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GEOLOGIC HAZARDS EVALUATION AND PRELIMINARY GEOTECHNICAL INVESTIGATION
HAY CREEK DEVELOPMENT
2855 HAY CREEK ROAD
EL PASO COUNTY, COLORADO

Prepared for:

COLA, LLC
555 Middle Creek Parkway
Colorado Springs, Colorado 80921

Attention: Mr. Timothy Buschar

CTL|T Project No. CS19573-115

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SCOPE

This report presents the results of our Geologic Hazards Evaluation and Preliminary Geotechnical Investigation for the Hay Creek Development located at 2855 Hay Creek Road in El Paso County, Colorado. The investigated site includes six lots consisting of between 31.9 to 37.7 acres, totaling 213.41 acres. The six lots are planned to be subdivided into twenty single-family residential lots. Development is planned as single-family, detached residences with basements and attached one or two car garages. Each lot will consist of 5.5 to 17 acres of land and be occupied with one residence. The purpose of our investigation was to evaluate the site for the occurrence of potential geologic hazards that may impact development and to investigate the subsurface conditions to assist in planning of residential construction. The report includes descriptions of the subsurface conditions encountered in our exploratory borings, and discussions of construction as influenced by geotechnical considerations. The scope of our services was described in our proposal (CS-22-0113) dated June 14, 2022. Evaluation of the property for the presence of potentially hazardous materials (Environmental Site Assessment) was included under a separate letter head.

This report is based on our understanding of the planned construction, subsurface conditions disclosed by exploratory borings, results of field and laboratory tests, engineering analysis, and our experience. It contains descriptions of the soil and bedrock conditions and groundwater levels found in our exploratory borings, our opinion of the potential influence of geologic conditions, and preliminary design and construction criteria for foundations, floor systems, surface and subsurface drainage, and roadway design sections. The discussions of foundation and floor systems are intended for planning purposes only. Additional, lot-specific investigations will be necessary and can use the information obtained during this investigation unless a proposed residence locations are significantly different as currently planned. A brief summary of our conclusions and recommendations follows, with more detailed discussion in the report.

The following section summarizes the report. A more complete description of the conditions found at the site, our interpretations, and our recommendations are included in the report.

SUMMARY

1. We did not identify geologic hazards that we anticipate will preclude development of the project as planned. The conditions we identified include expansive soils and bedrock, shallow bedrock, erosion, steep slopes, and flood potential. Regional geologic conditions that impact the site include seismicity and radioactivity. We believe each of these conditions can be mitigated with engineering design and construction methods commonly employed in this area.
2. The near-surface soils encountered in the fifteen exploratory borings drilled during this investigation consisted of up to 26 feet of natural, silty sand with occasional lenses of sandy clay. The natural soils are underlain by weathered and intact sandy to very sandy claystone and clayey to very clayey or slightly silty to silty sandstone bedrock to the maximum depths explored of 20 to 30 feet.
3. Groundwater was encountered in one exploratory boring at a depth of 29 feet during our investigation. The borings were found to be dry at the time of our delayed groundwater measurements. Groundwater levels will vary with seasonal precipitation and landscaping irrigation.
4. We anticipate site grading will be minimal and restricted to the vicinity of each residence footprint. In our opinion, site grading and utility installation across the site can be accomplished using conventional, heavy-duty construction equipment. Areas of shallow hard to very hard bedrock may be encountered. The underlying bedrock may be present difficult conditions during excavation and site grading.
5. We anticipate spread footing foundations and conventional, slab-on-grade floors underlain by a layer of sub-excavation fill and/or new site grading fill will be appropriate for the proposed residences where loose granular soils or expansive soils and bedrock are encountered near anticipated foundation elevations. Where subsurface soils are relatively dense and non-expansive, a sub-excavation layer is not necessary, and foundations may rely on the in place, natural soils or bedrock. Non-expansive bedrock may need to be over excavated if depths are variable at the foundation elevations.
6. Overall plans should provide for the rapid conveyance of surface runoff to the storm sewer system.

SITE CONDITIONS

The investigated property currently includes six individual lots consisting of between 31.9 and 37.7 acres. The western most lot is addressed as 2855 Hay Creek Road in Northern El paso County, Colorado. The remaining five lots do not have an assigned address, according to the El Paso County Assessor. The site lies within the southeast quarter of Section 33 and the southwest quarter of Section 34, Township 11 South, Range 67 West of the 6th Principal Meridian), in El Paso County, Colorado. With exception to Lot 10, the site is undeveloped. Lot 10 is occupied with a single-family residence, an indoor horse-riding arena, and indoor horse stables. An outdoor arena is present, south of the existing residence. Past uses of the site have included horse boarding and grazing. The site and location of exploratory borings is shown in Fig. 1.

Overall, the property is located within a valley, bound on the north, south, and west by bluffs ranging from about 40 to 200 feet above the valley floor. Generally, the overall ground surface across the property slopes downward to the east at grades of between about less than 2 percent to up to about 15 percent. Steeper slopes are located near the north and south site boundaries, sloping toward the valley floor by an estimated grade of between 5 and 40 percent. Vegetation on the site consists of a slight to moderate stand of mostly grasses, weeds, and coniferous trees. Dense scrub oak and coniferous trees are generally concentrated at the higher elevations along north and south property boundaries. The valley floor is generally barren of shrubs and trees.

The land to the north, east, and west are developed with large lot residences/mini ranches. The Air Force Academy bounds the site on the south. Hay Creek Road is located to the north of the Site.

PROPOSED DEVELOPMENT

We understand the overall property consisting of six, 31.9 to 37.7 acre lots and is planned to be subdivided into twenty lots ranging from 5.5 to 17.2 acres to be developed with twenty single family, detached residences. The residences are anticipated to be one to two-story, wood-frame structures with basements and attached multi-car garages. Based on the preliminary development plan, the residences are planned to be constructed at the locations of the exploratory borings, identified on Fig. 1 of this report. The locations are comparatively gently sloped. Areas observed and mapped as steeply slopping are not planned to be developed. The development will include an 11.5-acre open space and a 3-acre pond for stormwater quality located near the northeast corner of the overall property. Paved roadways will include a local street, providing access to Hay Creek Road. We anticipate the development will be serviced by a centralized sanitary sewer collection system and potable water distribution system.

SUBSURFACE INVESTIGATION

Subsurface conditions across the site were investigated by drilling fifteen (15) exploratory borings to depths of 20 to 30 feet at the approximate locations shown in Fig. 1. The borings were drilled using 4-inch diameter, continuous-flight, solid-stem auger and a truck-mounted drilling rig.

Samples of the soils were obtained at 5 to 10-foot intervals using a 2.5-inch diameter (O.D.) modified California barrel sampler driven by blows from a 140-pound hammer falling 30 inches. Our field representative was present to observe drilling operations, log the soils and bedrock encountered, and obtain samples for laboratory tests. The number of borings was determined referencing El Paso County criteria for Geologic Hazards Evaluations and the locations were identified on the preliminary site plan by the client that included one exploratory boring at fifteen of the proposed residence footprints. The borings were located in the field by GPS and referencing the site plan. Graphical logs of the conditions found in our exploratory borings, the results of field penetration resistance tests, and some laboratory data are shown in Appendix A. Results of swell-consolidation testing are presented in Appendix B. Laboratory test data are summarized in Table B-1.

Soil samples obtained during this study were returned to our laboratory and visually classified. Laboratory testing was then assigned to representative samples. Testing included moisture content and dry density, sieve analysis (percent passing the No. 200 sieve), swell-consolidation, and water-soluble sulfate content tests.

SUBSURFACE CONDITIONS

The near-surface soils encountered in the fifteen (15) exploratory borings consisted of up to 26 feet of natural, slightly silty to very silty sand with occasional lenses of sandy clay. The natural soils are underlain by weathered and intact sandy to very sandy claystone and clayey to very clayey or slightly silty to silty sandstone bedrock to the maximum depths explored of 20 to 30 feet. Some of the pertinent engineering characteristics of the soils encountered and groundwater conditions are discussed in the following paragraphs.

Sand Soils

Slightly silty to very silty sand with occasional interbedded lenses of sandy clay was encountered in each of the fifteen exploratory borings at the ground surface and extended to depths of between 3 and 26 feet. The sand is judged to be loose to very dense based on field penetration resistance test results. Fourteen samples of the sand were subjected to laboratory testing and contained 9 to 37 percent silty and clay-sized particles. Based on experience, sands are typically non-expansive to slightly expansive when wetted.

Interbedded sandy clay lenses were encountered in several borings within the natural sands. The clay lenses ranged from about 4 to 5 feet in thickness, and were judged to be very stiff based on field penetration resistance testing. Thinner lenses of clay were identified in the sand layer during drilling. Two samples of the clay were subjected to laboratory testing. One sample contained 56 percent clay and silt-sized particles. A second sample was subjected to swell-consolidation testing resulting in a measured swell of 0.8 percent when wetted under estimated overburden pressures. Our experience and results of laboratory testing suggests the clay may exhibit low measured swell values when wetted.

Bedrock

Weathered and intact claystone as well as sandstone bedrock was encountered underlying the natural soils in each of the borings. The bedrock was encountered at depths between 3 and 26 feet and extended to the maximum depths explored of 30 feet. Weathered bedrock was encountered overlying the intact bedrock. The following discusses details regarding the various bedrock types encountered at the site.

Weathered bedrock was encountered in six of the exploratory borings and was judged to be medium hard based on field penetration resistance testing. The weathered bedrock varied from claystone to sandstone and was encountered at depths of about 3 to18 feet and was approximately 2 to 3 feet thick. Four samples of the weathered bedrock were subjected to laboratory testing. One sample contained 28 percent silt and clay-sized particles. Three samples were subjected to swell-consolidation testing, resulting in measured swells of between 1.4 and 7.8 percent when wetted under estimated overburden pressures. The weathered bedrock is generally considered to exhibit low to high expansion potential.

Sandy to very sandy, intact claystone bedrock was encountered in nine of the exploratory borings at depths of about 6 to 16 feet. The claystone was judged to be medium hard to very hard based on the results of field penetration resistance tests. Seven samples of the bedrock were subjected to laboratory testing. Three samples contained 50 to 75 percent clay and silt-sized particles, and five samples of the claystone were subjected to swell-consolidation testing resulting in measured swells of between 0.8 to 8.7 percent when wetted under estimated overburden pressures. One sample did not swell when wetted. The claystone is judged to exhibit low to high measured swell when wetted under estimated overburden pressures.

Slightly silty to silty and clayey to very clayey sandstone bedrock was encountered underlying the natural sand soils, weathered bedrock, or claystone bedrock in each of the exploratory borings. The sandstone was judged to be hard to very hard based on field penetration resistance testing, and was encountered at depths ranging from 6 to 26 feet, extending to the maximum depths explored of up to 30 feet. Claystone was found underlying the sandstone in one of the exploratory borings. Seven samples of the sandstone were subjected to laboratory testing. Six samples contained 9 to 42 percent silt and clay-sized particles. One sample exhibited a measured swell of 0.3 percent when wetted under estimated overburden pressures. The sandstone is judged to be non-expansive or slightly expansive.

Groundwater

At the time of drilling, groundwater was encountered in one of the fifteen exploratory borings at a depth of 29 feet. The borings found to be dry during our delayed groundwater measurements performed for each of the exploratory borings eight days following the completion of our drilling operation. Groundwater levels will vary with seasonal precipitation and landscaping irrigation.

SITE GEOLOGY

Geologic conditions at the site were evaluated through the review of published geologic maps, field reconnaissance, and exploratory borings. Information from these sources was used to produce our interpretation of site geology (Fig. 2). A list of references is included at the end of this report.

The gentle to steeply sloping site contains surficial materials consisting of silty sand with occasional lenses of sandy clay. The natural soils are underlain by weathered to intact bedrock. Bedrock encountered at the site includes sandy to very sandy claystone and slightly silty to silty or clayey to very clayey sandstone. The following paragraphs discuss the mapped units, which appear to be generally consistent with our borings.

The surficial overburden soils are considered to be alluvial and colluvial deposits (Map Units: al, Qc, Qv, Qrf) and are underlain by bedrock of the Dawson formation (Tkd). The materials are geologically recent, early to late Pleistocene, Holocene, Upper Cretaceous, and Paleocene-age materials. The overburden materials are light brown to brown, red-brown, and gray to gray brown and considered the dominant stratum at the site. Alluvial and Colluvial deposits (al and Qc) are generally mapped as being found within the valley or low lying areas of the site while the bedrock (Tkd) is mapped as generally located at the higher elevations. The bedrock is overlain by Rocky Flats Alluvium (Qrf) in the vicinity of the southeastern corner. The bedrock is exposed in various areas along the north and south bluffs. Alluvium and Colluvium materials generally originate from the weathering of in place bedrock and overburden materials present upstream from the site.

Engineering Geologic Mapping

The engineering geology conditions from Robinson (1977) were considered and areas were mapped as described below and shown in Fig. 3. The other issues are site-wide concerns and are not depicted in Fig. 3.

Map Unit “2A” depicts stable alluvium, colluvium, and bedrock on gentle to moderate slopes (5%-12%). Emphasis on surface and subsurface drainage.

Map Unit “3A” depicts stable alluvium, colluvium, and bedrock on moderate to steep slopes (12%-24%). Includes some old alluvium fans along mountain front that have been dissected by modern streams. Emphasis on drainage, slope bedrock structure and design of cuts.

Map Unit “3B” depicts expansive and potentially expansive soil and bedrock on flat to moderate slopes (0%-12%). Emphasis on potential for swell, depth of bedrock, design of foundation and drainage.

Map Unit “4A” depicts potentially unstable colluvium and bedrock on moderate to steep slopes (12%-24%). Includes expansive and potentially expansive soil and bedrock. Emphasis on slope stability, swelling characteristics, bedrock structure and surface and subsurface drainage.

Map Unit “5C” depicts unstable and potentially unstable colluvium or bedrock on steep slopes. Emphasis on slope stability, control of cuts and surface drainage.

Map Unit “7A” depicts physiographic floodplain where erosion and deposition presently occur and is generally subject to recurrent flooding. Includes 100-year floodplain along major streams where floodplain studies have been conducted. Emphasis on frequency, depth, and control.

GEOLOGIC HAZARDS

We did not identify geologic hazards that we believe will preclude development of the project as planned. The conditions we identified that may impact the development include expansive near surface soils and bedrock, soils susceptible to erosion, steep slopes, and flooding. Regional geologic conditions that impact the site include seismicity and radioactivity. We believe each of these conditions can be mitigated with engineering design and construction methods commonly employed in this area. These conditions are discussed in greater detail in the sections that follow.

Expansive Soils and Bedrock

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. Both types of soil are believed to exist on this site. Other soils can compress significantly upon wetting 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. Expansive soils and expansive bedrock (collectively referred to as expansive soils) are present at this site, which 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. Sub-excavation is a ground improvement method that can be used to reduce the impacts of swelling soils.

Slope Stability/Potentially Unstable Slopes

Based on review of geologic mapping by Charles S. Robinson and Associates, Inc. unstable or potentially unstable slopes are present within the bounds of the site. Areas mapped as containing unstable or potentially unstable slopes are mapped as being located along the north site boundary (the north half of Lots 1 through Lot 9) and a relatively small area at the east site boundary (Lot 20). Although these areas are mapped as unstable of potentially unstable, we understand individual, single-family residences are planned to be constructed on each lot. Preliminary development mapping indicates the residences are generally located on the southern edge of the mapped area, indicated as units 4A and 5C on Fig. 3.

We have not been provided grading plans; however, we anticipate grading will be relatively minor and restricted to within the general vicinity of each residence footprint. Grading in the vicinity of each residence, particularly on Lots 1 through Lot 9 need to take into account conservative slope design, and most importantly, surface drainage must be controlled to minimize ponding and infiltration that can soften sensitive clay and claystone. Current plans show proposed residences on these lots are located at the base of the northern slope, near the northern site boundary. Changes to the existing slopes in the vicinity of each residence should not include the steepening of the slope. Residence construction and layout should be evaluated to limit cuts at this slope. We believe the risk of landslide at this site is low when cuts into the slope are avoided or minimized. If basement construction includes cutting into the existing slope, basement construction should avoid cuts into the slope as much as possible.

Where significant cuts and/or site grading are planned along the slope for Lots 1 through Lot 9, evaluation of the cut slope, new site grading, and retaining wall/foundation wall construction should be performed that includes slope stability analysis. Slope evaluation will need to include the evaluation of the temporary cuts, if performed, and permanent wall conditions, including slope stability analysis. These analyses may impact the proposed residence foundation.

<u>Flooding and Streamside Overlay Zone</u>

Hay Creek crosses the northeastern corner of the site, in an east-west direction. Review of available Flood Insurance Rate Maps (FIRM) and our site observations suggest this drainage channel is subject to periodic flooding. Mapping identifies areas adjacent to the drainage are located within a special flood hazard area, Flood Zone A, which is subject to inundation by the 1% annual chance of flood (100-year flood). No base flood elevations are determined for the portion of Hay Creek crossing the site. Areas affected by flooding should be addressed by the project Civil Engineer in a site-specific drainage report.

We understand the general vicinity of the mapped flood hazard area is planned to be open space as well as designated as Preble's Mouse Habitat. Construction is not planned for this area of the site. We recommend grading plans address stabilization of the channel banks along the drainage if necessary.

We understand a 3-acre storm water detention or quality pond is planned to be constructed near the drainage, and that the outlet from the pond will drain into the adjacent Hay Creek. The project Civ
design surface drainage.

Unresolved V1 Comment
Include a section in the GEOTECH report addressing the following sections of the Drainage Criteria manual. Detention Storage
11.2.2 Detention Facility Construction
11.3.3 Embankment Structures

<u>Seismicity</u>

Unresolved - dotschoenheit
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This area, like most of central Colorado, is subject to a degree of seismic activity. Geologic evidence indicates that movement along some Front Range faults has occurred during the last two million years (Quaternary). This includes the Rampart Range and Ute Pass Faults. The Rampart Range Fault is located about 1 to 2 miles west of the site. In our opinion, the soil conditions at the site represent a Seismic Site Class C (very dense soil and soft rock).

Radioactivity / Radon

There is believed to be no unusual hazard from naturally occurring sources of radioactivity on this site. However, the types of materials found often are associated with the production of radon gas and concentrations in excess of those currently recommended by the EPA. Radon often accumulates in residential basement areas. Passive and active mitigation procedures are commonly employed in this region and effectively reduce the buildup of radon gas. Measures that can be taken after building construction include sealing the joints and cracks in concrete floors and foundation walls. If the occurrence of radon is a concern, we recommend the building be tested after it is enclosed, and commonly utilized techniques be employed to mitigate the risk.

SITE DEVELOPMENT CONSIDERATIONS

The following sections discuss various aspects of development at the site. A conceptual development plan by Matrix, dated September 2022, updated October 5, 2022 was provided to us during our investigation. The conceptual development plan indicates development of the site is limited to the nineteen single-family residences as indicated on Fig. 1 of this report. Lot 10 is currently developed with a single-family residence. A conceptual grading plan was not available for review; however, we anticipate site grading cuts and fills to be minimal and limited to foundation construction at each of the residence footprints. Bedrock was encountered at significantly more shallow depths (between 3 and 10 feet) on Lots 9, 11 through 13, 15 through 17, and Lots 19 and 20. Bedrock will impact new foundations constructed on these ten lots. The following should be considered for construction of the residences at the property.

Site Grading

We anticipate site grading will be minimal and limited to the construction of each residence. We recommend grading plans consider long-term cut and fill slopes no steeper than 3:1 (horizontal to vertical) where not reinforced or retained by walls. This ratio considers that no seepage of groundwater occurs. If groundwater seepage does occur, a drain system and/or flatter slopes may be appropriate. Flatter slopes of 4:1 (horizontal to vertical) can help reduce the potential for erosion.

The existing topography, subsurface conditions, and the proposed grading will impact the development and the construction process. Further site grading considerations are discussed in the following sections.

Excavation

We believe the soils and bedrock encountered in our exploratory borings can be excavated with conventional, heavy-duty excavation equipment. Shallow claystone and sandstone bedrock are present at the site. Cuts into the hard bedrock will likely require ripping or the use of rock teeth and rock buckets to expedite the excavation process.

We recommend 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, to determine appropriate excavation slopes. We anticipate the near-surface silty to clayey sand soils and bedrock will classify as Type C and Type A materials, respectively. Temporary excavations in Type C and Type A materials require a maximum slope inclination of 1.5:1 (horizontal to vertical) and 0.75:1, respectively, unless the excavation is shored or braced. If groundwater seepage occurs, flatter slopes will likely be required. The contractor's "competent person" should review excavation conditions and refer to OSHA standards when worker exposure is anticipated. Stockpiles and equipment should not be placed within a horizontal distance equal to one-half the excavation depth, from the edge of the excavation. Excavations deeper than 20 feet should be designed by a registered professional engineer.

Fill Placement

Vegetation and organic materials should be removed from the ground surface in areas to be filled. The ground surface in areas to receive fill should be scarified, moisture conditioned and compacted. Soft or loose soils, if encountered, should be stabilized or removed to a depth that exposes more stable material prior to placement of fill.

The properties of the fill will affect the performance of foundations, slabs-on-grade, and pavements. We anticipate the on-site soils and bedrock will be suitable for use as fill, provided they are free from vegetation, debris, or other deleterious materials. Organic soils should be wasted in landscaping areas. If insufficient landscaping areas are planned, topsoil can be mixed with clean fill soils at a ratio of 15:1 (fill:topsoil) and placed as fill deeper than 8 feet below final grade. Soils containing debris, ash, or cinders should be disposed of properly and not included within site grading fill. Import soils, if needed, should be evaluated to determine if they are suitable for use on the site.

We recommend fill materials should be placed in thin, loose lifts, and moisture conditioned prior to compaction. Cohesive materials (sandy clay, and claystone) are typically tested using a standard Proctor (ASTM D 698). The moisture specifications for the cohesive materials may vary from near the optimum moisture content to above the moisture content, based on the distance below grade and whether structures are planned above the fill. Granular materials are typically tested using a modified Proctor (ASTM D1557). The moisture specifications for the granular materials are typically near the optimum moisture contents. Guideline specifications for overlot grading are presented in Appendix C. Placement and compaction of the grading fill should be observed and tested by our representative during construction.

Buried Utilities

We anticipate each of the residences are planned to be serviced by local municipal utilities. Water and sewer lines are often constructed beneath slabs and pavements. Compaction of utility trench backfill can have a significant effect on the life and serviceability of floor slabs, pavements, and exterior flatwork. We recommend utility trench backfill be placed in compliance with El Paso County specifications. Our experience indicates the use of a self-propelled compactor results in more reliable performance compared to trench 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. Personnel from our firm should periodically observe utility trench backfill placement and test the density of the backfill materials during construction. If on-site wastewater systems are planned, they should be designed by a Professional Engineer.

FOUNDATION AND FLOOR SYSTEM CONCEPTS

The near surface materials encountered at each of the proposed residence locations are variable. The near surface soils anticipated to impact shallow foundations vary from non-expensive, loose to very dense granular soils, non-expansive to slightly expansive sandstone bedrock, and slightly expansive to highly expansive claystone bedrock.

We anticipate spread footing foundations underlain by natural sand, sandstone, sub-excavation fill and/or densely compacted site grading fill will be appropriate for the proposed residences located on lots where significant site grading is required to establish a building pad and where loose granular soil or expansive claystone is encountered at anticipated foundation elevations. Based on our exploratory borings, sub-excavation may be required on Lots 5 and 17 due to loose, granular soils and on Lots 9, 11, 13, 15, and 16 due to near surface expansive claystone bedrock. We estimate about 40 to 50 percent of the lots may require sub-excavation to reduce the risk of settlement or heave.

Where loose granular soils and expansive bedrock are present, we expect a low risk of detrimental movement and damage will exist for conventional slab-on-grade floors, if underlain by the sub-excavation fill and/or properly moisture conditioned and compacted sand grading fill. We recommend sub-excavation below foundations should range from 4 to 10 feet to help reduce potential heave and settlement and reduce risk of foundation damage. Where a combination of loose to medium dense non-expansive soils and hard to very hard sandstone bedrock are exposed at foundation elevations, we recommend a sub-excavation be performed to reduce the potential for differential settlement and to establish a more uniform layer of support within the residence footprint. We estimate a 4-foot-thick, uniform layer of sub-excavation backfill may be necessary.

A Soils and Foundation Investigation report prepared after completion of site grading for each residence should address appropriate foundation systems and floor system alternatives on a building-by-building basis. If grades at each of the residences is not anticipated to include significant grade change, we can perform the investigation when each residence location is determined. A lot specific soils and foundation investigation will identify the specific design and construction criteria for each residence and will outline the depth of sub-excavation required, if any, at each residence location.

PAVEMENTS

Natural silty to clayey sand materials were encountered across the site and is expected to be the predominant pavement subgrade materials. Based on laboratory test results, we estimate an R-Value of about 50 can be assigned to the near surface, silty to clayey sands. These sand materials generally exhibit good to excellent subgrade support characteristics for pavement systems. We anticipate pavement sections that conform to the minimums required by El Paso County will be appropriate. Minimum pavement sections for local roadways require 3 inches of asphalt over 4 inches of aggregate base course, based on current El Paso County criteria for the street classification expected. Based on our experience, we typically recommend aggregate base course be no less than 6 inches. These pavement thicknesses may not be sufficient for construction traffic and some maintenance and repair work may be needed prior to completion of the project. A subgrade investigation and pavement design should be performed after site grading and utility installation are complete.

CONCRETE

Concrete in contact with soil can be subject to sulfate attack. We measured water-soluble sulfate concentrations in three samples at between less than 0.1 percent. As indicated in our tests and ACI 332-20, the sulfate exposure class is *not applicable* or *RS0.* Deviations from the exposure class may occur as a result of additional sampling and testing.

SULFATE EXPOSURE CLASSES PER ACI 332-20

Exposure Classes		Water-Soluble Sulfate (SO_4) in Soil [A] (%)
Not Applicable	RS0	< 0.10
Moderate	RS1	0.10 to 0.20
Severe	RS2	>0.20 to 2.00
Very Severe	RS3	> 2.00

A) Percent sulfate by mass in soil determined by ASTM C1580

For this level of sulfate concentration, ACI 332-20 *Code Requirements for Residential Concrete* indicates there are special cement type requirements for sulfate resistance as indicated in the table below. Additional sulfate testing is recommended during the design-level phase.

CONCRETE DESIGN REQUIREMENTS FOR SULFATE EXPOSURE PER ACI 332-20

Exposure Class	Maximum Water/ Cement Ratio	Minimum Compressive Strength [A] (psi)	Cementitious Material Types [B]			Calcium Chloride Admixtures
			ASTM C150/ C150M	ASTM C595/ C595M	ASTM C1157/ C1157M	
RS0	N/A	2500	No Type Restrictions	No Type Restrictions	No Type Restrictions	No Restrictions
RS1	0.50	2500	II	Type with (MS) Designation	MS	No Restrictions
RS2	0.45	3000	V [C]	Type with (HS) Designation	HS	Not Permitted
RS3	0.45	3000	V + Pozzolan or Slag Cement [D]	Type with (HS) Designation plus Pozzolan or Slag Cement [E]	HS + Pozzolan or Slag Cement [E]	Not Permitted

A) Concrete compressive strength specified shall be based on 28-day tests per ASTM C39/C39M
B) Alternate combinations of cementitious materials of those listed in ACI 332-20 Table 5.4.2 shall be permitted when tested for sulfate resistance meeting the criteria in section 5.5.
C) Other available types of cement such as Type III or Type I are permitted in Exposure Classes RS1 or RS2 if the C3A contents are less than 8 or 5 percent, respectively.
D) The amount of the specific source of pozzolan or slag to be used shall not be less than the amount that has been determined by service record to improve sulfate resistance when used in concrete containing Type V cement. Alternatively, the amount of the specific source of the pozzolan or slab to be used shall not be less than the amount tested in accordance with ASTM C1012/C1012M and meeting the criteria in section 5.5.1 of ACI 332-20.
E) Water-soluble chloride ion content that is contributed from the ingredients including water aggregates, cementitious materials, and admixtures shall be determined on the concrete mixture ASTM C1218/C1218M between 29 and 42 days.

Superficial damage may occur to the exposed surfaces of highly permeable concrete. 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 ± 1.5 percent. We advocate damp-proofing of all foundation walls and grade beams in contact with the subsoils (including the inside and outside faces of garage and crawl space grade beams).

SUBSURFACE DRAINAGE

Surface water can penetrate relatively permeable backfill soils located adjacent to residences and collect at the bottom of relatively impermeable foundation excavations, causing wet or moist conditions after construction. Foundation drains should be constructed around the lowest excavation levels of basement and/or crawl space areas. These drains should discharge to a positive gravity outlet or to a sump where water can be removed by pumping. The discharge pipe should be located at least 5 feet from the exterior of the structure, or beyond the extents of the foundation excavation backfill to reduce infiltration into the backfill and adjacent to foundation walls.

SURFACE DRAINAGE AND IRRIGATION

The performance of structures, flatwork, and roads within the site will be influenced by surface drainage. When developing an overall drainage scheme, consideration should be given to drainage around each structure and pavement area. Drainage should be planned such that surface runoff is directed away from foundations and is not allowed to pond adjacent to or between buildings or over pavements. Ideally, slopes of at least 6 inches in the first 10 feet should be planned for the areas surrounding the buildings, where possible. Roof downspouts and other water collection systems should discharge well beyond the limits of all backfill around the structures. Proper control of surface runoff is also important to prevent the erosion of surface soils. Concentrated flows should not be directed over unprotected slopes. Permanent overlot slopes should be seeded or mulched to reduce the potential for erosion. Backfill soils behind the curb and gutter adjacent to streets and in utility trenches should be compacted. If surface drainage between preliminary development and construction phases is neglected, performance of the roadways, flatwork, and foundations may be compromised.

RECOMMENDED FUTURE INVESTIGATIONS

Based on the results of this study, we recommend the following investigations and services be provided by our firm:

1. Construction materials testing and observation services during site development and construction.
2. Soils and Foundation Investigations for foundation designs.
3. Subgrade Investigation and Pavement Design for on-site pavements.

LIMITATIONS

The recommendations and conclusions presented in this report were prepared based on conditions disclosed by our exploratory borings, geologic reconnaissance, engineering analyses, and our experience. Variations in the subsurface conditions not indicated by the borings are possible and should be expected.

We believe this report was prepared with that level of skill and care ordinarily used by geologists and geotechnical engineers practicing under similar conditions. No warranty, express or implied, is made.

Should you have any questions regarding the contents of this report or the project from a geotechnical engineering point-of-view, please call.

CTL | THOMPSON, INC.

Patrick Foley, E.I.
Staff Engineer

Reviewed by:

COLORADO LICENSED
JEFFREY MARK JONES
47539
PROFESSIONAL ENGINEER

Jeffrey M. Jones, P.E.
Associate Engineer

PF:JMJ:cw

Jeffrey Jones
Dec 27 2022 8:42 AM

(1 copy sent via email)

Via email: tbuschar@aspenviewhomes.net

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2. Federal Emergency Management Agency, Flood Insurance Rate Maps, Map Number 08041C0267G, Panel 267 of 1300, effective date December 7, 2018.

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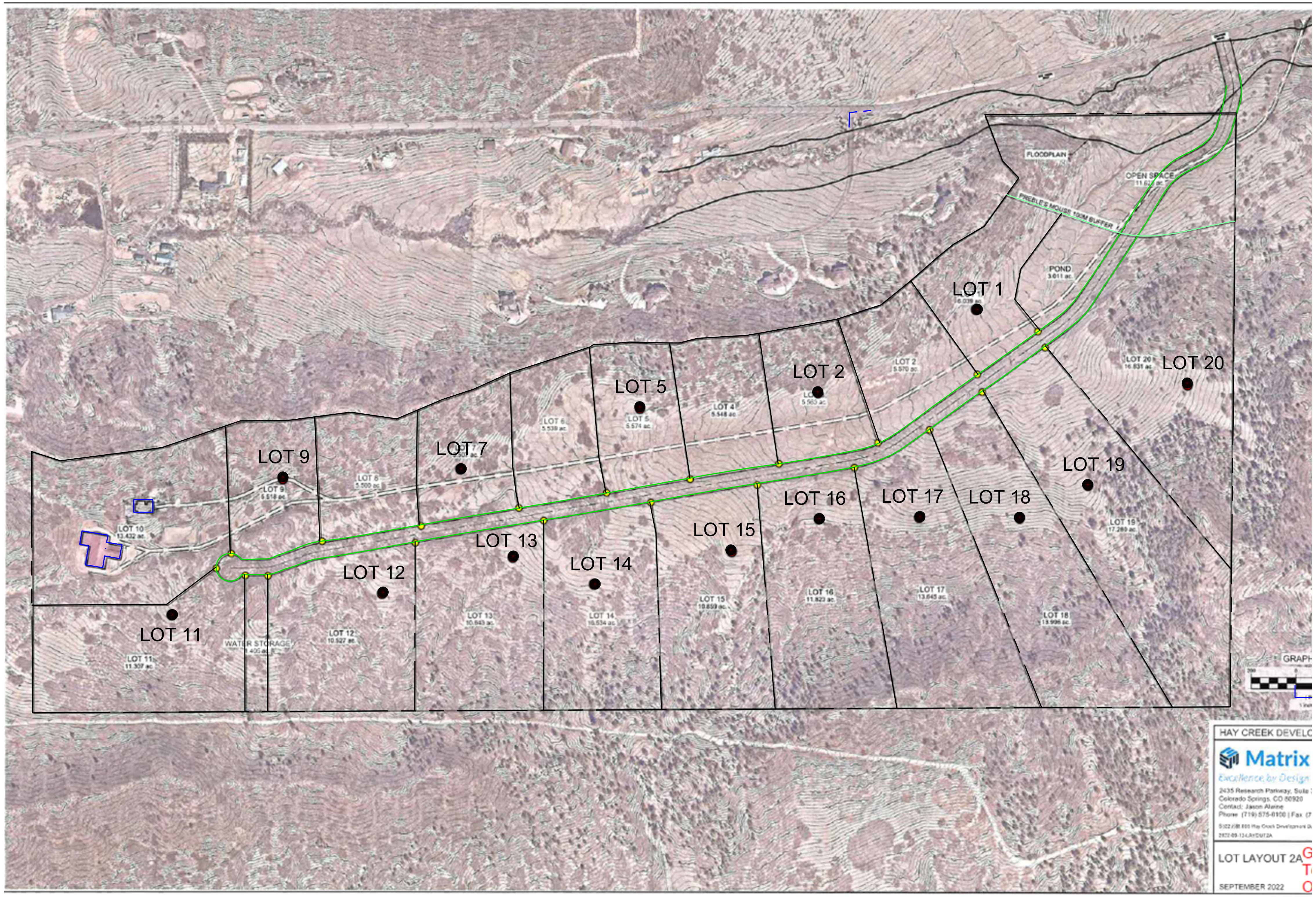
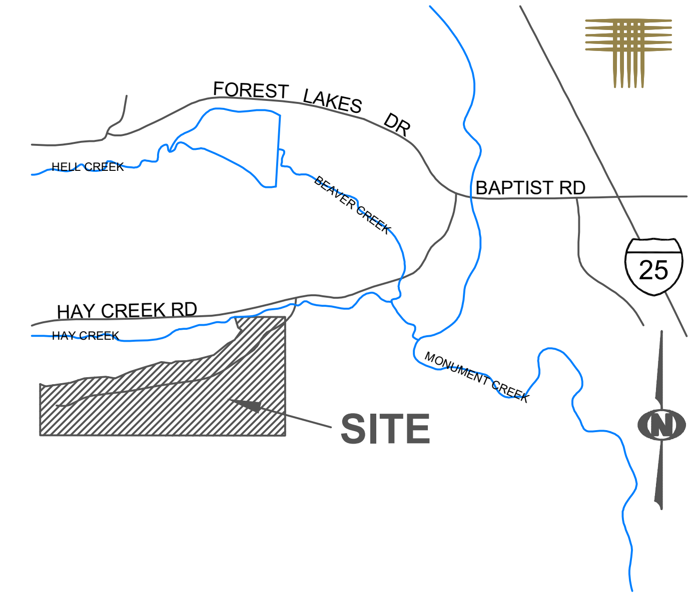
5. Robinson and Associates, Inc. (1977). El Paso County, Colorado - Potential Geologic Hazards and Surficial Deposits, Environmental and Engineering Geologic Maps and Tables for Land Use, Maps 1A and 1B.

6. State of Colorado, Division of Mined Land Reclamation (April 1985). Prepared by Dames and Moore. Colorado Springs Subsidence Investigation.

7. Keller John W., Morgan Matthew L, Thorson Jon P., Lindsey Neil R., and Barkmann Peter E. “Geologic Map of the Palmer Lake Quadrangle, El Paso County, Colorado,” Colorado Geological Survey (2007).





VICINITY MAP
(NOT TO SCALE)

LEGEND:

LOT 1 ● APPROXIMATE LOCATION OF EXPLORATORY BORING AND APPROXIMATE LOCATION OF PLANNED RESIDENCE.

PROJECT BOUNDARY

LOCATION OF EXISTING BUILDING FOOTPRINT.

LOCATION OF PROPOSED DRIVE LANES AND PARKING AREAS.

0 250' 500'
SCALE: 1" = 500'

NOTE:
BASE DRAWING WAS PROVIDED BY MATRIX
(DATED SEPTEMBER 2022, UPDATED OCTOBER 5, 2022).

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Location of Exploratory Borings

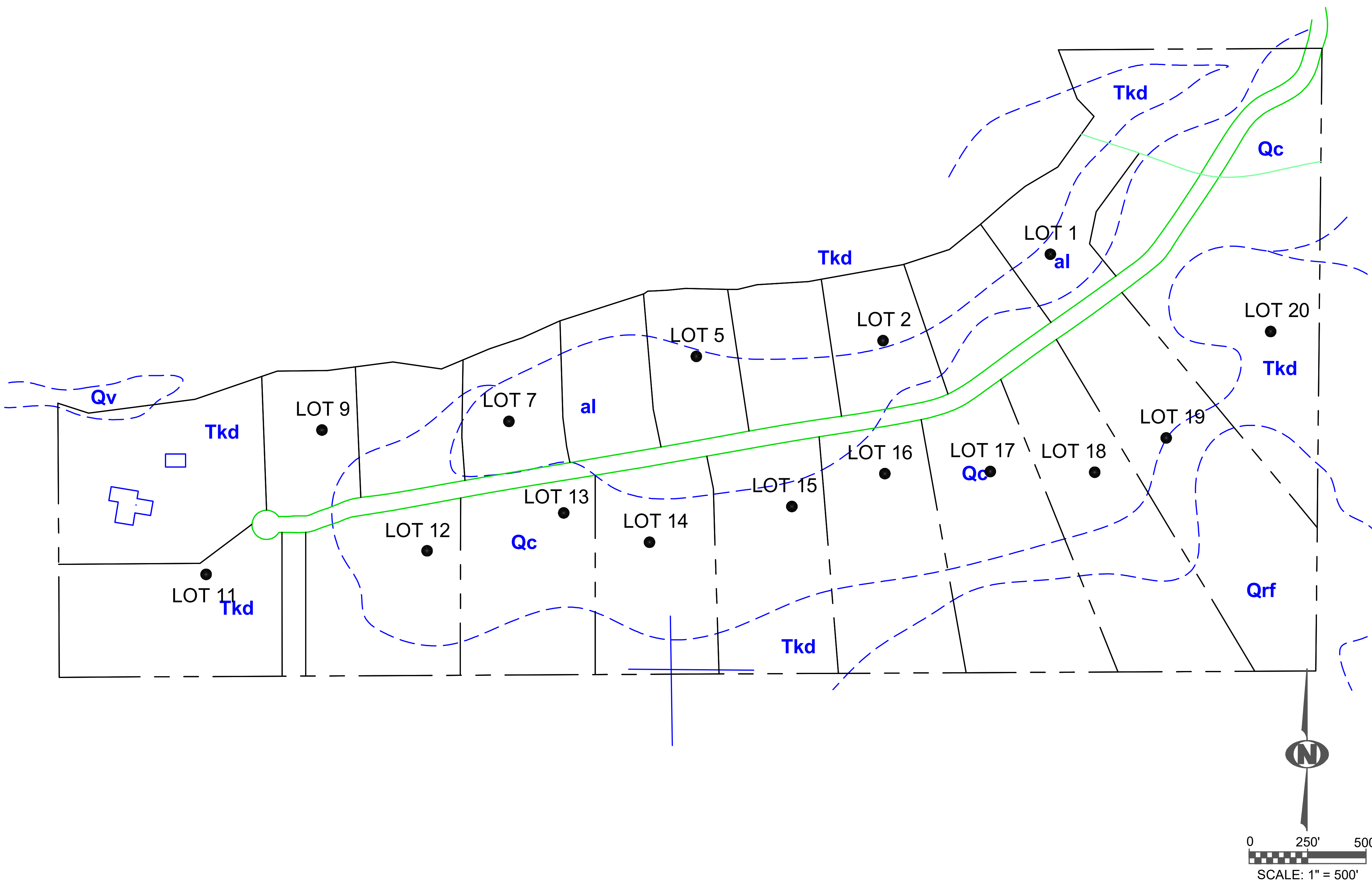
FIG. 1

LEGEND:

TH-1 ●	APPROXIMATE LOCATION OF EXPLORATORY BORING.
— — —	PROJECT BOUNDARY
——	LOCATION OF EXISTING BUILDING FOOTPRINT.

GEOLOGIC UNITS AND (MODIFIERS)

⌒ ‿	SURFICIAL GEOLOGIC CONTACTS
al	LATE HOLOCENE AGE, ALLUVIUM, SILT, SAND, GRAVEL, AND BOULDERS IN STREAM BEDS AND ON LOWER TERRACES ON VALLEY FLOORS.
Qc	HOLOCENE AND LATE PLEISTOCENE AGE, COLLUVIUM, CLAYEY OR SILTY SAND LOCALLY WITH BOULDERS DERIVED FROM IN-PLACE WEATHERING OF BEDROCK.
Qv	EARLY MIDDLE PLEISTOCENE AGE, VERDE ALLUVIUM, POORLY SORTED STRATIFIED GRAVEL CONTAINING LENSES OF SAND, SILT, AND CLAY.
Qrf	EARLY PLEISTOCENE, ROCKY FLATS ALLUVIUM: PEBBLY, COBBLY, AND BOULDERY GRAVEL AND CLAYEY COARSE SAND.
Tkd	COLLUVIUM, DAWSON FORMATION



NOTES:
1. BASE DRAWING WAS PROVIDED BY MATRIX (DATED SEPTEMBER 2022, REVISED OCTOBER 5, 2022).
2. ALL BOUNDARIES SHOWN SHOULD BE CONSIDERED APPROXIMATE. THEY ARE BASED UPON A SUBJECTIVE INTERPRETATION OF PUBLISHED MAPS, AERIAL PHOTOGRAPHS AND AN INITIAL FIELD RECONNAISSANCE. CHANGES IN THE MAPPED BOUNDARIES SHOWN ARE POSSIBLE AND SHOULD BE EXPECTED WITH MORE DETAILED WORK AND FURTHER INFORMATION. ALL INTERPRETATIONS AND CONDITIONS SHOWN ARE PRELIMINARY AND FOR LAND-USE PLANNING ONLY.
3. MAP LEGEND IS MODIFIED FROM CHARLES S. ROBINSON & ASSOCIATES, INC., GOLDEN, COLORADO, DATED 1977.

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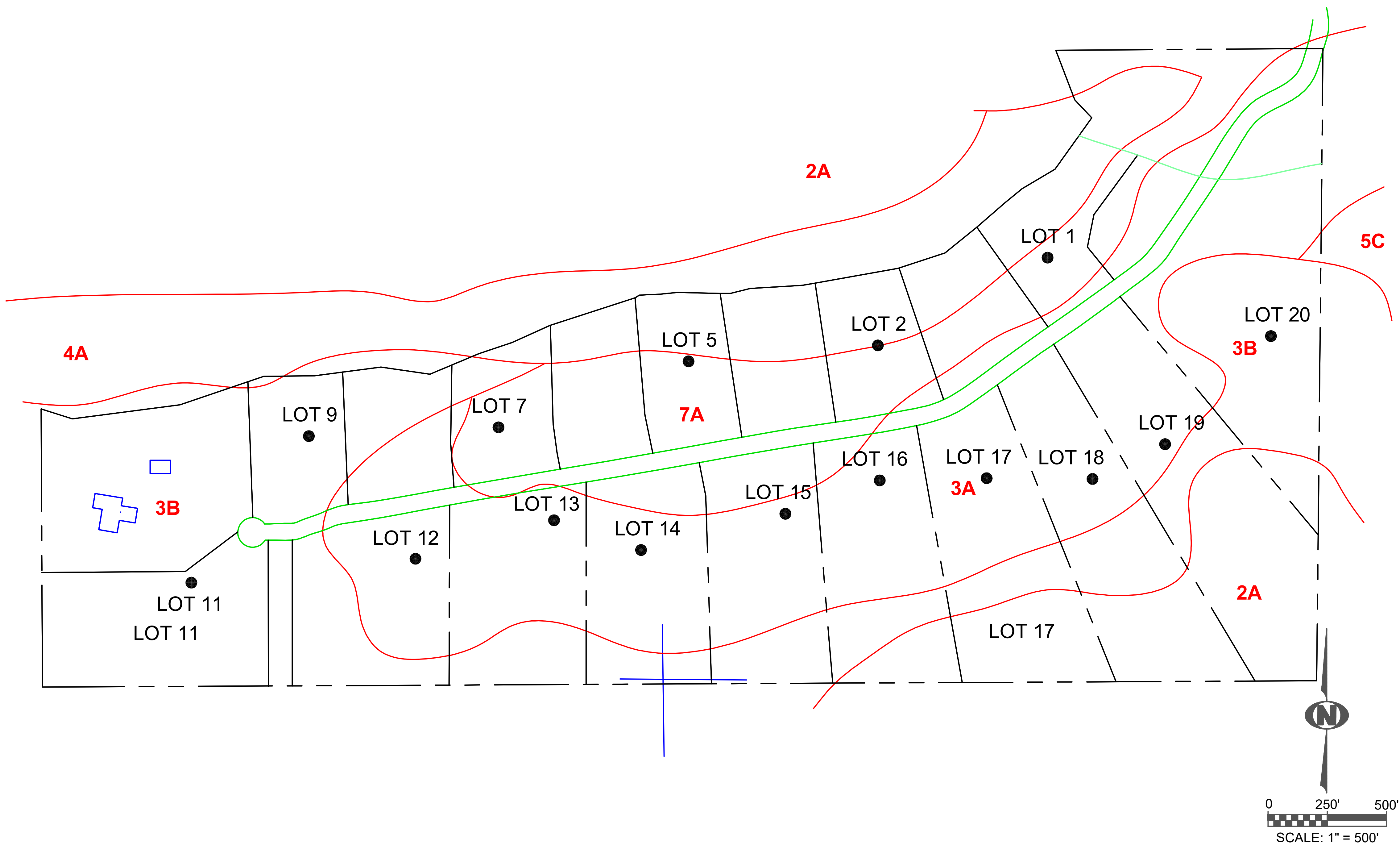
Surficial Geologic Conditions

FIG. 2



LEGEND:

TH-1 ●	APPROXIMATE LOCATION OF EXPLORATORY BORING.
– – – –	PROJECT BOUNDARY
———	LOCATION OF EXISTING BUILDING FOOTPRINT.

ENGINEERING UNITS AND (MODIFIERS)

∼	ENGINEERING CONTACTS
2A	STABLE ALLUVIUM, COLLUVIUM, AND BEDROCK ON GENTLE TO MODERATE SLOPES (5%-12%). EMPHASIS ON SURFACE AND SUBSURFACE DRAINAGE.
3A	STABLE ALLUVIUM, COLLUVIUM, AND BEDROCK ON MODERATE TO STEEP SLOPES (12%-24%). INCLUDES SOME OLD ALLUVIAL FANS ALONG MOUNTAIN FRONT THAT HAVE BEEN DISSECTED BY MODERN STREAMS. EMPHASIS ON DRAINAGE, SLOPE, BEDROCK STRUCTURE, AND DESIGN OF CUTS.
3B	EXPANSIVE AND POTENTIALLY EXPANSIVE SOIL AND BEDROCK ON FLAT TO MODERATE SLOPES (0-12%). EMPHASIS ON POTENTIAL FOR SWELL, DEPTH OF BEDROCK, DESIGN OF FOUNDATIONS AND DRAINAGE.
4A	POTENTIALLY UNSTABLE COLLUVIUM AND BEDROCK ON MODERATE TO STEEP SLOPES (12% - 24%). INCLUDES EXPANSIVE AND POTENTIALLY EXPANSIVE SOIL AND BEDROCK. EMPHASIS ON SLOPE STABILITY, SWELLING CHARACTERISTICS, BEDROCK STRUCTURE, AND SURFACE AND SUBSURFACE DRAINAGE.
5C	UNSTABLE OR POTENTIALLY UNSTABLE COLLUVIUM OR BEDROCK ON STEEP SLOPES. EMPHASIS ON SLOPE STABILITY, CONTROL OF CUTS AND SURFACE DRAINAGE.
7A	PHYSIOGRAPHIC FLOOD PLAIN WHERE EROSION AND DEPOSITION PRESENTLY OCCUR AND IS GENERALLY SUBJECT TO RECURRENT FLOODING. INCLUDES 100-YEAR FLOODPLAIN ALONG MAJOR STREAMS WHERE FLOODPLAIN STUDIES HAVE BEEN CONDUCTED. EMPHASIS ON FREQUENCY, DEPTH AND CONTROL.

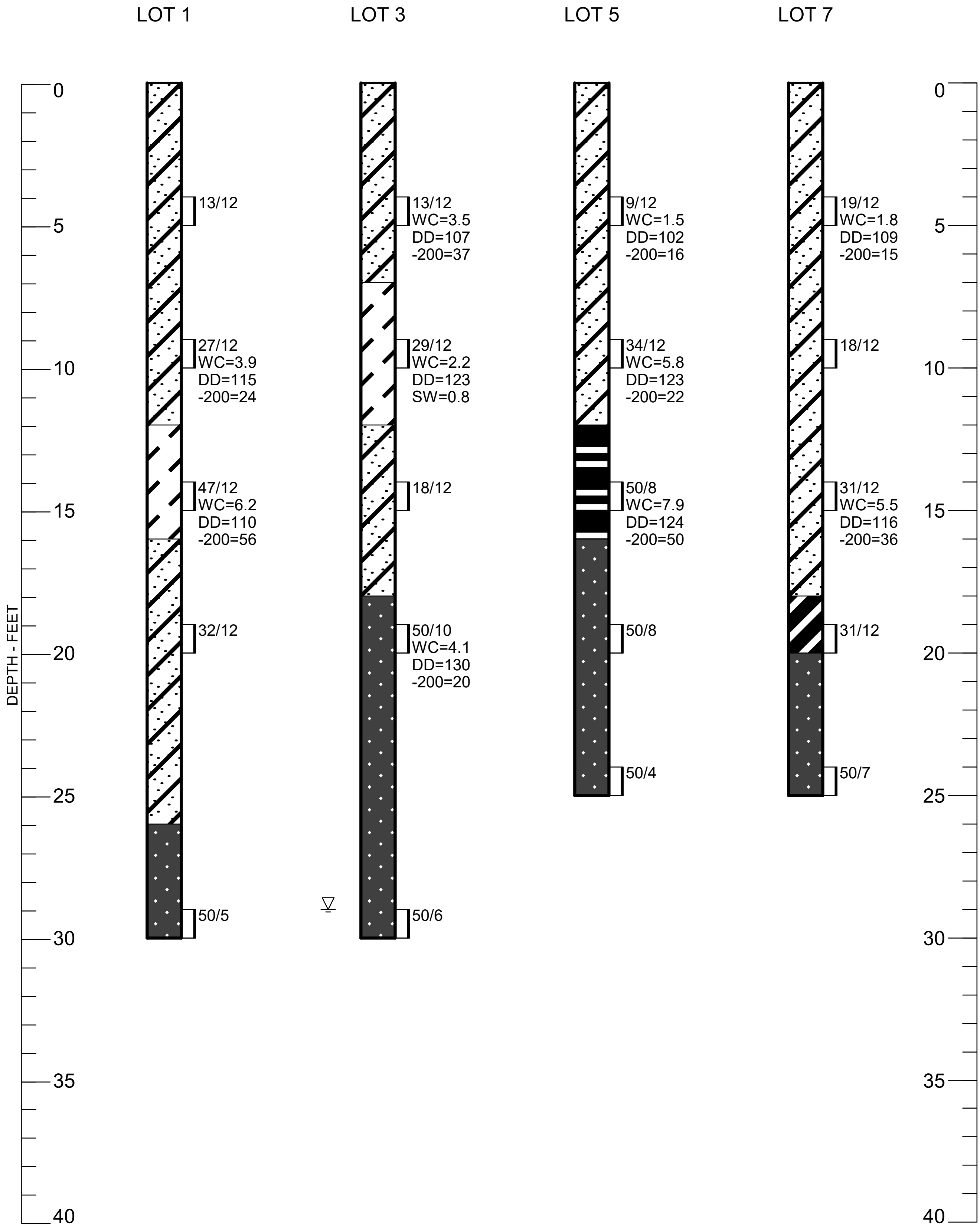
NOTES:
1. BASE DRAWING WAS PROVIDED BY MATRIX (DATED SEPTEMBER 2022, REVISED OCTOBER 5, 2022).
2. ALL BOUNDARIES SHOWN SHOULD BE CONSIDERED APPROXIMATE. THEY ARE BASED UPON A SUBJECTIVE INTERPRETATION OF PUBLISHED MAPS, AERIAL PHOTOGRAPHS AND AN INITIAL FIELD RECONNAISSANCE. CHANGES IN THE MAPPED BOUNDARIES SHOWN ARE POSSIBLE AND SHOULD BE EXPECTED WITH MORE DETAILED WORK AND FURTHER INFORMATION. ALL INTERPRETATIONS AND CONDITIONS SHOWN ARE PRELIMINARY AND FOR INITIAL LAND-USE PLANNING ONLY.
3. MAP LEGEND IS MODIFIED FROM CHARLES S. ROBINSON & ASSOCIATES, INC., GOLDEN, COLORADO, DATED 1977.

Engineering Conditions

FIG. 3

APPENDIX A

SUMMARY LOGS OF EXPLORATORY BORINGS



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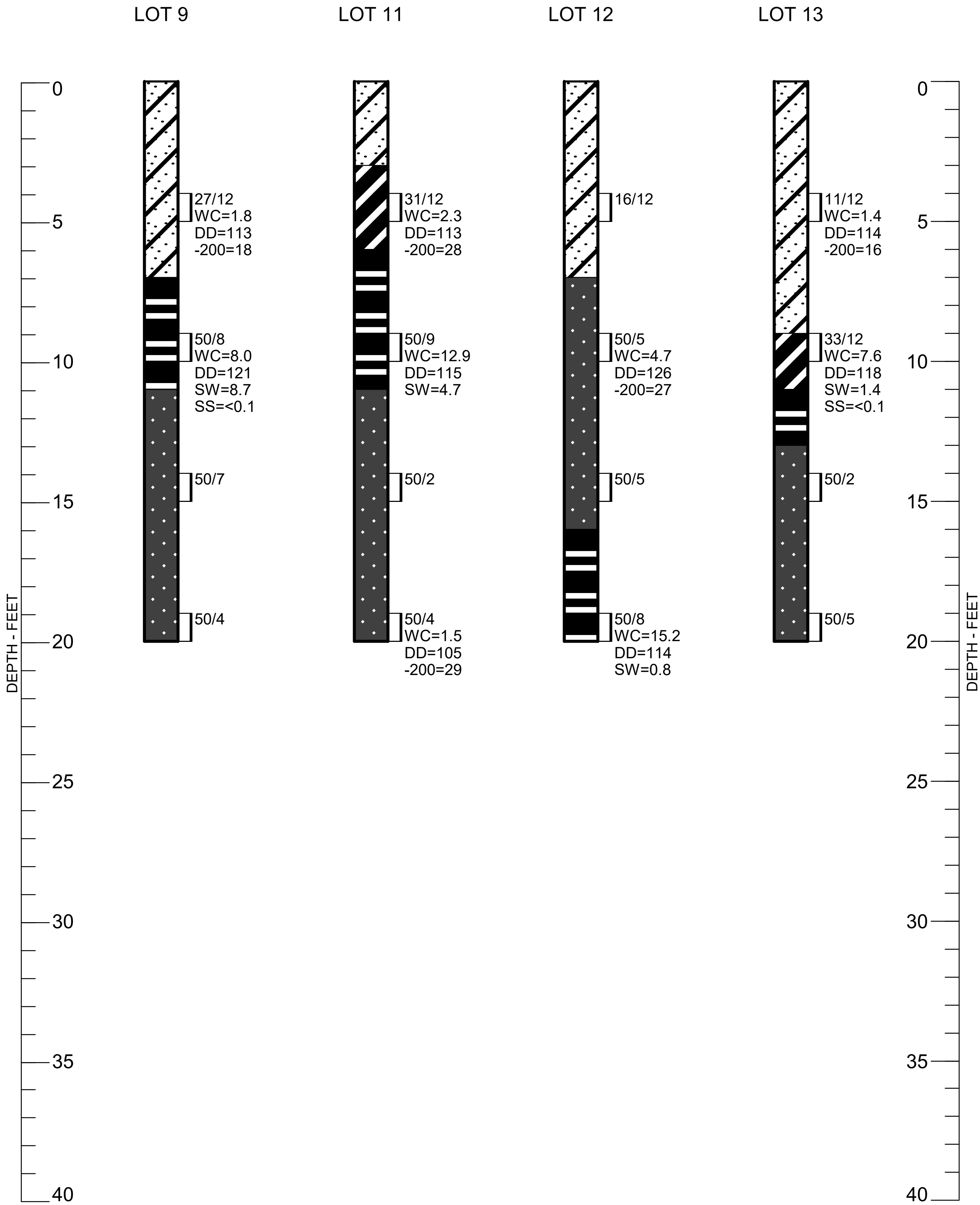
Summary Logs of Exploratory Borings

FIG. A-1



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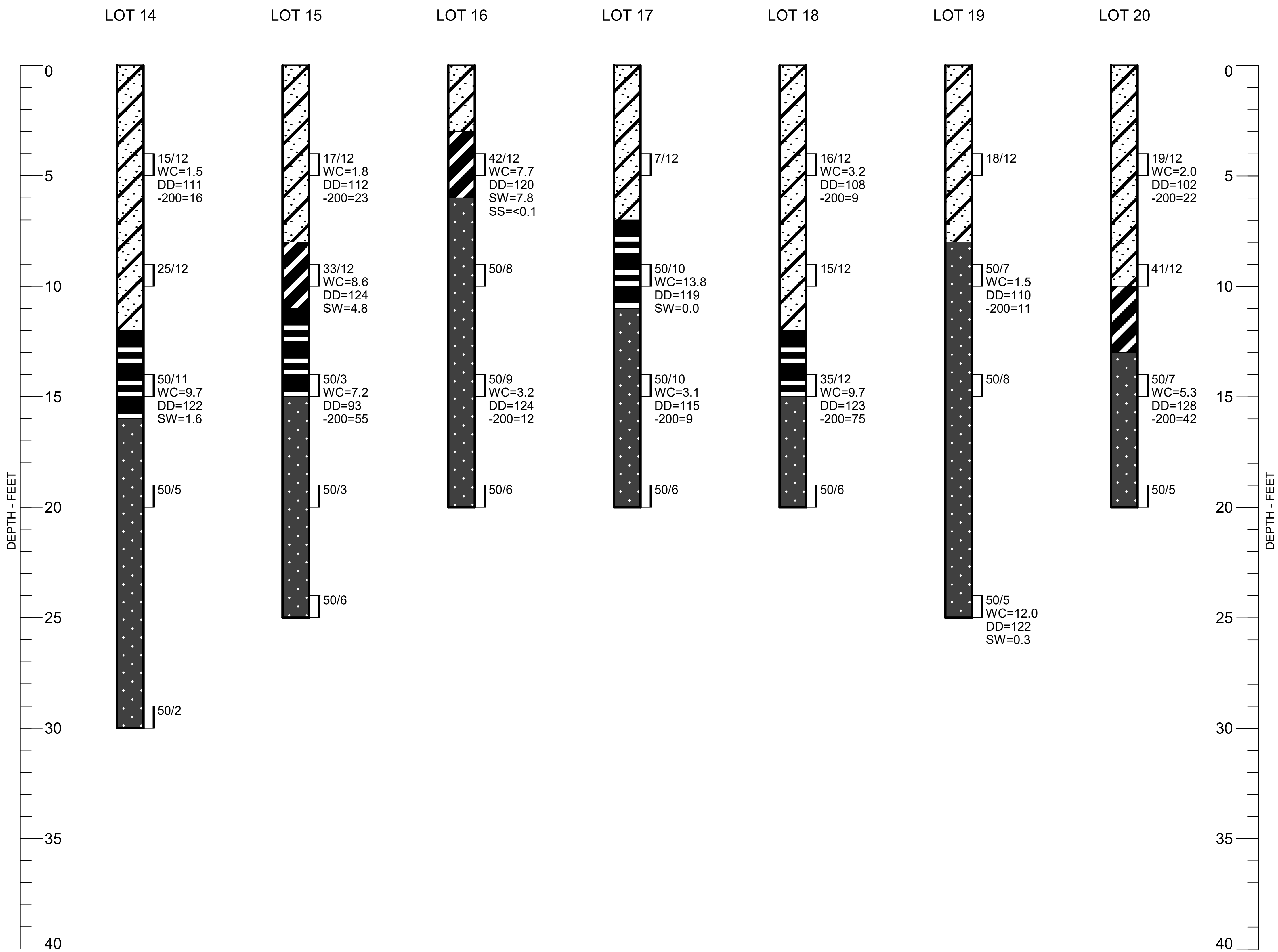
Summary Logs of Exploratory Borings

FIG. A-2



LEGEND:

SAND, SLIGHTLY SILTY TO VERY SILTY, LOOSE TO VERY DENSE, SLIGHTLY MOIST TO MOIST, LIGHT BROWN TO BROWN, OCCASIONAL LENSES OF SANDY CLAY (SP-SM, SM).

CLAY, SANDY TO VERY SANDY, VERY STIFF, SLIGHTLY MOIST TO MOIST, BROWN (CL).

WEATHERED BEDROCK, CLAYSTONE AND SANDSTONE, SANDY (CLAYSTONE) OR SILTY TO CLAYEY (SANDSTONE), MEDIUM HARD, MOIST, LIGHT BROWN TO RED BROWN.

BEDROCK. CLAYSTONE, SANDY TO VERY SANDY, MEDIUM HARD TO VERY HARD, MOIST, LIGHT BROWN TO BROWN, RED BROWN, GRAY BROWN.

BEDROCK. SANDSTONE, SLIGHTLY SILTY TO SILTY, CLAYEY TO VERY CLAYEY, HARD TO VERY HARD, SLIGHTLY MOIST TO MOIST, LIGHT BROWN TO BROWN, RED BROWN, GRAY TO GRAY BROWN.

DRIVE SAMPLE. THE SYMBOL 13/12 INDICATES 13 BLOWS OF A 140-POUND HAMMER FALLING 30 INCHES WERE REQUIRED TO DRIVE A 2.5-INCH O.D. SAMPLER 12 INCHES.

GROUNDWATER LEVEL MEASURED AT TIME OF DRILLING.

NOTES:

1. THE BORINGS WERE DRILLED OCTOBER 3, 7, AND 14, 2022 USING A 4-INCH DIAMETER, CONTINUOUS-FLIGHT AUGER AND A DIEDRICH D-90, TRUCK-MOUNTED DRILL RIG.
2. THESE LOGS ARE SUBJECT TO THE EXPLANATIONS, LIMITATIONS, AND CONCLUSIONS AS CONTAINED IN THIS REPORT.
3. WC - INDICATES MOISTURE CONTENT. (%)
   DD - INDICATES DRY DENSITY. (PCF)
   SW - INDICATES SWELL WHEN WETTED UNDER APPROXIMATE OVERBURDEN PRESSURE. (%)
   -200 - INDICATES PASSING NO. 200 SIEVE. (%)
   SS - INDICATES WATER-SOLUBLE SULFATE CONTENT. (%)

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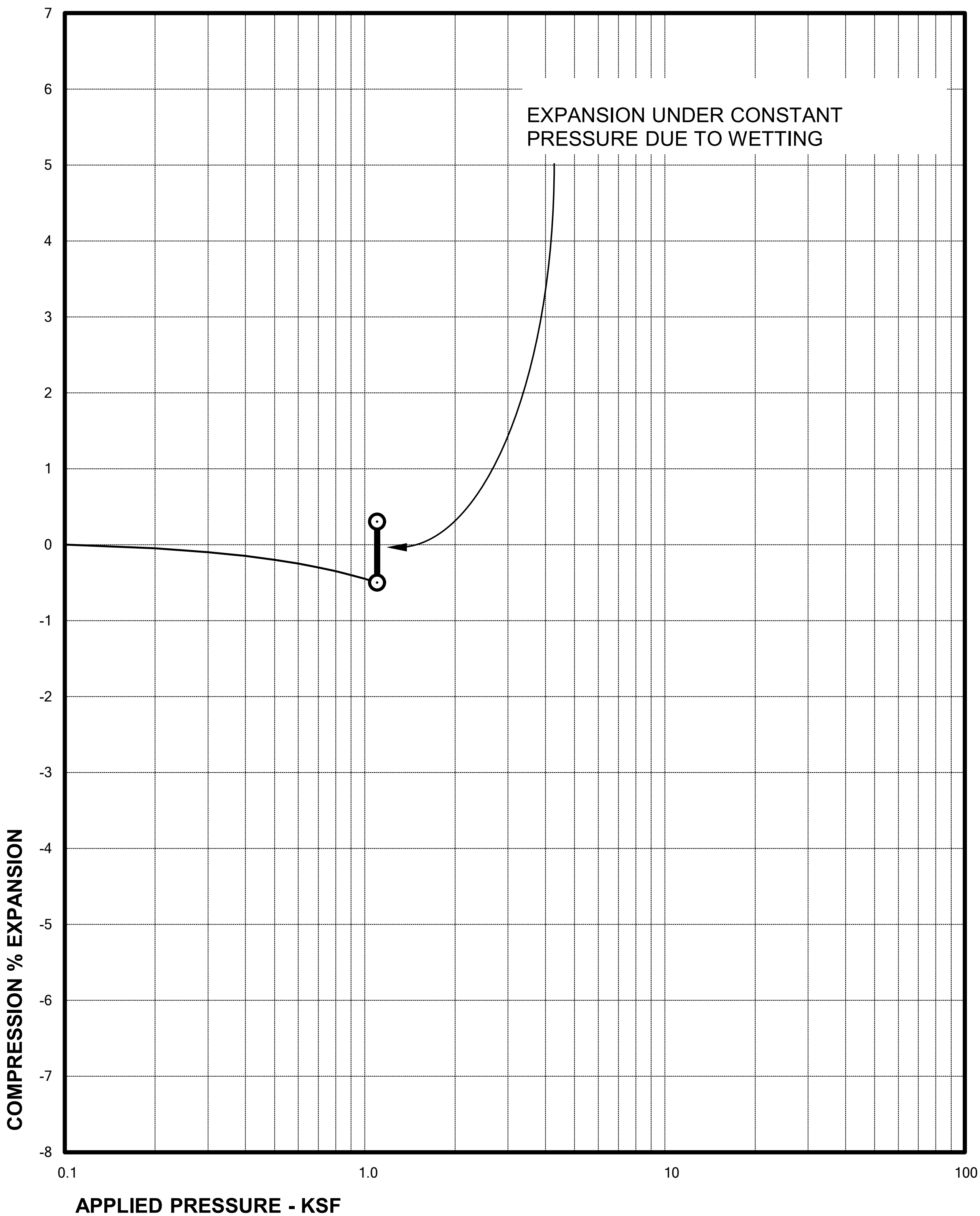
CTL|T PROJECT NO. CS19573.000-115

Summary Logs of Exploratory Borings

FIG. A-3

APPENDIX B

LABORATORY TEST RESULTS
TABLE B-1: SUMMARY OF LABORATORY TESTING



Sample of CLAY, SANDY (CL)
From LOT 3 AT 9 FEET

DRY UNIT WEIGHT= 123 PCF
MOISTURE CONTENT= 2.2 %

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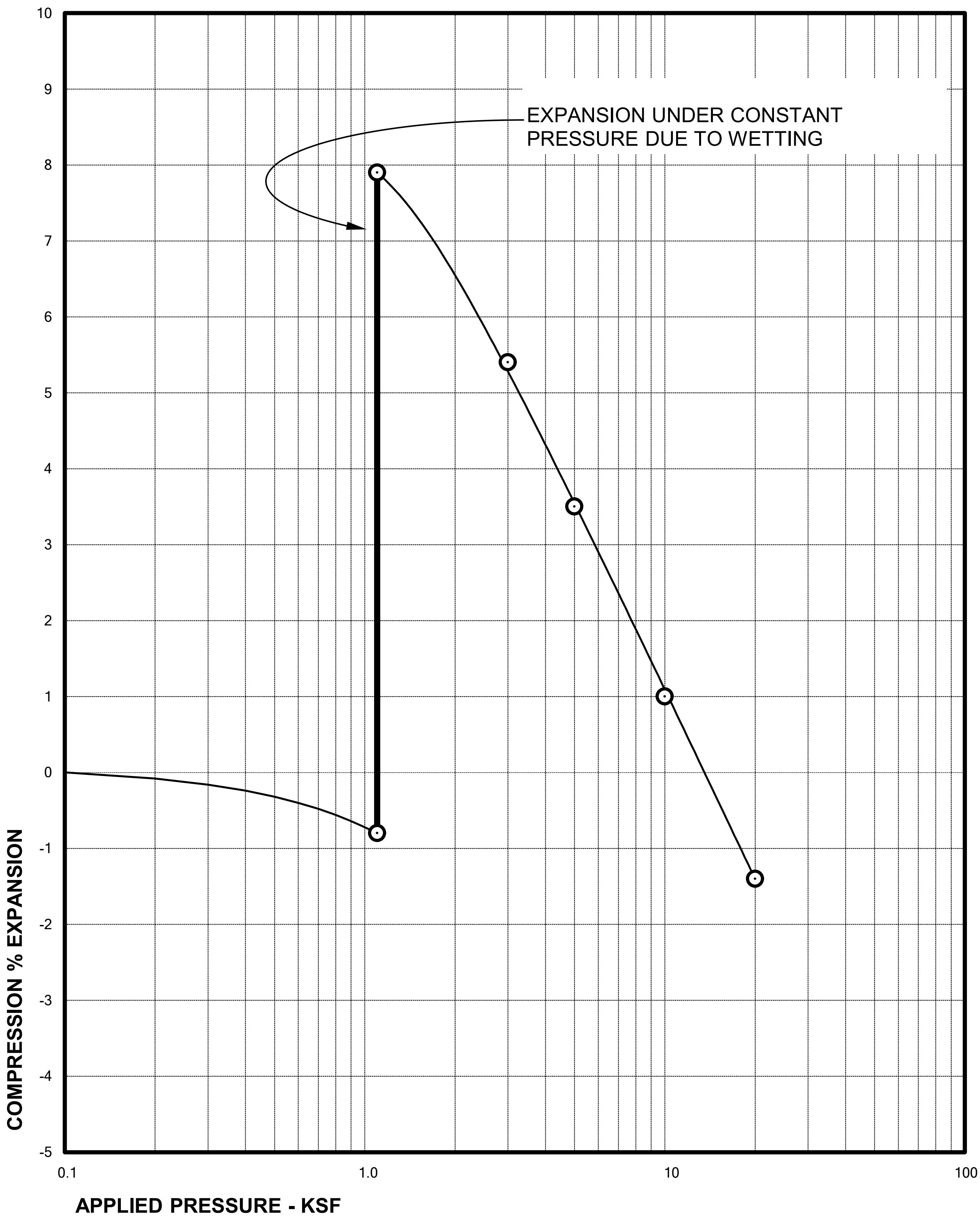
CTL|T PROJECT NO. CS19573.000-115

Swell Consolidation Test Results

FIG. B-1



Sample of CLAYSTONE, SANDY
From LOT 9 AT 9 FEET

DRY UNIT WEIGHT= 121 PCF
MOISTURE CONTENT= 8.0 %

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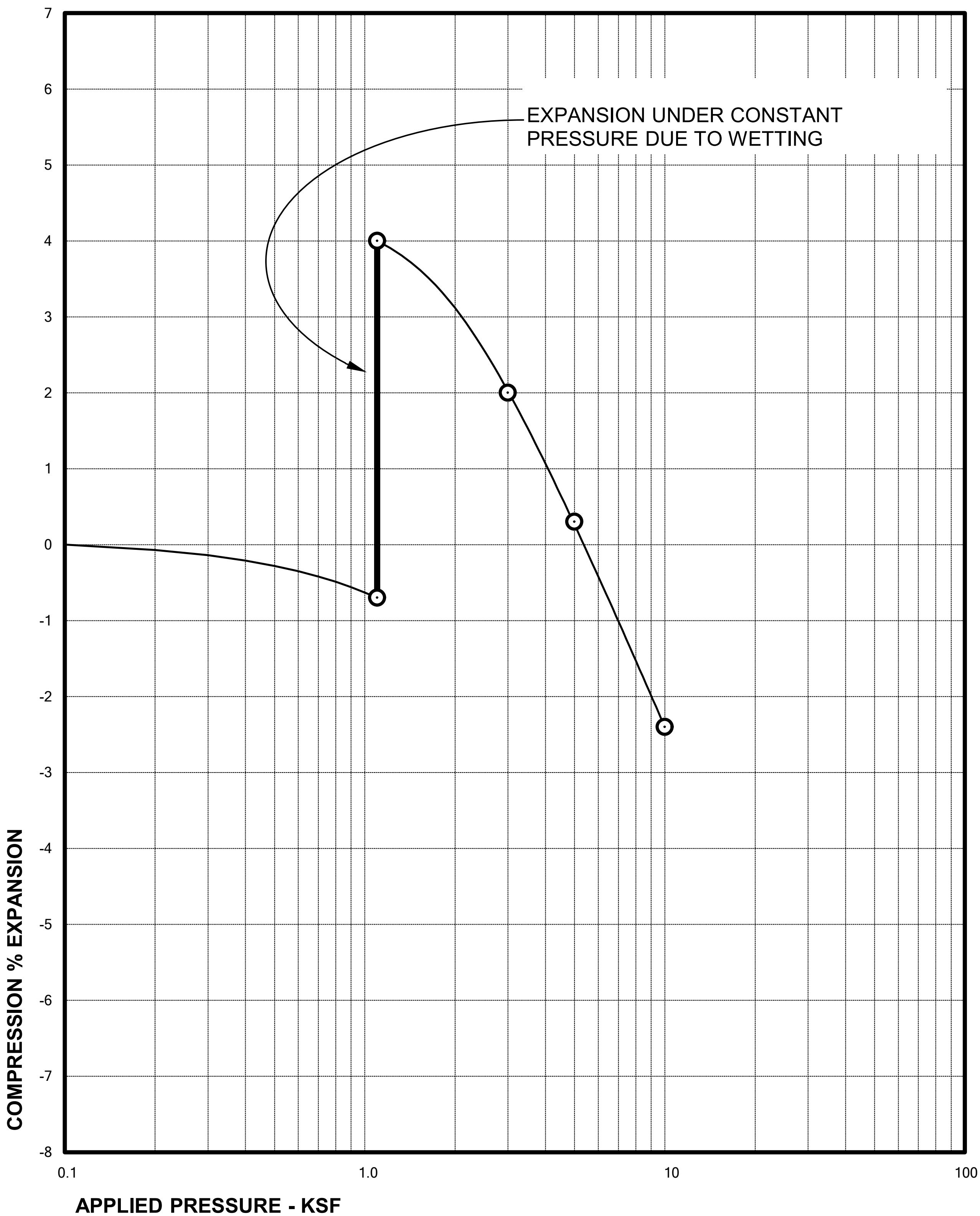
Swell Consolidation Test Results

FIG. B-2



Sample of CLAYSTONE, SANDY
From LOT 11 AT 9 FEET

DRY UNIT WEIGHT= 115 PCF
MOISTURE CONTENT= 12.9 %

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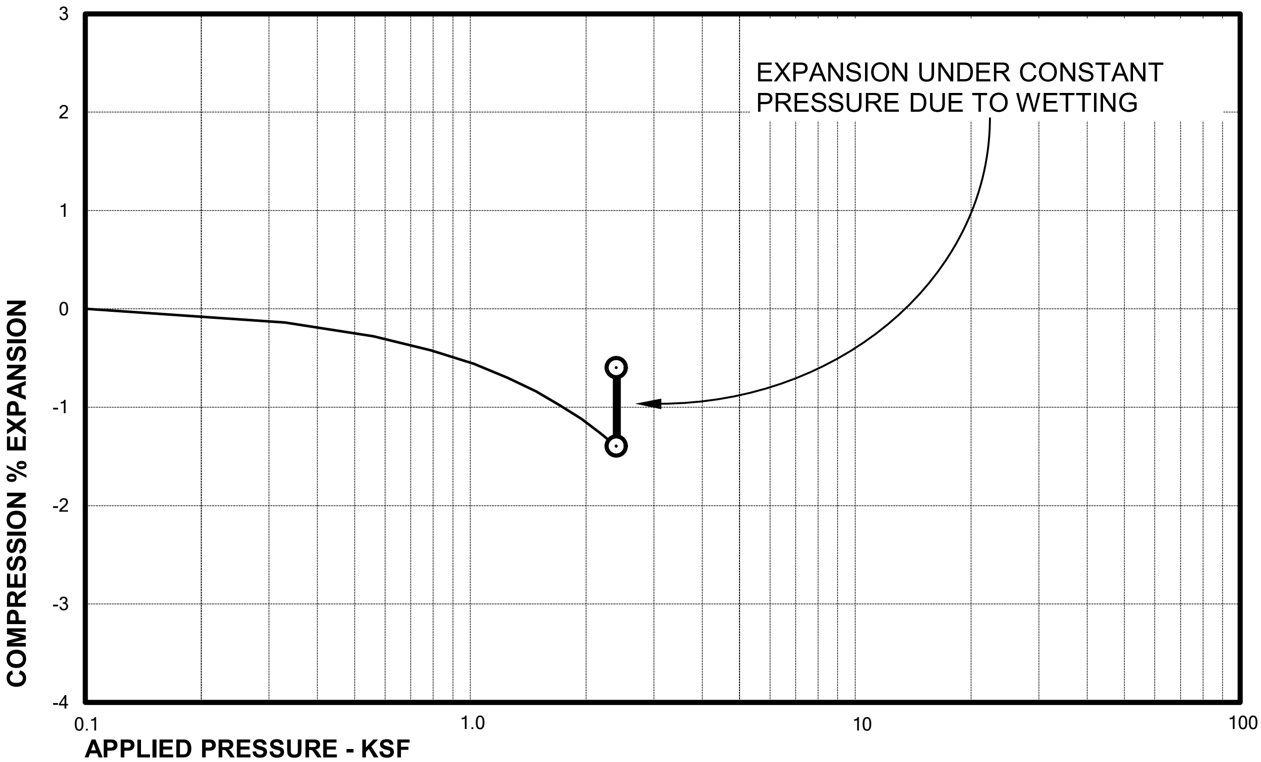
Swell Consolidation Test Results

FIG. B-3

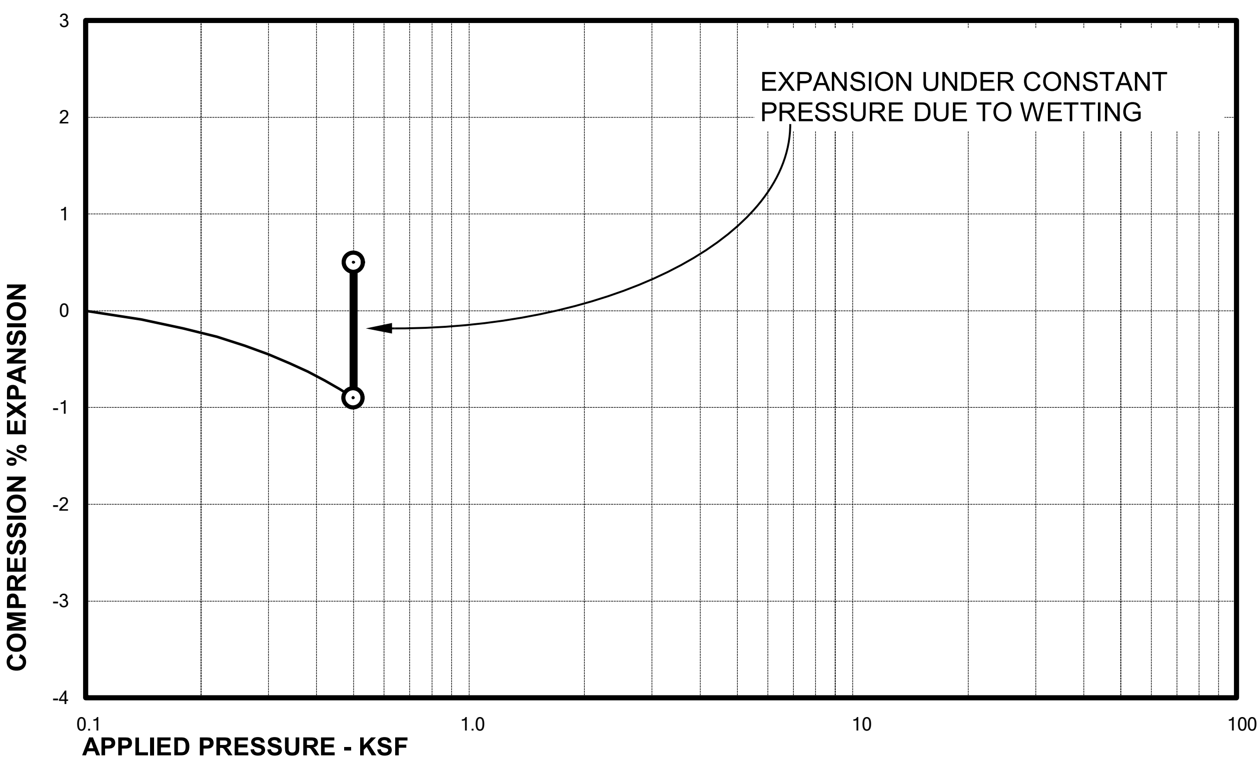


Sample of CLAYSTONE, SANDY

From LOT 12 AT 19 FEET

DRY UNIT WEIGHT= 114 PCF

MOISTURE CONTENT= 15.2 %



Sample of WEATHERED CLAYSTONE

From LOT 13 AT 9 FEET

DRY UNIT WEIGHT= 118 PCF

MOISTURE CONTENT= 7.6 %

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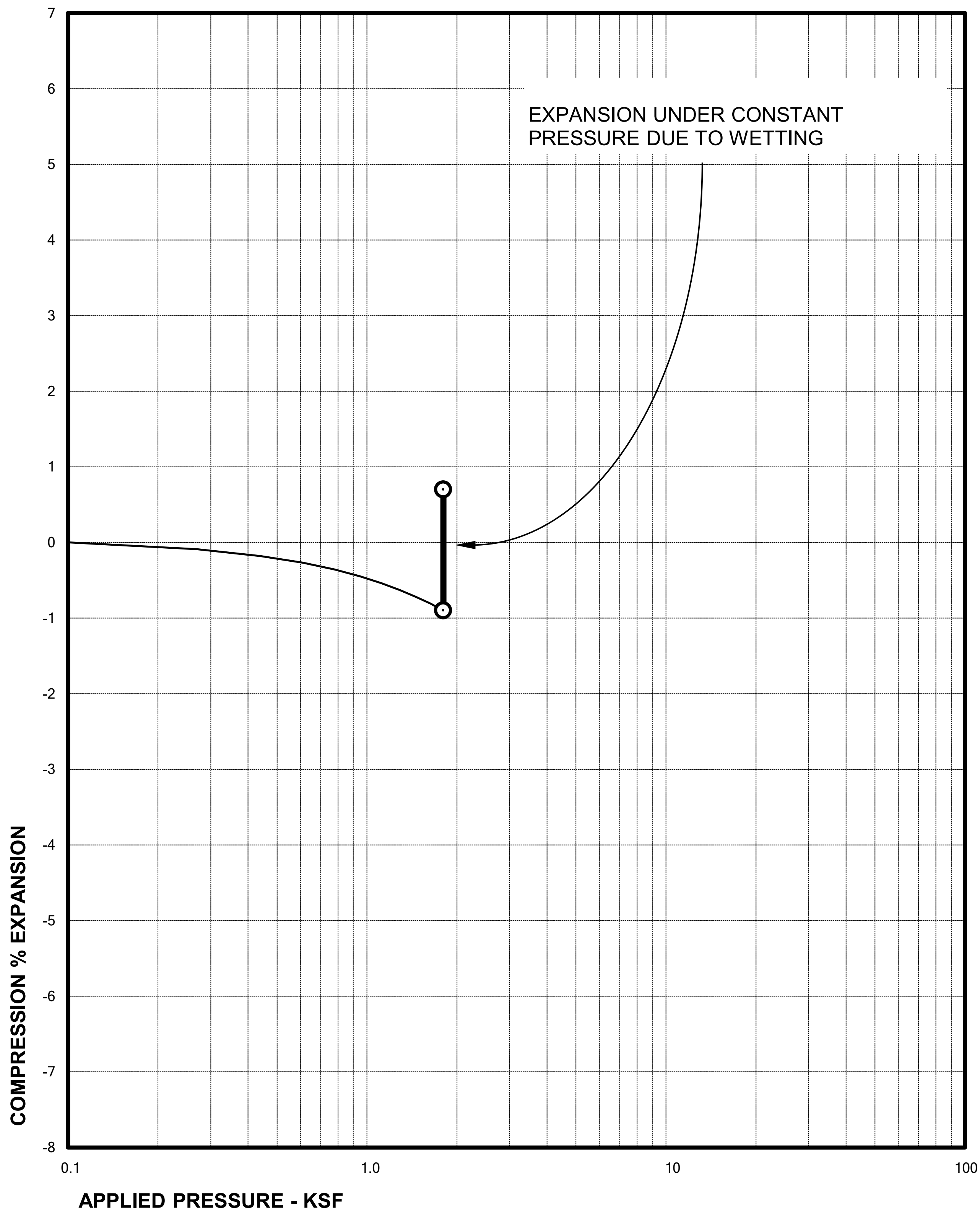
HAY CREEK DEVELOPMENT
CTL|T PROJECT NO. CS19573.000-115

Swell Consolidation



Sample of CLAYSTONE, SANDY
From LOT 14 AT 14 FEET

DRY UNIT WEIGHT= 122 PCF
MOISTURE CONTENT= 9.7 %

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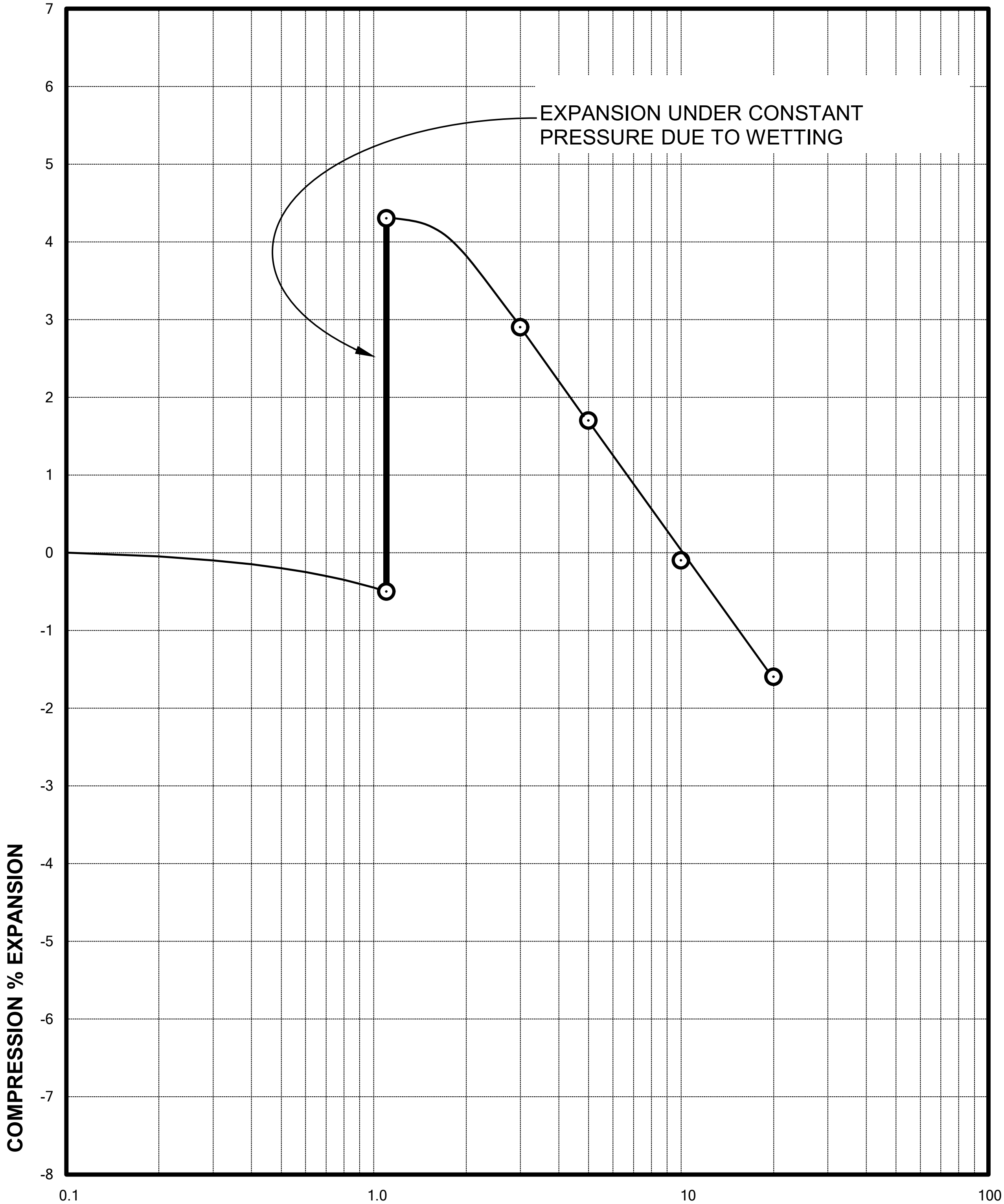
HAY CREEK DEVELOPMENT
CTL|T PROJECT NO. CS19573.000-115

Swell Consolidation Test Results

FIG. B-5



Sample of WEATHERED CLAYSTONE
From LOT 15 AT 9 FEET

DRY UNIT WEIGHT= 124 PCF
MOISTURE CONTENT= 8.6 %

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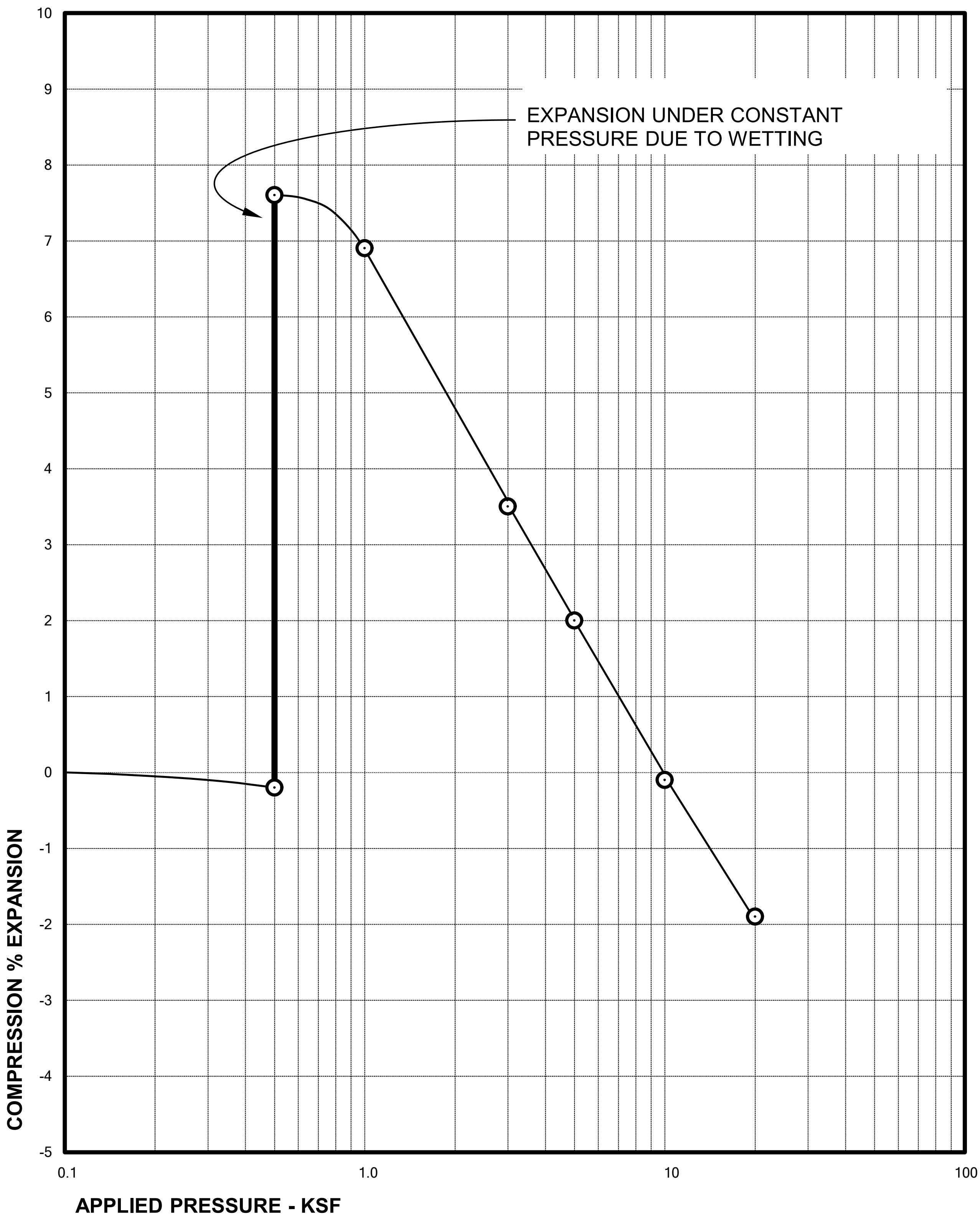
HAY CREEK DEVELOPMENT
CTL|T PROJECT NO. CS19573.000-115

Swell Consolidation Test Results

FIG. B-6



Sample of	WEATHERED CLAYSTONE	DRY UNIT WEIGHT=	120	PCF
From	LOT 16 AT 4 FEET	MOISTURE CONTENT=	7.7	%

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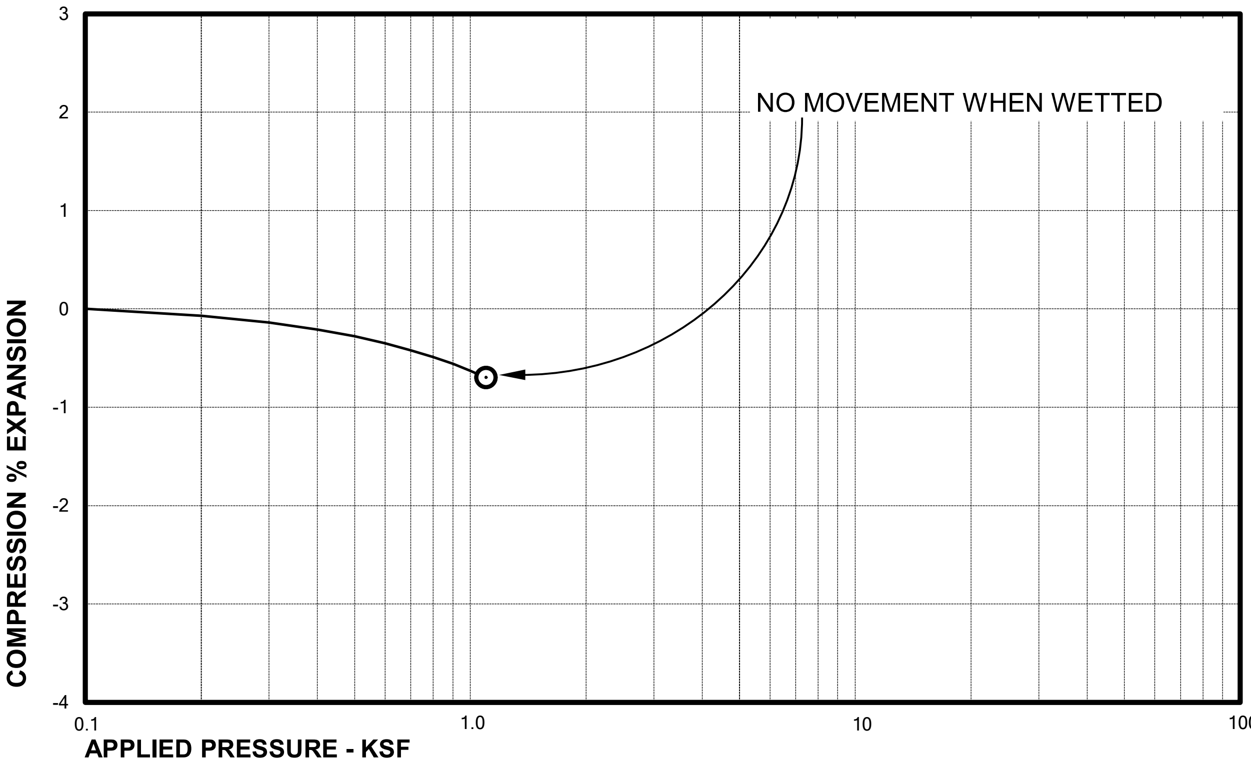
HAY CREEK DEVELOPMENT
CTL|T PROJECT NO. CS19573.000-115

Swell Consolidation Test Results

FIG. B-7

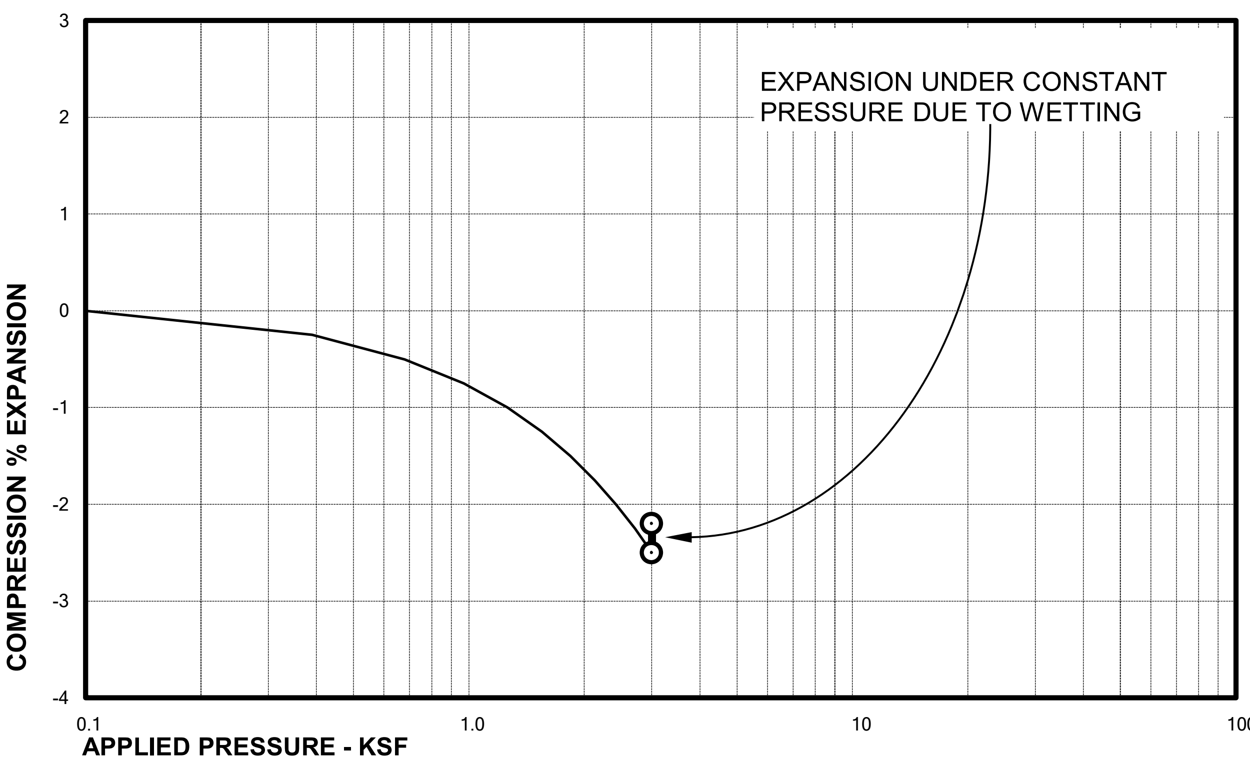


Sample of CLAYSTONE, SANDY

From LOT 17 AT 9 FEET

DRY UNIT WEIGHT= 119 PCF

MOISTURE CONTENT= 13.8 %



Sample of SANDSTONE, CLAYEY

From LOT 19 AT 24 FEET

DRY UNIT WEIGHT= 122 PCF

MOISTURE CONTENT= 12.0 %

COLA, LLC
HAY CREEK DEVELOPMENT
CTL|T PROJECT NO. CS19573.000-115

Swell Consolidation

FIG. B-8

TABLE B-I

SUMMARY OF LABORATORY TESTING
CTL|T PROJECT NO. CS19573.000-115

LOT	DEPTH (FEET)	MOISTURE CONTENT (%)	DRY DENSITY (PCF)	ATTERBERG LIMITS LIQUID LIMIT	ATTERBERG LIMITS PLASTICITY INDEX	SWELL TEST RESULTS* SWELL (%)	SWELL TEST RESULTS* APPLIED PRESSURE (PSF)	SWELL TEST RESULTS* SWELL PRESSURE (PSF)	PASSING NO. 200 SIEVE (%)	WATER SOLUBLE SULFATES (%)	DESCRIPTION
1	4	2.3	113						28		SAND, SILTY (SM)
1	9	3.9	115						24		SAND, SILTY (SM)
1	14	6.2	110						56		CLAY, VERY SANDY (CL)
3	4	3.5	107						37		SAND, VERY SILTY (SM)
3	9	2.2	123			0.8	1100				CLAY, SANDY (CL)
3	19	4.1	130						20		SAND, SILTY (SM)
5	4	1.5	102						16		SAND, SILTY (SM)
5	9	5.8	123						22		SAND, SILTY (SM)
5	14	7.9	124						50		CLAYSTONE, VERY SANDY
7	4	1.8	109						15		SAND, SILTY (SM)
7	14	5.5	116						36		SAND, VERY SILTY (SM)
9	4	1.8	113						18		SAND, SILTY (SM)
9	9	8.0	121			8.7	1100	17,000		<0.1	CLAYSTONE, SANDY
11	9	12.9	115			4.7	1100	6,500			CLAYSTONE, SANDY
11	19	1.5	105						29		SANDSTONE, SILTY
12	9	4.7	126						27		SANDSTONE, SILTY
12	19	15.2	114			0.8	2400				CLAYSTONE, SANDY
13	4	1.4	114						16		SAND, SILTY (SM)
13	9	7.6	118			1.4	1100			<0.1	WEATHERED CLAYSTONE
14	4	1.5	111						16		SAND, SILTY (SM)
14	14	9.7	122			1.6	1800				CLAYSTONE, SANDY
15	4	1.8	112						23		SAND, SILTY (SM)
15	9	8.6	124			4.8	1100	12,000			WEATHERED CLAYSTONE
15	14	7.2	93						55		CLAYSTONE, VERY SANDY
16	4	7.7	120			7.8	500	11,000		<0.1	WEATHERED CLAYSTONE
16	14	3.2	124						12		SANDSTONE, SLIGHTLY SILTY
17	9	13.8	119			0.0	1100				CLAYSTONE, SANDY
17	14	3.1	115						9		SANDSTONE, SLIGHTLY SILTY
18	4	3.2	108						9		SAND, SLIGHTLY SILTY (SP-SM)
18	14	9.7	123						75		CLAYSTONE, SANDY
19	9	1.5	110						11		SANDSTONE, SLIGHTLY SILTY
19	24	12.0	122			0.3	3000				SANDSTONE, CLAYEY

* SWELL MEASURED UNDER ESTIMATED IN-SITU OVERBURDEN PRESSURE.
NEGATIVE VALUE INDICATES COMPRESSION.

TABLE B-I

SUMMARY OF LABORATORY TESTING
CTL|T PROJECT NO. CS19573.000-115

				ATTERBERG LIMITS		SWELL TEST RESULTS*					
LOT	DEPTH (FEET)	MOISTURE CONTENT (%)	DRY DENSITY (PCF)	LIQUID LIMIT	PLASTICITY INDEX	SWELL (%)	APPLIED PRESSURE (PSF)	SWELL PRESSURE (PSF)	PASSING NO. 200 SIEVE (%)	WATER SOLUBLE SULFATES (%)	DESCRIPTION
20	4	2.0	102						22		SAND, SILTY (SM)
20	14	5.3	128						42		SANDSTONE, VERY CLAYEY

* SWELL MEASURED UNDER ESTIMATED IN-SITU OVERBURDEN PRESSURE.
NEGATIVE VALUE INDICATES COMPRESSION.

APPENDIX C

GUIDELINE SITE GRADING SPECIFICATIONS
HAY CREEK DEVELOPMENT
EL PASO COUNTY, COLORADO

GUIDELINE SITE GRADING SPECIFICATIONS
HAY CREEK DEVELOPMENT
EL PASO COUNTY, COLORADO

1. DESCRIPTION

This item consists of the excavation, transportation, placement and compaction of materials from locations indicated on the plans, or staked by the Civil Engineer, as necessary to achieve preliminary pavement and building pad elevations. These specifications also apply to compaction of materials that may be placed outside of the project.

2. GENERAL

The Geotechnical Engineer will be the Owner's representative. The Geotechnical Engineer will approve fill materials, method of placement, moisture contents and percent compaction.

3. CLEARING JOB SITE

The Contractor shall remove all trees, brush and rubbish 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 or where the material will support structures of any kind.

4. SCARIFYING AREA TO BE FILLED

All topsoil, vegetable matter, and existing fill 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 that would prevent uniform compaction by the equipment to be used.

5. PLACEMENT OF FILL ON NATURAL SLOPES

Where natural slopes are steeper than 20 percent (5:1, horizontal to vertical) and fill placement is required, horizontal benches shall be cut into the hillside. The benches shall be at least 12 feet wide or 1-1/2 times the width of the compaction equipment and be provided at a vertical spacing of not more than 5 feet (minimum of two benches). Larger bench widths may be required by the Geotechnical Engineer. Fill shall be placed on completed benches as outlined within this specification.

6. COMPACTING AREA TO BE FILLED

After the foundation for the fill has been cleared and scarified, it shall be disced or bladed until it is free from large clods, brought to a workable moisture content and compacted.

7. FILL MATERIALS

Fill soils shall be free from vegetable matter or other deleterious substances and shall not contain rocks or lumps having a diameter greater than six (6) inches. Fill materials shall be obtained from cut areas shown on the plans or staked in the field by the Civil Engineer or imported to the site.

8. MOISTURE CONTENT

For fill material classifying as CH or CL, the fill shall be moisture treated to between 1 and 4 percent above optimum moisture content as determined by ASTM D 698 if it is to be placed within 15 feet of the final grade. Deep cohesive fill (greater than 15 feet below final grade) shall be moisture conditioned to within ±2 percent of optimum. Soils classifying as SM, SC, SW, SP, GP, GC and GM shall be moisture treated to within 2 percent of optimum moisture content as determined by ASTM D 1557. 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 Geotechnical Engineer, 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 throughout the soils.

The application of water to embankment materials shall be made with any type of watering equipment approved by the Geotechnical 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 to be obtained, 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.

9. 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. Granular fill placed less than 15 feet below final grade shall be compacted to at least 95 percent of maximum dry density as determined in accordance with ASTM D 1557. Cohesive fills placed less than 15 feet below final grade shall be compacted to at least 95 percent of maximum dry density as determined in accordance with ASTM D 698. Deep cohesive fill (to be placed 15 feet or deeper below final grade), shall be compacted to at least 98 percent of maximum standard Proctor dry density (ASTM D 698). Granular fill placed more than 15 feet below final grade shall be compacted to at least 95 percent of maximum modified Proctor dry density (ASTM D 1557). Deep fills shall be placed within 2 percent of optimum moisture content. Fill materials shall be placed such that the thickness of loose materials does not exceed 10 inches and the compacted lift thickness does not exceed 6 inches.

Compaction, as specified above, shall be obtained using sheepsfoot rollers, multiple-wheel pneumatic-tired rollers, or other equipment approved by the Geotechnical Engineer for soils classifying as claystone, CL, CH or SC. Granular fill shall be compacted using vibratory equipment or other equipment approved by the

Geotechnical 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.

10. COMPACTION OF SLOPES

Fill slopes shall be compacted by means of sheepsfoot rollers or other suitable equipment. Compaction operations shall be continued until slopes are stable, but not too dense for planting, and there is no appreciable amount of loose soil on the slopes. Compaction of slopes may be done progressively in increments of 3 to 5 feet in height or after the fill is brought to its total height. Permanent fill slopes shall not exceed 3:1 (horizontal to vertical).

11. DENSITY TESTS

Field density tests will be made by the Geotechnical Engineer at locations and depths of his/her choosing. Where sheepsfoot rollers are used, the soil may be disturbed to a depth of several inches. Density tests will 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 is below that required, the particular layer or portion shall be reworked until the required density or moisture content has been achieved. The criteria for acceptance of fill shall be:

A. Moisture:

The allowable ranges for moisture content of the fill materials specified above in "Moisture Content" 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 Geotechnical Engineer, shall be within the limits given. The Geotechnical Engineer will inform the Contractor when the placement moisture is less than or exceeds the limits specified above and the Contractor shall immediately adjust the procedures as necessary to maintain placement moisture content within the specified limits.

B. Density:

1. The average dry density of all material shall not be less than the specified dry density.

2. No more than 20 percent of the material represented by the tested samples shall be at dry densities less than the specified dry density.

3. Material represented by tested samples having a dry density more than 2 percent below the specified dry density will be rejected. Such rejected materials shall be reworked until a dry density equal to or greater than the specified dry density is obtained.

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 Geotechnical Engineer indicates 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 Geotechnical Engineer 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 three 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 Geotechnical Engineer, as specified under “Density Tests” above, will be submitted progressively to the Owner. Dry density, moisture content and percent compaction will be reported for each test taken.