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SUBSOIL STUDY
FOR FOUNDATION DESIGN
PROPOSED NORTH BY NORTHWEST
WAREHOUSE DEVELOPMENT
LOT C-13, KEMP SUBDIVISION
1215 CHAMBERS AVENUE
EAGLE, COLORADO

PROJECT NO. 21-7-927.01

FEBRUARY 19, 2025

PREPARED FOR:

ASPECT DEVELOPMENT
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PURPOSE AND SCOPE OF STUDY

This report presents the results of a subsoil study for the proposed North by Northwest Warehouse Development to be located on Lot C-13, Kemp Subdivision, 1215 Chambers Avenue, Eagle, Colorado. The project site is shown on Figures 1A and 1B. The purpose of the study was to develop recommendations for the foundation design. The study was conducted as supplemental and in general accordance with our agreement for geotechnical engineering services with Aspect Development dated December 15, 2021. Findings from exploratory borings made at the site for previously proposed development in the northern part of the site, report dated March 15, 2022, Project No. 21-7-927 are included in the current study.

A field exploration program consisting of exploratory borings was conducted to obtain information on the subsurface conditions. Samples of the subsoils obtained during the field exploration were tested in the laboratory to determine their classification, compressibility or swell and other engineering characteristics. The results of the field exploration and laboratory testing were analyzed to develop recommendations for foundation types, depths and allowable pressures for the proposed building foundation. This report summarizes the data obtained during this study and presents our conclusions, design recommendations and other geotechnical engineering considerations based on the proposed construction and the subsurface conditions encountered.

PROPOSED CONSTRUCTION

The buildings will be single story, steel frame and metal structures located on the lot as shown on Figure 1B. Ground floors will be slab-on-grade at a finish elevation at to slightly above the existing ground surface. Grading for the structures is expected to be relatively minor with cut depths between about 2 to 4 feet. We assume relatively light to moderate foundation loadings carried by footing pads with connecting grade beams, and typical of the proposed type of construction.

If building loadings, locations or grading plans change significantly from those described above, we should be notified to re-evaluate the recommendations contained in this report.

SITE CONDITIONS

The lot was vacant at the time of our field exploration and covered with a variable snow depth. Some fill was encountered in Boring 2 indicating the site has undergone some previous grading including a soil berm along the north side of the property. The terrain is relatively flat with a gentle slope down to the southeast toward Chambers Avenue as indicated by the contour lines shown on Figure 1A. Elevation difference across the footprint of the individual proposed buildings shown on Figure 1B is estimated at about 2 to 4 feet. Vegetation consists of grass and weeds.

SUBSIDENCE POTENTIAL

Bedrock of the Pennsylvanian age Eagle Valley Evaporite underlies the subject site. These rocks are a sequence of gypsiferous shale, fine-grained sandstone and siltstone with some massive beds of gypsum and limestone. There is a possibility that massive gypsum deposits associated with the Eagle Valley Evaporite underlie portions of the lot. Dissolution of the gypsum under certain conditions can cause sinkholes to develop and can produce areas of localized subsidence. During previous work in the area, several sinkholes were observed scattered in the Eagle area. These sinkholes appear similar to others associated with the Eagle Valley Evaporite in other areas of the Eagle River valley underlain by Eagle Valley Evaporite.

Sinkholes were not observed in the immediate area of the subject lot. No evidence of cavities was encountered in the subsurface materials; however, the exploratory borings were relatively shallow, for foundation design only. Based on our present knowledge of the subsurface conditions at the site, it cannot be said for certain that sinkholes will not develop. The risk of future ground subsidence on Lot C-13 throughout the service life of the proposed buildings in our opinion is low; however, the owner should be made aware of the potential for sinkhole development. If further investigation of possible cavities in the bedrock below the site is desired, we should be contacted.

FIELD EXPLORATION

The field exploration for the project was conducted on January 7, 2022 for the initial study and on November 22 and 25, 2024 for the supplemental study. A total of nine exploratory borings were drilled at the locations shown on Figures 1A and 1B to evaluate the subsurface conditions. The borings were advanced with 4-inch diameter continuous flight augers powered by a truck-mounted CME-45B drill rig. The borings were logged by a representative of Kumar & Associates.

Samples of the subsoils were taken with 1⅜-inch and 2-inch I.D. spoon samplers. The samplers were driven into the subsoils at various depths 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. The penetration resistance values are an indication of the relative density or consistency of the subsoils. Depths at which the samples were taken and the penetration resistance values are shown on the Logs of Exploratory Borings, Figure 2. The samples were returned to our laboratory for review by the project engineer and testing.

SUBSURFACE CONDITIONS

Graphic logs of the subsurface conditions encountered at the site are shown on Figure 2. The subsoils encountered, below about ½ to 1 foot of topsoil or 2 feet of fill, consisted of loose to medium dense/medium stiff to stiff, intermixed sand and silt with scattered gravel to gravelly zones underlain at depths of about 29½ to 33 feet by dense, sandy gravel and cobble soils down to the maximum explored depths of 32 to 35 feet.

Laboratory testing performed on samples obtained from the borings included natural moisture content and density, percent finer than sand size gradation analyses, and liquid and plastic limits. Results of swell-consolidation testing performed on relatively undisturbed drive samples of the sand and silt soils, presented on Figures 4 through 15, indicate generally low compressibility under conditions of light loading and natural low moisture conditions and low to moderate hydro-compression potential when wetted and additionally loaded. The laboratory testing is summarized in Table 1.

No groundwater was encountered in the borings at the time of drilling and the subsoils were slightly moist to typically moist with depth.

FOUNDATION BEARING CONDITIONS

The fine-grained sand and silt soils possess low bearing capacity and tend to settle under load, especially when wetted. The relatively dense, coarse granular soils encountered at depths of about 29½ to 33 feet in Borings 4 and 6 within the central part of the property possess moderate bearing capacity and relatively low settlement potential.

At assumed excavation depths, the subgrade will consist of the fine-grained compressible soils. Spread footings placed on these soils can be used for foundation support of the buildings with a risk of settlement. The risk of settlement is primarily if the bearing soils were to become wetted, and precautions should be taken to keep the bearing soils dry. A lower foundation settlement risk could be achieved by placing the footings on a depth (typically 3 feet) of compacted structural fill. The structural fill can consist of the removed and replaced on-site soils. Bearing the foundation entirely on the underlying coarse granular soils encountered at around 30 feet or greater depth, such as with piles or piers, would provide a relatively low settlement risk.

Provided below are recommendations for spread footings bearing on the natural soils and on compacted structural fill. If recommendations for a deep foundation system such as piles or piers are desired, we should be contacted.

DESIGN RECOMMENDATIONS

FOUNDATIONS

Considering the subsurface conditions encountered in the exploratory borings and the nature of the proposed construction, we believe the buildings can be founded with spread footings bearing on the natural soils or on compacted structural fill with a risk of settlement. Precautions should be taken to prevent wetting of bearing soils.

The design and construction criteria presented below should be observed for a spread footing foundation system.

1) Footings placed on the undisturbed natural soils should be designed for an allowable bearing pressure of 1,500 psf. Based on experience, we expect initial settlement of footings designed and constructed as discussed in this section will be about 1 inch or less. There could be additional post-construction settlement mainly if the bearing soils were to become wetted. The magnitude of the additional settlement would depend on the depth and extent of the wetting but could be on the order of 1 to 2 inches.
2) Footings placed on at least 3 feet of removed and replaced onsite soils as structural fill can be designed for an allowable bearing pressure of 2,000 psf. Based on experience, we expect initial settlement of footings designed and constructed as discussed in this section will be about 1 inch or less. There could be additional post-construction settlement if the bearing soils were to become wetted. The magnitude of the additional settlement could be on the order of 1 inch depending on the depth and extent of the wetting.
3) The footings should have a minimum width of 18 inches for continuous walls and 2 feet for isolated pads.
4) Exterior footings and footings beneath unheated areas should be provided with adequate soil cover above their bearing elevation for frost protection. Placement of foundations at least 48 inches below exterior grade is typically used in this area.
5) Continuous foundation walls should be heavily reinforced top and bottom to span local anomalies and better withstand the effects of some differential settlement such as by assuming an unsupported length of at least 12 feet. Foundation walls acting as retaining structures should also be designed to resist lateral earth pressures as discussed in the "Foundation and Retaining Walls" section of this report.
6) All fill, topsoil and loose disturbed soils should be removed and the footing bearing level extended down to the firm natural soils. The exposed soils in footing areas should then be moistened and compacted to at least 95% standard Proctor density (SPD). Structural fill placed below footing areas should extend at least 1½ feet laterally beyond footing edges and be compacted to at least 98% of SPD at a moisture content within about 2% of optimum.
7) A representative of the geotechnical engineer should evaluate structural fill compaction on a regular basis during placement and observe footing excavations prior to concrete placement to evaluate bearing conditions.

FOUNDATION AND RETAINING WALLS

Foundation walls and retaining structures which are laterally supported and can be expected to undergo only a slight amount of deflection should be designed for a lateral earth pressure computed on the basis of an equivalent fluid unit weight of at least 55 pcf for backfill consisting of the on-site soils. Cantilevered retaining structures which are separate from the building and can be expected to deflect sufficiently to mobilize the full active earth pressure condition should be designed for a lateral earth pressure computed on the basis of an equivalent fluid unit weight of at least 45 pcf for backfill consisting of the on-site soils.

All foundation and retaining structures should be designed for appropriate hydrostatic and surcharge pressures such as adjacent footings, traffic, construction materials and equipment. The pressures recommended above assume drained conditions behind the walls and a horizontal backfill surface. The buildup of water behind a wall or an upward sloping backfill surface will increase the lateral pressure imposed on a foundation wall or retaining structure. An underdrain should be provided to prevent hydrostatic pressure buildup behind retaining walls.

Backfill should be placed in uniform lifts and compacted to at least 90% of the maximum standard Proctor density at a moisture content slightly above optimum. Backfill placed in pavement and walkway areas should be compacted to at least 95% of the maximum standard Proctor density. Care should be taken not to over-compact the backfill or use large equipment near the wall, since this could cause excessive lateral pressure on the wall. Some settlement of deeper wall backfill should be expected, even if the material is placed correctly, and could result in distress to facilities constructed on the backfill.

The lateral resistance of foundation or retaining wall footings will be a combination of the sliding resistance of the footing on the foundation materials and passive earth pressure against the side of the footing. Resistance to sliding at the bottoms of the footings can be calculated based on a coefficient of friction of 0.35. Passive pressure of compacted backfill against the sides of the footings can be calculated using an equivalent fluid unit weight of 350 pcf. The coefficient of friction and passive pressure values recommended above assume ultimate soil strength. Suitable factors of safety should be included in the design to limit the strain which will occur at the ultimate strength, particularly in the case of passive resistance. Fill placed against the sides of the footings to resist lateral loads can consist of the onsite soils compacted to at least 95% of the maximum standard Proctor density at a moisture content near optimum.

FLOOR SLABS

The natural onsite soils, exclusive of topsoil, can be used to support lightly loaded slab-on-grade construction with a risk of settlement similar to that described above for footing areas. For moderately loaded slabs, an increased depth of base course should be provided below the slab. There could be some slab settlement if the subgrade becomes wetted. The slab could be placed on about 2 feet of CDOT Class 5 or 6 aggregate base course to reduce the risk of settlement and improve the long term performance of the slab.

To reduce the effects of some differential movement, non-structural floor slabs should be separated from all bearing walls and columns with expansion joints which allow unrestrained vertical movement. Floor slab control joints should be used to reduce damage due to shrinkage cracking. The requirements for joint spacing and slab reinforcement should be established by the designer based on experience and the intended slab use. A minimum 6-inch layer of CDOT Class 6 aggregate base course should be placed immediately beneath the floor slabs for support. This material should consist of minus 2-inch aggregate with at least 50% retained on the No. 4 sieve and less than 12% passing the No. 200 sieve.

All fill materials for support of floor slabs should be compacted to at least 95% of maximum standard Proctor density at a moisture content near optimum. Required fill can consist of imported aggregate base course or the onsite soils devoid of topsoil and oversized (plus 6-inch) rocks.

SURFACE DRAINAGE

Positive surface drainage is a very important aspect of the project to prevent wetting of the bearing soils beneath the building. The following drainage precautions should be observed during construction and maintained at all times after each building has been completed:

1) Inundation of the foundation excavations and underslab areas should be avoided during construction.
2) Exterior backfill should be adjusted to near optimum moisture and compacted to at least 95% of the maximum standard Proctor density in pavement and slab areas and to at least 90% of the maximum standard Proctor density in landscape areas.
3) The ground surface surrounding the exterior of the building should be sloped to drain away from the foundation in all directions. We recommend a minimum slope of 12 inches in the first 10 feet in unpaved areas and a minimum slope of 2 inches in the first 10 feet in paved areas.
4) Roof downspouts and drains should discharge well beyond the limits of all backfill.
5) Landscaping which requires regular heavy irrigation such as sod, and sprinkler heads should be located at least 10 feet from foundation walls. Consideration should be given to use of xeriscape to reduce the potential for wetting of soils below the building caused by irrigation.

LIMITATIONS

This study has been conducted in accordance with generally accepted geotechnical engineering principles and practices in this area at this time. We make no warranty either express or implied.

The conclusions and recommendations submitted in this report are based upon the data obtained from the exploratory borings drilled at the locations indicated on Figures 1A and 1B, the proposed type of construction and our experience in the area. Our services do not include determining the presence, prevention or possibility of mold or other biological contaminants (MOBC) developing in the future. If the client is concerned about MOBC, then a professional in this special field of practice should be consulted. Our findings include interpolation and extrapolation of the subsurface conditions identified at the exploratory borings and variations in the subsurface conditions may not become evident until excavation is performed. If conditions encountered during construction appear different from those described in this report, we should be notified so that re-evaluation of the recommendations may be made.

This report has been prepared for the exclusive use by our client for design purposes. We are not responsible for technical interpretations by others of our information. As the project evolves, we should provide continued consultation and field services during construction to review and monitor the implementation of our recommendations, and to verify that the recommendations have been appropriately interpreted. Significant design changes may require additional analysis or modifications to the recommendations presented herein. We recommend on-site observation of excavations and foundation bearing strata and testing of structural fill by a representative of the geotechnical engineer.

Respectfully Submitted,

Kumar & Associates, Inc.

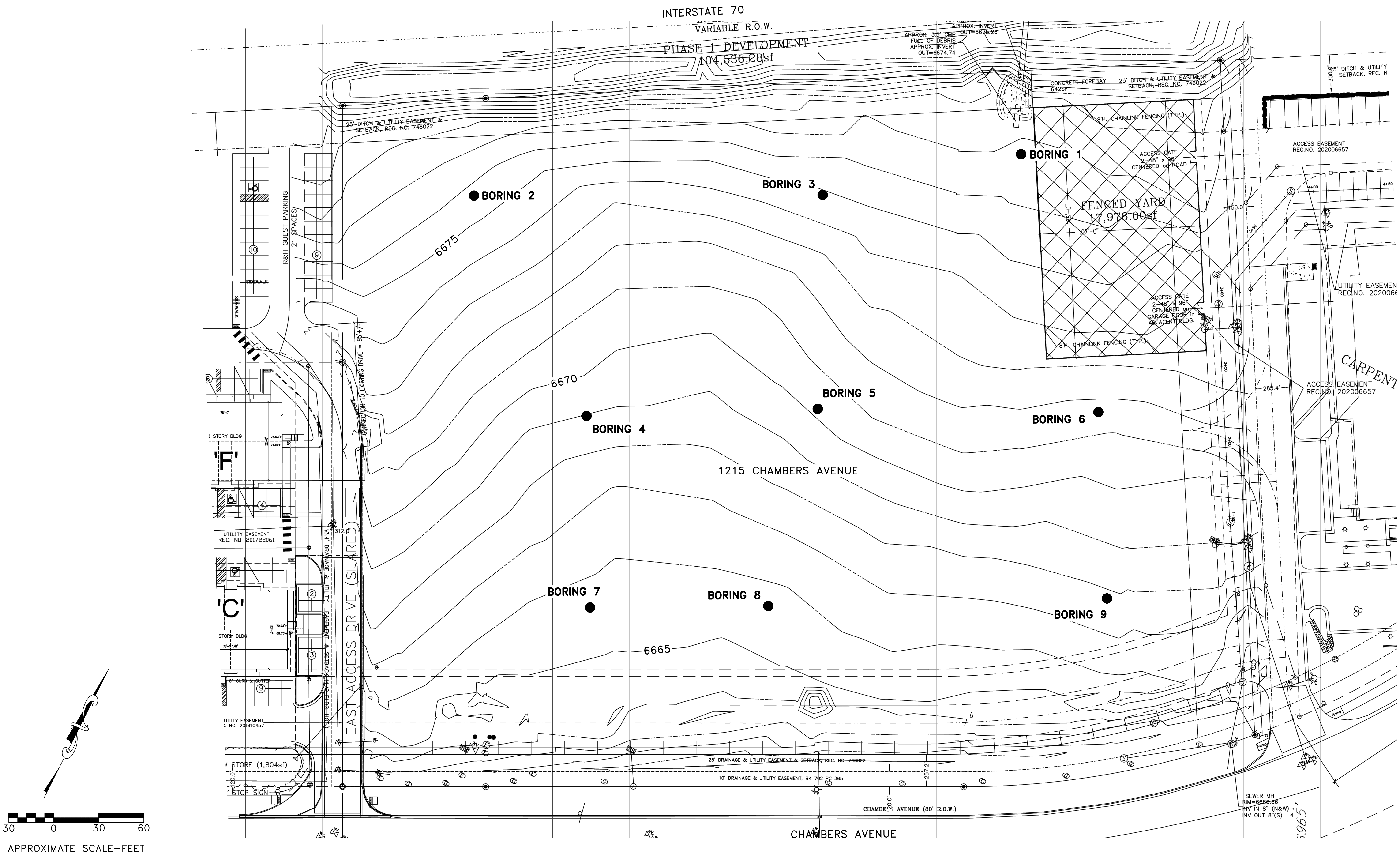
Steven L. Pawlak, P.E.

Reviewed by:

David A. Young, P.E.

SLP/kac

Cc: Jirsa Hedrick – Matthew Hood (mhood@jirsahedrick.com)



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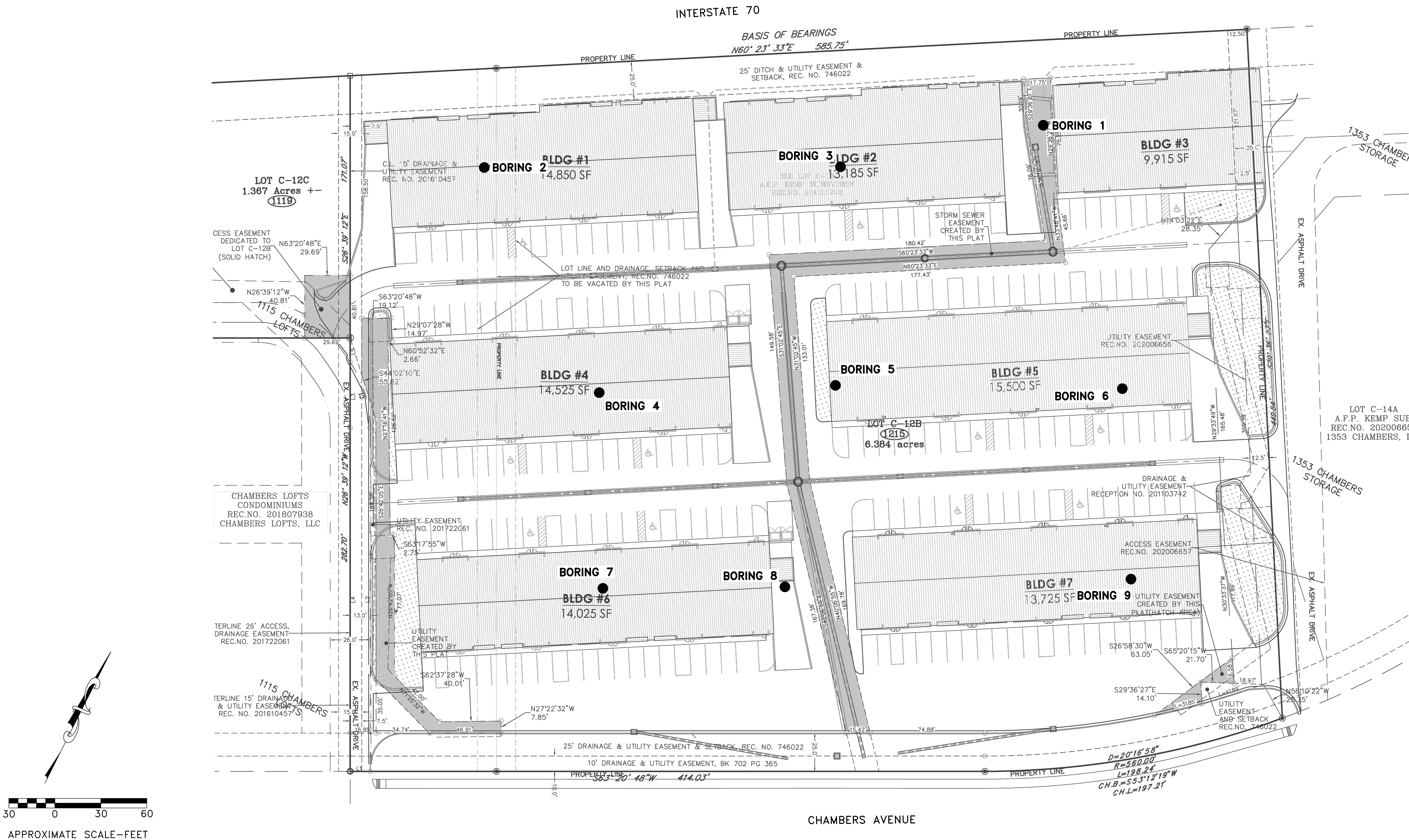
21-7-927.01	Kumar & Associates	NORTH BY NW WAREHOUSE DEVELOPMENT 1215 CHAMBERS AVENUE	LOCATION OF EXPLORATORY BORINGS EXISTING CONDITIONS	Fig. 1A



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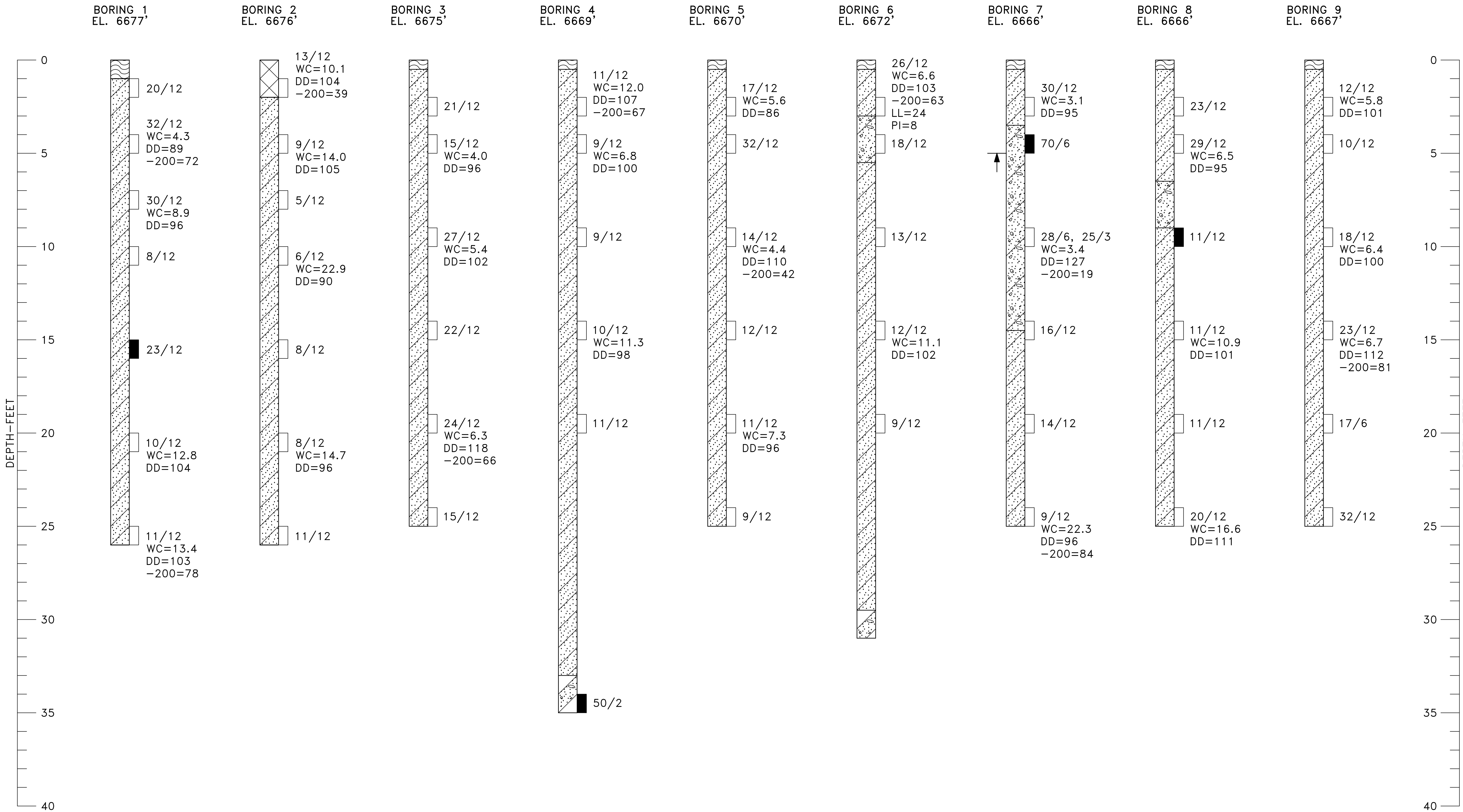

21−7−927.01	Kumar & Associates	NORTH BY NW WAREHOUSE DEVELOPMENT 1215 CHAMBERS AVENUE	LOGS OF EXPLORATORY BORINGS	Fig. 2

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LEGEND

TOPSOIL; SANDY CLAYEY SILT, FIRM, MOIST, BROWN, FROZEN.

FILL; MAN-PLACED SILTY CLAYEY SAND AND GRAVEL, LOOSE, SLIGHTLY MOIST, MIXED BROWN.

SAND AND SILT (SM-ML); INTERMIXED, SCATTERED GRAVEL TO OCCASIONALLY GRAVELLY WITH SCATTERED SMALL COBBLES, OCCASIONALLY CLAYEY, LOOSE TO MEDIUM DENSE/MEDIUM STIFF TO STIFF, SLIGHTLY MOIST TO MOIST AND OCCASIONALLY VERY MOIST, MIXED BROWN AND RED-BROWN, SUBANGULAR ROCKS.

SAND AND GRAVEL (SM-GM); SILTY TO VERY SILTY, SCATTERED COBBLES, MEDIUM DENSE, SLIGHTLY MOIST, BROWN, SUBANGULAR ROCK.

GRAVEL AND COBBLES (GM-GP); SILTY, SANDY, PROBABLE BOULDERS, DENSE, SLIGHTLY MOIST, BROWN, ROUNDED ROCK.

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

DRIVE SAMPLE, 1 3/8-INCH I.D. SPLIT SPOON STANDARD PENETRATION TEST.

20/12 DRIVE SAMPLE BLOW COUNT. INDICATES THAT 20 BLOWS OF A 140-POUND HAMMER FALLING 30 INCHES WERE REQUIRED TO DRIVE THE SAMPLER 12 INCHES.

PRACTICAL AUGER REFUSAL. WHERE SHOWN ABOVE BOTTOM OF BORING, INDICATES THAT MULTIPLE ATTEMPTS WHERE MADE TO ADVANCE THE HOLE.

NOTES

1. EXPLORATORY BORINGS 1 AND 2 WERE DRILLED ON JANUARY 7, 2022 AND BORINGS 3 THROUGH 9 WERE DRILLED ON NOV 22 AND 25, 2024 WITH A 4-INCH-DIAMETER CONTINUOUS-FLIGHT POWER AUGER.

2. THE LOCATIONS OF THE EXPLORATORY BORINGS WERE APPROXIMATED BY PACING FROM FEATURES SHOWN ON THE SITE PLAN PROVIDED.

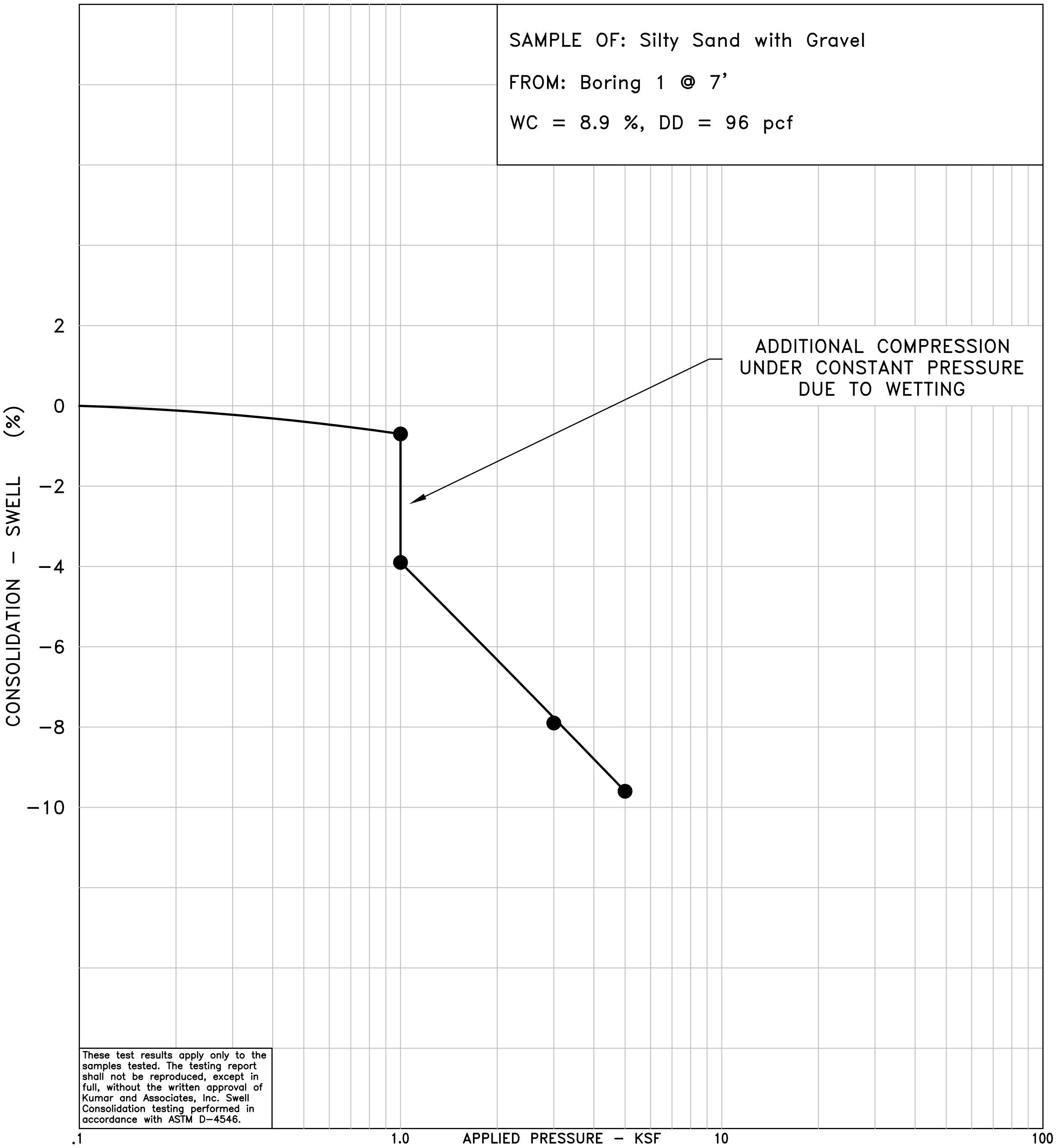
3. THE ELEVATIONS OF THE EXPLORATORY BORINGS WERE OBTAINED BY INTERPOLATION BETWEEN CONTOURS ON THE SITE PLAN PROVIDED.

4. THE EXPLORATORY BORING LOCATIONS AND ELEVATIONS SHOULD BE CONSIDERED ACCURATE ONLY TO THE DEGREE IMPLIED BY THE METHOD USED.

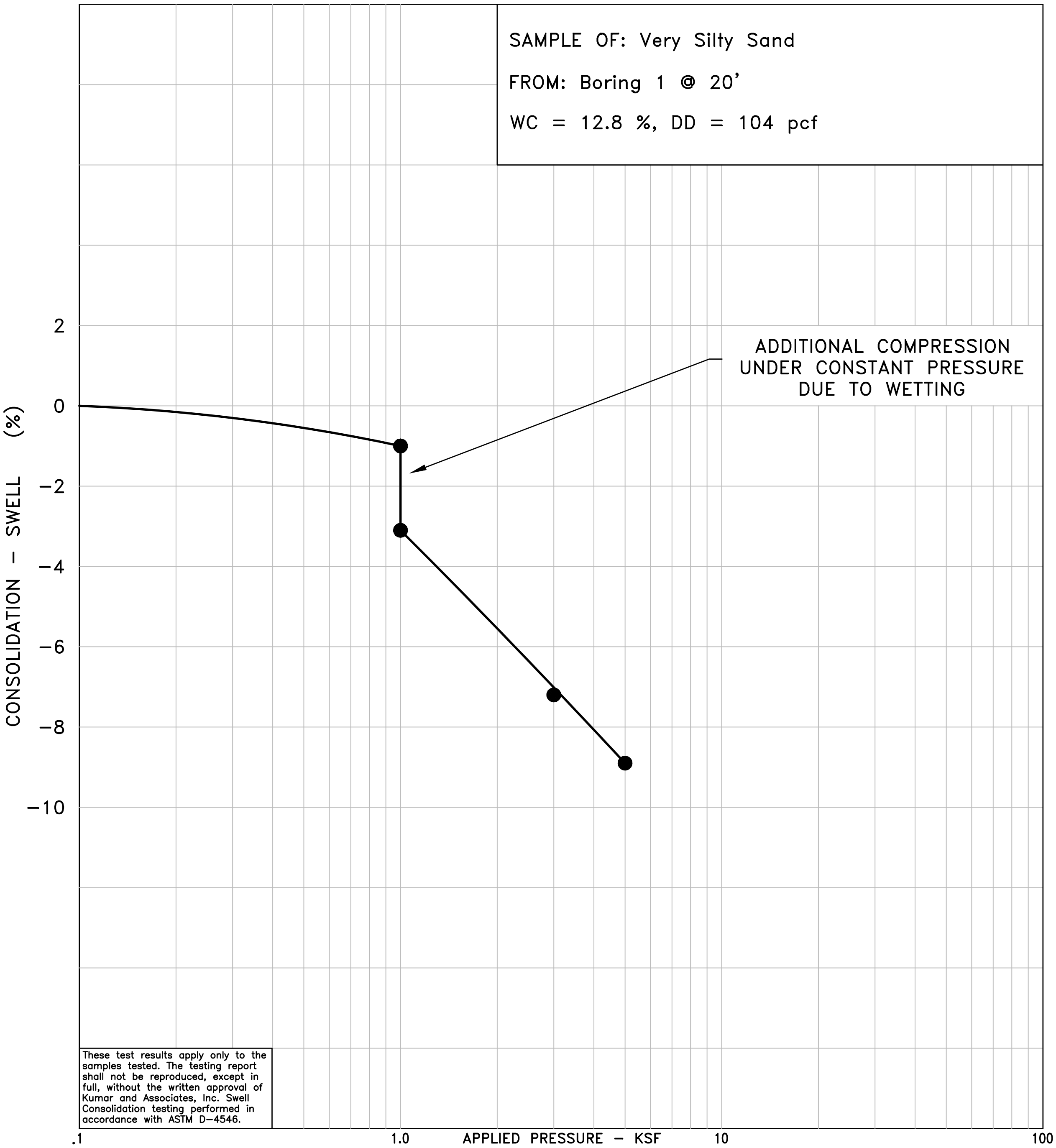
5. THE LINES BETWEEN MATERIALS SHOWN ON THE EXPLORATORY BORING LOGS REPRESENT THE APPROXIMATE BOUNDARIES BETWEEN MATERIAL TYPES AND THE TRANSITIONS MAY BE GRADUAL.

6. GROUNDWATER WAS NOT ENCOUNTERED IN THE BORINGS AT THE TIME OF DRILLING. FLUCTUATIONS IN THE WATER LEVEL MAY OCCUR WITH TIME.

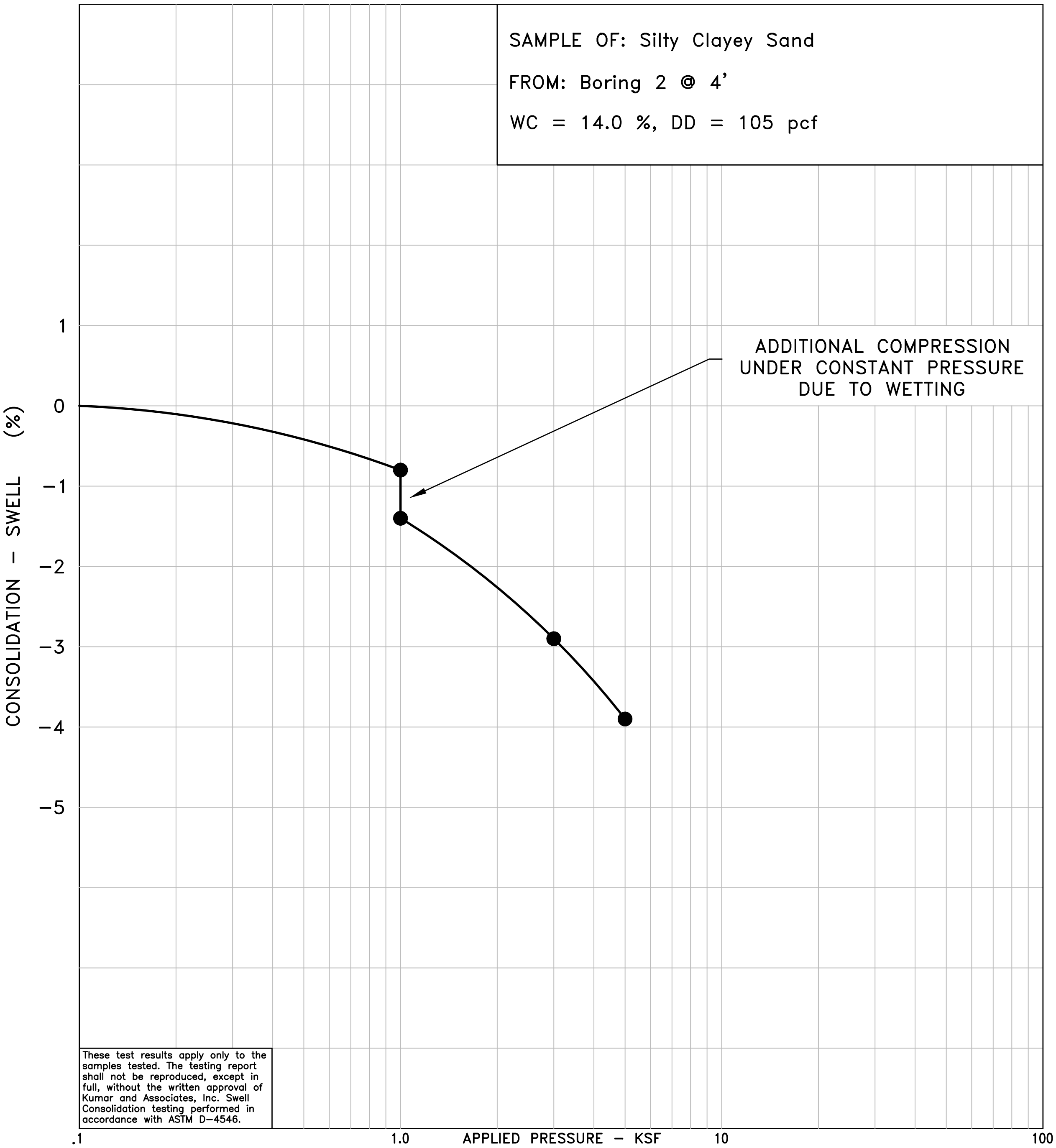
7. LABORATORY TEST RESULTS:
   WC = WATER CONTENT (%) (ASTM D2216);
   DD = DRY DENSITY (pcf) (ASTM D2216);
   -200= PERCENTAGE PASSING NO. 200 SIEVE (ASTM D1140);
   LL = LIQUID LIMIT (ASTM D4318);
   PI = PLASTICITY INDEX (ASTM D4318).



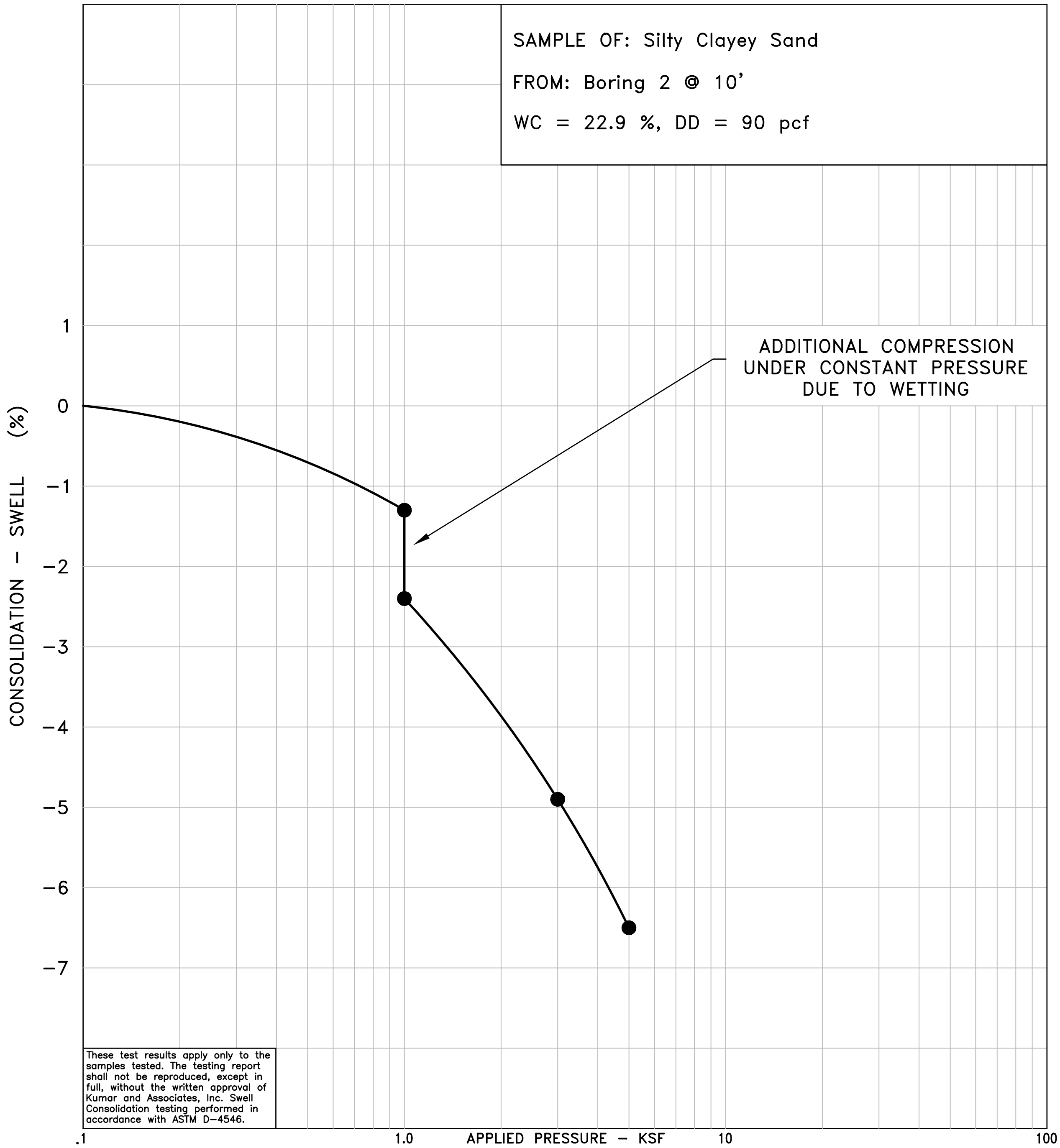
21-7-927.01	Kumar & Associates	SWELL-CONSOLIDATION TEST RESULTS	Fig. 4



21-7-927.01	Kumar & Associates	SWELL-CONSOLIDATION TEST RESULTS	Fig. 5



21-7-927.01	Kumar & Associates	SWELL-CONSOLIDATION TEST RESULTS	Fig. 6



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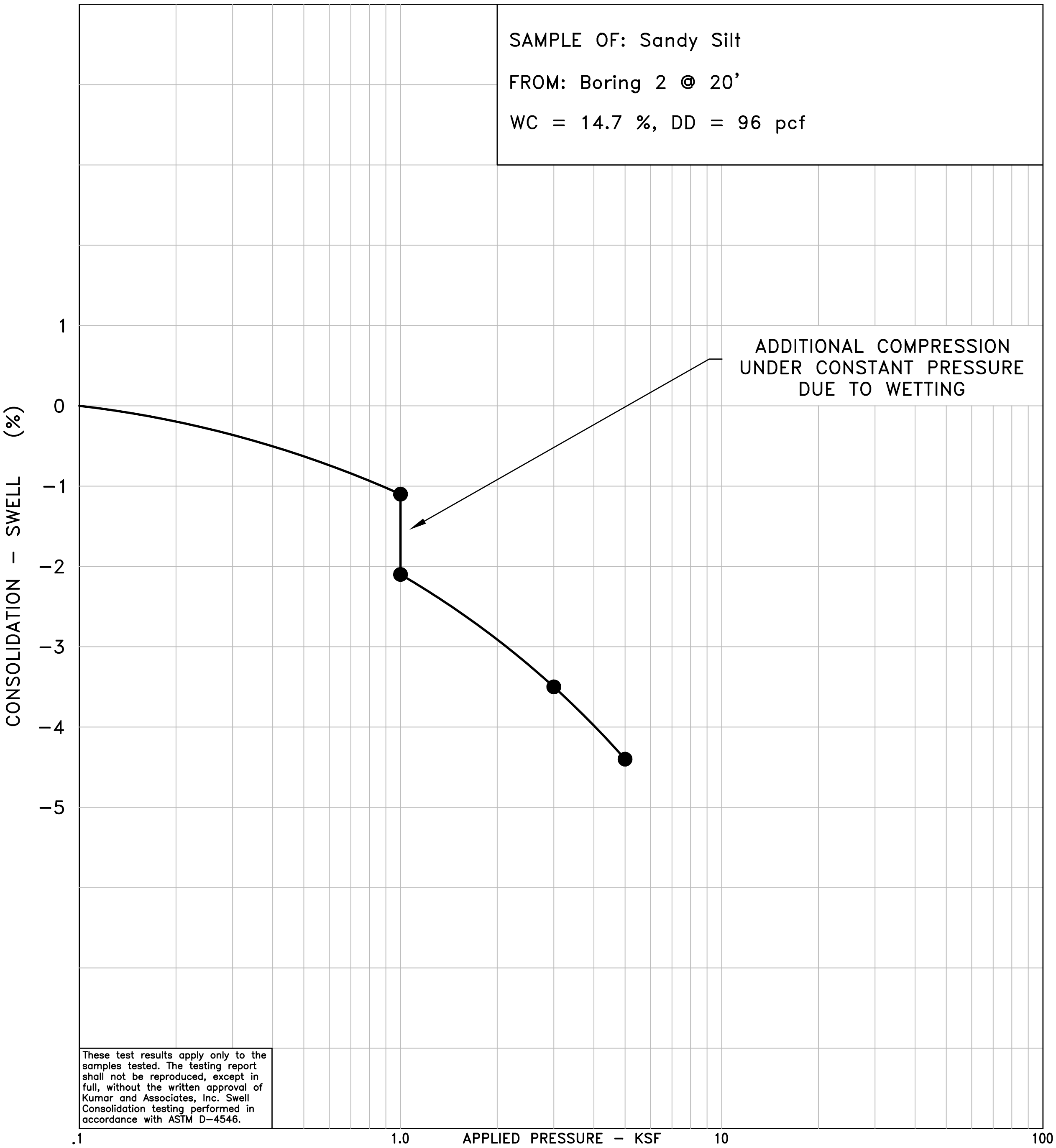
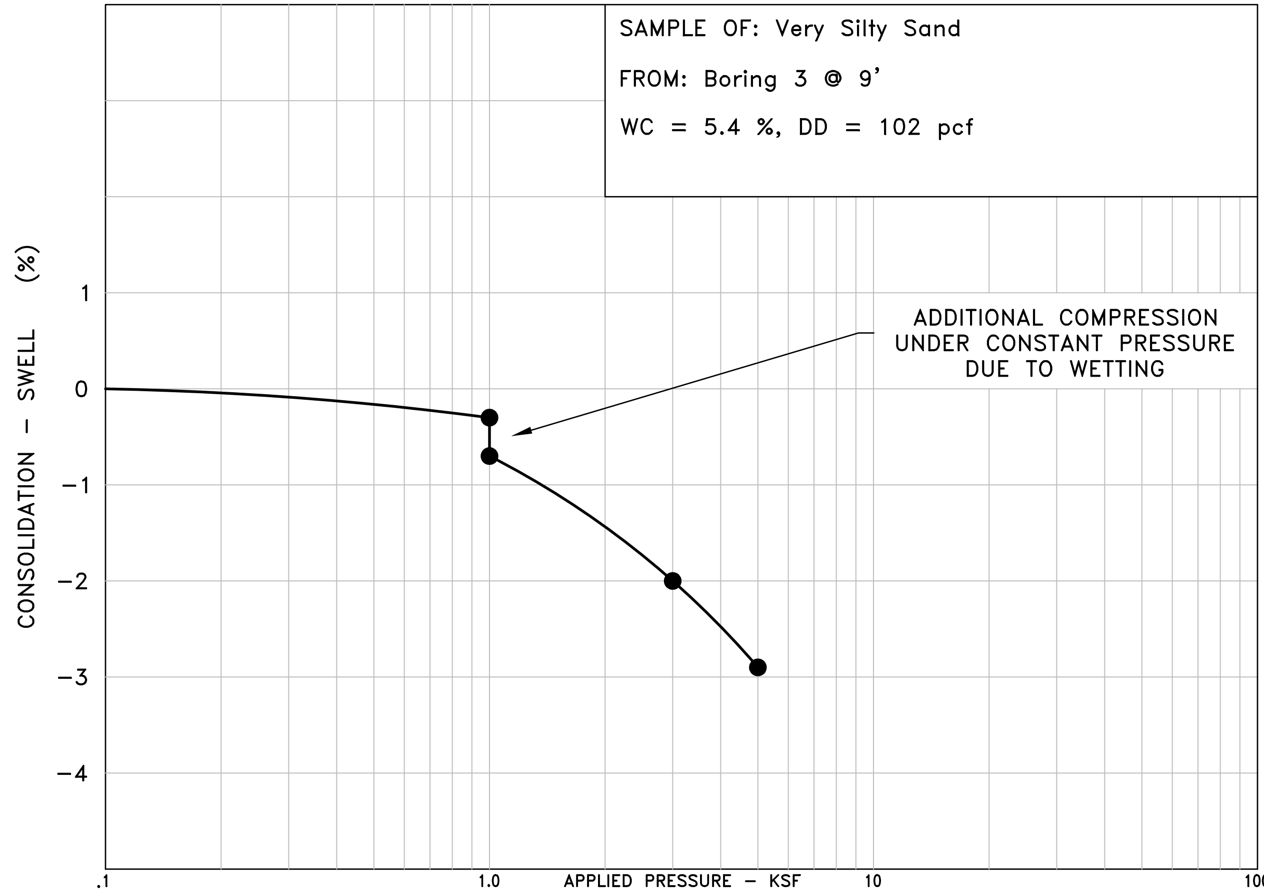
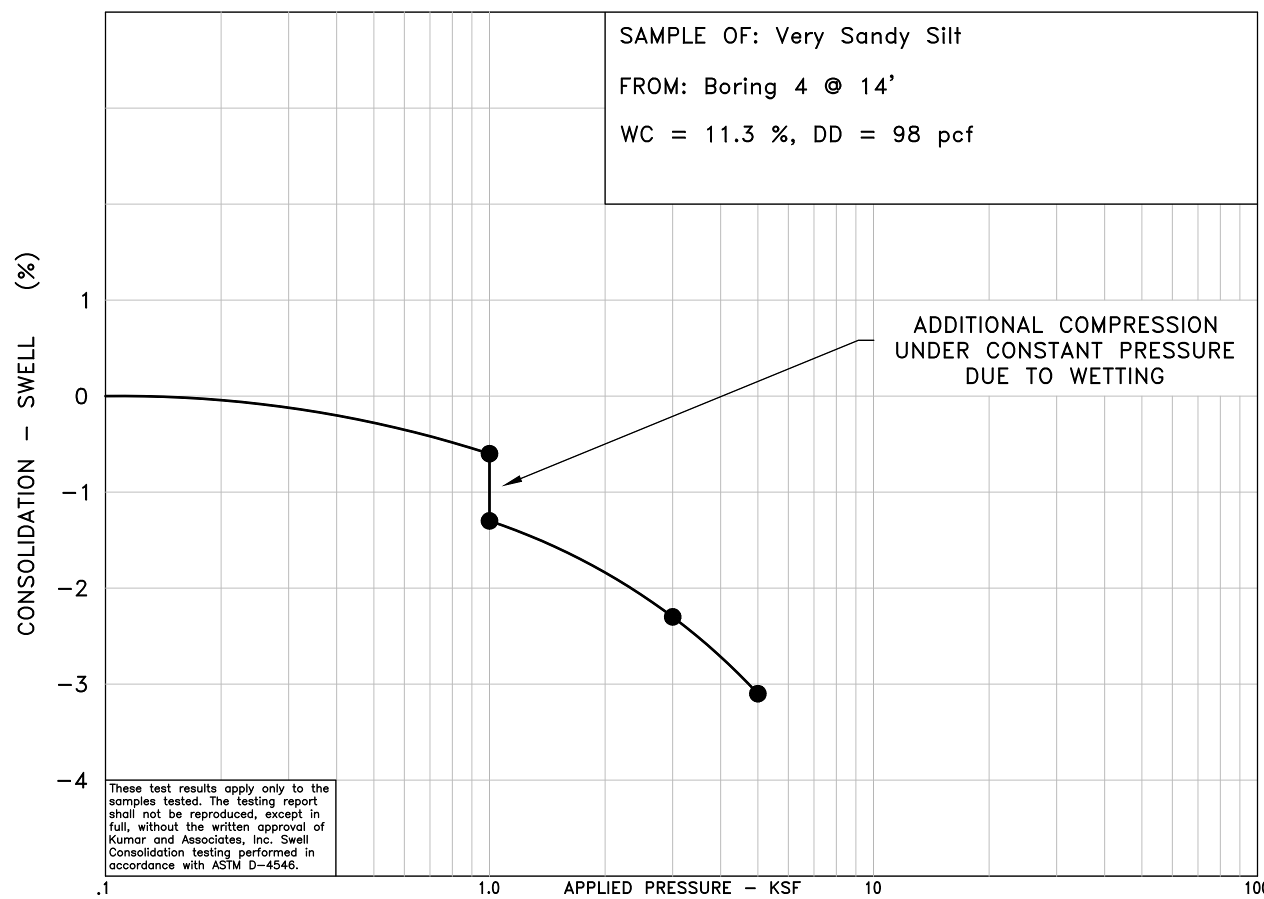
21-7-927.01	Kumar & Associates	SWELL-CONSOLIDATION TEST RESULTS	Fig. 7



21-7-927.01	Kumar & Associates	SWELL-CONSOLIDATION TEST RESULTS	Fig. 8





21-7-927.01	Kumar & Associates	SWELL-CONSOLIDATION TEST RESULTS	Fig. 9

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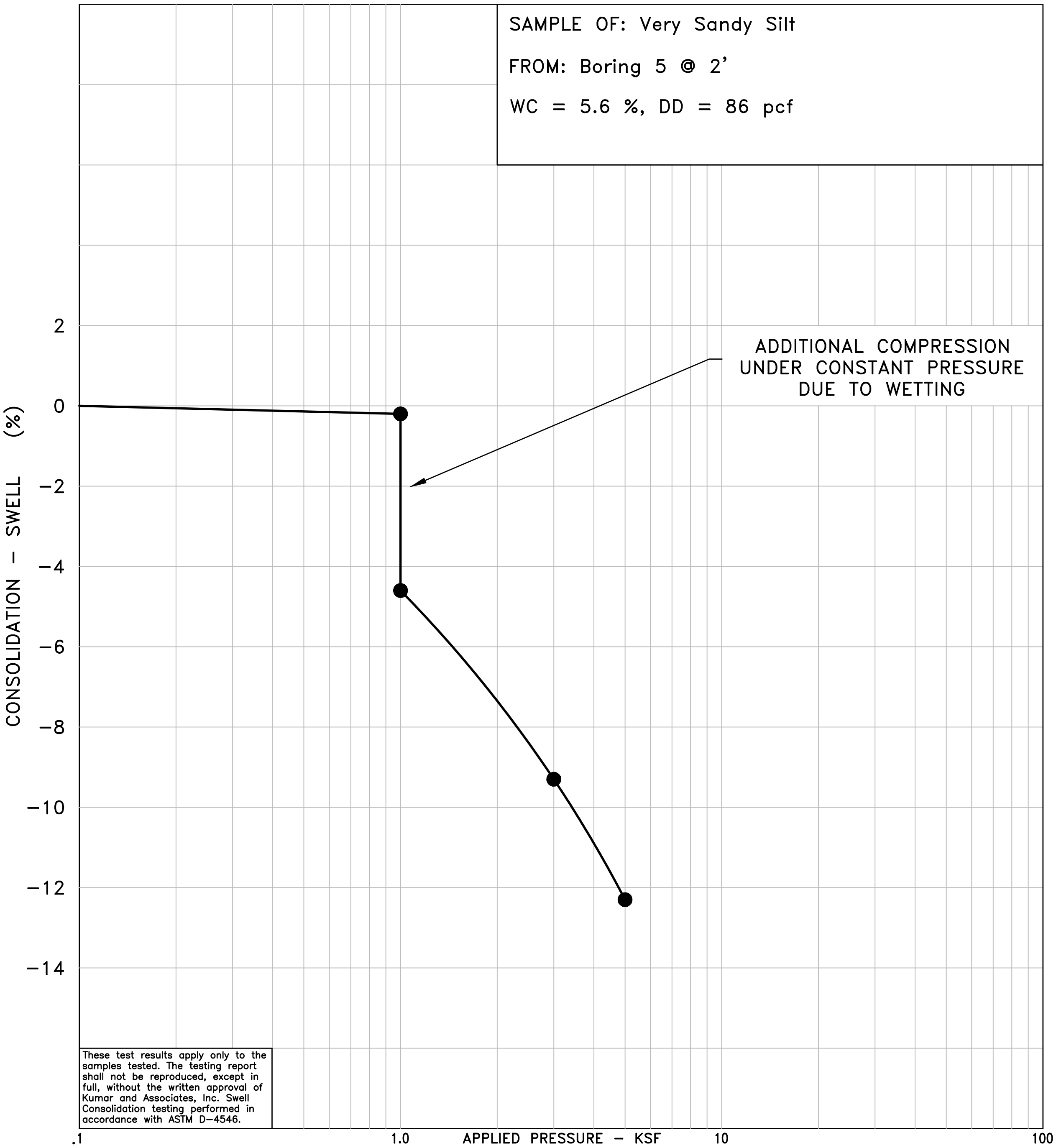
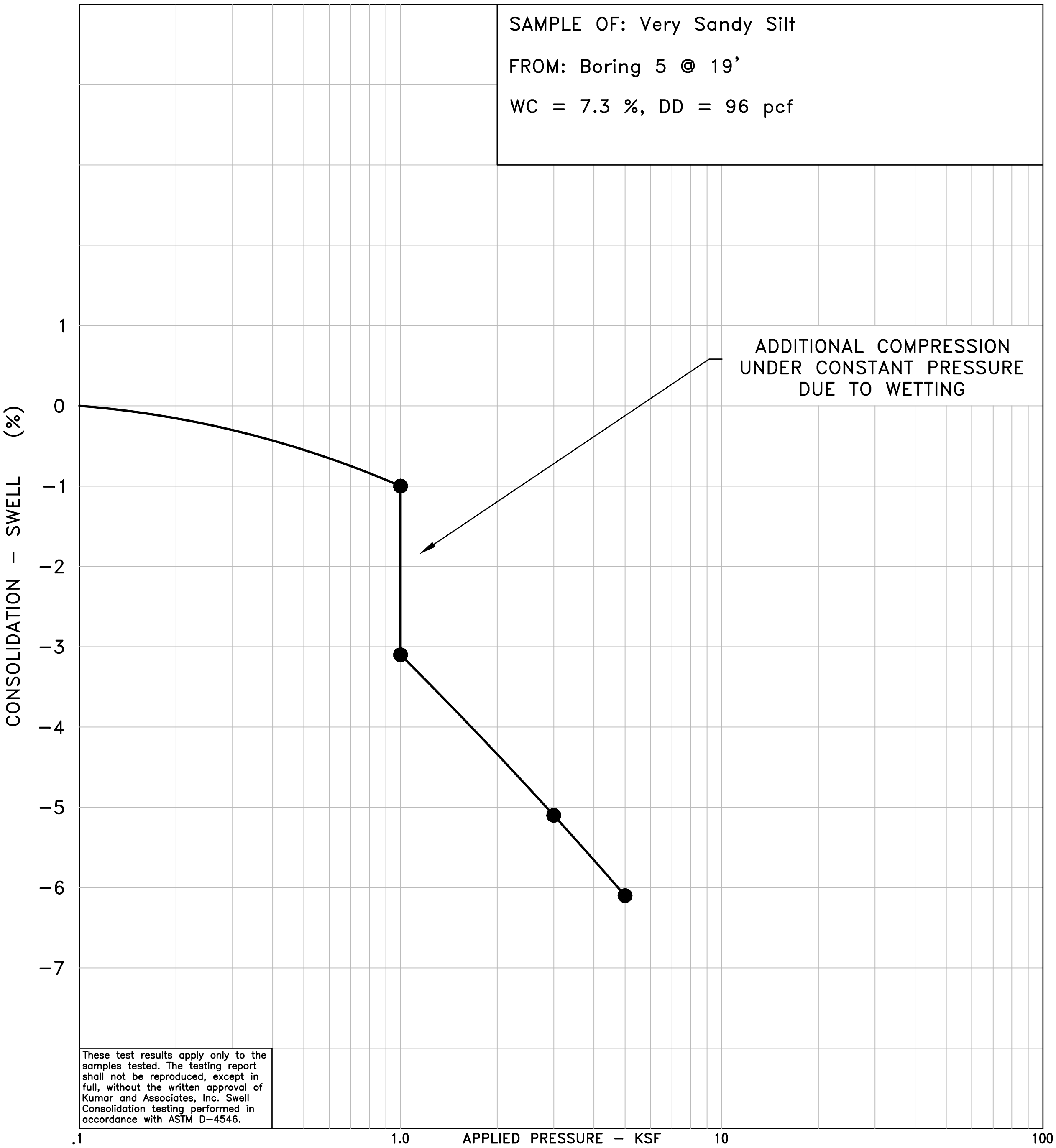


21-7-927.01	Kumar & Associates	SWELL-CONSOLIDATION TEST RESULTS	Fig. 10



21-7-927.01	Kumar & Associates	SWELL-CONSOLIDATION TEST RESULTS	Fig. 11

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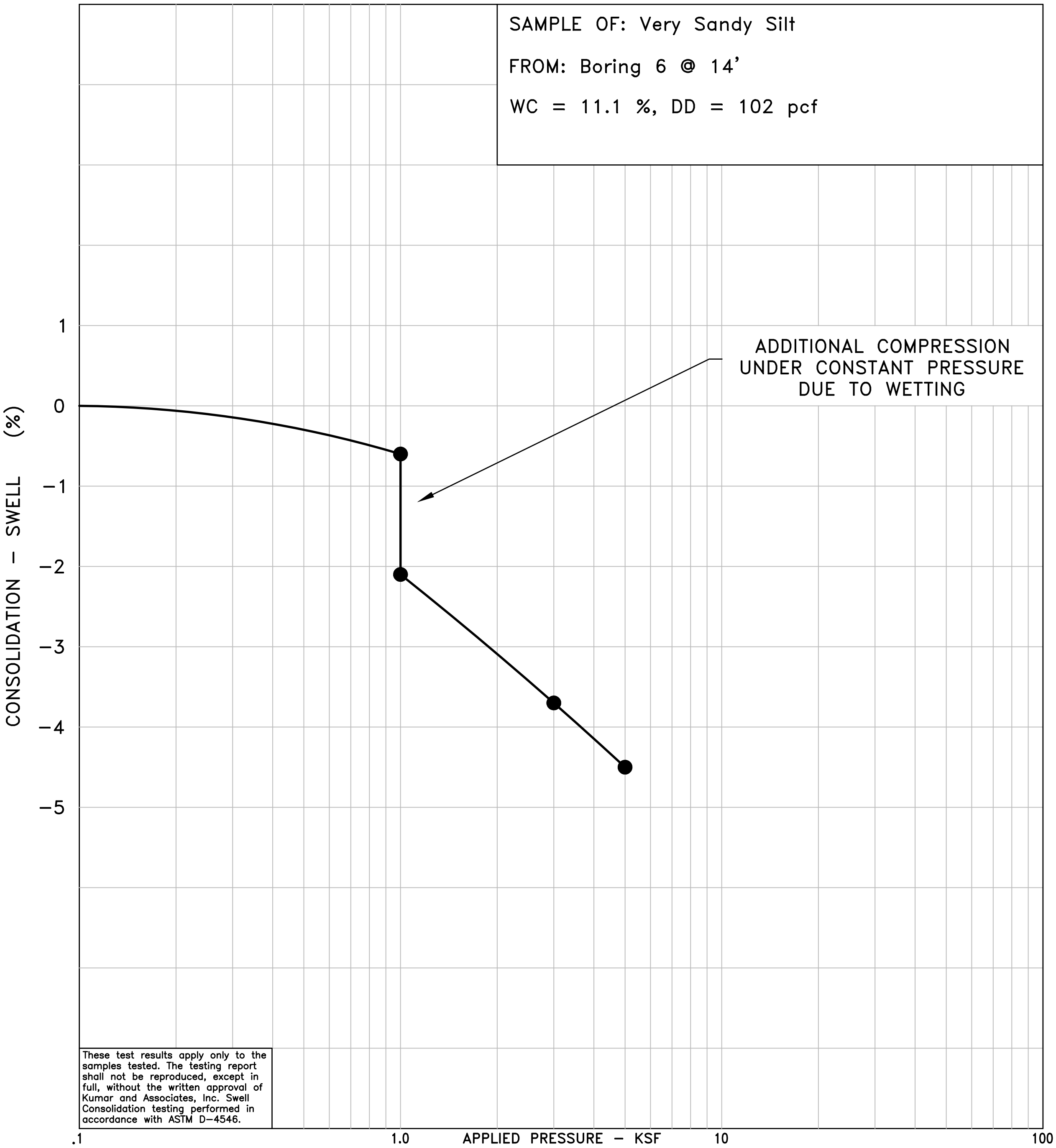

21-7-927.01	Kumar & Associates	SWELL-CONSOLIDATION TEST RESULTS	Fig. 12

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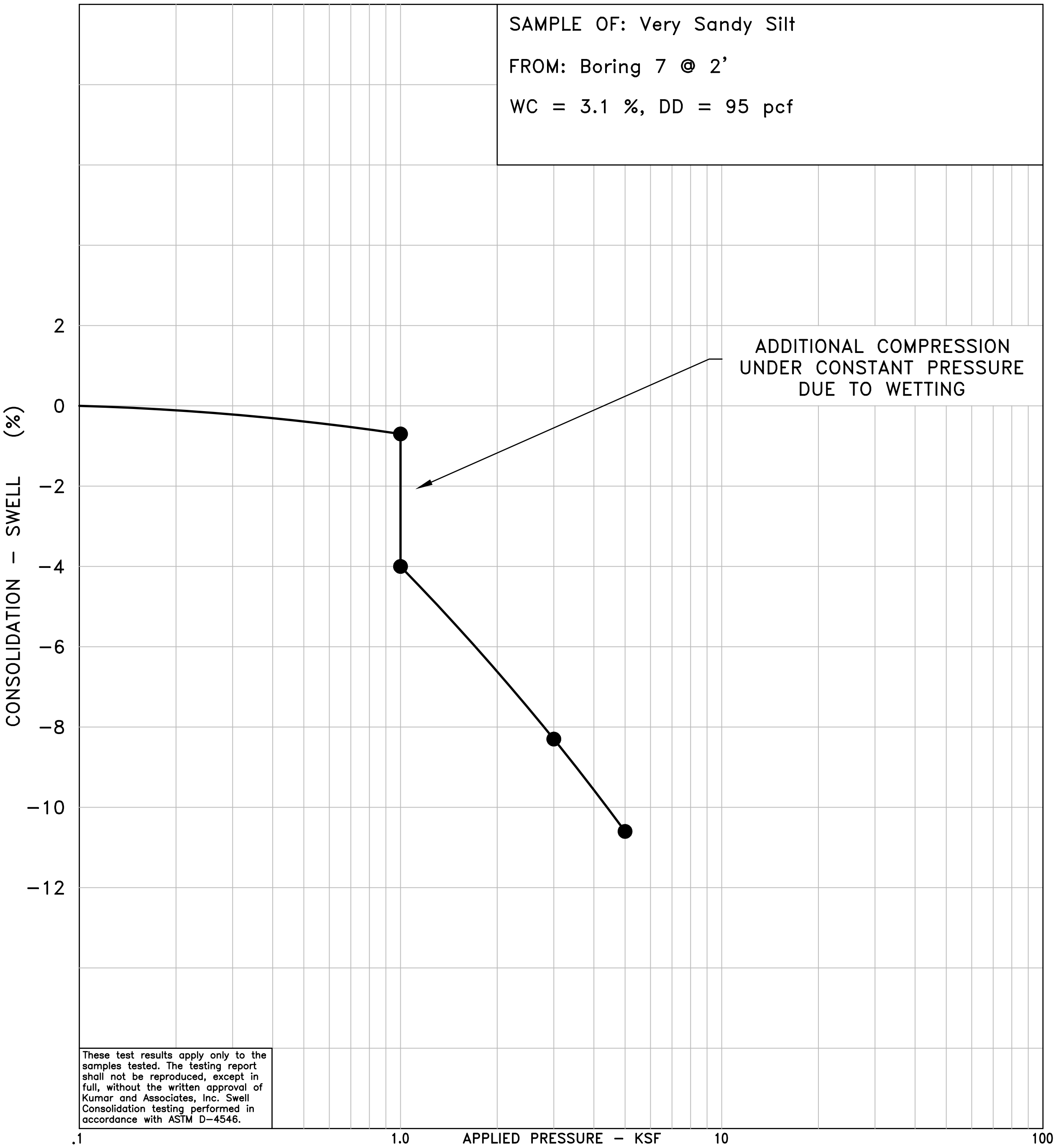
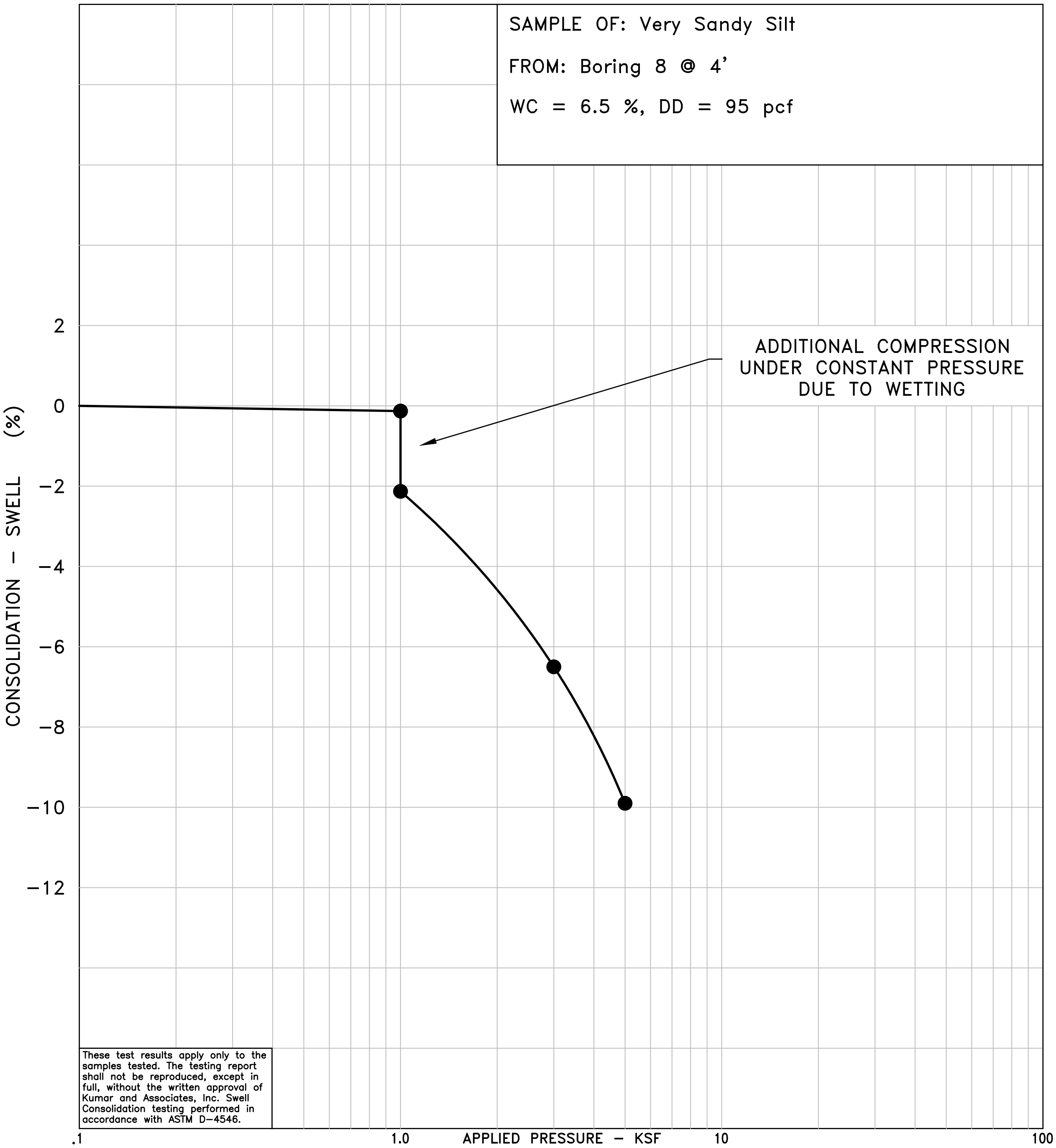
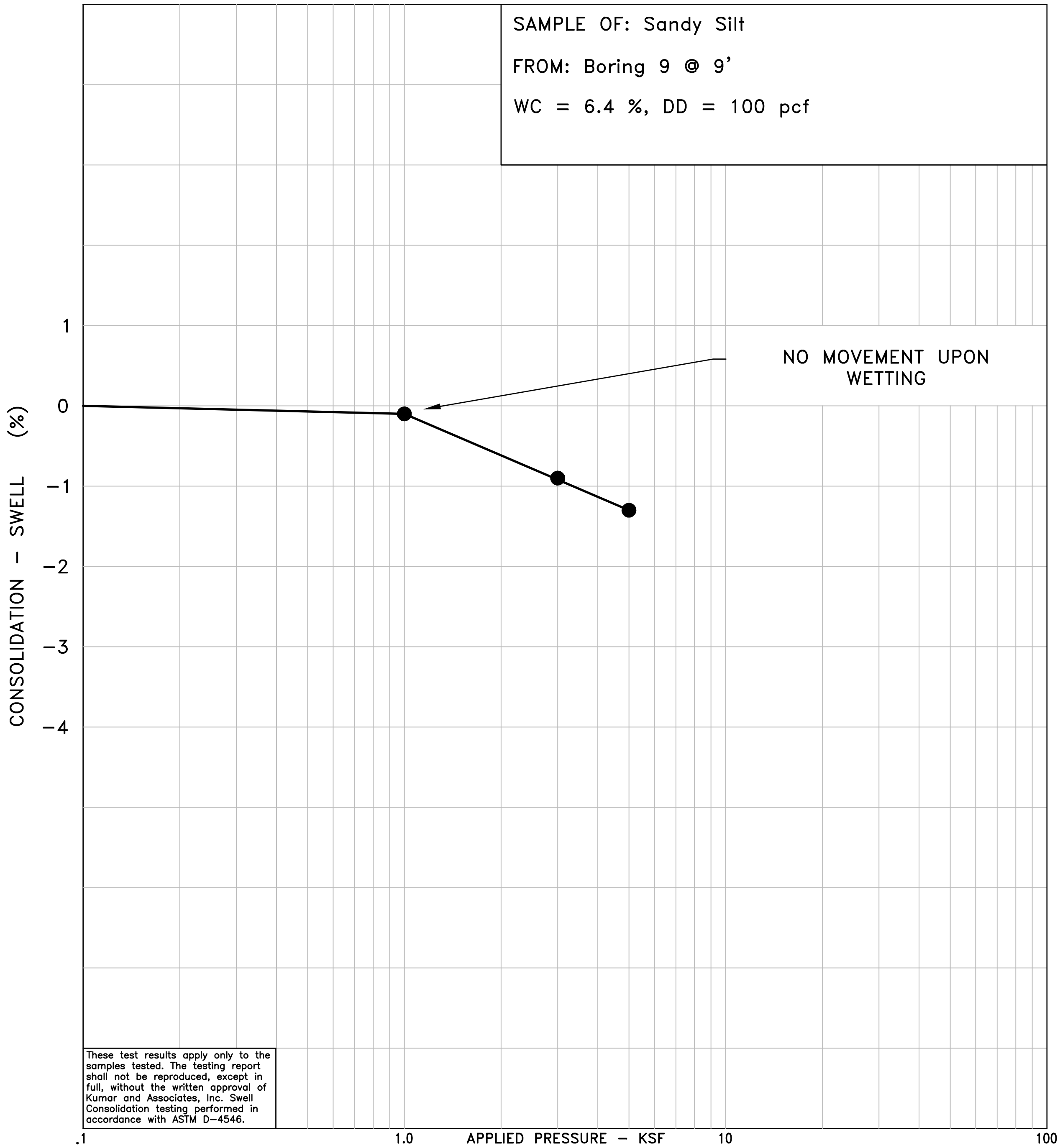


21-7-927.01	Kumar & Associates	SWELL-CONSOLIDATION TEST RESULTS	Fig. 13



21-7-927.01	Kumar & Associates	SWELL-CONSOLIDATION TEST RESULTS	Fig. 14



21-7-927.01	Kumar & Associates	SWELL-CONSOLIDATION TEST RESULTS	Fig. 15

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TABLE 1
SUMMARY OF LABORATORY TEST RESULTS

Project No. 21-7-927.01

SAMPLE LOCATION		NATURAL MOISTURE CONTENT	NATURAL DRY DENSITY	GRADATION		PERCENT PASSING NO. 200 SIEVE	ATTERBERG LIMITS		UNCONFINED COMPRESSIVE STRENGTH	SOIL TYPE
BORING	DEPTH (ft)	(%)	(pcf)	GRAVEL (%)	SAND (%)		LIQUID LIMIT (%)	PLASTIC INDEX (%)	(psf)	
1	4	4.3	89			72				Sandy Silt
	7	8.9	96							Silty Sand with Gravel
	20	12.8	104							Silty Sand
	25	13.4	103			78				Sandy Clayey Silt
2	1	10.1	104			39				Silty Clayey Sand and Gravel (Fill)
	4	14.0	105							Silty Clayey Sand
	10	22.9	90							Silty Clayey Sand
	20	14.7	96							Sandy Silt
3	4	4.0	96							Very Silty Sand
	9	5.4	102							Very Silty Sand
	19	6.3	118			66				Very Sandy Silt

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TABLE 1
SUMMARY OF LABORATORY TEST RESULTS

SAMPLE LOCATION		NATURAL MOISTURE CONTENT	NATURAL DRY DENSITY	GRADATION		PERCENT PASSING NO. 200 SIEVE	ATTERBERG LIMITS		UNCONFINED COMPRESSIVE STRENGTH	SOIL TYPE
BORING	DEPTH (ft)	(%)	(pcf)	GRAVEL (%)	SAND (%)		LIQUID LIMIT (%)	PLASTIC INDEX (%)	(psf)	
4	2	12.0	107			67				Very Sandy Silt
	4	6.8	100							Very Silty Sand with Gravel
	14	11.3	98							Very Sandy Silt
5	2	5.6	86							Very Sandy Silt
	9	4.4	110			42				Very Silty Sand
	19	7.3	96							Very Sandy Silt
6	2	6.6	103			63	24	8		Very Sandy Silt and Clay
	14	11.1	102							Very Sandy Silt
7	2	3.1	95							Very Sandy Silt
	9	3.4	127			19				Silty Sand and Gravel
	24	22.3	96			84				Sandy Clayey Silt

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and Environmental Scientists

TABLE 1
SUMMARY OF LABORATORY TEST RESULTS

SAMPLE LOCATION		NATURAL MOISTURE CONTENT	NATURAL DRY DENSITY	GRADATION		PERCENT PASSING NO. 200 SIEVE	ATTERBERG LIMITS		UNCONFINED COMPRESSIVE STRENGTH	SOIL TYPE
BORING	DEPTH (ft)	(%)	(pcf)	GRAVEL (%)	SAND (%)		LIQUID LIMIT (%)	PLASTIC INDEX (%)	(psf)	
8	4	6.5	95							Very Sandy Silt
	14	10.9	101							Sandy Silt
	24	16.6	111							Sandy Silt
9	2	5.8	101							Very Sandy Silt
	9	6.4	100							Sandy Silt
	14	6.7	112			81				Sandy Silt