Austin Light Rail Phase 1

Final Environmental Impact Statement

Appendix F-3: Soils and Geologic Resources Technical Report

Contents

Tables

Figures

Acronyms and Abbreviations

Term/Acronym	Definition
ATP	Austin Transit Partnership
CEF	critical environmental feature
City	City of Austin
DEIS	Draft Environmental Impact Statement
FEIS	Final Environmental Impact Statement
FTA	Federal Transit Administration
NRCS	Natural Resources Conservation Service
Project	Austin Light Rail Phase 1 Project
ROD	Record of Decision
TCEQ	Texas Commission on Environmental Quality

1 Introduction

This technical report provides the basis of analysis included in the Draft Environmental Impact Statement (DEIS) and supports decisions made in the combined Final Environmental Impact Statement (FEIS)/Record of Decision (ROD). The analysis and references in this technical report remain unchanged from the DEIS except for technical updates. There are no changes to effects on soils and geology from technical updates made since publication of the DEIS.

The Federal Transit Administration (FTA) and Austin Transit Partnership (ATP) are completing an environmental review of the Austin Light Rail Phase 1 Project (the Project) in Austin, Texas. This soils and geologic resources technical report was prepared to support the Project's DEIS and FEIS/ROD in accordance with the National Environmental Policy Act and related laws and regulations. FTA and ATP are the Lead Agencies in the National Environmental Policy Act process.

This report provides a general description of soils, surface geology, and seismicity and assesses potential effects relevant to the Project. In addition, this report identifies measures to mitigate potential effects based on currently available preliminary engineering information. The Study Area considered for soils and geologic resources is based on the limits of construction for the Project.

2 Regulatory Setting

Project construction activities may be subject to environmental regulations at state and local levels. Geotechnical investigations and design recommendations would be in accordance with standard practices as specified in the Federal Highway Administration *Geotechnical Technical Guidance Manual* (2007), Texas Department of Transportation *Geotechnical Manual* (2020), and City of Austin (City) design and construction guidelines (City of Austin 2021a). Additional information about state and local regulations is provided below.

2.1 State of Texas Regulations

The Texas Commission on Environmental Quality (TCEQ) has established the Edwards Aquifer Protection Program to regulate construction activities that have the potential to affect groundwater quality in the Edwards Aquifer, which serves as a water supply for much of central Texas. The recharge zone of the Edwards Aquifer is defined as the land surface area where caves, sinkholes, faults, fractures, or other permeable features provide pathways for recharge of surface waters into the Edwards Aquifer, and the contributing zone is the area or watershed where runoff from precipitation flows downgradient to the recharge zone (TCEQ 2005). The Project is located near, but outside of, the recharge and contributing zones of the Edwards Aquifer and therefore likely would not be subject to Edwards Aquifer Protection Program restrictions or oversight of ground disturbance. However, the Project is located near regulated zones, and local/municipal regulations associated with aquifer management may still apply.

2.2 City of Austin Regulations

The City has established rules to protect critical environmental features (CEFs), defined as bluffs, canyon rimrocks, point recharge features (e.g., sinkholes), springs and seeps, and wetlands, as well as other naturally occurring features related to aquifer recharge, discharge, and/or surface-groundwater interaction. Pursuant to the City's Land Development Code, Section 25-8-121 or 30-5-121, an Environmental Resource Inventory documenting CEFs is required for proposed development located on a tract within the Edwards Aquifer recharge or contributing zone (with boundaries defined by the City based on mapped surface geology), within the Drinking Water Protection Zone, containing a water quality transition zone, containing a critical water quality zone, containing the 100-year floodplain, or with a gradient of more than 15 percent. For the purposes of this report, CEFs are defined as follows (City of Austin 2021b):

- **Bluffs** are an abrupt vertical change in topography of more than 40 feet with an average slope steeper than 4 feet of rise for 1 foot of horizontal travel (400 percent or 76 degrees). Bluffs do not include manmade cuts such as roadside rock outcrops and active rock quarry walls. Bluffs are often associated with riparian areas.

- **Canyon rimrocks** are an abrupt vertical rock outcrop, defined as a naturally occurring aggregate of one or more minerals that is visible on the Earth's surface, of more than 60 percent slope (31 degrees), greater than 4 feet vertically, and a horizontal extent equal to or greater than 50 feet.

- **Point recharge features** include karst features such as caves, sinkholes, faults, and other natural features that may transmit a substantial amount of surface water to groundwater. While the Project does not occur over City-regulated zones for the Edwards Aquifer, recharge features, springs, and other sensitive features could be present in the area; therefore, a Texas Licensed Geoscientist familiar with local hydrogeological characteristics and ordinance objectives should determine the occurrence of karst features by completing a karst feature survey. Intensive investigations of potential karst features to determine recharge potential must be approved by TCEQ, if in their jurisdiction under the Edwards Aquifer Protection Program, and/or from the City's Watershed Protection Department.

- **Springs and seeps** are points or zones of natural groundwater discharge that produce measurable flow and/or maintain a hydrophytic plant community, especially during drought conditions. Physical indicators of a spring or a seep include the existence of a pool of water, the mineralization of calcium carbonate such as surficial travertine (tufa), and/or the detection of a water temperature gradient. Geologic indicators include lithologic contacts and structural features such as a fracture, a conduit, a fault zone, and a bedding plane.

- **Wetlands** are transitional lands between terrestrial and aquatic systems where the water table is usually at or near the surface and may have shallow water present. The three parameters for wetland determination include prevalence of hydrophytic vegetation, hydric soil formation, and the presence of adequate hydrology. Permitted water quality wet ponds, roadside ditches, and ponds fed by wells or other artificial sources of hydrology are not considered wetlands.

Per City Land Development Code 25-8-151, 25-8-281, and 25-8-282 (CEFs must be protected to prevent the loss or contamination of aquifer recharge and to maintain the water quality in the aquifers. To protect CEFs, a buffer radius must be established. The standard buffer distance for all CEFs is 150 feet from the center point of the feature with a maximum of 300 feet for point recharge features; however, they may be reduced depending on the CEF. Generally, the buffer distances would be determined after an intensive CEF survey is completed and through coordination with the City's Watershed Protection Department. Additional information on CEFs and related groundwater protection measures can be found in **FEIS Appendix F-4**.

3 Methodology

The methodology used to assess soils, geology, and seismicity is described below. The Study Area for soils, geology, and seismicity encompasses the limits of construction, including temporary and permanent impact areas associated with construction of the guideway, stations, operations and maintenance facility, park-and-rides, proposed roadway reconstruction and bicycle and pedestrian facility improvements, stormwater infrastructure, and contractor access and laydown/staging areas. An additional 150-foot buffer was added to evaluate the potential for occurrence of CEFs within this distance.

An investigation of soils, geology, and seismicity was undertaken to identify and document the underlying conditions within the Study Area. The investigation aimed to evaluate any concerns that could affect construction or operation of the Project.

3.1 Soils

A desktop analysis using publicly available data from the U.S. Department of Agriculture, Natural Resources Conservation Service (NRCS) Web Soil Survey (NRCS 2023a) was conducted to determine the mapped soil units and their characteristics within the Study Area. The assessed characteristics included soil drainage properties, erosion potential, shrink-swell potential, and soil plasticity to identify soils that may be otherwise potentially unsuitable for construction or operation of the Project. Data were cross verified against geologic maps (Texas Natural Resources Information System 2010a, 2010b) and a SoilWeb application with detailed information about soil map unit properties available from the University of California Davis (2023). Potential effects on the Project because of these soil characteristics were considered for each soil map unit, including soil permeability and how likely flooding could remain for prolonged periods; the potential for substantial soil loss; the potential for soil to shrink when dry and swell when wet; and how susceptible a soil is to deformation resulting from applied stress and/or vibration. The criteria discussed below were used to characterize drainage properties, erosion potential, shrink-swell potential, and soil plasticity and to evaluate potential long-term effects on the Project. In addition, soils were evaluated for designation as prime and unique farmlands as discussed below. Much of the data for criteria evaluation were unavailable due to the presence of urban land soils; however, in urban landscapes, soil stability and drainage are altered due to the presence of pavement and/or compacted fill material, erosion control measures, and stormwater infrastructure.

3.1.1 Drainage

As a soil property, drainage refers to the propensity of a soil to transmit water through its most limiting layer by gravity alone (Neuendorf et al. 2005). Soil is classified into Hydrologic Groups, designated A, B, C, or D to indicate the amount of runoff to be expected from the soil when saturated. According to the NRCS Soil Survey Manual (2023), “Soils in Group A yield very little runoff because they are rapidly or very rapidly permeable and take in water at equal or faster rates than most rains fall in the area. Soils in Hydrologic Group D take water very slowly and yield large amounts of runoff. Soils in Group B and C yield less than Group D and more than Group A. Poorly drained soils generally are in Group D because a high-water table prevents movement of water in the soil.”

“Drainage class refers to the frequency and duration of wet periods under conditions similar to those under which the soil formed” (NRCS 2017). Alterations of the water regime by human activities, either through engineered drainage or irrigation, are not a consideration unless they have substantially changed the morphology of the soil. Seven classes of natural soil drainage are recognized: excessively drained, somewhat excessively drained, well drained, moderately well drained, somewhat poorly drained, poorly drained, and very poorly drained (NRCS 2017). Soils with low permeability that are somewhat poorly drained to very poorly drained and are likely to remain flooded for substantial portions of the year typically are poorly suited for building foundations and transportation construction, including railroad subgrades. In addition, hydric soils are one of the three criteria, in addition to hydrology and hydrophytic vegetation, for identifying and delineating wetland habitats.

3.1.2 Erosion Potential

Erosion potential indicates the susceptibility of a soil to be transported and redeposited by water or wind (Neuendorf et al 2005). The K-factor is one of six factors in the Universal Soil Loss Equation used to predict the average annual rate of soil loss by surface water flow in tons per acre per year. According to the NRCS Soil Survey, K-factor values are based on the percentage of silt, sand, and organic matter in a soil unit and on soil structure and saturated hydraulic conductivity. Values of K range from

0.02 to 0.69 (unitless) (Wischmeier and Smith 1965). While other factors in the Universal Soil Loss Equation also influence the total soil loss of an area over time, the K-factor can be used as a comparative index across soil units provided that all other conditions are held equal. For purposes of this assessment, the following values were considered for classification:

- **Low:** 0.02 to 0.24
- **Moderate:** 0.25 to 0.39
- **High:** 0.40 to 0.69

Soil loss, whether by sheetwash or channelized flow, potentially undermines structures and roads and can be a particular design challenge for railways at water crossings and in low-lying areas prone to overland flow and/or flooding. Areas of moderate erosion potential have reduced surface suitability for railway construction and operation, and areas of high erosion potential are likely to result in long-term instability.

3.1.3 Shrink-Swell Potential

The shrink-swell potential of a soil is the volume change that occurs as a result of changes in moisture content (Neuendorf et al 2005). Shrink-swell potential is quantified by linear extensibility percentage, which is the linear expression of the change in percent volume of a clump of a particular soil as the moisture content is decreased under laboratory conditions (NRCS 2023a). Classes of shrink-swell potential are defined by the following linear extensibility percentage values:

- **Low:** 2% or less
- **Moderate:** 3% to 5%
- **High:** 6% to 8%
- **Very High:** 9% or greater

Soils that are classified as having a moderate to very high shrink-swell potential have a greater potential to cause damage to lines, buildings, roads, and other structures constructed over these soils. Railways on shrink-swell soils are subjected to substantial stress over time, generally leading to uneven settlements.

3.1.4 Plasticity

Plasticity refers to the tendency of a soil to behave as a plastic material with increased water content and consequently to become susceptible to deformation (Neuendorf et al. 2005). Soil plasticity is quantified by the Plasticity Index (unitless), which is a range of moisture in which a soil remains in a plastic state while passing from a semisolid state to a liquid state (Texas Department of Transportation 1999). For purposes of this assessment, classes of plasticity are defined as follows:

- **Non-plastic:** Zero
- **Slightly Plastic:** 6 or less
- **Medium Plastic:** 7 to 17
- **Highly Plastic:** 18 or greater

Railway subgrades are subject to deformation with increased dynamic loading and shear stress produced by train movement. Medium to highly plastic soils in subgrade material introduce risk where cumulative deformation can reduce the effectiveness of ballast and contribute to instability.

3.1.5 Prime and Unique Farmlands

The Farmland Protection Policy Act was passed by Congress as part of the Agriculture and Food Act of 1981 (Public Law 97-98). For the Farmland Protection Policy Act, farmland includes prime farmland (designated by certain soil properties), unique farmland related to high-value crops, and land of statewide or local importance related to substantial agricultural production. Prime farmland is land that has the best combination of physical and chemical characteristics for producing food, feed, forage, fiber, and oilseed crops and that is available for these uses. Unique farmlands are defined as land other than prime farmland that is used for production of specific high-value food and fiber crops, such as citrus, tree nuts, olives, cranberries, fruits, and vegetables. Similarly, farmland that is of statewide or local importance is used for the production of other substantial food, feed, fiber, forage, or oilseed crops (Title 7 Code of Federal Regulations 657.5). Soil types and land uses were reviewed to determine the occurrence and extent of potentially affected farmland (NRCS 2024). Available data from NRCS (2023c, 2023d) were reviewed to determine whether soils that are designated as prime, unique, or otherwise statewide or local importance are present within the Study Area.

3.2 Geology

A desktop analysis using publicly available data was conducted to determine the existing geological conditions and characteristics within the Study Area. Data reviewed included information from the University of Texas at Austin, Bureau of Economic Geology, U.S. Geological Survey (USGS), and Texas Water Development Board. Mapped geologic units and unit descriptions were obtained from the *Geologic Atlas of Texas* (Texas Natural Resources Information System 2010a, 2010b), which provided the highest resolution coverage of the Study Area. Information was obtained on the geological factors that may influence the stability of structures, such as topography, composition and characteristics of geologic units, restrictive layers, and areas susceptible to faulting. Potential effects on geological resources (including karst features), areas that may shift or otherwise become unstable, and areas susceptible to faulting were assessed based on the local geologic setting.

3.3 Seismicity

Seismicity refers to the geographic and historical distribution of earthquakes, which are measured using magnitude and intensity. Earthquakes occur on faults, which are fractures “along which the blocks of crust on either side have moved relative to one another parallel to the facture” (USGS n.d.). The energy released during earthquakes is measured in magnitude. A commonly recognized method of measurement is the Richter scale, which is determined from the logarithm of the amplitude of waves recorded by a seismograph. Generally, earthquakes with a magnitude of 2.5 or less cannot be felt and pose a low risk, whereas earthquakes with a magnitude greater than 6.1 pose a high risk; the greatest magnitude ever recorded was 9.5 (USGS 2023a). The intensity of the earthquake, or the effect it has on the earth’s surface, is often measured using the Modified Mercalli Intensity scale (USGS 1988), which enables a relative comparison of earthquake strength and effects on civil infrastructure, even from historical accounts. The Modified Mercalli Intensity scale consists of 12 categories of increasing intensity, as summarized below (USGS 1988):

- Intensities of I, II, and III cannot be felt or are felt by a limited number of people and pose little to no hazard;
- Intensities of IV and V are felt by nearly everyone and result in potentially overturned objects with possible damage to dishes and windows;
- Intensities of VI and above are felt by everyone. Effects from Intensity VI earthquakes include some slight damage, such as fallen plaster;
- Intensity VII results in negligible damage to well-constructed buildings and considerable damage to poorly built structures;
- Intensity VIII causes slight damage to well-constructed buildings, considerable damage to ordinary structures, and great damage to poorly built structures;
- Intensity IX causes considerable damage to all structures, including buildings shifting off their foundations;
- Intensity X is likely to bend rails;
- Intensity XI is likely to bend rails greatly; and
- Intensity XII results in massive, widespread damage, including distorted visibility and propelled objects.

Earthquake data from USGS (2023a) and seismic hazard maps, including the *Seismicity Map of the State of Texas* (USGS 1988) and the *Seismic Hazard Map for the United States* (Rukstales 2012), were reviewed to determine the annual probability of seismic hazards occurring in the Study Area. Historical earthquakes rated using the

Modified Mercalli Intensity scale were assumed to be representative of potential modern earthquakes.

Mapped faults in the Study Area were obtained from the *Geologic Atlas of Texas* (Texas Natural Resources Information System 2010b). The largest available scale map with coverage of the Study Area was selected because faulting occurs across scales, and larger scale maps provide more accurate estimations of fault surface expression and orientation. Mapped faults are often inferred between disparate locations of field observations and/or delineated from aerial imagery; precise determination of faulting is often achievable only by excavation.

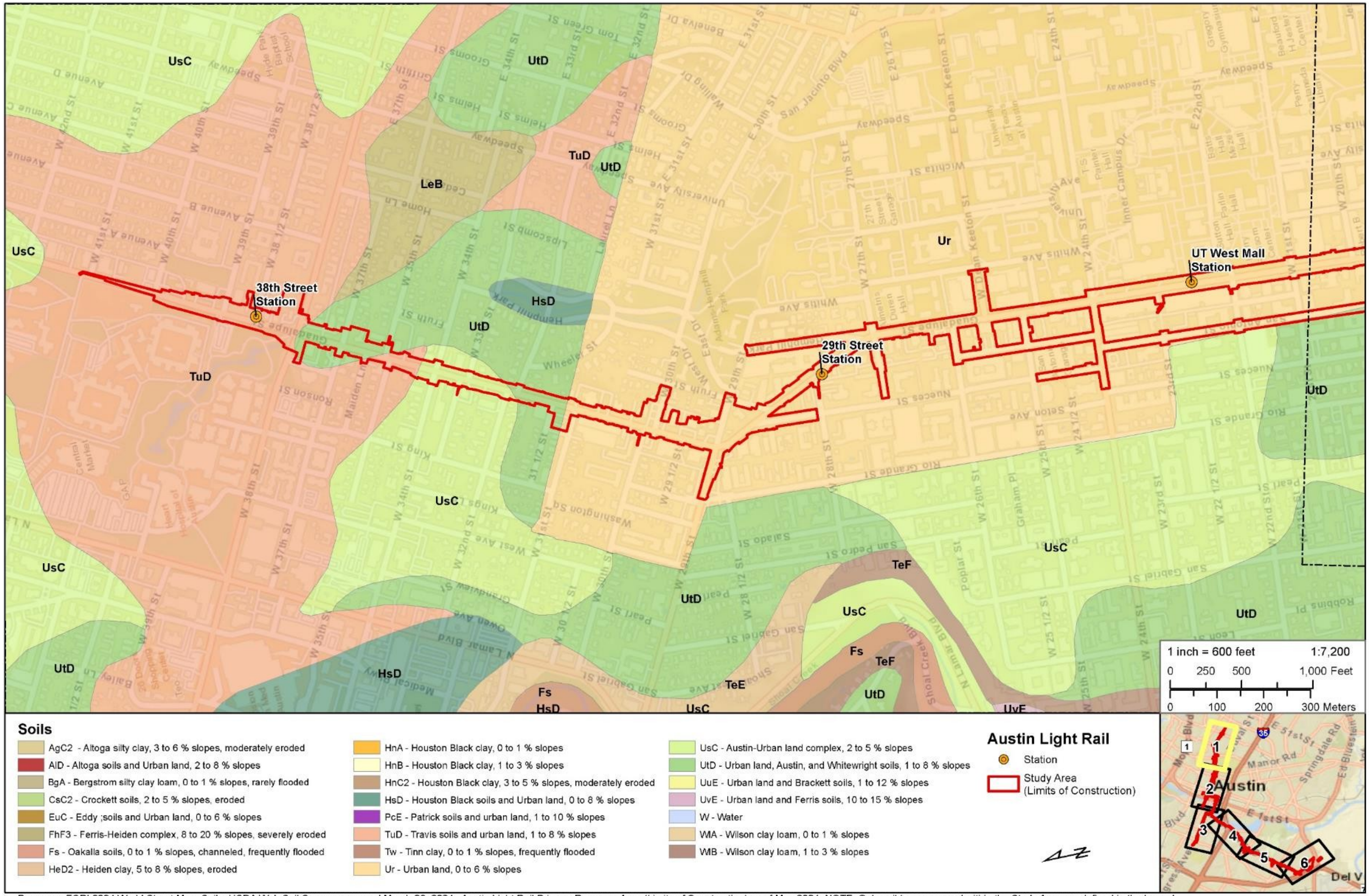
4 Affected Environment

4.1 Soils

4.1.1 Mapped Soil Units

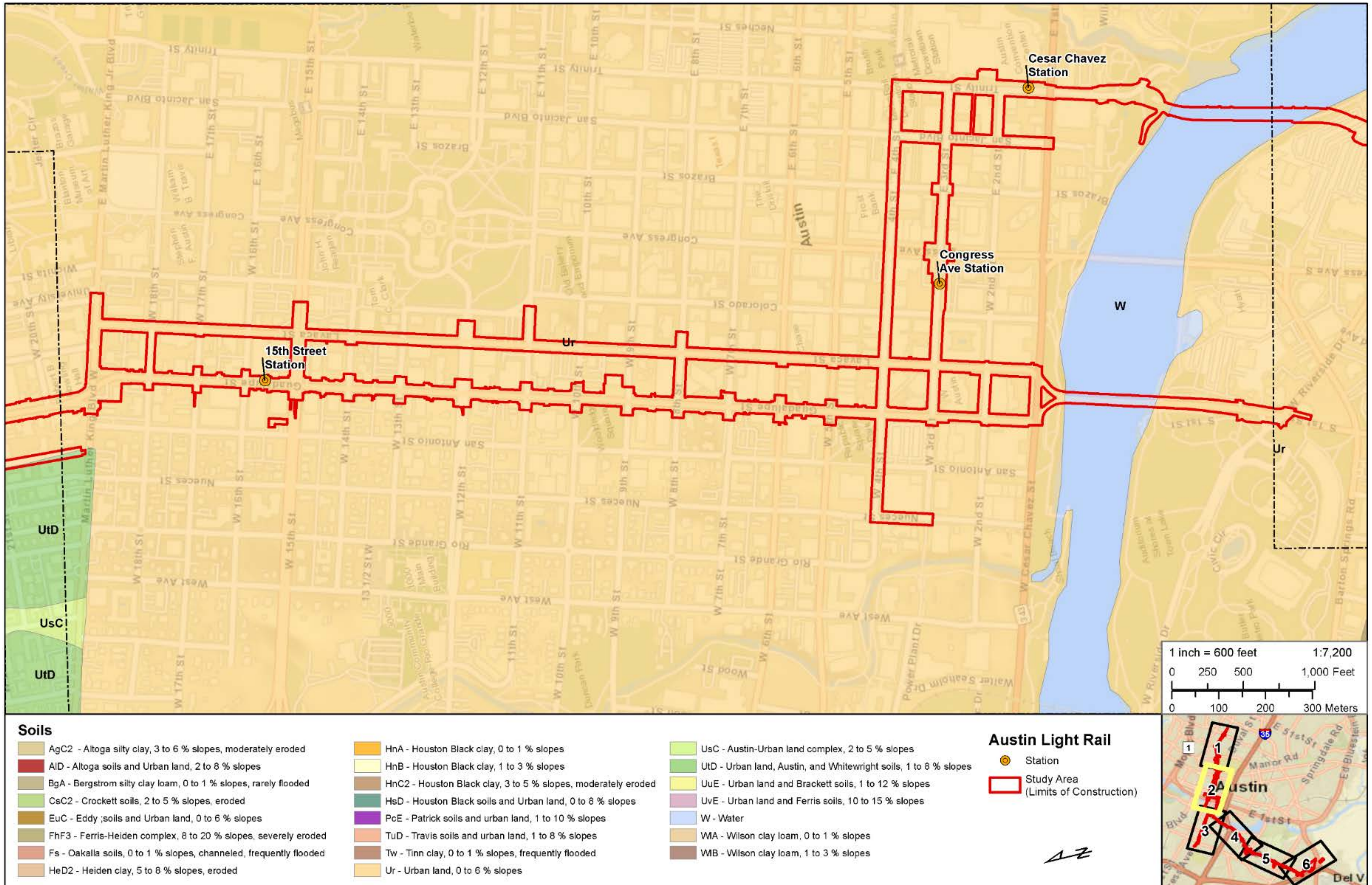
The NRCS Web Soil Survey (2023a) identified 22 unique soil types in 16 soil associations within the Study Area. Mapped soil units are shown in **Figure 1** through **Figure 6** and are presented in **Table 1**.

Figure 1: Mapped Soil Units in the Study Area, Sheet 1



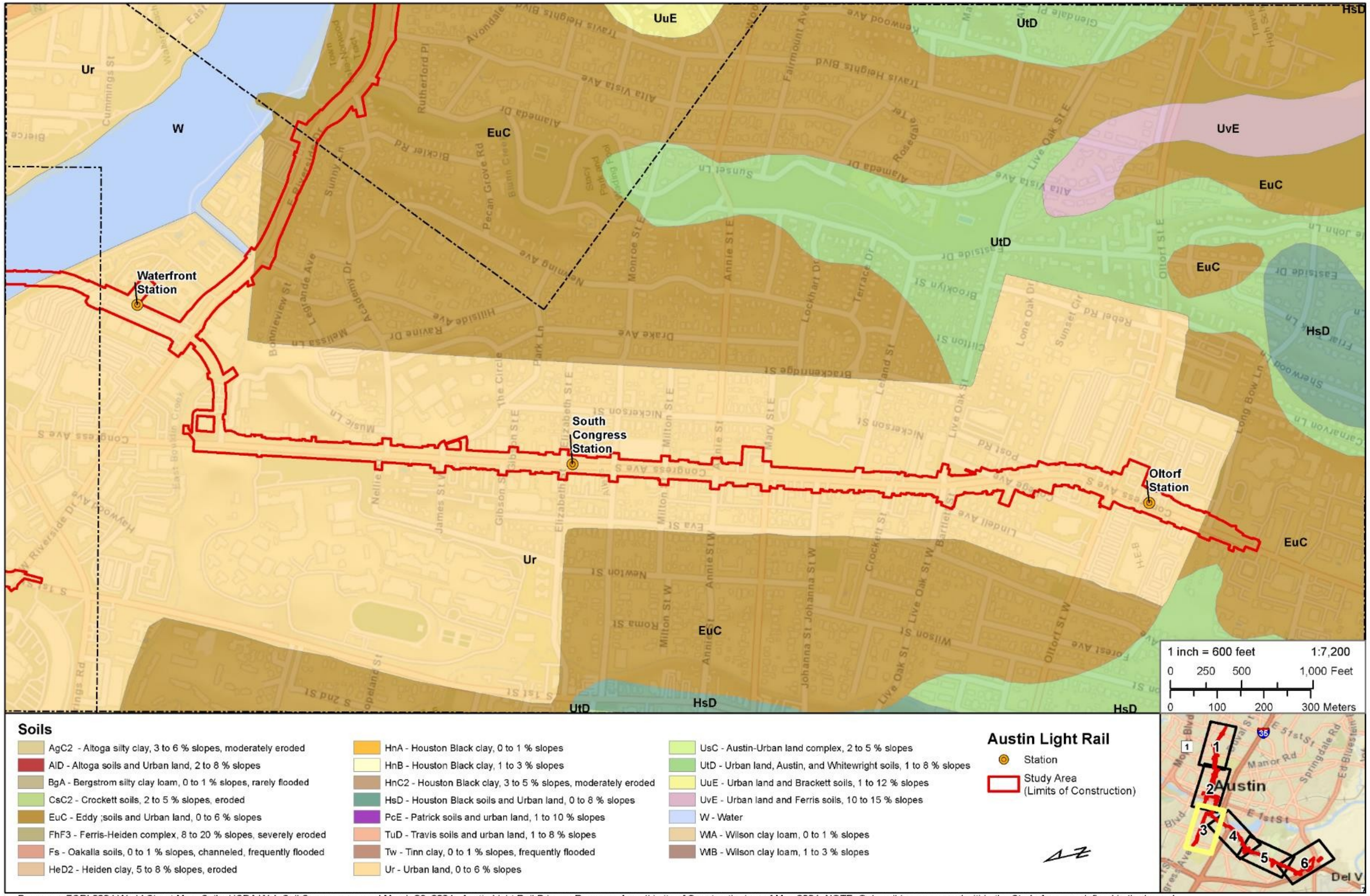
Basemap: ESRI 2024 World Street Map; Soils: USDA Web Soil Survey, accessed March 26, 2024; Austin Light Rail Primary Resource Area (Limits of Construction) as of May 2024. NOTE: Only soil types mapped within the Study Area are defined in the legend.

Figure 2: Mapped Soil Units in the Study Area, Sheet 2



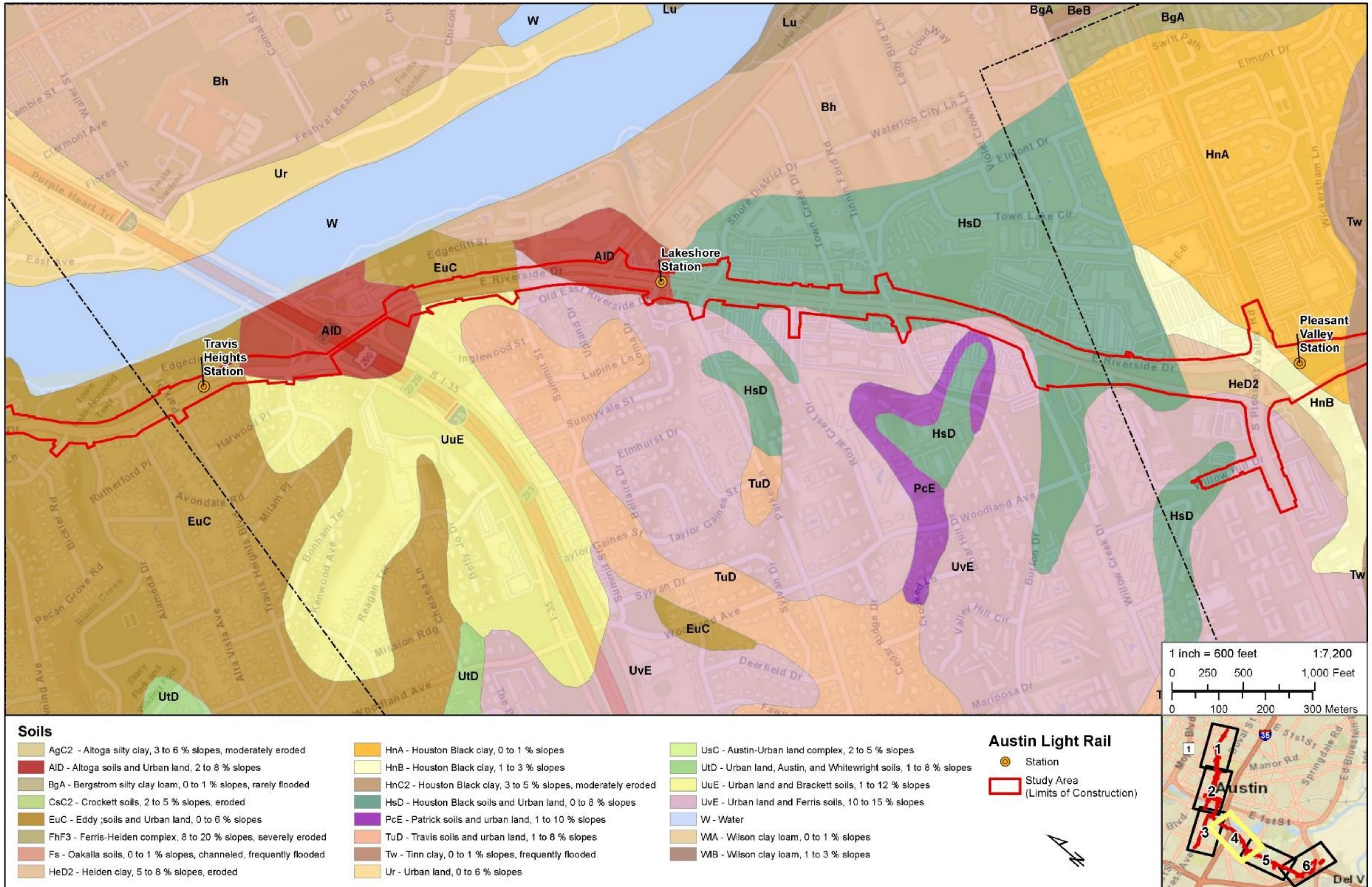
Basemap: ESRI 2024 World Street Map; Soils: USDA Web Soil Survey, accessed March 26, 2024; Austin Light Rail Primary Resource Area (Limits of Construction) as of May 2024. NOTE: Only soil types mapped within the Study Area are defined in the legend.

Figure 3: Mapped Soil Units in the Study Area, Sheet 3



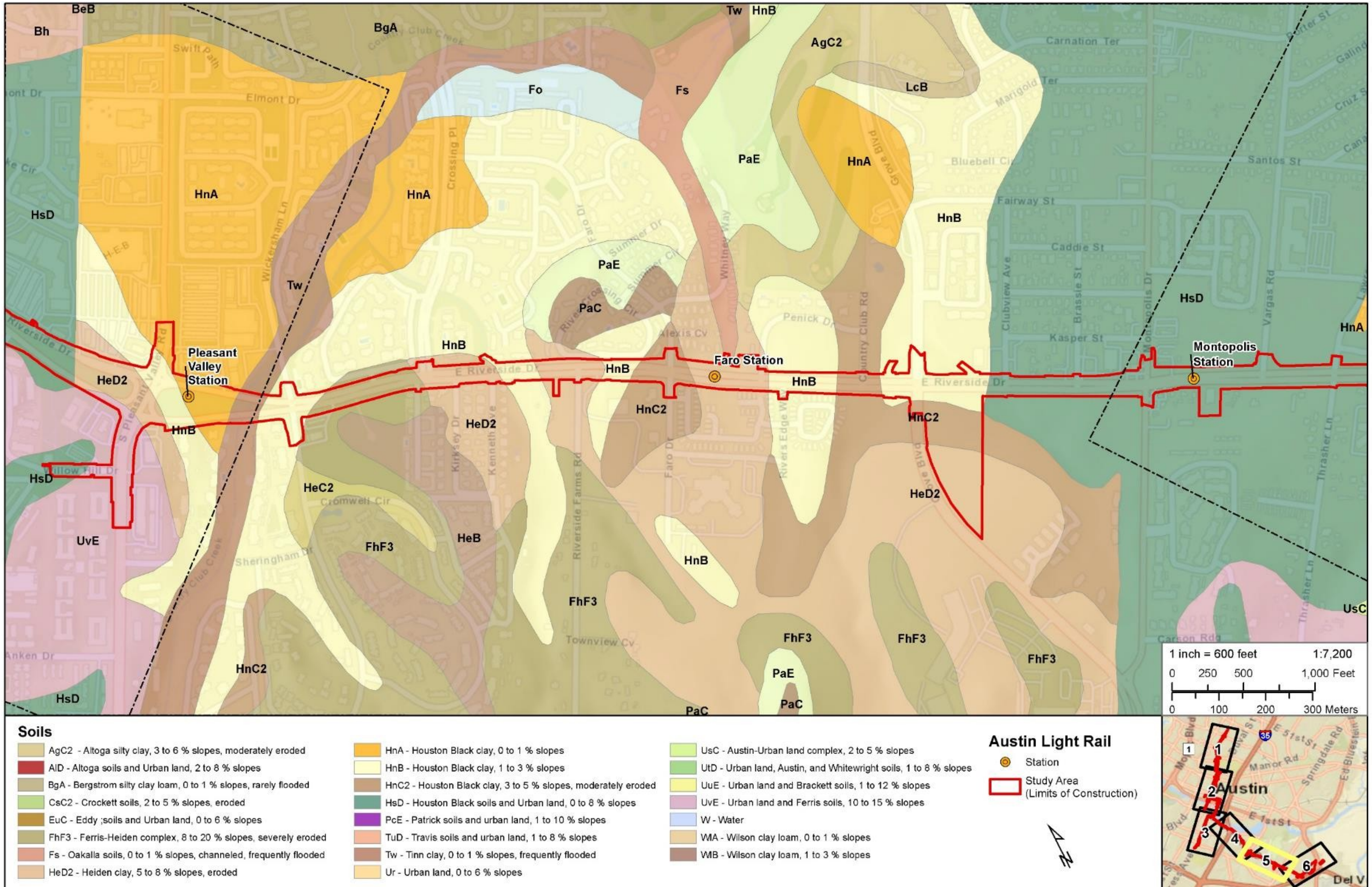
Basemap: ESRI 2024 World Street Map; Soils: USDA Web Soil Survey, accessed March 26, 2024; Austin Light Rail Primary Resource Area (Limits of Construction) as of May 2024. NOTE: Only soil types mapped within the Study Area are defined in the legend.

Figure 4: Mapped Soil Units in the Study Area, Sheet 4



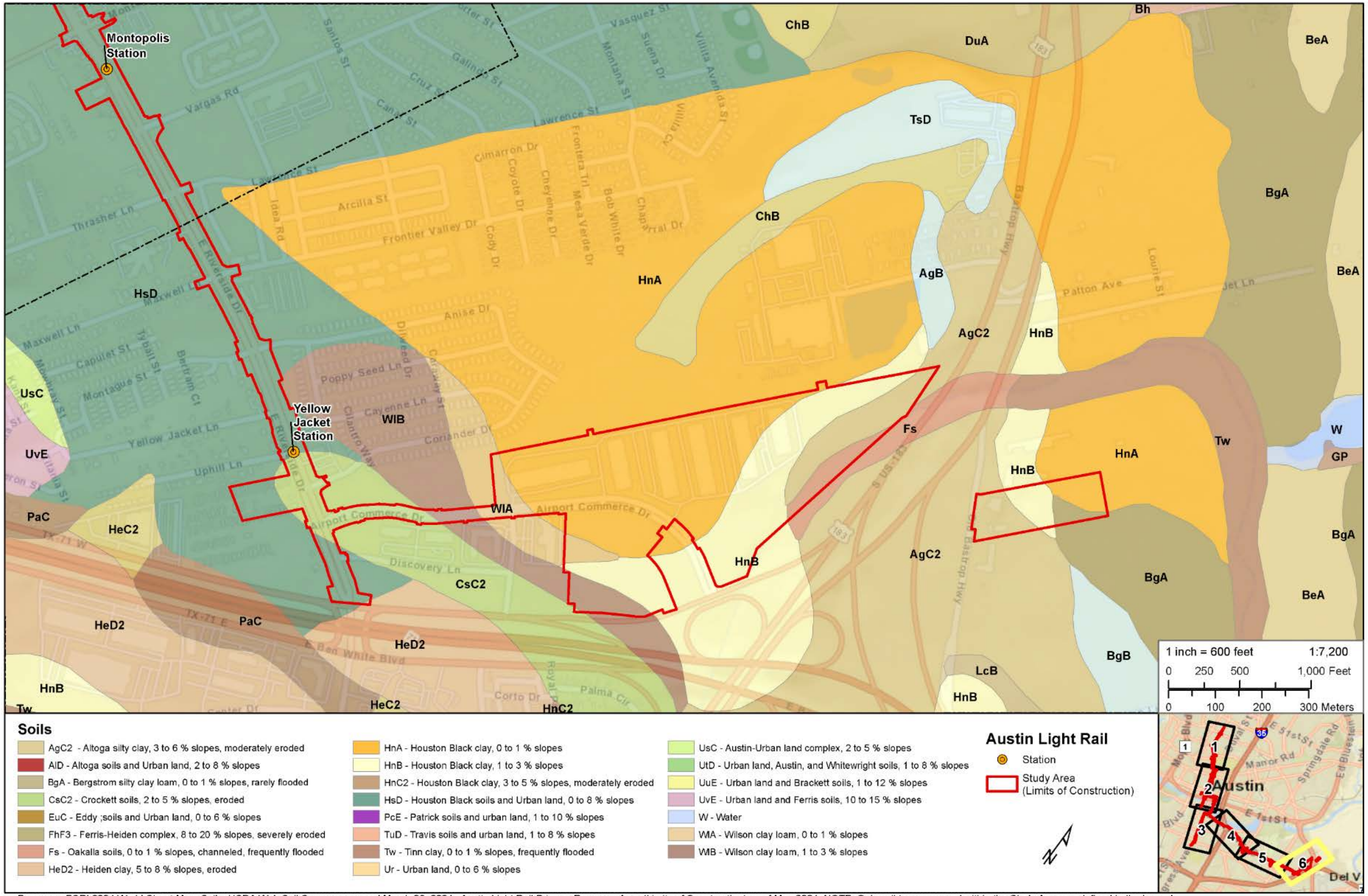
Basemap: ESRI 2024 World Street Map; Soils: USDA Web Soil Survey, accessed March 26, 2024; Austin Light Rail Primary Resource Area (Limits of Construction) as of May 2024. NOTE: Only soil types mapped within the Study Area are defined in the legend.

Figure 5: Mapped Soil Units in the Study Area, Sheet 5



Basemap: ESRI 2024 World Street Map; Soils: USDA Web Soil Survey, accessed March 26, 2024; Austin Light Rail Primary Resource Area (Limits of Construction) as of May 2024. NOTE: Only soil types mapped within the Study Area are defined in the legend.

Figure 6: Mapped Soil Units in the Study Area, Sheet 6



Basemap: ESRI 2024 World Street Map; Soils: USDA Web Soil Survey, accessed March 26, 2024; Austin Light Rail Primary Resource Area (Limits of Construction) as of May 2024. NOTE: Only soil types mapped within the Study Area are defined in the legend.

Table 1: Soil Descriptions for Mapped Units in the Study Area

Map Unit Symbol	Unit Name	Depth to Bedrock (feet)	Description[1]	Acres in Study Area	% of Study Area
AgC2	Altoga silty clay, 3 to 6% slopes, moderately eroded	>5	Clayey alluvium derived from mixed sources; occurs on slopes of stream terraces; medium grained, subangular, blocky; light brownish gray.	7.8	2.6
AlD	Altoga soils and urban land, 2 to 8% slopes			7.1	2.3
BgA	Bergstrom silty clay loam, 0 to 1% slopes, rarely flooded	>5	Loamy alluvium of Holocene age derived from mixed sources; occurs on floodplain steps on river valleys; fine-silty, mixed, very friable; dark grayish brown.	0.9	0.3
CsC2	Crockett soils, 2 to 5% slopes, eroded	4.4	Sandy loam derived from weathered calcareous shale; occurs on sloping ridges and dissected plains; massive, friable; brown to dark brown.	4.9	1.6
EuC	Eddy soils and urban land, 0 to 6% slopes	1.2	Gravelly sediment derived from chalky limestone; occurs on sloping uplands; granular, about 35% platy fragments of limestone; light brownish gray.	12.8	4.2
FhF3	Ferris-Heiden complex, 8 to 20% slopes, severely eroded	3.0	Clayey residuum derived from calcareous mudstone; occurs on backslopes and side slopes of ridges; fine, angular, blocky; olive to yellow.	2.6	0.8
Fs	Oakalla soils, 0 to 1% slopes, channeled, frequently flooded	>5	Loamy alluvium derived from limestone; occurs on floodplains and perennial streams; subangular, blocky; dark grayish brown.	2.2	0.7

Map Unit Symbol	Unit Name	Depth to Bedrock (feet)	Description[1]	Acres in Study Area	% of Study Area
HeD2	Heiden clay, 5 to 8% slopes, eroded	>5	Clayey residuum derived from calcareous mudstone; occurs on foot slopes, shoulders of interfluves, and backslopes; blocky, limestone rock fragments common at surface; dark grayish brown.	13.3	4.4
HnA	Houston Black clay, 0 to 1% slopes	3.3 to >5	Clayey residuum derived from calcareous mudstone; occurs on side slopes and upland ridges; fine to medium grained, subangular; dark grayish brown with olive to yellow mottle.	33.5	11.0
HnB	Houston Black clay, 1 to 3% slopes			30.3	9.9
HnC2	Houston Black clay, 3 to 5% slopes, moderately eroded			5.8	1.9
HsD	Houston Black soils and urban land, 0 to 8% slopes	4.0 to >5	Cyclic soil that formed in alkaline clays and chalk of the Blackland Prairies; occurs in floodplains and low-lying areas; clay-rich, medium granular; very dark gray.	38.2	12.5
PcE	Patrick soils and urban land, 1 to 10% slopes	>5	Clayey and gravelly sediment derived from shale and siltstone; occurs on slopes of stream terraces; moderate to fine granular structure, friable; very dark grayish brown.	<0.1	<0.1
TuD	Travis soils and urban land, 1 to 8% slopes	>5	Clayey and loamy sediment of ancient terrace deposits; occurs on level to sloping uplands; fine, granular, rounded siliceous pebbles; light to dark brown	5.5	1.8

Map Unit Symbol	Unit Name	Depth to Bedrock (feet)	Description[1]	Acres in Study Area	% of Study Area
Tw	Tinn clay, 0 to 1% slopes, frequently flooded	>5	Clayey residuum derived from calcareous alluvium; occurs on floodplains; angular and compact; very dark gray to black.	1.0	0.3
Ur	Urban land, 0 to 6% slopes	NA	Areas of more than 50% urban cover, including asphalt, pavement, compacted gravel, and fill material. Lesser components include highly disturbed native soils; generally thin, silty clays and gravelly soils derived from weathered limestone.	117.1	38.4
UsC	Austin-urban land complex, 2 to 5% slopes	2.4		1.9	0.6
UtD	Urban land, Austin, and Whitewright soils, 1 to 8% slopes	NA		3.8	1.2
UuE	Urban land and Brackett soils, 1 to 12% slopes	NA		0.7	0.2
UvE	Urban land and Ferris soils, 10 to 15% slopes	NA		6.8	2.2
W	Water	NA	NA	3.2	1.1
WIA	Wilson clay loam, 0 to 1% slopes	>5	Loamy and/or clayey alluvium derived from calcareous mudstone; occurs on stream terraces on dissected plains; fine and granular, some gypsum; light brownish gray.	2.8	0.9
WiB	Wilson clay loam, 1 to 3% slopes	>5		3.0	1.0
			Totals	**305.3**	**100**

Source: NRCS 2023a.
NA = not applicable
1 Texture and colors describe surficial appearance when moist.

The Study Area contains 305 acres of developed land, which includes the limits of Project construction. Of this, 42.1 percent consists of urban land with minor soil coverage, and another 21.4 percent consists of soil and urban land associations, forming a total of 63.5 percent of highly disturbed, altered, or covered urban landscape. Native soil units compose 36.5 percent of the Study Area, and water composes the remaining 1.0 percent.

The land cover along the north-south portion of the Build Alternative, from 38th Street Station to Oltorf Station, primarily consists of urban development and highly disturbed ground, but small patches of soil are mapped in disparate areas near the northern extent of the Study Area. These include *Travis soils and urban land, 1 to 8 percent slopes (TuD)* and *Lewisville soils and urban land, 0 to 2 percent slopes (LeB)*, which are gravelly river deposits of Quaternary age and range from 6.0 to 6.25 feet deep.

The land cover along the eastern portion of the Build Alternative, from Waterfront Station to Yellow Jacket Station, also consists predominantly of urban land; however, the Build Alternative would cross a variety of clay-rich soils toward the eastern terminus. The most prevalent of these are *Houston Black soils and urban land, 0 to 8 percent slopes (HsD)*, which are clayey residuum weathered primarily from the Eagle Ford Shale and are often more than 6 feet deep. *Eddy soils and urban land, 0 to 6 percent slopes (EuC)* are found in the eastern portion of the Study Area; these are thin, rocky soils derived from weathered Austin Chalk and are typically no more than 1.6 feet deep.

4.1.2 Soil Properties

Generally, soils in the Study Area are well drained, have low to moderate erosion potential, have variable shrink-swell potential ranging from low to very high, and have moderate to high plasticity. All of these characteristics are influenced by soil sediment size and composition and thus are strongly correlated with clay content. The clay content of soils in the Study Area ranges from 16 to 55 percent, and most clay-rich units are found in the eastern portion of the Study Area. The properties for each mapped soil unit are summarized in **Table 1** above and **Table 2** and are discussed below.

Table 2: Soil Property Data for Mapped Units in the Study Area

Map Unit Symbol	Clay Content[1] (%)	Hydrologic Group	Drainage Class	K-Factor, Whole Soil	Water Erosion Potential	Linear Extensibility Percentage	Shrink-Swell Potential	Plasticity Index	Plasticity Class
AgC2	38.6	B	Well drained	0.17	Low	4.8	Moderate	25.1	Highly plastic
AlD	38.7	B	Well drained	0.17	Low	4.8	Moderate	25.1	Highly plastic
BgA[3]	28.9	B	Well drained	0.32	Moderate	4.5	Moderate	18.4	Highly plastic
CsC2	38.2	C	Moderately well drained	0.49	High	6.1	High	31.5	Highly plastic
EuC	26.0	D	Well drained	0.10	Low	1.5	Low	16.0	Medium plastic
FhF3	54.5	D	Well drained	0.24	Low	13.2	Very high	51.1	Highly plastic
Fs[2]	30.4	B	Well drained	0.28	Moderate	2.4	Moderate	17.0	Highly plastic
HeD2	51.8	D	Well drained	0.24	Low	11.1	Very high	42.2	Highly plastic
HnA[3]	54.1	D	Moderately well drained	0.24	Low	12	Very high	44.1	Highly plastic
HnB[3]	54.1	D	Moderately well drained	0.24	Low	12	Very high	44.1	Highly plastic
HnC2	54.1	D	Moderately well drained	0.24	Low	12	Very high	44.1	Highly plastic

Map Unit Symbol	Clay Content[1] (%)	Hydrologic Group	Drainage Class	K-Factor, Whole Soil	Water Erosion Potential	Linear Extensibility Percentage	Shrink-Swell Potential	Plasticity Index	Plasticity Class
HsD	55.0	D	Moderately well drained	0.20	Low	17	Very high	54.2	Highly plastic
PcE	15.9	B	Well drained	0.20	Low	2.3	Moderate	8.5	Medium plastic
TuD	30.9	C	NA	NA	NA	2.8	Moderate	16.8	Medium plastic
Tw[2]	50.0	D	Moderately well drained	0.24	Low	9.6	Very high	41.0	Highly plastic
Ur	NA	D	NA	NA	NA	NA	NA	NA	NA
UsC	45.0	C	Well drained	0.24	Low	4.8	Moderate	29.5	Highly plastic
UtD	NA	D	Well drained	NA	NA	NA	NA	NA	NA
UuE	NA	D	Well drained	NA	NA	NA	NA	NA	NA
UvE	NA	D	NA	NA	NA	NA	NA	NA	NA
W	NA	D	NA	NA	NA	NA	NA	NA	NA
WlA[4]	39.7	D	Moderately well drained	0.37	Moderate	7.1	High	34.0	Highly plastic
WiB[4]	39.7	C	Moderately well drained	0.37	Moderate	6.2	High	32.6	Highly plastic

Source: NRCS 2023a.
NA = not available
[1] Average of upper 3 feet of typical soil profile as an aggregate sample from multiple
[2] Hydric soil
[3] Prime farmland
[4] Farmland of statewide importance

4.1.2.1 Drainage

In the Study Area, most soils are in Hydrologic Group D (yielding high runoff, likely due to the urban nature of the soils) but are classified as well drained. Notably, urban land and urban soil associations do not have drainage class ratings; areas with stormwater infrastructure can be assumed to be well drained for most practical purposes. Most of the north-south portion of the Study Area lacks drainage ratings due to urban land cover. Drainage class categories for the soil map units within the Study Area are presented in **Figure 7** through **Figure 12** and are summarized in **Table 2**.

Hydric soils include *Tinn clay, 0 to 1 percent slopes, frequently flooded (Tw)*, which are found along the banks of Country Club Creek southeast of Pleasant Valley Station, and *Oakalla soils, 0 to 1 percent slopes, channeled, frequently flooded (Fs)*, which lie north of Faro Station. The Tinn clay is described as a clayey alluvium derived from limestone and is typically more than 5 feet deep (*Hydrologic Group D)*. The Oakalla soils are described as silty clay loam derived from limestone and are typically more than 5 feet deep (*Hydrologic Group B)*. Potential wetlands may be present within these areas and therefore potentially subject to regulation; additional details regarding wetlands are provided in **FEIS Appendix F-4**.

Figure 7: Drainage Classes of Mapped Soil Units in the Study Area, Sheet 1

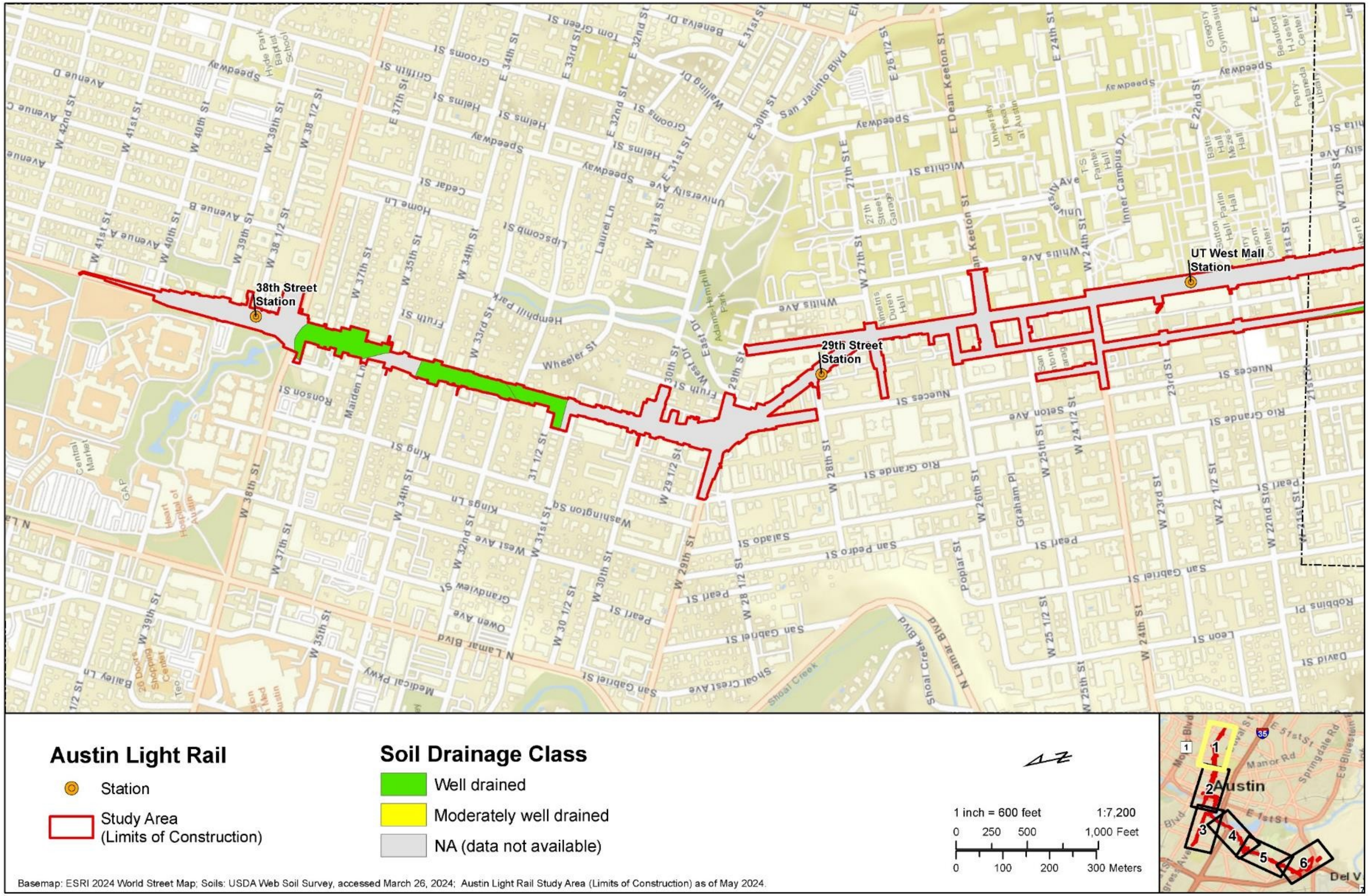


Figure 8: Drainage Classes of Mapped Soil Units in the Study Area, Sheet 2

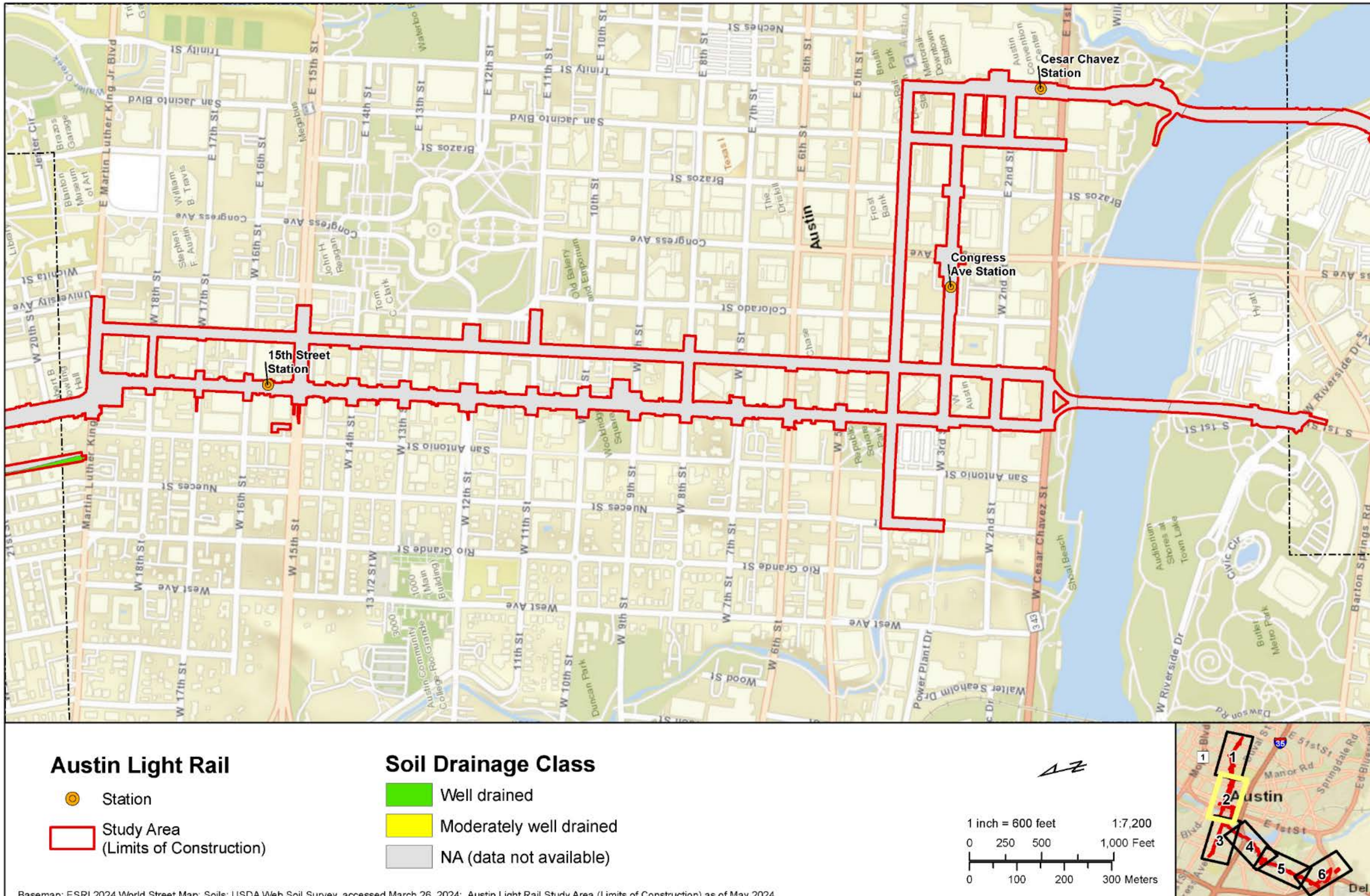


Figure 9: Drainage Classes of Mapped Soil Units in the Study Area, Sheet 3

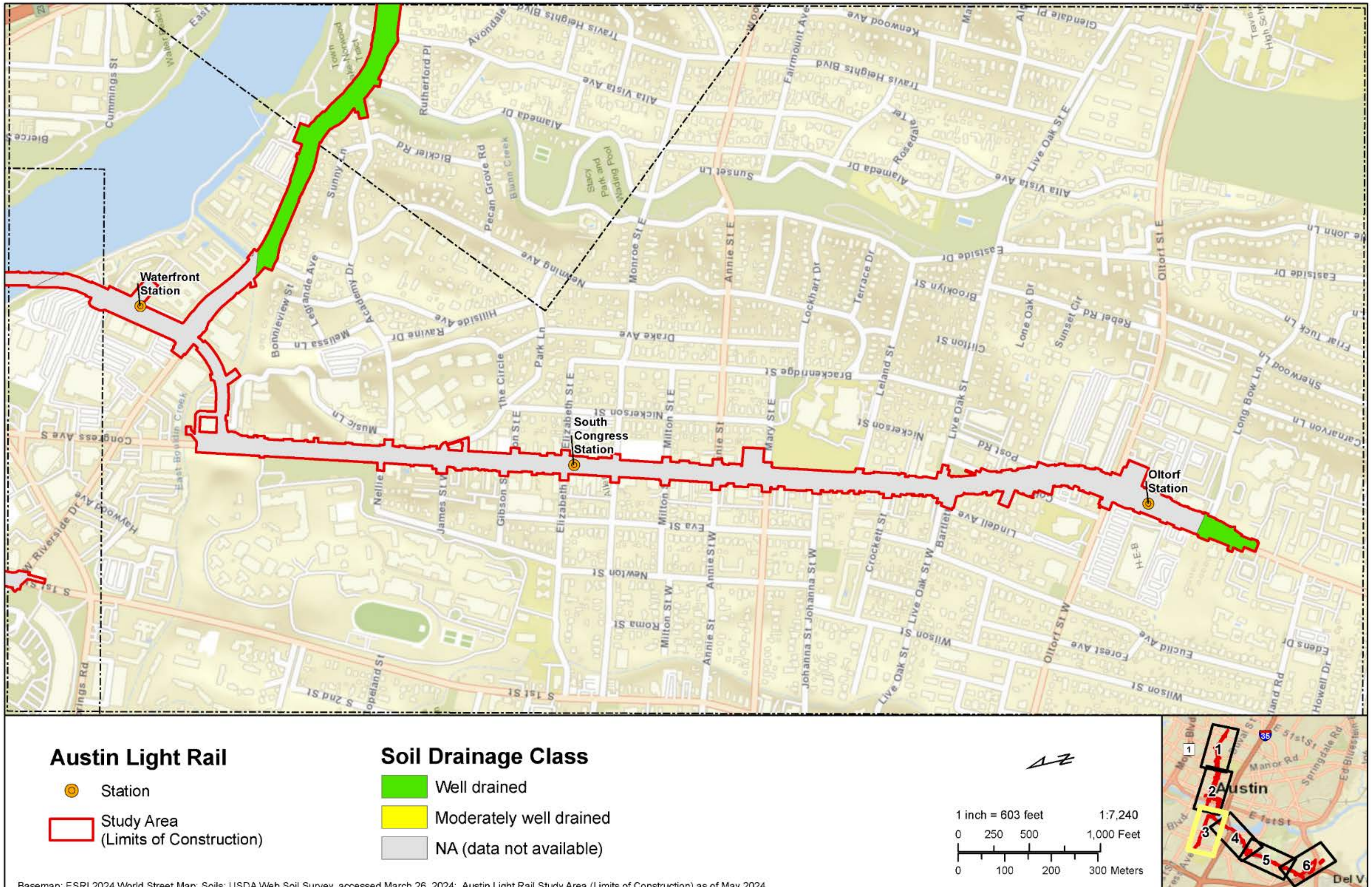


Figure 10: Drainage Classes of Mapped Soil Units in the Study Area, Sheet 4

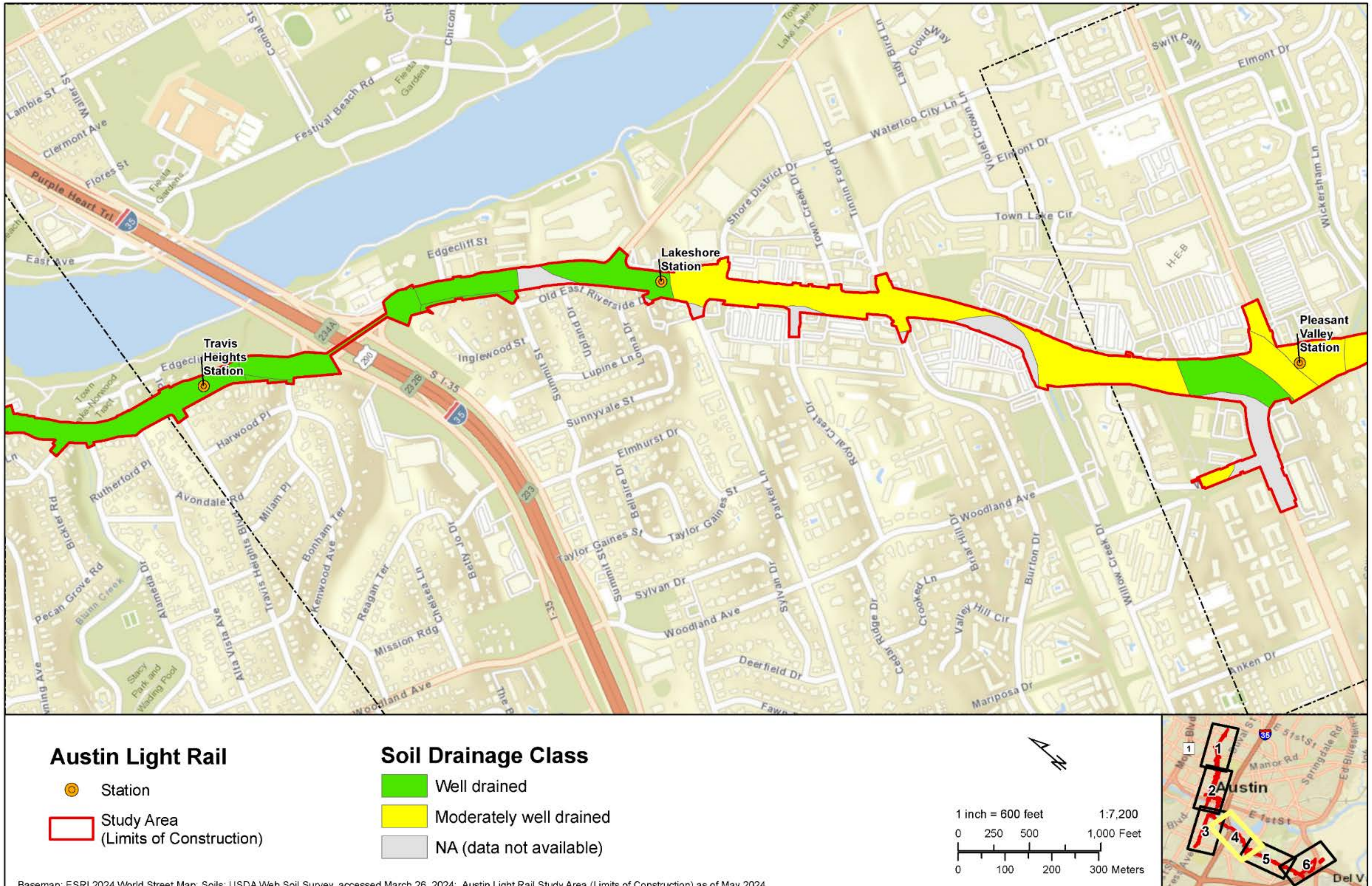


Figure 11: Drainage Classes of Mapped Soil Units in the Study Area, Sheet 5

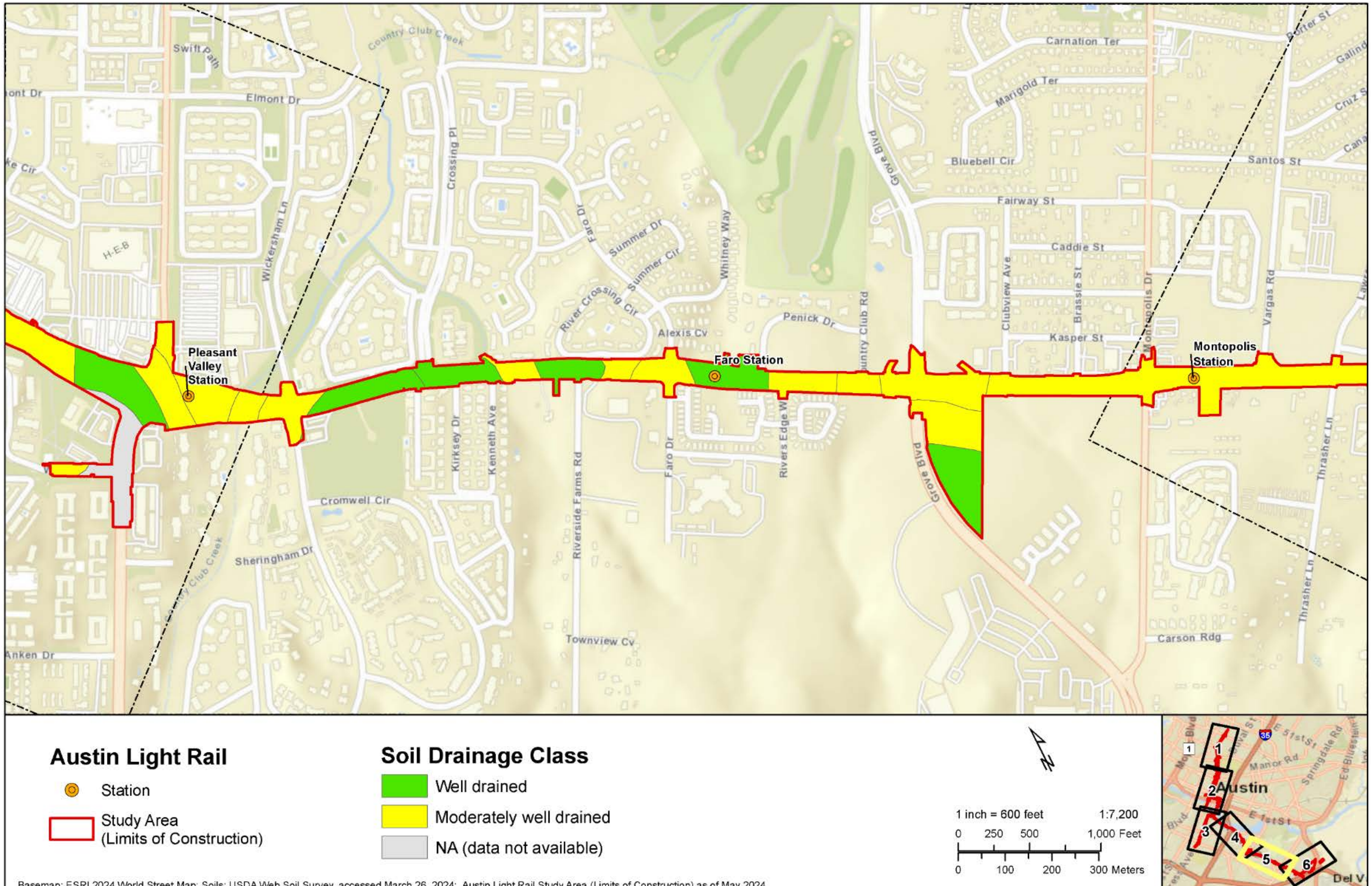
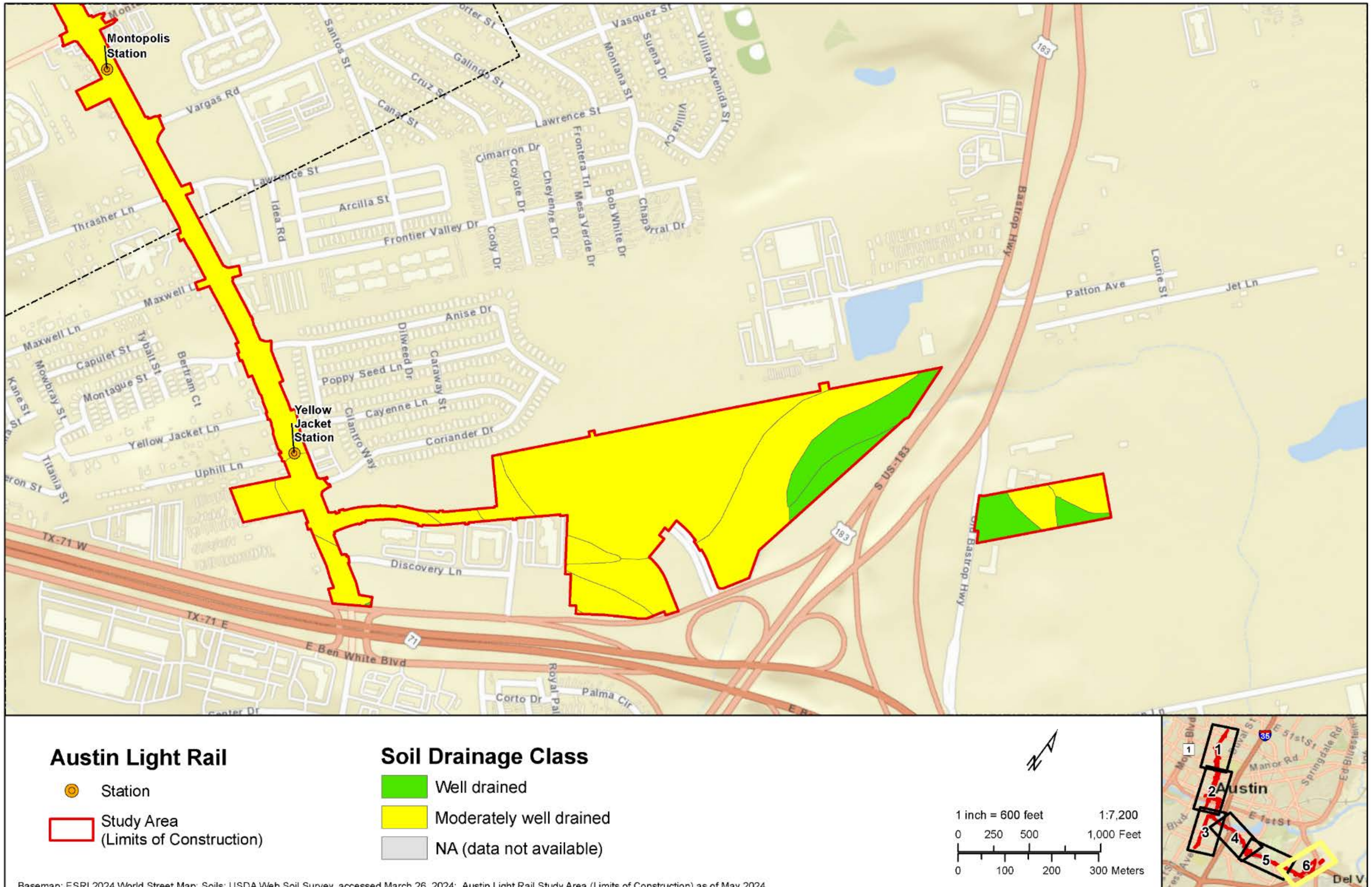


Figure 12: Drainage Classes of Mapped Soil Units in the Study Area, Sheet 6



4.1.2.2 Erosion Potential

In the Study Area, K-factors range from 0.10 to 0.49, with typical values of 0.24. Overall, erosion potential by surface water within the Study Area is low to moderate, with the highest potential occurring in *Wilson Clay loam, 0 to 1 percent slopes (WIA), Wilson Clay loam, 1 to 3 percent slopes (WIB)* and *Crocket soils, 2 to 5 percent slopes, eroded (CsC2)* near the Yellow Jacket Station and the operations and maintenance facility at the eastern terminus of the Study Area. Other soils in the north-south portion of the Study Area may also be susceptible; however, much of the land is not rated due to urban land cover. Erosion potential categories for the soil map units within the Study Area are presented in **Figure 13** through **Figure 18** and are summarized in **Table 2**.

Figure 13: Erosion Potential of Mapped Soil Units in the Study Area, Sheet 1

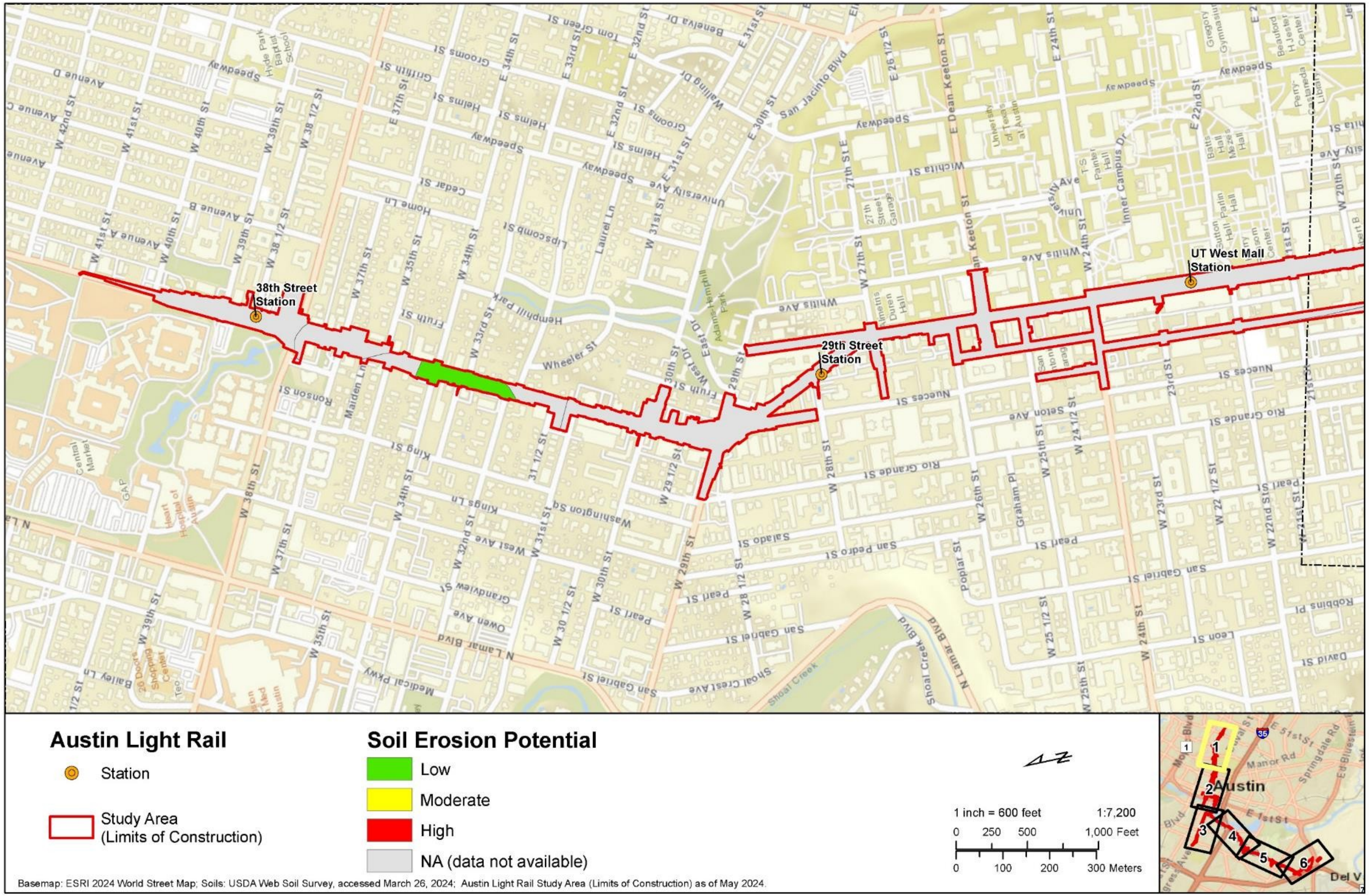


Figure 14: Erosion Potential of Mapped Soil Units in the Study Area, Sheet 2

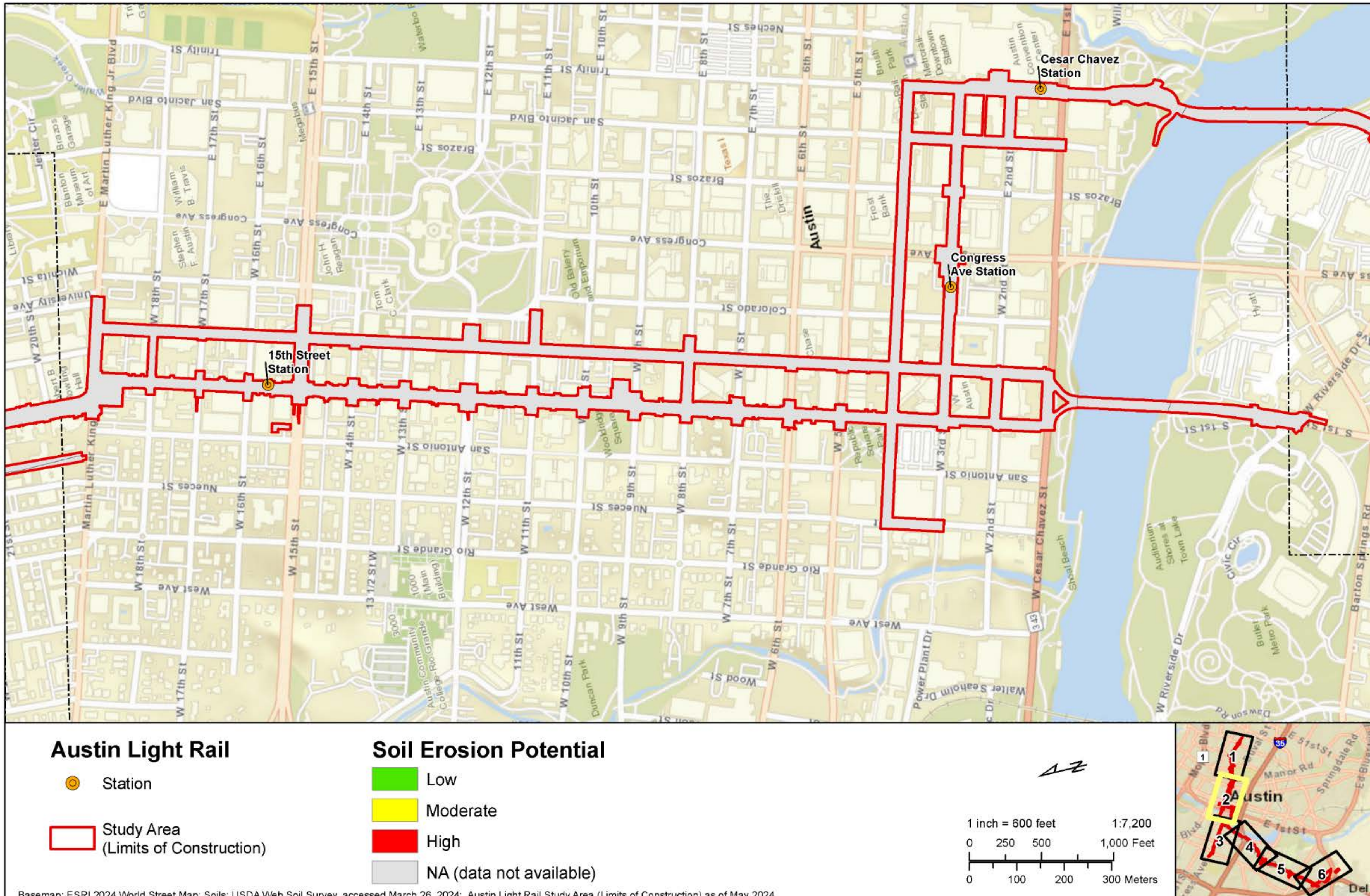


Figure 15: Erosion Potential of Mapped Soil Units in the Study Area, Sheet 3

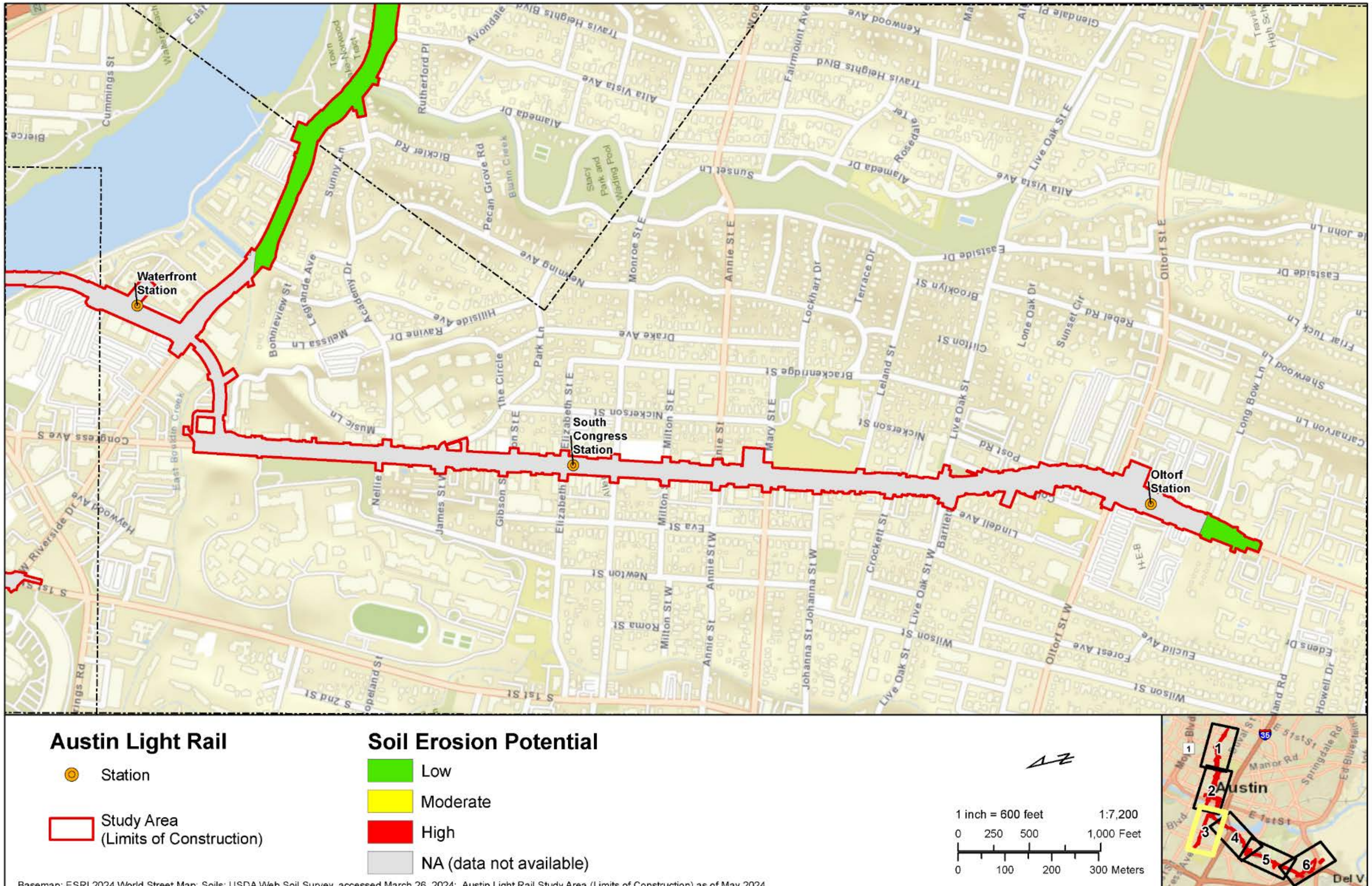


Figure 16: Erosion Potential of Mapped Soil Units in the Study Area, Sheet 4

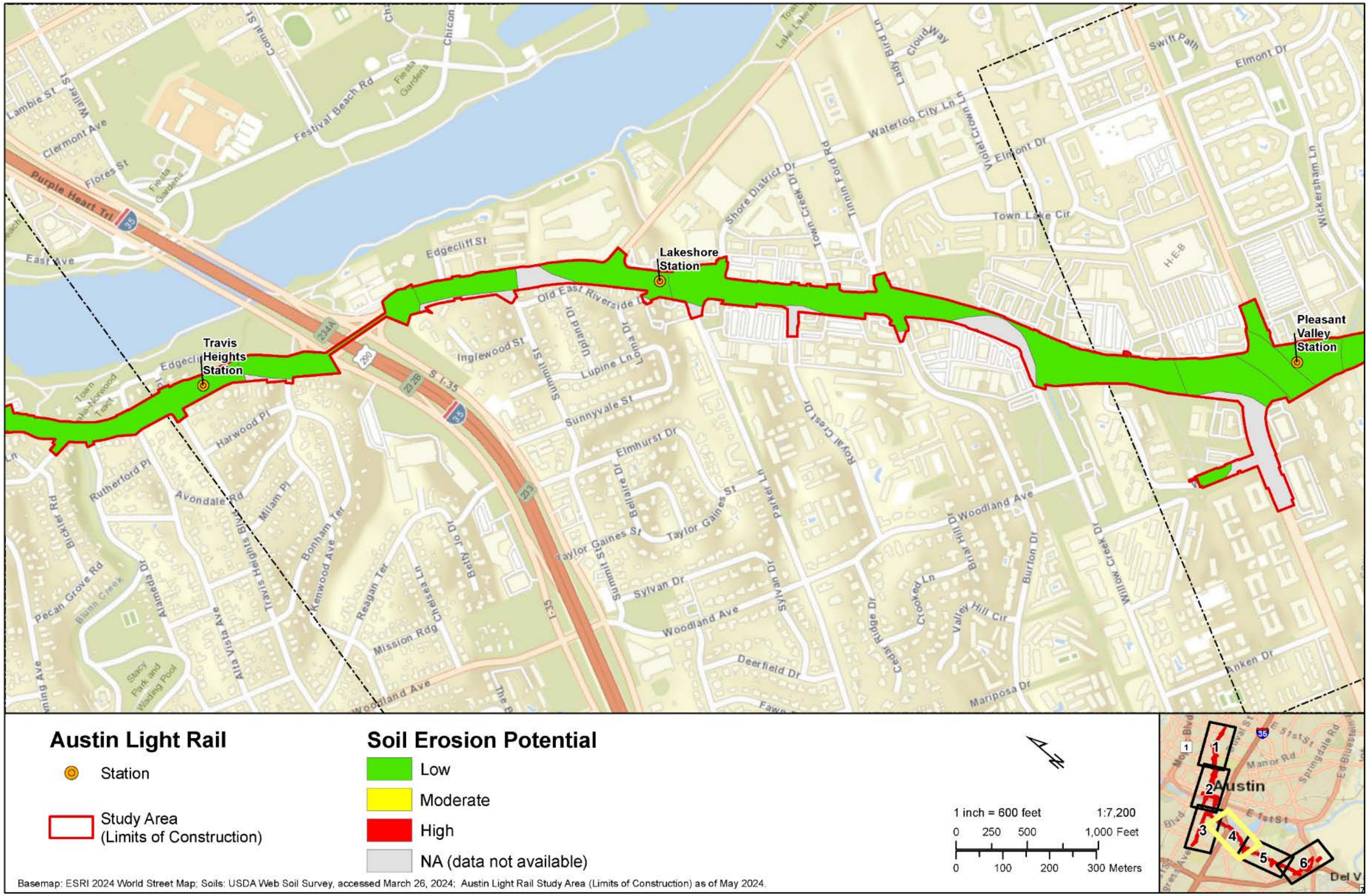


Figure 17: Erosion Potential of Mapped Soil Units in the Study Area, Sheet 5

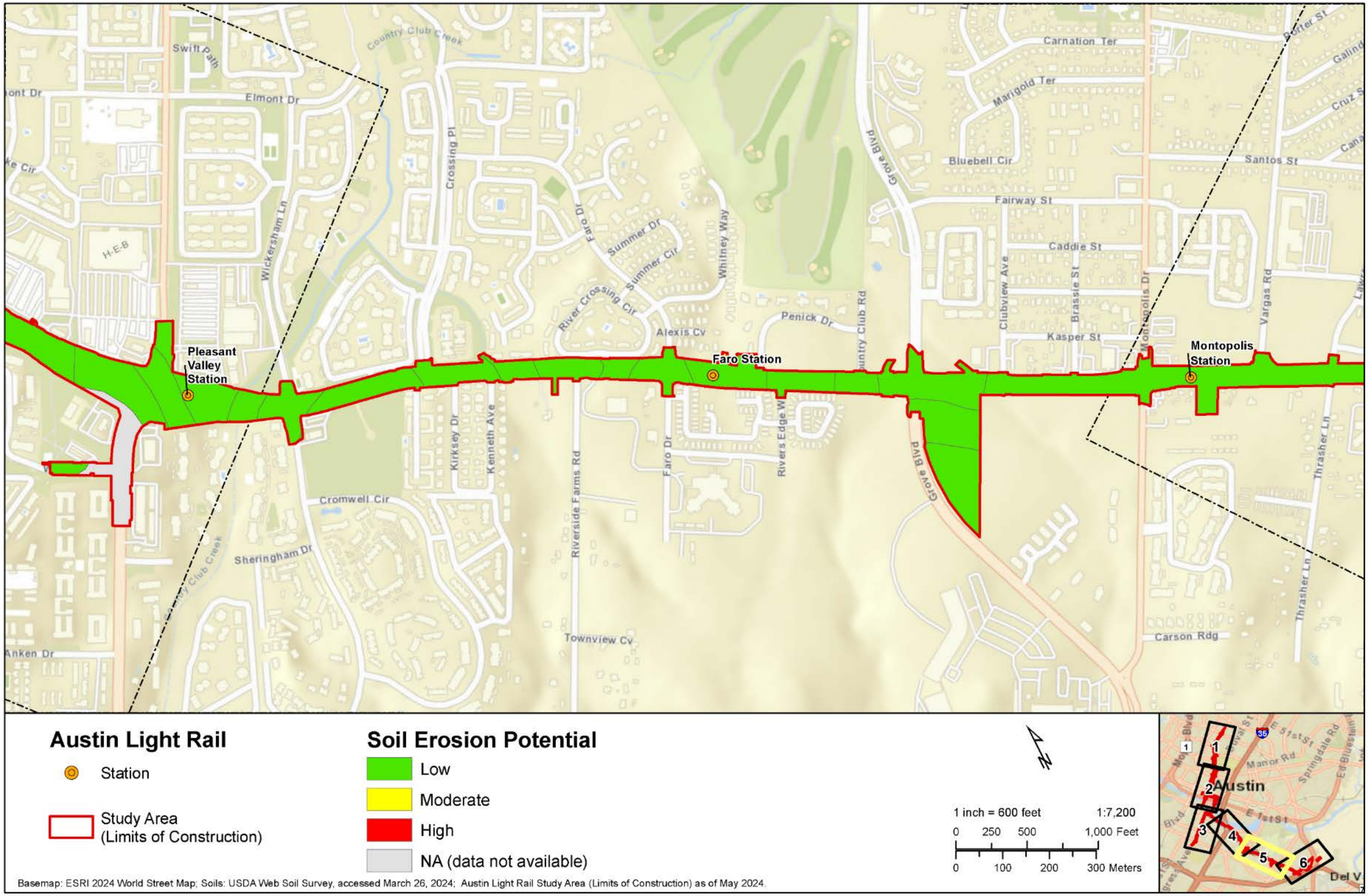
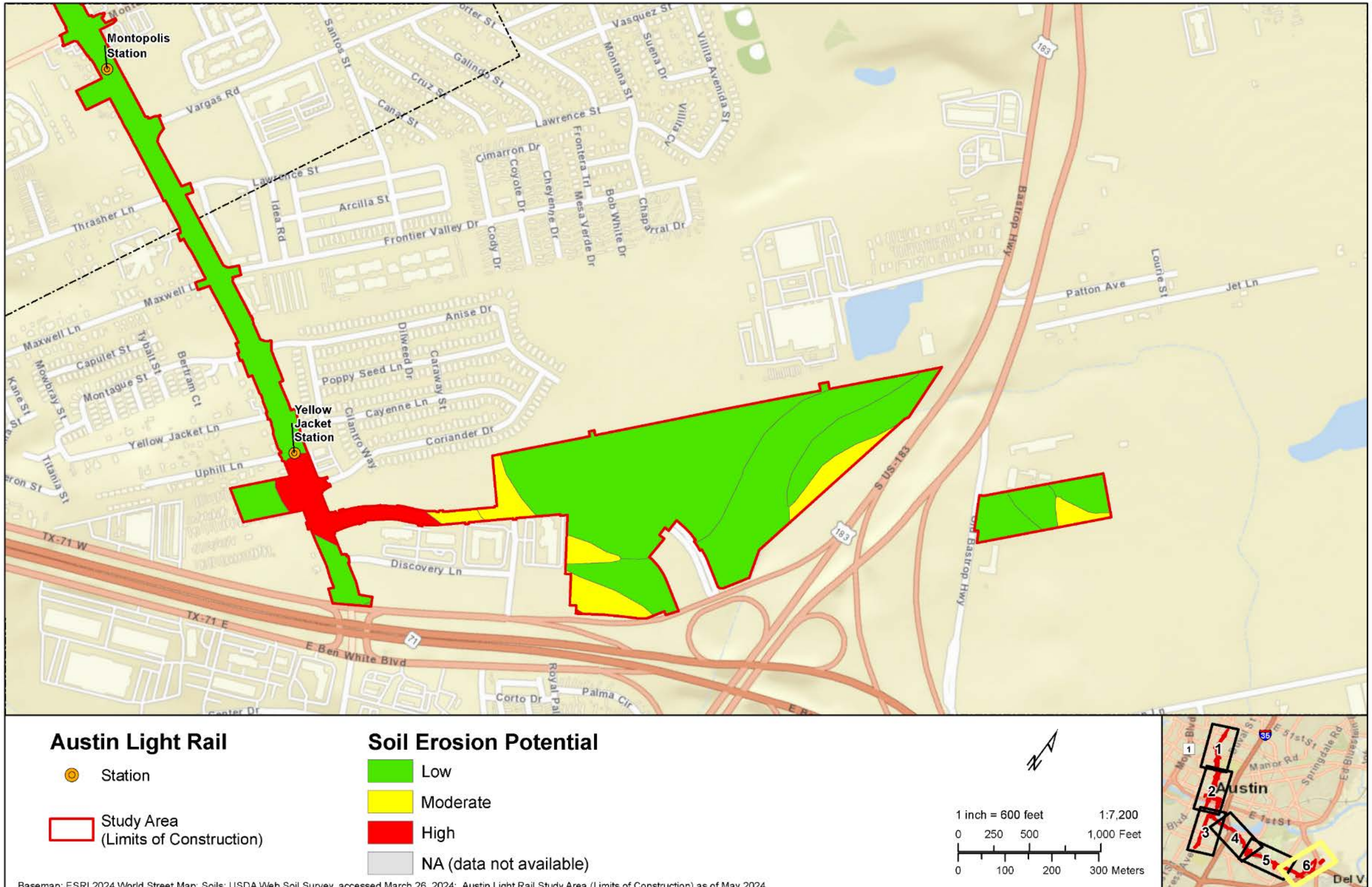


Figure 18: Erosion Potential of Mapped Soil Units in the Study Area, Sheet 6



4.1.2.3 Shrink-Swell Potential

Linear extensibility percentage values in the Study Area range from less than 2 percent in the *Eddy soils and urban land, 0 to 6 percent slopes (EuC)* at the southern terminus near Oltorf Station to 17 percent in the *Houston Black soils and urban land, 0 to 8 percent slopes (HsD)* found throughout the eastern portion of the Study Area. Soils with high to very high shrink-swell potential are located mostly within the eastern portion of the Study Area, including *Houston Black clay, 0 to 1 percent (HnA); Houston Black clay, 1 to 3 percent slopes (HnB);* and *Houston Black clay, 3 to 5 percent slopes, moderately eroded (HnC2)*. According to the NRCS soil descriptions, Houston Black clays can form cracks that are 0.5 to 4 inches wide at 12-inch depths during dry periods; cracks remain open for 90 to 150 cumulative days in most years. A majority of the north-south portion of the Study Area has no rating due to urban land cover, however, shrink-swell potential is low to moderate where soil units are mapped. Shrink-swell potential categories for the soil map units within the Study Area are presented in **Figure 19** through **Figure 24** and are summarized in **Table 2**.

Figure 19: Shrink-Swell Potential of Mapped Soil Units in the Study Area, Sheet 1

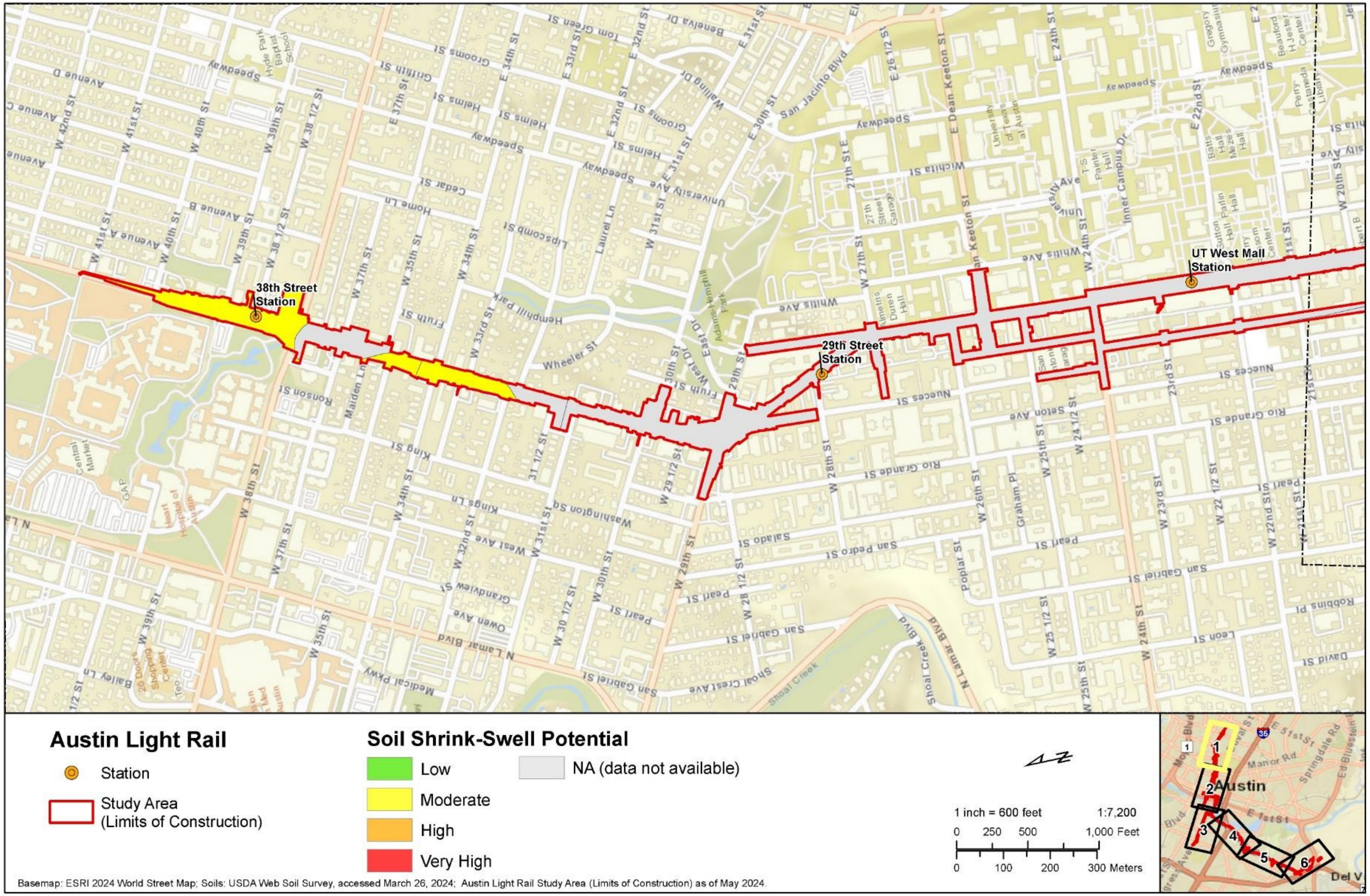


Figure 20: Shrink-Swell Potential of Mapped Soil Units in the Study Area, Sheet 2

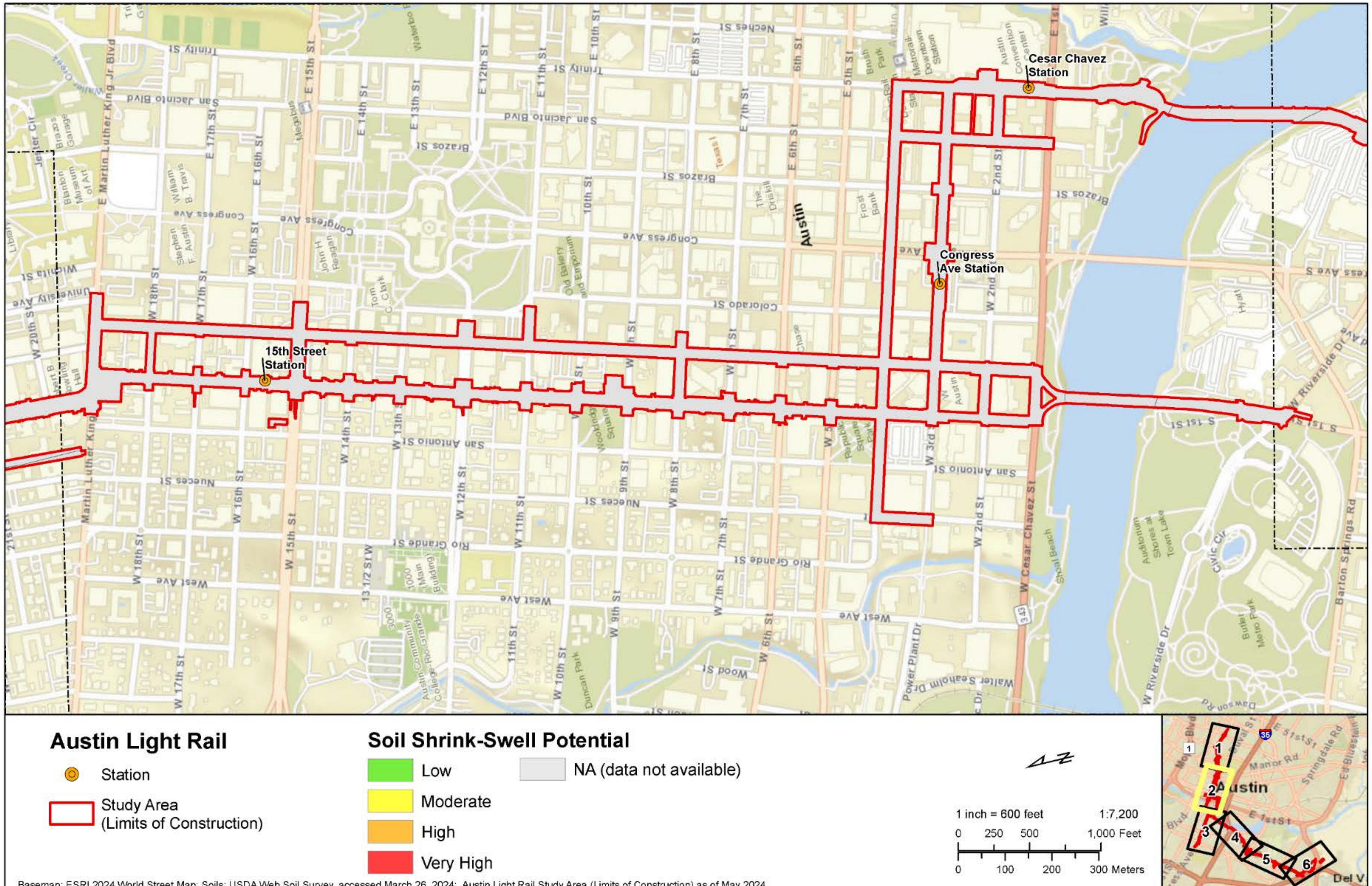


Figure 21: Shrink-Swell Potential of Mapped Soil Units in the Study Area, Sheet 3

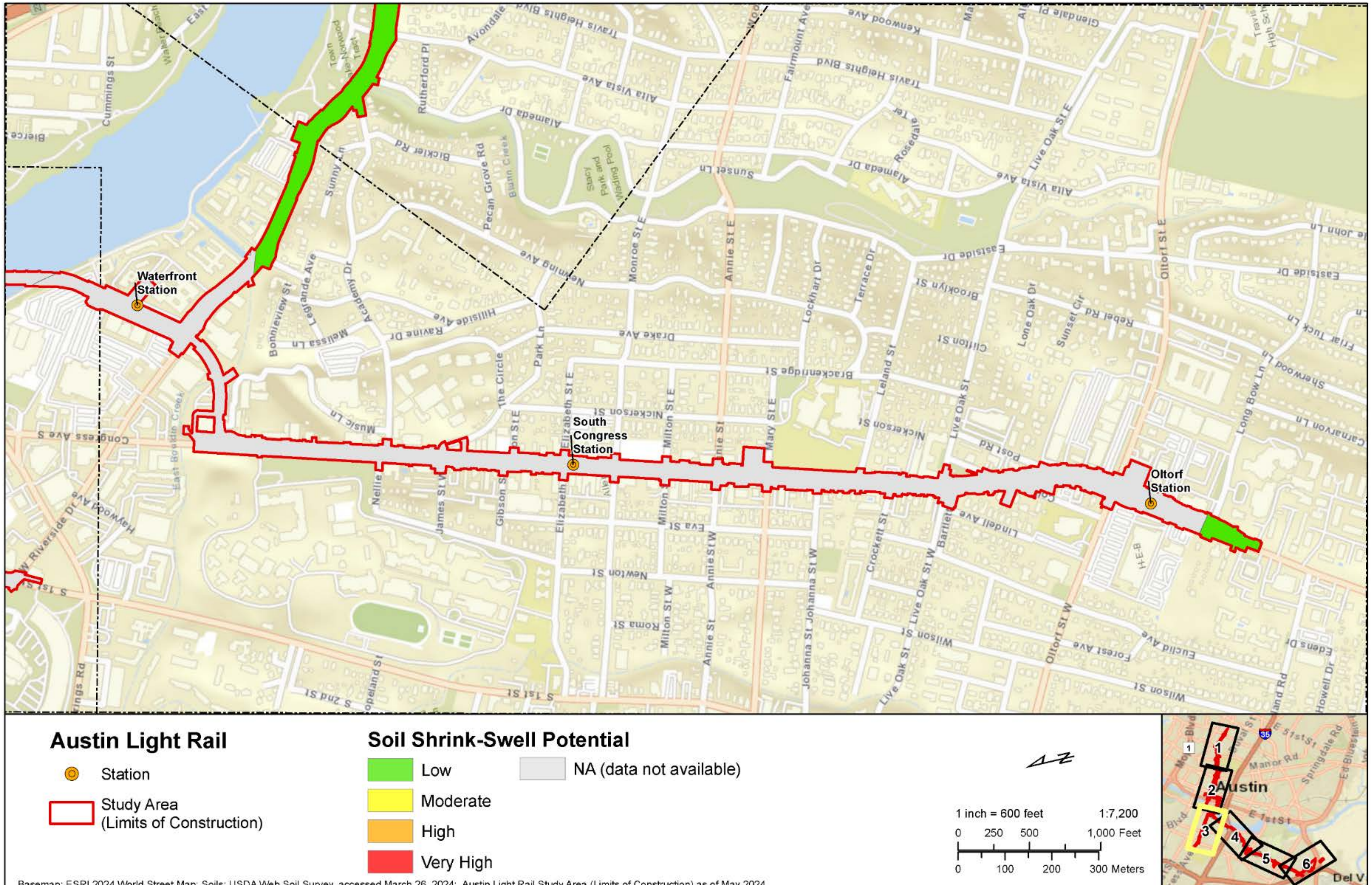


Figure 22: Shrink-Swell Potential of Mapped Soil Units in the Study Area, Sheet 4

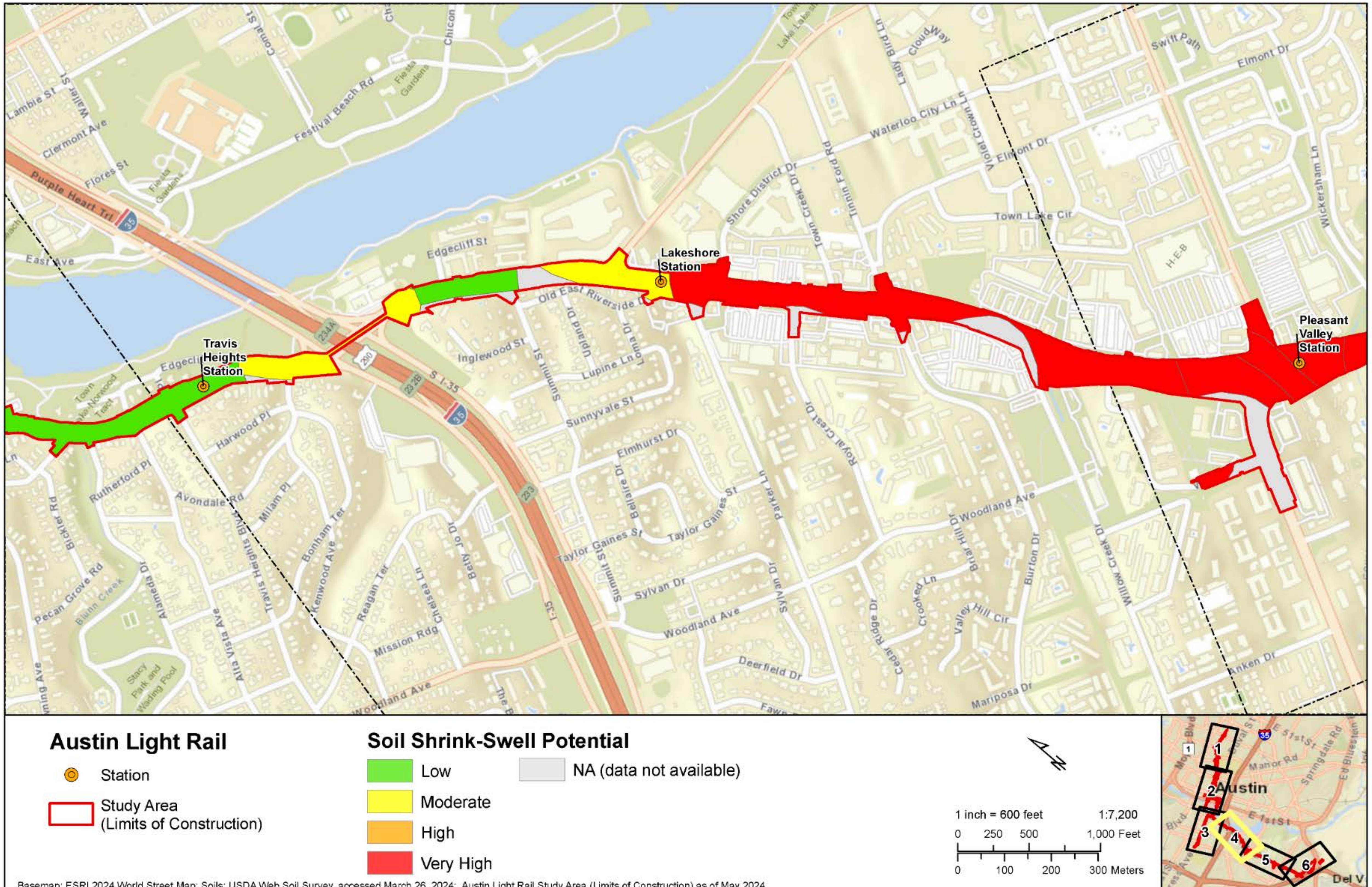


Figure 23: Shrink-Swell Potential of Mapped Soil Units in the Study Area, Sheet 5

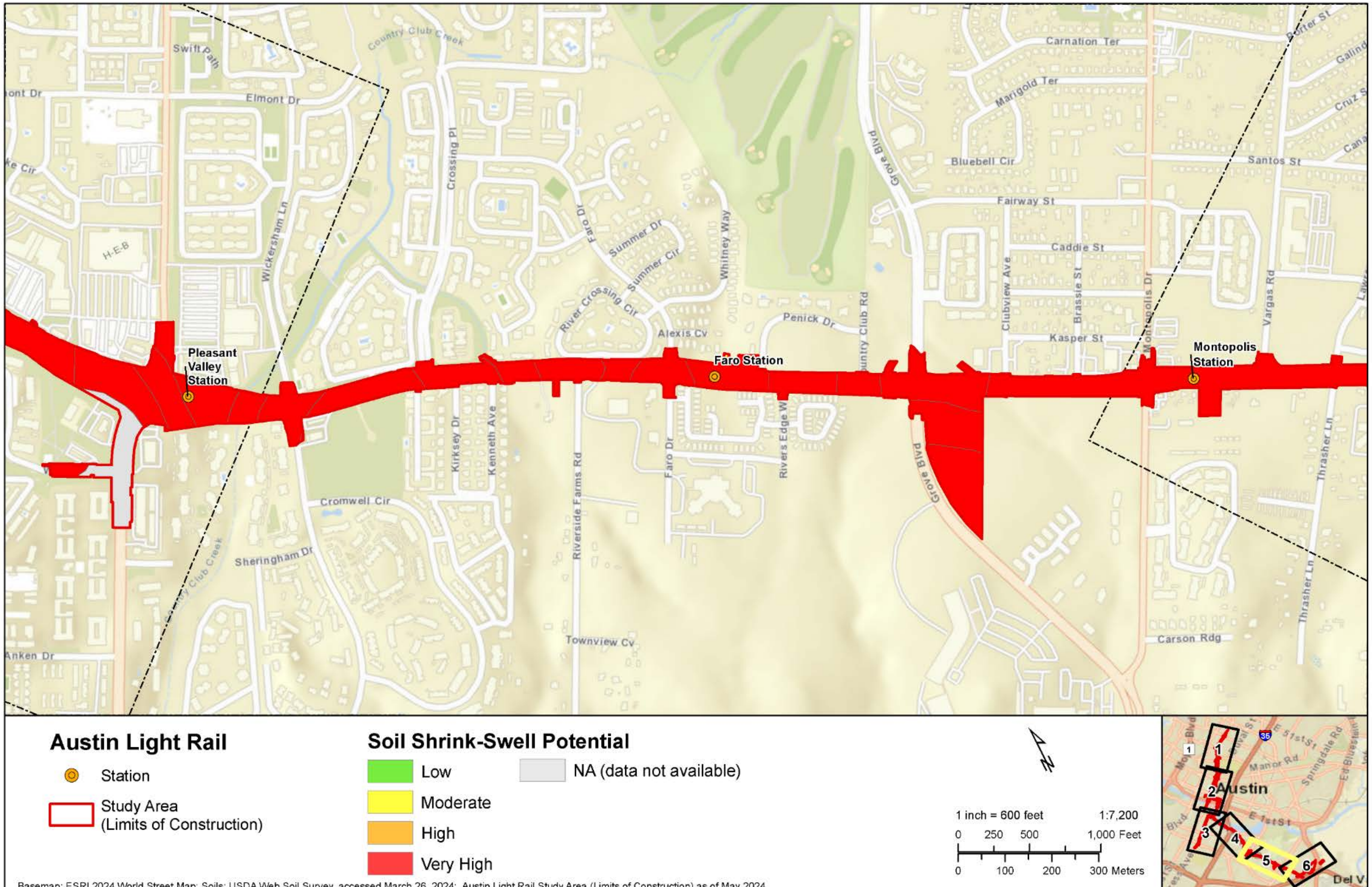
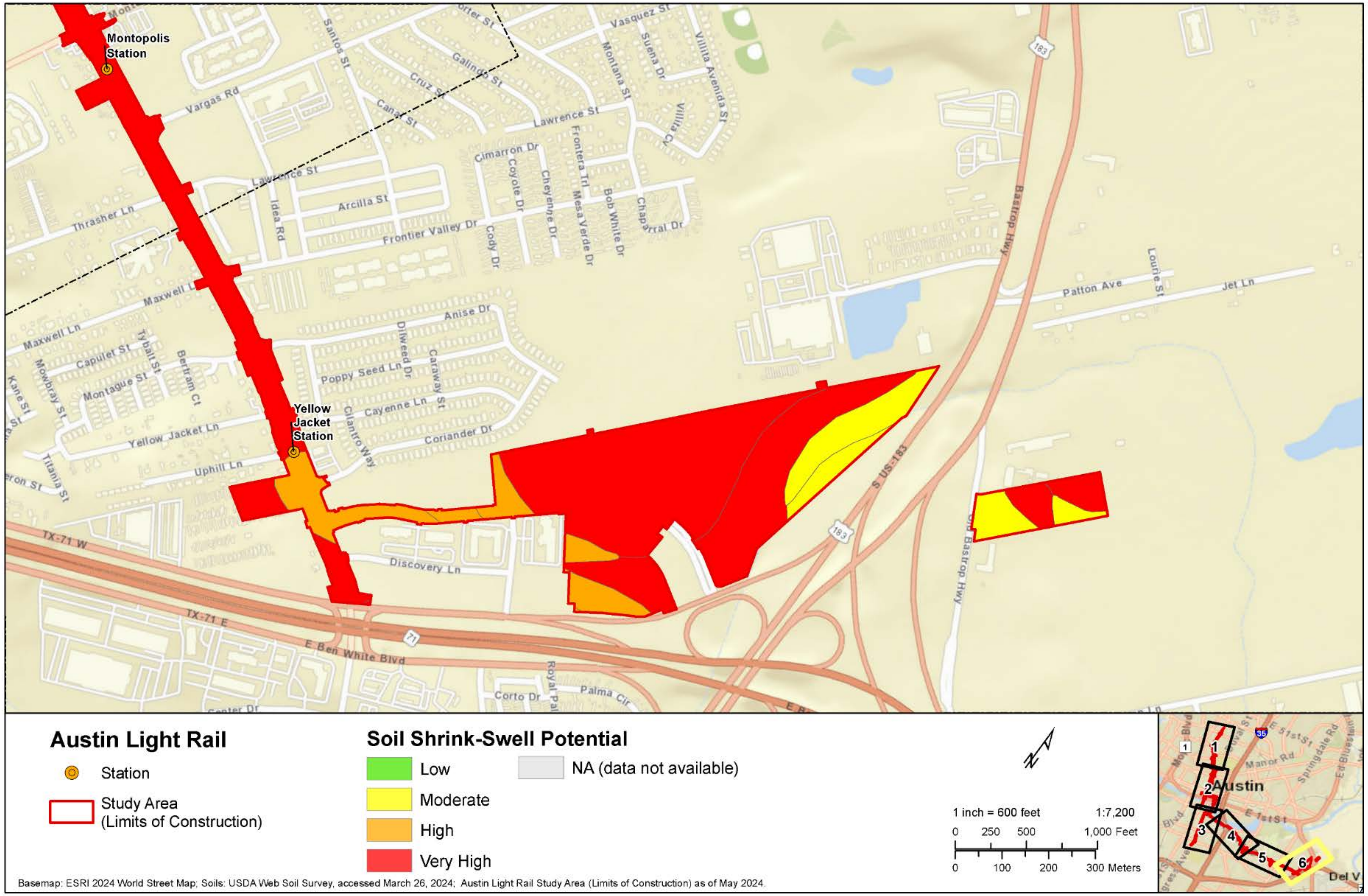


Figure 24: Shrink-Swell Potential of Mapped Soil Units in the Study Area, Sheet 6



4.1.2.4 Plasticity

Plasticity Index values in the Study Area range from 8.5 in *Patrick soils, 5 to 10 percent slopes (PcE)* to the north of Faro Station to 54 in the *Houston Black soils and urban land, 0 to 8 percent slopes (HsD)* present throughout the eastern portion of the Study Area. Most soils in the Study Area are highly plastic, and most of these soil units are mapped in the eastern portion of the Study Area. A majority of the north-south portion of the Study Area is not rated due to urban land cover, but areas with mapped soils are classified as having medium plasticity. Plasticity categories for the soil map units within the Study Area are presented in **Figure 25** through **Figure 30** and are summarized in **Table 2**.

Figure 25: Plasticity Class of Mapped Soil Units in the Study Area, Sheet 1

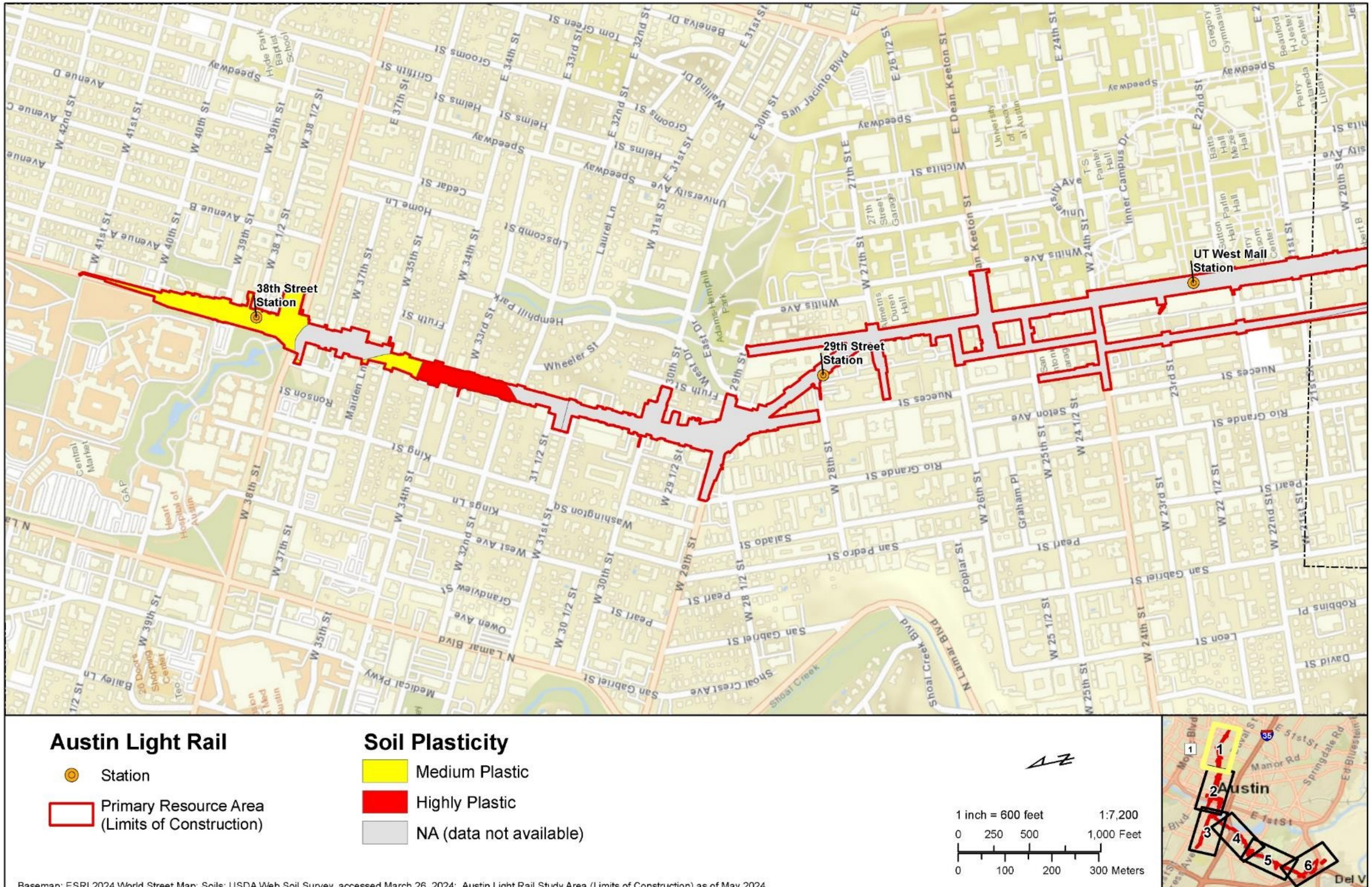


Figure 26: Plasticity Class of Mapped Soil Units in the Study Area, Sheet 2

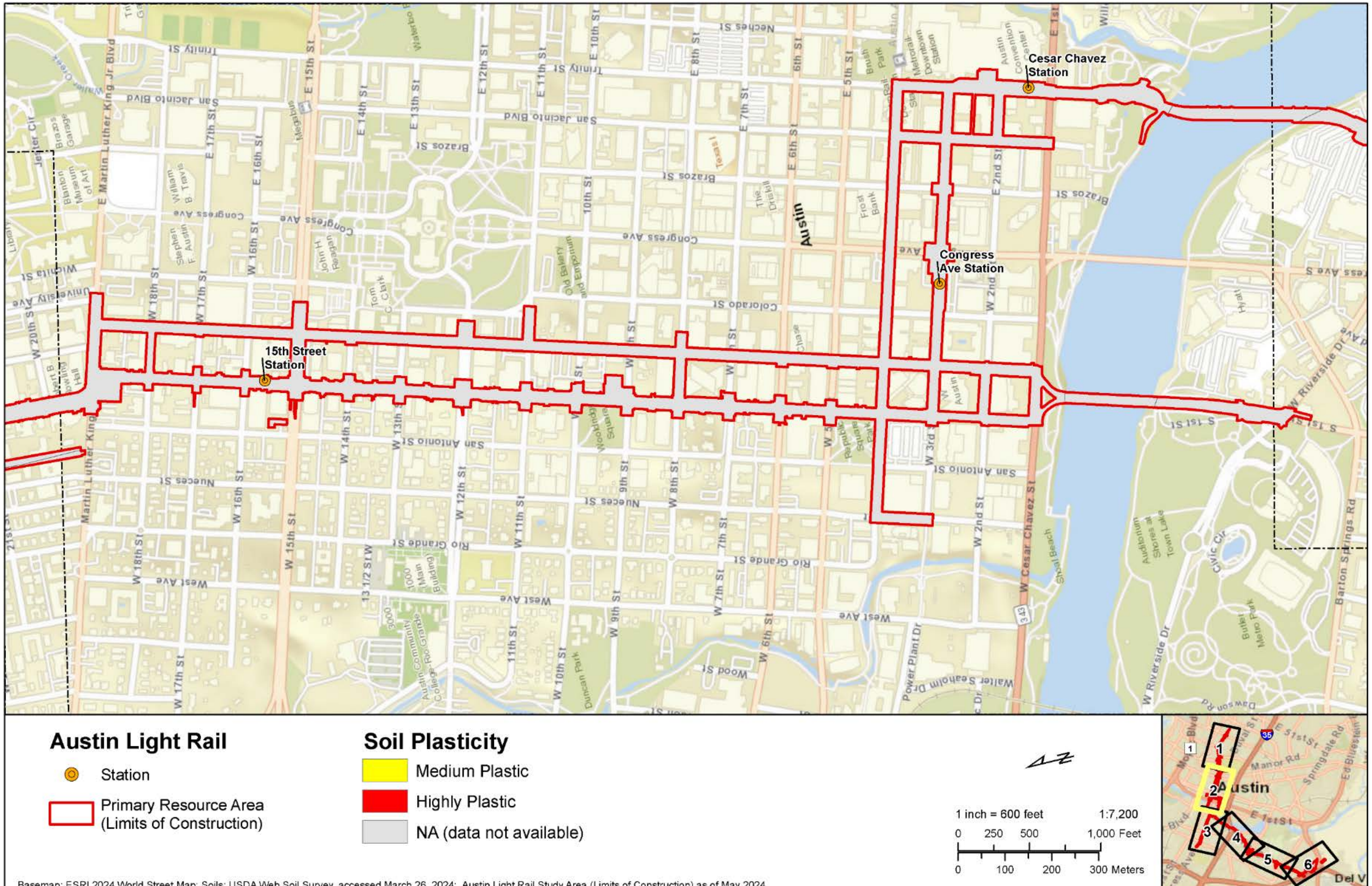


Figure 27: Plasticity Class of Mapped Soil Units in the Study Area, Sheet 3

Figure 28: Plasticity Class of Mapped Soil Units in the Study Area, Sheet 4

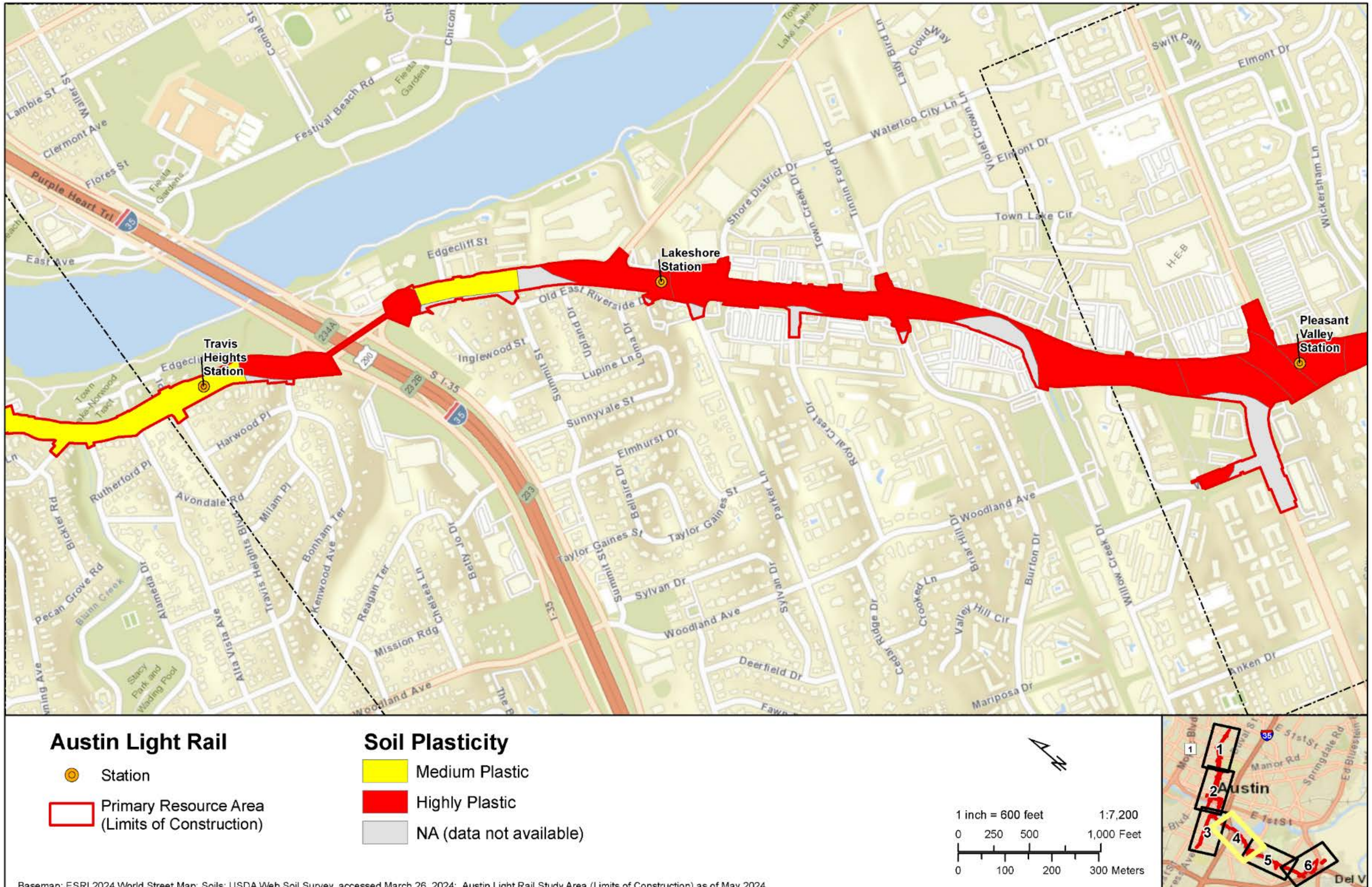


Figure 29: Plasticity Class of Mapped Soil Units in the Study Area, Sheet 5

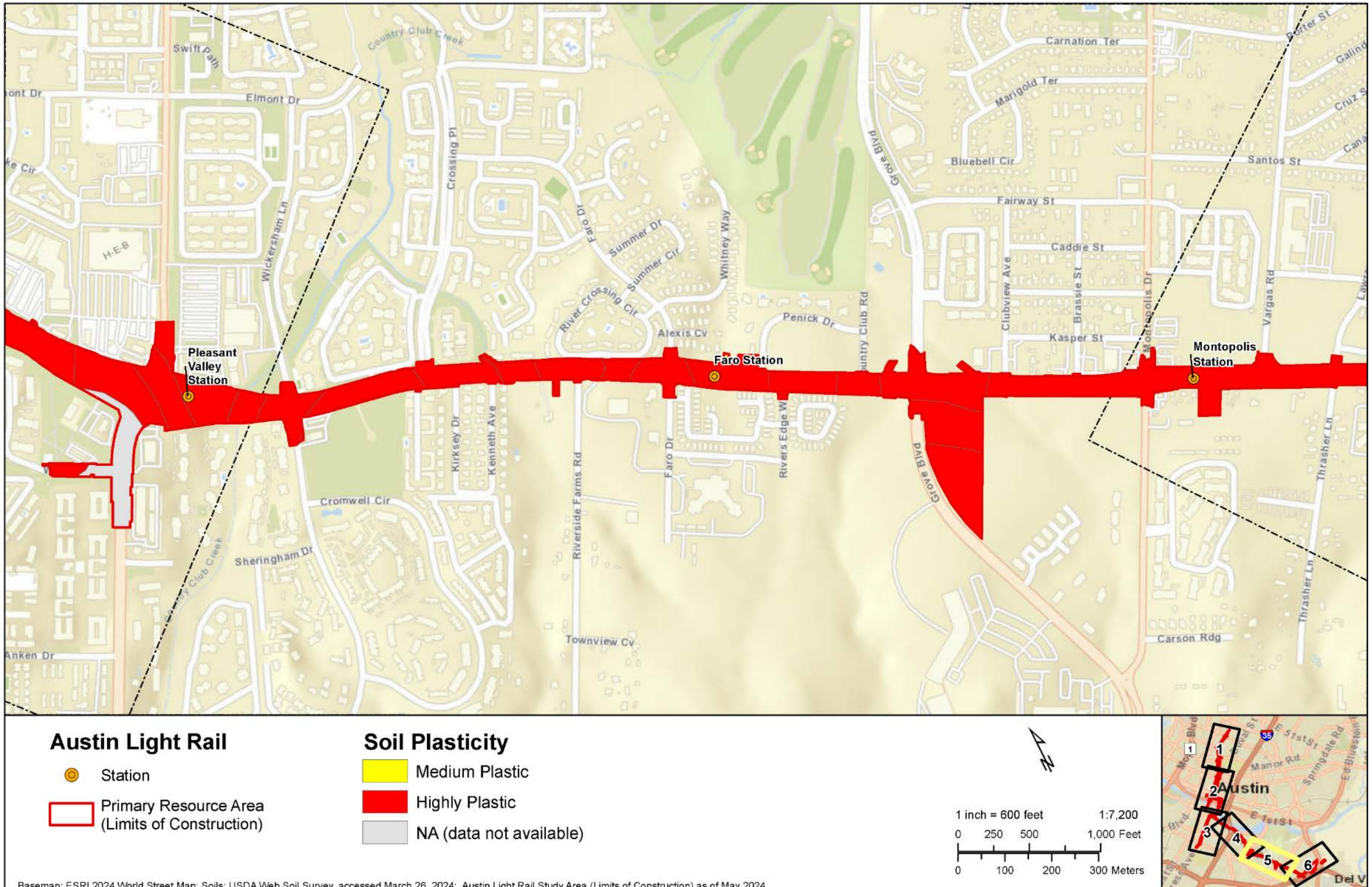
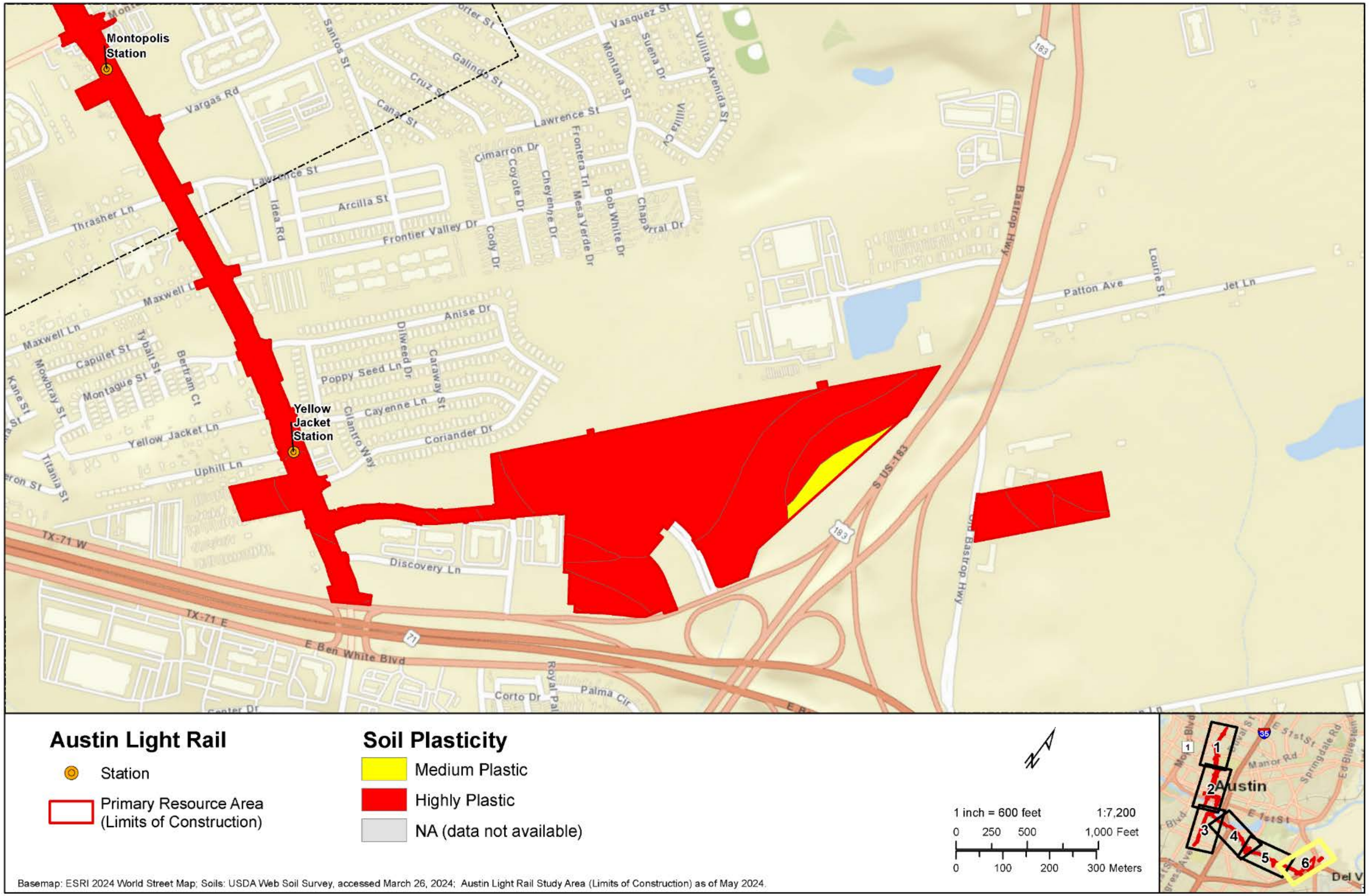


Figure 30: Plasticity Class of Mapped Soil Units in the Study Area, Sheet 6



4.1.2.5 Prime and Unique Farmland

Prime farmland soil units within the Study Area include the *Bergstrom silty clay loam, 0 to 1% slopes; rarely flooded (BgA); Houston Black clay, 0 to 1 percent slopes (HnA)*; and *Houston Black clay, 1 to 3 percent slopes (HnB)*. Bergstrom and Houston Black soils occur in patches along creeks and drainages within a highly developed urban area. The Bergstrom soil is found near the operations and maintenance facility, and both Houston Black soils are found between the Pleasant Valley Station and the Faro Station as well as the operations and maintenance facility (see **Figure 1** through **Figure 4** and **Table 2**). These soils are described as clayey residuum weathered from calcareous mudstone and are typically more than 6.6 feet deep. However, prime farmland is defined by soil properties only and does not take into consideration existing urban development.

According to NRCS (2023c, 2023d), the *Wilson clay loam, 0 to 1 percent slopes (WiA)* and *Wilson clay loam, 1 to 3 percent slopes (WiB)* are designated as a farmland soil of statewide importance within the Study Area. These soils occur in the Study Area near the Yellow Jacket Station and at the operations and maintenance facility (see **Figure 1** through **Figure 4**; and **Table 2**). According to available aerial imagery, this area generally is developed for residential and commercial use. No portion is currently in use for agriculture.

4.2 Geology

4.2.1 Physiographic Setting

The Project is located along the Balcones Fault Zone that forms the boundary of the Edwards Plateau and Blackland Prairies physiographic regions of Texas. The Balcones Fault Zone also forms the Balcones Escarpment, which is a highly eroded region bordering the Edwards Plateau on the south and west. The region is typified by higher elevations to the north and west, generally sloping to the southeast. Elevations across the Edwards Plateau range from over 3,000 feet above mean sea level to slightly less than 450 feet above mean sea level (University of Texas at Austin, Bureau of Economic Geology 1996). To the east of the Balcones Fault Zone lies the Blackland Prairies. The Blackland Prairies are typified by low, rolling terrain with beds of chalks and marls tilted to the south and east. Elevations across the Blackland Prairies range from 1,000 feet above mean sea level to slightly less than 450 feet above mean sea level (University of Texas at Austin, Bureau of Economic Geology 1996). Locally across each region, canyons and drainage basins were formed by surface flow of the Colorado River and its tributaries, which also drain the Study Area.

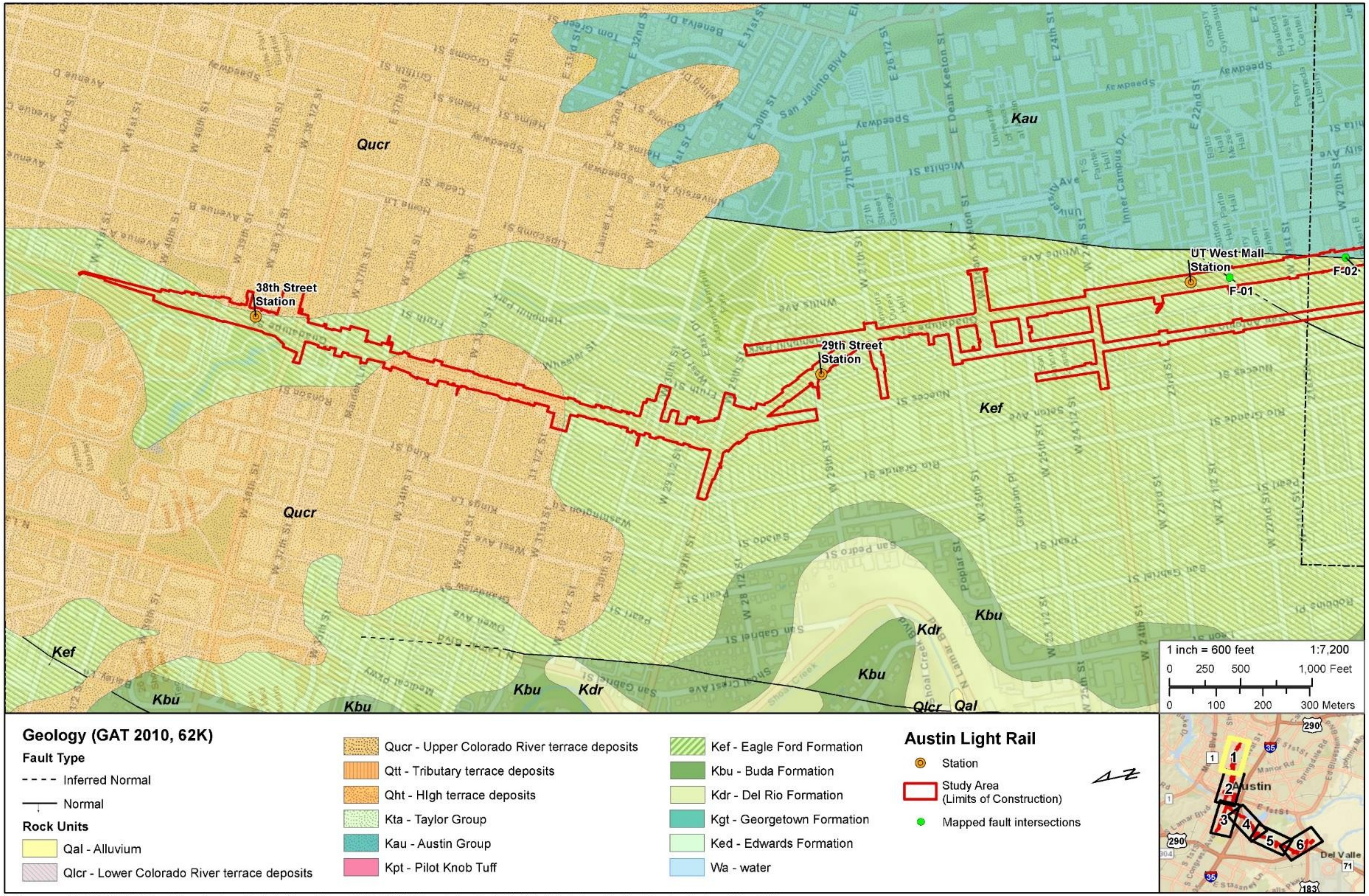
The Edwards Plateau is commonly associated with the Trinity and Edwards Aquifers, highly soluble limestone aquifers formed from dissolution of limestone. This type of aquifer is referred to as a karst aquifer and is characterized by surface and subsurface expression of caves, sinkholes, enlarged fractures, and other pathways for infiltrating surface runoff to recharge the aquifer. While often requiring protective measures to prevent groundwater contamination, karst features can also present as geologic hazards for land development if not properly understood. Additional information regarding karst geology is provided below.

Topography within the Study Area is gently undulating to rolling with surface elevation decreasing toward Lady Bird Lake and the Colorado River below Longhorn Dam / Lady Bird Lake. The highest elevation is at the northernmost point of the Study Area at approximately 620 feet above mean sea level (USGS 2019). The lowest elevation is in the central portion of the Study Area along Lady Bird Lake at approximately 430 feet above mean sea level (USGS 2019). The Study Area does not pass over portions of the Edwards Plateau with hydrogeological connections to the Edwards or Trinity Aquifers, but both aquifers occur under the portions of the Project. The highly karstified limestone units associated with the Edwards Aquifer recharge zone are generally found outcropping 1 to 2 miles west of the Study Area. Additional information regarding water resources, including groundwater, is provided in **FEIS Appendix F-4**.

4.2.2 Mapped Surface Geology

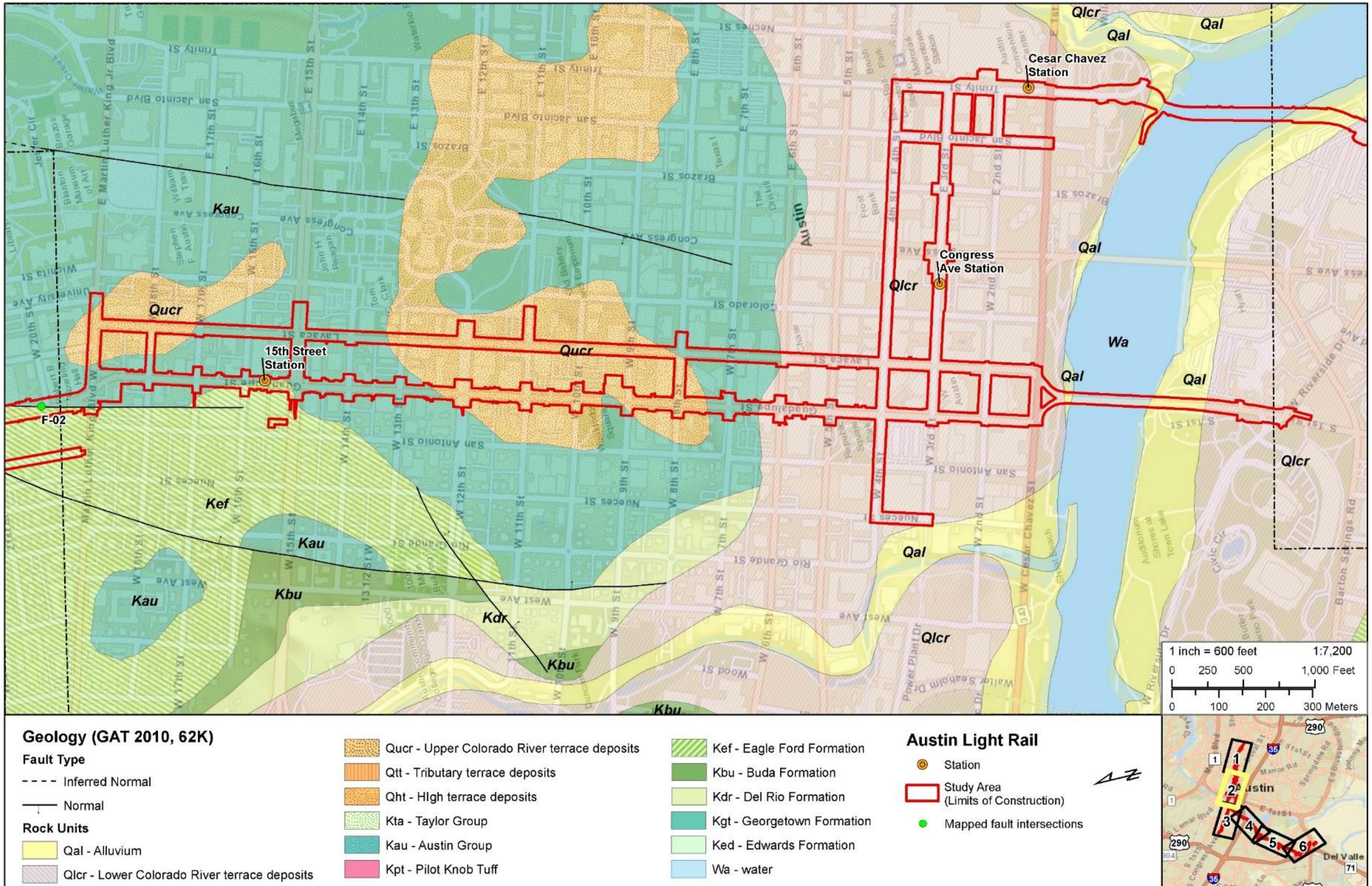
The geologic formations occurring within the Study Area are composed mostly of Cretaceous rocks with Quaternary alluvium deposits overlying areas along surface drainages (see **Figure 31** through **Figure 34**; note that mapped fault lines are depicted and further are discussed in Section 4.3). The limestone bedrock in the Study Area developed from the accumulation of thick sequences of marine sediments deposited in a lagoon environment on the San Marcos Platform protected by a barrier reef during the Cretaceous period about 100 million years ago (Rose 1972). In descending order of deposition, the units mapped at the surface of the Study Area include *Alluvium (Qal)*, *High Gravel Deposits (Qhg)*, *Fluvial Terrace Deposits (Qt)*, *Taylor (Kta)*, *Austin Chalk (Kau)*, *Eagle Ford Shale (Kef)*, and the *Del Rio Clay & Georgetown formations (undivided) (Kdg)*. **Figure 37** is a stratigraphic column showing the mapped surface units and their hydro-stratigraphic units. Descriptions of mapped units modified from the Geologic Atlas of Texas, Austin Sheet (Barnes et al. 1974; USGS 2023b) are provided in **Table 3**. In particular, the Austin Chalk is a relatively dense and competent limestone, with minimal karst development expected in the Study Area. Underlying layers, namely the Eagle Ford Formation, Del Rio Clay, and Georgetown Formations, are recognized as upper confining units of the Edwards Aquifer and reduce potential for groundwater contamination from infiltrating surface waters. Faults near the Study Area are presented in **Figure 31** through **Figure 36**. Approximately 61.2 percent of the Study Area consists of Quaternary deposits while 37.1 percent consists of Cretaceous limestone, with the remaining 0.9 percent mapped as water.

Figure 31: Mapped Surface Geology in the Study Area, Sheet 1



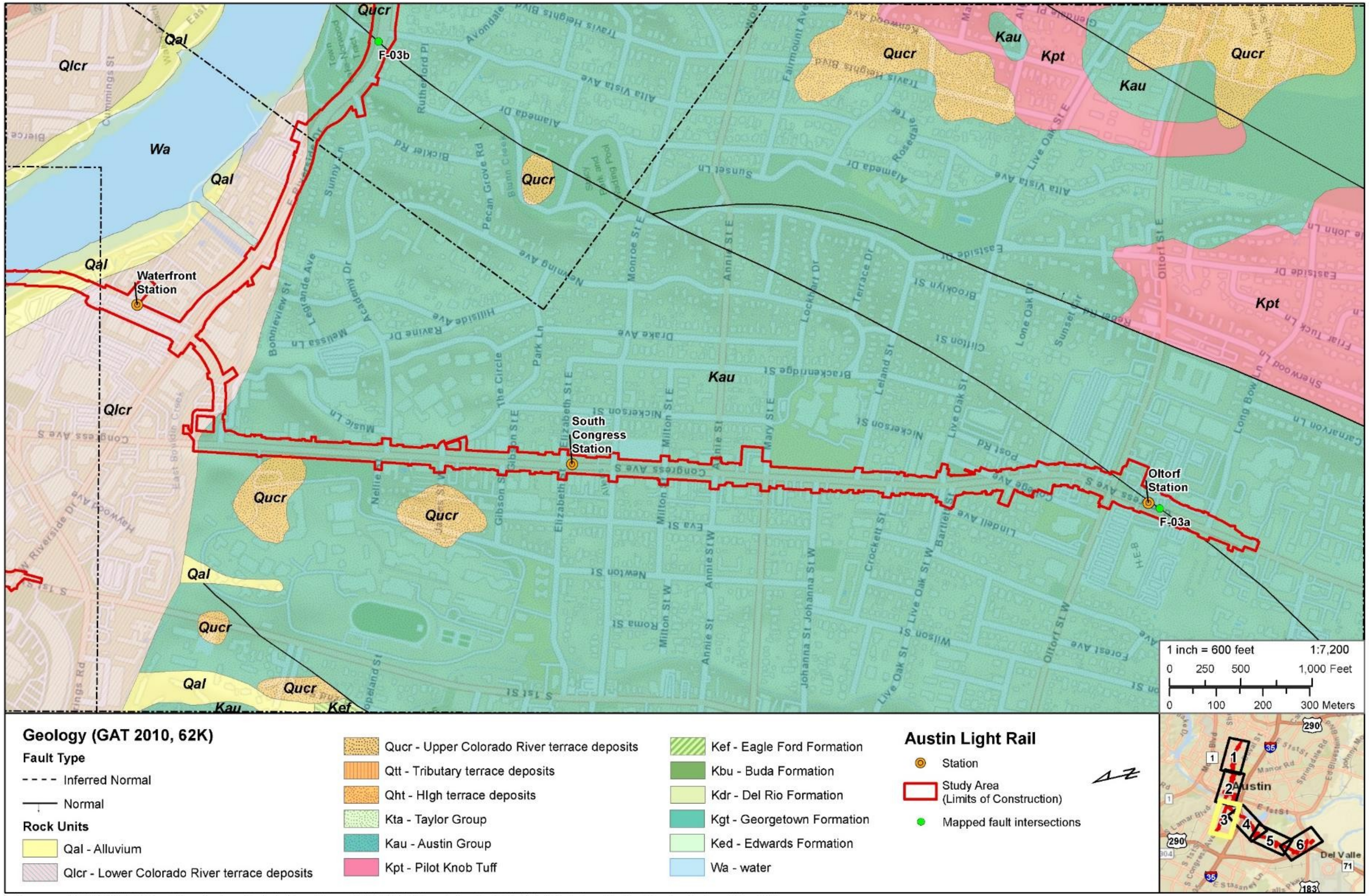
Basemap: ESRI 2024 World Street Map; Geology: Geologic Atlas of Texas (GAT) 2010, 62K resolution; Austin Light Rail Study Area (Limits of Construction) as of May 2024.

Figure 32: Mapped Surface Geology in the Study Area, Sheet 2



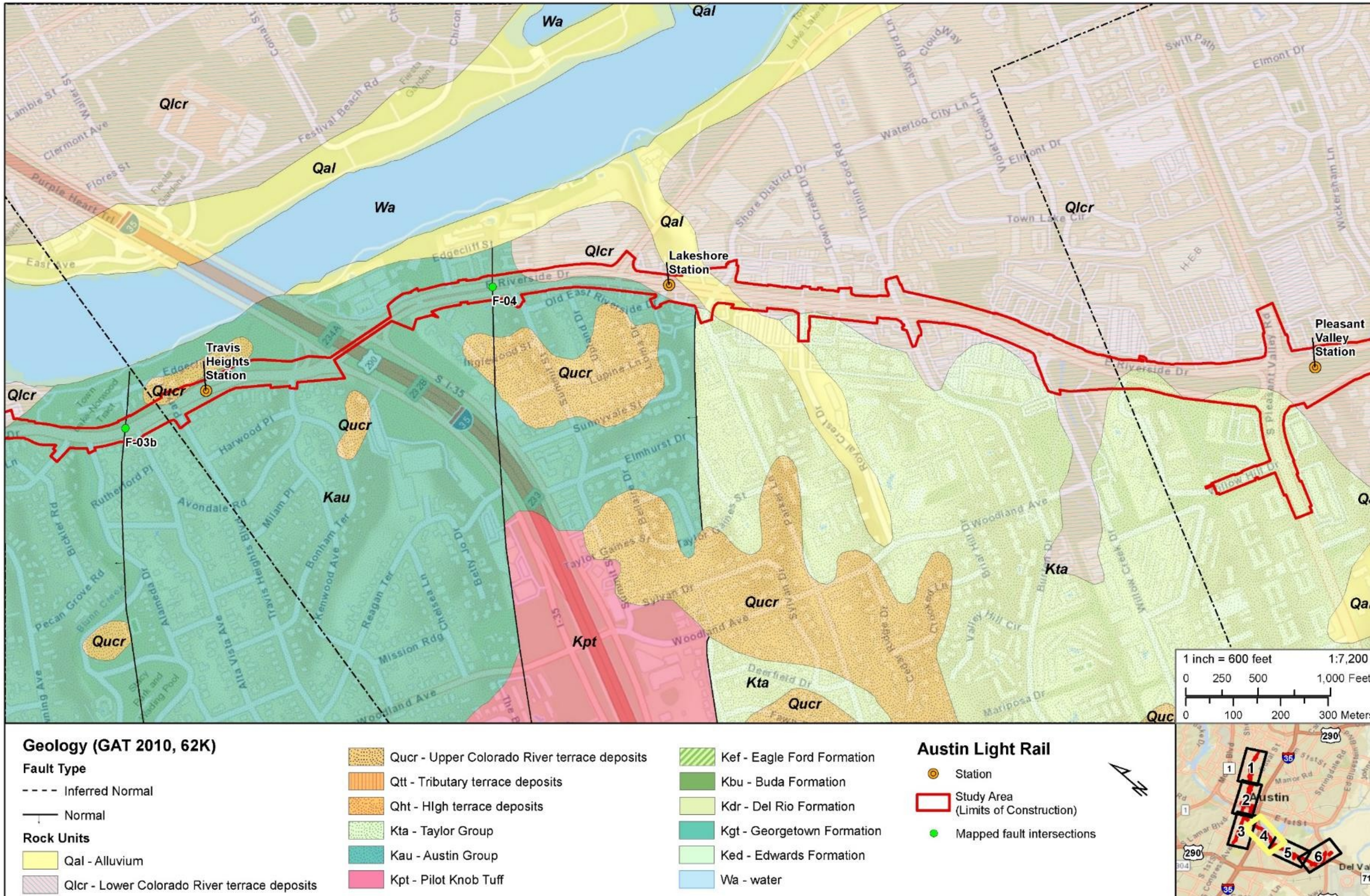
Basemap: ESRI 2024 World Street Map; Geology: Geologic Atlas of Texas (GAT) 2010, 62K resolution; Austin Light Rail Study Area (Limits of Construction) as of May 2024.

Figure 33: Mapped Surface Geology in the Study Area, Sheet 3



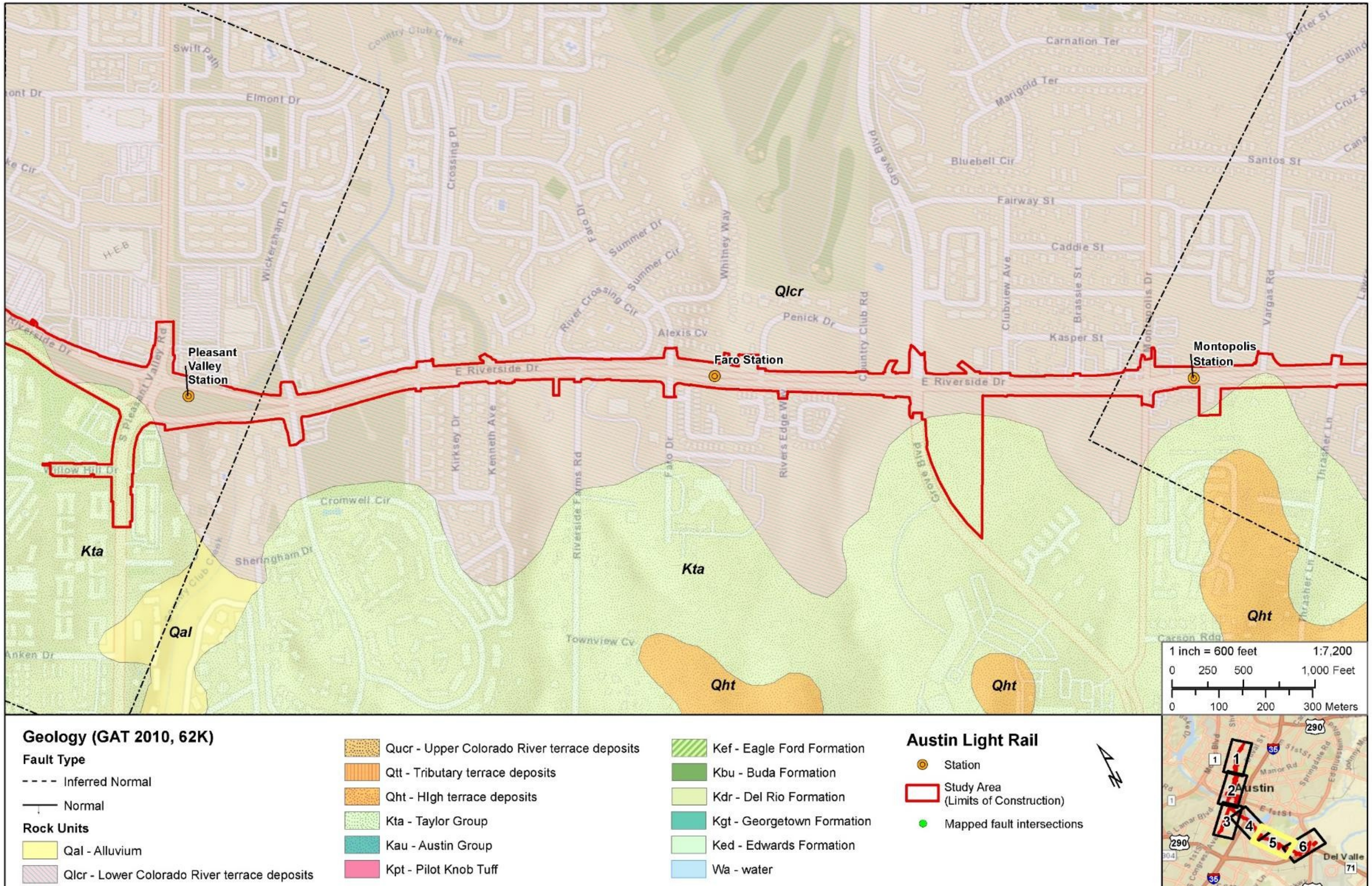
Basemap: ESRI 2024 World Street Map; Geology: Geologic Atlas of Texas (GAT) 2010, 62K resolution; Austin Light Rail Study Area (Limits of Construction) as of May 2024.

Figure 34: Mapped Surface Geology in the Study Area, Sheet 4



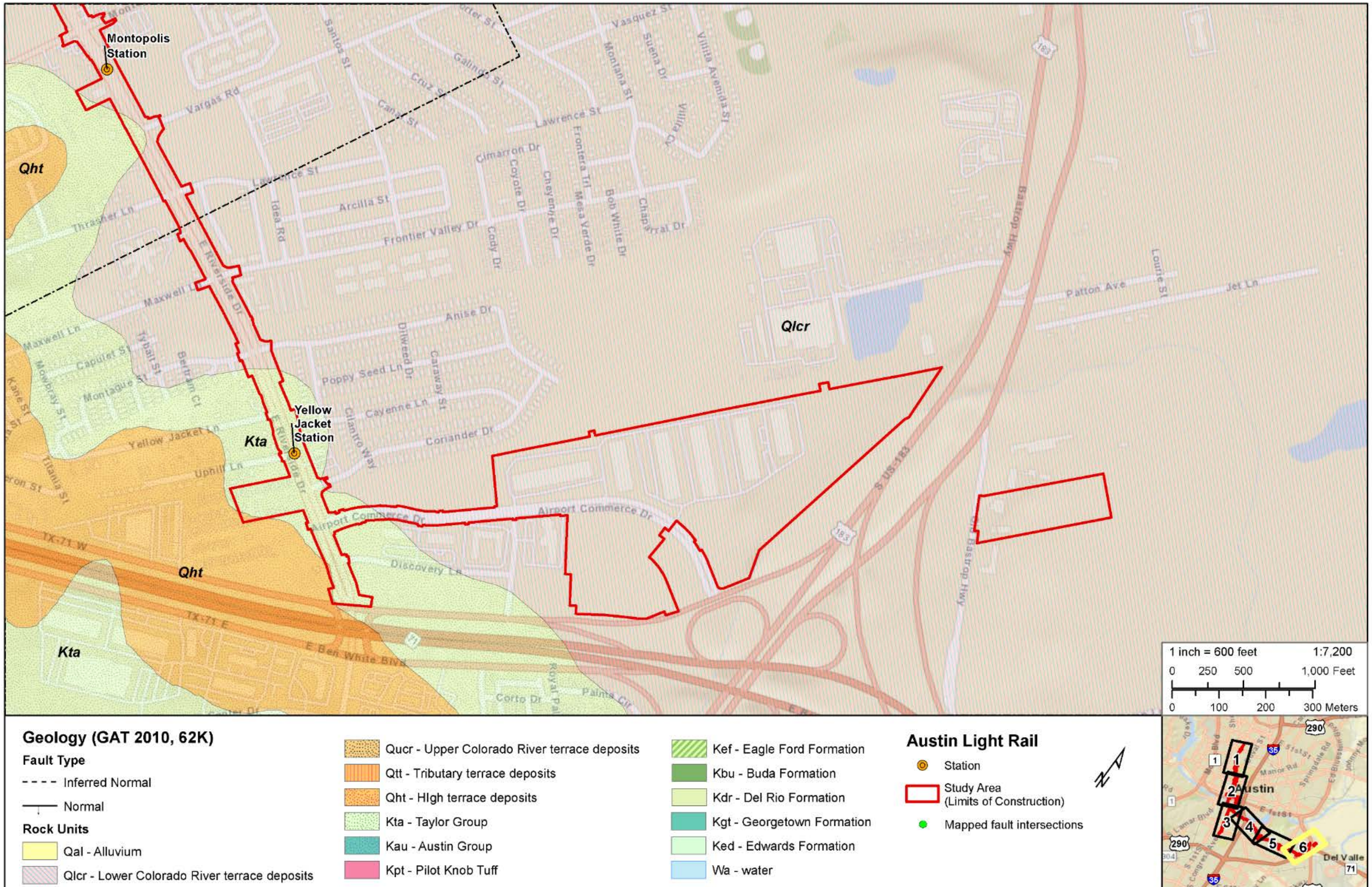
Basemap: ESRI 2024 World Street Map; Geology: Geologic Atlas of Texas (GAT) 2010, 62K resolution; Austin Light Rail Study Area (Limits of Construction) as of May 2024.

Figure 35: Mapped Surface Geology in the Study Area, Sheet 5



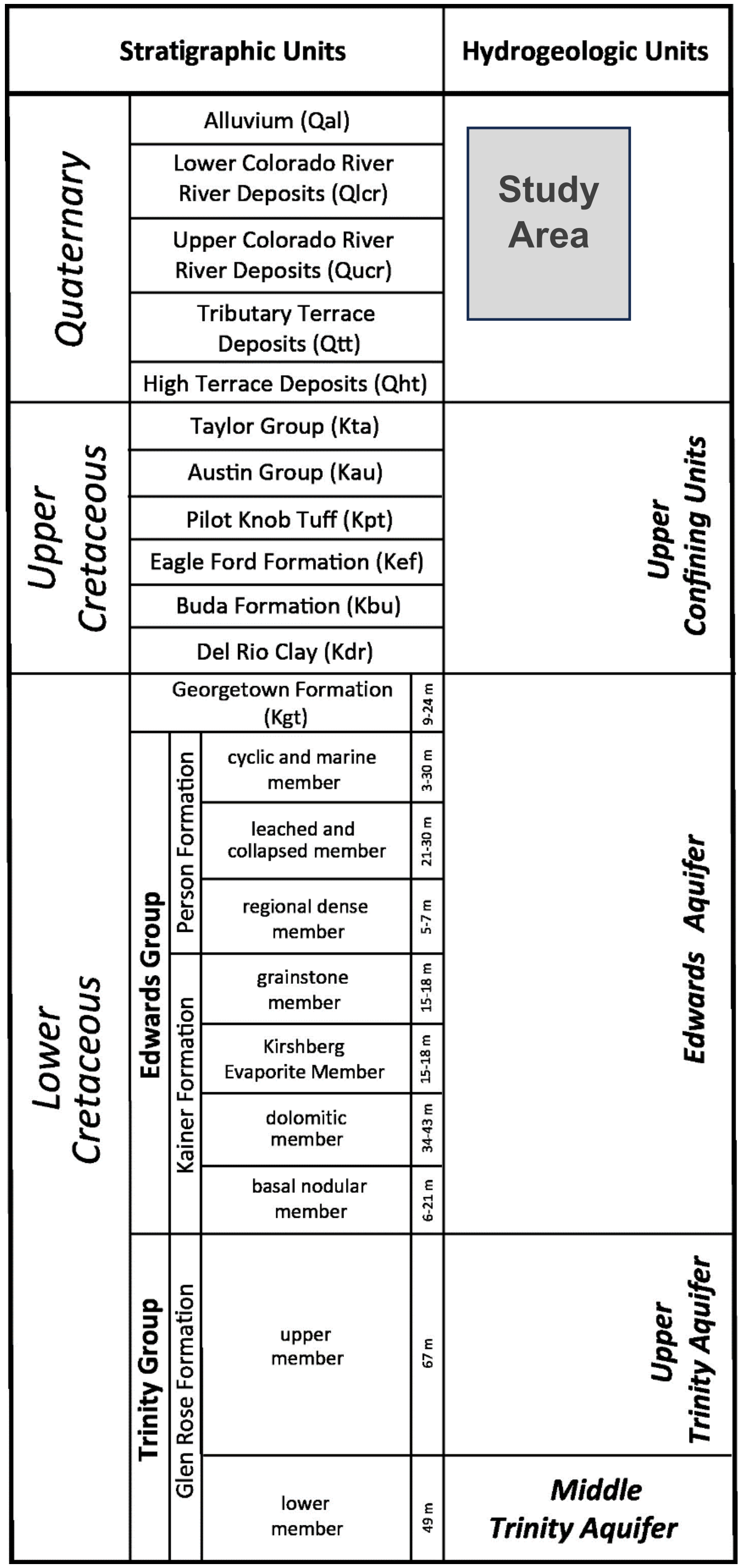
Basemap: ESRI 2024 World Street Map; Geology: Geologic Atlas of Texas (GAT) 2010, 62K resolution; Austin Light Rail Study Area (Limits of Construction) as of May 2024.

Figure 36: Mapped Surface Geology in the Study Area, Sheet 6



Basemap: ESRI 2024 World Street Map; Geology: Geologic Atlas of Texas (GAT) 2010, 62K resolution; Austin Light Rail Study Area (Limits of Construction) as of May 2024.

Figure 37: Stratigraphic Column of Geologic Units Mapped in the Study Area



Source: Modified from Lindgren et al. 2004 and Barnes et al. 1974.

Table 3: Descriptions of Mapped Geologic Units in the Study Area

Map Symbol	Unit/ Formation	Age	Description	Area in Study Area (ac)	% of Study Area[1]
Qal	Alluvium	Quaternary/ Pleistocene	Floodplain and low terrace deposits; clay, silt, sand, and gravel; sand largely quartz, gravel mostly chert, quartzite, limestone, and petrified wood; also reworked igneous and metamorphic rock along the Colorado River; fluvial morphology preserved with point bars, oxbows, and channel deposits.	4.0	1.3
Qlcr	Lower Colorado River Terrace Deposits	Quaternary/ Pleistocene	Fluvial deposits along the Colorado River; variable amounts of clay, silt, sand, and gravel; yellow to orange-brown.	167.4	54.8
Qucr	Upper Colorado River Terrace Deposits	Quaternary/ Pleistocene	Fluvial deposits along the Colorado River; variable amounts of clay, silt, sand, and gravel; brown orange brown.	17.5	5.7
Qht	High Terrace Deposits	Quaternary/ Pleistocene	Gravel commonly exposed to the surface, in northwest part of Austin Sheet (1974) composed of an upper silty clay unit good for crop production and a lower coarse unit that yields some water (possibly correlates with the Onion Creek Marl); thickness of limestone gravel 5–25 feet.	0.2	<0.1

Map Symbol	Unit/ Formation	Age	Description	Area in Study Area (ac)	% of Study Area[1]
Kta	Taylor Group	Cretaceous/ Gulfian	Clay, marine mudstone with calcareous content decreasing upward, montmorillonitic; some glauconite, hematite, and pyrite nodules; variable amounts of quartz and calcite fragments; weathers light gray to grayish orange and white; poor fissility; thickness 600+ feet.	23.1	7.6
Kau	Austin Group	Cretaceous/ Gulfian	Upper and lower parts: chalk, mostly microgranular calcite, massive, some interbeds and partings of calcareous clay; thin bentonitic locally in lower part, lower part forms westward-facing scarp; light gray. Middle part: mostly thin-bedded marl with interbeds of massive chalk, locally burrowed, marcasite-pyrite modules common, light gray. Weathers white; marine mega fossils scarce; thickness 300–500 feet; thins southward.	55.9	18.3
Kef	Eagle Ford Formation	Cretaceous/ Gulfian	Upper formation is limestone and shale, light yellowish-brown, flaggy; lower part is siltstone and very fine-grained sandstone, light yellow to gray, laminated flaggy, some limestone, silty, medium brown, laminated; thickness 75–200 feet, thins toward the northeast.	34.3	11.2
Wa	Water	--	Water	2.8	0.9
			Totals	**305.3**	**100.0**

1 Excludes 106 acres of water (4% of Study Area)

4.2.3 Karst Geology

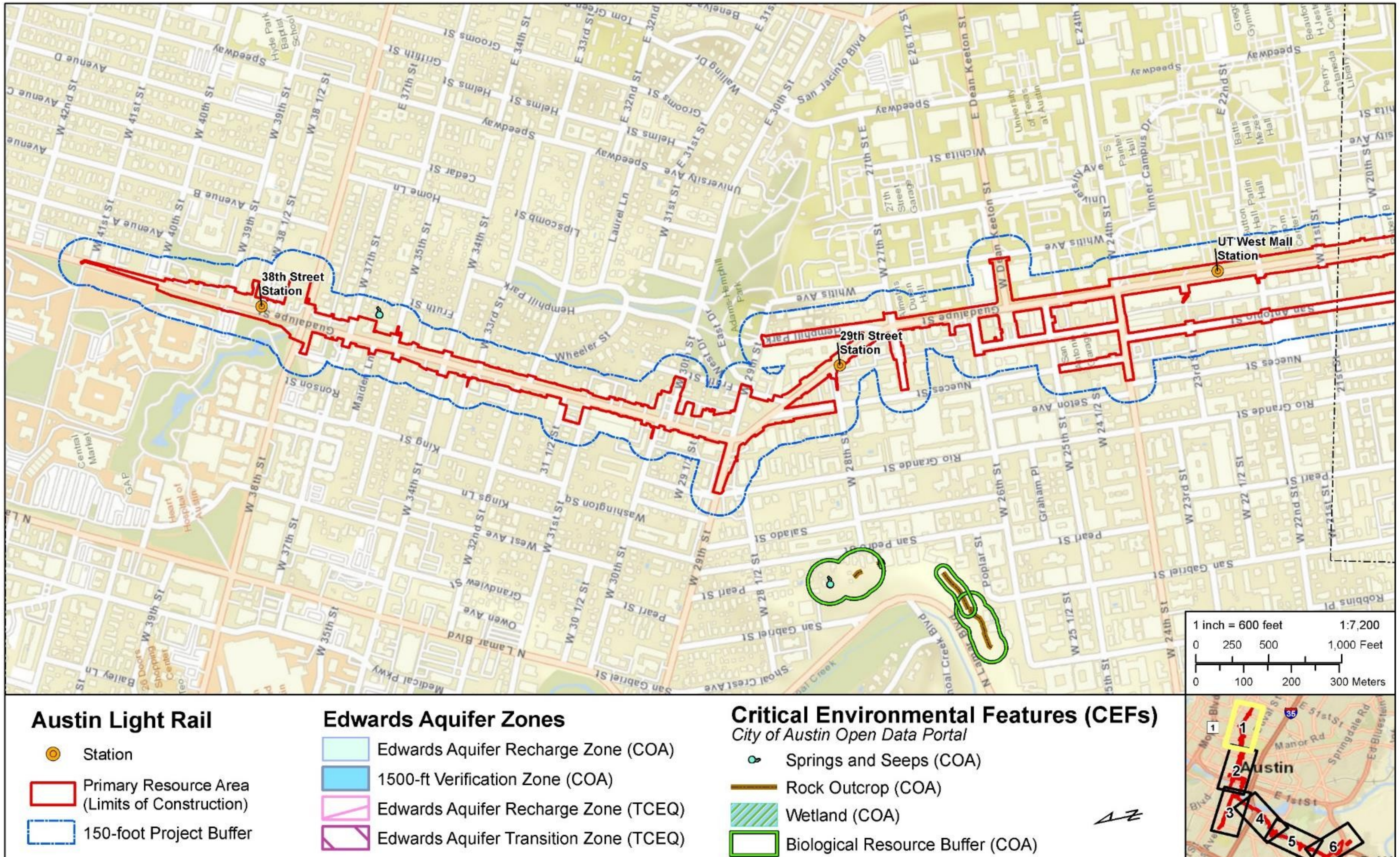
The Study Area is located within an expansive karst landscape that extends south from Dallas to San Antonio and west toward Del Rio, Texas. It contains thick-bedded to massive Cretaceous limestones and some dolomite beds from the Edwards Group and Glen Rose, Buda, Georgetown, Austin, and Anacacho Formations. Faults are generally downthrown toward the Gulf of Mexico (Rose 1972). Karst is a type of geological formation where the dissolving of the bedrock has created sinkholes, sinking streams, caves, springs, voids, and other characteristic features. Karst is associated with soluble rock types such as limestone, marble, and gypsum. In general, a typical karst landscape forms when much of the water falling on the surface interacts with and enters the subsurface through cracks, fractures, and holes that have been dissolved into the bedrock. After traveling underground, sometimes for long distances, this water is then discharged from springs, many of which are cave entrances.

The Edwards and Trinity Aquifers, which are situated near the Study Area, are karst aquifers that exhibit high porosity and permeability. The karst geology allows for the transmission of large volumes of water into the aquifer, which means that during rainfall events the aquifer is able to recharge quickly (Edwards Aquifer Authority 2023). The Study Area is located over confined portions of both the Edwards and Trinity Aquifers, where the Edwards overlies the Trinity; thus, this assessment focuses primarily on characterizing potential effects on the Edwards Aquifer. The Study Area is located near, but outside of (beyond 150 feet), Edwards Aquifer regulatory zones. Additional information regarding karstic geology and groundwater is included in **FEIS Appendix F-4** and **FEIS Appendix F-5**. The TCEQ and City Edwards Aquifer regulatory zones are shown in **Figure 38** through **Figure 41**.

4.2.4 Critical Environmental Features

The Study Area potentially contains CEFs along Lady Bird Lake and its tributaries. According to the City, bluffs and rimrocks are located along the south bank of Lady Bird Lake below Interstate 35, near the Travis Heights Station. Point recharge features such as caves and sinkholes are not common in the geologic units mapped in the Study Area and are not likely to be encountered during Project construction. Springs and seeps can be found in cutbanks of creeks in the Study Area; however, the location and flow rate of springs is dependent on recharge and is seasonally variable. Wetlands identified by the City are located along the banks of Waller Creek and Country Club Creek and along the south bank of Lady Bird Lake between South Congress Avenue and South Pleasant Valley Road (City of Austin 2023). An additional spring/seep is located south of 38th Street within 150 feet of, but outside of, the Study Area. A karst feature and CEF survey would be necessary to identify any unrecorded CEFs potentially affected by Project operations and to establish the appropriate protective buffers for such features. Additional information regarding CEFs is provided in **FEIS Appendix F-4**. The identified CEFs within the Study Area are shown in **Figure 38** through **Figure 43**.

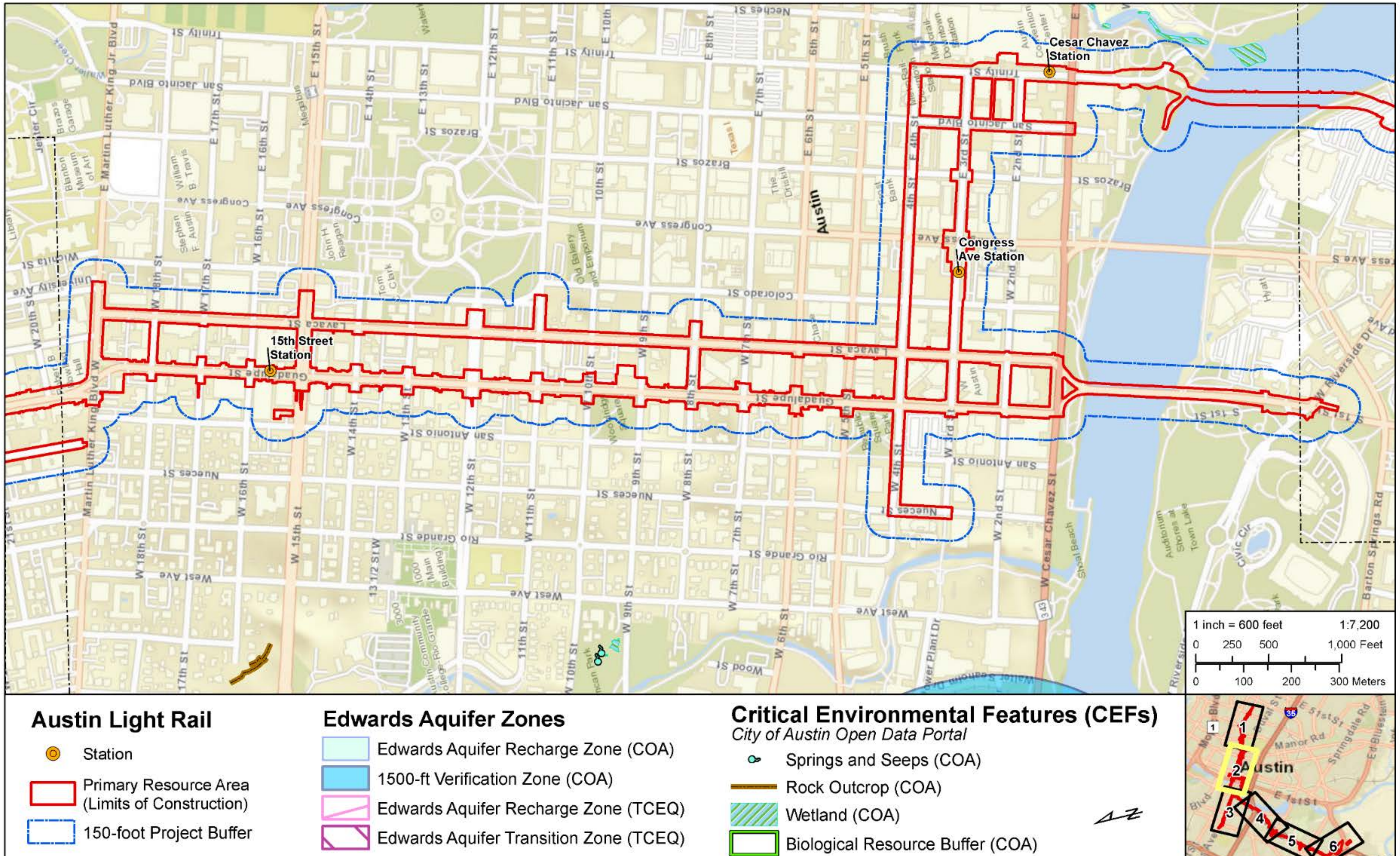
Figure 38: Known CEFs Mapped in the Study Area, Sheet 1



NOTE: Map does not include CEFs or Resource Buffers that may be present but are not included in the publicly available data at the City of Austin Open Data Portal (data.austintexas.gov), accessed January 2024.

Basemap: ESRI 2024 World Street Map; CEFs: COA Open Data Portal, accessed January 15, 2024; Edwards Aquifer Zones: TCEQ 2005 and COA Open Data Portal, accessed October 15, 2023. Austin Light Rail Study Area (Limits of Construction) as of May 2024.

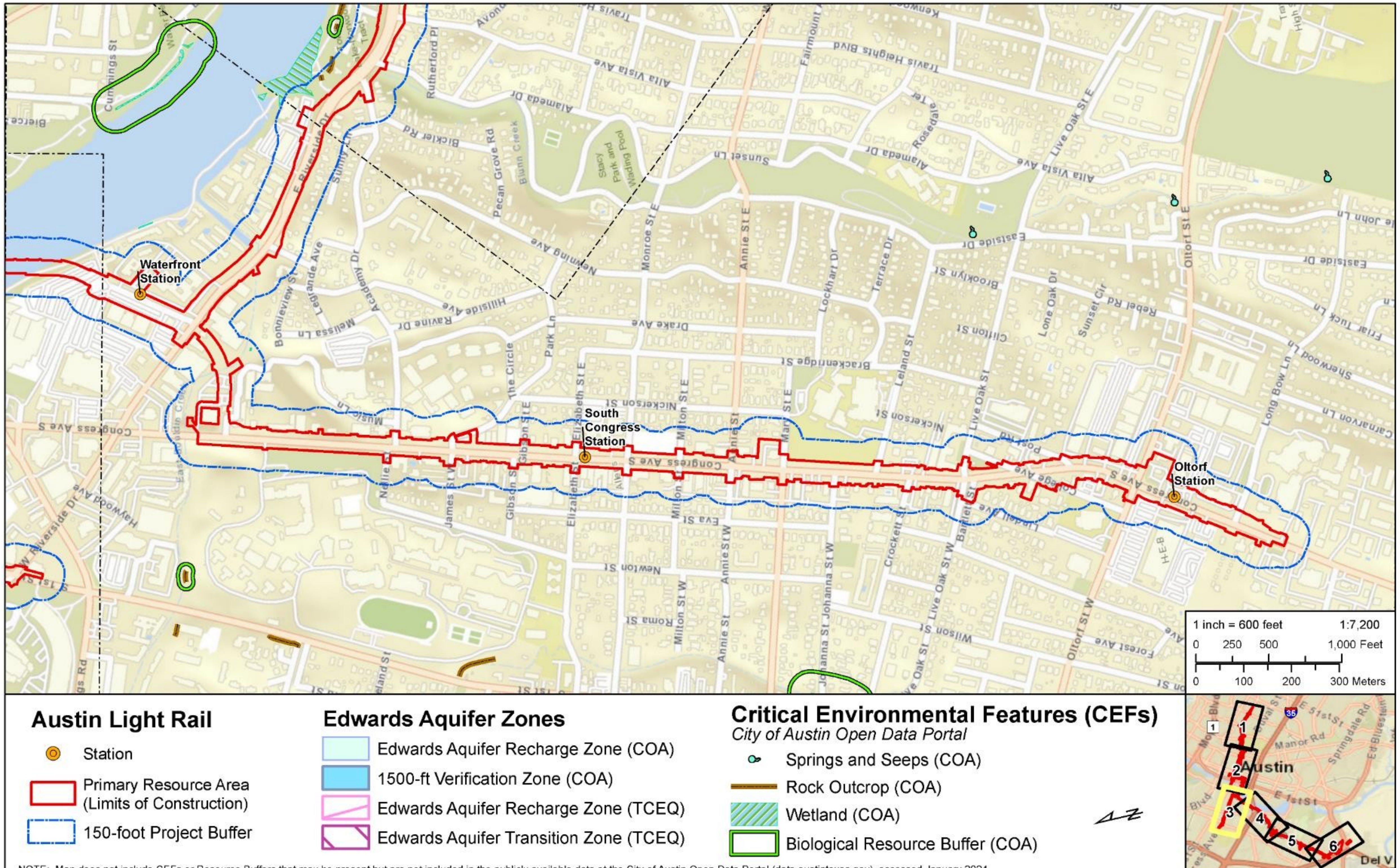
Figure 39: Known CEFs Mapped in the Study Area, Sheet 2



NOTE: Map does not include CEFs or Resource Buffers that may be present but are not included in the publicly available data at the City of Austin Open Data Portal (data.austintexas.gov), accessed January 2024.

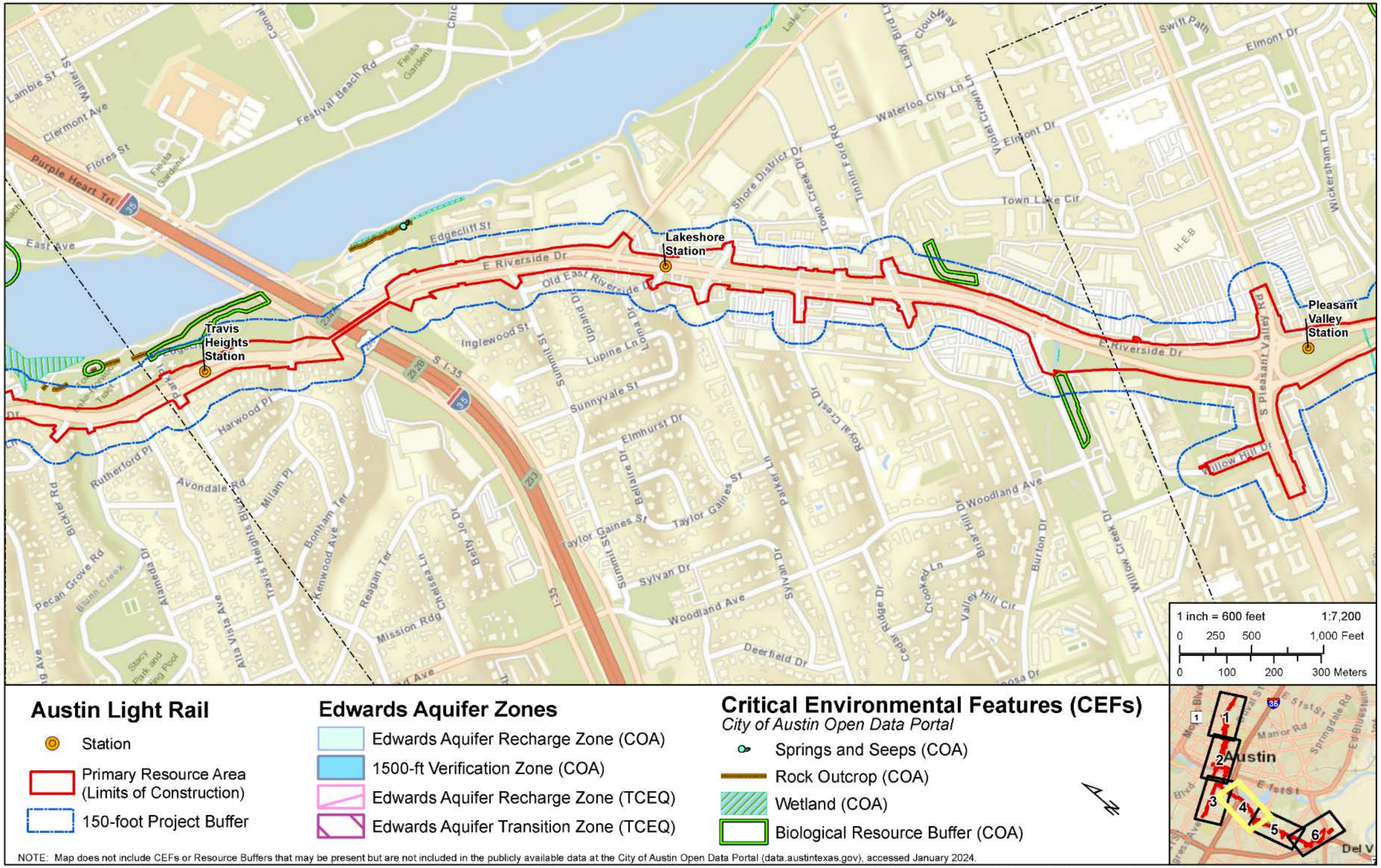
Basemap: ESRI 2024 World Street Map; CEFs: COA Open Data Portal, accessed January 15, 2024; Edwards Aquifer Zones: TCEQ 2005 and COA Open Data Portal, accessed October 15, 2023. Austin Light Rail Study Area (Limits of Construction) as of May 2024.

Figure 40: Known CEFs Mapped in the Study Area, Sheet 3



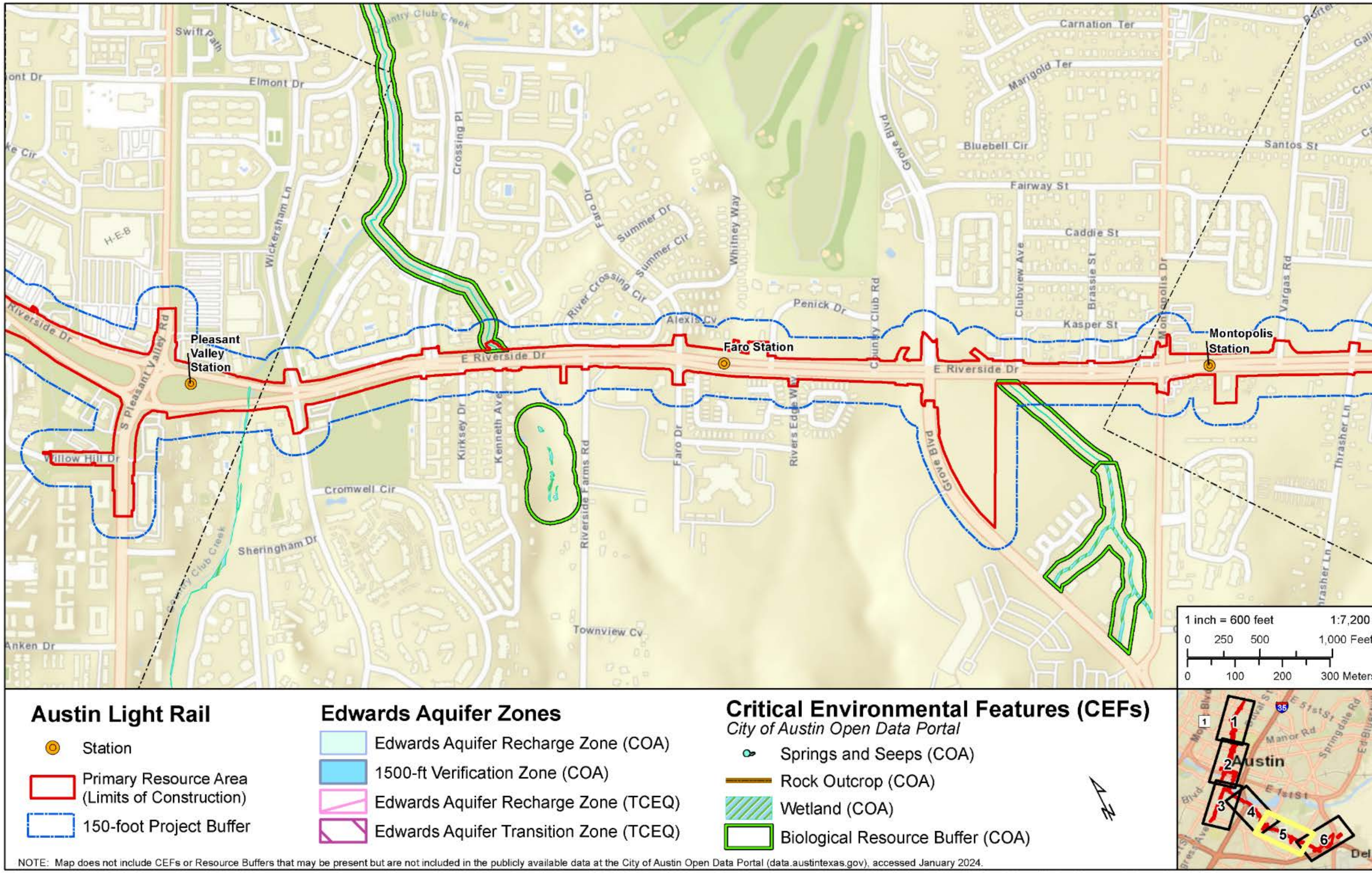
Basemap: ESRI 2024 World Street Map; CEFs: COA Open Data Portal, accessed January 15, 2024; Edwards Aquifer Zones: TCEQ 2005 and COA Open Data Portal, accessed October 15, 2023. Austin Light Rail Study Area (Limits of Construction) as of May 2024.

Figure 41: Known CEFs Mapped in the Study Area, Sheet 4



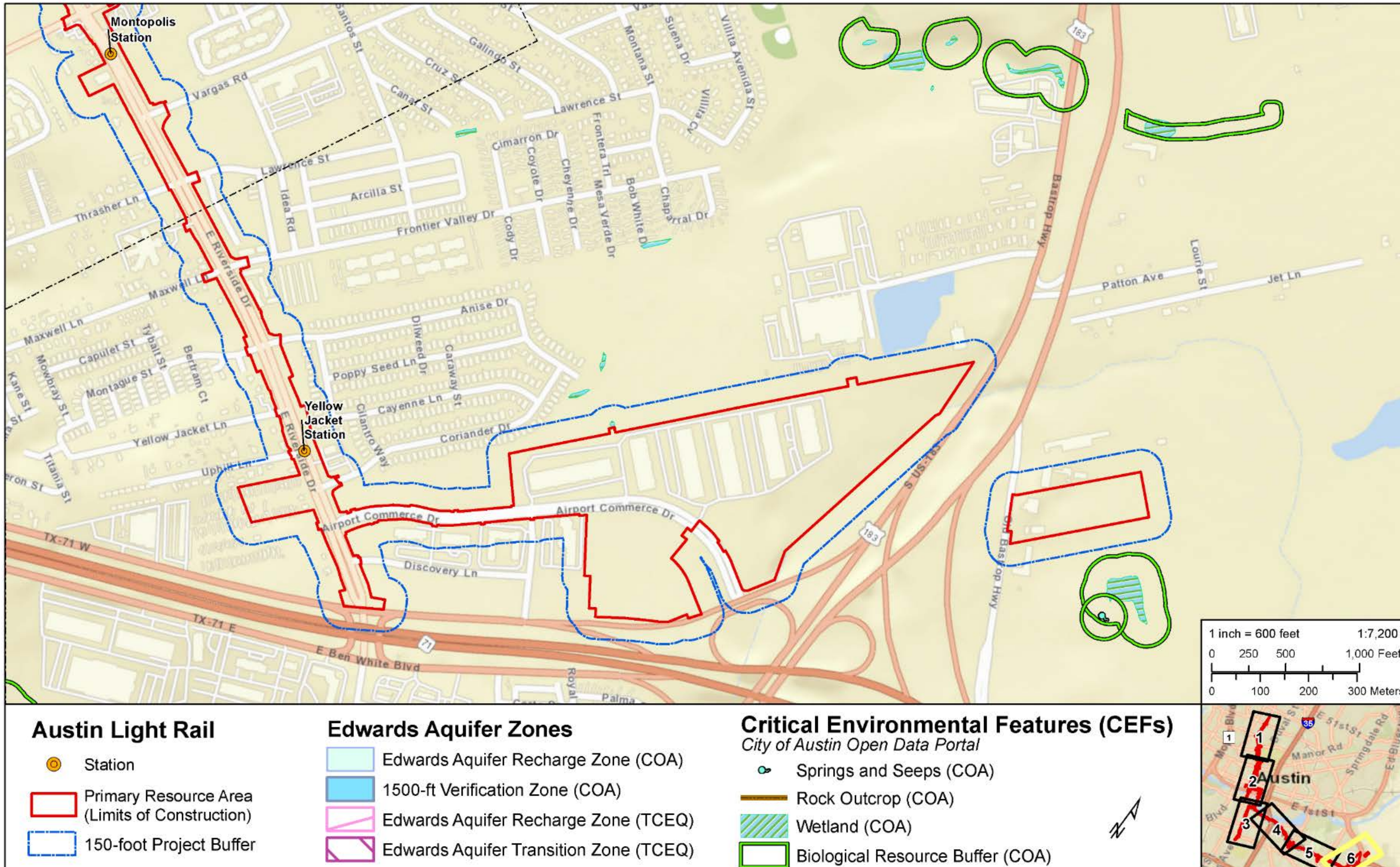
Basemap: ESRI 2024 World Street Map; CEFs: COA Open Data Portal, accessed January 15, 2024; Edwards Aquifer Zones: TCEQ 2005 and COA Open Data Portal, accessed October 15, 2023. Austin Light Rail Study Area (Limits of Construction) as of May 2024.

Figure 42: Known CEFs Mapped in the Study Area, Sheet 5



Basemap: ESRI 2024 World Street Map; CEFs: COA Open Data Portal, accessed January 15, 2024; Edwards Aquifer Zones: TCEQ 2005 and COA Open Data Portal, accessed October 15, 2023. Austin Light Rail Study Area (Limits of Construction) as of May 2024.

Figure 43: Known CEFs Mapped in the Study Area, Sheet 6



NOTE: Map does not include CEFs or Resource Buffers that may be present but are not included in the publicly available data at the City of Austin Open Data Portal (data.austintexas.gov), accessed January 2024.

Basemap: ESRI 2024 World Street Map; CEFs: COA Open Data Portal, accessed January 15, 2024; Edwards Aquifer Zones: TCEQ 2005 and COA Open Data Portal, accessed October 15, 2023. Austin Light Rail Study Area (Limits of Construction) as of May 2024.

4.3 Seismicity

The Balcones Fault Zone consists of a series of normal faults with hanging walls generally down dropping to the southeast toward the Gulf of Mexico, with substantial displacement ranging from approximately 100 feet to more than 500 feet (Collins 1995). Numerous smaller-scale faults occur with displacement less than 100 feet. Regional faulting is typically oriented at 50 to 60 degrees in the Austin area. Movement along the Balcones Fault Zone may have caused two small earthquakes in the last 130 years (1893 and 1902); however, no movement has occurred in recorded history (University of Texas at Austin, Bureau of Economic Geology 2021). The annual probability for seismic hazards or earthquakes to occur within or surrounding the Study Area is very low, with an intensity rating of "I" on the Modified Mercalli Intensity Scale.

There are four mapped faults crossing the Study Area. In the north-south portion, faults cross the Build Alternative approximately 280 feet south of UT West Mall Station and directly underneath 15th Street Station. One fault (F-03) crosses the Study Area in two locations, extending northeast at 50 to 55 degrees from immediately south of Oltorf Station to approximately 600 feet west of Travis Heights Station. No faults are mapped east of Lakeshore Station. Due to urban development and thick soil cover, any surface expression of faulting is likely not observable in the field except along creek banks and where road cuts have exposed strata. The latitude and longitude coordinates (North American Datum 1983) where mapped faults intersect the Build Alternative (**Figure 31** through **Figure 34**) and their respective linear orientations are provided in **Table 4**.

Table 4: Mapped Faults Crossing the Study Area

Fault Intersection ID	Latitude	Longitude	Fault Orientation
F-01	30.285014	-97.741803	45°
F-02	30.282747	-97.74198	15°
F-03a	30.237963	-97.75421	50°
F-03b	30.250293	-97.739811	55°
F-04	30.246575	-97.732329	50°

5 Environmental Consequences

The potential soils and geology effects under the No Build Alternative and Build Alternative are discussed in the following sections.

5.1 No Build Alternative

The No Build Alternative serves as the baseline from which to compare the effects of the Project. Under the No Build Alternative, the Project would not be constructed. The

No Build Alternative is defined as the existing transportation system as well as any committed highway and transit improvements defined in the *2045 Regional Transportation Plan* (Capital Area Metropolitan Planning Organization 2024) except for the Project. Effects related to soils and geology would likely occur as a result of the committed improvements under the No Build Alternative; however, the magnitude of the effects are unknown at this time and would be determined for each individual project.

5.2 Build Alternative and Design Options

Specific soil and geologic conditions may contribute to potential effects on the Project. While the soil characteristics vary along the entire Project alignment, there may be differences in soil type or geological formation in the location of the Design Options. Construction effects on geologic resources would be similar in portions of the Project alignment that would be constructed at-grade or on bridge, but construction effects may be different for the Design Options depending on the ultimate location, design, and construction methods.

5.2.1 Operational (Long-Term) Effects

5.2.1.1 Soils

Operational effects considered in the Project's design as a result of soil conditions include unstable soils, highly expansive soils, low soil bearing strength, and slope failures. Unstable soils could cause impacts during operations due to potential for failures to slopes, embankments, and/or structures (i.e., as a result of exposure to groundwater creep or heavy precipitation events), which typically are more likely to occur in proximity to water resources and other areas containing loose or soft deposits of sand, silts, and clays.

Soils with high shrink-swell potential generally shrink during dry conditions and expand when wet. The frequency at which soils are affected by shrink-swell cycles as a result of intensified extreme weather is expected to increase over time due to the elevated incidence of drought and flood cycles on the region (Nielsen-Gammon et al. 2024). Impacts associated with a high shrink-swell potential would be greater in areas along the Build Alternative that are at-grade within the eastern branch where these soils exist. Loads associated with at-grade construction may not be sufficient to handle the shrink-swell variability of those soils, resulting in movement of structures or track sections if design measures, such as minimizing moisture content changes or soil improvement, are not incorporated.

In areas where the Project would occur along slopes that vary in height and steepness, localized failures of these slopes could occur with increasing risk as the slope steepness and height increases. Slope failures may occur as a result of instable cut or fill slopes at retaining structures or near water resource crossings. Slope failures could also cause increased load to structures or blockage in the pathway of the slope failure.

These risk factors would be lower with the incorporation of best management practices to the maximum extent practicable (see Section 6 and **FEIS Appendix F-4**). The dominant soil characteristic and associated potential for erosion and shrink-swell shown in **Table 2** would be considered during final design of the Project as part of pre-construction site inspections (see Section 6).

5.2.1.2 Geology

The light rail alignment would follow local topography, where practicable, in order to minimize effects. Geological CEFs would be considered during the Project's final design (see Section 6). Operational effects on geologic formations are not anticipated as a result of the Project.

5.2.1.3 Seismicity

The Project is located within the Balcones Fault Zone and has several mapped faults at similar orientation to regional fault trends. However, the Balcones Fault Zone is not seismically active, and the probability of seismic effects is very low. Operational effects on seismicity are not anticipated as a result of the Project.

5.2.2 Construction-Related (Short-Term) Effects

5.2.2.1 Soils

Potential effects as a result of soil erosion or unstable soils could occur in areas that are graded or require vegetation removal during construction until these areas are permanently stabilized (i.e., soil stabilization such as with revegetation or other ground covering). These areas would require implementation of soil stabilization and erosion control practices during the construction phase such as silt fence and erosion control matting (see Section 6). In areas where construction activities would occur along slopes that vary in height and steepness, localized failures of these slopes could occur with increasing risk as the slope height and steepness increase. The risk for slope failures or collapse of retaining structures would increase as a result of exposure to heavy precipitation events particularly near areas outside of the existing roadway, and near water resources and other areas containing loose or soft deposits of sand, silts, and clays. Slope failures could also cause increased load to structures or blockage in the pathway of the slope failure. In addition to slope failures, settlement could occur during construction if underlying materials become compressed under large loads with placement of new fill material. Settlement is more likely to occur in areas of soft deposits of silty or clay soils that have not been previously compressed by loads of similar size.

These risk factors would be lower with the incorporation of best management practices such as avoiding deep slopes to the maximum extent practicable and stockpiling topsoil for reclamation as detailed in Section 6. Final design of the Build Alternative would incorporate structure types such as bridges, retaining walls, noise walls, and utilities. In addition, some portions of the Build Alternative would require cutting, excavation, and grading into existing subsurface materials at varying depths, as well as vegetation removal. Additional information regarding erosion, including areas mapped by the City as Erosion Hazard Zones, is provided in **FEIS Appendix F-4**.

5.2.2.2 Geology

During Project construction, ground-disturbing activities, such as cutting and grading, and the installation of bridge piers and foundation elements would affect geology. The Project is located within the Balcones Fault Zone karst region, as previously mentioned; therefore, there is potential to encounter karst features and mesocavernous voids during construction. Prior to construction, avoidance measures would be incorporated into final design to the extent possible. In addition, the unanticipated discovery of concealed karst features (voids) may occur during construction. Areas with an increased risk of unanticipated discovery of voids during construction include areas where below grade activities such as cutting or trenching would be required. Additionally, trenching or excavation below 5 feet deep into native bedrock within or near City-regulated zones or aquifer verification zones may require daily trench inspections. Voids discovered during construction may become contaminated with hazardous materials, sediment runoff, and/or other non-native materials. In addition, opening a previously concealed karst feature and introducing outside environmental conditions can alter ambient conditions and microclimate, such as humidity and temperature, that can result in increased or modified airflow. The discovery of voids can result in a direct connection to shallow groundwater, which would increase the potential for contamination. While the Study Area is not located within a regulated zone of the Edwards Aquifer, there is potential for groundwater connectivity with nearby springs. Geological CEFs would be considered during the Project's final design (see Section 6). Void mitigation best management practices, if necessary, would be incorporated into the Project's design (see Section 6).

5.2.2.3 Seismicity

Construction-related effects on seismicity are not anticipated as a result of the Project construction.

6 References

Barnes, V.E., Shell Oil Co., Humble Oil and Refining Co., Mobile Oil Co., C.V. Proctor, T.E. Brown, J.H. McGowen, N.B. Waechter, D.H. Eargle, E.T. Baker, R.C. Peckman, and R.L. Bluntzer. 1974. Geologic Atlas of Texas, Austin Sheet. Geologic Atlas of Texas 3. 1:250,000. University of Texas at Austin, Bureau of Economic Geology.

Capital Area Metropolitan Planning Organization. 2024. *2045 Regional Transportation Plan*. Adopted May 4, 2020. Updated May 2024. Accessed July 2024. https://www.campotexas.org/regional-transportation-plans/2045-plan/.

City of Austin. 2021a. Standards Manual. Accessed September 2023. https://library.municode.com/tx/austin/codes/standards_manual.

City of Austin. 2021b. Environmental Criteria Manual. Effective November 17, 2021. Accessed September 2023. https://library.municode.com/tx/austin/codes/environmental_criteria_manual.

City of Austin. 2023. Property Profile: A Development Services Tool. Accessed October 2023. https://maps.austintexas.gov/GIS/PropertyProfile/.

Collins, Edward W. 1995. "Structural Framework of the Edwards Aquifer, Balcones Fault Zone, Central Texas." *Gulf Coast Association of Geological Societies Transactions* 45: 135–142.

Edwards Aquifer Authority. 2023. *About the Edwards Aquifer*. Accessed October 2023. https://www.edwardsaquifer.org/science-maps/about-the-edwards-aquifer/.

ESRI. 2024a. World Street Map. Sources: Esri, DeLorme, HERE, USGS, Intermap, iPC, NRCAN, Esri Japan, METI, Esri China (Hong Kong), Esri (Thailand), MapmyIndia, Tomtom. Accessed July 2024.

ESRI. 2024b. World Topographic Map. Sources: Esri, DeLorme, HERE, TomTom, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), swisstopo, MapmyIndia, and the GIS User Community. Accessed July 2024.

Federal Highway Administration. 2007. *Geotechnical Technical Guidance Manual*. May. Accessed September 2023. https://flh.fhwa.dot.gov/resources/design/pddm/Geotechnical_TGM.pdf.

Lindgren, R.J., A.R. Dutton, S.D. Hovorka, S.R.H. Worthington, and Scott Painter. 2004. *Conceptualization and Simulation of the Edwards Aquifer, San Antonio Region, Texas*. Scientific Investigations Report 2004-5277. US Geological Survey. https://pubs.usgs.gov/sir/2004/5277/pdf/sir2004-5277.pdf.

Neuendorf, Klaus K.E., James P. Mehl Jr., and Julia A. Jackson. 2005. *Glossary of Geology*. 5th ed. Alexandria: American Geological Institute.

Nielsen-Gammon, John, Sara Holman, Austin Buley, Savannah Jorgensen, Jacob Escobedo, Catherine Ott, Jeramy Dedrick, and Ali Van Fleet. 2024. Assessment of Historic and Future Trends of Extreme Weather in Texas, 1900-2036. Office of Texas State Climatologist, Texas A&M University. Document OSC-202401. April 22. Accessed July 15, 2024. https://texas2036.org/wp-content/uploads/2023/06/2024_ClimateReport.pdf.

NRCS. 2017. *Soil Survey Manual*. Agriculture Handbook No. 18. Soil Science Division Staff, U.S. Department of Agriculture. https://www.nrcs.usda.gov/sites/default/files/2022-09/The-Soil-Survey-Manual.pdf.

NRCS. 2023a. Web Soil Survey. U.S. Department of Agriculture, National Resources Conservation Service. Accessed March 2024. https://websoilsurvey.sc.egov.usda.gov/App/WebSoilSurvey.aspx.

NRCS. 2023b. Field Office Technical Guide. U.S. Department of Agriculture, National Resources Conservation Service. Accessed September 2023. https://efotg.sc.egov.usda.gov/references/public/CO/5a_Prime_Farmland_Definition.pdf.

NRCS. 2023c. Griddled National Soil Survey Geographic Database. National Resources Conservation Service. Accessed October 2023. https://www.nrcs.usda.gov/resources/data-and-reports/gridded-national-soil-survey-geographic-database-gnatsgo.

NRCS. 2023d. Griddled Soil Survey Geographic Database. National Resources Conservation Service. Accessed October 2023. https://www.nrcs.usda.gov/resources/data-and-reports/gridded-soil-survey-geographic-gssurgo-database.

NRCS. 2024. Soil Data Access Prime and other Important Farmlands. Accessed March 2024. https://efotg.sc.egov.usda.gov/references/public/LA/Prime_and_other_Important_Farmland.html.

Rose, Peter R. 1972. Edwards Group, Surface and Subsurface, Central Texas. Report of Investigations No. 74. University of Texas at Austin, Bureau of Economic Geology.

Rukstales, Kenneth S. 2012. Seismic Hazard Map for the United States. Accessed September 2023. https://hgl.harvard.edu/catalog/stanford-rm034qp5477.

TCEQ. 2005. Edwards Aquifer Protection Program, Chapter 213 Rules – Recharge Zone, Transition Zone, Contributing Zone, and Contributing Zone Within the Transition Zone. Vector digital data. Austin, Texas. September 1.

Texas Department of Transportation. 1999. Test Procedure for Calculating the Plasticity Index of Soils. TxDOT Designation: Tex-106-E. August. Accessed September 2023. https://ftp.dot.state.tx.us/pub/txdot-info/cst/TMS/100-E_series/pdfs/soi106.pdf.

Texas Department of Transportation. 2020. *Geotechnical Manual*. July. Accessed September 2023. http://onlinemanuals.txdot.gov/txdotmanuals/geo/geo.pdf.

Texas Natural Resources Information System. 2010a. Digital conversion of 1:250,000 Geologic Atlas Sheets originally published by the Bureau of Economic Geology. Accessed September 2023. https://tnris.org/data-catalog/entry/geologic-atlas-of-texas/.

Texas Natural Resources Information System. 2010b. Digital conversion of 1:62,000 Geologic Atlas Sheets originally published by the Bureau of Economic Geology. Accessed September 2023. https://tnris.org/data-catalog/entry/geologic-atlas-of-texas/.

University of California Davis. 2023. SoilWeb Application. University of California Davis, California Soil Resource Lab. Accessed September 2023. https://casoilresource.lawr.ucdavis.edu/gmap/.

University of Texas at Austin, Bureau of Economic Geology. 1996. Physiographic Map of Texas. Bureau of Economic Geology, The University of Texas at Austin. Accessed September 2023. https://s3.amazonaws.com/libapps/accounts/96635/images/physiographic-map-of-texas-1996.jpg.

University of Texas at Austin, Bureau of Economic Geology. 2021. "Central Texas." *Geologic Wonders of Texas*. Bureau of Economic Geology, The University of Texas at Austin. Accessed September 2023. https://www.beg.utexas.edu/geowonders/centtex.

USGS. 1988. Seismicity Map of the State of Texas. U.S. Geological Survey. Accessed September 2023. https://pubs.usgs.gov/publication/mf2034.

USGS. 2019. 7.5-minute Topographic Maps. Accessed September 2023. https://viewer.nationalmap.gov/basic/?basemap=b1&category=histtopo,ustopo&title=Map%20View.

USGS. 2023a. "Earthquake Magnitude, Energy Release, and Shaking Intensity." Earthquake Hazards Program. Accessed October 2023. https://www.usgs.gov/programs/earthquake-hazards/.

USGS. 2023b. Geologic Atlas of Texas Online (1:250,000). Accessed September 2023. https://txpub.usgs.gov/txgeology/.

USGS. n.d. "Glossary." Earthquake Hazards Program. Accessed February 2, 2024. https://www.usgs.gov/glossary/earthquake-hazards-program.

Wischmeier, Walter H., and Dwight D. Smith. 1965. *Predicting Rainfall-Erosion Losses from Cropland East of the Rocky Mountains: Guide for Selection of Practices for Soil and Water Conservation.* Agriculture Handbook No. 282. Agricultural Research Service, U.S. Department of Agriculture. https://www.govinfo.gov/content/pkg/GOVPUB-A-PURL-gpo22285/pdf/GOVPUB-A-PURL-gpo22285.pdf.