

**GEOLOGIC AND PRELIMINARY
GEOTECHNICAL INVESTIGATION
FOUNDERS VISTA, FILING NO. 1, 258 LOTS
NORTHWEST OF NORTH RIDGE ROAD
AND ENDERUD BOULEVARD
CASTLE ROCK, COLORADO**

Prepared for:

**D.R. HORTON
9555 South Kingston Court
Englewood, Colorado 80112**

Attention: Shelly Oschman

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SCOPE

This report presents the results of our Geologic and Preliminary Geotechnical Investigation for 258 residences planned within Founders Vista, Filing No. 1 in Castle Rock, Colorado (Fig. 1). The purpose of our investigation was to evaluate the subsurface conditions to assist in due diligence and planning of site development and residential construction. The report includes descriptions of the subsurface conditions encountered in exploratory borings, and discussions of site development and construction as influenced by geotechnical considerations. The scope was described in our Service Agreement (DN 20-0190) dated April 23, 2020. Evaluation of the property for the presence of potentially hazardous materials (Phase I Environmental Site Assessment) was not included in our scope.

This report is based on our understanding of the planned construction, subsurface conditions disclosed by exploratory drilling and sampling, results of field and laboratory tests, engineering analysis of field and laboratory data, previous investigation, and our experience. It contains descriptions of the soil and bedrock conditions and groundwater levels found in our exploratory borings, preliminary discussions of site development, and preliminary design and construction criteria for foundations, floor systems, pavements, and surface and subsurface drainage. The discussions of foundation, floor system and pavement alternatives are intended for planning purposes only. Additional, site-specific investigations will be necessary to design structures, pavements, and other improvements. A summary of our conclusions and recommendations follows, with more detailed discussion in the report.

SUMMARY

1. The site is suitable for development. The primary geotechnical concerns are the presence of expansive soil and bedrock, cemented and very hard sandstone bedrock, and differential settlement due to filling in drainages. We believe these concerns can be mitigated with proper planning, engineering, design, and construction. We believe there are no geotechnical constraints that would preclude development. Grading plans should be



reviewed once they are available to determine whether our recommendations remain valid.

2. Strata found in our borings consisted of nil to about 16 feet of sandy clay with some clayey sand underlain by weathered and comparatively unweathered sandstone and claystone bedrock. Sandstone was predominant. The sandstone is hard to very hard or cemented, causing refusal in some borings. The sandstone was within about 8 feet of the ground surface in three-quarters of the borings. Shallow claystone was found in two borings. Testing indicates the clay and claystone are expansive. The sandstone is judged to be non-expansive.
3. Water was measured in four borings at depths of about 13.5 to 22 feet (Fig. 2). Groundwater is not expected to influence the planned construction. Water levels may fluctuate seasonally, and develop or rise in response to development, precipitation, landscape irrigation and changes in land-use.
4. Our investigation revealed shallow sandstone at depths likely to influence foundations and slabs-on-grade over the majority of the site (depending on grading). Footing foundations are appropriate in areas with sandstone at foundation levels. The clay and claystone above the sandstone is considered to be expansive. We identified three areas with expansive clay and/or claystone at shallow depths, TH-101, TH-112 and TH-116. Two borings, TH-109 and TH-110 had deeper clay with intermediate-depth claystone. Drilled piers and structurally supported basement floors are recommended in areas with swelling clay and claystone at foundation levels. Sub-excavation can be considered in areas where expansive clay and/or claystone are present (Fig. 3).
5. Cemented sandstone bedrock is often exposed on the ground surface on the mesa top and edge, such as what may have caused refusal in TH-115 at the south end of the site. Cemented and very hard bedrock pose excavation challenges. Our experience is that the cemented sandstone can have composition and strength similar to normal concrete. Nearby developments such as Founders Village, Castlewood Ranch and Terrain have similar conditions. It has proven difficult and expensive to excavate these materials, and once they are removed, they have to be mechanically broken down to use as backfill. Heavy ripping, pneumatic hammers/stingers and rock saws have all been used to excavate the Castle Rock Conglomerate. Controlled blasting has also been used.
6. Pavement subgrade will likely consist of sandy clay, clayey sand, sandstone and claystone. Mitigation of expansive subgrade with sub-excavation and moisture treatment of 3 to 5 feet may be necessary in clay/claystone areas. The upper foot will need to be stabilized in expansive clayey



areas. The City's minimum pavement sections are included in the report. A design-level subgrade investigation should be performed prior to paving.

7. Control of surface drainage will be critical to the performance of foundations, slabs-on-grade, and pavements. Overall surface drainage should be designed to provide rapid run-off of surface water away from structures and off pavements and flatwork. Water should not be allowed to pond near the crests of slopes, near structures or on pavements and flatwork. Conservative irrigation practices should be employed to reduce the risk of sub-surface wetting. Subsurface drains are recommended around all below-grade areas.

SITE CONDITIONS

Founders Vista, Filing No. 1 is located northwest of North Ridge Road and Enderud Boulevard in Castle Rock, Colorado (Fig. 1 and Photo 1). Memmen's 2nd and 3rd Additions to Castle Rock residential developments are west. A water tank and retail/commercial developments are across North Ridge Road to the northeast. Vacant Memmen property is south. The property consists of a mesa with semi-rolling hills which generally slope to the west-south toward a drainage, with a few of southwesterly ephemeral drainages at the northern and south-central areas of the site. Locally, some parts slope toward the drainages. A moderately steep slope is present along the southwest edge of the mesa that leads down the drainage. Outcrops and boulders were noted around the northwest and northeast perimeters and in the south-central area. The ground surface is covered with grasses, weeds and bushes, with scrub oak and trees around the low-lying drainages. Historically, the southern edge of the site may have been used for agricultural or livestock purposes, but the remaining portion has been undeveloped.



Photo 1 – Google Earth Aerial Image, October 2019

PROPOSED CONSTRUCTION

The current plat indicates you may develop the north portion of Filing No. 1 with 258 residences served by paved roadways, buried utilities and other infrastructure. There will be 124 single-family residences and 134 paired homes or duplexes in the central and south portions. We anticipate the homes will be wood-frame, one or two-story structures with basements and attached multicar garages. East and north-facing lots may be graded for walkout or garden-level basement construction. Grading plans are not available at the time of this investigation. We anticipate the drainages will be



obliterated and filled, while local ridges are flattened, resulting in cut/fill depths of 10 to 15 feet or less.

PREVIOUS CONSULTATION

We performed a Preliminary Geologic Hazards Evaluation for the portion of the Memmen property south of the subject site under Project No. DN47,512-115 (report dated September 30, 2014). We reviewed geologic mapping and literature and performed site reconnaissance which indicated the hazards include hard, cemented sandstone bedrock, rockfall and rock topple, steep potentially unstable slopes, and high erosion potential. These types of hazards were also identified and successfully mitigated during development of nearby properties, such as Founders Village, Castlewood Ranch and Terrain. Pertinent information and experience from the previous investigation and nearby developments were considered in preparation of this report.

INVESTIGATION

We investigated subsurface conditions between May 8 and 15, 2020 by drilling and sampling 23 exploratory borings at the approximate locations shown on Fig. 1. The boring locations and elevations were staked by the project surveyor prior to drilling. We could not access TH-105 due to steep slopes and heavy scrub oak, and we moved the boring southeast and estimated the elevation. Prior to drilling, we contacted the Utility Notification Center of Colorado and local sewer and water districts to mark the presence of buried utilities. The borings were drilled to depths of 6 to 30 feet below existing grades using 4-inch diameter, continuous-flight solid-stem auger and truck-mounted drill rigs. Refusal was encountered in four borings at depths of 6 feet in one boring, and 22 to 28 feet in the other three.

Samples were obtained at approximate 2 to 5 feet intervals using a 2.5-inch diameter (O.D.) modified California barrel sampler driven by blows from an automatic 140-pound hammer falling 30 inches. Our field representative was present to observe



drilling operations, log the strata encountered and obtain samples. Borings were left open to facilitate delayed water level measurements. Summary logs of the exploratory borings are presented in Appendix A.

Samples were returned to our laboratory where they were examined, and testing was assigned. Laboratory tests included moisture content, dry density, percent silt and clay-sized particles (passing No. 200 sieve), Atterberg Limits, swell-consolidation, soil suction, and water-soluble sulfate concentration. Swell-consolidation tests were performed by wetting the samples under approximate overburden pressures (the pressure exerted of the overlying soils). Results of the laboratory tests are presented in Appendix B and summarized in Table B-I.

SUBSURFACE CONDITIONS

Strata encountered in our exploratory borings consisted of nil to about 16 feet of sandy clay with clayey sand underlain by weathered and comparatively unweathered claystone and sandstone bedrock. The upper 5 feet of clayey sand soil found in TH-117 was dark brown to blackish, and may have contained organic matter. Some pertinent engineering characteristics of the soils and bedrock are described in the following paragraphs.

Overburden soils consisted of sandy to very sandy, silty clay with occasional clayey to very clayey, silty sand and seldom gravel. The average overburden thickness was 5 feet, and it was 8 feet or less in 20 of 23 borings (excluding TH-101, TH-110 and TH-116). The clay was stiff to very stiff and the sand was medium dense to dense based on results of field penetration resistance tests. Sixteen clay samples swelled between 0.4 and 11.2 percent when wetted, with an average of 4.6 percent. Seven samples had load-back swelling pressures of about 1,500 to 10,000 psf and three had total soil suction values of 4.41 and 4.78 pF. Three clay samples contained 54 to 64 percent fines and showed moderate to high plasticity. A clayey sand sample from TH-120 at 4 feet



depth swelled 0.6 percent when wetted, had 43 percent fines and exhibited high plasticity. This sample had a dark brown or blackish organic appearance.

Bedrock consisted of weathered and comparatively unweathered claystone and sandstone bedrock, and was found at depths of 0 to 16 feet, with 20 of 23 borings having bedrock within 8 feet from existing grade. Sandstone was predominant. The sandstone was silty and poorly cemented and/or very hard much of the time. The claystone was silty. Claystone was encountered at the ground surface in TH-112, and below clay in TH-101 and TH-116. The comparatively unweathered claystone was medium hard to hard, and the sandstone was hard to very hard. The sandstone was hard to very hard, with some cemented zones. Cemented sandstone caused practical drill refusal in TH-115 at a depth of about 6 feet, and in three other borings at depths of about 20.5 to 28 feet. One claystone sample did not swell and nine swelled 1.1 to 7.5 percent when wetted, with an average of 2.7 percent. Seven claystone samples developed load-back swelling pressures of approximately 9,500 and 18,000 psf and had soil suction values ranging from 3.95 to 4.47 pF. One claystone sample contained 98 percent fines and was highly plastic. Ten sandstone samples contained 9 to 24 percent silt and clay-sized particles.

Groundwater

Groundwater was encountered during drilling in three borings at a depth of about 22 feet below existing grades. When the holes were checked after drilling on June 2, 2020, water was measured in three borings at depths of 13.5 feet in TH-118, and 18 and 23 feet in two other borings. Groundwater is not expected to influence the planned construction unless drilled piers are used. Deep utility cuts near TH-118 may expose water. Groundwater levels may fluctuate seasonally, and develop or rise in response to development, precipitation, landscape irrigation and changes in land-use.



SITE GEOLOGY AND GEOLOGIC HAZARDS

This section is intended to discuss concerns related to geologic hazards review that occurs during planning and zoning for land use changes. Specific requirements of Colorado House Bill 1041, “Areas and Activities of State Interest,” and Colorado Senate Bill 35, “County Planning and Building Codes” are addressed. This portion of the report was prepared based on field reconnaissance, examination of samples and data, review of subsurface data, and review of pertinent published reports and maps

We reviewed geologic mapping of the site (Geologic Map of the Castle Rock South Quadrangle, Douglas County, Colorado, Colorado Geological Survey Open File Report 04-5, 2004). The mapping and our investigation indicate that the site is covered by clay, sand and gravel of Pleistocene and Holocene Age that overlies Tertiary age sandstone and minor claystone from the Castle Rock Conglomerate and Dawson Formations.

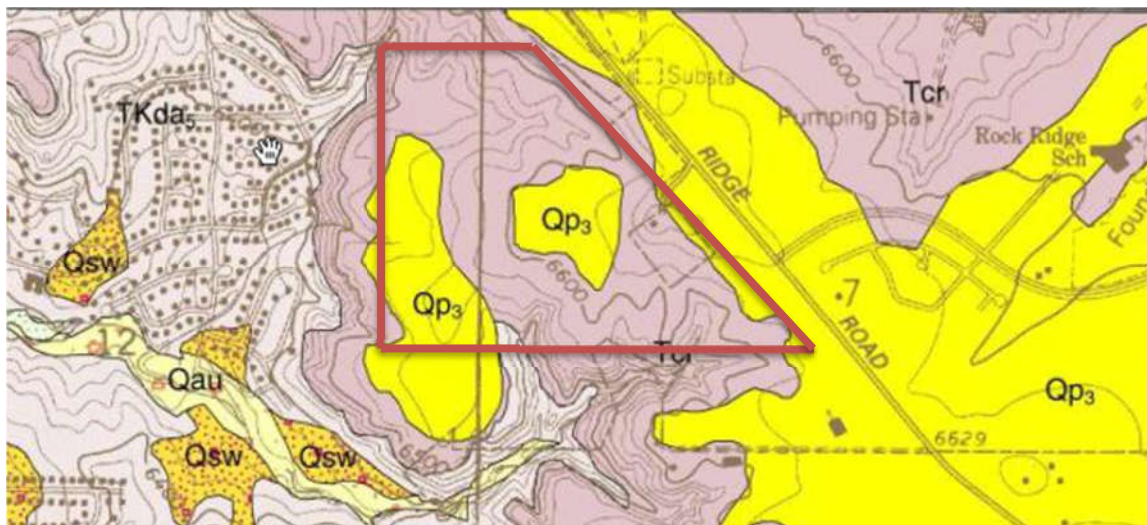


Photo 2 – Cropped Image of Geologic Map Referenced Above

Geologic hazards at the site include expansive soil and bedrock, cemented and very hard bedrock, risk of differential settlement over filled drainages, filling on steep slopes and along drainages, high erosion potential, and the regional geologic hazards of seismicity and naturally occurring radioactive materials. No geologic hazards were



noted that would preclude the proposed development. We believe potential hazards can be mitigated with proper engineering, design, and construction practices, as discussed in this report.

Expansive Soils

Colorado is a challenging location to practice geotechnical engineering. The climate is relatively dry and the near-surface soils are typically dry and comparatively stiff. These soils and related sedimentary bedrock formations react to changes in moisture conditions. Some of the soils swell as they increase in moisture and are referred to as expansive soils. Other soils can compress significantly upon wetting and/or additional loading (from foundations or site grading fill) and are identified as compressible or collapsible soils. Much of the land available for development east of the Front Range is underlain by expansive clay or claystone bedrock near the surface. The soils that exhibit compressible behavior are more likely west of the Continental Divide; however, both types of soils occur throughout the state.

Covering the ground with structures, streets, driveways, patios, etc., coupled with lawn irrigation and changing drainage patterns, leads to an increase in subsurface moisture conditions. As a result, some soil movement due to heave or settlement is inevitable. It is critical that procedures are followed to increase the chances that foundations and slabs will perform adequately.

Expansive soils and bedrock, collectively referred to as expansive soils, are present at this site. Some of the near-surface clay samples had pin-holes or porous structure, which are indicative of compressible soils. The presence of these materials constitutes a geologic hazard. There is risk that foundations and slab-on-grade floors will experience heave or settlement and damage. It is critical that precautions are taken to increase the chances that the foundations and slabs-on-grade will perform satisfactorily. Engineered planning, design and construction of grading, pavements, foundations, slabs-on-grade, and drainage can mitigate, but not eliminate, the effects of expansive



and compressible soils. Deep foundations are often used to isolate structures from expansive soil and bedrock. Sub-excavation is a ground improvement method that can be used to reduce the impacts of swelling and compressible soils. Sub-excavation should be done to remove the clay and claystone at this site where it is present at or near foundation depths.

Cemented and Very Hard Sandstone

Although cemented and very hard sandstone are not typically considered geologic hazards, their presence implies excavation into the material will be difficult. Rock outcrops are present at various locations around the northeast and northwest perimeters and south-central end. In addition to visible outcrops, our borings revealed very hard, cemented sandstone within 8 feet of the ground surface in 17 of the 23 borings, or about three-quarters (i.e., TH-102 through TH-108, TH-111, TH-113 through TH-115, and TH-118 through TH-123).

Overlot grading into cemented or very hard sandstone using scrapers will probably not be possible or efficient. Utility trench excavations using backhoes may also be precluded. Nearby developments such as Founders Village, Castlewood Ranch and Terrain have similar conditions. It has proven difficult and expensive to excavate these materials, and once they are removed, they have to be mechanically broken down to use as backfill. These layers will likely require rock excavation methods using heavy rippers, blasting, rock saws, and/or pneumatic hammers and stingers. In order to reuse the excavated rock, it would need to be broken down to pieces no larger than 3 inches in diameter, then blended with soil fill.

Erosion

We observed no evidence of unstable slopes. Clay slopes as shallow as 3H:1V may exhibit creep. Erosion potential is moderate to high across the site due to erodible soil (such as exposed in the near-vertical banks of the ephemeral drainages) and friable



sandstone. Uncontrolled and concentrated surface runoff has the potential to create damaging erosion. Erosion potential will increase during construction, but should return to preconstruction rates or less if proper grading practices, surface drainage design, and revegetation efforts are implemented. Construction sites within the Denver Metropolitan area are subject to the U.S. Environmental Protection Agency (EPA) regulations regarding the control of storm water discharge and soil erosion.

Seismicity

The soil and bedrock units are not expected to respond unusually to seismic activity. The area is considered by the Uniform Building Code (UBC) as Zone 1. According to the 2018 International Residential Code (IRC Standard Penetration Resistance method of Section 16), and based upon the results of our investigation, we judge the site classifies as Seismic Site Class C. This area, like most of Colorado, is subject to a low degree of seismic risk. Only minor damage to relatively new, properly designed and constructed structures would be expected with a major seismic event. Wind loads, not seismic considerations, typically govern dynamic structural design in this area.

Shallow Groundwater

We measured groundwater at about 13.5 feet below the ground surface in TH-118. Shallow groundwater is considered a geologic hazard. Site grades should be designed to avoid creating shallow groundwater conditions. We recommend providing at least 3 feet, and preferably 5 feet, of separation between basement excavations and groundwater.

Radioactivity

It is normal in the Front Range of Colorado and nearby eastern plains to measure radon gas in poorly ventilated spaces (e.g., basements and crawl spaces) in contact with soil or bedrock. Radon 222 gas is considered a health hazard and is just one of



several radioactive products in the chain of the natural decay of uranium into lead. Radioactive nuclides are common in the soil and bedrock underlying the subject site. Because these sources exist or will exist on most sites in the area, there is a potential for radon gas accumulation in poorly ventilated spaces. The concentration of radon that can develop is a function of many factors, including the radionuclide activity of the soil and bedrock, construction methods and materials, soil gas pathways, and accumulation areas. The only reliable method to determine if a hazard exists is to perform radon testing of completed residential structures. Typical mitigation methods consist of sealing soil gas entry areas, ventilation of below-grade spaces, and venting from foundation drain systems. We recommend provision for ventilation of foundation drain systems if a radon problem is discovered.

Other Considerations

Site topography indicates that some water would be expected to flow onto the site from the northeast. During peak precipitation events, some accumulation of surface sheet flow in drainages is expected. Development will increase the relative amount of impervious surfaces, which can lead to drainage problems and erosion if surface water flow is not adequately designed. Surface drainage design and evaluation of flood potential should be performed by a civil engineer as part of the project design.

Fill or organic soil may be present. These are considered unsuitable for foundation or structure support because of variable, unpredictable performance. Undocumented fill and organics should be removed and replaced as low swelling, uniformly compacted soil capable of reliably supporting planned loads. Our experience on sites with heavy scrub oak indicates the upper soils within the root zone can contain more than 5 percent organic matter, which is considered unsuitable for new fill.

We did not identify economically recoverable, high quality aggregate in our borings. We believe there are no economic aggregate resources on the site. In most of the Denver area, oil and gas is present in deep formations, particularly shales that until



recently were uneconomic for production. We do not believe there are energy resources present in economic quantities on the property.

ESTIMATED POTENTIAL HEAVE

Based on the subsurface profiles, swell-consolidation test results, and our experience, we have estimated the total potential ground heave for each test hole as tabulated below. The analysis involves dividing the soil profile into layers and modeling the heave of each layer from representative swell tests. A depth of wetting of 24 feet below existing grades was considered for the analysis. This depth of wetting is typically used for irrigated residential sites with basements.

We estimate potential ground heave may range from less than 0.5-inch to about 8.5 inches. Variation from our estimates should be anticipated. It is not certain the estimated heave will occur. The planned grading will affect the potential heave estimates.

Based on our investigation and experience in this area, we believe there is moderate to high risk that foundations and slab-on-grade floors will experience damaging heave without ground modification where clay or claystone remain present within influence depths. The risk is judged to be high at TH-101, TH-112 and TH-116.

ESTIMATED TOTAL POTENTIAL GROUND HEAVE

Boring	Estimated Potential Heave (in)
TH-101	4.9
TH-102	1.4
TH-103	1.4
TH-104	0.9
TH-105	0.8
TH-106	1.4
TH-107	2.7
TH-108	<0.5
TH-109	3.7
TH-110	6.4
TH-111	3.9



Boring	Estimated Potential Heave (in)
TH-112	8.1
TH-113	0.5
TH-114	1.4
TH-115	<0.5
TH-116	8.6
TH-117	2.8
TH-118	0.8
TH-119	4.8
TH-120	0.5
TH-121	2.1
TH-122	0.7
TH-123	3.2

SITE DEVELOPMENT

The primary geotechnical concern that is expected to influence site development and structure performance is the presence of expansive soil and bedrock, and cemented or very hard bedrock. These concerns can be mitigated with proper planning, engineering, design and construction. Grading plans should be reviewed once they are available to determine whether our recommendations remain valid. Considering the variation in the subsurface conditions, and that we were unable to access the north edge of the site with a truck rig, additional exploratory borings should be considered to better delineate the subsurface conditions. We believe there are no geologic or geotechnical constraints at this site that would preclude development. The following sections provide site development recommendations based on anticipated construction.

Excavation

We believe the soil and medium hard to hard bedrock penetrated by our exploratory borings can generally be excavated with typical heavy-duty equipment, possibly with the exception of the cemented and very hard sandstone. We recommend the owner and the contractor become familiar with applicable local, state and federal safety regulations, including the current Occupational Safety and Health Administration



(OSHA) Excavation and Trench Safety Standards. Based on our investigation and OSHA standards, we anticipate the clay may classify as Type B soil, the sand as Type C, and bedrock as Type A or B, depending on hardness and degree of cementation. Type A, B, and C soils require maximum slope inclinations of $\frac{3}{4}$:1, 1:1, and 1.5:1 (horizontal:vertical), respectively, for temporary excavations in dry conditions. Flatter slopes may be needed if seepage is present. Excavation slopes specified by OSHA are dependent upon soil types and groundwater conditions encountered. The contractor's "competent person" is required to identify the materials encountered in the excavations and refer to OSHA standards to determine appropriate slopes. Stockpiles of soils and equipment should not be placed within a horizontal distance equal to one-half the excavation depth, from the edge of the excavation. A professional engineer should design excavations deeper than 20 feet.

Excavations in cemented sandstone, and perhaps very hard sandstone (50/5 and harder), will be challenging and will require additional effort for efficient excavation. Hard rock excavation techniques typically include combinations of heavy ripping, pneumatic hammers, rock saws and/or controlled blasting. Heavy ripping and slower than normal excavating should be anticipated.

Residential builders typically retain excavation contractors with equipment capable of digging basement excavations in soil and bedrock typical along the Front Range, but not cemented rock. It would be advantageous to convey this issue to potential builders. Where cemented sandstone is present, blasting to bottom of basement level or slightly deeper can be considered to reduce excavation challenges. Excavated cemented bedrock may require crushing in order to reuse as fill. Crushing should result in 3 inch particle size or finer. A site development contractor with hard rock excavation experience and equipment is recommended for this project.



Site Grading

Prior to fill placement, the ground surface in areas to be filled should be stripped of existing fill and debris (if any), vegetation/organics (including scrub oak root-soil), and other deleterious materials, scarified to a depth of at least 8 inches, and moisture conditioned according to the table below. Additional scarifying and grubbing may be needed in drainage areas to remove organic materials. Drainages should be substantially free of soft soils and organics. Sub-fill drains should be installed at the discretion of the developer if deep fills are planned over the backfilled drainages.

If imported fill is necessary it should ideally consist of soil which is similar to the on-site soil, which are sand-predominant. Potential fill materials should be submitted to our office for approval prior to importing to the site.

The properties of fill will affect the performance of foundations, slabs-on-grade, utilities, pavements, flatwork and other improvements. The on-site soils are suitable for use as new fill provided they are substantially free of debris, vegetation/organics, deleterious materials, and chunks greater than 3 inches. Bedrock chunks should be broken down, by mechanical means if necessary. Fill should be placed in thin loose lifts no more than 8 inches, moisture conditioned and compacted prior to placement of the next lift. Recommended moisture conditioning and compaction criteria are tabulated below. The placement and compaction of new fill should be observed and density tested by our representative during construction. Guideline site grading specifications are presented in Appendix C.

SUMMARY OF GRADING FILL PLACEMENT CRITERIA

Soil Classification	Depth of Fill (feet)	Minimum Compaction (ASTM D 698)	Moisture Content From Optimum
Clay and Claystone	0 to 15 15+	95 % ASTM D 698 Not Recommended	+1 to +4 Not Recommended
Sand and Sandstone	0 to 20 20 to 25	95 % ASTM D 698 100% ASTM D 698	-2 to +2 -2 to +2



Our experience has shown clay fill moisture-treated at optimum moisture content or above will exhibit lower swell than clay fill receiving the same compactive effort but moisture treated below optimum moisture content.

Our experience indicates fill will settle under its own weight. We estimate potential settlement of about 1 to 2 percent of the fill thickness even if the fill is compacted to the specified criteria. Most of this settlement usually occurs during and soon after construction; for clayey fill, it may continue for a longer period of time. Additional heave and settlement may occur after development as landscape irrigation increases the moisture of the soils.

Sub-Excavation

Strata found in our exploratory borings in the southwest and southeast parts of the site were erratic. Claystone was found at the ground surface in TH-112, where up to 8.5 inches of heave is possible. At TH-101, TH-116, and TH-117, we found expansive clay near the surface and expansive claystone at intermediate depths. Moderately deep, expansive clay was found in TH-109 and TH-110 to about 12 feet. Drilled piers and structurally supported basement floors are typically recommended for sites with significant potential heave. Considering the presence of sandstone within 8 feet of the ground surface in three-quarters of the site, most of the site is considered to have relatively low risk of damaging movements excluding the materials above the bedrock, which appear to be thin based on our borings. Site grading will have a significant impact on sub-excavation which is merited at this site. The discussions presented in this section assume no grading or are relative to the existing ground surface without any grading being taken into account.

The expansive surficial clay likely necessitates use of Type II footings constructed at the basement level or sub-excavation to reduce potential heave for standard-depth Type I footings. Type II footings result in more concrete to extend garage and



crawl space walls downward. As an alternative to using Type II footings for most lots, sub-excavation of the materials above the sandstone can be performed.

It is likely that deep sub-excavation to depths of at least 10 feet below basement foundations will be merited in the areas of TH-101, TH-112 and TH-116 to mitigate the impacts of clay and claystone. The remainder of the site can be considered to have expansive clay to depths ranging from 1 to 12 feet, with sandstone below. Therefore, we prepared sub-excavation considerations on Fig. 3 and contoured the top of the sandstone bedrock on Fig. 4 as an estimate of the bottom of the sub-excavation outside the deep sub-excavation areas. Where deep sub-excavation areas terminate, consideration should be given to not construct ramps below foundations just outside the sub-excavation area. Differential depths of fill below house footprints may result in differential footing settlement.

The erratic nature of the soil and bedrock in this area increases the likelihood that expansive claystone is encountered after site grading in areas which are considered to have shallow sandstone. If you desire better definition of the depths and areas that may benefit from sub-excavation, we recommend further investigation after a grading plan has been established. In addition, we were unable to drill the north end of the site due to steep uphill slopes and heavy scrub oak. While the area is considered to likely have shallow sandstone considering the nearby outcrops, a boring should be drilled to determine the conditions.

We encountered practical refusal at 6 feet in TH-115 in cemented sandstone bedrock. The two adjacent borings to the northwest, TH-112 and TH-116 had claystone, one at the surface and one at intermediate depth. It is possible claystone is present below the sandstone at TH-115. A specialized drill rig is needed to core the sandstone to explore the presence of claystone beneath the sandstone. We can arrange this specialized drilling as part of additional investigation once grading plans are developed.



Sub-excavation has been used in the Denver area with satisfactory performance for most of the sites where this ground modification method has been completed. We have seen isolated instances where settlement of sub-excavation fill has led to damage to houses supported on footings. In most cases, the settlement was caused by wetting associated with poor surface drainage or seepage, and/or poorly compacted fill placed at the horizontal limits of excavation. Wetting of the fill may cause softening and settlement. Use of drilled pier foundations would be prudent if risk of footing movement is not tolerable.

There can be cases where the sub-excavation limits and depth are not adequate to encompass an entire building footprint including deck, patio and porch. As a result, the building must be founded on deep foundations. Proper planning of the sub-excavation limits and depth based on the largest model plan and as-built surveying of the limits and depth during the sub-excavation is important to reduce this risk. The sub-excavation areas should be staked by a surveyor, and we recommend periodic surveying verification of the “as-built” bottom of the excavations. An “as-built” sub-excavation plan should be prepared and provided to construction and sales staff to ensure entire building footprints are located within the sub-excavated area.

The excavation slopes should meet OSHA, state, and local safety standards. The bottom of the sub-excavated area should extend laterally at least 5 feet and outside the largest possible foundation footprints to ensure foundations are constructed over moisture conditioned fill. Conceptual sub-excavation profiles are shown on Figs. 5 and 6.

The excavation contractor should be chosen carefully to assure they have experience with fill placement at over-optimum moisture and have the necessary compaction equipment. The contractor should provide a construction disc to break down fill materials and anticipate use of push-pull scraper operations and dozer assistance. The operation will be relatively slow. In order for the procedure to be performed properly, close contractor control of fill placement to specifications is required. The swell of the sub-excavation fill should be tested during and after fill placement to better evaluate whether



the desired results have been achieved. Soils and bedrock chunks should be broken down to 3 inches and less. Sub-excavation fill should be moisture-conditioned between 1 and 4 percent above optimum moisture content for clay or within 2 percent of optimum for sand, and compacted at least 95 percent of standard Proctor maximum dry density. The average test moisture content of each day's testing should be at least 1.5 percent above optimum.

Special precautions should be taken for compaction of fill at corners, access ramps, and along the perimeters of the sub-excavation as large compaction equipment cannot easily reach these areas. Our representative should observe placement procedures and test compaction of the fill on a nearly full-time basis. The swell of the moisture-conditioned fill should be tested during the fill placement. Guideline sub-excavation specifications are presented in Appendix D.

If the fill dries excessively prior to construction, it may be necessary to rework the upper drier materials just prior to constructing foundations. We estimate the fill should retain adequate moisture for about two years and can check moisture conditions in each excavation as construction progresses, if requested.

Sub-excavation and replacement with low swell fill will likely allow use of standard-depth footing foundations for lightly loaded structures and enhance performance of slab-on-grade floors. Sub-excavation will also enhance performance of concrete flatwork (driveways and sidewalks) and pavements, potentially reducing maintenance costs. Sub-excavation between 3 and 5 feet below subgrade will likely enhance the pavement performance. We suggest you consider some sub-excavation below all hardscapes (driveways, sidewalks, etc.).

Slopes

We recommend permanent cut and fill slopes be designed with a maximum grade of 3:1 (horizontal to vertical). If site constraints do not permit construction with



recommended slopes, we should be contacted to evaluate the subsurface soils and steeper slopes. Surface drainage should not be allowed to sheet flow across slopes or pond near the crest of slopes. All cut and fill slopes should be designed and re-vegetated as soon as possible after grading to reduce potential for erosion problems. Excavation contractors should evaluate ground conditions and control slopes in accordance with OSHA criteria. Where fill is placed on slopes of 20 percent or steeper, the slope should be benched prior to fill placement, as shown on Fig. 10.

Underdrain

With long-term development and subsequent irrigation, groundwater may develop and rise and subsoils may become wetted by irrigation. We believe this water should be controlled. The water could lead to expansive soil related problems and frequent pumping of foundation drains. If allowed, we advocate the use of an underdrain system incorporated into the design of sanitary sewer systems to provide a means to control water and allow gravity discharge from the basement foundation drains. Our experience suggests the Town of Castle Rock will not allow use of underdrains installed near sewer mains or under streets. Given Castle Rock's position, use of sump pits with pumps in each house should also be anticipated. Sump discharge can result in ponding and recycling if slopes between lots are not adequately graded. Problems with chronic ice or algae formation at sidewalks have also been blamed on sump discharge. If used, conceptual sewer underdrain details are provided on Figs. 7 through 9. The underdrain should be provided with clean-outs and be maintained. Drain outfalls should be designed with a concrete head wall large enough to protect the pipe from damage during maintenance. We are available to assist in design of the underdrain systems, if pursued.

Sub-Fill Drains

Sub-fill drains may be considered where deep fills are planned over pre-existing drainages. Each drain alignment and profile should be designed by the civil engineer. Drains should be designed along lot lines and not under residences or where it could be



damaged by future excavations such as installation of utilities or deep foundations. The bottom of the drains should follow the bottom elevation of adjacent drainages as close as practical. Shallow excavations below existing grade will be necessary to accommodate the drainage elevation. It appears drains can “day light” to grade at the southwest end of the site. The Civil Engineer should evaluate the practicality of day lighting drains to grade and check with governing water agencies to see if they will permit discharge. Discharge may also affect downstream sites. We can discuss this further, if desired.

Utilities

Water and sewer lines are usually constructed beneath paved roads. Compaction of trench backfill can have a significant effect on the life and serviceability of pavements. Trench backfill should be placed in thin (8 inches or less) loose lifts and moisture conditioned to between optimum and 4 percent above optimum moisture content for clay and claystone and compacted to at least 95 percent of maximum dry density (ASTM D 698). Sand fill should be moisture conditioned to within 2 percent of optimum moisture content and compacted to 100 percent of maximum dry density. The placement and compaction of trench fill and backfill should be observed and tested by our firm during construction.

Our experience indicates use of a self-propelled compactor results in more reliable performance compared to backfill “compacted” by a sheepsfoot wheel attachment on a backhoe or trackhoe. The upper portion of the trenches should be widened to allow the use of a self-propelled compactor. Special attention should be paid to backfill placed adjacent to manholes as we have seen instances where settlement in excess of 2 percent has occurred. Any improvements placed over backfill should be designed to accommodate movement.

We have seen occurrences of sharp differential settlement and pavement distress where utilities are saw cut into cemented sandstone and clay backfill is used. To mitigate this issue, we recommend that sand and/or sandstone be used as backfill and



compacted to higher degree where near vertical excavations are cut into cemented sandstone. This will likely apply for utilities on top of the mesa. This recommendation applies to material placed adjacent to cemented sandstone only. For example, if a utility cut results in soil over cemented sandstone, clay and/or claystone can be used as back-fill for the portion of the excavation in natural soil.

Pavements

Clay and claystone are considered poor pavement subgrade material, while sand and sandstone are considered better support subgrade. Expansive soil mitigation including 3 feet, and preferably 5 feet, of sub-excavation should be considered. It may be advantageous to do street sub-excavation during or after deep utilities are installed.

Our experience with the Town of Castle Rock leads us to believe that local streets will consist of at least 4 inches of asphalt over 6 inches of aggregate base course or 6 inches of Portland cement concrete. Full-depth asphalt pavement sections are not allowed by the Town on expansive soil sites. Lime or cement subgrade treatment may be needed to treat the upper 12 inches of clay subgrade if moisture treatment results in soft or yielding subgrade. Cemented bedrock subgrade causes point loads on the pavement and will likely need to be removed to provide more uniform support conditions. A design-level subgrade investigation should be done prior to paving.

BUILDING CONSTRUCTION CONSIDERATIONS

The following discussions are preliminary and are not intended for design or construction. After grading is completed, design-level investigations should be performed on a lot-specific basis.



Foundations

Drilled piers bottomed in bedrock are typically used where relatively high swelling soil and bedrock are encountered and are likely where clay/claystone are present at or just below foundation levels unless sub-excavation is performed, as discussed previously. Drilled pier lengths may be relatively long, 25 to 30 feet or longer, where expansive claystone is present, and shorter, 15 to 20 feet where clay extends to intermediate depths or weathered claystone is present above sandstone.

The expansive surficial clay likely necessitates use of Type II footings constructed at the basement level or sub-excavation to reduce potential heave for standard-depth Type I footings. Type II footings result in more concrete to extend garage and crawl space walls downward. As an alternative to using Type II footings for most lots, sub-excavation of the materials above the sandstone can be performed.

Footing foundations will likely be suitable where sandstone is present at foundation depths, or after sub-excavation is successfully implemented. We preliminarily estimate maximum allowable soil pressures of 2500-3000 psf for new fill, and up to 10,000 psf for sandstone.

Floor Systems

Slab-on-grade basement floors may be considered on low and some moderate swell sites where potential heave is acceptable to the homebuyers. Structurally supported basement floors should be used on all sites with high risk of poor basement slab performance. Sub-excavation should reduce potential heave and upgrade the risk to low.

The performance of garage floors, driveways, sidewalks and other surface flat-work may be poor where expansive soils are present, unless sub-excavation is



performed. The following precautions will be required to reduce the potential for damage due to movement of slabs-on-grade placed at this site:

1. Isolation of the slabs from foundation walls, columns and other slab penetrations;
2. Voiding of interior partition walls to allow for slab movement without transferring the movement to the structure;
3. Flexible water and gas connections to allow for slab movement. A flexible plenum above furnaces will be required; and
4. Proper surface grading and foundation drain installation to reduce water availability to sub-slab and foundation soils.

Below-Grade Areas

Surface water can penetrate relatively permeable loose backfill soils located adjacent to residences and collect at the bottom of relatively impermeable basement or crawl space excavations, causing wet or moist conditions after construction. Foundation walls and grade beams should be designed to resist lateral earth pressures. Foundation drains should be constructed around the lowest excavation levels of basement and/or crawl space areas. These drains could be connected to an underdrain system (Fig. 9) to provide a gravity outlet, if allowed. Sump pits should be provided if underdrains are not allowed so pumps can be installed as a backup if underdrains do not perform as intended. The drains can be connected to a gravity outfall, underdrain, or a sump pit where water can be removed by pumping.

Concrete

Concrete in contact with soil can be subject to sulfate attack. We measured water-soluble sulfate concentrations of 0.04 percent and less in two samples from this site. For this level of sulfate concentration, ACI 332-08 *Code Requirements for Residential Concrete* indicates there are no special requirements for sulfate resistance.



In our experience, superficial damage may occur to the exposed surfaces of highly permeable concrete, even though sulfate levels are relatively low. To control this risk and to resist freeze-thaw deterioration, the water-to-cementitious materials ratio should not exceed 0.50 for concrete in contact with soils that are likely to stay moist due to surface drainage or high water tables. Concrete should have a total air content of 6 percent $\pm$ 1.5 percent. We recommend all foundation walls and grade beams in contact with the subsoils (including the inside and outside faces of garage and crawl space grade beams) be damp-proofed.

Surface Drainage

The performance of improvements will be influenced by surface drainage. When developing an overall drainage scheme, consideration should be given to drainage around each residence. The ground surface around the residences should be sloped to provide positive drainage away from the foundations. We recommend a slope of at least 10 percent for the first 10 feet surrounding each residence, where practical. If the distance between houses is less than 20 feet, the slope in this area should be 10 percent to the swale between houses. Where possible, drainage swales should slope at least 2 percent. More slope is desirable. Variation from these criteria is acceptable in some areas. For examples, for lots graded to direct drainage from the rear yard to the front, it is difficult to achieve the recommended slope at the high point behind the house. We believe it is acceptable to use a slope of about 6 inches in the first 10 feet at this location. Roof downspouts and other water collection systems should discharge well beyond the limits of all backfill around structures.

Proper control of surface runoff is also important to control the erosion of surface soils. Sheet flow should not be directed over unprotected slopes. Water should not be allowed to pond at the crest of slopes. Permanent slopes should be prepared in such a way to reduce erosion.



Attention should be paid to compact the soils behind curb and gutter adjacent to streets and in utility trenches during the development. If surface drainage between preliminary development and construction phases is neglected, performance of the roadways, flatwork and foundations may be poor.

CONSTRUCTION OBSERVATIONS

This report has been prepared for the exclusive use of D.R. Horton and your design team for due diligence assessment and planning for the proposed project. The information, conclusions, and recommendations presented herein are based upon consideration of many factors including, but not limited to, the type of structures proposed, the geologic setting, and the subsurface conditions encountered. The conclusions and recommendations contained in the report are not valid for use by others. Standards of practice evolve in the area of geotechnical engineering. The recommendations provided are appropriate for about three years. If the site is not developed within about three years, we should be contacted to determine if we should update this report.

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

RECOMMENDED SERVICES

Based on the results of this investigation and the proposed development being considered, we recommend the following investigations and services:

1. Review of grading plans to evaluate our sub-excavation discussions;
2. Review of the subsequent sub-excavation plans;



3. Review of subsurface drainage systems, if considered;
4. Construction testing and observation during site development, sub-excavation, and building or pavement construction, including compaction testing of grading fill, utility trench backfill, and pavements;
5. Subgrade investigation and pavement design after grading;
6. Design-level soils and foundation investigations after grading; and
7. Foundation installation observations.

LIMITATIONS

Our borings were widely spaced to provide a general picture of subsurface conditions for preliminary assessment and planning purposes. Variations in the subsoil conditions not indicated by our borings are possible. We believe this investigation was conducted with that level of skill and care ordinarily used by geotechnical engineers practicing under similar conditions. No warranty, express or implied, is made.

If we can be of further service in discussing the contents of this report or in the analysis of the influence of subsoil conditions on design of the structures, please call.

CTL | THOMPSON, INC.

Hayden J. Ehrle
Staff Engineer

Reviewed by:

Benny I. Lujan, P.E.
Associate

Reviewed by:

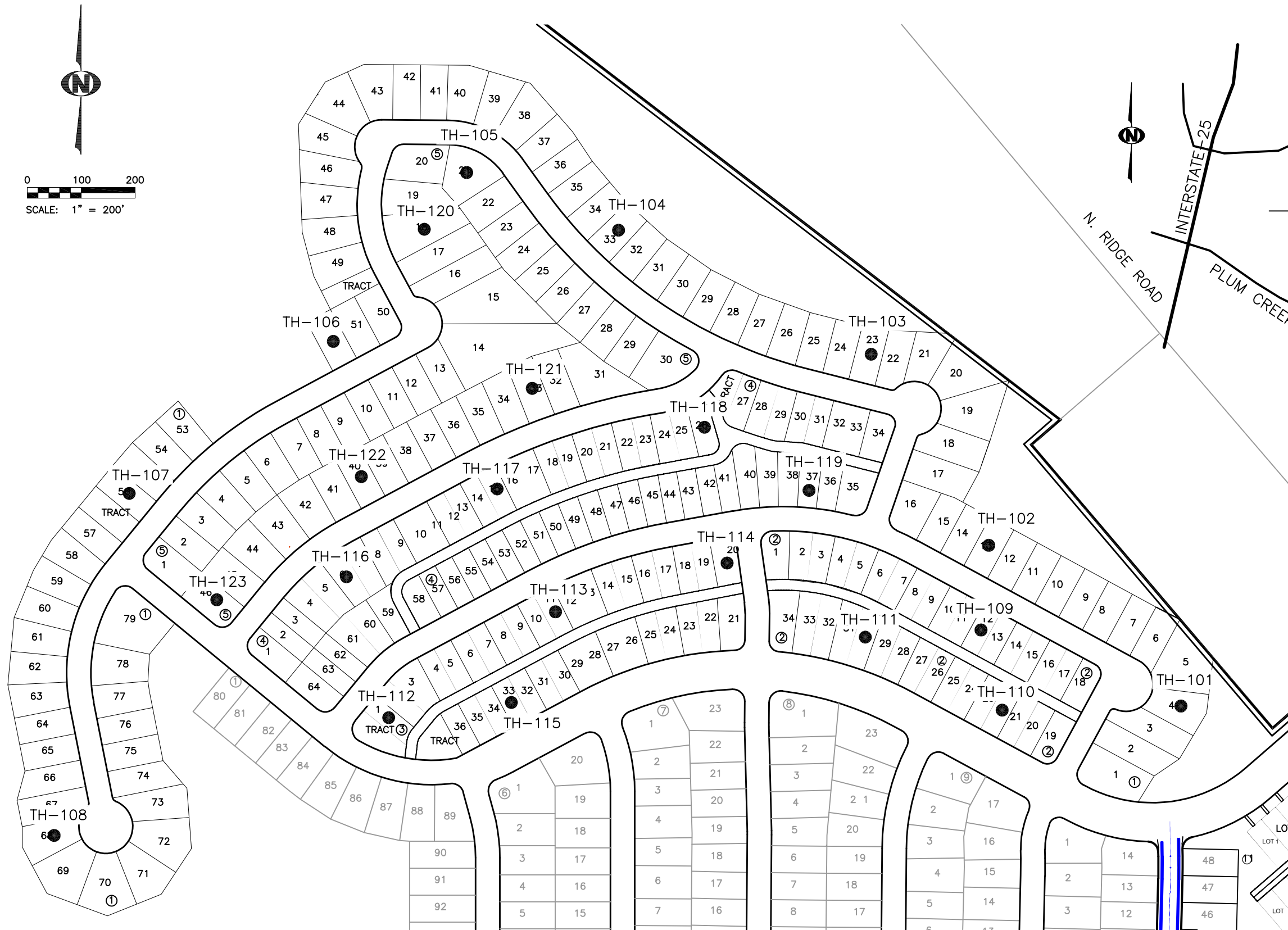
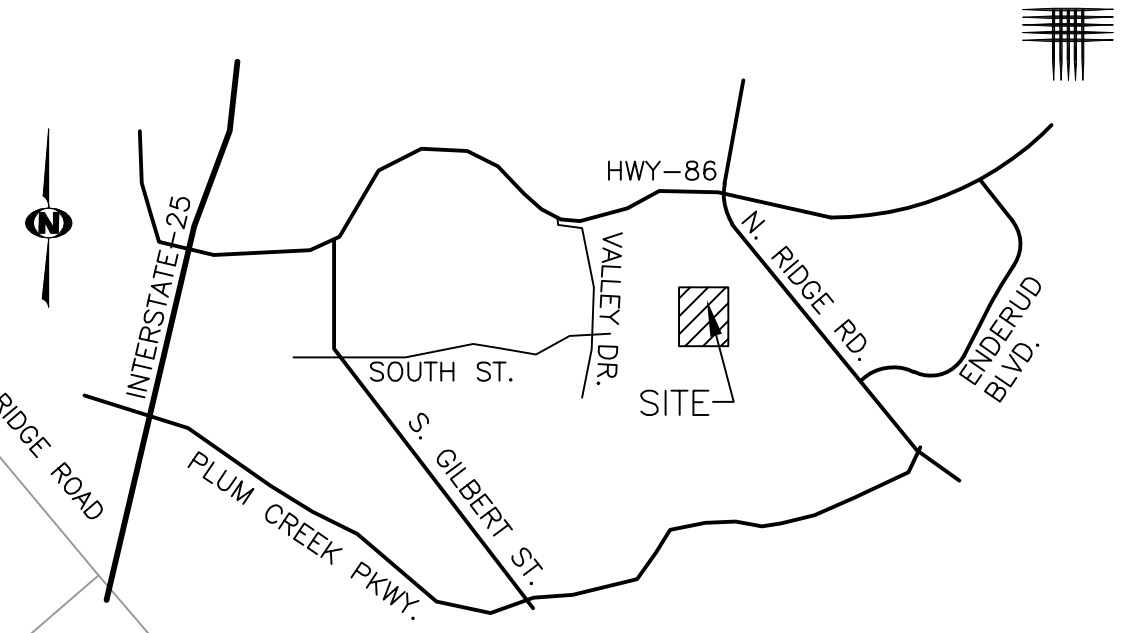
David A. Glater, P.E., C.P.G.
Principal Geological Engineer

HE:BIL:DAG/he/bil/nn

Via e-mail: soschman@drhorton.com

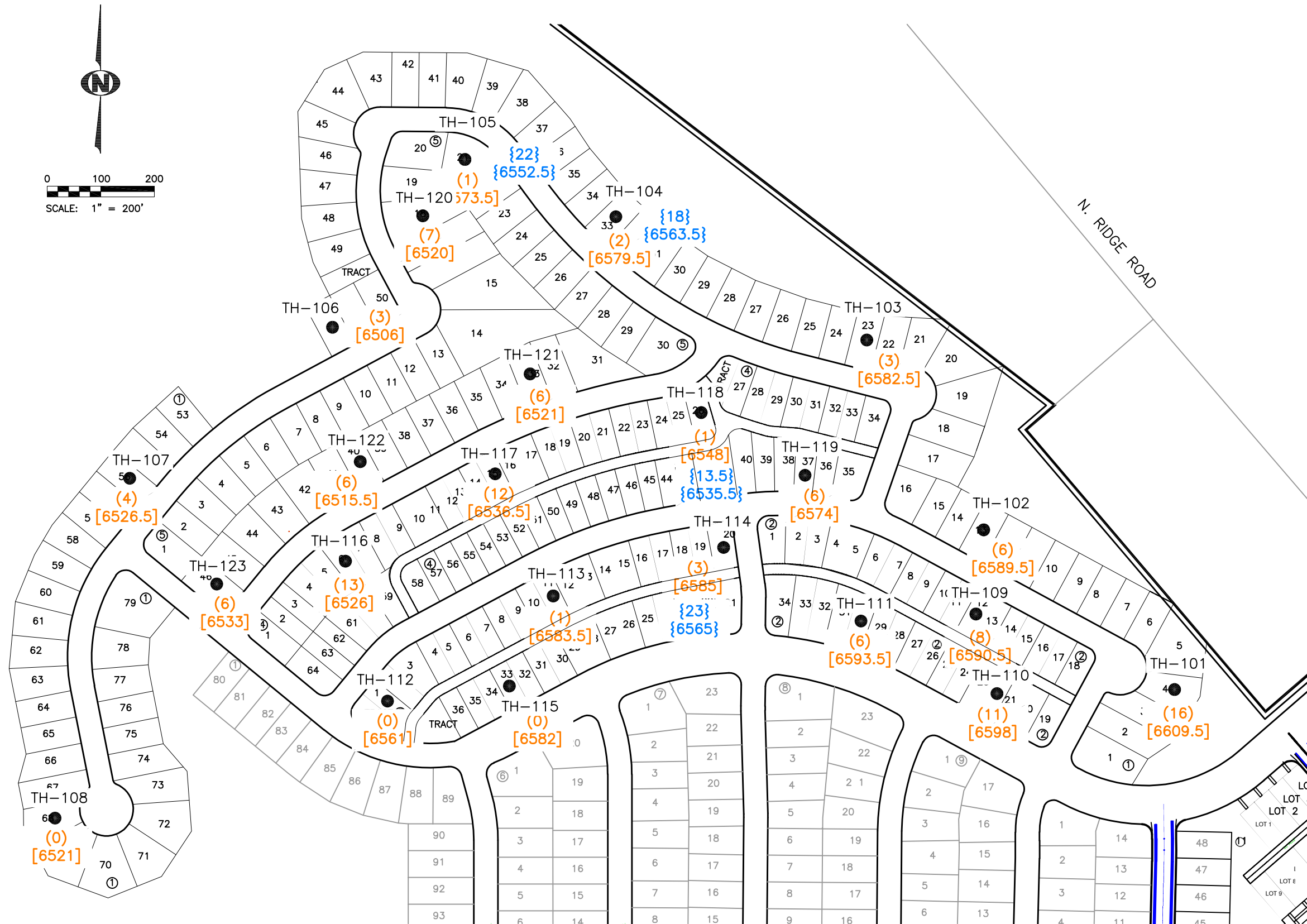


Benny I. Lujan
Jun 19 2020



VICINITY MAP
NOT TO SCALE

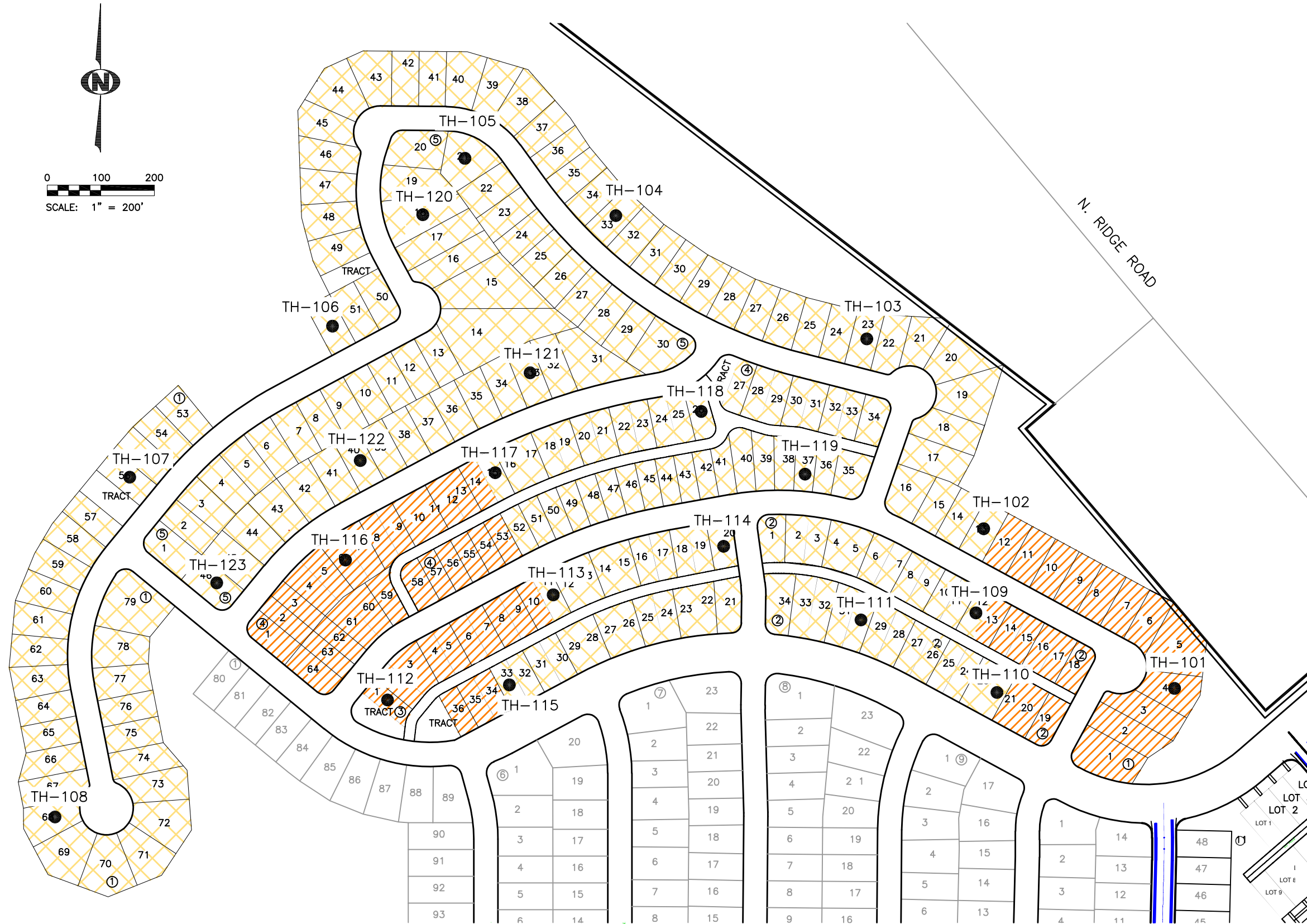
LEGEND:
 TH-101 APPROXIMATE LOCATION OF EXPLORATORY BORING



LEGEND:

- TH-101 APPROXIMATE LOCATION OF EXPLORATORY BORING
- (16) INDICATES APPROXIMATE DEPTH TO BEDROCK AT BORING LOCATION (FEET)
- [6609.5] INDICATES APPROXIMATE BEDROCK ELEVATION AT BORING LOCATION (FEET)
- {20.5} INDICATES APPROXIMATE DEPTH TO GROUNDWATER AT BORING LOCATION (FEET)
- {6563.5} INDICATES APPROXIMATE GROUNDWATER ELEVATION AT BORING LOCATION (FEET)

NOTE: THIS ESTIMATE WAS BASED UPON A SUBJECTIVE ANALYSIS OF DRILL HOLE DATA AND MAY NOT REFLECT LOCAL VARIATIONS.



LEGEND:

TH-101 APPROXIMATE LOCATION OF EXPLORATORY BORING

SUB-EXCAVATION TO SANDSTONE APPEARS MERITED TO REDUCE POTENTIAL HEAVE

DEEPER SUB-EXCAVATION (10 FEET BELOW BASEMENT APPEARS MERITED TO REDUCE POTENTIAL HEAVE

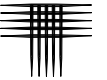
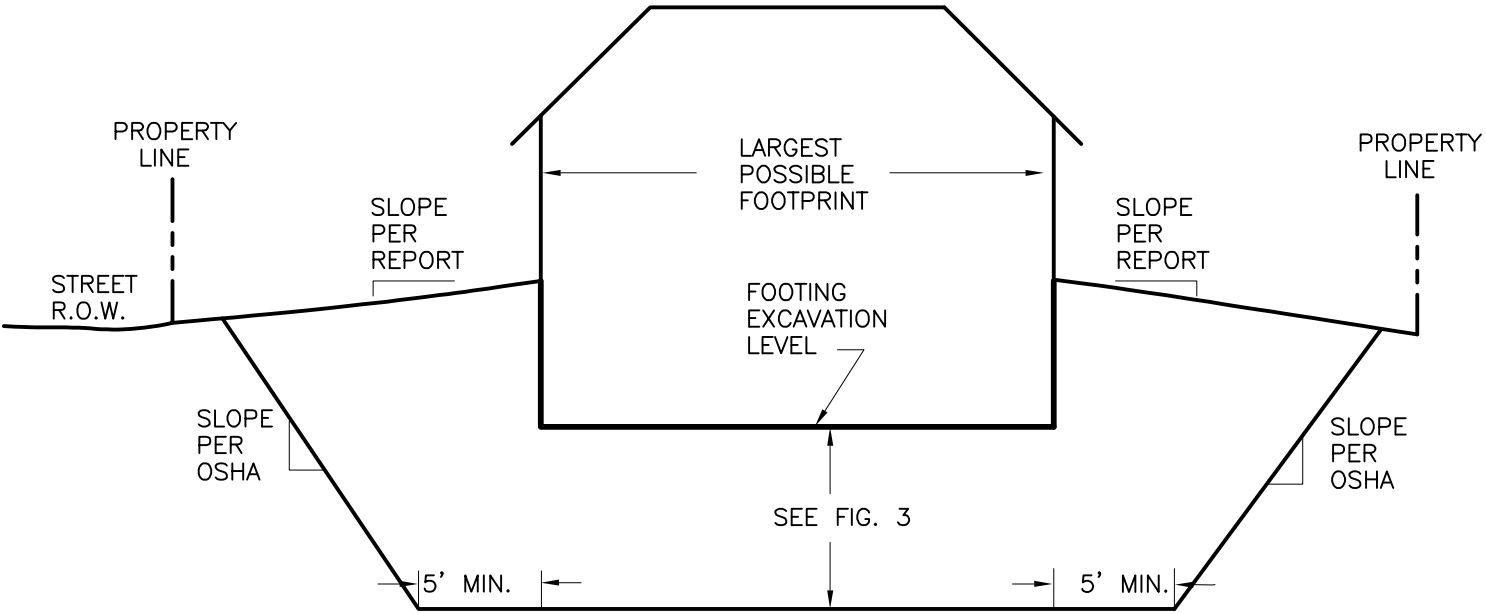
NOTE: GRADING PLANS WILL AFFECT THIS ESTIMATE



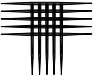
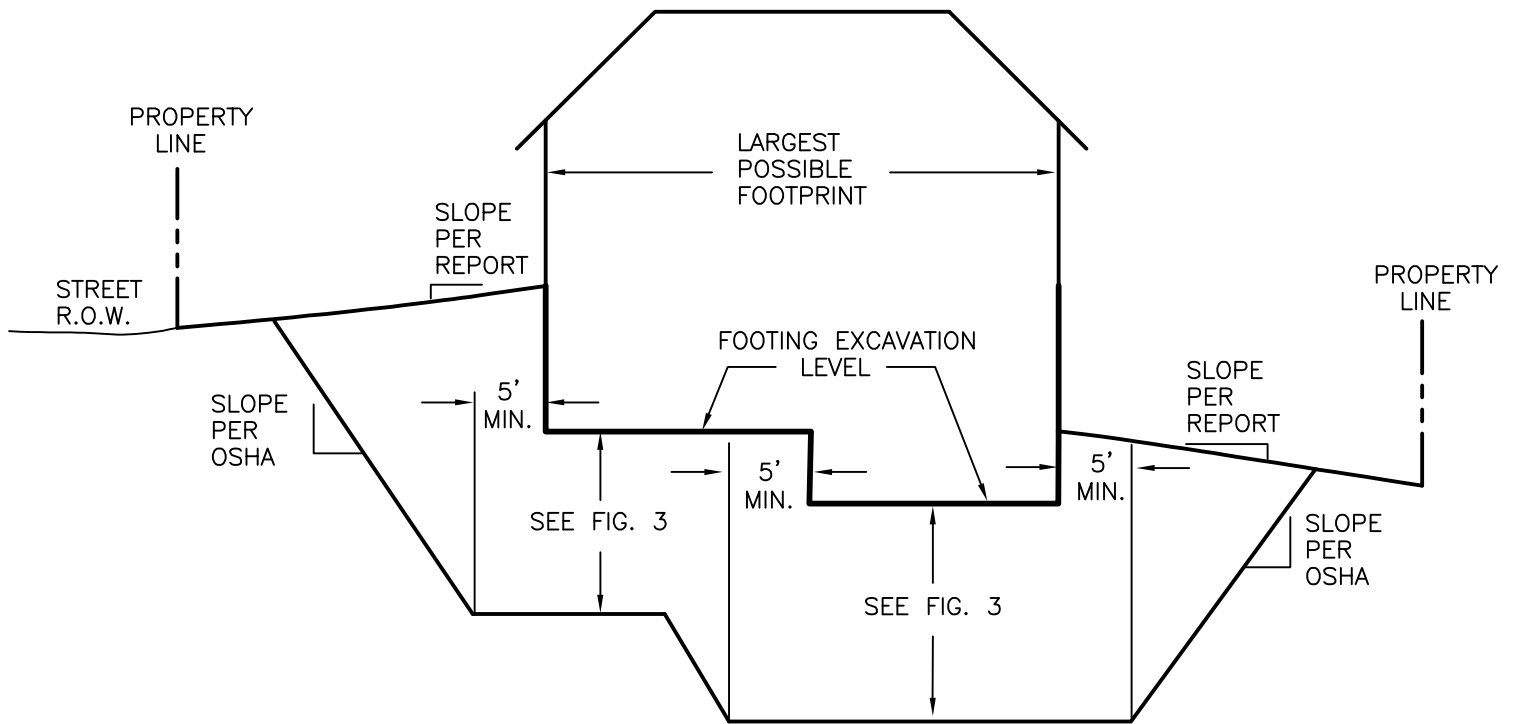
LEGEND:

TH-101 APPROXIMATE LOCATION OF
EXPLORATORY BORING

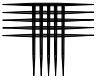
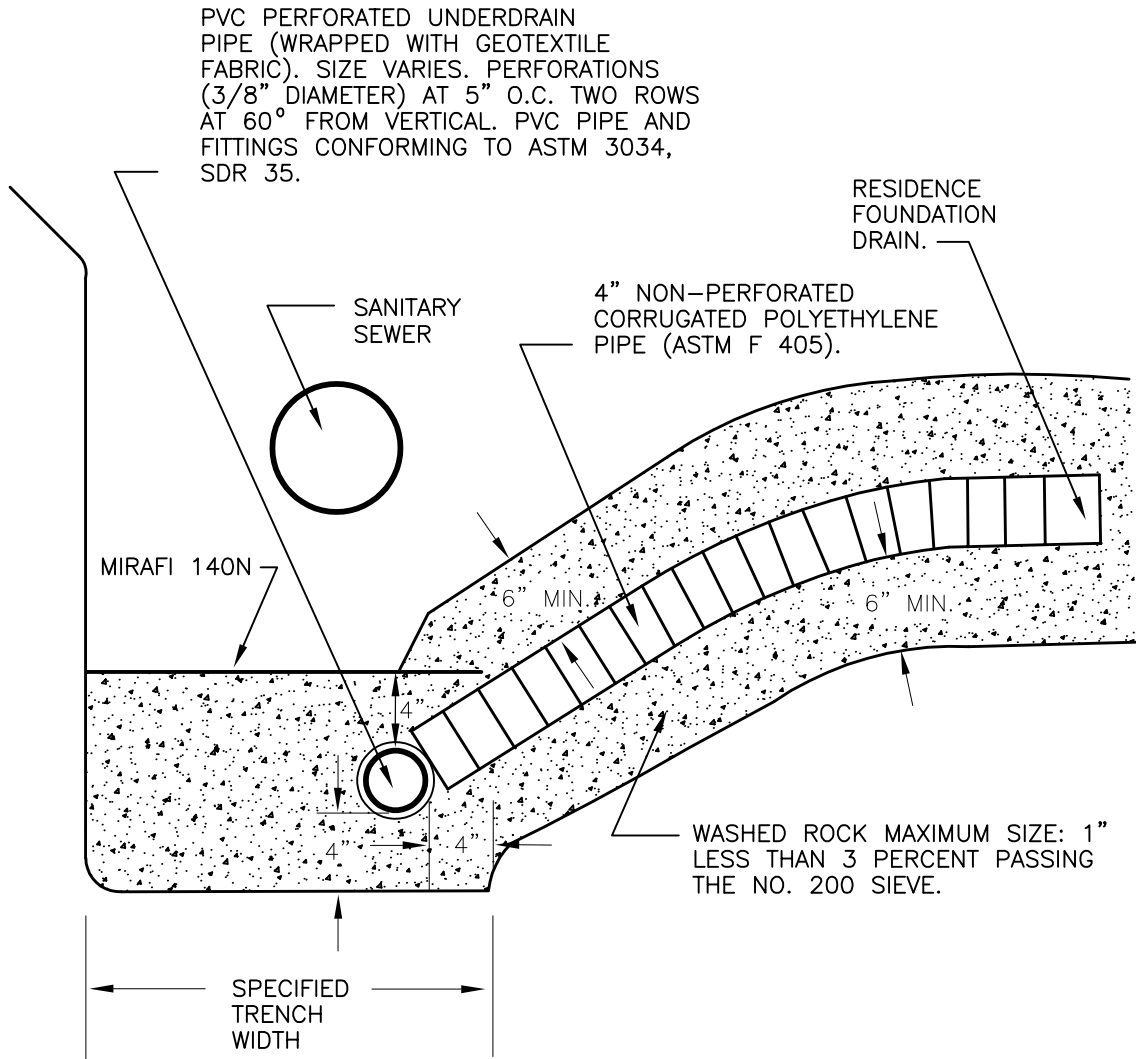
6590 ESTIMATED TOP OF SANDSTONE
ELEVATION (FEET)



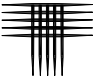
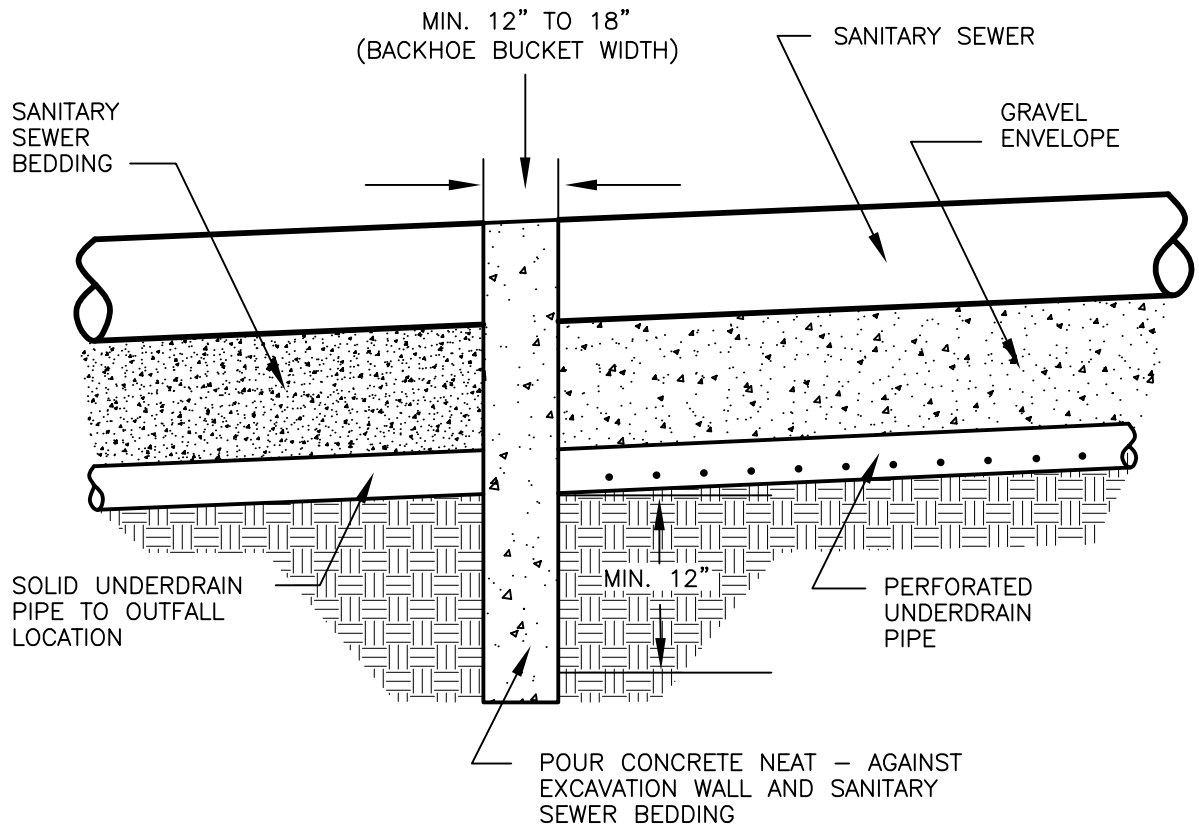
NOT TO SCALE



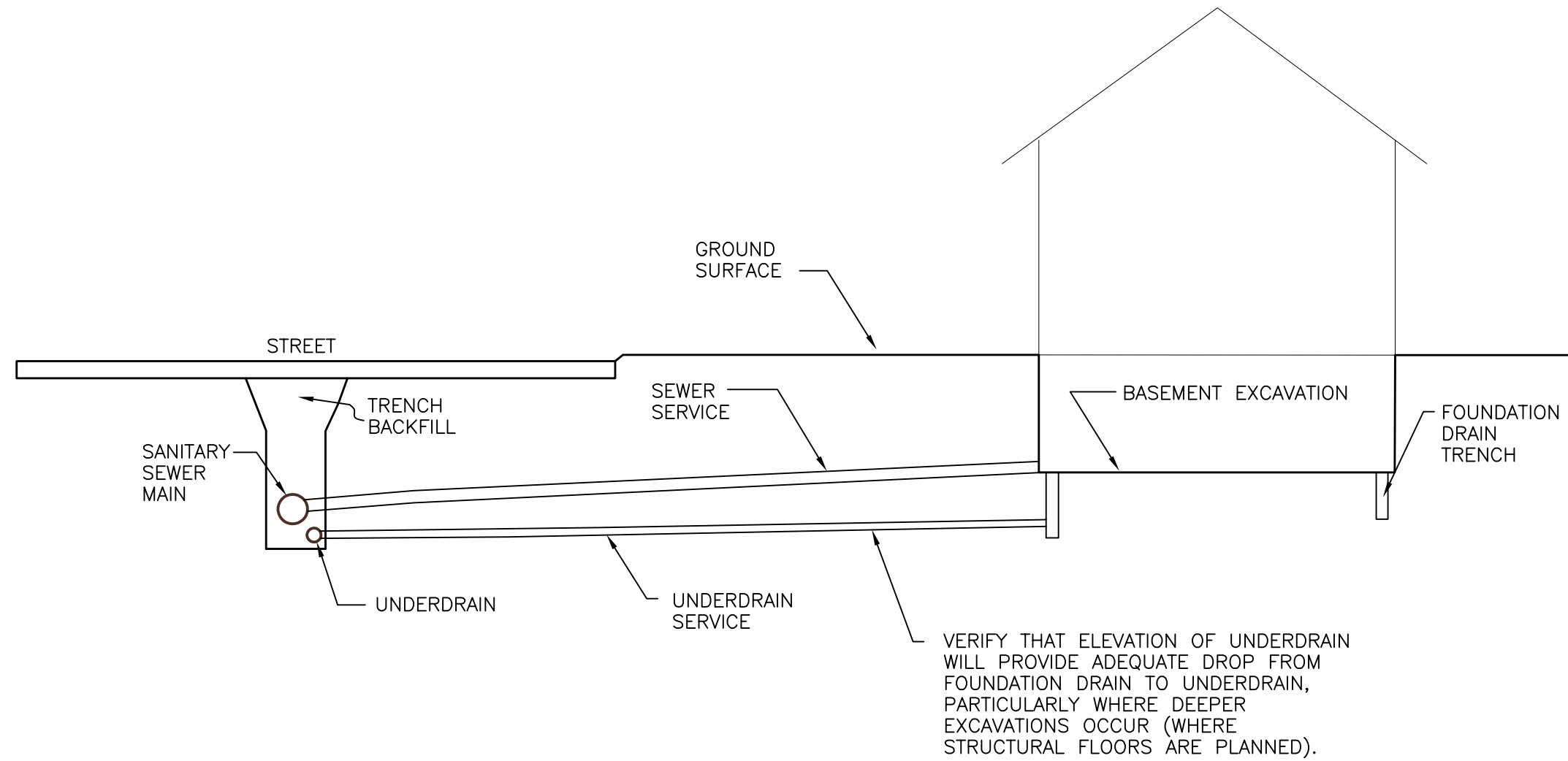
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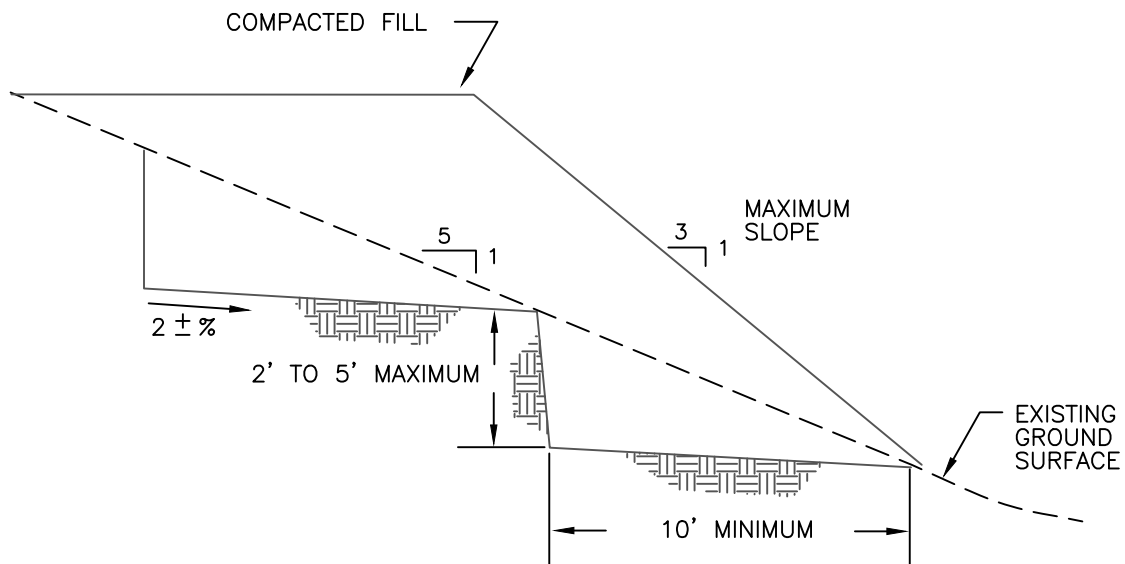
NOTE: NOT TO SCALE.



NOTE:
THE CONCRETE CUTOFF WALL SHOULD EXTEND INTO THE UNDISTURBED SOILS OUTSIDE THE UNDERDRAIN AND SANITARY SEWER TRENCH A MINIMUM DISTANCE OF 12 INCHES.



NOT TO SCALE



NOTES:

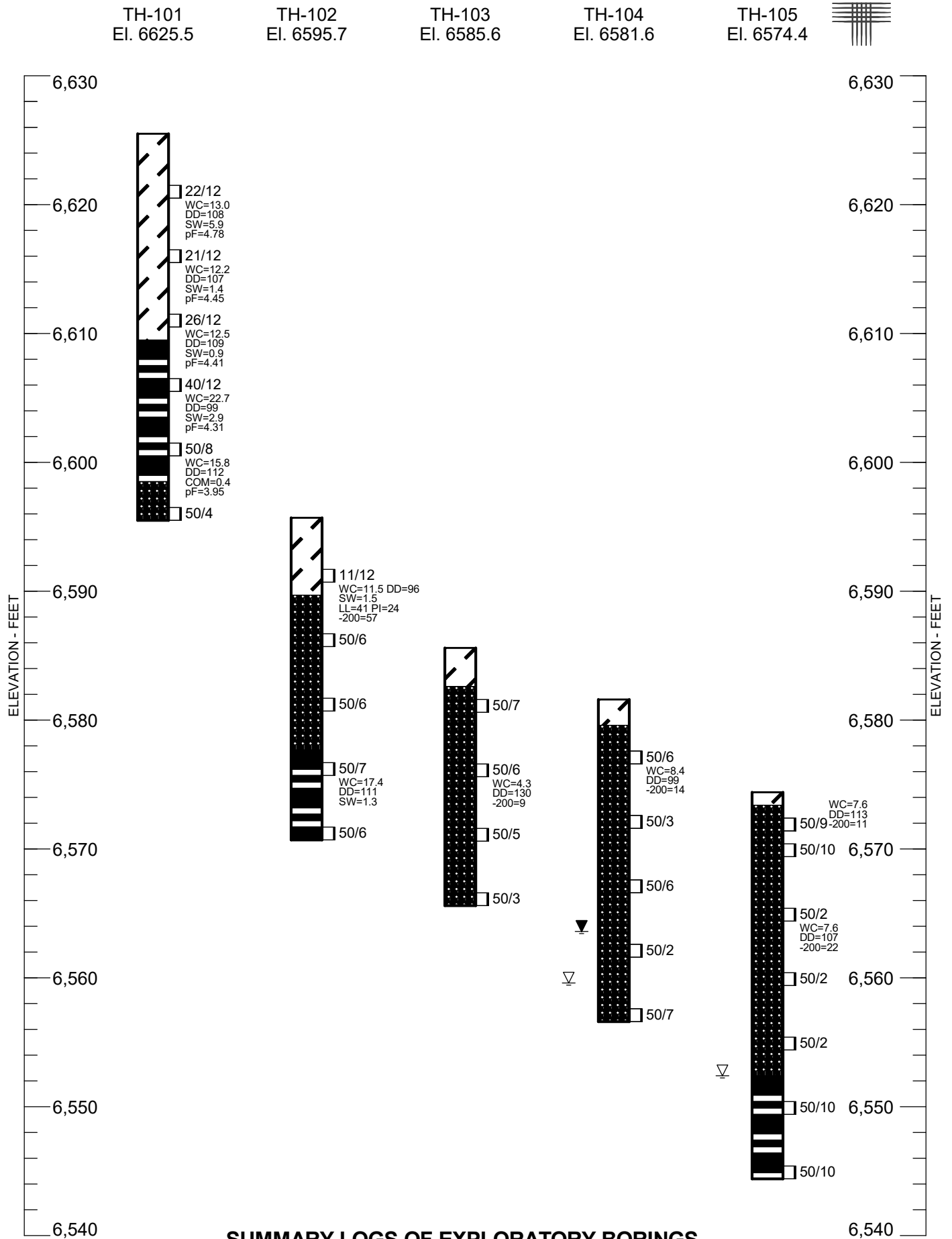
- 1) NATURAL SLOPES OF 20 PERCENT OR STEEPER ARE TO BE BENCHED PRIOR TO FILL PLACEMENT.
- 2) SLOPE BENCHES TO OUTSLOPE AT $2 \pm$ PERCENT.

Benched
Fill
Detail



APPENDIX A

SUMMARY LOGS OF EXPLORATORY BORINGS



SUMMARY LOGS OF EXPLORATORY BORINGS

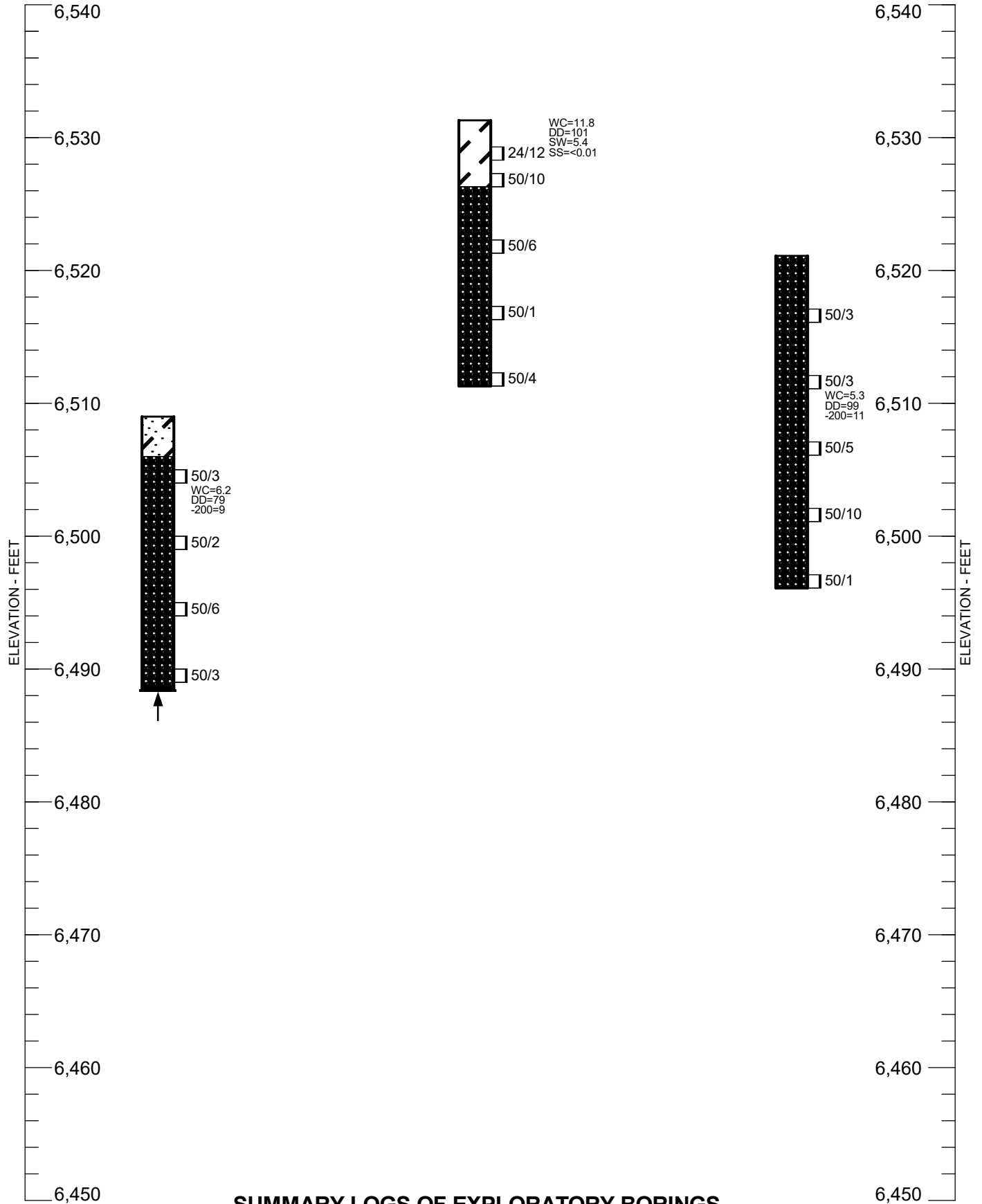
D.R. HORTON
FOUNDERS VISTA, FILING NO. 1, 258 LOTS
CTLJT PROJECT NO. DN50,536-115-R1

FIG. A- 1

TH-106
El. 6509.0

TH-107
El. 6531.3

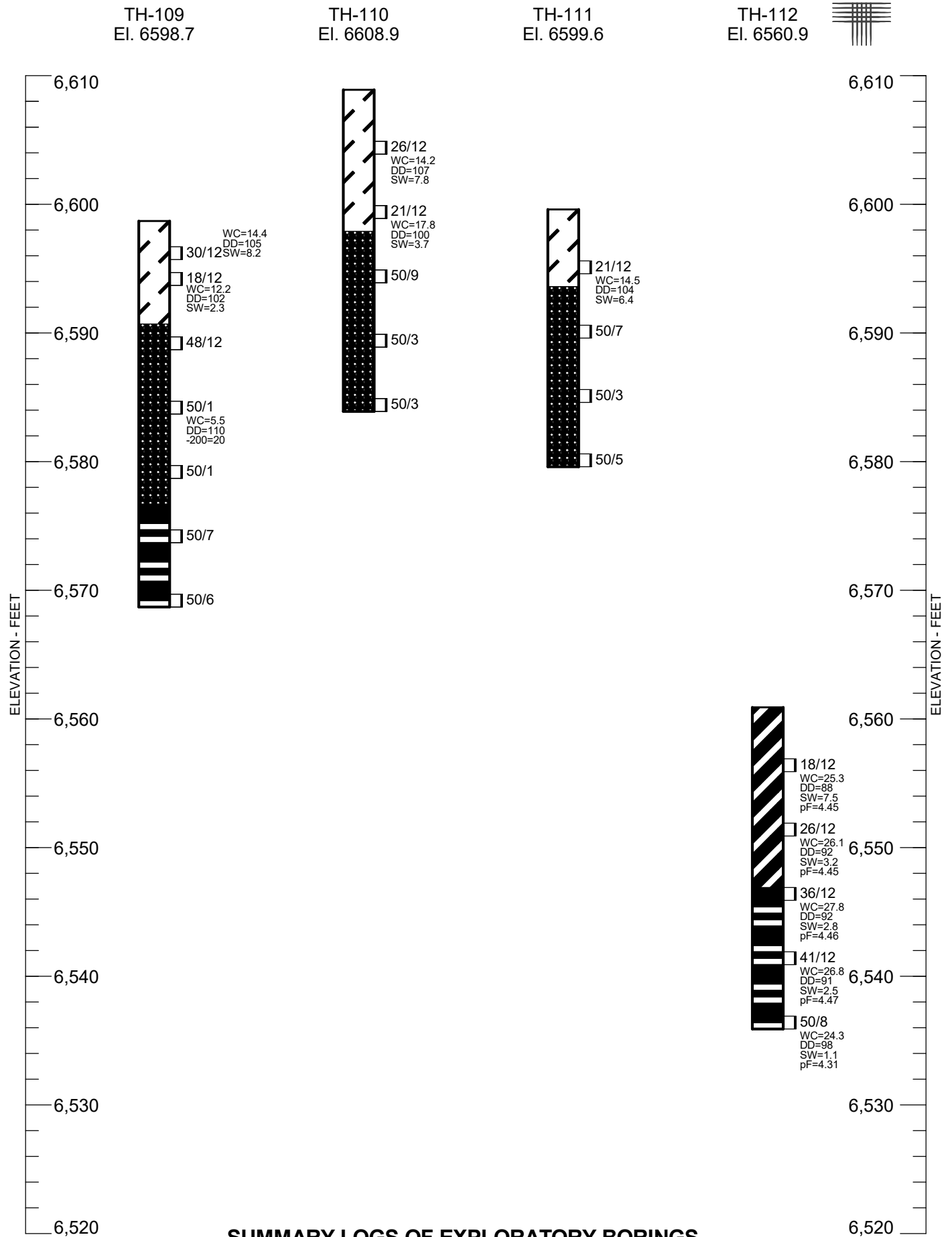
TH-108
El. 6521.1



SUMMARY LOGS OF EXPLORATORY BORINGS

D.R. HORTON
FOUNDERS VISTA, FILING NO. 1, 258 LOTS
CTLJT PROJECT NO. DN50,536-115-R1

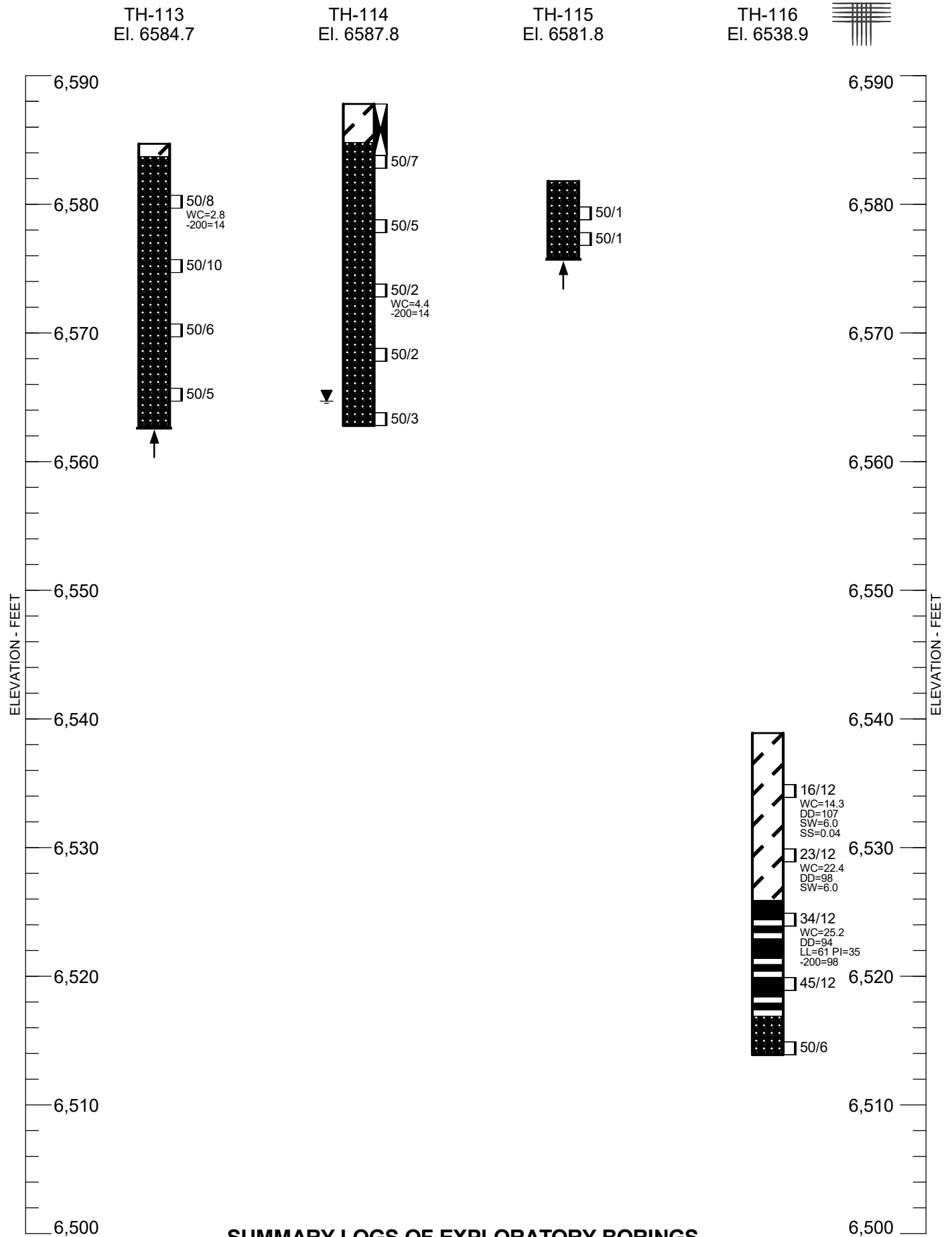
FIG. A-2



SUMMARY LOGS OF EXPLORATORY BORINGS

D.R. HORTON
FOUNDERS VISTA, FILING NO. 1, 258 LOTS
CTLJT PROJECT NO. DN50,536-115-R1

FIG. A- 3



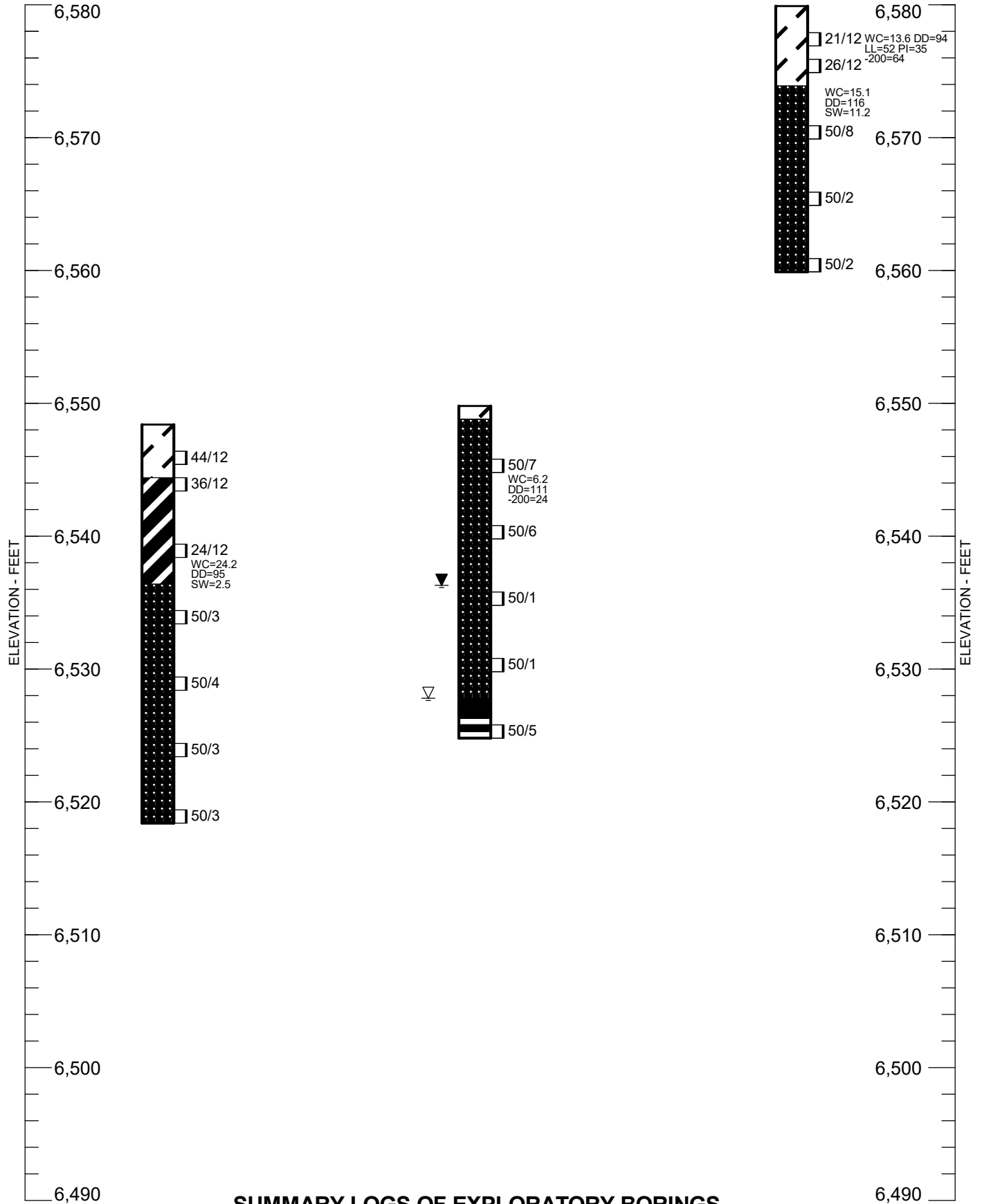
D.R. HORTON
FOUNDERS VISTA, FILING NO. 1, 258 LOTS
CTLJT PROJECT NO. DN50,536-115-R1

FIG. A- 4

TH-117
El. 6548.4

TH-118
El. 6549.8

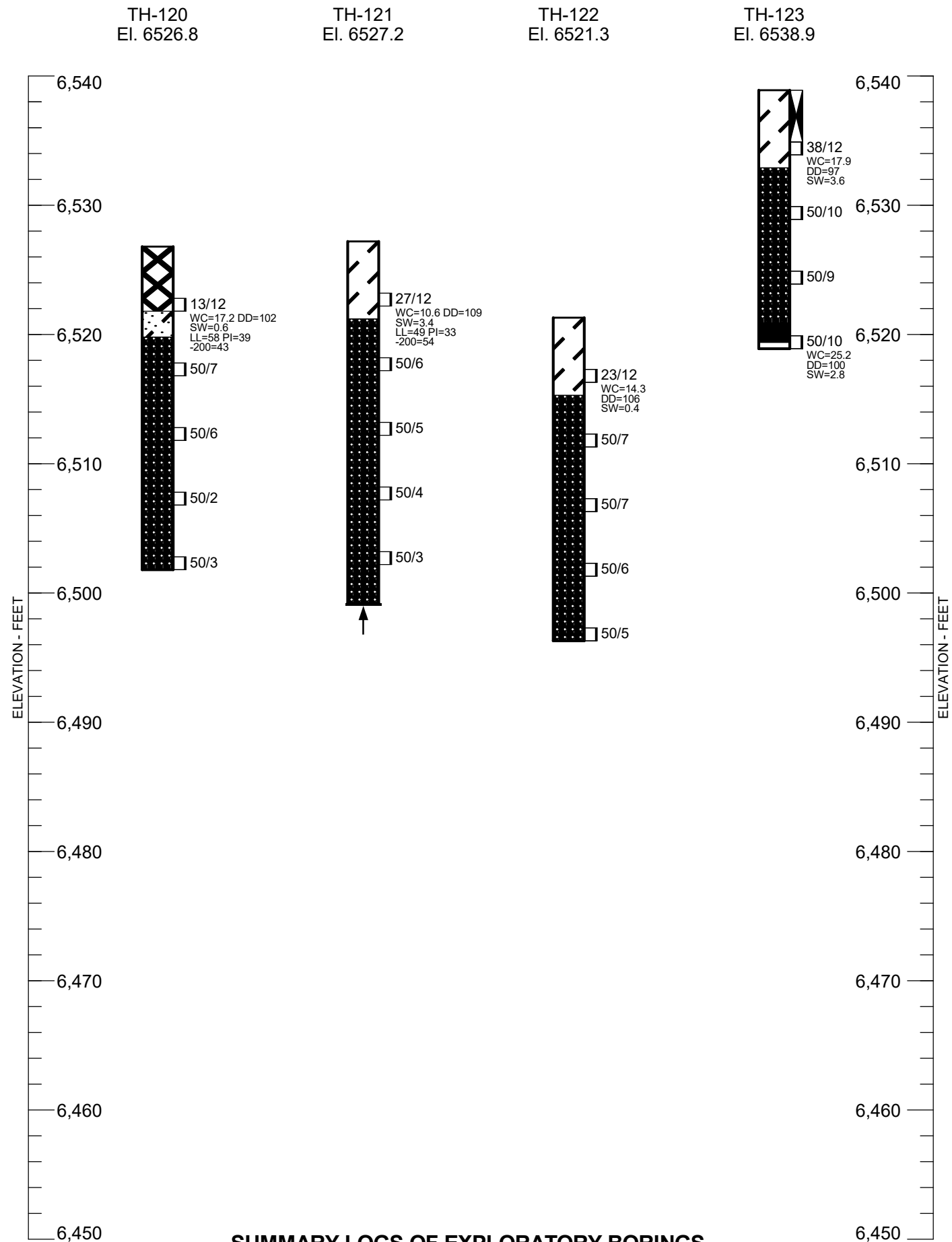
TH-119
El. 6579.9



SUMMARY LOGS OF EXPLORATORY BORINGS

D.R. HORTON
FOUNDERS VISTA, FILING NO. 1, 258 LOTS
CTLT PROJECT NO. DN50,536-115-R1

FIG. A- 5



SUMMARY LOGS OF EXPLORATORY BORINGS

D.R. HORTON
FOUNDERS VISTA, FILING NO. 1, 258 LOTS
CT/LT PROJECT NO. DN50,536-115-R1

LEGEND:

- POSSIBLE FILL OR ORGANIC SOIL, SAND, CLAYEY, COARSE-GRAINED, DARK BROWN, BLACK.
- CLAY, SANDY TO VERY SANDY, SILTY TO VERY SILTY, OCCASIONAL GRAVEL, CACLAREOUS, PIN-HOLE STRUCTURE IN TH-123, STIFF TO VERY STIFF, SLGIHTLY MOIST TO MOIST, BROWN, TAN, LIGHT BROWN, GRAY, WHITE (CL, CH).
- SAND, CLAYEY TO VERY CLAYEY, GRAVELLY, MEDIUM DENSE TO DENSE, SLGHTLY MOIST, BROWN, TAN, GRAY, WHITE, BLACK, RUST (SC).
- WEATHERED CLAYSTONE, SILTY, LIGHT GRAY, OLIVE, RUST, WHITE.
- BEDROCK, CLAYSTONE, SILTY, SANDY, MEDIUM HARD TO HARD, MOIST, LIGHT GRAY, OLIVE, RUST, WHITE, TAN, BROWN.
- BEDROCK, SANDSTONE, SILTY, FINE-GRAINED TO PEBBLY, POORLY CEMENTED MUCH OF THE TIME, HARD TO VERY HARD, SLIGHTLY MOIST, LIGHT BROWN, LIGHT GRAY, TAN, WHITE, LIGHT BROWN, RUST.
- DRIVE SAMPLE. THE SYMBOL 22/12 INDICATES 22 BLOWS OF AN AUTOMATIC 140-POUND HAMMER FALLING 30 INCHES WERE REQUIRED TO DRIVE A 2.5-INCH O.D. SAMPLER 12 INCHES.
- BULK SAMPLE COLLECTED FROM AUGER CUTTINGS.
- WATER LEVEL MEASURED AT TIME OF DRILLING.
- WATER LEVEL MEASURED AFTER DRILLING ON JUNE 2, 2020.
- INDICATES PRACTICAL DRILL RIG REFUSAL.

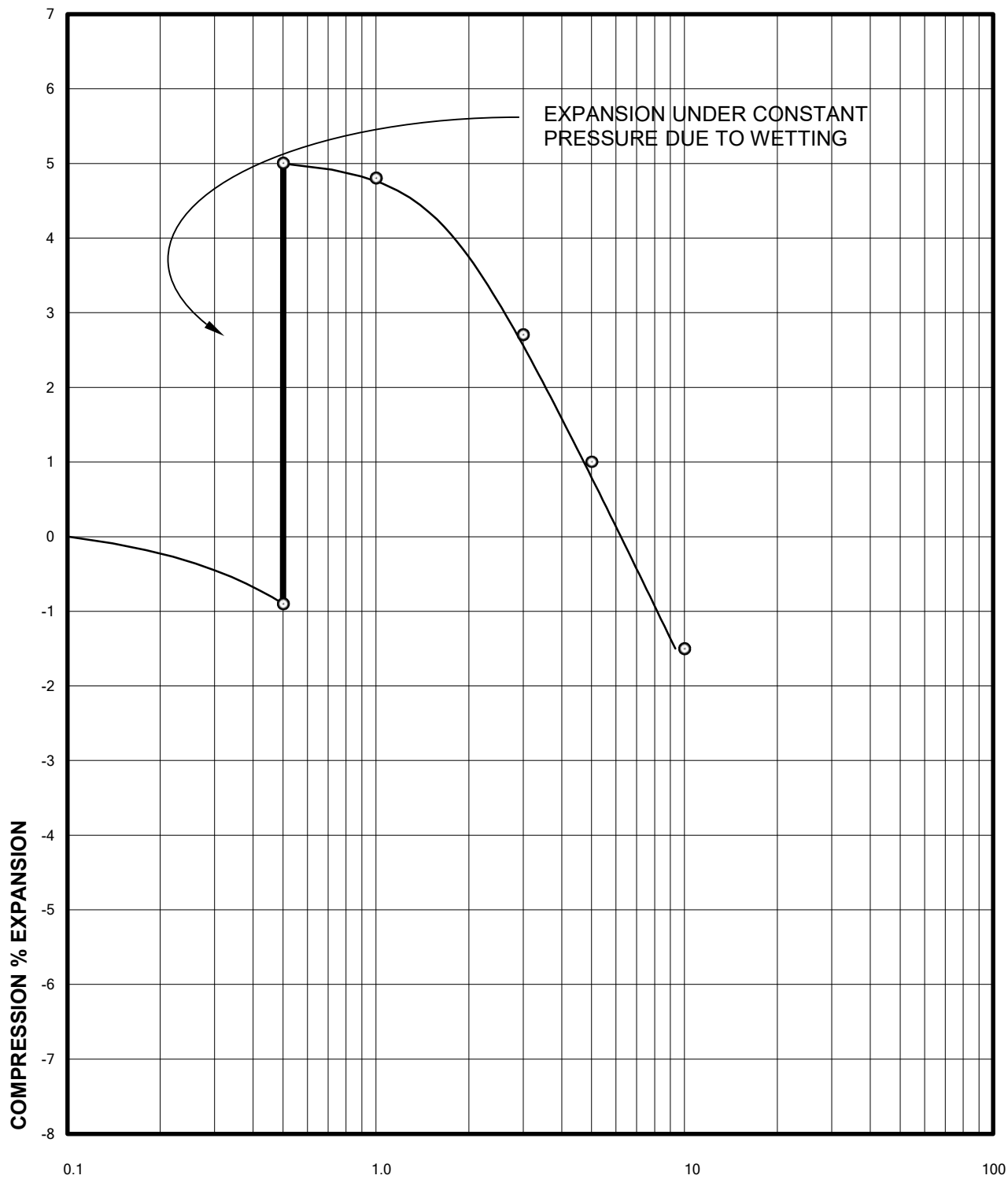
NOTES:

- THE BORINGS WERE DRILLED BETWEEN MAY 8 AND 15, 2020 USING 4-INCH DIAMETER, CONTINUOUS-FLIGHT SOLID-STEM AUGER AND TRUCK-MOUNTED CME-45 DRILL RIG.
- BORING LOCATIONS AND ELEVATIONS WERE PROVIDED BY YOUR SURVEYOR. TH-105 WAS ESTIMATED BY OUR REPRESENTATIVE USING A LEICA GS-18 GPS UNIT REFERENCING THE NORTH AMERICAN VERTICAL DATUM OF 1988 (NAVD 88).
- WC - INDICATES MOISTURE CONTENT (%).
DD - INDICATES DRY DENSITY (PCF).
SW - INDICATES SWELL WHEN WETTED UNDER APPROXIMATE OVERBURDEN PRESSURE (%).
COM- INDICATES COMPRESSION WHEN WETTED UNDER APPROXIMATE OVERBURDEN PRESSURE (%).
LL - INDICATES LIQUID LIMIT.
PI - INDICATES PLASTICITY INDEX.
-200 - INDICATES PASSING NO. 200 SIEVE (%).
SS - INDICATES WATER-SOLUBLE SULFATE CONTENT (%).
pF - INDICATES SOIL SUCTION VALUE (pF).
- THESE LOGS ARE SUBJECT TO THE EXPLANATIONS, LIMITATIONS AND CONCLUSIONS CONTAINED IN THIS REPORT.



APPENDIX B

LABORATORY TEST RESULTS

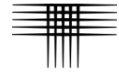
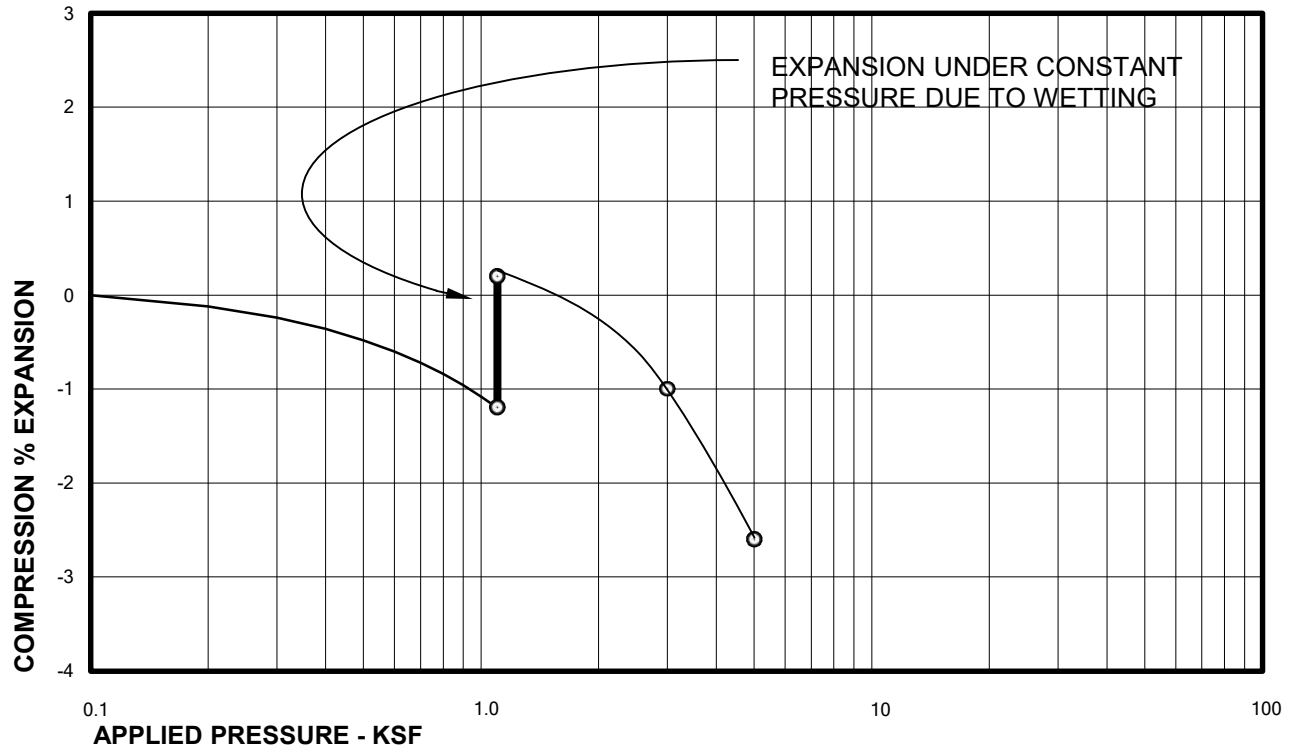


APPLIED PRESSURE - KSF
Sample of CLAY, SANDY (CL)
From TH-101 AT 4 FEET

DRY UNIT WEIGHT= 108 PCF
MOISTURE CONTENT= 13.0 %

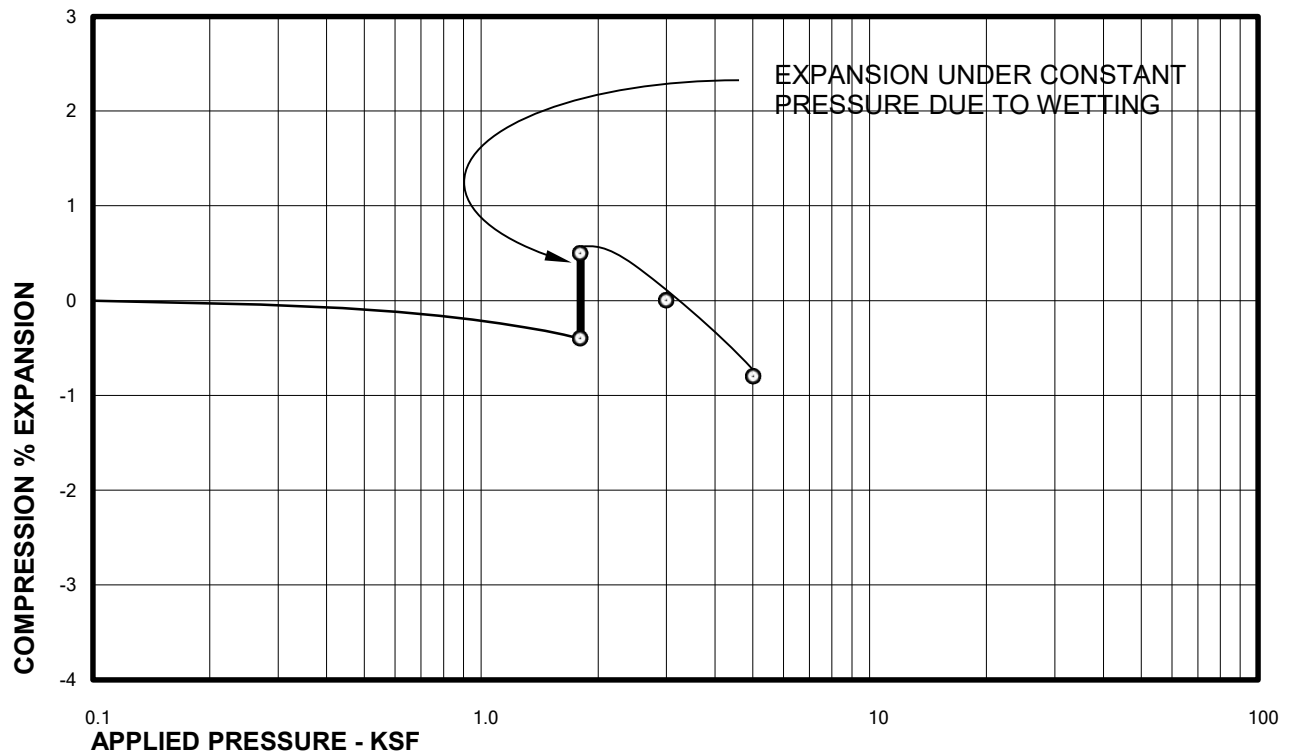
Swell Consolidation Test Results

FIG. B-1



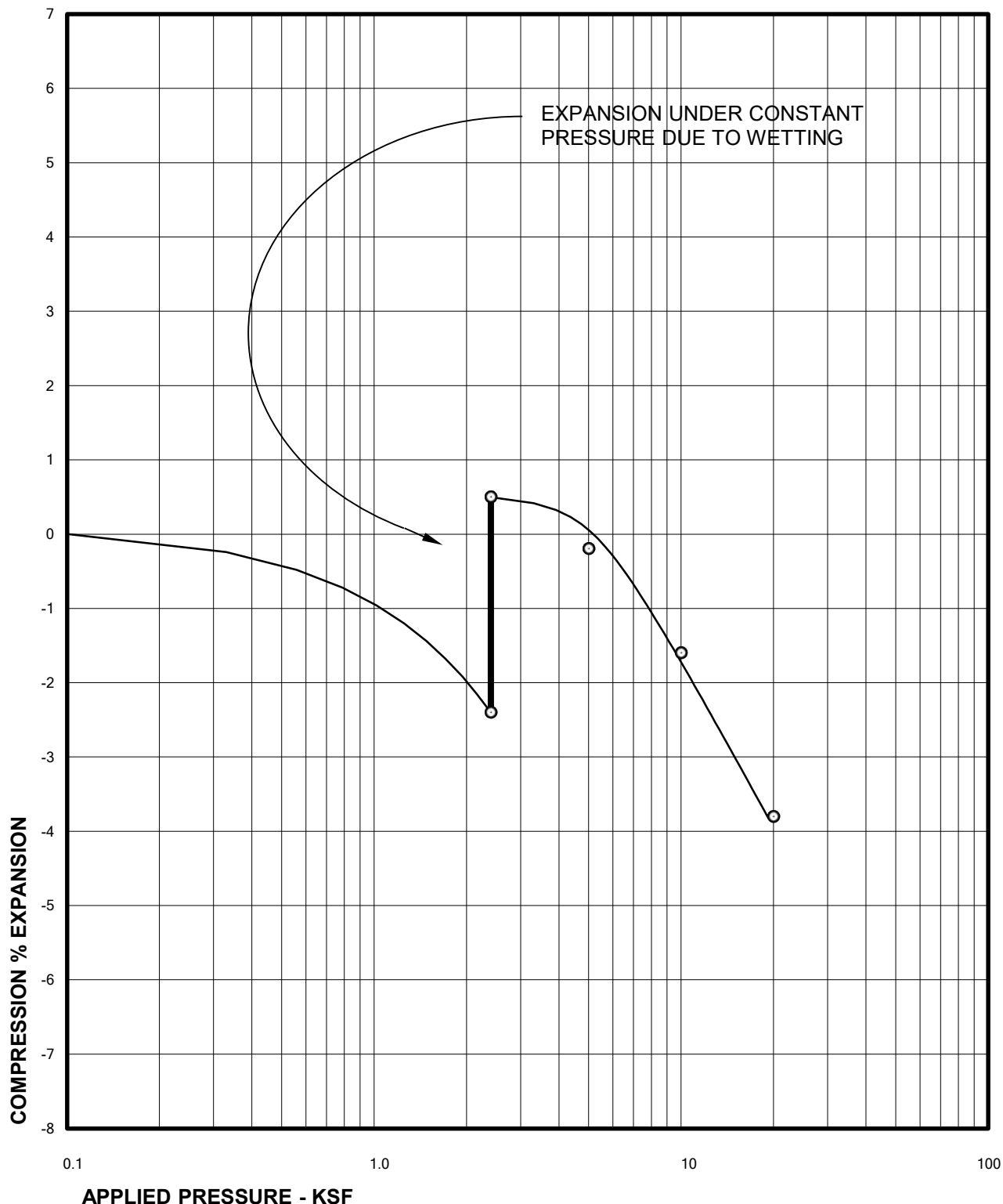
Sample of CLAY, SANDY (CL)
From TH-101 AT 9 FEET

DRY UNIT WEIGHT= 107 PCF
MOISTURE CONTENT= 12.2 %



Sample of CLAY, SANDY (CL)
From TH-101 AT 14 FEET

DRY UNIT WEIGHT= 109 PCF
MOISTURE CONTENT= 12.5 %

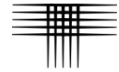
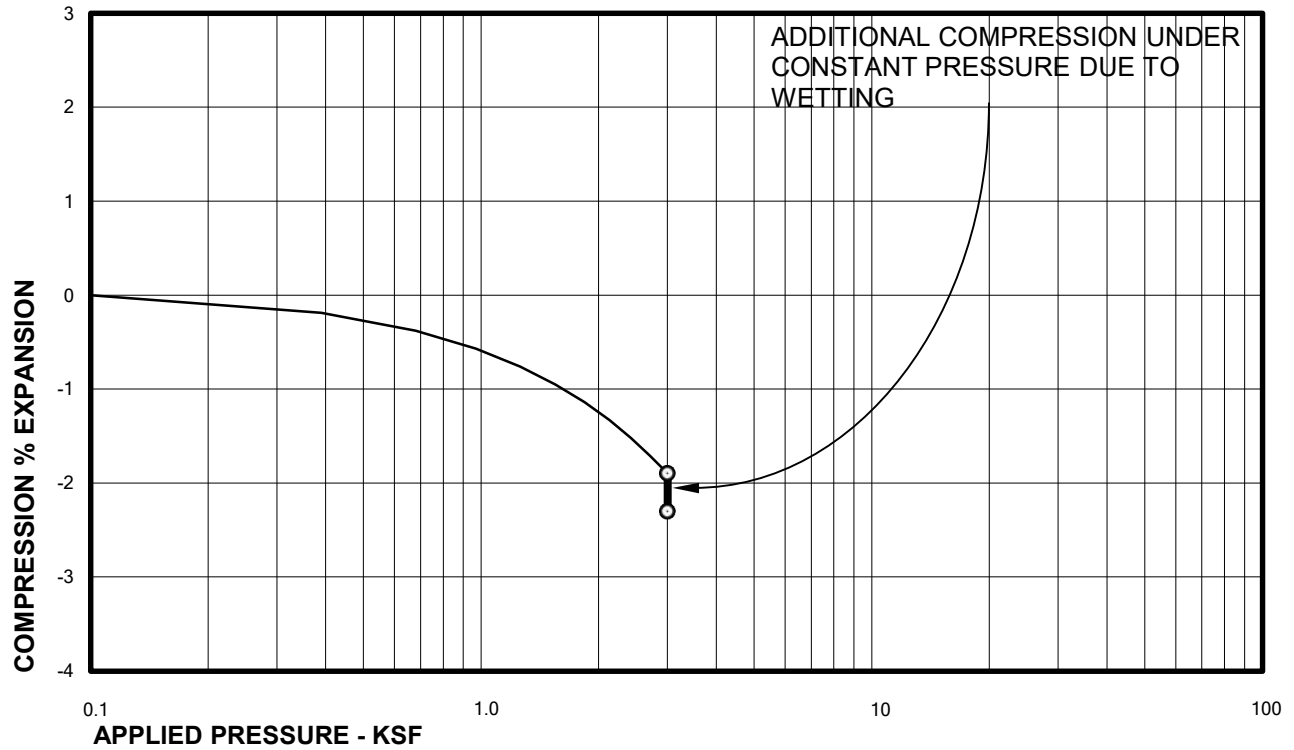


Sample of CLAYSTONE
From TH-101 AT 19 FEET

DRY UNIT WEIGHT= 99 PCF
MOISTURE CONTENT= 22.7 %

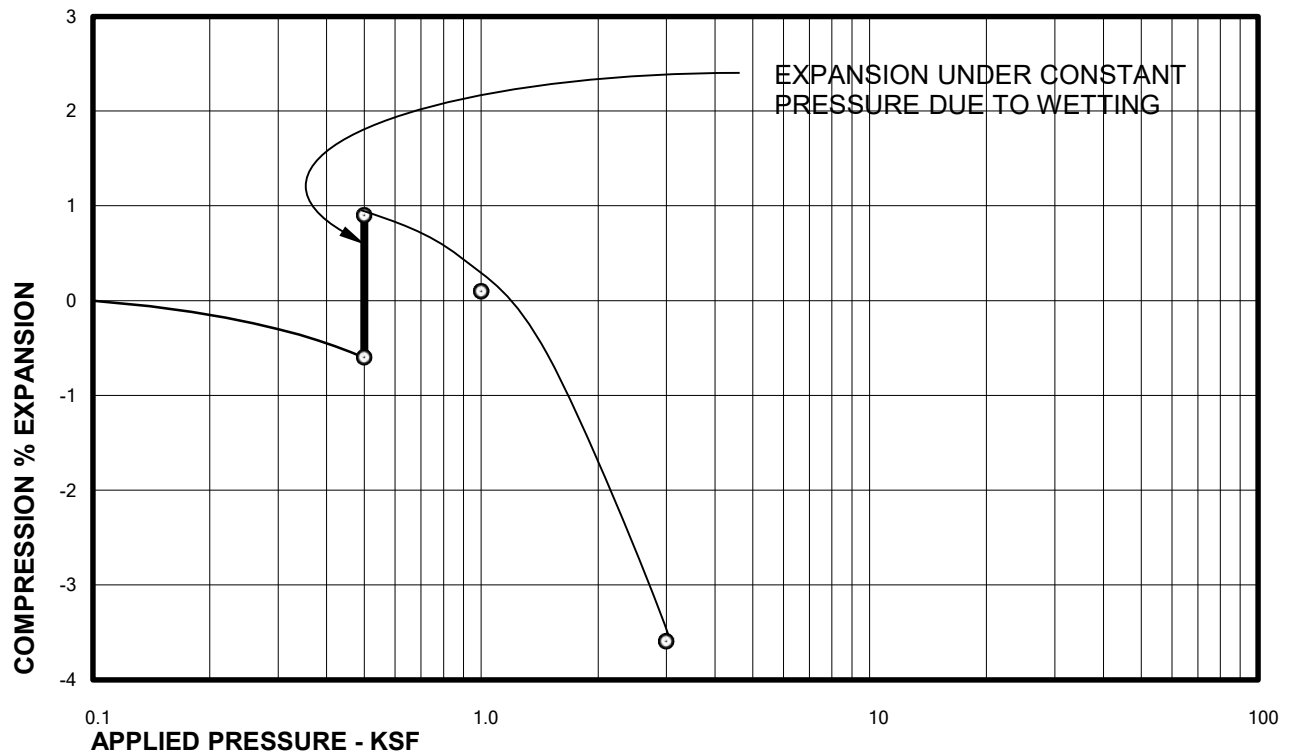
Swell Consolidation Test Results

FIG. B-3



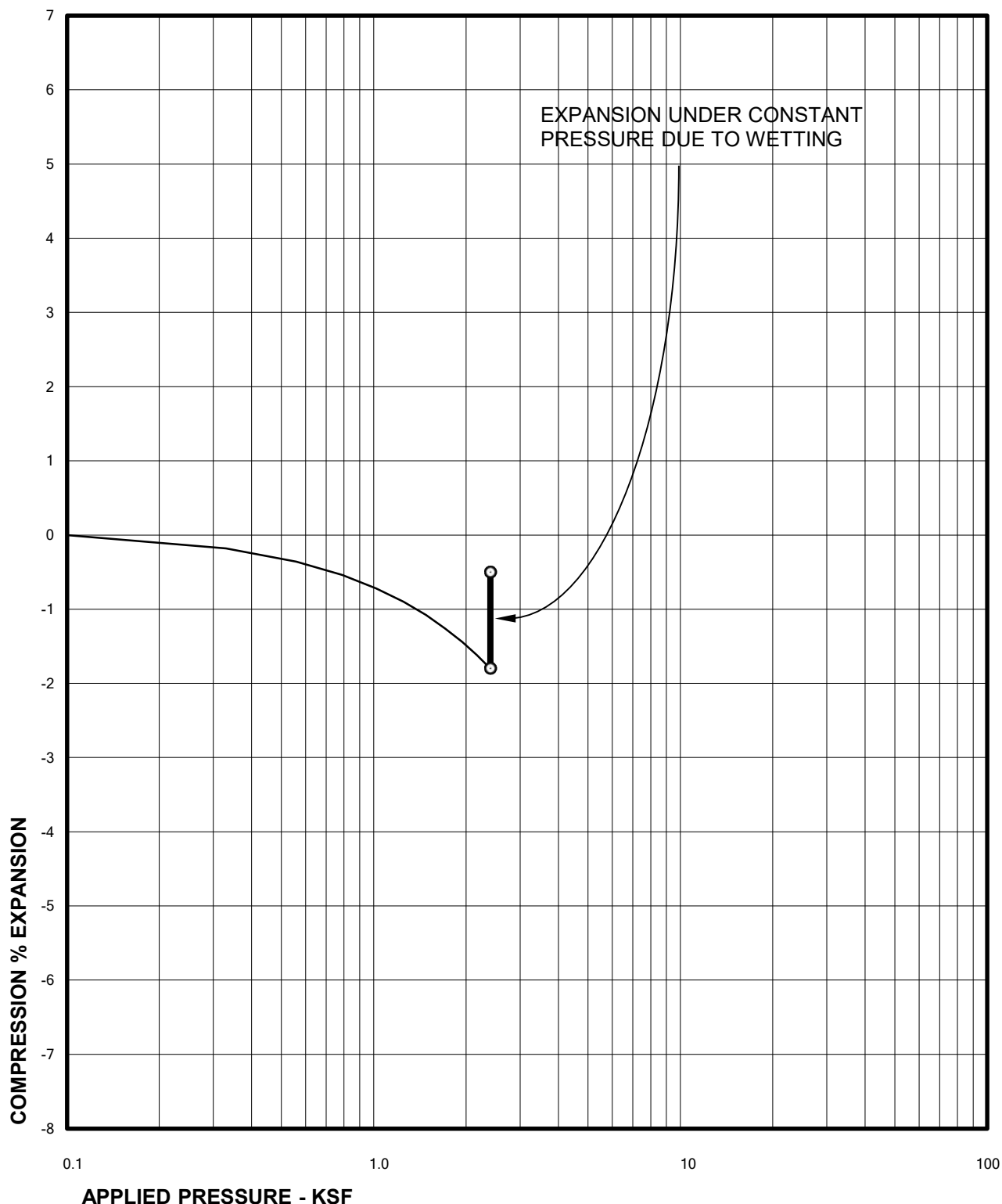
Sample of CLAYSTONE
From TH-101 AT 24 FEET

DRY UNIT WEIGHT= 112 PCF
MOISTURE CONTENT= 15.8 %



Sample of CLAY, SANDY (CL)
From TH-102 AT 4 FEET

DRY UNIT WEIGHT= 96 PCF
MOISTURE CONTENT= 11.5 %



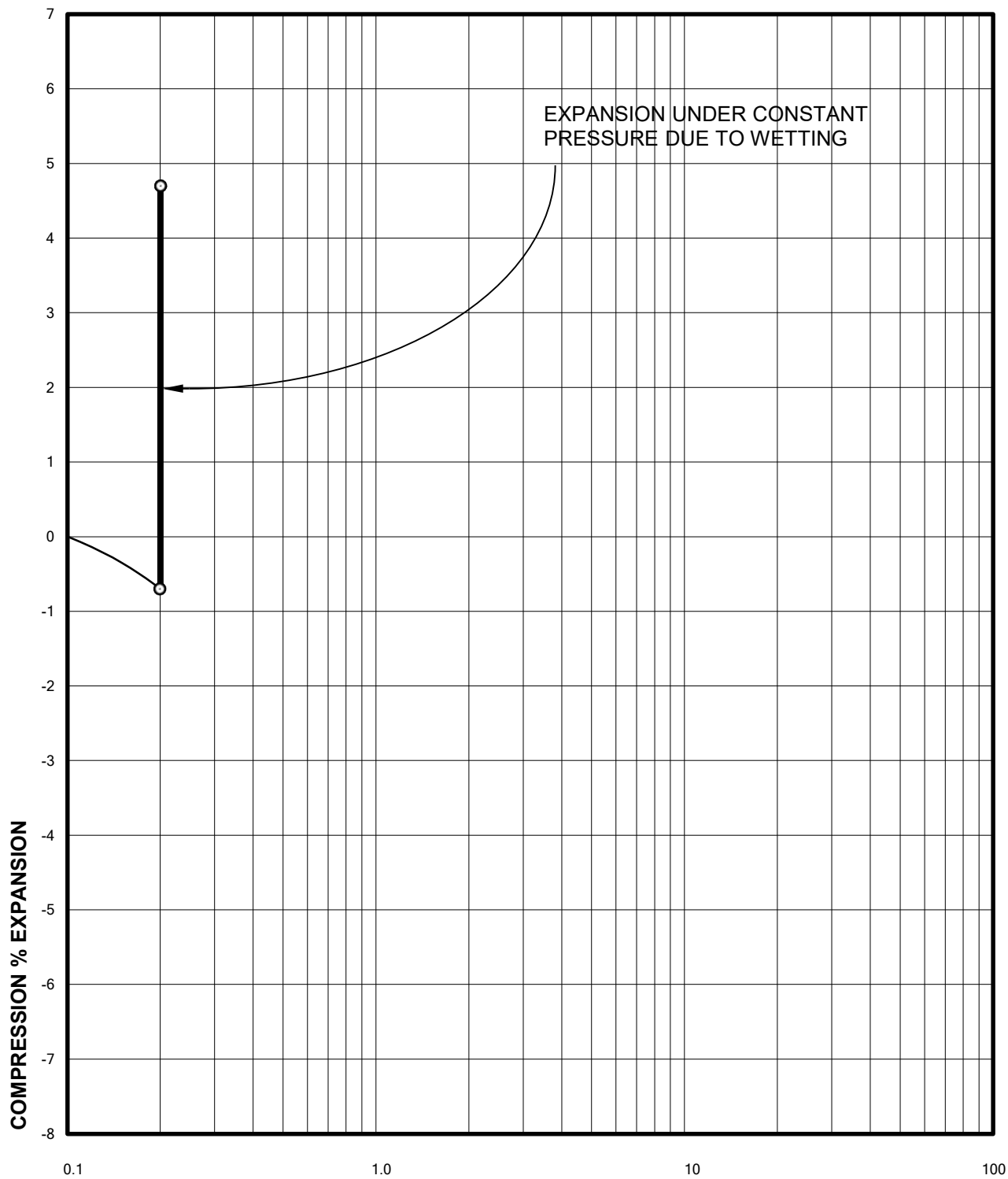
Sample of CLAYSTONE
From TH-102 AT 19 FEET

DRY UNIT WEIGHT= 111 PCF
MOISTURE CONTENT= 17.4 %

Swell Consolidation Test Results

D.R. HORTON
FOUNDERS VISTA, FILING NO. 1, 258 LOTS
CTLJT PROJECT NO. DN50,536-115-R1

FIG. B-5

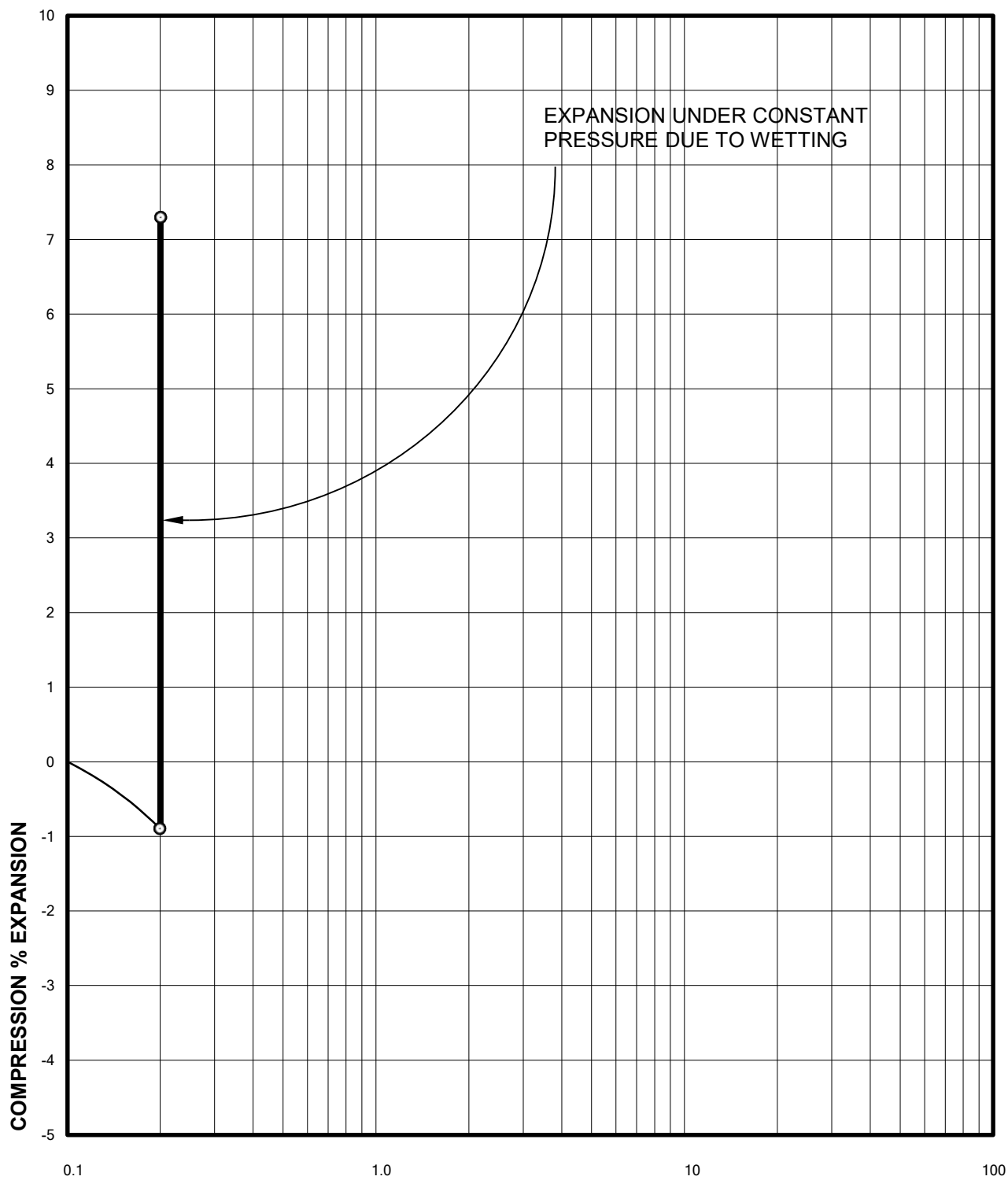


APPLIED PRESSURE - KSF
Sample of CLAY, SANDY (CL)
From TH-107 AT 2 FEET

DRY UNIT WEIGHT= 101 PCF
MOISTURE CONTENT= 11.8 %

Swell Consolidation Test Results

FIG. B-6



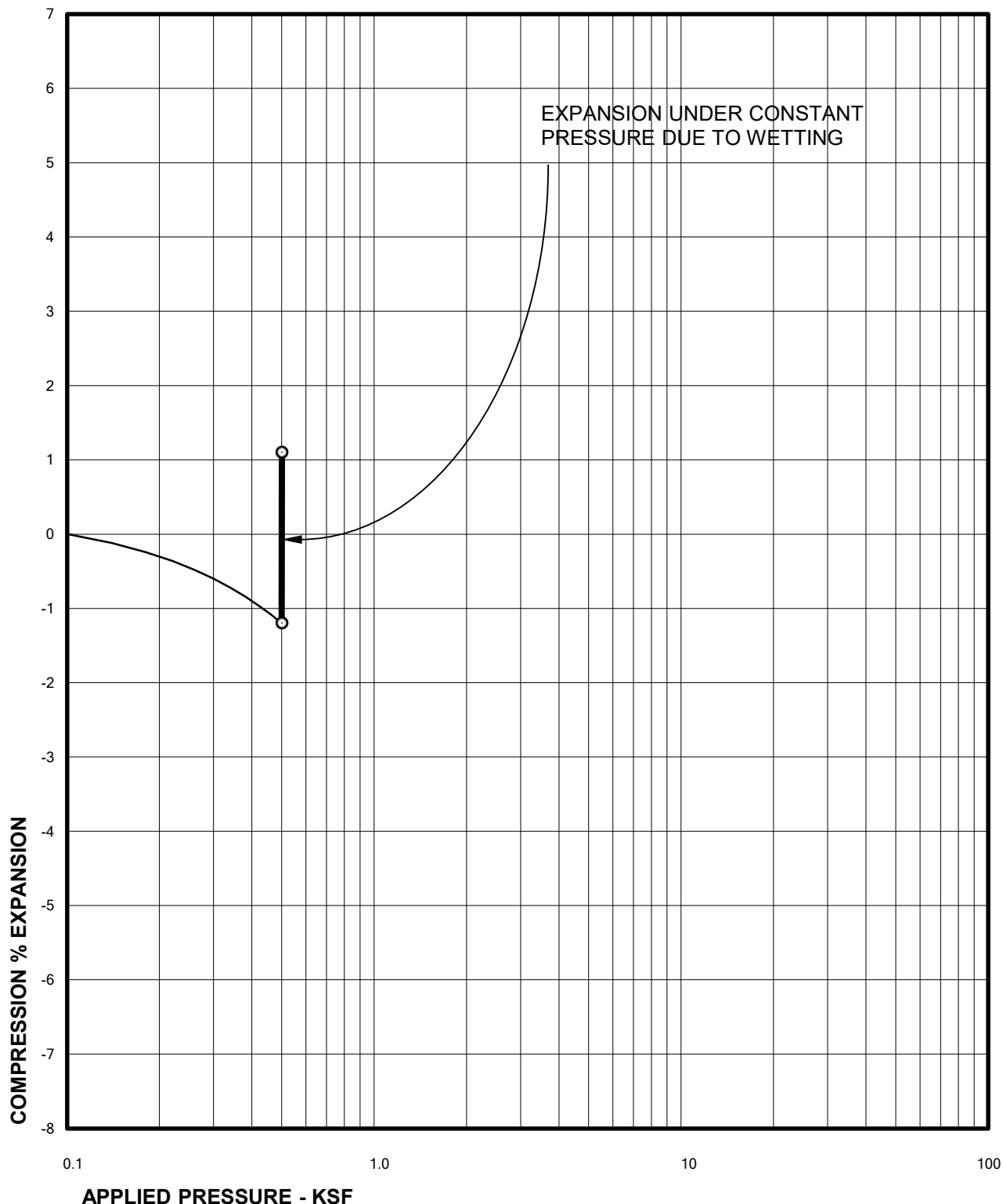
APPLIED PRESSURE - KSF
Sample of CLAY, SANDY (CL)
From TH-109 AT 2 FEET

DRY UNIT WEIGHT= 105 PCF
MOISTURE CONTENT= 14.4 %

Swell Consolidation Test Results

D.R. HORTON
FOUNDERS VISTA, FILING NO. 1, 258 LOTS
CTLJT PROJECT NO. DN50,536-115-R1

FIG. B-7

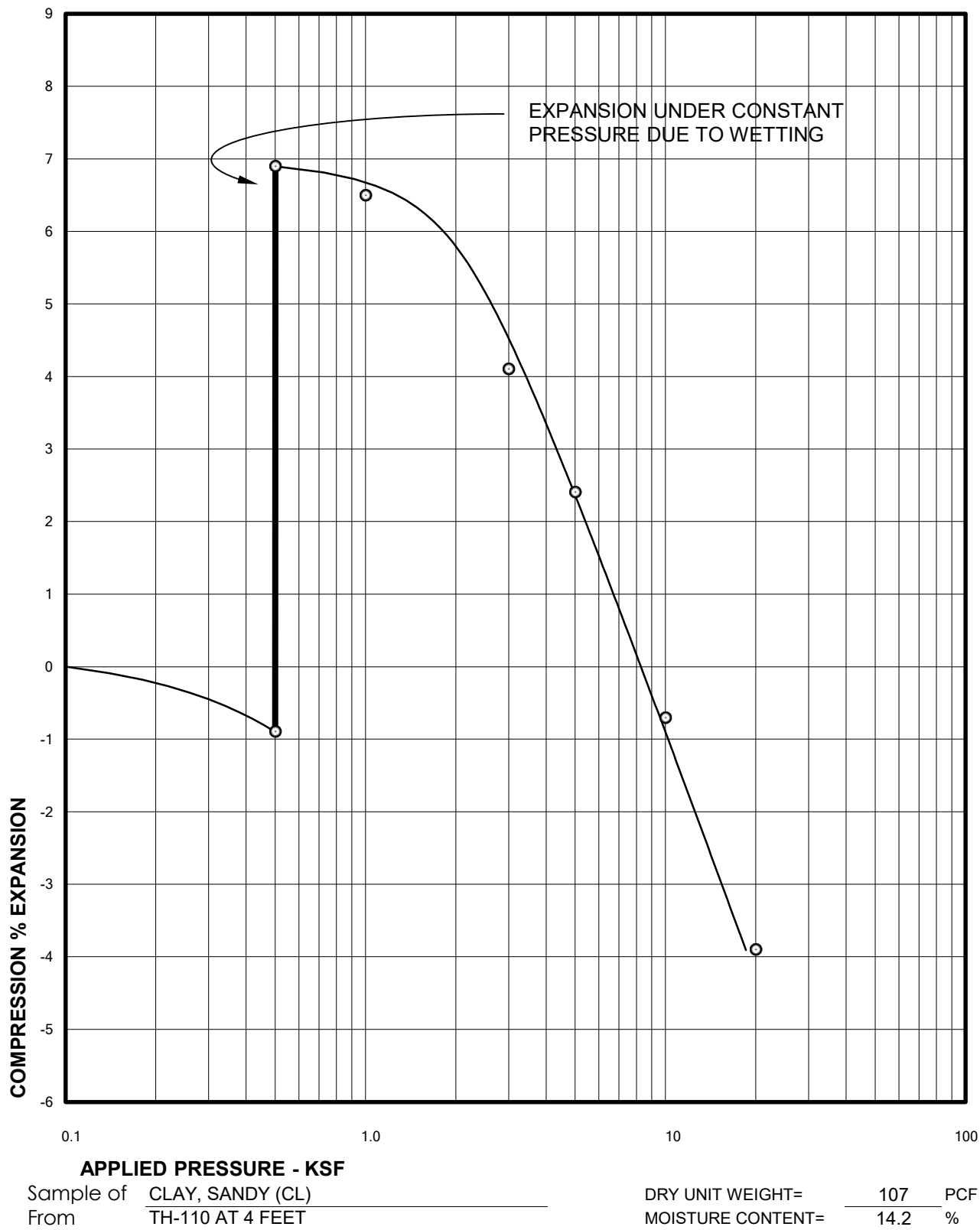


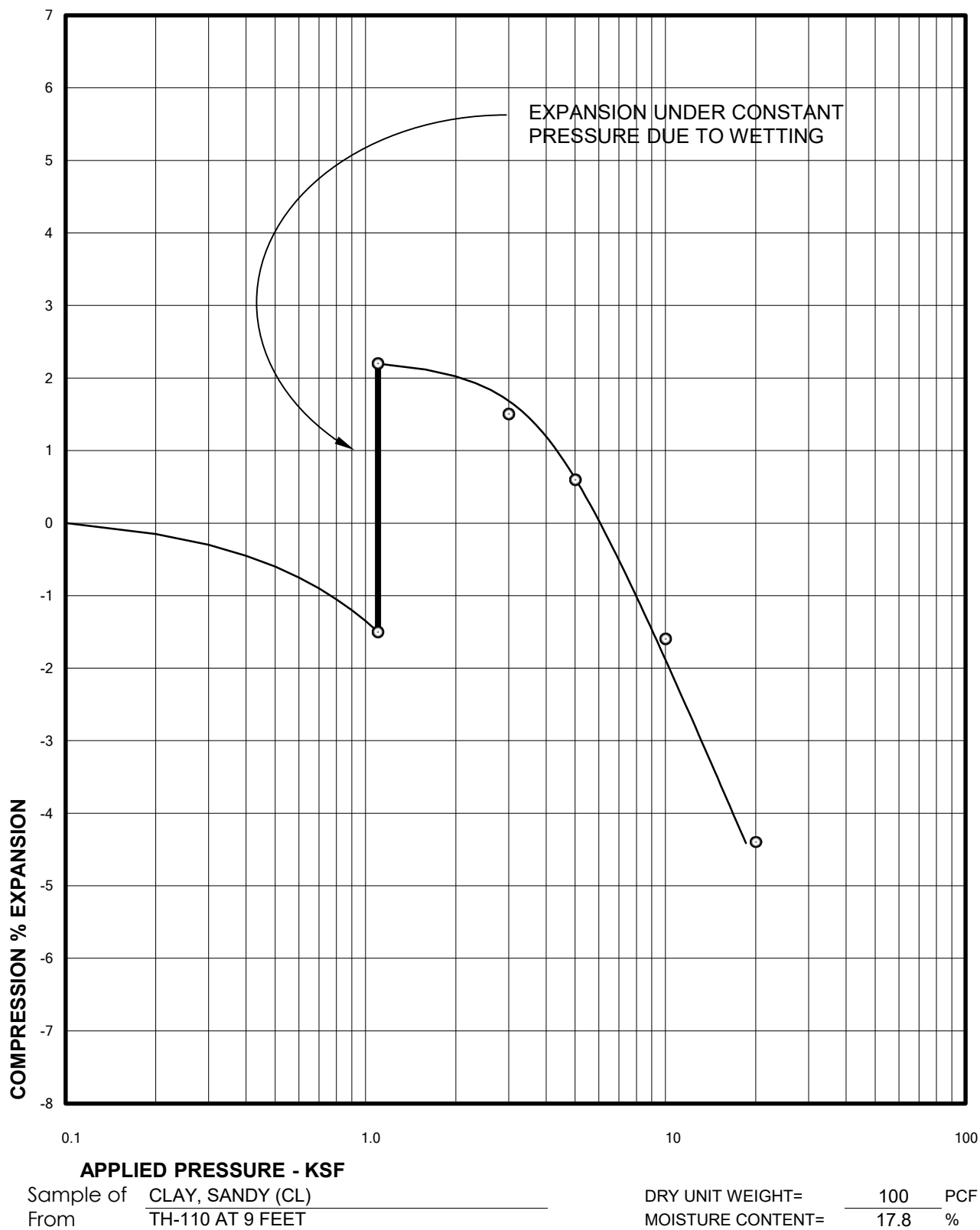
APPLIED PRESSURE - KSF
Sample of CLAY, SANDY (CL)
From TH-109 AT 4 FEET

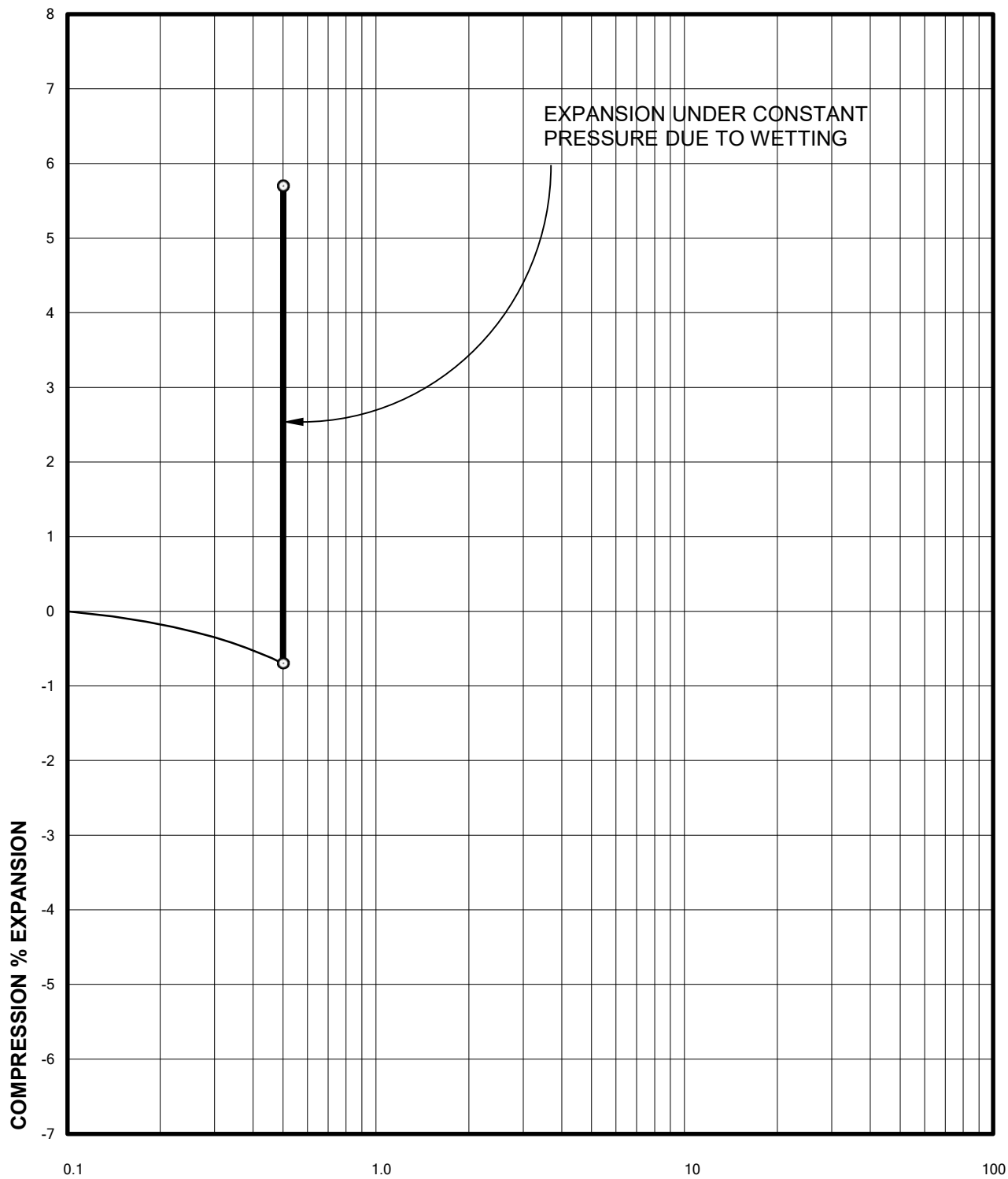
DRY UNIT WEIGHT= 102 PCF
MOISTURE CONTENT= 12.2 %

Swell Consolidation Test Results

FIG. B-8





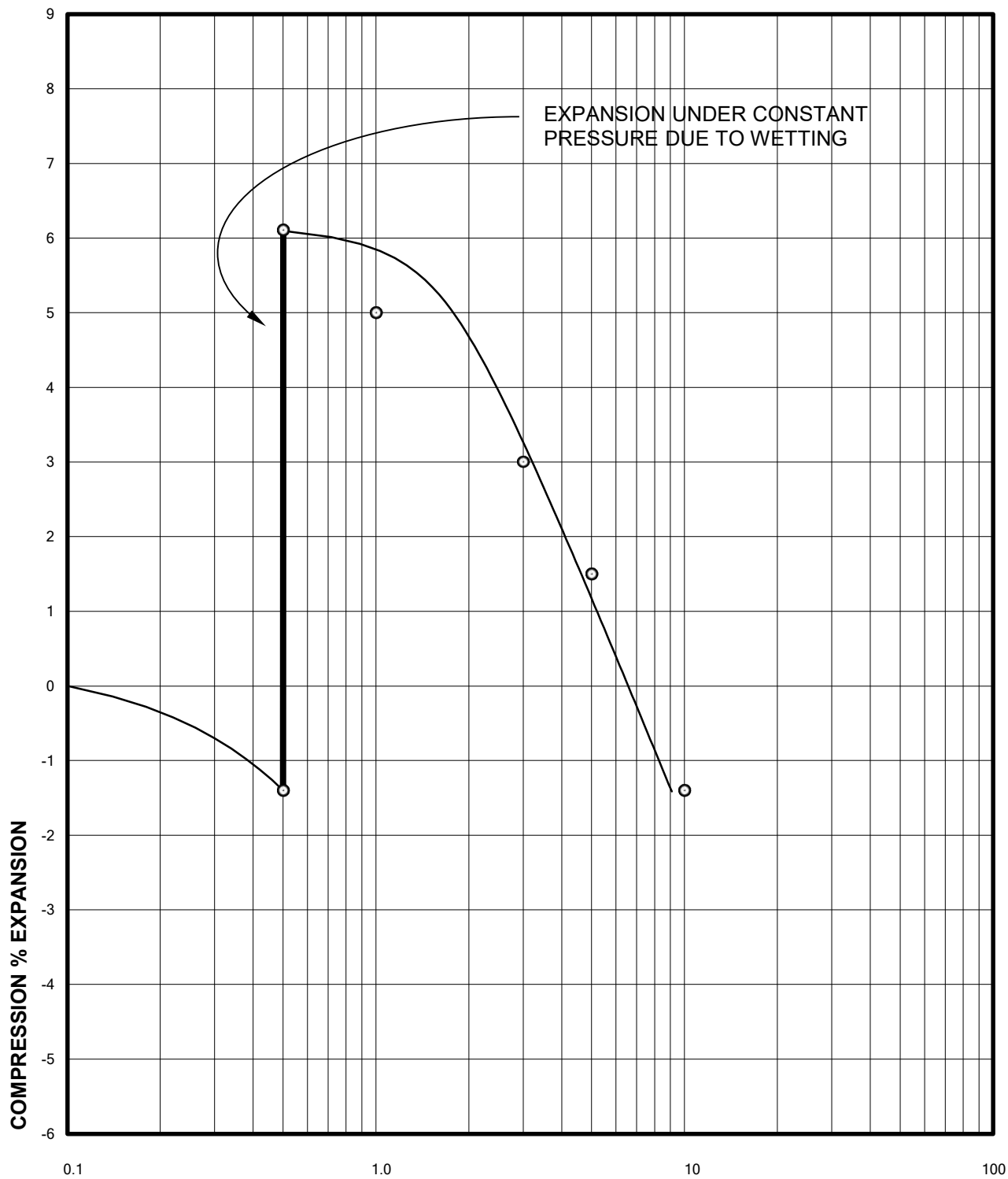


APPLIED PRESSURE - KSF
Sample of CLAY, SANDY (CL)
From TH-111 AT 4 FEET

DRY UNIT WEIGHT= 104 PCF
MOISTURE CONTENT= 14.5 %

Swell Consolidation Test Results

FIG. B-11

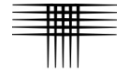
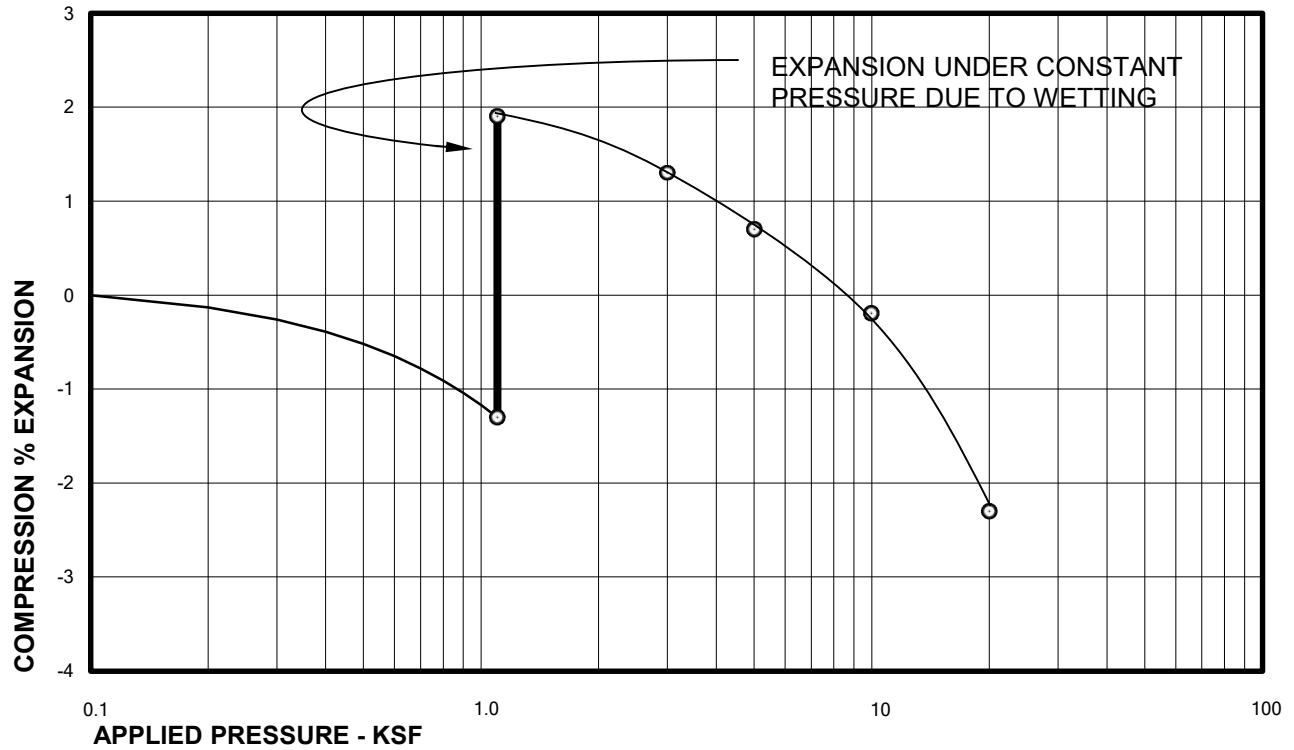
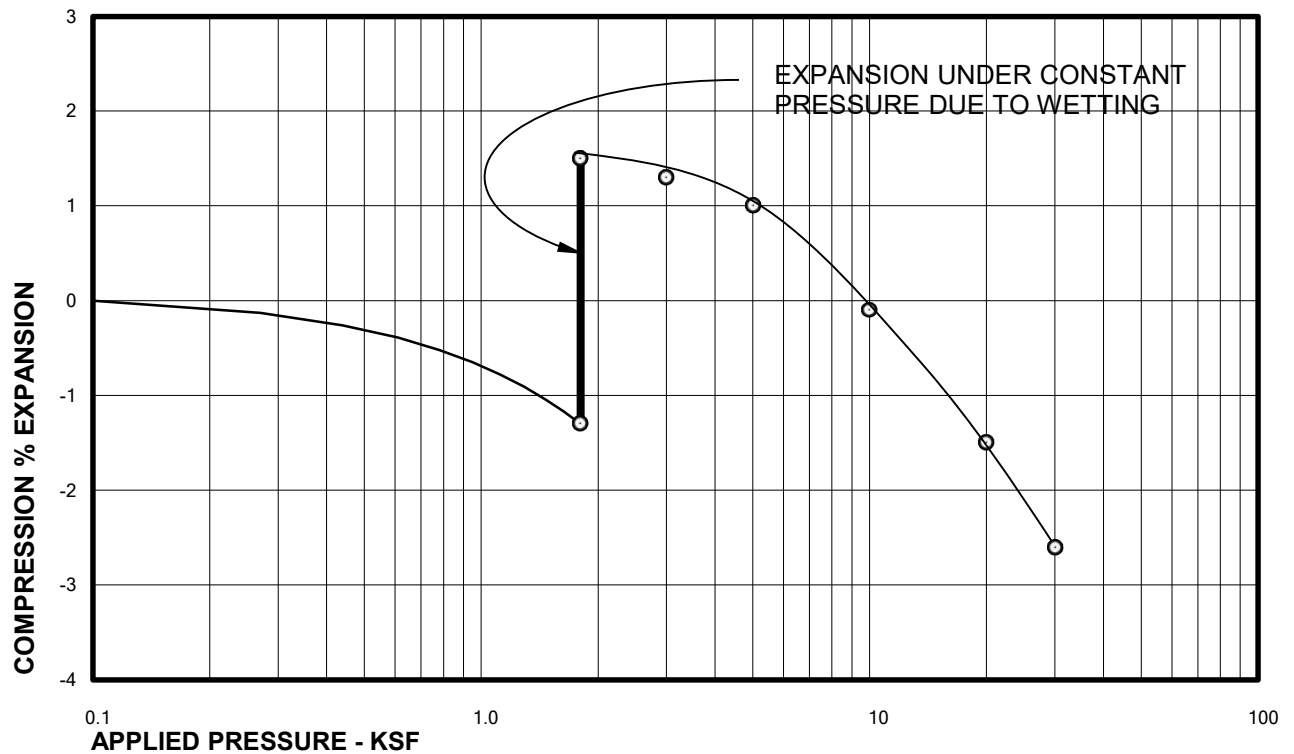


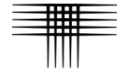
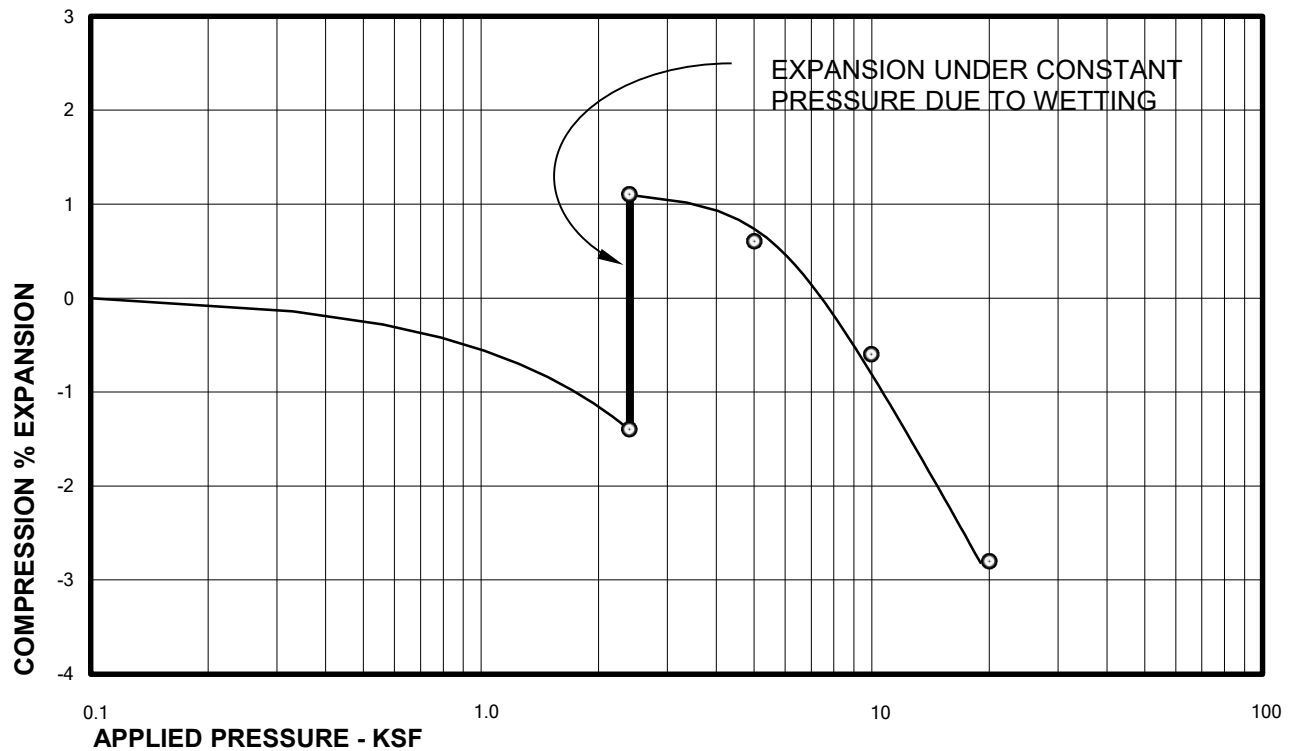
APPLIED PRESSURE - KSF
Sample of WEATHERED CLAYSTONE
From TH-112 AT 4 FEET

DRY UNIT WEIGHT= 88 PCF
MOISTURE CONTENT= 25.3 %

Swell Consolidation Test Results

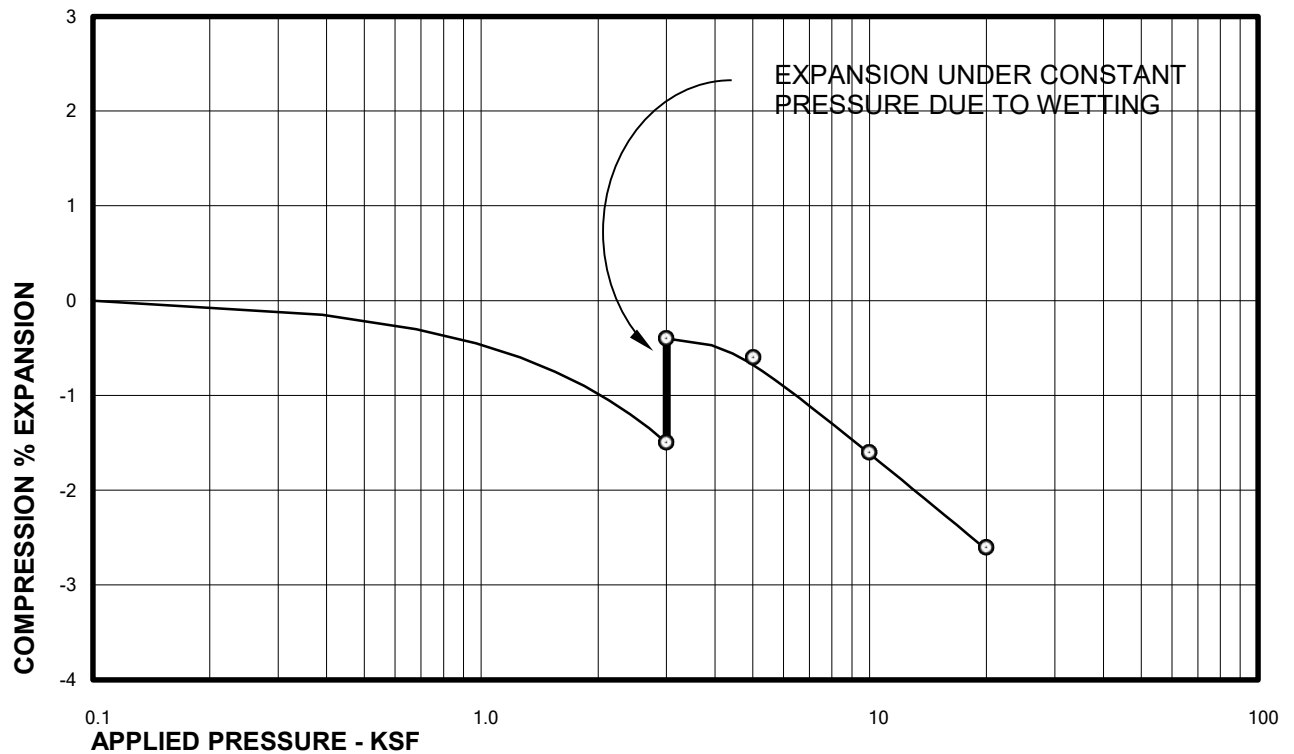
FIG. B-12





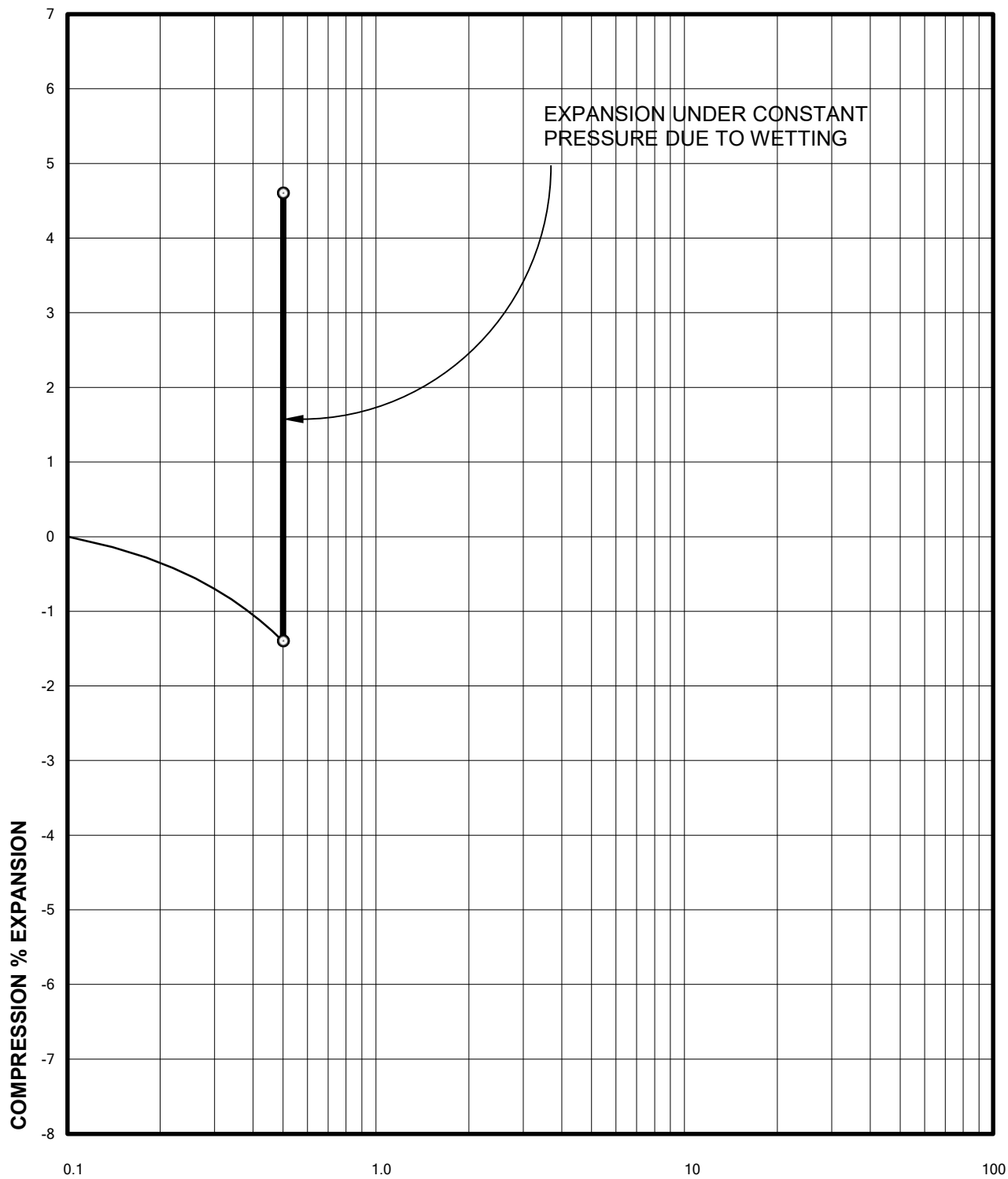
Sample of CLAYSTONE
From TH-112 AT 19 FEET

DRY UNIT WEIGHT= 91 PCF
MOISTURE CONTENT= 26.8 %



Sample of CLAYSTONE
From TH-112 AT 24 FEET

DRY UNIT WEIGHT= 98 PCF
MOISTURE CONTENT= 24.3 %

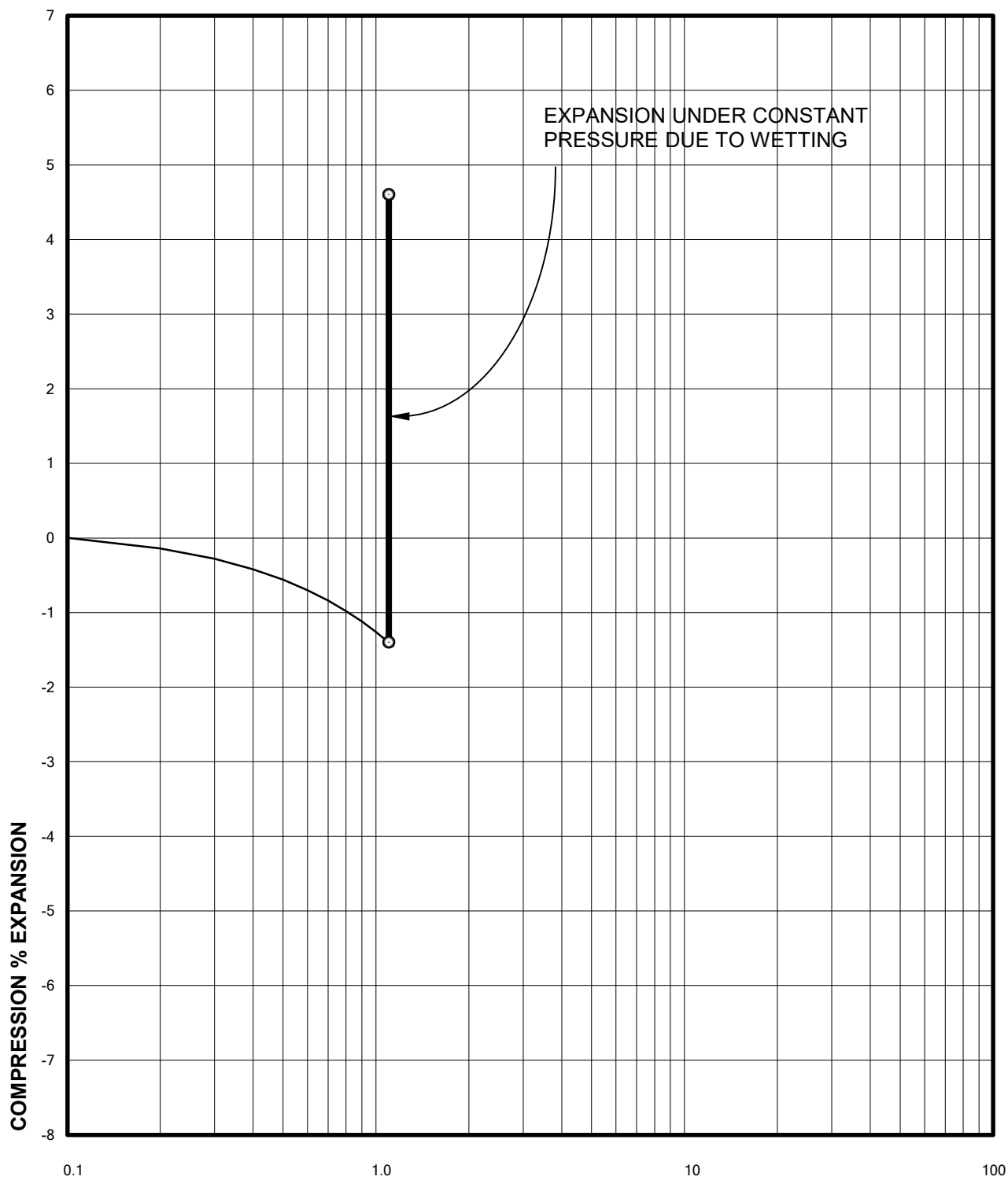


APPLIED PRESSURE - KSF
Sample of CLAY, SANDY (CL)
From TH-116 AT 4 FEET

DRY UNIT WEIGHT= 107 PCF
MOISTURE CONTENT= 14.3 %

Swell Consolidation Test Results

FIG. B-15

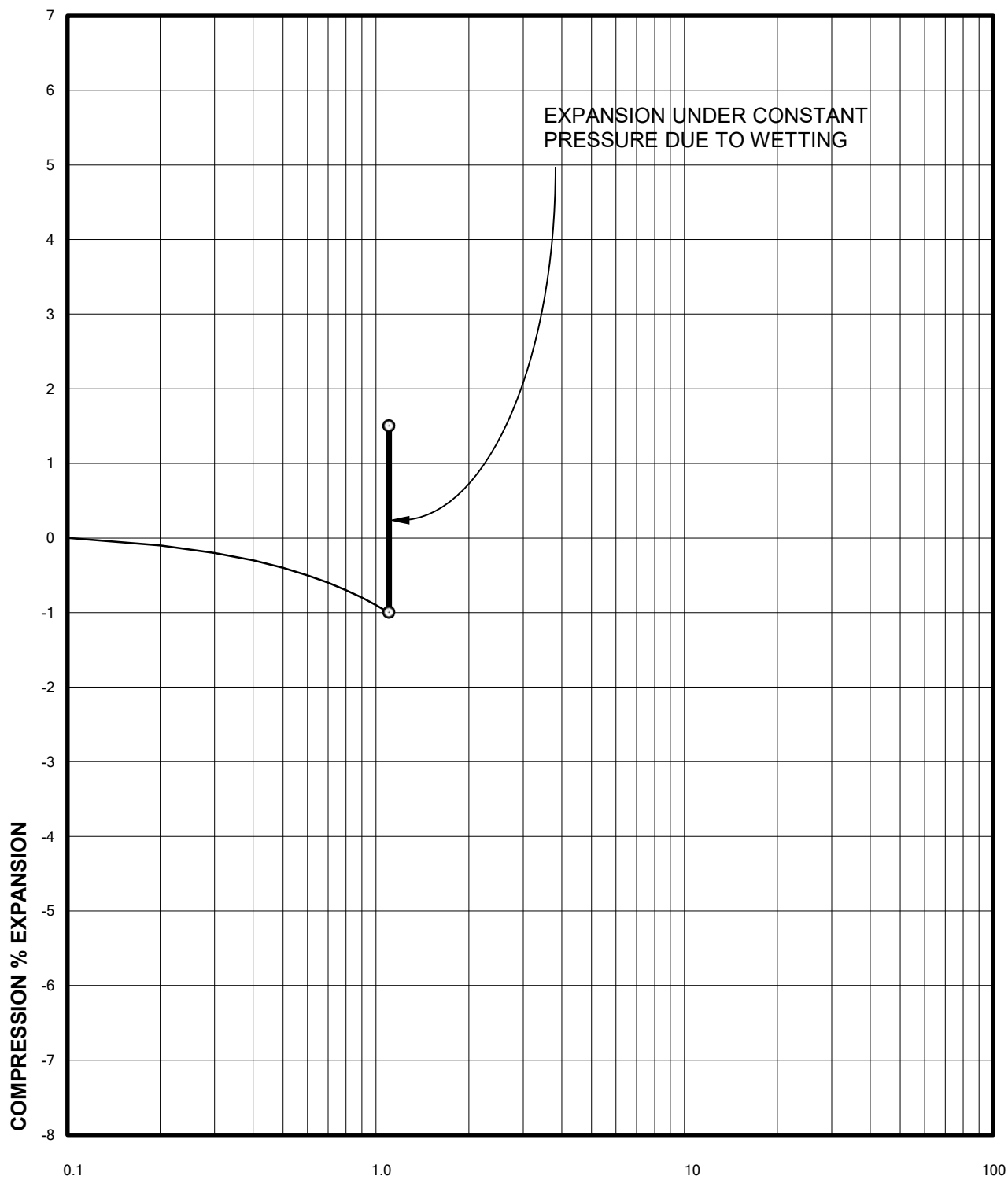


APPLIED PRESSURE - KSF
Sample of CLAY, SANDY (CL)
From TH-116 AT 9 FEET

DRY UNIT WEIGHT= 98 PCF
MOISTURE CONTENT= 22.4 %

Swell Consolidation Test Results

FIG. B-16

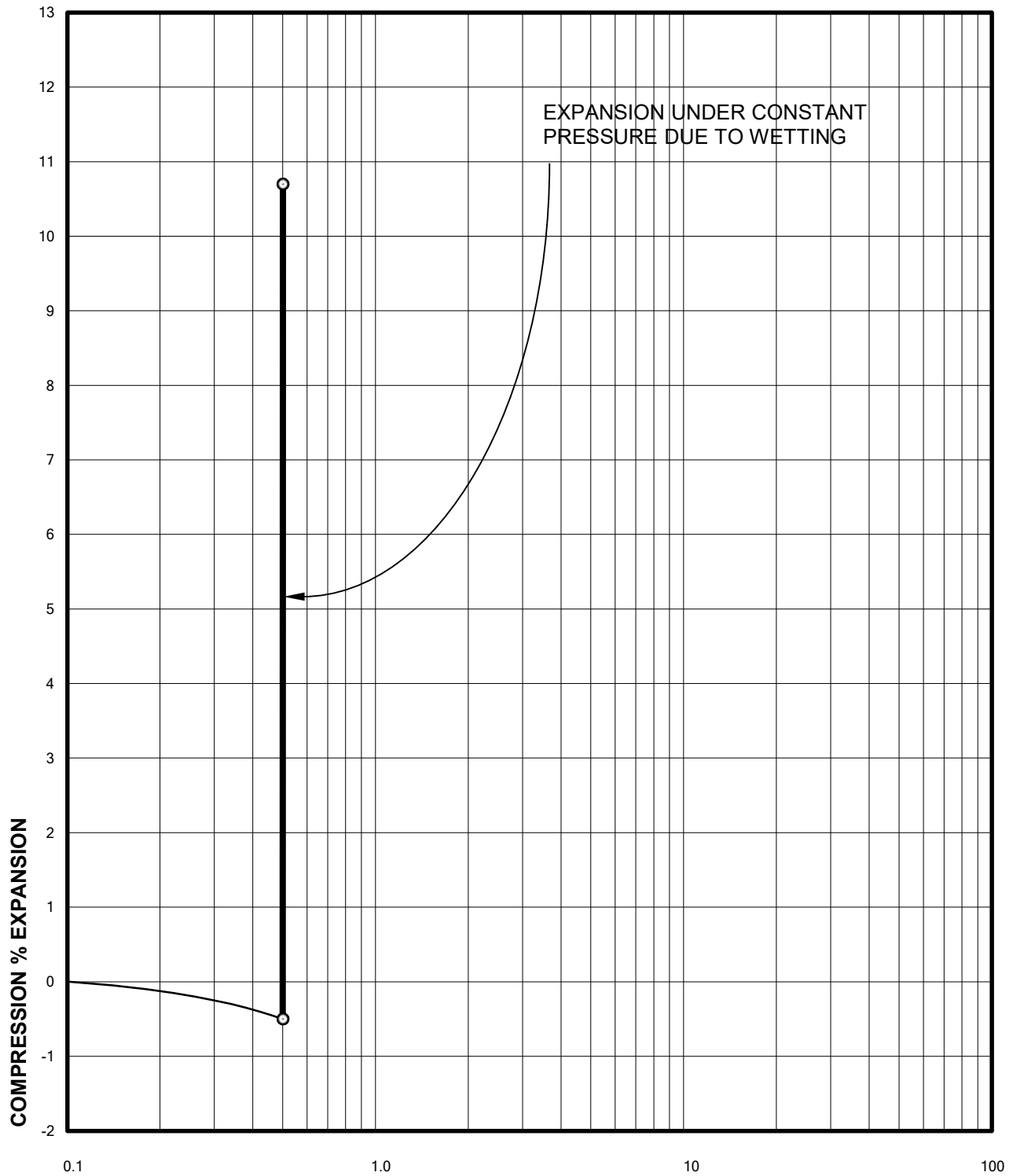


APPLIED PRESSURE - KSF
Sample of WEATHERED CLAYSTONE
From TH-117 AT 9 FEET

DRY UNIT WEIGHT= 95 PCF
MOISTURE CONTENT= 24.2 %

Swell Consolidation Test Results

FIG. B-17

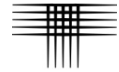
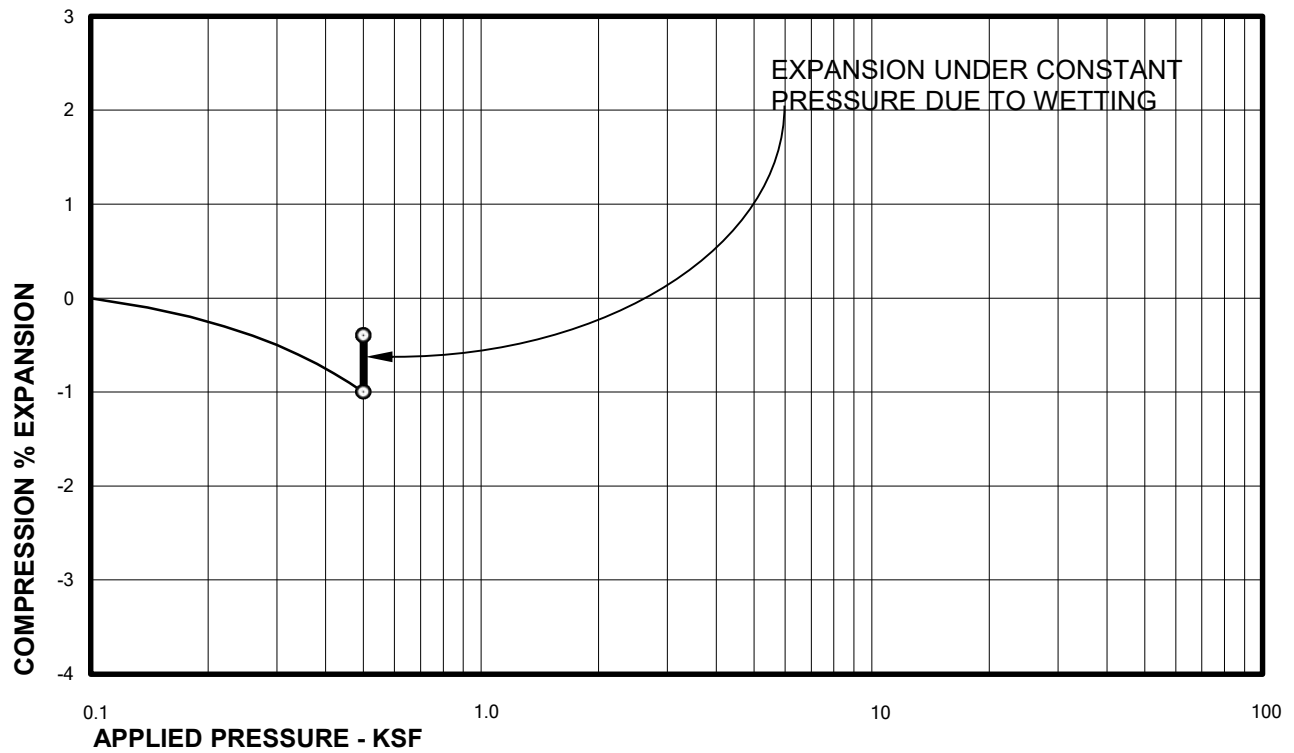


APPLIED PRESSURE - KSF
Sample of CLAY, SANDY (CL)
From TH-119 AT 4 FEET

DRY UNIT WEIGHT= 116 PCF
MOISTURE CONTENT= 15.1 %

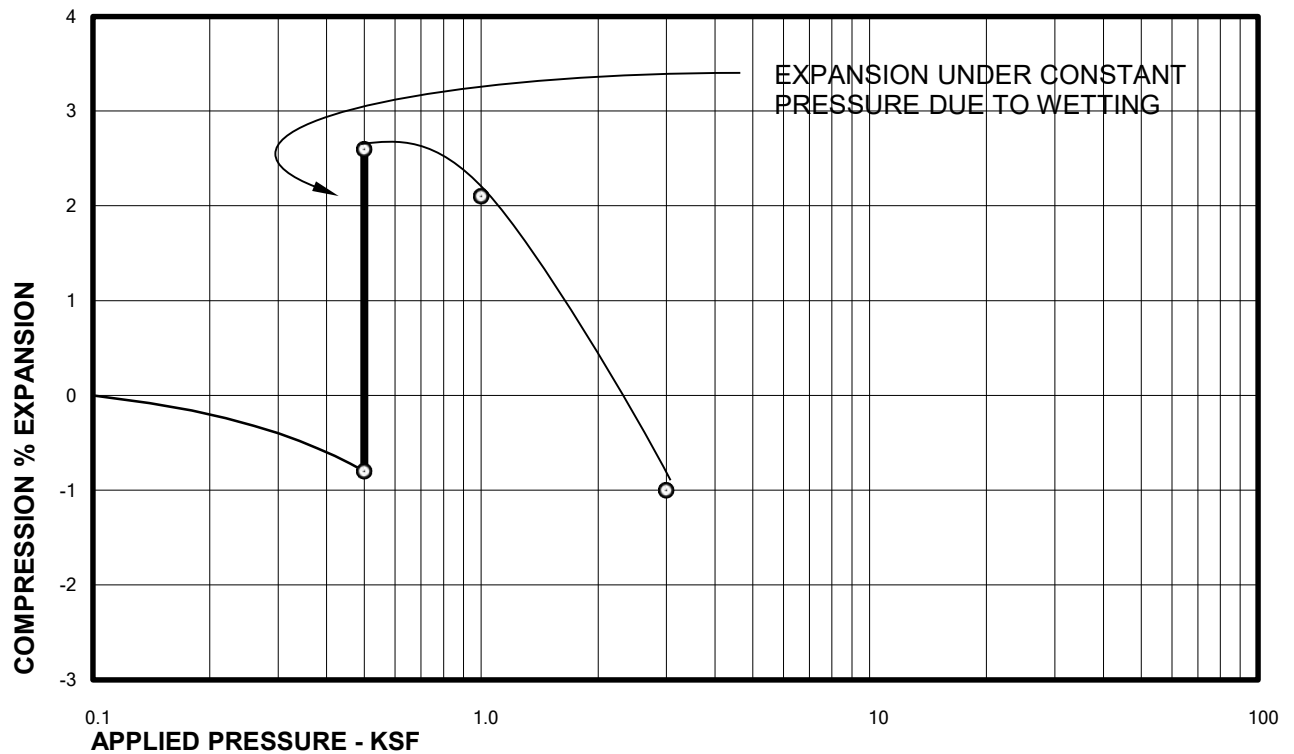
Swell Consolidation Test Results

FIG. B-18



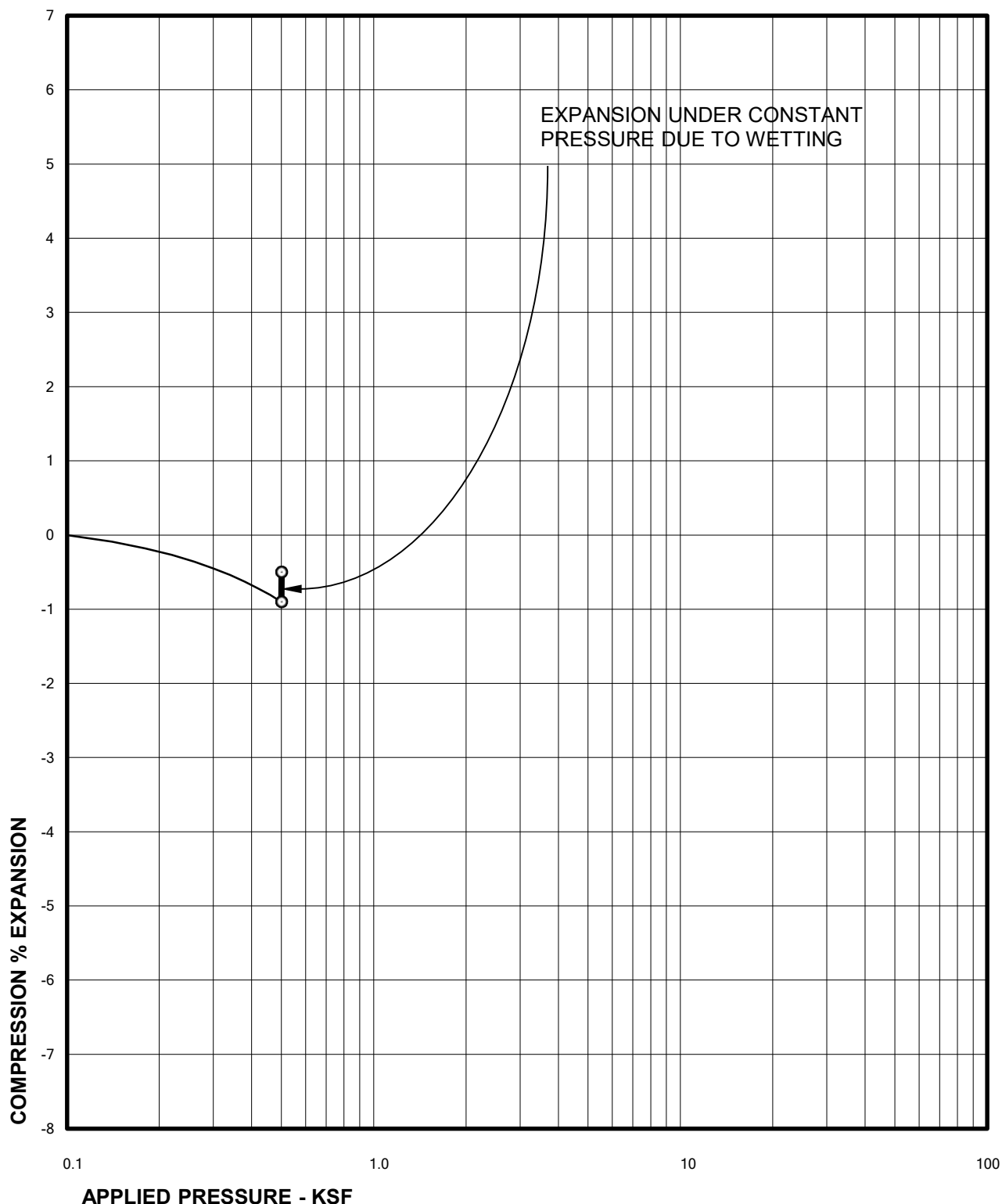
Sample of SAND, CLAYEY (SC)
From TH-120 AT 4 FEET

DRY UNIT WEIGHT= 102 PCF
MOISTURE CONTENT= 17.2 %



Sample of CLAY, SANDY (CL)
From TH-121 AT 4 FEET

DRY UNIT WEIGHT= 109 PCF
MOISTURE CONTENT= 10.6 %

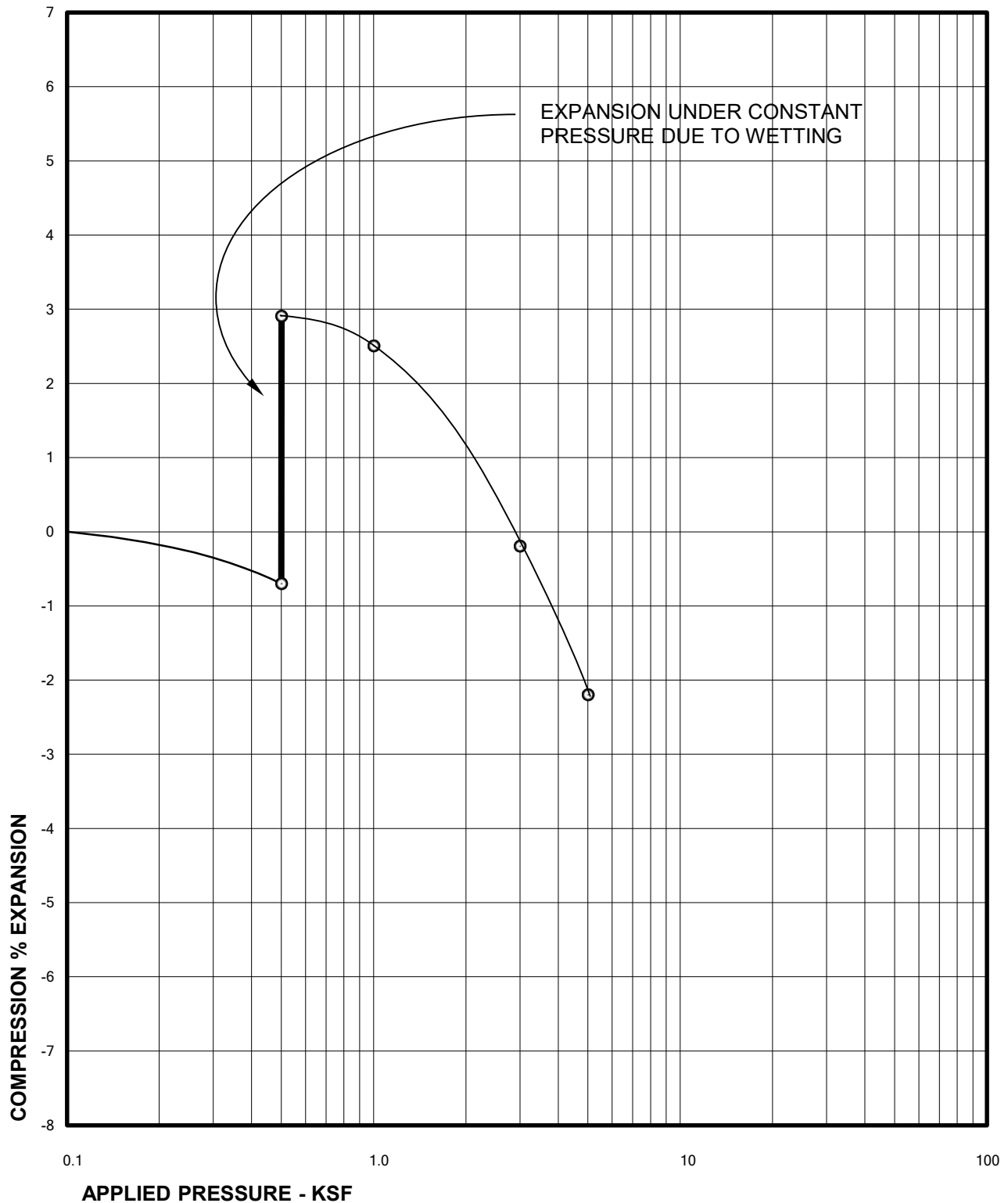


APPLIED PRESSURE - KSF
Sample of CLAY, SANDY (CL)
From TH-122 AT 4 FEET

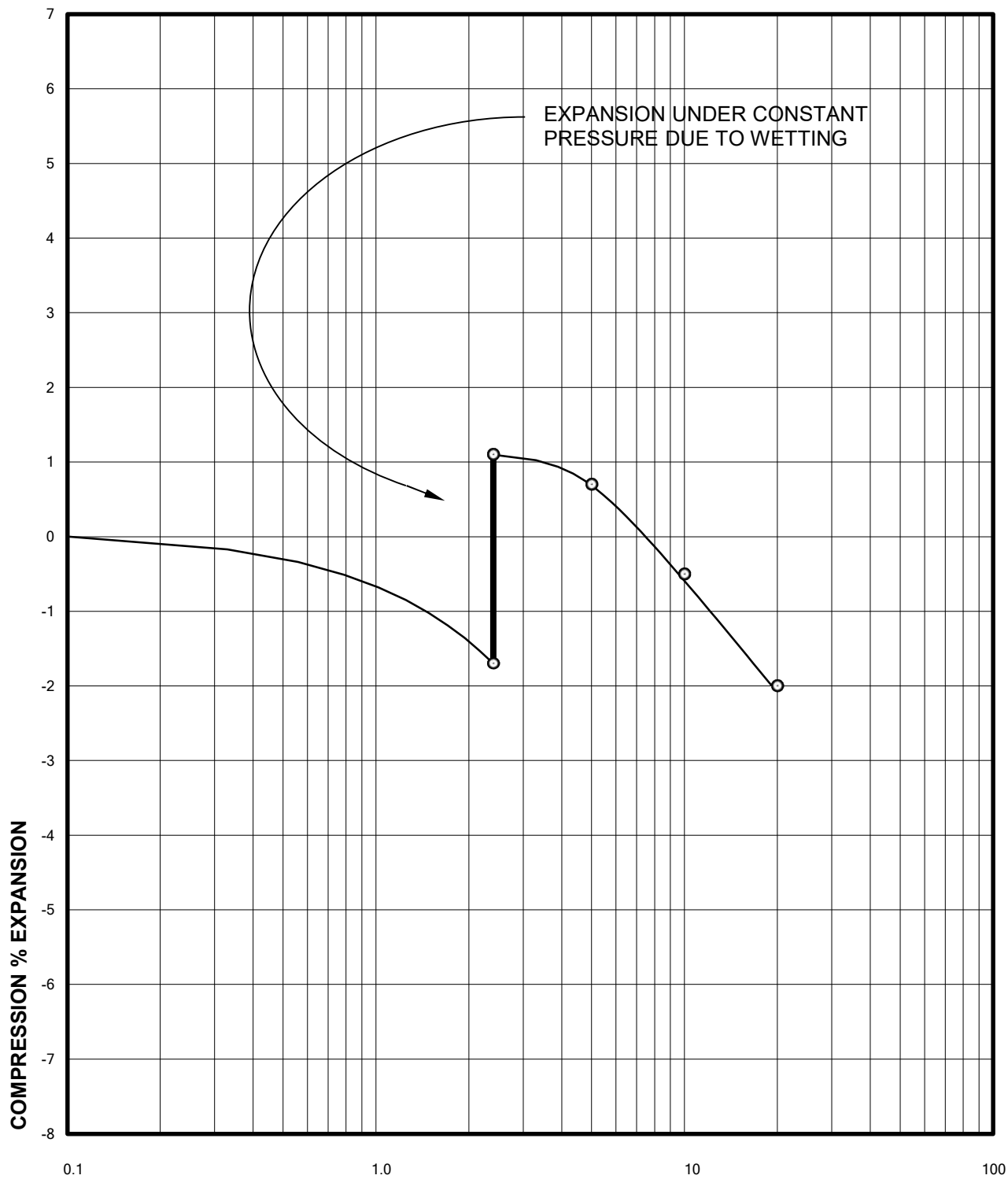
DRY UNIT WEIGHT= 106 PCF
MOISTURE CONTENT= 14.3 %

Swell Consolidation Test Results

FIG. B-20



Swell Consolidation Test Results



APPLIED PRESSURE - KSF
Sample of CLAYSTONE
From TH-123 AT 19 FEET

DRY UNIT WEIGHT= 100 PCF
MOISTURE CONTENT= 25.2 %

Swell Consolidation Test Results

FIG. B-22

TABLE B - I



SUMMARY OF LABORATORY TEST RESULTS

BORING	DEPTH (ft)	MOISTURE CONTENT (%)	DRY DENSITY (pcf)	SWELL TEST DATA				SOIL SUCTION VALUE (pF)	ATTERBERG LIMITS		SOLUBLE SULFATE CONTENT (%)	PASSING NO. 200 SIEVE (%)	SOIL TYPE
				SWELL (%)	COMPRESSION (%)	APPLIED PRESSURE (psf)	SWELL PRESSURE (psf)		LIQUID LIMIT	PLASTICITY INDEX			
TH-101	4	13.0	108	5.9		500	8,000	4.78					CLAY, SANDY (CL)
TH-101	9	12.2	107	1.4		1,100	3,200	4.45					CLAY, SANDY (CL)
TH-101	14	12.5	109	0.9		1,800	4,100	4.41					CLAY, SANDY (CL)
TH-101	19	22.7	99	2.9		2,400	12,000	4.31					CLAYSTONE
TH-101	24	15.8	112		0.4	3,000		3.95					CLAYSTONE
TH-102	4	11.5	96	1.5		500	1,500		41	24		57	CLAY, SANDY (CL)
TH-102	19	17.4	111	1.3		2,400							CLAYSTONE
TH-103	9	4.3	130									9	SANDSTONE
TH-104	4	8.4	99									14	SANDSTONE
TH-105	2	7.6	113									11	SANDSTONE
TH-105	9	7.6	107									22	SANDSTONE, SILTY
TH-106	4	6.2	79									9	SANDSTONE
TH-107	2	11.8	101	5.4		200					<0.01		CLAY, SANDY (CL)
TH-108	9	5.3	99									11	SANDSTONE
TH-109	2	14.4	105	8.2		200							CLAY, SANDY (CL)
TH-109	4	12.2	102	2.3		500							CLAY, SANDY (CL)
TH-109	14	5.5	110									20	SANDSTONE, SILTY
TH-110	4	14.2	107	7.8		500	10,000						CLAY, SANDY (CL)
TH-110	9	17.8	100	3.7		1,100	9,000						CLAY, SANDY (CL)
TH-111	4	14.5	104	6.4		500							CLAY, SANDY (CL)
TH-112	4	25.3	88	7.5		500	9,500	4.45					WEATHERED CLAYSTONE
TH-112	9	26.1	92	3.2		1,100	16,000	4.45					WEATHERED CLAYSTONE
TH-112	14	27.8	92	2.8		1,800	18,000	4.46					CLAYSTONE
TH-112	19	26.8	91	2.5		2,400	13,000	4.47					CLAYSTONE
TH-112	24	24.3	98	1.1		3,000	9,500	4.31					CLAYSTONE
TH-113	4	2.8										14	SANDSTONE
TH-114	14	4.4										14	SANDSTONE
TH-116	4	14.3	107	6.0		500					0.04		CLAY, SANDY (CL)
TH-116	9	22.4	98	6.0		1,100							CLAY, SANDY (CL)
TH-116	14	25.2	94						61	35		98	CLAYSTONE
TH-117	9	24.2	95	2.5		1,100							WEATHERED CLAYSTONE
TH-118	4	6.2	111									24	SANDSTONE, SILTY
TH-119	2	13.6	94						52	35		64	CLAY, SANDY (CH)
TH-119	4	15.1	116	11.2		500							CLAY, SANDY (CL)
TH-120	4	17.2	102	0.6		500			58	39		43	POSSIBLE FILL/ORGANIC SOIL, SAND, CLAYEY
TH-121	4	10.6	109	3.4		500	3,000		49	33		54	CLAY, VERY SANDY (CL)
TH-122	4	14.3	106	0.4		500							CLAY, SANDY (CL)
TH-123	4	17.9	97	3.6		500	3,500						CLAY, SANDY (CL)
TH-123	19	25.2	100	2.8		2,400	18,000						CLAYSTONE



APPENDIX C

GUIDELINE SITE GRADING SPECIFICATIONS
FOUNDERS VISTA, FILING NO. 1, 258 LOTS



GUIDELINE SITE GRADING SPECIFICATIONS

Founders Vista, Filing No. 1, 258 Lots
Castle Rock, Colorado

1. DESCRIPTION

This item shall consist of the excavation, transportation, placement and compaction of materials from locations indicated on the plans, or staked by the Engineer, as necessary to achieve preliminary street and overlot elevations. These specifications shall also apply to compaction of excess cut materials that may be placed outside of the subdivision and/or filing boundaries.

2. GENERAL

The Soils Representative shall be the Owner's representative. The Soils Representative shall approve fill materials, method of placement, moisture contents and percent compaction, and shall give written approval of the completed fill.

3. CLEARING JOB SITE

The Contractor shall remove all vegetation, trees, brush and rubbish before excavation or fill placement begins. The Contractor shall dispose of the cleared material to provide the Owner with a clean, neat appearing job site. Cleared material shall not be placed in areas to receive fill or where the material will support structures of any kind.

4. SCARIFYING AREA TO BE FILLED

Topsoil and vegetable matter shall be substantially removed from the ground surface upon which fill is to be placed. The surface shall then be plowed or scarified to a depth of 8 inches, moisture treated to above optimum moisture content, and compacted until the surface is free from ruts, hummocks or other uneven features, which would prevent uniform compaction by the equipment to be used.

5. COMPACTING AREA TO BE FILLED

After the foundation for the fill has been cleared and scarified, it shall be disked or bladed until it is free from large clods to a depth of 8 to 12 inches, brought to the proper moisture content (between 1 and 4 percent above optimum moisture content for clay and within 2 percent of optimum for sand) and compacted to not less than 95 percent of maximum density as determined in accordance with ASTM D 698. The foundation materials shall be worked, stabilized, or removed and replaced if necessary in accordance with the soils representative's recommendations in preparation for fill.

6. FILL MATERIALS

Fill soils shall be substantially free from vegetable matter or other deleterious substances, and shall not contain rocks having a diameter greater than six (6) inches and bedrock chunks larger than three (3) inches. Fill materials shall be obtained from cut areas shown on the plans or staked in the field by the Engineer.



On-site materials classifying as CL, CH, SC, SM, SW, SP, GP, GC and GM are acceptable. Concrete, asphalt, organic matter and other deleterious materials or debris shall not be used as fill.

7. MOISTURE CONTENT

For fill material classifying as CH, CL or SC, the fill shall be moisture treated to between 1 and 4 percent above optimum moisture content. Soils classifying as SM, SW, SP, GP, GC and GM shall be moisture treated to within 2 percent of optimum moisture content as determined from Proctor compaction tests. Sufficient laboratory compaction tests shall be made to determine the optimum moisture content for the various soils encountered in borrow areas.

The Contractor may be required to add moisture to the excavation materials in the borrow area if, in the opinion of the Soils Representative, it is not possible to obtain uniform moisture content by adding water on the fill surface. The Contractor may be required to rake or disc the fill soils to provide uniform moisture content through the soils.

The application of water to embankment materials shall be made with any type of watering equipment approved by the Soils Representative, which will give the desired results. Water jets from the spreader shall not be directed at the embankment with such force that fill materials are washed out.

Should too much water be added to any part of the fill, such that the material is too wet to permit the desired compaction from being obtained, rolling and all work on that section of the fill shall be delayed until the material has been allowed to dry to the required moisture content. The Contractor will be permitted to rework wet material in an approved manner to hasten its drying.

8. COMPACTION OF FILL AREAS

Selected fill material shall be placed and mixed in evenly spread layers. After each fill layer has been placed, it shall be uniformly compacted to not less than the specified percentage of maximum density. Fill shall be compacted to at least 95 percent of the maximum density as determined in accordance with ASTM D 698. At the option of the Soils Representative, soils classifying as SW, GP, GC, or GM may be compacted to 95 percent of maximum density as determined in accordance with ASTM D 1557 or 70 percent relative density for cohesionless sand soils. Fill materials shall be placed such that the thickness of loose materials does not exceed 8 inches and the compacted lift thickness does not exceed 6 inches.

Compaction as specified above shall be obtained by the use of sheepfoot rollers, multiple-wheel pneumatic-tired rollers, or other equipment approved for soils classifying as CL, CH, or SC. Granular fill shall be compacted using vibratory equipment or other approved equipment. Compaction shall be accomplished while the fill material is at the specified moisture content. Compaction of each layer shall be continuous over the entire area. Compaction equipment shall make sufficient passes to ensure that the required density is obtained.



9. COMPACTION OF SLOPES

Fill slopes shall be compacted by means of sheepfoot rollers or other suitable equipment. Compaction operations shall be continued until slopes are stable, but not too dense for planting, and there is not an appreciable amount of loose soils on the slopes. Compaction of slopes may be done progressively in increments of three to five feet (3' to 5') in height or after the fill is brought to its total height. Permanent fill slopes shall not exceed 3:1 (horizontal to vertical).

10. PLACEMENT OF FILL ON NATURAL SLOPES

Where natural slopes are steeper than 20 percent in grade and the placement of fill is required, cut benches shall be provided at the rate of one bench for each 5 feet in height (minimum of two benches). Benches shall be at least 10 feet in width. Larger bench widths may be required by the Engineer. Fill shall be placed on completed benches as outlined within this specification.

11. DENSITY TESTS

Field density tests shall be made by the Soils Representative at locations and depths of his choosing. Where sheepfoot rollers are used, the soil may be disturbed to a depth of several inches. Density tests shall be taken in compacted material below the disturbed surface. When density tests indicate that the density or moisture content of any layer of fill or portion thereof is below that required, the particular layer or portion shall be re-worked until the required density or moisture content has been achieved.

12. SEASONAL LIMITS

No fill material shall be placed, spread or rolled while it is frozen, thawing, or during unfavorable weather conditions. When work is interrupted by heavy precipitation, fill operations shall not be resumed until the Soils Representative indicates that the moisture content and density of previously placed materials are as specified.

13. NOTICE REGARDING START OF GRADING

The Contractor shall submit notification to the Soils Representative and Owner advising them of the start of grading operations at least three (3) days in advance of the starting date. Notification shall also be submitted at least 3 days in advance of any resumption dates when grading operations have been stopped for any reason other than adverse weather conditions.

14. REPORTING OF FIELD DENSITY TESTS

Density tests made by the Soils Representative, as specified under "Density Tests" above, shall be submitted progressively to the Owner. Dry density, moisture content, and percentage compaction shall be reported for each test taken.

15. DECLARATION REGARDING COMPLETED FILL

The Soils Engineer shall provide a written declaration stating that the site was filled with acceptable materials, and was placed in general accordance with the specifications.



APPENDIX D
GUIDELINE SUB-EXCAVATION SPECIFICATIONS
Founders Vista Property
Castle Rock, Colorado

Note: This guideline is intended for use with sub-excavation. If sub-excavation is not selected, the guidelines in Appendix C should be followed.



GUIDELINE SUB-EXCAVATION SPECIFICATIONS

Founders Vista Property,
Castle Rock, Colorado

1. DESCRIPTION

This item shall consist of the excavation, transportation, placement and compaction of materials from locations indicated on the plans, or staked by the Engineer, as necessary to achieve preliminary street and overlot elevations. These specifications shall also apply to compaction of materials that may be placed outside of the development boundaries.

2. GENERAL

The Soils Engineer shall be the Owners representative. The Soils Engineer shall approve fill materials, method of placement, moisture content and percent compaction, and shall give written approval of the completed fill.

3. CLEARING JOB SITE

The Contractor shall remove all vegetation and debris before excavation or fill placement is begun. The Contractor shall dispose of the cleared material to provide the Owner with a clean, neat appearing job site. Cleared material shall not be placed in areas to receive fill where the material will support structures of any kind.

4. SCARIFYING AREA TO BE FILLED

All topsoil and vegetable matter shall be removed from the ground surface upon which fill is to be placed. The surface shall then be plowed or scarified until the surface is free from ruts, hummocks or other uneven features which would prevent uniform compaction.

5. COMPACTING AREA TO BE FILLED

After the foundation for the fill has been cleared and scarified, it shall be disked or bladed until it is free from large clods, brought to the proper moisture content, (1 to 4 percent above optimum moisture content) and compacted to not less than 95 percent of maximum density as determined in accordance with ASTM D 698.

6. FILL MATERIALS

Fill soils shall be free from vegetable matter or other deleterious substances, and shall not contain rocks having a diameter greater than six (6) inches and bedrock chunks larger than three (3) inches. Fill materials shall be obtained from cut areas shown on the plans or staked in the field by the Engineer.

On-site materials classifying as CL, CH, SC, SM, SP, GP, GC and GM are acceptable. Concrete, asphalt, and other deleterious materials or debris shall not be used as fill.



7. MOISTURE CONTENT

Fill materials shall be moisture treated to within limits of optimum moisture content specified in "Moisture Content and Density Criteria". Sufficient laboratory compaction tests shall be made to determine the optimum moisture content for the various soils encountered in borrow areas or imported to the site.

The Contractor may be required to add moisture to the excavation materials in the borrow area if, in the opinion of the Soils Engineer, it is not possible to obtain uniform moisture content by adding water on the fill surface. The Contractor will be required to rake or disc the fill to provide uniform moisture content throughout the fill.

The application of water to embankment materials shall be made with any type of watering equipment approved by the Soils Engineer, which will give the desired results. Water jets from the spreader shall not be directed at the embankment with such force that fill materials are washed out.

Should too much water be added to any part of the fill, such that the material is too wet to permit the desired compaction from being obtained, rolling and all work on that section of the fill shall be delayed until the material has been allowed to dry to the required moisture content. The Contractor will be permitted to rework wet material in an approved manner to hasten its drying.

8. COMPACTION OF FILL MATERIALS

Selected fill material shall be placed and mixed in evenly spread layers. After each fill layer has been placed, it shall be uniformly compacted to not less than the specified percentage of maximum density given in "Moisture Content and Density Criteria". Fill materials shall be placed such that the thickness of loose material does not exceed 8 inches and the compacted lift thickness does not exceed 6 inches.

Compaction, as specified above, shall be obtained by the use of sheepfoot rollers, multiple-wheel pneumatic-tired rollers, or other equipment approved by the Soils Engineer for soils classifying as CL, CH or SC. Granular fill shall be compacted using vibratory equipment or other equipment approved by the Soils Engineer. Compaction shall be accomplished while the fill material is at the specified moisture content. Compaction of each layer shall be continuous over the entire area. Compaction equipment shall make sufficient trips to ensure that the required density is obtained.

9. MOISTURE CONTENT AND DENSITY CRITERIA

Fill material shall be substantially compacted to at least 95 percent of maximum ASTM D 698 (AASHTO T 99) dry density at 1 to 4 percent above optimum moisture content for clay or within 2 percent of optimum for sand. Additional criteria for acceptance are presented in DENSITY TESTS.

10. DENSITY TESTS

Field density tests shall be made by the Soils Engineer at locations and depths of his choosing. Where sheepfoot rollers are used, the soil may be disturbed to a depth of several inches. Density tests shall be taken in compacted material below the disturbed



surface. When density tests indicate the density or moisture content of any layer of fill or portion thereof not within specifications, the particular layer or portion shall be reworked until the required density or moisture content has been achieved.

Allowable ranges of moisture content and density given in MOISTURE CONTENT AND DENSITY CRITERIA are based on design considerations. The moisture shall be controlled by the Contractor so that moisture content of the compacted earth fill, as determined by tests performed by the Soils Engineer, shall be within the limits given. The Soils Engineer will inform the Contractor when the placement moisture is less than or exceeds the limits specified and the Contractor shall immediately make adjustments in procedures as necessary to maintain placement moisture content within the specified limits, to satisfy the following requirements.

A. Moisture

1. The average moisture content of material tested each day shall not be less than 1.5 percent over optimum moisture content.
2. Material represented by samples tested having moisture lower than 1 percent over optimum will be rejected. Such rejected materials shall be reworked until moisture equal to or greater than 1 percent above optimum is achieved.

B. Density

1. The average dry density of material tested each day shall not be less than 95 percent of maximum ASTM D 698 dry density.
2. No more than 10 percent of the material represented by the samples tested shall be at dry densities less than 95 percent of maximum ASTM D 698 dry density.
3. Material represented by samples tested having dry density less than 94 percent of maximum ASTM D 698 dry density will be rejected. Such rejected materials shall be reworked until a dry density equal to or greater than 95 percent of maximum ASTM D 698 dry density is obtained.

11. INSPECTION AND TESTING OF FILL

Inspection by the Soils Engineer shall be sufficient during the placement of fill and compaction operations so that they can declare the fill was placed in general conformance with specifications. All inspections necessary to test the placement of fill and observe compaction operations will be at the expense of the Owner.

12. SEASONAL LIMITS

No fill material shall be placed, spread or rolled while it is frozen, thawing, or during unfavorable weather conditions. When work is interrupted by heavy precipitation, fill operations shall not be resumed until the Soils Engineer indicates the moisture content and density of previously placed materials are as specified.



13. REPORTING OF FIELD DENSITY TESTS

Density tests made by the Soils Engineer, as specified under "Density Tests" above, shall be submitted progressively to the Owner. Dry density, moisture content and percentage compaction shall be reported for each test taken.