Geologic Assessment

U.S. Highway 290 (US 290) / State Highway (SH) 71 West from State Loop 1 (MoPac) to Ranch-to-Market (RM) 1826 and SH 71 to Silvermine Drive
Travis County, Texas

CSJ: 0113-08-060 and 0700-03-077

December 2016; Revised November 2017

The environmental review, consultation, and other actions required by applicable Federal environmental laws for this project are being, or have been, carried-out by TxDOT pursuant to 23 U.S.C. 327 and a Memorandum of Understanding dated December 16, 2014, and executed by FHWA and TxDOT.

Geologic Assessment

Texas Commission on Environmental Quality

For Regulated Activities on The Edwards Aquifer Recharge/transition Zones and Relating to 30 TAC §213.5(b)(3), Effective June 1, 1999

To ensure that the application is administratively complete, confirm that all fields in the form are complete, verify that all requested information is provided, consistently reference the same site and contact person in all forms in the application, and ensure forms are signed by the appropriate party.

Note: Including all the information requested in the form and attachments contributes to more streamlined technical reviews.

Signature

To the best of my knowledge, the responses to this form accurately reflect all information requested concerning the proposed regulated activities and methods to protect the Edwards Aquifer. My signature certifies that I am qualified as a geologist as defined by 30 TAC Chapter 213.

Print Name of Geologist: Paula Jo Lemonds Telephone: 512-912-5127

Date: 8/24/2016 Fax: 512-912-5158

Representing: HDR Engineering, Inc. (TBPG Firm No. 50226, TBPE Firm No. F-754) (Name of Company and TBPG or TBPE registration number)

Signature of Geologist:

Paula Jo Lemonds

STATE OF TEXAS
PAULA JO MUDD LEMONDS
Geology
10173
PROFESSIONAL LICENSED GEOSCIENTIST

Paula Lemonds 11/10/17

Regulated Entity Name: U.S. Highway 290 (US 290) / State Highway (SH) 71 West from State Loop 1 (Mopac) to Ranch-to-Market (RM) 1826 and SH 71 to Silvermine Drive- Travis County, Texas

Project Information

1. Date(s) Geologic Assessment was performed: March 18, 2016

2. Type of Project:

   ☒ WPAP ☐ AST
   ☐ SCS ☐ UST

3. Location of Project:

   ☒ Recharge Zone
   ☐ Transition Zone

Draft

☒ Contributing Zone within the Transition Zone

4. ☒ **Attachment A - Geologic Assessment Table**. Completed Geologic Assessment Table (Form TCEQ-0585-Table) is attached.

5. ☒ Soil cover on the project site is summarized in the table below and uses the SCS Hydrologic Soil Groups* (Urban Hydrology for Small Watersheds, Technical Release No. 55, Appendix A, Soil Conservation Service, 1986). If there is more than one soil type on the project site, show each soil type on the site Geologic Map or a separate soils map.

Table 1 - Soil Units, Infiltration Characteristics and Thickness

Soil Name	Group*	Thickness(feet)
See Attached Table 1		

** Soil Group Definitions (Abbreviated)*

A. Soils having a high infiltration rate when thoroughly wetted.
B. Soils having a moderate infiltration rate when thoroughly wetted.
C. Soils having a slow infiltration rate when thoroughly wetted.
D. Soils having a very slow infiltration rate when thoroughly wetted.

6. ☒ **Attachment B – Stratigraphic Column**. A stratigraphic column showing formations, members, and thicknesses is attached. The outcropping unit, if present, should be at the top of the stratigraphic column. Otherwise, the uppermost unit should be at the top of the stratigraphic column.

7. ☒ **Attachment C – Site Geology**. A narrative description of the site specific geology including any features identified in the Geologic Assessment Table, a discussion of the potential for fluid movement to the Edwards Aquifer, stratigraphy, structure(s), and karst characteristics is attached.

8. ☒ **Attachment D – Site Geologic Map(s)**. The Site Geologic Map must be the same scale as the applicant's Site Plan. The minimum scale is 1”: 400'

   Applicant's Site Plan Scale: 1" = <u>400</u>'
   Site Geologic Map Scale: 1" = <u>400</u>'
   Site Soils Map Scale (if more than 1 soil type): 1" = <u>400</u>'

9. Method of collecting positional data:

   ☒ Global Positioning System (GPS) technology.
   ☐ Other method(s). Please describe method of data collection: _____

10. ☒ The project site and boundaries are clearly shown and labeled on the Site Geologic Map.

Draft

11. ☒ Surface geologic units are shown and labeled on the Site Geologic Map.

12. ☒ Geologic or manmade features were discovered on the project site during the field investigation. They are shown and labeled on the Site Geologic Map and are described in the attached Geologic Assessment Table.

    ☐ Geologic or manmade features were not discovered on the project site during the field investigation.

13. ☒ The Recharge Zone boundary is shown and labeled, if appropriate.

14. All known wells (test holes, water, oil, unplugged, capped and/or abandoned, etc.): If applicable, the information must agree with Item No. 20 of the WPAP Application Section.

    ☐ There are _____ (#) wells present on the project site and the locations are shown and labeled. (Check all of the following that apply.)
    ☐ The wells are not in use and have been properly abandoned.
    ☐ The wells are not in use and will be properly abandoned.
    ☐ The wells are in use and comply with 16 TAC Chapter 76.
    ☒ There are no wells or test holes of any kind known to exist on the project site.

Administrative Information

15. ☒ Submit one (1) original and one (1) copy of the application, plus additional copies as needed for each affected incorporated city, groundwater conservation district, and county in which the project will be located. The TCEQ will distribute the additional copies to these jurisdictions. The copies must be submitted to the appropriate regional office.

Table 1 - Soil Units, Infiltration Characteristics and Thickness

Soil Name	Group*	Thickness(feet)
Brackett-Rock outcrop complex, 1 to 12 percent slopes (BlD)	D	Veneer to 1.5 ft
Brackett-Rock outcrop-Real complex, 8 to 30 percent slopes (BoF)	D	Veneer to 1.5 ft
Crawford clay, 0 to 1 percent slopes (CrA)	D	Greater than 6.7 ft
Crawford clay, 1 to 3 percent slopes (CrB)	D	2.7 ft
Denton silty clay, 1 to 3 percent slopes (DeB)	D	3 ft
Pits, gravel, 1 to 90 percent slopes (GP)	-	-
Mixed alluvial land, 0 to 1 percent slopes, frequently flooded (Md)	A	4 ft
Purves silty clay, 1 to 5 percent slopes (PuC)	D	Veneer to 1.5 ft
San Saba clay, 1 to 2 percent slopes (SaB)	D	3.2 ft
Speck stony clay loam, 1 to 5 percent slopes (SsC)	D	1.5 ft
Tarrant and Speck soils, 0 to 2 percent slopes (TcA)	D	Veneer to 1.5 ft
Volente silty clay loam, 1 to 8 percent slopes (VoD)	D	Greater than 6.7 ft

** Soil Group Definitions (Abbreviated)*

A. *Soils having a high infiltration rate when thoroughly wetted.*
B. *Soils having a moderate infiltration rate when thoroughly wetted.*
C. *Soils having a slow infiltration rate when thoroughly wetted.*
D. *Soils having a very slow infiltration rate when thoroughly wetted.*

Attachment A

Geologic Assessment Table

(TCEQ-0585 Table)

Comments to Geologic Assessment Table

Project and Feature Photographs

GEOLOGIC ASSESSMENT TABLE								**PROJECT NAME:**			U.S. Highway 290 (US 290) / State Highway (SH) 71 West from State Loop 1 (MoPac) to Ranch-to-Market (RM) 1826 and SH 71 to Silvermine Drive, Travis County, Texas									
LOCATION			**FEATURE CHARACTERISTICS**												**EVALUATION**			**PHYSICAL SETTING**		
1A	1B *	1C*	2A	2B	3	4			5	5A	6	7	8A	8B	9	10		11		12
FEATURE ID	LATITUDE	LONGITUDE	FEATURE TYPE	POINTS	FORMATION	DIMENSIONS (FEET)			TREND (DEGREES)	DOM	DENSITY (NO/FT)	APERTURE (FEET)	INFILL	RELATIVE INFILTRATION RATE	TOTAL	SENSITIVITY		CATCHMENT AREA (ACRES)		TOPOGRAPHY
						X	Y	Z		10						<40	>40	<1.6	>1.6	
F-1	30 14.124	97 51.624	Z-SF	30	Ked	12	1	0.05	N34E	10	0.1	0.005	N	5	45		X		X	Floodplain
F-2	30 14.084	97 51.632	SC	20	Ked	4	2	0.5	-	0	-	-	O	10	30	X		X		Hillside
F-3	30 14.073	97 51.724	O	5	Ked	15	10	0.1	-	0	4	0.1	N	15	20	X		X		Drainage
F-4	30 14.068	97 51.621	Z-SF	30	Ked	100	30	0.05	N20E	10	0.5	0.1	O	15	55		X	X		Hillside
F-5	30 14.144	97 51.685	F	20	Ked	17	4	1.1	N12E	10	1	0.01	C	20	50		X		X	Streambed
F-6	30 14.034	97 51.747	SC	20	Ked	2	2	4	-	0	-	-	F	36	56		X		X	Hillside

* DATUM: WGS84

2A TYPE	TYPE	2B POINTS
C	Cave	30
SC	Solution cavity	20
SF	Solution-enlarged fracture(s)	20
F	Fault	20
O	Other natural bedrock features	5
MB	Manmade feature in bedrock	30
SW	Swallow hole	30
SH	Sinkhole	20
CD	Non-karst closed depression	5
Z	Zone, clustered or aligned features	30

8A INFILLING	
N	None, exposed bedrock
C	Coarse - cobbles, breakdown, sand, gravel
O	Loose or soft mud or soil, organics, leaves, sticks, dark colors
F	Fines, compacted clay-rich sediment, soil profile, gray or red colors
V	Vegetation. Give details in narrative description
FS	Flowstone, cements, cave deposits
X	Other materials

12 TOPOGRAPHY

Cliff, Hilltop, Hillside, Drainage, Floodplain, Streambed

I have read, I understood, and I have followed the Texas Commission on Environmental Quality's Instructions to Geologists. The information presented here complies with that document and is a true representation of the conditions observed in the field. My signature certifies that I am qualified as a geologist as defined by 30 TAC Chapter 213.

Paula Jo Lemonds

Date

Sheet 1 of 1

STATE OF TEXAS
PAULA JO MUDD LEMONDS
Geology
10173
LICENSED
PROFESSIONAL GEOSCIENTIST

Paula Jo Lemonds
11/10/19

TCEQ-0585-Table (Rev. 10-01-04)

Comments to Geologic Assessment Table
U.S. Highway 290 (US 290) / State Highway (SH) 71 West from
State Loop 1 (MoPac) to Ranch-to-Market (RM) 1826 and
SH 71 to Silvermine Drive
Travis County, Texas
CSJ: 0113-08-060 and 0700-03-077

Feature F-1

GPS Coordinates: N 30 14.124 W 97 51.624

Feature F-1 is a group of widely spaced fractures within the Williamson Creek streambed located just upstream of US290. The orientation of the fractures, N34ºE, suggests they may be related to displacement along the Mount Bonnell Fault, which is located a few hundred feet to the northwest. However, these fractures do not appear to be able to convey a significant amount of recharge into the subsurface because fracture apertures are less than one-tenth of one inch and the opposing sides are similar in shape. This suggests that enlargement through dissolution has occurred. As such, there is limited likelihood that recharge occurs through this feature.

Recommendations:

Because of the correspondence of the orientation of these fractures with the orientation of Mount Bonnell Fault, the feature could have a connection to a deeper karst feature in the subsurface. Appropriate precautions should be considered in planning for construction and during construction.

Feature F-2

GPS Coordinates: N 30 14.084 W 97 51.632

Features F-2 is a solution cavity situated along the base of a bedding outcrop. The extent of the feature is limited due to infilling by soil and organic debris and animal burrowing is evident. The potential for rapid infiltration is low and the feature was evaluated as non-sensitive.

Recommendations:

This feature likely does not have a strong connection to a deeper karst feature in the subsurface. Appropriate precautions should be considered in planning for construction and during construction.

Feature F-3

GPS Coordinates: N 30 14.073 W 97 51.724

Feature F-3 is a small outcrop of limestone on the south side of US290 exhibiting small interconnected solution enlarged cavities. This type of feature, commonly referred to as a “honeycomb” texture, suggests the outcrop may at one time have been exposed to significant groundwater flow. It is positioned along a small drainage paralleling US290, however no water was present in the drainage, and it appears that surface flow is only present during significant precipitation events. Natural vegetation, plant debris, and high runoff potential soils appear to cover most of the area. These factors limit infiltration while supporting rapid runoff. The feature was evaluated as non-sensitive with a low relative potential for infiltration.

Recommendations:

This feature likely does not exhibit high infiltration and recharge to the subsurface. Appropriate precautions should be considered in planning for construction and during construction.

Feature F-4

GPS Coordinates: N 30 14.068 W 97 51.621

Feature F-4 is zone of fractures located south of US290 along the southern margin of the TxDOT right-of-way. The feature encompasses an approximately 100-ft by 30-ft area on a gently sloping hillside covered with live oak trees and Ashe juniper (locally referred to as cedar). Multiple fractures are present, and apertures appear to show some evidence of solution enlargement although most are infilled with vegetation and soil. While there are slight variations, the average trend of the fractures is about N20ºE, which is consistent with the regional structural trend. This suggests the fractures may be related to displacement along the Mount Bonnell Fault to the northwest. The outcrop in which the fractures are present also shows some honeycomb texture that supports the possibility of recharge enhancement through solution enlargement. However, the large amount of vegetative debris filling the fractures, coupled with the Speck soils that are characterized by high runoff potential and occur across this portion of the study area, suggest a rapid runoff potential in lieu of infiltration. Overall, the feature is expected to have a low potential for recharge to the aquifer. However, due to the zone classification of the feature and similarity with the regional structural trend, the feature was evaluated as sensitive.

Recommendations:

This feature contains a zone of fractures coincident with the regional structural trend and could have a connection to a deeper karst feature in the subsurface that contributes greater than average recharge to the Edwards Aquifer. Appropriate precautions should be considered in planning for construction and during construction.

Feature F-5

GPS Coordinates: N 30 14.144 W 97 51.685

Feature F-5 is identified as the surface expression of the Mount Bonnell Fault within Williamson Creek. According to the available publications (USGS, 1996; BEG, 1981) this fault is referred to as the Mount Bonnell Fault. It is a major fault that marks the boundary between the Edwards Aquifer Contributing and Recharge Zones. The only surface expression of this fault was identified along the streambed of Williamson Creek north of US290. Normal displacement along the fault denotes displacement to the southeast, typical of the majority of other nearby faults. The amount of vertical throw along the Mount Bonnell Fault has been estimated to be up to 670-ft (USGS, 1996). This and other faults within the surrounding region generally trend from southwest to northeast at about N35ºE.

Where exposed within Williamson Creek, the Mount Bonnell Fault shows little evidence of solution enlargement. The location of the feature is based upon nearby fractures and changes in lithology on opposing sides of the fault. The fault juxtaposes the Glen Rose Limestone to the northwest against Edwards Limestone. Most fractures within the streambed appear to be sealed with fine grained sediment and vegetative debris. This feature is not exposed in any other location within the project area. It was evaluated as sensitive with a moderate potential for infiltration.

Recommendations:

Feature F-5, the surface expression of the Mount Bonnell Fault within Williamson Creek, does not occur within the existing right-of-way area and would not be affected by project activities.

Feature F-6

GPS Coordinates: N 30 14.034 W 97 51.747

Feature F-6 is a solution cavity located along the southern limits of the TxDOT right-of-way south of US290. The area where the feature is exposed in the bedrock is about two square feet. The adjacent area is partly covered with native vegetation. However, an abandoned small business surrounded by a security fence is located about 20 ft to the east. The feature itself appears Y-shaped in plan view and extends vertically about 4 ft. Native soils infill the cavity on the sides and the feature does not appear to open or expand laterally with depth. The feature was evaluated as sensitive with a moderate potential for infiltration.

Recommendations:

This feature includes characteristics that could contribute greater than average recharge to the Edwards Aquifer. The feature is currently surrounded with silt fencing, and similarly, appropriate precautions should be considered in planning for construction and during construction.

Site and Feature Photographs
Comments to Geologic Assessment Table
U.S. Highway 290 (US 290) / State Highway (SH) 71 West from
State Loop 1 (MoPac) to Ranch-to-Market (RM) 1826 and
SH 71 to Silvermine Drive
Travis County, Texas
CSJ: 0113-08-060 and 0700-03-077

General Site Photographs

Feature F-1. Widely spaced fractures within the Williamson Creek streambed located just upstream of US290

Feature F-2 solution cavity situated along the base of a bedding outcrop

Feature F-2 zoom-in of solution cavity situated along the base of a bedding outcrop

Feature F-3 small outcrop of limestone on the south side of US290 exhibiting small interconnected solution enlarged cavities (Depression, veg cover)

Feature F-4. Zone of fractures located south of US290 along the southern margin of the TxDOT right-of-way

Feature F-4. Zone of fractures looking to the east.

Feature F-5. Surface expression of the Mount Bonnell Fault within Williamson Creek.

Feature F-6 – solution cavity located along the southern limits of the TxDOT right-of-way south of US290

Feature F-6 – solution cavity located along the southern limits of the TxDOT right-of-way south of US290

Attachment B

Stratigraphic Column

Stratigraphic Column
Comments to Geologic Assessment Table
U.S. Highway 290 (US 290) / State Highway (SH) 71 West from
State Loop 1 (MoPac) to Ranch-to-Market (RM) 1826 and
SH 71 to Silvermine Drive
Travis County, Texas
CSJ: 0113-08-060 and 0700-03-077

Bureau of Economic Geology (BEG) (1972) describes the Edwards Group, as present in the project area. Further modification and description of groups, formations, members and thicknesses were modified from the USGS Publication WRIR 96-4306 (USGS, 1996), and the BEG Geologic Atlas of Texas, Austin Sheet (BEG, 1981).The stratigraphic column below shows the lithology and hydrogeologic properties of the hydrogeologic subdivisions of the Edwards Group and associated units.

Table 1. Stratigraphic Column and Hydrogeologic Summary of the Edwards Aquifer Outcrop (Barton Springs Segment)

System	Hydrogeologic Unit		Group, Formation, or Member				Map Symbol	Thickness	Description
Quaternary	----		Alluvium				Q_{al}	Variable	Floodplain and terrace deposits; clay, silt, sand, and gravel.
Upper Cretaceous	Upper Confining Units		Taylor Group				K_{nt}	600	Clay; chalky limestone
			Austin Group				K_{au}	130 – 150	White to light-tan to gray limestone
			Eagle Ford Group				K_{ef}	30 – 50	Brown, flaggy sandy shale and argillaceous limestone
			Buda Limestone				K_{bu}	40 – 50	Buff, light-gray, dense mudstone
			Del Rio Clay				K_{dr}	50 - 60	Blue-green to yellow-brown clay
Lower Cretaceous	I	Edwards Aquifer	Georgetown Formation				K_{gt}	40 - 60	Gray to light-tan, marly limestone
	II		Devils River Formation	Edwards Group	Person Formation	Cyclic and Marine Members	K_p	50 - 180	Mudstone to packstone; *miliolid* grainstone; chert.
	III					Leached and Collapsed Member			Crystalline limestone; mudstone to wackestone to *miliolid* grainstone; chert; collapsed breccia
	IV					Regional Dense Member			Light-tan, dense, argillaceous mudstone
	V				Kainer Formation	Grainstone Member	K_k	265 - 345	*Light-gray, Miliolid* grainstone; mudstone to wackestone; chert.
	VI					Kirschberg Evaporite Member			Light-gray, crystalline limestone; chalky mudstone; chert.
	VII					Dolomitic Member			Mudstone to grainstone; crystalline limestone; chert.
	VIII					Basal Nodular Member			Shaly, fossiliferous, nodular limestone; mudstone; *miliolid* grainstone.
	Upper Trinity Aquifer		Upper member of the Glen Rose Limestone				K_{gru}	350 – 500	Yellowish-tan, thinly bedded limestone and marl

Notes: Groups, formations, and members and thicknesses were modified from the USGS Publication WRIR 96-4306 (USGS, 1996), and the Bureau of Economic Geology Geologic Atlas of Texas, Austin Sheet (BEG, 1981).

Attachment C

Site Geology
Narrative of Project Specific Geology

Narrative of Project Specific Geology
Comments to Geologic Assessment Table
U.S. Highway 290 (US 290) / State Highway (SH) 71 West from
State Loop 1 (MoPac) to Ranch-to-Market (RM) 1826 and
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1.0 Introduction and Purpose

The Texas Department of Transportation (TxDOT) and the Central Texas Regional Mobility Authority (Mobility Authority) are considering implementing mobility improvements to U.S. Highway 290 (US 290) / State Highway (SH) 71 West through Oak Hill (the Oak Hill Parkway). The project corridor extends along US 290 from State Loop 1 (Loop 1 or MoPac) to Ranch-to-Market Road (RM) 1826 for a distance of approximately 3.6 miles with a transition to Circle Drive in the west. The project also includes the interchange on SH 71 from US 290 to Silvermine Drive, a distance of approximately 1.2 miles. The proposed project corridor is within the City of Austin, Travis County, Texas.

The following discussion is a site-specific assessment of existing geological conditions and potential aquifer recharge features within the project boundaries. This Geologic Assessment documents conditions observed by HDR within the project boundaries on March 18, 2016.

The purpose of this document is to complete a Geologic Assessment compliant with the requirements of Title 30, Texas Administrative Code (TAC) Chapter 213, related to the protection of the Edwards Aquifer Recharge Zone. The Geologic Assessment was prepared in accordance with the revised *Instructions to Geologists for Geologic Assessments on the Edwards Aquifer Recharge/Transition Zones* (TCEQ-0585) (TCEQ, 2004). The Geologic Assessment is a component of a Water Pollution Abatement Plan (WPAP), which will be completed based on the final design of the project. The WPAP identifies measures that will be implemented to protect the water quality of the aquifer.

This Geologic Assessment report focuses on the project area (Figure 1) defined as the area within the existing right-of-way (ROW) boundary where the mapped extent of the surface expression of the Edwards Aquifer Recharge Zone intersects U.S. Highway 290 (US 290) / State Highway (SH) 71 West through Oak Hill (the Oak Hill Parkway). The survey area is defined as existing TxDOT ROW and proposed ROW of the project limits described in this section. A portion of the project that was not surveyed is the proposed ROW areas of two water quality ponds depicted in Figure 2.

2.0 Geologic Setting

The following sections address the geology and soils within the study area, which is defined as an area within one-half mile of the existing right-of-way.

The study area is situated at the eastern edge of the Edwards Plateau ecoregion, just west of the Blackland Prairies ecoregion (Griffith et al., 2004). The topography in the study area is hilly and highly dissected by the tributaries and main channels of larger creeks. Devils Pen Creek and other tributaries of Slaughter Creek flow cut through the western portion of the study area. Tributaries of Williamson Creek, including Kincheon Branch, Wheeler Branch, and Motorola Branch, as well as several unnamed tributaries and Williamson Creek proper, dissect the central portion of the study area, and unnamed tributaries of Barton Creek divide the far northeastern portion. Bluffs run parallel to US 290 near its intersection with SH 71. Elevations in the study area range from approximately 1,050 feet above mean sea level (amsl) in the west to approximately 700 feet amsl in the east. Total topographic relief is approximately 350 feet, and most slopes are in the 5 percent to 10 percent range with steeper slopes up to 15 percent in isolated locales (USGS, 1986a; USGS, 1986b; USGS, 1988a; USGS, 1988b).

Rocks within the study area are of sedimentary origin. Geologic formations within the project area are Lower Cretaceous marine deposits and more recent Quaternary sediments. These rocks, comprised chiefly of limestone, were deposited on a vast submerged plain known as the Comanche Shelf (BEG, 1972). The Comanche Shelf depositional environment is located between the San Marcos Platform to the south and the Maverick Basin to the west (Abbott et al., 1986).

Edwards Aquifer Recharge and Contributing Zones

Based on available published geologic maps and field observations, the geologic units mapped within the Edwards Aquifer Recharge Zone (EARZ) portion of the project area include the following from youngest to oldest: Quaternary Alluvium (Qal), Quaternary Fluviatile terrace deposits (Qhg), the Kainer Formation (Kk) of the Edwards Group and the Upper member of the Glen Rose Limestone (Kgru). The Kk and the younger Person Formation (Kp) of the Edwards Group have been further divided into seven geologic members (BEG, 1972; Table 1). These subdivisions were later modified into eight hydrogeologic subdivisions that include the overlying Georgetown Formation (USGS, 1996), Table 1). Members of the Kk, from youngest to oldest, include the Basal Nodular, Dolomitic, Kirschberg Evaporite, and Grainstone Members. The overlying Kp is divided into four members: Regional Dense, Leached and Collapsed, and Cyclic and Marine Members. Geologic units found within the EARZ portion of the project area predominantly include Kk and a smaller area of Qhg along the southeastern border. The remaining portion of the project area lies within the Edwards Aquifer Contributing Zone and contains mainly Kgru areas and moderate portions of Qal located within the north-central portion of the project study area. **Figure 2** represents the geologic formations and features previously mapped within a one mile buffer of the project study area.

Geologic publications including reports and published maps were used in preparation of this report. The Texas Speleological Survey (TSS) database was queried for possible known or existing recharge features within the boundaries of the investigation area. The TSS did not find any records for existing recharge features within the project area (TSS, 2008).

Some of the development within the project area predates the era of comprehensive record- keeping of karst features. Thus, it is possible that construction in the vicinity of developed lots might encounter undocumented karst features covered during prior development. According to communications from the TSS, the distribution of caves on a countywide basis suggests a concentration of caves exists along the east side of the Mount Bonnell Fault. The Mount Bonnell Fault forms the boundary between the Edwards Aquifer Contributing and Recharge Zones and occurs within the central portion of the project area (**Figure 2**). Fracturing coincident with the fault may provide a pathway for groundwater to enter the limestone and enhance the formation of caves. This suggests that the likelihood of karst features occurring within the project area may be greatest east of the Mount Bonnell Fault within the EARZ.

As previously discussed, a portion of the project study area lies within an environmentally sensitive area known as the Edwards Aquifer. Numerous enhanced karst features occur within this area, and as a result the Edwards Aquifer is a very productive groundwater aquifer. Karst features are formed from the dissolution of soluble rocks, including limestone, and are characterized by sinkholes, caves, and underground drainage systems. The majority of the recharge into the Edwards Aquifer occurs where surface water flows over faults, fractures, and karst features that have been solutionally enhanced.

The Edwards Aquifer contains several zones, which are based on how water drains in these areas; these include the Recharge Zone, Transition Zone, and Contributing Zone. The Recharge Zone includes an area where highly faulted and fractured Edwards Limestone outcrops occur at the surface, providing a means for large quantities of water to flow into the aquifer with little filtration. The Transition Zone contains areas where limestone that overlies the aquifer are faulted and fractured and include caves and sinkholes. Within this area, it is possible for surface water to flow into the Edwards Aquifer below. The Contributing Zone consists of areas of non-Edwards Aquifer limestones, which outcrop at a higher elevation, causing water to drain to stream courses that overlie the Recharge Zone.

The portion of the project area east of the Mount Bonnell Fault is located in the Recharge Zone of the Barton Springs Segment of the Edwards Aquifer (BSEACD, 2010). Groundwater in this area generally flows from the southwest to northeast toward a few focused discharge points and recharge is typically focused at faults and karst features, such as caves and sinkholes. Within the project area, the groundwater hydrology is largely influenced by the karst units of the Edwards Group, which form an outcrop east of the Mount Bonnell Fault.

3.0 Investigation Methods

The following investigation methods and activities were used to develop this technical memorandum.

- Review of data and literature to determine the regional geology and known caves associated with the right of way;
- Review of existing geological field reports, cave studies, and correspondence regarding geologic features on the right of way, including those previously referenced, and
- Analysis of collected field data.

Reconnaissance of the site included the methodology described in Texas Commission on Environmental Quality's (TCEQ's) (2004) *Instructions to Geologists for Geologic Assessments*. The geologic assessment was conducted with a team of two people (Professional Geologist #10173 and a karst technician) walking about 25 ft apart in the same direction toward a specific point. When that point was reached, the team walked back to the starting point in the opposite direction, searching the area adjacent to the original pass. The site reconnaissance was completed on March 18, 2016. Visibility during the day was high with high humidity and temperatures of approximately 65°F and a cloudy sky.

Specific publications and data sources reviewed and utilized in this investigation include the following list and those included in the Section 6.0 References:

- Bureau of Economic Geology (BEG) (1972), which describes the Edwards Group, as present in the project area;
- USGS Publication WRIR 96-4306 (USGS, 1996), which further modifies and describes the geologic groups, formations, members and thicknesses;

- BEG Geologic Atlas of Texas, Austin Sheet (BEG, 1981); and
- Geologic assessment of a similar areal extent completed in 2009 by Bret Rahe.
- Environmental geologic assessment of a similar areal extent completed by Charles Woodruff, Jr. (1986).
- Soil descriptions were compiled from the Web Soil Survey of the U.S. Department of Agriculture (USDA) (2015a).
- Texas Water Development Board (TWDB) and TCEQ water well data were used to locate water wells in proximity of the right of way.

3.1 Water Wells

A search of the TWDB Groundwater Database (GWDB) Record of Wells Report for Travis County was completed (TWDB, 2016). Several wells are located near the project area but none are located within the survey area defined as the existing TxDOT ROW and proposed ROW. One well in the TWDB database was identified within 50 ft of the survey area, TWDB Well #5849310. The TWDB GWDB information on this well indicates that it was completed in 1962 in the Upper Member of Glen Rose Limestone and is currently unused. The well was not located during the survey. The well's location according to the TWDB GWDB is shown on page one of eight of **Figure 2.**

3.2 Gaines Sink

Gaines Sink, also known as Gaines Ranch Sink, is located to the east of the eastern boundary of the project area that includes existing TxDOT ROW and proposed ROW. **Figure 2** shows the location of the sinkhole and its surface expression. Gaines Sink was not assessed during the field geologic survey, as it was outside the bounds of the survey area. However, a description of its location and its characteristics are described in this document for reference. In a geologic assessment provided by TxDOT staff, it is stated that before the construction of MoPac, the sinkhole drained approximately 4 acres of land (ZARA Environmental, 2016).

ZARA Environmental (2016) describe the area where the sinkhole is located as being "protected from surface runoff from adjacent at-grade roadways by curbs and gutters that are conveyed by a surface and subsurface stormwater system, treated by existing water quality facilities, and released to the north into the Barton Creek drainage." No dye tracing has been done at this site. ZARA Environmental (2016) describe the site as being close to the groundwater divide between Cold Springs and Sunset Valley (Barton Springs) and that recharge into Gaines Sink could flow to either Cold Springs, Barton Springs, or both (Hauwert et al. 2004).

4.0 Site Visit

HDR personnel completed the site reconnaissance visit on March 18, 2016. At the time of the site visit, Williamson Creek contained flowing water. It is estimated that the depth of the water ranged from a few inches upstream of SH 290/71 to more than one foot downstream of SH 290/71.

5.0 References

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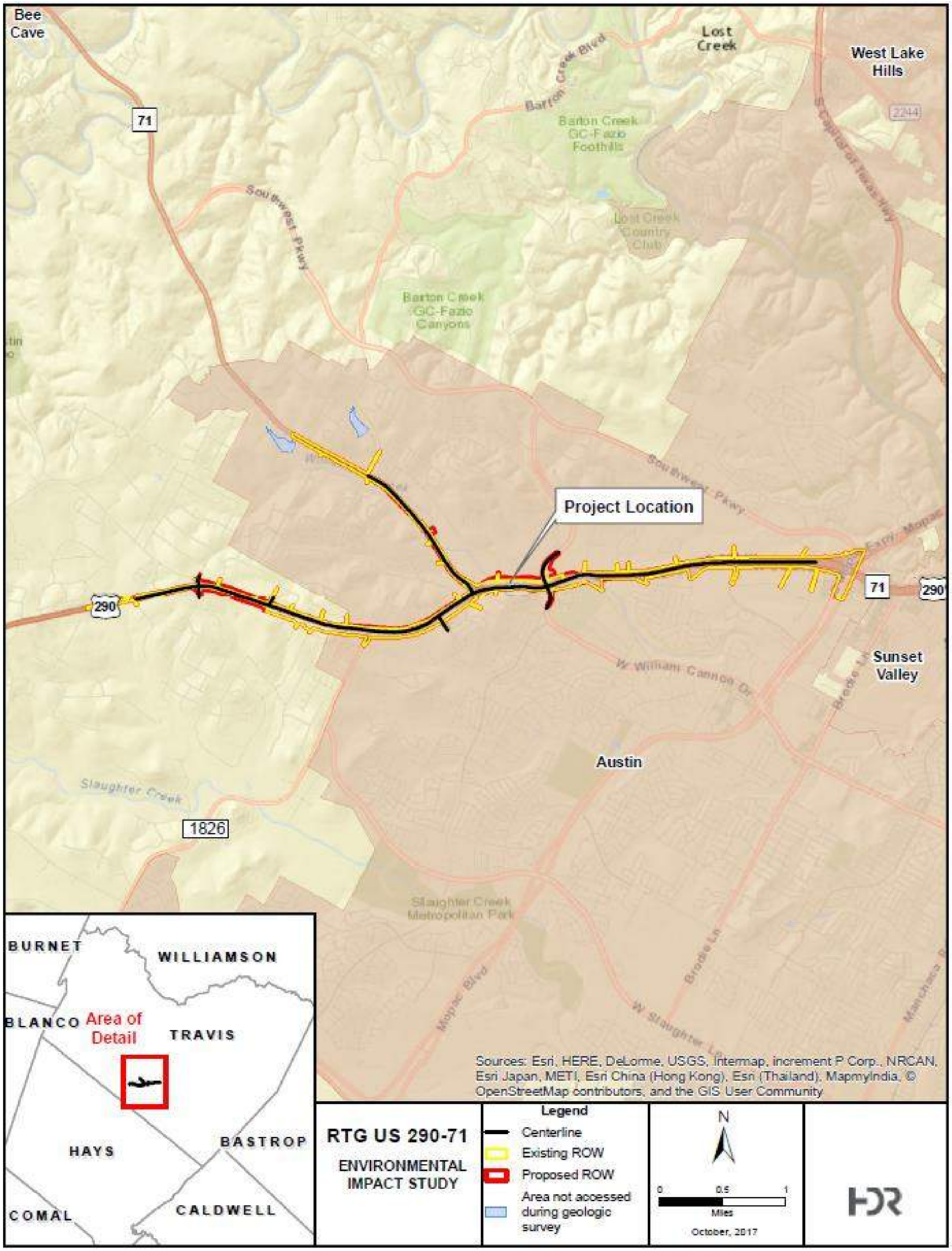

Figure 1. Project location

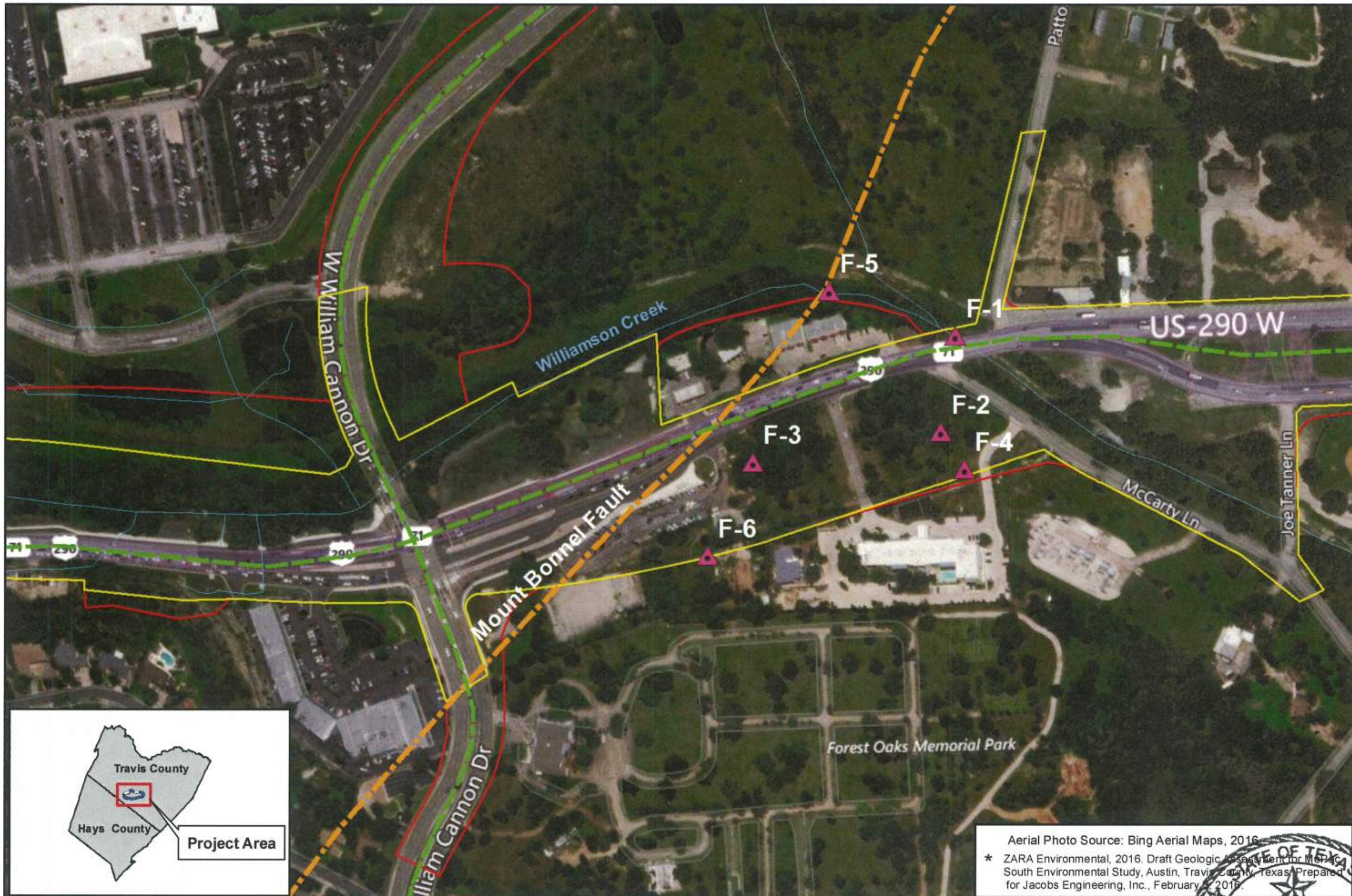

Figure 2a. Geologic Features Map

Oak Hill Parkway: US 290W from Mopac/Loop1 to west of Circle Drive and SH 71 from US 290W to Silvermine Drive

Legend

- Geologic Feature
- Geologic Feature Outside of Project Area
- Gaines Sink Feature Outline
- Centerline
- Mount Bonnel Fault
- Existing ROW
- Proposed ROW

N

0 175 350 Feet

Prepared for: TxDOT

CSJ: 0013-08-060 and 0700-03-077

Date: Oct 2017

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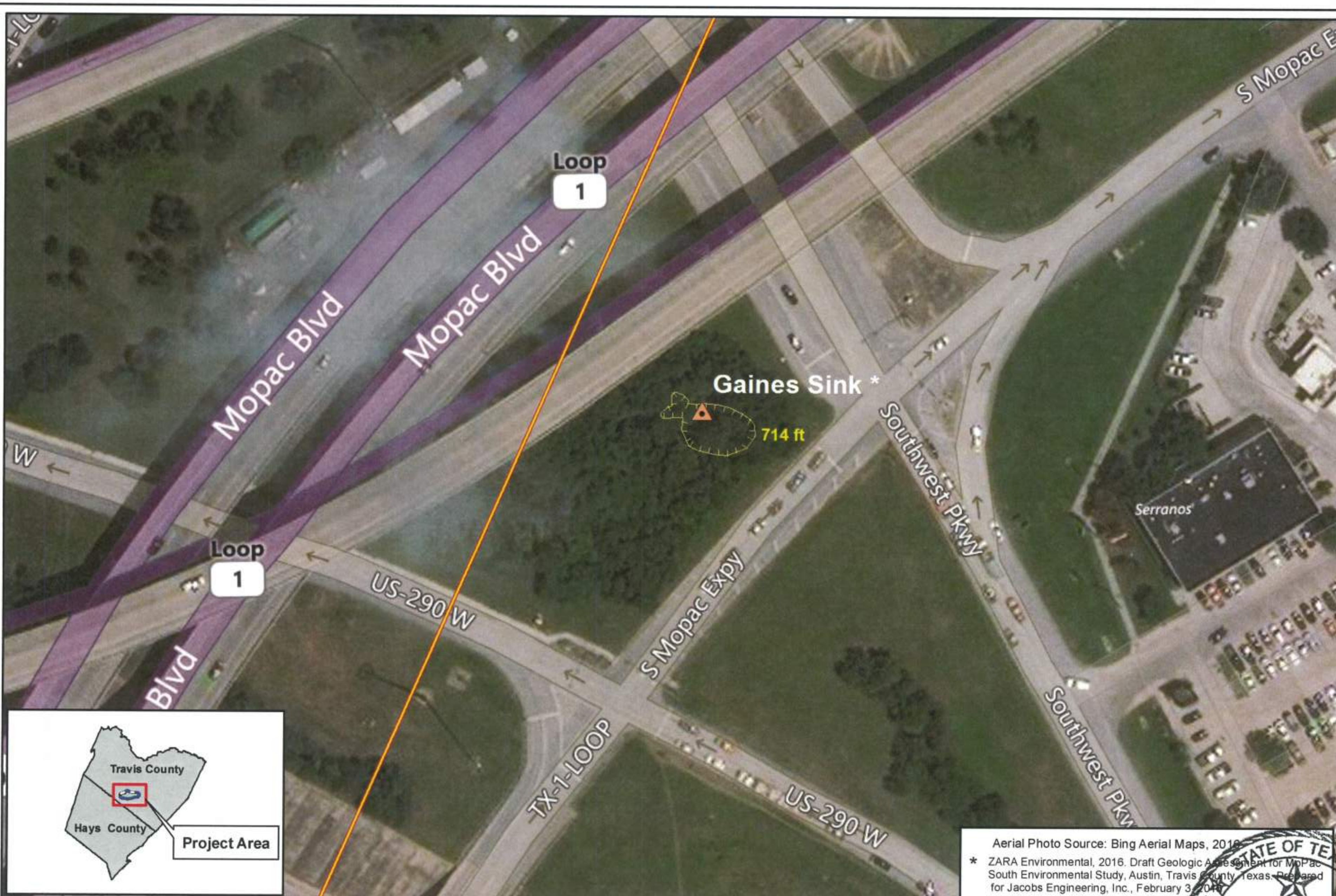

Figure 2b. Geologic Features Map

Oak Hill Parkway: US 290W from Mopac/Loop1 to west of Circle Drive and SH 71 from US 290W to Silvermine Drive

Legend

- Geologic Feature
- Geologic Feature Outside of Project Area
- Gaines Sink Feature Outline
- Centerline
- Mount Bonnel Fault
- Existing ROW
- Proposed ROW

N

0 50 100 Feet

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Figure 2c.

Oak Hill Parkway: US 290W from Mopac/Loop1 to west of Circle Drive and SH 71 from US 290W to Silvermine Drive

Legend

- Centerline
- Existing ROW
- Proposed ROW
- Area not accessed during geologic survey

N

0 500 1,000 Feet

Prepared for: TxDOT

CSJ: 0013-08-060 and 0700-03-077

Date: Oct 2017

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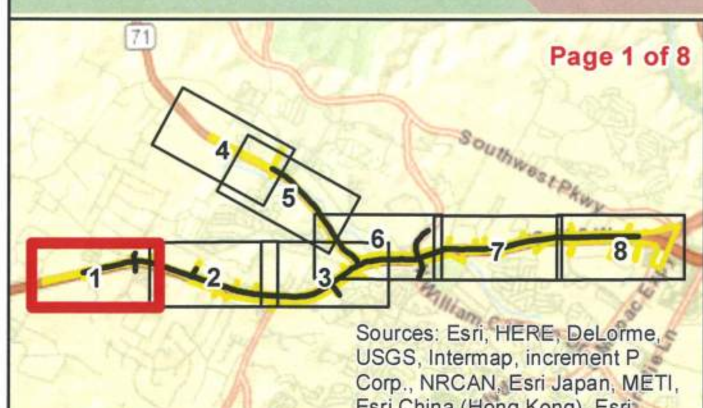
Attachment D

Site Geologic Map

Soil Profile and Narrative of Soil Units

Site Soils Map

Site Geologic Map
U.S. Highway 290 (US 290) / State Highway (SH) 71 West from
State Loop 1 (MoPac) to Ranch-to-Market (RM) 1826 and
SH 71 to Silvermine Drive
Travis County, Texas
CSJ: 0113-08-060 and 0700-03-077



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Legend

- Centerline
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SSURGO Soil Data

- BID - Brackett-Rock outcrop complex, 1 to 12 percent slopes
- BoF - Brackett-Rock outcrop-Real complex, 8 to 30 percent slopes
- CrB - Crawford clay, 1 to 3 percent slopes
- DeB - Denton silty clay, 1 to 3 percent slopes
- GP - Pits, gravel, 1 to 90 percent slopes
- Md - Mixed alluvial land, 0 to 1 percent slopes, frequently flooded
- PuC - Purves silty clay, 1 to 5 percent slopes
- QU - Quarry, 1 to 40 percent slopes
- SaB - San Saba clay, 1 to 2 percent slopes
- SsC - Speck stony clay loam, 1 to 5 percent slopes
- TaD - Tarrant soils, 5 to 18 percent slopes
- TcA - Tarrant and Speck soils, 0 to 2 percent slopes
- TdF - Tarrant-Rock outcrop complex, 18 to 50 percent slopes
- CrA - Crawford clay, 0 to 1 percent slopes

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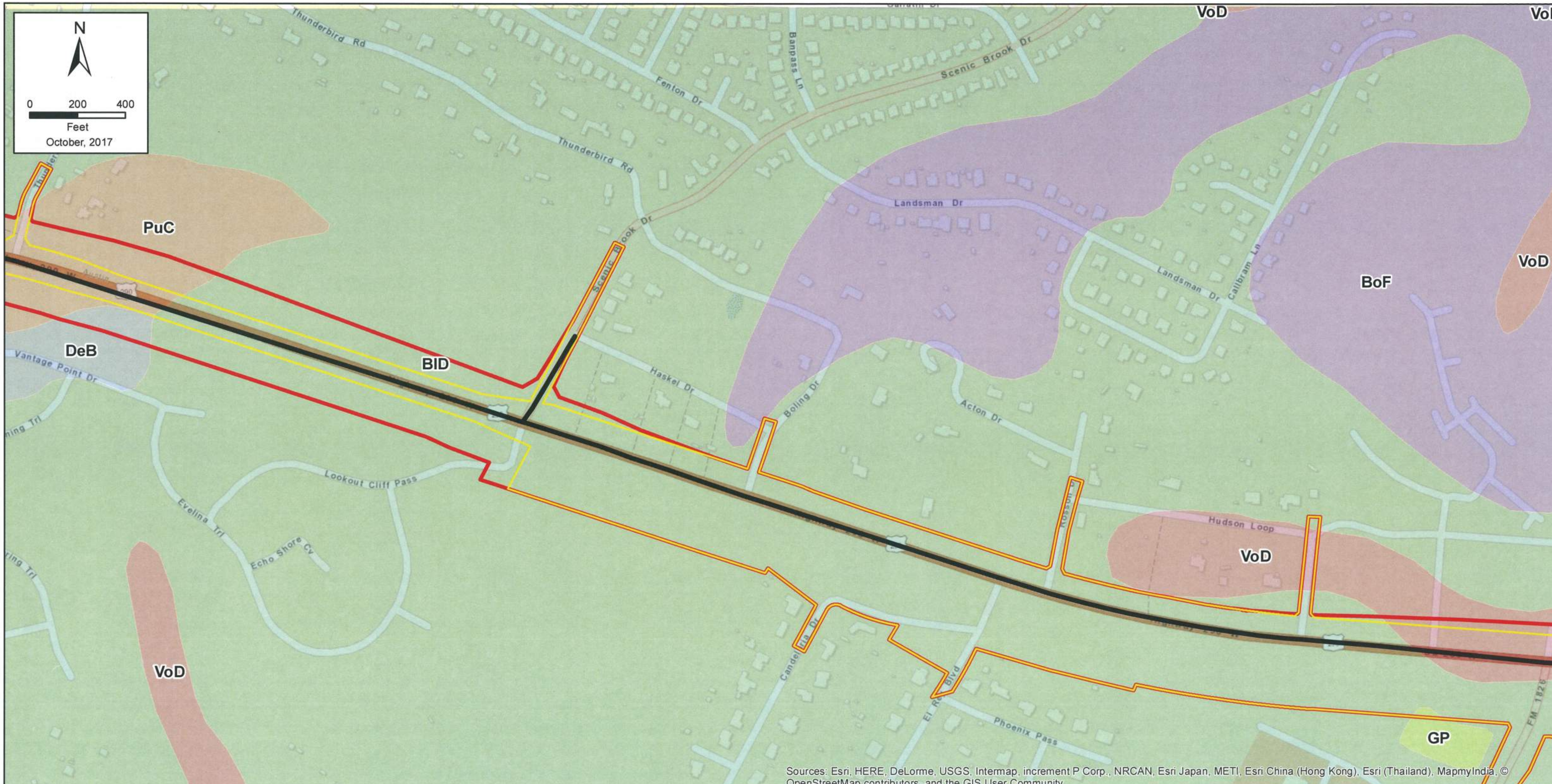

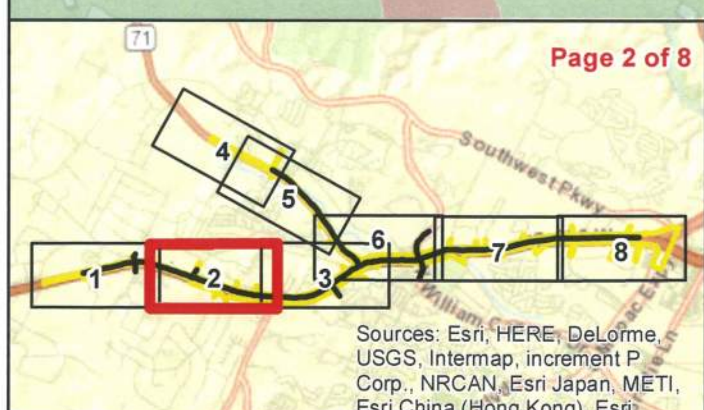

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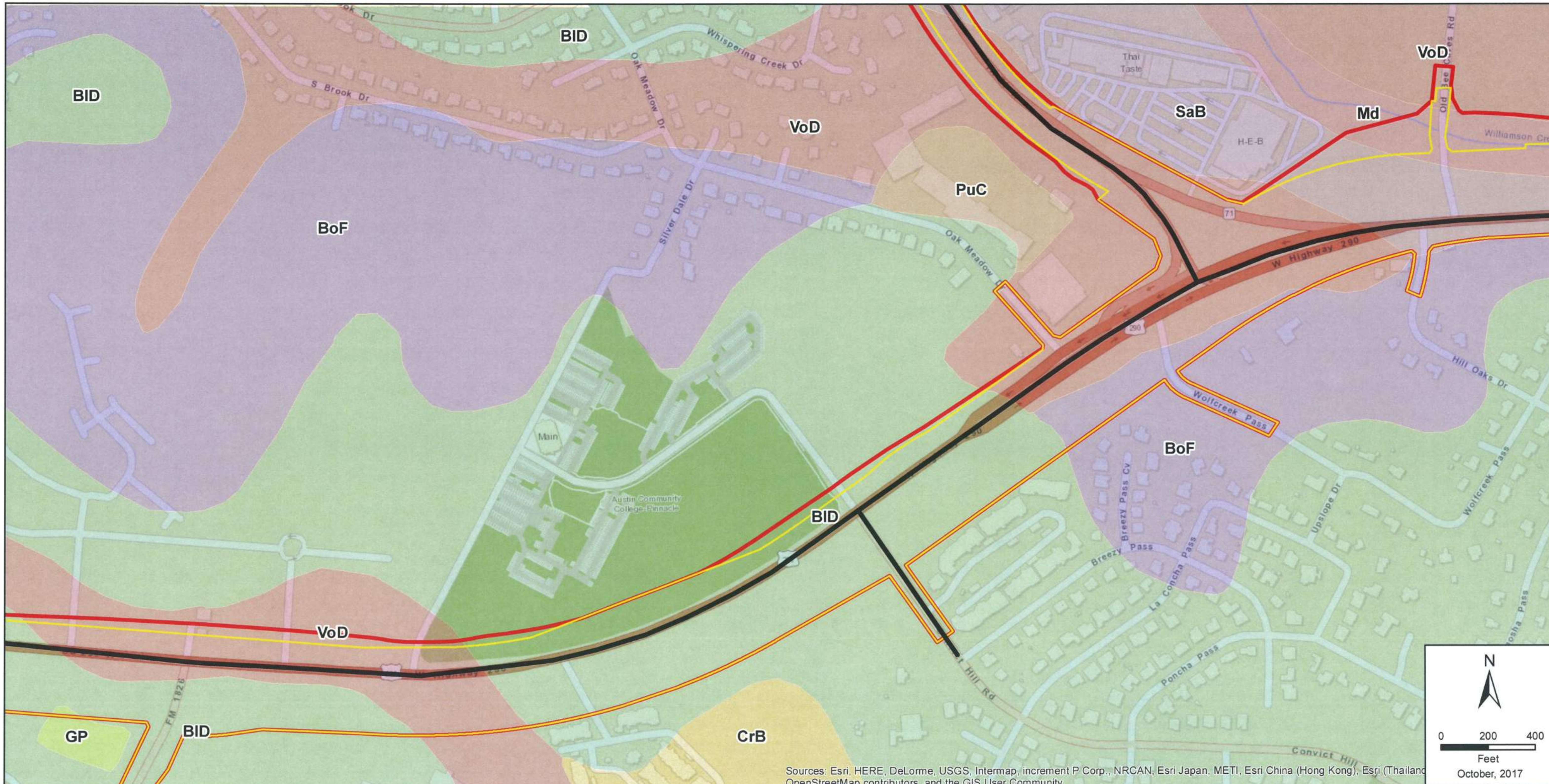

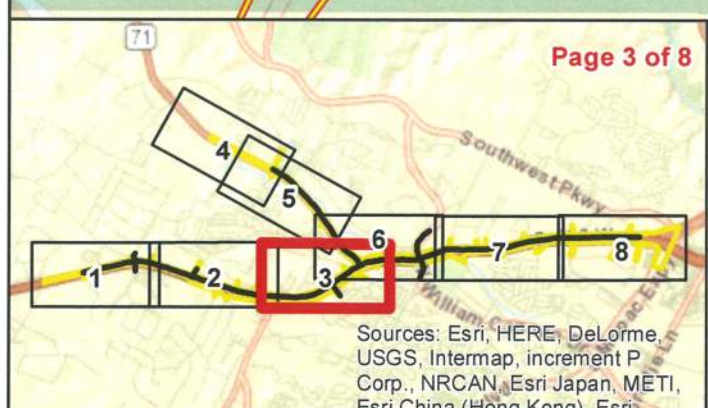

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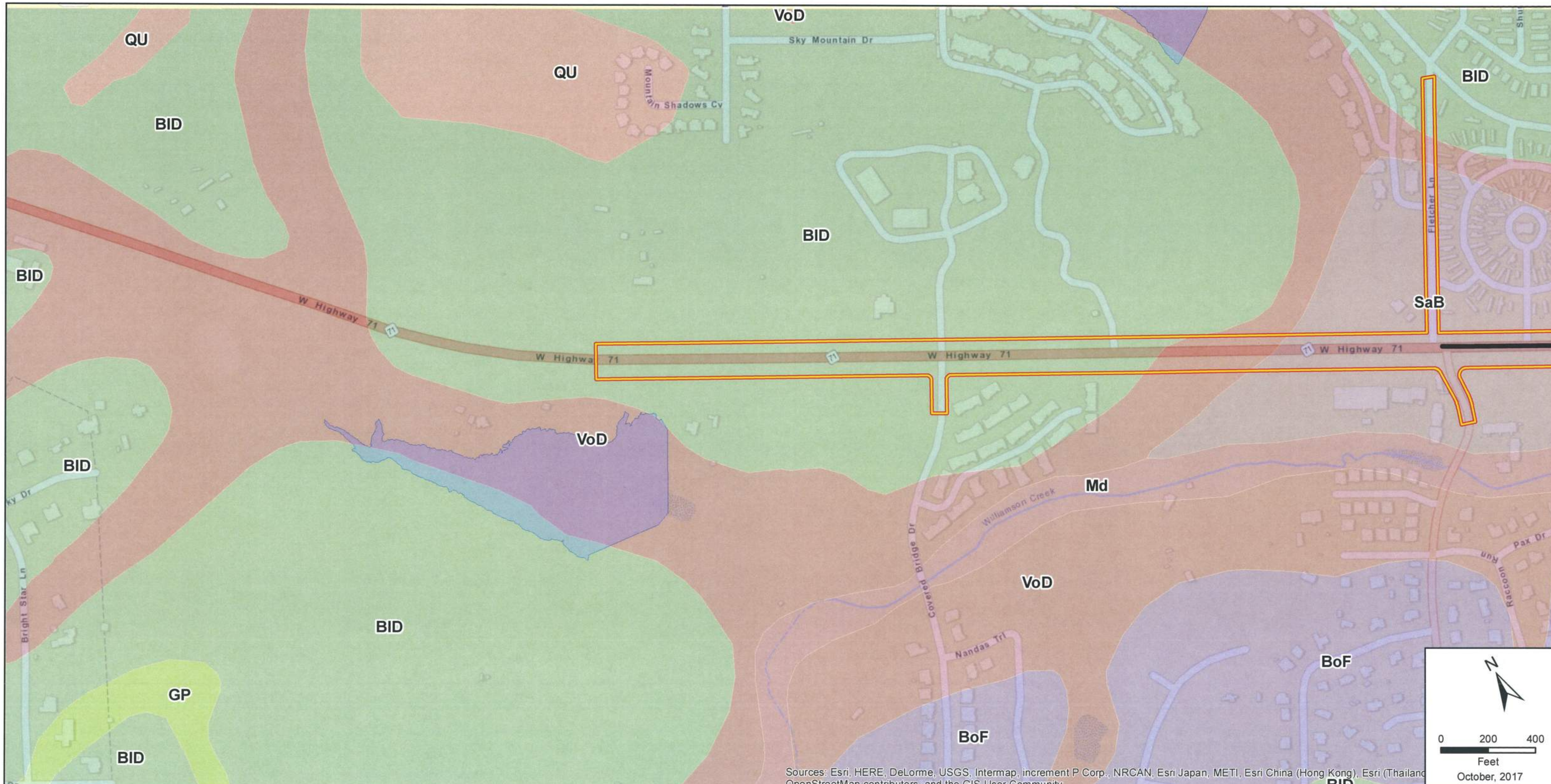

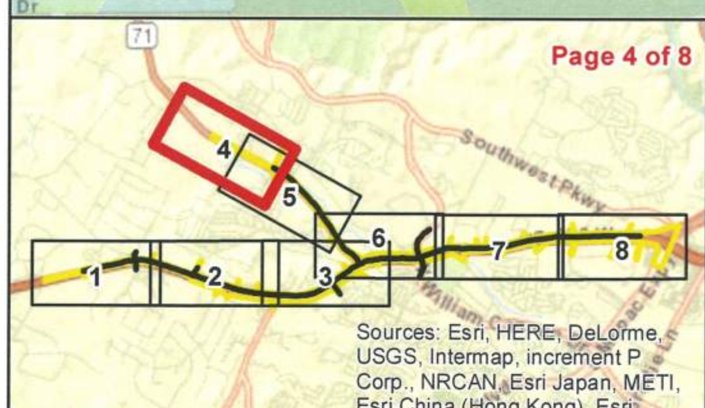

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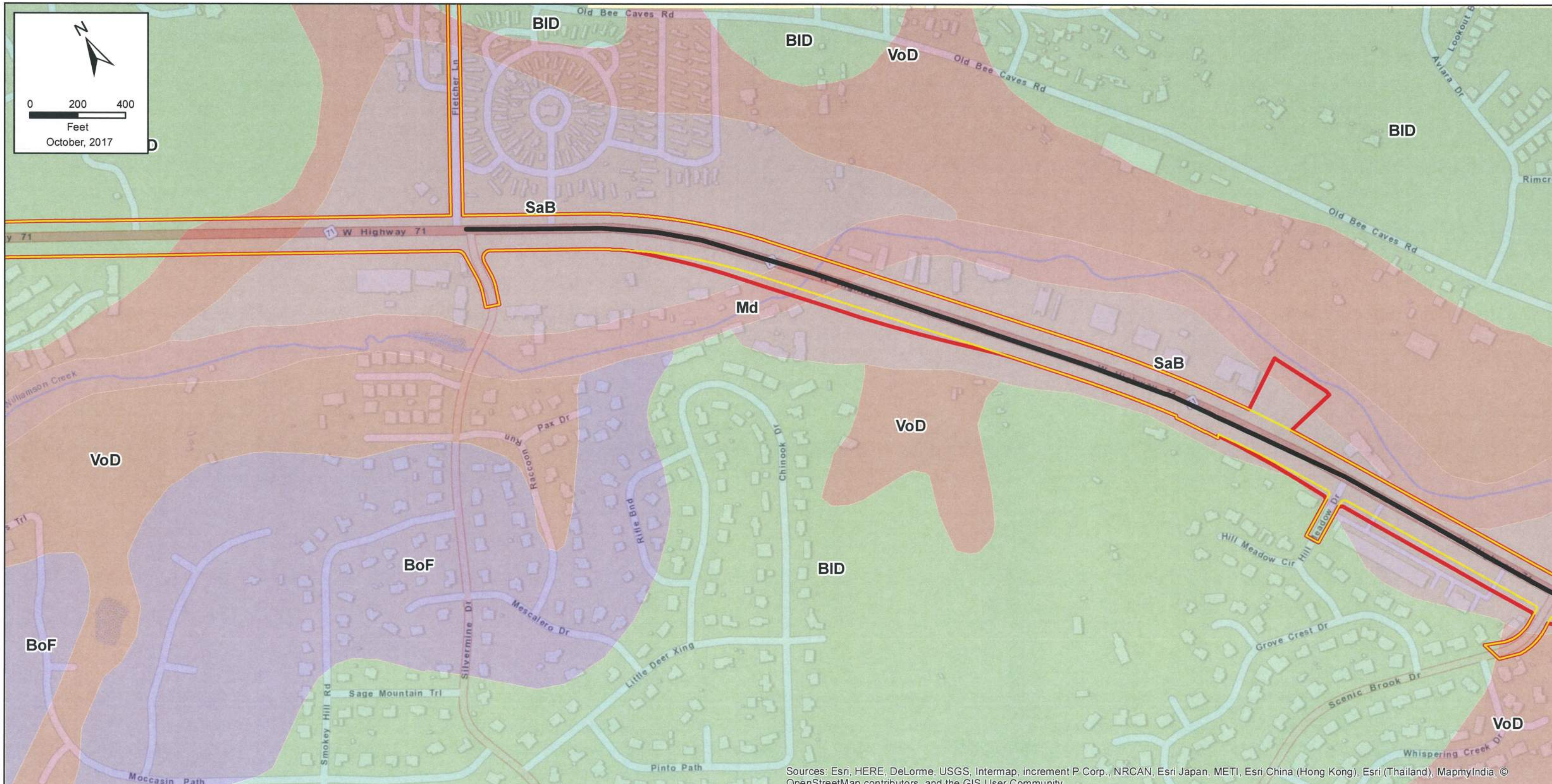

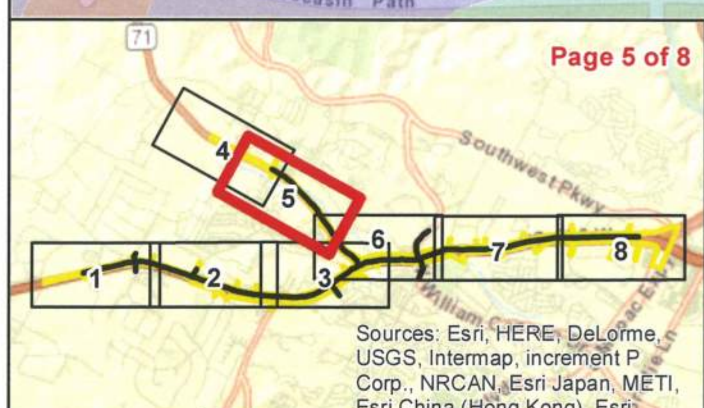

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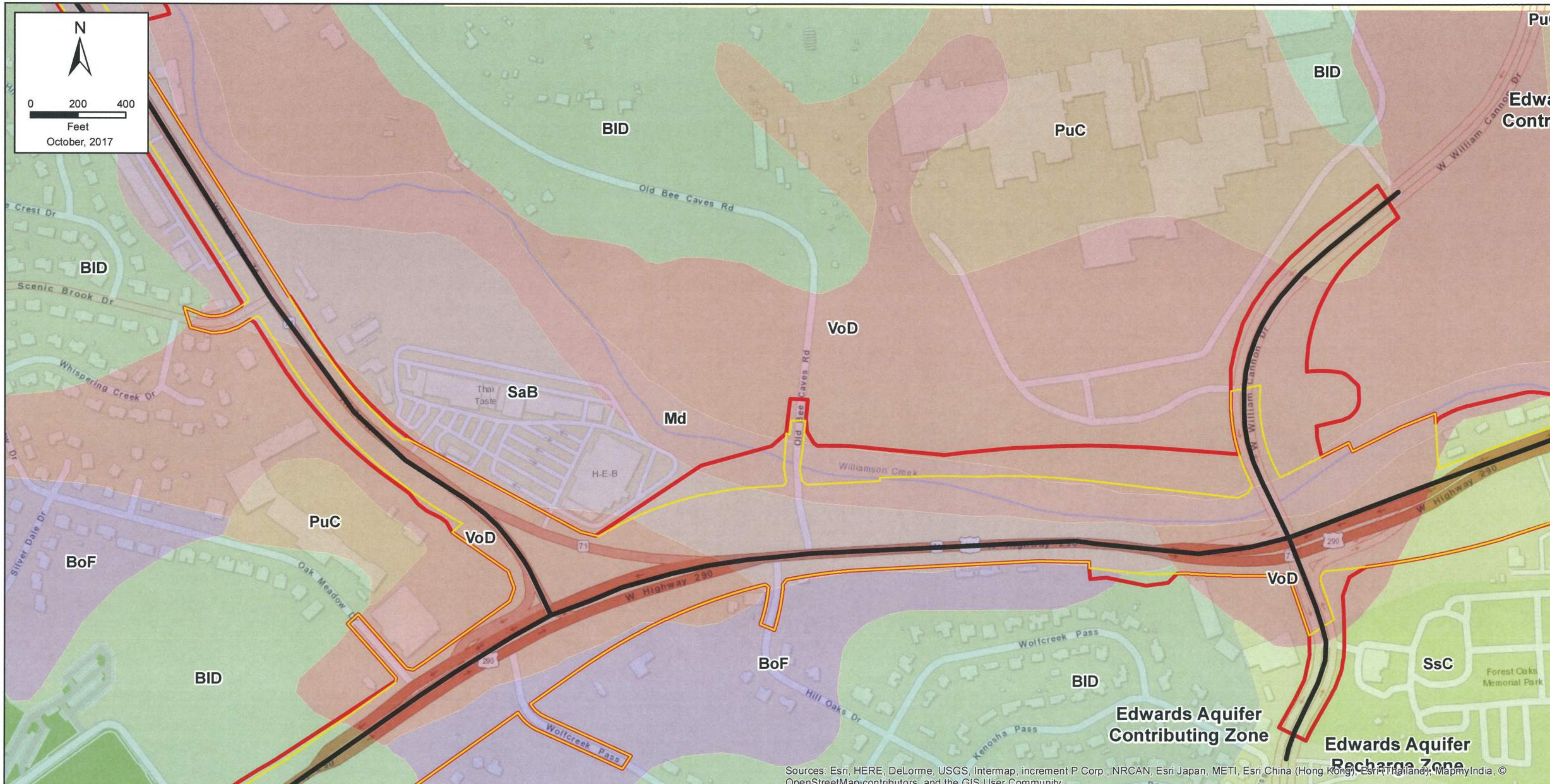

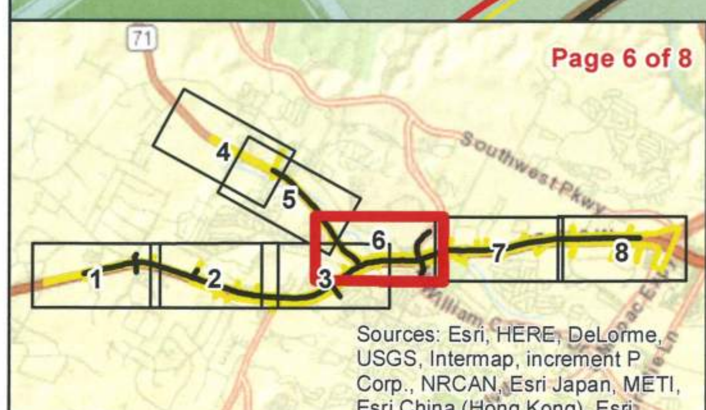

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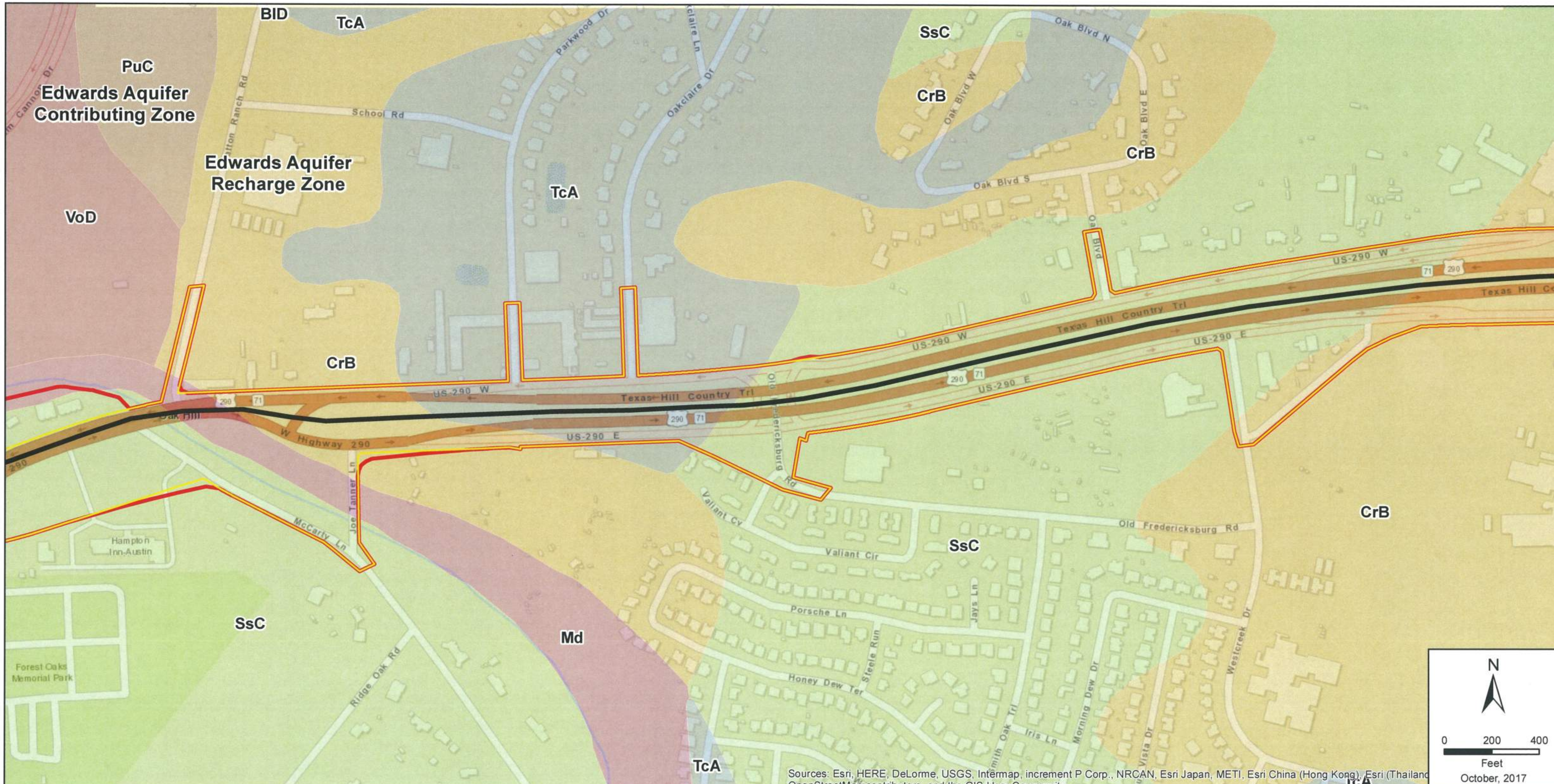

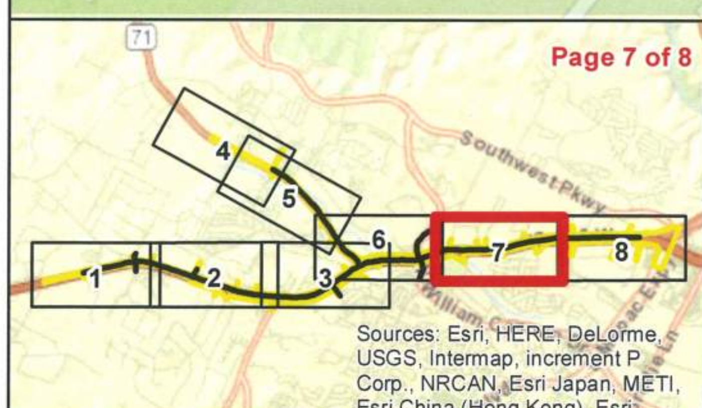

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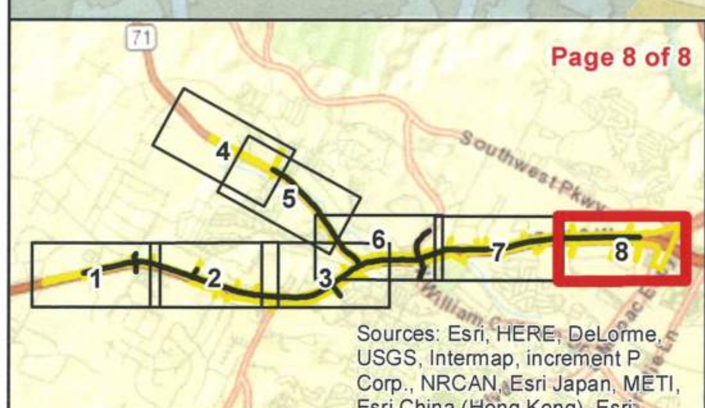

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Soil Profile, Narrative of Soil Units, Site Soils Map
U.S. Highway 290 (US 290) / State Highway (SH) 71 West from
State Loop 1 (MoPac) to Ranch-to-Market (RM) 1826 and
SH 71 to Silvermine Drive
Travis County, Texas
CSJ: 0113-08-060 and 0700-03-077

Site Soils Description and Map

The following table of site soil descriptions was prepared based on the United States Department of Agriculture's (USDA) Natural Resources Conservation Service (NRCS) Soil Survey Geographic Database (SSURGO) (2015) in addition to field visit observations.

The project study area includes two general soil map units, the Brackett Association and the Speck-Tarrant Association. These soil associations are described as mainly shallow, rolling and steep soils of the Edwards Plateau (USDA, 1974). The Brackett Association occurs in the western portion of the project area, beginning near the intersection of US 290 and William Cannon Drive. This general soil map unit includes gently undulating to steep soils capped in some locations on narrow ridges (USDA, 1974). The Brackett Association primarily includes Brackett and Tarrant soils, with lesser percentages of Volente, Denton, San Saba, Pedernales, and Altoga soils. Although this association is generally considered to be too shallow, stony, gravelly or steep for farming, it is well suited for use as rangeland.

The Speck-Tarrant Association includes shallow, stony, loamy soils and very shallow, stony, clayey soils overlying limestone (USDA, 1974). This soil association occurs east of the Brackett Association soils and is described as nearly level to gently sloping and gently undulating. The Speck-Tarrant Association contains two major soil types, Speck soils and Tarrant soils, along with minimal amounts of San Saba soils, Crawford soils and mixed alluvial land. Areas of this soil association are commonly used for range and are well suited as wildlife habitat.

According to the Soil Survey of Travis County, Texas (USDA, 1974), and the USDA Web Soil Service (http://websoilsurvey.nrcs.usda.gov/app/) (NRCS, 2015a), twelve soil units occur within an area defined as 500 ft. wide on either side of the project centerline and within the detention pond areas (Figure 3). These soils are described in detail within Table 2 below.

Table 2. Soil Series and Descriptions

Soil Series and Description	Map Unit Name and (ID)	Description of Map Unit	Thickness (feet)	Prime Farmland Soil	Hydric Soil	Hydrologic Group*	Acres within Area	% of Area
The Brackett soil series consists of shallow, well-drained soils that developed under prairie vegetation of mid and tall grasses and trees. Brackett soils mostly have a gravelly surface layer and are underlain by interbedded limestone and marl; some are underlain by fractured chalk. Permeability is moderately slow, and the available water capacity is low.	Brackett-Rock outcrop complex, 1 to 12 percent slopes (BID)	This complex occupies rolling topography with areas of soil separated by outcrops of limestone and marl. Slopes are typically 5 to 12 percent.	Veneer to 1.5 ft	N	N	D	338.9	35.4
	Brackett-Rock outcrop complex, 12 to 60 percent slopes (BoF)	This unit occurs on steep breaks along creeks and rivers with areas of soil separated by outcrops of limestone and marl.	Veneer to 1.5 ft	N	N	D	21.1	2.2
Crawford series consists of well-drained, moderately deep, noncalcareous, clay soils that developed over hard limestone. These soils are in valleys and on side slopes and ridges, and developed under bunch and short grasses and scattered clumps of trees. These soils crack when dry and are very slowly permeable when wet	Crawford clay, 0 to 1 percent slopes (CrA)	This soil occupies valleys and ridges, mostly in association with more sloping Crawford soils.	Greater than 6.7 ft	Y	N	D	6.4	0.7
	Crawford clay, 1 to 2 percent slopes (CrB)	Slopes on this soil are smooth and this soil seldom gullies. Well suited to range, crops,	2.7 ft	Y	N	D	129.7	13.5

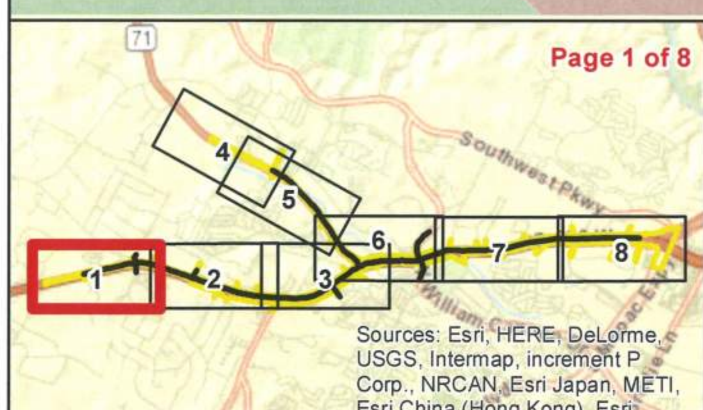
with a high available water capacity.		improved pasture, or hay.						
The Denton series consists of moderately deep, well-drained, calcareous, clayey soils that developed over interbedded limestone and marly clays. Typically gently sloping and mildly undulating, these soils developed under mid and tall grasses. Denton soils are slowly permeable with high available water capacity.	Denton silty clay, 1 to 3 percent slopes (DeB)	This soil occurs on smooth ridges and has a moderate erosion hazard, but is mostly cultivated.	3 ft	Y	N	D	8.3	0.9
Gravel Pits	Gravel pits, 1 to 90 percent slopes (GP)	Gravel pits.	-	N	N	--	1.4	0.2
Mixed alluvial land is a miscellaneous land type that occurs on floodplains of creeks and rivers. It consists of gravelly alluvium, beds of gravel, and exposed limestone beds and boulders randomly interspersed with moderately deep to deep calcareous alluvial materials.	Mixed alluvial land, 0 to 1 percent slopes, frequently flooded (Md)	Mixed alluvial land is found on floodplains. It typically includes very gravelly coarse sand. Well drained, this map unit has very low available water storage.	4 ft	N	N	A	41.5	4.3

Purves series soils consist of shallow, well-drained soils that developed in interbedded limestone and marl under a cover of mid and tall grasses. Purves soils are moderately, slowly permeable and have a low available water capacity.	Purves silty clay, 1 to 5 percent slopes (PuC)	These soils are typically on small knolls where the weathered limestone has been exposed.	Veneer to 1.5 ft	N	N	D	37.3	3.9
San Saba series soils include moderately well drained, moderately deep, clay soils which overly limestone. These soils are found in irregular areas on high broad ridges in addition to long, narrow valleys.	San Saba clay, 1 to 2 percent slopes (SaB)	This soil typically occupies smooth, single and complex slopes on broad uplands and in narrow valleys.	3.2 ft	Y	N	D	99.8	10.4
Speck series soils consist of shallow, well-drained soils overlying limestone. Slopes are smooth and complex and are dissected by widely spaced shallow drainageways. These soils developed under a cover of mid and tall grasses. Speck soils are slowly permeable and the water capacity is low.	Speck stony clay loam, 1 to 5 percent slopes (SsC)	This soil occupies smooth, gently undulating topography. Reddish-brown chert pebbles and cobblestones cover up to 50 percent of the surface in most areas.	1.5 ft	N	N	D	108.0	11.3

Tarrant series soils consist of shallow to very shallow, well-drained, stony, clayey soils overlying limestone. Large limestone rocks cover 25 to 85 percent of the surface in these soils. They occupy nearly level to gently sloping ridges, rolling side slopes, and steep, hilly breaks. These soils developed under tall grass and an open canopy of trees and are moderately slowly permeable and low water capacity.	Tarrant and Speck soils, 0 to 2 percent slopes (TcA)	This group occupies long areas on ridges with about 60 percent Tarrant soils, 30 percent Speck soils and small amounts of Crawford soils and rock outcrop. This soil unit is well suited to range use.	Veneer to 1.5 ft	N	N	D	21.6	2.3
The Volente series consists of deep, well-drained soils that developed in slope alluvium under a cover of mid and tall grasses and a scattered overstory of trees. Volente soils are moderately slowly permeable, and their water capacity is high.	Volente silty clay loam, 1 to 8 percent slopes (VoD)	This soil series is found on stream terraces. It is well drained with high water storage capabilities.	Greater than 6.7 ft	N	N	C	144.4	15.1
						Total	958.6	100.0

** Soil Group Definitions (Abbreviated)*

A. Soils having a high infiltration rate when thoroughly wetted.
B. Soils having a moderate infiltration rate when thoroughly wetted.
C. Soils having a slow infiltration rate when thoroughly wetted.
D. Soils having a very slow infiltration rate when thoroughly wetted.



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Legend

- TWDB Wells
- Centerline
- Existing ROW
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SSURGO Soil Data

- BID - Brackett-Rock outcrop complex, 1 to 12 percent slopes
- BoF - Brackett-Rock outcrop-Real complex, 8 to 30 percent slopes
- CrB - Crawford clay, 1 to 3 percent slopes
- DeB - Denton silty clay, 1 to 3 percent slopes
- GP - Pits, gravel, 1 to 90 percent slopes
- Md - Mixed alluvial land, 0 to 1 percent slopes, frequently flooded
- PuC - Purves silty clay, 1 to 5 percent slopes
- QU - Quarry, 1 to 40 percent slopes
- SaB - San Saba clay, 1 to 2 percent slopes
- SsC - Speck stony clay loam, 1 to 5 percent slopes
- TaD - Tarrant soils, 5 to 18 percent slopes
- TcA - Tarrant and Speck soils, 0 to 2 percent slopes
- TdF - Tarrant-Rock outcrop complex, 18 to 50 percent slopes
- CrA - Crawford clay, 0 to 1 percent slopes

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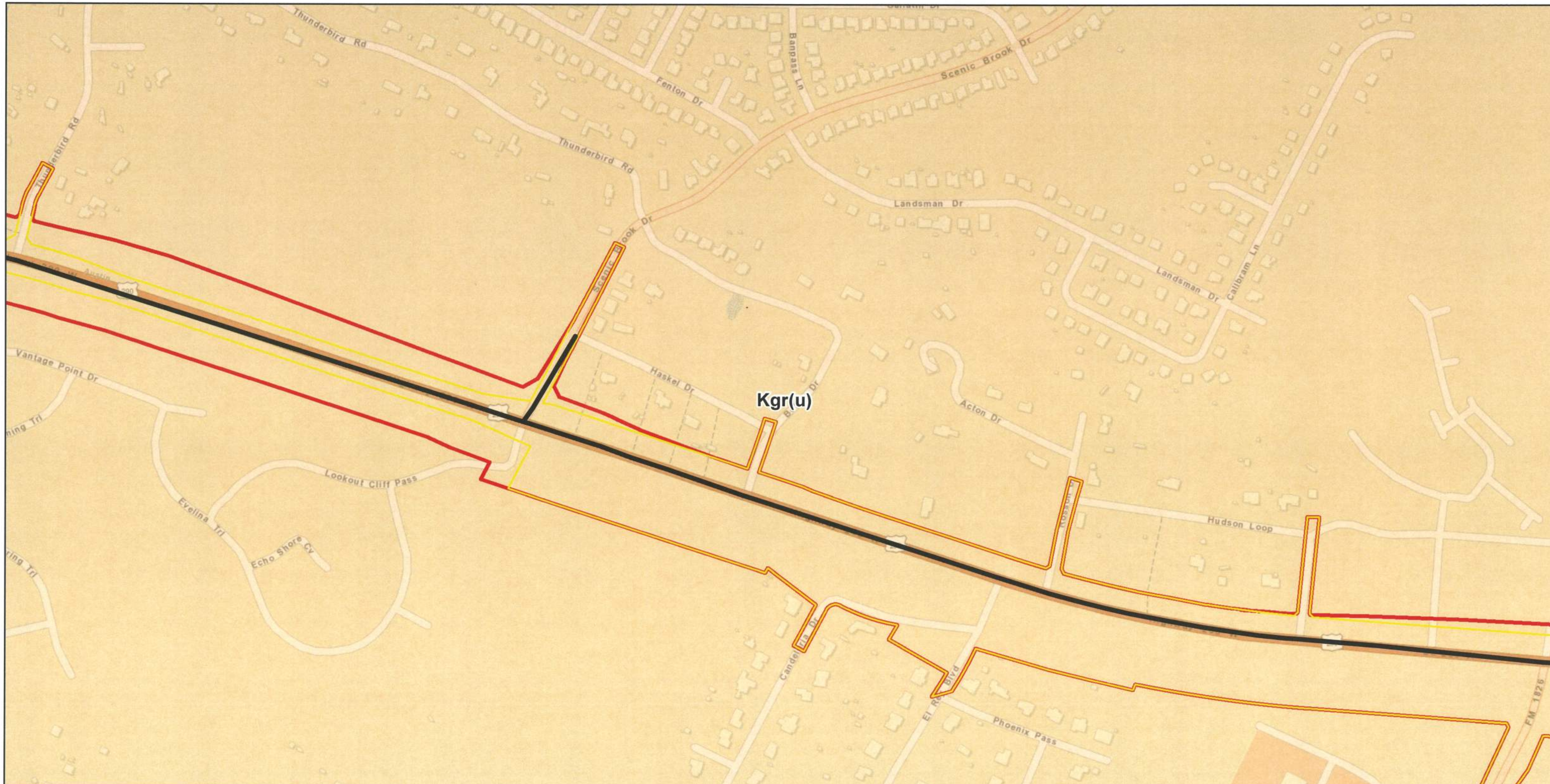

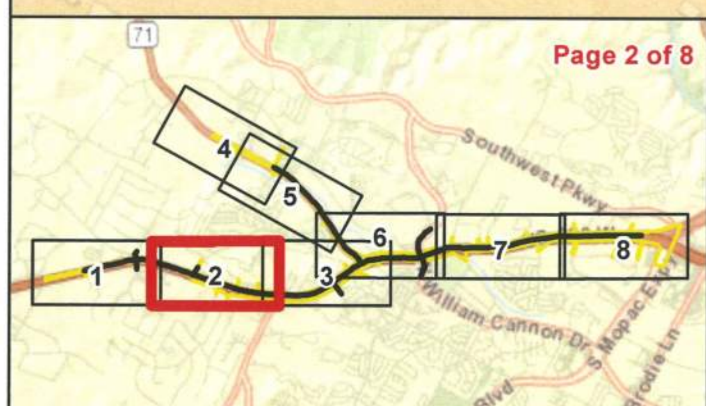

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Geologic Formations

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- Keb - Eagle Ford Group and Buda Limestone undivided
- Kfr - Fredricksburg Group undivided
- Kgr(u) - Upper Glen Rose Formation
- Qal - Alluvium
- Qhg - High gravel deposits

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Feet

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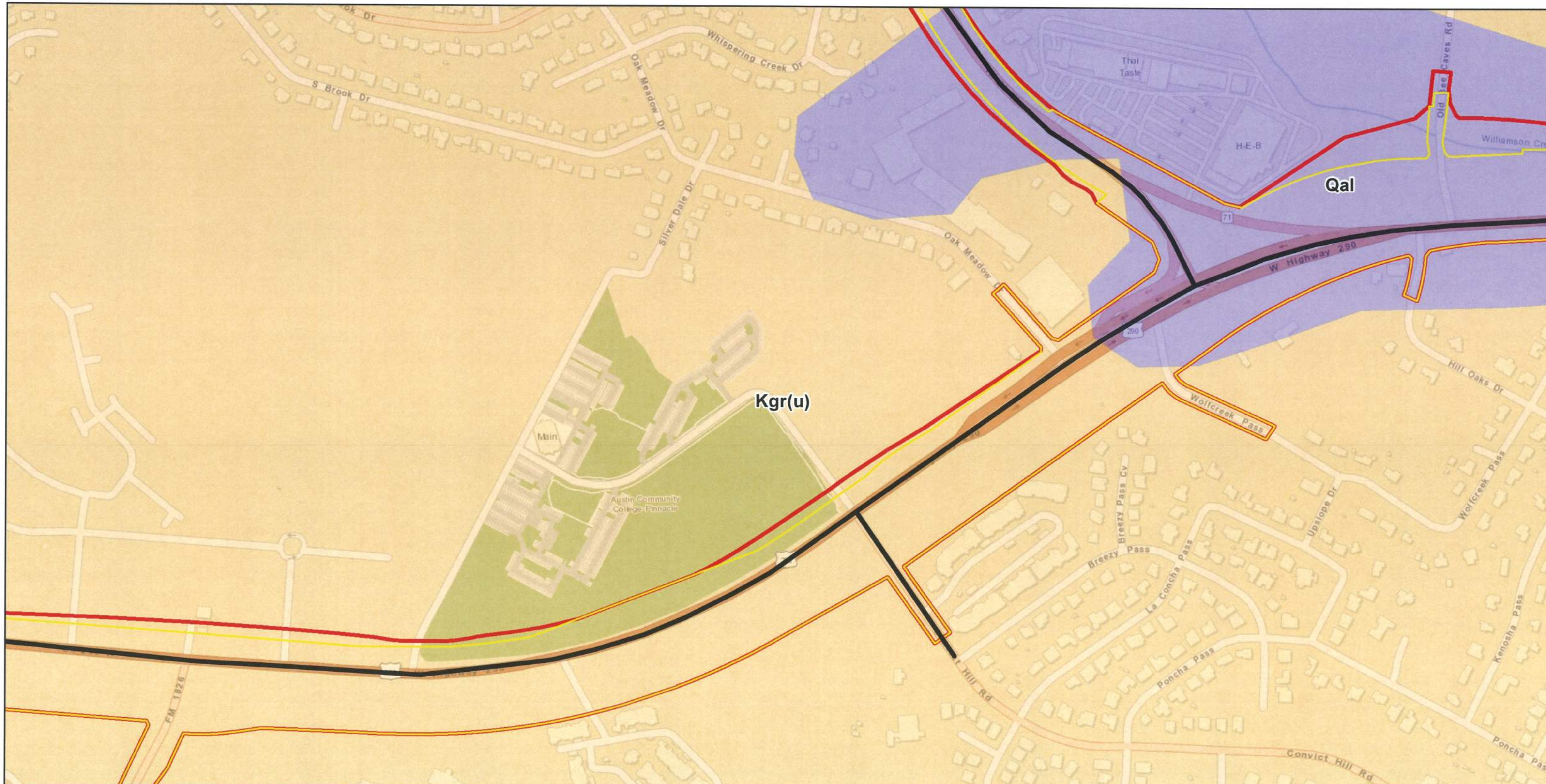

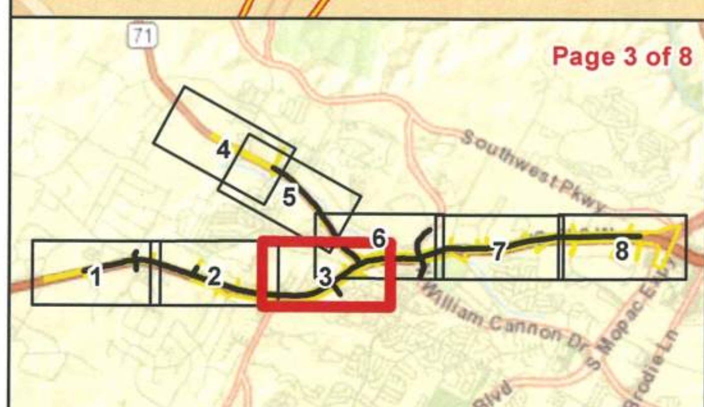

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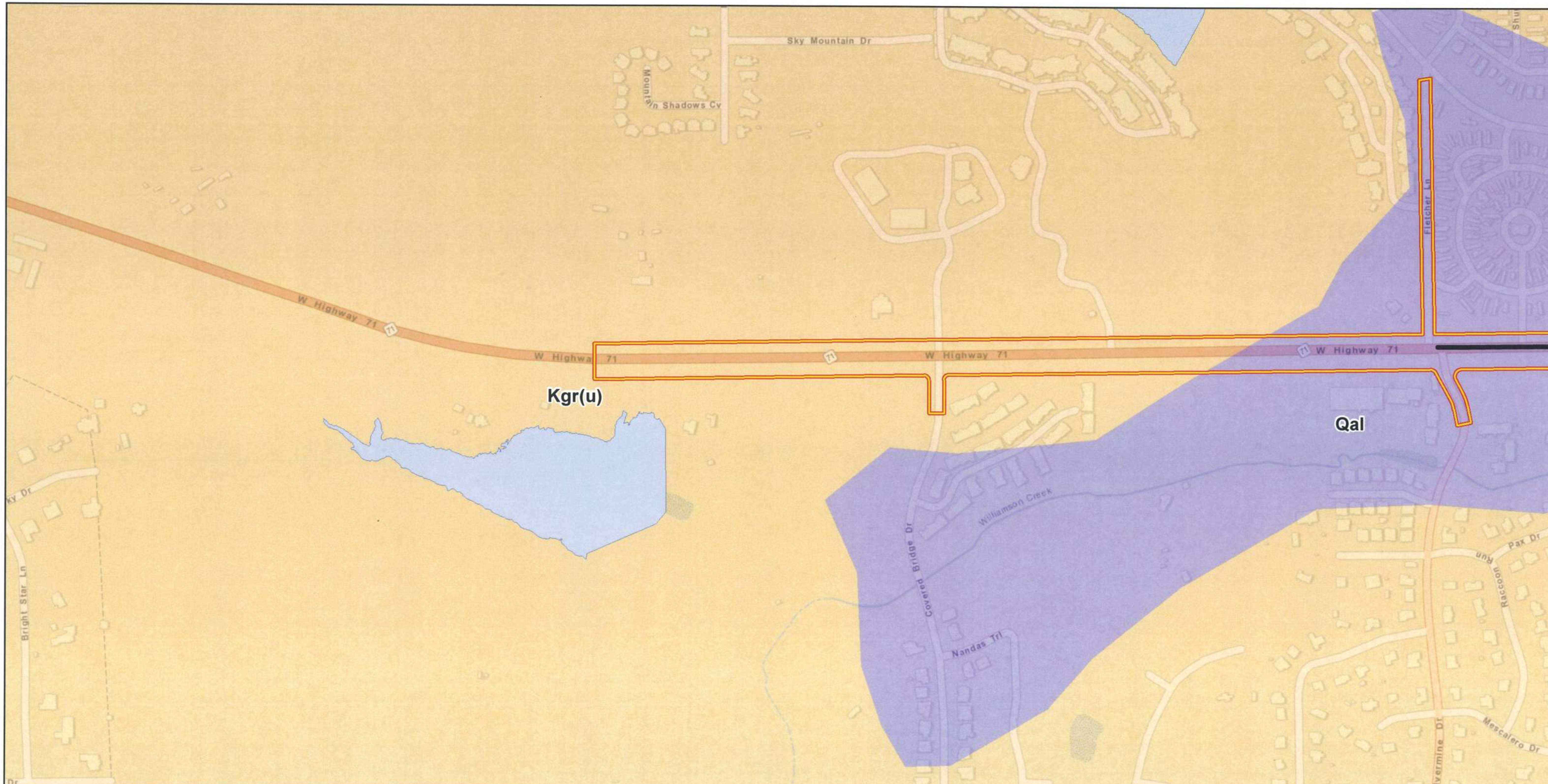

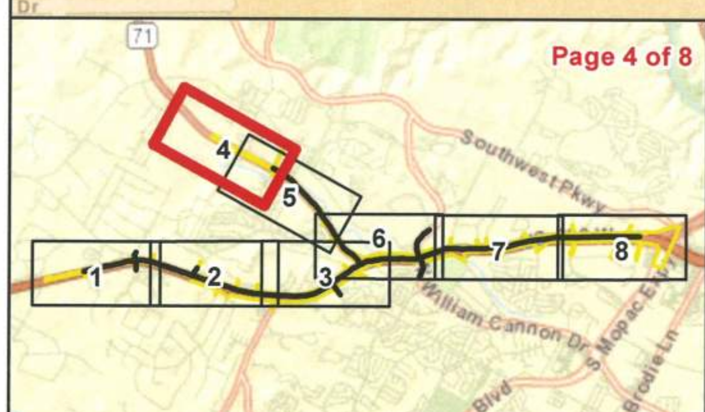

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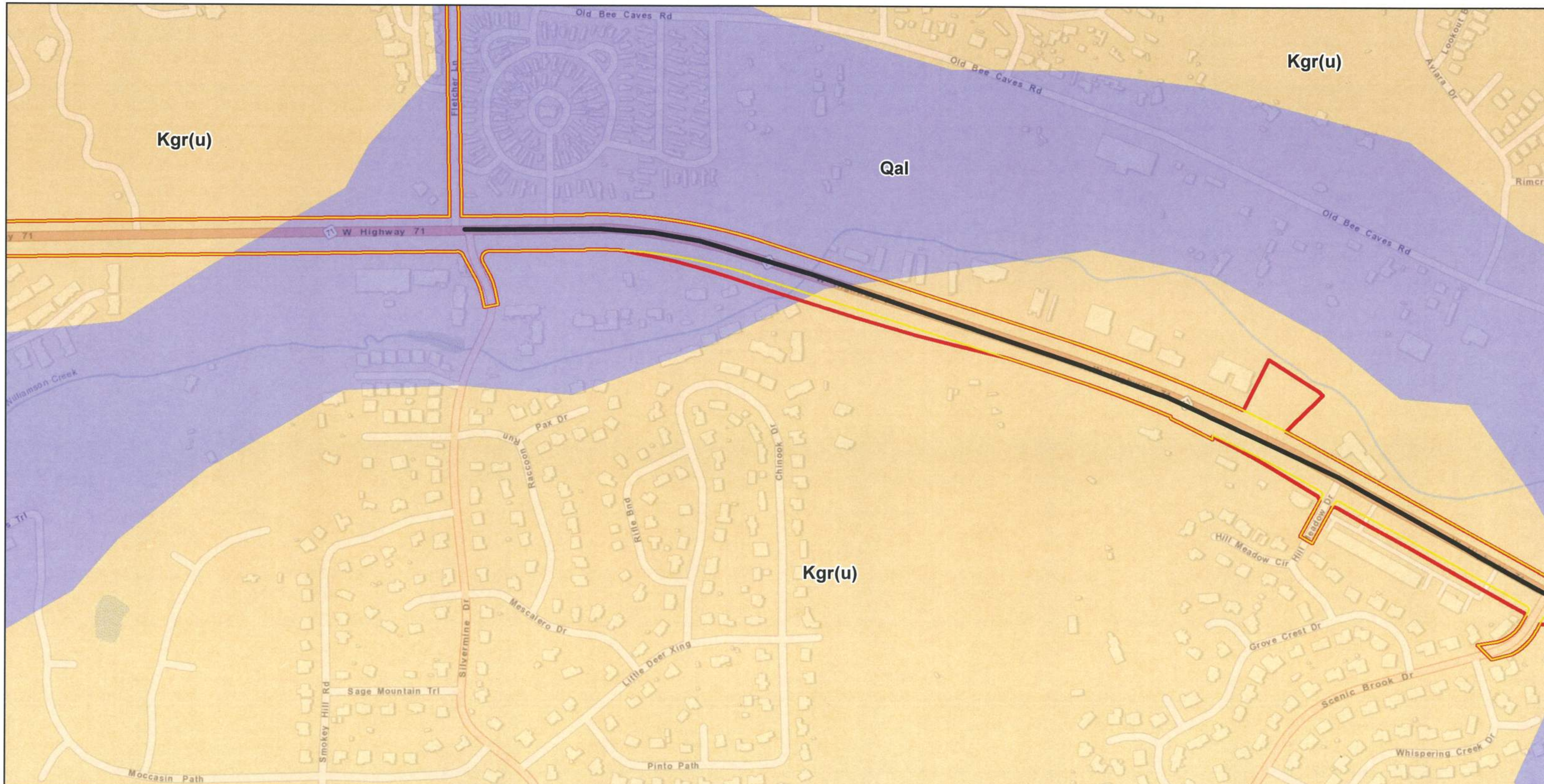

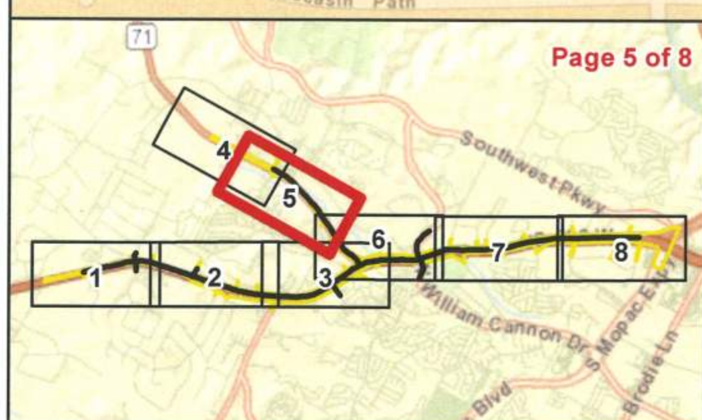

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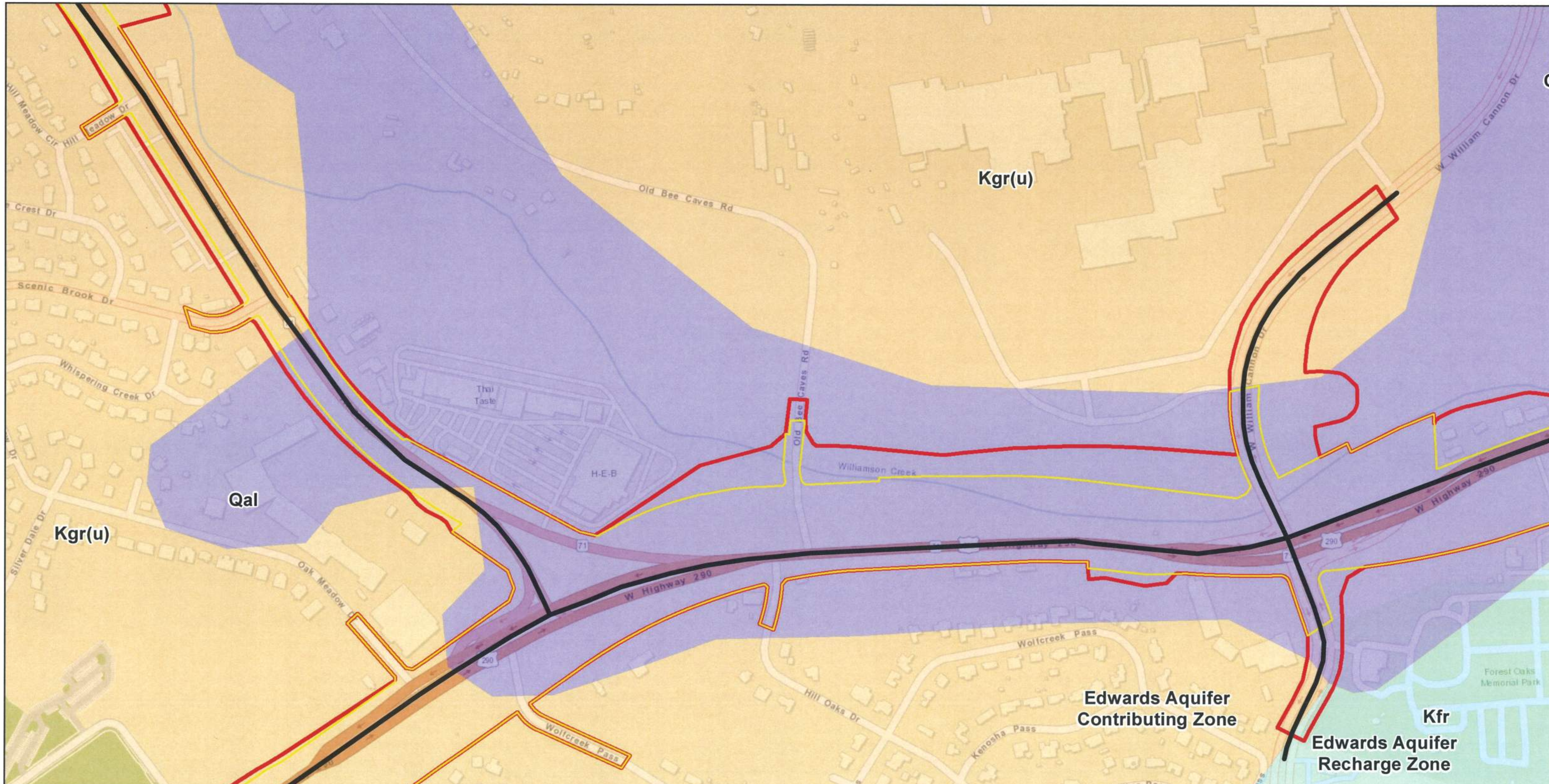

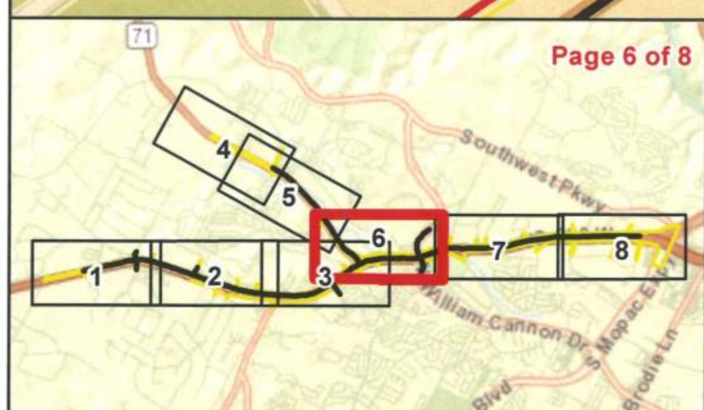

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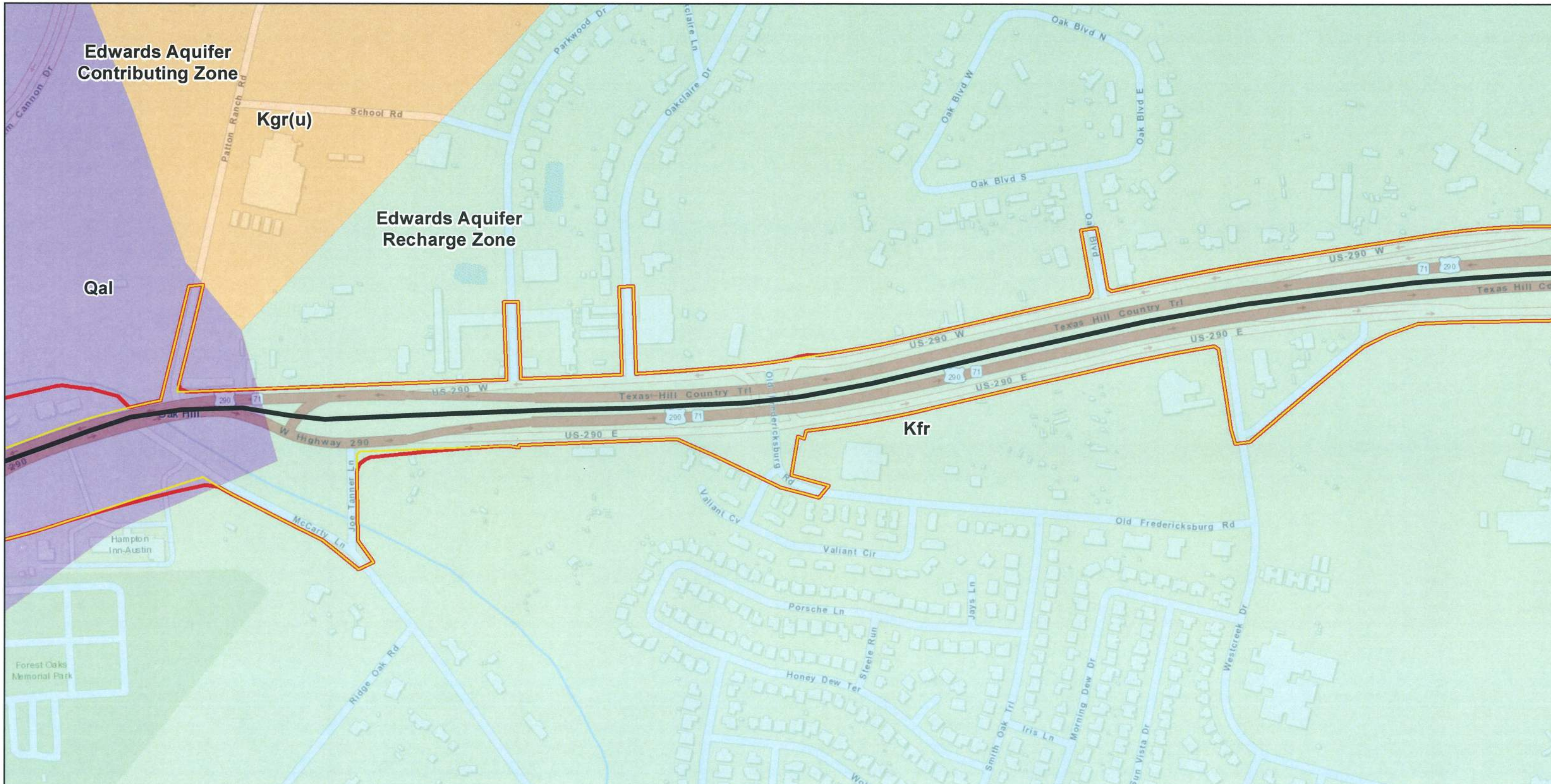

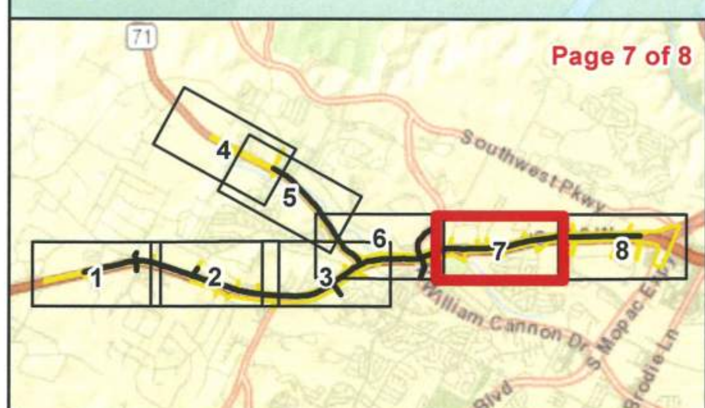

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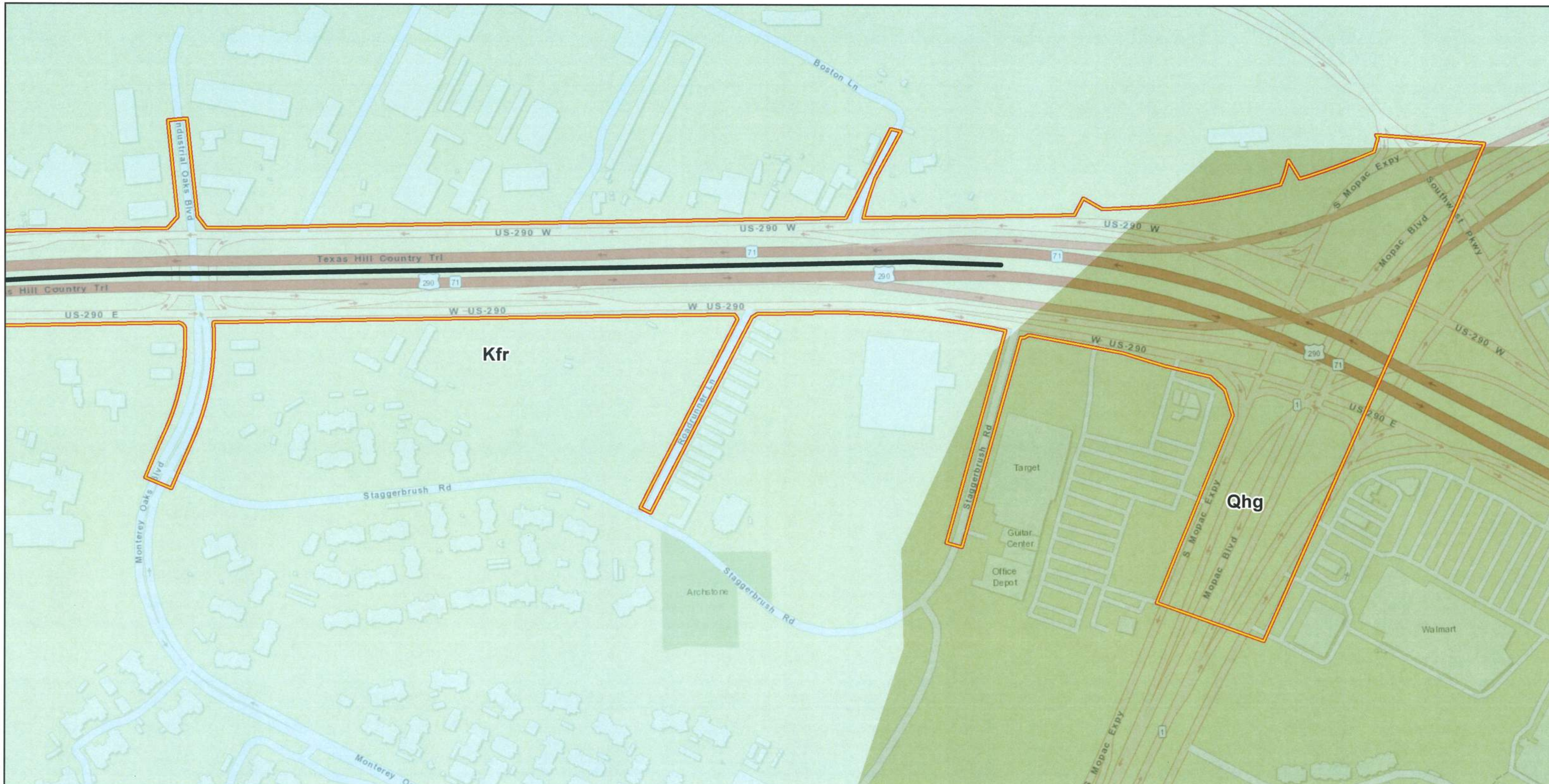

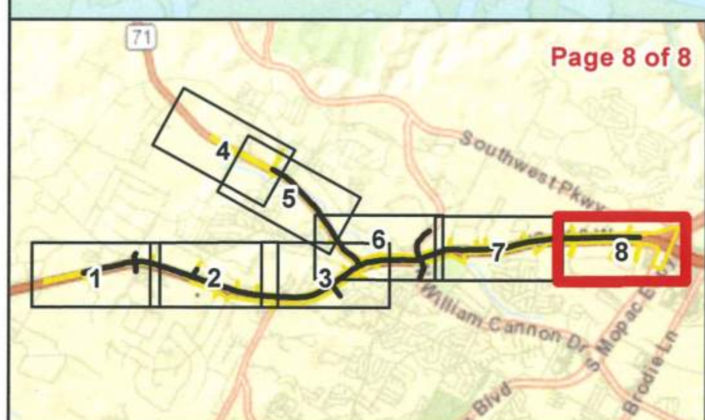

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This report was written on behalf of the Texas Department of Transportation by

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