SECTION 01020

GEOTECHNICAL REPORT

PART 1 GENERAL

1.1 SECTION INCLUDES

A. Reports of explorations and tests of subsurface conditions at the project site.

1.2 RELATED SECTIONS

A. Section 01010 – Summary of Work

B. Section 02300 – Earthwork

1.3 INVESTIGATION

A. Soil and subsurface investigations were conducted at the site, the results of which are to be found in the report issued by Shannon & Wilson, Inc, Geotechnical and Pavement Design Report, July 6, 2017.

B. A reference copy of the report is included herein, Supplement A (01020)

C. Bidders are expected to examine soils investigation data and to make their own investigation of the site on or prior to the bid date.

1.4 INTERPRETATION

A. Soil investigation data is provided only for information and the convenience of bidders. Owner and Engineer disclaim any responsibility for the accuracy, true location, and extent of the soils investigation that has been prepared by others. They further disclaim responsibility for interpretations of that data by bidders, as in projecting soil-bearing values, rock profiles, soil stability and the presence, and level and extent of underground water.

PART 2 PRODUCTS (NOT APPLICABLE)

PART 3 EXECUTION (NOT APPLICABLE)

END OF SECTION

Geotechnical and Pavement Design Report
Highway 105
Full Corridor Design
El Paso County, Colorado

July 6, 2017

SHANNON & WILSON, INC.

GEOTECHNICAL AND ENVIRONMENTAL CONSULTANTS

Excellence. Innovation. Service. Value.
Since 1954.

Submitted To:
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Colorado Springs, Colorado 80920

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23-1-01311-002

SHANNON & WILSON, INC.
GEOTECHNICAL AND ENVIRONMENTAL CONSULTANTS

July 6, 2017

HDR Engineering, Inc.
2060 Briargate Parkway, Suite 120
Colorado Springs, Colorado 80920

Attn: Cory Beasley, P.E.

RE: GEOTECHNICAL AND PAVEMENT DESIGN REPORT, HIGHWAY 105 FULL CORRIDOR DESIGN, EL PASO COUNTY, COLORADO

We are pleased to submit our geotechnical report for the above-referenced project. The enclosed report summarizes subsurface conditions encountered in a subsurface exploration program, laboratory tests, and geotechnical engineering and pavement design recommendations.

We appreciate the opportunity to be of service to you on this project. If you have any questions or require further information, please contact me at 303-825-3800.

Sincerely,

SHANNON & WILSON, INC.

Gregory R. Fischer, PhD, P.E.
Senior Vice President

JCG:GRF/lmr

Encl: Geotechnical and Pavement Design Report

01311-002_L1/wp/lmr

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GEOTECHNICAL AND PAVEMENT DESIGN REPORT
HIGHWAY 105
FULL CORRIDOR DESIGN
EL PASO COUNTY, COLORADO

1.0 INTRODUCTION

This geotechnical and pavement design report provides our recommendations for the Highway (Hwy) 105 Full Corridor Design Project. The following report summarizes our subsurface explorations and laboratory testing, and presents geotechnical design recommendations. Our services were conducted in general accordance with our amendment to subconsultant agreement with HDR, Inc. (HDR), signed November 18, 2015.

2.0 PROJECT AND SITE DESCRIPTION

Proposed improvements to Hwy 105 consists of approximately 4.8 miles of roadway widening between Interstate 25 (I-25) and State Highway (SH) 83 (refer to Figure 1). The eastern ¼-mile of the corridor is located within the Town on Monument, Colorado with the remaining western portion of Hwy 105 located in unincorporated El Paso County. East of the improvement corridor, Hwy 105 transitions into SH 105. The existing topography along Hwy 105 generally consists of forested rolling hills with residential development along the corridor. The roadway is currently paved with asphalt, and we understand the proposed roadway surface will remain asphalt.

The Hwy 105 improvement project is divided into two projects. The western project (Project A), is located east of the I-25 ramp intersection and extends to the east of Lake Woodmoor Drive (Station [Sta.] 104+00 to Sta. 154+70, respectively). The eastern project (Project B), extends from Lake Woodmoor Drive to SH 83 (Sta. 154+70 to Sta. 358+46, respectively). Refer to Figure 2 for an overview of the alignment and the corresponding stationing discussed in this report. For the purposes of this report, we understand Project A will be taken through final design while preliminary geotechnical recommendations will be provided for Project B.

Project A will be widened to support two eastbound (EB) and two westbound (WB) travel lanes with a separated median. Based on preliminary plans available at the time of this report, Project B will be widened to accommodate 2 traffic lanes and a center turn lane. Improvements to the existing roadway include the widening of the existing right of way and will require both cut and fill walls throughout the alignment. In general, the widening improvements will be made both to the north and south of the existing alignment.

It is our understanding that overlay alternatives are being considered for rehabilitation of the pavement in Project A. In general, the existing pavement in Project A is in fair condition with occasional longitudinal, transverse, and fatigue cracking. We understand that the pavements in Project B will be fully reconstructed.

At this time, the proposed walls for both Projects A and B include mechanically stabilized earth (MSE) walls, drilled shaft tangent pile walls, and cast-in-place (CIP) concrete cantilever walls. Project A includes 4 proposed walls designated Wall 1 through Wall 4. Wall 1 (Sta. 131+48 to Sta. 137+27) and Wall 2 (Sta. 145+57 to Sta. 150+94) will be constructed as MSE walls with approximate maximum heights of 16 feet and 10 feet, respectively. Wall 3 (Sta. 152+20 to Sta. 154+75) and Wall 4 (Sta. A 152+99 to Sta. 154+70) are proposed cantilevered drilled shaft walls, with maximum exposed heights of approximately 10 feet for both walls.

We understand the proposed walls for Project B have been advanced to the preliminary design stage. The preliminary plans indicate eleven walls are proposed and are designated RW-01 through RW-11. RW-01 and RW-02 are continuations of Walls 4 and 3 from project A, respectively. The remaining walls will consist of either MSE wall in fill locations and CIP concrete cantilever walls in cut locations. Refer to Figure 2 for the proposed wall locations at the time of this report.

3.0 FIELD EXPLORATIONS AND LABORATORY TEST RESULTS

3.1 Preliminary Subsurface Investigation

Shannon & Wilson conducted a preliminary field exploration program in June 2012 with nine borings designated SW-01 and SW-03 through SW-10. These preliminary investigation boring were presented in our June 22, 2012 preliminary geotechnical report and logs of these borings are reproduced in Appendix D of this report.

3.2 Final Subsurface Explorations

Shannon & Wilson implemented the final geotechnical exploration program in two mobilizations, one to evaluate pavement subgrade conditions in June of 2016 and a second at proposed retaining wall locations in November 2016. The initial mobilization consisted of 28 pavement borings drilled along the alignment (designated as SW-P-01 through SW-P-28). Our second mobilization consisted of 29 borings and 9 test pits with both borings and test pits designated sequentially from west to east (borings designated as SW-W-01 through SW-W-38 with test pits explorations at TP-06 though TP-08, TP-14, TP-17, TP-19, TP-28, TP-29, and TP-33). The approximate boring locations are shown on Figure 2. In general, the location of pavement borings on Hwy 105 were drilled through the existing asphalt pavement. The wall borings and test pits were completed at wall locations adjacent to the existing pavement where feasible. In areas where drilling access was restricted due to available right-of-way or overhead and underground utilities, wall borings were completed within the existing roadway. Cores of the existing pavement were completed at each pavement boring location in Project A (borings SW-P-01 though SW-P-06) and photographs of the pavement cores are presented in Appendix C. Appendix A describes the procedures used to complete the drilling and sampling of the borings and excavations of the test pits, provides an explanation of the symbols and terminology used, and presents the individual boring logs.

3.3 Falling Weight Deflectometer Testing

As part of our investigation of the existing Hwy 105 pavements, nondestructive falling weight deflectometer (FWD) testing was completed on the existing pavements for consideration for future rehabilitation within Project A. Testing was completed on the existing travel lane of both the eastbound and westbound lanes from the I-25 ramps to Lake Woodmoor Drive. Appendix D contains the summary report.

3.4 Laboratory Test Results

Shannon & Wilson completed geotechnical laboratory testing to determine index and engineering properties of samples retrieved from the borings. Laboratory tests included natural water content, grain size distribution, Atterberg limits, R-Values, swell/consolidation, and corrosion testing. Laboratory test results and a discussion of testing procedures for each of the borings are included in Appendix B. The natural water contents, Atterberg limits, and percent fines are also indicated on the individual boring logs in Appendix A.

4.0 REGIONAL GEOLOGY AND SUBSURFACE CONDITIONS

4.1 Regional Geology

Published geologic information (Thorson and Madole, 2003) encompassing the project area indicates the bedrock geology consists of Paleocene (approximately 56 to 65 million years old) sedimentary rocks of the Dawson Formation, specifically, facies units four and five in the upper part of the formation. Facies unit four is shown as underlying the western end of the alignment. It transitions to the overlying facies unit five near Lake Woodmoor Drive (approximate Sta. 153+00). Facies unit five extends beneath the alignment to the east edge of the project area.

Facies unit four is dominated by thick bedded to massive arkosic sandstone and conglomerate with several interbeds of finer grained, friable sandstone with high clay content. The top of this unit is defined by a well developed paleosol, or ancient soil horizon, characterized by mottled reddish clayey sandstone. Facies unit five is similar to facies unit four in containing thick arkosic sandstone and conglomerate beds interspersed with thin beds of finer grained, clay-rich sandstone. Geologic structure is dominated by bedding within the Dawson Formation, which dips gently to the northeast.

Surficial deposits are mapped along the west end of the alignment between approximate Sta. 105+00 and 152+00 and, intermittently along the east end of the alignment between approximate Sta. 321+00 and 358+46. At the west end of the alignment, surficial deposits are typically 5 to 15 feet thick and include sheetwash and older stream alluvium characterized by thin beds of poorly sorted sand and sandy fine pebble gravel. Older stream alluvium, up to 60 feet thick, consisting of poorly sorted, fine to coarse sand and pebble gravel and modern stream alluvium, approximately 5 feet thick, characterized by sand, silt, and minor gravel comprise the surficial deposits at the east end of the alignment.

4.2 Subsurface Conditions

The explorations were performed to evaluate geotechnical soil conditions at the project site. Our observations are specific to the locations, depths, and times noted on the logs and may not be applicable to all areas of the site. No amount of explorations or testing can precisely predict the characteristics, quality, or distribution of subsurface and site conditions. Potential variation includes, but is not limited to:

- The conditions between explorations may be different.
- The passage of time or intervening causes (natural and manmade) may result in changes to site and subsurface conditions.

If conditions different from those described herein are encountered during construction, we should review our description of the subsurface conditions to reconsider our conclusions and recommendations.

4.2.1 Project A Walls

Borings SW-W-01 through SW-W-05, SW-W-09, and SW-W-10 and test pits TP-06 through TP-08 were completed at the proposed Project A walls. Our borings and test pits generally encountered overburden material consisting of very loose to medium dense sand with varying percentages of silt and clay. Sandstone was then encountered in each boring to the termination depth of each boring and test pit. The sandstone was very low strength, completely to moderately weathered.

4.2.2 Project B Walls

Borings SW-W-11 through SW-W-38 and TP-14, TP-17, TP-19, TP-28, TP-29, TP-33 were completed at the proposed Project B walls. The explorations generally encountered overburden consisting of very loose to dense sand with silt and clay, clayey sand, and silty sand. Occasional soft to stiff sandy clay layers were also encountered. Underlying the overburden was very low strength sandstone with occasional claystone and siltstone layers.

4.2.3 Pavement Subgrade Conditions

Based on the pavement borings (SW-P-01 through SW-P-26), the existing pavement asphalt thicknesses ranged from 6 to 12.5 inches along the alignment. In general, the existing Hwy 105 pavement consisted of a full-depth hot mix asphalt (HMA) pavement section overlying native subgrade soils. Borings SW-P-01 and SW-P-02 encountered 11 and 5 inches, respectively, of aggregate base course (ABC) material below the existing HMA. A scattered, thin granular material was observed below the existing pavement in 11 of the 26 pavement borings. These granular layers (logged as base course in our logs) are generally 1 to 3 inches thick and it is unclear if this material was placed is an ABC or are granular soils generated from native subgrade material used to level the roadway (during the initial construction).

Pavement subgrade soils were variable but predominately consisted of loose to dense clayey sand, silty sand, and sands with silt and sand (AASHTO A-1-b, A-2-4, and A-2-6). Sandstone and claystone were also occasionally encountered throughout the alignment (A-2-4 and A-6).

4.2.4 Groundwater

Groundwater was encountered at the wall locations in boring SW-W-02, SW-W-09, and SW-W-12 at a depth of approximately 20, 17, and 14 feet, respectively. Boring SW-P-05 encountered groundwater at a depth of 7 feet. All other borings did not encountered groundwater during drilling. Groundwater fluctuations are likely and will depend on seasonal variations, local precipitation and runoff, and other factors.

5.0 GEOLOGIC HAZARD EVALUATION

5.1 Seismic Hazards and Ground Motion Design Parameters

The Front Range of Colorado is an area of low potential for damaging earthquakes. Unfortunately, it is not possible to accurately estimate the timing or location of future earthquakes, because the occurrence of earthquakes is relatively infrequent and the historical earthquake record in Colorado is short (about 130 years). Based on a recent geologic map by the U.S. Geological Survey (Rogers and others, 1998), the nearest fault to the proposed project is the Rampart Range Fault, approximately 4 miles to the west. Based on geomorphic features along the fault trace, this fault is suspected to have been active less than 750,000 years ago. Therefore, in our opinion, the potential for ground surface fault rupture is low.

Liquefaction may occur in loose, saturated, cohesionless soils when subjected to earthquake ground shaking. Based on the subsurface conditions encountered at the project site and the relatively low peak ground acceleration (PGA) for this area, it is our opinion that the risk of liquefaction is low.

Using the American Association of State Highway and Transportation Officials (AASHTO) Load and Resistance Factor Design (LRFD) Bridge Design Specifications (AASHTO, 2014) criteria, and based on subsurface conditions encountered in our boring at the proposed walls (assuming that similar conditions are present from the maximum depth of our boring to a depth of 100 feet), Site Class D is recommended.

Ground motion parameters were determined for the project site using the USGS U.S. Seismic Design Map Web Application (USGS, 2016) and procedures recommended by AASHTO (2014). Table 1 presents recommended seismic design ground motion parameters.

5.2 Swell

Many of the soil formations along the Front Range of Colorado are susceptible to volume change by swelling/shrinking. This geologic hazard has the potential to cause substantial damage to lightly loaded structures (in particular pavements) when exposed to water. To provide an initial indication of the swell potential of near surface soil and bedrock materials in the area, we reviewed a geologic map of potentially swelling soil and rock developed by Hart (1974). The map generally indicates low swell potential throughout the project area with occasional areas of moderate swell potential.

To further evaluate the potential for swell at the site, we performed swell/consolidation tests on soil samples encountered in our explorations. We performed two swell tests on subgrade samples, one on claystone from boring SW-P-07 and a second on overburden silty sand from SW-P-23. The swell test results indicated 2.2 percent swell and 1.2 percent collapse, respectively. Our swell test result on the claystone sample does indicate a moderate swell potential, but we only occasionally encountered claystone throughout the alignment. In general, the materials encountered throughout the alignment were granular in nature (less than 30 percent fines), and in our opinion, Dawson Formation sandstone and fill soils generated from Dawson Formation are low swell susceptible.

5.3 Corrosion

The subsurface materials in the Front Range of Colorado can be corrosive to substructure elements. To assist in estimating the corrosion potential at each wall location, a soil sample was tested for pH, resistivity, and water-soluble sulfates and chlorides. The results are summarized in Table B-1 in Appendix B.

The measured resistivity in the three samples, one of overburden lean clay, and two samples of sandstone were 570; 2,200; and 2,100 Ohm-centimeters (Ω-cm), respectively. Resistivity values less than 1,000 Ω-cm indicate extremely corrosive conditions and highly corrosive for samples with resistivity between 1,000 to 3,000 Ω-cm (Roberge, 2012). Resistivity results from our preliminary borings (Shannon & Wilson, 2012) indicate highly corrosive conditions.

The concentration of water soluble sulfates measured in a sample from the site was less than 0.09 percent by weight. Based on classifications as defined by ACI-318-14, these test results and those from the preliminary borings (Shannon & Wilson, 2012) suggest a negligible degree of sulfate attack on concrete exposed to site soils (exposure class S0).

The test results provided in our report are meant to assist in the selection of wall materials, concrete type or other features that should consider the subsurface conditions with respect to corrosion. If more evaluation is needed, we recommend a specialist in corrosion-resistance design review the results included in Table B-1 to determine actual construction materials and methods based on the test results.

6.0 PAVEMENT DESIGN RECOMMENDATIONS

Pavements along the Hwy 105 corridor were designed in accordance with the 2015 El Paso County Engineering Criteria Manual. The pavement design is for Hwy 105 from the CDOT right-of-way near Interstate 25 to State Highway (SH) 83.

For our analysis, we assumed the final roadway configuration will consist of:

- two eastbound (EB) and two westbound (WB) travel lanes from I-25 to Lake Woodmoor Drive and;
- one EB and WB travel lane with center turn lanes from Lake Woodmoor Drive to SH83.

Based on discussions with HDR and the County, the roadway classification for Hwy 105 is divided into an urban, principle arterial classification west of Lake Woodmoor Drive (Project A) and either a rural, minor or principal arterial classification east of Lake Woodmoor Drive (Project B). For Project A, we further subdivided the alignment into sub-segments at Knollwood Drive based on the anticipated traffic projections provided by HDR and to accommodate a potential rehabilitation of the existing pavement.

To accommodate the proposed Hwy 105 grade changes, we understand the pavements for the cross streets will be reconstructed at the tie-in locations. Because the cross streets are predominately access roads for residential roads, the preliminary pavement section for these roads assumes a Local roadway classification and minimum traffic loading. This Local roadway classification should be validated with El Paso County for the cross streets along the alignment, including Furrow Road and Roller Coaster Road.

6.1 Subgrade Strength

Based on our subsurface explorations (see Section 4.0), subgrade soils for the proposed pavement were assumed to primarily consist of granular subgrade material (A-2-4, A-2-6, and A-1-b). Subgrade strengths for the pavement design are based on results obtained from the falling weight deflectometer (FWD) analysis of the existing Project A pavement and R-value testing of the subgrade in our geotechnical exploration program for the Hwy 105 corridor. We understand that rehabilitation of the existing pavement will be considered in the western segment where mill and overlay of the existing pavement is feasible.

In accordance with 2015 El Paso County Engineering Criteria Manual, subgrade strength was evaluated with Hveem stabilometer (R-value) tests completed on three bulk samples collected along the alignment. Bulk subgrade samples from borings SW-P-02, SW-P-08, and SW-P-19, SW-P-27. The R-Values ranged from 16 to 62 and are summarized in Table B-2.

For our analysis of Project A the subgrade strength is based on the FWD of the existing pavement. The FWD report is presented in Appendix D. For Project B we averaged the results from the R-Values from boring SW-P-02, SW-P-19, and SW-P-27 resulting in an average R-Value of 19. We discarded the results from SW-P-08 as the R-Value was uncharacteristically high. We used a subgrade modulus of 5,400 psi and 4,800 psi for the west and east segment, respectively.

6.2 Subgrade Treatment

Based on the requirements outlined in Section D.2.4 of the El Paso County Engineering Criteria Manual swell mitigation is required for swells greater than 2 percent. In accordance with the Table J-3 of the El Paso County Engineering Criteria Manual the upper 12 inches of the subgrade should be scarified, moisture-treated to above the optimum moisture content, and recompacted in areas where existing pavement is replaced (Section 8.2.2).

6.3 Traffic Loading

To estimate an 18-kip Equivalent Single-Axle Loading (ESAL) value for the roadways, assumptions were made regarding traffic distributions. Traffic loading for Hwy 105 were determined based on discussion with HDR. For Project A we assumed an average daily traffic (ADT) of 13,924 vehicles for the paving year and 19,846 vehicles at the end of the project design life (20 years). For Project B, we assumed an ADT of 10,357 vehicles for the paving year and 18,807 vehicles at the end of the project design life (20 years). We assumed 4 percent truck traffic for the entire length of the alignment. In addition, El Paso County has a minimum required ESAL for design based on roadway classifications. A summary of these traffic projections along with the County minimum traffic loading is provided in Table 2. For Project A, the projected traffic loading is below the County minimum. For Project B, the projected traffic loading is above the County minimum for a for a rural, minor arterial (which assumes two travel lanes) and below the minimum for a rural, principle arterial (which assumes four travel lanes). To provide the County options for consideration, we provided pavement designs for both the projected traffic loading and County minimums as summarized in Table 2.

6.4 Overlay Alternative

We understand that an overlay rehabilitation of the existing pavement in Project A is also being considered. Based on the condition of the pavements along Project A of Hwy 105 an overlay on the existing pavements is feasible within this segment.

Based on pavement cores in this section from borings SW-P-01 through SW-P-06, the thickness of the existing pavement varies and there were indications of significant asphalt degradation. For our overlay analysis, we assumed the asphalt was in good to fair condition (with an existing structural layer coefficient of 0.30). Refer to Table 2 for the Project A overlay design recommendations.

6.5 Recommended Pavement Sections

Appendix D presents a summary of design parameters used in our pavement analyses. For our analysis, HMA thicknesses were rounded up to the nearest ½ inch and ABC thicknesses were rounded up to the nearest inch. Our recommended pavement sections are presented in Table 2.

7.0 RETAINING WALL RECOMMENDATIONS

The proposed walls for the project include MSE, cantilevered drilled shaft wall, and cast-in-place concrete cantilevered gravity wall. Design recommendations based on AASHTO (2014) for these walls are provided in the following sections.

7.1 Project A Walls

As indicated in Section 2.0, Project A will consist of MSE walls (Walls 1 and 2) and drilled shaft tangent walls (Walls 3 and 4).

7.1.1 MSE Walls

Consistent with AASHTO (2014) requirements, a minimum 4-foot wide horizontal bench should be provided in front of MSE walls bearing on slopes. The horizontal bench may be formed or the slope may be continued above the elevation of the bench. Regardless, the base of the reinforced zone should be embedded a minimum of 3 feet below the bench elevation for frost protection.

To satisfy global stability requirements (i.e., provide a minimum factor of safety (FS) of 1.5 for static conditions and 1.1 for seismic conditions) and reduce potential for compound stability to control the design, we recommend a minimum MSE wall reinforcement length of

0.7H (where H is the height measured from the bottom of the reinforced fill zone to the top of the wall) or 8 feet, whichever is greater. The reinforcement lengths may need to be increased to meet internal, external (sliding and overturning), or compound stability requirements. These failure modes should be evaluated by the MSE wall designer/vendor as these failure modes depend on the reinforcement type and spacing.

Our recommended lateral earth pressures for design of MSE walls are provided in Table 3. The parameters are based on AASHTO (2014) criteria and assume CDOT Class 1 Structure Backfill is used in the reinforced and either CDOT Class Structure Backfill or fills generated onsite from sandstone or clayey sand within the retained zones (i.e., the 1H:1V zone extending upward from the heel of the reinforced zone). The recommended active lateral earth pressures should be applied to the back of the reinforced zone of MSE walls. The static earth pressures assume a vertical wall face with a horizontal backslope and do not include any hydrostatic pressure related to accumulation of water in the backfill. The MSE vendor/designer may use alternative earth pressure parameters for design based on further testing and characterization of the actual fill materials used for construction. Surcharge loads should be added to the pressures in Table 3.

Soil-reinforcement interaction coefficients should be selected based on the properties of the soil above and below the reinforcement and the selected reinforcement type (continuous or discontinuous) and properties. Sliding parameters and analyses should be evaluated by the MSE wall vendor/designer considering the friction angle of the foundation soil provided in Table 4 and appropriate interaction coefficients. AASHTO (2014) recommends a resistance factor of 1.0 for sliding analyses. Table 4 provides the anticipated subgrade conditions at each of the proposed walls. Based on these observed subgrade conditions, we recommend the following drained strength parameters for sliding analysis:

- Clayey Sand subgrade: ϕ' = 30 degrees, c' = 0 psf
- Sandstone: ϕ' = 38 degrees, c' = 0 psf

The anticipated settlement values for MSE walls are provided in Table 4. Differential settlement of approximately ½ the overall settlement is expected to occur over a distance of 25 feet. We anticipate that the majority of settlement will occur during wall construction.

We recommend that MSE walls include the drainage measures similar to the CDOT Structural MSE Worksheet Sheets and as discussed in Section 7.4.

We understand that the existing private wall located south of the Monument Academy School near Wall 1 will be removed and replaced by Wall 1. We recommend that all elements of the existing wall including; facing, reinforcements, and all other deleterious material associated with the current wall be completely removed.

7.1.2 Drilled Shaft Wall

We understand that Walls 3 and 4 will be constructed as a drilled shaft tangent pile wall. The design of tangent pile walls could be completed using force-moment equilibrium methods, with the active and passive earth pressure parameters provided in Table 5. Alternatively, the walls could be designed using the p-y method to evaluate the lateral behavior of the deep foundation elements. Such an analysis could be completed with a combination of the active earth pressure parameters and the LPILE parameters provided in Table 5.

The active parameters assume the top of the wall will be free to deflect at least 0.001 times the height of the wall. If such deflections are not feasible, at-rest parameters should be used. We have assumed that these walls will incorporate appropriate drainage system such that water will not accumulate in the backfill (see Section 7.3). Accordingly, our design recommendations do not include hydrostatic pressure behind the wall. As appropriate, surcharge loads should be added to the earth pressures in Table 5. Surcharge pressures can be determined using the parameters provided in Table 5 and the diagrams provided in Figure 3.

For the tangent drilled shaft walls, standard earth pressure theory and force/moment balance analyses should be used to design the drilled shaft size and embedment depth. Earth pressure distributions are appropriate for design of the wall and should be used above the base of the retained wall excavation. We recommend a minimum shaft spacing of six inches between shafts for constructability and a maximum separation between shafts (edge to edge) equal to one diameter, up to a maximum of 2.5 feet. At this spacing, arching stresses in the soil and concrete loss into the formation should strengthen the soil between shafts and reduce the potential for ground loss between shafts prior to permanent facing installation. For permanent facing design, the lateral earth pressure between shafts can be reduced by 50 percent due to arching stresses. A minimum shotcrete thickness of 4 inches is recommended for the excavated space between tangent shafts as part of the permanent facing detail. Should soil loss tend to occur between shafts during excavation of the tangent wall, a flash application of shotcrete could be applied to temporarily retain soil. Partial excavation heights and immediate placement of shotcrete can mitigate soil loss during excavation.

To provide adequate global stability, we recommend a bedrock penetration of approximately 5 feet for deep foundation supporting retaining structures.

7.2 Preliminary Project B Walls Recommendations

As indicated in Section 2.0, preliminary design plans indicate MSE walls and cast-in-place cantilever gravity walls are proposed for Project B walls. Limited information is available for the walls in Project B and the parameters provided for walls in Project B should be considered preliminary. Once final layout and wall heights for the Project B walls are determined, we should be contacted to review and provide final design recommendations.

Based on preliminary plans provided by HDR, eleven walls will be completed in project B. The walls are indicated as RW-01 through RW-11. RW-01 and RW-02 are continuations of Project A Walls 4 and 3, respectively. The remaining walls will consist of three fill walls and six cut walls. Refer to Figure 2 for approximate wall locations.

7.2.1 MSE Walls

All recommendations and assumptions presented in Section 7.1.1 are applicable for Project B MSE walls. Our preliminary recommended lateral earth pressures and anticipated settlement values for Project B MSE walls are provided in Table 6. Surcharge loads should be added to the pressures in Table 6.

To meet global stability requirements (i.e., provide a minimum factor of safety (FS) of 1.5 for static conditions and 1.1 for seismic conditions) and reduce potential for compound stability to control the design, we recommend a minimum MSE wall reinforcement length of 0.7H (where H is the height measured from the bottom of the reinforced fill zone to the top of the wall) or 8 feet, whichever is greater. The reinforcement lengths may need to be increased to meet internal, external (sliding and overturning), or compound stability requirements. These failure modes should be evaluated by the MSE wall designer/vendor as these failure modes depend on the reinforcement type and spacing.

Table 6 provides the anticipated subgrade conditions at each of the proposed walls. Based on these observed subgrade conditions, we recommend the following drained strength parameters for sliding analysis:

- Clayey Sand subgrade: ϕ' = 28 degrees, c' = 0 psf
- Sandstone: ϕ' = 38 degrees, c' = 0 psf

7.2.2 Cast-in-place Concrete Cantilever

Our recommended preliminary design parameters for Project B cast-in-place concrete cantilever (CIPCC) walls are provided in Table 7 based on the anticipated bearing stratum at each wall. Based on preliminary cross sections provided by HDR we anticipate that CIP walls RW-05, RW-07, RW-08, and RW-10 will bear predominately on sandstone while portions of walls RW-04 and RW-11 will bear on loose clayey sands. Additional recommendations and assumptions are summarized below:

- Active earth pressures assume walls are free to displace a minimum of 1/1,000th the structure height (0.001H).
- Active earth pressures assume walls are backfilled with either CDOT Class 1 Structure Backfill or fills generated onsite from sandstone or clayey sand in the 1 horizontal to 1 vertical (1H:1V) zone extending upward from a point 1.5 feet behind the heel of the wall.
- The earth pressures assume walls have a vertical wall face and horizontal back slope.
- Passive lateral earth pressures can be applied below the frost depth.
- The earth pressures assume drainage measures are provided such that hydrostatic pressures do not develop in the retained backfill (Section 7.3).

If any of these conditions are not met, we should be notified so that we may revise our recommendations.

Surcharge loads such as motor vehicles and construction equipment will induce lateral loads on retaining walls and buried structures. Consistent with AASHTO (2014) criteria, we recommend utilizing a live load traffic surcharge of 250 psf for areas subject to motor vehicle loading. Lateral loads due to various types of surcharges may be calculated using the parameters provided in Table 7 and the diagrams provided in Figure 3.

7.3 MSE and CIPCC Wall Drainage

The earth pressure parameters provided for the proposed walls assume a free-draining backfill condition. As such, it will be important to control surface water and to provide drainage measures that reduce the potential for water to accumulate behind walls.

Surface water behind the wall should not be allowed to discharge directly into the wall backfill materials. In addition, water should not be allowed to discharge or pond around retaining structures. We recommend sloping the ground surface in front of walls a minimum of 5 percent away from the wall face for a minimum horizontal distance of 10 feet measured from the face of the wall (or until a paved surface is encountered, whichever is less).

We recommend that MSE walls include the drainage measures shown in the CDOT Structural Worksheet Sheets, which include the use of a geomembrane installed above the reinforced and retained zones, a heel drain at the back of the reinforced zone, and geocomposite strip drains installed on the cut surface behind the retained zone. Providing adequate drainage to reduce hydrostatic forces against the back of the wall and accumulation of water in the reinforced zone will be critical to the long-term stability and performance of the wall.

In general, materials with greater than about 3 percent fines content are not considered free draining. CDOT Class 1 backfill may have a maximum fines content of 20 percent, indicating the material may not be free draining. Appropriate drainage features could include:

- Placement of a 12-inch thick drainage layer (CDOT Filter Material) on the back face of the wall, with a discharge system (e.g. weep holes or a perforated collector pipe at the base of the drainage layer, daylighting to a suitable discharge point).
- Installation of geocomposite drainage boards on the back face of the wall, with a suitable discharge system (e.g. weep holes or a perforated collector pipe, daylighting to a suitable discharge point)
- Limiting the fines content of the Class 1 backfill to 3 percent.

8.0 CONSTRUCTION AND MATERIALS CONSIDERATIONS

The applicability of the design parameters in Sections 6.0 and 7.0 is contingent on good construction practice. Poor construction techniques may alter conditions from those upon which our recommendations are based, and therefore result in poor performance. Our analyses assumed that this project is constructed according to El Paso County construction standards. The following sections provide additional construction considerations for this project.

8.1 Drilled Shaft Installation

8.1.1 Drilled Shaft Installation Methods and Equipment

Specifications and installation methods should be in general accordance with our recommendations and guidelines in the 2010 FHWA Manual, “Drilled Shafts: Construction Procedures and Design Methods” (Brown and others, 2010).

Drilled shafts for Walls 3 and 4 will be socketed in the bedrock. Our experience indicates heavy duty drill rigs using auger drill methods can usually penetrate bedrock similar to that encountered at the site. Moderately cemented layers of sandstone are not uncommon and may result in more difficult and slower drilling. These layers are variable in location and thickness. The specifications should require the drilled shaft contractor to demonstrate experience in this formation, or adequate evaluation of bedrock conditions, to confirm proposed methods and expected production.

Based on the borings and test pits completed at the proposed Walls 3 and 4, overburden along the wall alignment generally consists of medium stiff clay and medium dense sand with varying amounts of silt and clay. Groundwater was encountered at a depth of approximately 15 feet below the existing ground surface in the Sandstone. During drilled shaft installation, we anticipate the potential need for temporary casing sealed into the bedrock to prevent raveling and caving conditions in the overburden. Where casing is used, it should be pushed, rotated, vibrated, or driven into the bedrock. The inside diameter of the casing should be equal to or larger than the specified drilled shaft dimensions. The use of casings larger than the diameter of the specified casing must have prior approval from the Engineer. Groundwater can infiltrate into drilled shafts from perched water or within fractured or more permeable zones within the sandstone. Hence, the contractor should be prepared for underwater concrete placement techniques (tremie pipes).

If slurry methods are required to stabilize the excavation, we recommend the use of polymer slurry in the bedrock. Uncontrolled slurries should not be permitted. Additionally, the drilled shaft contractor should not be permitted to use mineral (e.g. bentonite) slurry in the bedrock. Mineral slurries may reduce the side resistance in the bedrock below the values provided herein. Construction of drilled shafts using wet methods (i.e. slurry) is more difficult than constructing shafts using dry methods. Because a wet excavation cannot be easily visually observed, good construction practices, particularly the recommendations discussed in Sections 8.1.2 and 8.1.3, are critical to constructing shafts that perform adequately. Wet installation methods and specifications should be in accordance with the 2010 FHWA Manual, "Drilled Shafts: Construction Procedures and Design Methods" (Brown and others, 2010).

8.1.2 Drilled Shaft Inspection and Observation

A geotechnical engineer familiar with the subsurface conditions at the site should observe drilled shaft installation to determine the top of rock elevation and shaft penetration into rock. The hole should be cleaned of loose material and observed by the geotechnical engineer prior to pouring concrete. The drilling and concreting process should be relatively continuous with minimal stoppage of work between the completion of drilling, cleaning the hole, and the placement of concrete after setting the rebar cage.

8.1.3 Concrete Placement

Groundwater inflow into drilled shafts from fractured or more permeable zones within the sandstone bedrock is possible. Pumping and/or tremie concrete placement may be required if significant water inflow develops in the bedrock or shafts are constructed using wet methods. Tremie placement should be used if wet methods are used to construct the shafts or if water cannot be controlled by pumping or bailing such that more than 3 inches of water is present when concrete is placed. The contractor should be prepared to address these issues.

We recommend concrete be designed and placed with a slump of 4 to 6 inches if placed in the dry (with no casing to be pulled), 5 to 7 inches if casing is to be pulled or the shaft is heavily reinforced, and 7 to 9 inches (with maximum aggregate size of 3/4 inch) when pumping and/or tremie placement is used. When casing and/or tremie concrete placement methods are used, a minimum head of concrete of 5 feet above the bottom of the tremie pipe and/or casing should be maintained at all times.

Drilled shaft defects in cased shafts are frequently the result of inadequate head of concrete, particularly when combined with marginal or low slump concrete. If a truck-mounted pump is used to tremie concrete, pull-out of the pipe can occur if a pressure surge causes upward boom movement. Adequate methods should be established to measure and confirm that minimum head requirements are met throughout the concrete placement process.

8.1.4 Non-Destructive Integrity Tests

We recommend that non-destructive tests be completed on select drilled shafts for the project. In our opinion, Cross-Hole Sonic Logging (CSL) will provide the best evaluation of the integrity of the drilled shafts, particularly where temporary casing is used. In our opinion, CSL should be performed on a minimum of ten percent of the total number of drilled shafts for Walls 3 and 4. As a minimum, consideration should be given to installing access tubes for CSL in all shafts in case uncertainty arises during installation regarding the integrity of the shaft.

CSL is a non-destructive testing method that requires steel (preferred for durability and to avoid delaminating from the concrete) or plastic tubes installed in the drilled shaft and tied to the rebar cage. The tubes are attached to the interior of the rebar cage and then the cage is lowered into the hole and the concrete is placed. After the concrete has cured, a sound source and receiver are lowered, maintaining a consistent elevation between source and sensor. A signal generator generates a sonic pulse from the emitter which is recorded by the sensor. Relative energy, waveform, and differential time are recorded and logged. This procedure is repeated at regular intervals throughout the shaft. By comparing the graphs from the various combinations of access tubes, a qualitative idea of the soundness of the concrete throughout the drilled shaft can be interpreted.

For small diameter shafts (less than 2 feet in diameter), CSL testing may not be cost-effective. For these small diameter shafts we recommend using a stress wave method, such as Sonic Echo (SE). The SE method involves generation of low-amplitude stress waves at the top of the shaft. Properties of the shaft concrete then are inferred from measured reflections and travel times of the stress waves. Defects or irregularities in a drilled shaft or any change in the shaft dimensions will change the impedance and result in reflection of wave energy, which allows interpretation of the irregularity or change in diameter. Generally, SE methods are less expensive and can be completed on a greater number of shafts than CSL testing. However, CSL test results are generally considered more accurate in identifying defects.

8.2 Site Preparation

Prior to site grading, ponded water should be drained from low-lying areas. In addition, construction areas should be cleared to a depth necessary to remove all surface and subsurface structures associated with current development of the site, including all pavements, utility poles, fence poles, underground utilities, and other deleterious material. Trees or shrubs to be removed should include the entire rootball and all roots larger than ½-inch-diameter. This may require laborers handpicking the roots from the subsurface soils prior to compaction.

Surface vegetation within construction areas should be removed by stripping. The depth of stripping should be determined at the time of construction based on existing conditions. Debris from the stripping should not be used in general fill construction in either pavement and wall foundation areas, but may be used in landscape areas.

8.3 Earthwork

8.3.1 Excavation Potential

We anticipate that excavation of overburden soil and shallow claystone/sandstone bedrock (where encountered) can be accomplished with conventional excavating equipment, such as dozers, front-end loaders or scrapers. We do not anticipate blasting will be required for rock excavation. However, excavation in fresh rock could be slow at times and require the use of hydraulic excavators and dozers with ripper attachments.

8.3.2 Proof Roll and Subgrade Preparation

Proper subgrade preparation is required for adequate foundation and pavement performance. In pavement areas the exposed material should be scarified in place an additional 12 inches, moisture treated, and recompacted. If granular soils are encountered (AASHTO soil classification A-1, A-2 and A-3), subgrade soils should be compacted within 2 percent of optimum moisture content and recompacted to at least 95 percent of the maximum dry density as determined by AASHTO T180 (modified compaction effort). If cohesive soils are encountered (AASHTO soil classification A-4, A-6 and A-7), subgrade soils should be compacted to 0 to 3 percent above optimum moisture content and recompacted to at least 95 percent AASHTO T99 (standard compaction effort).

The compacted surface below pavements and walls should be proof-rolled with a fully-loaded, tandem-axle, 10-yard dump truck or equivalent. Any areas that are delineated to be soft, loose, or yielding during proof-rolling should be removed and reconditioned, or replaced. We recommend the subgrade be overexcavated to a maximum depth of two feet and a geogrid (Tensar biaxial BX1200, Tensar triaxial TX5, or equivalent products) should be installed at the base of the excavation before backfilling. Below walls, we recommend a granular fill (such as an aggregate base course) placed above the geogrid. Care should be taken during proof-rolling and subgrade preparation to avoid disturbing subgrade soils and supporting soils that will remain in place, as they can rut and pump under repeated construction traffic. Additionally, subgrades should be protected from drying or wetting in excess of what is required to achieve the specified compaction requirements.

We recommend that the contract documents contain contingency for a unit rate for subgrade re-working. For cost estimating purposes, we recommend up to 10 percent of the alignment may encounter pumping subgrade conditions and require either sub-grade re-working or placing of geogrid.

8.3.3 Fill Materials

All fill placed should be free of organics, deleterious material, contaminants, construction debris, and rock fragments larger than 3 inches and which is compacted to a dense and unyielding condition meeting the relative compaction requirements of described in Section 8.3.4.

The on-site soils can be reused as retained fill behind walls provided the material contains less than 35 percent fines. Based on our laboratory testing, we anticipate the site soils will meet this criteria. However, if any soils with greater than 35 percent fines are encountered, such soils should only be used in landscaping or drainage areas of the site.

Import granular fill should have a maximum fines content of 35 percent and a minimum R-value of 20 if placed in the roadway profile.

8.3.4 Fill Placement and Moisture Conditioning

All fill material should be placed in horizontal lifts and be compacted to a dense and unyielding condition. The thickness of loose lifts should not exceed 8 inches for heavy equipment compactors and 4 inches for hand-operated compactors, but may be less depending on that required to obtain the required relative compaction. Granular soils (material with less than 35 percent fines) should be moisture treated to within 2 percent of optimum moisture content and compacted to at least 95 percent of the maximum dry density per AASHTO T180 (modified compaction effort). Cohesive soils should be placed to at least 95 percent of the maximum dry density per AASHTO T99 (standard compaction effort) and be moisture treated to within 0 to 3 percent above the optimum moisture content.

8.4 Temporary Slopes

We anticipate temporary excavations will be required to construct the project. The type of excavation support system selected for construction will depend on proposed depth of the excavation, proximity to existing structures, anticipated surcharge loads, and materials exposed during construction.

Temporary, unbraced excavations should be sloped, as needed, to provide a safe, stable slope. Consistent with conventional construction practice, the Contractor should be responsible for temporary excavation slopes. The Contractor is continually at the site, is able to observe the nature and conditions of the subsurface materials encountered, and is responsible for the methods, sequence, and schedule of construction.

For planning purposes only, we anticipate Type B soils will be encountered and 1:1 (H:V) slopes may be used. We recommend using the excavation criteria in OSHA 29 CFR, Part 1926, Subpart P, Excavations (1989).

If required, temporary, unbraced excavations should be sloped, as needed, to provide a safe, stable slope. Consistent with conventional construction practice, the Contractor should be responsible for temporary excavation slopes. The Contractor is continually at the site, is able to observe the nature and conditions of the subsurface materials encountered, and is responsible for the methods, sequence, and schedule of construction.

8.5 Paving Materials

Per section D.5 of El Paso County Engineering Criteria Manual, the ABC material shall consist of either CDOT Class 5 or Class 6 aggregated base course (CDOT, 2011) with the stipulation the ABC have a minimum R-value of 72.

HMA mix designs should be in accordance with the Pikes Peak Region Asphalt Paving Specification (2015). We recommend that the surface HMA lift be a Grade SX mix with a PG 64-22 binder. Below 2 inches, we recommend either a Grade S or SX mix with a PG 64-22 binder. We recommend a Superpave design gyratory number (N) of 75. In addition, a tack coat should be placed between subsequent lifts if the underlying lift will be used for traffic or left uncovered for a significant period of time.

9.0 PLAN REVIEW AND CONSTRUCTION OBSERVATION

We recommend that we be retained to review the geotechnical aspects of the plans and specifications prior to bidding the work to determine that they are in accordance with our recommendations. While this step is often skipped in design document preparation, our experience is that the review can find discrepancies or misinterpretations and correct them before bidding, thus avoiding potential change orders during construction.

Geotechnical design recommendations are developed from a limited number of explorations and tests. Therefore, recommendations may need to be adjusted in the field. To this end, we recommend that a construction observation and monitoring program be implemented for the project and that Shannon & Wilson be retained to monitor the geotechnical aspects of construction. This monitoring would allow us to confirm that conditions encountered are consistent with those indicated by the explorations and provide expedient recommendations should conditions be revealed during construction that are different from those anticipated.

10.0 LIMITATIONS

Our evaluations, analyses, conclusions, and recommendations are based on the limitations of our approved scope, schedule, and budget described in our Subconsultant Agreement dated November 18, 2015. Our understanding of the project is based on information provided by HDR throughout the project. This report was prepared for the exclusive use of HDR and their representatives for design of the Hwy 105 corridor improvements.

This report should not be used without our approval if any of the following occurs:

- Conditions change due to natural forces or human activity under, at, or adjacent to the site.
- Assumptions stated in this report have changed.
- Project details change or new information becomes available such that our analyses, conclusions, and recommendations may be affected.
- If the site ownership or land use has changed.
- More than 5 years has passed since the date of this report.

If any of these occur, we should be retained to review the applicability of our analyses, conclusions, and recommendations.

Unanticipated soil conditions are commonly encountered and cannot be fully determined by a limited boring and testing program. Such unexpected conditions frequently require that additional expenditures be made to attain a properly constructed project. Therefore, some contingency fund is recommended to accommodate such potential extra costs.

The scope of our services did not include an evaluation regarding the presence or absence of hazardous or toxic materials in the soil, surface water, groundwater, or air, on or below or around this site. If such contamination exists, it would not be possible to determine it within this limited scope of work.

Shannon & Wilson has prepared Appendix D, "Important Information About Your Geotechnical Report," to assist you and others in understanding the use and limitations of our reports.

SHANNON & WILSON, INC.

Joseph Goode, P.E.
Geotechnical Engineer

Mark J. Vessely, P.E.
Vice President

JCG:DAA:MJV/lmr

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NOTES

1. Map adapted from aerial imagery provided by Google Earth Pro, reproduced by permission granted by Google Earth ™ Mapping Service.

2. Alignment adapted from files *2D-HWY105 Project A_TO CAD-5-23-17.dwg* and *10_076DES_HCL_Hwy105_50s_Project_B_to_E.dwg*, received from HDR Engineering, Inc. on May 24, 2017.

0   3000   6000

Approximate Scale in Feet

N

LEGEND

SW-01 — Boring Designation and Approximate Location

SH 1 — Figure 2 Index Map and Reference Sheet Number

Highway 105
Corridor Improvements
El Paso County, Colorado

VICINITY MAP

July 2017   23-1-01311-002

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FIG. 1

FIG. 1

LEGEND

SW-P-01	⊕	Boring Designation and Approximate Location
TP-01	▬	Test Pit Designation and Approximate Location
SW-01	⊕	Preliminary Boring Designation and Approximate Location (Shannon & Wilson, 2012)

NOTES

1. Figure adapted from files *2D-HWY105 Project A_TO CAD-5-23-17.dwg* and *10_076DES_HCL_Hwy105_50s_Project_B_to_E.dwg*, received from HDR Engineering, Inc. on May 24, 2017.
2. Aerial image was derived from the U.S. Department of Agriculture, Farm Service Agency, National Agriculture Imagery Program (NAIP) 2009 digital ortho-mosaic of El Paso County, Colorado.

0 150 300

Approximate Scale in Feet

N

Highway 105
Corridor Improvements
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SITE AND EXPLORATION PLAN

July 2017 23-1-01311-002

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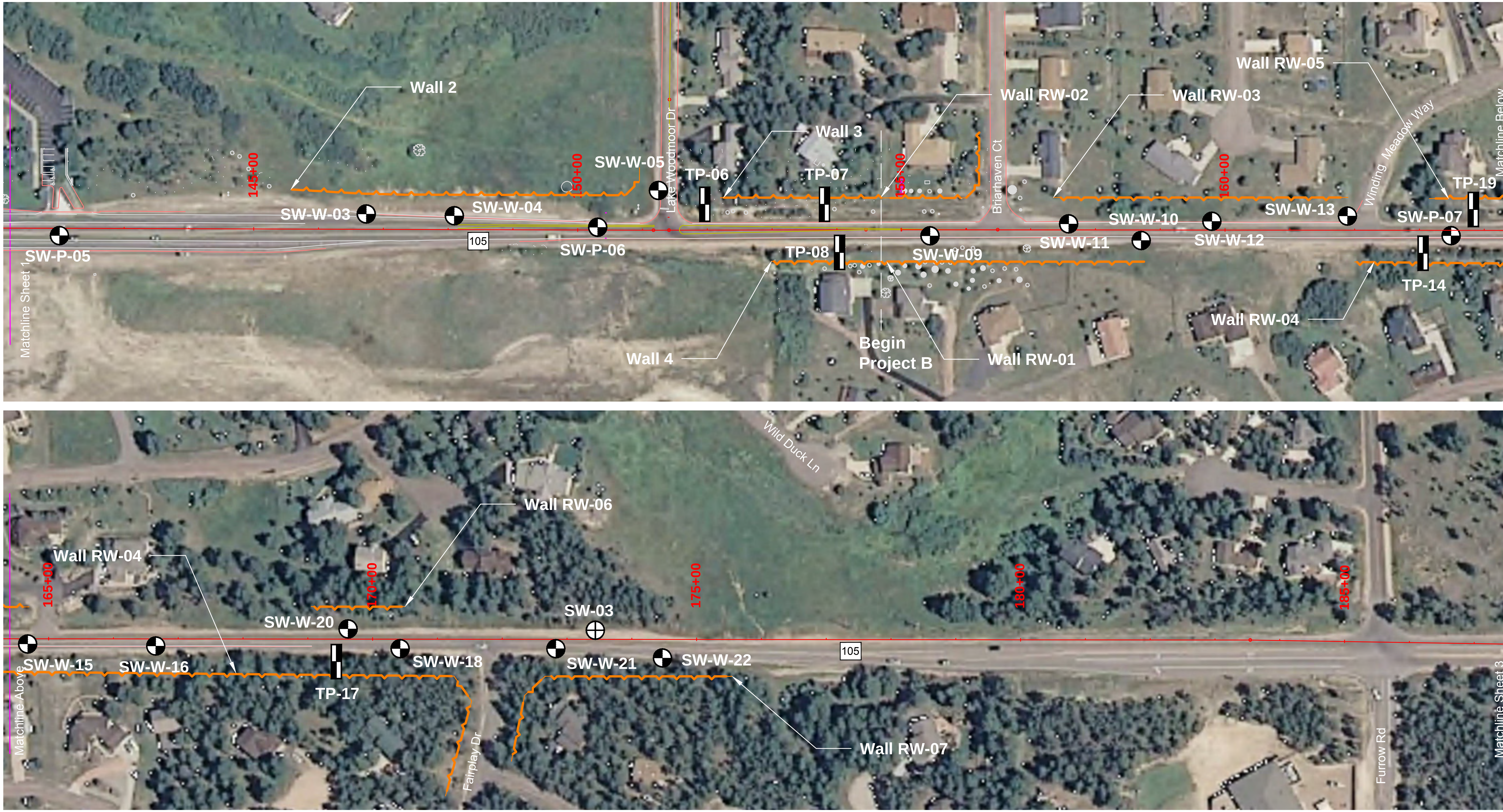
FIG. 2
Sheet 1 of 6

Filename: I:\EF\23-1 DEN\01300s\01311 SH105 Improvements\002 - Full Corridor Design\Drafting\01311-002_F2.dwg Date: 07-06-2017 Login: jcg



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SW-P-01	⊕	Boring Designation and Approximate Location
TP-01	▬	Test Pit Designation and Approximate Location
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Approximate Scale in Feet

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Highway 105
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SITE AND EXPLORATION PLAN

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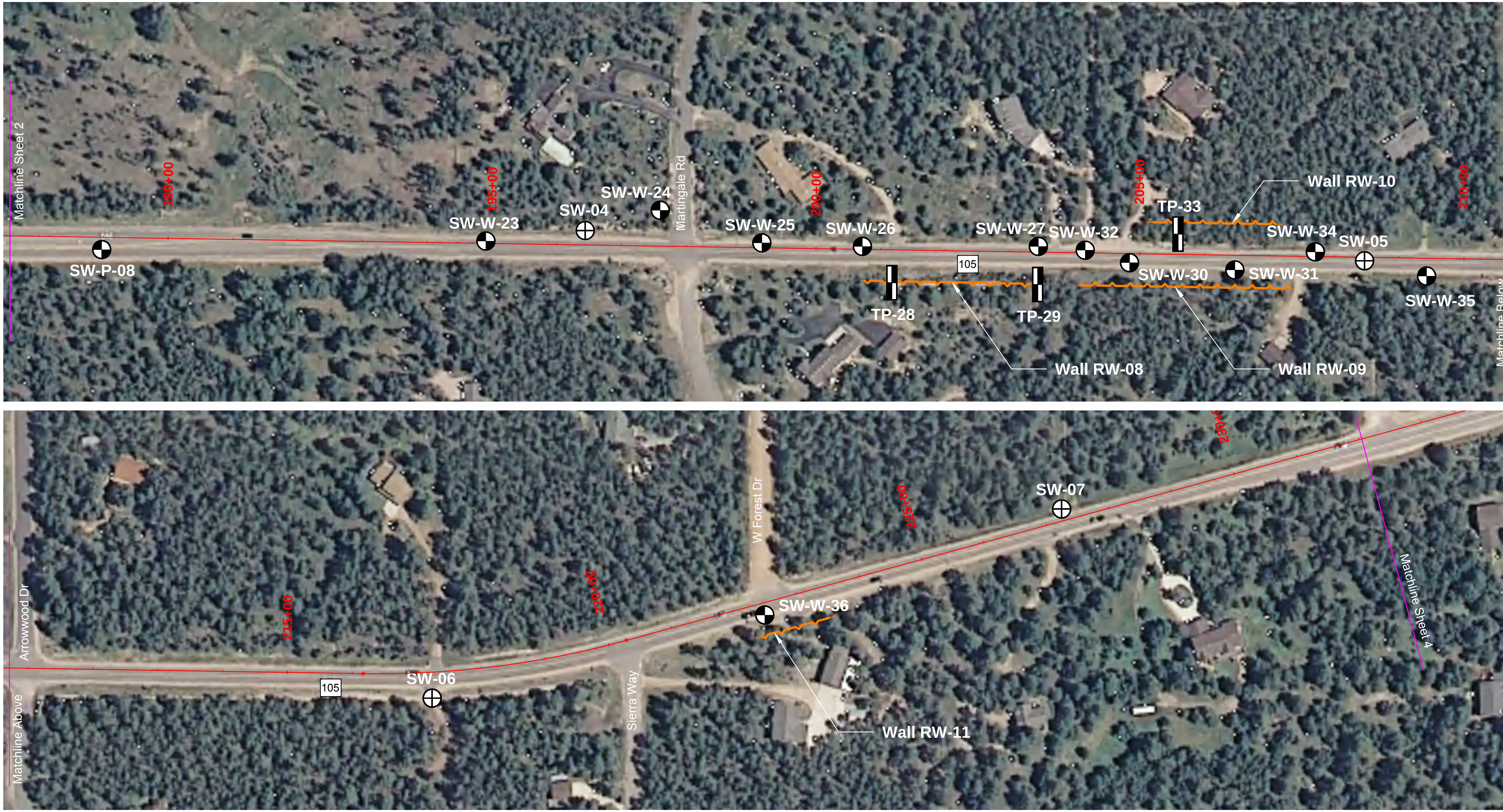
FIG. 2
Sheet 2 of 6

Filename: I:\EF\23-1 DEN\01300s\01311 SH105 Improvements\002 - Full Corridor Design\Drafting\01311-002_F2.dwg Date: 07-06-2017 Login: jcg



LEGEND

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TP-01	▬	Test Pit Designation and Approximate Location
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Approximate Scale in Feet

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SITE AND EXPLORATION PLAN

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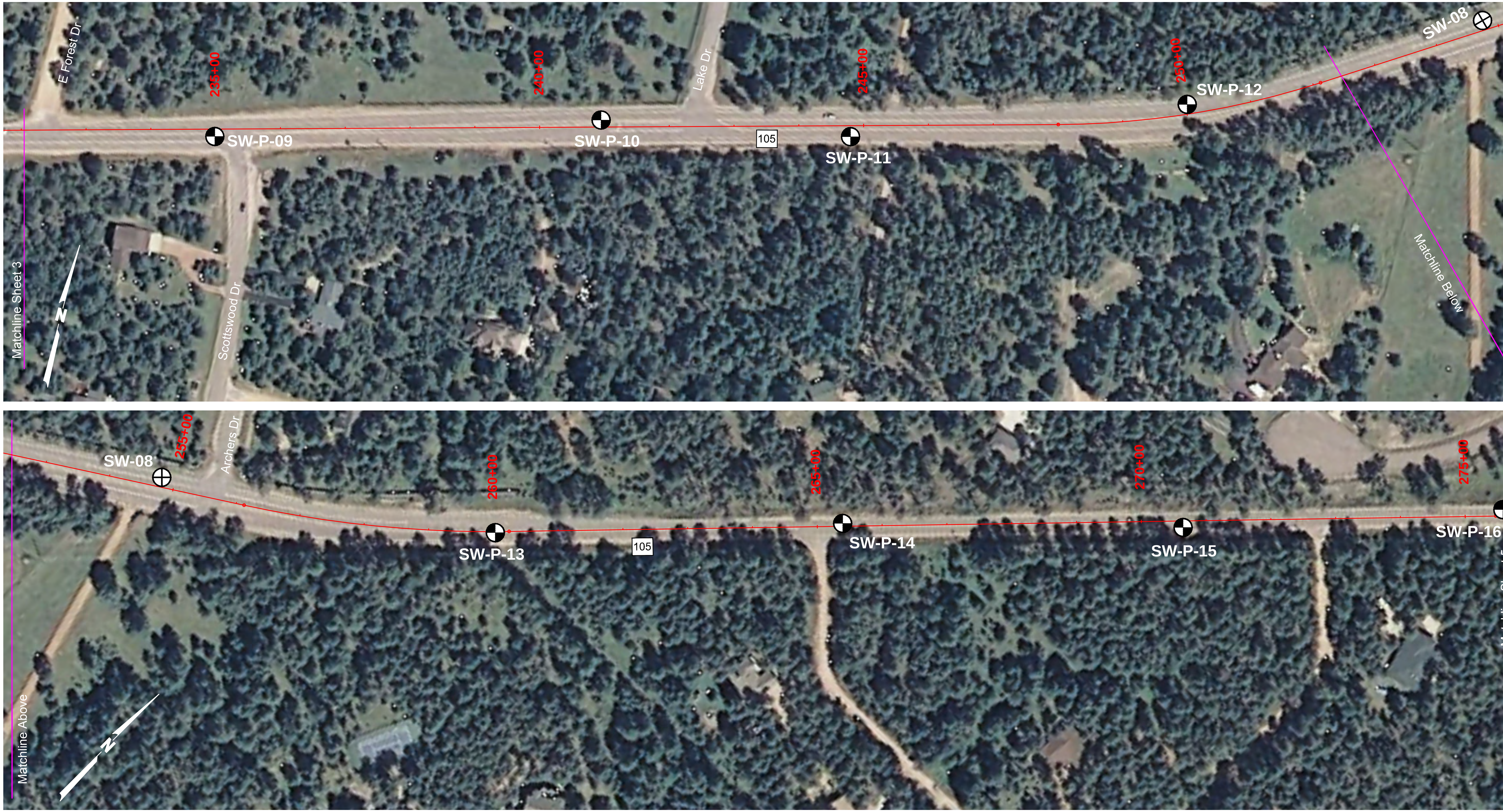
FIG. 2
Sheet 3 of 6

Filename: I:\EF\23-1 DEN\01300s\01311 SH105 Improvements\002 - Full Corridor Design\Drafting\01311-002_F2.dwg Date: 07-06-2017 Login: jcg



LEGEND

SW-P-01 — Boring Designation and Approximate Location

TP-01 — Test Pit Designation and Approximate Location

SW-01 — Preliminary Boring Designation and Approximate Location (Shannon & Wilson, 2012)

NOTES

1. Figure adapted from files *2D-HWY105 Project A_TO CAD-5-23-17.dwg* and *10_076DES_HCL_Hwy105_50s_Project_B_to_E.dwg*, received from HDR Engineering, Inc. on May 24, 2017.
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Approximate Scale in Feet

Highway 105
Corridor Improvements
El Paso County, Colorado

SITE AND EXPLORATION PLAN

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FIG. 2
Sheet 4 of 6

Filename: I:\EF\23-1 DEN\01300s\01311 SH105 Improvements\002 - Full Corridor Design\Drafting\01311-002_F2.dwg Date: 07-06-2017 Login: jcg

LEGEND

- **SW-P-01** — Boring Designation and Approximate Location
- **TP-01** — Test Pit Designation and Approximate Location
- **SW-01** — Preliminary Boring Designation and Approximate Location (Shannon & Wilson, 2012)

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1. Figure adapted from files *2D-HWY105 Project A_TO CAD-5-23-17.dwg* and *10_076DES_HCL_Hwy105_50s_Project_B_to_E.dwg*, received from HDR Engineering, Inc. on May 24, 2017.
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Highway 105
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El Paso County, Colorado

SITE AND EXPLORATION PLAN

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FIG. 2
Sheet 5 of 6

Filename: I:\EF\23-1 DEN\01300s\01311 SH105 Improvements\002 - Full Corridor Design\Drafting\01311-002_F2.dwg Date: 07-06-2017 Login: jcg

LEGEND

SW-P-01 — Boring Designation and Approximate Location

TP-01 — Test Pit Designation and Approximate Location

SW-01 — Preliminary Boring Designation and Approximate Location (Shannon & Wilson, 2012)

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Highway 105
Corridor Improvements
El Paso County, Colorado

SITE AND EXPLORATION PLAN

July 2017 23-1-01311-002

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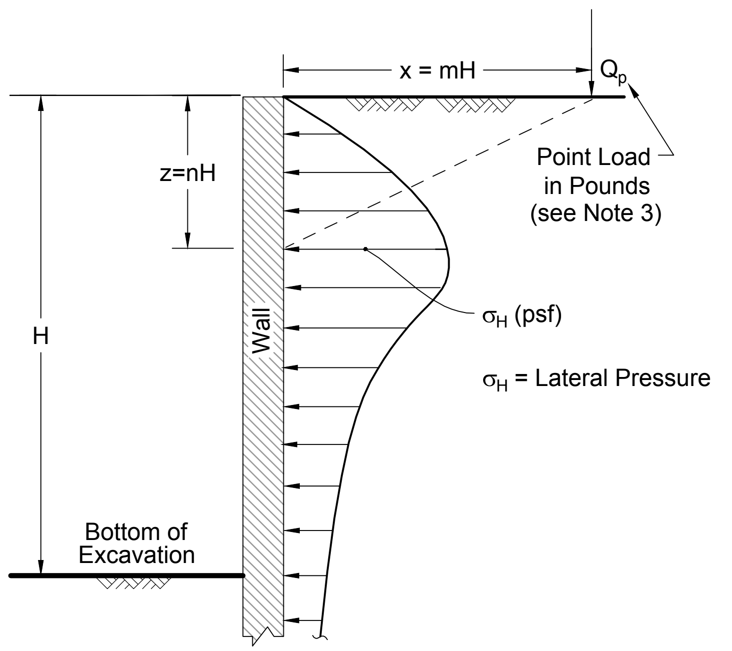
FIG. 2
Sheet 6 of 6

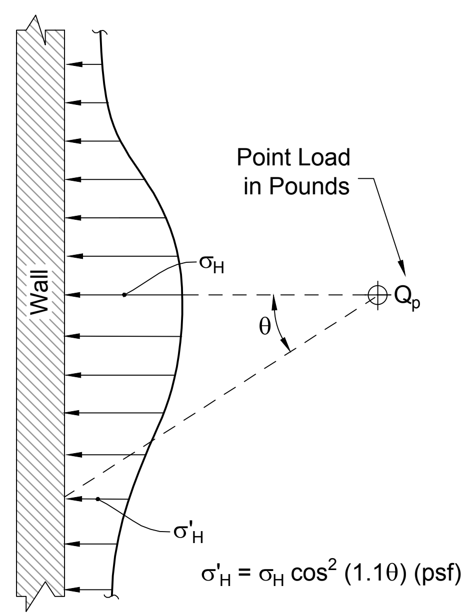
Filename: I:\EF\23-1 DEN\01300s\01311 SH105 Improvements\002 - Full Corridor Design\Drafting\01311-002_F2.dwg Date: 07-06-2017 Login: jcg



ELEVATION VIEW

For m ≤ 0.4: $\sigma_H = 0.28 \frac{Q_p}{H^2} \frac{n^2}{(0.16 + n^2)^3}$ (psf) (see Note 3)

For m > 0.4: $\sigma_H = 1.77 \frac{Q_p}{H^2} \frac{m^2 n^2}{(m^2 + n^2)^3}$ (psf)

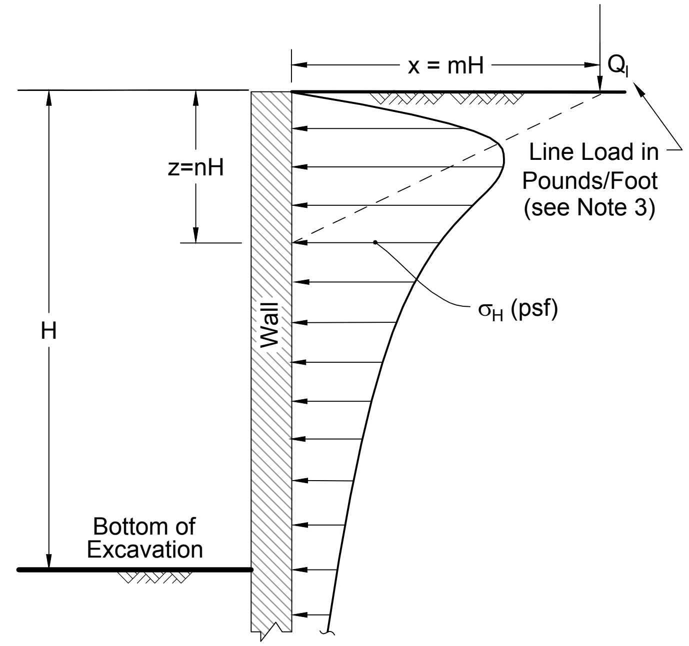


$\sigma'_H = \sigma_H \cos^2(1.1\theta)$ (psf)

PLAN VIEW

A) LATERAL PRESSURE DUE TO POINT LOAD i.e. SMALL ISOLATED FOOTING OR WHEEL LOAD

(NAVFAC DM 7.2, 1986)



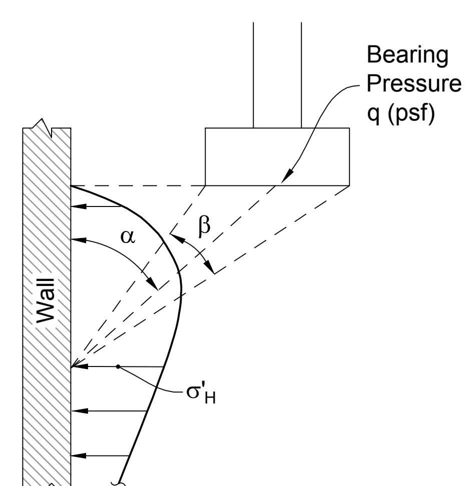
ELEVATION VIEW

For m ≤ 0.4: $\sigma_H = 0.20 \frac{Q_l}{H} \frac{n}{(0.16 + n^2)^2}$ (psf) (see Note 3)

For m > 0.4: $\sigma_H = 1.28 \frac{Q_l}{H} \frac{m^2 n}{(m^2 + n^2)^2}$ (psf)

B) LATERAL PRESSURE DUE TO LINE LOAD i.e. NARROW CONTINUOUS FOOTING PARALLEL TO WALL

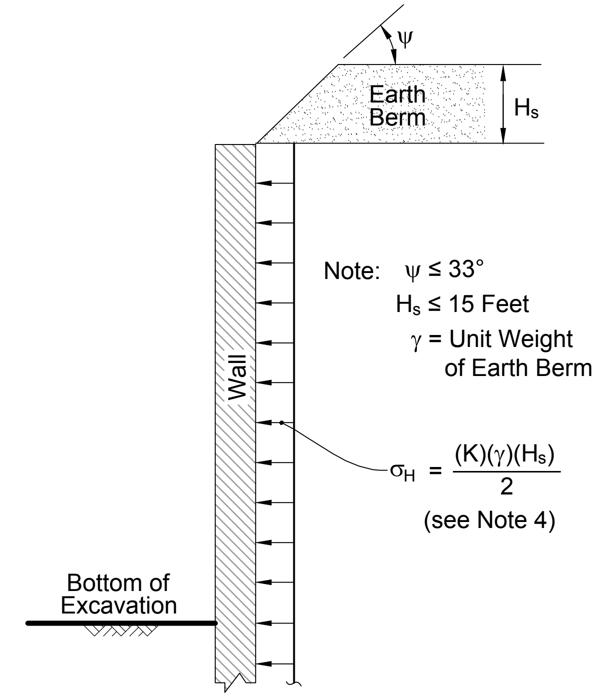
(NAVFAC DM 7.02, 1986)



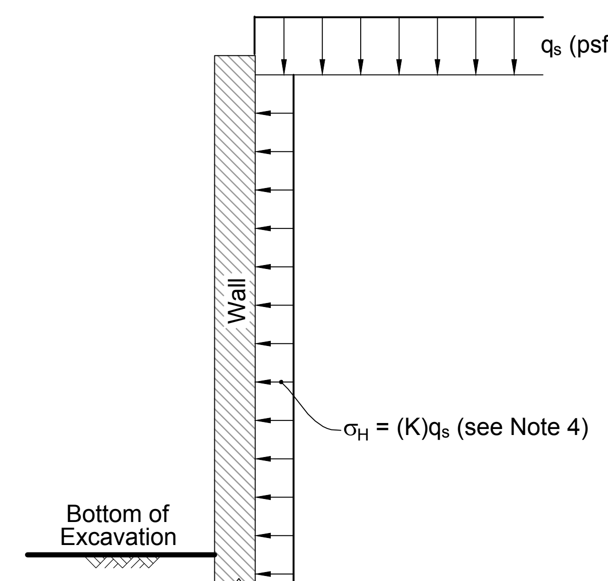
$\sigma_H = \frac{2q}{\pi} (\beta - \sin\beta \cos 2\alpha)$ (psf) (β in radians)

C) LATERAL PRESSURE DUE TO STRIP LOAD

(derived from Fang, *Foundation Engineering Handbook*, 1991)



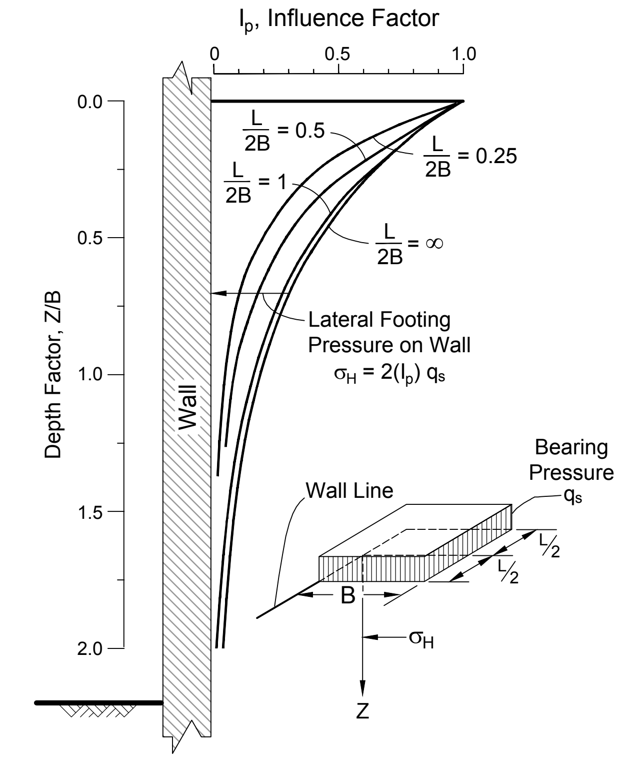
EARTH BERM



UNIFORM SURCHARGE

D) LATERAL PRESSURE DUE TO EARTH BERM OR UNIFORM SURCHARGE

(derived from Poulos and Davis, *Elastic Solutions for Soil and Rock Mechanics*, 1974; and Terzaghi and Peck, *Soil Mechanics in Engineering Practice*, 1967)



E) LATERAL PRESSURE DUE TO ADJACENT FOOTING
(see Notes 5 and 6)

(derived from NAVFAC DM 7.02, 1986; and Sandhu, *Earth Pressure on Walls Due to Surcharge*, 1974)

NOTES

1. Figures are not drawn to scale.
2. Applicable surcharge pressures should be added to appropriate temporary and permanent wall lateral earth and water pressure.
3. If point or line loads are close to the back of the wall such that m ≤ 0.4, it may be more appropriate to model the actual load distribution (i.e., Detail E) or use more rigorous analysis methods.
4. See text for recommended K values.
5. The stress is estimated on the back of the wall at the center of the length, L, of loading.
6. The estimated stress is based on a Poisson's ratio of 0.5.

Highway 105
Corridor Improvements
Colorado Springs, Colorado

RECOMMENDED SURCHARGE LOADING FOR TEMPORARY AND PERMANENT WALLS

July 2017 | 23-1-01311-002

SHANNON & WILSON, INC. GEOTECHNICAL AND ENVIRONMENTAL CONSULTANTS

FIG. 3

TABLE 1
SEISMIC DESIGN GROUND MOTION PARAMETERS

Ground Motion Parameters	
Peak Ground Acceleration[1] (PGA_B)	0.057 g
Site Class	D
Short-period Spectral Acceleration, S_s	0.123 g
Long-period Spectral Acceleration, S_1	0.035 g
Site Factor, F_{pga}	1.6
Site Factor, F_a	1.6
Site Factor, F_v	2.4
Peak Design Spectral Acceleration, A_S	0.091 g
Short-period Design Spectral Acceleration, S_{DS}	0.196 g
Long-period Design Spectral Acceleration, S_{D1}	0.083 g
T_0	0.085 sec.
T_S	0.423 sec.

Note:

[1] PGA_B = peak ground acceleration for a site underlain by Site Class B soil (soft rock).

TABLE 2
RECOMMENDED PAVEMENT SECTIONS

Segment		Subgrade Modulus (psi)	18 kip ESAL	Pavement Section
Hwy 105[1] Project A, (Urban Principal Arterial)	Eastern-most I-25 Ramps to Knollwood Dr.	5,400	2,216,000 (Projected Traffic)	7.5” HMA over 8” ABC
				2" mill, 2" HMA overlay
			5,256,000 (County Minimum for 4-lane Principal Arterial)	8.5” HMA over 8” ABC
				2" mill, 2" HMA overlay
	Knollwood Dr to Lake Woodmoor Dr.	5,400	1,611,000 (Projected Traffic)	7.0” HMA over 8” ABC
				2" mill, 4.5" HMA overlay
			5,256,000 (County Minimum for 4-lane Principal Arterial)	8.5” HMA over 8” ABC
				2" mill, 6.0" HMA overlay
Hwy 105[2] Project B (Rural Minor or Principal Arterial)	Lake Woodmoor Dr to SH 83	4,800	1,810,000 (Projected Traffic)	7.5” HMA over 8” ABC
			689,850 (County Minimum for Minor Arterial)	See note 2
			2,628,000 (County Minimum for 4-lane Principal Arterial)	8.0” HMA over 8” ABC
Cross Streets	Low Traffic Volume Cross Streets	4,800	36,500 (County Minimum for Local Roads)	3.5” HMA over 6” ABC

Notes:
[1] Based on communication from El Paso County, the selected pavement section should be based on County Minimum traffic loading.
[2] The projected traffic loading exceeds the County minimum value. Therefore, pavement sections based on the projected traffic loading should be used.
HMA = Hot Mix Asphalt
ABC = CDOT Class 6 Aggregate Base Course
ESAL = Single Axle Equivalent Loading

TABLE 3
RECOMMENDED BACKFILL DESIGN PARAMETERS FOR MSE AND CIP WALLS

DESIGN PARAMETER		VALUE
Backfill Design Parameters – CDOT Class 1 Structural Backfill		
Total Unit Weight (pcf)		135
Effective Friction Angle (degrees)		34
Cohesion (psf)		0
Active Earth Pressure Coefficient, K_A:	Horizontal Back Slope	0.28
	4H:1V Back Slope	0.33
Equivalent Fluid Density for Active Conditions (pcf):	Horizontal Back Slope	38
	4H:1V Back Slope	45
Seismic Active Earth Pressure Coefficient, K_{ae}	Horizontal Back Slope	0.31
	4H:1V Back Slope	0.36
Backfill Design Parameters – Fill Generated from On Site Sandstone and Clayey Sand		
Total Unit Weight (pcf)		125
Effective Friction Angle (degrees)		30
Cohesion (psf)		0
Active Earth Pressure Coefficient, K_A:	Horizontal Back Slope	0.33
	4H:1V Back Slope	0.40
Equivalent Fluid Density for Active Conditions (pcf):	Horizontal Back Slope	41
	4H:1V Back Slope	50
Seismic Active Earth Pressure Coefficient, K_{ae}	Horizontal Back Slope	0.36
	4H:1V Back Slope	0.44

Notes:
pcf = pounds per cubic foot
psf = pounds per square foot

TABLE 4
RECOMMENDED MSE WALL DESIGN PARAMETERS FOR WALLS 1 AND 2

DESIGN PARAMETER	VALUE	
Backfill Design Parameter	Refer to Table 3	
Bearing Resistance - Wall 1		
Strength Limit Nominal Bearing Resistance (psf)[1, 2]	5,500	
Anticipated Settlement (S_T) for the corresponding Service Limit Nominal Bearing Resistance (psf)[2, 4]	S_T = 1”	1,100
	S_T = 2”	2,000
Strength Limit Resistance Factor for Bearing[3]	0.65	
Nominal Coefficient of Friction for Sliding	See Section 7.1.1	
Bearing Resistance - Wall 2		
Strength Limit Nominal Bearing Resistance (psf)[1, 2]	10,000	
Service Limit Nominal Bearing Resistance (psf)[2, 5] 0.5-inches of settlement	3,000	
Strength Limit Resistance Factor for Bearing[3]	0.65	
Nominal Coefficient of Friction for Sliding	See Section 7.1.1	

Notes:
1 Nominal bearing resistance assumes a minimum reinforcement length of 8 feet.
2 The provided nominal bearing resistance assumes groundwater is more than 1.5 B below the base of the wall, where B is the footing width in feet.
3 Bearing resistance factor based on AASHTO (2014), Table 11.5.7-1.
4 MSE Wall 1 is anticipated to bear on loose to medium dense sand subgrade.
5 MSE Wall 2 is anticipated to bear on sandstone.
pcf = pounds per cubic foot
psf = pounds per square foot

TABLE 5
RECOMMENDED CANTILEVERED DRILLED SHAFT WALL DESIGN PARAMETERS FOR WALLS 3 AND 4

Location (Boring ID)	Depth Below Bottom of Cut		Depth to Groundwater[1] (ft)	Representative Soil/Rock Description	LATERAL EARTH PRESSURE PARAMETERS[2, 3, 4, 5]								LPILE PARAMETERS FOR LATERAL ANALYSIS[6, 7]		
	Top (ft)	Bottom (ft)			Effective Friction Angle, ϕ (degrees)	Effective Unit Weight γ' (pcf)	Active Earth Pressure Coefficient, K_A	Equivalent Active Fluid Weight, $\gamma_{eq,A}$ (pcf)	At-Rest Earth Pressure Coefficient, K_0	Equivalent At-Rest Fluid Weight, $\gamma_{eq,0}$ (pcf)	Seismic Active Earth Pressure Coefficient, K_{ae}	Nominal Passive Earth Pressure[5]	LPile Soil Type	Drained Friction Angle ϕ' (deg)	Undrained Shear Strength s_u (psf)
Walls 3 and 4 (TP-06 through TP-08, SW-W-09)	Retained Fill		15	Medium Stiff Clay to Medium Dense, Sand with Silt	28	120	0.36	43	0.53	64	0.39	-	Sand (Reese)	28	-
	0	5									-				
	5	10		SANDSTONE: Very Low Strength, Highly Weathered	38	130	0.24	32	0.38	50	-	1,400 pcf EFW	Sand (Reese)	38	-
	10	15		SANDSTONE: Very Low Strength, Moderately Weathered	-	130	-	-			-	8,000 psf	Stiff clay w/o free water	-	4,000
	15	20 (BOE)		SANDSTONE: Very Low Strength, Moderately Weathered	-	67.6	-	-			-	8,000 psf	Stiff clay w/o free water	-	4,000

Notes:

1 Design groundwater elevation above assumes an elevation of 2 feet above the highest observed water level in boring SW-W-09.

2 Above cut, apply earth pressure to the full width of wall. Active pressures should be used if the wall is able to deflect at least 0.001 times the height of the wall, otherwise at-rest pressure should be used.

3 Passive resistance should be ignored above the frost depth (3 feet) from below the bottom of the cut.

4 A resistance factor of 0.75 should be applied for passive resistance AASHTO (2014), Section 11.5.7.

5 Resistance factors based on AASHTO (2014). See AASHTO (2014) Sections 3.4.1 and 11.8 for appropriate load factors and load combinations and static forces to be evaluated.

6 The above LPILE parameters are for a horizontal ground surface on the side of the drilled shaft resisting lateral loading. Sloping ground surface modifications should be included as per Ensoft, Inc.'s recommendations for the LPILE program as necessary.

7 The LPILE parameters do not consider group effects. We recommend p-reduction factors according to the equation $\beta_a = 0.64(S/D)^{0.34}$ for 1< (S/D) <0.375, where S = center-to-center spacing and D = drilled shaft diameter. (Reese and others, 2006)

psf = pounds per square foot

pcf = pounds per cubic foot

deg = degrees

ft = foot

BOE = bottom of exploration

EFW = equivalent fluid weight

TABLE 6
PRELIMINARY PROJECT B MSE WALL DESIGN PARAMETERS

DESIGN PARAMETER	VALUE
Backfill Design Parameters	**Refer to Table 3**
Walls Bearing on Clayey Sand Overburden – **Bearing Resistance – Clayey Sand Subgrade**	**Wall RW-03**
Strength Limit Nominal Bearing Resistance (psf)[1, 2]	7,000
Service Limit Nominal Bearing Resistance (psf)[2, 4] 0.5-inches of settlement	2,000
Strength Limit Resistance Factor for Bearing[3]	0.65
Nominal Coefficient of Friction for Sliding	See Section 7.2.1
Bearing Resistance – Sandstone Subgrade	**Walls RW-06 and RW-09**
Strength Limit Nominal Bearing Resistance (psf)[1, 2]	10,000
Service Limit Nominal Bearing Resistance (psf)[2, 5] 0.5-inches of settlement	3,000
Strength Limit Resistance Factor for Bearing[3]	0.65
Nominal Coefficient of Friction for Sliding	See Section 7.2.1

Notes:
[1] Nominal bearing resistance assumes a minimum reinforcement length of 8 feet.
[2] The provided nominal bearing resistance assumes groundwater is more than 1.5 B below the base o the wall, where B is the footing width in feet.
[3] Bearing resistance factor based on AASHTO (2014), Table 11.5.7-1.
[4] MSE Wall RW-03 is anticipated to bear on loose to medium dense clayey sand subgrade.
[5] MSE Wall RW-06 and RW-09 are anticipated to bear on sandstone.
pcf = pounds per cubic foot
psf = pounds per square foot

TABLE 7
PRELIMINARY PROJECT B CIP GRAVITY WALL DESIGN PARAMETERS

DESIGN PARAMETER	VALUE
Backfill Design Parameter	Refer to Table 3
Bearing Resistance – Sandstone Subgrade	**Walls RW-05, RW-07, RW-08, and RW-10**
Strength Limit Nominal Bearing Resistance (psf)[1, 2]	10,000
Service Limit Nominal Bearing Resistance (psf)[2] 0.5-inches of settlement	3,000
Strength Limit Resistance Factor for Bearing[3]	0.55
Passive Earth Pressure Coefficient, K_P:	11.0
Equivalent Fluid Density for Passive Conditions (pcf)[4]	1,400
Resistance Factor for Passive Sliding Resistance	0.50
Coefficient of Friction for Sliding (tan δ)	0.40
Strength Limit Resistance Factor for Sliding	0.80
Bearing Resistance – Clayey Sand Subgrade	**Walls RW-04 and RW-11**
Strength Limit Nominal Bearing Resistance (psf)[1, 2]	7,000
Service Limit Nominal Bearing Resistance (psf)[2] 0.5-inches of settlement	3,000
Strength Limit Resistance Factor for Bearing[3]	0.55
Passive Earth Pressure Coefficient, K_P:	4.9
Equivalent Fluid Density for Passive Conditions (pcf)[4]	500
Resistance Factor for Passive Sliding Resistance	0.50
Coefficient of Friction for Sliding (tan δ)	0.32
Strength Limit Resistance Factor for Sliding	0.80

Notes:
1 Nominal bearing resistance assumes a minimum footing width of 8 feet.
2 The provided nominal bearing resistance assumes groundwater is more than 1.5 B below the base of the wall, where B is the footing width in feet.
3 Bearing and sliding resistance factors based on AASHTO (2014), Tables 11.5.7-1 and 10.5.5.2.2-1, respectively. Sliding resistance factors assumes cast-in-place concrete.
4 Passive resistance should be ignored above the frost depth (3 feet) from below the bottom of the cut.
pcf = pounds per cubic foot
psf = pounds per square foot

APPENDIX A

SUBSURFACE EXPLORATIONS

APPENDIX A

SUBSURFACE EXPLORATIONS

TABLE OF CONTENTS

FIGURES

FIGURES (cont.)

FIGURES (cont.)

APPENDIX A

SUBSURFACE EXPLORATIONS

A.1 INTRODUCTION

The field exploration program consisted of drilling and sampling 57 geotechnical borings and 9 test pits on June 27 and 28, 2016 and November 9 through 21, 2016. Borings drilled for the pavement subsurface investigation were designated SW-P-01 through SW-P-28, and borings drilled for the retaining wall subsurface investigation were designated SW-W-01 through SW-W-38. The test pits were completed as part of the retaining wall subsurface investigation where access and right-of-way were limited and designated as “TP” in the exploration naming convention. Locations of the explorations are shown on Figure 2. A representative from Shannon & Wilson observed the drilling and excavation operations, retrieved representative samples for laboratory testing, and prepared descriptive field logs of the explorations. The methods used to conduct the field exploration program are described below.

The drilling and test pit excavation was coordinated (including subcontractor coordination and utility locates) and observed by our field representative. Individual boring logs and test pit logs are presented in Figures A-3 through A-68. These logs represent our interpretation of the subsurface conditions encountered and the results of laboratory testing.

A.2 BORINGS

All borings were drilled by Entech Engineering, Inc. of Colorado Springs, Colorado (under subcontract to Shannon & Wilson) using a truck-mounted drill rig. Borings were advanced with solid stem auger drilling techniques. All borings were backfilled with drill cuttings and repairs were made to existing pavement with hot mix asphalt.

Following sampling, representative portions of the excavation samples were placed in airtight plastic containers and transported to our laboratory in Denver, Colorado for further observation and testing.

A.2.1 Standard Penetration Test

Disturbed samples were obtained in the borings in general accordance with the Standard Penetration Test (SPT) ASTM International (ASTM) Designation: D 1586. The SPT consists of driving a 2-inch outside diameter (O.D.), 1.375-inch inside diameter (I.D.) split-spoon sampler a distance of 18 inches with a 140-pound hammer free-falling a distance of 30 inches. An automatic hammer system was used to advance the samplers. During sampling, the Shannon &

Wilson field representative recorded the number of blows for each 6-inch increment of penetration and summed the blow counts for the last two 6-inch increments. This sum is recorded as the penetration resistance number, or N-value. The N-values provide a means for evaluating the relative density or compactness of cohesionless (granular) soils and consistency or stiffness of cohesive (fine-grained) soils (see Figure A-1). The N-values are shown on the individual boring logs.

A.2.2 Modified California (MC) Test and Sampling

Samples were also obtained using a modified California (MC) barrel sampler. The MC test procedure is similar to the SPT, except a larger diameter barrel sampler (2½-inch O.D., lined with 2-inch-diameter brass tubing) is used and only driven 12 inches. During sampling, the Shannon & Wilson field representative recorded the number of blows for each 6-inch increment of penetration. As a result of the larger diameter, the MC sampler yields slightly higher raw blow count numbers when compared to SPT N-values for similar soils. In our opinion, the blow count numbers are similar between the two samplers. Because the difference in blow counts does not significantly impact our evaluation, we used the field MC blow counts over the 12-inch increment to define the relative density and consistency/stiffness of the subsurface materials following SPT terminology.

A.2.3 Bulk Samples

Bulk soil samples were obtained by collecting the drill cuttings from the upper 5 feet of select borings. Approximately 20 to 30 pounds of cuttings were placed in a plastic bag and transported to our laboratory for further analysis and testing.

A.2.4 Soil and Rock Classification System

During drilling, our field representative collected soil/rock samples and prepared field logs of the borings. Soil classifications, as shown on the boring logs, are based on ASTM International (ASTM) Designation: D 2487, Standard Test Method for Classification of Soil for Engineering Purposes, and ASTM Designation: D 2488, Standard Recommended Practice for Description of Soils (Visual-Manual Procedure). The system is called the Unified Soil Classification System (USCS) and is summarized in Figure A-1. Our representative classified rock samples in general accordance with the International Society of Rock Mechanics (ISRM) classification method. According to this system, rocks are classified based on the stratigraphic structure, rock strength, degree of weathering, and other properties. The rock classification system is summarized in Figure A-2.

A.3 TEST PITS

The test pits were excavated using a John Deere 35G track mounted backhoe operated by Entech Engineering, Inc. Test pit excavation was typically completed to a depth of 3 feet in the existing roadway cut slope where soil samples were obtained and the upper 3 feet of subgrade was probed with a ½-inch diameter T-probe. Excavation was then continued up to a depth of 9 feet where samples were obtained from the excavations by collecting samples from the excavation pit or from material removed once the pit was greater than three feet in depth. The observed soil and rock were classified using the system described in Section A.2.4. On completion, the test pits were backfilled with excavated spoils and tamped with the bucket of the backhoe in approximately 3 foot-thick lifts.

Shannon & Wilson, Inc. (S&W), uses a soil identification system modified from the Unified Soil Classification System (USCS). Elements of the USCS and other definitions are provided on this and the following pages. Soil descriptions are based on visual-manual procedures (ASTM D2488) and laboratory testing procedures (ASTM D2487), if performed.

S&W INORGANIC SOIL CONSTITUENT DEFINITIONS

CONSTITUENT[2]	FINE-GRAINED SOILS (50% or more fines)[1]	COARSE-GRAINED SOILS (less than 50% fines)[1]
Major	***Silt, Lean Clay, Elastic Silt,*** or ***Fat Clay***[3]	***Sand*** or ***Gravel***[4]
Modifying (Secondary) Precedes major constituent	30% or more coarse-grained: ***Sandy*** or ***Gravelly***[4]	More than 12% fine-grained: ***Silty*** or ***Clayey***[3]
Minor Follows major constituent	15% to 30% coarse-grained: ***with Sand*** or ***with Gravel***[4]	5% to 12% fine-grained: ***with Silt*** or ***with Clay***[3]
	30% or more total coarse-grained *and* lesser coarse-grained constituent is 15% or more: ***with Sand*** or ***with Gravel***[5]	15% or more of a second coarse-grained constituent: ***with Sand*** or ***with Gravel***[5]

[1]All percentages are by weight of total specimen passing a 3-inch sieve.
[2]The order of terms is: *Modifying Major with Minor*.
[3]Determined based on behavior.
[4]Determined based on which constituent comprises a larger percentage.
[5]Whichever is the lesser constituent.

MOISTURE CONTENT TERMS

Dry	Absence of moisture, dusty, dry to the touch
Moist	Damp but no visible water
Wet	Visible free water, from below water table

STANDARD PENETRATION TEST (SPT) SPECIFICATIONS

Hammer:	140 pounds with a 30-inch free fall. Rope on 6- to 10-inch-diam. cathead 2-1/4 rope turns, > 100 rpm NOTE: If automatic hammers are used, blow counts shown on boring logs should be adjusted to account for efficiency of hammer.
Sampler:	10 to 30 inches long Shoe I.D. = 1.375 inches Barrel I.D. = 1.5 inches Barrel O.D. = 2 inches
N-Value:	Sum blow counts for second and third 6-inch increments. Refusal: 50 blows for 6 inches or less; 10 blows for 0 inches.

NOTE: Penetration resistances (N-values) shown on boring logs are as recorded in the field and have not been corrected for hammer efficiency, overburden, or other factors.

PARTICLE SIZE DEFINITIONS

DESCRIPTION	SIEVE NUMBER AND/OR APPROXIMATE SIZE
FINES	< #200 (0.075 mm = 0.003 in.)
SAND	
Fine	#200 to #40 (0.075 to 0.4 mm; 0.003 to 0.02 in.)
Medium	#40 to #10 (0.4 to 2 mm; 0.02 to 0.08 in.)
Coarse	#10 to #4 (2 to 4.75 mm; 0.08 to 0.187 in.)
GRAVEL	
Fine	#4 to 3/4 in. (4.75 to 19 mm; 0.187 to 0.75 in.)
Coarse	3/4 to 3 in. (19 to 76 mm)
COBBLES	3 to 12 in. (76 to 305 mm)
BOULDERS	> 12 in. (305 mm)

RELATIVE DENSITY / CONSISTENCY

COHESIONLESS SOILS

N, SPT, BLOWS/FT.	RELATIVE DENSITY
< 4	Very loose
4 - 10	Loose
10 - 30	Medium dense
30 - 50	Dense
> 50	Very dense

COHESIVE SOILS

N, SPT, BLOWS/FT.	RELATIVE CONSISTENCY
< 2	Very soft
2 - 4	Soft
4 - 8	Medium stiff
8 - 15	Stiff
15 - 30	Very stiff
> 30	Hard

WELL AND BACKFILL SYMBOLS

- Bentonite Cement Grout
- Bentonite Grout
- Bentonite Chips
- Silica Sand
- Perforated or Screened Casing
- Surface Cement Seal
- Asphalt or Cap
- Slough
- Inclinometer or Non-perforated Casing
- Vibrating Wire Piezometer

PERCENTAGES TERMS[1, 2]

Trace	< 5%
Few	5 to 10%
Little	15 to 25%
Some	30 to 45%
Mostly	50 to 100%

[1]Gravel, sand, and fines estimated by mass. Other constituents, such as organics, cobbles, and boulders, estimated by volume.

[2]Reprinted, with permission, from ASTM D2488 - 09a Standard Practice for Description and Identification of Soils (Visual-Manual Procedure), copyright ASTM International, 100 Barr Harbor Drive, West Conshohocken, PA 19428. A copy of the complete standard may be obtained from ASTM International, www.astm.org.

Highway 105
Corridor Improvements
El Paso County, Colorado

SOIL DESCRIPTION AND LOG KEY

July 2017 23-1-01311-002

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. A-1
Sheet 1 of 3

UNIFIED SOIL CLASSIFICATION SYSTEM (USCS)
(Modified From USACE Tech Memo 3-357, ASTM D2487, and ASTM D2488)

MAJOR DIVISIONS			GROUP/GRAPHIC SYMBOL	TYPICAL IDENTIFICATIONS
COARSE-GRAINED SOILS *(more than 50% retained on No. 200 sieve)*	Gravels *(more than 50% of coarse fraction retained on No. 4 sieve)*	Gravel *(less than 5% fines)*	GW	Well-Graded Gravel; Well-Graded Gravel with Sand
			GP	Poorly Graded Gravel; Poorly Graded Gravel with Sand
		Silty or Clayey Gravel *(more than 12% fines)*	GM	Silty Gravel; Silty Gravel with Sand
			GC	Clayey Gravel; Clayey Gravel with Sand
	Sands *(50% or more of coarse fraction passes the No. 4 sieve)*	Sand *(less than 5% fines)*	SW	Well-Graded Sand; Well-Graded Sand with Gravel
			SP	Poorly Graded Sand; Poorly Graded Sand with Gravel
		Silty or Clayey Sand *(more than 12% fines)*	SM	Silty Sand; Silty Sand with Gravel
			SC	Clayey Sand; Clayey Sand with Gravel
FINE-GRAINED SOILS *(50% or more passes the No. 200 sieve)*	Silts and Clays *(liquid limit less than 50)*	Inorganic	ML	Silt; Silt with Sand or Gravel; Sandy or Gravelly Silt
			CL	Lean Clay; Lean Clay with Sand or Gravel; Sandy or Gravelly Lean Clay
		Organic	OL	Organic Silt or Clay; Organic Silt or Clay with Sand or Gravel; Sandy or Gravelly Organic Silt or Clay
	Silts and Clays *(liquid limit 50 or more)*	Inorganic	MH	Elastic Silt; Elastic Silt with Sand or Gravel; Sandy or Gravelly Elastic Silt
			CH	Fat Clay; Fat Clay with Sand or Gravel; Sandy or Gravelly Fat Clay
		Organic	OH	Organic Silt or Clay; Organic Silt or Clay with Sand or Gravel; Sandy or Gravelly Organic Silt or Clay
HIGHLY-ORGANIC SOILS	Primarily organic matter, dark in color, and organic odor		PT	Peat or other highly organic soils (see ASTM D4427)

NOTE: No. 4 size = 4.75 mm = 0.187 in.; No. 200 size = 0.075 mm = 0.003 in.

NOTES

1. Dual symbols *(symbols separated by a hyphen, i.e., SP-SM, Sand with Silt)* are used for soils with between 5% and 12% fines or when the liquid limit and plasticity index values plot in the CL-ML area of the plasticity chart. Graphics shown on the logs for these soil types are a combination of the two graphic symbols (e.g., SP and SM).

2. Borderline symbols *(symbols separated by a slash, i.e., CL/ML, Lean Clay to Silt; SP-SM/SM, Sand with Silt to Silty Sand)* indicate that the soil properties are close to the defining boundary between two groups.

Highway 105
Corridor Improvements
El Paso County, Colorado

SOIL DESCRIPTION AND LOG KEY

July 2017 23-1-01311-002

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. A-1
Sheet 2 of 3

2013 BORING CLASS2 23-1-01311-002.GPJ SWNEW.GDT 7/6/17

GRADATION TERMS

Poorly Graded	Narrow range of grain sizes present or, within the range of grain sizes present, one or more sizes are missing (Gap Graded). Meets criteria in ASTM D2487, if tested.
Well-Graded	Full range and even distribution of grain sizes present. Meets criteria in ASTM D2487, if tested.

CEMENTATION TERMS[1]

Weak	Crumbles or breaks with handling or slight finger pressure
Moderate	Crumbles or breaks with considerable finger pressure
Strong	Will not crumble or break with finger pressure

PLASTICITY[2]

DESCRIPTION	VISUAL-MANUAL CRITERIA	APPROX. PLASITICTY INDEX RANGE
Nonplastic	A 1/8-in. thread cannot be rolled at any water content.	< 4
Low	A thread can barely be rolled and a lump cannot be formed when drier than the plastic limit.	4 to 10
Medium	A thread is easy to roll and not much time is required to reach the plastic limit. The thread cannot be rerolled after reaching the plastic limit. A lump crumbles when drier than the plastic limit.	10 to 20
High	It take considerable time rolling and kneading to reach the plastic limit. A thread can be rerolled several times after reaching the plastic limit. A lump can be formed without crumbling when drier than the plastic limit.	> 20

ADDITIONAL TERMS

Mottled	Irregular patches of different colors.
Bioturbated	Soil disturbance or mixing by plants or animals.
Diamict	Nonsorted sediment; sand and gravel in silt and/or clay matrix.
Cuttings	Material brought to surface by drilling.
Slough	Material that caved from sides of borehole.
Sheared	Disturbed texture, mix of strengths.

PARTICLE ANGULARITY AND SHAPE TERMS[1]

Angular	Sharp edges and unpolished planar surfaces.
Subangular	Similar to angular, but with rounded edges.
Subrounded	Nearly planar sides with well-rounded edges.
Rounded	Smoothly curved sides with no edges.
Flat	Width/thickness ratio > 3.
Elongated	Length/width ratio > 3.

[1]Reprinted, with permission, from ASTM D2488 - 09a Standard Practice for Description and Identification of Soils (Visual-Manual Procedure), copyright ASTM International, 100 Barr Harbor Drive, West Conshohocken, PA 19428. A copy of the complete standard may be obtained from ASTM International, www.astm.org.
[2]Adapted, with permission, from ASTM D2488 - 09a Standard Practice for Description and Identification of Soils (Visual-Manual Procedure), copyright ASTM International, 100 Barr Harbor Drive, West Conshohocken, PA 19428. A copy of the complete standard may be obtained from ASTM International, www.astm.org.

ACRONYMS AND ABBREVIATIONS

ATD	At Time of Drilling
Diam.	Diameter
Elev.	Elevation
ft.	Feet
FeO	Iron Oxide
gal.	Gallons
Horiz.	Horizontal
HSA	Hollow Stem Auger
I.D.	Inside Diameter
in.	Inches
lbs.	Pounds
MgO	Magnesium Oxide
mm	Millimeter
MnO	Manganese Oxide
NA	Not Applicable or Not Available
NP	Nonplastic
O.D.	Outside Diameter
OW	Observation Well
pcf	Pounds per Cubic Foot
PID	Photo-Ionization Detector
PMT	Pressuremeter Test
ppm	Parts per Million
psi	Pounds per Square Inch
PVC	Polyvinyl Chloride
rpm	Rotations per Minute
SPT	Standard Penetration Test
USCS	Unified Soil Classification System
q_u	Unconfined Compressive Strength
VWP	Vibrating Wire Piezometer
Vert.	Vertical
WOH	Weight of Hammer
WOR	Weight of Rods
Wt.	Weight

STRUCTURE TERMS[1]

Interbedded	Alternating layers of varying material or color with layers at least 1/4-inch thick; singular: bed.
Laminated	Alternating layers of varying material or color with layers less than 1/4-inch thick; singular: lamination.
Fissured	Breaks along definite planes or fractures with little resistance.
Slickensided	Fracture planes appear polished or glossy; sometimes striated.
Blocky	Cohesive soil that can be broken down into small angular lumps that resist further breakdown.
Lensed	Inclusion of small pockets of different soils, such as small lenses of sand scattered through a mass of clay.
Homogeneous	Same color and appearance throughout.

Highway 105
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SOIL DESCRIPTION AND LOG KEY

July 2017 23-1-01311-002

SHANNON & WILSON, INC.
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FIG. A-1
Sheet 3 of 3

2013_BORING_CLASS3 23-1-01311-002.GPJ SWNEW.GDT 7/6/17

WEATHERING OR ALTERATION

TERM	DESCRIPTION
Fresh	No evidence of alteration
Slightly	Slight discoloration on surface
Moderately	Discoloring evident; Alteration penetrating well below rock surface
Highly	Entire rock mass discolored
Completely	Rock reduced to a soil with relict rock texture

STRENGTH

TERM	APPROX. UCS (psi x 1000)
Very Low	<0.7
Low	0.7 to 4
Moderate	4 to 7
Medium High	7 to 15
High	15 to 36
Very High	>36

JOINT ROUGHNESS COEFFICIENT (JRC)

COEFFICIENT	DESCRIPTION
14 to 20	VERY ROUGH: Near vertical edges evident
10 to 14	ROUGH: Smooth ridges, surface abrasion
6 to 10	SLIGHTLY ROUGH: Asperities on surface can be felt
2 to 6	SMOOTH: Appears and feels smooth
0 to 2	SLICKENSIDED: Visible polishing, striated surface

DISCONTINUITY DATA

SPACING	
TERM	SPACING
Very Wide	>10 ft.
Wide	3 to 10 ft.
Moderately Close	1 to 3 ft.
Close	2 in. to 1 ft.
Very Close	<2 in.

APERTURE WIDTH	
TERM	SPACING
Very Tight	<0.1mm
Tight	0.1 to 0.25mm
Partly Open	0.25 to 0.5mm
Open	0.5 to 2.5mm
Moderately Wide	2.5 to 10mm
Wide	10mm to 1cm
Very Wide	1 to 10cm
Extremely Wide	10 to 100cm
Cavernous	>1m

DISCONTINUITY TERMS

FRACTURE - Collective term for any natural break excluding shears, shear zones, and faults

JOINT (JT) - Planar break with little or no displacement

FOLIATION JOINT (FJ) or BEDDING JOINT (BJ) - Joint along foliation or bedding

INCIPIENT JOINT (IJ) or INCIPIENT FRACTURE (IF) - Joint or fracture not evident until wetted and dried; breaks along existing surface

RANDOM FRACTURE (RF) - Natural, very irregular fracture that does not belong to a set

BEDDING PLANE SEPARATION or PARTING - A separation along bedding after extraction from stress relief or slaking

FRACTURE ZONE (FZ) - Planar zone of broken rock without gouge

MECHANICAL BREAK (MB) - Breaks due to drilling or handling; drilling break (DB), hammer break (HB)

SHEAR (SH) - Surface of differential movement evident by presence of slickensides, striations, or polishing

SHEAR ZONE (SZ) - Zone of gouge and rock fragments bounded by planar shear surfaces

FAULT (FT) - Shear zone of significant extent; differentiation from shear zone may be site-specific

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ROCK CLASSIFICATION AND LOG KEY

July 2017   23-1-01311-002

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. A-2
Sheet 1 of 2

ROCK CLASSIFICATION SYMBOLS

BEDROCK TYPE	GRAPHIC SYMBOL	ROCK NAME
Clastic Sedimentary Rocks		Breccia
		Conglomerate
		Sandstone
		Siltstone
		Claystone
		Shale
		Coal
Carbonate Sedimentary Rocks		Limestone
		Dolomite
		Coral
Evaporite Rocks		Gypsum
		Halite
		Calcite
Extrusive Igneous Rocks		Tuff
		Rhyolite
		Dacite
		Andesite
		Basalt
Intrusive Igneous Rocks		Granite
		Grano-diorite
		Diorite
		Gabbro
Metamorphic Rocks		Marble
		Quartzite
		Slate
		Phyllite
		Schist
		Gneiss

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ROCK CLASSIFICATION AND LOG KEY

July 2017 23-1-01311-002

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FIG. A-2
Sheet 2 of 2

Total Depth:	*5.5 ft.*	Latitude:		Drilling Method:	*Solid-Stem Auger*	Hole Diam.:	*4 in.*
Top Elevation:	*~*	Longitude:		Drilling Company:	*Entech Engineering, Inc*	Rod Type.:	*AWJ*
Vert. Datum:		Station:		Drill Rig Equipment:	*Simco 2800 Truck Mount*	Hammer Type:	*Automatic*
Horiz. Datum:		Offset:		Other Comments:			

SOIL DESCRIPTION

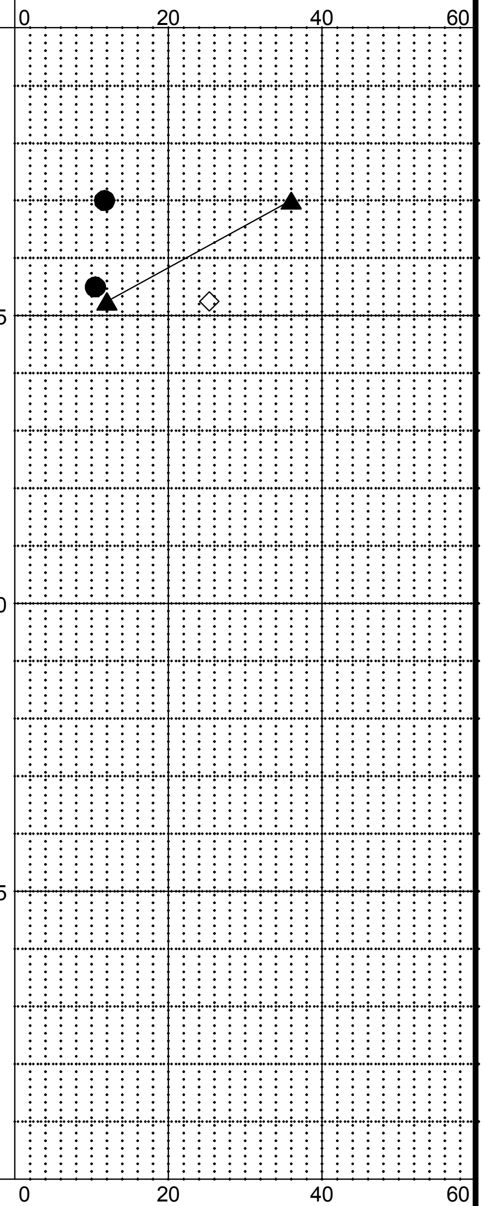
Refer to the report text for a proper understanding of the subsurface materials and drilling methods. The stratification lines indicated below represent the approximate boundaries between material types, and the transition may be gradual.

Soil Description	Depth, ft.	Samples
9.5 inches of Asphalt		
11 inches of Base Course	0.8	
Dense to medium dense, brown, *Clayey Sand (SC)*; moist; trace gravel. [A-2-6]	1.7	S-1, S-2
BOTTOM OF BORING COMPLETED 6/27/2016	5.5	

Ground Water: Groundwater not encountered during drilling.

PENETRATION RESISTANCE (blows/foot)

▲ Hammer Wt. & Drop: *140 lbs / 30 inches*



◇ % Fines (<0.075mm)
● % Water Content

LEGEND

* Sample Not Recovered
Modified California Sampler
Standard Penetration Test

NOTES

1. Refer to Figures A-1 and A-2 for explanation of symbols, codes, abbreviations and definitions.
2. The stratification lines represent the approximate boundaries between soil types, and the transition may be gradual.
3. The discussion in the text of this report is necessary for a proper understanding of the nature of the subsurface materials.
4. Groundwater level, if indicated above, is for the date specified and may vary.
5. USCS designation is based on visual-manual classification and selected lab testing.

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LOG OF BORING SW-P-01

July 2017 23-1-01311-002

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FIG. A-3

REV 2

MASTER_LOG_E_POCKETPEN LAT&LONG 23-1-01311-002.GPJ 7/6/17

Total Depth:	5.5 ft.	Latitude:		Drilling Method:	Solid-Stem Auger	Hole Diam.:	4 in.
Top Elevation:	~	Longitude:		Drilling Company:	Entech Engineering, Inc	Rod Type.:	AWJ
Vert. Datum:		Station:		Drill Rig Equipment:	Simco 2800 Truck Mount	Hammer Type:	Automatic
Horiz. Datum:		Offset:		Other Comments:			

SOIL DESCRIPTION

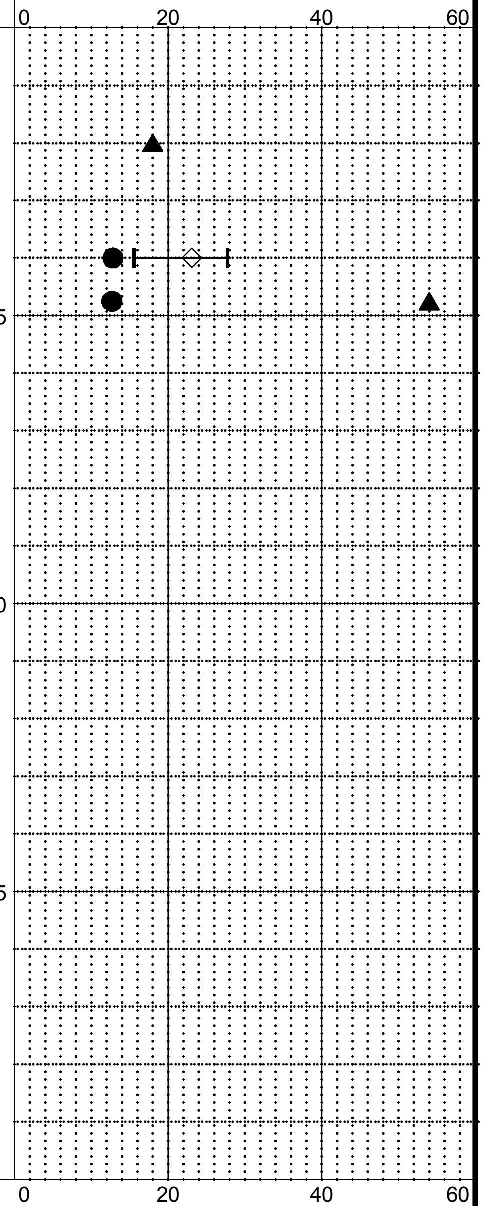
Refer to the report text for a proper understanding of the subsurface materials and drilling methods. The stratification lines indicated below represent the approximate boundaries between material types, and the transition may be gradual.

Soil Description	Depth, ft.	Samples
10.0 inches of Asphalt	0.8	
5 inches of Base Course	1.3	
Medium dense, brown, *Poorly Graded Sand with Silt (SP-SM)*; moist. [A-2-4]	2.5	S-1 *
SANDSTONE: very low strength, gray to brown, weakly cemented; moderately weathered (Dawson Formation). [Very dense, gray to brown, *Clayey Sand (SC)*; moist; few gravel. (A-2-6)]	5.5	S-2 Bulk

Groundwater not encountered during drilling.

BOTTOM OF BORING
COMPLETED 6/27/2016

PENETRATION RESISTANCE (blows/foot)
▲ Hammer Wt. & Drop: 140 lbs / 30 inches



◇ % Fines (<0.075mm)
● % Water Content
Plastic Limit ├─●─┤ Liquid Limit
Natural Water Content

LEGEND

* Sample Not Recovered
Modified California Sampler
Grab Sample
Standard Penetration Test

NOTES

1. Refer to Figures A-1 and A-2 for explanation of symbols, codes, abbreviations and definitions.
2. The stratification lines represent the approximate boundaries between soil types, and the transition may be gradual.
3. The discussion in the text of this report is necessary for a proper understanding of the nature of the subsurface materials.
4. Groundwater level, if indicated above, is for the date specified and may vary.
5. USCS designation is based on visual-manual classification and selected lab testing.

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LOG OF BORING SW-P-02

July 2017 23-1-01311-002

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FIG. A-4

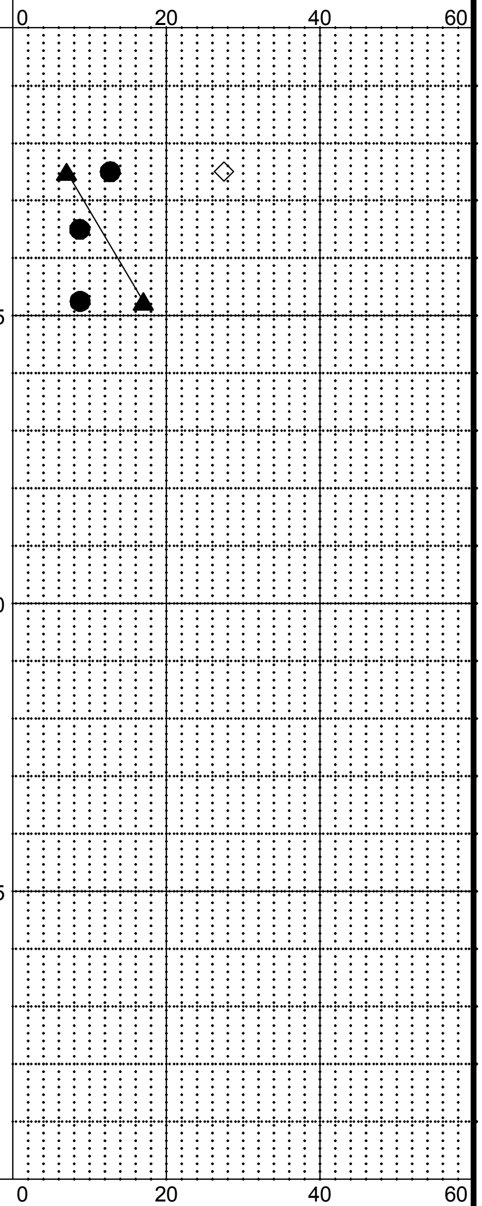
REV 2

Total Depth:	5.5 ft.	Latitude:		Drilling Method:	Solid-Stem Auger	Hole Diam.:	4 in.
Top Elevation:	~	Longitude:		Drilling Company:	Entech Engineering, Inc	Rod Type.:	AWJ
Vert. Datum:		Station:		Drill Rig Equipment:	Simco 2800 Truck Mount	Hammer Type:	Automatic
Horiz. Datum:		Offset:		Other Comments:			

SOIL DESCRIPTION *Refer to the report text for a proper understanding of the subsurface materials and drilling methods. The stratification lines indicated below represent the approximate boundaries between material types, and the transition may be gradual.*	Depth, ft.	Symbol	Samples	Ground Water	Depth, ft.
7.5 inches of Asphalt				Groundwater not encountered during drilling.	
Loose to medium dense, brown, *Clayey Sand (SC)*; moist; few gravel. [A-2-6]	0.7		S-1 Bulk S-2		5
BOTTOM OF BORING COMPLETED 6/27/2016	5.5				10 15

PENETRATION RESISTANCE (blows/foot)

▲ Hammer Wt. & Drop: 140 lbs / 30 inches



◇ % Fines (<0.075mm)

● % Water Content

LEGEND

* Sample Not Recovered

Modified California Sampler

Grab Sample

Standard Penetration Test

NOTES

1. Refer to Figures A-1 and A-2 for explanation of symbols, codes, abbreviations and definitions.
2. The stratification lines represent the approximate boundaries between soil types, and the transition may be gradual.
3. The discussion in the text of this report is necessary for a proper understanding of the nature of the subsurface materials.
4. Groundwater level, if indicated above, is for the date specified and may vary.
5. USCS designation is based on visual-manual classification and selected lab testing.

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LOG OF BORING SW-P-03

July 2017 23-1-01311-002

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FIG. A-5

REV 2

Total Depth:	5.5 ft.	Latitude:		Drilling Method:	Solid-Stem Auger	Hole Diam.:	4 in.
Top Elevation:	~	Longitude:		Drilling Company:	Entech Engineering, Inc	Rod Type.:	AWJ
Vert. Datum:		Station:		Drill Rig Equipment:	Simco 2800 Truck Mount	Hammer Type:	Automatic
Horiz. Datum:		Offset:		Other Comments:			

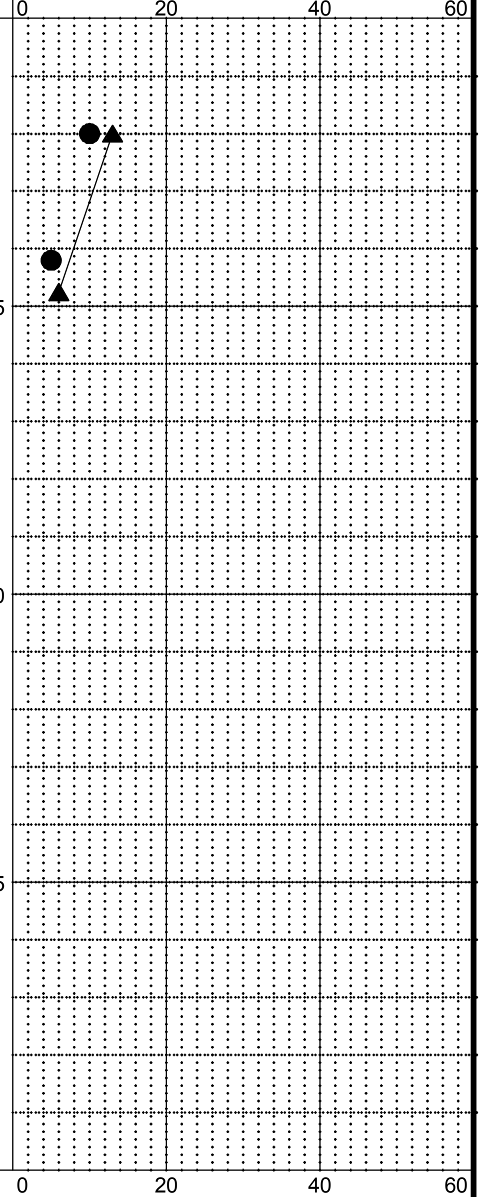
SOIL DESCRIPTION

Refer to the report text for a proper understanding of the subsurface materials and drilling methods. The stratification lines indicated below represent the approximate boundaries between material types, and the transition may be gradual.

Soil Description	Depth, ft.	Samples	Ground Water
8.0 inches of Asphalt	0.8		Groundwater not encountered during drilling.
Medium dense, dark brown, *Clayey Sand (SC)*; moist. [A-2-6]	4.0	S-1	
Loose, brown, *Poorly Graded Sand with Clay (SP-SC)*; moist. [A-2-6]	5.5	S-2	
BOTTOM OF BORING COMPLETED 6/27/2016			

PENETRATION RESISTANCE (blows/foot)

▲ Hammer Wt. & Drop: 140 lbs / 30 inches



● % Water Content

LEGEND

* Sample Not Recovered

Modified California Sampler

Standard Penetration Test

NOTES

1. Refer to Figures A-1 and A-2 for explanation of symbols, codes, abbreviations and definitions.
2. The stratification lines represent the approximate boundaries between soil types, and the transition may be gradual.
3. The discussion in the text of this report is necessary for a proper understanding of the nature of the subsurface materials.
4. Groundwater level, if indicated above, is for the date specified and may vary.
5. USCS designation is based on visual-manual classification and selected lab testing.

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LOG OF BORING SW-P-04

July 2017 23-1-01311-002

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FIG. A-6

REV 2

MASTER_LOG_E_POCKETPEN_LAT&LONG 23-1-01311-002.GPJ 7/6/17

Total Depth:	*10.5 ft.*	Latitude:		Drilling Method:	*Solid-Stem Auger*	Hole Diam.:	*4 in.*
Top Elevation:	*~*	Longitude:		Drilling Company:	*Entech Engineering, Inc*	Rod Type.:	*AWJ*
Vert. Datum:		Station:		Drill Rig Equipment:	*Simco 2800 Truck Mount*	Hammer Type:	*Automatic*
Horiz. Datum:		Offset:		Other Comments:			

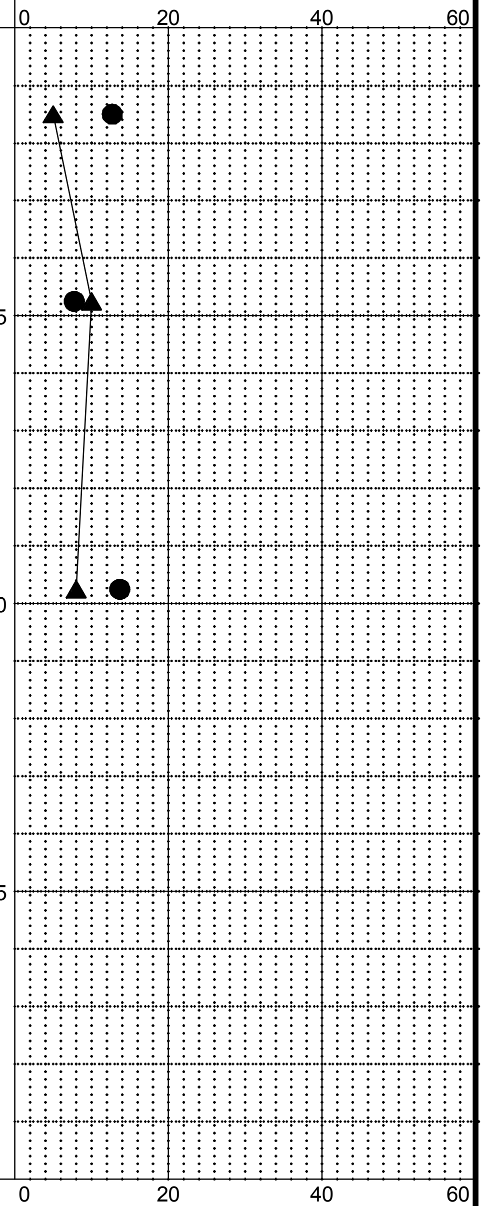
SOIL DESCRIPTION

Refer to the report text for a proper understanding of the subsurface materials and drilling methods. The stratification lines indicated below represent the approximate boundaries between material types, and the transition may be gradual.

Soil Description	Depth, ft.	Samples	Ground Water
7.0 inches of Asphalt	0.7		
Loose, brown, *Poorly Graded Sand with Clay (SP-SC)*; moist. [A-2-6]	4.0	S-1	
Loose to medium dense, brown, *Poorly Graded Sand (SP)*; moist to wet; trace gravel, trace silt. [A-1-b]	10.5	S-2, S-3	During Drilling ∇
BOTTOM OF BORING COMPLETED 6/27/2016			

PENETRATION RESISTANCE (blows/foot)

▲ Hammer Wt. & Drop: *140 lbs / 30 inches*



● % Water Content

LEGEND

* Sample Not Recovered

Modified California Sampler

Standard Penetration Test

∇ Ground Water Level ATD

NOTES

1. Refer to Figures A-1 and A-2 for explanation of symbols, codes, abbreviations and definitions.
2. The stratification lines represent the approximate boundaries between soil types, and the transition may be gradual.
3. The discussion in the text of this report is necessary for a proper understanding of the nature of the subsurface materials.
4. Groundwater level, if indicated above, is for the date specified and may vary.
5. USCS designation is based on visual-manual classification and selected lab testing.

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LOG OF BORING SW-P-05

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FIG. A-7

REV 2

MASTER_LOG_E POCKETPEN LAT&LONG 23-1-01311-002.GPJ 7/6/17

Total Depth:	5.5 ft.	Latitude:		Drilling Method:	Solid-Stem Auger	Hole Diam.:	4 in.
Top Elevation:	~	Longitude:		Drilling Company:	Entech Engineering, Inc	Rod Type.:	AWJ
Vert. Datum:		Station:		Drill Rig Equipment:	Simco 2800 Truck Mount	Hammer Type:	Automatic
Horiz. Datum:		Offset:		Other Comments:			

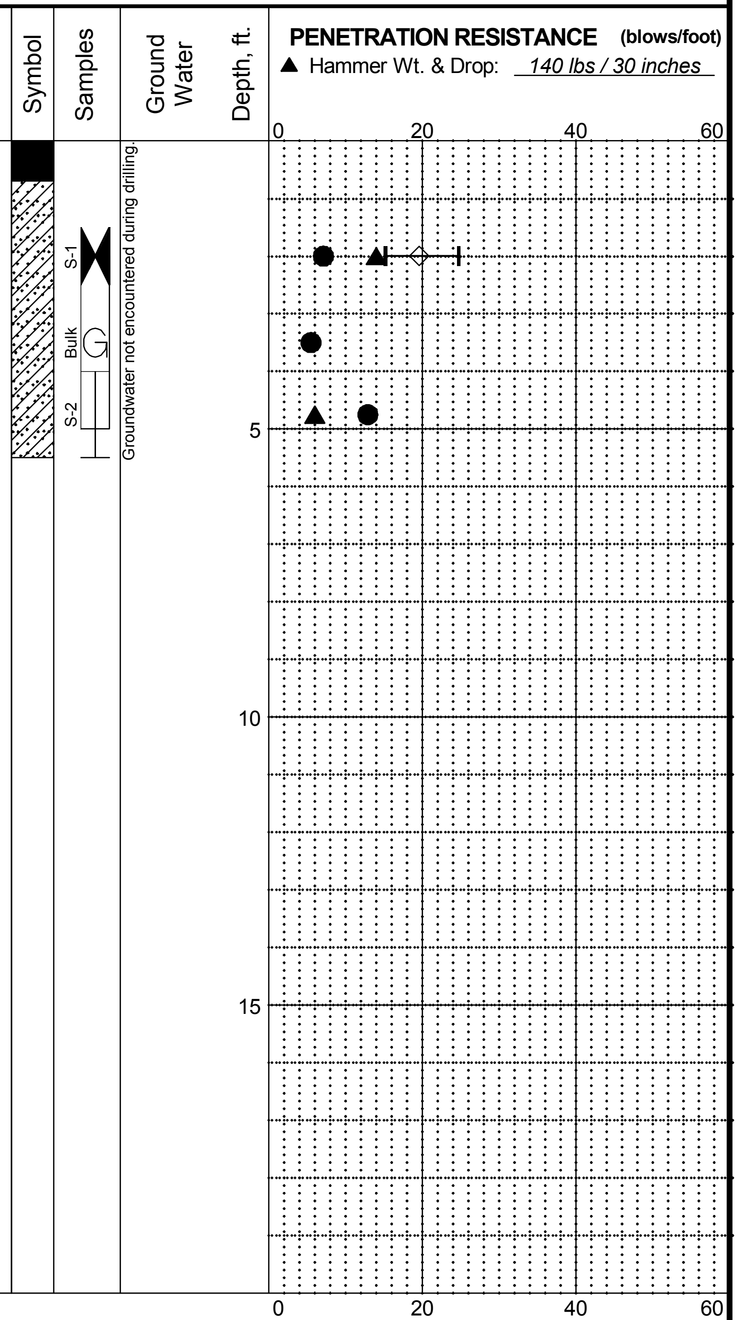
SOIL DESCRIPTION

Refer to the report text for a proper understanding of the subsurface materials and drilling methods. The stratification lines indicated below represent the approximate boundaries between material types, and the transition may be gradual.

PENETRATION RESISTANCE (blows/foot)

▲ Hammer Wt. & Drop: 140 lbs / 30 inches

Soil Description	Depth, ft.
8.0 inches of Asphalt	0.7
Medium dense to loose, brown, *Clayey Sand (SC)*; moist; trace gravel. [A-2-4]	5.5
BOTTOM OF BORING COMPLETED 6/27/2016	



LEGEND

* Sample Not Recovered
Modified California Sampler
Grab Sample
Standard Penetration Test

◇ % Fines (<0.075mm)
● % Water Content
Plastic Limit ├─●─┤ Liquid Limit
Natural Water Content

NOTES

1. Refer to Figures A-1 and A-2 for explanation of symbols, codes, abbreviations and definitions.
2. The stratification lines represent the approximate boundaries between soil types, and the transition may be gradual.
3. The discussion in the text of this report is necessary for a proper understanding of the nature of the subsurface materials.
4. Groundwater level, if indicated above, is for the date specified and may vary.
5. USCS designation is based on visual-manual classification and selected lab testing.

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LOG OF BORING SW-P-06

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FIG. A-8

REV 2

Total Depth:	4.5 ft.	Latitude:		Drilling Method:	Solid-Stem Auger	Hole Diam.:	4 in.
Top Elevation:	~	Longitude:		Drilling Company:	Entech Engineering, Inc	Rod Type.:	AWJ
Vert. Datum:		Station:		Drill Rig Equipment:	Simco 2800 Truck Mount	Hammer Type:	Automatic
Horiz. Datum:		Offset:		Other Comments:			

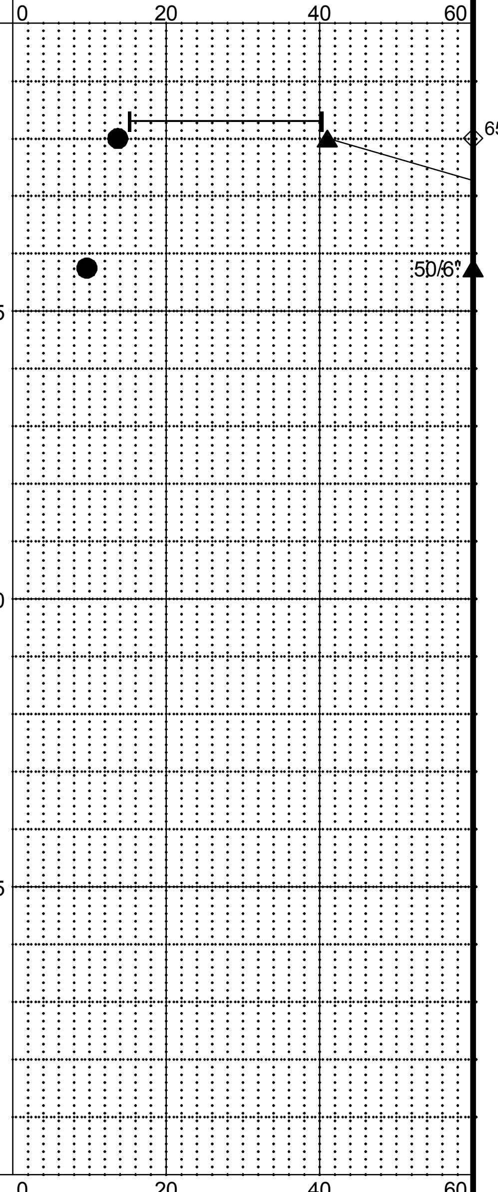
SOIL DESCRIPTION

Refer to the report text for a proper understanding of the subsurface materials and drilling methods. The stratification lines indicated below represent the approximate boundaries between material types, and the transition may be gradual.

Soil Description	Depth, ft.	Samples	Ground Water
9.5 inches of Asphalt	0.8		Groundwater not encountered during drilling.
CLAYSTONE: very low strength, gray to brown; moderately to highly weathered (Dawson Formation). [Dense to very dense, gray, *Sandy Lean Clay (CL)*; moist. (A-6)]	4.5	S-1, S-2	
BOTTOM OF BORING COMPLETED 6/27/2016			

PENETRATION RESISTANCE (blows/foot)

▲ Hammer Wt. & Drop: 140 lbs / 30 inches



◇ % Fines (<0.075mm)
● % Water Content
Plastic Limit ├─●─┤ Liquid Limit
Natural Water Content

LEGEND

* Sample Not Recovered
Modified California Sampler
Standard Penetration Test

NOTES

1. Refer to Figures A-1 and A-2 for explanation of symbols, codes, abbreviations and definitions.
2. The stratification lines represent the approximate boundaries between soil types, and the transition may be gradual.
3. The discussion in the text of this report is necessary for a proper understanding of the nature of the subsurface materials.
4. Groundwater level, if indicated above, is for the date specified and may vary.
5. USCS designation is based on visual-manual classification and selected lab testing.

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LOG OF BORING SW-P-07

July 2017 23-1-01311-002

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FIG. A-9

REV 2

Total Depth:	5.5 ft.	Latitude:		Drilling Method:	Solid-Stem Auger	Hole Diam.:	4 in.
Top Elevation:	~	Longitude:		Drilling Company:	Entech Engineering, Inc	Rod Type.:	AWJ
Vert. Datum:		Station:		Drill Rig Equipment:	Simco 2800 Truck Mount	Hammer Type:	Automatic
Horiz. Datum:		Offset:		Other Comments:			

SOIL DESCRIPTION

Refer to the report text for a proper understanding of the subsurface materials and drilling methods. The stratification lines indicated below represent the approximate boundaries between material types, and the transition may be gradual.

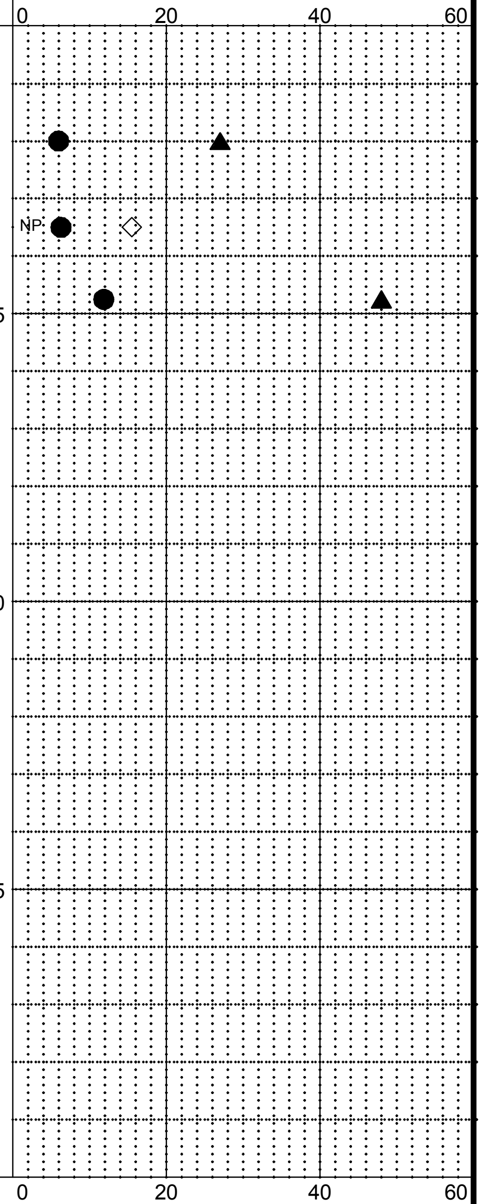
Soil Description	Depth, ft.	Samples
9.0 inches of Asphalt	0.8	
2 inches of Base Course	1.0	
Medium dense, brown, *Silty Sand (SM)*; moist; few gravel. [A-2-4]	4.0	S-1, Bulk
SANDSTONE: very low strength, red-yellow to light red, weakly cemented; slightly weathered (Dawson Formation). [Dense, red-yellow to light red, *Poorly Graded Sand (SP)*; moist; trace silt. (A-2-4)]	5.5	S-2

BOTTOM OF BORING
COMPLETED 6/27/2016

Ground Water: Groundwater not encountered during drilling.

PENETRATION RESISTANCE (blows/foot)

▲ Hammer Wt. & Drop: 140 lbs / 30 inches



◇ % Fines (<0.075mm)
● % Water Content
Plastic Limit ├─●─┤ Liquid Limit
Natural Water Content

LEGEND

* Sample Not Recovered
Modified California Sampler
Grab Sample
Standard Penetration Test

NOTES

1. Refer to Figures A-1 and A-2 for explanation of symbols, codes, abbreviations and definitions.
2. The stratification lines represent the approximate boundaries between soil types, and the transition may be gradual.
3. The discussion in the text of this report is necessary for a proper understanding of the nature of the subsurface materials.
4. Groundwater level, if indicated above, is for the date specified and may vary.
5. USCS designation is based on visual-manual classification and selected lab testing.

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LOG OF BORING SW-P-08

July 2017 23-1-01311-002

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FIG. A-10

REV 3

MASTER_LOG_E_POCKETPEN_LAT&LONG 23-1-01311-002.GPJ 7/6/17

Total Depth:	5.5 ft.	Latitude:		Drilling Method:	Solid-Stem Auger
Top Elevation:	~	Longitude:		Drilling Company:	Entech Engineering, Inc
Vert. Datum:		Station:		Drill Rig Equipment:	Simco 2800 Truck Mount
Horiz. Datum:		Offset:		Other Comments:	

Hole Diam.:	4 in.
Rod Type.:	AWJ
Hammer Type:	Automatic

SOIL DESCRIPTION

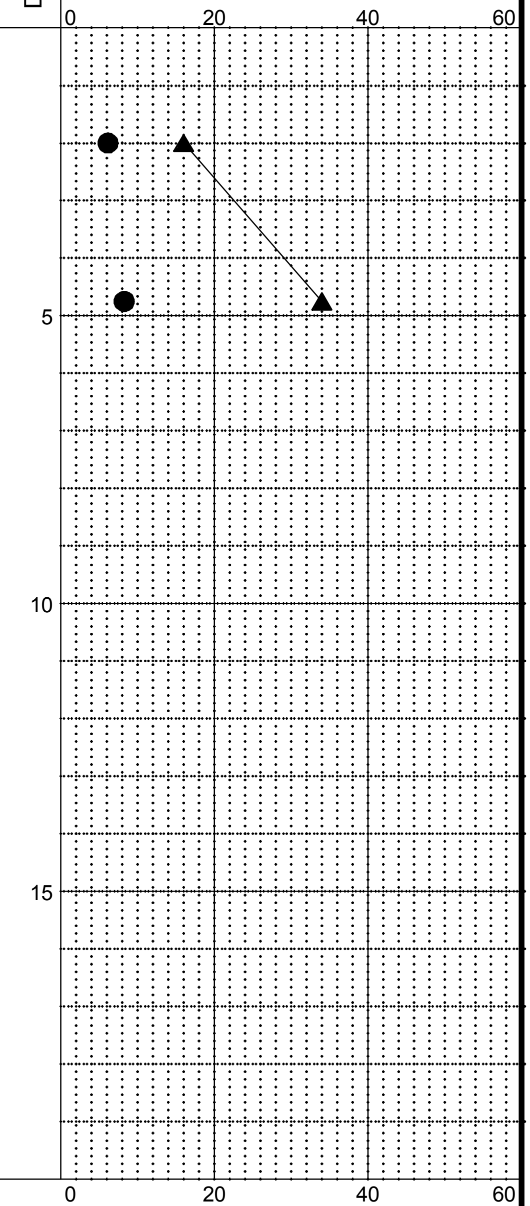
Refer to the report text for a proper understanding of the subsurface materials and drilling methods. The stratification lines indicated below represent the approximate boundaries between material types, and the transition may be gradual.

Soil Description	Depth, ft.	Samples
10.5 inches of Asphalt		
Medium dense, brown, *Silty Sand (SM) to Clayey Sand (SC)*; moist. [A-2-6]	0.9	S-1
SANDSTONE: very low strength, red-brown to yellow to light red, weakly cemented; moderately weathered (Dawson Formation). [Dense, red-brown to yellow to light red, *Poorly Graded Sand with Silt (SP-SM)*; moist. (A-2-4)]	4.0	S-2
BOTTOM OF BORING COMPLETED 6/27/2016	5.5	

Ground Water: Groundwater not encountered during drilling.

PENETRATION RESISTANCE (blows/foot)

▲ Hammer Wt. & Drop: 140 lbs / 30 inches



● % Water Content

LEGEND

* Sample Not Recovered
Modified California Sampler
Standard Penetration Test

NOTES

1. Refer to Figures A-1 and A-2 for explanation of symbols, codes, abbreviations and definitions.
2. The stratification lines represent the approximate boundaries between soil types, and the transition may be gradual.
3. The discussion in the text of this report is necessary for a proper understanding of the nature of the subsurface materials.
4. Groundwater level, if indicated above, is for the date specified and may vary.
5. USCS designation is based on visual-manual classification and selected lab testing.

Highway 105
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LOG OF BORING SW-P-09

July 2017 23-1-01311-002

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. A-11

REV 3

Total Depth:	*10.5 ft.*	Latitude:		Drilling Method:	*Solid-Stem Auger*	Hole Diam.:	*4 in.*
Top Elevation:	*~*	Longitude:		Drilling Company:	*Entech Engineering, Inc*	Rod Type.:	*AWJ*
Vert. Datum:		Station:		Drill Rig Equipment:	*Simco 2800 Truck Mount*	Hammer Type:	*Automatic*
Horiz. Datum:		Offset:		Other Comments:			

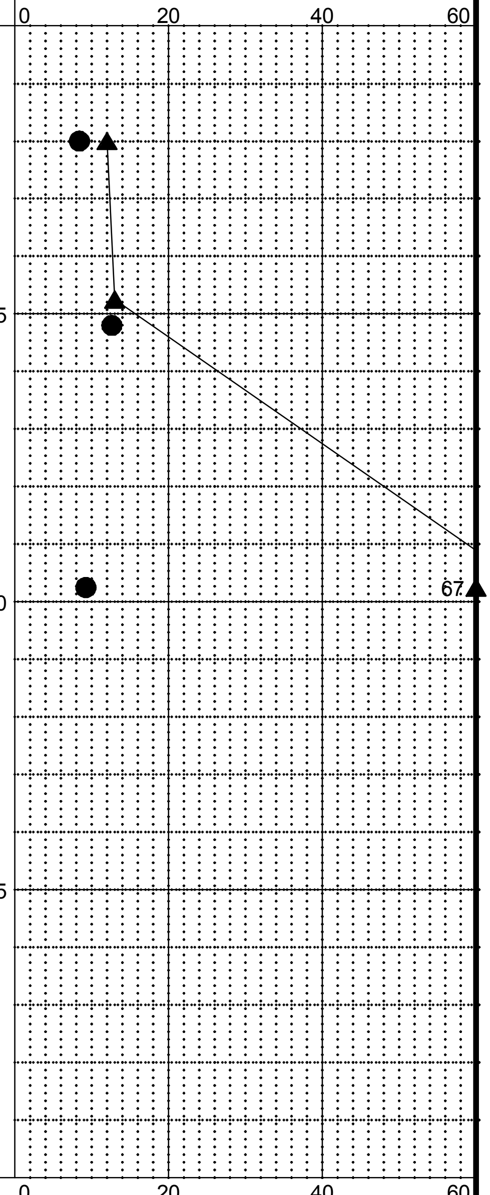
SOIL DESCRIPTION

Refer to the report text for a proper understanding of the subsurface materials and drilling methods. The stratification lines indicated below represent the approximate boundaries between material types, and the transition may be gradual.

Soil Description	Depth, ft.	Samples	Ground Water
10.0 inches of Asphalt			Groundwater not encountered during drilling.
Medium dense, gray, *Clayey Sand (SC)* to *Poorly Graded Sand with Clay (SP-SC)*; moist; trace gravel; trace fine roots from 1.5 feet to 2.5 feet. [A-2-6]	0.8	S-1, S-2	
SANDSTONE: very low strength, red-yellow to brown, weakly cemented; moderately weathered (Dawson Formation). [Very dense, red-yellow to brown, *Poorly Graded Sand with Clay (SP-SC)*; moist; trace silt and clay. (A-2-4)]	8.0	S-3	
BOTTOM OF BORING COMPLETED 6/28/2016	10.5		

PENETRATION RESISTANCE (blows/foot)

▲ Hammer Wt. & Drop: *140 lbs / 30 inches*



● % Water Content

LEGEND

* Sample Not Recovered

Modified California Sampler

Standard Penetration Test

NOTES

1. Refer to Figures A-1 and A-2 for explanation of symbols, codes, abbreviations and definitions.
2. The stratification lines represent the approximate boundaries between soil types, and the transition may be gradual.
3. The discussion in the text of this report is necessary for a proper understanding of the nature of the subsurface materials.
4. Groundwater level, if indicated above, is for the date specified and may vary.
5. USCS designation is based on visual-manual classification and selected lab testing.

Highway 105
Corridor Improvements
El Paso County, Colorado

LOG OF BORING SW-P-10

July 2017 23-1-01311-002

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. A-12

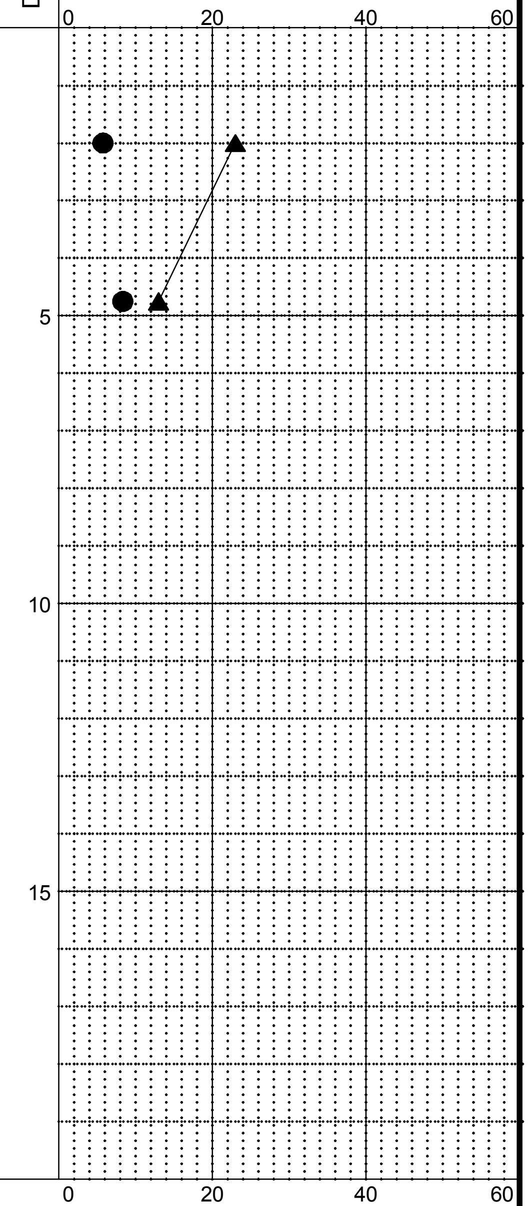
REV 3

Total Depth: 5.5 ft.	Latitude:	Drilling Method:	Solid-Stem Auger	Hole Diam.:	4 in.
Top Elevation: ~	Longitude:	Drilling Company:	Entech Engineering, Inc	Rod Type.:	AWJ
Vert. Datum:	Station:	Drill Rig Equipment:	Simco 2800 Truck Mount	Hammer Type:	Automatic
Horiz. Datum:	Offset:	Other Comments:			

SOIL DESCRIPTION	Depth, ft.	Symbol	Samples	Ground Water
Refer to the report text for a proper understanding of the subsurface materials and drilling methods. The stratification lines indicated below represent the approximate boundaries between material types, and the transition may be gradual.				
9.0 inches of Asphalt				Groundwater not encountered during drilling.
Medium dense, red-yellow to brown, *Poorly Graded Sand with Silt (SP-SM)*; moist. [A-2-4]	0.8		S-1, S-2	
BOTTOM OF BORING COMPLETED 6/28/2016	5.5			

PENETRATION RESISTANCE (blows/foot)

▲ Hammer Wt. & Drop: 140 lbs / 30 inches



LEGEND

* Sample Not Recovered

Modified California Sampler

Standard Penetration Test

● % Water Content

NOTES

1. Refer to Figures A-1 and A-2 for explanation of symbols, codes, abbreviations and definitions.
2. The stratification lines represent the approximate boundaries between soil types, and the transition may be gradual.
3. The discussion in the text of this report is necessary for a proper understanding of the nature of the subsurface materials.
4. Groundwater level, if indicated above, is for the date specified and may vary.
5. USCS designation is based on visual-manual classification and selected lab testing.

Highway 105
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LOG OF BORING SW-P-11

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FIG. A-13

REV 3

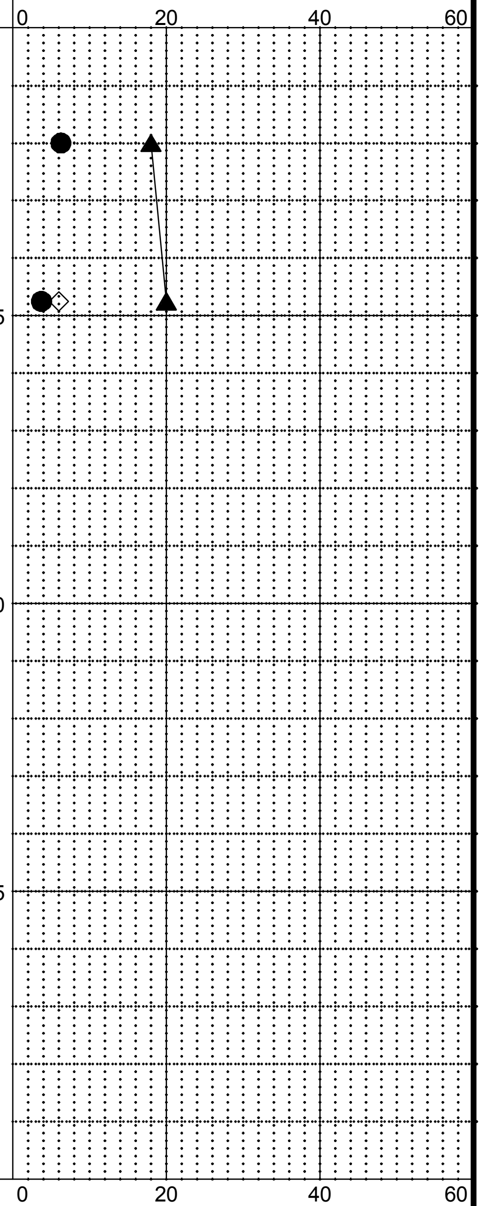
MASTER_LOG_E_POCKETPEN_LAT&LONG 23-1-01311-002.GPJ 7/6/17

Total Depth:	*5.5 ft.*	Latitude:		Drilling Method:	*Solid-Stem Auger*
Top Elevation:	~	Longitude:		Drilling Company:	*Entech Engineering, Inc*
Vert. Datum:		Station:		Drill Rig Equipment:	*Simco 2800 Truck Mount*
Horiz. Datum:		Offset:		Other Comments:	

Hole Diam.:	*4 in.*
Rod Type.:	*AWJ*
Hammer Type:	*Automatic*

SOIL DESCRIPTION *Refer to the report text for a proper understanding of the subsurface materials and drilling methods. The stratification lines indicated below represent the approximate boundaries between material types, and the transition may be gradual.*	Depth, ft.	Symbol	Samples	Ground Water
9.0 inches of Asphalt	0.8			Groundwater not encountered during drilling.
Medium dense, red-brown to brown, *Well-Graded Sand with Silt (SW-SM)*; moist; few gravel. [A-1-b]	5.5		S-1, S-2	
BOTTOM OF BORING COMPLETED 6/28/2016				

PENETRATION RESISTANCE (blows/foot)
▲ Hammer Wt. & Drop: *140 lbs / 30 inches*



◇ % Fines (<0.075mm)
● % Water Content

LEGEND

- * Sample Not Recovered
- Modified California Sampler
- Standard Penetration Test

NOTES

1. Refer to Figures A-1 and A-2 for explanation of symbols, codes, abbreviations and definitions.
2. The stratification lines represent the approximate boundaries between soil types, and the transition may be gradual.
3. The discussion in the text of this report is necessary for a proper understanding of the nature of the subsurface materials.
4. Groundwater level, if indicated above, is for the date specified and may vary.
5. USCS designation is based on visual-manual classification and selected lab testing.

Highway 105
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LOG OF BORING SW-P-12

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FIG. A-14

REV 3

Total Depth:	5.5 ft.	Latitude:		Drilling Method:	Solid-Stem Auger	Hole Diam.:	4 in.
Top Elevation:	~	Longitude:		Drilling Company:	Entech Engineering, Inc	Rod Type.:	AWJ
Vert. Datum:		Station:		Drill Rig Equipment:	Simco 2800 Truck Mount	Hammer Type:	Automatic
Horiz. Datum:		Offset:		Other Comments:			

SOIL DESCRIPTION

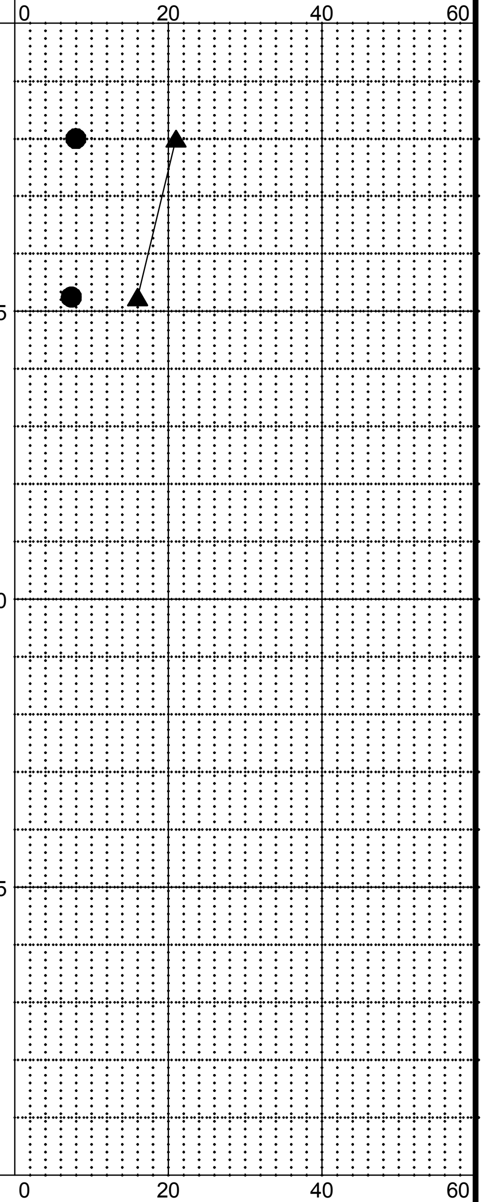
Refer to the report text for a proper understanding of the subsurface materials and drilling methods. The stratification lines indicated below represent the approximate boundaries between material types, and the transition may be gradual.

Soil Description	Depth, ft.	Samples
7.5 inches of Asphalt	0.7	
Medium dense, red-brown to brown, *Poorly Graded Sand with Silt (SP-SM)*; moist. [A-1-b]	5.5	S-1, S-2
BOTTOM OF BORING COMPLETED 6/27/2016		

Ground Water: Groundwater not encountered during drilling.

PENETRATION RESISTANCE (blows/foot)

▲ Hammer Wt. & Drop: 140 lbs / 30 inches



● % Water Content

LEGEND

* Sample Not Recovered

Modified California Sampler

Standard Penetration Test

NOTES

1. Refer to Figures A-1 and A-2 for explanation of symbols, codes, abbreviations and definitions.
2. The stratification lines represent the approximate boundaries between soil types, and the transition may be gradual.
3. The discussion in the text of this report is necessary for a proper understanding of the nature of the subsurface materials.
4. Groundwater level, if indicated above, is for the date specified and may vary.
5. USCS designation is based on visual-manual classification and selected lab testing.

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FIG. A-15

REV 3

Total Depth:	*5.5 ft.*	Latitude:		Drilling Method:	*Solid-Stem Auger*	Hole Diam.:	*4 in.*
Top Elevation:	~	Longitude:		Drilling Company:	*Entech Engineering, Inc*	Rod Type.:	*AWJ*
Vert. Datum:		Station:		Drill Rig Equipment:	*Simco 2800 Truck Mount*	Hammer Type:	*Automatic*
Horiz. Datum:		Offset:		Other Comments:			

SOIL DESCRIPTION

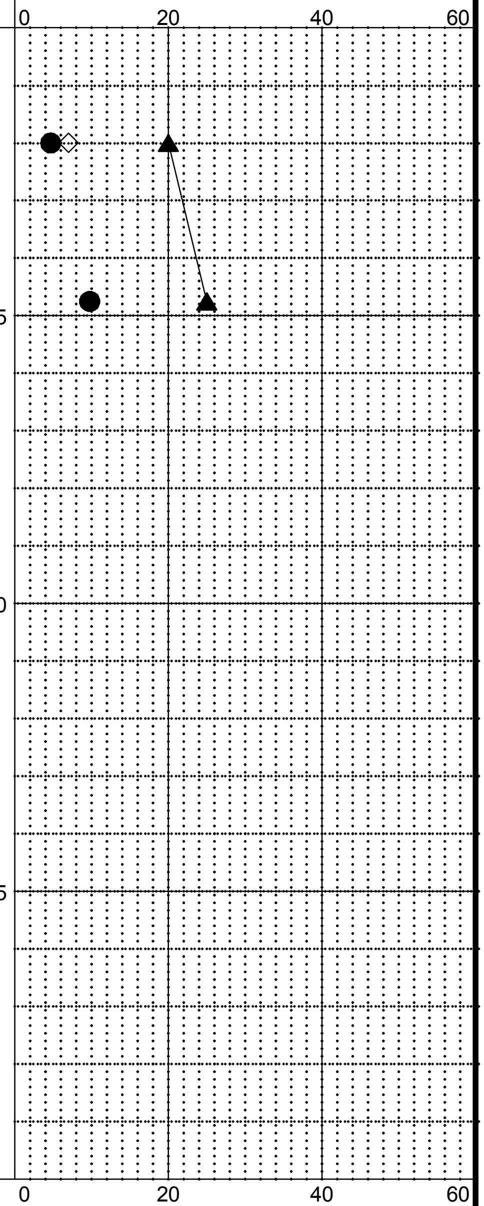
Refer to the report text for a proper understanding of the subsurface materials and drilling methods. The stratification lines indicated below represent the approximate boundaries between material types, and the transition may be gradual.

Soil Description	Depth, ft.	Samples	Ground Water
8.0 inches of Asphalt	0.7		Groundwater not encountered during drilling.
2 inches of Base Course	0.9		
Medium dense, red-yellow to brown, *Well-Graded Sand with Silt (SW-SM)*; moist; few gravel. [A-1-b]	4.0	S-1	
Medium dense, red-yellow to brown, *Poorly Graded Sand with Clay (SP-SC)*; moist; trace gravel. [A-1-b]	5.5	S-2	

BOTTOM OF BORING
COMPLETED 6/28/2016

PENETRATION RESISTANCE (blows/foot)

▲ Hammer Wt. & Drop: *140 lbs / 30 inches*



◇ % Fines (<0.075mm)
● % Water Content

LEGEND

* Sample Not Recovered
Modified California Sampler
Standard Penetration Test

NOTES

1. Refer to Figures A-1 and A-2 for explanation of symbols, codes, abbreviations and definitions.
2. The stratification lines represent the approximate boundaries between soil types, and the transition may be gradual.
3. The discussion in the text of this report is necessary for a proper understanding of the nature of the subsurface materials.
4. Groundwater level, if indicated above, is for the date specified and may vary.
5. USCS designation is based on visual-manual classification and selected lab testing.

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LOG OF BORING SW-P-14

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FIG. A-16

REV 3

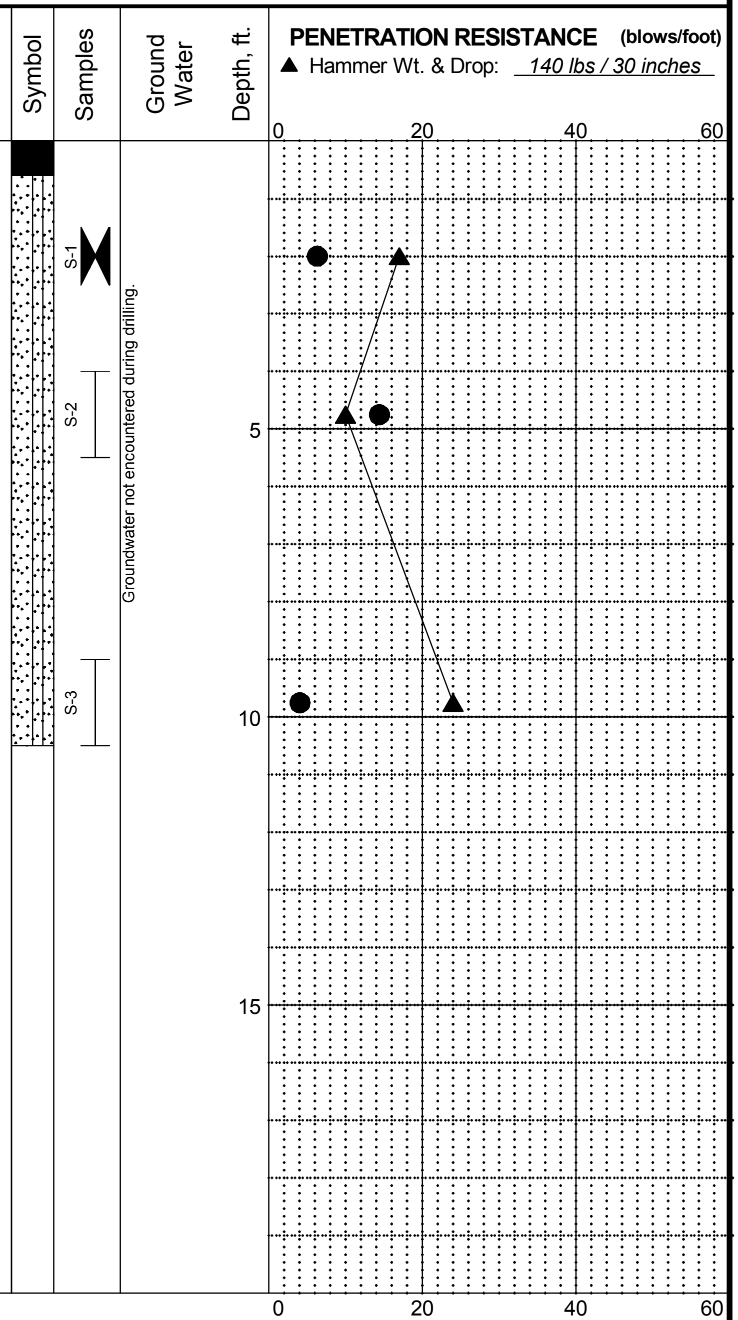
MASTER_LOG_E_POCKETPEN_LAT&LONG 23-1-01311-002.GPJ 7/6/17

Total Depth:	*10.5 ft.*	Latitude:		Drilling Method:	*Solid-Stem Auger*	Hole Diam.:	*4 in.*
Top Elevation:	*~*	Longitude:		Drilling Company:	*Entech Engineering, Inc*	Rod Type.:	*AWJ*
Vert. Datum:		Station:		Drill Rig Equipment:	*Simco 2800 Truck Mount*	Hammer Type:	*Automatic*
Horiz. Datum:		Offset:		Other Comments:			

SOIL DESCRIPTION

Refer to the report text for a proper understanding of the subsurface materials and drilling methods. The stratification lines indicated below represent the approximate boundaries between material types, and the transition may be gradual.

Soil Description	Depth, ft.
6.5 inches of Asphalt	0.6
Medium dense to loose, red-yellow to brown, *Poorly Graded Sand with Silt (SP-SM)*; moist. [A-2-4]	10.5
BOTTOM OF BORING COMPLETED 6/27/2016	



LEGEND

* Sample Not Recovered
Modified California Sampler
Standard Penetration Test

NOTES

1. Refer to Figures A-1 and A-2 for explanation of symbols, codes, abbreviations and definitions.
2. The stratification lines represent the approximate boundaries between soil types, and the transition may be gradual.
3. The discussion in the text of this report is necessary for a proper understanding of the nature of the subsurface materials.
4. Groundwater level, if indicated above, is for the date specified and may vary.
5. USCS designation is based on visual-manual classification and selected lab testing.

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FIG. A-17

REV 3

Total Depth:	5.5 ft.	Latitude:		Drilling Method:	Solid-Stem Auger	Hole Diam.:	4 in.
Top Elevation:	~	Longitude:		Drilling Company:	Entech Engineering, Inc	Rod Type.:	AWJ
Vert. Datum:		Station:		Drill Rig Equipment:	Simco 2800 Truck Mount	Hammer Type:	Automatic
Horiz. Datum:		Offset:		Other Comments:			

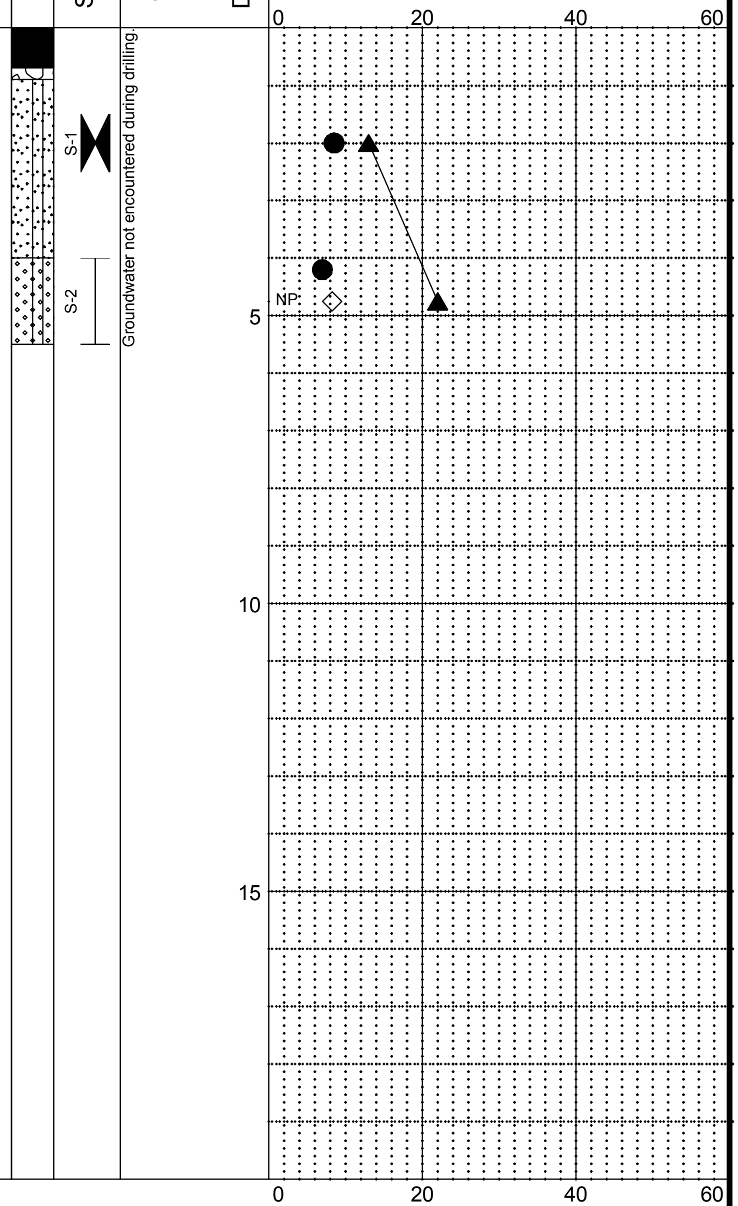
SOIL DESCRIPTION

Refer to the report text for a proper understanding of the subsurface materials and drilling methods. The stratification lines indicated below represent the approximate boundaries between material types, and the transition may be gradual.

Soil Description	Depth, ft.	Samples	Ground Water
8.0 inches of Asphalt	0.7		Groundwater not encountered during drilling.
2 inches of Base Course	0.9		
Medium dense, brown, *Poorly Graded Sand with Silt (SP-SM)*; moist. [A-2-4]	4.0	S-1	
Medium dense, red-yellow to brown, *Well-Graded Sand with Silt (SW-SM)*; moist; trace gravel. [A-1-b]	5.5	S-2	
BOTTOM OF BORING COMPLETED 6/28/2016			

PENETRATION RESISTANCE (blows/foot)

▲ Hammer Wt. & Drop: 140 lbs / 30 inches



LEGEND

- * Sample Not Recovered
- Modified California Sampler
- Standard Penetration Test

◇ % Fines (<0.075mm)

● % Water Content

Plastic Limit ├─●─┤ Liquid Limit
Natural Water Content

NOTES

1. Refer to Figures A-1 and A-2 for explanation of symbols, codes, abbreviations and definitions.
2. The stratification lines represent the approximate boundaries between soil types, and the transition may be gradual.
3. The discussion in the text of this report is necessary for a proper understanding of the nature of the subsurface materials.
4. Groundwater level, if indicated above, is for the date specified and may vary.
5. USCS designation is based on visual-manual classification and selected lab testing.

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FIG. A-18

REV 3

MASTER LOG E POCKETPEN LAT&LONG 23-1-01311-002.GPJ 7/6/17

Total Depth:	*5.5 ft.*	Latitude:		Drilling Method:	*Solid-Stem Auger*
Top Elevation:	*~*	Longitude:		Drilling Company:	*Entech Engineering, Inc*
Vert. Datum:		Station:		Drill Rig Equipment:	*Simco 2800 Truck Mount*
Horiz. Datum:		Offset:		Other Comments:	

Hole Diam.:	*4 in.*
Rod Type.:	*AWJ*
Hammer Type:	*Automatic*

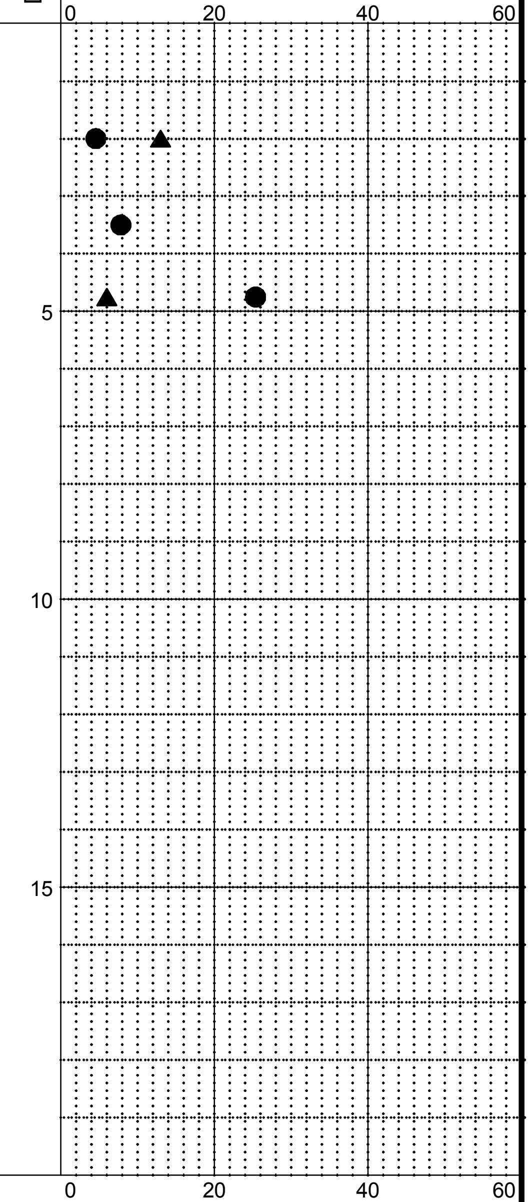
SOIL DESCRIPTION

Refer to the report text for a proper understanding of the subsurface materials and drilling methods. The stratification lines indicated below represent the approximate boundaries between material types, and the transition may be gradual.

Soil Description	Depth, ft.	Samples	Ground Water
7.0 inches of Asphalt	0.6		Groundwater not encountered during drilling.
3 inches of Base Course	0.9		
Medium dense, brown, *Poorly Graded Sand with Clay (SP-SC)*; moist. [A-2-6]		S-1, Bulk	
Loose, brown, *Clayey Sand (SC)*; moist to wet; trace organics.	4.5	S-2	
BOTTOM OF BORING COMPLETED 6/27/2016	5.5		

PENETRATION RESISTANCE **(blows/foot)**

▲ Hammer Wt. & Drop: *140 lbs / 30 inches*



● % Water Content

LEGEND

* Sample Not Recovered

Modified California Sampler

Grab Sample

Standard Penetration Test

NOTES

1. Refer to Figures A-1 and A-2 for explanation of symbols, codes, abbreviations and definitions.
2. The stratification lines represent the approximate boundaries between soil types, and the transition may be gradual.
3. The discussion in the text of this report is necessary for a proper understanding of the nature of the subsurface materials.
4. Groundwater level, if indicated above, is for the date specified and may vary.
5. USCS designation is based on visual-manual classification and selected lab testing.

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LOG OF BORING SW-P-17

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FIG. A-19

REV 3

MASTER_LOG_E_POCKETPEN_LAT&LONG 23-1-01311-002.GPJ 7/6/17

Total Depth:	*5.5 ft.*	Latitude:		Drilling Method:	*Solid-Stem Auger*	Hole Diam.:	*4 in.*
Top Elevation:	~	Longitude:		Drilling Company:	*Entech Engineering, Inc*	Rod Type.:	*AWJ*
Vert. Datum:		Station:		Drill Rig Equipment:	*Simco 2800 Truck Mount*	Hammer Type:	*Automatic*
Horiz. Datum:		Offset:		Other Comments:			

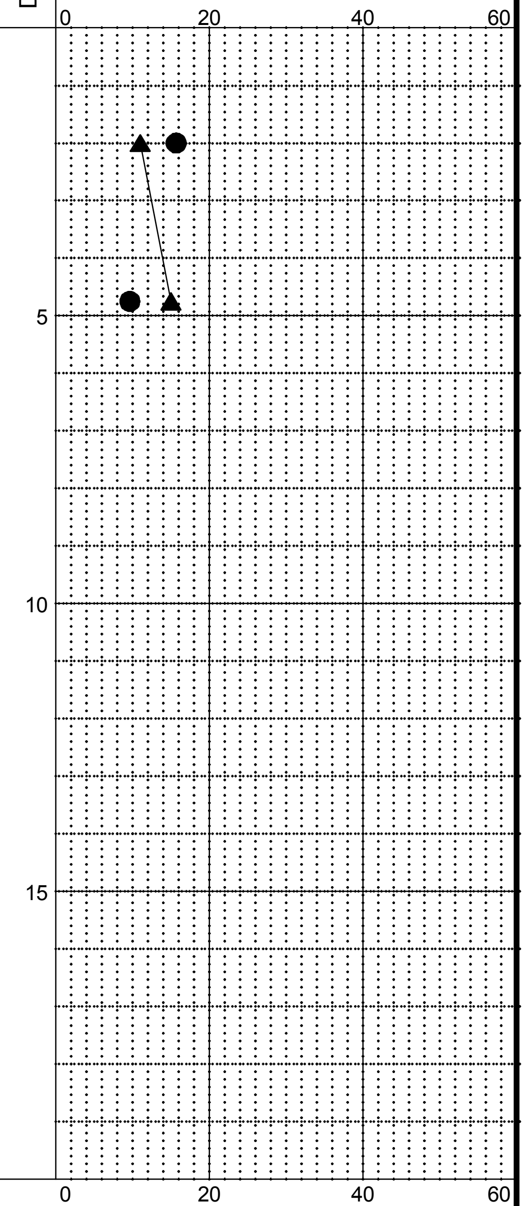
SOIL DESCRIPTION

Refer to the report text for a proper understanding of the subsurface materials and drilling methods. The stratification lines indicated below represent the approximate boundaries between material types, and the transition may be gradual.

Soil Description	Depth, ft.	Symbol	Samples	Ground Water
10.0 inches of Asphalt	0.8			Groundwater not encountered during drilling.
Medium dense, brown, *Poorly Graded Sand with Silt (SP-SM)*; moist. [A-2-4]	5.5		S-1, S-2	
BOTTOM OF BORING COMPLETED 6/28/2016				

PENETRATION RESISTANCE (blows/foot)

▲ Hammer Wt. & Drop: *140 lbs / 30 inches*



● % Water Content

LEGEND

* Sample Not Recovered

Modified California Sampler

Standard Penetration Test

NOTES

1. Refer to Figures A-1 and A-2 for explanation of symbols, codes, abbreviations and definitions.
2. The stratification lines represent the approximate boundaries between soil types, and the transition may be gradual.
3. The discussion in the text of this report is necessary for a proper understanding of the nature of the subsurface materials.
4. Groundwater level, if indicated above, is for the date specified and may vary.
5. USCS designation is based on visual-manual classification and selected lab testing.

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LOG OF BORING SW-P-18

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SHANNON & WILSON, INC.
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FIG. A-20

REV 3

Total Depth:	5.5 ft.	Latitude:		Drilling Method:	Solid-Stem Auger
Top Elevation:	~	Longitude:		Drilling Company:	Entech Engineering, Inc
Vert. Datum:		Station:		Drill Rig Equipment:	Simco 2800 Truck Mount
Horiz. Datum:		Offset:		Other Comments:	

Hole Diam.:	4 in.
Rod Type.:	AWJ
Hammer Type:	Automatic

SOIL DESCRIPTION

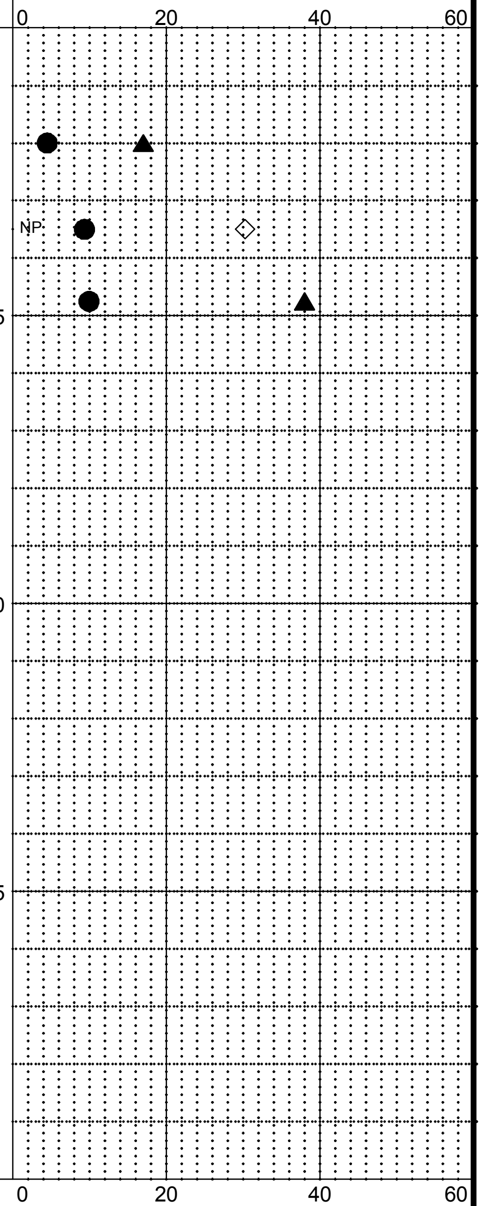
Refer to the report text for a proper understanding of the subsurface materials and drilling methods. The stratification lines indicated below represent the approximate boundaries between material types, and the transition may be gradual.

Soil Description	Depth, ft.	Samples
8.5 inches of Asphalt	0.8	
3 inches of Base Course	1.0	
Medium dense, brown, *Silty Sand (SM)*; moist; trace gravel. [A-2-4]	4.0	S-1, Bulk
CLAYSTONE: very low strength, gray; moderately to highly weathered (Dawson Formation). [Dense, gray, *Clayey Sand (SC)*; moist. (A-2-6)]	5.5	S-2

Ground Water: Groundwater not encountered during drilling.

BOTTOM OF BORING
COMPLETED 6/28/2016

PENETRATION RESISTANCE (blows/foot)
▲ Hammer Wt. & Drop: 140 lbs / 30 inches



◇ % Fines (<0.075mm)
● % Water Content
Plastic Limit ├──●──┤ Liquid Limit
Natural Water Content

LEGEND

* Sample Not Recovered
Modified California Sampler
Grab Sample
Standard Penetration Test

NOTES

1. Refer to Figures A-1 and A-2 for explanation of symbols, codes, abbreviations and definitions.
2. The stratification lines represent the approximate boundaries between soil types, and the transition may be gradual.
3. The discussion in the text of this report is necessary for a proper understanding of the nature of the subsurface materials.
4. Groundwater level, if indicated above, is for the date specified and may vary.
5. USCS designation is based on visual-manual classification and selected lab testing.

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LOG OF BORING SW-P-19

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FIG. A-21

MASTER_LOG_E POCKETPEN LAT&LONG 23-1-01311-002.GPJ 7/6/17

REV 3

Total Depth:	*10.5 ft.*	Latitude:		Drilling Method:	*Solid-Stem Auger*	Hole Diam.:	*4 in.*
Top Elevation:	*~*	Longitude:		Drilling Company:	*Entech Engineering, Inc*	Rod Type.:	*AWJ*
Vert. Datum:		Station:		Drill Rig Equipment:	*Simco 2800 Truck Mount*	Hammer Type:	*Automatic*
Horiz. Datum:		Offset:		Other Comments:			

SOIL DESCRIPTION

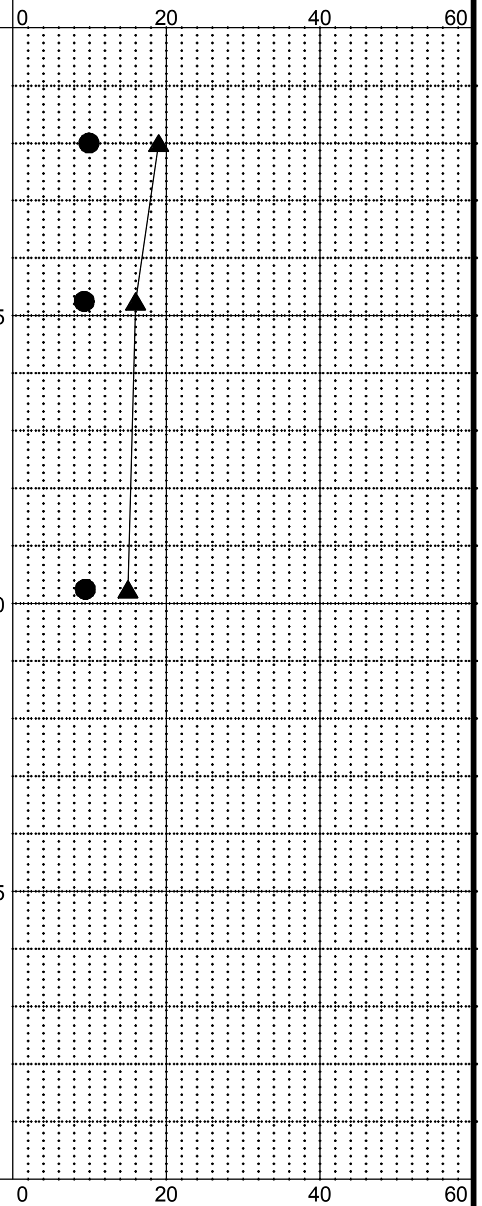
Refer to the report text for a proper understanding of the subsurface materials and drilling methods. The stratification lines indicated below represent the approximate boundaries between material types, and the transition may be gradual.

Soil Description	Depth, ft.	Samples
7.0 inches of Asphalt	0.6	
3 inches of Base Course	0.9	
Medium dense, brown, *Poorly Graded Sand with Silt (SP-SM)*; moist; trace organics. [A-1-b]	10.0	S-1, S-2, S-3
Medium dense, brown to gray, *Poorly Graded Sand with Clay (SP-SC)*; moist. [A-2-6]	10.5	

BOTTOM OF BORING
COMPLETED 6/28/2016

Ground Water: Groundwater not encountered during drilling.

PENETRATION RESISTANCE (blows/foot)
▲ Hammer Wt. & Drop: *140 lbs / 30 inches*



● % Water Content

LEGEND

* Sample Not Recovered
Modified California Sampler
Standard Penetration Test

NOTES

1. Refer to Figures A-1 and A-2 for explanation of symbols, codes, abbreviations and definitions.
2. The stratification lines represent the approximate boundaries between soil types, and the transition may be gradual.
3. The discussion in the text of this report is necessary for a proper understanding of the nature of the subsurface materials.
4. Groundwater level, if indicated above, is for the date specified and may vary.
5. USCS designation is based on visual-manual classification and selected lab testing.

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FIG. A-22

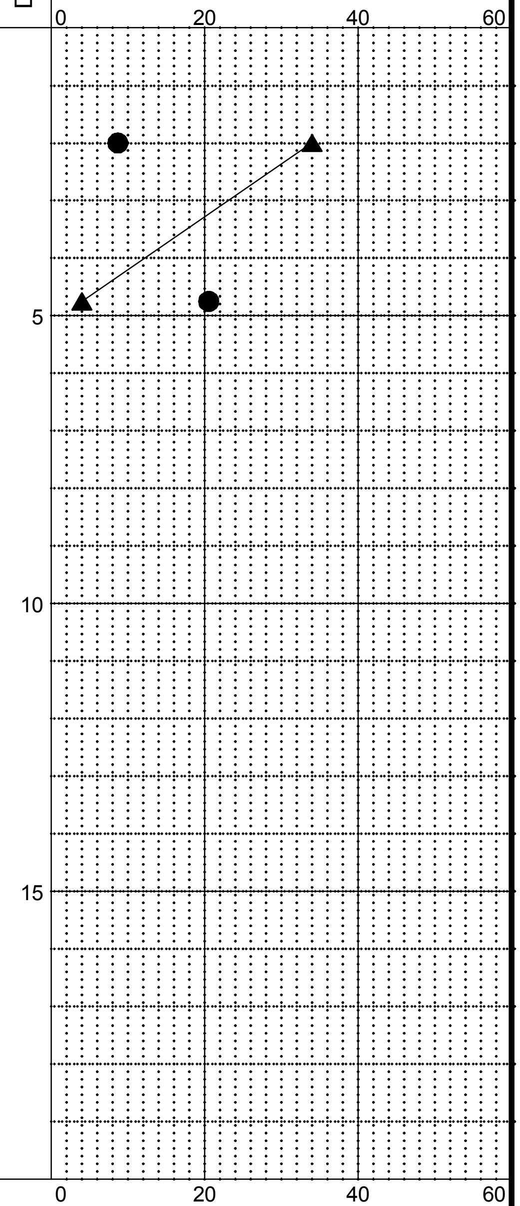
REV 3

MASTER_LOG_E_POCKETPEN_LAT&LONG 23-1-01311-002.GPJ 7/6/17

Total Depth:	5.5 ft.	Latitude:		Drilling Method:	Solid-Stem Auger	Hole Diam.:	4 in.
Top Elevation:	~	Longitude:		Drilling Company:	Entech Engineering, Inc	Rod Type.:	AWJ
Vert. Datum:		Station:		Drill Rig Equipment:	Simco 2800 Truck Mount	Hammer Type:	Automatic
Horiz. Datum:		Offset:		Other Comments:			

SOIL DESCRIPTION *Refer to the report text for a proper understanding of the subsurface materials and drilling methods. The stratification lines indicated below represent the approximate boundaries between material types, and the transition may be gradual.*	Depth, ft.	Symbol	Samples	Ground Water
11.5 inches of Asphalt	1.0			Groundwater not encountered during drilling.
1 inch of Base Course	1.1			
Dense, brown, *Silty Sand (SM)*; moist. [A-2-4]	4.0		S-1	
Loose, brown to red-yellow, *Poorly Graded Sand with Clay (SP-SC)*; moist. [A-2-6]	5.5		S-2	
BOTTOM OF BORING COMPLETED 6/28/2016				

PENETRATION RESISTANCE (blows/foot)
▲ Hammer Wt. & Drop: 140 lbs / 30 inches



● % Water Content

LEGEND

* Sample Not Recovered
Modified California Sampler
Standard Penetration Test

NOTES

1. Refer to Figures A-1 and A-2 for explanation of symbols, codes, abbreviations and definitions.
2. The stratification lines represent the approximate boundaries between soil types, and the transition may be gradual.
3. The discussion in the text of this report is necessary for a proper understanding of the nature of the subsurface materials.
4. Groundwater level, if indicated above, is for the date specified and may vary.
5. USCS designation is based on visual-manual classification and selected lab testing.

Highway 105
Corridor Improvements
El Paso County, Colorado

LOG OF BORING SW-P-21

July 2017 23-1-01311-002

SHANNON & WILSON, INC.
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FIG. A-23

REV 3

Total Depth: 5.5 ft.	Latitude:	Drilling Method:	Solid-Stem Auger	Hole Diam.:	4 in.
Top Elevation: ~	Longitude:	Drilling Company:	Entech Engineering, Inc	Rod Type.:	AWJ
Vert. Datum:	Station:	Drill Rig Equipment:	Simco 2800 Truck Mount	Hammer Type:	Automatic
Horiz. Datum:	Offset:	Other Comments:			

SOIL DESCRIPTION

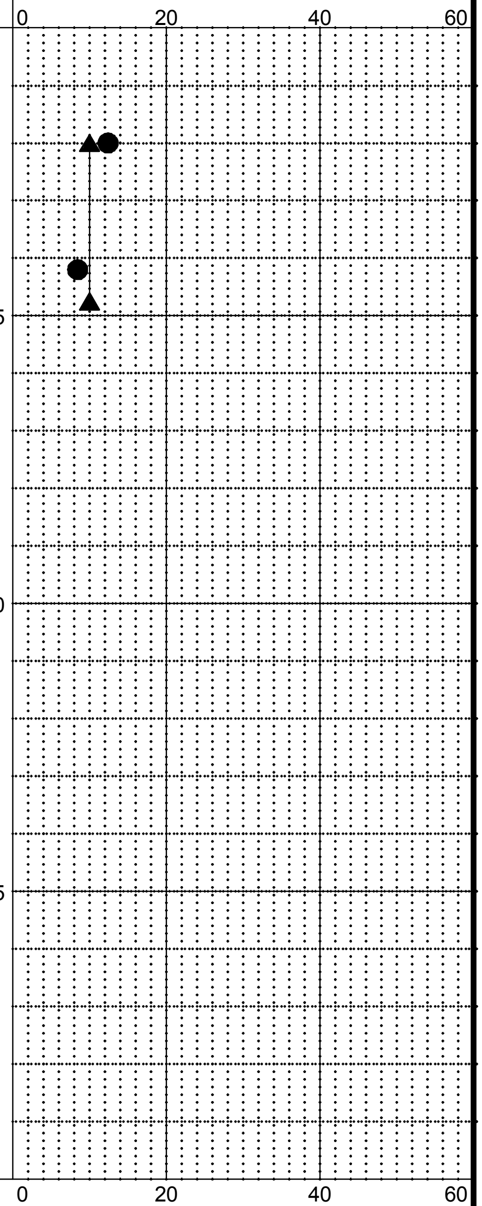
Refer to the report text for a proper understanding of the subsurface materials and drilling methods. The stratification lines indicated below represent the approximate boundaries between material types, and the transition may be gradual.

Soil Description	Depth, ft.	Samples
10.5 inches of Asphalt	0.9	
2 inches of Base Course	1.1	
Loose, brown, *Silty Sand (SM)*; moist. [A-2-4]	4.0	S-1
Loose, brown to red-yellow, *Poorly Graded Sand with Silt (SP-SM)*; moist. [A-2-4]	5.5	S-2

Groundwater not encountered during drilling.

BOTTOM OF BORING
COMPLETED 6/28/2016

PENETRATION RESISTANCE (blows/foot)
▲ Hammer Wt. & Drop: 140 lbs / 30 inches



LEGEND

* Sample Not Recovered
Modified California Sampler
Standard Penetration Test

NOTES

1. Refer to Figures A-1 and A-2 for explanation of symbols, codes, abbreviations and definitions.
2. The stratification lines represent the approximate boundaries between soil types, and the transition may be gradual.
3. The discussion in the text of this report is necessary for a proper understanding of the nature of the subsurface materials.
4. Groundwater level, if indicated above, is for the date specified and may vary.
5. USCS designation is based on visual-manual classification and selected lab testing.

Highway 105
Corridor Improvements
El Paso County, Colorado

LOG OF BORING SW-P-22

July 2017 — 23-1-01311-002

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. A-24

REV 3

MASTER_LOG_E_POCKETPEN_LAT&LONG 23-1-01311-002.GPJ 7/6/17

Total Depth: 5.5 ft.	Latitude:	Drilling Method:	Solid-Stem Auger	Hole Diam.:	4 in.
Top Elevation: ~	Longitude:	Drilling Company:	Entech Engineering, Inc	Rod Type.:	AWJ
Vert. Datum:	Station:	Drill Rig Equipment:	Simco 2800 Truck Mount	Hammer Type:	Automatic
Horiz. Datum:	Offset:	Other Comments:			

SOIL DESCRIPTION

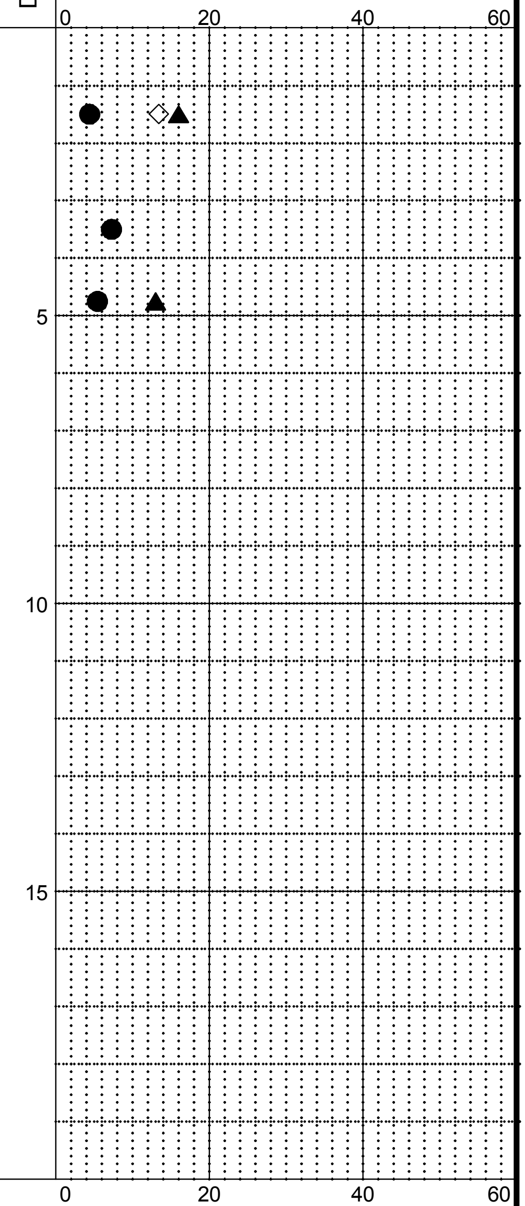
Refer to the report text for a proper understanding of the subsurface materials and drilling methods. The stratification lines indicated below represent the approximate boundaries between material types, and the transition may be gradual.

Soil Description	Depth, ft.	Samples
11.0 inches of Asphalt	0.9	
2 inches of Base Course	1.0	S-1
Medium dense, brown, *Silty Sand (SM)*; moist; few gravel. [A-1-b]	4.0	Bulk
Medium dense, brown to red-yellow, *Poorly Graded Sand with Clay (SP-SC)*; moist. [A-2-4]	5.5	S-2

BOTTOM OF BORING
COMPLETED 6/28/2016

Groundwater not encountered during drilling.

PENETRATION RESISTANCE (blows/foot)
▲ Hammer Wt. & Drop: 140 lbs / 30 inches



◇ % Fines (<0.075mm)
● % Water Content

LEGEND

* Sample Not Recovered
Modified California Sampler
Grab Sample
Standard Penetration Test

NOTES

1. Refer to Figures A-1 and A-2 for explanation of symbols, codes, abbreviations and definitions.
2. The stratification lines represent the approximate boundaries between soil types, and the transition may be gradual.
3. The discussion in the text of this report is necessary for a proper understanding of the nature of the subsurface materials.
4. Groundwater level, if indicated above, is for the date specified and may vary.
5. USCS designation is based on visual-manual classification and selected lab testing.

Highway 105
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LOG OF BORING SW-P-23

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SHANNON & WILSON, INC.
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FIG. A-25

REV 3

MASTER_LOG_E_POCKETPEN LAT&LONG 23-1-01311-002.GPJ 7/6/17

Total Depth:	5.5 ft.	Latitude:		Drilling Method:	Solid-Stem Auger	Hole Diam.:	4 in.
Top Elevation:	~	Longitude:		Drilling Company:	Entech Engineering, Inc	Rod Type.:	AWJ
Vert. Datum:		Station:		Drill Rig Equipment:	Simco 2800 Truck Mount	Hammer Type:	Automatic
Horiz. Datum:		Offset:		Other Comments:			

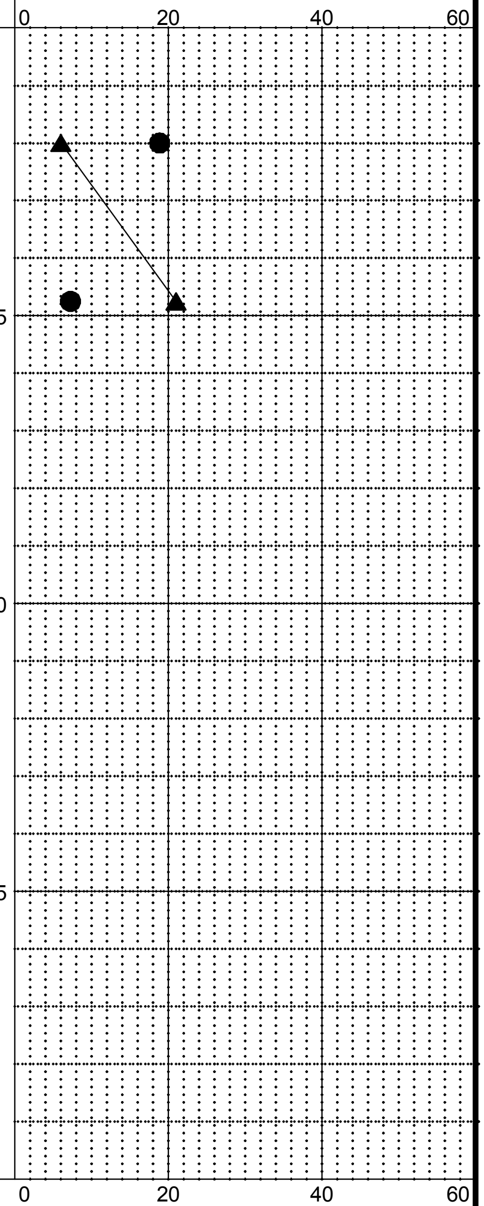
SOIL DESCRIPTION

Refer to the report text for a proper understanding of the subsurface materials and drilling methods. The stratification lines indicated below represent the approximate boundaries between material types, and the transition may be gradual.

Soil Description	Depth, ft.	Samples	Ground Water
11.5 inches of Asphalt			Groundwater not encountered during drilling.
Loose, brown, *Silty Sand (SM)*; moist. [A-2-4]	1.0	S-1	
Medium dense, brown to red-yellow, *Poorly Graded Sand with Clay (SP-SC)*; moist; trace gravel. [A-2-6]	4.0	S-2	
BOTTOM OF BORING COMPLETED 6/28/2016	5.5		

PENETRATION RESISTANCE (blows/foot)

▲ Hammer Wt. & Drop: *140 lbs / 30 inches*



● % Water Content

LEGEND

* Sample Not Recovered

Modified California Sampler

Standard Penetration Test

NOTES

1. Refer to Figures A-1 and A-2 for explanation of symbols, codes, abbreviations and definitions.
2. The stratification lines represent the approximate boundaries between soil types, and the transition may be gradual.
3. The discussion in the text of this report is necessary for a proper understanding of the nature of the subsurface materials.
4. Groundwater level, if indicated above, is for the date specified and may vary.
5. USCS designation is based on visual-manual classification and selected lab testing.

Highway 105
Corridor Improvements
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LOG OF BORING SW-P-24

July 2017 23-1-01311-002

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. A-26

REV 3

MASTER_LOG_E_POCKETPEN_LAT&LONG 23-1-01311-002.GPJ 7/6/17

Total Depth:	*10.5 ft.*	Latitude:		Drilling Method:	*Solid-Stem Auger*	Hole Diam.:	*4 in.*
Top Elevation:	~	Longitude:		Drilling Company:	*Entech Engineering, Inc*	Rod Type.:	*AWJ*
Vert. Datum:		Station:		Drill Rig Equipment:	*Simco 2800 Truck Mount*	Hammer Type:	*Automatic*
Horiz. Datum:		Offset:		Other Comments:			

SOIL DESCRIPTION

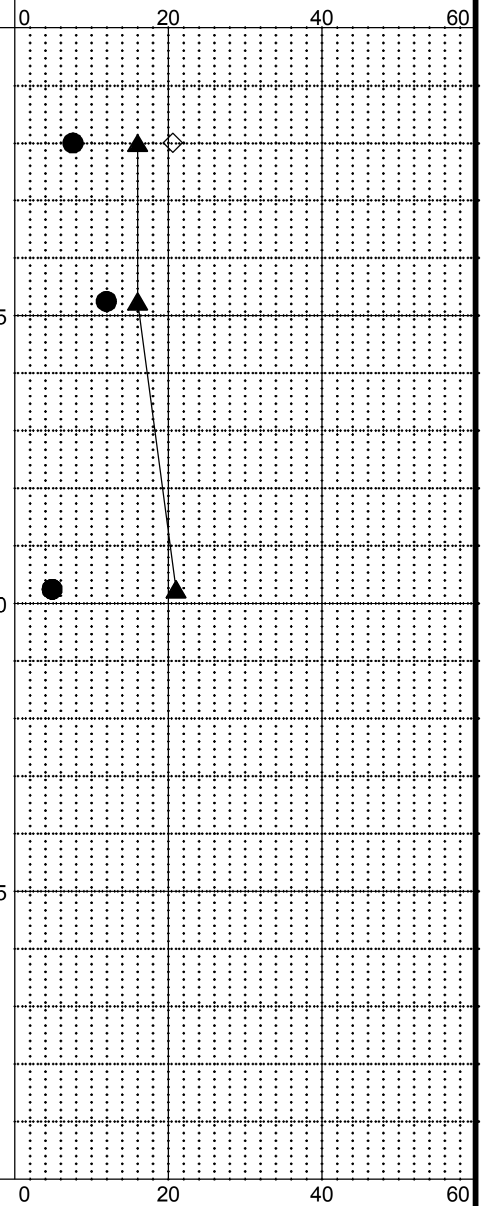
Refer to the report text for a proper understanding of the subsurface materials and drilling methods. The stratification lines indicated below represent the approximate boundaries between material types, and the transition may be gradual.

Soil Description	Depth, ft.	Samples
12.5 inches of Asphalt	1.1	
1 inch of Base Course	1.2	
Medium dense, brown, *Silty Sand (SM)*; moist. [A-2-4]	4.0	S-1
Medium dense, brown to red-yellow, *Poorly Graded Sand with Clay (SP-SC)*; moist. [A-2-6]	8.0	S-2
Medium dense, brown to red-yellow, *Poorly Graded Sand (SP)*; moist; trace gravel, trace silt. [A-1-b]	10.5	S-3

BOTTOM OF BORING
COMPLETED 6/28/2016

Ground Water: Groundwater not encountered during drilling.

PENETRATION RESISTANCE (blows/foot)
▲ Hammer Wt. & Drop: *140 lbs / 30 inches*



LEGEND

* Sample Not Recovered
Modified California Sampler
Standard Penetration Test

NOTES

1. Refer to Figures A-1 and A-2 for explanation of symbols, codes, abbreviations and definitions.
2. The stratification lines represent the approximate boundaries between soil types, and the transition may be gradual.
3. The discussion in the text of this report is necessary for a proper understanding of the nature of the subsurface materials.
4. Groundwater level, if indicated above, is for the date specified and may vary.
5. USCS designation is based on visual-manual classification and selected lab testing.

Highway 105
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LOG OF BORING SW-P-25

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FIG. A-27

REV 3

Total Depth: 5.5 ft.	Latitude:	Drilling Method:	Solid-Stem Auger	Hole Diam.:	4 in.
Top Elevation: ~	Longitude:	Drilling Company:	Entech Engineering, Inc	Rod Type.:	AWJ
Vert. Datum:	Station:	Drill Rig Equipment:	Simco 2800 Truck Mount	Hammer Type:	Automatic
Horiz. Datum:	Offset:	Other Comments:			

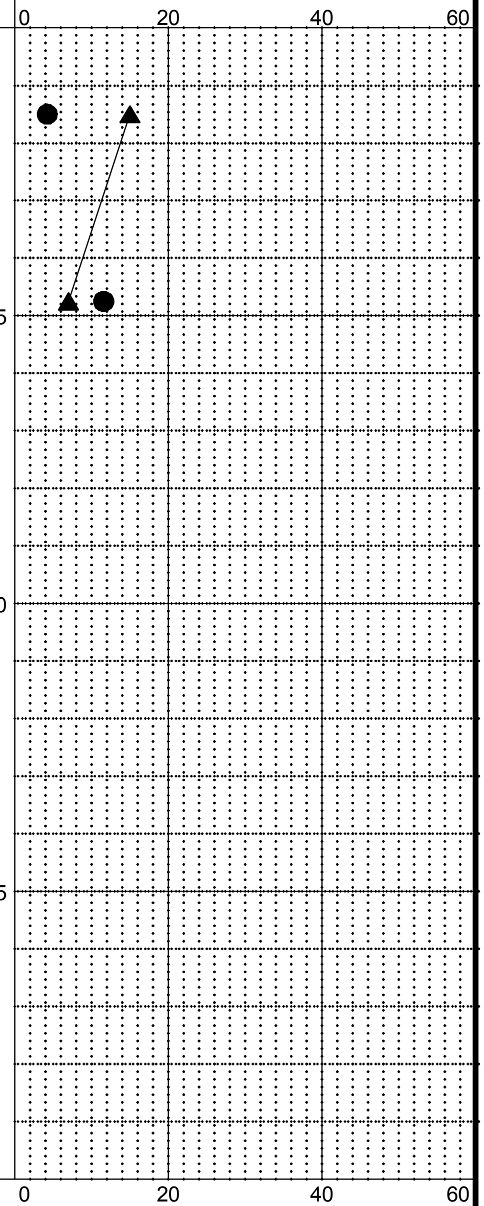
SOIL DESCRIPTION

Refer to the report text for a proper understanding of the subsurface materials and drilling methods. The stratification lines indicated below represent the approximate boundaries between material types, and the transition may be gradual.

Soil Description	Depth, ft.	Samples	Ground Water
10.0 inches of Asphalt	0.8		Groundwater not encountered during drilling.
2 inches of Base Course	1.0		
Medium dense, brown to dark brown, *Silty Sand (SM)*; moist. [A-2-4]	4.0	S-1	
Loose, brown to red-yellow, *Poorly Graded Sand with Silt (SP-SM)*; moist. [A-2-6]	5.5	S-2	
BOTTOM OF BORING COMPLETED 6/28/2016			

PENETRATION RESISTANCE (blows/foot)

▲ Hammer Wt. & Drop: 140 lbs / 30 inches



● % Water Content

LEGEND

* Sample Not Recovered

Modified California Sampler

Standard Penetration Test

NOTES

1. Refer to Figures A-1 and A-2 for explanation of symbols, codes, abbreviations and definitions.
2. The stratification lines represent the approximate boundaries between soil types, and the transition may be gradual.
3. The discussion in the text of this report is necessary for a proper understanding of the nature of the subsurface materials.
4. Groundwater level, if indicated above, is for the date specified and may vary.
5. USCS designation is based on visual-manual classification and selected lab testing.

Highway 105
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El Paso County, Colorado

LOG OF BORING SW-P-26

July 2017 23-1-01311-002

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FIG. A-28

REV 3

MASTER_LOG_E POCKETPEN LAT&LONG 23-1-01311-002.GPJ 7/6/17

Total Depth:	5.5 ft.	Latitude:		Drilling Method:	Solid-Stem Auger
Top Elevation:	~	Longitude:		Drilling Company:	Entech Engineering, Inc
Vert. Datum:		Station:		Drill Rig Equipment:	Simco 2800 Truck Mount
Horiz. Datum:		Offset:		Other Comments:	

Hole Diam.: 4 in.
Rod Type.: AWJ
Hammer Type: Automatic

SOIL DESCRIPTION

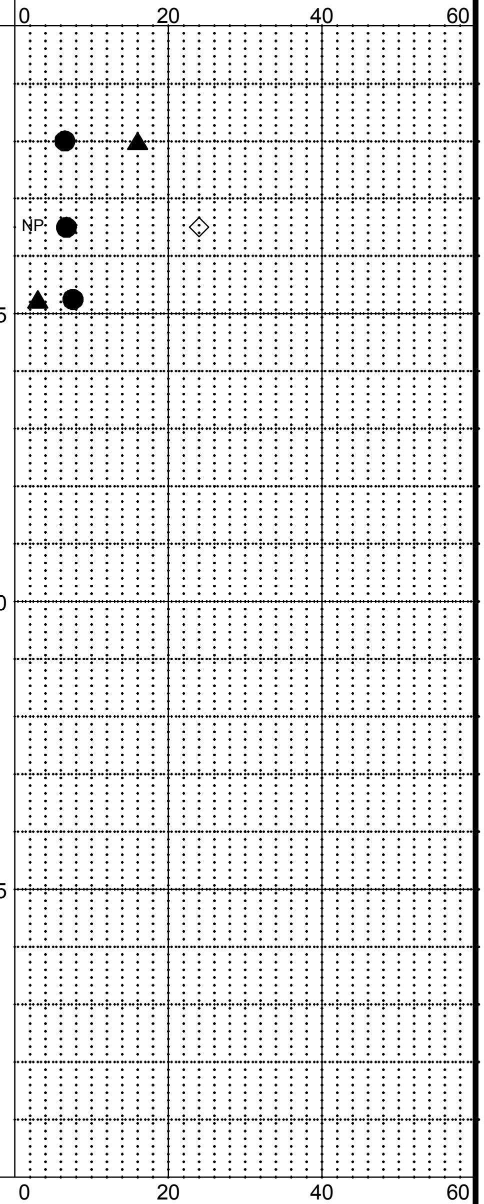
Refer to the report text for a proper understanding of the subsurface materials and drilling methods. The stratification lines indicated below represent the approximate boundaries between material types, and the transition may be gradual.

Soil Description	Depth, ft.	Samples
10.0 inches of Asphalt	0.8	
Medium dense to loose, brown to red-yellow, *Silty Sand (SM)*; moist; few gravel. [A-2-4]	5.5	S-1, Bulk, S-2
BOTTOM OF BORING COMPLETED 6/28/2016		

Ground Water: Groundwater not encountered during drilling.

PENETRATION RESISTANCE (blows/foot)

▲ Hammer Wt. & Drop: 140 lbs / 30 inches



LEGEND

* Sample Not Recovered
Modified California Sampler
Grab Sample
Standard Penetration Test

◇ % Fines (<0.075mm)
● % Water Content
Plastic Limit ├─●─┤ Liquid Limit
Natural Water Content

NOTES

1. Refer to Figures A-1 and A-2 for explanation of symbols, codes, abbreviations and definitions.
2. The stratification lines represent the approximate boundaries between soil types, and the transition may be gradual.
3. The discussion in the text of this report is necessary for a proper understanding of the nature of the subsurface materials.
4. Groundwater level, if indicated above, is for the date specified and may vary.
5. USCS designation is based on visual-manual classification and selected lab testing.

Highway 105
Corridor Improvements
El Paso County, Colorado

LOG OF BORING SW-P-27

July 2017 23-1-01311-002

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Geotechnical and Environmental Consultants

FIG. A-29

REV 3

Total Depth:	*5 ft.*	Latitude:		Drilling Method:	*Solid-Stem Auger*	Hole Diam.:	*4 in.*
Top Elevation:	*~*	Longitude:		Drilling Company:	*Entech Engineering, Inc*	Rod Type.:	*AWJ*
Vert. Datum:		Station:		Drill Rig Equipment:	*Simco 2800 Truck Mount*	Hammer Type:	*Automatic*
Horiz. Datum:		Offset:		Other Comments:			

SOIL DESCRIPTION

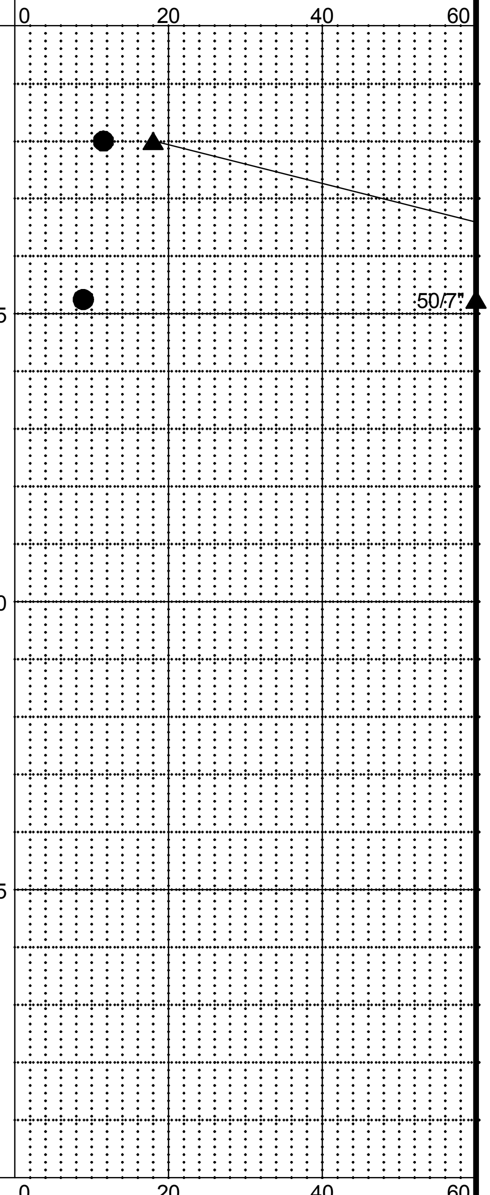
Refer to the report text for a proper understanding of the subsurface materials and drilling methods. The stratification lines indicated below represent the approximate boundaries between material types, and the transition may be gradual.

Soil Description	Depth, ft.	Samples	Ground Water
6.0 inches of Asphalt	0.5		Groundwater not encountered during drilling.
Medium dense, dark brown, *Poorly Graded Sand with Clay (SP-SC)*; moist; trace gravel. [A-2-6] Fill - >>Asphalt debris encountered at a depth of 4.5 feet.	5.0	S-1, S-2	
BOTTOM OF BORING COMPLETED 6/28/2016			

Depth, ft.: 5, 10, 15

PENETRATION RESISTANCE **(blows/foot)**

▲ Hammer Wt. & Drop: *140 lbs / 30 inches*



● % Water Content

LEGEND

* Sample Not Recovered

Modified California Sampler

Standard Penetration Test

NOTES

1. Refer to Figures A-1 and A-2 for explanation of symbols, codes, abbreviations and definitions.
2. The stratification lines represent the approximate boundaries between soil types, and the transition may be gradual.
3. The discussion in the text of this report is necessary for a proper understanding of the nature of the subsurface materials.
4. Groundwater level, if indicated above, is for the date specified and may vary.
5. USCS designation is based on visual-manual classification and selected lab testing.

Highway 105
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FIG. A-30

REV 3

Total Depth:	30.9 ft.	Latitude:		Drilling Method:	Solid-Stem Auger	Hole Diam.:	4 in.
Top Elevation:	~	Longitude:		Drilling Company:	Entech Engineering, Inc	Rod Type.:	AWJ
Vert. Datum:		Station:		Drill Rig Equipment:	Simco 2800 Truck Mount	Hammer Type:	Automatic
Horiz. Datum:		Offset:		Other Comments:			

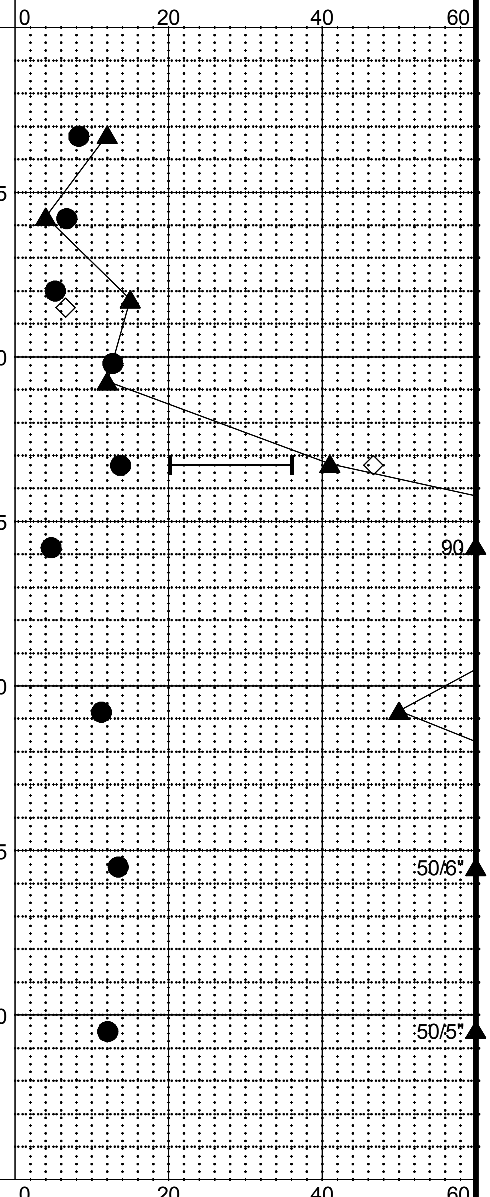
SOIL DESCRIPTION

Refer to the report text for a proper understanding of the subsurface materials and drilling methods. The stratification lines indicated below represent the approximate boundaries between material types, and the transition may be gradual.

Soil Description	Depth, ft.	Samples
6.0 inches of Asphalt	0.5	
Stiff, medium brown, *Lean Clay with Sand (CL)*; moist. Fill	4.5	S-1
Very loose to medium dense, brown to red-brown, *Well-Graded Sand with Silt and Gravel (SW-SM)*; moist. - Trace to few gravel from 7.0 to 9.5 feet.	9.5	S-2, S-3
Medium dense, gray to tan, *Clayey Sand (SC)*; moist. [SANDSTONE: very low strength; weakly cemented; completely weathered (Dawson Formation)].	12.5	S-4
SANDSTONE: very low strength, tan; weakly cemented; medium to thick bedding; highly to moderately weathered (Dawson Formation). [Dense to very dense, *Clayey Sand (SC)*; moist.] - Very low strength claystone at 23.0 to 28.0 feet.	30.9	S-5, S-6, S-7, S-8, S-9
BOTTOM OF BORING COMPLETED 11/9/2016		

Ground Water: Groundwater not encountered during drilling.

PENETRATION RESISTANCE (blows/foot)
▲ Hammer Wt. & Drop: 140 lbs / 30 inches



% Fines (<0.075mm)
% Water Content
Plastic Limit — Liquid Limit
Natural Water Content

LEGEND

* Sample Not Recovered
Standard Penetration Test

NOTES

1. Refer to Figures A-1 and A-2 for explanation of symbols, codes, abbreviations and definitions.
2. The stratification lines represent the approximate boundaries between soil types, and the transition may be gradual.
3. The discussion in the text of this report is necessary for a proper understanding of the nature of the subsurface materials.
4. Groundwater level, if indicated above, is for the date specified and may vary.
5. USCS designation is based on visual-manual classification and selected lab testing.

Highway 105
Corridor Improvements
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LOG OF BORING SW-W-01

July 2017 23-1-01311-002

SHANNON & WILSON, INC.
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FIG. A-31

REV 3

Total Depth:	31 ft.	Latitude:		Drilling Method:	Solid-Stem Auger	Hole Diam.:	4 in.
Top Elevation:	~	Longitude:		Drilling Company:	Entech Engineering, Inc	Rod Type.:	AWJ
Vert. Datum:		Station:		Drill Rig Equipment:	Simco 2800 Truck Mount	Hammer Type:	Automatic
Horiz. Datum:		Offset:		Other Comments:			

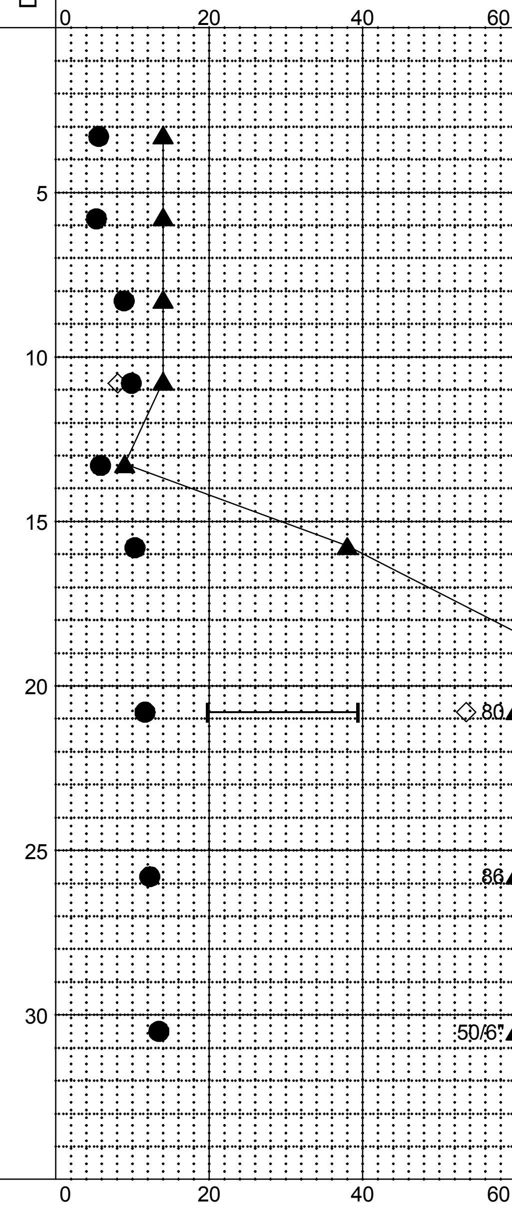
SOIL DESCRIPTION

Refer to the report text for a proper understanding of the subsurface materials and drilling methods. The stratification lines indicated below represent the approximate boundaries between material types, and the transition may be gradual.

SOIL DESCRIPTION	Depth, ft.	Samples	Ground Water
6.0 inches of Asphalt	0.5		
Medium dense, brown, *Poorly Graded Sand with Silt (SP-SM)*; moist; trace to few gravel.	3.0	S-1	
Loose to medium dense, red-brown, *Well-Graded Sand with Clay (SW-SC)*; moist; few gravel.	14.5	S-2, S-3, S-4, S-5	
SANDSTONE: very low strength, tan; weakly cemented; medium to thick bedding; highly to moderately weathered (Dawson Formation). [Dense to very dense, *Clayey Sand (SC)*; moist to wet.] - Very low strength claystone encountered at 20.0 to 23.0 feet [Sandy Lean Clay (CL)].	31.0	S-6, S-7, S-8, S-9	During Drilling ▽ (at 20 ft)
BOTTOM OF BORING COMPLETED 11/9/2016			

PENETRATION RESISTANCE (blows/foot)

▲ Hammer Wt. & Drop: 140 lbs / 30 inches



LEGEND

* Sample Not Recovered

⌶ Standard Penetration Test

▽ Ground Water Level ATD

◇ % Fines (<0.075mm)

● % Water Content

Plastic Limit ├─●─┤ Liquid Limit

Natural Water Content

NOTES

1. Refer to Figures A-1 and A-2 for explanation of symbols, codes, abbreviations and definitions.
2. The stratification lines represent the approximate boundaries between soil types, and the transition may be gradual.
3. The discussion in the text of this report is necessary for a proper understanding of the nature of the subsurface materials.
4. Groundwater level, if indicated above, is for the date specified and may vary.
5. USCS designation is based on visual-manual classification and selected lab testing.

Highway 105
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LOG OF BORING SW-W-02

July 2017 23-1-01311-002

SHANNON & WILSON, INC.
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FIG. A-32

REV 3

Total Depth:	*31.5 ft.*	Latitude:		Drilling Method:	*Solid-Stem Auger*	Hole Diam.:	*4 in.*
Top Elevation:	*~*	Longitude:		Drilling Company:	*Entech Engineering, Inc*	Rod Type.:	*AWJ*
Vert. Datum:		Station:		Drill Rig Equipment:	*Simco 2800 Truck Mount*	Hammer Type:	*Automatic*
Horiz. Datum:		Offset:		Other Comments:			

SOIL DESCRIPTION

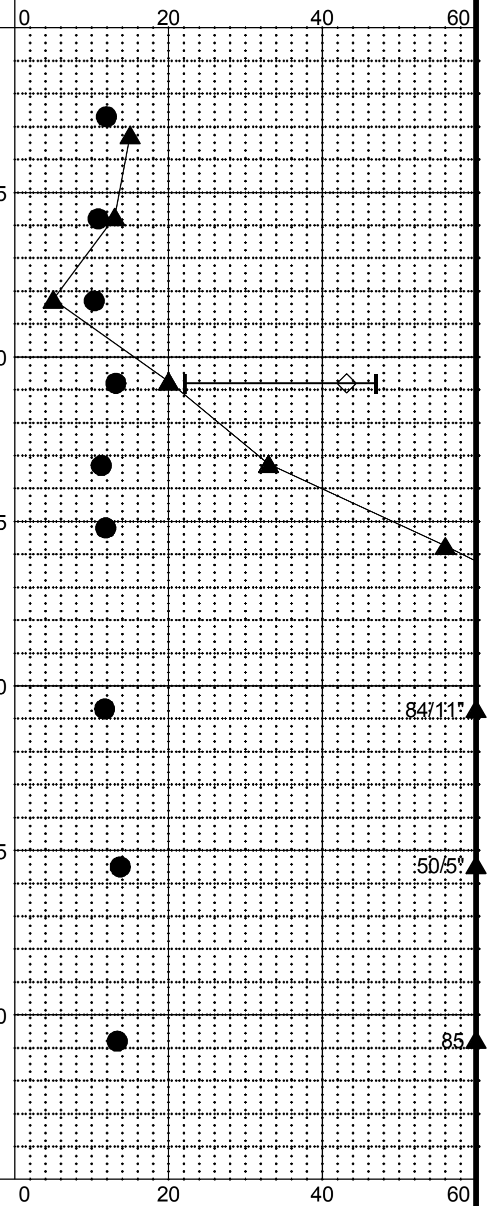
Refer to the report text for a proper understanding of the subsurface materials and drilling methods. The stratification lines indicated below represent the approximate boundaries between material types, and the transition may be gradual.

Soil Description	Depth, ft.	Samples
8.0 inches of Asphalt	0.7	
Loose to medium dense, brown, *Poorly Graded Sand with Silt (SP-SM)* to *Clayey Sand (SC)*; moist. Fill		S-1, S-2, S-3
Medium dense, brown, *Clayey Sand (SC)*; moist. [SANDSTONE: very low strength; weakly cemented; completely weathered (Dawson Formation)].	9.5	S-4
SANDSTONE: very low strength, tan; weakly cemented; medium to thick bedding; highly to moderately weathered (Dawson Formation). [Dense to very dense, *Clayey Sand (SC)*; moist to wet.]	12.5	S-5, S-6, S-7, S-8, S-9
BOTTOM OF BORING COMPLETED 11/9/2016	31.5	

Ground Water: Groundwater not encountered during drilling.

PENETRATION RESISTANCE (blows/foot)

▲ Hammer Wt. & Drop: *140 lbs / 30 inches*



◇ % Fines (<0.075mm)
● % Water Content
Plastic Limit ├─●─┤ Liquid Limit
Natural Water Content

LEGEND

* Sample Not Recovered
⌶ Standard Penetration Test

NOTES

1. Refer to Figures A-1 and A-2 for explanation of symbols, codes, abbreviations and definitions.
2. The stratification lines represent the approximate boundaries between soil types, and the transition may be gradual.
3. The discussion in the text of this report is necessary for a proper understanding of the nature of the subsurface materials.
4. Groundwater level, if indicated above, is for the date specified and may vary.
5. USCS designation is based on visual-manual classification and selected lab testing.

Highway 105
Corridor Improvements
El Paso County, Colorado

LOG OF BORING SW-W-03

July 2017 23-1-01311-002

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. A-33

REV 3

Total Depth:	30.8 ft.	Latitude:		Drilling Method:	Solid-Stem Auger	Hole Diam.:	4 in.
Top Elevation:	~	Longitude:		Drilling Company:	Entech Engineering, Inc	Rod Type.:	AWJ
Vert. Datum:		Station:		Drill Rig Equipment:	Simco 2800 Truck Mount	Hammer Type:	Automatic
Horiz. Datum:		Offset:		Other Comments:			

SOIL DESCRIPTION

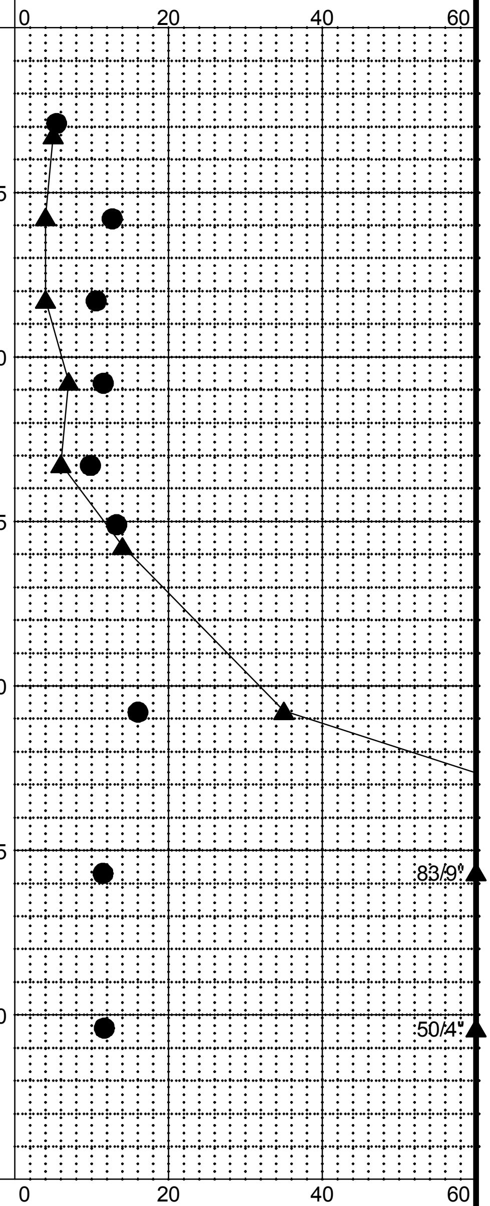
Refer to the report text for a proper understanding of the subsurface materials and drilling methods. The stratification lines indicated below represent the approximate boundaries between material types, and the transition may be gradual.

Soil Description	Depth, ft.	Samples
24.0 inches of Asphalt	2.0	
Loose, red-brown, *Poorly Graded Sand with Silt (SP-SM)*; moist. Fill	4.5	S-1
Very loose to loose, tan to brown, *Clayey Sand (SC)*; moist. Fill	14.5	S-2, S-3, S-4, S-5
Medium dense, tan, *Clayey Sand (SC)*; moist. [SANDSTONE: very low strength; weakly cemented; completely weathered (Dawson Formation)].	18.0	S-6
SANDSTONE: very low strength, tan; weakly cemented; medium to thick bedding; highly to moderately weathered (Dawson Formation). [Dense to very dense, *Clayey Sand (SC)*; moist to wet.]	30.8	S-7, S-8, S-9
BOTTOM OF BORING COMPLETED 11/9/2016		

Ground Water: Groundwater not encountered during drilling.

PENETRATION RESISTANCE (blows/foot)

▲ Hammer Wt. & Drop: 140 lbs / 30 inches



● % Water Content

LEGEND

* Sample Not Recovered

Standard Penetration Test

NOTES

1. Refer to Figures A-1 and A-2 for explanation of symbols, codes, abbreviations and definitions.
2. The stratification lines represent the approximate boundaries between soil types, and the transition may be gradual.
3. The discussion in the text of this report is necessary for a proper understanding of the nature of the subsurface materials.
4. Groundwater level, if indicated above, is for the date specified and may vary.
5. USCS designation is based on visual-manual classification and selected lab testing.

Highway 105
Corridor Improvements
El Paso County, Colorado

LOG OF BORING SW-W-04

July 2017 23-1-01311-002

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. A-34

REV 3

MASTER_LOG_E_POCKETPEN_LAT&LONG 23-1-01311-002.GPJ 7/6/17

Total Depth:	*25.9 ft.*	Latitude:		Drilling Method:	*Solid-Stem Auger*	Hole Diam.:	*4 in.*
Top Elevation:	*~*	Longitude:		Drilling Company:	*Entech Engineering, Inc*	Rod Type.:	*AWJ*
Vert. Datum:		Station:		Drill Rig Equipment:	*Simco 2800 Truck Mount*	Hammer Type:	*Automatic*
Horiz. Datum:		Offset:		Other Comments:			

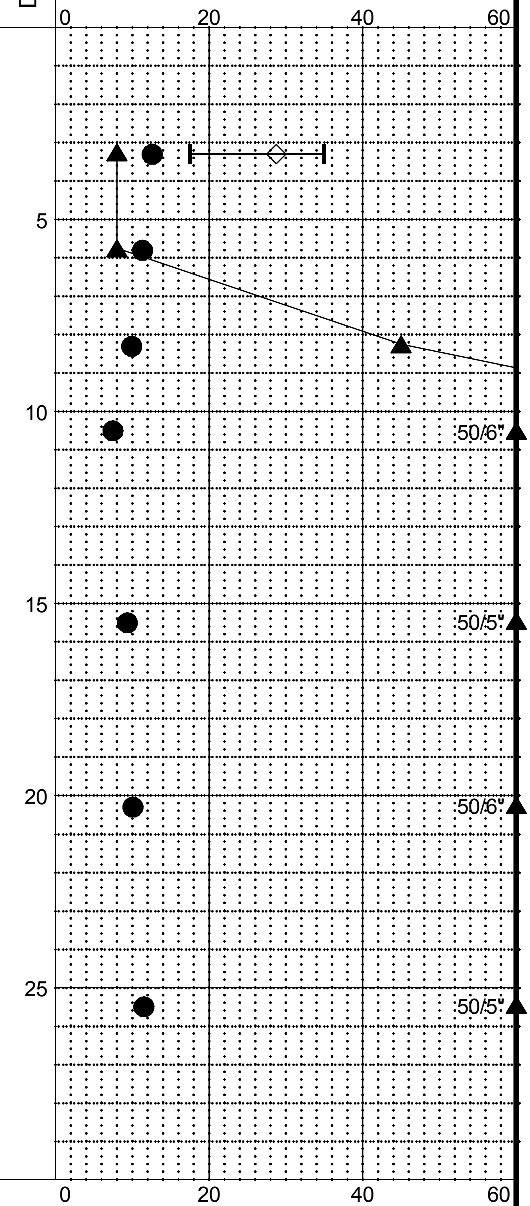
SOIL DESCRIPTION

Refer to the report text for a proper understanding of the subsurface materials and drilling methods. The stratification lines indicated below represent the approximate boundaries between material types, and the transition may be gradual.

Soil Description	Depth, ft.	Samples	Ground Water
Loose, brown to red-brown, *Clayey Sand (SC)*; moist.		S-1, S-2	
SANDSTONE: very low strength, tan; weakly cemented; medium to thick bedding; highly to moderately weathered (Dawson Formation). [Dense to very dense, *Clayey Sand (SC)* to *Poorly Graded Sand with Clay (SP-SC)*; moist to wet.]	7.0	S-3, S-4, S-5, S-6, S-7	Groundwater not encountered during drilling.
BOTTOM OF BORING COMPLETED 11/11/2016	25.9		

PENETRATION RESISTANCE (blows/foot)

▲ Hammer Wt. & Drop: *140 lbs / 30 inches*



◇ % Fines (<0.075mm)
● % Water Content
Plastic Limit ├─●─┤ Liquid Limit
Natural Water Content

LEGEND

* Sample Not Recovered
Ⅰ Standard Penetration Test

NOTES

1. Refer to Figures A-1 and A-2 for explanation of symbols, codes, abbreviations and definitions.
2. The stratification lines represent the approximate boundaries between soil types, and the transition may be gradual.
3. The discussion in the text of this report is necessary for a proper understanding of the nature of the subsurface materials.
4. Groundwater level, if indicated above, is for the date specified and may vary.
5. USCS designation is based on visual-manual classification and selected lab testing.

Highway 105
Corridor Improvements
El Paso County, Colorado

LOG OF BORING SW-W-05

July 2017 23-1-01311-002

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. A-35

REV 3

MASTER_LOG_E_POCKETPEN_LAT&LONG 23-1-01311-002.GPJ 7/6/17

SHANNON & WILSON, INC.
GEOTECHNICAL AND ENVIRONMENTAL CONSULTANTS

LOG OF TEST PIT TP-06

JOB NO: 23-1-01311-002   EXCAVATION DATE: 11-15-2016

PROJECT: Highway 105 Corridor Improvements

Sketch of East Pit Side   Approximate Road Elevation(ft): 7153   Sta. ~152+40

SOIL DESCRIPTION

(1) SANDSTONE: very low strength, tan; weakly cemented; thin to medium bedding; highly to moderately weathered (Dawson Formation). [Dense, *Poorly Graded Sand with Silt (SP-SM)* to *Well-Graded Sand with Silt (SW-SM)*; moist.]

(2) CLAYSTONE: low strength, red; moderately weathered; iron oxide stains (Dawson Formation).
[Hard, *Fat Clay (CH)* to *Fat Clay with Sand (CH)*; moist.]

(3) SANDSTONE: low strength, red to red-brown; moderately cemented; thin to medium bedding; moderately weathered; iron oxide stains (Dawson Formation).
[Very dense, *Well-Graded Sand with Clay and Gravel (SW-SC)* to *Clayey Sand (SC)*; moist.]

Ground Water	% Water Content	Samples
Groundwater Not Encountered	2.7	S-1
	17.6	S-2
	7.2	S-3

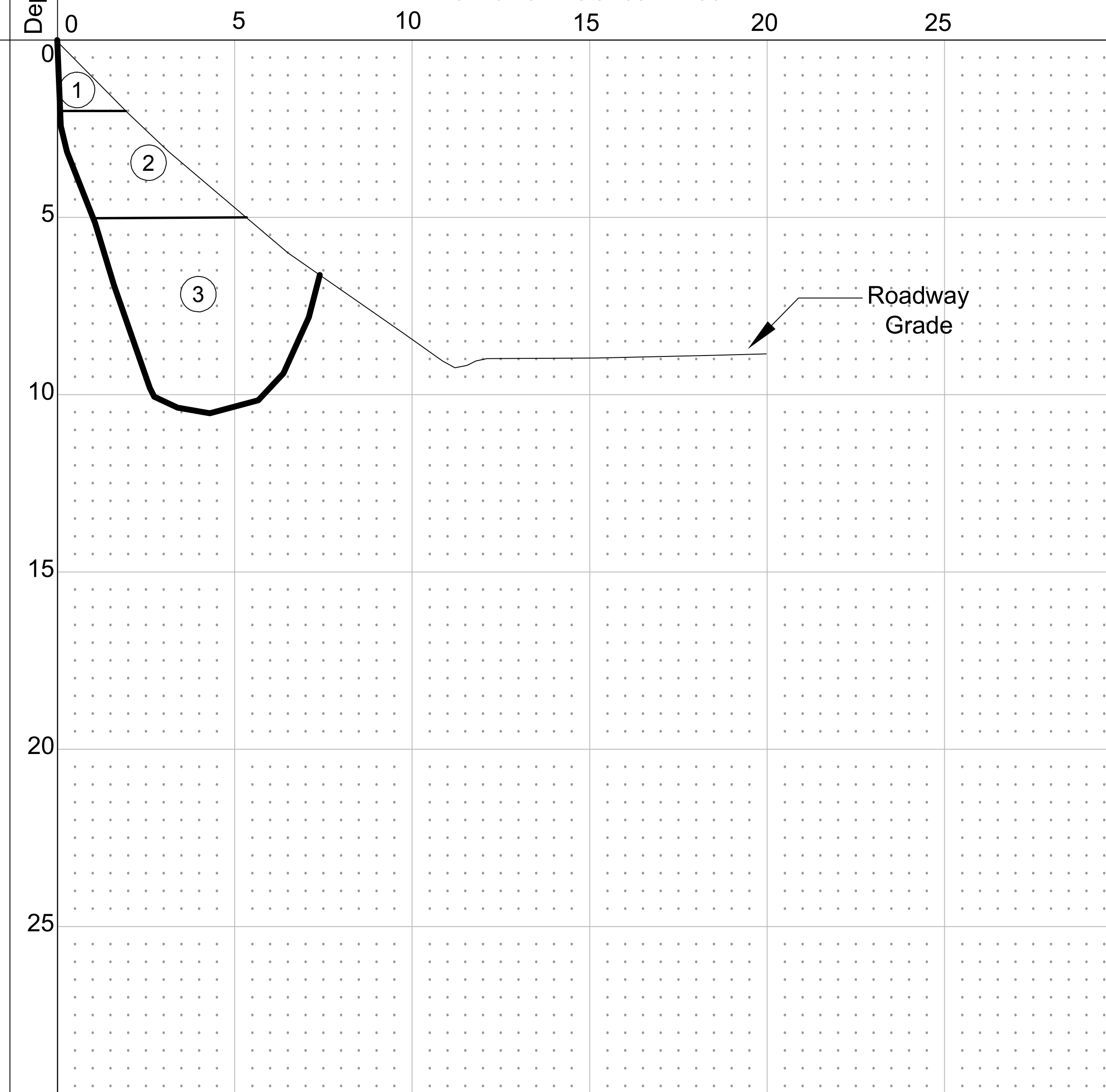


FIG. A-36

SHANNON & WILSON, INC.
GEOTECHNICAL AND ENVIRONMENTAL CONSULTANTS

LOG OF TEST PIT TP-07

JOB NO: 23-1-01311-002 EXCAVATION DATE: 11-15-2016

PROJECT: Highway 105 Corridor Improvements

Sketch of East Pit Side Approximate Road Elevation(ft): 7168 Sta. ~154+00

SOIL DESCRIPTION	Ground Water	% Water Content	Samples	Depth, Ft.
(1) SANDSTONE: very low strength, brown to tan; weakly cemented; thin to medium bedding; moderately weathered; medium spaced claystone layers (Dawson Formation). [Medium dense to very dense, *Poorly Graded Sand with Clay (SP-SC)* to *Clayey Sand (SC)*; moist; trace gravel.]	Groundwater Not Encountered	4.4	S-1	
		12.7	S-2	

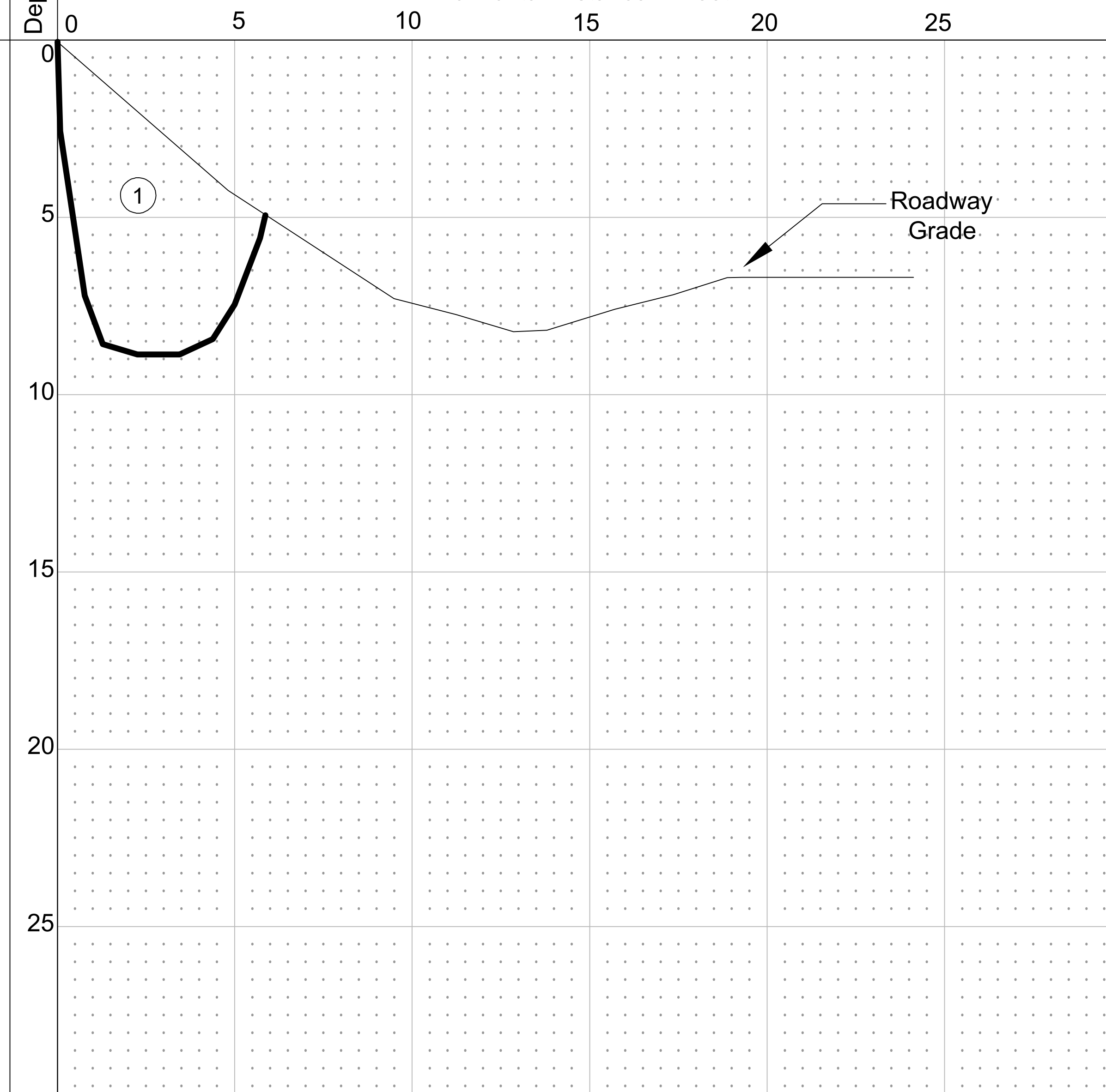


FIG. A-37

SHANNON & WILSON, INC.
GEOTECHNICAL AND ENVIRONMENTAL CONSULTANTS

LOG OF TEST PIT TP-08

JOB NO: 23-1-01311-002   EXCAVATION DATE: 11-15-2016

PROJECT: Highway 105 Corridor Improvements

Sketch of West Pit Side   Approximate Roadway Elevation(ft): 7,171   Sta. ~154+40

SOIL DESCRIPTION

1. Medium stiff, brown, *Lean Clay (CL)*; moist.
2. Medium dense, brown to red-brown, *Well-Graded Sand with Silt (SW-SM)*; moist.
3. SANDSTONE: very low strength, tan; weakly cemented; thin to medium bedding; highly to moderately weathered (Dawson Formation). [Dense to very dense, *Clayey Sand (SC)*; moist.]

Ground Water	% Water Content	Samples
Groundwater Not Encountered	4.0	S-1
	1.9	S-2
	10.1	S-3
	11.5	S-4

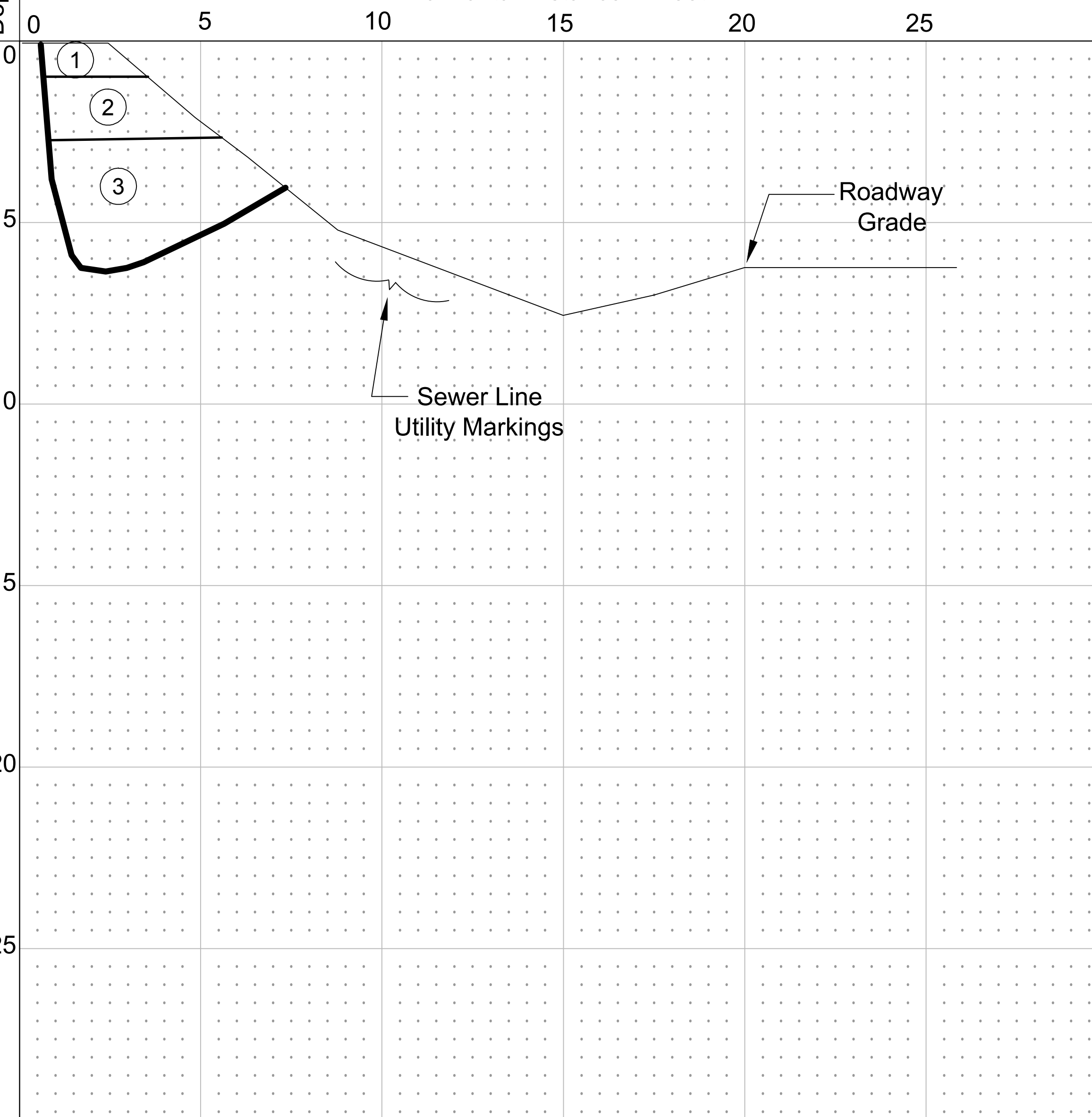


FIG. A-38

Total Depth:	20.9 ft.	Latitude:		Drilling Method:	Solid-Stem Auger	Hole Diam.: 4 in.
Top Elevation:	~	Longitude:		Drilling Company:	Entech Engineering, Inc	Rod Type.: AWJ
Vert. Datum:		Station:		Drill Rig Equipment:	Simco 2800 Truck Mount	Hammer Type: Automatic
Horiz. Datum:		Offset:		Other Comments:		

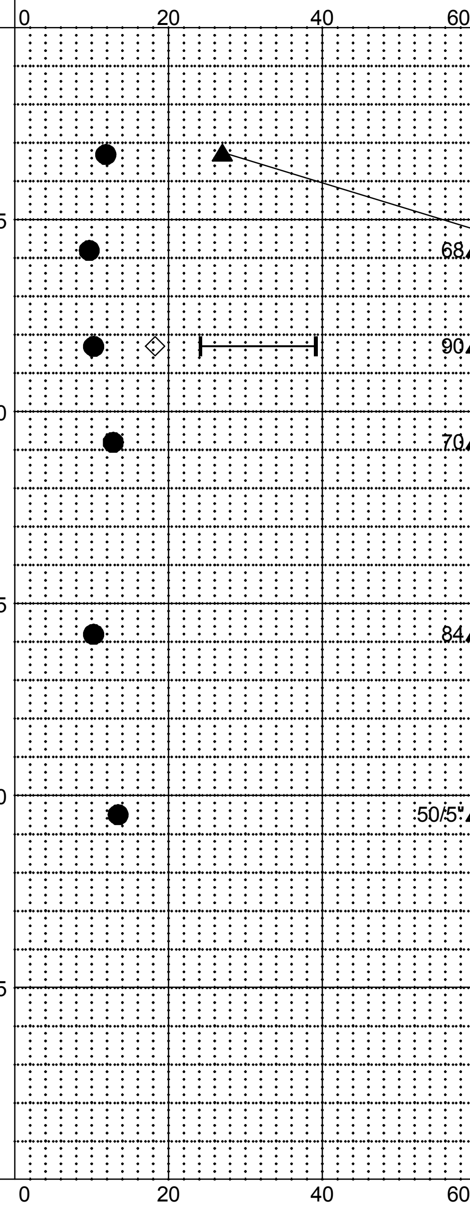
SOIL DESCRIPTION

Refer to the report text for a proper understanding of the subsurface materials and drilling methods. The stratification lines indicated below represent the approximate boundaries between material types, and the transition may be gradual.

Soil Description	Depth, ft.	Samples	Ground Water
9.0 inches of Asphalt	0.8		
3 inches of Base Course	1.0		
Medium dense, brown to tan, *Clayey Sand (SC)*; moist.	4.5	S-1	
SANDSTONE: very low strength, tan; weakly cemented; thick bedding; highly to moderately weathered (Dawson Formation). [Very dense, *Poorly Graded Sand with Clay (SP-SC)* to *Clayey Sand (SC)*; moist to wet; trace to few gravel.]	20.9	S-2, S-3, S-4, S-5, S-6	During Drilling ▽
BOTTOM OF BORING COMPLETED 11/11/2016			

PENETRATION RESISTANCE (blows/foot)

▲ Hammer Wt. & Drop: 140 lbs / 30 inches



◇ % Fines (<0.075mm)
● % Water Content
Plastic Limit ├─●─┤ Liquid Limit
Natural Water Content

LEGEND

* Sample Not Recovered
Ɪ Standard Penetration Test
▽ Ground Water Level ATD

NOTES

1. Refer to Figures A-1 and A-2 for explanation of symbols, codes, abbreviations and definitions.
2. The stratification lines represent the approximate boundaries between soil types, and the transition may be gradual.
3. The discussion in the text of this report is necessary for a proper understanding of the nature of the subsurface materials.
4. Groundwater level, if indicated above, is for the date specified and may vary.
5. USCS designation is based on visual-manual classification and selected lab testing.

Highway 105
Corridor Improvements
El Paso County, Colorado

LOG OF BORING SW-W-09

July 2017 23-1-01311-002

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. A-39

REV 3

MASTER_LOG_E_POCKETPEN LAT&LONG 23-1-01311-002.GPJ 7/6/17

Total Depth:	20.9 ft.	Latitude:		Drilling Method:	Solid-Stem Auger	Hole Diam.:	4 in.
Top Elevation:	~	Longitude:		Drilling Company:	Entech Engineering, Inc	Rod Type.:	AWJ
Vert. Datum:		Station:		Drill Rig Equipment:	Simco 2800 Truck Mount	Hammer Type:	Automatic
Horiz. Datum:		Offset:		Other Comments:			

SOIL DESCRIPTION

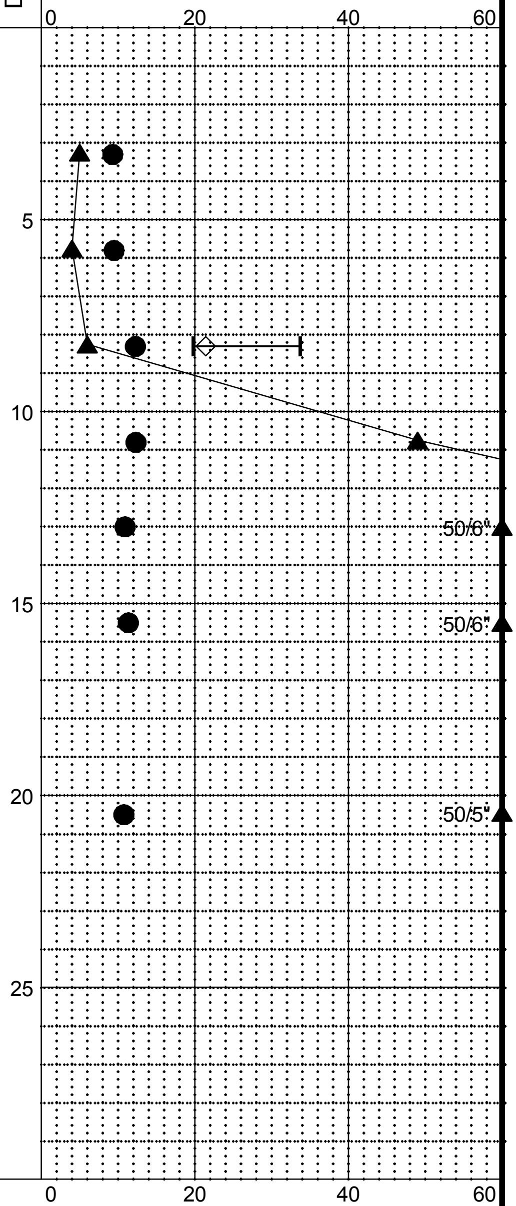
Refer to the report text for a proper understanding of the subsurface materials and drilling methods. The stratification lines indicated below represent the approximate boundaries between material types, and the transition may be gradual.

Soil Description	Depth, ft.	Samples
Loose, brown, *Clayey Sand (SC)*; moist.		S-1
Loose, brown, *Poorly Graded Sand with Silt (SP-SM)*; moist.	4.5	S-2
Loose, brown, *Clayey Sand (SC)*; moist; few gravel.	7.0	S-3
SANDSTONE: very low strength, tan; weakly cemented; thick bedding; highly to moderately weathered (Dawson Formation). [Dense to very dense, *Clayey Sand (SC)*; moist to wet.]	9.5	S-4, S-5, S-6, S-7
BOTTOM OF BORING COMPLETED 11/11/2016	20.9	

Ground Water: Groundwater not encountered during drilling.

PENETRATION RESISTANCE (blows/foot)

▲ Hammer Wt. & Drop: 140 lbs / 30 inches



◇ % Fines (<0.075mm)
● % Water Content
Plastic Limit ├─●─┤ Liquid Limit
Natural Water Content

LEGEND

* Sample Not Recovered
⌶ Standard Penetration Test

NOTES

1. Refer to Figures A-1 and A-2 for explanation of symbols, codes, abbreviations and definitions.
2. The stratification lines represent the approximate boundaries between soil types, and the transition may be gradual.
3. The discussion in the text of this report is necessary for a proper understanding of the nature of the subsurface materials.
4. Groundwater level, if indicated above, is for the date specified and may vary.
5. USCS designation is based on visual-manual classification and selected lab testing.

Highway 105
Corridor Improvements
El Paso County, Colorado

LOG OF BORING SW-W-10

July 2017 23-1-01311-002

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. A-40

REV 3

MASTER_LOG_E_POCKETPEN_LAT&LONG 23-1-01311-002.GPJ 7/6/17

Total Depth:	20.8 ft.	Latitude:		Drilling Method:	Solid-Stem Auger	Hole Diam.:	4 in.
Top Elevation:	~	Longitude:		Drilling Company:	Entech Engineering, Inc	Rod Type.:	AWJ
Vert. Datum:		Station:		Drill Rig Equipment:	Simco 2800 Truck Mount	Hammer Type:	Automatic
Horiz. Datum:		Offset:		Other Comments:			

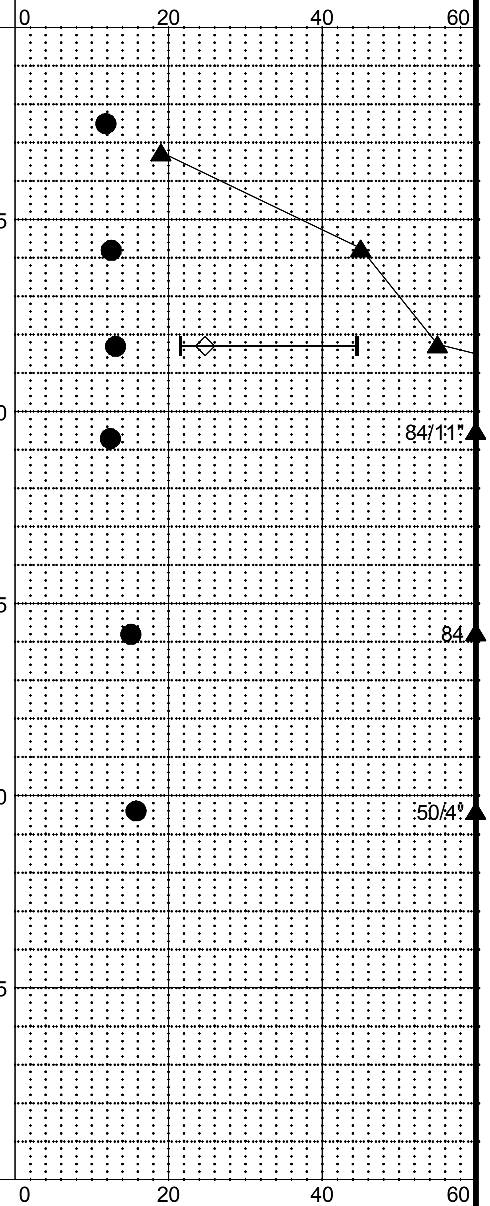
SOIL DESCRIPTION

Refer to the report text for a proper understanding of the subsurface materials and drilling methods. The stratification lines indicated below represent the approximate boundaries between material types, and the transition may be gradual.

Soil Description	Depth, ft.	Samples
Medium dense, brown, *Poorly Graded Sand with Silt (SP-SM)*; moist. Fill		S-1
SANDSTONE: very low strength, tan; weakly cemented; thick bedding; highly to moderately weathered (Dawson Formation). [Dense to very dense, *Clayey Sand (SC)*; moist to wet; trace gravel.] - Iron oxides stains from 13 to 20.8 feet.	4.5	S-2, S-3, S-4, S-5, S-6
BOTTOM OF BORING COMPLETED 11/11/2016	20.8	

Ground Water: Groundwater not encountered during drilling.

PENETRATION RESISTANCE (blows/foot)
▲ Hammer Wt. & Drop: 140 lbs / 30 inches



◇ % Fines (<0.075mm)
● % Water Content
Plastic Limit ├─●─┤ Liquid Limit
Natural Water Content

LEGEND

* Sample Not Recovered
Ι Standard Penetration Test

NOTES

1. Refer to Figures A-1 and A-2 for explanation of symbols, codes, abbreviations and definitions.
2. The stratification lines represent the approximate boundaries between soil types, and the transition may be gradual.
3. The discussion in the text of this report is necessary for a proper understanding of the nature of the subsurface materials.
4. Groundwater level, if indicated above, is for the date specified and may vary.
5. USCS designation is based on visual-manual classification and selected lab testing.

Highway 105
Corridor Improvements
El Paso County, Colorado

LOG OF BORING SW-W-11

July 2017 23-1-01311-002

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. A-41

REV 3

MASTER_LOG_E_POCKETPEN_LAT&LONG 23-1-01311-002.GPJ 7/6/17

Total Depth:	21.5 ft.	Latitude:		Drilling Method:	Solid-Stem Auger	Hole Diam.:	4 in.
Top Elevation:	~	Longitude:		Drilling Company:	Entech Engineering, Inc	Rod Type.:	AWJ
Vert. Datum:		Station:		Drill Rig Equipment:	Simco 2800 Truck Mount	Hammer Type:	Automatic
Horiz. Datum:		Offset:		Other Comments:			

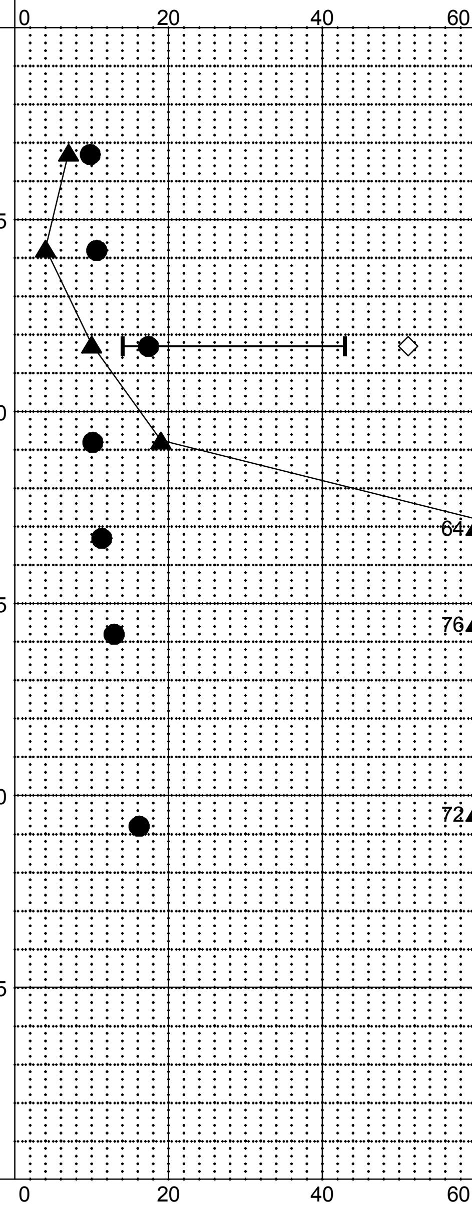
SOIL DESCRIPTION

Refer to the report text for a proper understanding of the subsurface materials and drilling methods. The stratification lines indicated below represent the approximate boundaries between material types, and the transition may be gradual.

SOIL DESCRIPTION	Depth, ft.	Samples	Ground Water
Loose, brown to red-brown, *Clayey Sand (SC)*; moist. Fill		S-1	
Soft to medium stiff, brown, *Sandy Lean Clay (CL)* to *Lean Clay with Sand (CL)*; moist.	4.5	S-2	
Stiff, brown, *Sandy Lean Clay (CL)*; moist.	7.0	S-3	
Medium dense, red-brown to tan, *Clayey Sand (SC)*; moist.	9.0	S-4	
SANDSTONE: very low strength, tan; weakly cemented; thick bedding; highly to moderately weathered (Dawson Formation). [Very dense, *Poorly Graded Sand with Clay (SP-SC)* to *Clayey Sand (SC)*; moist.]	12.0	S-5, S-6	During Drilling ⊻
CLAYSTONE: very low strength, brown; massive; moderately weathered; iron oxide stains (Dawson Formation). [Hard, *Fat Clay (CH)* to *Fat Clay with Sand (CH)*; moist.]	18.0	S-7	
BOTTOM OF BORING COMPLETED 11/11/2016	21.5		

PENETRATION RESISTANCE (blows/foot)

▲ Hammer Wt. & Drop: 140 lbs / 30 inches



◇ % Fines (<0.075mm)
● % Water Content
Plastic Limit |—●—| Liquid Limit
Natural Water Content

LEGEND

* Sample Not Recovered
⌶ Standard Penetration Test
⊻ Ground Water Level ATD

NOTES

1. Refer to Figures A-1 and A-2 for explanation of symbols, codes, abbreviations and definitions.
2. The stratification lines represent the approximate boundaries between soil types, and the transition may be gradual.
3. The discussion in the text of this report is necessary for a proper understanding of the nature of the subsurface materials.
4. Groundwater level, if indicated above, is for the date specified and may vary.
5. USCS designation is based on visual-manual classification and selected lab testing.

Highway 105
Corridor Improvements
El Paso County, Colorado

LOG OF BORING SW-W-12

July 2017 23-1-01311-002

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. A-42

REV 3

Total Depth:	21.4 ft.	Drilling Method:	Solid-Stem Auger	Hole Diam.:	4 in.
Top Elevation:	~	Drilling Company:	Entech Engineering, Inc	Rod Type.:	AWJ
Vert. Datum:		Drill Rig Equipment:	Simco 2800 Truck Mount	Hammer Type:	Automatic
Horiz. Datum:		Other Comments:			
Latitude:		Longitude:		Station:	
Offset:					

SOIL DESCRIPTION

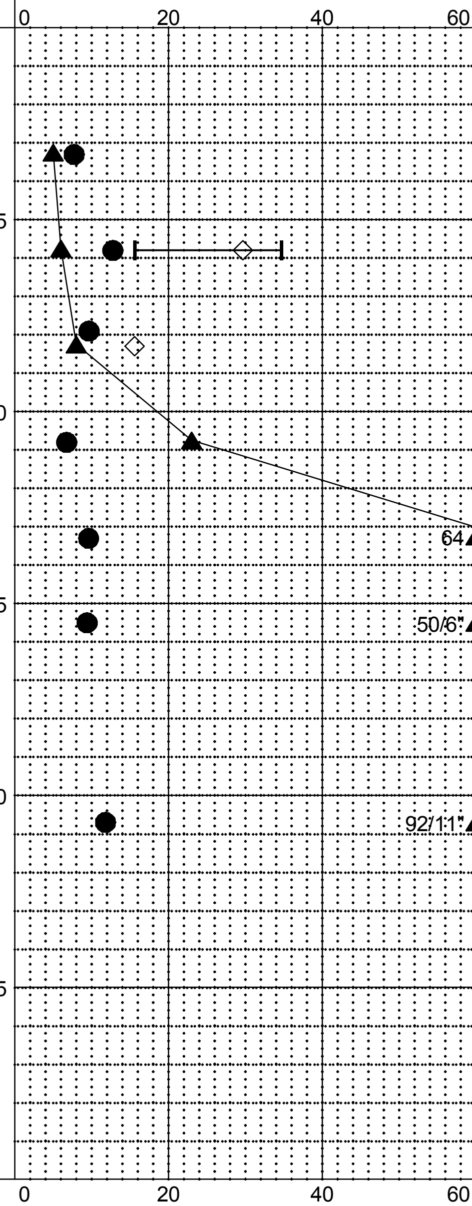
Refer to the report text for a proper understanding of the subsurface materials and drilling methods. The stratification lines indicated below represent the approximate boundaries between material types, and the transition may be gradual.

Soil Description	Depth, ft.	Samples
Loose, brown to red-brown, *Poorly Graded Sand with Silt (SP-SM)*; moist. Fill		S-1
Loose, brown, *Clayey Sand (SC)*; moist; few gravel.	4.5	S-2
Loose to medium dense, red-brown, *Clayey Sand (SC)*; moist; trace to few gravel.	7.0	S-3, S-4
SANDSTONE: very low strength, tan; weakly cemented; thick bedding; highly to moderately weathered (Dawson Formation). [Very dense, *Poorly Graded Sand with Clay (SP-SC)* to *Clayey Sand (SC)*; moist.]	11.2	S-5, S-6, S-7
BOTTOM OF BORING COMPLETED 11/11/2016	21.4	

Ground Water: Groundwater not encountered during drilling.

PENETRATION RESISTANCE (blows/foot)

▲ Hammer Wt. & Drop: 140 lbs / 30 inches



◇ % Fines (<0.075mm)
● % Water Content
Plastic Limit ├─●─┤ Liquid Limit
Natural Water Content

LEGEND

* Sample Not Recovered
⌶ Standard Penetration Test

NOTES

1. Refer to Figures A-1 and A-2 for explanation of symbols, codes, abbreviations and definitions.
2. The stratification lines represent the approximate boundaries between soil types, and the transition may be gradual.
3. The discussion in the text of this report is necessary for a proper understanding of the nature of the subsurface materials.
4. Groundwater level, if indicated above, is for the date specified and may vary.
5. USCS designation is based on visual-manual classification and selected lab testing.

Highway 105
Corridor Improvements
El Paso County, Colorado

LOG OF BORING SW-W-13

July 2017 23-1-01311-002

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. A-43

REV 3

SHANNON & WILSON, INC.
GEOTECHNICAL AND ENVIRONMENTAL CONSULTANTS

LOG OF TEST PIT TP-14

JOB NO: 23-1-01311-002 EXCAVATION DATE: 11-15-2016

PROJECT: Highway 105 Corridor Improvements

Sketch of West Pit Side Approximate Roadway Elevation(ft): 7200 Sta. ~163+00

SOIL DESCRIPTION	Ground Water	% Water Content	Samples	Depth, Ft.
(1) SANDSTONE: very low strength, brown to red-brown; weakly cemented; thin to medium bedding; highly weathered (Dawson Formation). [Dense, *Poorly Graded Sand with Silt (SP-SM)* to *Well-Graded Sand with Silt (SW-SM)*; moist.]	Groundwater Not Encountered	3.0	S-1	
		11.4	S-2	
(2) CLAYSTONE: very low strength, brown to tan; massive; moderately weathered (Dawson Formation). [Hard, *Sandy Fat Clay (CH)* to *Fat Clay (CH)*; moist.]		9.0	S-3	

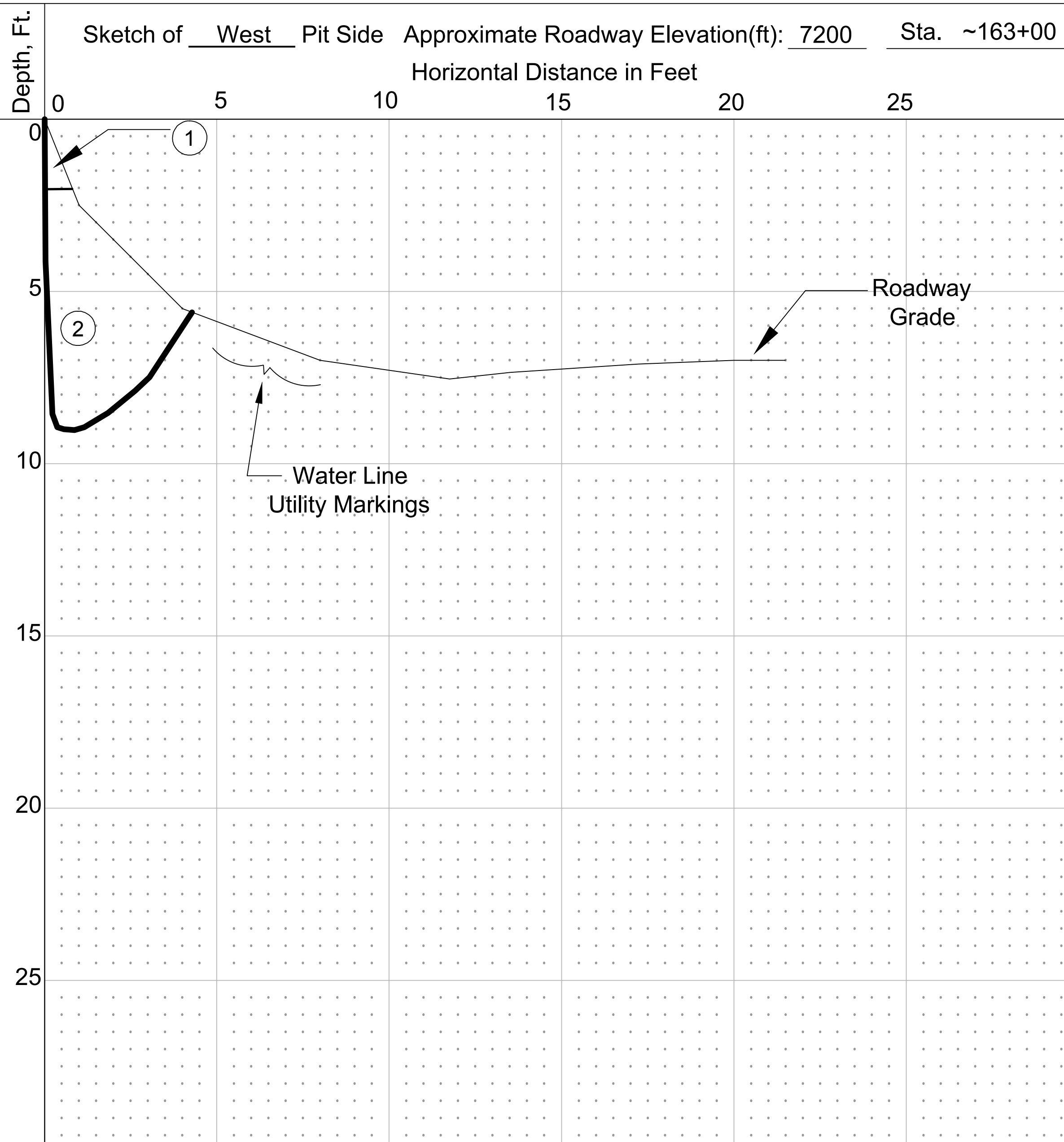


FIG. A-44

Total Depth:	*15.9 ft.*	Latitude:		Drilling Method:	*Solid-Stem Auger*	Hole Diam.:	*4 in.*
Top Elevation:	*~*	Longitude:		Drilling Company:	*Entech Engineering, Inc*	Rod Type.:	*AWJ*
Vert. Datum:		Station:		Drill Rig Equipment:	*Simco 2800 Truck Mount*	Hammer Type:	*Automatic*
Horiz. Datum:		Offset:		Other Comments:			

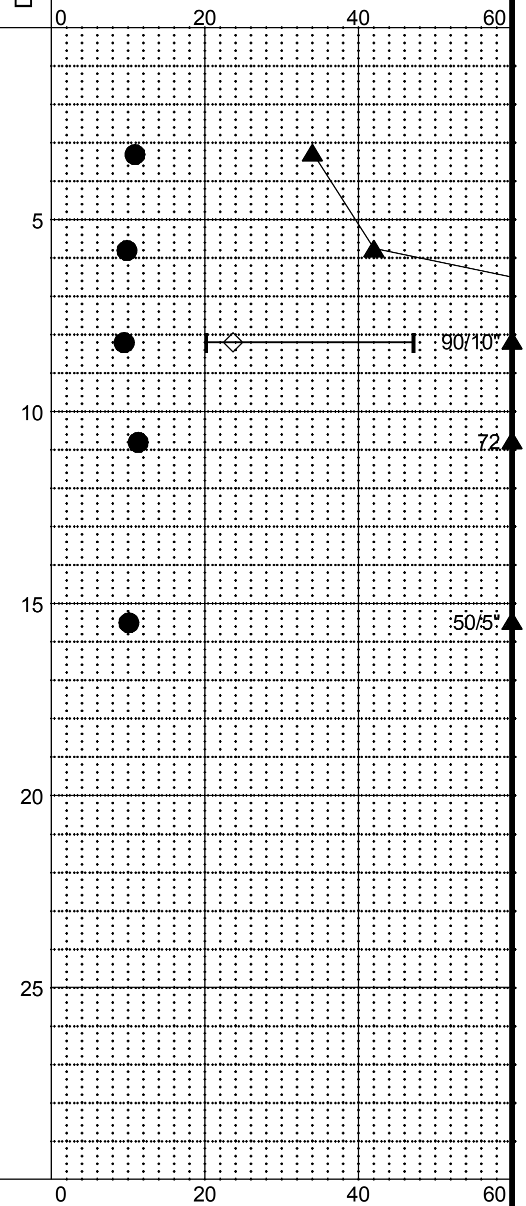
SOIL DESCRIPTION

Refer to the report text for a proper understanding of the subsurface materials and drilling methods. The stratification lines indicated below represent the approximate boundaries between material types, and the transition may be gradual.

Soil Description	Depth, ft.	Samples	Ground Water
8.0 inches of Asphalt	0.7		Groundwater not encountered during drilling.
4 inches of Base Course	1.0		
SANDSTONE: very low strength, tan to brown; weakly cemented; medium to thick bedding; highly to moderately weathered (Dawson Formation). [Very dense, *Clayey Sand (SC)*; moist; trace to few gravel.]		S-1, S-2, S-3, S-4, S-5	
BOTTOM OF BORING COMPLETED 11/17/2016	15.9		

PENETRATION RESISTANCE **(blows/foot)**

▲ Hammer Wt. & Drop: *140 lbs / 30 inches*



LEGEND

* Sample Not Recovered

⌶ Standard Penetration Test

◇ % Fines (<0.075mm)

● % Water Content

Plastic Limit ├─●─┤ Liquid Limit

Natural Water Content

NOTES

1. Refer to Figures A-1 and A-2 for explanation of symbols, codes, abbreviations and definitions.
2. The stratification lines represent the approximate boundaries between soil types, and the transition may be gradual.
3. The discussion in the text of this report is necessary for a proper understanding of the nature of the subsurface materials.
4. Groundwater level, if indicated above, is for the date specified and may vary.
5. USCS designation is based on visual-manual classification and selected lab testing.

Highway 105
Corridor Improvements
El Paso County, Colorado

LOG OF BORING SW-W-15

July 2017 23-1-01311-002

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. A-45

REV 3

MASTER_LOG_E_POCKETPEN_LAT&LONG 23-1-01311-002.GPJ 7/6/17

Total Depth:	11.5 ft.	Latitude:		Drilling Method:	Solid-Stem Auger	Hole Diam.:	4 in.
Top Elevation:	~	Longitude:		Drilling Company:	Entech Engineering, Inc	Rod Type.:	AWJ
Vert. Datum:		Station:		Drill Rig Equipment:	Simco 2800 Truck Mount	Hammer Type:	Automatic
Horiz. Datum:		Offset:		Other Comments:			

SOIL DESCRIPTION

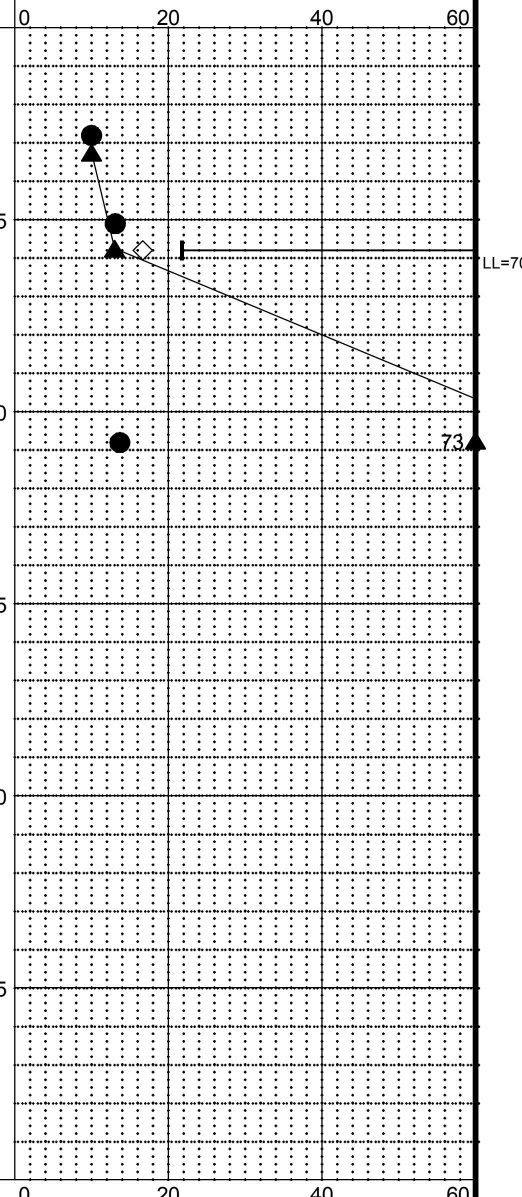
Refer to the report text for a proper understanding of the subsurface materials and drilling methods. The stratification lines indicated below represent the approximate boundaries between material types, and the transition may be gradual.

SOIL DESCRIPTION	Depth, ft.	Samples
9.0 inches of Asphalt	0.8	
5 inches of Base Course	1.2	
Loose to medium dense, brown to tan, *Clayey Sand (SC)*; moist; trace to few gravel.		S-1, S-2
SANDSTONE: very low strength, tan to brown; weakly cemented; medium to thick bedding; highly to moderately weathered (Dawson Formation). [Very dense, *Clayey Sand (SC)*; moist; trace to few gravel.]	6.5	S-3
BOTTOM OF BORING COMPLETED 11/17/2016	11.5	

Ground Water: Groundwater not encountered during drilling.

PENETRATION RESISTANCE (blows/foot)

▲ Hammer Wt. & Drop: 140 lbs / 30 inches



LEGEND

* Sample Not Recovered

Standard Penetration Test

◇ % Fines (<0.075mm)

● % Water Content

Plastic Limit ├─●─┤ Liquid Limit

Natural Water Content

NOTES

1. Refer to Figures A-1 and A-2 for explanation of symbols, codes, abbreviations and definitions.
2. The stratification lines represent the approximate boundaries between soil types, and the transition may be gradual.
3. The discussion in the text of this report is necessary for a proper understanding of the nature of the subsurface materials.
4. Groundwater level, if indicated above, is for the date specified and may vary.
5. USCS designation is based on visual-manual classification and selected lab testing.

Highway 105
Corridor Improvements
El Paso County, Colorado

LOG OF BORING SW-W-16

July 2017 23-1-01311-002

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. A-46

REV 3

MASTER_LOG_E_POCKETPEN_LAT&LONG 23-1-01311-002.GPJ 7/6/17

SHANNON & WILSON, INC.
GEOTECHNICAL AND ENVIRONMENTAL CONSULTANTS

LOG OF TEST PIT TP-17

JOB NO: 23-1-01311-002 EXCAVATION DATE: 11-15-2016

PROJECT: Highway 105 Corridor Improvements

SOIL DESCRIPTION	Ground Water	% Water Content	Samples	Depth, Ft.
(1) SANDSTONE: very low strength, tan; weakly cemented; thin bedding; highly to moderately weathered (Dawson Formation). [Medium dense to dense, *Poorly Graded Sand with Silt (SP-SM))*; moist.]	Groundwater Not Encountered	3.3	S-1	

Sketch of West Pit Side Approximate Roadway Elevation(ft): 7231 Sta. ~169+60

Horizontal Distance in Feet

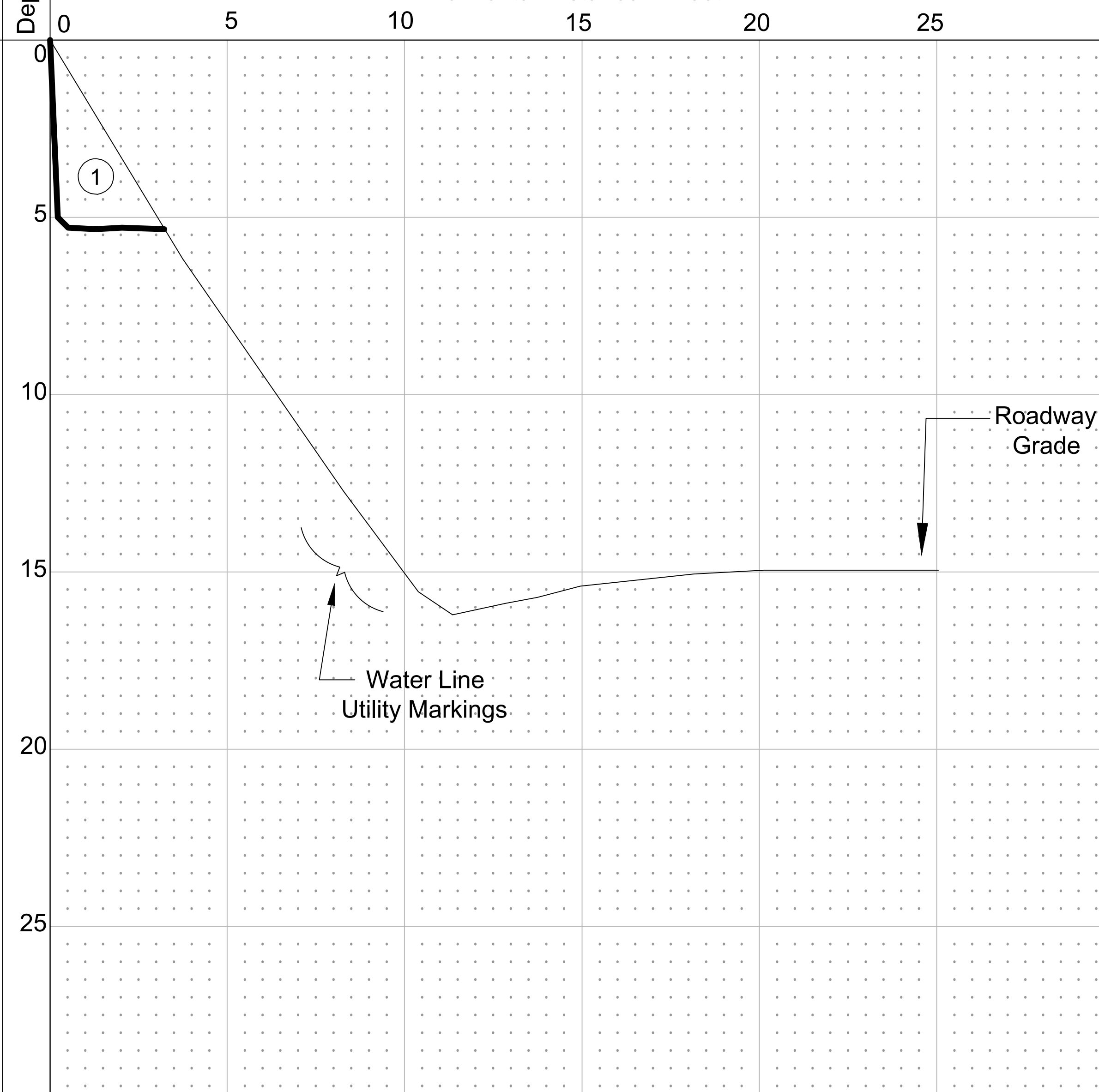


FIG. A-47

Total Depth: 10.9 ft.	Latitude:	Drilling Method:	Solid-Stem Auger	Hole Diam.:	4 in.
Top Elevation: ~	Longitude:	Drilling Company:	Entech Engineering, Inc	Rod Type.:	AWJ
Vert. Datum:	Station:	Drill Rig Equipment:	Simco 2800 Truck Mount	Hammer Type:	Automatic
Horiz. Datum:	Offset:	Other Comments:			

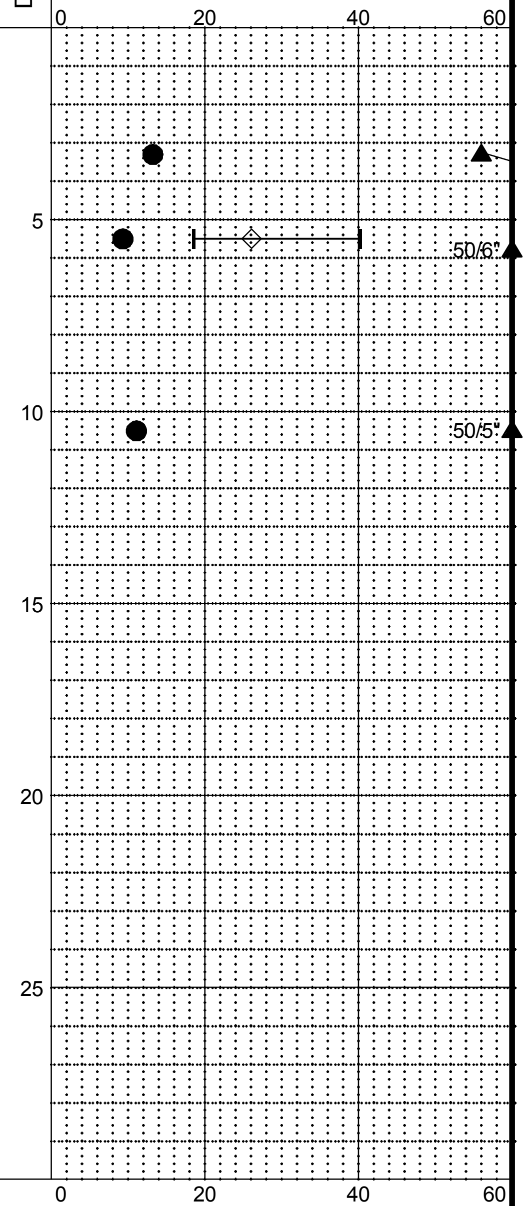
SOIL DESCRIPTION

Refer to the report text for a proper understanding of the subsurface materials and drilling methods. The stratification lines indicated below represent the approximate boundaries between material types, and the transition may be gradual.

Soil Description	Depth, ft.	Samples	Ground Water
8.0 inches of Asphalt	0.7		
4 inches of Base Course	1.0		
SANDSTONE: very low strength, tan to brown; weakly cemented; medium to thick bedding; highly to moderately weathered (Dawson Formation). [Very dense, *Clayey Sand (SC)*; moist; trace to few gravel.]	10.9	S-1, S-2, S-3	Groundwater not encountered during drilling.
BOTTOM OF BORING COMPLETED 11/17/2016			

PENETRATION RESISTANCE (blows/foot)

▲ Hammer Wt. & Drop: 140 lbs / 30 inches



◇ % Fines (<0.075mm)
● % Water Content
Plastic Limit |—●—| Liquid Limit
Natural Water Content

LEGEND

* Sample Not Recovered
⌶ Standard Penetration Test

NOTES

1. Refer to Figures A-1 and A-2 for explanation of symbols, codes, abbreviations and definitions.
2. The stratification lines represent the approximate boundaries between soil types, and the transition may be gradual.
3. The discussion in the text of this report is necessary for a proper understanding of the nature of the subsurface materials.
4. Groundwater level, if indicated above, is for the date specified and may vary.
5. USCS designation is based on visual-manual classification and selected lab testing.

Highway 105
Corridor Improvements
El Paso County, Colorado

LOG OF BORING SW-W-18

July 2017 23-1-01311-002

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. A-48

REV 3

MASTER_LOG_E_POCKETPEN_LAT&LONG 23-1-01311-002.GPJ 7/6/17

File: I:\EF\23-1 DEN\01300s\01311 SH105 Improvements\002 - Full Corridor Design\Expl\23-1-01311-002 Test Pits.dwg   Date: 01-09-2017   Author: jcg

SHANNON & WILSON, INC.
GEOTECHNICAL AND ENVIRONMENTAL CONSULTANTS

LOG OF TEST PIT TP-19

JOB NO: 23-1-01311-002   EXCAVATION DATE: 11-15-2016

PROJECT: Highway 105 Corridor Improvements

Sketch of East Pit Side   Approximate Roadway Elevation(ft): 7209   Sta. ~164+00

SOIL DESCRIPTION	Ground Water	% Water Content	Samples
(1) Loose to medium dense, brown, *Poorly Graded Sand with Silt (SP-SM)*; moist.	Groundwater Not Encountered	2.1	S-1
(2) SANDSTONE: very low strength, brown to red-brown; weakly cemented; thin bedding; highly to moderately weathered (Dawson Formation). [Medium dense to dense, *Poorly Graded Sand with Silt (SP-SM))*; moist.]		4.4	S-2

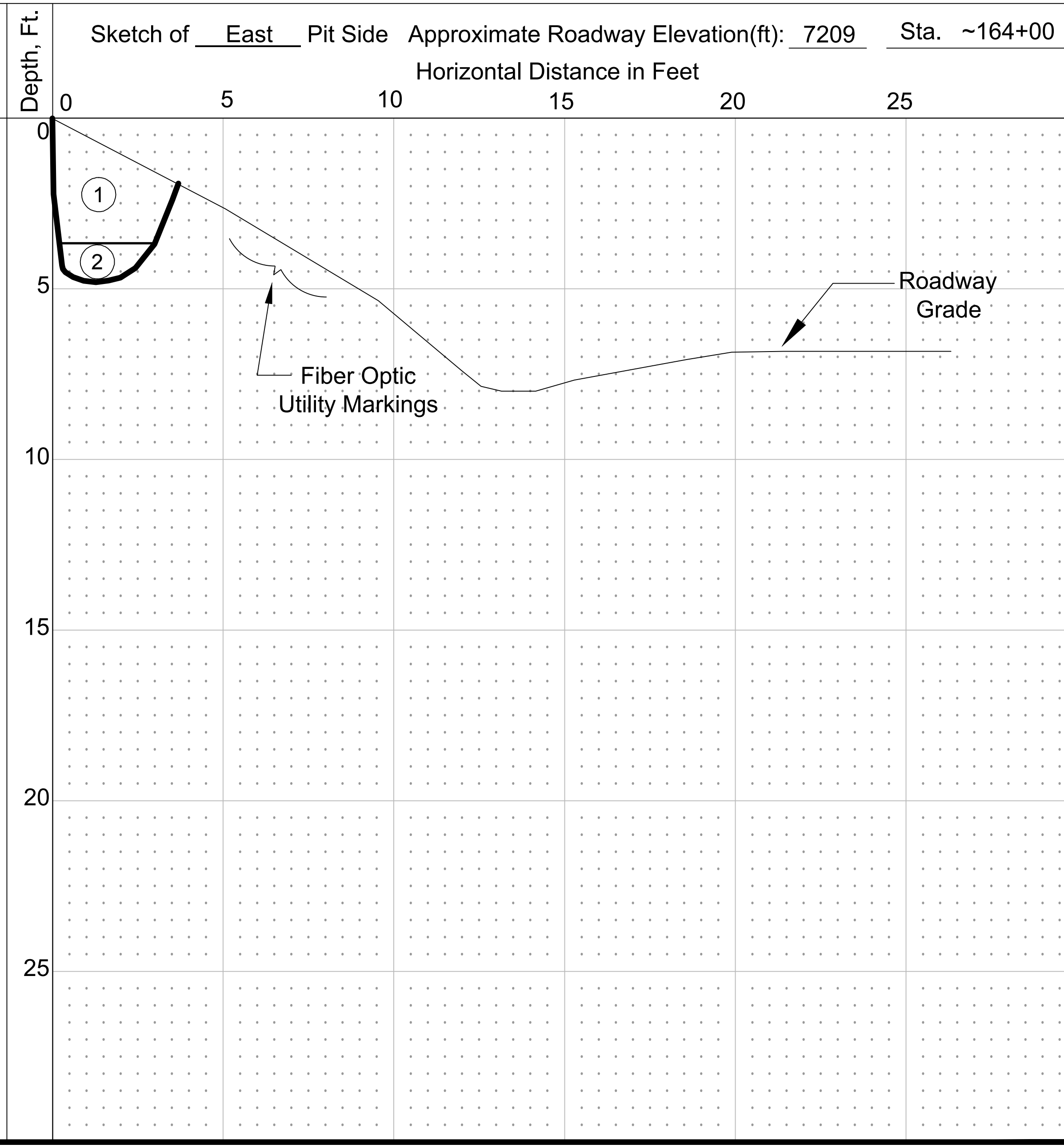


FIG. A-49

Total Depth:	20.8 ft.	Latitude:		Drilling Method:	Solid-Stem Auger	Hole Diam.:	4 in.
Top Elevation:	~	Longitude:		Drilling Company:	Entech Engineering, Inc	Rod Type.:	AWJ
Vert. Datum:		Station:		Drill Rig Equipment:	Simco 2800 Truck Mount	Hammer Type:	Automatic
Horiz. Datum:		Offset:		Other Comments:			

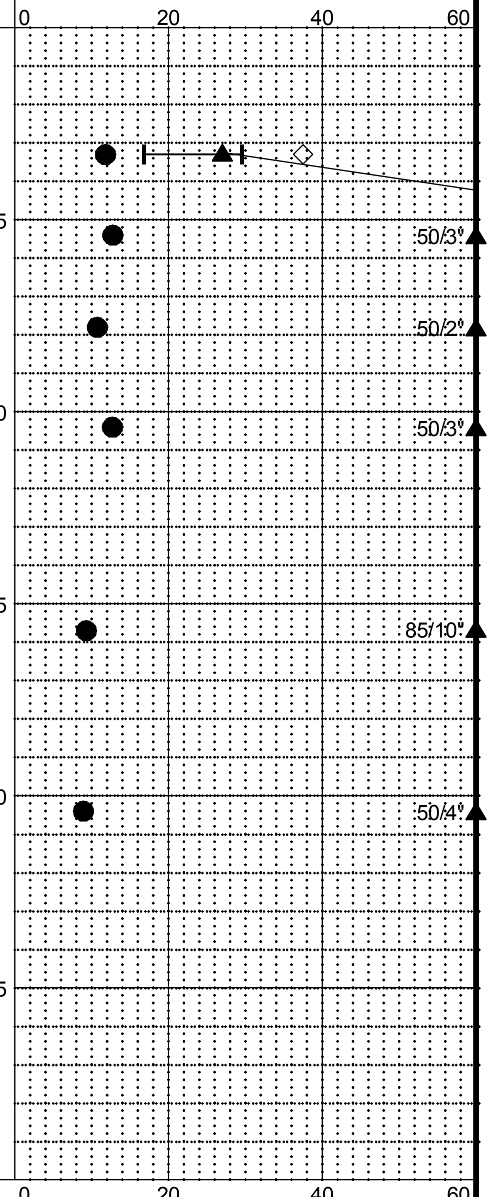
SOIL DESCRIPTION

Refer to the report text for a proper understanding of the subsurface materials and drilling methods. The stratification lines indicated below represent the approximate boundaries between material types, and the transition may be gradual.

Soil Description	Depth, ft.	Samples
9.0 inches of Asphalt	0.8	
Brown, *Poorly Graded Sand with Silt (SP-SM)*; moist; trace gravel. Fill	2.5	
Medium dense, tan, *Clayey Sand (SC)*; moist; trace gravel.	3.5	S-1
SANDSTONE: very low strength, tan to brown; weakly cemented; medium to thick bedding; highly to moderately weathered (Dawson Formation). [Very dense, *Clayey Sand (SC)* to *Poorly Graded Sand with Clay (SP-SC)*; moist.] - Iron oxide stains from 16.0 to 20.8 feet.	20.8	S-2, S-3, S-4, S-5, S-6
BOTTOM OF BORING COMPLETED 11/17/2016		

Ground Water: Groundwater not encountered during drilling.

PENETRATION RESISTANCE (blows/foot)
▲ Hammer Wt. & Drop: 140 lbs / 30 inches



◇ % Fines (<0.075mm)
● % Water Content
Plastic Limit ├─●─┤ Liquid Limit
Natural Water Content

LEGEND

* Sample Not Recovered
⌶ Standard Penetration Test

NOTES

1. Refer to Figures A-1 and A-2 for explanation of symbols, codes, abbreviations and definitions.
2. The stratification lines represent the approximate boundaries between soil types, and the transition may be gradual.
3. The discussion in the text of this report is necessary for a proper understanding of the nature of the subsurface materials.
4. Groundwater level, if indicated above, is for the date specified and may vary.
5. USCS designation is based on visual-manual classification and selected lab testing.

Highway 105
Corridor Improvements
El Paso County, Colorado

LOG OF BORING SW-W-20

July 2017 — 23-1-01311-002

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. A-50

REV 3

MASTER_LOG_E_POCKETPEN_LAT&LONG 23-1-01311-002.GPJ 7/6/17

Total Depth:	*10.3 ft.*	Latitude:		Drilling Method:	*Solid-Stem Auger*
Top Elevation:	*~*	Longitude:		Drilling Company:	*Entech Engineering, Inc*
Vert. Datum:		Station:		Drill Rig Equipment:	*Simco 2800 Truck Mount*
Horiz. Datum:		Offset:		Other Comments:	

Hole Diam.:	*4 in.*
Rod Type.:	*AWJ*
Hammer Type:	*Automatic*

SOIL DESCRIPTION

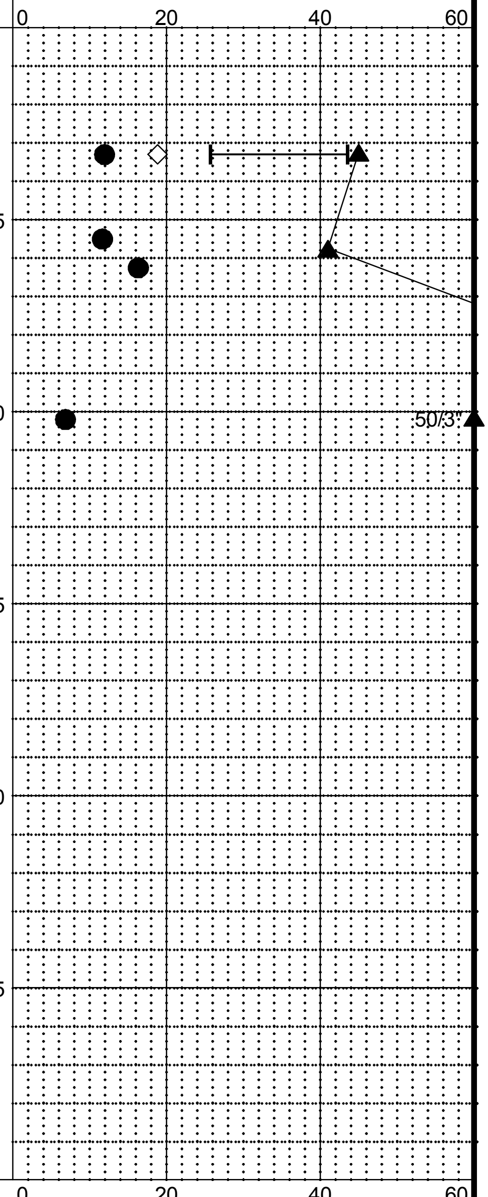
Refer to the report text for a proper understanding of the subsurface materials and drilling methods. The stratification lines indicated below represent the approximate boundaries between material types, and the transition may be gradual.

Soil Description	Depth, ft.	Samples
7.0 inches of Asphalt	0.6	
4 inches of Base Course	0.9	
SANDSTONE: very low strength, tan to brown; weakly cemented; medium to thick bedding; highly to moderately weathered (Dawson Formation). [Dense, *Clayey Sand (SC)*; moist; trace gravel.]	6.0	S-1, S-2
CLAYSTONE: very low strength, brown; massive; moderately weathered (Dawson Formation). [Hard, *Fat Clay (CH)*; moist; trace sand.]	8.0	
SANDSTONE: very low strength, tan; weakly to moderately cemented; medium bedding; moderately weathered (Dawson Formation). [Very dense, *Poorly Graded Sand with Silt (SP-SM)*; moist.]	10.3	S-3

BOTTOM OF BORING
COMPLETED 11/17/2016

Ground Water: Groundwater not encountered during drilling.

PENETRATION RESISTANCE (blows/foot)
▲ Hammer Wt. & Drop: *140 lbs / 30 inches*



LEGEND
* Sample Not Recovered
Standard Penetration Test

◇ % Fines (<0.075mm)
● % Water Content
Plastic Limit ├─●─┤ Liquid Limit
Natural Water Content

NOTES

1. Refer to Figures A-1 and A-2 for explanation of symbols, codes, abbreviations and definitions.
2. The stratification lines represent the approximate boundaries between soil types, and the transition may be gradual.
3. The discussion in the text of this report is necessary for a proper understanding of the nature of the subsurface materials.
4. Groundwater level, if indicated above, is for the date specified and may vary.
5. USCS designation is based on visual-manual classification and selected lab testing.

Highway 105
Corridor Improvements
El Paso County, Colorado

LOG OF BORING SW-W-21

July 2017 23-1-01311-002

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. A-51

REV 3

MASTER_LOG_E_POCKETPEN_LAT&LONG 23-1-01311-002.GPJ 7/6/17

Total Depth:	*11.4 ft.*	Latitude:		Drilling Method:	*Solid-Stem Auger*	Hole Diam.:	*4 in.*
Top Elevation:	*~*	Longitude:		Drilling Company:	*Entech Engineering, Inc*	Rod Type.:	*AWJ*
Vert. Datum:		Station:		Drill Rig Equipment:	*Simco 2800 Truck Mount*	Hammer Type:	*Automatic*
Horiz. Datum:		Offset:		Other Comments:			

SOIL DESCRIPTION

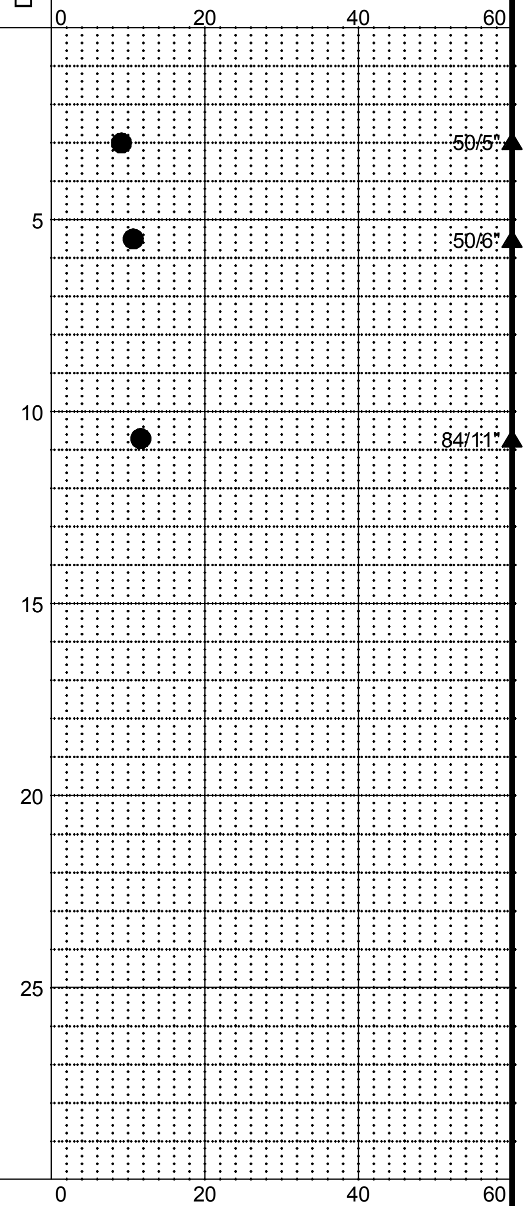
Refer to the report text for a proper understanding of the subsurface materials and drilling methods. The stratification lines indicated below represent the approximate boundaries between material types, and the transition may be gradual.

Soil Description	Depth, ft.	Samples
9.0 inches of Asphalt	0.8	
5 inches of Base Course	1.2	
SANDSTONE: very low strength, tan to brown; weakly cemented; medium to thick bedding; moderately weathered (Dawson Formation). [Very dense, *Clayey Sand (SC)*; moist.]		S-1, S-2
- Red-brown and iron oxides stains from 10.5 to 11.5 feet.	11.4	S-3
BOTTOM OF BORING COMPLETED 11/17/2016		

Ground Water: Groundwater not encountered during drilling.

PENETRATION RESISTANCE **(blows/foot)**

▲ Hammer Wt. & Drop: *140 lbs / 30 inches*



● % Water Content

LEGEND

* Sample Not Recovered

⌶ Standard Penetration Test

NOTES

1. Refer to Figures A-1 and A-2 for explanation of symbols, codes, abbreviations and definitions.
2. The stratification lines represent the approximate boundaries between soil types, and the transition may be gradual.
3. The discussion in the text of this report is necessary for a proper understanding of the nature of the subsurface materials.
4. Groundwater level, if indicated above, is for the date specified and may vary.
5. USCS designation is based on visual-manual classification and selected lab testing.

Highway 105
Corridor Improvements
El Paso County, Colorado

LOG OF BORING SW-W-22

July 2017 23-1-01311-002

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. A-52

REV 3

Total Depth:	*11.5 ft.*	Latitude:		Drilling Method:	*Solid-Stem Auger*
Top Elevation:	*~*	Longitude:		Drilling Company:	*Entech Engineering, Inc*
Vert. Datum:		Station:		Drill Rig Equipment:	*Simco 2800 Truck Mount*
Horiz. Datum:		Offset:		Other Comments:	

Hole Diam.:	*4 in.*
Rod Type.:	*AWJ*
Hammer Type:	*Automatic*

SOIL DESCRIPTION

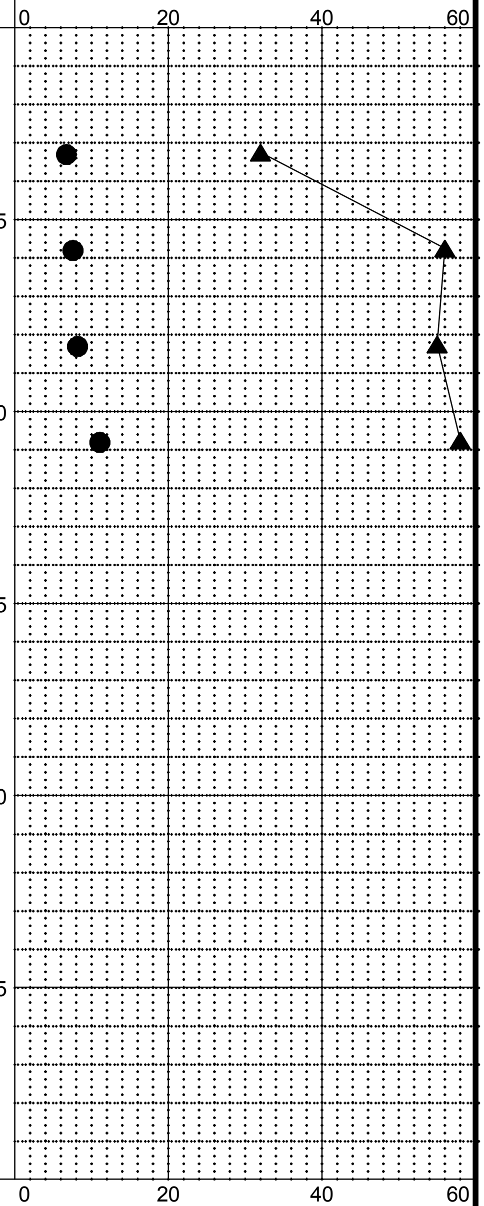
Refer to the report text for a proper understanding of the subsurface materials and drilling methods. The stratification lines indicated below represent the approximate boundaries between material types, and the transition may be gradual.

Soil Description	Depth, ft.	Samples
8.0 inches of Asphalt	0.7	
5 inches of Base Course	1.1	
Dense, red-brown, *Well-Graded Sand with Silt and Gravel (SW-SM)*; moist.	4.5	S-1
SANDSTONE: very low strength, tan to yellow-brown; weakly cemented; thick bedding; highly to moderately weathered (Dawson Formation). [Very dense, *Clayey Sand (SC)*; moist.]	11.5	S-2, S-3, S-4

Ground Water: Groundwater not encountered during drilling.

BOTTOM OF BORING
COMPLETED 11/10/2016

PENETRATION RESISTANCE (blows/foot)
▲ Hammer Wt. & Drop: *140 lbs / 30 inches*



● % Water Content

LEGEND
* Sample Not Recovered
⌶ Standard Penetration Test

NOTES
1. Refer to Figures A-1 and A-2 for explanation of symbols, codes, abbreviations and definitions.
2. The stratification lines represent the approximate boundaries between soil types, and the transition may be gradual.
3. The discussion in the text of this report is necessary for a proper understanding of the nature of the subsurface materials.
4. Groundwater level, if indicated above, is for the date specified and may vary.
5. USCS designation is based on visual-manual classification and selected lab testing.

Highway 105
Corridor Improvements
El Paso County, Colorado

LOG OF BORING SW-W-23

July 2017 23-1-01311-002

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. A-53

REV 3

Total Depth: 21.5 ft.	Latitude:	Drilling Method:	Solid-Stem Auger	Hole Diam.:	4 in.
Top Elevation: ~	Longitude:	Drilling Company:	Entech Engineering, Inc	Rod Type.:	AWJ
Vert. Datum:	Station:	Drill Rig Equipment:	Simco 2800 Truck Mount	Hammer Type:	Automatic
Horiz. Datum:	Offset:	Other Comments:			

SOIL DESCRIPTION

Refer to the report text for a proper understanding of the subsurface materials and drilling methods. The stratification lines indicated below represent the approximate boundaries between material types, and the transition may be gradual.

Depth, ft. | Symbol | Samples | Ground Water | Depth, ft.

PENETRATION RESISTANCE (blows/foot)
▲ Hammer Wt. & Drop: 140 lbs / 30 inches

0.1 — 1.0 inch of Asphalt

SANDSTONE: very low strength, red-brown to tan; weakly cemented; medium spaced bedding; highly to moderately weathered (Dawson Formation).

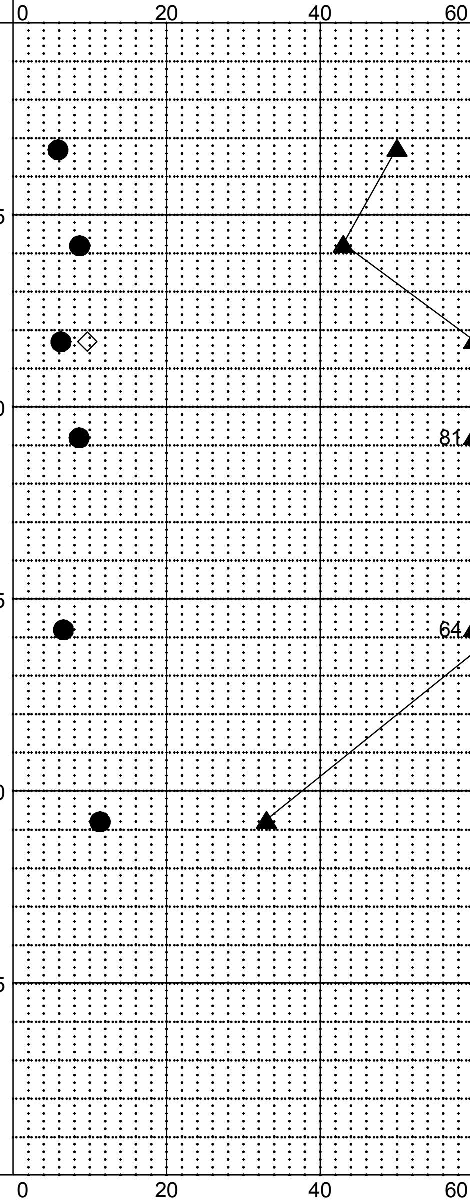
[Dense to very dense, *Well-Graded Sand with Clay and Gravel (SW-SC)* to *Clayey Sand (SC)*; moist.]

- Iron oxide stains from 18 to 21.5 feet.

21.5 — BOTTOM OF BORING
COMPLETED 11/10/2016

Samples: S-1, S-2, S-3, S-4, S-5, S-6

Groundwater not encountered during drilling.



◇ % Fines (<0.075mm)
● % Water Content

LEGEND
* Sample Not Recovered
⌶ Standard Penetration Test

NOTES
1. Refer to Figures A-1 and A-2 for explanation of symbols, codes, abbreviations and definitions.
2. The stratification lines represent the approximate boundaries between soil types, and the transition may be gradual.
3. The discussion in the text of this report is necessary for a proper understanding of the nature of the subsurface materials.
4. Groundwater level, if indicated above, is for the date specified and may vary.
5. USCS designation is based on visual-manual classification and selected lab testing.

Highway 105
Corridor Improvements
El Paso County, Colorado

LOG OF BORING SW-W-24

July 2017 23-1-01311-002

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. A-54

REV 3

Total Depth:	15.5 ft.	Latitude:		Drilling Method:	Solid-Stem Auger
Top Elevation:	~	Longitude:		Drilling Company:	Entech Engineering, Inc
Vert. Datum:		Station:		Drill Rig Equipment:	Simco 2800 Truck Mount
Horiz. Datum:		Offset:		Other Comments:	

Hole Diam.: 4 in.
Rod Type.: AWJ
Hammer Type: Automatic

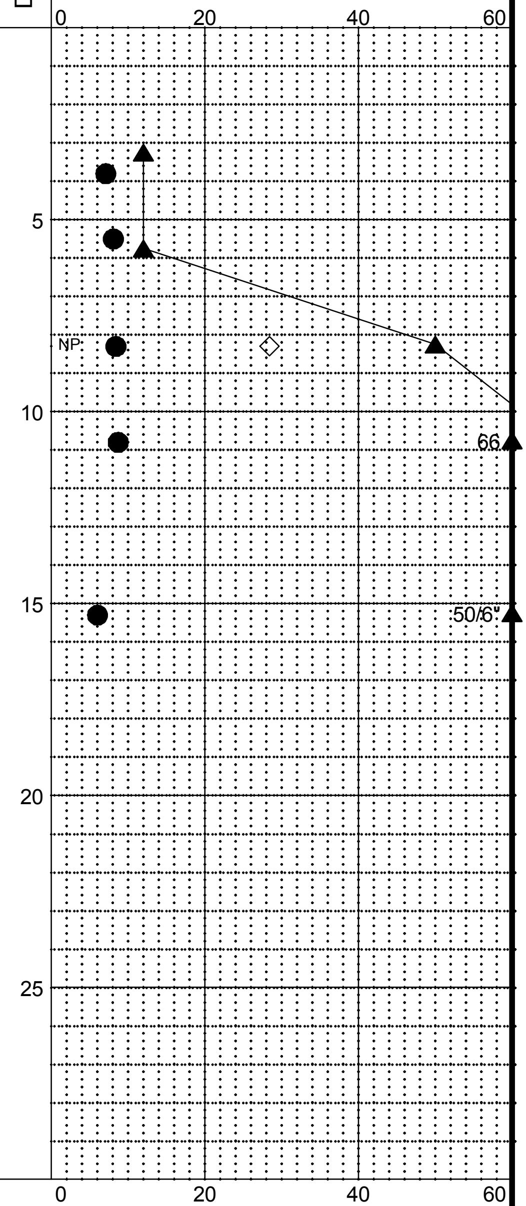
SOIL DESCRIPTION

Refer to the report text for a proper understanding of the subsurface materials and drilling methods. The stratification lines indicated below represent the approximate boundaries between material types, and the transition may be gradual.

Soil Description	Depth, ft.	Samples
7.0 inches of Asphalt	0.6	
4 inches of Base Course	1.0	
Medium dense, red-brown, *Poorly Graded Sand with Silt (SP-SM)*; moist; trace gravel.		S-1, S-2
SANDSTONE: very low strength, red-brown to tan; weakly cemented; thick spaced bedding; highly to moderately weathered (Dawson Formation). [Dense to very dense, *Silty Sand (SM)* to *Clayey Sand (SC)*; moist.]	6.0	S-3, S-4, S-5
BOTTOM OF BORING COMPLETED 11/10/2016	15.5	

Ground Water: Groundwater not encountered during drilling.

PENETRATION RESISTANCE (blows/foot)
▲ Hammer Wt. & Drop: 140 lbs / 30 inches



◇ % Fines (<0.075mm)
● % Water Content
Plastic Limit ├─●─┤ Liquid Limit
Natural Water Content

LEGEND

* Sample Not Recovered
⌶ Standard Penetration Test

NOTES

1. Refer to Figures A-1 and A-2 for explanation of symbols, codes, abbreviations and definitions.
2. The stratification lines represent the approximate boundaries between soil types, and the transition may be gradual.
3. The discussion in the text of this report is necessary for a proper understanding of the nature of the subsurface materials.
4. Groundwater level, if indicated above, is for the date specified and may vary.
5. USCS designation is based on visual-manual classification and selected lab testing.

Highway 105
Corridor Improvements
El Paso County, Colorado

LOG OF BORING SW-W-25

July 2017 23-1-01311-002

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

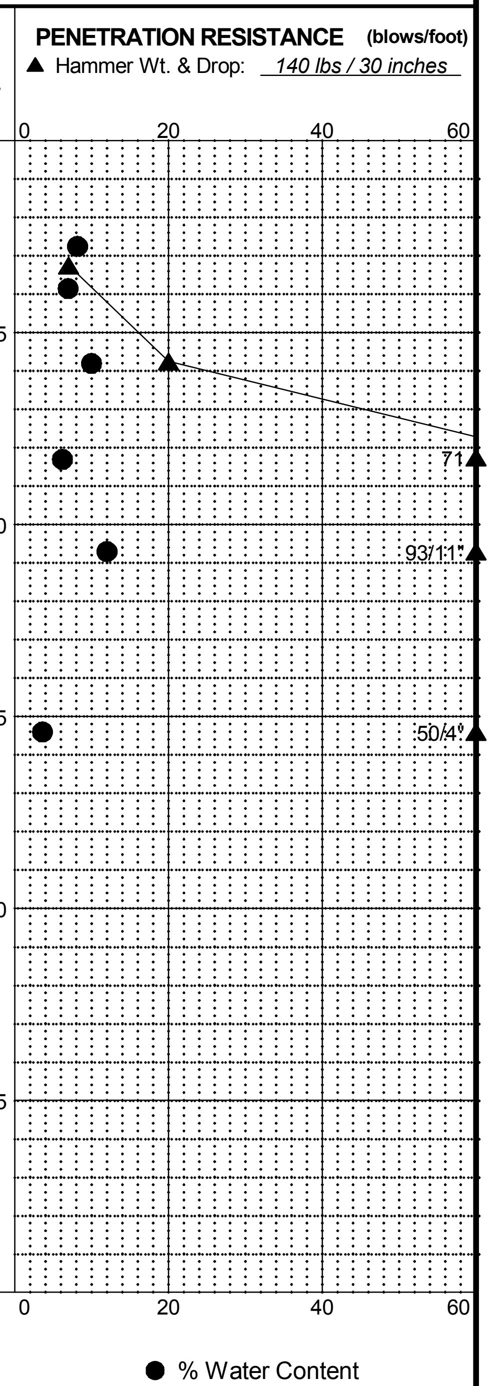
FIG. A-55

REV 3

Total Depth:	15.8 ft.	Latitude:		Drilling Method:	Solid-Stem Auger	Hole Diam.:	4 in.
Top Elevation:	~	Longitude:		Drilling Company:	Entech Engineering, Inc	Rod Type.:	AWJ
Vert. Datum:		Station:		Drill Rig Equipment:	Simco 2800 Truck Mount	Hammer Type:	Automatic
Horiz. Datum:		Offset:		Other Comments:			

SOIL DESCRIPTION *Refer to the report text for a proper understanding of the subsurface materials and drilling methods. The stratification lines indicated below represent the approximate boundaries between material types, and the transition may be gradual.*	Depth, ft.	Samples
9.0 inches Asphalt	0.8	
3 inches of Base Course	1.0	
Loose to medium dense, red-brown to brown, *Poorly Graded Sand with Silt (SP-SM)* to *Clayey Sand (SC)*; moist; trace gravel.		S-1, S-2
SANDSTONE: very low strength, tan to red-brown; weakly cemented; medium to thick bedding; highly to moderately weathered; trace gravel (Dawson Formation). [Very dense, *Clayey Sand (SC)*; moist.]	7.0	S-3, S-4, S-5
BOTTOM OF BORING COMPLETED 11/10/2016	15.8	

Ground Water: Groundwater not encountered during drilling.



LEGEND

* Sample Not Recovered

⌶ Standard Penetration Test

NOTES

1. Refer to Figures A-1 and A-2 for explanation of symbols, codes, abbreviations and definitions.
2. The stratification lines represent the approximate boundaries between soil types, and the transition may be gradual.
3. The discussion in the text of this report is necessary for a proper understanding of the nature of the subsurface materials.
4. Groundwater level, if indicated above, is for the date specified and may vary.
5. USCS designation is based on visual-manual classification and selected lab testing.

Highway 105
Corridor Improvements
El Paso County, Colorado

LOG OF BORING SW-W-26

July 2017 23-1-01311-002

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. A-56

REV 3

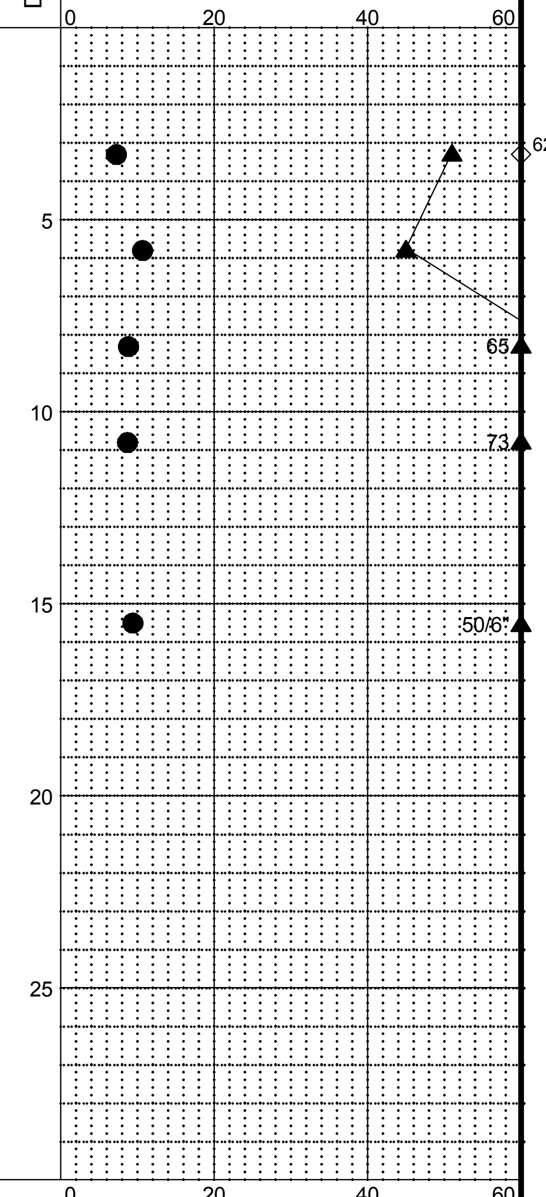
MASTER_LOG_E_POCKETPEN_LAT&LONG 23-1-01311-002.GPJ 7/6/17

Total Depth:	16 ft.	Latitude:		Drilling Method:	Solid-Stem Auger
Top Elevation:	~	Longitude:		Drilling Company:	Entech Engineering, Inc
Vert. Datum:		Station:		Drill Rig Equipment:	Simco 2800 Truck Mount
Horiz. Datum:		Offset:		Other Comments:	

Hole Diam.: 4 in.
Rod Type.: AWJ
Hammer Type: Automatic

SOIL DESCRIPTION *Refer to the report text for a proper understanding of the subsurface materials and drilling methods. The stratification lines indicated below represent the approximate boundaries between material types, and the transition may be gradual.*	Depth, ft.	Symbol	Samples	Ground Water
8.0 inches of Asphalt	0.7			Groundwater not encountered during drilling.
4 inches of Base Course	1.0			
SANDSTONE: very low strength, tan; weakly cemented; medium to thick bedding; interbedded with seams of claystone, highly to moderately weathered; (Dawson Formation). [Dense to very dense, *Poorly Graded Sand with Clay (SP-SC)* and *Clayey Sand (SC)* to hard, *Sandy Lean Clay (CL)*; moist; trace gravel.]	16.0		S-1, S-2, S-3, S-4, S-5	
BOTTOM OF BORING COMPLETED 11/10/2016				

PENETRATION RESISTANCE (blows/foot)
▲ Hammer Wt. & Drop: 140 lbs / 30 inches



◇ % Fines (<0.075mm)
● % Water Content

LEGEND
* Sample Not Recovered
⌶ Standard Penetration Test

NOTES
1. Refer to Figures A-1 and A-2 for explanation of symbols, codes, abbreviations and definitions.
2. The stratification lines represent the approximate boundaries between soil types, and the transition may be gradual.
3. The discussion in the text of this report is necessary for a proper understanding of the nature of the subsurface materials.
4. Groundwater level, if indicated above, is for the date specified and may vary.
5. USCS designation is based on visual-manual classification and selected lab testing.

Highway 105
Corridor Improvements
El Paso County, Colorado

LOG OF BORING SW-W-27

July 2017 23-1-01311-002

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. A-57

REV 3

SHANNON & WILSON, INC.
GEOTECHNICAL AND ENVIRONMENTAL CONSULTANTS

LOG OF TEST PIT TP-28

JOB NO: 23-1-01311-002   EXCAVATION DATE: 11-16-2016

PROJECT: Highway 105 Corridor Improvements

SOIL DESCRIPTION	Ground Water	% Water Content	Samples	Depth, Ft.
(1) Loose, brown, *Poorly Graded Sand with Silt (SP-SM)*; moist; few gravel.	Groundwater Not Encountered			0
(2) SANDSTONE: very low strength, brown; weakly cemented; thin to medium bedding; moderately weathered; thin spaced coarse sand to fine gravel layers (Dawson Formation). [Very dense, *Poorly Graded Sand with Clay (SP-SC)* to *Clayey Sand (SC)*; moist; trace gravel.]		7.1	S-1	
(3) CLAYSTONE: very low strength, red-brown; highly to moderately weathered (Dawson Formation). [Hard, *Lean Clay with Sand (CL)*; moist.]		12.8	S-2	5
(4) SANDSTONE: very low strength, brown to tan; weakly cemented; thin to medium bedding; moderately weathered; thin spaced claystone layers (Dawson Formation). [Very dense, *Poorly Graded Sand with Clay (SP-SC)* to *Clayey Sand (SC)*; moist; trace gravel.]				10, 15, 20, 25

Sketch of West Pit Side   Approximate Roadway Elevation(ft): 7398   Sta. ~201+50

Horizontal Distance in Feet

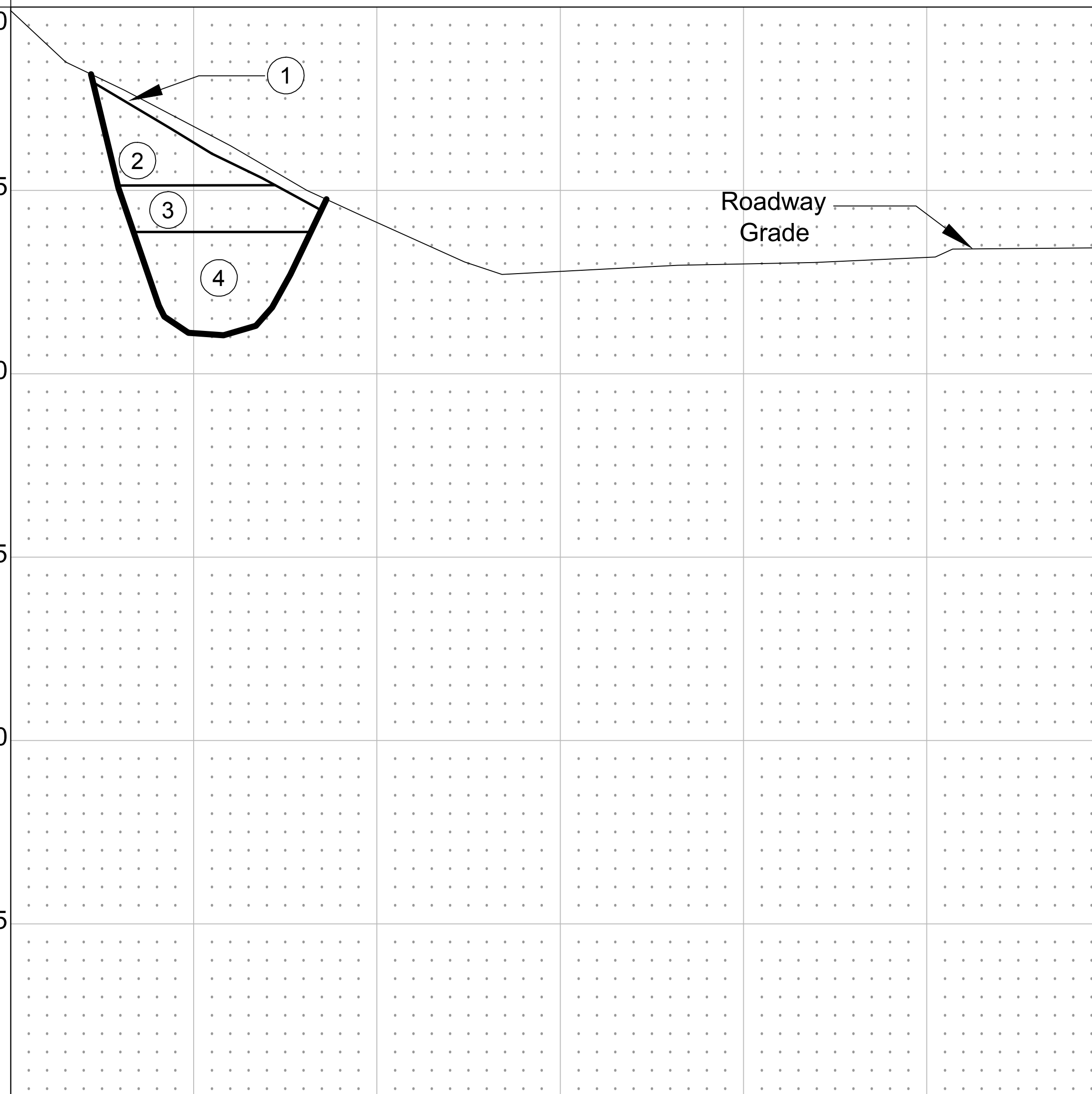


FIG. A-58

SHANNON & WILSON, INC.
GEOTECHNICAL AND ENVIRONMENTAL CONSULTANTS

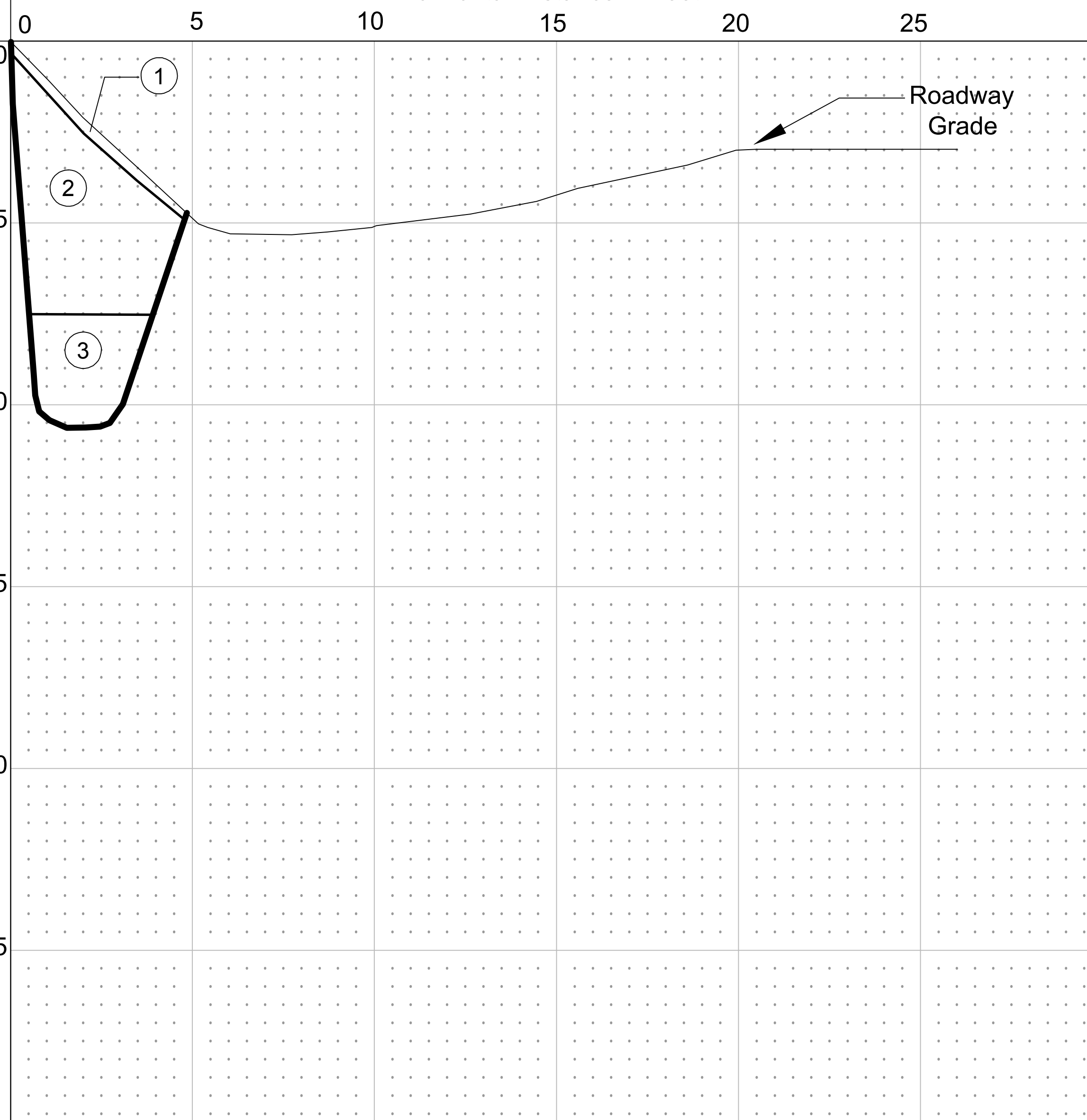
LOG OF TEST PIT TP-29

JOB NO: 23-1-01311-002 EXCAVATION DATE: 11-16-2016

PROJECT: Highway 105 Corridor Improvements

SOIL DESCRIPTION	Ground Water	% Water Content	Samples
(1) Medium dense, brown to tan, *Well-Graded Sand with Clay (SW-SC)*; moist; trace to few gravel.	Groundwater Not Encountered		
(2) SANDSTONE: very low strength, tan; weakly cemented; thin to medium bedding; moderately weathered; thin spaced coarse sand to fine gravel layers (Dawson Formation). [Very dense, *Poorly Graded Sand with Silt (SP-SM)*; moist; trace gravel.]		7.1	S-1
(3) SANDSTONE: very low strength, brown to tan; weakly cemented; thin to medium bedding; moderately weathered (Dawson Formation). [Very dense, *Clayey Sand (SC)*; moist.]		11.1	S-2

Sketch of West Pit Side Approximate Roadway Elevation(ft): 7409 Sta. ~203+30



Total Depth:	21 ft.	Latitude:		Drilling Method:	Solid-Stem Auger	Hole Diam.:	4 in.
Top Elevation:	~	Longitude:		Drilling Company:	Entech Engineering, Inc	Rod Type.:	AWJ
Vert. Datum:		Station:		Drill Rig Equipment:	Simco 2800 Truck Mount	Hammer Type:	Automatic
Horiz. Datum:		Offset:		Other Comments:			

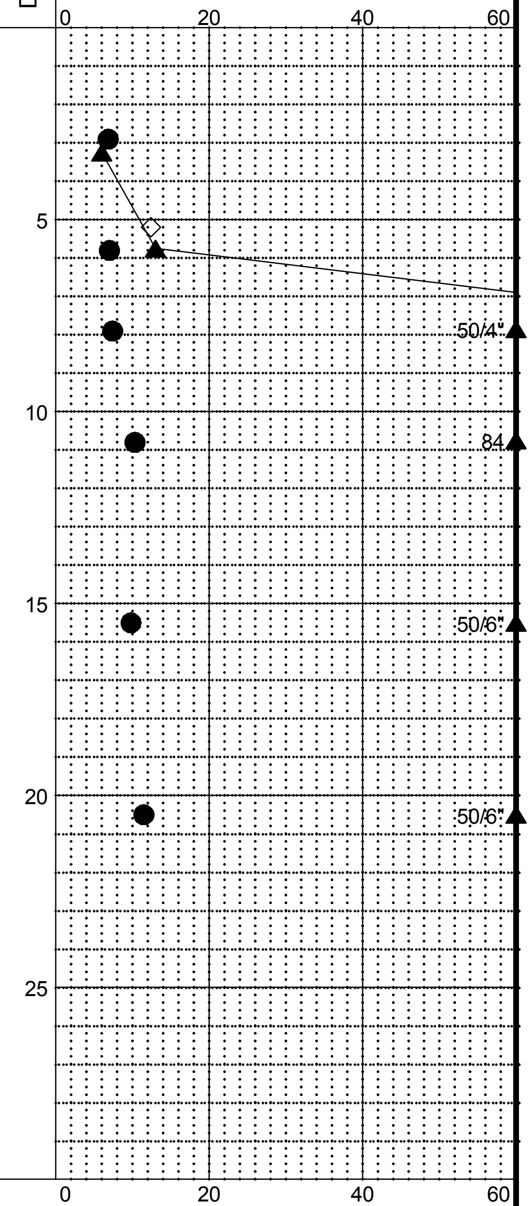
SOIL DESCRIPTION

Refer to the report text for a proper understanding of the subsurface materials and drilling methods. The stratification lines indicated below represent the approximate boundaries between material types, and the transition may be gradual.

SOIL DESCRIPTION	Depth, ft.	Samples	Ground Water
8 inches of Asphalt	0.7		Groundwater not encountered during drilling.
Loose to medium dense, brown to red-brown, *Well-Graded Sand with Clay (SW-SC)*; moist; few gravel. Fill	6.0	S-1, S-2	
SANDSTONE: very low strength, brown to tan; weakly cemented; thick spaced bedding; moderately weathered (Dawson Formation). [Very dense, *Well-Graded Sand with Clay (SW-SC)* to *Clayey Sand (SC)*; moist; trace to few gravel.] - Silty Sandstone 18.0 to 21.0 feet.	21.0	S-3, S-4, S-5, S-6	
BOTTOM OF BORING COMPLETED 11/17/2016			

PENETRATION RESISTANCE (blows/foot)

▲ Hammer Wt. & Drop: 140 lbs / 30 inches



◇ % Fines (<0.075mm)
● % Water Content

LEGEND
* Sample Not Recovered
⌶ Standard Penetration Test

NOTES
1. Refer to Figures A-1 and A-2 for explanation of symbols, codes, abbreviations and definitions.
2. The stratification lines represent the approximate boundaries between soil types, and the transition may be gradual.
3. The discussion in the text of this report is necessary for a proper understanding of the nature of the subsurface materials.
4. Groundwater level, if indicated above, is for the date specified and may vary.
5. USCS designation is based on visual-manual classification and selected lab testing.

Highway 105
Corridor Improvements
El Paso County, Colorado

LOG OF BORING SW-W-30

July 2017 23-1-01311-002

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. A-60

REV 3

MASTER_LOG_E_POCKETPEN_LAT&LONG 23-1-01311-002.GPJ 7/6/17

Total Depth:	*20.7 ft.*	Latitude:		Drilling Method:	*Solid-Stem Auger*	Hole Diam.:	*4 in.*
Top Elevation:	*~*	Longitude:		Drilling Company:	*Entech Engineering, Inc*	Rod Type.:	*AWJ*
Vert. Datum:		Station:		Drill Rig Equipment:	*Simco 2800 Truck Mount*	Hammer Type:	*Automatic*
Horiz. Datum:		Offset:		Other Comments:			

SOIL DESCRIPTION

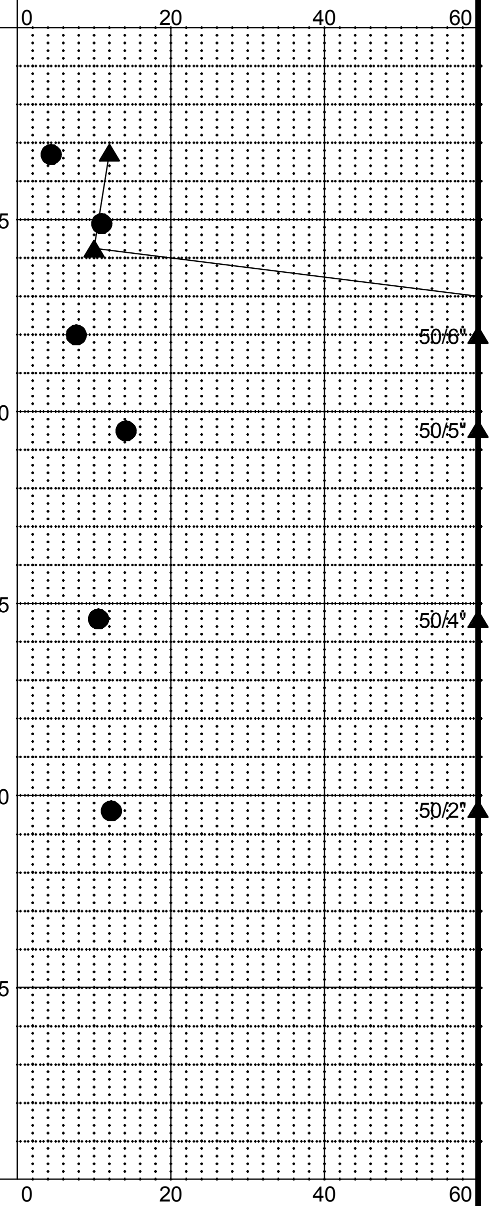
Refer to the report text for a proper understanding of the subsurface materials and drilling methods. The stratification lines indicated below represent the approximate boundaries between material types, and the transition may be gradual.

Soil Description	Depth, ft.	Samples
6.0 inches of Asphalt	0.5	
Medium dense, brown to red-brown, *Poorly Graded Sand with Silt (SP-SM)*; moist. Fill	4.5	S-1
Loose to medium dense, brown to tan, *Poorly Graded Sand with Clay (SP-SC)* to *Clayey Sand (SC)*; moist.	7.0	S-2
SANDSTONE: very low strength, tan; weakly cemented; medium to thickly bedded; highly to moderately weathered (Dawson Formation). [Very dense, interbedded *Poorly Graded Sand with Clay (SP-SC)*, *Clayey Sand (SC)*, and *Silty Sand (SM)*; moist; trace to few gravel.] - Iron oxide stains from 8 to 10 feet.	20.7	S-3, S-4, S-5, S-6

Ground Water: Groundwater not encountered during drilling.

BOTTOM OF BORING
COMPLETED 11/21/2016

PENETRATION RESISTANCE (blows/foot)
▲ Hammer Wt. & Drop: *140 lbs / 30 inches*



LEGEND
* Sample Not Recovered
Ⲓ Standard Penetration Test

● % Water Content

NOTES

1. Refer to Figures A-1 and A-2 for explanation of symbols, codes, abbreviations and definitions.
2. The stratification lines represent the approximate boundaries between soil types, and the transition may be gradual.
3. The discussion in the text of this report is necessary for a proper understanding of the nature of the subsurface materials.
4. Groundwater level, if indicated above, is for the date specified and may vary.
5. USCS designation is based on visual-manual classification and selected lab testing.

Highway 105
Corridor Improvements
El Paso County, Colorado

LOG OF BORING SW-W-31

July 2017 23-1-01311-002

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. A-61

REV 3

MASTER_LOG_E_POCKETPEN_LAT&LONG 23-1-01311-002.GPJ 7/6/17

Total Depth:	*20.9 ft.*	Latitude:		Drilling Method:	*Solid-Stem Auger*	Hole Diam.:	*4 in.*
Top Elevation:	~	Longitude:		Drilling Company:	*Entech Engineering, Inc*	Rod Type.:	*AWJ*
Vert. Datum:		Station:		Drill Rig Equipment:	*Simco 2800 Truck Mount*	Hammer Type:	*Automatic*
Horiz. Datum:		Offset:		Other Comments:			

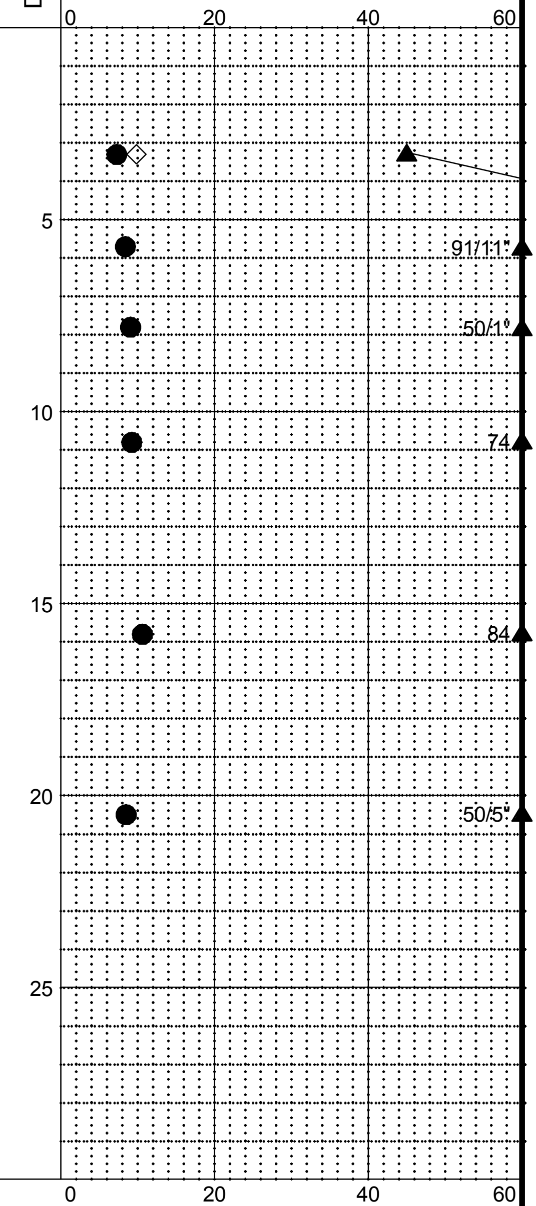
SOIL DESCRIPTION

Refer to the report text for a proper understanding of the subsurface materials and drilling methods. The stratification lines indicated below represent the approximate boundaries between material types, and the transition may be gradual.

Soil Description	Depth, ft.	Samples	Ground Water
8.0 inches of Asphalt	0.7		
4 inches of Base Course	1.0		
SANDSTONE: very low strength, red-brown to tan; weakly cemented; thick spaced bedding; highly to moderately weathered (Dawson Formation). [Dense to very dense, *Well-Graded Sand with Clay (SW-SC)* to *Clayey Sand (SC)*; moist; few gravel.]		S-1, S-2, S-3, S-4, S-5, S-6	Groundwater not encountered during drilling.
BOTTOM OF BORING COMPLETED 11/10/2016	20.9		

PENETRATION RESISTANCE (blows/foot)

▲ Hammer Wt. & Drop: *140 lbs / 30 inches*



◇ % Fines (<0.075mm)
● % Water Content

LEGEND

* Sample Not Recovered
Ⅰ Standard Penetration Test

NOTES

1. Refer to Figures A-1 and A-2 for explanation of symbols, codes, abbreviations and definitions.
2. The stratification lines represent the approximate boundaries between soil types, and the transition may be gradual.
3. The discussion in the text of this report is necessary for a proper understanding of the nature of the subsurface materials.
4. Groundwater level, if indicated above, is for the date specified and may vary.
5. USCS designation is based on visual-manual classification and selected lab testing.

Highway 105
Corridor Improvements
El Paso County, Colorado

LOG OF BORING SW-W-32

July 2017 23-1-01311-002

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. A-62

REV 3

MASTER_LOG_E_POCKETPEN LAT&LONG 23-1-01311-002.GPJ 7/6/17

SHANNON & WILSON, INC.
GEOTECHNICAL AND ENVIRONMENTAL CONSULTANTS

LOG OF TEST PIT TP-33

JOB NO: 23-1-01311-002 EXCAVATION DATE: 11-16-2016

PROJECT: Highway 105 Corridor Improvements

SOIL DESCRIPTION

1. Medium dense, brown to tan, *Poorly Graded Sand with Silt (SP-SM)*; moist; few to little gravel at surface.
2. SANDSTONE: very low strength, tan; weakly to moderately cemented; thin to medium bedding; moderately weathered (Dawson Formation).
   [Very dense, *Clayey Sand (SC)*; moist.]
3. CLAYSTONE: very low strength, brown to tan; moderately weathered (Dawson Formation).
   [Hard, *Fat Clay with Sand (CH)*; moist.]
4. SANDSTONE: very low strength, brown to red-brown; weakly cemented; thin to medium bedding; moderately weathered (Dawson Formation).
   [Very dense, *Poorly Graded Sand with Silt (SP-SM)*; moist; thin to medium spaced clayey sand layers.]

Ground Water	% Water Content	Samples
Groundwater Not Encountered	7.2	S-1
	14.2	S-2
	8.9	S-3

Sketch of East Pit Side Approximate Roadway Elevation(ft): 7412 Sta. ~205+90

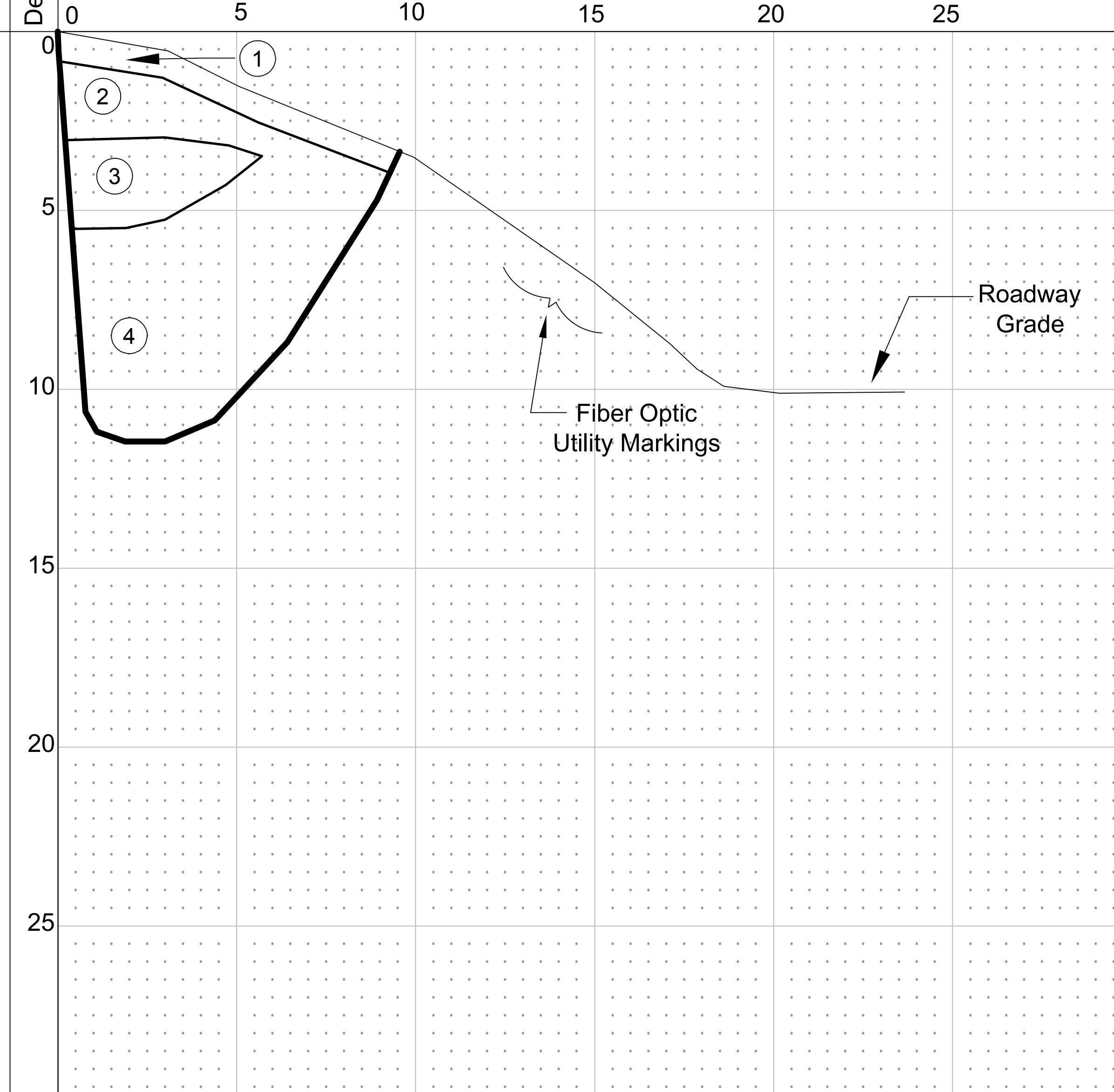


FIG. A-63

Total Depth:	20.9 ft.	Latitude:		Drilling Method:	Solid-Stem Auger
Top Elevation:	~	Longitude:		Drilling Company:	Entech Engineering, Inc
Vert. Datum:		Station:		Drill Rig Equipment:	Simco 2800 Truck Mount
Horiz. Datum:		Offset:		Other Comments:	

Hole Diam.: 4 in.
Rod Type.: AWJ
Hammer Type: Automatic

SOIL DESCRIPTION

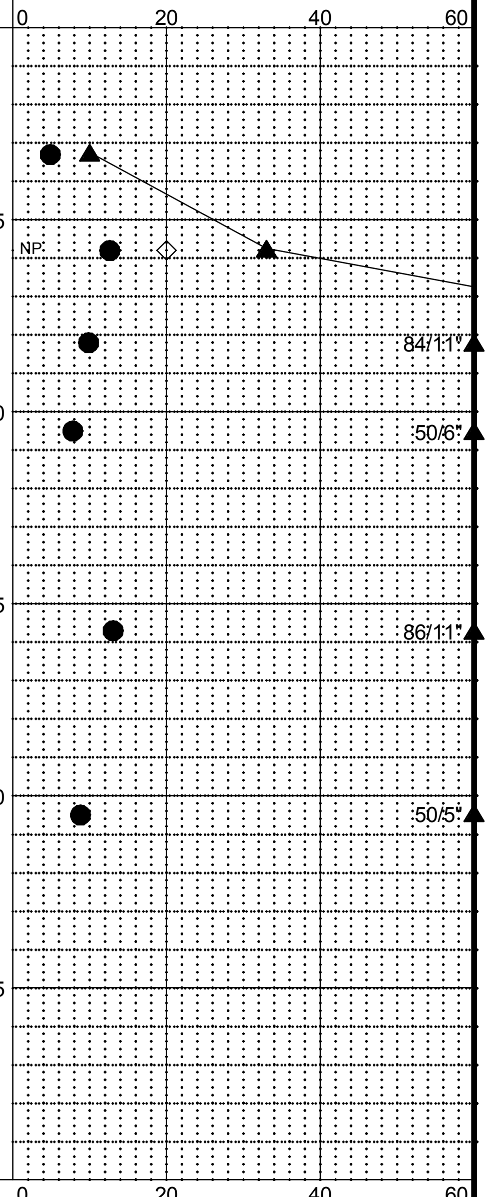
Refer to the report text for a proper understanding of the subsurface materials and drilling methods. The stratification lines indicated below represent the approximate boundaries between material types, and the transition may be gradual.

Soil Description	Depth, ft.	Samples
7.0 inches of Asphalt	0.6	
Loose to medium dense, red-brown, *Poorly Graded Sand with Silt (SP-SM)*; moist; trace to few gravel.	4.5	S-1
SANDSTONE: very low strength, red-brown to tan; weakly cemented; medium to thick spaced bedding; highly to moderately weathered (Dawson Formation). [Dense to very dense, interbedded *Silty Sand (SM)*, *Poorly Graded Sand with Clay (SP-SC)*, and *Clayey Sand (SC)*; moist.]	13.0	S-2, S-3, S-4
SILTSTONE: very low strength, tan; weakly cemented; laminated; moderately weathered (Dawson Formation). [Very dense, *Silt with Sand (ML)*; moist.]	18.0	S-5
SANDSTONE: very low strength, red-brown to tan; weakly cemented; medium to thick spaced bedding; moderately weathered (Dawson Formation). [Very dense, *Clayey Sand (SC)*; moist.]	20.9	S-6

BOTTOM OF BORING
COMPLETED 11/10/2016

Ground Water: Groundwater not encountered during drilling.

PENETRATION RESISTANCE (blows/foot)
▲ Hammer Wt. & Drop: 140 lbs / 30 inches



LEGEND
* Sample Not Recovered
Standard Penetration Test

◇ % Fines (<0.075mm)
● % Water Content
Plastic Limit ├─●─┤ Liquid Limit
Natural Water Content

NOTES
1. Refer to Figures A-1 and A-2 for explanation of symbols, codes, abbreviations and definitions.
2. The stratification lines represent the approximate boundaries between soil types, and the transition may be gradual.
3. The discussion in the text of this report is necessary for a proper understanding of the nature of the subsurface materials.
4. Groundwater level, if indicated above, is for the date specified and may vary.
5. USCS designation is based on visual-manual classification and selected lab testing.

Highway 105
Corridor Improvements
El Paso County, Colorado

LOG OF BORING SW-W-34

July 2017 23-1-01311-002

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. A-64

REV 3

Total Depth: 15.9 ft.	Latitude:	Drilling Method:	Solid-Stem Auger	Hole Diam.:	4 in.
Top Elevation: ~	Longitude:	Drilling Company:	Entech Engineering, Inc	Rod Type.:	AWJ
Vert. Datum:	Station:	Drill Rig Equipment:	Simco 2800 Truck Mount	Hammer Type:	Automatic
Horiz. Datum:	Offset:	Other Comments:			

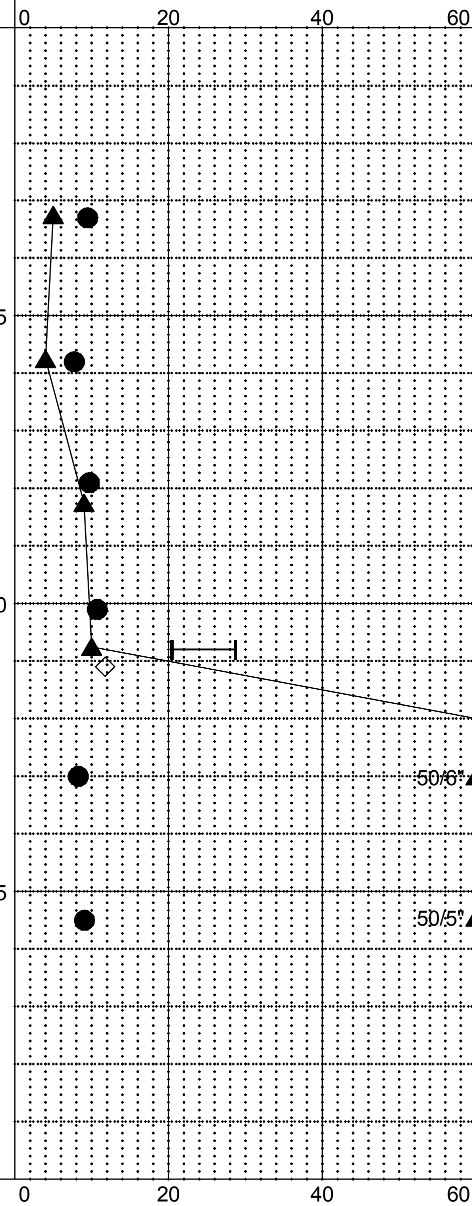
SOIL DESCRIPTION

Refer to the report text for a proper understanding of the subsurface materials and drilling methods. The stratification lines indicated below represent the approximate boundaries between material types, and the transition may be gradual.

Soil Description	Depth, ft.	Samples	Ground Water
Very loose to loose, brown, *Poorly Graded Sand with Silt (SP-SM)* to *Poorly Graded Sand with Clay (SP-SC)*; moist. Fill		S-1, S-2	Groundwater not encountered during drilling.
Loose to medium dense, brown to tan, *Well-Graded Sand with Clay (SW-SC)*; moist; few gravel.	7.0	S-3, S-4	
SANDSTONE: very low strength, tan; weakly cemented; medium to thickly bedded; highly to moderately weathered (Dawson Formation). [Very dense, *Poorly Graded Sand with Clay (SP-SC)* to *Clayey Sand (SC)*; moist.]	12.0	S-5, S-6	
BOTTOM OF BORING COMPLETED 11/21/2016	15.9		

PENETRATION RESISTANCE (blows/foot)

▲ Hammer Wt. & Drop: 140 lbs / 30 inches



◇ % Fines (<0.075mm)
● % Water Content
Plastic Limit ├─●─┤ Liquid Limit
Natural Water Content

LEGEND

* Sample Not Recovered
Ⅰ Standard Penetration Test

NOTES

1. Refer to Figures A-1 and A-2 for explanation of symbols, codes, abbreviations and definitions.
2. The stratification lines represent the approximate boundaries between soil types, and the transition may be gradual.
3. The discussion in the text of this report is necessary for a proper understanding of the nature of the subsurface materials.
4. Groundwater level, if indicated above, is for the date specified and may vary.
5. USCS designation is based on visual-manual classification and selected lab testing.

Highway 105
Corridor Improvements
El Paso County, Colorado

LOG OF BORING SW-W-35

July 2017 23-1-01311-002

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. A-65

REV 3

Total Depth:	16 ft.	Latitude:		Drilling Method:	Solid-Stem Auger	Hole Diam.:	4 in.
Top Elevation:	~	Longitude:		Drilling Company:	Entech Engineering, Inc	Rod Type.:	AWJ
Vert. Datum:		Station:		Drill Rig Equipment:	Simco 2800 Truck Mount	Hammer Type:	Automatic
Horiz. Datum:		Offset:		Other Comments:			

SOIL DESCRIPTION

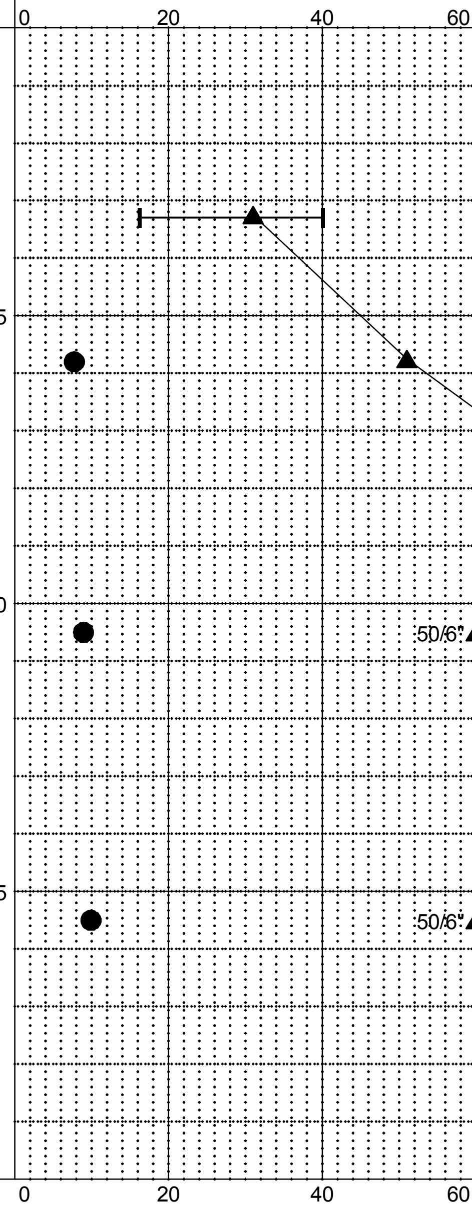
Refer to the report text for a proper understanding of the subsurface materials and drilling methods. The stratification lines indicated below represent the approximate boundaries between material types, and the transition may be gradual.

Soil Description	Depth, ft.	Samples
Dense, red-brown to tan, *Clayey Sand (SC)*; moist; few gravel.		S-1
SANDSTONE: very low strength, tan to brown; weakly cemented; medium to thickly bedded; highly to moderately weathered (Dawson Formation). [Very dense, *Poorly Graded Sand with Clay (SP-SC)* to *Clayey Sand (SC)*; moist.]	4.5	S-2, S-3, S-4
BOTTOM OF BORING COMPLETED 11/21/2016	16.0	

Ground Water: Groundwater not encountered during drilling.

PENETRATION RESISTANCE (blows/foot)

▲ Hammer Wt. & Drop: 140 lbs / 30 inches



LEGEND

* Sample Not Recovered

Standard Penetration Test

● % Water Content

Plastic Limit ├─●─┤ Liquid Limit

Natural Water Content

NOTES

1. Refer to Figures A-1 and A-2 for explanation of symbols, codes, abbreviations and definitions.
2. The stratification lines represent the approximate boundaries between soil types, and the transition may be gradual.
3. The discussion in the text of this report is necessary for a proper understanding of the nature of the subsurface materials.
4. Groundwater level, if indicated above, is for the date specified and may vary.
5. USCS designation is based on visual-manual classification and selected lab testing.

Highway 105
Corridor Improvements
El Paso County, Colorado

LOG OF BORING SW-W-36

July 2017 23-1-01311-002

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. A-66

REV 3

MASTER_LOG_E_POCKETPEN_LAT&LONG 23-1-01311-002.GPJ 7/6/17

Total Depth: 16.5 ft.	Latitude:	Drilling Method:	Solid-Stem Auger	Hole Diam.:	4 in.
Top Elevation: ~	Longitude:	Drilling Company:	Entech Engineering, Inc	Rod Type.:	AWJ
Vert. Datum:	Station:	Drill Rig Equipment:	Simco 2800 Truck Mount	Hammer Type:	Automatic
Horiz. Datum:	Offset:	Other Comments:			

SOIL DESCRIPTION

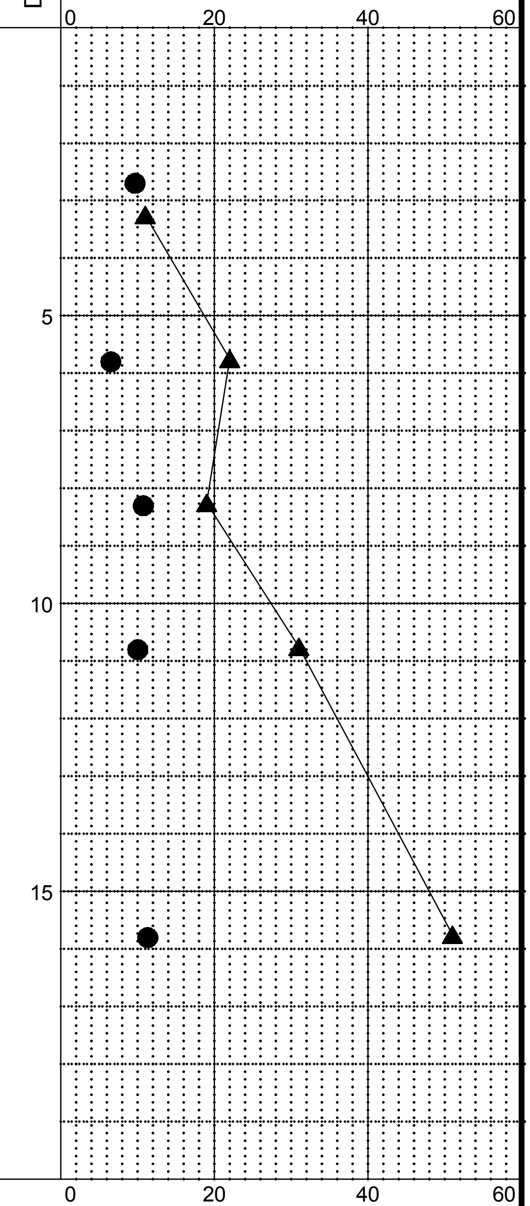
Refer to the report text for a proper understanding of the subsurface materials and drilling methods. The stratification lines indicated below represent the approximate boundaries between material types, and the transition may be gradual.

Soil Description	Depth, ft.	Samples
Medium dense, brown to red-brown, *Clayey Sand (SC)*; moist; few gravel.		S-1, S-2, S-3
SANDSTONE: very low strength, red-brown to brown; weakly cemented; medium to thickly bedded; highly to moderately weathered (Dawson Formation). [Very dense, *Poorly Graded Sand with Clay (SP-SC)* to *Clayey Sand (SC)*; moist; trace gravel.]	9.5	S-4, S-5
BOTTOM OF BORING COMPLETED 11/21/2016	16.5	

Groundwater not encountered during drilling.

PENETRATION RESISTANCE (blows/foot)

▲ Hammer Wt. & Drop: 140 lbs / 30 inches



● % Water Content

LEGEND

* Sample Not Recovered

⌶ Standard Penetration Test

NOTES

1. Refer to Figures A-1 and A-2 for explanation of symbols, codes, abbreviations and definitions.
2. The stratification lines represent the approximate boundaries between soil types, and the transition may be gradual.
3. The discussion in the text of this report is necessary for a proper understanding of the nature of the subsurface materials.
4. Groundwater level, if indicated above, is for the date specified and may vary.
5. USCS designation is based on visual-manual classification and selected lab testing.

Highway 105
Corridor Improvements
El Paso County, Colorado

LOG OF BORING SW-W-37

July 2017 23-1-01311-002

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. A-67

REV 3

MASTER_LOG_E_POCKETPEN LAT&LONG 23-1-01311-002.GPJ 7/6/17

Total Depth:	16.5 ft.	Latitude:		Drilling Method:	Solid-Stem Auger	Hole Diam.:	4 in.
Top Elevation:	~	Longitude:		Drilling Company:	Entech Engineering, Inc	Rod Type.:	AWJ
Vert. Datum:		Station:		Drill Rig Equipment:	Simco 2800 Truck Mount	Hammer Type:	Automatic
Horiz. Datum:		Offset:		Other Comments:			

SOIL DESCRIPTION

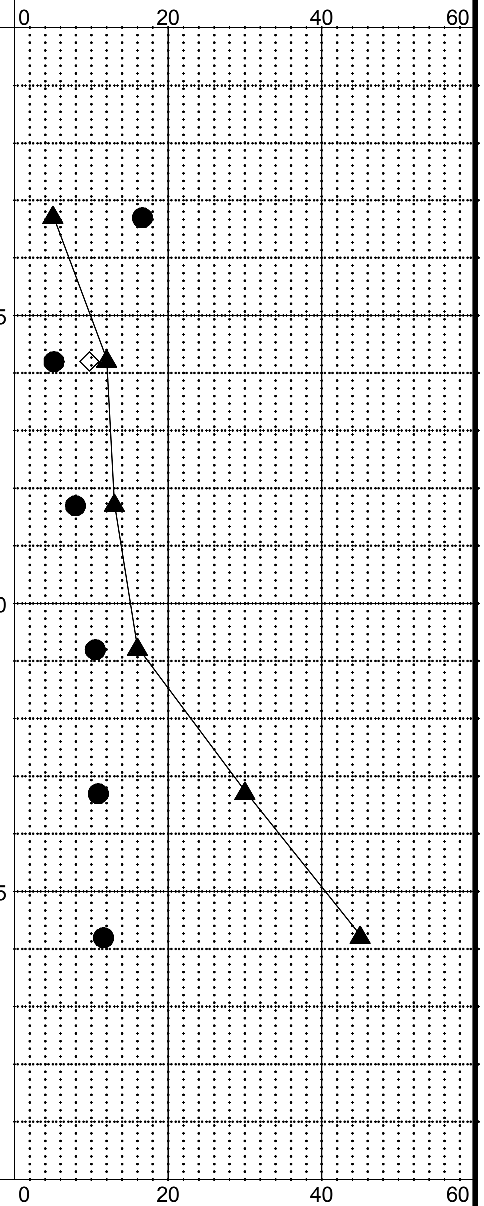
Refer to the report text for a proper understanding of the subsurface materials and drilling methods. The stratification lines indicated below represent the approximate boundaries between material types, and the transition may be gradual.

Soil Description	Depth, ft.	Samples
12.0 inches of Ashalt	1.0	
4 inches of Base Course	1.3	
Medium stiff, brown, *Lean Clay (CL)*; moist; thin spaced interbedded silty sand.	4.5	S-1
Medium dense, brown to red-brown, *Poorly Graded Sand with Silt (SP-SM)*; moist.	7.0	S-2
Medium dense, red-brown, *Poorly Graded Sand with Clay (SP-SC)* to *Clayey Sand (SC)*; moist; trace to few gravel.	12.0	S-3, S-4
SANDSTONE: very low strength, red-brown to brown; weakly cemented; medium to thickly bedded; highly to moderately weathered; trace gravel (Dawson Formation). [Medium dense to dense, *Poorly Graded Sand with Clay (SP-SC)* to *Clayey Sand (SC)*; moist; trace gravel.]	16.5	S-5, S-6
BOTTOM OF BORING COMPLETED 11/21/2016		

Ground Water: Groundwater not encountered during drilling.

PENETRATION RESISTANCE (blows/foot)

▲ Hammer Wt. & Drop: 140 lbs / 30 inches



◇ % Fines (<0.075mm)
● % Water Content

LEGEND

* Sample Not Recovered
⌶ Standard Penetration Test

NOTES

1. Refer to Figures A-1 and A-2 for explanation of symbols, codes, abbreviations and definitions.
2. The stratification lines represent the approximate boundaries between soil types, and the transition may be gradual.
3. The discussion in the text of this report is necessary for a proper understanding of the nature of the subsurface materials.
4. Groundwater level, if indicated above, is for the date specified and may vary.
5. USCS designation is based on visual-manual classification and selected lab testing.

Highway 105
Corridor Improvements
El Paso County, Colorado

LOG OF BORING SW-W-38

July 2017 — 23-1-01311-002

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. A-68

REV 3

Pavement Core at SW-P-01
Eastbound lane, 9.5 inches thickness measured

Highway 105
Corridor Improvements
El Paso County, Colorado

PAVEMENT CORE PHOTOGRAPH
BORING SW-P-01

July 2017 23-1-01311-002

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. A-69

<u>**Pavement Core at at SW-P-02**</u>
Westbound lane. 10 inches thickness measured

Highway 105
Corridor Improvements
El Paso County, Colorado

PAVEMENT CORE PHOTOGRAPH
BORING SW-P-02

July 2017 23-1-01311-002

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. A-70

Pavement Core at SW-P-03
Eastbound lane, 7.5 inches thickness measured

Highway 105
Corridor Improvements
El Paso County, Colorado

PAVEMENT CORE PHOTOGRAPH
BORING SW-P-03

July 2017 | 23-1-01311-002

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. A-71

<u>Pavement Core at SW-P-04</u>
Westbound lane, 8 inches thickness measured

Highway 105 Corridor Improvements El Paso County, Colorado
PAVEMENT CORE PHOTOGRAPH **BORING SW-P-04**
July 2017 23-1-01311-002
SHANNON & WILSON, INC. Geotechnical and Environmental Consultants — **FIG. A-72**

<u>**Pavement Core at SW-P-05**</u>
Eastbound lane, 7 inches thickness measured

Highway 105 Corridor Improvements El Paso County, Colorado	
PAVEMENT CORE PHOTOGRAPH BORING SW-P-05	
July 2017	23-1-01311-002
SHANNON & WILSON, INC. Geotechnical and Environmental Consultants	**FIG. A-73**

<u>Pavement Core at SW-P-06</u>
Westbound lane, 8 inches thickness measured

Highway 105
Corridor Improvements
El Paso County, Colorado

PAVEMENT CORE PHOTOGRAPH
BORING SW-P-06

July 2017 | 23-1-01311-002

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Geotechnical and Environmental Consultants

FIG. A-74

APPENDIX B

LABORATORY TEST RESULTS

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LABORATORY TEST RESULTS

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LABORATORY TEST RESULTS

B.1 INTRODUCTION

Laboratory tests were completed on soil and bedrock samples retrieved from the borings in general accordance with ASTM International (ASTM), the American Association of State Highway and Transportation Officials (AASHTO), and the Colorado Department of Transportation (CDOT) testing methods. The laboratory testing program was performed to classify the materials into similar geologic groups and provide data that can be used for design of the project. The geotechnical laboratory testing was performed at our laboratory. The testing program included index tests and corrosion tests. A summary of the laboratory test results is presented in Table B-1. The following sections describe the laboratory testing procedures.

B.2 GEOTECHNICAL INDEX TESTS

B.2.1 Water Content and Unit Weight

Water content was determined for selected samples in general accordance with AASHTO T 265, Laboratory Determination of Moisture Content of Soils. To perform this test, samples were weighed before and after oven-drying, and the water contents calculated. Water content determinations are shown graphically on the boring logs and are also summarized in Table B-1.

Unit weights were determined from selected modified California drive samples. To perform these tests, the dimensions of the sample were measured, the sample was weighed, and the moist unit weight was calculated.

B.2.2 Grain Size Analysis

The grain size distribution of selected samples was determined in general accordance with AASHTO T 88, Standard Method of Test for Particle Size Analysis of Soils. Results of these analyses are presented as grain size distribution curves in Figure B-1 and summarized in Table B-1.

Selected samples were also tested for the percentage of material passing the No. 200 sieve in general accordance with AASHTO T 11, Standard Method of Test for Materials Finer than 75-µm (No. 200) Sieve in Mineral Aggregates by Washing. The percent fines (silt- and clay-sized particles passing the No. 200 sieve) are shown graphically on the boring logs in Appendix A and are also summarized in Table B-1.

B.2.3 Atterberg Limits

Soil plasticity was determined by performing Atterberg limits tests on selected fine-grained samples. The tests were completed in general accordance with ASTM D 4318, Standard Test Methods for Liquid Limit, Plastic Limit, and Plasticity Index of Soils. The Atterberg limits include liquid limit (LL), plastic limit (PL), and plasticity index (PI equals LL minus PL) and are generally used to assist in classification of soils, to indicate soil consistency (when compared to natural water content), and to provide correlation to soil properties. The results of the Atterberg limits tests are plotted on a plasticity chart in Figure B-2, shown graphically on the boring logs in Appendix A, and summarized in Table B-1.

B.3 GEOTECHNICAL ENGINEERING PROPERTY TESTS

B.3.1 One-Dimensional Swell/Consolidation Tests

One-dimensional swell/consolidation tests were performed in general accordance with ASTM D 4546, Standard Test Methods for One-Dimensional Swell or Settlement Potential of Cohesive Soils. The results of the swell tests are included on Figures B-3 and B-4. The samples were loaded at field moisture conditions in a fixed-ring consolidometer that measures vertical changes in volume for different loading conditions. During loading, the sample's pore pressures are allowed to drain from both the top and bottom of the sample. At a specified pressure, the sample is inundated with distilled water and then allowed to reach equilibrium. The vertical volume change caused from the inundation of water (expressed in percent strain) is then determined. Various samples were loaded down to the original height that existed prior to the inundation of water.

B.3.2 R-Value

Hveem Stabilometer (R-value) tests were completed by Vine Laboratories, Inc. of Denver, Colorado to evaluate the stiffness of soils that may be used in the subgrade of the roadway. Tests were completed according to CP-L 3101, Standard Method of Test for Resistance R-value and Expansion Pressure of Compacted Soils. R-value test results are presented on Figures B-5 through B-8 and summarized in Table B-1.

B.3.3 Corrosion

Corrosion testing of select samples was performed for pH, resistivity, sulfate content, and chloride content. Testing for pH and resistivity were done in general accordance with AASHTO T 289, Standard Method of Test for Determining pH of Soil for Use in Corrosion Testing and ASTM G 57, Standard Method of Test for Determining Minimum Laboratory Soil Resistivity, respectively. Sulfate content testing was done in accordance with CDOT laboratory procedure CP-L 2103, Sulfate Ion Content in Soil. Chloride content was done in accordance with AASHTO T 291, Standard Method of Test for Determining Water-Soluble Chloride Ion Content in Soil. Test results for sulfate and chloride content are reported in units of percent by weight. The test results are summarized in Table B-1.

TABLE B-1
SUMMARY OF LABORATORY TEST RESULTS BY BORING

SAMPLE DATA				USCS Symbol[1]	AASHTO Classification	Natural Moisture Content	Moist Unit Weight	GRAIN-SIZE ANALYSES[2]			ATTERBERG LIMITS[3]			R-VALUE		SWELL TEST		CORROSION			
Boring	Sample	Depth (feet) Top	Depth (feet) Bottom			(%)	(pcf)	Gravel (%)	Sand (%)	Fines (%)	Liquid Limit (%)	Plastic Limit (%)	Plasticity Index (%)	R-Value	Exudation Pressure (psi)	Swell (+) Consolidation (-) (%)	Inundation Pressure (psf)	pH	Resistivity (ohm-cm)	Sulfates (%)	Chlorides (%)
SW-P-01	S-1	2.5	3.5			11.7															
	S-2	4.0	5.5	SC	A-2-6	10.5		4	71	25											
SW-P-02	S-1	1.5	2.5			1.3															
	S-2	4.0	5.5			12.7															
	Bulk	2.5	5.5	SC	A-2-6(0)	12.8		9	68	23	28	16	12	24	300						
SW-P-03	S-1	2.0	3.0	SC	A-2-6	12.7		7	66	27											
	S-2	4.0	5.5			8.8															
	Bulk	2.0	5.0			8.7															
SW-P-04	S-1	1.5	2.5			10.0														0.06	
	S-2	4.0	5.5			5.0															
SW-P-05	S-1	1.0	2.0			12.7															
	S-2	4.0	5.5			7.7															
	S-3	9.0	10.5			13.7															
SW-P-06	S-1	1.5	2.5	SC	A-2-4(0)	7.1		4	76	20	25	15	10								
	S-2	4.0	5.5			12.9															
	Bulk	2.0	5.0			5.5															
SW-P-07	S-1	1.5	2.5	CL	A-6(14)	13.7	127.7			65	40	15	25			2.2	150				
	S-2	4.0	4.5			9.7															
SW-P-08	S-1	1.5	2.5			6.0															
	S-2	4.0	5.5			11.9															
	Bulk	2.0	5.0	SM	A-2-4(0)	6.3		14	70	16	NV	NP	NP	62	300						
SW-P-09	S-1	1.5	2.5			6.1															
	S-2	4.0	5.5			8.3															
SW-P-10	S-1	1.5	2.5			8.4															
	S-2	4.0	5.5			12.6															
	S-3	9.0	10.5			9.2															

Notes:

[1] Refer to Appendix A, Figure A-1 for definitions.

[2] Gravel defined as particles larger than the No. 4 sieve size, Sand as particles between the No. 4 and No. 200 sieve sizes, and Fines as particles passing the No. 200 sieve.

[3] NV = No Value; NP = Non-plastic

TABLE B-1
SUMMARY OF LABORATORY TEST RESULTS BY BORING

SAMPLE DATA								GRAIN-SIZE ANALYSES[2]			ATTERBERG LIMITS[3]			R-VALUE		SWELL TEST		CORROSION			
Boring	Sample	Depth (feet) Top	Depth (feet) Bottom	USCS Symbol[1]	AASHTO Classification	Natural Moisture Content (%)	Moist Unit Weight (pcf)	Gravel (%)	Sand (%)	Fines (%)	Liquid Limit (%)	Plastic Limit (%)	Plasticity Index (%)	R-Value	Exudation Pressure (psi)	Swell (+) Consolidation (-) (%)	Inundation Pressure (psf)	pH	Resistivity (ohm-cm)	Sulfates (%)	Chlorides (%)
SW-P-11	S-1	1.5	2.5			5.8															
	S-2	4.0	5.5			8.3															
SW-P-12	S-1	1.5	2.5			6.3															
	S-2	4.0	5.5	SW-SM	A-1-b	3.7		6	88	6											
SW-P-13	S-1	1.5	2.5			8.0															
	S-2	4.0	5.5			7.4															
SW-P-14	S-1	1.5	2.5	SW-SM	A-1-b	4.7		9	84	7											
	S-2	4.0	5.5			9.8															
SW-P-15	S-1	1.5	2.5			6.3															
	S-2	4.0	5.5			14.4															
	S-3	9.0	10.5			4.1															
SW-P-16	S-1	1.5	2.5			8.5															
	S-2	4.0	5.5	SW-SM	A-1-b(0)	7.0		4	88	8	NV	NP	NP								
SW-P-17	S-1	1.5	2.5			4.6															
	S-2	4.0	5.5			25.4															
	Bulk	2.0	5.0			7.8															
SW-P-18	S-1	1.5	2.5			15.7															
	S-2	4.0	5.5			9.6															
SW-P-19	S-1	1.5	2.5			4.5															
	S-2	4.0	5.5			9.9															
	Bulk	2.0	5.0	SM	A-2-4(0)	9.3		2	68	30	NV	NP	NP	16	300						
SW-P-20	S-1	1.5	2.5			9.9															
	S-2	4.0	5.5			9.3															
	S-3	9.0	10.5			9.5															
SW-P-21	S-1	1.5	2.5			8.7														0.01	
	S-2	4.0	5.5			20.5															

Notes:

1 Refer to Appendix A, Figure A-1 for definitions.

2 Gravel defined as particles larger than the No. 4 sieve size, Sand as particles between the No. 4 and No. 200 sieve sizes, and Fines as particles passing the No. 200 sieve.

3 NV = No Value; NP = Non-plastic

TABLE B-1
SUMMARY OF LABORATORY TEST RESULTS BY BORING

SAMPLE DATA								GRAIN-SIZE ANALYSES[2]			ATTERBERG LIMITS[3]			R-VALUE		SWELL TEST		CORROSION			
Boring	Sample	Depth (feet) Top	Depth (feet) Bottom	USCS Symbol[1]	AASHTO Classification	Natural Moisture Content (%)	Moist Unit Weight (pcf)	Gravel (%)	Sand (%)	Fines (%)	Liquid Limit (%)	Plastic Limit (%)	Plasticity Index (%)	R-Value	Exudation Pressure (psi)	Swell (+) Consolidation (-) (%)	Inundation Pressure (psf)	pH	Resistivity (ohm-cm)	Sulfates (%)	Chlorides (%)
SW-P-22	S-1	1.5	2.5			12.4															
	S-2	4.0	5.5			8.5															
SW-P-23	S-1	1.0	2.0	SM	A-1-b	4.4	104.9	9	78	13						-1.2	150				
	S-2	4.0	5.5			5.4															
	Bulk	2.0	5.0			7.3															
SW-P-24	S-1	1.5	2.5			18.9															
	S-2	4.0	5.5			7.3															
SW-P-25	S-1	1.5	2.5	SM	A-2-4	7.6		0	79	21											
	S-2	4.0	5.5			11.9															
	S-3	9.0	10.5			4.9															
SW-P-26	S-1	1.0	2.0			4.2															
	S-2	4.0	5.5			11.6															
SW-P-27	S-1	1.5	2.5			6.5															
	S-2	4.0	5.5			7.6															
	Bulk	2.0	5.0	SM	A-2-4(0)	6.7		8	68	24	NV	NP	NP	16	300						
SW-P-28	S-1	1.5	2.5			11.5															
	S-2	4.5	5.0			8.9															

Notes:

1 Refer to Appendix A, Figure A-1 for definitions.

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3 NV = No Value; NP = Non-plastic

TABLE B-1
SUMMARY OF LABORATORY TEST RESULTS BY BORING

SAMPLE DATA				USCS Symbol[1]	AASHTO Classification	Natural Moisture Content	Moist Unit Weight	GRAIN-SIZE ANALYSES[2]			ATTERBERG LIMITS[3]			R-VALUE		SWELL TEST		CORROSION			
Boring	Sample	Depth (feet) Top	Depth (feet) Bottom			(%)	(pcf)	Gravel (%)	Sand (%)	Fines (%)	Liquid Limit (%)	Plastic Limit (%)	Plasticity Index (%)	R-Value	Exudation Pressure (psi)	Swell (+) Consolidation (-) (%)	Inundation Pressure (psf)	pH	Resistivity (ohm-cm)	Sulfates (%)	Chlorides (%)
	S-1	2.5	4.0			8.3															
	S-2	5.0	6.5			6.7															
	S-3	7.5	9.0	SW-SM		5.2		17	76	7											
	S-4	10.0	11.5			12.7															
SW-W-01	S-5	12.5	14.0	SC	A-6(4)	13.7				47	36	20	16								
	S-6	15.0	16.5			4.7															
	S-7	20.0	21.5			11.2															
	S-8	25.0	26.0			13.4															
	S-9	30.0	30.9			12.1															
	S-1	2.5	4.0			5.6															
	S-2	5.0	6.5			5.3															
	S-3	7.5	9.0			8.9															
	S-4	10.0	11.5	SW-SC		9.9		7	85	8											
SW-W-02	S-5	12.5	14.0			5.8															
	S-6	15.0	16.5			10.3															
	S-7	20.0	21.5	CL	A-6(7)	11.6				54	39	20	19								
	S-8	25.0	26.5			12.3															
	S-9	30.0	31.0			13.5															
	S-1	2.5	4.0			11.9															
	S-2	5.0	6.5			10.8															
	S-3	7.5	9.0			10.3															
	S-4	10.0	11.5	SC	A-7-6(6)	13.1				43	47	22	25								
SW-W-03	S-5	12.5	14.0			11.3															
	S-6	15.0	16.5			11.8															
	S-7	20.0	21.4			11.7															
	S-8	25.0	25.9			13.7															
	S-9	30.0	31.5			13.3															

Notes:
1 Refer to Appendix A, Figure A-1 for definitions.
2 Gravel defined as particles larger than the No. 4 sieve size, Sand as particles between the No. 4 and No. 200 sieve sizes, and Fines as particles passing the No. 200 sieve.
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TABLE B-1
SUMMARY OF LABORATORY TEST RESULTS BY BORING

SAMPLE DATA								GRAIN-SIZE ANALYSES[2]			ATTERBERG LIMITS[3]			R-VALUE		SWELL TEST		CORROSION			
Boring	Sample	Depth (feet) Top	Depth (feet) Bottom	USCS Symbol[1]	AASHTO Classification	Natural Moisture Content (%)	Moist Unit Weight (pcf)	Gravel (%)	Sand (%)	Fines (%)	Liquid Limit (%)	Plastic Limit (%)	Plasticity Index (%)	R-Value	Exudation Pressure (psi)	Swell (+) Consolidation (-) (%)	Inundation Pressure (psf)	pH	Resistivity (ohm-cm)	Sulfates (%)	Chlorides (%)
SW-W-04	S-1	2.5	4.0			5.4															
	S-2	5.0	6.5			12.7															
	S-3	7.5	9.0			10.6															
	S-4	10.0	11.5			11.5															
	S-5	12.5	14.0			9.8															
	S-6	15.0	16.5			13.2															
	S-7	20.0	21.5			16.0															
	S-8	25.0	26.3			11.5															
	S-9	30.0	30.8			11.6															
SW-W-05	S-1	2.5	4.0	SC	A-2-6(1)	12.6				29	35	18	17								
	S-2	5.0	6.5			11.3															
	S-3	7.5	9.0			9.9															
	S-4	10.0	11.0			7.5															
	S-5	15.0	15.9			9.4															
	S-6	20.0	20.5			10.1															
	S-7	25.0	25.9			11.5															
TP-06	S-1	1.0	1.5			2.7															
	S-2	3.0	4.0			17.6															
	S-3	8.0	9.0	SW-SC	A-2-7(0)	7.2		18	70	12	51	20	31								
TP-07	S-1	2.0	3.0			4.4															
	S-2	7.0	8.0	SC		12.7		3	65	32											
TP-08	S-1	0.5	1.0			4.0															
	S-2	1.0	2.7			1.9															
	S-3	3.0	3.5			10.1															
	S-4	4.5	6.0			11.5															

Notes:

[1] Refer to Appendix A, Figure A-1 for definitions.

[2] Gravel defined as particles larger than the No. 4 sieve size, Sand as particles between the No. 4 and No. 200 sieve sizes, and Fines as particles passing the No. 200 sieve.

[3] NV = No Value; NP = Non-plastic

TABLE B-1
SUMMARY OF LABORATORY TEST RESULTS BY BORING

SAMPLE DATA: Boring	Sample	Depth (feet) Top	Depth (feet) Bottom	USCS Symbol[1]	AASHTO Classification	Natural Moisture Content (%)	Moist Unit Weight (pcf)	GRAIN-SIZE ANALYSES[2]: Gravel (%)	Sand (%)	Fines (%)	ATTERBERG LIMITS[3]: Liquid Limit (%)	Plastic Limit (%)	Plasticity Index (%)	R-VALUE: R-Value	Exudation Pressure (psi)	SWELL TEST: Swell (+) Consolidation (-) (%)	Inundation Pressure (psf)	CORROSION: pH	Resistivity (ohm-cm)	Sulfates (%)	Chlorides (%)
SW-W-09	S-1	2.5	4.0			11.8															
	S-2	5.0	6.5			9.7															
	S-3	7.5	9.0	SC	A-2-6(0)	10.3		11	71	18	39	24	15								
	S-4	10.0	11.5			12.8															
	S-5	15.0	16.5			10.2															
	S-6	20.0	20.9			13.4															
SW-W-10	S-1	2.5	4.0			9.3															
	S-2	5.0	6.5			9.5															
	S-3	7.5	9.0	SC	A-2-6(0)	12.3		11	68	21	34	20	14								
	S-4	10.0	11.5			12.3															
	S-5	12.5	13.5			10.9															
	S-6	15.0	16.0			11.3															
	S-7	20.0	20.9			10.8															
SW-W-11	S-1	2.5	2.5			11.8															
	S-2	5.0	6.5			12.5															
	S-3	7.5	9.0	SC	A-2-7(1)	13.1		2	73	25	44	21	23								
	S-4	10.0	11.4			12.4															
	S-5	15.0	16.5			15.1															
	S-6	20.0	20.8			15.8															
SW-W-12	S-1	2.5	4.0			9.8															
	S-2	5.0	6.5			10.7												6.4	2,100	0.030	0.024
	S-3	7.5	9.0	CL	A-2-7(7)	17.4				51	43	14	29								
	S-4	10.0	11.5			10.1															
	S-5	12.5	14.0			11.3															
	S-6	15.0	16.5			12.9															
	S-7	20.0	21.5			16.2															

Notes:

1 Refer to Appendix A, Figure A-1 for definitions.

2 Gravel defined as particles larger than the No. 4 sieve size, Sand as particles between the No. 4 and No. 200 sieve sizes, and Fines as particles passing the No. 200 sieve.

3 NV = No Value; NP = Non-plastic

TABLE B-1
SUMMARY OF LABORATORY TEST RESULTS BY BORING

SAMPLE DATA				USCS Symbol[1]	AASHTO Classification	Natural Moisture Content	Moist Unit Weight	GRAIN-SIZE ANALYSES[2]			ATTERBERG LIMITS[3]			R-VALUE		SWELL TEST		CORROSION			
Boring	Sample	Depth (feet) Top	Depth (feet) Bottom			(%)	(pcf)	Gravel (%)	Sand (%)	Fines (%)	Liquid Limit (%)	Plastic Limit (%)	Plasticity Index (%)	R-Value	Exudation Pressure (psi)	Swell (+) Consolidation (-) (%)	Inundation Pressure (psf)	pH	Resistivity (ohm-cm)	Sulfates (%)	Chlorides (%)
SW-W-13	S-1	2.5	4.0			7.7															
	S-2	5.0	6.5	SC	A-2-6(1)	12.8				30	35	16	19								
	S-3	7.5	9.0	SC		9.7		10	74	16											
	S-4	10.0	11.5			6.7															
	S-5	12.5	14.0			9.6															
	S-6	15.0	16.0			9.4															
	S-7	20.0	21.4			11.8															
TP-14	S-1	1.0	2.0			3.0															
	S-2	4.0	5.0			11.4															
	S-3	7.0	8.0			9.0															
SW-W-15	S-1	2.5	4.0			10.9															
	S-2	5.0	6.5			9.9															
	S-3	7.5	8.8	SC	A-2-7(2)	9.5		7	69	24	47	20	27								
	S-4	10.0	11.5			11.3															
	S-5	15.0	15.9			10.1															
SW-W-16	S-1	2.5	4.0			10.0															
	S-2	5.0	6.5	SC	A-2-7(1)	13.1		6	77	17	70	22	48								
	S-3	10.0	11.5			13.7															
TP-17	S-1	2.5	3.5			3.3															
SW-W-18	S-1	2.5	4.0			13.2															
	S-2	5.0	6.0	SC	A-2-6(1)	9.3		1	73	26	40	19	21								
	S-3	10.0	10.9			11.1															
TP-19	S-1	1.5	2.5			2.1															
	S-2	3.6	4.6			4.4															

Notes:

1 Refer to Appendix A, Figure A-1 for definitions.

2 Gravel defined as particles larger than the No. 4 sieve size, Sand as particles between the No. 4 and No. 200 sieve sizes, and Fines as particles passing the No. 200 sieve.

3 NV = No Value; NP = Non-plastic

TABLE B-1
SUMMARY OF LABORATORY TEST RESULTS BY BORING

SAMPLE DATA								GRAIN-SIZE ANALYSES[2]			ATTERBERG LIMITS[3]			R-VALUE		SWELL TEST		CORROSION			
Boring	Sample	Depth (feet) Top	Depth (feet) Bottom	USCS Symbol[1]	AASHTO Classification	Natural Moisture Content (%)	Moist Unit Weight (pcf)	Gravel (%)	Sand (%)	Fines (%)	Liquid Limit (%)	Plastic Limit (%)	Plasticity Index (%)	R-Value	Exudation Pressure (psi)	Swell (+) Consolidation (-) (%)	Inundation Pressure (psf)	pH	Resistivity (ohm-cm)	Sulfates (%)	Chlorides (%)
SW-W-20	S-1	2.5	4.0	SC	A-6(0)	11.8		1	61	38	29	17	12								
	S-2	5.0	5.8			12.8															
	S-3	7.5	8.1			10.7															
	S-4	10.0	10.8			12.7															
	S-5	15.0	16.3			9.3															
	S-6	20.0	20.8			8.9															
SW-W-21	S-1	2.5	4.0	SC	A-2-7(0)	11.9		1	80	19	44	26	18								
	S-2A	5.0	6.0			11.7															
	S-2B	6.0	6.5			16.3															
	S-3	10.0	10.3			6.9															
SW-W-22	S-1	2.5	3.4			9.1															
	S-2	5.0	6.0			10.7												6.8	570	0.01	0.098
	S-3	10.0	11.4			11.7															
SW-W-23	S-1	2.5	4.0			6.7															
	S-2	5.0	6.5			7.6															
	S-3	7.5	9.0			8.2															
	S-4	10.0	11.5			11.1															
SW-W-24	S-1	2.5	4.0			5.9															
	S-2	5.0	6.5			8.7															
	S-3	7.5	9.0	SW-SC		6.2		20	70	10											
	S-4	10.0	11.5			8.6															
	S-5	15.0	16.5			6.6															
	S-6	20.0	21.5			11.3															

Notes:

1 Refer to Appendix A, Figure A-1 for definitions.

2 Gravel defined as particles larger than the No. 4 sieve size, Sand as particles between the No. 4 and No. 200 sieve sizes, and Fines as particles passing the No. 200 sieve.

3 NV = No Value; NP = Non-plastic

TABLE B-1
SUMMARY OF LABORATORY TEST RESULTS BY BORING

SAMPLE DATA								GRAIN-SIZE ANALYSES[2]			ATTERBERG LIMITS[3]			R-VALUE		SWELL TEST		CORROSION			
Boring	Sample	Depth (feet) Top	Depth (feet) Bottom	USCS Symbol[1]	AASHTO Classification	Natural Moisture Content (%)	Moist Unit Weight (pcf)	Gravel (%)	Sand (%)	Fines (%)	Liquid Limit (%)	Plastic Limit (%)	Plasticity Index (%)	R-Value	Exudation Pressure (psi)	Swell (+) Consolidation (-) (%)	Inundation Pressure (psf)	pH	Resistivity (ohm-cm)	Sulfates (%)	Chlorides (%)
SW-W-25	S-1	2.5	5.0			7.1															
	S-2	5.0	6.5			8.1															
	S-3	7.5	9.0	SM	A-2-4(0)	8.4		0	72	28	NV	NP	NP								
	S-4	10.0	11.5			8.7															
	S-5	15.0	15.5			6.0															
SW-W-26	S-1A	2.5	3.0			8.2															
	S-1B	3.0	4.0			6.9															
	S-2	5.0	6.5			10.0															
	S-3	7.5	9.0			6.2															
	S-4	10.0	11.4			12.0															
	S-5	15.0	15.8			3.6															
SW-W-27	S-1	2.5	4.0	CL		7.3		3	35	62											
	S-2	5.0	6.5			10.7															
	S-3	7.5	9.0			8.8															
	S-4	10.0	11.5			8.7															
	S-5	15.0	16.0			9.4															
TP-28	S-1	3.5	4.8			7.1															
	S-2	5.0	6.0			12.8															
TP-29	S-1	3.5	4.5	SW-SM	A-2-6(0)	7.1		9	83	8	38	26	12								
	S-2	8.0	9.0			11.1															
SW-W-30	S-1	2.5	4.0			6.9															
	S-2	5.0	6.5	SC		7.0		12	76	12											
	S-3	7.5	8.2			7.4															
	S-4	10.0	11.5			10.3															
	S-5	15.0	16.0			9.8															
	S-6	20.0	21.0			11.5															

Notes:

1 Refer to Appendix A, Figure A-1 for definitions.

2 Gravel defined as particles larger than the No. 4 sieve size, Sand as particles between the No. 4 and No. 200 sieve sizes, and Fines as particles passing the No. 200 sieve.

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TABLE B-1
SUMMARY OF LABORATORY TEST RESULTS BY BORING

SAMPLE DATA: Boring	Sample	Depth (feet): Top	Depth (feet): Bottom	USCS Symbol[1]	AASHTO Classification	Natural Moisture Content (%)	Moist Unit Weight (pcf)	GRAIN-SIZE ANALYSES[2]: Gravel (%)	Sand (%)	Fines (%)	ATTERBERG LIMITS[3]: Liquid Limit (%)	Plastic Limit (%)	Plasticity Index (%)	R-VALUE: R-Value	Exudation Pressure (psi)	SWELL TEST: Swell (+) Consolidation (-) (%)	Inundation Pressure (psf)	CORROSION: pH	Resistivity (ohm-cm)	Sulfates (%)	Chlorides (%)
SW-W-31	S-1	2.5	4.0			4.4															
	S-2	5.0	6.5			11.0															
	S-3	7.5	8.5			7.7															
	S-4	10.0	10.9			14.2															
	S-5	15.0	15.8			10.6															
	S-6	20.0	20.7			12.2															
SW-W-32	S-1	2.5	4.0	SW-SC		7.3		14	76	10											
	S-2	5.0	6.4			8.4															
	S-3	7.5	8.1			9.1															
	S-4	10.0	11.5			9.2															
	S-5	15.0	16.5			10.6															
	S-6	20.0	20.9			8.5															
TP-33	S-1	2.5	3.0			7.2															
	S-2	4.0	5.0			14.2															
	S-3	7.0	8.0			8.9															
SW-W-34	S-1	2.5	4.0			4.9															
	S-2	5.0	6.5	SM	A-2-4(0)	12.6		0	80	20	NV	NP	NP								
	S-3	7.5	8.9			9.9															
	S-4	10.0	11.0			7.8															
	S-5	15.0	16.4			13.0															
	S-6	20.0	20.9			8.8															
SW-W-35	S-1	2.5	4.0			9.5															
	S-2	5.0	6.5			7.7															
	S-3	7.5	9.0			9.7															
	S-4	10.0	11.5	SW-SC	A-2-4(0)	10.7		13	75	12	29	20	9								
	S-5	12.5	13.5			8.3															
	S-6	15.0	15.9			9.1															

Notes:

1 Refer to Appendix A, Figure A-1 for definitions.

2 Gravel defined as particles larger than the No. 4 sieve size, Sand as particles between the No. 4 and No. 200 sieve sizes, and Fines as particles passing the No. 200 sieve.

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TABLE B-1
SUMMARY OF LABORATORY TEST RESULTS BY BORING

SAMPLE DATA: Boring	SAMPLE DATA: Sample	Depth (feet): Top	Depth (feet): Bottom	USCS Symbol[1]	AASHTO Classification	Natural Moisture Content (%)	Moist Unit Weight (pcf)	GRAIN-SIZE ANALYSES[2]: Gravel (%)	GRAIN-SIZE ANALYSES[2]: Sand (%)	GRAIN-SIZE ANALYSES[2]: Fines (%)	ATTERBERG LIMITS[3]: Liquid Limit (%)	ATTERBERG LIMITS[3]: Plastic Limit (%)	ATTERBERG LIMITS[3]: Plasticity Index (%)	R-VALUE: R-Value	R-VALUE: Exudation Pressure (psi)	SWELL TEST: Swell (+) Consolidation (-) (%)	SWELL TEST: Inundation Pressure (psf)	CORROSION: pH	CORROSION: Resistivity (ohm-cm)	CORROSION: Sulfates (%)	CORROSION: Chlorides (%)
SW-W-36	S-1	2.5	4.0	SC							40	16	24								
	S-2	5.0	6.5			7.7												7.6	2,200	0.090	0.021
	S-3	10.0	11.0			8.9															
	S-4	15.0	16.0			9.9															
SW-W-37	S-1	2.5	4.0			9.7															
	S-2	5.0	6.5			6.5															
	S-3	7.5	9.0			10.7															
	S-4	10.0	11.5			10.0															
	S-5	15.0	16.5			11.3															
SW-W-38	S-1	2.5	4.0			16.6															
	S-2	5.0	6.5	SP-SM		5.1		0	90	10											
	S-3	7.5	9.0			7.9															
	S-4	10.0	11.5			10.5															
	S-5	12.5	14.0			10.9															
	S-6	15.0	16.5			11.6															

Notes:

1 Refer to Appendix A, Figure A-1 for definitions.

2 Gravel defined as particles larger than the No. 4 sieve size, Sand as particles between the No. 4 and No. 200 sieve sizes, and Fines as particles passing the No. 200 sieve.

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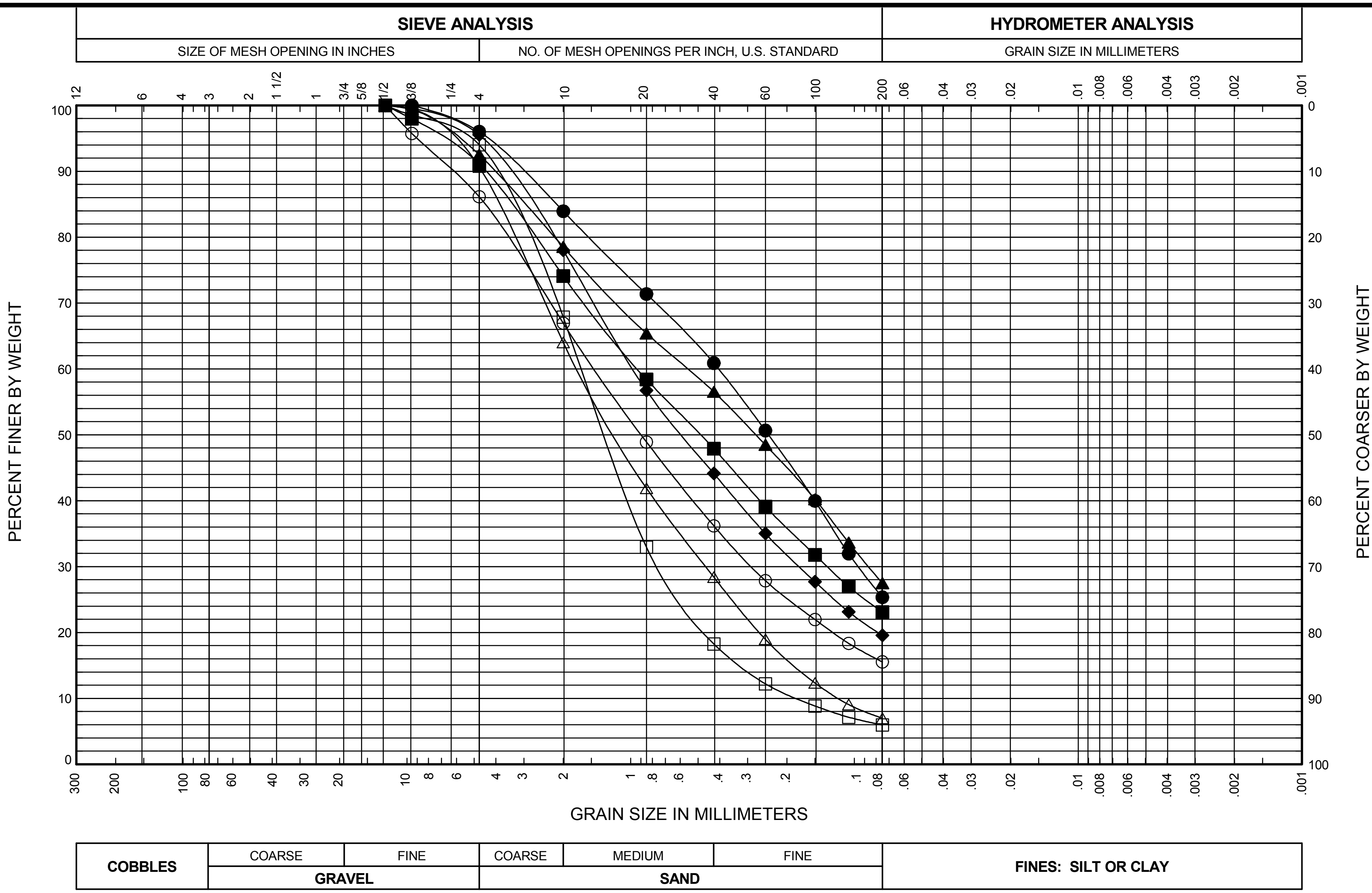

SAMPLE ID	DEPTH (feet)	U.S.C.S. SYMBOL	SAMPLE DESCRIPTION	FINES %	NAT. W.C. %	LL %	PL %	PI %
● SW-P-01, S-2	4.8	SC	Clayey Sand; trace gravel. [A-2-6]	25.3	10.5			
■ SW-P-02, Bulk	4.0	SC	SANDSTONE: Clayey Sand; few gravel. [A-2-6]	23.1	12.8	28	16	12
▲ SW-P-03, S-1	2.5	SC	Clayey Sand; few gravel. [A-2-6]	27.5	12.7			
◆ SW-P-06, S-1	2.0	SC	Clayey Sand; trace gravel. [A-2-4]	19.5	7.1	25	15	10
○ SW-P-08, Bulk	3.5	SM	Silty Sand; few gravel. [A-2-4]	15.5	6.3	NV	NP	NP
□ SW-P-12, S-2	4.8	SW-SM	Well-Graded Sand with Silt; few gravel. [A-1-b]	6.0	3.7			
△ SW-P-14, S-1	2.0	SW-SM	Well-Graded Sand with Silt; few gravel. [A-1-b]	7.0	4.7			

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FIG. B-1
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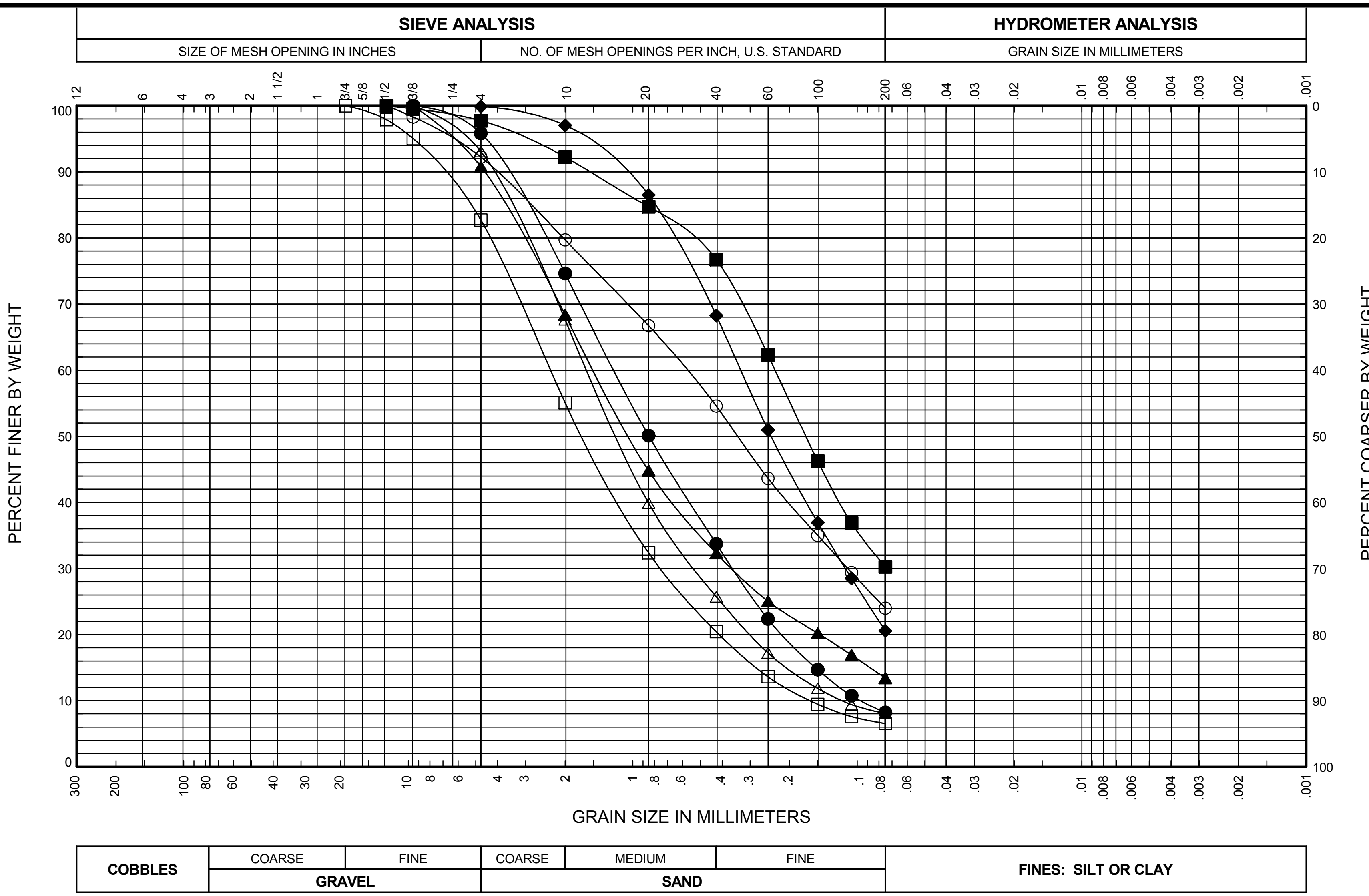

SAMPLE ID	DEPTH (feet)	U.S.C.S. SYMBOL	SAMPLE DESCRIPTION	FINES %	NAT. W.C. %	LL %	PL %	PI %
● SW-P-16, S-2	4.8	SW-SM	Well-Graded Sand with Silt; trace gravel. [A-1-b]	8.2	7.0	NV	NP	NP
■ SW-P-19, Bulk	3.5	SM	Silty Sand; trace gravel. [A-2-4]	30.3	9.3	NV	NP	NP
▲ SW-P-23, S-1	1.5	SM	Silty Sand; few gravel. [A-1-b]	13.4	4.4			
◆ SW-P-25, S-1	2.0	SM	Silty Sand. [A-2-4]	20.6	7.6			
○ SW-P-27, Bulk	3.5	SM	Silty Sand; few gravel. [A-2-4]	24.0	6.7	NV	NP	NP
□ SW-W-01, S-3	8.3	SW-SM	Well-Graded Sand with Silt and Gravel.	6.5	5.2			
△ SW-W-02, S-4	10.8	SW-SC	Well-Graded Sand with Clay; few gravel.	8.1	9.9			

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FIG. B-1
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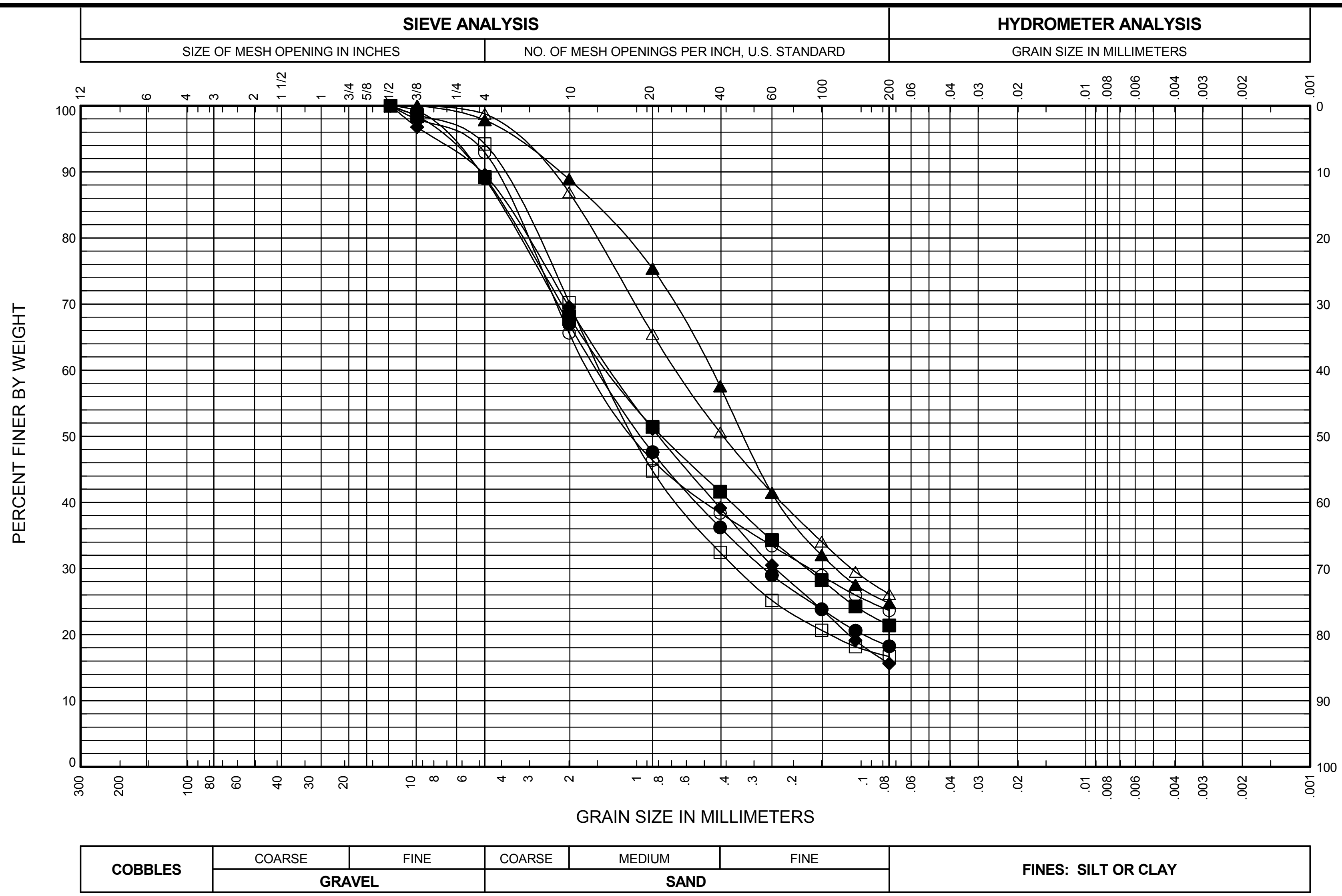

SAMPLE ID	DEPTH (feet)	U.S.C.S. SYMBOL	SAMPLE DESCRIPTION	FINES %	NAT. W.C. %	LL %	PL %	PI %
● SW-W-09, S-3	8.3	SC	SANDSTONE: Clayey Sand; few gravel.	18.2	10.3	39	24	15
■ SW-W-10, S-3	8.3	SC	Clayey Sand; few gravel.	21.4	12.3	34	20	14
▲ SW-W-11, S-3	8.3	SC	SANDSTONE: Clayey Sand; trace gravel.	24.7	13.1	44	21	23
◆ SW-W-13, S-3	8.3	SC	Clayey Sand; few gravel.	15.6	9.7			
○ SW-W-15, S-3	8.2	SC	SANDSTONE: Clayey Sand; few gravel.	23.6	9.5	47	20	27
□ SW-W-16, S-2	5.8	SC	Clayey Sand; few gravel.	16.7	13.1	70	22	48
△ SW-W-18, S-2	5.5	SC	SANDSTONE: Clayey Sand; trace gravel.	26.1	9.3	40	19	21

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FIG. B-1
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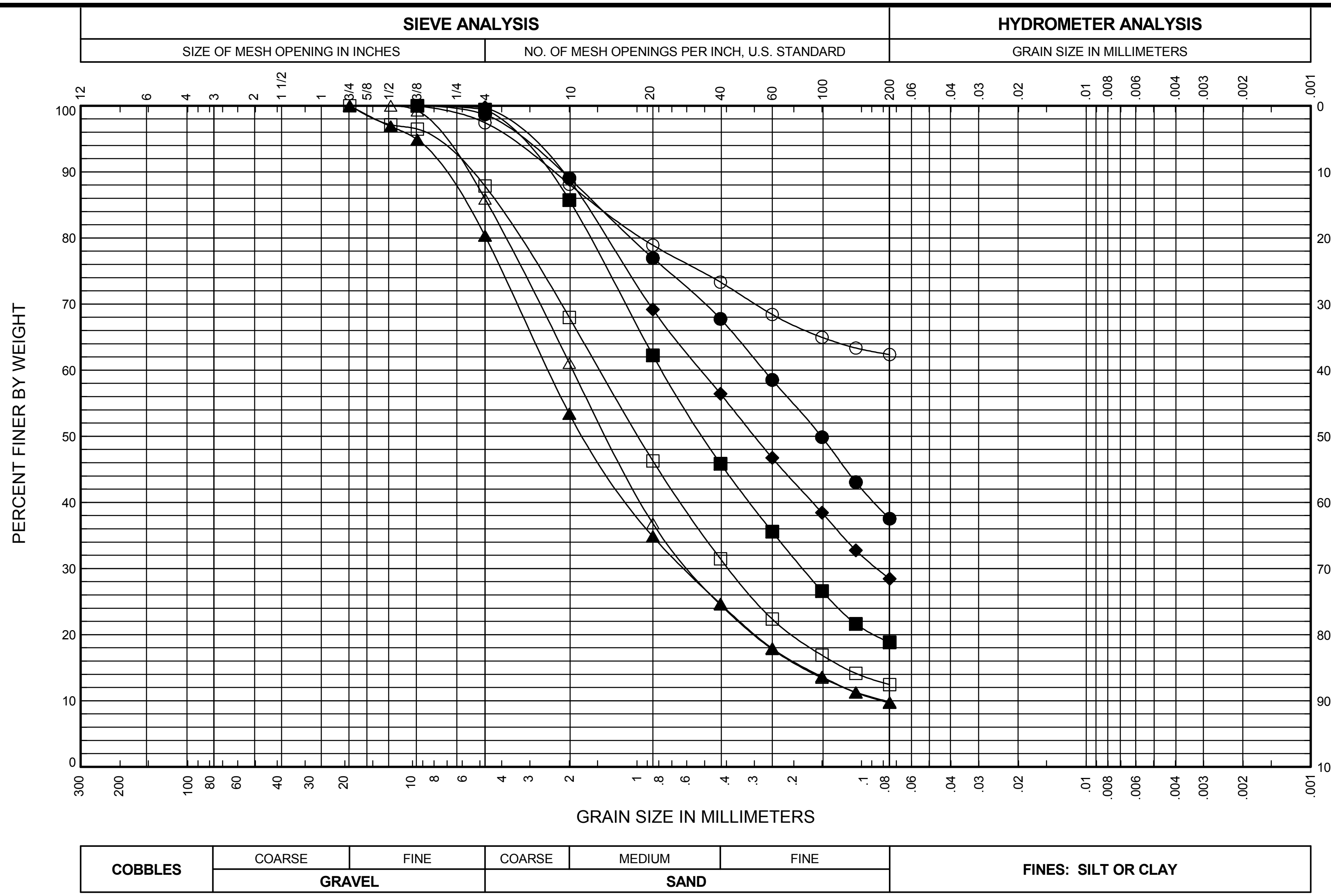

SAMPLE ID	DEPTH (feet)	U.S.C.S. SYMBOL	SAMPLE DESCRIPTION	FINES %	NAT. W.C. %	LL %	PL %	PI %
● SW-W-20, S-1	3.3	SC	Clayey Sand; trace gravel.	37.5	11.8	29	17	12
■ SW-W-21, S-1	3.3	SC	SANDSTONE: Clayey Sand; trace gravel.	18.8	11.9	44	26	18
▲ SW-W-24, S-3	8.3	SW-SC	Well-Graded Sand with Clay and Gravel.	9.7	6.2			
◆ SW-W-25, S-3	8.3	SM	SANDSTONE: Silty Sand.	28.4	8.4	NV	NP	NP
○ SW-W-27, S-1	3.3	CL	CLAYSTONE: Sandy Lean Clay; trace gravel.	62.4	7.3			
□ SW-W-30, S-2	5.8	SC	Clayey Sand; few gravel.	12.4	7.0			
△ SW-W-32, S-1	3.3	SW-SC	SANDSTONE: Well-Graded Sand with Clay; few gravel.	9.8	7.3			

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FIG. B-1
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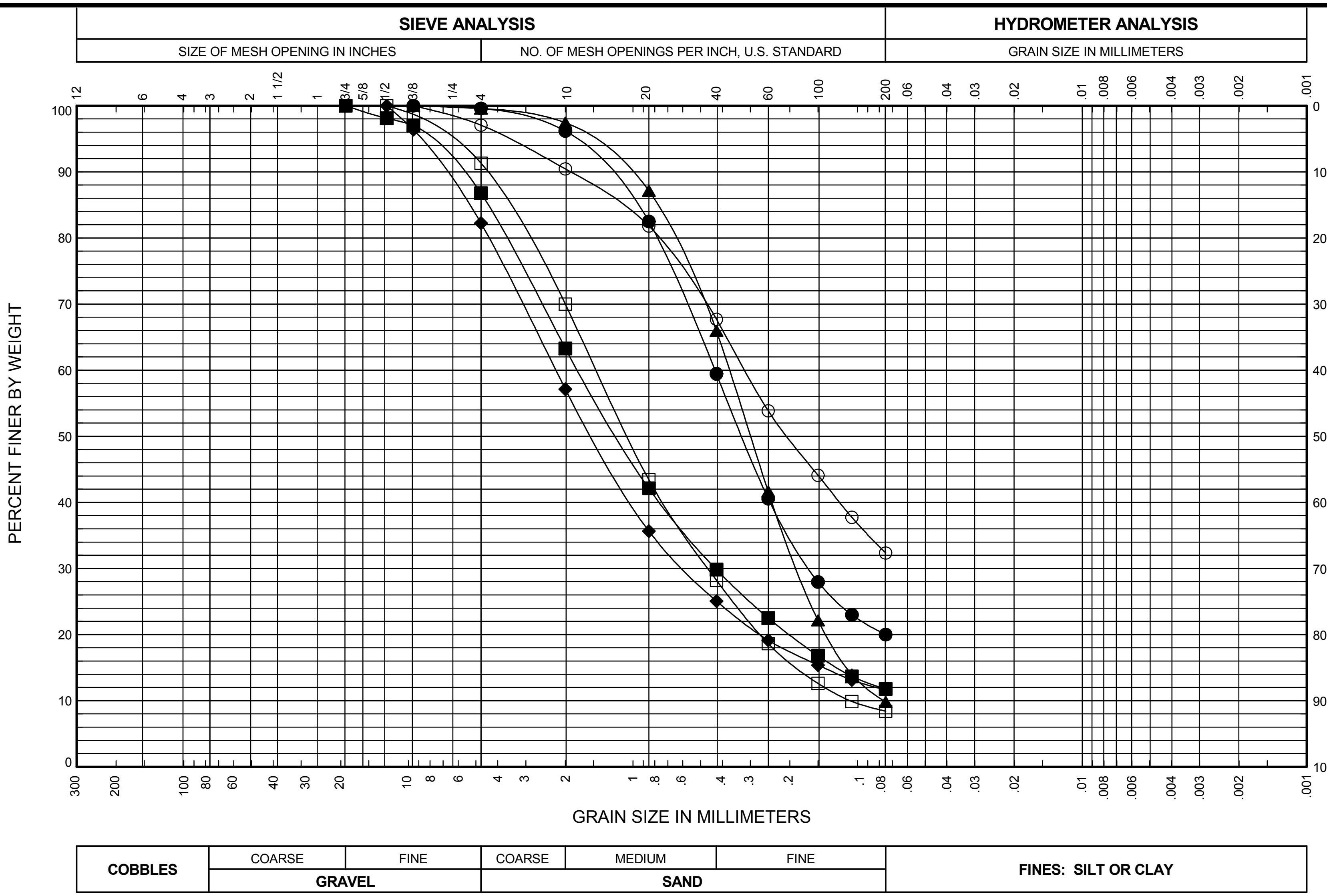

SAMPLE ID	DEPTH (feet)	U.S.C.S. SYMBOL	SAMPLE DESCRIPTION	FINES %	NAT. W.C. %	LL %	PL %	PI %
● SW-W-34, S-2	5.8	SM	SANDSTONE: Silty Sand.	20.0	12.6	NV	NP	NP
■ SW-W-35, S-4	10.8	SW-SC	Well-Graded Sand with Clay; few gravel.	11.8	10.7	29	20	9
▲ SW-W-38, S-2	5.8	SP-SM	Poorly Graded Sand with Silt.	9.8	5.1			
◆ TP-06, S-3	8.5	SW-SC	SANDSTONE: Well-Graded Sand with Clay and Gravel.	11.6	7.2	51	20	31
○ TP-07, S-2	7.5	SC	SANDSTONE: Clayey Sand; trace gravel.	32.3	12.7			
□ TP-29, S-1	4.0	SW-SM	SANDSTONE: Well-Graded Sand with Silt; few gravel.	8.4	7.1	38	26	12

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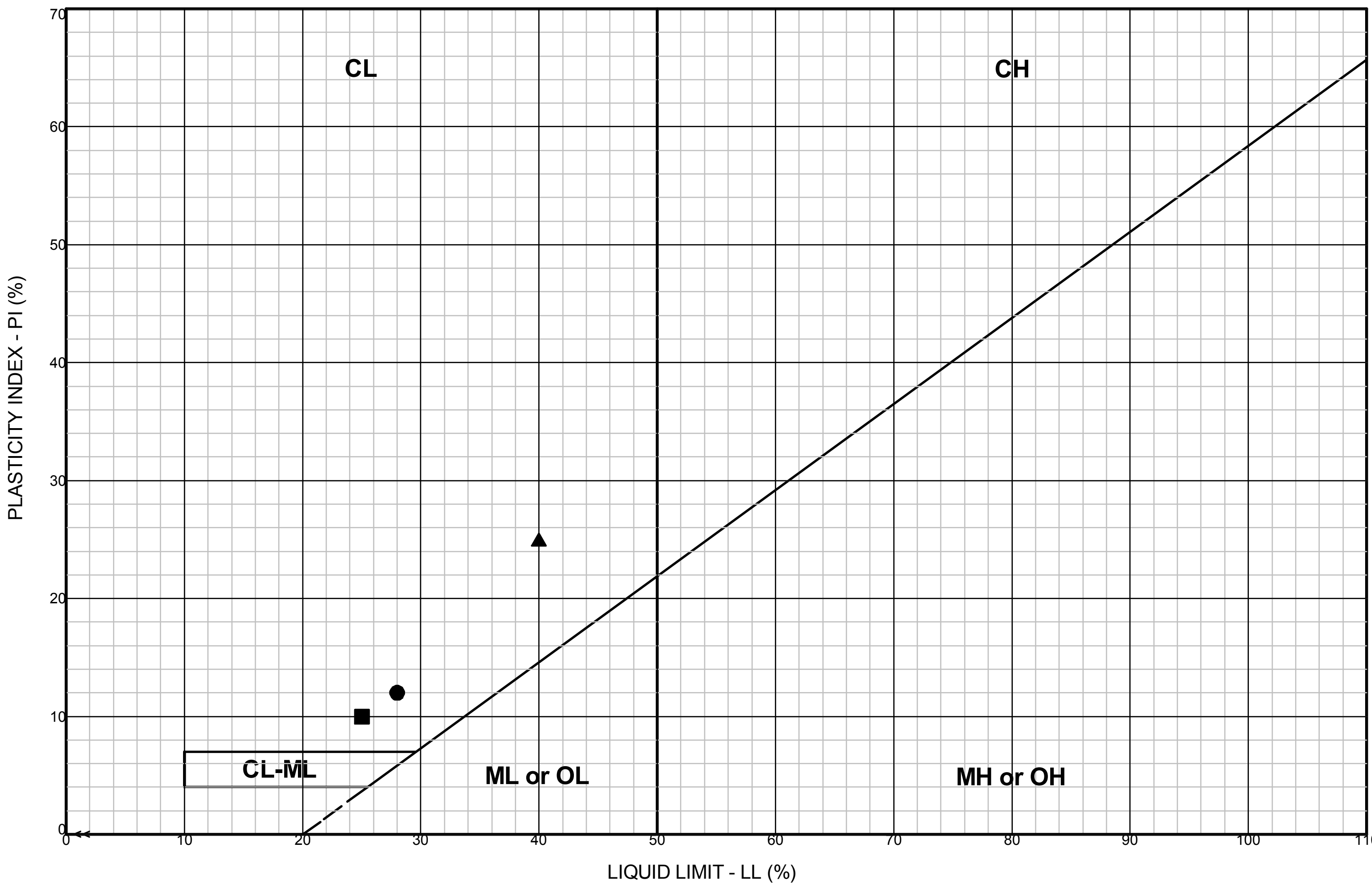
FIG. B-1
Sheet 5 of 5

FIG. B-1
Sheet 5 of 5



LEGEND

CL: Low plasticity inorganic clays; sandy and silty clays

CH: High plasticity inorganic clays

ML or OL: Inorganic and organic silts and clayey silts of low plasticity

MH or OH: Inorganic and organic silts and clayey silts of high plasticity

CL-ML: Silty clays and clayey silts

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SAMPLE ID	DEPTH (feet)	U.S.C.S. SYMBOL	SOIL CLASSIFICATION	LL %	PL %	PI %	NAT. W.C. %	PASS. #200, %
● SW-P-02, Bulk	4.0	SC	SANDSTONE: Clayey Sand; few gravel. [A-2-6]	28	16	12	12.8	23.1
■ SW-P-06, S-1	2.0	SC	Clayey Sand; trace gravel. [A-2-4]	25	15	10	7.1	19.5
▲ SW-P-07, S-1	2.0	CL	CLAYSTONE: Sandy Lean Clay. [A-6]	40	15	25	13.7	64.9
SW-P-08, Bulk	3.5	SM	Silty Sand; few gravel. [A-2-4]	NV	NP	NP	6.3	15.5
SW-P-16, S-2	4.8	SW-SM	Well-Graded Sand with Silt; trace gravel. [A-1-b]	NV	NP	NP	7.0	8.2
SW-P-19, Bulk	3.5	SM	Silty Sand; trace gravel. [A-2-4]	NV	NP	NP	9.3	30.3
SW-P-27, Bulk	3.5	SM	Silty Sand; few gravel. [A-2-4]	NV	NP	NP	6.7	24.0

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PLASTICITY CHART

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FIG. B-2
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FIG. B-2
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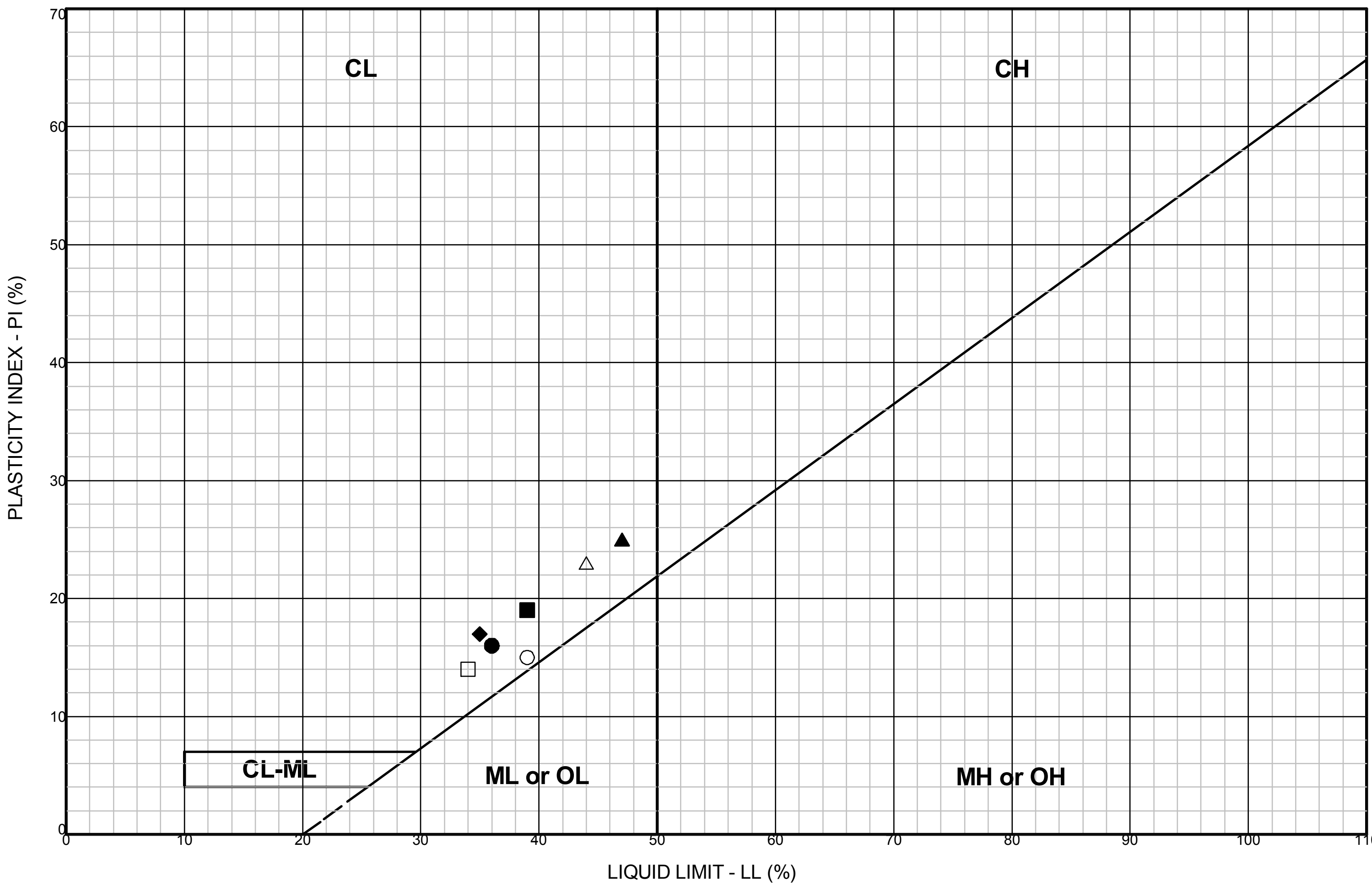

LEGEND

CL: Low plasticity inorganic clays; sandy and silty clays

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ML or OL: Inorganic and organic silts and clayey silts of low plasticity

MH or OH: Inorganic and organic silts and clayey silts of high plasticity

CL-ML: Silty clays and clayey silts

SAMPLE ID	DEPTH (feet)	U.S.C.S. SYMBOL	SOIL CLASSIFICATION	LL %	PL %	PI %	NAT. W.C. %	PASS. #200, %
● SW-W-01, S-5	13.3	SC	SANDSTONE: Clayey Sand.	36	20	16	13.7	46.7
■ SW-W-02, S-7	20.8	CL	CLAYSTONE: Sandy Lean Clay.	39	20	19	11.6	53.5
▲ SW-W-03, S-4	10.8	SC	Clayey Sand.	47	22	25	13.1	43.2
◆ SW-W-05, S-1	3.3	SC	Clayey Sand.	35	18	17	12.6	28.8
○ SW-W-09, S-3	8.3	SC	SANDSTONE: Clayey Sand; few gravel.	39	24	15	10.3	18.2
□ SW-W-10, S-3	8.3	SC	Clayey Sand; few gravel.	34	20	14	12.3	21.4
△ SW-W-11, S-3	8.3	SC	SANDSTONE: Clayey Sand; trace gravel.	44	21	23	13.1	24.7

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PLASTICITY CHART

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FIG. B-2
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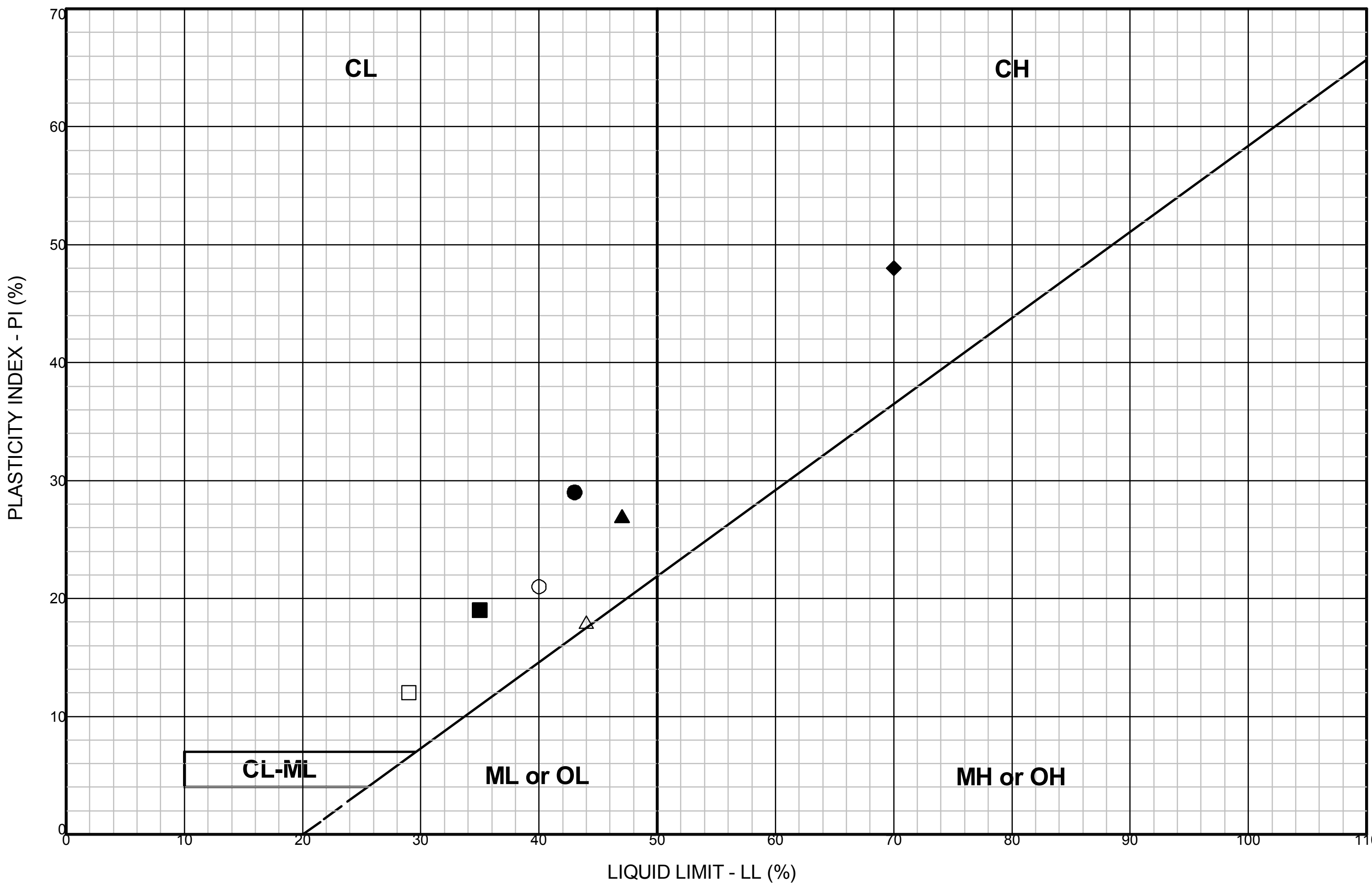

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SAMPLE ID	DEPTH (feet)	U.S.C.S. SYMBOL	SOIL CLASSIFICATION	LL %	PL %	PI %	NAT. W.C. %	PASS. #200, %
● SW-W-12, S-3	8.3	CL	Sandy Lean Clay.	43	14	29	17.4	51.2
■ SW-W-13, S-2	5.8	SC	Clayey Sand.	35	16	19	12.8	29.7
▲ SW-W-15, S-3	8.2	SC	SANDSTONE: Clayey Sand; few gravel.	47	20	27	9.5	23.6
◆ SW-W-16, S-2	5.8	SC	Clayey Sand; few gravel.	70	22	48	13.1	16.7
○ SW-W-18, S-2	5.5	SC	SANDSTONE: Clayey Sand; trace gravel.	40	19	21	9.3	26.1
□ SW-W-20, S-1	3.3	SC	Clayey Sand; trace gravel.	29	17	12	11.8	37.5
△ SW-W-21, S-1	3.3	SC	SANDSTONE: Clayey Sand; trace gravel.	44	26	18	11.9	18.8

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PLASTICITY CHART

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FIG. B-2
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FIG. B-2
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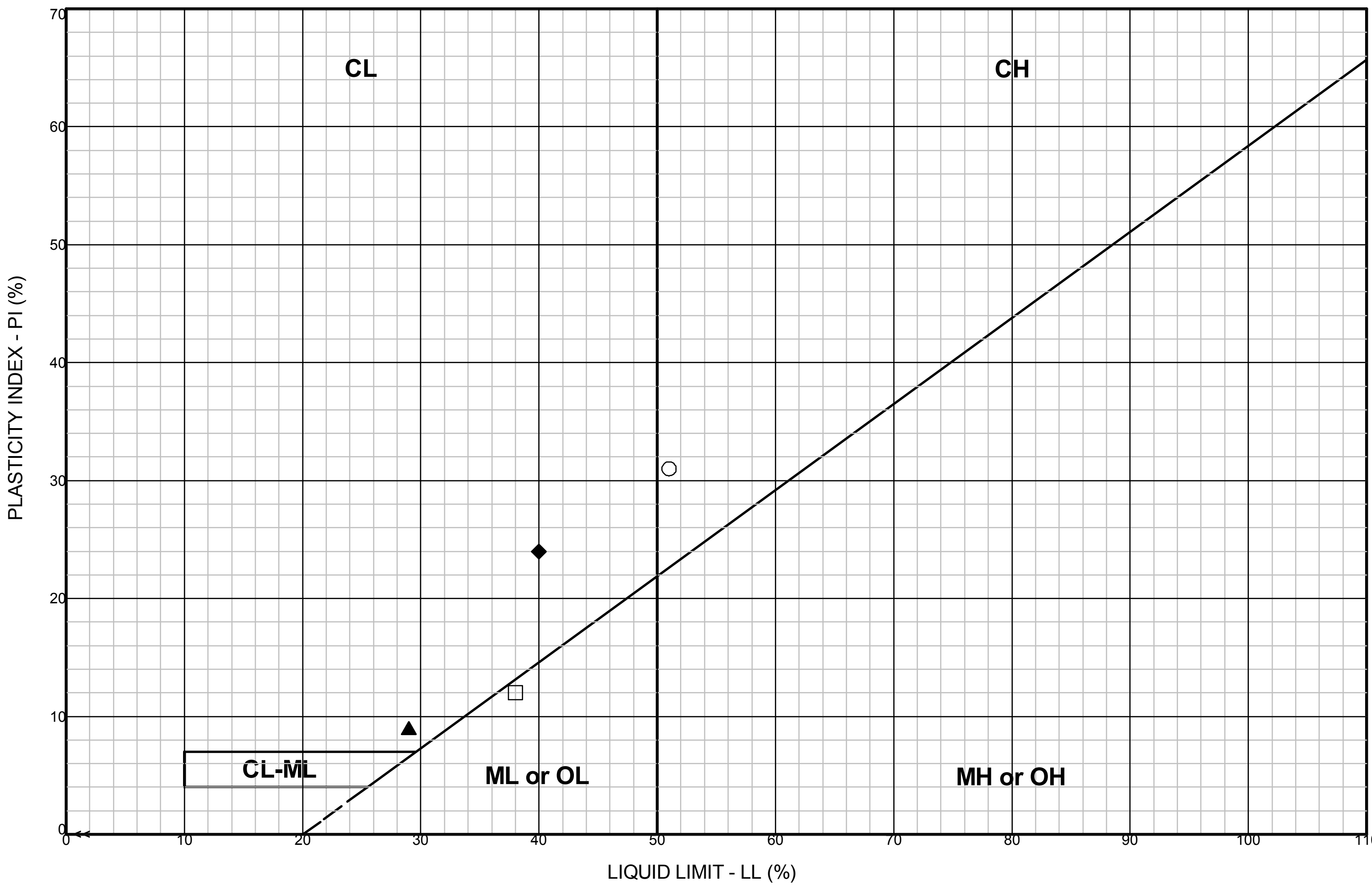

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SAMPLE ID	DEPTH (feet)	U.S.C.S. SYMBOL	SOIL CLASSIFICATION	LL %	PL %	PI %	NAT. W.C. %	PASS. #200, %
SW-W-25, S-3	8.3	SM	SANDSTONE: Silty Sand.	NV	NP	NP	8.4	28.4
SW-W-34, S-2	5.8	SM	SANDSTONE: Silty Sand.	NV	NP	NP	12.6	20.0
▲ SW-W-35, S-4	10.8	SW-SC	Well-Graded Sand with Clay; few gravel.	29	20	9	10.7	11.8
◆ SW-W-36, S-1	3.3	SC	Clayey Sand.	40	16	24		
○ TP-06, S-3	8.5	SW-SC	SANDSTONE: Well-Graded Sand with Clay and Gravel.	51	20	31	7.2	11.6
□ TP-29, S-1	4.0	SW-SM	SANDSTONE: Well-Graded Sand with Silt; few gravel.	38	26	12	7.1	8.4

Highway 105
Corridor Improvements
El Paso County, Colorado

PLASTICITY CHART

July 2017 23-1-01311-002

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

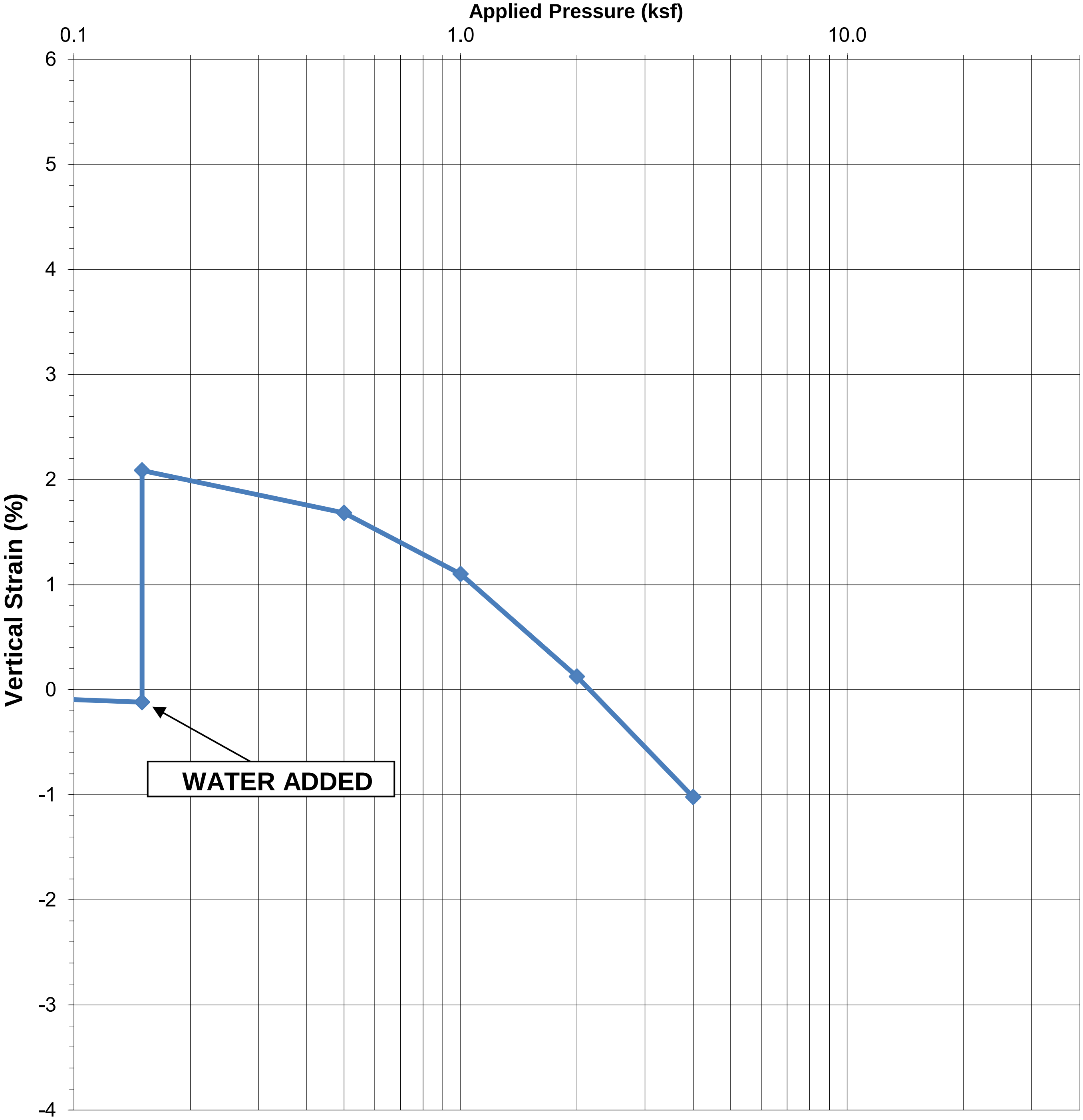
FIG. B-2
Sheet 4 of 4

HDR Engineering, Inc.

FIG. B-2
Sheet 4 of 4

ATT_MAIN 23-1-01311-002.GPJ SHAN_WIL.GDT 7/6/17

CONSOLIDATION/SWELL TEST REPORT
Boring SW-P-07: Sample 1, 1.5 - 2.5 ft



Swell =	2.2	%
Inundation Pressure =	150	psf
Initial Moisture Content =	13.7	%
Final Moisture Content =	17.4	%
Moist Density =	127.7	pcf

NOTE:

Testing was done in general accordance with ASTM D 4546(B), Standard Test Methods for One-Dimensional Swell or Settlement Potential of Cohesive Soils.

Highway 105
Corridor Improvements
El Paso County, Colorado

CONSOLIDATION/SWELL TEST REPORT
BORING SW-P-07, SAMPLE 1

July 2017 | 23-1-01311-002

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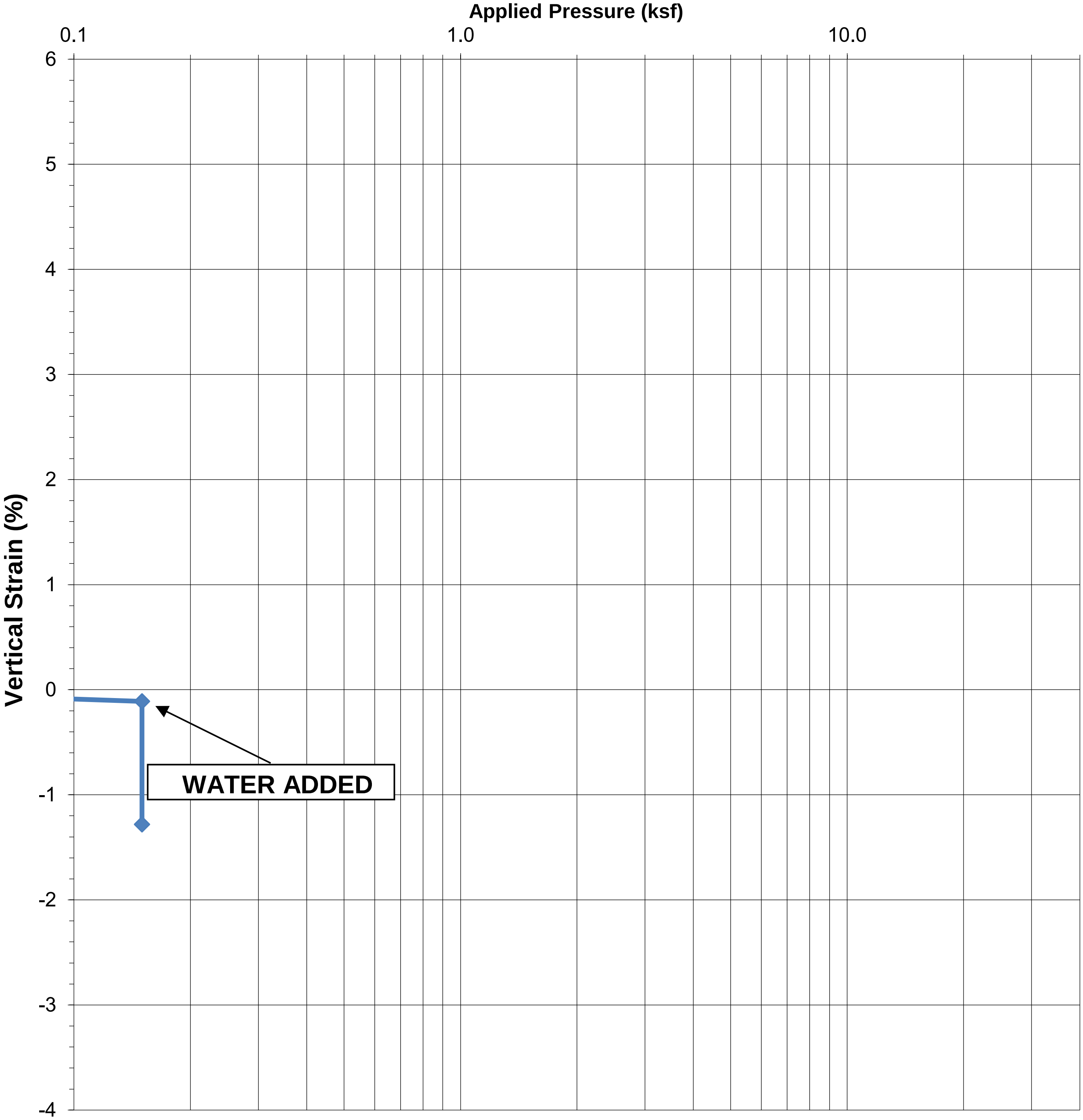
Geotechnical and Environmental Consultants

FIG. B-3

CONSOLIDATION/SWELL TEST REPORT
Boring SW-P-23: Sample 1, 1.0 - 2.0 ft



Swell =	-1.2	%
Inundation Pressure =	150	psf
Initial Moisture Content =	4.4	%
Final Moisture Content =	16.0	%
Moist Density =	104.9	pcf

NOTE:

Testing was done in general accordance with ASTM D 4546(B), Standard Test Methods for One-Dimensional Swell or Settlement Potential of Cohesive Soils.

Highway 105
Corridor Improvements
El Paso County, Colorado

CONSOLIDATION/SWELL TEST REPORT
BORING SW-P-23, SAMPLE 1

July 2017 23-1-01311-002

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. B-4

R-Value Test Report

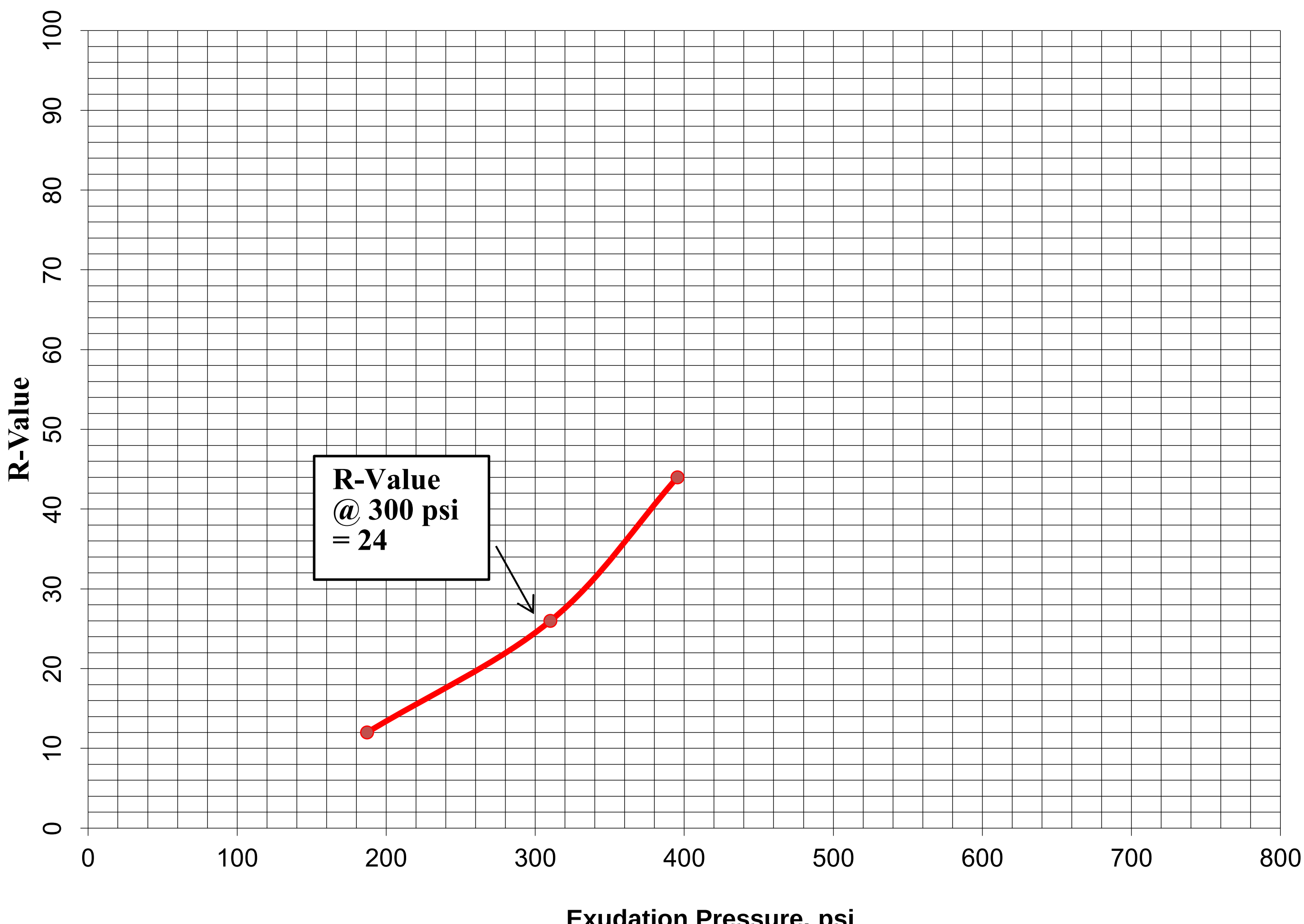
CP-L 3101

Project: SH 105
Job Number: 23-1-01311-002

Report Date: 7/12/16

Reported to: Shannon & Wilson , Inc

Sample Information		Test Data Summary			
Sample Number:	587	Specimen No.	1	2	3
Sample Location:	SW / P / 02	Moisture %	10.17	8.72	7.85
Material Desc.:	SW / P / 02 Bulk Sample				
Date Sampled:	7/12/16	R-Value (corrected)	12.0	26.0	44.0
Sampled By:	S&W	Exudation Pressure, psi	187	310	395



Vine Laboratories, Inc.

Tested By: Juan Romero

Reviewed By: Darrell Evig, P.E.

FIG. B-5

R-Value Test Report
CP-L 3101

Project: SH 105
Job Number: 23-1-01311-002

Report Date: 7/12/16

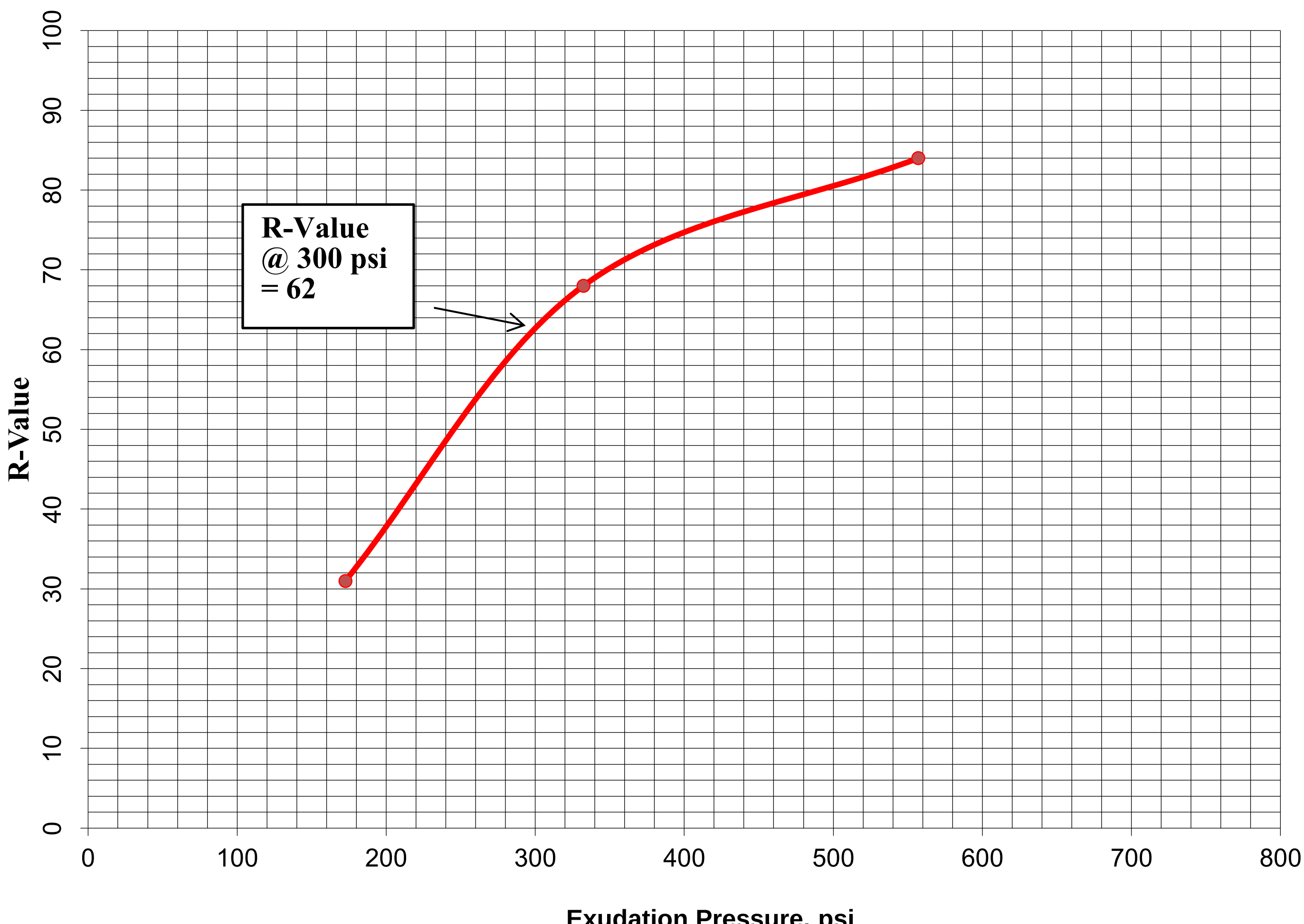
Reported to: Shannon & Wilson , Inc

Sample Information

Sample Number:	588
Sample Location:	SW / P / 08
Material Desc.:	SW / P / 08 Bulk Sampl
Date Sampled:	7/12/16
Sampled By:	S&W

Test Data Summary

Specimen No.	1	2	3
Moisture %	8.53	7.62	6.56
R-Value (corrected)	31.0	68.0	84.0
Exudation Pressure, psi	173	332	557



Vine Laboratories, Inc.

Tested By: Juan Romero

Reviewed By: Darrell Evig, P.E.

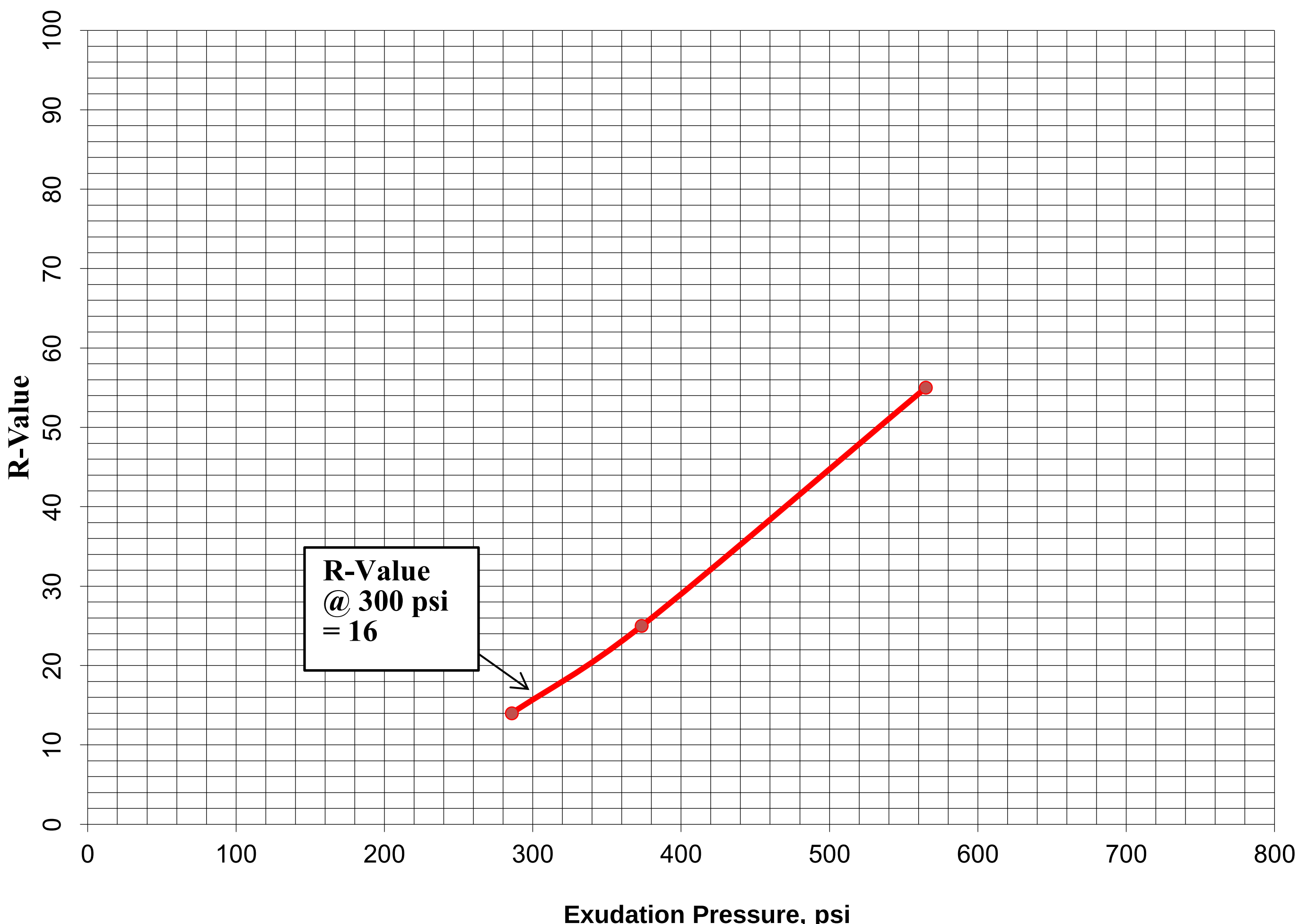
FIG. B-6

R-Value Test Report
CP-L 3101

Project: SH 105
Job Number: 23-1-01311-002
Report Date: 7/12/16

Reported to: Shannon & Wilson , Inc

Sample Information		**Test Data Summary**			
Sample Number:	586	Specimen No.	1	2	3
Sample Location:	SW / P / 19	Moisture %	10.70	9.87	8.72
Material Desc.:	SW / P / 19 Bulk Sample				
Date Sampled:	7/12/16	R-Value (corrected)	14.0	25.0	55.0
Sampled By:	S&W	Exudation Pressure, psi	286	373	565



Vine Laboratories, Inc.

Tested By: Juan Romero
Reviewed By: Darrell Evig, P.E.

FIG. B-7

R-Value Test Report

CP-L 3101

Project: SH 105

Job Number: 23-1-01311-002

Report Date: 7/12/16

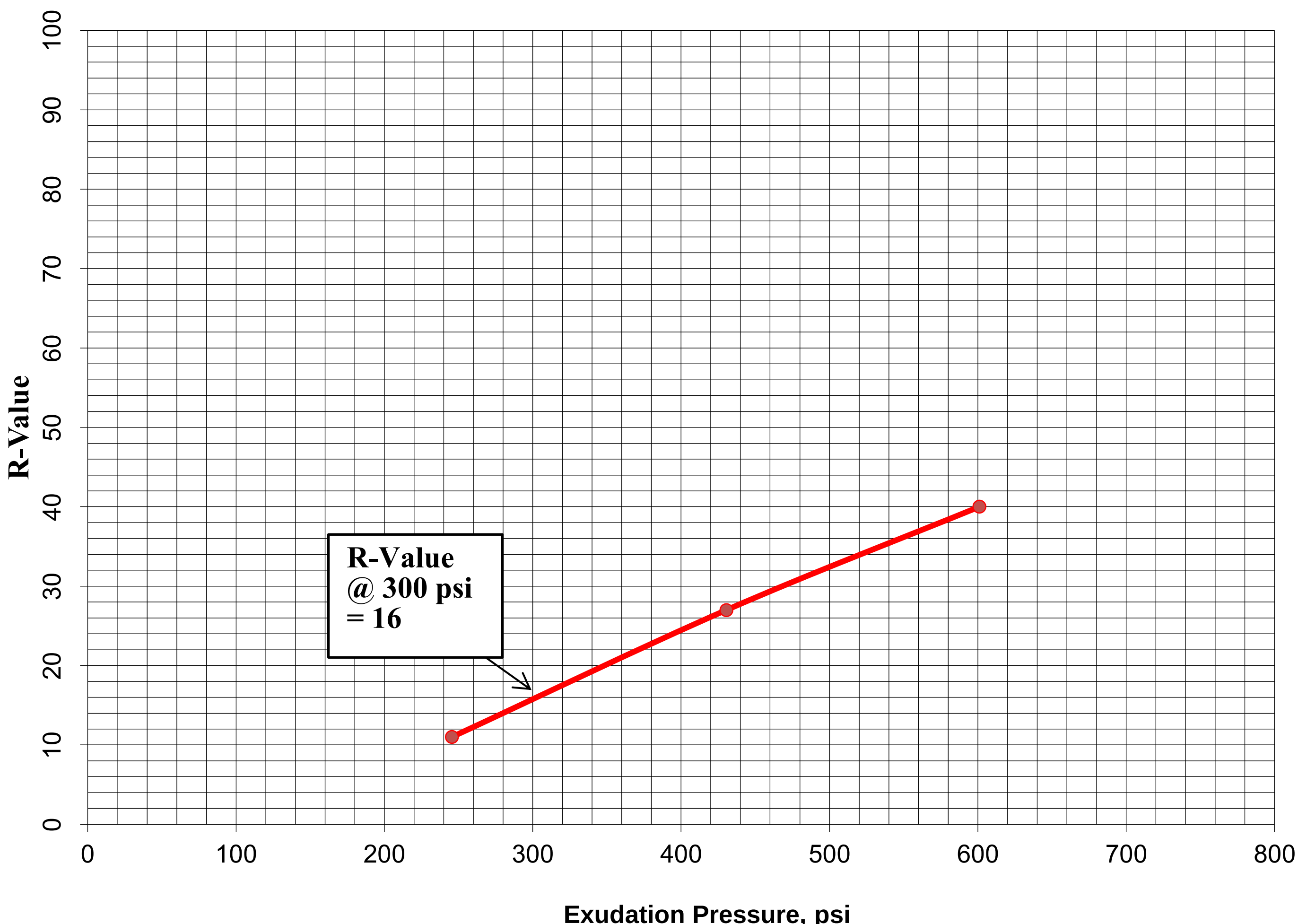
Reported to: Shannon & Wilson , Inc

Sample Information

Sample Number:	585
Sample Location:	SW / P / 27
Material Desc.:	SW / P / 27 Bulk Sample
Date Sampled:	7/12/16
Sampled By:	S&W

Test Data Summary

Specimen No.	1	2	3
Moisture %	11.05	8.31	8.02
R-Value (corrected)	11.0	27.0	40.0
Exudation Pressure, psi	245	431	601



Vine Laboratories, Inc.

Tested By: Juan Romero

Reviewed By: Darrell Evig, P.E.

FIG. B-8

APPENDIX C

FALLING WEIGHT DEFLECTOMETER TESTING

APPENDIX C

FALLING WEIGHT DEFLECTOMETER TETING

DATA REPORT

Kumar & Associates, Inc. (2016)
Nondestructive Deflection Testing Results and Pavement Structural Evaluation, Highway 105 from I-25 off Ramp to Lake Woodmoor Drive, El Paso County, Colorado, Project No. 16-1-401 (3 pages)

Kumar & Associates, Inc.
Geotechnical and Materials Engineers
and Environmental Scientists

ACEC MEMBER

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www.kumarusa.com

Office Locations: Denver (HQ), Colorado Springs, Fort Collins, and Frisco, Colorado

August 2, 2016

Mr. David Asunskis, P.E.
Shannon & Wilson Inc.,
1321 Bannock Street, Suite 200
Denver, Colorado 80204

Subject: Nondestructive Deflection Testing Results and Pavement Structural Evaluation, Highway 105 from I-25 off Ramp to Lake Woodmoore Drive, El Paso County, Colorado

Project No. 16-1-401

Dear Mr. Asunskis:

This letter presents the results of a nondestructive, falling weight deflectometer (FWD) testing program and pavement structural evaluation performed for approximately 1.0 centerline mile of Highway 105 in El Paso County, Colorado. Testing within the alignment included one lane in both the east bound and west bound directions. The study was conducted in general accordance with the scope of work in our proposal to Shannon & Wilson dated May 4, 2016.

Existing Site/Pavement Conditions: The alignment of Highway 105 within the limits of the testing consisted of two travel lanes with various turn lanes, accel/decal lanes, and median configurations. Testing took place in the outside travel lane in both directions between the I-25 northbound off ramp and Lake Woodmore Drive.

The existing pavement section types and thicknesses for the project segment were provided by Shannon & Wilson and were used in the data analysis. The pavement section type and thickness were based on cores taken throughout the pavement sections at various locations. In general, the cores encountered a flexible pavement section consisting of full-depth hot mix asphalt (HMA) or a flexible composite section consisting of HMA over of aggregate base course (ABC). Thicknesses of full depth HMA encountered varied from approximately 7.5 to 9.0 inches. Thicknesses of composite sections encountered in two of the borings consisted of 9.0 to 10.0 inches of HMA over 11.0 and 5.0 inches of ABC, respectively. Composite sections were located on the western portion of the testing sections, towards the I-25 off ramp, and full depth HMA sections were located along the remaining eastern portion of the alignment.

Field Testing: The FWD is an impulse-loading device that generates a force by dropping a pre-determined load on a set of springs. The force is then transmitted to the pavement surface through a 12-inch diameter rigid plate. The force applied to the pavement surface measures the elastic response of the pavement layers and underlying subgrade material, as measured through a set of 7 deflection sensors placed at various offsets from the load source. The deflection sensors used in this study were placed at offsets from the load source at distances of 0, 8, 12, 18, 24, 36 and 60 inches.

The FWD tests were taken at approximate 250-foot intervals within the travel lane with a 125-foot staggered pattern between the eastbound and westbound directions.

Analysis and Results: The structural characteristics of the pavement section and underlying subgrade were determined from various computer software programs.

In analyzing flexible pavements, the FWD tests can be evaluated where the combined stiffness influence of the various pavement layer moduli represents the overall structural capacity of the pavement. The structural capacity obtained from this procedure is generally a function of the maximum deflection determined at the load center as well as the subgrade resilient modulus. The maximum measured deflection obtained at the load center is used to predict the effective pavement modulus of the pavement layers. The effective pavement modulus of the pavement layers and the known pavement thickness were correlated to an overall existing structural number of the pavement section at each test location. The existing structural numbers are a function of the pavement modulus, and the existing pavement thickness assumed at each test location.

In general, the deflection sensors located at a greater distance from the load source are used to determine the subgrade resilient modulus. When the deflection basin is measured using the FWD, the outer readings of the deflection basin under the imposed load represent the in-situ resilient modulus of the subgrade soil. The subgrade resilient modulus is the value that represents the pavement support condition.

The results of the analyses indicate subgrade resilient modulus values for the flexible composite section ranging from 4,072 psi to 6,924 psi with an average value of 5,395 psi. The existing structural number of the flexible composite section ranged from 3.61 to 6.36 with an average value of 4.46.

For the full-depth asphalt section, the subgrade resilient modulus values ranged from 3,845 psi to 7,764 psi with an average value of 5,490 psi. The existing structural number for the full-depth asphalt alignment area ranged from 2.04 to 3.72 with an average value of 2.63.

The design subgrade resilient modulus and existing structural numbers determined at each of the FWD test locations are provided in the attached Table.

Limitations: This study has been conducted in accordance with generally accepted pavement engineering practices in this area. The results and conclusions provided in this report are based upon the data obtained from the FWD tests taken at the approximate locations summarized in the attached table, and the asphalt pavement section thicknesses provided by Shannon & Wilson. Kumar & Associates, Inc. is not responsible for liability associated with interpretation of the data by others.

Sincerely,
KUMAR & ASSOCIATES, INC.

Justin Cupich, Staff Engineer

Reviewed By:

James A. Noll, P.E.

COLORADO REGISTERED
JAMES A. NOLL
27051
8-2-2016
PROFESSIONAL ENGINEER

JDC/jw
Attachments
cc: File, book

TABLE 1 Highway 105 Between Northbound I-25 Off Ramp and Lake Woodmore Dirve

FALLING WEIGHT DEFLECTOMETER RESULTS

Lane	Station	Subgrade Resilient Modulus (psi)	Effective Pavement Section Modulus (psi)	Pvm't Existing SN
WB Outside Lane	104+00	5,772	628665	6.36
WB Outside Lane	106+50	4,554	209337	4.41
WB Outside Lane	109+00	5,872	238814	4.61
WB Outside Lane	111+50	5,657	222857	4.50
WB Outside Lane	114+00	5,171	219388	4.48
WB Outside Lane	116+50	5,680	184170	4.22
WB Outside Lane	119+00	5,721	229539	4.55
WB Outside Lane	121+50	4,309	164411	4.07
EB Outside Lane	121+25	4,072	114870	3.61
EB Outside Lane	118+75	5,577	321110	5.08
EB Outside Lane	116+25	5,194	168106	4.10
EB Outside Lane	113+75	4,736	173354	4.14
EB Outside Lane	111+25	6,559	164773	4.07
EB Outside Lane	108+75	5,441	206911	4.39
EB Outside Lane	106+25	5,083	157579	4.01
EB Outside Lane	104+00	6,924	251787	4.69
Average Section Values		**5,395**	**228,479**	**4.46**
Standard Deviation		**734**	**113,212**	**0.59**
WB Outside Lane	124+00	4,748	334931	2.50
WB Outside Lane	126+50	5,845	460900	2.78
WB Outside Lane	129+00	4,932	319803	2.46
WB Outside Lane	131+50	5,275	401681	2.66
WB Outside Lane	134+00	5,497	349825	2.54
WB Outside Lane	136+50	5,536	455799	2.77
WB Outside Lane	139+00	6,425	435759	2.73
WB Outside Lane	141+50	6,647	384097	2.62
WB Outside Lane	144+00	7,764	455267	2.77
WB Outside Lane	146+50	6,996	530037	2.91
WB Outside Lane	149+00	5,288	340808	2.51
WB Outside Lane	150+00	3,845	181648	2.04
EB Outside Lane	150+00	5,708	408126	2.67
EB Outside Lane	148+75	5,682	1101913	3.72
EB Outside Lane	146+25	4,785	319862	2.46
EB Outside Lane	143+75	5,207	275638	2.34
EB Outside Lane	141+25	5,106	253619	2.28
EB Outside Lane	138+75	5,167	305467	2.42
EB Outside Lane	136+25	5,685	361802	2.57
EB Outside Lane	133+75	5,161	406604	2.67
EB Outside Lane	131+25	4,308	313320	2.45
EB Outside Lane	128+75	4,766	346608	2.53
EB Outside Lane	126+25	5,219	458631	2.78
EB Outside Lane	123+75	6,177	524103	2.90
Average Section Values		**5,490**	**400,093**	**2.63**
Standard Deviation		**841**	**166,799**	**0.30**

APPENDIX D

PREVIOUS SUBSURFACE EXPLORATIONS

APPENDIX D

PREVIOUS SUBSURFACE EXPLORATIONS

TABLE OF CONTENTS

TABLE

FIGURES

Note: Figure numbers reflect designations from our 2012 preliminary geotechnical report.

TABLE B-1
SUMMARY OF LABORATORY TEST RESULTS BY BORING

SAMPLE DATA				USCS Symbol[(1)]	AASHTO Classification	Natural Water Content	GRAIN-SIZE ANALYSES[(2)]			ATTERBERG LIMITS			R-VALUE		CORROSION			
Boring	Sample	Depth (feet) Top	Depth (feet) Bottom			(%)	Gravel (%)	Sand (%)	Fines (%)	Liquid Limit (%)	Plastic Limit (%)	Plasticity Index (%)	R-Value	Exudation Pressure (psi)	pH	Resistivity (ohm-cm)	Sulfates (%)	Chlorides (%)
SW-01	S-1	1.0	2.5			12.6			22									
	S-2	5.0	6.5	SP-SM		8.8	9	82	9									
	S-4	15.0	15.9	CL	A-6(6)	13.0	0	46	54	35	19	16						
	S-5	20.0	20.3															
	Bulk	0.0	5.0										40	300				
SW-03	S-1	1.0	2.5	SW-SM		6.1	12	81	7									
	S-2	5.0	6.0			7.8			29						6.4	1,750	0.0027	0.001
SW-04	S-1	1.0	2.5			6.5												
	S-2	5.0	5.9	SW-SM		7.8	14	78	8									
SW-05	S-1	1.0	2.5			4.5												
	S-2	5.0	6.5	CL	A-6(15)	15.2			68	40	14	26						
SW-06	S-1	1.0	2.0	SW-SC		9.7	18	76	6									
	S-2	5.0	5.7			9.7			28									
SW-07	S-1	1.0	2.5	CL	A-7-5(12)	16.5			54	43	14	29						
	S-3	10.0	10.5	SC		11.7	11	68	21									
SW-08	S-1	1.0	2.0	SC		8.5	18	70	12									
	S-2	5.0	6.5	SW-SM		5.8	8	87	5									
SW-09	S-1	1.0	2.0	SC		8.6	9	78	13									
	S-2	5.0	5.5			6.3			9									
SW-10	S-1	1.0	2.0			10.1									6.0	1,210	0.023	0.015
	S-2	5.0	6.0	SM	A-2-4	17.1			28	NV	NP	NP						
	S-3	10.0	11.0	SP-SM		14.3	11	83	6									
	S-4	20.0	21.0			16.4			25									
		21.0	21.5			13.3			4									

NOTES: 1) Refer to Appendix A, Figure A-1 for definitions.
2) Gravel defined as particles larger than the No. 4 sieve size, Sand as particles between the No. 4 and No. 200 sieve sizes, and Fines as particles passing the No. 200 sieve.
3) USCS and AASHTO soil classifications are only provided on soil samples with sufficient laboratory index tests to assign such classifications.

Total Depth:	25.3 ft.	Northing:		Drilling Method:	Solid Auger
Top Elevation:	~	Easting:		Drilling Company:	Dakota Drilling
Vert. Datum:		Station:		Drill Rig Equipment:	Dietrich 50
Horiz. Datum:		Offset:		Other Comments:	

Hole Diam.:	4.5 in.
Rod Type.:	AWJ
Hammer Type:	Cathead

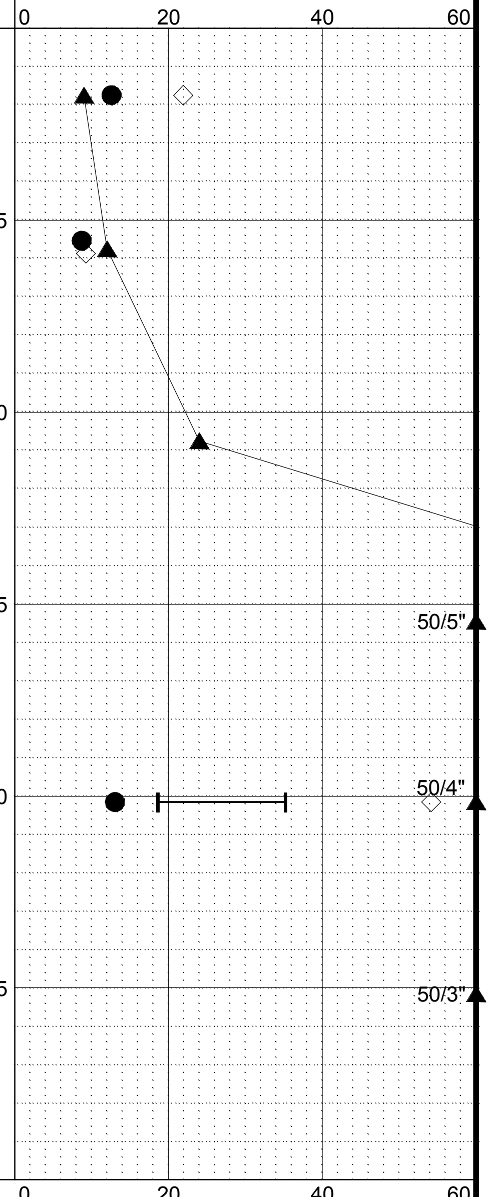
SOIL DESCRIPTION

Refer to the report text for a proper understanding of the subsurface materials and drilling methods. The stratification lines indicated below represent the approximate boundaries between material types, and the transition may be gradual.

Soil Description	Depth, ft.	Samples	Ground Water
Loose, brown, silty, fine SAND; moist; [A-2-4] SM.		1 Bulk	No Groundwater Encountered During Drilling
Medium dense, brown, slighlty silty, slightly gravelly to gravelly SAND; moist [A-2-4] SP-SM.	3.8	2, 3, 4	
SANDSTONE/CLAYSTONE: very low strength, gray and brown, weakly cemented; slightly weathered (Dawson Formation). [Interbedded very dense, slighlty clayey to clayey SAND and hard, sandy, silty CLAY; moist; SC and CL.]	15.5	5	
SANDSTONE: very low strength, brown, gray, and pink, weakly cemented; slightly weathered (Dawson Formation). [Very dense, slightly clayey SAND; moist; [A-2-6] SP-SC.]	21.0	6	
BOTTOM OF BORING COMPLETED ON 6/5/2012	25.3		

PENETRATION RESISTANCE (blows/foot)

▲ Hammer Wt. & Drop: 140 lbs / 30 inches



◇ % Fines (<0.075mm)
● % Water Content
Plastic Limit ├─●─┤ Liquid Limit
Natural Water Content

LEGEND

* Sample Not Recovered
G Grab Sample
Standard Penetration Test

NOTES

1. Refer to Figures A-1 and A-2 for explanation of symbols, codes, abbreviations and definitions.
2. The stratification lines represent the approximate boundaries between soil types, and the transition may be gradual.
3. The discussion in the text of this report is necessary for a proper understanding of the nature of the subsurface materials.
4. Groundwater level, if indicated above, is for the date specified and may vary.
5. USCS designation is based on visual-manual classification and selected lab testing.
6. The hole location was measured from existing site features and should be considered approximate.
7. Samples 4 and 5 were combined for water content, Atterberg limits, and gradation analysis.

Highway 105
Corridor Improvements
El Paso County, Colorado

LOG OF BORING SW-01

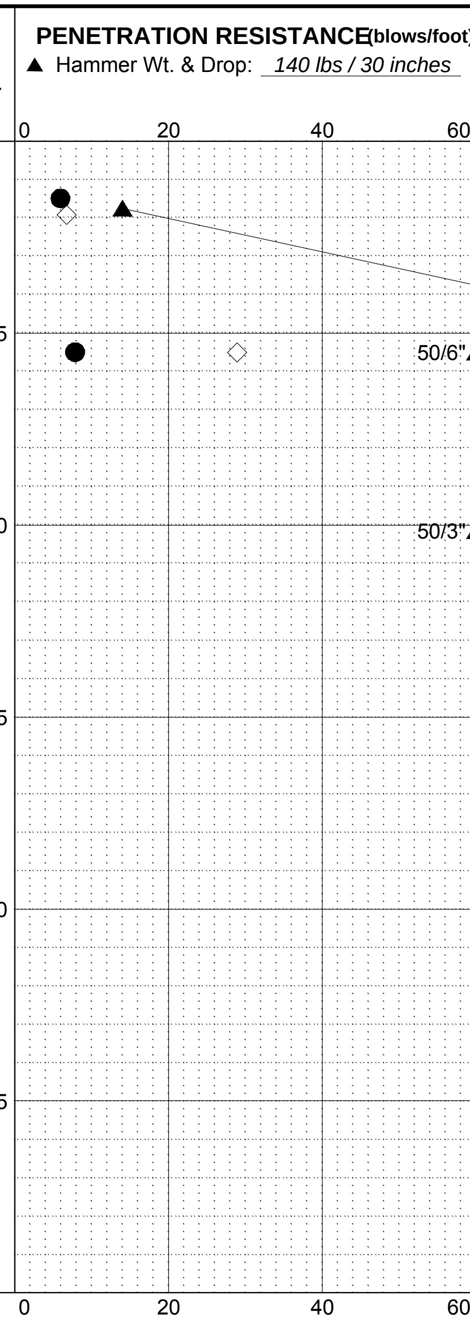
June 2012 23-1-01311-001

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. A-3

Total Depth:	10.3 ft.	Northing:		Drilling Method:	Solid Auger	Hole Diam.:	4.5 in.
Top Elevation:	~	Easting:		Drilling Company:	Dakota Drilling	Rod Type.:	AWJ
Vert. Datum:		Station:		Drill Rig Equipment:	Dietrich 50	Hammer Type:	Cathead
Horiz. Datum:		Offset:		Other Comments:			

SOIL DESCRIPTION *Refer to the report text for a proper understanding of the subsurface materials and drilling methods. The stratification lines indicated below represent the approximate boundaries between material types, and the transition may be gradual.*	Depth, ft.	Symbol	Samples	Ground Water
Medium dense, red-brown, slightly silty, slightly fine gravelly SAND; moist; [A-2-4] SW-SM.			1	No Groundwater Encountered During Drilling
SANDSTONE: very low strength, light gray with iron oxide stains, weakly cemented; slightly to moderately weathered (Dawson Formation). [Very dense, clayey SAND; moist; [A-2-6] SC.]	3.0		2, 3	
BOTTOM OF BORING COMPLETED ON 6/5/2012	10.3			



LEGEND

* Sample Not Recovered

⌶ Standard Penetration Test

NOTES

1. Refer to Figures A-1 and A-2 for explanation of symbols, codes, abbreviations and definitions.
2. The stratification lines represent the approximate boundaries between soil types, and the transition may be gradual.
3. The discussion in the text of this report is necessary for a proper understanding of the nature of the subsurface materials.
4. Groundwater level, if indicated above, is for the date specified and may vary.
5. USCS designation is based on visual-manual classification and selected lab testing.
6. The hole location was measured from existing site features and should be considered approximate.

Highway 105
Corridor Improvements
El Paso County, Colorado

LOG OF BORING SW-03

June 2012 23-1-01311-001

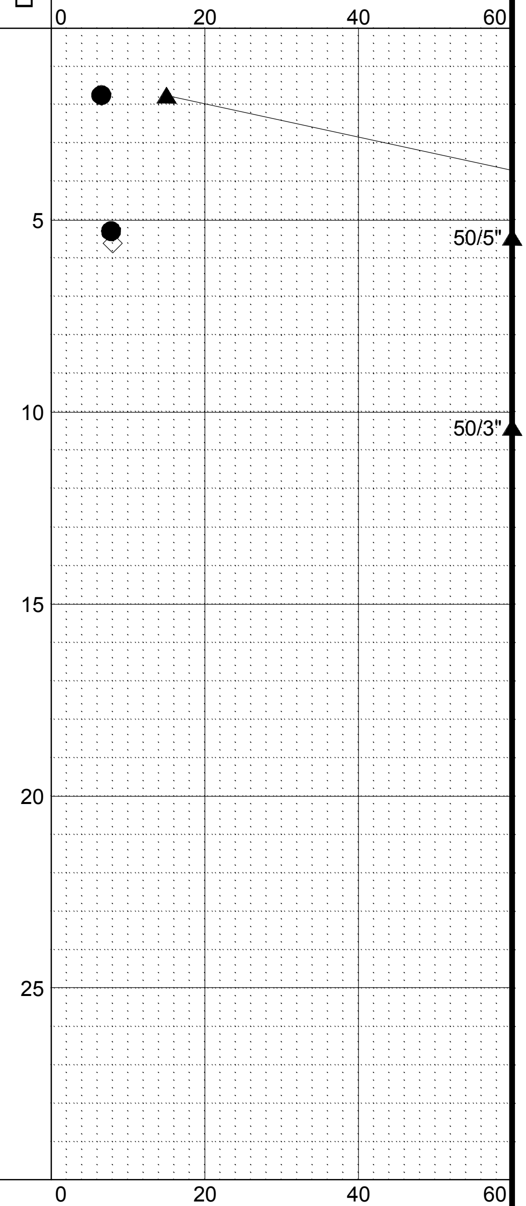
SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. A-4

Total Depth: 10.8 ft.	Northing:	Drilling Method:	Solid Auger	Hole Diam.:	4.5 in.
Top Elevation: ~	Easting:	Drilling Company:	Dakota Drilling	Rod Type.:	AWJ
Vert. Datum:	Station:	Drill Rig Equipment:	Dietrich 50	Hammer Type:	Cathead
Horiz. Datum:	Offset:	Other Comments:			

SOIL DESCRIPTION *Refer to the report text for a proper understanding of the subsurface materials and drilling methods. The stratification lines indicated below represent the approximate boundaries between material types, and the transition may be gradual.*	Depth, ft.	Symbol	Samples	Ground Water
Medium dense, brown, slightly silty, gravelly SAND; moist; [A-2-4] SP-SM.			1	No Groundwater Encountered During Drilling
SANDSTONE: very low strength, brown and pink, weakly cemented; moderately weathered (Dawson Formation). [Very dense, slightly silty, slightly gravelly to gravelly SAND; moist; [A-2-4] SW-SM.]	3.0		2 3	
BOTTOM OF BORING COMPLETED ON 6/5/2012	10.8			

PENETRATION RESISTANCE (blows/foot)
▲ Hammer Wt. & Drop: 140 lbs / 30 inches



◇ % Fines (<0.075mm)
● % Water Content

LEGEND

* Sample Not Recovered
⌶ Standard Penetration Test

NOTES

1. Refer to Figures A-1 and A-2 for explanation of symbols, codes, abbreviations and definitions.
2. The stratification lines represent the approximate boundaries between soil types, and the transition may be gradual.
3. The discussion in the text of this report is necessary for a proper understanding of the nature of the subsurface materials.
4. Groundwater level, if indicated above, is for the date specified and may vary.
5. USCS designation is based on visual-manual classification and selected lab testing.
6. The hole location was measured from existing site features and should be considered approximate.

Highway 105
Corridor Improvements
El Paso County, Colorado

LOG OF BORING SW-04

June 2012 23-1-01311-001

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. A-5

MASTER_LOG_E 23-1-01311 (SH105).GPJ SHAN_WIL.GDT 6/18/12

Total Depth:	*10.3 ft.*	Northing:		Drilling Method:	*Solid Auger*
Top Elevation:	*~*	Easting:		Drilling Company:	*Dakota Drilling*
Vert. Datum:		Station:		Drill Rig Equipment:	*Dietrich 50*
Horiz. Datum:		Offset:		Other Comments:	

Hole Diam.:	*4.5 in.*
Rod Type.:	*AWJ*
Hammer Type:	*Cathead*

SOIL DESCRIPTION

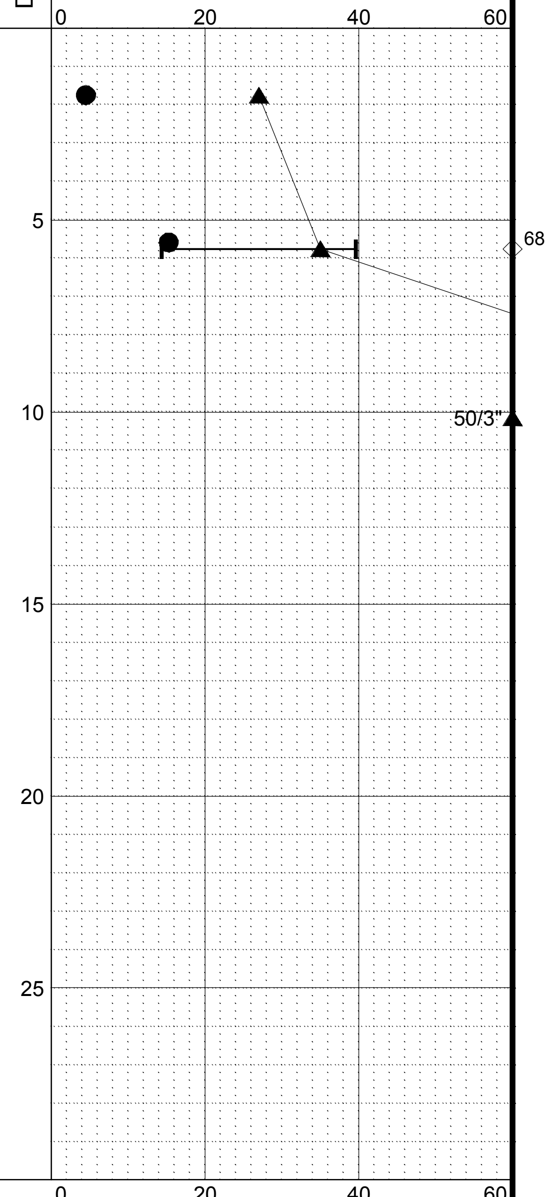
Refer to the report text for a proper understanding of the subsurface materials and drilling methods. The stratification lines indicated below represent the approximate boundaries between material types, and the transition may be gradual.

Soil Description	Depth, ft.	Samples	Ground Water
6 inches of asphalt.	0.5		No Groundwater Encountered During Drilling
3 inches of base course.	0.8	1	
Medium dense, brown, slightly gravelly, slightly silty SAND; moist [A-2-4] SP-SM.	5.0		
CLAYSTONE: very low strength, brown and gray; moderately to highly weathered (Dawson Formation). [Hard, slightly silty to silty, sandy CLAY; moist; CL.]	8.3	2	
SANDSTONE: very low strength, gray and brown with iron oxide stains, weakly cemented; moderately to highly weathered (Dawson Formation). [Very dense, clayey SAND; moist; SC.]	10.3	3	

BOTTOM OF BORING
COMPLETED ON 6/5/2012

PENETRATION RESISTANCE (blows/foot)

▲ Hammer Wt. & Drop: *140 lbs / 30 inches*



◇ % Fines (<0.075mm)
● % Water Content
Plastic Limit ├──●──┤ Liquid Limit
Natural Water Content

LEGEND
* Sample Not Recovered
Ⅰ Standard Penetration Test

NOTES
1. Refer to Figures A-1 and A-2 for explanation of symbols, codes, abbreviations and definitions.
2. The stratification lines represent the approximate boundaries between soil types, and the transition may be gradual.
3. The discussion in the text of this report is necessary for a proper understanding of the nature of the subsurface materials.
4. Groundwater level, if indicated above, is for the date specified and may vary.
5. USCS designation is based on visual-manual classification and selected lab testing.
6. The hole location was measured from existing site features and should be considered approximate.

Highway 105
Corridor Improvements
El Paso County, Colorado

LOG OF BORING SW-05

June 2012 23-1-01311-001

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. A-6

Total Depth:	*10.5 ft.*	Northing:		Drilling Method:	*Solid Auger*	Hole Diam.:	*4.5 in.*
Top Elevation:	~	Easting:		Drilling Company:	*Dakota Drilling*	Rod Type.:	*AWJ*
Vert. Datum:		Station:		Drill Rig Equipment:	*Dietrich 50*	Hammer Type:	*Cathead*
Horiz. Datum:		Offset:		Other Comments:			

SOIL DESCRIPTION

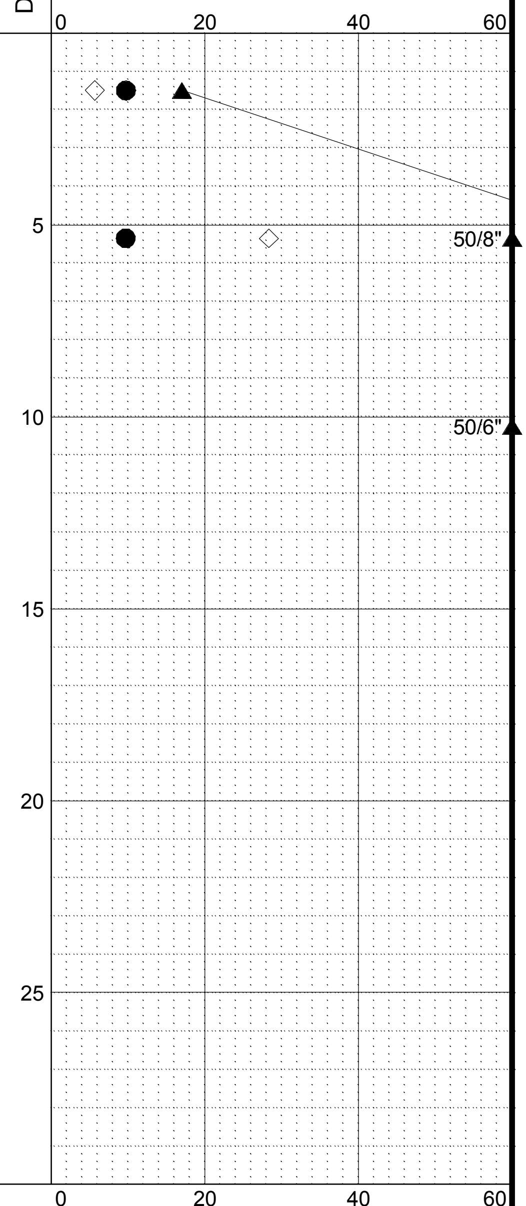
Refer to the report text for a proper understanding of the subsurface materials and drilling methods. The stratification lines indicated below represent the approximate boundaries between material types, and the transition may be gradual.

Soil Description	Depth, ft.	Samples
8 inches of asphalt.	0.7	
2 inches of base course.	0.8	1
Medium dense, red-brown, slightly clayey, fine gravelly SAND; moist; [A-2-6] SW-SC.	3.0	
SANDSTONE: very low strength, brown, red-brown, and pink, weakly cemented; moderately weathered (Dawson Formation). [Very dense, slightly clayey to clayey SAND; moist; [A-2-6] SP-SC/SC.]	10.5	2, 3
BOTTOM OF BORING COMPLETED ON 6/5/2012		

Ground Water: No Groundwater Encountered During Drilling

PENETRATION RESISTANCE (blows/foot)

▲ Hammer Wt. & Drop: *140 lbs / 30 inches*



◇ % Fines (<0.075mm)
● % Water Content

LEGEND

* Sample Not Recovered
⧓ Modified California Sampler

NOTES

1. Refer to Figures A-1 and A-2 for explanation of symbols, codes, abbreviations and definitions.
2. The stratification lines represent the approximate boundaries between soil types, and the transition may be gradual.
3. The discussion in the text of this report is necessary for a proper understanding of the nature of the subsurface materials.
4. Groundwater level, if indicated above, is for the date specified and may vary.
5. USCS designation is based on visual-manual classification and selected lab testing.
6. The hole location was measured from existing site features and should be considered approximate.

Highway 105
Corridor Improvements
El Paso County, Colorado

LOG OF BORING SW-06

June 2012 23-1-01311-001

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. A-7

Total Depth:	10.5 ft.	Northing:		Drilling Method:	Solid Auger
Top Elevation:	~	Easting:		Drilling Company:	Dakota Drilling
Vert. Datum:		Station:		Drill Rig Equipment:	Dietrich 50
Horiz. Datum:		Offset:		Other Comments:	

Hole Diam.:	4.5 in.
Rod Type.:	AWJ
Hammer Type:	Cathead

SOIL DESCRIPTION

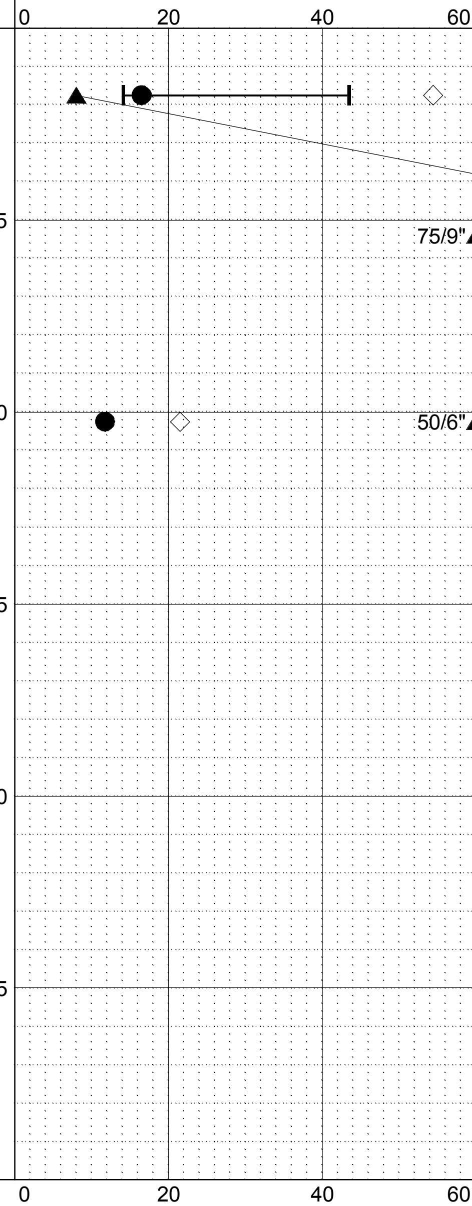
Refer to the report text for a proper understanding of the subsurface materials and drilling methods. The stratification lines indicated below represent the approximate boundaries between material types, and the transition may be gradual.

Soil Description	Depth, ft.	Samples
6 inches of asphalt.	0.5	
3 inches of base course.	0.8	
Medium stiff, dark brown, sandy, silty CLAY; moist; (Fill) [A-7-5] CL.	2.0	1 Bulk
Medium stiff, red-brown, slightly sandy, silty CLAY; moist; [A-6] CL.	5.5	2
SANDSTONE: very low strength, gray and brown with iron oxide stains, weakly cemented; occasionally interbedded with claystone; moderately to highly weathered (Dawson Formation). [Very dense, slightly fine gravelly, clayey SAND; moist; SC.]	10.5	3

BOTTOM OF BORING
COMPLETED ON 6/5/2012

Ground Water: No Groundwater Encountered During Drilling

PENETRATION RESISTANCE (blows/foot)
▲ Hammer Wt. & Drop: 140 lbs / 30 inches



◇ % Fines (<0.075mm)
● % Water Content
Plastic Limit ├─●─┤ Liquid Limit
Natural Water Content

LEGEND

- * Sample Not Recovered
- Grab Sample
- Standard Penetration Test
- Modified California Sampler

NOTES

1. Refer to Figures A-1 and A-2 for explanation of symbols, codes, abbreviations and definitions.
2. The stratification lines represent the approximate boundaries between soil types, and the transition may be gradual.
3. The discussion in the text of this report is necessary for a proper understanding of the nature of the subsurface materials.
4. Groundwater level, if indicated above, is for the date specified and may vary.
5. USCS designation is based on visual-manual classification and selected lab testing.
6. The hole location was measured from existing site features and should be considered approximate.

Highway 105
Corridor Improvements
El Paso County, Colorado

LOG OF BORING SW-07

June 2012 23-1-01311-001

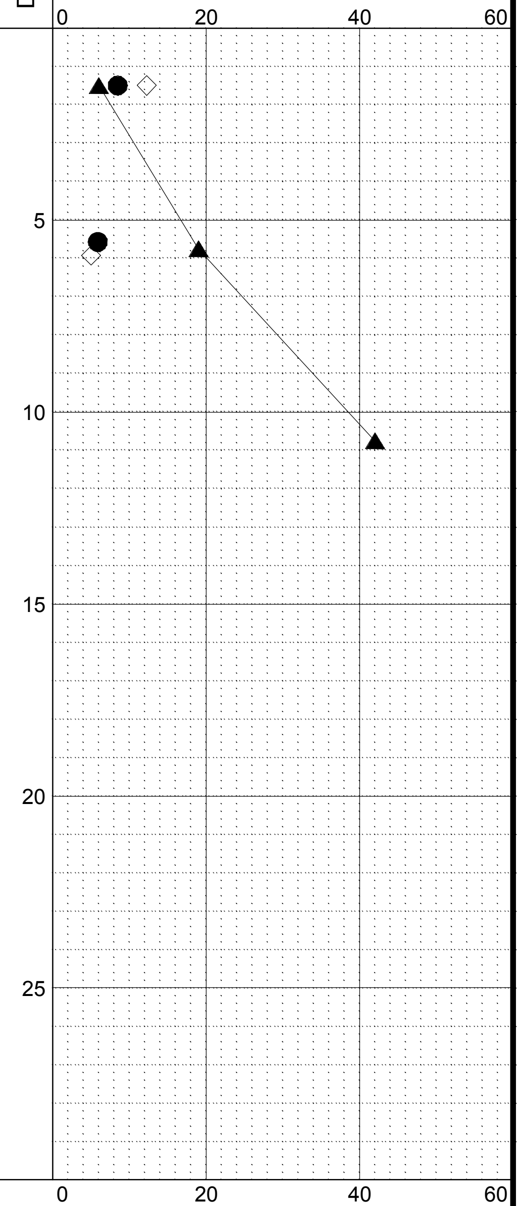
SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. A-8

Total Depth:	11.5 ft.	Northing:		Drilling Method:	Solid Auger	Hole Diam.:	4.5 in.
Top Elevation:	~	Easting:		Drilling Company:	Dakota Drilling	Rod Type.:	AWJ
Vert. Datum:		Station:		Drill Rig Equipment:	Dietrich 50	Hammer Type:	Cathead
Horiz. Datum:		Offset:		Other Comments:			

SOIL DESCRIPTION *Refer to the report text for a proper understanding of the subsurface materials and drilling methods. The stratification lines indicated below represent the approximate boundaries between material types, and the transition may be gradual.*	Depth, ft.	Symbol	Samples	Ground Water
Loose, dark brown, clayey, fine gravelly SAND; moist; (Fill) [A-2-6] SC.			1	No Groundwater Encountered During Drilling
Medium dense to dense, red-brown, slightly silty, slightly fine gravelly SAND; [A-2-4] SW-SM.	3.5		2 3	
BOTTOM OF BORING COMPLETED ON 6/5/2012	11.5			

PENETRATION RESISTANCE (blows/foot)
▲ Hammer Wt. & Drop: *140 lbs / 30 inches*



LEGEND

* Sample Not Recovered
Modified California Sampler
Standard Penetration Test

NOTES

1. Refer to Figures A-1 and A-2 for explanation of symbols, codes, abbreviations and definitions.
2. The stratification lines represent the approximate boundaries between soil types, and the transition may be gradual.
3. The discussion in the text of this report is necessary for a proper understanding of the nature of the subsurface materials.
4. Groundwater level, if indicated above, is for the date specified and may vary.
5. USCS designation is based on visual-manual classification and selected lab testing.
6. The hole location was measured from existing site features and should be considered approximate.

Highway 105
Corridor Improvements
El Paso County, Colorado

LOG OF BORING SW-08

June 2012 23-1-01311-001

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. A-9

Total Depth:	*10.5 ft.*	Northing:		Drilling Method:	*Solid Auger*
Top Elevation:	*~*	Easting:		Drilling Company:	*Dakota Drilling*
Vert. Datum:		Station:		Drill Rig Equipment:	*Dietrich 50*
Horiz. Datum:		Offset:		Other Comments:	

Hole Diam.:	*4.5 in.*
Rod Type.:	*AWJ*
Hammer Type:	*Cathead*

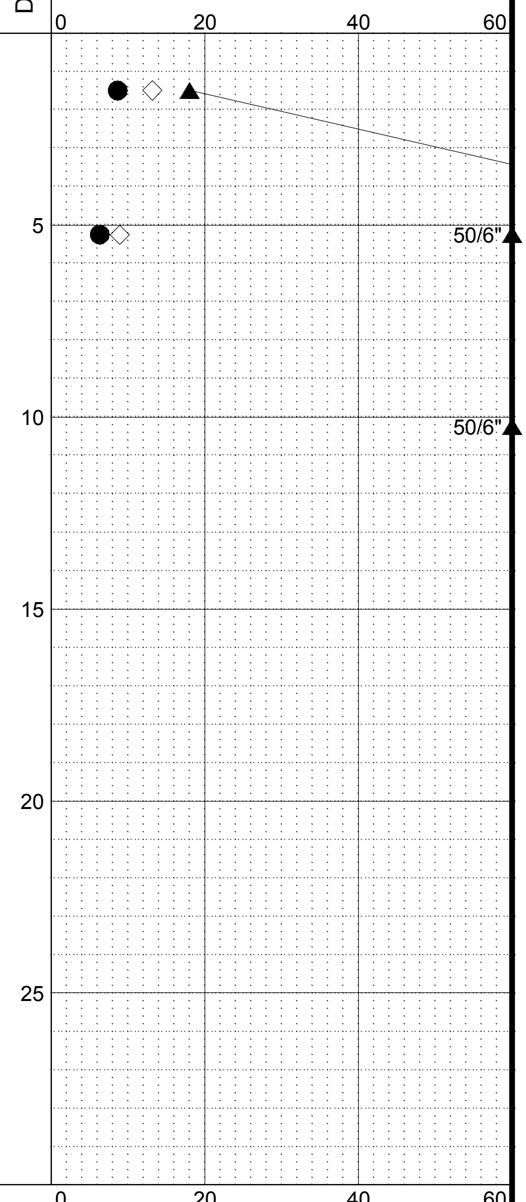
SOIL DESCRIPTION

Refer to the report text for a proper understanding of the subsurface materials and drilling methods. The stratification lines indicated below represent the approximate boundaries between material types, and the transition may be gradual.

Soil Description	Depth, ft.	Samples	Ground Water
Medium dense, dark brown, slightly fine gravelly, clayey SAND; moist; (Possible Fill) [A-2-6] SC.		1	No Groundwater Encountered During Drilling
SANDSTONE: very low strength, white and pink, weakly cemented; moderately weathered (Dawson Formation). [Very dense, slightly silty, gravelly SAND; moist; SP-SM.]	5.0	2, 3	
BOTTOM OF BORING COMPLETED ON 6/5/2012	10.5		

PENETRATION RESISTANCE (blows/foot)

▲ Hammer Wt. & Drop: *140 lbs / 30 inches*



◇ % Fines (<0.075mm)
● % Water Content

LEGEND

- * Sample Not Recovered
- Modified California Sampler
- Standard Penetration Test

NOTES

1. Refer to Figures A-1 and A-2 for explanation of symbols, codes, abbreviations and definitions.
2. The stratification lines represent the approximate boundaries between soil types, and the transition may be gradual.
3. The discussion in the text of this report is necessary for a proper understanding of the nature of the subsurface materials.
4. Groundwater level, if indicated above, is for the date specified and may vary.
5. USCS designation is based on visual-manual classification and selected lab testing.
6. The hole location was measured from existing site features and should be considered approximate.

Highway 105
Corridor Improvements
El Paso County, Colorado

LOG OF BORING SW-09

June 2012 23-1-01311-001

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

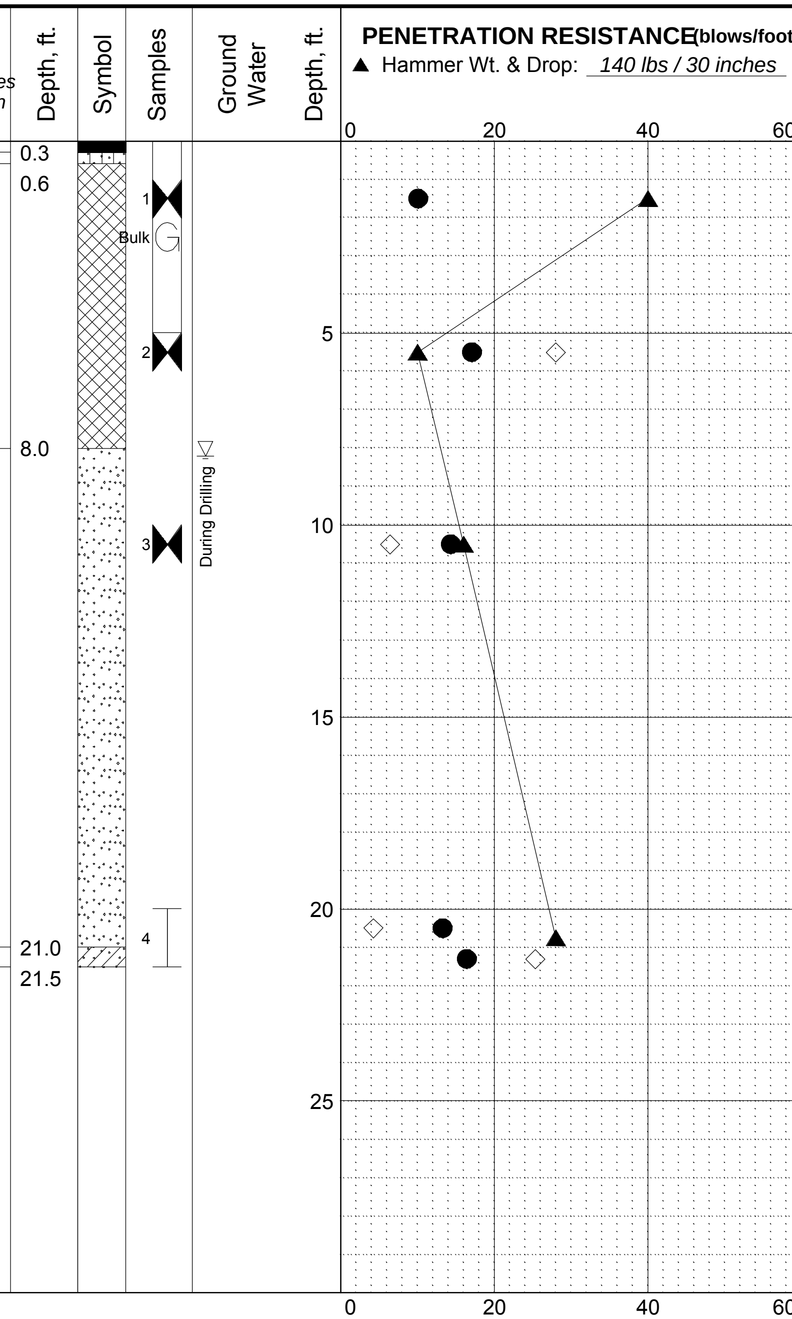
FIG. A-10

Total Depth:	*21.5 ft.*	Northing:		Drilling Method:	*Solid Auger*	Hole Diam.:	*4.5 in.*
Top Elevation:	*~*	Easting:		Drilling Company:	*Dakota Drilling*	Rod Type.:	*AWJ*
Vert. Datum:		Station:		Drill Rig Equipment:	*Dietrich 50*	Hammer Type:	*Cathead*
Horiz. Datum:		Offset:		Other Comments:			

SOIL DESCRIPTION

Refer to the report text for a proper understanding of the subsurface materials and drilling methods. The stratification lines indicated below represent the approximate boundaries between material types, and the transition may be gradual.

Soil Description	Depth, ft.
4 inches of asphalt.	0.3
3 inches of base course.	0.6
Loose to dense, dark brown, silty SAND; moist; (Fill) [A-2-4] SM.	
Medium dense, brown and gray, trace to slightly silty, slightly fine gravelly SAND; wet; SP-SM/SP.	8.0
Medium dense, brown and gray, clayey SAND; wet; SC.	21.0
BOTTOM OF BORING COMPLETED ON 6/5/2012	21.5



LEGEND

- * Sample Not Recovered
- Grab Sample
- Modified California Sampler
- Standard Penetration Test
- Ground Water Level ATD

NOTES

1. Refer to Figures A-1 and A-2 for explanation of symbols, codes, abbreviations and definitions.
2. The stratification lines represent the approximate boundaries between soil types, and the transition may be gradual.
3. The discussion in the text of this report is necessary for a proper understanding of the nature of the subsurface materials.
4. Groundwater level, if indicated above, is for the date specified and may vary.
5. USCS designation is based on visual-manual classification and selected lab testing.
6. The hole location was measured from existing site features and should be considered approximate.

Highway 105
Corridor Improvements
El Paso County, Colorado

LOG OF BORING SW-10

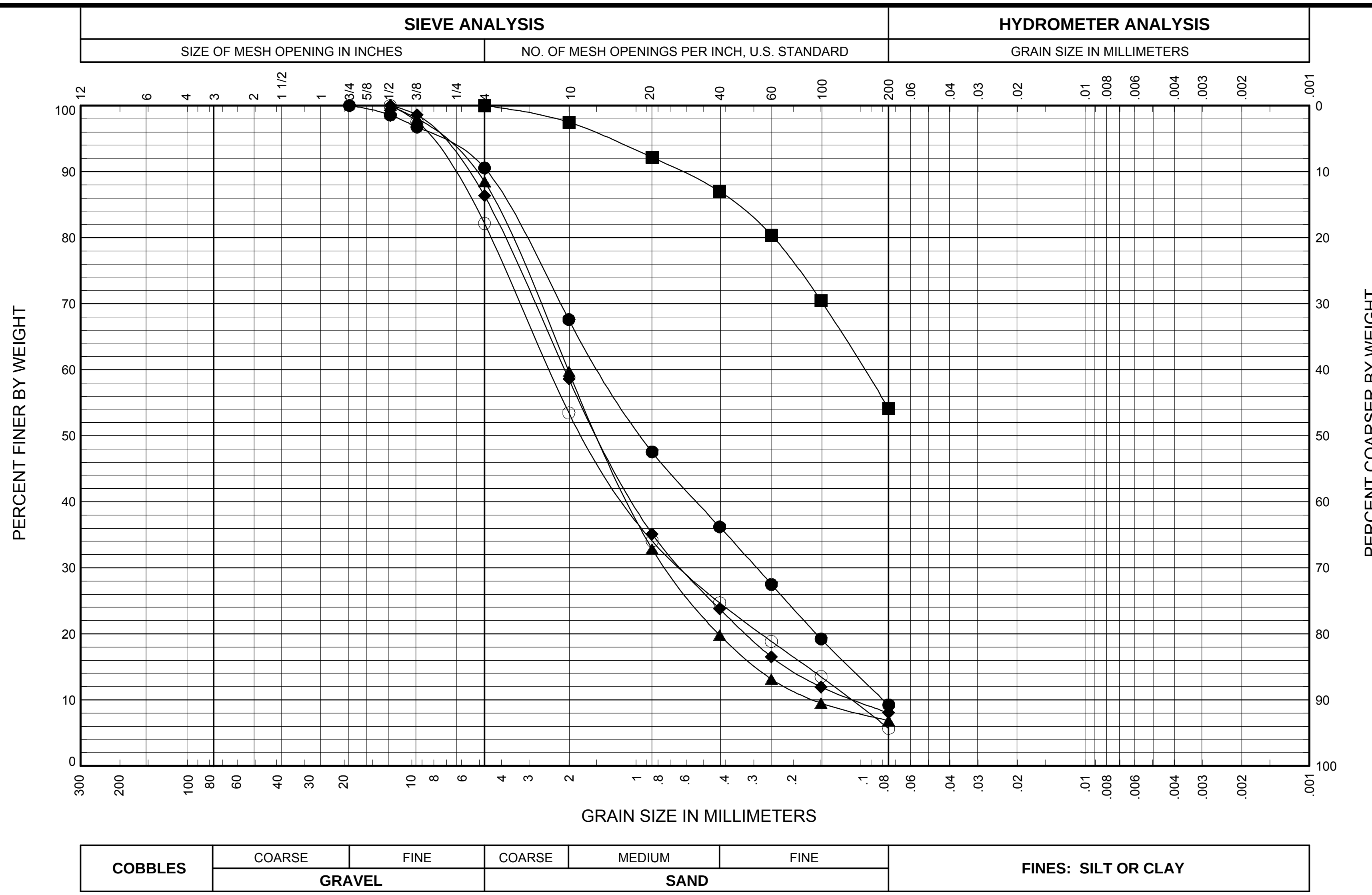
June 2012 23-1-01311-001

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. A-11

FIG. B-1

GSA_MAIN 23-1-01311 (SH105).GPJ CLONE FROM THIS PROJECT.GPJ 6/11/12



BORING AND SAMPLE NO.	DEPTH (feet)	U.S.C.S. SYMBOL	SAMPLE DESCRIPTION	FINES %	NAT. W.C. %	LL %	PL %	PI %
● SW-01, S-2	5.8	SP-SM	Slightly silty, slightly fine gravelly SAND	9.2	8.8			
■ SW-01, S-4 & S-5	15.4 & 20.1	CL	CLAYSTONE	54.1	13.0	35	19	16
▲ SW-03, S-1	1.8	SW-SM	Slightly silty, fine gravelly SAND	6.9	6.1			
◆ SW-04, S-2	5.5	SW-SM	SANDSTONE	8.0	7.8			
○ SW-06, S-1	1.5	SW-SC	Slightly clayey, fine gravelly SAND	5.7	9.7			

Highway 105
Corridor Improvements
El Paso County, Colorado

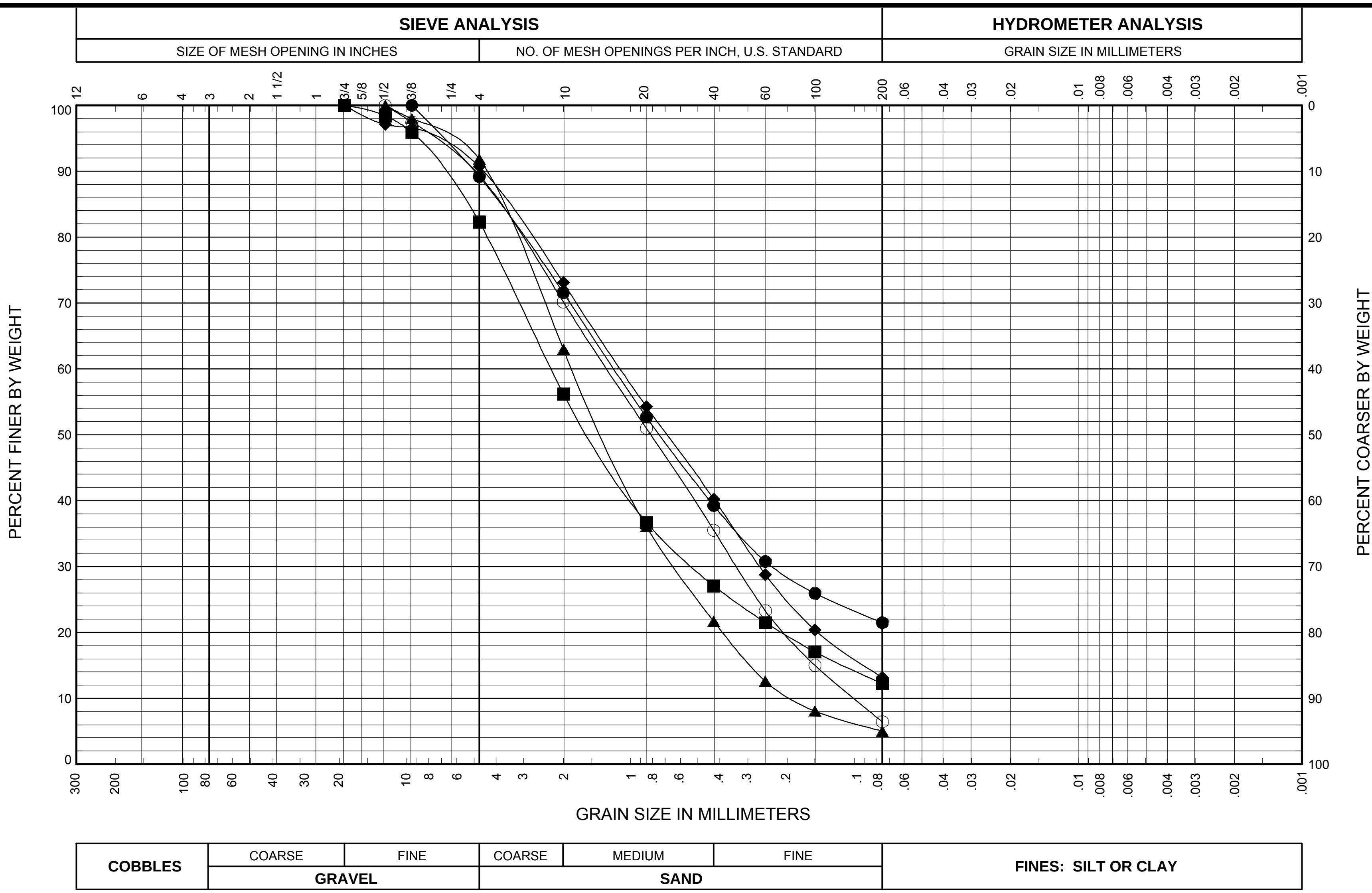
GRAIN SIZE DISTRIBUTION

June 2012 23-1-01311-001

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. B-1
Sheet 1 of 2

HDR



BORING AND SAMPLE NO.	DEPTH (feet)	U.S.C.S. SYMBOL	SAMPLE DESCRIPTION	FINES %	NAT. W.C. %	LL %	PL %	PI %
● SW-07, S-3	10.3	SC	SANDSTONE	21.5	11.7			
■ SW-08, S-1	1.5	SC	Clayey, fine gravelly SAND	12.3	8.5			
▲ SW-08, S-2	5.8	SW-SM	Slightly silty, slightly fine gravelly SAND	5.0	5.8			
◆ SW-09, S-1	1.5	SC	Slightly fine gravelly, clayey SAND	13.2	8.6			
○ SW-10, S-3	10.5	SP-SM	Slightly silty, slightly fine gravelly SAND	6.5	14.3			

Highway 105
Corridor Improvements
El Paso County, Colorado

GRAIN SIZE DISTRIBUTION

June 2012 23-1-01311-001

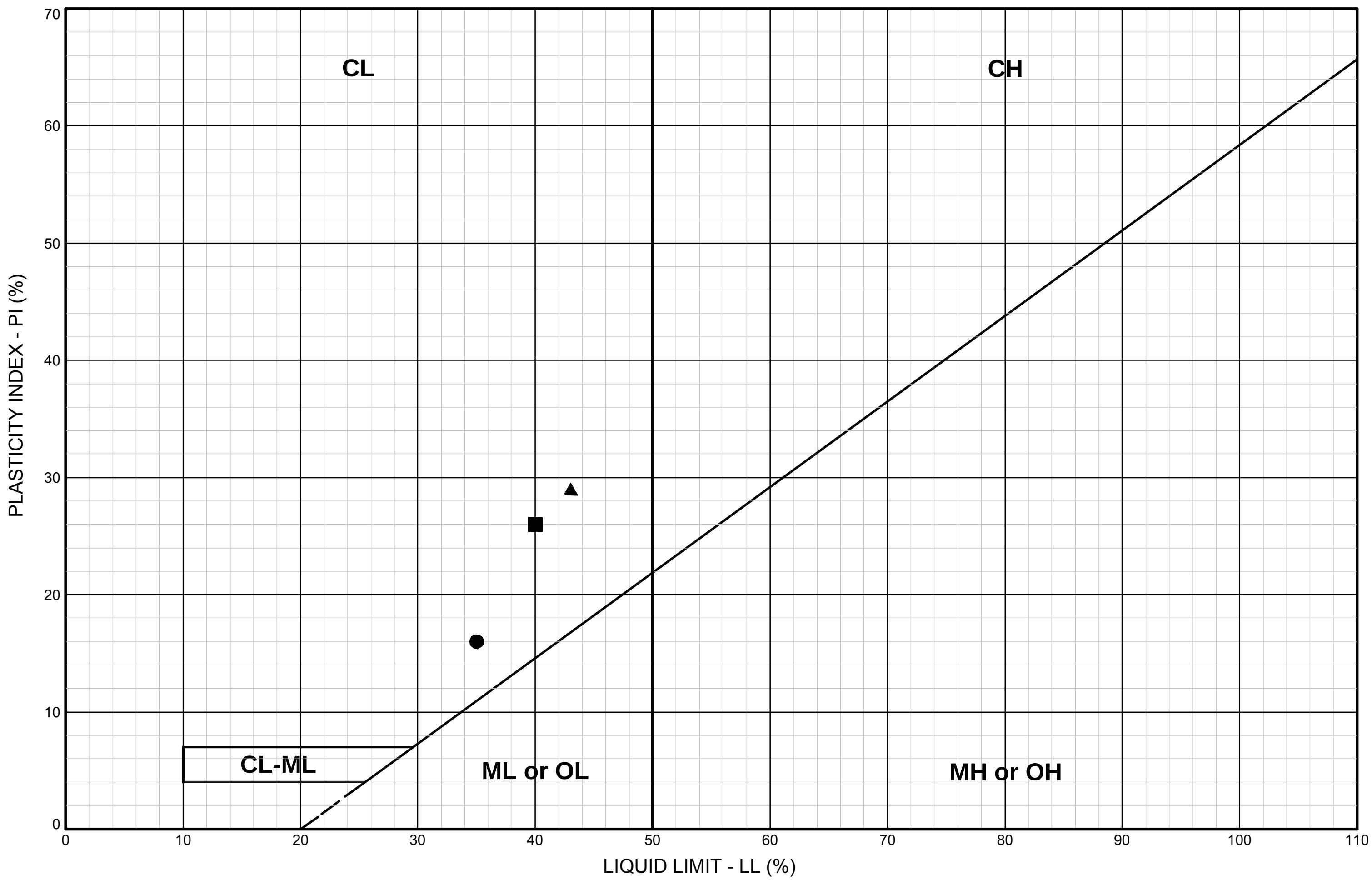
SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. B-1
Sheet 2 of 2

HDR

FIG. B-1

GSA_MAIN 23-1-01311 (SH105).GPJ CLONE FROM THIS PROJECT.GPJ 6/18/12



LEGEND

CL: Low plasticity inorganic clays; sandy and silty clays

CH: High plasticity inorganic clays

ML or OL: Inorganic and organic silts and clayey silts of low plasticity

MH or OH: Inorganic and organic silts and clayey silts of high plasticity

CL-ML: Silty clays and clayey silts

BORING AND SAMPLE NO.	DEPTH (feet)	U.S.C.S. SYMBOL	SOIL CLASSIFICATION	LL %	PL %	PI %	NAT. W.C. %	PASS. #200, %
● SW-01, S-4 & S-5	15.4 & 20.1	CL	CLAYSTONE	35	19	16	13.0	54.1
■ SW-05, S-2	5.8	CL	CLAYSTONE	40	14	26	15.2	67.8
▲ SW-07, S-1	1.8	CL	Sandy, silty CLAY	43	14	29	16.5	54.4

Highway 105
Corridor Improvements
El Paso County, Colorado

PLASTICITY CHART

June 2012 23-1-01311-001

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. B-2

HDR

R-VALUE
ASTM D 2844

CLIENT Shannon & Wilson

JOB NO. 2481-177

BORING NO.
DEPTH 0-5'
SAMPLE NO. SW-OK
SOIL DESCR. 23-1-01311-011
LOCATION: SH PO5 Improvements

SAMPLED
DATE TESTED 06/20/12 WAR

MOLD #	15	12	16
WEIGHT OF WET SOIL & DISH (g)	1177.97	1152.98	1110.81
WEIGHT OF DRY SOIL & DISH (g)	1055.3	1045.51	1010.86
WEIGHT OF LOST MOISTURE (g)	122.67	107.47	99.95
WEIGHT OF DISH (g)	17.73	15.67	14.16
WEIGHT OF DRY SOIL (g)	1037.57	1029.84	996.70
MOISTURE CONTENT (%)	11.82	10.44	10.03
SAMPLE HEIGHT (in.)	2.59	2.54	2.45
TOTAL WEIGHT OF WET SAMPLE (g)	1168.3	1140.7	1090.9
WET DENSITY (PCF)	136.7	136.1	135.0
DRY DENSITY (PCF)	122.3	123.3	122.7
EXUDATION PRESSURE (PSI)	208.91	334.53	679.87
2000 LB. LOAD DIAL READING (PSI)	120	65	30
DISPLACEMENT TURNS	4.09	4.26	3.79
CALCULATED R-VALUE	17	46	74
CORRECTED R-VALUE	18	49	74

CORRECTED R-VALUE AT 300 PSI: **40**

Data entered by: DAW Date: 06/22/2012
Data checked by: KR Date: 6/22/12
FileName: SVRV05SH

ADVANCED TERRA TESTING, INC. ATT

FIG. B-3

APPENDIX E

PAVEMENT DESIGN CALCULATIONS

APPENDIX E

PAVEMENT DESIGN CALCULATIONS

ATTACHMENTS

SHANNON & WILSON, INC.
GEOTECHNICAL AND ENVIRONMENTAL CONSULTANTS

Calculation No. 1

CALCULATION SUMMARY

Project: SH105 Job No: 23-1-01311-002

Feature and Subject:: Pavement Overlay and Widening Design

Calculation Purpose *(describe purpose/goal of calculation)*

Design pavements for the proposed SH105 widening.

General Approach/Assumptions *(please describe in general – can refer to calculation sheets for more information)*

Alignment consists of Western and Eastern Segment divided at Lake Woodmoor Dr. The Western Segment is split into two sub-segments at Knollwood Dr. Overlay will be considered in the Western segment

Revisions to Analyses:

- Revised El Paso County Engineering Criteria Manual used (revised July 29, 2015)
- Additional traffic projections for SH105 were analyzed for critical traffic loading.
- Traffic for the Eastern Segment will consist of a two-traffic lane road (with a center turning lane). Western Segment consists of four traffic lanes (two EB and two WB).
- Pavement sections for local cross streets

Traffic Information: ADT provided by HDR, West Segment: Urban Principal Arterial (4-lane), East Segment: Rural Principal Arterial, (4-lane)

Existing Pavement Assessment: S&W soil survey, S&W pavement cores, and Kumar & Associates FWD testing.

Subgrade Strength: Western Segment: FWD analysis (average value of 5,400 psi [R-value of about ~22.7]). Eastern Segment: Average R-Value = 19, exclude high outlier of 62 from boring SW-P-08.

Assume: 20 year pavement design

Sources of Data and Equations *(please describe in general – can refer to calculation sheets for more information – if other calculations are referenced, please include)*

Flexible Pavement Design: In-house Pavement Design Spreadsheet (per El Paso Co design criteria)

SHANNON & WILSON, INC.
GEOTECHNICAL AND ENVIRONMENTAL CONSULTANTS

Calculation No. 1

CALCULATION SUMMARY

Summary and Conclusions *(please describe general conclusions – do not only refer to calculation sheets, but include conclusion here)*

Traffic Loading:

Western Segment:

East of Knollwood Dr projected ESAL of 2,628,000 and 1,611,000 west of Knollwood Dr; West Segment County Min. ESAL (Urban)= 5,256,000

Eastern Segment:

County Min. ESAL (Rural)= 689,850 to 2,628,000 depending of the arterial classification; projected ESAL of 1,810,000

Cross Streets:

County minimum for rural/urban (low-volume) of 36,500

Recommend Pavement Sections:

See Summary Table for recommended pavement sections

PM Check of Assumptions and Input Properties

Rev No.	Calculation By	Date	Checked By	Date
2	[signature]	12/5/16	[signature]	12/5/16
PM Review of Assumptions and Input Properties				

Segment		Subrade Modulus (psi)	18 kip ESAL	Pavement Section
SH105 West Segment, (Urban Arterial	Eastern-most I-25 Ramps to Knollwood Dr.	5,400	2,216,000 (Projected Traffic)	7.5" HMA over 8" ABC
				2" mill, 2" HMA overlay
			5,256,000 (County Minimum for 4-lane Priciple Arterial)	8.5" HMA over 8" ABC
				2" mill, 2" HMA overlay
	Knollwood Dr to Lake Woodmoor Dr.	5,400	1,611,000 (Projected Traffic)	7" ~~7.5"~~ HMA over 8" ABC
				2" mill, 4.5" HMA overlay
			5,256,000 (County Minimum for 4-lane Priciple Arterial)	8.5" HMA over 8" ABC
				2" mill, 6.0" HMA overlay
SH105 East Segment (Rural Arterial)	Lake Woodmoor Dr to SH 83	4,800	1,810,000 ~~2,216,000~~ (Projected Traffic)	7.5" HMA over 8" ABC
			689,850 (County Minimum for Minor Arterial)	6.0" HMA over 8" ABC
			2,628,000 (County Minimum for 4-lane Priciple Arterial)	8.0" HMA over 8" ABC
Cross Streets	Low Traffic Volume Cross Streets	4,800	36,500 (County Minimum for Local Roads)	3.5" HMA over 6" ABC

Table 1.4: Comparison of Average Daily Traffic (ADT) Count Data and Alternative Traffic Forecasts

Count Location	2005		2010		2035		2040	
	Count	Raw Model	Count	Raw Model	CDOT Forecast	Raw Model	CDOT Forecast	Adjusted Model
North of 3rd Street	13,634	8,278	15,504	8,395	24,854	16,885	26,724	24,929
North of SB I-25 On-Ramp	16,692	8,278	17,974	8,395	24,387	17.100	25,669	29,334
West of Woodmoor Drive	15,880	13,336	17,700	13,525	26,980	23,195	28,880	28,160
East of Woodmoor Drive	15,580	10,432	17,480	10,580	26,980	20,030	28,880	27,385
West of Jackson Creek Parkway		9,772	16,396	10,390		16,205		22.201
West of Knollwood Drive		10,600	15,479	12,120		19,885		22,499
East of Knollwood Drive		11,080	12,388	12,300		21,235		20,480
West of Lake Woodmoor Drive		11,080	12,388	12,300		21.235		20,930
West of Fairplay Drive		11,043	12,388	8,405		16,585		20,568
East of Fairplay Drive		7,162	10,779	6,155		13,980		18,604
East of Furrow Road		7,733	7,563	6,290		14,625		15,898
West of Roller Coaster Road		5,656	4,778	5,565		12,610		13,397
East of Roller Coaster Road		6,516	5,188	6,365		13,885		15,062
East of Canterbury Drive		6,960	5,188	6,150		13,460		14,422
West of Highway 83		7,404	5,188	6,885		15,855		17,552

Source: http://dtdapps.coloradodot.info/otis/TrafficData#ui/1/2/0/criteria/105A/4.731/9.48/true/true/

Notes: Red text indicates estimated ADT (from counts for another year) vs. actual ground count ADT for that year.
Blue text indicates CDOT forecast ADT volumes and PPACG model-generated ADT volumes.

Example Calc:

$$r = \left\{ \left[\frac{28{,}160}{13{,}525}\right]^{(1/30)} - 1 \right\} \times 100\% = 2.48\%$$

$$\Rightarrow 2017\ ADT \cong 13{,}525\,(1 + 0.0248)^{7} = 16{,}049 \text{ vehicles/day}$$

From:	Mark Vessely
To:	David Asunskis; Joey Goode
Subject:	Fwd: Highway 105 Traffic
Date:	Thursday, July 28, 2016 2:15:35 PM

FYI

Begin forwarded message:

From: "Seyer, John M." <John.Seyer@hdrinc.com>
Date: July 28, 2016 at 12:45:07 PM PDT
To: "McQuilkin, Stephen" <Stephen.McQuilkin@hdrinc.com>, Mark Vessely <MJV@shanwil.com>
Subject: RE: Highway 105 Traffic

% Truck Traffic

Steve – I'd go with 4%. SH 105 carries ~3% west of I-25 and SH 83 carries ~5%, so 4% seems like a good middle ground.

John Seyer, PE, PTOE
D 970.416.4407 M 970.227.7941

E. of Woodmoor 2017 ADT = 19,380(1+0.0139)^2 = 19,923
W. of Lake Woodmoor: 2017 AD = 12,495(1+0.0209)^2 = 13,023

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From: McQuilkin, Stephen
Sent: Thursday, July 28, 2016 8:32 AM
To: Mark Vessely
Cc: Seyer, John M.
Subject: Highway 105 Traffic

Located West of I-25 NB off Ramp

Mark, here are ADT's for Highway 105. These are 2-way ADT's
East of Woodmoor Drive: 2015 traffic counts = 19,380, 2040 projections = 27,385
West of Lake Woodmoor Drive: 2015 traffic counts = 12,495, 2040 projections = 20,930

I don't know what to assume for truck percentage – 8%? It is more residential than commercial/industrial but they do get some truck 'cut-through' traffic between SH 83 and I 25.

John, any thoughts?

2040 - 2015 = 25 Years ✓

Growth Rate: West Segment 2 West of Lake Woodmoor $\frac{20,930}{12,495} = (1+r)^{25}$ ✓
r = 2.09% ✓

West Segment 1 East of Woodmoor $\frac{27,385}{19,380} = (1+r)^{25}$ ✓
r = 1.39% ✓

Steve McQuilkin, PE
Senior Transportation Project Manager

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* Assume Traffic Volumes Change at Knollwood Dr. ✓

Flexible Pavement 18-kip Equivalent Single-Axle Loading (ESAL) Worksheet

Location: SH 105, El Paso County Colorado - West Segment 2 (Knollwood to Lake Woodmoor Dr)
Comment: Analysis based on Table D.21 of the 1993 AASHTO Guide for the Design of Pavement Structures

Paving Year:	2017	
Pavement Design Life (N):	20	years[3]
2010 Average Daily Traffic (ADT)[1]:	12,300	vehicles per day
2017 Average Daily Traffic (ADT)[1]:	13,924	
Estimated 2037 ADT[1]:	19,846	vehicles per day
Growth Rate (r) :	1.79	%

Equations

$b = 2017\ ADT * (a/100)$

$c = b * 365$

$d = [(1+r/100)^N - 1]/(r/100)$

$e = c * d$

$g = e * f$

$j = g * h * i$

FHWA Vehical Classification and Description	a Traffic [1] Percentage	b 2016 AADT	c Total 2016 Traffic	d Growth Factors	e Design Traffic Volume (total two-way volume)	f Flexible [2] Pavement Equivalency Factor	g Roadway Design 18k ESAL	h Directional[4] Distribution Factor	i Traffic[4] Lane Factor	j Design Lane 18k ESAL
1) Passenger Cars and Pickup Trucks	96	13,367	4,879,075	23.79	116,075,102	0	348,225	0.50	0.9	156,701
2) Single Unit Trucks	2	278	101,647	23.79	2,418,231	0.2490	602,140	0.50	0.9	270,963
3) Combination Trucks	2	278	101,647	23.79	2,418,231	1.0870	2,628,617	0.50	0.9	1,182,878
All Vehicles	100	13,924			120,911,565		3,578,982			**1,610,542**

Design ESAL **1,611,000**

Notes

1) The current and projected ADT were based on traffic data provided by HDR.
2) Table 1.2 Colorado Equivalency Factors. CDOT Pavment Design Manual (2014) provides a 3-Bin Classification of traffic with factors for each classification.
3) Assume a 20 year pavement design life.
4) The CDOT Pavement Design Manual recommends a directional distribution factor of 0.5 and lane distribution factor of 0.9 percent for a four lane (two direction) road.

Flexible Pavement 18-kip Equivalent Single-Axle Loading (ESAL) Worksheet

Location: SH 105, El Paso County Colorado - East Segment (east of Lake Woodmoor Dr)

Comment: Analysis based on Table D.21 of the 1993 AASHTO Guide for the Design of Pavement Structures

Paving Year:	2017	
Pavement Design Life (N):	20	years[3]
2010 Average Daily Traffic (ADT)[1]:	8,405	vehicles per day
2017 Average Daily Traffic (ADT)[1]:	10,357	
Estimated 2037 ADT[1]:	18,807	vehicles per day
Growth Rate (r) :	3.03	%

Equations

$b = 2017\ ADT * (a/100)$

$c = b * 365$

$d = [(1+r/100)^N-1]/(r/100)$

$e = c * d$

$g = e * f$

$j = g * h * i$

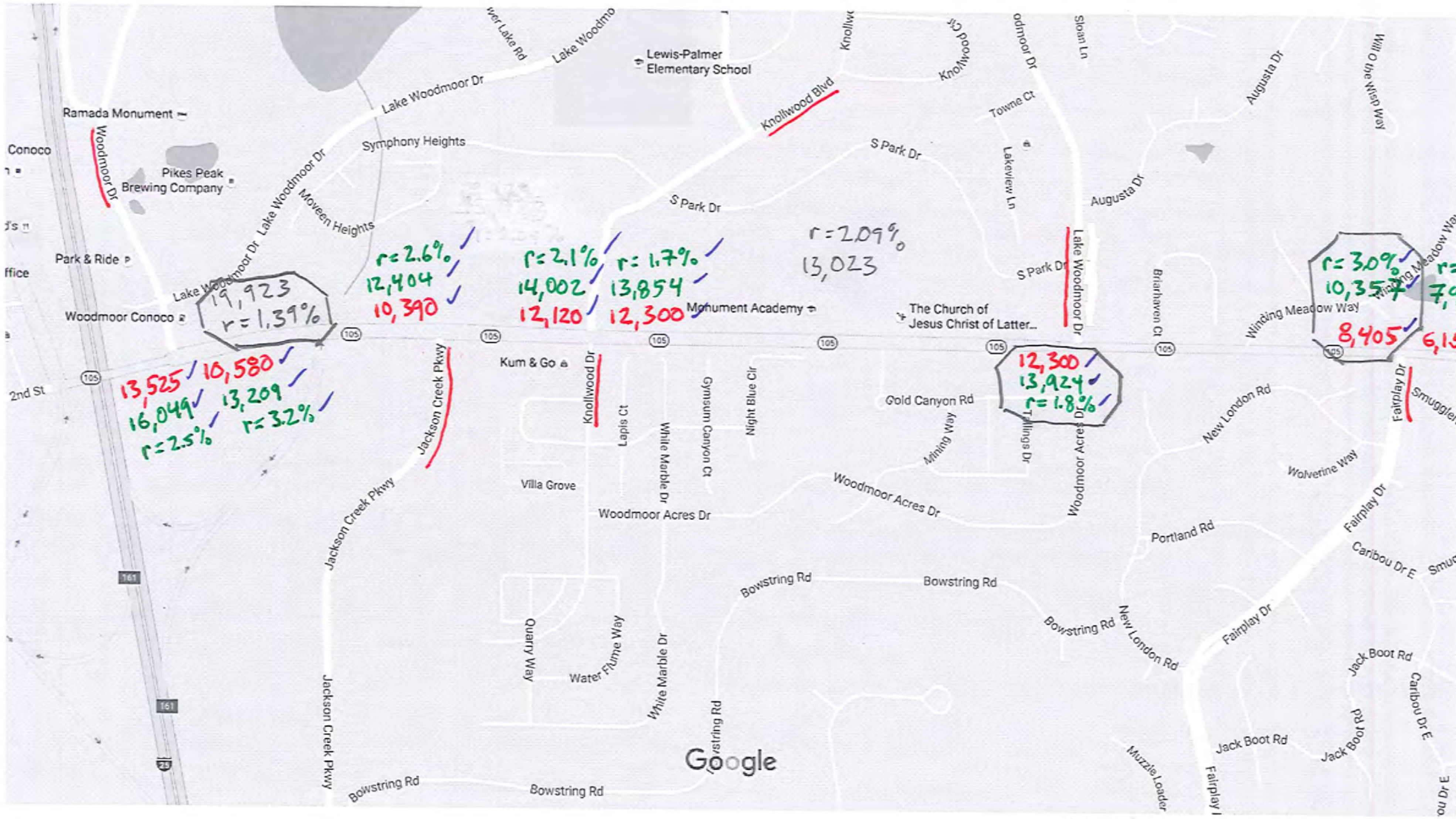
		a	b	c	d	e	f	g	h	i	j
FHWA Vehical Classification and Description		Traffic [1] Percentage	2016 AADT	Total 2016 Traffic	Growth Factors	Design Traffic Volume (total two-way volume)	Flexible [2] Pavement Equivalency Factor	Roadway Design 18k ESAL	Directional[4] Distribution Factor	Traffic[4] Lane Factor	Design Lane 18k ESAL
1)	Passenger Cars and Pickup Trucks	96	9,942	3,629,007	26.95	97,790,696	0	293,372	0.60	1.0	176,023
2)	Single Unit Trucks	2	207	75,604	26.95	2,037,306	0.2490	507,289	0.60	1.0	304,373
3)	Combination Trucks	2	207	75,604	26.95	2,037,306	1.0870	2,214,552	0.60	1.0	1,328,731
All Vehicles		100	10,357			101,865,308		3,015,213			**1,809,127**

Design ESAL **1,810,000**

Notes

1) The current and projected ADT were based on traffic data provided by HDR.
2) Table 1.2 Colorado Equivalency Factors. CDOT Pavment Design Manual (2014) provides a 3-Bin Classification of traffic with factors for each classification.
3) Assume a 20 year pavement design life.
4) The CDOT Pavement Design Manual recommends a directional distribution factor of 0.6 and lane distribution factor of 1 percent for a two lane road, one lane per direction.

Google Maps Monument



Map data ©2016 Google 500 ft

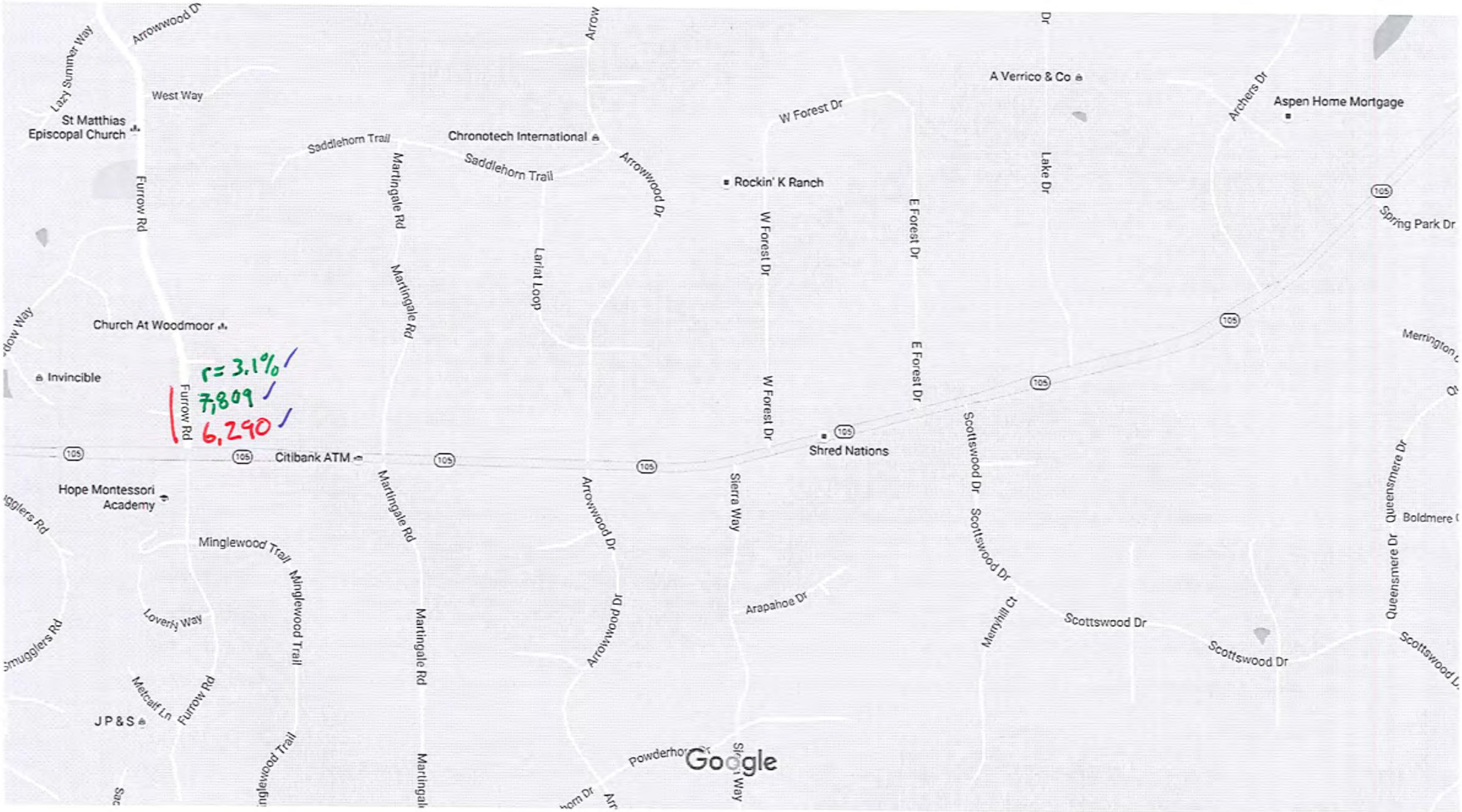
2010 'Raw Model' ADT for SH105

2017 Projected ADT & Growth Rate (projected from 2040 'Adjusted Model' ADT)

2017 Projected ADT 7/28/16 Email

[octagon symbol] Indicates Values used in ESAL calc.

Google Maps Monument



Map data ©2016 Google 500 ft

Google Maps Monument

Map data ©2016 Google 500 ft

Table D-2. Minimum Pavement Sections

Roadway Functional Classification	ESAL	Composite Sections[1]		Portland Cement Concrete (in)
		Asphalt (in)	Base (in)	
Rural				
Local	36,500	3.0	4.0	5.0
Minor Collector	109,500	3.0	6.0	5.0
Major Collector	273,750	3.0	8.0	6.0
Minor Arterial	689,850	4.0	8.0	6.0
Principal Arterial, 4-lane	2,628,000	5.0	8.0	6.0
Principal Arterial, 6-lane	9,198,000	6.5	8.0	6.0
Expressway, 4-lane	3,942,000	6.5	10.0	6.0
Expressway, 6-lane	12,264,000	6.5	10.0	7.0
Urban				
Local (low volume)	36,500	3.0	4.0	5.0
Local	292,000	3.0	8.0	5.0
Residential Collector	821,000	4.0	8.0	6.0
Nonresidential Collector	821,000	4.0	8.0	6.0
Minor Arterial	1,971,000	5.0	8.0	6.0
Principal Arterial, 4-lane	5,256,000	5.0	8.0	6.0
Principal Arterial, 6-lane	8,176,000	6.5	8.0	6.0
Expressway, 4-lane	7,884,000	6.5	8.0	6.0
Expressway, 6-lane	9,811,000	6.5	10.0	7.0

D.3.4 Flexible Pavement Strength Coefficients

The standard design coefficients for pavement materials are provided in Table D-3. Design values shall be verified by predesign mix test data and supported by daily construction tests.

D.3.5 Portland Cement Concrete Working Stress (f_t)

The working stress (f_t) shall be 75% of that provided by third-point beam loading which shall have minimum laboratory 28-day strength of 650 psi based on actual tests of materials to be used.

D.3.6 Gravel Roads

A minimum thickness of 6-inches shall be used on all newly constructed gravel roads meeting material specifications presented in Table D-7.

D.4 PAVEMENT DESIGN PROCEDURE

D.4.1 Flexible Pavements

The following procedure shall be used in determining the Structural Number (SN) and thickness of the pavement being designed.

Flexible Pavement Design Worksheet

Location: State Highway 105 Rural Principal Arterial, 4-lane
Comment: West Segment 1 - Projected ESAL (I-25 to Knollwood)

1. Pavement Design Life: 20.0 years

   Traffic Loading (W_{18}): 18k ESALs: 2,216,000 per lane

3. Serviceability:

p_0:	4.5
p_t:	2.5

   ΔPSI: 2.0

4. Subgrade Resilient Modulus (M_R):

   R-value: 22.7

   Section D.4.1 (C)

   $S_1 = [(\text{R-value} - 5) / 11.29] + 3$

   $M_R = 10^{[(S_1 + 18.72)/6.24]} =$ 5,400 psi

   M_R: 5,400 psi

5. Reliability:

   R: 80 % D.4.1 - C

   Z_R: -0.842

6. Design Standard Deviation (S_o):

   S_o: 0.45 D.4.1 - C

7. Requred Structural Numbers (SN_i): [Fig. D-1]

Analysis M_R		
32,883	SN_1:	**2.063**
5,400	SN_2:	**3.988**
-NA-	SN_3:	**-NA-**

$$\log_{10}(W_{18}) = Z_R\, S_o + 9.36\, \log_{10}(SN+1) - 0.20 + \frac{\log_{10}\left[\dfrac{\Delta PSI}{4.2-1.5}\right]}{0.40 + \dfrac{1094}{(SN+1)^{5.19}}} + 2.32\, \log_{10}(M_R) - 8.07$$

Layer Analysis

8. Pavement Materials Characterization: Table D-3

Layer	Material	Structural Layer Coefficients	Drainage Coefficients	Layer Modulus (psi)
1	HMA	a_1: 0.44	-	-
2	ABC	a_2: 0.11	m_2: 1.00	32,883
3		a_3:	m_3:	

9. Solutions for thicknesses: [Figure 3.2, Part II of 1993 AASHTO]

$SN^*_1 = a_1D^*_1 >= SN_1$

$SN^*_2 = a_1D^*_1 + a_2D^*_2m_2 >= SN_2$

$SN^*_3 = a_1D^*_1 + a_2D^*_2m_2 + a_3D^*_3m_3 >= SN_3$

Recommended Thicknesses				
Layer	Material	Thickness (D^*_i)	SN^*_i	SN_i
1	HMA	7.5 inches	3.300	2.063
2	ABC	8.0 inches	4.180	3.988
3		inches		

Note: Required SN <= Pavement SN, Design is Acceptable

Flexible Pavement Design Worksheet

Location: State Highway 105 Rural Principal Arterial, 4-lane
Comment: West Segment 2 - Projected ESAL (Knollwood to Lake Woodmoor Dr)

1. Pavement Design Life: | 20.0 years |
   Traffic Loading (W_{18}): | 18k ESALs: 1,611,000 per lane |

3. Serviceability:

p_0:	4.5
p_t:	2.5

ΔPSI: 2.0

4. Subgrade Resilient Modulus (M_R):
   R-value: 22.7

   Section D.4.1 (C)
   $S_1 = [(\text{R-value} - 5) / 11.29] + 3$
   $M_R = 10^{[(S_1 + 18.72)/6.24]} =$ 5,400 psi

   M_R: 5,400 psi

5. Reliability:
   R: 80 % D.4.1 - C
   Z_R: -0.842

6. Design Standard Deviation (S_o):
   S_o: 0.45 D.4.1 - C

7. Requred Structural Numbers (SN_i): [Fig. D-1]

Analysis M_R		
32,883	SN_1:	**1.957**
5,400	SN_2:	**3.802**
-NA-	SN_3:	**-NA-**

$$\log_{10}(W_{18}) = Z_R\ S_o + 9.36\ \log_{10}(SN+1) - 0.20 + \frac{\log_{10}\left[\frac{\Delta PSI}{4.2-1.5}\right]}{0.40 + \frac{1094}{(SN+1)^{5.19}}} + 2.32\ \log_{10}(M_R) - 8.07$$

Layer Analysis

8. Pavement Materials Characterization: Table D-3

Layer	Material	Structural Layer Coefficients	Drainage Coefficients	Layer Modulus (psi)
1	HMA	a_1: 0.44	-	-
2	ABC	a_2: 0.11	m_2: 1.00	32,883
3		a_3:	m_3:	

9. Solutions for thicknesses: [Figure 3.2, Part II of 1993 AASHTO]

$SN^*_1 = a_1D^*_1 >= SN_1$
$SN^*_2 = a_1D^*_1 + a_2D^*_2m_2 >= SN_2$
$SN^*_3 = a_1D^*_1 + a_2D^*_2m_2 + a_3D^*_3m_3 >= SN_3$

Recommended Thicknesses				
Layer	Material	Thickness (D^*_i)	SN^*_i	SN_i
1	HMA	7.0 inches	3.080	1.957
2	ABC	8.0 inches	3.960	3.802
3		inches		

Note: Required SN <= Pavement SN, Design is Acceptable

Flexible Pavement Design Worksheet

Location: State Highway 105 Rural Principal Arterial, 4-lane
Comment: West Segment - Urban 4 lane Principal Arterial, Minimum ESAL (I-25 to Lake Woodmoor Dr)

1. Pavement Design Life: 20.0 years
   Traffic Loading (W_{18}): 18k ESALs: 5,256,000 per lane

3. Serviceability:
   p_0: 4.5
   p_t: 2.5
   ΔPSI: 2.0

4. Subgrade Resilient Modulus (M_R):
   R-value: 22.7
   Section D.4.1 (C)
   $S_1 = [(\text{R-value} - 5) / 11.29] + 3$
   $M_R = 10^{[(S_1 + 18.72)/6.24]} =$ 5,400 psi
   M_R: 5,400 psi

5. Reliability:
   R: 80 % D.4.1 - C
   Z_R: -0.842

6. Design Standard Deviation (S_o):
   S_o: 0.45 D.4.1 - C

7. Requred Structural Numbers (SN_i): [Fig. D-1]

Analysis M_R		
32,883	SN_1:	**2.375**
5,400	SN_2:	**4.521**
-NA-	SN_3:	**-NA-**

$$\log_{10}(W_{18}) = Z_R\ S_o + 9.36\ \log_{10}(SN+1) - 0.20 + \frac{\log_{10}\left[\frac{\Delta PSI}{4.2-1.5}\right]}{0.40 + \frac{1094}{(SN+1)^{5.19}}} + 2.32\ \log_{10}(M_R) - 8.07$$

Layer Analysis

8. Pavement Materials Characterization: Table D-3

Layer	Material	Structural Layer Coefficients		Drainage Coefficients		Layer Modulus (psi)
1	HMA	a_1:	0.44	-		-
2	ABC	a_2:	0.11	m_2:	1.00	32,883
3		a_3:		m_3:		

9. Solutions for thicknesses: [Figure 3.2, Part II of 1993 AASHTO]

$SN^*_1 = a_1D^*_1 >= SN_1$

$SN^*_2 = a_1D^*_1 + a_2D^*_2m_2 >= SN_2$

$SN^*_3 = a_1D^*_1 + a_2D^*_2m_2 + a_3D^*_3m_3 >= SN_3$

Recommended Thicknesses					
Layer	Material	Thickness (D^*_i)		SN^*_i	SN_i
1	HMA	8.5	inches	3.740	2.375
2	ABC	8.0	inches	4.620	4.521
3			inches		

Note: Required SN <= Pavement SN, Design is Acceptable

Flexible Pavement Design Worksheet

Location: State Highway 105 Rural Principal Arterial, 4-lane
Comment: East Segment - Projected ESAL (Knollwood to SH83)

1. Pavement Design Life: 20.0 years
   Traffic Loading (W_{18}): 18k ESALs: 1,810,000 per lane

3. Serviceability:
   p_0: 4.5
   p_t: 2.5
   ΔPSI: 2.0

4. Subgrade Resilient Modulus (M_R):
   R-value: 19

   Section D.4.1 (C)
   $S_1 = [(\text{R-value} - 5) / 11.29] + 3$
   $M_R = 10^{[(S_1 + 18.72) / 6.24]} =$ 4,781 psi

   M_R: 4,800 psi

5. Reliability:
   R: 80 % D.4.1 - C
   Z_R: -0.842

6. Design Standard Deviation (S_o):
   S_o: 0.45 D.4.1 - C

7. Requred Structural Numbers (SN_i): [Fig. D-1]

Analysis M_R	
32,883	SN_1: **1.995**
4,800	SN_2: **4.030**
-NA-	SN_3: **-NA-**

$$\log_{10}(W_{18}) = Z_R\ S_o + 9.36\ \log_{10}(SN+1) - 0.20 + \frac{\log_{10}\left[\frac{\Delta PSI}{4.2-1.5}\right]}{0.40 + \frac{1094}{(SN+1)^{5.19}}} + 2.32\ \log_{10}(M_R) - 8.07$$

Layer Analysis

8. Pavement Materials Characterization: Table D-3

Layer	Material	Structural Layer Coefficients	Drainage Coefficients	Layer Modulus (psi)
1	HMA	a_1: 0.44	-	-
2	ABC	a_2: 0.11	m_2: 1.00	32,883
3		a_3:	m_3:	

9. Solutions for thicknesses: [Figure 3.2, Part II of 1993 AASHTO]
   $SN^*_1 = a_1D^*_1 >= SN_1$
   $SN^*_2 = a_1D^*_1 + a_2D^*_2m_2 >= SN_2$
   $SN^*_3 = a_1D^*_1 + a_2D^*_2m_2 + a_3D^*_3m_3 >= SN_3$

Recommended Thicknesses				
Layer	Material	Thickness (D^*_i)	SN^*_i	SN_i
1	HMA	7.5 inches	3.300	1.995
2	ABC	8.0 inches	4.180	4.030
3		inches		

Note: Required SN <= Pavement SN, Design is Acceptable

Flexible Pavement Design Worksheet

Location: State Highway 105 Rural Principal Arterial, 4-lane
Comment: East Segment - Rural 4 lane Principal Arterial, Minimum ESAL (Lake Woodmoor Dr to SH 83)

1. Pavement Design Life: 20.0 years
   Traffic Loading (W_{18}): 18k ESALs: 2,628,000 per lane

3. Serviceability:
   p_0: 4.5
   p_t: 2.5
   ΔPSI: 2.0

4. Subgrade Resilient Modulus (M_R):
   R-value: 19

   Section D.4.1 (C)
   $S_1 = [(\text{R-value} - 5) / 11.29] + 3$
   $M_R = 10^{[(S_1 + 18.72)/6.24]} =$ 4,781 psi

   M_R: 4,800 psi

5. Reliability:
   R: 80 % D.4.1 - C
   Z_R: -0.842

6. Design Standard Deviation (S_o):
   S_o: 0.45 D.4.1 - C

7. Requred Structural Numbers (SN_i): [Fig. D-1]

Analysis M_R	
32,883	SN_1: **2.122**
4,800	SN_2: **4.262**
-NA-	SN_3: **-NA-**

$$\log_{10}(W_{18}) = Z_R\ S_o + 9.36\ \log_{10}(SN+1) - 0.20 + \frac{\log_{10}\left[\frac{\Delta PSI}{4.2-1.5}\right]}{0.40 + \frac{1094}{(SN+1)^{5.19}}} + 2.32\ \log_{10}(M_R) - 8.07$$

Layer Analysis

8. Pavement Materials Characterization: Table D-3

Layer	Material	Structural Layer Coefficients	Drainage Coefficients	Layer Modulus (psi)
1	HMA	a_1: 0.44	-	-
2	ABC	a_2: 0.11	m_2: 1.00	32,883
3		a_3:	m_3:	

9. Solutions for thicknesses: [Figure 3.2, Part II of 1993 AASHTO]

$SN^*_1 = a_1D^*_1 >= SN_1$

$SN^*_2 = a_1D^*_1 + a_2D^*_2m_2 >= SN_2$

$SN^*_3 = a_1D^*_1 + a_2D^*_2m_2 + a_3D^*_3m_3 >= SN_3$

Recommended Thicknesses				
Layer	Material	Thickness (D^*_i)	SN^*_i	SN_i
1	HMA	8.0 inches	3.520	2.122
2	ABC	8.0 inches	4.400	4.262
3		inches		

Note: Required SN <= Pavement SN, Design is Acceptable

Flexible Pavement Design Worksheet

Location: State Highway 105 Rural Principal Arterial, 4-lane
Comment: East Segment - Rural Minor Arterial, Minimum ESAL (Lake Woodmoor Dr to SH 83)

1. Pavement Design Life: | 20.0 years |

   Traffic Loading (W_{18}): | 18k ESALs: 689,850 per lane |

3. Serviceability:
   | p_0: 4.5 |
   | p_t: 2.5 |

   | ΔPSI: 2.0 |

4. Subgrade Resilient Modulus (M_R):
   | R-value: 19 |

   Section D.4.1 (C)

   S_1 = [(R-value - 5) / 11.29] + 3

   $M_R = 10^{[(S_1 + 18.72)/6.24]} =$ 4,781 psi

   | M_R: 4,800 psi |

5. Reliability:
   | R: 80 % | D.4.1 - C

   | Z_R: -0.842 |

6. Design Standard Deviation (S_o):
   | S_o: 0.45 | D.4.1 - C

7. Required Structural Numbers (SN_i): [Fig. D-1]

Analysis M_R	
32,883	SN_1: **1.694**
4,800	SN_2: **3.485**
-NA-	SN_3: **-NA-**

$$\log_{10}(W_{18}) = Z_R\ S_o + 9.36\ \log_{10}(SN+1) - 0.20 + \frac{\log_{10}\left[\frac{\Delta PSI}{4.2-1.5}\right]}{0.40 + \frac{1094}{(SN+1)^{5.19}}} + 2.32\ \log_{10}(M_R) - 8.07$$

Layer Analysis

8. Pavement Materials Characterization: Table D-3

Layer	Material	Structural Layer Coefficients	Drainage Coefficients	Layer Modulus (psi)
1	HMA	a_1: 0.44	-	-
2	ABC	a_2: 0.11	m_2: 1.00	32,883
3		a_3:	m_3:	

9. Solutions for thicknesses: [Figure 3.2, Part II of 1993 AASHTO]

$SN^*_1 = a_1D^*_1 >= SN_1$

$SN^*_2 = a_1D^*_1 + a_2D^*_2m_2 >= SN_2$

$SN^*_3 = a_1D^*_1 + a_2D^*_2m_2 + a_3D^*_3m_3 >= SN_3$

Recommended Thicknesses				
Layer	Material	Thickness (D^*_i)	SN^*_i	SN_i
1	HMA	6.0 inches	2.640	1.694
2	ABC	8.0 inches	3.520	3.485
3		inches		

Note: Required SN <= Pavement SN, Design is Acceptable

Flexible Pavement Design Worksheet

Location: State Highway 105 Rural Principal Arterial, 4-lane
Comment: Local Road Minimum ESAL

1. Pavement Design Life: | 20.0 years |
   Traffic Loading (W_{18}): | 18k ESALs: 36,500 per lane |

3. Serviceability:
   - p_0: 4.5
   - p_t: 2.5

   ΔPSI: 2.0

4. Subgrade Resilient Modulus (M_R):
   R-value: 19

   Section D.4.1 (C)
   $S_1 = [(\text{R-value} - 5) / 11.29] + 3$
   $M_R = 10^{[(S_1 + 18.72) / 6.24]} =$ 4,781 psi

   M_R: 4,800 psi

5. Reliability:
   R: 80 % D.4.1 - C
   Z_R: -0.842

6. Design Standard Deviation (S_o):
   S_o: 0.45 D.4.1 - C

7. Required Structural Numbers (SN_i): [Fig. D-1]

Analysis M_R		
32,883	SN_1:	**0.960**
4,800	SN_2:	**2.188**
-NA-	SN_3:	**-NA-**

$$\log_{10}(W_{18}) = Z_R\, S_o + 9.36\, \log_{10}(SN+1) - 0.20 + \frac{\log_{10}\left[\frac{\Delta PSI}{4.2-1.5}\right]}{0.40 + \frac{1094}{(SN+1)^{5.19}}} + 2.32\, \log_{10}(M_R) - 8.07$$

Layer Analysis

8. Pavement Materials Characterization: Table D-3

Layer	Material	Structural Layer Coefficients	Drainage Coefficients	Layer Modulus (psi)
1	HMA	a_1: 0.44	-	-
2	ABC	a_2: 0.11	m_2: 1.00	32,883
3		a_3:	m_3:	

9. Solutions for thicknesses: [Figure 3.2, Part II of 1993 AASHTO]

$$SN^*_1 = a_1D^*_1 >= SN_1$$
$$SN^*_2 = a_1D^*_1 + a_2D^*_2m_2 >= SN_2$$
$$SN^*_3 = a_1D^*_1 + a_2D^*_2m_2 + a_3D^*_3m_3 >= SN_3$$

Recommended Thicknesses				
Layer	Material	Thickness (D^*_i)	SN^*_i	SN_i
1	HMA	3.5 inches	1.540	0.960
2	ABC	6.0 inches	2.200	2.188
3		inches		

Note: Required SN <= Pavement SN, Design is Acceptable

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

JOB NAME SH 105 | JOB NO. 23-1-01311-002
SUBJECT Overlay Analysis | DATE 10/27/16
BY JCG | CHK'D | SHEET of

SH 105

Revised by DAA 12/5/2016

Existing Pavement Sections

West Segment 1 (I-25 to Knollwood)

SW-P-01: 9.5" HMA, 11" ABC ✓
SW-P-02: 10" HMA, 5" ABC ✓

West Segment 2 (Knollwood to Lake Woodmoor)

SW-P-03: 7.5" HMA ✓
SW-P-04: 9" HMA
SW-P-05: 8" HMA
SW-P-06: 8" HMA

Overlay Analysis

West Segment 1

$SN_{EXISTING}$ = 4.46 ✓ ← existing section is sufficient for calculated ESAL

Min. Rural ESAL = 5,256,000 ✓ $SN_{REQUIRED}$ = 4.521 ✓

2" mill ($a \cong 0.30$) ✓

Required Overlay = [4.521 − (4.46 − 0.3(2))] / ~~0.40~~ 0.44 ✓

= ~~1.7"~~ 1.5" ✓

2 inch mill, 2 inch overlay (same for ESAL = 7,216,000) ✓

West Segment 2

$SN_{EXISTING}$ = 2.63 ✓

ESAL = ~~1,553,000~~ 1,611,000 ✓ $SN_{REQUIRED}$ = ~~3.781~~ 3.802 ✓

Required Overlay = [~~3.781~~ 3.802 − (2.63 − 0.3(2))] / ~~0.40~~ 0.44 ✓

= ~~4.4"~~ ✓ 4.03" ✓ (2" Mill, 4.5" OL) ✓

ESAL = 5,256,000 $SN_{REQUIRED}$ = 4.54 ✓

Required Overlay = [4.521 − (2.63 − 0.3(2))] / ~~0.40~~ 0.44 ✓

= ~~6.3"~~ ✓ 5.66" ✓

2" mill, ~~6.5"~~ 6.0" overlay ✓

APPENDIX F

IMPORTANT INFORMATION ABOUT YOUR GEOTECHINAL REPORT

IMPORTANT INFORMATION ABOUT YOUR GEOTECHNICAL REPORT

CONSULTING SERVICES ARE PERFORMED FOR SPECIFIC PURPOSES AND FOR SPECIFIC CLIENTS.

Consultants prepare reports to meet the specific needs of specific individuals. A report prepared for a civil engineer may not be adequate for a construction contractor or even another civil engineer. Unless indicated otherwise, your consultant prepared your report expressly for you and expressly for the purposes you indicated. No one other than you should apply this report for its intended purpose without first conferring with the consultant. No party should apply this report for any purpose other than that originally contemplated without first conferring with the consultant.

THE CONSULTANT'S REPORT IS BASED ON PROJECT-SPECIFIC FACTORS.

A geotechnical/environmental report is based on a subsurface exploration plan designed to consider a unique set of project-specific factors. Depending on the project, these may include: the general nature of the structure and property involved; its size and configuration; its historical use and practice; the location of the structure on the site and its orientation; other improvements such as access roads, parking lots, and underground utilities; and the additional risk created by scope-of-service limitations imposed by the client. To help avoid costly problems, ask the consultant to evaluate how any factors that change subsequent to the date of the report may affect the recommendations. Unless your consultant indicates otherwise, your report should not be used: (1) when the nature of the proposed project is changed (for example, if an office building will be erected instead of a parking garage, or if a refrigerated warehouse will be built instead of an unrefrigerated one, or chemicals are discovered on or near the site); (2) when the size, elevation, or configuration of the proposed project is altered; (3) when the location or orientation of the proposed project is modified; (4) when there is a change of ownership; or (5) for application to an adjacent site. Consultants cannot accept responsibility for problems that may occur if they are not consulted after factors which were considered in the development of the report have changed.

SUBSURFACE CONDITIONS CAN CHANGE.

Subsurface conditions may be affected as a result of natural processes or human activity. Because a geotechnical/environmental report is based on conditions that existed at the time of subsurface exploration, construction decisions should not be based on a report whose adequacy may have been affected by time. Ask the consultant to advise if additional tests are desirable before construction starts; for example, groundwater conditions commonly vary seasonally.

Construction operations at or adjacent to the site and natural events such as floods, earthquakes, or groundwater fluctuations may also affect subsurface conditions and, thus, the continuing adequacy of a geotechnical/environmental report. The consultant should be kept apprised of any such events, and should be consulted to determine if additional tests are necessary.

MOST RECOMMENDATIONS ARE PROFESSIONAL JUDGMENTS.

Site exploration and testing identifies actual surface and subsurface conditions only at those points where samples are taken. The data were extrapolated by your consultant, who then applied judgment to render an opinion about overall subsurface conditions. The actual interface between materials may be far more gradual or abrupt than your report indicates. Actual conditions in areas not sampled may differ from those predicted in your report. While nothing can be done to prevent such situations, you and your consultant can work together to help reduce their impacts. Retaining your consultant to observe subsurface construction operations can be particularly beneficial in this respect.

A REPORT'S CONCLUSIONS ARE PRELIMINARY.

The conclusions contained in your consultant's report are preliminary because they must be based on the assumption that conditions revealed through selective exploratory sampling are indicative of actual conditions throughout a site. Actual subsurface conditions can be discerned only during earthwork; therefore, you should retain your consultant to observe actual conditions and to provide conclusions. Only the consultant who prepared the report is fully familiar with the background information needed to determine whether or not the report's recommendations based on those conclusions are valid and whether or not the contractor is abiding by applicable recommendations. The consultant who developed your report cannot assume responsibility or liability for the adequacy of the report's recommendations if another party is retained to observe construction.

THE CONSULTANT'S REPORT IS SUBJECT TO MISINTERPRETATION.

Costly problems can occur when other design professionals develop their plans based on misinterpretation of a geotechnical/environmental report. To help avoid these problems, the consultant should be retained to work with other project design professionals to explain relevant geotechnical, geological, hydrogeological, and environmental findings, and to review the adequacy of their plans and specifications relative to these issues.

BORING LOGS AND/OR MONITORING WELL DATA SHOULD NOT BE SEPARATED FROM THE REPORT.

Final boring logs developed by the consultant are based upon interpretation of field logs (assembled by site personnel), field test results, and laboratory and/or office evaluation of field samples and data. Only final boring logs and data are customarily included in geotechnical/environmental reports. These final logs should not, under any circumstances, be redrawn for inclusion in architectural or other design drawings, because drafters may commit errors or omissions in the transfer process.

To reduce the likelihood of boring log or monitoring well misinterpretation, contractors should be given ready access to the complete geotechnical engineering/environmental report prepared or authorized for their use. If access is provided only to the report prepared for you, you should advise contractors of the report's limitations, assuming that a contractor was not one of the specific persons for whom the report was prepared, and that developing construction cost estimates was not one of the specific purposes for which it was prepared. While a contractor may gain important knowledge from a report prepared for another party, the contractor should discuss the report with your consultant and perform the additional or alternative work believed necessary to obtain the data specifically appropriate for construction cost estimating purposes. Some clients hold the mistaken impression that simply disclaiming responsibility for the accuracy of subsurface information always insulates them from attendant liability. Providing the best available information to contractors helps prevent costly construction problems and the adversarial attitudes that aggravate them to a disproportionate scale.

READ RESPONSIBILITY CLAUSES CLOSELY.

Because geotechnical/environmental engineering is based extensively on judgment and opinion, it is far less exact than other design disciplines. This situation has resulted in wholly unwarranted claims being lodged against consultants. To help prevent this problem, consultants have developed a number of clauses for use in their contracts, reports, and other documents. These responsibility clauses are not exculpatory clauses designed to transfer the consultant's liabilities to other parties; rather, they are definitive clauses that identify where the consultant's responsibilities begin and end. Their use helps all parties involved recognize their individual responsibilities and take appropriate action. Some of these definitive clauses are likely to appear in your report, and you are encouraged to read them closely. Your consultant will be pleased to give full and frank answers to your questions.

The preceding paragraphs are based on information provided by the
ASFE/Association of Engineering Firms Practicing in the Geosciences, Silver Spring, Maryland