CENTRAL TEXAS REGIONAL
MOBILITY AUTHORITY

Geological Assessment

Barton Skyway Ramp Relief, Austin (Travis County) Texas

(CSJ 3136-01-193)

June 2021

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 USC 327 and a Memorandum of Understanding dated December 16, 2019, and executed by the Federal Highway Administration and Texas Department of Transportation.

Contact Information

This document is released for the purpose of interim review under the authority of Heather Beatty, P.G. (Texas Geoscience License #1350). It is not to be used for permitting, final planning decisions, bidding or construction.

Revision History

The following table shows the revision history for this document.

Effective Date Month Year	Reason for and Description of Change
June 2021	Draft released for review

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I. Introduction

A. Purpose

This narrative Geologic Assessment accompanies the Texas Commission on Environmental Quality (TCEQ) Geologic Assessment Form TCEQ-0585 (Appendix A) completed for the Barton Skyway Ramp Relief project (project) from Barton Skyway to State Loop 360 (SL 360) in Travis County, Texas (Figure 1). The project lies within the recharge zone of the Barton Springs Segment (BSS) of the Edwards Aquifer. The Project Area includes approximately 220.2 acres of existing right-of-way (ROW) of State Loop 1 (MoPac Expressway or MoPac). This assessment covers the entire area (colored red) shown in the report figures although the project activities will occur along the southbound portion of the ROW.

The Project Area lies within the Balcones Fault Zone (BFZ), which is a major geologic expression of a structural hinge that bisects the State from the Dallas area in north Texas to the border with Mexico near Del Rio (Figure 2, Project Photo 1 in Appendix B). The geologic faults in the BFZ reflect the stresses of this hinge. About two miles west of the project, the Mount Bonnell Fault is the major break along the fault zone. It has a stratigraphic displacement of approximately 400 feet in the BSS. Other faults have displacements in the tens of feet but can be as high as 120 feet. Faults within the BFZ are no longer seismically active. Strata are generally displaced downward towards the Gulf Coast as a result of normal faulting.

Mass grading of soil and drainage system alterations have occurred during previous roadway construction. The Project Area lies entirely within the Barton Creek watershed where the elevation ranges from approximately 568 to 685 feet above mean sea level. The Lower Colorado River is a hydrologic divide that separates the BSS from the northern segment of the Edwards Aquifer.

B. Previous Geologic Assessments

Previous geologic assessments were reviewed that include the Project Area. The first is a geologic assessment of two bicycle and pedestrian bridge projects that was completed in portions of the Project Area. One project was the bridge over Barton Creek and the other was over SL 360 (HDR 2013). The results section of this report details how the 22 identified features included in the above geological assessment were evaluated. The second report is a draft geologic assessment (Zara Environmental 2016) from an earlier version of the MoPac South project. The results section of this report contains an explanation of all of features noted in the draft MoPac South geologic assessment. Additionally, a karst feature and stormwater vulnerability survey (SWCA Environmental Consultants 2002) conducted in all the TxDOT ROW within the City of Austin was reviewed.

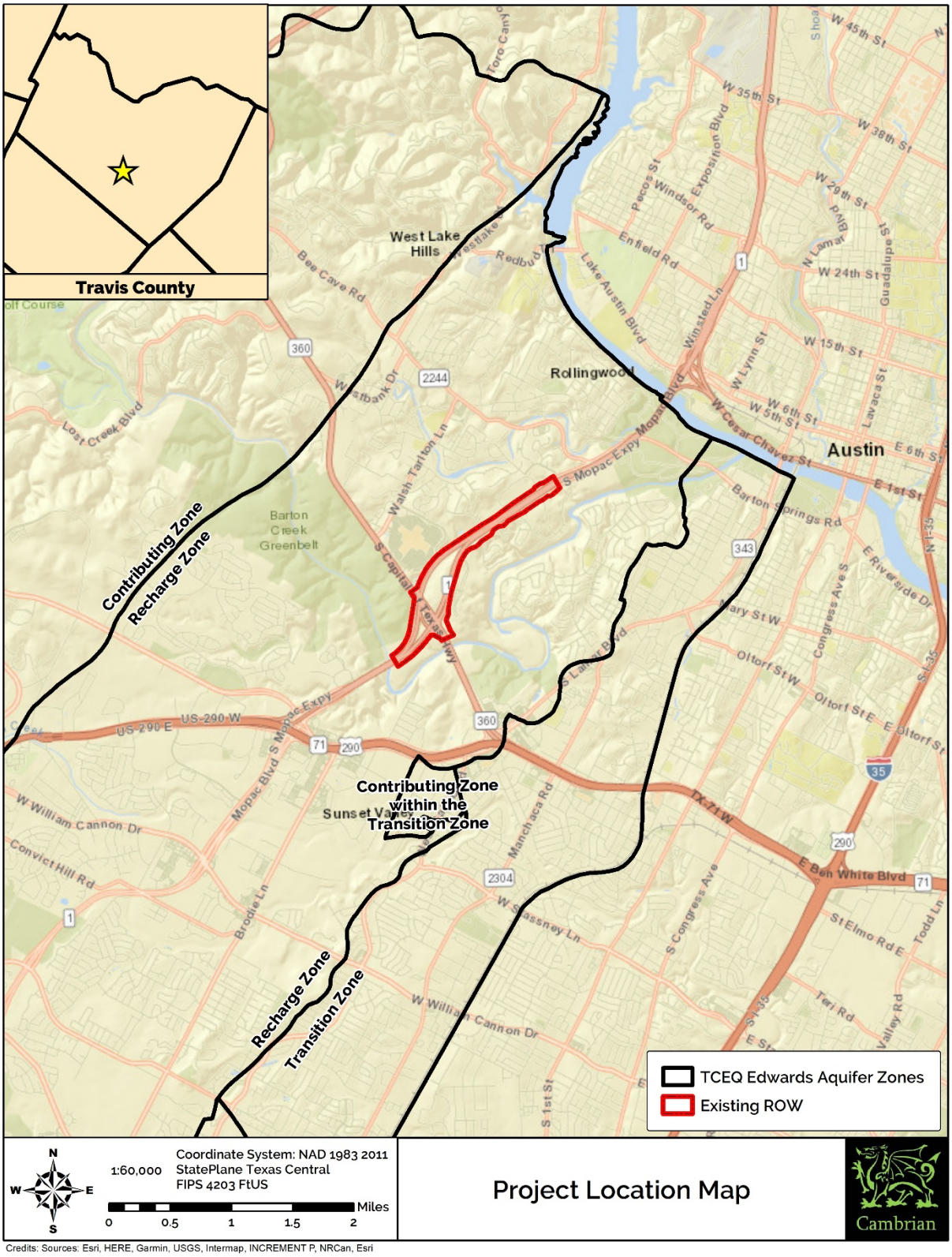


Figure 1. Project location map.

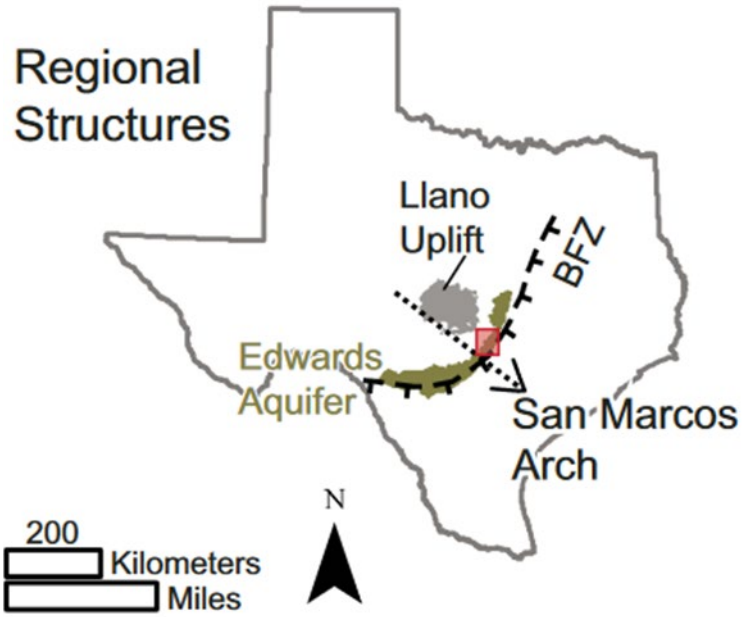


Figure 2. Regional Geologic and Structural Features (Hunt et al. 2019). Location of the Edwards Aquifer (olive green) in Texas along the Balcones Fault Zone (BFZ). The Barton Springs Segment of the Edwards Aquifer is marked by a red box on the north side of the San Marcos Arch.

C. Methodology

Cambrian Environmental Registered Professional Geoscientists (Texas Licenses #s 1350, 3863 and 10791) and two karst technicians conducted a karst feature field survey in the Project Area between January and April 2020. The pedestrian survey was completed by walking parallel transects spaced approximately 50 feet apart as directed by the TCEQ in the *Instructions to Geologists for Geologic Assessments on the Edwards Aquifer Recharge/Transition Zones (Rev. 10-01-04)*. Closer spacing was used where vegetation inhibited clear observation. All potential karst features, including depressions, holes, and animal burrows, were carefully examined for evidence of subsurface extent. A number of techniques were used for this effort including probing with a digging implement to determine the thickness and consistency of fill material and feeling for the presence of air flow, which may indicate the presence of a sub-surface void space. Other techniques included making observations of any notable characteristics of the feature site such as the presence of various types of vegetation or a semi-circular burrow mound produced by the activities of small mammals. The locations of discovered features were recorded with a handheld GPS unit. Feature locations were then correlated with features identified in previous assessments using GPS coordinates and compared using photo documentation.

Additionally, the locations of known karst features and caves were reviewed from available literature and databases. The main source of cave information was the City of Austin Watershed Protection Department karst feature database (COA 2020). In addition to various published geologic maps of the project, ArcGIS files of the City of Austin Geologic Map of the Austin Area (COA 2014) were reviewed. These files were used to create field maps to aid in site-specific geological interpretation.

II. Results

A. Soils

Soil units in the Project Area are shallow, undulating to steep, and predominantly occur over limestone. Half of the Project Area is covered by the Brackett-Rock outcrop complex (BID) soil unit. Other soils occurring in the Project Area are mapped within Crawford clay (CrB), Tarrant soils (TaD), Tarrant and Speck soils (TcA), Speck stony clay loam (SsC), Brackett-Rock outcrop-Real complex (BoF), Gravel pits (GP), Tarrant-Rock outcrop complex (TdF), and the Volente silty clay loam (VoD) soil units (Figure 3; USDA NRCS 2014; USDA 1972).

The Crawford and Speck soil series are within the "D" classification of the hydrologic soil groups. The "D" soils have a very slow infiltration rate (very high runoff potential) when thoroughly wet. These consist chiefly of clays that have a high shrink-swell potential, soils that have a permanent high-water table, soils that have a claypan or clay layer at or near the surface, and soils that are shallow over nearly impervious cover. These soils have a very slow rate of water transmission.

The Brackett, Tarrant, and Volente soil series are within the "C" classification of the hydrologic soil groups. Type "C" soils have slow infiltration rates when thoroughly wet. These consist chiefly of soils in which a layer impedes the downward movement of water or soils that are moderately fine to fine textured. These soils have a slow rate of water transmission.

B. Geology

Bedrock units in the Project Area are all Cretaceous age sedimentary rocks (limestone, marl, and clay) that were deposited in a marine shelf or shelf-margin environment. The lithology underlying the Project Area consists of the lower Cretaceous age Edwards Group which consists of the Kainer and Person Formations, and the Georgetown Formation, as well as the upper Cretaceous Del Rio Clay and Buda Limestone Formations. The general geology and stratigraphy of the project are graphically shown in Figures 4 and 5.

The Kainer Formation of the Edwards Group contains limestone, dolomitic limestone and chert occurs throughout the formation. The thickness ranges between 270 to 335 feet (Hunt et al. 2019; Blome 2005). The Kainer is divided into hydrostratigraphic units (Basal Nodular, Dolomitic, Kirschberg Evaporite, and Grainstone members). The Walnut Formation is equivalent to or indistinguishable from the Basal Nodular member in Travis County. There are few caves developed in the massively-bedded Basal Nodular. The Dolomitic member consists of a resistant wackestone with isolated chert nodules. Caves developed in the Dolomitic typically are formed along bedding planes. Caves are extensively developed in the Kirschberg Evaporite member. The Kirschberg consists of an evaporitic limestone, pulverulite and either chert beds or nodules. Few caves are developed in the Grainstone member, which consists of light-colored milolid grainstone and chert beds. Much of Kainer Formation is fossiliferous; typified by rudistid-rich mudstones and wackestones that grade into intertidal and supratidal dolomitic mudstones with evaporites and miliolid grainstones. Other fossil groups include oysters and gastropods (Blome 2005).

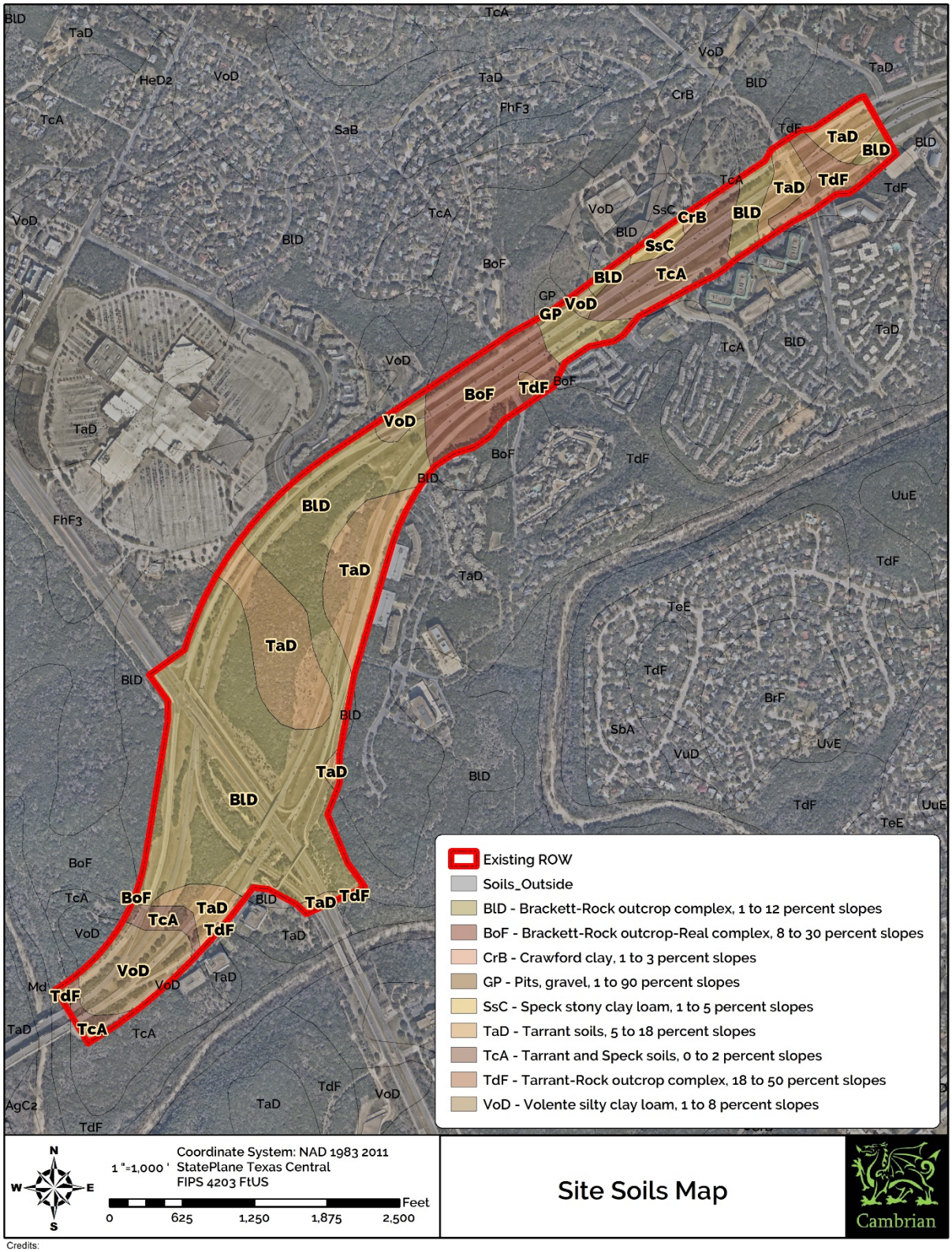
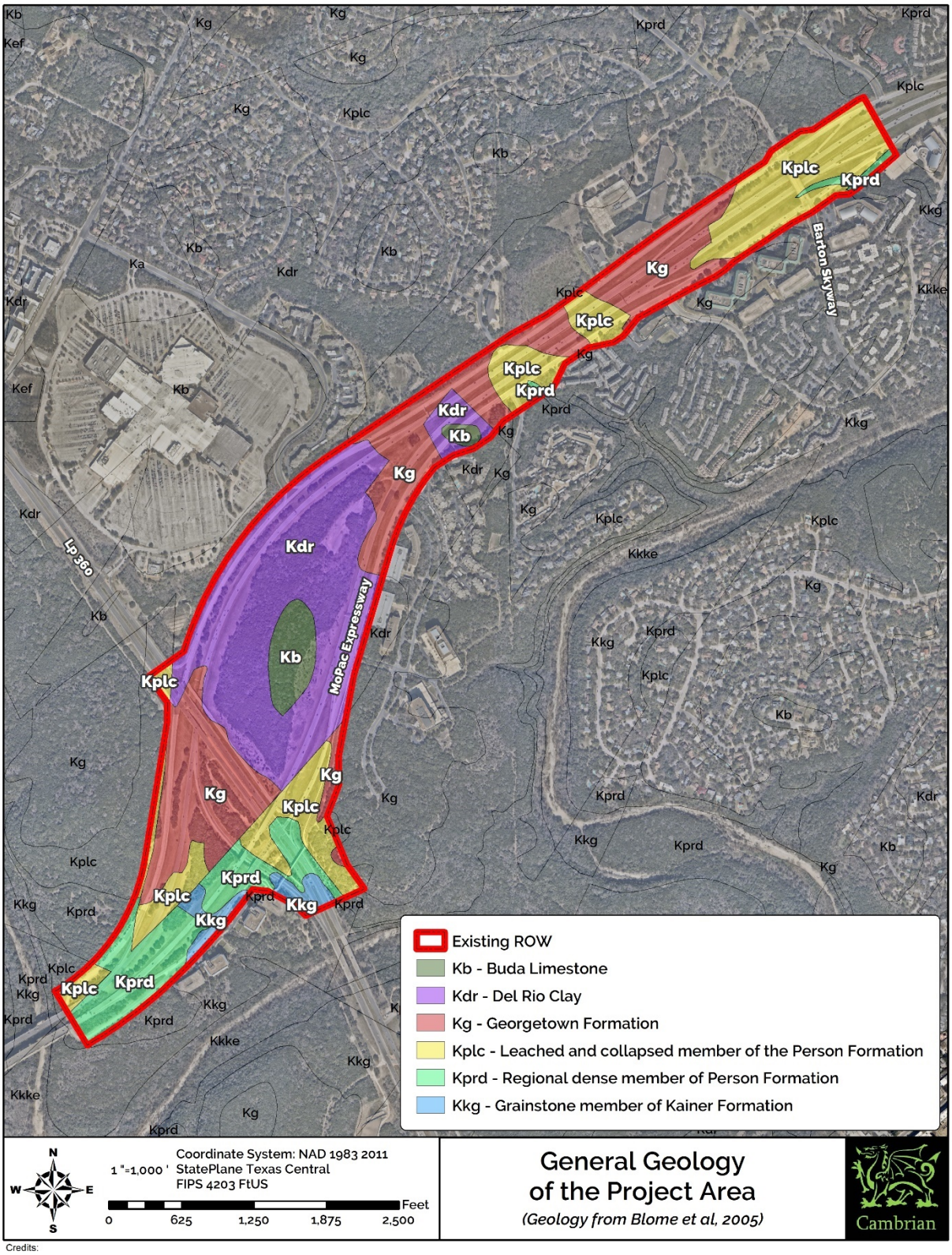


Figure 3. Soils of the Project Area.



Credits:

Figure 4. General Geology of the Project Area.

Period	Stratigraphic Unit				Thickness (ft)
Quaternary	Alluvium (Qal)				10-30
Upper Cretaceous	Navarro and Taylor Groups (Knt)				600
	Austin Group (Ka)				275
	Eagle Ford Group (Kef)				40
	Buda Limestone (Kb)				40
	Del Rio Clay (Kdr)				60
Lower Cretaceous	Edwards Aquifer	Georgetown Fm. (Kg)			50
		Edwards Group	Person Fm. 50–170 feet thick	Cyclic and Marine mbr (Kpcm)	0-70
				Leached and Collapsed (Kplc)	30-80
				Regional Dense mbr (Kprd)	20
			Kainer Fm. 270–335 feet thick	Grainstone mbr (Kkg)	45-60
				Kirschberg Evaporite mbr (Kkke)	65-75
				Dolomitic mbr (Kkd)	110-150
				Basal Nodular/Walnut Fm. (Kkbn)	50
	Upper Glen Rose mbr (Kgru)				450

Figure 5. Stratigraphic Column. Shaded areas represent lithologies underlying the project. Abbreviations from Blome 2005. Stratigraphic nomenclature and thickness from Hunt et al. 2019 and Small et al. 1996.

The Person Formation contains grainstone and crystalline limestone, and the thickness ranges between 50 and 170 feet (Hunt et al. 2019; Blome 2005). The Person is further divided into hydrostratigraphic units (Regional Dense, Leached and Collapsed, and Cyclic and Marine members). The dense carbonate mudstone of the Regional Dense member is not known to form caves. The undivided porous and permeable Leached and Collapsed members consist of light-colored wackestone, although burrowed mudstones, grainstones, and intervals of crystalline limestone also can be found (Hauwert, 2009). The Cyclic and Marine member is not mapped in the Project Area due to erosion prior to deposition of the Georgetown (Hauwert 2009). Common fossils of the Person Formation include pelecypods, gastropods, and rudistids (Blome 2005).

The Georgetown Formation is the uppermost unit of the Edwards Aquifer. It is included in the Edwards Aquifer because well drillers historically have considered the Georgetown the top of the Edwards Aquifer (Small et al., 1996). The Georgetown Formation is up to 50 feet thick (Hunt et al. 2019) and can be seen along the ramp from southbound MoPac to southbound SL 360 where the beds are folded in the Loop 1 Syncline (Project Photo 2), and along the north end of the Project Area (Project Photo 3). The Georgetown was deposited in a more open, shallow marine environment (Hunt et al. 2019), and is generally more fossiliferous than the Kainer or Person Formations. It is reddish-brown and gray to light-tan, marly limestone with biomicritic texture; commonly contains the brachiopod *Waconella wacoensis*, *pectins*, as well as the mollusks *Kingena wacoensis* and *Gryphaea washitaensis* (Blome 2005). Karst features are uncommon in the Georgetown Formation.

The Del Rio Clay is a predominantly a mudstone formation that averages about 60 feet thick in the BSS. It is a bluish clay that weathers to an olive-green color, and commonly contains fossil “rams horns” (*Ilymatogyra Arietina)*. The low permeability clay forms a seal above the Edwards Aquifer. The Del Rio Clay is easily erodible and, especially on steep slopes, can cause construction problems related to shrinking and swelling clays.

The Buda Limestone has an average thickness of 40 feet in the BSS. It is generally a hard, fine grained limestone but the lower part of the formation can be marly. Blocks of Buda Limestone can become detached and move downslope which can contribute to slope failure of the Del Rio Clay. A large area of Del Rio Clay with a thin Buda Limestone cap is located north of the project’s separated mainlanes, north of the MoPac/SL 360 intersection.

A search was made for water wells located within the Project Area using the groundwater data viewer hosted by the Texas Water Development Board. None were found in the database and no water wells were found during the pedestrian survey. See Appendix C for a distribution of geologic units based on Blome et al. 2005. The most prominent units are the Del Rio Clay (32%), the Georgetown Formation (28%) and the Leached and Collapsed member (23%) of the Edwards Group. Regulatory boundaries on the maps are according to TCEQ 2005. Lithologic descriptions for outcropping units originate primarily from Small et al. 1996, Blome et al. 2005, and Hauwert 2009 who use the Dunham carbonate rock classification system. Field identification is hampered by previous land disturbance with the ROW.

C. Hydrologic Assessment

Recharge into the karstic Edwards Aquifer primarily occurs in areas where the Kainer, Person and Georgetown Formations are exposed at the surface. The majority of recharge in the BSS occurs in the main stream channels of creeks. Less recharge occurs on the uplands and along tributaries compared to the main streams (see Hunt et al. 2019 for the recharge range in terms of fraction of total recharge). The conditions for recharge are dependent on the amount of storage in the aquifer. Groundwater levels beneath the project range from 458 to 491 feet above mean sea level based on high flow aquifer conditions (BSEACD 2020). Comparison of land surface and water table elevations in the Project Area reveals they are separated by approximately 100 to 200 feet.

Karst features are commonly formed along joints, fractures, and bedding plane surfaces in the Kainer and Person Formations. The Kirschberg Evaporite member is extensively cavernous and the undivided Leached and Collapsed member has extensive lateral cave development. Surface karst recharge features are less common in the Georgetown Formation but caves can be encountered where excavation breaches the underlying Leached and Collapsed member (ex. Barton Skyway and Spyglass caves were sealed in the late 1990's). Recharge does not occur where the Del Rio and Buda Formations are exposed. Recharge is not expected to occur beneath impervious surfaces (pavement) as these areas have a high runoff potential.

Seven karst features occur in the Project Area, including sinkholes and solution enlarged fractures: MPS-7, MPS-19, MPS-20, MPS-21, MPS-22, MPS-23, and MPS-32 (Appendices C and D). Of these seven, two features were determined to be sensitive with a potential for rapid recharge according to TCEQ guidance: MPS-7 (solution cavity) and MPS-19 (solution enlarged fracture). Sensitive feature MPS-7 has a drainage basin of about 1 acre and is located between the MoPac mainlanes south of SL 360. Feature MPS-19 drains less than 1 acre and is located on an isolated pinnacle east of the MoPac northbound mainlanes within the SL 360 ROW. The sensitive features are outside the expected limits of construction for the project.

Eight geologic faults, labeled as F-4 through F-9, F-14 and F-17, are mapped crossing the Project Area (Blome 2005). Fault segments have variable lengths from hundreds to thousands of feet long. Faults were measured based on mapped segments and the lengths rounded to the nearest 100 feet. The lengths themselves do not indicate any particular sensitivity although all mapped faults are considered primary, meaning that they are prominent and mappable. Mapped faults are associated with bedrock damage zones that can be filled with variable materials influencing fluid transmissivity. Although most faults are poorly exposed in the Project Area, the F-14 fault trace and associated fractures can be observed in the roadcuts along both sides of the ramp between southbound MoPac and southbound SL 360. The fault may also be observed on the top of the slope north of SL 360 between the northbound mainlanes and the frontage road. No other faults were observed during the pedestrian survey.

Utility potholes, which are manmade excavations for the purpose of locating utility lines, are classified as non-karst closed depressions. Project utility information may be obtained by request but an assessment is beyond the scope of this report. Should any karst features be discovered during the construction phase of the project, they should be reported to TCEQ to determine the appropriate mitigation measures.

D. Data Review

A review of previously identified natural and manmade features was conducted of the geologic assessment for the MoPac South project (Cambrian Environmental 2020). Appendix D provides a reference to reconcile the feature numbers for the features in the Project Area. For reference, features identified as MP-001 through MP-014 in a draft geologic assessment (Zara Environmental 2016) from an earlier version of the MoPac South project were reconciled with field observations for this assessment. Feature MP-001, a sensitive fractured rock outcrop is located in the bed of Slaughter Creek which is not within the Project Area. Non-sensitive features MP-002 through MP-005 were removed during previous construction activities and they are outside the Project Area. Therefore MP-001 through MP-005 are not included in the feature descriptions for this geological assessment. Features MP-006 through MP-014 were evaluated in the field and re-numbered as features MPS-1 through MPS-9, respectively. Within this data set only MPS-6 and MPS-7 occur within the Project Area.

Twenty-two features (MBB-1 through MBB-22) identified in the MoPac bicycle and pedestrian bridge geologic assessment were re-numbered beginning with identifier MPS-10. However, due to the following circumstances, these features are not consecutively renumbered. Three of the previously identified features are outside the ROW (non-sensitive features MBB-7, MBB-8 and MBB-19) are therefore are excluded from the updated MoPac South report. Two features (MBB-9, MBB-10) were not located during the pedestrian survey although the locations are included on the geologic map for reference. Four numbered faults (MBB-13, MBB-15, MBB-16 and MBB-17) are numbered separately as mapped faults crossing the project (Cambrian Environmental 2020). One drilled hole (MBB-18) was not located and was likely filled by construction of the bike ped bridge over SL 360. Therefore, within this data set features MPS-18 through MPS-23, MPS-27, MPS-28, MPS-30 through MPS-33 occur within the Project Area.

A data review for known karst features adjacent to the ROW was conducted. The geologic map (Appendix C) includes known features within 500 feet of the ROW along MoPac (COA, 2010). Notable features in the vicinity of the Project Area include Jones Sink, Five Pocket Cave and Spyglass Cave. South of the Project Area, Jones Sink is located in the bed of Barton Creek within the Kirschberg member approximately 500 feet southwest of the Project Area and 325 feet downstream of the existing bicycle and pedestrian bridge over Barton Creek. A 1999 dye injection into Jones Sink initially reached Cold Springs in 5 days (Hauwert et al. 2004). The injection point at Jones Sink was called "*Site A MoPac Bridge*" in the above study. On the north end of the project, Five Pocket Cave and Spyglass Cave (sealed after being encountered during construction) are known to contain endemic karst invertebrates. Hobo Hotel Cave is identified in the karst feature database as being located within the Project Area at the entrance of the Barton Creek Greenbelt. However, no cave was observed at this location during the pedestrian survey, and the feature is believed to be sealed. An alternate location is shown on the south bank of Barton Creek although no feature was found at this location during the pedestrian survey for MoPac South (Cambrian Environmental, 2020). Cave maps for these features were not available, although a dimensional analysis of 28 cave maps located within a mile of the MoPac ROW south of the Project Area showed that 86% have longest segments that are less than 100 feet (TxDOT, 2014).

III. Conclusion

This geologic assessment covers the entire ROW of the Barton Skyway Ramp Relief project limits. The Project Area is underlain primarily by the Del Rio Clay, Georgetown Formation and the Leached and Collapsed Member of the Edwards Group. The Leached and Collapsed member is known for extensive cavern development. The majority of recharge to the Edwards Aquifer occurs within the channels of major creeks (e.g., Barton Creek).

Eight features, including sinkholes and solution enlarged fractures, have a karst origin. Of these, two features were determined to be sensitive with a potential for rapid recharge according to TCEQ guidance: MPS-7 (solution cavity) and MPS-19 (solution enlarged fractures). These sensitive features occur southeast of the project activities within separate drainage areas such that they will not be affected by the project.

Geologic faults are poorly exposed with the exception of the F-14 fault trace near MoPac and SL 360. Faults are unlikely to rapidly transmit fluid to the subsurface.

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V. Appendices

Appendix A:
TCEQ Geologic Assessment Form and Table

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: Heather Beatty, PG

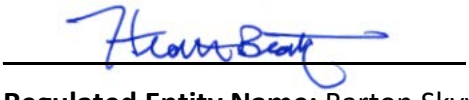
Telephone: 512-470-4013

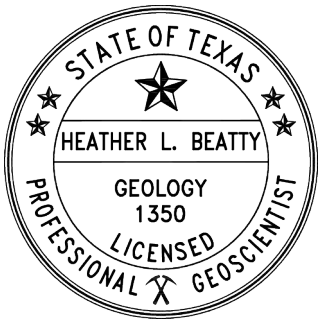
Fax: _____

Date: 16 June 2021

Representing: Cambrian Environmental (Tx Geo Firm #50484) (Name of Company and TBPG or TBPE registration number)

Signature of Geologist:





Regulated Entity Name: Barton Skyway Ramp Relief

Project Information

1. Date(s) Geologic Assessment was performed: Janaury 13, 2020; March 24, 2020; April 1, 7, 8; and June 12, 2020
2. Type of Project:
   - ☒ WPAP
   - ☐ SCS
   - ☐ AST
   - ☐ UST
3. Location of Project:
   - ☒ Recharge Zone
   - ☐ Transition Zone

☐ 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 next page		

** 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" = 100'
   Site Geologic Map Scale: 1" = 200'
   Site Soils Map Scale (if more than 1 soil type): 1" = 1000'

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.

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

Soil Unit Name and Description	Group	Thickness (ft)
BID - Brackett-Rock outcrop complex, 1 to 12 percent slopes	C	0.8 - 1.7
BoF - Brackett-Rock outcrop-Real complex, 8 to 30 percent slopes	C	0.8 - 1.7
CrB - Crawford clay, 1 to 3 percent slopes	D	2.0 - 2.7
GP - Pits, gravel, 1 to 90 percent slopes	None	None
SsC - Speck stony clay loam, 1 to 5 percent slopes	C	1.2 - 1.5
TaD - Tarrant soils, 5 to 18 percent slopes	C	0.3 – 1.2
TcA - Tarrant and Speck soils, 0 to 2 percent slopes	C	0.3 – 1.2
TdF - Tarrant-Rock outcrop complex, 18 to 50 percent slopes	D	0.3 – 1.2
VoD - Volente silty clay loam, 1 to 8 percent slopes	C	2.8 – 4.2

Table 1, Form TCEQ-0585 (Rev. 02-11-15)

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.

GEOLOGIC ASSESSMENT TABLE

PROJECT NAME: Barton Skyway Ramp Relief

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)	MOD	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	
MPS-6	30.254792°	-97.801800°	CD	5	Kdr	9	7	2	N/A	0	N/A	N/A	O,F	19	24	X		X		Hillside
MPS-7	30.247087	-97.805636	SC	20	Kprd	3.8	3.6	7	45	10	N/A	N/A	N,O,F	25	55		X	X		Hillside
MPS-18	30.245460°	-97.805800°	O	5	Kkg	2.5	2.5	<1	N/A	0	N/A	N/A	N,O	5	10	X			X	Drainage
MPS-19	30.246830°	-97.804000°	SF	20	Kklc	27	1.5	1.3	140	0	1/50	1.5	N,F	25	45		X	X		Hilltop
MPS-20	30.247010°	-97.804900°	SC	20	Kprd	8	1	3	25	10	1/10	0.1	N	5	35	X		X		Cliff
MPS-21	30.247360°	-97.803200°	SF	20	Kklc	2	2	1.5	N/A	0	N/A	N/A	O,F	5	25	X		X		Hillside
MPS-22	30.246991°	-97.804458°	SF	20	Kklc	0.4	10	2	122	0	1/25	N/A	N,O	5	25	X		X		Cliff
MPS-23	30.247060°	-97.804400°	SF	20	Kklc	0.5	10	2.5	125	0	1/25	N/A	N,O,V	5	25	X		X		Cliff
MPS-27	30.263260°	-97.790480°	CD	5	Kklc	2	2	1	N/A	0	N/A	N/A	N,O	5	10	X		X		Hillside
MPS-28	30.262599°	-97.788403°	CD	5	Kklc	1.5	1.5	1	N/A	0	N/A	N/A	O	5	10	X		X		Hillside
MPS-30	30.249685°	-97.806204°	CD	5	Kg	1.3	1.3	1	N/A	0	N/A	N/A	C,O	5	10	X		X		Hillside
MPS-31	30.249600°	-97.806105°	CD	5	Kg	3.5	2.5	1	N/A	0	N/A	N/A	C,O	5	10	X		X		Hillside
MPS-32	30.247718°	-97.806459°	SC	20	Kplc	1.5	0.8	1.3	N/A	0	N/A	N/A	V,O	15	35	X		X		Hillside
MPS-33	30.258305°	-97.797072°	CD	5	Kplc	32	32	15	N/A	0	N/A	N/A	X	10	15	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.

Date: June 16, 2021

Sheet 1 of 2

STATE OF TEXAS
HEATHER L. BEATTY
GEOLOGY
1350
LICENSED
PROFESSIONAL GEOSCIENTIST

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

GEOLOGIC ASSESSMENT TABLE

PROJECT NAME: Barton Skyway Ramp Relief

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-4			F	20	KKlc/Kkg	7000			45	10	N/A	N/A	X	5	35	X			X	Hillside
F-5			F	20	Kg	7500			35	10	N/A	N/A	X	5	35	X			X	Hillside
F-6			F	20	Kdr	800			318	0	N/A	N/A	X	5	25	X			X	Hillside
F-7			F	20	Kg/Kdr	3000			45	10	N/A	N/A	X	5	35	X			X	Hillside
F-8			F	20	Kdr	900			335	0	N/A	N/A	X	5	25	X			X	Hillside
F-9			F	20	Kplc/Kg	2850			8	10	N/A	N/A	X	5	35	X			X	Hillside
F-14			F	20	Kg/Krdm	4600			55	10	N/A	N/A	X	5	35	X			X	Hillside/Floodplain
F-17			F	20	Krdm/Klc	2200			297	0	N/A	N/A	X	5	25	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
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V	Vegetation. Give details in narrative description
FS	Flowstone, cements, cave deposits
X	Other materials

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Date: June 16, 2021

Sheet 2 of 2

STATE OF TEXAS
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TCEQ-0585-Table (Rev. 10-01-04)

Appendix B:
Project Photos

Project Photo 1. Fault lines of the Balcones Fault Zone are expressed in sets that reflect adjustments within damage zones. There is an angular contrast between vertical drill scars and slashed fracture lines. This image is facing northeast along the ramp from southbound MoPac to southbound SL 360 (towards South Lamar Boulevard). On the left side of the photo, strata are dipping northwest towards the Loop 1 Syncline (Detail in Project Photo 2). This fault crosses the Project Area from 550 feet south of Tuscan Terrace to 820 feet north of Barton Creek at a 45° trend and has a displacement of 40 feet.

Project Photo 2. The Loop 1 Syncline is an expression of downward folded bedding in the Georgetown Formation. Folded beds can be seen along the ramp from southbound Mopac to southbound State Loop 360. The hinge line of the sinkhole is shown as a purple line on the geologic map (COA 2014).

Project Photo 3. Exposure of the Georgetown Formation (gray bedrock in foreground) between the southbound mainlanes and the frontage road.

Appendix C:
Site Geologic Map

- Non-sensitive Feature
- Sensitive Feature
- COA Features
- Existing ROW
- Loop 1 Syncline
- Faults
- Geologic Unit Boundaries
- 100-Year Floodplain

Edwards Aquifer Recharge Zone

MPS-18

Ben White Shelter

Sinkhole upstream mopac

Hobo Hotel

Hobo Hotel Cave (alt.)

Jones Sink

Kplc Kprd Kkg Kkke Kg

F-7 F-9 F-14 F-17

Mopac Blvd S Mopac Expy S Mo Pac Expy TX-1-LOOP S TX-1-LOOP N TX-360-LOOP S TX-360-LOOP N S Capital of Texas Hwy

3559 3560 3556 3552 3600 3610 3620

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16 June 2021

N W E S

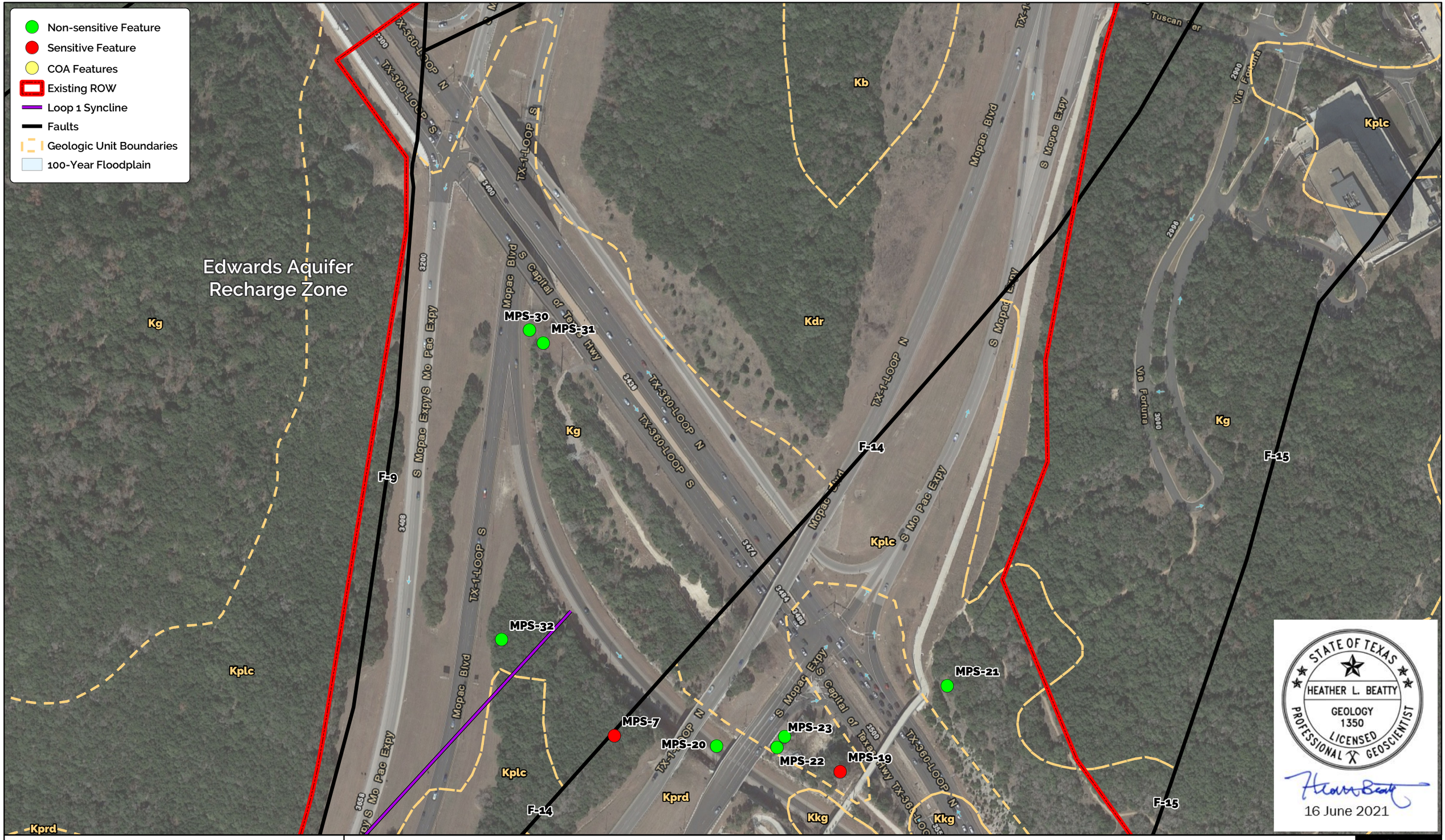
Coordinate System: NAD 1983 2011
1 "=200 ' StatePlane Texas Central
FIPS 4203 FtUS

0 125 250 375 500 Feet

(Geology from Blome et al, 2005)

Geology of the Project Area

Cambrian



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Coordinate System: NAD 1983 2011
1 "=200 ' StatePlane Texas Central
FIPS 4203 FtUS

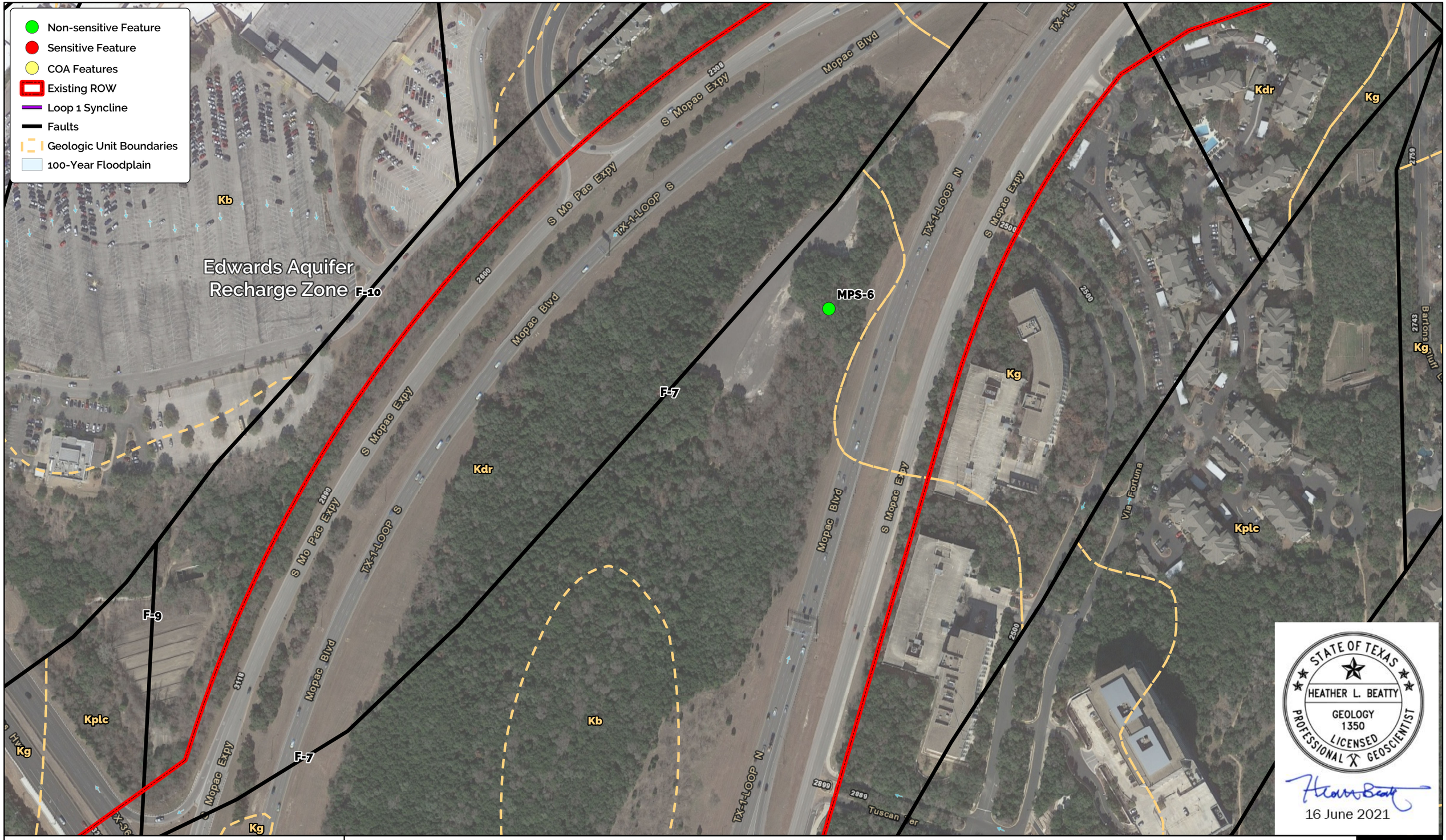
0 125 250 375 500 Feet

(Geology from Blome et al, 2005)

Geology of the Project Area

Page 2 of 5

Cambrian



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Coordinate System: NAD 1983 2011
1 "=200 ' StatePlane Texas Central
FIPS 4203 FtUS

0 125 250 375 500 Feet

(Geology from Blome et al, 2005)

Geology of the Project Area

Cambrian

Non-sensitive Feature
Sensitive Feature
COA Features
Existing ROW
Loop 1 Syncline
Faults
Geologic Unit Boundaries
100-Year Floodplain

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16 June 2021

Edwards Aquifer
Recharge Zone

Kb
Kdr
Kplc
Kg
Kprd
Kkg
Kkke

F-5
F-6
F-7
F-8

MPS-33

Unknown

Steamboat Springs Cv
Holly Hill Cv
Capital Pkwy
S Mopac Expy
Mopac Blvd
Mopac Blvd TX-1-LOOP S
TX-1-LOOP N
TX-1-LOOP S
Mopac Blvd TX-1-LOOP N
Mopac Expy
Mopac Blvd
S Mopac Expy
TX-1-LOOP S
TX-1-LOOP N Mopac Blvd
S Mopac Expy
Mopac Blvd
Mopac Expy
Cimarron Blvd

1900
1920
1920
1928
1800
1934
1900
1552
2000
2000
2289
2083
2208

N
W
E
S

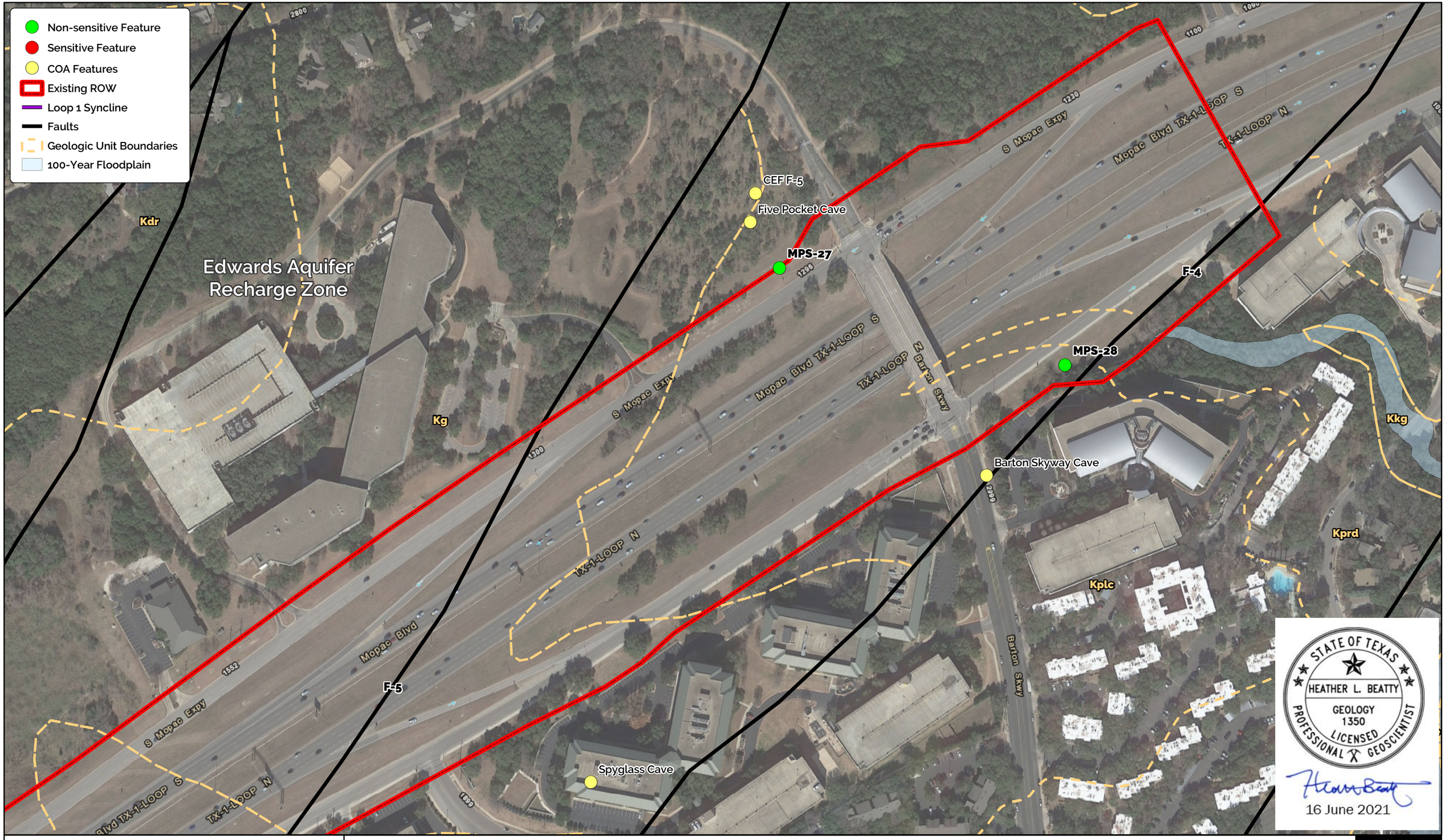
Coordinate System: NAD 1983 2011
1 "=200 ' StatePlane Texas Central
FIPS 4203 FtUS

0 125 250 375 500 Feet

(Geology from Blome et al, 2005)

Geology of the Project Area

Cambrian



N
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Coordinate System: NAD 1983 2011
1 "=200 ' StatePlane Texas Central
FIPS 4203 FtUS

0 125 250 375 500 Feet

(Geology from Blome et al, 2005)

Geology of the Project Area

Page 5 of 5

Cambrian

Appendix D:
Feature List, Photos and Descriptions

Features identified within the Project Area with equivalent feature numbers as a previous geologic assessment. The Geologic Assessment Table (Appendix C) contains coordinates for these features. Faults are not included for simplicity. NB=northbound, SB=southbound, ML=mainlanes, FR=frontage road.

Feature Identification	Previous GA Feature Identification[1]	Feature type and setting	Recharge Sensitivity
MPS-6	MP-011	Non-karst depression on a hillside adjacent to the MoPac NBML	Not sensitive
MPS-7	MP-012	Sinkhole between the MoPac ML south of Lp 360	Sensitive
MPS-18	MBB-11	Non-karst bedrock feature at a cross drainage structure outside the MoPac NBFR	Not sensitive
MPS-19	MBB-12	Solution enlarged fracture on isolated pinnacle east of the MoPac NBML within Lp 360 ROW	Sensitive
MPS-20	MBB-14	Solution cavity in roadcut east of MoPac NBML at Lp 360	Not sensitive
MPS-21	MBB-20	Non-karst depression east of the MoPac NBML	Not sensitive
MPS-22	MBB-21	Solution cavity in roadcut along the MoPac NBFR at Lp 360	Not sensitive
MPS-23	MBB-22	Solution cavity in roadcut along the MoPac NBFR at Lp 360	Not sensitive
MPS-27	No equivalent feature	Non-karst depression at the edge of the ROW adjacent to the MoPac SBFR	Not sensitive
MPS-28	No equivalent feature	Non-karst depression adjacent to the MoPac NBFR	Not sensitive
MPS-30	No equivalent feature	Non-karst depression south of Lp 360	Not sensitive
MPS-31	No equivalent feature	Non-karst depression south of Lp 360	Not sensitive
MPS-32	No equivalent feature	Solution cavity between the MoPac ML south of Lp 360	Not sensitive
MPS-33	No equivalent feature	Depression/human induced sinkhole (not a natural feature) related to pipe collapse along the NBFR north of Lp 360	Not sensitive

[1] Zara Environmental (2016)

MPS-6 NON-KARST CLOSED DEPRESSION. This feature is a previously excavated closed depressed in the Del Rio Clay. The depression is 9 feet by 7 feet by 2 feet deep. The depression was previously identified as "MP-011" in the draft MoPac South report cited in the Previous Geologic Assessments section of this report. Limestone cobbles observed within the depression likely originated upslope (i.e., Buda Limestone fragments were transported downslope). The feature is not sensitive and was not re-excavated.

Feature Photo MPS-6 Non-karst Closed Depression. The depression is formed in the Del Rio Clay.

MPS-7 SOLUTION CAVITY. This previously excavated karst feature formed in the Leached and Collapsed Member of the Person Formation. The cavity opening is 46 by 43 inches across and 7 feet deep. Rock dissolution was focused along a 45° fracture trend. The feature was previously identified as "MP-012" in the draft MoPac South report cited in the Previous Geologic Assessments section of this report. The feature was not excavated as rock floor was reached during previous excavation work. The feature is considered sensitive to recharge.

Feature Photo MPS-7 Solution Cavity. Remnant plastic tarp and plywood covers from a previous investigation are present near the opening.

MPS-18 OTHER NATURAL BEDROCK FEATURE. This feature is located below a stormwater outfall outside the northbound frontage road and was described in a previous geologic assessment as a solution enlarged fracture. It is now being classified as an other natural bedrock feature because no fractured rock was observed. Debris from a recent vehicle crash may have obscured fractured rock. The feature was previously identified as "MBB-11" in the draft MoPac South report cited in the Previous Geologic Assessments section of this report.

Feature Photo MPS-18 Other natural bedrock features. The image shows rock slabs that are likely not in place. The fractured rock reported at this location was not observed.

MPS-19 SOLUTION ENLARGED FRACTURE. The fracture is 27 feet long, extending to the west edge of the pinnacle between the southbound MoPac frontage road and the taper of the ramp from southbound MoPac to southbound State Loop 360. The width ranges between 12 and 18 inches. The depth is at least 15 inches but could extend further as the leaves and soil filling the fracture are loose. The feature was previously identified as "MBB-12" in the draft MoPac South report cited in the Previous Geologic Assessments section of this report. The feature is rated as sensitive.

Feature Photo MPS-19 Solution Enlarged Fracture (Photo 1 of 2). The 27-foot long fracture is situated on top of a pinnacle. The fracture is partly covered with leaves. It runs between the two limestone slabs in the lower part of the image, to the right of the person standing for scale.

Feature Photo MPS-19 Solution Enlarged Fracture (Photo 2 of 2). The hammer is for scale at the widest part of the fracture (18 inches). The depth is at least 15 inches but could extend further as the leaves and soil filling the fracture are loose.

MPS-20 SOLUTION CAVITY. This feature consists of a solution cavity along a cliff face. The one-foot diameter solution cavity is associated with a fracture that trends 25°. The cavity extends approximately 3 feet into the cliff face. It is about 5 feet above the flow line at the base of the cliff making the recharge potential low. The feature was previously identified as "MBB-14" (a solution enlarged fracture containing a cavity) in the draft MoPac South report cited in the Previous Geologic Assessments section of this report. The feature is non-sensitive and was not excavated.

Feature Photo MPS-20 Solution Enlarged Fracture (Photo 1 of 2). This feature consists of a fracture with a solution cavity along a cliff face.

Feature Photo MPS-20 Solution Enlarged Fracture (Photo 2 of 2). The solution cavity associated with this fracture (center of image) is about 5 feet above the flow line at the base of the cliff.

MPS-21 NON-KARST CLOSED DEPRESSION. This feature consists of a closed depression located north of State Loop 360 adjacent to a utility pole above the bicycle and pedestrian bridge abutment. The depression is 22 feet by 16 feet and 2 feet deep. The bottom has an intact soil floor. Isolated bedrock slabs are on the margins indicate that the depression is the result of grading. The feature was previously identified as "MBB-20" in the draft MoPac South report cited in the Previous Geologic Assessments section of this report. The feature is non-sensitive and was not excavated.

Feature Photo MPS-21 Closed Depression. Facing north at the shallow depression.

MPS-22 SOLUTION ENLARGED FRACTURE. This is a prominent fracture (southwest of MPS-23) exposed in a 100-foot wide cliff face along the west side of a pinnacle. The feature was previously identified as "MBB-21" in the draft MoPac South report cited in the Previous Geologic Assessments section of this report. The previous feature coordinates placed it within the transmission tower pad. Based on the description and photo comparison, the feature is located on the west pinnacle face. The feature is non-sensitive and was not excavated.

Feature Photo MPS-22 Solution enlarged fracture. The fracture is obscured by trees.

MPS-23 SOLUTION ENLARGED FRACTURE. This feature is a prominent vertical fracture (one of eight including MPS-22) exposed in the center a 100-foot wide cliff face along the west side of a pinnacle. A tree is growing in the soil infill.

Feature Photo MPS-23 Solution Enlarged Fracture (Photo 1 of 2). Facing east at the cliff face. Southbound State Loop 360 is to the left.

Feature Photo MPS-23 Solution Enlarged Fracture (Photo 2 of 2). The fracture was enlarged from chemical dissolution and physical (tree root growth) processes.

MPS-27 NON-KARST CLOSED DEPRESSION. This feature consists of a collapse associated with a utility line. The depression is 24 inches by 12 inches. There is a small opening that extended 24 inches deep. No in place bedrock was observed.

Feature Photo MPS-27 Non-karst Closed Depression.

MPS-28 NON-KARST CLOSED DEPRESSION. This feature consists of three utility potholes likely associated with fiber optic installation outside of the northbound frontage road between Spyglass Drive and RM 2244. The sides of the hole had a smooth edge consistent with a hole dug with a shovel and no in place bedrock was observed.

Feature Photo MPS-28 Non-karst Closed Depression. Group of three utility potholes each about 18 inches in diameter. No bedrock exposures were present.

MPS-30 NON-KARST CLOSED DEPRESSION. This feature consists of a manmade excavation that is 16 inches in diameter and one foot deep. There was no in place bedrock observed. The hole is aligned with an existing electric transmission line.

Feature Photo MPS-30 Non-karst Closed Depression. This closed depression is likely related to the existing utility line. No bedrock exposures are present.

MPS-31 NON-KARST CLOSED DEPRESSION. This feature consists of a manmade excavation that is 3.5 feet by 2.5 feet and one foot deep. There was no in place bedrock observed. The hole is aligned with an existing electric transmission line.

Feature Photo MPS-31 Non-karst Closed Depression. This closed depression is likely related to the existing utility line. No bedrock exposures are present within the depression.

MPS-32 SOLUTION CAVITY. This feature consists of a solution cavity rimmed with limestone on three sides, measuring 1.5 feet by 0.8 feet. The feature was filled with dark loose organic-rich soil. The depth of probing reached 1.3 feet. The feature was excavated 8 to 10 inches which revealed abundant tree roots within the loose soil infill indicating that the soil has a long residence time.

Feature Photo MPS-32 Solution Cavity.

MPS-33 NON-KARST CLOSED DEPRESSION. The depression formed suddenly (first observed on 7 April 2020), and the ground surface surrounding it has since been restored. The depression that formed was a non-karst, human induced sinkhole within fill material situated over a stormwater culvert. The depression was adjacent to the northbound frontage road approximately160 feet north of Bartons Bluff. It formed suddenly following a rain event during the first four days of April 2020. The visible depression was 17 feet in diameter but the feature extended under the pavement and was approximately 32 feet in diameter in total and at least 15 feet deep. A 40-foot long pavement patch along the left lane of the northbound frontage road indicates that the land surface had previously changed and, according to the maintenance crew responding to the hazard, a repair was made in the spring of 2019. The top of a 96-inch diameter culvert structure (a corrugated galvanized metal pipe) is approximately 35 feet below the ground surface. The feature is situated within a former topographic low at a sharp bend in an unnamed tributary to Barton Creek.

Feature Photo MPS-33 Non-karst Closed Depression (Photo 1 of 3). Traffic barriers were in place surrounding the hazard. Photo taken on April 8, 2020.

Feature Photo MPS-33 Non-karst Closed Depression (Photo 2 of 3). The depression was not excavated or probed due to the risk of further collapse. Photo taken on April 8, 2020.

Feature Photo MPS-33 Non-karst Closed Depression (Photo 3 of 3). The land surface surrounding the depression was subsequently restored.