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Submittal number	024.0	Date	05/06/2021
Project	TRAILS AT CROWFOOT F9	6454 N. Crowfoot Valley Road Parker, CO	
Project number	202103		
Spec section			
Subsection		Status	Open
Current action	Submitted	Ball in court	
Topic	Pavement Design-AP South of NPP		

Submitter	MICHAEL TOMAS SNYDER
Reviewer	
Cc	

Date submitted	05/06/2021	Submission due date	05/06/2021
Released for review	05/06/2021	Review due date	05/13/2021
Date returned		Required on site date	
Date closed			

Notes
Please see attached CTL Thompson Subgrade Investigation and Pavement Design for Alpine Phlox Street South of North Pinery Parkway.

CTL | THOMPSON
INCORPORATED

SUBGRADE INVESTIGATION
AND PAVEMENT DESIGN
TRAILS AT CROWFOOT, FILING 9
ALPINE PHLOX STREET
PARKER, COLORADO

Prepared for:

D. R. Horton
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Englewood, Colorado 80112

Attention: Michael Snyder

Project No. DN50,626.001-135-R1

April 6, 2021
(Revised May 5, 2021)

TABLE OF CONTENTS

SCOPE

This report presents the results of our Subgrade Investigation and Pavement Design for Alpine Phlox Street as part of Filing No. 9 of the Trails at Crowfoot subdivision in Parker, Colorado. The purpose of our investigation was to determine the type of subgrade soils present at the site, evaluate pavement support characteristics, and provide design pavement alternatives.

This report was prepared from data developed during field exploration, laboratory testing, engineering analysis and experience with similar conditions. The report includes a description of the subgrade soils found in exploratory borings, laboratory test results, alternative pavement sections, construction, and materials recommendations, and recommendations for maintenance. The pavement alternatives presented in this report were based on the Town of Parker design criteria and method which is based in the American Association of State Highway and Transportation Officials (AASHTO) Guide for Pavement Design Structures, and our experience. If plans change significantly, we should be contacted to review our recommendations. A brief summary of our conclusions and recommendations is presented below, with more detailed criteria and recommendations contained in the report.

SUMMARY OF CONCLUSIONS

1. Subsoils found in our borings consisted of clayey sand fill and sandy clay fill over silty sand and claystone bedrock to the total depth drilled of 5 to 10 feet. One sample of the onsite soils exhibited a swell of 1.6 percent under a confining pressure of 200 psf.

2. Our pavement recommendation includes asphalt concrete over aggregate base course. Pavement alternatives are presented in Table I and on Fig. 3. Design thicknesses, material properties and construction criteria for the pavements are presented in the report.

SITE CONDITIONS

The site is located northeast of the intersection of Pradera Parkway and North Crowfoot Valley Road, in Parker, Colorado (Fig. 1). The street segment included in this design is approximately 1,000 feet in length. At the time of our field investigation, the street had been rough graded, and some utilities had been installed in the street.

INVESTIGATION

Subsurface conditions at the site were investigated by drilling four exploratory borings to a depth of 5 to 10 feet at the approximate locations shown on Fig.1. Subsoils found in the borings consisted of clayey sand fill and sandy clay fill over silty sand and claystone bedrock to the maximum depth drilled. Claystone bedrock was encountered in borings S-4 at a depth of 7 feet. Free ground water was not encountered in the exploratory borings at the time of drilling.

Laboratory testing was designed to provide index properties of the soils sampled and subgrade support values for those soil types which influence the pavement design. To evaluate potential heave, swell-consolidation testing was performed on one sample of the soils at a depth of 1 foot under a confining pressure of 200 psf. The swell test result was 1.6 percent. Results of laboratory tests are presented in Appendix A and summarized in Table A-I.

A composite sample of the Group II soil (A-7-6) was subjected to standard Proctor (ASTM D 698, AASHTO T99) compaction test procedures (Fig. A-2), remolded swell-consolidation test, and a Hveem Stabilometer (R-Value) test (ASTM D 2844, AASHTO T 190) to determine a design support value for the subgrade soils. The test sample “squeezed out” during Hveem Stabilometer testing, so a R-Value of 5 was assigned for this design. Through use of the equation found in Section 6.2.4.6 of the Town of Parker Roadway Design and Construction Criteria Manual, this R-Value was converted to a Resilient Modulus of 3,025 psi.

Soluble sulfates were measured on two samples with results of less than 0.01 percent and 0.06 percent. The purpose of the sulfate testing was to determine the likelihood of sulfate attack if Portland cement concrete is used. Normal Portland Type I and Type II cement may be used on this site.

EXPANSIVE SOIL MITIGATION

Natural soil and bedrock at this site include expansive materials. The presence of expansive soils implies risk that pavements may heave and be damaged. The risks associated with swelling soils cannot be eliminated, but may be mitigated by careful design, construction, and maintenance procedures.

We believe the existing fill possesses low potential for damaging differential heave of the subgrade. Our experience is that the fill will not heave substantially after construction of pavements, particularly compared to a situation where natural soil and bedrock are directly below pavements. We do not believe there is a need for further swell mitigation.

The subgrade soils below pavement should be moisture conditioned to within 2 percent of optimum and compacted to at least 95 percent of maximum ASTM D698 dry density prior to base course placement to re-establish moisture in the subgrade prior to paving. A minimum of 12 inches of moisture treatment is also recommended beneath curb and gutter and sidewalks.

Town of Parker Requirements

The Town of Parker follows the AASHTO design criteria and requires mitigation of expansive soils below pavements for soils that have a measured swell greater than 2.0 percent (under a confining pressure of 200 psf). Section 6.4 of the Town of Parker pavement design manual calls for 12 inches of moisture conditioning and recompact ion.

PAVEMENT DESIGN

The Town of Parker requires use of its own design criteria and method, which is based on the AASHTO (1993) design method. Alpine Phlox Street is classified as a Local Residential street servicing more than 50 dwelling units (DU). According to Table 6-1 of the Town of Parker Roadway Design and Construction Criteria Manual, the minimum Equivalent Single Axle Load (ESAL) value for Local Residentials servicing more than 50 DU is 73,000. This ESAL value is for a 20-year design life, required by the Town of Parker. ESAL values used in our design are presented on Fig. 2.

We have provided one pavement design recommendation for the road in this design: asphalt concrete over aggregate base course. Our pavement thickness alternatives are presented on Table I and shown on Fig. 3. Additional discussion regarding advantages and disadvantages of the pavement alternatives and their expected performance is included under PAVEMENT SELECTION.

TABLE I
PAVEMENT THICKNESS ALTERNATIVES

Classification	Asphalt Concrete + Aggregate Base Course (AC + ABC)
Local Residential, >50 DU (ESAL = 73,000)	5.0” AC + 6.0” ABC

PAVEMENT SELECTION

Asphalt concrete over aggregate base course generally has had good performance history in swelling soil environments. Some municipalities believe base course provides a flexible layer to help distribute swell of the subgrade and may reduce the likelihood of longitudinal cracks. Conversely, there have been problems where base course has “pushed” into wet clay subgrade. The base course may allow moisture to infiltrate under the pavement. Some aggregate base course that is available in the front range area is highly sensitive to moisture and can lose a significant portion of its strength when wetted.

PAVEMENT MATERIALS

Material properties and construction criteria for the pavement alternatives are provided below. These criteria were developed from analysis of the field and laboratory data, our experience and the Town of Parker requirements. If the materials cannot meet these recommendations, then the pavement design should be reevaluated based upon available materials. Materials and construction requirements of the Town of Parker should be followed. Materials planned for construction should be submitted and the applicable laboratory tests performed to verify compliance with the specifications.

Asphalt Concrete (AC) or Hot Mix Asphalt (HMA)

1. HMA should be composed of a mixture of aggregate, filler, hydrated lime and asphalt cement. Some mixes may require polymer modified asphalt cement, or make use of up to 20 percent reclaimed asphalt pavement (RAP). A job mix design is recommended and periodic checks on the job site should be made to verify compliance with specifications.

2. HMA should be relatively impermeable to moisture and should be designed with crushed aggregates that have a minimum of 80 percent of the aggregate retained on the No. 4 sieve with two mechanically fractured faces.

3. Gradations that approach the maximum density line (within 5 percent between the No. 4 and 50 sieve) should be avoided. A gradation with a nominal maximum size of 1 or 2 inches developed on the fine side of the maximum density line should be used.

4. Total void content, voids in the mineral aggregate (VMA) and voids filled should be considered in the selection of the optimum asphalt cement content. The optimum asphalt content should be selected at a total air void content of approximately 4 percent. The mixture should have a minimum VMA of 14 percent and between 65 percent and 80 percent of voids filled.

5. Asphalt cement should meet the requirements of the Superpave Performance Graded (PG) Binders. The minimum performing asphalt cement should be PG 58-28 for local streets and PG 64-22 for collectors and arterials.

6. Hydrated lime should be added at the rate of 1 percent by dry weight of the aggregate and should be included in the amount passing the No. 200 sieve. Hydrated lime for aggregate pretreatment should conform to the requirements of ASTM C 207, Type N.

7. Paving should only be performed when subgrade temperatures are above 40°F and air temperature is at least 40°F and rising.

8. HMA should not be placed at a temperature lower than 245°F for mixes containing PG 58-28 and PG 64-22 asphalt, and 290°F for mixes containing polymer modified asphalt. The breakdown compaction should be completed before the mixture temperature drops 20°F.

9. The maximum compacted lift should be 3.0 inches and joints should be staggered. No joints should be placed within wheel paths.

10. HMA should be compacted to between 92 and 96 percent of Maximum Theoretical Density. The surface shall be sealed with a finish roller prior to the mix cooling to 185°F.

11. Placement and compaction of HMA should be observed and tested by a representative of our firm. Placement should not commence until the subgrade is properly prepared (or stabilized), tested and proof-rolled. Proof rolling should be performed with the heaviest machine available at

the time. The proof roller should be selected from machines providing both mass and high contact pressure.

Aggregate Base Course (ABC)

1. A CDOT Class 6 aggregate base course should be used. A recycled concrete alternative which meets the Class 6 designation is also acceptable.

2. Aggregate base course should have a minimum Hveem stabilometer value of 78. Aggregate base course or recycled concrete material must be moisture stable. The change in R-value from 300 psi to 100 psi exudation pressure should be 12 points or less.

3. Aggregate base course or recycled concrete should be laid in thin lifts not to exceed 8 inches, moisture treated to within 2 percent of optimum moisture content, and compacted to at least 95 percent of maximum modified Proctor dry density (ASTM D 1557, AASHTO T 180).

4. Placement and compaction of aggregate base course or recycled concrete should be observed and tested by a representative of our firm. Placement should not commence until the underlying subgrade is properly prepared and tested.

Prepared Subgrade (PS)

1. Subgrade should be stripped of organic matter, scarified, moisture treated and compacted.

2. Cohesive soils (A-7-6) should be moisture conditioned to between optimum and 2 percent above optimum moisture content and compacted to at least 95 percent of standard Proctor maximum dry density (ASTM D 698, AASHTO T 99).

3. Granular soils (A-1 to A-5) should be moisture conditioned to between 2 percent below and 2 percent above optimum moisture content and compacted to at least 95 percent of maximum modified Proctor dry density (ASTM D 1557, AASHTO T 180).

4. Final grading of the subgrade should be carefully controlled so the design cross-slope is maintained and low spots in the subgrade that could trap water are eliminated.

5. Once final subgrade elevation has been reached and the subgrade compacted and tested, the area should be proof-rolled with the heaviest machine available at the time. The proof roller should be selected from machines providing both mass and high contact pressure.

6. The proof-roll should be performed while moisture contents of the subgrade are still within the recommended limits. Drying of the subgrade prior to proof-roll or paving should be avoided. Areas of soft or wet subgrade should be remedied.

CONSTRUCTION DETAILS

The design of a pavement system is as much a function of the quality of the paving materials and construction as the support characteristics of the subgrade. The construction materials are assumed to possess sufficient quality as reflected by the strength coefficients used in the flexible pavement design calculations. These strength coefficients were developed through research and experience to simulate expected material of good quality, as explained herein. During construction, careful attention should be paid to the following details:

- Placement and compaction of trench backfill.
- Compaction at curblines and around manholes and water valves.
- Excavation of completed pavements for utility construction and repair.
- Moisture treating or stabilization of the subgrade to reduce swell potential.
- Design slopes of the adjacent ground and pavement to rapidly remove water from the pavement surface.

MAINTENANCE

Routine maintenance, such as sealing and repair of cracks, is necessary to achieve the long-term life of a pavement system. We recommend a preventive maintenance program be developed and followed for all pavement systems to assure the design life can be realized. Choosing to defer maintenance usually results in accelerated deterioration leading to higher future maintenance costs, and/or repair. A recommended maintenance program is outlined in Appendix C.

CONSTRUCTION OBSERVATIONS

This report has been prepared for the exclusive use of D. R. Horton for the purpose of providing geotechnical design and construction criteria for the proposed project. The information, conclusions, and recommendations presented herein are based upon consideration of many factors including, but not limited to, the type of construction, geologic setting, and subsurface conditions encountered. The conclusions and recommendations contained in the report are not valid for use by others. Standards of practice change continuously in the area of geotechnical engineering. The recommendations provided are appropriate for about three years. If the proposed pavements are not constructed within about three years, we should be contacted to determine if we should update this report.

We recommend that CTL | Thompson, Inc. provide construction observation services to allow us the opportunity to confirm whether soil conditions are consistent with those found during this investigation. If others perform these observations, they must accept responsibility to judge whether the recommendations in this report remain appropriate.

GEOTECHNICAL RISK

The concept of risk is an important aspect with any geotechnical evaluation primarily because the methods used to develop geotechnical recommendations do not comprise an exact science. We never have complete knowledge of subsurface conditions. Our analysis must be tempered with engineering judgment and experience. Therefore, the recommendations presented in any geotechnical evaluation should not be considered risk-free. We cannot provide a guarantee that the interaction between the soils and pavements will be as desired or intended. Our recommendations represent our judgment of those measures that are necessary to increase the chances that the streets will perform satisfactorily. It is critical that all recommendations in this report are followed during construction. The Town of Parker must assume responsibility for maintaining the streets and use appropriate practices regarding maintenance and repair.

LIMITATIONS

Our borings were spaced within proposed streets to obtain a reasonably accurate indication of pavement conditions for the proposed construction. The borings are representative of conditions encountered only at the exact boring locations. Variations in the subsoil conditions not indicated by our borings are possible. A representative of our firm should observe subgrade preparation and pavement construction.

We believe this investigation was conducted with that level of skill and care ordinarily used by geotechnical engineers practicing in this area at this time. No warranty, express or implied, is made. If we can be of further service in discussing the contents of this report or in the analysis of the influence of subsoil conditions on design of the pavements, please call.

CTL | THOMPSON, INC. Reviewed by:

COLORADO REGISTERED PROFESSIONAL ENGINEER DAMON B. THOMAS 30990

5/5/21

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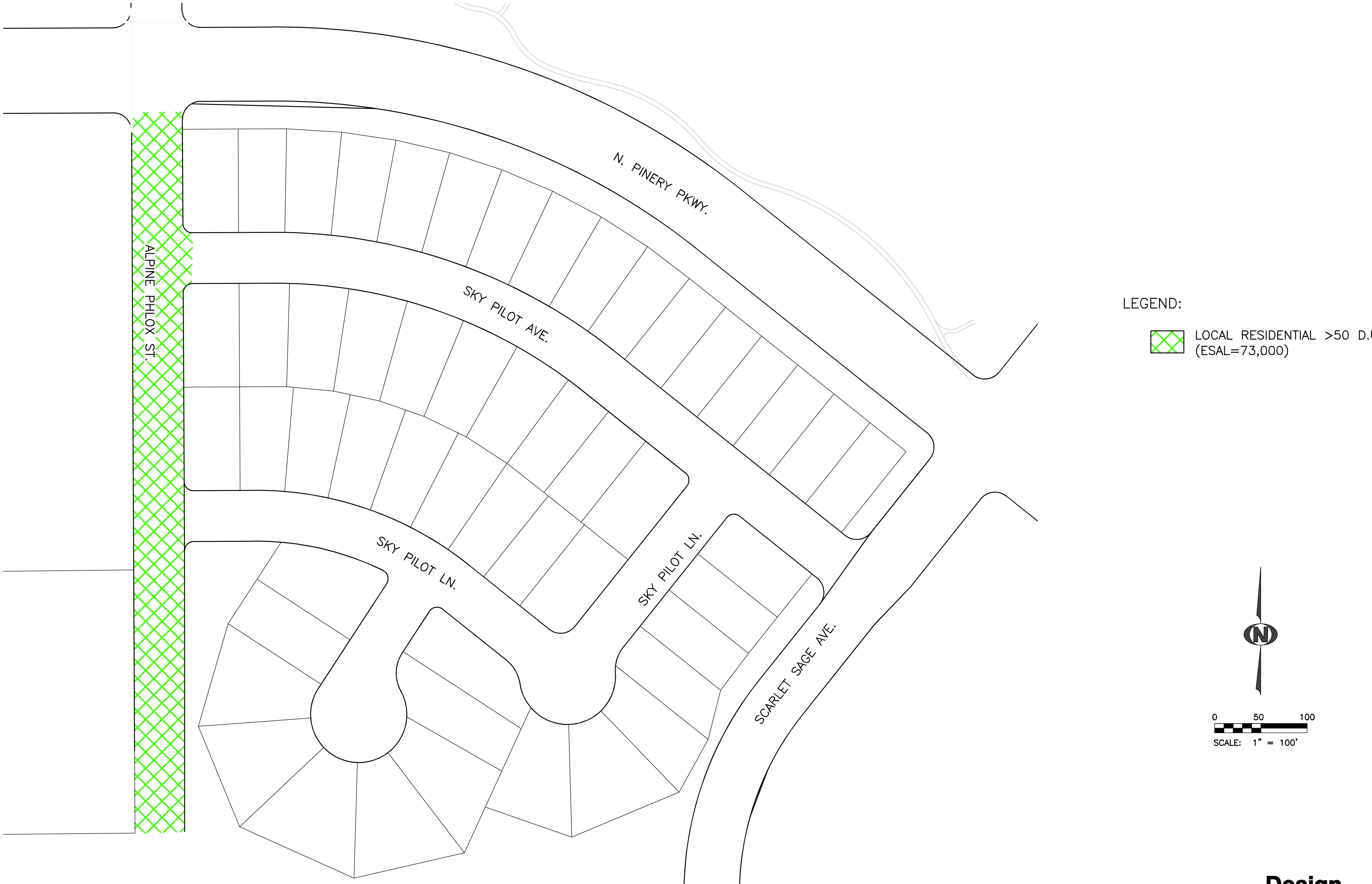
D.R. HORTON
TRAILS AT CROWFOOT, FILING 9 (ALPINE PHLOX STREET)
CTL|T Project No. DN50,626.001-135-R1

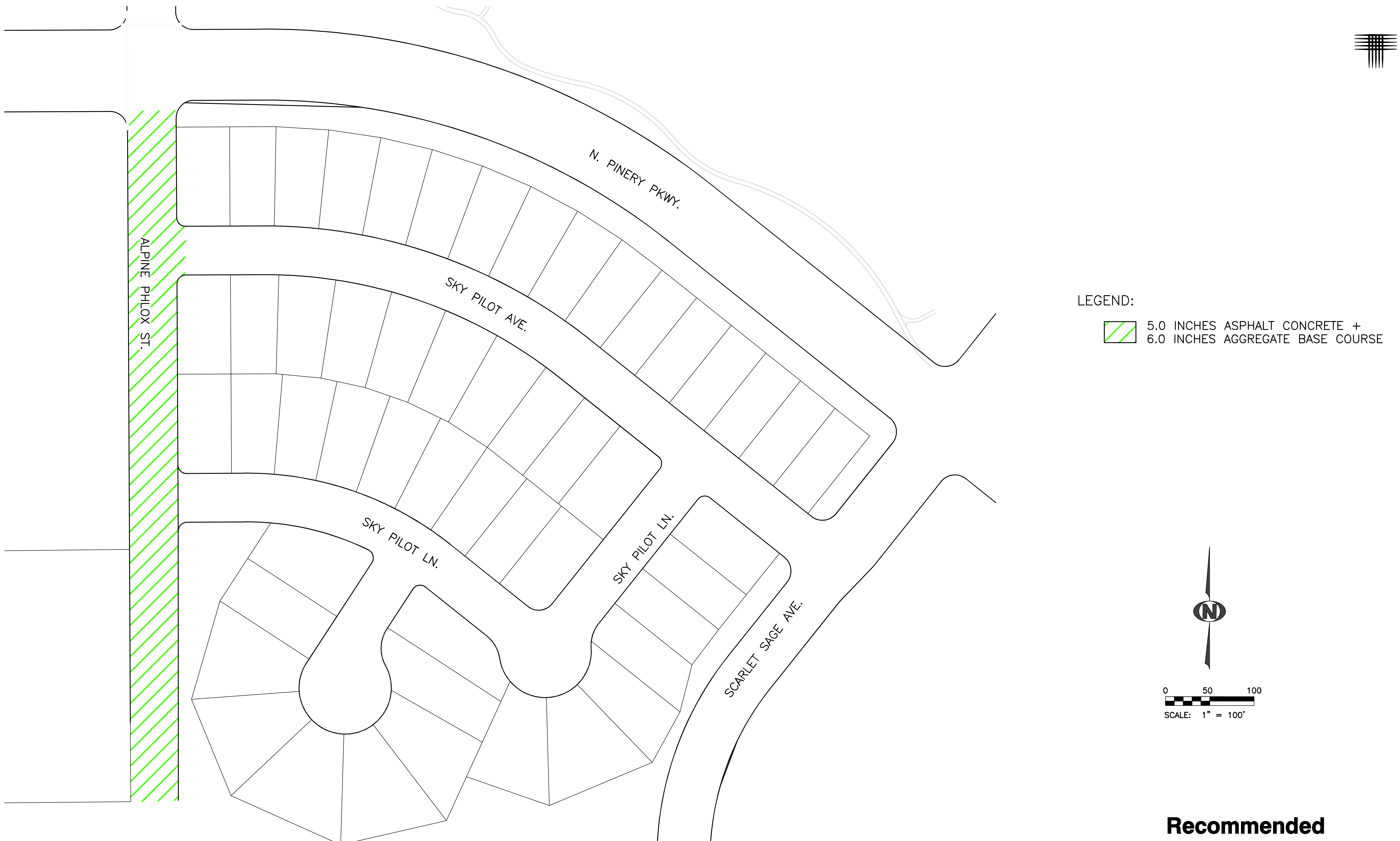
Locations of Exploratory Borings

Fig. 1

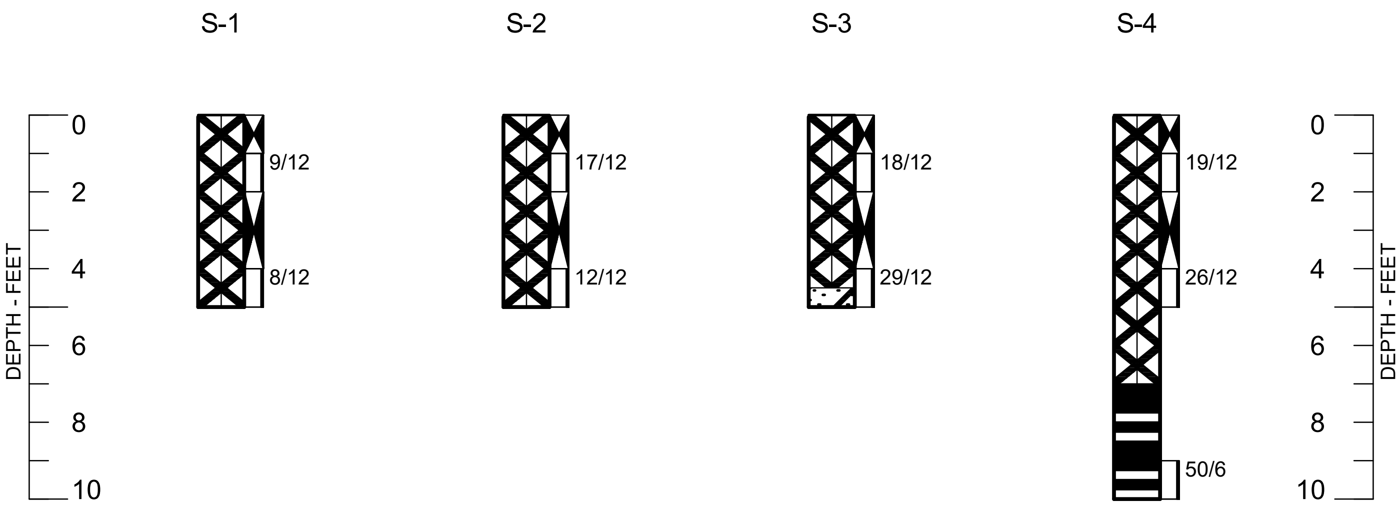


Design Traffic Values

Fig. 2



Recommended Pavement Design Alternatives Fig. 3



LEGEND:

FILL, CLAY, SANDY, VERY STIFF, MOIST, BROWN, DARK BROWN, RUST.

SAND, SILTY, DENSE, MOIST, BROWN, WHITE (SM).

BEDROCK, CLAYSTONE, HARD, MOIST, GRAY, BLACK.

DRIVE SAMPLE. THE SYMBOL 9/12 INDICATES 9 BLOWS OF AN AUTOMATIC 140-POUND HAMMER FALLING 30 INCHES WERE REQUIRED TO DRIVE A 2.5-INCH O.D. SAMPLER 12 INCHES.

BULK SAMPLE COLLECTED FROM AUGER CUTTINGS.

NOTES:

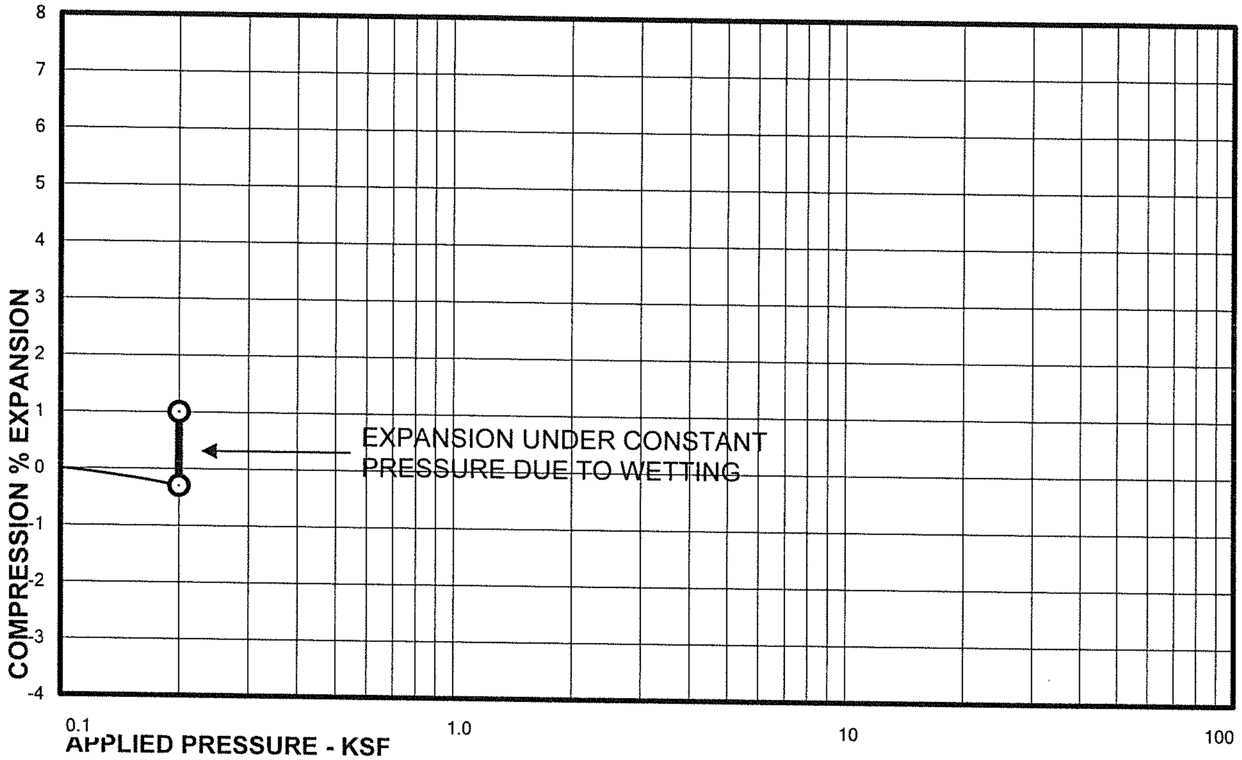
1. THE BORINGS WERE DRILLED ON FEBURARY 23 AND MARCH 1, 2021 USING 4-INCH DIAMETER, CONTINUOUS-FLIGHT SOLID-STEM AUGER AND TRUCK-MOUNTED CME-45 DRILL RIG.

2. THESE LOGS ARE SUBJECT TO THE EXPLANATIONS, LIMITATIONS AND CONCLUSIONS CONTAINED IN THIS REPORT.

SUMMARY LOGS OF EXPLORATORY BORINGS

APPENDIX A

LABORATORY TEST RESULTS

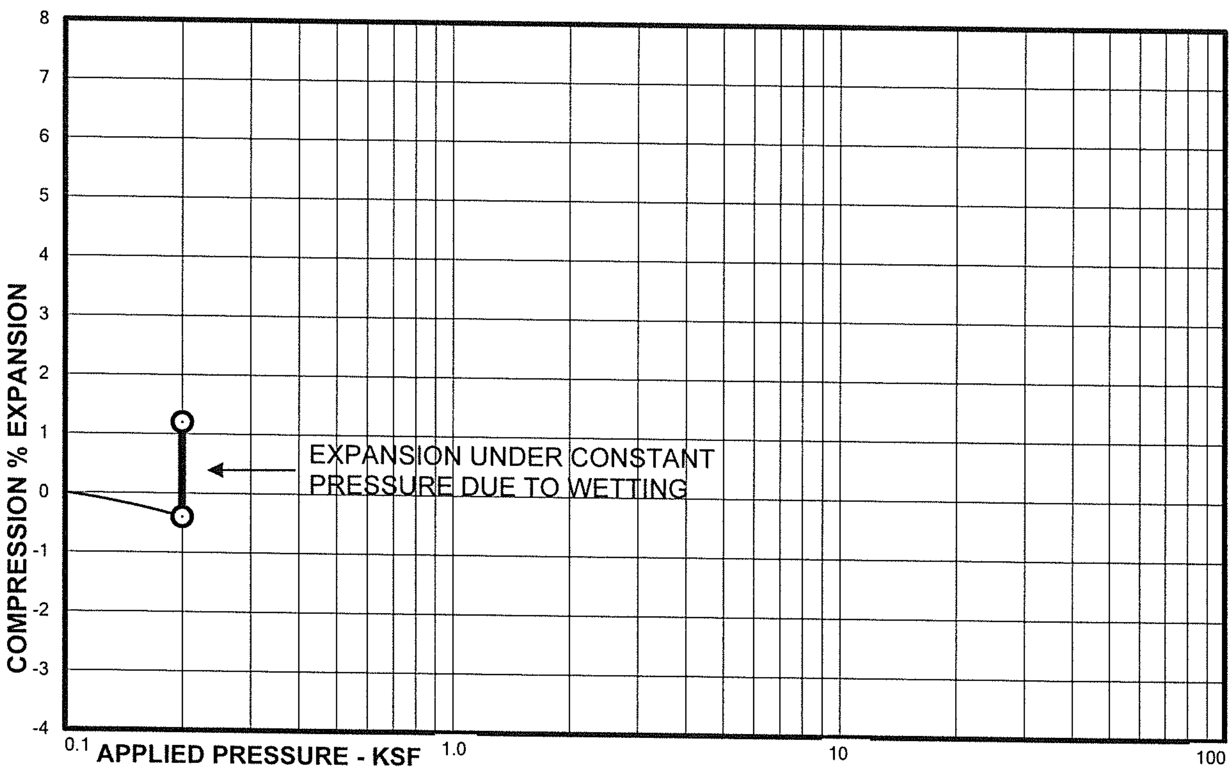


Sample of FILL, SAND, CLAYEY

From GROUP- AT 0-5 FEET

NATURAL DRY UNIT WEIGHT= 109 PCF

NATURAL MOISTURE CONTENT= 13.5 %



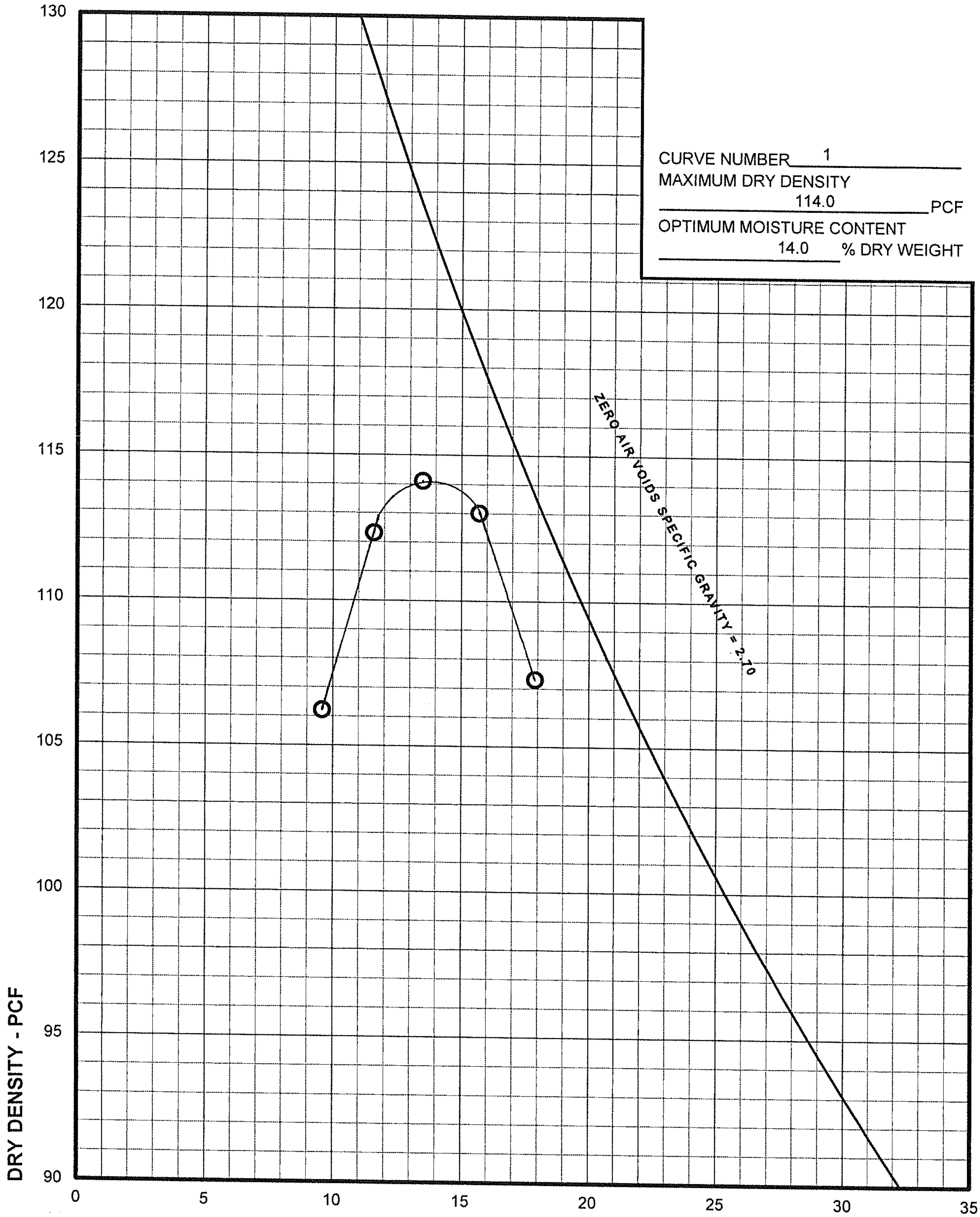
Sample of FILL, SAND, CLAYEY

From S-2- AT 1 FEET

NATURAL DRY UNIT WEIGHT= 108 PCF

NATURAL MOISTURE CONTENT= 13.9 %

Swell Consolidation Test Results



MOISTURE CONTENT - %

Sample Description Fill, Sand, Clayey

Location GROUP II SOILS (A-7-6)

Compaction Test Procedure ASTM D 698 - 91
METHOD "A"

LIQUID LIMIT	41	%
PLASTICITY INDEX	21	%
GRAVEL	-	%
SAND	-	%
SILT AND CLAY	47	%

Compaction Test Results

PROJECT NO. DN50,626.001-135-R1

Fig. A-2

TABLE A-I
SUMMARY OF LABORATORY TEST RESULTS

Sample No.	Depth (feet)	Group No.	Natural Moisture Content (%)	Natural Dry Density (psf)	Percent Passing No. 200 Sieve	Atterberg Limits: Liquid Limit (%)	Atterberg Limits: Plasticity Index (%)	Group Index	Classification: AASHTO	Classification: Unified	Percent Swell @ 200 psf (%)	Water Soluble Sulfates (%)	Description
Group	**0-5**	**II**	**-**	**-**	**47**	**41**	**21**	**6**	**A-7-6**	**SC**	**1.3**	**-**	**Fill, Sand, Clayey**
S-1	0-5	II	14.7	-	45	42	26	7	A-7-6	SC	-	-	Fill, Sand, Clayey
	1	II	13.8	117	-	-	-	-	A-7-6	SC	-	0.06	Fill, Sand, Clayey
	4	II	15.8	114	-	-	-	-	A-7-6	SC	-	-	Fill, Sand, Clayey
S-2	0-5	II	14.7	-	44	42	26	7	A-7-6	SC	-	-	Fill, Sand, Clayey
	1	II	13.9	108	-	-	-	-	A-7-6	SC	1.6	-	Fill, Sand, Clayey
	4	II	16.4	112	-	-	-	-	A-7-6	SC	-	-	Fill, Sand, Clayey
S-3	0-5	I	11.6	-	46	39	24	7	A-6	SC	-	-	Fill, Sand, Clayey
	1	I	5.3	118	-	-	-	-	A-6	SC	-	<0.01	Fill, Sand, Clayey
	4	I	9.0	121	-	-	-	-	A-6	SC	-	-	Fill, Sand, Clayey
S-4	0-5	II	12.0	-	62	46	29	15	A-7-6	CL	-	-	Fill, Clay, Sandy
	1	II	10.5	97	-	-	-	-	A-7-6	CL	-	-	Fill, Clay, Sandy
	4	II	9.3	120	-	-	-	-	A-7-6	CL	-	-	Fill, Clay, Sandy
	9	II	16.4	114	-	-	-	-	-	CL	-	-	Bedrock, Claystone

APPENDIX B

DESIGN CALCULATIONS

PaveXpress

Project Information

Scenario Name	Local Residentials
Scenario Description	
Estimated Completion Year	2021
State	Colorado
Roadway Classification	Local
Pavement Type	New - Asphalt

Design Parameters

Design Period (Years)	20 years
Reliability Level (R)	80 Z_R=-0.841
Combined Standard Error (S0)	0.44
Initial Serviceability Index (pi)	4.5
Terminal Serviceability Index (pt)	2
Change in Serviceability (ΔPSI)	2.5

Traffic Data

Completion Year Traffic	N/A
Load Equivalency Factor	N/A
Completion Year ESALs	N/A
Design Period	N/A
Future Traffic Growth Rate (%)	N/A
ESAL Growth Rate (%)	N/A
Total Design ESALs (W18)	73,000

Pavement Structure

Surface Lifts

Layer	Layer Coef	Drainage	Thickness
Surface	0.44	1	1

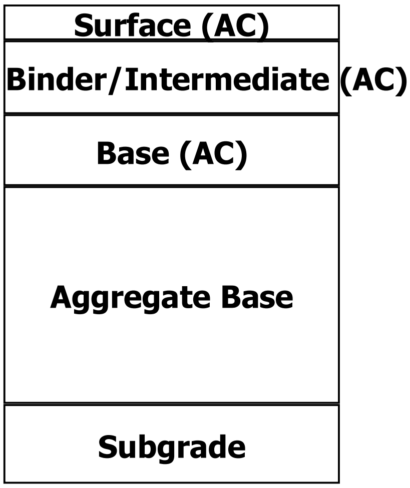
Binder/Intermediate	0.44	1	2
Base	0.44	1	?

Base Layers

Type	Layer Coef	Drainage	Thickness
Aggregate Base	0.12	1	6

Resilient Modulus (MR) 3025 psi

Design Guidance



Required minimum design SN: 2.90

Layer Thicknesses (in)

Surface (AC): 1.00

Binder/Intermediate (AC): 2.00

Base (AC): 2.00

Aggregate Base: 6.00

Total SN: 2.92

Design Notes

APPENDIX C

GUIDELINE MAINTENANCE RECOMMENDATIONS

MAINTENANCE RECOMMENDATIONS FOR FLEXIBLE PAVEMENTS

A primary cause for deterioration of pavements is oxidative aging resulting in brittle pavements. Tire loads from traffic are necessary to "work" or knead the asphalt concrete to keep it flexible and rejuvenated. Preventive maintenance treatments will typically preserve the original or existing pavement by providing a protective seal or rejuvenating the asphalt binder to extend pavement life.

1. Annual Preventive Maintenance

   a. Visual pavement evaluations should be performed each spring or fall.
   b. Reports documenting the progress of distress should be kept current to provide information on effective times to apply preventive maintenance treatments.
   c. Crack sealing should be performed annually as new cracks appear.

2. 3 to 5 Year Preventive Maintenance

   a. The owner should budget for a preventive treatment at approximate intervals of 3 to 5 years to reduce oxidative embrittlement problems.
   b. Typical preventive maintenance treatments include chip seals, fog seals, slurry seals and crack sealing.

3. 5 to 10 Year Corrective Maintenance

   a. Corrective maintenance may be necessary, as dictated by the pavement condition, to correct rutting, cracking and structurally failed areas.
   b. Corrective maintenance may include full-depth patching, milling and overlays.
   c. In order for the pavement to provide a 20-year service life, at least one major corrective overlay should be expected.