Sports Medicine & Weight Room Renovations at Coors Event Center
University of Colorado
Boulder, CO
University Project No.: CP166889
SCD Project # 1301

OWNER
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ADDENDUM #2
August 30, 2013

This Addendum becomes part of the contract documents and shall be acknowledged by the Contractor. All parts of the contract documents dated August 12, 2013, as modified by Addendum #1, shall remain in force except as modified by this addendum.

GENERAL ITEMS: BIDDING QUESTIONS

1. Bid Question: Interior masonry walls – notes on sheet A9.3 indicate to refer to structural drawings for wall reinforcing criteria and connection of wall to deck above, do not find this information on structural drawings or architectural drawings?
Response: See new details 9/A9.2 and 10/A9.2 for interior masonry wall reinforcing criteria. DELETE the reference to the structural drawings.

2. Bid Question: Sheet A0.5 – equipment item E9 dishwasher states it is CFCI. Sheets A4.21 & A4.22 shows a Dishwasher KE14 as OFOI?
Response: These are two separate and different dishwashers. Dishwasher E9 is located in the sports medicine area in room Wet/Ice NW192 and is CFCI. Dishwasher KE14 is located in the Catering kitchen NW272 and is OFOI.

3. Bid Question: In the specifications, page 8 of the General Conditions, the Contactor is to pay for all Permits and Licenses. However in the pre bid it was noted that CU would pay for the Permit? Who is responsible for the Building Permit Fee?
Response: UCB is their own code authority so the permit expense will be picked up by UCB. However, City of Boulder Use Tax must be paid by the Contractor.
4. **Bid Question:** In the specifications, page 8 of the General Conditions, the Contactor is to pay for all Permits and Licenses. However in the pre bid it was noted that CU would pay for the Permit? Who is responsible for the Building Permit Fee?

*Response: UCB is their own code authority so the permit expense will be picked up by UCB. However, City of Boulder Use Tax must be paid by the Contractor.*

5. **Bid Question:** Does the "Contractor's Statement of Experience" forms need to be included in the bid package?

*Response: Yes, these must be submitted with the bid package.*

6. **Bid Question:** Sheet S3.0; key note 5: Please provide a soils report for the placement of the helical piers.

*Response: A new site-specific soils report was not completed for this project and presumptive soil design parameters were used for the design. The soils report for the adjacent practice facility that completed on March 4, 2009 is attached and included herein. This soils report is for reference only and should give the bidders an indication of the soils types that can be assumed to be encountered during excavation. For the purposes of the bidding, assume a helical pier depth of 15'-0".*

7. **Bid Question:** General: Currently there is a contractor (Sun Construction) removing carpet tiles. Are they going to remove the carpet tile adhesive down to the concrete surface or is it up to us to take care of that?

*Response: Removal of the glue will remain in the project, it is up to the bidders to remove the glue.*

*Removal of the existing ceiling tiles from the weight room area on the Street Level only is currently being preformed and shall be removed from the scope of work.*

8. **Bid Question:** Sheet M2.2; grid C-9: The 24x12 return air grille/duct work will not fit in that location as it will be obstructed by the concrete beam. Possible solution would be to relocate the return air grille to the North-West of the room above wood ceiling feature, or install a side wall return grille with sound boot in new framed drywall wall. Please advise.

*Response: Please change to a 24"x12" sidewall return grille with a sound boot.*

9. **Bid Question:** Sheet P1.2: How will installation of waste lines for Phase 1 be coordinated: a) above the plaster ceiling in the women's volleyball locker room shower? b) above the plaster ceiling in the lacrosse locker room?.

*Response: Refer to clarifications issue on sheets A6.12 and new sheet A6.13 contained within this addendum to address these ceilings.*
10. **Bid Question:** Sheet P2.2: Note 9: a) is located where a 3 comp sink is shown; b) refers to sink S-3; c) spec 15440-4: 2.05 sinks D: kitchen 2 compartment sink S-3 supplied by kitchen contractor. Please clarify the discrepancy.

*Response:* Owner will provide and install this sink. Please provide rough-in for it.

**REVISIONS TO PROJECT MANUAL:**

1. **RE: PROCEDURAL DOCUMENTS, Bid Form:**
   See attached updated bid form.

2. **RE: Contractor Parking:**
   See attached contractor parking area and dumpster location.

3. **RE: Noise Limitations:**
   There will be no noise limitations or special working hours. 24/7 access will be allowed. Access during events can be coordinated through the UCB PM if necessary.

4. **RE: Spec Section 08740, 2.04 ELECTRO-MAGNETIC LOCKS:**
   CHANGE the basis of design to RCI 8320-28 Mag Lock with LED.

5. **RE: Spec Section 08740, 2.08 ELECTRIFIED HINGES:**
   CHANGE the basis of design to Murray Electric Hinge 18-2, 22-4.

6. **RE: Spec Section 08710, 3.04 Hardware Schedule, hardware group EDDI-E:**
   Change the hardware group to the following:
   EDDI-E (Double door – interior entrance function - card reader)
   EACH PAIR TO HAVE:
   6 EA. FBB 179NRP (ST) HINGE
   2 EA. 18-2, 22-4 (MAR) CONCEALED CIRCUIT ELECT HINGE
   2 EA. 4040XP (LCN) CLOSER
   2 EA 8190-2-O (IVE) OFFSET DOOR PULL
   2 EA 100S (GJ) OVERHEAD STOP
   2 EA 8320-28 (RCI) ELECTRO-MAGNETIC LOCK
   1 EA RMP2-MP (SM) CCURE CARD READER
   2 EA 2505A (SN) STATUS MONITOR
   1 EA MKA SECURITRON KEYSWITCH
   2 EA 330RXRX (VD) ELECT PANIC DEVICE
   1EA EEB3N (STR) SECURETRON EMERGENCY EXIT BUTTON

7. **RE: Spec Section 08710, 3.04 Hardware Schedule, hardware group ESDI-E:**
   Change the electric hinge to the Murray 18-2, 22-4.
REVISIONS TO ARCHITECTURAL DRAWINGS:

1. **Re: Sheet A2.12: Service Level Corridor Treatment**
   Refer to attached sheets A2.12 for misc. notes added to clarify the patching repairing and replacement of floor, wall and base finishes in the corridor outside of the sports medicine remodel area.

2. **Re: Sheet A2.21 and A2.22: CCure Electronic Access Panel Re-location**
   Refer to attached sheets A2.21 and A2.22 for information on relocating an existing CCure electronic door access panel from demolished room NW280 Women’s BB storage to new room NW261B WBB Storage. This control panel only controls 2 doors: The entry doors into the Men’s and Women’s BB office located off Entry NW209. See notes on the plans for re-connecting the doors to the panel.
   - Provide a new 120v 20a electric power outlet on a dedicated circuit at the new panel location. This outlet is in addition to the outlets shown in this room already.
   - Provide a new tele/jack at this location.

3. **Re: Sheet A6.12: Service Level Reflected Ceiling Plan**
   Refer to attached sheet A6.12 for misc. clarifications to hallway ceiling work. ADD a soffit above the removed double doors on the east end of corridor CRNW170. See attached sheet A6.12 for note regarding the north demising wall of the sports medicine complex and the corridor. This wall must jog above the ceiling in order to clear existing ductwork and piping above the ceiling in the corridor.

4. **Re: Sheet A6.12: Lid of Mechanical Chase**
   Refer to attached sheet A6.12 for notes on providing a gyp-board lid over the top of the mechanical chase in hydro pool/shower area.

5. **Re: Sheet A6.13: Service Level Reflected Ceiling Plan**
   Add new sheet A6.13 showing existing ceilings on the service level that fall under the new plumbing work above. Refer to notes on the drawing for cutting, patching and replacing gyp-board, plaster and ACT ceilings to accommodate the installation of new plumbing work above.

6. **Re: Sheet A9.2:**
   ADD details 9/A9.2 and 10/A9.2 that clarify the interior CMU wall reinforcing criteria.

7. **Re: Sheet A9.2:**
   ADD detail 13/A9.2 for pit ladder. Relocate the pit ladder to the north wall of the pit hatch area.
REVISIONS TO COMMUNICATIONS SYSTEMS DRAWINGS:

1. RE: CS3.1, Detail 2
   Refer to attached sheet CS3.1 for a revised detail 2 for the double door diagram for hardware group EDDI-E.

REVISIONS TO MECHANICAL SYSTEMS DRAWINGS:

1. RE: Refer to attached Addendum and drawings from PCD Engineering.

END OF ADDENDUM #2
1. **BID:** Pursuant to the advertisement by the State of Colorado dated **August 13, 2013** the undersigned bidder hereby proposes to furnish all the labor and materials and to perform all the work required for the complete and prompt execution of everything described or shown in or reasonably implied from the Bidding Documents, including the Drawings and Specifications, for the work and for the base bid indicated above. Bidders should include all taxes that are applicable.

2. **EXAMINATION OF DOCUMENTS AND SITE:** The bidder has carefully examined the Bidding Documents, including the Drawings and Specifications, and has examined the site of the Work, so as to make certain of the conditions at the site and to gain a clear understanding of the work to be done.

3. **PARTIES INTERESTED IN BID:** The bidder hereby certifies that the only persons or parties interested in this Bid are those named herein, and that no other bidder or prospective bidder has given any information concerning this Bid. For State Public Works, not less than eighty percent of the labor employed on such projects shall consist of Colorado Labor C.R.S 8-17-101.

4. **BID GUARANTEE:** This Bid is accompanied by the required Bid Guarantee. You are authorized to hold said Bid Guarantee for a period of not more than thirty (30) days after the opening of the Bids for the work above indicated, unless the undersigned bidder is awarded the Contract, within said period, in which event the Director, State Buildings Programs, may retain said Bid Guarantee, until the undersigned bidder has executed the required Agreement and furnished the required Performance Bond, Labor and Material Payment Bond, Insurance Policy and Certificates of Insurance and Affidavit Regarding Unauthorized Immigrants.

5. **TIME OF COMPLETION:** The bidder agrees to achieve Substantial Completion of the Project from the date of the Notice to Proceed within the number of calendar days entered above, and in addition, further agrees that the period between Substantial Completion and Final Acceptance of the Project will not exceed the number of calendar days noted above. If awarded the Work, the bidder agrees to begin performance within ten (10) days from the date of the Notice to Proceed subject to Article 46, Time of Completion and Liquidated Damages of The General Conditions of the Contract, and agrees to prosecute the Work with due diligence to completion. The bidder represents that Article 7D of the Contractor’s Agreement (SC-6.21) has been reviewed to determine the type and amount of any liquidated damages that may be specified for this contract.
6. **EXECUTION OF DOCUMENTS**: The bidder understands that if this Bid is accepted, bidder must execute the required Agreement and furnish the required Performance Bond, Labor and Material Payment Bond, Insurance Policy and Certificates of Insurance and Affidavit Regarding Unauthorized Immigrants within ten (10) days from the date of the Notice of Award, and that the bidder will be required to sign to acknowledge and accept the Contract Documents, including the Drawings and Specifications.

7. **ALTERNATES**: Refer to the Information for Bidders (SC-6.12) for Method of Award for Alternates and use State Form SBP-6.13.1 Bid Alternates form to be submitted with this bid form if alternates are requested by the institution/agency in the solicitation documents.

8. **Submit wage rates** (direct labor costs) for prime contractor and subcontractor as requested by the institution/agency in the solicitation documents.

9. **The right is reserved to waive informalities and to reject any and all Bids.**

Dated this ______ Day of ______________________, 2013

THE BIDDER:

________________________________________________________
Company Name

________________________________________________________
Address including city, state & zip)

________________________________________________________

Phone Number:

________________________________________________________

Email Address:

________________________________________________________

Responsible person (print name):

________________________________________________________

Signature:

________________________________________________________

Name (print) and Title:

________________________________________________________

SIGNATURES: If the Bid is being submitted by a Corporation, the Bid should be signed by an officer, i.e., President or Vice-President. If a sole proprietorship or a partnership is submitting the Bid, the Bid shall so indicate and be properly signed.
Sports Medicine & Weight Room Renovations at Coors Event Center  
University of Colorado  
Boulder, Colorado

**Mechanical and Plumbing Addendum #2**  
August 30, 2013

**Bid Questions:**

1. **Bid Question: Sheet M2.2; grid C-9:** The 24x12 return air grille/duct work will not fit in that location as it will be obstructed by the concrete beam. Possible solution would be to relocate the return air grille to the North-West of the room above wood ceiling feature, or install a side wall return grille with sound boot in new framed drywall wall. Please advise.  
   Response: Please change to a 24”x12” sidewall return grille with a sound boot.

2. **Bid Question: Sheet P1.2:** How will installation of waste lines for Phase 1 be coordinated: a) above the plaster ceiling in the women’s volleyball locker room shower? B) above the plaster ceiling in the lacrosse locker room?  
   Response: Please see Architectural Response.

3. **Bid Question: Sheet P2.2:** Note 9: a) is located where a 3 comp sink is shown; b) refers to sink S-3; c) spec 15440-4: 2.05 sinks D: kitchen 2 compartment sink S-3 supplied by kitchen contractor. Please clarify the discrepancy.  
   Response: Owner will provide and install this sink. Please provide rough-in for it.

**Specifications Amendments:**

1. 15440-4, Paragraph 2.05, Sinks; Delete Sink S-3 as this sink will be provided by the Owner.

**Drawing Amendments:**

1. M2.2: Modify ductwork in various areas regarding return air path, grilles, etc. See attached drawing.
2. P1.2: Clarify piping in Wet/Ice NW192. See attached drawing.
Prior Addenda Amendments:

No addenda amendments.

Attachments:

- Drawing M2.2.
- Drawing P1.2.

END
SECTION 00320 - GEOTECHNICAL DATA

PART 1 - GENERAL

1.00 RELATED DOCUMENTS:

Drawings and general provisions of the contract, including General and Supplementary Conditions and Division 1-Specification sections, apply to the work of this section.

1.01 DESCRIPTION OF WORK:

A. The Owner's Soils Engineer, Geotechnical Group, has prepared a soil and foundation investigation dated March 4, 2009, with Addendum No 1, dated October 15, 2009. The report is bound in the Project Manual following this section for convenience of reference but is not a part of the contract documents.

B. A complete report is available for review through the Owner.

C. The report is not a warranty of subsurface conditions and Owner will not be responsible for interpretations or conclusions drawn therefrom by Contractor.

D. Contractor is responsible to review reports and to visit and examine the site. Contractor is cautioned to examine this data before preparing his proposal. The Owner will not entertain claims for extra cost based on allegations of lack of knowledge of the soil conditions.

E. The exploring borings were spaced in order to obtain a comprehensive report of the subsoil condition; however, erratic soil conditions may occur between test holes. If such conditions are found during construction, the Architect shall be notified.

F. Bench marks, monuments, pins and other reference points shall be provided and maintained by the Contractor.

PART 2 - PRODUCTS (Not applicable)

PART 3 - EXECUTION (Not applicable)

END OF SECTION 00320
March 4, 2009

University of Colorado at Boulder
Facilities Management
453 UCB
Boulder, Colorado 80309-0453

Attn: Ms. Katherine Dunklau

Re: Geotechnical Engineering Report
Proposed Basketball/Volleyball Practice Facility
University of Colorado
Regent Drive
Boulder, Colorado
Terracon Project No. 25095009

Terracon Consultants, Inc. (Terracon) has completed a geotechnical engineering exploration for the proposed basketball/volleyball practice facility located along Regent Drive at the University of Colorado campus in Boulder, Colorado. This study was performed in general accordance with our proposal number D25090031 dated January 23, 2009.

The results of our engineering study, including the Boring Location Map, laboratory test results, Logs of Borings, and the geotechnical recommendations needed to aid in the design and construction of foundations and other earth connected phases of this project are attached.

Based on the geotechnical engineering analyses, subsurface exploration and laboratory test results, and to the presence of potentially low to highly expansive claystone bedrock materials, we recommend that the proposed structure be supported on drilled piers. Based on the properties of the subsurface materials and to reduce the potential for slab movement, structural floor systems are recommended for the interior floor system of the buildings utilizing drilled pier foundation systems.

Other design and construction recommendations, based upon geotechnical conditions, are presented in the report.
We appreciate being of service to you in the geotechnical engineering phase of this project, and are prepared to assist you during the remaining phases as well. If you have any questions concerning this report or any of our testing, inspection, design and consulting services, please do not hesitate to contact us.

Sincerely,

TERRACON CONSULTANTS, INC.

Thomas J. Nevin, P.E.
Senior Project Engineer

Andrew J. Garner, P.E.
Geotechnical Department Manager

Copies to: Addressee (5)
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APPENDIX A: LOGS OF BORINGS

APPENDIX B: LABORATORY TEST RESULTS

APPENDIX C: GENERAL NOTES
INTRODUCTION

This report contains the results of our geotechnical engineering exploration for the proposed basketball/volleyball practice facility along Regent Drive at the University of Colorado campus in Boulder, Colorado.

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

- Subsurface soil and bedrock conditions.
- Groundwater conditions.
- Foundation design and construction.
- Floor slab design and construction.
- Lateral earth pressures.
- Retaining wall design parameters.
- Earthwork.
- Drainage.

The recommendations contained in this report are based upon the results of field and laboratory testing, engineering analyses, and experience with similar soil conditions, structures and our understanding of the proposed project.

PROJECT INFORMATION

We understand this project will include the construction of a basketball/volleyball practice facility located just north of the Coors Event Center at the University of Colorado in Boulder, Colorado. We understand the proposed basketball/volleyball practice facility will have a plan area of about 35,680 square feet and will include practice courts, coaching offices, locker rooms and equipment facilities.

The proposed facility will be two-stories and portion of the facility will span over an existing drive/loading dock for the Coors Event Center. Basement construction is likely along the eastern portion of the proposed building against the slope. We assume maximum wall and
column loads to be about 4 to 6 kips per lineal foot and 200 to 500 kips, respectively. We assume the building may house equipment with significant loads, however, we have not been provided information regarding this equipment. We understand that due to the nature of the proposed practice facility, movement of the building and floor system should be kept to a minimum.

Based upon the provided Topographic Survey, as much as 12 feet of grade change occurs within the proposed building location. We assume the lower-level finished floor will be about 5348 feet or just above the elevation of the drive lane on the north side of the Coors Event Center. Additionally, the project will include underground utilities and courtyard improvements to the west of the proposed building.

SITE EXPLORATION PROCEDURES

The scope of the services performed for this project included site reconnaissance by a geological engineer, a subsurface exploration program, laboratory testing and engineering analysis.

**Field Exploration:** A total of six test borings were drilled on February 12, 2009, to depths of about 10 to 35 feet below existing site grade. Specifically, Boring Nos. 1 through 4 were drilled within the proposed practice facility and Boring Nos. 5 and 6 were drilled within the proposed courtyard. The approximate boring locations are shown on the Boring Location Map, Figure 1.

The borings were located in the field by measuring from property lines and/or existing site features. Ground surface elevations at the boring locations were estimated from the provided site plan and should be considered approximate. The accuracy of boring locations and elevations should only be assumed to the level implied by the methods used.

Lithologic logs of the borings were recorded by the field engineer during the drilling operations. At selected intervals, samples of the subsurface materials were obtained by driving ring barrel samplers.

The borings were drilled with a CME-55 truck-mounted rotary drill rig with continuous flight solid-stem augers. During the drilling operations, lithologic logs of the borings were recorded by the field engineer. Relatively undisturbed samples were obtained at selected intervals utilizing a 3-inch outside diameter ring barrel sampler. Disturbed samples were obtained from auger cuttings. Penetration resistance values were recorded using methods based on the standard penetration test (SPT). This test consists of driving the sampler into the ground with a 140-pound hammer free-falling through a distance of 30 inches. The number of blows required to advance the ring barrel sampler 12 inches or the interval indicated, is recorded and can be
correlated to the standard penetration resistance value (N-value). The blow count values are indicated on the boring logs at the respective sample depths, but are not considered N-values.

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

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

Groundwater measurements were obtained in the borings at the time of site exploration. The boring was immediately backfilled following the completion of drilling operations for safety considerations. Therefore, a subsequent groundwater measurement was not obtained.

**Laboratory Testing:** Samples retrieved during the field exploration were returned to the laboratory for observation by the project geotechnical engineer, and were classified in general accordance with the Unified Soil Classification System described in Appendix C. Samples of bedrock were classified in accordance with the general notes for Rock Classification.

At that time, an applicable laboratory testing program was formulated to determine engineering properties of the subsurface materials. Following completion of the laboratory testing, the field descriptions were confirmed or modified as necessary and Logs of Borings were prepared and are presented in Appendix A.

Laboratory test results are presented in Appendix B, and were used for the geotechnical engineering analyses, and the development of foundation and earthwork recommendations. Laboratory tests were performed in general accordance with the applicable local standards.
Selected soil and bedrock samples were tested for the following engineering properties:

- Water content
- Dry density
- Consolidation/Expansion
- Grain size
- Plasticity Index
- Water soluble sulfates

SITE CONDITIONS

The site was currently developed and had ground cover consisting of native grasses, manicured sod and an asphalt access drive and loading dock. The site is bound to the north by an access road, to the south by Coors Event Center, to the west by Regent Drive, and to the east by open land (soon to be the heating and cooling plant). Topographically, the site sloped downward from the west and east towards the access drive/loading dock with a maximum difference in elevation of about 12 feet. A retaining wall was observed east of the access roadway with a slope of about 2:1 (H:V) above the retaining wall. Site drainage was generally in the form of sheet surface flow directed toward the access roadway, towards a stormwater inlet.

SUBSURFACE CONDITIONS

Geology: Surficial geologic conditions at the site, as mapped by the U.S. Geological Survey (USGS) (Colton, 1978), consist of the Verdos Alluvium of Pleistocene Age. These materials are described as a yellowish-red silty clayey sand containing varying amounts of gravel, generally on the order of 5 to 15 feet in thickness.

Bedrock underlying the surface units consists of the Denver and Dawson Formations of Paleocene and Upper Cretaceous Age. These formations typically consist of Arkosic sandstone, siltstone, claystone, and/or minor conglomerate.

Due to the sloping nature of the site, geologic hazards at the site are anticipated to be relatively low, provided that the recommendations contained herein are followed. Seismic activity in the area is anticipated to be low, and the property should be relatively stable from a structural standpoint. With proper site grading around the proposed structures, erosional problems at the site should be reduced.

Mapping completed by the Colorado Geological Survey (Hart, 1972), indicates the site in an area of "Very High Swell Potential". Potentially expansive materials mapped in this area include bedrock, weathered bedrock and colluvium (surficial units).

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Soil and Bedrock Conditions: As presented on the Logs of Borings, fill materials consisting of sandy lean clay and clayey sand was observed in Boring Nos. 1, 5 and 6 (western portion of the site) from the ground surface to depths ranging from about 10 to 13 feet below the existing ground surface. Concrete and brick fragments were also encountered within the lower portions of this fill material in Boring Nos. 5 and 6 from about 5 to 10 feet below the existing ground surface. Native soils consisting of sandy lean clay were encountered in Boring No. 2 at the ground surface and extended to a depth of about 1-1/2 feet below the existing ground surface. Claystone bedrock was encountered below these soils and immediately below the asphalt in Boring Nos. 3 and 4 and extended to the full depth of exploration.

Field and Laboratory Test Results: Field test results indicate that the clay fill materials soils are medium stiff to stiff in consistency and the clayey sand fill materials are loose to medium dense in relative density. The claystone bedrock varies from medium hard to very hard in hardness.

Laboratory test results indicate that the on-site clay and clayey sand fill materials exhibit low expansive potential and the claystone bedrock generally exhibits low to high expansive potential at their in-situ moisture contents. Results of water soluble sulfate testing indicated a negligible value of about 6 mg/l.

Groundwater Conditions: Groundwater was not encountered in the borings at the time of field exploration. The boring was immediately backfilled following the completion of drilling operations for safety considerations. Therefore, a subsequent groundwater measurement was not obtained. These observations represent groundwater conditions at the time of the field exploration, and may not be indicative of other times or at other locations. Groundwater conditions can change with varying seasonal and weather conditions, and other factors.

Based upon review of USGS maps, (Hillier, et al, 1983), regional groundwater beneath the project area is expected to be encountered in colluvial, landslide, windblown deposits and consolidated sedimentary rocks on the site at depths ranging from 5 to 20 feet below present ground surface.

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

The possibility of groundwater fluctuations should be considered when developing design and construction plans for the project.

ENGINEERING RECOMMENDATIONS

Geotechnical Considerations: Based on the field and laboratory testing and geotechnical engineering analyses, the site appears suitable for the proposed construction. Expansive soils and bedrock are present on this site. This report provides recommendations to help mitigate the effects of soil shrinkage and expansion. However, even if these procedures are followed, some movement and at least minor cracking in the structure should be anticipated. The severity of cracking and other cosmetic damage such as uneven floor slabs will probably increase if any modification of the site results in excessive wetting or drying of the expansive soils. Eliminating the risk of movement and cosmetic distress may not be feasible, but it may be possible to further reduce the risk of movement if significantly more expensive measures are used during construction. We would be pleased to discuss other construction alternatives with you upon request.

In addition, approximately 10 to 13 feet of fill was encountered in the western portion of the site, particularly within the proposed courtyard. We do not possess any information regarding whether the fill was placed under the observation of a geotechnical engineer. Support of foundations, floor slabs, and pavements on or above existing fill soils is discussed in this report. However, even with the recommended construction testing services, there is an inherent risk for the owner that compressible fill or unsuitable material within or buried by the fill will not be discovered. This risk cannot be eliminated without completely removing the existing fill, but can be minimized by thorough exploration and testing.

Based upon the field penetration resistance values, in-situ dry densities and the laboratory swell/expansion test data, it is our opinion that the existing fill should not be used for support of foundations, floor slabs-on-grade and pavements. Within the courtyard and for relatively small structures, these structures may be supported on the existing fill materials, provided movement and distress can be tolerated. All critical elements should be founded on drilled piers.

Terracon’s services did not include delineating the horizontal or vertical extent of the existing fill material. It should be noted that there exists the potential for other debris and/or domestic trash to be encountered within the fill on some portions of the site. However, based upon the boring log data, the potential is considered to be low. This should be verified by additional geotechnical exploration or evaluation at the site. If additional exploration is not performed, the owner should make allowances for such conditions to exist in the preparation of the project budget and/or construction plans.
As mentioned previously, we understand that due to the nature of the proposed practice facility, movement of the building and floor system should be kept to a minimum. Based on the geotechnical engineering analyses, subsurface exploration and laboratory test results, and the presence of potentially low to highly expansive claystone bedrock materials, we recommend that the proposed practice facility structure be supported on drilled piers. Based on the properties of the subsurface materials and to reduce the potential for floor slab movement, structural floor systems are recommended for the interior floor system of the building.

The assessment of site environmental conditions or the potential presence of pollutants in the soil, rock or groundwater of the site is beyond the proposed scope of this exploration.

**Drilled Pier Foundation System:** Due to the presence of potentially low to highly expansive claystone bedrock at or near foundation bearing elevation, we recommend that the proposed building be supported on a grade beam and drilled pier foundation system. Straight shaft piers, drilled a minimum of 10 feet into firm or harder bedrock, with a minimum shaft length of 25 feet are recommended.

For axial compression loads, piers may be design for a maximum end-bearing pressure of 30,000 pounds per square foot (psf), and skin friction of 3,000 psf for the portion of the pier in firm or harder bedrock.

Required pier penetration should be balanced against potential uplift forces due to expansion of the subsoils and bedrock on the site. For design purposes, the uplift force on each pier due to expansive soil can be determined on the basis of the following equation:

\[ U_p = 70 \times D \]

Where: \( U_p \) = the uplift force in kips, and \( D \) = the pier diameter in feet

Uplift forces on piers should be resisted by a combination of dead load and pier penetration below a depth of 15 feet beneath final subgrade elevation and in the bearing strata. All piers should be reinforced full depth for the applied axial, lateral and uplift stresses imposed. The amount of reinforcing steel for expansion should be determined by the tensile force created by the uplift force on each pier, with allowance for dead load.

To reduce potential uplift forces on piers, use of long grade beam spans to increase individual pier loading, and small diameter piers are recommended. A minimum 8-inch or greater void space should be provided beneath grade beams between piers. The void material should be of suitable strength to support the weight of fresh concrete used in grade beam construction, and to avoid collapse when foundation backfill is placed.
Piers should be considered to work in group action if the horizontal spacing is less than three pier diameters. A minimum practical horizontal clear spacing between piers of at least three diameters should be maintained, and adjacent piers should bear at the same elevation. The capacity of individual piers must be reduced when considering the effects of group action. Capacity reduction is a function of pier spacing and the number of piers within a group. If group action analyses are necessary, capacity reduction factors can be provided for the analyses.

To satisfy forces in the horizontal direction, piers may be designed for lateral loads using a modulus of 25 tons per square foot (tsf) for the portion of the pier in the overburden soils and/or engineered fill and 300 tsf in bedrock. Lateral load design parameters are valid for maximum soil strain of 5 percent acting over a distance of 1 pier diameter. The soil modulus and coefficient of subgrade reaction are ultimate values; therefore, appropriate factors of safety should be applied in the pier design.

To satisfy forces in the horizontal direction using L-pile/Com624, piers may be designed for the following lateral load criteria:

<table>
<thead>
<tr>
<th>Soil Layer</th>
<th>Unit Weight (pcf)</th>
<th>Cohesion (psf)</th>
<th>Angle of Internal Friction, $\phi$ (degrees)</th>
<th>Coeff. of Subgrade Reaction, $k$ (pci)</th>
<th>Strain, $\varepsilon_{50}$ (Percent)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Medium Stiff to stiff Clay</td>
<td>120</td>
<td>1,000</td>
<td>0</td>
<td>500-static 200-cyclic</td>
<td>0.007</td>
</tr>
<tr>
<td>Medium Hard Bedrock</td>
<td>125</td>
<td>8,000</td>
<td>0</td>
<td>2000-static 800-cyclic</td>
<td>0.004</td>
</tr>
</tbody>
</table>

Drilling to design depths will likely be possible with conventional single flight power augers; however, heavy duty equipment and rock augers may be required in very hard bedrock materials. Groundwater (if encountered) should be removed from each pier hole prior to concrete placement. Pier concrete should be placed immediately after completion of drilling and cleaning. If pier concrete cannot be placed in dry conditions, a tremie should be used for concrete placement. Due to potential sloughing and raveling, foundation concrete quantities may exceed calculated geometric volumes.

If casing is used for pier construction, it should be withdrawn in a slow continuous manner maintaining a sufficient head of concrete to prevent infiltration of water or the creation of voids in pier concrete. Pier concrete should have a relatively high fluidity when placed in cased pier holes or through a tremie. Pier concrete with slump in the range of 6 to 8 inches is recommended. The drilled pier excavation/construction should be confirmed through field observations.
A representative of the geotechnical engineer should observe the bearing surface and pier installation and construction.

**Lateral Earth Pressures:** For soils above any free water surface, recommended equivalent fluid pressures for design of unrestrained foundation elements (free to move laterally) are:

- **Active:**
  - Cohesive soil backfill (on-site or imported clay soils).......................... 55 psf/ft
  - Cohesionless soil backfill (on-site sand or imported granular soils)........... 40 psf/ft
  - On-site claystone bedrock materials ............................................ not recommended for use

- **Passive:**
  - Cohesive soil backfill (on-site or imported clay soils).......................... 265 psf/ft
  - Cohesionless soil backfill (on-site sand or imported granular soils)........... 350 psf/ft
  - Undisturbed soils or bedrock....................................................... 400 psf/ft

Where the design includes restrained elements or where movement cannot be tolerated, the following equivalent fluid pressures are recommended:

- **At rest:**
  - Cohesive soil backfill (on-site or imported clay soils).......................... 75 psf/ft
  - Cohesionless soil backfill (on-site sand or imported granular soils)........... 60 psf/ft
  - On-site claystone bedrock materials ............................................ not recommended for use

The lateral earth pressures herein do not include any factor of safety and are not applicable for submerged soils. Additional recommendations may be necessary if such conditions are to be included in the design.

Fill against foundations should be compacted to densities specified in the "Earthwork" section of this report. Compaction of each lift adjacent to walls should be accomplished with hand-operated tampers or other lightweight compactors. Overcompaction may cause excessive lateral earth pressures that could result in wall movement.

**Basement Construction:** Groundwater was not encountered in the borings at the time of field exploration. The borings were immediately backfilled following the completion of drilling operations for safety considerations. Therefore, subsequent groundwater measurements were not obtained. Therefore, full-depth basement construction is considered acceptable on the site.

Perched groundwater may occur at times since the subsurface soils are relatively impermeable and tend to trap water. Completion of site development, including installation of landscaping and irrigation systems, will likely lead to perched groundwater development.
To reduce the potential for perched groundwater to impact foundation-bearing soils and enter the basement of the structure, installation of a perimeter drainage system is recommended. The drainage system should be constructed around the exterior perimeter of the basement foundation and sloped at a minimum 1/8 inch per foot to a suitable outlet, such as a sump and pump system.

The drainage system should consist of a minimum 4-inch diameter perforated or slotted pipe, embedded in free-draining gravel, placed in a trench at least 12 inches in width. The edge of the trench should be sloped at a 1:1 slope beginning at the bottom outside edge of the foundation. The trench should not be cut vertically at the edge of the foundation.

The drainage system should consist of a properly sized, perforated pipe that is embedded in free-draining gravel and placed in a trench at least 12 inches in width. Gravel should extend a minimum of 3 inches beneath the bottom of the pipe and at least 2 feet above the bottom of the foundation wall. The system should be underlain with a polyethylene moisture barrier that is sealed to the foundation walls and extended to at least the edge of the backfill zone. The gravel should be covered with drainage fabric prior to placement of foundation backfill.

Deep Backfill Zones: The magnitude of settlement of the deep backfill zones associated with the below grade/basement levels will be directly related to the type of fill material used, the degree of compaction, and the thickness of the fill zone. If the on-site soils are used as the fill material, the settlement of fill zones about 12 feet or less in thickness is estimated to be about 1 to 2 inches. This assumes that the degrees of compaction for fill zones are maintained in accordance with this report. Using gravel, aggregate base course, or flowable fill for backfill could reduce settlement. A filter fabric will be required if gravel is used as backfill. A clay cap should be placed over the top of the backfill zone to reduce surface water infiltration in areas where hardscaping is not directly adjacent to the building. In addition, consideration could be given to supporting certain ancillary elements with braces, haunches or counterforts, which would be structurally connected to the building and span over the backfill zone. Structural exterior slabs could also be considered where movement must be held to a minimum.

Seismic Considerations: A site classification “C” should be used for the design of structures for the proposed project (2006 International Building Code, Table No. 1613.5.2).

Floor Slab Design and Construction: Expansive clay soils and claystone bedrock are present on this site. The variability of the existing soils and bedrock at approximate slab subgrade elevation could result in movement of floor slab-on-grade should expansive materials become elevated in moisture content. Based upon existing conditions, potential slab movement on the order of 4 to 6 inches or more is possible. Therefore, we recommend the use of structural floor systems, structurally supported independent of the subgrade
soils/bedrock, as a positive means of reducing the potentially detrimental effects of floor movement. We recommend the crawl space have a minimum clearance of 8 inches and more if plumbing will be present. The crawl space should be well ventilated or have a vapor barrier present.

Earthwork:

**General Considerations:** The following presents recommendations for site preparation, excavation, subgrade preparation and placement of engineered fills on the project.

All earthwork on the project should be observed and evaluated by Terracon. The evaluation of earthwork should include observation and testing of engineered fill, subgrade preparation, foundation bearing soils, and other geotechnical conditions exposed during the construction of the project.

**Site Preparation:** Strip and remove existing vegetation, debris, asphalt or other deleterious materials. All exposed surfaces should be free of mounds and depressions, which could prevent uniform compaction. Any loose, soft, or otherwise unsuitable fill encountered at the site will require removal and replacement or recompaction. Stripped materials consisting of vegetation and organic materials should be wasted from the site.

All exposed areas which will receive fill, once properly cleared, should be scarified to a minimum depth of 12 inches, conditioned to near optimum moisture content, and compacted.

It is anticipated that excavations for the proposed construction can be accomplished with conventional earthmoving equipment.

Excavations penetrating the bedrock or cemented soils may require the use of specialized heavy-duty equipment, rippers and pneumatic equipment to facilitate rock break-up and removal. Consideration should be given to obtaining a unit price for difficult excavation in the contract documents for the project.

Depending upon depth of excavation and seasonal conditions, groundwater may be encountered in excavations on the site. Pumping from sumps may be utilized to control water within excavations. Well points may be required for significant groundwater flow, or where excavations penetrate groundwater to a significant depth.

The stability of the subgrade may be affected by proximity to existing groundwater conditions, precipitation, repetitive construction traffic or other factors. If unstable conditions are encountered or develop during construction, workability may be improved by
scarifying and drying. Overexcavation of wet zones and replacement with granular materials may be necessary. Use of lime, fly ash, kiln dust, cement or geotextiles could also be considered as a stabilization technique. Laboratory evaluation is recommended to determine the effect of chemical stabilization on subgrade soils prior to construction. Lightweight excavation equipment may be required to reduce subgrade pumping.

The individual contractor(s) is responsible for designing and constructing stable, temporary excavations as required to maintain stability of both the excavation sides and bottom. All excavations should be sloped or shored in the interest of safety following local and federal regulations, including current OSHA excavation and trench safety standards.

**Fill Materials and Placement:** Clean on-site soils or approved imported materials may be used as fill material. Organics or other deleterious materials (if any) should not be used in engineered fill.

Imported soils (if required) should conform to the following:

<table>
<thead>
<tr>
<th>Gradation</th>
<th>Percent finer by weight (ASTM C136)</th>
</tr>
</thead>
<tbody>
<tr>
<td>3&quot;</td>
<td>..........................................................100</td>
</tr>
<tr>
<td>No. 4 Sieve</td>
<td>..................................................50-100</td>
</tr>
<tr>
<td>No. 200 Sieve</td>
<td>..............................................70 (max)</td>
</tr>
</tbody>
</table>

- Liquid Limit ..........................................................40 (max)
- Plasticity Index .........................................................20 (max)
- Maximum expansive potential (%)* ........................................1.5

*Measured on a sample compacted to approximately 95 percent of the ASTM D698 maximum dry density at about the optimum water content. The sample is confined under a 100 psf surcharge and submerged.

Engineered fill should be placed and compacted in horizontal lifts, using equipment and procedures that will produce recommended moisture contents and densities throughout the lift. Recommended compaction criteria for engineered fill materials is 95 percent of the standard Proctor maximum dry density (ASTM D698).

On-site or imported clay soils should be compacted within a moisture content range of 1 to 4 percent above optimum moisture content. Within paved areas (if any), we recommend that the clay soils and processed claystone bedrock materials be compacted within a range from the optimum moisture content to 2 percent above optimum moisture content. Imported granular soils (if required) should be compacted
within a moisture range of 3 percent below to 3 percent above optimum moisture content unless modified by the project geotechnical engineer.

**Slopes:** For permanent slopes less than 15 feet in height in compacted fill areas, a recommended maximum configuration for on-site materials is 3:1 (horizontal to vertical).

For permanent slopes less than 15 feet in height in cut areas, recommended maximum configurations for on-site materials are as follows:

<table>
<thead>
<tr>
<th>Material</th>
<th>Maximum Slope Horizontal:Vertical</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cohesive soils (on-site clays)</td>
<td>3:1</td>
</tr>
<tr>
<td>Cohesionless soils (on-site sands and imported soils)</td>
<td>2-1/2:1</td>
</tr>
<tr>
<td>Bedrock</td>
<td>2:1</td>
</tr>
</tbody>
</table>

If steeper slopes are required for site development, stability analyses should be completed to design the grading plan.

The face of all slopes should be compacted to the minimum specification for fill embankments. Alternately, fill slopes can be overbuilt and trimmed of compacted material. If any slope in cut or fill will exceed 15 feet in height, the grading design should include mid-height benches to intercept surface drainage and divert flow from the face of the embankment.

Saturation or near saturation of the slopes may likely result in slope failure, even if the slopes are constructed to the recommended configurations. If saturated conditions are likely, due to irrigation, surface flows or other sources, Terracon should be informed and stability analyses should be performed.

**Excavation and Trench Construction:** Excavations into the on-site soils will generally stand on relatively steep slopes; however, caving soils and possibly groundwater could be encountered, depending upon the final depth of excavation. The individual contractor(s) should be made responsible for designing and constructing stable, temporary excavations as required to maintain stability of both the excavation sides and bottom. All excavations should be sloped or shored in the interest of safety following local and federal regulations, including current OSHA excavation and trench safety standards.

The soils to be penetrated by the proposed excavations may vary significantly across the site. The contractor should verify that similar conditions exist throughout the proposed area of excavation. If different subsurface conditions are encountered at the time of
construction, the actual conditions should be evaluated to determine any excavation modifications necessary to maintain safe conditions.

As a safety measure, it is recommended that all vehicles and soil piles be kept to a minimum lateral distance from the crest of the slope equal to no less than the slope height. The exposed slope face should be protected against the elements.

Additional Design and Construction Considerations:

**Exterior Slab Design and Construction:** Compacted subgrade or existing clay soils will expand with increasing moisture content; therefore, exterior concrete grade slabs may heave resulting in cracking or vertical offsets. We estimate that up to 3 to 4 inches of movement may be possible. The potential for damage would be greatest where exterior slabs are constructed adjacent to the building or other structural elements. To reduce the potential for damage, we recommend:

- Exterior slabs in critical areas be supported on a minimum of 3 feet of fill with no, or very low, expansion potential to reduce potential movement to about 1 to 2 inches.
- Strict moisture-density control during placement of subgrade fills.
- Placement of effective control joints on relatively close centers and isolation joints between slabs and other structural elements.
- Provision for adequate drainage in areas adjoining the slabs.
- Use of designs which allow vertical movement between the exterior slabs and adjoining structural elements.

**Underground Utility Systems:** Utility trenches are a common source of water infiltration and migration. All utility trenches that penetrate beneath the buildings should be effectively sealed to restrict water intrusion and flow through the trenches that could migrate below the buildings. We recommend constructing an effective clay “trench plug” that extends at least 5 feet out from the face of building exteriors. The clay plug material should consist of friable on-site lean clay or claystone bedrock compacted at a water content at or above the soils optimum water content. The clay fill should completely surround the utility line and be properly placed and compacted in accordance with recommendations in this report.

All underground piping within or near the proposed structure should be designed with flexible couplings, so minor deviations in alignment do not result in breakage or distress. Utility knockouts in foundation walls should be oversized to accommodate differential movements.
It is strongly recommended that a representative of the geotechnical engineer be contacted to provide full-time observation and compaction testing of trench backfill within building and pavement areas.

**Corrosion Protection:** Results of soluble sulfate testing indicate that ASTM Type I Portland cement is suitable for all project concrete on and below grade. However, if there is no (or minimal) cost differential, use of ASTM Type II Portland cement is recommended for additional sulfate resistance of construction concrete. Foundation concrete should be designed in accordance with the provisions of Section 318, Chapter 4, of the *ACI Design Manual*.

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

Exposed ground should be sloped at a minimum of 10 percent grade for at least 10 feet beyond the perimeter of buildings, where possible. Use of area drains, swales, sidewalk chases may be required. Backfill against footings, exterior walls and in utility and sprinkler line trenches should be well compacted and free of all construction debris to reduce the possibility of moisture infiltration. After building construction and prior to project completion, we recommend that verification of final grading be performed to document that positive drainage, as described above, has been achieved.

Flatwork and pavements will be subject to post construction movement. Maximum grades practical should be used for paving and flatwork to prevent areas where water can pond. In addition, allowances in final grades should take into consideration post-construction movement of flatwork, particularly if such movement would be critical. Where paving or flatwork abuts the structure, care should be taken that joints are properly sealed and maintained to prevent the infiltration of surface water.

Planters located adjacent to structures should preferably be self-contained. Sprinkler mains and spray heads should be located a minimum of 5 feet away from building lines. Roof drains should discharge on pavements or be extended away from structures a minimum of 10 feet through the use of splash blocks or downspout extensions. A
preferred alternative is to have the roof drains discharge to storm sewers by solid pipe or daylighted to a detention pond or other appropriate outfall.

GENERAL COMMENTS

Terracon should be retained to review the final design plans and specifications so comments can be made regarding interpretation and implementation of our geotechnical recommendations in the design and specifications. Terracon should also be retained to provide testing and observation during the excavation, grading, foundation and construction phases of the project.

The analysis and recommendations presented in this report are based upon the data obtained from the borings performed at the indicated locations and from other information discussed in this report. This report does not reflect variations that may occur between borings, across the site, or due to the modifying effects of weather. The nature and extent of such variations may not become evident until during or after construction. If variations appear, we should be immediately notified so that further evaluation and supplemental recommendations can be provided.

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

This report has been prepared for the exclusive use of our client for specific application to the project discussed and has been prepared in accordance with generally accepted geotechnical engineering practices. No warranties, either express or implied, are intended or made. Site safety, excavation support, and dewatering requirements are the responsibility of others. In the event that changes are planned in the nature, design, or location of the project as outlined in this report, the conclusions and recommendations contained in this report shall not be considered valid unless Terracon reviews the changes, and either verifies or modifies the conclusions of this report in writing.
# LOG OF BORING NO. 1

## University of Colorado

### SITE

**Boulder, Colorado**

### PROJECT

**CU Practice Facility**

#### GRAPHIC LOG

- **Approx. Surface Elev.:** 5359 ft

**Inside View:**

- **FILL, SANDY LEAN CLAY**
  - with claystone fragments, brown, medium stiff to stiff

- **CLAYSTONE**
  - yellow-brown, medium hard to very hard

**Outside View:**

- **BOTTOM OF BORING**
  - Approx. Surface Elev.: 5359 ft

#### SUMMARY

<table>
<thead>
<tr>
<th>DEPTH, ft</th>
<th>USCS SYMBOL</th>
<th>NUMBER</th>
<th>TYPE</th>
<th>RECOVERY, %</th>
<th>BLOWS / in.</th>
<th>WATER CONTENT, %</th>
<th>DRY UNIT WT</th>
<th>UNCONFINED STRENGTH, psf</th>
<th>%Swell or Consol/Surcharge Load</th>
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**WATER LEVEL OBSERVATIONS, ft**

- **NONE**

**WATER LEVEL BACKFILLED**

- **WD**

**WATER LEVEL BACKFILLED**

- **WD**

**BOTTOM OF BORING**

- **CLAYSTONE**
  - yellow-brown, medium hard to very hard

**The stratification lines represent the approximate boundary lines between soil and rock types: in-situ, the transition may be gradual.**

*CME 140lb SPT automatic hammer*

**BORING STARTED** 2-12-09

**BORING COMPLETED** 2-12-09

**RIG** CME 55

**FOREMAN** SF

**APPROVED** AJG

**JOB #** 25095009
### LOG OF BORING NO. 2

**University of Colorado**

**SITE**

Boulder, Colorado

**PROJECT**

CU Practice Facility

---

#### GRAPHIC LOG

- **Approx. Surface Elev.:** 5348 ft
- **5346.5**

**DESCRIPTION**

1. **SANDY LEAN CLAY**, brown
2. **CLAYSTONE**, yellow-brown to gray, very hard

---

#### WATER LEVEL OBSERVATIONS, ft

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<thead>
<tr>
<th>WL</th>
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<th>WD</th>
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#### BOREHOLE _99_ 25095009.GPJ  TERRACON TEST.GDT  3/3/09

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#### SITE TESTS

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---

**BOTTOM OF BORING**

5318 ft

---

The stratification lines represent the approximate boundary lines between soil and rock types: in-situ, the transition may be gradual.

---

**BOREHOLE ** 25095009.GPJ  TERRACON TEST.GDT  3/3/09

---

**Boring started** 2-12-09

**Boring completed** 2-12-09

**Rig** CME 55

**Foreman** SF

**Approved** AJG

**Job #** 25095009

---

*CME 140lb SPT automatic hammer*
Approx. Surface Elev.: 5347 ft

0.7 ASPHALT-7 inches
CLAYSTONE, yellow-brown to dark gray, very hard

BOTTOM OF BORING

The stratification lines represent the approximate boundary lines between soil and rock types: in-situ, the transition may be gradual.

WATER LEVEL OBSERVATIONS, ft
WL Y NONE WD Y BACKFILLED
WL Y Y

BORING STARTED 2-12-09
BORING COMPLETED 2-12-09
RIG CME 55 FOREMAN SF
APPROVED AJG JOB # 25095009

*CME 140lb SPT automatic hammer
### LOG OF BORING NO. 4

#### University of Colorado
**SITE**
Boulder, Colorado

#### PROJECT
CU Practice Facility

### GRAPHIC LOG

Approx. Surface Elev.: 5347 ft

<table>
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<th>Depth, ft</th>
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<th>Type</th>
<th>Recovery, %</th>
<th>BLOWS / in.</th>
<th>WATER CONTENT, %</th>
<th>DRY UNIT WT</th>
<th>UNCONFINED STRENGTH, psf</th>
<th>%Swell or Consol/Surcharge Load</th>
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<td>5346.3</td>
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<td>110</td>
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#### BOTTOM OF BORING

- 5312 ft

---

The stratification lines represent the approximate boundary lines between soil and rock types: in-situ, the transition may be gradual.

---

**WATER LEVEL OBSERVATIONS, ft**

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<th>Water Level</th>
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**BORING STARTED**
2-12-09

**BORING COMPLETED**
2-12-09

**RIG**
CME 55

**FOREMAN**
SF

**APPROVED**
AJG

**JOB #**
25095009
### LOG OF BORING NO. 5

**University of Colorado**

**SITE**
Boulder, Colorado

**PROJECT**
CU Practice Facility

<table>
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<tr>
<th>DEPTH, ft.</th>
<th>USCS SYMBOL</th>
<th>NUMBER</th>
<th>TYPE</th>
<th>BLOWS / in.</th>
<th>WATER CONTENT, %</th>
<th>DRY UNIT WT</th>
<th>UNCONFINED STRENGTH, psi</th>
<th>%Swell or Consol/Surcharge Load</th>
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<td>RS</td>
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</table>

**DESCRIPTION**

- **FILL, CLAYEY SAND** fine to coarse grained, with claystone fragments, trace gravel, brown, medium dense
- **FILL, CLAYEY SAND** fine to coarse grained, with concrete and brick fragments, dark brown, medium dense

Approx. Surface Elev.: 5362 ft

**GRAPHIC LOG**

- WATER LEVEL OBSERVATIONS, ft: NONE
- WATER LEVEL OBSERVATIONS, ft: BACKFILLED

**WATER LEVEL OBSERVATIONS, ft**

- **WL**: NONE
- **WD**: BACKFILLED

**BOTTOM OF BORING**

- **BORING STARTED**: 2-12-09
- **BORING COMPLETED**: 2-12-09
- **RIG**: CME 55
- **FOREMAN**: SF
- **APPROVED**: AJG
- **JOB #**: 25095009

---

The stratification lines represent the approximate boundary lines between soil and rock types: in-situ, the transition may be gradual.

*CME 140lb SPT automatic hammer*
**LOG OF BORING NO. 6**

**University of Colorado**

**SITE**  
Boulder, Colorado

**PROJECT**  
CU Practice Facility

---

**DESCRIPTION**

Approx. Surface Elev.: 5358 ft

**FILL, CLAYEY SAND**, fine to coarse grained, trace gravel, brown, loose to medium dense

- **USCS SYMBOL**: SC
- **DEPTH, ft**: 5
- **NUMBER**: 1
- **BLOW Number**: BS
- **RECOVERY, %**: 2
- **WATER CONTENT, %**: 12
- **DRY UNIT WT, psf**: 14
- **UNCONFINED STRENGTH, psf**: 23
- **%Swell or Consol/Surcharge Load**: +2.6/200psf

---

**CLAYEY SAND**, fine to coarse grained, with concrete and brick fragments and gravel, dark brown, loose

- **USCS SYMBOL**: SC
- **DEPTH, ft**: 5
- **NUMBER**: 2
- **BLOW Number**: RS
- **RECOVERY, %**: 40
- **WATER CONTENT, %**: 12
- **DRY UNIT WT, psf**: 15
- **UNCONFINED STRENGTH, psf**: 121

---

**BOTTOM OF BORING**

- **USCS SYMBOL**: SC
- **DEPTH, ft**: 10
- **NUMBER**: 4
- **BLOW Number**: RS
- **RECOVERY, %**: 9

---

**WATER LEVEL OBSERVATIONS, ft**

- **WL**: NONE
- **WD**: BACKFILLED

---

**BORING STARTED** 2-12-09  
**BORING COMPLETED** 2-12-09

**RIG** CME 55  
**FOREMAN** SF  
**APPROVED** AJG  
**JOB #** 25095009

---

The stratification lines represent the approximate boundary lines between soil and rock types: in-situ, the transition may be gradual.

---

*CME 140lb SPT automatic hammer*
APPENDIX B

LABORATORY TEST RESULTS
SUMMARY TABLES
Notes:

<table>
<thead>
<tr>
<th>Specimen Identification</th>
<th>Classification</th>
<th>$\gamma_b$ pcf</th>
<th>WC, %</th>
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</thead>
<tbody>
<tr>
<td>1</td>
<td>4.0ft FILL, SANDY LEAN CLAY</td>
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Notes:
Site: Boulder, Colorado

Pressures, psf

Notes:

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<td>13</td>
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Swell Consolidation Test

Project: CU Practice Facility
Site: Boulder, Colorado
Job #: 25095009
Date: 2-13-09
SWELL CONSOLIDATION TEST

Project: CU Practice Facility
Site: Boulder, Colorado
Job #: 25095009
Date: 2-13-09

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Notes:
Notes:

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SWELL CONSOLIDATION TEST

Project: CU Practice Facility
Site: Boulder, Colorado
Job #: 25095009
Date: 2-13-09
Notes:

Specimen Identification | Classification | $\gamma_b$ pcf | WC, %
--- | --- | --- | ---
4 | 4.0ft | CLAYSTONE | 110 | 11

Project: CU Practice Facility
Site: Boulder, Colorado
Job #: 25095009
Date: 2-13-09
<table>
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<tbody>
<tr>
<td>4</td>
<td>19.0ft</td>
<td>117</td>
<td>12</td>
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</table>

Notes:

---

**Swell Consolidation Test**

Project: CU Practice Facility
Site: Boulder, Colorado
Job #: 25095009
Date: 2-13-09
Notes:

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<th>( \gamma_b ) pcf</th>
<th>WC, %</th>
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<tr>
<td>5</td>
<td>FILL, SANDY LEAN CLAY</td>
<td>118</td>
<td>9</td>
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Notes:
Notes:
GRAIN SIZE DISTRIBUTION

Project: CU Practice Facility
Site: Boulder, Colorado
Job #: 25095009
Date: 2-16-09
Specimen Identification | Classification | LL | PL | PI | Cc | Cu
--- | --- | --- | --- | --- | --- | ---
4 | 4.1ft | LEAN CLAY (CL) | 42 | 17 | 25 | 6 | 200

GRAIN SIZE DISTRIBUTION

Project: CU Practice Facility
Site: Boulder, Colorado
Job #: 25095009
Date: 2-16-09
### SUMMARY OF LABORATORY TEST RESULTS

Proposed Basketball/Volleyball Practice Facility - University of Colorado - Boulder, Colorado

Terracon Project No. 25095009

<table>
<thead>
<tr>
<th>Boring No.</th>
<th>Depth (ft.)</th>
<th>USCS Soil Classification</th>
<th>Initial Dry Density (pcf)</th>
<th>Initial Water Content (%)</th>
<th>Swell/Consolidation</th>
<th>Particle Size Distribution, Percent Passing by Weight</th>
<th>Atterberg Limits</th>
<th>Water Soluble Sulfates (mg/l)</th>
<th>Remarks</th>
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Notes:
- Initial Dry Density, Initial Water Content, and Swell/Consolidation values obtained from undisturbed samples unless otherwise noted.
- * = Partially disturbed sample
- - = Compression/settlement
- NV = no value
- NP = non-plastic

**REMARKS**
1. Remolded Compacted density (approximately 95% of ASTM D698 maximum density near optimum)
2. Remolded Compacted density (approximately 95% of ASTM D1557 maximum density near optimum)
3. Submerged to approximate saturation
4. Dry density and/or moisture content determined from one ring of a multi-ring sample
5. Visual Classification
6. Minus #200 Only
### SUMMARY OF LABORATORY TEST RESULTS

Proposed Basketball/Volleyball Practice Facility - University of Colorado - Boulder, Colorado
Terracon Project No. 25095009

<table>
<thead>
<tr>
<th>Boring No.</th>
<th>Depth (ft.)</th>
<th>USCS Soil Classification</th>
<th>Initial Dry Density (pcf)</th>
<th>Initial Water Content (%)</th>
<th>Swell/Consolidation Surcharge (ksf)</th>
<th>Swell (%)</th>
<th>Particle Size Distribution, Percent Passing by Weight</th>
<th>Atterberg Limits</th>
<th>Water Soluble Sulfates (mg/l)</th>
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**Notes:**
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* = Partially disturbed sample
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NV = no value
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**REMARKS**
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2. Remolded Compacted density (approximately 95% of ASTM D1557 maximum density near optimum)
3. Submerged to approximate saturation
4. Dry density and/or moisture content determined from one ring of a multi-ring sample
5. Visual Classification
6. Minus #200 Only
GENERAL NOTES

DRILLING & SAMPLING SYMBOLS:
SS: Split Spoon - 1-7/8” I.D., 2” O.D., unless otherwise noted
ST: Thin-Walled Tube - 2” O.D., unless otherwise noted
RS: Ring Sampler - 2.42” I.D., 3” O.D., unless otherwise noted
DB: Diamond Bit Coring - 4”, N, B
BS: Bulk Sample or Auger Sample

HS: Hollow Stem Auger
PA: Power Auger
HA: Hand Auger
RB: Rock Bit
WB: Wash Boring or Mud Rotary

The number of blows required to advance a standard 2-inch O.D. split-spoon sampler (SS) the last 12 inches of the total 18-inch penetration with a 140-pound hammer falling 30 inches is considered the “Standard Penetration” or “N-value”. For 3” O.D. ring samplers (RS) the penetration value is reported as the number of blows required to advance the sampler 12 inches using a 140-pound hammer falling 30 inches, reported as “blows per foot,” and is not considered equivalent to the “Standard Penetration” or “N-value”.

WATER LEVEL MEASUREMENT SYMBOLS:
WL: Water Level
WS: While Sampling
WC: Wet Cave in
WD: While Drilling
DCI: Dry Cave in
BCR: Before Casing Removal
AB: After Boring
ACR: After Casing Removal

Water levels indicated on the boring logs are the levels measured in the borings at the times indicated. Groundwater levels at other times and other locations across the site could vary. In pervious soils, the indicated levels may reflect the location of groundwater. In low permeability soils, the accurate determination of groundwater levels may not be possible with only short-term observations.

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

<table>
<thead>
<tr>
<th>FINE-GRAINED SOILS</th>
<th>COARSE-GRAINED SOILS</th>
<th>BEDROCK</th>
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<td>Density</td>
<td>Consistency</td>
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</tr>
<tr>
<td>10-18</td>
<td>9-15</td>
<td>49-79</td>
</tr>
<tr>
<td>19-42</td>
<td>16-30</td>
<td>79-119</td>
</tr>
<tr>
<td>&gt; 42</td>
<td>&gt; 30</td>
<td>&gt; 119</td>
</tr>
<tr>
<td></td>
<td></td>
<td>&gt; 79</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Very Hard</td>
</tr>
</tbody>
</table>

RELATIVE PROPORTIONS OF SAND AND GRAVEL
Descriptive Terms of Other Constituents | Percent of Dry Weight
--- | ---
Trace | < 15
With | 15 – 29
Modifier | > 30

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

RELATIVE PROPORTIONS OF FINES
Descriptive Terms of Other Constituents | Percent of Dry Weight
--- | ---
Trace | < 5
With | 5 – 12
Modifiers | > 12

PLASTICITY DESCRIPTION
Term | Plasticity Index
--- | ---
Non-plastic | 0
Low | 1-10
Medium | 11-30
High | 30+
<table>
<thead>
<tr>
<th>Group</th>
<th>Symbol</th>
<th>Group Name</th>
</tr>
</thead>
<tbody>
<tr>
<td>B</td>
<td>Cu4 and 1</td>
<td>GW Well graded gravel</td>
</tr>
<tr>
<td></td>
<td>Cu &lt; 4 and/or 1</td>
<td>GP Poorly graded gravel</td>
</tr>
<tr>
<td></td>
<td>Cc3</td>
<td>GM Silty gravel</td>
</tr>
<tr>
<td>C</td>
<td>Cu4 and/or 1</td>
<td>GW Well graded gravel</td>
</tr>
<tr>
<td></td>
<td>Cc3</td>
<td>GP Poorly graded gravel</td>
</tr>
<tr>
<td></td>
<td>3E GM</td>
<td>Silty gravel</td>
</tr>
<tr>
<td>D</td>
<td>Cu6 and/or 1</td>
<td>SW Well graded sand</td>
</tr>
<tr>
<td></td>
<td>Cc6</td>
<td>SP Poorly graded sand</td>
</tr>
<tr>
<td></td>
<td>3E SP</td>
<td>Silty sand</td>
</tr>
<tr>
<td>E</td>
<td>Cu6 and/or 1</td>
<td>SW Well graded sand</td>
</tr>
<tr>
<td></td>
<td>Cc6</td>
<td>SP Poorly graded sand</td>
</tr>
<tr>
<td></td>
<td>3E SP</td>
<td>Silty sand</td>
</tr>
<tr>
<td>F</td>
<td>Cu6 and/or 1</td>
<td>SW Well graded sand</td>
</tr>
<tr>
<td></td>
<td>Cc6</td>
<td>SP Poorly graded sand</td>
</tr>
<tr>
<td></td>
<td>3E SP</td>
<td>Silty sand</td>
</tr>
</tbody>
</table>

**Coarse Grained Soils**

- Gravels: More than 50% of coarse fraction retained on No. 4 sieve
  - Clean Gravels: Less than 5% fines
  - Gravels with Fines: More than 12% fines

- Sands: 50% or more of coarse fraction passes No. 4 sieve
  - Clean Sands: Less than 5% fines
  - Sands with Fines: More than 12% fines

**Fine-Grained Soils**

- Silts and Clays: 50% or more passes the No. 200 sieve
  - Liquid limit less than 50
    - Inorganic: PI > 7 and plots on or above “A” line
    - Organic: PI plots on or above “A” line
  - Liquid limit 50 or more
    - Inorganic: PI plots below “A” line
    - Organic: PI plots below “A” line

**Highly Organic Soils**

- Primarily organic matter, dark in color, and organic odor

---

**Criteria for Assigning Group Symbols and Group Names Using Laboratory Tests**

- **A** Based on the material passing the 3-in. (75-mm) sieve
- **B** If field sample contained cobbles or boulders, or both, add “with cobbles or boulders, or both” to group name.
- **C** Gravels with 5 to 12% fines require dual symbols: GW-GM well graded gravel with silt, GW-GC well graded gravel with clay, GP-GM poorly graded gravel with silt, GP-GC poorly graded gravel with clay.
- **D** Sands with 5 to 12% fines require dual symbols: SW-SM well graded sand with silt, SW-SC well graded sand with clay, SP-SC poorly graded sand with silt, SP-SC poorly graded sand with clay.
- **E** Cu = D60/D10  
  Cc = \( \frac{(D_{60})^2}{D_{10} \times D_{60}} \)
- **F** If soil contains ≥ 15% gravel, add “with gravel” to group name.
- **G** If fines classify as CL-ML, use dual symbol GC-GM, or SC-SC.

---

**Equation of “A” line**

Horizontal at PI-4 to LL-25.5, then PI=0.73 (LL-20)

**Equation of “U” line**

Vertical at LL=16 to PI=7, then PI=0.8 (LL-8)

---

**For classification of fine-grained soils and fine-grained fraction of coarse-grained soils**

- ML or OL
- CL or ML
- CI or OL
- ML or CL
- MI or OH
- CI or CH
- OH or OL
- CH or OH
- CL or OL
- ML or OL

---

**For classification of fine-grained soils and fine-grained fraction of coarse-grained soils**

- CL or ML
- CI or OL
- MI or OH
- CI or CH
- OH or OL
- CH or OH
- CL or OL
- ML or OL

---

**Plasticity Index (PI)**

- PLASTICITY INDEX (PI)

- LIQUID LIMIT (LL)

---

**Terracon**
ROCK CLASSIFICATION
(Based on ASTM C-294)

Sedimentary Rocks

Sedimentary rocks are stratified materials laid down by water or wind. The sediments may be composed of particles or pre-existing rocks derived by mechanical weathering, evaporation or by chemical or organic origin. The sediments are usually indurated by cementation or compaction.

**Chert**
Very fine-grained siliceous rock composed of micro-crystalline or cryptocrystalline quartz, chalcedony or opal. Chert is various colored, porous to dense, hard and has a conchoidal to splintery fracture.

**Claystone**
Fine-grained rock composed of or derived by erosion of silts and clays or any rock containing clay. Soft massive and may contain carbonate minerals.

**Conglomerate**
Rock consisting of a considerable amount of rounded gravel, sand and cobbles with or without interstitial or cementing material. The cementing or interstitial material may be quartz, opal, calcite, dolomite, clay, iron oxides or other materials.

**Dolomite**
A fine-grained carbonate rock consisting of the mineral dolomite [CaMg(CO₃)₂]. May contain noncarbonate impurities such as quartz, chert, clay minerals, organic matter, gypsum and sulfides. Reacts with hydrochloric acid (HCL).

**Limestone**
A fine-grained carbonate rock consisting of the mineral calcite (CaCO₃). May contain noncarbonate impurities such as quartz, chert, clay minerals, organic matter, gypsum and sulfides. Reacts with hydrochloric acid (HCL).

**Sandstone**
Rock consisting of particles of sand with or without interstitial and cementing materials. The cementing or interstitial material may be quartz, opal, calcite, dolomite, clay, iron oxides or other material.

**Shale**
Fine-grained rock composed of or derived by erosion of silts and clays or any rock containing clay. Shale is hard, platy, of fissile may be gray, black, reddish or green and may contain some carbonate minerals (calcareous shale).

**Siltstone**
Fine grained rock composed of or derived by erosion of silts or rock containing silt. Siltstones consist predominantly of silt sized particles (0.0625 to 0.002 mm in diameter) and are intermediate rocks between claystones and sandstones and may contain carbonate minerals.
<table>
<thead>
<tr>
<th>TEST</th>
<th>SIGNIFICANCE</th>
<th>PURPOSE</th>
</tr>
</thead>
<tbody>
<tr>
<td>California Bearing Ratio</td>
<td>Used to evaluate the potential strength of subgrade soil, subbase, and base course material, including recycled materials for use in road and airfield pavements.</td>
<td>Pavement Thickness Design</td>
</tr>
<tr>
<td>Consolidation</td>
<td>Used to develop an estimate of both the rate and amount of both differential and total settlement of a structure.</td>
<td>Foundation Design</td>
</tr>
<tr>
<td>Direct Shear</td>
<td>Used to determine the consolidated drained shear strength of soil or rock.</td>
<td>Bearing Capacity, Foundation Design, and Slope Stability</td>
</tr>
<tr>
<td>Dry Density</td>
<td>Used to determine the in-place density of natural, inorganic, fine-grained soils.</td>
<td>Index Property Soil Behavior</td>
</tr>
<tr>
<td>Expansion</td>
<td>Used to measure the expansive potential of fine-grained soil and to provide a basis for swell potential classification.</td>
<td>Foundation and Slab Design</td>
</tr>
<tr>
<td>Gradation</td>
<td>Used for the quantitative determination of the distribution of particle sizes in soil.</td>
<td>Soil Classification</td>
</tr>
<tr>
<td>Liquid &amp; Plastic Limit, Plasticity Index</td>
<td>Used as an integral part of engineering classification systems to characterize the fine-grained fraction of soils, and to specify the fine-grained fraction of construction materials.</td>
<td>Soil Classification</td>
</tr>
<tr>
<td>Permeability</td>
<td>Used to determine the capacity of soil or rock to conduct a liquid or gas.</td>
<td>Groundwater Flow Analysis</td>
</tr>
<tr>
<td>pH</td>
<td>Used to determine the degree of acidity or alkalinity of a soil.</td>
<td>Corrosion Potential</td>
</tr>
<tr>
<td>Resistivity</td>
<td>Used to indicate the relative ability of a soil medium to carry electrical currents.</td>
<td>Corrosion Potential</td>
</tr>
<tr>
<td>R-Value</td>
<td>Used to evaluate the potential strength of subgrade soil, subbase, and base course material, including recycled materials for use in road and airfield pavements.</td>
<td>Pavement Thickness Design</td>
</tr>
<tr>
<td>Soluble Sulphate</td>
<td>Used to determine the quantitative amount of soluble sulfates within a soil mass.</td>
<td>Corrosion Potential</td>
</tr>
<tr>
<td>Unconfined Compression</td>
<td>To obtain the approximate compressive strength of soils that possess sufficient cohesion to permit testing in the unconfined state.</td>
<td>Bearing Capacity Analysis for Foundations</td>
</tr>
<tr>
<td>Water Content</td>
<td>Used to determine the quantitative amount of water in a soil mass.</td>
<td>Index Property Soil Behavior</td>
</tr>
</tbody>
</table>
# REPORT TERMINOLOGY
*(Based on ASTM D653)*

<table>
<thead>
<tr>
<th>Term</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Allowable Soil Bearing Capacity</strong></td>
<td>The recommended maximum contact stress developed at the interface of the foundation element and the supporting material.</td>
</tr>
<tr>
<td><strong>Alluvium</strong></td>
<td>Soil, the constituents of which have been transported in suspension by flowing water and subsequently deposited by sedimentation.</td>
</tr>
<tr>
<td><strong>Aggregate Base Course</strong></td>
<td>A layer of specified material placed on a subgrade or subbase usually beneath slabs or pavements.</td>
</tr>
<tr>
<td><strong>Backfill</strong></td>
<td>A specified material placed and compacted in a confined area.</td>
</tr>
<tr>
<td><strong>Bedrock</strong></td>
<td>A natural aggregate of mineral grains connected by strong and permanent cohesive forces. Usually requires drilling, wedging, blasting or other methods of extraordinary force for excavation.</td>
</tr>
<tr>
<td><strong>Bench</strong></td>
<td>A horizontal surface in a sloped deposit.</td>
</tr>
<tr>
<td><strong>Caisson (Drilled Pier or Shaft)</strong></td>
<td>A concrete foundation element cast in a circular excavation which may have an enlarged base. Sometimes referred to as a cast-in-place pier or drilled shaft.</td>
</tr>
<tr>
<td><strong>Coefficient of Friction</strong></td>
<td>A constant proportionality factor relating normal stress and the corresponding shear stress at which sliding starts between the two surfaces.</td>
</tr>
<tr>
<td><strong>Colluvium</strong></td>
<td>Soil, the constituents of which have been deposited chiefly by gravity such as at the foot of a slope or cliff.</td>
</tr>
<tr>
<td><strong>Compaction</strong></td>
<td>The densification of a soil by means of mechanical manipulation.</td>
</tr>
<tr>
<td><strong>Concrete Slab-on-Grade</strong></td>
<td>A concrete surface layer cast directly upon a base, subbase or subgrade, and typically used as a floor system.</td>
</tr>
<tr>
<td><strong>Differential Movement</strong></td>
<td>Unequal settlement or heave between, or within foundation elements of structure.</td>
</tr>
<tr>
<td><strong>Earth Pressure</strong></td>
<td>The pressure exerted by soil on any boundary such as a foundation wall.</td>
</tr>
<tr>
<td><strong>ESAL</strong></td>
<td>Equivalent Single Axle Load, a criteria used to convert traffic to a uniform standard, (18,000 pound axle loads).</td>
</tr>
<tr>
<td><strong>Engineered Fill</strong></td>
<td>Specified material placed and compacted to specified density and/or moisture conditions under observations of a representative of a geotechnical engineer.</td>
</tr>
<tr>
<td><strong>Equivalent Fluid</strong></td>
<td>A hypothetical fluid having a unit weight such that it will produce a pressure against a lateral support presumed to be equivalent to that produced by the actual soil. This simplified approach is valid only when deformation conditions are such that the pressure increases linearly with depth and the wall friction is neglected.</td>
</tr>
<tr>
<td><strong>Existing Fill (or Man-Made Fill)</strong></td>
<td>Materials deposited throughout the action of man prior to exploration of the site.</td>
</tr>
<tr>
<td><strong>Existing Grade</strong></td>
<td>The ground surface at the time of field exploration.</td>
</tr>
</tbody>
</table>
### REPORT TERMINOLOGY
(Based on ASTM D653)

<table>
<thead>
<tr>
<th>Term</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Expansive Potential</strong></td>
<td>The potential of a soil to expand (increase in volume) due to absorption of moisture.</td>
</tr>
<tr>
<td><strong>Finished Grade</strong></td>
<td>The final grade created as a part of the project.</td>
</tr>
<tr>
<td><strong>Footing</strong></td>
<td>A portion of the foundation of a structure that transmits loads directly to the soil.</td>
</tr>
<tr>
<td><strong>Foundation</strong></td>
<td>The lower part of a structure that transmits the loads to the soil or bedrock.</td>
</tr>
<tr>
<td><strong>Frost Depth</strong></td>
<td>The depth at which the ground becomes frozen during the winter season.</td>
</tr>
<tr>
<td><strong>Grade Beam</strong></td>
<td>A foundation element or wall, typically constructed of reinforced concrete, used to span between other foundation elements such as drilled piers.</td>
</tr>
<tr>
<td><strong>Groundwater</strong></td>
<td>Subsurface water found in the zone of saturation of soils or within fractures in bedrock.</td>
</tr>
<tr>
<td><strong>Heave</strong></td>
<td>Upward movement.</td>
</tr>
<tr>
<td><strong>Lithologic</strong></td>
<td>The characteristics which describe the composition and texture of soil and rock by observation.</td>
</tr>
<tr>
<td><strong>Native Grade</strong></td>
<td>The naturally occurring ground surface.</td>
</tr>
<tr>
<td><strong>Native Soil</strong></td>
<td>Naturally occurring on-site soil, sometimes referred to as natural soil.</td>
</tr>
<tr>
<td><strong>Optimum Moisture Content</strong></td>
<td>The water content at which a soil can be compacted to a maximum dry unit weight by a given compactive effort.</td>
</tr>
<tr>
<td><strong>Perched Water</strong></td>
<td>Groundwater, usually of limited area maintained above a normal water elevation by the presence of an intervening relatively impervious continuous stratum.</td>
</tr>
<tr>
<td><strong>Scarify</strong></td>
<td>To mechanically loosen soil or break down existing soil structure.</td>
</tr>
<tr>
<td><strong>Settlement</strong></td>
<td>Downward movement.</td>
</tr>
<tr>
<td><strong>Skin Friction (Side Shear)</strong></td>
<td>The frictional resistance developed between soil and an element of the structure such as a drilled pier.</td>
</tr>
<tr>
<td><strong>Soil (Earth)</strong></td>
<td>Sediments or other unconsolidated accumulations of solid particles produced by the physical and chemical disintegration of rocks, and which may or may not contain organic matter.</td>
</tr>
<tr>
<td><strong>Strain</strong></td>
<td>The change in length per unit of length in a given direction.</td>
</tr>
<tr>
<td><strong>Stress</strong></td>
<td>The force per unit area acting within a soil mass.</td>
</tr>
<tr>
<td><strong>Strip</strong></td>
<td>To remove from present location.</td>
</tr>
<tr>
<td><strong>Subbase</strong></td>
<td>A layer of specified material in a pavement system between the subgrade and base course.</td>
</tr>
<tr>
<td><strong>Subgrade</strong></td>
<td>The soil prepared and compacted to support a structure, slab or pavement system.</td>
</tr>
</tbody>
</table>
October 15, 2009

University of Colorado at Boulder
Facilities Management
453 UCB
Boulder, Colorado 80309-0453

Attn: Ms. Katherine Dunklau

Re: Addendum No. 1 to the Geotechnical Engineering Report
Proposed Basketball/Volleyball Practice Facility
University of Colorado
Regent Drive
Boulder, Colorado
Terracon Project No. 25095009

Terracon Consultants, Inc. (Terracon) previously performed a geotechnical exploration of the subject site (Terracon Project No. 25095009) that was documented in a report dated March 3, 2009. We understand it is desired to provide typical pavement thickness design recommendations and retaining wall design recommendations for the subject project.

Pavement Design and Construction: Design of privately maintained pavements for the project has been based on the procedures outlined by the Asphalt Institute and the American Concrete Institute. It should be noted that no borings or laboratory testing has been done specifically for pavements for this project. If a more extensive pavement thickness design including R-value testing is desired, please contact us.

For improvements to public roadways such as Regent Drive, a pavement design report meeting the City of Boulder specifications will likely need to be prepared for submittal, subsequent to final grading. For utility trenches within Regent Drive, the City of Boulder may the pavement to match the thickness of the existing pavement.

We recommend performing swell mitigation of the subgrade materials within the proposed pavement areas due to the presence of expansive soils at or near pavement subgrade elevation. Swell mitigation should consist of overexcavating the expansive soils to a minimum depth of about 3 feet below pavement subgrade elevation, moisture conditioning to above optimum, and recompressing. If this procedure does not reduce the swell potential to acceptable limits, chemical treatment of the subgrade and/or the use of aggregate base course may also be required.

We assumed the following design parameters for Asphalt Institute flexible pavement thickness design:
Automobile Parking Areas
   Parking stalls and parking lots for cars and pick-up trucks, up to 200 stalls

Main Traffic Corridors
   Parking lots with a maximum of 20 trucks per day

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

   - Automobile Parking Areas
     ACI Category A-1: Automobile parking with an ADTT of 1 over 20 years
   - Main Traffic Corridors
     ACI Category B: Commercial entrance and service lanes with an ADTT of 25 over 20 years
   - Concrete modulus of rupture value of 600 psi

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

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

<table>
<thead>
<tr>
<th>Traffic Area</th>
<th>Alternative</th>
<th>Recommended Minimum Pavement Thickness (inches)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Asphalt Concrete Surface</td>
</tr>
<tr>
<td></td>
<td>A</td>
<td>5-1/2</td>
</tr>
<tr>
<td></td>
<td>B</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>C</td>
<td></td>
</tr>
<tr>
<td>Automobile Parking</td>
<td>A</td>
<td>7-1/2</td>
</tr>
<tr>
<td></td>
<td>B</td>
<td>4-1/2</td>
</tr>
<tr>
<td></td>
<td>C</td>
<td></td>
</tr>
<tr>
<td>Main Traffic Corridors</td>
<td>A</td>
<td></td>
</tr>
<tr>
<td></td>
<td>B</td>
<td></td>
</tr>
<tr>
<td></td>
<td>C</td>
<td></td>
</tr>
</tbody>
</table>

For areas subject to concentrated and repetitive loading conditions such as dumpster pads, truck delivery docks and ingress/egress aprons, we recommend using a Portland cement concrete pavement with a thickness of at least 7 inches. Prior to placement of the concrete, the areas should be thoroughly proofrolled. For dumpster pads, the concrete pavement area should be large enough to support the container and tipping axle of the refuse truck. Heavy traffic, such as construction traffic and tractor-trailers, should be diverted from automobile pavement areas through appropriate geometry and/or signage.
For sidewalks, our recommendations for exterior slab design and construction in our previous report should be followed. Sidewalks are generally constructed at least 4 inches thick.

The placement of a partial pavement thickness for use during construction is not suggested without a detailed pavement analysis incorporating construction traffic. In addition, we should be contacted to confirm the traffic assumptions outlined above. If the actual traffic varies from the assumptions outlined above, modification of the pavement section thickness will be required.

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

<table>
<thead>
<tr>
<th>Pavement Component</th>
<th>Colorado Department of Transportation Criteria</th>
</tr>
</thead>
<tbody>
<tr>
<td>Asphalt Concrete Surface</td>
<td>Grading S or SX</td>
</tr>
<tr>
<td>Aggregate Base Course</td>
<td>Class 5 or 6</td>
</tr>
<tr>
<td>Portland Cement Concrete</td>
<td>Class P</td>
</tr>
</tbody>
</table>

Pavement Compliance: Recommendations for pavement design and construction presented depend upon compliance with recommended material specifications. To assess compliance, observation and testing should be performed under the observation of the geotechnical engineer.

Pavement Performance: Future performance of pavements constructed on the soils at this site will be dependent upon several factors, including:

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

Pavement surfaces could crack in the future primarily because of settlement of the supporting soils when subjected to an increase in moisture content to the subgrade. The cracking, while not desirable, does not necessarily constitute structural failure of the pavement, provided that timely maintenance, such as crack sealing is performed. Excessive movement and cracking could result if the subgrade soils are allowed to dry out before paving and subsequently become rewetted.
The performance of all pavements can be enhanced by minimizing excess moisture, which can reach the subgrade soils. The following recommendations should be considered at minimum:

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

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

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

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

We recommend the pavement areas be rough graded and then thoroughly proof rolled with a loaded tandem axle dump truck prior to final grading and paving. Particular attention should be paid to high traffic areas that were rutted and disturbed earlier and to areas where backfilled trenches are located. Areas where unsuitable conditions are located should be repaired by removing and replacing the materials with properly compacted fills. All pavement areas should be moisture conditioned and properly compacted to the recommendations in this report immediately prior to paving.
The placement of a partial pavement thickness for use during construction is not recommended without a detailed pavement analysis incorporating construction traffic. In addition, if the actual traffic varies from the assumptions outlined above, we should be contacted to confirm and/or modify the pavement thickness recommendations outlined above.

**Retaining Wall Design and Construction Considerations:** We understand retaining walls will be constructed at this site. We do not know the type of retaining wall, location(s) or wall heights. We should be provided this information for further recommendations.

For planning purposes, Cast-in-place (C.I.P.) retaining walls should be supported on drilled piers unless movement can be tolerated. If movement and subsequent distress can be tolerated, CIP walls could be supported on spread footing foundation systems bearing on a zone of non- to low expansive engineered fill.

Swell mitigation of the subgrade materials within the proposed retaining walls will be required as a result of the presence of potentially expansive clay and claystone bedrock anticipated to be encountered at or near the retaining wall elevations. We recommend overexcavating the expansive clay and/or claystone bedrock materials to a minimum depth of about 3 feet, processing, moisture conditioning and compacting this material in order to reduce swell/expansion of the subgrade soils to about 1 to 2 inches. Additional movement could occur with deeper wetting and poor surface drainage.

A maximum allowable toe bearing pressure of 2,000 pounds per square foot (psf) could be used. The use of spread footing foundation systems for the C.I.P. retaining walls assumes that some foundation movement on the order of about 1 to 2 inches or more can be tolerated. An adhesion at the base of the footing of up to 500 psf may be used in the design.

Foundations adjacent to slopes should be setback such that an imaginary line extending downward at 45 degrees from the nearest foundation edge does not intersect the slope. In addition, proper drainage should be provided in the final design and during construction to reduce potential foundation movement. Footings, foundations, and walls should be reinforced as necessary to reduce the potential for distress caused by differential foundation movement.

Mechanically stabilized earth (MSE) or a flexible retaining wall system could be used as an alternative for the C.I.P. retaining walls. The following parameters are typical for soils encountered on the subject site and the free-draining materials recommended within the reinforced backfill zone:
Soil Parameters

<table>
<thead>
<tr>
<th>Material Type</th>
<th>Soil Parameters</th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Drained</td>
<td>Undrained</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Cohesion (psf)</td>
<td>Angle of Internal Friction, Phi (degrees)</td>
<td>Unit Weight (pcf)</td>
<td>Cohesion (psf)</td>
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<tr>
<td>Free-Draining Sand/Gravel*</td>
<td>0</td>
<td>34</td>
<td>125</td>
<td>0</td>
<td>30</td>
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<tr>
<td>Clay</td>
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<td>22</td>
<td>125</td>
<td>0</td>
<td>20</td>
</tr>
<tr>
<td>Claystone</td>
<td>0</td>
<td>20</td>
<td>125</td>
<td>0</td>
<td>18</td>
</tr>
</tbody>
</table>

* Imported granular soils with less than 30 percent passing the No. 200 mesh sieve and Liquid Limit less than 30 and Plasticity Index less than 15.

Based upon the engineering properties of the on-site clay and claystone bedrock materials, we recommend that an imported free-draining granular soil will be used in the reinforced zone behind the walls. Properties of granular backfill materials to be used in the reinforced zone should be determined with additional laboratory testing including direct shear testing. We should be contacted to confirm and verify the design parameters outlined above once preliminary wall designs have been established through additional field exploration and/or laboratory testing. In addition, we should be provided with final designs to assess and evaluate global stability issues of the walls prior to construction.

**Retaining Wall Drainage:** To reduce hydrostatic loading on retaining walls, a subsurface drain system should be placed behind the wall. The drain system should consist of free-draining granular soils containing less than 10 percent fines (by weight) passing a No. 200 sieve placed adjacent to the wall. The free-draining granular material should be graded to prevent the intrusion of fines or encapsulated in a suitable filter fabric. A drainage system consisting of either weep holes or perforated drain lines (placed near the base of the wall) should be used to intercept and discharge water which would tend to saturate the backfill. Where used, drain lines should be embedded in a uniformly graded filter material and provided with adequate clean-outs for periodic maintenance. As an alternative, a prefabricated drainage structure, such as geocomposite, may be used as a substitute for the granular backfill adjacent to the wall.

**General Comments:** If a more extensive pavement thickness design and retaining wall evaluation is desired, please contact us. We should be contacted to review wall design, wall design calculations and grading plans. Other design and construction recommendations, based upon geotechnical conditions, were presented in the report and should be followed.
Addendum No. 1 to the Geotechnical Engineering Report
Proposed Basketball/Volleyball Practice Facility – Boulder, Colorado
Terracon Project No. 25095009

If you have any questions concerning this letter or any of our design and consulting services, please do not hesitate to contact us.

Sincerely,
TERRACON CONSULTANTS, INC.

Thomas J. Nevin, P.E.
Senior Project Engineer

Andrew J. Garner, P.E.
Senior Project Engineer

Copies to: Addressee (1 via e-mail)