Preliminary Geotechnical Evaluation

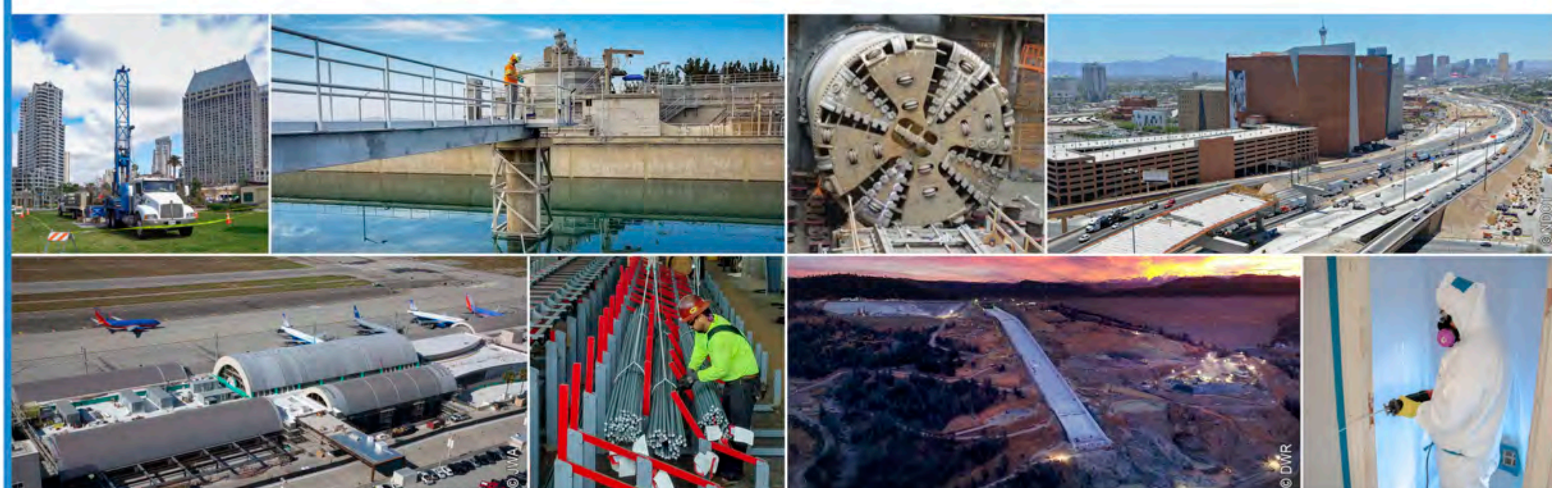
Proposed Multi-Family Development
Compark South – Portion of Tract G
Compark Village South, Filing No. 1

Parker, Colorado

Century Living

8390 East Crescent Parkway, Suite 650 | Greenwood Village, Colorado 80111

March 29, 2021 | Project No. 502090001



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Ninyo & Moore

Geotechnical & Environmental Sciences Consultants

March 29, 2021
Project No. 502090001

Ms. Kari Remmen
Century Living
8390 East Crescent Parkway, Suite 650
Greenwood Village, Colorado 80111

Subject: Preliminary Geotechnical Evaluation
Proposed Multi-Family Development
Compark South – Portion of Tract G
Compark Village South, Filing No. 1
Parker, Colorado

Dear Ms. Remmen:

In accordance with your request and authorization, we have performed a geotechnical evaluation for the Proposed Multi-Family Development located in Parker, Colorado. This report presents our geotechnical findings, conclusions, and recommendations regarding the proposed project.

We appreciate the opportunity to be of service on this project.

Sincerely,
NINYO & MOORE

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Distribution: (1) Addressee (via e-mail)

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1. INTRODUCTION

In accordance with your request and authorization and our proposal dated February 10, 2021, we have performed a geotechnical evaluation for the proposed Multi-Family Development located within the development referred as Compark South – Portion of Tract G located within the part of the south half of Section 6, Township 6, South Range 66 West of the Sixth Principal Meridian in the City of Parker, County of Douglas, Colorado. The approximate location of the site is depicted on Figure 1.

The purpose of our study was to evaluate the subsurface conditions and to provide preliminary design and construction recommendations regarding geotechnical aspects of the proposed project. This report presents the findings of our subsurface exploration, results of our laboratory testing, conclusions regarding the subsurface conditions at the site, and preliminary geotechnical recommendations for the design and construction of this project.

2. SCOPE OF SERVICES

The scope of our services for the project generally included:

- Review of referenced background information, including aerial photographs, published geologic and soil maps, previous geotechnical evaluations, in-house geotechnical data, and available topographical information pertaining to the project site and vicinity.

- Site reconnaissance to document site conditions and establish boring locations, and arrange for the mark-out of publicly owned underground utilities through Utility Notification Center of Colorado of the boring locations prior to drilling.

- Drilling, logging, and sampling of 11 small-diameter exploratory borings within the project site. Borings were performed within the proposed building footprints to depths ranging between approximately 19.5 to 39.5 feet below the ground surface (bgs). The boring logs are presented in Appendix A. Approximate boring locations are presented on Figure 2.

- Performing laboratory tests on selected samples obtained from the borings to evaluate engineering properties including in-situ moisture content and dry density, Atterberg limits, percent materials passing the No. 200 sieve and grain size analysis, swell/consolidation potential, Proctor density, and soil corrosivity characteristics (including pH, resistivity, water soluble sulfates and chlorides). The results of the laboratory testing are presented on the boring logs and in Appendix B.

- Compilation and analysis of the data obtained.

- Preparation of this report presenting our findings, conclusions, and preliminary geotechnical recommendations regarding design and construction of the project.

3. SITE DESCRIPTION AND BACKGROUND REVIEW

The project site consists of an approximately 13.76-acre parcel of land located south of E-470 Toll Road, west of South Chambers Road in Parker, Colorado. The site is bordered by Cherokee Trail followed by E-470 Toll Road to the north, by Happy Canyon gulch/drainage to the east, by single-family homes to the south, and by a development under construction to the west.

Historical research revealed that the site has been vacant land from the 1930s or earlier to around 2011 when the placement of grade-raise fill occurred as part of the drainage improvement activities located to the west of South Chambers Road and south of E-470 Toll Road. The northern portions of the site remain undeveloped. The approximate location of the site is depicted on Figure 1. The approximate boundary of the grade-raise fill is presented on Figure 3.

Based on the Schematic Design site plan with the site elevations, the topography of the site generally slopes towards the east with several undulations across the site. The high point of the site is generally the southwestern portion which is at an elevation of approximately 5,825 feet and generally slopes down to the east to an elevation of approximately 5,790 feet and to the north towards the drainage feature located within the center of the project site. The northeast corner of the site is the low point with an elevation of approximately 5,780 feet.

4. PROPOSED CONSTRUCTION

The project is in its preliminary stage, based on the Schematic Design Site Plan provided by EV Studio dated December 18, 2020 (EV Studio, 2020), the proposed construction may consist of a multi-family apartment community consisting of 10 buildings and a clubhouse with a pool. In addition, the site development will include the design and construction of privately-maintained paved streets and parking areas and landscaping improvements. Project specific structural plans, grading/drainage plans, and finished floor elevation (FFE) information were not available at the time of report preparation. For the purposes of this report, the buildings are referenced based on the respective boring number.

5. FIELD EXPLORATION AND LABORATORY TESTING

On February 22 and 23, 2021, Ninyo & Moore conducted a subsurface exploration at the site to evaluate the existing subsurface conditions and to collect soil samples for laboratory testing. The evaluation consisted of the drilling, logging, and sampling of 11 small-diameter using a truck-mounted drill rig equipped with 4-inch diameter solid-stem augers. The borings were performed within the proposed building footprints to depths ranging between approximately 19.5 and 39.5 feet bgs. The approximate locations of the borings are presented on Figure 2. Relatively undisturbed and disturbed soil samples were collected at selected intervals. The sampling methods used during the subsurface evaluation are presented in Appendix A.

Soil samples collected during the subsurface exploration were transported to the Ninyo & Moore laboratory for geotechnical laboratory analyses. Selected samples were analyzed to evaluate engineering properties including in-situ moisture content and dry density, Atterberg limits, percent materials passing the No. 200 sieve and grain size analysis, swell/consolidation potential, Proctor density, and soil corrosivity characteristics (including pH, resistivity, water soluble sulfates and chlorides). The results of the in-situ moisture content and dry density tests are presented on the boring logs in Appendix A. Descriptions of the laboratory test methods and the remainder of the test results are presented in Appendix B.

6. GEOLOGIC AND SUBSURFACE CONDITIONS

6.1. Regional Geologic Setting

The site is located in Parker, Colorado, approximately 19 miles east of the Rocky Mountains, within the Colorado Piedmont section of the Great Plains Physiographic Province. The Laramide Orogeny uplifted the Rocky Mountains during the late Cretaceous and early Tertiary Periods. Subsequent erosion deposited sediments east of the Rocky Mountains, including the Dawson Formation in the area. As a result of regional uplift approximately 5 to 10 million years ago, streams down-cut and excavated into the Great Plains forming the Colorado Piedmont section (Trimble, 1980).

The surficial geology of the site vicinity is mapped by Maberry and Lindvall (1972) as the upper part of the Pleistocene-age Louviers Alluvium consisting of poorly sorted gravel, sand, silt, and clay. The project site is underlain by Dawson Formation at depth.

6.2. Subsurface Conditions

Our understanding of the subsurface conditions at the project site is based on our field exploration and laboratory testing, review of published geologic maps, historic aerial photographs, and our experience with the general geology of the area. The following sections provide a generalized description of the subsurface materials encountered. More detailed descriptions are presented on the boring logs in Appendix A.

6.2.1. Fill

Fill material was encountered at the surface in Borings B-1, B-2, B-4, and B-8 through B-11 and extended to depths between approximately 2 and 33 feet bgs. The fill material generally consisted of various shades of brown, gray, orange, red, and black, moist, clayey sand with varying amounts of gravel, and lean and fat clay with varying amounts of sand and gravel. Claystone fragments were encountered within the fill material.

Based on the results of the laboratory testing, selected samples of the fill material had in-place moisture contents between approximately 6.5 and 24.7 percent and dry densities between approximately 103.1 and 123.4 pounds per cubic foot (pcf)

In addition to the fill encountered in our borings, other fill material may be present across the site. Based on aerial history review, we assume a majority of the deep fills encountered in our borings is associated with the grade-raise fill placement that occurred around 2011. The approximate limits of the fill placement are presented on Figure 3. Information regarding the placement of existing fill material, including ground preparation, remedial excavation, methods of fill placement, and the degree of compaction during placement, is unknown to this firm. Consequently, the fill material is considered undocumented.

6.2.2. Alluvium

Alluvial deposits were encountered at the surface of Borings B-3, and B-5 through B-7, and beneath fill materials in the remaining borings and extended to depths of approximately 6 to 38.5 feet bgs. The alluvial deposits generally consisted of various shades of brown, gray, and orange, dry to moist, very stiff to hard, lean and fat clay with varying amounts of sand, and loose to dense, clayey sand with varying amounts of gravel.

Based on the results of the laboratory testing, selected samples of the alluvium had in-place moisture contents between approximately 4.2 and 17.4 percent and dry densities between approximately 91.5 and 125.3 pcf.

6.2.3. Dawson Formation Bedrock

Bedrock mapped as the Dawson Formation was encountered in Borings B-1, B-2, B-4, B-7 through B-9, and B-11 at depths between approximately 6 and 38.5 feet bgs and extended to the boring termination depths of up to approximately 39.5 feet bgs. The Dawson Formation bedrock generally consisted of various shades of blue, red, and gray, moist, moderately hard to hard claystone with interbedded moderately to strongly cemented sandstone.

Based on the results of the laboratory testing, selected samples of the Dawson Formation had in-place moisture contents between approximately 3.1 and 21.0 percent and dry densities between approximately 107.8 and 123.5 pcf.

6.3. Groundwater

Groundwater was not encountered at the time of drilling. Groundwater levels will fluctuate due to seasonal variations in the amount of rainfall, runoff, water level of nearby streams, groundwater withdrawal from adjacent sites, and other factors. In addition, perched water can develop in the higher permeability alluvium deposits following periods of heavy or prolonged precipitation. The possibility of groundwater level fluctuations and perched water should be considered when developing the design and construction plans for the project. In general, groundwater is not anticipated to be encountered during construction of proposed improvements.

7. GEOLOGIC HAZARDS

The following sections describe potential geologic hazards at the site including faulting and seismicity, expansive soils, compressible/collapsible soils, and liquefaction potential.

7.1. Faulting and Seismicity

Historically, several minor earthquakes have been recorded in the Broomfield area. Based on our field observations and our review of readily available published geological maps and literature, there are no known active faults underlying or adjacent to the subject site. The faults closest to the project site include the Rocky Mountain Arsenal Fault and the Golden Fault.

The Rocky Mountain Arsenal Fault lies approximately 18 miles north of the site (Kirkham and Rogers, 1981). This fault is approximately 15 miles in length, trends generally northwest to southeast, and is considered to be a right lateral strike-slip fault. The most recent significant seismic movements associated with the Rocky Mountain Arsenal Fault occurred in the 1960's, with recorded earthquake magnitudes up to 5.5. United States Geological Survey (USGS) investigators concluded that a strong correlation existed between the seismic activity of this fault and pressure injection of liquid waste into a disposal well located at the nearby Rocky Mountain Arsenal. Pressure injection in the disposal well was discontinued in 1966 and minor seismic movements along the fault have been recorded since. The risk of this fault giving rise to damaging, earthquake-induced ground motions at the site during the design life of the proposed structure is considered to be relatively low, based on the previously recorded low seismic magnitudes.

The closest Quarternary-age fault to the site is the Golden Fault, which lies approximately 25 miles northwest of the site (USGS, 2017). The fault is considered to be late Quaternary in age and has not shown displacement in Holocene time, as Pleistocene deposits overlie the fault (approximately 75 to 125 thousand years before the present [Kirkham, 1977]). Therefore, the probability of damage at the site from seismically induced ground surface rupture from this fault is considered to be low.

Design of the proposed improvements should be performed in accordance with the requirements of the governing jurisdictions and applicable building codes. Table 1 presents the seismic design parameters for the site in accordance with the 2018 International Building Code (IBC) guidelines and adjusted maximum considered earthquake spectral response acceleration parameters evaluated using the OSHPD (OSHPD, 2021) ground motion calculator (web-based).

Table 1 – 2018 International Building Code Seismic Design Criteria

Seismic Design Factors	Value
Site Class	D
Site Coefficient, F_a	1.6
Site Coefficient, F_v	2.4
Mapped Spectral Acceleration at 0.2-second Period, S_s	0.175 g
Mapped Spectral Acceleration at 1.0-second Period, S_1	0.057 g
Spectral Acceleration at 0.2-second Period Adjusted for Site Class, S_{MS}	0.280 g
Spectral Acceleration at 1.0-second Period Adjusted for Site Class, S_{M1}	0.138 g
Design Spectral Response Acceleration at 0.2-second Period, S_{DS}	0.187 g
Design Spectral Response Acceleration at 1.0-second Period, S_{D1}	0.092 g

7.2. Expansive Soils

One of the more significant geologic hazards in the Front Range area is the presence of swelling clays in bedrock or surficial deposits. Wetting and drying of bedrock or surficial deposits containing swelling clays can result in expansion and collapse of those units, which can cause major damage to structures. A review of a Colorado Geological Survey map delineating areas based on their relative potential for swelling in the Front Range by Hart (1973-1974) indicates that the soil and bedrock materials in the site vicinity are typically low to moderate swell potential.

Based on the results of our laboratory testing, select samples of site soils tested exhibited swell potentials of approximately 0.1 to 8.8 percent at surcharge pressures of approximately 200 pounds per square foot (psf), approximately 0.7 to 4.9 at surcharge pressures of approximately 500 psf, approximately 0.3 to 1.3 at surcharge pressures of approximately 1,000 psf, approximately 0.1 to 4.5 at surcharge pressures of approximately 1,500 psf, and approximately 0.7 to 1.5 at surcharge pressures of approximately 2,000 psf. The slab performance risk categories per the representative percent swell value under a given surcharge pressure are presented in Table 2.

Based on the results of our subsurface exploration, laboratory testing, and the information obtained from our background review, the on-site soils expected to be encountered during project development would have a slab performance risk category of “LOW” to “MODERATE” based on the criteria presented in Table 2.

Table 2 – Slab Performance Risk Categories		
Slab Performance Risk Category	**Representative Percent Swell (500 psf Surcharge)**	**Representative Percent Swell (1,000 psf Surcharge)**
LOW	0 to <3	0 to <2
MODERATE	3 to <5	2 to <4
HIGH	5 to <8	4 to <6
VERY HIGH	> 8	> 6

NOTE: The information provided in this table is based on Colorado Association of Geotechnical Engineers (CAGE), Guidelines for Slab Performance Risk Evaluation and Residential Basement Floor System Recommendations (Denver Metropolitan Area, 1996).

Recommendations are provided in this report to reduce the swell potential of the site soils and bedrock by means of sub-excavation (excavation of soils/bedrock, processing and moisture conditioning of the soils/bedrock, and replacing the processed soil/bedrock as properly compacted engineered fill). The recommendations provided in this report will not eliminate the post-construction swell risk and are intended to reduce and control the risk. Further reduction of the risk for the proposed buildings would involve total isolation of the buildings from the swelling soils by supporting them on deep foundation system with grade beams placed on void forms and providing the buildings with similarly supported structural floors spanning above a well-ventilated crawl space.

7.3. Compressible/Collapsible Soils

Compressible soils are generally comprised of soils that undergo consolidation when exposed to new loadings, such as fill or foundation loads. Soil collapse (or hydrocollapse) is a phenomenon where soils undergo a significant decrease in volume upon an increase in moisture content, with or without an increase in external loads. Buildings, structures, and other improvements may be subject to excessive settlement-related distress when compressible soils or collapsible soils are present.

Based on our subsurface evaluation and the results of our laboratory testing, the potential for post-construction consolidation of the alluvial deposits is low. However, compression of the undocumented fill material could occur due to the new building loads. As a result, removal and recompaction of these materials as engineered fill will be need below the proposed improvements.

7.4. Liquefaction Potential

Liquefaction is a phenomenon in which loose, saturated soils lose shear strength under short-term (dynamic) loading conditions. Ground shaking of sufficient duration results in the loss of grain-to-grain contact in potentially liquefiable soils due to a rapid increase in pore water pressure, causing the soil to behave as a fluid for a short period of time.

To be potentially liquefiable, a soil is typically cohesionless with a grain-size distribution generally consisting of sand and silt. It is generally loose to medium dense and has a relatively high moisture content, which is typical near or below groundwater level. The potential for liquefaction decreases with increasing clay and gravel content, but increases as the ground acceleration and duration of shaking increase. Potentially liquefiable soils need to be subjected to sufficient magnitude and duration of ground shaking for liquefaction to occur. Based on our subsurface exploration and laboratory testing, liquefaction is not considered a hazard at this site

8. CONCLUSIONS

The purpose of our study was to provide a preliminary evaluation of the site with regard to the geotechnical aspects of the future site development. Based on the results of our limited geotechnical evaluation, it is our preliminary opinion that residential development of the site is feasible from a geotechnical perspective. However, the presence of undocumented fill encountered in our buildings will be a constraint to this development. Our preliminary findings and conclusions pertaining to the geotechnical aspects of the property are presented below.

- Fill material was encountered at the surface in Borings B-1, B-2, B-4, and B-8 through B-11 and extended to depths between approximately 2 and 33 feet bgs. The fill material generally consisted of various shades of brown, gray, orange, red, and black, moist, clayey sand with varying amounts of gravel, and lean and fat clay with varying amounts of sand and gravel. Claystone fragments were encountered within the fill material.

- In addition to the fill material encountered in our borings, other fill material may be present across the site. Based on aerial history review, we assume a majority of the deep fills encountered in our borings is associated with the grade-raise fill placement that occurred around 2011. The approximate limits of the fill placement are presented on Figure 3. Information regarding the placement of existing fill material, including ground preparation, remedial excavation, methods of fill placement, and the degree of compaction during placement, is unknown to this firm. Consequently, the fill material is considered undocumented.

- Alluvial deposits were encountered at the surface of Borings B-3, and B-5 through B-7, and beneath fill materials in the remaining borings and extended to depths of approximately 6 to 38.5 feet bgs. The alluvial deposits generally consisted of various shades of brown, gray, and orange, dry to moist, very stiff to hard, lean and fat clay with varying amounts of sand, and loose to dense, clayey sand with varying amounts of gravel.

- Dawson Formation bedrock was encountered in Borings B-1, B-2, B-4, B-7 through B-9, and B-

11 at depths between approximately 6 and 38.5 feet bgs and extended to the boring termination depths of up to approximately 39.5 feet bgs. The Dawson Formation bedrock generally consisted of various shades of blue, red, and gray, moist, moderately hard to hard claystone with interbedded moderately to strongly cemented sandstone.

- Groundwater was not encountered at the time of drilling. Groundwater levels will fluctuate due to seasonal variations in the amount of rainfall, runoff, water level of nearby streams, groundwater withdrawal from adjacent sites, and other factors. In addition, perched water can develop in the higher permeability alluvium deposits following periods of heavy or prolonged precipitation. The possibility of groundwater level fluctuations and perched water should be considered when developing the design and construction plans for the project. In general, groundwater is not anticipated to be encountered during construction of the proposed improvements.

- Based on the results of our laboratory testing, the soils expected to be encountered during project development exhibit a slab performance risk category of low to moderate on a scale that ranges between low, moderate, high, and very high.

- The proposed Buildings B-3, B-4, B-5, and B-6 that may tolerate approximately 1 to 2 inches of post-construction movement may be supported on post-tensioned slab-on-grade foundations or spread footing foundations with slab-on-grade floors that are bearing on a relatively uniform thickness of engineered fill. The thickness of the engineered fill will depend on variety of factors such as distance to Dawson Formation bedrock, swell/consolidation potential of the alluvial deposits, etc. We anticipate engineered fill thicknesses ranging between 7 to 12 feet may be needed. The engineering fill layer will also need to extend 10 feet or more feet beyond the building foundation limits to include the building appurtenances.

- The proposed Buildings B-1, B-2, B-7, B-8, B-9, B-10, and the Clubhouse (B-11) or buildings with lower post-construction movement tolerance may be supported on deep foundation systems (i.e. drilled piers) penetrating into the underlying Dawson Formation and provided with structural floors spanning over a well-ventilated crawl space. Buildings B-2 and B-7 may be able to be supported on shallow foundations, provided additional exploration is performed to further delineate the historical fill boundary.

- There are risks associated with supporting pavements and exterior flatwork over undocumented fill material without soil modification. However, the costs associated with full removal and replacement of the undocumented fill materials are generally considered cost-prohibitive. Assuming the owner is willing to accept some risk, pavements and exterior flatwork may be placed on 12 to 24 inches of moisture conditioned and compacted engineered fill. Chemical stabilization of the upper 12 inches of the engineered fill may be needed under the pavements and exterior flatwork that is attached to the pavements, such as curb and gutter.

- The on-site overburden deposits (fill and alluvial deposits) should generally be excavated with medium- to heavy-duty earthmoving or excavation equipment in good operating condition. The excavation of the Dawson Formation will be very difficult with heavy-duty excavating equipment and the use of special equipment (i.e. single-shank rippers) may be needed. The earthwork contractor should anticipate encountering very difficult excavation conditions, including increased wear and tear on equipment, within Dawson Formation bedrock. Moreover, cemented layers and lenses of sandstone may be encountered within Dawson Formation that where removal of such layers/lenses with specialty equipment is not possible. In those cases, additional evaluation of the extent of the cemented sandstone layers/lenses may need to be performed. Excavations within 5 feet of the perched groundwater table may encounter soft and/or wet conditions.

- Site soils generated from on-site excavation activities consisting of alluvial deposits that are free of deleterious materials, and do not contain particles larger than 3 inches in diameter, can generally be used as engineered fill during site grading.

- Excavated formational materials (Dawson Formation) may be used as engineered fill, however significant processing will be needed to breakdown the bedrock to 3-inch or smaller fragments and increase its moisture content prior to placement. The excavated formational materials should be placed as deep as possible during site grading and capped with the site soils generated from on-site excavation activities of alluvial deposits.

- Based on our laboratory data and our experience with similar materials at adjacent sites, the sulfate content of the tested soils presents a moderate risk of sulfate attack to concrete. Notwithstanding the sulfate test results, we recommend the use of Type II or Type V cement for construction of concrete structures at this site.

- Based on our laboratory data and our experience with similar materials at adjacent sites, the subgrade soils at the site have a moderate potential for corrosivity to ferrous metals. Special consideration should be given to the use of heavy gauge, corrosion-protected, underground steel pipe or culverts, if any are planned. As an alternative, plastic pipe or reinforced concrete pipe could be considered. A corrosion specialist should be consulted for further recommendations.

- Other than the presence of expansive (swelling) soils and undocumented fill materials, which is addressed in this report, no known or reported geologic hazards are reported underlying, or adjacent to, the site. Based on the driven sample blow-count values at the site, and the low ground motion hazard (relatively low ground accelerations), the likelihood or potential for liquefaction is considered to be negligible and therefore not a design consideration.

9. PRELIMINARY RECOMMENDATIONS

The following sections present our preliminary geotechnical recommendations for the proposed site development. Final geotechnical engineering studies with additional borings, laboratory testing, and engineering analysis will be needed when project design documents are available for review and information concerning the anticipated site grading, locations and finished floor elevations of the proposed structures, structural loads, and infrastructure improvements are known.

9.1. Earthwork

The following sections provide our earthwork recommendations for this project. In general, the City of Parker, County of Douglas, and/or project specific earthwork specifications are expected to apply, unless noted.

9.1.1. Excavations

Our evaluation of the excavation characteristics of the on-site materials is based on the results of our subsurface exploration, our site observations, and our experience with similar materials.

The on-site overburden deposits (fill and alluvial deposits) should generally be excavated with medium- to heavy-duty earthmoving or excavation equipment in good operating condition.

Considering the in-fill nature of the site and its historic past-uses, there may be buried concrete remnants, areas of deeper fills, tanks, or other features present below the ground surface.

The excavation of the Dawson Formation will be very difficult with heavy-duty excavating equipment and the use of special equipment (i.e. single-shank rippers) may be needed. Moderately to strongly cemented sandstone and moderately soft to very hard claystone was encountered at shallow depths in Borings B-2 and B-7. The earthwork contractor should anticipate encountering very difficult excavation conditions, including increased wear and tear on equipment, within Dawson Formation bedrock. Moreover, cemented layers and lenses of sandstone may be encountered within Dawson Formation that where removal of such layers/lenses with specialty equipment is not possible. In those cases, additional evaluation of the extent of the cemented sandstone layers/lenses may need to be performed. Excavations within 5 feet of the perched groundwater table may encounter soft and/or wet conditions.

Equipment and procedures that do not cause significant disturbance to the excavation bottoms should be used. Excavators and backhoes with buckets having large claws to loosen the subgrade material should be avoided when excavating the bottom 6 to 12 inches of excavations as such equipment may disturb the excavation bases.

9.1.2. Temporary Excavations

Temporary excavations will be needed for this project to construct foundations and utilities, and during the demolition of the existing improvements. Based on the subsurface information obtained from our exploratory excavations and our experience with similar projects, we anticipate that the soil conditions and stability of the excavation sidewalls may vary with depth. Soils with higher fines content may stand vertically for a short time (less than 12 hours) with little sloughing. However, as the soil dries after excavation or as the excavations are exposed to rainfall, sloughing may occur. Soils with low cohesion (e.g., predominately sandy or gravelly material), may slough or cave during excavation, especially if wet or saturated.

The contractor should provide safely sloped excavations or an adequately constructed and braced shoring system, in compliance with Occupational Safety and Health Administration regulations (OSHA, 2005), for employees working in excavations that may expose them to the danger of moving ground. Reducing the inclination of the sidewalls of the excavations, where feasible, may increase the stability of the excavations. If construction or earth material is stored, or equipment is operated near an excavation, flatter slope geometry or shoring should be used during construction.

In our opinion, the alluvial deposits should generally be considered a Type B soil when applying OSHA regulations. For these soil conditions, OSHA recommends a temporary slope inclination of 1H (Horizontal):1V (Vertical) or flatter for excavations 20 feet or less in depth. Steeper cut slopes may be utilized for excavations that are less than 4 feet deep depending on the strength, moisture content, and homogeneity of the soils as observed in the field. The formational materials at the site should generally be considered Type A soil or Stable rock, where inclinations of 3/4(H):1V or flatter can be considered.

Appropriate slope inclinations should be evaluated in the field by an OSHA-qualified “Competent Person” based on the conditions encountered.

9.1.3. Site and Remedial Grading

Prior to grading, the ground surface in proposed structure and improvement areas should be cleared of any surface obstructions, debris, topsoil, organics (including vegetation) and other deleterious material. Materials generated from the clearing operations should be removed from the site and disposed of at a legal dumpsite. Obstructions that extend below finish grade, if present, should be removed and the resulting holes filled with compacted soil or cement slurry, or in accordance with the recommendations of the geotechnical engineer. Topsoil, if encountered, on-site should not be incorporated into engineered fill.

Uncontrolled fill materials were encountered at this site (Figure 3). The earthwork contractors should assume the previously placed undocumented fill materials present on site are not suitable for reuse unless they are observed and evaluated by a geotechnical engineer during construction in regard to their suitability for reuse. Environmental factors that may restrict the re-use of the undocumented fill material was not studied in this report.

Soils generated from on-site excavation activities in the alluvial deposits that are free of deleterious materials and do not contain particles larger than 3 inches in diameter can generally be used as engineered fill as evaluated by the geotechnical consultant.

If the excavated formational materials are to be used as engineered fill, significant processing (i.e. disking in an open area) of these materials will be needed to break-down the bedrock to

3-inch or smaller fragments prior to placement. The in-place moisture content of the formational material is several percentage points below its optimum moisture content. The addition of a significant amount of moisture will be needed to raise the moisture contents of the excavated formational materials to their optimum moisture content or higher. Processing the excavated formational materials will reduce but not eliminate its swell potential.

The remedial grading recommendations provided below are preliminary and are subject to change, as we do not possess the information regarding site grading, finished floor elevations, etc.

- The proposed Buildings B-3, B-4, B-5, and B-6, that may tolerate approximately 1 to 2 inches of post-construction movement, may be supported on post-tensioned slab-on-grade foundations or spread footing foundations with slab-on-grade floors that are bearing on a relatively uniform thickness of engineered fill. The thickness of the engineered fill will depend on variety of factors such as distance to Dawson Formation bedrock, swell/consolidation potential of the alluvial deposits, etc. We anticipate engineered fill thicknesses ranging between 5 to 10 feet may be needed. The engineering fill layer will also need to extend 10 feet or more feet beyond the building foundation limits to include the building appurtenances.

- Proposed Buildings B-1, B-2, B-7, B-8, B-9, B-10, and the Clubhouse (B-11), or buildings with lower (1-inch or less) post-construction movement tolerance, may be supported on deep foundation systems (i.e. drilled piers) penetrating into the underlying Dawson Formation and provided with structural floors spanning over a well-ventilated crawl space. Buildings B-2 and B-7 may be able to be supported on shallow foundations, provided additional exploration is performed to more accurately delineate the historical fill boundary.

We anticipate engineered fill thicknesses of approximately 7 to 12 feet may be needed below the building post-tensioned slab-on-grade foundations and slab-on-grade floor slabs. The anticipated engineered fill thickness of approximately 4 to 9 feet will be needed below the thickened edges of post-tensioned slabs and below spread-footing foundations that are bearing at a frost depth of 3 feet below the ground surface. The engineering fill layer will also need to extend 10 feet or more feet beyond the building foundation limits to include the building appurtenances.

There are risks associated with supporting pavements and exterior flatwork over undocumented fill material without soil modification. However, the costs associated with full removal and replacement of the undocumented fill material are generally considered cost-prohibitive. Therefore, the following recommendation for pavement and exterior flatwork subgrade preparation is provided assuming the owner is willing to accept some risk of poor pavement performance as a result of post-construction vertical movements associated with the potential settlement of the undocumented fill material.

- We anticipate engineered fill thicknesses of approximately 12 to 36 inches below the site pavements and exterior flatwork.
- Chemical stabilization, such as lime, or fly ash treatment, of the upper 12 inches of the engineered fill may be needed under the pavements and exterior flatwork that is attached to the pavements, such as curb and gutter.

Care should be taken to maintain the subgrade moisture content after fill placement but prior to construction of grade supported slabs and pavements. The site should be graded to prevent ponding of surface water on the prepared subgrades or in excavations. If the subgrade should become desiccated, saturated, frozen, or disturbed, the affected material should be removed or these materials should be scarified, moisture conditioned, and compacted prior to slab and pavement construction.

The exposed subgrade materials should be firm and unyielding prior to fill placement. The extent of and depths of removal should be evaluated by our representative during the excavation work based on observation of the soils exposed. Additional recommendations specific to the site conditions encountered may be provided at the time of construction. The project budget should include additional cost associated with the removal and replacement of additional fill material. Subgrade materials that are disturbed during grading should be moisture conditioned and re-compacted according to the recommendations provided in this report.

The geotechnical consultant should be retained to observe the remedial excavations, and the elevations of the excavation bottoms should be surveyed by the project civil engineer. Additional evaluation and laboratory testing should be performed during earthwork activities to better evaluate the suitability of the on-site soils for re-use as engineered fill at this site. An evaluation of the potential for contamination by hazardous materials was beyond the scope of this study and the possibility of restrictions on re-use due to environmental factors was not studied.

9.1.4. Fill Placement and Compaction

Fine-grained, cohesive soils (CL and CH) used as engineered fill should be moisture-conditioned to moisture contents between optimum and 4 percent over optimum moisture content. Granular soils (SC, SP, or import soils) used as engineered fill should be moisture-conditioned to moisture contents within 2 percent of optimum moisture content. Engineered fill should be compacted to a relative compaction of 95 percent or more as evaluated by ASTM D698.

The engineered fill should be compacted by appropriate mechanical methods. Lift thickness for fill will be dependent upon the type of compaction equipment utilized. Backfill should be placed in lifts not exceeding 8 inches in loose thickness in areas compacted by other-than hand operated machines. Backfill should be placed in lifts not exceeding 6 inches in loose thickness in areas compacted by hand operated machines.

Fill materials should not be placed, worked, rolled while they are frozen, thawing, or during poor/inclement weather conditions.

Compaction areas should be kept separate, and no lift should be covered by another until relative compaction and moisture content within the recommended ranges are obtained.

9.1.5. Imported Soil

Imported soil for use as engineered fill should have 15 to 40 percent passing the No. 200 sieve, a very low swell potential (approximately 1 percent or less when wetted against a surcharge pressure of 200 psf), and a low plasticity index (less than 20). Imported soil should not contain organic matter, clay lumps, bedrock (claystone, sandstone, etc.) fragments, debris, other deleterious matter, or rocks or hard chunks larger than approximately 3 inches' nominal diameter.

Imported soil for use as engineered fill should exhibit low corrosion potential. Imported soil placed in contact with ferrous materials should have a saturated soil resistivity of 2,000 ohm-cm or more and a chloride content of 25 parts per million or less. Soils in contact with concrete should exhibit a soluble sulfate content less than 0.1 percent.

We further recommend that proposed import material be evaluated by the project's geotechnical consultant at the borrow source for its suitability prior to importation to the project site.

9.1.6. Controlled Low Strength Material

Use of Controlled Low Strength Material (CLSM) should be considered in lieu of compacted fill for areas with low tolerances for surface settlements, for excavations that extend below the groundwater table and in areas with difficult access for compaction equipment. CLSM consists of a fluid, workable mixture of aggregate, Portland cement, and water. CLSM should be placed in lifts of 5 feet or less with a 24-hour or more curing period between each lift.

The use of CLSM has several advantages:

- A narrower excavation can be used where shoring is present, thereby minimizing the quantity of soil to be excavated and possibly reducing disturbance to the near-by traffic;
- Compaction requirements do not apply;
- There is less risk of damage to improvements, since little compaction is needed to place CLSM;
- CLSM can be batched to flow into irregularities in excavation bottoms and walls; and
- The number of workers needed inside the trench excavation is reduced.

The CLSM mix design should be submitted for review prior to placement. The 28-day strength of the material should be no less than 50 pounds per square inch (psi) and no more than 150 psi. CLSM should be observed and tested by the geotechnical consultant.

9.1.7. Utility Installation

The contractor should take care to achieve and maintain adequate compaction of the backfill soils around manholes, valve risers and other vertical pipeline elements where settlements commonly are observed. Use of CLSM should be considered in lieu of compacted soil backfill for areas with low tolerances for surface settlements. This would also reduce the permeability of the utility trenches.

Pipe bedding materials, placement and compaction should meet the specifications of the pipe manufacturer and applicable municipal standards. Materials proposed for use as pipe bedding should be tested for suitability prior to use.

Special care should be exercised to avoid damaging the pipe or other structures during the compaction of the backfill. In addition, the underside (or haunches) of the buried pipe should be supported on bedding material that is compacted as described above. This may need to be performed with placement by hand or small-scale compaction equipment.

Surface drainage should direct water away from utility trench alignments. Where topography, site constraints or other factors limit or preclude adequate surface drainage, the granular bedding materials should be surrounded by non-woven filter fabric (e.g., TenCate Mirafi® 140N or the equivalent) to reduce migration of fines into the bedding which can result in severe, isolated settlements.

Development of site grading plans should consider the subsurface transfer of water in utility trenches and the pipe bedding. Sandy pipe bedding materials can function as efficient conduits for re-distribution of natural and applied waters in the subsurface. Cut-off walls in utility trenches or other water-stopping measures should be implemented to reduce the rates and volumes of water transmitted along utility alignments and toward buildings, pavements and other structures where excessive wetting of the underlying soils will be damaging. Incorporation of water cut-offs and/or outlet mechanisms for saturated bedding materials into development plans could be beneficial to the project. These measures also will reduce the risk of loss of fine-grained backfill soils into the bedding material with resultant surface settlement.

9.2. Anticipated Foundation and Floor Systems

We recommend the performance of a geotechnical evaluation for each structure prior to selecting a foundation/floor type. The project design team should incorporate the geotechnical recommendations into the foundation design. The foundation type should be chosen based on the building type, building loads, building specific subsurface conditions, building specific site grading proposed, and other factors. The following recommendations are preliminary and should not be used for final design.

9.2.1. Post-Tensioned Slab-On-Grade Foundations

Post-tensioned slab-on-grade foundations should be designed by the project's structural engineer in accordance with the 2018 IBC and the Post-Tensioning Institute (PTI, 2008), 3rd Edition of the Design of Post-Tensioned Slabs-On-Ground. Remedial grading, as outlined in Section 9.1.3, will need to be performed prior to construction of post-tensioned foundations.

For preliminary design, the post-tensioned slab-on-grade foundations can be designed using an allowable net bearing capacity ranging between 2,000 and 3,000 pounds per square foot (psf) and using a frost depth of 3 feet below the lowest adjacent grade. Estimated Edge Moisture Variation Distance (e_m) due to shrinking soils (center lift condition) is anticipated to vary between 8 and 9 feet, while the Estimated Edge Moisture Variation Distance due to swelling soils (edge lift condition) is approximately 4.2 to 5.3 feet. The Estimated Differential Soil Movement (y_m) values of 0.54 to 2.06 and -0.75 to -1.38 may be used for the Center Lift (Shrinking) condition and Edge Lift (Swelling) condition, respectively.

Interior partitions and bearing walls resting on the post-tensioned slabs should be designed to account for slab flexure as evaluated by the Structural Engineer. Utility lines entering the slab should be provided with positive bond breaks that allow 2 or more inches of differential movement.

The need for a moisture-retarding system should be considered by the structural engineer or architect, based on the moisture sensitivity of the anticipated flooring. The placement of a vapor retarder is recommended in areas where moisture-sensitive floor coverings are anticipated.

9.2.2. Spread-Footing Foundations

Perimeter footings should extend to 36 inches or more below the lowest exterior finished grade (for frost protection), and bear on a zone of adequately placed and compacted engineered fill as described in Section 9.1.3 of this report. Continuous wall footings should have a width of 18 inches or more and column footings should have a width of 24 inches or more.

Footings for lightly- to moderately-loaded structures are anticipated to be designed using net allowable soil bearing pressures ranging between 2,000 and 3,000 psf for static conditions. The allowable end bearing may be increased by one-third when considering loads of short duration such as wind or seismic forces.

The base of foundation excavations should be free of ice, snow, water, frost, and loose soil prior to placing concrete. Concrete should be placed soon after subgrade compaction to reduce bearing soil disturbance. Should the soils at bearing level become excessively dry, disturbed, or saturated, the affected soil should be moisture conditioned and re-compacted. Ninyo & Moore should be retained to observe, test, and evaluate the soil foundation bearing materials. An “open hole” site visit letter will not be issued unless Ninyo & Moore representatives are retained to be on-site during footing excavation and subsequent engineered fill placement.

9.2.3. Slab on Grade Floor Slabs

Based on understanding of the use for the development, it is anticipated that slab-on-grade floors may be utilized for the some of the structures within the development. The recommendations provided Section 9.1.3 should be followed during remedial grading associated with the preparation of the engineered fill below the building slab-on-grade floors.

The design of the floor slabs (including jointing and reinforcement) is the responsibility of the structural engineer. Joints should be constructed at intervals designed by the Structural Engineer to help reduce the random cracking of the slab. Recommendations based on structural considerations for slab thickness, jointing, and steel reinforcement should be developed by the Structural Engineer in accordance with the American Concrete Institute

(ACI) recommendations. The proper placement of the reinforcement in the slab is vital for satisfactory performance.

The floor slabs should be constructed so that it "floats" independent of the foundations. Floor slabs should be separated from bearing walls and columns with expansion joints, which allow unrestrained vertical movement. Joints should be observed periodically, particularly during the first several years after construction. Slab movement can cause previously free-slipping joints to bind. Measures should be taken so that slab isolation is maintained in order to reduce the likelihood of damage to walls and other interior improvements. Utility lines entering the slab should be provided with positive bond breaks that allow 2 or more inches of differential movement.

Due to the site soils and to allow for the use of slab-on-grade floors, it is recommended that non load-bearing interior partitions resting on floor slabs be provided with slip joints, so that if the slabs move, the movement cannot be transmitted to the upper structure, including wallboards and door frames. A slip joint that allows 2 or more inches of vertical movement is anticipated to be recommended for placement at the bottoms of the interior partitions. If slip joints are placed at the tops of walls, in the event that the floor slabs move, it is expected that the wall will show signs of distress, especially where the floors meet the exterior wall. Plumbing lines should be carefully tested before operation. Where plumbing lines enter through the floor, a positive bond break should be provided.

Where floor slabs are tied to perimeter walls or turn-down slabs to meet structural or other construction objectives, our experience indicates that any differential movement between the walls and slabs will probably be observed in adjacent slab expansion joints or floor slab cracks that occur beyond the length of the structural dowels. The Structural Engineer should account for this potential differential settlement through use of sufficient control joints, appropriate reinforcing or other means.

The slab should be underlain by four or more inches of moist, clean sand and/or gravel. The need for a moisture-retarding system should be considered by the structural engineer or architect based on the moisture sensitivity of the anticipated flooring.

9.2.4. Drilled Pier Foundations

Drilled pier foundations bearing in the Dawson Formational materials may be designed for allowable end bearing pressures ranging between 20,000 and 40,000 psf. The portion of the pier penetrating bedrock may be designed for an allowable skin friction ranging between

2,000 to 4,000 psf. This allowable skin friction value is applicable to provide bearing support and resist uplift. End bearing and skin friction/uplift pressures will be dependent on shaft length and depth of embedment in bedrock.

A pier diameter of 24 or more inches, or 5 percent of the expected total shaft length, whichever is greater, is recommended to facilitate cleaning and observation of the pier hole. The structural engineer should design the actual length to diameter ratio.

Piers should be proportioned by the structural engineer. Piers that can maintain a minimum dead load of 10,000 psf or more, should be approximately 35 to 45 or more feet in length and should penetrate approximately 15 to 20 or more feet into competent bedrock. Both criteria for bedrock penetration and pier length should be met. The actual drilled pier length and bedrock penetration will depend on the results of the building specific geotechnical evaluation.

A void form of approximately 6 to 8 inches or more should be designed below the grade beams/pier caps. Void space created after the void forms disintegrate should be protected by placing a backfill retainer on all sides that are exposed to site soils to discourage the site soils from sloughing into the void space.

Fill and alluvial soils penetrated by the drilled piers will be vulnerable to caving during the drilling process. As a result, casing or slurry drilling procedures may be needed. Cased zones should not be included in load calculations and the lengths of individual piers should be increased correspondingly.

In general, the Dawson Formation encountered within our borings was moderately hard to very hard and contained strongly cemented sandstone layers/lenses. The drilled pier contractor should anticipate difficult drilling conditions within the Dawson Formation, including the need for the utilization of special coring bits. Additionally, coal and lignite seams may be encountered, which may further complicate drilled pier excavations. Deepening of piers will be needed where coal and lignite seams are encountered within the bedrock penetration zone.

9.2.5. Structural Floors

Requirements for the number and position of additional piers to support the structural floors will depend upon the span, design load, and structural design, and should be developed by the Structural Engineer. Geotechnical recommendations for design and installation of drilled piers are provided in Section 9.2.4 of this report.

Structural floors should be constructed to span above a well-ventilated crawl space with sufficient height that allows access for maintenance of under floor utility piping. Interior utility lines should be suspended from the bottom of the structural floor and should be placed 12 or more inches above the site soils. Incorporation of a utility corridor under the buildings should be considered.

In areas where utility piping supported by site soils enter the structural floor, positive bond breaks that allow 3 inches of differential movement should be used. Design and installation of associated fixtures should also accommodate this potential movement. Plumbing lines should be carefully tested before operation.

A moisture retarding and/or vapor retarding system meeting ASTM E-1745 (Class "A") should be considered for installation below the structurally supported floors and should be attached/sealed to grade beams/pier caps located above the void forms. The sheet material should not be attached to horizontal surfaces such that condensate might drain to wood or corrodible metal surfaces.

New buildings generally lack ventilation due primarily to systematic efforts to construct air-tight, energy-efficient structures. Therefore, areas such as crawl spaces beneath structural floors are typically areas of elevated humidity. Persistently warm, humid conditions in the presence of cellulose, which is the base material found in many typical construction products, creates an ideal environment for the growth of fungi, molds, and mildew. Published data suggest links between molds and negative health effects. Therefore, we recommend that the crawl space beneath the structural floor be provided with adequate, positive active ventilation system or other active mechanisms such as specially designed HVAC systems to reduce the potential for mold, fungus and mildew growth. The owner should understand the risks of potential mold, fungus, and mildew growth when utilizing a structural floor system. Crawl spaces should be inspected periodically so that remedial measures can be taken in a timely manner.

Water caused by poor surface drainage, pipe leaks, etc. may also enter the crawl spaces. Placement of an interior underdrain system within the crawl spaces may assist drainage of free water that may accumulate within the crawl space, and should be considered by the design team. Additional recommendations for the interior underdrain systems can be provided upon request during the final geotechnical recommendations phase of the project.

9.3. Anticipated Pavement Sections

We understand project pavements will be privately maintained. The preliminary recommendations provided below will not apply to pavement sections that will be publicly maintained.

The pavement sections recommended below were developed in general accordance with the guidelines and procedures of the American Association of State Highway and Transportation Officials (AASHTO) (AASHTO, 1993), the CDOT, and the Douglas County specifications and standards for roadway design (Douglas County, 2020). Table 2 summarizes the anticipated range of pavement sections that may be needed at this project site. Pavements should be constructed on an improved subgrade per Section 9.1.3 of this report.

Table 3 – Anticipated Pavement Sections

Traffic Type	Anticipated Pavement Sections		
	AC/ABC (inches)	Full Depth AC (inches)	PCCP (inches)
Standard-Duty Pavements	4.0 to 5.0 / 6.0	6.0 to 7.0	5.0 to 6.0
Heavy-Duty Pavements	6.0 to 7.0 / 8.0	8.0 to 9.0	6.0 to 7.0

NOTE: AC = Asphalt Concrete, ABC = CDOT Class 6 Aggregate Base Course, PCCP = Portland Cement Concrete Pavement

We recommend PCCP be utilized in dumpster pads, loading areas, or other areas where extensive wheel maneuvering are expected. The dumpster pad should be large enough to support the wheels of the truck which will bear the load of the dumpster. Although the use of ABC is not integral for structural support in PCCP pavements, the placement of 4 or more inches of ABC below PCCP will develop a more stable subgrade for concrete truck traffic associated with the pavement construction and help reduce potential slab curl, shrinkage cracking, and subgrade “pumping” through joints.

The collection and diversion of surface drainage away from paved areas is vital to satisfactory performance of the pavements. The subsurface and surface drainage systems should be carefully designed to facilitate removal of the water from paved areas and subgrade soils. Allowing surface waters to pond on pavements will cause premature pavement deterioration. Where topography, site constraints or other factors limit or preclude adequate surface drainage, pavements should be provided with edge drains to reduce loss of subgrade support. The long-term performance of the pavement also can be improved greatly by backfilling and compaction behind curbs, gutters, and sidewalks so that ponding is not permitted and water infiltration is reduced.

The performance of the pavement sections constructed on swelling soils, regardless of the subgrade preparation performed will be poor. Increased maintenance budget to seal joints and cracks, and repair distressed areas is recommended should be anticipated throughout the life of the development.

9.4. Concrete Flatwork

Exterior walkways and flatwork should be 4 or more inches thick. The slab edges should be deepened by two or more inches where exterior slabs-on-grade are placed adjacent to landscaping areas and taper to the recommended thickness 12 inches inward from the edge. Exterior flatwork should be constructed on an improved subgrade per Section 9.1.3 of this report.

Ground-supported flatwork, such as walkways, will be subject to soil-related movements resulting from heave/settlement, frost, etc. Thus, where these types of elements abut rigid building foundations or isolated/suspended structures, differential movements should be anticipated. We recommend that flexible joints be provided where such elements abut the main structure to allow for differential movement at these locations. Positive drainage should be established and maintained adjacent to flatwork. Water should not be allowed to pond on flatwork.

To reduce the potential manifestation of distress to exterior concrete flatwork due to movement of the underlying soil, we recommend that such flatwork be installed with crack-control joints at appropriate spacing as designed by the Structural Engineer.

In no case should exterior flatwork extend under any portion of the buildings where there is less than 3 inches of clearance between the flatwork and any element of the building. Exterior flatwork in contact with brick, rock facades, or any other element of the building can cause damage to the structure if the flatwork experiences movements.

9.5. Corrosion Considerations

The corrosion potential of on-site soils to concrete and buried metal was evaluated in the laboratory using selected samples obtained from the exploratory borings. Laboratory testing was performed to assess the effects of sulfate on concrete and the effects of soil resistivity on buried metal. Results of these tests are presented in Appendix B. Recommendations regarding concrete to be utilized in construction of proposed improvements and for buried metal pipes are provided in the following sections.

9.5.1. Concrete

The test for water-soluble sulfate content of the soils was performed using CDOT Test Method CP-L 2104. The laboratory test results are presented in Appendix B. The percentage of water-soluble sulfates in water measured was approximately 9 to 200 parts per million for selected samples. Based on Table 601-2 of the CDOT 2011 Standard Specifications for Road and Bridge Construction, the on-site soils represent a Class 1 severity of sulfate exposure to concrete on a scale that ranges between Class 0 and Class 3. Therefore, we recommend that the concrete used for this project should have a maximum water to cementitious material ratio of 0.45 and the cementitious materials should meet one of the below outlined requirements.

- ASTM C 150 Type II or V; Class C fly ash shall not be substituted for cement.
- ASTM C 595 Type IP(MS) or IP(HS); Class C fly ash shall not be substituted for cement.
- ASTM C 1157 Type MS or HS; Class C fly ash shall not be substituted for cement.
- When ASTM C 150 Type III cement is allowed, as in Class E concrete, it shall have no more than 8 percent C3A. Class C fly ash shall not be substituted for cement.

The Structural Engineer should ultimately select the concrete design strength based on the project specific loading conditions. However, higher strength concrete may be selected for increased durability, resistance to slab curling and shrinkage cracking. We recommend the use of concrete with a design 28-day compressive strength of 4,000 psi or more, for concrete slabs at this site. Concrete exposed to the elements should be air-entrained.

9.5.2. Buried Metal Pipes

The corrosion potential of the on-site materials was analyzed to evaluate its potential effects on buried metals. Corrosion potential was evaluated using the results of laboratory testing of samples obtained during the subsurface evaluation that were considered representative of soils at the subject site.

The results of the laboratory testing indicate the on-site materials have moderate resistivity and could potentially be corrosive to ferrous metals. Therefore, special consideration should be given to the use of heavy gauge, corrosion protected, underground steel pipe or culverts, if any are planned. As an alternative, plastic pipe or reinforced concrete pipe could be considered. A corrosion specialist should be consulted for further recommendations.

9.6. Scaling

Climatic conditions in the project area including relatively low humidity, large temperature changes and repeated freeze-thaw cycles, may cause surficial scaling and spalling of exterior concrete. Occurrence of surficial scaling and spalling can be aggravated by poor workmanship during construction, such as “over-finishing” concrete surfaces and the use of de-icing salts on exterior concrete flatwork, particularly during the first winter after construction. The use of de-icing salts on nearby roadways, which can be transferred by vehicle traffic onto newly placed concrete, can be sufficient to induce scaling.

The measures below can be beneficial for reducing the concrete scaling. However, because of the other factors involved, including workmanship, surface damage to concrete can develop even though the measures provided below were followed. The mix design criteria should be coordinated with other project requirements including the criteria for soluble sulfate resistance presented in Section 9.5.1.

- Curing concrete in accordance with applicable codes and guidelines.
- Maintaining a water/cement ratio of 0.45 by weight for exterior concrete mixes.
- Including Type F fly ash in exterior concrete mixes as 20 percent of the cementitious material.
- Specifying a 28-day, compressive strength of 4,500 or more psi for exterior concrete that may be exposed to de-icing salts.
- Avoiding the use of de-icing salts through the first winter after construction.
- Avoiding the use of dark colored concrete that may experience additional freeze-thaw cycles and specialty concrete finishes other than standard broom finish.

9.7. Frost Heave

Site soils are susceptible to frost heave if allowed to become saturated and exposed to freezing temperatures and repeated freeze/thaw cycling. The formation of ice in the underlying soils can result in two or more inches of heave of pavements, flatwork and other hardscaping in sustained cold weather. A portion of this movement may be recovered when the soils thaw, but due to loss of soil density some degree of displacement will remain. Frost heave of hardscaping could also result in areas where the subgrade soils were placed on engineered fill.

In areas where hardscape movements are a design concern (i.e. exterior flatwork located adjacent to the building within the doorway swing zone), replacement of the subgrade soils with 2.5 or more feet of clean, coarse sand or gravel, or supporting the element on foundations similar to the building, or spanning over a void should be considered. Detailed recommendations in this regard can be provided upon request.

9.8. Construction in Cold or Wet Weather

During construction, the site should be graded such that surface water can drain readily away from the building areas. Given the soil conditions, it is important to avoid ponding of water in or near excavations. Water that accumulates in excavations should be promptly pumped out or otherwise removed and these areas should be allowed to dry out before resuming construction. Berms, ditches, and similar means should be used to decrease stormwater entering the work area and to efficiently convey it off site.

Earthwork activities undertaken during the cold weather season may be difficult and should be done by an experienced contractor. Fill should not be placed on top of frozen soils. The frozen soils should be removed prior to the placement of fill or other construction material. Frozen soil should not be used as engineered fill or backfill. The frozen soil may be reused (provided it meets the selection criteria) once it has thawed completely. In addition, compaction of the soils may be more difficult due to the viscosity change in water at lower temperatures.

If construction proceeds during cold weather, foundations, slabs, or other concrete elements should not be placed on frozen subgrade soil. Frozen soil should either be removed from beneath concrete elements, or thawed and recompacted. To limit the potential for soil freezing, the time passing between excavation and construction should be minimized. Blankets, straw, soil cover, or heating may be used to discourage the soil from freezing.

9.9. Site Drainage

Infiltration of water into subsurface soils can lead to soil movement and associated distress, and chemically and physically related deterioration of concrete and masonry structures. To reduce the potential for infiltration of moisture into subsurface soils at the site, we recommend the following:

- Positive drainage should be established and maintained away from the proposed building and canopy foundations. Positive drainage may be established by providing a surface gradient for paved areas of 2 to 5 percent or more for a distance of 10 feet or more away from structures. Where concrete flatwork is placed adjacent to structures and other considerations are required by law, such as ADA requirements, slopes of 1 percent or more are considered acceptable. For unpaved areas, positive drainage may be established by a slope of 5 to 10 percent for 10 feet or more away from structures, where possible.

- Adequate surface drainage should be provided to channel surface water away from on-site structures and off paved surfaces to a suitable outlet such as a storm drain. Adequate surface drainage may be enhanced by utilization of graded swales, area drains, and other drainage devices. Surface run-off should not be allowed to pond near structures.

- Building roof drains should have downspouts tightlined to an appropriate outlet, such as a storm drain or the street, away from structures, pavements, and flatwork. If tightlining of the downspouts is not practicable, they should discharge 5 feet or more away from structures and onto surfaces that slope away from the structure. Downspouts should not be allowed to discharge onto the ground surface adjacent to building foundations or on exterior walkways.

- The possibility of moisture infiltration beneath a structure, in the event of plumbing leaks, should be considered in the design and construction of underground water and sewer conduits. Permitting increases in moisture to the building supporting soils may result in a decrease in bearing capacity and an increase in settlement, heave, and/or differential movement. Incorporating a perimeter drainage system around the building foundations that will aid in reduction of the moisture infiltration of subsurface soils may be considered. Due to the proposed construction (i.e. no below grade construction) and anticipated utilities within the structures, not placing the perimeter drainage would be considered a low risk to the owner.

- Irrigated landscaping, consisting of sprinklers to water plants with high demands for water, should not be placed within 10 feet of the building(s). Drip irrigation is considered acceptable between 5 and 10 feet of the building exterior. If drip irrigated plants are needed within 5 feet of the building exterior, drip irrigation system should be provided with sensors that limit over irrigation.

- Utility trenches should be backfilled with compacted, low permeability fill (i.e. permeability of 5-10 cm/s or less) within 5 feet of the building. Planters, if any, should be maintained 5 feet or more from the building and constructed with closed bottoms or with drainage systems to drain excess irrigation away from the building.

9.10. Additional Geotechnical Studies

Additional geotechnical engineering studies with additional exploratory soil test borings will be required once project plans are more complete and information concerning the locations of the proposed structures, structural loads, roadways, and site grading are finalized. Site grading will have a significant impact on the site due to the observed groundwater and building foundations in terms of potential settlement, expansive ground movements, feasible foundation types, foundation performance, and drainage issues. Proposed site grades should be incorporated into the preparation of a final geotechnical exploration program. Final geotechnical recommendations regarding earthwork, foundations and floor slabs, foundation walls, subsurface drainage, retaining walls, pavement sections, and exterior flatwork will be included in the additional evaluations.

9.11. Construction Observation and Testing

A qualified geotechnical consultant should perform appropriate observation and testing services during grading and construction operations. These services should include observation of any soft, loose, or otherwise unsuitable soils, evaluation of subgrade conditions where soil removals are performed, evaluation of the suitability of proposed borrow materials for use as fill, evaluation of the stability of open temporary excavations, evaluation of the results of any subgrade stabilization or dewatering activities, and performance of observation and testing services during placement and compaction of engineered fill and backfill soils.

The geotechnical consultant should also perform observation and testing services during placement of concrete, mortar, grout, asphalt concrete, and steel reinforcement. If another geotechnical consultant is selected to perform observation and testing services for the project, we request that the selected consultant provide a letter to the owner, with a copy to Ninyo & Moore, indicating that they fully understand our recommendations and they are in full agreement with the recommendations contained in this report. Qualified subcontractors utilizing appropriate techniques and construction materials should perform construction of the proposed improvements.

9.12. Plan Review

The recommendations presented in this report are based on conceptual plans for the proposed project and on the findings of our geotechnical evaluation. When finished, project plans and specifications should be reviewed by the geotechnical consultant prior to submitting the plans and specifications for bid. Additional field exploration and laboratory testing may be needed upon review of the project design plans.

9.13. Pre-Construction Meeting

We recommend a pre-construction meeting be held. The owner or the owner's representative, the architect, the contractor, and the geotechnical consultant should be in attendance to discuss the plans and the project.

10. LIMITATIONS

The field evaluation, laboratory testing, and geotechnical analyses presented in this geotechnical report have been conducted in general accordance with current practice and the standard of care exercised by geotechnical consultants performing similar tasks in the project area. No warranty, expressed or implied, is made regarding the conclusions, recommendations, and opinions presented in this report. There is no evaluation detailed enough to reveal every subsurface condition. Variations may exist and conditions not observed or described in this report may be encountered during construction. Uncertainties relative to subsurface conditions can be reduced through additional subsurface exploration. Additional subsurface evaluation will be performed upon request.

This document is intended to be used only in its entirety. No portion of the document, by itself, is designed to completely represent any aspect of the project described herein. Ninyo & Moore should be contacted if the reader requires additional information or has questions regarding the content, interpretations presented, or completeness of this document.

This report is intended for design purposes only. It does not provide sufficient data to prepare an accurate bid by contractors. It is suggested that the bidders and their geotechnical consultant perform an independent evaluation of the subsurface conditions in the project areas. The independent evaluations may include, but not be limited to, review of other geotechnical reports prepared for the adjacent areas, site reconnaissance, and additional exploration and laboratory testing.

Our conclusions, recommendations, and opinions are based on an analysis of the observed site conditions. If geotechnical conditions different from those described in this report are encountered, our office should be notified, and additional recommendations, if warranted, will be provided upon request. It should be understood that the conditions of a site could change with time as a result of natural processes or the activities of man at the subject site or nearby sites. In addition, changes to the applicable laws, regulations, codes, and standards of practice may occur due to government action or the broadening of knowledge. The findings of this report may, therefore, be invalidated over time, in part or in whole, by changes over which Ninyo & Moore has no control.

This report is intended exclusively for use by the client. Any use or reuse of the findings, conclusions, and/or recommendations of this report by parties other than the client is undertaken at said parties' sole risk.

11. REFERENCES

American Association of State Highway and Transportation Officials (AASHTO), 1993, AASHTO Guide for Design of Pavement Structures.

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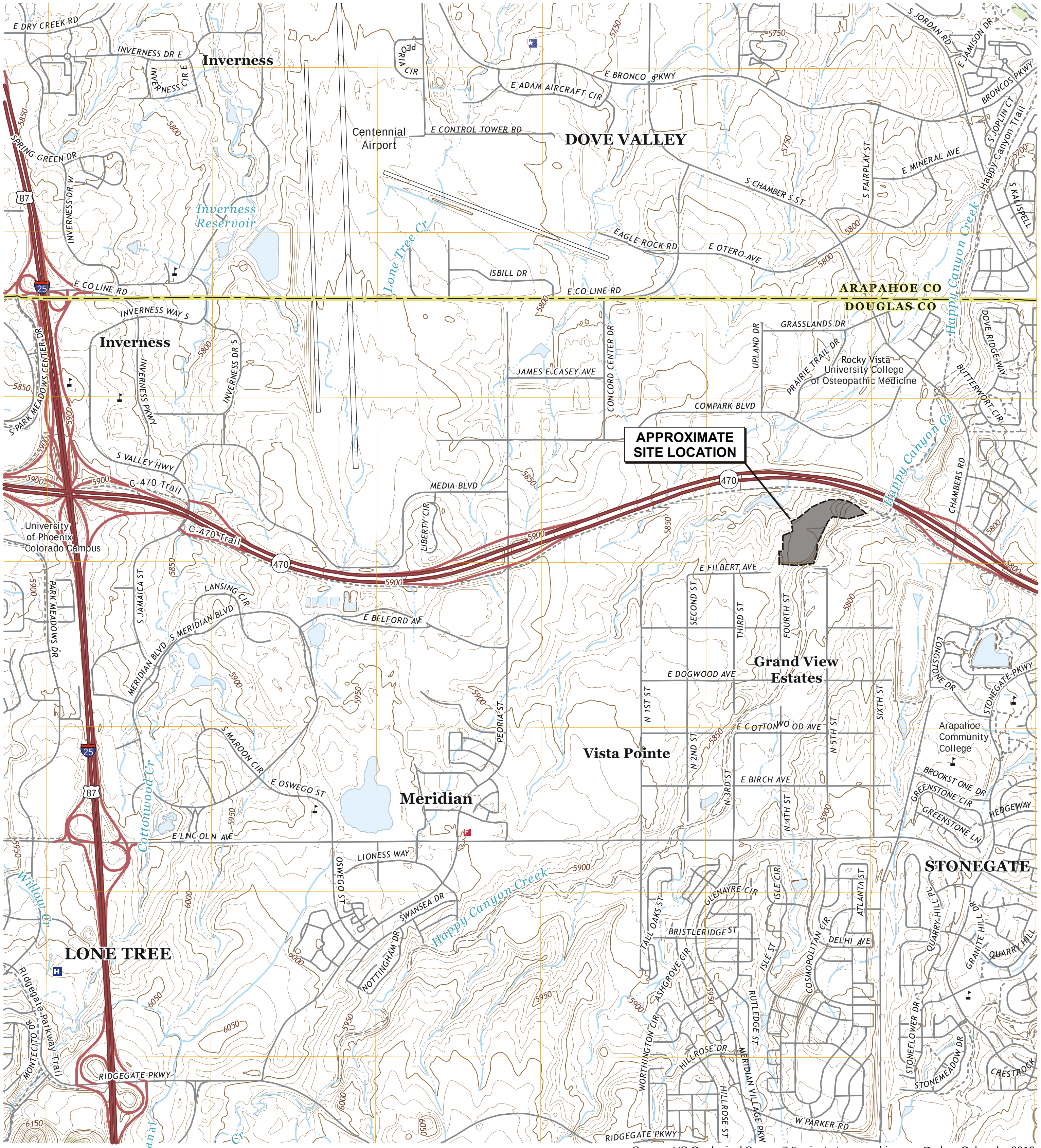
FIGURES



Source: US Geological Survey 7.5-minute topographic map, Parker, Colorado, 2019.

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NOTE: DIMENSIONS, DIRECTIONS AND LOCATIONS ARE APPROXIMATE.

FIGURE 1

SITE LOCATION

PROPOSED MULTI-FAMILY DEVELOPMENT
COMPARK SOUTH - PORTION OF TRACT G
PARKER, COLORADO

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elt file no: 20900vmap0321a

NOTE: DIMENSIONS, DIRECTIONS AND LOCATIONS ARE APPROXIMATE.

elt file no: 2090sp0321a

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FIGURE 2

SITE PLAN

PROPOSED MULTI-FAMILY DEVELOPMENT
COMPARK SOUTH - PORTION OF TRACT G
PARKER, COLORADO

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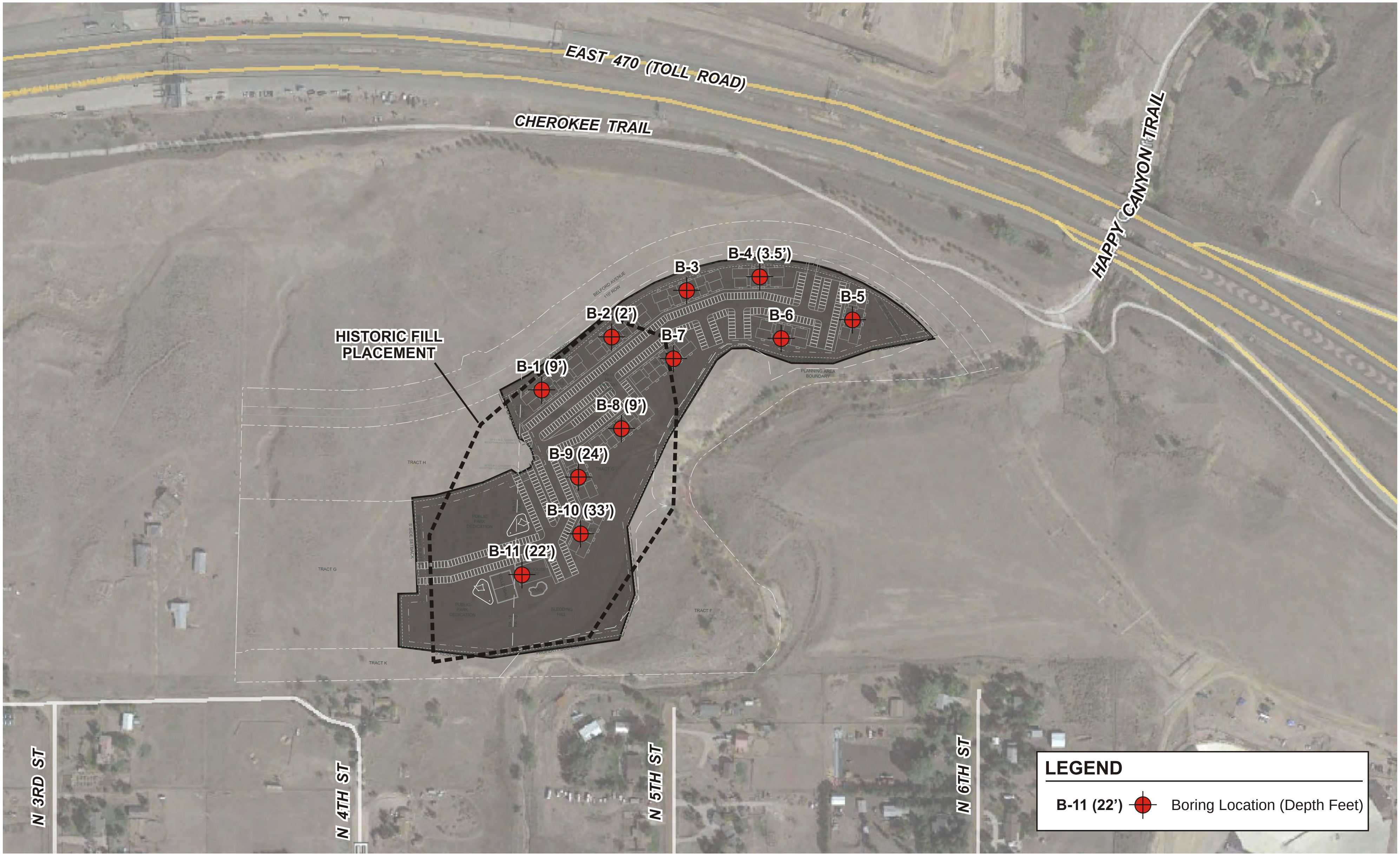

Source: NAVTEQ, 09/29/20.

NOTE: DIMENSIONS, DIRECTIONS AND LOCATIONS ARE APPROXIMATE.

FIGURE 3

HISTORIC FILL PLAN

PROPOSED MULTI-FAMILY DEVELOPMENT
COMPARK SOUTH - PORTION OF TRACT G
PARKER, COLORADO

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elt file no: 2090sp0321a

APPENDIX A

Boring Logs

APPENDIX A

BORING LOGS

Field Procedure for the Collection of Disturbed Samples
Disturbed soil samples were obtained in the field using the following method.

Bulk Samples
Bulk samples of representative earth materials were obtained from the exploratory borings. The samples were bagged and transported to the laboratory for testing.

Field Procedure for the Collection of Relatively Undisturbed Samples
Relatively undisturbed soil samples were obtained in the field using the following method.

The California Drive Sampler
The sampler, with an external diameter of 2.4 inches, was lined with four 4-inch long, thin brass rings with inside diameters of approximately 1.9 inches. The sample barrel was driven into the ground with the weight of a hammer in general accordance with ASTM D 3550. The driving weight was permitted to fall freely. The approximate length of the fall, the weight of the hammer, and the number of blows per foot of driving are presented on the boring logs as an index to the relative resistance of the materials sampled. The samples were removed from the sample barrel in the brass liners, sealed, and transported to the laboratory for testing.

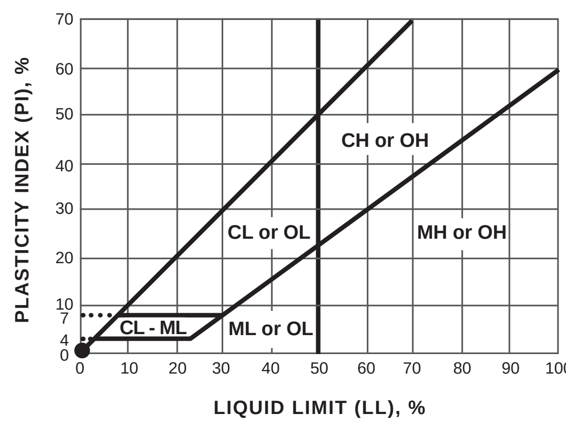
SOIL CLASSIFICATION CHART PER ASTM D 2488

PRIMARY DIVISIONS			SECONDARY DIVISIONS	
			GROUP SYMBOL	GROUP NAME
COARSE-GRAINED SOILS more than 50% retained on No. 200 sieve	**GRAVEL** more than 50% of coarse fraction retained on No. 4 sieve	CLEAN GRAVEL less than 5% fines	GW	well-graded GRAVEL
			GP	poorly graded GRAVEL
		GRAVEL with DUAL CLASSIFICATIONS 5% to 12% fines	GW-GM	well-graded GRAVEL with silt
			GP-GM	poorly graded GRAVEL with silt
			GW-GC	well-graded GRAVEL with clay
			GP-GC	poorly graded GRAVEL with clay
		GRAVEL with FINES more than 12% fines	GM	silty GRAVEL
			GC	clayey GRAVEL
			GC-GM	silty, clayey GRAVEL
	SAND 50% or more of coarse fraction passes No. 4 sieve	CLEAN SAND less than 5% fines	SW	well-graded SAND
			SP	poorly graded SAND
		SAND with DUAL CLASSIFICATIONS 5% to 12% fines	SW-SM	well-graded SAND with silt
			SP-SM	poorly graded SAND with silt
			SW-SC	well-graded SAND with clay
			SP-SC	poorly graded SAND with clay
		SAND with FINES more than 12% fines	SM	silty SAND
			SC	clayey SAND
			SC-SM	silty, clayey SAND
FINE-GRAINED SOILS 50% or more passes No. 200 sieve	**SILT and CLAY** liquid limit less than 50%	INORGANIC	CL	lean CLAY
			ML	SILT
			CL-ML	silty CLAY
		ORGANIC	OL (PI > 4)	organic CLAY
			OL (PI < 4)	organic SILT
	SILT and CLAY liquid limit 50% or more	INORGANIC	CH	fat CLAY
			MH	elastic SILT
		ORGANIC	OH (plots on or above "A"-line)	organic CLAY
			OH (plots below "A"-line)	organic SILT
	Highly Organic Soils		PT	Peat

GRAIN SIZE

DESCRIPTION		SIEVE SIZE	GRAIN SIZE	APPROXIMATE SIZE
Boulders		> 12"	> 12"	Larger than basketball-sized
Cobbles		3 - 12"	3 - 12"	Fist-sized to basketball-sized
Gravel	Coarse	3/4 - 3"	3/4 - 3"	Thumb-sized to fist-sized
	Fine	#4 - 3/4"	0.19 - 0.75"	Pea-sized to thumb-sized
Sand	Coarse	#10 - #4	0.079 - 0.19"	Rock-salt-sized to pea-sized
	Medium	#40 - #10	0.017 - 0.079"	Sugar-sized to rock-salt-sized
	Fine	#200 - #40	0.0029 - 0.017"	Flour-sized to sugar-sized
Fines		Passing #200	< 0.0029"	Flour-sized and smaller

PLASTICITY CHART



APPARENT DENSITY - COARSE-GRAINED SOIL

APPARENT DENSITY	SPOOLING CABLE OR CATHEAD		AUTOMATIC TRIP HAMMER	
	SPT (blows/foot)	MODIFIED SPLIT BARREL (blows/foot)	SPT (blows/foot)	MODIFIED SPLIT BARREL (blows/foot)
Very Loose	≤ 4	≤ 8	≤ 3	≤ 5
Loose	5 - 10	9 - 21	4 - 7	6 - 14
Medium Dense	11 - 30	22 - 63	8 - 20	15 - 42
Dense	31 - 50	64 - 105	21 - 33	43 - 70
Very Dense	> 50	> 105	> 33	> 70

CONSISTENCY - FINE-GRAINED SOIL

CONSIS-TENCY	SPOOLING CABLE OR CATHEAD		AUTOMATIC TRIP HAMMER	
	SPT (blows/foot)	MODIFIED SPLIT BARREL (blows/foot)	SPT (blows/foot)	MODIFIED SPLIT BARREL (blows/foot)
Very Soft	< 2	< 3	< 1	< 2
Soft	2 - 4	3 - 5	1 - 3	2 - 3
Firm	5 - 8	6 - 10	4 - 5	4 - 6
Stiff	9 - 15	11 - 20	6 - 10	7 - 13
Very Stiff	16 - 30	21 - 39	11 - 20	14 - 26
Hard	> 30	> 39	> 20	> 26

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USCS METHOD OF SOIL CLASSIFICATION

Explanation of USCS Method of Soil Classification

PROJECT NO.	DATE	FIGURE

BORING LOG EXPLANATION SHEET

DEPTH (feet)	SAMPLES Bulk	SAMPLES Driven	BLOWS/FOOT	MOISTURE (%)	DRY DENSITY (PCF)	SYMBOL	CLASSIFICATION U.S.C.S.	
0								Bulk sample.
								Modified split-barrel drive sampler.
								2-inch inner diameter split-barrel drive sampler.
								No recovery with modified split-barrel drive sampler, or 2-inch inner diameter split-barrel drive sampler.
								Sample retained by others.
5								Standard Penetration Test (SPT).
								No recovery with a SPT.
			XX/XX					Shelby tube sample. Distance pushed in inches/length of sample recovered in inches.
								No recovery with Shelby tube sampler.
								Continuous Push Sample.
10								Seepage.
								Groundwater encountered during drilling.
								Groundwater measured after drilling.
							SM	MAJOR MATERIAL TYPE (SOIL): Solid line denotes unit change.
							CL	Dashed line denotes material change.
15								Attitudes: Strike/Dip b: Bedding c: Contact j: Joint f: Fracture F: Fault cs: Clay Seam s: Shear bss: Basal Slide Surface sf: Shear Fracture sz: Shear Zone sbs: Shear Bedding Surface
20								The total depth line is a solid line that is drawn at the bottom of the boring.

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BORING LOG

Explanation of Boring Log Symbols

PROJECT NO.	DATE	FIGURE

DEPTH (feet)	SAMPLES Bulk	SAMPLES Driven	BLOWS/FOOT	MOISTURE (%)	DRY DENSITY (PCF)	SYMBOL	CLASSIFICATION U.S.C.S.	DESCRIPTION/INTERPRETATION
0	X							FILL: Brown and gray, moist, sandy fat CLAY; trace gravel and claystone fragments.
	X	X	12	15.6	106.6			
	X	X	26	17.0	110.6			Orange and brown, moist, fat CLAY with sand; trace gravel and claystone fragments.
10		X	24	17.0	110.6		CH	ALLUVIUM: Brown, moist, very stiff, sandy fat CLAY.
		X	41	13.2	125.3		SC	Light gray, moist, medium dense, clayey SAND with iron staining and calcium deposits.
20		X	46					DAWSON FORMATION: Bluish and reddish gray, moist, moderately hard, CLAYSTONE.
								Total Depth: 20 feet. Groundwater not encountered during drilling. Backfilled with onsite material on 2/23/2021. Notes: Groundwater, though not encountered at the time of drilling, may rise to a higher level due to seasonal variations in precipitation and several other factors as discussed in the report. The ground elevation shown above is an estimation only. It is based on our interpretations of published maps and other documents reviewed for the purposes of this evaluation. It is not sufficiently accurate for preparing construction bids and design documents.
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DATE DRILLED 2/23/2021 BORING NO. B-1

GROUND ELEVATION 5823' ± SHEET 1 OF 1

METHOD OF DRILLING CME45-4" Solid Stem Auger (Odell Drilling)

DRIVE WEIGHT 140 lbs (Auto-Hammer) DROP 30"

SAMPLED BY JMR LOGGED BY JMR REVIEWED BY BFG

DATE DRILLED	2/23/2021
BORING NO.	B-2
GROUND ELEVATION	5825'±
SHEET	1 OF 1
METHOD OF DRILLING	CME45-4" Solid Stem Auger (Odell Drilling)
DRIVE WEIGHT	140 lbs (Auto-Hammer)
DROP	30"
SAMPLED BY	JMR
LOGGED BY	JMR
REVIEWED BY	BFG

DEPTH (feet)	SAMPLES Bulk	SAMPLES Driven	BLOWS/FOOT	MOISTURE (%)	DRY DENSITY (PCF)	SYMBOL	CLASSIFICATION U.S.C.S.	DESCRIPTION/INTERPRETATION
0	X							FILL: Orange and brown, clayey SAND; trace gravel and claystone fragments.
	X	X	20	15.2	110.7		SC	ALLUVIUM: Orange and brown, moist, medium dense, clayey SAND; trace gravel.
	X	X	24					
								DAWSON FORMATION: Gray, moist, moderately cemented, clayey SANDSTONE with interbedded claystone.
10		X	50/11"	14.0	113.4			
		X	50/11"	3.7	108.0			Light orange, brown and gray.
		X	50/6"					Strongly cemented.
20								Total Depth: 19.5 feet. Groundwater was not encountered during drilling. Backfilled with onsite soil after drilling on 2/23/2021. Notes: Groundwater, though not encountered at the time of drilling, may rise to a higher level due to seasonal variations in precipitation and several other factors as discussed in the report. The ground elevation shown above is an estimation only. It is based on our interpretations of published maps and other documents reviewed for the purposes of this evaluation. It is not sufficiently accurate preparing construction bids and design documents.
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DATE DRILLED 2/23/2021	BORING NO. B-3	
GROUND ELEVATION 5823'±	SHEET 1 OF 1	
METHOD OF DRILLING CME45-4" Solid Stem Auger (Odell Drilling)		
DRIVE WEIGHT 140 lbs (Auto-Hammer)	DROP 30"	
SAMPLED BY JMR	LOGGED BY JMR	REVIEWED BY BFG

DEPTH (feet)	SAMPLES Bulk	SAMPLES Driven	BLOWS/FOOT	MOISTURE (%)	DRY DENSITY (PCF)	SYMBOL	CLASSIFICATION U.S.C.S.	DESCRIPTION/INTERPRETATION
0	X						CL	ALLUVIUM: Orange, brown and gray, moist, hard, sandy lean CLAY; trace gravel.
	X	X	34					
	X	X	50/9"	7.2				
							SC	Light brown, dry, medium dense, clayey SAND; trace gravel.
10		X	25	4.6	123.8			
		X	33					Orange and brown; moist.
20		X	25					
								Total Depth: 20 feet. Groundwater not encountered during drilling. Backfilled with onsite soil after drilling on 2/23/2021. Notes: Groundwater, though not encountered at the time of drilling, may rise to a higher level due to seasonal variations in precipitation and several other factors as discussed in the report. The ground elevation shown above is an estimation only. It is based on our interpretations of published maps and other documents reviewed for the purposes of this evaluation. It is not sufficiently accurate for preparing construction bids and design documents.
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DATE DRILLED 2/23/2021 BORING NO. B-4

GROUND ELEVATION 5802' ± SHEET 1 OF 2

METHOD OF DRILLING CME 45-4" Solid Stem Auger (Odell Drilling)

DRIVE WEIGHT 140 lbs. (Auto-Hammer) DROP 30"

SAMPLED BY JMR LOGGED BY JMR REVIEWED BY BFG

DEPTH (feet)	SAMPLES Bulk	SAMPLES Driven	BLOWS/FOOT	MOISTURE (%)	DRY DENSITY (PCF)	SYMBOL	CLASSIFICATION U.S.C.S.	DESCRIPTION/INTERPRETATION
0								FILL: Brown, moist, clayey SAND with gravel and rootlets.
			31	6.5	113.6			
			50/11"				SC	ALLUVIUM: Brown, dry, dense, clayey SAND; trace gravel.
10			32	7.0	116.7			Light brown; medium dense.
			25					Moist.
20			19					Orange and brown.
			20	11.6	122.8			Light brown.
30			24					
			14	16.9	116.2			Brown; moist to wet; loose.
			50/6"	6.1	109.2			DAWSON FORMATION: Brown, moist to wet, strongly cemented, SANDSTONE.
40								

FIGURE A- 4

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PROPOSED MULTIFAMILY DEVELOPMENT
COMPARK SOUTH, PARKER, COLORADO
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DEPTH (feet)	SAMPLES Bulk	SAMPLES Driven	BLOWS/FOOT	MOISTURE (%)	DRY DENSITY (PCF)	SYMBOL	CLASSIFICATION U.S.C.S.	DESCRIPTION/INTERPRETATION
40								Total Depth: 39.5 feet. Groundwater not encountered during drilling. Backfilled with onsite soil after drilling on 2/23/2021. Notes: Groundwater, though not encountered at the time of drilling, may rise to a higher level due to seasonal variations in precipitation and several other factors as discussed in the report. The ground elevation shown above is an estimation only. It is based on our interpretations of published maps and other documents reviewed for the purposes of this evaluation. It is not sufficiently accurate for preparing construction bids and design documents.
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DATE DRILLED 2/23/2021 BORING NO. B-4

GROUND ELEVATION 5802' ± SHEET 2 OF 2

METHOD OF DRILLING CME 45-4" Solid Stem Auger (Odell Drilling)

DRIVE WEIGHT 140 lbs. (Auto-Hammer) DROP 30"

SAMPLED BY JMR LOGGED BY JMR REVIEWED BY BFG

DATE DRILLED 2/23/2021 BORING NO. B-5

GROUND ELEVATION 5783' ± SHEET 1 OF 1

METHOD OF DRILLING CME 45-4" Solid Stem Auger (Odell Drilling)

DRIVE WEIGHT 140 lbs. (Auto-Hammer) DROP 30"

SAMPLED BY JMR LOGGED BY JMR REVIEWED BY BFG

DEPTH (feet)	SAMPLES Bulk	SAMPLES Driven	BLOWS/FOOT	MOISTURE (%)	DRY DENSITY (PCF)	SYMBOL	CLASSIFICATION U.S.C.S.	DESCRIPTION/INTERPRETATION
0							CL	ALLUVIUM: Brown, moist, sandy lean CLAY; trace rootlets.
			17	10.2	96.7		SC	Light brown, moist, medium dense, clayey SAND.
			9	9.6	98.8			Loose.
10			12				SP	Orange and brown, moist, loose, fine to coarse, SAND with clay.
							CL	Grayish brown, moist, stiff, lean CLAY with sand; trace gravel.
			13	17.4	110.5			
20			11				SC	Brown, moist, loose, clayey SAND.
								Total Depth: 20 feet. Groundwater not encountered during drilling. Backfilled with onsite soil after drilling on 2/23/2021. Notes: Groundwater, though not encountered at the time of drilling, may rise to a higher level due to seasonal variations in precipitation and several other factors as discussed in the report. The ground elevation shown above is an estimation only. It is based on our interpretations of published maps and other documents reviewed for the purposes of this evaluation. It is not sufficiently accurate for preparing construction bids and design documents.
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DATE DRILLED	2/23/2021	BORING NO.	B-6
GROUND ELEVATION	5787' ±	SHEET	1 OF 1
METHOD OF DRILLING	CME 45-4" Solid Stem Auger (Odell Drilling)		
DRIVE WEIGHT	140 lbs. (Auto-Hammer)	DROP	30"
SAMPLED BY	JMR	LOGGED BY	JMR
REVIEWED BY	BFG		

DEPTH (feet)	SAMPLES Bulk	SAMPLES Driven	BLOWS/FOOT	MOISTURE (%)	DRY DENSITY (PCF)	SYMBOL	CLASSIFICATION U.S.C.S.	DESCRIPTION/INTERPRETATION
0	Bulk						SC	ALLUVIUM: Orange and brown, dry to moist, medium dense, clayey SAND; trace calcium.
	Bulk	Driven	17	5.6	105.7			
	Bulk	Driven	13	8.8	91.5		CL	Brown, moist, stiff, sandy lean CLAY; trace gravel.
		Driven	18				SC	Light brown, moist, medium dense, clayey SAND; trace gravel.
10								
		Driven	10					Loose.
		Driven	10					Orange and brown.
20								Total Depth: 20 feet. Groundwater was not encountered during drilling. Backfilled with onsite soil after drilling on 2/23/2021. Notes: Groundwater, though not encountered at the time of drilling, may rise to a higher level due to seasonal variations in precipitation and several other factors as discussed in the report. The ground elevation shown above is an estimation only. It is based on our interpretations of published maps and other documents reviewed for the purposes of this evaluation. It is not sufficiently accurate for preparing construction bids and design documents.
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DATE DRILLED	2/23/2021	BORING NO.	B-7
GROUND ELEVATION	5824' ±	SHEET 1 OF 1	
METHOD OF DRILLING	CME 45-4" Solid Stem Auger (Odell Drilling)		
DRIVE WEIGHT	140 lbs. (Auto-Hammer)	DROP	30"
SAMPLED BY	JMR	LOGGED BY JMR	REVIEWED BY BFG

DEPTH (feet)	SAMPLES Bulk	SAMPLES Driven	BLOWS/FOOT	MOISTURE (%)	DRY DENSITY (PCF)	SYMBOL	CLASSIFICATION U.S.C.S.	DESCRIPTION/INTERPRETATION
0	X						SC	ALLUVIUM: Light orange and brown, dry, medium dense, clayey SAND; trace gravel.
	X	X	22	7.2	94.9			
	X	X	19	7.3	111.5			
10		X	20	4.2	109.2			
								DAWSON FORMATION: Orange and brown, moist, moderately cemented, SANDSTONE.
		X	50/9"	8.6	123.0			
								Gray, moist, hard, sandy CLAYSTONE; trace iron staining.
20		X	50/8"	21.0	107.8			
								Total Depth: 19.7 feet. Groundwater not encountered during drilling. Backfilled with onsite soil after drilling on 2/23/2021.
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Total Depth: 19.7 feet.
Groundwater not encountered during drilling.
Backfilled with onsite soil after drilling on 2/23/2021.

Notes:
Groundwater, though not encountered at the time of drilling, may rise to a higher level due to seasonal variations in precipitation and several other factors as discussed in the report.

The ground elevation shown above is an estimation only. It is based on our interpretations of published maps and other documents reviewed for the purposes of this evaluation. It is not sufficiently accurate for preparing construction bids and design documents.

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DATE DRILLED	2/23/2021	BORING NO.	B-8
GROUND ELEVATION	5813' ±	SHEET 1 OF 1	
METHOD OF DRILLING	CME 45-4" Solid Stem Auger (Odell Drilling)		
DRIVE WEIGHT	140 lbs. (Auto-Hammer)	DROP	30"
SAMPLED BY	JMR	LOGGED BY JMR	REVIEWED BY BFG

DEPTH (feet)	SAMPLES Bulk	SAMPLES Driven	BLOWS/FOOT	MOISTURE (%)	DRY DENSITY (PCF)	SYMBOL	CLASSIFICATION U.S.C.S.	DESCRIPTION/INTERPRETATION
0	X							FILL: Brown and orange, moist, lean CLAY with sand and claystone fragments.
	X	X	13	15.7	109.3			
	X	X	20	14.8	117.3			Light gray, moist, fat CLAY with sand and claystone fragments.
		X	11	17.3	113.6		SC	ALLUVIUM: Bluish gray and brown, moist, loose, clayey SAND; trace gravel.
10								
		X	24					Brown; medium dense.
		X	27					Light brown.
20								DAWSON FORMATION: Reddish brown and gray, moist, moderately hard, CLAYSTONE.
		X	41	18.2	113.0			
								Total Depth: 25 feet. Groundwater not encountered during drilling. Backfilled with onsite soil after drilling on 2/23/2021.
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40								

Total Depth: 25 feet.
Groundwater not encountered during drilling.
Backfilled with onsite soil after drilling on 2/23/2021.

Notes:
Groundwater, though not encountered at the time of drilling, may rise to a higher level due to seasonal variations in precipitation and several other factors as discussed in the report.

The ground elevation shown above is an estimation only. It is based on our interpretations of published maps and other documents reviewed for the purposes of this evaluation. It is not sufficiently accurate for preparing construction bids and design documents.

DATE DRILLED	2/23/2021	BORING NO.	B-9
GROUND ELEVATION	5823' ±	SHEET	1 OF 2
METHOD OF DRILLING	CME 45-4" Solid Stem Auger (Odell Drilling)		
DRIVE WEIGHT	140 lbs. (Auto-Hammer)	DROP	30"
SAMPLED BY	JMR	LOGGED BY	JMR
REVIEWED BY	BFG		

DEPTH (feet)	SAMPLES Bulk	SAMPLES Driven	BLOWS/FOOT	MOISTURE (%)	DRY DENSITY (PCF)	SYMBOL	CLASSIFICATION U.S.C.S.	DESCRIPTION/INTERPRETATION
0	X							FILL: Brown, gray and reddish brown, moist, clayey SAND; trace gravel with claystone fragments.
	X	X	16	13.2	108.3			
	X	X	8	18.4	110.0			Orange and brown, moist, lean CLAY with sand; trace gravel.
10		X	16	12.8	121.5			Black and brown, moist, clayey SAND.
		X	18	15.2	112.8			Orange and brown; claystone fragments.
20		X	26	18.3	110.3			
		X	30	7.5	99.9		CL	ALLUVIUM: Brown, dry, hard, lean CLAY with sand.
30		X	25	11.6	117.9			Gray; very stiff.
		X	50/8"	12.0	123.5			DAWSON FORMATION: Reddish gray, moist, strongly cemented, SANDSTONE with iron staining.
40								Total Depth: 34.7 feet. Groundwater not encountered during drilling. Backfilled with onsite soil after drilling on 2/23/2021. Notes: Groundwater, though not encountered at the time of drilling, may rise to a higher level due

DEPTH (feet)	SAMPLES Bulk	SAMPLES Driven	BLOWS/FOOT	MOISTURE (%)	DRY DENSITY (PCF)	SYMBOL	CLASSIFICATION U.S.C.S.	DATE DRILLED 2/23/2021 BORING NO. B-9 GROUND ELEVATION 5823' ± SHEET 2 OF 2 METHOD OF DRILLING CME 45-4" Solid Stem Auger (Odell Drilling) DRIVE WEIGHT 140 lbs. (Auto-Hammer) DROP 30" SAMPLED BY JMR LOGGED BY JMR REVIEWED BY BFG DESCRIPTION/INTERPRETATION
40								to seasonal variations in precipitation and several other factors as discussed in the report. The ground elevation shown above is an estimation only. It is based on our interpretations of published maps and other documents reviewed for the purposes of this evaluation. It is not sufficiently accurate for preparing construction bids and design documents.
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DATE DRILLED	2/22/2021	BORING NO.	B-10
GROUND ELEVATION	5824' ±	SHEET	1 OF 2
METHOD OF DRILLING	CME 75-4" Diameter Solid Stem Auger (Dakota Drilling)		
DRIVE WEIGHT	140 lbs. (Spooling Cathead)	DROP	30"
SAMPLED BY	ACL	LOGGED BY	JMR
REVIEWED BY	BFG		

DEPTH (feet)	SAMPLES Bulk / Driven	BLOWS/FOOT	MOISTURE (%)	DRY DENSITY (PCF)	SYMBOL	CLASSIFICATION U.S.C.S.	DESCRIPTION/INTERPRETATION
0	Bulk						FILL: Light brown, moist, clayey SAND; trace gravel and claystone fragments.
	Driven	54	9.7	123.4			
	Driven	21	18.7	111.7			Brown, moist, sandy lean CLAY; trace gravel.
10	Driven	26	15.6	112.7			Orange and brown, moist, clayey SAND.
	Driven	26	13.8	118.0			Trace gravel.
20	Driven	30	14.3	114.9			Light brown.
	Driven	40					Reddish brown; claystone fragments.
30	Driven	50/9"	10.9	113.0			Olive gray; with gravel.
	Driven	34	11.1	111.2		CL	ALLUVIUM: Light brown, dry to moist, hard, lean CLAY with sand.
40							Total Depth: 35 feet. Groundwater not encountered during drilling. Backfilled with onsite soil after drilling on 2/22/2021. Notes: Groundwater, though not encountered at the time of drilling, may rise to a higher level due to seasonal variations in precipitation and several other factors as discussed in the report.

DEPTH (feet)	SAMPLES Bulk	SAMPLES Driven	BLOWS/FOOT	MOISTURE (%)	DRY DENSITY (PCF)	SYMBOL	CLASSIFICATION U.S.C.S.	DESCRIPTION/INTERPRETATION
40								The ground elevation shown above is an estimation only. It is based on our interpretations of published maps and other documents reviewed for the purposes of this evaluation. It is not sufficiently accurate for preparing construction bids and design documents.
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DATE DRILLED 2/22/2021 BORING NO. B-10

GROUND ELEVATION 5824' ± SHEET 2 OF 2

METHOD OF DRILLING CME 75-4" Diameter Solid Stem Auger (Dakota Drilling)

DRIVE WEIGHT 140 lbs. (Spooling Cathead) DROP 30"

SAMPLED BY ACL LOGGED BY JMR REVIEWED BY BFG

DATE DRILLED	2/22/2021	BORING NO.	B-11
GROUND ELEVATION	5824' ±	SHEET	1 OF 2
METHOD OF DRILLING	CME 75-4" Diameter Solid Stem Auger (Dakota Drilling)		
DRIVE WEIGHT	140 lbs. (Spooling Cathead)	DROP	30"
SAMPLED BY	ACL	LOGGED BY / REVIEWED BY	JMR / BFG

DEPTH (feet)	SAMPLES (Bulk / Driven)	BLOWS/FOOT	MOISTURE (%)	DRY DENSITY (PCF)	SYMBOL	CLASSIFICATION U.S.C.S.	DESCRIPTION/INTERPRETATION
0	Bulk						FILL: Brown and gray, moist, clayey SAND; trace gravel.
	Driven	20	14.1	117.6			
	Driven	19	24.7	103.1			Bluish gray, moist, sandy lean CLAY; trace gravel and claystone and sandstone fragments.
10	Driven	13	11.4	122.6			Brown, moist, clayey SAND; trace gravel and claystone fragments.
	Driven	50/8"	13.3				
20	Driven	29	14.5	114.7			
						CH	ALLUVIUM: Brown, moist, hard, sandy fat CLAY.
	Driven	50/10"	14.0	115.3			
30	Driven	24					Light brown; very stiff.
	Driven	50/11"					DAWSON FORMATION: Olive gray, moist, hard, CLAYSTONE; iron staining.
40	Driven	50/6"	10.1	123.2			Total Depth: 39.5 feet.

FIGURE A- 14

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PROPOSED MULTIFAMILY DEVELOPMENT
COMPARK SOUTH, PARKER, COLORADO

DEPTH (feet)	SAMPLES Bulk	SAMPLES Driven	BLOWS/FOOT	MOISTURE (%)	DRY DENSITY (PCF)	SYMBOL	CLASSIFICATION U.S.C.S.	DATE DRILLED 2/22/2021 BORING NO. B-11 GROUND ELEVATION 5824' ± SHEET 2 OF 2 METHOD OF DRILLING CME 75-4" Diameter Solid Stem Auger (Dakota Drilling) DRIVE WEIGHT 140 lbs. (Spooling Cathead) DROP 30" SAMPLED BY ACL LOGGED BY JMR REVIEWED BY BFG DESCRIPTION/INTERPRETATION
40								Groundwater was not encountered during drilling. Backfilled with onsite soil after drilling on 2/22/2021. Notes: Groundwater, though not encountered at the time of drilling, may rise to a higher level due to seasonal variations in precipitation and several other factors as discussed in the report. The ground elevation shown above is an estimation only. It is based on our interpretations of published maps and other documents reviewed for the purposes of this evaluation. It is not sufficiently accurate for preparing construction bids and design documents.
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60								
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80								

APPENDIX B

Laboratory Testing

APPENDIX B

LABORATORY TESTING

Classification
Soils were visually and texturally classified in accordance with the Unified Soil Classification System (USCS) in general accordance with ASTM D 2488-00. Soil classifications are indicated on the logs of the exploratory borings in Appendix B.

In-Place Moisture and Density Tests
The moisture content and dry density of relatively undisturbed samples obtained from the exploratory borings were evaluated in general accordance with ASTM D 2937-04. The test results are presented on the logs of the exploratory borings in Appendix A.

Atterberg Limits
Tests were performed on selected representative fine-grained soil samples to evaluate the liquid limit, plastic limit, and plasticity index in general accordance with ASTM D 4318. These test results were utilized to evaluate the soil classification in accordance with the Unified Soil Classification System. The test results and classifications are shown on Figures B-1 through B-4.

No. 200 Sieve Analysis
An evaluation of the percentage of particles finer than the No. 200 sieve in selected soil samples was performed in general accordance with ASTM D 1140. The results of the tests are presented on Figures B-5 through B-8.

Gradation Analysis
Gradation analysis tests were performed on selected representative soil samples in general accordance with ASTM D 6913. The grain-size distribution curves are shown on Figures B-9 and B-10. These test results were utilized in evaluating the soil classifications in accordance with the USCS.

Swell/Consolidation Tests
The consolidation and/or swell potential of selected materials were evaluated in general accordance with ASTM D 4546. Specimens were loaded with a specified surcharge before inundation with water. Readings of volumetric consolidation/swell were recorded until completion of primary consolidation/swell. After the completion of primary swell, surcharge loads were increased incrementally to evaluate swell pressure. The results of the consolidation/swell tests are presented on Figures B-11 through B-38.

Proctor Density Tests
The maximum dry density and optimum moisture content of selected representative soil samples were evaluated using the Standard Proctor method in general accordance with ASTM D 698. The results of these tests are summarized on Figures B-39 through B-41.

Soil Corrosivity Tests
A soil pH test was performed on a representative sample in general accordance with ASTM Test Method D 4972. A soil minimum resistivity test was performed on a representative sample in general accordance with AASHTO T288. The sulfate content of a selected sample was evaluated in general accordance with CDOT Test Method CP-L 2103. The chloride content of a selected sample was evaluated in general accordance with CDOT Test Method CP-L 2104. The test results are presented on Figure B-42.

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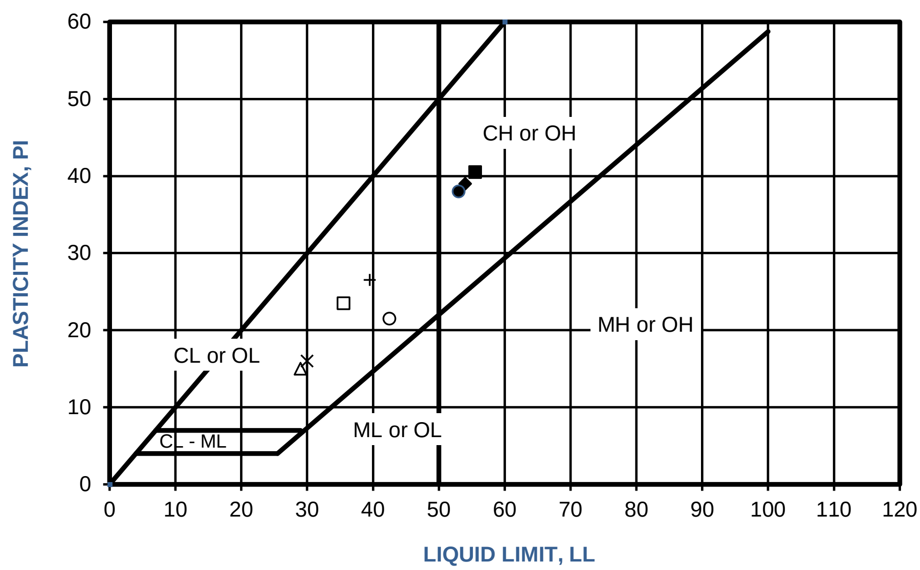
SYMBOL	LOCATION	DEPTH (ft)	LIQUID LIMIT	PLASTIC LIMIT	PLASTICITY INDEX	USCS CLASSIFICATION (Fraction Finer Than No. 40 Sieve)	EQUIVALENT USCS
●	B-1	2.0-3.0	53	15	38	CH	CH
■	B-1	4.0-5.0	56	15	41	CH	CH
◆	B-1	9.0-10.0	54	15	39	CH	CH
○	B-2	2.0-3.0	43	21	22	CL	SC
□	B-3	4.0-4.8	36	12	24	CL	CL
Δ	B-4	9.0-10.0	29	14	15	CL	SC
X	B-4	34.0-35.0	30	14	16	CL	SC
+	B-5	4.0-5.0	40	13	27	CL	SC

NP - INDICATES NON-PLASTIC



PERFORMED IN GENERAL ACCORDANCE WITH ASTM D 4318

FIGURE B-1

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ATTERBERG LIMITS TEST RESULTS

PROPOSED MULTI-FAMILY DEVELOPMENT
COMPARK SOUTH, PARKER, COLORADO

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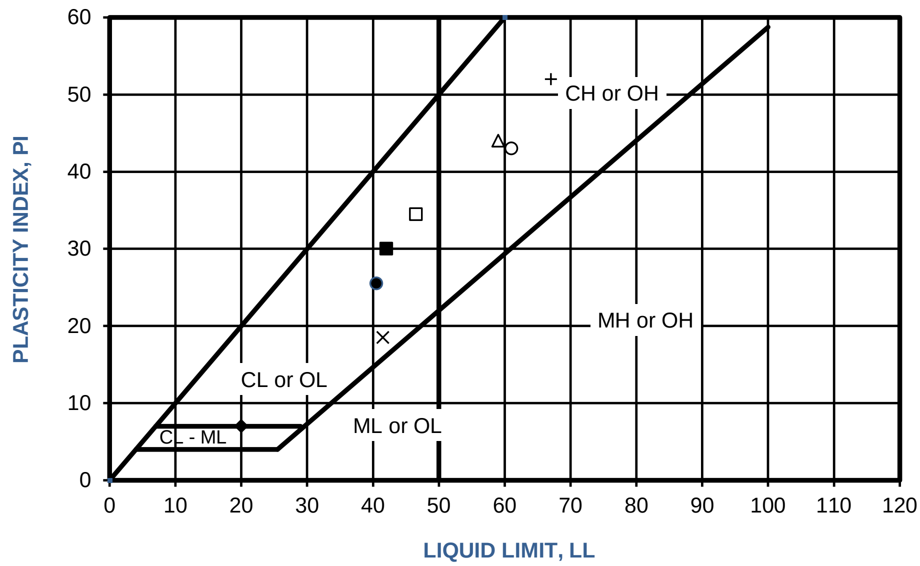
SYMBOL	LOCATION	DEPTH (ft)	LIQUID LIMIT	PLASTIC LIMIT	PLASTICITY INDEX	USCS CLASSIFICATION (Fraction Finer Than No. 40 Sieve)	EQUIVALENT USCS
●	B-5	14.0-15.0	41	15	26	CL	CL
■	B-6	4.0-5.0	42	12	30	CL	CL
◆	B-7	9.0-10.0	20	13	7	CL	SC
○	B-7	19.0-19.7	61	18	43	CH	CH
□	B-8	2.0-3.0	47	12	35	CL	CL
Δ	B-8	4.0-5.0	59	15	44	CH	CH
X	B-8	9.0-10.0	42	23	19	CL	SC
+	B-8	24.0-25.0	67	15	52	CH	CH

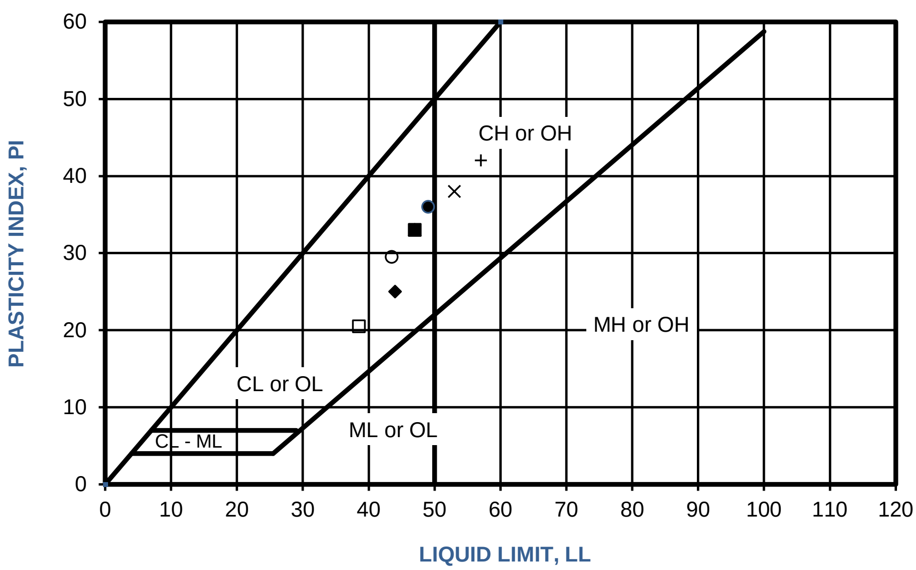
NP - INDICATES NON-PLASTIC



PERFORMED IN GENERAL ACCORDANCE WITH ASTM D 4318

SYMBOL	LOCATION	DEPTH (ft)	LIQUID LIMIT	PLASTIC LIMIT	PLASTICITY INDEX	USCS CLASSIFICATION (Fraction Finer Than No. 40 Sieve)	EQUIVALENT USCS
●	B-9	4.0-5.0	49	13	36	CL	CL
■	B-9	29.0-30.0	47	14	33	CL	CL
◆	B-9	34.0-34.7	44	19	25	CL	SC
○	B-10	34.0-35.0	44	14	30	CL	CL
□	B-11	2.0-3.0	39	18	21	CL	SC
Δ	B-11	9.0-10.0	47	14	33	CL	SC
X	B-11	24.0-25.0	53	15	38	CH	CH
+	B-11	39.0-39.5	57	15	42	CH	CH

NP - INDICATES NON-PLASTIC



PERFORMED IN GENERAL ACCORDANCE WITH ASTM D 4318

FIGURE B-3

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ATTERBERG LIMITS TEST RESULTS

PROPOSED MULTI-FAMILY DEVELOPMENT
COMPARK SOUTH, PARKER, COLORADO
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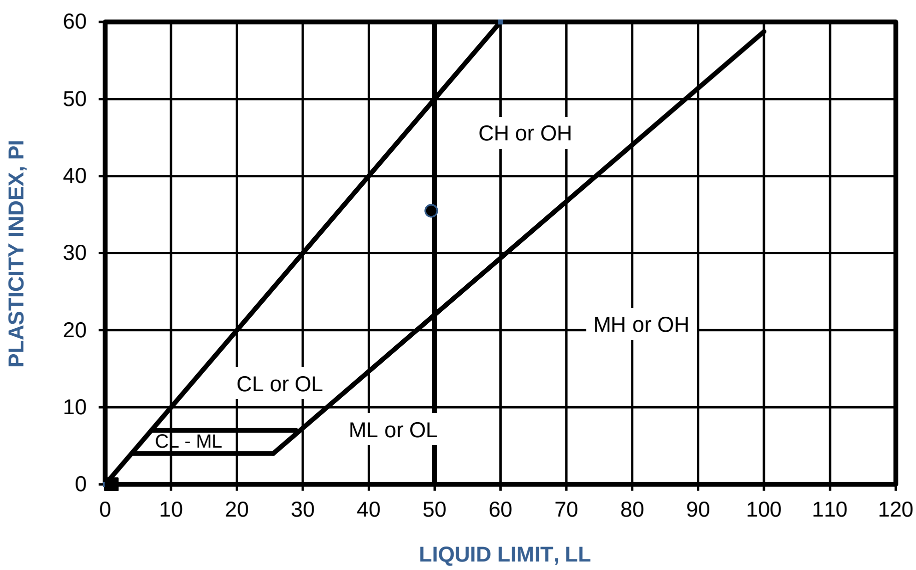
SYMBOL	LOCATION	DEPTH (ft)	LIQUID LIMIT	PLASTIC LIMIT	PLASTICITY INDEX	USCS CLASSIFICATION (Fraction Finer Than No. 40 Sieve)	EQUIVALENT USCS
●	B-1, B-8, B-9	0.0-5.0	50	14	36	CL	SC

NP - INDICATES NON-PLASTIC



PERFORMED IN GENERAL ACCORDANCE WITH ASTM D 4318

SAMPLE LOCATION	SAMPLE DEPTH (ft)	DESCRIPTION	PERCENT PASSING NO. 4	PERCENT PASSING NO. 200	EQUIVALENT USCS
B-1	2.0-3.0	Brown and Gray, Sandy Fat CLAY; Trace Gravel	99	60	CH
B-1	4.0-5.0	Orange and Brown Fat CLAY with Sand; Trace Gravel	99	72	CH
B-1	9.0-10.0	Brown Sandy Fat CLAY	100	68	CH
B-2	2.0-3.0	Orange and Brown Clayey SAND; Trace Gravel	98	45	SC
B-2	9.0-9.9	Gray Clayey SANDSTONE; DAWSON FORMATION	95	31	SC
B-2	14.0-14.9	Light Orange and Brown SANDSTONE; DAWSON FORMATION	99	8	SC
B-3	4.0-4.8	Orange Brown and Gray Sandy Lean CLAY; Trace Gravel	98	54	CL
B-4	9.0-9.9	Brown Clayey SAND; Trace Gravel	98	32	SC
B-4	34.0-35.0	Brown Clayey Clayey SAND; Trace Gravel	97	32	SC

PERFORMED IN GENERAL ACCORDANCE WITH ASTM D 1140

FIGURE B-5

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NO. 200 SIEVE ANALYSIS TEST RESULTS

PROPOSED MULTI-FAMILY DEVELOPMENT
COMPARK SOUTH, PARKER, COLORADO
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SAMPLE LOCATION	SAMPLE DEPTH (ft)	DESCRIPTION	PERCENT PASSING NO. 4	PERCENT PASSING NO. 200	EQUIVALENT USCS
B-4	39.0-40.0	Brown SANDSTONE; DAWSON FORMATION	97	7	SC
B-5	4.0-5.0	Light brown Clayey SAND	100	38	SC
B-5	14.0-15.0	Grayish Brown Lean CLAY with Sand; Trace Gravel	99	75	CL
B-6	4.0-5.0	Brown Sandy Lean CLAY; Trace Gravel	99	58	CL
B-7	9.0-10.0	Light Orange and Brown Clayey SAND; Trace Gravel	99	20	SC
B-7	14.0-15.0	Orange and Brown SANDSTONE; DAWSON FORMATION	98	20	SC
B-7	19.0-19.7	Gray CLAYSTONE; DAWSON FORMATION	100	63	CH
B-8	2.0-3.0	Brown and Orange Lean CLAY; trace Sand	100	76	CL
B-8	9.0-10.0	Bluish Gray and Brown Clayey SAND; Trace Gravel	98	30	SC

PERFORMED IN GENERAL ACCORDANCE WITH ASTM D 1140

SAMPLE LOCATION	SAMPLE DEPTH (ft)	DESCRIPTION	PERCENT PASSING NO. 4	PERCENT PASSING NO. 200	EQUIVALENT USCS
B-8	24.0-25.0	Reddish Brown and Gray CLAYSTONE; DAWSON FORMATION	100	79	CH
B-9	4.0-5.0	Orange and Brown Lean CLAY with Sand; Trace Gravel	99	51	CL
B-9	29.0-30.0.	Brown Lean CLAY with Sand	100	71	CL
B-9	34.0-34.7	Reddish Gray SANDSTONE; DAWSON ARKOSE	97	20	SC
B-10	34.0-35.0	Light Brown Lean CLAY with Sand	100	73	CL
B-11	2.0-3.0	Brown and Gray Clayey SAND; Trace Gravel	98	48	SC
B-11	4.0-5.0	Bluish Gray Sandy Lean CLAY; Trace Gravel	94	51	CL
B-11	9.0-10.0	Brown Clayey SAND; Trace Gravel	93	29	SC
B-11	24.0-25.0	Brown Sandy Fat CLAY	100	70	CH

PERFORMED IN GENERAL ACCORDANCE WITH ASTM D 1140

NO. 200 SIEVE ANALYSIS TEST RESULTS

SAMPLE LOCATION	SAMPLE DEPTH (ft)	DESCRIPTION	PERCENT PASSING NO. 4	PERCENT PASSING NO. 200	EQUIVALENT USCS
B-11	39.0-39.5	Olive Gray CLAYSTONE; DAWSON FORMATION	100	64	CH

PERFORMED IN GENERAL ACCORDANCE WITH ASTM D 1140

FIGURE B-8

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NO. 200 SIEVE ANALYSIS TEST RESULTS

PROPOSED MULTI-FAMILY DEVELOPMENT
COMPARK SOUTH, PARKER, COLORADO
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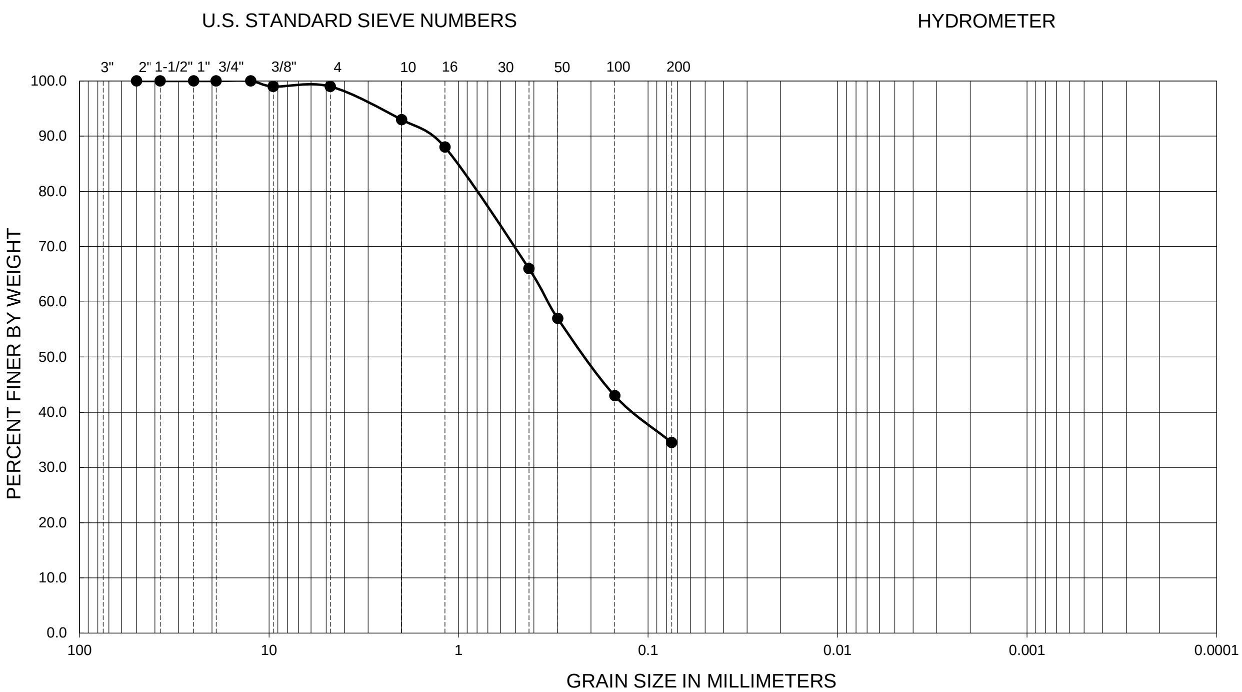
GRAVEL		SAND			FINES	
Coarse	Fine	Coarse	Medium	Fine	SILT	CLAY



Symbol	Sample Location	Depth (ft)	Liquid Limit	Plastic Limit	Plasticity Index	D_{10}	D_{30}	D_{60}	C_u	C_c	Passing No. 200 (percent)	Equivalent USCS
●	B-3	9.0-10.0	--	--	--	--	--	--	--	--	34	SC

PERFORMED IN GENERAL ACCORDANCE WITH ASTM D 6913

FIGURE B-9

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GRADATION TEST RESULTS
PROPOSED MULTI-FAMILY DEVELOPMENT
COMPARK SOUTH, PARKER, COLORADO
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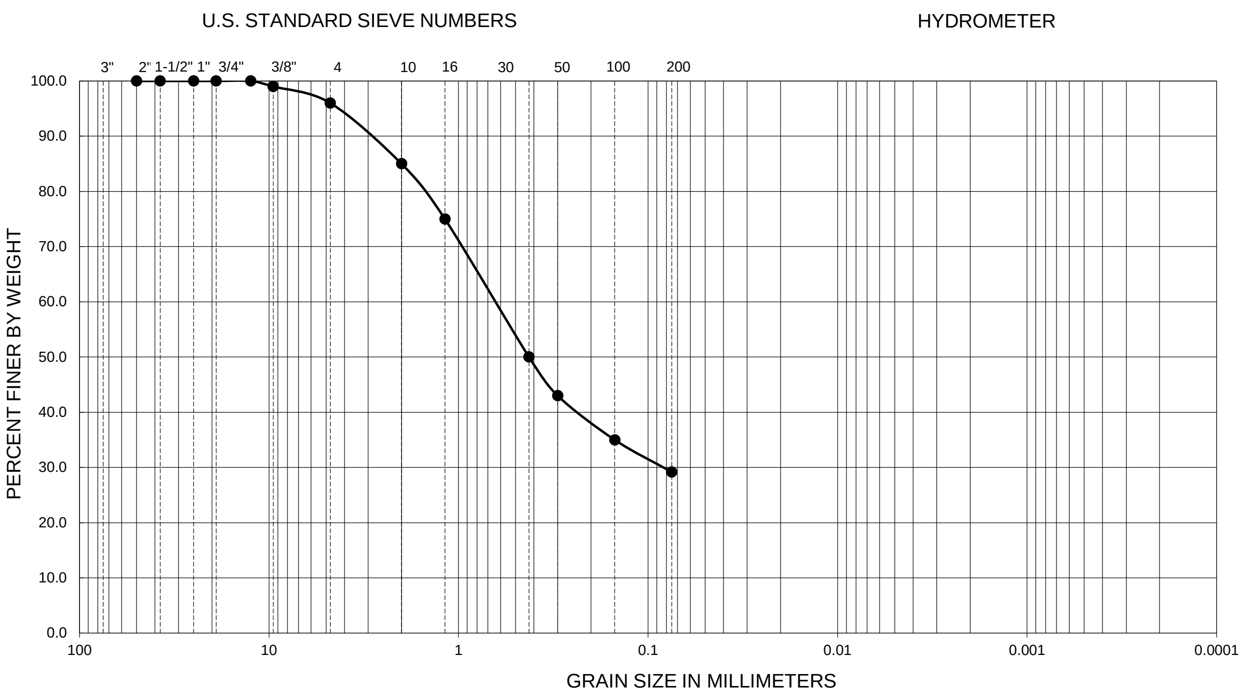
GRAVEL		SAND			FINES	
Coarse	Fine	Coarse	Medium	Fine	SILT	CLAY



Symbol	Sample Location	Depth (ft)	Liquid Limit	Plastic Limit	Plasticity Index	D_{10}	D_{30}	D_{60}	C_u	C_c	Passing No. 200 (percent)	Equivalent USCS
●	B-4	24.0-25.0	--	--	--	--	--	--	--	--	29	SC

PERFORMED IN GENERAL ACCORDANCE WITH ASTM D 6913

FIGURE B-10

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GRADATION TEST RESULTS
PROPOSED MULTI-FAMILY DEVELOPMENT
COMPARK SOUTH, PARKER, COLORADO
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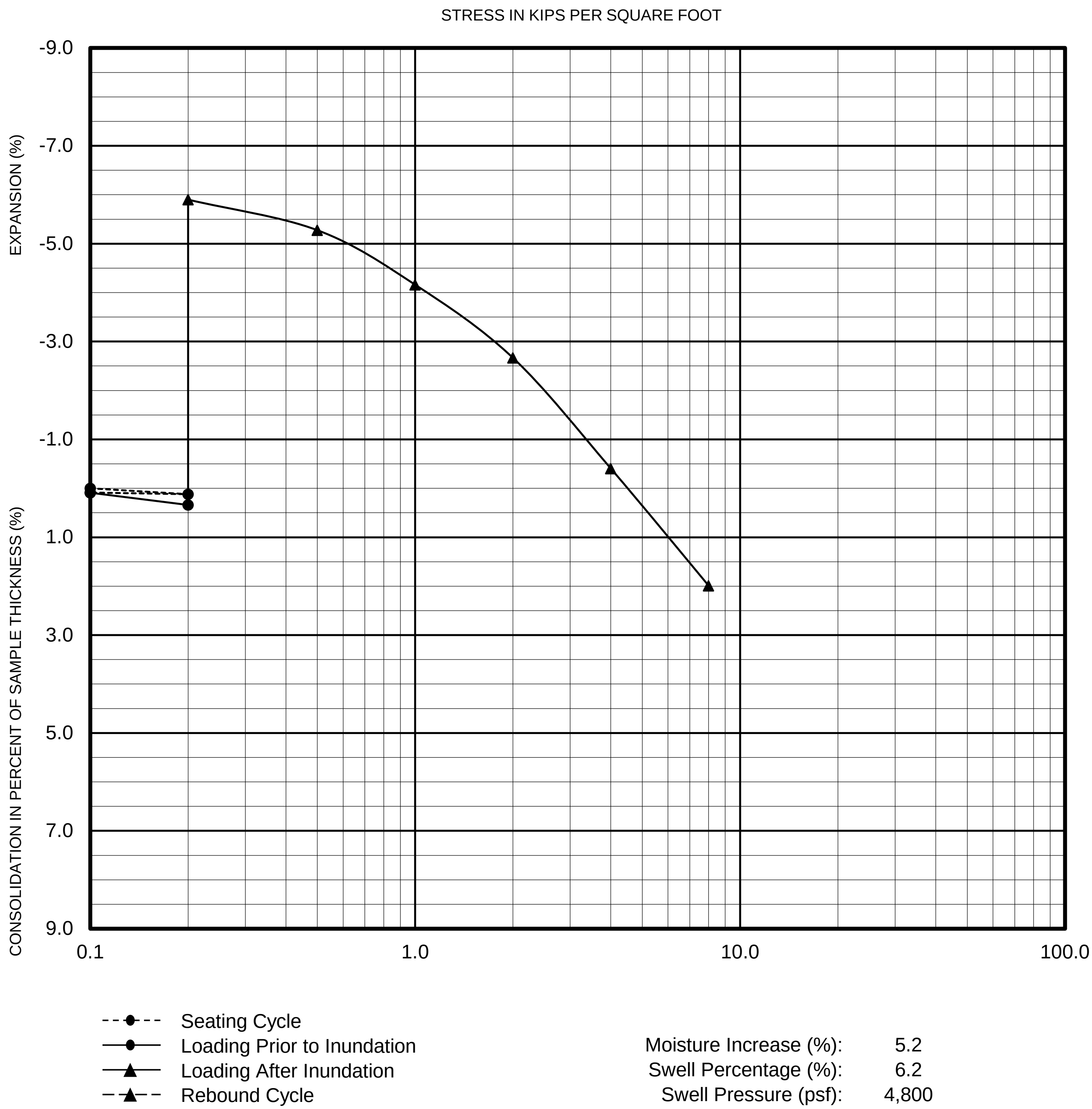

Moisture Increase (%): 5.2
Swell Percentage (%): 6.2
Swell Pressure (psf): 4,800

Sample Location: B-1
Depth (ft): 2.0-3.0
Soil Type: CH (Fill)

PERFORMED IN GENERAL ACCORDANCE WITH ASTM D 4546

FIGURE B-11

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CONSOLIDATION TEST RESULTS

PROPOSED MULTI-FAMILY DEVELOPMENT
COMPARK SOUTH, PARKER, COLORADO

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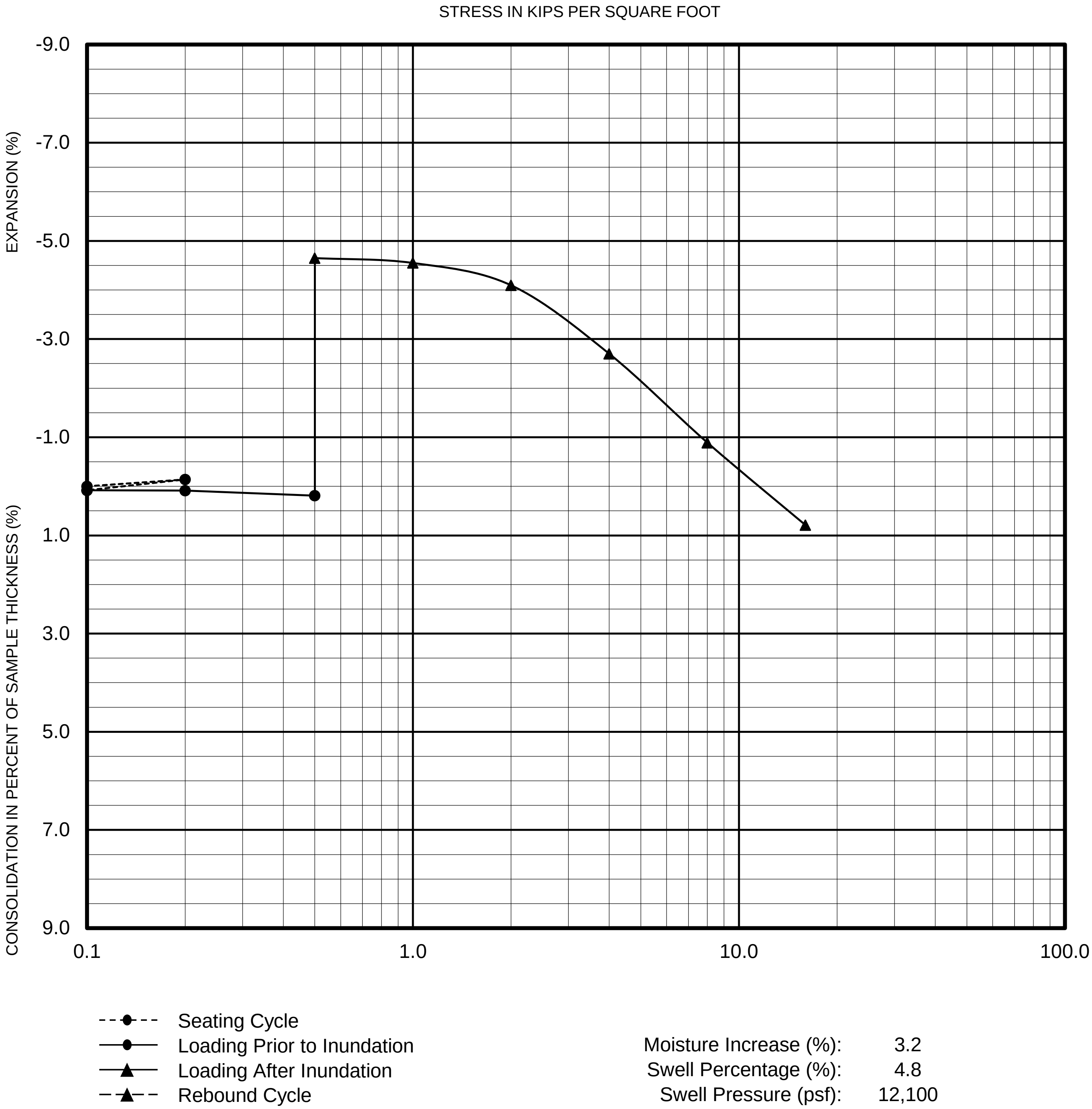

Moisture Increase (%):	3.2
Swell Percentage (%):	4.8
Swell Pressure (psf):	12,100

Sample Location: B-1
Depth (ft): 4.0-5.0
Soil Type: CH (Fill)

PERFORMED IN GENERAL ACCORDANCE WITH ASTM D 4546

FIGURE B-12

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CONSOLIDATION TEST RESULTS

PROPOSED MULTI-FAMILY DEVELOPMENT
COMPARK SOUTH, PARKER, COLORADO

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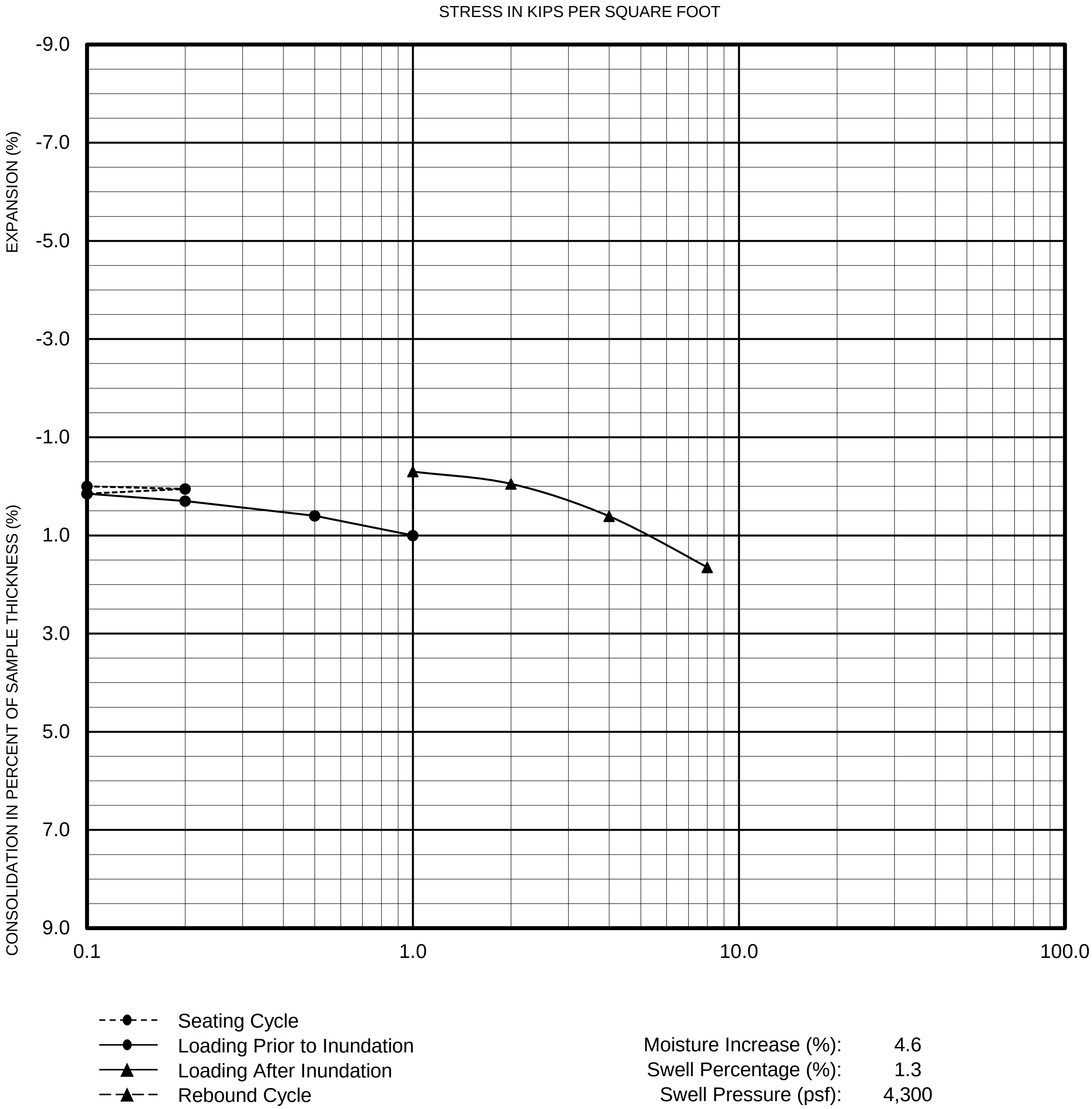

Moisture Increase (%):	4.6
Swell Percentage (%):	1.3
Swell Pressure (psf):	4,300

Sample Location: B-1
Depth (ft): 9.0-10.0
Soil Type: CH

PERFORMED IN GENERAL ACCORDANCE WITH ASTM D 4546

FIGURE B-13

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CONSOLIDATION TEST RESULTS

PROPOSED MULTI-FAMILY DEVELOPMENT
COMPARK SOUTH, PARKER, COLORADO

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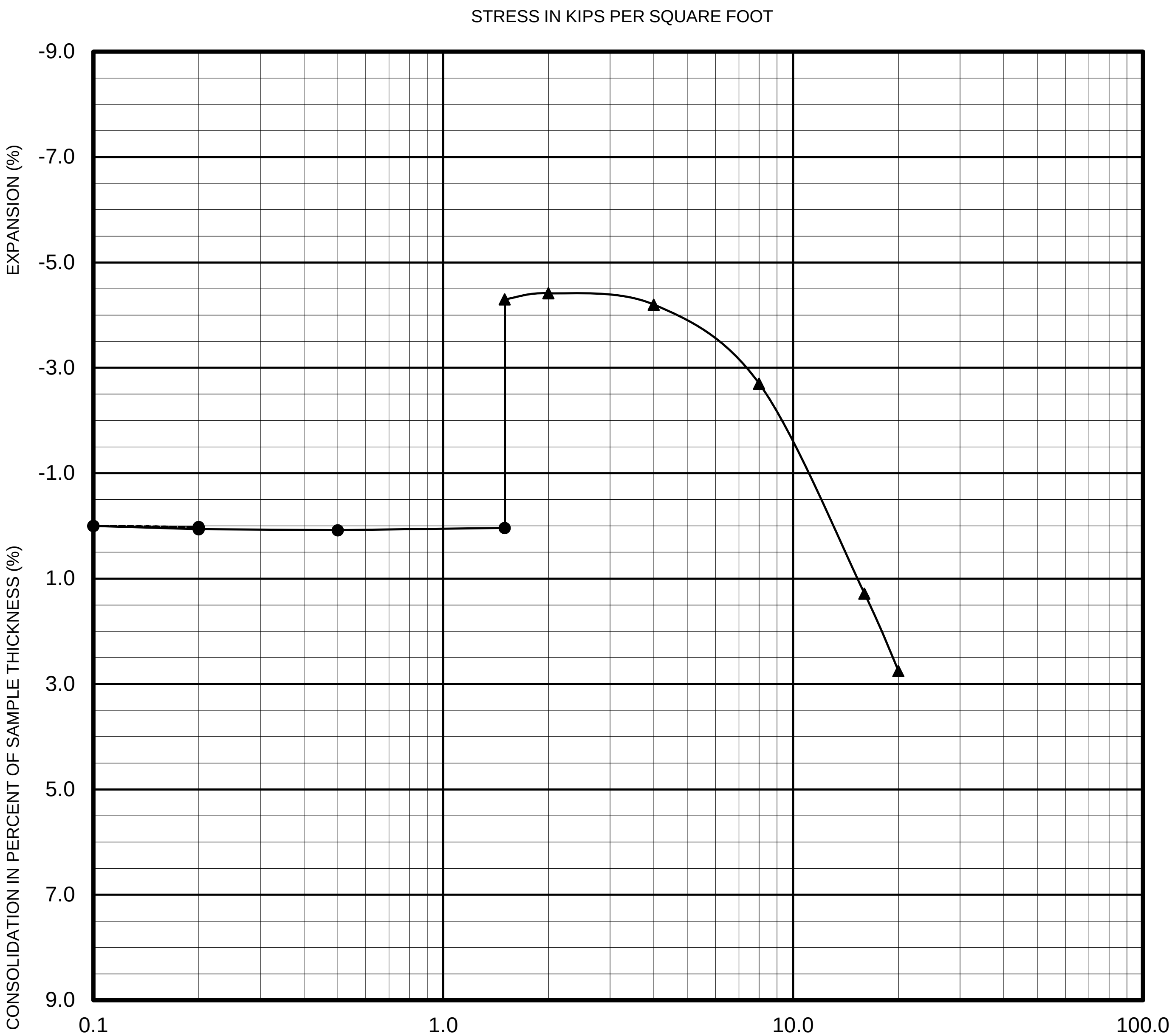

Seating Cycle
Loading Prior to Inundation
Loading After Inundation
Rebound Cycle

Moisture Increase (%): 3.7
Swell Percentage (%): 4.3
Swell Pressure (psf): 11,600

Sample Location: B-1
Depth (ft): 14.0-15.0
Soil Type: SC

PERFORMED IN GENERAL ACCORDANCE WITH ASTM D 4546

FIGURE B-14

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CONSOLIDATION TEST RESULTS

PROPOSED MULTI-FAMILY DEVELOPMENT
COMPARK SOUTH, PARKER, COLORADO

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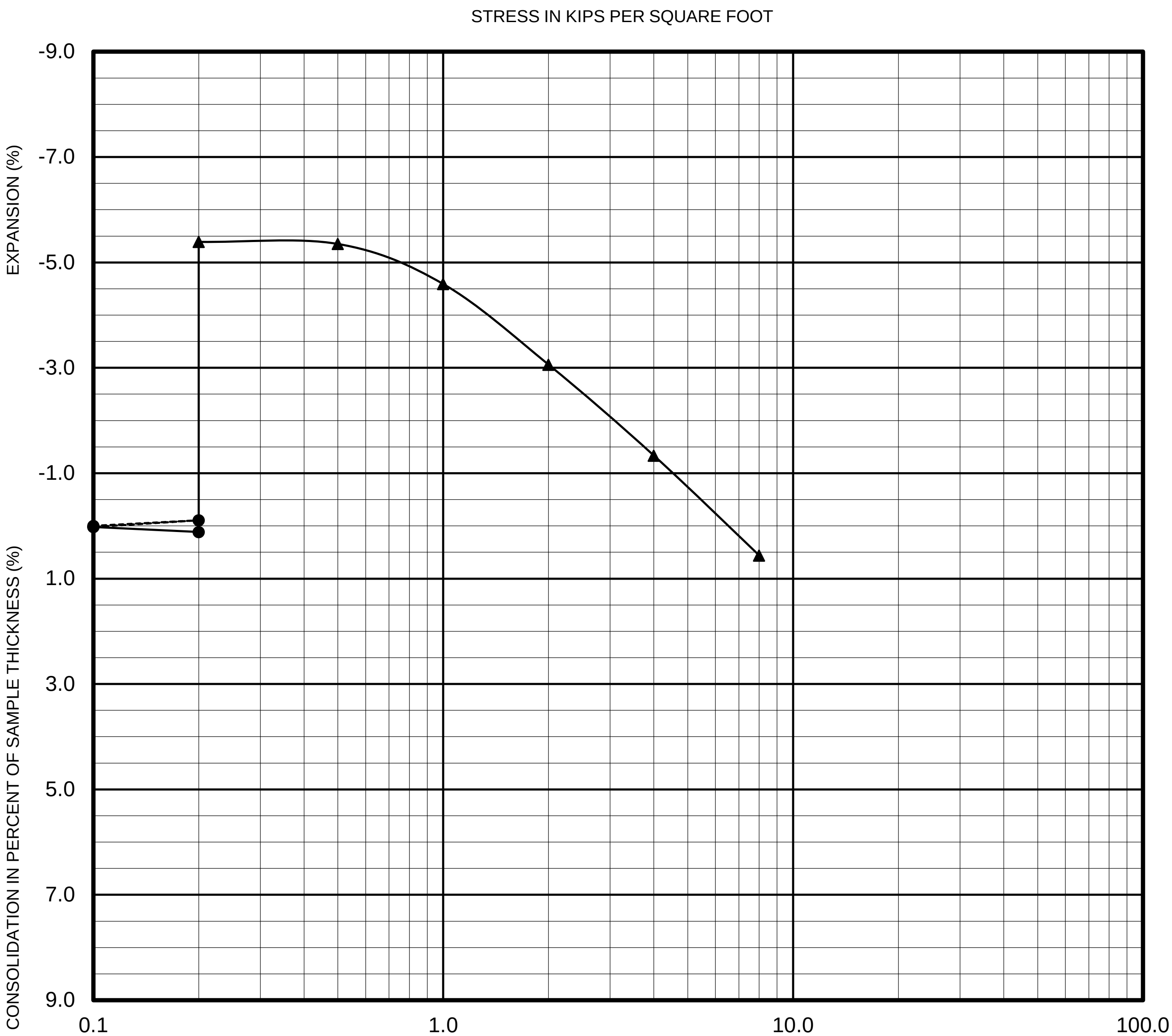

Seating Cycle
Loading Prior to Inundation
Loading After Inundation
Rebound Cycle

Moisture Increase (%): 6.9
Swell Percentage (%): 5.5
Swell Pressure (psf): 6,800

Sample Location: B-3
Depth (ft): 2.0-3.0
Soil Type: CL

PERFORMED IN GENERAL ACCORDANCE WITH ASTM D 4546

FIGURE B-15

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CONSOLIDATION TEST RESULTS

PROPOSED MULTI-FAMILY DEVELOPMENT

COMPARK SOUTH, PARKER, COLORADO

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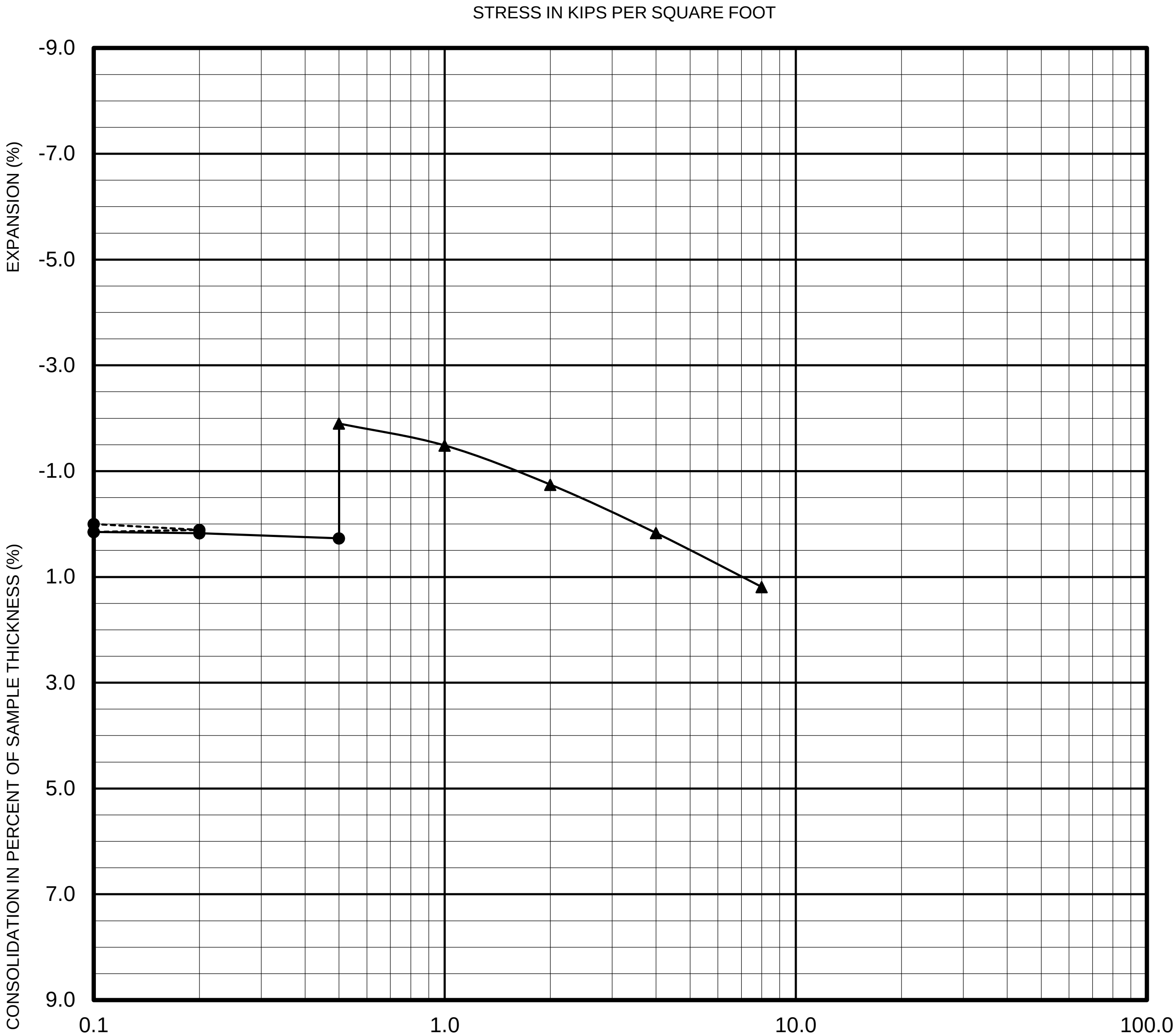

Seating Cycle
Loading Prior to Inundation
Loading After Inundation
Rebound Cycle

Moisture Increase (%):	8.6
Swell Percentage (%):	2.2
Swell Pressure (psf):	3,700

Sample Location: B-3
Depth (ft): 4.0-4.8
Soil Type: CL

PERFORMED IN GENERAL ACCORDANCE WITH ASTM D 4546

FIGURE B-16

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CONSOLIDATION TEST RESULTS
PROPOSED MULTI-FAMILY DEVELOPMENT
COMPARK SOUTH, PARKER, COLORADO

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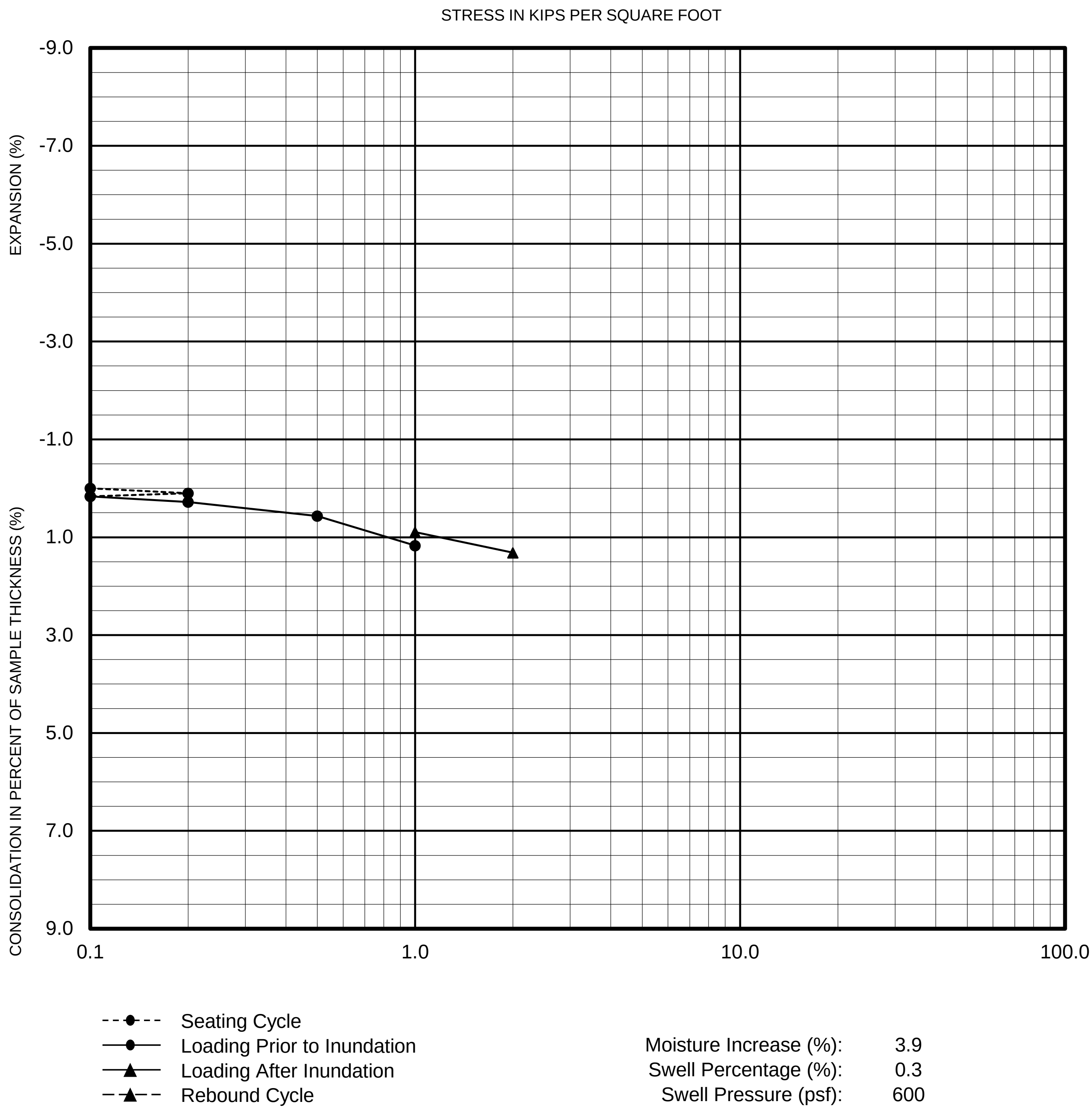

Moisture Increase (%):	3.9
Swell Percentage (%):	0.3
Swell Pressure (psf):	600

Sample Location: B-3
Depth (ft): 14.0-15.0
Soil Type: SC

PERFORMED IN GENERAL ACCORDANCE WITH ASTM D 4546

FIGURE B-17

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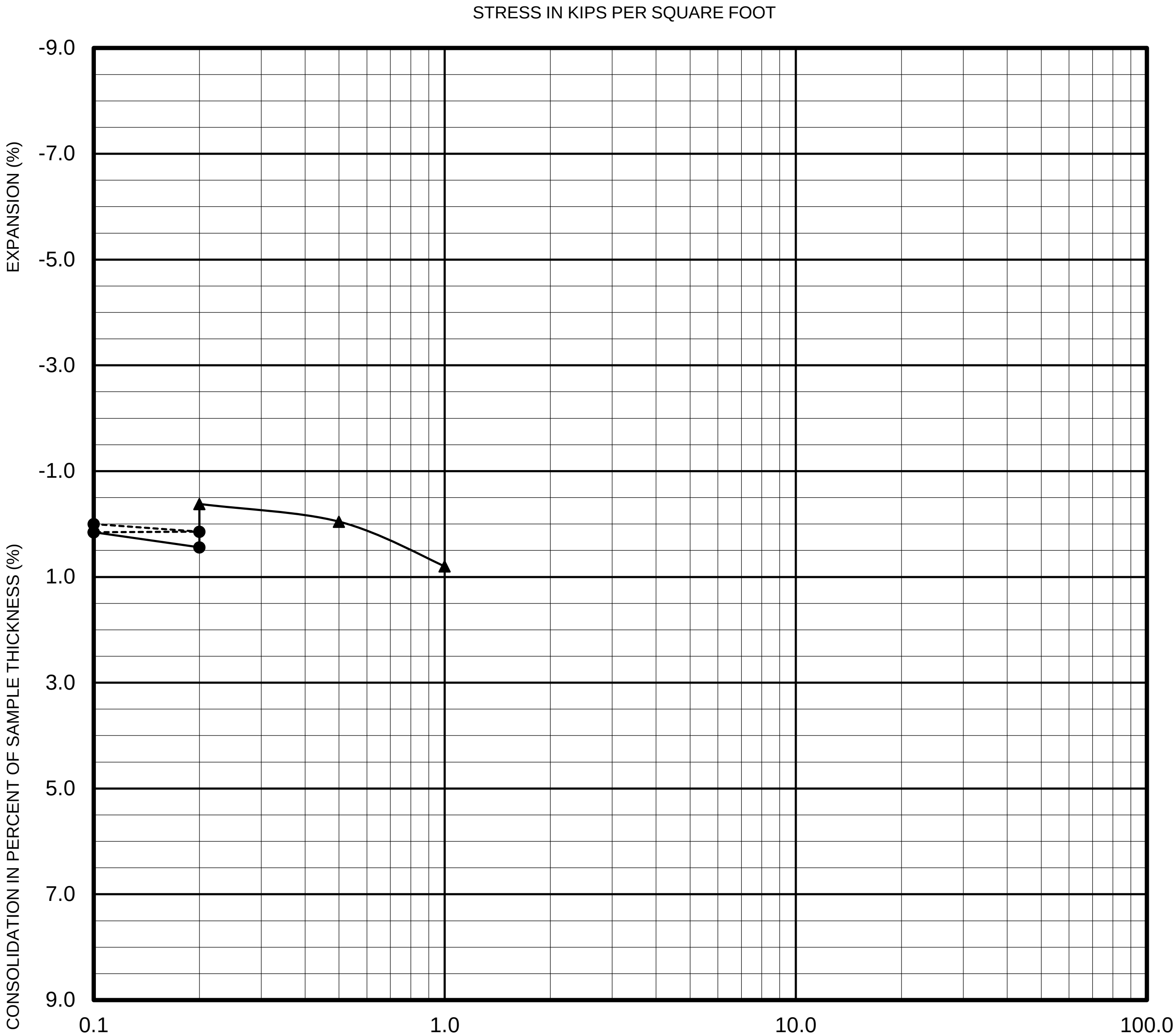
CONSOLIDATION TEST RESULTS

PROPOSED MULTI-FAMILY DEVELOPMENT
COMPARK SOUTH, PARKER, COLORADO



Seating Cycle
Loading Prior to Inundation
Loading After Inundation
Rebound Cycle

Moisture Increase (%):	10.9
Swell Percentage (%):	0.8
Swell Pressure (psf):	600

Sample Location: B-4
Depth (ft): 2.0-3.0
Soil Type: SC (Fill)

PERFORMED IN GENERAL ACCORDANCE WITH ASTM D 4546

FIGURE B-18

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CONSOLIDATION TEST RESULTS

PROPOSED MULTI-FAMILY DEVELOPMENT
COMPARK SOUTH, PARKER, COLORADO

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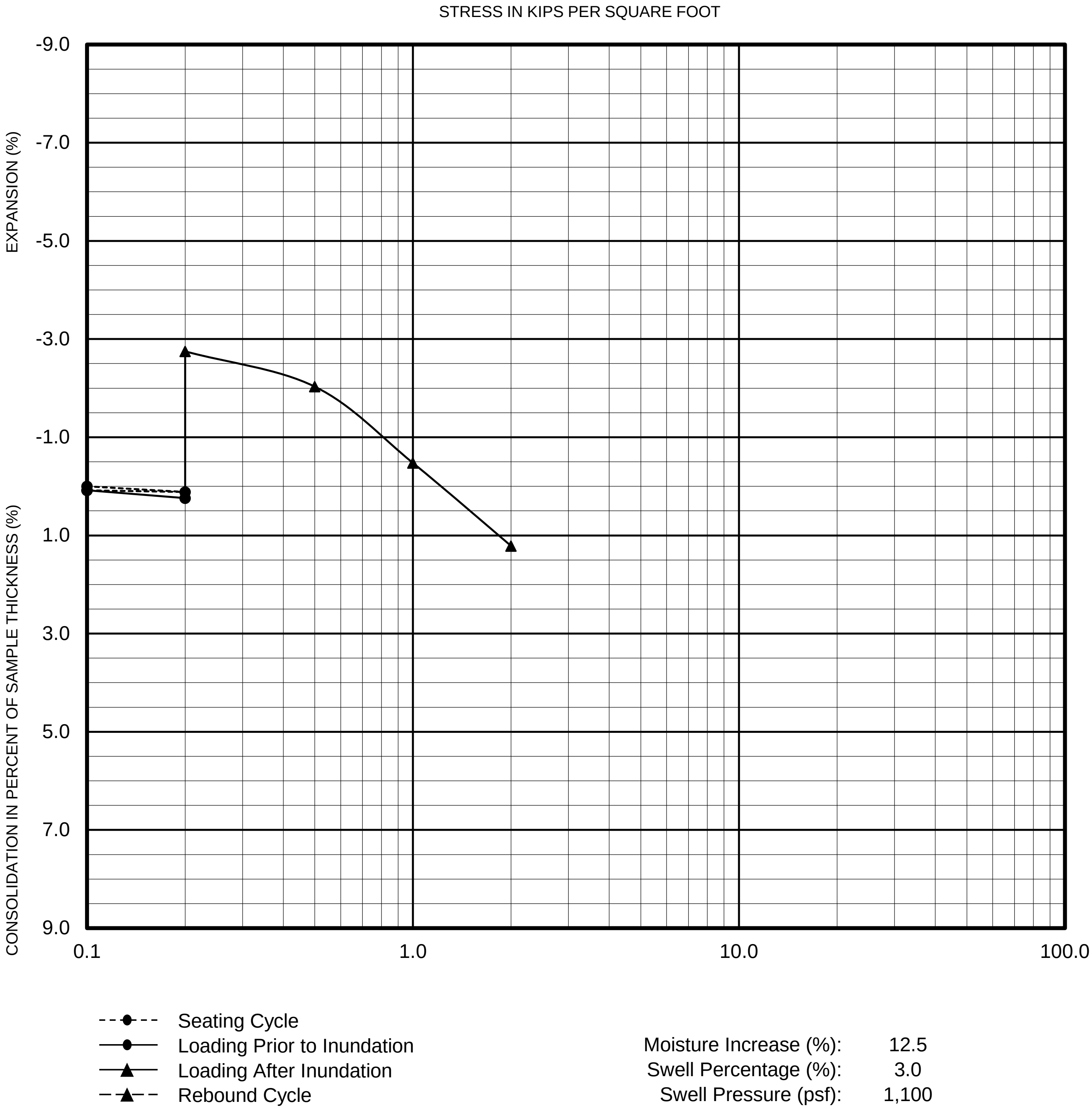

Moisture Increase (%): 12.5
Swell Percentage (%): 3.0
Swell Pressure (psf): 1,100

Sample Location: B-5
Depth (ft): 2.0-3.0
Soil Type: SC

PERFORMED IN GENERAL ACCORDANCE WITH ASTM D 4546

FIGURE B-19

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CONSOLIDATION TEST RESULTS

PROPOSED MULTI-FAMILY DEVELOPMENT
COMPARK SOUTH, PARKER, COLORADO

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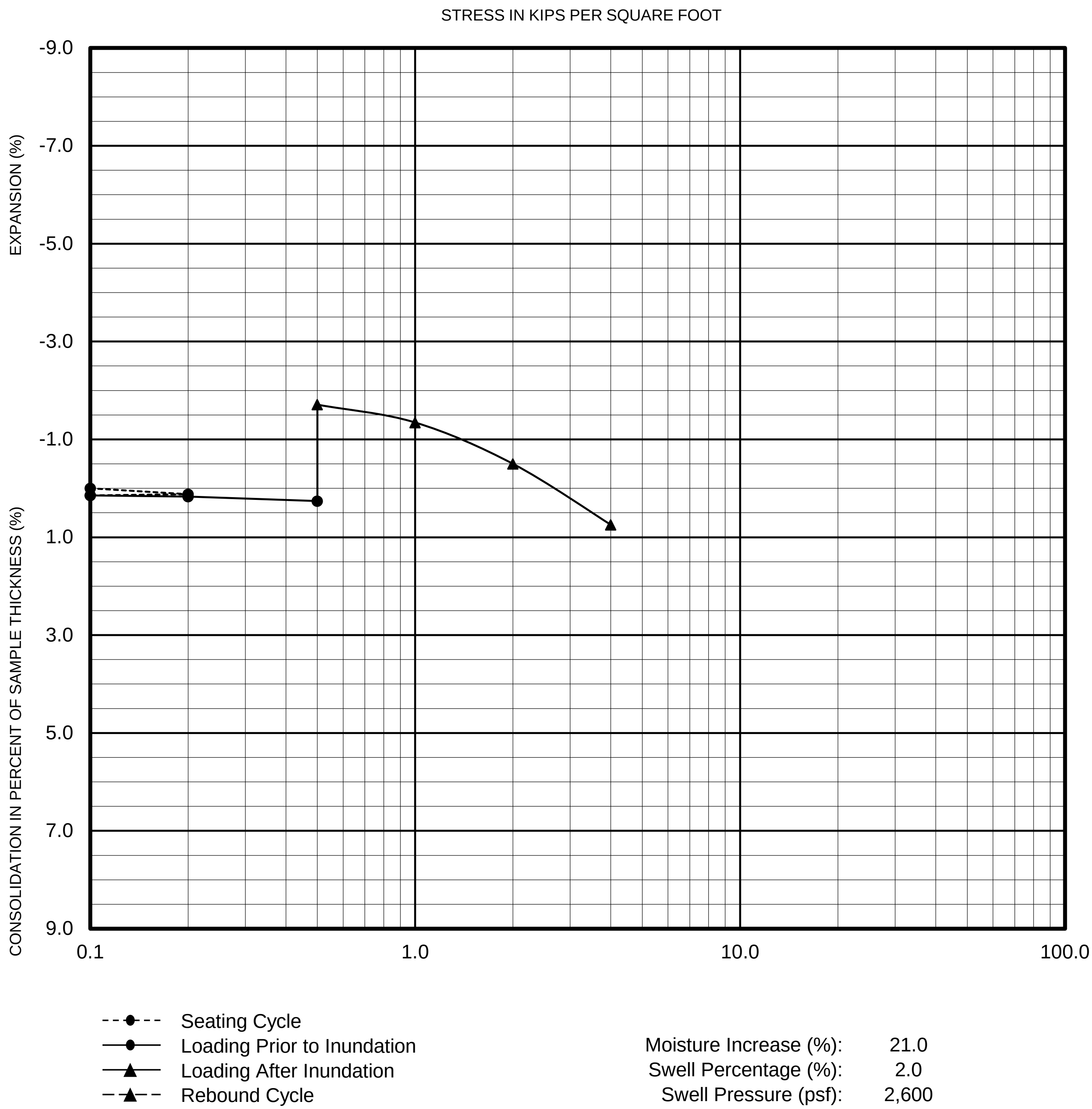

Moisture Increase (%): 21.0
Swell Percentage (%): 2.0
Swell Pressure (psf): 2,600

Sample Location: B-5
Depth (ft): 4.0-5.0
Soil Type: SC

PERFORMED IN GENERAL ACCORDANCE WITH ASTM D 4546

FIGURE B-20

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CONSOLIDATION TEST RESULTS

PROPOSED MULTI-FAMILY DEVELOPMENT

COMPARK SOUTH, PARKER, COLORADO

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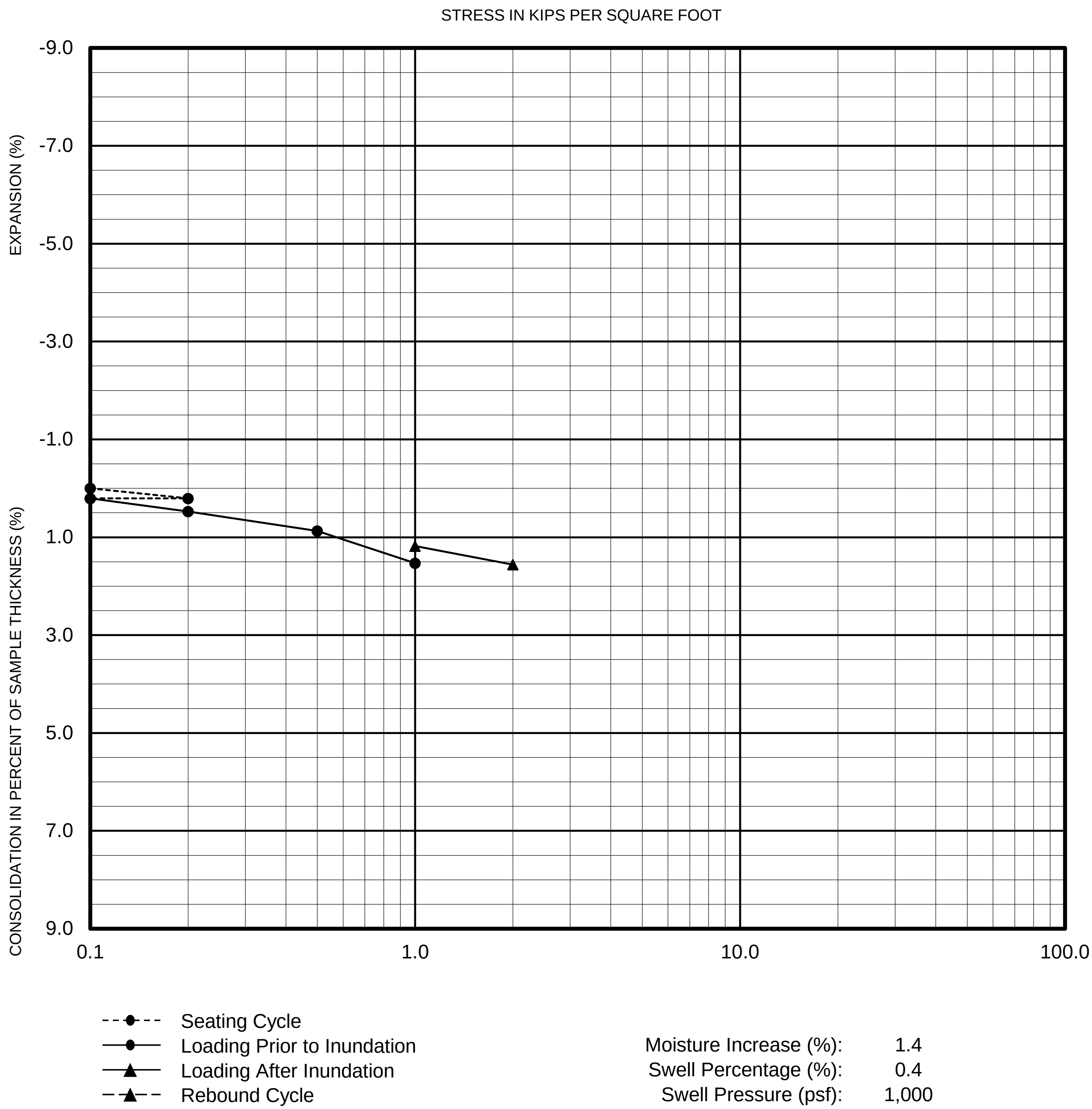

Moisture Increase (%): 1.4
Swell Percentage (%): 0.4
Swell Pressure (psf): 1,000

Sample Location: B-5
Depth (ft): 14.0-15.0
Soil Type: CL

PERFORMED IN GENERAL ACCORDANCE WITH ASTM D 4546

FIGURE B-21

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CONSOLIDATION TEST RESULTS

PROPOSED MULTI-FAMILY DEVELOPMENT
COMPARK SOUTH, PARKER, COLORADO

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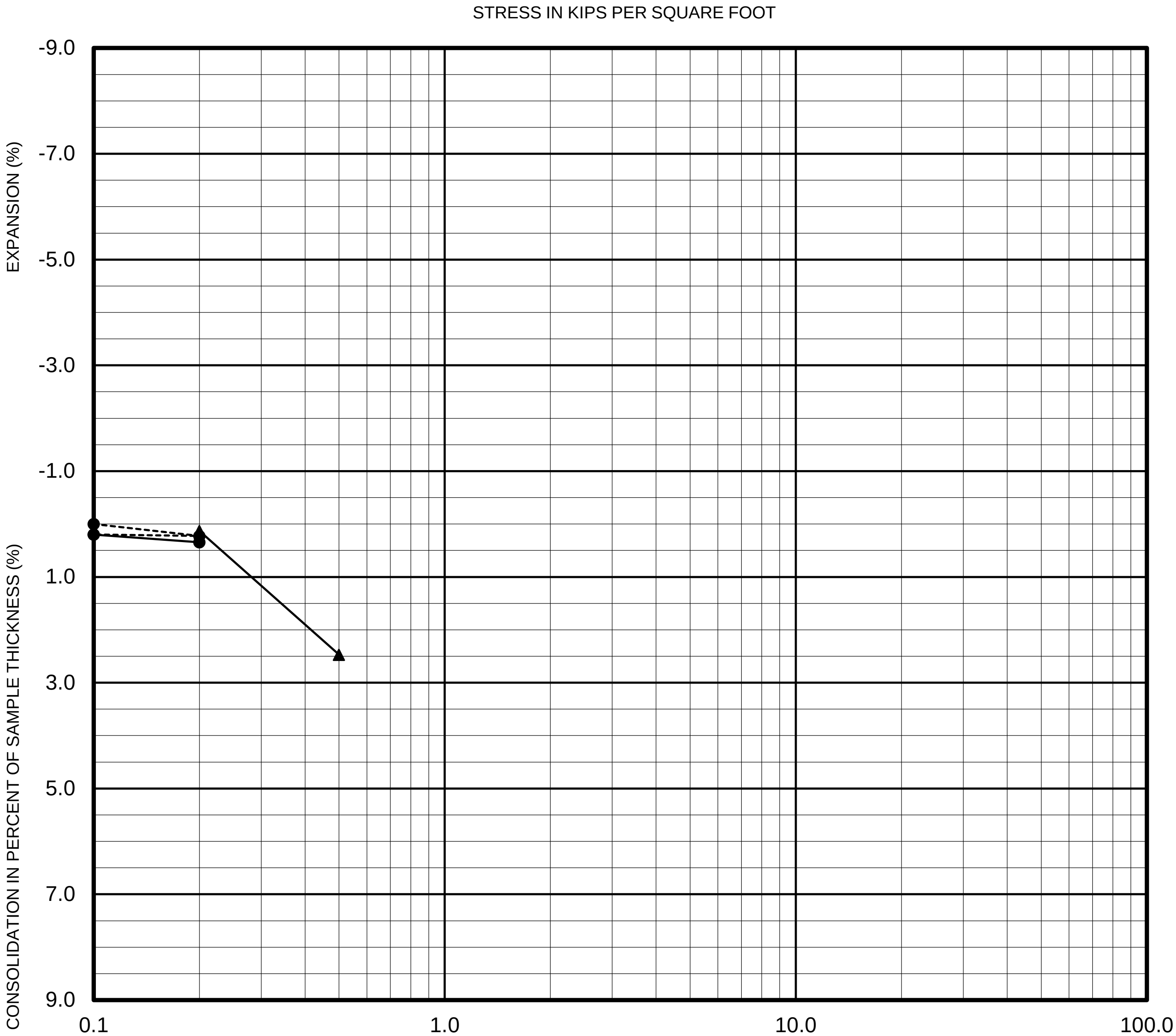

Seating Cycle
Loading Prior to Inundation
Loading After Inundation
Rebound Cycle

Moisture Increase (%): 15.5
Swell Percentage (%): 0.2
Swell Pressure (psf): 20

Sample Location: B-7
Depth (ft): 2.0-3.0
Soil Type: SC

PERFORMED IN GENERAL ACCORDANCE WITH ASTM D 4546

FIGURE B-22

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CONSOLIDATION TEST RESULTS

PROPOSED MULTI-FAMILY DEVELOPMENT
COMPARK SOUTH, PARKER, COLORADO

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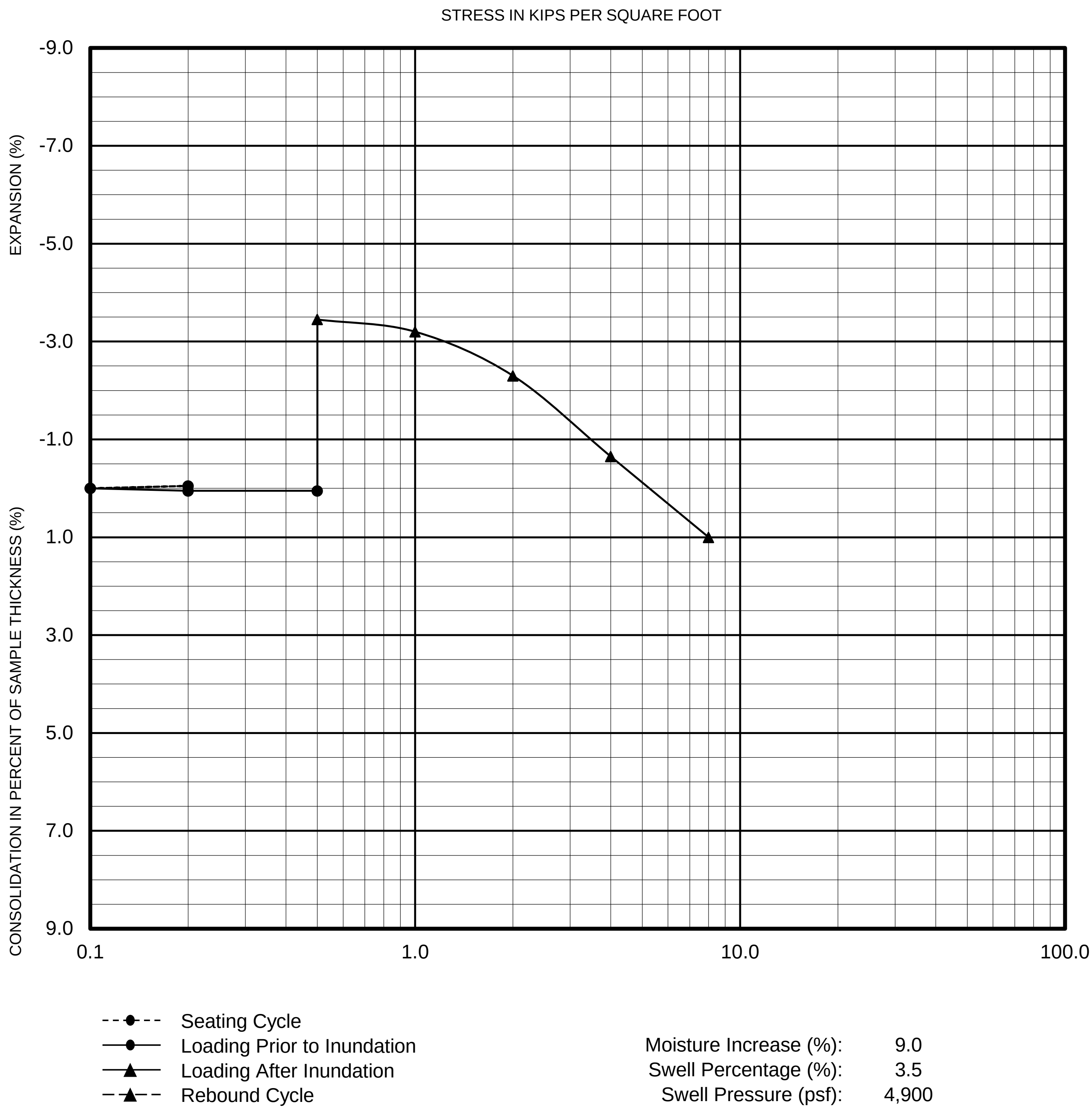

Moisture Increase (%):	9.0
Swell Percentage (%):	3.5
Swell Pressure (psf):	4,900

Sample Location: B-7
Depth (ft): 4.0-5.0
Soil Type: SC

PERFORMED IN GENERAL ACCORDANCE WITH ASTM D 4546

FIGURE B-23

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CONSOLIDATION TEST RESULTS

PROPOSED MULTI-FAMILY DEVELOPMENT
COMPARK SOUTH, PARKER, COLORADO

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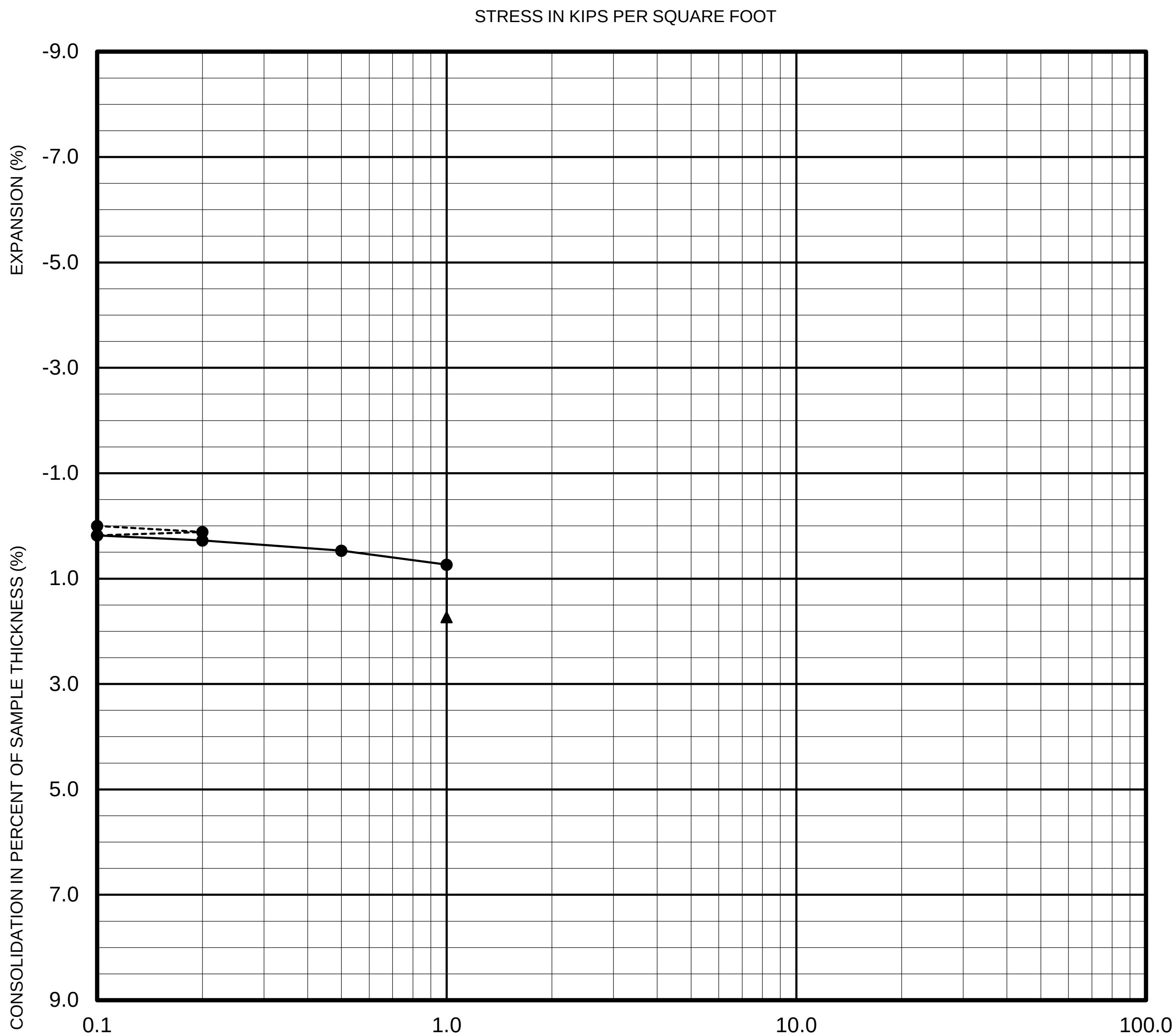

Seating Cycle
Loading Prior to Inundation
Loading After Inundation
Rebound Cycle

Moisture Increase (%):	12.5
Swell Percentage (%):	-1.0
Swell Pressure (psf):	--

Sample Location: B-7
Depth (ft): 9.0-10.0
Soil Type: SC

PERFORMED IN GENERAL ACCORDANCE WITH ASTM D 4546

FIGURE B-24

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CONSOLIDATION TEST RESULTS

PROPOSED MULTI-FAMILY DEVELOPMENT
COMPARK SOUTH, PARKER, COLORADO

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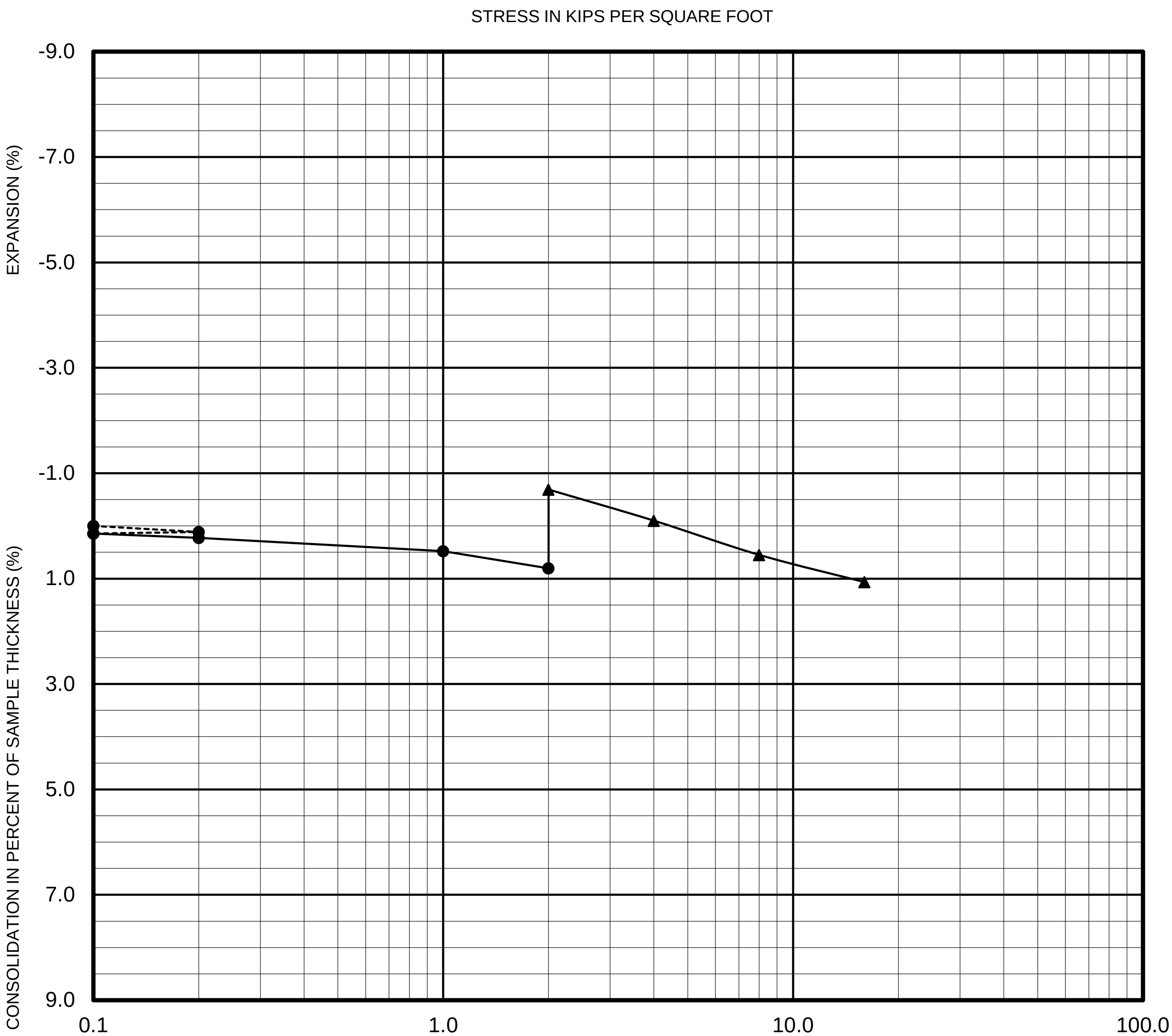

Seating Cycle
Loading Prior to Inundation
Loading After Inundation
Rebound Cycle

Moisture Increase (%):	3.2
Swell Percentage (%):	1.5
Swell Pressure (psf):	12,000

Sample Location: B-7
Depth (ft): 19.0-19.7
Soil Type: DAWSON FORMATION

PERFORMED IN GENERAL ACCORDANCE WITH ASTM D 4546

FIGURE B-25

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CONSOLIDATION TEST RESULTS

PROPOSED MULTI-FAMILY DEVELOPMENT
COMPARK SOUTH, PARKER, COLORADO

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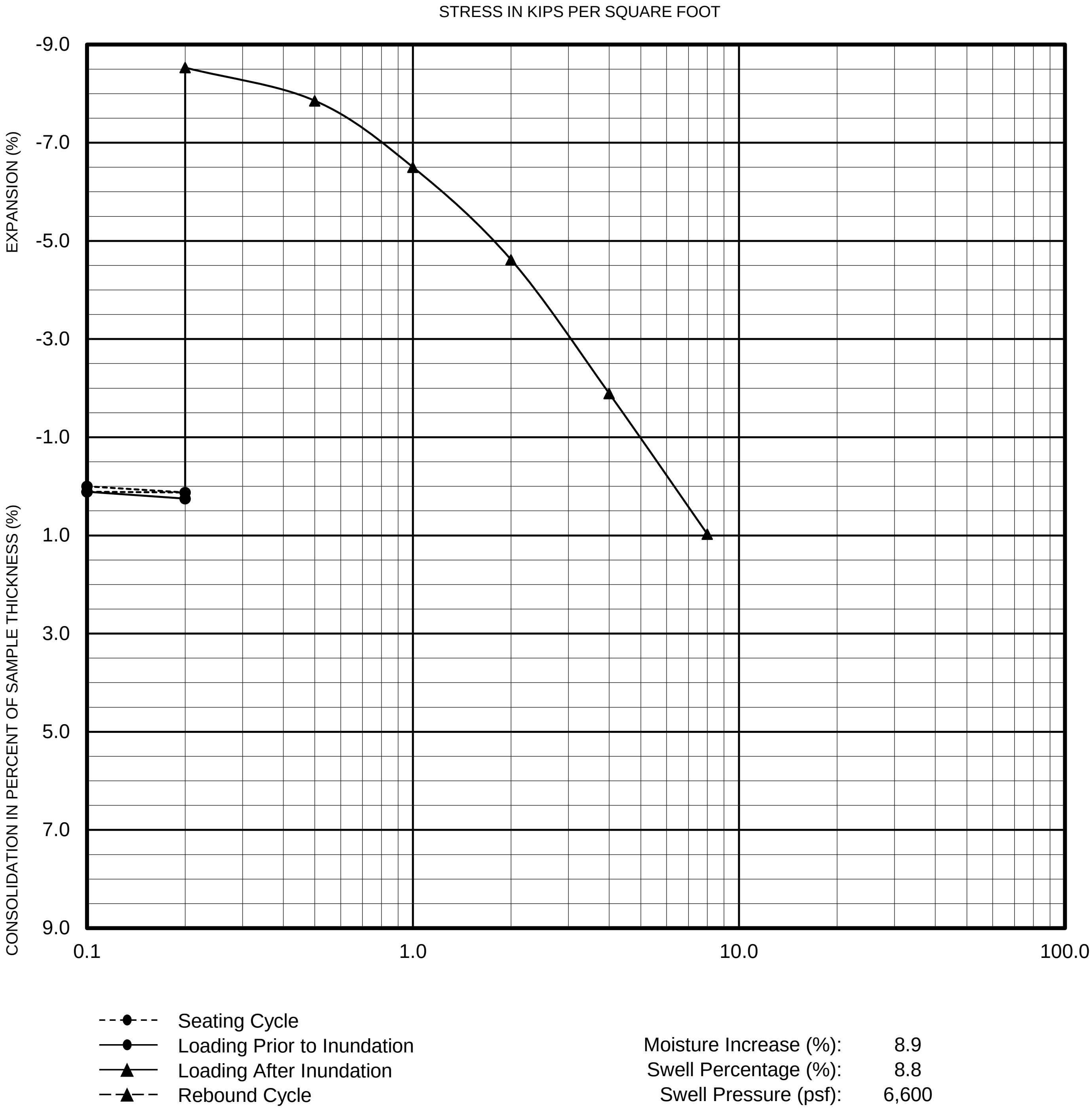

Moisture Increase (%):	8.9
Swell Percentage (%):	8.8
Swell Pressure (psf):	6,600

Sample Location: B-8
Depth (ft): 2.0-3.0
Soil Type: CH (Fill)

PERFORMED IN GENERAL ACCORDANCE WITH ASTM D 4546

FIGURE B-26

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CONSOLIDATION TEST RESULTS

PROPOSED MULTI-FAMILY DEVELOPMENT
COMPARK SOUTH, PARKER, COLORADO

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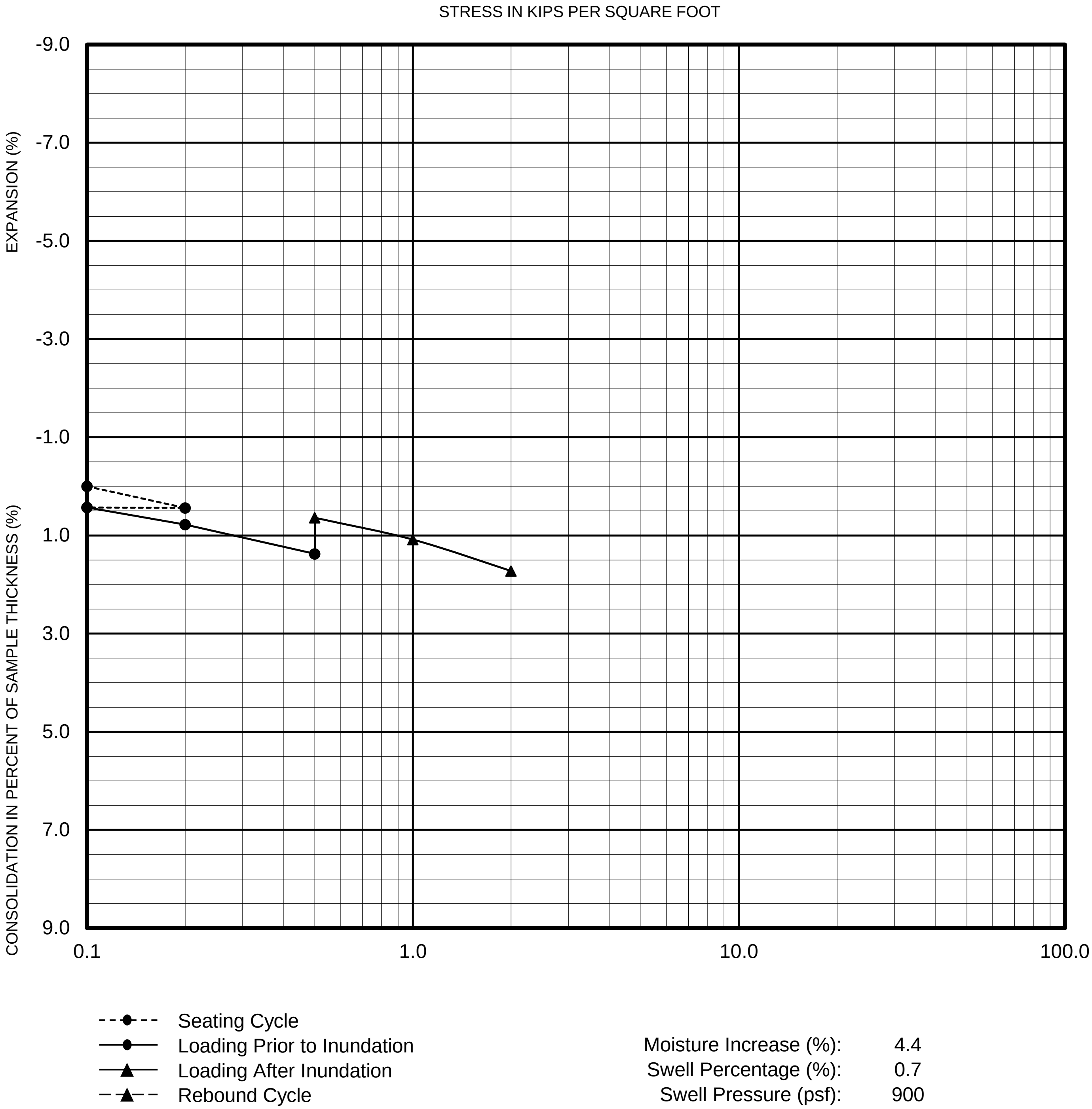

Moisture Increase (%):	4.4
Swell Percentage (%):	0.7
Swell Pressure (psf):	900

Sample Location:	B-8
Depth (ft):	4.0-5.0
Soil Type:	CH (Fill)

PERFORMED IN GENERAL ACCORDANCE WITH ASTM D 4546

FIGURE B-27

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CONSOLIDATION TEST RESULTS

PROPOSED MULTI-FAMILY DEVELOPMENT

COMPARK SOUTH, PARKER, COLORADO

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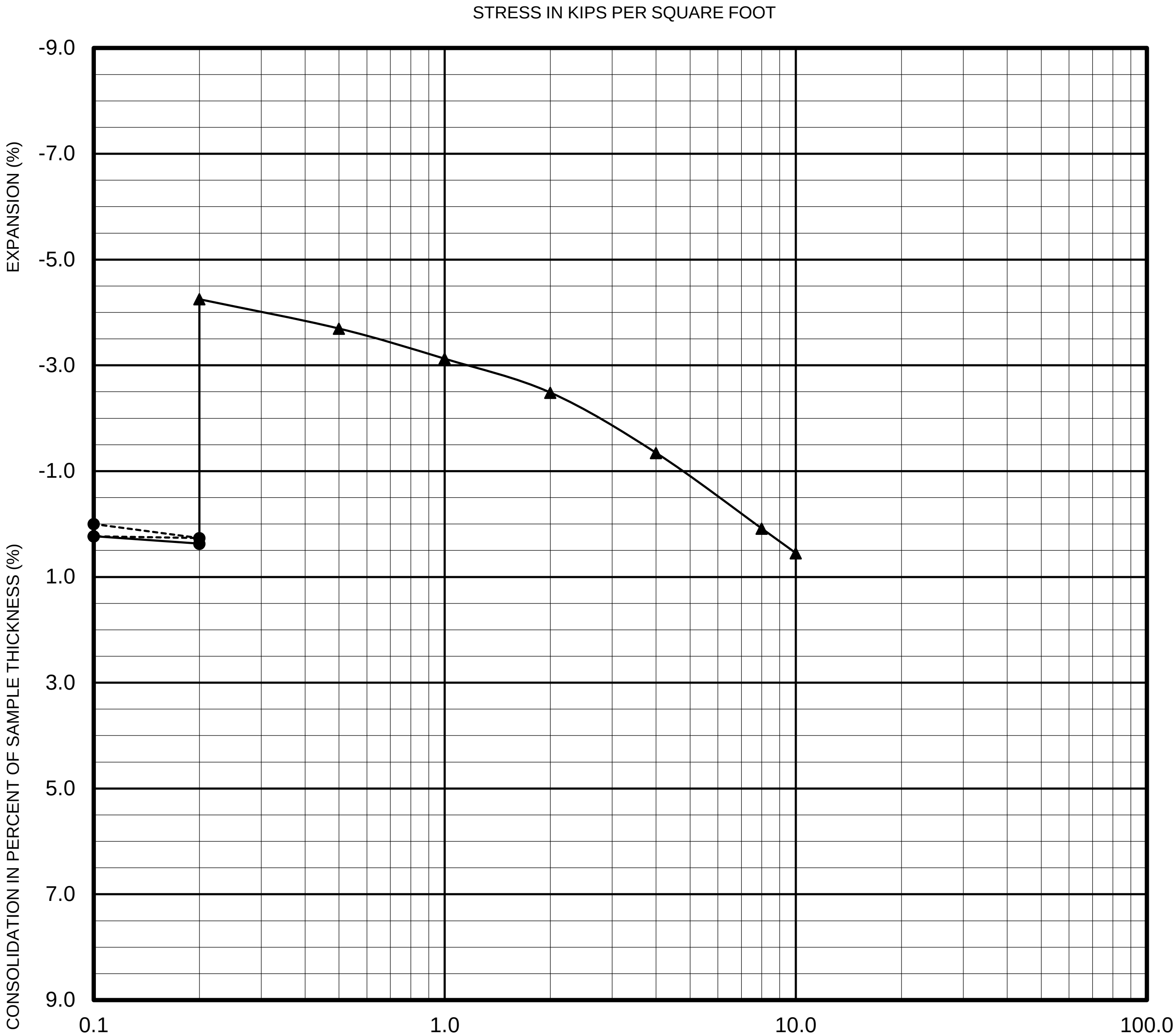

Seating Cycle
Loading Prior to Inundation
Loading After Inundation
Rebound Cycle

Moisture Increase (%): 8.5
Swell Percentage (%): 4.6
Swell Pressure (psf): 9,000

Sample Location: B-9
Depth (ft): 2.0-3.0
Soil Type: SC (Fill)

PERFORMED IN GENERAL ACCORDANCE WITH ASTM D 4546

FIGURE B-28

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CONSOLIDATION TEST RESULTS

PROPOSED MULTI-FAMILY DEVELOPMENT
COMPARK SOUTH, PARKER, COLORADO

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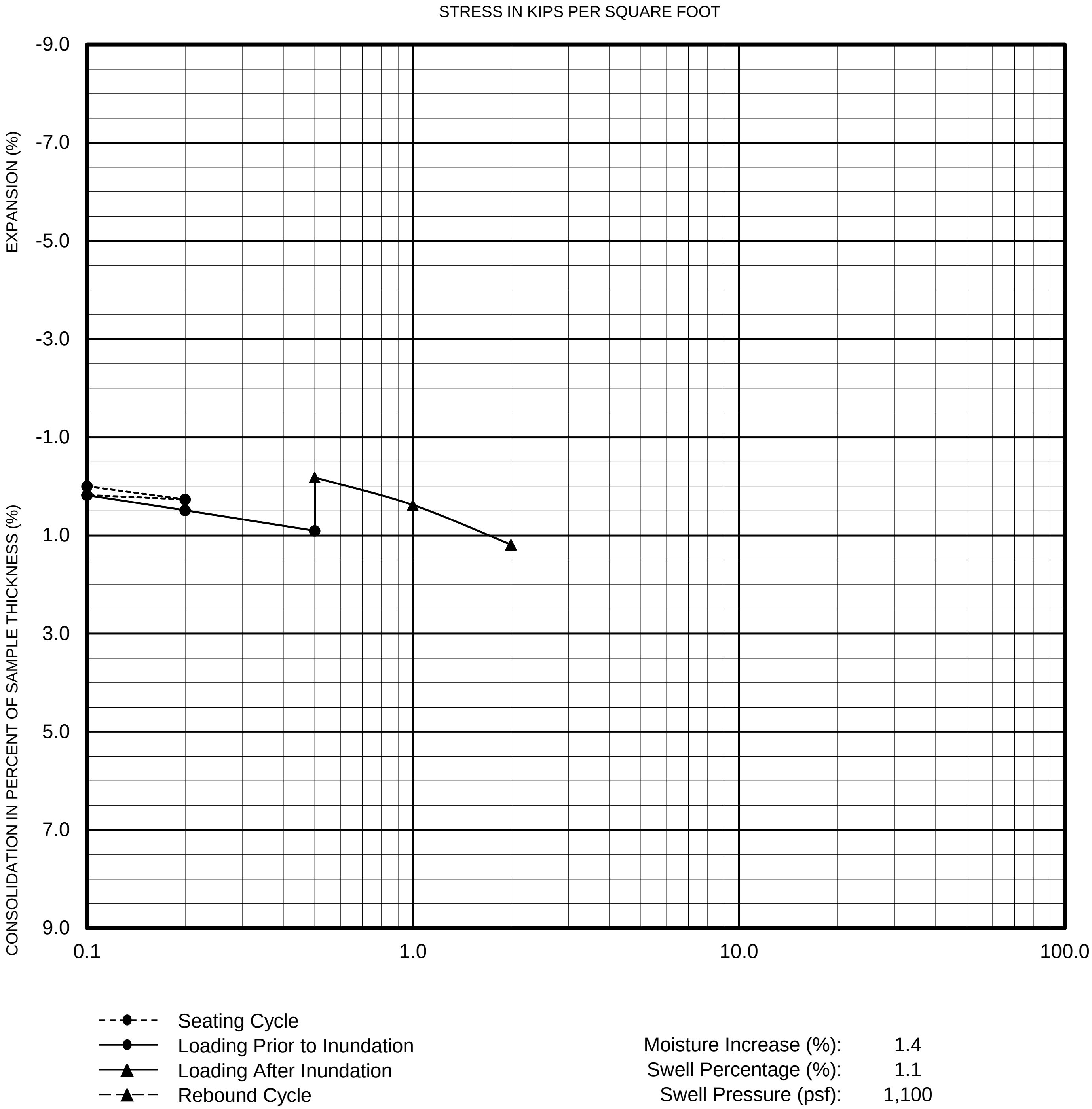

Moisture Increase (%):	1.4
Swell Percentage (%):	1.1
Swell Pressure (psf):	1,100

Sample Location: B-9
Depth (ft): 4.0-5.0
Soil Type: CL (Fill)

PERFORMED IN GENERAL ACCORDANCE WITH ASTM D 4546

FIGURE B-29

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CONSOLIDATION TEST RESULTS

PROPOSED MULTI-FAMILY DEVELOPMENT
COMPARK SOUTH, PARKER, COLORADO

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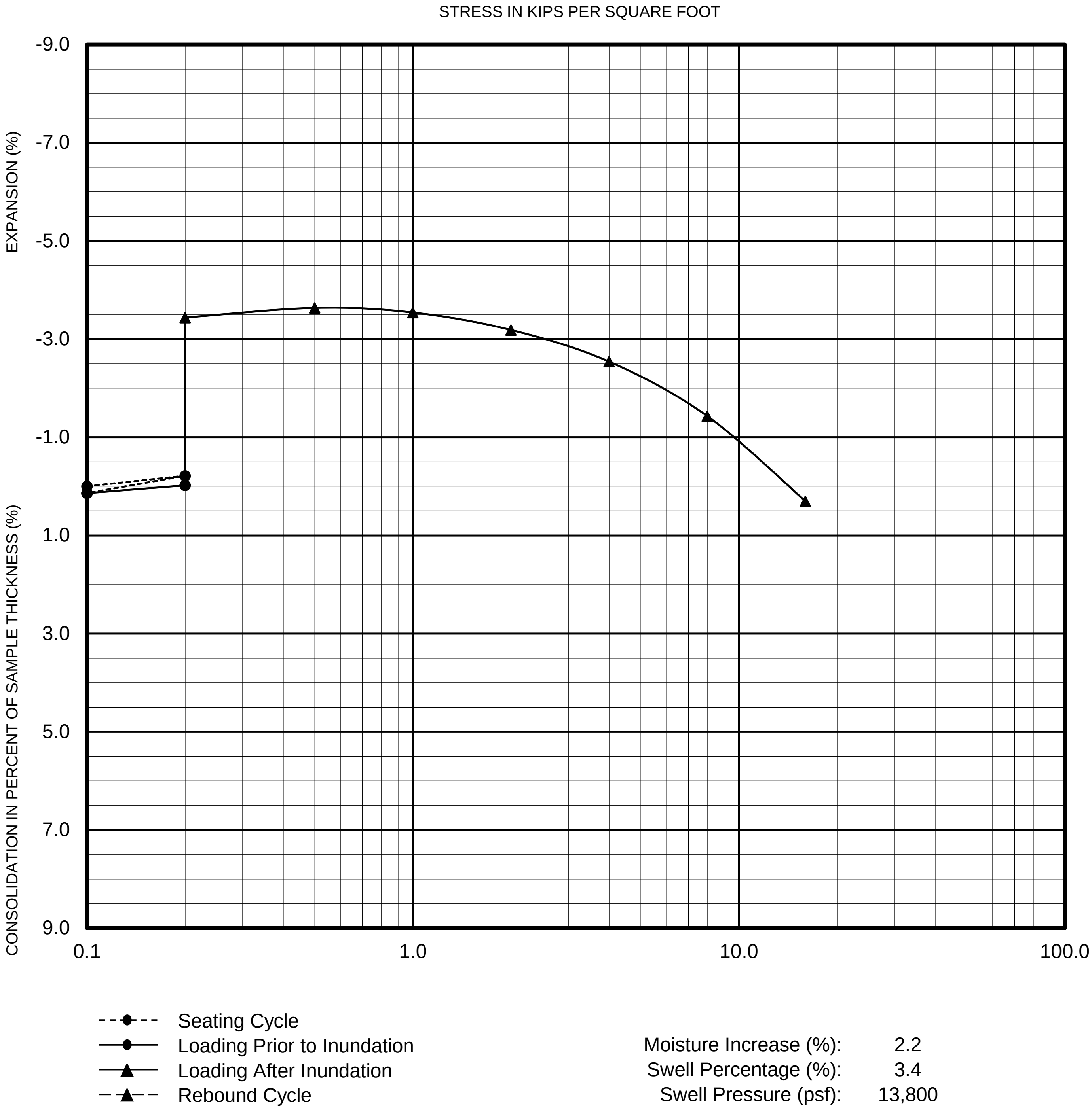

Moisture Increase (%):	2.2
Swell Percentage (%):	3.4
Swell Pressure (psf):	13,800

Sample Location: B-10
Depth (ft): 2.0-3.5
Soil Type: SC (Fill)

PERFORMED IN GENERAL ACCORDANCE WITH ASTM D 4546

FIGURE B-30

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CONSOLIDATION TEST RESULTS

PROPOSED MULTI-FAMILY DEVELOPMENT
COMPARK SOUTH, PARKER, COLORADO

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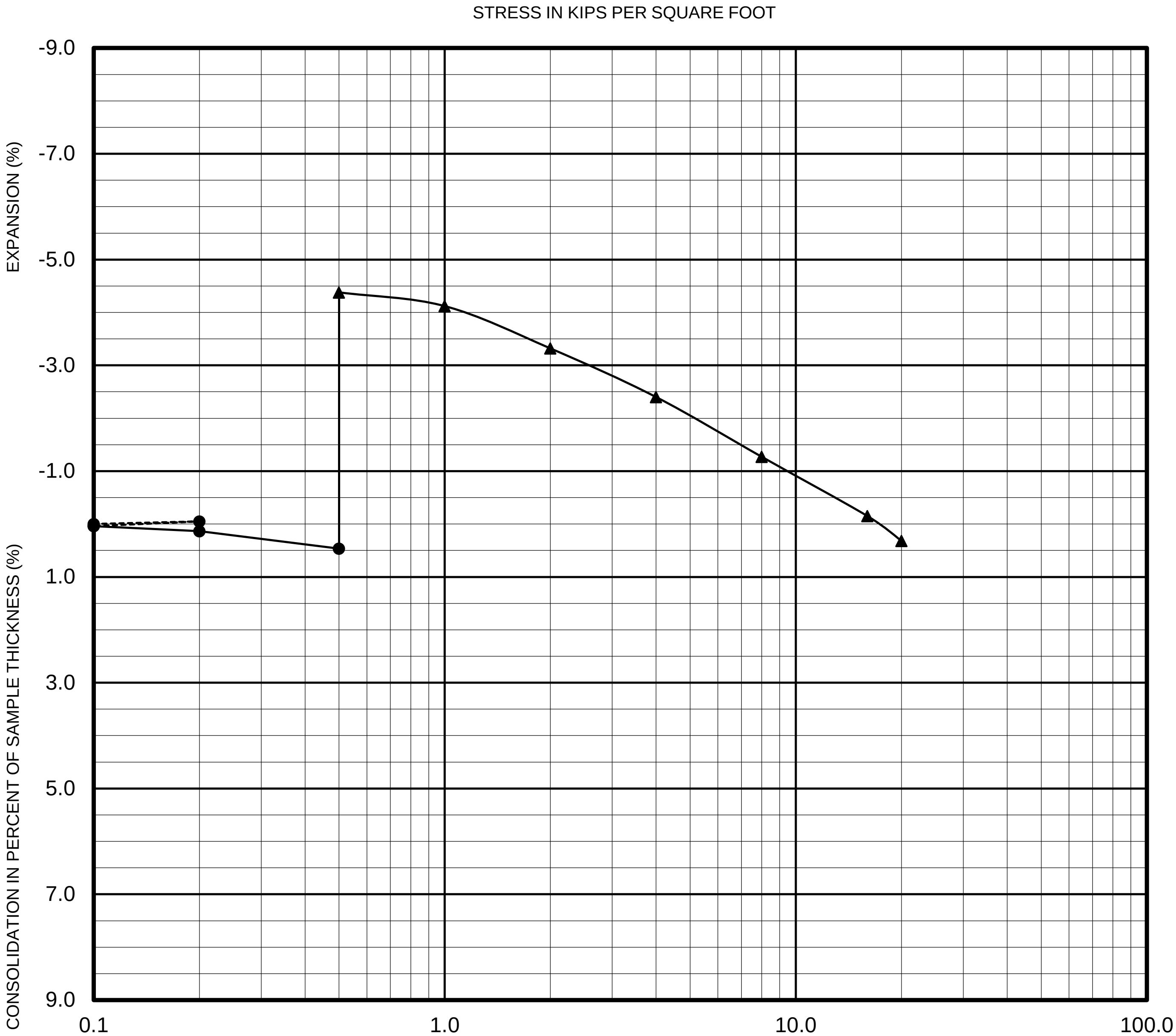

Seating Cycle
Loading Prior to Inundation
Loading After Inundation
Rebound Cycle

Moisture Increase (%): 34.3
Swell Percentage (%): 4.9
Swell Pressure (psf): 19,500

Sample Location: B-10
Depth (ft): 4.0-5.0
Soil Type: CL (Fill)

PERFORMED IN GENERAL ACCORDANCE WITH ASTM D 4546

FIGURE B-31

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CONSOLIDATION TEST RESULTS

PROPOSED MULTI-FAMILY DEVELOPMENT

COMPARK SOUTH, PARKER, COLORADO

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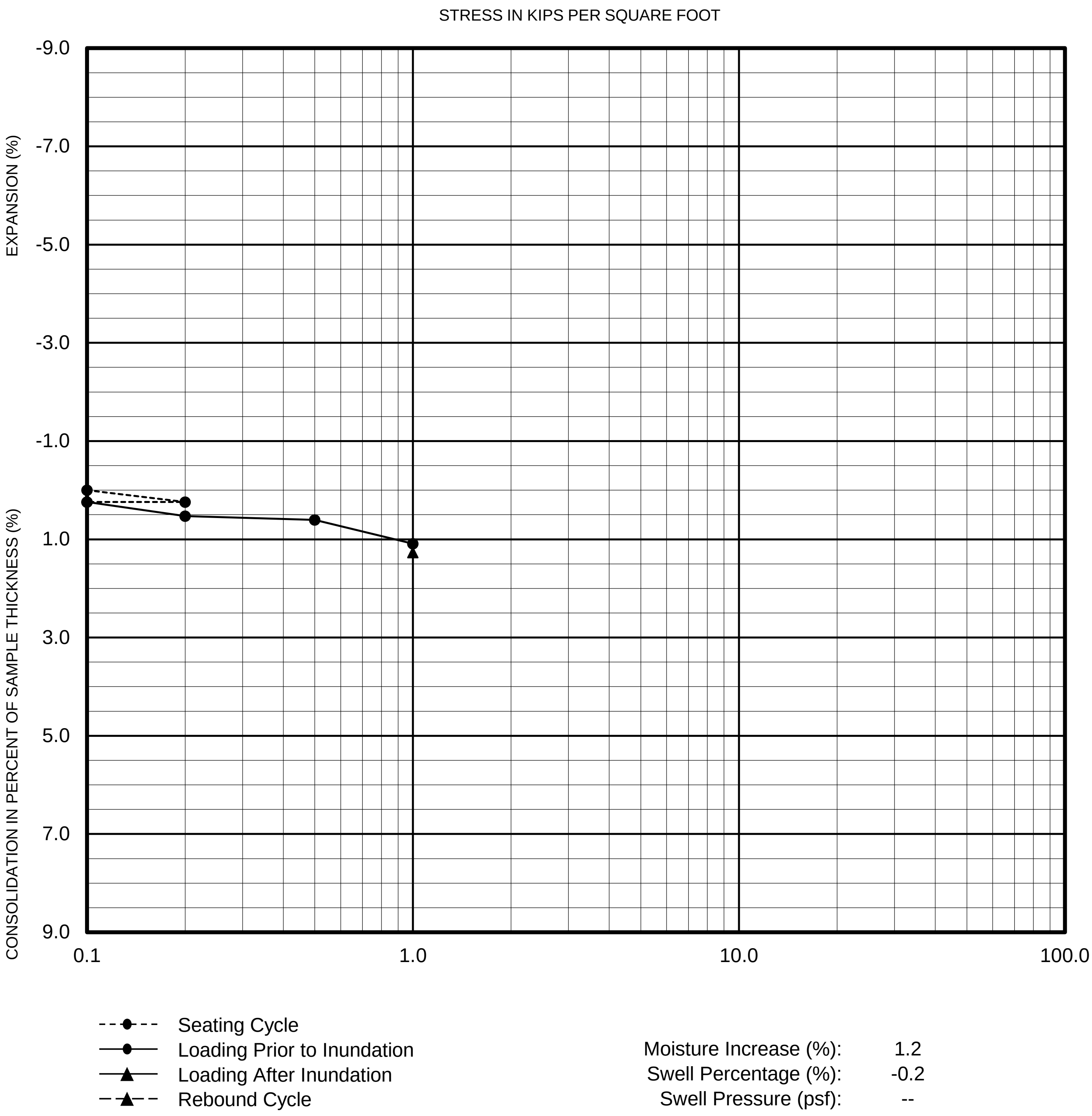

Moisture Increase (%):	1.2
Swell Percentage (%):	-0.2
Swell Pressure (psf):	--

Sample Location: B-10
Depth (ft): 9.0-10.0
Soil Type: SC (Fill)

PERFORMED IN GENERAL ACCORDANCE WITH ASTM D 4546

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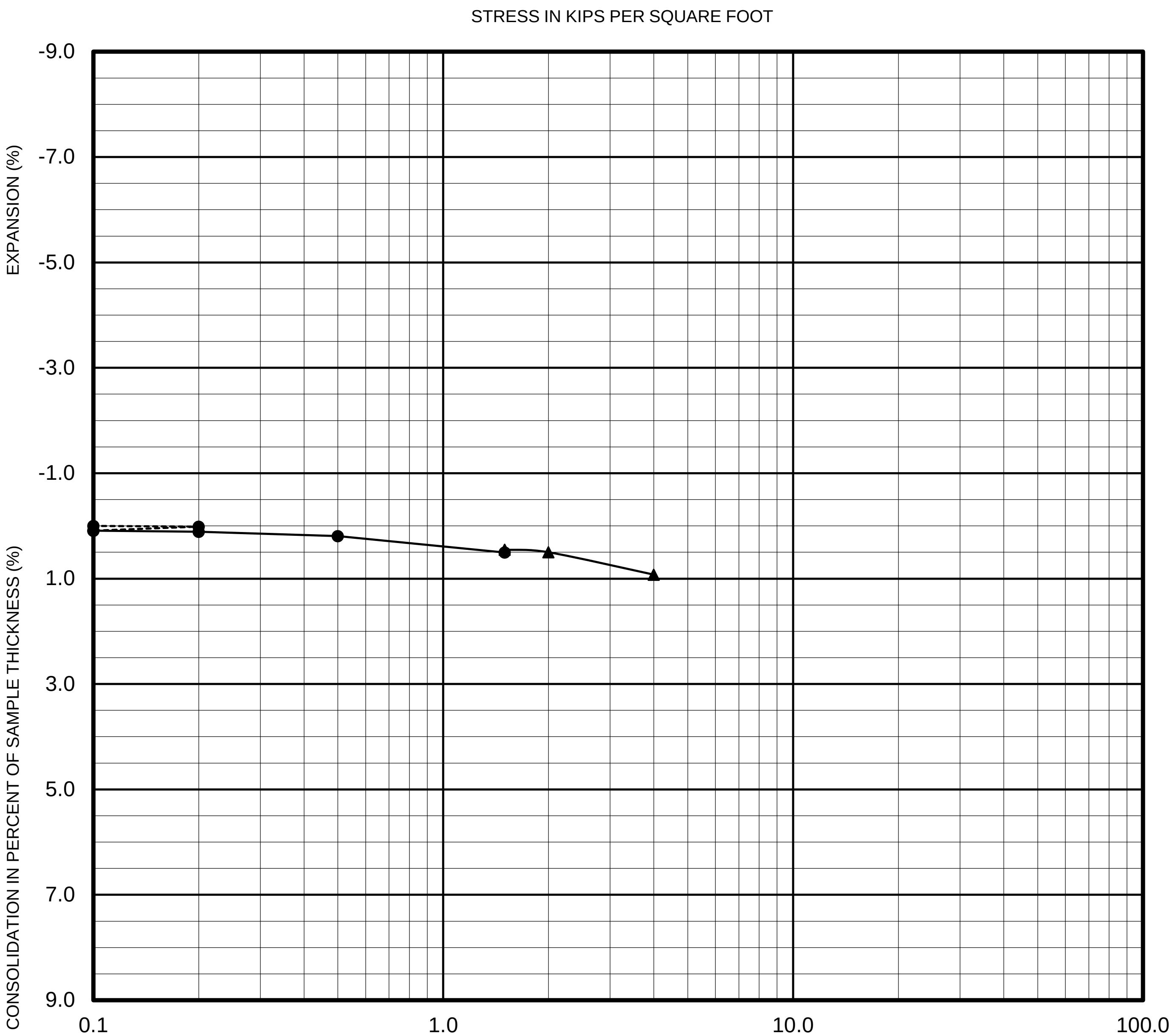
CONSOLIDATION TEST RESULTS

PROPOSED MULTI-FAMILY DEVELOPMENT
COMPARK SOUTH, PARKER, COLORADO



Seating Cycle
Loading Prior to Inundation
Loading After Inundation
Rebound Cycle

Moisture Increase (%):	0.7
Swell Percentage (%):	0.1
Swell Pressure (psf):	700

Sample Location: B-10
Depth (ft): 14.0-15.0
Soil Type: SC (Fill)

PERFORMED IN GENERAL ACCORDANCE WITH ASTM D 4546

FIGURE B-33

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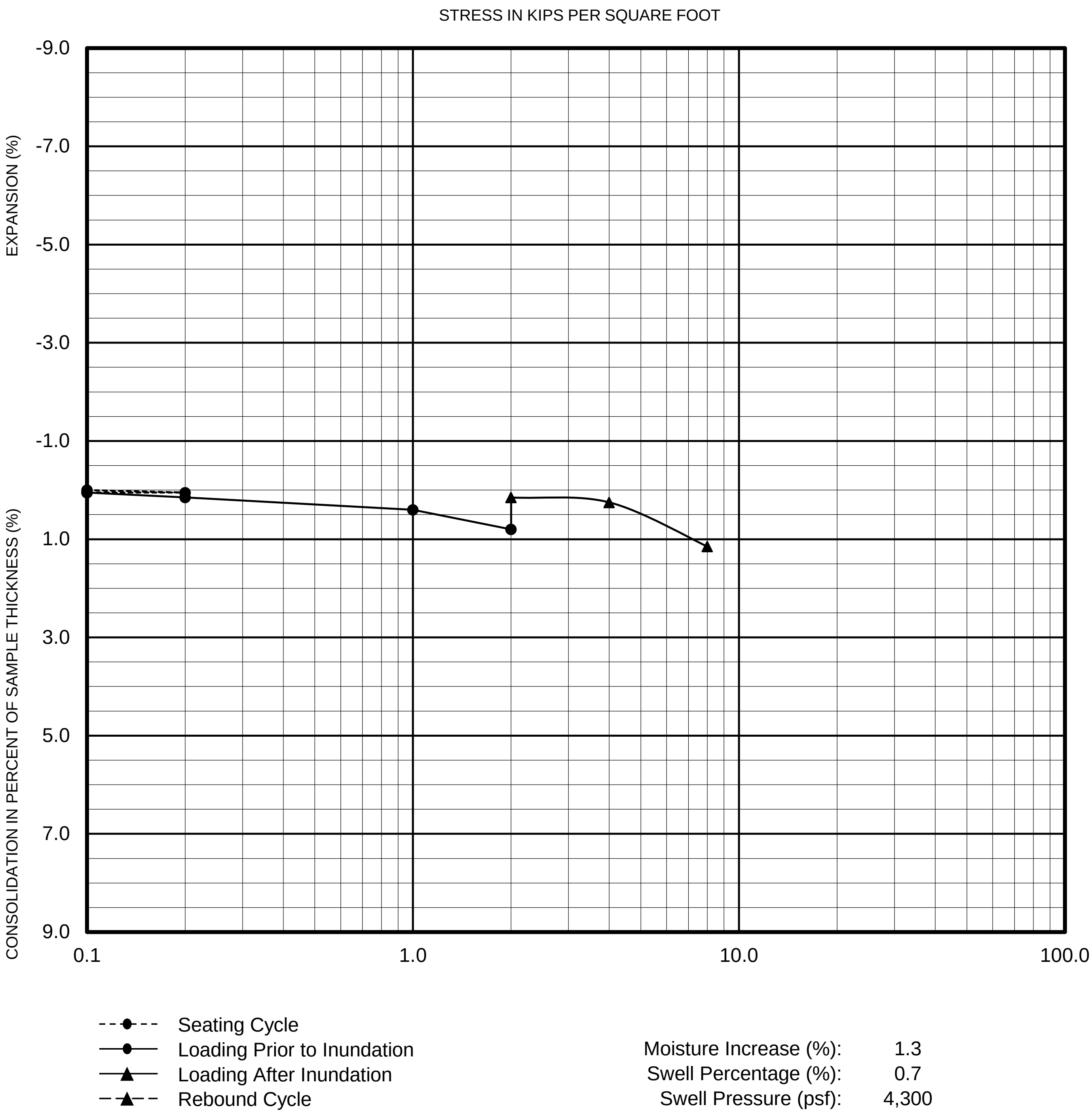
CONSOLIDATION TEST RESULTS
PROPOSED MULTI-FAMILY DEVELOPMENT
COMPARK SOUTH, PARKER, COLORADO



Moisture Increase (%):	1.3
Swell Percentage (%):	0.7
Swell Pressure (psf):	4,300

Sample Location: B-10
Depth (ft): 19.0-20.0
Soil Type: SC (Fill)

PERFORMED IN GENERAL ACCORDANCE WITH ASTM D 4546

FIGURE B-34

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CONSOLIDATION TEST RESULTS

PROPOSED MULTI-FAMILY DEVELOPMENT

COMPARK SOUTH, PARKER, COLORADO

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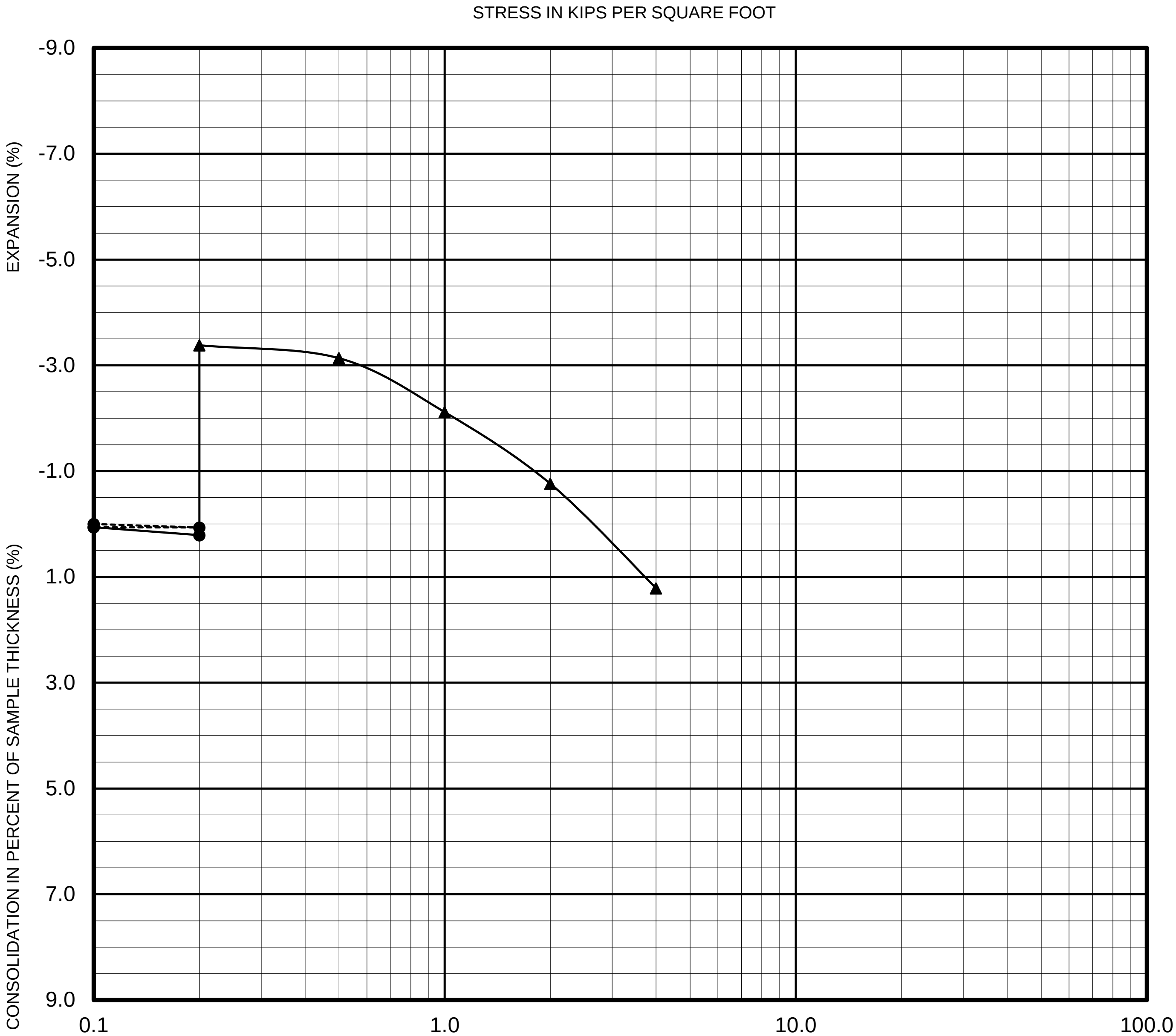

- Seating Cycle
- Loading Prior to Inundation
- Loading After Inundation
- Rebound Cycle

Moisture Increase (%): 6.1
Swell Percentage (%): 3.6
Swell Pressure (psf): 2,600

Sample Location: B-11
Depth (ft): 2.0-3.0
Soil Type: SC (Fill)

PERFORMED IN GENERAL ACCORDANCE WITH ASTM D 4546

FIGURE B-35

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CONSOLIDATION TEST RESULTS

PROPOSED MULTI-FAMILY DEVELOPMENT
COMPARK SOUTH, PARKER, COLORADO

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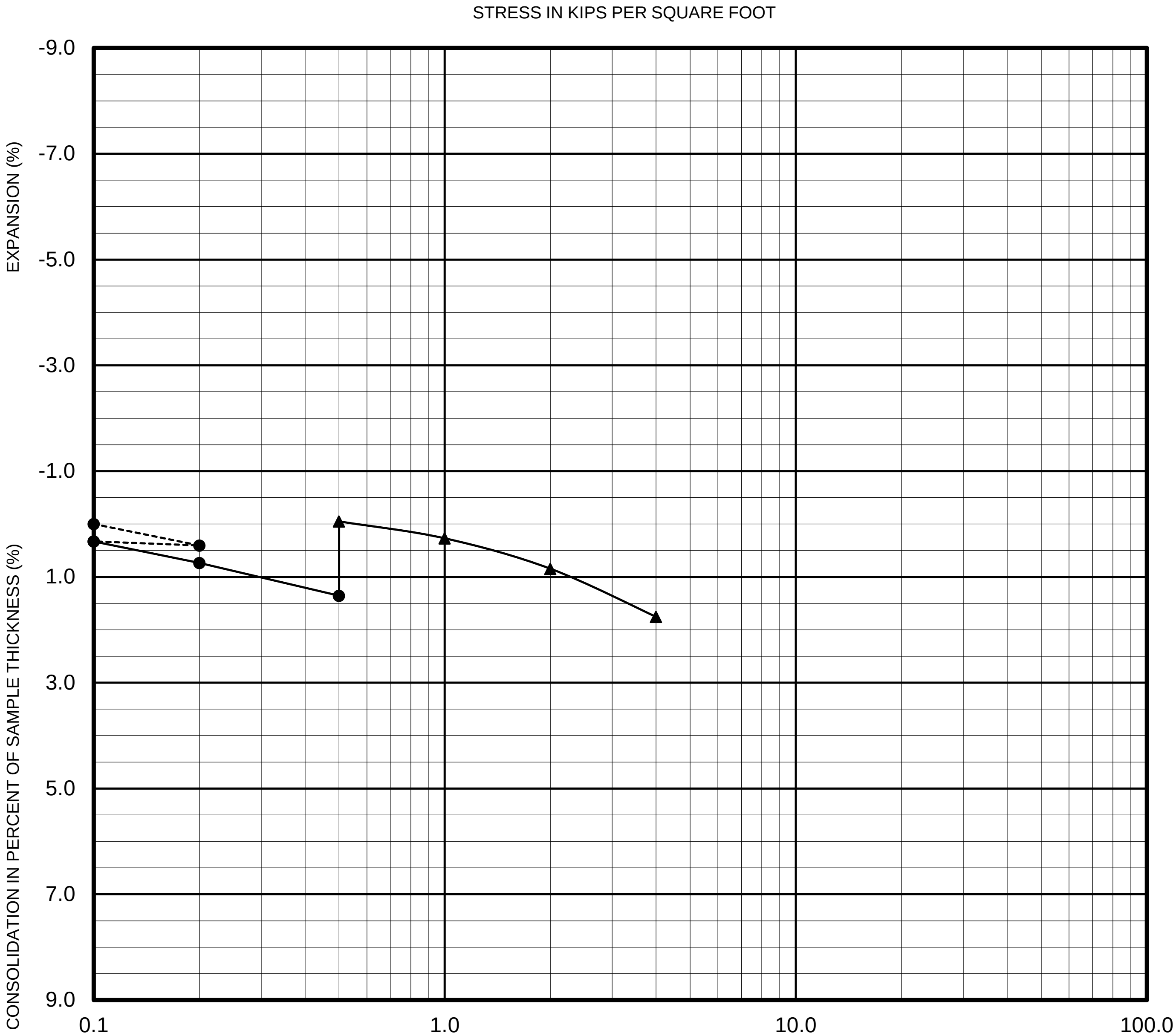

- - ● - - Seating Cycle
—●— Loading Prior to Inundation
—▲— Loading After Inundation
- - ▲ - - Rebound Cycle

Moisture Increase (%):	1.8
Swell Percentage (%):	1.4
Swell Pressure (psf):	2,600

Sample Location:	B-11
Depth (ft):	4.0-5.0
Soil Type:	CL (Fill)

PERFORMED IN GENERAL ACCORDANCE WITH ASTM D 4546

FIGURE B-36

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CONSOLIDATION TEST RESULTS

PROPOSED MULTI-FAMILY DEVELOPMENT

COMPARK SOUTH, PARKER, COLORADO

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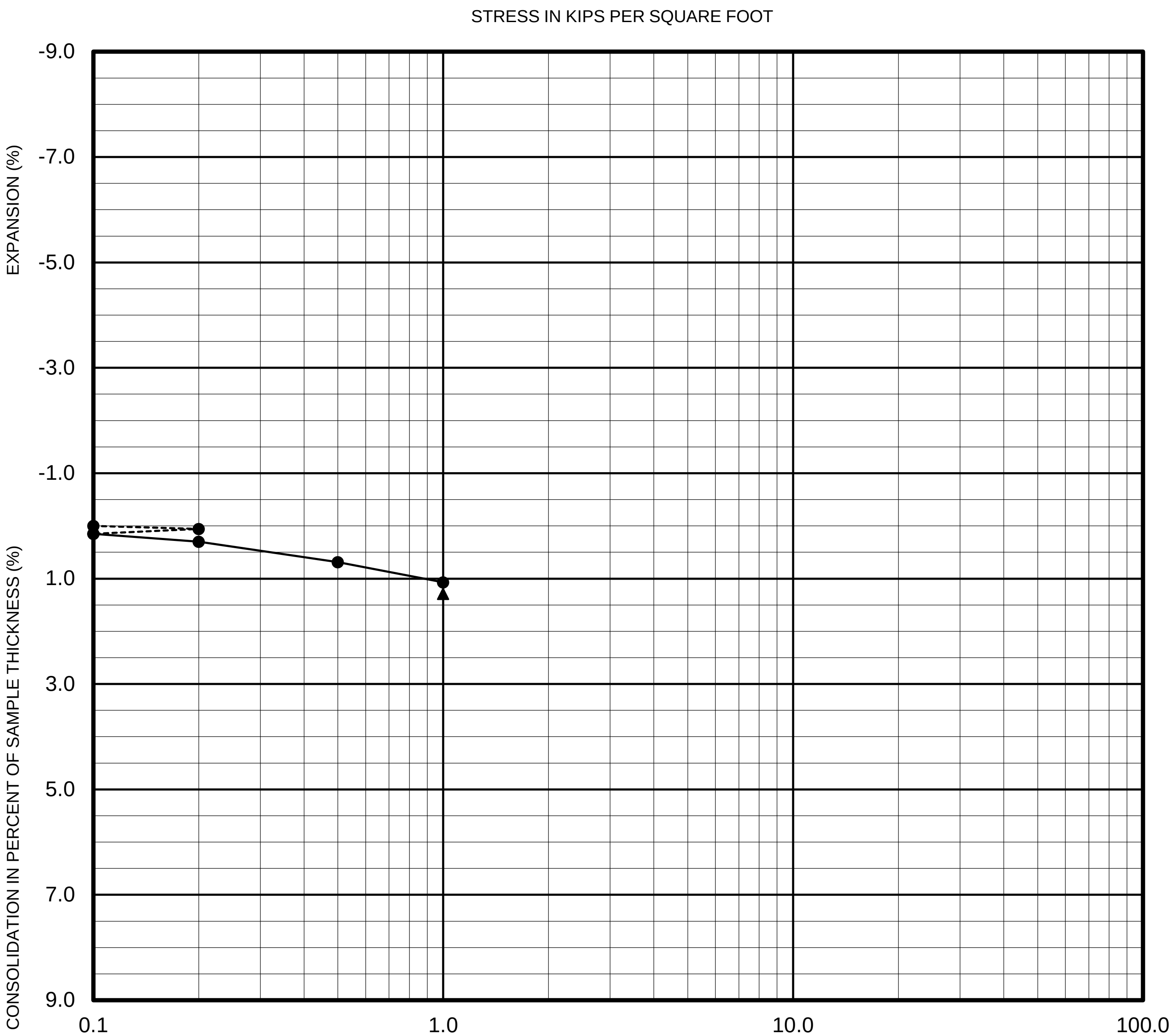

Seating Cycle
Loading Prior to Inundation
Loading After Inundation
Rebound Cycle

Moisture Increase (%):	0.4
Swell Percentage (%):	-0.2
Swell Pressure (psf):	--

Sample Location: B-11
Depth (ft): 9.0-10.0
Soil Type: SC (Fill)

PERFORMED IN GENERAL ACCORDANCE WITH ASTM D 4546

FIGURE B-37

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CONSOLIDATION TEST RESULTS

PROPOSED MULTI-FAMILY DEVELOPMENT
COMPARK SOUTH, PARKER, COLORADO

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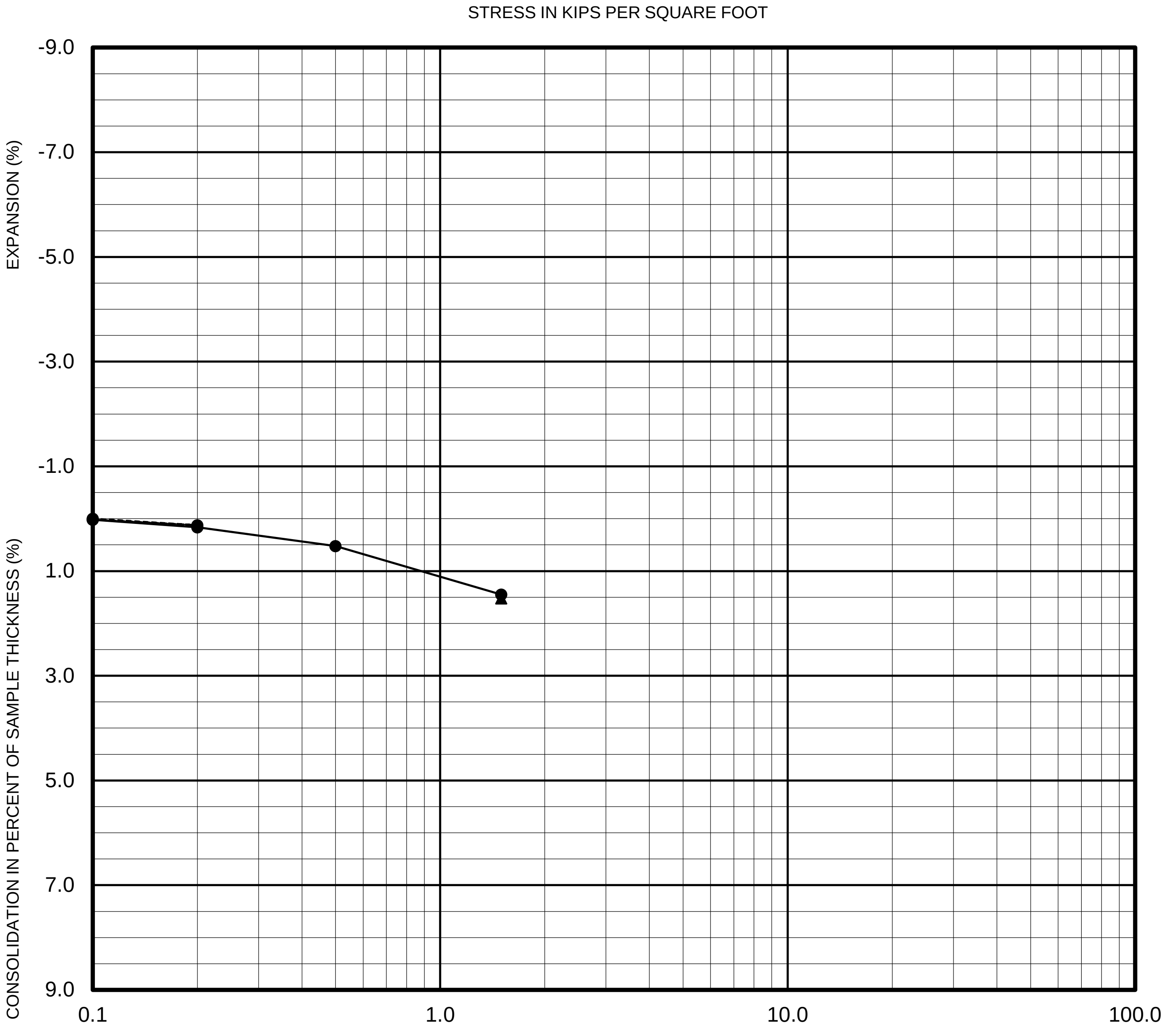

Seating Cycle
Loading Prior to Inundation
Loading After Inundation
Rebound Cycle

Moisture Increase (%):	2.0
Swell Percentage (%):	-0.1
Swell Pressure (psf):	--

Sample Location: B-11
Depth (ft): 14.0-14.7
Soil Type: SC (Fill)

PERFORMED IN GENERAL ACCORDANCE WITH ASTM D 4546

FIGURE B-38

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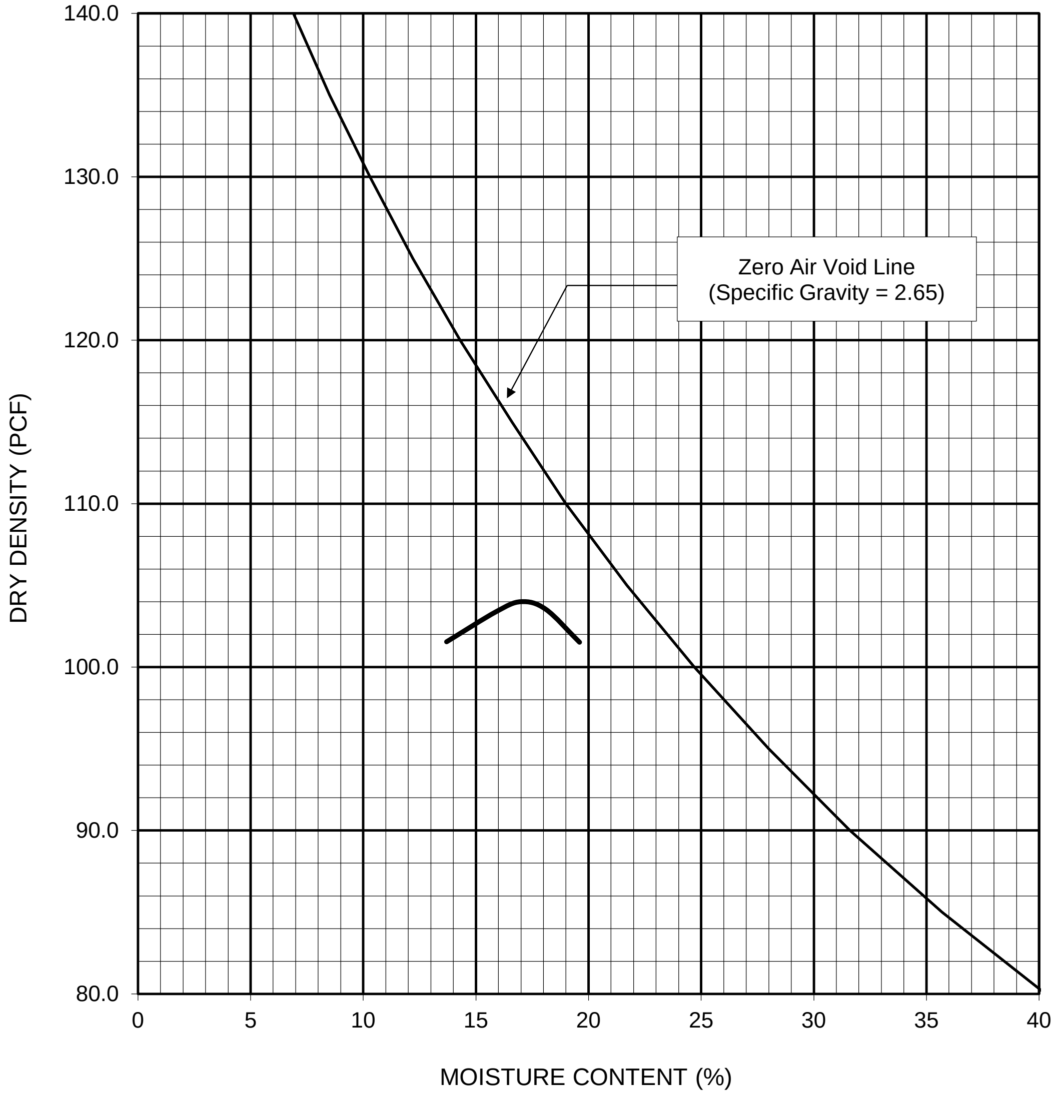
CONSOLIDATION TEST RESULTS

PROPOSED MULTI-FAMILY DEVELOPMENT
COMPARK SOUTH, PARKER, COLORADO



Sample Location	Depth (ft)	Soil Description	Maximum Dry Density (pcf)	Optimum Moisture Content (percent)
B-1,B-8,B-9	0.0-5.0	Brown Well-graded Clayey SAND; Trace Gravel	104.0	17.0
Dry Density and Moisture Content Values Corrected for Oversize (ASTM D 4718)			N/A	N/A

PERFORMED IN GENERAL ACCORDANCE WITH ☐ ASTM D 1557 ☑ ASTM D 698 METHOD ☑ A ☐ B ☐ C

FIGURE B-39

PROCTOR DENSITY TEST RESULTS

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PROPOSED MULTI-FAMILY DEVELOPMENT
COMPARK SOUTH, PARKER, COLORADO

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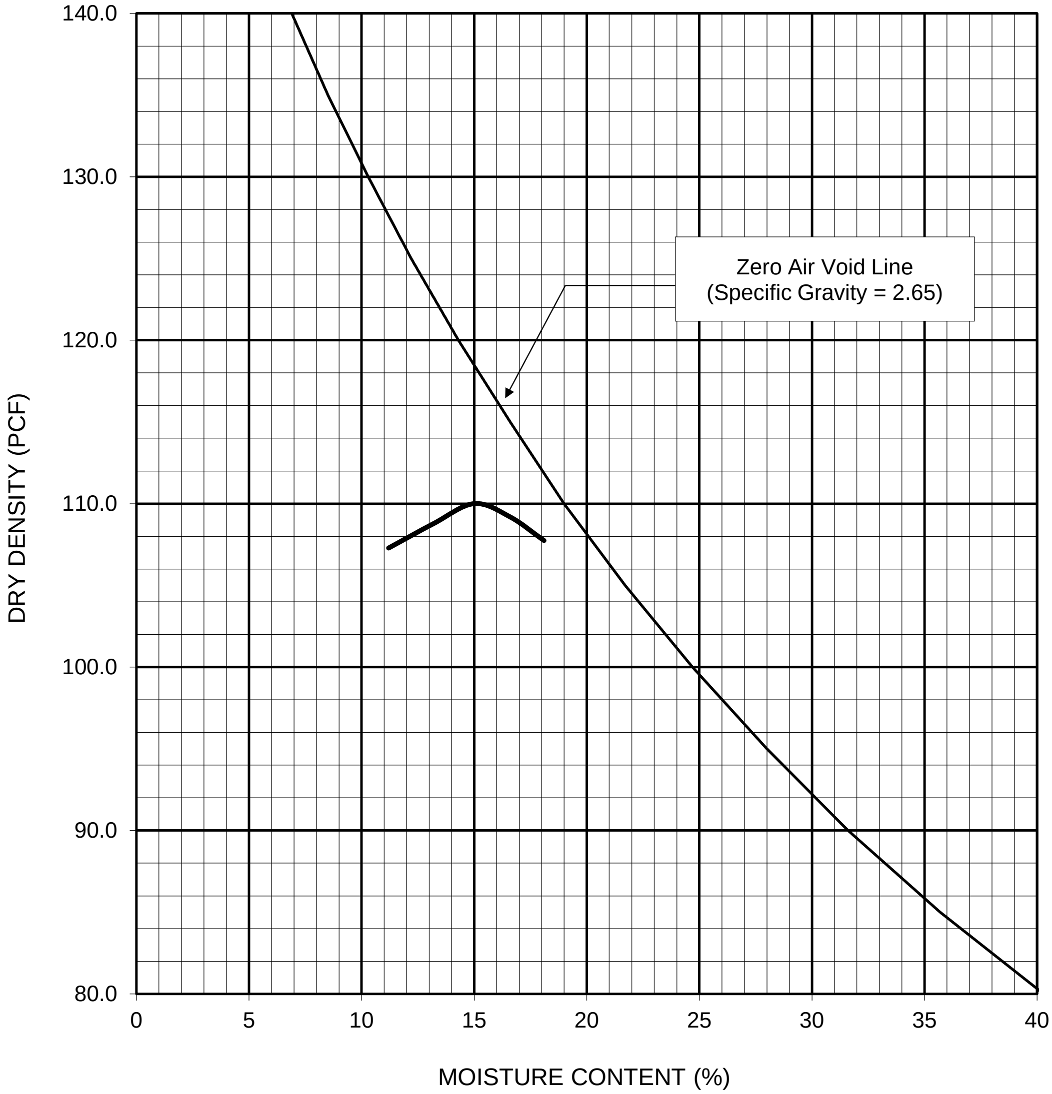

Sample Location	Depth (ft)	Soil Description	Maximum Dry Density (pcf)	Optimum Moisture Content (percent)
B-2,B-5,B-6,B-7	0.0-5.0	Light Brown Clayey SAND	110.0	15.0
Dry Density and Moisture Content Values Corrected for Oversize (ASTM D 4718)			N/A	N/A

PERFORMED IN GENERAL ACCORDANCE WITH ☐ ASTM D 1557 ☑ ASTM D 698 METHOD ☐ A ☑ B ☐ C

FIGURE B-40

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PROCTOR DENSITY TEST RESULTS

PROPOSED MULTI-FAMILY DEVELOPMENT
COMPARK SOUTH, PARKER, COLORADO
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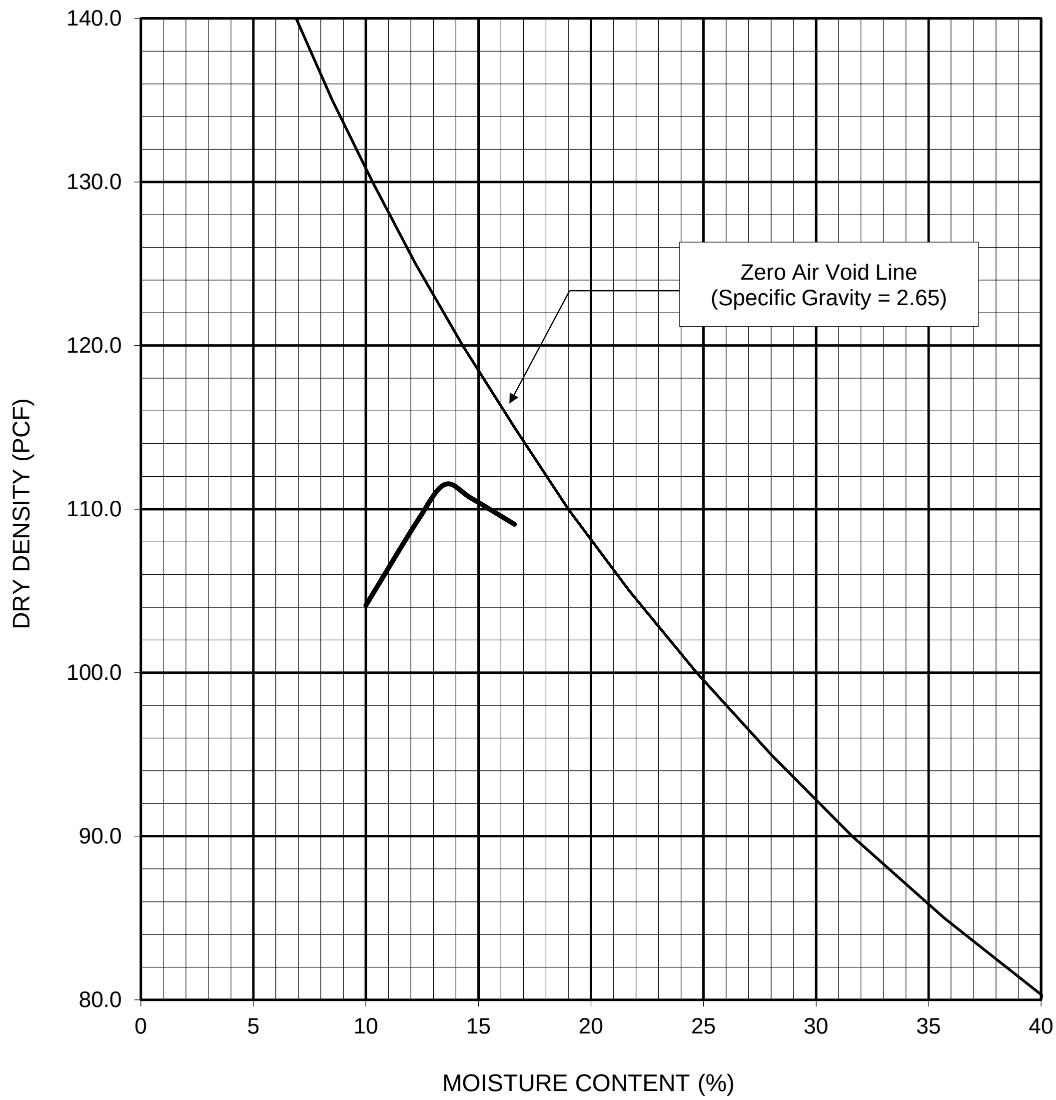

Sample Location	Depth (ft)	Soil Description	Maximum Dry Density (pcf)	Optimum Moisture Content (percent)
B-3, B-4, B-10, B-11	0.0-5.0	Brown Sandy Lean CLAY; Trace Gravel	111.5	13.5
Dry Density and Moisture Content Values Corrected for Oversize (ASTM D 4718)			N/A	N/A

PERFORMED IN GENERAL ACCORDANCE WITH ☐ ASTM D 1557 ☑ ASTM D 698 METHOD ☐ A ☑ B ☐ C

FIGURE B-41

PROCTOR DENSITY TEST RESULTS

PROPOSED MULTI-FAMILY DEVELOPMENT
COMPARK SOUTH, PARKER, COLORADO

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SAMPLE LOCATION	SAMPLE DEPTH (ft)	pH [1]	RESISTIVITY [2] (ohm-cm)	SULFATE CONTENT [3] (ppm)	(%)	CHLORIDE CONTENT [4] (ppm)
B-1,B-8,B-9	0.0-5.0	6.9	2,083	200	0.020	15
B-2,B-5,B-6,B-7	0.0-5.0	7.1	5,000	9	0.001	15

[1] PERFORMED IN GENERAL ACCORDANCE WITH ASTM D 4972
[2] PERFORMED IN GENERAL ACCORDANCE WITH AASHTO T288
[3] PERFORMED IN GENERAL ACCORDANCE WITH CDOT TEST METHOD CP-L 2103
[4] PERFORMED IN GENERAL ACCORDANCE WITH CDOT TEST METHOD CP-L 2104

CORROSIVITY TEST RESULTS

PROPOSED MULTI-FAMILY DEVELOPMENT
COMPARK SOUTH, PARKER, COLORADO

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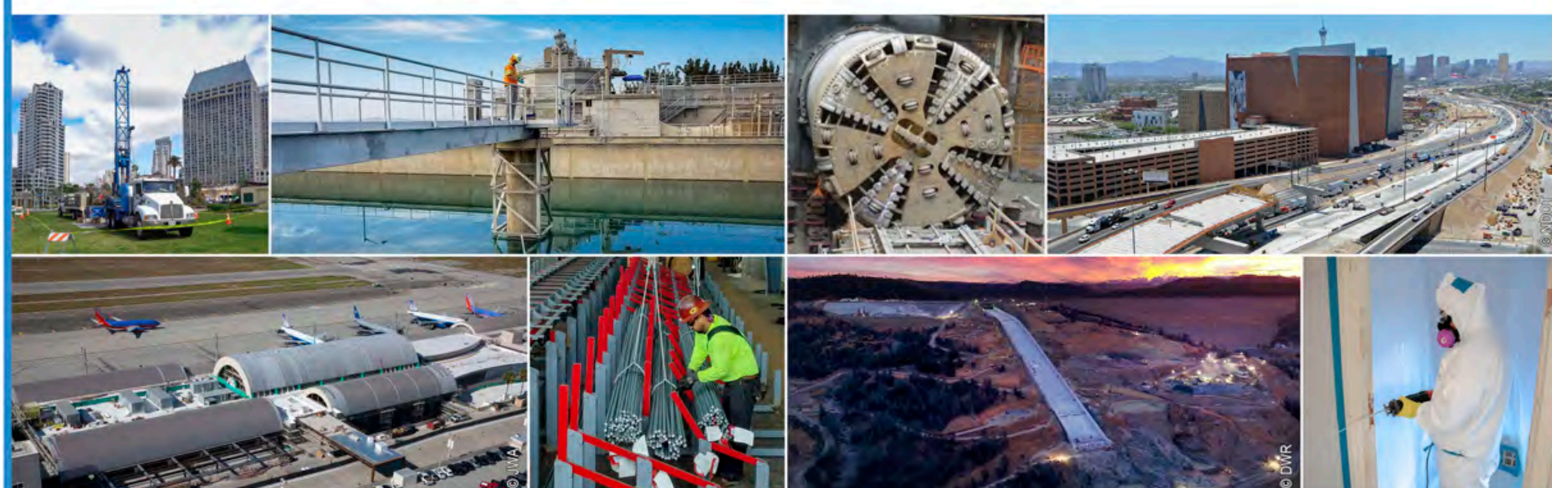

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