

DG2.4 PAVEMENT DESIGN

DG2.401 GENERAL

- A. The City of Pflugerville recognizes the need to revise and upgrade the pavement design section of the City’s Engineering Design Manual to meet current industry standards. The City of Pflugerville acknowledges the Capital Area Pavement Engineering Council (CAPEC) study as a guiding document for civil and geotechnical engineers to reference during the design phase of all public streets within Pflugerville’s city limits and extra-territorial jurisdiction.

All new City Streets, alleys and rehabilitation of existing streets shall be constructed in accordance with the latest editions of the City of Pflugerville Construction Standards and Specifications.

- B. A soil evaluation report by a registered professional engineer shall be required. The soil evaluation report shall be submitted in connection with the plans and specifications for street improvements.

This section references and specifies the minimum standards for the pavement and subgrade design for roadways and alleys within the City. These minimum standards are not intended to replace the professional judgment of the Design and the Geotechnical Engineer. The standards may need to be expanded or modified as determined necessary by the Geotechnical Engineer and approved by the City Engineer in writing. The pavement and subgrade design for roadways shall be in accordance with CAPEC Phase 3 Report or latest version.

- C. All roadways, alleys and fire lanes shall have a geotechnical investigation performed to include pavement and subgrade design. The results of the geotechnical investigation, analysis, and recommendations shall be presented in a Geotechnical Report for Roadways (GRR). The report shall recommend a pavement section or sections based on analyses using traffic inputs, service factors, and subgrade conditions at the project site. The report and any subsequent modifications or additions shall be signed and sealed by a Licensed Professional Engineer in the State of Texas trained and qualified to provide geotechnical engineering analysis for pavement and subgrade design. At the City Engineer’s discretion, validity in the form of a letter from a geotechnical or civil engineer of a GRR older than 3 years may be required. A pavement design which includes lime stabilization, shall be included in the Geotechnical Report. An Edas Grim (lime series) test is required for all geotechnical reports recommending lime stabilization. The base and lime sections shall be extended 3-feet behind back of curb for all street sections.
- D. Based on the road classification type and as directed by the City Engineer, the submission of a pavement design may require a Life Cycle Cost Analysis (LCCA) as defined in Section 6 of the CAPEC Phase 3 Final Report or latest version. The LCCA summary output shall provide similar format to Figure 6.1 of CAPEC study, including graphical information. The analysis period should be long enough to capture reconstruction activities for all pavement options, which shall be no less than 30 years or as determined by the roadway classification and pavement type..
- E. The geotechnical investigation and recommendations report shall address all items listed in the GRR checklist. The checklist shall be filled out completely and submitted with the report. Any “N/A” response on the checklist shall include a written explanation and adequate justification as deemed necessary by the City Engineer. Refer to Exhibit 1 at the end of the DG2.4 for GRR checklist and Section 1.4 of CAPEC Phase 3 Report or latest version.

- F. The City review of the GRR will be conducted as a means to verify that the pavement and subgrade design recommendations are performed in general conformance to the City requirements and shall not be considered a detailed technical review of the pavement and subgrade design. The Geotechnical Engineer shall remain responsible for the technical adequacy, accuracy, and completeness of the pavement and subgrade design.

DG2.402 SUBSURFACE INVESTIGATION

- A. Borings shall be drilled on center of proposed roadway or within proposed right-of-way depending upon access and existing utilities. Borings shall be spaced at 500 feet or less; boring shall also be drilled for culverts, retaining walls, bridges or other structures associated with the proposed roadway. A minimum of 3 borings should be performed on each project regardless of roadway length. Pavement borings shall be drilled a depth of 15 feet. High plasticity clay shale (siltstone, mudstone, claystone) of the Navarro-Taylor Groups undivided are not considered competent intact rock for the purposes of roadway design due to the shrink/swell potential of these units.
- B. Laboratory testing shall include
1. Moisture content tests
 2. Soil classification tests – Atterberg Limits (ASTM D4318), Percent Passing No. 200-mesh sieve (ASTM D1140), grain size distribution if granular materials were encountered
 3. Unconfined compression tests or other shear strength tests as appropriate (ASTM D2166)
 4. Swell tests (ASTM D 546)
 5. Lime Curies test or pH lime (Eads Grimm) or by Atterberg Limits at varying percentages of lime (ASTM D6276)
 6. Soluble Sulfate testing, TEX 145-E or alternate
 7. Modified Texas Triaxial Classification (Tex-117-E "Triaxial Compression for Disturbed Soils and Base Materials"
- C. Additional testing may be determined to be appropriate dependent upon subsurface conditions and project requirements.

DG2.403 SUBSURFACE DESIGN BELOW THE PAVEMENT SUGRADE

- A. Ranges in various subsurface soil properties are provided in Table 2.3 to convey a means in which the City relates plasticity index to swell. Site specific soil testing is required. Refer to Pflugerville’s USGS PI map (Exhibit 2 at the end of DG2.4) and Section 5.3 of the CAPEC Phase 3 Final Report or latest version. High swell potential is detrimental to pavement. City of Pflugerville anticipates roadway design within high swell areas to include measures to aid in the mitigation of these potential movements.

Table 2.3 Range of Subsurface Soil Properties				
	Low Swell	Moderate Swell	High Swell	Very High Swell
Soil Classification	Rock, Gravel, Sands, Silt	Lean Clay, Clayey Sands, Sandy Clays	Lean Clay, Fat Clay, Shale	Fat Clay, Shale
Range in PI (%)	NP < PI < 20	20 < PI < 35	35 < PI < 45	PI > 45
Range in LL (%)	0 – 45	45 – 60	60 – 70	> 70
Range in -200 sieve (%)	0 – 100	30 – 100	50 – 100	80 - 100

- B. Laboratory test results as well as the core boring information shall be incorporated into the determination of swell characteristics and movement potential using the swell test results and the calculated Potential Vertical Rise (PVR) TxDOT Tex-124-E method. The results of the tests and the calculations shall be included in the GRR. A sample output for the Tex-124 is included in Figure 5.3 of the CAPEC Phase 3 Final Report or latest version.
 - 1. For calculated Potential Vertical Rise (PVR) of 2 inches or less, standard subgrade treatment will be incorporated. For PVR greater than 2 inches, the GRR should include subgrade treatment options for reducing the amount of expansive soil movement.
 - 2. Horizontal or vertical moisture barriers to reduce moisture fluctuations within clays underlying the roadway section may be presented as options for the City's review.
- C. All subsurface improvements shall be in accordance with the Pflugerville Technical Specifications unless otherwise approved by the City Engineer.

DG2.404 SUBGRADE DESIGN:

- A. Treatment of the pavement subgrade soils is important for pavement support and to provide a working platform for construction of the overlying pavement. Lime stabilization shall be used with a minimum thickness of 8 inches unless the GRR prepared by the design or geotechnical engineer indicates that sulfate levels in the soil prevent the effective use of lime stabilization.
- B. Lime treatment of clay subgrade will be used beneath the pavement layers. Lime series for each soil type expected to be in the upper 12 inches of the subgrade should be performed in accordance with the Eades & Grimm pH testing and this value shall be used as the beginning value under consideration for lime treatment. Lime may be placed dry or in slurry form. Applications shall be as outlined in Items 260 and 263 of TxDOT's Standard Specifications for Construction and Maintenance of Highways, Streets, and Bridges, latest edition. Minimum design criteria as follows:
 - 1. A pH of 12.4 or greater prior to compaction (ASTM D2976).
 - 2. The minimum compressive strength of the subgrade shall be 150 psi
 - 3. The treated subgrade shall have less than 1% swell.
 - 4. Lime content shall be by percent of hydrated lime compared to the dry unit weight of soil as determined by the pH lime series. The minimum percent lime shall be 5 percent but in most cases 6 to 8 percent lime should be anticipated.
 - 5. Lime treatment should extend 3 or more feet beyond the back of curb for all street sections.

6. Test for sulfates in the upper 3 feet of subgrade. If the roadway has cut and fill, the anticipated fill soil or exposed cut grade should be tested. Subgrade soils testing over 5,000 ppm sulfates shall be lime treated using a double application method (see Table 2.4*). Soils testing over 8,000 ppm should not be lime treated and alternate approaches for subgrade preparation should be considered, subject to approval by the City Engineer. The sulfate content should be confirmed by additional tests at the time of construction when the roadway grades have been formed, after utility construction (within the pavement area) and grading.

Risk of Adverse Effects	Range of Soil Sulfate (ppm)	Recommended Action
Minimal Risk	< 3,000	Follow mix design and good construction practices explicitly. If soluble sulfates are detected, lime slurry should be used in lieu of dry lime. Adequate water (optimum for compaction plus at least 3%) should be used for mixing.
Moderate Risk	3,000 – 5,000	Follow mix design and good construction practices explicitly. Mixing of soil-lime treatment should be at moisture content of at least 3% to 5% above optimum for compaction. Lime slurry should be used in lieu of dry quicklime or hydrated lime.
Moderate to High Risk	5,000 – 7,000	Follow same guidelines as recommended for soils of moderate risk. Before treating, laboratory tests shall be performed to determine swell potential. *
High to Unacceptable Risk	> 8,000	Not recommended for lime stabilization.

* Double application method is a process that adds one-half of the optimum lime content, allowing it to react with the soil components for a specified time period (~ 7 days) and then adding the other one-half of the lime before compacting to final density.

7. If crushed limestone is to be used as base material or as an alternate to treated subgrade, the base material should have a minimum depth of 8 inches and extend 3 or more feet beyond the back of curb. City Engineer may consider a different subgrade thickness when specified and recommended in the geotechnical report by the engineer. Flexible base shall be in accordance with the Pflugerville Technical Specifications unless otherwise approved by the City Engineer
8. Geogrid Applications: For flexible pavement sections (base and subgrade), the designer may consider a layer of geogrid between the flexible base material and the underlying subgrade. An appropriate gain in strength and resulting reduction in base material thickness may be proposed but must be accompanied with substantiating pavement thickness calculations. Geogrid should be a triaxial material. Refer to Section 5.6.5 of CAPEC Phase 3 Final Report or latest version for recommended design approach.
9. The geotechnical engineer is responsible for identifying when subgrade improvement is required, and which improvement alternative should be

considered. Alternative subgrade options may be considered and presented to the City Engineer and approved in writing. Refer to Sections 5.4, 5.5, and 5.6 of the CAPEC Phase 3 Final Report or latest version for selection of subgrade improvement methods strategies.

- C. All subgrade improvements shall be in accordance with the Pflugerville Technical Specifications unless otherwise approved by the City Engineer.

DG2.405 PAVEMENT DESIGN

- A. All rigid and flexible pavement sections shall be in accordance with Pflugerville Technical Specifications, unless otherwise approved by the City Engineer. Table 2.5 provides an assigned roadway type based on road classifications per Pflugerville’s Engineering Design Manual (EDM) and Transportation Master Plan (TMP). The roadway type letters assigned are used to identify the pavement design input values in Table 2.6.

Classification	Roadway Type
Major/Principal Arterials / Industrial Streets	A
Minor Arterials / Industrial Streets	B
Major Collectors	C
Minor Collector / Rural Collector	D
Local Streets / Typical Rural / Alley	E
Urban Main Street	D
Urban 3-Lane	C

Criteria	Type A	Type B	Type C	Type D	Type E
Design Period (1)	20 years	20 years	20 years	20 years	20 years
Initial Serviceability (Pi) – Rigid/Asphalt (2)	4.5 - 4.2	4.5 - 4.2	4.5 - 4.2	4.5 - 4.2	4.5 - 4.2
Terminal Serviceability (Pt) – Rigid/Asphalt (3)	2.5	2.5	2.0	2.0	2.0
Reliability (%) (4)	95	95	90	90	85
Conc Flex strength	620 psi	620 psi	620 psi	620 psi	620 psi
Modulus of Subgrade Reaction	Site Specific	Site Specific	Site Specific	Site Specific	Site Specific

- (1) Refer to CAPEC Table 1.1 for guidance on Design Life values.
- (2) Refer to CAPEC Table 1.3 & 3.2 for guidance on Initial Serviceability Index Range
- (3) Refer to CAPEC Table 1.3, 3.3, & 4.1 for guidance on Terminal Serviceability Index Range.
- (4) Refer to CAPEC Table 3.1 and 4.2 for guidance on Design Confidence and Reliability Levels (%).

- B. Refer to Sections 3.8 (Tables 3.7) and Section 4.6 (Table 4.3) of CAPEC Phase 3 Final Report or latest version for flexible and rigid pavement thicknesses guidance. It is the Design/Geotechnical Engineer’s responsibility to verify the Traffic Loading Input Values are applicable to specific sites and locations. In no case shall the pavement sections be less than the CAPEC’s representative pavement design sections. Pavement design shall be based on American Association of State

Highway and Transportation Officials (AASHTO) current edition of Guide for Design of Pavement Structures utilizing PavementDesigner found at PavementDesigner.org. This is a free web-based pavement design tool for streets, local road, parking lots and intermodal/industrial facilities, and is the latest available software from American Concrete Pavement Association, ACPA for Portland Cement Concrete (PCC) pavement design and FPS-21 (TxDOT) for Hot Mix Asphalt Concrete (HMAC) flexible pavement design..

- C. Alleys subject to public access for garbage collection and fire-fighting equipment shall have a minimum 6-inch concrete section with 6 inches of lime treated subgrade. The geotechnical or civil engineer shall recommend a pavement section if alley serves a commercial use. Access drives and private alleys shall be designed to support the weight of a 75,000 pound live-load under all weather conditions.
- D. Prime coat is required and shall comply with City of Pflugerville Technical Specifications unless otherwise approved by the City Engineer.
- E. Fire lane pavement design will include support of a 12,500 pound-wheel load for fire lanes outside City roadways. Fire lane pavement needs to support 75,000 pound live-load under all weather conditions. Fire truck and construction traffic loads must be considered in the pavement design sections for fire stations and phased development, respectively.
- F. Traffic Parameters
 - 1. The average daily traffic (ADT) in Table 2.7 provides the maximum capacity value per the City of Pflugerville Transportation Master Plan (TMP) adopted by the City in November 2019. The design engineer is responsible for obtaining or validating the data for average daily traffic (ADT) calculations, growth rate percentage, and truck traffic mix and percentages. If the design engineer cannot obtain the traffic parameter information, the City Engineer may allow the use of Table 2.7. The design engineer should explain the assumptions for City approval prior to design of the pavement section. The required traffic parameters shall be in accordance with Section 2.1 of the CAPEC Phase 3 Final Report or latest version.

Table 2.7 TRAFFIC LOADING DESIGN INPUT VALUES					
Input	Thoroughfare Classification				
	Type A	Type B	Type C	Type D	Type E
Design Period – Years	20	20	20	20	20
ADT (1)	32,760	21,840	26,400	12,800	8,000
Growth Rate - % (2)	4.0	4.0	4.0	3.5	3.0
<u>Percent Trucks (%)</u>	<u>4.5</u>	<u>4.5</u>	<u>4.0</u>	<u>3.5</u>	<u>3.0</u>

(1) LOS ADT value from Transportation Master Plan (TMP)

(2) Growth rate is not applicable to alley section. Refer to City’s GIS information for all other roadway types

Note: All the values in Input Data Table must be applicable to StreetPave 12 (American Concrete Pavement Association, ACPA) and FPS-21 (TxDOT). Refer to Table 2.1.3 of CAPEC Phase 1 Final Report for design software.

2. Traffic data must be developed for new roadways or existing roadways to be widened for added capacity.
3. Traffic data must address the variety of factors usually depicted with Traffic Impact Analysis (TIA) that predict the type and volume of future traffic.
4. Traffic projections will consider complete build-out of subdivisions and any future development that will be served by a specific street.
5. The traffic growth rate for design in Table 2.7 represents the annual traffic growth rate for a designated street classification. This rate should be used to calculate ending ADT (if maximum capacity values from TMP are omitted), unless the results of a TIA or traffic study indicate a higher value.

G. Design Life:

1. The design life and performance criteria for ride quality and distresses should be in accordance with Section 1.2.1 of the TAPEC Phase 3 Final Report or latest version.
2. Flexible pavements to be constructed in public right-of-way (ROW) shall be designed for a minimum 20-year design life.
3. Rigid pavements to be constructed in public right-of-way (ROW) shall be designed for a minimum 30-year design life.

EXHIBIT 1
Geotechnical Roadway Report Checklist

Project Name: _____

Geotechnical Engineer/Firm: _____

Report Date: _____

Date Received: _____

Note: Any N/A response shall include a written explanation with adequate justification, as deemed necessary by the City Engineer.

COMPLETE	N/A	
<input type="checkbox"/>	<input type="checkbox"/>	1. SECTION DG2.401 GENERAL
<input type="checkbox"/>	<input type="checkbox"/>	A. Executive summary
<input type="checkbox"/>	<input type="checkbox"/>	B. Description of Project
<input type="checkbox"/>	<input type="checkbox"/>	C. Location of Project
<input type="checkbox"/>	<input type="checkbox"/>	D. Roadway type and classification
<input type="checkbox"/>	<input type="checkbox"/>	E. Grading plan summary
<input type="checkbox"/>	<input type="checkbox"/>	F. Discussion of underground utilities
COMPLETE	N/A	2. SECTION DG2.402 SUBSURFACE
<input type="checkbox"/>	<input type="checkbox"/>	A. Discussion of existing subsurface conditions that may affect subgrade and pavement design or performance (i.e. vegetation, terrain, existing structures, existing pavement, etc.)
<input type="checkbox"/>	<input type="checkbox"/>	B. Discussion of geological conditions that may impact subgrade and pavement design or performance. Specify formation.
<input type="checkbox"/>	<input type="checkbox"/>	C. Subsurface conditions with logs <ul style="list-style-type: none"> • Sampling techniques • Description of soil and rock encountered, • Laboratory test results • Discussion of water and groundwater conditions • Discussion of seasonal variations in moisture content
<input type="checkbox"/>	<input type="checkbox"/>	D. Identify any deviations to standard procedures
COMPLETE	N/A	3. SECTION DG2.403 SUBSURFACE RECOMMENDATIONS
<input type="checkbox"/>	<input type="checkbox"/>	A. Expansive Soils Evaluation <ul style="list-style-type: none"> • Percent swell calculation and test results • Effect of cut/fills (i.e. long-term soil uplift in cut areas; settlement overburden pressure effects in fill areas) • Provide soil movement estimates
<input type="checkbox"/>	<input type="checkbox"/>	B. Soil Moisture Conditioning – Discuss documented details
COMPLETE	N/A	4. SECTION DG2.404 SUBGRADE RECOMMENDATIONS
<input type="checkbox"/>	<input type="checkbox"/>	A. Subgrade Treatment <ul style="list-style-type: none"> • Typical subgrade type • Explanation of anomalous soil conditions anticipated and discussion of potential variations to consider • Construction techniques to implement • Effects of rock/rock fragments encountered during construction and recommendations to abate
<input type="checkbox"/>	<input type="checkbox"/>	B. Soluble Sulfates Testing <ul style="list-style-type: none"> • Identify soluble sulfate test results; summarize results and discuss variations

- Discussion of techniques during construction to mitigate sulfate-induced heaving
- Sulfate retesting and management during construction

C. Geogrid Applications - Flexible Pavement

- Provide specifications
- Materials product

COMPLETE **N/A**

5. SECTION DG2.405 PAVEMENT RECOMMENDATIONS

- A. Identify roadway type(s) and classifications(s)
- B. Identify deviations from Pavement Design Input Values (Table 2.5)
- C. Identify recommended pavement section

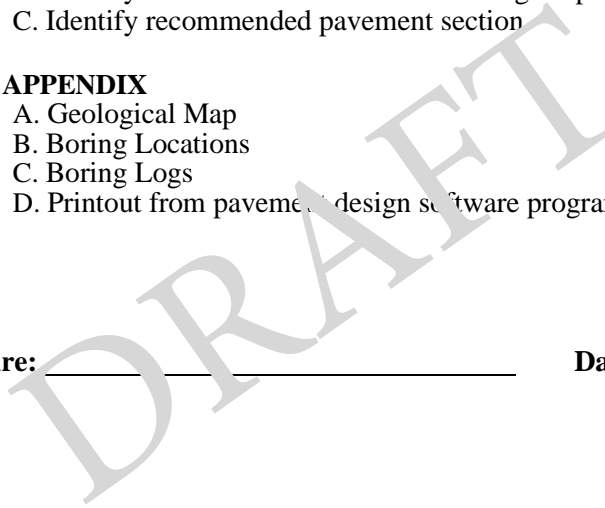
COMPLETE **N/A**

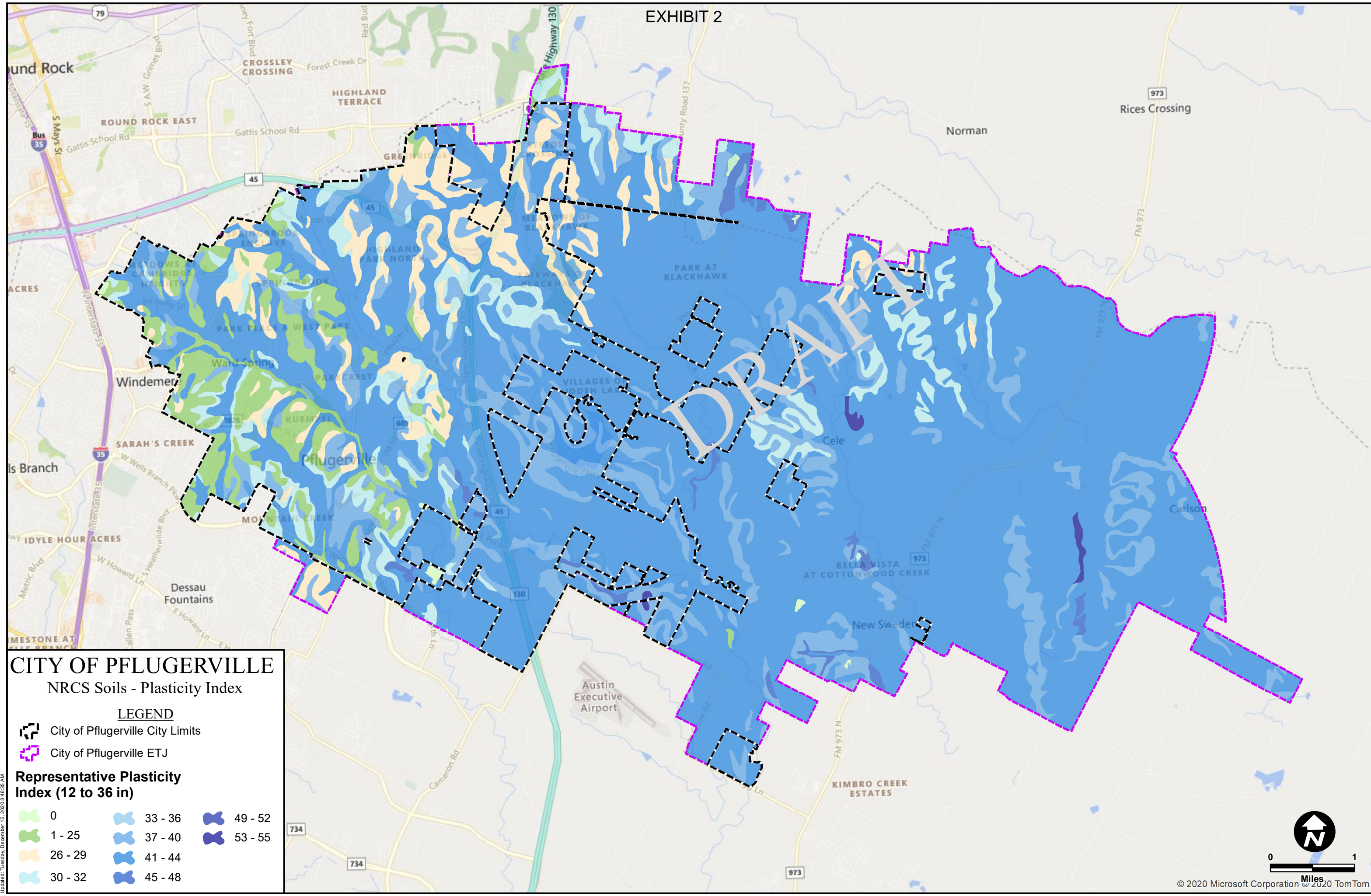
6. APPENDIX

- A. Geological Map
- B. Boring Locations
- C. Boring Logs
- D. Printout from pavement design software program

Geotechnical Engineer Signature: _____

Date:





CITY OF PFLUGERVILLE
NRCS Soils - Plasticity Index

LEGEND

- City of Pflugerville City Limits
- City of Pflugerville ETJ

Representative Plasticity Index (12 to 36 in)

0	33 - 36	49 - 52
1 - 25	37 - 40	53 - 55
26 - 29	41 - 44	
30 - 32	45 - 48	

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