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"put us to the test"
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GEOTECHNICAL INVESTIGATION PAVEMENT THICKNESS RECOMMENDATIONS

Mayfair E9N
New Braunfels, Texas

Report For:

Continental Homes of Texas, LP - San Marcos
1306 East McCarty Lane, Suite 100
San Marcos, Texas 78666

May 2024

Engineer's Job # 24201102.002

MLA Geotechnical TBPE FIRM # F-2684
Geotechnical Engineering and
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PAVEMENT THICKNESS RECOMMENDATIONS

Mayfair E9N
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BACKGROUND

The purpose of this investigation was to determine subsurface conditions relative to the establishment and design of pavement thickness sections for *Mayfair E9N* located in New Braunfels, Texas. Authorization to perform this exploration and analysis was by Agreement for Engineering Services with Mr. Devin Lee Kleinfelder of Continental Homes of Texas, LP - San Marcos.

More specifically, the purposes of this investigation were to determine the soil profile, the engineering characteristics of the foundation soil and to provide criteria for use by the design engineers in preparing the pavement thickness designs for the subdivision streets. The scope included a review of geologic literature, a reconnaissance of the immediate site, the subsurface exploration, field and laboratory testing, and an engineering analysis and evaluation of the foundation materials.

Index and engineering properties of the different soil types encountered on this project were determined and used as a basis for assigning parameters for pavement thickness designs. Pavement thicknesses were then designed using the computerized procedure, "*Flexible Pavement Design System FPS 21*" (FPS-21) (1). Input data and assumptions as well as results are listed in later sections of this report. Output from the computer analysis is enclosed in ***Appendix C***.

The exploration and analysis of the subsurface conditions reported herein is considered in sufficient detail and scope to form a reasonable basis for the preliminary pavement thickness designs. The recommendations submitted are based on the available soil information and the assumed preliminary design for the proposed streets. Any revision in the plans for the proposed street system from those stated in this report should be brought to the attention of the geotechnical engineer so that he may determine if changes in the recommendations are required.

MLA Geotechnical should be retained to monitor site work and construction so that these preliminary recommendations may be finalized, and so that deviations from expected conditions can be properly evaluated.

This report has been prepared for the exclusive use of the client and their design professionals for specific application to the proposed project in accordance with generally accepted soils and pavement engineering practice. This report is not intended to be used as a specification or construction contract document, but as a guide and information source to those qualified professionals who prepare such documents.

FIELD AND LABORATORY INVESTIGATION

Three borings were drilled and nine test pits were excavated to various depths spaced at locations as shown on the enclosed Logs of Boring and Test Pits and Plan of Borings and Test Pits using a truck-mounted drilling rig and a backhoe. Water was not introduced into the borings or test pits. The field investigation included completing the soil borings and test pits, performing field tests, and recovering samples. Pocket penetrometer tests were performed on specimens during sampling. Representative soil samples were selected for laboratory index tests including Atterberg Limits and moisture content tests. The results of these tests and stratigraphy are presented on the Logs of Boring and Test Pits found in ***Appendix A***. A key to the Soil Classification and symbols is located behind the last Log of Boring. See ***Appendix B*** for details of field and laboratory procedures, as applicable.

SITE TOPOGRAPHY, DRAINAGE AND VEGETATION

The site is situated on variably sloping topography with typical slopes varying from approximately 4 percent to 10 percent. Regionally, the site drains to the north, northeast, and east. The predeveloped vegetation on this site consists of mature trees and wild grasses.

SUBSURFACE CONDITIONS AND LOCAL GEOLOGY

Natural Soil Profiles

The native soil profile encountered in the borings and test pits consists of dark brown high plasticity clay (CH), that varies in color to yellowish tan and gray, and is underlain by tan to yellowish tan low to moderate plasticity clay (CL to CL/CH).

Geologic Profile

Geologic maps indicate the Lower Taylor Group, *Ktl*, beneath the subject site (2.3). The Lower Taylor Group is from the Cretaceous period and is comprised of the Pecan Gap and Anacacho Formations. The Taylor is underlain unconformably by the Austin Group and overlain by Upper Taylor or Navarro Groups. The Lower Taylor is typically a medium gray to white calcareous chalk or marl and clay. Zones of soft to medium limestone are commonly noted in this group. Generally, the lower Taylor contains more calcareous clay than its Upper Taylor counterpart. The Lower Taylor ranges to approximately 400 feet in the South Central Texas area.

Faults

Published geology maps do not indicate the presence of a fault on the project site and faulted conditions were not noted in the borings.

Ground Water

Ground water was not encountered in the borings during the field investigation. However, ground water may be encountered at other portions of the site and at different times of the year, especially at lower elevations near the existing pond. The presence of ground water is seasonal and random, depending on the amount of preceding rainfall, weather patterns, and changes in land use.

PAVEMENT ANALYSIS AND DESIGN

Pavement thickness sections were developed using the computerized pavement analysis software called "*Flexible Pavement Design System FPS 21*" also known as FPS-21 (1). This program accepts a number of input variables and predicts the performance of the pavement section including the number and type of overlays required for the specified pavement design life. The different sections are ranked on total cost, overlay cost, user cost, routine maintenance cost, and salvage value.

Minimum layer thicknesses are taken from the City of New Braunfels' *Standard Details* (4). The Standard Details do not provide any guidelines for anticipated traffic loading for its designated street classifications; therefore, the following traffic input data was assumed based on traditional values provided by nearby municipalities. The assumed traffic used for each street type are shown in Table 1 below.

Table 1 - Traffic Input Data

Street Classification	Design Life	Initial Avg. Daily Traffic (ADT)	Average Growth Rate	Trucks in the ADT	Truck Factor	Initial/ Terminal Serviceability
Local Streets	20 years	1,000 vpd	3.5 %	4 %	0.40	4.2 / 2.0
Collectors	20 years	5,000 vpd	4.0 %	6 %	0.53	4.2 / 2.5

Based upon the traffic inputs assumed, the resulting Total Equivalent 18-kip Single Axle Load (ESAL) Applications were calculated. The Standard Details do not provide any required minimum ESALs for design. The ESALs shown in the table below were used in design as an input of the FPS-21 program:

Table 2 - Design ESALs

Street Classification	Design ESALs
Local Streets	82,500
Collectors	864,000

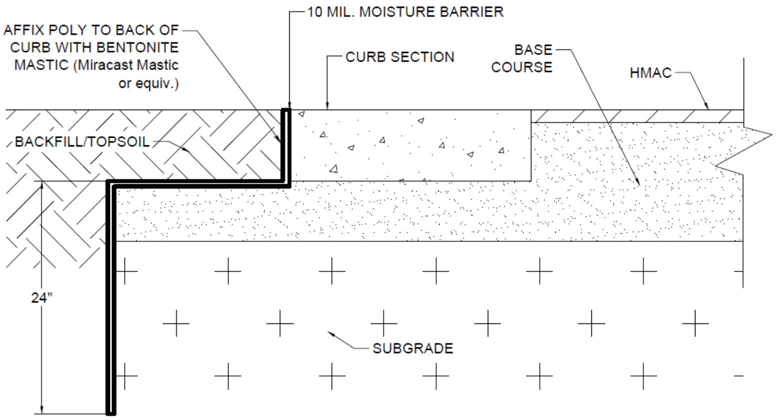
The pavement layer properties and costs used are shown in ***Appendix C*** in the program output. We assume that the pavements will be built at or near the existing grade and that the typical road cut will be on the order of 0 feet to 2 feet or less. Pavement options for the expected subgrade conditions are presented in the following table. Final pavement sections should be evaluated in the field by the Geotechnical Engineer.

RECOMMENDATIONS - PAVEMENT THICKNESS SECTIONS

Street Classification	Subgrade Material	Hot Mix Asphaltic Concrete, in	Crushed Limestone Base, in	Lime Stabilized Subgrade, in
Alleys*	Expansive subgrade PI > 25	3.0	12	8
Local Streets	Expansive subgrade PI > 25	3.0	12	8
Collectors	Expansive subgrade PI > 25	3.5	15	10

Notes:

1. * Due to the drainage challenges associated with the proposed alleys and the proximity of the adjacent lots, a vertical moisture barrier (10 mil. poly) should be used at the edge of pavement. The poly should be affixed to the back of curb or edge of pavement, cover the base and stabilized subgrade overbuild, and extend a minimum of 24 inches below the bottom of curb. Please reference the detail shown below. The moisture barrier may be eliminated if a traditional crown with curb and gutter is used.
2. The surface clay must first be tested for sulfate reaction and a mix design should be completed to determine the proper lime content, lime type, mixing procedure and curing conditions required. Expected values for lime content and application rate are included in Item 2 of the following section.
3. The subgrade improvement and full thickness of the base section should be extended 12 inches beyond the back of the curb line.
4. These pavement thickness designs are intended to transfer the load from the anticipated traffic conditions.
5. The responsibility of assigning street classification to the streets in this project is left to the civil engineer.
6. If pavement designs other than those listed above are desired, please contact MLA Geotechnical.



VERTICAL MOISTURE BARRIER DETAIL
N.T.S

CONSTRUCTION CONSIDERATIONS

Ground Water

Should ground water become a problem during excavation, the wastewater utility trenches could be turned in to French drains. To achieve this, additional open-graded gravel, such as the gravel already being used for pipe bedding at this site, should be placed above the pipe bedding material to the elevation where ground water is encountered. This extra layer of gravel should be covered with a geotextile fabric to prevent material above the gravel from infiltrating the gravel layer. Then, the utility trench should be filled in compacted layers in accordance with the construction plans. The wastewater utility trench must then be allowed to daylight from its lowest point such that water does not accumulate in the utility trench. Additional gravel may be required in the utility trench depending upon the depth that ground water is entering the utility trench during construction. A line item for French drains should be included in construction bid documents.

If surface water accumulates during a rainy period, saturated soil should be dried out and/or removed and replaced with crushed limestone base.

Pavement

1. Subgrade and Foundation Soil Preparation
    a. Strip and remove from construction area any topsoil, organics, and vegetation to a minimum depth of 6 inches below the existing natural ground surface.
    b. Fill sections may be composed of on-site material <u>excluding</u> topsoil, vegetation, and organics meeting. Fill sections meet the requirements of TxDOT Item 132. Fills should be compacted in lifts not exceeding 8 inches loose and meet TxDOT Item 132.
    c. Cut and fill slopes adjacent to the pavements should be graded no steeper than a 3:1 (horizontal to vertical) slope. The area within 3 feet of the edge of the pavements must remain relatively flat.

  d. Compaction of cut areas, on-grade areas, and fill sections should be to 95 to 100 percent of TxDOT TEX-114-E. Compaction should be performed with the moisture content of the soil adjusted to greater than 3 percent above optimum moisture content.
  e. The upper 6 inches of the subgrade should be tested for compaction as described in Item 1d above, per the City of New Braunfels' Standard Details.
  e. After final grades are achieved and prior to base installation, the subgrade should be proof-rolled in accordance with TxDOT Item 216.

2. Lime Stabilized Subgrade
   a. Lime stabilization of the subgrade should be performed in accordance with TxDOT Item 260.
   b. The surface clay should be tested for sulfate reaction to make sure that lime stabilization is feasible.
   c. The surface clay shall be tested using the Atterberg Limits procedure (ASTM D 4318) to determine the percent lime to be added. This should be done by added varying percentages of lime to samples of the surface soil and then determining the Plasticity Index of each sample. The lowest percentage of lime added that significantly reduces the Plasticity Index of the lime-clay sample, as determined by the Geotechnical Engineer, shall be the percent lime to be added in the field.
3. Base Course
   a. Base material should consist of Type A Grade 2 and meet the specifications outlined by TxDOT Item 247.
   b. Thickness of the base course should be as shown on the enclosed ***Recommendations - Pavement Thickness Sections***.
   c. Base course compaction shall be 100 to 105 percent of TxDOT TEX-113-E using 13.26 ft. lbs./cu.in. compaction effort. The moisture content during compaction

shall be maintained within 2 percent of optimum moisture content. Density control by means of field density determination shall be exercised.

d. After compaction, testing, and curing of the base material, the surface shall be primed using an Asphalt Emulsified Petroleum (AE-P) primer or other acceptable priming material as per TxDOT Item 310.

e. A full thickness of the base course and subgrade improvement should be extended 12 inches beyond the back of curb line.

4. Flexible Pavement - Hot Mixed Asphalt Concrete

 a. This surfacing shall consist of a hot-mix asphaltic concrete (HMAC) meeting the requirement of TxDOT Item 340 (2004), Type D. Thickness should be as shown on the included ***Recommendations - Pavement Thickness Sections***.

5. General Conditions

 a. Should at any stage in the construction of the street pavements a non-stable or weaving condition of the subgrade or base course be noted under loads of construction equipment, such areas should be delineated and the Geotechnical Engineer consulted for remedial action before completing the pavement section.

 b. Seepage areas or unusual subgrade soil conditions should be similarly brought to the Geotechnical Engineer's attention before proceeding with pavement completion.

 c. Where completed pavements are trenched for utilities, backfill should be compacted to 95 percent of TEX-113-E and a minimum of 18 inches or twice the design base thickness (if greater) of compacted flexible base should be placed below the new crushed stone base, according to the enclosed Base Course Recommendation.

 d. Trenches beneath structures should be strategically backfilled with borrow or suitable material excavated from the trench and free of stone or rock over 8 inches in diameter. The backfill should be compacted to 95 percent of the maximum dry density when determined by TEX-114-E. The moisture content should be within 2 percent of the optimum moisture content at the time of compaction. If stormwater trenches are backfilled with freely draining materials such as crushed stone, pea gravel or sand, the trench must be sloped a minimum of 0.5 percent to provide positive drainage to daylight.

e. If ground water or seepage is encountered at the time of construction, French drains may be required to drain or intercept the flow of water from the subsurface pavement materials. These drains should be sloped a minimum of 0.5 percent to provide positive drainage to daylight. French drains should be constructed in general accordance with ASTM D2321 - "Standard Practice for Underground Installation of Thermoplastic Pipe of Sewer and Other Gravity Flow Applications (5)." The French drain design should be reviewed by the geotechnical engineer prior to installation.

f. All pavements should be constructed with a curb and gutter system.

POND REMEDIATION RECOMMENDATIONS

1. Drain the pond, if necessary. This is usually done by removing a portion of the berm or by pump.

2. Completely remove all berms, pipe, rip rap, outlet structures, or any other debris from the pond.

3. Clean/muck out the bottom of the pond. This is done to prepare the former pond to be filled in using compacted layers of fill. This involves removing any silt that has collected in the bottom of the pond and allowing the pond bottom to dry out. The dried subgrade should then be scarified, compacted and tested for compaction via proof-roll or nuclear density methods.

4. **On Future Lots**: Fill the remaining hole that used to be the pond with compacted layers of fill. The remediation area should be located on a final plat or grading plan to determine if additional grading requirements are necessary for foundation construction. A uniform thickness of fill will be necessary beneath foundations in order to prevent differential fill settlement.

5. **In Street ROW**: Fill the remaining hole that used to be the pond with compacted layers of fill. The fill should be placed in compacted layers, with each layer tested for compaction upon completion of placement. Fill operation should follow the lift thickness and testing requirements of street embankment fill for the municipality governing the project, as described on page 7 of this report.

6. Perform final proof-roll at the completion of fill placement. This proof-roll is a verification that the layers of fill have been compacted and consists of driving large construction equipment back and forth over the completed fill area. Observation of this process to verify that little to no deflection occurs should be performed. If little to no deflection occurs, then the fill is considered approved for supporting light structures (such as residences) and pavements.

REFERENCES

1. "Municipal Pavement Structural Design and Life Cycle Cost Analysis", City of Austin, Austin, Texas, December 1992.

2. Local geologic maps published by The Bureau of Economic Geology. Austin, Texas including:
    "Geologic Atlas of Texas" 15-minute quadrangles. March 9, 2004 geospatial data.
    "Geologic Map of the Austin Area, Texas 1992" Geology of Austin Area Plate VII.
    "Geologic Map of the West Half of Taylor Texas, 30 x 60 min quad. 2005. misc. map 43
    "Geologic Map of the New Braunfels, Texas 30 x 60 min quad" 2000. misc. map 39

3. "The Geology of Texas, Volume I, Stratigraphy", The University of Texas Bulletin No. 3232: August 22, 1932, The University of Texas, Austin, Texas, 1981.

4. "City of New Braunfels Standard Details", City of New Braunfels, Latest Adopted Revision.

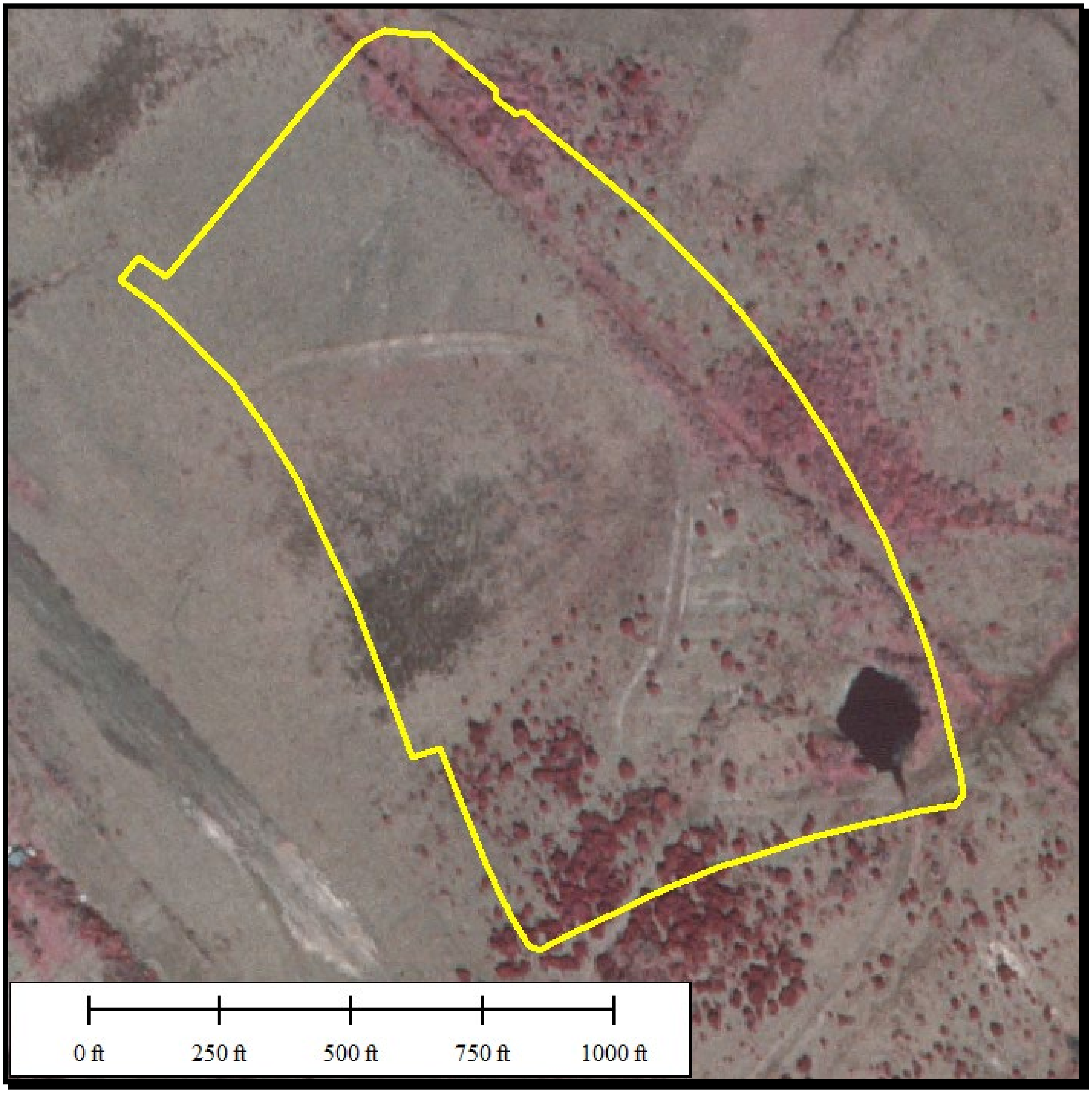
5. "ASTM D-2321-89 Standard Practice for Underground Installation of Thermoplastic Pipe Sewers and Other Gravity Flow Applications", ASTM International, 100 Barr Harbor Drive, PO Box C700, West Conshohocken, Pennsylvania, USA 19428-2959.

LIMITATION OF REPORT

Conditions of the site at locations other than the boring and test pit locations are not expressed or implied, and conditions may be different at different times from the time of this investigation. Contractors or others desiring more complete information are advised to secure their own supplemental borings or test pits. The analysis and recommendations contained herein are based on the available data as shown in this report and the writer's professional expertise, experience and training, and no other warranty is expressed or implied concerning the satisfactory use of these recommendations or data.

APPENDIX A

GEOTECHNICAL DATA



Approximate location of site in yellow

NAPP Aerial Photograph of Site – 1995

Source: TEXAS NATURAL RESOURCES INFORMATION SYSTEM
3.75-minute DOQQ. 1-meter ground resolution. apx. date 1995-6
(http://www.tnris.state.tx.us/digital.htm)

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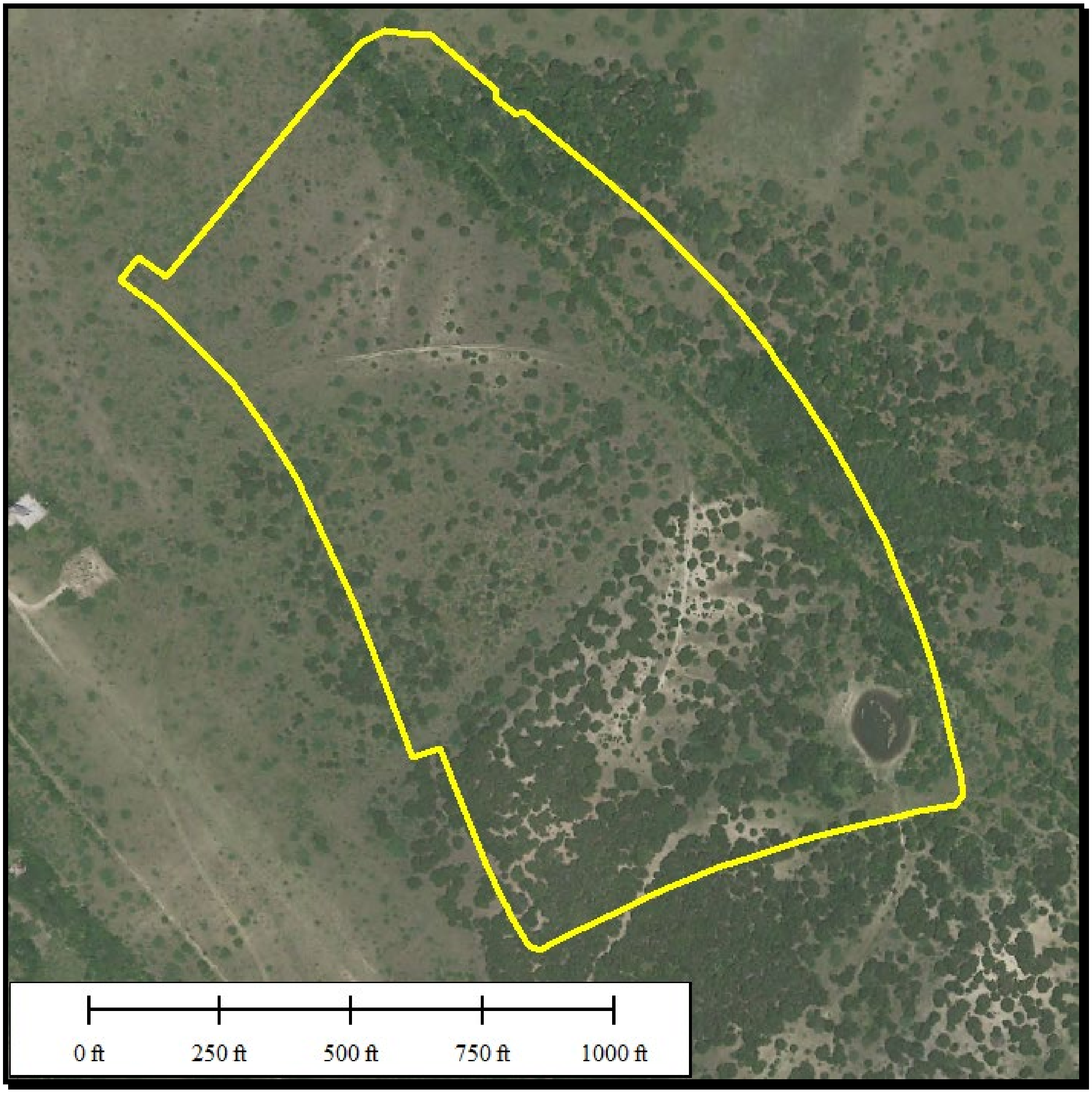
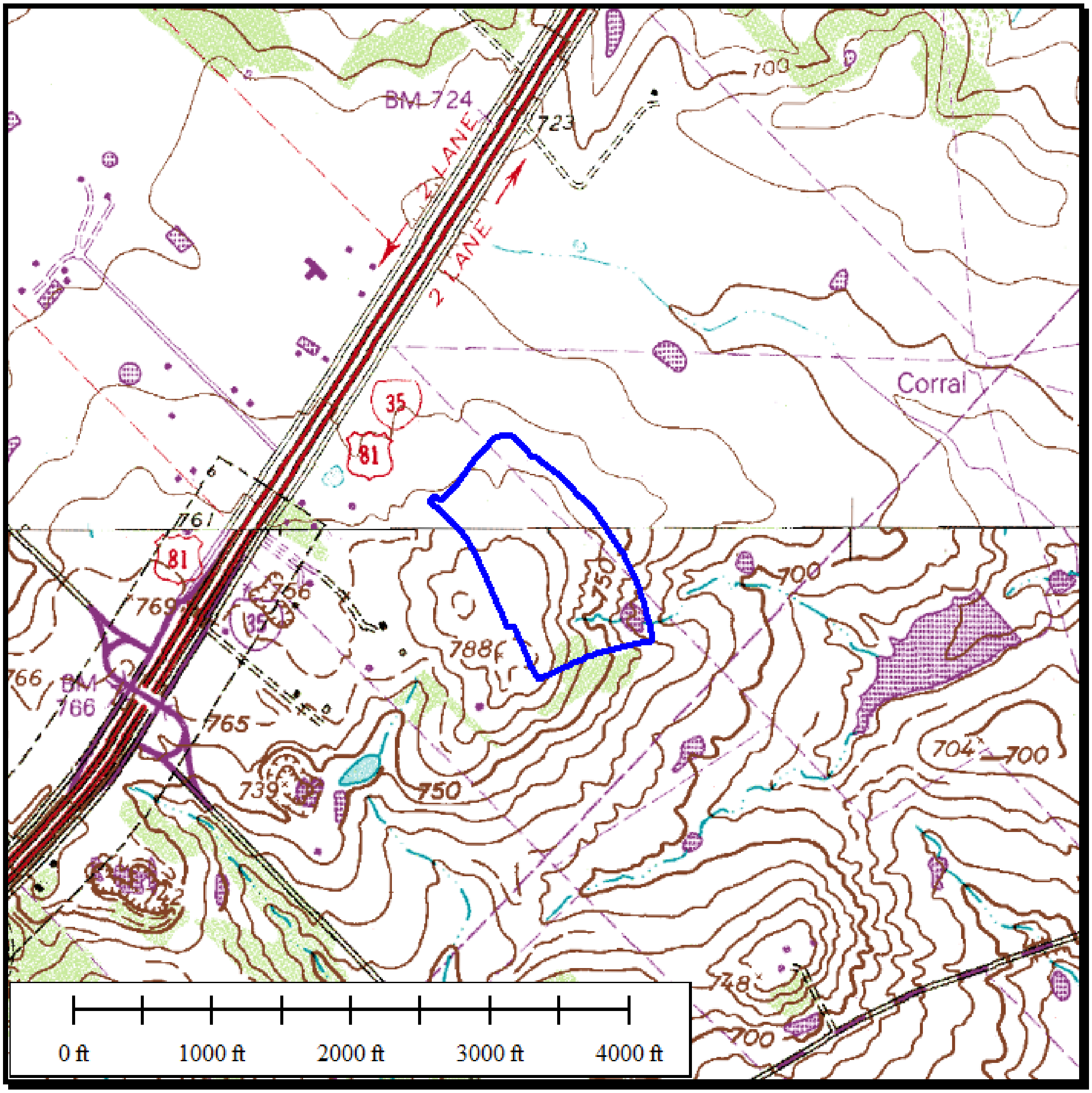


Approximate location of site in yellow

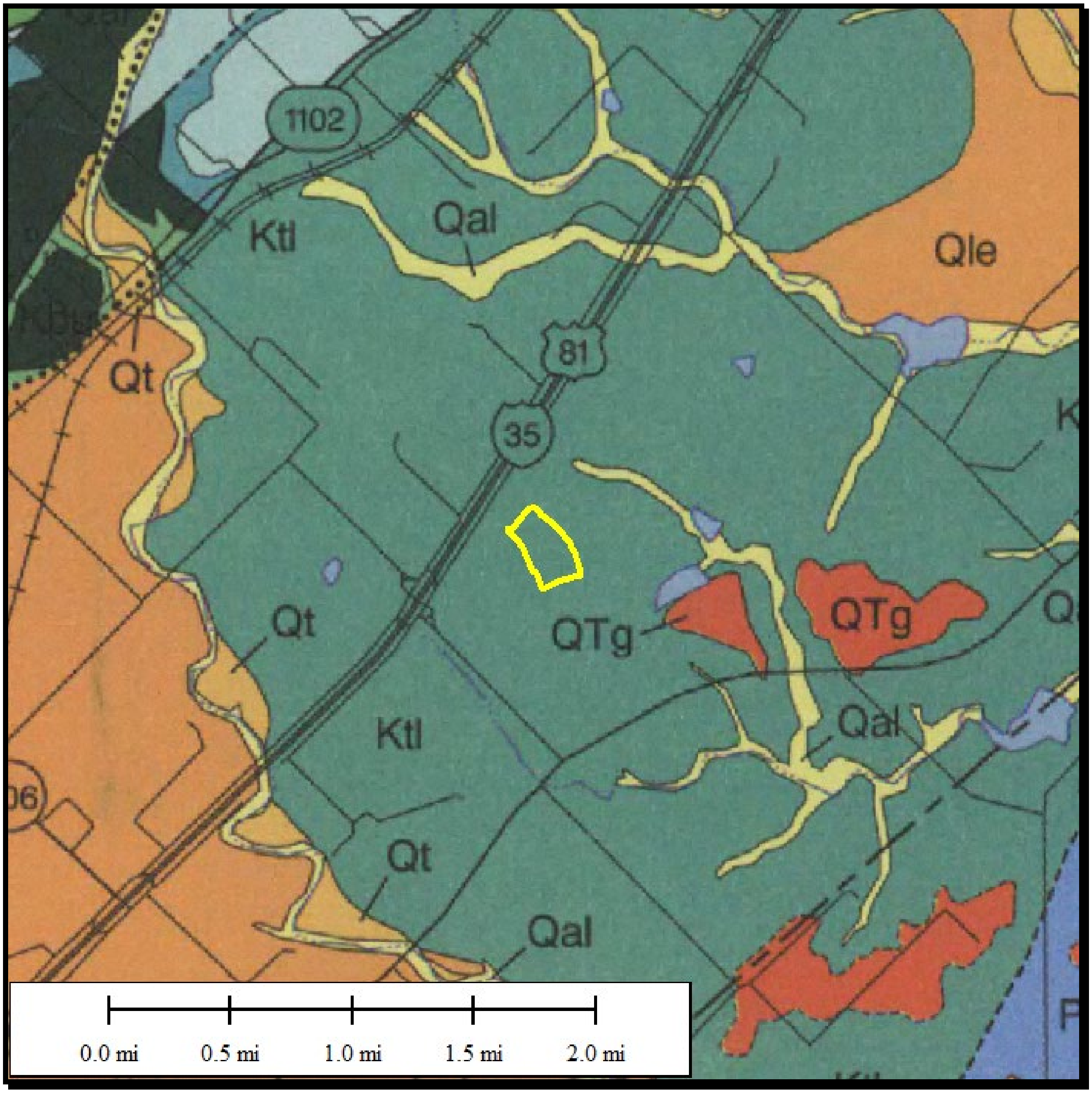
Aerial Photograph of Site – 2020

Source: TEXAS NATURAL RESOURCES INFORMATION SYSTEM
Apx. Date - 2020
(https://tnris.org/)



Approximate location of site in blue

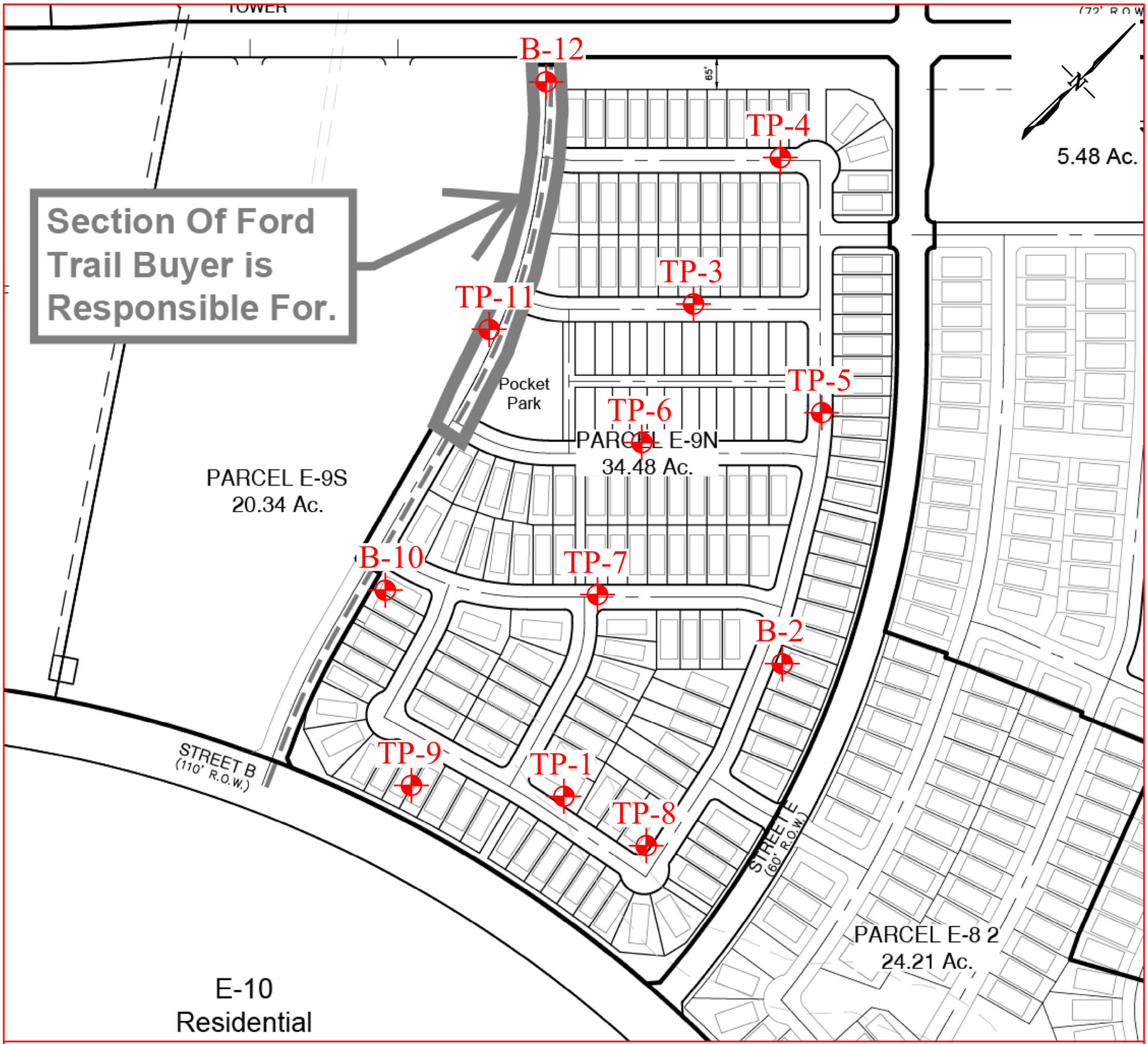
U.S. 7.5 Minute Series Topographic Map
New Braunfels East Quadrangle, Texas
Contour Interval = 10 feet and 20 feet
Source: TEXAS NATURAL RESOURCES INFORMATION SYSTEM
(http://www.tnris.state.tx.us/digital.htm)



Approximate location of site in yellow

Geologic Setting of Site
Geologic Map of the New Braunfels, Texas, 30 x 60 Minute Quadrangle (2000)

Source: Bureau of Economic Geology, The University of Texas at Austin. Misc. Map 39



SCALE = N.T.S.

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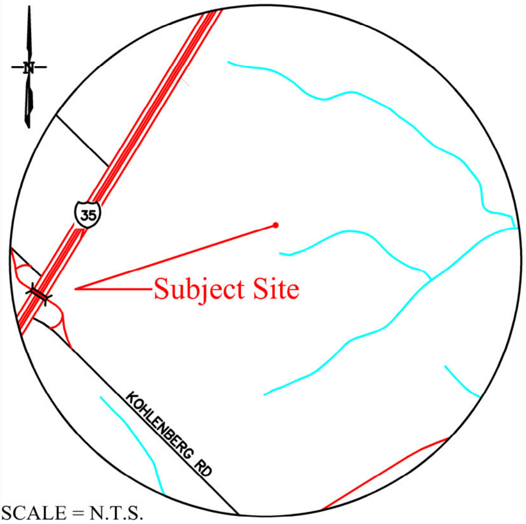
PLAN OF BORINGS & TEST PITS

Mayfair E9N
New Braunfels, Texas
Job. No.: 24201102.002
Client: Continental Homes of Texas, LP - San Marcos

LEGEND

B-#	Boring Number
TP-#	Test Pit Number
⊕	Approx. Boring or Test Pit Location

VICINITY MAP



SCALE = N.T.S.

LOG OF TEST PIT

Test Pit TP-1

PAGE 1 OF 1

Job Name: Mayfair E9N
Job Location: New Braunfels, Texas
Engineer's Job #: 24201102.002
Client: Continental Homes of Texas, LP - San Marcos

Excavation Date: May 1, 2024

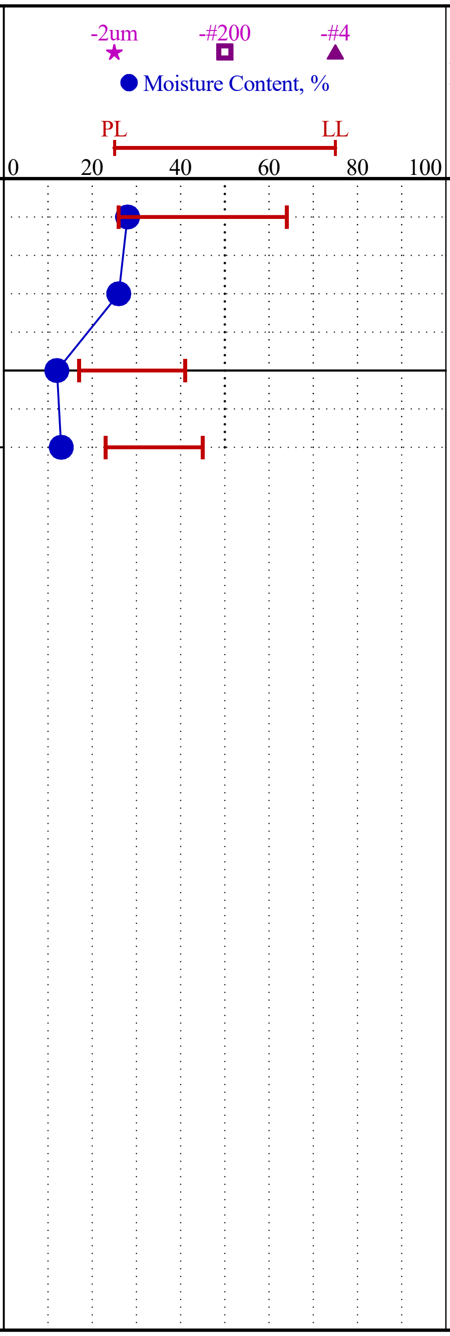
Ground Elevation: n/a

Ground Water Levels:
AT TIME OF EXCAVATION: ---
AT END OF EXCAVATION: ---
AFTER EXCAVATION: ---

Notes:

DEPTH, ft.	MATERIAL DESCRIPTION	GEOLOGY U.S.C.S.	POCKET PEN. (tsf)	Plasticity Index, %
0	CLAY, dark brown, damp	CH		38
5	CLAY, yellowish tan, silty, damp	CL		24
	CLAY, light tan, calcareous, damp	Ktl CL-CH		22

Termination Depth: 7.0 feet



LOG OF BORING

Boring B-2
PAGE 1 OF 1

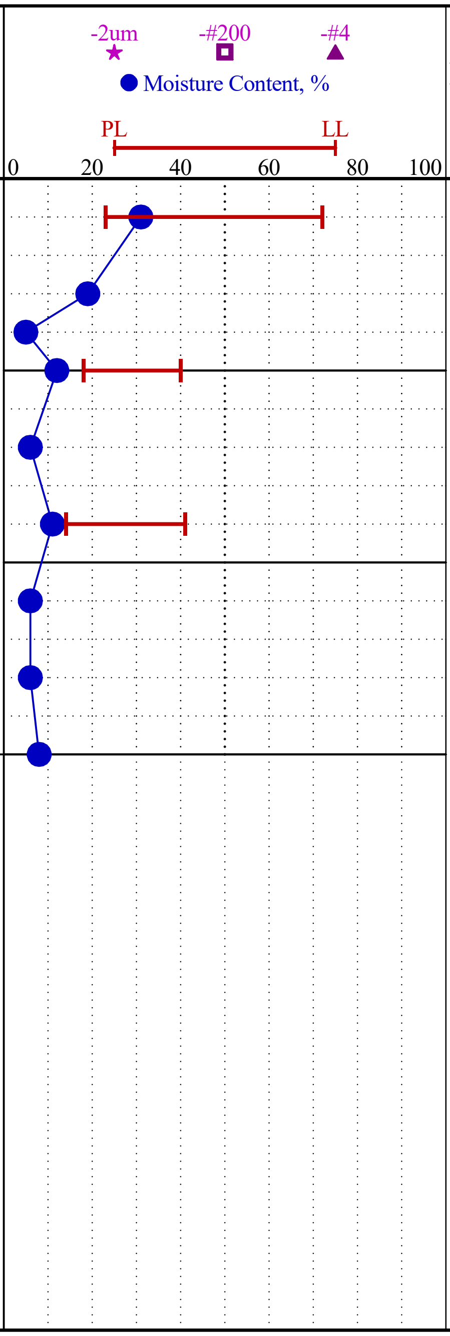
Job Name: Mayfair E9N
Job Location: New Braunfels, Texas
Engineer's Job #: 24201102.002
Client: Continental Homes of Texas, LP - San Marcos

Drill Date: March 28, 2024
Ground Elevation: n/a
Hole Size: 4.5 in.

Notes:

Ground Water Levels:
AT TIME OF DRILLING: ---
AT END OF DRILLING: ---
AFTER DRILLING: ---

DEPTH, ft.	GRAPHIC LOG	MATERIAL DESCRIPTION	GEOLOGY U.S.C.S.	POCKET PEN. (tsf)	Plasticity Index, %
0	▨	CLAY, dark brown, damp	CH	2.0	49
				4.5	
	▨	CLAY, light tan, silty, calcareous, damp *Push refusal at 4.5'* ...tan 6.0' to 8.0' ...yellowish tan below 8.0'	CL		
5					22
					27
10					
15		Termination Depth: 15.0 feet	Ktl		
20					
25					
30					



LOG OF TEST PIT

Test Pit TP-3

PAGE 1 OF 1

Job Name: Mayfair E9N
Job Location: New Braunfels, Texas
Engineer's Job #: 24201102.002
Client: Continental Homes of Texas, LP - San Marcos

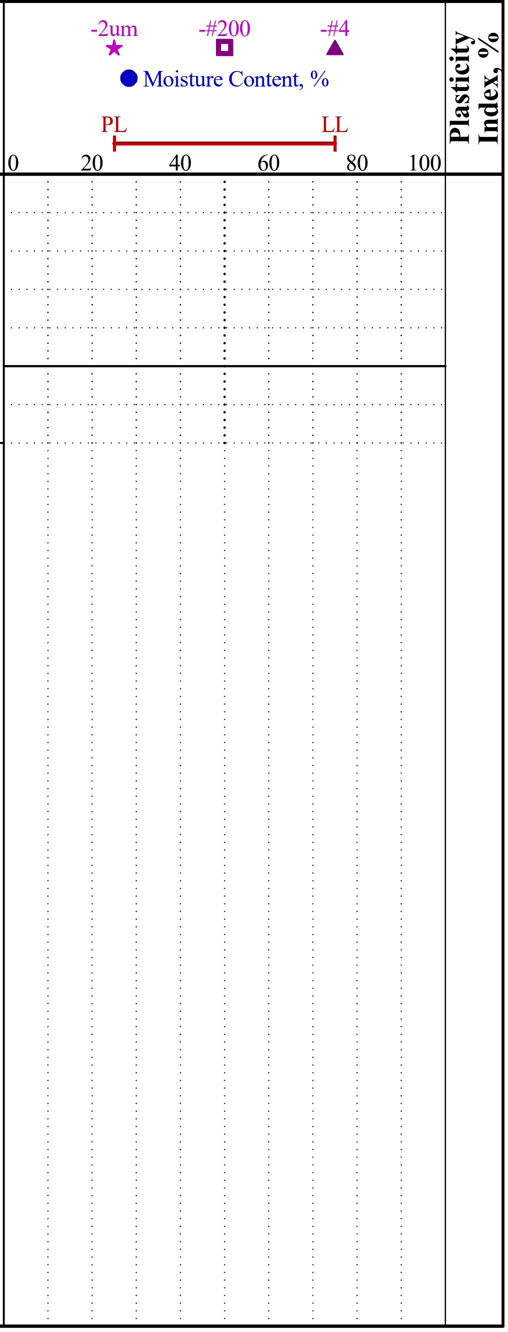
Excavation Date: May 1, 2024

Ground Elevation: n/a

Ground Water Levels:
AT TIME OF EXCAVATION: ---
AT END OF EXCAVATION: ---
AFTER EXCAVATION: ---

Notes:

DEPTH, ft.	GRAPHIC LOG	MATERIAL DESCRIPTION	GEOLOGY U.S.C.S.	POCKET PEN. (tsf)
0		CLAY, dark brown, damp	CH	
		CLAY, yellowish tan, silty, damp	CL	
5		CLAY, yellowish tan, silty, damp	CL-CH Ktl	
		Termination Depth: 7.0 feet		
10				
15				
20				
25				
30				



LOG OF TEST PIT

Test Pit TP-4

PAGE 1 OF 1

Job Name: Mayfair E9N
Job Location: New Braunfels, Texas
Engineer's Job #: 24201102.002
Client: Continental Homes of Texas, LP - San Marcos

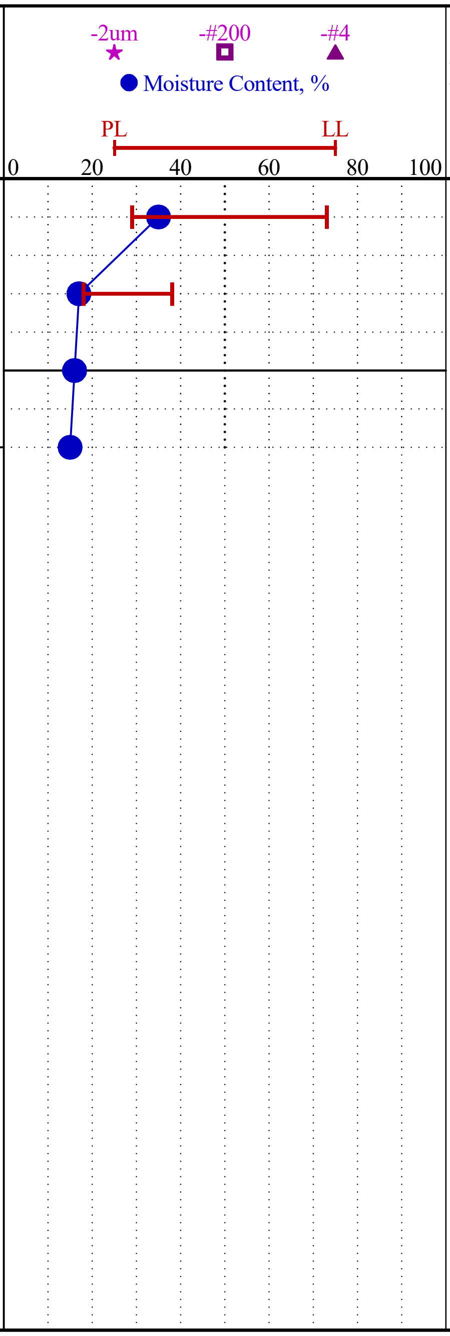
Excavation Date: May 1, 2024

Ground Elevation: n/a

Ground Water Levels:
AT TIME OF EXCAVATION: ---
AT END OF EXCAVATION: ---
AFTER EXCAVATION: ---

Notes:

DEPTH, ft.	GRAPHIC LOG	MATERIAL DESCRIPTION	GEOLOGY U.S.C.S.	POCKET PEN. (tsf)	Plasticity Index, %
0	▨	CLAY, dark brown, damp	CH		44
	▨	CLAY, yellowish tan, silty, with calcium, damp	CL		20
5	▨		Ktl		
		Termination Depth: 7.0 feet			
10					
15					
20					
25					
30					



LOG OF TEST PIT

Test Pit TP-5

PAGE 1 OF 1

Job Name: Mayfair E9N
Job Location: New Braunfels, Texas
Engineer's Job #: 24201102.002
Client: Continental Homes of Texas, LP - San Marcos

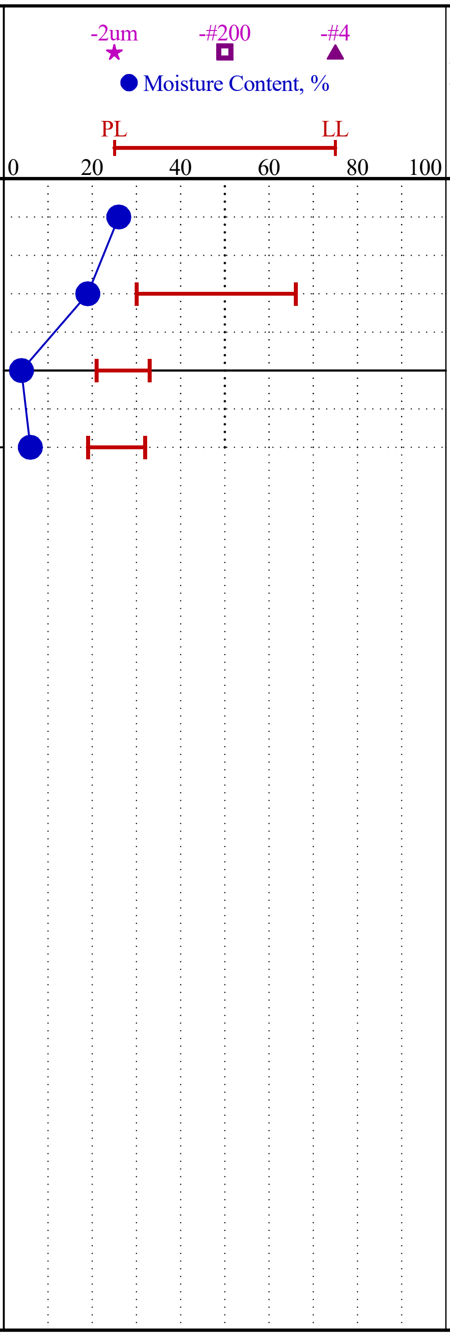
Excavation Date: May 1, 2024

Ground Elevation: n/a

Ground Water Levels:
AT TIME OF EXCAVATION: ---
AT END OF EXCAVATION: ---
AFTER EXCAVATION: ---

Notes:

DEPTH, ft.	GRAPHIC LOG	MATERIAL DESCRIPTION	GEOLOGY U.S.C.S.	POCKET PEN. (tsf)	Plasticity Index, %
0	▨	CLAY, dark brown, damp	CH		36
5	▨	CLAY, light tan, silty, calcareous, with weakly cemented layers, damp ...yellowish tan, without calcium below 6.0'	CL Ktl		12 13
		Termination Depth: 7.0 feet			



Depth scale: 0, 5, 10, 15, 20, 25, 30

24201102.002 - MAYFAIR E9N - LOGS.GPJ 5/15/24

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LOG OF TEST PIT

Test Pit TP-6

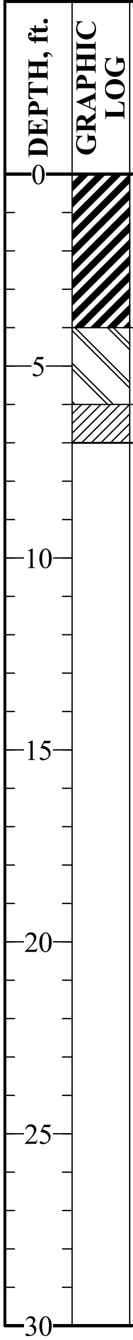
PAGE 1 OF 1

Job Name: Mayfair E9N
Job Location: New Braunfels, Texas
Engineer's Job #: 24201102.002
Client: Continental Homes of Texas, LP - San Marcos

Excavation Date: May 1, 2024 **Ground Elevation:** n/a

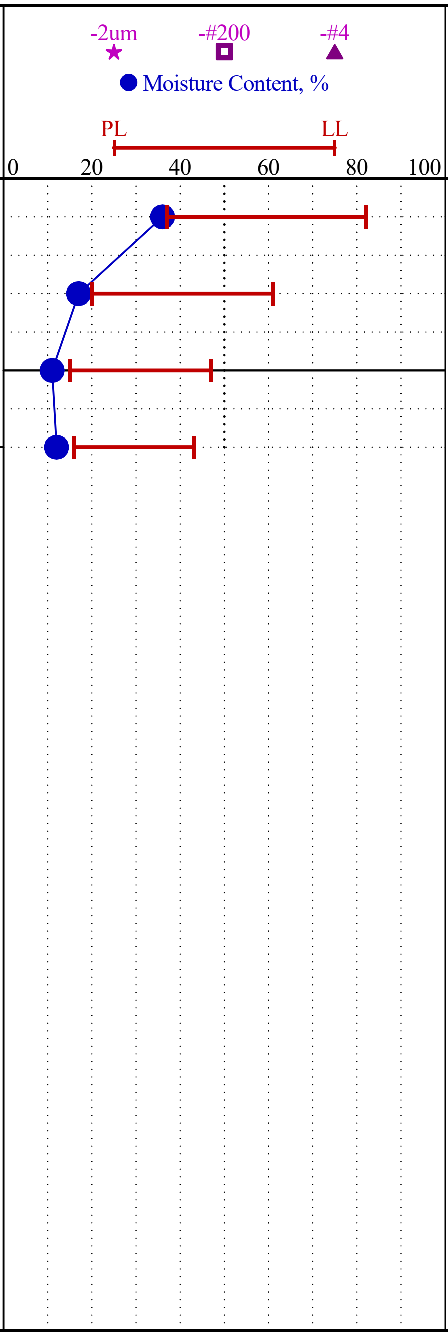
Ground Water Levels:
AT TIME OF EXCAVATION: ---
AT END OF EXCAVATION: ---
AFTER EXCAVATION: ---

Notes:



MATERIAL DESCRIPTION	GEOLOGY U.S.C.S.	POCKET PEN. (tsf)	Plasticity Index, %
CLAY, dark brown, damp ...gray, silty below 2.6'	CH		45 41
CLAY, yellowish tan and gray, silty, with weakly cemented layers, damp	CL-CH		32
CLAY, yellowish tan and gray, with weakly cemented layers, damp	CL		27
	Ktl		

Termination Depth: 7.0 feet



"put us to the test"

LOG OF TEST PIT

Test Pit TP-7

PAGE 1 OF 1

Job Name: Mayfair E9N
Job Location: New Braunfels, Texas
Engineer's Job #: 24201102.002
Client: Continental Homes of Texas, LP - San Marcos

Excavation Date: May 1, 2024

Ground Elevation: n/a

Ground Water Levels:
AT TIME OF EXCAVATION: ---
AT END OF EXCAVATION: ---
AFTER EXCAVATION: ---

Notes:

DEPTH, ft.	GRAPHIC LOG	MATERIAL DESCRIPTION	GEOLOGY U.S.C.S.	POCKET PEN. (tsf)	-2um ★ -#200 ◻ -#4 ▲ ● Moisture Content, % PL ├─┤ LL 0 20 40 60 80 100	Plasticity Index, %
0	▨	CLAY, dark brown, damp	CH			
	▨	CLAY, yellowish tan and gray, silty, damp	CL			
5	▨	CLAY, yellowish tan and gray, damp	CH Ktl			
		Termination Depth: 7.0 feet				
10						
15						
20						
25						
30						

24201102.002 - MAYFAIR E9N - LOGS.GPJ 5/15/24

LOG OF TEST PIT

Test Pit TP-8
PAGE 1 OF 1

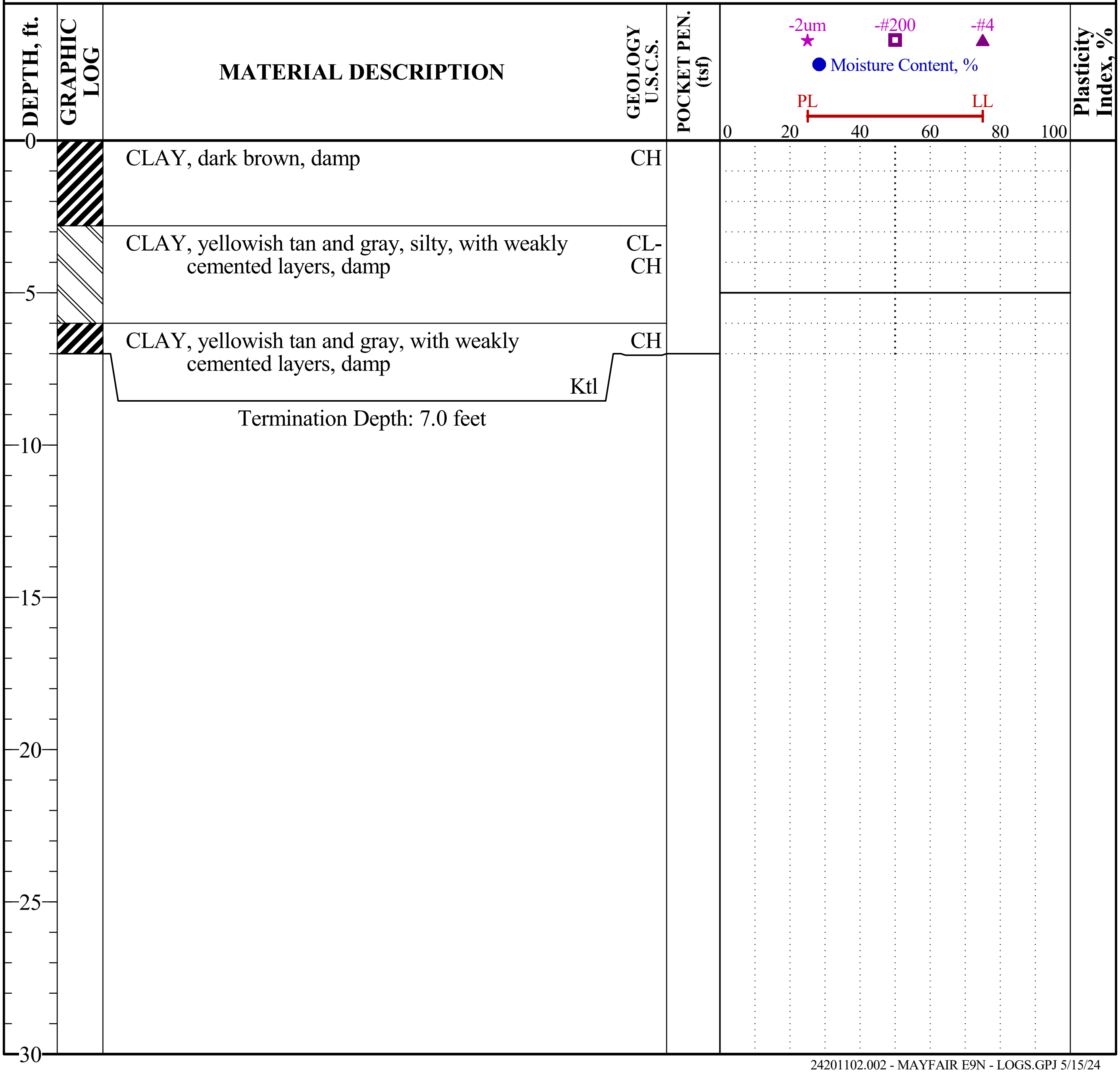
Job Name: Mayfair E9N
Job Location: New Braunfels, Texas
Engineer's Job #: 24201102.002
Client: Continental Homes of Texas, LP - San Marcos

Excavation Date: May 1, 2024

Ground Elevation: n/a

Ground Water Levels:
AT TIME OF EXCAVATION: ---
AT END OF EXCAVATION: ---
AFTER EXCAVATION: ---

Notes:



MATERIAL DESCRIPTION	GEOLOGY U.S.C.S.
CLAY, dark brown, damp	CH
CLAY, yellowish tan and gray, silty, with weakly cemented layers, damp	CL-CH
CLAY, yellowish tan and gray, with weakly cemented layers, damp	CH

Termination Depth: 7.0 feet

LOG OF TEST PIT

Test Pit TP-9

PAGE 1 OF 1

Job Name: Mayfair E9N
Job Location: New Braunfels, Texas
Engineer's Job #: 24201102.002
Client: Continental Homes of Texas, LP - San Marcos

Excavation Date: May 1, 2024

Ground Elevation: n/a

Ground Water Levels:
AT TIME OF EXCAVATION: ---
AT END OF EXCAVATION: ---
AFTER EXCAVATION: ---

Notes:

DEPTH, ft.	GRAPHIC LOG	MATERIAL DESCRIPTION	GEOLOGY U.S.C.S.	POCKET PEN. (tsf)	-2um ★ -#200 ▣ -#4 ▲ ● Moisture Content, % PL LL 0 20 40 60 80 100	Plasticity Index, %
0		CLAY, brown, damp	CL-CH			
		CLAY, yellowish tan and gray, silty, damp	CL			
5		CLAY, yellowish tan and gray, silty, with weakly cemented layers, damp	CL-CH			
		CLAY, yellowish tan and gray, with weakly cemented layers, damp	CH			
		Ktl				
10		Termination Depth: 7.0 feet				
15						
20						
25						
30						

24201102.002 - MAYFAIR E9N - LOGS.GPJ 5/15/24

LOG OF BORING

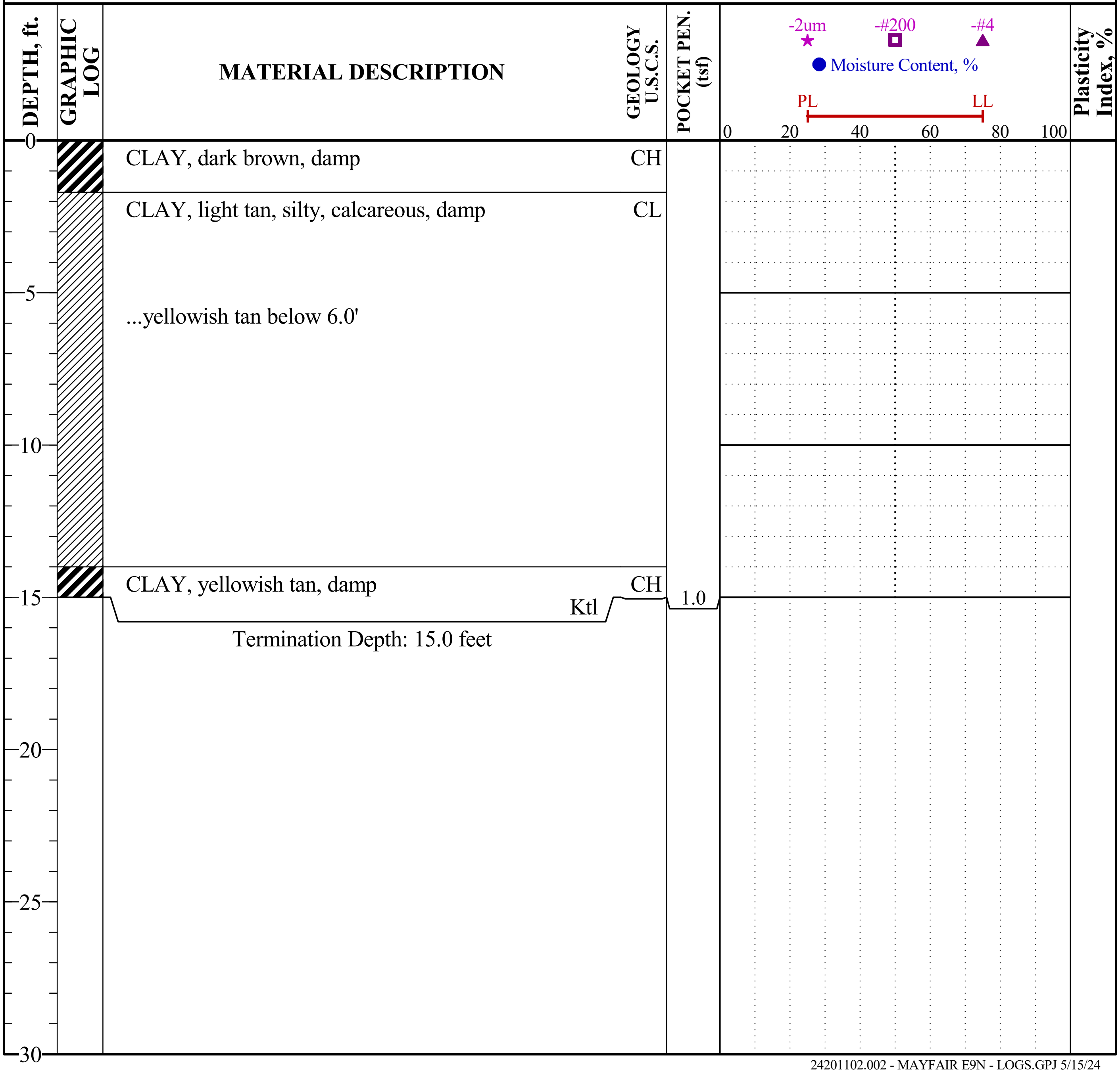
Boring B-10
PAGE 1 OF 1

Job Name: Mayfair E9N
Job Location: New Braunfels, Texas
Engineer's Job #: 24201102.002
Client: Continental Homes of Texas, LP - San Marcos

Drill Date: March 28, 2024
Hole Size: 4.5 in.
Ground Elevation: n/a

Notes:

Ground Water Levels:
AT TIME OF DRILLING: ---
AT END OF DRILLING: ---
AFTER DRILLING: ---



MATERIAL DESCRIPTION	GEOLOGY U.S.C.S.	POCKET PEN. (tsf)
CLAY, dark brown, damp	CH	
CLAY, light tan, silty, calcareous, damp	CL	
...yellowish tan below 6.0'		
CLAY, yellowish tan, damp	CH Ktl	1.0

Termination Depth: 15.0 feet

24201102.002 - MAYFAIR E9N - LOGS.GPJ 5/15/24

MLA
Geotechnical

"put us to the test"

LOG OF TEST PIT

Test Pit TP-11

PAGE 1 OF 1

Job Name: Mayfair E9N
Job Location: New Braunfels, Texas
Engineer's Job #: 24201102.002
Client: Continental Homes of Texas, LP - San Marcos

Excavation Date: May 1, 2024
Ground Elevation: n/a

Ground Water Levels:
AT TIME OF EXCAVATION: ---
AT END OF EXCAVATION: ---
AFTER EXCAVATION: ---

Notes:

-2um ★ -#200 ◘ -#4 ▲
● Moisture Content, %
PL ├──┤ LL
0 20 40 60 80 100

DEPTH, ft.	GRAPHIC LOG	MATERIAL DESCRIPTION	GEOLOGY	U.S.C.S.	POCKET PEN. (tsf)	Plasticity Index, %
0	▨	CLAY, dark brown, damp	Ktl	CH		
5	▨	CLAY, yellowish tan, silty, damp		CL		
	▨	CLAY, yellowish tan and gray, with weakly cemented layers, damp		CL-CH		
		Termination Depth: 7.0 feet				
10						
15						
20						
25						
30						

"put us to the test"

LOG OF BORING

Boring B-12

PAGE 1 OF 1

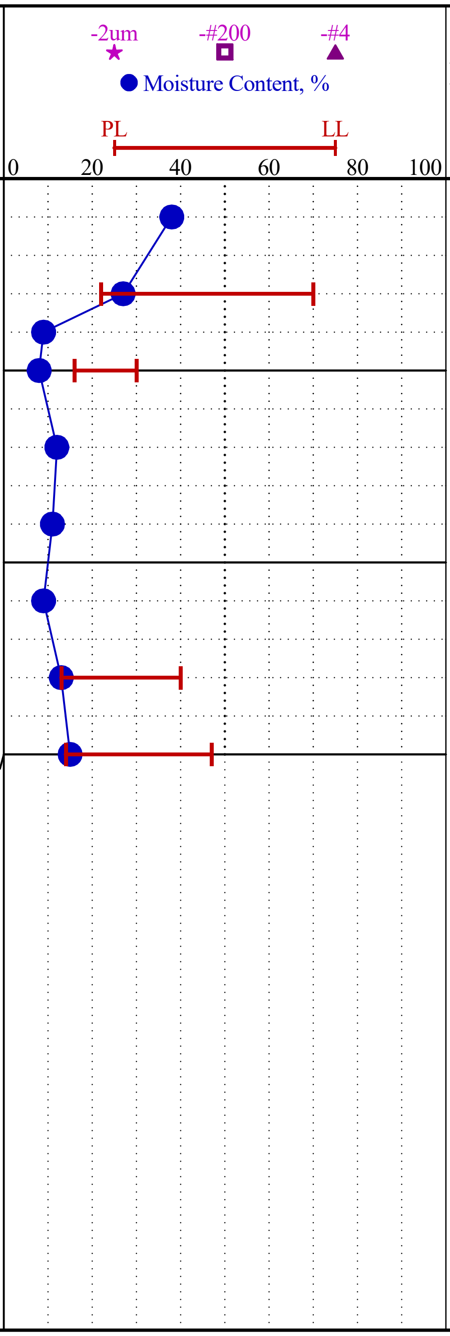
Job Name: Mayfair E9N
Job Location: New Braunfels, Texas
Engineer's Job #: 24201102.002
Client: Continental Homes of Texas, LP - San Marcos

Drill Date: March 28, 2024
Ground Elevation: n/a
Hole Size: 4.5 in.

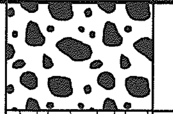
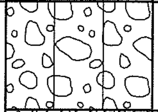
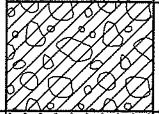
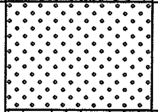
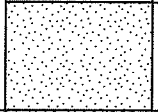
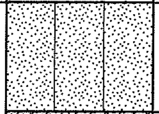
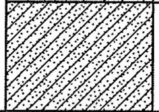
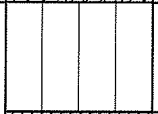
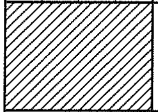
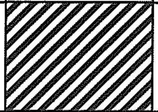
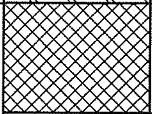
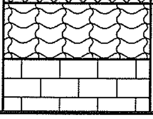
Notes:

Ground Water Levels:
AT TIME OF DRILLING: ---
AT END OF DRILLING: ---
AFTER DRILLING: ---

DEPTH, ft.	GRAPHIC LOG	MATERIAL DESCRIPTION	GEOLOGY U.S.C.S.	POCKET PEN. (tsf)	Plasticity Index, %
0	▨	CLAY, dark brown, damp	CH	2.5 2.5	 48
5	▨	CLAY, tan to yellowish tan, silty, with calcium, damp *Push refusal at 5.5'* ...yellowish tan below 6.0' ...without calcium below 12.0'	CL	4.0 1.0	14 27
15	▨	CLAY, yellowish tan, damp	Ktl CL-CH	1.5	33
20		Termination Depth: 15.0 feet			
25					
30					



SOIL CLASSIFICATION CHART

MAJOR DIVISIONS			SYMBOLS		TYPICAL DESCRIPTIONS
			GRAPH	LETTER	
COARSE GRAINED SOILS MORE THAN 50% OF MATERIAL IS LARGER THAN NO. 200 SIEVE SIZE	GRAVEL AND GRAVELLY SOILS MORE THAN 50% OF COARSE FRACTION RETAINED ON NO. 4 SIEVE	CLEAN GRAVELS (LITTLE OR NO FINES)		GW	WELL-GRADED GRAVELS, GRAVEL - SAND MIXTURES, LITTLE OR NO FINES
				GP	POORLY-GRADED GRAVELS, GRAVEL - SAND MIXTURES, LITTLE OR NO FINES
		GRAVELS WITH FINES (APPRECIABLE AMOUNT OF FINES)		GM	SILTY GRAVELS, GRAVEL - SAND - SILT MIXTURES
				GC	CLAYEY GRAVELS, GRAVEL - SAND - CLAY MIXTURES
	SAND AND SANDY SOILS MORE THAN 50% OF COARSE FRACTION PASSING ON NO. 4 SIEVE	CLEAN SANDS (LITTLE OR NO FINES)		SW	WELL-GRADED SANDS, GRAVELLY SANDS, LITTLE OR NO FINES
				SP	POORLY-GRADED SANDS, GRAVELLY SAND, LITTLE OR NO FINES
		SANDS WITH FINES (APPRECIABLE AMOUNT OF FINES)		SM	SILTY SANDS, SAND - SILT MIXTURES
				SC	CLAYEY SANDS, SAND - CLAY MIXTURES
FINE GRAINED SOILS MORE THAN 50% OF MATERIAL IS SMALLER THAN NO. 200 SIEVE SIZE	SILTS AND CLAYS	LIQUID LIMIT LESS THAN 50		ML	INORGANIC SILTS AND VERY FINE SANDS, ROCK FLOUR, SILTY OR CLAYEY FINE SANDS OR CLAYEY SILTS WITH SLIGHT PLASTICITY
				CL	INORGANIC CLAYS OF LOW TO MEDIUM PLASTICITY, GRAVELLY CLAYS, SANDY CLAYS, SILTY CLAYS, LEAN CLAYS
				OL	ORGANIC SILTS AND ORGANIC SILTY CLAYS OF LOW PLASTICITY
	CLAYS	LIQUID LIMIT GREATER THAN 50		CH	INORGANIC CLAYS OF HIGH PLASTICITY
SOILS OF MODERATE PLASTICITY				CL-CH	LOW PI CLAYS WITH APPRECIABLE HIGH PI MOTTLING, CLAY WITH BORDERLINE CLASSIFICATION
OTHER MATERIALS				FILL	MATERIAL NOT NATURALLY DEPOSITED
				LS	WEATHERED LIMESTONE INTACT LIMESTONE

NOTE: DUAL SYMBOLS ARE USED TO INDICATE BORDERLINE SOIL CLASSIFICATIONS

Key to Terms and Abbreviations

Descriptive Terms Characterizing Soils and Rock

Argillaceous – having appreciable amounts of clay in the soil or rock mass. Used most often in describing limestones, occasionally sandstones.

Calcareous – containing appreciable quantities of calcium carbonate. Can be either nodular or "powder."

Crumbly – cohesive soils which break into small blocks or crumbs on drying.

Evaporite – deposits of salts and other soluble compounds. Most commonly calcium carbonate or gypsum. May be in either "powder" or visible crystal form.

Ferruginous – having deposits of iron or nodules, typically oxidized and dark red in color.

Ferrous – see Ferruginous

Fissured – containing shrinkage cracks frequently filled with fine sand or silt, usually more or less vertical.

Fossiliferous – containing appreciable quantities of fossils, fossil fragments, or traces of fossils

Laminated – composed of thin layers of varying color or texture. Layers are typically distinct and varying in composition from sand to silt and clay.

Mottled – characterized as having multiple colors organized in a marbled pattern.

Slickensided – having inclined planes of weakness that are slick and glossy in appearance.

Varved – see Laminated.

Standard Description Abbreviations and Terms

brn = brown
dk = dark
lt = light
wx = weathered
calc = calcareous
sw = severely weathered
cw = completely weathered
n/a = not available
b. = below

Engineering Units

pcf = pounds per cubic foot
psf = pounds per square foot
tsf = tons per square foot
pF = picofarad
psi = pounds per square inch
kips = thousand pounds (force)
ksf = kips per square foot

Symbols and Abbreviations for Test Data

LL = Liquid Limit
PL = Plastic Limit
PI = Plasticity Index (LL-PL)
NP = non-plastic
γ_d = dry unit weight
q_u = unconfined compressive strength
q_c = confined compressive strength
SPT = standard penetration test
TCP = Texas cone penetration test (Texas Highway Department)
N or N_{SPT} = blows per foot from SPT
N_{TCP} = blows per foot from TCP
SCR = standard core recovery
RQD = rock quality designation
RQI = see RQD

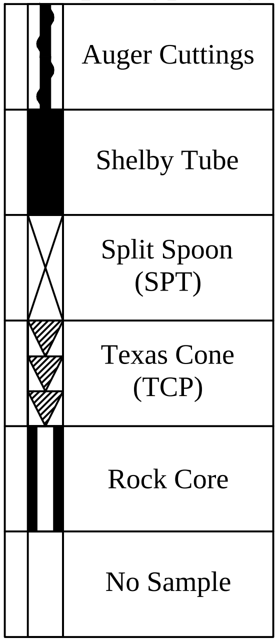
Terms Describing Consistency of Soil and Rock

COARSE GRAINED MATERIAL		SEDIMENTARY ROCK	
DESCRIPTIVE TERM	BLOWS/FT (SPT)	DESCRIPTIVE TERM	STRENGTH, TSF
very loose	0 – 4	soft	4 – 8
loose	4 – 10	medium	8 – 15
firm (medium)	10 – 30	hard	15 – 50
dense	30 – 50	very hard	over 50
very dense	over 50		

Describing Consistency of Fine Grained Soil

DESCRIPTIVE TERM	BLOWS/FT (SPT)	UNCONFINED COMPRESSION, TSF
very soft	< 2	< 0.25
soft	2 – 4	0.25 – 0.50
medium stiff	4 – 8	0.50 – 1.00
stiff	8 – 15	1.00 – 2.00
very stiff	15 – 30	2.00 – 4.00
hard	over 30	over 4.00

Sample Type Key



Revised: October 2018

APPENDIX B

STANDARD FIELD AND LABORATORY PROCEDURES

STANDARD FIELD AND LABORATORY PROCEDURES

STANDARD FIELD PROCEDURES

Drilling and Sampling

Borings and test pits are typically staked in the field by the drillers, using simple taping or pacing procedures and locations are assumed to be accurate to within several feet. Unless noted otherwise, ground surface elevations (GSE) when shown on logs are estimated from topographic maps and are assumed to be accurate to within a foot. A Plan of Borings or Plan of Test Pits showing the boring locations and the proposed structures is provided in the Appendix.

A log of each boring or pit is prepared as drilling and sampling progressed. In the laboratory, the driller's classification and description is reviewed by a Geotechnical Engineer. Individual logs of each boring or pit are provided in the Appendix. Descriptive terms and symbols used on the logs are in accordance with the Unified Soil Classification System (ASTM D-2487). A reference key is also provided. The stratification of the subsurface material represents the soil conditions at the actual boring locations, and variations may occur between borings. Lines of demarcation represent the approximate boundary between the different material types, but the transition may be gradual.

A truck-mounted rotary drill rig utilizing rotary wash drilling or continuous flight hollow or solid stem auger procedures is used to advance the borings, unless otherwise noted. A backhoe provided by others is used to place test pits. Test pits are advanced to the required depth, refusal (typically bedrock) or to the limits of the equipment. Samples of soil are obtained from the borings or test pit spoils for subsequent laboratory study. Samples are sealed in plastic bags and marked as to depth and boring/pit locations in the field. Cores are wrapped in a polyethylene wrap to preserve field moisture conditions, placed in core boxes and marked as to depth and core runs. Unless notified to the contrary, samples and cores will be stored for 90 days, then discarded.

Standard Penetration Test and Split-Barrel Sampling of Soils (ASTM D-1586) (SPT)

This sampling method consists of driving a 2 inch outside diameter split barrel sampler using a 140 pound hammer freely falling through a distance of 30 inches. The sampler is first seated 6 inches into the material to be sampled and then driven an additional 12 inches. The number of blows required to drive the sampler the final 12 inches is known as the Standard Penetration Resistance. The results of the SPT is recorded on the boring logs as "N" values.

Thin-Walled Tube Sampling of Soils (ASTM D-1587) (Shelby Tube Sampling)

This method consists of pushing thin walled steel tubes, usually 3 inches in diameter, into the soils to be sampled using hydraulic pressure or other means. Cohesive soils are usually sampled in this manner and relatively undisturbed samples are recovered.

Soil Investigation and Sampling by Auger Borings (ASTM D-1452)

This method consists of auguring a hole and removing representative soil samples from the auger flight or bit at intervals or with each change in the substrata. Disturbed samples are obtained and this method is, therefore, limited to situations where it is satisfactory to determine the approximate subsurface profile and obtain samples suitable for Index Property testing.

Diamond Core Drilling for Site Investigation (ASTM D-2113)

This method consists of advancing a hole into hard strata by rotating a single or double tube core barrel equipped with a cutting bit. Diamond, tungsten carbide, or other cutting agents may be used for the bit. Wash water or air is used to remove the cuttings and to cool the bit. Normally, a 3 inch outside diameter by 2-1/8 inch inside diameter coring bit is used unless otherwise noted. The rock or hard material recovered within the core barrel is examined in the field and in the laboratory and the cores are stored in partitioned boxes. The intactness of all rock core specimens is evaluated in two ways. The first method is the Standard Core Recovery (SCR) expressed as the length of the total core recovered divided by the length of the core run, expressed as a percentage:

$$\text{SCR} = \frac{\text{total core length recovered}}{\text{length of core run}} \times 100\%$$

This value is exhibited on the boring logs as the Standard Core Recovery (SCR).

The second procedure for evaluating the intactness of the rock cores is by Rock Quality Designation (RQD). The RQD provides an additional qualitative measure of soundness of the rock. This index is determined by measuring the intact recovered core unit which exceed four inches in length divided by the total length of the core run:

$$\text{RQD} = \frac{\text{all core lengths greater than 4''}}{\text{length of core run}} \times 100\%$$

The RQD is also expressed as a percentage and is shown on the boring logs.

Vane Shear Tests

In-situ vane shear tests may be used to determine the shear strength of soft to medium cohesive soil. This test consists of placing a four-bladed vane in the undisturbed soil and determining the torsional force applied at the ground surface required to cause the cylindrical perimeter surface of the vane to be sheared. The torsional force sufficient to cause shearing is converted to a unit of shearing resistance or cohesion of the soil surrounding the cylindrical surface.

THD Cone Penetrometer Test

The THD Cone Penetrometer Test is a standard field test to determine the relative density or consistency and load carrying capacity of foundation soils. This test is performed in much the same manner as the Standard Penetration Test described above. In this test, a 3 inch diameter penetrometer cone is used in place of a split-spoon sampler. This test calls for a 170-pound weight falling 24 inches. The actual test in hard materials consists of driving the penetrometer cone and accurately recording the inches of penetration for the first and second 50 blows for a total of 100 blows. These results are then correlated using a table of load capacity vs. number of inches penetrated per 100 blows.

Pocket Penetrometer Test

A pocket penetrometer or hand penetrometer is a small device used to estimate the shear capacity or unconfined compressive strength of a soil sample. The device consists of a spring-loaded probe which measures the pressure required to penetrate the probe into a soil sample for specified depth. This test can only be performed on cohesive soil samples. This pressure is reported in tons per square foot (tsf) on the Logs of Boring. A hyphen (-) indicates that the soil sample was too loose or too soft to perform the test. This test is considered rudimentary and too inaccurate to be used for direct design parameters; however, this test is useful for correlations among soil strata and general stiffness descriptions.

Ground Water Observation

Ground moisture observations are made during the operations and are reported on the logs of boring or pit. Moisture condition of cuttings are noted, however, the use of water for circulation precludes direct observation of wet conditions. Water levels after completing the borings or pits are noted. Seasonal variations, temperatures and recent rainfall conditions may influence the levels of the ground water table and water may be present in excavations, even though not indicated on the logs.

STANDARD LABORATORY PROCEDURES

To adequately characterize the subsurface material at this site, some or all of the following laboratory tests are performed. The results of the actual tests performed are shown graphically on the Logs of Boring or Pit.

Moisture Content - ASTM D-2216

Natural moisture contents of the samples (based on dry weight of soil) are determined for selected samples at depths shown on the respective boring logs. These moisture contents are useful in delineating the depth of the zone of moisture change and as a gauge of correlation between the various index properties and the engineering properties of the soil. For example, the relationship between the plasticity index and moisture content is a source of information for the correlation of shear strength data.

Dry Density - ASTM D-7263

The dry density, γ_d, (bulk density or unit weight) of the samples is determined for selected samples at depths shown on the respective boring logs using Method B of the aforementioned ASTM standard. The in-situ density was determined from undisturbed SPT samples and the dry density was calculated using moisture content results. These dry density values are useful for calculating other characteristic values such as porosity, void ratio, and mass composition of soil. Additionally, these values can also be used to assess the degree of compaction or consolidation of fill materials.

Atterberg Limits - ASTM D-4318

The Atterberg Limits are the moisture contents at the time the soil meets certain arbitrarily defined tests. At the moisture content defined as the plastic limit, Pw, the soil is assumed to change from a semi-solid state to a plastic state. By the addition of more moisture, the soil may be brought up to the moisture content defined as the liquid limit, Lw, or that point where the soil changes from a plastic state to a liquid state. A soil existing at a moisture content between these two previously described states is said to be in a plastic state. The difference between the liquid limit, Lw, and the plastic limit, Pw, is termed the plasticity index, Iw. As the plasticity index increases, the ability of a soil to attract water and remain in a plastic state increases. The Atterberg Limits that were determined are plotted on the appropriate log.

The Atterberg Limits are quite useful in soil exploration as an indexing parameter. Using the Atterberg Limits and grain size analysis, A. Casagrande developed the Unified Soils Classification System (USCS) which is widely used in the geotechnical engineering field. This system related the liquid limit to the plasticity index by dividing a classification chart into various zones according to degrees of plasticity of clays and silts. Although the Atterberg Limits are an indexing parameter, K. Terzaghi has related these limits to various engineering properties of a soil. Some of these relationships are as follows:

1. As the grain size of the soil decreases, the Atterberg Limits increase.
2. As the percent clay in the soil increases, the Atterberg Limits increase.
3. As the shear strength increases, the Atterberg Limits decrease.
4. As the compressibility of a soil increases, the Atterberg Limits increase.

Free Swell Test - ASTM D-4546-96

The free swell test assesses the potential for swell of soil. This value is useful for the design of various structures such as slab-on-ground foundations, piers and piles, and underground utilities. Method B of the aforementioned ASTM standard determines the amount of swell (vertical heave) of a sample. This is done by placing the sample in a consolidometer under a seating load equal to the overburden pressure and giving the sample free access to water. The height is measured and the swell is calculated as the vertical displacement divided by the original height of the specimen. The results of these tests are presented on the Logs of Boring at the depth of the samples tested.

Swell Pressure Test - ASTM D-4546-96

The swell pressure test assesses the potential for swell of soil. This value is useful for the design of various structures such as slab-on-ground foundations, piers and piles, and underground utilities. Method C of the aforementioned ASTM standard determines the pressure required to keep a soil sample at equilibrium under swelling conditions. This is done by placing the sample in a consolidometer under a seating load and giving the sample free access to water. A constant height of the sample is maintained and the vertical pressure on the sample is adjusted until equilibrium is reached. The vertical pressure on the sample at equilibrium is reported as the swell pressure. The results of these tests are presented on the Logs of Boring at the depth of the samples tested.

Soil Suction Test - ASTM D-5298-94

Soil suction (potential) tests are performed to determine both the matric and total suction values for the samples tested. Soil suction measures the free energy of the pore water in a soil. In a practical sense, soil suction is an indication of the affinity of a given soil sample to retain water. Soil suction provides useful information on a variety of characteristics of the soil that are affected by the soil water including volume change, deformation, and strength.

Soil suction tests are performed using the filter paper method per ASTM D-5298. Results of these tests are shown graphically on the logs of boring and tabulated in summary sheet of laboratory data.

For matric suction values found using this method, it should be noted that when the soil is in a dry state adequate contact between the filter paper and the soil may not be possible. This lack of contact may result in the determination of total suction instead of matric suction.

Triaxial Shear Test - ASTM D-2850-70

Triaxial tests may be performed on samples that are approximately 2.83 inches in diameter, unless a smaller diameter sample was necessary to achieve a more favorable length:diameter (L:D) ratio. A minimum length to diameter ratio (L:D) of 2.0 is maintained to reduce end effects.

The triaxial tests are typically unconsolidated-undrained using nitrogen gas for chamber confining pressure. Confining pressures are selected to conform to in-situ hydrostatic pressure considering the earth to be a fluid of 120 pcf. In this test, undisturbed Shelby tube samples are trimmed so that their ends are square and then pressed in a triaxial compression machine. The load at which failure occurs is the compressive strength. The results of the triaxial tests and the correlated hand penetrometer strengths can be utilized to develop soil shear strength values. These test provide the confined compressive strength, q_c, which are presented on the Logs of Boring at the depth of the samples tested.

Unconfined Compressive Strength of Rock Cores - ASTM D-2938

The unconfined compressive strength, q_u, is a valuable parameter useful in the design of foundation footings. This value, qu, is related to the shearing resistance of the rock and thus to the capacity of the rock to support a load. In completing this test it is imperative that the length:diameter ratio of the core specimens are maintained at a minimum of 2:1. This ratio is set so that the shear plane will not extend through either of the end caps. If the ratio is less than 2.0 a correction is applied to the result.

Grain Size Analysis - ASTM D-421 and D-422

Grain size analysis tests are performed to determine the particle size and distribution of the samples tested. The grain size distribution of the soils coarser than the Standard Number 200 sieve is determined by passing the sample through a standard set of nested sieves, and the distribution of sizes smaller than the No. 200 sieve is determined by a sedimentation process, using a hydrometer. The results are given on the log of Boring/Pit or on Grain Size Distribution semi-log graphs within the report.

Slake Durability Test - ASTM D-4644

The slake durability test provides an index for the durability of a shale, or similar rock, considering the effects of wetting, drying, and abrasion. This index is used to quantify the strength of weak rock formations when exposed to natural wetting and drying cycles, especially in the context of underground tunneling and excavation. The index, $I_d(2)$, represents the percentage, by mass, of rock material retained after two wetting and drying cycles. These cycles are simulated by oven drying the sample followed by ten minutes of tumbling and soaking in water within a drum and trough apparatus. After tumbling and soaking, the sample is oven-dried and the mass of the sample is recorded. The results of these tests are presented on the Logs of Boring at the depth of the samples tested.

Brazilian Tensile Strength - ASTM D-3967

The Brazilian (splitting) tensile strength, σ_t, is useful in rock mechanics design, especially in regard to tunneling. This value is an indirect representation of the true uniaxial tensile strength. The Brazilian test is typically used more commonly than direct tensile strength tests because it is less difficult, more cost effective, and more represented of in-situ conditions. The test is conducted by mechanically compressing a rock core sample along its vertical diameter, causing the sample to fail due to tension along the horizontal diameter caused by the Poisson effect.

CERCHAR Abrasivity Index (CAI) Test - ASTM D-7625

The CERCHAR Abrasivity Index (CAI) is used to determine the abrasivity of rocks. This is particularly useful in assessing the potential wearing on cutting tools during excavation. The CAI of a rock is determined by the CERCHAR test, which consists of scraping steel pins across a rock surface and measuring the wear of each pin. The rock specimen is held in a mechanical vice, while a conical steel pin fastened to a 15-pound head is drug across the face of the specimen using a lever being pulled 1 centimeter in 1 second. The CAI is calculated based on the resultant diameter on the end of the pin.

APPENDIX C

FPS-21 COMPUTER OUTPUT

Texas Department of Transportation

TEXAS DEPARTMENT OF TRANSPORTATION

F P S21-1.5 *FLEXIBLE PAVEMENT SYSTEM* *Release:12-12-2018*

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     PAVEMENT DESIGN TYPE # 5 -- ACP + FLEX BASE + STAB SBGR OVER SUBGRADE

PROB   DIST.-15   COUNTY- 46   CONT.  SECT.  JOB     HIGHWAY       DATE    PAGE

1     San Antonio     COMAL      NA      NA    NA     Local      5/14/2024   1
--------------------------------------------------------------------------------
                        COMMENTS ABOUT THIS PROBLEM

MLA Geotechnical; Local Street - City of New Braunfels




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```

BASIC DESIGN CRITERIA

```
  LENGTH OF THE ANALYSIS PERIOD (YEARS)                                 20.0
  MINIMUM TIME TO FIRST OVERLAY (YEARS)                                 20.0
  MINIMUM TIME BETWEEN OVERLAYS (YEARS)                                 10.0
  DESIGN CONFIDENCE LEVEL ( 90.0%)                                        B
  SERVICEABILITY INDEX OF THE INITIAL STRUCTURE                          4.2
  FINAL SERVICEABILITY INDEX P2                                          2.0
  SERVICEABILITY INDEX P1 AFTER AN OVERLAY                               4.0
  DISTRICT TEMPERATURE CONSTANT                                         31.0
  SUBGRADE ELASTIC MODULUS by COUNTY (ksi)                               2.00
  INTEREST RATE OR TIME VALUE OF MONEY (PERCENT)                         7.0
```

PROGRAM CONTROLS AND CONSTRAINTS

```
  NUMBER OF SUMMARY OUTPUT PAGES DESIRED ( 8 DESIGNS/PAGE)              3
  MAX FUNDS AVAILABLE PER SQ.YD. FOR INITIAL DESIGN (DOLLARS)          99.00
  MAXIMUM ALLOWED THICKNESS OF INITIAL CONSTRUCTION (INCHES)           99.0
  ACCUMULATED MAX DEPTH OF ALL OVERLAYS (INCHES) (EXCLUDING LEVEL-UP)   6.0
```

TRAFFIC DATA

```
  ADT AT BEGINNING OF ANALYSIS PERIOD (VEHICLES/DAY)                  1000.
  ADT AT END OF TWENTY YEARS (VEHICLES/DAY)                           1800.
  ONE-DIRECTION 20YEAR 18 kip ESAL (millions)                         0.083
  AVERAGE APPROACH SPEED TO THE OVERLAY ZONE(MPH)                       30.0
  AVERAGE SPEED THROUGH OVERLAY ZONE (OVERLAY DIRECTION)(MPH)           30.0
  AVERAGE SPEED THROUGH OVERLAY ZONE (NON-OVERLAY DIRECTION) (MPH)      30.0
  PROPORTION OF ADT ARRIVING EACH HOUR OF CONSTRUCTION (PERCENT)        10.0
  PERCENT TRUCKS IN ADT                                                  4.0
--------------------------------------------------------------------------------
```

```
---------------------------------------------------------------------------------

         PAVEMENT DESIGN TYPE # 5 -- ACP + FLEX BASE + STAB SBGR OVER SUBGRADE

PROB   DIST.-15   COUNTY- 46   CONT.  SECT.  JOB     HIGHWAY       DATE    PAGE

1     San Antonio     COMAL      NA      NA    NA     Local      5/14/2024   2
---------------------------------------------------------------------------------

                           INPUT DATA CONTINUED
```

CONSTRUCTION AND MAINTENANCE DATA

```
  MINIMUM OVERLAY THICKNESS (INCHES)                                         2.0
  OVERLAY CONSTRUCTION TIME (HOURS/DAY)                                     10.0
  ASPHALTIC CONCRETE COMPACTED DENSITY (TONS/C.Y.)                           1.90
  ASPHALTIC CONCRETE PRODUCTION RATE (TONS/HOUR)                           200.0
  WIDTH OF EACH LANE (FEET)                                                 12.0
  FIRST YEAR COST OF ROUTINE MAINTENANCE (DOLLARS/LANE-MILE)                 0.00
  ANNUAL INCREMENTAL INCREASE IN MAINTENANCE COST (DOLLARS/LANE-MILE)        0.00
```

DETOUR DESIGN FOR OVERLAYS

```
  TRAFFIC MODEL USED DURING OVERLAYING                                       2
  TOTAL NUMBER OF LANES OF THE FACILITY                                      2
  NUMBER OF OPEN LANES IN RESTRICTED ZONE (OVERLAY DIRECTION)                0
  NUMBER OF OPEN LANES  IN RESTRICTED ZONE (NON-OVERLAY DIRECTION)           1
  DISTANCE TRAFFIC IS SLOWED (OVERLAY DIRECTION) (MILES)                     0.60
  DISTANCE TRAFFIC IS SLOWED (NON-OVERLAY DIRECTION) (MILES)                 0.00
  DETOUR DISTANCE AROUND THE OVERLAY ZONE (MILES)                            0.00
```

PAVING MATERIALS INFORMATION

```
              MATERIALS       COST     E    POISSON   MIN.    MAX. SALVAGE
LAYER CODE       NAME        PER CY MODULUS  RATIO   DEPTH   DEPTH   PCT.
  1    A  ASPH CONC PVMT    150.00  500000.   0.35    3.00    4.00   30.00
  2    B  FLEXIBLE BASE      54.00   40000.   0.35   12.00   16.00   75.00
  3    C  STABILIZED SUBGR   15.00   20000.   0.30    8.00    8.00   90.00
  4    D  SUBGRADE(200)       2.00    2000.   0.40  200.00  200.00   90.00
```

PAVEMENT DESIGN TYPE # 5 -- ACP + FLEX BASE + STAB SBGR OVER SUBGRADE

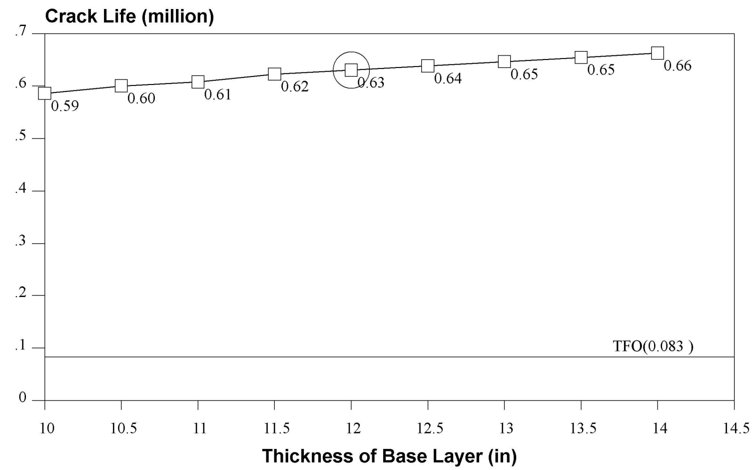
```
PROB   DIST.-15   COUNTY- 46   CONT.  SECT.  JOB     HIGHWAY       DATE     PAGE

1     San Antonio     COMAL      NA      NA    NA     Local      5/14/2024   3
--------------------------------------------------------------------------------


     C. LEVEL B       SUMMARY OF THE BEST DESIGN STRATEGIES
                        IN ORDER OF INCREASING TOTAL COST
                         1
--------------------------------------------------------------------------------
MATERIAL ARRANGEMENT   ABC
INIT. CONST. COST     33.83
OVERLAY CONST. COST    0.00
USER COST              0.00
ROUTINE MAINT. COST    0.00
SALVAGE VALUE         -5.23
--------------------------------------------------------------------------------
TOTAL COST            28.60
--------------------------------------------------------------------------------
NUMBER OF LAYERS        3
--------------------------------------------------------------------------------
LAYER DEPTH (INCHES)
     D(1)              3.00
     D(2)             12.00
     D(3)              8.00
--------------------------------------------------------------------------------
NO.OF PERF.PERIODS      1
--------------------------------------------------------------------------------
PERF. TIME (YEARS)
     T(1)              40.
--------------------------------------------------------------------------------
OVERLAY POLICY(INCH)
(INCLUDING LEVEL-UP)
--------------------------------------------------------------------------------


        THE TOTAL NUMBER OF FEASIBLE DESIGNS CONSIDERED WAS        27
```

	Thickness (inches)	*Modulus (ksi)*	*Poisson's Ratio*	*Material Name*
AC	3.00	500.00	0.35	ASPH CONC PVMT
Base	12.00	40.00	0.35	FLEXIBLE BASE
Subbase	8.00	20.00	0.30	STABILIZED SUBGR
Subgrade	200.00	2.00	0.40	SUBGRADE(200)



Fatigue Crack Model:

$$N_f = f_1(\varepsilon_t)^{-f_2}(E_1)^{-f_3}$$

f_1 =7.96E-02

f_2 = 3.291

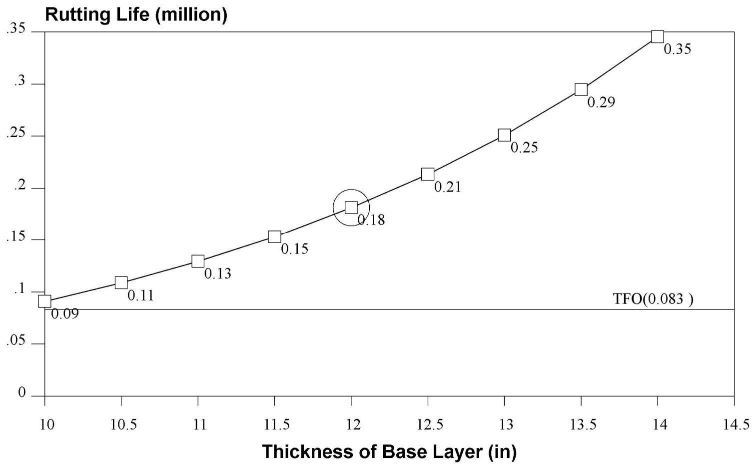
f_3 = .854

Rutting Model:

$$N_d = f_4(\varepsilon_v)^{-f_5}$$

f_4 =1.37E-09

f_5 = 4.477



TFO(Traffic to 1st Overlay): 0.08 (million)

Crack Life: 0.63 (million) ε_τ = 266.00 ($\mu\varepsilon$)

Rut Life: 0.18 (million) ε_v = -701.00 ($\mu\varepsilon$)

Traffic to 1st Overlay is calculated by analysis period: 20years and 18 kips:.08millions.
Also the start ADT:1000.0 and ending ADT:1800.0

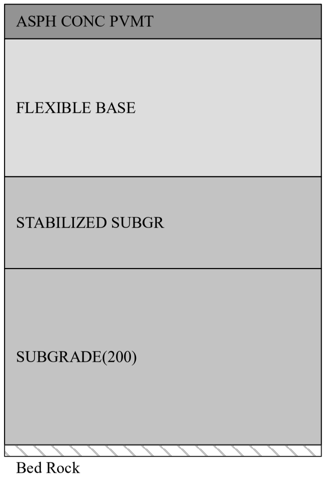
Mechanistic Check Conclusion:

The design is OK !

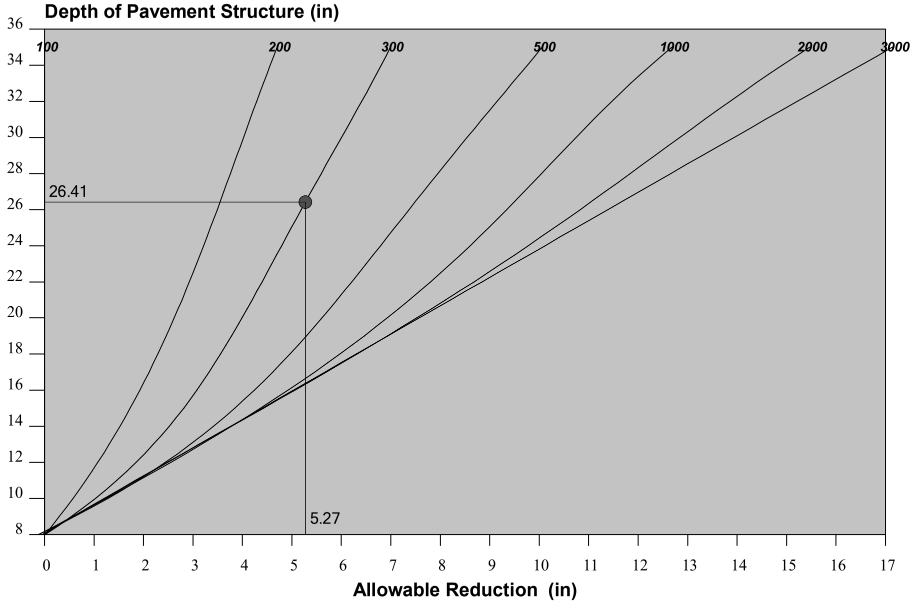
FPS 21 Mechanistic Design Check Output (FPS21-1.5Release:12-12-2018)

Highway	Local	Problem	1
C-S-J	NA - NA - NA	Date	5/14/2024
District	San Antonio	County	COMAL

Design Type:Asphalt concrete + Flexible Base + Stabilized Subgrade over Subgrade



Thickness (inches)	Modulus (ksi)	Poisson's Ratio	Material Name
3.00	500.00	0.35	ASPH CONC PVMT
12.00	40.00	0.35	FLEXIBLE BASE
8.00	20.00	0.30	STABILIZED SUBGR
200.00	2.00	0.40	SUBGRADE(200)
	200.00	0.15	Bed Rock



Thickness Reduction Chart for Stabilized Layers

INPUT PARAMETERS:

The Heaviest Wheel Loads Daily (ATHWLD)	10000.0 (lb)
Percentage of TandemAxles	49.0 (%)
Modified Cohesionmeter Value	300.0
Design Wheel Load	10000.0 (lb)
Subgrade Texas Triaxial Class Number (TTC)	6.28
Calculated TTC based on input soil PI	
User Input Sub-Grade Plasticity Index (PI)	60.00

RESULT:

Triaxial Thickness Required	26.4 (in)
The FPS Design Thickness	23.0 (in)
Allowable Thickness Reduction	5.3 (in)
Modified Triaxial Thickness	21.1 (in)

TRIAXIAL CHECK CONCLUSION:

The Design OK !

FPS 21 Triaxial Design Check Output	**(FPS21-1.5Release:12-12-2018)**		
Highway	Local	Problem	1
C-S-J	NA - NA - NA	Date	5/14/2024
District	San Antonio	County	COMAL
Design Type:Asphalt concrete + Flexible Base + Stabilized Subgrade over Subgrade			

Texas Department of Transportation

```
--------------------------------------------------------------------------------
```

TEXAS DEPARTMENT OF TRANSPORTATION

F P S21-1.5 *FLEXIBLE PAVEMENT SYSTEM* *Release:12-12-2018*

```
--------------------------------------------------------------------------------
```

PAVEMENT DESIGN TYPE # 5 -- ACP + FLEX BASE + STAB SBGR OVER SUBGRADE

```
PROB   DIST.-15   COUNTY- 46   CONT.  SECT.  JOB     HIGHWAY       DATE    PAGE

1     San Antonio     COMAL      NA      NA    NA     Local      5/14/2024   1
--------------------------------------------------------------------------------
                        COMMENTS ABOUT THIS PROBLEM

MLA Geotechnical; Collector - City of New Braunfels

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```

BASIC DESIGN CRITERIA

```
  LENGTH OF THE ANALYSIS PERIOD (YEARS)                                     20.0
  MINIMUM TIME TO FIRST OVERLAY (YEARS)                                     20.0
  MINIMUM TIME BETWEEN OVERLAYS (YEARS)                                     10.0
  DESIGN CONFIDENCE LEVEL ( 90.0%)                                            B
  SERVICEABILITY INDEX OF THE INITIAL STRUCTURE                              4.2
  FINAL SERVICEABILITY INDEX P2                                              2.5
  SERVICEABILITY INDEX P1 AFTER AN OVERLAY                                   4.0
  DISTRICT TEMPERATURE CONSTANT                                             31.0
  SUBGRADE ELASTIC MODULUS by COUNTY (ksi)                                   2.00
  INTEREST RATE OR TIME VALUE OF MONEY (PERCENT)                             7.0
```

PROGRAM CONTROLS AND CONSTRAINTS

```
  NUMBER OF SUMMARY OUTPUT PAGES DESIRED ( 8 DESIGNS/PAGE)                  3
  MAX FUNDS AVAILABLE PER SQ.YD. FOR INITIAL DESIGN (DOLLARS)              99.00
  MAXIMUM ALLOWED THICKNESS OF INITIAL CONSTRUCTION (INCHES)               99.0
  ACCUMULATED MAX DEPTH OF ALL OVERLAYS (INCHES) (EXCLUDING LEVEL-UP)       6.0
```

TRAFFIC DATA

```
  ADT AT BEGINNING OF ANALYSIS PERIOD (VEHICLES/DAY)                      5000.
  ADT AT END OF TWENTY YEARS (VEHICLES/DAY)                              10956.
  ONE-DIRECTION 20YEAR 18 kip ESAL (millions)                             0.864
  AVERAGE APPROACH SPEED TO THE OVERLAY ZONE(MPH)                           30.0
  AVERAGE SPEED THROUGH OVERLAY ZONE (OVERLAY DIRECTION)(MPH)               30.0
  AVERAGE SPEED THROUGH OVERLAY ZONE (NON-OVERLAY DIRECTION) (MPH)          30.0
  PROPORTION OF ADT ARRIVING EACH HOUR OF CONSTRUCTION (PERCENT)            10.0
  PERCENT TRUCKS IN ADT                                                      6.0

--------------------------------------------------------------------------------
```

```
--------------------------------------------------------------------------------
                    TEXAS DEPARTMENT OF TRANSPORTATION
 F P S21-1.5              FLEXIBLE PAVEMENT SYSTEM              Release:12-12-2018
--------------------------------------------------------------------------------

          PAVEMENT DESIGN TYPE # 5 -- ACP + FLEX BASE + STAB SBGR OVER SUBGRADE

PROB   DIST.-15   COUNTY- 46   CONT.  SECT.  JOB     HIGHWAY       DATE    PAGE

1     San Antonio     COMAL      NA      NA    NA     Local      5/14/2024   2
--------------------------------------------------------------------------------

                            INPUT DATA CONTINUED
```

CONSTRUCTION AND MAINTENANCE DATA

```
  MINIMUM OVERLAY THICKNESS (INCHES)                                      2.0
  OVERLAY CONSTRUCTION TIME (HOURS/DAY)                                  10.0
  ASPHALTIC CONCRETE COMPACTED DENSITY (TONS/C.Y.)                        1.90
  ASPHALTIC CONCRETE PRODUCTION RATE (TONS/HOUR)                        200.0
  WIDTH OF EACH LANE (FEET)                                              12.0
  FIRST YEAR COST OF ROUTINE MAINTENANCE (DOLLARS/LANE-MILE)              0.00
  ANNUAL INCREMENTAL INCREASE IN MAINTENANCE COST (DOLLARS/LANE-MILE)     0.00
```

DETOUR DESIGN FOR OVERLAYS

```
  TRAFFIC MODEL USED DURING OVERLAYING                                    2
  TOTAL NUMBER OF LANES OF THE FACILITY                                   2
  NUMBER OF OPEN LANES IN RESTRICTED ZONE (OVERLAY DIRECTION)             0
  NUMBER OF OPEN LANES  IN RESTRICTED ZONE (NON-OVERLAY DIRECTION)        1
  DISTANCE TRAFFIC IS SLOWED (OVERLAY DIRECTION) (MILES)                  0.60
  DISTANCE TRAFFIC IS SLOWED (NON-OVERLAY DIRECTION) (MILES)              0.00
  DETOUR DISTANCE AROUND THE OVERLAY ZONE (MILES)                         0.00
```

PAVING MATERIALS INFORMATION

```
              MATERIALS       COST      E    POISSON   MIN.    MAX. SALVAGE
LAYER CODE       NAME        PER CY MODULUS  RATIO    DEPTH   DEPTH   PCT.
  1    A  ASPH CONC PVMT    150.00  500000.   0.35    3.50    4.00   30.00
  2    B  FLEXIBLE BASE      54.00   40000.   0.35   15.00   18.00   75.00
  3    C  STABILIZED SUBGR   15.00   20000.   0.30   10.00   10.00   90.00
  4    D  SUBGRADE(200)       2.00    2000.   0.40  200.00  200.00   90.00
```

```
--------------------------------------------------------------------------------
```

```
--------------------------------------------------------------------------------
                     TEXAS DEPARTMENT OF TRANSPORTATION
F P S21-1.5                  FLEXIBLE PAVEMENT SYSTEM              Release:12-12-2018

--------------------------------------------------------------------------------

             PAVEMENT DESIGN TYPE # 5 -- ACP + FLEX BASE + STAB SBGR OVER SUBGRADE

PROB   DIST.-15   COUNTY- 46   CONT.  SECT.  JOB     HIGHWAY       DATE    PAGE

1     San Antonio     COMAL      NA      NA    NA     Local      5/14/2024   3
--------------------------------------------------------------------------------


     C. LEVEL B       SUMMARY OF THE BEST DESIGN STRATEGIES
                        IN ORDER OF INCREASING TOTAL COST
                          1
--------------------------------------------------------------------------------
MATERIAL ARRANGEMENT   ABC
INIT. CONST. COST     41.25
OVERLAY CONST. COST    0.00
USER COST              0.00
ROUTINE MAINT. COST    0.00
SALVAGE VALUE         -6.46
--------------------------------------------------------------------------------
TOTAL COST            34.79
--------------------------------------------------------------------------------
NUMBER OF LAYERS        3
--------------------------------------------------------------------------------
LAYER DEPTH (INCHES)
     D(1)              3.50
     D(2)             15.00
     D(3)             10.00
--------------------------------------------------------------------------------
NO.OF PERF.PERIODS      1
--------------------------------------------------------------------------------
PERF. TIME (YEARS)
     T(1)              35.
--------------------------------------------------------------------------------
OVERLAY POLICY(INCH)
(INCLUDING LEVEL-UP)
--------------------------------------------------------------------------------


        THE TOTAL NUMBER OF FEASIBLE DESIGNS CONSIDERED WAS        14

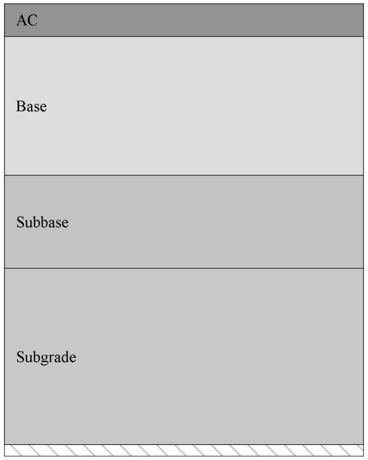




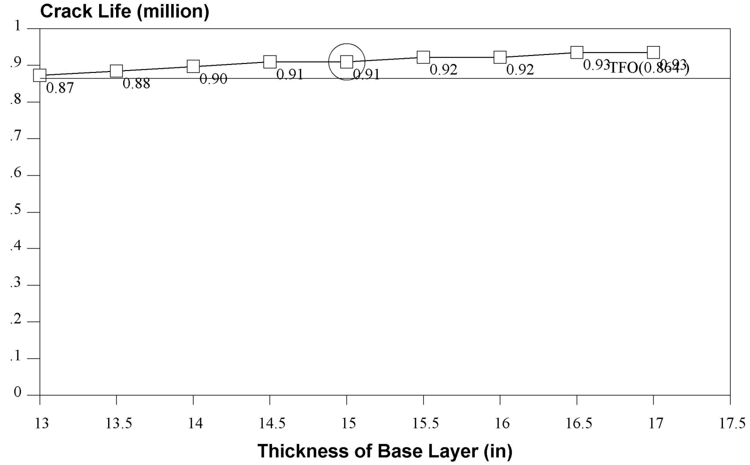


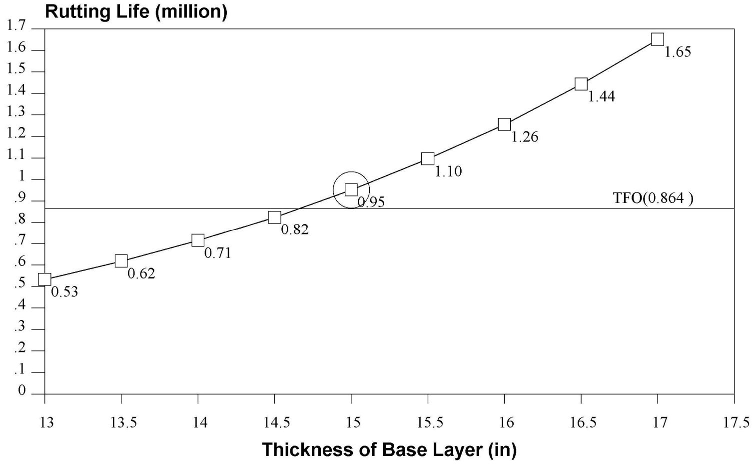


--------------------------------------------------------------------------------
```



Thickness (inches)	Modulus (ksi)	Poisson's Ratio	Material Name
3.50	500.00	0.35	ASPH CONC PVMT
15.00	40.00	0.35	FLEXIBLE BASE
10.00	20.00	0.30	STABILIZED SUBGR
200.00	2.00	0.40	SUBGRADE(200)





Fatigue Crack Model:

$$N_f = f_1 (\varepsilon_t)^{-f_2} (E_1)^{-f_3}$$

f_1 =7.96E-02

f_2 = 3.291

f_3 = .854

Rutting Model:

$$N_d = f_4 (\varepsilon_v)^{-f_5}$$

f_4 =1.37E-09

f_5 = 4.477

TFO(Traffic to 1st Overlay): 0.86 (million)

Crack Life: 0.91 (million) ε_τ = 238.00 (με)

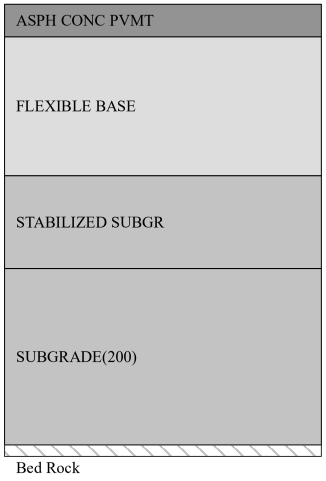
Rut Life: 0.95 (million) ε_v = -484.00 (με)

Traffic to 1st Overlay is calculated by analysis period: 20years and 18 kips:.86millions.
Also the start ADT:5000.0 and ending ADT:10956.0

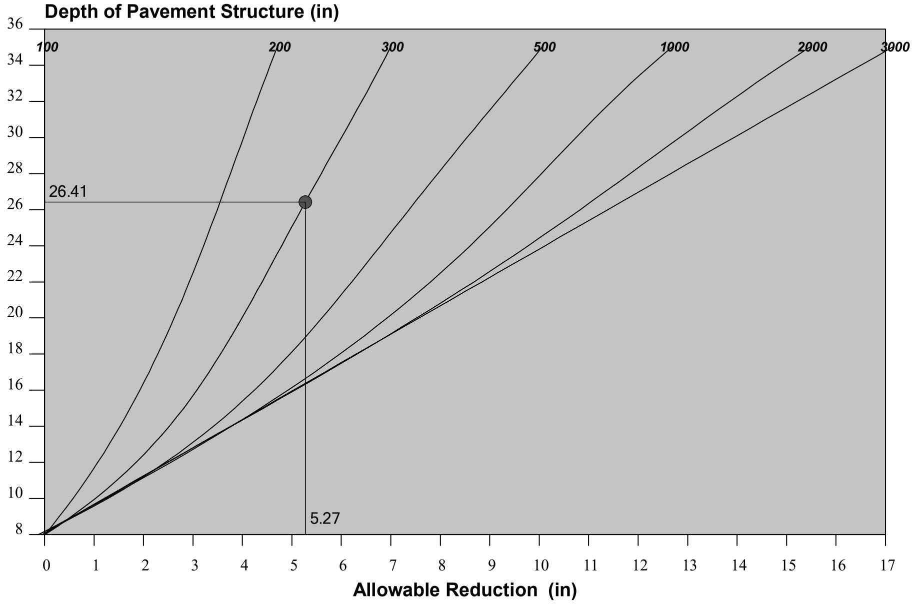
Mechanistic Check Conclusion:

The design is OK !

FPS 21 Mechanistic Design Check Output (FPS21-1.5Release:12-12-2018)			
Highway	Local	Problem	1
C-S-J	NA - NA - NA	Date	5/14/2024
District	San Antonio	County	COMAL
Design Type:Asphalt concrete + Flexible Base + Stabilized Subgrade over Subgrade			



Thickness (inches)	Modulus (ksi)	Poisson's Ratio	Material Name
3.50	500.00	0.35	ASPH CONC PVMT
15.00	40.00	0.35	FLEXIBLE BASE
10.00	20.00	0.30	STABILIZED SUBGR
200.00	2.00	0.40	SUBGRADE(200)
	200.00	0.15	Bed Rock



Thickness Reduction Chart for Stabilized Layers

INPUT PARAMETERS:

The Heaviest Wheel Loads Daily (ATHWLD)	10000.0 (lb)
Percentage of TandemAxles	49.0 (%)
Modified Cohesionmeter Value	300.0
Design Wheel Load	10000.0 (lb)
Subgrade Texas Triaxial Class Number (TTC)	6.28
Calculated TTC based on input soil PI	
User Input Sub-Grade Plasticity Index (PI)	60.00

RESULT:

Triaxial Thickness Required	26.4 (in)
The FPS Design Thickness	28.5 (in)
Allowable Thickness Reduction	5.3 (in)
Modified Triaxial Thickness	21.1 (in)

TRIAXIAL CHECK CONCLUSION:

The Design OK !

FPS 21 Triaxial Design Check Output (FPS21-1.5Release:12-12-2018)

Highway	Local	Problem	1
C-S-J	NA - NA - NA	Date	5/14/2024
District	San Antonio	County	COMAL

Design Type:Asphalt concrete + Flexible Base + Stabilized Subgrade over Subgrade