APPROVED

By: _____ Date: 3-18-14

City of Fort Collins
Engineering Department

March 14, 2014

Subsurface Exploration, Pavement Thickness Design recommendations, ***Banner Health Medical Campus – Cinquefoil Lane***, Fort Collins, Colorado

Job Number: 13-0604

Banner Health Development and Construction
1801 16th Street
Greeley, Co 80631

Attn: Mr. Mark Ostrand

The site grading and utility installations for Cinquefoil Lane of the new Banner Health Medical Campus had recently been completed including two feet of moisture density treatment of the pavement subgrade. GROUND Engineering has sampled the materials within this alignment of Cinquefoil Lane, from La Fever Drive to Harmony Road, as required by Larimer County Urban Street Standards, to provide a final pavement design report for the subject roadway. A total of 10 test holes were advanced along the subject roadway alignment (at a frequency of at least 1 sample per 500 LF) to obtain drive samples and a composite sample of these materials. It should be noted that site utilities including water, sanitary sewer, and storm sewer utilities had been installed in this section of roadway in late 2013 and early 2014. Test holes identified with a suffix A were drilled outside utility backfill and test hole with a suffix B were drilled within utility backfill. Note: no utilities were harmed during this exploration.

The test holes were logged and sampled by a representative of GROUND Engineering. Locations of the test holes are shown on Figure 1, logs of the test holes on Figure 2, and the legend on Figure 3. The sampled subgrade materials were tested in the laboratory to provide final subgrade characteristics of the site soils in addition to final pavement subgrade and section recommendations. The subgrade conditions along the roadway alignments appeared to be uniform and generally consisted of sandy clay materials. During our field exploration it was determined that groundwater and bedrock soils are generally greater than 10 feet in depth below existing grades and should not impact the pavement section recommendations. Only negligible amounts of water-soluble sulfates are present in the site soils.

Additional information was obtained from a geotechnical report for the site prepared by Kumar & Associates, Inc (Kumar Project # 12-1-490). This report is labeled Geotechnical Engineering Study and Pavement Thickness Design, Proposed Harmony Road Medical Center, Southeast Corner of Harmony Road and Lady Moon Drive, Fort Collins, Colorado, prepared for Atwell LLC and Banner Health, last revised date of November 28th, 2012. This report should be referenced for further site geotechnical information in addition to recommendations concerning the placement of concrete materials on site soils.

The laboratory test results for the samples taken at each test hole are presented in the attached Table 1 and test results of the composite sample are presented below.

Laboratory Test Results of composite sample :

- Classification: Sandy Clay (CL), AASHTO: A-6 (9)
- Percent Passing #200 Sieve: 64%
- Atteberg Limits: LL=29 , PI=19
- Hveem R-Value = 8: Correlates to a Resilient Modulus of 3,337 psi in accordance with the Larimer County Pavement Design Standards.

R-Value test results are shown on Figure 4.

Note: The above composite sample results were obtained from La Fever Drive road on the south side of the project and were incorporated in this report since the material properties were similar to the materials encountered in Cinquefoil Drive.

Design Traffic: Traffic information was obtained through the City of Fort Collins on March 17th, 2014 and consists of an EDLA (Equivalent Daily Load Application) value of 25 for Cinquefoil Lane. The EDLA value of 25 was converted to equivalent 18-kip single axle load (ESAL) value of 182,500 for a 20-year design life. In addition, the roadway is classified as a minor collector in accordance with Table 10-1 of the Larimer County Urban Area Street Standards for design criteria.

Pavement Section Thickness Recommendations: The soil resilient modulus 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.

Street I.D.	Road Classification	Assumed Traffic EDLA Values	Minimum ESAL Values	Composite Pavement Section* Asphalt / Base (in. / in.)
Cinquefoil Lane	Minor Collector	25	182,500	*5.5 / 7.0

Notes: * Larimer County requires a minimum 5.5 inches of asphalt and 7 inches of road base for Minor Collectors composite sections.

Subgrade Preparation: The majority of the site soils classify as a sandy clay material. These materials generally consist of A-6 soils based on the AASHTO classification system and are anticipated to provide relatively poor pavement support characteristics. The swell potential measured from samples of undisturbed site soils ranged from approximately 0.1 to 2.0 percent when tested under a surcharge pressure of 150psf.

The proposed roadway had previously been moisture density treated to a depth of 24-inches in October of 2013 per the guidelines set forth in the previously referenced Kumar & Associates, Inc. soils report. GROUND concurs with the recommendation and treatment that has already occurred. During placement of the overexcavation and replacement, GROUND performed moisture density testing of fill materials. However, the subgrade materials have weathered significantly since October.

Shortly before placement of pavement, including aggregate base, the exposed site subgrade soils should be reprocessed and moisture-density treated to a depth of at least 12 inches depending upon condition of subgrade after it has thawed. Subgrade preparation should extend the full width of the pavement from back-of-curb to back-of-curb.

Site soils that classify as A-6 and A-7 (cohesive materials) should be compacted to 95 or more percent of the maximum standard Proctor density at moisture contents from 1 percent below to 3 percent above optimum moisture content as determined by ASTM D698 / AASHTO T-99.

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, including use of chemical stabilization, if necessary.

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

During construction the subgrade materials can often become saturated several inches during seasonal weather events and become difficult to stabilize. Other times it has been observed that some clay subgrades will become unstable at moisture contents at or slightly above the optimum (during moisture treatment) that are still within the project moisture specifications. If stabilization is required for this project, GROUND recommends fly ash treatment consisting of a minimum of 10-12% Type C Fly Ash by dry unit weight processed to a depth of approximately 12 inches for the subject roadway. Subgrade materials treated with fly ash will help reduce the potential of movement associated with moisture infiltration into the subgrade materials. Fly ash treatment also helps to provide a stabilized working platform, extra pavement support, decrease the potential for swell in the treated section, and decrease the amount of moisture infiltrating into the soils below the treated section. Additional recommendations can be provided for this type of stabilization upon request.

Additional Observations:

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. Where topography, site constraints or other factors limit or preclude adequate surface drainage, pavements should be provided with edge drains to reduce loss of subgrade support. 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.

If you have any questions, please contact this office.

Sincerely,

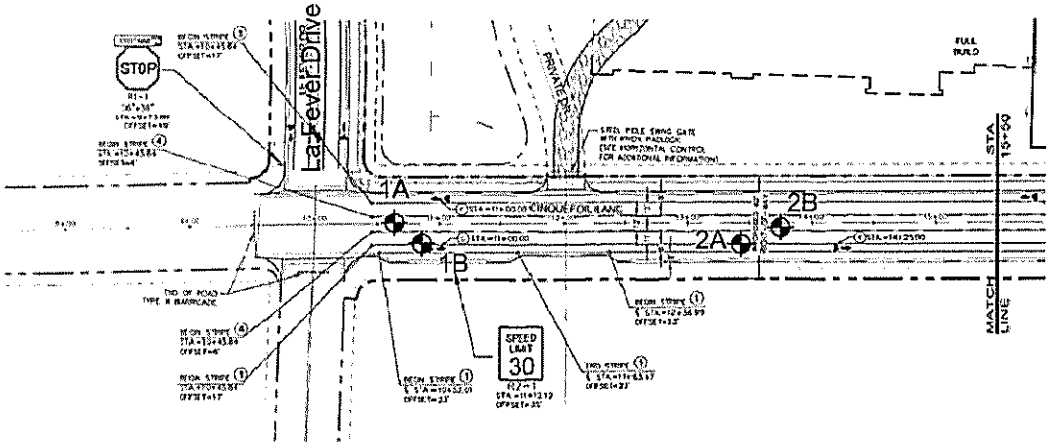
GROUND Engineering Consultants, Inc.

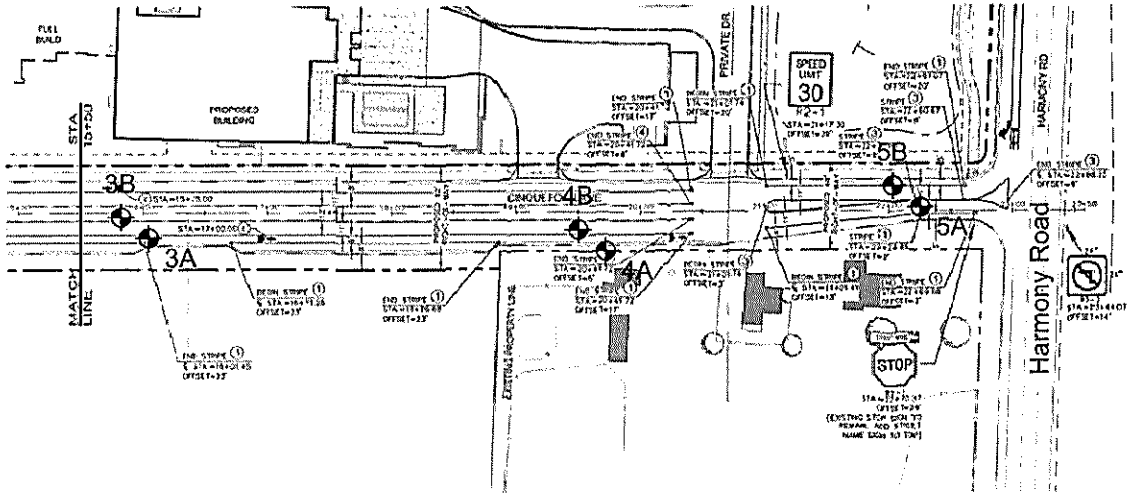
Joseph Zorack

Digitally signed by Joseph Zorack
DN: cn=Joseph Zorack, o=GROUND Engineering Consultants, Inc., ou, email=joez@groundeng.com, c=US
Date: 2014.03.17 12:23:13 -06'00'

Joseph Zorack, P.E.

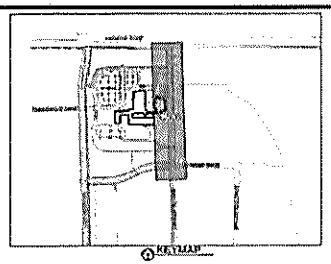
Cinquefoil Lane from La Fever Drive to Harmony Road





1
Indicates test hole number and approximate location.

(Not to Scale)



NORTH

LEGEND:

SIGNAGE NOTES:

STRIPING LEGEND:

Banner Health

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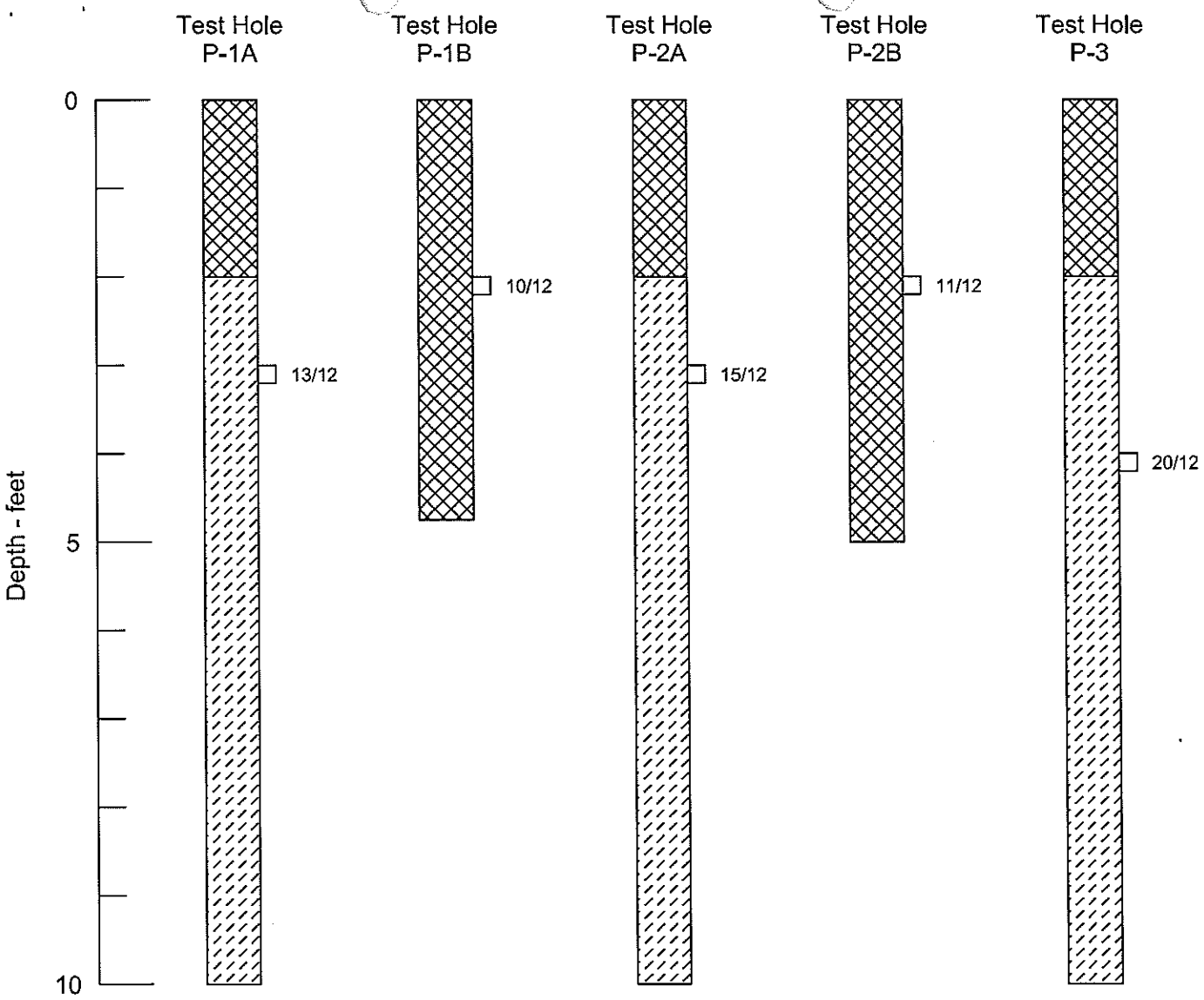
LOCATION OF TEST HOLES

JOB NO.: 13-0604	FIGURE: 1
CADFILE NAME: 0604SITE.DWG	



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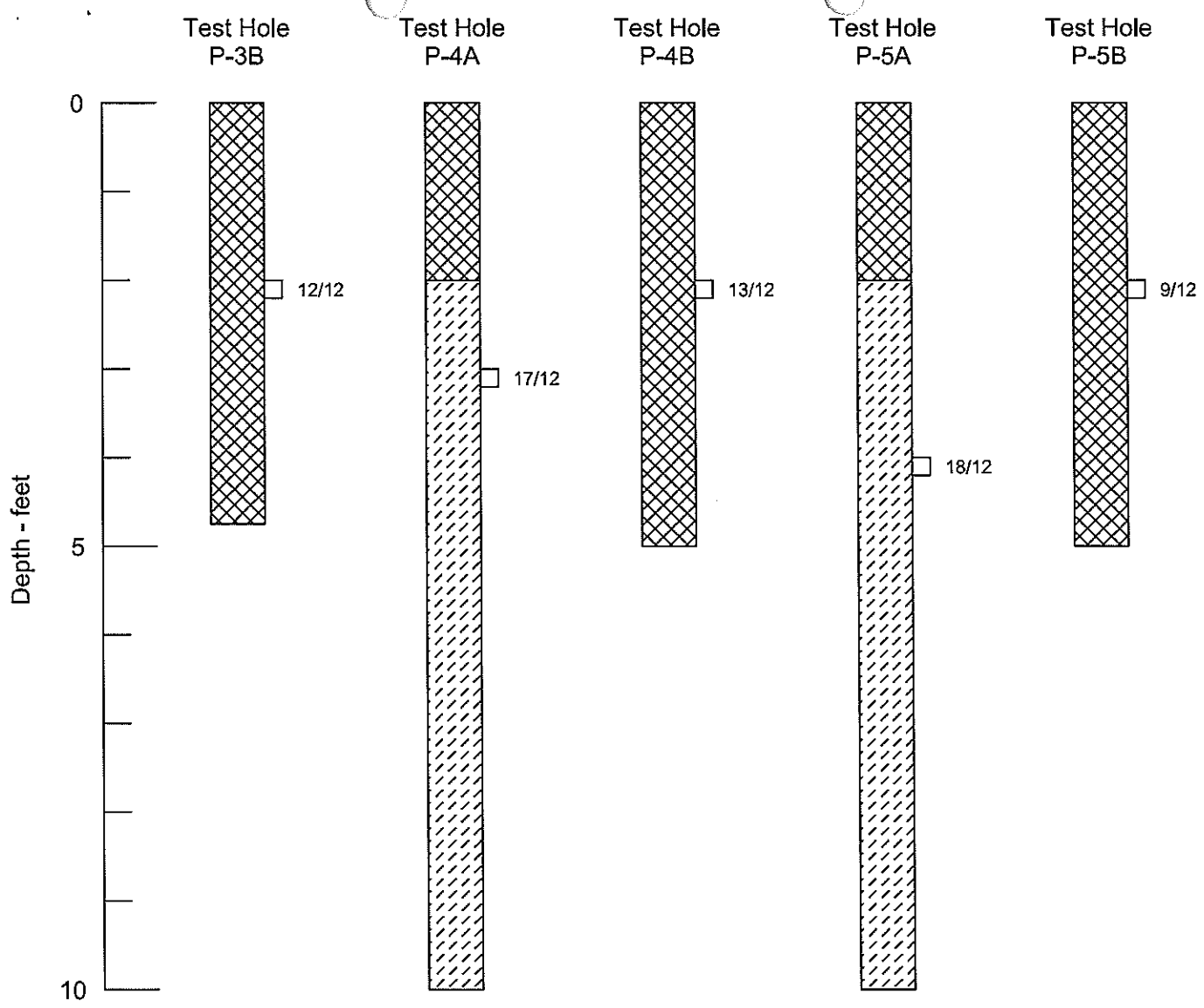
LOGS OF TEST HOLES

JOB NO.: 13-0604	FIGURE: 2
CADFILE NAME: 0604LOG1.DWG	



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LOGS OF TEST HOLES

JOB NO.: 13-0604	FIGURE: 3
CADFILE NAME: 0604LOG2.DWG	

LEGEND:

Fill: Sandy Clay, fine to medium grained, medium plasticity, relatively compact, slightly moist to moist, and light brown to dark brown in color.

Clay: Sandy, fine to medium grained, medium plastic, very stiff, slightly moist to moist, and tan to brown in color.

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 02/24/13 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.: 13-0604	FIGURE: 4
CADFILE NAME: 0604LEG.DWG	

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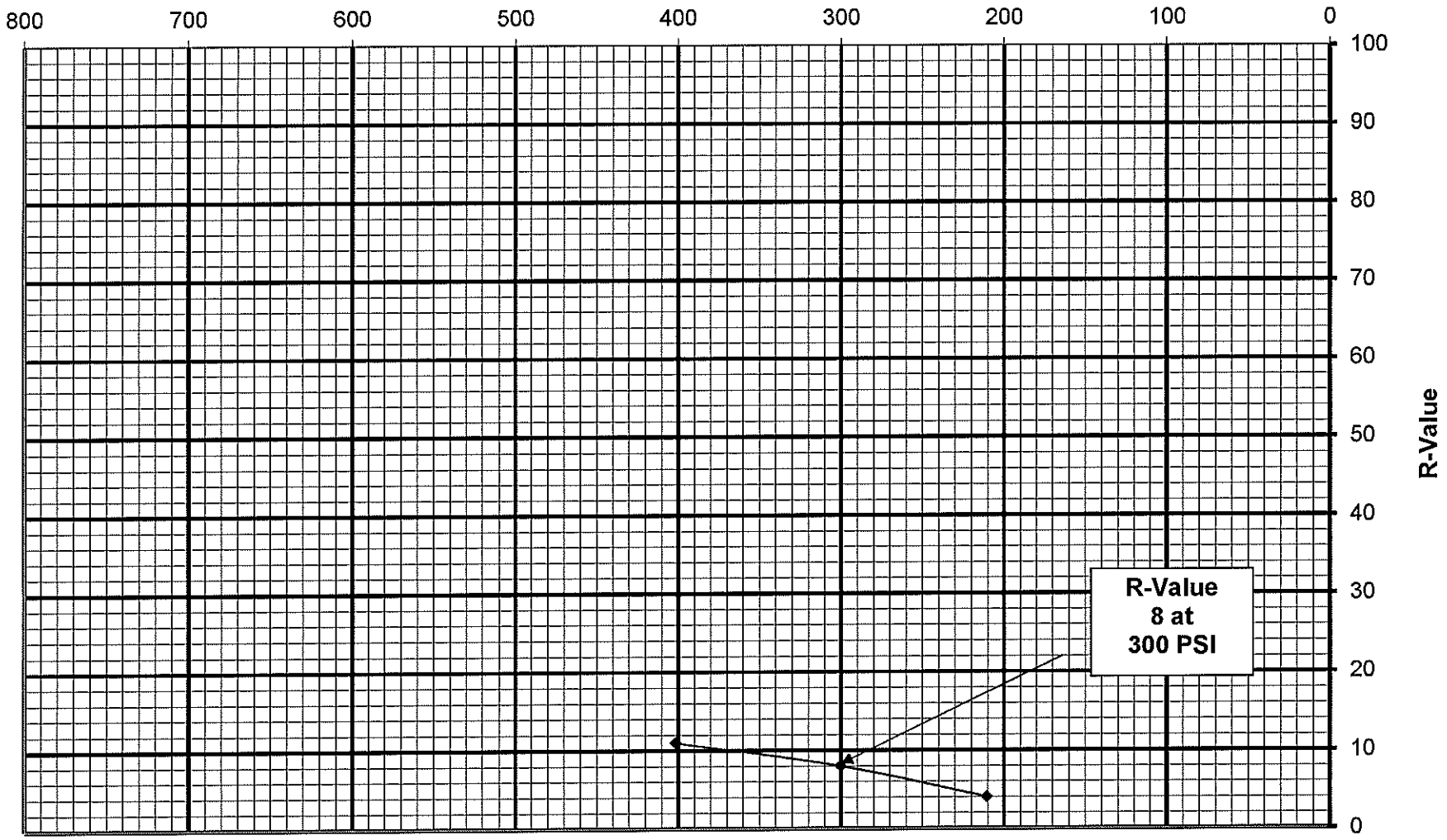
TABLE 1
SUMMARY OF LABORATORY TEST RESULTS - Cinquefoil Lane

Sample Location		Natural	Natural	Percent	Atterberg Limits		Percent	Water	AASHTO	Soil or
Test Hole No.	Depth *(feet)*	Moisture Content *(%)*	Dry Density *(pcf)*	Passing No. 200 Sieve	Liquid Limit	Plasticity Index	Swell (Surcharge Pressure of 150 psf)	Soluble Sulfates *(%)*	Classifi-cation (GI)	Bedrock Type
P-1A	3	15.4	104.9	71	32	17	1.3	-	A-6	Sandy Clay
P-1B (within storm trench)	3	17.6	106.1	73	30	16	1.0	-	A-6	Fill: Sandy Clay
P-2A	3	15.7	105.7	60	31	18	1.9	-	A-6	Sandy Clay
P-2B (within strom trench)	2	16.3	107.4	68	28	17	-	-	A-6	Fill: Sandy Clay
P-3A	2	15.8	106.2	52	30	17	0.1	0.05	A-6	Sandy Clay
P-3B (within storm trench)	2	15.9	105.0	70	33	20	0.5		A-6	Sandy Clay
P-4	3	13.5	-	62	36	18	-	-	A-6	Sandy Clay
P-5A	2	14.9	106.4	67	34	17	-	-	A-6	Fill: Sandy Clay
P-5B (within storm trench)	4	15.8	-	66	30	15	-	-	A-6	Sandy Clay
Composite from La Fever	0-5'	-	-	64	29	19	-	-	A-6(9)	Sandy Clay



Location: La Fever Comp. Sample: P-1 to P-3 @ 0-5 feet BG

Sample ID No. E585

Job No. 13-0604

Soil Type: Sandy Clay

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R-VALUE TEST RESULT
ASTM D 2844-07

Figure 4

Test Specimen	1	2	3
R-Value	11	8	4
Exudation Pressure	402	301	211
Moisture contents	17.7	18.7	19.6

***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

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

Banner Health Medical Campus
Cinquefoil Lane
Fort Collins, Colorado

Composite Pavement Section

Flexible Structural Design

18-kip ESALs Over Initial Performance Period	182,500
Initial Serviceability	4.5
Terminal Serviceability	2.3
Reliability Level	75 %
Overall Standard Deviation	0.44
Roadbed Soil Resilient Modulus	3,337 psi
Stage Construction	1
Calculated Design Structural Number	3.10 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	5.5	-	2.42
2	Aggregate Base Course	0.11	1	7	-	0.77
Total	-	-	-	12.50	-	3.19