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GEOTECHNICAL
ENVIRONMENTAL
MATERIALS

May 14, 2013

UTW Academy Development, LLC
One Metropolitan Square, Suite 3000
St. Louis, Missouri 63102

Attn: Mr. Alan Bornstein

GEOTECHNICAL EXPLORATION
MT JOB NO. 13173
SOUTH ACADEMY HIGHLANDS
EL PASO COUNTY, COLORADO

Gentlemen:

Transmitted herein is the report of our geotechnical exploration performed for the referenced project. This report is a compilation of our findings and recommendations regarding the geotechnical aspects of the proposed site development. This work was verbally authorized by Mr. Bornstein.

EXECUTIVE SUMMARY

A geotechnical exploration has been performed for a proposed shopping center in El Paso County, Colorado. The study consisted of reviewing borings and laboratory data by others, field exploration, laboratory testing, and engineering analyses. The following is a brief summary of the exploration including our findings, conclusions, and recommendations. Refer to subsequent sections within the report for a more detailed discussion.

- Development is planned for a 162–acre tract in El Paso County, Colorado. The site is northwest of the intersection of Interstate 25 and South Academy Boulevard. The proposed retail center will include a Sam's Club and Walmart Supercenter as major anchors, other retail buildings, outlots, parking lots, drives, and infrastructure. Plans also include the extension of Venetucci Boulevard through the development. The east side of Venetucci Boulevard will comprise the retail development. The west side is planned for residential construction.

- The building area for the Sam's Club is 136,085 square feet. Walmart is 189,622 square feet. Additional retail buildings will vary in size from 6,000 square feet to approximately 68,000 square feet. The buildings will be one–

story in height with slab–on–grade floors, as no basement levels are expected. The finished floor for the Sam's Club is El. 5864. The finished floor Walmart is El. 5888. Finished floors elevations for the retail buildings will vary from El. 5874 to El. 5882.

- The subject property is currently undeveloped. The topography of the site consists of a ridge generally in the central portion of the site, trending from southeast to northwest. The high point is the south-central portion of the property. The top of the ridge is generally level and slopes gently downward to the north. The areas around the ridge slope steeply downward to the east, west, and south. The northern portion flattens to gentler slopes. Vertical relief across the development area is on the order of 150 feet.

- Due to the topography, significant grading is expected. Cuts and fills approaching 70 feet are needed to establish the grades proposed for this development.

- The field explorations by others and our supplemental borings disclosed occasional areas of fill overlying natural undisturbed cohesive soil and granular deposits grading to weathered shale (locally referred to as claystone) and unweathered shale bedrock at depth.

- The natural overburden profile, where present, generally consists of interbedded layers of cohesive and granular deposits. The cohesive soils consist of low plastic silty clay and silt, and high plastic clay with inclusions of sand and gravel. The granular deposits consist of poorly to well–graded sand with various amounts of silt and clay fines, and gravel. Standard penetration resistances (N–values) obtained in the overburden indicated the cohesive soils to generally be of very stiff to hard consistency with occasional stiff zones. The sand deposits are generally medium dense to very dense in relative density.

- Bedrock consisting of claystone (weathered shale) and shale was encountered in 12 of the 13 borings drilled as part of our field exploration, at depths of 3 to 28 feet below the existing ground surface. The claystone and shale are medium hard to hard. The claystone and shale were penetrated with continuous–flight augers. N–values within the formation varied and were sometimes less than 30 blows per foot (bpf) but usually exceeded 50 blows in less than 6 inches of penetration by the sampler. The lower N–values typically occurred in the upper portion of the claystone where natural moisture contents exceeded about 15 percent. The higher N–values occurred at depth, where the moisture content was typically less than 15 percent.

- Ground water was encountered in two of the test holes drilled by us at a depth of 24 feet below the ground surface at the time of drilling. The remaining borings did not encounter ground water.

- Rock excavation is required to established design grades. Ripping is judged feasible for the claystone and shale but may yield slow production rates.

- Deep fills (fills exceeding 15 feet) are required in each building pad to establish the design elevations. Deep fills require higher degrees of compaction to limit internal consolidation of the fill. Fills exceeding 40 feet require compaction to at least 100 percent of modified Proctor. Fills 15 feet in depth to 40 feet require compaction to a minimum of 95 percent of modified Proctor.

- The claystone and shale at this site cause volume (shrink-swell) problems with corresponding changes in moisture content. Claystone and shale used as fill should be placed in fills deeper than 10 feet below finished grades. Claystone and shale present in the upper 10 feet of the building pads must be over-excavated, sealed, and replaced with low plastic cohesive soil or granular fill. The seal layer shall consist of bentonite-treated claystone or shale.

- Conventional spread footings are the recommended foundation support for the buildings, bearing on compacted fill. A net allowable soil bearing pressure of 3,500 psf is recommended for design.

- A slab–on–grade floor can be used. A modulus of subgrade reaction of 150 pci is recommended for design.

- Conventional asphalt over granular base course pavements can be used. Because of the volume change potential of the subgrade materials, lime stabilization of the upper 8 inches of the pavement subgrade and moisture-adjustment of the two lower 8-inch-thick layers of subgrade are required.

- Care must be exercised to maintain the stability of the subgrade during grading.

INTRODUCTION

A geotechnical exploration has been performed for a proposed shopping center in El Paso County, Colorado. The study consisted of field exploration, laboratory testing, and engineering analyses.

Purpose and Scope. The purpose of the study was to further explore the subsurface conditions at the site following several geotechnical studies by others, and develop recommendations for the earth–related aspects of the design and construction of the proposed project.

The scope of the study included:

- reviewing the field and laboratory data from several geotechnical studies performed by others,
- conducting a supplementary field exploration,
- conducting laboratory testing,
- performing engineering analyses to determine feasible foundation types and related design parameters, floor slab support, seismic design considerations, rock excavation, deep fill construction, shrink–swell potential of site materials, pavement section design, engineered slopes, general site drainage, suitability of on–site materials for use in engineered fills, and earth–related construction procedures, and
- preparing this summary report.

Project Characteristics. The project consists of the development of approximately 162 acres, located northwest of the intersection of Interstate 25 and South Academy Boulevard, in El Paso County, Colorado, as indicated in Figure 1. An expanded view of the site is provided on Sheet 1 in the map pocket.

The proposed development will include a Sam's Club with a fuel station and Walmart Supercenter as major anchors, other retail buildings, outlots, parking lots, drives, and site infrastructure.

Development plans also include the extension of Venetucci Boulevard, which will approximately bisect the approximate middle of the property in a north–south direction. The extension of Venetucci Boulevard will require construction of new intersections on the north end of the site, at "B" Street; and on the south end, at South Academy Boulevard.

The eastern portion of the planned development will comprise the retail buildings. Sam's Club is slated to be on the north end of the property and Walmart will be on the south end. Six retail buildings are planned between the two major anchors. Outlots will be developed along the east side of the Venetucci Boulevard extension.

We understand that the design and construction of the Walmart and Sam's Club buildings, pavements, and appurtenances are addressed by others (e.g., separate September 2012 reports by Kleinfelder and other reports possibly to follow).

We further understand that the western portion of the site will be residential. Borings were drilled by others for this portion of the property and are reproduced herein. This study does not address the specific considerations for the residential development of this portion of the site, although the geotechnical considerations discussed herein are applicable to this part of the property.

Proposed Buildings. The building area for the Sam's Club is 136,085 square feet. The building area for the Walmart is 189,622 square feet. The retail buildings will vary in size from 6,000 square feet to approximately 68,000 square feet. The buildings will be one–story in height with slab–on–grade floors, as no basement levels are expected. The finished floor for Sam's Club is El. 5864. The finished floor for Walmart is El. 5888. Finished floor elevations for the retail buildings will vary from El. 5874 to El. 5882. These structures are expected to be a combination of load–bearing concrete block walls and steel columns supporting roof loads with steel joist girders and bar joists.

For the Sam's Club, the typical bay spacing between columns is approximately 40 feet by 60 feet. The typical gravity load to an interior column is 80 kips. The estimated maximum gravity load that can occasionally occur due to severe live load is 150 kips. Maximum column uplift forces from wind is estimated at 30 kips. The estimated typical exterior column gravity load is 50 kips. The concrete masonry wall gravity loads range between 1.5 and 3.0 kips per lineal foot (klf). Maximum uniform and concentrated floor slab live loads are on the order of 250 pounds per square foot (psf) and 16 kips, respectively.

For the Walmart Supercenter, the typical bay spacing between columns is approximately 55 feet by 48 feet. Typical gravity loads to interior and exterior columns are on the order of 85 and 50 kips, respectively. Maximum column uplift forces from wind is estimated at 30 kips. The estimated maximum gravity load that can occasionally occur due to severe live load is 150 kips. The concrete masonry wall gravity loads range between 1.5 and 2.0 klf for non load–bearing walls and 4.0 to 6.0 klf for load–bearing walls. Maximum uniform and concentrated floor slab live loads are on the order of 125 psf and 5 kips, respectively.

Structural loads for the retail buildings are not known at this time; however, estimated column and wall loads are not expected to exceed 150 kips and 6 klf, respectively.

Site Conditions. The subject property (i.e., the combined retail and residential sites) is approximately 162 acres in size and is currently undeveloped. The topography of the study area consists of a ridge generally in the central portion of the site, trending from southeast to northwest. The high point is the south–central portion of the property, where two large above–ground water storage tanks are present. The top of the ridge is generally level and slopes gently downward to the north. The areas around the ridge slope steeply downward to the east, west, and south. The northern portion of the site flattens to gentler slopes. Vertical relief across the development area is on the order of 150 feet.

Fishers Canyon Drainageway flows west–to–east along the northern end of the site. Along the western property boundary is a well–defined tributary of Fishers Canyon, flowing north into Fishers Canyon. The roughly western portion of the site drains via numerous broad swales into the tributary to the west, and Fishers Canyon to the north. The site east of the main north–south ridge drains toward Interstate 25 to the east.

We understand surficial sands and gravels that capped the ridge were previously quarried in a few areas. This prior earthwork and apparent recreational uses (i.e., four–wheeling) across the site have resulted in mounds, trenches, and dirt roads in some areas of the site. The site is generally covered with low grasses, weeds, and shrubs, with scattered trees along the major drainage features.

There is an existing underground water line associated with the water tanks, the alignment of which is to the east and north, eventually crossing Interstate 25. We understand that this water line will be relocated around the Walmart site.

Proposed Grading. Due to the topography across this site, significant grading is expected. Cuts and fills approaching 70 feet are indicated by the current grading plan to establish the grades proposed for this development.

The following finished floors and needed grading are anticipated for the proposed buildings:

Structure	*Finished Floor El., ft.*	*Proposed Grading*
Sam’s Club	5864	13’ to 66’ fill
Walmart	5888	32’ cut to 38’ fill
Mini Anchor 1	5882	27’ cut to 26’ fill
Mini Anchor 2	5882	25’ cut to 15’ fill
Mini Anchor 3	5882	25’ cut to 34’ fill
Mini Anchor 4	5882	10’ to 35’ fill
Mini Anchor 5	5882	25’ to 50’ fill
Jr. Box	5874	3’ cut to 50’ fill

FIELD EXPLORATION

For this evaluation, we reviewed the logs of borings conducted at this site by others. The following geotechnical studies were reviewed:

- *Summary of Geotechnical Issues and Concerns—Proposed Lowe's HIW of SW Colorado Springs NW Corner of S. Academy Blvd & I–25—Colorado Springs* [El Paso County]*, Colorado*, Kleinfelder, March 28, 2008

- *Drainage Improvements—Subsurface Soil Investigation—South Academy Station—El Paso County, Colorado*, Entech Engineering, April 17, 2008

- *Preliminary Geotechnical Study—Bedrock Evaluation—South Academy Station—Northwest of Interstate 25 and South Academy Boulevard—Colorado Springs* [El Paso County]*, Colorado*, A.G. Wassenaar, April 22, 2008

- *Preliminary Geotechnical Study for Site Development—South Academy Station—Approximately 160 Acres—Northwest of South Academy Boulevard and Interstate 25—El Paso County, Colorado*, A.G. Wassenaar, April 23, 2008

- *Cut Slope Analysis Near Water Tanks—South Academy Station—El Paso County, Colorado*, Entech Engineering, May 13, 2008

- *Fill Compression—Lowe's HIW Site—South Academy Station—Northwest of South Academy Boulevard and I–25—Colorado Springs* [El Paso County]*, Colorado*, A.G. Wassenaar, May 21, 2008

- *Geotechnical Study for Slope Stability Analysis—Proposed Lowe's HIW of SW Colorado Springs—South Academy Station—Northwest of I–25 and South Academy Boulevard—Colorado Springs* [El Paso County]*, Colorado,* A.G. Wassenaar, May 21, 2008

- *Additional Cut Slope Analysis Near Water Tanks—South Academy Station—El Paso County, Colorado,* Entech, June 11, 2008

- *Initial Geotechnical Evaluation Report—Proposed Walmart Supercenter #3018–00—South Academy Station Development—Colorado Springs* [El Paso County]*, Colorado,* Kleinfelder, September 13, 2012

- *Initial Geotechnical Evaluation Report—Proposed SAM'S Club Store #8272–08—South Academy Station Development—Colorado Springs* [El Paso County]*, Colorado,* Kleinfelder, September 17, 2012

- *Geotechnical Study for Slope Stability Analysis—Proposed Walmart Supercenter and Sam's Club Sites—South Academy Station—Northwest of*

> *Interstate 24 and South Academy Boulevard—Colorado Springs* [El Paso County]*, Colorado,* A.G. Wassenaar, September 14, 2012

We supplemented the above information by drilling 13 borings (designated MT–1 through –13) at the locations shown in Figure 1 in Appendix A. An expanded view of the boring plan is provided in the map pocket. The boring locations were established in the field and their elevations determined by survey by Classic Consulting Engineers & Surveyors, the project civil engineer and surveyor. The terrain made moving around the site difficult, requiring the use of a dozer to assist the drill rig to access some of the boring locations.

The borings were advanced to depths of 15 to 45 feet below the existing ground surface using a truck–mounted rotary drill rig. Four–inch–diameter continuous–flight augers were used to advance the borings. Split–spoon samples were generally obtained at 2½– to 5–foot intervals in the subsurface materials. Representative samples of the soils and rock encountered were sealed in glass jars for further observation and laboratory testing. Bulk samples were collected from auger cuttings from selected borings. A Staff Engineer provided oversight and quality control during drilling.

The samples were sealed, secured, and transported to our laboratory for observation and testing. The sampling intervals, soil and rock descriptions, standard penetration data, ground water observations, and other pertinent field information are summarized on the boring logs in Appendix B.

For convenience, the boring logs from prior studies by others have been reproduced in Appendix C. The locations of these borings are shown in Figure 1 and on Sheet 1 in the map pocket.

LABORATORY TESTING

The samples were observed and visually classified, and the boring logs were edited as necessary. Moisture content determinations were made for all samples. The plasticity characteristics of selected samples were determined by performing Atterberg limits tests. The results of the laboratory index testing are presented on the boring logs.

Modified Proctor (ASTM D 1557) moisture–density relationship tests were performed on five bulk samples. These results are presented in Figures 13 through 17. The shear strengths of selected remolded samples were determined by performing direct shear tests, the results of which are presented Figures 18 through 20.

Consolidation tests were performed for eight samples remolded to selected densities, the results of which are presented in Figures 21 through 28.

Swell tests were conducted on remolded samples of shale and claystone, the results of which are summarized as follow:

Boring No.	*Remolded Sample*	*Swell Pressure for Zero Swell, psf*	*Free Swell, %*
5	Shale	6400	10
	Shale	5500	10
12	Shale	5750	13
12 & 13	Claystone	4100	11

A sieve analysis was conducted on a selected sample and the results are presented in Figure 29.

The plasticity characteristics of selected shale and claystone samples mixed with various percentages of hydrated lime (calcium hydroxide) were determined by performing Atterberg limits tests. Hydrated lime was incorporated at the rate of 2, 3½, and 5 percent by weight for the purpose of determining the lime’s affect on the material’s plasticity index. The results are summarized as follows:

Material	*Plasticity Index*			
		Lime by weight		
	Untreated	*2%*	*3½%*	*5%*
Shale	*42*	*39*	*29*	*26*
Claystone	*36*	*31*	*28*	*15*

Based on the above results, we performed swell tests on remolded shale and claystone samples treated with hydrated lime at the rate of 4 percent by weight. A surcharge load of 125 psf was applied to the samples to simulate the pavement section. The result of the testing on the treated shale and claystone samples yielded swells of 0.4 and 2.0 percent, respectively.

SITE GEOLOGY

Published geologic maps indicate the study area generally consists of Quaternary–age Pediment Gravel grading to Cretaceous Pierre Shale Formation bedrock. The overburden contains cobbles and boulders in a sandy matrix grading vertically to a silty and clayey matrix at the base. The shale includes numerous bentonite beds that are typically 1 to 3 inches thick and occasionally up to 8 inches in thickness. The shale typically weathers to brown and olive–green clay, with curvilinear fractures filled with sulfate salts.

From available resources, it is reported that sand and gravel was previously quarried from several locations on this site. Karst features, such as sinkholes or caves, were not observed at the site, do not appear on topographic maps, nor are prevalent in the area.

Samples collected during the field exploration generally agree with published geologic information.

GENERALIZED SUBSURFACE CONDITIONS

The subsurface conditions were developed by reviewing the logs of borings performed by others at this site and by drilling 13 supplemental test borings at the locations shown in Figure 1 and Sheet 1. The field explorations generally disclosed occasional fill overlying natural undisturbed cohesive soils and granular deposits grading to weathered shale (locally referred to as claystone) and unweathered shale bedrock at depth.

The overburden materials were thin or did not exist at some of the test holes drilled at this site. Although not encountered in any of the test holes drilled as part of this study, fill was disclosed at random locations in some of the borings drilled by others.

Generalized soil and rock profiles (Sections A–A through J–J) were developed from our borings and selected borings by others. The profiles are presented in Figures 2 through 11. A legend to aid in the interpretation of the profiles is provided in Figure 12.

Natural Overburden. The natural overburden profile, where present, generally consists of interbedded layers of cohesive and granular deposits. The cohesive soils consist of low plastic silty clay and silt, and high plastic clay with inclusions of sand and gravel. The granular deposits consist of poorly to well–graded sand with various amounts of silt and clay fines, and gravel. The thickness of the overburden in 11 of the 13 borings we drilled generally varied from 3 to 28 feet. The overburden was nonexistent in two of our test holes.

Standard penetration resistances (N–values) obtained in the overburden indicate the cohesive soils to generally be of very stiff to hard consistency with occasional stiff zones. The sand deposits are generally medium dense to very dense in relative density.

Bedrock. Bedrock consisting of claystone (weathered shale) and shale was encountered in 12 of the 13 borings drilled as part of our field exploration, at depths of 3 to 28 feet below the existing ground surface. Claystone was disclosed at the ground surface at two locations (Borings 6 and 10). One boring was terminated at a depth of 20 feet below the ground surface before encountering claystone or shale. A summary of bedrock surface elevations for the borings in Appendixes B and C is provided in Table 1.

The claystone and shale are medium hard to hard. The claystone and shale were penetrated with continuous–flight augers. N–values within the formation varied and were sometimes less than 30 blows per foot (bpf) but usually exceeded 50 blows in less than 6 inches of penetration by the sampler. The lower N–values typically occurred in the upper portion of the claystone where natural moisture contents exceeded about 15 percent. The higher N–values occurred at depth, where the moisture content was typically less than 15 percent.

The claystone and shale at this site exhibit a high risk of swelling. In order to evaluate the plasticity of the claystone and shale, we performed Atterberg limits tests on 13 samples. The results of the testing indicated liquid limits ranging from 42 to 77 and plasticity indexes ranging from 23 to 51. The data indicate that the claystone and shale fall into the 'medium' to 'very high' swell potential categories, per *Foundation Engineering* (Peck, Hanson, and Thornburn, 1974):

Table 20.1 Relation Between Swelling Potential of Soils and Plasticity Index

Swelling Potential	*Plasticity Index*
Low	0–15
Medium	10–35
High	20–55
Very high	≥ 35

In order to measure the potential swell of the claystone and shale, we performed one–dimensional swell tests using four remolded samples of these materials. The swell testing included determining the pressure necessary to render zero volume–change and the volume change potential under free–swell conditions (e.g., zero confining pressure).

The results of the swell testing indicated the pressure necessary to render zero volume–change varied from 4100 to 6400 psf. The results also indicated swell potentials of 10 to 13 percent at zero confining pressure. The swell testing confirmed that the tested materials are very susceptible to swelling when wetted.

<u>Ground Water</u>. Ground water was encountered in Borings MT–1 and –3, at a depth of 24 feet below the existing ground surface. The remainder were dry during drilling and upon completion. It should be realized that the relatively low permeability of the soil and rock at this site may not have allowed ground water levels to stabilize in the borings due to the short time the boreholes were open. The ground water level at this site may vary with climatic and seasonal changes.

Ground water readings made in borings drilled by others (Appendix C) may provide some ground water level information. However, these borings date to 2008 and 2012 and, as such, may not be representative of current conditions.

DESIGN RECOMMENDATIONS

Our findings indicate that the proposed development can be constructed as indicated on the grading plans. The proposed buildings can be supported on shallow foundations and the floors can be of conventional, slab–on–grade construction. Several conditions exist at this site, warranting special consideration for site grading, pavements, foundations and floor slabs.

Review of the grading plan indicates significant cuts and fills are required to achieve the desired finished grades. Cuts up to 32 feet and fills approaching 66 feet are planned within the various building pads. Deeper cuts and fills are proposed in places outside the building areas.

It is anticipated that much of the cut areas will require excavation of claystone and shale bedrock. These materials exhibit high shrink–swell potentials. The deep fills within the influence of the buildings warrant greater compactive effort to limit internal consolidation and control settlements. The materials with high shrink–swell potentials must be restricted to a minimum depth below finished grades and effectively sealed from moisture changes so as to not pose a risk for volume change.

Grading and design considerations for the development of this site include:

1) claystone and shale excavation,
2) internal consolidation and settlements induced by deep fills, and
3) swelling of claystone and shale.

Of particular importance is the sequence of grading, the location and depth of selected materials used for fill to control swelling of expansive materials, and the compaction procedures needed to limit the settlement of deep fills such that the proposed buildings can be built upon completion of grading without waiting for movements to reach completion. These and other design–related considerations are discussed in detail in the following sections.

Site Development Considerations. Several site–related issues will affect the development of this site. The presence of existing fill, claystone and/or shale above finished grades, the construction of deep fills, and the high swelling potential of the claystone and shale are discussed in the following paragraphs.

Existing Fills. Fills were reported in some of the borings drilled by others at this site. The study area has never been developed, and was reportedly previously quarried for sand and gravel at several locations. There are several unpaved roads throughout the site—likely the result of previous quarry and/or recreational activities. The isolated areas of existing fill are most likely the result of the past activities at this site and, therefore, were probably not placed in a controlled manner.

Some of the existing fill is present in areas expected to be cut as part of site grading and, therefore, will be removed during earthwork. Existing fill exposed in areas to be filled should be undercut to expose the underlying natural materials prior to placement of new grade–raise fill.

Bedrock Excavation. The test borings indicate that bedrock excavation will be required. As seen in the profiles (Figure 2 through 11) developed from the borings, numerous borings encountered claystone and shale bedrock above proposed grades.

The hard claystone and shale may be difficult to excavate with scrapers. It is anticipated that the claystone and shale can be ripped; however, production rates may be slow. It should be noted that the rippability of a material is more dependent on the type and size of the equipment used, the fracturing or quality of the rock, and the amount of effort expended than it is on the type of material.

The ripped claystone and shale will probably break into large pieces. The removed material should be processed by the larger earthmoving equipment to break it down to an appropriate size (less than about 3 inches) during movements and placement in structural fills.

Deep Fills. Review of the site plan indicates fills are required in each building pad to establish the design elevations. The depth of fill varies for each building. The maximum depth of fill approaches 66 feet for the Sam's Club pad.

It is our opinion that fills exceeding 15 feet in thickness must be placed at a higher degree of compaction to limit internal consolidation of the fill. It is recommended that fills in excess of 15 feet and less than 40 feet be compacted to a minimum of 95 percent of the material's modified Proctor (ASTM D 1557) maximum dry density. The portion of fills within the building in excess of 40 feet deep and a horizontal distance of 20 feet outside of the building must be compacted to at least 100 percent of the material's modified Proctor as depicted in Figure 35.

To expedite the time-rate of settlement of fills exceeding 40 feet in depth, a 4-inch-thick layer of on-site sand and/or gravel shall be placed between the fills compacted to 100 and 95 percent of modified Proctor. The purpose of this layer is to speed consolidation via drainage of the deep fill, by reducing the time of consolidation to less than 40 days to achieve 90 percent of the projected settlement.

With the exception of the upper 2 feet, fills less than 15 feet in depth can be placed using 90 percent of modified Proctor for control. The upper 2 feet of the building pad subgrades require 92 percent modified Proctor compaction which, in our opinion, meets or exceeds the Walmart– and Sam's–required 98 percent of *standard* Proctor compaction for the upper 2 feet of floor slab subgrade.

The above measures are necessary to allow building construction to start shortly after the completion of site grading. Otherwise, internal consolidation of deep fills could result in floor slab cracks and foundation settlements beyond tolerable limits if the fill construction is not properly controlled.

It is expected that deep fill construction will consist of the following generalized scope of work:

- site preparation, including clearing and stripping
- excavation and removal of existing fills and any soft, unstable materials exposed at subgrade
- excavation of benches at vertical intervals along existing slopes
- installation of core drains (locally referred to as 'burrito' drains) in the bases of existing ravines, gullies, and drainage features and their extension to a suitable outfall at lower elevations
- mechanical compaction of fill materials as specified herein
- placement of a 4-inch-thick granular layer between fills compacted to 95 and 100 percent of modified Proctor (e.g., where fills depths exceed 40 feet)
- placement and compaction of select materials within the upper 10 feet of building pad fills

The intent of the above recommendations is to establish building pads that will allow construction to begin without waiting for settlements to reach completion. We anticipate 90 percent of the expected consolidation of fills exceeding 40 feet in depth to occur less than 40 days after completion of grading. Minimum compaction is specified to limit settlements of fills to tolerable limits. Settlement calculations are presented in Appendix D.

Due to the sequence in which fill material will become available during grading (e.g., low plastic soil, sands, and gravels followed by claystone and shale), it is recommended that a placement sequence be implemented that will minimize the need for stockpiling or double–handling materials. The grading sequence needed to accomplish the needed fills, while controlling settlements and swelling of the shales and claystones, requires that the select material not be indiscriminately placed, particularly in deep fills.

It is important to understand that the materials needed to complete the upper 10 feet of the building pads is currently at or near the surface of the site in planned cuts areas and needs to be available to “cap” the building pads. The fill used in the deeper fills should consist of claystone and shale, which is currently in the lower portion of the subsurface profile. Claystone and shale must *not* be placed in the upper 10 feet of the building pad subgrades. These materials exhibit high shrink–swell potential and, therefore, are restricted to the fill zones below the upper 10 feet of the building pad areas.

Claystone and Shale Shrink–swell Control. The claystone and shale at this site can cause volume change (shrink–swell) problems with corresponding changes in moisture content. The volume–change potential exists both in natural (*in situ)* and remolded (fill) conditions.

Laboratory tests yielded swells ranging from 10 to 13 percent with no confining pressure when the samples were inundated. Pressures necessary to render zero volume–change varied from 4100 to 6400 pounds per square foot (psf), although the consolidation tests indicate that the bulk of the swelling occurs with confining pressures of 1 tsf or less. These data indicate that claystones and shales at this site exhibit high swell potentials.

In order to preclude the resulting structural distress that could occur in the building slabs and foundations from volume changes in the floor and foundations subgrades, it is recommended that claystone and/or shale *not* be present in the upper 10 feet of the building pad subgrades. Claystone and shale used as fill should be placed in fills deeper than 10 feet below finished grades.

For the portions of building pads that are in areas of cut, claystone and shale present in the upper 10–foot zone of the building pads must be over–excavated, sealed, and replaced with low plastic cohesive soil or granular fill. The overexcavation of the claystone and/or shale should extend a minimum distance of 10 feet outside the perimeter of the building footprints.

Exposed claystone and shale at the bases of the undercuts must be protected from changes in moisture content. This can be accomplished by scarifying the exposed claystone or shale to a depth of 12 inches and incorporating bentonite into the scarified zone at the rate of 8 to 10 percent by weight, moisture adjusting the treated materials to 3 to 5 percent over optimum, and compacting the treated layer to at least 90 percent of modified Proctor, all in two 6-inch-thick lifts.

The sealed surface must be sloped to a drain, which will be daylighted to slopes behind the buildings, per Figure 34. It is our opinion that this will effectively "seal" the surface of these materials and control changes in moisture, thereby controlling the shrink–swell potential of the claystone and shale.

Building Foundations. Following the mass grading recommendations above, it is our opinion that the buildings can be supported on shallow foundations designed using an allowable net bearing pressure not to exceed 3,500 pounds per square foot (psf), for both column and wall footings bearing on compacted fill.

Column and wall footings must have minimum dimensions of 2.0 and 1.5 feet, respectively, for bearing capacity considerations. In using net pressure for design, the weight of the foundation and the backfill over the footing need not be considered. Hence, only the loads applied at or above the finished floor level need be used in dimensioning the foundations.

It is expected that total settlements will be relatively limited with good construction technique and not exceed approximately 1 inch. Differential settlement between adjacent columns across a typical bay should not exceed one–half the total settlement. Exterior footings and foundations in unheated areas should be located at least 3.0 feet below final exterior grade for frost protection. Interior footings in heated areas can be located at a nominal depth below finished floor.

Horizontal Loads on Foundations. Selected interior column foundations can be used for bracing reactions to forces such as wind. It is recommended that a minimum factor of safety of 1.5 be used for lateral load analyses using the following design parameters for interior columns only:

Component	*Recommended Value*
Sliding resistance along base	0.45 times dead load (ϕ = 24°)
Sliding resistance along sides parallel to force	500 psf (adhesion—compacted soil)
Passive resistance on opposite face perpendicular to force	200 pcf equivalent fluid density

Floor Slabs. It is recommended and preferred that the floor slab be "floating," that is, not structurally connected to columns and foundation walls. This will permit modest horizontal and vertical movements to occur while minimizing cracking in these elements. If the slab is tied to the foundation wall, this method will pose more risk of slab cracking due to the structural connection of the lightly loaded slab to the much more heavily loaded wall foundation.

We recommend a minimum 4–inch–thick layer of granular base course beneath the floor slabs for the Walmart and retail buildings; Sam's Club requires 6 inches.

The base material shall conform to Colorado Department of Transportation (CDOT) Class 5 Aggregate. The granular base material will help to distribute concentrated loads and equalize moisture conditions beneath the slab. A vapor barrier is not needed, provided a capillary break is provided by the crushed stone base.

Construction sequence is also important for a tied slab. It is recommended that the foundation wall, roof, and any significant dead loads that will be applied to the footings be in place prior to tying the slab. If not, the addition of load following the connection of the slab to the foundation wall may crack the slab even though foundation settlements are within predicted limits.

The floor slabs will be supported by compacted fill, topped with a minimum 4–inch–thick granular base course layer. It is our recommendation that a subgrade reaction modulus not to exceed 150 pounds per square inch per inch (psi/in) be used for the design of the concrete floor slabs. Provided the recommendations set forth in this report are followed, the potential vertical rise (PVR) of the floor slab is not expected to exceed ½ inch.

Seismic Design Considerations. The International Building Code (IBC) requires the structural design of the buildings to be in accordance with the requirements of Section 1613.5.3 of the 2009 code. A site classification is required for seismic consideration. The classification is a function of the soil profile representing the average properties comprising the top 100 feet of the site.

Different IBC site classifications will apply due to varying depths to bedrock across this site. The boring data and current site plan for the Walmart, Sam's Club, and retail buildings indicate that Site Class D will apply to these buildings, as indicated in Figure 33. However, the outlot buildings will probably fall into the 'C' or 'B' classification, depending on the specific profile for each outlot.

IBC allows three methods of site class determination: N–values, shear strengths, and shear wave velocities. If Site Class D renders the structural design of the Walmart, Sam's Club, and retail buildings too costly, a shear wave velocity study can be conducted at this site. However, while possible, there is no guaranty that this study will produce a different site classification.

The site is located in an area of low seismic activity and no recently active faults are known to exist in the immediate site area. Fault rupture is not considered to be a credible hazard at the site. The subsurface materials and ground water conditions encountered at the project site indicate the risk of liquefaction is zero.

Lateral Earth Pressures. Site retaining walls (if any) and truck–dock walls must be designed to restrain the applicable lateral earth pressure. Three earth pressure conditions are generally considered for retaining wall design: at–rest, active, and passive. Retaining walls that are restrained at the top, such as truck–dock walls, should be designed for the at–rest condition. Walls which are free to rotate at the top at least ½ percent of the wall height may be designed using the active earth pressure condition. Resistance to the lateral loads may be provided using a combination of passive earth pressure and friction.

Recommended design values for total density, friction angle, cohesion, active earth pressure coefficient, active equivalent fluid density, at–rest earth pressure coefficient, passive earth pressure coefficient, and sliding friction values are tabulated as follows:

Material	*γ_t, pcf*	*ϕ, °*	*C, psf*	*K_a*	*EFD_a*	*K_o*	*K_p*[1]	*tan ϕ*
Silty clay (CL)	120	24	0	0.42	50	0.54	1.19	0.45
Clay (CH)	115	18	0	0.53	61	0.64	0.95	0.32
Sand & gravel (SP)	110	32	0	0.31	34	0.47	1.63	0.62
Cohesive fill	120	24	100	0.42	51	0.59	1.19	0.45
Sand & gravel fill	125	34	0	0.28	35	0.44	1.77	0.67
Claystone	125	15	50	0.59	74	0.74	0.85	0.27
Shale	135	24	250	0.42	57	0.59	1.19	0.45
Claystone fill	130	21	100	0.47	61	0.64	1.06	0.38
Shale fill	140	28	500	0.36	51	0.53	1.38	0.53
CDOT Class 5 stone	135	38	0	0.24	32	0.38	2.10	0.78

[1] half of full passive

The passive resistance recommended above is half of the available passive resistance. However, we do not recommend the use of full passive resistance in the design. This is due to the fact that the strains needed to mobilize the full passive earth pressure state are too large. That is, the horizontal movement needed to mobilize this resistance would result in unacceptable foundation translations. The use of 'one–half passive' is recommended as this state only requires about one–fourth the strain for the full passive state, and can be used in combination with the sliding resistances above.

It is further recommended that the passive resistance against the wall above the footing be ignored due to possible future changes in the soil conditions in this zone (e.g., frost action, excavation, utility installation, etc.). However, a passive resistance may be assumed against the face of the footing for design of the foundation wall. The foundation wall footing should bear at least 36 inches below grade to protect against frost action. Tension between the concrete and soil should not be used in the design.

The backfill for the walls should consist of low plastic cohesive soil or granular material, compacted to 90 percent of modified Proctor. High plastic clay, claystone, or shale shall not be used for foundation and retaining wall backfill.

The foundations for retaining walls should be designed for a maximum allowable net toe bearing pressure of 3,500 pounds per square foot. The resultant of the imposed load should act within the middle third of the footing base such that the foundation reaction is everywhere compressive. The factor of safety against sliding for the walls should not be less than 1.5.

The design further assumes that hydrostatic pressure will not develop behind the retaining walls. This can be accomplished by the installation of a subdrain behind retaining walls. To preclude a buildup of hydrostatic pressure, subdrains should be installed behind and at the base of retaining walls. This would consist of a perforated drain pipe behind the base of the wall at the footing level wrapped with synthetic filter fabric surrounded by a select filter material. The drain pipe should be a rigid 4–inch–diameter pipe with 3/8–inch maximum openings. As an alternative, weepholes can be provided in the walls, as shown in Figure 30.

The select filter material should consist of CDOT Class 4 or 5 Aggregate crushed stone. The pipe should be laid with the holes down and sloped to daylight or connected to a storm sewer. Weepholes can be used if they are protected by synthetic filter fabric to prevent future clogging from soil fines. A 4–ounce, *nonwoven*, synthetic filter fabric such as Mirafi 140N or equivalent is acceptable.

Pavement Section Design. Significant grading is required for the overall development of this site. It is anticipated that following earthwork the pavement subgrade will generally consist of claystone or shale. Because of the volume change potential of these materials we recommend that the upper 2 feet of design subgrade be specially treated in an attempt to limit potential swelling to 2 inches. This can be accomplished by establishing the following section:

- lime–stabilizing the upper 8 inches of the pavement subgrade
- moisture–adjusting the two lower 8–inch–thick layers of compacted subgrade

Based on the results of our laboratory lime analysis, lime stabilization can be accomplished by incorporating quicklime or hydrated lime into the claystone or shale at the rate of 4 percent by weight. Lime treatment of soils is more thoroughly discussed in Appendix D. The lime-stabilized layer should be compacted to at least 92 percent of the material's modified Proctor (ASTM D 1557) maximum dry density.

We performed swell tests on remolded shale and claystone samples treated with hydrated lime at the rate of 4 percent by weight. A surcharge load of 125 psf was applied to simulate the pavement section. The result of the testing on treated shale and claystone samples yielded swells of 0.4 and 2.0 percent, respectively.

Sulfate testing is in progress; however, problems are not expected based on the swell test samples.

The lime-stabilized layer shall be constructed on top of 16 inches (two 8-inch-lifts) of moisture-treated claystone or shale. We recommend the claystone and shale be moisture-adjusted to a point between 3 and 5 percent over optimum, and compacted to 90 percent of the material's modified Proctor. The moisture adjustment of the two lower lifts must be done immediately before lime-stabilizing the upper lift. Performing the moisture adjustment more than a few days before lime stabilization can allow the lower layers to dry and render the treatment ineffective.

An estimated CBR of 8 was used for our pavement analysis, representing a lime-stabilized or compacted sand and gravel subgrade. Acceptable materials which will yield a CBR of at least 8 include clays (CH), silty clay (CL), claystones, and shales, all of which must be lime-treated. A CBR of 8 or more can also be established using compacted sand and gravel.

The sections were determined with a computer program based on the AASHTO (American Association of State Highway and Traffic Officials) *Method of Flexible Pavement Design*, 1993. The following design parameters were used:

- 20–year design life
- terminal serviceability index of 2.0
- initial serviceability of 4.2
- reliability factor of 85 percent
- standard deviation of 0.45 for flexible pavements and 0.35 for rigid pavements
- equivalent axle load (18–dip EAL) of 15.0 per day for a total of 109,500 EALs in the standard duty pavement areas
- equivalent axle load (18–kip EAL) of 46.0 per day for a total of 335,800 EALs in the heavy duty pavement areas
- subgrade compaction of at least 92 percent of modified Proctor

The following layer coefficients for each pavement layer were used:

- structural number coefficient (per inch in place) for asphaltic concrete (wearing and binder course) of 0.44
- structural number coefficient (per inch in place) for base course (crushed stone) of 0.11

The drainage coefficient for the aggregate base course was assumed to be 0.8. The compressive strength for the concrete alternates for each section was assumed to be 4,000 psi at 28 days. The joints for the concrete alternates were assumed to be aggregate interlock joints with moderate edge support (i.e., tied perimeter slabs).

The following tables summarize the recommended pavement sections for the heavy and standard duty pavements using a 20–year design life:

	Thickness, in.				*Thickness, in.*	
Section	*Asphalt Wearing*	*Asphalt Binder*	*Base Course*	*ESALs*	*Concrete (alternate)*	*Base Course*
Heavy	2	3	7	335,800	6	4
Standard	1½	2	7	109,500	5	4

The asphalt mix, all associated materials, and construction standards should conform to the most recent version of Section 401 of the CDOT Specifications for Road and Bridge Construction.

The pavement base course should consist of minus–fraction crushed stone conforming to CDOT Specifications for Road and Bridge Construction, Section 703.03. The gradation of the crushed stone should conform to CDOT Class 5 or Class 6 Aggregate. We recommend placement of a 4–inch–thick layer of granular base course below all concrete pavements. The crushed rock base course should be compacted to a dry density of at least 90 percent of the modified Proctor. It is recommended that the base course material be ±2 percent of the material's optimum moisture content to facilitate achieving compaction.

Drainage of the pavement base course is imperative in order to reduce the opportunity for water to infiltrate the overburden and reach the swell–potential claystones and shales. The recommended drainage can be accomplished by installing stub drains at all stormwater structures within parking areas. Water which might infiltrate the pavements would be expected to travel through the base course and collect at the low points, which are the stormwater structures. By installing stub drains, the water can enter the structures and reduce ponding of collected water within the base course. The stub drains, as shown in Figure 31, should consist of a perforated pipe, wrapped in synthetic filter fabric and extending at least 2 feet from the storm water structure. The drains should be installed a minimum of 3½ feet below subgrade in a trench backfilled with clean crushed stone (CDOT Class 1).

Additional drainage should be provided by installing drains for the landscaped islands. These are typically irrigated or the infill often settles, allowing precipitation to pond and enter the pavement base course. Drains will allow such water to be removed from the islands and reduce the amount of water that might otherwise enter the base course, weakening this material and softening the subgrade. A detail depicting the drains is shown in Figure 32. The drains should follow the island alignments and discharge into stormwater structures or daylighted. Drain alignments can best be determined after the stormwater structure locations are established.

We recommend that a shallow swale be installed at the base of cut slopes adjacent to pavement areas and a French drain be installed below the base of the swale. The purpose of the swale and French drain is to intercept and discharge water away from the pavement subgrade. The drains should discharge into stormwater structures or daylighted.

It is recommended that a 7–inch–thick, unreinforced, 4,000 psi concrete slab–on–grade be constructed in the truck dock area and in front of the trash loading areas. The use of concrete paving will minimize the damage that would otherwise occur to asphalt pavement due to truck traffic at the dock area and high front wheel loads imposed by front–loading trash trucks.

The slabs should be adequately sized to ensure that they will sustain the load from the trucks while at the docks or emptying dumpsters. It may also be prudent to consider the use of concrete–paved entrances, where forces imposed by turning traffic can generate deformations in asphalt pavement.

It is assumed that the design of the Venetucci Boulevard extension will be dictated by a local governing design for public streets. As such, we have not addressed the design of this roadway except for fill construction and subgrade preparation. If a roadway section design is needed, we can provide this information on request.

Site Utilities. [COMMENT: Being developed in conjunction with Civil Engineer and will be included in the final report. Recommendations will address the need to property backfill utility trenches and not establish a conduit for infiltration to reach swelling claystones and shales. Options will be presented for backfill followed by the pavement subgrade prep treatment and "patching" utility trenches cut through already prepared pavement subgrade.]

Chemical Analyses. There are sufficient data presented in the geotechnical reports prepared by others indicating that water–soluble sulfates are present in the claystones and shales at this site. The risk is *severe* for sulfate attack of concrete exposed to the soils, according to ACI (American Concrete Institute). We recommend all concrete in contact with the soils on this site be designed for severe sulfate exposure in accordance with the most recent edition of the ACI Manual of Concrete Practice, ACI 318, Section 4.3. This includes, but is not limited to, foundations, floor slabs, exterior concrete pavements, curb and gutter, underground concrete pipe, and retaining walls.

Drainage, Grading, and Slopes. Positive drainage must be provided to minimize infiltration of surface water around the perimeter of the buildings and beneath the floor slabs. Grades must be sloped away from the structures, and roof and surface drainage collected and discharged in such a manner that it is not permitted to infiltrate the near–surface soils.

Of particular concern are construction joints between pavements and slabs, and the abutting buildings. These joints must be sealed with a high quality flexible caulk, and storm water drains (e.g., trench drains, grates, individual drains, etc.) must be kept clean to prevent ponding and the subsequent infiltration of surface water into the ground adjacent to foundations. Infiltration of surface water adjacent to foundations can cause settlement, as the water can soften cohesive soils and densify granular materials through flooding.

3H:1V Slopes. All cut and fill slopes must be designed so they have acceptable factors of safety against global failure. Proper drainage is required to minimize settlements, and maintain subgrade and slope stability. It is recommended that all cut and fill slopes be made not steeper than 3H:1V. Steeper cut and fill slopes must be evaluated for slope stability.

It is recommended that all exposed slopes be seeded to provide protection against erosion. Seeded slopes should be protected with erosion mat until the vegetation is established.

Existing slopes steeper than 5H:1V should be benched prior to the placement of fill to preclude the formation of a potential slip plan between the new fill and the existing slope. The benches should be cut flat in the slope (stair–stepped) with horizontal width of at least 10 feet.

We have reviewed the slope stability studies conducted by Entech and are in agreement with their findings.

Exposed Shales. The boring data indicate that the proposed cut slope between the water tanks and the Walmart parking lot and the outlot nearest the tanks will encounter shale in the lower portion of the proposed cut. The proposed cut slope will be acceptable; however, the Walmart parking area and drive can be increased in size, along with the nearby outlot. This can be accomplished by cutting the shale (i.e., the lower portion of the proposed cut) in a near–vertical orientation and protecting the shale from disintegration with a Shotcrete–faced, soil–nail wall with weep drains.

We understand that the design of such a wall was undertaken by others and may be close to completion. We can provide a review of the wall design, if available, or design a soil–nail wall if the increased land use area is desired.

Channel Protection. Erosion protection for channels shall be ___–inch d_{50} stone size rip–rap, as defined in Table 506–2 of *Standard Specifications for Road and Bridge Construction* (Colorado Department of Transportation, 2011). The rip–rap shall be placed in accordance with the requirements of Section 506.03. [COMMENT: Rip–rap size and placement areas to be coordinated with Civil Engineer.]

Shrink–swell Factors. It is our opinion that the cut overburden soils (clay, silt, sand, and gravel) will *shrink* approximately 12 percent as a result of compaction when placed as compacted fill. It is our further opinion that the excavated claystone and shale will *swell* approximately 10 percent after it is placed and compacted in the fill areas.

The determination of shrinkage and swell factors for soil and rock is not an exact science—particularly for rock. It is important to understand that these factors for soil and rock are *estimates* based on past experience.

Because of possible variations from the estimated volume change factors, we strongly suggest that the ability to make modest adjustments in the finished grades (probably ½ foot or less) be maintained during the course of the site development. It is our opinion that the earthwork can be monitored to the extent that such changes can be made to accomplish the needed site grading.

Outlot Development. The current grading plan shows that the three outlots, when cut to proposed subgrade, will expose shale over all but a tiny portion (i.e., the northeast corner) of the center outlot. Thus, the swell potential of the shale and the resulting detrimental effects on building foundations and floor slabs, and pavements, will need to be accommodated in the design of specific projects on these parcels. It is expected that outlot users will conduct their own geotechnical explorations and develop designs accordingly.

GENERAL CONSTRUCTION PROCEDURES/RECOMMENDATIONS

A geotechnical engineer must be retained during the earth–related portions of construction to verify compliance with the project documents and the recommendations presented herein.

Site Preparation. The existing vegetation at the site must be stripped. The strippings should be stockpiled on–site for later use in landscaped areas or disposed off–site in a legal manner. The depth of stripping required to remove this zone is estimated to not be more than 2 inches—essentially the vegetation and the upper root zone. Deeper stripping may be necessary in isolated areas and along the drainages. Trees should be completely removed including stumps and rootballs. The resulting holes should be backfilled with compacted fill.

Existing fills encountered in proposed fill areas should be undercut to expose the underlying natural materials prior to placement of fill. Prior to placing any fill, a proofroll must be performed to verify that the exposed surface is stable and no isolated soft spots or uncompacted fill zones exist.

The proofrolling can be accomplished with a heavily loaded tandem–axle dump truck, loaded scraper, or similar equipment approved by the Geotechnical Engineer. Unsuitable or uncompacted fill areas disclosed by the proofrolling operation must be remedied by removal and replacement, scarifying and recompaction, or other methods acceptable to the Geotechnical Engineer.

Existing slopes steeper than 5H:1V should be benched prior to the placement of fill to preclude the formation of a potential slip plan between the new fill and the existing slope. The benches should be cut flat in the slope (stair–stepped) with horizontal width of at least 10 feet.

Numerous drainage features, ravines, or gullies are located throughout this site. We recommend a core, or burrito, drain be installed along the bases of the drainage features prior to the placement of fill. The drain should consist of relatively clean crushed rock (such as CDOT Class 1 Aggregate) completely wrapped with a filer fabric (such as Mirafi 140N). The drains should have a minimum cross–sectional area of at least 4 square feet (e.g., a 2– by 2–foot trench in cross–section). The drains should generally follow the flowline of the ravines or gullies to an outfall location outside the toe of the fill embankments.

Siltation Control. The low–plastic cohesive soils, claystones, and shales at this site are susceptible to erosion. Due to the large area and sloping topography, the potential for off–site siltation exists. Appropriate erosion control measures, such as proper site contouring during construction and siltation fences or bales, must be used during construction. Maintenance may be required during construction in the form of removing accumulated sediments and restoring siltation control devices.

Subgrade Considerations. The low plastic cohesive soils on this site are susceptible to disturbance during grading operations (i.e., pumping and/or rutting). Additionally, the claystone and shale might be susceptible to pumping and rutting when wetted. Care must be exercised to maintain the integrity of the subgrade when preparing the site for the placement of fill, making excavations, and other earth–related construction activities.

If pumping and/or rutting occur, activity should be halted until the affected area can be stabilized. This can normally be accomplished with aeration and recompaction, the use of ground stabilization fabric, a working mat of clean coarse crushed stone, or admixture incorporation. The need for these measures will depend on soil, moisture, and weather conditions at the time of earthwork and can best be evaluated at that time.

Claystone and Shale Excavation. The test borings indicate that rock excavation will be required. As seen in the profiles developed from the borings, numerous borings encountered claystone and shale bedrock above proposed grades.

The hard claystone and shale may be difficult to excavate with scrapers. It is anticipated that the claystone and shale can be ripped; however, production rates may be slow. It should be noted that the rippability of a material is more dependent on the type and size of the equipment used, the fracturing or quality of the rock, and the amount of effort expended than it is on the type of material.

The ripped claystone and shale will probably break into large pieces. The removed material should be processed by the larger earthmoving equipment to break it down to an appropriate size (less than about 3 inches) for use in structural fills.

Fill Materials. Both soil and rock materials are expected to be generated by excavations at this site. It will be important for the grading contractor to determine the sequencing of fill materials. That is, the needed materials at any particular time in the filling operation must be available from the cut areas.

Soil Fill Materials. The cohesive and granular soils at this site are suitable for reuse in an engineered fill. On–site fill material should be free of organic and deleterious matter. Imported borrow material should be free of organics and deleterious matter with a liquid limit not to exceed 45. Depending on moisture conditions at the time of construction, it may be necessary to add water or aerate the fill material to achieve the required compaction.

Rock Fill Materials. Claystone and shale may be used as fill provided it is not placed in the upper 10–foot zone of the building pad subgrades. The removed claystone and shale to be used as fill must be processed by the larger earthmoving equipment to break it down to an appropriate size (less than 3 inches) for use in structural fills. It should be expected that these materials will require moisture incorporation before they can successfully be placed and compacted in engineered fills.

Compaction. Soil and rock fills and backfills will require mechanical compaction to achieve the needed strengths and limit settlements to tolerable values. Of particular concern is the need to limit internal consolidation (i.e., settlement due to self–weight) of deep fills.

On–site and imported fill and backfill must be placed in loose lifts and mechanically compacted. Field density tests must be performed as needed by a qualified soils technician to verify compliance with the density requirement.

We recommend the following compaction criteria:

Area	*Percent of Modified Proctor (ASTM D 1557)*
General site fill	
Fill ≤ 15 feet	90
Fill > 15 feet	95
Building pad fill	
Top 2 feet	92
Below the top 2 feet and ≤ 15 feet	90
Fill > 15 feet and ≤ 40 feet	95
Fill > 40 feet	100
Utility trench backfill	
Beneath building and pavements	90
Beneath landscaped areas	85
Landscape area fills	85

The maximum loose lift thickness conducive to achieving the required compaction is a function of the material type and the compactor, among other factors. We recommend the following for consideration:

Material	*Compactor*	*Area*	*Loose Lift Thickness, in.*
Cohesive	Sheepsfoot	Open	6–8
	Jumping jack	Confined	5–6
	Vibratory plate (backhoe)	Confined	8
	Tracking	Open	4
Granular	Vibratory roller (large)	Open	8–12
	Vibratory roller (small)	Confined	6
	Vibratory plate/sled	Confined	4–5
	Vibratory plate (backhoe)	Confined	12

Fill placed in the upper 2 feet of floor slab subgrade must be compacted to at least 92 percent of the material's modified Proctor maximum dry density. The upper 24 inches of pavement subgrade must be compacted to at least 90 percent of modified Proctor. Furthermore, the moisture content of the building should be in the range of optimum ± 2 points to minimize pumping and establish a firm subgrade. The moisture contents of the 24–inch subgrade layer (lime–stabilized over moisture–conditioned) shall be as required for lime treatment and within the range of optimum plus 3 to plus 5 points, respectively.

Compaction of any fill or backfill by jetting (sometimes referred to as flooding) is not considered acceptable. The success of this method requires a free–draining fill material and the drainage of the water through and away from a fill area. Jetting in cohesive soils or confined areas will result in the entrapment of water by the fill boundaries (e.g., backfill in a trench) or by cohesive fill materials. This technique will generally not achieve the desired compaction because of nonuniformity, submergence, and the weakening of the resultant fill.

Foundation Excavations. Foundation excavations should be observed to determine that the desired bearing stratum is exposed. The base of the excavation should be clean, dry, and free of soft soil or uncompacted fill. At this time, it may be necessary to probe the base of the excavation with a hand–auger, field vane, and cone penetrometer. Densities should be verified in foundation excavations which expose fill.

Satisfactory foundation excavations should be protected against detrimental changes in condition such as from freezing, disturbance, etc. If possible, the concrete for foundations should be placed the same day their excavation is made. If this is not practical, the foundation excavations must be adequately protected.

Construction Dewatering. Construction dewatering is not anticipated. If ground water seepage is experienced in shallow excavations, it is expected that it can be handled by pumping from sumps, or using perimeter trenches to collect and discharge the water away from the work area.

LIMITATIONS OF REPORT

The analyses, conclusions, and recommendations contained in this report are based on the site conditions described herein and further assume that the exploratory borings are representative of the subsurface conditions throughout the site (i.e., the subsurface conditions everywhere are not significantly different from those disclosed by the borings). If, during construction, subsurface conditions different from those encountered in the exploratory borings are observed or appear to be present beneath excavations, we should be advised at once so that we can review these conditions and reconsider our recommendations where necessary.

If there is a substantial lapse of time from the submittal of this report and the start of work at the site, or if conditions have changed due to natural causes or construction operations at or adjacent to the site, we recommend that this report be reviewed to determine the applicability of the conclusions and recommendations considering the changed conditions and time lapse.

The scope of the exploration reported herein did not include any environmental assessment or exploration for the presence or absence of hazardous or toxic materials in the soil, ground water, or air on, around, or beneath this site. Any notations or statements in this report, including notes on the boring log, regarding odors or unusual conditions observed are strictly presented for informational purposes only and are not intended as a definitive assessment of potential contaminants present.

We recommend that we be retained to review those portions of the plans and specifications which pertain to earthwork and foundations to determine if they are consistent with our recommendations. In addition, we are available to observe construction, particularly construction of foundations, site grading, parking lots, installation of underground utilities, and earthwork. We would also be available to make such other field observations as may be necessary.

This report was prepared for the exclusive use of the owner, architect, and engineer for evaluating the general development of the property as it relates to the geotechnical aspects discussed herein. It should be made available to prospective contractors for information on factual data only and not as a warranty of subsurface conditions included in this report. Unanticipated soil conditions are commonly encountered and cannot be fully determined by taking soil samples from a boring. Such unexpected conditions require that additional expense should be made to attain a properly constructed project. Therefore, some contingency fund is recommended to accommodate such potential extra costs.

* * * * *

The following are made part of and complete this report:

MAP POCKET
Sheet 1: Boring Plan

We appreciate the opportunity to be of service to you on this project. If we may be of further assistance, such as providing our quality control testing services during construction, please call.

Very truly yours,
MIDWEST TESTING

Daniel J. Barczykowski, P.E.
Principal

Richard D. Laughlin, P.E.
Principal

DJB/RDL/

Printed copies: UTW (___)
Oakwood Homes (1)
Classic Consulting (1)

Electronic copies: UTW/Alan Bornstein, Jeff Otto
Oakwood Homes/Chad Ellington
Classic Consulting/Kyle Campbell, Matt Larson

Table 1

SUMMARY OF BEDROCK SURFACE ELEVATIONS

South Academy Highlands
El Paso County, Colorado
Page 1

Boring No.	Surface Elevation, ft.	Depth to Bedrock, ft.	Top of Bedrock Elevation, ft.
KL B-1	5926.0	10.0	5916.0
KL B-2	5918.0	9.0	5909.0
KL B-3	5916.0	5.0	5911.0
KL B-4	5925.0	15.0	5910.0
KL B-5	5909.0	1.0	5908.0
KL B-6	5895.0	19.0	5876.0
KL B-7	5930.0	19.0	5911.0
KL B-8	5907.0	14.0	5893.0
KL B-9	5911.0	9.5	5901.5
KL B-10	5875.0	0.0	5875.0
KL P-1	5918.0	3.5	5914.5
KL P-2	5912.0	3.5	5908.5
KL P-3	5918.0	5.0	5913.0
KL P-4	5892.0	7.0	5885.0
KL P-5	5913.0	4.0	5909.0
KL P-6	5890.0	10.5	5879.5
KL P-7	5909.0	1.5	5907.5
KL P-8	5868.0	10.5	5857.5
KL DET-1	5906.0	3.0	5903.0
ENT B-1	5798.0	NA	NA
ENT B-2	5794.0	NA	NA
ENT B-3	5793.0	19.0	5774.0
ENT B-4	5794.0	21.0	5773.0
ENT B-5	5802.0	28.0	5774.0
ENT B-6	5792.0	21.0	5771.0
ENT B-7	5811.0	2.0	5809.0
ENT B-8	5820.0	9.0	5811.0
ENT B-9	5810.0	14.0	5796.0
ENT B-10	5814.0	19.0	5795.0
ENT B-11	5814.0	12.0	5802.0
ENT B-12	5808.0	12.0	5796.0
ENT B-13	5806.0	16.0	5790.0
ENT B-14	5806.0	9.0	5797.0
ENT B-15	NA	NA	NA

Table 1

SUMMARY OF BEDROCK SURFACE ELEVATIONS

South Academy Highlands
El Paso County, Colorado
Page 2

Boring No.	Surface Elevation, ft.	Depth to Bedrock, ft.	Top of Bedrock Elevation, ft.
ENT B-16	NA	NA	NA
ENT B-17	5822.0	14.0	5808.0
ENT B-18	5837.0	2.0	5835.0
ENT B-19	5846.0	6.0	5840.0
ENT B-20	5865.0	2.0	5863.0
ENT B-21	NA	NA	NA
ENT B-22	NA	NA	NA
AGW B-1	5911.0	9.0	5902.0
AGW B-2	5920.0	18.0	5902.0
AGW B-3	5917.0	15.5	5901.5
AGW B-4	5912.0	12.0	5900.0
AGW B-5	5899.0	2.0	5897.0
AGW B-6	5912.0	8.5	5903.5
AGW B-7	5921.0	12.0	5909.0
AGW B-8	5935.0	>15	NA
AGW B-9	5946.0	>15	NA
AGW B-10	5929.0	6.0	5923.0
AGW B-11	5895.0	>10	NA
AGW B-12	5893.0	1.5	5891.5
AGW B-13	5918.0	13.0	5905.0
AGW B-14	5937.0	>20	NA
AGW B-15	5931.0	1.0	5930.0
AGW B-16	5907.0	5.0	5902.0
AGW B-17	5910.0	8.0	5902.0
AGW B-18	5911.0	11.5	5899.5
AGW B-19	5924.0	15.0	5909.0
AGW B-20	5945.0	21.0	5924.0
AGW B-21	5934.0	4.5	5929.5
AGW B-22	5908.0	0.5	5907.5
AGW B-23	5903.0	4.5	5898.5
AGW B-24	5891.0	9.0	5882.0
AGW B-25	5918.0	8.0	5910.0
AGW B-26	5929.0	6.0	5923.0
AGW B-27	5919.0	9.0	5910.0

Table 1

SUMMARY OF BEDROCK SURFACE ELEVATIONS

South Academy Highlands
El Paso County, Colorado
Page 3

Boring No.	Surface Elevation, ft.	Depth to Bedrock, ft.	Top of Bedrock Elevation, ft.
AGW B-28	5897.0	2.5	5894.5
AGW B-29	5919.0	2.5	5916.5
AGW B-30	5926.0	11.0	5915.0
AGW B-31	5931.0	3.0	5928.0
AGW B-32	5917.0	2.5	5914.5
AGW B-33	5884.0	2.0	5882.0
AGW B-34	5917.0	4.0	5913.0
AGW B-35	5878.0	2.0	5876.0
AGW B-36	5897.0	11.0	5886.0
AGW B-37	5948.0	12.0	5936.0
AGW B-38	5908.0	0.0	5908.0
AGW B-39	5873.0	0.0	5873.0
AGW B-40	5935.0	12.0	5923.0
AGW B-41	5924.0	12.0	5912.0
AGW B-42	5884.0	1.0	5883.0
AGW B-43	5887.0	0.0	5887.0
AGW B-44	5885.0	2.0	5883.0
AGW B-45	5935.0	11.0	5924.0
AGW B-46	5880.0	3.5	5876.5
AGW B-47	5846.0	2.0	5844.0
AGW B-48	5861.0	2.5	5858.5
AGW B-49	5876.0	4.0	5872.0
AGW B-50	5852.0	1.0	5851.0
AGW B-51	5833.0	1.5	5831.5
AGW B-52	5844.0	3.0	5841.0
AGW B-53	5841.0	2.5	5838.5
AGW B-54	5833.0	3.0	5830.0
AGW B-55	5814.0	3.0	5811.0
AGW B-56	5801.0	12.5	5788.5
AGW B-57	5798.0	3.0	5795.0
AGW B-58	5823.0	2.5	5820.5
AGW B-59	5834.0	6.0	5828.0
AGW B-60	5836.0	8.0	5828.0
AGW B-61	5842.0	11.5	5830.5

Table 1

SUMMARY OF BEDROCK SURFACE ELEVATIONS

South Academy Highlands
El Paso County, Colorado
Page 4

Boring No.	Surface Elevation, ft.	Depth to Bedrock, ft.	Top of Bedrock Elevation, ft.
AGW B-62	5849.0	20.0	5829.0
AGW B-63	5851.0	13.5	5837.5
AGW B-64	5847.0	>20	NA
AGW B-65	5856.0	>15	NA
AGW B-66	5822.0	11.5	5810.5
AGW B-67	5833.0	NA	NA
AGW B-68	5852.0	>15	NA
AGW B-69	5843.0	4.0	5839.0
AGW B-70	5833.0	7.5	5825.5
AGW B-71	5841.0	17.0	5824.0
AGW B-101	5845.0	12.0	5833.0
AGW B-102	5847.0	5.0	5842.0
AGW B-103	5855.0	3.0	5852.0
AGW B-104	5859.0	8.0	5851.0
AGW B-105	5876.0	2.5	5873.5
AGW B-106	5877.0	4.0	5873.0
AGW B-107	5868.0	21.0	5847.0
AGW B-108	5865.0	20.0	5845.0
AGW B-109	5848.0	12.0	5836.0
KL B-1	5866.0	14.0	5852.0
KL B-2	5880.0	0.0	5880.0
KL B-3	5905.0	34.0	5871.0
KL B-4	5904.0	24.0	5880.0
KL P-1	5923.0	9.5	5913.5
KL P-2	5926.0	9.0	5917.0
KL B-1	5823.0	2.5	5820.5
KL B-2	5848.0	2.5	5845.5
KL B-3	5872.0	3.0	5869.0
KL P-1	5894.0	2.0	5892.0
KL P-2	5920.0	24.0	5896.0
KL P-3	5898.0	>5	NA
AGW A-1	5889.0	2.0	5887.0
AGW A-2	5904.0	9.0	5895.0
AGW A-3	5875.0	33.0	5842.0

Table 1

SUMMARY OF BEDROCK SURFACE ELEVATIONS

South Academy Highlands
El Paso County, Colorado
Page 5

Boring No.	Surface Elevation, ft.	Depth to Bedrock, ft.	Top of Bedrock Elevation, ft.
AGW A-4	5867.0	15.0	5852.0
AGW A-5	5865.0	32.0	5833.0
AGW A-6	5851.0	17.0	5834.0
AGW A-7	5826.0	4.0	5822.0
AGW B-1	5913.0	6.0	5907.0
AGW B-2	5890.0	15.0	5875.0
AGW B-3	5876.0	13.0	5863.0
AGW B-4	5864.0	12.0	5852.0
AGW B-5	5854.0	9.0	5845.0
AGW B-6	5849.0	3.0	5846.0
AGW B-7	5842.0	11.0	5831.0
AGW B-8	5831.0	14.0	5817.0
AGW B-9	5824.0	10.0	5814.0
AGW B-10	5814.0	6.0	5808.0
AGW C-1	5864.0	8.0	5856.0
AGW C-2	5851.0	11.0	5840.0
AGW C-3	5839.0	11.0	5828.0
AGW C-4	5835.0	3.0	5832.0
AGW C-5	5831.0	7.0	5824.0
AGW C-6	5823.0	31.0	5792.0
AGW C-7	5818.0	20.0	5798.0
AGW C-8	5812.0	44.0	5768.0
AGW C-9	5806.0	48.0	5758.0
AGW D-1	5875.0	12.0	5863.0
AGW D-2	5866.0	1.0	5865.0
AGW D-3	5859.0	3.0	5856.0
AGW D-4	5844.0	1.0	5843.0
AGW D-5	5829.0	4.0	5825.0
AGW D-6	5817.0	3.0	5814.0
AGW D-7	5809.0	1.0	5808.0
AGW D-8	5803.0	43.0	5760.0
AGW D-9	5800.0	51.0	5749.0
AGW B-101	5907.0	12.0	5895.0
AGW B-102	5852.0	2.0	5850.0

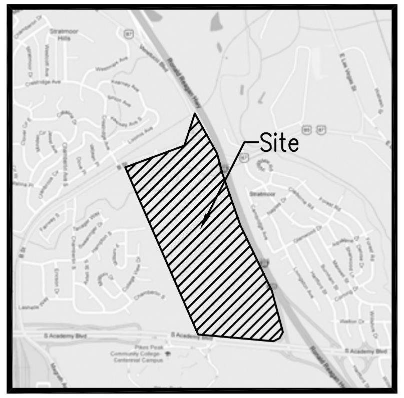
Table 1

SUMMARY OF BEDROCK SURFACE ELEVATIONS

South Academy Highlands
El Paso County, Colorado
Page 6

Boring No.	Surface Elevation, ft.	Depth to Bedrock, ft.	Top of Bedrock Elevation, ft.
AGW B-103	5843.0	3.0	5840.0
AGW B-104	5816.0	9.0	5807.0
AGW B-105	5810.0	50.0	5760.0
AGW B-106	5800.0	34.0	5766.0
AGW W-1	5930.0	22.0	5908.0
AGW W-2	5938.0	8.0	5930.0
AGW W-3	5933.0	4.0	5929.0
MT B-1	5792.0	23.0	5769.0
MT B-2	5799.0	13.0	5786.0
MT B-3	5790.0	28.0	5762.0
MT B-4	5798.0	28.0	5770.0
MT B-5	5819.0	6.0	5813.0
MT B-6	5820.0	0.0	5820.0
MT B-7	5799.0	25.0	5774.0
MT B-8	5816.0	8.0	5808.0
MT B-9	5834.0	3.0	5831.0
MT B-10	5850.0	0.0	5850.0
MT B-11	5908.0	8.0	5900.0
MT B-12	5915.0	6.0	5909.0
MT B-13	5917.0	6.0	5911.0

NOTES
1) See Figure 1 for locations of borings.
2) Ground surface elevations reference mean sea level (msl) datum.
3) Depth to bedrock is below existing ground surface.
4) Boring number designation "AGW" indicates A.G. Wassenaar.
5) Boring number designation "ENT" indicates Entech.
6) Boring number designation "KL" indicates Kleinfelder.
7) Boring number designation "MT" indicates Midwest Testing.



LOCATION MAP
(NOT TO SCALE)

Scale: 1"=400'

LEGEND

⊕ MT Feb. 2013 boring location

⊕ Kleinfelder Nov. 2012 boring location

⊕ Kleinfelder Sept. 2012 boring location

⊕ AGW 2012 boring location

⊕ Entech Apr./June 2008 boring location

⊕ AGW Apr./May 2008 boring location

⊕ Kleinfelder Mar. 2008 boring location

⊕ 2006 boring location by others

⊕ 2006 boring location by others

THIS SHEET IN COLOR

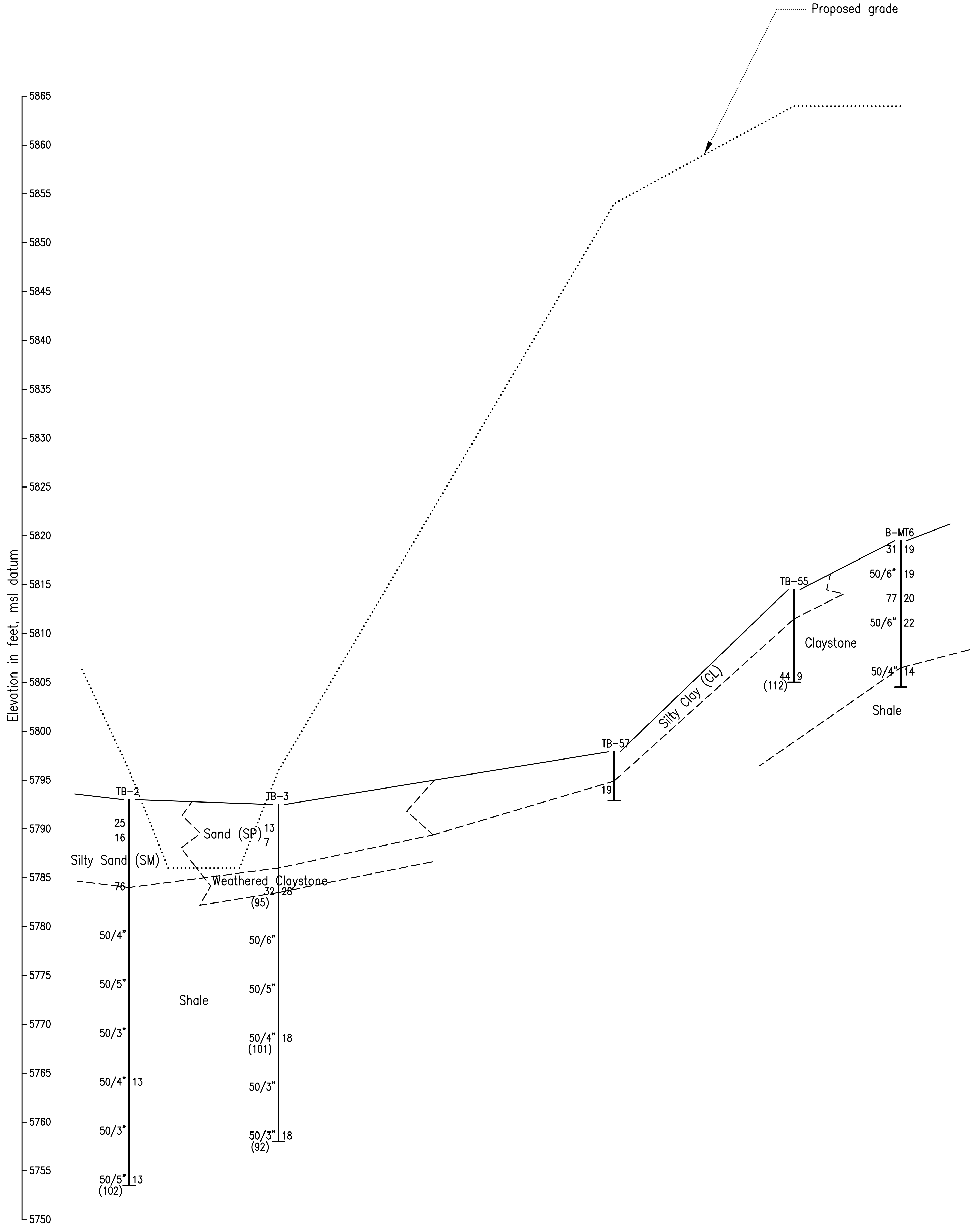
The civil information depicted hereon was supplied by Classic Consulting Engineers & Surveyors via email on 3-1-13. This information was used for the sole purpose of showing boring and/or test pit locations, and other geotechnical-related items as may be discussed in the text of this report. Midwest Testing and the engineer signing and sealing this report assume no responsibility or liability for the accuracy of this information, including, but not limited to, existing and proposed topography, infrastructure, and improvements. Our use of this information does not constitute our endorsement or approval of this plan.

13173

BORING PLAN
South Academy Highlands
El Paso County, Colorado

Figure 1

SECTION A–A



NOTES
1) See Figure 1 for location of section.
2) See Figure 12 for legend.

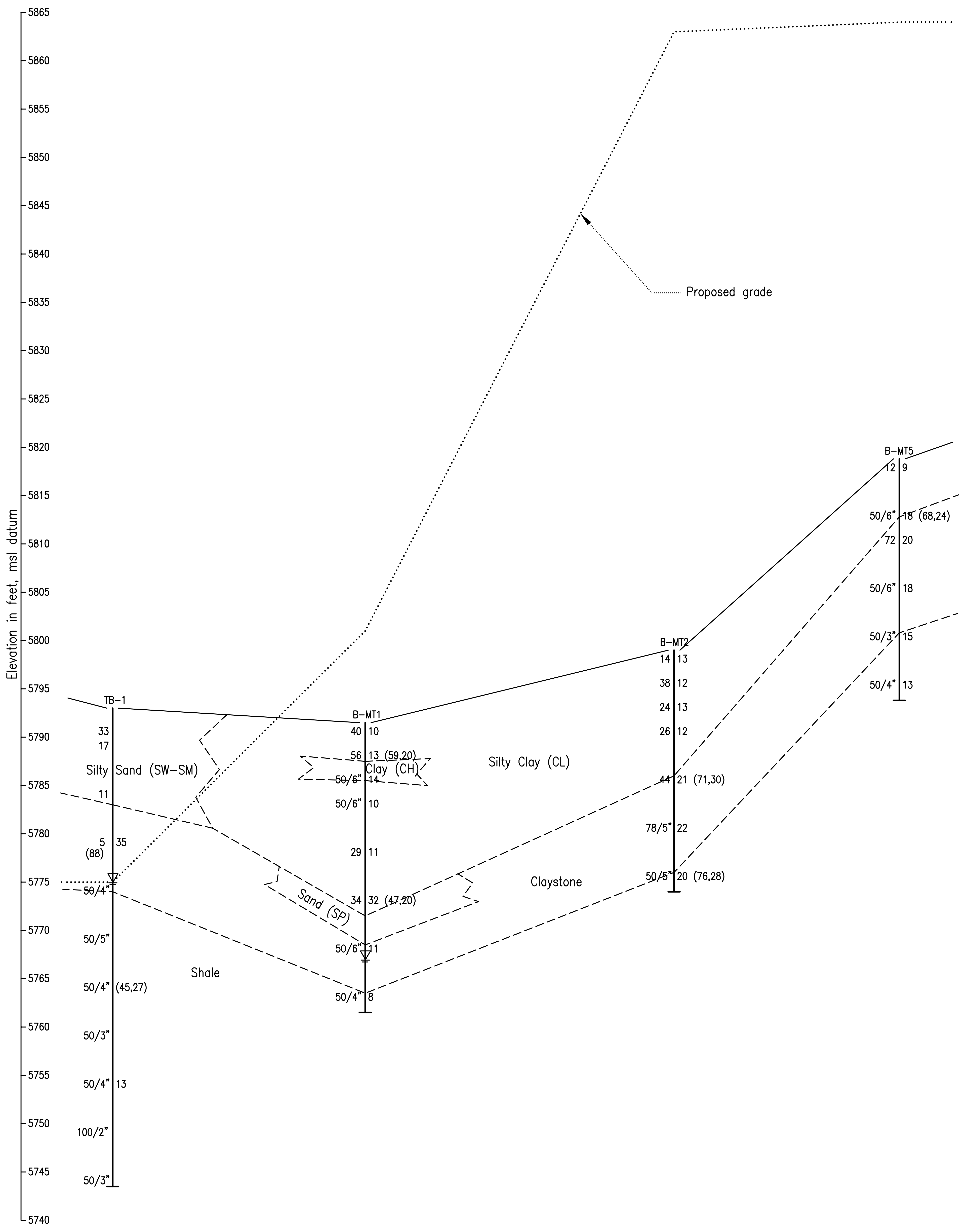
SCALES
Horizontal: 1" = 80'
Vertical: 1" = 10'

GENERALIZED SOIL & ROCK PROFILE
South Academy Highlands
El Paso County, Colorado

Figure 2

13173

SECTION B-B



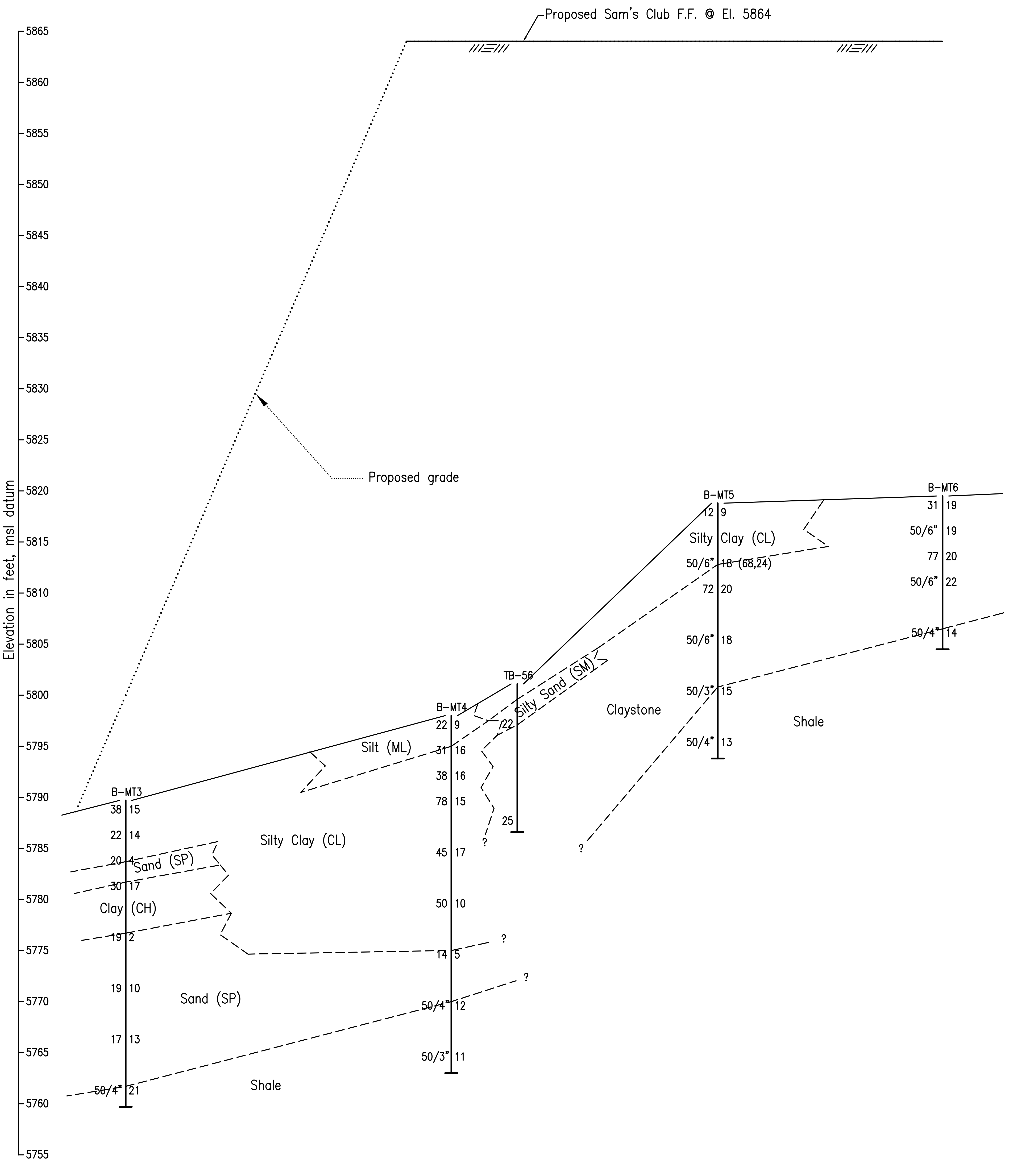
NOTES
1) See Figure 1 for location of section.
2) See Figure 12 for legend.

SCALES
Horizontal: 1" = 60'
Vertical: 1" = 10'

GENERALIZED SOIL & ROCK PROFILE
South Academy Highlands
El Paso County, Colorado

Figure 3

SECTION C-C



NOTES

1) See Figure 1 for location of section.
2) See Figure 12 for legend.

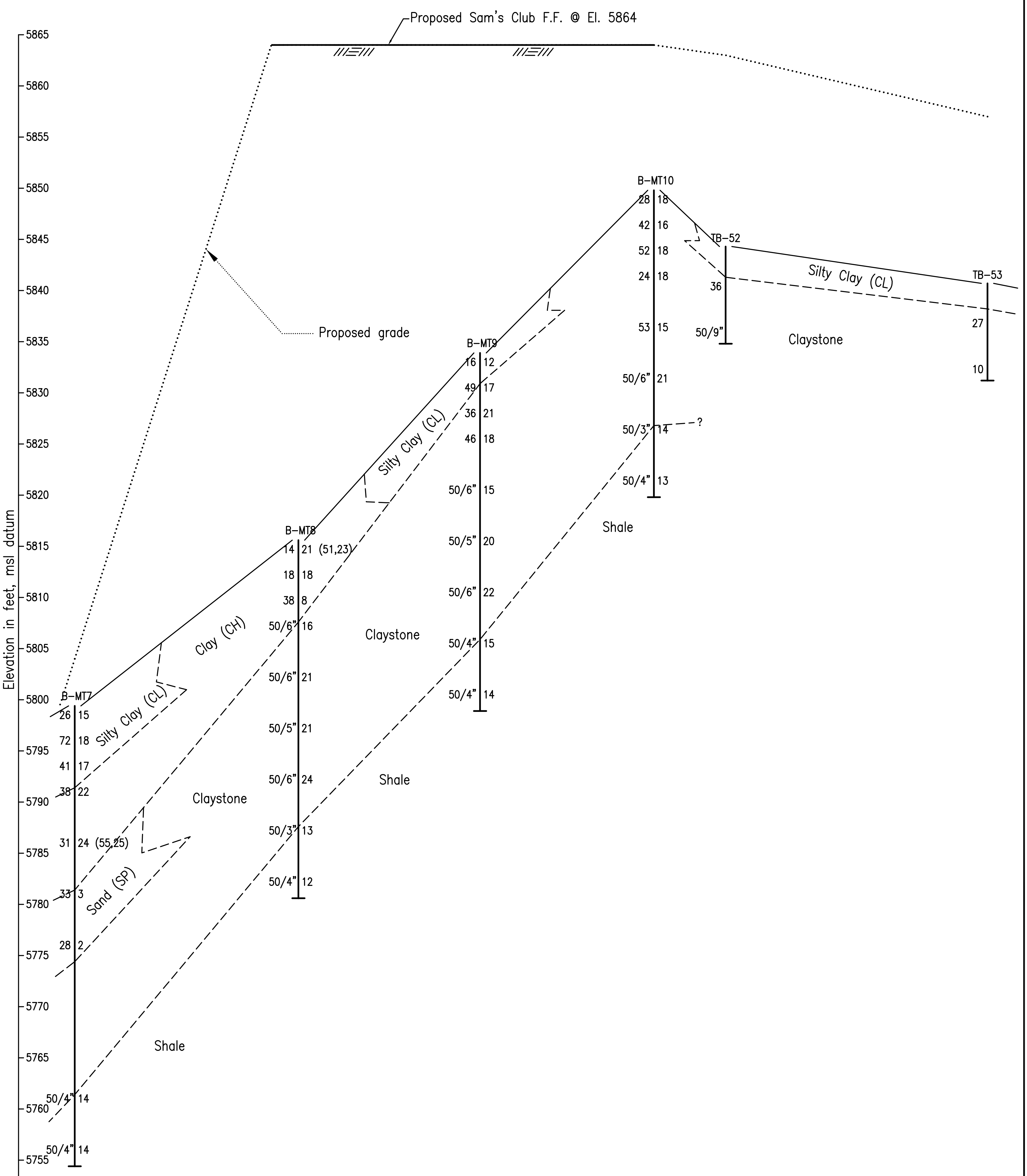
SCALES

Horizontal: 1" = 70'
Vertical: 1" = 10'

GENERALIZED SOIL & ROCK PROFILE
South Academy Highlands
El Paso County, Colorado

Figure 4

SECTION D–D



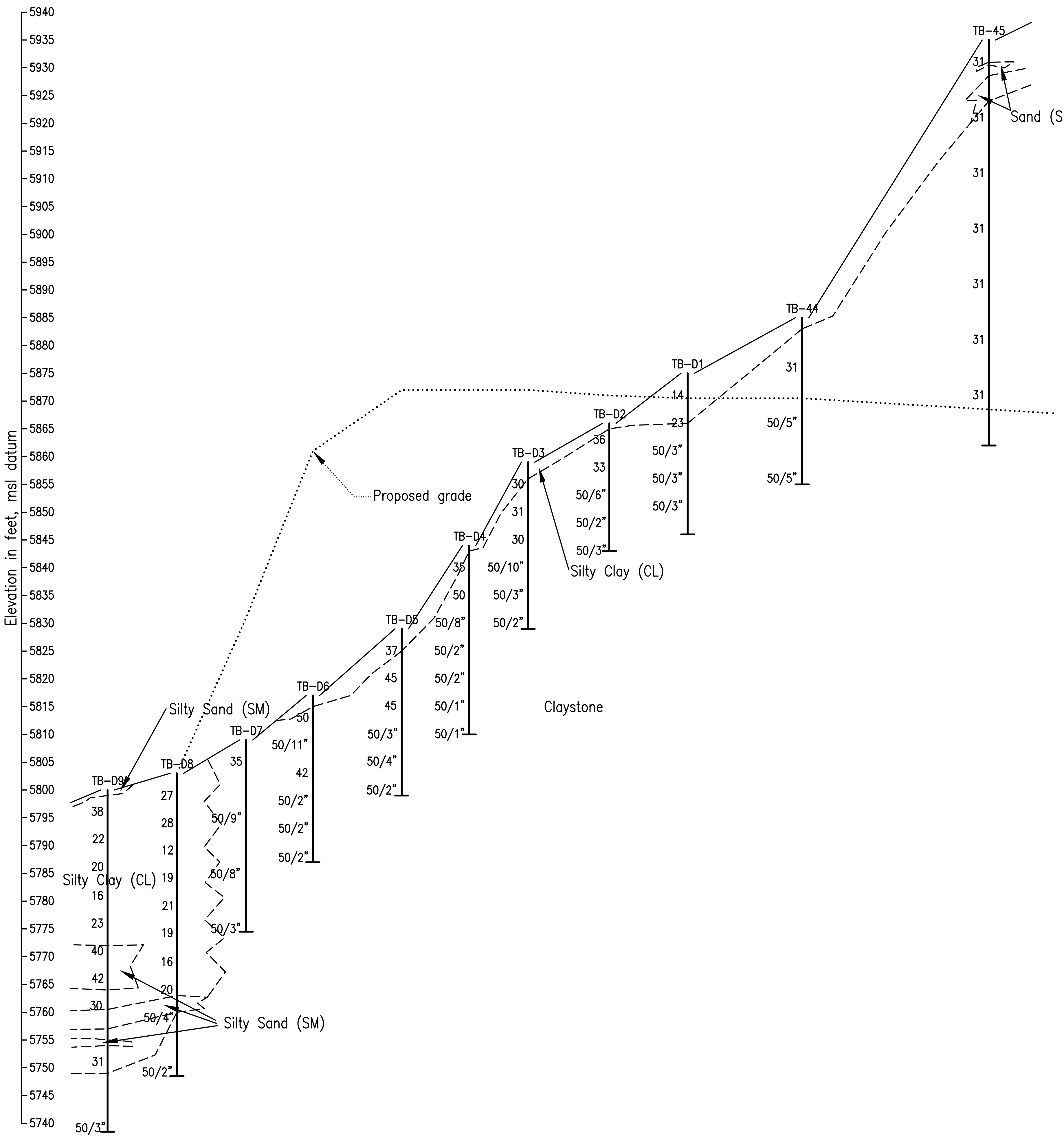
NOTES
1) See Figure 1 for location of section.
2) See Figure 12 for legend.

SCALES
Horizontal: 1" = 100'
Vertical: 1" = 10'

GENERALIZED SOIL & ROCK PROFILE
South Academy Highlands
El Paso County, Colorado

Figure 5

SECTION E–E



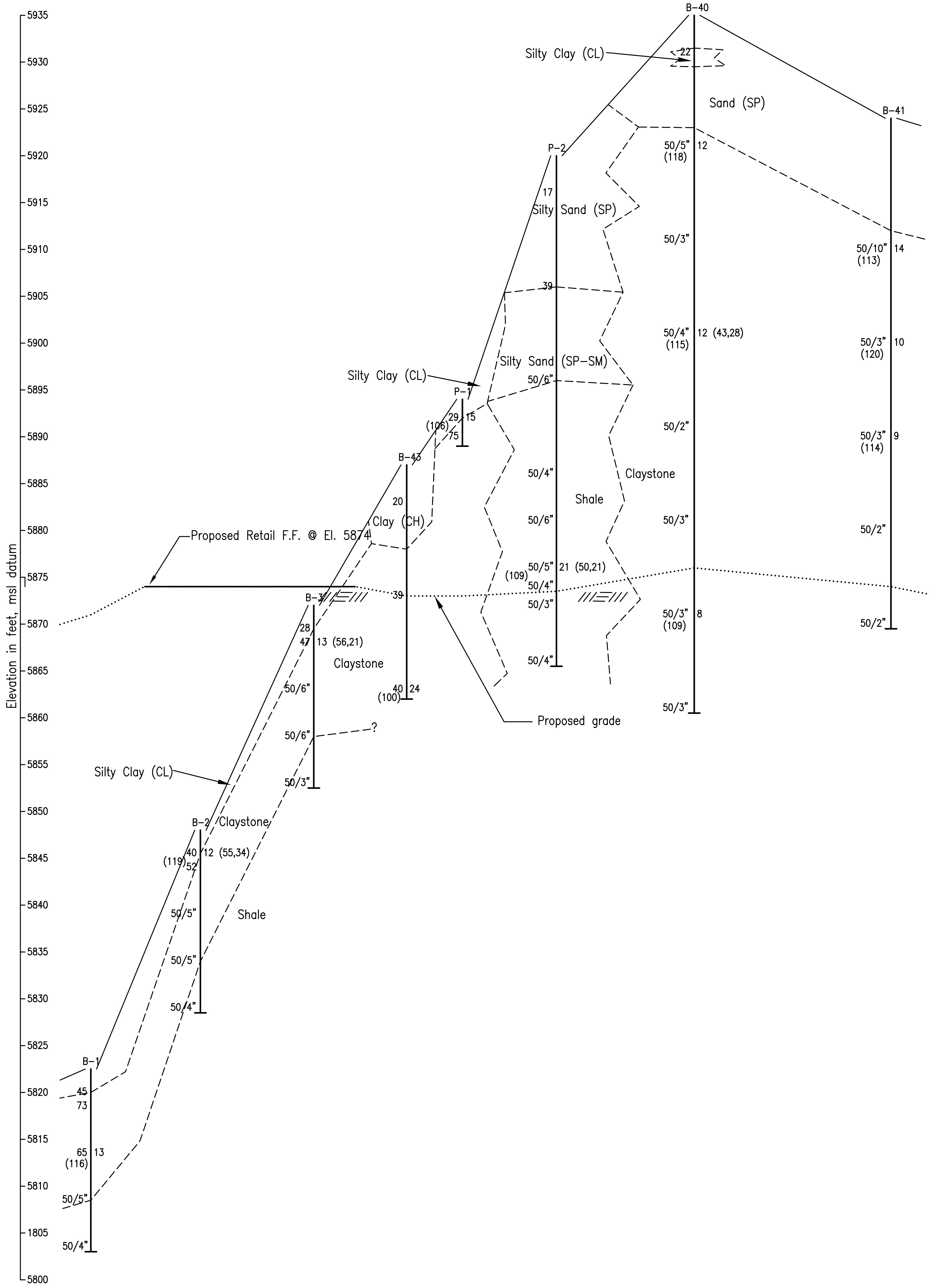
NOTES
1) See Figure 1 for location of section.
2) See Figure 12 for legend.

SCALES
Horizontal: 1" = 150'
Vertical: 1" = 20'

GENERALIZED SOIL & ROCK PROFILE
South Academy Highlands
El Paso County, Colorado

Figure 6

SECTION F-F



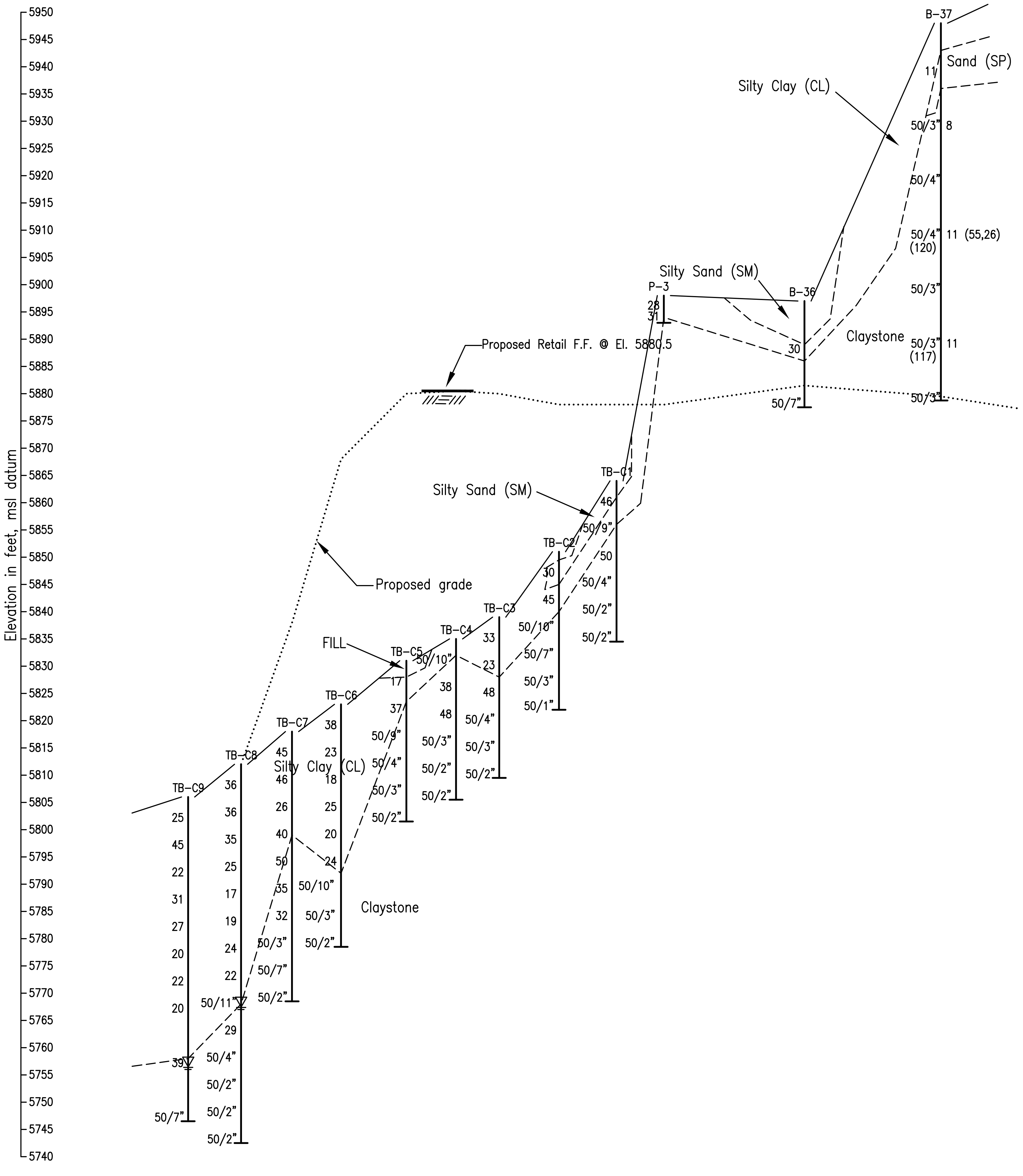
NOTES
1) See Figure 1 for location of section.
2) See Figure 12 for legend.

SCALES
Horizontal: 1" = 120'
Vertical: 1" = 10'

GENERALIZED SOIL & ROCK PROFILE
South Academy Highlands
El Paso County, Colorado

Figure 7

SECTION G-G

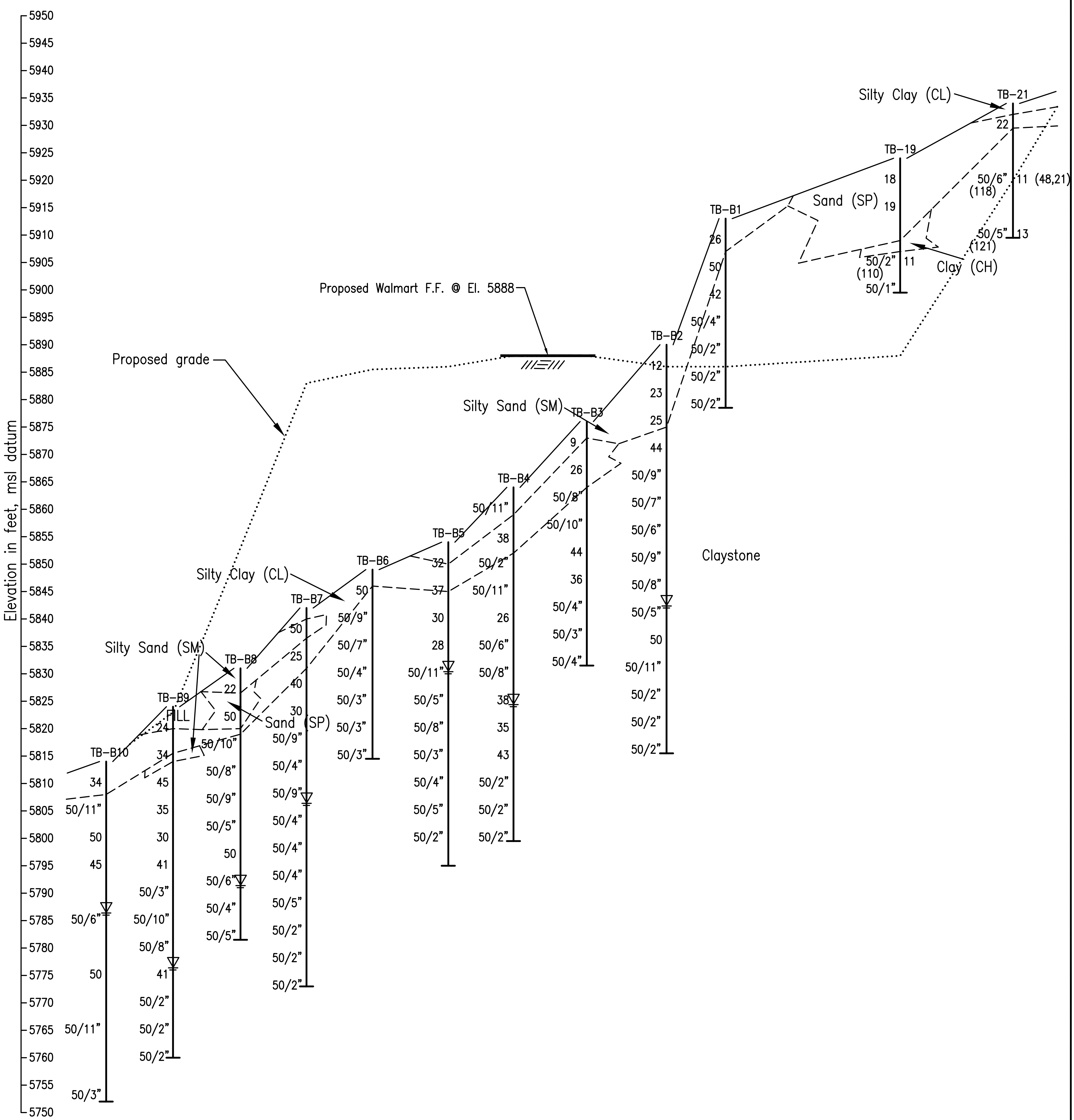


NOTES
1) See Figure 1 for location of section.
2) See Figure 12 for legend.

SCALES
Horizontal: 1" = 200'
Vertical: 1" = 20'

GENERALIZED SOIL & ROCK PROFILE
South Academy Highlands
El Paso County, Colorado

SECTION H-H



NOTES
1) See Figure 1 for location of section.
2) See Figure 12 for legend.

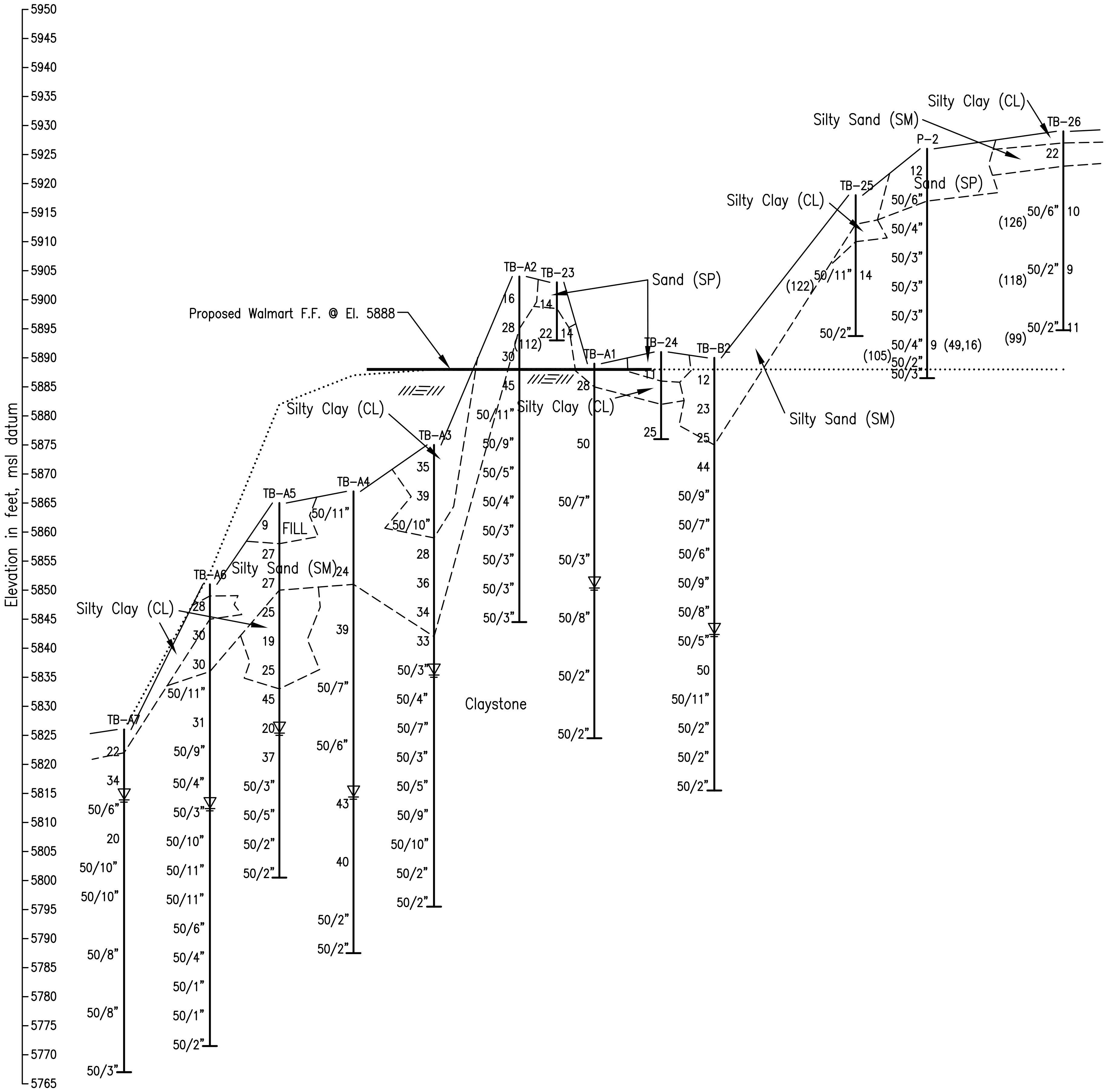
SCALES
Horizontal: 1" = 150'
Vertical: 1" = 20'

GENERALIZED SOIL & ROCK PROFILE
South Academy Highlands
El Paso County, Colorado

Figure 9

13173

SECTION I-I



NOTES
1) See Figure 1 for location of section.
2) See Figure 12 for legend.

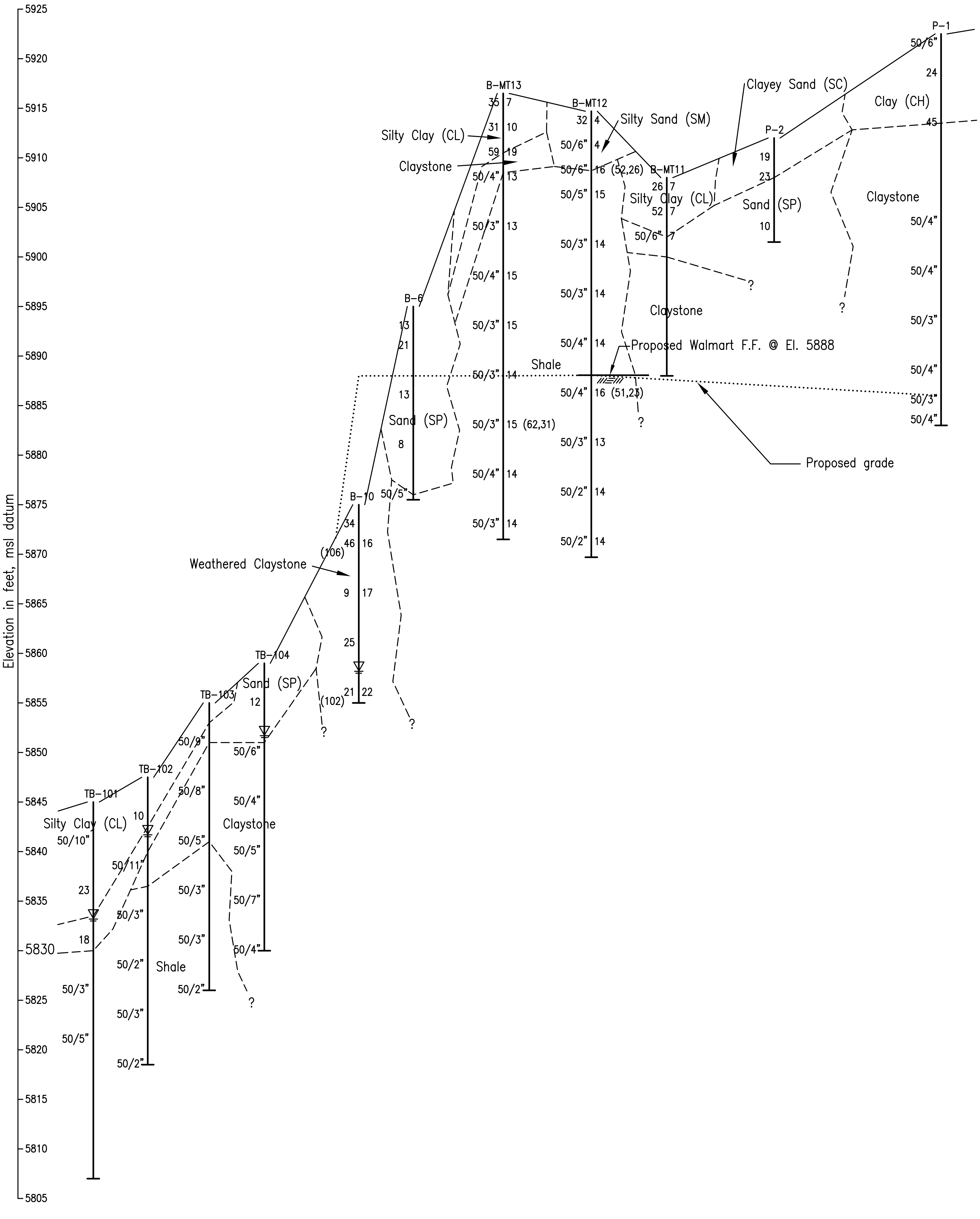
SCALES
Horizontal: 1" = 150'
Vertical: 1" = 20'

GENERALIZED SOIL & ROCK PROFILE
South Academy Highlands
El Paso County, Colorado

Figure 10

13173

SECTION J–J

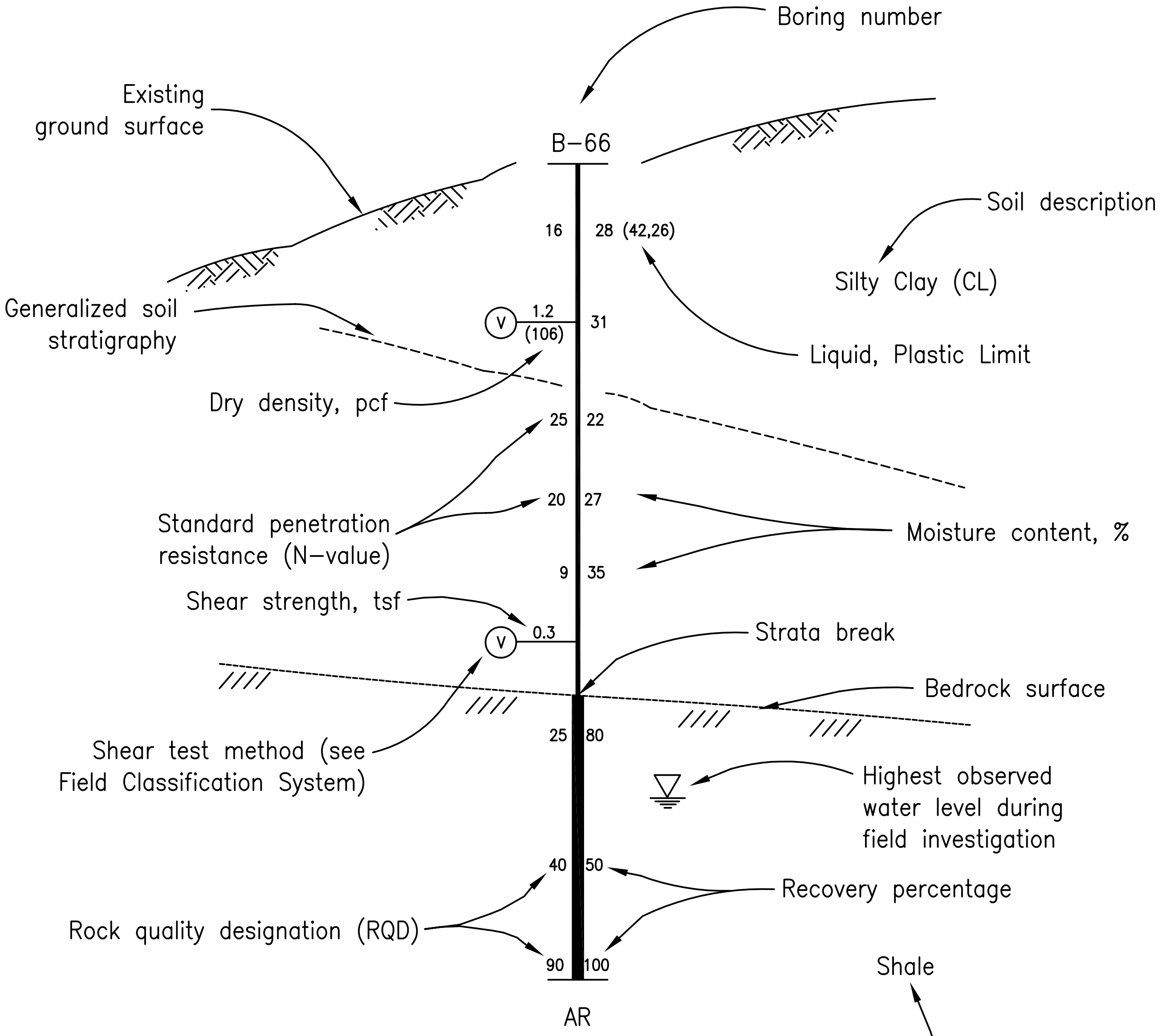


NOTES
1) See Figure 1 for location of section.
2) See Figure 12 for legend.

SCALES
Horizontal: 1" = 200'
Vertical: 1" = 10'

GENERALIZED SOIL & ROCK PROFILE
South Academy Highlands
Colorado Springs, Colorado

Figure 11



NOTE

1) This is an example and does not represent an actual boring drilled at the site.

2) AR = auger refusal

3) Heavier boring line indicates zone of rock coring.

4) Numbers to the left of rock coring zone indicate rock coring quality designations (RQD); numbers to the right indicate recovery percentages.

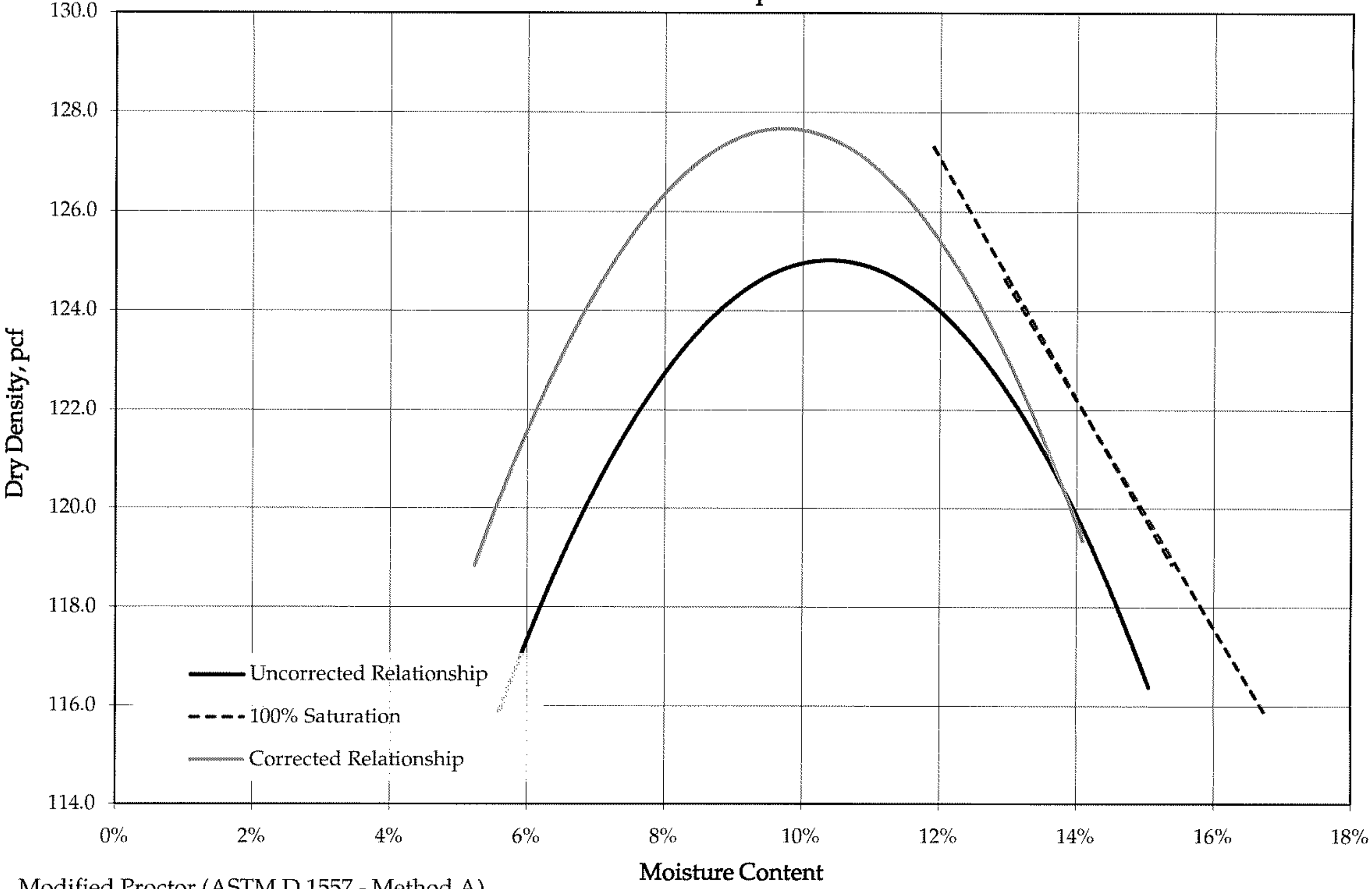
NOT TO SCALE

151/3

SOIL & ROCK PROFILE LEGEND
South Academy Highlands
El Paso County, Colorado

Figure 12

Brown Sandy Clay (CH) with some gravel
Bulk Sample



Modified Proctor (ASTM D 1557 - Method A)

Cγd (max.)	127.7 pcf
CWopt	9.7%
CW (range)	5.9%-13.6%

Liquid Limit	51%
Plastic Limit	22%
Plasticity Index	29%
#200 Sieve-Retained	N/A

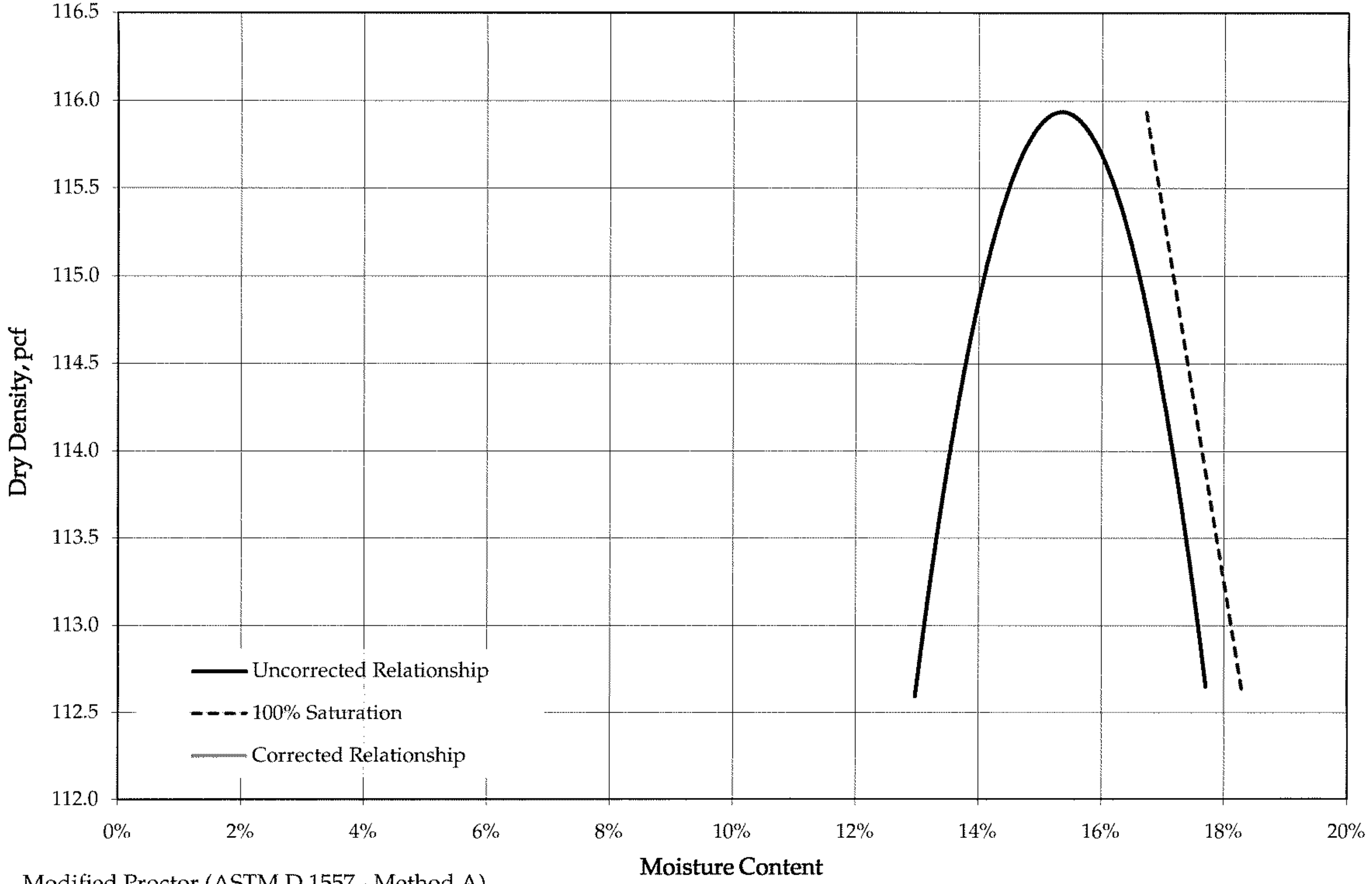
MOISTURE-DENSITY RELATIONSHIP
South Academy Highlands
El Paso County, Colorado

Notes: Performed using dry preparation with mechanical rammer. Specific gravity of 2.7 for zero air voids curve was assumed. The No. 4 sieve retained 8 percent of the sample.

Midwest Testing™

Figure 13

Claystone
B-9 and B-10



Modified Proctor (ASTM D 1557 - Method A)

γd (max.)	115.9 pcf
Wopt	15.3%
W (range)	12.2%-18.5%

Liquid Limit	77%
Plastic Limit	27%
Plasticity Index	50%
#200 Sieve-Retained	N/A

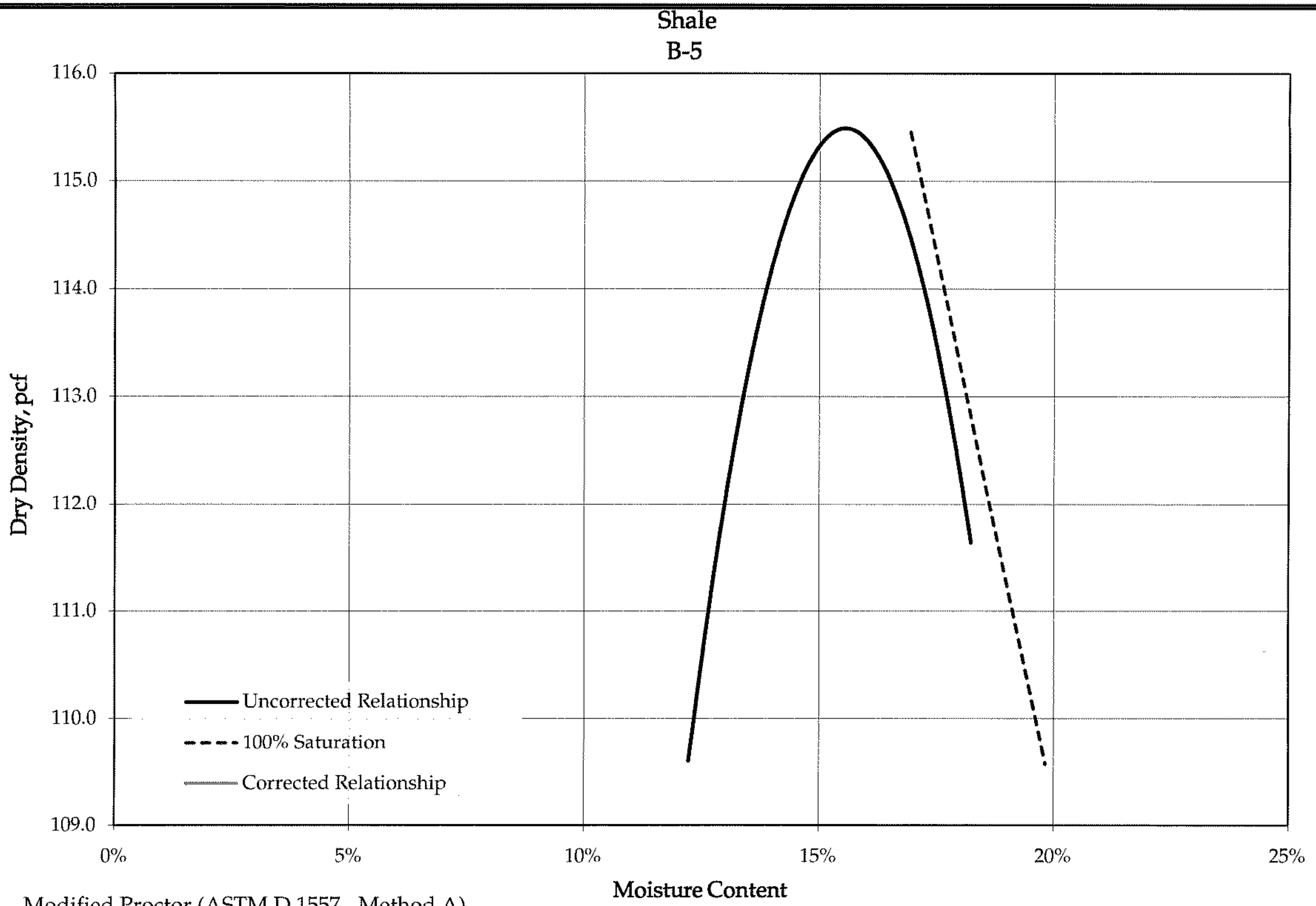
MOISTURE-DENSITY RELATIONSHIP

South Academy Highlands
El Paso County, Colorado

Midwest Testing

Notes: Performed using dry preparation with mechanical rammer. Specific gravity of 2.7 for zero air voids curve was assumed. The No. 4 sieve was not used to separate the sample.

Figure 14



Modified Proctor (ASTM D 1557 - Method A)

γd (max.)	115.5 pcf
Wopt	15.6%
W (range)	12.3%-18.8%

Liquid Limit	77%
Plastic Limit	26%
Plasticity Index	51%
#200 Sieve-Retained	N/A

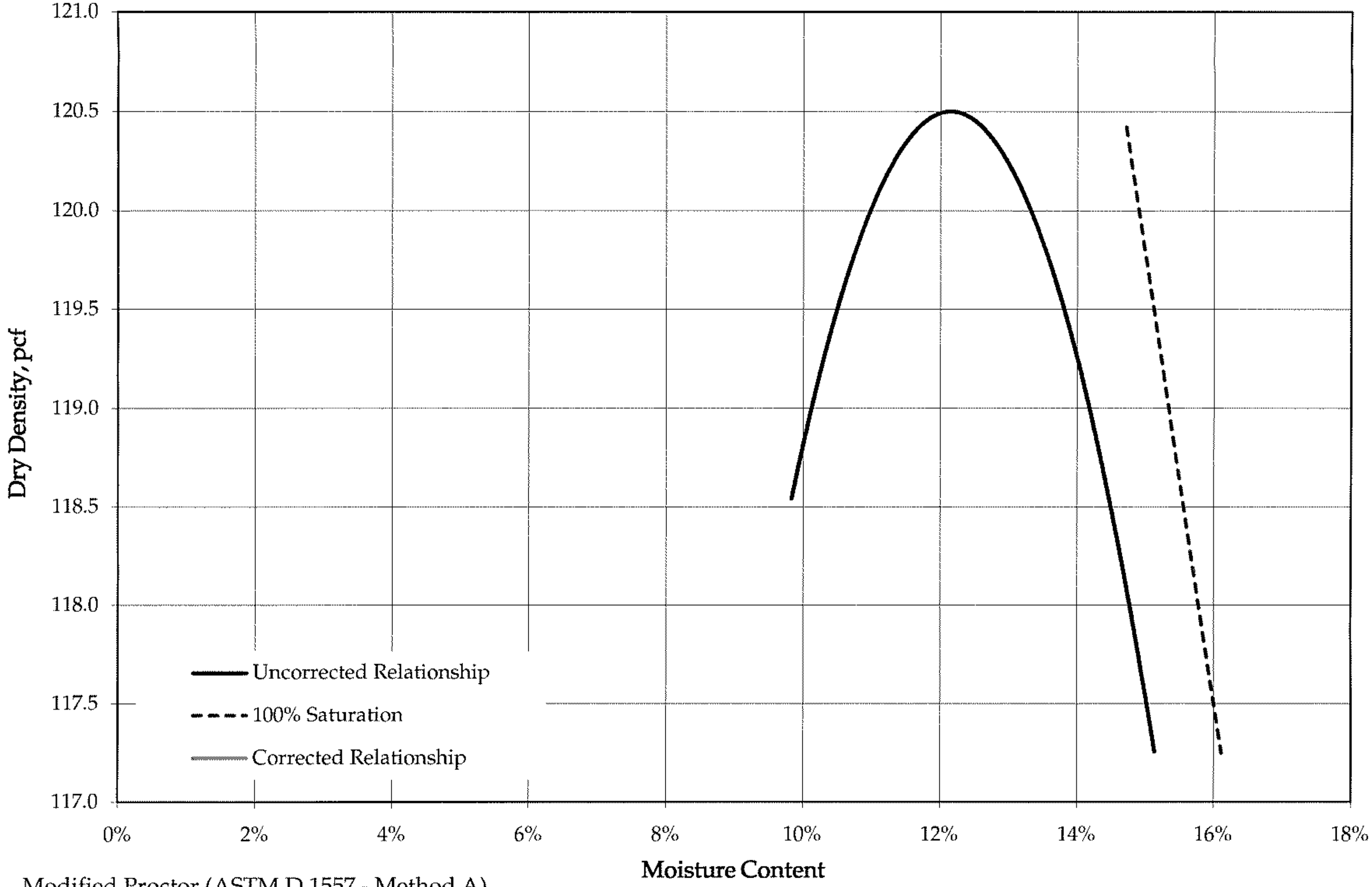
MOISTURE-DENSITY RELATIONSHIP
South Academy Highlands
El Paso County, Colorado

Notes: Performed using dry preparation with mechanical rammer. Specific gravity of 2.7 for zero air voids curve was assumed. The No. 4 sieve was not used to separate the sample.

Midwest Testing™

Figure 15

Shale
B-12



Modified Proctor (ASTM D 1557 - Method A)

γd (max.)	120.5 pcf
Wopt	12.2%
W (range)	8.1%-16.2%

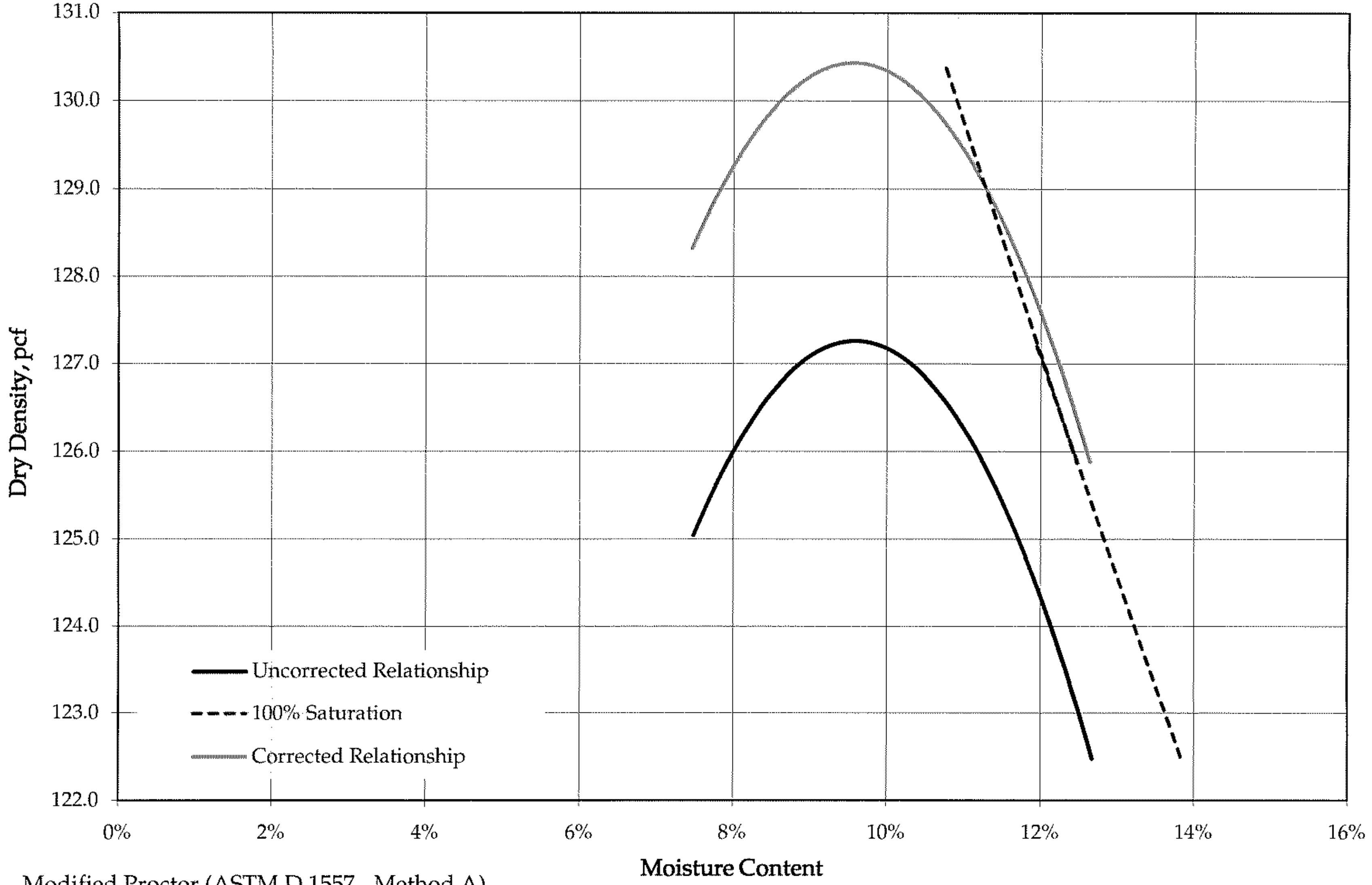
Liquid Limit	62%
Plastic Limit	25%
Plasticity Index	37%
#200 Sieve-Retained	N/A

MOISTURE-DENSITY RELATIONSHIP
South Academy Highlands
El Paso County, Colorado

Notes: Performed using dry preparation with mechanical rammer. Specific gravity of 2.7 for zero air voids curve was assumed. The No. 4 sieve was not used to separate the sample.

Midwest Testing™

Figure 16



Claystone
B-12 & 13

Modified Proctor (ASTM D 1557 - Method A)

Cγd (max.)	130.4 pcf
CWopt	9.6%
CW (range)	5.9%-13.3%

Liquid Limit	42%
Plastic Limit	19%
Plasticity Index	13%
#200 Sieve-Retained	N/A

MOISTURE-DENSITY RELATIONSHIP

South Academy Highlands
El Paso County, Colorado

Notes: Performed using dry preparation with mechanical rammer. Specific gravity of 2.7 for zero air voids curve was assumed. The No. 4 sieve retained 9.9 percent of the sample.

Midwest Testing

Figure 17

Midwest Testing

Direct Shear Test (ASTM D3080)

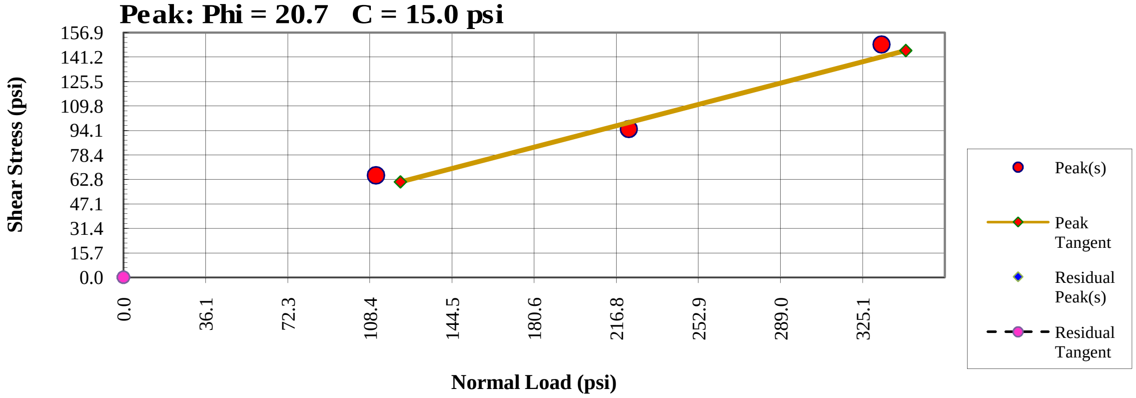
Date

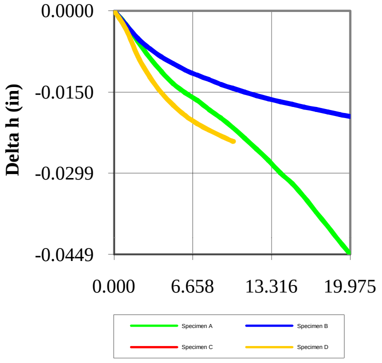
Checked By

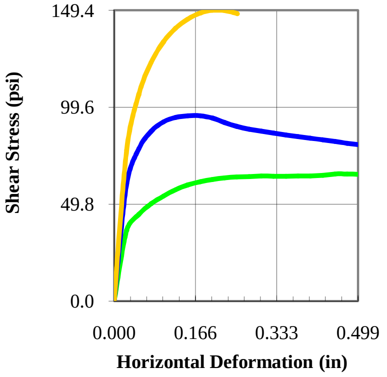
Date

Date

Tested By







Initial	Specimen A	B	C	D
Moisture (%)	15.40	15.40		15.40
Density (pcf)	110.18	110.18		110.18
Void Ratio	0.502	0.502		0.502
Saturation (%)	81.37	81.37		81.37
Diameter (in)	2.500	2.500		2.500
Height (in)	1.000	1.000		1.000

Final	A	B	C	D
Moisture (%)				
Density (pcf)				
Void Ratio				
Saturation (%)				
Diameter (in)				
Height (in)				
Normal Stress (psi)	111.1	222.2		333.3
Peak Stress (psi)	65.3	95.1		149.4
Residual Stress (psi)				
Strain (%)	18.080	19.962		8.036
Rate (in/min)	0.0055	0.0055		0.0055

Project Date
Date

Project:	South Academy Highlands
Location:	El Paso County, Colorado
Project Number:	13173
Boring Number	5
Sample Number:	
Depth:	
Sample Type:	Undisturbed
Description:	Shale
Test Type:	Direct Shear
Remarks:	Remolded sample to approximately 95 percent modified Proctor maximum dry density

N/A	N/A	N/A	N/A
Failure Photographs			

Figure 18

Midwest Testing

Direct Shear Test (ASTM D3080)

Date

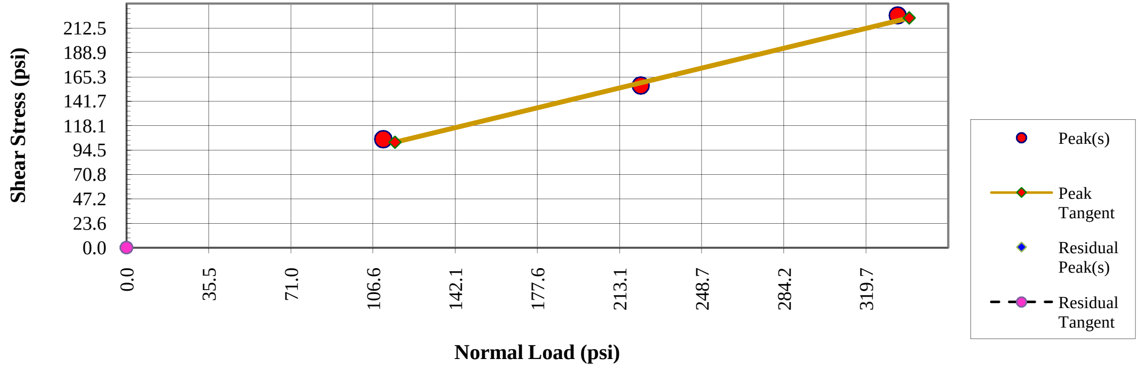
Checked By

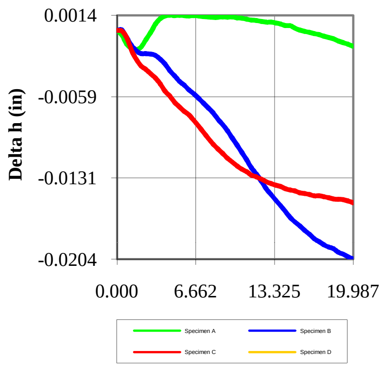
Date

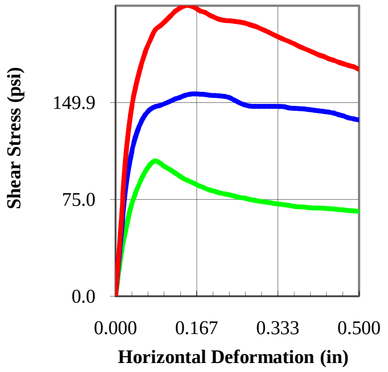
Date

Tested By

Peak: Phi = 28.4 C = 39.1 psi







	Specimen			
Initial	**A**	**B**	**C**	**D**
Moisture (%)	12.12	12.12	12.12	
Density (pcf)	118.94	118.94	118.94	
Void Ratio	0.391	0.391	0.391	
Saturation (%)	82.18	82.18	82.18	
Diameter (in)	2.500	2.500	2.500	
Height (in)	1.000	1.000	1.000	

Final	**A**	**B**	**C**	**D**
Moisture (%)				
Density (pcf)				
Void Ratio				
Saturation (%)				
Diameter (in)				
Height (in)				
Normal Stress (psi)	111.1	222.2	333.3	
Peak Stress (psi)	104.6	156.7	224.9	
Residual Stress (psi)				
Strain (%)	19.987	19.962	19.987	
Rate (in/min)	0.0055	0.0055	0.0055	

Project Date	
Date	

Project:	South Academy Highlands
Location:	El Paso County, Colorado
Project Number:	13173
Boring Number	12
Sample Number:	
Depth:	
Sample Type:	Remolded
Description:	Shale
Test Type:	Direct Shear
Remarks:	Remolded sample to approximately 95 percent modified Proctor maximum dry density

N/A	N/A	N/A	N/A
Failure Photographs			

Figure 19

Midwest Testing

Direct Shear Test (ASTM D3080)

Midwest Testing

Date

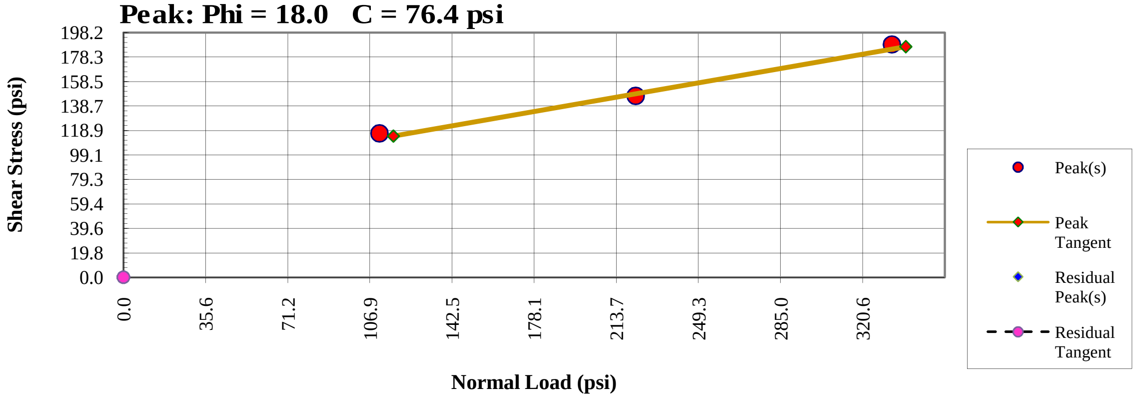
Checked By

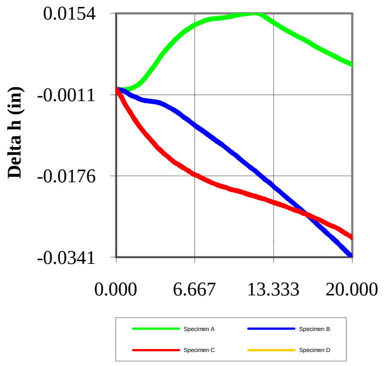
Date

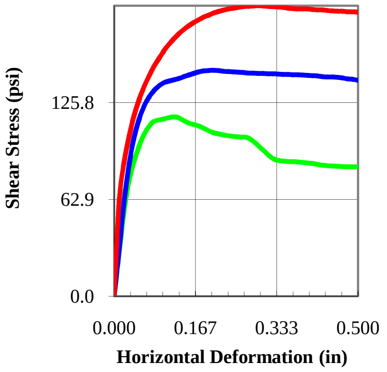
Date

Tested By

Peak: Phi = 18.0 C = 76.4 psi







Initial	Specimen A	B	C	D
Moisture (%)	9.54	9.54	9.54	
Density (pcf)	120.95	120.95	120.95	
Void Ratio	0.368	0.368	0.368	
Saturation (%)	68.75	68.75	68.75	
Diameter (in)	2.500	2.500	2.500	
Height (in)	1.000	1.000	1.000	

Final	A	B	C	D
Moisture (%)	0.00	0.00	0.00	
Density (pcf)	-84.82	-84.82	-84.82	
Void Ratio	-2.950	-2.950	-2.950	
Saturation (%)	0.00	0.00	0.00	
Diameter (in)	2.500	2.500	2.500	
Height (in)	0.986	0.986	0.986	
Normal Stress (psi)	111.1	222.2	333.3	
Peak Stress (psi)	116.4	146.8	188.7	
Residual Stress (psi)				
Strain (%)	20.000	19.975	19.975	
Rate (in/min)	0.0055	0.0055	0.0055	

Project Date
Date

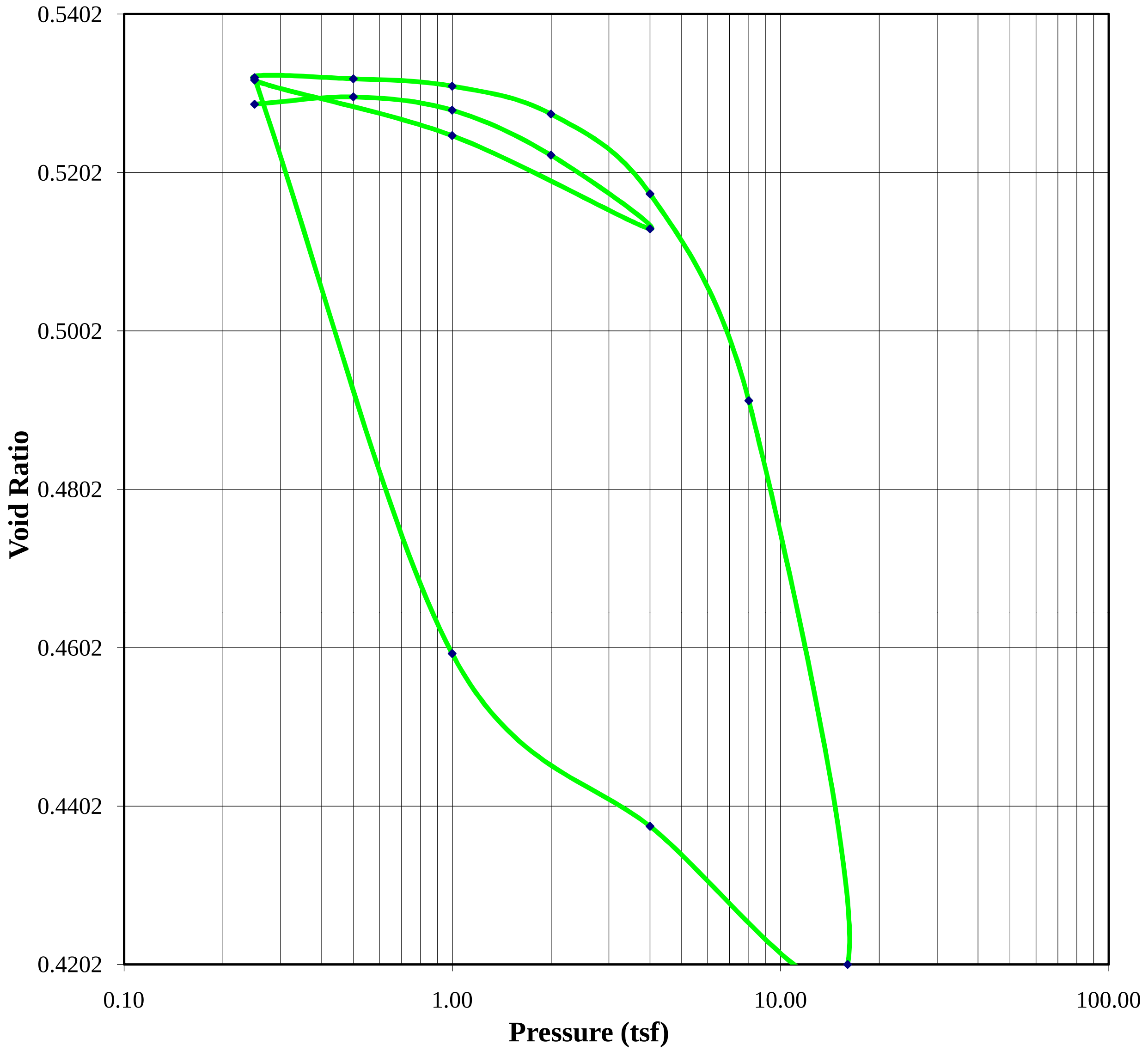
Project: South Academy Highlands
Location: El Paso County, Colorado
Project Number: 13173
Boring Number 12 & 13
Sample Number:
Depth:
Sample Type: Remolded

N/A	N/A	N/A	N/A
Failure Photographs			

Description: Claystone
Test Type: Direct Shear
Remarks: Remolded sample to approximately 95 percent modified Proctor maximum dry density

Consolidation Test

Test Results



	Before	After			
	Before	**After**	**Liquid Limits:**	77	**Test Date:**
Moisture (%):	16.18	20.74	**Plastic Limits:**	51	
Dry Density (pcf):	108.16	109.55	**Plasticity Index (%):**	26	
Saturation (%):	80.98	107.75			
Void Ratio:	0.5277	0.5233	**Specific Gravity:**	2.650	Assumed

Soil Description: Shale

Project Number: 13173 **Depth:**

Sample Number: **Boring Number:** 5

Project: Academic Boulevard Shopping Center

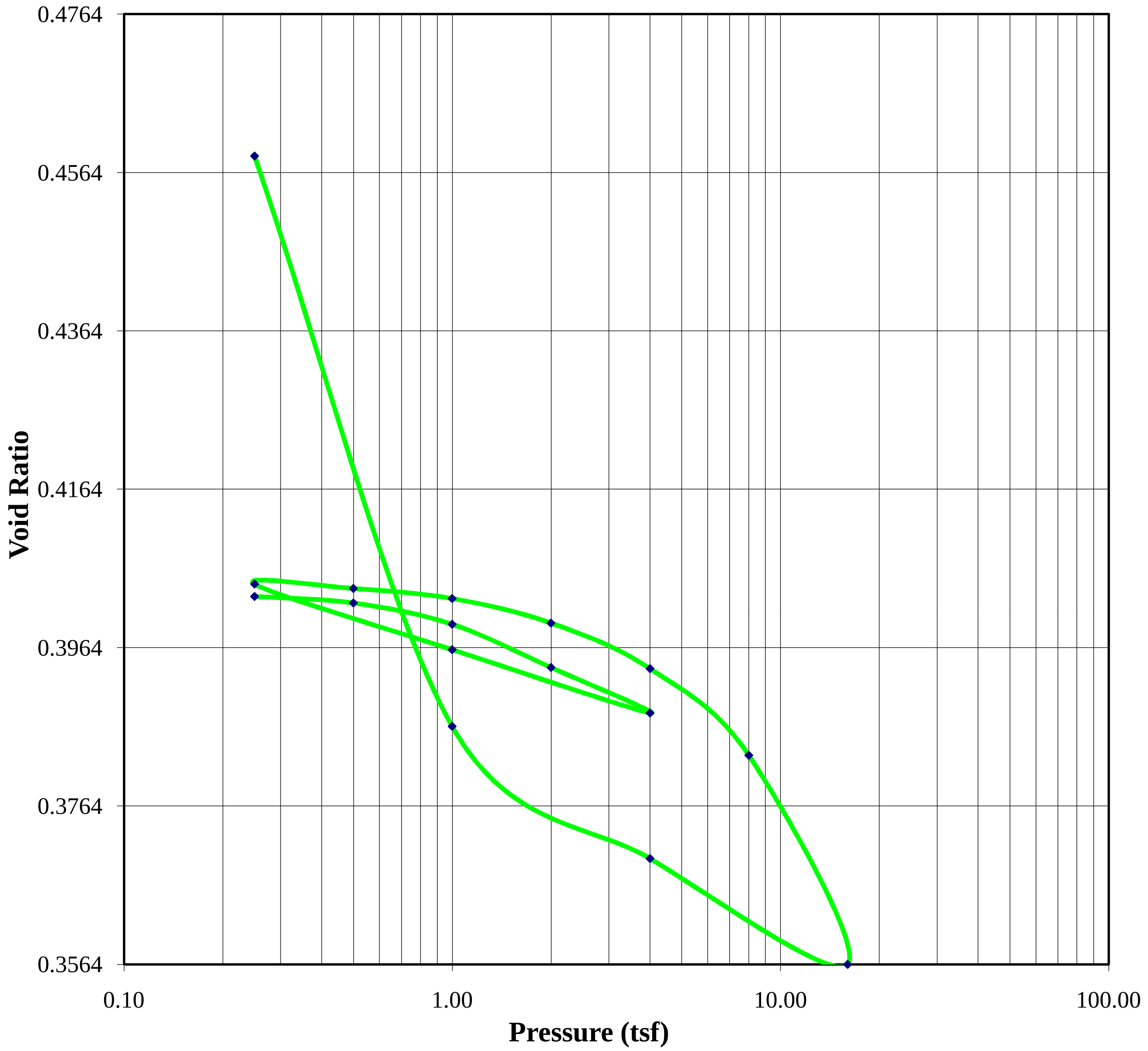
Client: UTW Academy Development

Location: El Paso County, Colorado

Remarks:
Remolded sample compacted to approximately 95 percent of modified Proctor maximum dry density.

Consolidation Test

Test Results



	Before	**After**	**Liquid Limits:**	77	**Test Date:**
Moisture (%):	15.28	19.37	**Plastic Limits:**	51	
Dry Density (pcf):	117.69	114.43	**Plasticity Index (%):**	26	
Saturation (%):	99.82	115.17			
Void Ratio:	0.4040	0.3496	**Specific Gravity:**	2.650	Assumed

Soil Description: Shale

Project Number: 13173 **Depth:**

Sample Number: **Boring Number:** 5

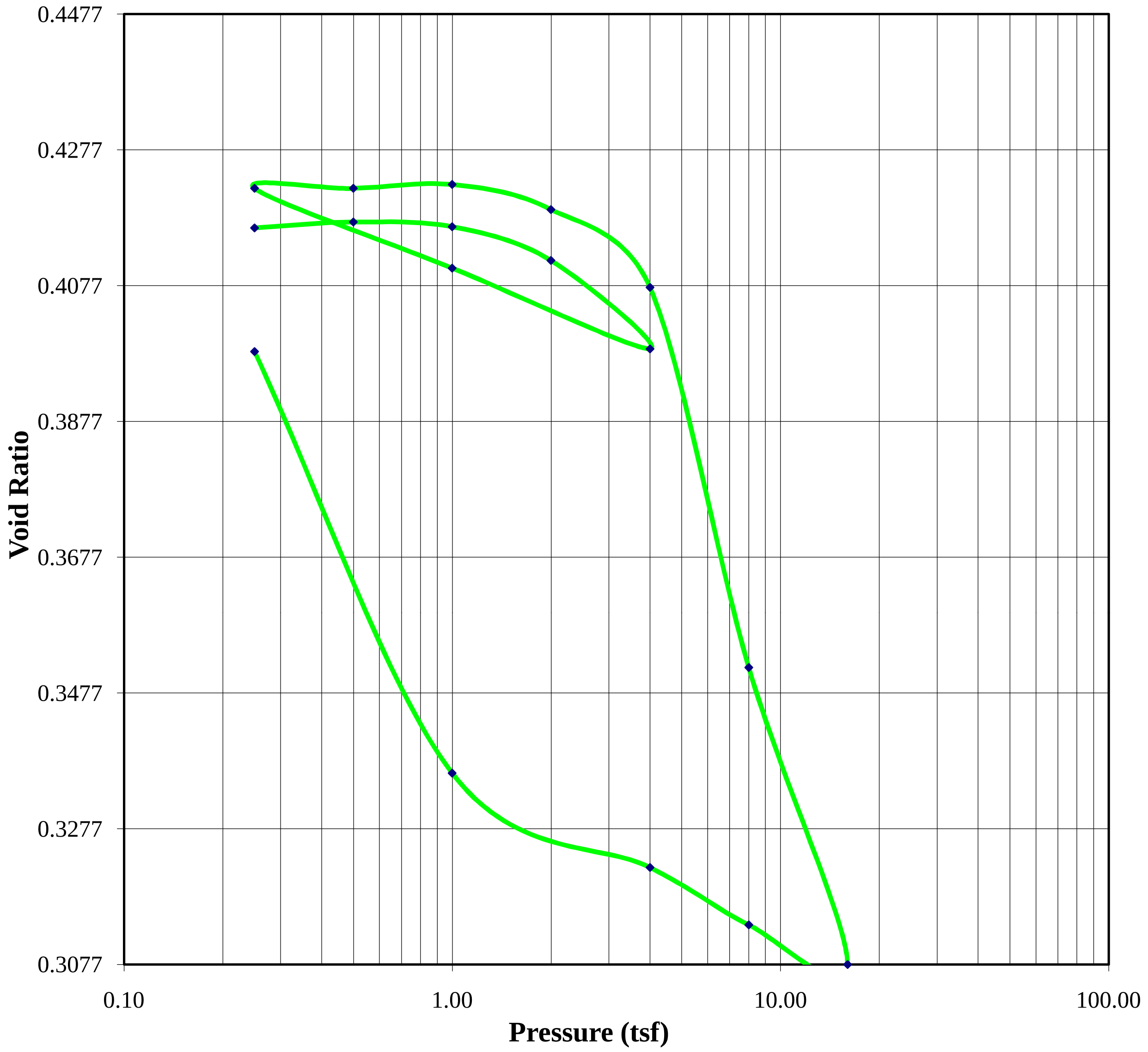
Project: Academic Boulevard Shopping Center

Client: UTW Academy Development

Location: El Paso County, Colorado

Remarks:
Remolded sample compacted to approximately 100 percent of modified Proctor maximum dry density.

Consolidation Test
Test Results



	Before	After	Liquid Limits:	61	Test Date:
Moisture (%):	13.32	17.53	**Plastic Limits:**	25	
Dry Density (pcf):	116.78	119.62	**Plasticity Index (%):**	36	
Saturation (%):	84.73	121.30			
Void Ratio:	0.4149	0.3980	**Specific Gravity:**	2.650	Assumed

Soil Description: Shale

Project Number: 13173 **Depth:**

Sample Number: **Boring Number:** 12

Project: Academic Boulevard Shopping Center

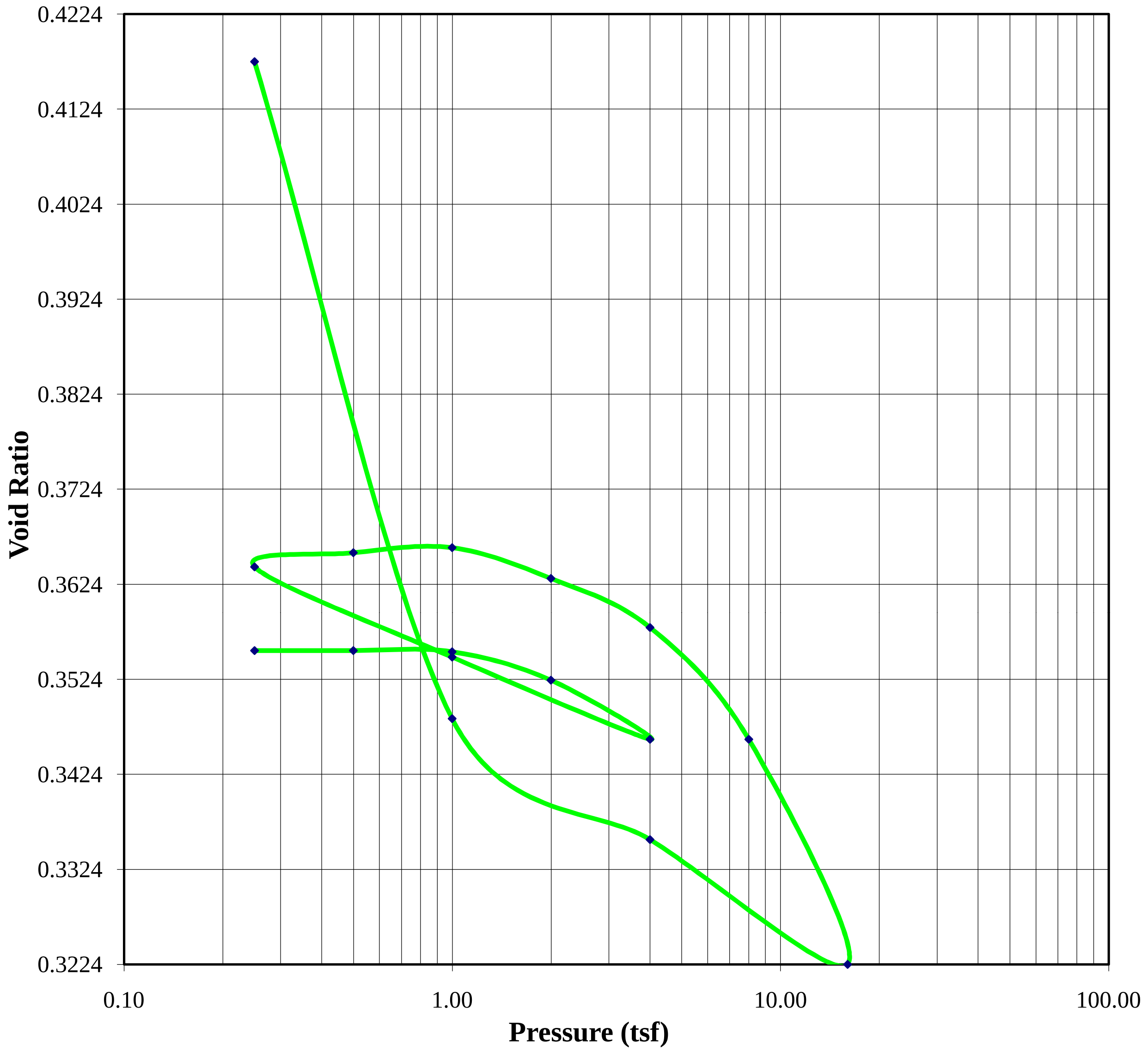
Client: UTW Academy Development

Location: El Paso County, Colorado

Remarks:
Remolded sample compacted to approximately 95 percent of modified Proctor maximum dry density.

Consolidation Test

Test Results



	Before	After			
Moisture (%):	13.32	17.71	**Liquid Limits:**	61	**Test Date:**
Dry Density (pcf):	122.09	118.40	**Plastic Limits:**	25	
Saturation (%):	99.43	118.16	**Plasticity Index (%):**	36	
Void Ratio:	0.3534	0.2894	**Specific Gravity:**	2.650	Assumed

Soil Description: Shale

Project Number: 13173 **Depth:**

Sample Number: **Boring Number:** 12

Project: South Academy Highlands

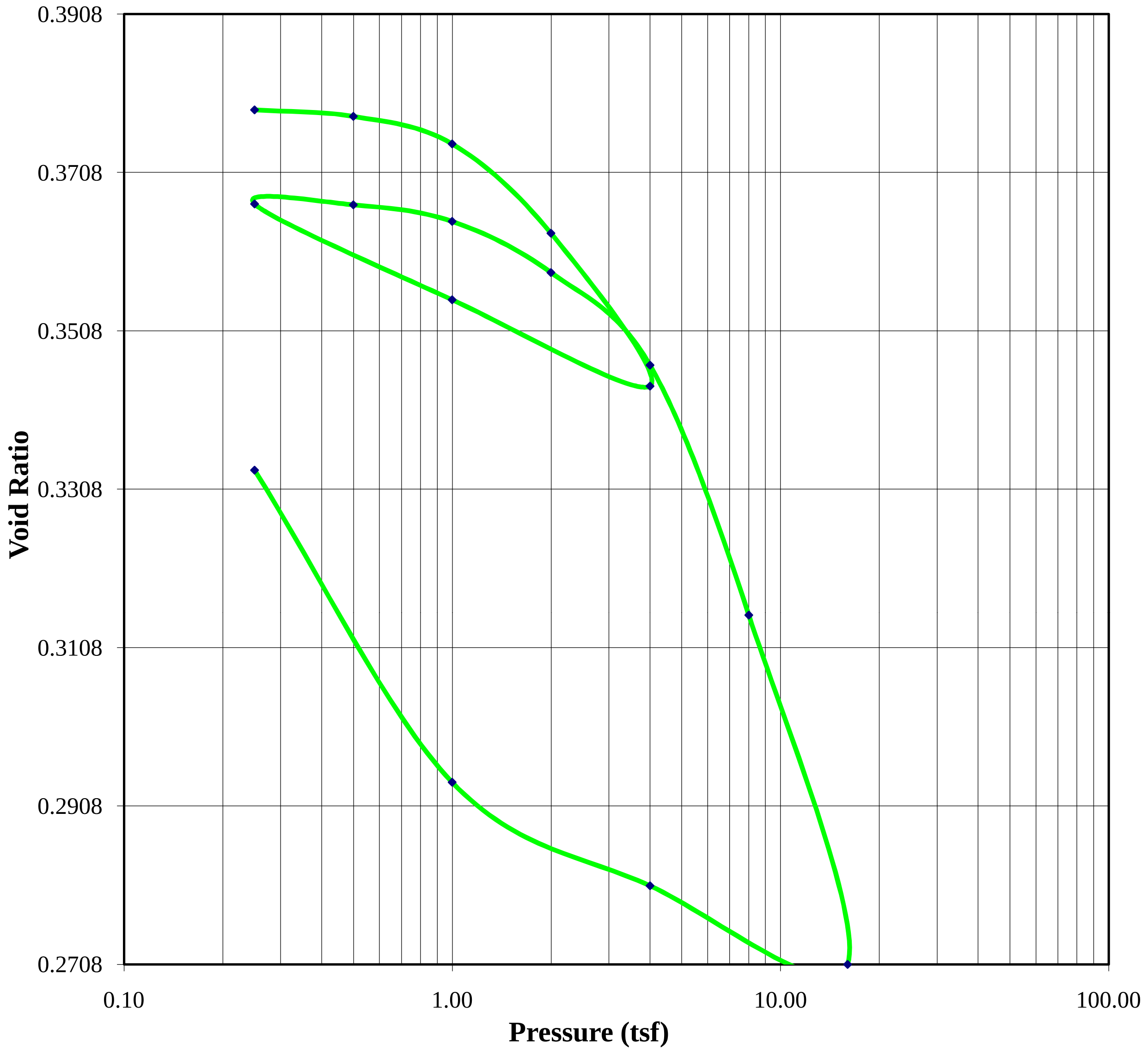
Client: UTW Academy Development

Location: El Paso County, Colorado

Remarks:
Remolded sample compacted to approximately 100 percent of modified Proctor maximum dry density.

Consolidation Test

Test Results



	Before	After			
Moisture (%):	10.09	14.58	**Liquid Limits:**	0	**Test Date:**
Dry Density (pcf):	119.91	126.41	**Plastic Limits:**	0	
Saturation (%):	70.44	125.17	**Plasticity Index (%):**	0	
Void Ratio:	0.3780	0.3333	**Specific Gravity:**	2.650	Assumed

Soil Description: Claystone

Project Number: 13173 **Depth:**

Sample Number: **Boring Number:** B-12 & B-13

Project: Academic Boulevard Shopping Center

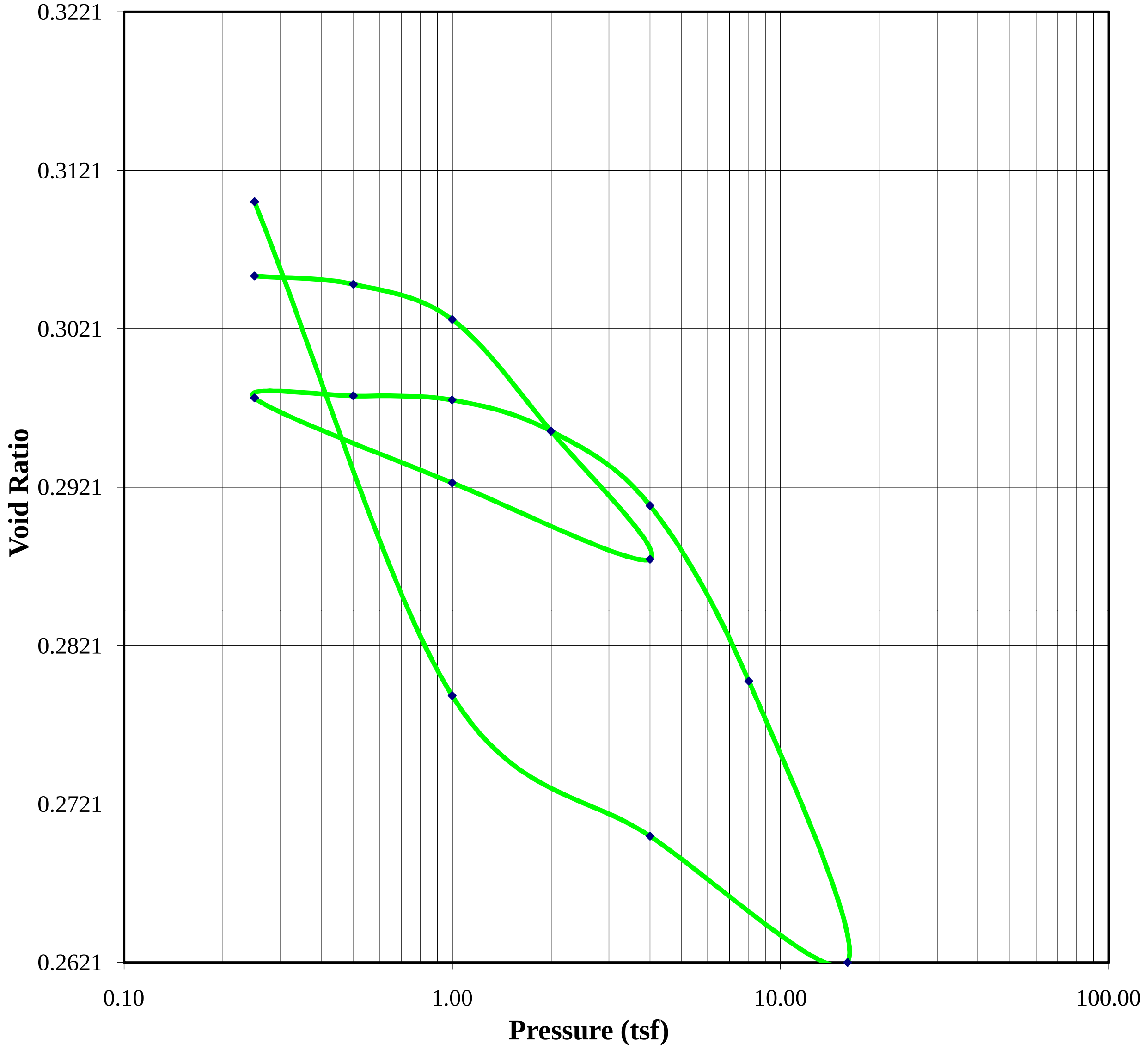
Client: UTW Academy Development

Location: El Paso County, Colorado

Remarks:
Remolded sample compacted to approximately 95 percent of modified Proctor maximum dry density.

Consolidation Test

Test Results



	Before	After			
Moisture (%):	10.14	12.53	**Liquid Limits:**	0	**Test Date:**
Dry Density (pcf):	126.64	127.89	**Plastic Limits:**	0	
Saturation (%):	87.71	113.11	**Plasticity Index (%):**	0	
Void Ratio:	0.3049	0.2997	**Specific Gravity:**	2.650	Assumed

Soil Description: Claystone

Project Number: 13173

Depth:

Sample Number:

Boring Number: B-12 & B-13

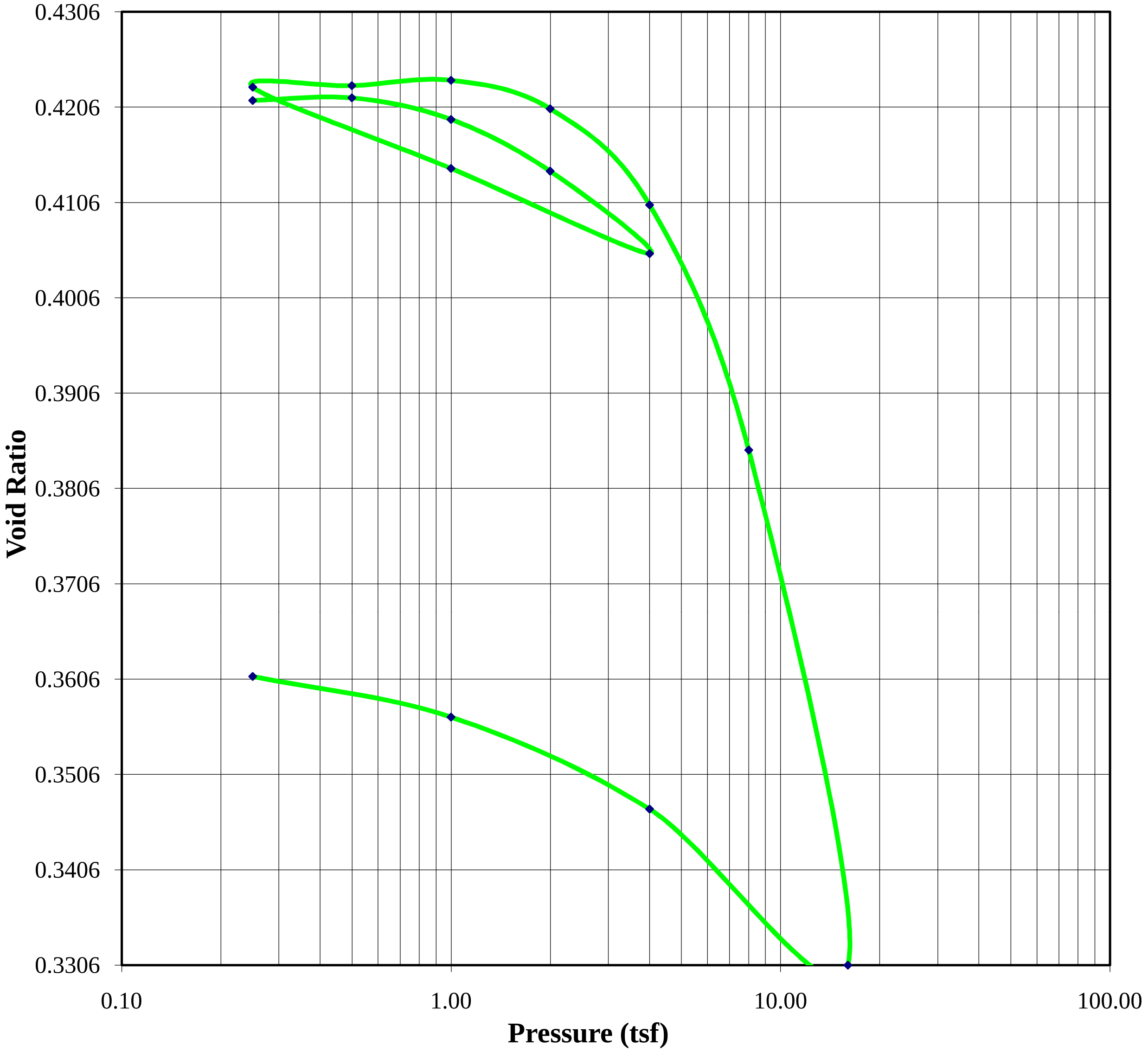
Project: Academic Boulevard Shopping Center

Client: UTW Academy Development

Location: El Paso County, Colorado

Remarks:
Remolded sample compacted to approximately 100 percent of modified Proctor maximum dry density.

Consolidation Test
Test Results



	Before	After			
Moisture (%):	11.88	15.04	**Liquid Limits:**	62	**Test Date:**
Dry Density (pcf):	116.24	124.38	**Plastic Limits:**	25	
Saturation (%):	74.39	120.76	**Plasticity Index (%):**	37	
Void Ratio:	0.4216	0.3609	**Specific Gravity:**	2.650	Assumed

Soil Description: Brown Sandy Clay (CH) with some gravel

Project Number: 13173 **Depth:**

Sample Number: **Boring Number:**

Project: Academic Boulevard Shopping Center

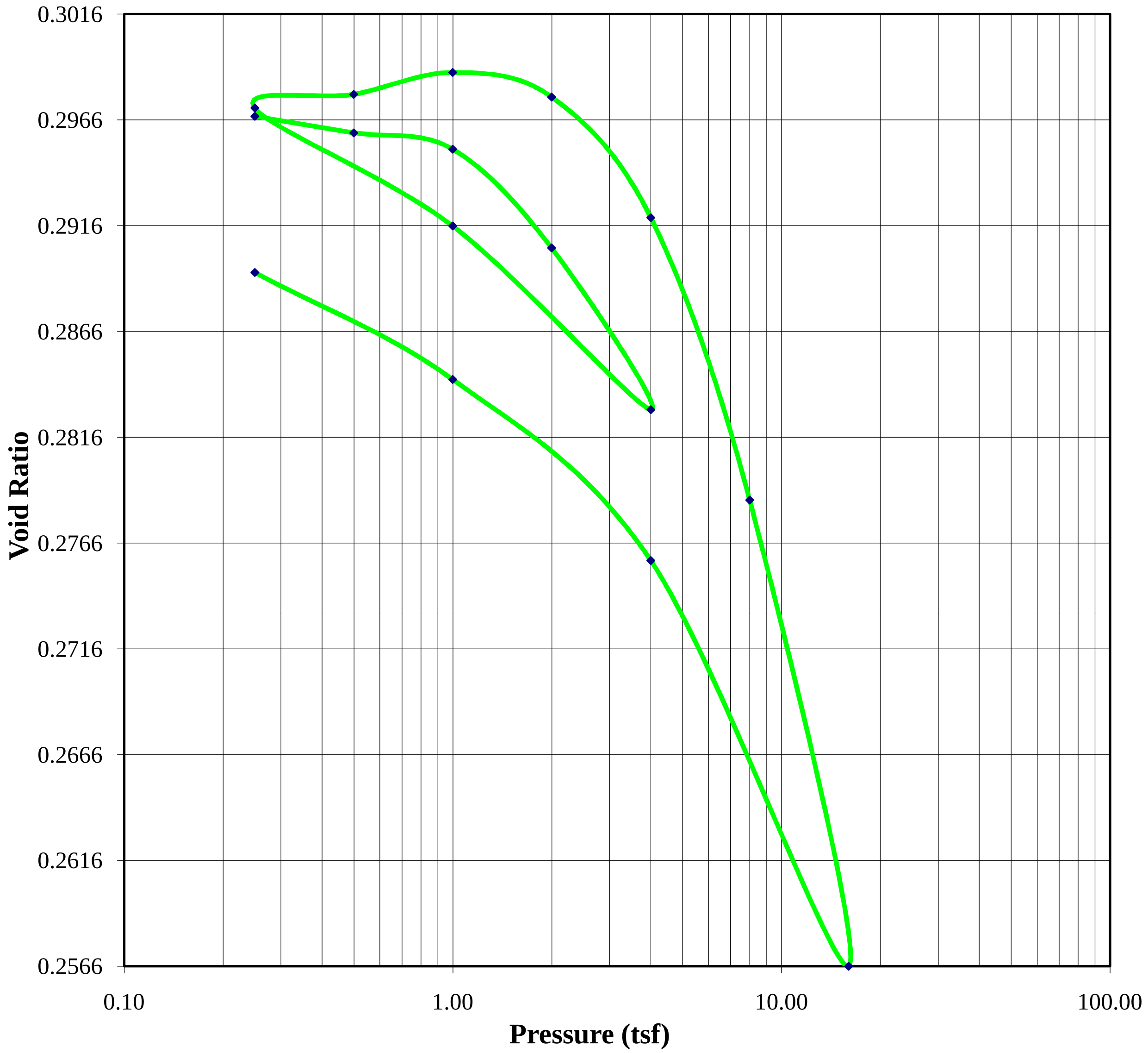
Client: UTW Academy Development

Location: El Paso County, Colorado

Remarks:
Remolded sample compacted to approximately 95 percent of modified Proctor maximum dry density.

Consolidation Test

Test Results



	Before	After	Liquid Limits:	62	Test Date:
Moisture (%):	10.89	13.99	**Plastic Limits:**	25	
Dry Density (pcf):	127.52	130.40	**Plasticity Index (%):**	37	
Saturation (%):	97.05	137.99			
Void Ratio:	0.2959	0.2894	**Specific Gravity:**	2.650	Assumed

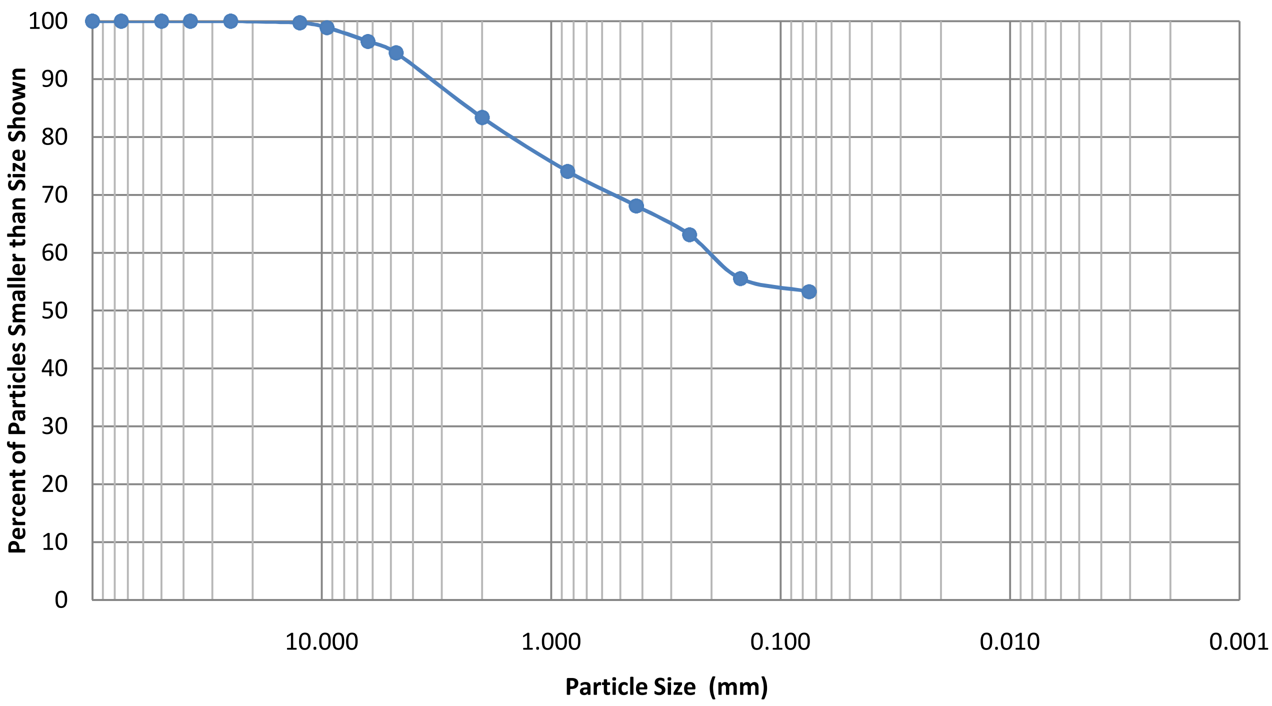
Soil Description: Brown Sandy Clay (CH) with some gravel

Project Number: 13173
Depth:
Sample Number:
Boring Number:

Project: Academic Boulevard Shopping Center
Client: UTW Academy Development
Location: El Paso County, Colorado

Remarks:
Remolded sample compacted to approximately 100 percent of modified Proctor maximum dry density.

ASTM D 2487-Classification of Soil (USCS) Report



USCS Classification: 0

Soil Description: Sandy Clay (CH) w/gravel

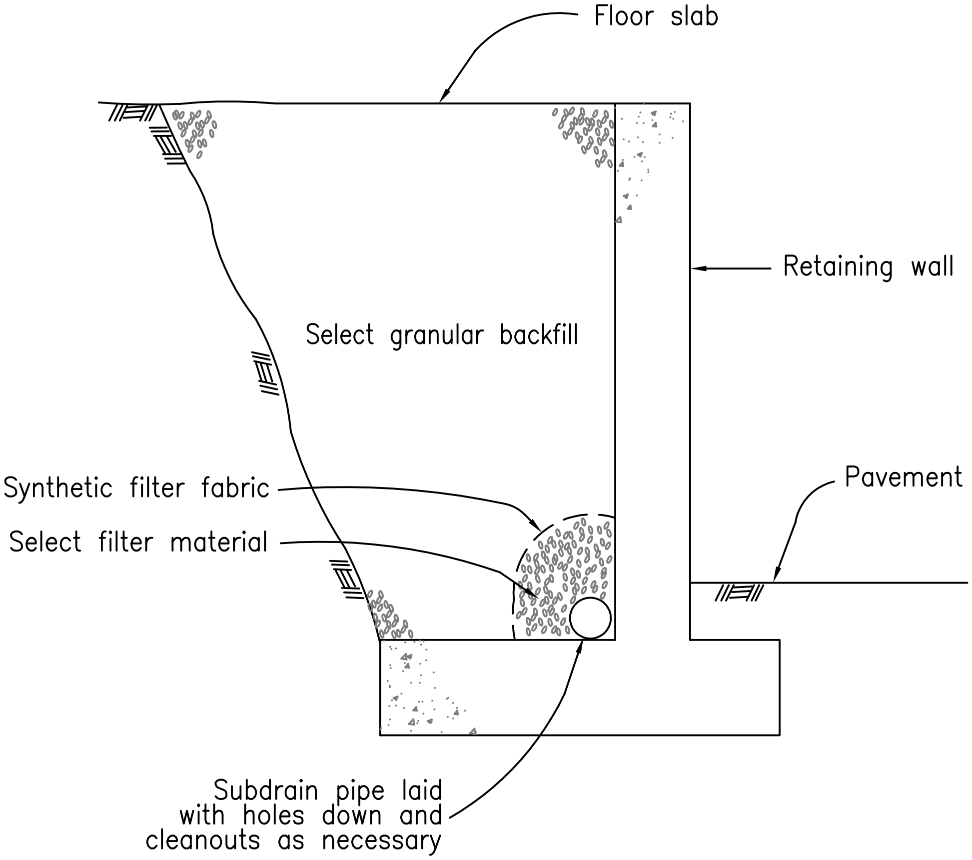
Methods Used (If Checked)	
C 117	X
C 136	
C 702	
D 421	X
D 422	X
D 1140	
D 2216	0
D 2217	
D 2488	0
D 4318	

Atterberg Limits	
Plastic Limit	51
Liquid Limit	22
Plasticity Index	29

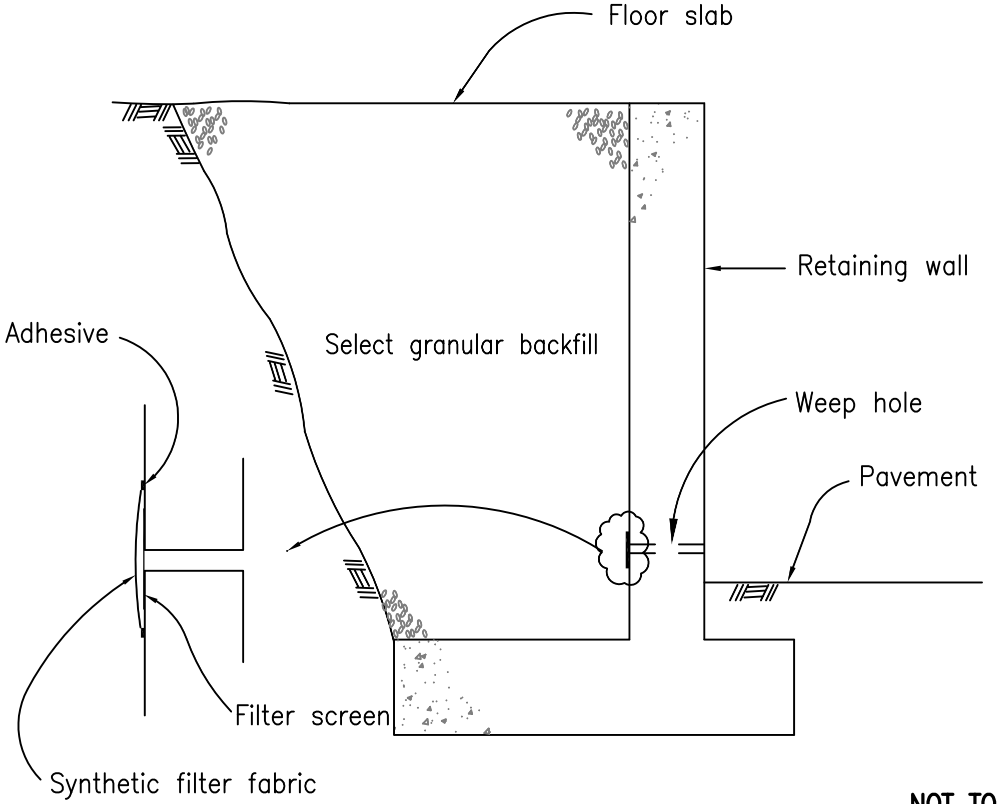
Particle Size Percents	
0.0	% > 3 in.
5.5	% Gravel
41.2	% Sand
53.3	% Fines

Midwest Testing™

Client: UTW Academy Development
Project: South Academy Highlands
El Paso County, Colorado
Job No.: 13173



SUBDRAIN



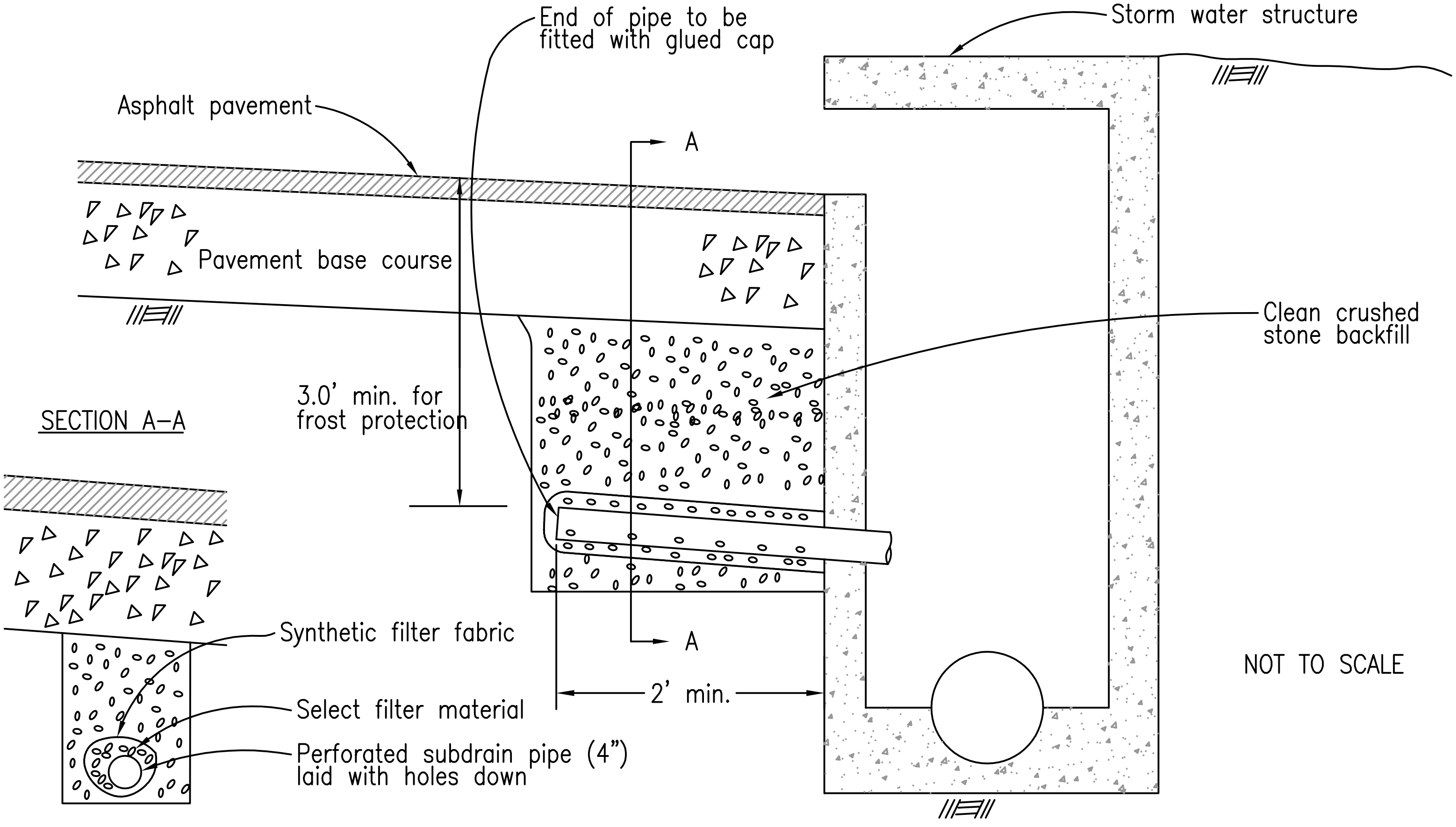
WEEP HOLE

NOT TO SCALE

WALL DRAINAGE
South Academy Highlands
El Paso County, Colorado

13173

Figure 30

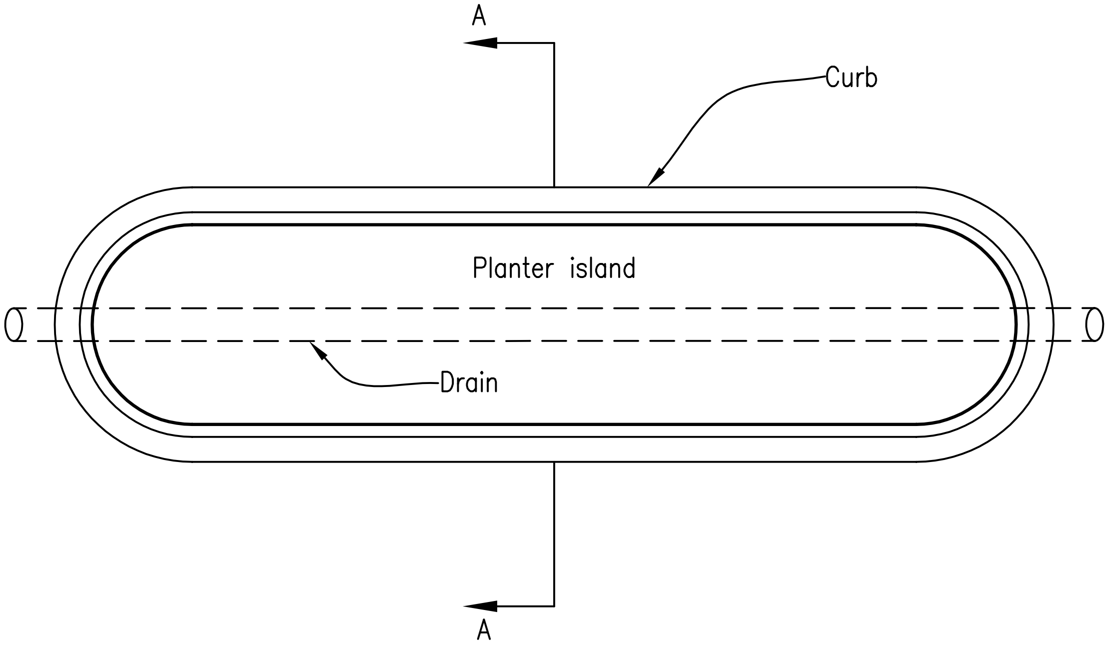


NOTES

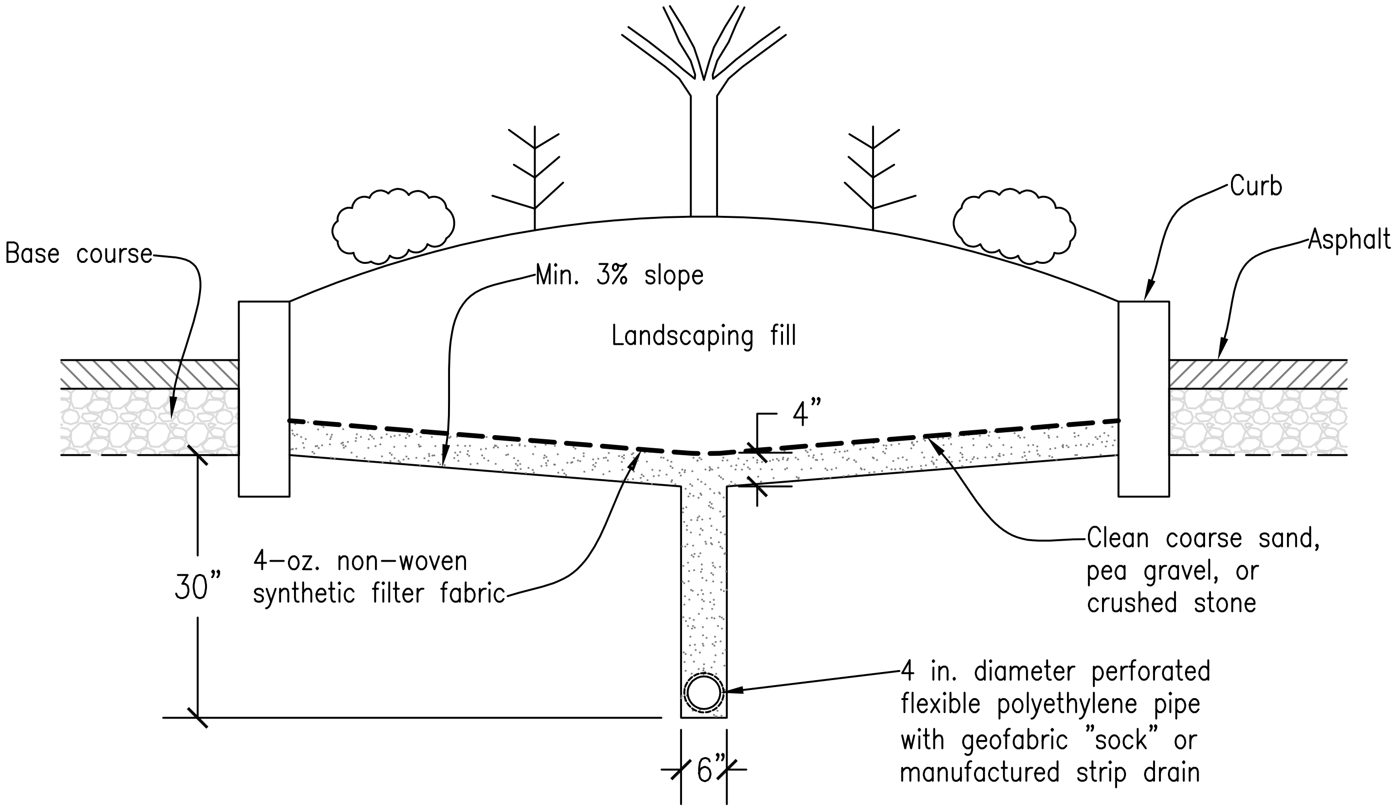
1) Stub–out aggregate drains to be installed at all storm water inlet structures.
2) Four drains to be installed at grate inlet locations – two on each upgradient side.
3) Two drains at curb inlet locations.

STUB DRAIN
South Academy Highlands
El Paso County, Colorado

Figure 31



PLAN VIEW
N.T.S.



CROSS-SECTION A-A
N.T.S.

PLANTER ISLANDS
South Academy Highlands
El Paso County, Colorado

13173

Figure 32

MT-4

t	C			N		
Layer thickness, ft.	Shear str., psf	t/C	t*C	N-Value	t/N	t*N
65		#DIV/0!	0	20	3.25	1300
29		#DIV/0!	0	40	0.725	1160
6				100	0.06	600

Total thickness, ft.	t/C sum	t*C sum	t/N sum	t*N sum
100	#DIV/0!	0	4.035	3060

Weighted Average	Weighted Average
0	30.6

"Average" shear per IBC	"Average" N-value per IBC
#DIV/0!	24.8

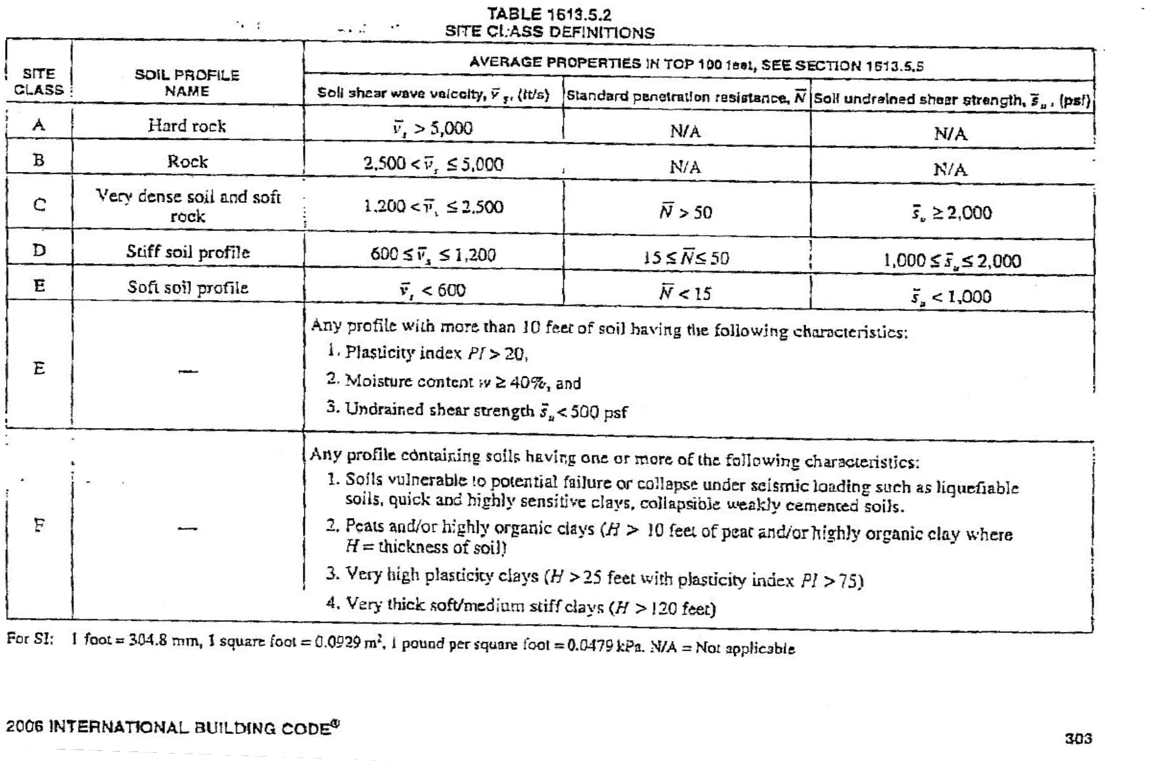


TABLE 1613.5.2
SITE CLASS DEFINITIONS

SITE CLASS	SOIL PROFILE NAME	AVERAGE PROPERTIES IN TOP 100 feet, SEE SECTION 1613.5.5		
		Soil shear wave velocity, $\bar{v}_s$, (ft/s)	Standard penetration resistance, $\bar{N}$	Soil undrained shear strength, $\bar{s}_u$, (psf)
A	Hard rock	$\bar{v}_s > 5{,}000$	N/A	N/A
B	Rock	$2{,}500 < \bar{v}_s \leq 5{,}000$	N/A	N/A
C	Very dense soil and soft rock	$1{,}200 < \bar{v}_s \leq 2{,}500$	$\bar{N} > 50$	$\bar{s}_u \geq 2{,}000$
D	Stiff soil profile	$600 \leq \bar{v}_s \leq 1{,}200$	$15 \leq \bar{N} \leq 50$	$1{,}000 \leq \bar{s}_u \leq 2{,}000$
E	Soft soil profile	$\bar{v}_s < 600$	$\bar{N} < 15$	$\bar{s}_u < 1{,}000$
E	—	Any profile with more than 10 feet of soil having the following characteristics: 1. Plasticity index $PI > 20$, 2. Moisture content $w \geq 40\%$, and 3. Undrained shear strength $\bar{s}_u < 500$ psf		
F	—	Any profile containing soils having one or more of the following characteristics: 1. Soils vulnerable to potential failure or collapse under seismic loading such as liquefiable soils, quick and highly sensitive clays, collapsible weakly cemented soils. 2. Peats and/or highly organic clays ($H >$ 10 feet of peat and/or highly organic clay where H = thickness of soil) 3. Very high plasticity clays ($H > 25$ feet with plasticity index $PI > 75$) 4. Very thick soft/medium stiff clays ($H > 120$ feet)		

For SI: 1 foot = 304.8 mm, 1 square foot = 0.0929 m², 1 pound per square foot = 0.0479 kPa. N/A = Not applicable

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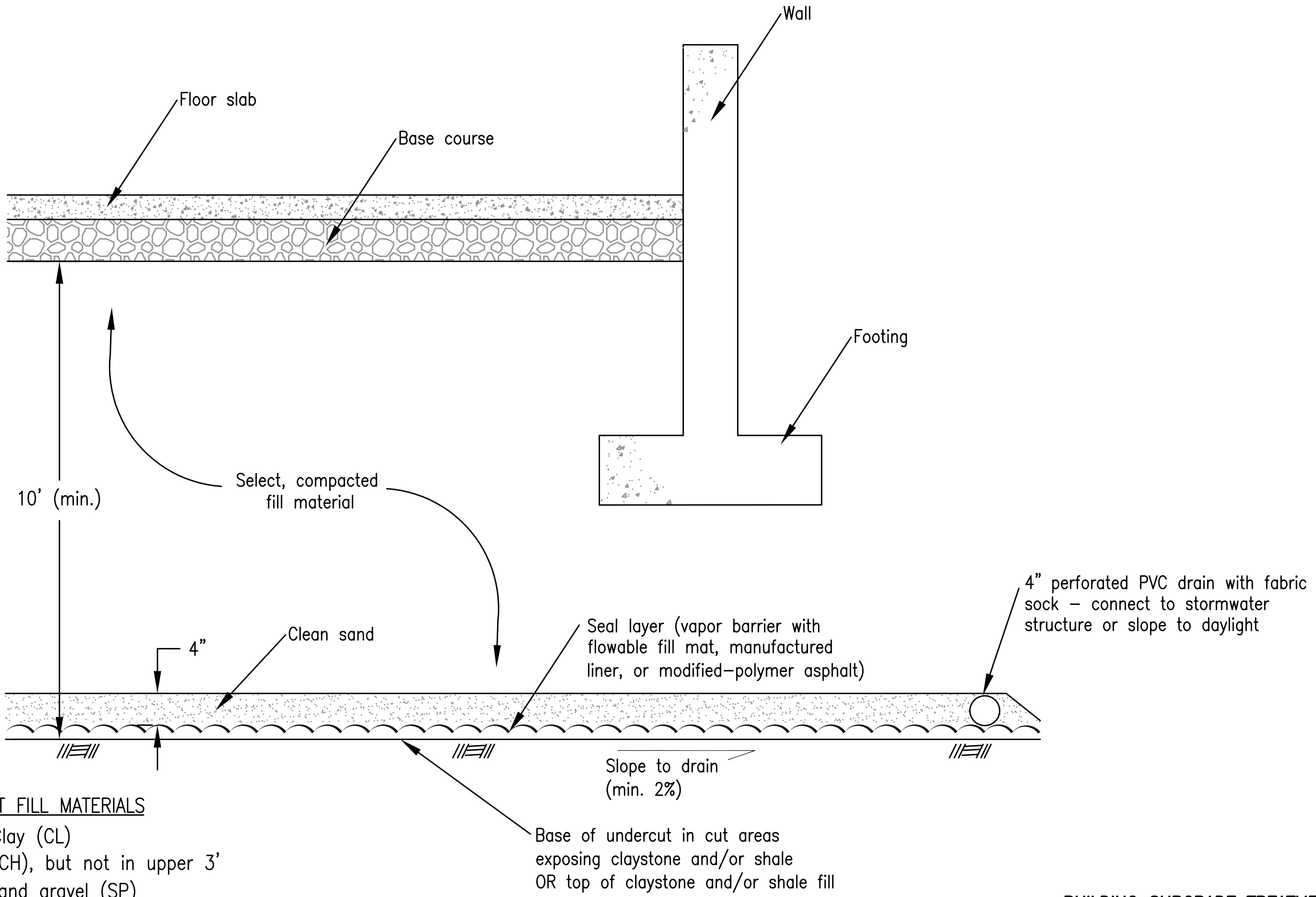
303

SEISMIC SITE CLASS
South Academy Highlands
El Paso County, Colorado

Figure 33



SELECT FILL MATERIALS

Silty Clay (CL)

Clay (CH), but not in upper 3'

Sand and gravel (SP)

Note: Claystone and shale not permitted

BUILDING SUBGRADE TREATMENT

South Academy Highlands
El Paso County, Colorado

Figure 34

FIELD CLASSIFICATION SYSTEM

BORING METHOD

HSA	Hollow-stem auger
CFA	Continuous-flight auger
RB	Rollerbit
MR	Mud rotary
RC	Rock coring
CA	Casing advancer
DC	Driven casing
HA	Hand-auger

SHEAR STRENGTH DATA

UC	Unconfined compression
TX-UU	Unconsolidated-undrained triaxial
TX-CU	Consolidated-undrained triaxial
V	Miniature vane
FV	Field vane
T	Torvane
PP	Pocket penetrometer
SCP	Static cone penetrometer

SOIL PARTICLE SIZE

Cohesive		Granular or Non-Cohesive							
		Sand			Gravel				
Clay	Silt	Fine	Medium	Coarse	Fine	Medium	Coarse	Cobbles	Boulders

0.002 mm 0.05 mm 0.02 mm 0.6 mm 0.25 in. 0.5 in. 1 in. 3 in. 8 in.

STANDARD PENETRATION TEST (ASTM D 1586)

Driving a 3.0-inch O.D. split-spoon sampler 18 inches with a 140-pound hammer free-falling a distance of 30 inches. The number of blows to drive the sampler these three successive 6-inch increments is recorded; the sum of the last two increments being the N-value.

N-VALUE & SHEAR STRENGTH CORRELATIONS

Granular Soils

N-Value	Relative Density
0-4	Very loose
5-10	Loose
11-30	Medium dense
31-50	Dense
Over 50	Very dense

Cohesive Soils

N-Value	Shear Strength, tsf	Consistency
0-2	< 0.125	Very soft
3-4	0.125 – 0.25	Soft
5-8	0.25 – 0.5	Medium stiff
9-15	0.5– 1.0	Stiff
16-30	1.0 – 2.0	Very stiff
Over 30	> 2.0	Hard

SOIL CLASSIFICATIONS of samples are made by visual inspection and/or laboratory test results in accordance with the Unified Soil Classification System, the symbol of which is indicated in parentheses following the description.

RELATIVE PROPORTIONS are indicated by the following descriptive terms: trace (0-15%), some (15-35%), and (35-50%).

STRATA CHANGES are indicated on the boring logs by horizontal lines. A solid line represents an observed change while a dashed line indicates an estimated change.

GROUND WATER OBSERVATIONS are made at the times and under the conditions stated on the boring logs. Fluctuations may occur due to changes in precipitation, temperature, site topography, etc.

South Academy Highlands
El Paso County, Colorado

LOG OF BORING MT1

PROJECT NO. 13173 **DATE:** 2/12/13 **LOCATION:** See Figure 1

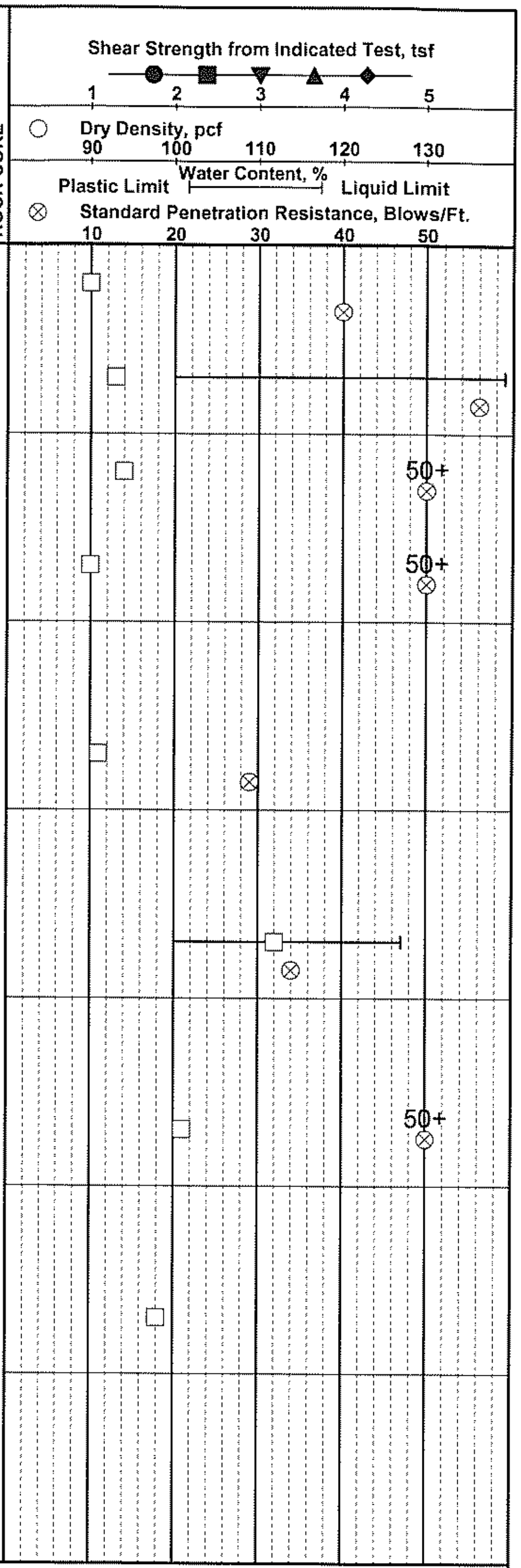
COMPLETION DEPTH 30.0 **FT.**

DRILLING METHOD CFA

ROCK CORE DIAMETER **IN.**

SURFACE ELEVATION 5791.5 **FT.**

DEPTH, FT.		STRATUM DEPTH, FT.	SPT BLOWS/6 in. THREE 6 in. INCREMENTS
	Brown very stiff Silty Clay (CL) with trace sand and gravel		15 20 20
	-hard below 3 feet		
5	Brown hard Clay (CH) with some sand	4.0	14 28 28
	Brown hard Silty Clay (CL) with trace sand and gravel	6.0	15 50/6"
10			31 50/6"
	-very stiff below 13 feet		
15			11 14 15
20			15 17 17
	Brown medium dense Sand (SP)	20.0	
	Gray hard Claystone	23.0	50/6"
25			
	Gray hard Shale	28.0	50/4"
30	Boring terminated at 30 feet	30.0	
35			



WATER LEVEL OBSERVATIONS		
DURING DRILLING	24	FT.
AT COMPLETION		FT.
AFTER HRS.		FT.

NOTES

Shear Test Types - Static Cone: ● Pocket Penetrometer: ■ Unconf. Compr.: ▼ Miniature Vane: ▲ Field Vane: ◆

South Academy Highlands
El Paso County, Colorado

LOG OF BORING MT2

PROJECT NO. 13173 **DATE:** 2/12/13 **LOCATION:** See Figure 1

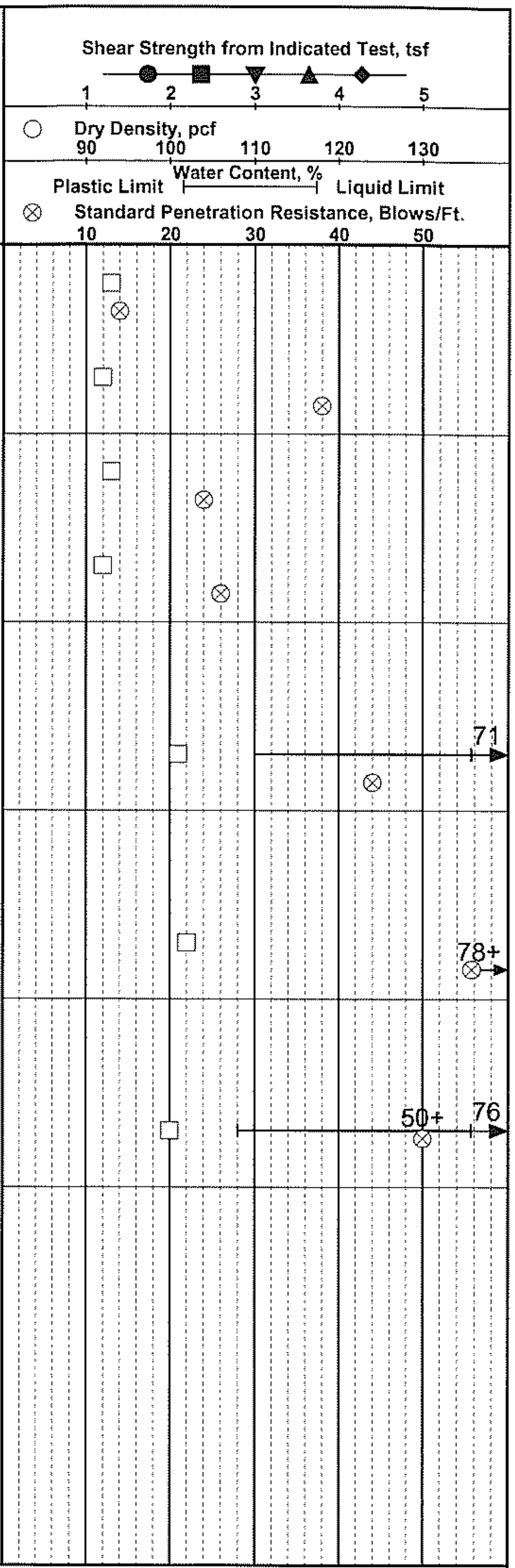
COMPLETION DEPTH 25.0 **FT.**

DRILLING METHOD CFA

ROCK CORE DIAMETER **IN.**

SURFACE ELEVATION 5799.0 **FT.**

DEPTH, FT.		STRATUM DEPTH, FT.	SPT SPLIT SPOON	SPT BLOWS/6 in. THREE 6 in. INCREMENTS	UNDISTURBED SAMPLE	PERCENT RECOVERY	ROCK CORE
	Brown stiff Silty Clay (CL)		■	7 7 7			
	-very stiff below 3 feet						
5			■	9 17 21			
	-with trace sand and gravel below 6 feet		■	7 11 13			
10			■	10 12 14			
	Gray very stiff Claystone	13.0					
15			■	12 17 27			
	-hard below 18 feet						
20			■	15 28 50/5"			
	Gray hard Shale	23.0	■	50/5"			
25	Boring terminated at 25 feet	25.0					
30							
35							



WATER LEVEL OBSERVATIONS		
DURING DRILLING	Dry	FT.
AT COMPLETION		FT.
AFTER HRS.		FT.

NOTES

Shear Test Types - Static Cone: ● Pocket Penetrometer: ■ Unconf. Compr.: ▼ Miniature Vane: ▲ Field Vane: ◆

MIDWEST TESTING

South Academy Highlands
El Paso County, Colorado

LOG OF BORING MT3

PROJECT NO. 13173 **DATE:** 2/12/13 **LOCATION:** See Figure 1

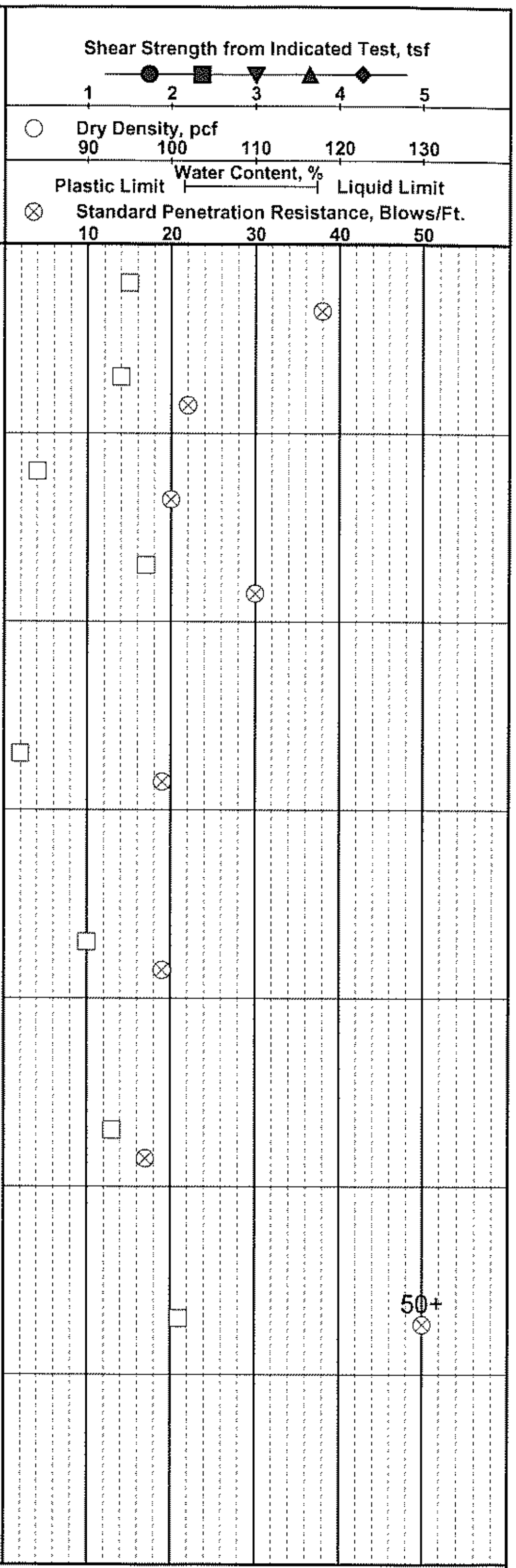
COMPLETION DEPTH 30.0 **FT.**

DRILLING METHOD CFA

ROCK CORE DIAMETER **IN.**

SURFACE ELEVATION 5789.7 **FT.**

DEPTH, FT.		STRATUM DEPTH, FT.	SPT SPLIT SPOON	SPT BLOWS/6 in. THREE 6 in. INCREMENTS	UNDISTURBED SAMPLE	PERCENT RECOVERY	ROCK CORE
	Brown hard Silty Clay (CL) with trace gravel		■	9 17 21			
	-with trace sand and gravel below 3 feet		■	11 11 11			
5							
	Brown medium dense Sand (SP)	6.0	■	12 10 10			
	Gray very stiff Clay (CH) with trace sand	8.0	■	10 14 16			
10							
	Brown medium dense Sand and Gravel (SP)	13.0	■	7 9 10			
15							
			■	14 11 8			
20							
			■	7 8 9			
25							
	Gray hard Shale	28.0	■	50/4"			
30							
	Boring terminated at 30 feet	30.0					
35							



WATER LEVEL OBSERVATIONS			NOTES
DURING DRILLING	24	FT.	
AT COMPLETION		FT.	
AFTER HRS.		FT.	

Shear Test Types - Static Cone: ● Pocket Penetrometer: ■ Unconf. Compr.: ▼ Miniature Vane: ▲ Field Vane: ◆

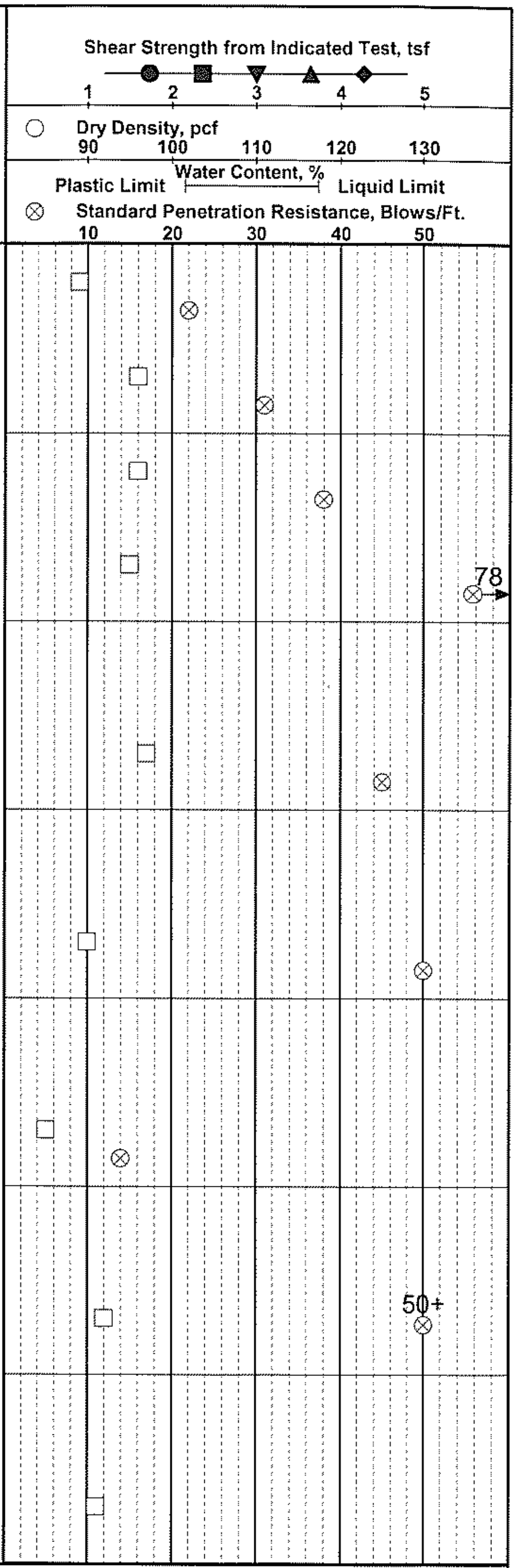
South Academy Highlands
El Paso County, Colorado

LOG OF BORING MT4

PROJECT NO. 13173 **DATE:** 2/12/13 **LOCATION:** See Figure 1

COMPLETION DEPTH 35.0 **FT.**
DRILLING METHOD CFA
ROCK CORE DIAMETER **IN.**
SURFACE ELEVATION 5798.0 **FT.**

DEPTH, FT.		STRATUM DEPTH, FT.	SPT SPLIT SPOON	SPT BLOWS/6 in. THREE 6 in. INCREMENTS	UNDISTURBED SAMPLE	PERCENT RECOVERY	ROCK CORE
	Brown very stiff Silt (ML) with trace sand		■	7 11 11			
5	Brown very stiff Silty Clay (CL)	3.0	■	7 14 17			
			■	7 17 21			
10	-hard with trace gravel below 8 feet		■	11 28 50			
15			■	12 20 25			
20	-with some sand and gravel below 18 feet		■	18 22 28			
25	Brown medium dense Sand (SP)	23.0	■	11 7 7			
30	Gray hard Shale	28.0	■	50/4"			
35	Boring terminated at 35 feet		■	50/3"			



WATER LEVEL OBSERVATIONS
DURING DRILLING Dry **FT.**
AT COMPLETION **FT.**
AFTER **HRS.** **FT.**

NOTES

Shear Test Types - Static Cone: ● Pocket Penetrometer: ■ Unconf. Compr.: ▼ Miniature Vane: ▲ Field Vane: ◆

MIDWEST TESTING

South Academy Highlands
El Paso County, Colorado

LOG OF BORING MT5

PROJECT NO. 13173

DATE: 2/12/13

LOCATION: See Figure 1

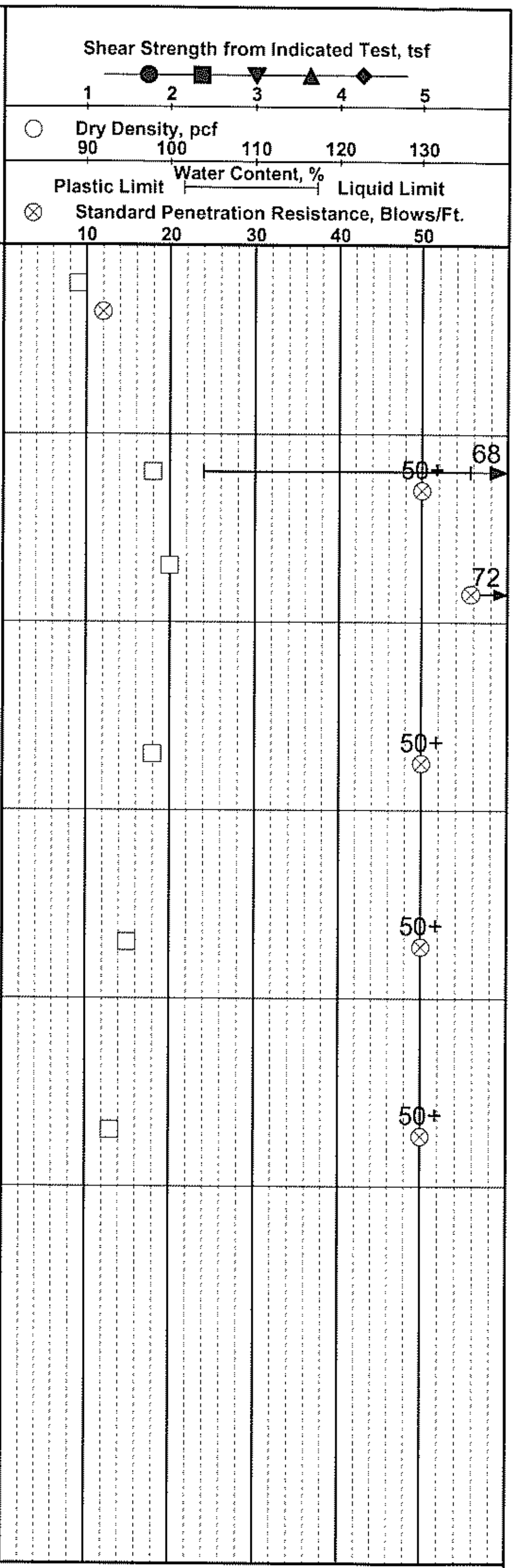
COMPLETION DEPTH 25.0 FT.

DRILLING METHOD CFA

ROCK CORE DIAMETER IN.

SURFACE ELEVATION 5818.8 FT.

DEPTH, FT.		STRATUM DEPTH, FT.	SPT SPLIT SPOON BLOWS/6 in. THREE 6 in. INCREMENTS	UNDISTURBED SAMPLE	PERCENT RECOVERY	ROCK CORE
	Brown stiff Silty Clay (CL)		6 7 5			
5						
	Brown hard Claystone	6.0	27 50/6"			
10			12 22 50			
	-gray below 13 feet		50/6"			
15						
	Gray hard Shale	18.0	50/3"			
20						
			50/4"			
25	Boring terminated at 25 feet	25.0				
30						
35						



WATER LEVEL OBSERVATIONS			**NOTES**
DURING DRILLING	Dry	**FT.**	
AT COMPLETION		**FT.**	
AFTER **HRS.**		**FT.**	

Shear Test Types - Static Cone: ● Pocket Penetrometer: ■ Unconf. Compr.: ▼ Miniature Vane: ▲ Field Vane: ◆

MIDWEST TESTING

South Academy Highlands
El Paso County, Colorado

LOG OF BORING MT6

PROJECT NO. 13173 **DATE:** 2/12/13 **LOCATION:** See Figure 1

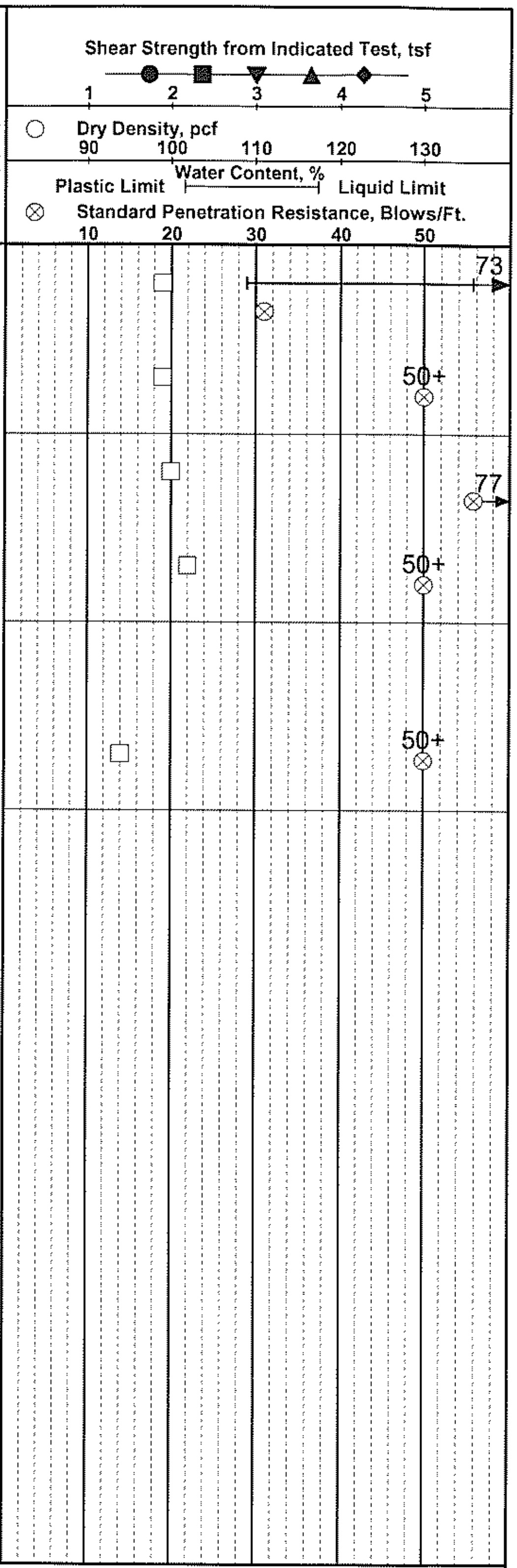
COMPLETION DEPTH 15.0 **FT.**

DRILLING METHOD CFA

ROCK CORE DIAMETER **IN.**

SURFACE ELEVATION 5819.5 **FT.**

DEPTH, FT.		STRATUM DEPTH, FT.	SPT: SPLIT SPOON	SPT: BLOWS/6 in. THREE 6 in. INCREMENTS	UNDISTURBED SAMPLE	PERCENT RECOVERY	ROCK CORE
	Brown very stiff Claystone		■	7 14 17			
	-gray and hard below 3 feet		■	21 50/6"			
5							
			■	16 27 50			
			■	17 50/6"			
10							
	Gray hard Shale	13.0	■	50/4"			
15	Boring terminated at 15 feet	15.0					
20							
25							
30							
35							



WATER LEVEL OBSERVATIONS		
DURING DRILLING	Dry	**FT.**
AT COMPLETION		**FT.**
AFTER HRS.		**FT.**

NOTES

Shear Test Types - Static Cone: ● Pocket Penetrometer: ■ Unconf. Compr.: ▼ Miniature Vane: ▲ Field Vane: ◆

MIDWEST TESTING

South Academy Highlands
El Paso County, Colorado

LOG OF BORING MT7

PROJECT NO. 13173 **DATE:** 2/12/13 **LOCATION:** See Figure 1

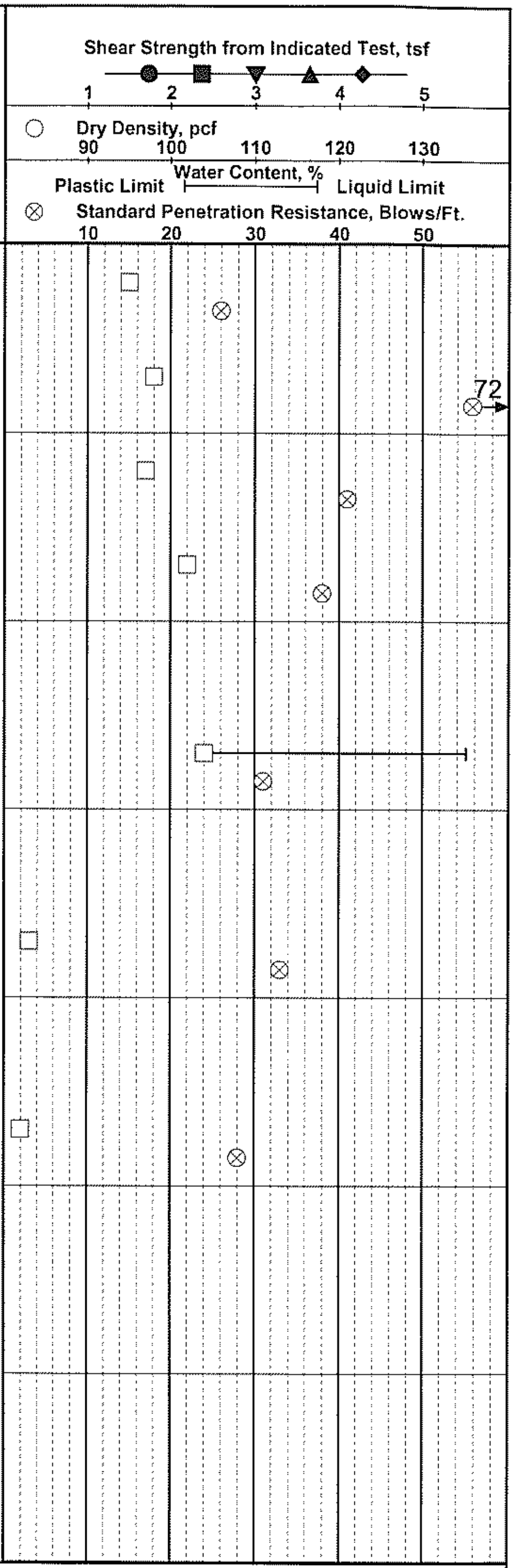
COMPLETION DEPTH 45.0 **FT.**

DRILLING METHOD CFA

ROCK CORE DIAMETER **IN.**

SURFACE ELEVATION 5799.4 **FT.**

DEPTH, FT.		STRATUM DEPTH, FT.	SPT SPLIT SPOON	SPT BLOWS/6 in. THREE 6 in. INCREMENTS	UNDISTURBED SAMPLE	PERCENT RECOVERY	ROCK CORE
	Brown very stiff Silty Clay (CL) with trace sand and gravel -hard below 3 feet		■	11 16 10			
5			■	17 44 28			
			■	8 17 24			
	Brown very stiff Clay (CH)	8.0					
10			■	8 15 23			
15			■	10 14 17			
	Brown dense Sand (SP)	18.0					
20			■	7 14 19			
25			■	14 14 14			
	Gray Claystone	25.0					
30							
35							



WATER LEVEL OBSERVATIONS			**NOTES**
DURING DRILLING	Dry	**FT.**	
AT COMPLETION		**FT.**	
AFTER **HRS.**		**FT.**	

Shear Test Types - Static Cone: ● Pocket Penetrometer: ■ Unconf. Compr.: ▼ Miniature Vane: ▲ Field Vane: ◆

South Academy Highlands
El Paso County, Colorado

LOG OF BORING MT7

PROJECT NO. 13173 **DATE:** 2/12/13 **LOCATION:** See Figure 1

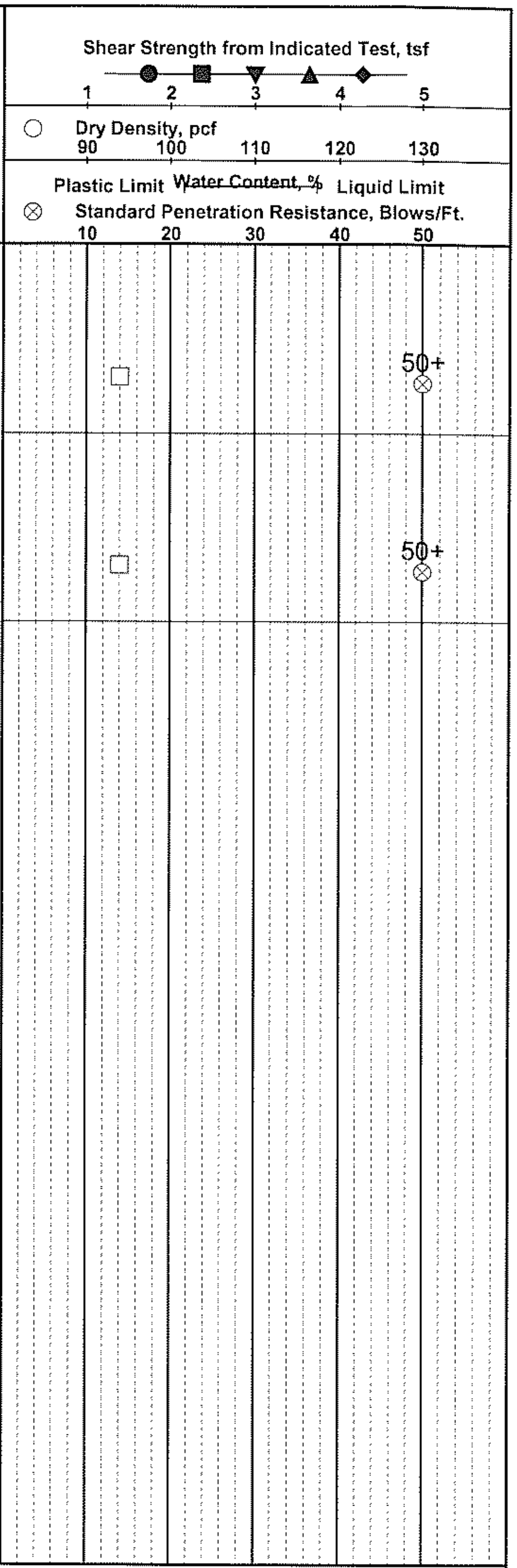
COMPLETION DEPTH 45.0 **FT.**

DRILLING METHOD CFA

ROCK CORE DIAMETER **IN.**

SURFACE ELEVATION 5799.4 **FT.**

DEPTH, FT.		STRATUM DEPTH, FT.	SPT SPLIT SPOON	SPT BLOWS/6 in. THREE 6 in. INCREMENTS	UNDISTURBED SAMPLE	PERCENT RECOVERY	ROCK CORE
	Gray hard Shale	38.0	▬	50/4"			
40							
			▬	50/4"			
45	Boring terminated at 45 feet	45.0					
50							
55							
60							
65							
70							



WATER LEVEL OBSERVATIONS			**NOTES**
DURING DRILLING	Dry	**FT.**	
AT COMPLETION		**FT.**	
AFTER HRS.		**FT.**	

Shear Test Types - Static Cone: ● Pocket Penetrometer: ■ Unconf. Compr.: ▼ Miniature Vane: ▲ Field Vane: ◆

MIDWEST TESTING

South Academy Highlands
El Paso County, Colorado

LOG OF BORING MT8

PROJECT NO. 13173 **DATE:** 2/13/13 **LOCATION:** See Figure 1

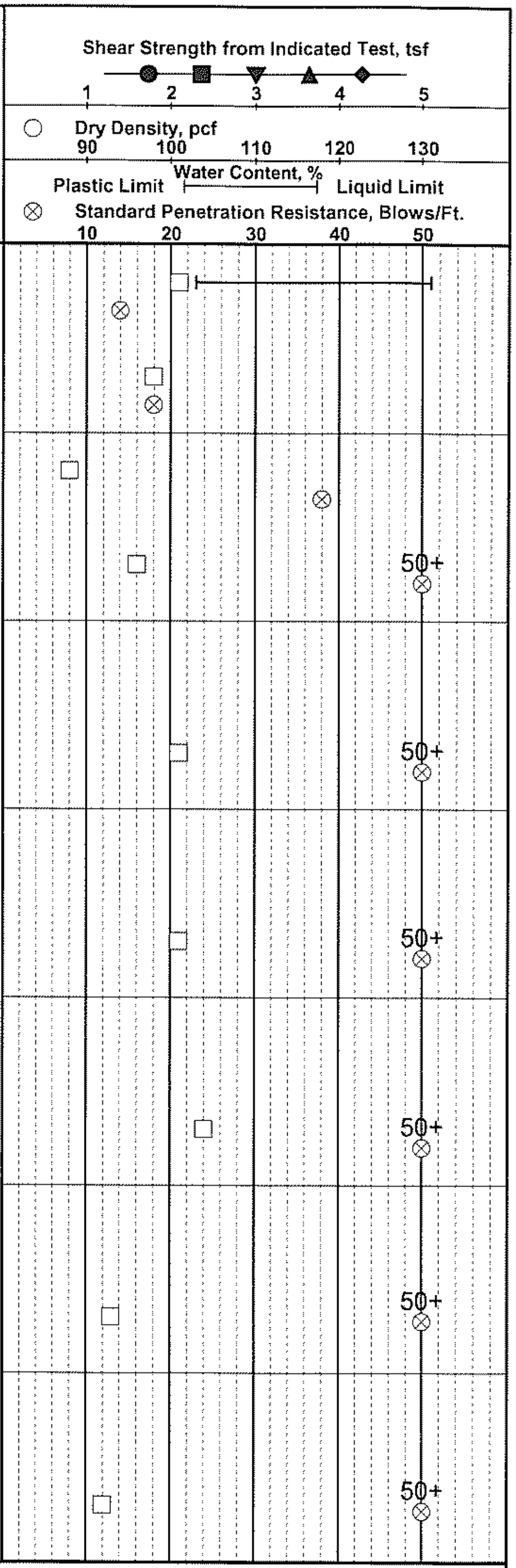
COMPLETION DEPTH 35.0 **FT.**

DRILLING METHOD CFA

ROCK CORE DIAMETER **IN.**

SURFACE ELEVATION 5815.6 **FT.**

DEPTH, FT.		STRATUM DEPTH, FT.	SPT BLOWS/6 in. THREE 6 in. INCREMENTS
	Gray very stiff Clay (CH)		8 7 7
5			8 9 9
	-with some sand and gravel below 6 feet		14 17 21
10	Brown hard Claystone with trace sand	8.0	21 50/6"
15			17 50/6"
20			28 50/5"
25			27 50/6"
30	Gray hard Shale	28.0	50/3"
35	Boring terminated at 35 feet		50/4"



WATER LEVEL OBSERVATIONS		**NOTES**
DURING DRILLING	Dry **FT.**	
AT COMPLETION	**FT.**	
AFTER HRS.	**FT.**	

Shear Test Types - Static Cone: ● Pocket Penetrometer: ■ Unconf. Compr.: ▼ Miniature Vane: ▲ Field Vane: ◆

South Academy Highlands
El Paso County, Colorado

LOG OF BORING MT9

PROJECT NO. 13173 **DATE:** 2/13/13 **LOCATION:** See Figure 1

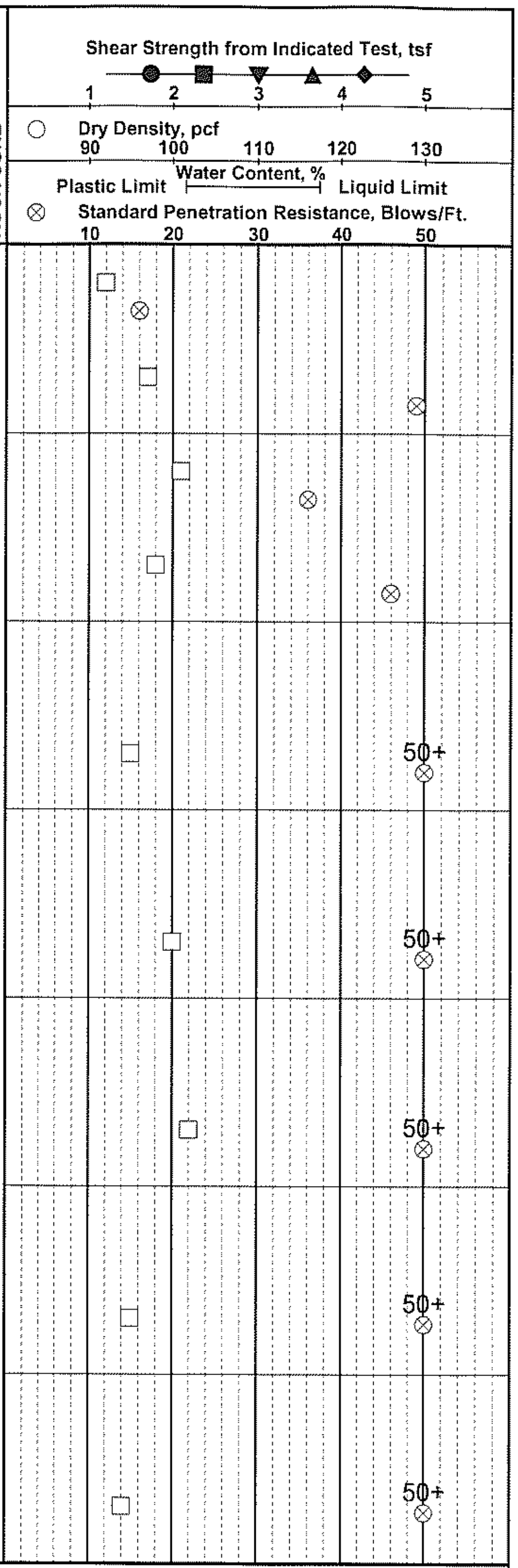
COMPLETION DEPTH 35.0 **FT.**

DRILLING METHOD CFA

ROCK CORE DIAMETER **IN.**

SURFACE ELEVATION 5833.9 **FT.**

DEPTH, FT.		STRATUM DEPTH, FT.	SPT BLOWS/6 in. THREE 6 in. INCREMENTS	UNDISTURBED SAMPLE	PERCENT RECOVERY	ROCK CORE
	Gray stiff Silty Clay (CL) with trace sand		7 5 11			
	Gray very stiff Claystone	3.0				
5			14 21 28			
			7 12 24			
	-hard below 8 feet					
10			12 18 28			
15			17 50/6"			
20			21 50/5"			
25			31 50/6"			
	Gray hard Shale	28.0	50/4"			
30						
			50/4"			
35	Boring terminated at 35 feet					



WATER LEVEL OBSERVATIONS		
DURING DRILLING	Dry	FT.
AT COMPLETION		FT.
AFTER HRS.		FT.

NOTES

Shear Test Types - Static Cone: ● Pocket Penetrometer: ■ Unconf. Compr.: ▼ Miniature Vane: ▲ Field Vane: ◆

MIDWEST TESTING

South Academy Highlands
El Paso County, Colorado

LOG OF BORING MT10

PROJECT NO. 13173 **DATE:** 2/13/13 **LOCATION:** See Figure 1

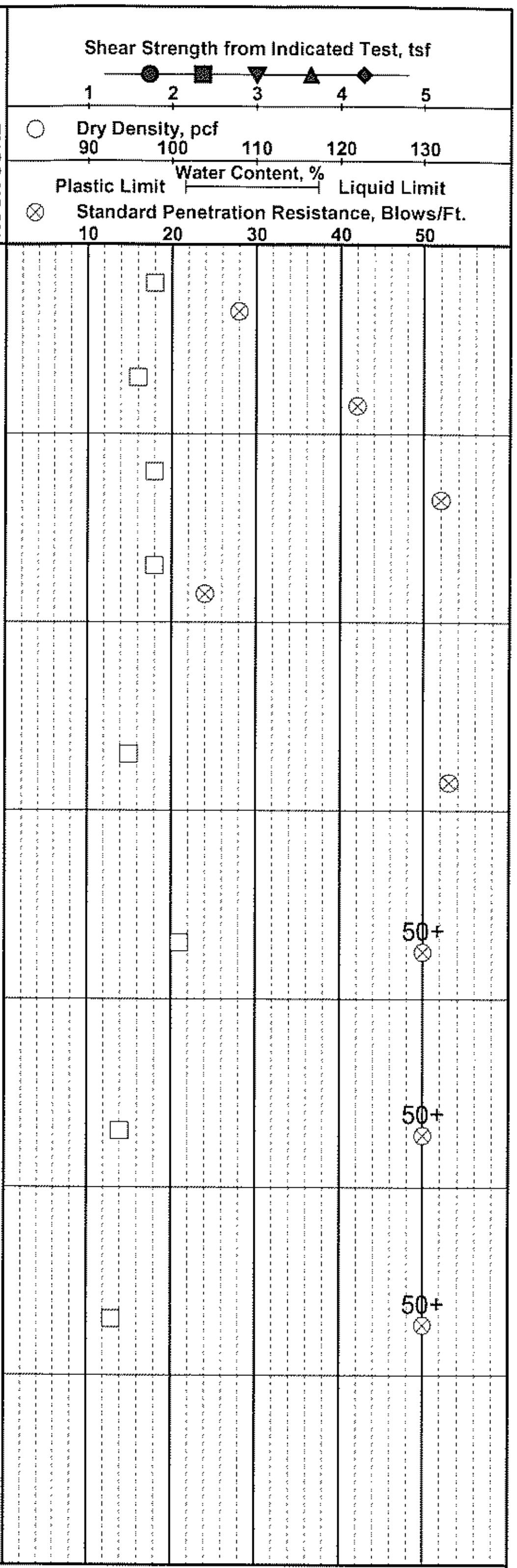
COMPLETION DEPTH 30.0 **FT.**

DRILLING METHOD CFA

ROCK CORE DIAMETER **IN.**

SURFACE ELEVATION 5849.8 **FT.**

DEPTH, FT.		STRATUM DEPTH, FT.	SPT BLOWS/6 in. THREE 6 in. INCREMENTS
	Gray very stiff Claystone		12 14 14
5			21 21 21
			17 24 28
10			7 12 12
	-with trace sand below 13 feet		
15			17 24 29
	-with trace gravel and cobbles below 18 feet		50/6"
20			
	Gray hard Shale	23.0	50/3"
25			
			50/4"
30	Boring terminated at 30 feet	30.0	
35			



WATER LEVEL OBSERVATIONS		
DURING DRILLING	Dry	**FT.**
AT COMPLETION		**FT.**
AFTER HRS.		**FT.**

NOTES

Shear Test Types - Static Cone: ● Pocket Penetrometer: ■ Unconf. Compr.: ▼ Miniature Vane: ▲ Field Vane: ◆

MIDWEST TESTING

South Academy Highlands
El Paso County, Colorado

LOG OF BORING MT11

PROJECT NO. 13173 **DATE:** 2/13/13 **LOCATION:** See Figure 1

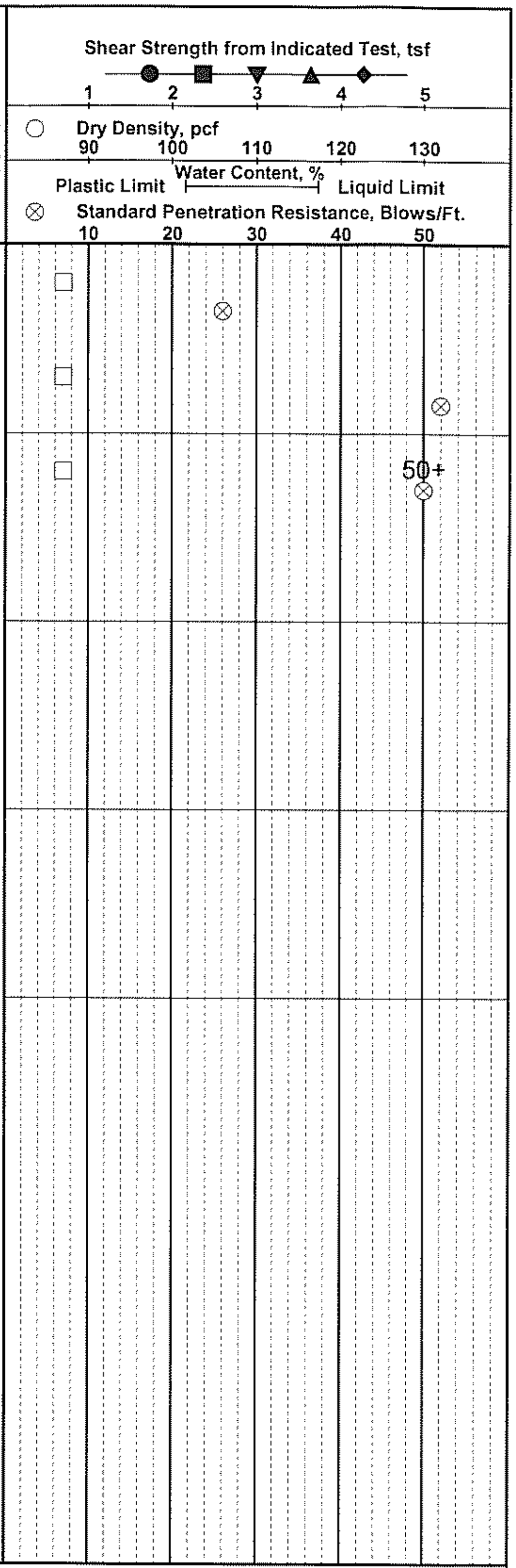
COMPLETION DEPTH 20.0 **FT.**

DRILLING METHOD CFA

ROCK CORE DIAMETER **IN.**

SURFACE ELEVATION 5908.0 **FT.**

DEPTH, FT.	Description	STRATUM DEPTH, FT.	SPT SPLIT SPOON	SPT BLOWS/6 in. THREE 6 in. INCREMENTS	UNDISTURBED SAMPLE	PERCENT RECOVERY	ROCK CORE
	Brown very stiff Silty Clay (CL) with some sand and gravel		■	10 12 14			
	-increasing sand and gravel below 3 feet		■	20 24 28			
5							
	Brown very dense Sand and Gravel (SP)	6.0	■	11 50/6"			
	Brown Claystone	8.0					
10							
15							
20	Boring terminated at 20 feet	20.0					
25							
30							
35							



WATER LEVEL OBSERVATIONS		
DURING DRILLING	Dry	**FT.**
AT COMPLETION		**FT.**
AFTER **HRS.**		**FT.**

NOTES

Shear Test Types - Static Cone: ● Pocket Penetrometer: ■ Unconf. Compr.: ▼ Miniature Vane: ▲ Field Vane: ◆

MIDWEST TESTING

South Academy Highlands
El Paso County, Colorado

LOG OF BORING MT12

PROJECT NO. 13173 **DATE:** 2/13/13 **LOCATION:** See Figure 1

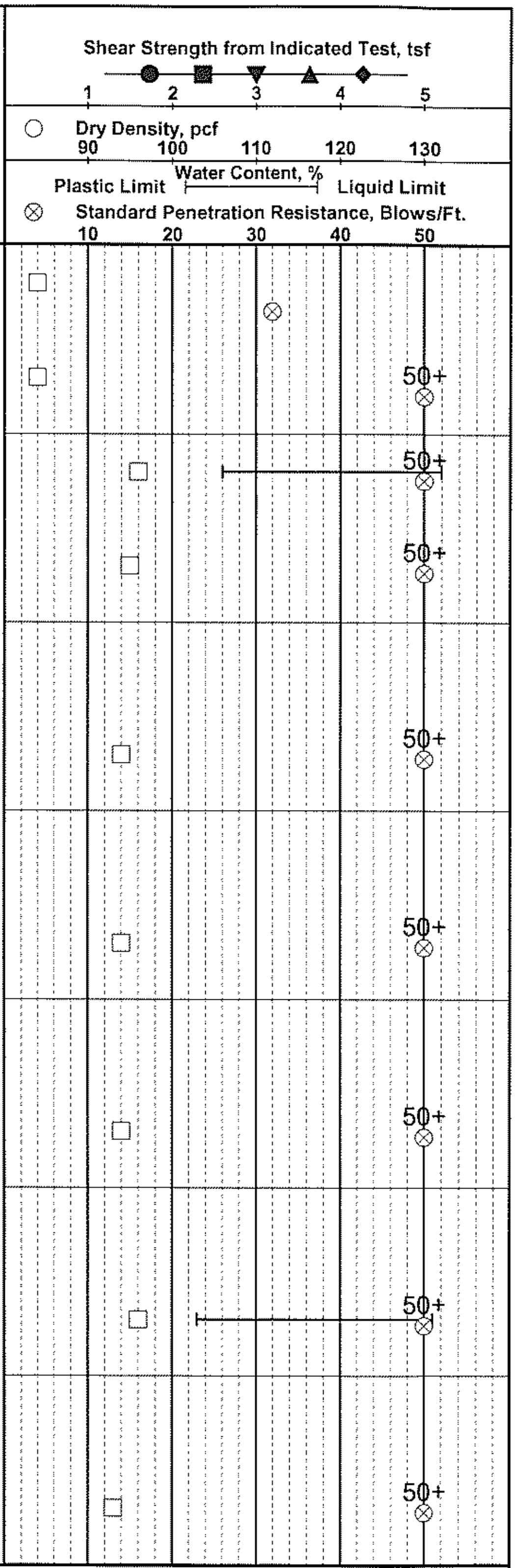
COMPLETION DEPTH 45.0 **FT.**

DRILLING METHOD CFA

ROCK CORE DIAMETER **IN.**

SURFACE ELEVATION 5914.7 **FT.**

DEPTH, FT.		STRATUM DEPTH, FT.	SPT SPLIT SPOON	SPT BLOWS/6 in. THREE 6 in. INCREMENTS	UNDISTURBED SAMPLE	PERCENT RECOVERY	ROCK CORE
	Brown dense Silty Sand (SM)			10 12 20			
	-very dense below 3 feet			15 50/6"			
5							
	Gray hard Shale	6.0		50/6"			
				50/5"			
10							
				50/3"			
15							
				50/3"			
20							
				50/4"			
25							
				50/4"			
30							
				50/3"			
35							



WATER LEVEL OBSERVATIONS		
DURING DRILLING	Dry	FT.
AT COMPLETION		FT.
AFTER HRS.		FT.

NOTES

Shear Test Types - Static Cone: ● Pocket Penetrometer: ■ Unconf. Compr.: ▼ Miniature Vane: ▲ Field Vane: ◆

MIDWEST TESTING

South Academy Highlands
El Paso County, Colorado

LOG OF BORING MT12

PROJECT NO. 13173 **DATE:** 2/13/13 **LOCATION:** See Figure 1

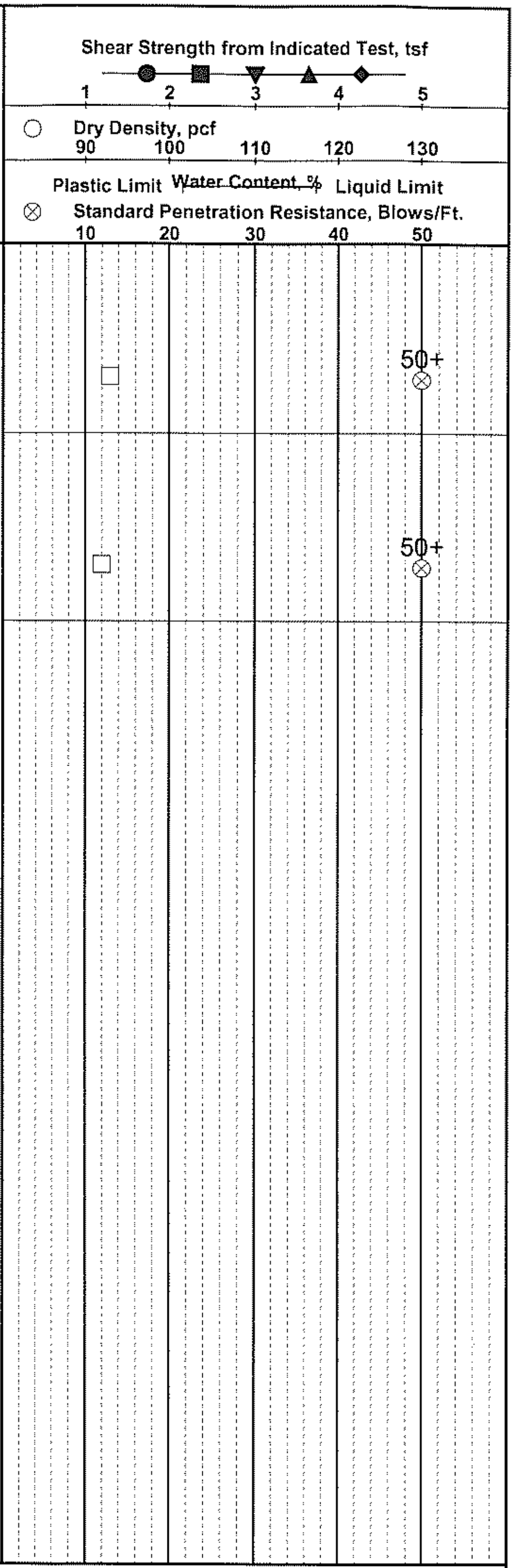
COMPLETION DEPTH 45.0 **FT.**

DRILLING METHOD CFA

ROCK CORE DIAMETER **IN.**

SURFACE ELEVATION 5914.7 **FT.**

DEPTH, FT.		STRATUM DEPTH, FT.	SPT SPLIT SPOON	SPT BLOWS/6 in. THREE 6 in. INCREMENTS	UNDISTURBED SAMPLE	PERCENT RECOVERY	ROCK CORE
			▬	50/2"			
40							
			▬	50/2"			
45	Boring terminated at 45 feet	45.0					
50							
55							
60							
65							
70							



WATER LEVEL OBSERVATIONS			NOTES
DURING DRILLING	Dry	FT.	
AT COMPLETION		FT.	
AFTER HRS.		FT.	

Shear Test Types - Static Cone: ● Pocket Penetrometer: ■ Unconf. Compr.: ▼ Miniature Vane: ▲ Field Vane: ◆

South Academy Highlands
El Paso County, Colorado

LOG OF BORING MT13

PROJECT NO. 13173 **DATE:** 2/13/13 **LOCATION:** See Figure 1

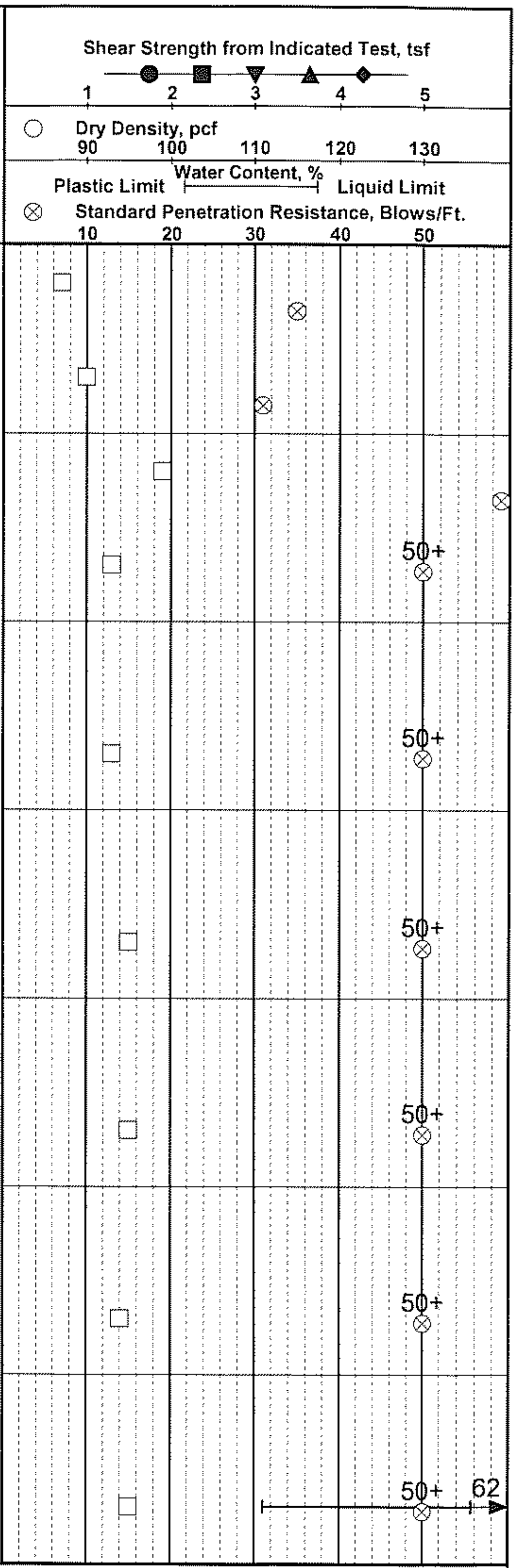
COMPLETION DEPTH 45.0 FT.

DRILLING METHOD CFA

ROCK CORE DIAMETER IN.

SURFACE ELEVATION 5916.5 FT.

DEPTH, FT.		STRATUM DEPTH, FT.	SPT BLOWS/6 in. THREE 6 in. INCREMENTS	UNDISTURBED SAMPLE	PERCENT RECOVERY	ROCK CORE
	Brown very stiff Silty Clay (CL) with trace sand and gravel		7 14 21			
5			14 14 17			
	Gray hard Claystone	6.0	14 24 35			
	Gray hard Shale	8.0	50/4"			
10						
15			50/3"			
20			50/4"			
25			50/3"			
30			50/3"			
35			50/3"			



WATER LEVEL OBSERVATIONS		
DURING DRILLING	Dry	FT.
AT COMPLETION		FT.
AFTER HRS.		FT.

NOTES

Shear Test Types - Static Cone: ● Pocket Penetrometer: ■ Unconf. Compr.: ▼ Miniature Vane: ▲ Field Vane: ◆

MIDWEST TESTING

South Academy Highlands
El Paso County, Colorado

LOG OF BORING MT13

PROJECT NO. 13173 **DATE:** 2/13/13 **LOCATION:** See Figure 1

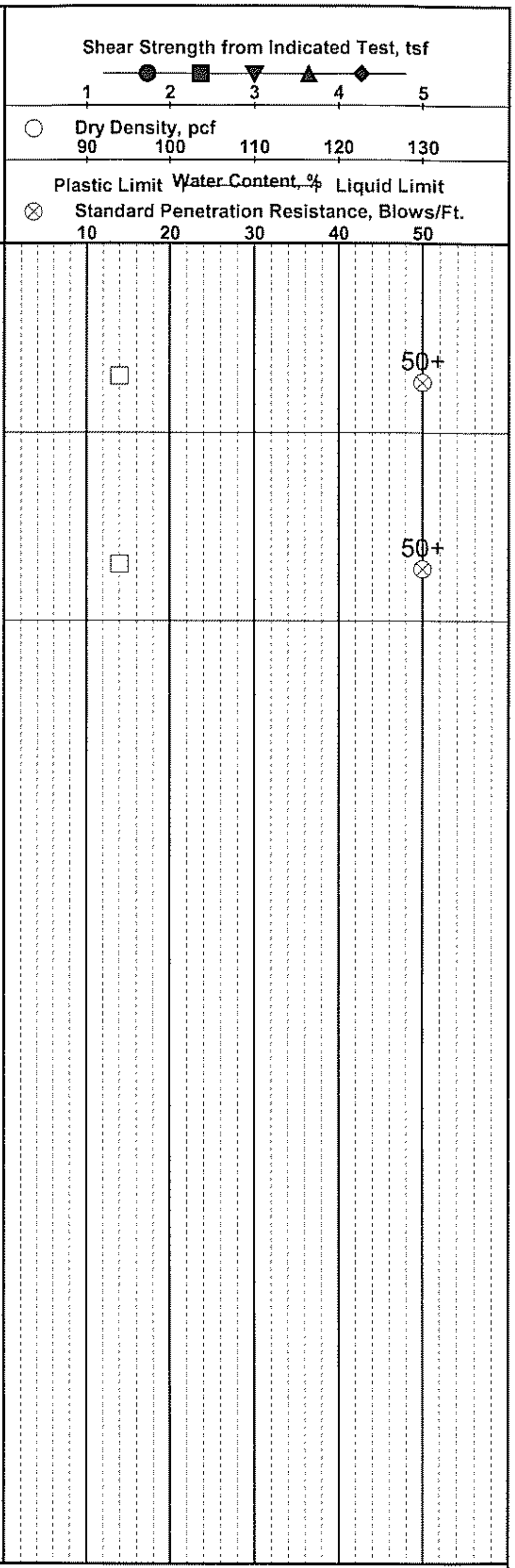
COMPLETION DEPTH 45.0 **FT.**

DRILLING METHOD CFA

ROCK CORE DIAMETER **IN.**

SURFACE ELEVATION 5916.5 **FT.**

DEPTH, FT.		STRATUM DEPTH, FT.	SPT: SPLIT SPOON	SPT: BLOWS/6 in. THREE 6 in. INCREMENTS	UNDISTURBED SAMPLE	PERCENT RECOVERY	ROCK CORE
			▆	50/4"			
40							
			▆	50/3"			
45		45.0					
	Boring terminated at 45 feet						
50							
55							
60							
65							
70							



WATER LEVEL OBSERVATIONS		
DURING DRILLING	Dry	**FT.**
AT COMPLETION		**FT.**
AFTER **HRS.**		**FT.**

NOTES

Shear Test Types - Static Cone: ● Pocket Penetrometer: ■ Unconf. Compr.: ▼ Miniature Vane: ▲ Field Vane: ◆

MIDWEST TESTING