



# Geotechnical Engineering Report

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**Proposed Parker McDonald's Restaurant #5078  
Southeast of South Chambers Road and South Red Sky Drive  
Parker, Colorado**

April 9, 2021  
Terracon Project No. 25215044

**Prepared for:**  
McDonald's USA, LLC  
Chicago, Illinois

**Prepared by:**  
Terracon Consultants, Inc.  
Wheat Ridge, Colorado



April 9, 2021

McDonald's USA, LLC  
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Re: Geotechnical Engineering Report  
Proposed Parker McDonald's Restaurant #5078  
Southeast of South Chambers Road and South Red Sky Drive  
Parker, Colorado  
Terracon Project No. 25215044

Ms. Nuno:

We have completed the geotechnical engineering services for the project referenced above. This study was performed in general accordance with Terracon Proposal No. P25215044 dated February 18, 2021. This report presents the findings of the subsurface exploration and provides geotechnical recommendations concerning earthwork and the design and construction of foundations, floor slabs, and pavements for the proposed project.

We appreciate the opportunity to be of service to you on this project. If you have any questions concerning this report or if we may be of further service, please contact us.

Sincerely,  
**Terracon Consultants, Inc.**

Dwight Fadel  
Staff Engineer

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Regional Senior Consultant

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Environmental



Facilities



Geotechnical



Materials

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**Note:** This report was originally delivered in a web-based format. For more interactive features, please view your project online at [client.terracon.com](http://client.terracon.com).

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## REPORT SUMMARY

Topic <sup>1</sup>	Overview Statement <sup>2</sup>
<b>Project Description</b>	We understand the project consists of constructing a new single-story, about 4,600 square-foot building with a double drive thru, trash enclosure area, and associated parking areas and access drives. No below-grade levels are planned.
<b>Geotechnical Characterization</b>	<p>Existing fill materials encountered to depths of about 2 to 3 feet below grade surface (bgs)</p> <p>Native sand soils underlying fill materials in Boring No. 6 to a depth of about 4 feet bgs.</p> <p>Interlayered sandstone, claystone and siltstone bedrock was encountered at the surface of Boring Nos. 1, 2, and 5 and underlying the existing fill materials and native soils in all other borings explored.</p> <p>Groundwater was not encountered during our field exploration.</p>
<b>Geotechnical Considerations</b>	Based on the results of the laboratory testing and our experience in the area, the clay fill materials and claystone bedrock have low to high expansive potential, while the native sand soils and sandstone bedrock are considered to have nil to low expansive potential. A summary of laboratory test results is included in the <b>Exploration Results</b> .
<b>Earthwork</b>	<p>Remove existing fill materials from below shallow foundations, floor slabs-on-grade, and pavements. We have provided an option for partial removal and replacement of existing fill materials from below pavements.</p> <p>The amount of movement associated with foundations, floor slabs, slabs-on-grade, etc. will be related to the wetting of the underlying soils and bedrock. Therefore, it is imperative the recommendations outlined in the <b>Grading and Drainage</b> subsection of <b>Earthwork</b> be followed to reduce potential movement. Moisture conditioning and/or replacement of the on-site fill materials and/or native soils and bedrock should follow the recommendations outlined in <b>Earthwork</b>.</p>
<b>Foundation Recommendations</b>	Due to the presence of expansive claystone bedrock, it is our opinion the proposed building should be constructed on a drilled pier foundation system bottomed in the underlying sandstone/claystone bedrock. If the owner is willing to accept a higher risk of movement, the proposed restaurant could be constructed on spread footings on a zone of engineered fill.
<b>Seismic Considerations</b>	The site is considered to have a seismic site classification of C.
<b>Interior Floors</b>	Based on the properties of the subsurface materials, the floor system for the proposed restaurant may consist of a slab-on-grade constructed a zone of engineered fill, provided the owner is willing to accept the risk of movement. If very little movement can be tolerated, structural floors, supported independent of the subgrade materials, are recommended.
<b>Exterior Flatwork</b>	Exterior flatwork may be constructed on a zone of engineered fill, provided the owner is willing to accept the risk of movement.

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Topic <sup>1</sup>	Overview Statement <sup>2</sup>
<b>Lateral Earth Pressures</b>	Based on materials encountered during the exploration and various possible earth pressure conditions, lateral earth pressure coefficients and equivalent fluid densities have been calculated.
<b>Pavements</b>	Pavements may be constructed on a zone of engineered fill, provided the owner is willing to accept the risk of movement.

1. If the reader is reviewing this report as a PDF, the topics above can be used to access the appropriate section of the report by simply clicking on the topic itself.
2. This summary should be used in conjunction with the entire report for design purposes. It should be recognized that details were not included or fully developed in this section, and the report must be read in its entirety for a comprehensive understanding of the items contained herein. The section titled **General Comments** should be read for an understanding of the report limitations.

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**Southeast of South Chambers Road and South Red Sky Drive**  
**Parker, Colorado**  
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**April 9, 2021**

## INTRODUCTION

This report presents the results of our subsurface exploration and geotechnical engineering services performed for the proposed Parker McDonald's Restaurant #50785 to be located northeast of South Chambers Road and East Hess Road in Parker, Colorado.

The purpose of these services is to provide information and geotechnical engineering recommendations relative to:

- Subsurface soil and bedrock conditions
- Groundwater levels
- Earthwork
- Drainage
- Lateral earth pressures
- Seismic site classification
- Foundation design and construction
- Floor slab design and construction
- Pavement design and construction

The geotechnical engineering Scope of Services for this project included the advancement of ten test borings (designated as Boring Nos. 1 through 7 and P1 through P3) to depths ranging from approximately 5 to 30 feet below existing site grades. Plans showing the site and boring locations are shown in the **Site Location and Exploration Plans** section. The results of the laboratory testing performed on soil and bedrock samples obtained from the site during the field exploration are included on the boring logs in the **Exploration Results** section.

## SITE CONDITIONS

The following description of site conditions is derived from our site visit in association with the field exploration.

Item	Description
<b>Parcel Information</b>	The project is to be located northeast of South Chambers Road and East Hess Road in Parker, Colorado. The general location of the proposed project is 39.4942° N, 104.8010° W. See <b>Site Location</b>

Item	Description
<b>Existing Improvements</b>	The subject site consists of a vacant lot. Based on our review of historical aerial imagery, the lot appears to have been previously graded. In addition, the Arapahoe Canal was once located on the western portion of the site and has since been graded to match the surrounding grades.
<b>Current Ground Cover</b>	Ground cover on the subject site consists of grass, weeds, and barren land.
<b>Existing Topography</b>	The site appears to be generally flat with an elevation difference of about 5 feet.

## PROJECT DESCRIPTION

Our initial understanding of the project was provided in our proposal and was discussed during project planning. Our final understanding of the project conditions is as follows:

Item	Description
<b>Project Description</b>	We understand the project consists of constructing a new single-story, about 4,600 square-foot building with a double drive thru, trash enclosure area, and associated parking areas and access drives. No below-grade levels are planned.
<b>Maximum Loads</b>	<ul style="list-style-type: none"> <li>■ Columns: up to 50 kips (assumed)</li> <li>■ Walls: 2 to 3 kips per linear foot (klf)(assumed)</li> <li>■ Slabs: 150 to 250 pounds per square foot (psf)(assumed)</li> </ul>
<b>Grading/Slopes</b>	Cut and fill, 3 feet (±) max
<b>Below-Grade Structures</b>	None indicated
<b>Free-Standing Retaining Walls</b>	None indicated
<b>Below-Grade Areas</b>	None indicated
<b>Pavements</b>	Traffic loads were not available at the time of this report. We will assume traffic loads consistent with that of similar use.

## GEOTECHNICAL CHARACTERIZATION

We have developed a general characterization of the subsurface conditions based upon our review of the subsurface exploration, laboratory data, geologic setting, and our understanding of the project. This characterization, termed GeoModel, forms the basis of our geotechnical calculations and evaluation of site preparation and foundation options. Conditions encountered at each exploration point are indicated on the individual logs. The individual logs can be found in the **Exploration Results** section and the GeoModel can be found in the **Figures** section of this report. As noted in **General Comments**, the characterization is based upon widely spaced exploration points across the site, and variations are likely.

## Subsurface Profile

As part of our analyses, we identified the following model layers within the subsurface profile. For a more detailed view of the model layer depths at each boring location, refer to the GeoModel.

Model Layer	Layer Name	General Description
1	Existing Fill	Fill materials consisting of lean clay with varying amounts of sand and gravel and sand with varying amounts of clay, silt, and gravel; variable densities
2	Native Sand	Native sand soils; dense
3	Sandstone Bedrock	Sandstone bedrock with varying amounts of silt and clay; soft to hard
4	Claystone Bedrock	Claystone bedrock with varying amounts of sand and silt; soft to hard
5	Siltstone Bedrock	Siltstone, trace sand; hard

Based on the results of the laboratory testing and our experience in the area, the clay fill materials and claystone bedrock have low to high expansive potential, while the native sand soils and sandstone bedrock are considered to have nil to low expansive potential. A summary of

## Groundwater Conditions

The borings were observed while drilling and upon completion of drilling for the presence and level of groundwater. The water levels encountered in the boreholes can be found on the boring logs in **Exploration Results** and are summarized below.

Boring No.	Shallowest Depth to Groundwater Encountered While or Upon Completion of Drilling <sup>1</sup>
1	None encountered
2	None encountered
3	None encountered
4	None encountered
5	None encountered
6	None encountered
7	None encountered
P1	None encountered
P2	None encountered
P3	None encountered

1. Due to safety concerns, borings were backfilled immediately after completion. Therefore, subsequent groundwater measurements were not obtained.

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These observations represent groundwater conditions at the time of the field exploration and may not be indicative of other times or at other locations. Groundwater levels can be expected to fluctuate with varying seasonal and weather conditions.

Based upon review of U.S. Geological Survey maps (<sup>1</sup>Hillier, et al, 1983), regional groundwater is expected to be encountered in the Dawson Aquifer, generally below a depth of 20 feet and commonly more than 100 feet below present ground surface. Shallowest depths to water table generally occur along stream valleys and in colluvial deposits.

Zones of perched and/or trapped groundwater may also occur at times in the subsurface soils overlying bedrock, on top of the bedrock surface or within permeable fractures in the bedrock materials. The location and amount of perched water is dependent upon several factors, including hydrologic conditions, type of site development, irrigation demands on or adjacent to the site, fluctuations in water features, seasonal and weather conditions.

Groundwater level fluctuations occur due to seasonal variations in the amount of rainfall, runoff, and other factors not evident at the time the borings were performed. Groundwater levels during construction or at other times in the life of the structure may be higher or lower than the levels indicated on the boring logs. The possibility of groundwater level fluctuations should be considered when developing the design and construction plans for the project.

## GEOTECHNICAL OVERVIEW

Based on subsurface conditions encountered in the borings, the site appears suitable for the proposed construction from a geotechnical point of view provided certain precautions and design and construction recommendations outlined in this report are followed. We have identified geotechnical conditions that could impact design and construction of the proposed building and other site improvements.

### Existing Fill Materials

Up to about 3 feet of fill materials were encountered in portions of the site. Fill depths presented in the boring logs are approximate and the depth, lateral extents, and composition of fill should be expected to vary. We do not possess any information regarding whether the fill was placed under the observation of a Geotechnical Engineer.

Based upon the results of our field exploration and laboratory testing, it is our opinion the existing fill should not be used to support foundations, interior slabs, exterior slabs-on-grade, or pavement construction without complete removal and modification.

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<sup>1</sup>Hillier, Donald E.; Schneider, Paul A., Jr.; and Hutchinson, E. Carter, 1983, *Depth to Water Table (1976-1977) in the Greater Denver Area, Front Range Urban Corridor, Colorado*, United States Geological Survey, Map I-856-K.

If the owner is willing to accept a higher risk of movement for pavements and exterior slabs, consideration could be given to overexcavating a portion of the existing fill materials below these elements, then processing, moisture conditioning and compacting the materials back to subgrade elevation.

There exists the potential for construction debris and/or domestic trash to be encountered within the fill on some portions of the site. The potential for encountering construction debris or domestic trash is considered to be low. The fill materials should be observed for the presence of trash and debris during site grading and construction.

The existing fill can be reused as engineered fill below foundations, slabs-on-grade, and pavements, provided the material meets the requirements of imported soils in the **Material Types** subsection in **Earthwork**, any deleterious materials are removed, and some movement can be tolerated. Some removal and replacement may be required if unsuitable or soft materials are exposed.

### **Expansive Soils and Bedrock**

Based on the results of the laboratory testing and our experience in the area, the clay fill materials and claystone bedrock have low to high expansive potential, while the sand fill materials, native sand soils, and sandstone bedrock are considered to have nil to low expansive potential.

This report provides recommendations to help mitigate the effects of soil and bedrock shrinkage and expansion. However, even if these procedures are followed, some movement and cracking in the buildings, pavements, and flatwork should be anticipated. The severity of cracking and other damage such as uneven floor slabs will probably increase if any modification of the site results in excessive wetting or drying of the expansive soils and bedrock. Eliminating the risk of movement and distress is generally not feasible, but it may be possible to further reduce the risk of movement if significantly more expensive measures are used during construction. It is imperative the recommendations outlined in the **Grading and Drainage** subsection of **Earthwork** in this report be followed to reduce movement.

## **EARTHWORK**

The following presents recommendations for site preparation, excavation, subgrade preparation, and placement of engineered fills on the project. All earthwork on the project should be observed and evaluated by Terracon.

### **Site Preparation**

Strip and remove existing vegetation, organics, and other deleterious materials from proposed building and pavement areas. All exposed surfaces should be free of mounds and depressions that could prevent uniform compaction.

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Stripped materials consisting of vegetation, unsuitable fills, and organic materials should be wasted from the site or used to revegetate landscaped areas or exposed slopes after completion of grading operations.

Where possible, the site should be initially graded to create a relatively level surface to receive fill and to provide for a relatively uniform thickness of fill beneath the proposed building and improvement areas. All exposed areas that will receive fill, once properly cleared, should be scarified to a minimum depth of 12 inches, conditioned to near optimum moisture content, and compacted. It is imperative the moisture content of prepared materials be protected from moisture loss.

Although evidence of underground facilities such as grease pits, septic tanks, and basements was not observed during our exploration, such features could be encountered during construction. The Arapahoe Canal previously ran through the property. If deeper fills or underground facilities are encountered, such features should be removed, and the excavation should be thoroughly cleaned of loose soils and generated debris prior to backfill placement and/or construction.

Due to the presence of very hard sandstone/claystone bedrock, we anticipate heavy-duty construction equipment will be necessary to complete the required excavations and processing of bedrock materials. Specialized heavy-duty equipment capable of ripping or jack hammering may be required for excavation of isolated areas of hard sandstone/claystone bedrock. Consideration should be given to obtaining a unit price for difficult excavation in the contract documents for the project.

Depending upon seasonal conditions, surface water may infiltrate into the excavations on the site. Water seeping into excavations at this site could most likely be controlled by shallow trenches leading to a sump pit where the water could be removed by pumping.

The stability of subgrade soils may be affected by precipitation, repetitive construction traffic, or other factors. If unstable conditions are encountered or develop during construction, workability may be improved by overexcavation of wet zones and mixing these soils with crushed gravel. Use of geotextiles could also be considered as a stabilization technique. Lightweight excavation equipment may be required to reduce subgrade pumping.

### Material Types

Fill for this project should consist of engineered fill. Engineered fill is fill that meets the criteria presented in this report and has been properly documented.

Engineered fill should meet the following material property requirements:

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Fill Type <sup>1,2</sup>	USCS Classification	Acceptable Location for Placement
On-site clay soils	CL	On-site clay soils are considered suitable for reuse as engineered fill below foundation, slab, and pavement areas, and as general fill for this project
On-site sand soils	SP, SC	On-site sand soils are considered suitable for reuse as engineered fill below foundation, slab, and pavement areas and as general fill for this project.
Processed sandstone/claystone bedrock <sup>5</sup>	N/A	Properly processed on-site sandstone/claystone bedrock is considered suitable for engineered fill below foundation, slab and pavement areas.
Imported soils	Varies	Imported soils meeting the gradation outlined herein can be considered acceptable for use as engineered fill below foundation, slab, and pavement areas, and as general fill for this project.

1. Controlled, compacted fill should consist of approved materials that are free of organic matter and debris. Frozen material should not be used, and fill should not be placed on a frozen subgrade. A sample of each material type should be submitted to the Geotechnical Engineer for evaluation.
2. Care should be taken during the fill placement process to avoid zones of dis-similar fill. Improvements constructed over varying fill types are at a higher risk of differential movement compared to improvements over a uniform fill zone.
3. On-site sandstone/claystone bedrock materials should be staged separately from excavated soils and processed to a soil-like consistency with a maximum particle size of 1½ inches.

Imported soils and on-site materials for engineered fill (if required) should meet the following material property requirements:

Gradation	Percent Finer by Weight (ASTM C136)
1½"	100
1"	90-100
¾"	50-100
No. 4 Sieve	50-100
No. 200 Sieve	>50

- Liquid Limit ..... 30 (max)
- Plasticity Index ..... 15 (max)
- Maximum Expansive Potential (%) ..... 1.0\*

\*Measured on a sample compacted to approximately 95 percent of the ASTM D698 maximum dry density at optimum water content. The sample is confined under a 200-psf surcharge and submerged.

## Compaction Requirements

Engineered fill should be placed and compacted in horizontal lifts, using equipment and

procedures that will produce recommended moisture contents and densities throughout the lift.

Item	Description
<b>Fill Lift Thickness</b>	8 inches or less in loose thickness when heavy, self-propelled compaction equipment is used 4 to 6 inches in loose thickness when hand-guided equipment (e.g. jumping jack, plate compactor) is used
<b>Compaction Requirements</b> <sup>1,2</sup>	Minimum of 95% of the material's standard Proctor maximum dry density (ASTM D698)
<b>Moisture Content of Cohesive Soils (Clay Soils)</b> <sup>3</sup>	+1 to +4% of the optimum moisture content below building 0 to +2% of the optimum moisture content below exterior flatwork and pavements
<b>Moisture Content of Cohesionless Soils (Sand Soils)</b>	-1 to +3% of the optimum moisture content

1. We recommend that engineered fill be tested for water content and compaction during placement. Should the results of the in-place density tests indicate the specified water or compaction limits have not been met, the area represented by the test should be reworked and retested as required until the specified water and compaction requirements are achieved.
2. Water levels should be maintained low enough to allow for satisfactory compaction to be achieved without the compacted fill material pumping when proofrolled.
3. Moisture conditioned clay soils should not be allowed to dry out. A loss of moisture within these materials could result in an increase in the materials expansive potential. Subsequent wetting of these materials could result in undesirable movement.

## Excavation

Excavations into the subsurface soils and bedrock will encounter a variety of conditions. The individual contractor(s) is responsible for designing and constructing stable, temporary excavations as required to maintain stability of both the excavation sides and bottom. All excavations should be sloped or shored in the interest of safety following local and federal regulations, including current Occupational Safety and Health Administration (OSHA) excavation and trench safety standards.

Soils and bedrock penetrated by the proposed excavations may vary significantly across the site. The soil and bedrock classifications are based solely on the materials encountered in the exploratory borings. The contractor should verify that similar conditions exist throughout the proposed area of excavation. If different subsurface conditions are encountered at the time of construction, the actual conditions should be evaluated to determine any excavation modifications necessary to maintain safe conditions.

Construction site safety is the sole responsibility of the contractor who controls the means, methods, and sequencing of construction operations. Under no circumstances shall the information provided herein be interpreted to mean Terracon is assuming responsibility for

construction site safety or the contractor's activities; such responsibility shall neither be implied nor inferred.

## **Grading and Drainage**

All grades must be adjusted to provide positive drainage away from the building during construction and maintained throughout the life of the proposed project. Infiltration of water into utility or foundation excavations must be prevented during construction. Landscaped irrigation adjacent to the foundation systems should be minimized or eliminated. Water permitted to pond near or adjacent to the perimeter of the structure (either during or post-construction) can result in significantly higher soil movements than those discussed in this report. As a result, any estimations of potential movement described in this report cannot be relied upon if positive drainage is not obtained and maintained, and water is allowed to infiltrate the fill and/or subgrade.

Permanent grades should be sloped at a minimum of 10 percent grade for at least 10 feet beyond the perimeter of the building. Asphalt pavement or concrete flatwork should be sloped at a minimum of 2 percent beyond the building perimeters for the life of the building. Where Americans with Disabilities Act (ADA) or other requirements or existing site features limit the gradient, slopes on the order of ½ to 1 percent minimum may be necessary to comply with the ADA but do increase the risk of unanticipated movement. Backfill against footings, exterior walls, and in utility and sprinkler line trenches should be compacted in accordance with recommendations in this report and free of all construction debris to reduce the possibility of water infiltration. After building construction and prior to project completion, we recommend that verification of final grading be performed to document that positive drainage, as described above, has been achieved.

Where paving or flatwork abuts the structure, care should be taken that joints are properly sealed and maintained to prevent the infiltration of surface water.

Landscape or xeriscape areas within 10 feet of the foundation systems shall not be hindered by landscape edging, grade variations, or vegetation. In addition, consideration should be given to snow removal practices that will minimize the stockpiling of snow in planter and landscaped areas adjacent to structural improvements.

Planters located adjacent to the structure should be watertight. Sprinkler mains and spray heads should be located a minimum of 10 feet away from the building lines. Where drip line irrigation is located near the building, we recommend that drip line irrigation systems be located at least 5 feet from the outside edge of the foundations. Roof drains should discharge on pavements or be extended away from the structure a minimum of 10 feet through the use of splash blocks or downspout extensions.

Trees or other vegetation whose root systems have the ability to remove excessive moisture from the subgrade and foundation soils should not be planted next to the building. Trees and shrubbery should be kept away from the exterior edges of foundations, a distance at least equal to their expected mature height.

## **Earthwork Construction Considerations**

Upon completion of grading operations, care should be taken to maintain the moisture content of the subgrade prior to construction of slabs-on-grade, pavements, etc. Construction traffic over prepared subgrade should be minimized and avoided to the extent practical. Construction traffic over processed clay subgrade will eventually reduce the moisture content and increase the density of the subgrade. Subsequent wetting of these materials will result in undesirable movement.

The site should also be graded to prevent ponding of surface water on prepared subgrade or in excavations. In areas where water is allowed to pond over a period of time, the affected area should be removed and allowed to dry out; however, allowing the clay soils to dry out below the optimum moisture content is not recommended. If constraints do not allow for moisture conditioning of affected clays as recommended in this report, the affected area should be overexcavated and replaced with engineered fill. As an alternative, geotextiles could also be considered as a stabilization technique.

The Geotechnical Engineer should be retained during the construction phase of the project to observe earthwork and to perform necessary tests and observations during overexcavation operations, excavations, subgrade preparation; proof-rolling; placement and compaction of controlled compacted fills; backfilling of excavations into the completed subgrade, and just prior to construction of building floor slabs.

### **Utility Trench Backfill**

Utility trenches penetrating beneath the building should be effectively sealed to restrict water intrusion and flow through the trenches, which could migrate below the building. The trench should provide an effective trench plug that extends at least 5 feet from the face of the building exterior. The plug material should consist of cementitious flowable fill or low permeability clay. The trench plug material should be placed to surround the utility line. If used, the clay trench plug material should be placed and compacted to comply with the water content and compaction recommendations for structural fill stated previously in this report.

## **FOUNDATION RECOMMENDATIONS**

Based upon the results of the field exploration and laboratory testing program for this exploration, the following foundation systems were evaluated for use in supporting the proposed building:

- Spread footing on a zone of engineered fill.
- Straight-shaft, cast-in-place piers/shafts constructed in bedrock.

Due to the presence of expansive claystone materials, it is our opinion the proposed building should be constructed on drilled pier foundation systems bottomed in the underlying sandstone/claystone bedrock.

If the owner is willing to accept a higher risk of movement, the proposed building could be constructed on spread footings on a 6-foot zone of engineered fill or a combination of engineered fill and sandstone bedrock, provided all existing fill below footings is removed. The intent of the zone of engineered fill or a combination of engineered fill and sandstone is to create a minimum 6-foot separation from the bottom of the lowest foundation elements and the underlying claystone bedrock.

### Drilled Pier Recommendations

Design recommendations for a drilled pier foundation system are presented in the following paragraphs:

Description	Value
<b>Minimum Pier Length <sup>1</sup></b>	25 feet
<b>Minimum Bedrock Embedment <sup>2,3,4</sup></b>	10 feet
<b>Maximum Allowable End-Bearing Pressure <sup>5</sup></b>	30,000 psf
<b>Maximum Allowable Skin Friction <sup>6</sup></b>	2,500 psf
<b>Minimum Dead Load (kips) <sup>7</sup></b>	None
<b>Uplift Force (Tension due to Soil/Bedrock Uplift, kips)</b>	45 x pier diameter (feet)
<b>Minimum Pier Diameter</b>	18 inches or length/diameter <30
<b>Shear Rings</b>	3 inches high by 3 inches deep at 16 inches on center within bottom 8 feet of shaft
<b>Minimum Required Grade Beam Void Thickness <sup>8</sup></b>	4 inches

1. The required minimum length is from the bottom of grade beams or pier caps.
2. The required minimum bedrock embedment considers the uplift force from soil/bedrock uplift only.
3. Drilled shafts should be embedded into firm or harder bedrock materials.
4. The portion of the drilled piers that can resist the uplift force must be (a) embedded in firm or harder bedrock and (b) be at least 10 feet below the top of the drilled pier.
5. In accordance with IBC Section 1806.1, if design of the pier foundations is completed using allowable stress design (ASD) methods, the vertical bearing resistance may be increased by 1/3 where used with the alternative basic load combinations that include wind or seismic loads that are described in IBC Section 1605.3.2. This 1/3 increase does not apply if design is completed using load and resistance factor design (LRFD) methods. Increases also do not apply to the resistance of uplift loads, nor to the soil properties provided in this report for modeling the pier response to lateral loads, nor the resulting lateral pier deflection vs. applied load graph.

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Description	Value
6. Skin friction should not be applied in fill or overburden soils, or the upper 5 feet of the drilled pier, whichever is deepest.	
7. Provided the minimum bedrock embedment is achieved, a minimum dead load is not necessary.	
8. The void space below grade beams (between the piers) and pier caps should be periodically maintained and re-established, as necessary.	
9. Movement on the order of less than ½ inch should be anticipated for the drilled piers, provided the piers are properly designed and constructed. Skin friction capacity provided may be used for compression and tension loading.	

Piers should be considered to work in group action if the center-to-center horizontal spacing is less than three pier diameters. A minimum practical center-to-center horizontal spacing between piers of at least three diameters should be maintained, and adjacent piers should bottom at the same elevation. The capacity of individual piers must be reduced when considering the effects of group action. Capacity reduction is a function of pier spacing and the number of piers within a group. The following table presents capacity reductions for closely spaced piers.

Description	Value		
<b>Drilled Pier Spacing (Center-to-Center)</b>	>3 diameters	>2 to 3 diameters	1 to 2 diameters
<b>Pier Capacity Reduction</b>	None	30 percent	50 percent

1. End bearing values do not need to be reduced for closely spaced piers, if the bottoms of piers are at the same elevation.

To satisfy forces in the horizontal direction using the computer program LPile<sup>®</sup>, piers may be designed for the following lateral load criteria:

Soil Layer	LPile <sup>®</sup> p-y Curve Type	Unit Weight (pcf) <sup>1</sup>	Undrained Shear Strength (psf)	Angle of Internal Friction, Φ (degrees)	Coeff. of Subgrade Reaction, k (pci)	Strain, ε <sub>50</sub> (%)
Clay Soils	Stiff clay w/out free water	110	1,000	0	800-static 200-cyclic	0.005
Sand Soils and Sandstone	Sand (Reese)	115	--	30	60	--
Claystone	Stiff clay w/out free water	120	2,000	0	1,500-static 600-cyclic	0.004

1. Buoyant unit weight values should be used below water table.

Lateral analysis should account for the center-to-center spacing and p multiplier values per the following table:

Pier Center-to-Center Spacing (In Direction of Loading)	p multiplier, $p_M$		
	Row 1	Row 2	Row 3 and Higher
3 x diameter	0.8	0.4	0.3
5 x diameter	1.0	0.85	0.7

The structural engineer should determine the reinforcement necessary for the piers. At a minimum, all piers should be reinforced full depth for the applied axial, lateral, and uplift stresses imposed. We recommend a minimum reinforcement of at least 1 percent of the cross-sectional area of the pier.

Drilling to design depth will most likely require the use of heavy-duty equipment due to the presence of very hard cemented bedrock layers.

Pier casing may be required if groundwater, loose soils, or caving soils are encountered. Casing should be withdrawn in a slow continuous manner maintaining a sufficient head of concrete to prevent infiltration of water or caving soils or the creation of voids in pier concrete. Pier concrete should have a relatively high fluidity when placed in cased pier holes or through a tremie. Pier concrete with slump in the range of 5 to 7 inches is recommended for uncased piers. For cased piers, a slump in the range of 7 to 9 inches is recommended.

Groundwater (if encountered) should be removed from each pier hole prior to concrete placement. Pier concrete should be placed immediately after completion of drilling and cleaning. If pier concrete cannot be placed in dry conditions, a tremie should be used for concrete placement. Free-fall concrete placement in piers will only be acceptable if provisions are taken to avoid striking the concrete on the sides of the hole or reinforcing steel. The use of a bottom-dump hopper, or an elephant's trunk discharging near the bottom of the hole where concrete segregation will be reduced, is recommended.

Due to potential sloughing and raveling, foundation concrete quantities may exceed calculated geometric volumes. Pier-bearing surfaces must be cleaned prior to concrete placement. A Terracon representative should observe the bearing surface and shaft configuration.

The top of the piers should be cylindrical in shape. Forms may be necessary at the top of the piers in order to minimize the disturbance of the soils and to maintain a cylindrical shape. Failure to provide this shape (e.g. allowing mushrooming of pier tops) may result in additional uplift forces and unanticipated movement.

## Spread Footing Foundation Recommendations

Design recommendations for spread footing foundation systems are presented in the following table and paragraphs.

Description	Value
<b>Minimum Separation Between Bottom of Footing and Claystone Bedrock</b>	6 feet
<b>Supporting Stratum</b>	Minimum of 2 feet of engineered fill. All existing fill below footings must be removed and replaced with engineered fill
<b>Maximum Gross Allowable Bearing Pressure <sup>1,2</sup></b>	2,500
<b>Minimum Dead Load Pressure</b>	800 psf or what is practical
<b>Void Thickness, If Needed</b>	4 inches
<b>Coefficient of Friction (Sliding)</b>	0.3
<b>Minimum Footing Dimensions</b>	Isolated footings: 24 inches Continuous footings: 18 inches
<b>Minimum Embedment Below Finished Grade for Frost Protection <sup>3,4</sup></b>	3 feet
<b>Approximate Total Movement <sup>5</sup></b>	About 1 inch
<b>Estimated Differential Movement <sup>5,6</sup></b>	About ½ to ¾ inch

1. The recommended maximum allowable bearing pressure assumes that any existing fill or lower strength soils, if encountered, will be excavated and replaced with engineered fill.
2. The maximum allowable soil bearing pressure can be increased by 1/3 for transient loading conditions.
3. For perimeter footings, footings beneath unheated areas, and footings that will be exposed to freezing conditions during construction. Interior footings may bottom at a minimum depth of 12 inches below finished grade in heated areas.
4. If a frost protected shallow foundation (FPSF) system is used, the minimum embedment below finished grade can be reduced. FPSF systems should be designed in accordance with the ASCE 32-01 with approval from the local building department.
5. Foundation movement will depend upon the variations within the subsurface soil profile, the structural loading conditions, the embedment depth of the footings, the thickness of engineered fill, the quality of the earthwork operations and footing construction, and maintaining uniform soil water content throughout the life of the structure.
6. Footings should be proportioned on the basis of equal total dead load pressure to reduce differential movement between adjacent footings.

Additional foundation movements could occur if water from any source infiltrates the foundation soils; therefore, proper drainage should be provided in the final design and during construction and throughout the life of the structure. Failure to maintain the proper drainage as recommended in the **Grading and Drainage** subsection of **Earthwork** will nullify the movement estimates provided above.

Unstable subgrade conditions should be observed by the Geotechnical Engineer to assess the subgrade and provide suitable alternatives for stabilization. Stabilized areas should be proofrolled prior to continuing construction to assess the stability of the subgrade.

The base of all foundation excavations should be free of water and loose soil prior to concrete placement. Concrete should be placed soon after excavating to reduce bearing soil disturbance. Should the soils at bearing level become excessively dry, disturbed or saturated, or frozen, the affected soil should be removed prior to placing concrete.

Footings, foundations, and masonry walls should be detailed and reinforced as necessary to reduce the potential for distress caused by differential foundation movement. The use of joints at openings or other discontinuities in masonry walls is recommended.

## SEISMIC CONSIDERATIONS

The following table presents the seismic site classification based on the 2018 International Building Code (IBC) and the subsurface conditions encountered within the borings:

Code Used	Site Classification
2018 International Building Code (IBC) <sup>1,2</sup>	C

1. In general accordance with the 2018 International Building Code, Section 1613.2.2.  
2. The 2018 International Building Code (IBC) requires a site subsurface profile determination extending a depth of 100 feet for seismic site classification. The current scope requested does not include the required 100-foot subsurface profile determination. The deepest borings of this exploration extended to a maximum depth of about 30 feet and this seismic site class definition considers that similar subsurface conditions exist below the maximum depth of the subsurface exploration.

## FLOOR SLABS

### Interior Floors

Slab-on-grade floors may be utilized for the interior floor systems, provided slabs-on-grade are constructed on a minimum of 3 feet of engineered fill, all existing fill is removed and replaced with new engineered fill, and some slab movement can be tolerated. If very little movement can be tolerated, structural floors, supported independent of the subgrade materials, are recommended.

Conventional slab-on-grade constructed on expansive soils and bedrock, whether in their natural state or moisture-conditioned and recompacted to a certain depth, will move. The severity and magnitude of movement will depend on the depth of treatment, the resulting expansion potential of these materials, and the circumstances causing future wetting.

For structural design of concrete slabs-on-grade, a modulus of subgrade reaction of 100 pounds per cubic inch (pci) may be used for point or limited area loads for floors supported on an engineered fill.

Additional floor slab design and construction recommendations are as follows:

- Positive separations and/or isolation joints should be provided between slabs and all foundations, columns, or utility lines to allow independent movement.
- Control joints should be provided in slabs to control the location and extent of cracking.
- A minimum 3-inch void space should be constructed above or below non-bearing partition walls placed on the floor slab. Special framing details should be provided at doorjambes and frames within partition walls to avoid potential distortion. Partition walls should be isolated from suspended ceilings.
- Interior trench backfill placed beneath slabs should be compacted in accordance with recommended specifications described previously.
- The use of a vapor retarder should be considered beneath concrete slabs on grade that will be covered with wood, tile, carpet, or other moisture sensitive or impervious coverings, or when the slab will support equipment sensitive to moisture. When conditions warrant the use of a vapor retarder, the slab designer and slab contractor should refer to ACI 302 for procedures and cautions regarding the use and placement of a vapor retarder.
- Floor slabs should not be constructed on frozen subgrade.
- Other design and construction considerations, as outlined in Section 302.1R of the ACI Design Manual, are recommended.

Movements of slab-on-grades using the above outlined technique will likely be reduced and tend to be more uniform. The estimates outlined previously assume that the other recommendations in this report are followed. Additional movement could occur should the subsurface soils become wetted to significant depths, which could result in potential excessive movement causing uneven floor slabs and severe cracking. This could be due to over watering of landscaping, poor drainage, improperly functioning drain systems, and/or broken utility lines. Therefore, it is imperative that the recommendations outlined in this section and in the **Grading and Drainage** subsection of **Earthwork** be followed.

## **EXTERIOR FLATWORK**

Exterior slabs-on-grade and flatwork constructed on the on-site materials will have a risk of movement. To improve performance, the exterior slab-on-grade subgrade soils are overexcavated to a depth of at least 2 feet, moisture conditioned, and recompacted to grade. New fill materials beneath slabs-on-grade should be placed and compacted as outlined in the **Earthwork** section of this report.

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For structural design of exterior concrete slabs-on-grade, a modulus of subgrade reaction of 100 pci may be used for point or limited area loads for exterior slabs-on-grade at this site.

Additional slab design and construction recommendations are as follows:

- Minimizing moisture increases in the backfill.
- Controlling moisture-density during placement of backfill.
- Positive separations and/or isolation joints should be provided between exterior slabs and the building to allow independent movement.
- Control joints should be provided in slabs to control the location and extent of cracking.
- Exterior slabs should not be constructed on frozen subgrade
- Other design and construction considerations, as outlined in Section 302.1R of the ACI Design Manual, are recommended.

Movements of exterior slabs-on-grade using the above technique will likely be reduced and tend to be more uniform. Additional movement could occur should the subsurface soils and bedrock become wetted to significant depths, which could result in potential excessive movement causing uneven exterior slabs and severe cracking. This could be due to over watering of landscaping, poor drainage, and/or broken utility lines. Therefore, it is imperative that the recommendations outlined in the **Grading and Drainage** subsection of **Earthwork** be followed.

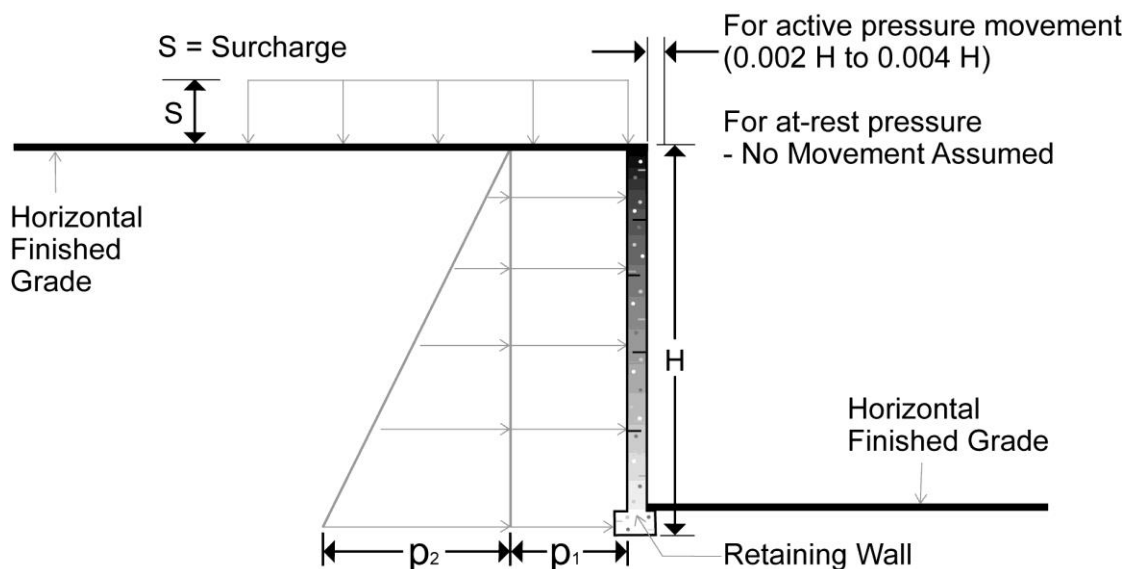
## LATERAL EARTH PRESSURES

Below-grade walls or free-standing retaining walls are not anticipated for this project; however, we have included lateral earth pressures recommendations in case plans should change. Reinforced concrete walls with unbalanced backfill levels on opposite sides should be designed for earth pressures at least equal to those indicated in the following table. Earth pressures will be influenced by structural design of the walls, conditions of wall restraint, methods of construction and/or compaction and the strength of the materials being restrained. Two wall restraint conditions are shown. Active earth pressure is commonly used for design of free-standing cantilever retaining walls and assumes wall movement. The "at-rest" condition assumes no wall movement. The recommended design lateral earth pressures do not include a factor of safety and do not provide for possible hydrostatic pressure on the walls.

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Earth Pressure Conditions	Lateral Earth Pressure Coefficient	Equivalent Fluid Density (pcf)	Surcharge Pressure, $p_1$ (psf)	Earth Pressure, $p_2$ (psf)
Active ( $K_a$ )	0.33	40	$(0.33)S$	$(40)H$
At-Rest ( $K_o$ )	0.50	60	$(0.50)S$	$(60)H$
Passive ( $K_p$ )	3.00	300	---	---

### Applicable conditions to the above include:

- For active earth pressure, wall must rotate about base, with top lateral movements of about  $0.002 H$  to  $0.004 H$ , where  $H$  is wall height
- For passive earth pressure to develop, wall must move horizontally to mobilize resistance.
- Uniform surcharge, where  $S$  is surcharge pressure
- In-situ soil backfill weight a maximum of 120 pcf
- Horizontal backfill, compacted to at least 95 percent of standard Proctor maximum dry density
- Loading from heavy compaction equipment not included
- No hydrostatic pressures acting on wall
- No dynamic loading
- No safety factor included in soil parameters

We recommend that a perforated rigid plastic drain line installed behind the base of walls and extends below adjacent grade is recommended to prevent hydrostatic loading on the walls. The invert of a drain line around a below-grade building area or exterior retaining wall should be placed near foundation bearing level. The drain line should be sloped to provide positive gravity drainage to daylight or to a sump pit and pump. The drain line should be surrounded by clean, free-draining granular material having less than 5% passing the No. 200 sieve, such as No. 57 aggregate. The

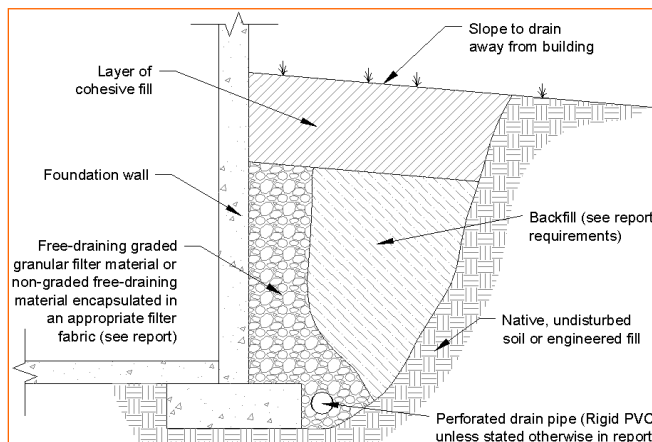
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free-draining aggregate should be encapsulated in a filter fabric. The granular fill should extend to within 2 feet of final grade, where it should be capped with compacted cohesive fill to reduce infiltration of surface water into the drain system.



As an alternative to free-draining granular fill, a prefabricated drainage structure may be used. A prefabricated drainage structure is a plastic drainage core or mesh covered with filter fabric to prevent soil intrusion that is fastened to the wall prior to placing backfill.

The combined hydrostatic and lateral earth pressures should be calculated for lean clay backfill using an equivalent fluid weighing 90 and 100 pcf for active and at-rest conditions, respectively. For granular backfill, an equivalent fluid weighing 85 and 90 pcf should be used for active and at-rest conditions, respectively. The above pressures do not include the influence of surcharge, equipment, or floor loading, which should be added. Heavy equipment should not operate within a distance closer than the exposed height of retaining walls to prevent lateral pressures more than those provided.

The preceding data are applicable only to cast-in-place concrete or modular block walls up to 4 feet in height. **If taller single walls, tiered walls, or Mechanically Stabilized Earth (MSE) walls will be included in the proposed development, additional site-specific studies and laboratory testing will be required.** In addition, the wall designer should perform standard wall design practices including analysis for overturning, sliding, bearing capacity, and global stability, and results of these analyses should be provided for our review. Additional sampling, laboratory testing and document review associated with retaining walls is beyond the original scope of work but can be performed as a separate scope, for a separate fee.

## PAVEMENTS

Design of privately maintained pavements for the project has been based on the procedures outlined by the Asphalt Institute (AI) and the American Concrete Institute (ACI).

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## Design Traffic

We assumed the following design parameters for AI flexible pavement thickness design:

- Automobile Parking Areas
  - Parking stalls and parking lots for cars and pick-up trucks, up to 50 stalls
- Main Traffic Corridors
  - Parking lots with a maximum of 5 trucks per day
- Subgrade Soil Characteristics
  - USCS Classification – CL to SP (poor to good subgrade)

We assumed the following design parameters for ACI rigid pavement thickness design based upon the average daily truck traffic (ADTT):

- Automobile Parking Areas
  - ACI Category A-1: Automobile parking with an ADTT of 1 over 20 years
- Main Traffic Corridors
  - ACI Category B: Commercial entrance and service lanes with an ADTT of 25 over 20 years
- Subgrade Soil Characteristics
  - USCS Classification – CL to SP (low to high support)
- Concrete modulus of rupture value of 500 psi

We should be contacted to confirm and/or modify the recommendations contained herein if actual traffic volumes differ from the assumed values shown above.

## Subgrade Soils

Based on a subgrade soil classification of CL to SP per the Unified Soil Classification System (USCS), AI classifies the subgrade soil as poor to good subgrade, while ACI classifies the subgrade soil as low to high support. Subgrade performance can be improved by overexcavating the materials to a depth of 2 feet and properly moisture conditioning and compacting the materials to grade.

## Recommended Minimum Pavement Sections and Materials

Recommended alternatives for flexible and rigid pavements are summarized for each traffic area as follows:

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Traffic Area	Alternative	Recommended Pavement Thickness (Inches)			
		Asphalt Concrete Surface	Aggregate Base Course	Portland Cement Concrete	Total
Automobile Parking (AI Class I and ACI Category A)	A	6	--	--	6
	B	4	8	--	12
	C <sup>1</sup>	--	--	5	5
Main Traffic Corridors (AI Class III and ACI Category B)	A	7	--	--	7
	B	45	10	--	15
	C <sup>1</sup>	--	--	6	6

1. The minimum pavement section thickness per ACI

Each alternative should be investigated with respect to current material availability and economic conditions. A minimum 7-inch thickness of rigid reinforced concrete pavement is recommended at the location of dumpsters where trash trucks park and load, and in areas of tight turning radius.

Concrete pavement joint spacing and reinforcement should be in accordance with ACI 330R-08 and/or AASHTO requirements.

For analysis of pavement costs, the following specifications should be considered for each pavement component:

Pavement Component	Colorado Department of Transportation Criteria
Asphalt Concrete Surface	Grading S or SX
Aggregate Base Course	Class 5 or 6
Portland Cement Concrete	Class P

### Drainage Adjacent to Pavements

Clay subgrade materials will expand and/or lose stability with increases in moisture content. To reduce pavement distress due to wetting of the subgrade in areas of water intensive landscaping or other nearby water sources (or if aggregate base course is used) located adjacent to pavements, edge drains should be considered.

### Pavement Maintenance

Future performance of pavements constructed at this site will be dependent upon several factors, including:

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- Maintaining stable moisture content of the subgrade soils both before and after pavement construction.
- Providing for a planned program of preventative maintenance.

The performance of all pavements can be enhanced by minimizing excess moisture, which can reach the subgrade soils. The following recommendations should be implemented:

- Site grading at a minimum 2 percent grade onto or away from the pavements.
- Water should not be allowed to pond behind curbs.
- Compaction of any utility trenches for landscaped areas to the same criteria as the pavement subgrade.
- Sealing all landscaped areas in or adjacent to pavements, or providing drains to reduce the risk of moisture migration to subgrade soils.
- Placing compacted backfill against the exterior side of curb and gutter.
- Placing curb, gutter, and/or sidewalk directly on subgrade soils without the use of base course materials.

Preventative maintenance should be planned and provided for an ongoing pavement management program in order to enhance future pavement performance. Preventative maintenance activities are intended to slow the rate of pavement deterioration.

Preventative maintenance consists of both localized maintenance (e.g. crack sealing and patching) and global maintenance (e.g. surface sealing). Preventative maintenance is usually the first priority when implementing a planned pavement maintenance program.

### **Pavement Construction Considerations**

Site grading is generally accomplished early in the construction phase. However, as construction proceeds, the subgrade may be disturbed due to utility excavations, construction traffic, desiccation, or rainfall. As a result, the pavement subgrade may not be suitable for pavement construction and corrective action will be required. The subgrade should be carefully evaluated at the time of pavement construction for signs of disturbance or excessive rutting. If disturbance has occurred, pavement subgrade areas should be reworked, moisture conditioned, and properly compacted to the recommendations in this report immediately prior to paving.

We recommend the pavement areas be rough graded and then thoroughly proofrolled with a loaded tandem axle dump truck prior to final grading and paving. Particular attention should be paid to high traffic areas that were rutted and disturbed earlier and to areas where backfilled trenches are located. Areas where unsuitable conditions are located should be repaired by removing and replacing the materials with properly compacted fills. All pavement areas should be moisture conditioned and properly compacted to the recommendations in this report immediately prior to paving.

The placement of a partial pavement thickness for use during construction is not recommended without a detailed pavement analysis incorporating construction traffic. In addition, if the actual traffic varies from the assumptions outlined above, we should be contacted to confirm and/or modify the pavement thickness recommendations outlined above.

## CORROSIVITY

The following table lists the results of laboratory water-soluble sulfate testing performed on samples obtained during our field exploration. These values should be used to help determine potential corrosive characteristics of the on-site soils with respect to contact with the various underground materials that will be used for project construction. Refer to the **Summary of Laboratory Test Results** presented in the **Exploration Results** section for the complete results of the corrosivity testing performed on the on-site soils in conjunction with this geotechnical exploration.

The corrosion information presented is specific to the samples tested. If the actual soils that will be in contact with the structures at the site are different than those tested, then additional corrosion testing should be performed. Terracon is not a corrosion engineer, and our scope of work was limited to performing corrosion laboratory tests on selected samples, presenting these results, and providing a brief comparison of the results to selected criteria. A qualified corrosion engineer should be consulted if corrosion of underground utilities and structures is a concern.

Boring No.	Sample Depth (feet)	Water-Soluble Sulfate <sup>1</sup> (%)
3	0 – 5	<0.10
4	2	<0.10
6	2	<0.10

1. Results of water-soluble sulfate testing indicate that samples of the on-site soils have an exposure class of S0 when classified in accordance with Table 19.3.1.1 of the American Concrete Institute (ACI) Design Manual. The results of the testing indicate ASTM Type I Portland Cement is suitable for project concrete in contact with on-site soils. However, if there is no (or minimal) cost differential, use of ASTM Type II Portland Cement is recommended for additional sulfate resistance of construction concrete. Concrete should be designed in accordance with the provisions of the ACI Design Manual, Section 318, Chapter 19.

## GENERAL COMMENTS

Our analysis and opinions are based upon our understanding of the project, the geotechnical conditions in the area, and the data obtained from our site exploration. Natural variations will occur between exploration point locations or due to the modifying effects of construction or weather. The nature and extent of such variations may not become evident until during or after construction. Terracon should be retained as the Geotechnical Engineer, where noted in this

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report, to provide observation and testing services during pertinent construction phases. If variations appear, we can provide further evaluation and supplemental recommendations. If variations are noted in the absence of our observation and testing services on-site, we should be immediately notified so that we can provide evaluation and supplemental recommendations.

Our Scope of Services does not include either specifically or by implication any environmental or biological (e.g., mold, fungi, bacteria) assessment of the site or identification or prevention of pollutants, hazardous materials, or conditions. If the owner is concerned about the potential for such contamination or pollution, other studies should be undertaken.

Our services and any correspondence or collaboration through this system are intended for the sole benefit and exclusive use of our client for specific application to the project discussed and are accomplished in accordance with generally accepted geotechnical engineering practices with no third-party beneficiaries intended. Any third-party access to services or correspondence is solely for information purposes to support the services provided by Terracon to our client. Reliance upon the services and any work product is limited to our client, and is not intended for third parties. Any use or reliance of the provided information by third parties is done solely at their own risk. No warranties, either express or implied, are intended or made.

Site characteristics as provided are for design purposes and not to estimate excavation cost. Any use of our report in that regard is done at the sole risk of the excavating cost estimator as there may be variations on the site that are not apparent in the data that could significantly impact excavation cost. Any parties charged with estimating excavation costs should seek their own site characterization for specific purposes to obtain the specific level of detail necessary for costing. Site safety, and cost estimating including, excavation support, and dewatering requirements/design are the responsibility of others. If changes in the nature, design, or location of the project are planned, our conclusions and recommendations shall not be considered valid unless we review the changes and either verify or modify our conclusions in writing.

## FIGURES

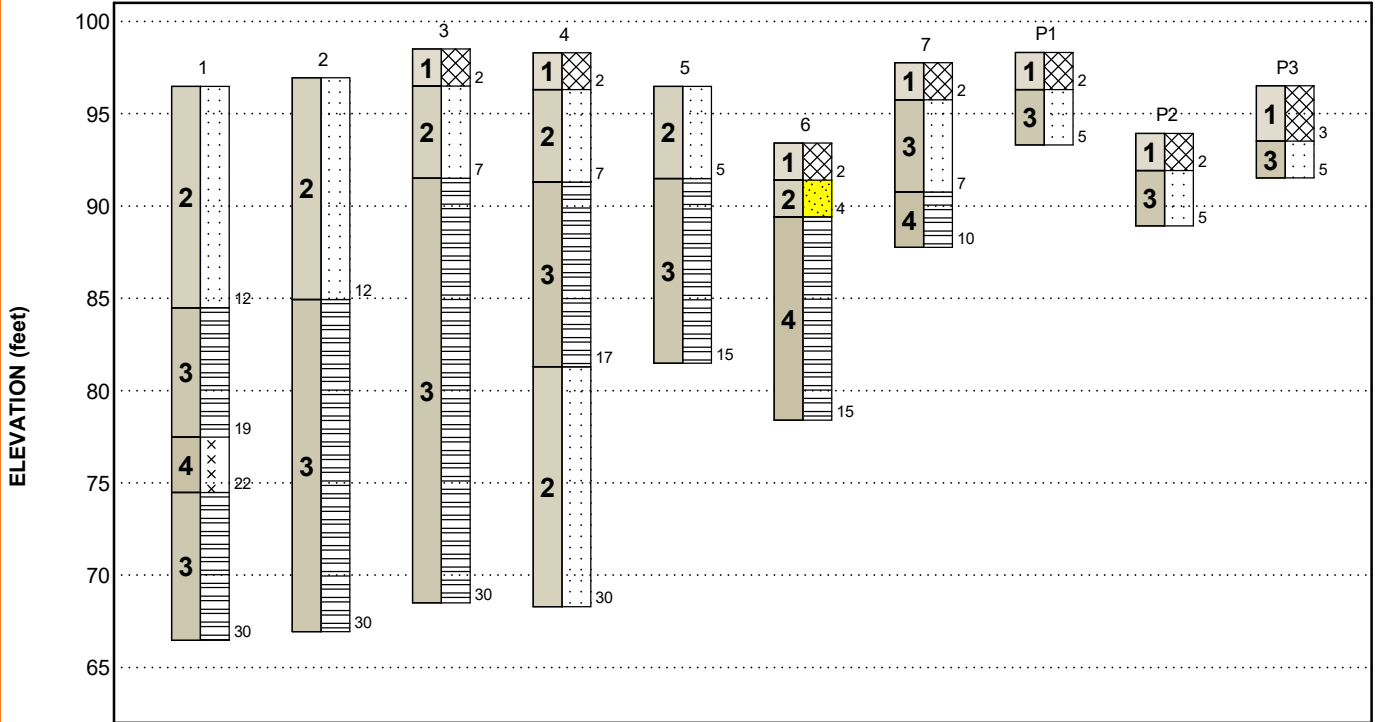
### Contents:

GeoModel

Note: All attachments are one page unless noted above.

**GEOMODEL**

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This is not a cross section. This is intended to display the Geotechnical Model only. See individual logs for more detailed conditions.

Model Layer	Layer Name	General Description
1	Existing Fill	Fill materials consisting of lean clay with varying amounts of sand and gravel and sand with varying amounts of clay, silt, and gravel, variable densities
2	Native Sand	Native sand soils; dense
3	Sandstone Bedrock	Sandstone bedrock with varying amounts of silt and clay; soft to hard
4	Claystone Bedrock	Claystone bedrock with varying amounts of sand and silt; soft to hard
5	Siltstone	Siltstone, trace sand; hard

**LEGEND**

- Sandstone
- Shale
- Siltstone
- Fill
- Poorly-graded Sand

**NOTES:**

Layering shown on this figure has been developed by the geotechnical engineer for purposes of modeling the subsurface conditions as required for the subsequent geotechnical engineering for this project. Numbers adjacent to soil column indicate depth below ground surface.

## ATTACHMENTS

## EXPLORATION AND TESTING PROCEDURES

### Field Exploration

**Boring Layout and Elevations:** The locations of the borings are presented in the **Site Location and Exploration Plans**. The borings were located in the field by overlaying the site plan on Google Earth, recording the latitude and longitude coordinates, and staking the borings using a handheld, recreational-grade GPS unit. The accuracy of the latitude and longitude values is typically about +/- 25 feet when obtaining the values using this method. Elevations at the borings were obtained using a level and using the rim of the water manhole in the northbound lane of South Chambers Road about 10 feet south of the intersection of South Chambers Road and South Red Sky Drive (approximately 39.4951° N, 104.8020° W) as a temporary benchmark with an assigned elevation of 100.0 feet. The accuracy of the boring locations and elevations should only be assumed to the level implied by the methods used.

**Subsurface Exploration Procedures:** The borings were drilled with a CME-75 truck-mounted rotary drill rigs with solid-stem augers. During the drilling operations, lithologic logs of the borings were recorded by the field engineer. Relatively undisturbed samples were obtained at selected intervals using a 2½-inch outside diameter modified California barrel sampler. Bulk samples were obtained from auger cuttings. Penetration resistance values were recorded in a manner similar to the standard penetration test (SPT). This test consists of driving the sampler into the ground with a 140-pound hammer free falling through a distance of 30 inches. The number of blows required to advance the barrel sampler 12 inches or the interval indicated is recorded and can be correlated to the standard penetration resistance value (N-value). The blow count values are indicated on the boring logs at the respective sample depths, barrel sampler blow counts are not considered N-values.

An automatic hammer was used to advance the samplers in the borings performed on this site. A greater efficiency is typically achieved with the automatic hammer compared to the conventional safety hammer operated with a cathead and rope. Published correlations between the SPT values and soil properties are based on the lower efficiency cathead and rope method. This higher efficiency affects the standard penetration resistance blow count value by increasing the penetration per hammer blow over what would be obtained using the cathead and rope method. The effect of the automatic hammer's efficiency has been considered in the interpretation and analysis of the subsurface information for this report.

The standard penetration test provides a reasonable indication of the in-place density of sandy type materials, but only provides an indication of the relative stiffness of cohesive materials since the blow count in these soils may be affected by the moisture content of the soils. In addition, considerable care should be exercised in interpreting the N-values in gravelly soils, particularly where the size of the gravel particle exceeds the inside diameter of the sampler.

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Groundwater measurements were obtained in the borings at the time of drilling. Due to safety concerns, the borings were backfilled with auger cuttings after drilling. Some settlement of the backfill may occur and should be repaired as soon as possible.

### Laboratory Testing

Samples retrieved during the field exploration were returned to the laboratory for observation by the project Geotechnical Engineer and were classified in general accordance with the Unified Soil Classification System presented in the **Supporting Information**.

An applicable laboratory-testing program was formulated to determine engineering properties of the subsurface materials. Following the completion of the laboratory testing, the field descriptions were confirmed or modified as necessary, and the boring logs were prepared. The boring logs are included in the **Exploration Results**.

Laboratory test results are included in the **Exploration Results**. These results were used for the geotechnical engineering analyses and the development of foundation, earthwork, and pavement recommendations. Laboratory tests were performed in general accordance with the applicable local or other accepted standards.

Selected soil and bedrock samples were tested for the following engineering properties:

- Water content
- Dry density
- Grain size distribution
- Atterberg limits
- Swell/consolidation
- Water-soluble sulfate content

## **SITE LOCATION AND EXPLORATION PLANS**

### **Contents:**

Site Location Plan  
Exploration Plan with Aerial Image  
Exploration Plan with Project Overlay

Note: All attachments are one page unless noted above.

**SITE LOCATION**

Proposed Parker McDonald's Restaurant #50785 ■ Parker, Colorado  
April 9, 2021 ■ Terracon Project No. 25215044

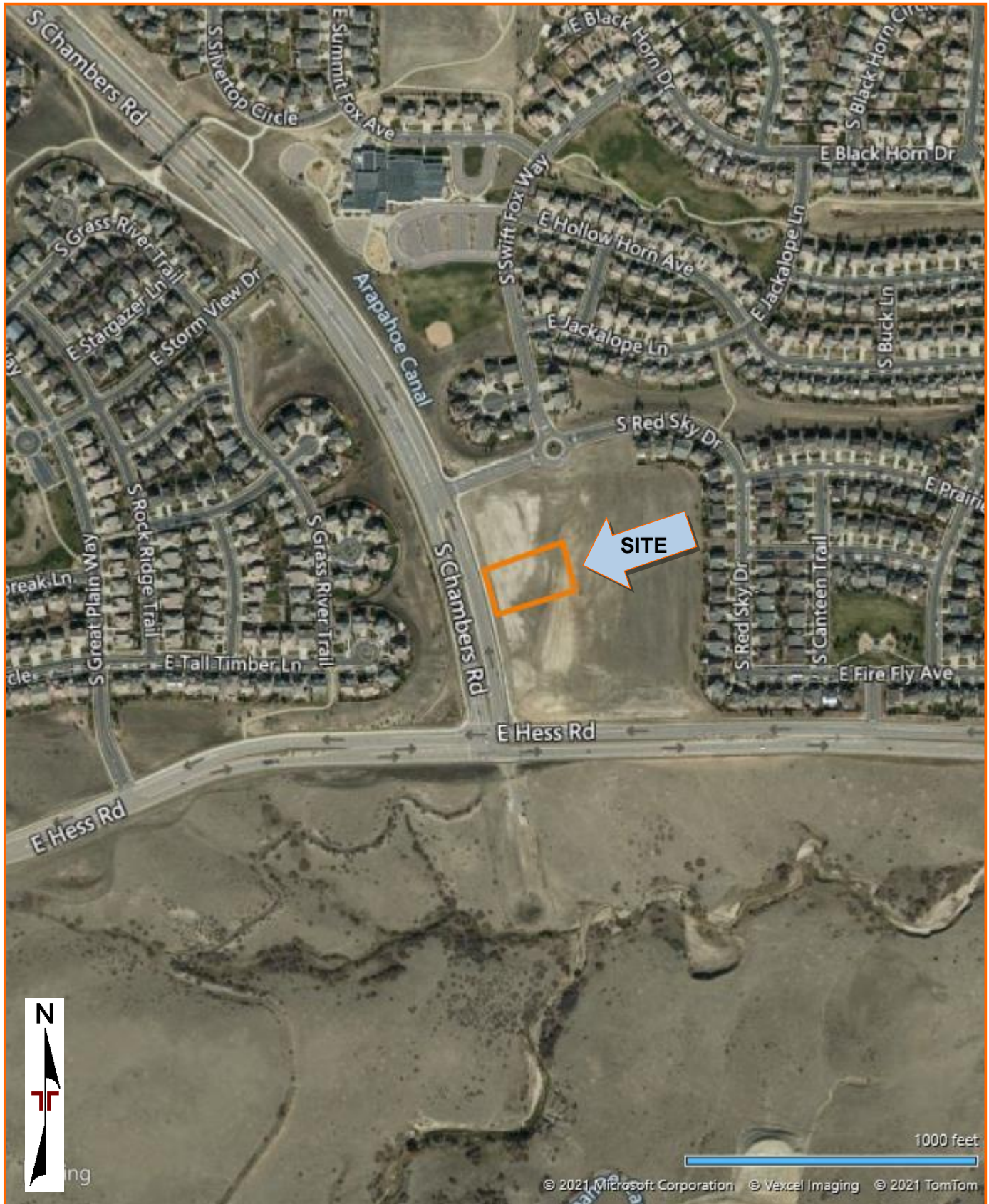


DIAGRAM IS FOR GENERAL LOCATION ONLY, AND IS NOT INTENDED FOR CONSTRUCTION PURPOSES

TOPOGRAPHIC MAP IMAGE COURTESY OF THE U.S. GEOLOGICAL SURVEY  
QUADRANGLES INCLUDE: PARKER, CO (1/1/1994) and CASTLE ROCK NORTH, CO (1/1/1994).

**EXPLORATION PLAN**

Proposed Parker McDonald's Restaurant #50785 ■ Parker, Colorado  
April 9, 2021 ■ Terracon Project No. 25215044

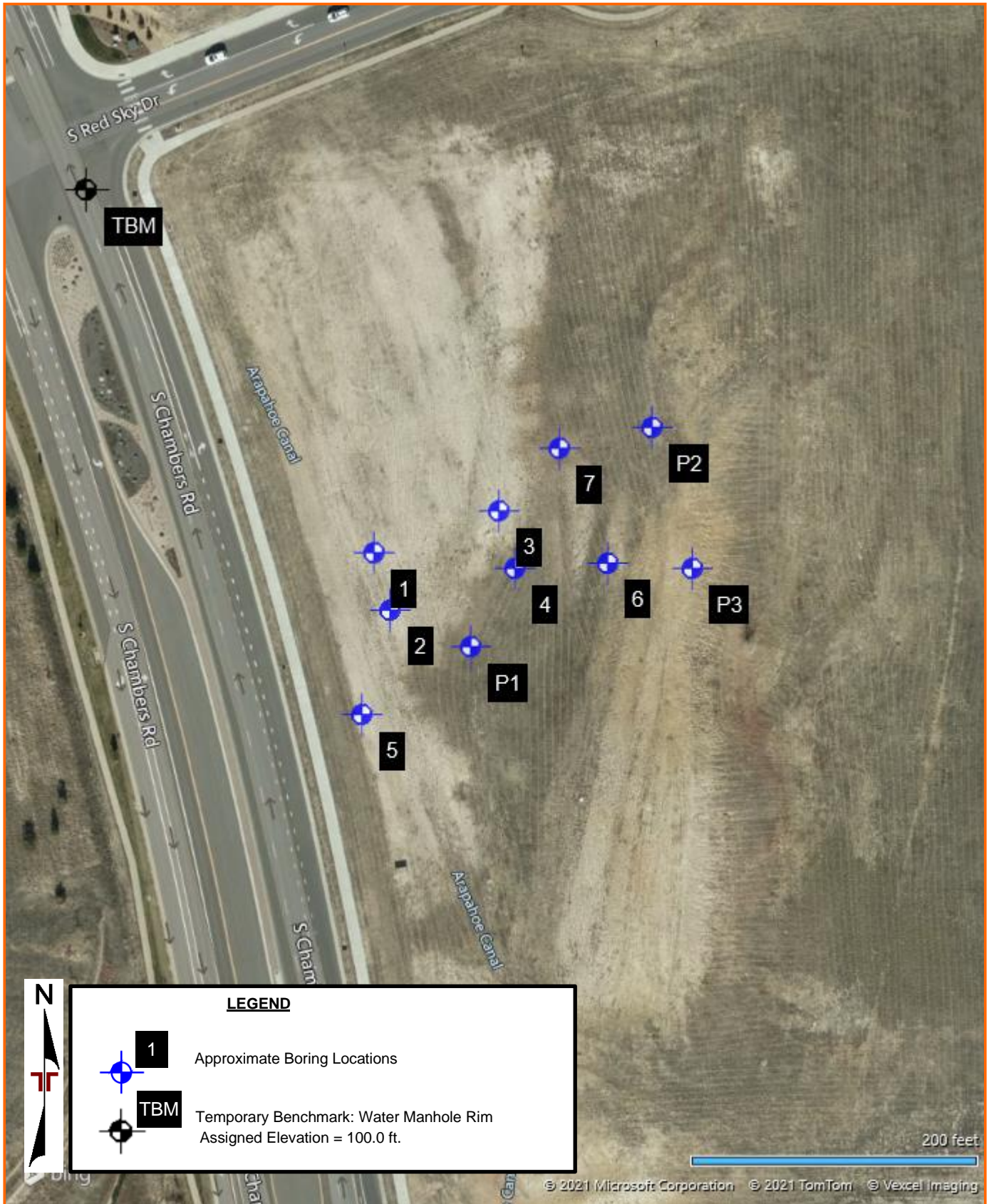


DIAGRAM IS FOR GENERAL LOCATION ONLY, AND IS NOT INTENDED FOR CONSTRUCTION PURPOSES

AERIAL PHOTOGRAPHY PROVIDED BY MICROSOFT BING MAPS

**EXPLORATION PLAN WITH PROJECT OVERLAY**

Proposed Parker McDonald's Restaurant #50785 ■ Parker, Colorado  
April 9, 2021 ■ Terracon Project No. 25215044

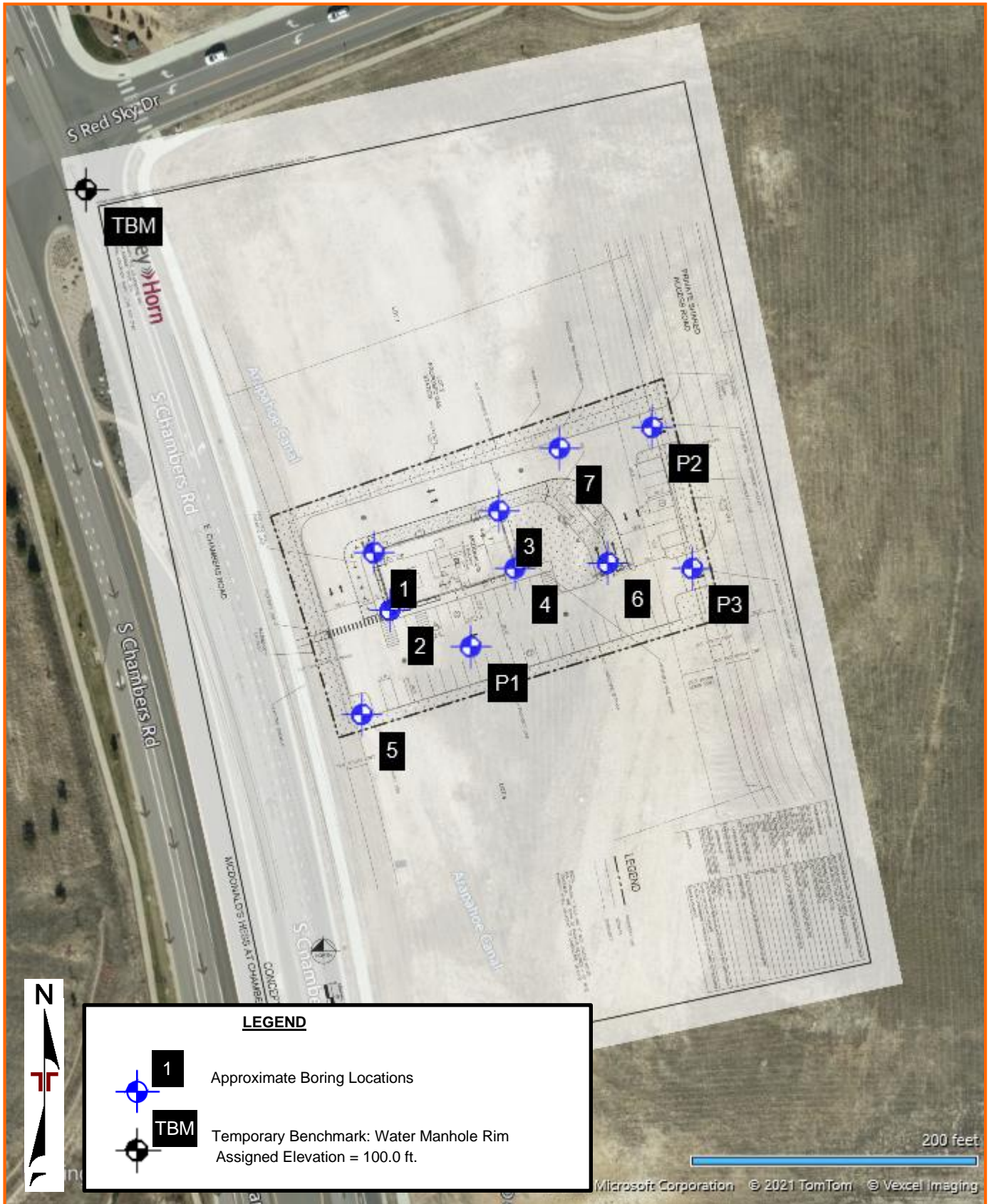


DIAGRAM IS FOR GENERAL LOCATION ONLY, AND IS NOT INTENDED FOR CONSTRUCTION PURPOSES

AERIAL PHOTOGRAPHY PROVIDED BY MICROSOFT BING MAPS

## **EXPLORATION RESULTS**

### **Contents:**

- Boring Logs (Boring Nos. 1 through 7 and P1 through P3)
- Swell Consolidation Test (7 pages)
- Grain Size Distribution (2 pages)
- Summary of Laboratory Test Results (3 pages)

Note: All attachments are one page unless noted above.

# BORING LOG NO. 1

**PROJECT: Proposed Parker McDonald's Restaurant #50785**

**CLIENT: McDonald's USA LLC**

**SITE: SE of S Chambers Rd and S Red Sky Dr Parker, Colorado**

MODEL LAYER	GRAPHIC LOG	LOCATION See <a href="#">Exploration Plan</a> Latitude: 39.4945° Longitude: -104.8013°  Approximate Surface Elev.: 96.48 (Ft.) +/- DEPTH ELEVATION (Ft.)	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	FIELD TEST RESULTS	SWELL (%)	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	ATTERBERG LIMITS			
										LL-PL-PI	PERCENT FINES		
2	[Dotted Pattern]	<b>SANDSTONE</b> , with silt, fine to coarse grained, grayish white, medium hard to hard	5		50/7"						NP	13	
			5		50/6"			7.6	103				
			10		50/8"			12.8	113				
			15		50/10"			18.0	114				
			20		50/5"								
4	[Cross-hatch Pattern]	<b>SILTSTONE</b> , trace sand, reddish brown, hard	20		50/5"								
3	[Horizontal Line Pattern]	<b>SANDY CLAYSTONE</b> , light grayish brown to light brown, medium hard	15		50/10"			18.0	114				
3	[Horizontal Line Pattern]	<b>SILTY CLAYSTONE</b> , interbedded with SANDSTONE, grayish brown, hard	25		50/8"			24.3	101				
3	[Horizontal Line Pattern]	<b>SANDSTONE</b> , with silt, fine to coarse grained, grayish white, medium hard to hard	5		50/7"						NP	13	
3	[Horizontal Line Pattern]	<b>SANDY CLAYSTONE</b> , light grayish brown to light brown, medium hard	15		50/10"			18.0	114				
3	[Horizontal Line Pattern]	<b>SILTSTONE</b> , trace sand, reddish brown, hard	20		50/5"								
3	[Horizontal Line Pattern]	<b>SILTY CLAYSTONE</b> , interbedded with SANDSTONE, grayish brown, hard	25		50/8"			24.3	101				
3	[Horizontal Line Pattern]	<b>SANDSTONE</b> , with silt, fine to coarse grained, grayish white, medium hard to hard	5		50/7"						NP	13	
3	[Horizontal Line Pattern]	<b>SANDY CLAYSTONE</b> , light grayish brown to light brown, medium hard	15		50/10"			18.0	114				
3	[Horizontal Line Pattern]	<b>SILTSTONE</b> , trace sand, reddish brown, hard	20		50/5"								
3	[Horizontal Line Pattern]	<b>SILTY CLAYSTONE</b> , interbedded with SANDSTONE, grayish brown, hard	25		50/8"			24.3	101				
		<b>Boring Terminated at 30 Feet</b>	30		50/9"			24.4	101				

Stratification lines are approximate. In-situ, the transition may be gradual.

Hammer Type: Automatic

Advancement Method:  
4-inch diameter, solid stem, continuous flight power auger

See [Exploration and Testing Procedures](#) for a description of field and laboratory procedures used and additional data (if any).

**Notes:**

Elevations at the borings were obtained using a level and using the rim of the water manhole in the northbound lane of South Chambers Road about 10 feet south of the intersection of South Chambers Road and South Red Sky Drive (approximately 39.4951° N, 104.8020° W) as a temporary benchmark with an assigned elevation of 100.0 feet.

Abandonment Method:  
Boring backfilled with auger cuttings upon completion.

See [Supporting Information](#) for explanation of symbols and abbreviations.

**WATER LEVEL OBSERVATIONS**

None encountered while drilling



Boring Started: 03-10-2021

Boring Completed: 03-10-2021

Drill Rig: CME-75

Driller: Terracon

Project No.: 25215044

THIS BORING LOG IS NOT VALID IF SEPARATED FROM ORIGINAL REPORT. GEO SMART LOG-NO WELL\_25215044 PROPOSED PARKER M.GPJ TERRACON\_DATATEMPLATE.GDT\_4/9/21

# BORING LOG NO. 2

**PROJECT:** Proposed Parker McDonald's Restaurant #50785

**CLIENT:** McDonald's USA LLC

**SITE:** SE of S Chambers Rd and S Red Sky Dr  
Parker, Colorado

MODEL LAYER	GRAPHIC LOG	LOCATION See <a href="#">Exploration Plan</a> Latitude: 39.4944° Longitude: -104.8013°  Approximate Surface Elev.: 96.94 (Ft.) +/- ELEVATION (Ft.)	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	FIELD TEST RESULTS	SWELL (%)	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	ATTERBERG LIMITS		PERCENT FINES
										LL-PL-PI		
2	[Dotted Pattern]	<b>SANDSTONE</b> , with silt, fine to coarse grained, grayish white, medium hard to hard	12.0									
			5	50/7"	6.8	103						
			5	50/10"	9.0	114						
			10	50/7"	9.4	104	NP	10				
3	[Horizontal Line Pattern]	<b>CLAYSTONE</b> , with silt and sand, light grayish brown to light brown, hard	12.0	85+/-								
			15	50/7"								
			20	50/7"								
			25	50/7"	16.8							
		30.0	67+/-	30	50/7"	20.6	109					
<b>Boring Terminated at 30 Feet</b>												

Stratification lines are approximate. In-situ, the transition may be gradual.

Hammer Type: Automatic

**Advancement Method:**  
4-inch diameter, solid stem, continuous flight power auger

See [Exploration and Testing Procedures](#) for a description of field and laboratory procedures used and additional data (if any).

**Notes:**

Elevations at the borings were obtained using a level and using the rim of the water manhole in the northbound lane of South Chambers Road about 10 feet south of the intersection of South Chambers Road and South Red Sky Drive (approximately 39.4951° N, 104.8020° W) as a temporary benchmark with an assigned elevation of 100.0 feet.

**Abandonment Method:**  
Boring backfilled with auger cuttings upon completion.

See [Supporting Information](#) for explanation of symbols and abbreviations.

**WATER LEVEL OBSERVATIONS**

None encountered while drilling



Boring Started: 03-10-2021

Boring Completed: 03-10-2021

Drill Rig: CME-75

Driller: Terracon

Project No.: 25215044

THIS BORING LOG IS NOT VALID IF SEPARATED FROM ORIGINAL REPORT. GEO SMART LOG-NO WELL - 25215044 PROPOSED PARKER M.G.P.J TERRACON\_DATATEMPLATE.GDT 4/9/21

# BORING LOG NO. 3

**PROJECT:** Proposed Parker McDonald's Restaurant #50785

**CLIENT:** McDonald's USA LLC

**SITE:** SE of S Chambers Rd and S Red Sky Dr  
Parker, Colorado

THIS BORING LOG IS NOT VALID IF SEPARATED FROM ORIGINAL REPORT. GEO SMART LOG-NO WELL\_25215044 PROPOSED PARKER M.GPJ TERRACON\_DATATEMPLATE.GDT\_4/9/21

MODEL LAYER	GRAPHIC LOG	LOCATION See <a href="#">Exploration Plan</a>		DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	FIELD TEST RESULTS	SWELL (%)	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	ATTERBERG LIMITS		PERCENT FINES
		Latitude: 39.4946° Longitude: -104.8010°	Approximate Surface Elev.: 98.5 (Ft.) +/-								DEPTH	ELEVATION (Ft.)	
1		<b>FILL - SANDY LEAN CLAY (CL)</b> , light gray		2.0									
2		<b>SANDSTONE</b> , fine to coarse grained, grayish white, medium hard		7.0	96.5+/-	50/11"			6.2				
						50/11"			7.4	109			
3		<b>CLAYSTONE</b> , with sand, trace silt, white to dark brown, medium hard to hard		30.0	91.5+/-	50/9"		+6.0 @ 500 psf	9.4	122			
						50/9"		+3.0 @ 500 psf	19.0	109			
						50/8"							
						50/10"			18.1	110			
						50/6"			21.9	104			
		<b>Boring Terminated at 30 Feet</b>		30									

Stratification lines are approximate. In-situ, the transition may be gradual.

Hammer Type: Automatic

**Advancement Method:**  
4-inch diameter, solid stem, continuous flight power auger

See [Exploration and Testing Procedures](#) for a description of field and laboratory procedures used and additional data (if any).

**Notes:**

Elevations at the borings were obtained using a level and using the rim of the water manhole in the northbound lane of South Chambers Road about 10 feet south of the intersection of South Chambers Road and South Red Sky Drive (approximately 39.4951° N, 104.8020° W) as a temporary benchmark with an assigned elevation of 100.0 feet.

**Abandonment Method:**  
Boring backfilled with auger cuttings upon completion.

See [Supporting Information](#) for explanation of symbols and abbreviations.

**WATER LEVEL OBSERVATIONS**

None encountered while drilling



Boring Started: 03-10-2021

Boring Completed: 03-10-2021

Drill Rig: CME-75

Driller: Terracon

Project No.: 25215044

# BORING LOG NO. 4

**PROJECT:** Proposed Parker McDonald's Restaurant  
#50785

**CLIENT:** McDonald's USA LLC

**SITE:** SE of S Chambers Rd and S Red Sky Dr  
Parker, Colorado

THIS BORING LOG IS NOT VALID IF SEPARATED FROM ORIGINAL REPORT. GEO SMART LOG-NO WELL - 25215044 PROPOSED PARKER M.GPJ TERRACON\_DATATEMPLATE.GDT 4/9/21

MODEL LAYER	GRAPHIC LOG	LOCATION See <a href="#">Exploration Plan</a> Latitude: 39.4945° Longitude: -104.8010°  Approximate Surface Elev.: 98.3 (Ft.) +/- DEPTH ELEVATION (Ft.)	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	FIELD TEST RESULTS	SWELL (%)	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	ATTERBERG LIMITS		PERCENT FINES
										LL-PL-PI		
1		<b>FILL - SANDY LEAN CLAY (CL)</b> , brown 2.0 96.5+/-										
2		<b>SANDSTONE</b> , trace clay, fine to coarse grained, grayish white, medium hard to hard 7.0 91.5+/-	5			14-22 50/7"		4.3 7.7		104		
3		<b>CLAYSTONE</b> , with silt, red to light gray, medium hard to hard 17.0 81.5+/-	10			50/10"	-0.5 @ 500 psf	18.4		108		
			15			50/9"		23.0		104		
2		<b>SANDSTONE</b> , interbedded with CLAYSTONE, fine to coarse grained, light gray to yellowish brown, hard 17.0 81.5+/-	20			50/7"		19.3		103		
			25			50/9"		20.9		101		
			30			50/6"		17.8				
<b>Boring Terminated at 30 Feet</b>												

Stratification lines are approximate. In-situ, the transition may be gradual.

Hammer Type: Automatic

**Advancement Method:**  
4-inch diameter, solid stem, continuous flight power auger

See [Exploration and Testing Procedures](#) for a description of field and laboratory procedures used and additional data (If any).

**Notes:**

Elevations at the borings were obtained using a level and using the rim of the water manhole in the northbound lane of South Chambers Road about 10 feet south of the intersection of South Chambers Road and South Red Sky Drive (approximately 39.4951° N, 104.8020° W) as a temporary benchmark with an assigned elevation of 100.0 feet.

**Abandonment Method:**  
Boring backfilled with auger cuttings upon completion.

See [Supporting Information](#) for explanation of symbols and abbreviations.

**WATER LEVEL OBSERVATIONS**

None encountered while drilling



Boring Started: 03-10-2021

Boring Completed: 03-10-2021

Drill Rig: CME-75

Driller: Terracon

Project No.: 25215044

# BORING LOG NO. 5

**PROJECT: Proposed Parker McDonald's Restaurant #50785**

**CLIENT: McDonald's USA LLC**

**SITE: SE of S Chambers Rd and S Red Sky Dr Parker, Colorado**

MODEL LAYER	GRAPHIC LOG	LOCATION See <a href="#">Exploration Plan</a> Latitude: 39.4942° Longitude: -104.8013°  Approximate Surface Elev.: 96.48 (Ft.) +/- DEPTH ELEVATION (Ft.)	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	FIELD TEST RESULTS	SWELL (%)	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	ATTERBERG LIMITS	
										LL-PL-PI	PERCENT FINES
2	[Dotted Pattern]	<b>SANDSTONE</b> , with silt, fine to coarse grained, grayish white, hard	5.0	91.5+/-	50/9"			6.9		NP	11
			5	91.5+/-	50/10"			7.5			
3	[Horizontal Line Pattern]	<b>CLAYSTONE</b> , grayish brown to yellowish brown, medium hard to hard	10	105	50/11"		+5.1 @ 500 psf	21.8	105		
			15	114	50/7"			17.2	114		
<b>Boring Terminated at 15 Feet</b>											

Stratification lines are approximate. In-situ, the transition may be gradual.

Hammer Type: Automatic

**Advancement Method:**  
4-inch diameter, solid stem, continuous flight power auger

See [Exploration and Testing Procedures](#) for a description of field and laboratory procedures used and additional data (If any).

**Notes:**

Elevations at the borings were obtained using a level and using the rim of the water manhole in the northbound lane of South Chambers Road about 10 feet south of the intersection of South Chambers Road and South Red Sky Drive (approximately 39.4951° N, 104.8020° W) as a temporary benchmark with an assigned elevation of 100.0 feet.

**Abandonment Method:**  
Boring backfilled with auger cuttings upon completion.

See [Supporting Information](#) for explanation of symbols and abbreviations.

**WATER LEVEL OBSERVATIONS**

*None encountered while drilling*



Boring Started: 03-10-2021

Boring Completed: 03-10-2021

Drill Rig: CME-75

Driller: Terracon

Project No.: 25215044

THIS BORING LOG IS NOT VALID IF SEPARATED FROM ORIGINAL REPORT. GEO SMART LOG-NO WELL - 25215044 PROPOSED PARKER M.GPJ TERRACON\_DATATEMPLATE.GDT 4/9/21

# BORING LOG NO. 6

**PROJECT:** Proposed Parker McDonald's Restaurant  
#50785

**CLIENT:** McDonald's USA LLC

**SITE:** SE of S Chambers Rd and S Red Sky Dr  
Parker, Colorado

THIS BORING LOG IS NOT VALID IF SEPARATED FROM ORIGINAL REPORT. GEO SMART LOG-NO WELL - 25215044 PROPOSED PARKER M.GPJ TERRACON\_DATATEMPLATE.GDT 4/9/21

MODEL LAYER	GRAPHIC LOG	LOCATION See <a href="#">Exploration Plan</a>		DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	FIELD TEST RESULTS	SWELL (%)	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	ATTERBERG LIMITS		PERCENT FINES
		Latitude: 39.4945° Longitude: -104.8007°	Approximate Surface Elev.: 93.40 (Ft.) +/-								LL-PL-PI		
		DEPTH	ELEVATION (Ft.)										
1		<b>FILL - SANDY LEAN CLAY (CL)</b> , brown	2.0	91.5+/-									
2		<b>POORLY GRADED SAND (SP)</b> , trace gravel, fine to coarse grained, grayish white, dense	4.0	89.5+/-			21-29		3.3				
		<b>CLAYSTONE</b> , with sand, grayish brown to pale red, soft to medium hard					8-15	+1.2 @ 500 psf	10.2	111			
4							12-29		20.0	108	56-25-31	54	
			15.0	78.5+/-			15-35		17.4	115			
		<b>Boring Terminated at 15 Feet</b>											

Stratification lines are approximate. In-situ, the transition may be gradual.

Hammer Type: Automatic

**Advancement Method:**  
4-inch diameter, solid stem, continuous flight power auger

See [Exploration and Testing Procedures](#) for a description of field and laboratory procedures used and additional data (if any).

**Notes:**

Elevations at the borings were obtained using a level and using the rim of the water manhole in the northbound lane of South Chambers Road about 10 feet south of the intersection of South Chambers Road and South Red Sky Drive (approximately 39.4951° N, 104.8020° W) as a temporary benchmark with an assigned elevation of 100.0 feet.

**Abandonment Method:**  
Boring backfilled with auger cuttings upon completion.

See [Supporting Information](#) for explanation of symbols and abbreviations.

**WATER LEVEL OBSERVATIONS**

None encountered while drilling



Boring Started: 03-10-2021

Boring Completed: 03-10-2021

Drill Rig: CME-75

Driller: Terracon

Project No.: 25215044

# BORING LOG NO. 7

**PROJECT: Proposed Parker McDonald's Restaurant #50785**

**CLIENT: McDonald's USA LLC**

**SITE: SE of S Chambers Rd and S Red Sky Dr Parker, Colorado**

MODEL LAYER	GRAPHIC LOG	LOCATION See <a href="#">Exploration Plan</a> Latitude: 39.4947° Longitude: -104.8009°  Approximate Surface Elev.: 97.75 (Ft.) +/- ELEVATION (Ft.)	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	FIELD TEST RESULTS	SWELL (%)	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	ATTERBERG LIMITS		PERCENT FINES
										LL-PL-PI		
1	X	<b>FILL - SANDY LEAN CLAY (CL)</b> , brown	2.0									
3	.	<b>SANDSTONE</b> , fine to coarse grained, grayish white, medium hard to hard	7.0		X	24-26		6.6	108			
					X	50/6"		4.3				
4		<b>CLAYSTONE</b> , with silt, red, hard	10.0		X	50/9"	+3.4 @ 500 psf	18.4	111			
<b>Boring Terminated at 10 Feet</b>												

Stratification lines are approximate. In-situ, the transition may be gradual.

Hammer Type: Automatic

Advancement Method:  
4-inch diameter, solid stem, continuous flight power auger

See [Exploration and Testing Procedures](#) for a description of field and laboratory procedures used and additional data (if any).

**Notes:**

Elevations at the borings were obtained using a level and using the rim of the water manhole in the northbound lane of South Chambers Road about 10 feet south of the intersection of South Chambers Road and South Red Sky Drive (approximately 39.4951° N, 104.8020° W) as a temporary benchmark with an assigned elevation of 100.0 feet.

Abandonment Method:  
Boring backfilled with auger cuttings upon completion.

See [Supporting Information](#) for explanation of symbols and abbreviations.

**WATER LEVEL OBSERVATIONS**

*None encountered while drilling*



Boring Started: 03-10-2021

Boring Completed: 03-10-2021

Drill Rig: CME-75

Driller: Terracon

Project No.: 25215044

THIS BORING LOG IS NOT VALID IF SEPARATED FROM ORIGINAL REPORT. GEO SMART LOG-NO WELL\_25215044 PROPOSED PARKER M.GPJ TERRACON\_DATATEMPLATE.GDT\_4/9/21

# BORING LOG NO. P1

**PROJECT:** Proposed Parker McDonald's Restaurant  
#50785

**CLIENT:** McDonald's USA LLC

**SITE:** SE of S Chambers Rd and S Red Sky Dr  
Parker, Colorado

MODEL LAYER	GRAPHIC LOG	LOCATION See <a href="#">Exploration Plan</a> Latitude: 39.4943° Longitude: -104.8011°  Approximate Surface Elev.: 98.31 (Ft.) +/- DEPTH ELEVATION (Ft.)	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	FIELD TEST RESULTS	SWELL (%)	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	ATTERBERG LIMITS LL-PL-PI	PERCENT FINES
1		<b>FILL - CLAYEY SAND (SC)</b> , trace gravel, fine to coarse grained, brown	2.0								
3		<b>SANDSTONE</b> , fine to coarse grained, grayish white, firm to hard	5.0		X	14-16		5.4	107	40-16-24	30
		<b>Boring Terminated at 5 Feet</b>	5		X	50/9"		4.8	114		

Stratification lines are approximate. In-situ, the transition may be gradual.

Hammer Type: Automatic

**Advancement Method:**  
4-inch diameter, solid stem, continuous flight power auger

See [Exploration and Testing Procedures](#) for a description of field and laboratory procedures used and additional data (If any).

**Notes:**

Elevations at the borings were obtained using a level and using the rim of the water manhole in the northbound lane of South Chambers Road about 10 feet south of the intersection of South Chambers Road and South Red Sky Drive (approximately 39.4951° N, 104.8020° W) as a temporary benchmark with an assigned elevation of 100.0 feet.

**Abandonment Method:**  
Boring backfilled with auger cuttings upon completion.

See [Supporting Information](#) for explanation of symbols and abbreviations.

**WATER LEVEL OBSERVATIONS**

*None encountered while drilling*



Boring Started: 03-10-2021

Boring Completed: 03-10-2021

Drill Rig: CME-75

Driller: Terracon

Project No.: 25215044

THIS BORING LOG IS NOT VALID IF SEPARATED FROM ORIGINAL REPORT. GEO SMART LOG-NO WELL - 25215044 PROPOSED PARKER M.GPJ TERRACON\_DATATEMPLATE.GDT 4/9/21

# BORING LOG NO. P2

**PROJECT:** Proposed Parker McDonald's Restaurant  
#50785

**CLIENT:** McDonald's USA LLC

**SITE:** SE of S Chambers Rd and S Red Sky Dr  
Parker, Colorado

MODEL LAYER	GRAPHIC LOG	LOCATION See <a href="#">Exploration Plan</a> Latitude: 39.4947° Longitude: -104.8006°  Approximate Surface Elev.: 93.92 (Ft.) +/- DEPTH ELEVATION (Ft.)	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	FIELD TEST RESULTS	SWELL (%)	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	ATTERBERG LIMITS LL-PL-PI	PERCENT FINES
1		<b>FILL - WELL GRADED SAND WITH SILT AND GRAVEL (SW-SM)</b> , fine to coarse grained, brown	2.0								
3		<b>SANDSTONE</b> , with silt, fine to coarse grained, grayish white, soft to firm	5.0		X	11-11				NP	11
		<b>Boring Terminated at 5 Feet</b>	5		X	10-16		9.0	114		

Stratification lines are approximate. In-situ, the transition may be gradual.

Hammer Type: Automatic

**Advancement Method:**  
4-inch diameter, solid stem, continuous flight power auger

See [Exploration and Testing Procedures](#) for a description of field and laboratory procedures used and additional data (If any).

**Notes:**

Elevations at the borings were obtained using a level and using the rim of the water manhole in the northbound lane of South Chambers Road about 10 feet south of the intersection of South Chambers Road and South Red Sky Drive (approximately 39.4951° N, 104.8020° W) as a temporary benchmark with an assigned elevation of 100.0 feet.

**Abandonment Method:**  
Boring backfilled with auger cuttings upon completion.

See [Supporting Information](#) for explanation of symbols and abbreviations.

**WATER LEVEL OBSERVATIONS**

*None encountered while drilling*



Boring Started: 03-10-2021

Boring Completed: 03-10-2021

Drill Rig: CME-75

Driller: Terracon

Project No.: 25215044

THIS BORING LOG IS NOT VALID IF SEPARATED FROM ORIGINAL REPORT. GEO SMART LOG-NO WELL - 25215044 PROPOSED PARKER M.GPJ TERRACON\_DATATEMPLATE.GDT 4/9/21

# BORING LOG NO. P3

**PROJECT:** Proposed Parker McDonald's Restaurant  
#50785

**CLIENT:** McDonald's USA LLC

**SITE:** SE of S Chambers Rd and S Red Sky Dr  
Parker, Colorado

MODEL LAYER	GRAPHIC LOG	LOCATION See <a href="#">Exploration Plan</a> Latitude: 39.4945° Longitude: -104.8005°  Approximate Surface Elev.: 96.51 (Ft.) +/- DEPTH ELEVATION (Ft.)	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	FIELD TEST RESULTS	SWELL (%)	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	ATTERBERG LIMITS LL-PL-PI	PERCENT FINES
1		<b>FILL - CLAYEY SAND (SC)</b> , trace gravel, fine to coarse grained, orangish brown to grayish white, stiff	3.0		XX	4-8	+0.4 @ 200 psf	21.7	93	55-26-29	42
3		<b>SANDSTONE</b> , trace clay, fine to coarse grained, grayish white, soft	5.0		XX	6-10		14.6	103		
		<b>Boring Terminated at 5 Feet</b>	5								

Stratification lines are approximate. In-situ, the transition may be gradual.

Hammer Type: Automatic

**Advancement Method:**  
4-inch diameter, solid stem, continuous flight power auger

See [Exploration and Testing Procedures](#) for a description of field and laboratory procedures used and additional data (If any).

**Notes:**

Elevations at the borings were obtained using a level and using the rim of the water manhole in the northbound lane of South Chambers Road about 10 feet south of the intersection of South Chambers Road and South Red Sky Drive (approximately 39.4951° N, 104.8020° W) as a temporary benchmark with an assigned elevation of 100.0 feet.

**Abandonment Method:**  
Boring backfilled with auger cuttings upon completion.

See [Supporting Information](#) for explanation of symbols and abbreviations.

**WATER LEVEL OBSERVATIONS**

*None encountered while drilling*



Boring Started: 03-10-2021

Boring Completed: 03-10-2021

Drill Rig: CME-75

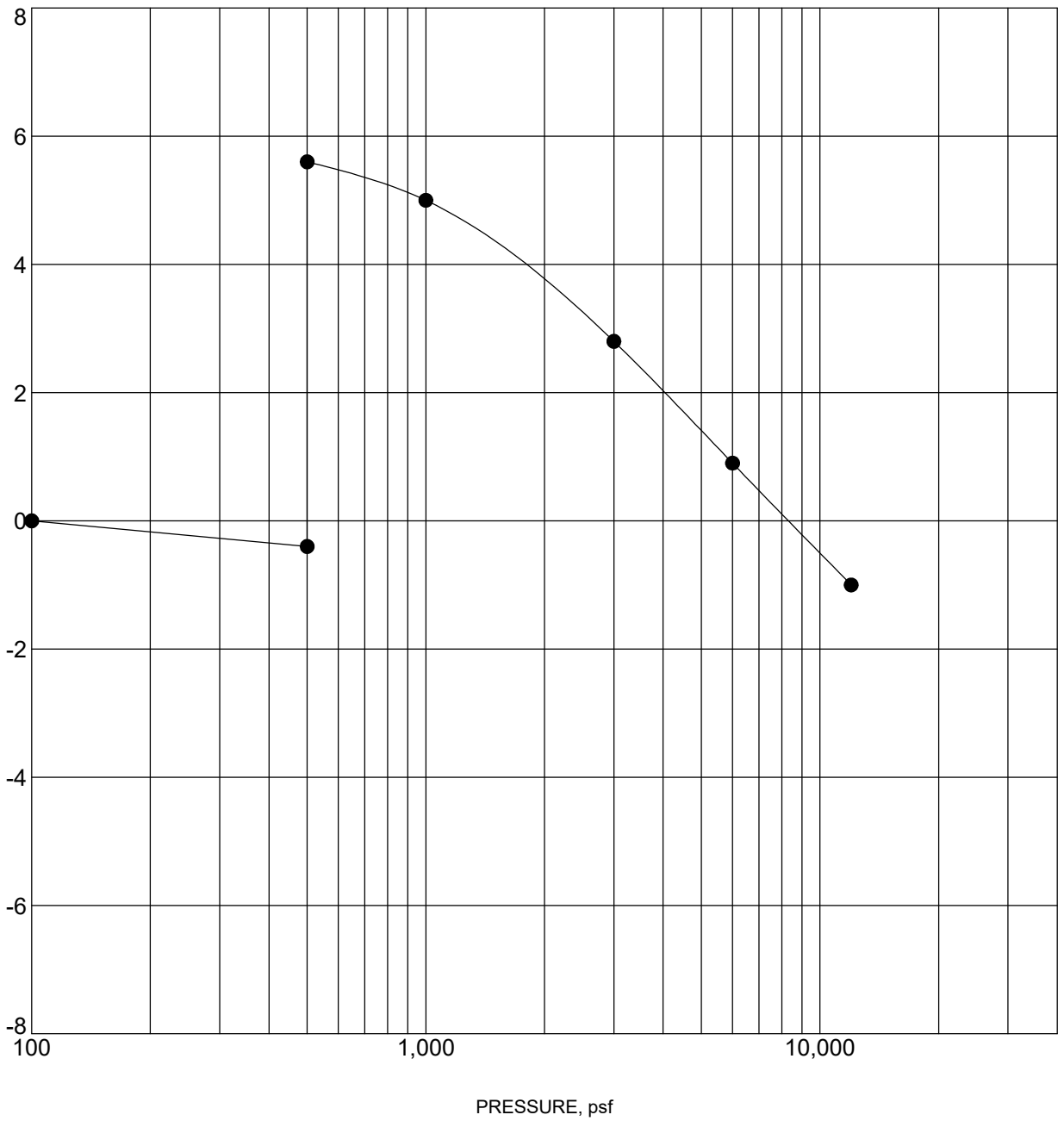
Driller: Terracon

Project No.: 25215044

THIS BORING LOG IS NOT VALID IF SEPARATED FROM ORIGINAL REPORT. GEO SMART LOG-NO WELL - 25215044 PROPOSED PARKER M.GPJ TERRACON\_DATATEMPLATE.GDT 4/9/21

# SWELL CONSOLIDATION TEST

AXIAL STRAIN, %



Specimen Identification		Classification	$\gamma_d$ , pcf	WC, %
●	3      9 - 10 ft	CLAYSTONE	122	9.4

NOTES: Water was added at 500 psf.

LABORATORY TESTS ARE NOT VALID IF SEPARATED FROM ORIGINAL REPORT. TC\_CONSOL\_STRAIN-AASHTO-NO ASTM 25215044 PROPOSED PARKER M.GPJ TERRACON\_DATATEMPLATE.GDT 4/6/21

PROJECT: Proposed Parker McDonald's Restaurant #50785

SITE: SE of S Chambers Rd and S Red Sky Dr  
Parker, Colorado

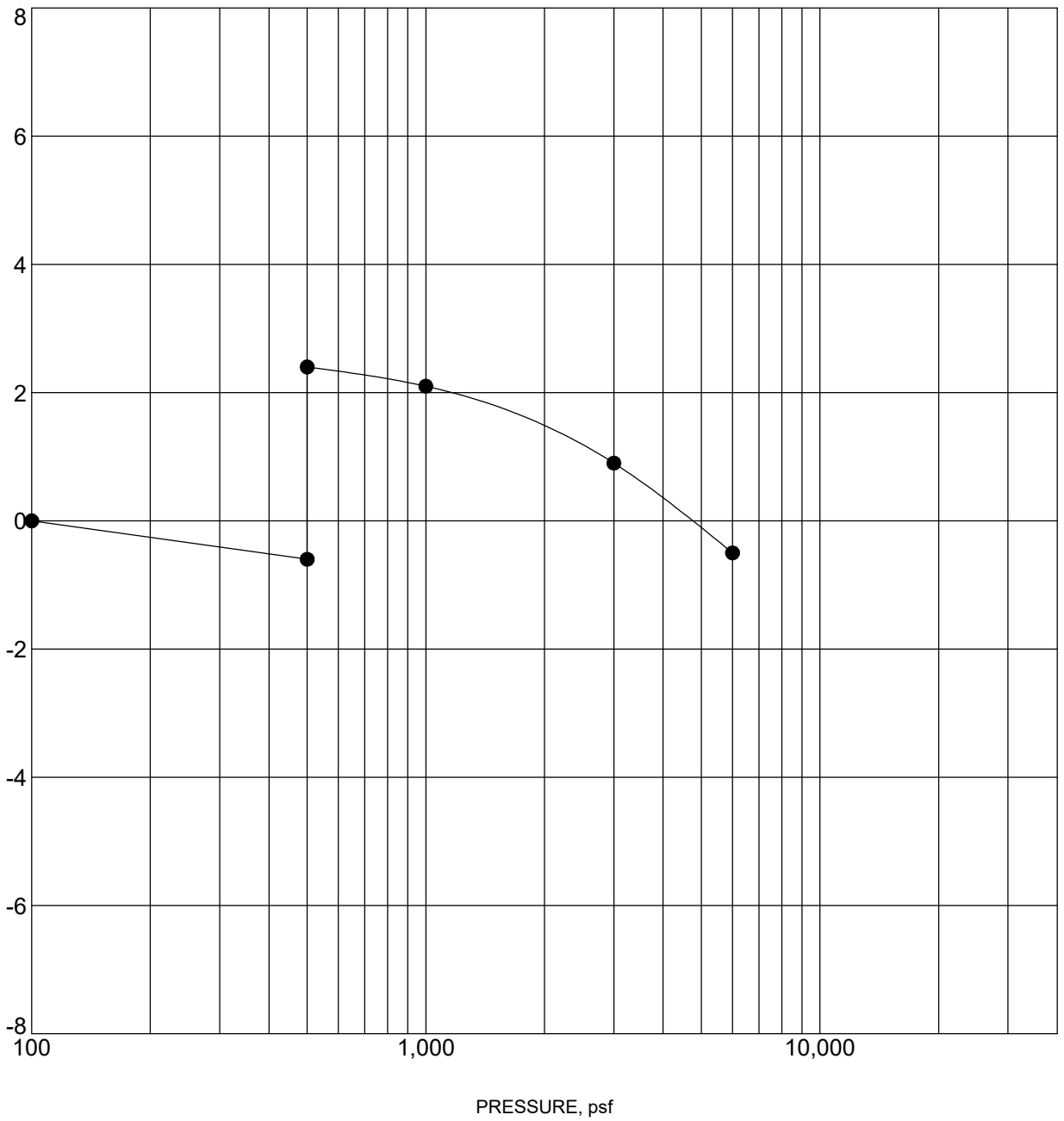


PROJECT NUMBER: 25215044

CLIENT: McDonalds USA LLC

# SWELL CONSOLIDATION TEST

LABORATORY TESTS ARE NOT VALID IF SEPARATED FROM ORIGINAL REPORT. TC\_CONSOL\_STRAIN-AASHTO-NO ASTM 25215044 PROPOSED PARKER M.GPJ TERRACON\_DATATEMPLATE.GDT 4/6/21



Specimen Identification			Classification	$\gamma_d$ , pcf	WC, %
●	3	14 - 15 ft	CLAYSTONE	109	19.0

NOTES: Water was added at 500 psf.

PROJECT: Proposed Parker McDonald's Restaurant #50785

SITE: SE of S Chambers Rd and S Red Sky Dr Parker, Colorado

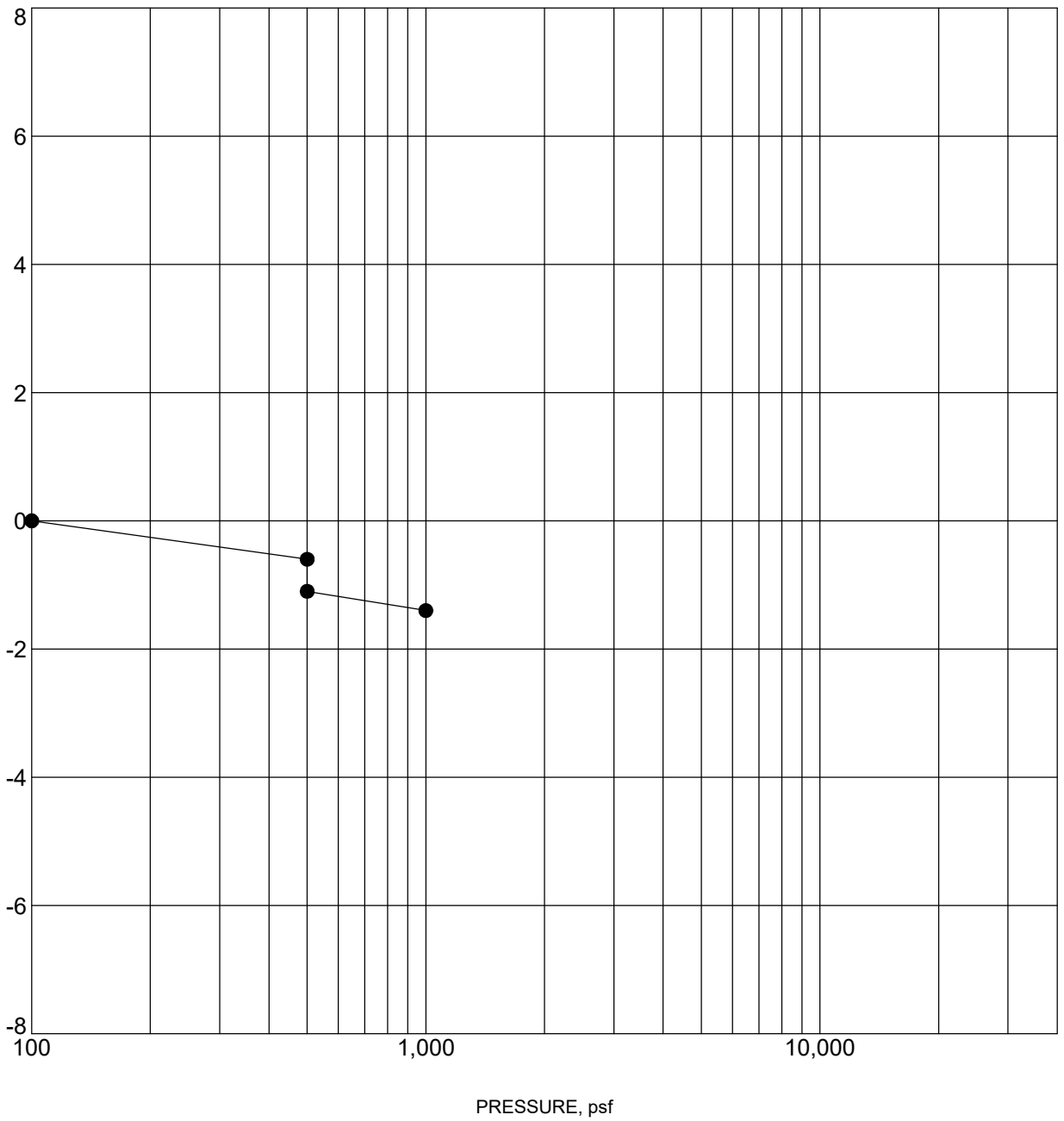


PROJECT NUMBER: 25215044

CLIENT: McDonalds USA LLC

# SWELL CONSOLIDATION TEST

AXIAL STRAIN, %



Specimen Identification		Classification	$\gamma_d$ , pcf	WC, %
●	4      9 - 10 ft	CLAYSTONE	108	18.4

NOTES: Water was added at 500 psf.

LABORATORY TESTS ARE NOT VALID IF SEPARATED FROM ORIGINAL REPORT. TC\_CONSOL\_STRAIN-AASHTO-NO ASTM 25215044 PROPOSED PARKER M.GPJ TERRACON\_DATATEMPLATE.GDT 4/6/21

PROJECT: Proposed Parker McDonald's Restaurant #50785

SITE: SE of S Chambers Rd and S Red Sky Dr  
Parker, Colorado

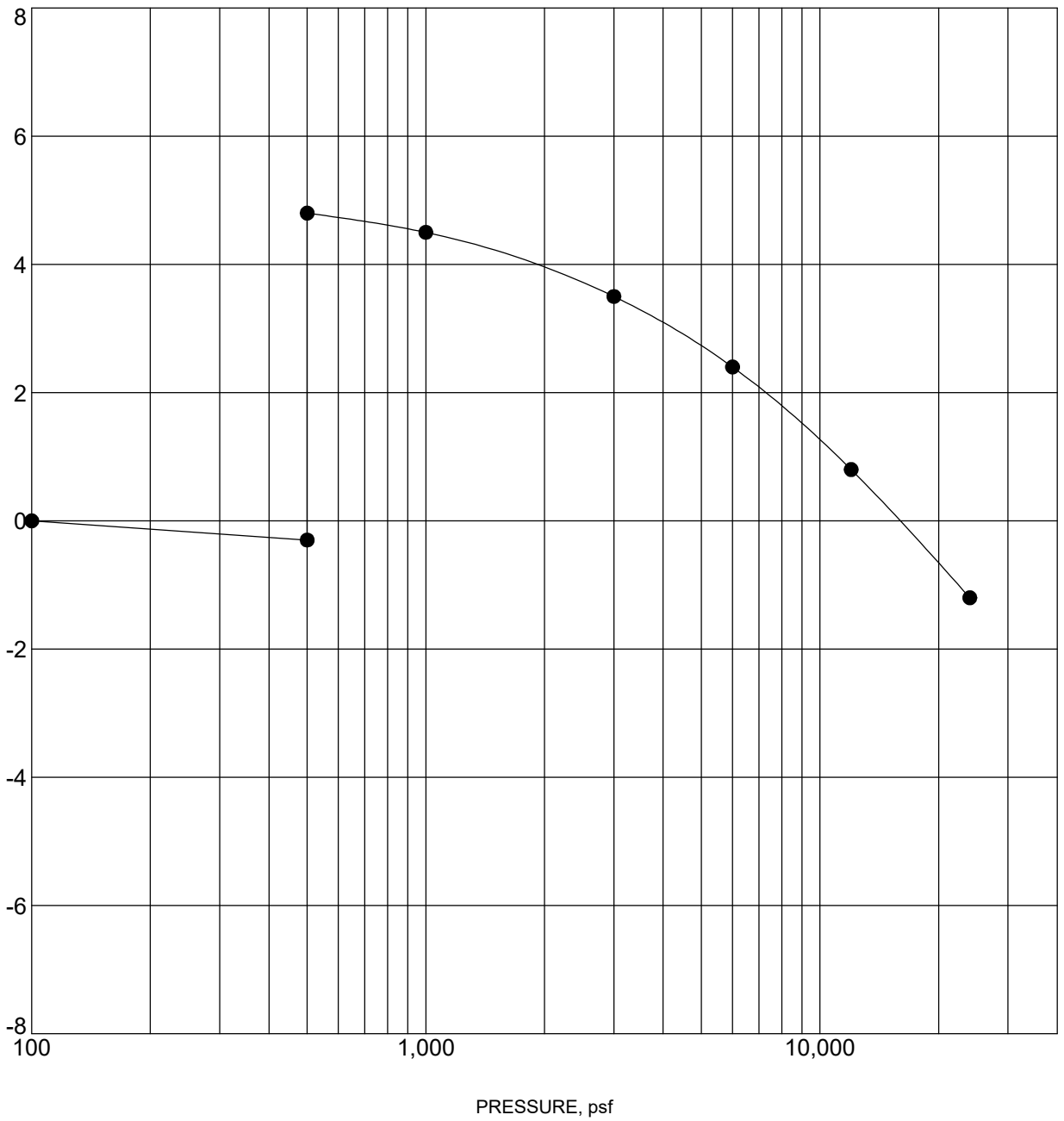


PROJECT NUMBER: 25215044

CLIENT: McDonalds USA LLC

# SWELL CONSOLIDATION TEST

LABORATORY TESTS ARE NOT VALID IF SEPARATED FROM ORIGINAL REPORT. TC\_CONSOL\_STRAIN-AASHTO-NO ASTM 25215044 PROPOSED PARKER M.GPJ TERRACON\_DATATEMPLATE.GDT 4/6/21



Specimen Identification		Classification	$\gamma_d$ , pcf	WC, %
●	5 9 - 10 ft	CLAYSTONE	105	21.8

NOTES: Water was added at 500 psf.

PROJECT: Proposed Parker McDonald's Restaurant #50785

SITE: SE of S Chambers Rd and S Red Sky Dr  
Parker, Colorado

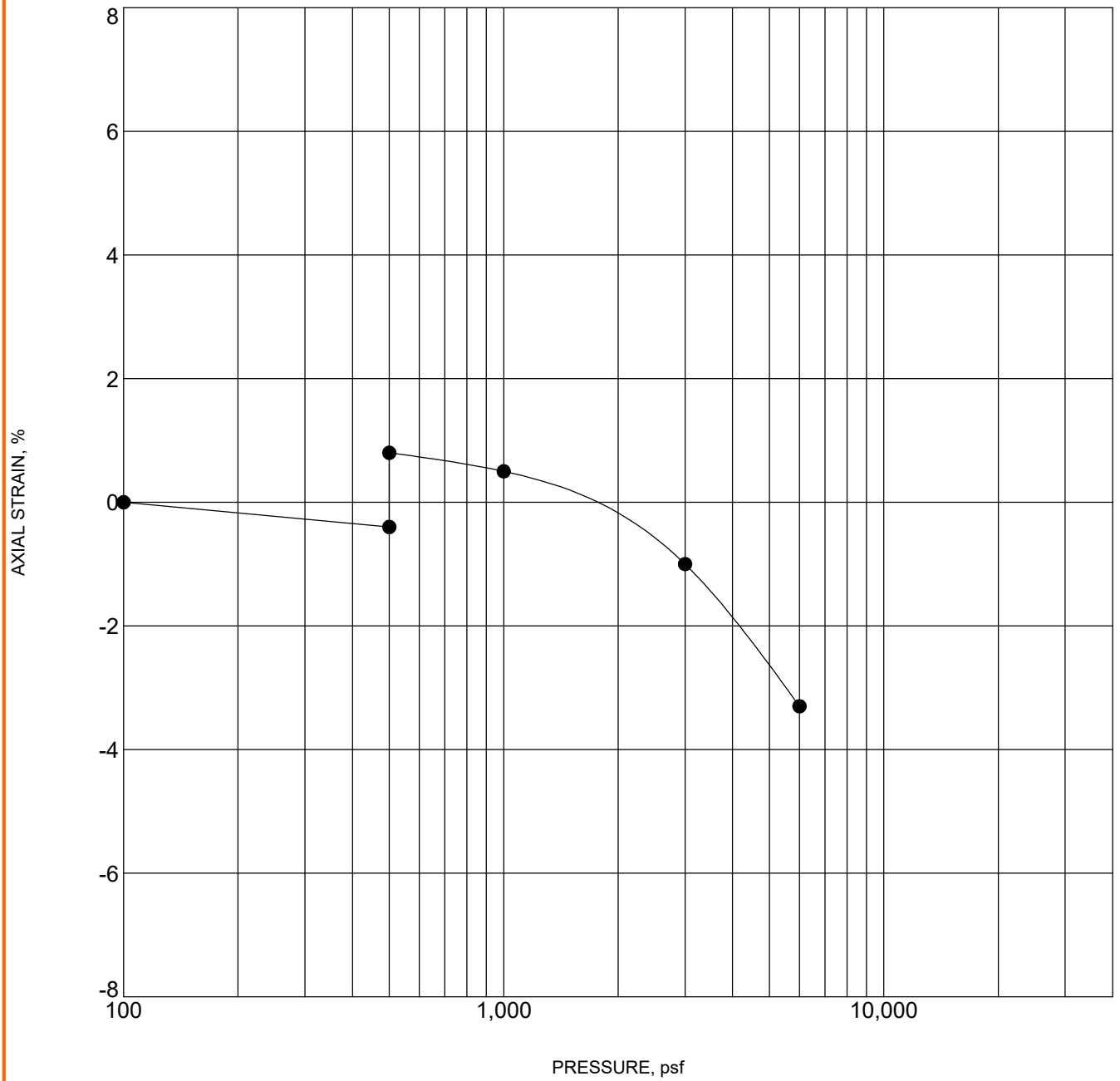


PROJECT NUMBER: 25215044

CLIENT: McDonalds USA LLC

# SWELL CONSOLIDATION TEST

LABORATORY TESTS ARE NOT VALID IF SEPARATED FROM ORIGINAL REPORT. TC\_CONSOL\_STRAIN-AASHTO-NO ASTM 25215044 PROPOSED PARKER M.GPJ TERRACON\_DATATEMPLATE.GDT 4/6/21



Specimen Identification			Classification	$\gamma_d$ , pcf	WC, %
●	6	4 - 5 ft	CLAYSTONE	111	10.2

NOTES: Water was added at 500 psf.

PROJECT: Proposed Parker McDonald's Restaurant #50785

SITE: SE of S Chambers Rd and S Red Sky Dr  
Parker, Colorado

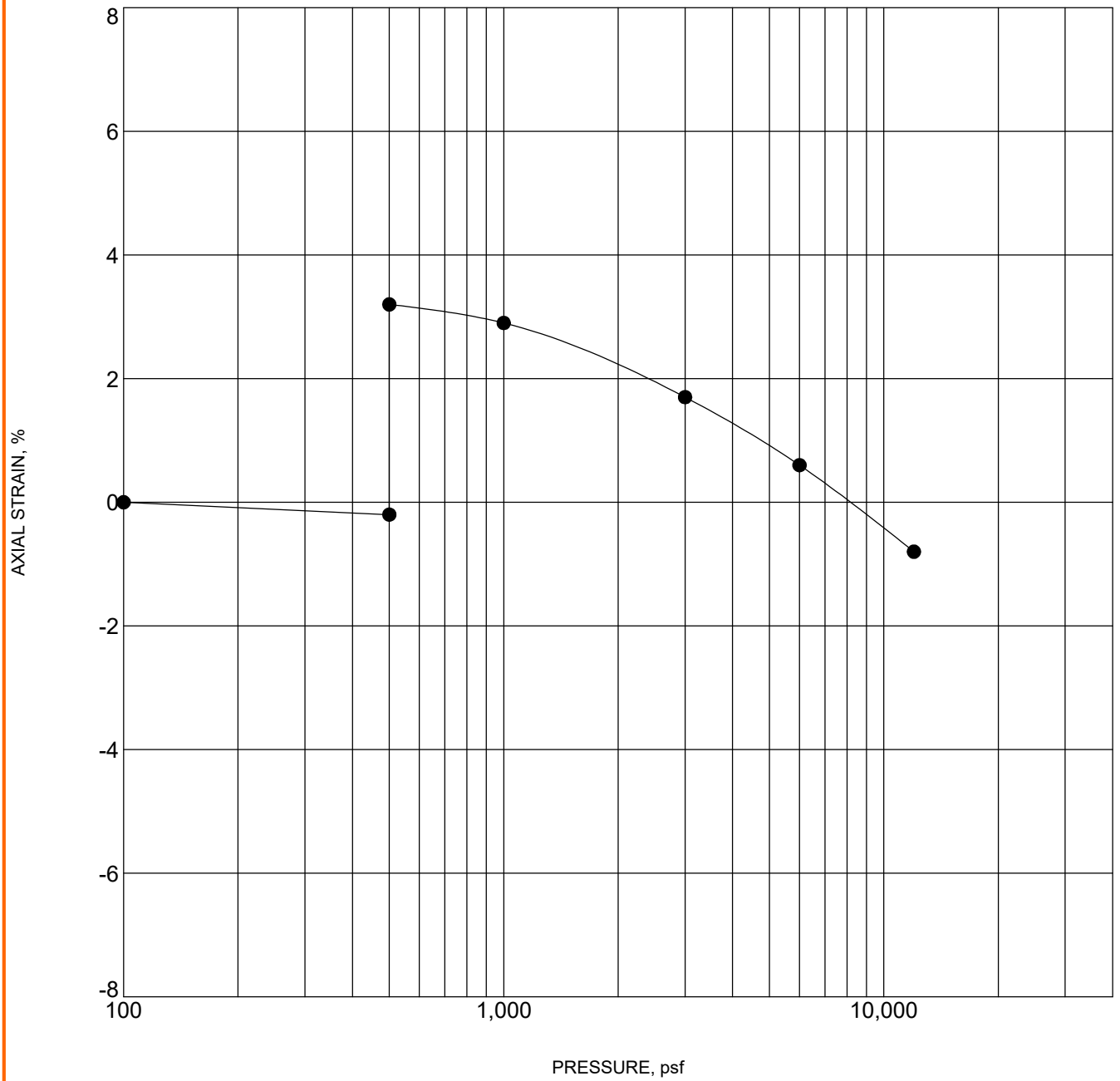


PROJECT NUMBER: 25215044

CLIENT: McDonalds USA LLC

# SWELL CONSOLIDATION TEST

LABORATORY TESTS ARE NOT VALID IF SEPARATED FROM ORIGINAL REPORT. TC\_CONSOL\_STRAIN-AASHTO-NO ASTM 25215044 PROPOSED PARKER M.GPJ TERRACON\_DATATEMPLATE.GDT 4/6/21



Specimen Identification		Classification	$\gamma_d$ , pcf	WC, %
●	7      9 - 10 ft	CLAYSTONE	111	18.4

NOTES: Water was added at 500 psf.

PROJECT: Proposed Parker McDonald's Restaurant #50785

SITE: SE of S Chambers Rd and S Red Sky Dr  
Parker, Colorado

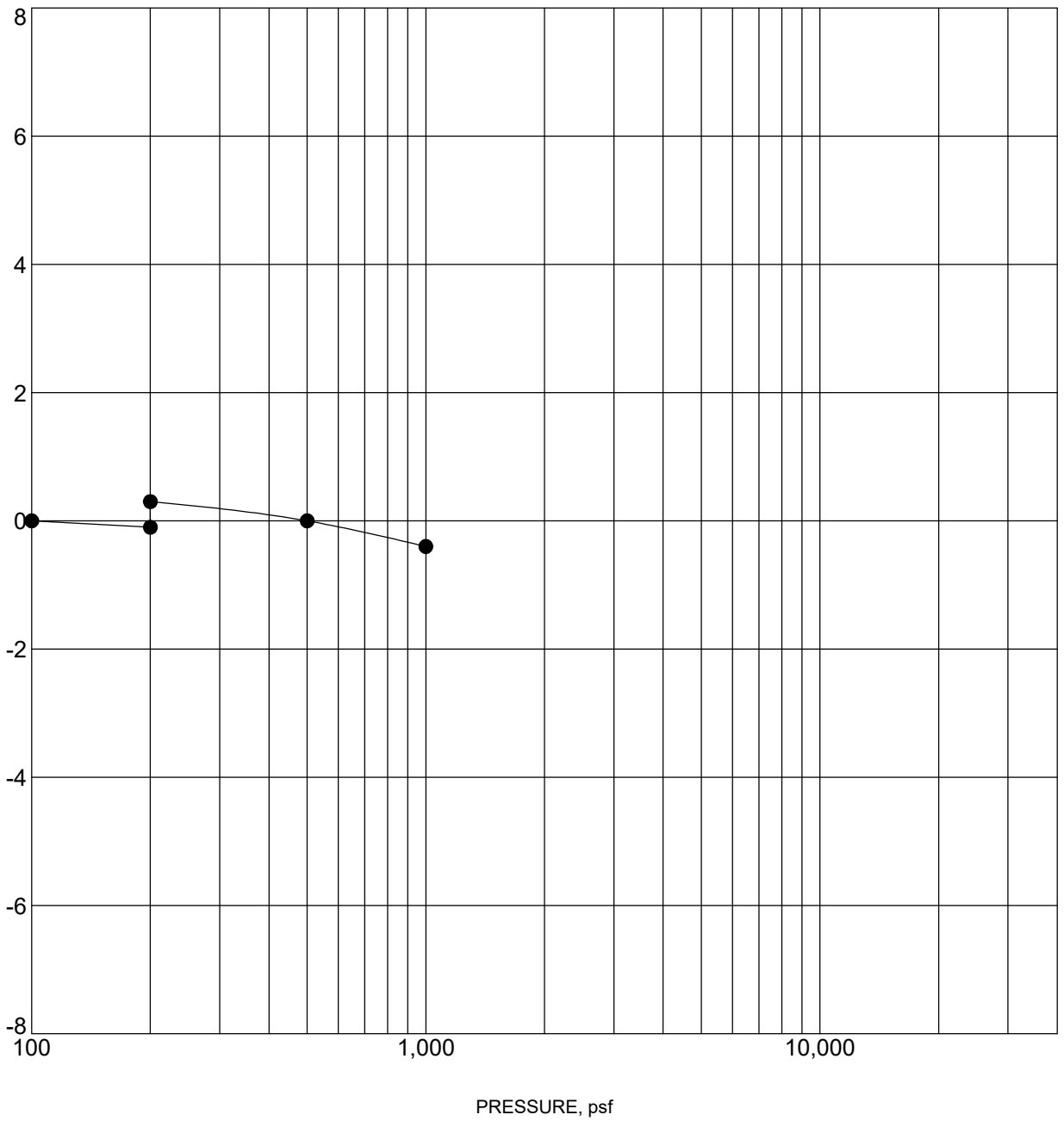


PROJECT NUMBER: 25215044

CLIENT: McDonalds USA LLC

# SWELL CONSOLIDATION TEST

AXIAL STRAIN, %



Specimen Identification		Classification	$\gamma_d$ , pcf	WC, %
●	P3 2 - 3 ft	FILL - CLAYEY SAND (SC)	93	21.7

NOTES: Water was added at 200 psf.

LABORATORY TESTS ARE NOT VALID IF SEPARATED FROM ORIGINAL REPORT. TC\_CONSOL\_STRAIN-AASHTO-NO ASTM 25215044 PROPOSED PARKER M.GPJ TERRACON\_DATATEMPLATE.GDT 4/6/21

PROJECT: Proposed Parker McDonald's Restaurant #50785

SITE: SE of S Chambers Rd and S Red Sky Dr  
Parker, Colorado



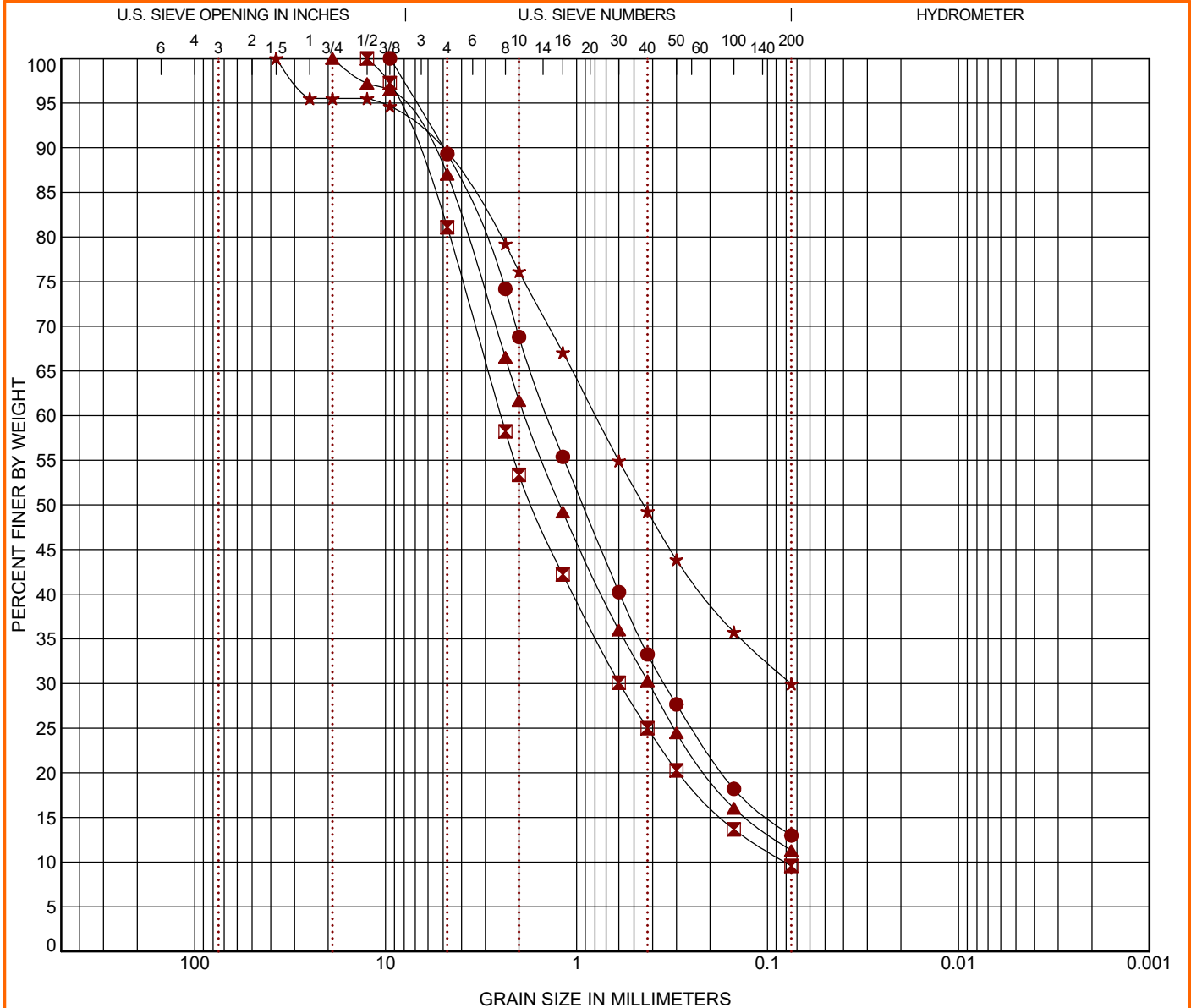
PROJECT NUMBER: 25215044

CLIENT: McDonalds USA LLC

# GRAIN SIZE DISTRIBUTION

ASTM D422 / ASTM C136

LABORATORY TESTS ARE NOT VALID IF SEPARATED FROM ORIGINAL REPORT. GRAIN SIZE: USCS & AASHTO DESC COMBINED 25215044 PROPOSED PARKER M.GPJ TERRACON\_DATATEMPLATE.GDT 4/8/21



COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

Boring ID	Depth	USCS Classification	AASHTO Classification	WC (%)	LL	PL	PI	Cc	Cu
● 1	2 - 3	SILTY SAND (SM)	A-1-b (0)		NP	NP	NP		
■ 2	9 - 10	WELL-GRADED SAND with SILT and GRAVEL (SW-SM)	A-1-b (0)	9.4	NP	NP	NP	1.77	30.86
▲ 5	2 - 3	WELL-GRADED SAND with SILT (SW-SM)	A-1-b (0)	6.9	NP	NP	NP	1.51	29.99
★ P1	0 - 5	CLAYEY SAND (SC)	A-2-6 (2)		40	16	24		

Boring ID	Depth	D <sub>100</sub>	D <sub>60</sub>	D <sub>30</sub>	D <sub>10</sub>	%Gravel	%Sand	%Silt	%Fines	%Clay
● 1	2 - 3	9.5	1.415	0.347		10.7	76.3		13.0	
■ 2	9 - 10	12.5	2.489	0.596	0.081	18.9	71.5		9.6	
▲ 5	2 - 3	19	1.862	0.417		13.0	75.7		11.3	
★ P1	0 - 5	37.5	0.796	0.075		10.5	59.6		30.0	

PROJECT: Proposed Parker McDonald's Restaurant #50785

SITE: SE of S Chambers Rd and S Red Sky Dr  
Parker, Colorado

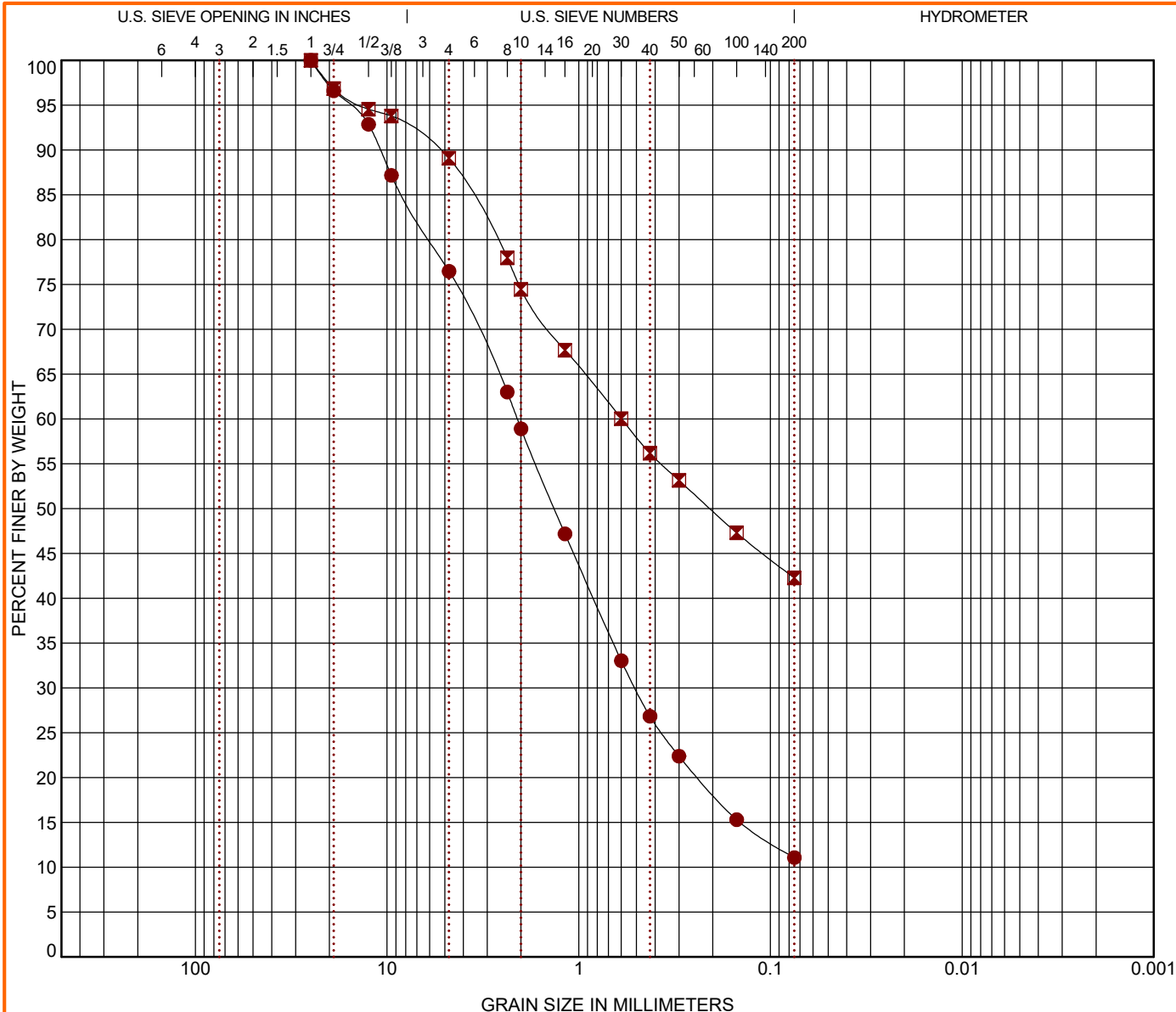


PROJECT NUMBER: 25215044

CLIENT: McDonalds USA LLC

# GRAIN SIZE DISTRIBUTION

ASTM D422 / ASTM C136



COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

Boring ID	Depth	USCS Classification	AASHTO Classification	WC (%)	LL	PL	PI	Cc	Cu
● P2	2 - 3	WELL-GRADED SAND with SILT and GRAVEL (SW-SM)	A-1-b (0)		NP	NP	NP	1.95	33.22
■ P3	0 - 5	CLAYEY SAND (SC)	A-7-6 (7)		55	26	29		

Boring ID	Depth	D <sub>100</sub>	D <sub>60</sub>	D <sub>30</sub>	D <sub>10</sub>	%Gravel	%Sand	%Silt	%Fines	%Clay
● P2	2 - 3	25	2.091	0.507		23.5	65.4		11.1	
■ P3	0 - 5	25	0.598			10.9	46.8		42.3	

LABORATORY TESTS ARE NOT VALID IF SEPARATED FROM ORIGINAL REPORT. GRAIN SIZE: USCS & AASHTO DESC COMBINED 25215044 PROPOSED PARKER M.GPJ TERRACON\_DATATEMPLATE.GDT 4/8/21

PROJECT: Proposed Parker McDonald's Restaurant #50785

SITE: SE of S Chambers Rd and S Red Sky Dr  
Parker, Colorado



PROJECT NUMBER: 25215044

CLIENT: McDonalds USA LLC

## SUMMARY OF LABORATORY TEST RESULTS

Proposed Parker McDonald's Restaurant #50785 - Parker, Colorado

Terracon Project No. 25215044



Boring No.	Depth (ft)	USCS Class.	Initial Water Content (%)	Initial Dry Density (pcf)	Swell/Consolidation		Particle Size Distribution, Percent Passing by Weight								Atterberg Limits		Water Soluble Sulfates (%)	Remarks
					Surcharge (ksf)	Swell (%)	1-1/4"	3/4"	1/2"	3/8"	#4	#10	#40	#200	LL	PI		
1	2						100	100	100	100	89	69	33	13	NV	NP		4,5
1	4		7.6	103														4
1	9		12.8	113														4
1	14		18.0	114														4
1	24		24.3	101														4
1	29		24.4	101														4
2	2		6.8	103														4
2	4		9.0	114														4
2	9		9.4	104			100	100	100	97	81	53	25	10	NV	NP		4,5
2	24		16.8															4
2	29		20.6	109														4
3	0 - 5																<0.10	
3	2		6.2															4
3	4		7.4	109														4
3	9		9.4	122	0.5	+6.0												3,4
3	14		19.0	109	0.5	+3.0												3,4
3	24		18.1	110														4
3	29		21.9	104														4
4	2		4.3														<0.10	4
4	4		7.7	104														4
4	9		18.4	108	0.5	-0.5												3,4

**Notes:**

Initial Dry Density and Initial Water Content are in-situ values unless otherwise noted.  
 \* = Partially disturbed sample  
 - = Compression/settlement  
 NV = no value  
 NP = non-plastic

**Remarks:**

1 Remolded Compacted density (about 95% of ASTM D698 maximum density near optimum moisture content)  
 2 Remolded Compacted density (about 95% of ASTM D1557 maximum density near optimum moisture content)  
 3 Water added to sample  
 4 Dry density and/or moisture content determined from one ring of a multi-ring sample  
 5 Minus #200 Only  
 6 Moisture-Density Relationship Test Method ASTM D698/AASHTO T99  
 7 Moisture-Density Relationship Test Method ASTM D1557/AASHTO T180

## SUMMARY OF LABORATORY TEST RESULTS

Proposed Parker McDonald's Restaurant #50785 - Parker, Colorado

Terracon Project No. 25215044



Boring No.	Depth (ft)	USCS Class.	Initial Water Content (%)	Initial Dry Density (pcf)	Swell/Consolidation		Particle Size Distribution, Percent Passing by Weight								Atterberg Limits		Water Soluble Sulfates (%)	Remarks
					Surcharge (ksf)	Swell (%)	1-1/4"	3/4"	1/2"	3/8"	#4	#10	#40	#200	LL	PI		
4	14		23.0	104														4
4	19		19.3	103														4
4	24		20.9	101														4
4	29		17.8															4
5	2		6.9				100	100	97	96	87	62	30	11	NV	NP		4,5
5	4		7.5															4
5	9		21.8	105	0.5	+5.1												3,4
5	14		17.2	114														4
6	2	SP	3.3														<0.10	4
6	4		10.2	111	0.5	+1.2												3,4
6	9		20.0	108									54	56	31			4,5
6	14		17.4	115														4
7	2		6.6	108														4
7	4		4.3															4
7	9		18.4	111	0.5	+3.4												3,4
P1	0 - 5	SC					100	96	96	95	90	76	49	30	40	24		
P1	2		5.4	107														4
P1	4		4.8	114														4
P2	2						100	96	93	87	76	59	27	11	NV	NP		4,5
P2	4		9.0	114														4
P3	0 - 5	SC					100	97	95	94	90	74	56	42	55	29		

**Notes:**

Initial Dry Density and Initial Water Content are in-situ values unless otherwise noted.  
 \* = Partially disturbed sample  
 - = Compression/settlement  
 NV = no value  
 NP = non-plastic

**Remarks:**

- 1 Remolded Compacted density (about 95% of ASTM D698 maximum density near optimum moisture content)
- 2 Remolded Compacted density (about 95% of ASTM D1557 maximum density near optimum moisture content)
- 3 Water added to sample
- 4 Dry density and/or moisture content determined from one ring of a multi-ring sample
- 5 Minus #200 Only
- 6 Moisture-Density Relationship Test Method ASTM D698/AASHTO T99
- 7 Moisture-Density Relationship Test Method ASTM D1557/AASHTO T180



## **SUPPORTING INFORMATION**

### **Contents:**













General Notes

Unified Soil Classification System

Note: All attachments are one page unless noted above.

# GENERAL NOTES

## DESCRIPTION OF SYMBOLS AND ABBREVIATIONS

<b>SAMPLING</b>				<b>WATER LEVEL</b>		Water Initially Encountered	<b>FIELD TESTS</b>	(HP)	Hand Penetrometer
						Water Level After a Specified Period of Time		(T)	Torvane
						Water Level After a Specified Period of Time		(b/f)	Standard Penetration Test (blows per foot)
					Water levels indicated on the soil boring logs are the levels measured in the borehole at the times indicated. Groundwater level variations will occur over time. In low permeability soils, accurate determination of groundwater levels is not possible with short term water level observations.				
								(N)	N value
								(PID)	Photo-Ionization Detector
								(OVA)	Organic Vapor Analyzer

## DESCRIPTIVE SOIL CLASSIFICATION

Soil classification is based on the Unified Soil Classification System. Coarse Grained Soils have more than 50% of their dry weight retained on a #200 sieve; their principal descriptors are: boulders, cobbles, gravel or sand. Fine Grained Soils have less than 50% of their dry weight retained on a #200 sieve; they are principally described as clays if they are plastic, and silts if they are slightly plastic or non-plastic. Major constituents may be added as modifiers and minor constituents may be added according to the relative proportions based on grain size. In addition to gradation, coarse-grained soils are defined on the basis of their in-place relative density and fine-grained soils on the basis of their consistency.

## LOCATION AND ELEVATION NOTES

Unless otherwise noted, Latitude and Longitude are approximately determined using a hand-held GPS device. The accuracy of such devices is variable. Surface elevation data annotated with +/- indicates that no actual topographical survey was conducted to confirm the surface elevation. Instead, the surface elevation was approximately determined from topographic maps of the area.

STRENGTH TERMS	RELATIVE DENSITY OF COARSE-GRAINED SOILS <small>(More than 50% retained on No. 200 sieve.) Density determined by Standard Penetration Resistance Includes gravels, sands and silts.</small>			CONSISTENCY OF FINE-GRAINED SOILS <small>(50% or more passing the No. 200 sieve.) Consistency determined by laboratory shear strength testing, field visual-manual procedures or standard penetration resistance</small>			BEDROCK		
	Descriptive Term (Density)	Standard Penetration or N-Value Blows/Ft.	Ring Sampler Blows/Ft.	Descriptive Term (Consistency)	Unconfined Compressive Strength, Qu, psf	Standard Penetration or N-Value Blows/Ft.	Ring Sampler Blows/Ft.	Ring Sampler Blows/Ft.	Standard Penetration or N-Value Blows/Ft.
Very Loose	0 - 3	0 - 5	Very Soft	less than 500	0 - 1	< 3	< 24	< 20	Soft
Loose	4 - 9	6 - 14	Soft	500 to 1,000	2 - 4	3 - 5	24 - 35	20 - 29	Firm
Medium Dense	10 - 29	15 - 46	Medium-Stiff	1,000 to 2,000	4 - 8	6 - 10	36 - 60	30 - 49	Medium Hard
Dense	30 - 50	47 - 79	Stiff	2,000 to 4,000	8 - 15	11 - 18	61 - 96	50 - 79	Hard
Very Dense	> 50	≥ 80	Very Stiff	4,000 to 8,000	15 - 30	19 - 36	> 96	> 79	Very Hard
			Hard	> 8,000	> 30	> 36			

## RELATIVE PROPORTIONS OF SAND AND GRAVEL

Descriptive Term(s) of other constituents	Percent of Dry Weight
Trace	< 15
With	15 - 29
Modifier	> 30

## RELATIVE PROPORTIONS OF FINES

Descriptive Term(s) of other constituents	Percent of Dry Weight
Trace	< 5
With	5 - 12
Modifier	> 12

## GRAIN SIZE TERMINOLOGY

Major Component of Sample	Particle Size
Boulders	Over 12 in. (300 mm)
Cobbles	12 in. to 3 in. (300mm to 75mm)
Gravel	3 in. to #4 sieve (75mm to 4.75 mm)
Sand	#4 to #200 sieve (4.75mm to 0.075mm)
Silt or Clay	Passing #200 sieve (0.075mm)

## PLASTICITY DESCRIPTION

Term	Plasticity Index
Non-plastic	0
Low	1 - 10
Medium	11 - 30
High	> 30

# UNIFIED SOIL CLASSIFICATION SYSTEM

Criteria for Assigning Group Symbols and Group Names Using Laboratory Tests <sup>A</sup>				Soil Classification		
				Group Symbol	Group Name <sup>B</sup>	
<b>Coarse Grained Soils:</b> More than 50% retained on No. 200 sieve	<b>Gravels:</b> More than 50% of coarse fraction retained on No. 4 sieve	<b>Clean Gravels:</b> Less than 5% fines <sup>C</sup>	$Cu \geq 4$ and $1 \leq Cc \leq 3$ <sup>E</sup>	GW	Well-graded gravel <sup>F</sup>	
		<b>Gravels with Fines:</b> More than 12% fines <sup>C</sup>	Fines classify as ML or MH	GP	Poorly graded gravel <sup>F</sup>	
			Fines classify as CL or CH	GM	Silty gravel <sup>F,G,H</sup>	
		<b>Sands:</b> 50% or more of coarse fraction passes No. 4 sieve	<b>Clean Sands:</b> Less than 5% fines <sup>D</sup>	$Cu < 4$ and/or $1 > Cc > 3$ <sup>E</sup>	GC	Clayey gravel <sup>F,G,H</sup>
	<b>Sands with Fines:</b> More than 12% fines <sup>D</sup>		$Cu \geq 6$ and $1 \leq Cc \leq 3$ <sup>E</sup>	SW	Well-graded sand <sup>I</sup>	
			$Cu < 6$ and/or $1 > Cc > 3$ <sup>E</sup>	SP	Poorly graded sand <sup>I</sup>	
			Fines classify as ML or MH	SM	Silty sand <sup>G,H,I</sup>	
		Fines classify as CL or CH	SC	Clayey sand <sup>G,H,I</sup>		
<b>Fine-Grained Soils:</b> 50% or more passes the No. 200 sieve	<b>Silts and Clays:</b> Liquid limit less than 50	<b>Inorganic:</b>	$PI > 7$ and plots on or above "A" line <sup>J</sup>	CL	Lean clay <sup>K,L,M</sup>	
			$PI < 4$ or plots below "A" line <sup>J</sup>	ML	Silt <sup>K,L,M</sup>	
		<b>Organic:</b>	Liquid limit - oven dried	< 0.75	OL	Organic clay <sup>K,L,M,N</sup>
			Liquid limit - not dried		OH	Organic silt <sup>K,L,M,O</sup>
	<b>Silts and Clays:</b> Liquid limit 50 or more	<b>Inorganic:</b>	PI plots on or above "A" line	CH	Fat clay <sup>K,L,M</sup>	
			PI plots below "A" line	MH	Elastic Silt <sup>K,L,M</sup>	
		<b>Organic:</b>	Liquid limit - oven dried	< 0.75	OH	Organic clay <sup>K,L,M,P</sup>
			Liquid limit - not dried		OH	Organic silt <sup>K,L,M,Q</sup>
<b>Highly organic soils:</b>	Primarily organic matter, dark in color, and organic odor			PT	Peat	

<sup>A</sup> Based on the material passing the 3-inch (75-mm) sieve

<sup>B</sup> If field sample contained cobbles or boulders, or both, add "with cobbles or boulders, or both" to group name.

<sup>C</sup> Gravels with 5 to 12% fines require dual symbols: GW-GM well-graded gravel with silt, GW-GC well-graded gravel with clay, GP-GM poorly graded gravel with silt, GP-GC poorly graded gravel with clay.

<sup>D</sup> Sands with 5 to 12% fines require dual symbols: SW-SM well-graded sand with silt, SW-SC well-graded sand with clay, SP-SM poorly graded sand with silt, SP-SC poorly graded sand with clay

$$^E Cu = D_{60}/D_{10} \quad Cc = \frac{(D_{30})^2}{D_{10} \times D_{60}}$$

<sup>F</sup> If soil contains  $\geq 15\%$  sand, add "with sand" to group name.

<sup>G</sup> If fines classify as CL-ML, use dual symbol GC-GM, or SC-SM.

<sup>H</sup> If fines are organic, add "with organic fines" to group name.

<sup>I</sup> If soil contains  $\geq 15\%$  gravel, add "with gravel" to group name.

<sup>J</sup> If Atterberg limits plot in shaded area, soil is a CL-ML, silty clay.

<sup>K</sup> If soil contains 15 to 29% plus No. 200, add "with sand" or "with gravel," whichever is predominant.

<sup>L</sup> If soil contains  $\geq 30\%$  plus No. 200 predominantly sand, add "sandy" to group name.

<sup>M</sup> If soil contains  $\geq 30\%$  plus No. 200, predominantly gravel, add "gravelly" to group name.

<sup>N</sup>  $PI \geq 4$  and plots on or above "A" line.

<sup>O</sup>  $PI < 4$  or plots below "A" line.

<sup>P</sup> PI plots on or above "A" line.

<sup>Q</sup> PI plots below "A" line.

