the right overbank. For selected cross section 1 (XS01), a 235-ft flat bench is proposed with 3:1 slope back to existing ground. For selected cross section 2 (XS02), a 418-ft flat bench is proposed with 3:1 slope back to existing ground.

To meet the risk reduction requirement for Scenario 2, the proposed channel excavation would start at 2-ft above the channel bottom elevation on the right. For selected cross section 1 (XS01), a 96-ft flat bench is proposed with 3:1 slope back to existing ground. For selected cross section 2 (XS02), a 212-ft flat bench is proposed with 3:1 slope back to existing ground.

Figure 5-32 and Figure 5-33 below show the grading limits at each cross section.

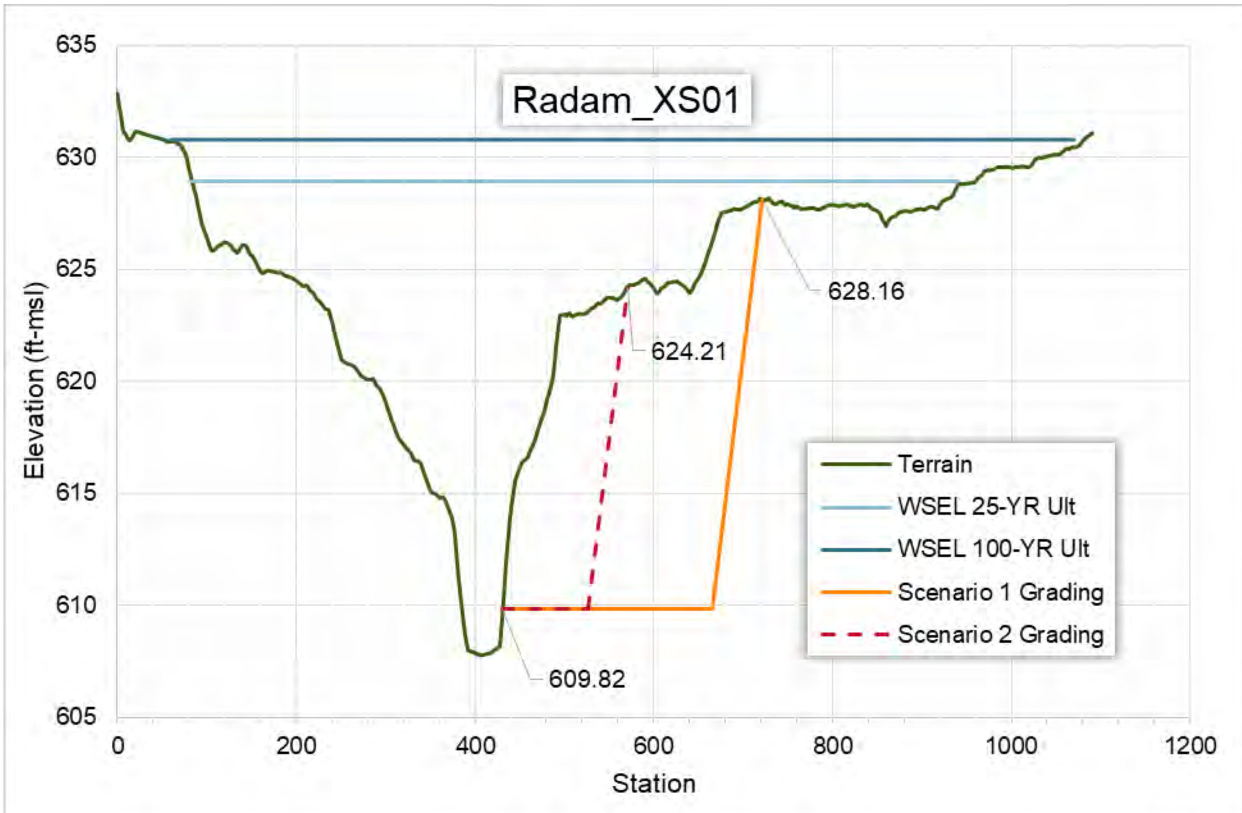

Figure 5-32. Alternative G – Radam_XS01 Proposed Grading

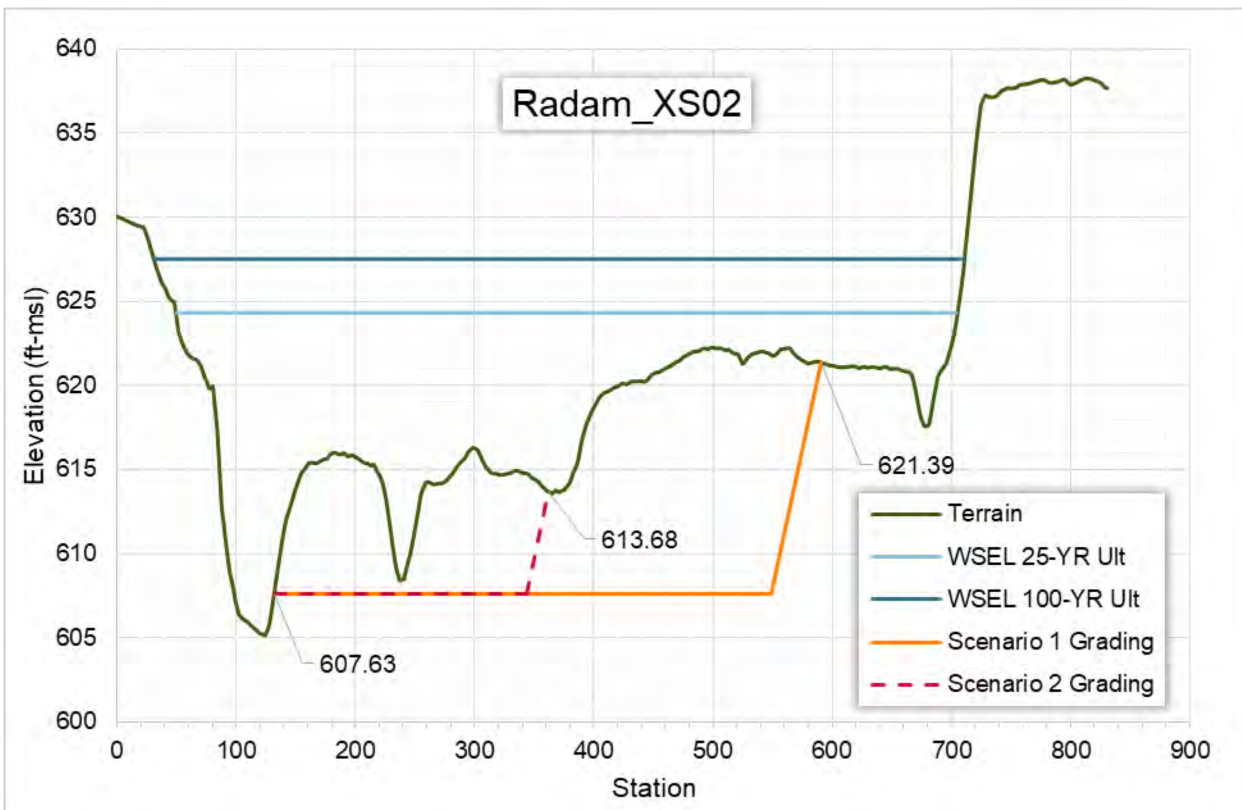

Figure 5-33. Alternative G – Radam_XS02 Proposed Grading

Table 5-39 below compares the pre-project and post-project water surface elevation for Scenario 2. Scenario 2 will remove approximately 51% to 68% of the structures out of the ultimate condition 25-year floodplain and 13% to 44% out of the ultimate condition 100-year floodplain.

Table 5-39. Alternative G – Radam: Pre-Project versus Post Project Results

Radam XS ID	Channel Bottom Elev.	WSEL 25yrUlt				WSEL 100yrUlt			
		Pre[a]	Post[b]	+/-[c]	%[d,e]	Pre[a]	Post[b]	+/-[c]	%[d,f]
01	607.77	628.93	625.67	-3.26	51%	630.79	629.16	-1.63	13%
02	605.13	624.32	619.72	-4.60	68%	627.53	625.29	-2.24	44%

[a] Pre-Project Conditions
[b] Post-Project Conditions
[c] Change from pre-project to post-project
[d] Percent of structural inundations removed.
[e] Total of 41 habitable structures were inundated under pre-project ultimate condition 25-yr storm event.
[f] Total of 112 habitable structures were inundated under pre-project ultimate condition 100-yr storm event.

Heartwood

The selected cross sections are located approximately 700-ft upstream of South Congress Ave. as shown in Figure 5-34.

Figure 5-34. Alternative G – Heartwood: Location of Selected Cross-Sections

The maximum structure inundation depths for the ultimate 25-year and 100-year storm events and structure addresses are summarized in Table 5-40.

Table 5-40. Alternative G – Heartwood: Maximum Structure Inundation Depth Summary

Event	Max Depth	Location	Address
25-yr Ult	5.31	Heartwood Dr and Hedgewood Dr on the ROB	204 Heartwood Dr
100-yr Ult	8.52	Heartwood Dr and Hedgewood Dr on the ROB	204 Heartwood Dr

To meet the risk reduction requirement for Scenario 1, the proposed channel excavation would start at 2-ft above the channel bottom elevation on the right overbank. For selected cross section 1 (XS01), a 154-ft flat bench is proposed with 3:1 slope back to existing ground. For selected cross section 2 (XS02), a 204-ft flat bench is proposed with 3:1 slope back to existing ground. For selected cross section 3 (XS03), a 300-ft flat bench is proposed with 3:1 slope back to existing ground.

To meet the risk reduction requirement for Scenario 2, the proposed channel excavation would start at 2-ft above the channel bottom elevation on the right overbank. For selected cross section 1 (XS01), a 126-ft flat bench is proposed with 3:1 slope back to existing ground. For selected cross section 2 (XS02), a 144-ft flat bench is proposed with 3:1 slope back to existing ground. For selected cross section 3 (XS03), a 104-ft flat bench is proposed with 3:1 slope back to existing ground.

Figure 5-35 through Figure 5-37 below show the grading limits at each cross section.

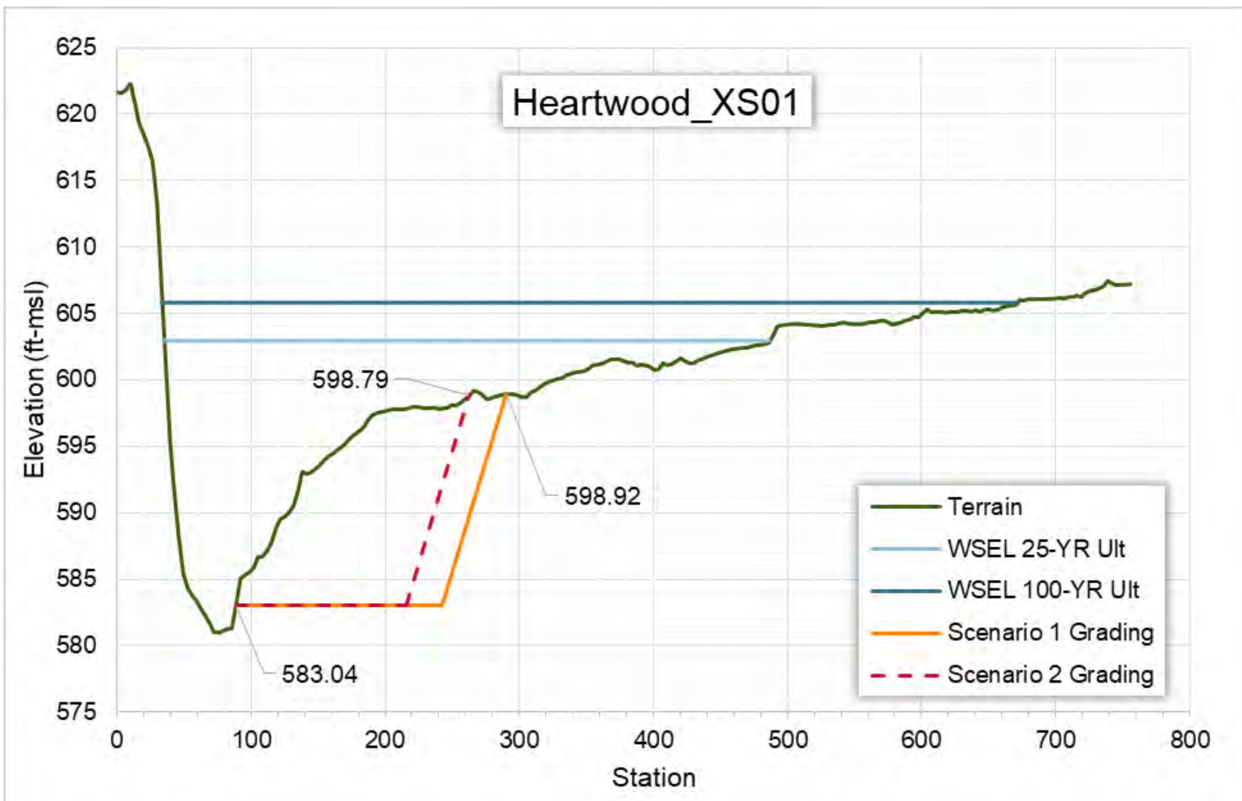

Figure 5-35. Alternative G – Heartwood_XS01 Proposed Grading

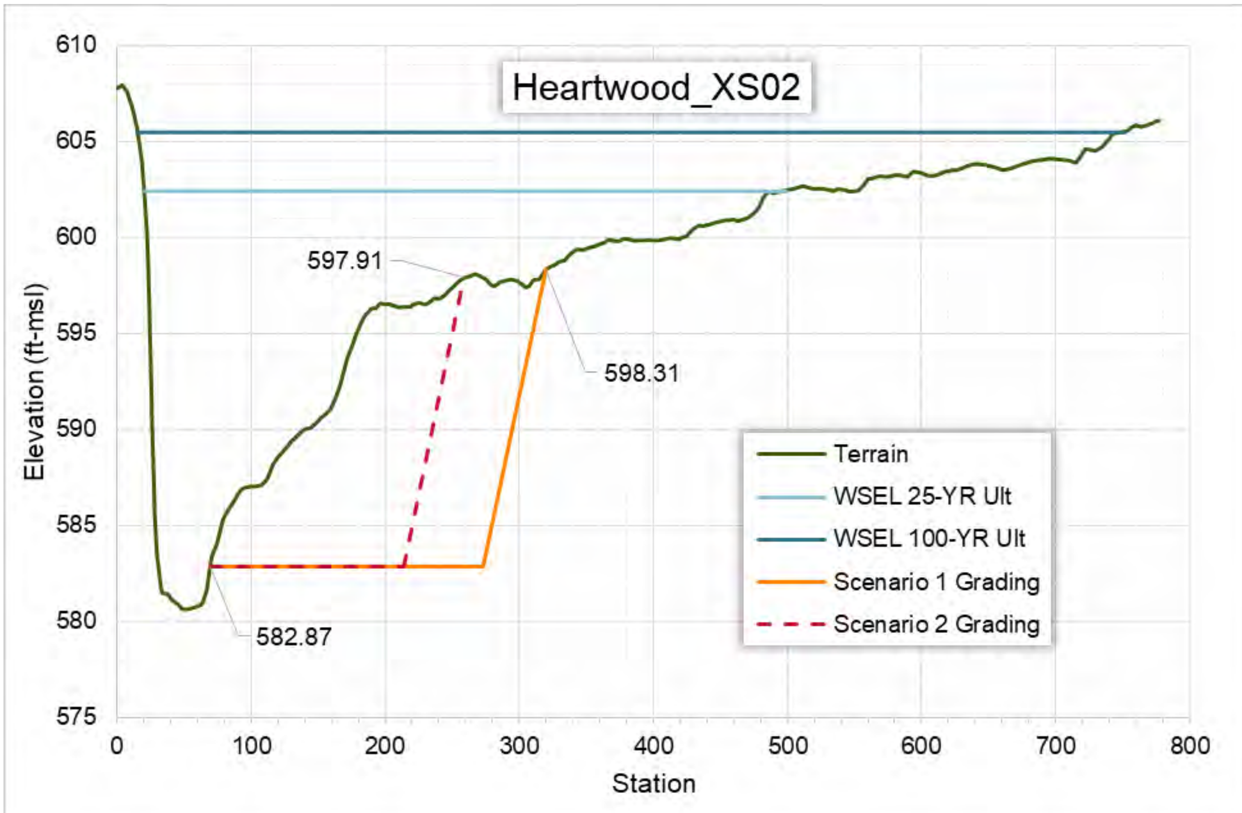

Figure 5-36. Alternative G – Heartwood_XS02 Proposed Grading

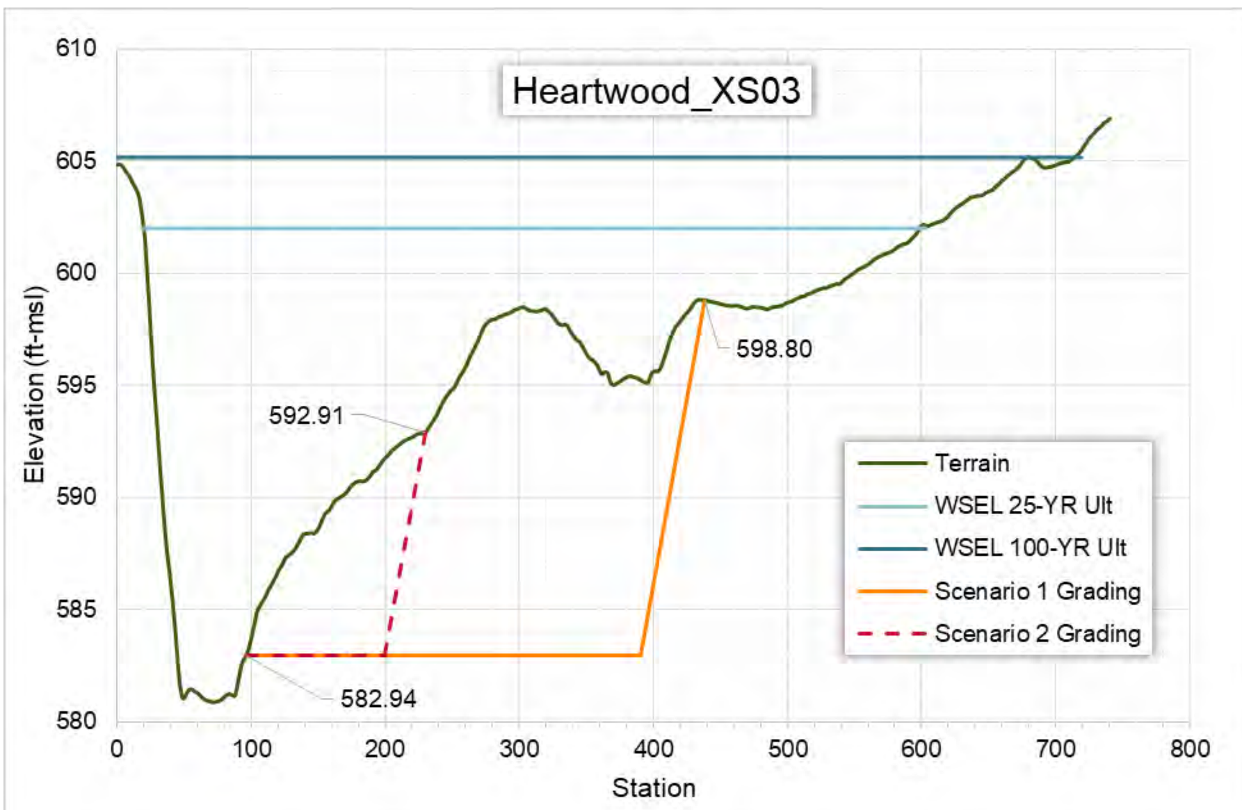

Figure 5-37. Alternative G – Heartwood_XS03 Proposed Grading

Table 5-41 below compares the pre-project and post-project water surface elevation for Scenario 2. Scenario 2 will remove approximately 45% to 100% of the structures out of the ultimate condition 25-year floodplain and 65% to 93% out of the ultimate condition 100-year floodplain.

Table 5-41. Alternative G – Heartwood: Pre-Project versus Post Project Results

Heart-wood XS ID	Channel Bottom Elev.	WSEL 25yrUlt				WSEL 100yrUlt			
		Pre[a]	Post[b]	+/-[c]	%[d,e]	Pre[a]	Post[b]	+/-[c]	%[d,f]
01	580.96	602.95	594.57	-8.38	100%	605.81	599.21	-6.60	93%
02	580.63	602.42	595.23	-7.19	100%	605.48	601.56	-3.93	83%
03	580.87	602.00	600.40	-1.60	45%	605.16	603.61	-1.55	65%

[a] Pre-Project Conditions
[b] Post-Project Conditions
[c] Change from pre-project to post-project
[d] Percent of structural inundations removed.
[e] Total of 11 habitable structures were inundated under pre-project ultimate condition 25-yr storm event.
[f] Total of 54 habitable structures were inundated under pre-project ultimate condition 100-yr storm event.

5.8.2 Environmental Constraints and Permitting Efforts

DCM Compliance

Due to the level of detail this Alternative was scoped to be evaluated, adverse impacts to habitable structures is unknown.

Stream Stability

Alternative G channel modifications have the potential to affect stream stability. The proposed flood benches are similar in nature to those evaluated in the 2007 HDR Field Reconnaissance for Stability Assessment report and, therefore, the conclusions of this report are assumed to still be applicable. Heartwood, Radam, and Other reaches were reported as appearing stable, with the reaches able to transport any sediment that enters. Rock was prevalent along the bed and bank of these reaches and may pose as a challenge during excavation, but also during the revegetation of the bank. The upper two thirds of the Broken Bow reach were evaluated as stable, with some deposition occurring in the lower two thirds. The downstream Broken Bow flood bench may slow velocities and increase this deposition even more. For the West Gate reach, the backwater from Jones Road prevents larger alluvial material introduced into the channel from the right bank from being transported downstream. Without stabilization of these banks, the proposed flood bench in the West Gate reach may be hard to maintain.

Environmental

Impacts associated with the placement of dredge or fill material in Waters of the U.S. would require a Clean Water Act, Section 404 permit. During the design phase, each reach would need to be delineated to determine the location of the ordinary high water mark (OHWM) and the limits of construction to determine whether a Section 404 permit would be required, and if a general (e.g., nationwide) permit notification or an individual permit application is needed. During the delineation all waters of the U.S. including wetlands would be mapped. If the excavation required for the channel modification (benching) is located above the OHWM and can be conducted in a way that avoids placement of permanent or temporary fill within a Water of the U.S., it is possible no Section 404 permit will be required. However, given the constrained nature of the sites and limited points of ingress and egress for construction access, it will anticipated to be difficult to avoid the need for a Section 404 permit, General Permits (e.g., Nationwide Permits) may be applicable to the project if permanent loss of existing stream is minimized and the other general conditions are met.

The project would not require a Sand and Gravel Permit through the TPWD, however if any seasonal or perennial pools are present, coordination with TPWD for an aquatic resource relocation plan (ARRP) may be required.

The proposed channel excavations would be entirely within the City's suburban CWQZ. Development within the CWQZ must abide by the City Code 25-8-261 and should be revegetated with native species and restored within the limits of construction as prescribed by the City Environmental Criteria Manual. Due to the extent of excavation, it is unlikely that all protected trees can be avoided, and tree mitigation would likely be required. Variances to the City environmental ordinance criteria may be required or an exemption sought due flood risk management benefits.

Several City critical environmental features (CEF) were located near the Broken Bow reach based on a review of the City property profile online mapping database tool. J. Berry Yard Spring is located in a small grotto to the north of Williamson Creek, between XS03 and XS01, Little S. Berry Spring is located approximately 70 feet west of XS03, an unnamed spring is located approximately 180 feet west of XS03. A mapped wetland is located from west of XS03 and extends approximately 500 feet between XS03 and XS01, these CEFs were all identified in the City's CEF dataset. A spring was located within the Heartwood reach. Spring1 was located approximately 280 feet north of Heartwood XS01. Several seeps were also located between Heartwood XS01 and XS03, however seeps are not protected as CEFs. According to City Code 25-8-281, the width of the CEF buffer should be 150 feet from the edge of the CEF.

The Westgate/Indio, Broken Bow, and Other channel excavation areas are located within the Edwards Aquifer Transition Zone. No EAPP would be required for the proposed activities, unless water from the Project Area drains back into or is temporarily impounded during construction over the recharge zone, which is located approximately 200 feet north of the Westgate/Indio channel modification areas XS01 and XS02. Drainage patterns and project limits should be confirmed during design to ensure an EAPP is not required.

The TXNDD is maintained by the TPWD and contains information on the documented occurrences of threatened, endangered and SGCN in the state of Texas. SGCN are those species which do not have legal protections due to the risk of extinction but are those that are declining or rare and in need of attention to recover, or to prevent the need to list under state or federal regulation. Four SGCN have been documented within the project area for this alternative, Heller's marbleseed (*Onosmodium helleri*), Texas fescue (*Festuca versuta*), arrowleaf milkvine (*Matelea sagittifolia*), and the plateau spot-tailed earless lizard (*Holbrookia lacerata*). However, these species have not been observed in the project vicinity since 1943, 1917, 1984, and 1953, respectively. No documented occurrences of any state or federally listed threatened or endangered species were reported in the vicinity of the proposed channel excavations. A resource list from the USFWS's IPaC and the Travis County Endangered Species List from TPWD were reviewed. While no field visit or species-specific surveys were completed, no impacts to state or federally listed threatened or endangered species would be expected due to the lack of required habitat within the project area.

Cultural Resources

A cultural resources memo was completed for the project on December 3, 2020 which detailed the geologic background, soils, and previously recorded cultural resources within 1 mile of each alternative.

Presented here are the database results and recommendations for Alternative G. The Atlas review indicated that there have been nine previous cultural resources surveys conducted within 1 mile (mi; 1.6 kilometers [km]) of Alternative G (Appendix G). None of the previous surveys overlap Alternative G. In addition, the review revealed that seventeen archaeological sites, two Official Texas Historical Markers (OTHMs), and three cemeteries have been recorded within the 1-mile search radius (see Appendix G). None of the cultural resources overlap or come in close proximity to Alternative G (See Appendix G. Cultural Resources Memo).

Recommendations

The Atlas search revealed there are various cultural resources recorded within one mile of Alternative G and that the alternative has not been previously surveyed. Although Alternative G is located along Williamson Creek which is a high probability setting for cultural resources, the banks of Williamson Creek have been extensively disturbed by residential construction. Due to this previous disturbance and past flooding of the creek, it is highly unlikely that any cultural resources remain intact within the project area.

As discussed in the Cultural Resources Memo, this project would be required to be in compliance with Chapter 191 of the Texas Natural Resources Code (Antiquities Code of Texas) and its accompanying Rules of Practice and Procedure (13 TAC 26). For projects larger than 5 acres or those that disturb more than 5,000 cubic yards of soil, compliance requires either a cultural resources survey of the project Area of Potential Effects or a determination from the Texas Historical Commission that the proposed project will have No Effect on historic properties as defined in Section 106 of the National Historic Preservation Act of 1966, as amended.

5.8.3 Land and Easement Acquisition

There are approximately 6.4 acres across 19 different properties of permanent drainage easement required for construction of the flood benches for an estimated $11.2M. Adverse impacts for this alternative are unknown due to the level of detail this alternative was scoped for. These proposed drainage easements exclude the existing easements, right of way, or city owned property. See Appendix H for detailed exhibits and tables of the proposed drainage easements.

5.8.4 Potential Major Utility Impacts

Utility impacts are anticipated in the Westgate and Radam reaches. Table 5-42 summarizes the anticipated linear feet of relocation for Alternative G. See Appendix I for a plan view exhibit.

Table 5-42. Alternative G – Summary of Anticipated Linear Feet of Utility Relocation

Problem Area	Water (<24")	Water (≥24")	Waste Water (<24")	Waste Water (≥24")
West Gate	-	140	-	-
Radam	-	-	760	1,070

5.8.5 Time of Implementation

The anticipated time of implementation, once funding is available, is four to five years assuming two to three years for design and permitting, and two years for construction.

5.8.6 Social/Community Impacts and Public Inputs

Approximately 48% of survey respondents considered creek modifications to be an acceptable project, however 54% and 41% of respondents said that preserving the natural appearance of the creek and avoiding impacts to wildlife, respectively, were one of their three most important considerations when choosing options to reduce flooding. Additionally, 39% said that it was not acceptable to remove large trees or alter the current, natural look and feel of the creek.

5.8.7 Percent of Structures at Risk of Interior Flooding (100-year storm) with Risk Removed

In order to be conservative since this alternative was not dynamically modeled, the cross-section from each problem area with the least effectiveness was used to determine the number of structures removed from the floodplain. Table 5-43 summarizes the number of structures removed by problem area for the 25-year and 100-year ultimate conditions. For the 100-year ultimate conditions event, the proposed alternative removes 62 structures from the floodplain, a 16% reduction.

Table 5-43. Alternative G – Structures Removed from Risk of Interior Flooding

Problem Area	Controlling XS	25-yr Ult		100-yr Ult	
		Number of Structures Removed	Percent Removal (%)	Number of Structures Removed	Percent Removal (%)
West Gate	01/02[a]	10	30	1	2
Broken Bow	03	10	13	2	2
Other	01	22	100	10	12
Radam	01	21	51	14	13
Heartwood	03	5	45	35	54
Total		**68**	**37**	**62**	**16**

[a] 01 is the controlling cross-section for the 100-yr Ult, 02 is the controlling cross-section for the 25-yr Ult.

5.8.8 Cost Effectiveness of Flood Risk Reduction

Like the estimation of the number of structures removed, the reduction in depth was estimated from the controlling cross-section change in water surface elevation detailed in Section 5.8.1. To prevent an over-estimation of reduction in depth, the assumed average reduction in depth per cross-section was equal to the change in water surface elevation of the controlling cross-section or the average depth of inundation of the structures in the area, whichever was lower. The opinion of probable cost for this project is estimated to be $69.6M and is detailed in Appendix J. Cost effectiveness for the 25-year and 100-year ultimate conditions events are summarized in Table 5-44.

Table 5-44. Alternative G – Cost Effectiveness Summary

Storm Event	Total Change in Inundation Depth for All Structures (ft)	Cost Effectiveness ($/ft)
25-Year Ultimate	-145.8	$478,000
100-Year Ultimate	-411.4	$169,000

5.8.9 Anticipated O&M

The channel modifications proposed would be designed with anticipation that dense vegetation would eventually grow along the flood bench and modified slopes, and necessary O&M costs would be minimized.

5.8.10 Summary

Alternative G – Channel Modifications proposes flood benching at select locations to benefit problem areas within the project area. Scenario 1 propose a maximum extent to encompass all of the floodwaters for the 25-year and 100-year ultimate conditions. Scenario 2 proposes a more realistic extent for modification for the channel considering City owned property and existing easements. Scenario 2 results were used to evaluate this alternative relative to the other alternatives. This alternative was evaluated using select cross-sections in a 1D steady-state analysis, and, therefore, the level of detail of the results in comparison to the other alternatives is substantially less.

Long term, moderate environmental impact with permits among multiple jurisdictions and a more challenging local site plan permitting and Nationwide Permit are likely required.

Eight acres of permanent easement acquisition is anticipated for an estimated $8.6M. There are approximately 140 linear feet and 1,830 linear feet of water and wastewater utility line relocations, respectively.

This alternative has moderate social and community impacts and received a 48% approval rating from the 2022 community survey respondents.

The project is anticipated to take four to five years to implement at a total construction cost of $69.6M with minimal O&M.

The alternative removes 16% of structural inundations for the 100-year ultimate conditions and has a cost effectiveness of $478k and $169k per foot of inundation reduction for the 25-year and 100-year ultimate conditions events, respectively.

5.9 Alternative H – Stassney Bypass

5.9.1 Alternative Description

In Alternative H, HDR explored potential flood bypass alternatives for the project area. Two smaller 10’x10’ box culvert diversions were initially modeled. The Jones Road bypass and 1st St Bypass, shown in Figure 5-38, intended to reduce inundations for the Broken Bow and Heartwood areas. The Jones Road Bypass provided little benefit to structures in Broken Bow, caused adverse impacts downstream, and there is no substantial open space for the outlet structure. The 1st St Bypass did provided benefit to the Heartwood area and minimal, if any, adverse impacts downstream.

Figure 5-38. Alternative H – Other Potential Bypass Alignments

Investigations concluded that a bypass that outfalls downstream of South Congress Ave, just downstream of the Tributary 4 confluence incur little, if any, adverse impacts to habitable structures without additional mitigation measures. This was not the case for outfalls between Menchaca Road and South Congress Avenue. There are a multitude of options for intakes into the diversion, including upstream of West Gate Boulevard in Bayton Loop, Jones Road, Menchaca Road, Union Pacific Railroad Crossing, Emerald Forest Drive, and S 1st Street. For the purposes of this study, the bypass inlet pond was modeled at Bayton Loop, in which the City owns approximately 8 acres of land acquired through voluntary buyouts. This inlet location would also provide benefits for the entire project area.

To provide a structural alternative with a similar level of service as Alternative C – Voluntary Buyouts, Alternative H proposes a 26’ equivalent diameter bypass. The bypass inlet pond receives inflows from Williamson Creek at Bayton Loop and extends approximately 12,700 feet (2.4 miles) east generally along Stassney Lane before the outlet structure in a small tributary of Williamson Creek just downstream of South Congress Avenue (Figure 5-39 and Figure 5-40). With a slope of

0.5%, the maximum diversion capacity of the bypass is approximately 15,000 cfs. The intake into the system is modeled as a 150’ broad crested weir at elevation 652 ft-msl, approximately 7 feet above the invert of Williamson Creek. The 2-year ultimate conditions water surface elevation in this location is 659.5 ft-msl. The inlet weir length and elevation could be modified to meet flood, water quality, and sediment objectives. In this hydraulic modeling exercise, the inlet is not expected to be continuously submerged. The outfall structure is a weir set at elevation 596 ft-msl, approximately 2 feet above the 100-yr Ultimate Conditions water surface elevation at that location. Proposed profiles near the inlet and outlet structures are shown in Figure 5-41 and Figure 5-42, respectively. Actual invert elevations of the bypass could change dependent on the geologic investigations in the area but should maintain the hydraulic capacity with the specified slope and inlet/outlet structures able to accommodate the flows.

Figure 5-39. Alternative H – Stassney Bypass Plan View

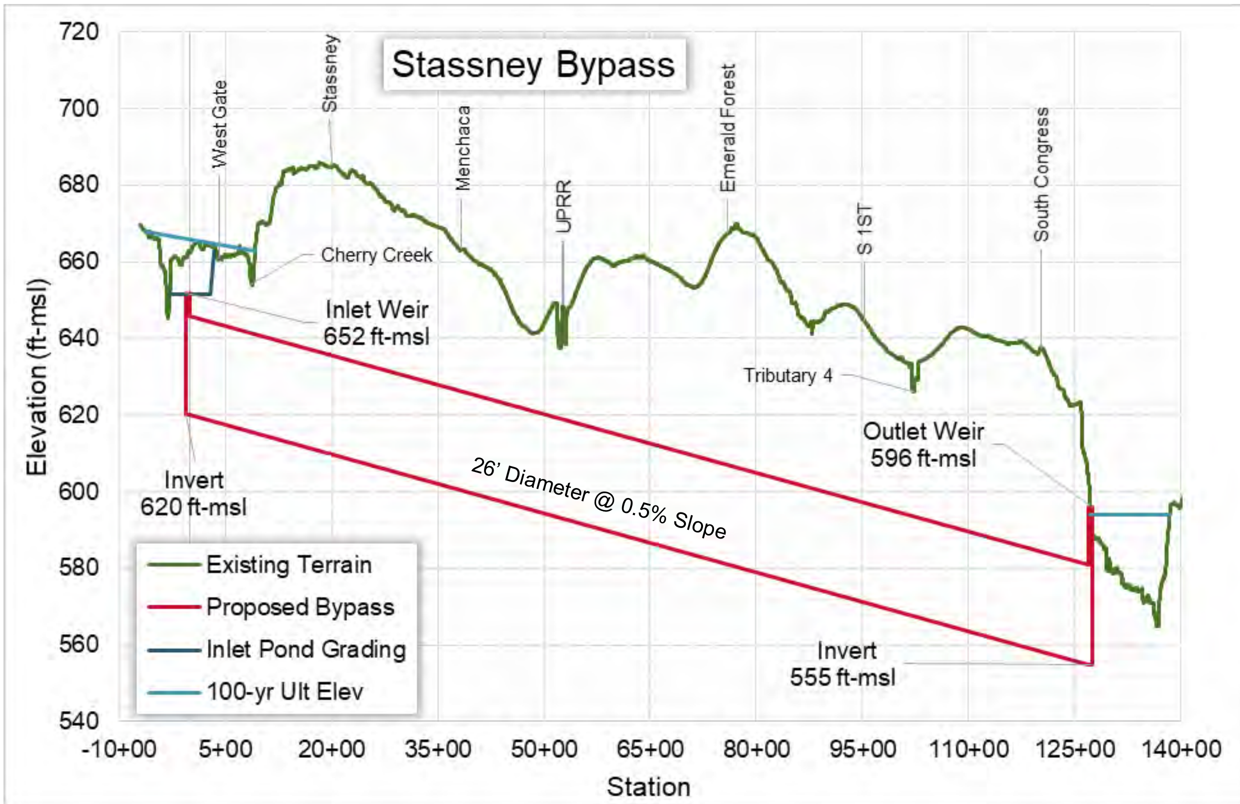

Figure 5-40. Alternative H – Stassney Bypass Profile View

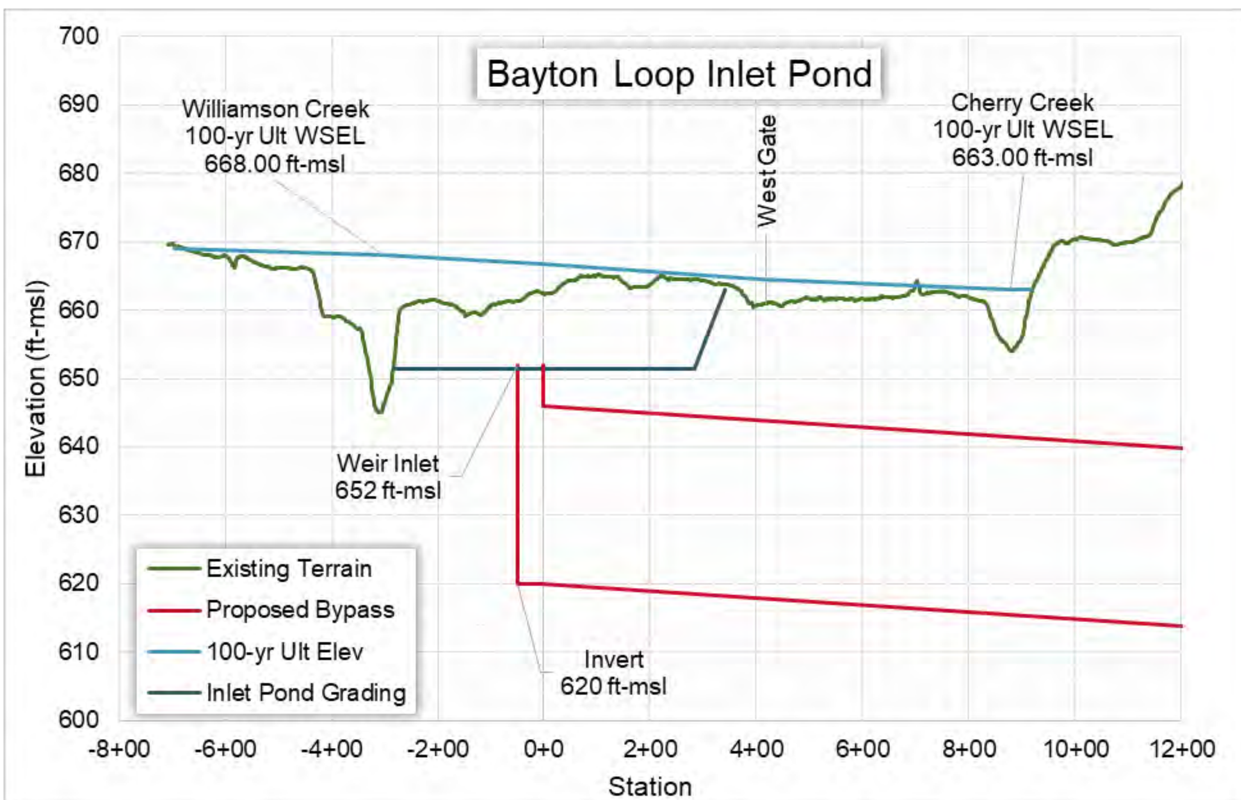

Figure 5-41. Alternative H – Bayton Loop Inlet Pond Profile

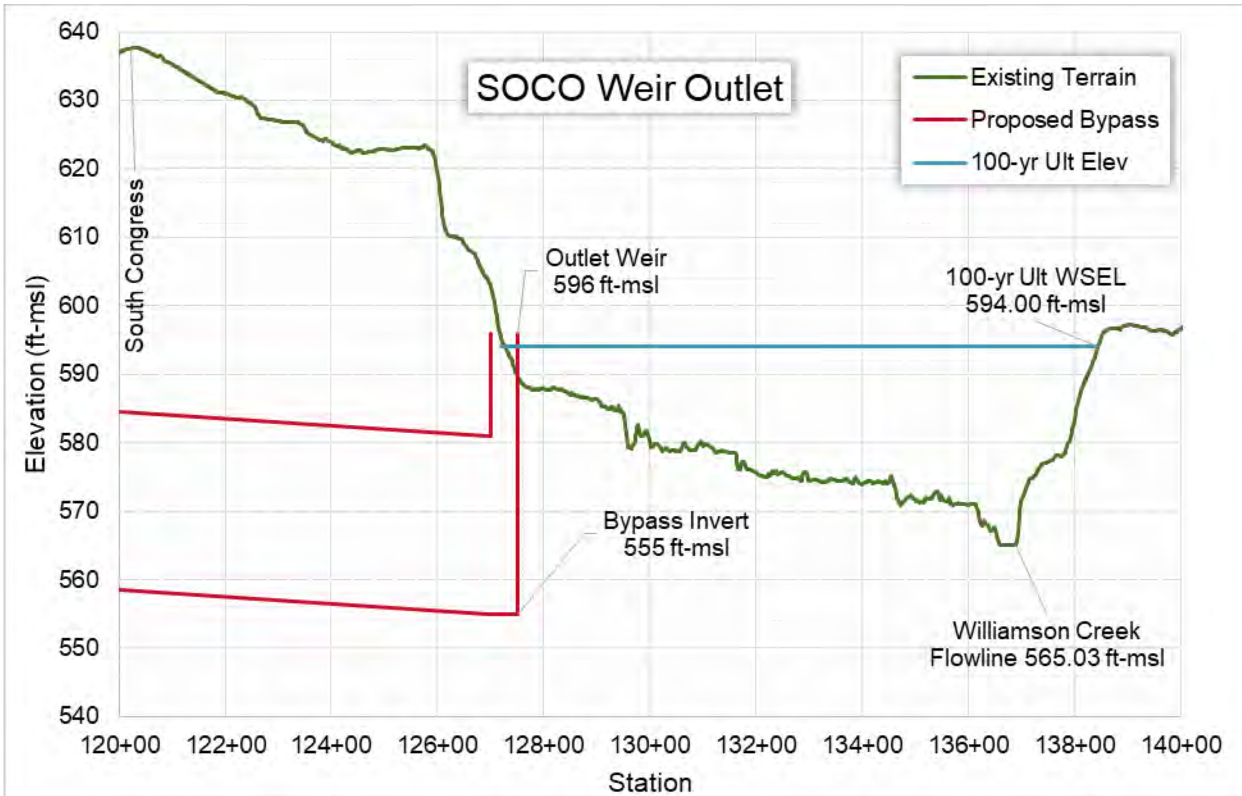

Figure 5-42. Alternative H – SOCO Weir Outlet

Conceptually, this alternative would provide flood control via a 26-foot diameter concrete lined bypass, extending approximately 12,700 feet along Stassney Lane. The depth of the bypass invert would generally range from 50 to 80 feet below ground, depending on surface elevation. The subsurface materials would be excavated using an open-face tunnel boring machine (TBM) with automated or semi-automated muck removal. Excavation operations would likely start in an initial or launch workshaft near the South Congress Outlet Weir and extend a relatively short distance to an intermediate workshaft near South Congress Avenue. At that point, the TBM would be redirected westward along Stassney Lane until veering off towards the Bayton Loop Inlet Pond. The alignment would stay within the Stassney Lane right-of-way to the extent practical, which may necessitate intermediate workshafts to keep the TBM on the planned alignment. The current alignment has four shifts in direction, and, therefore, the potential of four intermediate workshafts. Excavating from east-to-west in an upgradient fashion would facilitate dewatering during excavation operations.

Based on the Austin Sheet of the Geological Atlas of Texas, shown in Figure 5-43, excavation operations would encounter several geological formations, including Austin Chalk, Eagle Ford Group and Buda Limestone, and the Del Rio Clay and Georgetown Formation. The Edwards Limestone of the Fredericksburg Group, a known karst material, may lie immediately underneath the Del Rio Clay and Georgetown Formation near the western terminus of the tunnel alignment. However, based on the proposed vertical alignment of the bypass, the Del Rio Clay and Georgetown Formation may be of sufficient thickness to keep the tunnel zone above the Fredericksburg Group and any associated karst materials.

A geologic investigation would be required along the alignment to define the actual composition and spatial characteristics of the various formations. However, from a concept point of view, marl, claystone, chalk, and limestone should be expected along the alignment. These expected materials are typical of the Austin area and generally compatible with standard TBMs. Karst limestone, if encountered, can be a more difficult rock to tunnel and possibly present some additional dewatering and environmental challenges (e.g. Edwards Aquifer).

The proposed bypass would intersect the Balcones Fault Zone (BFZ) along the western half of the alignment. The BFZ is an inactive set of faults that generally extend northeast-southwest through Austin. The fault lines often give rise to an abrupt formational change associated with the former upward/downward block movement in the earth's crust. Though inactive, the abrupt material change could pose a slight-to-moderate risk for the contractor if the fault(s) are not characterized or identified during the geologic investigation. A secondary risk associated with the fault zone is the potential encounter of a thick zone of gouge material (soil and rock debris) within the actual fracture/shear zone of the fault. Generally, TBM selection in combination with construction design and experience can mitigate nearly all difficult geologic conditions, especially if prior knowledge exists.

Preliminarily, the anticipated subsurface conditions along the alignment are judged to be compatible for the proposed bypass. In addition, there are multiple examples of successful bypass projects in the Austin area that encountered the same or similar subsurface conditions as those anticipated along the proposed alignment.

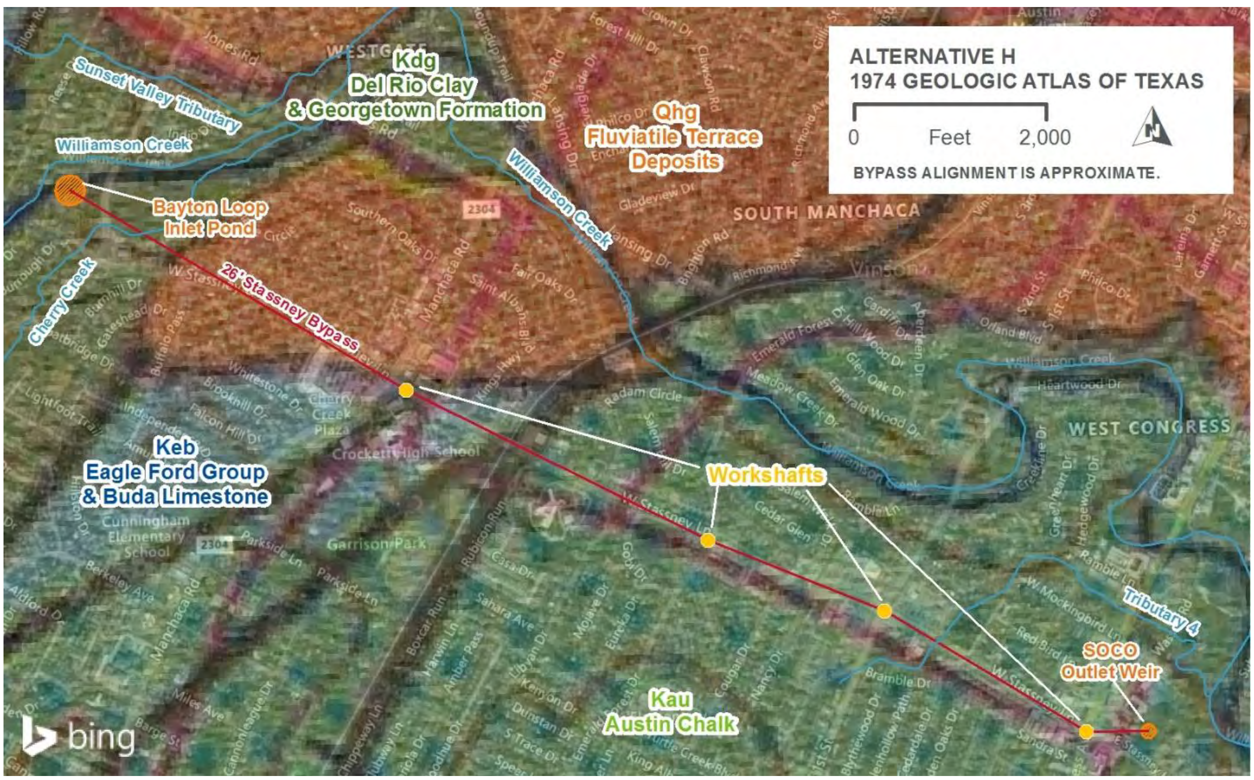

Figure 5-43. 1974 Geologic Atlas of Texas

Structural inundation results from Alternative H for the 25-year and 100-year ultimate conditions are summarized in Table 5-45 and shown in Figure 5-44 and Figure 5-45, respectively. There is an increase in water surface elevation near the outlet weir, but these dissipate quickly down to less than an inch. The increase in water surface elevation appear to only impact property, not habitable structures, but this is unconfirmed as the finished floor elevations in this area are unknown. Additionally, the downstream boundary of the model is in close proximity and may be artificially affecting the water surface elevations in the area. If this alternative is moved forward in Phase 2, adverse impacts to habitable structures should be fully investigated. Further refinement of the bypass design may be able to minimize these adverse impacts.

Table 5-45. Alternative H impact to structure inundation depth

Impact to Structure Inundation Depth	25-Year Ultimate Conditions		100-Year Ultimate Conditions	
	Number of Structures	Avg Change in Depth (ft)	Number of Structures	Avg Change in Depth (ft)
Added	0	-	0	-
Increased	0	-	0	-
No Change	0	-	0	-
Decreased	23	-1.46	92	-3.53
Removed	160	-1.69	304	-2.02

Figure 5-44. Alternative H vs Ultimate Conditions – 25yr: Change to Structural Inundation

Figure 5-45. Alternative H vs Ultimate Conditions – 100yr: Change to Structural Inundation

5.9.2 Environmental Constraints and Permitting Efforts

DCM Compliance

There are adverse impacts to properties, but none appear to impact existing structures which is necessary in order to meet DCM compliance. If in fact the bypass does adversely impact existing structures, it is extremely unlikely that the project would be granted a variance and allowed to proceed.

Stream Stability

Construction of the bypass could be considered a long-term investment in the stability of the creek. While most of the sediment transportation occurs during more frequent events, a reduction in flow may limit the less frequent but more drastic transformations that occur with larger storm events. As the bypass is not intended to be submerged, frequent lower flows that facilitate aggradation and degradation will still occur in Williamson Creek.

Environmental

Alternative H would include the installation of a large underground bypass to handle flood flow for approximately 2.4 miles along Stassney Lane. Construction impacts would include potential roadway detours and/or traffic pattern changes, utility relocation, and increased noise. These impacts would be temporary but have the potential to be disruptive to the local community.

Impacts due to placement of dredge or fill material in Waters of the U.S. would require a Clean Water Act, Section 404 permit. During the design phase, Williamson and Cherry Creeks should be delineated near the inlet and outfall points to determine the location of the OHWM. Nationwide Permit (NWP) 7 for Outfall Structures and Associated Intake Structures, or NWP 43 for Stormwater Management Facilities may be used to authorize construction of these alternatives. Both of these NWPs require submission of a pre-construction notification to the U.S. Army Corps of Engineers – Regulatory Division.

The proposed bypass would cross portions of the City's suburban CWQZ, primarily at the intake and outfall locations. Development within the CWQZ must abide by the City Code 25-8-261 and should be revegetated and restored within the limits of construction as prescribed by the City Environmental Criteria Manual. It is unlikely that all protected trees can be avoided and tree mitigation would likely be required. Variances to the City environmental ordinance criteria may be required or an exemption sought due flood risk management benefits.

The western portion of the Stassney Bypass is within the Edwards Aquifer Transition Zone. No EAPP would be required for construction activities located within the transition zone unless water from the project area would drain back into the recharge zone (the proposed inlet pond would be located approximately 185 feet southeast of the recharge zone).

The TXNDD is maintained by the TPWD and contains information on the documented occurrences of threatened, endangered and SGCN in the state of Texas. SGCN are those species which do not have legal protections due to the risk of extinction but are those that are declining or rare and in need of attention to recover or to prevent the need to list under state or federal regulation. Two SGCN have been documented within the vicinity of Alternative H, Heller's marbleseed (*Onosmodium helleri*) and the plateau spot-tailed earless lizard (*Holbrookia lacerata*). However, these species have not been observed in the area since 1943 and 1953, respectively. No documented occurrences of any state or federally listed threatened or endangered species were reported in the vicinity of the proposed bypass. A resource list from the USFWS's IPaC and the Travis County Endangered Species List from TPWD were reviewed. While no field visit or species-specific surveys were completed, no impacts to state or federally listed threatened or endangered species would be expected due to the lack of required habitat within the project area.

The project would not require a Sand and Gravel Permit through the TPWD, however if any seasonal or perennial pools are present, coordination with TPWD for an aquatic resource relocation plan (ARRP) may be required.

Cultural Resources

A cultural resources memo was completed for the project on December 3, 2020, which detailed the geologic background, soils, and previously recorded cultural resources within 1 mile of each alternative.

Presented here are the database results and recommendations for Alternative H. The Atlas review indicated that there have been twelve previous cultural resources surveys conducted within 1 mile (mi; 1.6 kilometers [km]) of Alternative H (Appendix G). One of the previous cultural resource surveys (ID 8400009881) overlaps Alternative H (see Figure 8 in Appendix G. Cultural Resources Memo). In addition, the review revealed that seventeen archaeological sites, two OTHMs, and four cemeteries have been recorded within the 1-mile search radius (see Appendix G. Cultural Resources Memo). None of the cultural resources overlap or come in close proximity to Alternative H.

Recommendations

The Atlas search revealed that there are various cultural resources recorded within one mile of Alternative H and that very little of the alternative has been previously surveyed. Alternative H is located along existing roadways which have been heavily disturbed by past infrastructure and residential construction. Therefore, it is highly unlikely that any cultural resources remain intact within the project area.

As discussed in the Cultural Resources Memo, this project would be required to be in compliance with Chapter 191 of the Texas Natural Resources Code (Antiquities Code of Texas) and its accompanying Rules of Practice and Procedure (13 TAC 26). For projects larger than 5 acres or those that disturb more than 5,000 cubic yards of soil, compliance requires either a cultural resources survey of the project Area of Potential Effects or a determination from the Texas Historical Commission that the proposed project will have No Effect on historic properties as defined in Section 106 of the National Historic Preservation Act of 1966, as amended.

5.9.3 Land and Easement Acquisition

The proposed inlet facility location is within city owned property. The outlet facility location proposed would require the acquisition of approximately 1.25 acres of land for an estimated $5.4M. This alternative also requires two acres across 34 different properties of permanent drainage easement for construction of the bypass for an estimated $4.8M. There are some adverse impacts for this alternative and an additional 9.5 acres across 46 properties of permanent drainage easement is required due to increases in the proposed 100-yr water surface elevations within the project area for an estimated cost of $19.6M. Total anticipated costs for acquisitions and drainage easements for this alternative is $29.7M. Due to the lower level of detail for costing for this alternative, a 50%

contingency is included in these values. These proposed drainage easements exclude the existing easements, right of way, or city owned property. See Appendix H for detailed exhibits and tables of the proposed drainage easements.

5.9.4 Potential Major Utility Impacts

Due to the depth necessary for the bypass, there are minimal anticipated water or wastewater utility impacts. There are roughly 3,000 linear feet of decommissioned water and wastewater lines in Bayton Loop which would need to be removed for the inlet facility and pond. See Appendix I for exhibits of surrounding water/wastewater utilities.

5.9.5 Time of Implementation

Based on a similar project along Waller Creek, the time of implementation for this project, once funding is available, is anticipated to be 7 to 10 years.

5.9.6 Social/Community Impacts and Public Inputs

Approximately 64% of respondents considered this alternative as an acceptable alternative for reducing flooding. There were concerns regarding an increase in taxes and tunnel maintenance. Residents near the inlet (Cherry Creek Neighborhood) and outlet (East Congress Neighborhood), would be most affected by the construction of the Stassney Bypass and don't receive any flood reduction benefits. It was indiscernible if these residents responded to the survey.

5.9.7 Percent of Structures at Risk of Interior Flooding (100-year storm) with Risk Removed

As shown in Figure 5-45, for the 100-year ultimate conditions event, the proposed alternative removes 304 structures from the floodplain, a 77% reduction. Because of the location of the inlet, this project also benefits structures in Sunset Valley that are not included in the FFE structural count of this project.

If the size of the bypass was reduced from 26' diameter to 16' diameter (4,100 cfs capacity), the proposed alternative would remove approximately 67 structures from the floodplain, a 17% reduction.

5.9.8 Cost Effectiveness of Flood Risk Reduction

Using a similar project along Waller Creek and adjusting per linear foot, the opinion of probable cost for this project, with a 50% contingency, is estimated to be $234.2M. See Appendix J for more information. If this project were to move forward a more detailed cost estimated should be completed. Cost effectiveness for the 25-year and 100-year ultimate conditions events are summarized in Table 5-46.

Table 5-46. Alternative H – Cost Effectiveness Summary

Storm Event	Total Change in Inundation Depth for All Structures (ft)	Cost Effectiveness ($/ft)
25-Year Ultimate	-304.1	$770,000
100-Year Ultimate	-940.5	$249,000

If the size of the bypass was reduced from 26' diameter to 16' diameter (4,100 cfs capacity) and adjusting the cost of the bypass for that reduction in diameter, the opinion of probable construction cost lowers to $174.9M. However, the cost-effectiveness increases to $862k and $536k per foot for the 25-year and 100-year ultimate conditions, respectively.

5.9.9 Anticipated O&M

Of all of the proposed alternatives, the Stassney Bypass is anticipated to have the highest O&M cost due to the need to dewater the bypass in order to perform maintenance which can cost in the millions of dollars. Management of storm debris will be one of the major issues in the bypass design/planning. A design that would allow debris pass through with only screening for debris large enough to plug the bypass (i.e. capture large trees, cars, etc.) would decrease the anticipated O&M.

5.9.10 Summary

Alternative H – Stassney Bypass, proposes a 26' equivalent diameter underground flood bypass for Williamson Creek. The intake is along Williamson Creek upstream of West Gate Blvd, in Bayton Loop. The outfall is downstream of the Tributary 4 confluence and South Congress Avenue in an unnamed tributary. The total length of the bypass is roughly 2.4 miles with a 0.5% slope and maximum diversion capacity of 15,000 cfs. There are some adverse impacts near the outlet weir, but these only appear to impact property, not habitable structures.

If this alternative is selected to move forward, other intake locations and bypass sizing should be considered to provide optimal flood reduction benefits.

The Stassney Bypass is expected to have short term environmental impacts during construction with environmental surveys required and local site plan permitting, or variances required. A Nationwide permit is also likely required.

This alternative requires 1.25 acres of land acquisition for the outfall location with 11.5 acres of permanent drainage easement. It also requires the removal of 3,000 linear feet of decommissioned water/wastewater lines and, therefore, has minimal anticipated utility impacts.

This alternative has minimal social and community impacts and received a 64% approval rating from the 2022 community survey respondents.

The project is anticipated to take seven to ten years to implement at a total construction cost of $234.2M and significant O&M costs. The alternative removes 77% of structural inundations and has a cost effectiveness of $770k and $249k per foot of inundation reduction for the 25-year and 100-year ultimate conditions events, respectively.

5.10 Alternative I – Combination

5.10.1 Alternative Description

Alternative I combines pieces of several different alternatives including channel modifications, flood walls, and voluntary buyouts. Channel modifications implemented into this alternative are generally based on recommendations in Scenario 2 of Alternative G – Channel Modifications. These channel modifications are a flood bench that begins roughly two feet above the flowline and has varying widths depending on constraints like natural grade, parcels, and crossings. Some of these channel modifications require the acquisition of several homes that are inundated in both the 25-yr and 100-yr ultimate conditions events. The length (relative to the channel flowline) and typical width of each segment (including the sloped bank) is summarized in Table 5-47. Refer to Alternative G – Channel Modifications for typical sections. There are ten proposed acquisitions required to construct some of the proposed channel modifications. Of the ten acquisitions, seven are inundated in the 10-year event, and the remaining three are inundated in the 25-year event.

Table 5-47. Alternative I – Summary of Channel Flood Bench Modifications

Area	Length (ft)	Typical Width (ft)
Broken Bow US	700	200
Broken Bow DS	1,500	240
Other	1,300	170
Radam	1,200	150
Heartwood	1,850	240

Flood walls three and four from Alternative B – Flood Walls were integrated into this alternative, plus an additional flood wall (five), made feasible by the channel modifications in the Heartwood area. Flood wall properties are summarized in Table 5-48. Note, that the height of the wall my differ from Alternative B because of the 3-foot freeboard required over the proposed water surface elevation, which differs between alternatives.

Table 5-48. Alternative I – Summary of Flood Wall Properties

Flood Wall	Length (ft)	Maximum Height (ft)	Average Height (ft)
3	1,900	10.0	6.0
4	500	7.9	5.9
5	2,000	13.8	10.4

The final piece of this alternative is voluntary buyouts of single-family homes with a 100-yr ultimate conditions inundation greater than 5 feet which amounted to 41 structures. The 41 voluntary buyouts, in addition to the 10 acquisitions required to construct some of the proposed channel modifications, would bring the total number of property acquisitions to 51. The voluntary buyouts and proposed acquisitions along with conceptual layouts of the channel modifications and flood walls are shown in Figure 5-46. Changes in structural inundation and inundation boundary for the 25-yr and

100-yr ultimate conditions are shown in Figure 5-47 and Figure 5-48, respectively, with a summary in Table 5-49.

A small bypass diversion was considered for this alternative, but the 1st Street diversion that serviced the Heartwood area benefitted structures already being serviced with channel modifications and flood walls. The Jones Road diversion was known to cause adverse impacts and would have likely compounded on top of those already modeled. The channel modification/flood walls in the area are proposed in land that is already owned by the City of Austin as a result of previous buyouts and were therefore a better fit for this alternative than the diversion.

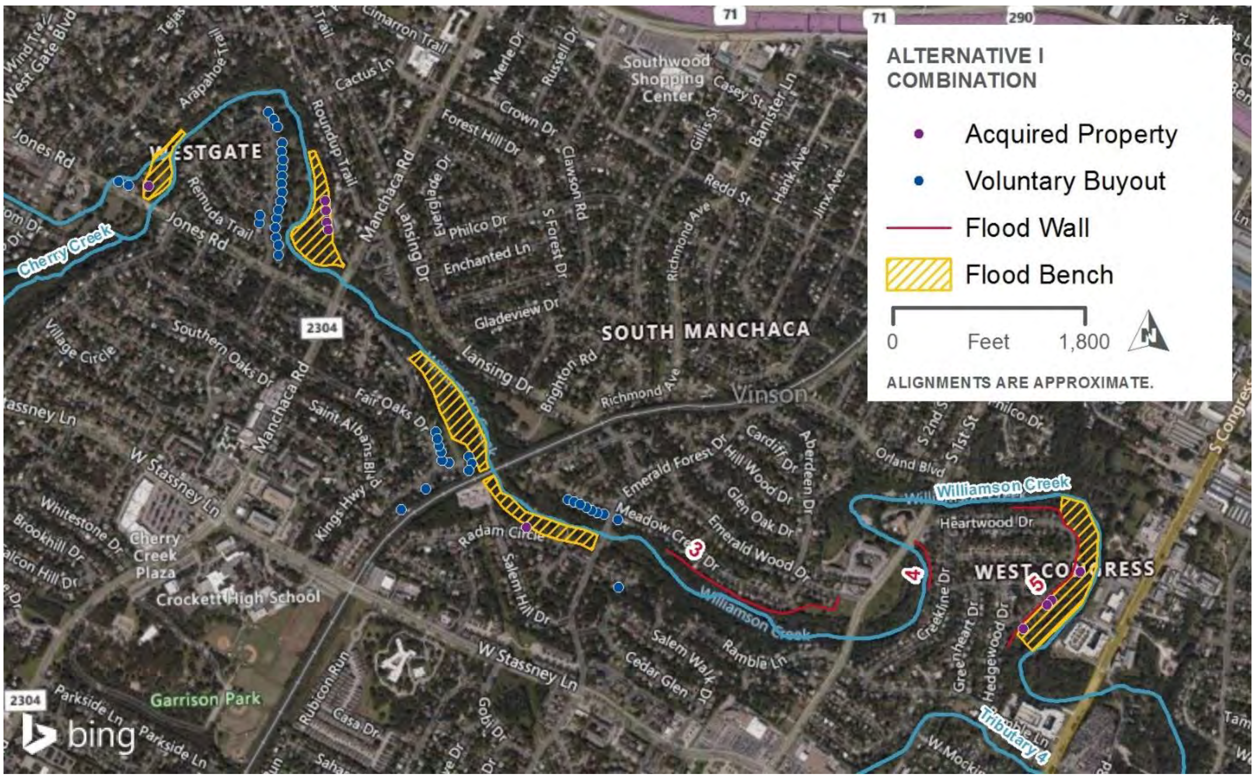

Figure 5-46. Alternative I – Combination Schematic

Table 5-49. Alternative I impact to structure inundation depth

Impact to Structure Inundation Depth	25-Year Ultimate Conditions		100-Year Ultimate Conditions	
	Number of Structures	Avg Change in Depth (ft)	Number of Structures	Avg Change in Depth (ft)
Added	1	0.25	0	-
Increased	22	0.12	35	0.36
No Change	0	-	58	-
Decreased	96	-0.18	169	-0.23
Removed	65	-2.90	134	-3.17

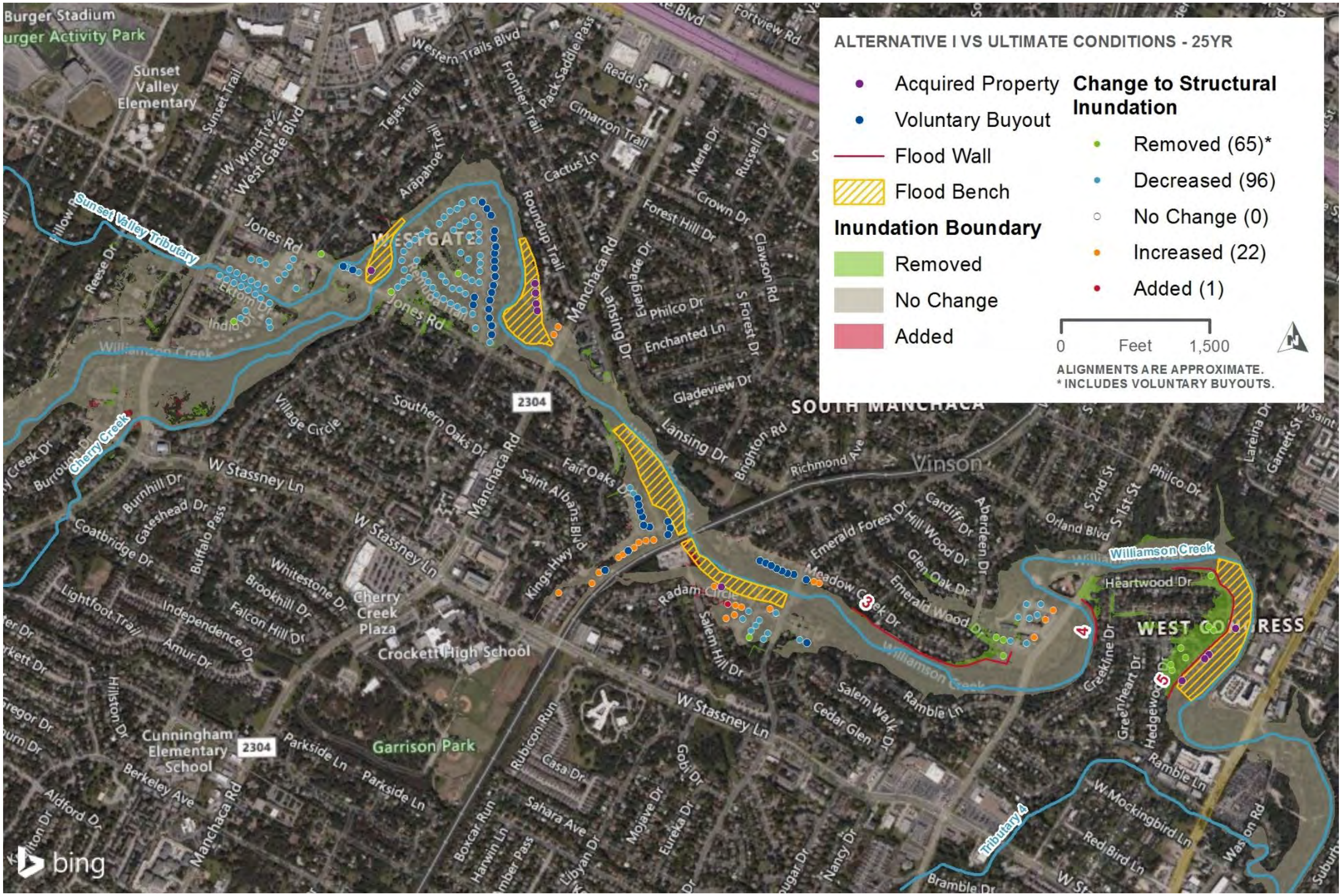

Figure 5-47. Alternative I vs Ultimate Conditions – 25yr: Change to Structural Inundation

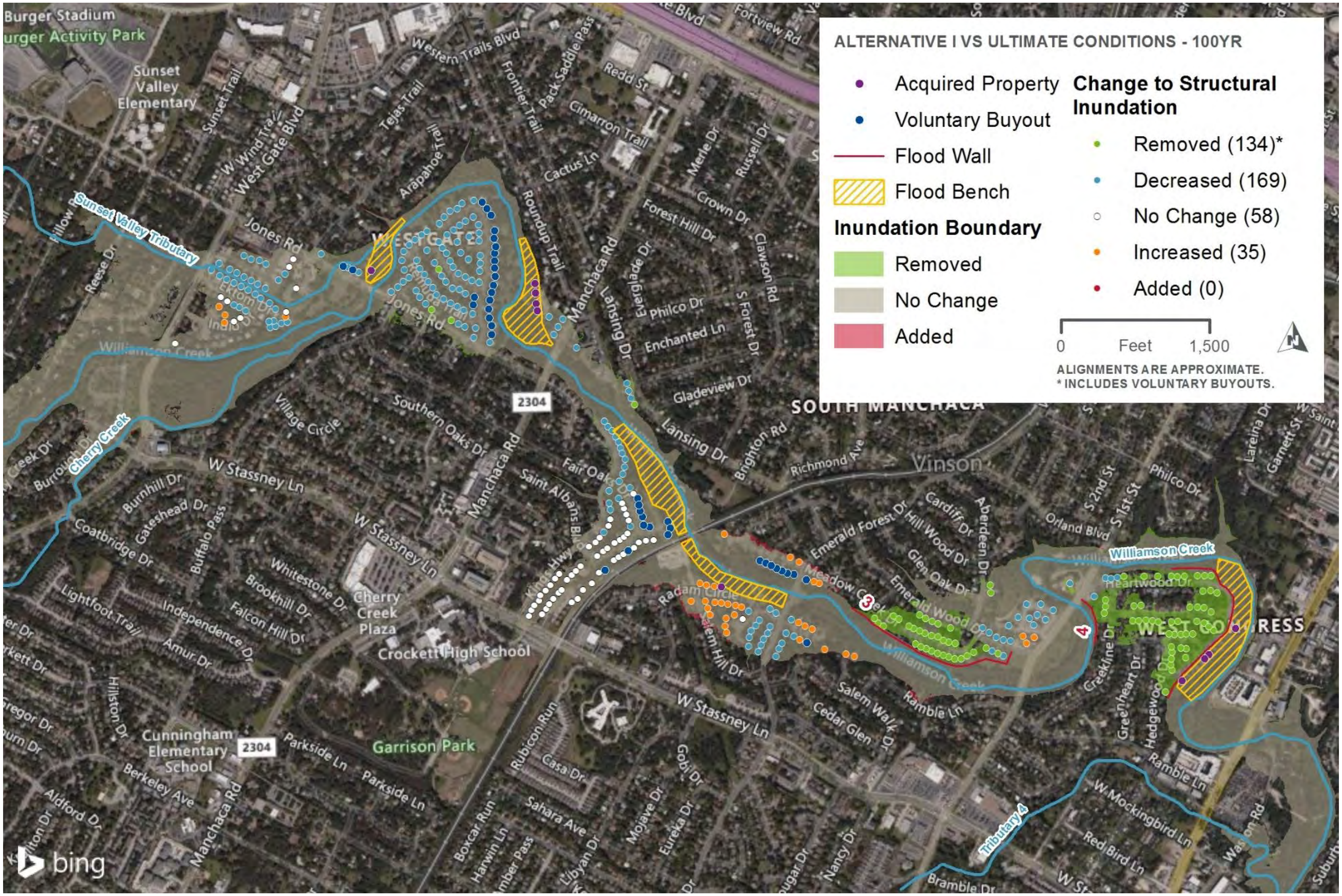

Figure 5-48. Alternative I vs Ultimate Conditions – 100yr: Change to Structural Inundation

5.10.2 Environmental Constraints and Permitting Efforts

DCM Compliance

Due to adverse impacts to existing structures, this alternative fails to meet DCM compliance, and it is extremely unlikely that it would be granted a variance.

Stream Stability

Channel modifications in the Heartwood, Radam, Other, and Broken Bow areas have the potential to affect stream stability. The proposed flood benches are similar in nature to those evaluated in the 2007 HDR Field Reconnaissance for Stability Assessment report and, therefore, the conclusions of this report are assumed to still be applicable. Heartwood, Radam, and Other reaches were reported as appearing stable, with the reaches able to transport any sediment that enters. Rock was prevalent along the bed and bank of these reaches and may pose as a challenge during excavation, but also during the revegetation of the bank. The upper two thirds of the Broken Bow reach were evaluated as stable, with some deposition occurring in the lower two thirds. The downstream Broken Bow flood bench may slow velocities and increase this deposition even more. The proposed flood walls are not anticipated to impact stream stability as they do not affect the higher frequency events which perform the majority of sediment aggradation and degradation.

Environmental

This alternative includes a combination of flood walls, channel excavation (benching), and voluntary buyouts. Impacts due to placement of dredge or fill material in Waters of the U.S. would require a Clean Water Act, Section 404 permit. The western-most area proposed for benching encompasses the Sunset Valley Tributary, the other channel excavations would be along Williamson Creek. During the design phase, the five reaches for benching would need to be delineated to determine the location of the OHWM and the limits of construction to determine whether a Section 404 permit would be required. If the excavation required for benching is located above the OHWM and can be conducted in a way that avoids placement of permanent or temporary fill within a Water of the U.S., it is possible no Section 404 permit will be required. It is anticipated that the proposed flood walls would be located outside of the OHWM of any waters of the U.S. and a Section 404 permit would not be required. However, given the constrained nature of the sites and limited points of ingress and egress for construction access, it would be difficult to avoid the need for a Section 404 permit, General Permits (e.g., Nationwide Permits) may be applicable to the project if permanent loss of existing stream is minimized and the other general conditions are met.

The proposed benching and flood walls would be entirely within the City’s suburban CWQZ. Development within the CWQZ must abide by the City Code 25-8-261 and should be revegetated with native species and restored within the limits of construction as prescribed by the City Environmental Criteria Manual. It is unlikely that all protected trees can be avoided, and tree mitigation would likely be required. Variances to the City environmental ordinance criteria may be required or an exemption sought due flood risk management benefits.

Several City critical environmental features (CEFs) were located near Alternative I. Little S. Berry Spring, and another unnamed spring are both located near the eastern end of western-most channel excavation area. In addition to the spring, a wetland CEF was identified near this channel excavation area. Spring Horizon was located along Williamson Creek approximately 385 feet northwest of the proposed benching west of the railroad tracks (Other reach). A spring and several seeps were located within the Heartwood reach. Spring1 was located within the area of proposed benching and within approximately 300 feet northeast of the northern end of Flood Wall 5. Several seeps were also located within the Heartwood reach area of proposed benching; however, seeps are not protected as CEFs. According to City Code 25-8-281, the width of the CEF buffer should be 150 feet from the edge of the CEF.

The project would not require a Sand and Gravel Permit through the TPWD, however if any seasonal or perennial pools are present, coordination with TPWD for an aquatic resource relocation plan (ARRP) may be required.

The proposed excavation areas located west of the Union Pacific Railroad tracks are within the Edwards Aquifer Transition Zone. No EAPP would be required for the proposed activities, unless water from the Project Area drains back into or is temporarily impounded during construction over the recharge zone, which is located approximately 200 feet west of the proposed project impacts. Drainage patterns and project limits should be confirmed during design to ensure an EAPP is not required.

The TXNDD is maintained by the TPWD and contains information on the documented occurrences of threatened, endangered and SGCN in the state of Texas. SGCN are those species which do not have legal protections due to the risk of extinction but are those that are declining or rare and in need of attention to recover, or to prevent the need to list under state or federal regulation. Three SGCN have been documented within the project area for this alternative, Heller's marbleseed (Onosmodium helleri), Texas fescue (Festuca versuta), and the plateau spot-tailed earless lizard (Holbrookia lacerata). However, these species have not been observed within the project vicinity since 1943, 1917, and 1953, respectively. No documented occurrences of any state or federally listed threatened or endangered species were reported in the vicinity of the proposed flood control benches. A resource list from the USFWS's IPaC and the Travis County Endangered Species List from TPWD were reviewed. While no field visit or species-specific surveys were completed, no impacts to state or federally listed threatened or endangered species would be expected due to the lack of required habitat within the project area.

There would also be temporary impacts to noise and traffic levels from construction equipment during the construction activities, but these impacts would be minimal and managed through construction timing limits.

Cultural Resources

A cultural resources memo was completed for the project on December 3, 2020 which detailed the geologic background, soils, and previously recorded cultural resources within 1 mile of each alternative.

Presented here are the database results and recommendations for Alternative I. The Atlas review indicated that there have been five previous cultural resources surveys conducted within 1 mile (mi; 1.6 kilometers [km]) of Alternative I (Appendix G). None of the previous surveys overlap Alternative I. In addition, the review revealed that six archaeological sites, two OTHMs, and three cemeteries have been recorded within the 1-mile search radius (see Appendix G. Cultural Resources Memo). While none of the cultural resources overlap the alternative, site 41TV1389 is located approximately 385 ft from Alternative I. Site 41TV1389 is recorded as a prehistoric lithic scatter and has not been evaluated for NRHP eligibility.

Recommendations

The Atlas search revealed that there are various cultural resources recorded within one mile of Alternative I and that the alternative has not been previously surveyed. Although Alternative I is located along Williamson Creek which is a high probability setting for cultural resources, the banks of Williamson Creek have been extensively disturbed by residential construction. Due to this previous disturbance and past flooding of the creek, it is highly unlikely that any cultural resources remain intact within the project area.

As discussed in the Cultural Resources Memo, this project would be required to be in compliance with Chapter 191 of the Texas Natural Resources Code (Antiquities Code of Texas) and its accompanying Rules of Practice and Procedure (13 TAC 26). For projects larger than 5 acres or those that disturb more than 5,000 cubic yards of soil, compliance requires either a cultural resources survey of the project Area of Potential Effects or a determination from the Texas Historical Commission that the proposed project will have No Effect on historic properties as defined in Section 106 of the National Historic Preservation Act of 1966, as amended.

5.10.3 Land and Easement Acquisition

For construction of the flood walls and flood benches, this alternative also requires 2.5 acres across 37 different properties of permanent drainage easement for an estimated $5.0M and the acquisition of 9.1 acres across 10 properties for an estimated $8.9M. An additional 43.6 acres across 265 properties of permanent drainage easement due to increases in the proposed 100-yr water surface elevations within the project area for an estimated cost of $79.4M. Total anticipated costs for acquisitions and drainage easements for this alternative is $93.3M. These proposed drainage easements and acquisitions exclude the existing easements, right of way, or city owned property. See Appendix H for detailed exhibits and tables of the proposed drainage easements.

5.10.4 Potential Major Utility Impacts

There are no anticipated major water or waste water utility impacts due to the flood walls or voluntary buyouts. The proposed flood benches do necessitate the relocation of 2,500 linear feet of wastewater line (8” to 18”). There is also 2,500 linear feet of previously decommissioned wastewater lines that will need to be removed. There are no anticipated water utility impacts with implementation of the flood bench. See Appendix I for proposed relocations and removals of utility lines.

5.10.5 Time of Implementation

The anticipated time of implementation, once funding is available, is five to seven years assuming four to five years for design and permitting, and one to two years for construction.

5.10.6 Social/Community Impacts and Public Inputs

This alternative was not included in the 2022 community survey as it was considered not a viable option for flood risk reduction, however, it is likely that the project would have received a 25% to 50% approval rating as it does combine pieces of Alternative C (Buyouts) and Alternative G (Channel Modifications).

5.10.7 Percent of Structures at Risk of Interior Flooding (100-year storm) with Risk Removed

As shown in Figure 5-48, for the 100-year ultimate conditions event, the proposed alternative removes 134 structures from the floodplain, a 34% reduction.

5.10.8 Cost Effectiveness of Flood Risk Reduction

This alternative involves the voluntary buyout of 41 structures, the acquisition of 10 properties, approximately 4,000 cubic yards of concrete for flood walls, 275,000 cubic yards of excavation for channel modifications, and 2.4 acres of permanent drainage easement for an estimated $153.3M. An additional $61.1M is anticipated for permanent drainage easements due to adverse impacts. The total opinion of probable cost for this Alternative I is estimated to be $232.7M. See Appendix J for more detailed line items. Cost effectiveness for the 25-year and 100-year ultimate conditions events are summarized in Table 5-50.

Table 5-50. Alternative I – Cost Effectiveness Summary

Storm Event	Total Change in Inundation Depth for All Structures (ft)	Cost Effectiveness ($/ft)
25-Year Ultimate	-202.7	$1,148,000
100-Year Ultimate	-451.4	$516,000

5.10.9 Anticipated O&M

This alternative is anticipated to have moderate long-term O&M associated with the channel modifications and voluntary buyouts. Channel modifications are designed to be heavily vegetated, but still require periodic maintenance, especially after larger storm events. Generally, after voluntary buyouts have been demoed, the associated lot is mowed regularly to prevent overgrowth of vegetation.

5.10.10 Summary

Alternative I – Combination, proposes channel modifications, flood walls, and voluntary buyouts in order to reduce flood risk to middle Williamson Creek. Conceptual layouts have channel modifications in the Broken Bow, Other, Radam, and Heartwood areas with flood walls also located in the Radam and Heartwood areas. The voluntary buyouts are throughout the project area and consist of 41 structures with a 100-yr ultimate conditions inundation depth greater than 5 feet. This alternative has adverse impacts to structures within the project area, and in its current concept, is not viable.

The Combination alternative is expected to have long term, moderate environmental impact with permits among multiple jurisdictions along with challenging local site plan permitting and Nationwide or Individual Permit likely required.

This alternative requires the acquisition of 10 properties and 46 acres of permanent drainage easement for construction. The alternative requires the removal of 2,500 linear feet of previously decommissioned wastewater lines and 2,500 linear feet of wastewater line relocation, a significant utility impact.

This alternative was not included in the 2022 community survey as it was considered not a viable option for flood risk reduction, however, it is likely that the project would have received a 25% to 50% approval rating as it does combine pieces of Alternative C (Buyouts) and Alternative G (Channel Modifications).

The project is anticipated to take five to seven years to implement at a total construction cost of $232.7M and moderate O&M costs. The alternative removes 34% of structural inundations and has a cost effectiveness of $1,148k and $516k per foot of inundation reduction for the 25-year and 100-year ultimate conditions events, respectively.

5.11 Summary of Results and Conclusion

Using the results of the alternatives analysis detailed in the sections above, Table 5-51 summarizes the alternatives with relation to the criteria and ranks them based on the matrix defined in Section 5.1 Evaluation Criteria. A “No-Project” alternative was also added to the matrix for a point of comparison. This matrix can be used by the City to determine the next steps forward for this project in Phase 2. Alternatives A, D, E, and F were considered not viable options prior to the full matrix evaluation and are not recommended for further consideration for flood risk reduction for structures in Middle Williamson Creek. Of the alternatives that were fully evaluated, based on the results of the matrix, for the overall project area, HDR recommends further investigation of Alternatives C, G, and H and eliminating Alternatives I and B from consideration. However, some pieces of Alternatives I and B may be applicable for smaller areas within Middle Williamson Creek. This along with other conclusions from this study are as follows:

- Channel modifications, by themselves, are unable to provide any meaningful flood risk reduction to structures in Middle Williamson Creek, as is evident by the results of Alternative A, Alternative G, and around the Broken Bow flood bench in Alternative I.
- Flood walls, modeled in Alternative B, are effective at reducing flood risk to the structures behind the wall, however, location of these walls is constrained by local drainage patterns and location of roadways/homes. In Middle Williamson Creek, flood walls also do tend to cause adverse impacts to structures on the opposing bank and upstream which without additional mitigation, is not a feasible option.
- The adverse impacts of flood walls may be mitigated with strategically placed channel modifications, as is evident by the flood wall and flood bench in the Heartwood area of Alternative I.
- Voluntary buyouts, costed in Alternative C, continue to be a feasible option for permanently reducing flood risk, and will likely be necessary as this study has shown that even the most capital intense structural alternatives are unable to fully reduce risk to all structures in the 100-yr floodplain.
- The project team acknowledges that there has been a substantial increase in property values (25-40%) in the project area from the time the ORES study was completed in December of 2020 to the finalization of this report in July of 2022. If the increase in property values was included in the cost, Alternative C, would likely lower to the second preferred alternative, however, the project team has chosen not to escalate the estimated cost as this increase would not affect the overall recommendations of the study which is to further evaluate Alternative C, G, and H.
- Flood proofing, or elevating, single-family homes, costed in Alternative D, can be a cost-effective solution for homeowners to mitigate their own risk, however, at this time, based on the City of Austin’s Law Department review and interpretation of state and local government code, it does not appear that the elevation of buildings on private property is an acceptable use of the City’s funding sources.
- Regional detention, or a dam, along Williamson Creek, has been shown in Alternative E to provide substantial flood reduction benefit to inundated structures downstream of the dam, however, the dam embankment would likely overtop in the 100-year frequency event which

does not meet the criteria for regional detention in DCM Section 8.3.3. Raising the dam crest or lowering the auxiliary spillway in order to meet the criteria, would be unlikely to have any net benefits to flood risk reduction for habitable structures. In the configuration presented, the alternative requires the acquisition of 60 properties for construction and adverse impacts, which negates the 56 structures removed from the 100-year floodplain downstream. For both of these reasons, Alternative E was not considered a feasible option.

- Using the open green space near Bayton Loop and West Gate Blvd for construction of detention or flood benches was modeled and shown to only have localized impacts to flood risk reduction, primarily outside of the project area in the City of Sunset Valley. While not in the scope of this study, using these localized reductions may allow for the opportunity to bring the West Gate crossings of Sunset Valley Tributary, Williamson Creek, and Cherry Creek into DCM compliance. Williamson Creek is currently estimated to overtop by 3.6’ and 6.3’ in the 25-yr and 100-yr ultimate conditions events, respectively.
- The Stassney Bypass, an underground diversion modeled in Alternative H, is the structural alternative that provides the most benefit with regards to comprehensive flood risk reduction throughout the project area, however, this reduction would require a considerable capital investment by the City, not only during construction, but in perpetuity with the required O&M. A detailed cost estimate, geological investigation, and refinement of inlet locations and tunnel size should be completed if this is further considered.
- Alternative I, a combination of flood walls, channel improvements, and voluntary buyouts, provides insight into what a long term structural comprehensive solution for the project area could look like. If this alternative moves forward, the flood walls and channel improvements should be refined to remove any adverse impacts shown.
- Not scoped for this study, but worth mentioning that four out of the six roadways that cross Williamson Creek from West Gate Boulevard to South Congress Avenue are overtopped in at least the 10-year ultimate conditions event, well below DCM standards. The limited capacity of these crossings, along with the Union Pacific Railroad crossing, create back water behind them and inundate structures.
- The results of the 2022 community survey indicate that most respondents support some project to reduce flood risk in the project area with the Stassney Bypass being the most preferred option (64%) compared to voluntary buyouts (48%) and channel modifications (48%). The respondents also expressed importance on preserving the natural appearance of the creek, avoiding impacts to wildlife, and preserving trees which are often in conflict with structural solutions. This has been and continues to be a challenge for reducing flood risk in the Middle Williamson Creek watershed.

Table 5-51. Results of Alternatives Matrix Analysis

Alternative	Description	C1. Environmental Constraints & Permitting (10%)	C2. Land and Easement Acquisition (5%)	C3. Potential Major Utility Impacts (5%)	C4. Time of Implementation (yrs) (5%)	C5. Social/ Community Impacts and Public Input (10%)	C6. 100yr Percent Inundation Reduction (30%)	C7. 25-yr Cost Effectiveness ($/ft) (15%)	C8. 100-yr Cost Effectiveness ($/ft) (15%)	C9. O&M Costs (5%)		
Alternatives Results												
-	No Project	Minimal	None	None	0-2	Less than 25% Approval	0%	NA	NA	None		
B	Flood Walls	Significant	Substantial	None	5-7	Less than 25% Approval	33%	$3,243k	$630k	Moderate		
C	Voluntary Buyouts	Minimal	None	None	2-5	25% to 50% Approval	100%	$868k	$262k	None		
G	Channel Modifications	Moderate to Significant	Moderate	Moderate	5-7	25% to 50% Approval	16%	$478k	$169k	Minimal		
H	Stassney Bypass	Moderate	Moderate	Minimal	7-10	Greater than 50% Approval	77%	$770k	$249k	Significant		
I	Combination	Moderate to Significant	Significant	Significant	5-7	25% to 50% Approval	34%	$1,118k	$516k	Moderate		
Criteria Ratings											**Points**	**Rank**
-	No Project	5	5	5	5	1	1	1	1	5	2.20	5
B	Flood Walls	1	1	5	3	1	3	1	1	3	2.00	6
C	Voluntary Buyouts	5	5	5	4	3	5	3	4	5	4.30	1
G	Channel Modifications	2	3	3	3	3	1	5	5	4	2.95	3
H	Stassney Bypass	3	3	4	2	5	5	4	4	2	4.05	2
I	Combination	2	2	2	3	3	3	1	2	3	2.35	4

See Section 5.1 Evaluation Criteria for criteria descriptions and rating definitions.

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Appendix A. Williamson Creek Hydrologic Exhibits

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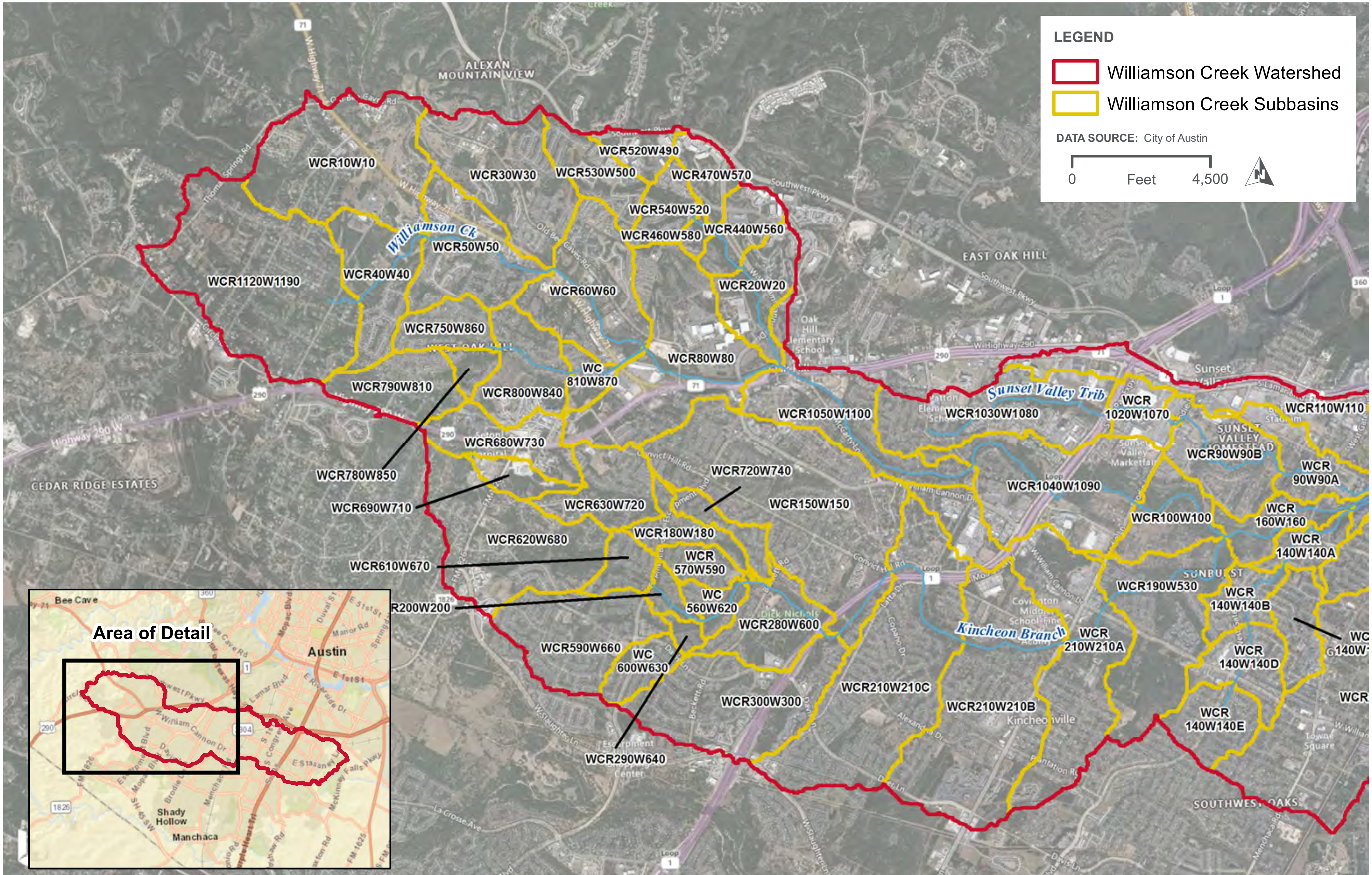

SUBBASIN DELINEATION (1 OF 2)

WILLIAMSON CREEK WATERSHED

EXHIBIT A-1

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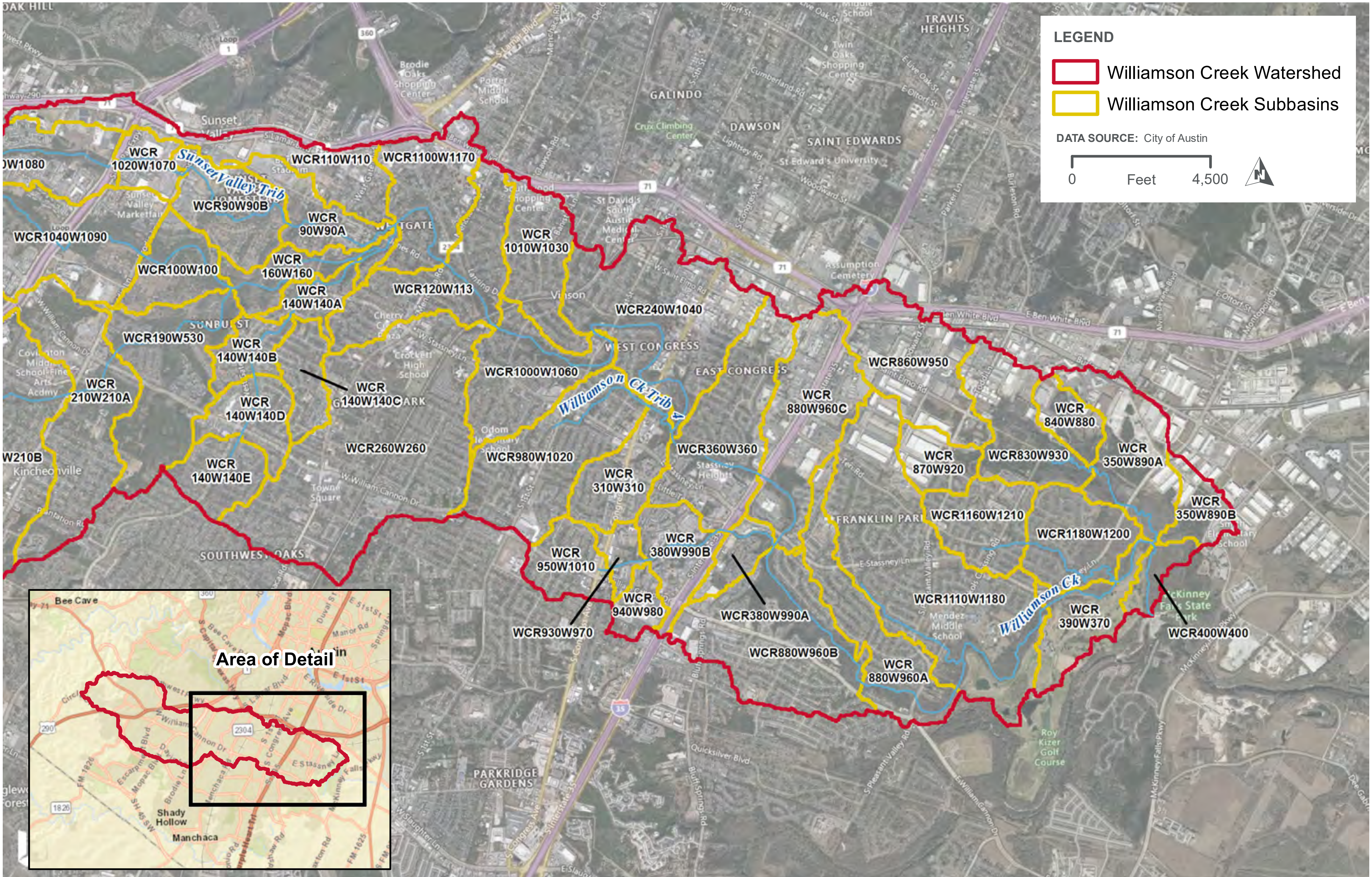

SUBBASIN DELINEATION (2 OF 2)

WILLIAMSON CREEK WATERSHED

EXHIBIT A-2

Appendix B. October 2013 High Water Mark Exhibits

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OCTOBER 2013 OBSERVED HIGH WATER MARKS (1 OF 3)

WILLIAMSON CREEK WATERSHED

EXHIBIT B-1

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OCTOBER 2013 OBSERVED HIGH WATER MARKS (2 OF 3)

WILLIAMSON CREEK WATERSHED

EXHIBIT B-2

OCTOBER 2013 OBSERVED HIGH WATER MARKS (3 OF 3)

WILLIAMSON CREEK WATERSHED

EXHIBIT B-3

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Appendix C. Revised Existing and Ultimate Inundation Exhibits by Problem Area

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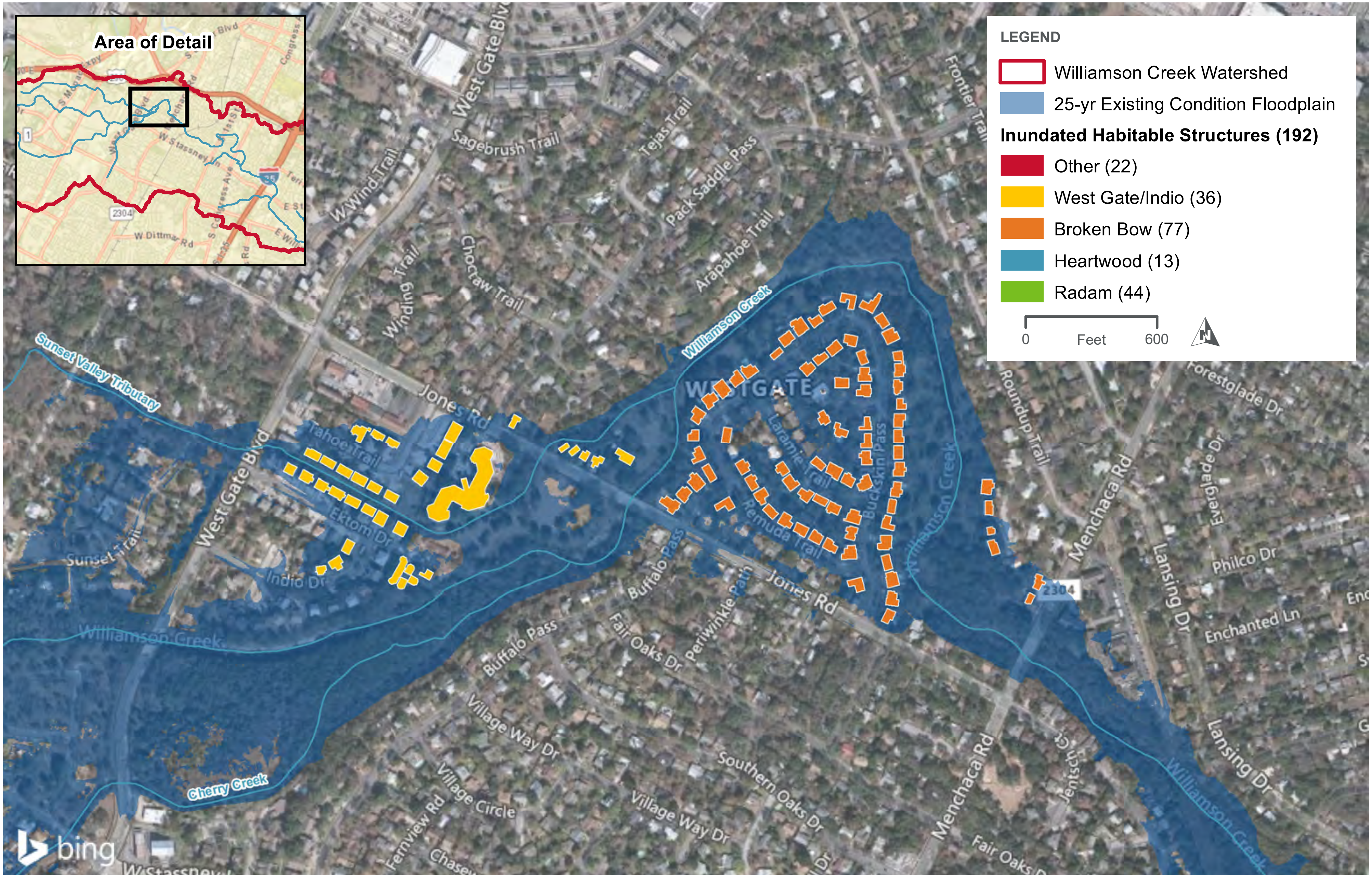

REVISED EXISTING 25-YEAR INUNDATION (1 OF 3)

WILLIAMSON CREEK WATERSHED

EXHIBIT C-1

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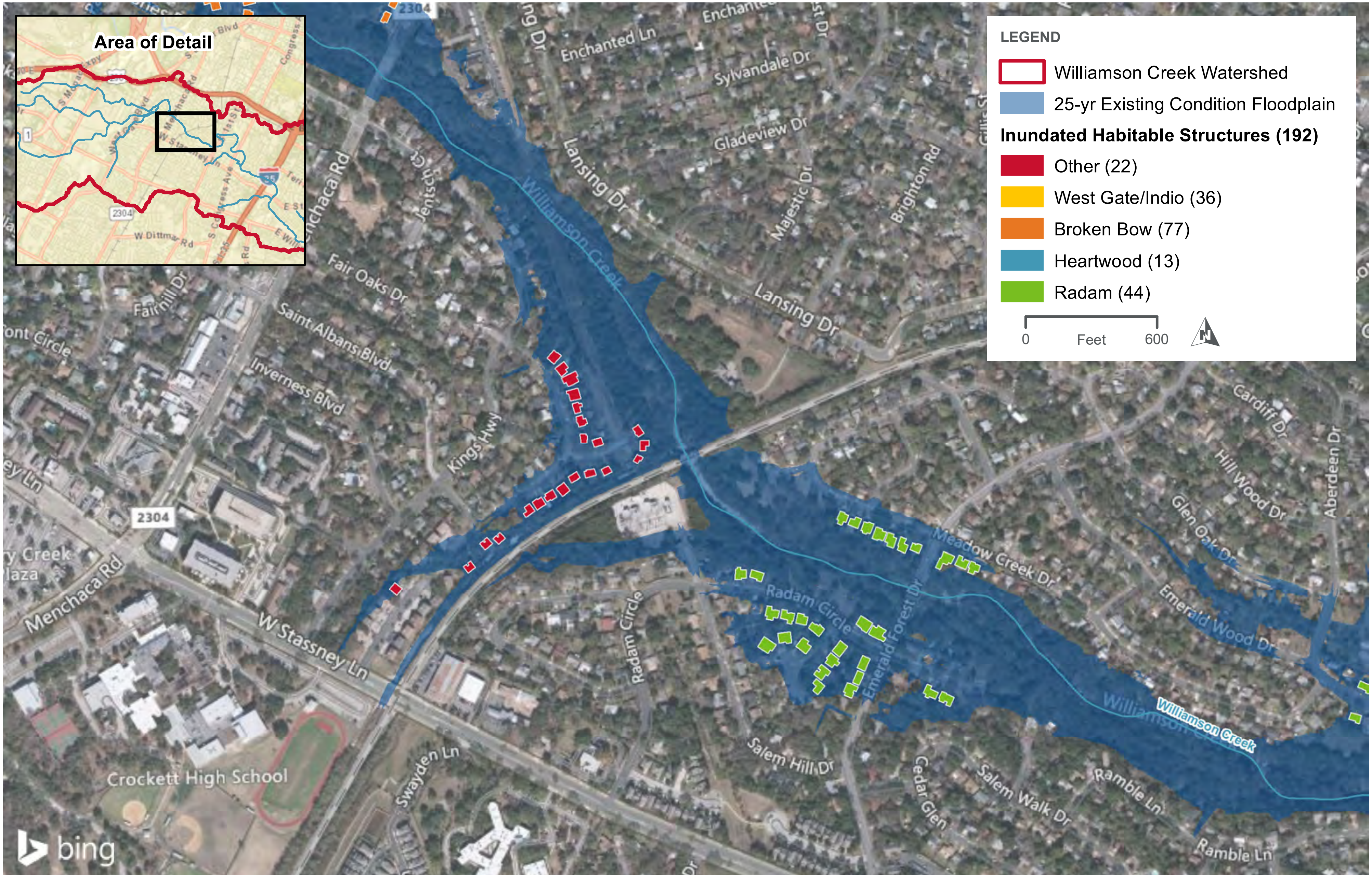

REVISED EXISTING 25-YEAR INUNDATION (2 OF 3)

WILLIAMSON CREEK WATERSHED

EXHIBIT C-2

REVISED EXISTING 25-YEAR INUNDATION (3 OF 3)

WILLIAMSON CREEK WATERSHED

EXHIBIT C-3

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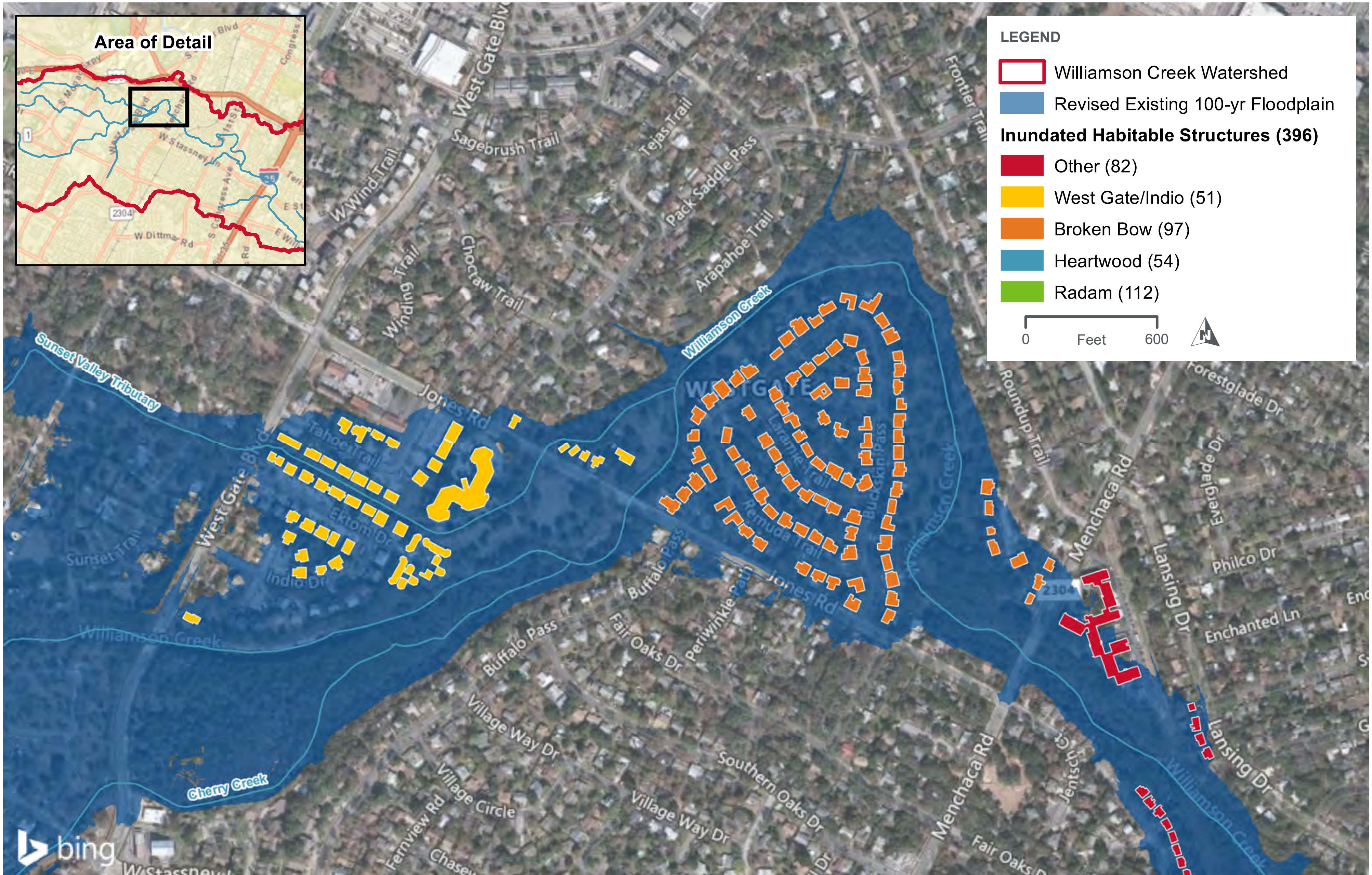

REVISED EXISTING 100-YEAR INUNDATION (1 OF 3)

WILLIAMSON CREEK WATERSHED

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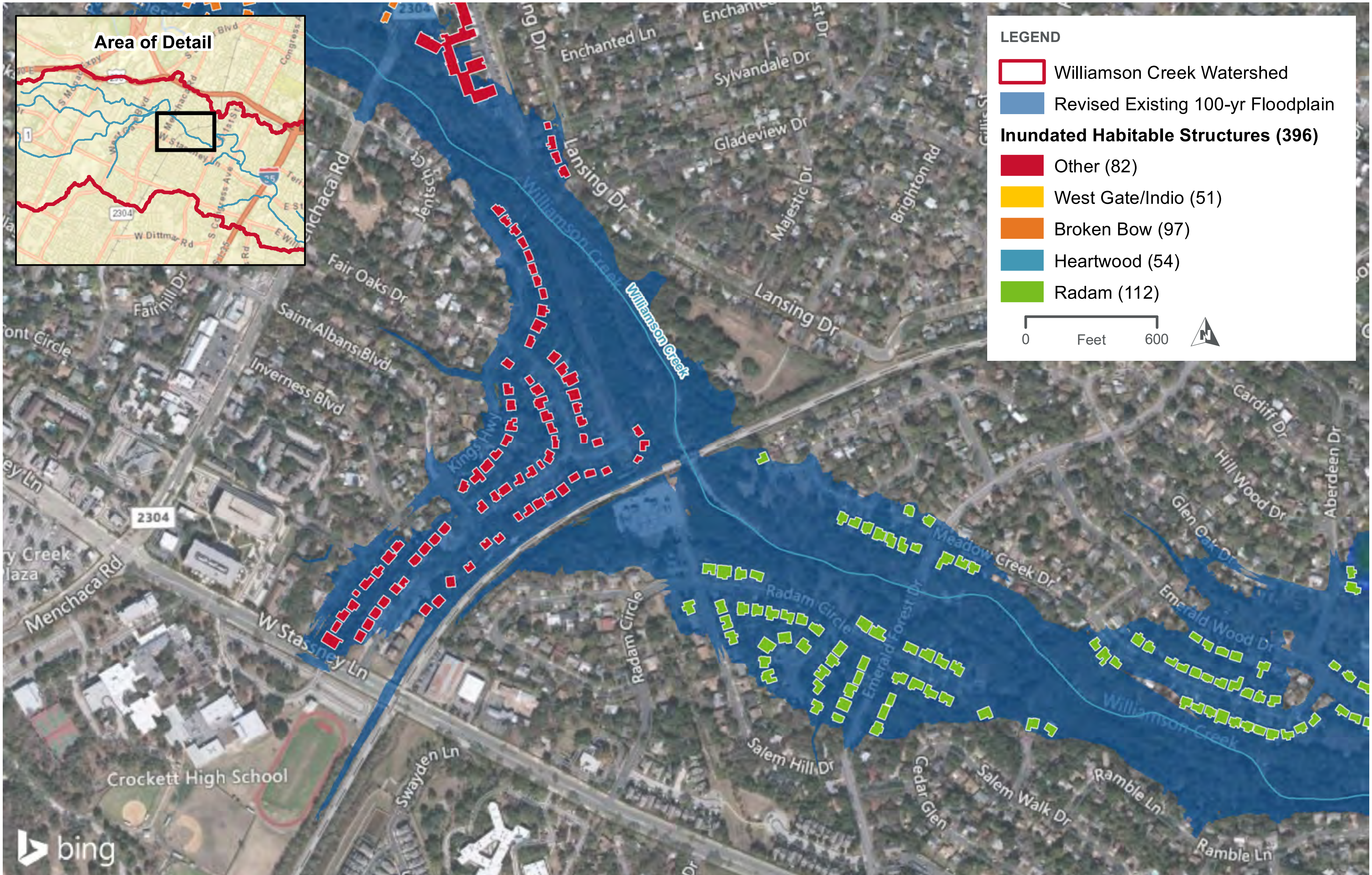

REVISED EXISTING 100-YEAR INUNDATION (2 OF 3)

WILLIAMSON CREEK WATERSHED

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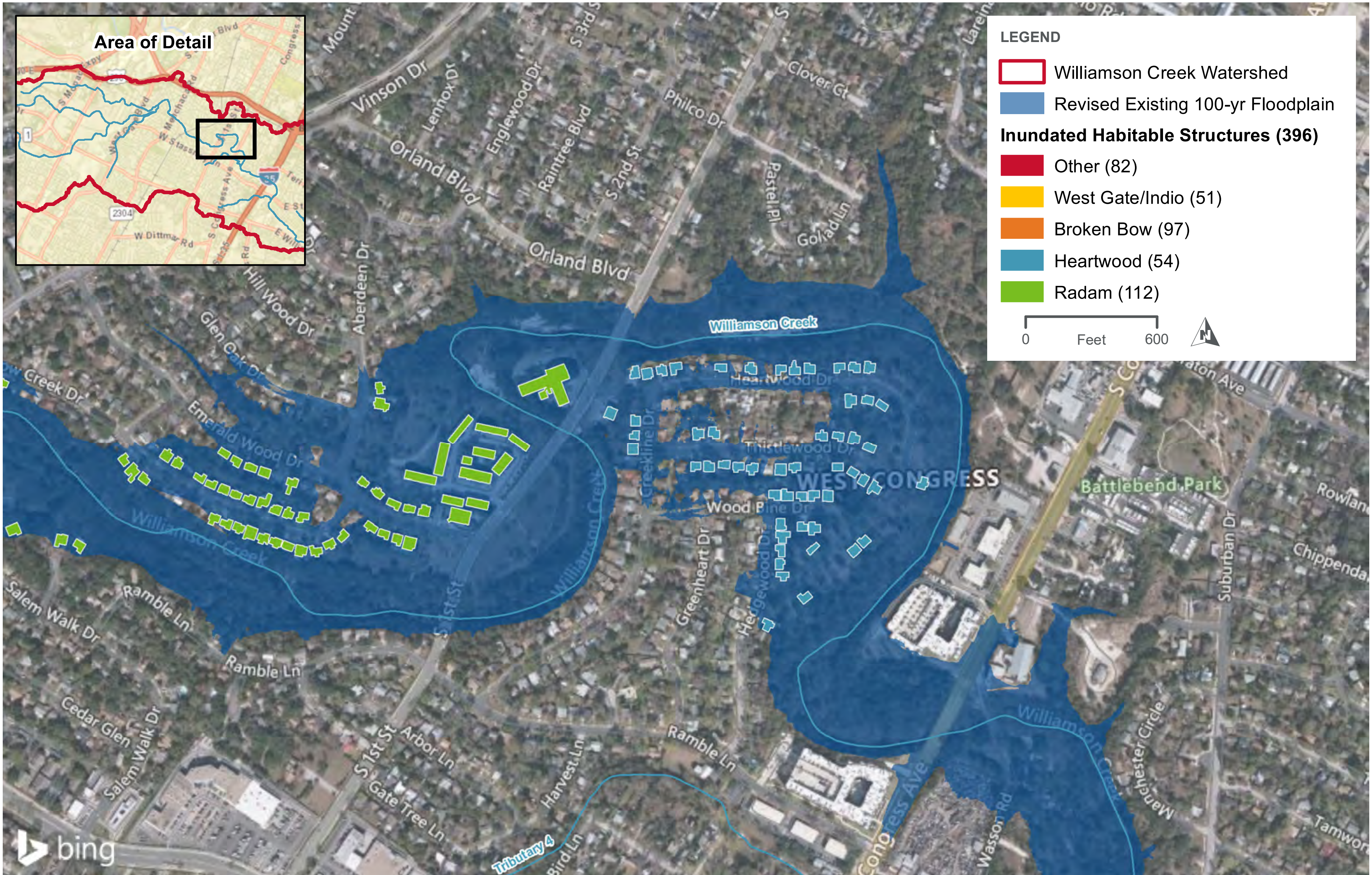

REVISED EXISTING 100-YEAR INUNDATION (3 OF 3)

WILLIAMSON CREEK WATERSHED

EXHIBIT C-6

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REVISED ULTIMATE 2-YEAR INUNDATION (1 OF 3)

WILLIAMSON CREEK WATERSHED

EXHIBIT C-7

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REVISED ULTIMATE 2-YEAR INUNDATION (2 OF 3)

WILLIAMSON CREEK WATERSHED

EXHIBIT C-8

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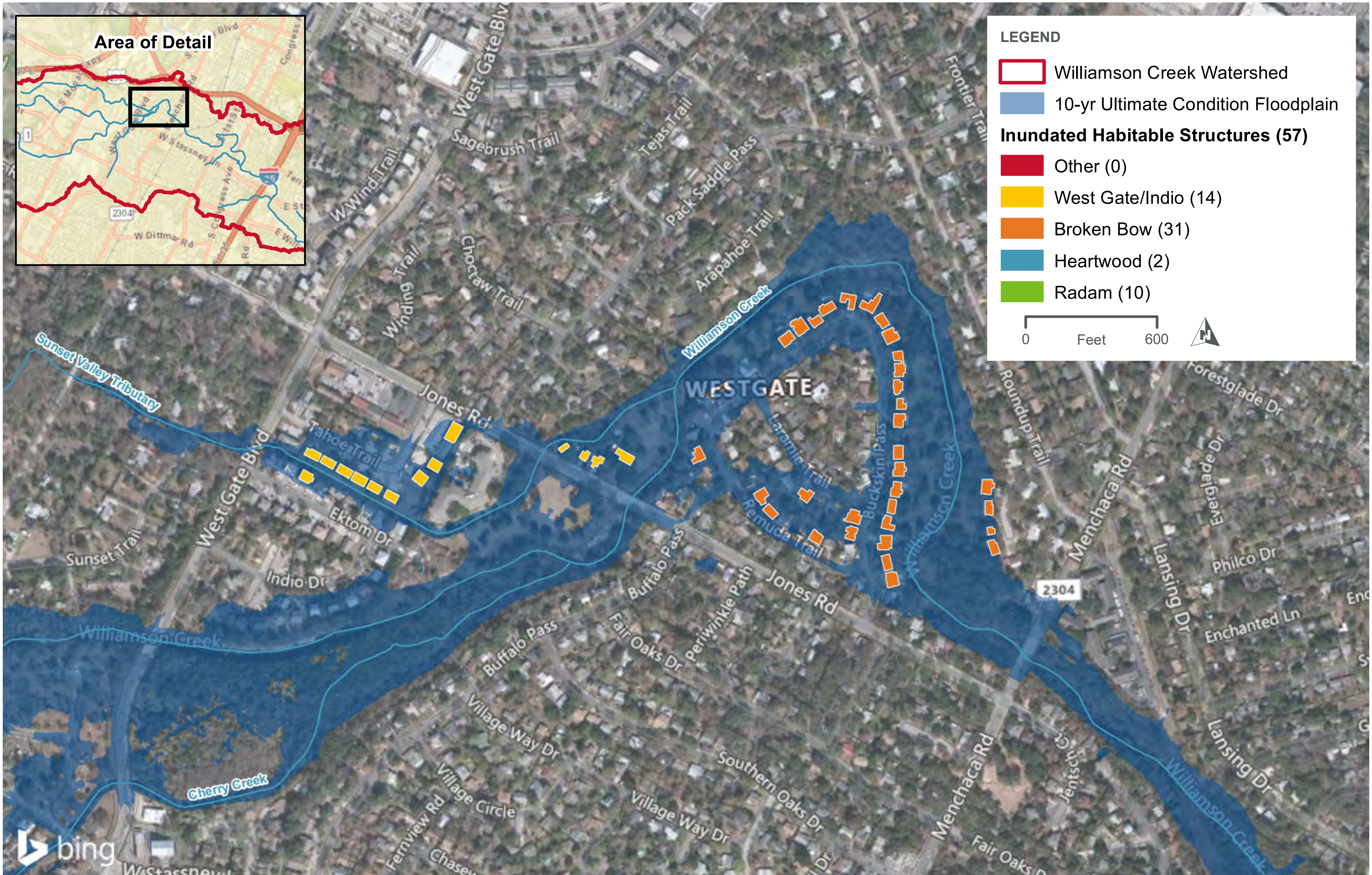
REVISED ULTIMATE 2-YEAR INUNDATION (3 OF 3)

WILLIAMSON CREEK WATERSHED

EXHIBIT C-9



REVISED ULTIMATE 10-YEAR INUNDATION (1 OF 3)

WILLIAMSON CREEK WATERSHED

EXHIBIT C-10

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REVISED ULTIMATE 10-YEAR INUNDATION (2 OF 3)

WILLIAMSON CREEK WATERSHED

EXHIBIT C-11

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REVISED ULTIMATE 10-YEAR INUNDATION (3 OF 3)

WILLIAMSON CREEK WATERSHED

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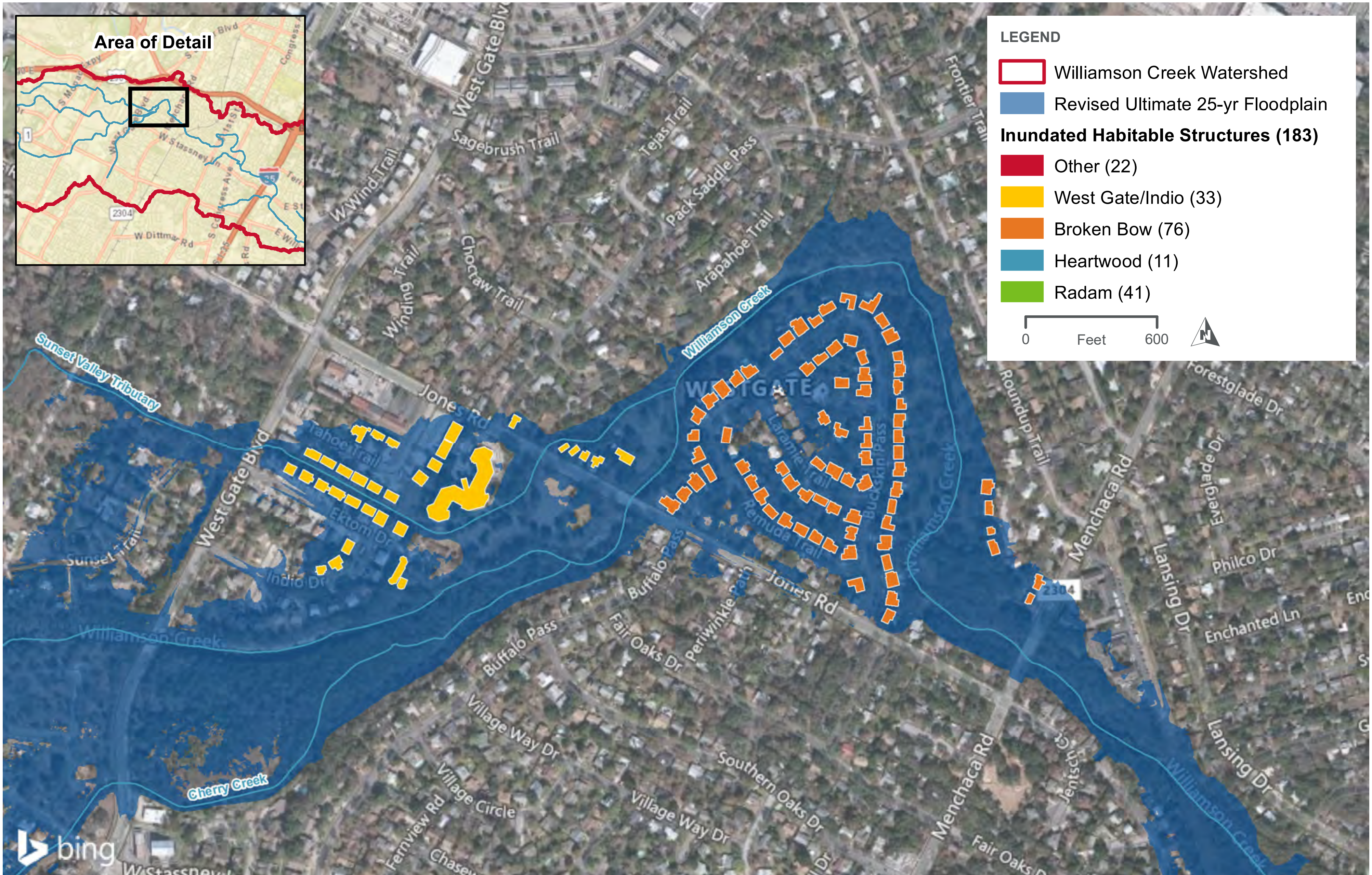

REVISED ULTIMATE 25-YEAR INUNDATION (1 OF 3)

WILLIAMSON CREEK WATERSHED

EXHIBIT C-13

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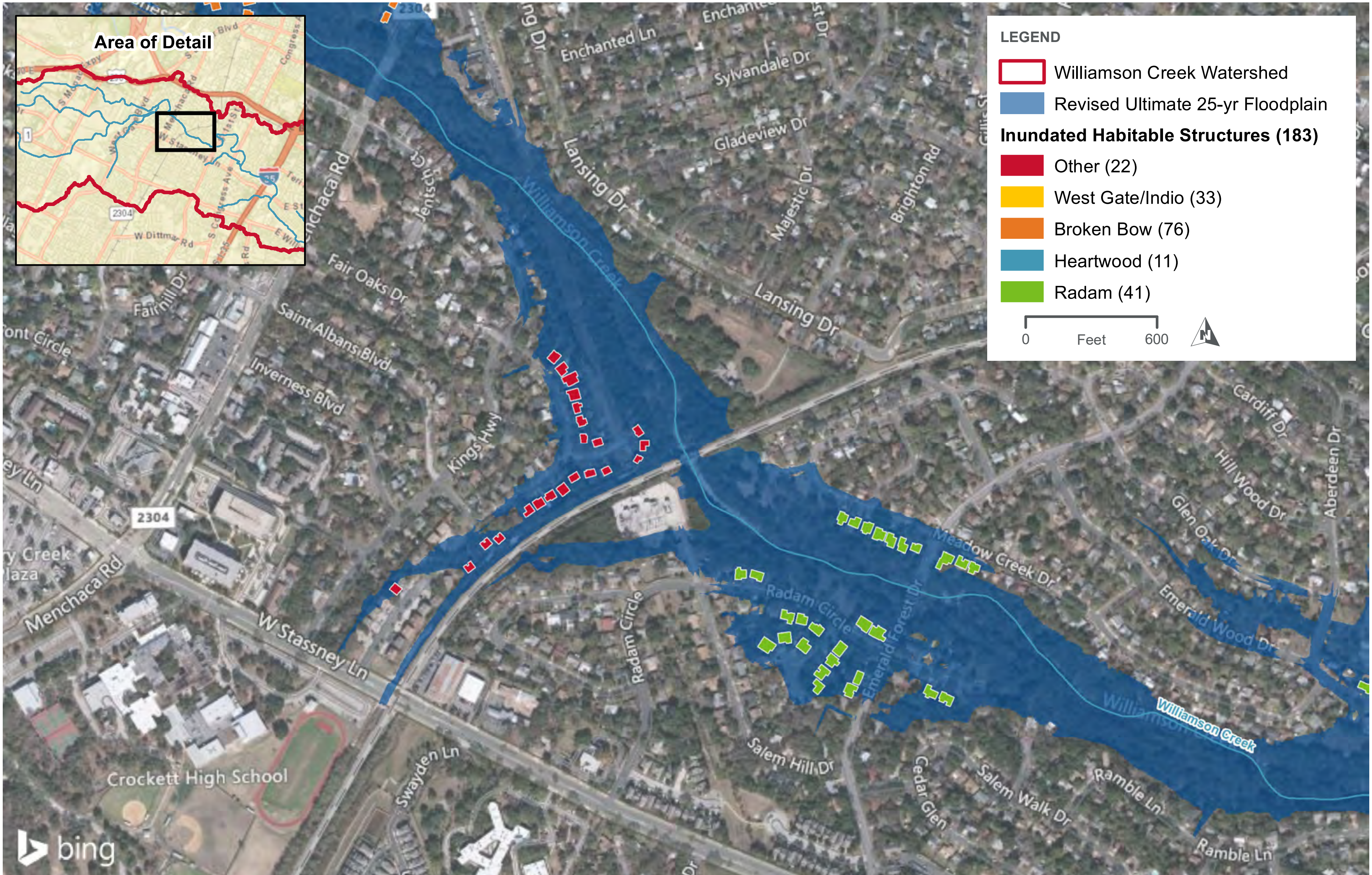

REVISED ULTIMATE 25-YEAR INUNDATION (2 OF 3)

WILLIAMSON CREEK WATERSHED

EXHIBIT C-14

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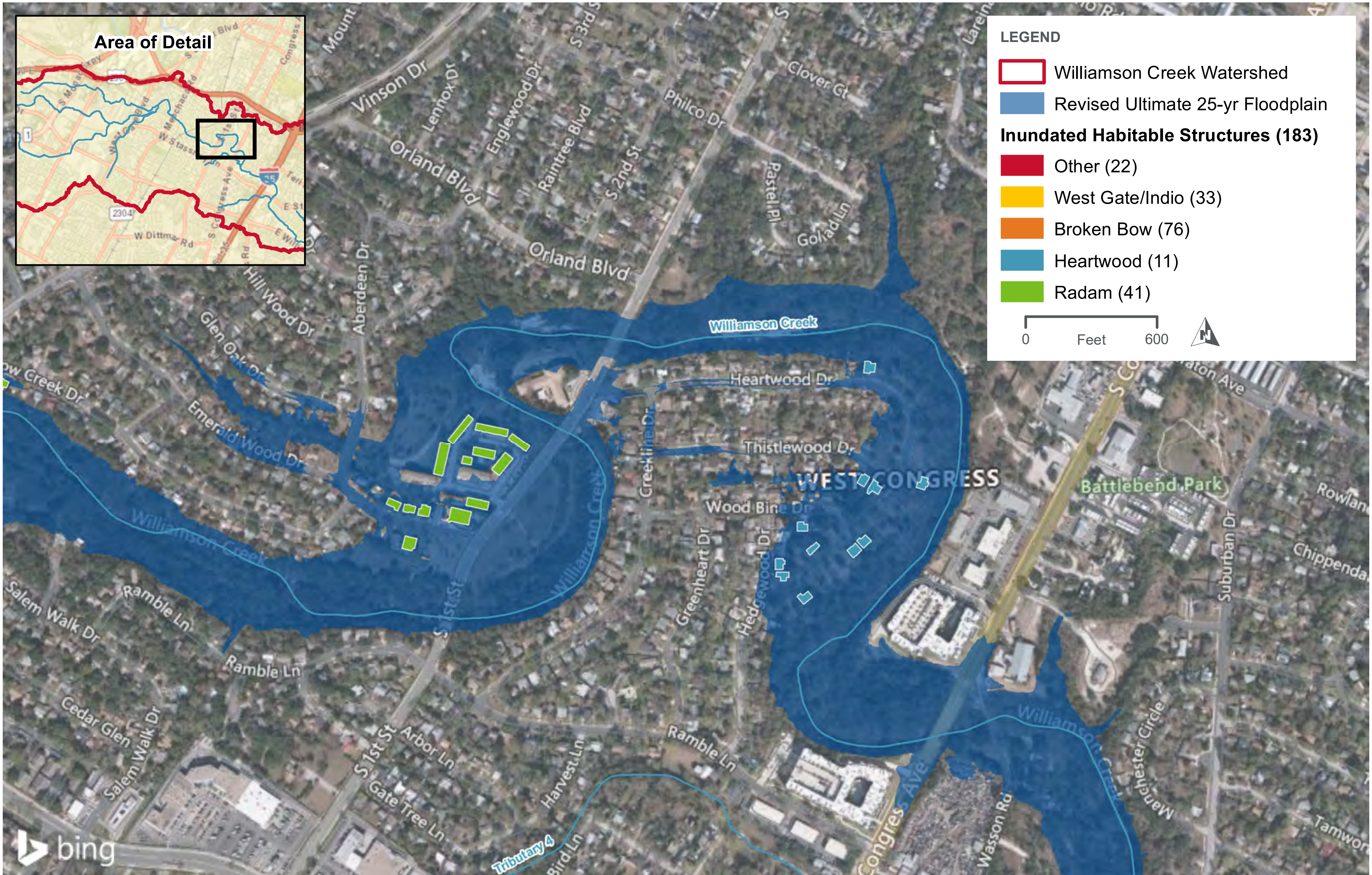

REVISED ULTIMATE 25-YEAR INUNDATION (3 OF 3)

WILLIAMSON CREEK WATERSHED

EXHIBIT C-15

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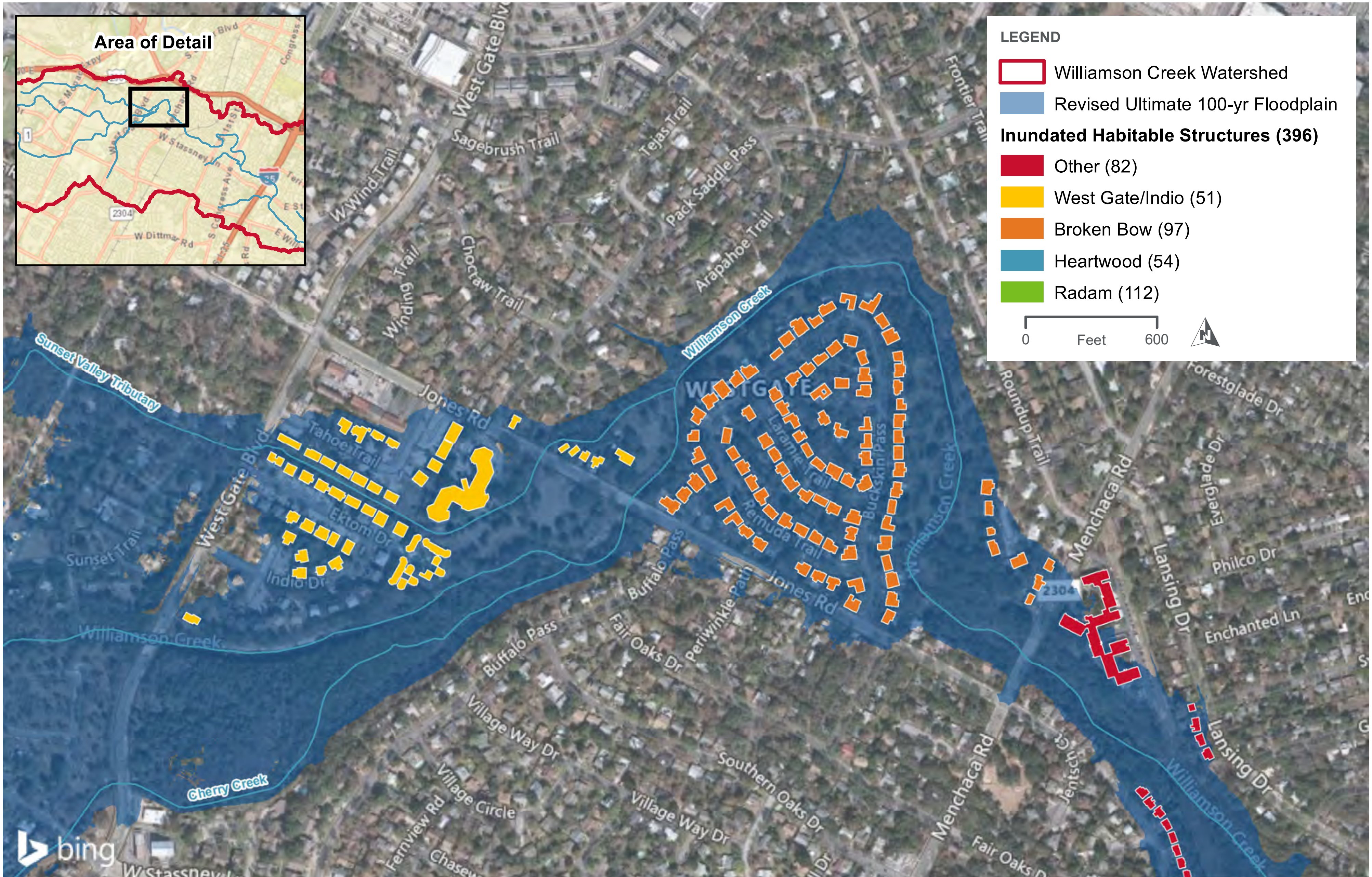
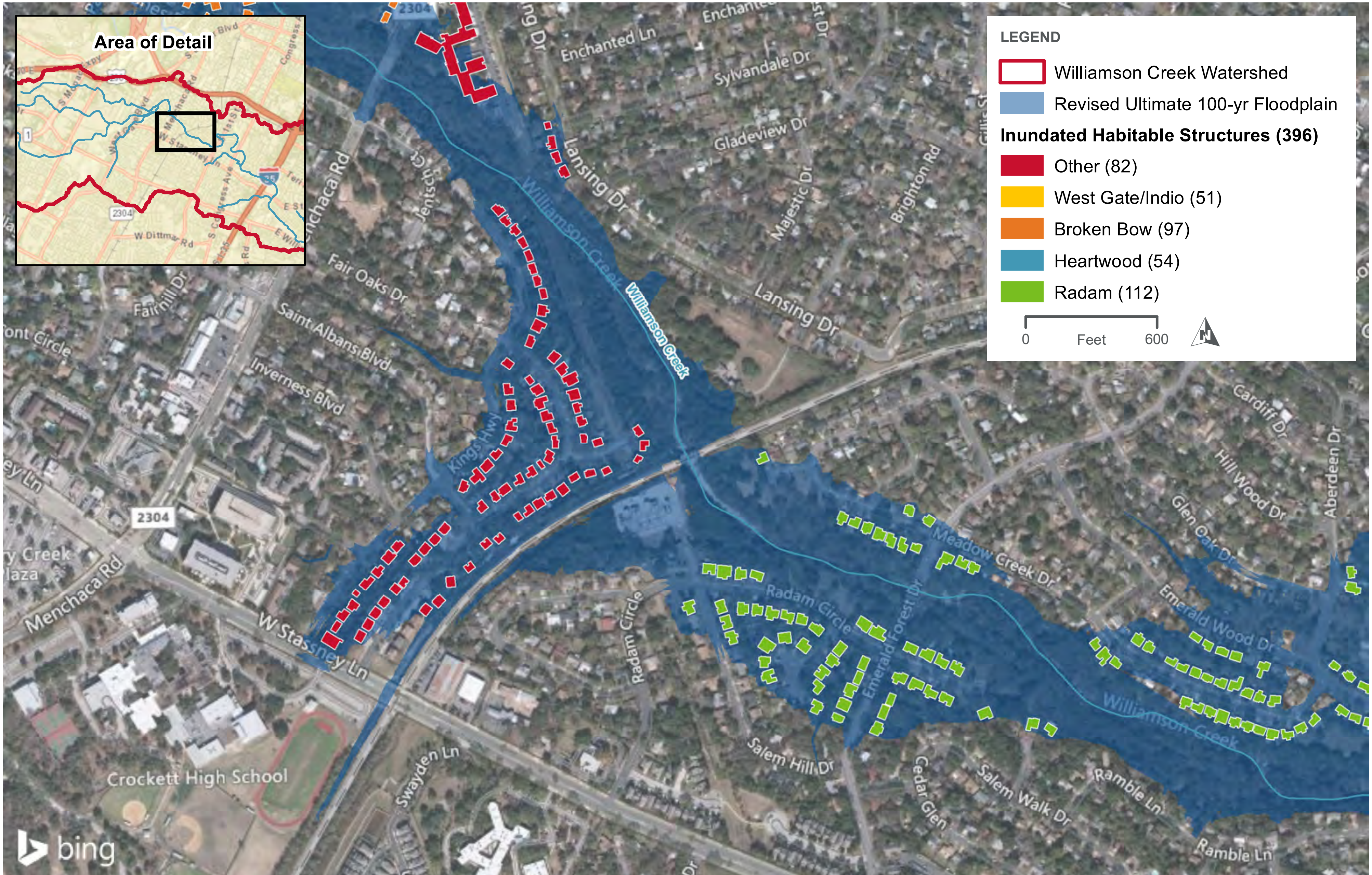


REVISED ULTIMATE 100-YEAR INUNDATION (1 OF 3)

WILLIAMSON CREEK WATERSHED

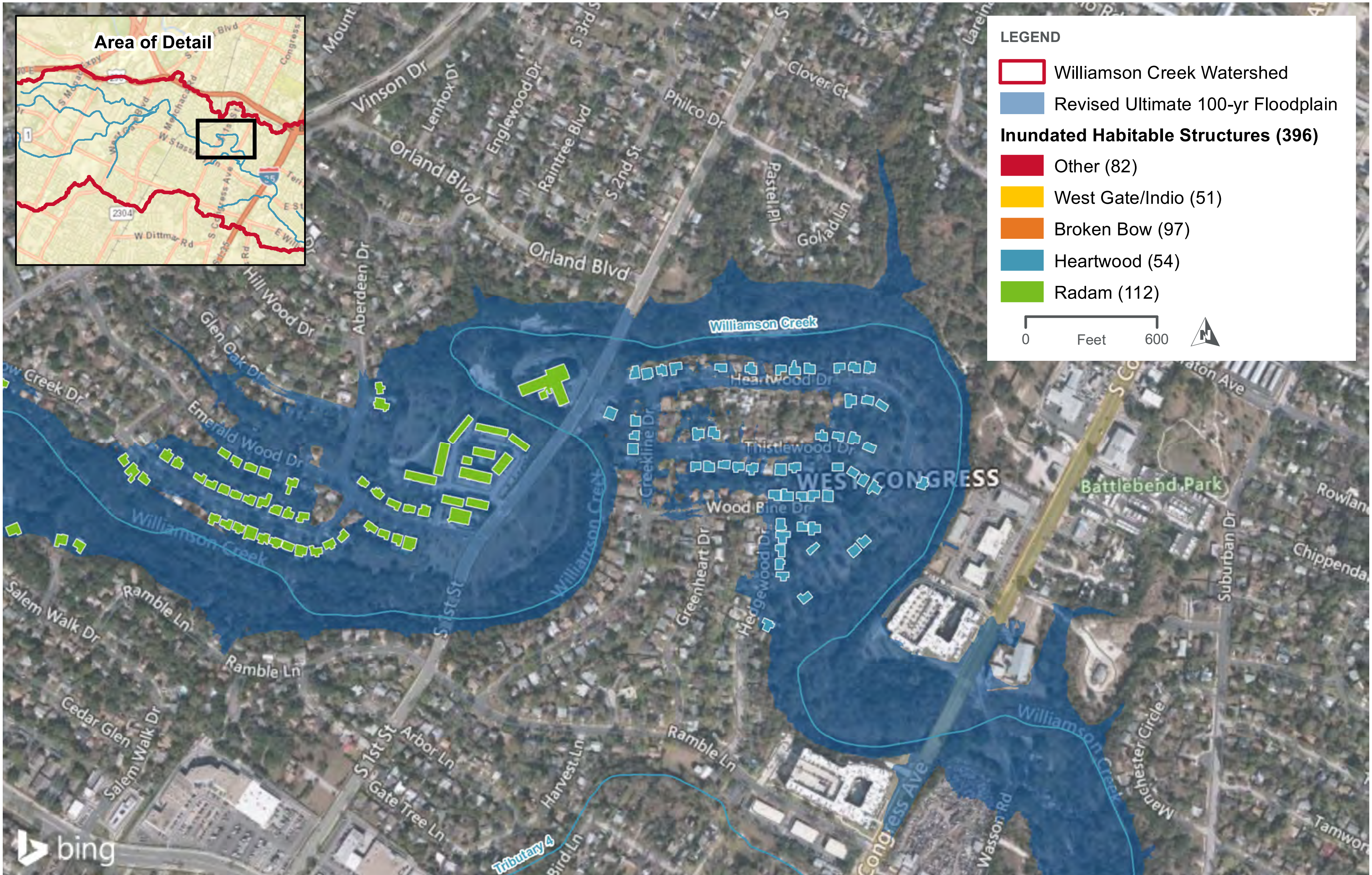
EXHIBIT C-16



REVISED ULTIMATE 100-YEAR INUNDATION (2 OF 3)

WILLIAMSON CREEK WATERSHED

EXHIBIT C-17



REVISED ULTIMATE 100-YEAR INUNDATION (3 OF 3)

WILLIAMSON CREEK WATERSHED

EXHIBIT C-18

Appendix D. Revised Existing and Ultimate Flood Depth and Structural Inundation Exhibits

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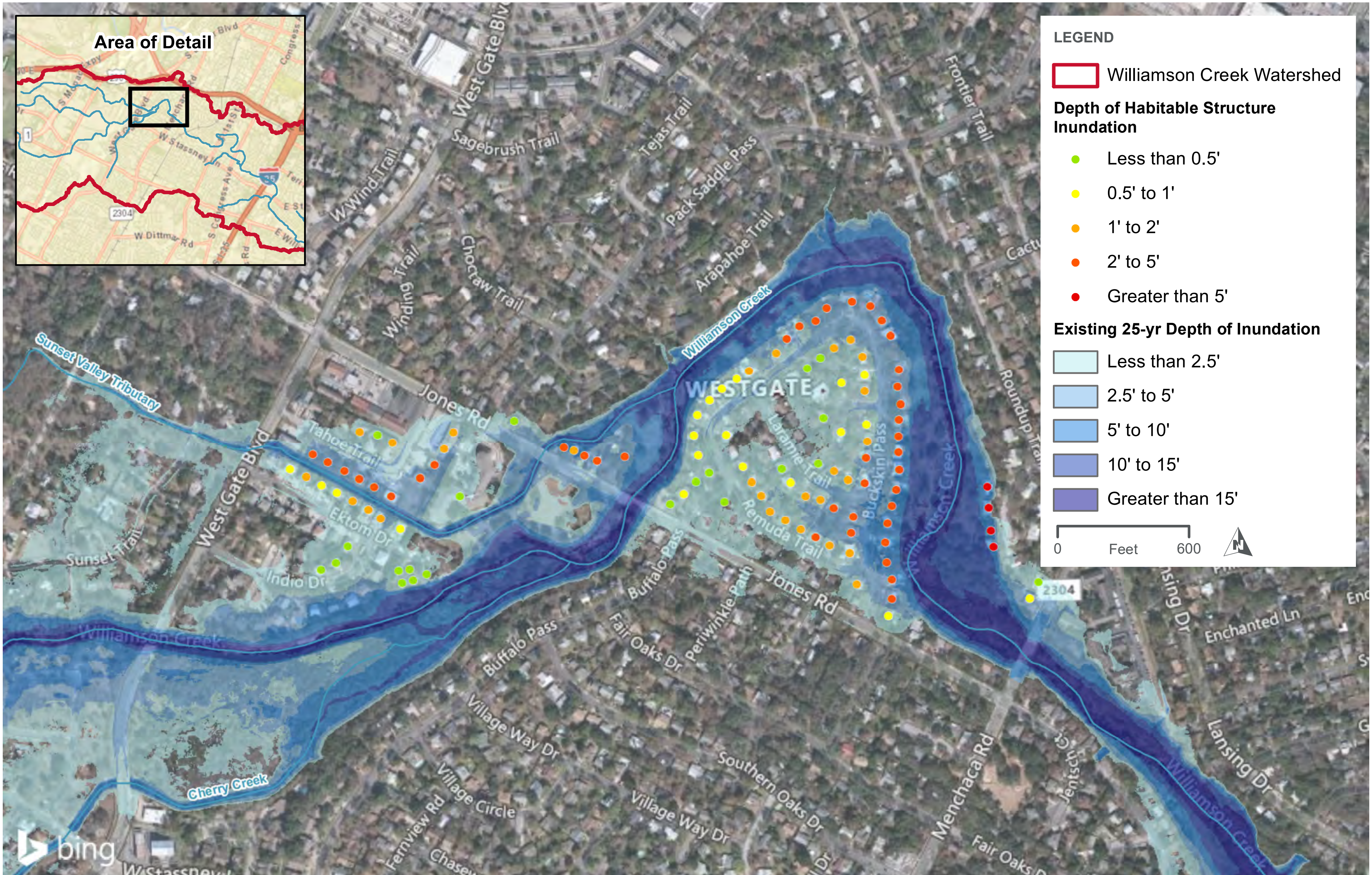

REVISED EXISTING 25-YEAR DEPTH OF INUNDATION (1 OF 3)

WILLIAMSON CREEK WATERSHED

EXHIBIT D-1

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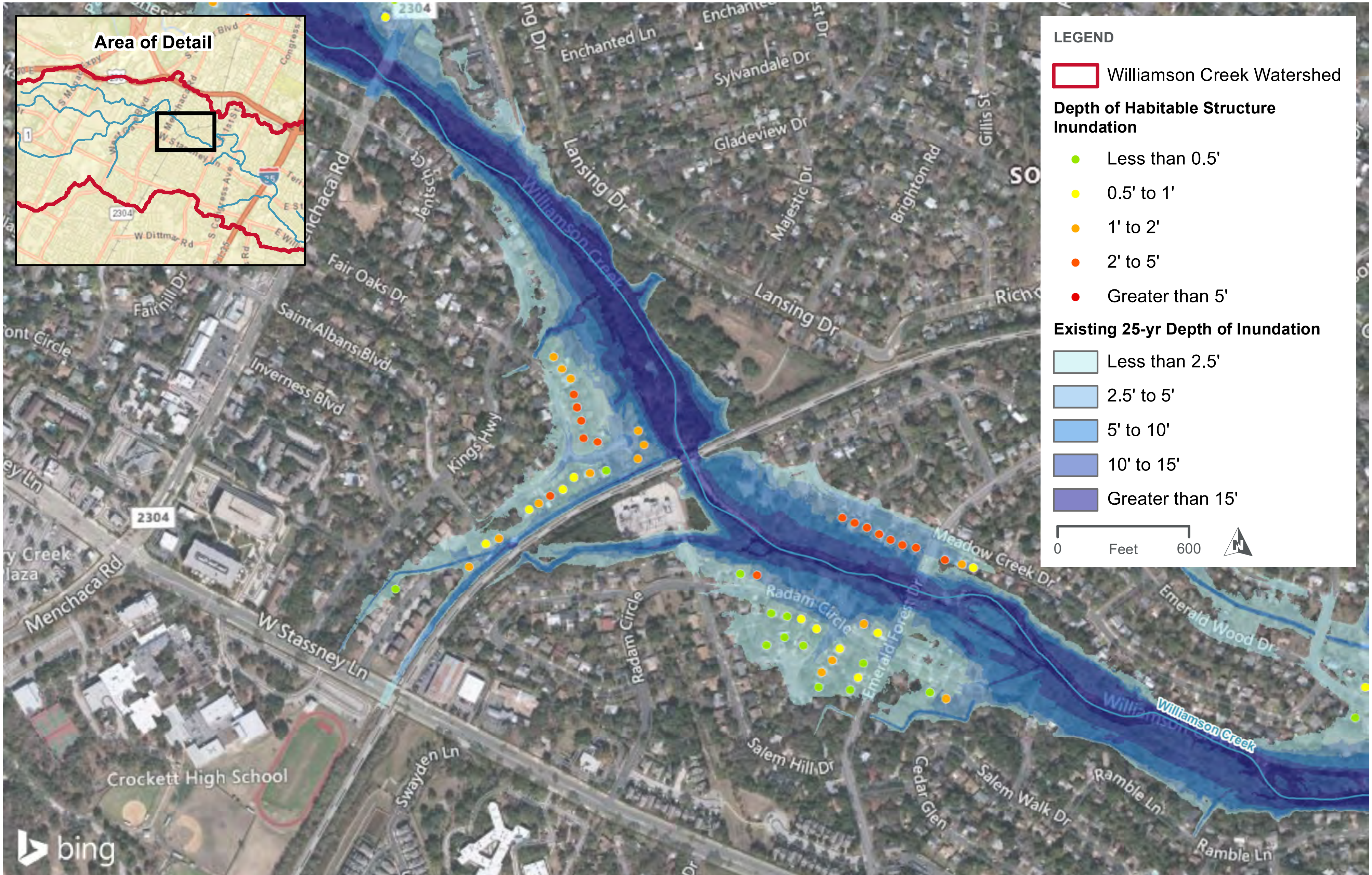

REVISED EXISTING 25-YEAR DEPTH OF INUNDATION (2 OF 3)

WILLIAMSON CREEK WATERSHED

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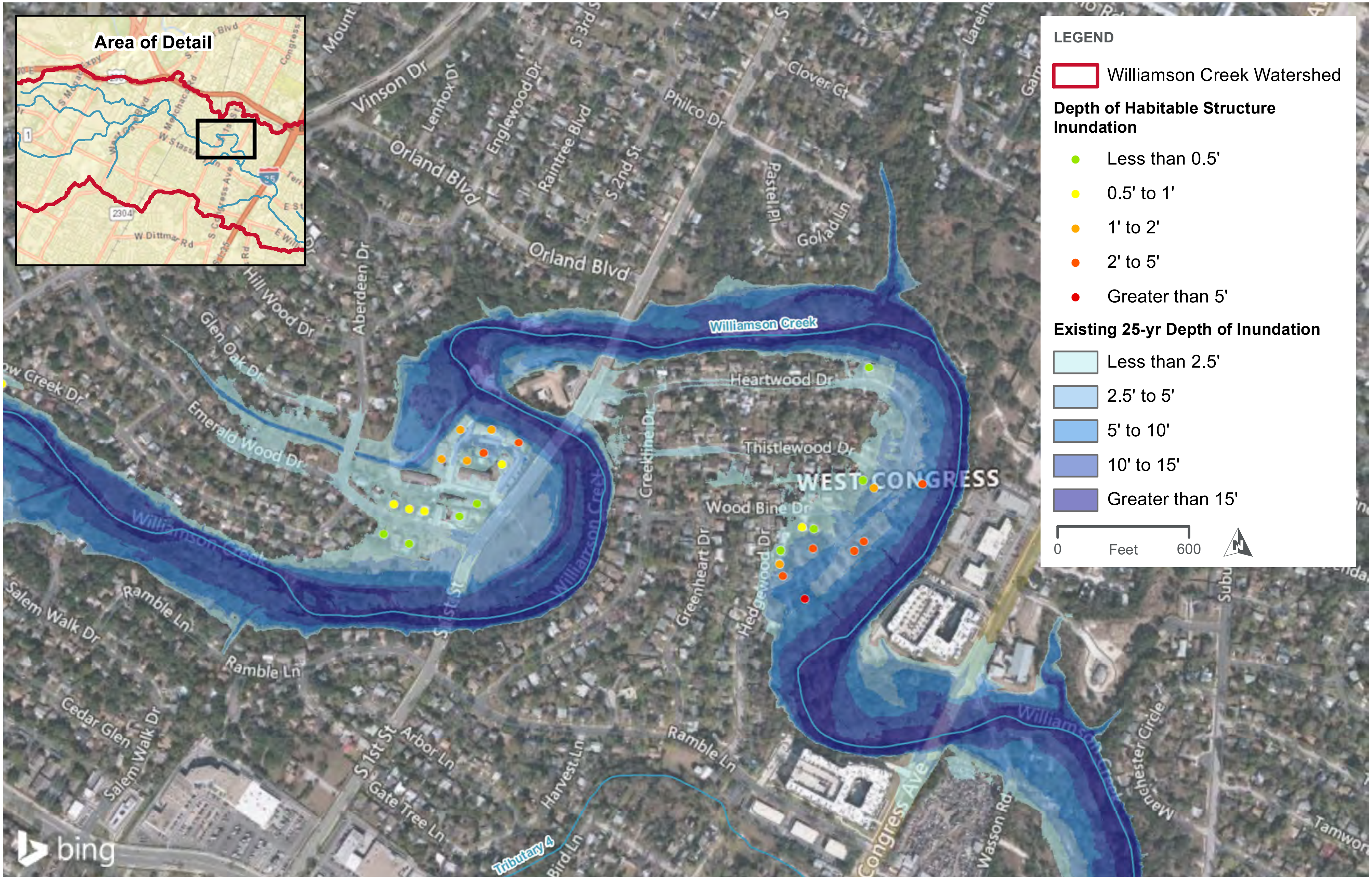

REVISED EXISTING 25-YEAR DEPTH OF INUNDATION (3 OF 3)

WILLIAMSON CREEK WATERSHED

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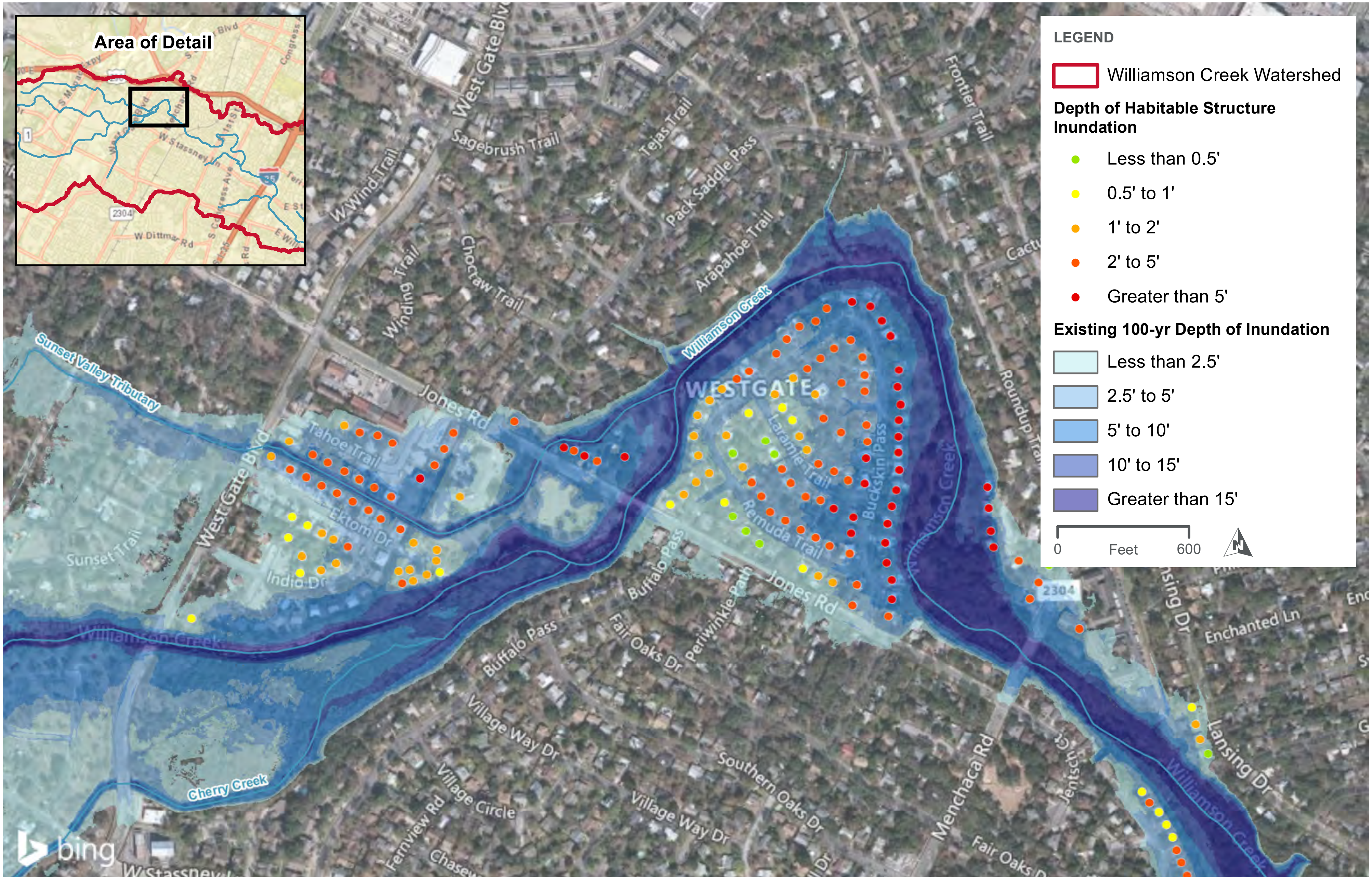

REVISED EXISTING 100-YEAR DEPTH OF INUNDATION (1 OF 3)

WILLIAMSON CREEK WATERSHED

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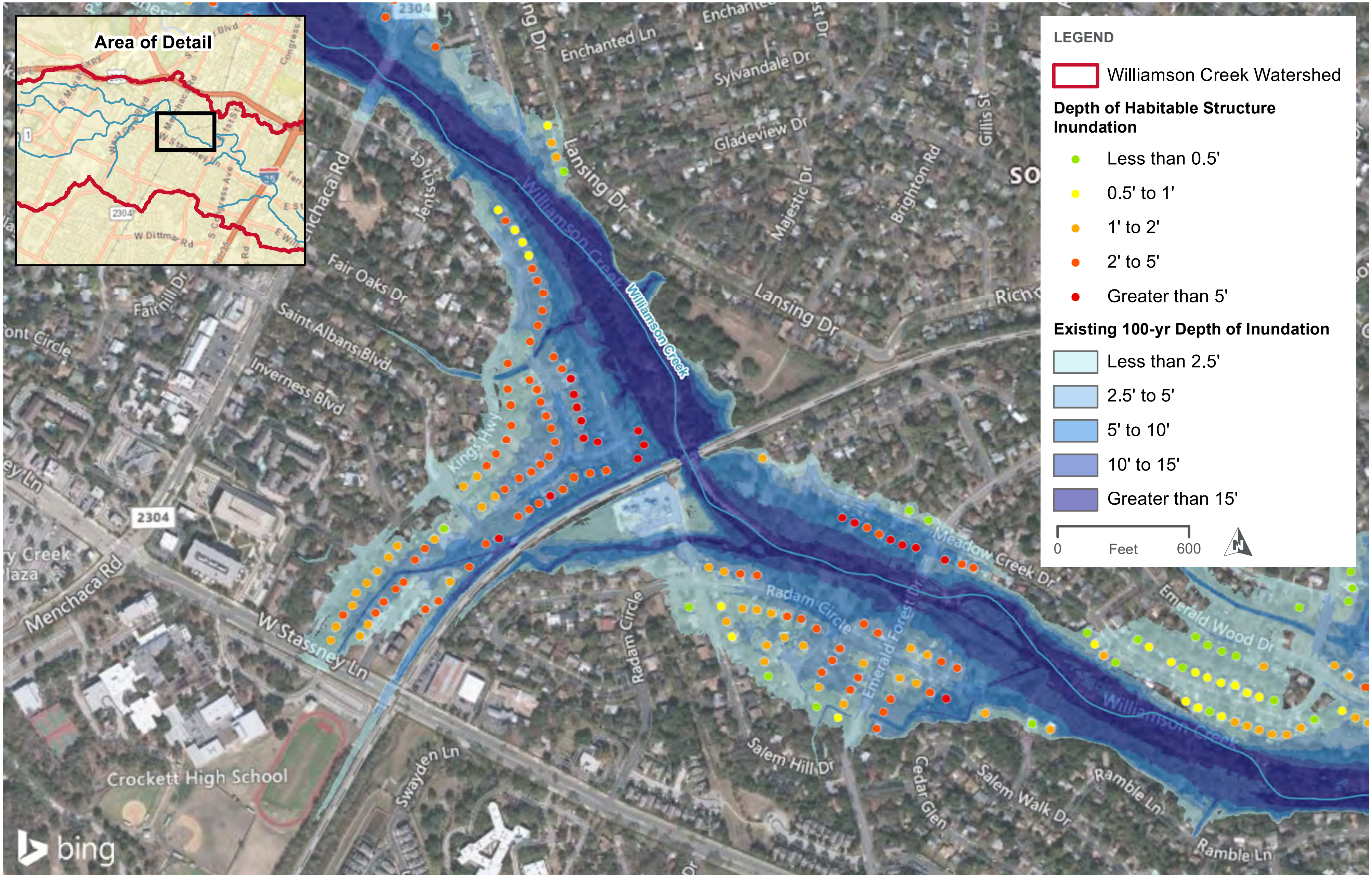

REVISED EXISTING 100-YEAR DEPTH OF INUNDATION (2 OF 3)

WILLIAMSON CREEK WATERSHED

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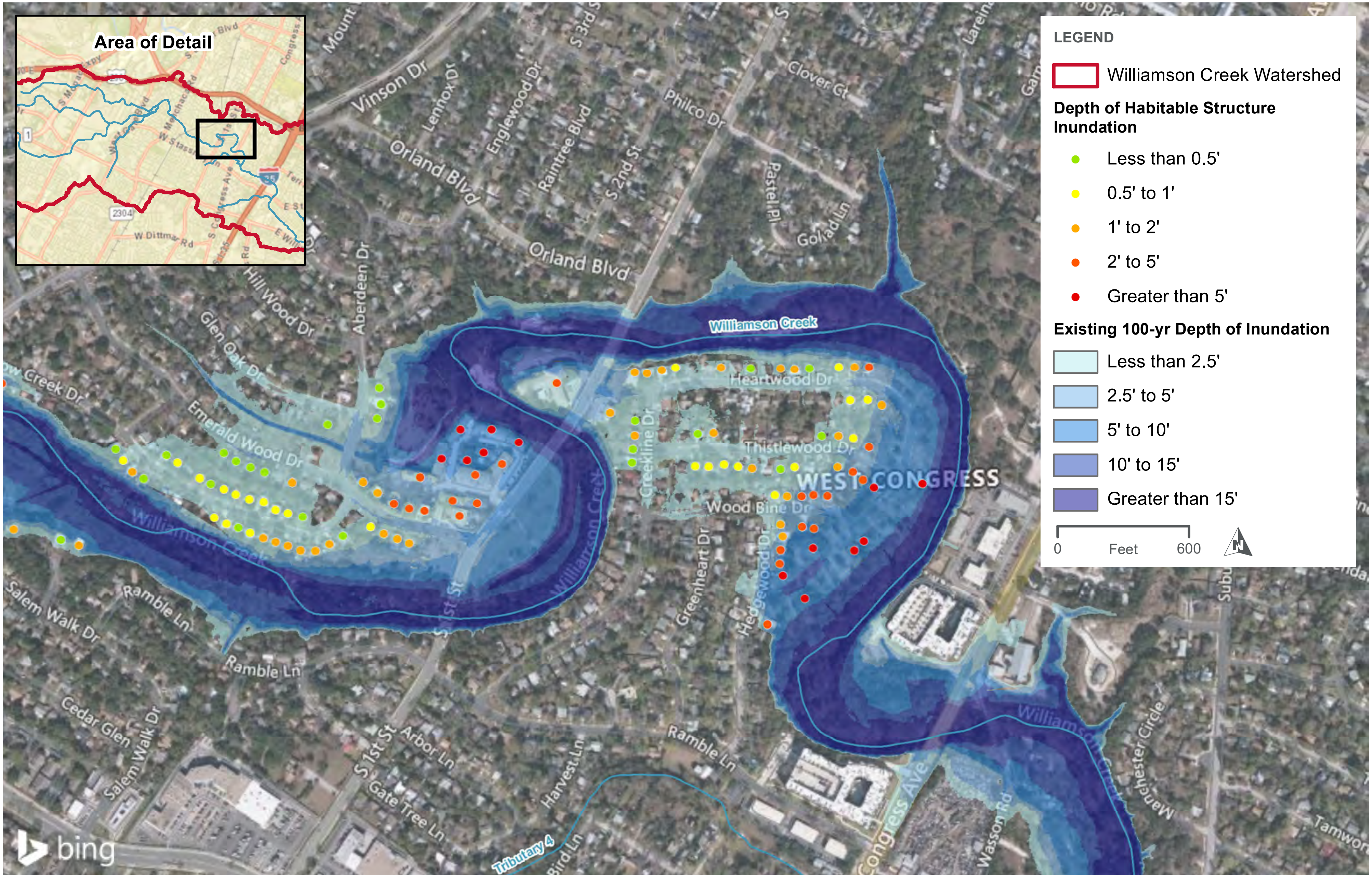

REVISED EXISTING 100-YEAR DEPTH OF INUNDATION (3 OF 3)

WILLIAMSON CREEK WATERSHED

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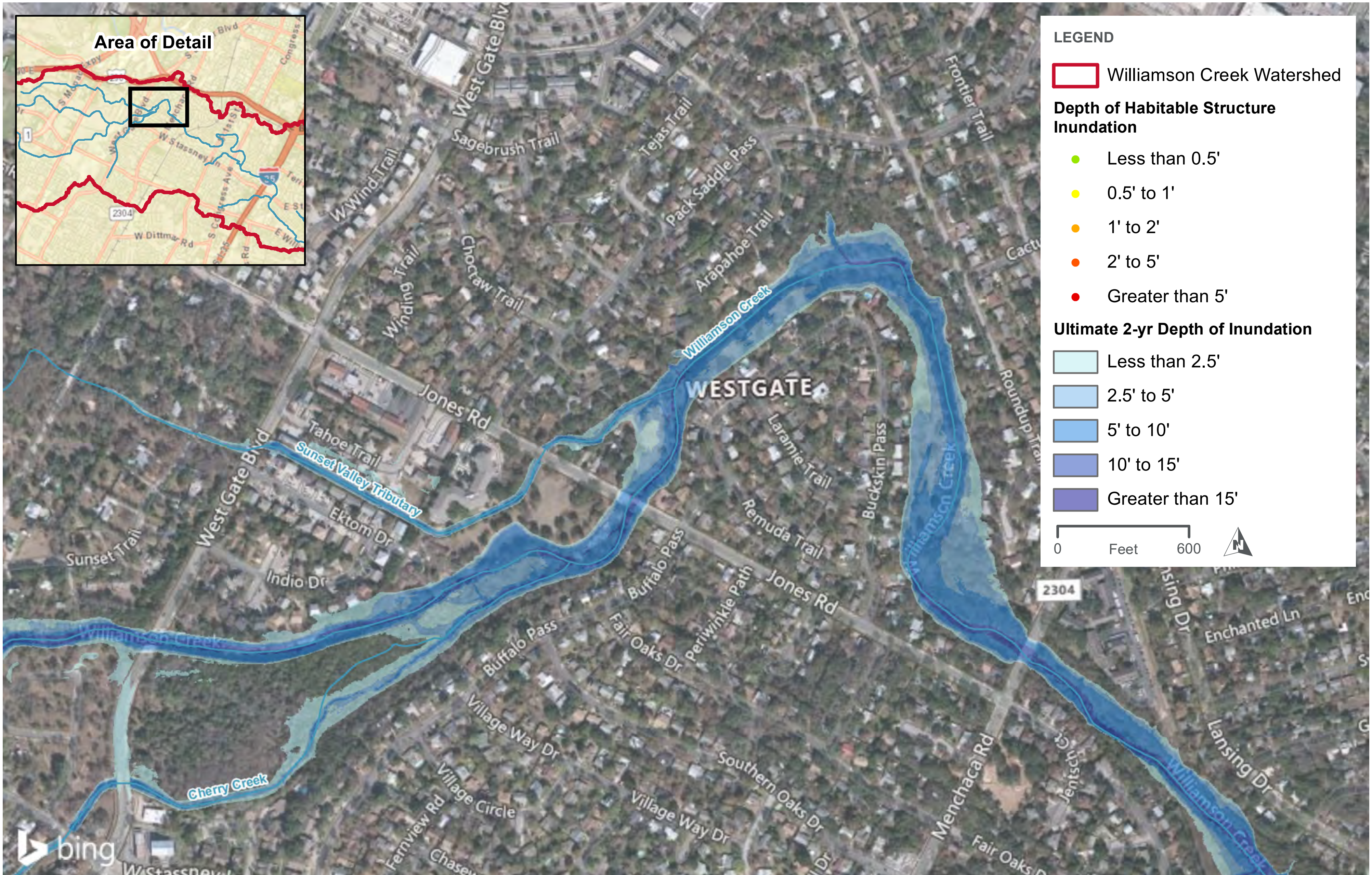

REVISED ULTIMATE 2-YEAR DEPTH OF INUNDATION (1 OF 3)

WILLIAMSON CREEK WATERSHED

EXHIBIT D-7

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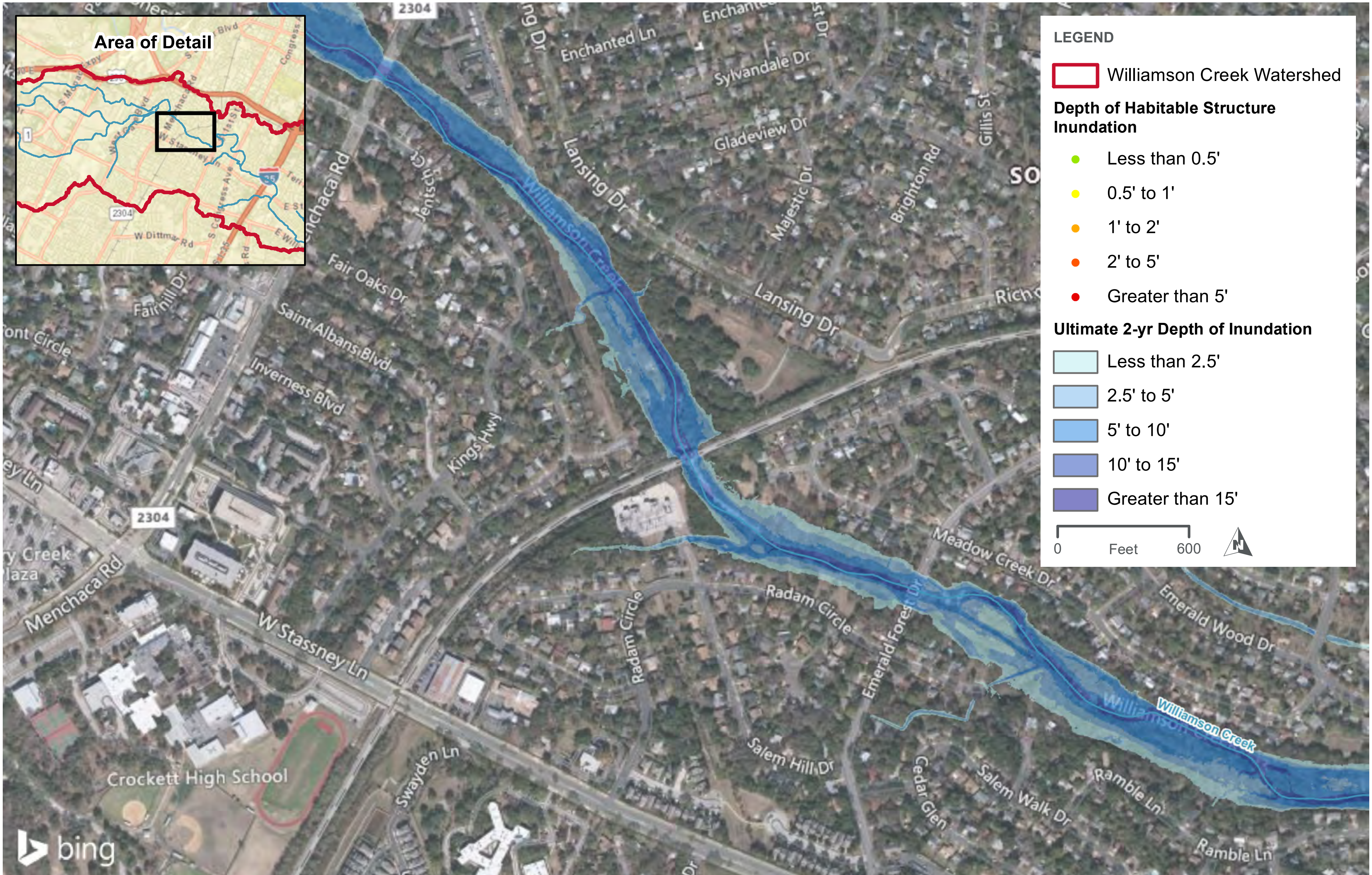

REVISED ULTIMATE 2-YEAR DEPTH OF INUNDATION (2 OF 3)

WILLIAMSON CREEK WATERSHED

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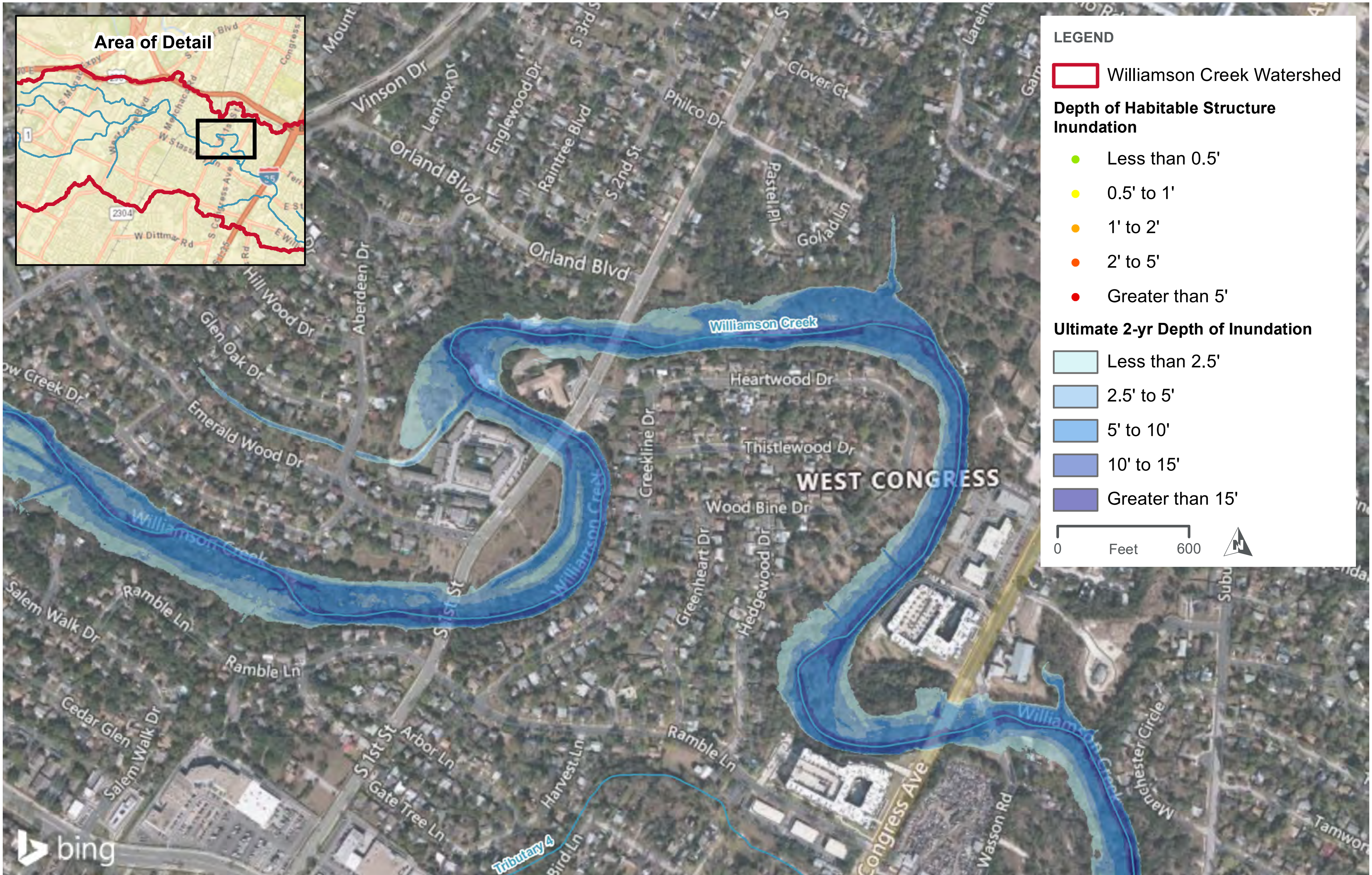
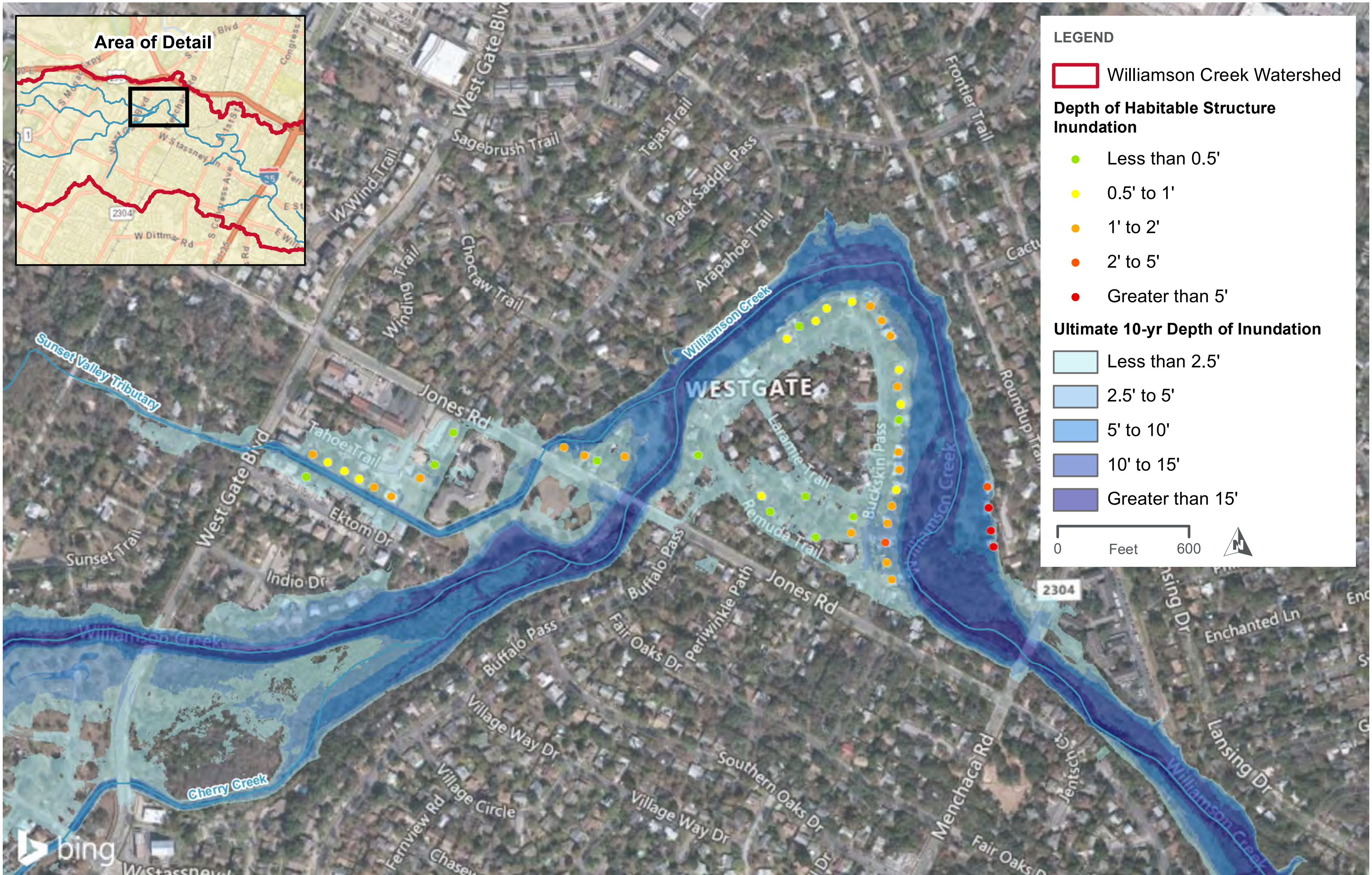


REVISED ULTIMATE 2-YEAR DEPTH OF INUNDATION (3 OF 3)

WILLIAMSON CREEK WATERSHED

EXHIBIT D-9



REVISED ULTIMATE 10-YEAR DEPTH OF INUNDATION (1 OF 3)

WILLIAMSON CREEK WATERSHED

EXHIBIT D-10

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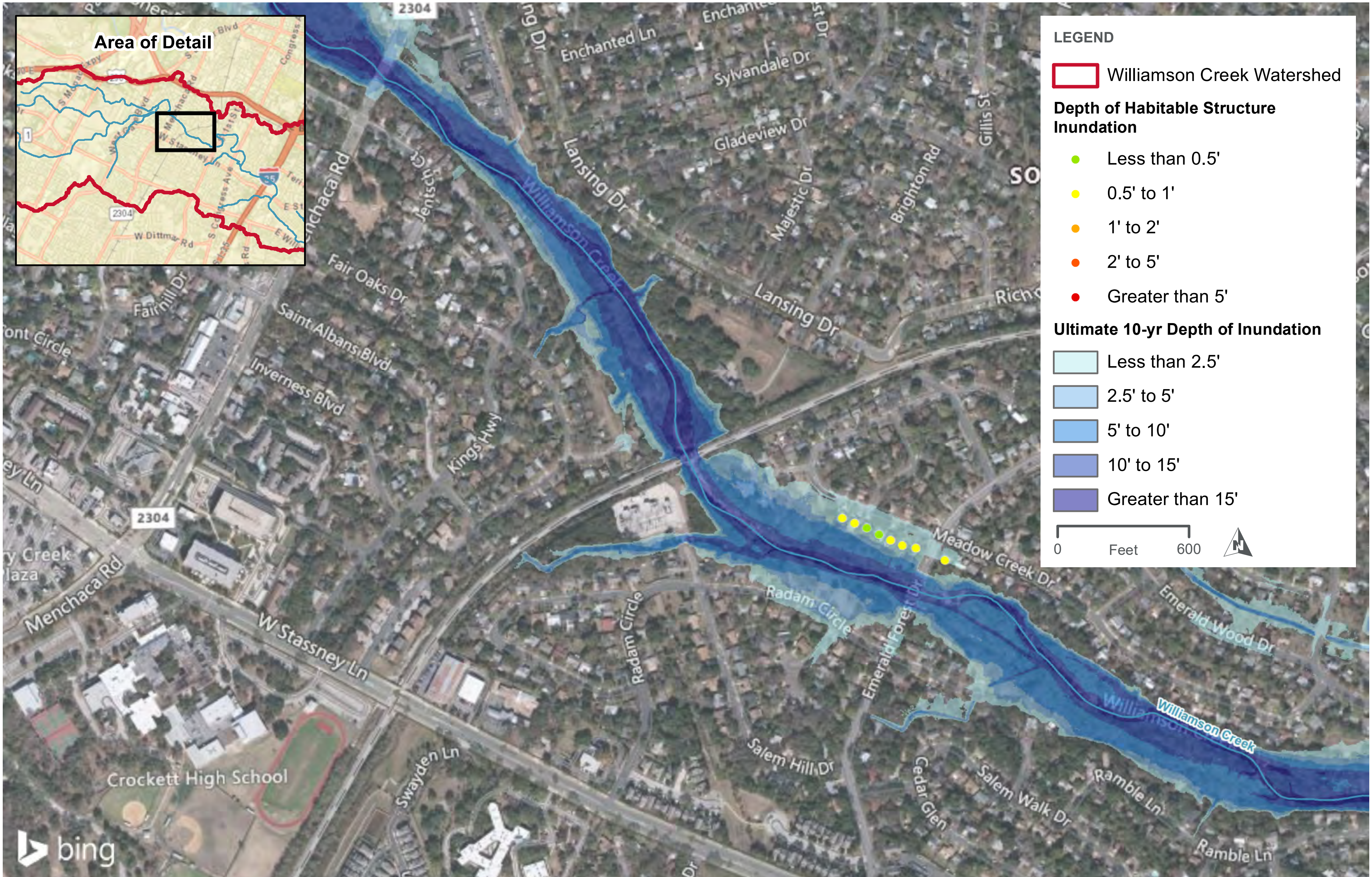

REVISED ULTIMATE 10-YEAR DEPTH OF INUNDATION (2 OF 3)

WILLIAMSON CREEK WATERSHED

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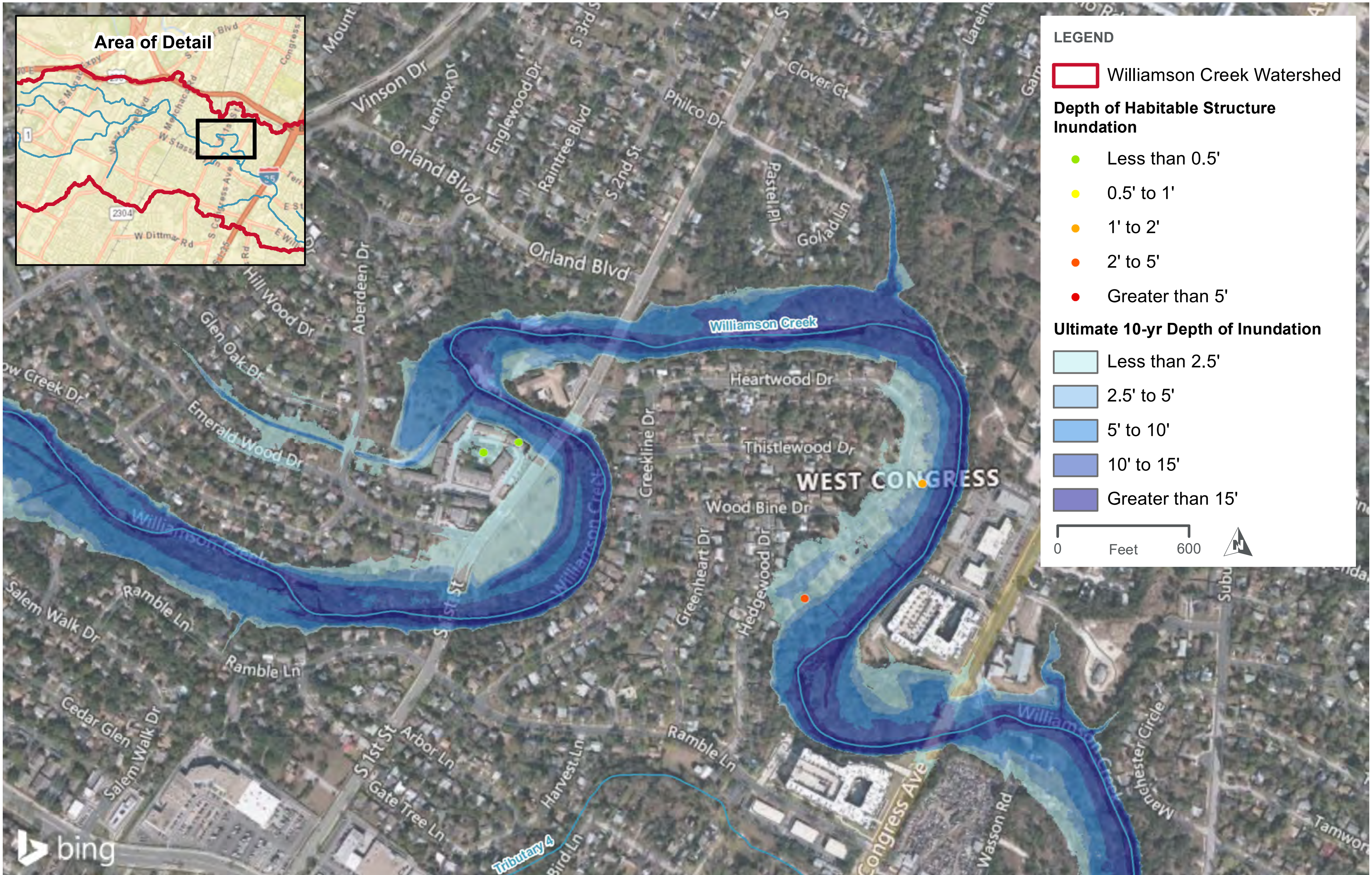

REVISED ULTIMATE 10-YEAR DEPTH OF INUNDATION (3 OF 3)

WILLIAMSON CREEK WATERSHED

EXHIBIT D-12

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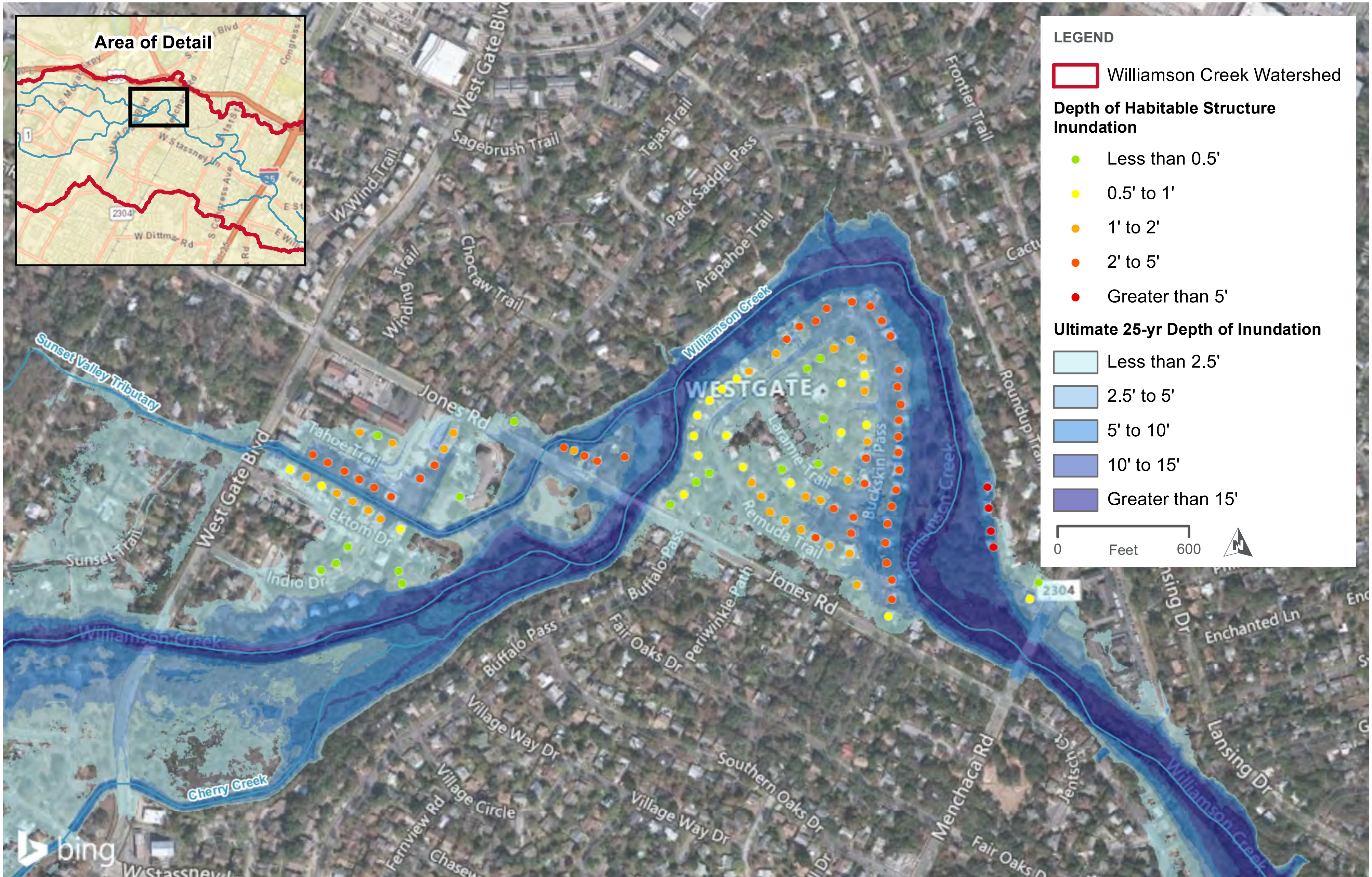
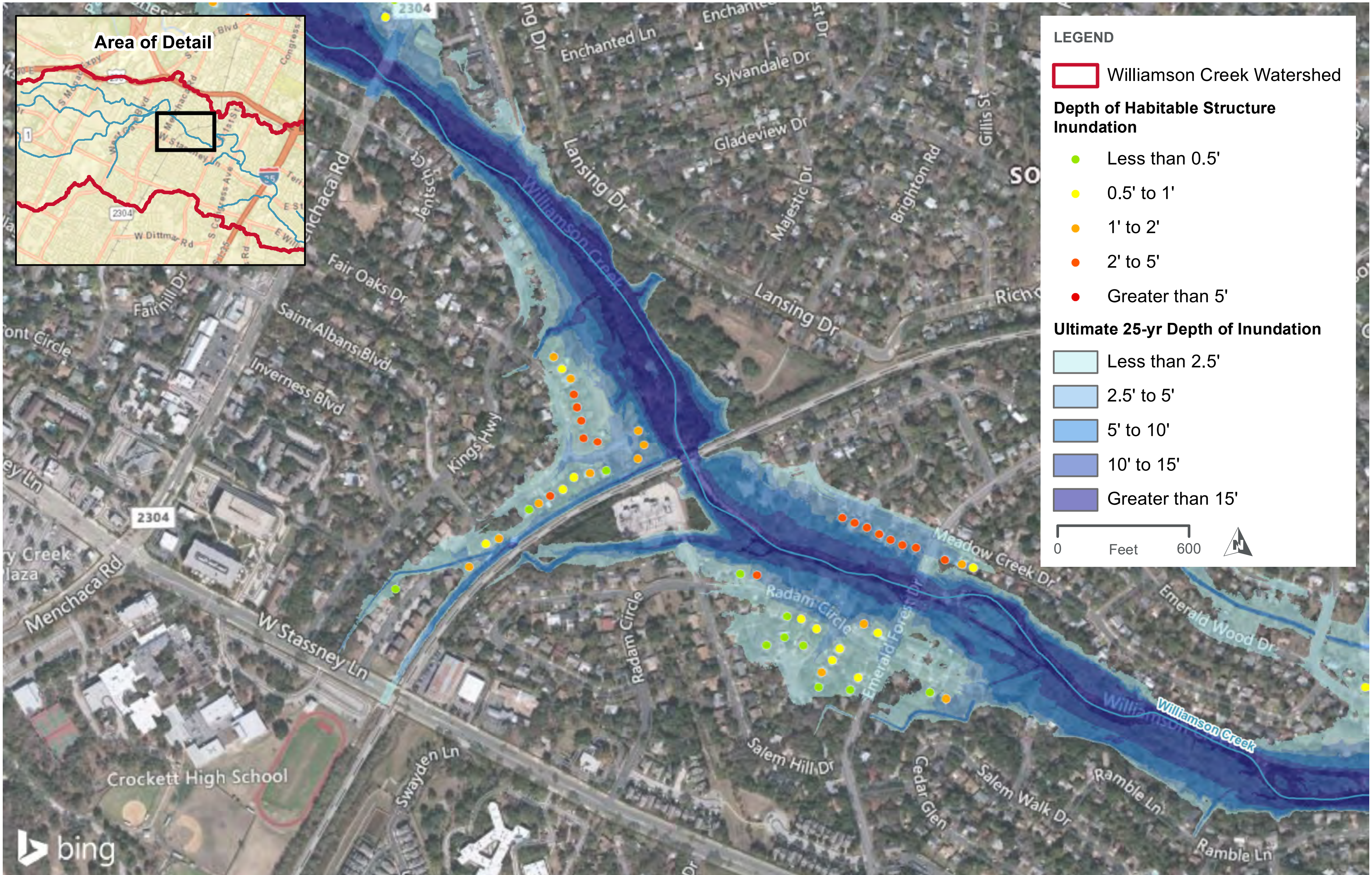


REVISED ULTIMATE 25-YEAR DEPTH OF INUNDATION (1 OF 3)

WILLIAMSON CREEK WATERSHED

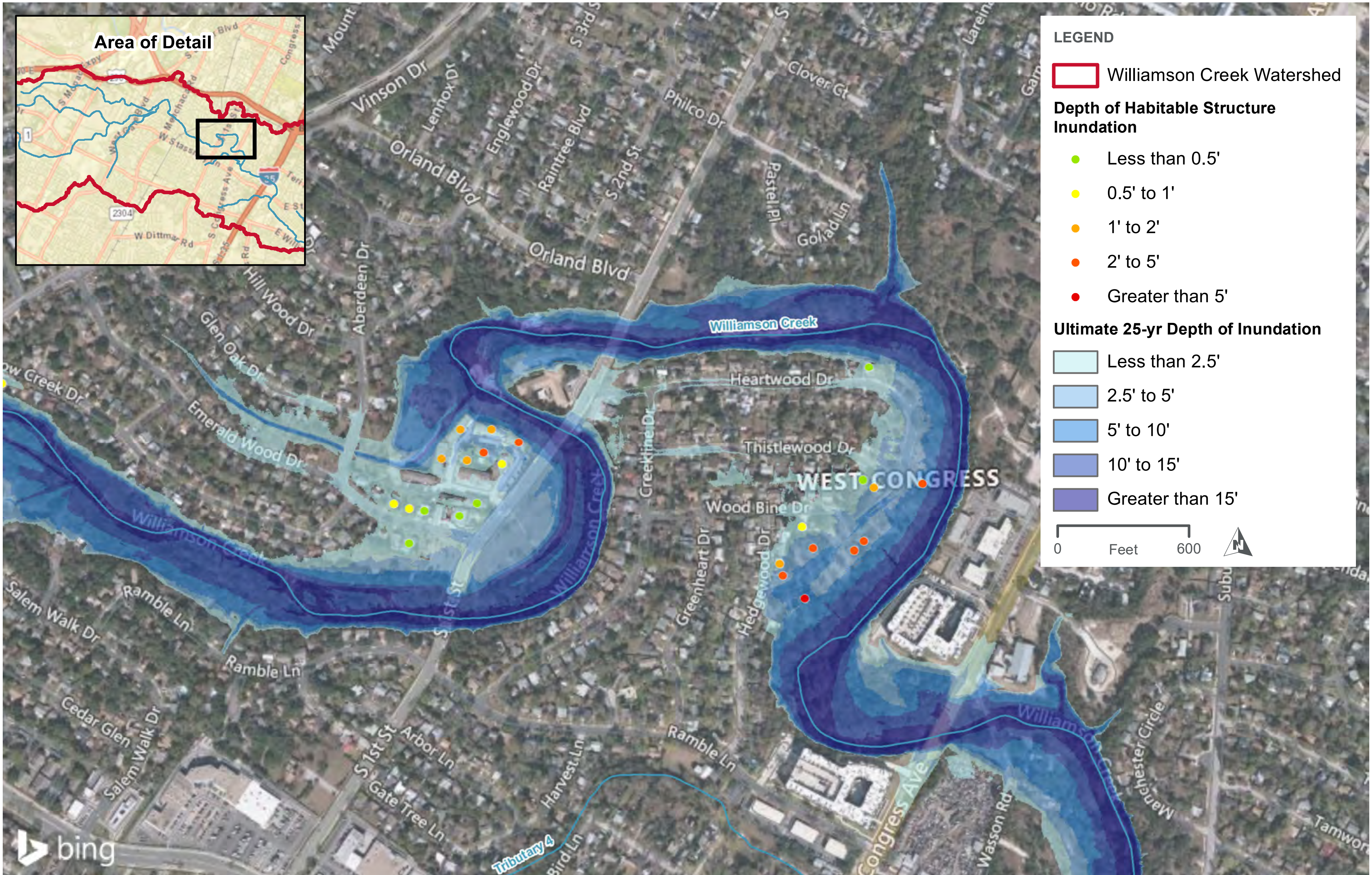
EXHIBIT D-13



REVISED ULTIMATE 25-YEAR DEPTH OF INUNDATION (2 OF 3)

WILLIAMSON CREEK WATERSHED

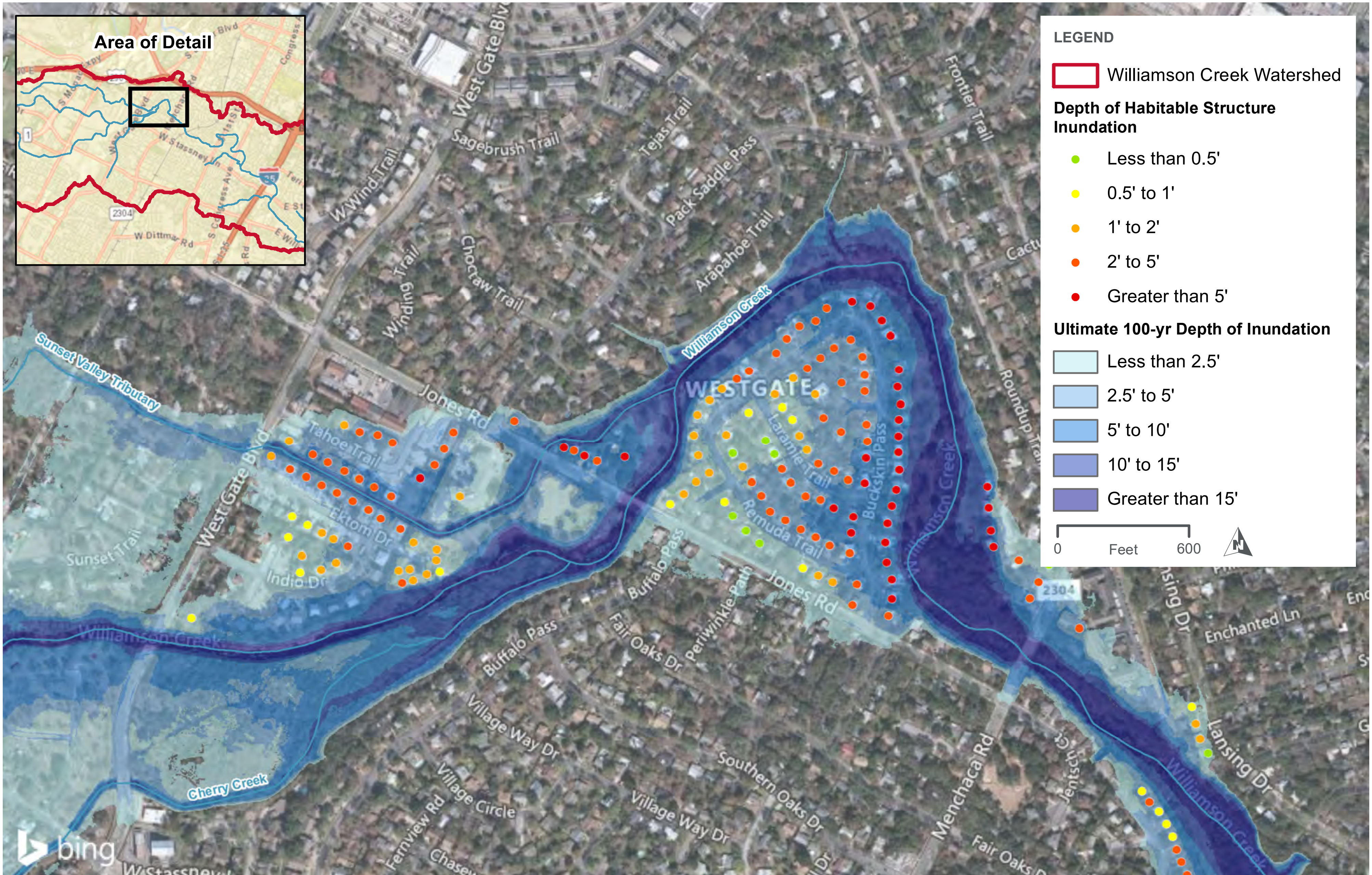
EXHIBIT D-14



REVISED ULTIMATE 25-YEAR DEPTH OF INUNDATION (3 OF 3)

WILLIAMSON CREEK WATERSHED

EXHIBIT D-15



REVISED ULTIMATE 100-YEAR DEPTH OF INUNDATION (1 OF 3)

WILLIAMSON CREEK WATERSHED

EXHIBIT D-16

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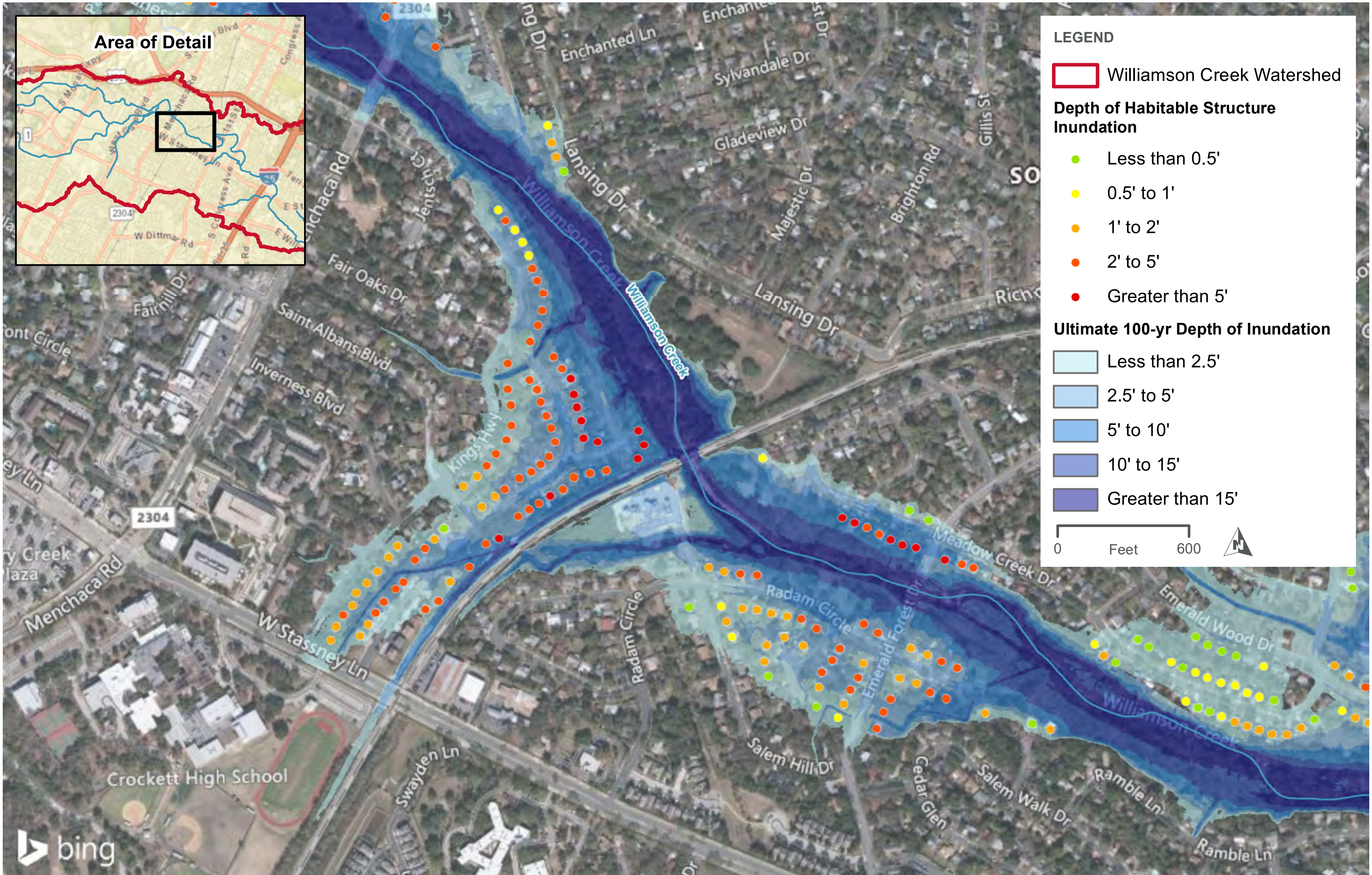

REVISED ULTIMATE 100-YEAR DEPTH OF INUNDATION (2 OF 3)

WILLIAMSON CREEK WATERSHED

EXHIBIT D-17

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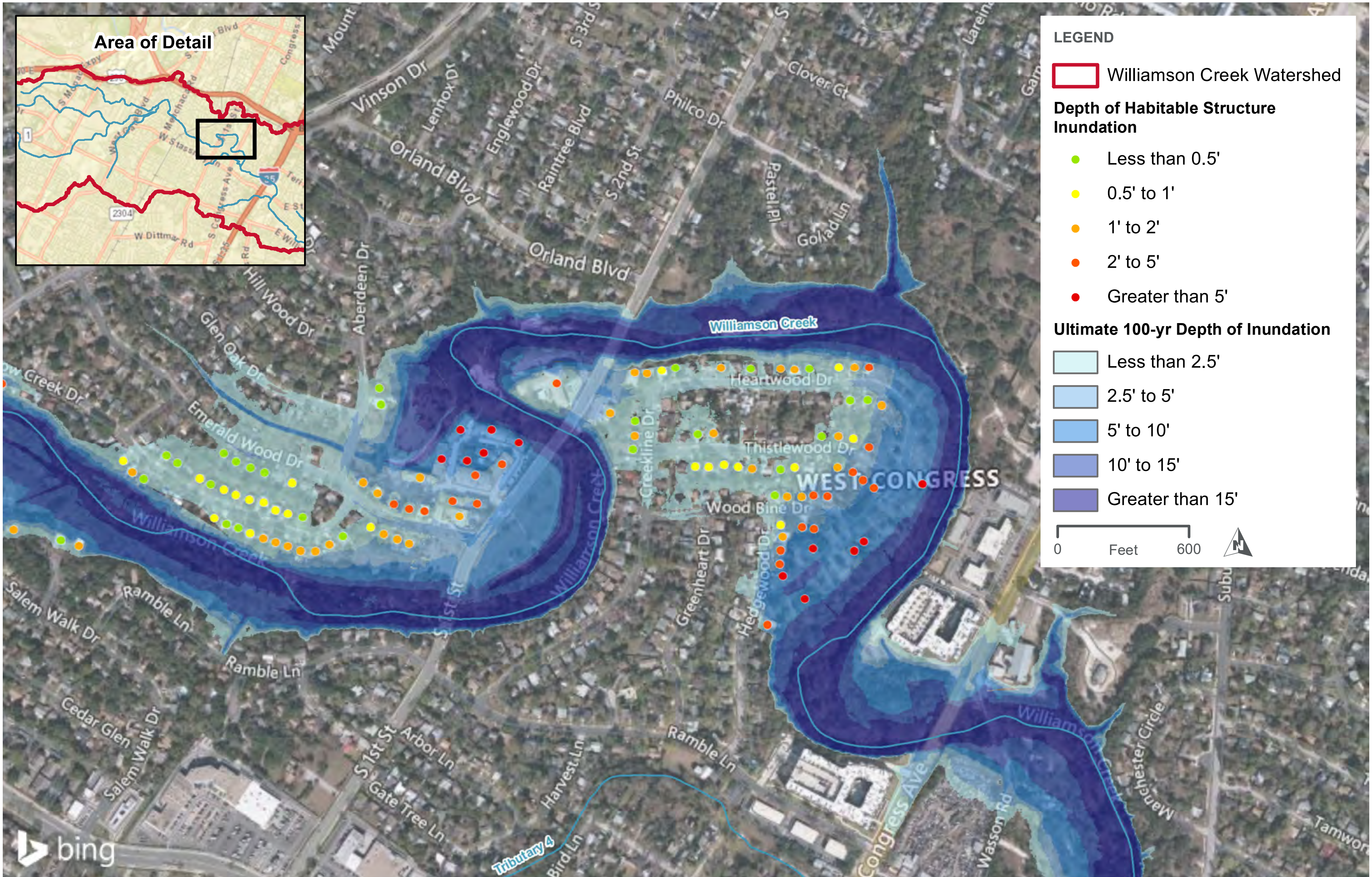

REVISED ULTIMATE 100-YEAR DEPTH OF INUNDATION (3 OF 3)

WILLIAMSON CREEK WATERSHED

EXHIBIT D-18

Appendix E. Revised Existing and Ultimate Habitable Structures FFE and Depth of Inundation Inventory

Table E-1. West Gate/Indio Inundated Structure Depth

Structure Address	Finished Floor Elevation (ft-msl)	25-YR Depth (ft)		100-YR Depth (ft)	
		Revised Existing	Revised Ultimate	Revised Existing	Revised Ultimate
2412 JONES RD	648.42	2.96	2.96	5.39	5.39
2414 JONES RD	649.76	2.26	2.26	4.87	4.88
2500 JONES RD	648.54	3.66	3.67	6.27	6.28
2502 JONES RD	650.44	2.00	2.00	4.61	4.62
2504 JONES RD	648.71	3.93	3.93	6.54	6.55
2603 EKTOM DR_A	657.97	0.33	0.34	2.03	2.04
2603 EKTOM DR_B	657.97	0.21	-	1.91	1.92
2603 EKTOM DR_C	657.97	0.07	-	1.73	1.74
2603 EKTOM DR_D	657.97	-	-	0.82	0.84
2603 EKTOM DR_E	657.97	0.13	-	1.82	1.84
2603 EKTOM DR_F	657.97	0.30	0.31	1.96	1.97
2603 EKTOM DR_G	657.97	-	-	1.50	1.51
2603 EKTOM DR_H	657.97	-	-	1.30	1.32
2603 EKTOM DR_I	657.97	-	-	1.63	1.64
2603 JONES RD	657.32	0.22	0.23	1.75	1.76
2604 EKTOM DR	656.88	0.81	0.81	2.78	2.80
2605 JONES RD_A	655.70	1.88	1.88	3.53	3.54
2605 JONES RD_B	655.61	-	1.85	3.21	3.22
2606 EKTOM DR	655.98	1.77	1.78	3.74	3.75
2607 EKTOM DR	658.37	-	-	1.75	1.76
2608 EKTOM DR	656.30	1.48	1.48	3.45	3.47
2609 EKTOM DR	657.81	0.37	0.37	2.13	2.14
2610 EKTOM DR	656.83	1.01	1.02	2.99	3.01
2611 EKTOM DR	658.78	-	-	1.41	1.42
2612 EKTOM DR	656.97	0.99	1.00	2.94	2.96
2613 EKTOM DR	659.33	-	-	0.87	0.89
2614 EKTOM DR	657.50	0.61	0.62	2.54	2.56
2615 EKTOM DR	659.76	-	-	0.52	0.54
2616 EKTOM DR	657.25	1.10	1.11	2.97	2.99
2618 EKTOM DR	657.85	0.58	0.59	2.49	2.51
2620 EKTOM DR	659.00	-	-	1.49	1.51
5003 PACK SADDLE PASS	652.95	0.11	0.10	2.62	2.63
5201 TAHOE TRL	655.65	2.01	2.01	3.83	3.84

Table E-1. West Gate/Indio Inundated Structure Depth

Structure Address	Finished Floor Elevation (ft-msl)	25-YR Depth (ft)		100-YR Depth (ft)	
		Revised Existing	Revised Ultimate	Revised Existing	Revised Ultimate
5203 TAHOE TRL	654.09	3.61	3.61	5.53	5.55
5207 TAHOE TRL	654.80	2.94	2.95	4.89	4.91
5208 TAHOE TRL	656.52	1.26	1.26	3.19	3.21
5209 TAHOE TRL	655.08	2.70	2.70	4.65	4.66
5210 TAHOE TRL	657.41	0.42	0.42	2.35	2.37
5211 TAHOE TRL	655.41	2.40	2.41	4.35	4.37
5212 TAHOE TRL	656.80	-	1.12	3.05	3.06
5213 TAHOE TRL	655.60	2.34	2.35	4.28	4.29
5214 TAHOE TRL	658.28	-	-	1.67	1.69
5215 TAHOE TRL	656.11	2.01	2.02	3.91	3.93
5217 TAHOE TRL	655.59	2.78	2.79	4.66	4.68
5221 TAHOE TRL	659.10	-	-	1.29	1.31
5300 INDIO CIR	660.06	-	-	0.55	0.56
5301 INDIO CIR	659.43	-	-	1.25	1.26
5302 INDIO DR	658.50	0.19	0.21	1.95	1.96
5303 INDIO CIR	660.06	-	-	0.70	0.71
5304 INDIO DR	658.76	0.04	0.05	1.76	1.77
5403 WEST GATE BLVD	662.05	-	-	0.66	0.68

Table E-2. Broken Bow Inundated Structure Depth

Structure Address	Finished Floor Elevation (ft-msl)	25-YR Depth (ft)		100-YR Depth (ft)	
		Revised Existing	Revised Ultimate	Revised Existing	Revised Ultimate
2200 LARAMIE TRL	643.40	2.16	2.14	5.17	5.15
2202 LARAMIE TRL	643.76	1.81	1.80	4.82	4.80
2202 REMUDA TRL	644.12	1.56	1.55	4.46	4.44
2203 LARAMIE TRL	643.48	2.16	2.14	5.10	5.08
2203 REMUDA TRL	646.57	-	-	1.97	1.96
2204 LARAMIE TRL	644.46	1.14	1.13	4.14	4.13
2204 REMUDA TRL	643.75	2.06	2.04	4.84	4.83
2205 LARAMIE TRL	644.45	1.34	1.33	4.16	4.14
2205 REMUDA TRL	647.02	-	-	1.54	1.52
2206 REMUDA TRL	644.70	1.36	1.35	3.92	3.90
2207 REMUDA TRL	647.90	-	-	0.67	0.65
2300 LARAMIE TRL	645.52	0.14	0.12	3.10	3.08
2300 REMUDA TRL	645.47	1.10	1.09	3.23	3.21
2301 LARAMIE TRL	644.56	1.60	1.59	4.11	4.10
2302 LARAMIE TRL	646.84	-	-	1.85	1.84
2302 REMUDA TRL	646.51	1.08	1.08	2.70	2.69
2303 LARAMIE TRL	645.72	0.99	0.98	3.09	3.08
2303 REMUDA TRL	648.75	-	-	0.22	0.20
2304 CHEYENNE CIR	645.35	0.75	0.74	3.41	3.40
2304 LARAMIE TRL	646.89	-	-	1.90	1.88
2304 REMUDA TRL	645.96	1.88	1.88	3.37	3.36
2305 CHEYENNE CIR	644.98	-	0.67	3.67	3.65
2305 LARAMIE TRL	646.62	0.46	0.46	2.32	2.31
2305 REMUDA TRL	649.17	-	-	0.46	0.45
2306 CHEYENNE CIR	646.96	-	-	1.94	1.93
2306 REMUDA TRL	647.01	1.15	1.15	2.46	2.45
2307 CHEYENNE CIR	645.94	0.15	0.13	2.80	2.79
2307 LARAMIE TRL	648.80	-	-	0.28	0.27
2307 REMUDA TRL	649.57	-	-	0.36	0.36
2309 REMUDA TRL	649.19	0.10	-	0.99	0.98
2400 LARAMIE TRL	647.90	-	-	1.00	0.99
2400 REMUDA TRL	647.76	0.75	0.75	1.96	1.95
2401 LARAMIE TRL	648.90	-	-	0.35	0.34

Table E-2. Broken Bow Inundated Structure Depth

Structure Address	Finished Floor Elevation (ft-msl)	25-YR Depth (ft)		100-YR Depth (ft)	
		Revised Existing	Revised Ultimate	Revised Existing	Revised Ultimate
2401 REMUDA TRL	649.03	0.46	0.46	1.33	1.33
2402 LARAMIE TRL	648.40	-	-	0.62	0.61
2402 REMUDA TRL	649.58	-	-	0.45	0.45
2403 REMUDA TRL	648.49	0.97	0.97	1.86	1.86
2404 LARAMIE TRL	648.10	-	-	1.12	1.10
2405 LARAMIE TRL	649.20	-	-	0.64	0.64
2405 REMUDA TRL	648.43	0.77	0.77	1.78	1.77
4800 BROKEN BOW PASS	643.30	3.00	2.98	5.57	5.55
4801 BROKEN BOW PASS	645.00	1.31	1.30	3.86	3.85
4801 BUCKSKIN PASS	642.60	3.63	3.62	6.25	6.24
4802 BROKEN BOW PASS	643.60	2.79	2.78	5.31	5.30
4802 BUCKSKIN PASS	645.00	1.25	1.24	3.82	3.80
4802 PAWNEE PATHWAY	638.46	7.01	7.00	9.85	9.84
4803 BUCKSKIN PASS	642.70	3.44	3.42	6.11	6.09
4804 BROKEN BOW PASS	644.30	2.36	2.35	4.70	4.68
4804 BUCKSKIN PASS	645.10	0.95	0.94	3.65	3.64
4804 PAWNEE PATHWAY	637.50	7.93	7.91	10.77	10.76
4805 BROKEN BOW PASS	645.18	1.61	1.60	3.85	3.83
4806 BROKEN BOW PASS	644.40	2.44	2.43	4.65	4.64
4806 BUCKSKIN PASS	644.60	1.25	1.23	4.09	4.08
4806 PAWNEE PATHWAY	637.00	8.38	8.36	11.22	11.20
4807 BROKEN BOW PASS	646.90	0.25	0.24	2.21	2.20
4807 BUCKSKIN PASS	642.60	3.34	3.32	6.12	6.11
4808 BROKEN BOW PASS	645.10	2.03	2.02	4.05	4.04
4808 PAWNEE PATHWAY	636.70	8.64	8.62	11.47	11.46
4809 BUCKSKIN PASS	641.90	3.91	3.90	6.77	6.75
4809 PAWNEE PATHWAY	645.05	-	-	2.13	2.12
4811 BUCKSKIN PASS	642.20	3.48	3.47	6.42	6.41
4900 BROKEN BOW PASS	645.20	2.14	2.13	4.03	4.02
4900 BUCKSKIN PASS	644.74	0.97	0.96	3.91	3.89
4901 BROKEN BOW PASS	646.90	0.24	0.23	2.19	2.18
4901 BUCKSKIN PASS	642.60	3.02	3.00	5.99	5.98
4902 BROKEN BOW PASS	646.00	1.46	1.45	3.28	3.27

Table E-2. Broken Bow Inundated Structure Depth

Structure Address	Finished Floor Elevation (ft-msl)	25-YR Depth (ft)		100-YR Depth (ft)	
		Revised Existing	Revised Ultimate	Revised Existing	Revised Ultimate
4902 BUCKSKIN PASS	644.20	1.40	1.39	4.41	4.39
4903 BROKEN BOW PASS	647.30	-	-	1.82	1.80
4903 BUCKSKIN PASS	642.80	2.76	2.75	5.76	5.75
4904 BUCKSKIN PASS	643.20	2.37	2.36	5.38	5.37
4904 MENCHACA RD	646.04	-	-	0.33	0.32
4905 BUCKSKIN PASS	641.50	4.05	4.03	7.05	7.03
4906 BROKEN BOW PASS	647.00	1.15	1.14	2.62	2.61
4906 MENCHACA RD	643.46	0.43	0.42	2.93	2.92
4907 BUCKSKIN PASS	641.50	4.03	4.02	7.03	7.02
4908 BROKEN BOW PASS	647.60	0.88	0.88	2.29	2.28
4908 MENCHACA RD	643.08	0.92	0.90	3.19	3.18
4909 BUCKSKIN PASS	641.80	3.73	3.71	6.74	6.72
4911 BUCKSKIN PASS	641.40	4.11	4.09	7.13	7.11
5000 BROKEN BOW PASS	648.18	0.55	0.55	1.84	1.83
5000 BUCKSKIN PASS	642.60	2.98	2.96	5.96	5.95
5001 BUCKSKIN PASS	641.10	4.38	4.37	7.41	7.39
5002 BROKEN BOW PASS	648.40	0.72	0.72	1.77	1.77
5002 BUCKSKIN PASS	641.80	3.77	3.75	6.76	6.75
5002 BUFFALO PASS	649.48	0.32	0.33	1.09	1.09
5003 BUCKSKIN PASS	640.60	4.88	4.86	7.90	7.89
5004 BROKEN BOW PASS	648.62	0.55	0.55	1.58	1.57
5004 BUCKSKIN PASS	643.78	1.77	1.76	4.77	4.75
5004 BUFFALO PASS	650.56	0.59	0.59	1.18	1.18
5005 BROKEN BOW PASS	648.64	0.52	0.52	1.57	1.56
5005 BUCKSKIN PASS	641.30	4.15	4.14	7.20	7.18
5006 BUCKSKIN PASS	643.52	1.98	1.97	4.98	4.97
5006 BUFFALO PASS	651.12	0.17	0.18	0.72	0.72
5007 BUCKSKIN PASS	640.80	4.44	4.42	7.25	7.23
5008 BUCKSKIN PASS	645.68	-	-	2.81	2.80
5009 BUCKSKIN PASS	642.80	2.61	2.60	5.69	5.67
5011 BUCKSKIN PASS	644.60	0.79	0.77	3.87	3.86

Table E-3. Radam Inundated Structure Depth

Structure Address	Finished Floor Elevation (ft-msl)	25-YR Depth (ft)		100-YR Depth (ft)	
		Revised Existing	Revised Ultimate	Revised Existing	Revised Ultimate
1101 RADAM CIR	625.62	-	-	1.73	1.68
1105 RADAM CIR	622.70	1.48	1.37	5.04	4.99
1106 RADAM CIR	624.81	-	-	2.77	2.71
1107 RADAM CIR	624.58	0.47	0.38	3.50	3.45
1108 RADAM CIR	625.73	-	-	2.24	2.19
1109 RADAM CIR	627.00	-	-	1.45	1.40
1110 RADAM CIR	626.48	-	-	1.82	1.77
1111 RADAM CIR	627.81	-	-	1.22	1.18
1112 RADAM CIR	627.47	-	-	1.25	1.21
1200 RADAM CIR	627.75	0.59	0.54	2.17	2.14
1202 RADAM CIR	626.99	1.78	1.73	3.37	3.34
1207 RADAM CIR	628.25	0.56	0.52	2.11	2.08
1209 RADAM CIR	628.15	0.70	0.65	2.26	2.23
1211 RADAM CIR	628.39	0.46	0.41	2.03	2.00
1213 RADAM CIR	628.83	0.02	-	1.62	1.59
1215 RADAM CIR	629.23	-	-	1.26	1.23
1216 RADAM CIR	626.74	2.27	2.22	4.07	4.04
1217 RADAM CIR	629.57	-	-	1.04	1.01
1218 RADAM CIR	628.87	0.33	0.28	2.22	2.19
1220 RADAM CIR	629.39	-	-	1.78	1.75
1222 RADAM CIR	629.55	-	-	1.71	1.68
4900 S 1ST ST	615.80	-	-	2.59	2.52
5005 ABERDEEN DR	617.04	-	-	0.18	0.01
5007 ABERDEEN DR	616.93	-	-	0.36	0.19
5009 ABERDEEN DR	617.27	-	-	0.07	-
5105 MEADOW CREEK DR	621.15	-	-	0.15	0.10
5107 MEADOW CREEK DR	621.23	-	-	1.11	1.06
5109 MEADOW CREEK DR	621.30	-	-	1.14	1.09
5111 MEADOW CREEK DR	621.21	-	-	1.47	1.42
5112 MEADOW CREEK DR	621.87	-	-	0.46	0.42
5112 S 1ST ST_A	616.42	-	-	2.19	2.09
5112 S 1ST ST_B	616.29	0.44	0.39	2.55	2.47
5112 S 1ST ST_C	615.47	-	-	2.07	1.92

Table E-3. Radam Inundated Structure Depth

Structure Address	Finished Floor Elevation (ft-msl)	25-YR Depth (ft)		100-YR Depth (ft)	
		Revised Existing	Revised Ultimate	Revised Existing	Revised Ultimate
5112 S 1ST ST_D	610.79	1.26	1.17	6.58	6.42
5112 S 1ST ST_E	615.22	-	-	2.97	2.84
5112 S 1ST ST_F	611.31	1.24	1.16	6.27	6.11
5112 S 1ST ST_G	610.43	2.64	2.57	7.15	7.00
5112 S 1ST ST_H	610.24	1.71	1.62	6.98	6.81
5112 S 1ST ST_I	610.19	1.63	1.51	7.14	6.97
5112 S 1ST ST_J	612.17	2.13	2.13	5.51	5.36
5112 S 1ST ST_K	613.73	0.88	0.85	4.44	4.32
5113 MEADOW CREEK DR	621.24	-	-	1.56	1.51
5114 MEADOW CREEK DR	622.23	-	-	0.66	0.61
5115 MEADOW CREEK DR	621.71	-	-	1.20	1.15
5116 MEADOW CREEK DR	622.09	-	-	0.84	0.80
5117 MEADOW CREEK DR	621.88	-	-	1.21	1.15
5118 MEADOW CREEK DR	622.06	-	-	0.88	0.84
5119 MEADOW CREEK DR	622.52	-	-	0.67	0.62
5120 MEADOW CREEK DR	622.25	-	-	0.86	0.82
5121 MEADOW CREEK DR	622.93	-	-	0.42	0.38
5122 MEADOW CREEK DR	622.68	-	-	0.70	0.67
5123 MEADOW CREEK DR	622.92	-	-	0.53	0.49
5124 MEADOW CREEK DR	622.58	-	-	0.87	0.83
5125 MEADOW CREEK DR	622.82	-	-	0.74	0.70
5126 MEADOW CREEK DR	623.44	-	-	0.19	0.16
5128 MEADOW CREEK DR	623.12	-	-	0.81	0.78
5132 MEADOW CREEK DR	624.26	-	-	0.52	0.48
5134 MEADOW CREEK DR	624.73	-	-	0.42	0.38
5137 MEADOW CREEK DR	625.21	-	-	0.21	0.17
5139 MEADOW CREEK DR	624.54	-	-	1.23	1.19
5141 MEADOW CREEK DR	625.09	-	-	0.98	0.93
5143 MEADOW CREEK DR	626.22	-	-	0.05	-
5208 EMERALD FOREST DR	630.52	-	-	0.08	0.06
5219 MEADOW CREEK DR	627.17	0.92	0.86	2.88	2.86
5221 MEADOW CREEK DR	626.59	1.66	1.60	3.59	3.56
5223 MEADOW CREEK DR	624.92	3.55	3.49	5.45	5.42

Table E-3. Radam Inundated Structure Depth

Structure Address	Finished Floor Elevation (ft-msl)	25-YR Depth (ft)		100-YR Depth (ft)	
		Revised Existing	Revised Ultimate	Revised Existing	Revised Ultimate
5225 MEADOW CREEK DR	625.06	3.61	3.55	5.54	5.51
5226 MEADOW CREEK DR	630.43	-	-	0.22	0.20
5227 MEADOW CREEK DR	624.82	3.88	3.82	5.81	5.78
5229 MEADOW CREEK DR	625.22	3.51	3.45	5.44	5.41
5231 MEADOW CREEK DR	625.96	2.84	2.79	4.74	4.71
5233 MEADOW CREEK DR	625.95	2.92	2.87	4.79	4.76
5235 MEADOW CREEK DR	625.51	3.41	3.36	5.26	5.23
5237 MEADOW CREEK DR	625.72	3.23	3.18	5.07	5.04
5304 MEADOW CREEK CIR	630.31	-	-	1.01	0.98
5400 EMERALD FOREST DR	628.14	0.05	-	1.48	1.45
5400 JEFFBURN CV	625.73	-	-	0.30	0.25
5400 SALEM HILL DR	630.81	-	-	0.33	0.30
5401 HUNTERS GLN	627.88	0.87	0.83	2.36	2.34
5401 JEFFBURN CV	624.41	-	-	1.39	1.34
5401 SALEM HILL DR	630.24	-	-	0.78	0.75
5402 EMERALD FOREST DR	627.28	0.91	0.87	2.21	2.18
5403 HUNTERS GLN	627.72	1.03	0.98	2.53	2.50
5403 SALEM HILL DR	629.60	-	-	1.05	1.02
5404 EMERALD FOREST DR	627.40	0.48	0.44	2.14	2.10
5404 HUNTERS GLN	628.43	0.34	0.29	1.86	1.83
5405 EMERALD FOREST DR	625.94	-	-	2.89	2.85
5405 HUNTERS GLN	627.67	1.07	1.03	2.56	2.53
5405 SALEM HILL DR	629.57	-	-	0.98	0.95
5406 EMERALD FOREST DR	628.28	-	-	1.10	1.06
5406 HUNTERS GLN	628.49	0.28	0.24	1.84	1.81
5407 EMERALD FOREST DR	625.13	-	-	3.71	3.66
5407 HUNTERS GLN	628.57	0.12	0.07	1.58	1.55
5408 EMERALD FOREST DR	628.63	-	-	0.64	0.60
5408 HUNTERS GLN	628.51	0.26	0.21	1.87	1.84
5409 EMERALD FOREST DR	626.65	-	-	2.29	2.25
5409 HUNTERS GLN	629.51	-	-	0.43	0.40
5410 HUNTERS GLN	629.27	-	-	1.08	1.05
5412 HUNTERS GLN	630.22	-	-	0.10	0.07

Table E-3. Radam Inundated Structure Depth

Structure Address	Finished Floor Elevation (ft-msl)	25-YR Depth (ft)		100-YR Depth (ft)	
		Revised Existing	Revised Ultimate	Revised Existing	Revised Ultimate
610 EMERALD WOOD DR	616.91	0.16	0.12	2.02	1.94
700 EMERALD WOOD DR	616.78	0.54	0.50	2.25	2.17
701 EMERALD WOOD DR	617.79	0.13	0.10	1.66	1.60
702 EMERALD WOOD DR	616.69	0.64	0.59	2.28	2.20
703 EMERALD WOOD DR	618.27	-	-	1.35	1.29
704 EMERALD WOOD DR	616.32	0.86	0.81	2.14	2.04
705 EMERALD WOOD DR	618.27	0.08	-	1.70	1.65
706 EMERALD WOOD DR	616.36	-	-	1.60	1.47
707 EMERALD WOOD DR	619.54	-	-	0.76	0.71
708 EMERALD WOOD DR	616.04	-	-	1.62	1.48
803 GLEN OAK DR	617.39	-	-	0.11	-
805 EMERALD WOOD DR	620.60	-	-	1.03	1.00
809 EMERALD WOOD DR	621.27	-	-	0.49	0.45
811 EMERALD WOOD DR	621.52	-	-	0.48	0.44
813 EMERALD WOOD DR	621.97	-	-	0.21	-
815 EMERALD WOOD DR	622.27	-	-	0.15	-

Table E-4. Heartwood Inundated Structure Depth

Structure Address	Finished Floor Elevation (ft-msl)	25-YR Depth (ft)		100-YR Depth (ft)	
		Revised Existing	Revised Ultimate	Revised Existing	Revised Ultimate
204 HEARTWOOD DR	596.50	5.38	5.31	8.66	8.52
209 HEARTWOOD DR	598.97	3.11	3.04	6.34	6.20
214 HEARTWOOD DR	599.63	2.53	2.46	5.72	5.58
300 HEARTWOOD DR	599.29	2.93	2.86	6.09	5.95
301 THISTLEWOOD DR	600.52	1.91	1.84	5.02	4.88
303 THISTLEWOOD DR	602.05	0.42	0.35	3.52	3.38
303 WOOD BINE DR	602.11	0.01	-	3.24	3.10
304 THISTLEWOOD DR	603.12	-	-	2.57	2.43
304 WOOD BINE DR	602.52	-	-	2.90	2.76
305 THISTLEWOOD DR	603.37	-	-	2.20	2.06
305 WOOD BINE DR	601.34	0.75	0.67	4.00	3.86
306 THISTLEWOOD DR	604.83	-	-	0.88	0.74
306 WOOD BINE DR	603.05	-	-	2.34	2.20
307 THISTLEWOOD DR	603.98	-	-	1.56	1.43
308 THISTLEWOOD DR	603.89	-	-	1.75	1.61
308 WOOD BINE DR	603.34	-	-	2.05	1.91
310 THISTLEWOOD DR	605.27	-	-	0.33	0.22
310 WOOD BINE DR	603.87	-	-	1.56	1.42
312 HEARTWOOD DR	598.28	4.35	4.28	7.46	7.33
312 WOOD BINE DR	604.83	-	-	0.57	0.44
323 HEARTWOOD DR	604.03	-	-	1.97	1.84
325 HEARTWOOD DR	605.51	-	-	0.56	0.43
327 HEARTWOOD DR	605.70	-	-	0.52	0.40
330 HEARTWOOD DR	604.07	0.13	0.08	2.43	2.31
332 HEARTWOOD DR	605.54	-	-	1.18	1.07
334 HEARTWOOD DR	606.37	-	-	0.72	0.61
402 HEARTWOOD DR	608.15	-	-	0.20	0.13
403 THISTLEWOOD DR	604.90	-	-	0.79	0.69
404 HEARTWOOD DR	607.47	-	-	1.60	1.53
405 THISTLEWOOD DR	605.74	-	-	0.22	0.14
406 HEARTWOOD DR	607.48	-	-	1.57	1.50
409 THISTLEWOOD DR	608.05	-	-	1.59	1.56
410 HEARTWOOD DR	610.42	-	-	0.16	0.03

Table E-4. Heartwood Inundated Structure Depth

Structure Address	Finished Floor Elevation (ft-msl)	25-YR Depth (ft)		100-YR Depth (ft)	
		Revised Existing	Revised Ultimate	Revised Existing	Revised Ultimate
411 THISTLEWOOD DR	610.20	-	-	0.86	0.84
412 THISTLEWOOD DR	611.58	-	-	1.86	1.83
413 THISTLEWOOD DR	611.58	-	-	0.61	0.58
414 HEARTWOOD DR	610.42	-	-	1.51	1.43
414 THISTLEWOOD DR	613.84	-	-	0.41	0.38
415 THISTLEWOOD DR	612.98	-	-	0.55	0.53
417 THISTLEWOOD DR	613.84	-	-	0.68	0.64
4901 S 1ST ST	613.24	-	-	1.67	1.52
4902 CREEKLINE DR	614.95	-	-	0.35	0.30
4904 CREEKLINE DR	614.35	-	-	1.07	1.07
4906 CREEKLINE DR	615.51	-	-	0.46	0.43
500 HEARTWOOD DR	613.11	-	-	0.57	0.43
5000 CREEKLINE DR	616.33	-	-	0.02	-
5001 HEDGEWOOD DR	604.30	-	-	1.02	0.87
5003 HEDGEWOOD DR	603.33	-	-	1.96	1.82
5005 HEDGEWOOD DR	601.90	0.06	-	3.32	3.18
5007 HEDGEWOOD DR	600.66	1.23	1.16	4.52	4.37
5009 HEDGEWOOD DR	599.17	2.72	2.65	6.00	5.86
502 HEARTWOOD DR	613.11	-	-	1.05	0.88
504 HEARTWOOD DR	613.11	-	-	1.37	1.20
506 HEARTWOOD DR	613.11	-	-	1.47	1.29
5103 HEDGEWOOD DR	602.82	-	-	2.27	2.12

Appendix F. Public Engagement Results and Discussion

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Williamson Creek Flood Risk Reduction- History of Public Engagement

There is a long history of public communication regarding flooding risk in the area. This history includes both outreach efforts initiated by the City of Austin (COA) and other entities as part of flood reduction projects, as well as community involvement in the maintenance of the green spaces in the adjacent area. This section of the report attempts to provide some of the highlights of flood related public outreach.

After significant flooding of Williamson Creek in 1998 and 2001, the COA partnered with the United States Army Corps of Engineers (USACE) to research ways to reduce flooding. During the original study, which began in 1999 as a reconnaissance study and in 2000 as a feasibility, the USACE evaluated a wide variety of possible solutions, which included widening or “benching” the creek banks to allow it to carry more water, expanding and raising the bridges that cross the creek, constructing detention ponds to store and slowly release floodwaters, and/or buying out homes at risk in the floodplain

Public scoping for the Interim Feasibility Study began in March 2002 with the Lower Colorado river Authority (LCRA), COA, City of Sunset Valley, Travis County and the USACE holding a public information meeting at St. Elmo Elementary School for Williamson Creek Residences. A presentation was shown explaining the USACE planning process and a timeline for completion of the feasibility study. At that time, Travis County also sent a survey to residents and 34 Williamson Creek residents responded. On September 24 and 25, 2002, the local sponsors and the USACE held a second public meeting at St. Elmo Elementary School to disclose the results of Phase 1 of the Interim Feasibility Study.

In January 2005, as the feasibility study continued into Phase 2, the USACE and COA planners met with citizens to discuss recreation components of the project area. On June 29, 2005, a public meeting was held at Woodlawn Baptist Church where two USACE alternatives were presented: a structural alternative (combined multipurpose federal plan) requiring excavation in the creek with ecosystem restoration and a public trail system; and a non-structural alternative requiring buyout of flood prone houses under eminent domain. The structural alternative would protect houses from flooding during less severe floods, but would not fully protect them from the 25- and 100-year storm events

Thirty-two comments were received from the Williamson Creek residents. Many the commenter’s expressed significant concerns about both alternatives. Residents’ concerns included acquisition of portions of lots for a public trail system and ecosystem restoration, degradation of the natural creek system, and the buyout/relocation of established residents under the Federal eminent domain process.

A follow up survey of residents along Williamson Creek, which was sent to 422 property owners, was performed in the fall of 2005. The survey asked residents if they were in favor of a structural solution, if they would support a voluntary buyout, or if they would prefer a no-action approach. The COA received 184 responses (44%). The residents of the Broken Bow area were the most vocal on their opposition to a structural solution (only 20% selected this alternative) or property buyouts (9% selected this alternative) and preferred the no action approach (60% of respondents). Also, notably, 55% of residents opposed any type of ecosystem restoration or public trails at the time. Among the Radam area respondents, 74% chose a structural alternative as the preferred option, compared to 13% who chose buyouts, and only 5% chose the no action alternative. As far as restoration, half of respondents selected the ecosystem restoration along the creek without public trails. The results were mixed from residents in the Heartwood area with

44% favoring a structural solution, 35% a no-action approach, and 15% a voluntary buyout of the residents responding the survey. Also, over 40% of residents selected the ecosystem restoration along the creek without public trails.

In response to the concerns expressed by the public, the COA recommended that the USACE project not include mandatory buyouts and recommended for the development of improved structural alternative in order to reduce the impact to individual large trees and development of additional detail on specific property impacts associated with excavation. The COA also asked the USACE to explore the use of alternative lands for ecosystem restoration and public trail systems that are not adjacent to residential areas as well as replacement of existing turf grass backyards after earth moving operations are completed. This option was included in a survey the City sent to the neighborhood, which also seeked to assess the specific concerns of each of the four areas.

As a result of the June 2005 public meeting on Williamson Creek and the public opposition to the federal plan on Williamson Creek, the USACE met with local residents on August 13, 2005 at two locations to further discuss the proposed plan. As a result of this meeting and continued opposition, the local sponsors and the USACE arranged for a follow-up workshop with Williamson Creek neighborhood representatives that was held on January 25, 2006. At this meeting, it was decided that a series of workshops needed to be conducted with a group of individuals form each neighborhood group to resolve issues with the project. During these small workshops, select individuals recommended by the neighborhood groups met with members of the COA or Sunset Valley and the USACE. Plans were shown to the neighborhood representatives for them to go back and share with the other members of the neighborhoods and the report suggestions back to the cities and the USACE on a locally preferred plan. Meetings were held at the City of Sunset Valley with the following representatives on the following dates: Radam Neighborhood on February 1 and March 9, 2006; Bayton Loop Neighborhood on February 2 and March 2, 2006; Broken Bow Neighborhood on February 8, 2006; Heartwood Neighborhood on February 9 and March 23, 2006; and Sunset Valley Residents on April 27, 2006.

The workshops documented that the residents did not support the proposed recreational trails as detailed in the recommended Federal plan. In addition, Bayton Loop residents in the city of Austin did not support ecosystem restoration directly behind their houses. Most residents in Broken Bow still opposed all features of the project in their neighborhood. As a result of these workshops a letter dated April 4, 2006 was sent to the USACE, stating that a locally preferred plan should be formulated consisting of removing all of the trails from the Williamson Creek plan, continuing with the federal plan without recreation in all areas of interest, continuing with the structural benching plan only in Broken Bow and Bayton Loop areas of interest, and the structural benching plan with ecosystem restoration in Heartwood and Radam. The letter also stated that the city council may request further modifications to the locally preferred plan prior to the beginning of the preconstruction, engineering, and design phase of the project.

The residents in the city of Sunset Valley did not completely support the Federal plan as the project was benefiting city of Austin residents primarily and the project features were predominately located in the city of Sunset Valley. However, the residents of Sunset Valley were willing to enter the next phase of the project as it provided flood protection and a substantial amount of ecosystem restoration for the city of Sunset Valley. The City of Sunset Valley provided a letter dated May 18, 2006, supporting the combined plan, with several modifications. In addition to public meetings and workshops, the project study team held monthly business meetings at the LCRA, City of Austin, or City of Sunset Valley offices. Portions of those meetings were open to the public. There were citizens that attended many of those meetings.

Public meetings where then held for each of the project areas as follows: Bayton Loop neighborhood on August 31, 2006; Broken Bow Area on September 5, 2006; and for the Radam and Heartwood Areas on September 7, 2006. The meetings had very high participation, to the point that there was not sufficient time to answer all of the questions from the public. The meetings were generally attended by residents that did not support the project because they did not feel that the environmental impacts associated with the Recommended Plan were justified given the small level of protection. This was particularly true for the Bayton Loop and Broken Bow meetings. The Radam and Heartwood meeting was attended by residents that both supported the project because they had been historically flood several times in the past and by those that did not support the project for the same reason.

In the October 2006 USACE Interim Feasibility Report, the tentatively selected plan consisted of channel modifications consisting of benching of channel (up to 200 feet wide) in conjunction with 3:1 slopes, for 1,200 feet in the Heartwood area and 1,400 feet in the Radam Area) and ecosystem restoration. The cost of restoration lands in highly urbanized areas exceeded criteria for federal participation. During the public comment period, three comments supported the Tentatively Selected Plan in Williamson Creek related to flood control. These residents were located in the Radam and Heartwood areas. One additional comment supported the ecosystem restoration efforts and said that all things including benefits needed to be considered if the plan was to be implemented, not just the impacts to trees. This resident lived in Broken Bow. Ten comments were received from people that opposed the Tentatively Selected Plan for Williamson Creek. These residents lived throughout the areas of interest. A summary of the main reasons for not supporting the plan are as follows 1) the residents feel that since the project does not provide them much benefit, that the impacts to woodlands are not worth it, 2) there are increased security risks and a decrease in privacy with ecosystem restoration, 3) they have flood insurance to protect them if they are flooded, 4) the cancellation of the greenbelt portion makes the plan less beneficial to the neighborhood as a whole, 5) the maintenance of the habitat restoration seems quite optimistic at best, 6) enlarging the conveyance at bridges would be more beneficial than the current plan 7) the impacts to the woodlands will reduce habitat value in the creek, and 8) they do not feel that their house is actually at flood risk.

As stated in the December 2006 USACE report "Proposing the procurement of additional, adjacent lands for ecosystem restoration purposes is contrary to the views of many residents of the neighborhood." In addition, there was no support by the community for buyouts under eminent domain; therefore, the COA dropped this alternative from the mix. As a result, the USACE did not recommend that this project move forward.

The COA requested the USACE to re-evaluate the project and provide protection for the 25- and 100-year storm event. In December 2008, the USACE used updated construction and land costs and updated floodplain models to reevaluate the mitigation alternatives. The plan reformulation by the USACE found there was not a federal feasible project in the Heartwood area. Even a concrete lined trapezoidal channel in the creek through the neighborhood would not fully mitigate flooding. None of the alternatives evaluated had an acceptable Benefit- Cost ratio, except for home buyouts in the Bayton Loop area.

After the USACE project, the COA continued work to reduce flood risk in the area. The Bayton Loop Flood Hazard Mitigation Project was a buyout project funded in part through FEMA's Hazard Mitigation Grant Program (HMGP). The project included the acquisition of 25 properties in the Bayton Loop/Burrough Cove area of the Williamson Creek watershed that were at high risk of flooding in the 25-year floodplain. The acquisitions occurred in 2010 and 2011. Owners and residents were offered voluntary buyouts and relocation assistance to move to residences outside of the 100-year floodplain. Upon acquisition, the homes were tested and abated for asbestos-containing materials and the structures and improvements were demolished. The City holds title to the land in perpetuity and will maintain it as open space and a floodplain restoration area. The City also partnered with the surrounding neighborhood to create a community garden in part of the buyout area.

The Williamson Creek Flood Risk Reduction Project (phase 1) consisted of buyouts and was initiated following significant flooding in October 2013. In 2014, City Council approved $18M of funding as part of FY15 budget for acquisition of properties at risk of building flooding during a 25-year flood event. (66 properties). A public meeting for the project was held on October 20th and 29th 2014.

In November 2014 Council authorized to proceed with offers for 3 properties severely damaged by October 13, 2013 flood. Discussions with these property owners about the possibility of buyouts began shortly after the flood. These properties were acquired in December 2014, January 2015, and March 2015.The WPD has acquired 52 properties between 2015 and 2019, with the bulk of buyouts happening in 2016.

In early 2019, WPD participated in Southwood Neighborhood Association meeting to talk about the history of flood risk reduction projects in the area, and to discuss the Phase 2 of the Williamson Creek flood Risk Reduction project, which was launching at that time. Also in 2019, the Nature Conservancy, the Community-Powered Workshop, and other organizations started the *Central Williamson Creek Vision Plan* with the goal of creating a greenbelt along this section of Williamson Creek. The Watershed Protection Department along with other COA Departments has participated in meetings with the organizations as part of their project, in order to avoid potential conflicts between the projects.

Williamson Creek Flood Risk Reduction- Public Engagement 2022

Public outreach was conducted in order to inform residents of the work conducted as part of this feasibility study and to gather the community's feedback and preferences.

In January 2022, the project team sent a brochure to approximately 3,300 addresses, targeting the project area with a 500-foot buffer. The brochure presented the three alternatives that showed the greatest potential (buyouts, channel modifications, and diversion tunnel) and invited residents to participate in the community survey. The survey was available online, though text, and printed copies at the Menchaca Branch of the Austin Public Library from January 25 through March 1, 2022. In addition, the project website was updated with information on the current study; a project video was developed and shared, and posts were made in Facebook and Next Door, targeting zip code 78745. In addition, project and community outreach update e-mails were sent to 17 neighborhood associations, 8 schools, and 246 residents who subscribed to receive e-mail updates. Watershed Protection Department staff met and provided update to the Council Member offices for District Nos. 2, 3, and 5, where the project is located.

A total of 268 survey responses were received, including 77 open comments. Residents were asked to voluntarily provide the street in which their residence is located. Over 90% of participants self-reported that they lived in the project area. The rest of the respondents either chose not to respond to that question or do not live in the property area, but they may own property there.

The results of the survey showed that overall, there is concern about flooding, although there are different thoughts on how to address the flood risk. Overall, over a third of respondents said they are aware of being at risk of flooding, and an additional 13% had experienced flooding in their house or garage. Clearly, the participants overwhelmingly believe it is very important for there to be a project to reduce flood risk in the project area. Over70% of respondents (and 88% of those that had previously flooded) stated that it was absolutely essential or very important for there to be a project to reduce flood risk in the area.

Based on the survey results, residents have a number of concerns related to living in an area at risk of flooding.; the top three concerns are the effect on property value, cost of repairs, and personal safety. Very few residents responded not having concerns.

Despite flood risk, the majority of residents had not considered moving because of flooding. However, 29% of those that have experienced flooding responded that they had considered moving because of flooding, which was higher than responses from the overall group.

Another question was for residents to select the three most important considerations when choosing options to reduce flooding. Overall, preserving the natural appearance of the creek was ranked first (54% of respondents), followed by considering the number of houses protected, and avoiding impacts to wildlife. There are three additional considerations selected by over 35% percent of respondents. These responses illustrate the challenge for this project area, as there are often competing considerations when selecting an alternative.

Residents were asked to select any of the three alternatives under consideration that would be acceptable to them. The tunnel was preferred by the most respondents (64%). Channel modifications and buyouts were found to be acceptable by approximately 48% of respondents each, only 9% of respondents found none of the alternatives to be acceptable.

Since buyouts and channel modifications have the potential to impact residents more directly than the tunnel, additional questions were asked related to those alternatives. On buyouts, residents were asked what criteria should be used to determine eligibility for buyouts. Most residents (54%) believed that only those that have experienced repetitive flooding should be considered. 35% of respondents believed that structures in the 25-year floodplain should be included if buyouts are selected, and 28% believed that all homes in the 100-year floodplain should be included. This indicates that residents are most likely to support buyouts for those homes most at risk.

On the question of whether residents would consider selling their home if buyouts are recommended and they receive a fair offer, 21% responded that they would consider it. The rest of respondents are split between those that are not sure and those that would not consider it at this point.

On the environmental side, 39% of residents responded that it is not acceptable to remove large trees in order to reduce flood risk, and 41% responded that it would only be acceptable to remove a limited number of trees. Regarding a question on whether it is acceptable to alter the look and feel of parts of the creek in order to reduce flood risk, respondents were split between those that believe it is acceptable and those that don’t.

As for the open comments, about a third of them were related to commenting on the respondent’s preferred alternative. Of those, the tunnel was favored by more respondents, creek modifications and buyouts had equal support; this matches the responses from the survey questions.

Over twenty percent of comments discussed desired outcomes from this project. These desired outcomes consisted of preserving natural habitat, having more green space and having more trails.

Residents also expressed concerns regarding some of the alternatives, floodplain boundaries, and tax increases.

Two virtual meetings were held in the Spring of 2022. The first meeting was held on April 30, and 44 residents registered to attend. The second public meeting was held on May 3, and 45 residents registered to attend. Overall, input received during the public meetings was consistent with the feedback received through the survey as well as other interactions with residents. Some of the questions during the meetings were related to details on the different alternatives that the project team will be in a better position to answer after the PER work has been conducted.

ATX FLOOD SAFETY

MIDDLE WILLIAMSON CREEK | FLOOD RISK REDUCTION

Reducción del riesgo de inundación del curso medio del Arroyo Williamson

CIP ID#: 5754.090

Survey Results

Resultados de la encuesta

Overview

Resumen

As part of an engineering feasibility study, the City of Austin conducted a community survey to gather feedback about three potential alternatives to reduce the risk of flooding along Middle Williamson Creek.

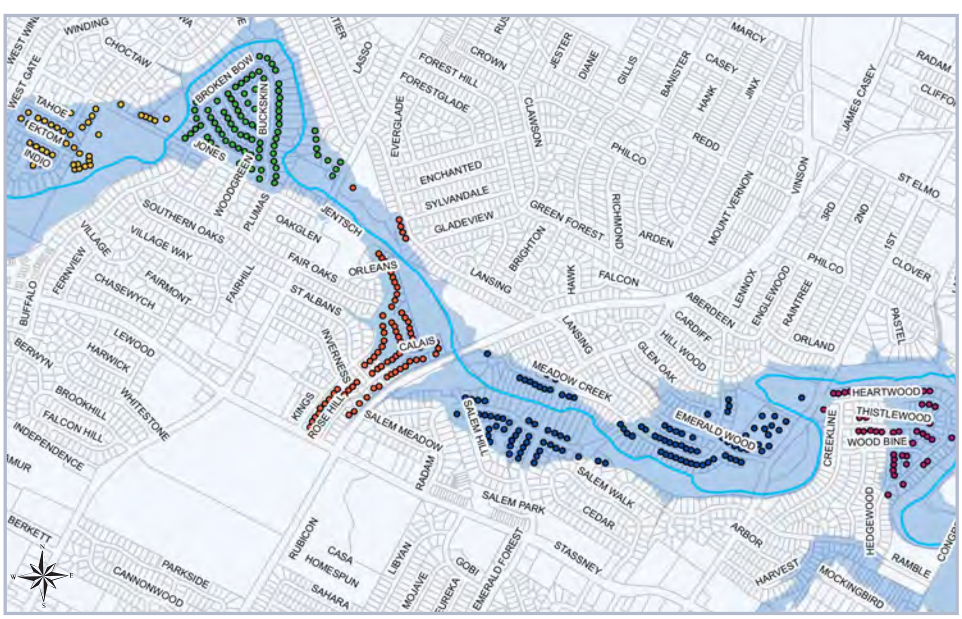
Como parte de un estudio de viabilidad de ingeniería, la ciudad de Austin realizó una encuesta comunitaria para recopilar comentarios sobre tres posibles alternativas para reducir el riesgo de inundaciones a lo largo del curso medio del Arroyo Williamson.

268 Total Surveys Received / 268 Total de Encuestas Recibidas

- **246 online /** 246 en línea
- **20 through text message /** 20 por mensaje de texto
- **2 on paper /** 2 en papel impreso

Dates / Fechas

January 25, 2022, through March 1, 2022 / del 25 de Enero al 1 de Marzo del 2022



Legend

Structures at Risk of Flooding

- Bayton Loop Area
- Broken Bow Area
- Fair Oaks Area
- Radam Area
- Heartwood Area
- Williamson Creek Floodplain*

Survey Distribution

Distribución de la encuesta

Direct mail to about 3,300 addresses / Correo directo a unas 3.300 direcciones:

- **Includes project area with a 500-foot buffer**
  Incluye el área del proyecto con una zona adicional de 500 pies
- **Includes property owners and residents**
  Incluye propietarios y residentes

Next Door post to zip code 78745 / Mensajes en Next Door al código postal 78745

Email to 17 neighborhood associations and 8 schools / Correos electronicos a 17 associaciones de vecinos y 8 escuelas.

Facebook post / Mensaje en Facebook

Streets Represented in Survey

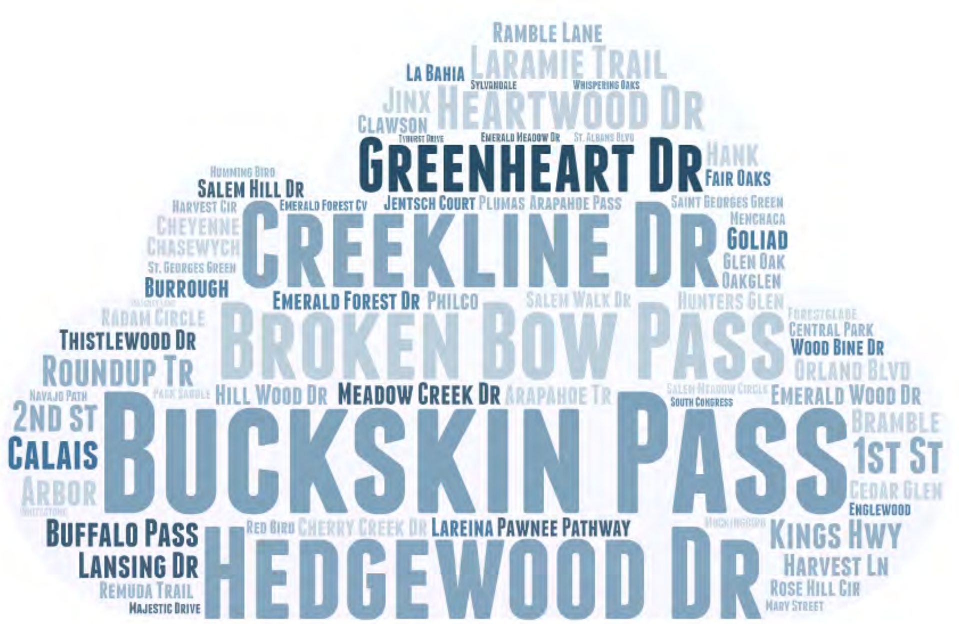
Calles representadas en la encuesta

245 or 91% of participants self-reported that they lived in the project area. 15 participants do not live in the property area, but they may own property there. Seven people did not respond to this question.

245 o el 91% de los participantes informaron que vivían en el área del proyecto. 15 participantes no viven en el área de la propiedad, pero pueden poseer una propiedad allí. Siete personas no respondieron a esta pregunta.

Respondents were asked to provide their street. Responses are shown in the word cloud above. Larger text indicates greater participation on that street.

Se pidió a los encuestados que proporcionaran su calle. Las respuestas se muestran en la nube de palabras de arriba. Un texto más grande indica una mayor participación en esa calle.

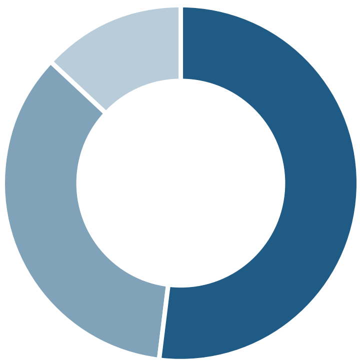


Survey Results

Resultados de la encuesta

Please share your experience with flooding in your current home in the project area.

Por favor comparta su experiencia con inundaciones en su vivienda actual en el área del proyecto.



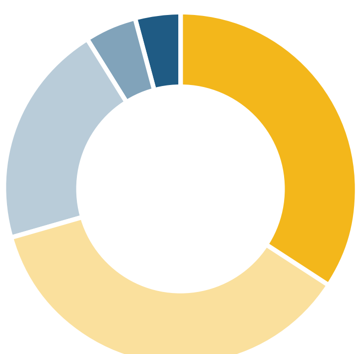
- **52%** — **I'm not aware that my house is at risk of flooding.** No sé si mi casa está en riesgo de inundación.
- **35%** — **My house is at risk of flooding.** Mi casa está en riesgo de inundación.
- **13%** — **My house or garage has flooded.** El garaje de mi casa se ha inundado.

How important is a project to reduce flood risk in the project area?

¿Qué tan importante es un proyecto para reducir el riesgo de inundación en el área?

All participants said

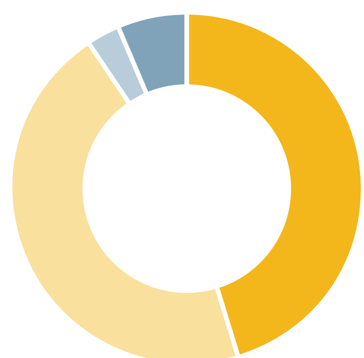
Las respuestas de todos los participantes fueron



- **35%** — **Absolutely essential** absolutamente esencial
- **37%** — **Very important** muy importante
- **21%** — **Of average importance** importancia normal
- **5%** — **Of little importance** poca importancia
- **4%** — **Not important at all** no es importante

People who have experienced flooding said

Las respuestas de las personas que han experimentado inundaciones fueron



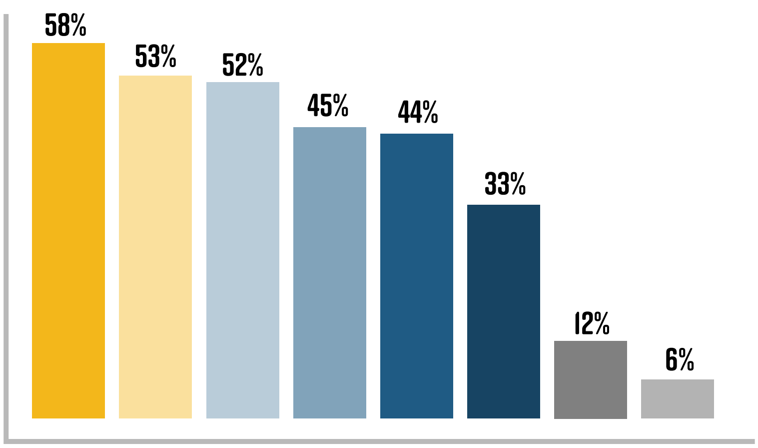
- **44%** — **Absolutely essential** absolutamente esencial
- **44%** — **Very important** muy importante
- **3%** — **Of average importance** importancia normal
- **6%** — **Of little importance** poca importancia
- **0%** — **Not important at all** no es importante

Survey Results

Resultados de la encuesta

What concerns you about flooding or being in the floodplain? Check your top three.

¿Qué le preocupa de las inundaciones o de estar en la llanura de inundación? Marque las tres más importantes para usted.



Effect on property value
Efecto en el valor de la propiedad

Cost of repairs
Costo de reparaciones

Safety
Seguridad

Loss of possessions
Pérdida de posesiones

Cost of flood insurance
Costo de seguro contra inundaciones

Loss time/hassle of repairs
Pérdida de tiempo/dificultad de las reparaciones

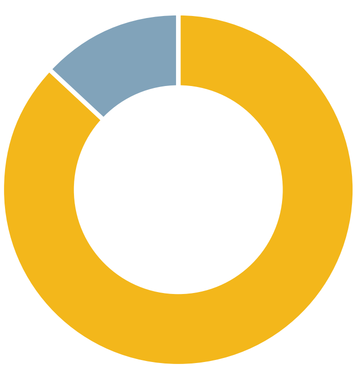
Not concerned
No estoy preocupado

Other
Otra

Have you ever considered moving because of flooding?

¿Ha considerado mudarse debido a las inundaciones?

All participants said
Las respuestas de todos los participantes fueron



87%	**No** No
13%	**Yes** Sí

People who have experienced flooding said
Las respuestas de las personas que han experimentado inundaciones fueron

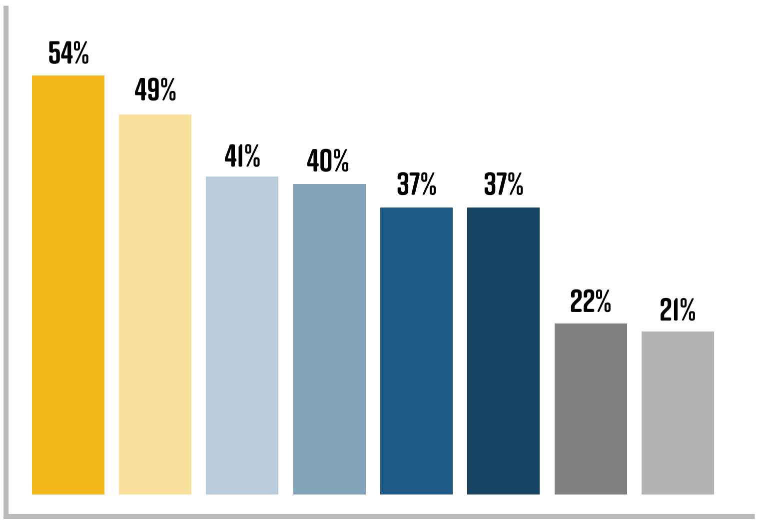
65%	**No** No
29%	**Yes** Sí

Survey Results

Resultados de la encuesta

Select the three most important considerations when choosing options to reduce flooding.

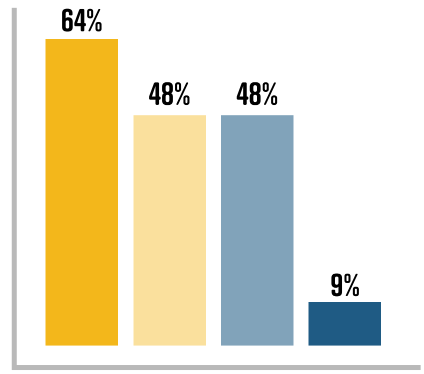
Seleccione los tres puntos más importantes a la hora de escoger las opciones para reducir las inundaciones.



- **Preserving the natural appearance of the creek**
  Preservación de la apariencia natural del riachuelo
- **The number of houses protected**
  El número de viviendas protegidas
- **Avoiding impacts to wildlife**
  Evitar efectos en la fauna silvestre
- **Avoiding home buyouts**
  Evitar las adquisiciones de viviendas
- **Sufficient protection so flood insurance would no longer be required**
  Protección suficiente para que ya no se requiera seguro contra inundaciones
- **Preserving trees**
  Preservación de árboles
- **Cost of the project**
  Costo del Proyecto
- **How quickly the project can be implemented**
  Rapidez para ejecutar el Proyecto

Which of these projects are acceptable to you? Check all that apply.

¿Cuál de estos proyectos es aceptable para usted? Marque todos los que apliquen.



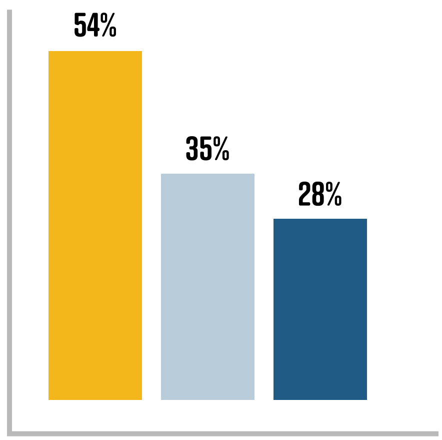
- **Bypass tunnel under Stassney Lane**
  Túnel de desviación debajo de Stassney Lane
- **Optional buyouts**
  Adquisiciones opcionales de propiedades en riesgo de inundación
- **Creek modifications**
  Modificaciones al riachuelo
- **None of these are acceptable. I would prefer no project.**
  Ninguno de estos es aceptable. Prefiero que no haya ningún proyecto.

Survey Results

Resultados de la encuesta

If optional buyouts are chosen, what criteria should be used for eligibility?

Si se escogen adquisiciones opcionales de propiedades, ¿cuáles criterios deberían usarse para calificar?



Only structures that have already experienced repetitive flooding
Solo las estructuras que ya han tenido inundaciones repetidas

All structures at risk in a 25-year flood (flooding with 9 inches of rain in 24 hours).
Todas las estructuras en riesgo de retorno de inundación de 25 años (inundación con 9 pulgadas de lluvia en 24 horas)

All structures at risk in a 100-year flood (flooding with 13.5 inches of rain in 24 hours).
Todas las estructuras en riesgo de retorno de inundación de 100 años (inundación con 13.5 pulgadas de lluvia en 24 horas)

To help reduce the flood risks at houses, is it acceptable to remove large trees?

Para ayudar a reducir el riesgo de inundación en las viviendas, ¿es aceptable eliminar árboles grandes?

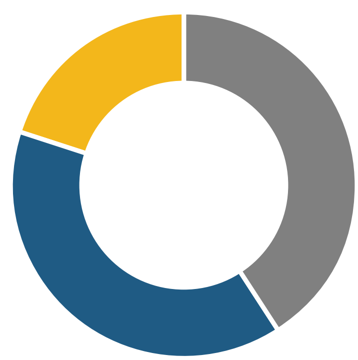
41% — **Only a limited number** / Sólo un número limitado

39% — **No** / No

20% — **Yes** / Sí

To help reduce flood risk, is it acceptable to alter the current, natural look and feel of parts of the creek?

Para ayudar a reducir el riesgo de inundación, ¿es aceptable alterar la apariencia natural actual de partes del riachuelo?



41% — **Yes** / Sí

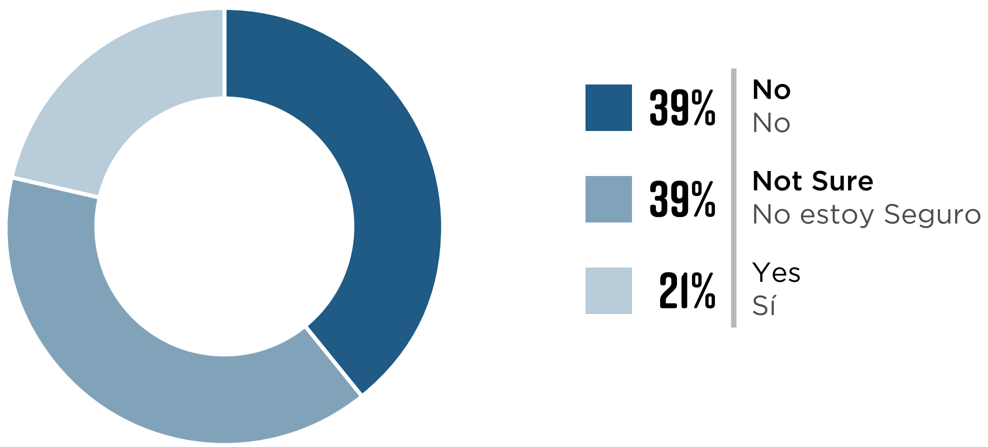
39% — **No** / No

20% — **Not Sure** / No estoy Seguro

Survey Results
Resultados de la encuesta

If optional home buyouts are recommended and if you received a fair offer, would you consider selling your property?

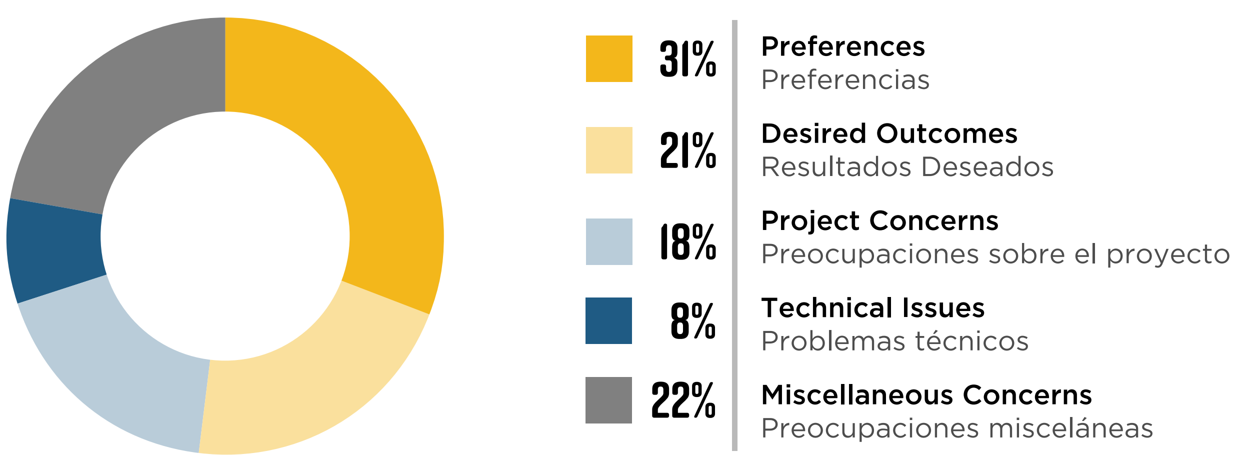
Si se recomiendan adquisiciones opcionales de viviendas y usted recibe una oferta justa, ¿consideraría vender su propiedad?



Survey Comments
Comentarios de la encuesta

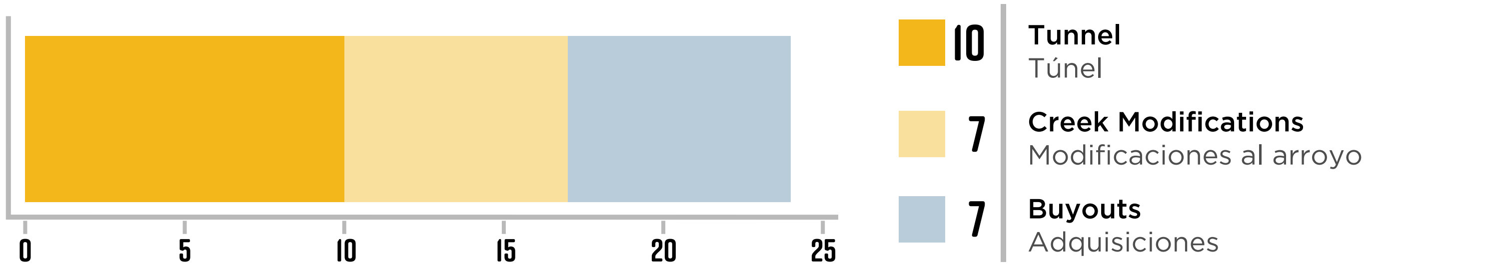
There were 77 comments made on the survey. They have been grouped into the following categories.

Se hicieron 77 comentarios en la encuesta. Se han agrupado en las siguientes categorías.



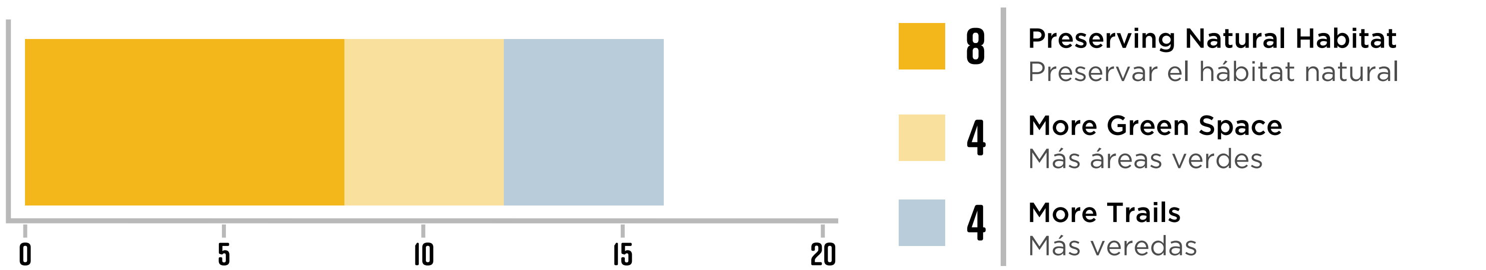
Comments About: Preferences
Comentarios Sobre: Preferencias

24 Comments / 24 comentarios



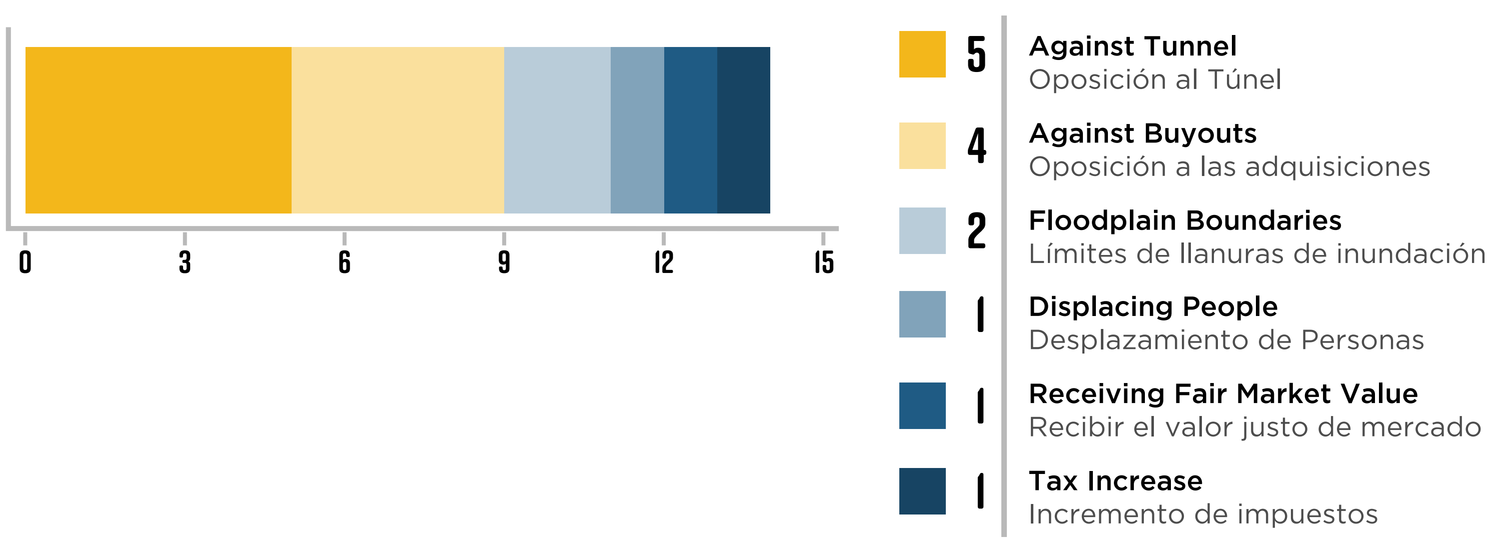
Comments About: Desired Outcomes
Comentarios Sobre: Resultados Deseados

16 comments / 16 comentarios



Comments About: Project Concerns
Comentarios Sobre: Preocupaciones

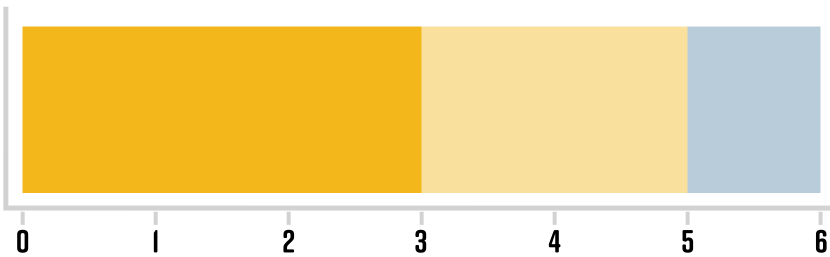
14 comments / 14 comentarios



Comments About: Technical Issues

Comentarios Sobre: Problemas técnicos

6 Comments / 6 comentarios

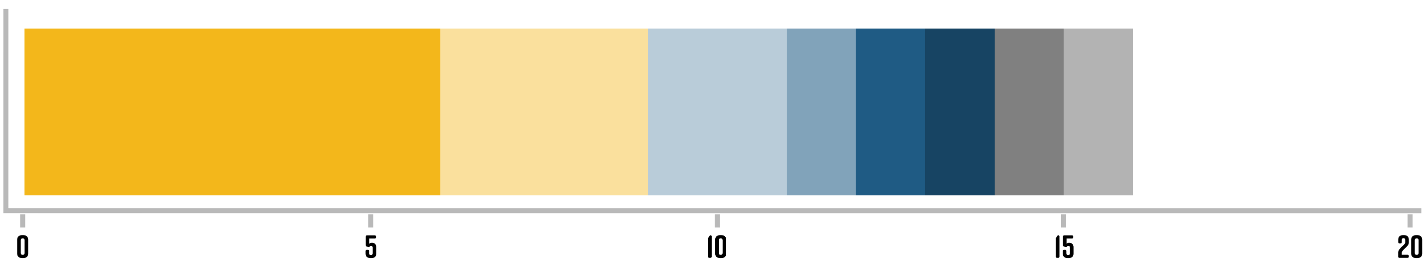


- 3 — **Legend and Map Errors** / Errores de leyenda del mapa
- 2 — **Demographic Questions** / Preguntas Demográficas
- 1 — **Numbering on Text Survey** / Numeración en la encuesta por texto

Comments About: Miscellaneous Concerns

Comentarios Sobre: Preocupaciones misceláneas

16 Comments / 16 comentarios



- 6 — **Prefer different solutions (financial assistance, fixing bridge, restricting more development)** / Preferencia por diferentes soluciones (asistencia financiera, arreglar puente, restringir más desarrollo)
- 3 — **Creek cleanups needed** / Limpieza del arroyo
- 2 — **Did not directly receive survey** / No recibió directamente la encuesta
- 1 — **Homeless population in area** / Población sin hogar en el área
- 1 — **Lack of flood risk information prior to survey** / Falta de información sobre el riesgo de inundación antes de la encuesta
- 1 — **Need for flood insurance when never flooded** / Necesidad de un seguro contra inundaciones cuando nunca se inundó
- 1 — **Survey needed more questions on tunnel** / La encuesta necesitaba más preguntas sobre el túnel
- 1 — **Tunnel maintenance** / Mantenimiento del túnel

Appendix G. Cultural Resources Memo

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HDR

Memo

Date:	Friday, January 8, 2021
Project:	Williamson Creek Flood Risk Reduction Phase I Project
To:	Sunit Deo, Water Resources Project Manager
From:	Edward Arevalo, Archaeology Crew Chief
Subject:	Cultural Resources Database Search

Project Details

The City of Austin contracted HDR Engineering, Inc. (HDR) to conduct a cultural resources background study in advance of proposed improvements for flood risk reductions surrounding Williamson Creek. The feasibility study includes evaluating 4 alternatives: Alternative B is composed of 4 flood walls to provide flood protection for 100-year ultimate land use conditions water surface elevation ranging from 540–1,810 feet (ft) (**Figure 1**); Alternative G will introduce new channel modifications through five reaches—Broken Bowl, Heartwood, Radam, Westgate, and Other (**Figure 2**); Alternative H proposes one box diversion utilizing a 10 ft x 20 ft culvert box that extends approximately 12,650 ft east along Stassney Lane (**Figure 3**); and Alternative H is a proposed combination of flood walls and benches to reduce flooding (**Figure 4**). While Alternative H is located along existing roads, the remaining three alternatives are located along Williamson Creek in the City of Austin, Travis County, Texas.

Due to the fact that the City of Austin is a sub-entity of the State of Texas, the project is required to be in compliance with Chapter 191 of the Texas Natural Resources Code, also known as the Antiquities Code of Texas (TAC) and its accompanying Rules of Practice and Procedure (13 TAC 26). This requires either a cultural resources survey of the project Area of Potential Effects or a determination from the Texas Historical Commission that the proposed project will have No Effect on historic properties as defined in Section 106 of the National Historic Preservation Act of 1966, as amended.

This document gives the results of the background review for each alternative. The background review included review of geology, soils, and previously recorded cultural resources. Sources for this information include the Texas Geology Map Viewer (USGS 2020), the Natural Resources Conservation Service (NRCS) Web Soil Survey (2020), and the Texas Historical Commission's Archeological Sites Atlas (Atlas).

Alternative B

Geological Background

Alternative B (see **Figure 1**) is underlain by Austin Chalk of Gulfian age and High Gravel deposits of Pleistocene age (USGS 2020). According to the NRCS (2020), there are five mapped soil units in Alternative B (**Table 1**).

Table 1. Mapped Soil Units in Alternative B.

Map Symbol	Soil Unit
LeB	Lewisville soils and Urban land, 0 to 2 percent slopes
Md	Mixed alluvial land, 0 to 1 percent slopes, frequently flooded
AID	Altoga soils and Urban land, 2 to 8 percent slopes
EuC	Eddy soils and Urban land, 0 to 6 percent slopes
UsC	Austin-Urban land complex, 2 to 5 percent slopes

Database Results

The Atlas review indicated that there have been five previous cultural resources surveys conducted within 1 mile (mi; 1.6 kilometers [km]) of Alternative B (**Table 2**). None of the previous surveys overlap Alternative B. In addition, the review revealed that three archaeological sites and two cemeteries have been recorded within the 1-mile search radius (see **Table 2**). While none of the cultural resources overlap Alternative B, site 41TV1389 is located approximately 336 ft from Alternative B (**Figure 5**). Site 41TV1389 is recorded as a prehistoric lithic scatter and has not been evaluated for NRHP eligibility.

Table 2. Previously Recorded Cultural Resources and Survey within 1 Mile of Alternative B.

Surveys					
ID	**Agency**	**Report Title**	**Contractor**	**Year**	**Comments/ Recommendations**
8400004156	FHWA	—	—	—	—
8400004324	FHWA	—	—	—	—
8500004887	—	—	—	—	—
8400009881	TxDOT	Phase I Cultural Resource Investigations for El Paso Global Networks Fiber Optics Project Travis County, Texas	Burns & McDonnell Co., Inc.	—	TAC Permit # 2476
8500081566	City of Austin	Battle Bend Neighborhood Park Green Infrastructure Retrofit Project	TRC Environmental	2019	TAC Permit # 8731
Archaeological Sites					
Identifier	**Affiliation**	**Features/Function**	**NRHP Eligibility**	**Comments / Recommendations**	
41TV162	Historic	Walter May site	Unknown	Approx. 0.39 mile from Alternative B	
41TV1380	Historic	Civil War fort and 1950s residences	Unknown	Approx. 0.95 mile from Alternative B	

Surveys					
ID	**Agency**	**Report Title**	**Contractor**	**Year**	**Comments/ Recommendations**
41TV1389	Prehistoric	Lithic scatter	Unknown	Approx. 336 ft from Alternative B	
Cemeteries					
Cemetery ID	**Name**	**Location**		**Comments / Recommendations**	
TV-C128	Chote	6205 Idlewood Cove, Austin TX 78745		Approx. 0.95 mile from Alternative B Also known as Chote Family	
TV-C129	Nolen-Stanley	South of Stassney Lane on Manchaca Road, Left into Garrison Park. Park in parking lot, walk around swimming pool and continue approx. 400 feet SE to the cemetery.		Approx. 0.67 mile from Alternative B	

Recommendations

The Atlas search revealed that there are various cultural resources recorded within one mile of Alternative B and that the alternative has not been previously surveyed. Although Alternative B is located along Williamson Creek which is a high probability setting for cultural resources, the banks of Williamson Creek have been extensively disturbed by residential construction. Due to this previous disturbance and past flooding of the creek, it is highly unlikely that any cultural resources remain intact within the project area.

Alternative G

Geological Background

Alternative G (see **Figure 2**) is underlain by the Del Rio Clay and Georgetown Formation of Comanchean age, Austin Chalk of Gulfian age, and High Gravel deposits of Pleistocene age (USGS 2020). According to the NRCS (2020), there are twelve mapped soil units in Alternative B (**Table 3**).

Table 3. Mapped Soil Units in Alternative G.

Map Symbol	Soil Unit
LeB	Lewisville soils and Urban land, 0 to 2 percent slopes
AlD	Altoga soils and Urban land, 2 to 8 percent slopes
Md	Mixed alluvial land, 0 to 1 percent slopes, frequently flooded
UsC	Austin-Urban land complex, 2 to 5 percent slopes
EuC	Eddy soils and Urban land, 0 to 6 percent slopes
TaD	Eckrant very stony clay, 5 to 18 percent slopes
Tv	Tinn clay, 0 to 1 percent slopes, occasionally flooded
TeA	Eckrant soils and Urban land, 0 to 2 percent slopes
TeE	Eckrant soils and Urban land, 5 to 18 percent slopes
PcE	Patrick soils and urban land, 1 to 10 percent slopes
SbA	San Saba soils and Urban land, 0 to 2 percent slopes
Fs	Oakalla soils, 0 to 1 percent slopes, channeled, frequently flooded

Database Results

The Atlas review indicated that there have been nine previous cultural resources surveys conducted within 1 mile (mi; 1.6 kilometers [km]) of Alternative G (**Table 4**). None of the previous surveys overlap Alternative G. In addition, the review revealed that seventeen archaeological sites, two Official Texas Historical Markers (OTHMs), and three cemeteries have been recorded within the 1-mile search radius (see **Table 4**). None of the cultural resources overlap or come in close proximity to Alternative G (**Figure 6**).

Table 4. Previously Recorded Cultural Resources and Survey within 1 Mile of Alternative G.

Surveys					
ID	**Agency**	**Report Title**	**Contractor**	**Year**	**Comments/ Recommendations**
8400004156	FHWA	—	—	—	—
8400004321	—	—	—	—	—
8400004324	FHWA	—	—	—	—
8400009881	TxDOT	Phase I Cultural Resource Investigations for El Paso Global Networks Fiber Optics Project Travis County, Texas	Burns & McDonnell Co., Inc.	—	TAC Permit # 2476
8500004887	—	—	—	—	—
8500032956	City of Austin	Archeological Survey of the Junebug Site (41TV2400), a Public Outreach Project in the Barton Creek Greenbelt, Austin, Travis County, Texas	Ringstaff	2011	TAC Permit # 3595 Barton Creek Greenbelt/Public Outreach
8500004886	Texas Department of Highways and Public Transportation	—	—	1983	—
8500004895	FHWA	—	—	1987	—
8500081566	City of Austin	Battle Bend Neighborhood Park Green Infrastructure Retrofit Project	TRC Environmental	2019	TAC Permit # 8731
Archaeological Sites					
Identifier	**Affiliation**	**Features/Function**	**NRHP Eligibility**	**Comments / Recommendations**	
41TV162	Historic	Walter May site	Unknown	Approx. 0.60 mile from Alternative G	
41TV533	Prehistoric	Scattered burned rock and flint flakes	Unknown	Approx. 0.93 mile from Alternative G	
41TV534	Historic	19th century–early 20th century dump	Unknown	Approx. 0.91 mile from Alternative G	
41TV679	Prehistoric	Lithic scatter	Unknown	Approx. 0.99 mile from Alternative G	

41TV716	Prehistoric	Quarry	Unknown	Approx. 0.69 mile from Alternative G
41TV978	Historic	Historic rock wall	Unknown	Approx. 0.98 mile from Alternative G
41TV979	Prehistoric	Lithic scatter	Unknown	Approx. 0.92 mile from Alternative G
41TV980	Prehistoric	Lithic scatter	Unknown	Approx. 0.97 mile from Alternative G
41TV981	Prehistoric	Lithic scatter	Unknown	Approx. 0.81 mile from Alternative G
41TV982	Prehistoric	Lithic scatter	Unknown	Approx. 0.82 mile from Alternative G
41TV987	Prehistoric/ Historic	Prehistoric lithic artifacts. Historic ranch house remains with barn & paddock	Unknown	Approx. 0.80 mile from Alternative G
41TV989	Prehistoric	Lithic scatter	Unknown	Approx. 0.86 mile from Alternative G
41TV990	Prehistoric	Lithic scatter	Unknown	Approx. 0.73 mile from Alternative G
41TV1336	Prehistoric	Small quarry/workshop	Unknown	Approx. 0.86 mile from Alternative G
41TV1380	Historic	Civil War fort and 1950s residences	Unknown	Approx. 0.85 mile from Alternative G
41TV1389	Prehistoric	Lithic scatter	Unknown	Approx. 0.80 mile from Alternative G
41TV1684	Historic	Cemeteries and burials	Eligible	Approx. 0.90 mile from Alternative G
OTHMs				
Marker Number	**Marker Name**	**Address**	**Year Erected**	**Comments**
13159	Fort Magruder, C.S.A.	3900 S Congress Ave	2003	Approx. 0.92 mile from Alternative G
16202	Williamson Creek Cemetery	1000 Little Texas Lane	2001	Approx. 0.97 mile from Alternative G
Cemeteries				
Cemetery ID	**Name**	**Location**		**Comments / Recommendations**
TV-C014	Williamson Creek	Off IH 35 S. 1 block south of Stassney Lane on Little Texas Dr.		Approx. 0.93 mile from Alternative G
TV-C128	Chote	6205 Idlewood Cove, Austin TX 78745		Approx. 0.9 mile from Alternative G Also known as Chote Family
TV-C129	Nolen-Stanley	South of Stassney Lane on Manchaca Road, Left into Garrison Park. Park in parking lot, walk around swimming pool and continue approx. 400 feet SE to the cemetery.		Approx. 0.48 mile from Alternative G

Recommendations

The Atlas search revealed that there are various cultural resources recorded within one mile of Alternative G and that the alternative has not been previously surveyed. Although Alternative G is located along Williamson Creek which is a high probability setting for cultural resources, the banks of Williamson Creek have been extensively disturbed by residential construction. Due to this previous disturbance and past flooding of the creek, it is highly unlikely that any cultural resources remain intact within the project area.

Alternative H

Geological Background

Alternative H (see **Figure 3**) is underlain by Austin Chalk of Gulfian age, High Gravel deposits of Pleistocene age, and the Eagle Ford Group and Buda Limestone undivided, and the Del Rio Clay and Georgetown Formation of Comanchean age (USGS 2020). According to the NRCS (2020), there are nine mapped soil units in Alternative H (**Table 5**).

Table 5. Mapped Soil Units in Alternative H.

Map Symbol	Soil Unit
TeA	Eckrant soils and Urban land, 0 to 2 percent slopes
SbA	San Saba soils and Urban land, 0 to 2 percent slopes
VuD	Volente soils and Urban land, 1 to 8 percent slopes
EuC	Eddy soils and Urban land, 0 to 6 percent slopes
UtD	Urban land, Austin, and Whitewright soils, 1 to 8 percent slopes
UsC	Austin-Urban land complex, 2 to 5 percent slopes
PcE	Patrick soils and urban land, 1 to 10 percent slopes
HsD	Houston Black soils and Urban land, 0 to 8 percent slopes
Tv	Tinn clay, 0 to 1 percent slopes, occasionally flooded

Database Results

The Atlas review indicated that there have been eleven previous cultural resources surveys conducted within 1 mile (mi; 1.6 kilometers [km]) of Alternative H (**Table 6**). One of the previous cultural resources surveys (ID 8400009881) overlaps Alternative H (**Figure 7**). In addition, the review revealed that fourteen archaeological sites, two OTHMs, and four cemeteries have been recorded within the 1-mile search radius (see **Figure 7**; see **Table 6**). None of the cultural resources overlap or come in close proximity to Alternative H.

Table 6. Previously Recorded Cultural Resources and Survey within 1 Mile of Alternative H.

Surveys					
ID	**Agency**	**Report Title**	**Contractor**	**Year**	**Comments/ Recommendations**
8400004324	FHWA	—	—	—	—
8400009881	TxDOT	Phase I Cultural Resource Investigations for El Paso Global Networks Fiber Optics Project Travis County, Texas	Burns & McDonnell Co., Inc.	—	TAC Permit # 2476 Overlaps APE

8500004879	Texas Department of Highways and Public Transportation, FHWA	—	—	1986	—
8500004883	Texas Department of Highways and Public Transportation	—	—	1983	—
8500004885	Texas Department of Highways and Public Transportation	—	—	1983	—
8500004886	Texas Department of Highways and Public Transportation	—	—	1983	—
8500004895	FHWA	—	—	1987	—
8500081566	City of Austin	Battle Bend Neighborhood Park Green Infrastructure Retrofit Project	TRC Environmental	2019	TAC Permit # 8731
8500013008	City of Austin	Final Cultural Resources Survey for the Lower Williamson Creek Relief Interceptor Austin, Travis County, Texas	PBS&J	2003	TAC Permit # 3011 Same as 8500013197
8500013197	City of Austin	Final Cultural Resources Survey for the Lower Williamson Creek Relief Interceptor Austin, Travis County, Texas	PBS&J	2003	TAC Permit # 3011 Same as 8500013008
8500016260	Austin ISD	An Intensive Archeological Survey of the Austin Independent School District Early Childhood Center/Linder Project, Travis County, Texas	GTI Environmental	2009	TAC Permit #5404

Archaeological Sites

Identifier	Affiliation	Features/Function	NRHP Eligibility	Comments / Recommendations
41TV162	Historic	Walter May site	Unknown	Approx. 0.67 mile from Alternative H
41TV679	Prehistoric	Lithic scatter	Unknown	Approx. 0.59 mile from Alternative H
41TV680	Historic	Two-story rubble stone house and associated artifacts scatter	—	Approx. 0.96 mile from Alternative H
41TV716	Prehistoric	Quarry	Unknown	Approx. 0.92 mile from Alternative H

41TV987	Prehistoric Historic	Prehistoric lithic artifacts. Historic ranch house remains with barn & paddock	Unknown	Approx. 0.69 mile from Alternative H
41TV988	Prehistoric	Lithic scatter	Unknown	Approx. 0.92 mile from Alternative H
41TV989	Prehistoric	Lithic scatter	Unknown	Approx. 0.79 mile from Alternative H
41TV990	Prehistoric	Lithic scatter	Unknown	Approx. 0.60 mile from Alternative H
41TV1336	Prehistoric	Small quarry/workshop	Unknown	Approx. 0.97 mile from Alternative H
41TV1389	Prehistoric	Lithic scatter	Unknown	Approx. 0.51 mile from Alternative H
41TV1684	Historic	Cemeteries and burials	Eligible	Approx. 0.48 mile from Alternative H
41TV1685	—	—	—	Approx. 0.81 mile from Alternative H
41TV2030	Prehistoric	Debitage flakes and 500 burned rocks	Ineligible	Approx. 0.91 mile from Alternative H
41TV2358	Prehistoric/ Historic	Historic scatter/Lithic scatter	Ineligible	Approx. 1 mile from Alternative H
OTHMs				
Marker Number	**Marker Name**	**Address**	**Year Erected**	**Comments**
16202	Williamson Creek Cemetery	1000 Little Texas Lane	2001	Approx. 0.54 mile from Alternative H
14905	Onion Creek Lodge 220, AF & AM	South off Crow Ln, right on N Bluff Dr 0.21 mile, on the right	1964	Approx. 0.73 mile from Alternative H
Cemeteries				
Cemetery ID	**Name**	**Location**		**Comments / Recommendations**
TV-C014	Williamson Creek	Off IH 35 S. 1 block south of Stassney Lane on Little Texas Dr.		Approx. 0.52 mile from Alternative H
TV-C127	Sebron G. Sneed	6200 Sneed Cove		Approx. 0.86 mile from Alternative H
TV-C128	Chote	6205 Idlewood Cove, Austin TX 78745		Approx. 0.42 mile from Alternative H Also known as Chote Family
TV-C129	Nolen-Stanley	South of Stassney Lane on Manchaca Road, Left into Garrison Park. Park in parking lot, walk around swimming pool and continue approx. 400 feet SE to the cemetery.		Approx. 0.2 mile from Alternative H

Recommendations

The Atlas search revealed that there are various cultural resources recorded within one mile of Alternative H and that very little of the alternative has been previously surveyed. Alternative H is located along existing roadways which have been heavily disturbed by past infrastructure and residential construction. Therefore, it is highly unlikely that any cultural resources remain intact within the project area.

Alternative I

Geological Background

Alternative I (see **Figure 4**) is underlain by Austin Chalk of Gulfian age and High Gravel deposits of Pleistocene age (USGS 2020). According to the NRCS (2020), there are eight mapped soil units in Alternative I (**Table 7**).

Table 7. Mapped Soil Units in Alternative I.

Map Symbol	Soil Unit
Fs	Oakalla soils, 0 to 1 percent slopes, channeled, frequently flooded
AID	Altoga soils and Urban land, 2 to 8 percent slopes
Md	Mixed alluvial land, 0 to 1 percent slopes, frequently flooded
UsC	Austin-Urban land complex, 2 to 5 percent slopes
EuC	Eddy soils and Urban land, 0 to 6 percent slopes
TeE	Eckrant soils and Urban land, 5 to 18 percent slopes
PcE	Patrick soils and urban land, 1 to 10 percent slopes
LeB	Lewisville soils and Urban land, 0 to 2 percent slopes

Database Results

The Atlas review indicated that there have been seven previous cultural resources surveys conducted within 1 mile (mi; 1.6 kilometers [km]) of Alternative I (**Table 8**). None of the previous surveys overlap Alternative I. In addition, the review revealed that thirteen archaeological sites, two OTHMs, and three cemeteries have been recorded within the 1-mile search radius (**Figure 8**; see **Table 8**). While none of the cultural resources overlap the alternative, site 41TV1389 is located approximately 385 ft from Alternative I. Site 41TV1389 is recorded as a prehistoric lithic scatter and has not been evaluated for NRHP eligibility.

Table 8. Previously Recorded Cultural Resources and Survey within 1 Mile of Alternative I.

Surveys					
ID	**Agency**	**Report Title**	**Contractor**	**Year**	**Comments/ Recommendations**
8400004324	FHWA	—	—	—	—
8400009881	TxDOT	Phase I Cultural Resource Investigations for El Paso Global Networks Fiber Optics Project Travis County, Texas	Burns & McDonnell Co., Inc.	—	TAC Permit # 2476

8500004886	Texas Department of Highways and Public Transportation	—	—	1983	—
8500004887	—	—	—	—	—
8500081566	City of Austin	Battle Bend Neighborhood Park Green Infrastructure Retrofit Project	TRC Environmental	2019	TAC Permit # 8731
8400004156	FHWA	—	—	—	—
8500032956	City of Austin	Archeological Survey of the Junebug Site (41TV2400), a Public Outreach Project in the Barton Creek Greenbelt, Austin, Travis County, Texas	Ringstaff	2011	TAC Permit # 3595 Barton Creek Greenbelt/Public Outreach

Archaeological Sites

Identifier	Affiliation	Features/Function	NRHP Eligibility	Comments / Recommendations
41TV162	Historic	Walter May site	Unknown	Approx. 0.43 mile from Alternative I
41TV533	Prehistoric	Scattered burned rock and flint flakes	Unknown	Approx. 0.85 mile from Alternative I
41TV534	Historic	19th century–early 20th century dump	Unknown	Approx. 0.92 mile from Alternative I
41TV679	Prehistoric	Lithic scatter	Unknown	Approx. 0.99 mile from Alternative I
41TV692	Prehistoric	Lithic scatter	Unknown	Approx. 0.99 mile from Alternative I
41TV716	Prehistoric	Quarry	Unknown	Approx. 0.54 mile from Alternative I
41TV979	Prehistoric	Lithic scatter	Unknown	Approx. 0.96 mile from Alternative I
41TV980	Prehistoric	Lithic scatter	Unknown	Approx. 0.95 mile from Alternative I
41TV981	Prehistoric	Lithic scatter	Unknown	Approx. 0.82 mile from Alternative I
41TV982	Prehistoric	Lithic scatter	Unknown	Approx. 0.77 mile from Alternative I
41TV1380	Historic	Civil War fort and 1950s residences	Unknown	Approx. 0.77 mile from Alternative I
41TV1389	Prehistoric	Lithic scatter	Unknown	Approx. 385 ft from Alternative I
41TV1684	Historic	Cemeteries and burials	Eligible	Approx. 0.92 mile from Alternative I

OTHMs

Marker Number	Marker Name	Address	Year Erected	Comments
13159	Fort Magruder, C.S.A.	3900 S Congress Ave	2003	Approx. 0.88 mile from Alternative I

16202	Williamson Creek Cemetery	1000 Little Texas Lane	2001	Approx. 0.97 mile from Alternative I
Cemeteries				
Cemetery ID	**Name**	**Location**		**Comments / Recommendations**
TV-C014	Williamson Creek	Off IH 35 S. 1 block south of Stassney Lane on Little Texas Dr.		Approx. 0.96 mile from Alternative I
TV-C128	Chote	6205 Idlewood Cove, Austin TX 78745		Approx. 0.86 mile from Alternative I Also known as Chote Family
TV-C129	Nolen-Stanley	South of Stassney Lane on Manchaca Road, Left into Garrison Park. Park in parking lot, walk around swimming pool and continue approx. 400 feet SE to the cemetery.		Approx. 0.54 mile from Alternative I

Recommendations

The Atlas search revealed that there are various cultural resources recorded within one mile of Alternative I and that the alternative has not been previously surveyed. Although Alternative I is located along Williamson Creek which is a high probability setting for cultural resources, the banks of Williamson Creek have been extensively disturbed by residential construction. Due to this previous disturbance and past flooding of the creek, it is highly unlikely that any cultural resources remain intact within the project area.

References

Natural Resources Conservation Service (NRCS), United States Department of Agriculture

2020 Web Soil Survey. Available online at: http://websoilsurvey.nrcs.usda.gov/, accessed December 1, 2020.

Texas Historical Commission

2020 Texas Historical Sites Atlas. Available online at https://atlas.thc.texas.gov/, accessed December 1, 2020.

United State Geologic Society (USGS).

2020 Texas Geology Map Viewer. Available online at: https://txpub.usgs.gov/dss/texasgeology/, accessed December 1, 2020.

Figure 1. General Location of Project Alternative B.

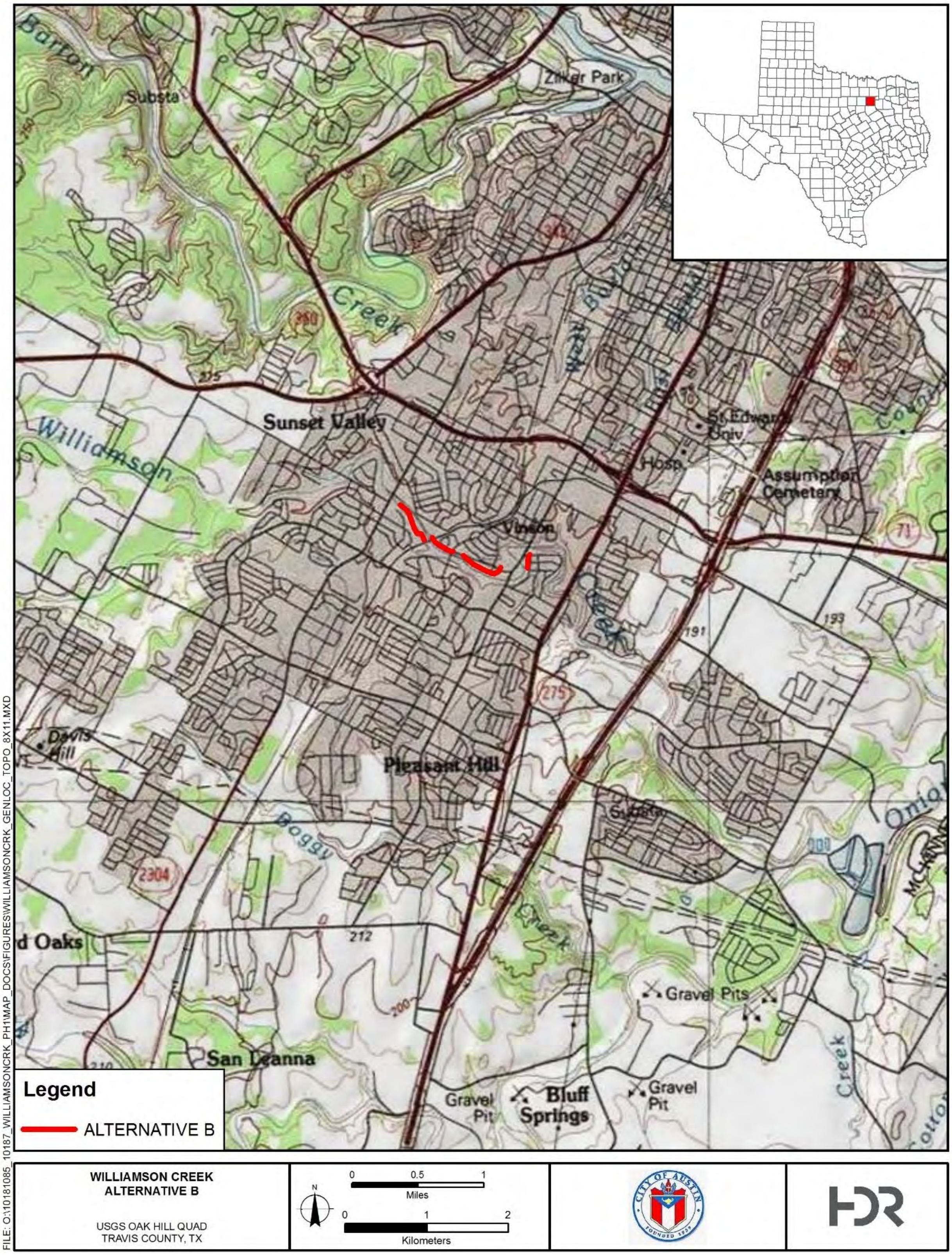

Figure 2. General Location of Project Alternative G.

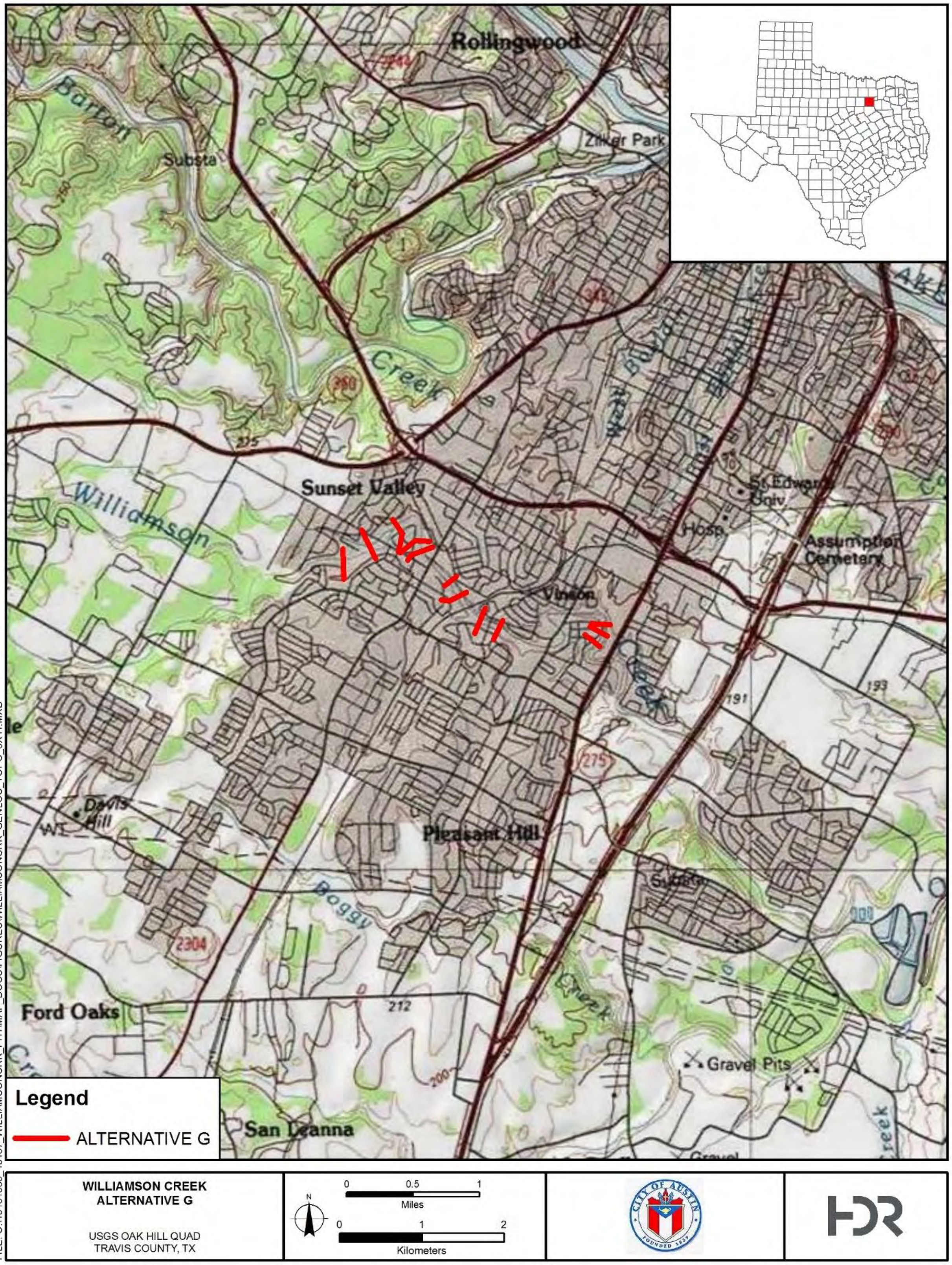

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Figure 3. General Location of Project Alternative H.

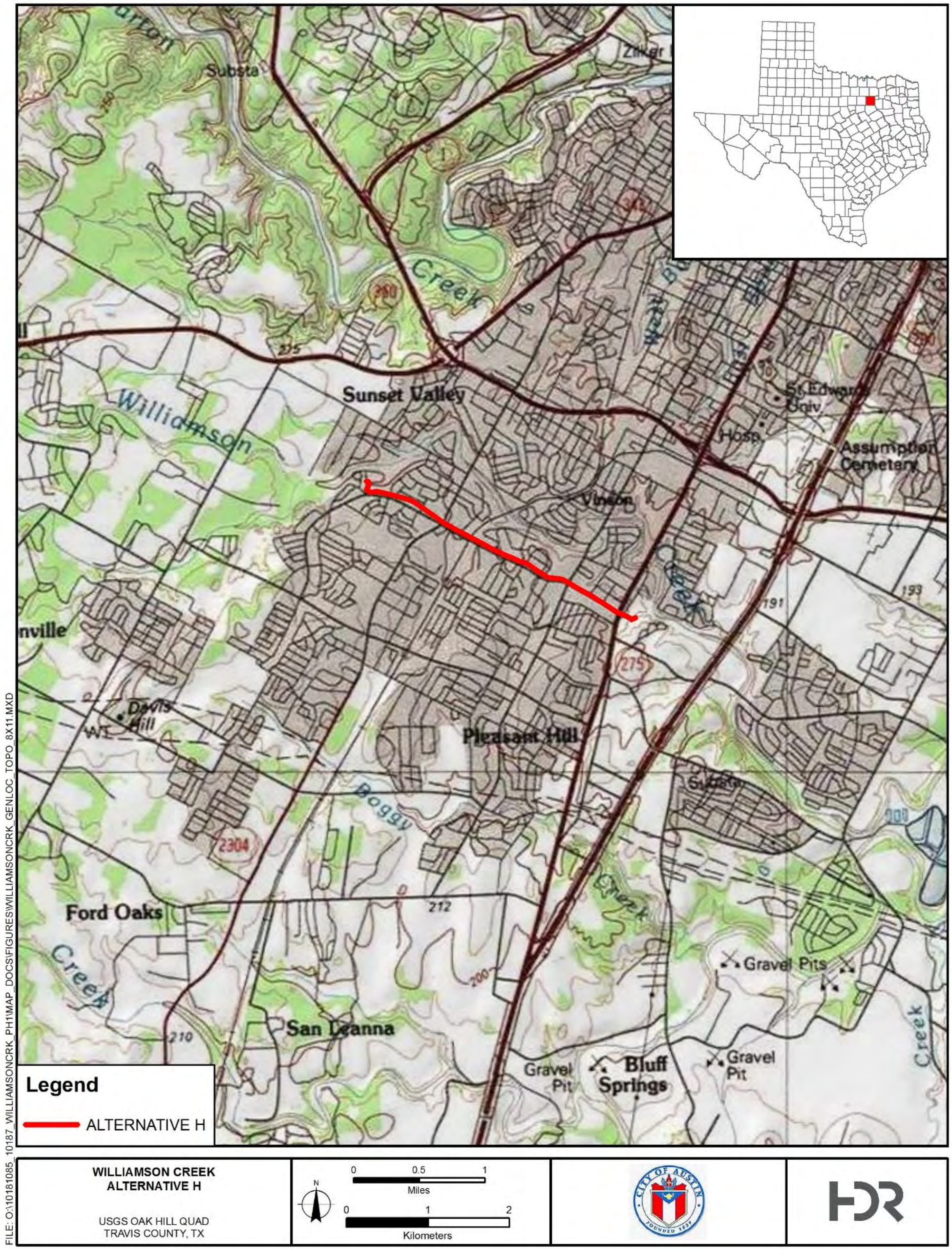

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Figure 4. General Location of Project Alternative I.

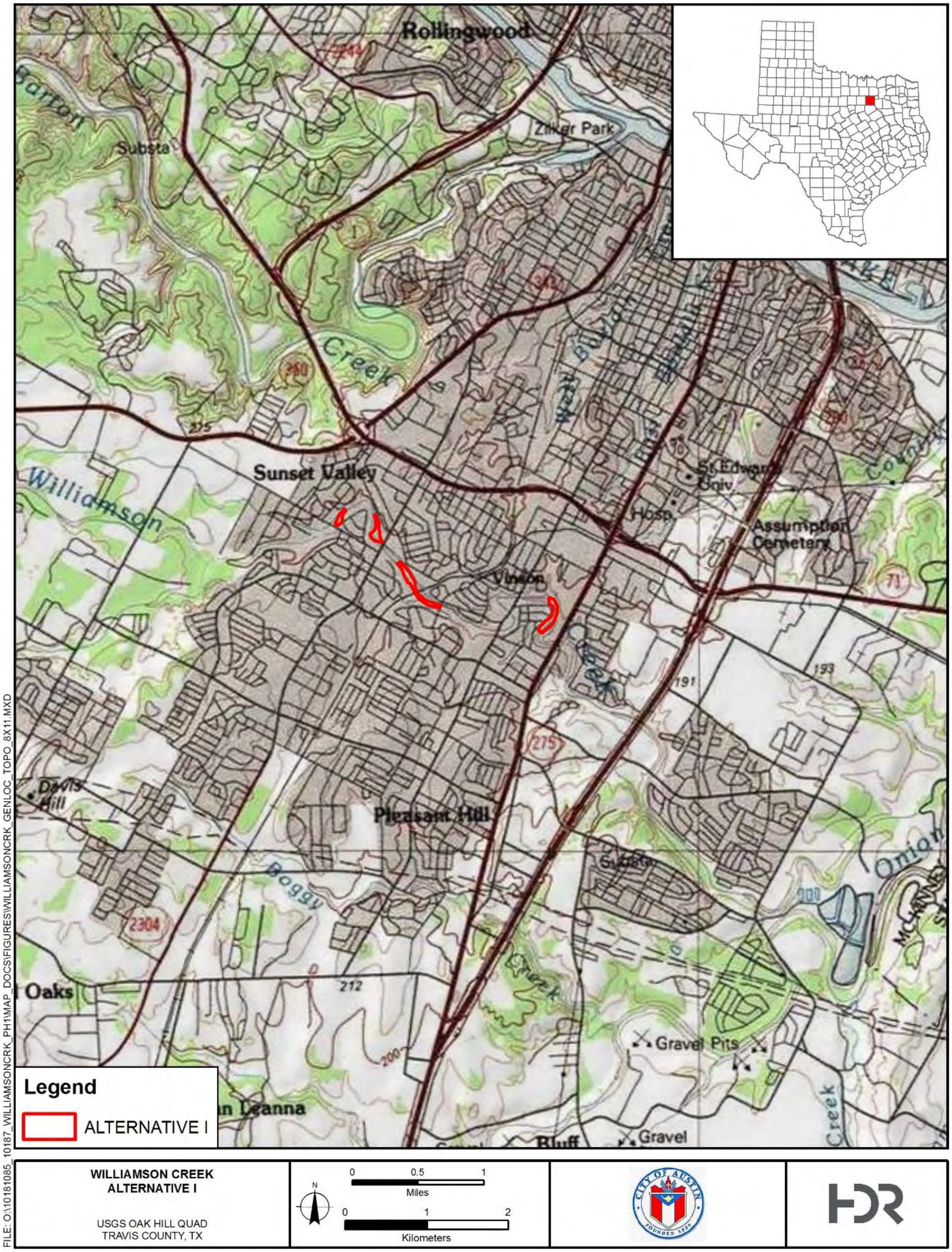

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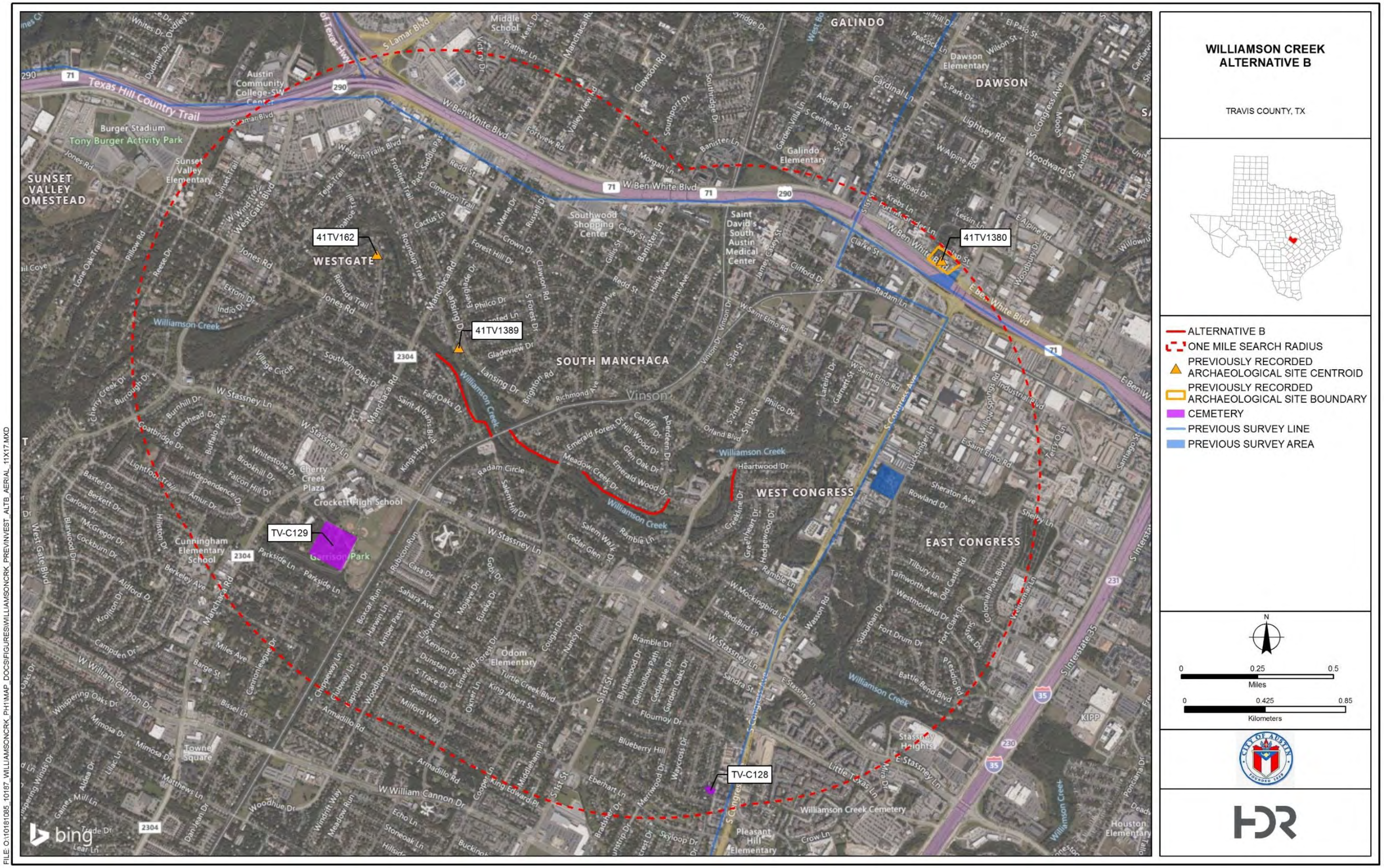
Figure 5. Previously Recorded Cultural Resources and Surveys within 1 Mile of Alternative B.



HDR

Figure 6. Previously Recorded Cultural Resources and Surveys within 1 Mile of Alternative G.

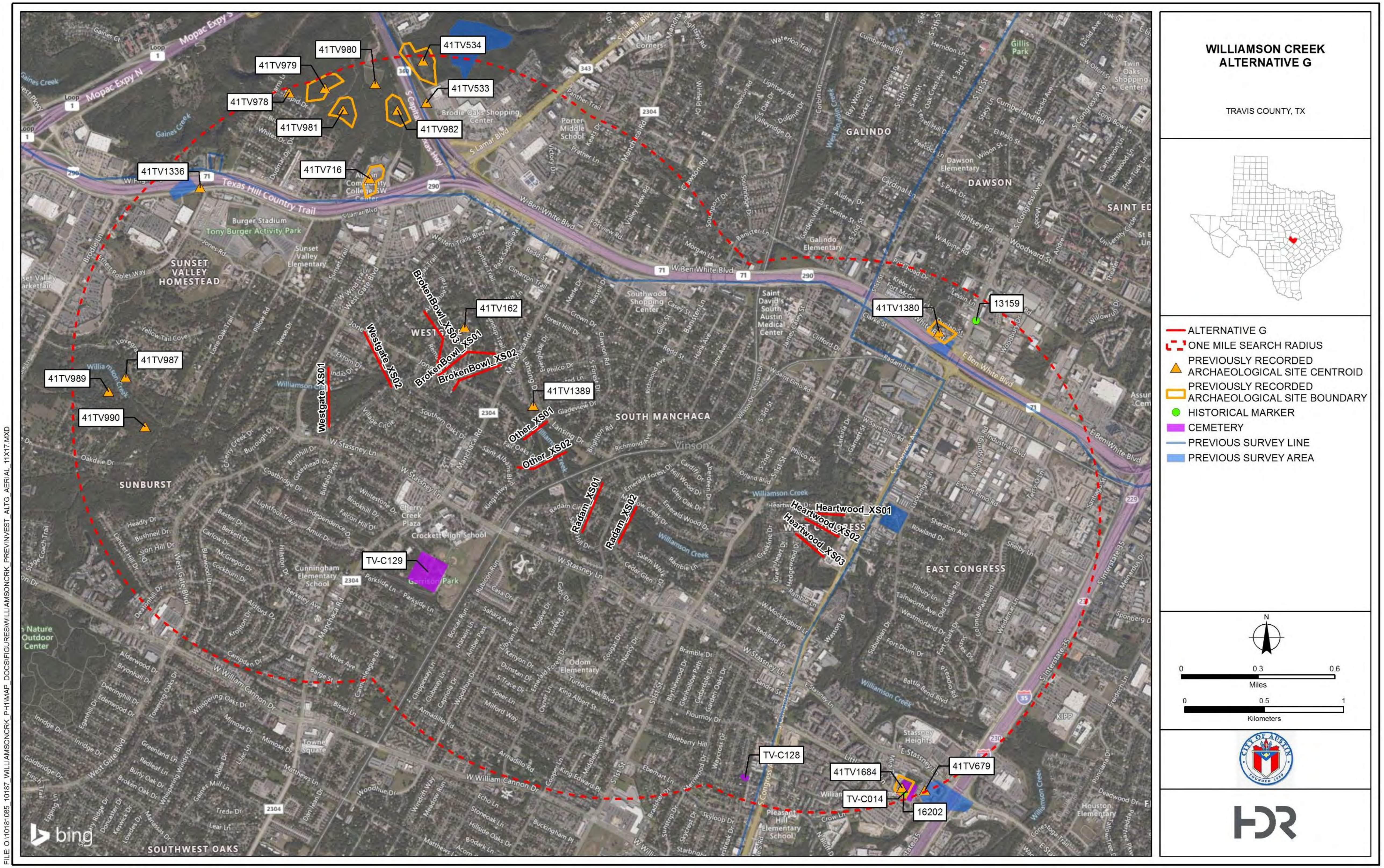


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Figure 7. Previously Recorded Cultural Resources and Surveys within 1 Mile of Alternative H.

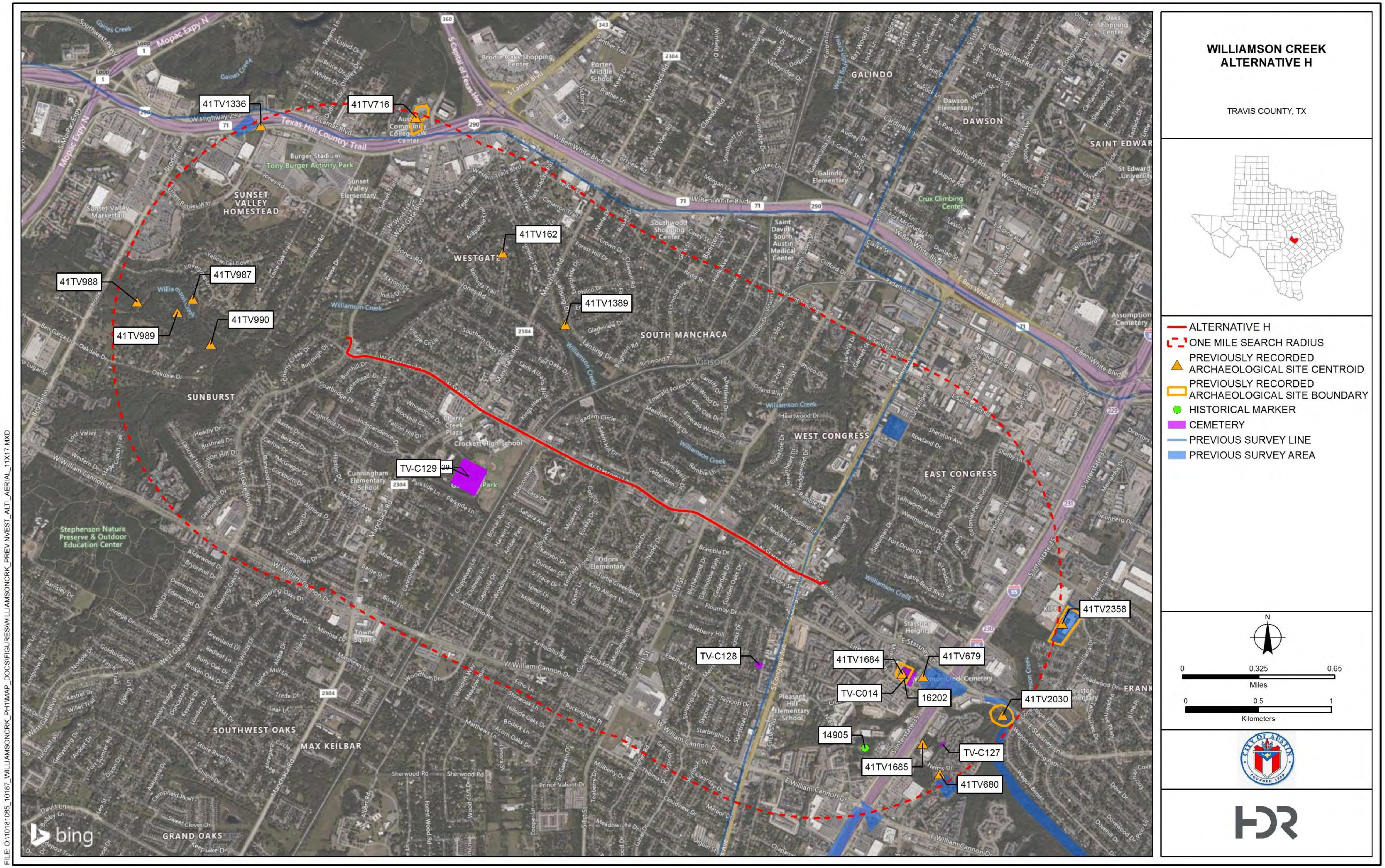

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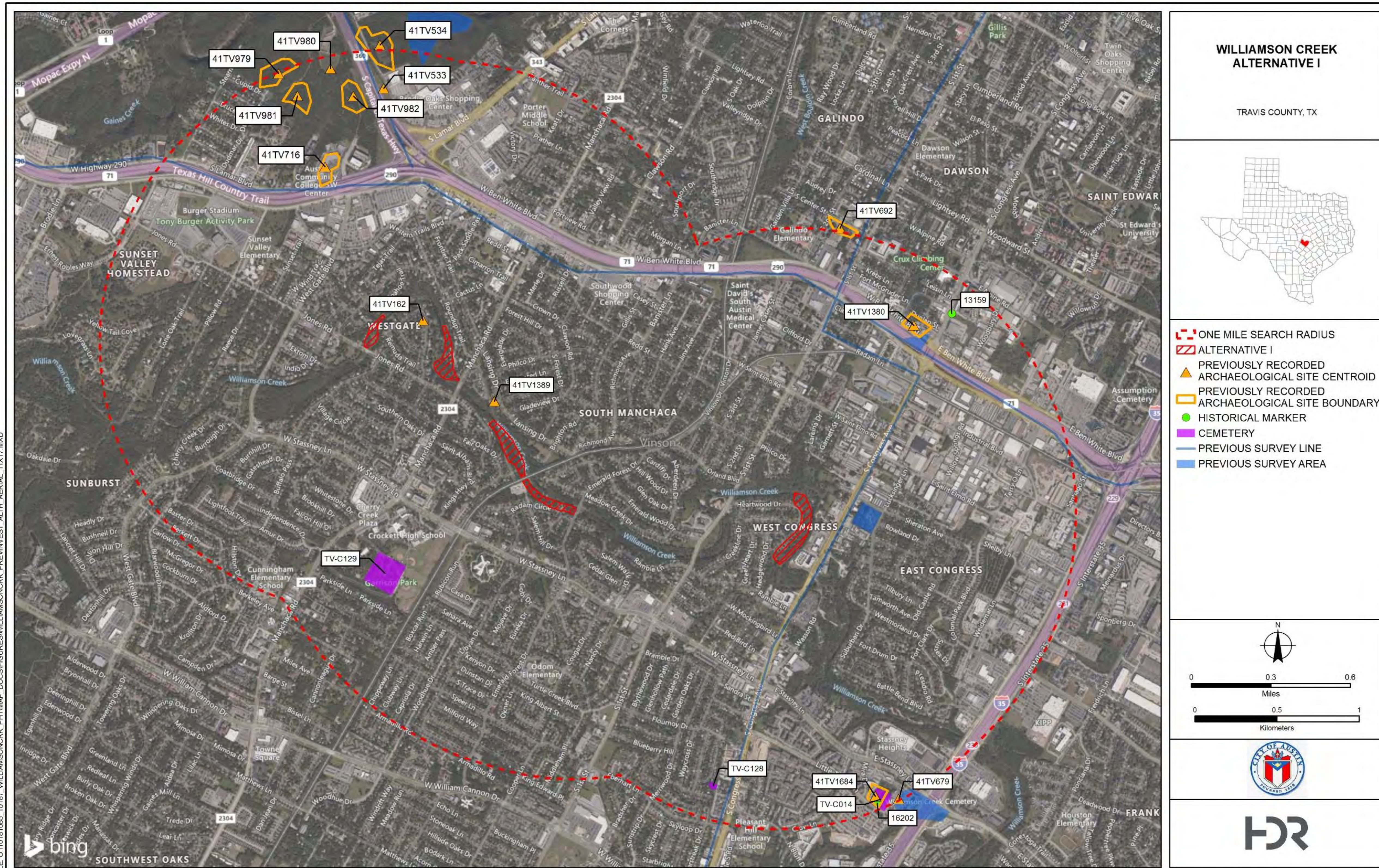
Figure 8. Previously Recorded Cultural Resources and Surveys within 1 Mile of Alternative I.



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Appendix H. Land and Easement Acquisition

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Table H-1. Voluntary buyouts or acquisitions in order to construct proposed alternatives

Alternative	Feature	Problem Area	Type	Address	Property ID	Total Area (ac)	Easement/ Acquisition Area (ac)	2020 TCAD Market Value	Adjusted Market Value[a]	Additional Costs[b]	Total Acquisition Cost[c]
H	Channel	Outlet	Acquisition	500 E Stassney Ln	329772	23.45	1.00	$49,680,000	$64,584,000	$130,000	$2,885,000
I	Channel	Heartwood	Acquisition	312 Heartwood Drive	319313	0.17	0.17	$307,732	$400,052	$130,000	$531,000
I	Channel	Heartwood	Acquisition	204 Heartwood Drive	319301	0.21	0.21	$303,644	$394,737	$130,000	$525,000
I	Channel	Heartwood	Acquisition	214 Heartwood Drive	319306	0.17	0.17	$326,280	$424,164	$130,000	$555,000
I	Channel	Heartwood	Acquisition	300 Heartwood Drive	319307	0.19	0.19	$243,000	$315,900	$130,000	$446,000
I	Channel	Radam	Acquisition	1216 Radam Cir	317254	0.36	0.36	$353,861	$460,019	$130,000	$596,000
I	Channel	Broken Bow	Acquisition	2412 Jones Rd	510038	2.76	2.76	$749,200	$973,960	$130,000	$1,104,000
I	Channel	Broken Bow	Acquisition	4808 Pawnee Pathway	510304	0.52	0.52	$551,331	$716,730	$130,000	$847,000
I	Channel	Broken Bow	Acquisition	4806 Pawnee Pathway	510303	0.60	0.60	$446,428	$580,356	$130,000	$711,000
I	Channel	Broken Bow	Acquisition	4804 Pawnee Pathway	510302	0.71	0.71	$502,342	$653,045	$130,000	$784,000
I	Channel	Broken Bow	Acquisition	4802 Pawnee Pathway	510301	0.60	0.60	$459,500	$597,350	$130,000	$728,000

[a] A 1.30 multiplier was used to adjust the 2020 TCAD Market Value to actual market prices.
[b] Additional costs include relocation, abatement, and others as determined by the City ORES in Appendix 5-E.
[c] Proposed acquisitions that do not include the entire property are estimated on a dollar per acre basis.

Table H-2. Summary of Permanent Drainage Easements and Land Acquisition/Voluntary Buyouts

Alternative	Necessary for Construction				Due to Adverse Impacts		Total Acquisitions and Easements		
	Number of Acquired Properties	Acquisition Costs ($)	Number of Properties with Proposed Drainage Easement	Permanent Drainage Easement Costs ($)	Number of Properties with Proposed Drainage Easement	Permanent Drainage Easement Costs ($)	Number of Properties	Contingency[a]	Cost ($)
B	-	-	30	$2,265,000	326	$126,553,000	356	$38,645,000	**$167,463,000**
G	-	-	19	$8,620,000	-	-	19	$2,586,000	**$11,206,000**
H	1	$3,573,00	34	$3,185,000	46	$13,066,000	81	$9,912,000	**$29,736,000**
I	9	$6,827,000	37	$3,865,000	265	$61,108,000	302	$21,540,000	**$93,340,000**

[a] 30% Contingency for Alternatives to B, G, and I. 50% contingency for Alternative H.

The following exhibits (Figure H-1 through Figure H-9) visualize the proposed drainage easements and acquisitions for alternatives B, G, H, and I.

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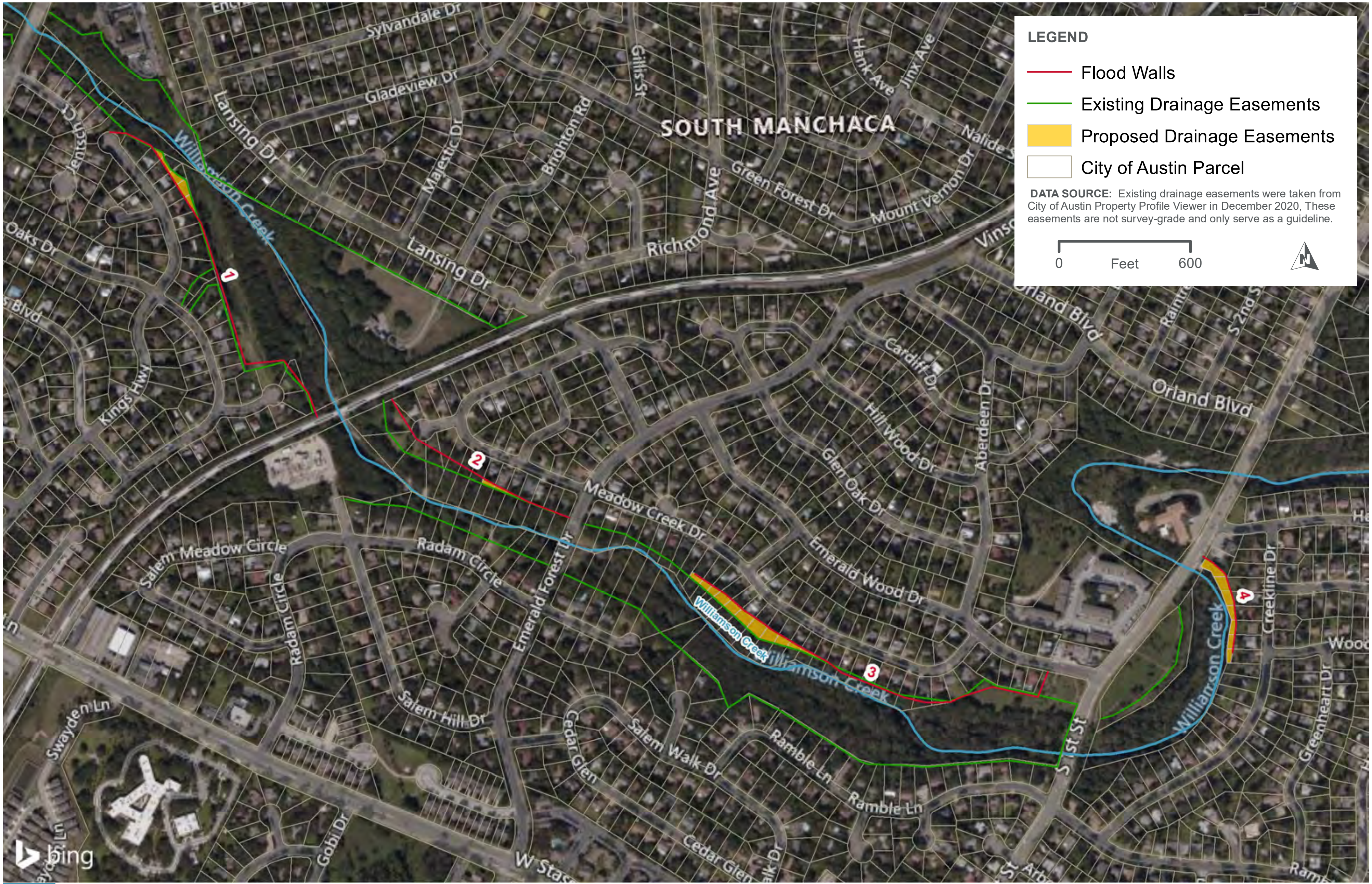

ALTERNATIVE B - FLOOD WALLS

PROPOSED DRAINAGE EASEMENTS FOR CONSTRUCTIONS

FIGURE H-1

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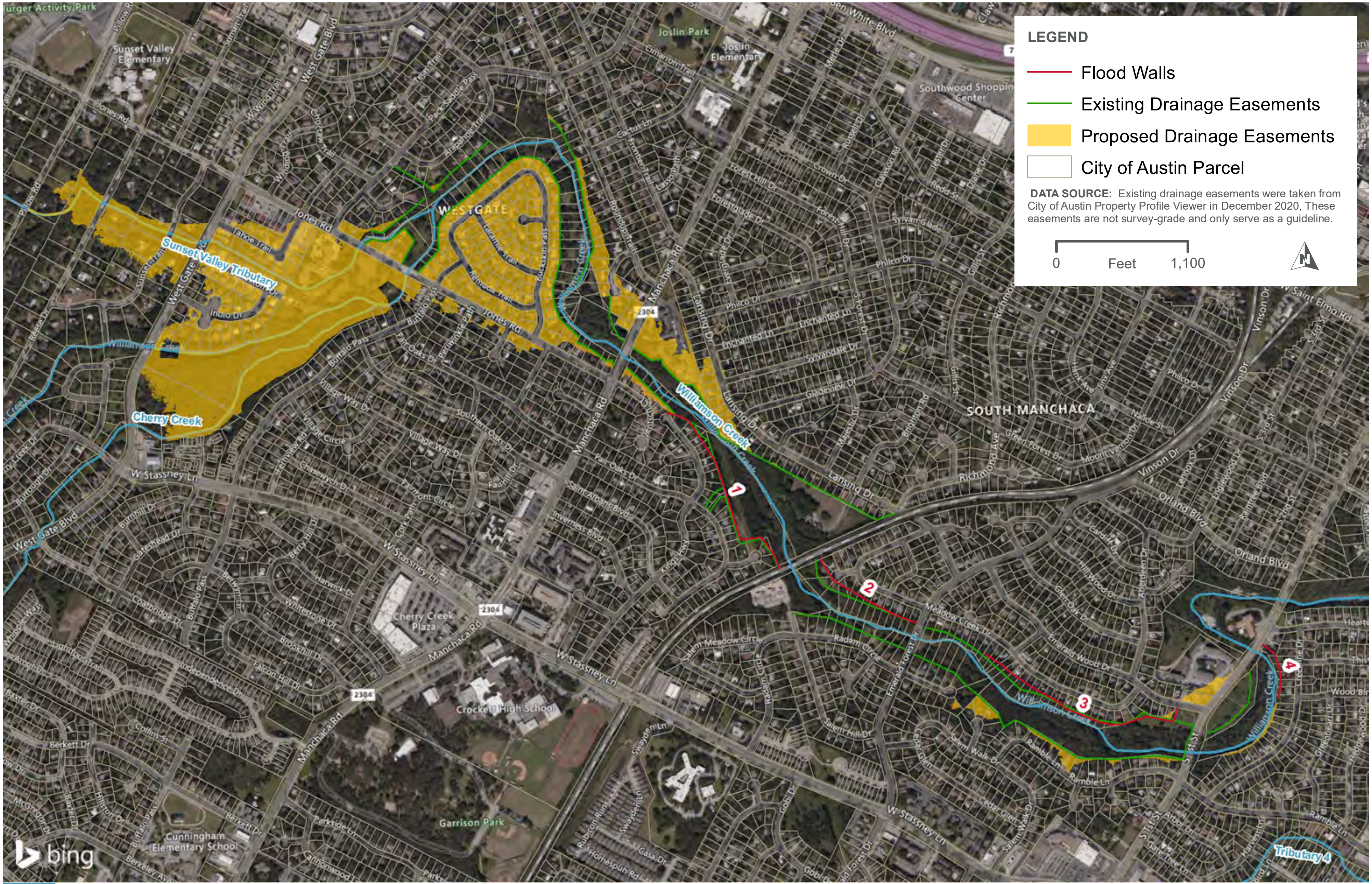
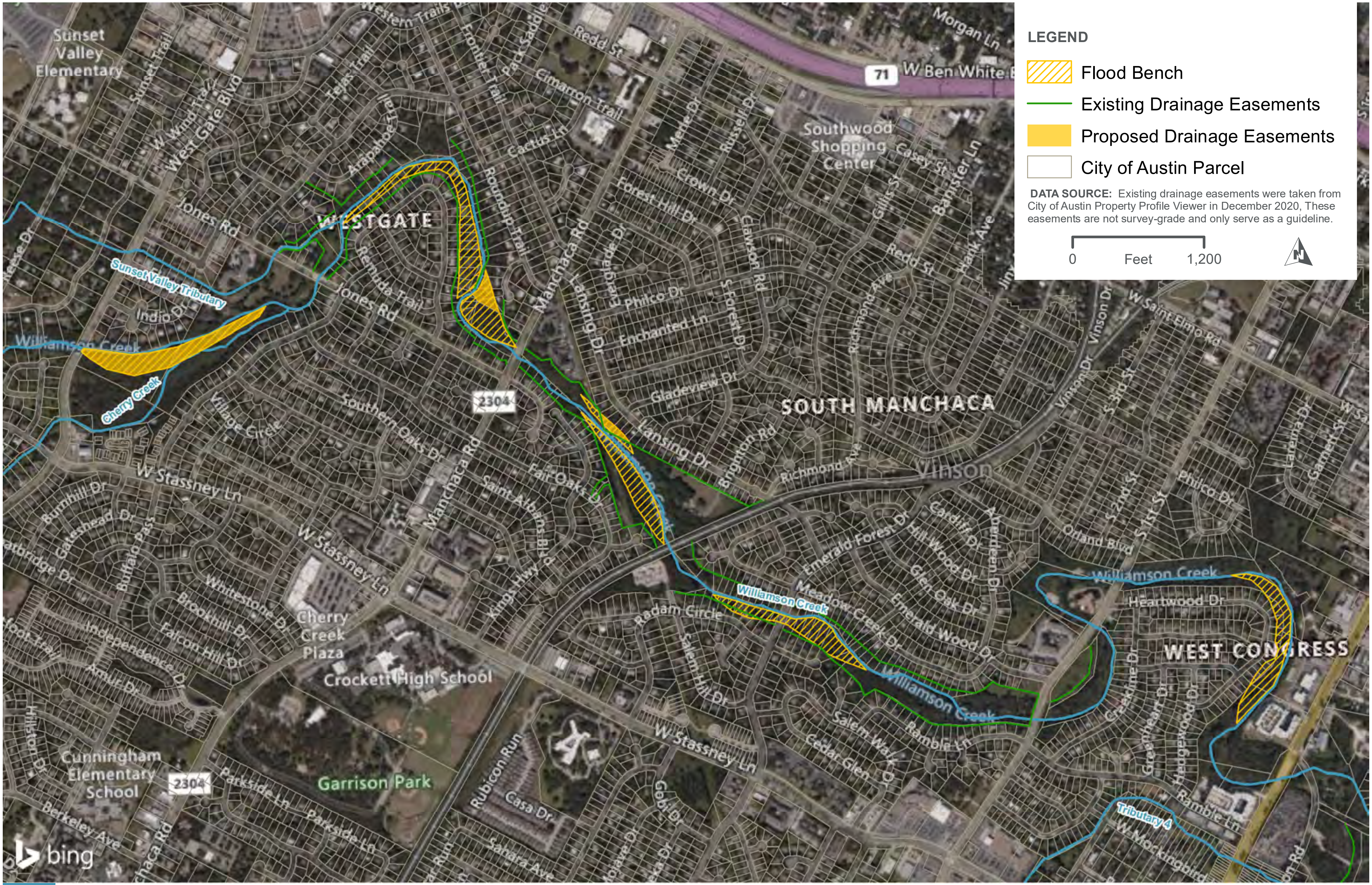


ALTERNATIVE B - FLOOD WALLS

PROPOSED DRAINAGE EASEMENTS FOR ADVERSE IMPACTS

FIGURE H-2



ALTERNATIVE G - CHANNEL MODIFICATIONS

PROPOSED DRAINAGE EASEMENTS FOR CONSTRUCTION

FIGURE H-3

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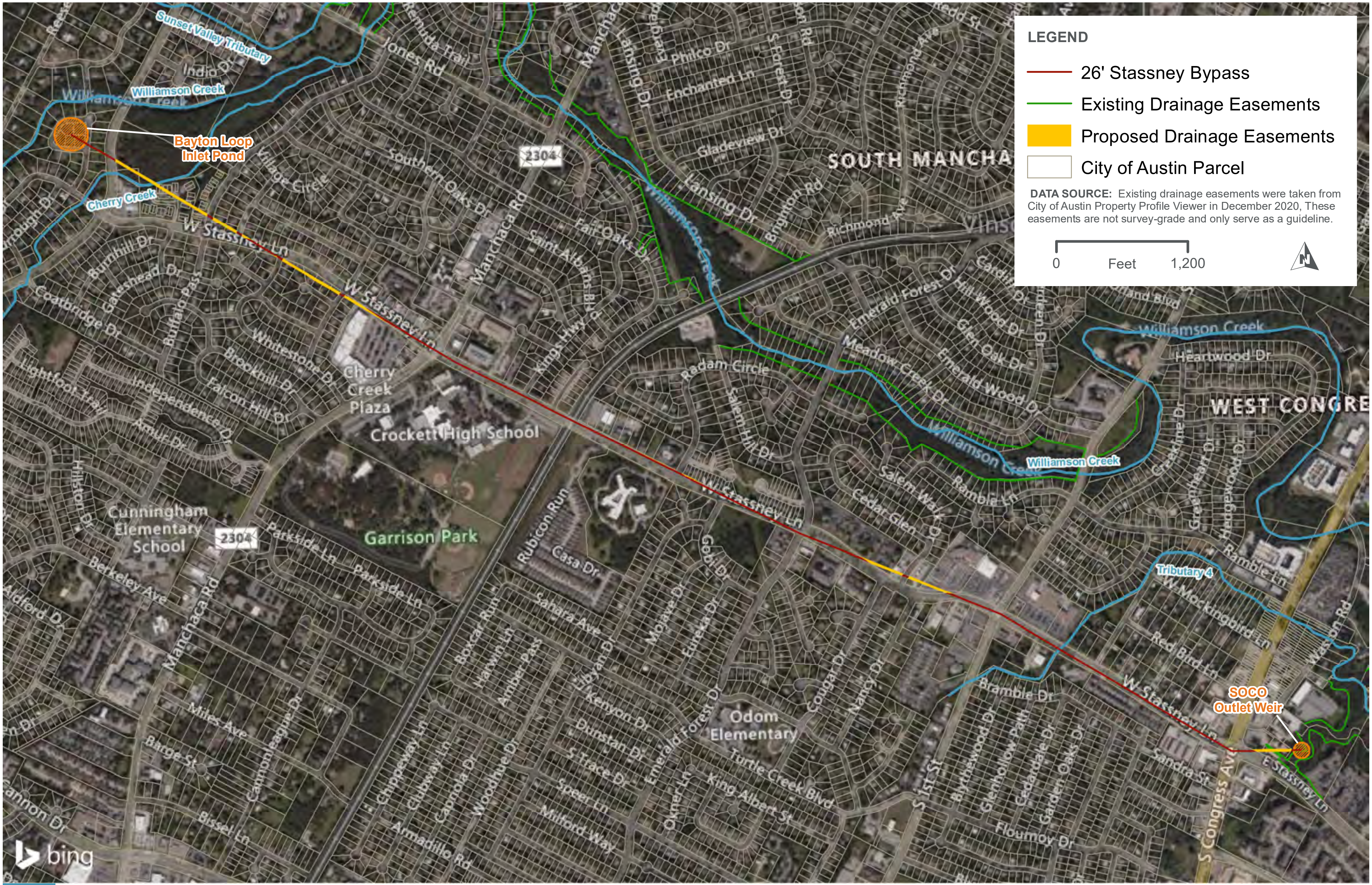
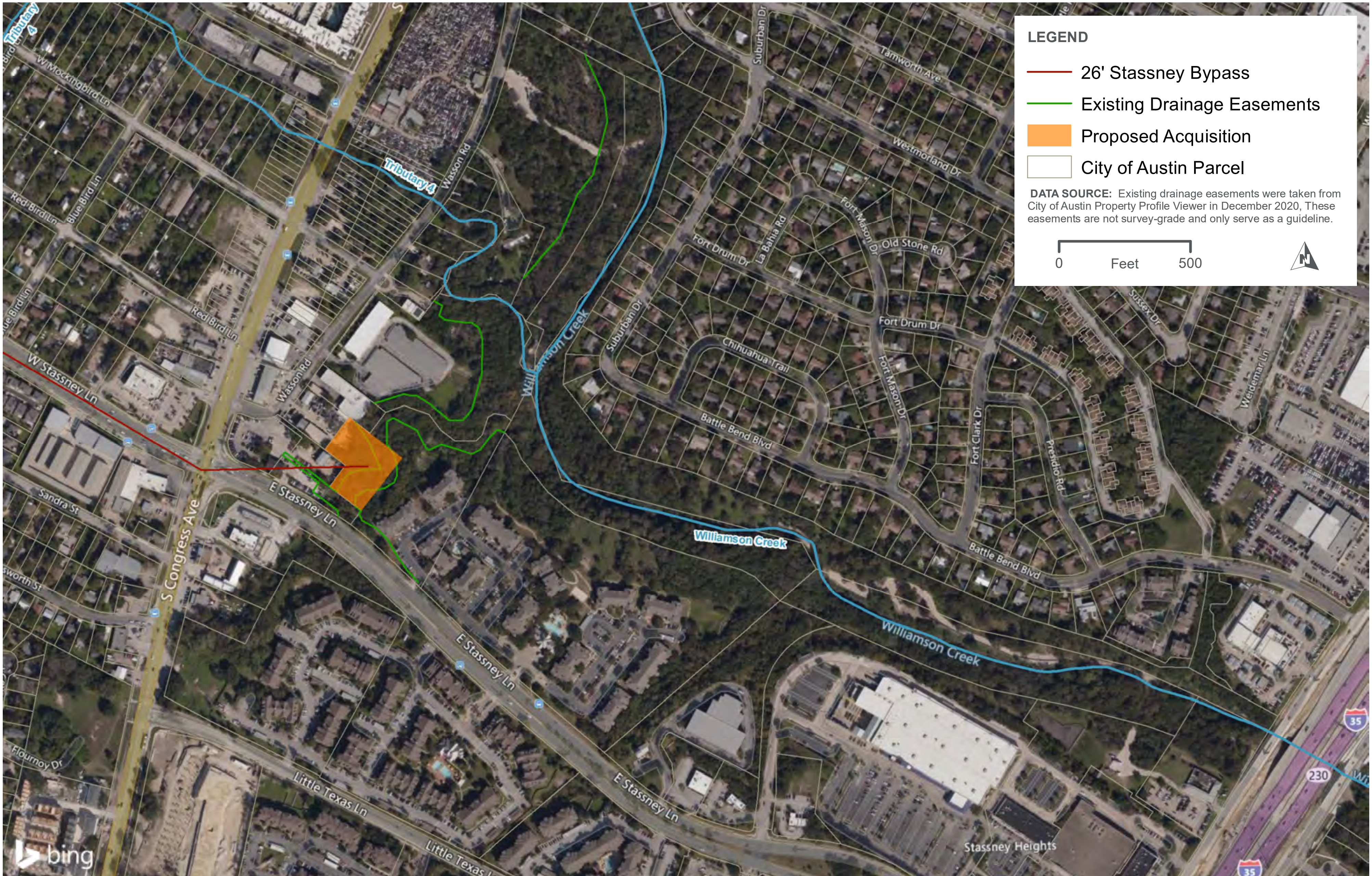


ALTERNATIVE H - STASSNEY BYPASS

PROPOSED DRAINAGE EASEMENTS FOR CONSTRUCTION

FIGURE H-4



ALTERNATIVE H - STASSNEY BYPASS

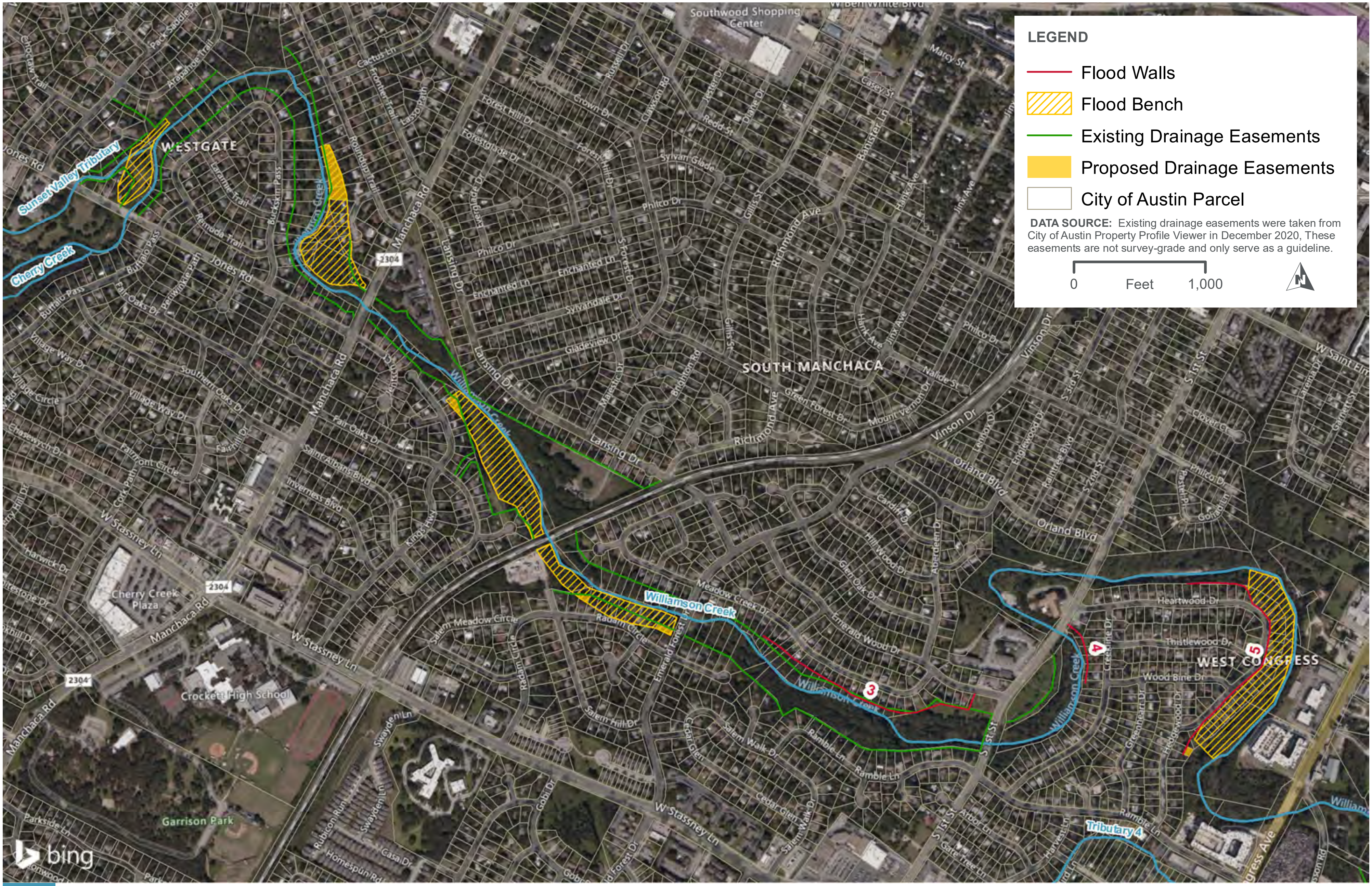
PROPOSED ACQUISITION FOR CONSTRUCTION

FIGURE H-5

ALTERNATIVE H - STASSNEY BYPASS

PROPOSED DRAINAGE EASEMENTS FOR ADVERSE IMPACTS

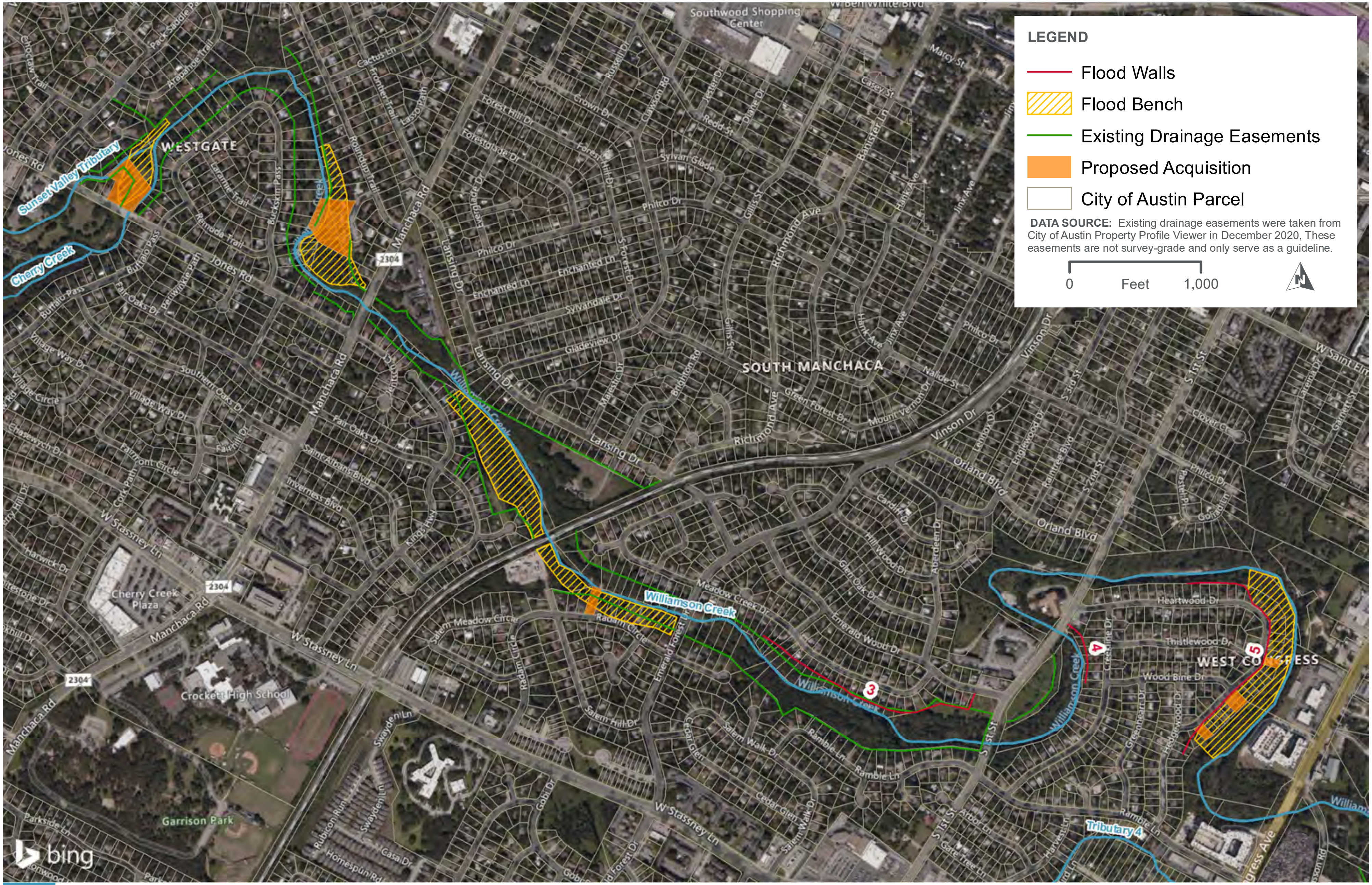
FIGURE H-6



ALTERNATIVE I - COMBINATION

PROPOSED DRAINAGE EASEMENTS FOR CONSTRUCTION

FIGURE H-7

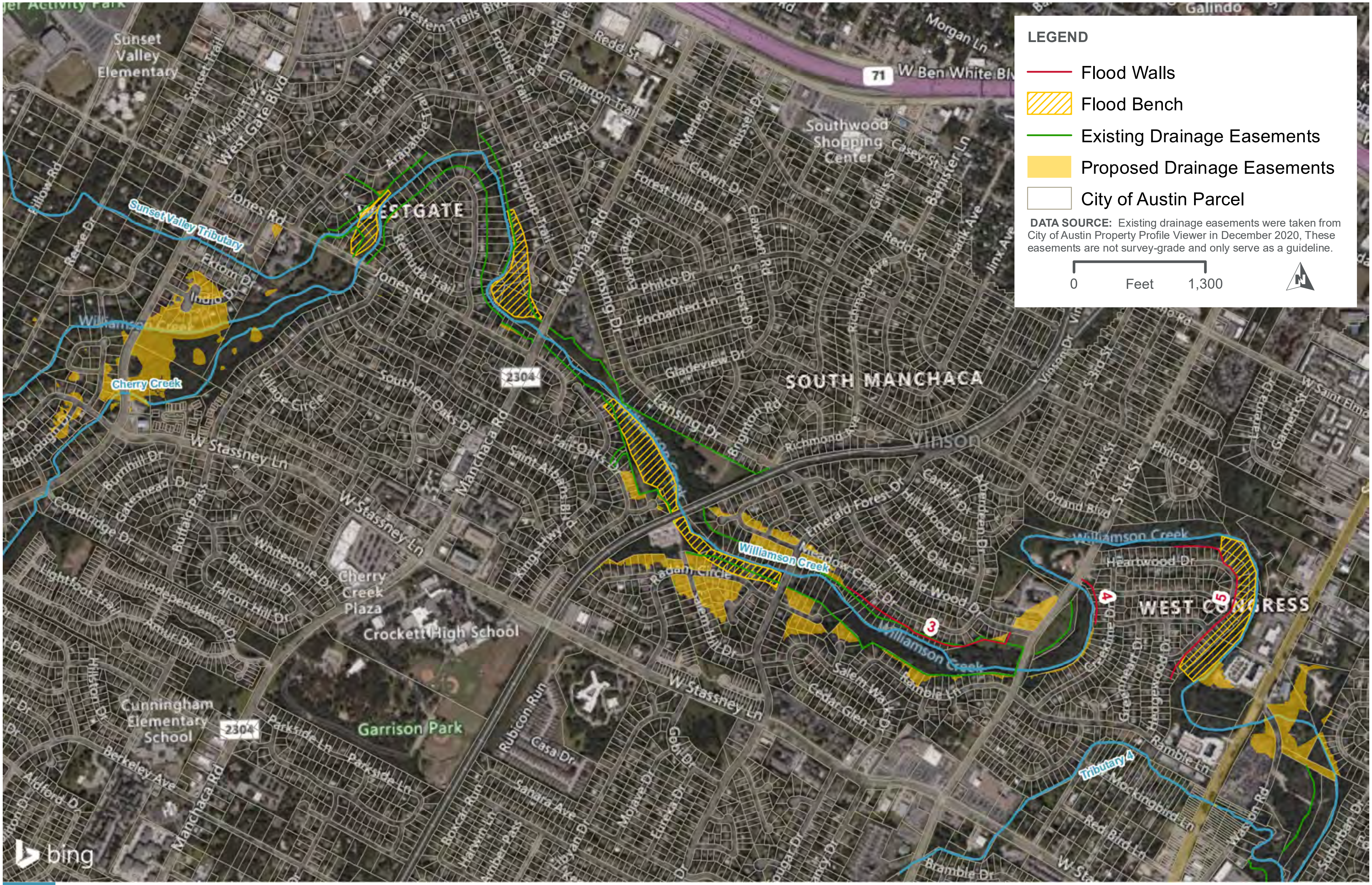


ALTERNATIVE I - COMBINATION

PROPOSED ACQUISITIONS FOR CONSTRUCTION

FIGURE H-8

PATH: P:\003027_CITYOFAUSTIN\10181085_COA_WILLIAMSONCREEK\GIS\MAP_DOCS\DRAFT\SECTION5FIGURES\5_10_ALTI_EASEMENT.MXD - USER: SADAVIS - DATE: 1/9/2021



ALTERNATIVE I - COMBINATION

PROPOSED DRAINAGE EASEMENTS FOR ADVERSE IMPACTS

FIGURE H-9

Appendix I. Major Utility Impacts

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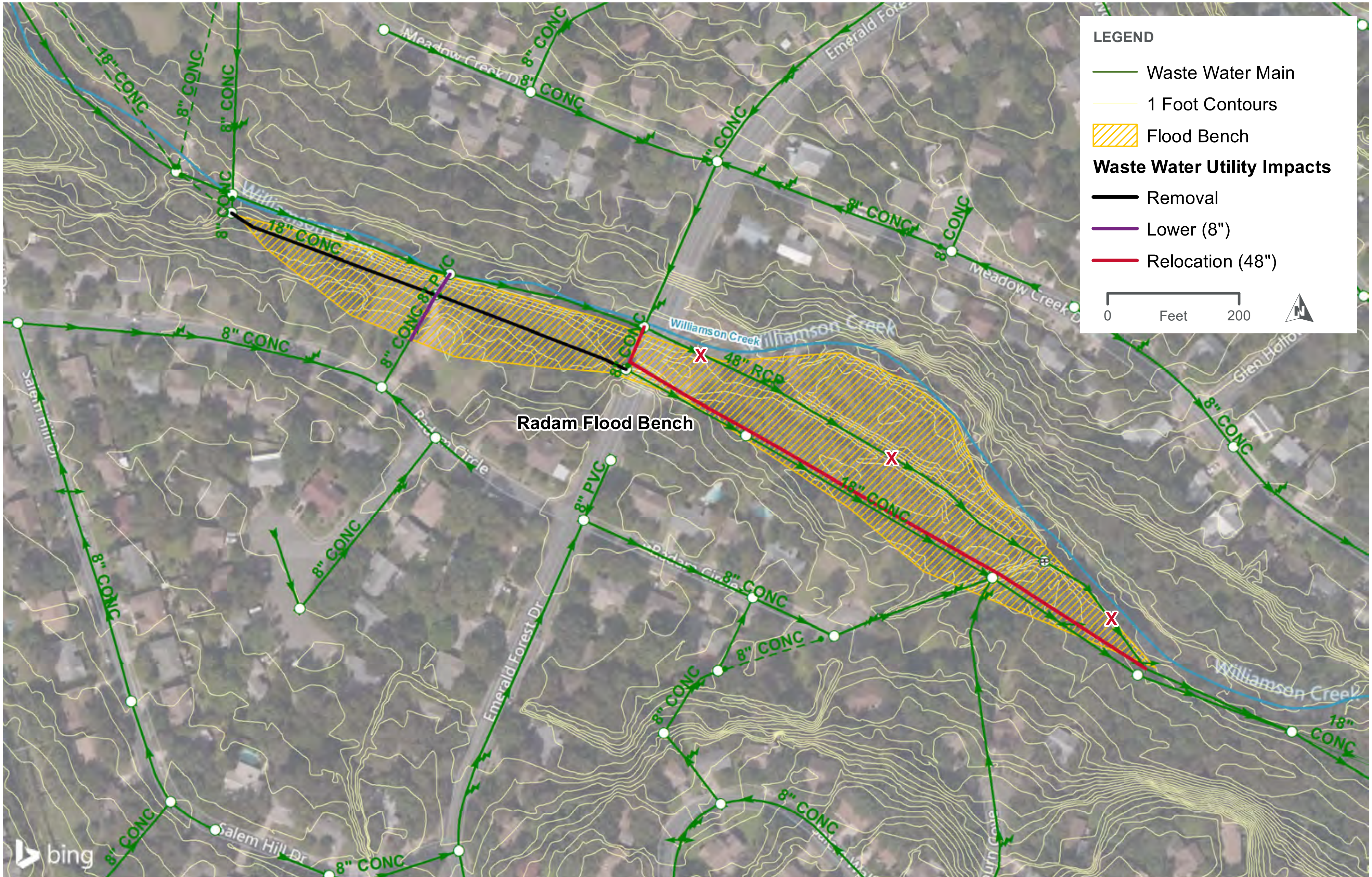
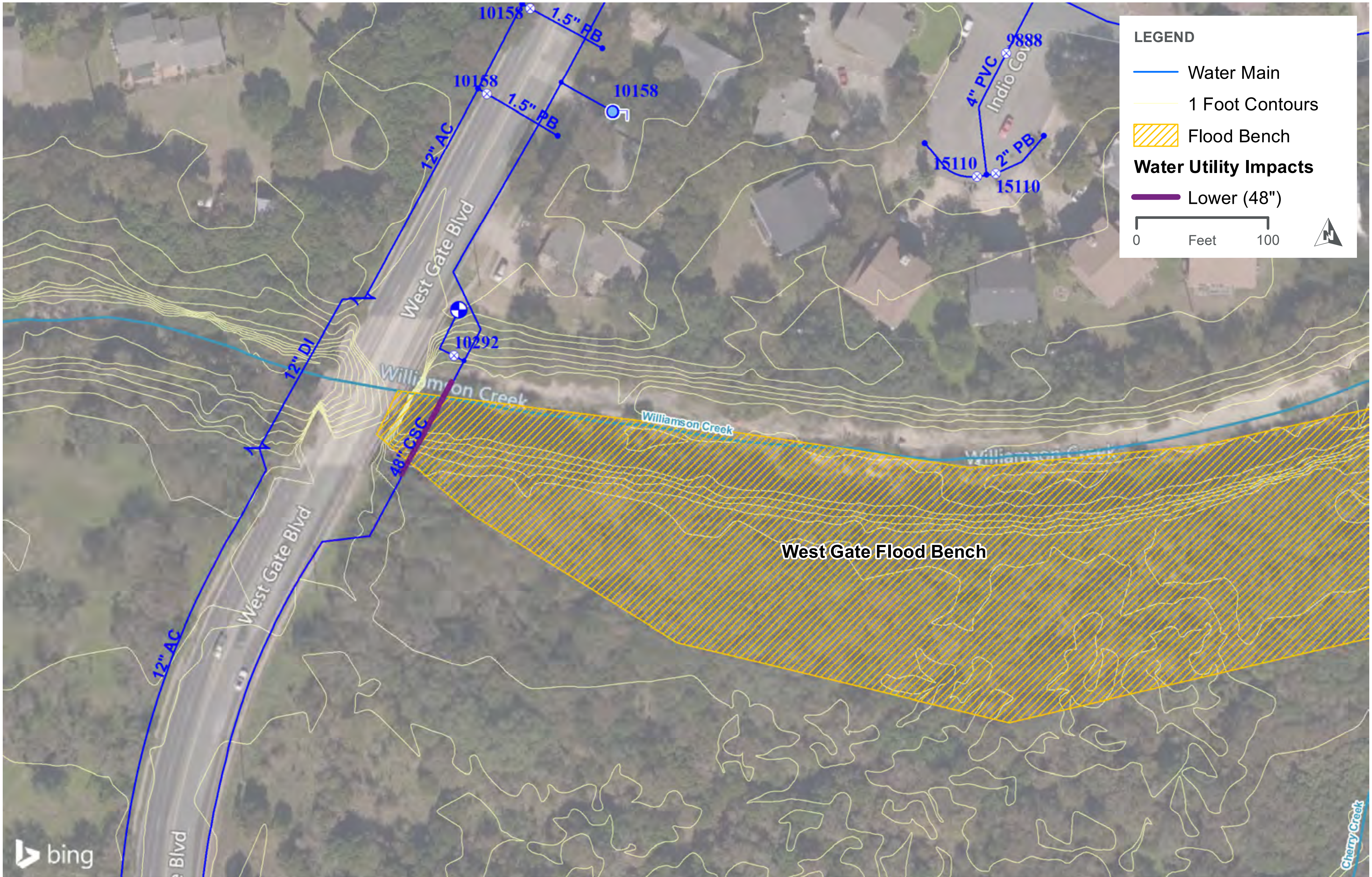


ALTERNATIVE G - CHANNEL MODIFICATION

WASTE WATER UTILITY IMPACTS

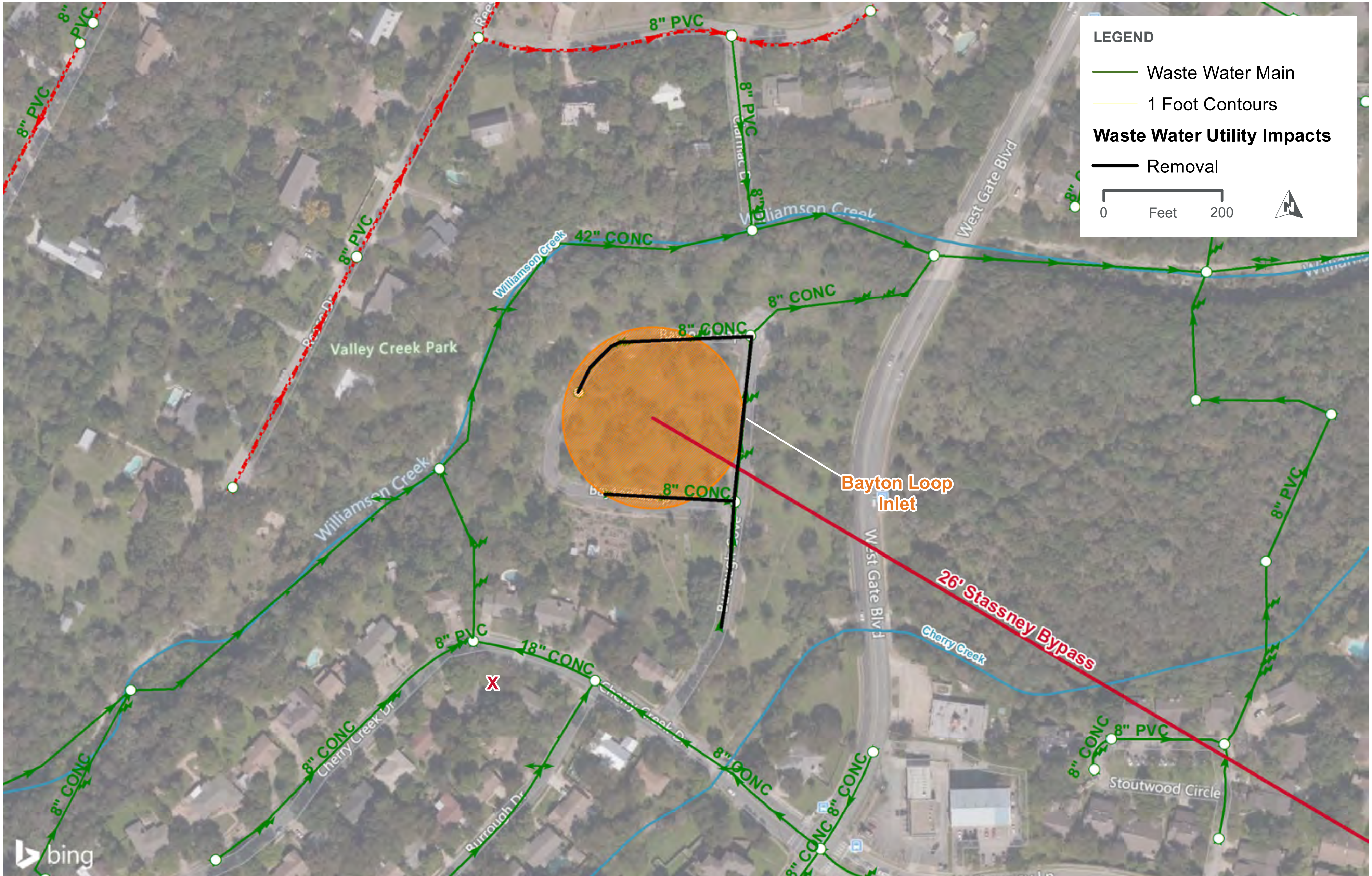
FIGURE I-1



ALTERNATIVE G - CHANNEL MODIFICATION

WATER UTILITY IMPACTS

FIGURE I-2



ALTERNATIVE H - STASSNEY BYPASS

UTILITY IMPACTS

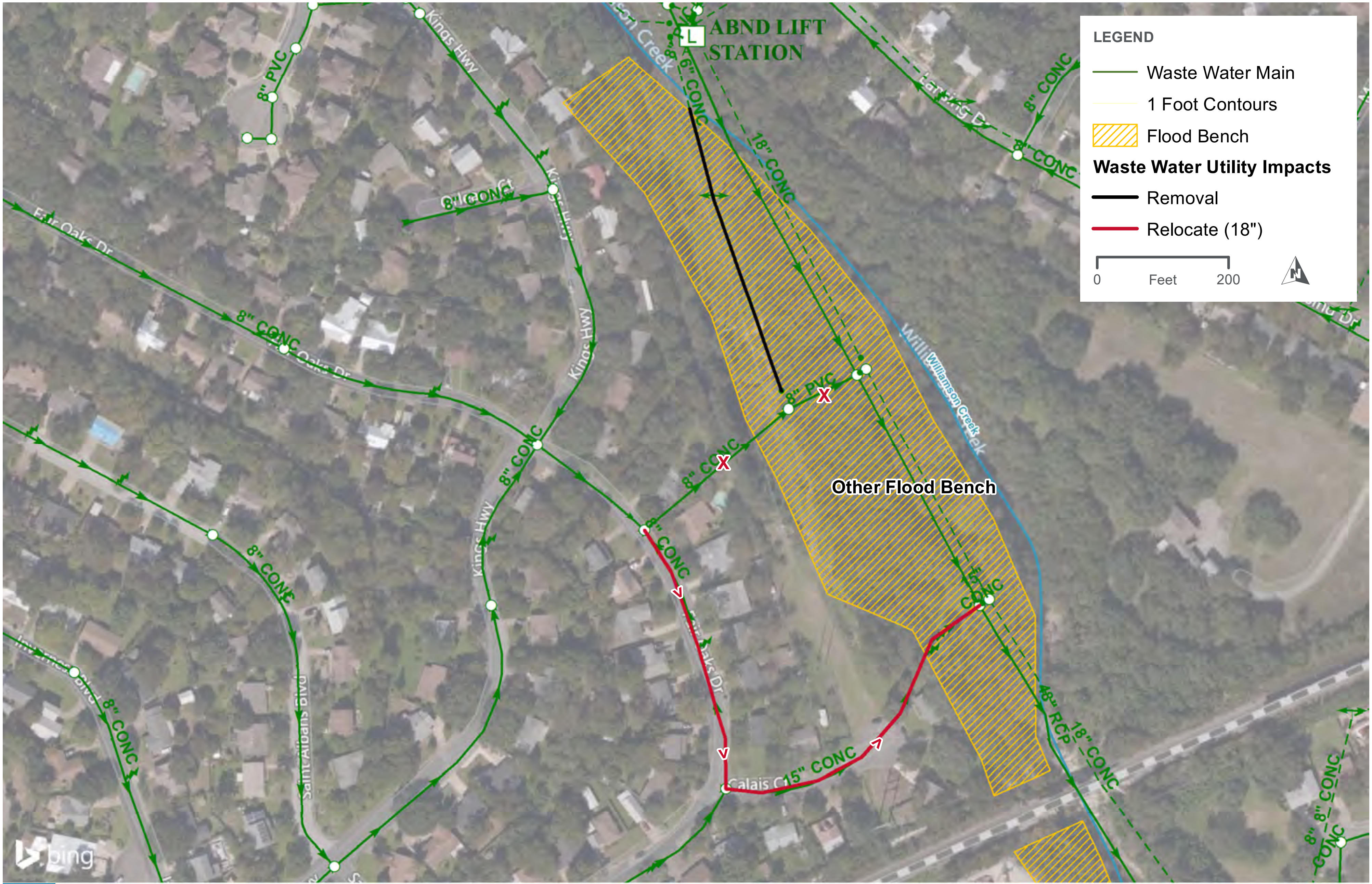
FIGURE I-3

ALTERNATIVE I - COMBINATION

UTILITY IMPACTS - BROKEN BOW

FIGURE I-4

PATH: P:\003027_CITYOFAUSTIN\10181085_COA_WILLIAMSONCREEK\GIS\MAP_DOCS\DRAFT\SECTION5FIGURES\5_10_ALTI_UTILITIES_OTHER.MXD - USER: SADAVIS - DATE: 1/12/2021

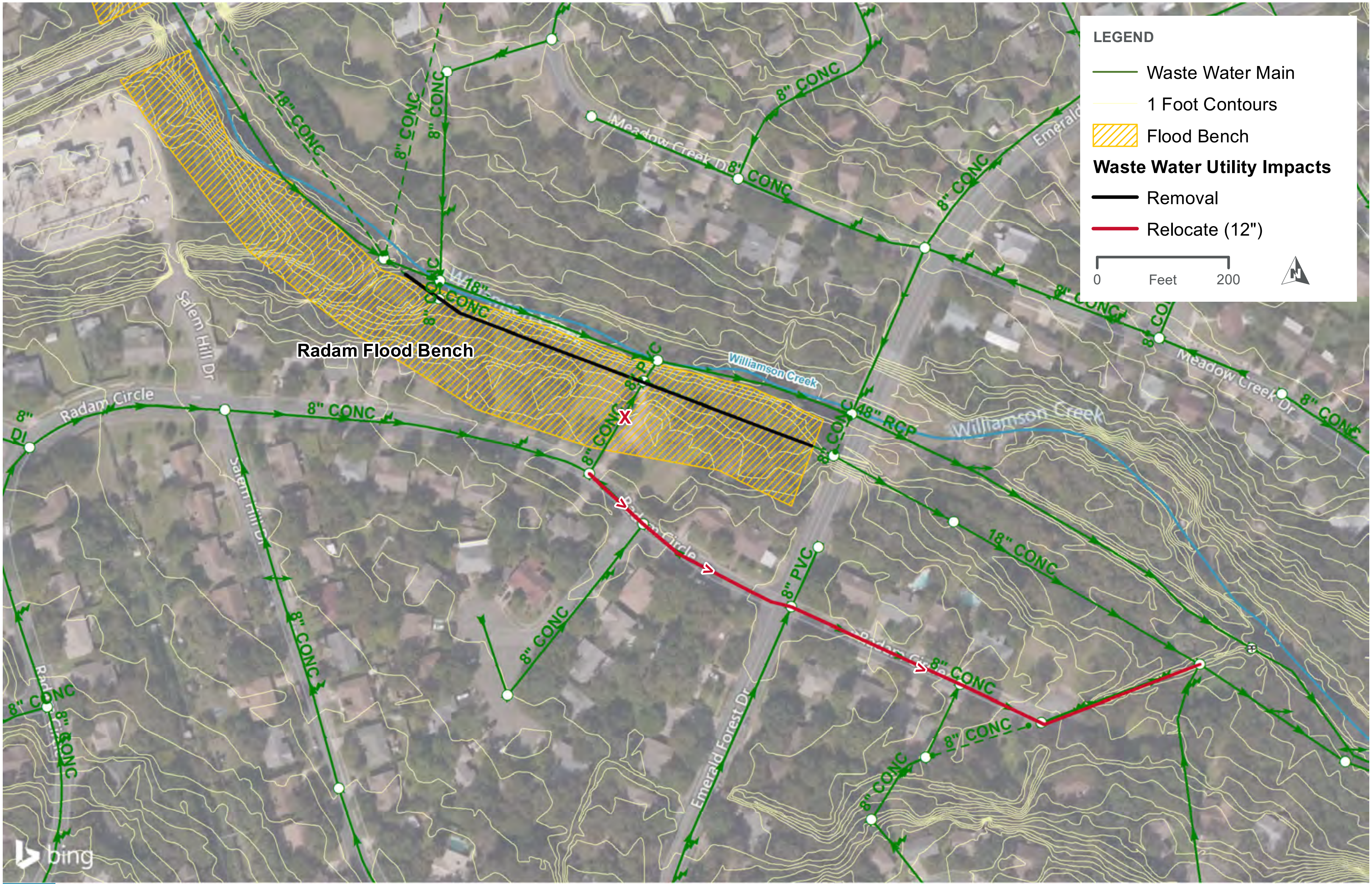


ALTERNATIVE I - COMBINATION

UTILITY IMPACTS - OTHER

FIGURE I-5

PATH: P:\003027_CITYOFAUSTIN\10181085_COA_WILLIAMSONCREEK\GIS\MAP_DOCS\DRAFT\SECTION5FIGURES\5_10_ALTI_UTILITIES_OTHER.MXD - USER: SADAVIS - DATE: 1/12/2021



ALTERNATIVE I - COMBINATION

UTILITY IMPACTS - RADAM

FIGURE I-6

ALTERNATIVE I - COMBINATION

UTILITY IMPACTS - HEARTWOOD

FIGURE I-7

Appendix J. Opinion of Probable Construction Costs

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TBPE Firm No. F-754

Middle Williamson Creek Flood Risk Reduction
Flood Risk Reduction Alternatives Analysis
Alternative B - Flood Walls
Opinion of Probable Construction Cost

ITEM	DESCRIPTION	UNIT	UNIT COST	QUANTITY	TOTAL COST
Flood Wall 1 (Length - 1,800 ft, Avg Height - 10.7')					
102S-A	Clearing and Grubbing	AC	$ 4,700	1.0	$ 4,900
111S-A	Excavation and Backfill	CY	$ 45	1,000	$ 45,000
414S-C	Cast in Place Portland Cement Concrete Retaining Wall	CY	$ 875	1,850	$ 1,618,800
605S-A-F	Soil Retention Blanket, Class 2 Type F	SY	$ 5	4,800	$ 24,000
609S	Topsoil/Seedbed Preperation and Native Seeding	SY	$ 10	4,800	$ 48,000
	Local Drainage Modifications (per Linear Foot of Wall)	LF	$ 25	1,800	$ 45,000
	Tree Protection and Mitigation	AC	$ 10,000	1.0	$ 10,400
	Subtotal				**$ 1,796,100**
Additional Costs					
	Permanent Easement (6 Properties, 0.2 acres)	SF	$ 30	9,000	$ 363,000
700S-TM	Mobilization	LS	11%	1	$ 197,600
	Temporary Erosion and Sediment Control	LS	5%	3	$ 89,900
	Construction Costs				$ 2,446,600
	Contingency		30%		$ 734,000
	Problem Area Total				**$ 3,180,600**
Flood Wall 2 (Length - 1,000 ft, Avg Height - 10.8')					
102S-A	Clearing and Grubbing	AC	$ 4,700	0.6	$ 2,700
111S-A	Excavation and Backfill	CY	$ 45	560	$ 25,200
414S-C	Cast in Place Portland Cement Concrete Retaining Wall	CY	$ 875	1,030	$ 901,300
605S-A-F	Soil Retention Blanket, Class 2 Type F	SY	$ 5	2,670	$ 13,400
609S	Topsoil/Seedbed Preperation and Native Seeding	SY	$ 10	2,670	$ 26,700
	Local Drainage Modifications (per Linear Foot of Wall)	LF	$ 25	1,000	$ 25,000
	Tree Protection and Mitigation	AC	$ 10,000	0.6	$ 5,800
	Subtotal				**$ 1,000,100**
Additional Costs					
	Permanent Easement (4 Properties, 0.1 acres)	SF	$ 30	3,000	$ 152,000
700S-TM	Mobilization	LS	11%	1	$ 197,600
	Temporary Erosion and Sediment Control	LS	5%	3	$ 50,100
	Construction Costs				$ 1,399,800
	Contingency		30%		$ 419,900
	Problem Area Total				**$ 1,819,700**
Flood Wall 3 (Length - 1,900 ft, Avg Height - 6.8')					
102S-A	Clearing and Grubbing	AC	$ 4,700	1.1	$ 5,200
111S-A	Excavation and Backfill	CY	$ 45	1,060	$ 47,700
414S-C	Cast in Place Portland Cement Concrete Retaining Wall	CY	$ 875	1,670	$ 1,461,300
605S-A-F	Soil Retention Blanket, Class 2 Type F	SY	$ 5	5,070	$ 25,400
609S	Topsoil/Seedbed Preperation and Native Seeding	SY	$ 10	5,070	$ 50,700
	Local Drainage Modifications (per Linear Foot of Wall)	LF	$ 25	1,900	$ 47,500
	Tree Protection and Mitigation	AC	$ 10,000	1.1	$ 11,000
	Subtotal				**$ 1,637,800**
Additional Costs					
	Permanent Easement (13 Properties, 0.7 acres)	SF	$ 30.00	30,000	$ 1,101,500
700S-TM	Mobilization	LS	11%	1	$ 197,600
	Temporary Erosion and Sediment Control	LS	5%	3	$ 81,900
	Construction Costs				$ 3,018,800
	Contingency		30%		$ 905,600
	Problem Area Total				**$ 3,924,400**

TBPE Firm No. F-754

Middle Williamson Creek Flood Risk Reduction
Flood Risk Reduction Alternatives Analysis
Alternative B - Flood Walls
Opinion of Probable Construction Cost

ITEM	DESCRIPTION	UNIT	UNIT COST	QUANTITY	TOTAL COST
Flood Wall 4 (Length - 500 ft, Avg Height - 5.9')					
102S-A	Clearing and Grubbing	AC	$ 4,700	0.3	$ 1,400
111S-A	Excavation and Backfill	CY	$ 45	280	$ 12,600
414S-C	Cast in Place Portland Cement Concrete Retaining Wall	CY	$ 875	420	$ 367,500
605S-A-F	Soil Retention Blanket, Class 2 Type F	SY	$ 5	1,330	$ 6,700
609S	Topsoil/Seedbed Preperation and Native Seeding	SY	$ 10	1,330	$ 13,300
	Local Drainage Modifications (per Linear Foot of Wall)	LF	$ 25	500	$ 12,500
	Tree Protection and Mitigation	AC	$ 10,000	0.3	$ 2,900
	Subtotal				**$ 401,500**
Additional Costs					
	Permanent Easement (7 Properties, 0.4 acres)	SF	$ 30.00	18,000	$ 648,500
700S-TM	Mobilization	LS	11%	1	$ 197,600
	Temporary Erosion and Sediment Control	LS	5%	3	$ 20,100
	Construction Costs				$ 1,267,700
	Contingency		30%		$ 380,300
	Problem Area Total				**$ 1,648,000**

Alternative B - Flood Walls					
	Adverse Impact Permanent Easement (326 Properties, 93 acres)	SF	$ 30.00	4,050,000	$ 126,553,000
	Construction Costs				$ 8,132,900
	Contingency		30%		$ 40,405,800
	Alternative B Total				**$ 175,092,000**

TBPE Firm No. F-754

Williamson Creek Flood Risk Reduction
Flood Risk Reduction Alternatives Analysis
Alternative G - Channel Modifications
Opinion of Probable Construction Cost

ITEM	DESCRIPTION	UNIT	UNIT COST	QUANTITY	TOTAL COST
Reach - Westgate/Indio					
Channel Improvements					
102S	Clearing and Grubbing	AC	$ 10,000.00	4	$ 42,100
120S	Excavation	CY	$ 30.00	44,312	$ 1,329,400
605S	SOIL RETENTION BLANKET CLASS 1; TYPE A	SY	$ 6.00	189,482	$ 1,136,900
609S	Native Seeding and Planting	SY	$ 9.00	189,482	$ 1,705,300
	Tree Protection and Mitigation	AC	$ 100,000	4	$ 421,000
	Channel Improvements Subtotal				**$ 4,634,700**
Additional Costs					
700S-TM	Mobilization	LS	10%	1	$ 463,500
	Temporary Erosion and Sediment Control	LS	8%	1	$ 370,800
	Permenant Easement (5 acres, 3 properties)	SF	$ 30.00	220,000	$ 6,646,500
	Water Main Relocation (48")	LF	$ 590.00	140	$ 82,600
	Additional Cost Subtotal				**$ 7,563,400**
	Construction Costs				$ 12,198,100
	Contingency		30%		$ 3,659,400
	Problem Area Total				**$ 15,857,500**
Reach - Broken Bow					
Channel Improvements					
102S	Clearing and Grubbing	AC	$ 10,000.00	8	$ 84,500
120S	Excavation	CY	$ 30.00	91,505	$ 2,745,200
605S	SOIL RETENTION BLANKET CLASS 1; TYPE A	SY	$ 6.00	616,034	$ 3,696,200
609S	Native Seeding and Planting	SY	$ 9.00	616,034	$ 5,544,300
	Tree Protection and Mitigation	AC	$ 100,000	8	$ 845,000
	Channel Improvements Subtotal				**$ 12,915,200**
Additional Costs					
700S-TM	Mobilization	LS	10%	1	$ 1,291,500
	Temporary Erosion and Sediment Control	LS	8%	1	$ 1,033,200
	Permenant Easement (0.9 acres, 8 properties)	SF	$ 30.00	38,000	$ 1,264,000
	Additional Cost Subtotal				**$ 3,588,700**
	Construction Costs				$ 16,503,900
	Contingency		30%		$ 4,951,200
	Problem Area Total				**$ 21,455,100**
Reach - Other					
Channel Improvements					
102S	Clearing and Grubbing	AC	$ 10,000.00	4	$ 40,800
120S	Excavation	CY	$ 30.00	64,135	$ 1,924,000
605S	SOIL RETENTION BLANKET CLASS 1; TYPE A	SY	$ 6.00	209,006	$ 1,254,000
609S	Native Seeding and Planting	SY	$ 9.00	209,006	$ 1,881,100
	Tree Protection and Mitigation	AC	$ 100,000	4	$ 407,800
	Channel Improvements Subtotal				**$ 5,507,700**
Additional Costs					
700S-TM	Mobilization	LS	10%	1	$ 550,800
	Temporary Erosion and Sediment Control	LS	8%	1	$ 440,600
	Permenant Easement (0.4 acres, 8 properties)	SF	$ 30.00	19,500	$ 709,000
	Additional Cost Subtotal				**$ 1,700,400**
	Construction Costs				$ 7,208,100
	Contingency		30%		$ 2,162,400
	Problem Area Total				**$ 9,370,500**

TBPE Firm No. F-754

Williamson Creek Flood Risk Reduction
Flood Risk Reduction Alternatives Analysis
Alternative G - Channel Modifications
Opinion of Probable Construction Cost

ITEM	DESCRIPTION	UNIT	UNIT COST	QUANTITY	TOTAL COST
Reach - Radam					
Channel Improvements					
102S	Clearing and Grubbing	AC	$ 10,000.00	4	$ 39,300
120S	Excavation	CY	$ 30.00	64,811	$ 1,944,300
605S	SOIL RETENTION BLANKET CLASS 1; TYPE A	SY	$ 6.00	253,326	$ 1,520,000
609S	Native Seeding and Planting	SY	$ 9.00	253,326	$ 2,279,900
	Tree Protection and Mitigation	AC	$ 100,000	4	$ 393,000
	Channel Improvements Subtotal				**$ 6,176,500**
Additional Costs					
700S-TM	Mobilization	LS	$ 0.10	1	$ 617,700
	Temporary Erosion and Sediment Control	LS	$ 0.08	1	$ 494,100
	Lower Waste Water Service Line (8")	LF	$ 140.00	120	$ 16,800
	Lower Waste Water Service Line (18")	LF	$ 280.00	636	$ 178,100
	Waste Water Service Line Relocation(48")	LF	$ 490.00	1,062	$ 520,400
	Additional Cost Subtotal				**$ 1,827,100**
	Construction Costs				$ 8,003,600
	Contingency		30%		$ 2,401,100
	Problem Area Total				**$ 10,404,700**
Reach - Heartwood					
Channel Improvements					
102S	Clearing and Grubbing	AC	$ 10,000.00	6	$ 64,200
120S	Excavation	CY	$ 30.00	140,742	$ 4,222,300
605S	SOIL RETENTION BLANKET CLASS 1; TYPE A	SY	$ 6.00	216,252	$ 1,297,500
609S	Native Seeding and Planting	SY	$ 9.00	216,252	$ 1,946,300
	Tree Protection and Mitigation	AC	$ 100,000	6	$ 642,000
	Subtotal				**$ 8,172,300**
Additional Costs					
700S-TM	Mobilization	LS	10%	1	$ 817,200
	Temporary Erosion and Sediment Control	LS	8%	1	$ 653,800
	Permenant Easement	SF	$ 30.00	0	$ -
	Additional Cost Subtotal				**$ 1,471,000**
	Construction Costs				$ 9,643,300
	Contingency		30%		$ 2,893,000
	Problem Area Total				**$ 12,536,300**
Alternative G - Channel Modifications					
	Construction Costs				$ 53,557,000
	Contingency		30%		$ 16,067,100
	Alternative G Total				**$ 69,624,100**

TBPE Firm No. F-754

Middle Williamson Creek Flood Risk Reduction
Flood Risk Reduction Alternatives Analysis
Alternative H - Stassney Bypass
Opinion of Probable Construction Cost

ITEM	DESCRIPTION	UNIT	UNIT COST	QUANTITY	TOTAL COST
Stassney Bypass					
	Bayton Loop Pond Inlet Facility[a]	EA	$ 15,269,000	1	$ 15,269,000
	26' Stassney Bypass[b]	LF	$ 8,000	13,200	$ 105,600,000
	SOCO Outlet[a]	EA	$ 15,269,000	1	$ 15,269,000
	Baton Loop Decomissioned Utility Removal	LF	$ 50.00	2,950	$ 147,500
	Subtotal				**$ 136,290,000**
Additional Costs					
	Bypass Permanent Drainage Easement (34 properties, 2 ac)	SF	$ 30	88,600	$ 3,185,000
	Adv Impact Permanent Drainage Easement (46 properties, 9.5 ac)	SF	$ 30	411,800	$ 13,066,000
	Land Acquisition	See Appendix 5-B.			$ 3,573,000
	Construction Costs				$ 156,114,000
	Contingency		50%		$ 78,057,000
	Alternative H Total				**$ 234,171,000**

a Original bid amount for a similar project along Waller Creek in 2012, adjusted 13% for inflation.
https://www.austintexas.gov/edims/document.cfm?id=254061

b Original bid amount for a similar project along Waller Creek (excluding $5.5M inlet) in 2011, adjusted 16% for inflation, and scaled per linear foot.
https://www.austintexas.gov/edims/document.cfm?id=254061

TBPE Firm No. F-754

Middle Williamson Creek Flood Risk Reduction
Flood Risk Reduction Alternatives Analysis
Alternative I - Combination
Opinion of Probable Construction Cost

ITEM	DESCRIPTION	UNIT	UNIT COST	QUANTITY	TOTAL COST
Flood Wall 3 (Length - 1,900 ft, Avg Height - 6.0')					
102S-A	Clearing and Grubbing	AC	$ 4,700	1.1	$ 5,200
111S-A	Excavation and Backfill	CY	$ 45	1,060	$ 47,700
414S-C	Cast in Place Portland Cement Concrete Retaining Wall	CY	$ 875	1,620	$ 1,417,500
605S-A-F	Soil Retention Blanket, Class 2 Type F	SY	$ 5	5,070	$ 25,400
609S	Topsoil/Seedbed Preperation and Native Seeding	SY	$ 10	5,070	$ 50,700
	Local Drainage Modifications (per Linear Foot of Wall)	LF	$ 25	1,900	$ 47,500
	Tree Protection and Mitigation	AC	$ 100,000	1.1	$ 109,100
	Subtotal				**$ 1,594,000**
Additional Costs					
	Permanent Easement (13 properties, 0.7 acres)	SF	$ 30.00	30,000	$ 1,101,500
700S-TM	Mobilization	LS	11%	1	$ 175,400
	Temporary Erosion and Sediment Control	LS	5%	3	$ 79,700
	Construction Costs				$ 2,950,600
	Contingency		30%		$ 885,200
	Problem Area Total				**$ 3,835,800**
Flood Wall 4 (Length - 500 ft, Avg Height - 5.9')					
102S-A	Clearing and Grubbing	AC	$ 4,700	0.3	$ 1,400
111S-A	Excavation and Backfill	CY	$ 45	280	$ 12,600
414S-C	Cast in Place Portland Cement Concrete Retaining Wall	CY	$ 875	420	$ 367,500
605S-A-F	Soil Retention Blanket, Class 2 Type F	SY	$ 5	1,330	$ 6,700
609S	Topsoil/Seedbed Preperation and Native Seeding	SY	$ 10	1,330	$ 13,300
	Local Drainage Modifications (per Linear Foot of Wall)	LF	$ 25	500.0	$ 12,500
	Tree Protection and Mitigation	AC	$ 100,000	0.3	$ 28,700
	Subtotal				**$ 401,500**
Additional Costs					
	Permanent Easement (7 properties, 0.4 acres)	SF	$ 30	18,000	$ 648,500
700S-TM	Mobilization	LS	11%	1	$ 44,200
	Temporary Erosion and Sediment Control	LS	5%	3	$ 20,100
	Construction Costs				$ 1,114,300
	Contingency		30%		$ 334,300
	Problem Area Total				**$ 1,448,600**
Flood Wall 5 (Length - 2,000 ft, Avg Height - 10.4')					
102S-A	Clearing and Grubbing	AC	$ 4,700	1.1	$ 5,400
111S-A	Excavation and Backfill	CY	$ 45	1,110	$ 50,000
414S-C	Cast in Place Portland Cement Concrete Retaining Wall	CY	$ 875	2,030	$ 1,776,300
605S-A-F	Soil Retention Blanket, Class 2 Type F	SY	$ 5	5,330	$ 26,700
609S	Topsoil/Seedbed Preperation and Native Seeding	SY	$ 10	5,330	$ 53,300
	Local Drainage Modifications (per Linear Foot of Wall)	LF	$ 25	2,000.0	$ 50,000
	Tree Protection and Mitigation	AC	$ 100,000	1.1	$ 114,800
	Subtotal				**$ 1,911,700**
Additional Costs					
	Permanent Easement (2 properties, 0.1 acres)	SF	$ 30	3,700	$ 142,000
700S-TM	Mobilization	LS	11%	1	$ 210,300
	Temporary Erosion and Sediment Control	LS	5%	3	$ 95,600
	Construction Costs				$ 2,359,600
	Contingency		30%		$ 707,900
	Problem Area Total				**$ 3,067,500**

TBPE Firm No. F-754

Middle Williamson Creek Flood Risk Reduction
Flood Risk Reduction Alternatives Analysis
Alternative I - Combination
Opinion of Probable Construction Cost

ITEM	DESCRIPTION	UNIT	UNIT COST	QUANTITY	TOTAL COST
Reach - Broken Bow					
102S	Clearing and Grubbing	AC	$ 10,000	7.7	$ 77,200
120S	Excavation	CY	$ 30	67,600	$ 2,028,000
605S	SOIL RETENTION BLANKET CLASS 1; TYPE A	SY	$ 6	37,400	$ 224,400
609S	Native Seeding and Planting	SY	$ 9	37,400	$ 336,600
	Tree Protection and Mitigation	AC	$ 100,000	7.7	$ 772,400
	Channel Improvements Subtotal				**$ 3,438,600**
Additional Costs					
700S-TM	Mobilization	LS	10%	1	$ 343,900
	Temporary Erosion and Sediment Control	LS	8%	1	$ 275,100
	Permanent Easement (5 properties, 0.9 acres)	SF	$ 30	37,400	$ 1,199,500
	Land Acquisition	See Appendix 5-B.			$ 4,174,000
	Removal of Abandoned W/WW Line	LF	$ 50	1,400	$ 70,000
	Additional Cost Subtotal				**$ 6,062,500**
	Construction Costs				**$ 9,501,100**
	Contingency		30%		**$ 2,850,330**
	Problem Area Total				**$ 12,351,430**
Channel Modifications - Other					
102S	Clearing and Grubbing	AC	$ 10,000	5.5	$ 55,300
120S	Excavation	CY	$ 30	53,200	$ 1,596,000
605S	SOIL RETENTION BLANKET CLASS 1; TYPE A	SY	$ 6	26,800	$ 160,800
609S	Native Seeding and Planting	SY	$ 9	26,800	$ 241,200
	Tree Protection and Mitigation	AC	$ 100,000	5.5	$ 553,100
	Channel Improvements Subtotal				**$ 2,606,400**
Additional Costs					
700S-TM	Mobilization	LS	10%	1	$ 260,600
	Temporary Erosion and Sediment Control	LS	8%	1	$ 208,500
	Permanent Easement (6 properties, 0.3 acres)	SF	$ 30	11,300	$ 432,000
	Removal of Abandoned W/WW Line	LF	$ 50	450	$ 22,500
	Waste Water Line Relocation (18")	LF	$ 280	1,050	$ 294,000
	Additional Cost Subtotal				**$ 1,217,600**
	Construction Costs				**$ 3,824,000**
	Contingency		30%		**$ 1,147,200**
	Problem Area Total				**$ 4,971,200**
Channel Modifications - Radam					
102S	Clearing and Grubbing	AC	$ 10,000	3.4	$ 34,300
120S	Excavation	CY	$ 30	43,300	$ 1,299,000
605S	SOIL RETENTION BLANKET CLASS 1; TYPE A	SY	$ 6	16,600	$ 99,600
609S	Native Seeding and Planting	SY	$ 9	16,600	$ 149,400
	Tree Protection and Mitigation	AC	$ 100,000	3.4	$ 343,100
	Channel Improvements Subtotal				**$ 1,925,400**
Additional Costs					
700S-TM	Mobilization	LS	10%	1	$ 192,500
	Temporary Erosion and Sediment Control	LS	8%	1	$ 154,000
	Permanent Easement (4 properties, 0.2 acres)	SF	$ 30	9,300	$ 341,000
	Land Acquisition	See Appendix 5-B.			$ 596,000
	Removal of Abandoned W/WW Line	LF	$ 50	675	$ 33,750
	Waste Water Line Relocation (12")	LF	$ 200	1,050	$ 210,000
	Additional Cost Subtotal				**$ 1,527,250**
	Construction Costs				**$ 3,452,650**
	Contingency		30%		**$ 1,035,795**
	Problem Area Total				**$ 4,488,445**

TBPE Firm No. F-754

Middle Williamson Creek Flood Risk Reduction
Flood Risk Reduction Alternatives Analysis
Alternative I - Combination
Opinion of Probable Construction Cost

ITEM	DESCRIPTION	UNIT	UNIT COST	QUANTITY	TOTAL COST
Channel Modifications - Heartwood					
102S	Clearing and Grubbing	AC	$ 10,000	8.3	$ 82,900
120S	Excavation	CY	$ 30	109,700	$ 3,291,000
605S	SOIL RETENTION BLANKET CLASS 1; TYPE A	SY	$ 6	40,100	$ 240,600
609S	Native Seeding and Planting	SY	$ 9	40,100	$ 360,900
	Tree Protection and Mitigation	AC	$ 100,000	8.3	$ 829,500
	Channel Improvements Subtotal				**$ 4,804,900**
Additional Costs					
700S-TM	Mobilization	LS	10%	1	$ 480,500
	Temporary Erosion and Sediment Control	LS	8%	1	$ 384,400
	Permanent Easement	SF	$ 30	0	$ -
	Land Acquisition		See Appendix 5-B.		$ 2,057,000
	Waste Water Line Relocation (8")	LF	$ 140	400	$ 56,000
	Additional Cost Subtotal				**$ 2,977,900**
	Construction Costs				**$ 7,782,800**
	Contingency		30%		**$ 2,334,840**
	Problem Area Total				**$ 10,117,640**

ITEM	DESCRIPTION	UNIT	UNIT COST	QUANTITY	TOTAL COST
Voluntary Buyouts					
	SF Homes with Inundation Greater Than 5' in 100-yr Ult	EA	$ 630,000	41	$ 25,830,000
	(See Alt B for Costing Explanation)				

ITEM	DESCRIPTION	UNIT	UNIT COST	QUANTITY	TOTAL COST
Alternative I - Combination					
	Adverse Impact Permanent Easement (265 properties, 43.6 acre)	SF	$ 30	1,900,000	$ 61,107,500
	Construction Costs				$ 117,922,550
	Contingency		30%		$ 53,709,100
	Alternative I Total				**$ 232,739,000**

Appendix K. ORES Middle Williamson Creek Study

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A NOTE FROM HDR: THE FOLLOWING INFORMATION WAS TRANSMITTED TO HDR ON DECEMBER 4TH, 2020, FROM DAVID TRUJILLO AT CITY OF AUSTIN WATERSHED PROTECTION DEPARTMENT.

The City of Austin Office of Real Estate (ORES) conducted a study to determine acquisition and relocation costs for properties at risk of flooding in the Middle Williamson Creek Flood Risk reduction project area. Based on 28 properties that were recently sold in the project area, the average cost was $299.11/ square foot. On the relocation side, based on 59 homes currently on sale, an average cost of $492,684 per replacement home was obtained. In addition to that, a total of eight non-residential addresses are at risk of flooding within the project area. These businesses include small offices, apartment complexes, day care, convenience stores, etc.

Total cost per residential structure		
Average square footage per structure (ft^2)		1671.57
Average cost per square foot ($/ft^2)		$299.12
Acquisition cost per structure		$500,000
Closing Cost[(a)]		$3,000
Relocation costs[(b)]		$70,000
Incidentals[(a)]		$4,000
Moving[(a)]		$5,000
Real estate services[(a)]		$28,000
Abatement[(a)]		$20,000
Total		**$630,000**

[(a)] Based on averages from similar projects
[(b)] Difference between projected cost for each property and the average list price for replacement homes.

Once the residential and commercial properties at risk were identified, cost estimates were developed for different levels of service, summarized in the tables below.

	All depths		
Residential	100 year	25 year	10 year
Homes	$ 231,840,000	$ 107,100,000	$ 35,280,000
Number of homes	368	170	56
Commercial			
Total Acquisition	$ 46,700,000	$ 27,080,000	$ 3,766,667
Total Relocation	$ 4,513,800	$ 2,926,100	$ 547,100
Total	$ 51,213,800	$ 30,006,100	$ 4,313,767
Grand total	$ 283,053,800	$ 137,106,100	$ 39,593,767

	2 ft depths			repetitive
Residential	100 year	25 year	10 year	loss
Homes	$ 121,590,000	$ 42,210,000	$ 3,780,000	$15,750,000
Number of homes	193	67	6	25
Commercial				
Total Acquisition	$ 35,100,000	$ 2,690,909	$ -	$ -
Total Relocation	$ 2,911,100	$ 206,982	$ -	$ -
Total	$ 38,011,100	$ 2,897,891	$ -	$ -
Grand total	$ 159,601,100	$ 45,107,891	$ 3,780,000	$15,750,000

Home elevations. While home elevations are not considered a feasible solution, cost estimates were made in order to be referenced in the report. In addition to the engineering and construction costs, the following non-construction related ancillary costs were estimated:

Displacement Costs		
Lodging	$195	per day
Meals/Incindetals	$125	per day
Subtotal (Meals/Lodging)	$24,000	for 75 days
POD storage	$1,000	per home
Total	$25,000	per home

Appendix L. Digital Data

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