GROUND
ENGINEERING

APPROVED

By: RCR Date: 9-6-16

City of Fort Collins
Engineering Department

Revised May 28th, 2014 / September 15, 2014/September 2, 2016

Subsurface Exploration, Pavement Thickness Design recommendations, ***Foothills Mall Redevelopment Roadway Improvements***, Fort Collins, Colorado

Job Number: 14-0008 (Horse tooth Turn Lane)

Walton Foothills Holdings
5750 DTC Parkway, Suite 210
Greenwood Village, CO 80111

Attn: Mr. Robert Walter

GROUND Engineering had previously sampled subgrade materials and provided pavement designs for the turn lane of Horse Tooth associated with the Foothills Mall Redevelopment Project located in Fort Collins, Colorado. The turn lane is located on westbound Horsetooth Road turning onto Stanford Road.

During the last 4 months we have reviewed the pavement designs and subgrade conditions at the site. Groundwater has been a major consideration and has altered our proposed scope during this process. Currently the groundwater appears to have receded from the shallow elevations that were observed this spring and summer.

In early August of 2016 GROUND observed groundwater was still at 4 feet below grades at the intersection of Stanford and Horse Tooth as observed 3 months ago, however the other potholes to the east of the intersection were showing groundwater elevations have dropped by more than 12 inches along the utility lines. Most of the holes were dry down to elevations of 2.5 -3.0 feet below existing grades. It is our opinion that water is likely traveling along the bedding planes of the utilities and perched groundwater conditions are seasonal.

However, we are likely still dealing with fairly moist to saturated subgrade conditions between and above the utilities. Special subgrade remedial measures including geogrid, and stabilization rock will be necessary to achieve stability prior to paving.

That being said, it is more feasible now to work in this area without the utilization of flow fill around the utilities for the majority of the alignment. It is also now feasible to utilize an asphalt pavement section. The original asphalt section was 8" asphalt over 14" of base (If needed we can reduce the total section to 9" asphalt over 10" base – see minimum pavement sections).

It is difficult to determine the quantity of stabilization rock and fabric that will be needed to achieve stability, however once construction activities resume in this area test pits can be excavated to provide tailored recommendations. The contractor will need to coordinate with GROUND Engineering Consultants daily to verify soil conditions and provide recommendations as necessary.

To start out with we should plan on having some of the following products on hand:

- The stabilization rock should consist of Class 5/6 recycled concrete base mixed with 3-inch crushed rock or concrete (mixed 50/50)
- The fabric should consist of a geo grid Tensar BX1200 or equivalent.
- There will likely be some areas such as the storm pipes at the intersection that will still require flow fill due to the water conditions and utility work at that location
- Vibratory compaction equipment is discouraged in this area due to the history of groundwater or saturation observed in the past.

Design Traffic*:* Traffic information for the turn lanes were obtained through the City of Fort Collins and consists of EDLA (Equivalent Daily Load Application) values of 225 for the turn lane off of Horsetooth Road. The EDLA values of 225 were converted to equivalent 18-kip single axle load (ESAL) values of 1,642,500 for a 20-year design life.

Pavement Section Thickness Recommendations The soil resilient modulus, effective modulus of subgrade reaction (k), and the design ESAL values were used to determine the required design structural number for the proposed pavement. The required structural number was then used to develop recommended pavement sections. Pavement designs were based on the DARWin™ computer program that solves the 1993 AASHTO pavement design equation. Pavement design parameters and calculations are summarized in Appendix A. Structural coefficients of 0.44 and 0.11 were used for hot bituminous asphalt and high quality aggregate base course, respectively.

Pavement Section Table

Minimum required pavement section thickness recommendations.

Location	Traffic EDLA Values	ESAL Values	Composite Pavement Section Asphalt / Base (in. / in.)	Rigid Pavement Portland Concrete / Base (in. / in.)
Turn lane off of Horsetooth	225	1,642,500	8.0 / 14.0 Or 9.0 / 10.0	9.0 / 6.0

Asphalt pavement should consist of a bituminous plant mix composed of a mixture of aggregate and bituminous material. Asphalt mixture(s) should meet the requirements of a job-mix formula established by a qualified engineer as well as applicable design requirements of the City of Fort Collins.

Concrete pavements should consist of a plant mix composed of a mixture of aggregate, Portland cement and appropriate admixtures meeting the requirements of a job-mix formula established by a qualified engineer as well as applicable design requirements of the City of Fort Collins. Concrete should have a minimum modulus of rupture of third point loading of 600 psi. The concrete should be air-entrained with approximately 6 percent air and should have a minimum cement content of 6 sacks per cubic yard. Maximum allowable slump should be 4 inches.

The concrete pavement should contain sawed or formed joints to ¼ of the depth of the slab at a maximum distance of 10 feet on centers. *In areas of repeated turning stresses we recommend that the concrete pavement joints be fully tied and doweled. We suggest that civil design consider joint layout in accordance with CDOT's M Standards. Standard plans for placement of ties and dowels, etc., (CDOT M Standards) for concrete pavements can be found at the CDOT website: http://www.dot.state.co.us/DesignSupport/*

Aggregate base material should meet the criteria of CDOT Class 5 or 6 aggregate base course. Base course should be placed in uniform lifts not exceeding 8 inches in loose thickness and compacted to at least 95 percent of the maximum dry density and uniform moisture contents within 2 percent of the optimum as determined by ASTM D1557 / AASHTO T-180, the "modified Proctor."

Subgrade Preparation for Horsetooth Road Turn Lanes: Please see pages 1 and 2 for information on the subgrade conditions. The majority of the site soils classify as sand

and clay material. These materials generally consist of A-6 and A-7-6 soils based on the AASHTO classification system and are anticipated to provide relatively poor pavement support characteristics. The swell potential measured from the site soils at shallow proposed grades ranged from approximately 1.7 to 3.7 percent when tested under a surcharge pressure of 150psf.

This area will require significant subgrade preparation to achieve stabilization prior to paving. Prior to the placement of pavement, including aggregate base, the exposed subgrade soils should be moisture density treated and/orover-excavated and replaced with some depth of stabilization rock and geo grid. The recommended depths will be determined in the field as subgrade preparation occurs. **The turn lane will be required to pass a proof roll prior to placing the pavement section.**

The Contractor should be prepared either to dry the subgrade materials or moisten them, as needed, prior to compaction. Some site soils likely will "pump" or deflect during compaction if moisture levels are not carefully controlled. The Contractor should be prepared to process and compact such soils to establish a stable platform for paving.

Storm Sewer Clearance

Currently there are several utilities including large diameter storm sewer pipes that cross at the west end of the Horse Tooth Road turn lane. With the expansion of the roadway to the north and the thickness of the pavement section at this location we understand the clearance over these utilities is anticipated to minimal. It should be noted that pavements, both rigid and flexible, located within 12 inches of the top of a utility can introduce the potential for differential support and differential settlement even with the above recommendations. As a result cracking can occur to relieve stress in the pavement. To help mitigate cracking at this location additional control joints should be considered.

General Subgrade Recommendations: Site soils that classify as A-4 through A-7-6 should be compacted to 95 or more percent of the maximum Standard Proctor density at moisture contents within 2 percentage points of the optimum moisture content as determined by ASTM D698 / AASHTO T-99.

Site soils that classify as A-1 through A-3 should be compacted to 95 or more percent of the maximum Modified Proctor density at moisture contents within 2 percentage points of the optimum moisture content as determined by ASTM D1557 / AASHTO T-180.

Immediately prior to paving, the subgrade should be proof rolled with a heavily loaded, pneumatic tired vehicle. Areas that show excessive deflection during proof rolling should be excavated and replaced and/or stabilized. Areas allowed to pond prior to paving will require significant re-working prior to proof-rolling. All subgrade preparation must ultimately comply with roadway inspection, testing, and construction procedures outlined by Larimer County and the City of Fort Collins.

Additional Observations (Including Drainage and Underdrains): The collection and diversion of surface drainage away from paved areas is extremely important to satisfactory performance of the pavements. The subsurface and surface drainage systems should be carefully designed to ensure removal of the water from paved areas and subgrade soils. Allowing surface waters to pond on pavements will cause premature pavement deterioration. Due to the existing topography and drainage, the pavement turn lane should be provided with an edge drain to reduce loss of subgrade support. An edge drain / underdrain detail is provided to help address subsurface drainage for the new widening. The long-term performance of the pavement also can be improved greatly by proper backfilling and compaction behind curbs, gutters, and sidewalks so that ponding is not permitted and water infiltration is reduced.

Landscape irrigation adjacent to sidewalks and pavements has a detrimental effect on the subgrade soils by introducing significant amounts of water into the sidewalk and pavement subgrades. This effect should be carefully considered or differential heave and/or rutting of the nearby pavements and sidewalks will result. Drip irrigation systems are recommended for planters to reduce over-spray and water infiltration beyond the planters and distancing any landscaping a distance of at least five feet away from the pavement section and sidewalks will also aid in reducing infiltration. Subsurface drains running parallel to the sidewalk and/or pavement section should be required if irrigation or surface drainage is not controlled.

GROUND's experience indicates that longitudinal cracking is common in asphalt-pavements generally parallel to the interface between the asphalt and concrete structures such as curbs, gutters or drain pans. Distress of this type is likely to occur

even where the subgrade has been prepared properly and the asphalt has been compacted properly.

The design traffic loading does not include excess loading conditions imposed by heavy construction vehicles. Consequently, heavily loaded concrete, lumber, and building material trucks can have a detrimental effect on the pavement. In particular, significant distress will be observed in areas where water infiltration has elevated the subgrade moisture content and reduced the subgrade support properties. Construction traffic can displace the pavements where they are not adequately supported and induce premature cracking and settlements.

GROUND recommends that an effective program of regular maintenance be developed and implemented to seal cracks, repair distressed areas, and perform thin overlays throughout the life of the pavements.

CLOSURE

Geotechnical Review: The author of this report should be retained to review project plans and specifications to evaluate whether they comply with the intent of the recommendations in this report. The review should be requested in writing.

Materials Testing: The performance of materials testing or lack thereof, in no way alleviates the burden of the contractor or subcontractor from constructing in a manner that conforms to applicable project documents and industry standards. The contractor or pertinent subcontractor is ultimately responsible for managing the quality of their work; furthermore, testing by the geotechnical engineer does not preclude the contractor from obtaining or providing whatever services they deem necessary to complete the project in accordance with applicable documents.

Limitations: This report has been prepared for Walton Foothills Holdings as it pertains to design of the proposed Horse Tooth Turn Lanes located at the Foothills Mall Redevelopment in Fort Collins, Colorado as described herein. It may not contain sufficient information for other parties or other purposes. The owner or any prospective buyer relying upon this report must be made aware of and must agree to the terms, conditions, and liability limitations outlined in the proposal.

The geotechnical conclusions and recommendations in this report relied upon subsurface exploration at a limited number of exploration points, as shown in Figure 1 a-c, as well as the means and methods described herein. Subsurface conditions were interpolated between and extrapolated beyond these locations. It is not possible to guarantee the subsurface conditions are as indicated in this report. Actual conditions exposed during construction may differ from those encountered during site exploration.

If during construction, surface, soil, bedrock, or groundwater conditions appear to be at variance with those described herein, the Geotechnical Engineer should be advised at once, so that re-evaluation of the recommendations may be made in a timely manner. In addition, a contractor who relies upon this report for development of his scope of work or cost estimates may find the geotechnical information in this report to be inadequate for his purposes or find the geotechnical conditions described herein to be at variance with his experience in the greater project area. The contractor is responsible for obtaining the additional geotechnical information that is necessary to develop his work scope and cost estimates with sufficient precision. This includes current depths to groundwater, etc.

The materials present on-site are stable at their natural moisture content, but may change volume or lose bearing capacity or stability with changes in moisture content. Performance of the proposed pavement will depend on implementation of the recommendations in this report and on proper maintenance after construction is completed. Because water is a significant cause of volume change in soils and rock, allowing moisture infiltration may result in movements, some of which will exceed estimates provided herein and should therefore be expected by the owner.

ALL DEVELOPMENT CONTAINS INHERENT RISKS. It is important that ALL aspects of this report, as well as the estimated performance (and limitations with any such estimations) of proposed project improvements are understood by the Client, Project Owner (if different), or properly conveyed to any future owner(s). Utilizing these recommendations for planning, design, and/or construction constitutes understanding and acceptance of recommendations or information provided herein, potential risks, associated improvement performance, as well as the limitations inherent within such estimations. If any information referred to herein is not well understood, it is imperative for the Client, Owner (if different), or anyone using this report to contact the author or a company principal immediately.

This report was prepared in accordance with generally accepted soil and foundation engineering practice in the project area at the date of preparation. Current applicable codes may contain criteria regarding performance of structures and/or site improvements which may differ from those provided herein. Our office should be contacted regarding any apparent disparity. GROUND makes no warranties, either expressed or implied, as to the professional data, opinions or recommendations contained herein. Because of numerous considerations that are beyond GROUND's control, the economic or technical performance of the project cannot be guaranteed in any respect.

If you have any questions, please contact this office.

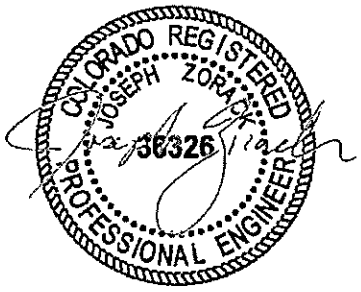
Sincerely,

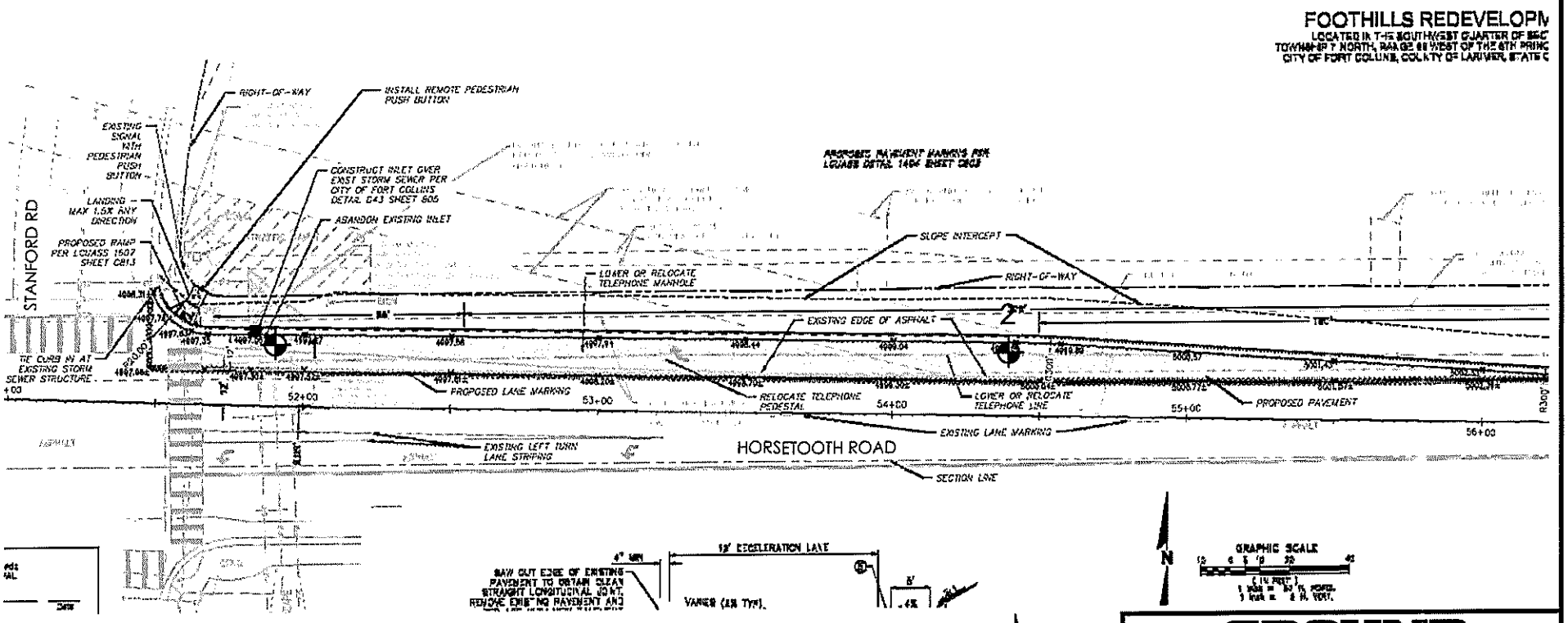
GROUND Engineering Consultants, Inc.

Joseph Zorack, P.E.

Digitally signed by Joseph Zorack, P.E.
DN: cn=Joseph Zorack, P.E., o=GROUND Engineering Consultants, Inc., ou, email=joe.zorack@groundeng.com, c=US
Date: 2016.09.06 13:31:23 -06'00'

Joseph Zorack, P.E.





1
Indicates test hole number and approximate location.

(Not to Scale)

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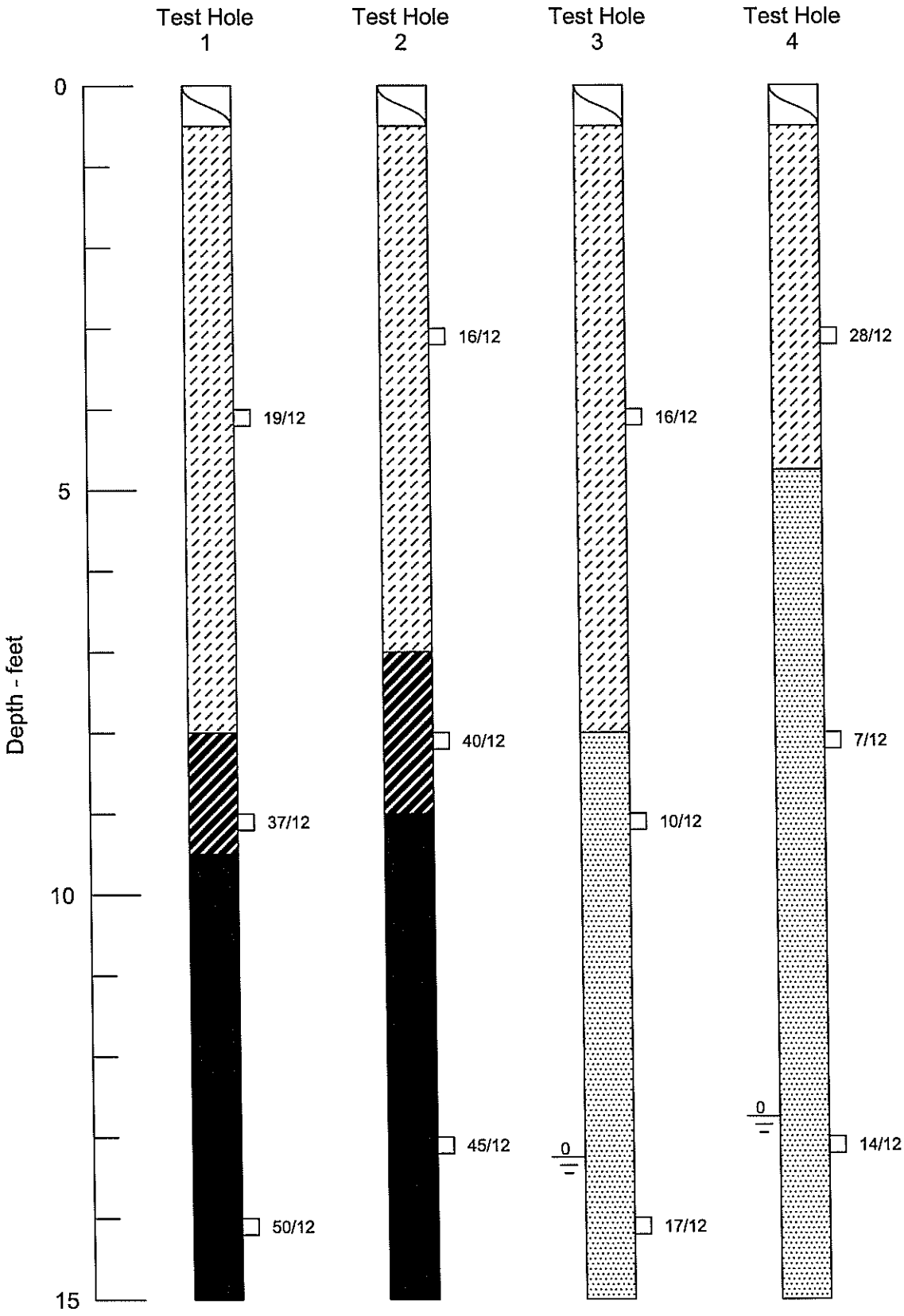
LOCATION OF TEST HOLES

JOB NO.: 14-0008	FIGURE: 1a
CADFILE NAME: 0008SITE.DWG	



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LOGS OF TEST HOLES

JOB NO.: 14-0008	FIGURE: 2
CADFILE NAME: 0008LOG1.DWG	

LEGEND:

Clay: Sandy, fine to medium grained, medium plastic, soft to stiff, moist to very moist, and brown to red-brown in color.

Sand: Silty to clayey with occasional gravel, medium to gravel grained, low to medium plastic, very loose to medium dense, moist to wet, and brown in color.

Weathered Claystone: fine to medium grained, medium to high plastic, weathered, moist, and gray to brown in color with iron staining.

Claystone Bedrock: fine grained, medium to high plastic, hard to very hard, moist, and gray to brown in color with iron staining.

Drive sample, 2-inch I.D. California liner sample

23/12 Drive sample blow count, indicates 23 blows of a 140-pound hammer falling 30 inches were required to drive the sampler 12 inches.

NOTES:

1) Test holes were drilled on 04/04/2014 with 4-inch diameter continuous flight augers.
2) Locations of the test holes were measured approximately by pacing from features shown on the site plan provided.
3) Elevations of the test holes were not measured and the logs of the test holes are drawn to depth.
4) The test hole locations and elevations should be considered accurate only to the degree implied by the method used.
5) The lines between materials shown on the test hole logs represent the approximate boundaries between material types and the transitions may be gradual.
6) Groundwater was not encountered during drilling. Groundwater levels can fluctuate seasonally and in response to landscape irrigation.
7) The material descriptions on this legend are for general classification purposes only. See the full text of this report for descriptions of the site materials and related recommendations.

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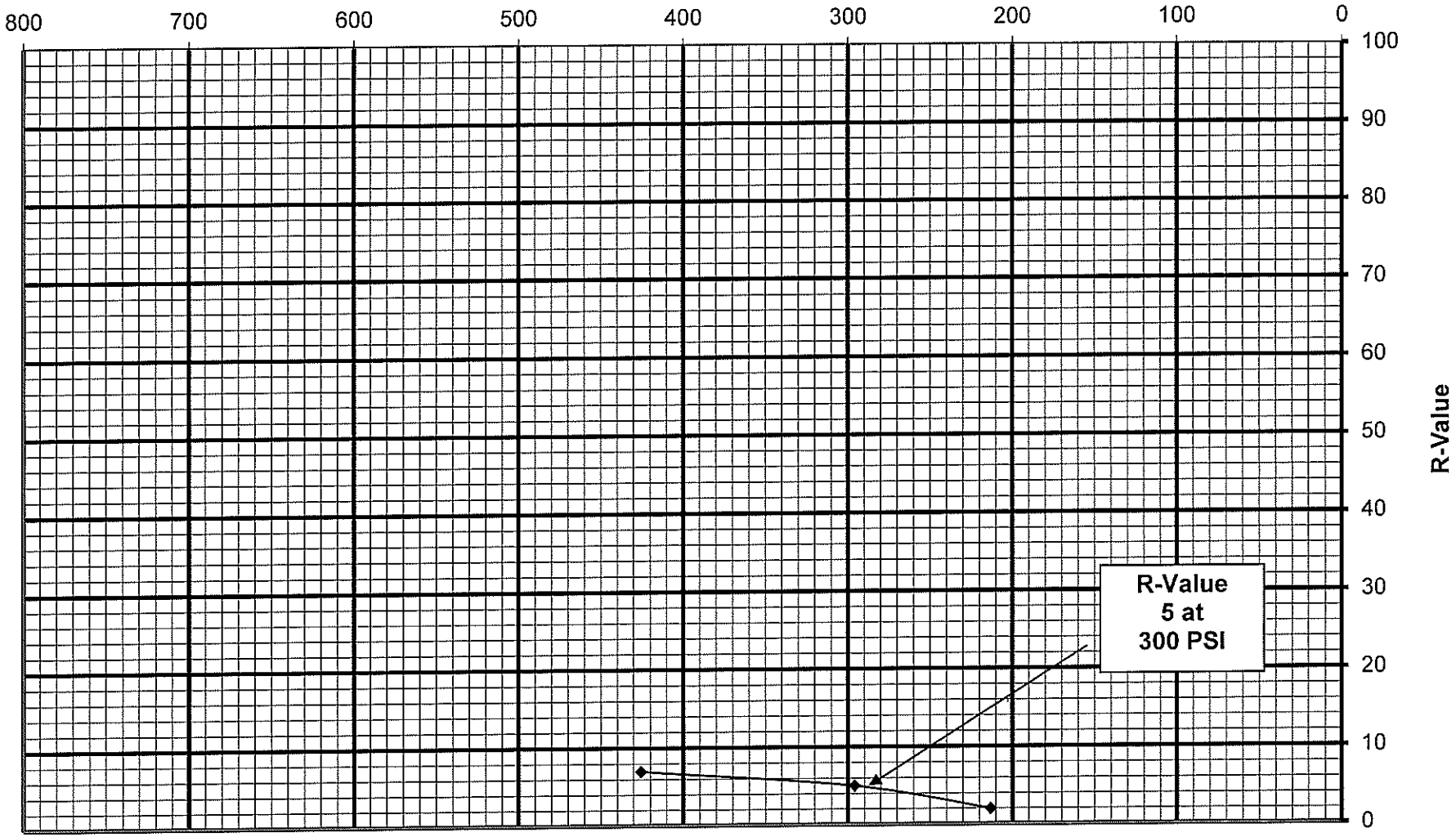
LEGEND AND NOTES

JOB NO.: 14-0008	FIGURE: 3
CADFILE NAME: 0008LEG.DWG	



Location: Horsetooth Composite 1 and 2 @ 3' to 7'

Test Specimen	1	2	3
R-Value	7	5	2
Exudation Pressure	426	296	213
Moisture contents	18.1	19.6	20.7

Sample ID No. E0008-2

Job No. 14-0008

Soil Type: Sandy Clay

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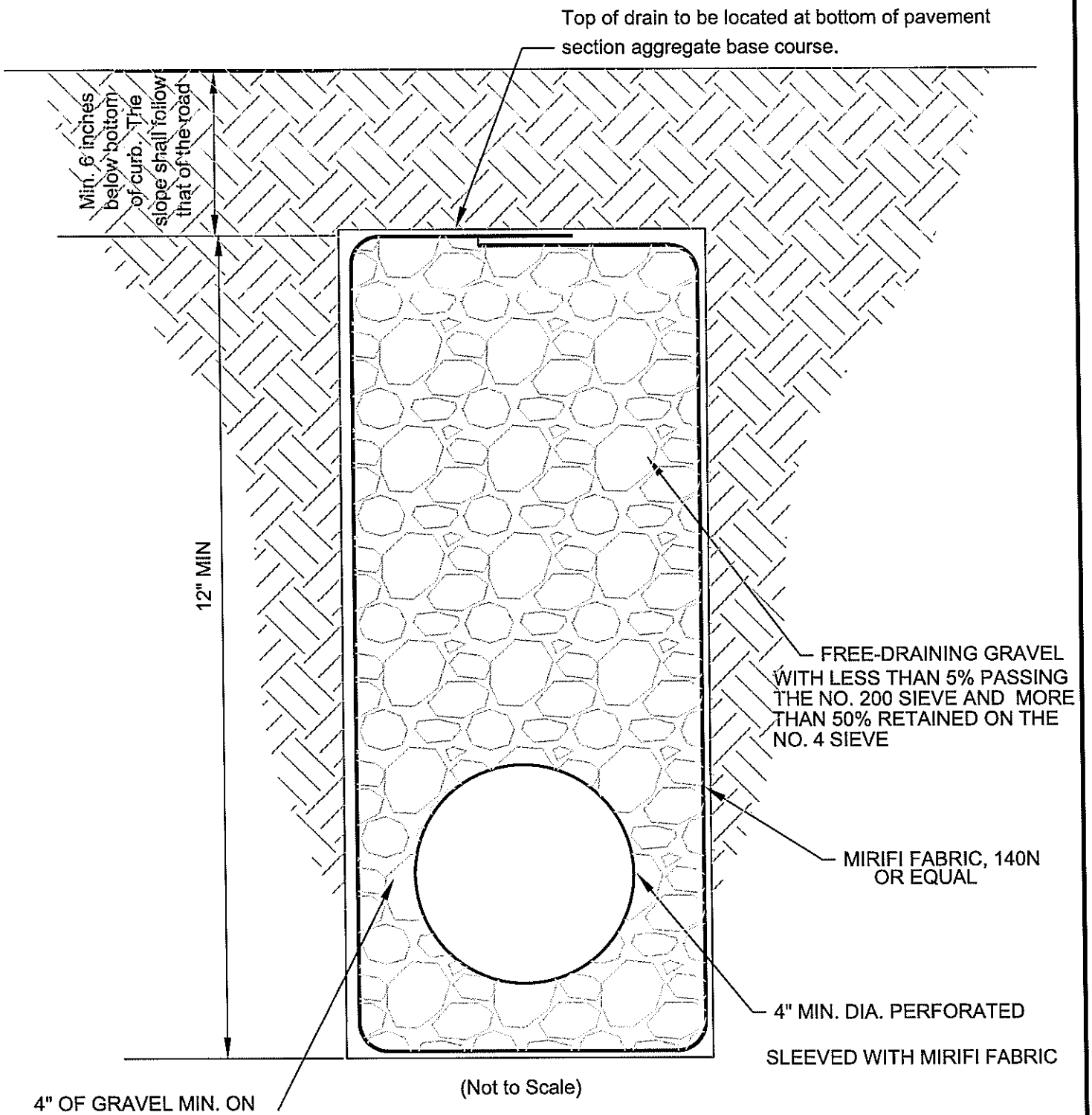
R-VALUE TEST RESULT
ASTM D 2844-07

Figure 4

***Material will be considered "unstable" if optimum moisture is greater than 300 psi exudation moisture and the decrease in R-value from 400 psi to 300 psi exudation pressure is 10 or greater



(Not to Scale)

The proposed underdrain should tie into the existing culverts that cross the road, or into the proposed storm sewer inlet, as called out on the drawings at the intersection of Horsetooth Road and Stanford Road .

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UNDER DRAIN DETAIL TO BE PLACED AT THE CURB LINE

JOB NO.: 14-0008	FIGURE: drain
CADFILE NAME: 0008DRAIN.DWG	

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TABLE 1
SUMMARY OF LABORATORY TEST RESULTS

Sample Location			Natural Moisture Content (%)	Natural Dry Density (pcf)	Percent Passing No. 200 Sieve	Atterberg Limits		Percent Swell (Surcharge Pressure of 150 psf)	Water Soluble Sulfates (%)	AASHTO Classification (GI)	Soil or Bedrock Type
Test Hole No.	Street Turn Lanes	Depth (feet)				Liquid Limit	Plasticity Index				
1	Horsetooth	4	17.5	105.7	65	35	17	1.7	0.03	A-6	Sandy Clay
2	Horsetooth	8	16.3	107.1	82	44	20	3.7	0.15	A-7-6	Weathered Claystone
3	College South Entrance	4	15.0	111.9	58	27	13	0.9	-	A-6	Sandy Clay
4	College North Entrance	3	13.2	115.1	40	21	10	0.1	0.08	A-6	Clayey Sand
Composite: 1 and 2 @ 3-7 Ft			-	-	78	42	20	R-Value = 5	-	A-7-6	Sandy Clay
Composite: 3 and 4 @ 1-5 Ft			-	-	47	23	12	R- Value = 9	-	A-6	Sand and Clay

Job No. 14-0008

Appendix A:

Pavement Section Calculations

1993 AASHTO Pavement Design

DARWin Pavement Design and Analysis System

A Proprietary AASHTOWare
Computer Software Product
Network Administrator

Flexible Structural Design Module

Turn Lane from EB Horsetooth onto Stanford Road
Fort Collins, Colorado
Composite Pavement

Flexible Structural Design

18-kip ESALs Over Initial Performance Period	1,642,500
Initial Serviceability	4.5
Terminal Serviceability	2.5
Reliability Level	90 %
Overall Standard Deviation	0.44
Roadbed Soil Resilient Modulus	3,025 psi
Stage Construction	1
Calculated Design Structural Number	4.92 in

Specified Layer Design

Layer	Material Description	Struct Coef. (Ai)	Drain Coef. (Mi)	Thickness (Di)(in)	Width (ft)	Calculated SN (in)
1	Asphalt	0.44	1	9	-	3.96
2	Base Course	0.11	1	10	-	1.10
Total	-	-	-	19.00	-	5.06

1993 AASHTO Pavement Design

DARWin Pavement Design and Analysis System

A Proprietary AASHTOWare
Computer Software Product
Network Administrator

Flexible Structural Design Module

Turn Lane from EB Horsetooth onto Stanford Road
Fort Collins, Colorado
Composite Pavement

Flexible Structural Design

18-kip ESALs Over Initial Performance Period	1,642,500
Initial Serviceability	4.5
Terminal Serviceability	2.5
Reliability Level	90 %
Overall Standard Deviation	0.44
Roadbed Soil Resilient Modulus	3,025 psi
Stage Construction	1
Calculated Design Structural Number	4.92 in

Specified Layer Design

Layer	Material Description	Struct Coef. (Ai)	Drain Coef. (Mi)	Thickness (Di)(in)	Width (ft)	Calculated SN (in)
1	Asphalt	0.44	1	8	-	3.52
2	Base Course	0.11	1	14	-	1.54
Total	-	-	-	22.00	-	5.06

1993 AASHTO Pavement Design

DARWin Pavement Design and Analysis System

A Proprietary AASHTOWare
Computer Software Product
Network Administrator

Rigid Structural Design Module

Turn Lane from EB Horsetooth onto Stanford Road
Fort Collins, Colorado
Rigid Pavement

Rigid Structural Design

Pavement Type	JPCP
18-kip ESALs Over Initial Performance Period	1,642,500
Initial Serviceability	4.5
Terminal Serviceability	2.5
28-day Mean PCC Modulus of Rupture	600 psi
28-day Mean Elastic Modulus of Slab	3,400,000 psi
Mean Effective k-value	21 psi/in
Reliability Level	90 %
Overall Standard Deviation	0.34
Load Transfer Coefficient, J	3.6
Overall Drainage Coefficient, Cd	1
Calculated Design Thickness	8.96 in