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GEOTECHNICAL ENGINEERING STUDY
PROPOSED COLORADO CENTRE
SUBDIVISION PAVEMENT REHABILITATION
EL PASO COUNTY, COLORADO

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Project No. 17-2-223

December 18, 2017

TABLE OF CONTENTS

SUMMARY

1. Under asphalt and composite asphalt and aggregate base course pavement sections, the soil borings generally encountered, silty sand (SM), clayey sand (SC), lean clay (CL) and fat clay (CH), extending to the maximum depth explored of 25 feet. Clayey sand man placed fill was observed in Boring locations 1 and 23. Sandy Silt was observed at Boring 35.

2. Groundwater was not encountered in the borings with the exception of Boring 25 where it was encountered at 3.7 feet at the time of drilling. Fluctuations in the groundwater level may occur with time.

3. The pavement sections developed include; composite HMA over ABC, HMA over 12 inches of FDR, and PCCP, assuming the on-site soils as a subbase. Additional alternatives were developed assuming a subbase of 2 feet of imported granular fill with a minimum R-value of 40. Recommended pavement section thicknesses are presented on Page 5.

PURPOSE AND SCOPE OF STUDY

This report presents the results of a geotechnical engineering study for the proposed Colorado Centre Subdivision pavement rehabilitation project in El Paso County, Colorado. The project site is shown on Fig. 1. The study was conducted in accordance with our Proposal No. C17-133R2, dated September 15, 2017, to develop rehabilitation recommendations for the existing pavement and sidewalks.

This report has been prepared to summarize the data obtained during this study, and to present our conclusions and recommendations based on the proposed construction and the subsurface conditions encountered. Design parameters and a discussion of geotechnical engineering considerations related to the proposed construction are included in the report.

PROPOSED CONSTRUCTION

We understand the proposed construction will include rehabilitation and/or replacement of the existing pavement, curbs, and sidewalk sections. No significant regrading is anticipated. If the proposed construction is significantly different from that described above or depicted in this report, we should be notified to reevaluate the recommendations contained in this report.

SITE CONDITIONS

The project site is located within the existing Colorado Centre Subdivision in El Paso County, Colorado, near the Northeast corner of S. Marksheffel Boulevard and Bradley Road. Regionally, the area consists of rolling hills with a gentle to moderate slope down to the south towards

Jimmy Camp Creek located just to the east of the subdivision. Based on the available USGS topographic maps, the subdivision appears to be about 15 to 20 feet above the creek bottom elevation.

The subdivision consists of single family residences and asphalt roadways. Sidewalks were constructed directly adjacent to the existing curb and gutter. The subdivision is relatively level.

The existing asphalt surface has experienced some raveling in various isolated areas. Throughout the subdivision there were many transverse and longitudinal cracks present, some of which had been sealed; However, the majority were unsealed. The severity of the cracking was generally moderate with some severe transverse cracks throughout the roadways. Some areas of fatigue cracking were present at various isolated areas within the existing roadways. The attached Pavement Condition survey in Appendix B, indicates the relative severity of the pavement distress based on a cursory visual inspection of the pavement performed during the field exploration. In general, the sections observed ranged from good to poor.

Based on a visual inspection, the existing sidewalks appeared to be in good to fair condition. There appeared to be some minor cracking and/or settlement in a few areas generally at some driveway crossings and where large trees are in a close proximity to the existing sidewalk. There are some isolated areas where scaling was observed on the concrete surface.

FIELD EXPLORATION

The field exploration for the project was conducted on November 16th through 17th and November 21, 2017. Forty-two exploratory borings were drilled at the locations shown on Fig. 1 to explore subsurface conditions. Approximate locations of the exploratory borings were determined pacing from existing site features. The borings were advanced through the overburden soils with 4-inch diameter continuous flight augers. The borings were logged by a representative of Kumar & Associates, Inc.

Samples of the soils materials were taken with a 2-inch I.D. California sampler. The sampler was driven into the various strata with blows from a 140-pound hammer falling 30 inches. This test is similar to the standard penetration test described by ASTM Method D 1586. Penetration resistance values, when properly evaluated, indicate the relative density or consistency of the soils.

Depths at which the samples were taken and the penetration resistance values are shown on the Logs of Exploratory Borings, Figs. 2 through 4 and a legend and notes are presented on Fig. 4.

Measurements of the water level were made in the borings by lowering an electronic water level indicator into the open hole shortly after completion of drilling. The depth of the water level measured is shown on the Logs of Exploratory Borings, and discussed in the “Subsurface Conditions” section below.

LABORATORY TESTING

Samples obtained from the exploratory borings were visually classified in the laboratory by the project engineer and samples were selected for laboratory testing. Laboratory testing included index property tests such as in-situ moisture content and dry unit weight, grain size analysis, and Atterberg limits. Additional testing performed included swell-consolidation, concentration of water soluble sulfates, moisture-density relationships (standard Proctor), and Hveem’s stabilometer (R-value). The testing was conducted in general accordance with recognized test procedures, primarily those of the American Society for Testing of Materials (ASTM) or American Society of State Highway and Transportation Officials (AASHTO). Results of the laboratory testing program are shown on Figs. 2 thru 4, and 5 thru 19, and are summarized in Table I.

SUBSURFACE CONDITIONS

Subsurface conditions encountered in the exploratory borings generally consisted of 4 to 16 inches of asphalt that was underlain by 4 to 11 inches of a base material in 6 of the boring locations. The base material was generally found along Horizonview Drive. The pavement sections were generally underlain by clayey sand (SC), silty sand (SM), fat clays with sand (CH), sandy fat clay (CH), sandy lean clay (CL) and Lean clay with sand (CL) which extended from the to the maximum boring terminations depths of 5 to 10 feet. The density of the granular soils ranged from loose to medium dense and the consistency of the clay soils generally ranged from medium to very stiff. Man placed fill was encountered at Boring Locations 1 and 23.

Clays varying between sandy lean clay (CL), lean clay with sand (CL), Sandy fat clay (CH), flat clay with sand (CH) and lean clay (CL) were encountered at 28 of the 42 boring locations. A standard proctor performed on the sandy lean clay (CL) indicated a maximum dry density of 102.8 pcf at 20.6 percent moisture. Based on in-place moisture contents ranging between 18.5 to 35.4 percent on the samples tested, the clays are generally at an elevated moisture content.

The clay soils will likely require drying before compaction. An R-value test performed on a composite sample of sandy lean clay from Boring 14 indicated a value of less than 5. Swell/ consolidation testing performed on the clay samples indicated slight consolidation to medium swell potential when wetted. A sample of the sandy lean clay was remolded at about 95 percent of the proctor compaction and a moisture content near optimum. The vertical expansion under a 150 psf surcharge pressure upon wetting was about 0.1 percent.

Clayey sand (SC) was encountered at 7 of the boring locations. A standard proctor test of the clayey sand from Boring 40 indicated a maximum dry density of 108.2 pcf at 16.6 percent moisture. The in-place moisture content of selected samples tested ranged from 11.4 to 23.5 percent, indicating that the moisture content of some of the in-place clayey sand is elevated, and will require drying prior to compaction. An R-value test performed on the clayey sand from Boring 40 indicated a value of 9. Swell/ consolidation testing performed on the clayey sand samples generally indicated slight compression upon wetting. A sample of the clayey sand was remolded at about 95 percent of the proctor compaction and a moisture content near optimum. The vertical expansion under a 150 psf surcharge pressure upon wetting was about 0.3 percent.

Silty sand (SM) was encountered at 5 of the boring locations. The tested moisture contents of the silty sands (SM) varied between 7.4 to 16.1 percent. This indicates that the silty sand is generally moist. Swell/ consolidation testing of the silty sands indicated slight compression upon wetting.

Sandy silt (ML) was encountered at one boring location. Moisture density testing of the silt indicated a moisture content of 8.0 percent. This indicates that the sample was slightly moist. Swell/ consolidation testing indicates a low swell potential when wetted.

Ground water was encountered in Boring 25 at 3.7 feet below grade, at the time of drilling. In the remainder of the boring locations the water table was not encountered at the time of drilling. Fluctuations in the ground-water level may occur with time.

SITE GRADING

Fill placed for support of pavements should consist of a low to non-expansive material. The on-site materials encountered will be suitable for reuse as fill; however, the top 2 feet of subgrade will be required to have the minimum R-value specified in the design of 5 for onsite soils or 40 for import soils. Fill should not contain concentrations of organic matter or other deleterious substances. Proposed import materials should be approved by the geotechnical engineer. All pavement subgrade fill should be placed and compacted to the criteria presented in Appendix K of the El Paso County Engineering Criteria Manual.

PAVEMENT DESIGN

A pavement section is a layered system designed to distribute concentrated traffic loads to the subgrade. Performance of the pavement structure is directly related to the physical properties of the subgrade soils and traffic loadings. Soils are represented for pavement design purposes by means of a soil support value for flexible pavements and a modulus of subgrade reaction for rigid pavements. Both values are empirically related to strength.

Pavement design procedures are based on strength properties of the subgrade and pavement materials assuming stable, uniform conditions. Certain soils, such as those encountered on this site, are potentially expansive/frost susceptible and require additional precautions be taken to provide for adequate pavement performance. Expansive/Frost susceptible soils are problematic only if a source of water is present. If those soils are wetted, the resulting movements can be large and erratic. Therefore, pavement design procedures address expansive/frost susceptible soils only by assuming they will not become wetted. Proper surface and subsurface drainage is essential for adequate performance of pavement on these soils.

<u>Mill/ Overlay:</u> Due to the varying thickness of the existing asphalt section, we do not recommend milling and resurfacing the existing asphalt as a practical option. It is our opinion that the existing asphalt is too thin in areas for milling since the remaining thickness after milling will likely not be structurally adequate to support the milling machine and paving equipment. In areas where the distress is severe, with significant longitudinal, transverse and fatigue (alligator) cracking, the underlying subgrade will require some amount of stabilization prior to paving. In areas where pavement distress is occurring, unless the subgrade is properly addressed prior to paving, the overlay will develop reflective cracking and will have a shortened life expectancy. Recommendations for subgrade stabilization are included in the “Pavement Design” section.

<u>Overlay:</u> Where tear out and subgrade stabilization would not be required, i.e. nil to low distress areas without severe cracking, an overlay may be suitable. However, considering the size of the project and the large areas with moderate to severe distress, we recommend complete removal of pavement, stabilization of subgrade where necessary, and repaving with the criterion that follows below.

<u>Subgrade Materials</u>: The materials encountered at the site classify as A-1-b, A-2-4, A-4, A-7-6 and A-6 with a group index between 0 and 32 in accordance with the American Association of State Highway Transportation Officials (AASHTO) soil classification system. The A-2-6 and A-6 soils are generally considered to have fair support characteristics for pavements, the A-7-6 soils are considered to have poor support characteristics, and the A-1-b and A-2-4 soils are considered to have good support characteristics. Hveem's stabilometer test results (R-values) presented on Figs. 14 and 15 indicate R-values of less than 5, and 9 for the tested samples of A-7-6 and A-6, respectively. For our pavement design, we have assumed a minimum R-value of 5 for design of flexible pavements, a k-value of 60 psi/in for the design of rigid pavements over native soils. A k-value of 100 psi/in was assumed for the design of rigid pavements over imported material with a minimum R-value of 40.

<u>Design Traffic</u>: We understand that Horizonview Drive classifies as "Urban Residential Collector" and the remaining roadways in this study classify as "Urban Local" per El Paso County criteria. Design traffic 18-kip equivalent single axle load (ESAL) values from the El Paso County Criteria included 20-year values, and the 30 year values were extrapolated from the given data. The ESALs are summarized in the table below.

	20-Year ESAL (flexible)	30-Year ESAL (rigid)
Horizonview Drive (Urban Residential Collector)	821,000	1,231,500
Other Roads (Urban Local)	292,000	438,000

If it is determined that actual traffic is significantly different from that provided, we should be contacted to reevaluate the pavement thickness design.

<u>Pavement Sections</u>: Recommended pavement sections were determined using the El Paso County Engineering Criteria Manual, and the DARWin 3.01 pavement design software based on the 1993 AASHTO pavement design procedures. The parameters used for the design analyses and the detailed results of the pavement design analyses are presented in the Appendix. Calculated results were rounded up to the nearest ¼ inch per County criteria. Based on the results of the analysis, we recommend the following pavement sections:

Location	Pavement Section Thickness (in.)					
	On-site Soils (1)				Import Soil (2)	
	Composite HMA over Base Course	HMA over 12” of Cement Treated Subgrade (3)	HMA over 12” of FDR	PCCP	Composite HMA over Base Course	PCCP
Horizonview Drive	6.75/13	---	7.5	9.0	4.5/8.5	8.5
Other Roads	5.25/10.5	---	5.5	7.25	3.25/8.5	6.75

(1) Assumes subgrade soils with a minimum R-value of 5.

(2) Assumes a minimum 24-inch thick layer of imported, non to low swelling subgrade soil with a minimum R-value of 40.

(3) Due to the measured sulfate concentrations in the subgrade, cement treated subgrades are not recommended

As an alternative to constructing the pavements on the on-site soils, we have provided composite asphalt (HMA) over base course (ABC) and portland cement concrete pavement (PCCP) sections for pavements constructed on a minimum 24 inches of imported granular non to low-swelling subgrade material having a minimum R-value of 40. This will require overexcavation and replacement in areas where less than 2 feet of fill is required. Using a select import subgrade for the upper 24 inches would have the advantage in that having a higher subgrade R-value results in a thinner pavement section; however, costs associated with the subgrade construction will be higher. Import materials will require frequent monitoring of the material properties during construction to assure the R-value requirements are met. Prior to placement of the imported R40 material, the surface of the subgrade should be sloped to drain towards the edge(s) of the roadway.

Cement Treated Subgrade: The measured sulfate concentrations in the soils tested ranged from 0.01% to approximately 1.23%. Significant sulfate concentration can cause an adverse reaction with the concrete treated subgrade causing loss of stability or heave. Per the CDOT 2017 M-E Pavement Design Manual, Lime or cement treated soils should be avoided when sulfate concentrations are above 0.2%. Because of the sulfate concentrations encountered, cement treated subgrade is not recommended.

Full Depth Reclamation (FDR): Although not common locally, we understand that CDOT has utilized the FDR process on several roadway projects with positive results. Typical projects generally treat the full depth of the existing asphalt thickness plus a few inches of the underlying subbase materials. If this option is considered, we recommend that the FDR process occur to a depth of at least 12 inches.

The pulverized/processed mixture should have a maximum particle size of 1.5 inches. The pulverized mixture should be moisture conditioned to within 2 percentage points of the optimum moisture content and compacted to at least 95% of the maximum modified Proctor (ASTM D 1557) dry density. The FDR should result in a compacted base layer suitable for new asphalt paving when completed.

As an alternate to FDR, the asphalt could be milled and stockpiled, and then processed for use as an aggregate base course layer. The recovered material would need to be crushed, screened and potentially blended with conventional aggregates to meet a Class 6 gradation per Appendix D of the El Paso County Engineering Criteria Manual. With this option, the processed material would be used as the aggregate base course as part of a composite HMA and base course pavement section. We do not recommend the use of unprocessed recycled asphalt as a substitute for base course because it has been our experience the material properties can vary considerably, and the strength characteristics of the material can therefore be unpredictable.

Expansive Soil Considerations: The El Paso County Engineering Criteria Manual requires mitigation of expansive soils when the measured swell is greater than 2% with a 100 or 150 psf surcharge pressure. Based on the subsurface conditions encountered in the borings and the measured in-situ and remolded swell testing performed, the swell potential within the project area is estimated to be low. Therefore, we anticipate special mitigation of expansive soils will not be required.

Subgrade Preparation: The suitability of existing fill materials and compaction should be evaluated prior to placement of new fill and/or pavement materials.

Prior to placing fill or a pavement section, the entire subgrade area should be scarified to a depth of 12 inches, adjusted to within two percent of the optimum moisture content and compacted to the minimum criteria presented in the “Site Grading” section of the report. The material should be verified by the project engineer to meet the minimum R-value requirements for import or native soils according to which option is selected. The pavement subgrade should be proofrolled with a heavily loaded pneumatic-tired vehicle. Pavement design procedures assume a stable subgrade. Areas which deform excessively under heavy wheel loads are not stable and should be removed and replaced to achieve a stable subgrade prior to paving.

Subgrade Stabilization: Given the conditions encountered, it should be anticipated that some unstable subgrade areas will be encountered during construction. We anticipate that a majority of the roadway will have soils with moisture contents above the optimum. Subgrade soils with elevated moisture contents are expected to be unstable and prone to deflections and rutting.

We anticipate stabilization may be achieved by methods such as scarification of the subgrade to accelerate partial drying of the materials; excavation and replacement of unstable soils with drier materials; or stabilization using geogrid reinforcement (Type 2 Geogrid or similar) in combination with 1 to 2 feet of aggregate base course. Specific stabilization requirements should be evaluated at the time of construction. Given the amount of subsurface information collected, we cannot predict or quantify areas where unstable subgrade conditions may occur. However, we recommend this work activity, if required, be included as a line item in the bid schedule to avoid cost overruns.

Drainage: The collection and diversion of surface drainage away from paved areas is extremely important to the satisfactory performance of the pavement. Drainage design should provide for the removal of water from paved areas and prevent wetting of the subgrade soils.

It is possible for irrigation and other surface water runoff to flow from behind the curb or sidewalk, and to wet the underlying subgrade soils. This is particularly problematic if an aggregate base course layer is present, since this layer promotes water migration over the subgrade area.

If surface drainage and landscape irrigation design cannot avoid this situation, interceptor underdrains should be considered. The drains should be located directly below the curb and gutter to a depth of at least 2 feet below the pavement elevation. The underdrains should have a minimum slope of 1% along the drain alignment and sufficient lateral outlets to divert the collected water to suitable discharge points. Drains should consist of perforated pipe surrounded by free-draining gravel wrapped with a geotextile. The gravel should extend to the curb subgrade level.

Pavement Materials: The HMA should conform to the requirements of Pikes Peak Region Asphalt Paving Specifications. Given the traffic ESAL provided, we recommend the mix have a binder grade of PG 58-28 and a design gyration (Ndes) of 75. The mix grading should consist of a Grading SX.

Aggregate base course should be a Class 6 material conforming to the requirements presented in Appendix D of the El Paso County Engineering Criteria Manual. Table D-7 of the Criteria

Manual provides a specification for gravel used on gravel roads, which we recommend for gravel surfaced shoulders.

The concrete pavement should meet the requirements in Section D.5.5 of the El Paso County Engineering Criteria Manual, which specifies CDOT Class P concrete. The concrete should contain joints not greater than 12 to 15 feet on centers. The joints should be hand formed, sawed or formed by premolded filler. The joints should be at least 1/4 of the slab thickness. Expansion joints should be provided at the end of each construction sequence and between the concrete slab and adjacent structures. Expansion joints where required, should be filled with a ½ inch-thick asphalt impregnated fiber. Concrete should be cured by protecting against loss of moisture, rapid temperature changes and mechanical injury for at least three days after placement.

SIDEWALK SUBGRADE

We anticipate that the sidewalk loadings and the traffic volume will be very low. Based on our understanding for what is typically used in the area, and based on experience, understand that the sidewalk thickness will be determined from the EL Paso County Engineering Criteria. We recommend that a subgrade be constructed in accordance with the subgrade recommendations for the pavement sections. For ease of construction, it may be effective to prepare the sidewalk subgrade during the roadway reconstruction.

EXCAVATION CONSIDERATIONS

In our opinion, excavation of the overburden soils should be possible with conventional excavation equipment.

All excavations should be in accordance with OSHA, state and local requirements. The contractor should follow appropriate safety precautions. In accordance with OSHA guidelines, the native soils will likely classify as a Type C material. A contractors competent person should make decisions regarding soil types encountered during excavation.

Per OSHA criteria, unless excavations are shored, temporary unretained excavations in Type C materials should have slopes no steeper than 1½:1 (H:V). Flatter slopes will be required where ground-water is encountered. Surface draining should be diverted away from all temporary cut slopes in order to reduce the potential for slope erosion and instability. OSHA regulations require that excavations greater than 20 feet in depth be designed by a professional engineer.

If ground water is encountered in excavations, we believe the dewatering can be accomplished by pumping from sumps installed within the excavation. The pits should be constructed well below the base of the excavation to avoid loss of supporting capacity of the soils. The dewatering system should be properly designed, installed and maintained. The bottom and sides of the excavation may become unstable if the ground-water level is not maintained at a sufficient depth below the bottom of the excavation. Overly moist soils may also contribute to unstable subgrade conditions when preparing roadway embankment. Refer to the “Pavement Design – Subgrade Stabilization” for additional discussions.

WATER SOLUBLE SULFATES

The concentration of water soluble sulfates measured in samples obtained from the exploratory borings ranges from 0.01% to approximately 1.23%. These concentrations of water soluble sulfates represent a Class 0 to 2 severity of exposure to sulfate attack on concrete exposed to these materials. The degree of attack is based on a range of Class 0 to Class 3 severity of exposure as presented in ACI 201. Special cement will be required for concrete in direct contact with soils in this area. Concrete meeting the specifications for Class 2 exposure as defined in ACI 201.2R-10 should be used.

DESIGN AND CONSTRUCTION SUPPORT SERVICES

Kumar & Associates, Inc. should be retained to review the project plans and specifications for conformance with the recommendations provided in our report. We are also available to assist the design team in preparing specifications for geotechnical aspects of the project, and performing additional studies if necessary to accommodate possible changes in the proposed construction.

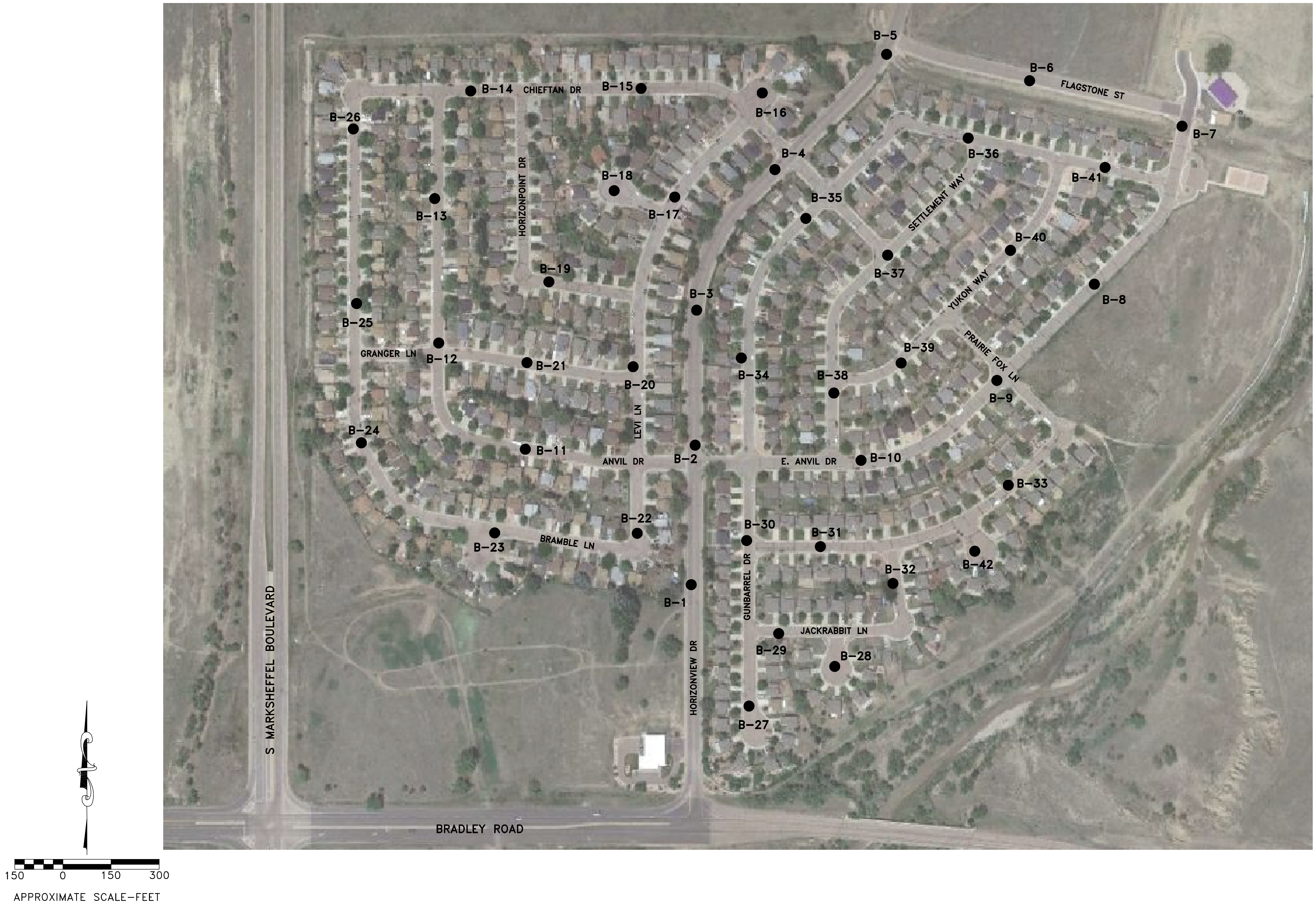
We recommend that Kumar & Associates, Inc. be retained to provide observation and testing services to document that the intent of this report and the requirements of the plans and specifications are being followed during construction, and to identify possible variations in subsurface conditions from those encountered in this study so that we can re-evaluate our recommendations, if needed.

LIMITATIONS

This study has been conducted in accordance with generally accepted geotechnical engineering practices in this area for use by the client for design purposes. The conclusions and recommendations submitted in this report are based upon the data obtained from the exploratory borings at the locations indicated on Fig. 1 and the proposed type of construction.

This report may not reflect subsurface variations that occur, and the nature and extent of variations across the site may not become evident until site grading and excavations are performed. If during construction, fill, soil, rock or water conditions appear to be different from those described herein, Kumar & Associates, Inc. should be advised at once so that a re-evaluation of the recommendations presented in this report can be made. Kumar & Associates, Inc. is not responsible for liability associated with interpretation of subsurface data by others.

JDC:bj



17-2-223	Kumar & Associates		LOCATION OF EXPLORATORY BORINGS	Fig. 1

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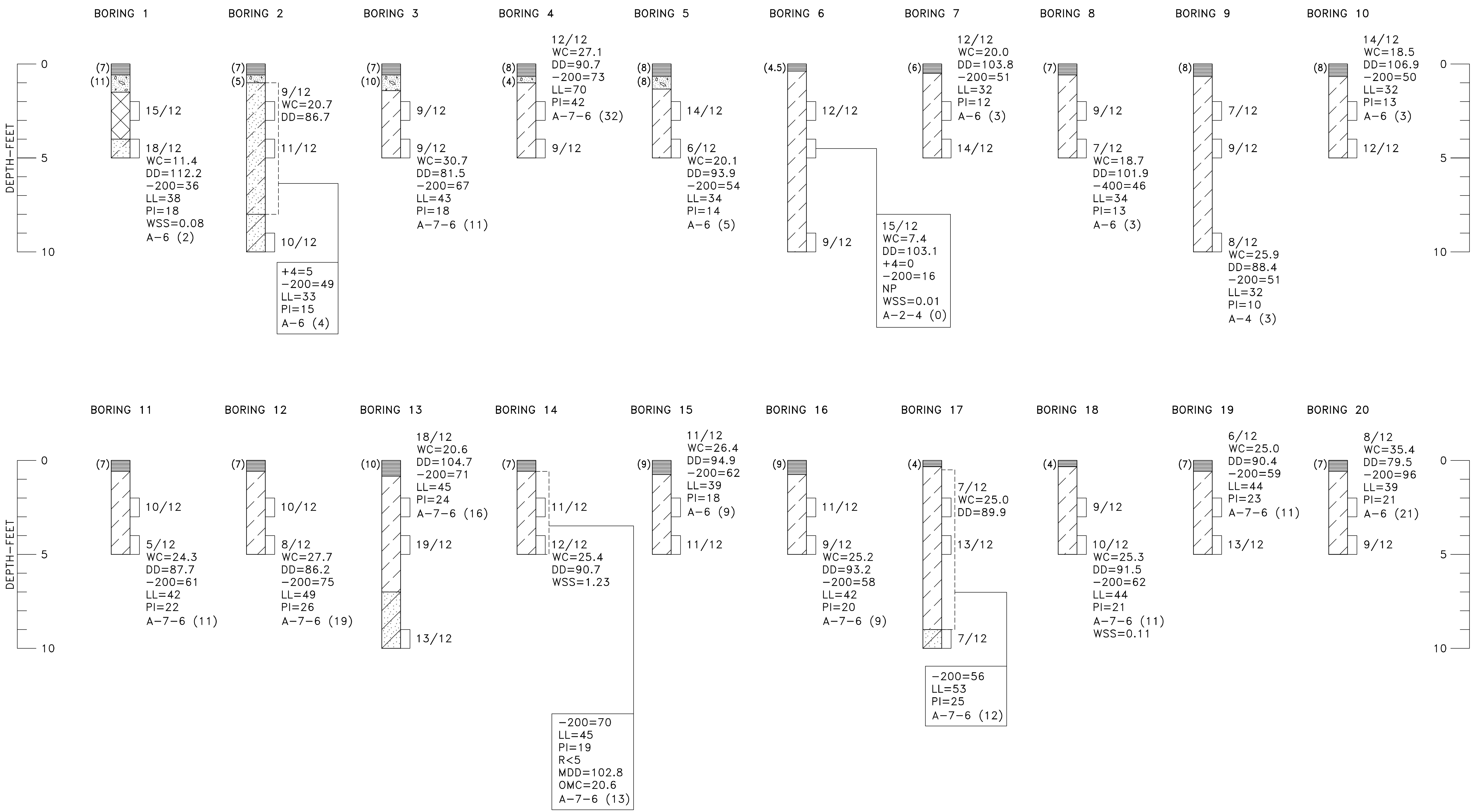
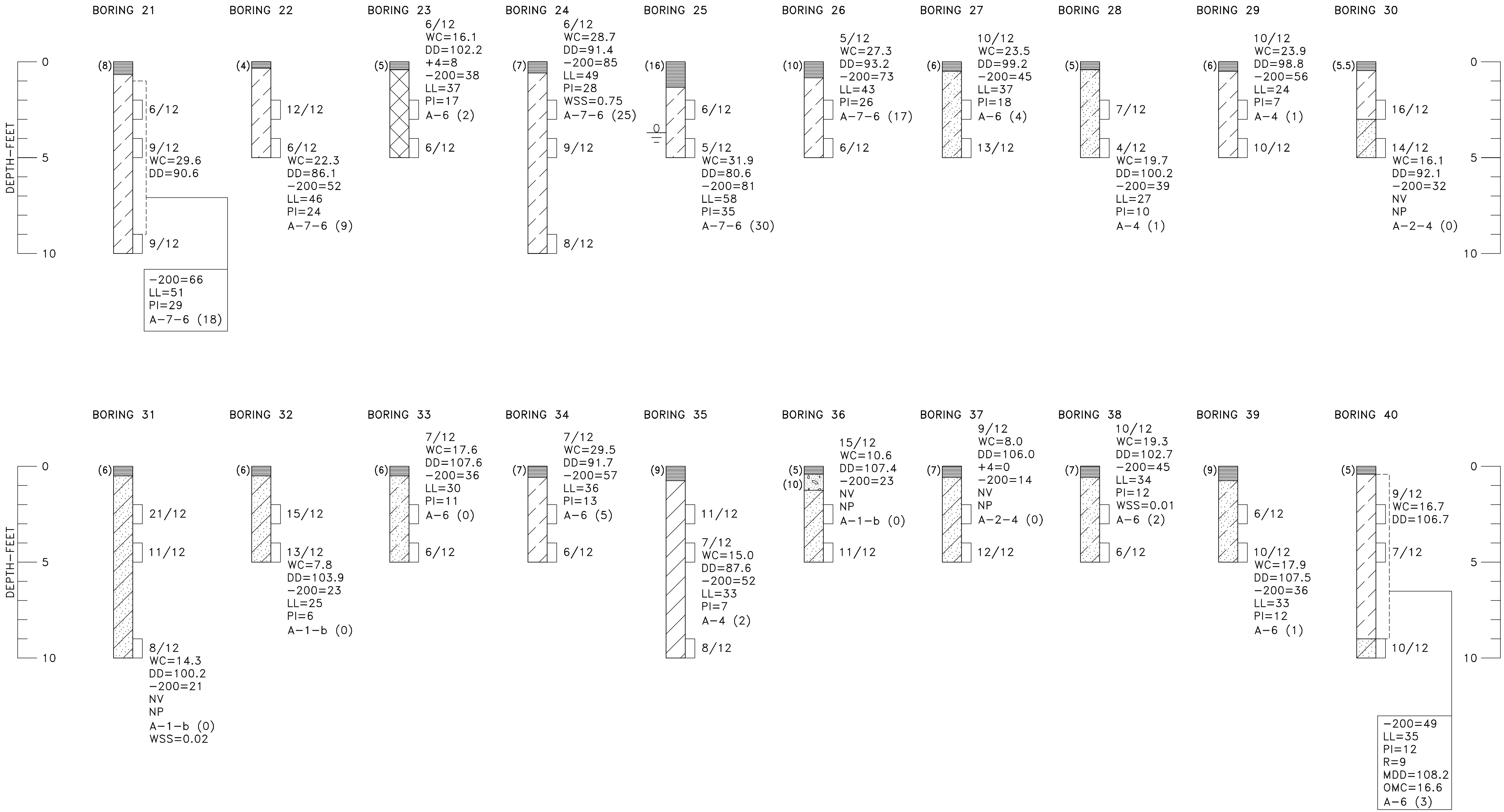


17-2-223	Kumar & Associates		LOGS OF EXPLORATORY BORINGS	Fig. 2



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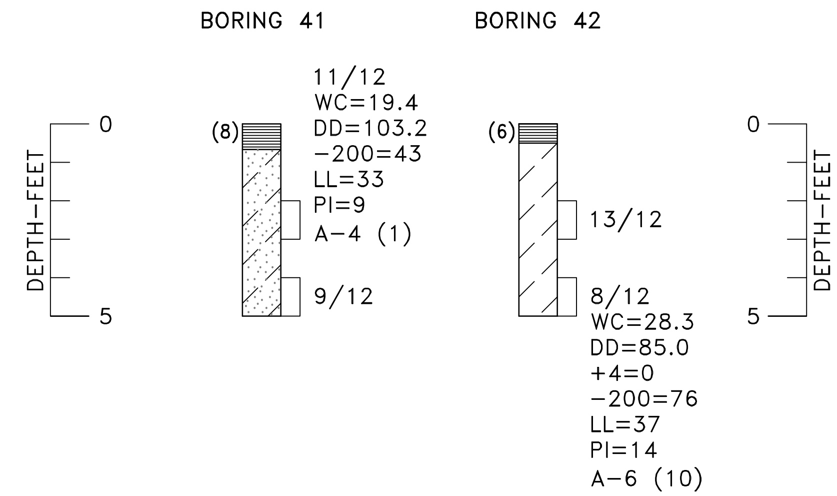
17-2-223	Kumar & Associates		LOGS OF EXPLORATORY BORINGS	Fig. 3



LEGEND

(7) ASPHALT, THICKNESS IN INCHES SHOWN IN PARENTHESES TO LEFT OF THE LOG.

(11) BASE COURSE, THICKNESS IN INCHES SHOWN IN PARENTHESES TO LEFT OF THE LOG.

FILL: CLAYEY SAND (SC), LOW PLASTICITY, FINE TO COARSE GRAINED WITH OCCASIONAL GRAVELS, LOOSE TO MEDIUM DENSE, MOIST, DARK BROWN.

SANDY LEAN CLAY (CL), LEAN CLAY (CL), SANDY SILTY CLAY (CL-ML), LEAN CLAY WITH SAND (CL), SANDY FAT CLAY (CH), FAT CLAY WITH SAND (CH), MEDIUM TO HIGH PLASTICITY, MEDIUM STIFF TO VERY STIFF, MOIST TO WET, BROWN TO GRAY.

SANDY SILT (ML) LOW PLASTICITY, FINE TO COARSE GRAINED, LOOSE TO MEDIUM DENSE, MOIST, BROWN.

SILTY SAND (SM), LOW PLASTICITY, FINE TO COARSE GRAINED, LOOSE TO MEDIUM DENSE, MOIST, BROWN.

CLAYEY SAND (SC), LOW TO MEDIUM PLASTICITY, FINE TO COARSE GRAINED, LOOSE TO MEDIUM DENSE, MOIST, BROWN.

DRIVE SAMPLE, 2-INCH I.D. CALIFORNIA LINER SAMPLE.

DISTURBED BULK SAMPLE.

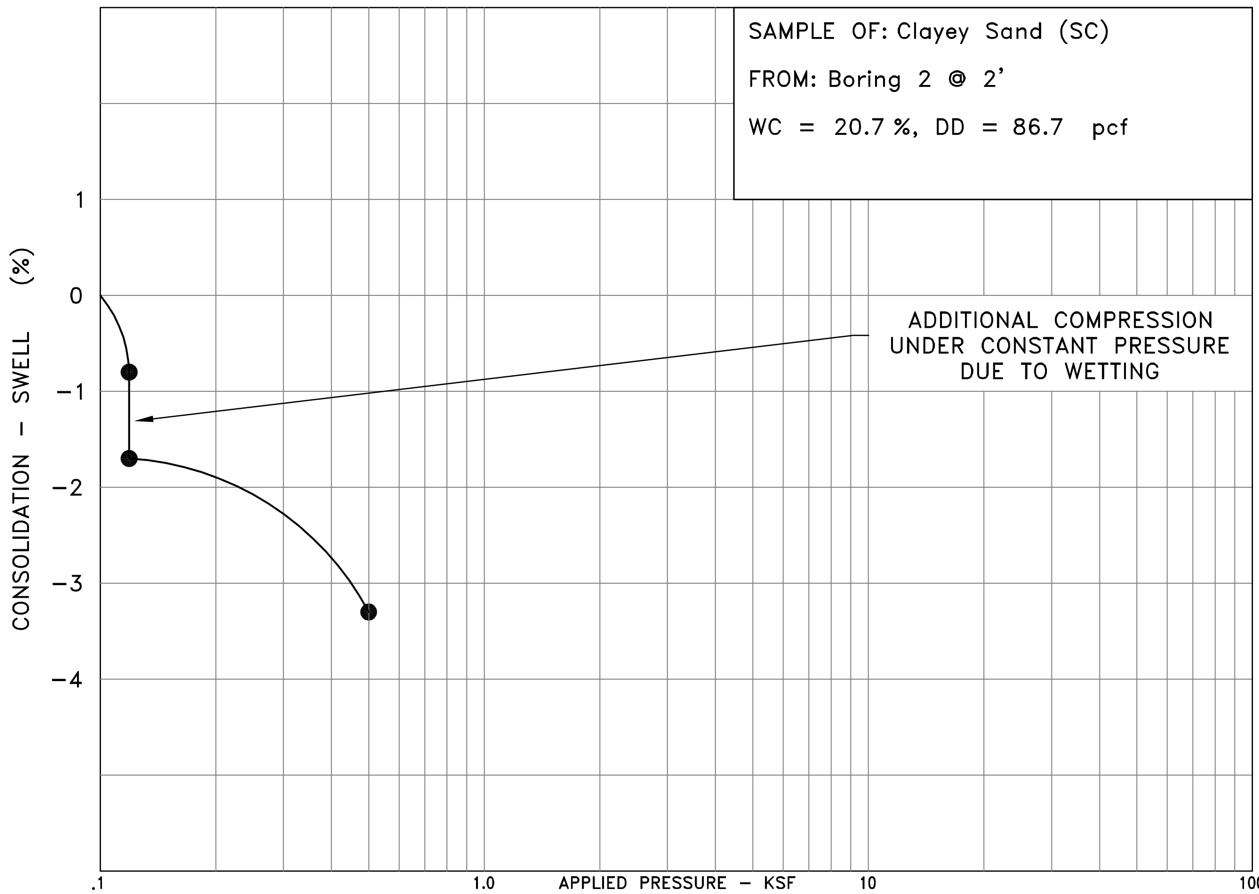
15/12 DRIVE SAMPLE BLOW COUNT. INDICATES THAT 15 BLOWS OF A 140-POUND HAMMER FALLING 30 INCHES WERE REQUIRED TO DRIVE THE SAMPLER 12 INCHES.

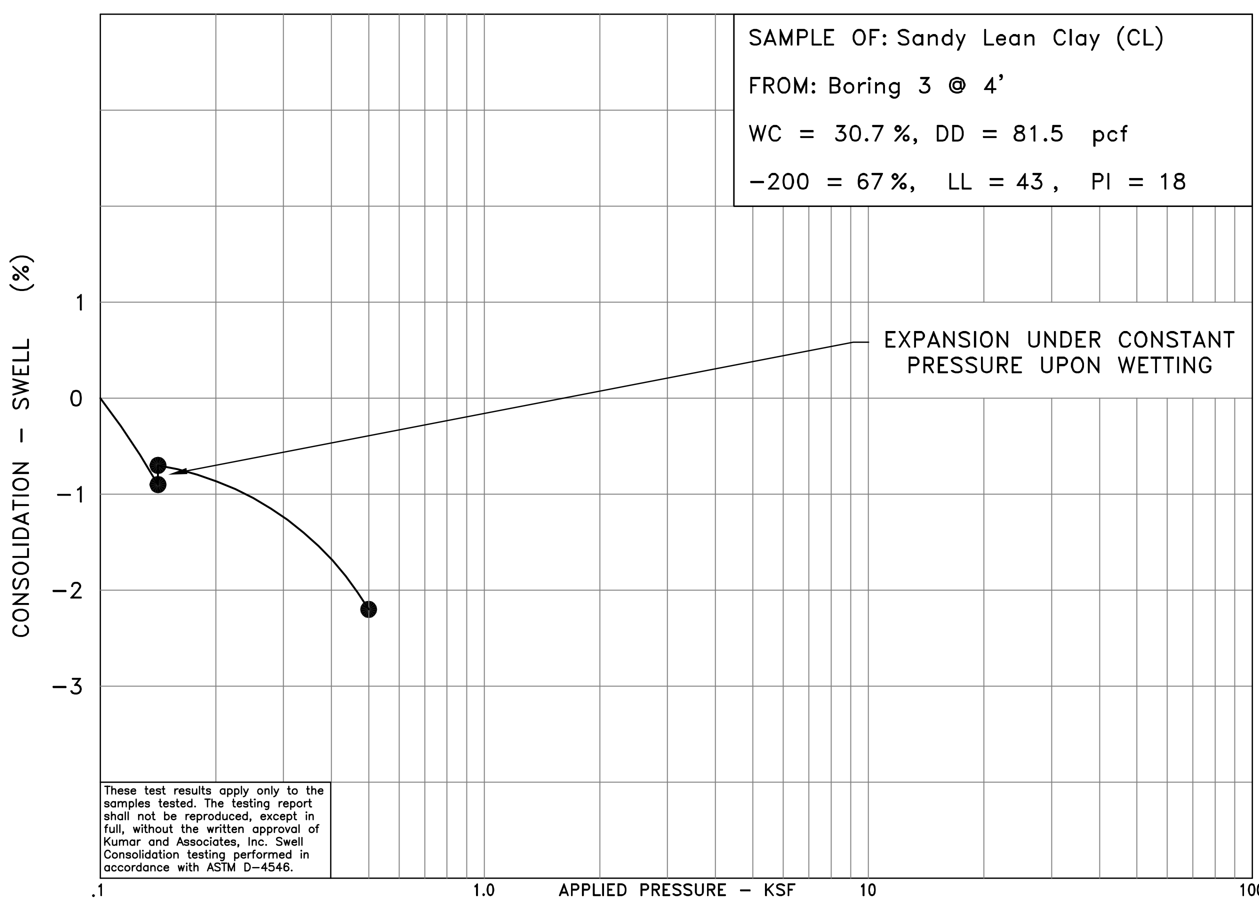
DEPTH TO WATER LEVEL ENCOUNTERED AT THE TIME OF DRILLING.

NOTES

1. THE EXPLORATORY BORINGS WERE DRILLED ON NOVEMBER 16, 17 AND 27, 2017 WITH A 4-INCH DIAMETER CONTINUOUS FLIGHT POWER AUGER.
2. THE LOCATIONS OF THE EXPLORATORY BORINGS WERE MEASURED APPROXIMATELY BY PACING FROM FEATURES SHOWN ON THE SITE PLAN PROVIDED.
3. THE ELEVATIONS OF THE EXPLORATORY BORINGS WERE NOT MEASURED AND THE LOGS OF THE EXPLORATORY BORINGS ARE PLOTTED TO DEPTH.
4. THE EXPLORATORY BORING LOCATIONS SHOULD BE CONSIDERED ACCURATE ONLY TO THE DEGREE IMPLIED BY THE METHOD USED.
5. THE LINES BETWEEN MATERIALS SHOWN ON THE EXPLORATORY BORING LOGS REPRESENT THE APPROXIMATE BOUNDARIES BETWEEN MATERIAL TYPES AND THE TRANSITIONS MAY BE GRADUAL.
6. GROUNDWATER LEVELS SHOWN ON THE LOGS WAS MEASURED AT THE TIME OF DRILLING. FLUCTUATIONS IN THE WATER LEVEL MAY OCCUR WITH TIME.
7. LABORATORY TEST RESULTS:
   WC = WATER CONTENT (%) (ASTM D 2216);
   DD = DRY DENSITY (pcf) (ASTM D 2216);
   +4 = PERCENTAGE RETAINED ON NO. 4 SIEVE (ASTM D 422);
   -200= PERCENTAGE PASSING NO. 200 SIEVE (ASTM D 1140);
   LL = LIQUID LIMIT (ASTM D 4318);
   PI = PLASTICITY INDEX (ASTM D 4318);
   NP = NON-PLASTIC (ASTM D 4318);
   WSS = WATER SOLUBLE SULFATES (%) (CP-L 2103);
   A-6 (2) = AASHTO CLASSIFICATION (GROUP INDEX) (AASHTO M 145);
   R = HVEEM R-VALUE (AT 300 psi) (ASTM D 2844);
   OMC = OPTIMUM MOISTURE CONTENT (%) (ASTM D 1557) or (ASTM D 698);
   MDD = MAXIMUM DRY DENSITY (pcf) (ASTM D 1557) or (ASTM D 698).

17-2-223	Kumar & Associates		LOGS, LEGEND AND NOTES OF EXPLORATORY BORINGS	Fig. 4





17-2-223	Kumar & Associates	SWELL-CONSOLIDATION TEST RESULTS	Fig. 5

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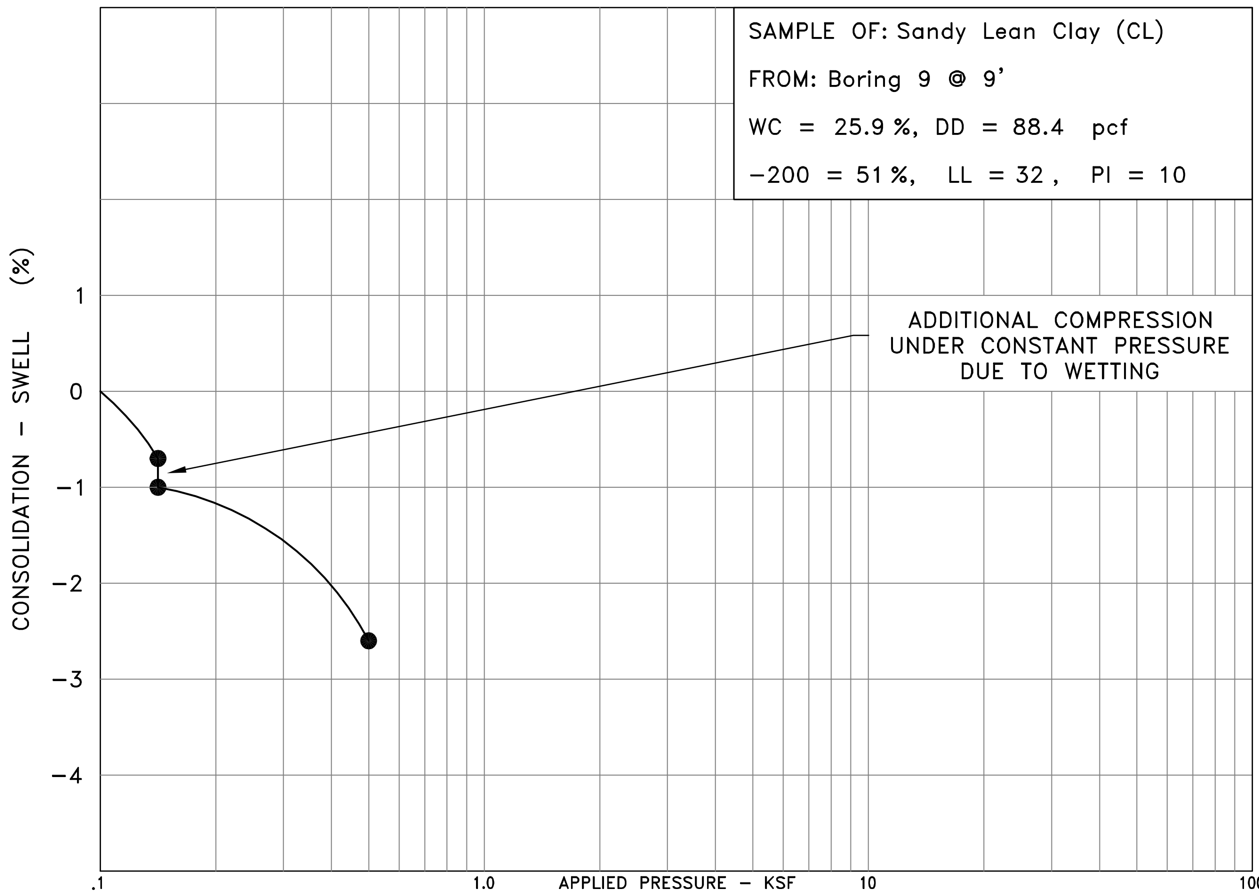
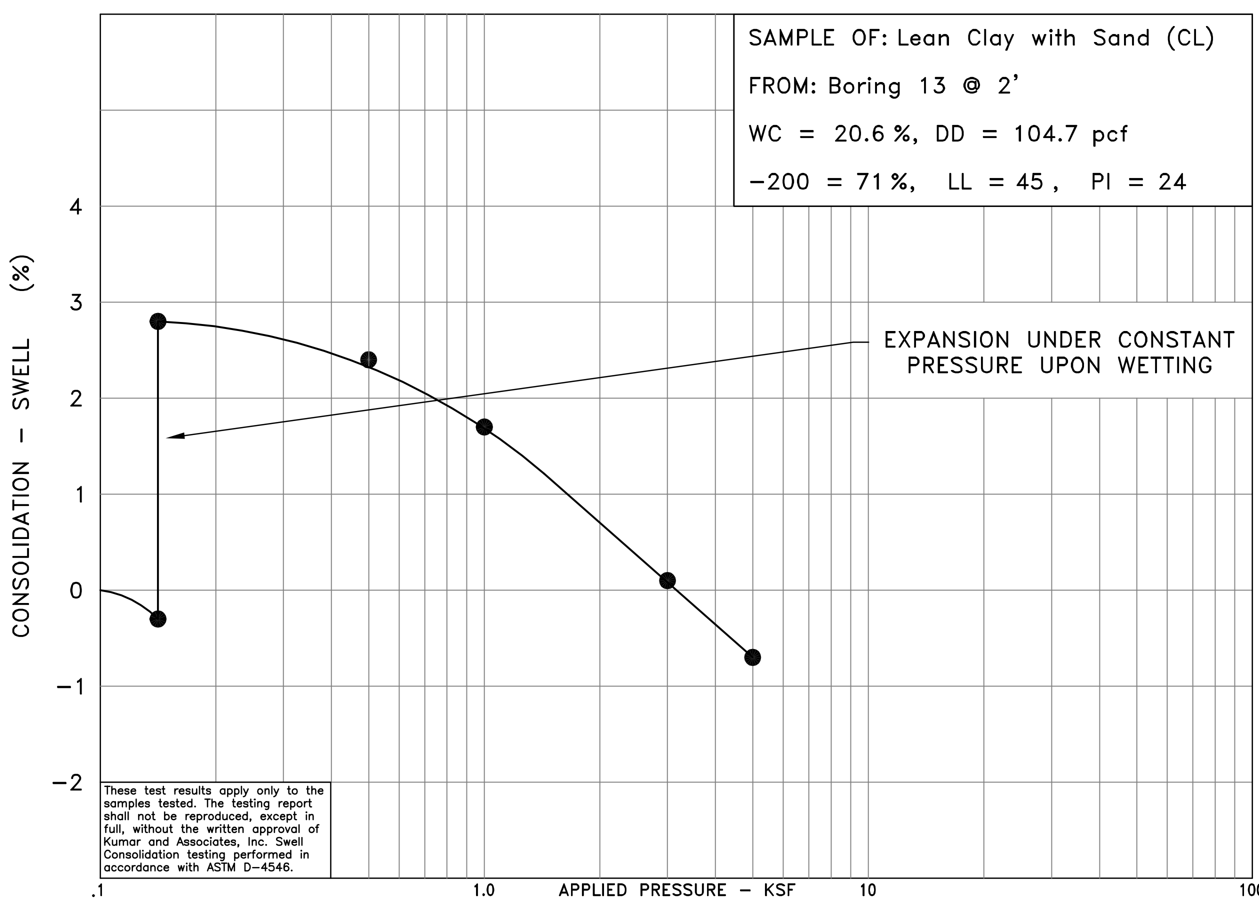
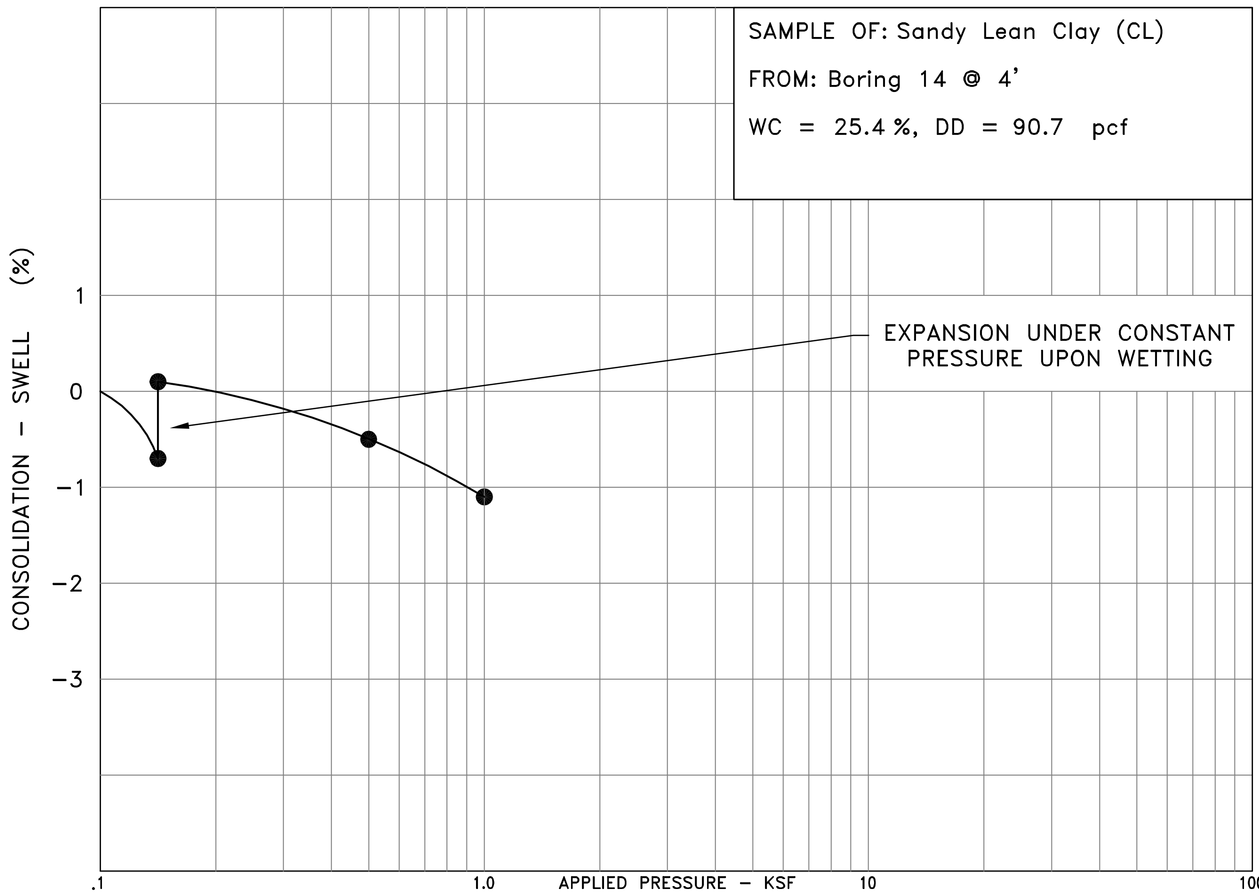
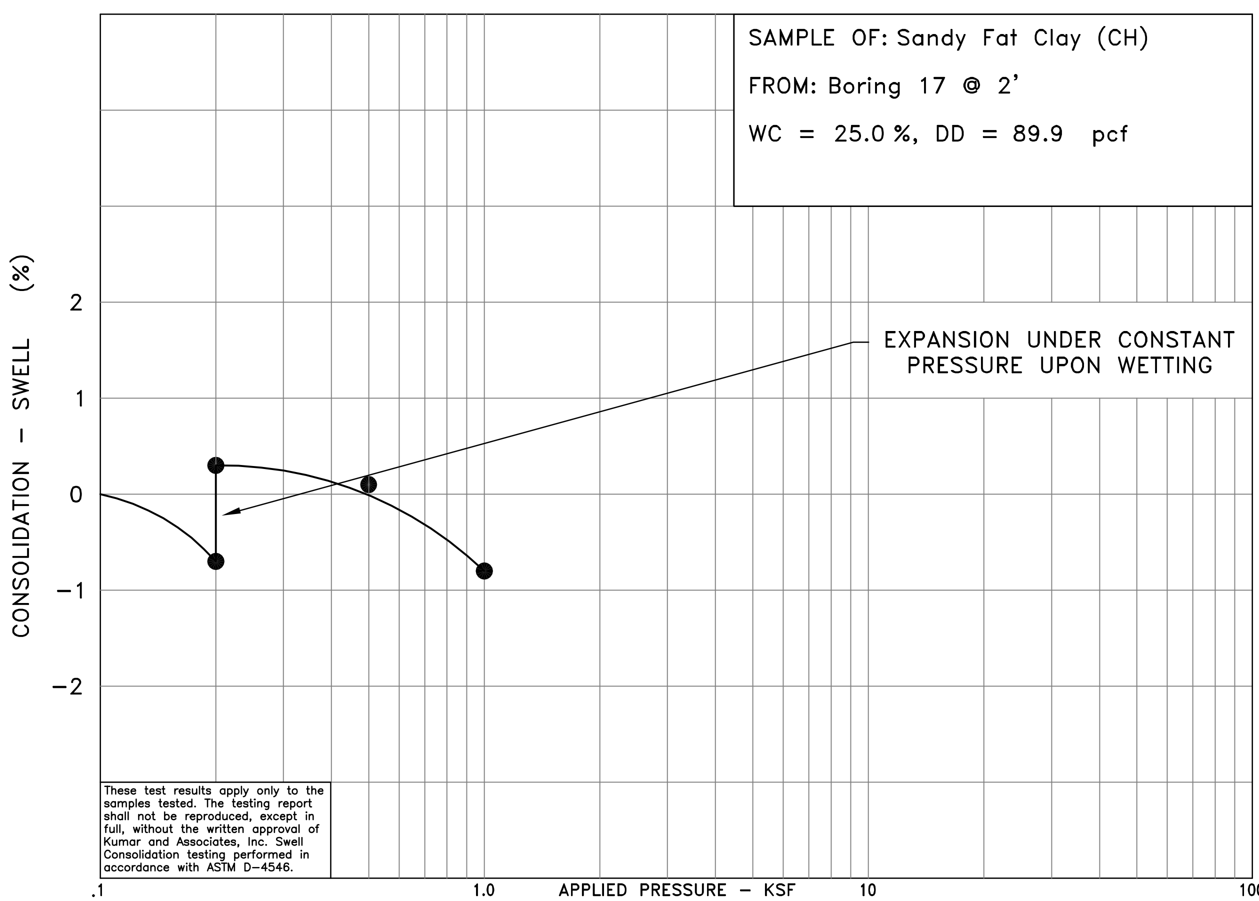




17-2-223	Kumar & Associates	SWELL-CONSOLIDATION TEST RESULTS	Fig. 6





17-2-223	Kumar & Associates	SWELL-CONSOLIDATION TEST RESULTS	Fig. 7

December 14, 2017 - 09:36am
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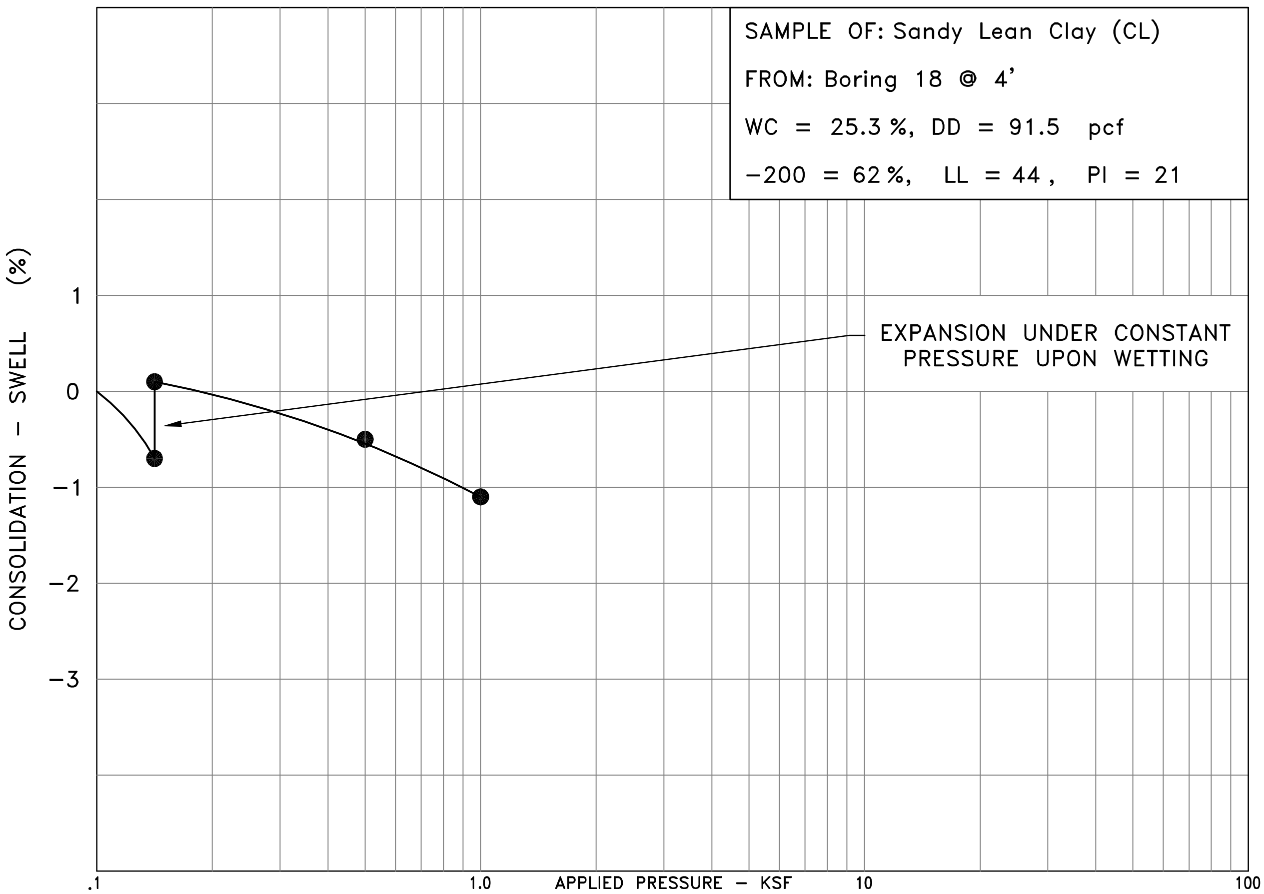

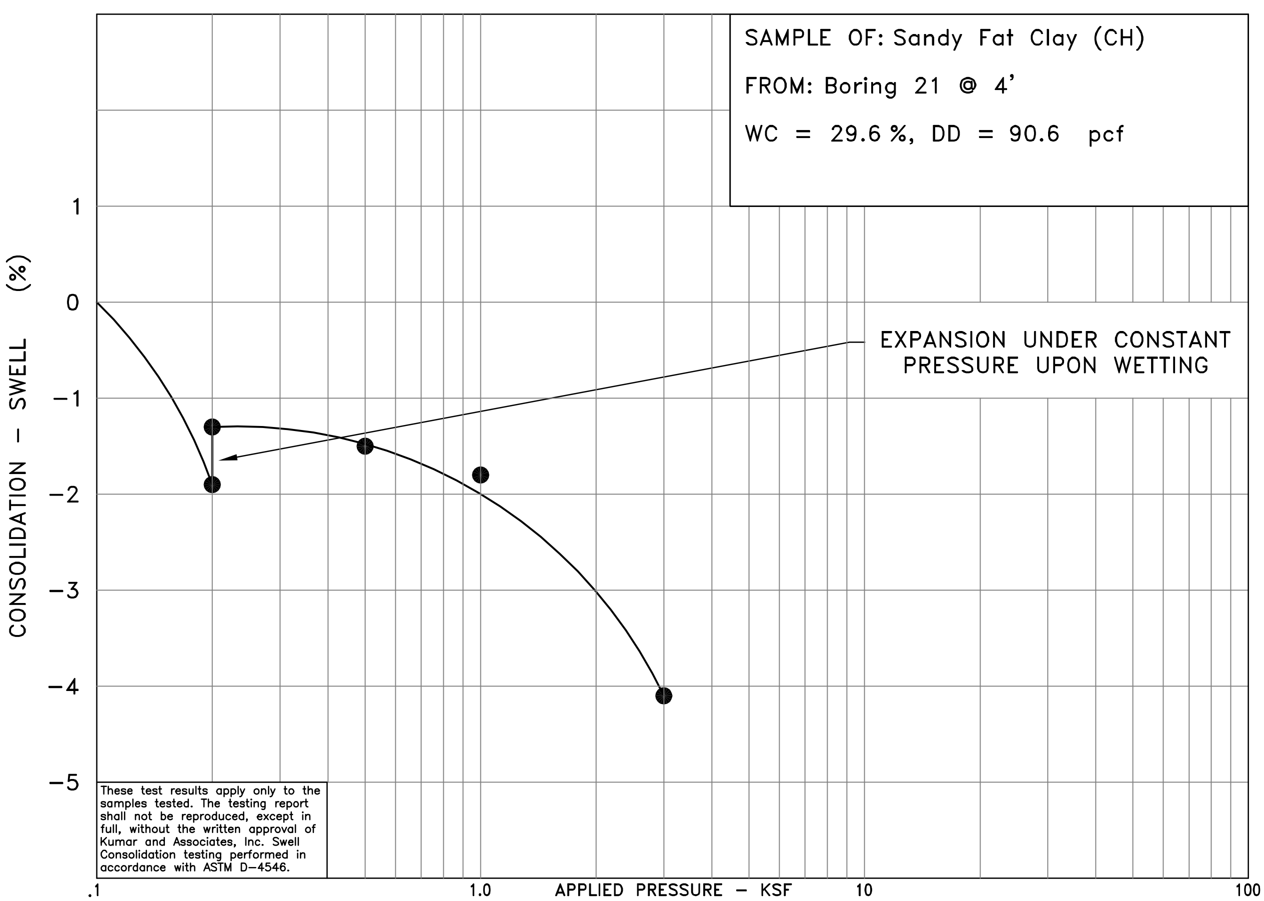

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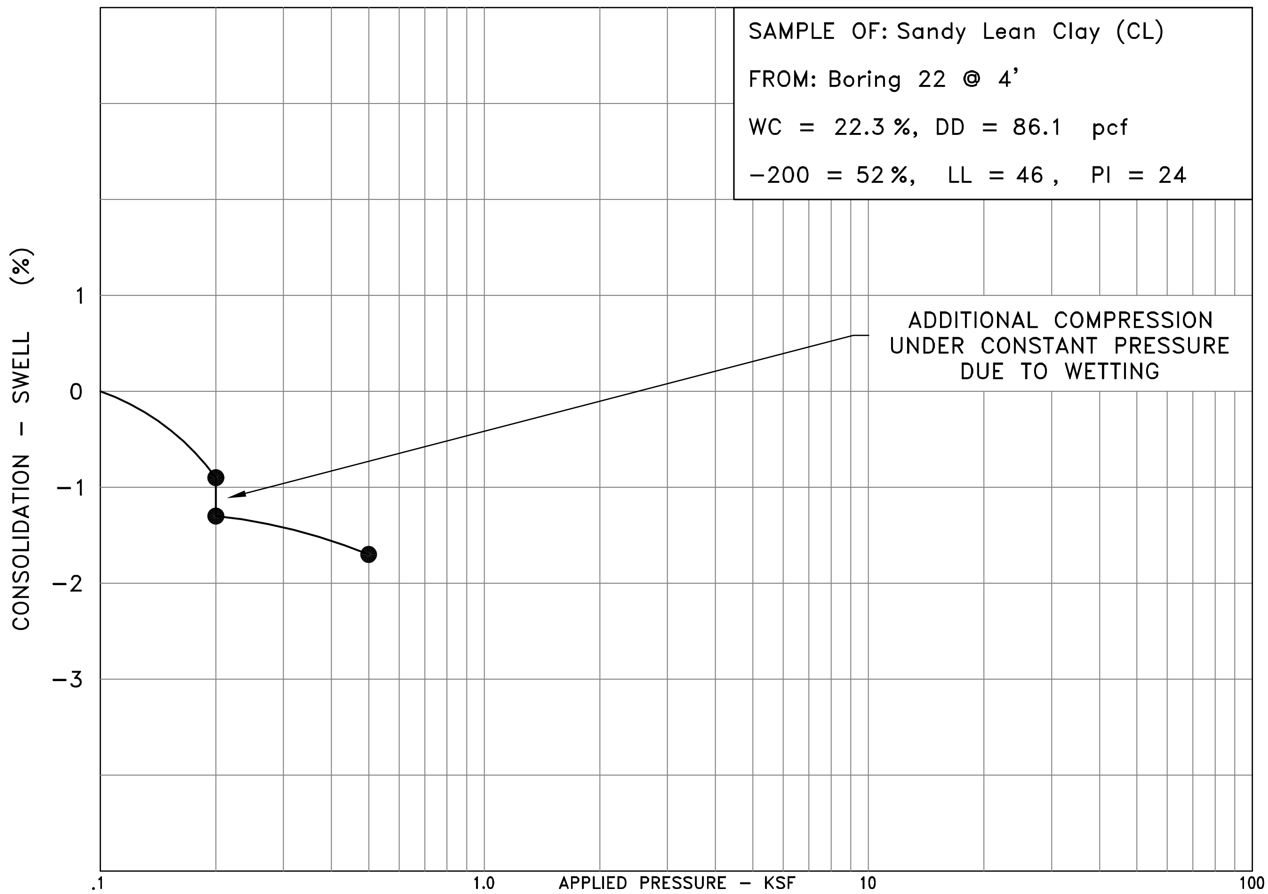
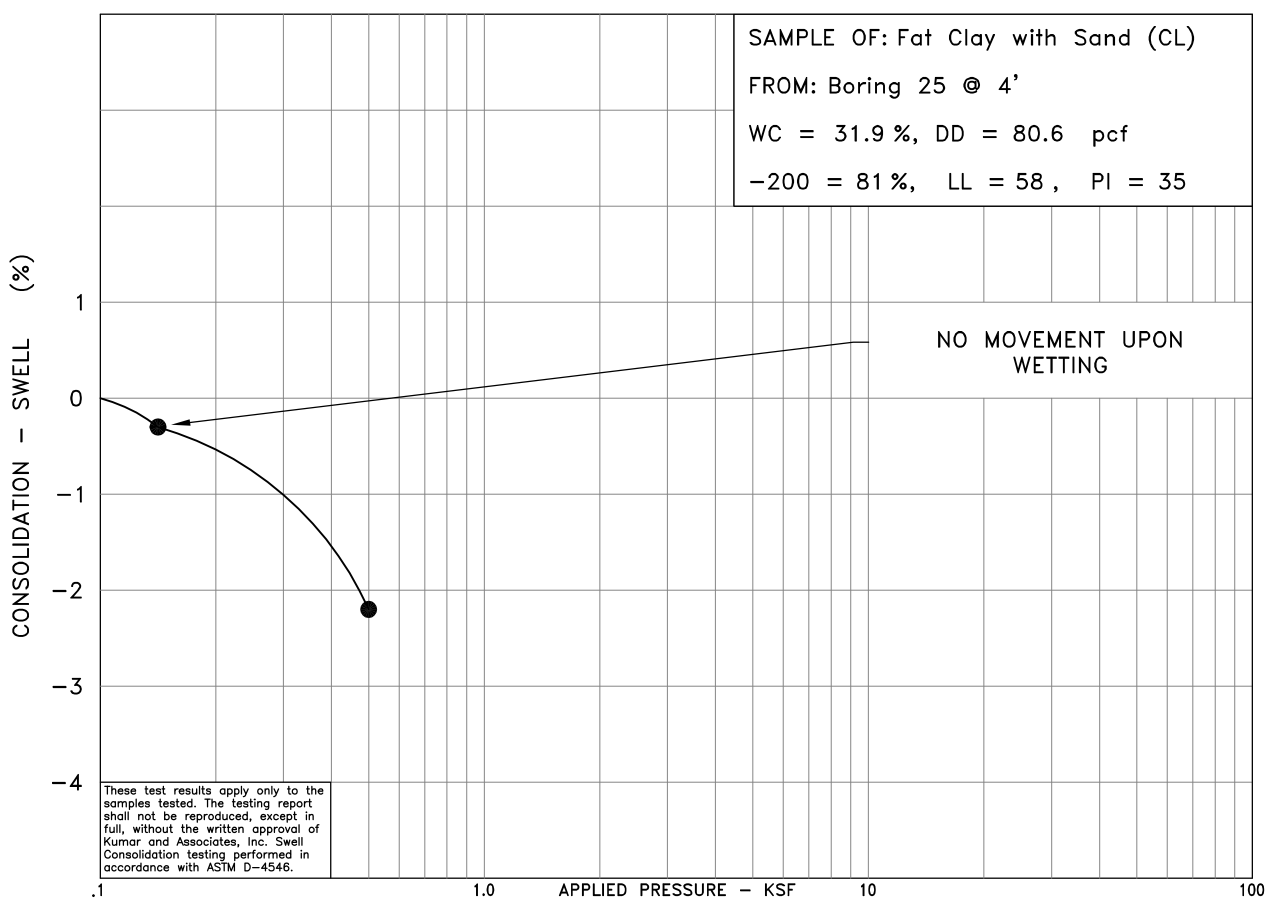
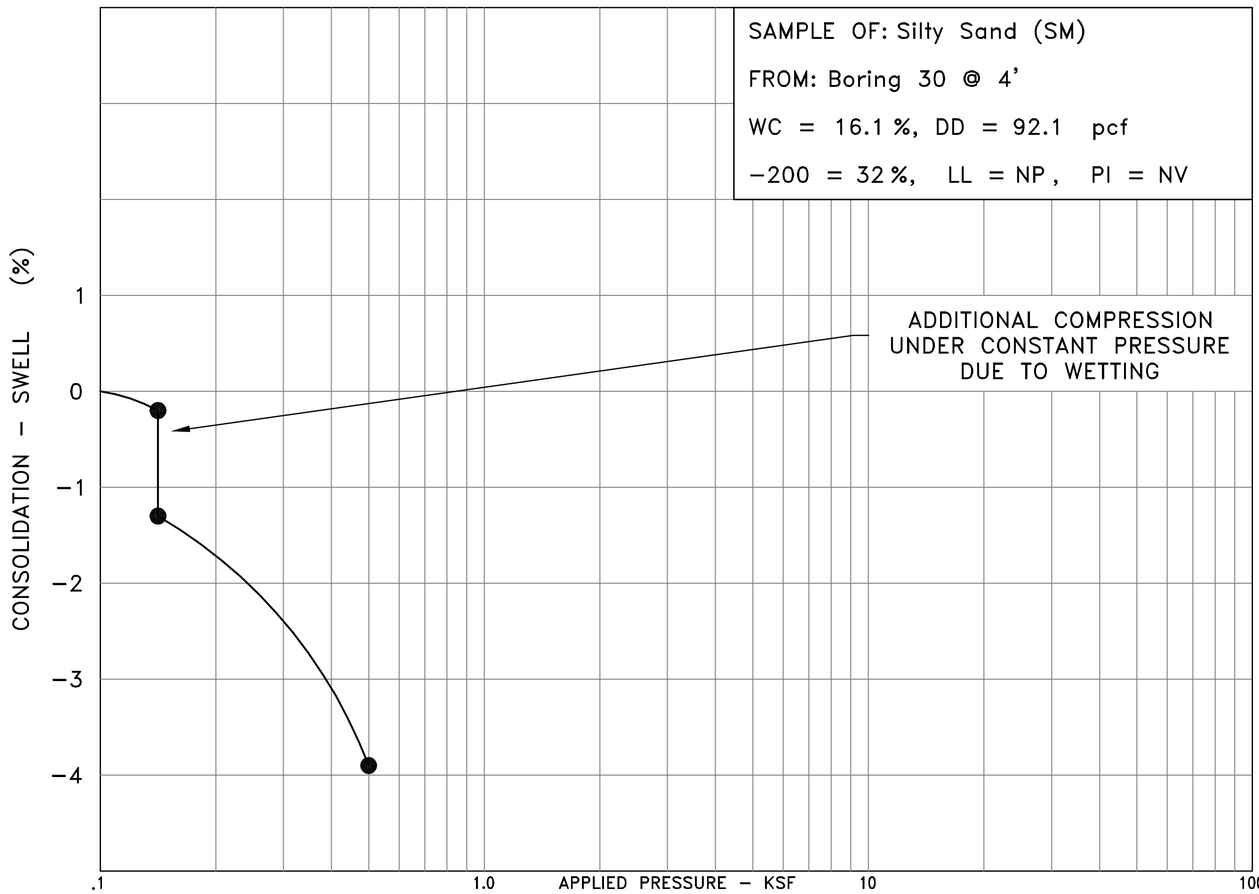
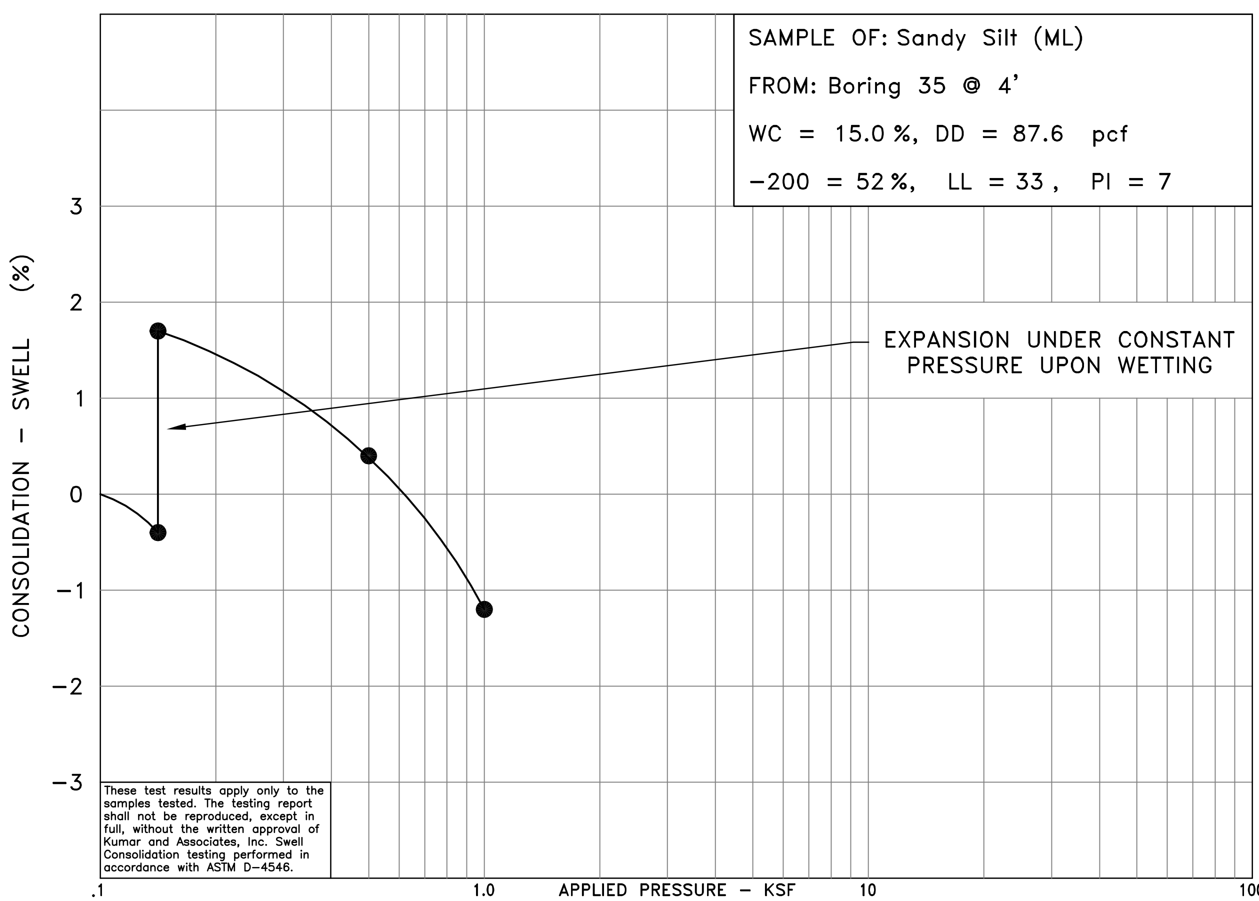
17−2−223	Kumar & Associates	SWELL−CONSOLIDATION TEST RESULTS	Fig. 8



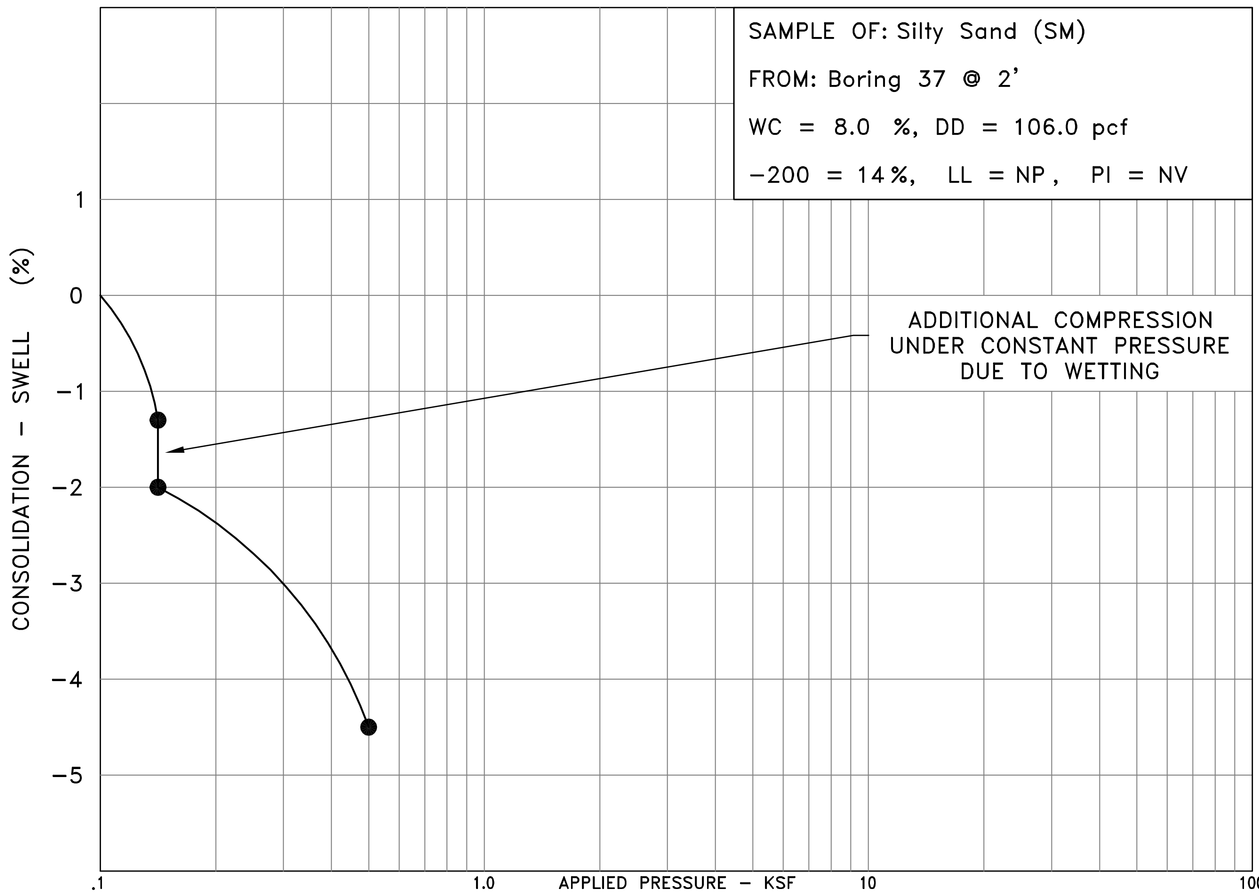


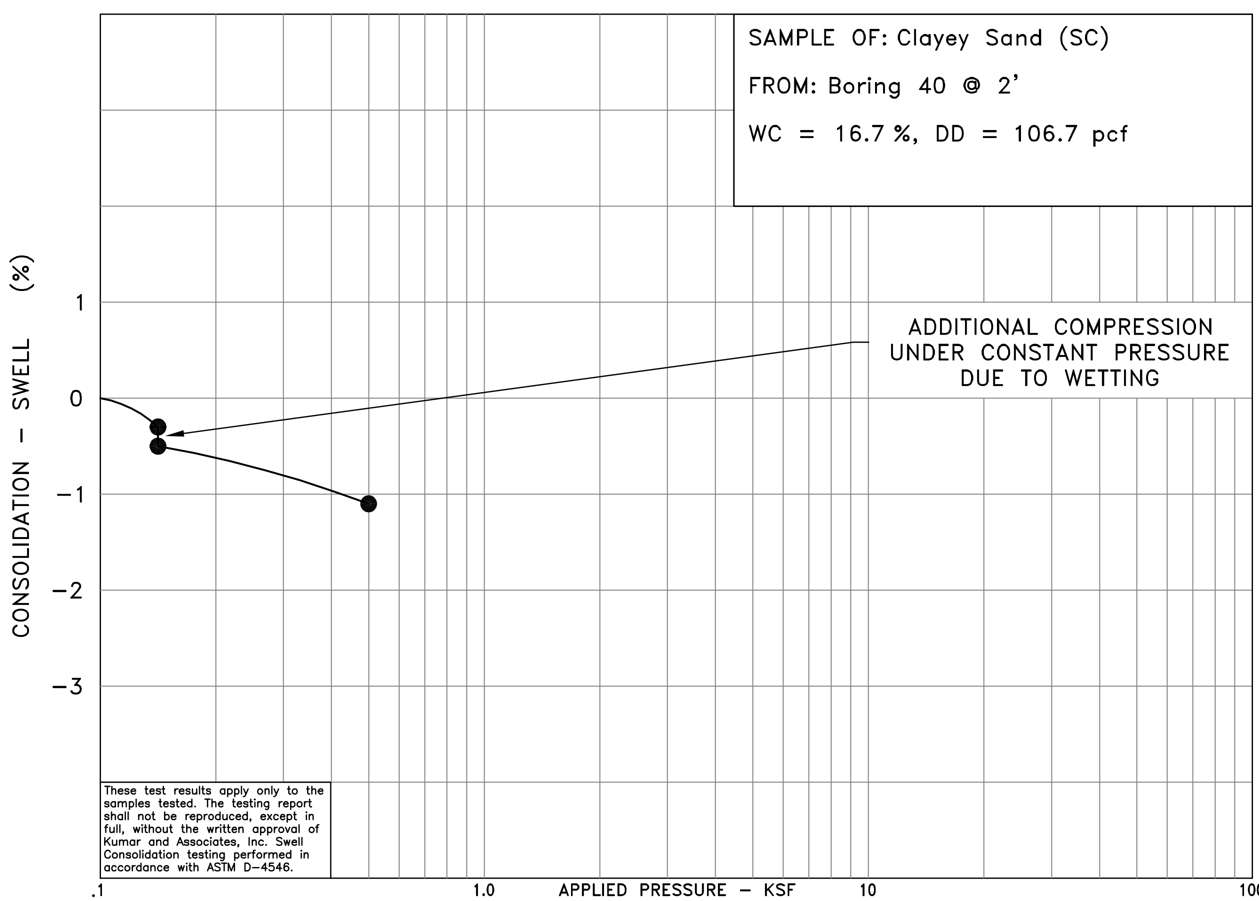
17−2−223	Kumar & Associates	SWELL−CONSOLIDATION TEST RESULTS	Fig. 9





17−2−223	Kumar & Associates	SWELL−CONSOLIDATION TEST RESULTS	Fig. 10





17-2-223	Kumar & Associates	SWELL-CONSOLIDATION TEST RESULTS	Fig. 10

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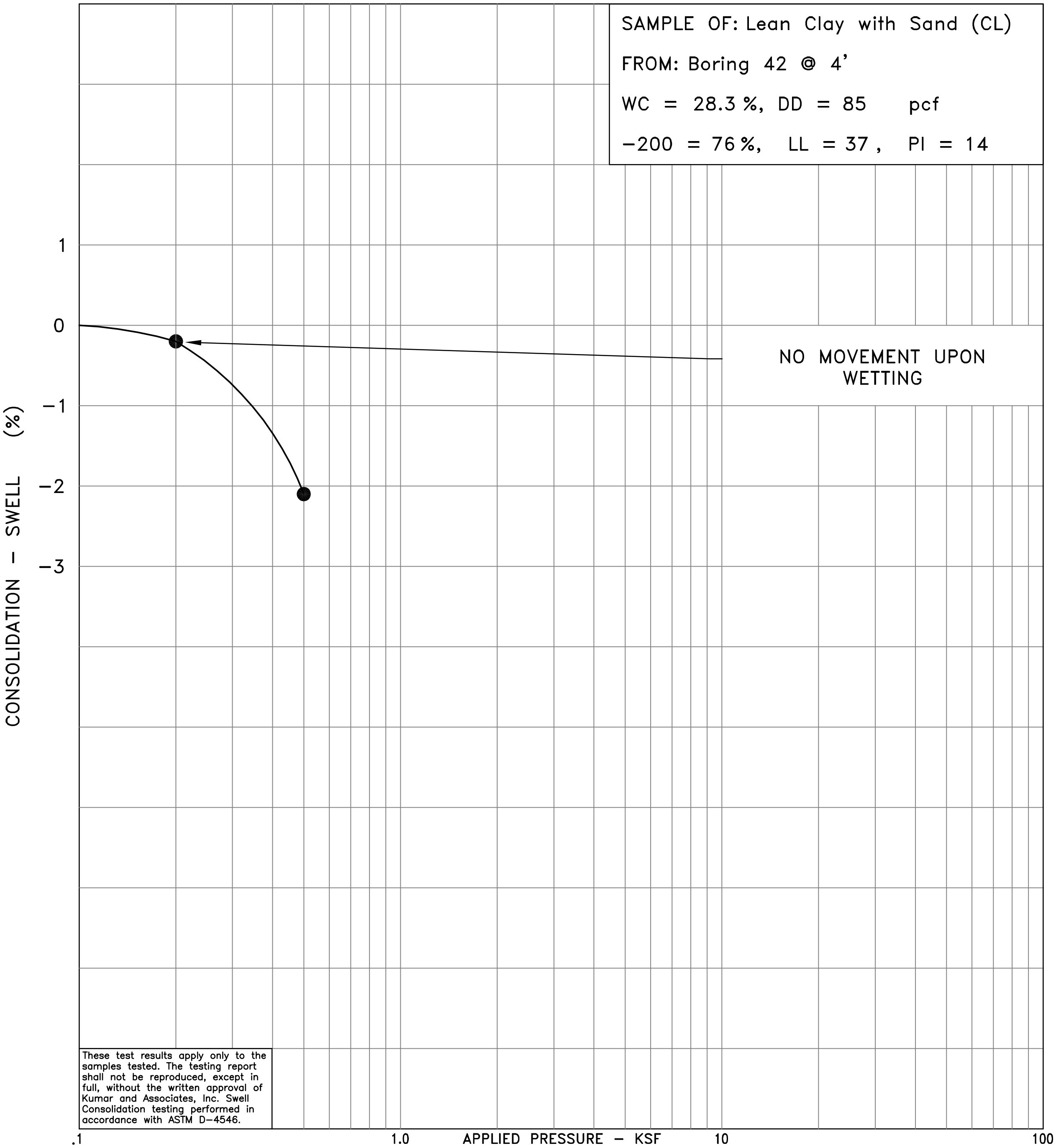
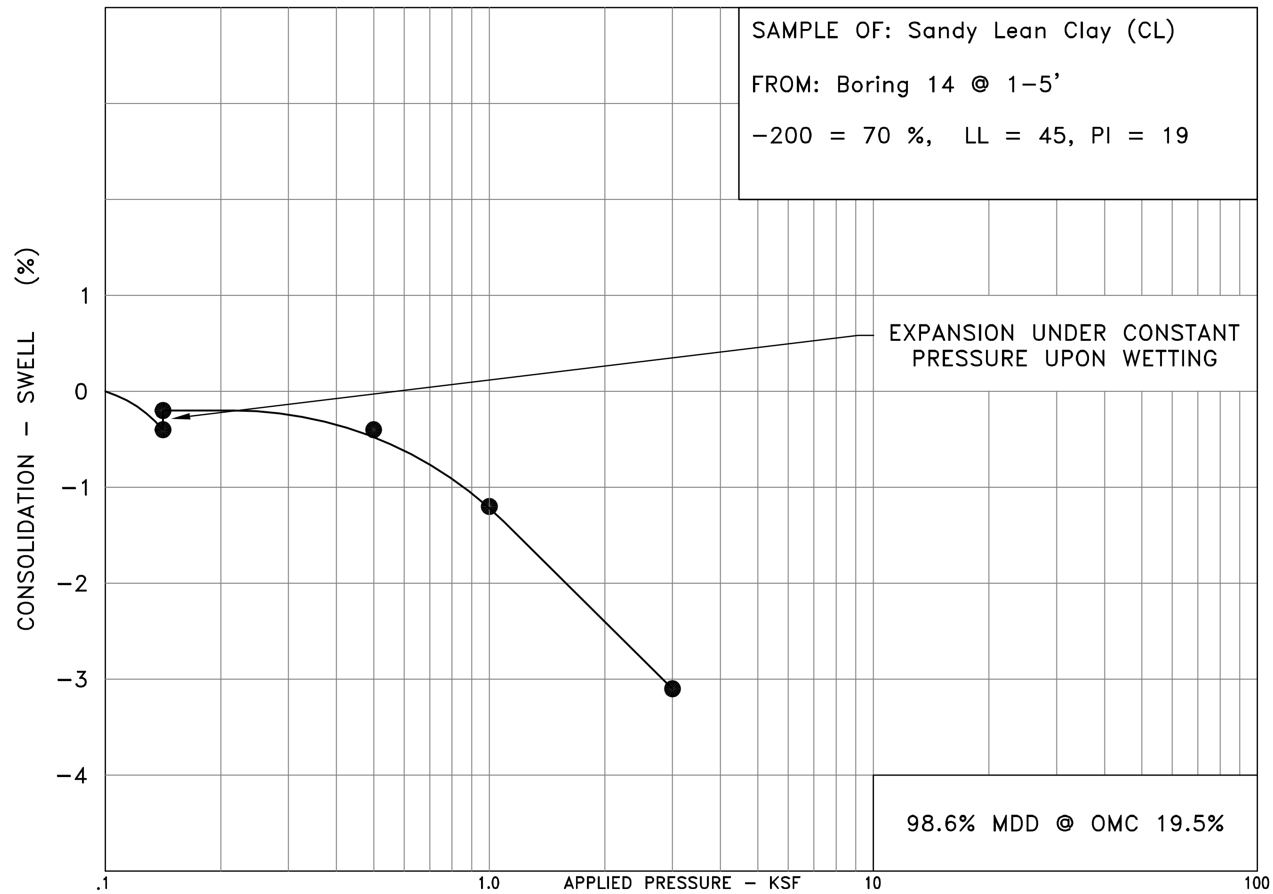
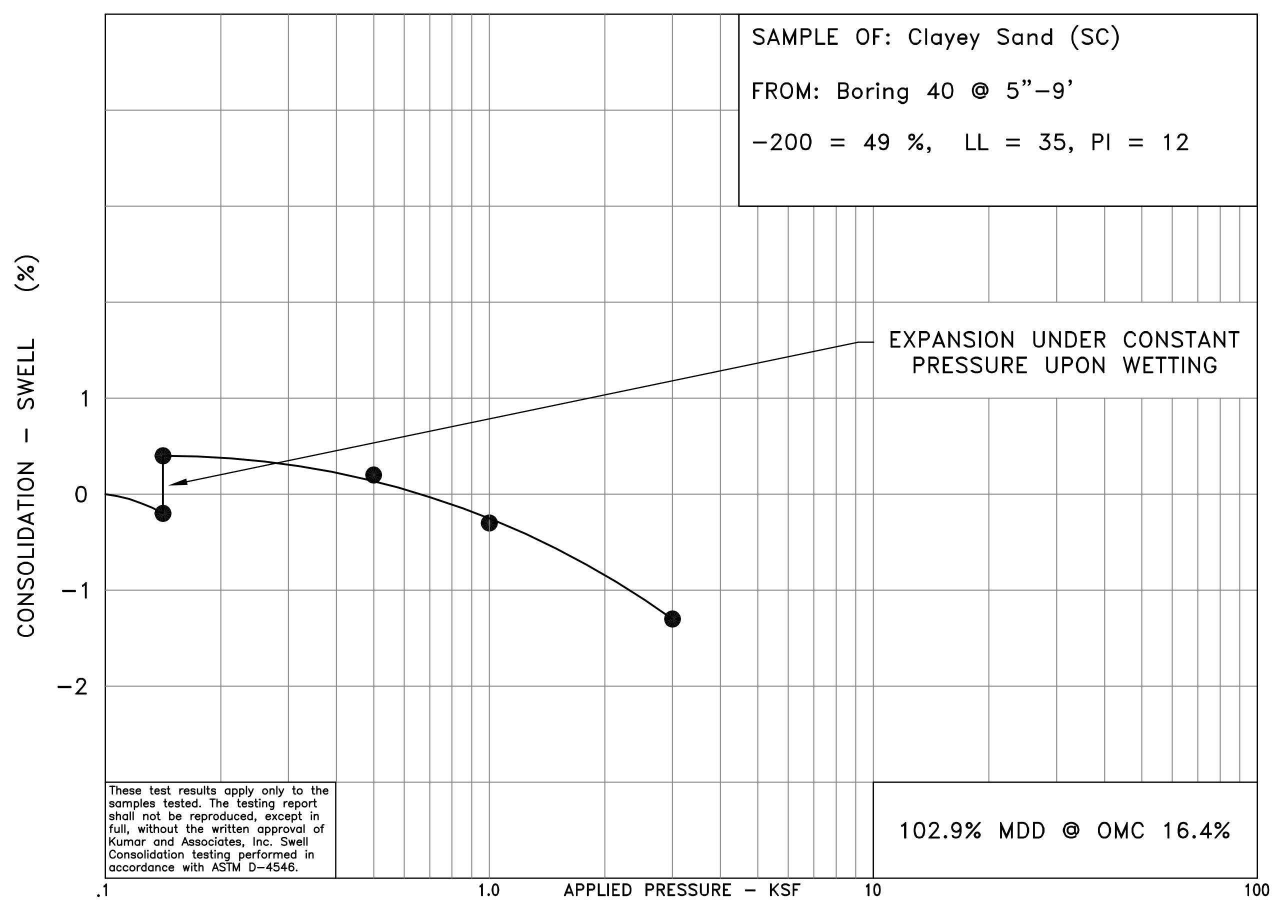
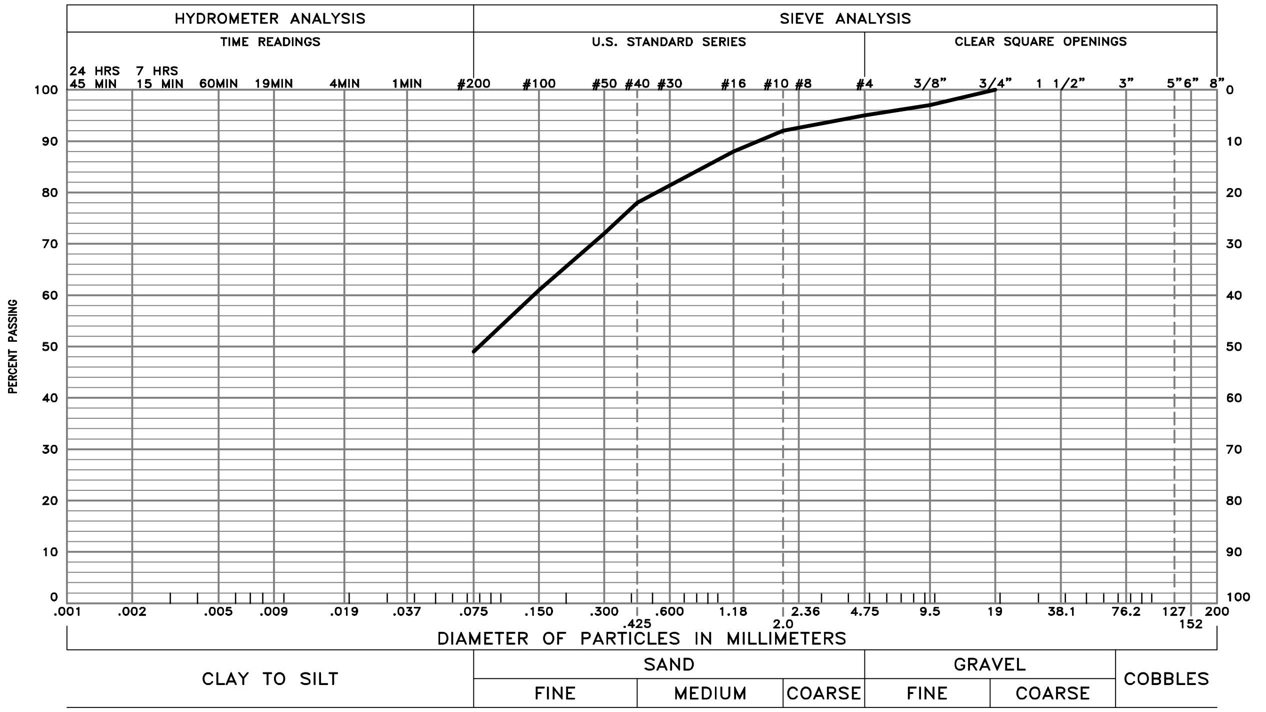


17−2−223	Kumar & Associates	SWELL−CONSOLIDATION TEST RESULTS	Fig. 12





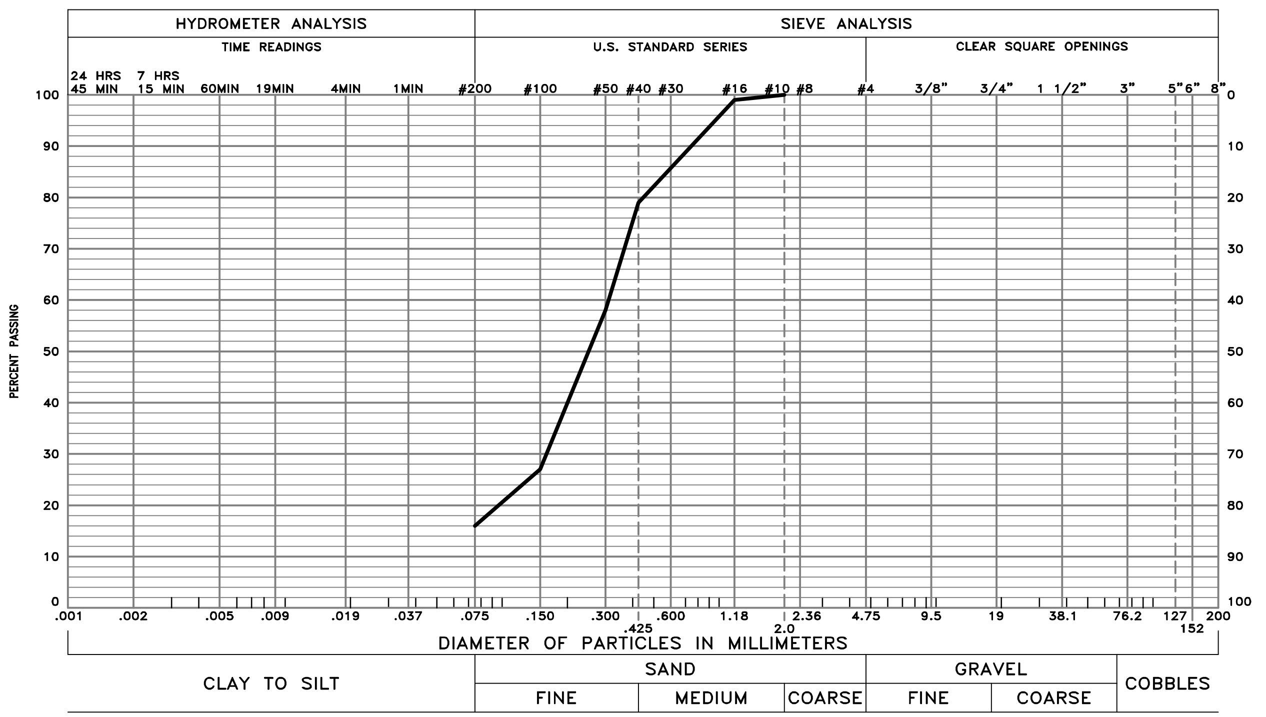
17–2–223	Kumar & Associates	SWELL–CONSOLIDATION TEST RESULTS	Fig. 13



GRAVEL 5 % SAND 46 % SILT AND CLAY 49 %

LIQUID LIMIT 33 PLASTICITY INDEX 15

SAMPLE OF: Clayey Sand (SC) FROM: Boring 2 @ 1-8'



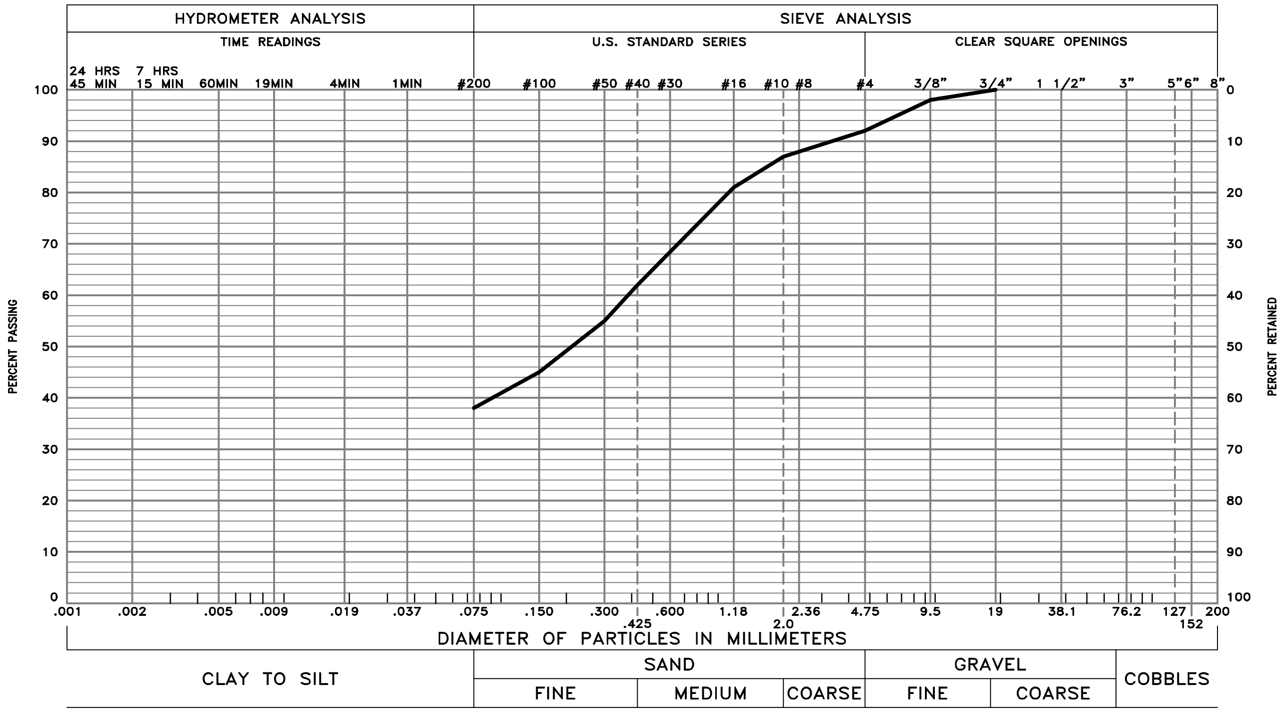
GRAVEL 0 % SAND 84 % SILT AND CLAY 16 %

LIQUID LIMIT PLASTICITY INDEX NP

SAMPLE OF: Silty Sand (SM) FROM: Boring 6 @ 4'

These test results apply only to the samples which were tested. The testing report shall not be reproduced, except in full, without the written approval of Kumar & Associates, Inc. Sieve analysis testing is performed in accordance with ASTM D422, ASTM C136 and/or ASTM D1140.

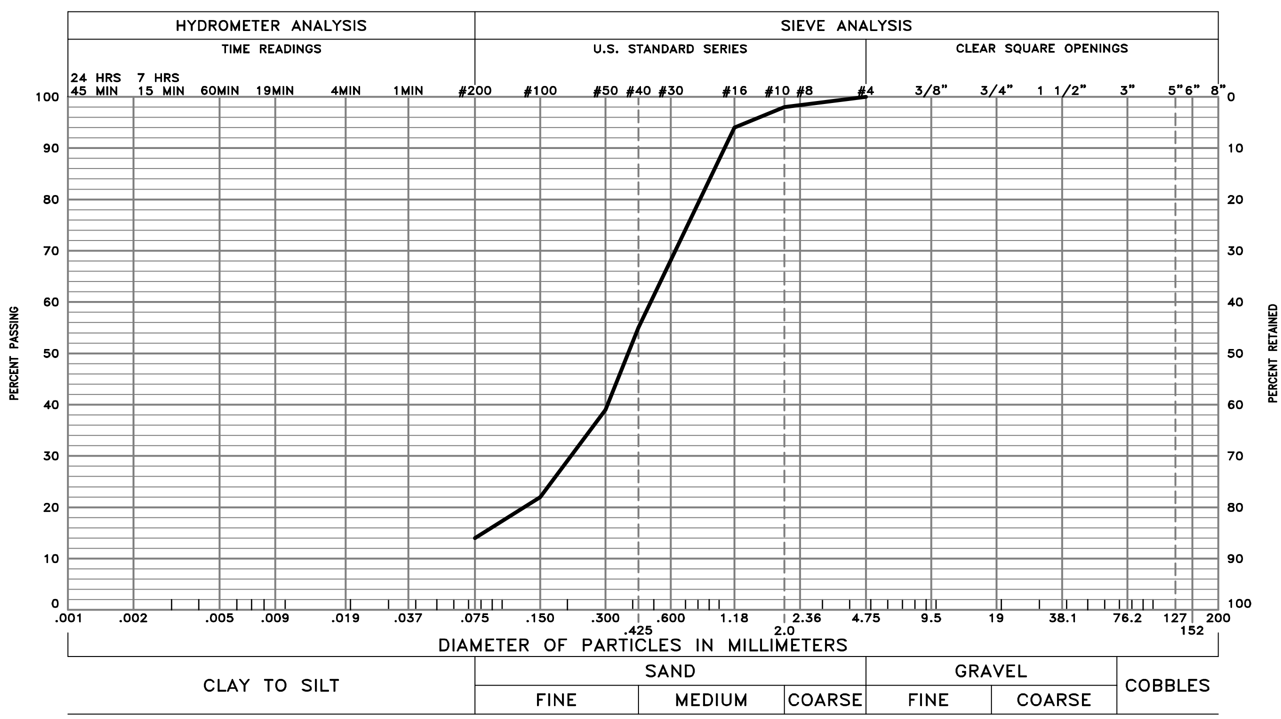
17-2-223	Kumar & Associates	GRADATION TEST RESULTS	Fig. 14



GRAVEL 8 % SAND 54 % SILT AND CLAY 38 %

LIQUID LIMIT 37 PLASTICITY INDEX 17

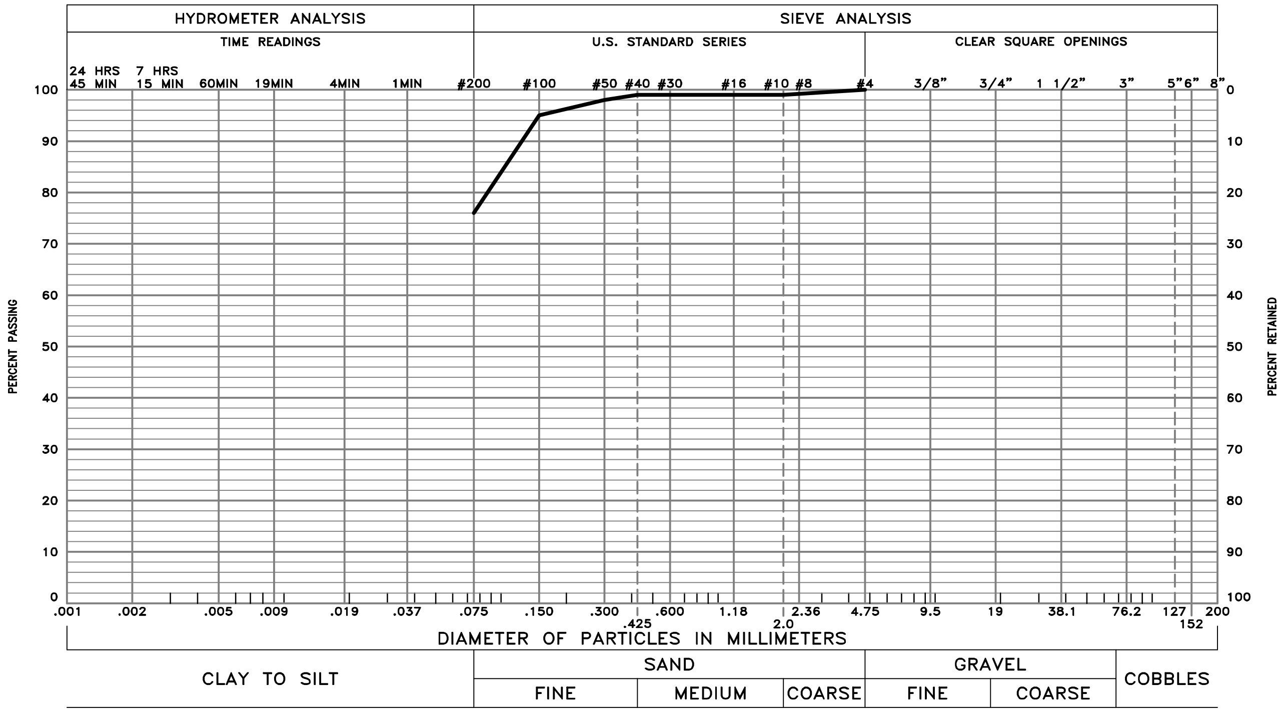
SAMPLE OF: Clayey Sand (SC) FROM: Boring 23 @ 2'



GRAVEL 0 % SAND 86 % SILT AND CLAY 14 %

LIQUID LIMIT PLASTICITY INDEX NP

SAMPLE OF: Silty Sand (SM) FROM: Boring 37 @ 2'



GRAVEL 0 % SAND 24 % SILT AND CLAY 76 %

LIQUID LIMIT 37 PLASTICITY INDEX 14

SAMPLE OF: Lean Clay with Sand (CL) FROM: Boring 42 @ 4'

These test results apply only to the samples which were tested. The testing report shall not be reproduced, except in full, without the written approval of Kumar & Associates, Inc. Sieve analysis testing is performed in accordance with ASTM D422, ASTM C136 and/or ASTM D1140.

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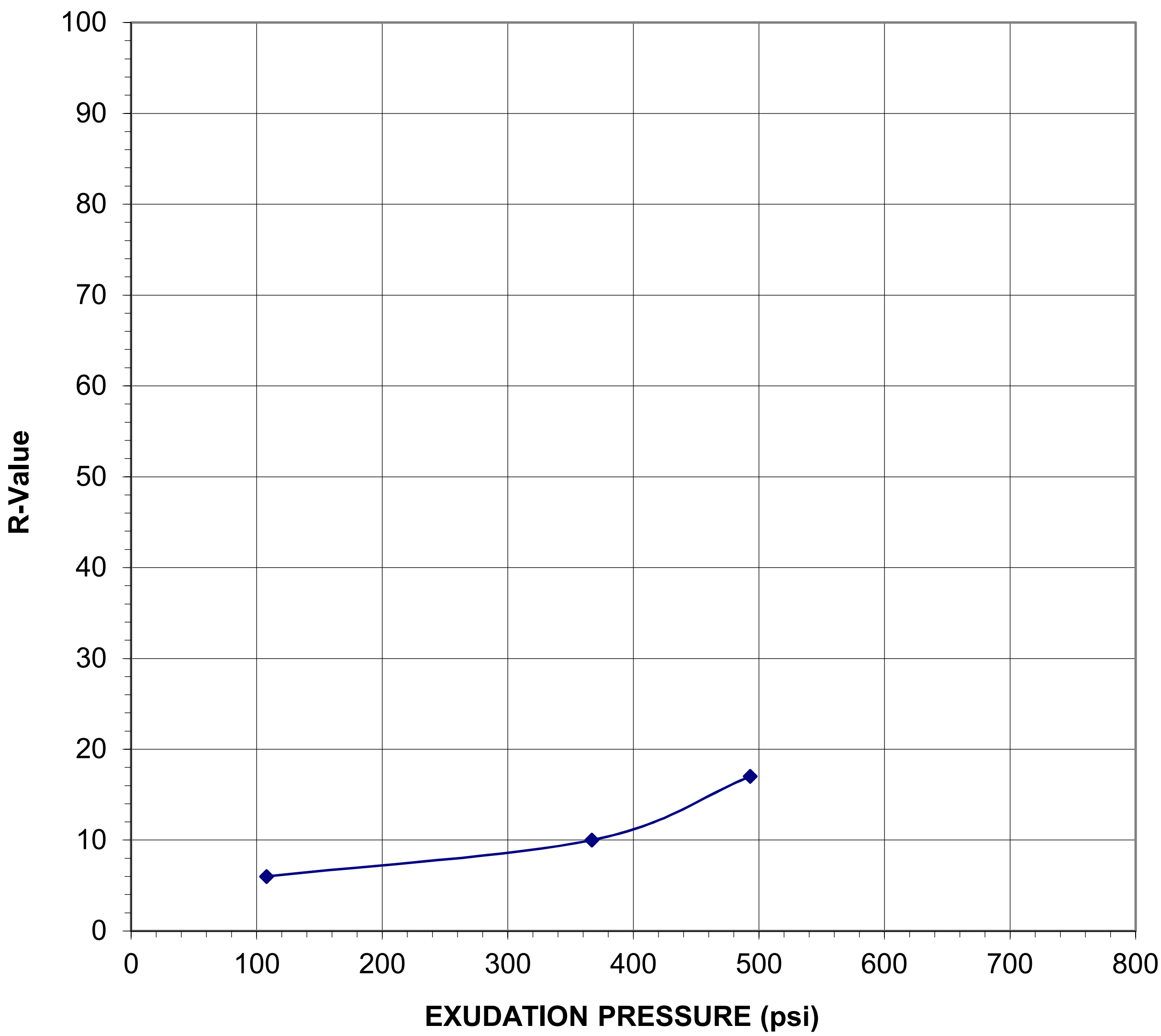
17-2-223	Kumar & Associates	GRADATION TEST RESULTS	Fig. 16

R-VALUE

TEST SPECIMEN	1	2	3	4	Rvalue @ 300 psi
MOISTURE CONTENT (%)	24.5	23.5	21.6		
DENSITY (pcf)	103.1	99.5	105.7		
EXPANSION PRESSURE (psi)	0.000	0.000	0.000		
EXUDATION PRESSURE (psi)	108	367	493		
R-VALUE	6	10	17		**9**



SOIL TYPE: **Clayey Sand**

LOCATION: **Boring 40 at 5"-9'**

DATE SAMPLED: DATE RECEIVED: **11/29/2017** DATE TESTED: **11/29/2017**

GRAVEL: SAND: SILT AND CLAY: **49**

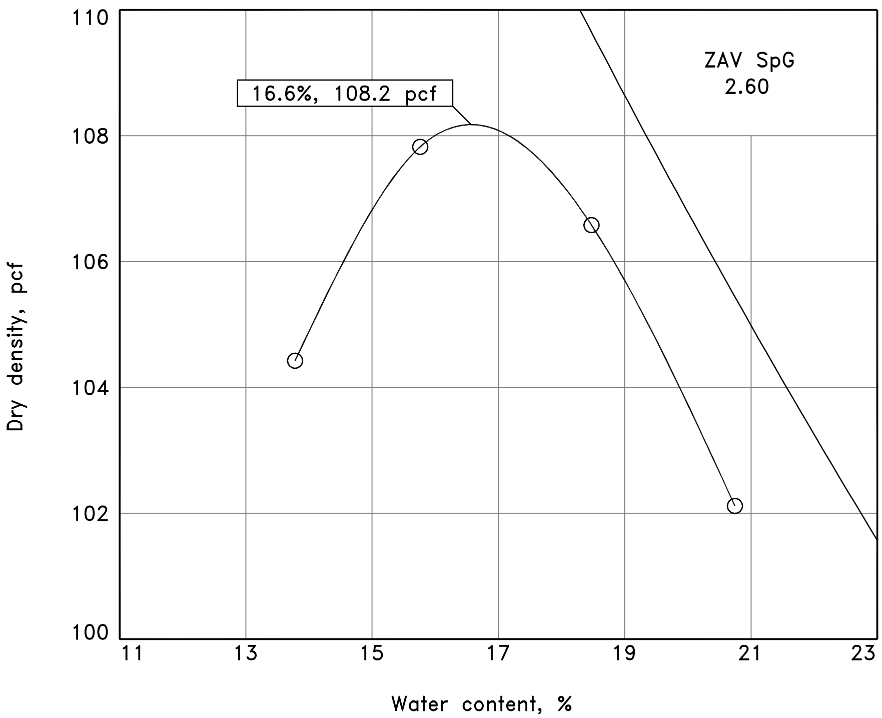
LIQUID LIMIT: **35** PLASTICITY INDEX: **12**

These test results apply to the samples which were tested. The testing report shall not be reproduced, except in full, without the written approval of Kumar & Associates, Inc. R-value performed in accordance with ASTM D2844. Atterberg limits performed in accordance with ASTM D4318. Sieve analyses performed in accordave with ASTM D422, D1140

17-2-223	KUMAR & ASSOCIATES	HVEEM STABILOMETER TEST RESULTS	Fig. 17

COMPACTION TEST REPORT

Curve No. 8136



Preparation Method	
Rammer: Wt.	5.50 lb.
Drop	12.00
Type	Manual
Layers: No.	3
Blows per	25
Mold Size	0.03333 cu. ft.
Test Performed on Material Passing	#4 Sieve
%>#4	
%<No.200	
Atterberg (D 4318): LL	
PI	
NM (D 2216)	
Sp.G. (D 854)	2.6
USCS (D 2487)	
AASHTO (M 145)	
Date: Sampled	11-29-17
Received	11-29-17
Tested	11-29-17
Tested By	AS

COMPACTION TESTING DATA
ASTM D 698-12 Method A Standard

	1	2	3	4	5	6
WM + WS	3972.0	4063.0	4085.0	4040.0		
WM	2172.0	2172.0	2172.0	2172.0		
WW + T #1	427.6	478.8	458.5	500.0		
WD + T #1	395.0	435.0	412.0	443.3		
TARE #1	158.4	157.1	160.3	170.0		
WW + T #2						
WD + T #2						
TARE #2						
MOIST.	13.8	15.8	18.5	20.7		
DRY DENS.	104.4	107.8	106.6	102.1		

SIEVE TEST RESULTS
ASTM D-422 ASTM D-1140

Opening Size	% Passing	Specs.

TEST RESULTS

Maximum dry density = 108.2 pcf

Optimum moisture = 16.6 %

Material Description

Remarks:

These test results apply only to the samples which were tested. the testing report shall not be reproduced, except in full, without the written approval of Kumar and Associates, Inc. Moisture/density relationships performed in accordance with ASTM D698, D1557. Atterberg limits performed in accordance with ASTM D4318 sieve analysis performed in accordance with ASTM D422, D1140.

Project No. 17-2-223 Client:

Project: Co Centre Subdivision

○ Location: Boring 40 Depth: 5”-9’ Sample Number: 8136

Checked by: DS

Title: Lab Manager

17-2-223	Kumar & Associates	MOISTURE-DENSITY RELATIONSHIPS	Fig. 18

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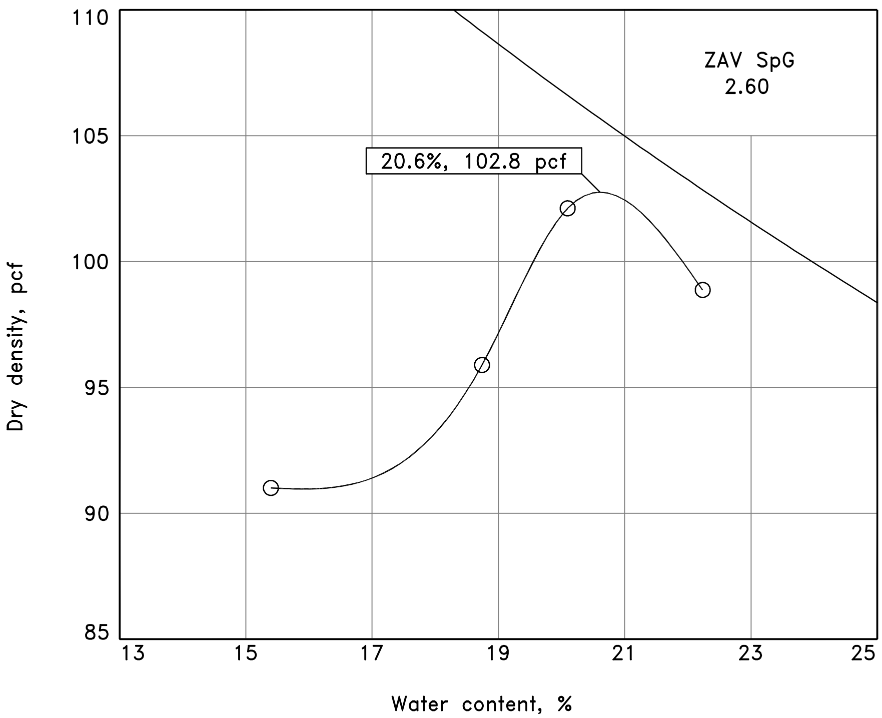
COMPACTION TEST REPORT

Curve No. 8137



Preparation Method	
Rammer: Wt.	5.50 lb.
Drop	12.00
Type	Manual
Layers: No.	3
Blows per	25
Mold Size	0.03333 cu. ft.
Test Performed on Material Passing	#4 Sieve
%>#4	
%<No.200	
Atterberg (D 4318): LL	
PI	
NM (D 2216)	
Sp.G. (D 854)	2.6
USCS (D 2487)	
AASHTO (M 145)	
Date: Sampled	11-29-17
Received	11-29-17
Tested	11-30-17
Tested By	AS

COMPACTION TESTING DATA
ASTM D 698-12 Method A Standard

	1	2	3	4	5	6
WM + WS	3763.0	3897.0	4030.0	4003.0		
WM	2172.0	2172.0	2172.0	2172.0		
WW + T #1	351.4	376.1	394.5	417.4		
WD + T #1	330.0	352.0	365.4	380.0		
TARE #1	191.0	223.4	220.6	211.8		
WW + T #2						
WD + T #2						
TARE #2						
MOIST.	15.4	18.7	20.1	22.2		
DRY DENS.	91.0	95.9	102.1	98.9		

SIEVE TEST RESULTS
ASTM D-422 ASTM D-1140

Opening Size	% Passing	Specs.

TEST RESULTS

Maximum dry density = 102.8 pcf

Optimum moisture = 20.6 %

Material Description

Project No. 17-2-223 Client:

Project: Co Centre Subdivision

○ Location: Boring 14 Depth: 1"-5' Sample Number: 8137

Remarks:

These test results apply only to the samples which were tested. the testing report shall not be reproduced, except in full, without the written approval of Kumar and Associates, Inc. Moisture/density relationships performed in accordance with ASTM D698, D1557. Atterberg limits performed in accordance with ASTM D4318 sieve analysis performed in accordance with ASTM D422, D1140.

Checked by: DS

Title: Lab Manager

17-2-223	Kumar & Associates	MOISTURE-DENSITY RELATIONSHIPS	Fig. 19

Kumar & Associates, Inc.

TABLE I

SUMMARY OF LABORATORY TEST RESULTS

Project No.: 17-2-223
Project Name: Colorado Centre Subdivision
Date Sampled: 11/16-17, 11/27/2017
Date Received: 11/27/2017

SAMPLE LOCATION		DATE TESTED	NATURAL MOISTURE CONTENT (%)	NATURAL DRY DENSITY (pcf)	GRADATION		PERCENT PASSING NO. 200 SIEVE	ATTERBERG LIMITS		R-Value	STANDARD PROCTOR		WATER SOLUBLE SULFATES (%)	AASHTO CLASSIFICATION (group index)	SOIL OR BEDROCK TYPE (Unified Soil Classification)
BORING	DEPTH				GRAVEL (%)	SAND (%)		LIQUID LIMIT	PLASTICITY INDEX		OPTIMUM MOISTURE CONTENT (%)	MAX DRY DENSITY (pcf)			
1	4'	11/29/17	11.4	112.2			36	38	18				0.08	A-6 (2)	Clayey Sand (SC)
2	2'	11/29/17	20.7	86.7											Clayey Sand (SC)
2	1'-8'	11/29/17			5	46	49	33	15					A-6 (4)	Clayey Sand (SC)
3	4'	11/29/17	30.7	81.5			67	43	18					A-7-6 (11)	Sandy Lean Clay (CL)
4	2'	11/29/17	27.1	90.7			73	70	42					A-7-6 (32)	Fat Clay with Sand (CH)
5	4'	11/29/17	20.1	93.9			54	34	14					A-6 (5)	Sandy Lean Clay (CL)
6	4'	11/29/17	7.4	103.1	0	84	16		NP				0.01	A-2-4 (0)	Silty Sand (SM)
7	2'	11/29/17	20.0	103.8			51	32	12					A-6 (3)	Sandy Lean Clay (CL)
8	4'	11/29/17	18.7	101.9			46	34	13					A-6 (3)	Clayey Sand (SC)
9	9'	11/29/17	25.9	88.4			51	32	10					A-4 (3)	Sandy Lean Clay (CL)
10	2'	11/29/17	18.5	106.9			50	32	13					A-6 (3)	Sandy Lean Clay (CL)
11	4'	11/29/17	24.3	87.7			61	42	22					A-7-6 (11)	Sandy Lean Clay (CL)
12	4'	11/29/17	27.7	86.2			75	49	26					A-7-6 (19)	Lean Clay with Sand (CL)
13	2'	11/29/17	20.6	104.7			71	45	24					A-7-6 (16)	Lean Clay with Sand (CL)

Kumar & Associates, Inc.

TABLE I

SUMMARY OF LABORATORY TEST RESULTS

Project No.: 17-2-223
Project Name: Colorado Centre Subdivision
Date Sampled: 11/16-17, 11/27/2017
Date Received: 11/27/2017

SAMPLE LOCATION		DATE TESTED	NATURAL MOISTURE CONTENT (%)	NATURAL DRY DENSITY (pcf)	GRADATION		PERCENT PASSING NO. 200 SIEVE	ATTERBERG LIMITS		R-Value	STANDARD PROCTOR		WATER SOLUBLE SULFATES (%)	AASHTO CLASSIFICATION (group index)	SOIL OR BEDROCK TYPE (Unified Soil Classification)
BORING	DEPTH				GRAVEL (%)	SAND (%)		LIQUID LIMIT	PLASTICITY INDEX		OPTIMUM MOISTURE CONTENT (%)	MAX DRY DENSITY (pcf)			
14	4'	11/29/17	25.4	90.7									1.23		Sandy Lean Clay (CL)
14	1'-5'	11/29/17					70	45	19	<5	20.6	102.8		A-7-6 (13)	Sandy Lean Clay (CL)
15	2'	11/29/17	26.4	94.9			62	39	18					A-6 (9)	Sandy Lean Clay (CL)
16	4'	11/29/17	25.2	93.2			58	42	20					A-7-6 (9)	Sandy Lean Clay (CL)
17	2'	11/29/17	25.0	89.9											Sandy Fat Clay (CH)
17	6"-9'	11/29/17					56	53	25					A-7-6 (12)	Sandy Fat Clay (CH)
18	4'	11/29/17	25.3	91.5			62	44	21				0.11	A-7-6 (11)	Sandy Lean Clay (CL)
19	2'	11/29/17	25.0	90.4			59	44	23					A-7-6 (11)	Sandy Lean Clay (CL)
20	2'	11/29/17	35.4	79.5			96	39	21					A-6 (21)	Lean Clay (CL)
21	4'	11/29/17	29.6	90.6											Sandy Fat Clay (CH)
21	1'-9'	11/29/17					66	51	29					A-7-6 (18)	Sandy Fat Clay (CH)
22	4'	11/29/17	22.3	86.1			52	46	24					A-7-6 (9)	Sandy Lean Clay (CL)
23	2'	11/29/17	16.1	102.2	8	54	38	37	17					A-6 (2)	Fill: Clayey Sand (SC)
24	2'	11/29/17	28.7	91.4			85	49	28				0.75	A-7-6 (25)	Lean Clay with Sand (CL)
25	4'	11/29/17	31.9	80.6			81	58	35					A-7-6 (30)	Fat Clay with Sand (CL)

Kumar & Associates, Inc.

TABLE I

SUMMARY OF LABORATORY TEST RESULTS

Project No.: 17-2-223
Project Name: Colorado Centre Subdivision
Date Sampled: 11/16-17, 11/27/2017
Date Received: 11/27/2017

SAMPLE LOCATION		DATE TESTED	NATURAL MOISTURE CONTENT (%)	NATURAL DRY DENSITY (pcf)	GRADATION		PERCENT PASSING NO. 200 SIEVE	ATTERBERG LIMITS		R-Value	STANDARD PROCTOR		WATER SOLUBLE SULFATES (%)	AASHTO CLASSIFICATION (group index)	SOIL OR BEDROCK TYPE (Unified Soil Classification)
BORING	DEPTH				GRAVEL (%)	SAND (%)		LIQUID LIMIT	PLASTICITY INDEX		OPTIMUM MOISTURE CONTENT (%)	MAX DRY DENSITY (pcf)			
26	2'	11/29/17	27.3	93.2			73	43	26					A-7-6 (17)	Lean Clay with Sand (CL)
27	2'	11/29/17	23.5	99.2			45	37	18					A-6 (4)	Clayey Sand (SC)
28	4'	11/29/17	19.7	100.2			39	27	10					A-4 (1)	Clayey Sand (SC)
29	2'	11/29/17	23.9	98.8			56	24	7					A-4 (1)	Sandy Silty Clay (CL-ML)
30	4'	11/29/17	16.1	92.1			32		NP					A-2-4 (0)	Silty Sand (SM)
31	9'	11/29/17	14.3	100.2			21		NP				0.02	A-1-6 (0)	Silty Sand (SM)
32	4'	11/29/17	7.8	103.9			23	25	6					A-1-b (0)	Silty Clayey Sand (SC-SM)
33	2'	11/29/17	17.6	107.6			36	30	11					A-6 (0)	Clayey Sand (SC)
34	2'	11/29/17	25.9	91.7			57	36	13					A-6 (5)	Sandy Lean Clay (CL)
35	4'	11/29/17	15.0	87.6			52	33	7					A-4 (2)	Sandy Silt (ML)
36	2'	11/29/17	10.6	107.4			23		NP					A-1-b (0)	Silty Sand (SM)
37	2'	11/29/17	8.0	106.0	0	86	14		NP					A-2-4 (0)	Silty Sand (SM)
38	2'	11/29/17	19.3	102.7			45	34	12				0.01	A-6 (2)	Clayey Sand (SC)
39	4'	11/29/17	17.9	107.5			36	33	12					A-6 (1)	Clayey Sand (SC)

Kumar & Associates, Inc.

TABLE I

SUMMARY OF LABORATORY TEST RESULTS

Project No.: 17-2-223
Project Name: Colorado Centre Subdivision
Date Sampled: 11/16-17, 11/27/2017
Date Received: 11/27/2017

SAMPLE LOCATION		DATE TESTED	NATURAL MOISTURE CONTENT (%)	NATURAL DRY DENSITY (pcf)	GRADATION		PERCENT PASSING NO. 200 SIEVE	ATTERBERG LIMITS		R-Value	STANDARD PROCTOR		WATER SOLUBLE SULFATES (%)	AASHTO CLASSIFICATION (group index)	SOIL OR BEDROCK TYPE (Unified Soil Classification)
BORING	DEPTH				GRAVEL (%)	SAND (%)		LIQUID LIMIT	PLASTICITY INDEX		OPTIMUM MOISTURE CONTENT (%)	MAX DRY DENSITY (pcf)			
40	2'	11/29/17	16.7	106.7											Clayey Sand (SC)
40	5"-9'	11/29/17					49	35	12	9	16.6	108.2		A-6 (3)	Clayey Sand (SC)
41	2'	11/29/17	19.4	103.2			43	33	9					A-4 (1)	Clayey Sand (SC)
42	4'	11/29/17	28.3	85.0	0	24	76	37	14					A-6 (10)	Lean Clay with Sand (CL)

APPENDIX A

(Pavement Design Calculations)

1993 AASHTO Pavement Design

DARWin Pavement Design and Analysis System

A Proprietary AASHTOWare Computer Software Product

Kumar & Associates
6735 Kumar Heights
Colorado Springs, CO 80918
USA

Flexible Structural Design Module

17-2-223
Colorado Centre Subdivision
Horizonview Drive
HMA/ABC, with on-site soils (R=5)

Flexible Structural Design

18-kip ESALs Over Initial Performance Period	821,000
Initial Serviceability	4.5
Terminal Serviceability	2.5
Reliability Level	85 %
Overall Standard Deviation	0.45
Roadbed Soil Resilient Modulus	3,025 psi
Stage Construction	1
Calculated Design Structural Number	4.32 in

Specified Layer Design

Layer	Material Description	Struct Coef. (Ai)	Drain Coef. (Mi)	Thickness (Di)(in)	Width (ft)	Calculated SN (in)
1	HMA	0.44	1	6.75	-	2.97
2	ABC	0.11	1	13	-	1.43
Total	-	-	-	19.75	-	4.40

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Flexible Structural Design Module

17-2-223
Colorado Centre Subdivision
Other Roadways
HMA/ABC, with on-site soils (R=5)

Flexible Structural Design

18-kip ESALs Over Initial Performance Period	292,000
Initial Serviceability	4.5
Terminal Serviceability	2
Reliability Level	80 %
Overall Standard Deviation	0.45
Roadbed Soil Resilient Modulus	3,025 psi
Stage Construction	1
Calculated Design Structural Number	3.46 in

Specified Layer Design

Layer	Material Description	Struct Coef. (Ai)	Drain Coef. (Mi)	Thickness (Di)(in)	Width (ft)	Calculated SN (in)
1	HMA	0.44	1	5.25	-	2.31
2	ABC	0.11	1	10.5	-	1.16
Total	-	-	-	15.75	-	3.47

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Horizonview Drive
HMA/FDR, with on-site soils (R=5)

Flexible Structural Design

18-kip ESALs Over Initial Performance Period	821,000
Initial Serviceability	4.5
Terminal Serviceability	2.5
Reliability Level	85 %
Overall Standard Deviation	0.45
Roadbed Soil Resilient Modulus	3,025 psi
Stage Construction	1
Calculated Design Structural Number	4.32 in

Specified Layer Design

Layer	Material Description	Struct Coef. (Ai)	Drain Coef. (Mi)	Thickness (Di)(in)	Width (ft)	Calculated SN (in)
1	HMA	0.44	1	7.5	-	3.30
2	FDR	0.09	1	12	-	1.08
Total	-	-	-	19.50	-	4.38

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Other Roads
HMA/FDR, with on-site soils (R=5)

Flexible Structural Design

18-kip ESALs Over Initial Performance Period	292,000
Initial Serviceability	4.5
Terminal Serviceability	2
Reliability Level	80 %
Overall Standard Deviation	0.45
Roadbed Soil Resilient Modulus	3,025 psi
Stage Construction	1
Calculated Design Structural Number	3.46 in

Specified Layer Design

Layer	Material Description	Struct Coef. (Ai)	Drain Coef. (Mi)	Thickness (Di)(in)	Width (ft)	Calculated SN (in)
1	HMA	0.44	1	5.5	-	2.42
2	FDR	0.09	1	12	-	1.08
Total	-	-	-	17.50	-	3.50

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Flexible Structural Design Module

17-2-223
Colorado Centre Subdivision
Horizonview Drive
HMA/ABC, with import soils (R=40)

Flexible Structural Design

18-kip ESALs Over Initial Performance Period	821,000
Initial Serviceability	4.5
Terminal Serviceability	2.5
Reliability Level	85 %
Overall Standard Deviation	0.45
Roadbed Soil Resilient Modulus	9,497 psi
Stage Construction	1
Calculated Design Structural Number	2.89 in

Specified Layer Design

Layer	Material Description	Struct Coef. (Ai)	Drain Coef. (Mi)	Thickness (Di)(in)	Width (ft)	Calculated SN (in)
1	HMA	0.44	1	4.5	-	1.98
2	ABC	0.11	1	8.5	-	0.94
Total	-	-	-	13.00	-	2.92

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Colorado Centre Subdivision
Other Roadways
HMA/ABC, with import soils (R=40)

Flexible Structural Design

18-kip ESALs Over Initial Performance Period	292,000
Initial Serviceability	4.5
Terminal Serviceability	2
Reliability Level	80 %
Overall Standard Deviation	0.45
Roadbed Soil Resilient Modulus	9,497 psi
Stage Construction	1
Calculated Design Structural Number	2.34 in

Specified Layer Design

Layer	Material Description	Struct Coef. (Ai)	Drain Coef. (Mi)	Thickness (Di)(in)	Width (ft)	Calculated SN (in)
1	HMA	0.44	1	3.25	-	1.43
2	ABC	0.11	1	8.5	-	0.94
Total	-	-	-	11.75	-	2.37

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Rigid Structural Design Module

17-2-223
Colorado Centre Subdivision
Horizonview Drive
PCCP, with on-site soils (R=5)

Rigid Structural Design

Pavement Type	JPCP
18-kip ESALs Over Initial Performance Period	1,231,500
Initial Serviceability	4.5
Terminal Serviceability	2.5
28-day Mean PCC Modulus of Rupture	650 psi
28-day Mean Elastic Modulus of Slab	3,400,000 psi
Mean Effective k-value	40 psi/in
Reliability Level	85 %
Overall Standard Deviation	0.45
Load Transfer Coefficient, J	4.2
Overall Drainage Coefficient, Cd	1
Calculated Design Thickness	8.83 in

use 9"

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Rigid Structural Design Module

17-2-223
Colorado Centre Subdivision
Other Roadways
PCCP, with on-site soils (R=5)

Rigid Structural Design

Pavement Type	JPCP
18-kip ESALs Over Initial Performance Period	438,000
Initial Serviceability	4.5
Terminal Serviceability	2
28-day Mean PCC Modulus of Rupture	650 psi
28-day Mean Elastic Modulus of Slab	3,400,000 psi
Mean Effective k-value	40 psi/in
Reliability Level	80 %
Overall Standard Deviation	0.45
Load Transfer Coefficient, J	4.2
Overall Drainage Coefficient, Cd	1
Calculated Design Thickness	7.11 in

use 7.25"

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Rigid Structural Design Module

17-2-223
Colorado Centre Subdivision
Horizonview Drive
PCCP, with import soils (R=40)

Rigid Structural Design

Pavement Type	JPCP
18-kip ESALs Over Initial Performance Period	1,231,500
Initial Serviceability	4.5
Terminal Serviceability	2.5
28-day Mean PCC Modulus of Rupture	650 psi
28-day Mean Elastic Modulus of Slab	3,400,000 psi
Mean Effective k-value	100 psi/in
Reliability Level	85 %
Overall Standard Deviation	0.45
Load Transfer Coefficient, J	4.2
Overall Drainage Coefficient, Cd	1
Calculated Design Thickness	8.49 in

use 8.5"

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Rigid Structural Design Module

17-2-223
Colorado Centre Subdivision
Other Roadways
PCCP, with import soils (R=40)

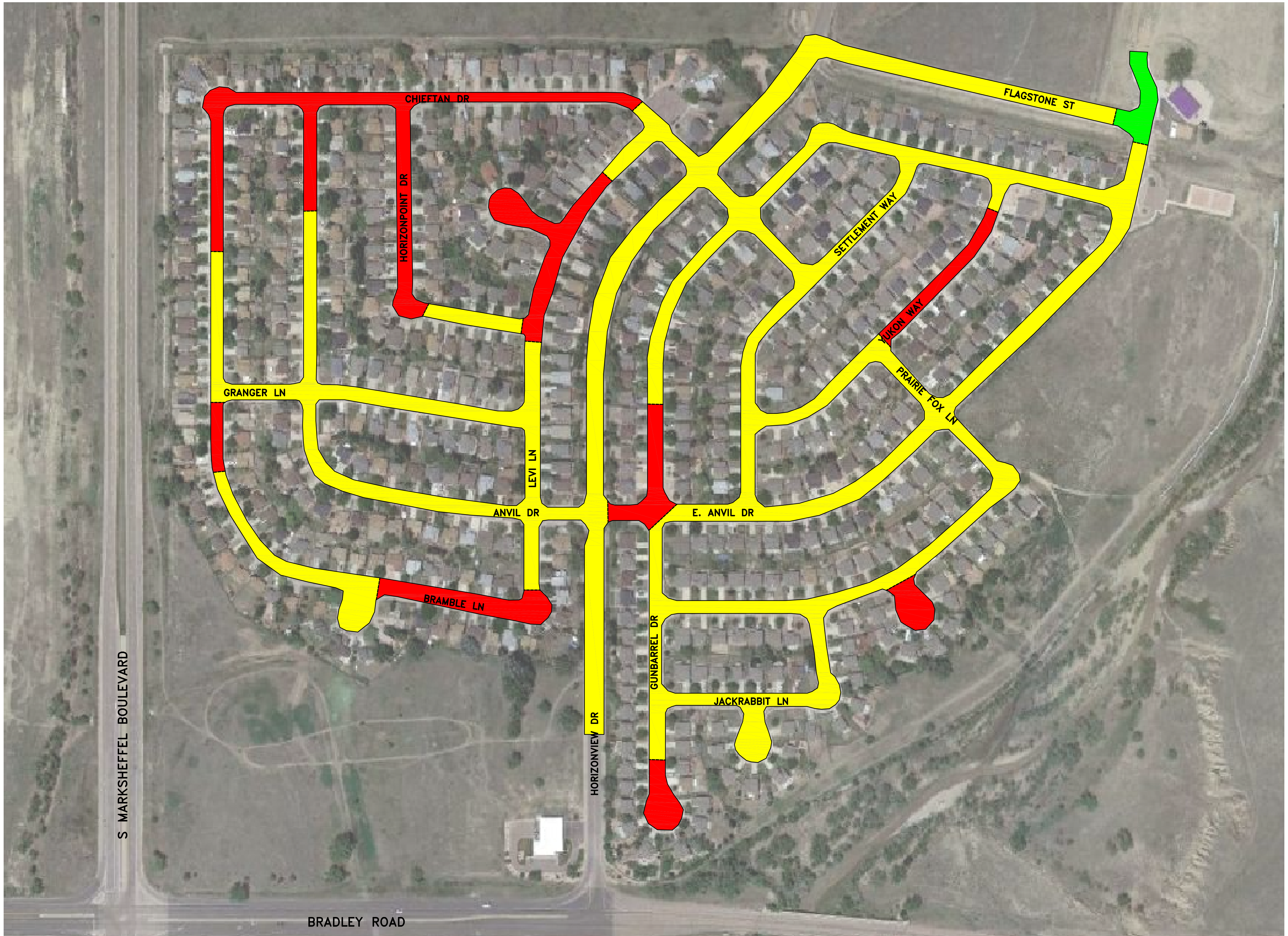
Rigid Structural Design

Pavement Type	JPCP
18-kip ESALs Over Initial Performance Period	438,000
Initial Serviceability	4.5
Terminal Serviceability	2
28-day Mean PCC Modulus of Rupture	650 psi
28-day Mean Elastic Modulus of Slab	3,400,000 psi
Mean Effective k-value	100 psi/in
Reliability Level	80 %
Overall Standard Deviation	0.45
Load Transfer Coefficient, J	4.2
Overall Drainage Coefficient, Cd	1
Calculated Design Thickness	6.73 in

use 6.75"

APPENDIX B

(Pavement Condition Survey)



LEGEND

- GOOD
- FAIR
- POOR

150 0 150 300

APPROXIMATE SCALE–FEET

17–2–223	Kumar & Associates		PAVED CONDITION SURVEY	Fig. B–1

December 14, 2017 – 12:00pm
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