intertek
psi

Project Number: 05462482
February 15, 2022

Professional Service Industries, Inc.
11825 S. Portland Avenue
Oklahoma City, OK 73170
Phone: (405) 735-6052
Fax: (405)735-6086

Mr. Keith Moore
CARLSON CONSULTING ENGINEERS, INC.
7068 Ledgestone Commons
Bartlett, TN 38133

Re: **Report of Geotechnical Engineering Services**
Proposed **Westchester Circle Apartments**
SEC W Gore Boulevard and SW 71st Street
Lawton, Oklahoma

Dear Mr. Moore:

Thank you for choosing Professional Service Industries, Inc. (PSI), an Intertek company. The information you requested is attached.

PSI performed the geotechnical exploration that you requested. PSI transmits the geotechnical report with this letter.

We thank you for your business and we look forward to finding ways to grow our partnership, expand our services, and continue Building Better Together.

For Professional Service Industries, Inc.
CA NO. 1111 Expires 06/30/23

Yicheng Zhang, P.E.
Project Engineer
Geotechnical Services

ADEDAMOLA IBIKUNLE OLUWAKEMI OYESANYA
18096

Adedamola I.O. Oyesanya, P.E.
Senior Geotechnical Engineer
Geotechnical Services

Report of Geotechnical Engineering Services

Proposed **Westchester Circle Apartments**
SEC W Gore Boulevard and SW 71st Street
Lawton, Oklahoma

Prepared for

CARLSON CONSULTING ENGINEERS, INC.
7068 Ledgestone Commons
Bartlett, TN 38133

Prepared by

Professional Service Industries, Inc.
11825 S. Portland Avenue
Oklahoma City, OK 73170

February 15, 2022

PSI Project 05462482

intertek
psi

Yicheng Zhang, P.E.
Project Engineer
Geotechnical Services

ADEDAMOLA
IBIKUNLE
OLUWAKEMI
OYESANYA
18098

Adedamola I.O. Oyesanya, P.E.
Senior Geotechnical Engineer
Geotechnical Services

2/15/2022

TABLE OF CONTENTS

FIGURES

LIST OF APPENDICES

1 PROJECT INFORMATION

1.1 PROJECT AUTHORIZATION

Professional Service Industries, Inc. (PSI), an Intertek company, has completed a geotechnical exploration for the proposed Westchester Circle Apartments located at the southeast corner of W Gore Boulevard and 71st Street in Lawton, Oklahoma. PSI's services were authorized via executed agreement for professional services between Carlson Consulting Engineers, Inc. and PSI dated July 7, 2021. This exploration was accomplished in general accordance with PSI Proposal No. P0546-361044 dated December 9, 2021.

1.2 PROJECT DESCRIPTION

The proposed construction will consist of the following:

Buildings

- Three 24-Unit Apartment Buildings.
- One Single-Story Community Building.
- Wood-Frame Structures Estimated.
- Basement Construction is not a Part of the Project to PSI's Knowledge.

This report is also based on the following:

Loading
- Column Loads on the Order of 100 Kips or Less.
- Continuous Wall Loads on the Order of 2 Kips Per Linear Foot or Less.
- Floor Slab Loads on the Order of 120 Pounds Per Square Foot or Less.

Grading
- Cut and Fill on the Order of 2 Feet or Less to Achieve Design Grades.
- Detention Pond Planned at the Northeast Corner of Project Site in the Area of an Existing Wet Sector.

Pavement
- Asphalt and/or Portland Cement Concrete.

The geotechnical recommendations presented in this report are based on the available project information, laboratory testing, and the site and subsurface materials described in this report. If the noted information is incorrect, please inform PSI in writing so that the recommendations presented in this report can be amended, if appropriate. PSI will not be responsible for the implementation of the recommendations when PSI has not been notified of changes in the project.

1.3 PURPOSE AND SCOPE OF SERVICES

The purpose of this study was to explore the subsurface conditions at the site and prepare recommendations for geotechnical design considerations for the proposed structures and paving, in addition to detention pond considerations. PSI's scope of services included drilling a total of 20 soil test borings (12 apartment building borings and 2 community building borings to depths of 25 feet, and 6 pavement borings to depths of 6 feet), laboratory testing of select soil samples, and preparation of this geotechnical report.

This report briefly outlines the testing procedures, presents available project information, describes the site and subsurface conditions, and includes the approximate boring locations, boring logs, and recommendations regarding the following:

- General site development and subgrade preparation.
- Foundation types and depths, allowable bearing capacities, and estimates of potential settlement.
- Pavement section recommendations.
- Detention pond considerations.
- Seismic site class and site coefficients according to the 2015 IBC criteria.
- Comments regarding factors that may impact construction and performance of the proposed project.

The scope of services did not include an environmental assessment for determining the presence or absence of wetlands or hazardous or toxic materials in the soil, bedrock, surface water, groundwater, or air, on or below, or around this site. Statements in this report or on the boring logs regarding odors, colors, and unusual or suspicious items or conditions are strictly for informational purposes.

PSI did not provide any service to investigate or detect the presence of moisture, mold, or other biological contaminants in or around any structures, or any service that was designed or intended to prevent or lower the risk of the occurrence or the amplification of the same. The client should be aware that mold is ubiquitous to the environment with mold amplification occurring when building materials are impacted by moisture. Client should also be aware that site conditions are outside of PSI's control, and that mold amplification will likely occur, or continue to occur, in the presence of moisture. As such, PSI cannot and shall not be held responsible for the occurrence of, or recurrence of, mold amplification.

Laboratory consolidation testing for detailed analysis of settlement characteristics is not included in the present scope. However, consolidation settlements are not anticipated to be an issue for this project site.

2 SITE AND SUBSURFACE CONDITIONS

2.1 SITE LOCATION AND DESCRIPTION

The site for the proposed Westchester Circle Apartments project is located at the southeast corner of W Gore Boulevard and 71st Street in Lawton, Oklahoma. The approximate latitude and longitude of the proposed construction site is 34.6082°N and 98.4802°W, respectively. The site is bordered by W Gore Boulevard to the north, existing concrete drive, residential properties, and SW Green Terrace Boulevard beyond to the east, residential properties and SW Beta Avenue beyond to the south, and residential properties and SW 71st Street beyond to the west. The site is currently undeveloped, appears relatively level and covered with grass and contained concrete drives and a parking area. An existing pond/wet area is present at the northeast corner of the property. The truck-mounted drill rig did not experience significant mobility difficulty accessing the boring locations.

2.2 SUBSURFACE CONDITIONS

The site subsurface conditions were explored with 20 soil test borings (14 structures and 6 pavements). The borings were located in the field by the drilling personnel using the available site plan and with the aid of a handheld GPS device, and by estimating distances from known site references.

The field explorations were performed with a truck-mounted CME-55 drill rig equipped with an automatic hammer using a weight of 140-pound dropping 30 inches. Soil samples were routinely obtained during the drilling process. Drilling and sampling techniques were accomplished generally in accordance with ASTM procedures. The approximate location and temporary elevations (arbitrarily based on Google Earth) of the borings are presented on the boring logs and summarized in the table below. The locations and elevations presented should be considered as accurate as the source and the means and methods used to obtain them. Actual boring elevations should be determined by others prior to the construction.

Summary of Approximate Boring Locations and Estimated Boring Elevations (Based on Google Earth)				
Boring	Proposed Depth, ft	Latitude (N)	Longitude (W)	Temporary Elev., ft
B-01	26.5	34.60871	98.48042	1179
B-02	26.5	34.60855	98.48059	1181
B-03	26.5	34.60845	98.48041	1182
B-04	26.5	34.60829	98.48058	1183
B-05	26.5	34.60844	98.47990	1176
B-06	26.5	34.60833	98.48006	1181
B-07	26.5	34.60808	98.48041	1184
B-08	26.5	34.60796	98.48059	1186
B-09	26.5	34.60784	98.48041	1184
B-10	26.5	34.60769	98.48059	1188
B-11	26.5	34.60809	98.47987	1180
B-12	26.5	34.60795	98.48006	1181
B-13	26.5	34.60784	98.47988	1181
B-14	26.5	34.60768	98.48005	1186
P-1	6.5	34.60868	98.48085	1187
P-2	6.5	34.60818	98.48084	1187

Summary of Approximate Boring Locations and Estimated Boring Elevations (Based on Google Earth)				
Boring	Proposed Depth, ft	Latitude (N)	Longitude (W)	Temporary Elev., ft
P-3	6.5	34.60782	98.48084	1190
P-4	6.5	34.60771	98.48027	1186
P-5	6.5	34.60820	98.48022	1184
P-6	6.5	34.60856	98.48016	1179

Select soil samples were tested in the laboratory for evaluation and determination of material properties including moisture content, Atterberg limits, and fines contents. Laboratory testing was accomplished generally in accordance with ASTM procedures. The results are presented in the boring logs in the Appendix.

Below surficial vegetation or approximately 5 inches of concrete pavement, the subgrade materials encountered in the borings generally consisted of fat clays, elastic silts, and in boring 10, lean clay that trend to fat clay, and with stiff to very stiff consistencies to depth ranges of approximately 1 to 16 feet below the surface. These overburden soils are underlain by harder shaley clay and/or elastic silt intermediate geo-materials (IGM) and that extended to the boring depths. The materials in the boring profiles contain various sand contents. Please refer to the attached boring logs in the Appendix for more specific information. For this report purpose, the project development areas are separated into the development structures consisting of borings performed for the planned apartment buildings, the community building, and the associated pavement for parking and driveway. The following table briefly summarizes the range of results from the field and laboratory testing programs:

General Range of material property values								
MATERIAL property Description Soil Strata Type	Approx. Depth Range, ft.	Standard Penetration, N, blows/foot	TCP, Pen./100 blows	Moisture Content, %	Percent Passing #200 Sieve	Atterberg Limits		
						Liquid Limit, %	Plastic Limit, %	Plasticity Index
Apartment Building (Northwest): Borings B-01 Thru B-04								
Fat CLAY	0 – 10.5	15 – 26	-	19 – 31	86.9 – 94.9	57 – 62	27 – 31	30 – 31
Elastic SILT	1.5 – 16	19 – 25	-	20 – 25	79.0	59	31	28
Shaley SOILS (IGM)	4 – 26.5	31 – 72	-	17 – 23	84.6	66	35	31
Community Building: B-05 and B-06								
Fat CLAY	0 – 1.5	-	-	20 – 24	-	-	-	-
Shaley SOILS (IGM)	1 – 26.5	64 – 79	-	11 – 22	73.5 – 92.0	60 – 64	32 – 34	26 – 32
Apartment Building (Southwest): Borings B-07 Thru B-10								
Fat CLAY	0 – 11	11 – 26	-	20 – 32	87.6 – 90.7	60 – 63	30 – 31	30 – 32
Shaley SOILS (IGM)	1.5 – 26.5	30 – 80	-	7 – 24	79.2 – 82.7	45 – 65	18 – 32	27 – 33
Apartment Building (Southeast): Borings B-11 Thru B-14								
Fat CLAY	0 – 26	8 – 28	-	18 – 31	80.5 – 87.9	51 – 58	25 – 27	24 – 33
Shaley SOILS (IGM)	1 – 26.5	32 – 77	-	16 – 21	87.1	64	25	39
Pavement (West): P-1 Thru P-3								
Fat CLAY	0 – 6	17 – 26	-	15 – 36	84.2 – 88.5	66 – 72	24 – 27	42 – 45
Shaley SOILS (IGM)	3.5 – 6.5	34 – 49	-	12 – 14	83.9	51	23	28
Pavement (Mid-site): P-4 Thru P-6								

General Range of material property values

MATERIAL property Description Soil Strata Type	Approx. Depth Range, ft.	Standard Penetration, N, blows/foot	TCP, Pen./100 blows	Moisture Content, %	Percent Passing #200 Sieve	Atterberg Limits		
						Liquid Limit, %	Plastic Limit, %	Plasticity Index
Fat CLAY	0 – 6.5	11 – 30	-	20 – 35	90.4 – 95.6	57 – 71	21 – 30	30 – 48
Shaley SOILS (IGM)	4 – 6.5	30 – 32	-	19	-	-	-	-

Please refer to the attached boring logs for more specific information.

The above subsurface description is of a generalized nature to highlight the major subsurface stratification features and material characteristics. The boring log included in the Appendix should be reviewed for specific information at the boring location. The boring logs include soil/IGM descriptions, stratifications, penetration resistances, and locations of the samples. The stratifications shown on the boring log represent the conditions only at the actual boring location. Variations may occur and should be expected at other building section locations. The stratifications represent the approximate boundary between subsurface materials and the actual transition may be gradual. Water level information obtained during field operations is also shown on the boring log. The samples that were transported to the laboratory will be retained for 60 days from the date of this report and then discarded.

2.3 GROUNDWATER INFORMATION

Groundwater was not observed in the borings during the duration of the filed work indicating the groundwater is below the maximum depth of those borings or additional time will be required for the ground water to collect in the open holes.

Groundwater can exist at varying depths during other times of the year depending upon climatic and rainfall conditions. Discontinuous zones of perched water can exist within the overburden materials and/or at the contact with bedrock.

3 EVALUATION AND RECOMMENDATIONS

3.1 GEOTECHNICAL DISCUSSION

The geotechnical related recommendations presented in this report have been developed on the basis of the subsurface conditions encountered and PSI's understanding of the proposed project. Should changes in the project criteria occur, a review must be made by PSI to determine if modifications to the recommendations will be required. The performance of the construction will be dependent upon site preparations and the shear strength of the overburden soils and the underlying intermediate geo-material (IGM)/soft bedrock.

There is a primary geotechnical related concern at this project site that should be expected to affect the proposed project such as floor slab type construction, foundation elements, and buried conduits, as well as pavement construction. The concern involves the shrink/swell potential of the soils encountered within the estimated moisture activity depth (estimated at a minimum of 10 feet for the site) in the borings. The concern is discussed in the report subsection below.

3.1.1 SWELL POTENTIAL CLAYS

Generally, high to very high plasticity clay and elastic soils with high shrink/swell potentials were encountered in the borings. These high shrink/swell potential materials are expected to exhibit significant volume changes with variations in subgrade moisture. The potential vertical rise (PVR) is expected to affect the community and apartment buildings and should also be of concern for the pavements and to some extent below grade conduits. The calculated Potential Vertical Rise (PVR) for slab-on-grade type construction at this project site could be on the order of 4 inches for these soils within the estimated moisture active depth of 10 feet for the site, assuming that the high to very high plasticity subgrade materials are allowed to increase in moisture content from a relatively dry condition to a relatively wet condition over the depth of approximately 10 feet.

The relatively dry condition can occur with severe dry weather situations, thereby resulting in a significant degree of shrinkage and eventual potential swell in the foundation material. Differential movements are expected to be about ½ of the PVR. However, it should be noted that for extreme conditions (i.e., soils dry and shrink in one area with soils in another area being exposed to water and swelling) differential movement can be equal to or even double the PVR.

A reduction in potential vertical movement in the building areas can be achieved by supporting the floor slabs on a minimum of 4 feet of properly compacted low plasticity structural fill or modified existing soils, over a properly placed moisture barrier, to reduce the calculated PVR to 1 inch or less. However, due to the potential for "bathtub effect" usually created by granular structural fill replacing and overlying relatively low permeability clay material in undercut areas, PSI recommends the amount of material in the structural fill passing the #200 sieve not be less than 60 percent, at least in replacing the undercut, unless the undercut is allowed to drain. The greater the structural fill or modified existing soil (used as structural fill) thickness beneath the floor slab, the less the probability of structural distress due to shrinkage and swelling of the clay soils. The structural fill should extend a minimum of 5 feet beyond the edges of the building. The desired thickness of fill can be provided by raising the building construction grade with the properly compacted recommended materials or undercutting and replacing with the recommended materials. Proof-roll and visual observation, as discussed later in this report, should be accomplished to aid in identifying soils which should be removed from the floor slab area prior to the moisture barrier and fill placement and/or floor slab construction.

The minimum 4 feet of properly compacted and moisture conditioned fill is for placement under the building floor slab and should extend a minimum of 2 feet below the bottom of shallow footings, unless the footings are extended to the natural subgrade while maintaining the necessary minimum 4 feet of the recommended low volume change (LVC) material below the grade supported floor slab.

For the pavement construction, lime, cement, or fly ash stabilization, as recommended later in this report, of a minimum 8 inches of the subgrade prior to the pavement construction is recommended to bridge the subgrade from excessive saturation and resultant swelling.

3.1.1.1 LIME STABILIZATION

If desired in the building areas, the existing high to very high plasticity subgrade clay soils with high shrink/swell potential can also be modified with hydrated lime from a source approved by ODOT and used as structural fill under floor slabs, grade beams, and footings. This will also reduce the potential for a “bathtub” effect when used as backfill in undercuts. Stabilizing the subgrade soil with an estimated 6 to 7 percent hydrated lime, by dry weight, will reduce the potential volumetric changes due to the moderately high to high shrink/swell potential soils. The actual lime percentage should be determined based on laboratory lime series test after the source of the stabilizing agent has been determined.

3.1.2 DIFFICULTY OF EQUIPMENT MOBILITY

The presence of wet surficial conditions will potentially weaken the sensitive surficial soils and will possibly increase the difficulty of site grading and equipment mobility. PSI has been involved with project sites where these type soils can undergo loss of stability during wetter portions of the year. PSI anticipates that the soils that become wet may become easily disturbed under construction equipment traffic resulting in a loss of strength and characteristic “pumping” or construction retardation. Soils that become disturbed may need to be excavated and replaced; however, this remedial excavation may expose progressively wetter soils with depth, thus compounding the condition. Hence, a normal approach to subgrade preparation may not be possible. Remediation in the paving areas may include stabilization as recommended in the preceding report sections and the sections for pavement design.

3.1.2.1 SOIL COMPACTION AND PROOF ROLL

Since the site soils are sensitive to moisture and some of the surficial soils at the project sites may also contain relatively high moisture content, it may become difficult to achieve proof roll and the desired compaction of the soils. The soils may need to be scarified and dried (in-situ or by disking) to a moisture content that will facilitate compaction in accordance with the structural fill requirements of this report, prior to placement of required fill. If scarifying, drying, and compaction of the soils does not stabilize the soils, removal and replacement with structural fill or treating the soils with class “C” fly ash or lime or Portland cement may be performed. If modification or stabilization is required, it may be performed with the recommended 6 to 7 percent hydrated lime or Portland cement or 12 to 14 percent class “C” fly ash, from source approved by ODOT. It may be necessary to perform the stabilization in test sections to determine appropriate additive and amount for effectiveness. Alternatively, the ground can also be improved to provide adequate mobility of equipment by working into the subgrade 3- to 4-inch size “shot/surge” rock in relatively thin layers at a time, until a stable work platform is attained.

3.2 GEOLOGIC UNIT

Division Seven publication of the “Engineering Classification of Geologic Materials” manual published by ODOT indicates the project site is underlain by the Addington Unit (Pad) in Comanche County.
This unit consists dominantly of red-brown soft sandstone, shale, and mudstone conglomerate. A persistent sandstone bed (Asphaltum Sandstone) marks the base of the unit. This sandstone varies in thickness from 10 to 50 feet. Generally it is thickest in Carter County and thins westward.

The total thickness of the unit is about 150 feet, but often much of the upper portion of the unit has been removed by erosion.

The unit outcrops in extensive areas of Comanche, Cotton, Stephens, Jefferson, Love, and Carter Counties of Division 7. It generally rests upon the Claypool Unit, but locally rests upon the highly folded older geologic units of the Arbuckle Mountains Uplift. Locally, within 6 miles of the Wichita Mountains, the Hennessey and Addington Units are gradational into the conglomerates of the Post Oak Unit. In Division 3, the strata of the Addington Unit are mapped within the Garber-Wellington Unit and are probably equivalent to strata of the Garber section.

Topographically, the unit generally forms gently rolling prairies. The sandstones at the base of the unit generally form a slight to pronounced scarp which is locally covered with brush and trees. High terrace deposits often mask much of the outcrop of the unit in the Marietta Basin area.

According to the United States Geologic Survey geospatial database of geologic units and structural features of Oklahoma, the highly generalized unit for the project area is described below:

LAWTON- "Garber Sandstone," Pg, reddish-brown, fine-grained sandstone and mudstone conglomerate, 160 to 210 feet (49 to 64 m) thick, containing a basal sandstone, the "Asphaltum Sandstone Bed," about 10 to 60 feet (3 to 18 m) thick. The formation belongs to the geologic Summer Group; a sedimentary geologic group of Lower Permian age.

3.3 SEISMIC INFORMATION

The 2015 International Building Code requires a site class for the calculation of earthquake design forces. This class is a function of soil type (i.e. depth of soil and strata types). Based on the type of materials encountered to the boring termination depths and the estimated shear strength of the soil at the boring locations, Site Class C is recommended. The IBC-2015 probabilistic ground motion values near the project site are as follows:

Period (seconds)	2% Probability of Event in 50 years (g)	Site Coefficient F_a	Site Coefficient F_v
0.2 (S_s)	0.325	1.2	N/A
1.0 (S_1)	0.097	N/A	1.7

S_{DS}: 0.260g
S_{D1}: 0.110g
PGA: 0.152g
PGA_M: 0.182g (Site modified peak ground acceleration)
Seismic Design Category (SDC): B

3.4 SITE PREPARATION

Vegetation, topsoil, existing concrete, deleterious materials, and soft and loose soil in the construction area should be stripped from the site and either wasted or stockpiled for later use in non-load bearing areas such as landscaping. The depth of removal should be determined by a representative of the Geotechnical Engineer at the time of construction.

After stripping and excavating to the proposed subgrade level, the construction area should be proof rolled with a tandem axle dump truck or similar rubber-tired vehicle. Soils which are observed to rut or deflect excessively (typically greater than 1 inch) under the moving load (typically 9 tons/axle) should be undercut and recompacted in place or replaced with properly compacted recommended fill. The recompacted soil or imported structural fill or engineered fill should be moisture conditioned during placement. The proof-rolling and undercutting activities should be witnessed by a representative of the Geotechnical Engineer and should be performed during a period of dry weather.

After proof-rolling and correcting soft areas or areas exhibiting rutting or pumping, the subgrade soils should be scarified and compacted for a depth of at least 8 inches below the surface.

After subgrade preparation and testing and placement of vapor retarder have been completed, fill placement that will be required to establish site design grades should begin. The first layer of fill material should be placed in a relatively uniform horizontal lift and adequately keyed into the stripped and scarified subgrade soils. PSI recommends fill materials be free of organic or other deleterious material, have a maximum particle size less than 3 inches, have a liquid limit not more than 40 and plasticity index in the range of 8 to 20 and percent of fines passing the #200 sieve not less than 60 percent, at least in replacing undercuts. The on-site soils do not appear suitable for use as structural fill without modification/stabilization as previously discussed but may be stockpiled for later use in non-load bearing areas such as landscaping if acceptable for such purpose. Accurate moisture control will be required to achieve the recommended degree of compaction. Structural fill should be compacted to at least 95 percent of standard Proctor maximum dry density as determined by ASTM D698.

Fill should be placed in maximum lifts of 8 inches of loose material and should be compacted at a moisture content ranging from -2 to +3 percentage points of optimum moisture content. If water must be added, it should be uniformly applied and thoroughly mixed into the soil by disking or scarifying. Stabilized soils placed as structural fill should be compacted within a moisture content of optimum to +4 percentage points of optimum moisture content. Each lift of compacted engineered fill should be tested by a representative of the Geotechnical Engineer prior to placement of subsequent lifts. The edges of compacted fill should extend a minimum of 5 feet beyond the edges of the proposed structure prior to sloping on as flat a gradient as practical. Care should be taken to apply compaction effort throughout the entire fill area.

For structural fill, PSI recommends that such fill be tested by a Geotechnical Technician and directed by a Geotechnical Engineer to monitor and document the placement of fill material. It should be noted that the Geotechnical Engineer of record can only certify the testing that is performed, and the work observed by that engineer or staff in direct report to that engineer. PSI recommends that the fill be monitored in general accordance with the following table:

Material Tested	Proctor Type	Min % Dry Density	Placement Moisture Content Range from OMC	Frequency of Testing (Based on 8-inch lifts)
Structural Fill	Standard	95%	-2 to +3%	1 per 2,500 ft^2 of fill placed
Stabilized Existing Soil			≥+4%	
Random Fill (non-load bearing)	Standard	90%	-2 to +3%	1 per 10,000 ft^2 of fill placed
Utility Trench Backfill	Standard	95%	-1 to +3%	1 per 200 cy of fill placed

A minimum of 3 field density tests per lift is recommended. If the borrow or source of fill changes, a new reference moisture/density relationship test should be performed.

The overall performance of the construction will also depend on how well the site drains during the construction and the life of the structure. Grading of the site around the structure's pads should be accomplished to enable positive drainage away from the pads by providing an adequate gradient. The surface gradient provided will be dependent on the landscaping type and vegetation. Water infiltration and seepage into the foundation should be avoided as much as possible. If it is possible for water to collect beneath the foundation and foundation areas, it will be necessary to use interceptor drains to remove the collected water.

Excavation for utility trenches should be performed in accordance with OSHA regulations as stated in 29 CFR Part 1926. It should be noted that utility trench excavations have the potential to degrade the properties of the adjacent fill materials. Utility trench walls that are allowed to move laterally can lead to reduced bearing capacity and increased settlement of adjacent structures and structural elements.

Backfill for utility trenches is as important as the original subgrade preparation or structural fill placed to support foundations. Unless otherwise specified, the backfill for the utility trenches should be placed in 4- to 6-inch loose lifts and compacted to a minimum of 95% of the maximum dry density achieved by the standard Proctor test. The backfill soil should be moisture conditioned in the range of 1 percentage point below to 2 percentage points above the optimum moisture content value as determined by the standard Proctor test. Up to 4 inches of bedding material placed directly under the pipes or conduits placed in the utility trench can be compacted to the 90% compaction criteria with respect to standard Proctor maximum dry density. Compaction testing should be performed for every 200 cubic yards of backfill placed or for each lift within 200 linear feet of trench, whichever is less. Backfill of utility trenches should not be performed with water standing in the trench. Structural fill should be used as the trench backfill material.

3.5 SHALLOW FOUNDATION RECOMMENDATIONS

PSI estimates shallow footing is the preferred foundation system for support of the proposed buildings. The project site is suitable for use of shallow foundations provided the recommendations provided in this report are performed. The types and depths of foundations suitable for a given structure depend on several factors including the subsurface conditions, the functions of the structure, the loads they will carry, the external (lateral and uplift) forces they will resist, and the cost of the foundations. A conventional type spread footing foundation system or a monolithic slab-on-grade foundation system (conventionally reinforced or post-tensioned) may be considered for support of the building units. PSI has provided in this report section parameters that may be considered for the recommended shallow foundation systems.

A shallow foundation system may be considered for the support of the buildings, based on the subsurface conditions encountered by the borings. PSI has provided recommendations for both a conventional type spread/continuous footing foundation system and a monolithic slab-on-grade foundation system (reinforced or post-tensioned) for consideration and support of the proposed structures.

3.5.1 CONVENTIONAL SPREAD FOOTING RECOMMENDATIONS

The planned structures may be supported on conventional spread footing foundations. Spread footings for columns and continuous wall footings bearing on the properly compacted and moisture conditioned structural fill or modified existing soil as recommended can be designed for allowable unit bearing pressures presented in the table below, based on dead load plus design live load.

Conventional Shallow Foundation Allowable Unit End Bearing Capacity		
Structure	Square Footing, psf	Continuous Footing, psf
Community Building	3,500	2,500
Apartment Building (Northwest)	3,500	2,500
Apartment Building (Southwest)	3,500	2,500
Apartment Building (Southeast)	3,000	2,100

If desired, for general design of all the planned structures, a uniform allowable unit bearing capacity for column loads and continuous wall loads of 3,000 and 2,100 psf, respectively, based on dead load plus design live load can be considered. Additionally, for footings bearing on more than 2 feet of the properly compacted and moisture conditioned recommended fill, the allowable unit bearing capacity for column loads and continuous wall loads should not exceed 2,500 and 2,000 psf, respectively, based on dead load plus design live load, and PSI may be contracted to perform additional analysis. Alternatively, the footings may be extended to the natural subgrade materials for the higher bearing capacities.

Foundation elements should bear a minimum depth of 2 feet below the final grade for frost protection. The allowable bearing capacities are based on a factor of safety of 3.

It is important that PSI observes and documents the footing excavations prior to concrete placement. Minimum dimensions of 24 inches for square footings and 18 inches for continuous wall footings should be used in design of the footings to reduce the possibility of a local bearing capacity failure.

The foundation excavations should be observed by a representative of PSI prior to steel or concrete placement to document that the foundation materials are consistent with the materials discussed in this report. Soft or loose soil zones encountered at the bottom of the footing excavations should be removed to the level of acceptable residual soils or adequately compacted structural fill as directed by the Geotechnical Engineer. The bottom of the footings should be probed to identify and locate soft areas. Cavities formed as a result of excavation of soft or loose soil zones should be backfilled with lean concrete or properly compacted structural fill.

The uplift resistance of the foundations will be limited by the weight of the foundation concrete and soil above them and the dead weight of the structure. For design purposes, the ultimate uplift resistance should be based on effective unit weights derived from presumptive total unit weights of 120 pcf and 150 pcf for soil and concrete, respectively. A factor of safety of 2 should be applied to the uplift resistance.

Footing excavations should be observed, and concrete placed as quickly as possible to avoid exposure of the footing bearing surfaces to wetting and drying. Surface run-off water should be drained away from the excavations and not be allowed to pond. If possible, the foundation concrete should be placed during the same day the excavation is made. If footing excavations are left open for more than 1 day, they should be protected to reduce evaporation or entry of moisture.

Based on the known subsurface conditions, site geology, laboratory testing, anticipated loading, and allowable bearing pressures, properly designed and constructed footings for the building supported on the properly compacted recommended materials should experience maximum total and differential settlements between adjacent columns of less than 1 inch and ¾ inch, respectively.

3.5.2 MONOLITHIC SLAB-ON-GRADE FOUNDATION RECOMMENDATIONS

As an alternative to remediation of the existing subgrade soils recommended for the new construction due to high to very high plasticity clay, the use of alternative type of foundation such as a monolithic slab type foundation may be considered, provided the anticipated movements can be tolerated. PSI has not performed a cost/benefit analysis of suitable foundation type for the project.

If additional movements can be tolerated, a steel-reinforced (conventional or post-tension reinforcing) slab on-grade foundation system (with or without waffle-type grade beam configuration) may be considered for support of the proposed structure. The slab-on-grade foundation system may be supported on the existing subgrade material, provided the associated expected movements can be tolerated, or on structural fill as recommended. The thickened edge portion may also be supported on the existing soils or the structural fill.

Structural fill/recommended fill should consist of materials as described in the Site Preparation and Fill Materials section of this report. Proof rolling, as discussed earlier in this report, should be accomplished to identify any soft or unstable soils that should be removed from the slab area prior to fill placement and floor slab construction. Select fill required to achieve grade should extend a minimum 5 foot beyond the perimeter of the slab. Fill soil below the slab should be moisture conditioned.

Thickened edges supported on properly compacted existing soils or structural fill materials may be designed using a maximum allowable unit bearing capacity of 2,000 pounds per square foot based on dead load plus design live load considerations. The grade beams should have a minimum width of 10 inches even if actual bearing pressure is less than the design value. If frost heave is a design consideration, the perimeter grade beams should bear at least 24 inches below adjacent surface grades. If soft or very loose soils are encountered at the design bearing level, they should be undercut to stiff residual soils and the excavation backfilled with concrete or controlled low strength material (CLSM) or properly compacted fill.

Several design methods use the modulus of subgrade reaction, k, to account for soil properties in design of flat grade-supported floor slabs. Based on our laboratory test results and the slab recommendations provided in this document, k-value of 120 pounds per cubic inch (pci) may be used in the grade slab design based on values typically obtained from 1 ft x 1 ft plate load tests. However, depending on how the slab load is applied, the value will have to be geometrically modified. The value should be adjusted for larger areas using the expression/formula presented in the “Floor Slab Recommendations” section of this report.

Uniform compaction of fill materials is important to reduce total and differential settlements. If the site is prepared as recommended, and based on the anticipated loading conditions, total and differential settlements of the foundation should be about 1 inch and ½ inch, respectively, or less. To reduce moisture problems below the floor slab, a vapor retarder such as polyethylene sheeting should be provided beneath the slab. PSI recommends that a minimum four-inch-thick, free draining granular mat be placed beneath the slab. Adequate construction joints, as necessary, and reinforcement should be provided to reduce the potential for cracking of the floor slab due to differential movement. The design should consider the added effect of trees and non-seasonal moisture sources, such as irrigation, plumbing or drainage leaks and poor surface drainage.

The foundation excavations should be observed by a representative of PSI prior to concrete placement to assess that the foundation materials are capable of supporting the design loads and are consistent with the materials discussed in this report. Soft or loose soil zones encountered at the bottom of the excavations should be removed to the level of firm soils or adequately compacted fill or stabilized soil as directed by the Geotechnical Engineer. Cavities formed as a result of excavation of soft or loose soil zones should be backfilled with lean concrete or recommended fill, as determined by the Geotechnical Engineer.

Surface run-off water should be drained away from the excavations and not be allowed to pond. The structures' foundation concrete should be placed during the same day the excavation is made. If it is required that excavations be left open for more than one day, they should be protected to reduce evaporation or entry of moisture. Consideration should be given to the use of interceptor drains to collect and remove water accumulating around the perimeter and underneath the slab. The interceptor drains could be incorporated with the storm drains of other utilities located on-site.

3.6 DRILLED PIER FOUNDATION RECOMMENDATIONS

If the projected movements associated with shallow foundation systems cannot be tolerated or to enable higher bearing capacities, while also reducing potential for excessive differential settlements, the use of straight shaft cast-in-place concrete drilled piers bearing in the underlying shaley clay and/or elastic silt (IGM) material (idealized for this site as materials with SPT N-values of ≥ 30 blows per foot of penetration) can be considered for support of the proposed structures. Properly sized straight shaft cast-in-place concrete drilled piers bearing in the shaley clay/elastic silt intermediate geo-material (IGM) can be used for the project.

The subsurface conditions encountered in the borings appear adequate for use of straight shaft concrete drilled piers and grade beams. The piers should be a minimum total length of 10 feet or a ratio of length to diameter (L/D) not less than 3, whichever is longer, below the grade beam and the depth and size, including reinforcing, should account for resistance of lateral loads. The piers should bear a minimum of 2 feet or one pier diameter whichever is greater, below the IGM stratum from the soil-IGM material interface. Piers bearing the recommended depths can be designed for general allowable unit end bearing and unit skin friction capacities for the entire site of 21,000 psf and 875 psf, based on dead load plus design live load. However, the allowable capacities in the table below can be considered for individual structural unit's site subgrade, if needed or warranted. The allowable capacities are based on factors of safety of 2 and 3 for end bearing and skin friction capacities, respectively.

The skin friction capacities are applicable to the portion of drilled shaft extended beyond the recommended minimum length into the bearing material.

Conventional Shallow Foundation Allowable Unit End Bearing Capacity			
Structure	Bearing Material	End Bearing, psf	Skin Friction, psf
Community Building	3 – 10	15,500	947
	10 – 25	43,000	1,750
Apartment Building (Northwest)	3 – 10	7,300	440
	10 – 15	17,500	700
	15 – 25	21,000	875
Apartment Building (Southwest)	0 – 10	8,100	500
	10 – 20	21,000	875
	20 – 25	33,700	1,400
Apartment Building (Southeast)	0 – 10	5,000	300
	10 – 15	17,500	700
	15 – 25	27,100	1,100

The allowable values are based on factors of safety of 2 and 3 for end bearing and skin friction, respectively.

The piers should be reinforced for the full depth to resist uplift forces due to the expansive clays. Reinforcement quantity should be adequate to resist tensile uplift forces generated by the clay soils equal to 30d (ksf) over the moisture activity depth (upper 10 feet) of the pier shaft, with the being the drilled pier diameter. The piers should be designed after considering the dead load, the friction force in the rock, and the uplift force within the active depth.

Piers should be designed with a shaft diameter of at least 18 inches. Properly constructed piers bearing in the recommended bearing materials should experience total maximum settlement on the order of ½ inch or less.

It will be difficult for the drilling contractor to determine or identify proper recommended bearing material. Therefore, it is recommended PSI perform the pier construction observations and documentation.

The pier construction should also be observed by a representative of the Geotechnical Engineer to assess that the foundation materials have adequate strength to support the design loads and are consistent with the materials recommended in this report. Particular attention should be given to observation at locations where soil sloughing or groundwater inflow problems may occur.

Soft or loose soil zones encountered at the bearing level should be removed from the drilled shafts. If the exposed bearing material becomes significantly wet or dry, it should be removed, and the pier deepened until more uniform moisture conditions are achieved. Concrete should be placed in the piers the same day they are excavated to prevent weakening of the shaft wall and bottom.

Slurry and/or casing may be required to advance the drilled piers, especially if sloughing soil or groundwater is encountered. Concrete placed in the piers should have a slump in the range of 5 to 7 inches. This range of slump will help to reduce the potential for formation of voids, especially as casing is extracted. The concrete mix should be designed to attain the required strength when placed at such a slump. The drilled shafts should be filled with concrete as soon as practical to reduce the potential of groundwater related problems and weathering of the excavation wall. During simultaneous concrete placement and casing removal operations, sufficient concrete head should be maintained inside the casing to offset hydrostatic head outside the casing, and to prevent the intrusion of soil and possible groundwater into the pier concrete, if present.

3.6.1 LATERAL RESISTANCE DESIGN PARAMETERS

For drilled shafts, the soils and IGM as well as the rigidity of the shaft will resist the lateral loads applied to the shaft. Lateral load analysis can be performed based on methods ranging from chart solutions to the ‘p-y’ approach utilizing computer programs such as LPILE or the public domain COM624.

The general lateral design information regarding the 'p-y' data is provided in this section. The relationship between the soil resistance (p) and pile deflection (y) is commonly referred to as 'p-y'. Along the depth of the shaft, soil resistance (p) is expressed as a non-linear function of lateral shaft deflection (y). Various researchers developed 'p-y' criteria for different kinds of soils. The 'p-y' curves can be automatically generated utilizing the computer program LPILE or the public domain COM 624. The program LPILE was developed by Lymon Reese and Shin-Tower Wang, Ensoft, Inc. and based on the COM 624 developed for the FHWA by the authors and made available by the FHWA. The recommended general parameters for generation of ‘p-y’ criteria from LPILE as well as COM 624 are provided for the analyses of the shafts.

Parameters to Be Used in the Lateral Load Analyses

Stratum	‘p-y’ Criteria	**Total Unit Weight, γ (pcf)	Ø (deg.) or S_u or Q_u (psf)	***K_s or $K_{unsat.}$(pci) or K_c or $K_{sat.}$ (pci) or E (psi)	***ε_{50} or K_{rm} or RQD
I*	Clay Criteria (Overburden soils)	120	S_u = 1,500	K_s = 500 or K_c = 200	ε_{50} = 0.0070
II	Clay Criteria (IGM)	130	S_u = 4,500	K_s = 1,500 or K_c = 600	ε_{50} = 0.0044

Note: S_u: Undrained Shear Strength (psf); Q_u: Unconfined Compressive Strength (psf); ϕ, Angle of Internal friction; kunsat: modulus of subgrade reaction (pci) for unsaturated soil condition; ksat: modulus of subgrade reaction (pci) for saturated soil condition; k_s: modulus of subgrade reaction (pci) for static loading condition; kc: modulus of subgrade reaction (pci) for cyclic loading condition; E: Initial modulus (psi); ε_{50}: strain corresponding to one-half the principle stress. K_{rm}: a constant for overall stiffness; RQD: Rock Quality Designation.

* Neglect the top 3’ of Stratum I soils for the lateral load analysis appropriately based on the location of the pile head
** For submerged portion of pier, use effective unit weight γ'
***It may be possible to default to the computer program generated values

PSI can assist in performing the lateral response analysis under a separate work proposal.

3.7 FLOOR SLAB RECOMMENDATIONS

The buildings’ grade supported floor slabs used in conjunction with the conventional spread footing or drilled pier and grade beam foundation system should be supported on a minimum 4 feet of properly compacted structural fill or modified existing soil used as fill, as recommended. When supported on a minimum 4 feet of the recommended materials, the potential vertical rise (PVR) is expected to be 1 inch or less. Proof-rolling, as discussed earlier in this report, should be accomplished to identify soft or unsuitable soils that should be removed from the floor slab areas prior to fill placement and floor slab construction. Fill soils under the slabs should be moisture conditioned at or above the optimum moisture content throughout the construction process.

For the properly compacted structural fill and modified existing soil, modulus of subgrade reaction, *k,* value of 120 pounds per cubic inch (pci) may be used in the grade slab design based on a 1 ft. x 1 ft. plate load test. However, depending on how the slab load is applied, the value will have to be geometrically modified. The value should be adjusted for larger areas using the following expression for cohesive and cohesionless soils:
Modulus of Subgrade Reaction,

$k_s = \frac{k}{B}$ for cohesive soil, and

$k_s = k\ (\frac{B+1}{2B})^2$ for cohesionless soil (not recommended for replacing undercut in relatively impermeable soils)

where:

k_s = coefficient of vertical subgrade reaction for loaded area,
k = coefficient of vertical subgrade reaction for 1x1 square foot area,
B = width of area loaded, in feet (or effective width, B', for grade beam, continuous footing, or mat/raft foundation)

PSI recommends that a minimum four-inch thick free draining granular mat be placed beneath the building floor slabs to enhance drainage. Prior to placing drainage layer, the subgrade should be graded to drain and not provide pockets to trap water. In moisture sensitive areas for equipment and flooring, vapor retarder should be installed with the grade supported slab construction according to ACI criteria. The floor slabs should have an adequate number of joints to reduce cracking resulting from differential movement and shrinkage.

3.7.1 STRUCTURAL SLAB

As an alternative to providing a minimum of 4 feet of suitable and properly compacted fill material below grade supported floor slab, a structural slab with a minimum of 8 inches of void space (to prevent contact with the subgrade expansive soils) along with the drilled pier and grade beam foundation system may be considered. The 8-inch void space should be provided below the slab and the grade beam elements and may be formed by casting the concrete on degradable concrete void forms/applicable cardboard void boxes or other engineer approved materials, or by forming the bottoms of the slab and grade beams above the ground surface. If cardboard void boxes are utilized, care must be taken to maintain their structural integrity up to the time the concrete is placed. Wet, damaged, or poorly constructed void boxes may collapse under the weight of the concrete. Grade beams should be structurally connected to the piers. If a structural slab as recommended above is used, removing and replacing a minimum 4 feet of the existing soil or recompacting the upper portion of the existing soil and placement of the vapor barrier below the fill will not be required.

3.8 LATERAL EARTH PRESSURE RECOMMENDATIONS

Basement construction or earth retention system is not anticipated to be a part of the project. However, based on the large scope of the project, PSI is providing this report section for the client's information should it be needed as part of the project or essential parts considered for possible elevator pits, if applicable.

To control hydrostatic loading on earth retention systems, it is recommended that a perforated drainpipe be installed at the footing level. The drainpipe should be sloped to provide positive drainage to a sump where water can be collected and removed or to a site storm sewer/drainage. The drain line should be wrapped with filter fabric to prevent intrusion of fines and backfilled with free draining granular material extending vertically above the drain line to within 1 foot of final grade. The granular section behind the earth retention system should have a minimum width of 1 foot and should be encapsulated in a suitable filter fabric to minimize intrusion of fines. The remaining portion of the excavation should be backfilled with structural fill or completed with granular material. The use of a prefabricated drainage blanket on the earth retention system may also be considered to prevent hydrostatic loading. Drainage blankets should be installed in accordance with manufacturer's recommendations.

The actual earth pressure on the walls will vary according to the type of material to be retained and backfill materials used and how the backfill is compacted. The equivalent fluid pressures (γ_{eq}) presented below, provide lateral earth pressures for design of walls using compacted granular backfill where the cut slope, if applicable, is 60° or less from the horizontal and for existing soil and structural backfill soil, and are applicable for a horizontal surface behind the earth retention system.

Soil Supported	**Angle of Internal Friction, ϕ**	**Lateral Coefficient, K**			**Presumptive Total Unit Weight, pcf**	**Equivalent Fluid Unit Weights, γ_{eq}, psf/ft**		
		Active, K_a	**Passive, K_p**	**At-Rest, K_o**		**Active**	**Passive**	**At-Rest**
Granular Soil Placed	32°	0.31	3.25	0.47	115	35	374	54
In-Situ Clay Soil	20°	0.49	2.04	0.66	120	59	245	79
In-Situ Shaley Clay Soil	25°	0.41	2.46	0.58	130	53	320	75

The at-rest values should be used if walls cannot yield at top during backfilling and service conditions and passive pressure values should be used where the structure will push into the soil. The active condition is applicable where the ratio of the horizontal movement of the top of the wall to the wall height is equal to or greater than *1/240.*

If granular soil is utilized at the base of the structure, ultimate base friction coefficient of 0.53 may be considered and if granular support is not provided at the base of the structure an ultimate base adhesion value of 600 psf may be considered. An appropriate factor of safety should be applied.

Typically, only half of the passive pressure may be used to resist lateral loads due to the amount of strain required to fully mobilize the passive pressure. The above values of equivalent fluid pressure are based upon horizontal grade at the top of the wall including no surcharge loads within a distance that is twice the wall height.

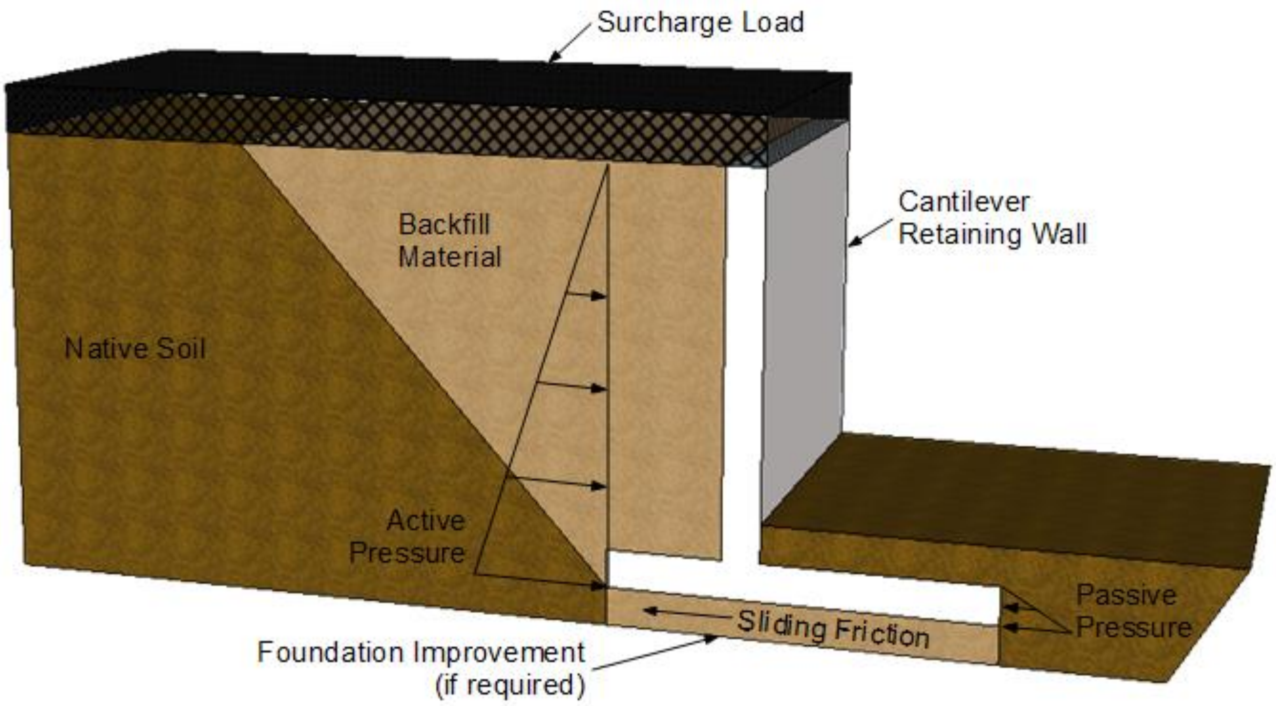
Since specific information about potential backfill material is not available for this report, PSI estimates the material may also consist of compacted clays or silts, apart from sand or structural fill assumed above, or combinations. For compacted lean clay and sandy silt, the following lateral pressure coefficient values behind the wall can be considered when applicable.

	Active		**At-Rest**	
Soil Type	**K_a**	$\gamma_{eq,}$ **psf/ft**	**K_o**	$\gamma_{eq,}$ **psf/ft**
Clay	0.59	74	0.74	93
Silt	0.53	66	0.69	86

$\gamma_{eq,}$ - equivalent fluid pressure

When loads including traffic are present near wall, the wall should be designed to resist an additional uniform lateral load based on the active coefficient. This additional traffic load may be taken as a 2-foot surcharge load with a total unit weight of 125 pcf. Care should be exercised during the backfilling of the walls to prevent overstressing and damage to the walls. Sub-drains should be installed to avoid the buildup of hydrostatic pressure behind the retaining walls.

The following illustration provides general requirements for the design and installation of retaining walls.



3.9 SIDEWALK AND GRADE PAVING

For sidewalks or other flatwork located adjacent to grade-supported foundations, the undercutting and select fill placement operations for the structure should extend beyond the perimeter of the structure to at least the width of the adjacent paving, sidewalk or flatwork.

Sidewalks or flatwork not adjacent to structures should be placed on an improved subgrade meeting or exceeding subgrade improvement methods previously recommended. Alternatively, for such sidewalk, or other flatwork subgrade consisting of material with a plasticity index of 25 or greater, as applicable for this project site, if additional movements can be tolerated, subgrade stabilization as recommended for pavements may be performed and should extend a minimum of one foot beyond the perimeter/edges. Structural fill materials should be compacted to 95% or greater than the maximum dry unit weight and should contain moisture content between -2 and +3% optimum moisture content.

Proper drainage around grade-supported sidewalk and flatwork is also very important to reduce potential movements. Elevating and/or sloping the paving, sidewalk, or other flat work where possible and providing rapid, positive drainage away from them will reduce moisture variations within the underlying soils.

3.10 DETENTION POND CONSIDERATION

A detention pond is proposed at the northeast corner of the site. Detention pond basin should be excavated below grade following the excavation and slope recommendation portions of this report. If an earthen embankment or berm is constructed up to 5 feet above original ground to provide additional freeboard, the fill should be placed and compacted in accordance with the structural fill portions of this report. The berm or embankment crest width should be adequately sized. If the height of the berm or embankment is greater than 5 feet above original ground the embankment may have to be evaluated in accordance with the State dam safety regulations.

Specific borings were not performed for the indicated proposed pond area. However, the classifications of the materials sampled in the vicinity of the proposed pond areas (Borings B-5 and P-6), are generally fat clays and elastic silts to a depth as deep as 10 feet underlain by the fat clay IGM to the boring depth in B-5. Atterberg limits values of the overburden soil materials tested indicated liquid limits of 60 and 71 with resultant plasticity indices of 26 to 41. Based on empirical correlation of the moisture characteristics of the overburden and available information from the borings performed, the overburden clay materials are expected to have typical coefficient of permeability on the order of $1x10^{-10}$ to $1x10^{-7}$ cm/sec. Additionally, the USDA/NRCS data indicate the site comprise Group D soils. Group D soils are soils having a very slow infiltration rate (high runoff potential) when thoroughly wet. They consist chiefly of clays that have high shrink-swell potential, soils that have a highwater table, soils that have a claypan or clay layer at or near the surface, and soils that are shallow over nearly impervious material. Group D soils have a very slow rate of water transmission. If present and needed or confirmed by permeability/infiltration tests to retain water in the pond, higher permeability value may require construction of an earthen clay liner or synthetic liner. Heavy clays, shale bedrock and shaley clay IGM can be expected to be relatively impermeable. If the client's plan or regulatory requirements involves a higher or lower permeability, some amendment to the soils or site will be required. The invert elevations of the proposed pond are not available to PSI and the watertable at the time of exploration may be below the proposed bottom grade of the basin. If the watertable is not at a depth of at least 4 feet below the bottom of the pond, state DEQ and Oklahoma Water Board regulations may be applicable and should be observed. Groundwater was not encountered until a depth of approximately 15 feet in the deeper borings during the field work and may be higher at other times and excavation may require dewatering during the construction. The contractor should be prepared for dewatering.

3.10.1 SLOPES

For general slope construction for the pond, temporary slopes may not be steeper than a ratio of one to one (1) horizontal to one (1) vertical where workers or equipment will occupy space at the toe or if the movement of the excavated slope will jeopardize the stability of an adjacent structure. Slopes in the shaley clay and/or bedrock may be constructed at or near vertical slope. PSI recommends temporary slopes exceeding ten (10) feet in vertical height have a slope stability analysis performed. Temporary slopes exceeding 20 feet in vertical height should have shear strength testing performed to assess the in-situ strength characteristics.

Permanent cut slopes may not be excavated to a final grade steeper than a ratio of one and one-half (1½) horizontal to one (1) vertical without a specific slope stability analysis. Specific shear strength testing should be performed to assess the in-situ strength characteristics for permanent slopes steeper than and one-half (1½) horizontal to one (1) vertical.

It is recommended permanent cut slopes that will be saturated either periodically or constantly should have a final slope no steeper than two (2) horizontal to one (one) vertical unless a specific slope stability analysis is performed.

Special consideration must also be given to the stability of the natural cut ground when supporting substantial fills, to structural fills themselves, and to cut surfaces in natural soil and rock excavations. The evaluation of slope stability aspects of this site and the proposed development is beyond the scope of this exploration. Relatively detailed grading plans will have to be developed before meaningful evaluation of slope stability can be accomplished. All slope stability evaluations should be performed by qualified geotechnical engineering personnel prior to the initiation of any significant grading activities at this site.

However, based on OSHA excavating criteria and the results of the field tests, the soils at the site should be able to sustain a slope that is not steeper than one (1) horizontal to one (1) vertical for short term construction.

Where lagoons, ponds and basins are excavated to a depth that intersects a more permeable layer or a rock interface, it may be required to line the basin with an impermeable layer. The impermeable layer can be a geosynthetic or constructed of natural material. If natural low permeable materials are not available, the below amendment method can be used. Typically, a relatively impermeable layer (less than $1x10^{-7}$ cm/sec permeability) is necessary to maintain a stable pond or to detain the water for an appreciable period of time. PSI recommends that, if encountered, permeable sand and silt layers be covered with a geosynthetic membrane or a minimum of 12 inches of properly compacted material that has a permeability of $1x10^{-7}$ cm/sec and where the slopes or basin is exposed to a water surface or fluctuating water surface, at least 12 inches of vegetative supporting soils that will both support a grass growth for erosion protection and also provide protection for the impermeable layer from mud cracking and drying out. Where the sustained pool of water exceeds 10 feet of water, the impermeable layer should be increased by 0.1 feet for each foot of sustained pool elevation. PSI recommends that the impermeable layer be increased by 50 percent at the intersection of the slopes with the bottom of the basin, at the location of penetrations into the basin, and over predominate geologic features such as fracture planes, joints, and other discontinuities.

3.10.2 BENTONITE CLAY FILL AMENDMENT

If needed, PSI recommends the following procedure when amending soils with Bentonite clay:

- Laboratory testing should be performed with the actual soils to be amended and the actual bentonite source materials. Remolded samples at varying percentages of amendment should be prepared, typically at 2 percent by weight increments, to determine how much amendment is required to achieve the desired permeability or other amendment property.

- A Proctor test, typically a standard proctor, should be performed on the actual soil to be amended with the actual bentonite source material for use in the placement and compaction of the amended soils.
- Flex-walled Permeability testing should be performed at low confining pressures and low gradients to measure the effects of the amendment on the in-situ soils. PSI recommends performing a permeability test on un-amended soils as a base reference. Special care will be necessary to hydrate the bentonite during the testing due to the swelling characteristics of the bentonite.
- The amendment material should be distributed evenly in the field and thoroughly mixed with tined or auger mixing equipment as used in mixing lime into soil bases. Moisture adjustment of the soil should be performed at the time of mixing bentonite material into the soil.
- Lift thicknesses of the placed material should be no deeper than the depth of the mixing equipment's ability to evenly mix unless the material is mixed remotely and placed in a re-handled lift. If the material is remotely mixed and placed, the lifts should be no greater than 8-inch loose lifts and should be placed with a sheep foot compactor with at least a 7-inch-long sheep's foot.
- Bentonite amended soils will be susceptible to "mud cracking", due to the increased plasticity of the amended soil. It is recommended that a cover layer of lower plasticity material be place over the amended soils to reduce the moisture changes in the amended soils and reduce the effects of surficial drying.

Bentonite amendment materials can come in many forms from powder to pellet size. Often the coarser the size of the bentonite the more material by weight is required to have the desired effect on the amended soil. However, due to the variability of soils it is difficult to determine these effects without actual testing. In the absence of laboratory data or for estimating purposes prior to laboratory testing, an application of 5 to 10 percent bentonite by weight is usually sufficient to reduce the permeability of silty fine sands and uniform silty soils. However, depending on the actual permeability of the in-situ soils, more or less bentonite made be required for a specific permeability requirement.

4 PAVEMENT RECOMMENDATIONS

4.1 SUBGRADE SOIL PREPARATION

PSI has based its recommendation on subgrade soils prepared to achieve a minimum CBR value of 3, with the recommended subgrade stabilization, proper proof-rolling, and the site not being wet at the time of construction. The pavement subgrade should be prepared as discussed in the “Site Preparation” section of this report.

4.2 PAVEMENT DESIGN

Pavement sections were evaluated using Pavement Assessment Software (PAS) which is based on the 1993 AASHTO Design equations; a reliability factor of 85%; and a flexible pavement 18-kip single axle load (ESAL) of 30,000 for standard duty (car parking) and 60,000 for heavy duty parking areas and drive areas. Design lives for standard duty and heavy-duty pavements are 20 years. Flexible Pavements were evaluated based on an initial serviceability of 4.2 and a terminal serviceability of 2.0. Rigid pavements were evaluated based on an initial serviceability of 4.5, a terminal serviceability of 2.0, and an unreinforced concrete mix with a 28-day modulus of rupture of 550 psi (approximately 3,000 psi compressive strength). The pavement sections presented for the rigid pavements represent minimum thickness recommendations by PSI and the ESAL loads are in excess of 0.2 million. PSI should be contacted if traffic loads, especially truck traffic in loading areas and the frequency idealized, are greater than used in the analysis. Pavement materials should conform to local and state guidelines, if applicable.

PSI has based its recommendation on subgrade soils prepared to achieve a minimum estimated CBR value of 3 with the recommended subgrade stabilization and with proper proof-rolling and the site not being wet at the time of construction. Based on the preceding, it is possible to design a typical pavement section consisting of the following:

Flexible Pavement Thickness (Inches)		
Pavement Materials	Light Duty (inch)	Heavy Duty (inch)
Asphaltic Surface Course	2	2
Asphaltic Base Course	3	4
ODOT Type A Aggregate Base **(Optional)**	6	6
Stabilized Subgrade	8	8
Rigid Pavement Thickness (Inches)		
Pavement Materials	Light Duty (inch)	Heavy Duty (inch)
Portland Cement Concrete	5	6
ODOT Type A Aggregate Base **(Optional)**	4	4
Stabilized Subgrade	8	8

Although considered optional, constructing the pavement section with the addition of six (6) and four (4) inches of crushed stone base such as ODOT Type "A" aggregate base beneath the flexible pavement and rigid pavement, respectively, in addition to the required subgrade stabilization, will provide a stronger, more uniform subgrade for wheel loads, and improve drainage.

Water should not be allowed to pond behind curbs. In down grade areas, base stone should extend through the slope to allow any water entering the base stone a path to exit.

Proper finishing of concrete pavements requires the use of appropriate construction joints to reduce the potential for cracking. Construction joints should be designed in accordance with current Portland Cement Association (PCA) guidelines. Joints should be sealed to reduce the potential for water infiltration into pavement joints and subsequent infiltration into the supporting soils.

The design of steel reinforcement should be in accordance with accepted codes. The concrete should also be designed with 5±1 percent entrained air to improve workability and durability. All pavement materials and construction procedures should conform to ODOT or appropriate city and county requirements.

Large front-loading trash dump trucks frequently impose concentrated front-wheel loads on pavements during loading. This type of loading typically results in rutting or cracking of the pavement and ultimately, pavement failures. Therefore, we recommend that the pavement in trash pickup areas consists of a minimum seven (7) inches thick, reinforced concrete slab placed over a minimum 4-inches thick crushed stone base in addition to the required subgrade stabilization.

Pavement may be placed after the subgrade has been properly compacted, fine graded and proof rolled. The work should be done in accordance with the Oklahoma State Department of Transportation guidelines.

If aggregate base is used, water should not be allowed to pond behind curbs and saturate the base stone. In down grade areas, the aggregate base should extend through the slope to allow water entering the base stone a path to exit.

4.2.1 PAVEMENT SUBGRADE PREPARATION

Prior to paving, the prepared subgrade should be proof rolled using a loaded tandem axle dump truck or similar type of pneumatic tired equipment with a minimum gross weight of nine (9) tons per single axle. Localized soft areas identified should be repaired prior to paving. Moisture content of the subgrade should be adequately maintained at the time of paving. It may require rework and modification when the subgrade is either desiccated or wet or pumps.

Construction traffic, including foot traffic, should be minimized to prevent unnecessary disturbance of the pavement subgrade. Disturbed areas, as verified by PSI, should be removed and replaced with properly compacted material.

4.2.2 PAVEMENT DRAINAGE AND MAINTENANCE

PSI recommends pavements be sloped to provide rapid surface drainage. Water allowed to pond on or adjacent to the pavement could saturate the subgrade and cause premature deterioration of the pavements, and removal and replacement may be required. Consideration should be given to the use of interceptor drains to collect and remove water collecting in the granular base. The interceptor drains could be incorporated with the storm drains of other utilities located on-site.

Periodic maintenance of the pavement should be anticipated. This should include sealing of cracks and joints and maintaining proper surface drainage to avoid ponding of water on or near the pavement areas.

4.2.3 CEMENT, LIME, OR FLY ASH STABILIZATION

To reduce the shrink/swell potential of the subgrade soils, the upper 8 inches of the subgrade soil should be stabilized with Portland cement, hydrated lime, or Class 'C' fly ash from a source approved by ODOT. Stabilizing the soil with an estimated 6 to 7 percent Portland cement or lime or an estimated 12 to 14 percent fly ash, by dry weight, will reduce the potential volumetric changes due to the high shrink/swell potential soil and extend the life of the pavement. The actual cement, lime or fly ash percentage should be determined based on laboratory tests after the source of the stabilizing agent has been determined.

PSI recommends soluble sulfate content test of the soils in pavement areas be determined for suitability of the stabilizing agent, especially the hydrated lime, when flexible pavement is under consideration. Research indicates soluble sulfate content in excess of 3% may be detrimental without performing some specific remediation measures.

5 CONSTRUCTION CONSIDERATIONS

5.1 MOISTURE SENSTIVE SOILS/WEATHER RELATED CONCERNS

The upper soils encountered at this site will be sensitive to disturbances caused by construction traffic and to changes in moisture content. During wet weather periods, increases in the moisture content of the soil can cause significant reduction in the soil strength and support capabilities. In addition, soils that become wet may be slow to dry and thus significantly retard the progress of grading and compaction activities. It will, therefore, be advantageous to perform earthwork and foundation construction activities during dry weather periods.

5.2 GROUNDWATER AND DRAINAGE CONSIDERATIONS

Although specific groundwater information has been provided in this report, it is recommended that the contractor determine the actual groundwater levels at the site at the time of the construction activities.

Water should not be allowed to collect in the foundation excavations, on floor slab areas, or on prepared subgrades of the construction area either during or after construction. Undercut or excavated areas should be sloped toward one corner to facilitate removal of collected rainwater, groundwater, or surface runoff. Positive site drainage should be provided to reduce infiltration of surface water around the perimeter of the building and beneath the floor slabs.

Roof drainage should be collected and transmitted by pipe to a storm drainage system or to an area where the water can drain away from buildings and pavements without entering the soils supporting buildings and pavements.

Sidewalks should not be structurally connected to buildings. They should be sloped away from buildings so that water will be drained away from structures.

Backfill for utility lines that are located in pavement, sidewalk, and building areas should consist of low plasticity structural fill. The backfill should be compacted as described in the **Site Preparation** section of this report. Special care should be taken during installation of sub-floor water and sewer lines to prevent the possibility of leaks.

Flower beds and planting areas should not be constructed along building perimeters. Constructing sidewalks or pavements adjacent to buildings would be preferable. If required, flower beds and planting areas could be constructed beyond the sidewalks away from the buildings. If it is desired to have flower beds and planting areas adjacent to a building, the use of above grade concrete box planters, or other methods which reduce the likelihood of large changes in moisture content of soils adjacent to or below structures should be considered.

Water sprinkling systems should not be located where water will be sprayed onto building walls and subsequently drain downward and flow into the soils beneath foundations.

Trees in general should not be planted closer to a structure than ½ the mature height of the tree. A tree planted closer to a structure than the recommended distance may extend its roots beneath the structure, allowing removal of subgrade moisture and/or causing structural distress.

Utilities which project through slab-on-grade floors, particularly where expansive soils or soils subject to settlement are present, should be designed with some degree of flexibility and/or with a sleeve to reduce the potential for damage to the utilities should movement occur.

Soil supported floor slabs are subject to vertical movements. This can often cause distress to interior wall partitions supported on soil supported floor slabs. This should be considered in the design.

5.3 EXCAVATIONS

The following is provided in this report for the client's information. In Federal Register, Volume 54, No. 209 (October 1989), the United States Department of Labor, Occupational Safety and Health Administration (OSHA) amended its "Construction Standards for Excavations, 29 CFR, part 1926, Subpart P". It is mandated by this Federal regulation that excavations, whether they be utility trenches, basement excavations or footing excavations, be constructed in accordance with the new OSHA guidelines. It is PSI's understanding that these regulations are being strictly enforced and if not closely followed, the owner and the contractor could be liable for substantial penalties.

The contractor is solely responsible for designing and constructing stable, temporary excavations and should shore, slope, or bench the sides of the excavations as required to maintain stability of both the excavation sides and bottom. The contractor's "responsible person", as defined in 29 CFR Part 1926, should evaluate the soil exposed in the excavations as part of the contractor's safety procedures. In no case should slope height, slope inclination, or excavation depth, including utility trench excavation depth, exceed those specified in local, state, and Federal safety regulations.

PSI is providing this information solely as a service to the client. PSI does not assume responsibility for construction site safety or the contractor's compliance with local, state, and Federal safety or other regulations.

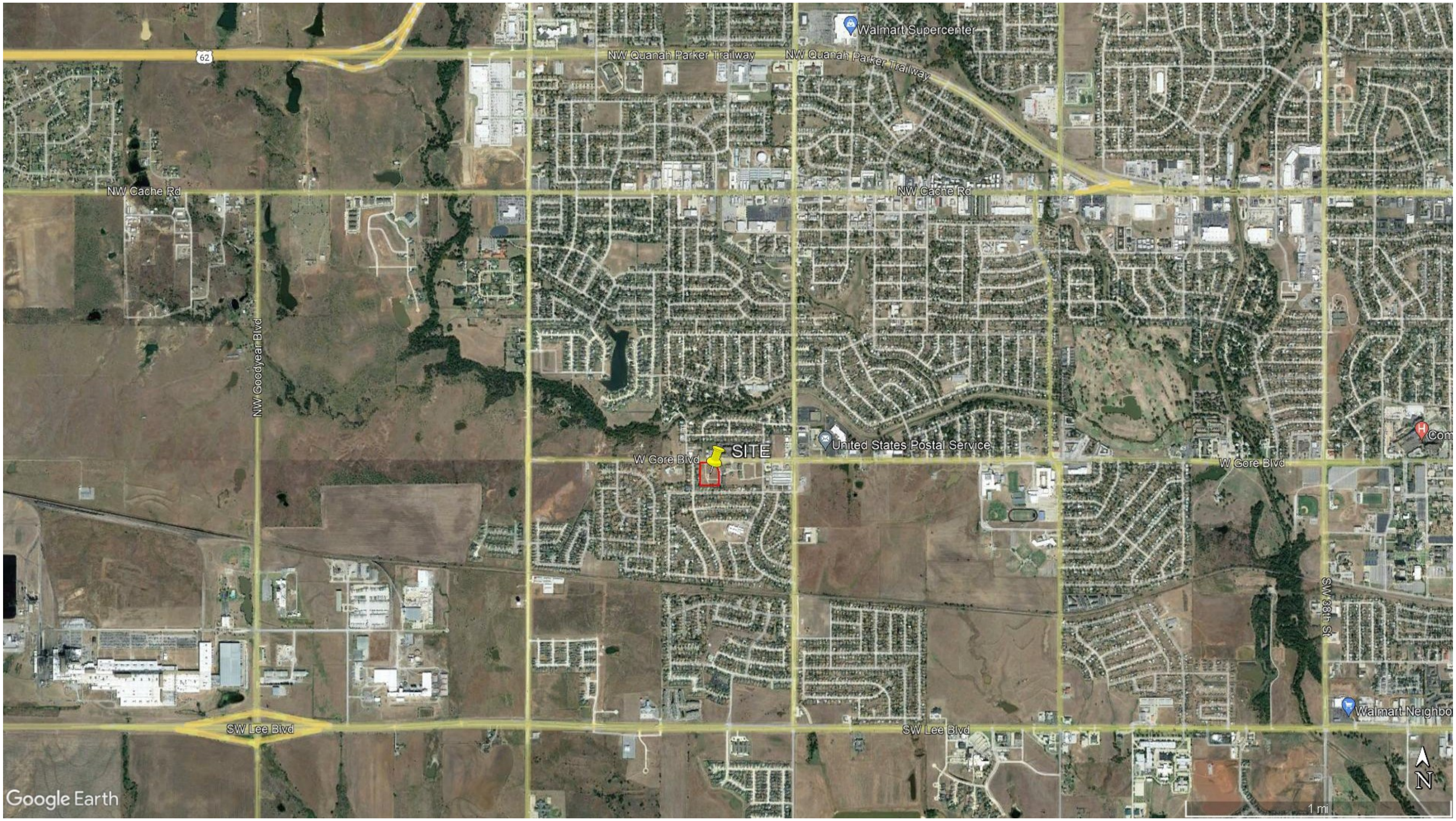
6 REPORT LIMITATIONS

The recommendations submitted are based on the available subsurface information obtained by PSI and details furnished by Carlson Consulting Engineers, Inc. for the proposed project. If there are revisions to the plans for this project or if deviations from the subsurface conditions noted in this report are encountered during construction, PSI should be notified immediately to determine if changes in the foundation recommendations are required. If PSI is not retained to perform these functions, PSI will not be responsible for the impact of those conditions on the project.

The Geotechnical Engineer warrants that the findings, recommendations, specifications, or professional advice contained herein have been made in accordance with generally accepted professional geotechnical engineering practices in the local area. No other warranties are implied or expressed.

After the plans and specifications are more complete, the Geotechnical Engineer should be retained and provided the opportunity to review the final design plans and specifications to check that PSI's engineering recommendations have been properly incorporated into the design documents. At this time, it may be necessary to submit supplementary recommendations. This report has been prepared for the exclusive use of by Carlson Consulting Engineers, Inc. and project team members for the specific application to the proposed Westchester Circle Apartments in Lawton, Oklahoma.

FIGURES



Project
WESTCHESTER CIRCLE APARTMENTS—LAWTON, OK

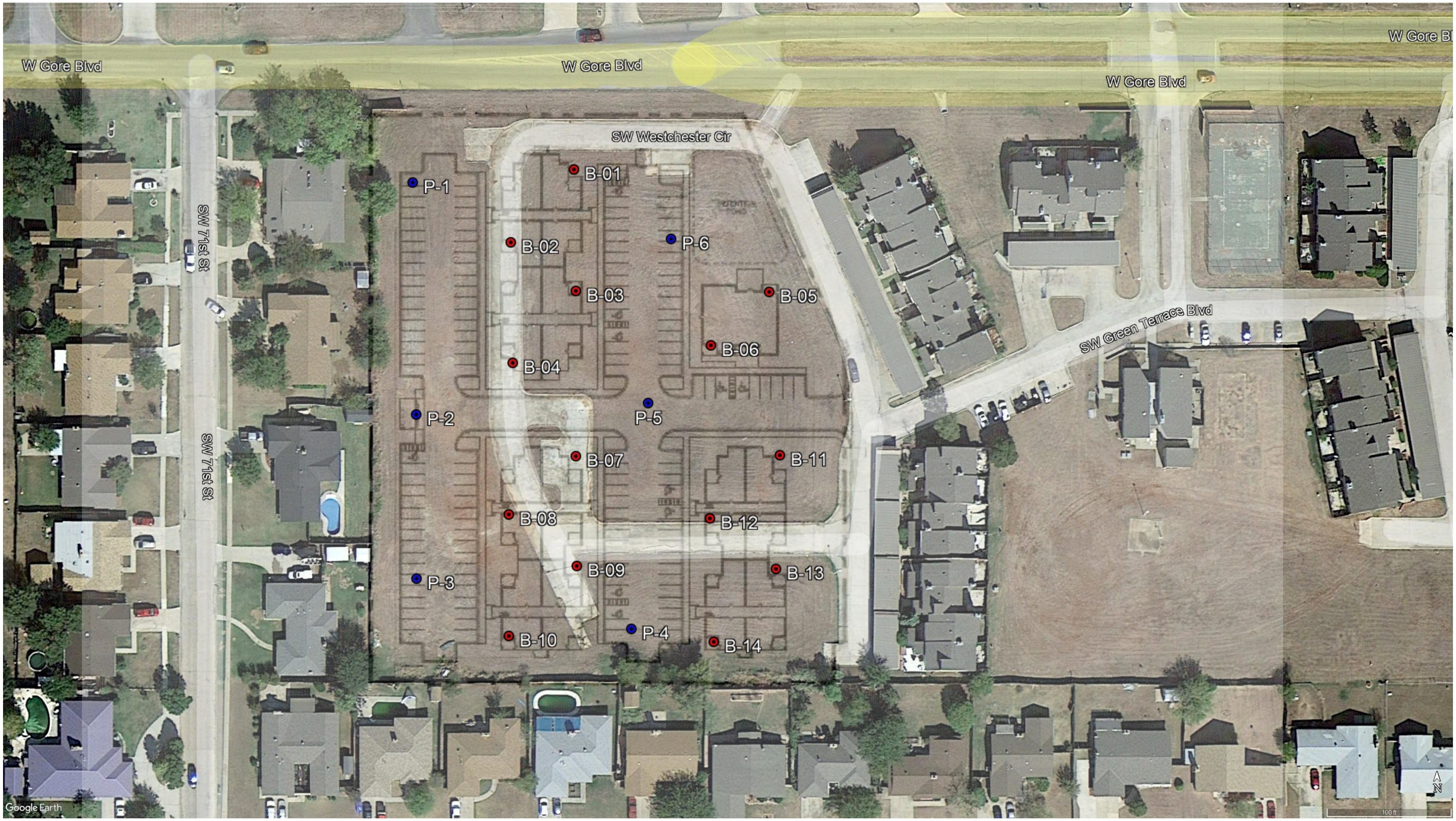
Drawing
SITE VICINITY

Project No.
05462482

Drawn By
Y. Zhang

Date
January 2022

Figure
FIGURE 1



Project	WESTCHESTER CIRCLE APARTMENTS—LAWTON, OK
Drawing	BORING LAYOUT PLAN
Project No.	05462489
Drawn By	Y. Zhang
Date	January 2022
Figure	**FIGURE 2**

LIST OF APPENDICES

APPENDIX A – BORING LOGS AND PROFILES

BORING B-01

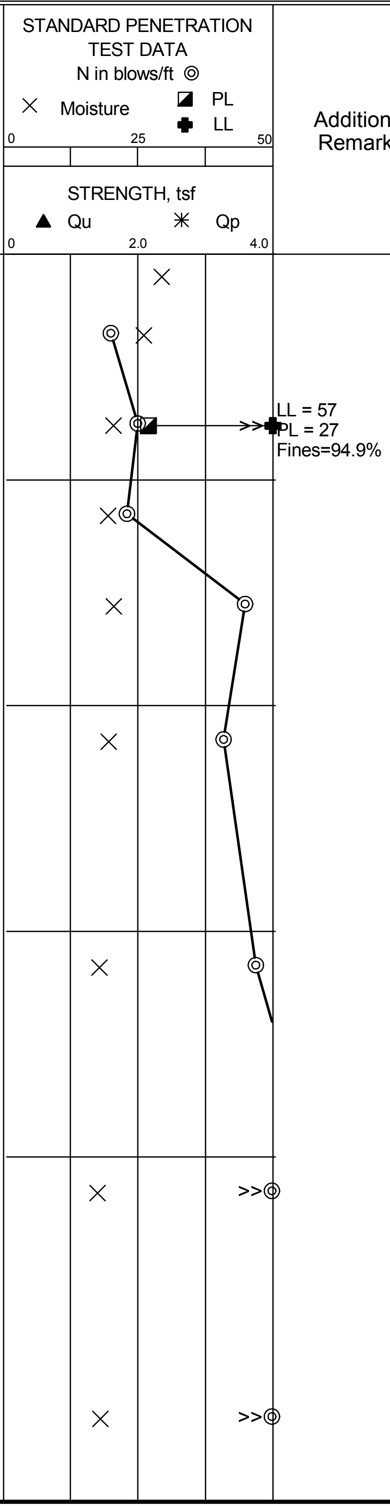
DATE STARTED: 1/4/22
DATE COMPLETED: 1/4/22
COMPLETION DEPTH 21.5 ft
BENCHMARK: N/A
ELEVATION: 1179 ft
LATITUDE: 34.60871°
LONGITUDE: -98.48042°
STATION: N/A **OFFSET:** N/A
REMARKS:

DRILL COMPANY: DSO.
DRILLER: B. Bettes **LOGGED BY:** B. Stone
DRILL RIG: CME-55
DRILLING METHOD: Solid Flight Auger
SAMPLING METHOD: SS
HAMMER TYPE: Automatic
EFFICIENCY: N/A
REVIEWED BY: A. Oyesanya

Water		
▽	While Drilling	None observed
▼	Upon Completion	None observed
▽	Delay	N/A

BORING LOCATION:

Elevation (feet)	Depth, (feet)	Sample No.	Recovery (inches)	MATERIAL DESCRIPTION	USCS Classification	SPT Blows per 6-inch (SS)	Moisture, %	Additional Remarks
	0	1		5-in Concrete **Fat CLAY**, stiff, maroon, blocky			29	
		2		**Fat CLAY**, very stiff, maroon		8/8/12 N=20	26	
1175		3				9/11/14 N=25	20	LL = 57 PL = 27 Fines=94.9%
	5	4			CH	7/10/13 N=23	19	
		5		**Fat CLAY**, shaley, hard, maroon, blocky		11/19/26 N=45	21	
1170	10	6				14/16/25 N=41	20	
1165	15	7				17/19/28 N=47	18	
1160	20	8				19/22/37 N=59	18	
		9		End of boring		15/26/33 N=59	18	



Professional Service Industries, Inc.
11825 S. Portland Avenue
Oklahoma City, OK 73170
Telephone: (405) 735-6052

PROJECT NO.: 05462482
PROJECT: Westchester Circle Apartments
LOCATION: Lawton, OK

The stratification lines represent approximate boundaries. The transition may be gradual.

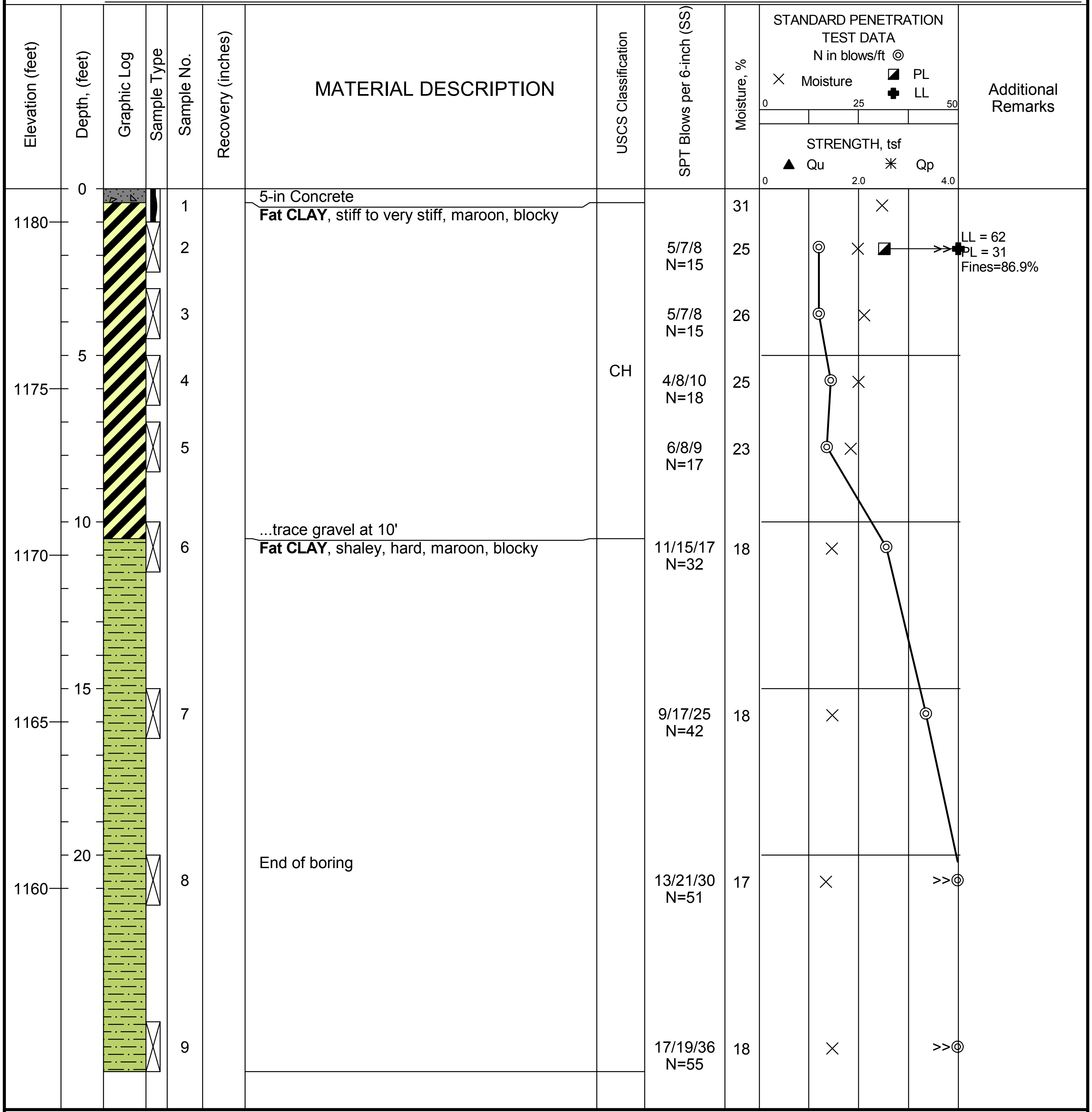
BORING B-02

DATE STARTED: 1/3/22
DATE COMPLETED: 1/3/22
COMPLETION DEPTH 21.5 ft
BENCHMARK: N/A
ELEVATION: 1181 ft
LATITUDE: 34.60855°
LONGITUDE: -98.48059°
STATION: N/A **OFFSET:** N/A
REMARKS:

DRILL COMPANY: DSO.
DRILLER: B. Bettes **LOGGED BY:** B. Stone
DRILL RIG: CME-55
DRILLING METHOD: Solid Flight Auger
SAMPLING METHOD: SS
HAMMER TYPE: Automatic
EFFICIENCY N/A
REVIEWED BY: A. Oyesanya

Water		
▽	While Drilling	None observed
▼	Upon Completion	None observed
▽	Delay	N/A

BORING LOCATION:



Sample No.	MATERIAL DESCRIPTION	USCS Classification	SPT Blows per 6-inch (SS)	Moisture, %	Additional Remarks
1	5-in Concrete **Fat CLAY**, stiff to very stiff, maroon, blocky			31	
2			5/7/8 N=15	25	LL = 62 PL = 31 Fines=86.9%
3			5/7/8 N=15	26	
4		CH	4/8/10 N=18	25	
5			6/8/9 N=17	23	
6	...trace gravel at 10' **Fat CLAY**, shaley, hard, maroon, blocky		11/15/17 N=32	18	
7			9/17/25 N=42	18	
8	End of boring		13/21/30 N=51	17	
9			17/19/36 N=55	18	

Professional Service Industries, Inc.
11825 S. Portland Avenue
Oklahoma City, OK 73170
Telephone: (405) 735-6052

PROJECT NO.: 05462482
PROJECT: Westchester Circle Apartments
LOCATION: Lawton, OK

The stratification lines represent approximate boundaries. The transition may be gradual.

BORING B-03

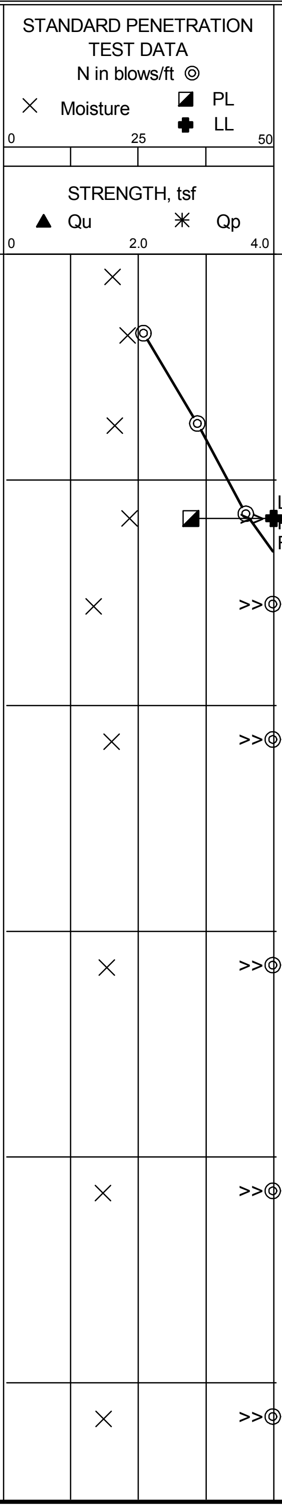
DATE STARTED: 1/3/22
DATE COMPLETED: 1/3/22
COMPLETION DEPTH 26.5 ft
BENCHMARK: N/A
ELEVATION: 1182 ft
LATITUDE: 34.60845°
LONGITUDE: -98.48041°
STATION: N/A **OFFSET:** N/A
REMARKS:

DRILL COMPANY: DSO.
DRILLER: J. Sanders **LOGGED BY:** B. Long
DRILL RIG: CME-750
DRILLING METHOD: Solid Flight Auger
SAMPLING METHOD: SS
HAMMER TYPE: Automatic
EFFICIENCY: N/A
REVIEWED BY: A. Oyesanya

Water		
▽	While Drilling	None observed
▼	Upon Completion	None observed
▼	Delay	N/A

BORING LOCATION:

Sample No.	MATERIAL DESCRIPTION	USCS Classification	SPT Blows per 6-inch (SS)	Moisture, %	Additional Remarks
1	**Fat CLAY**, very stiff, maroon			20	
2			9/12/14 N=26	23	
3	...trace gravel at 3'		13/17/19 N=36	21	
	Elastic SILT with Sand, shaley, hard, maroon	MH			
4			16/21/24 N=45	23	LL = 66 PL = 35 Fines=84.6%
5			12/24/33 N=57	17	
6	...trace gravel at 10'		14/27/38 N=65	20	
	Fat CLAY, shaley, hard, maroon, blocky				
7			16/24/37 N=61	19	
8			18/31/41 N=72	18	
9			15/33/39 N=72	19	
	End of boring				



The stratification lines represent approximate boundaries. The transition may be gradual.

intertek psi

Professional Service Industries, Inc.
11825 S. Portland Avenue
Oklahoma City, OK 73170
Telephone: (405) 735-6052

PROJECT NO.: 05462482
PROJECT: Westchester Circle Apartments
LOCATION: Lawton, OK

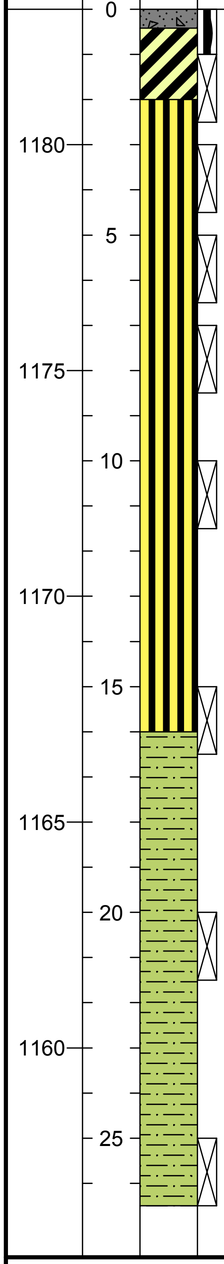
BORING B-04

DATE STARTED: 1/3/22
DATE COMPLETED: 1/3/22
COMPLETION DEPTH 26.5 ft
BENCHMARK: N/A
ELEVATION: 1183 ft
LATITUDE: 34.60829°
LONGITUDE: -98.48058°
STATION: N/A **OFFSET:** N/A
REMARKS:

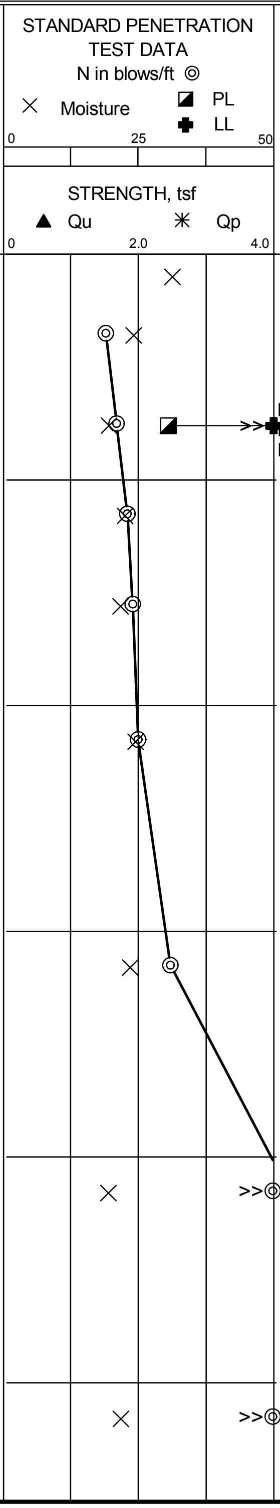
DRILL COMPANY: DSO.
DRILLER: B. Bettes **LOGGED BY:** B. Stone
DRILL RIG: CME-55
DRILLING METHOD: Solid Flight Auger
SAMPLING METHOD: SS
HAMMER TYPE: Automatic
EFFICIENCY N/A
REVIEWED BY: A. Oyesanya

Water		
▽	While Drilling	None observed
▼	Upon Completion	None observed
▽	Delay	N/A

BORING LOCATION:



Sample No.	Recovery (inches)	MATERIAL DESCRIPTION	USCS Classification	SPT Blows per 6-inch (SS)	Moisture, %	Additional Remarks
1		5-in Concrete **Fat CLAY**, stiff, maroon, blocky			31	
2		**Elastic SILT with Sand**, very stiff, maroon		7/9/10 N=19	24	
3				8/10/11 N=21	20	LL = 59 PL = 31 Fines=79.0%
4				8/10/13 N=23	23	
5			MH	9/12/12 N=24	22	
6				12/12/13 N=25	25	
7		**Fat CLAY**, shaley, hard, maroon, blocky		11/13/18 N=31	24	
8				16/22/31 N=53	19	
9		End of boring		21/29/40 N=69	22	



Professional Service Industries, Inc.
11825 S. Portland Avenue
Oklahoma City, OK 73170
Telephone: (405) 735-6052

PROJECT NO.: 05462482
PROJECT: Westchester Circle Apartments
LOCATION: Lawton, OK

The stratification lines represent approximate boundaries. The transition may be gradual.

BORING B-05

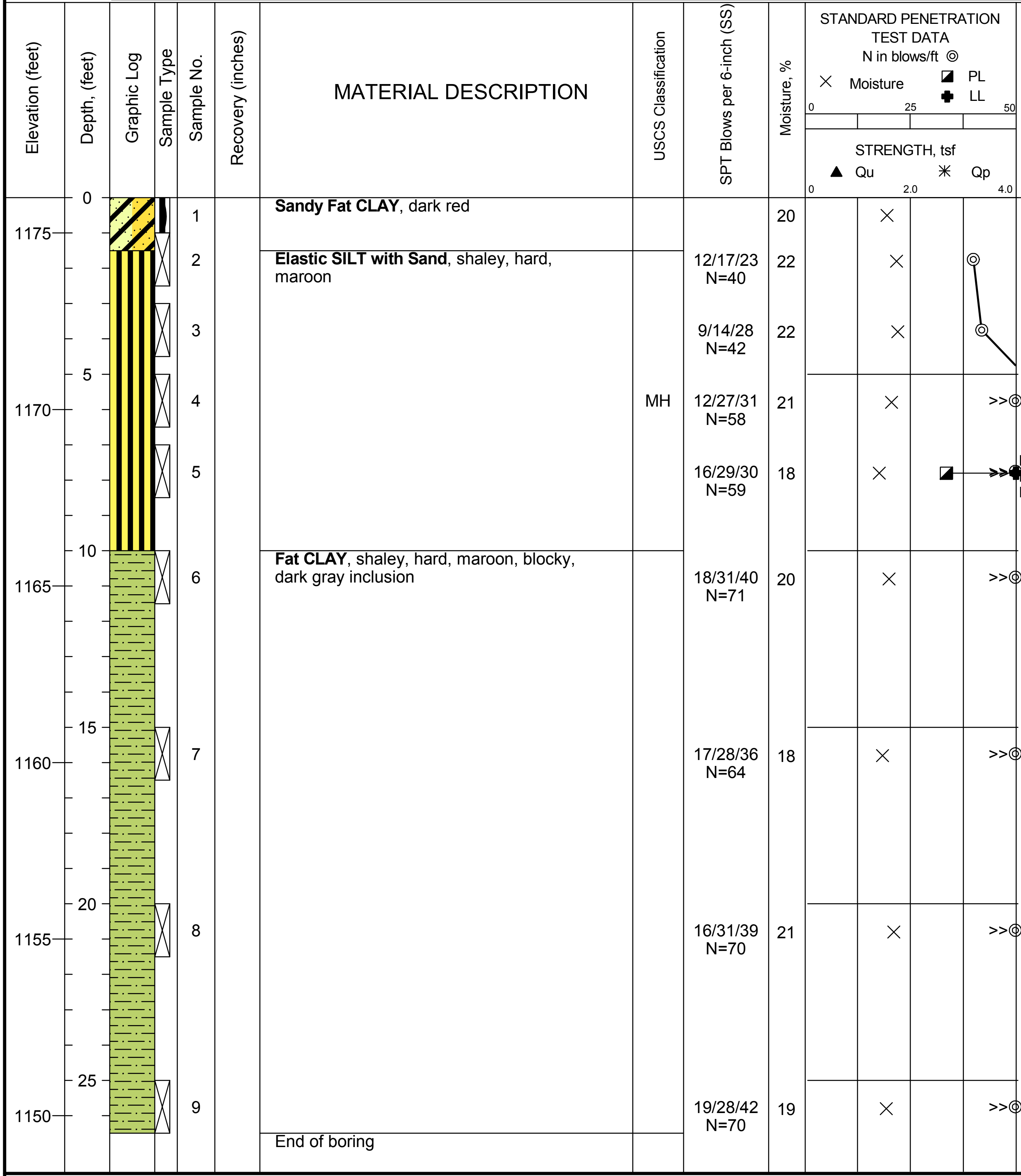
DATE STARTED: 1/3/22
DATE COMPLETED: 1/3/22
COMPLETION DEPTH 26.5 ft
BENCHMARK: N/A
ELEVATION: 1176 ft
LATITUDE: 34.60844°
LONGITUDE: -98.4799°
STATION: N/A **OFFSET:** N/A
REMARKS:

DRILL COMPANY: DSO.
DRILLER: J. Sanders **LOGGED BY:** B. Long
DRILL RIG: CME-750
DRILLING METHOD: Solid Flight Auger
SAMPLING METHOD: SS
HAMMER TYPE: Automatic
EFFICIENCY N/A
REVIEWED BY: A. Oyesanya

Water		
▽	While Drilling	None observed
▼	Upon Completion	None observed
⊻	Delay	N/A

BORING LOCATION:

Sample No.	MATERIAL DESCRIPTION	USCS Classification	SPT Blows per 6-inch (SS)	Moisture, %	Additional Remarks
1	**Sandy Fat CLAY**, dark red			20	
2	**Elastic SILT with Sand**, shaley, hard, maroon		12/17/23 N=40	22	
3			9/14/28 N=42	22	
4		MH	12/27/31 N=58	21	
5			16/29/30 N=59	18	LL = 60 PL = 34 Fines=73.5%
6	**Fat CLAY**, shaley, hard, maroon, blocky, dark gray inclusion		18/31/40 N=71	20	
7			17/28/36 N=64	18	
8			16/31/39 N=70	21	
9			19/28/42 N=70	19	
	End of boring				



intertek psi

Professional Service Industries, Inc.
11825 S. Portland Avenue
Oklahoma City, OK 73170
Telephone: (405) 735-6052

PROJECT NO.: 05462482
PROJECT: Westchester Circle Apartments
LOCATION: Lawton, OK

The stratification lines represent approximate boundaries. The transition may be gradual.

DATE STARTED: 1/3/22
DATE COMPLETED: 1/3/22
COMPLETION DEPTH 26.5 ft
BENCHMARK: N/A
ELEVATION: 1181 ft
LATITUDE: 34.60833°
LONGITUDE: -98.48006°
STATION: N/A **OFFSET:** N/A
REMARKS:

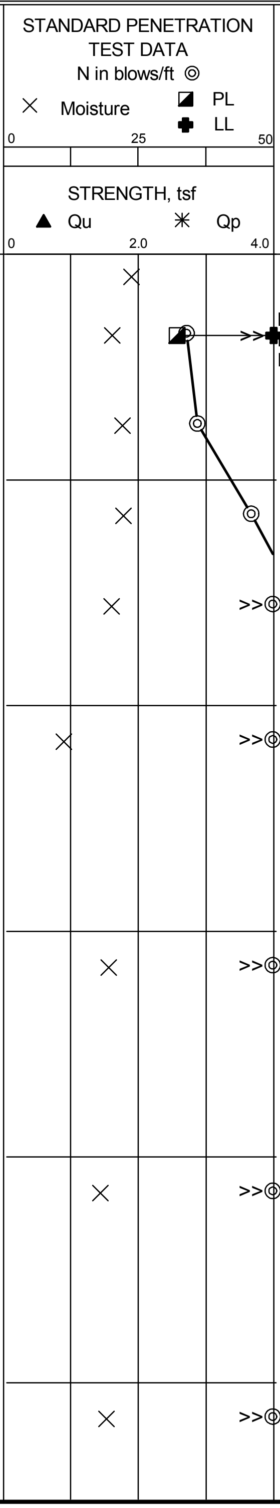
DRILL COMPANY: DSO.
DRILLER: J. Sanders **LOGGED BY:** B. Long
DRILL RIG: CME-750
DRILLING METHOD: Solid Flight Auger
SAMPLING METHOD: SS
HAMMER TYPE: Automatic
EFFICIENCY: N/A
REVIEWED BY: A. Oyesanya

BORING B-06

Water		
∇	While Drilling	None observed
▼	Upon Completion	None observed
∇	Delay	N/A

BORING LOCATION:

Elevation (feet)	Depth, (feet)	Sample No.	Recovery (inches)	MATERIAL DESCRIPTION	USCS Classification	SPT Blows per 6-inch (SS)	Moisture, %	Additional Remarks
	0	1		**Fat CLAY**, dark red			24	
1180		2		**Elastic SILT with Sand**, shaley, hard, maroon, blocky	MH	12/16/18 N=34	20	LL = 64 PL = 32 Fines=92.0%
		3				9/14/22 N=36	22	
1175	5	4				12/22/24 N=46	22	
		5				9/25/30 N=55	20	
1170	10	6		**Fat CLAY**, shaley, hard, maroon, with gray		31/40/39 N=79	11	
1165	15	7				21/30/42 N=72	20	
1160	20	8				16/27/40 N=67	18	
1155	25	9				17/31/41 N=72	19	
				End of boring				



intertek psi

Professional Service Industries, Inc.
11825 S. Portland Avenue
Oklahoma City, OK 73170
Telephone: (405) 735-6052

PROJECT NO.: 05462482
PROJECT: Westchester Circle Apartments
LOCATION: Lawton, OK

The stratification lines represent approximate boundaries. The transition may be gradual.

DATE STARTED: 1/3/22
DATE COMPLETED: 1/3/22
COMPLETION DEPTH 26.5 ft
BENCHMARK: N/A
ELEVATION: 1184 ft
LATITUDE: 34.60808°
LONGITUDE: -98.48041°
STATION: N/A **OFFSET:** N/A
REMARKS:

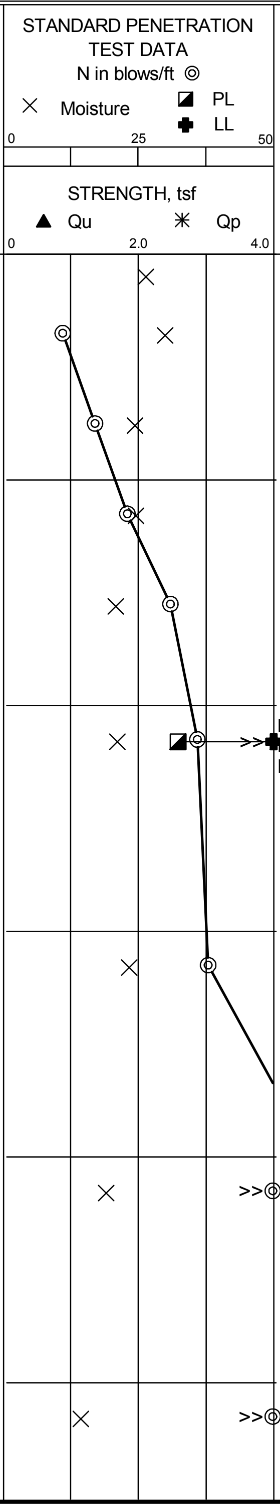
DRILL COMPANY: DSO.
DRILLER: B. Bettes **LOGGED BY:** B. Stone
DRILL RIG: CME-55
DRILLING METHOD: Solid Flight Auger
SAMPLING METHOD: SS
HAMMER TYPE: Automatic
EFFICIENCY N/A
REVIEWED BY: A. Oyesanya

BORING B-07

Water
▽ While Drilling None observed
▼ Upon Completion None observed
▽ Delay N/A

BORING LOCATION:

Elevation (feet)	Depth, (feet)	Sample No.	MATERIAL DESCRIPTION	USCS Classification	SPT Blows per 6-inch (SS)	Moisture, %	Additional Remarks
	0		5-in Concrete				
		1	**Fat CLAY**, stiff, dark red, blocky			26	
		2			3/5/6 N=11	30	
1180		3	**Fat CLAY**, very stiff, maroon, mottled with gray		5/7/10 N=17	24	
	5	4			6/8/15 N=23	25	
		5	**Fat CLAY with Sand**, shaley, hard, maroon, blocky, mottled with gray		9/11/20 N=31	21	
1175	10	6			12/15/21 N=36	21	LL = 65 PL = 32 Fines=79.2%
1170	15			CH			
		7			14/17/21 N=38	23	
1165	20		**Fat CLAY**, shaley, hard, dark red, blocky				
		8			14/23/38 N=61	19	
1160	25	9			16/27/39 N=66	14	
			End of boring				



intertek psi

Professional Service Industries, Inc.
11825 S. Portland Avenue
Oklahoma City, OK 73170
Telephone: (405) 735-6052

PROJECT NO.: 05462482
PROJECT: Westchester Circle Apartments
LOCATION: Lawton, OK

The stratification lines represent approximate boundaries. The transition may be gradual.

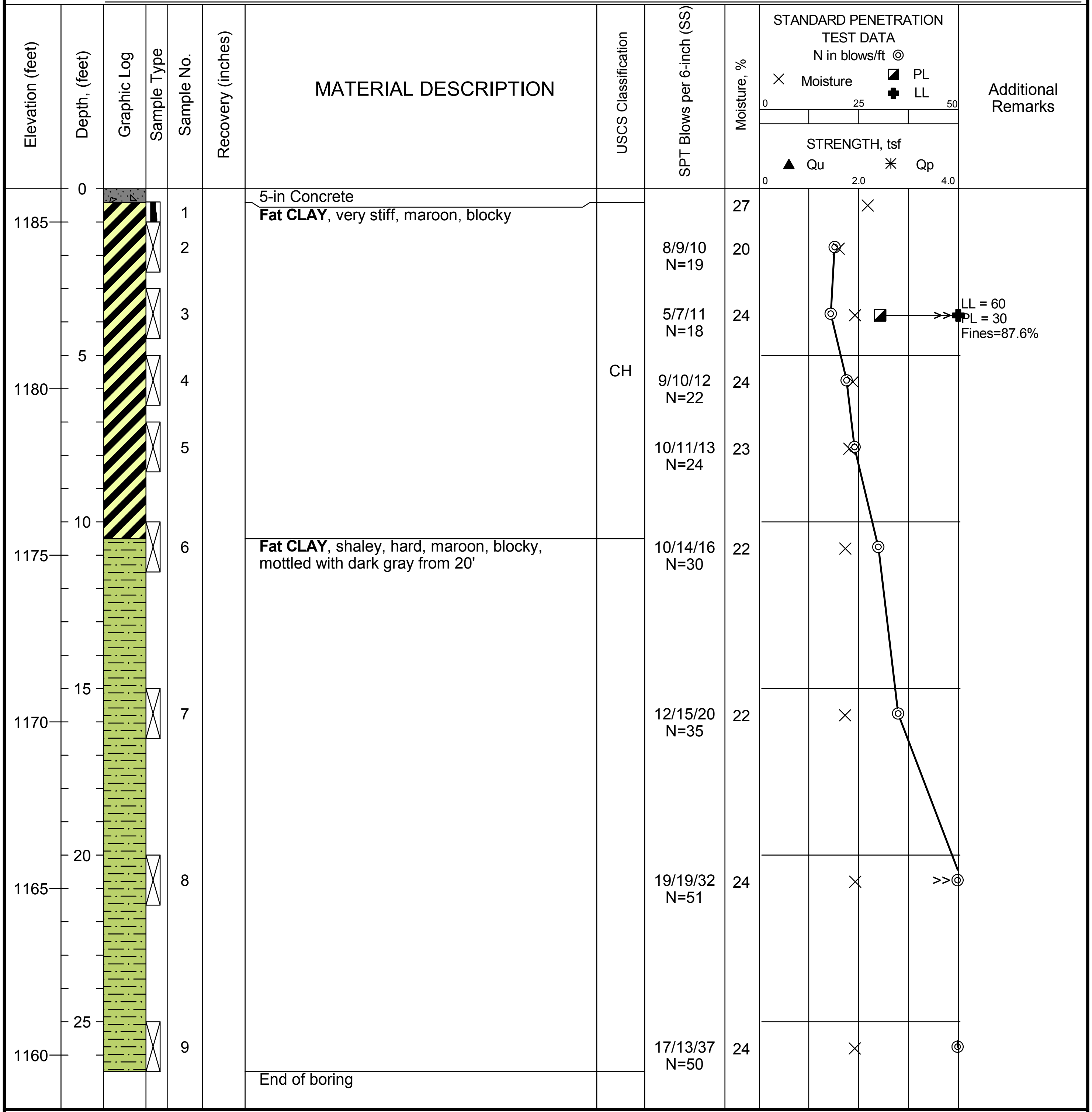
DATE STARTED: 1/3/22
DATE COMPLETED: 1/3/22
COMPLETION DEPTH 26.5 ft
BENCHMARK: N/A
ELEVATION: 1186 ft
LATITUDE: 34.60796°
LONGITUDE: -98.48059°
STATION: N/A **OFFSET:** N/A
REMARKS:

DRILL COMPANY: DSO.
DRILLER: B. Bettes **LOGGED BY:** B. Stone
DRILL RIG: CME-55
DRILLING METHOD: Solid Flight Auger
SAMPLING METHOD: SS
HAMMER TYPE: Automatic
EFFICIENCY N/A
REVIEWED BY: A. Oyesanya

BORING B-08

Water		
▽	While Drilling	None observed
▼	Upon Completion	None observed
▽	Delay	N/A

BORING LOCATION:



Depth (feet)	Material Description	USCS Classification
0	5-in Concrete	
	Fat CLAY, very stiff, maroon, blocky	CH
10.5	**Fat CLAY**, shaley, hard, maroon, blocky, mottled with dark gray from 20'	
26.5	End of boring	

Sample No.	SPT Blows per 6-inch (SS)	Moisture, %	Additional Remarks
1		27	
2	8/9/10 N=19	20	
3	5/7/11 N=18	24	LL = 60 PL = 30 Fines=87.6%
4	9/10/12 N=22	24	
5	10/11/13 N=24	23	
6	10/14/16 N=30	22	
7	12/15/20 N=35	22	
8	19/19/32 N=51	24	
9	17/13/37 N=50	24	

Professional Service Industries, Inc.
11825 S. Portland Avenue
Oklahoma City, OK 73170
Telephone: (405) 735-6052

PROJECT NO.: 05462482
PROJECT: Westchester Circle Apartments
LOCATION: Lawton, OK

The stratification lines represent approximate boundaries. The transition may be gradual.

BORING B-09

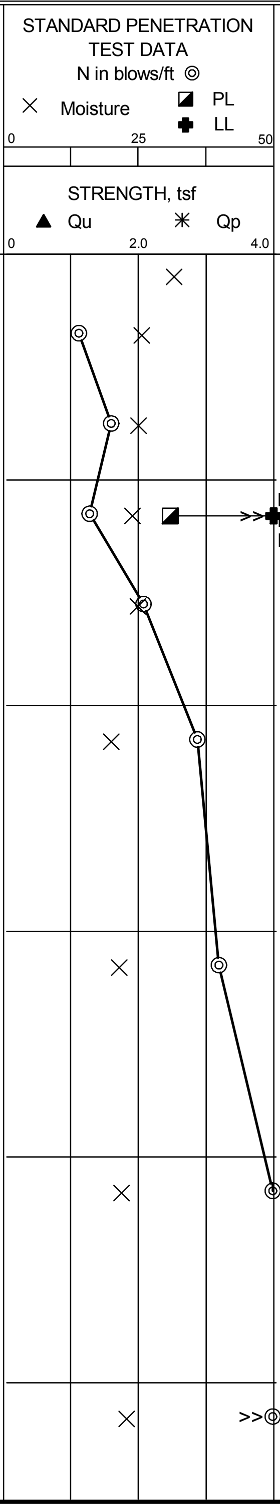
DATE STARTED: 1/3/22
DATE COMPLETED: 1/3/22
COMPLETION DEPTH 26.5 ft
BENCHMARK: N/A
ELEVATION: 1184 ft
LATITUDE: 34.60784°
LONGITUDE: -98.48041°
STATION: N/A **OFFSET:** N/A
REMARKS:

DRILL COMPANY: DSO.
DRILLER: B. Bettes **LOGGED BY:** B. Stone
DRILL RIG: CME-55
DRILLING METHOD: Solid Flight Auger
SAMPLING METHOD: SS
HAMMER TYPE: Automatic
EFFICIENCY N/A
REVIEWED BY: A. Oyesanya

Water		
▽	While Drilling	None observed
▼	Upon Completion	None observed
⊻	Delay	N/A

BORING LOCATION:

Elevation (feet)	Depth, (feet)	Sample No.	MATERIAL DESCRIPTION	USCS Classification	SPT Blows per 6-inch (SS)	Moisture, %	Additional Remarks
	0		5 inch concrete				
		1	**Fat CLAY**, stiff to very stiff, maroon, blocky			32	
		2			3/5/9 N=14	26	
		3			6/9/11 N=20	25	
1180			**Fat CLAY**, very stiff, dark red, blocky				
	5	4			5/6/10 N=16	24	LL = 63 PL = 31 Fines=90.7%
		5		CH	8/11/15 N=26	25	
1175	10	6			12/15/21 N=36	20	
			Fat CLAY, shaley, hard, maroon to dark red, blocky, mottled with dark gray from 20'				
1170	15	7			15/17/23 N=40	21	
1165	20	8			17/21/29 N=50	22	
1160	25	9			21/30/32 N=62	23	
			End of boring				



Professional Service Industries, Inc.
11825 S. Portland Avenue
Oklahoma City, OK 73170
Telephone: (405) 735-6052

PROJECT NO.: 05462482
PROJECT: Westchester Circle Apartments
LOCATION: Lawton, OK

The stratification lines represent approximate boundaries. The transition may be gradual.

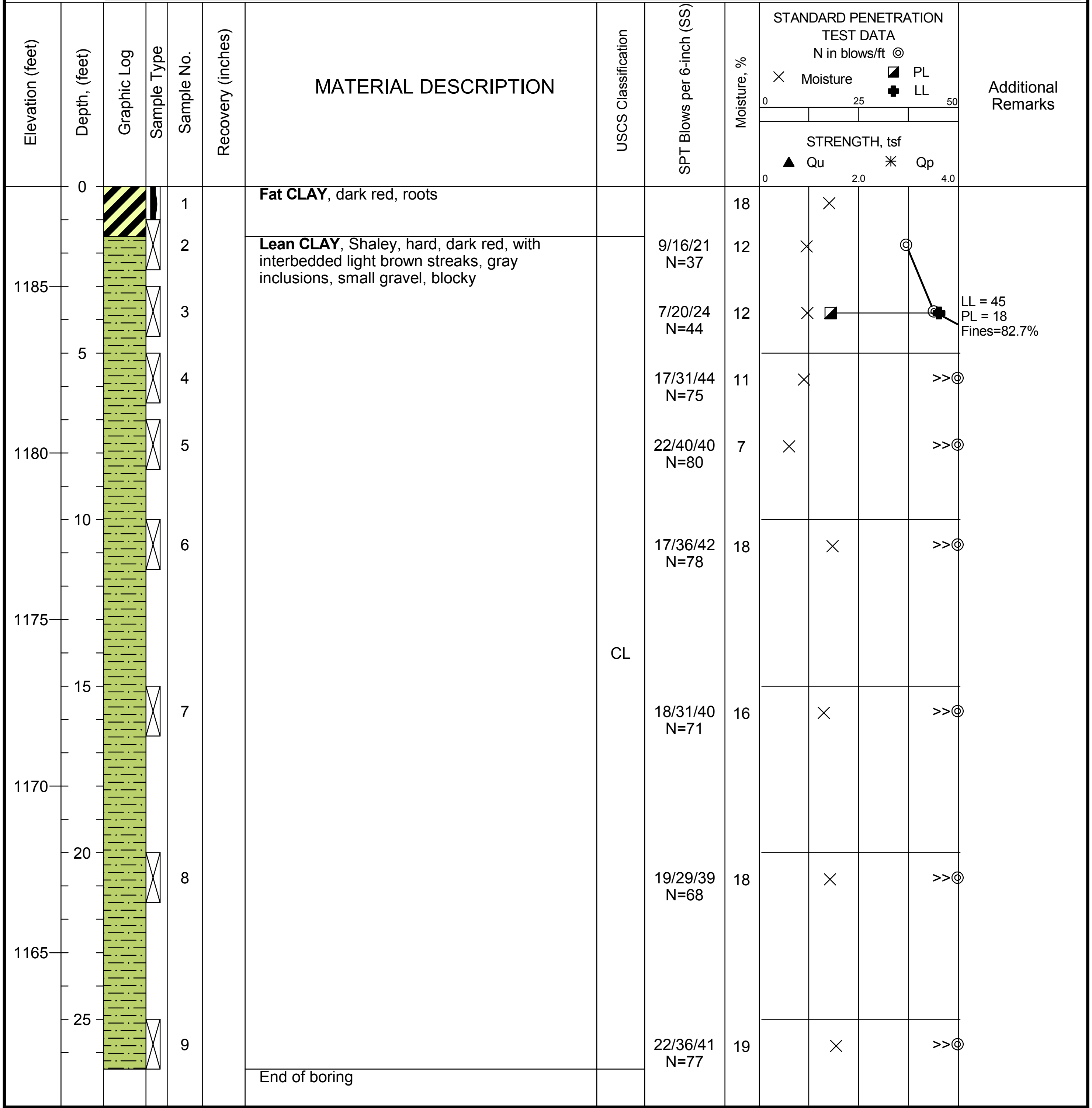
BORING B-10

DATE STARTED: 1/3/22
DATE COMPLETED: 1/3/22
COMPLETION DEPTH 26.5 ft
BENCHMARK: N/A
ELEVATION: 1188 ft
LATITUDE: 34.60769°
LONGITUDE: -98.48059°
STATION: N/A **OFFSET:** N/A
REMARKS:

DRILL COMPANY: DSO.
DRILLER: J. Sanders **LOGGED BY:** B. Long
DRILL RIG: CME-750
DRILLING METHOD: Solid Flight Auger
SAMPLING METHOD: SS
HAMMER TYPE: Automatic
EFFICIENCY: N/A
REVIEWED BY: A. Oyesanya

Water		
▽	While Drilling	None observed
▼	Upon Completion	None observed
▽	Delay	N/A

BORING LOCATION:



Depth (ft)	Material Description	USCS
0 – 1.5	**Fat CLAY**, dark red, roots	
1.5 – 26.5	**Lean CLAY**, Shaley, hard, dark red, with interbedded light brown streaks, gray inclusions, small gravel, blocky	CL
26.5	End of boring	

Sample No.	SPT Blows per 6-inch (SS)	Moisture, %	Additional Remarks
1		18	
2	9/16/21 N=37	12	
3	7/20/24 N=44	12	LL = 45 PL = 18 Fines=82.7%
4	17/31/44 N=75	11	
5	22/40/40 N=80	7	
6	17/36/42 N=78	18	
7	18/31/40 N=71	16	
8	19/29/39 N=68	18	
9	22/36/41 N=77	19	

Professional Service Industries, Inc.
11825 S. Portland Avenue
Oklahoma City, OK 73170
Telephone: (405) 735-6052

PROJECT NO.: 05462482
PROJECT: Westchester Circle Apartments
LOCATION: Lawton, OK

The stratification lines represent approximate boundaries. The transition may be gradual.

BORING B-11

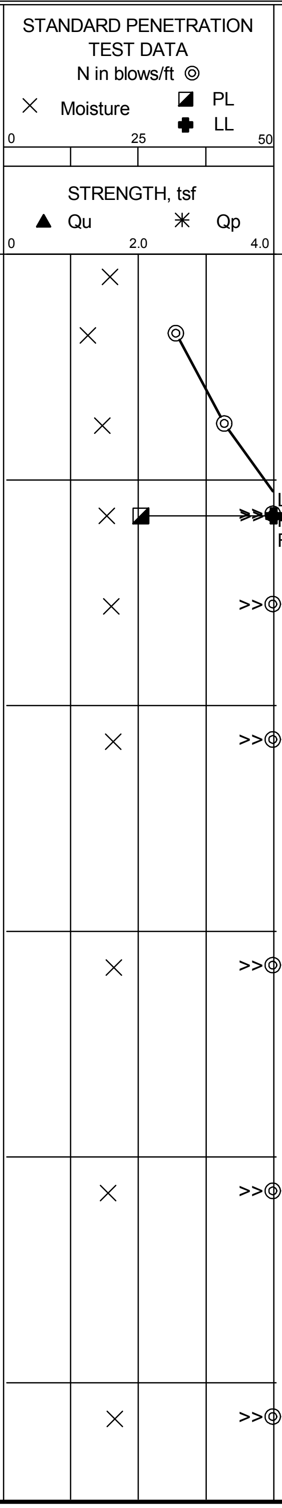
DATE STARTED: 1/3/22
DATE COMPLETED: 1/3/22
COMPLETION DEPTH 26.5 ft
BENCHMARK: N/A
ELEVATION: 1180 ft
LATITUDE: 34.60809°
LONGITUDE: -98.47987°
STATION: N/A **OFFSET:** N/A
REMARKS:

DRILL COMPANY: DSO.
DRILLER: J. Sanders **LOGGED BY:** B. Long
DRILL RIG: CME-750
DRILLING METHOD: Solid Flight Auger
SAMPLING METHOD: SS
HAMMER TYPE: Automatic
EFFICIENCY: N/A
REVIEWED BY: A. Oyesanya

Water		
▽	While Drilling	None observed
▼	Upon Completion	None observed
▽	Delay	N/A

BORING LOCATION:

Elevation (feet)	Depth, (feet)	Sample No.	Recovery (inches)	MATERIAL DESCRIPTION	USCS Classification	SPT Blows per 6-inch (SS)	Moisture, %	Additional Remarks
	0	1		**Fat CLAY**, maroon, roots			20	
		2		**Fat CLAY**, shaley, hard, maroon, blocky		12/16/16 N=32	16	
		3				9/17/24 N=41	18	
1175	5							
		4				12/21/32 N=53	19	LL = 64 PL = 25 Fines=87.1%
		5				18/31/38 N=69	20	
1170	10							
		6			CH	20/21/36 N=57	20	
1165	15							
		7				19/36/40 N=76	20	
1160	20			**Fat CLAY**, shaley, hard, maroon, blocky, with gray				
		8				22/38/39 N=77	19	
1155	25							
		9				21/33/40 N=73	21	
				End of boring				



Professional Service Industries, Inc.
11825 S. Portland Avenue
Oklahoma City, OK 73170
Telephone: (405) 735-6052

PROJECT NO.: 05462482
PROJECT: Westchester Circle Apartments
LOCATION: Lawton, OK

The stratification lines represent approximate boundaries. The transition may be gradual.

DATE STARTED: 1/4/22
DATE COMPLETED: 1/4/22
COMPLETION DEPTH 26.5 ft
BENCHMARK: N/A
ELEVATION: 1181 ft
LATITUDE: 34.60795°
LONGITUDE: -98.48006°
STATION: N/A **OFFSET:** N/A
REMARKS:

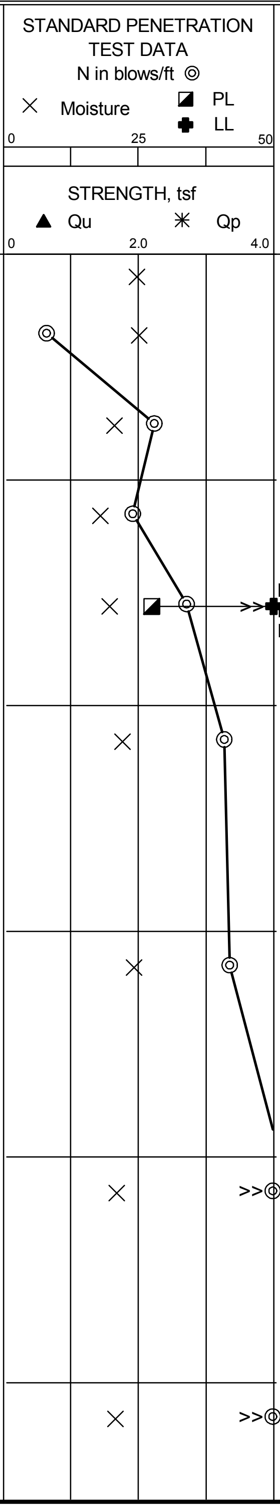
DRILL COMPANY: DSO.
DRILLER: B. Bettes **LOGGED BY:** B. Stone
DRILL RIG: CME-55
DRILLING METHOD: Solid Flight Auger
SAMPLING METHOD: SS
HAMMER TYPE: Automatic
EFFICIENCY N/A
REVIEWED BY: A. Oyesanya

BORING B-12

Water		
▽	While Drilling	None observed
▼	Upon Completion	None observed
▽	Delay	N/A

BORING LOCATION:

Elevation (feet)	Depth, (feet)	Sample No.	MATERIAL DESCRIPTION	USCS Classification	SPT Blows per 6-inch (SS)	Moisture, %	Additional Remarks
	0		5-in Concrete				
		1	**Fat CLAY**, stiff, maroon			25	
1180		2			4/4/4 N=8	25	
		3	**Fat CLAY with Sand**, very stiff, maroon, light brown sand inclusion		8/11/17 N=28	21	
	5						
1175		4		CH	7/10/14 N=24	18	
		5			12/15/19 N=34	20	LL = 57 PL = 27 Fines=85.0%
			Fat CLAY, shaley, hard, dark red, blocky				
	10						
1170		6			13/17/24 N=41	22	
	15						
1165		7			15/15/27 N=42	24	
	20						
1160		8			19/23/30 N=53	21	
	25						
1155		9			24/30/37 N=67	21	
			End of boring				



Professional Service Industries, Inc.
11825 S. Portland Avenue
Oklahoma City, OK 73170
Telephone: (405) 735-6052

PROJECT NO.: 05462482
PROJECT: Westchester Circle Apartments
LOCATION: Lawton, OK

The stratification lines represent approximate boundaries. The transition may be gradual.

BORING B-13

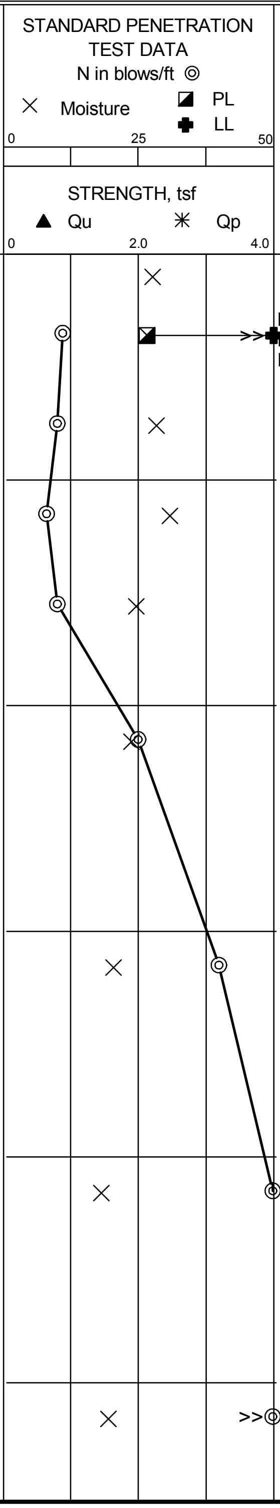
DATE STARTED: 1/4/22
DATE COMPLETED: 1/4/22
COMPLETION DEPTH 26.5 ft
BENCHMARK: N/A
ELEVATION: 1181 ft
LATITUDE: 34.60784°
LONGITUDE: -98.47988°
STATION: N/A **OFFSET:** N/A
REMARKS:

DRILL COMPANY: DSO.
DRILLER: B. Bettes **LOGGED BY:** B. Stone
DRILL RIG: CME-55
DRILLING METHOD: Solid Flight Auger
SAMPLING METHOD: SS
HAMMER TYPE: Automatic
EFFICIENCY N/A
REVIEWED BY: A. Oyesanya

Water		
▽	While Drilling	None observed
▼	Upon Completion	None observed
▽	Delay	N/A

BORING LOCATION:

Elevation (feet)	Depth, (feet)	Sample No.	Recovery (inches)	MATERIAL DESCRIPTION	USCS Classification	SPT Blows per 6-inch (SS)	Moisture, %	Additional Remarks
	0			5-in Concrete				
1180		1		**Fat CLAY with Sand**, stiff, red to dark red, blocky			28	
		2				3/5/6 N=11	27	LL = 51 PL = 27 Fines=80.5%
		3				4/5/5 N=10	28	
1175	5	4			CH	3/3/5 N=8	31	
		5				3/4/6 N=10	25	
1170	10	6		**Fat CLAY**, very stiff, maroon		7/10/15 N=25	24	
1165	15	7		**Fat CLAY**, shaley, hard, maroon		11/17/23 N=40	20	
1160	20	8				14/19/31 N=50	18	
1155	25	9				20/27/36 N=63	19	
				End of boring				



Professional Service Industries, Inc.
11825 S. Portland Avenue
Oklahoma City, OK 73170
Telephone: (405) 735-6052

PROJECT NO.: 05462482
PROJECT: Westchester Circle Apartments
LOCATION: Lawton, OK

The stratification lines represent approximate boundaries. The transition may be gradual.

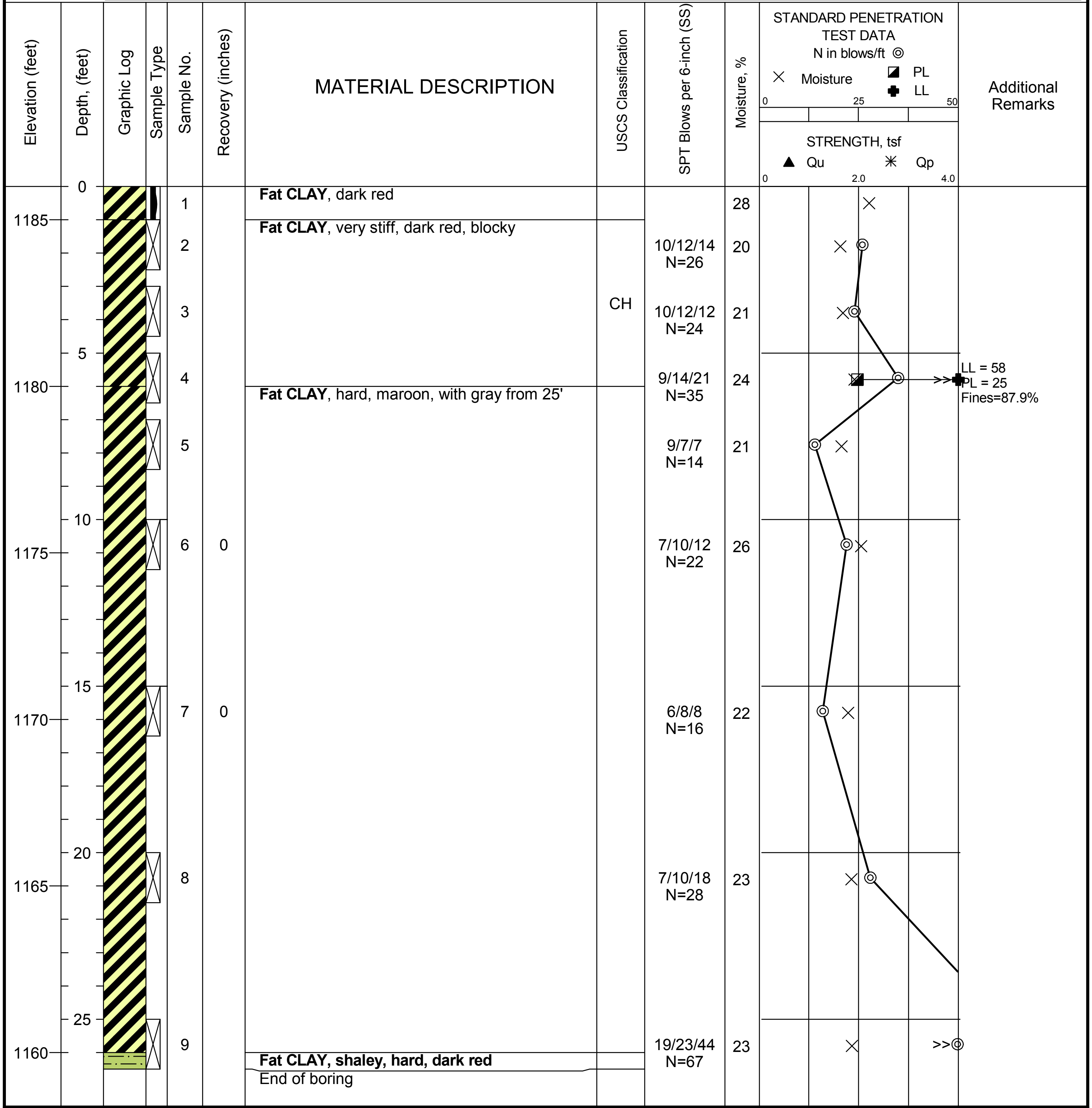
DATE STARTED: 1/4/22
DATE COMPLETED: 1/4/22
COMPLETION DEPTH 26.5 ft
BENCHMARK: N/A
ELEVATION: 1186 ft
LATITUDE: 34.60768°
LONGITUDE: -98.48005°
STATION: N/A **OFFSET:** N/A
REMARKS:

DRILL COMPANY: DSO.
DRILLER: J. Sanders **LOGGED BY:** B. Long
DRILL RIG: CME-750
DRILLING METHOD: Solid Flight Auger
SAMPLING METHOD: SS
HAMMER TYPE: Automatic
EFFICIENCY N/A
REVIEWED BY: A. Oyesanya

BORING B-14

Water		
∇	While Drilling	None observed
▼	Upon Completion	None observed
▼	Delay	N/A

BORING LOCATION:



Elevation (feet)	Depth, (feet)	Sample No.	Recovery (inches)	MATERIAL DESCRIPTION	USCS Classification	SPT Blows per 6-inch (SS)	Moisture, %	Additional Remarks
	0	1		**Fat CLAY**, dark red			28	
1185		2		**Fat CLAY**, very stiff, dark red, blocky		10/12/14 N=26	20	
		3			CH	10/12/12 N=24	21	
1180	5	4				9/14/21 N=35	24	LL = 58 PL = 25 Fines=87.9%
		5		**Fat CLAY**, hard, maroon, with gray from 25'		9/7/7 N=14	21	
1175	10	6	0			7/10/12 N=22	26	
1170	15	7	0			6/8/8 N=16	22	
1165	20	8				7/10/18 N=28	23	
1160	25	9		**Fat CLAY, shaley, hard, dark red**		19/23/44 N=67	23	
				End of boring				

intertek psi

Professional Service Industries, Inc.
11825 S. Portland Avenue
Oklahoma City, OK 73170
Telephone: (405) 735-6052

PROJECT NO.: 05462482
PROJECT: Westchester Circle Apartments
LOCATION: Lawton, OK

The stratification lines represent approximate boundaries. The transition may be gradual.

DATE STARTED: 1/4/22
DATE COMPLETED: 1/4/22
COMPLETION DEPTH 6.5 ft
BENCHMARK: N/A
ELEVATION: 1187 ft
LATITUDE: 34.60868°
LONGITUDE: -98.48085°
STATION: N/A **OFFSET:** N/A
REMARKS:

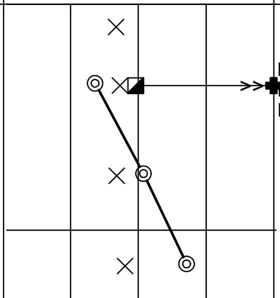
DRILL COMPANY: DSO.
DRILLER: B. Bettes **LOGGED BY:** B. Stone
DRILL RIG: CME-55
DRILLING METHOD: Solid Flight Auger
SAMPLING METHOD: SS
HAMMER TYPE: Automatic
EFFICIENCY N/A
REVIEWED BY: A. Oyesanya

BORING P-1

Water		
▽ While Drilling	None observed
▼ Upon Completion	None observed
▽ Delay	N/A

BORING LOCATION:

Elevation (feet)	Depth, (feet)	Graphic Log	Sample Type	Sample No.	Recovery (inches)	MATERIAL DESCRIPTION	USCS Classification	SPT Blows per 6-inch (SS)	Moisture, %	STANDARD PENETRATION TEST DATA N in blows/ft ◎ × Moisture ◪ PL ✚ LL 0 25 50 STRENGTH, tsf ▲ Qu ✳ Qp 0 2.0 4.0	Additional Remarks
	0			1		**Fat CLAY with Sand**, very stiff, dark red			21		
1185				2				5/7/10 N=17	22		LL = 66 PL = 24 Fines=84.2%
							CH				
				3				9/11/15 N=26	21		
	5										
				4				12/13/21 N=34	23		
						Fat CLAY, shaley, hard, dark red					
						End of boring					



intertek
psi

Professional Service Industries, Inc.
11825 S. Portland Avenue
Oklahoma City, OK 73170
Telephone: (405) 735-6052

PROJECT NO.: 05462482
PROJECT: Westchester Circle Apartments
LOCATION: Lawton, OK

The stratification lines represent approximate boundaries. The transition may be gradual.

BORING P-2

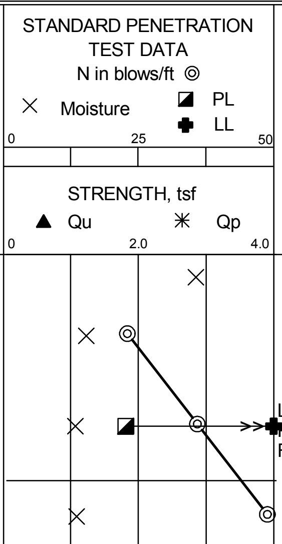
DATE STARTED: 1/4/22
DATE COMPLETED: 1/4/22
COMPLETION DEPTH 6.5 ft
BENCHMARK: N/A
ELEVATION: 1187 ft
LATITUDE: 34.60818°
LONGITUDE: -98.48084°
STATION: N/A **OFFSET:** N/A
REMARKS:

DRILL COMPANY: DSO.
DRILLER: B. Bettes **LOGGED BY:** B. Stone
DRILL RIG: CME-55
DRILLING METHOD: Solid Flight Auger
SAMPLING METHOD: SS
HAMMER TYPE: Automatic
EFFICIENCY N/A
REVIEWED BY: A. Oyesanya

Water		
▽	While Drilling	None observed
▼	Upon Completion	None observed
▼	Delay	N/A

BORING LOCATION:

Elevation (feet)	Depth, (feet)	Graphic Log	Sample Type	Sample No.	Recovery (inches)	MATERIAL DESCRIPTION	USCS Classification	SPT Blows per 6-inch (SS)	Moisture, %	Additional Remarks
	0			1		**Fat CLAY with Sand**, very stiff, dark red, blocky			36	
1185				2				5/9/14 N=23	15	
				3		**Fat CLAY**, shaley, hard, maroon		11/17/19 N=36	13	LL = 51 PL = 23 Fines=83.9%
	5						CH			
				4				14/21/28 N=49	14	
						End of boring				



intertek psi

Professional Service Industries, Inc.
11825 S. Portland Avenue
Oklahoma City, OK 73170
Telephone: (405) 735-6052

PROJECT NO.: 05462482
PROJECT: Westchester Circle Apartments
LOCATION: Lawton, OK

The stratification lines represent approximate boundaries. The transition may be gradual.

DATE STARTED: 1/4/22
DATE COMPLETED: 1/4/22
COMPLETION DEPTH 6.5 ft
BENCHMARK: N/A
ELEVATION: 1190 ft
LATITUDE: 34.60782°
LONGITUDE: -98.48084°
STATION: N/A **OFFSET:** N/A
REMARKS:

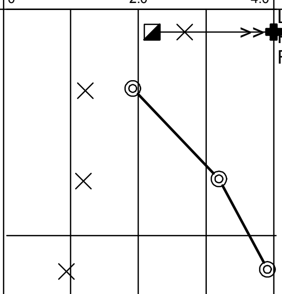
DRILL COMPANY: DSO.
DRILLER: B. Bettes **LOGGED BY:** B. Stone
DRILL RIG: CME-55
DRILLING METHOD: Solid Flight Auger
SAMPLING METHOD: SS
HAMMER TYPE: Automatic
EFFICIENCY N/A
REVIEWED BY: A. Oyesanya

BORING P-3

Water
▽ While Drilling None observed
▼ Upon Completion None observed
▽ Delay N/A

BORING LOCATION:

Elevation (feet)	Depth, (feet)	Graphic Log	Sample Type	Sample No.	Recovery (inches)	MATERIAL DESCRIPTION	USCS Classification	SPT Blows per 6-inch (SS)	Moisture, %	STANDARD PENETRATION TEST DATA N in blows/ft ◎ × Moisture ◪ PL ✚ LL 0 25 50 STRENGTH, tsf ▲ Qu ✳ Qp 0 2.0 4.0	Additional Remarks
	0			1		**Fat CLAY**, stiff, maroon, blocky	CH		34		LL = 72 PL = 27 Fines=88.5%
				2		**Fat CLAY**, very stiff, dark red, blocky		8/11/13 N=24	15		
				3				12/17/23 N=40	15		
						Fat CLAY, shaley, hard, dark red, blocky					
1185	5										
				4				14/18/31 N=49	12		
						End of boring					



Professional Service Industries, Inc.
11825 S. Portland Avenue
Oklahoma City, OK 73170
Telephone: (405) 735-6052

PROJECT NO.: 05462482
PROJECT: Westchester Circle Apartments
LOCATION: Lawton, OK

The stratification lines represent approximate boundaries. The transition may be gradual.

BORING P-4

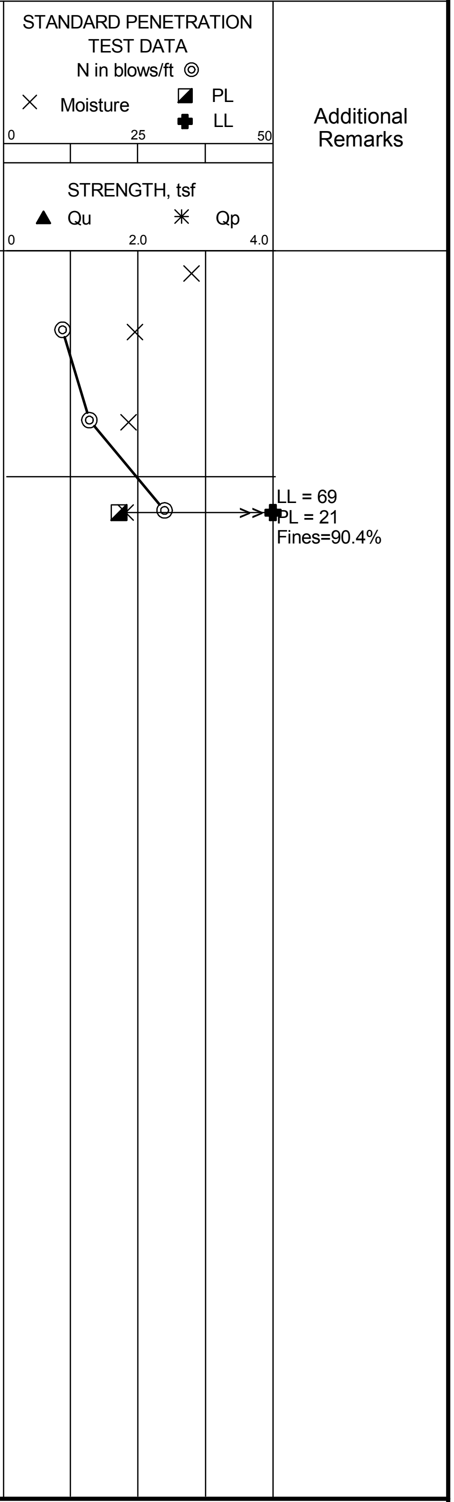
DATE STARTED: 1/4/22
DATE COMPLETED: 1/4/22
COMPLETION DEPTH 6.5 ft
BENCHMARK: N/A
ELEVATION: 1186 ft
LATITUDE: 34.60771°
LONGITUDE: -98.48027°
STATION: N/A **OFFSET:** N/A
REMARKS:

DRILL COMPANY: DSO.
DRILLER: B. Bettes **LOGGED BY:** B. Stone
DRILL RIG: CME-55
DRILLING METHOD: Solid Flight Auger
SAMPLING METHOD: SS
HAMMER TYPE: Automatic
EFFICIENCY N/A
REVIEWED BY: A. Oyesanya

Water		
▽	While Drilling	None observed
▼	Upon Completion	None observed
▽	Delay	N/A

BORING LOCATION:

Elevation (feet)	Depth, (feet)	Graphic Log	Sample Type	Sample No.	Recovery (inches)	MATERIAL DESCRIPTION	USCS Classification	SPT Blows per 6-inch (SS)	Moisture, %
	0			1		**Fat CLAY**, medium stiff, dark red			35
1185									
				2		**Fat CLAY**, very stiff, dark red, blocky		4/4/7 N=11	24
				3			CH	4/5/11 N=16	23
	5								
1180				4				9/13/17 N=30	23
						End of boring			



Professional Service Industries, Inc.
11825 S. Portland Avenue
Oklahoma City, OK 73170
Telephone: (405) 735-6052

PROJECT NO.: 05462482
PROJECT: Westchester Circle Apartments
LOCATION: Lawton, OK

The stratification lines represent approximate boundaries. The transition may be gradual.

DATE STARTED: 1/4/22
DATE COMPLETED: 1/4/22
COMPLETION DEPTH 6.5 ft
BENCHMARK: N/A
ELEVATION: 1184 ft
LATITUDE: 34.6082°
LONGITUDE: -98.48022°
STATION: N/A **OFFSET:** N/A
REMARKS:

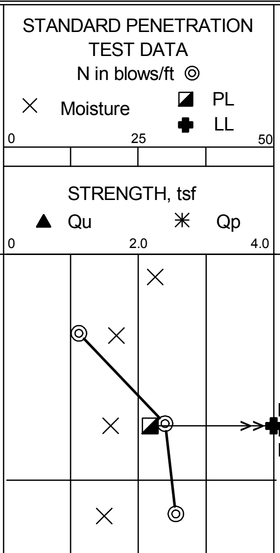
DRILL COMPANY: DSO.
DRILLER: B. Bettes **LOGGED BY:** B. Stone
DRILL RIG: CME-55
DRILLING METHOD: Solid Flight Auger
SAMPLING METHOD: SS
HAMMER TYPE: Automatic
EFFICIENCY N/A
REVIEWED BY: A. Oyesanya

BORING P-5

Water		
▽	While Drilling	None observed
▼	Upon Completion	None observed
▽	Delay	N/A

BORING LOCATION:

Elevation (feet)	Depth, (feet)	Graphic Log	Sample Type	Sample No.	Recovery (inches)	MATERIAL DESCRIPTION	USCS Classification	SPT Blows per 6-inch (SS)	Moisture, %	Additional Remarks
	0			1		**Sandy Fat CLAY**, dark red, blocky			28	
				2				4/7/7 N=14	21	
1180				3		**Fat CLAY**, shaley, hard, dark red, blocky		8/11/19 N=30	20	LL = 57 PL = 27 Fines=91.1%
	5			4			CH	12/14/18 N=32	19	
						End of boring				



Professional Service Industries, Inc.
11825 S. Portland Avenue
Oklahoma City, OK 73170
Telephone: (405) 735-6052

PROJECT NO.: 05462482
PROJECT: Westchester Circle Apartments
LOCATION: Lawton, OK

The stratification lines represent approximate boundaries. The transition may be gradual.

BORING P-6

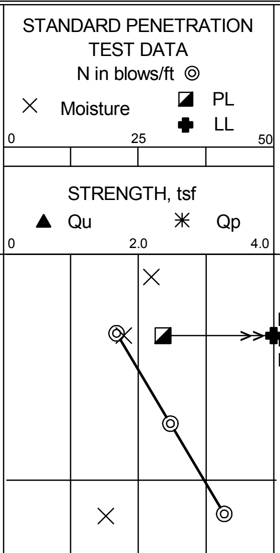
DATE STARTED: 1/4/22
DATE COMPLETED: 1/4/22
COMPLETION DEPTH 6.5 ft
BENCHMARK: N/A
ELEVATION: 1179 ft
LATITUDE: 34.60856°
LONGITUDE: -98.48016°
STATION: N/A **OFFSET:** N/A
REMARKS:

DRILL COMPANY: DSO.
DRILLER: B. Bettes **LOGGED BY:** B. Stone
DRILL RIG: CME-55
DRILLING METHOD: Solid Flight Auger
SAMPLING METHOD: SS
HAMMER TYPE: Automatic
EFFICIENCY N/A
REVIEWED BY: A. Oyesanya

Water		
▽	While Drilling	None observed
▼	Upon Completion	None observed
▼	Delay	N/A

BORING LOCATION:

Elevation (feet)	Depth, (feet)	Sample No.	Recovery (inches)	MATERIAL DESCRIPTION	USCS Classification	SPT Blows per 6-inch (SS)	Moisture, %	Additional Remarks
	0	1		**Fat CLAY**, dark red, roots			27	
		2		**Fat CLAY**, very stiff, dark red	CH	8/8/13 N=21	22	LL = 71 PL = 30 Fines=95.6%
		3				10/14/17 N=31		
1175				**Fat CLAY**, shaley, hard, dark red				
	5	4				11/19/22 N=41	19	
				End of boring				

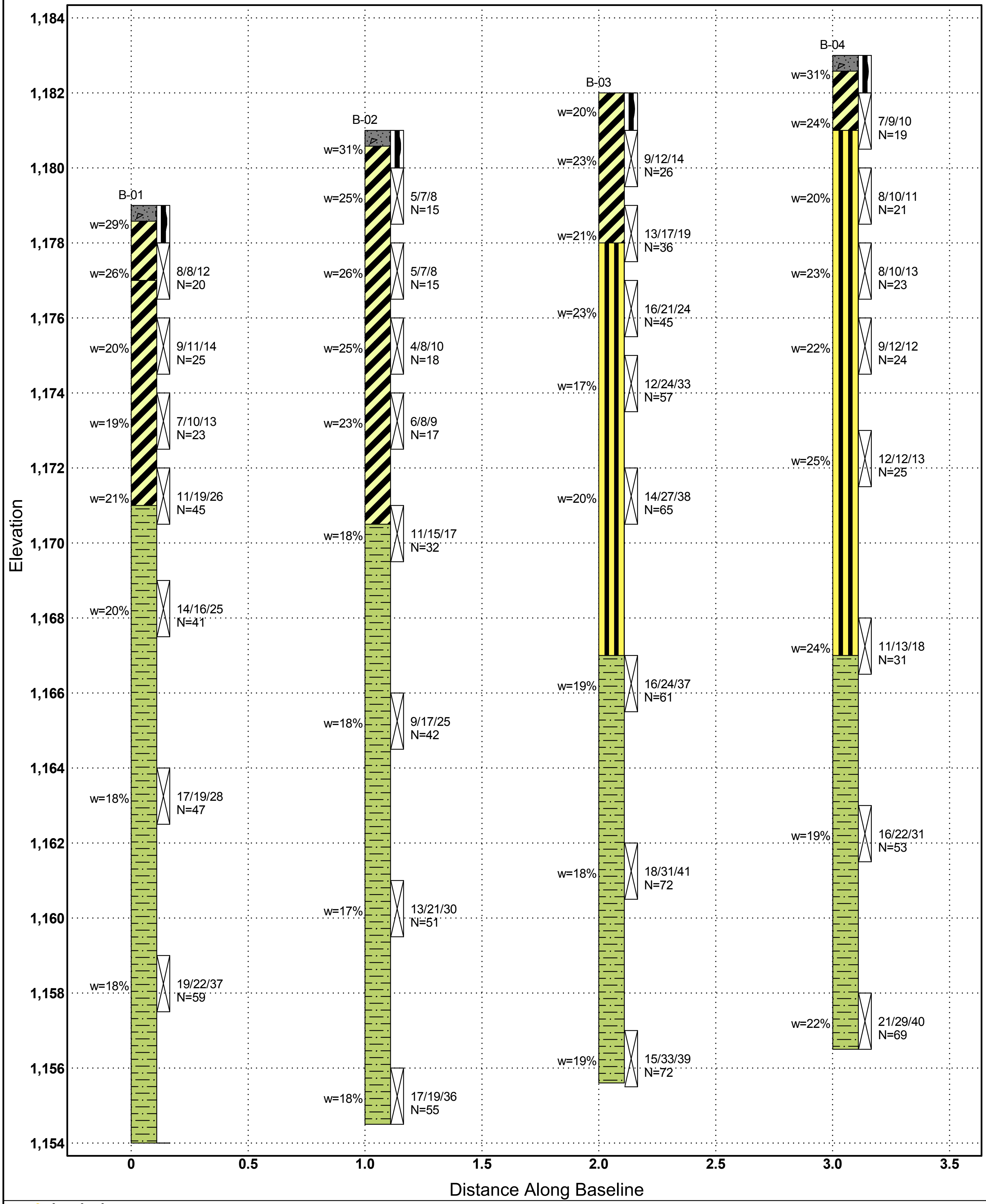


Professional Service Industries, Inc.
11825 S. Portland Avenue
Oklahoma City, OK 73170
Telephone: (405) 735-6052

PROJECT NO.: 05462482
PROJECT: Westchester Circle Apartments
LOCATION: Lawton, OK

The stratification lines represent approximate boundaries. The transition may be gradual.

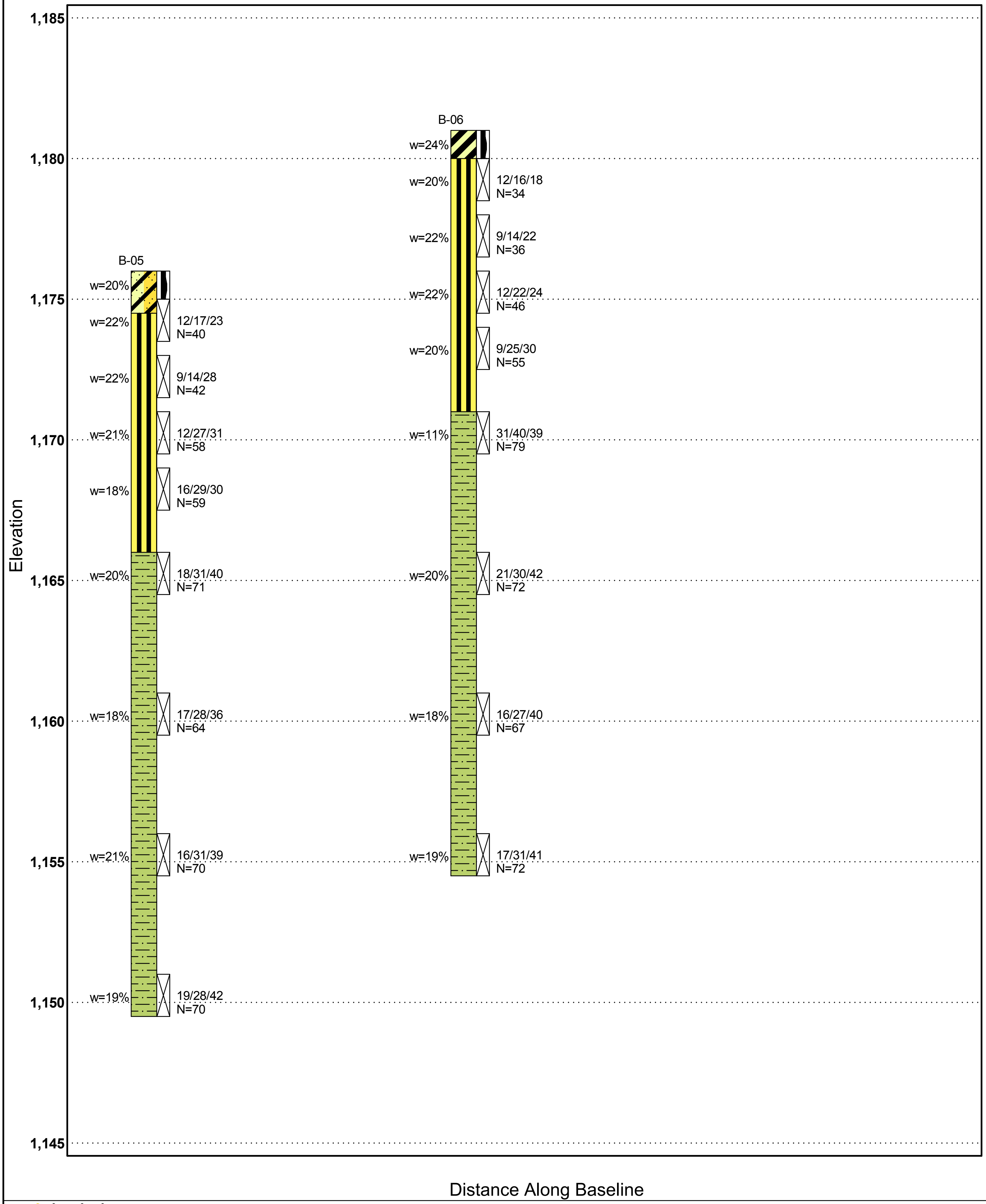
Profile



Professional Service Industries, Inc.
11825 S. Portland Avenue
Oklahoma City, OK 73170
Telephone: (405) 735-6052

Westchester Circle Apartments
PSI Project Number: 05462482

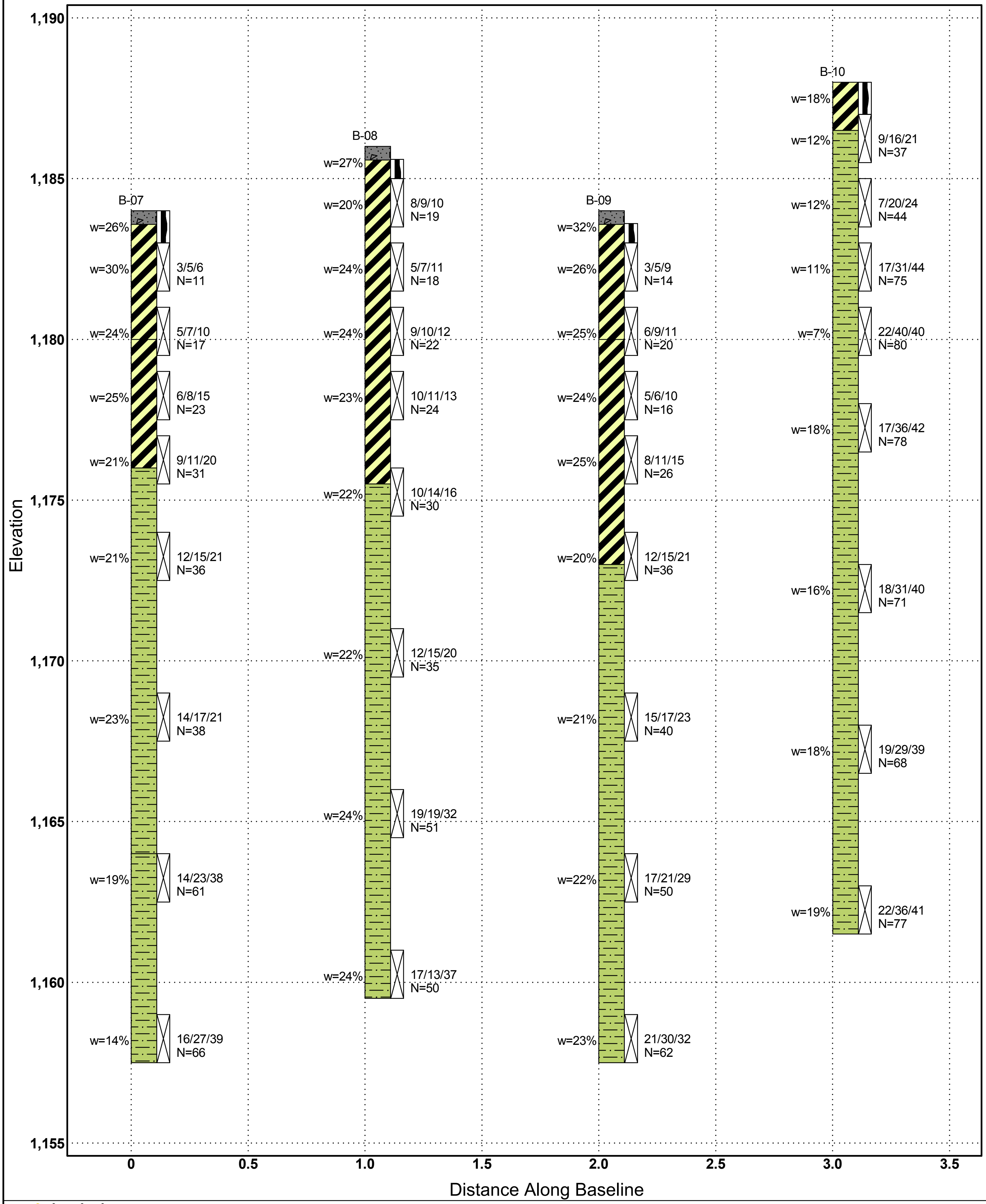
Profile



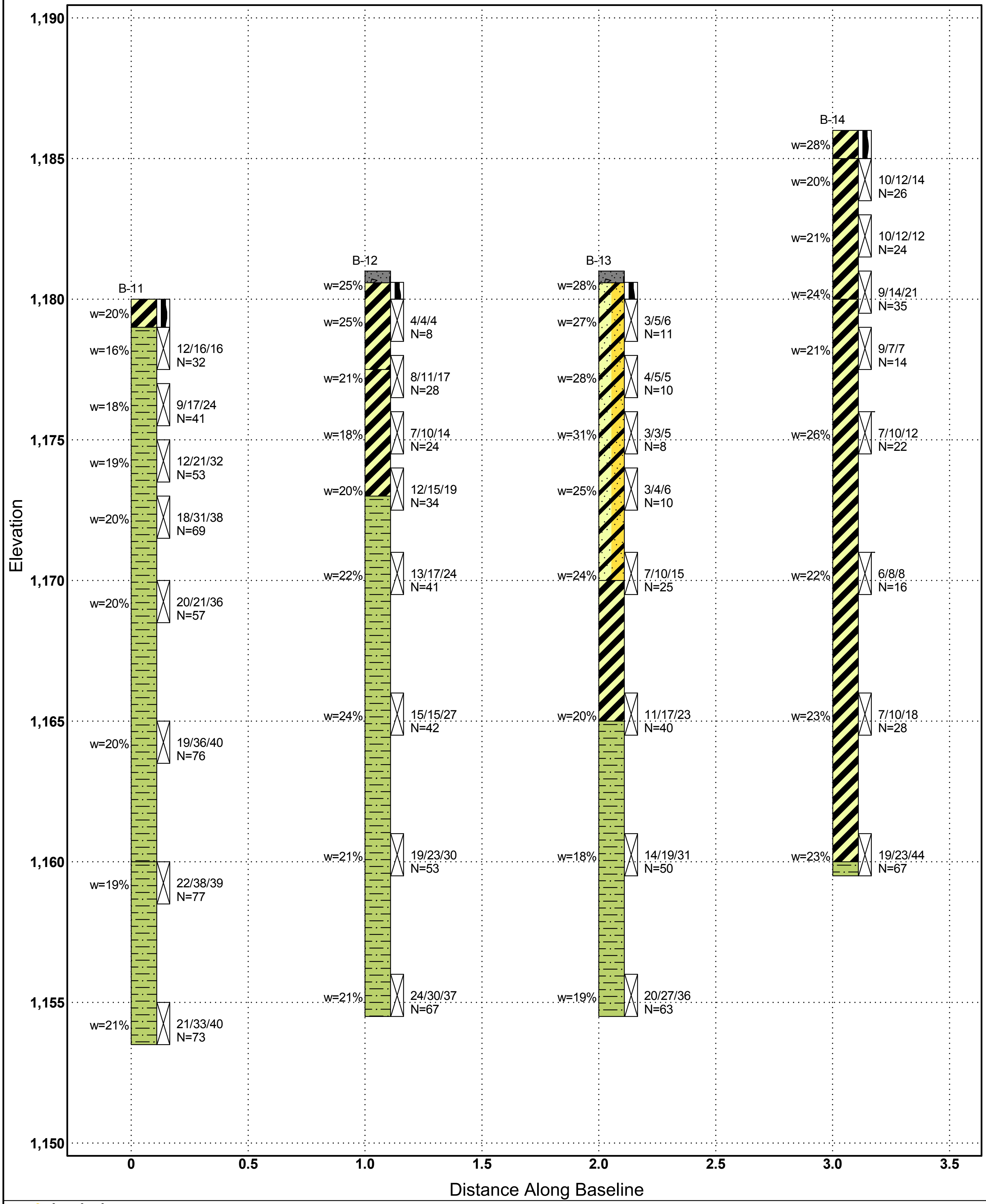
Professional Service Industries, Inc.
11825 S. Portland Avenue
Oklahoma City, OK 73170
Telephone: (405) 735-6052

Westchester Circle Apartments
PSI Project Number: 05462482

Profile


1,190
1,185
1,180
1,175
1,170
1,165
1,160
1,155
Elevation
0
0.5
1.0
1.5
2.0
2.5
3.0
3.5
Distance Along Baseline
B-07
w=26%
w=30%
3/5/6
N=11
w=24%
5/7/10
N=17
w=25%
6/8/15
N=23
w=21%
9/11/20
N=31
w=21%
12/15/21
N=36
w=23%
14/17/21
N=38
w=19%
14/23/38
N=61
w=14%
16/27/39
N=66
B-08
w=27%
w=20%
8/9/10
N=19
w=24%
5/7/11
N=18
w=24%
9/10/12
N=22
w=23%
10/11/13
N=24
w=22%
10/14/16
N=30
w=22%
12/15/20
N=35
w=24%
19/19/32
N=51
w=24%
17/13/37
N=50
B-09
w=32%
w=26%
3/5/9
N=14
w=25%
6/9/11
N=20
w=24%
5/6/10
N=16
w=25%
8/11/15
N=26
w=20%
12/15/21
N=36
w=21%
15/17/23
N=40
w=22%
17/21/29
N=50
w=23%
21/30/32
N=62
B-10
w=18%
w=12%
9/16/21
N=37
w=12%
7/20/24
N=44
w=11%
17/31/44
N=75
w=7%
22/40/40
N=80
w=18%
17/36/42
N=78
w=16%
18/31/40
N=71
w=18%
19/29/39
N=68
w=19%
22/36/41
N=77

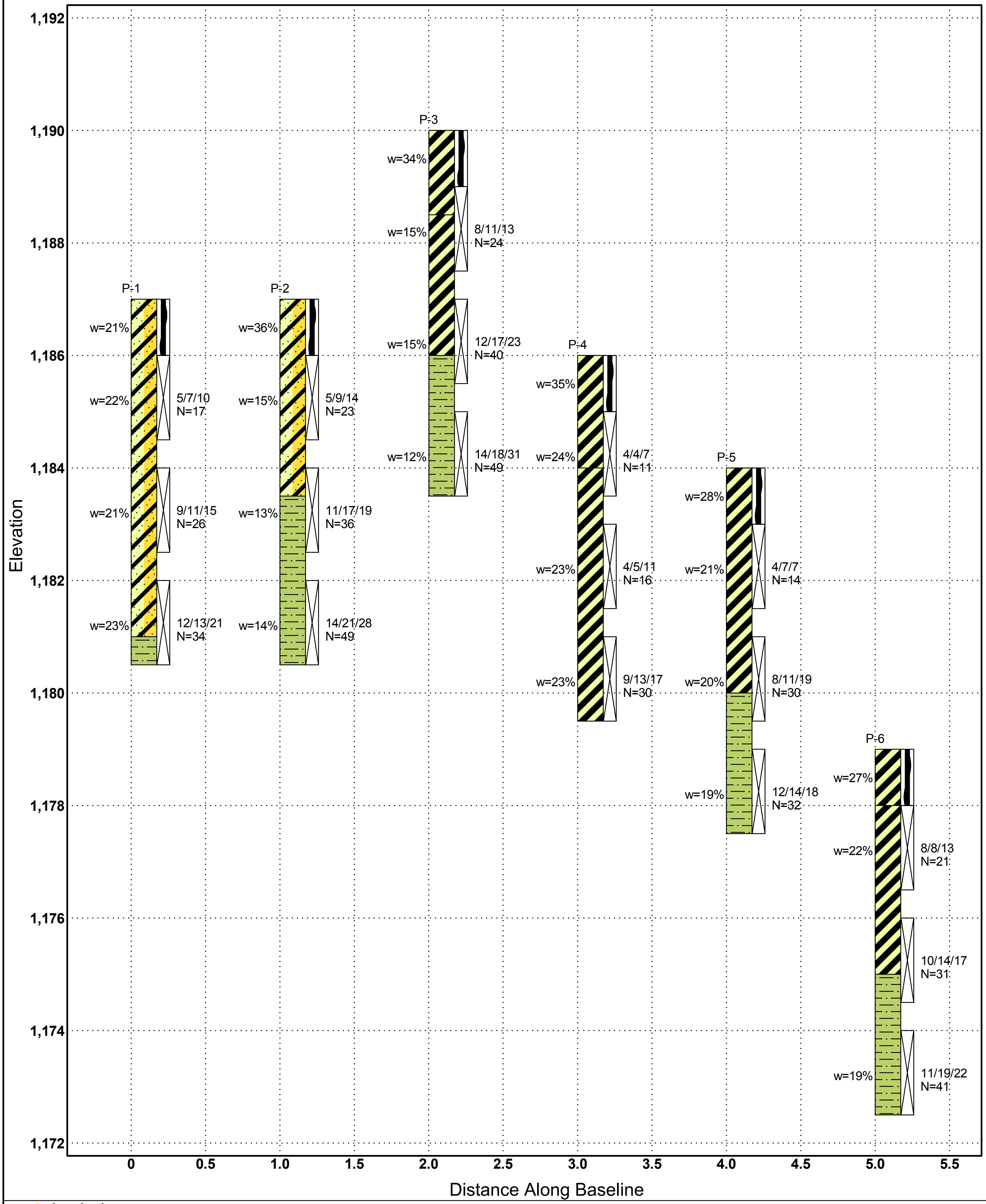
Profile



Professional Service Industries, Inc.
11825 S. Portland Avenue
Oklahoma City, OK 73170
Telephone: (405) 735-6052

Westchester Circle Apartments
PSI Project Number: 05462482

Profile

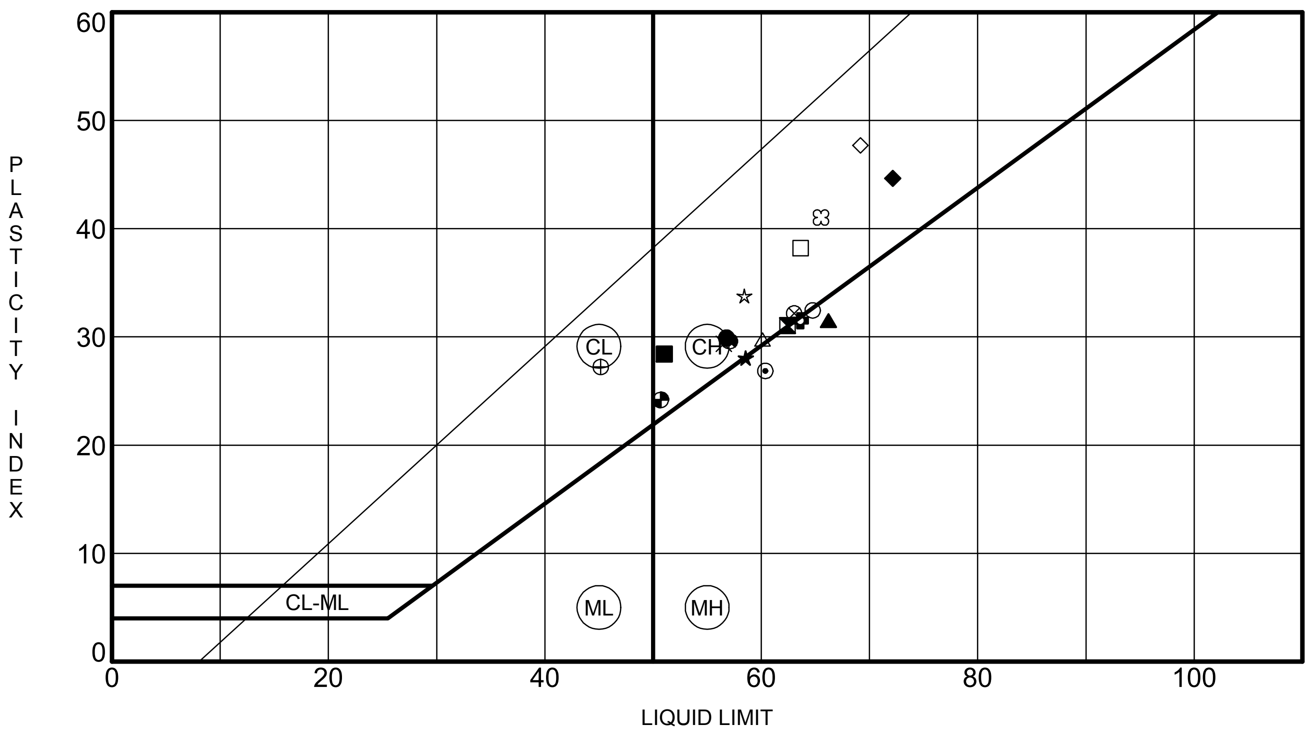


intertek
psi

Professional Service Industries, Inc.
11825 S. Portland Avenue
Oklahoma City, OK 73170
Telephone: (405) 735-6052

Westchester Circle Apartments
PSI Project Number: 05462482

APPENDIX B – LABORATORY TEST REPORTS

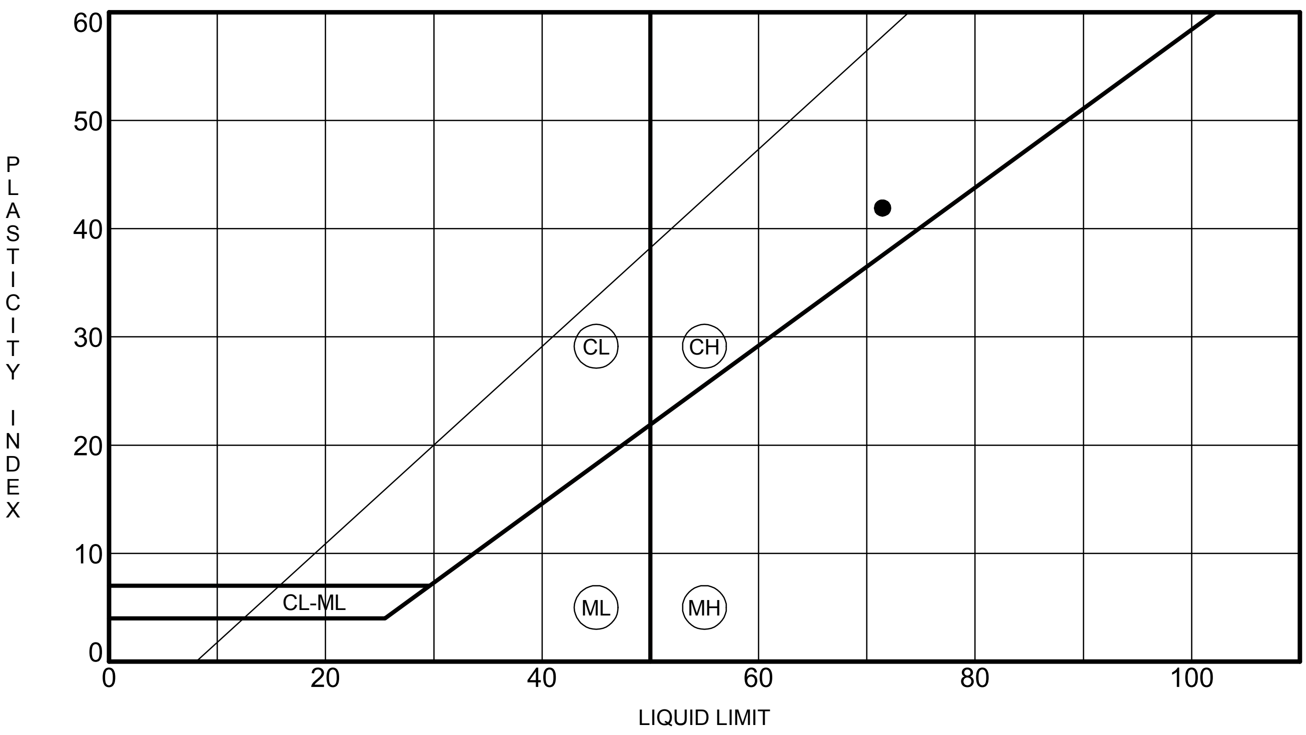


	Boring	Depth (ft)	LL	PL	PI	Fines	Classification (*Visual)
●	B-01	3.8	57	27	30	94.9	Fat CLAY
⧗	B-02	1.8	62	31	31	86.9	Fat CLAY
▲	B-03	5.9	66	35	31	84.6	Elastic SILT with Sand
★	B-04	3.8	59	31	28	79.0	Elastic SILT with Sand
⊙	B-05	7.8	60	34	26	73.5	Elastic SILT with Sand
✤	B-06	1.8	64	32	32	92.0	Elastic SILT
○	B-07	10.8	65	32	33	79.2	Elastic SILT with Sand
△	B-08	3.8	60	30	30	87.6	Fat CLAY
⊗	B-09	5.8	63	31	32	90.7	Fat CLAY
⊕	B-10	3.8	45	18	27	82.7	Lean CLAY with Sand
□	B-11	5.8	64	25	39	87.1	Fat CLAY
❂	B-12	7.8	57	27	30	85.0	Fat CLAY with Sand
◕	B-13	1.8	51	27	24	80.5	Fat CLAY with Sand
☆	B-14	5.8	58	25	33	87.9	Fat CLAY
⌘	P-1	1.8	66	24	42	84.2	Fat CLAY with Sand
■	P-2	3.8	51	23	28	83.9	Fat CLAY with Sand
◆	P-3	0.5	72	27	45	88.5	Fat CLAY
◇	P-4	5.8	69	21	48	90.4	Fat CLAY
✕	P-5	3.8	57	27	30	91.1	Fat CLAY

Professional Service Industries, Inc.
11825 S. Portland Avenue
Oklahoma City, OK 73170
Telephone: (405) 735-6052
Fax: (405) 735-6086

ATTERBERG LIMIT RESULTS

PSI Job No.: 05462482
Project: Westchester Circle Apartments
Location: Lawton, OK



	Boring	Depth (ft)	LL	PL	PI	Fines	Classification (*Visual)
●	**P-6**	**1.8**	**71**	**30**	**41**	**95.6**	**Fat CLAY**

Professional Service Industries, Inc.
11825 S. Portland Avenue
Oklahoma City, OK 73170
Telephone: (405) 735-6052
Fax: (405) 735-6086

ATTERBERG LIMIT RESULTS

PSI Job No.: 05462482
Project: Westchester Circle Apartments
Location: Lawton, OK

APPENDIX C – GENERAL NOTES

GENERAL NOTES

SAMPLE IDENTIFICATION

The Unified Soil Classification System (USCS), AASHTO 1988 and ASTM designations D2487 and D-2488 are used to identify the encountered materials unless otherwise noted. Coarse-grained soils are defined as having more than 50% of their dry weight retained on a #200 sieve (0.075mm); they are described as: boulders, cobbles, gravel or sand. Fine-grained soils have less than 50% of their dry weight retained on a #200 sieve; they are defined as silts or clay depending on their Atterberg Limit attributes. Major constituents may be added as modifiers and minor constituents may be added according to the relative proportions based on grain size.

DRILLING AND SAMPLING SYMBOLS

SFA: Solid Flight Auger - typically 4" diameter flights, except where noted.
HSA: Hollow Stem Auger - typically 3¼" or 4¼ I.D. openings, except where noted.
M.R.: Mud Rotary - Uses a rotary head with Bentonite or Polymer Slurry
R.C.: Diamond Bit Core Sampler
H.A.: Hand Auger
P.A.: Power Auger - Handheld motorized auger

☒ SS: Split-Spoon - 1 3/8" I.D., 2" O.D., except where noted.
■ ST: Shelby Tube - 3" O.D., except where noted.
▯ RC: Rock Core
⇓ TC: Texas Cone
✋ BS: Bulk Sample
▚ PM: Pressuremeter
CPT-U: Cone Penetrometer Testing with Pore-Pressure Readings

SOIL PROPERTY SYMBOLS

N: Standard "N" penetration: Blows per foot of a 140 pound hammer falling 30 inches on a 2-inch O.D. Split-Spoon.
N_{60}: A "N" penetration value corrected to an equivalent 60% hammer energy transfer efficiency (ETR)
Q_u: Unconfined compressive strength, TSF
Q_p: Pocket penetrometer value, unconfined compressive strength, TSF
w%: Moisture/water content, %
LL: Liquid Limit, %
PL: Plastic Limit, %
PI: Plasticity Index = (LL-PL),%
DD: Dry unit weight, pcf
▼, ▽, ▼: Apparent groundwater level at time noted

RELATIVE DENSITY OF COARSE-GRAINED SOILS

Relative Density	N - Blows/foot
Very Loose	0 - 3
Loose	4 - 9
Medium Dense	10 - 29
Dense	30 - 49
Very Dense	50+

ANGULARITY OF COARSE-GRAINED PARTICLES

Description	Criteria
Angular:	Particles have sharp edges and relatively plane sides with unpolished surfaces
Subangular:	Particles are similar to angular description, but have rounded edges
Subrounded:	Particles have nearly plane sides, but have well-rounded corners and edges
Rounded:	Particles have smoothly curved sides and no edges

GRAIN-SIZE TERMINOLOGY

Component	Size Range
Boulders:	Over 300 mm (>12 in.)
Cobbles:	75 mm to 300 mm (3 in. to 12 in.)
Coarse-Grained Gravel:	19 mm to 75 mm (¾ in. to 3 in.)
Fine-Grained Gravel:	4.75 mm to 19 mm (No.4 to ¾ in.)
Coarse-Grained Sand:	2 mm to 4.75 mm (No.10 to No.4)
Medium-Grained Sand:	0.42 mm to 2 mm (No.40 to No.10)
Fine-Grained Sand:	0.075 mm to 0.42 mm (No. 200 to No.40)
Silt:	0.005 mm to 0.075 mm
Clay:	<0.005 mm

PARTICLE SHAPE

Description	Criteria
Flat:	Particles with width/thickness ratio > 3
Elongated:	Particles with length/width ratio > 3
Flat & Elongated:	Particles meet criteria for both flat and elongated

RELATIVE PROPORTIONS OF FINES

Descriptive Term	% Dry Weight
Trace:	< 5%
With:	5% to 12%
Modifier:	>12%

GENERAL NOTES

(Continued)

CONSISTENCY OF FINE-GRAINED SOILS

Q_U - TSF	N - Blows/foot	Consistency
0 - 0.25	0 - 1	Very Soft
0.25 - 0.50	2 - 3	Soft
0.50 - 1.00	4 - 6	Medium Stiff
1.00 - 2.00	7 - 12	Stiff
2.00 - 4.00	13 - 26	Very Stiff
4.00 +	26+	Hard

MOISTURE CONDITION DESCRIPTION

Description	Criteria
Dry:	Absence of moisture, dusty, dry to the touch
Moist:	Damp but no visible water
Wet:	Visible free water, usually soil is below water table

RELATIVE PROPORTIONS OF SAND AND GRAVEL

Descriptive Term	% Dry Weight
Trace:	< 15%
With:	15% to 30%
Modifier:	>30%

STRUCTURE DESCRIPTION

Description	Criteria
Stratified:	Alternating layers of varying material or color with layers at least ¼-inch (6 mm) thick
Laminated:	Alternating layers of varying material or color with layers less than ¼-inch (6 mm) thick
Fissured:	Breaks along definite planes of fracture with little resistance to fracturing
Slickensided:	Fracture planes appear polished or glossy, sometimes striated

Description	Criteria
Blocky:	Cohesive soil that can be broken down into small angular lumps which resist further breakdown
Lensed:	Inclusion of small pockets of different soils
Layer:	Inclusion greater than 3 inches thick (75 mm)
Seam:	Inclusion 1/8-inch to 3 inches (3 to 75 mm) thick extending through the sample
Parting:	Inclusion less than 1/8-inch (3 mm) thick

SCALE OF RELATIVE ROCK HARDNESS

Q_U - TSF	Consistency
2.5 - 10	Extremely Soft
10 - 50	Very Soft
50 - 250	Soft
250 - 525	Medium Hard
525 - 1,050	Moderately Hard
1,050 - 2,600	Hard
>2,600	Very Hard

ROCK BEDDING THICKNESSES

Description	Criteria
Very Thick Bedded	Greater than 3-foot (>1.0 m)
Thick Bedded	1-foot to 3-foot (0.3 m to 1.0 m)
Medium Bedded	4-inch to 1-foot (0.1 m to 0.3 m)
Thin Bedded	1¼-inch to 4-inch (30 mm to 100 mm)
Very Thin Bedded	½-inch to 1¼-inch (10 mm to 30 mm)
Thickly Laminated	1/8-inch to ½-inch (3 mm to 10 mm)
Thinly Laminated	1/8-inch or less "paper thin" (<3 mm)

ROCK VOIDS

Voids	Void Diameter
Pit	<6 mm (<0.25 in)
Vug	6 mm to 50 mm (0.25 in to 2 in)
Cavity	50 mm to 600 mm (2 in to 24 in)
Cave	>600 mm (>24 in)

GRAIN-SIZED TERMINOLOGY

(Typically Sedimentary Rock)

Component	Size Range
Very Coarse Grained	>4.76 mm
Coarse Grained	2.0 mm - 4.76 mm
Medium Grained	0.42 mm - 2.0 mm
Fine Grained	0.075 mm - 0.42 mm
Very Fine Grained	<0.075 mm

ROCK QUALITY DESCRIPTION

Rock Mass Description	RQD Value
Excellent	90 -100
Good	75 - 90
Fair	50 - 75
Poor	25 -50
Very Poor	Less than 25

DEGREE OF WEATHERING

Slightly Weathered:	Rock generally fresh, joints stained and discoloration extends into rock up to 25 mm (1 in), open joints may contain clay, core rings under hammer impact.
Weathered:	Rock mass is decomposed 50% or less, significant portions of the rock show discoloration and weathering effects, cores cannot be broken by hand or scraped by knife.
Highly Weathered:	Rock mass is more than 50% decomposed, complete discoloration of rock fabric, core may be extremely broken and gives clunk sound when struck by hammer, may be shaved with a knife.

SOIL CLASSIFICATION CHART

NOTE: DUAL SYMBOLS ARE USED TO INDICATE BORDERLINE SOIL CLASSIFICATIONS

MAJOR DIVISIONS			SYMBOLS		TYPICAL DESCRIPTIONS
			GRAPH	LETTER	
COARSE GRAINED SOILS MORE THAN 50% OF MATERIAL IS LARGER THAN NO. 200 SIEVE SIZE	GRAVEL AND GRAVELLY SOILS MORE THAN 50% OF COARSE FRACTION RETAINED ON NO. 4 SIEVE	CLEAN GRAVELS (LITTLE OR NO FINES)	●	GW	WELL-GRADED GRAVELS, GRAVEL - SAND MIXTURES, LITTLE OR NO FINES
			○	GP	POORLY-GRADED GRAVELS, GRAVEL - SAND MIXTURES, LITTLE OR NO FINES
		GRAVELS WITH FINES (APPRECIABLE AMOUNT OF FINES)	○	GM	SILTY GRAVELS, GRAVEL - SAND - SILT MIXTURES
			▨	GC	CLAYEY GRAVELS, GRAVEL - SAND - CLAY MIXTURES
	SAND AND SANDY SOILS MORE THAN 50% OF COARSE FRACTION PASSING ON NO. 4 SIEVE	CLEAN SANDS (LITTLE OR NO FINES)	🟨	SW	WELL-GRADED SANDS, GRAVELLY SANDS, LITTLE OR NO FINES
			⋯	SP	POORLY-GRADED SANDS, GRAVELLY SAND, LITTLE OR NO FINES
		SANDS WITH FINES (APPRECIABLE AMOUNT OF FINES)	▥	SM	SILTY SANDS, SAND - SILT MIXTURES
			▨	SC	CLAYEY SANDS, SAND - CLAY MIXTURES
FINE GRAINED SOILS MORE THAN 50% OF MATERIAL IS SMALLER THAN NO. 200 SIEVE SIZE	SILTS AND CLAYS	LIQUID LIMIT LESS THAN 50	▥	ML	INORGANIC SILTS AND VERY FINE SANDS, ROCK FLOUR, SILTY OR CLAYEY FINE SANDS OR CLAYEY SILTS WITH SLIGHT PLASTICITY
			▨	CL	INORGANIC CLAYS OF LOW TO MEDIUM PLASTICITY, GRAVELLY CLAYS, SANDY CLAYS, SILTY CLAYS, LEAN CLAYS
			▤	OL	ORGANIC SILTS AND ORGANIC SILTY CLAYS OF LOW PLASTICITY
	SILTS AND CLAYS	LIQUID LIMIT GREATER THAN 50	▥	MH	INORGANIC SILTS, MICACEOUS OR DIATOMACEOUS FINE SAND OR SILTY SOILS
			▨	CH	INORGANIC CLAYS OF HIGH PLASTICITY
			▤	OH	ORGANIC CLAYS OF MEDIUM TO HIGH PLASTICITY, ORGANIC SILTS
HIGHLY ORGANIC SOILS			▤	PT	PEAT, HUMUS, SWAMP SOILS WITH HIGH ORGANIC CONTENTS

intertek psi

Graphic Symbols for Materials and Rock Deposits

▩	CONCRETE Portland Cement Concrete
■	BITUMINOUS CONCRETE
▤	CLAYSTONE
▧	COAL Coal, Anthracite Coal
▣	CONGLOMERATE/BRECCIA Conglomerate, Breccia
▦	IGNEOUS ROCK Anorthsite, Basalt, Metabasalt, Diabase (Gabbro), Gabbro, Granite/Granodionite, Homfels, Pegmatite, Rhyolite/Metarhyolite
▦	LIMESTONE Limestone, Dolomite
▨	METAMORPHIC ROCK Amphibolite, Gneiss, Marble, Phyllite, Quartzite, Schist, Serpentinite, Slate
▦	CHERT
▤	SANDSTONE Sandstone, Orthoquarzite (Sandstone)
▤	SHALE
▤	SILTSTONE
□	NO RECOVERY
☒	VOID

intertek
psi