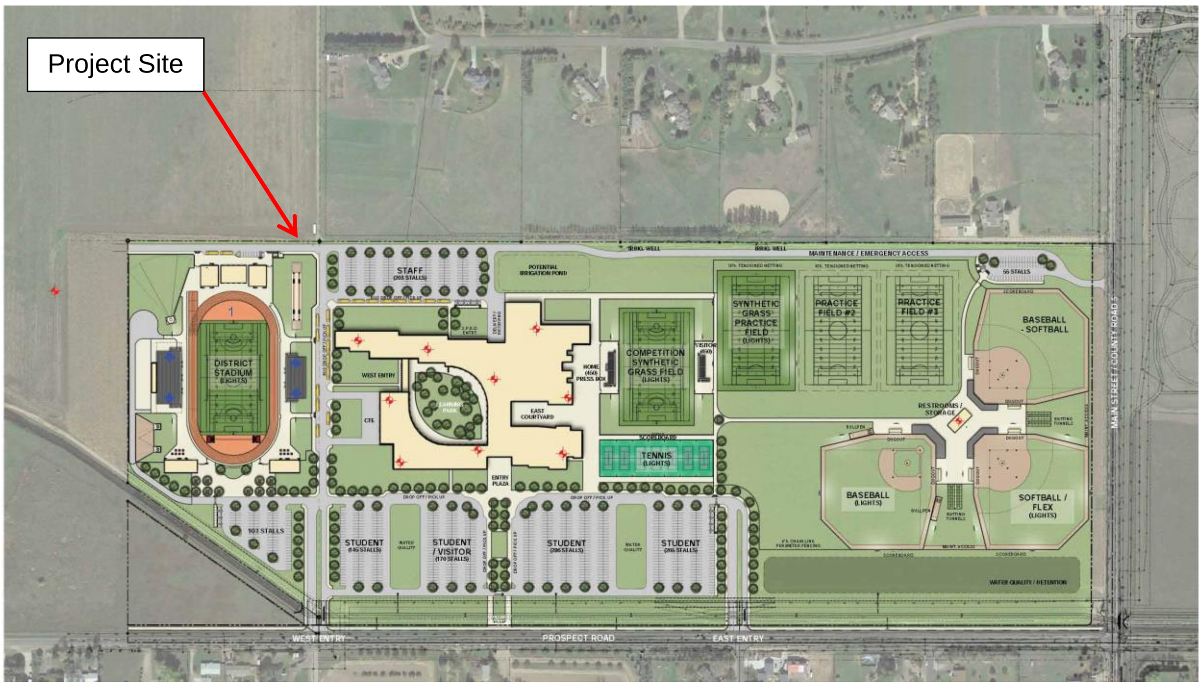
GROUND ENGINEERING

Geotechnical Subsurface Exploration Program
Poudre School District:
New Prospect 6-12 School
Fort Collins, Colorado



Prepared for:
Poudre School District
2407 La Porte Avenue
Fort Collins, Colorado

Attention: Mr. John Little

Job Number: 19-0013 **June 17, 2019**

LOVELAND OFFICE 2468 East 9th Street | Loveland, CO 80537 | (970) 622-0800 | www.groundeng.com
ENGLEWOOD | COMMERCE CITY | LOVELAND | GRANBY | GYPSUM

TABLE OF CONTENTS

PURPOSE AND SCOPE OF STUDY

This report presents the results of a geotechnical evaluation performed by GROUND Engineering Consultants, Inc. (GROUND) for the Poudre School District in support of design of the proposed New Prospect 6-12 School in Fort Collins, Colorado. Our study was conducted in general accordance with GROUND's Proposal No. 1904-0693, dated April 11th, 2019

A field exploration program was conducted to obtain information on the subsurface conditions. Material samples obtained during the subsurface exploration were tested in the laboratory to provide data on the engineering characteristics of the on-site soils. The results of the field exploration and laboratory testing are presented herein.

This report has been prepared to summarize the data obtained and to present our findings and conclusions based on the proposed development/improvements and the subsurface conditions encountered. Design parameters and a discussion of engineering considerations related to the proposed improvements are included herein. This report should be understood and utilized in its entirety; specific sections of the text, drawings, graphs, tables, and other information contained within this report are intended to be understood in the context of the entire report. This includes the *Closure* section of the report which outlines important limitations on the information contained herein.

This report was prepared for design purposes of Poudre School District based on our understanding of the proposed project at the time of preparation of this report. The data, conclusions, opinions, and geotechnical parameters provided herein should not be construed to be sufficient for other purposes, including the use by contractors, or any other parties for any reason not specifically related to the design of the project. Furthermore, the information provided in this report was based on the exploration and testing methods described below. Deviations between what was reported herein and the actual surface and/or subsurface conditions may exist, and in some cases those deviations may be significant.

PROPOSED CONSTRUCTION

GROUND understands this project will consist of the construction of a new school building, with no below-grade levels. Playgrounds, recreation fields, a track and football field, parking areas, drive lanes, flatwork, and landscaping also will be included as part of the project. Preliminary information indicated that strip footing loads are anticipated to be 4000 lbs/ft or less and column loads are anticipated to be 200 kips or less. Grading plans were not available at the time of our exploration, however based on preliminary information it appears that the site will require some minimal fills on the order of 1 to 4 feet to achieve project lines and grades. The project area and test hole locations are shown on Figure 1.

SITE CONDITIONS

At the time of our subsurface exploration program, the site generally existed as an agricultural field that had been partially harvested. The site is bordered by South County Road 5 to the east, an irrigation ditch and East Prospect Road to the south, undeveloped agricultural fields to the west, and residential housing to the north. The ground surface generally is flat with little notable slope.

Man-made fill was not recognized in the test holes during the subsurface exploration program. Based on historical Google Earth Imagery several structures formerly stood centrally located near the irrigation ditch on the south of the site. Man-made fill materials likely exist near where these structures stood. The exact extents, limits, and composition of any man-made fill were not determined under the scope of this study. Fills potentially, exist at varying depths and locations across the site.

SUBSURFACE EXPLORATION

The subsurface exploration for the project was conducted in May 2019. A total of thirty-three (32) test holes were drilled with a truck-mounted, continuous flight power auger rig to evaluate the subsurface conditions as well as to retrieve soil samples for laboratory testing and analysis. Nine (9) of the test holes were drilled within the approximate footprint of the new school building. One (1) test hole was drilled for the restroom structure near the baseball/softball fields. Four (4) test holes were drilled for the track and football field grandstands. Two (2) test holes were drilled for PT tennis courts. Ten

(10) test holes were drilled for site improvements including pavements and an irrigation pond. Four (4) test holes were drilled within the public right-of-way south and east of the site. The foundation test holes were drilled to depths ranging from approximately 30 to 40 feet below existing grade. The site and pavement test holes were drilled to depths ranging from 5 to 15 feet below existing grades. A GROUND engineer directed the subsurface exploration, logged the test holes in the field, and prepared the soil samples for transport to our laboratory.

Samples of the subsurface materials were retrieved with a 2-inch I.D. California liner sampler. The sampler was driven into the substrata with blows from a 140-pound hammer falling 30-inches. This procedure is similar to the Standard Penetration Test described by ASTM Method D1586. Penetration resistance values, when properly evaluated, indicate the relative density or consistency of soils. Depths at which the samples were obtained and associated penetration resistance values are shown on the test hole logs.

The approximate locations of the test holes are shown in Figure 1. Logs of the exploratory test holes are presented in Figure 2 to 6. Explanatory notes and a legend are provided in Figure 7.

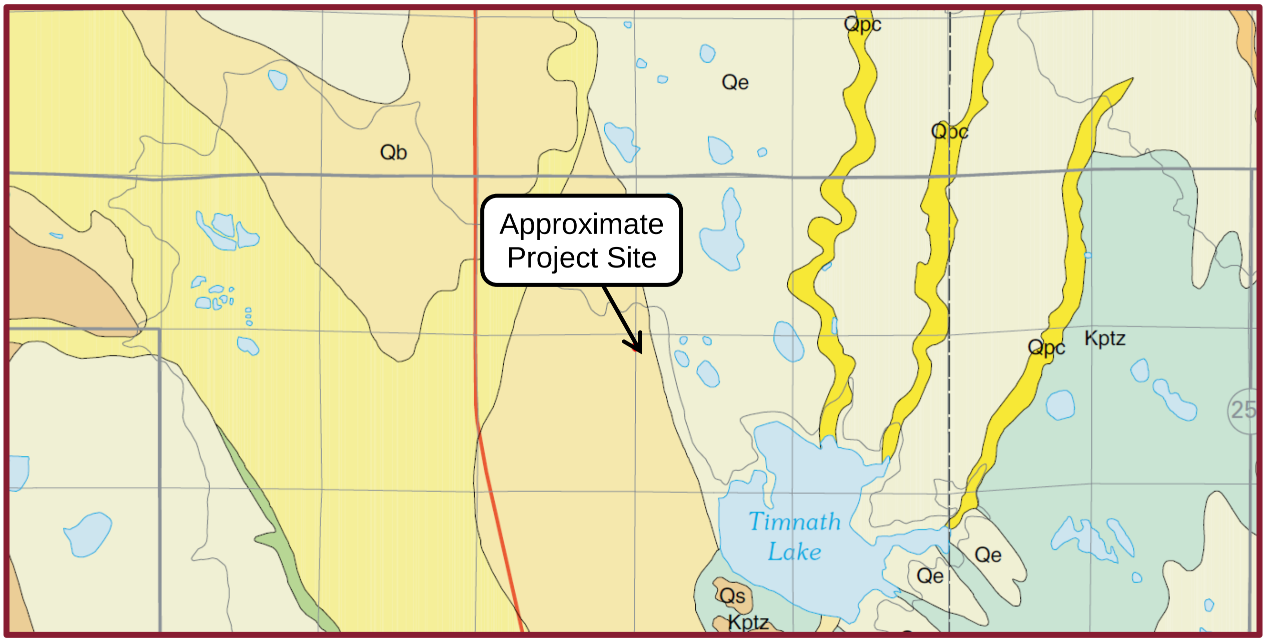
LABORATORY TESTING

Samples retrieved from our test holes were examined and visually classified in the laboratory by the project engineer. Laboratory testing of soil samples obtained from the subject site included standard property tests, such as natural moisture contents, dry unit weights, grain size analyses, liquid and plastic limits. Water-soluble sulfate and corrosivity tests were completed on selected samples of the soils as well. Laboratory tests were performed in general accordance with applicable ASTM protocols. Results of the laboratory testing program are summarized on Tables 1 and 2.

GEOLOGIC SETTING

The site lies within a geological structural depression within the Great Plains called the Denver Basin. Within this basin a sequence of sedimentary rock formations including the Pierre Shale were deposited. In the general project area, these sedimentary rocks dip eastward at low angles (less than 10 degrees, typically).

Published geologic maps, e.g., Moore et al. (2003)[1] depict the project area as underlain, by, Pleistocene Broadway Alluvium (**Qb**). Windblown deposits were mapped a short distance to the northeast, however. These alluvial materials are described as sand and gravel deposited by the South Platte River and its tributaries. These alluvial deposits are mapped as underlain by the upper shale member of the Upper Cretaceous Pierre Shale (**Kpu**). This unit is generally described as silty shale.



SUBSURFACE CONDITIONS

In general, the site test holes penetrated a thin layer of topsoil[2], approximately 12 inches thick (greater or lesser thicknesses likely exist locally), underlain by sand and gravel to depths of approximately 12 to 20 feet below grade. The sand and gravel was underlain by clay and sand with occasional gravel and extended to the test hole termination depths of approximately 25 to 40 feet below existing grades.

The test holes advanced within the public pavements encountered approximately 4.5 to 6.5 inches of asphalt at the surface underlain by sand and clay materials to a depth of

[1] Moore, Theodore R., Brandt David W., and Kyle E. Murray. "A spatial database of bedding attitudes to accompany Geologic Map of the Boulder--Fort Collins--Greeley area, Colorado, by Roger B. Colton." (2003).

[2] 'Topsoil' as used herein is defined geotechnically. The materials so described may or may not be suitable for landscaping or as a growth medium for such plantings as may be proposed for the project.

approximately 1 to 5 feet below existing grades. Sand and gravel materials were encountered below sand and clay materials and extended to the test hole termination depths of approximately 7 to 10 feet below existing grades.

It also should be noted that coarse gravel, cobbles and boulders are not well represented in samples obtained from small diameter test holes. At this site, therefore, it should be anticipated that gravel and cobbles, and possibly boulders, may be present in the fill and native soils, as well as comparably sized fragments of construction debris, even where not included in the general descriptions of the site soil types below. We interpret the soil to be Broadway Alluvium.

Topsoil was observed in the upper 12 inches of the site and was brown and humic.

Sand and Gravel were silty to clayey, non- to low plastic, fine to coarse grained with gravel, moist to wet, loose to dense, and light brown to pink to dark brown in color.

Sand and Clay was, was moderately plastic, fine to coarse grained, moist, medium to very stiff, and light brown to brown in color.

Bedrock materials were not encountered to the depths explored.

Groundwater was encountered in the majority of test holes at depths ranging from 8.5 to 16 feet below existing grades. Groundwater depths observed at the time of the preliminary study performed at this project site were as shallow as 6.5 feet below existing grades. Groundwater levels can be expected to fluctuate, however, in response to annual and longer-term cycles of precipitation, irrigation, surface drainage, nearby rivers, and drainage, land use, and the development of transient, perched water conditions.

SEISMIC CLASSIFICATION

According to the 2015 International Building Code® (Section 1613 Earthquake Loads), "Every structure, and portion thereof, including nonstructural components that are permanently attached to structures and their supports and attachments, shall be designed and constructed to resist the effects of earthquake motions in accordance with ASCE 7, excluding Chapter 14 and Appendix 11A. The seismic design category for a structure is permitted to be determined in accordance with Section 1613 (2015 IBC) or ASCE 7." Exceptions to this are further noted in Section 1613.

Based on extrapolation of available data to depth and our experience in the project area, we consider the site likely to meet the criteria for a Seismic Site Classification of **D** according to the 2015 IBC classification (Section 1613.3.2). If, however, a quantitative assessment of the site seismic properties is desired, then sampling or shear wave velocity testing to a depth of 100 feet or more should be performed.

Utilizing the OSHPD Seismic Design Maps website (https://seismicmaps.org/), the project area is indicated to possess an S_{DS} value of **0.188g** and an S_{D1} value of **0.091g** for the site latitude and longitude and a **Site Class of D.**

FOUNDATION/FLOOR SYSTEMS OVERVIEW

Geotechnical Considerations for Design: The native overburden materials encountered at the project site are in general suitable to support lightly loaded spread footing and slab on grade construction. The primary geotechnical concerns at the project site include some locally soft layers of subsurface materials below a depth of approximately 15 feet below grade and removal of potential relic foundations or utilities associated with the previously removed structures on the south central portion of the site.

School Facility Foundations: Footings should bear on firm undisturbed native materials at depths of at least 3 feet below exterior grades. A representative of the geotechnical engineer should be retained to verify bearing conditions. Footings bearing on **native soil** may be designed for an **allowable soil bearing pressure (Q) of 2,000 psf.**

Bleacher and Secondary Structure Foundations: Footings should bear on firm undisturbed native materials at depths of at least 3 feet below exterior grades. A representative of the geotechnical engineer should be retained to verify bearing conditions. Footings bearing on **native soil** may be designed for an **allowable soil bearing pressure (Q) of 1,750 psf.**

Floor System: At least 12 inches of onsite materials below the proposed slab-on-grade floor and under-slab gravel should be scarified and re-compacted in a properly moisture-density conditioned state in accordance with the *Project Earthworks* section of this report. If no sub-slab gravel is used, the re-work section should be increased correspondingly.

Geotechnical Risk: To use these parameters, the Owner must accept the risk of post-construction foundation movement associated with shallow foundation systems placed on the on-site soils. Utilizing the above parameters as well as other parameters in this report, we estimate likely post-construction foundation and floor movements to be on the order of 1 inch, with 1/2 inch differential movements over spans of about 40 feet. Movement estimates are difficult to predict and actual movements may be more or less

The conclusions and parameters provided in this report were based on the data presented herein, our experience in the general project area with similar structures, and our engineering judgment with regard to the applicability of the data and methods of forecasting future performance. A variety of engineering parameters were considered as indicators of potential future soil movements. Our recommendations were based on our judgment of "likely movement potentials," (i.e., the amount of movement likely to be realized if site drainage is generally effective, estimated to a reasonable degree of engineering certainty) as well as our assumptions about the owner's willingness to accept geotechnical risk. <u>"Maximum possible" movement estimates necessarily will be larger than those presented herein</u>. <u>They also have a significantly lower likelihood of being realized</u> in our opinion, and generally require more expensive measures to address. We encourage the Poudre School District, upon receipt of this report, however, to discuss potential risks and the geotechnical alternatives with us.

The Poudre School District must, therefore, understand the risks and remedial approaches presented in this report (and the risk-cost trade-offs addressed by the civil engineer and structural engineer) in order to direct the design team to the portion of the Higher Cost / Lower Risk – Lower Cost / Higher Risk spectrum in which this project should be designed. If the Poudre School District does not understand these risks, it is critical that they request additional information or clarification so that their expectations reasonably can be met.

SHALLOW FOUNDATION SYSTEM

The construction details should be considered when preparing project documents. The precautions and recommendations provided below will not prevent movement of the footings if the underlying materials are subjected to alternate wetting and drying cycles. However, the recommended measures will tend to make the movement more uniform, and reduce resultant damage if such movement occurs.

Geotechnical Parameters for Shallow Foundation Design:

1) Footings bearing on undisturbed, native materials or CDOT Class 5/6 Aggregate Base Course Materials can be designed for the allowable bearing pressure provided above.

   These values may be increased by ⅓ for transient loads such as wind or seismic loading.

   Compression of the bearing soils for the provided allowable bearing pressure is estimated to be 1 inch, based on an assumption of drained foundation conditions. If foundation soils are subjected to an increase/fluctuation in moisture content, the effective bearing capacity will be reduced and greater post-construction movements than those estimated above may result.

2) To be able to use the allowable bearing capacity values presented above, strip footings should be limited to **5 feet or less** in width and pad footing should have a maximum dimension of **10 feet**. For other estimated settlements associated with allowable bearing pressure values or footing widths exceeding the dimensions above please contact this office. To evaluate locally, GROUND requests proposed loading, depth, footing size, and location.

3) In order to reduce differential settlements between footings or along continuous footings, footing loads should be as uniform as possible. Differentially loaded footings will settle differentially.

   Similarly, differential fill thickness beneath footings will result in increased differential settlements.

4) Spread footings should have a minimum lateral dimension of **18 or more inches** for linear strip footings and **24 or more inches** for isolated pad footings. Actual footing dimensions, however, should be determined by the structural engineer.

5) All footings should bear at an elevation **3 or more feet** below the lowest adjacent exterior finish grades.

6) Continuous foundation walls should be reinforced top and bottom to span an unsupported length of at least **10 feet**.

7) Geotechnical parameters for lateral resistance to foundation loads are provided in the *Lateral Earth Pressures* section of this report.

8) Connections to the building of all types must be flexible and/or adjustable to accommodate the anticipated, post-construction movements.

9) Care should be taken when excavating the foundations to avoid disturbing the supporting materials. Hand excavation or careful backhoe soil removal may be required in excavating the last few inches.

10) Footing excavation bottoms may expose loose, organic or otherwise deleterious materials, including debris. Firm materials may become disturbed by the excavation process. All such unsuitable materials should be excavated and replaced with properly compacted fill or the footing deepened.

11) Compacted fill placed below and against the sides of the footings should be compacted in accordance with the criteria in the *Project Earthwork* section of this report.

SLAB-ON-GRADE FLOOR SYSTEM

The materials encountered during our field and laboratory study appear suitable, in general, to support a slab-on-grade floor system. However, as stated previously the materials should be scarified and re-compacted in general conformance with the *Project Earthworks* section of this report.

The following measures are recommended to reduce damage, which may result from movement of the slab subgrade material. These measures will not eliminate potential movements. If slab-on-grade construction is used in accordance with the following criteria, as well as other applicable parameters contained in this report, we estimate that potential slab movements may be on the order of 1 inch. The actual magnitude of movement is difficult to estimate and may be more or less.

Geotechnical Parameters for Design of Slab-on-Grade Floors

1) An allowable subgrade vertical modulus (K) of **100 pci** may be utilized for lightly loaded slabs supported by properly moisture-density treated existing materials. This value is for a 1-foot x 1-foot plate; they should be adjusted for slab dimension.

2) Floor slabs should be separated from all bearing walls and columns with slip joints, which allow unrestrained vertical movement.

   Slip joints should be observed periodically, particularly during the first several years after construction. Slab movement can cause previously free-slipping joints to bind. Measures should be taken to assure that slab isolation is maintained in order to reduce the likelihood of damage to walls and other interior improvements.

3) Concrete slabs-on-grade should be provided with properly designed control joints.

   ACI, AASHTO and other industry groups provide guidelines for proper design and construction concrete slabs-on-grade and associated jointing. The design and construction of such joints should account for cracking as a result of shrinkage, curling, tension, loading, and curing, as well as proposed slab use. Joint layout based on the slab design may require more frequent, additional, or deeper joints, and should reflect the configuration and proposed use of the slab.

   Particular attention in slab joint layout should be paid to areas where slabs consist of interior corners or curves (e.g., at column blockouts or reentrant corners) or where slabs have high length to width ratios, significant slopes, thickness transitions, high traffic loads, or other unique features. The improper placement or construction of control joints will increase the potential for slab cracking.

4) Interior partitions resting on floor slabs should be provided with slip joints so that if the slabs move, the movement cannot be transmitted to the upper structure. This detail is also important for wallboards and doorframes. Slip joints which will allow **2 inches or more** of differential vertical movement should be considered. It may not be practical to construct slip joints capable of accommodating movements of that magnitude. In such case, replacement of the slip joints or re-establishment of slip capacity should be anticipated and incorporated into building design. Accommodation for differential movement also should be made where partitions meet bearing walls.

5) Post-construction soil movements may not displace slab-on-grade floors and utility lines in the soils beneath them to the same extent. Design of floor penetrations, connections and fixtures should accommodate at least **2 inches** of differential movement.

6) Moisture can be introduced into a slab subgrade during construction and additional moisture will be released from the slab concrete as it cures. A properly compacted layer of free-draining gravel, 4 or more inches in thickness, should be placed beneath the slabs. This layer will help distribute floor slab loadings, ease construction, reduce capillary moisture rise, and aid in drainage.

   The free-draining gravel should contain **less than 5 percent** material passing the No. 200 Sieve, **more than 50 percent retained on the No. 4 Sieve**, and a maximum particle size **of 2 inches**.

   The capillary break and the drainage space provided by the gravel layer also may reduce the potential for excessive water vapor fluxes from the slab after construction as mix water is released from the concrete.

   We understand, however, that professional experience and opinion differ with regard to inclusion of a free-draining gravel layer beneath slab-on-grade floors. If these issues are understood by the owner and appropriate measures are implemented to address potential concerns including slab curling and moisture fluxes, then the gravel layer may be deleted.

7) A vapor barrier beneath a building floor slab is beneficial with regard to reducing sub-slab moisture vapor transmission through the floor slab and into the building, but can retard downward drainage of construction moisture. Elevated vapor fluxes can be detrimental to the adhesion and performance of many floor coverings and can also contribute to other moisture-induced concerns. Thus, an effective sub-slab vapor barrier is a published industry requirement for most slab-on-ground construction (i.e. IBC, ASTM), regardless of project location, soil conditions, and water table depth.

8) Per ACI 302.2R-15, a vapor barrier is recommended under concrete slabs-on-ground when they will receive (or could receive in the future) moisture-sensitive floor coverings, coatings, adhesives, underlayments, and/or stored goods. Moreover, ACI recommends a vapor barrier for any building which will be humidity or climate controlled, including exposed slabs (such as industrial warehouse). ACI 302 provides further guidance on the location of the vapor barrier beneath the slab.

However, when slabs are placed directly on the vapor barrier, considerations and steps may be needed to help reduce uneven drying/shrinkage concerns and potential slab curl.

Therefore, the owner, architect, and/or contractor should weigh many considerations when designing and implementing the sub-slab vapor barrier system, including building use and operating conditions, flooring products, sub-base (gravel layer) type, size, and thickness, expected construction traffic, etc.

When a vapor barrier is used, it should consist of a minimum 15-mil thickness, extruded polyolefin plastic (no recycled content or woven materials), maintain a permeance less than 0.01 perms per ASTM E96 or ASTM E1249 before and after mandatory conditioning testing, and comply with ASTM E1745-17 (Class "A"). Vapor barriers should be installed in accordance with ASTM E1643-18 and the manufacturer's guidelines. (Note that Polyethylene ("poly") sheeting (even if 15 mils in thickness which polyethylene sheeting commonly is not) does not meet the ASTM E1745 criteria and generally should not be used as a vapor barrier material.)

9) Loose, soft or otherwise unsuitable materials exposed on the prepared surface on which the floor slab will be cast should be excavated and replaced with properly compacted fill.

10) Concrete floor slabs should be constructed and cured in accordance with applicable industry standards and slab design specifications.

11) All plumbing lines should be carefully tested before operation. Where plumbing lines enter through the floor, a positive bond break should be provided.

POST-TENSIONED TENNIS COURT SLABS

The soils underlying the site generally consisted of sandy soils that should provide adequate support for the proposed improvements.

Remedial Earthwork A minimum of **12 inches** of existing materials below the tennis court should be scarified and re-compacted in a moisture conditioned and compacted state in accordance with the parameters provided in the *Project Earthwork* section of this report.

Inadequate site drainage and/or ineffective fill processing and compaction will result in an increase in the slab movement estimate provided. In addition, actual movements may be more or less depending on the subsurface materials present and the overall site drainage after construction is completed and landscape irrigation commences.

A post-tensioned slab will experience total and differential vertical movements. The remedial earthwork indicated will tend to make those movements more uniform but will not preclude them. The slabs will move and experience differential strains across their lengths and widths. If properly designed and constructed, post-tensioned slabs typically will accommodate those differential strains without unacceptable levels of cracking.

We estimate that likely post-construction (total) vertical slab movements where post-tensioned slabs bear on properly compacted fill will be about **1 inch**. This estimated post-construction (total) vertical movements will be superimposed on the *differential* vertical movements indicated below that were estimated by means of the PTI Institute methodology.

Parameters for Post-Tensioned Slab Design The parameters below were developed in general accordance with PTI methodology using the methods and recommendations provided by the Post-Tensioning Institute (PTI) in their recent design manuals.[3, 4, 5] PTI's 3rd Edition design methodology requires engineering judgment and interpretation of available data in order to develop the recommended parameters and differing interpretations can yield different parameters. Soil suction testing was not included in our scope of work and was not performed for this study. Therefore, some parameters used in this analysis were estimated, based on our experience with similar soils.

It should be noted that the use of PTI's 3rd Edition methodology remains a matter of controversy in Colorado within the geotechnical profession – particularly for residential structures. It also should be noted, however, that many structures have been constructed on post-tensioned slabs in the Colorado Front Range and, to our knowledge, the great majority of them have performed as intended.

Geotechnical Parameters for Post-Tensioned Slab Design

Edge Moisture Variation Distance (E_m)

Edge Lift ………………………………………………………….… **5.3 ft.**

Center Lift ……………………………………………………......… **9.0 ft.**

Differential Vertical Deflection (y_m)

Edge Lift ……………………………………………………….. …….. **0.6 in.**

Center Lift ………………………………………………………….…. **0.4 in.**

Allowable Soil Bearing Pressure ………………………………………….. **1,750 psf**

Design Frost Depth ……………………………………………………. **3 ft.**

Vertical Modulus of Subgrade Reaction………………………………… **75 pci**

(This value is for a 1-foot x 1-foot plate, and should be adjusted for slab dimension.)

[3] Post-Tensioning Institute, 2004, *Design and Construction of Post-Tensioned Slabs-on-Ground*, *3rd Edition*.
[4] Post-Tensioning Institute, 2007, *Addendum No. 1 to the 3rd Edition of the Design of Post-Tensioned Slabs-on-Ground*.
[5] Post-Tensioning Institute, 2008, *Addendum No. 2 to the 3rd Edition of the Design of Post-Tensioned Slabs-on-Ground*.

Slab Subgrade Friction Coefficient (μ)

0.75 for a ribbed or uniform thickness slab on polyethylene

1.00 for a slab cast directly on a sand base

WATER-SOLUBLE SULFATES

The concentrations of water-soluble sulfates measured in selected samples retrieved from the test holes ranged from less than 0.01 percent to 0.05 percent by weight. (See Table 2.) Such concentrations of water-soluble sulfates represent a negligible degree of sulfate attack on concrete exposed to these materials. Degrees of attack are based on the scale of 'negligible,' 'moderate,' 'severe' and 'very severe' as described in the “Design and Control of Concrete Mixtures,” published by the Portland Cement Association (PCA). The Colorado Department of Transportation (CDOT) utilizes a corresponding scale with 4 classes of severity of sulfate exposure (Class 0 to Class 3) as described in the published table below.

REQUIREMENTS TO PROTECT AGAINST DAMAGE TO CONCRETE BY SULFATE ATTACK FROM EXTERNAL SOURCES OF SULFATE

Severity of Sulfate Exposure	**Water-Soluble Sulfate (SO_4) In Dry Soil** *(%)*	**Sulfate (SO_4) In Water** *(ppm)*	**Water Cementitious Ratio** *(maximum)*	**Cementitious Material Requirements**
Class 0	0.00 to 0.10	0 to 150	0.45	Class 0
Class 1	0.11 to 0.20	151 to 1500	0.45	Class 1
Class 2	0.21 to 2.00	1501 to 10,000	0.45	Class 2
Class 3	2.01 or greater	10,001 or greater	0.40	Class 3

Based on these data no use of special, sulfate-resistant cement appears necessary in project concrete.

SOIL CORROSIVITY

The degree of risk for corrosion of metals in soils commonly is considered to be in two categories: corrosion in undisturbed soils and corrosion in disturbed soils. The potential for corrosion in undisturbed soil is generally low, regardless of soil types and conditions, because it is limited by the amount of oxygen that is available to create an electrolytic cell. In disturbed soils, the potential for corrosion typically is higher, but is strongly affected by soil chemistry and other factors.

A preliminary corrosivity analysis was performed to provide a general assessment of the potential for corrosion of ferrous metals installed in contact with earth materials at the site, based on the conditions existing at the time of GROUND's evaluation. Soil chemistry and physical property data including pH, and sulfides content were obtained. Test results are summarized on Table 2.

pH Where pH is less than 4.0, soil serves as an electrolyte; the pH range of about 6.5 to 7.5 indicates soil conditions that are optimum for sulfate reduction. In the pH range above 8.5, soils are generally high in dissolved salts, yielding a low soil resistivity AWWA, 2010). Testing indicated pH values ranging from approximately 8.3 to 8.7.

Reduction-Oxidation testing indicated negative potentials ranging from approximately -95 to -69 millivolts. Such a low potential typically creates a more corrosive environment.

Sulfide Reactivity testing for the presence of sulfides indicated 'positive' results. The presence of sulfides in the site soils also suggests a more corrosive environment.

Soil Resistivity In order to assess the "worst case" for mitigation planning, samples of materials retrieved from the test holes were tested for resistivity in the in the laboratory, after being saturated with water, rather than in the field. Resistivity also varies inversely with temperature. Therefore, the laboratory measurements were made at a controlled temperature.

A measurement of electrical resistivity indicated values of approximately 2,287 to 10,790 ohm-centimeters in respective samples of the site earth materials.

Corrosivity Assessment The American Water Works Association (AWWA, 2010[6]) has developed a point system scale used to predict corrosivity. The scale is intended for protection of ductile iron pipe but is valuable for project steel selection. When the scale equals 10 points or higher, protective measures for ductile iron pipe are suggested. The

[6] American Water Works Association ANSI/AWWA C105/A21.5-05 Standard.

AWWA scale (Table A.1 Soil-test Evaluation) is presented below. The soil characteristics refer to the conditions at and above pipe installation depth.

Table A.1 Soil-test Evaluation

Soil Characteristic / Value	Points
Resistivity	
<1,500 ohm-cm	10
1,500 to 1,800 ohm-cm	8
1,800 to 2,100 ohm-cm	5
2,100 to 2,500 ohm-cm	2
2,500 to 3,000 ohm-cm	1
>3,000 ohm-cm	0
pH	
0 to 2.0	5
2.0 to 4.0	3
4.0 to 6.5	0
6.5 to 7.5	0 *
7.5 to 8.5	0
>8.5	3
Redox Potential	
< 0 (negative values)	5
0 to +50 mV	4
+50 to +100 mV	3½
> +100 mV	0
Sulfide Reactivity	
Positive	3½
Trace	2
Negative	0
Moisture	
Poor drainage, continuously wet	2
Fair drainage, generally moist	1
Good drainage, generally dry	0

* If sulfides are present and low or negative redox-potential results (< 50 mV) are obtained, add three points for this range.

We anticipate that drainage at the site after construction will be effective. Based on the values obtained for the soil parameters, the overburden soils appear to comprise a highly corrosive environment for metals. (8.5 to 10.5 points)

If additional information are needed regarding soil corrosivity, the American Water Works Association or a Corrosion Engineer should be contacted. It should be noted, however, that changes to the site conditions during construction, such as the import of other soils, or the intended or unintended introduction of off-site water, may significantly alter corrosion potential.

LATERAL EARTH PRESSURES

Structures which are laterally supported and can be expected to undergo only a limited amount of deflection should be designed for "at-rest" lateral earth pressures. The cantilevered retaining structures will be designed to deflect sufficiently to mobilize the full active earth pressure condition, and may be designed for "active" lateral earth pressures. "Passive" earth pressures may be applied in front of the structural embedment to resist driving forces.

The at-rest, active, and passive earth pressures in terms of equivalent fluid unit weight for the on-site backfill is summarized on the table below. Base friction may be combined with passive earth pressure if the foundation is in a drained condition. The values for the on-site material in the upper 10 feet provided in the table below were approximated utilizing a unit weight of 125 pcf and a phi angle of 30 degrees, and are un-factored. Appropriate factors of safety should be included in design calculations.

Lateral Earth Pressures (Equivalent Fluid Unit Weights)

Material Type	**Water Condition**	**At-Rest** *(pcf)*	**Active** *(pcf)*	**Passive** *(pcf)*	**Friction Coefficient**
On-Site Backfill	Drained	63	42	335 (max. 3,350 psf)	0.38

The lateral earth pressures indicated above are for a horizontal upper backfill slope. The additional loading of an upward sloping backfill as well as loads from traffic, stockpiled materials, etc., should be included in the wall/shoring design.

Project Retaining Walls We are not aware of any significant retaining structures proposed as part of the facility improvements. Therefore, the above parameters should be considered preliminary with regard to design of walls, etc. In the event that retaining walls are added once project design begins, a geotechnical engineer should be retained to develop parameters for retaining wall parameter design. Global stability analysis may be needed, as well. The Poudre School District should realize that additional subsurface exploration may be necessary.

IRRIGATION POND LINER Either a compacted clay liner or a synthetic (HDPE membrane) liner appears feasible for the proposed storage pond. Criteria for fill placement and compaction are provided in the *Project Earthwork* section of this report.

Parameters for an earth material-derived pond liner, specified by the State of Colorado regarding plasticity, permeability(hydraulic conductivity), and gradation (Humphries, 2000[7]), should be adhered to. The maximum permeability(hydraulic conductivity) for such liner material is 1×10^{-6} cm/s.

It is our understanding that the proposed cross-section of the irrigation pond consists of a 4:1 (horizontal:vertical) slope for the first approximately 12 lateral feet of the pond transitioning to a 2:1 (h:v) slope to the bottom of the pond. Based on these proposed slopes the following clay liner / cover parameters are provided below.

4:1 slope: The clay liner should consist of at least 2 feet of clay with an in-place hydraulic conductivity of 10^{-6} cm/s or lower. Typically, local claystone-derived fills meet that criterion when moisture-conditioned and compacted properly. We suggest that a test section using the proposed liner soil be constructed so that the as-placed hydraulic conductivity may be evaluated. This clay liner should be protected with at least 2 feet of on-site native material.

2:1 slope: The clay liner should consist of at least 2 feet of clay with an in-place hydraulic conductivity of 10^{-6} cm/s or lower. This clay liner should be protected with at least 2 feet of a rip-rap soil mixture to protect the liner and stabilize the slope.

Alternatively a synthetic HDPE liner should be placed, lapped and sealed in accordance with the manufacturer's specifications. This alternative liner should be protected with at least 18 inches of common fill derived from the project site.

If the pond liner is placed below the anticipated groundwater table elevation, then it should be designed to resist buoyancy. We anticipate that this will entail lowering the liner elevation and placing additional fill above it.

---

[7]Humphries, Bruce, 2000, Guide to Specification Preparation for Slurry Walls and Clay Liners as a Component of a Colorado Mined Land Reclamation Permit, Colorado Department of Natural Resources, Division of Minerals and Geology, State of Colorado.

The Poudre School District should comply with applicable state requirements regarding dam construction and water storage rights associated with this pond. Due to the complexities of groundwater law in Colorado, Poudre School District should consider retaining a design professional with local experience with this type of structure.

Minor raveling or surficial sloughing should be anticipated on slopes cut at the proposed angles until vegetation is well re-established. Surface drainage should be designed to direct water away from slope faces.

PROJECT EARTHWORK

The following information is for private improvements; public roadways or utilities should be constructed in accordance with applicable municipal / agency standards.

General Considerations Site grading should be performed as early as possible in the construction sequence to allow settlement of fills and surcharged ground to be realized to the greatest extent prior to subsequent construction.

Prior to earthwork construction, vegetation and other deleterious materials should be removed and disposed of off-site. Relic underground utilities should be abandoned in accordance with applicable regulations, removed as necessary, and properly capped. All relic floor slab and footing foundation shall also be removed.

Topsoil present on-site should not be incorporated into ordinary fills. Instead, topsoil should be stockpiled during initial grading operations for placement in areas to be landscaped or for other approved uses. Due to the presence of large trees at the project site, significant root systems associate with those trees will also require removal to mitigate the risk of settlement caused by the breakdown of theses organic materials overtime.

Wet, Soft, or Unstable Subgrades Where wet, soft, or unstable subgrades are encountered, the contractor must establish a stable platform for fill placement and achieving compaction in the overlying fill soils. Therefore, excavation of the unstable soils and replacing them with relatively dry or granular material, possibly together with the use of stabilization geo-textile or geo-grid, may be necessary to achieve stability. A Geotechnical engineer should be retained to provide appropriate stabilization criteria based on conditions encountered. Stabilization methods should be verified using a test section to evaluate the effectiveness prior to use over a larger area.

Drainage During Construction The contractor should take pro-active measures to control surface waters during construction, to direct them away from excavations and into appropriate drainage structures. Wetting of foundation soils during construction can have adverse effects on the performance of the proposed facility.

Filled areas should be graded to drain effectively at the end of each work day.

Use of Existing Native Soils Overburden soils that are free of trash, organic material, construction debris, and other deleterious materials are suitable, in general, for placement as compacted fill. Organic materials, including excavated coal if encountered, should not be incorporated into project fills.

Fragments of rock, cobbles, and inert construction debris (e.g., concrete or asphalt) larger than 3 inches in maximum dimension will require special handling and/or placement to be incorporated into project fills. In general, such materials should be placed as deeply as possible in the project fills. A geotechnical engineer should be consulted regarding appropriate guidance for usage of such materials on a case-by-case basis when such materials have been identified during earthwork. Standard recommendations that likely will be generally applicable can be found in Section 203 of the current CDOT Standard Specifications for Road and Bridge Construction.

Where excavated bedrock materials are placed as fill, the contractor should anticipate significantly more than typical efforts to moisture condition and compact the fill properly. The excavated material should be disked or otherwise processed until it is broken down into fragments no larger than 3 inches in maximum dimension and moisture-conditioned prior to compaction.

Imported Fill Materials If it is necessary to import material to the site other than the CDOT Class 1 Structure backfill for the basement fills and slab-on-grade construction, the imported soils should be free of organic material, and other deleterious materials. **Imported material should consist of materials that have 50 percent or less passing the No. 200 Sieve and should have a plasticity index 15 or less.** Representative samples of the materials proposed for import should be tested and approved prior to transport to the site.

Fill Platform Preparation Prior to filling, the top 12 inches of in-place materials on which fill soils will be placed should be scarified, moisture conditioned and properly compacted in accordance with the parameters below to provide a uniform base for fill placement. *If over-excavation is to be performed, then these parameters for subgrade preparation are for the subgrade **below the bottom** of the specified over-excavation depth.*

If surfaces to receive fill expose loose, wet, soft or otherwise deleterious material, additional material should be excavated, or other measures taken to establish a firm platform for filling. The surfaces to receive fill must be effectively stable prior to placement of fill.

GROUND's experience within the project area suggests the frost depth to be approximately 3 feet below ground surface.

Fill Placement Fill materials should be thoroughly mixed to achieve a uniform moisture content, placed in uniform lifts not exceeding 8 inches in loose thickness, and properly compacted.

Soils that classify as GP, GW, GM, GC, SP, SW, SM, or SC in accordance with the USCS classification system (granular materials) should be compacted to **95 or more percent** of the maximum modified Proctor dry density at moisture contents within **2 percent** of optimum moisture content as determined by ASTM D1557.

Soils that classify as ML or CL should be compacted to **95 or more percent** of the maximum standard Proctor density at moisture contents within **2 percent** of the optimum moisture content as determined by ASTM D698. Soils that classify as MH or CH fine grained soils should be avoided for use under structures, flatwork, or pavements. GROUND Engineering should be contacted prior to using these materials for these potential uses.

It may be necessary to rework the fill materials more than once by adjusting moisture and replacing the materials, in order to achieve the recommended compaction and moisture criteria.

No fill materials should be placed, worked, or rolled while they are frozen, thawing, or during poor/inclement weather conditions.

Care should be taken with regard to achieving and maintaining proper moisture contents during placement and compaction. Materials that are not properly moisture conditioned may exhibit significant pumping, rutting, and deflection at moisture contents near optimum and above. The contractor should be prepared to handle soils of this type, including the use of chemical stabilization, if necessary.

Compaction areas should be kept separate, and no lift should be covered by another until relative compaction and moisture content within the suggested ranges are obtained.

Use of Squeegee Relatively uniformly graded fine gravel or coarse sand, i.e., “squeegee,” or similar materials commonly are proposed for backfilling foundation excavations, utility trenches (excluding approved pipe bedding), and other areas where employing compaction equipment is difficult. In general, GROUND does not suggest this procedure for the following reasons:

Although commonly considered “self-compacting,” uniformly graded granular materials require densification after placement, typically by vibration. The equipment to densify these materials is not available on many job-sites.

Even when properly densified, granular materials are permeable and allow water to reach and collect in the lower portions of the excavations backfilled with those materials. This leads to wetting of the underlying soils and resultant potential loss of bearing support as well as increased local heave or settlement.

It is GROUND’s opinion that wherever possible, excavations be backfilled with approved, on-site soils placed as properly compacted fill. Where this is not feasible, use of “Controlled Low Strength Material” (CLSM), i.e., a lean, sand-cement slurry (“flowable fill”) or a similar material for backfilling should be considered.

Where “squeegee” or similar materials are proposed for use by the contractor, the design team should be notified by means of a Request for Information (RFI), so that the proposed use can be considered on a case-by-case basis. “Squeegee” can be used where deemed acceptable by the project documents.

Settlements Settlements will occur in filled ground, typically on the order of 1 to 2 percent of the fill depth. For a 6-foot fill, for example, this corresponds to a settlement of about 1 inch. If fill placement is performed properly and is tightly controlled, in

GROUND's experience the majority (on the order of 60 to 80 percent) of that settlement will typically take place during earthwork construction, provided the contractor achieves the compaction levels herein. The remaining potential settlements likely will take several months or longer to be realized, and may be exacerbated if these fills are subjected to changes in moisture content.

Cut and Filled Slopes Permanent site slopes supported by on-site soils up to 10 feet in height may be constructed no steeper than 3:1 (horizontal : vertical). Minor raveling or surficial sloughing should be anticipated on slopes cut at this angle until vegetation is well re-established. Surface drainage should be designed to direct water away from slope faces.

EXCAVATION CONSIDERATIONS

Excavation Difficulty The test holes for the subsurface exploration were advanced to the depths indicated on the test hole logs by means of a conventional truck-mounted drill rig advancing 4-inch diameter continuous flight auger at 8-inch hollow stem auger equipment. We anticipate no significant excavation difficulties in the majority of the site with conventional heavy-duty excavation equipment in good working condition.

Temporary Excavations and Personnel Safety Excavations in which personnel will be working must comply with all applicable OSHA Standards and Regulations, particularly CFR 29 Part 1926, OSHA Standards-Excavations, adopted March 5, 1990. The contractor's "responsible person" should evaluate the soil exposed in the excavations as part of the contractor's safety procedures. GROUND has provided the information in this report solely as a service to the Poudre School District and is not assuming responsibility for construction site safety or the contractor's activities.

The contractor should take care when making excavations not to compromise the bearing or lateral support for any adjacent, existing improvements.

In general, temporary, un-shored excavation slopes up to 10 feet in height may be cut no steeper than 1 1/2 : 1 (horizontal : vertical) in the on-site soils <u>in the absence of seepage</u>. Some surface sloughing may occur on the slope faces at these angles. Should site constraints prohibit the use of the recommended slope angle, temporary shoring should be used. GROUND can be retained to perform shoring design upon request.

Groundwater and Surface Water Groundwater was observed as at depths ranging from 8.5 to 16 feet below existing grades at the time of drilling and as shallowly as 6.5 feet at the time of the preliminary exploration performed at this site. Therefore, wet soils, seepage or groundwater could be encountered as shallow as about 5 feet seasonally. If seepage or groundwater is encountered in shallow project excavations, a geotechnical engineer should evaluate the conditions and provided additional direction, as appropriate.

Good surface drainage should be provided around temporary excavation slopes to direct surface runoff away from the slope faces. A properly designed drainage swale should be provided at the top of the excavations. In no case should water be allowed to pond at the site. Slopes should also be protected against erosion. Erosion along the slopes will result in sloughing and could lead to a slope failure.

EXTERIOR FLATWORK

Proper design, drainage, construction and maintenance of the areas between individual buildings and parking/driveway areas are critical to the satisfactory performance of the project. Sidewalks, entranceway slabs and roofs, fountains, raised planters and other highly visible improvements commonly are installed within these zones, and distress in or near these improvements is common. Commonly, soil preparation in these areas receives little attention because they fall between the building and pavement (which are typically built with heavy equipment). Subsequent landscaping and hardscape installation often is performed by multiple sub-contractors with light or hand equipment, and over-excavation / soil processing is not performed. Therefore, GROUND recommends that the contractor take particular care with regard to proper subgrade preparation around the structure exteriors.

Similar to slab-on-grade floors, exterior flatwork and other hardscaping placed on the soils encountered on-site may experience post-construction movements due to volume change of the subsurface soils. Both vertical and lateral soil movements can be anticipated as the soils experience volume change as their moisture contents vary. Distress to rigid hardscaping likely will result. The measures outlined below will help to reduce damages to these improvements.

Provided the owner understands the risks identified above, we believe that subgrade under exterior flatwork and other hardscaping should be excavated and/or scarified to a depth of at least **12 inches.** The excavated soil should be replaced as properly moisture-conditioned and compacted fill as recommended in the *Project Earthwork* section of this report. Prior to placement of flatwork, a proof roll should be performed to identify areas that exhibit instability and deflection. The soils in these areas should be removed and replaced with properly compacted fill or stabilized.

Flatwork should be provided with effective control joints. Increasing the frequency of joints may improve performance. ACI recommendations should be followed regarding construction and/or control joints.

Exterior flatwork in contact with brick, rock facades, or any other element of the building can cause damage to the structure if the flatwork experiences movements. In no case should exterior flatwork extend to under any portion of the building where there is less than 3 inches of vertical clearance between the flatwork and any element of the building. As expansive soils heave is realized at the site over time, flatwork may need to be removed and reconstructed to prevent distress to exterior building finishes, etc. The need or frequency of reconstruction can be reduced by constructing an initial gap between flatwork and building elements greater than 3 inches.

Effective drainage should be maintained after completion of the project, and re-established as necessary. In no case should water be allowed to pond on or near any of the site improvements. Where water is allowed to pond, a reduction in performance should be anticipated. The owner should understand that anticipated maintenance likely will include removal and replacement of flatwork panels, reaches of curb and/or other project elements to re-establish effective surface drainage.

Concrete Scaling Climatic conditions in the project area including relatively low humidity, large temperature changes and repeated freeze – thaw cycles, make it likely that project sidewalks and other exterior concrete will experience surficial scaling or spalling. The likelihood of concrete scaling can be increased by poor workmanship during construction, such as ‘over-finishing’ the surfaces. In addition, the use of de-icing salts on exterior concrete flatwork, particularly during the first winter after construction, will increase the likelihood of scaling. Even use of de-icing salts on nearby roadways, from where vehicle traffic can transfer them to newly placed concrete, can be sufficient to induce scaling. Typical quality control / quality assurance tests that are performed during construction for concrete strength, air content, etc., do not provide information with regard to the properties and conditions that give rise to scaling.

We understand that some municipalities require removal and replacement of concrete that exhibits scaling, even if the material was within specification and placed correctly. The contractor should be aware of the local requirements and be prepared to take measures to reduce the potential for scaling and/or replace concrete that scales.

In GROUND's experience, the measures below can be beneficial for reducing the likelihood of concrete scaling. Which measures are implemented may depend on the project schedule and other factors. It must be understood, however, that because of the other factors involved, including weather conditions and workmanship, surface damage to concrete can develop even where all of these measures were followed. Also, the mix design criteria should be coordinated with other project requirements including the criteria for sulfate resistance presented in the *Water-Soluble Sulfates* section of this report.

1) Maintaining a maximum water/cement ratio of 0.45 by weight for exterior concrete mixes.
2) Include Type F fly ash in exterior concrete mixes as 20 percent of the cementitious material.
3) Specify a minimum, 28-day, compressive strength of 4,500 psi for all exterior concrete.
4) Include 'fibermesh' in the concrete mix may be beneficial for reducing surficial scaling.
5) Cure the concrete effectively at uniform temperature and humidity. This commonly will require fogging, blanketing and/or tenting, depending on the weather conditions. As long as 3 to 4 weeks of curing may be required, and possibly more.
6) Avoid placement of concrete during cold weather so that it is exposed to freeze-thaw cycling before it is fully cured.

7) Avoid the use of de-icing salts on given reaches of flatwork through the first winter after construction.

We understand that commonly it may not be practical to implement some of these measures for reducing scaling due to safety considerations, project scheduling, etc. In such cases, additional costs for flatwork maintenance or reconstruction should be incorporated into project budgets.

Frost and Ice Considerations Nearly all soils other than relatively coarse, clean, granular materials are susceptible to loss of density if allowed to become saturated and exposed to freezing temperatures and repeated freeze – thaw cycling. The formation of ice in the underlying soils can result in heaving of pavements, flatwork and other hardscaping ("ice jacking") in sustained cold weather up to 2 inches or more – in additional to any movements from expansive soils heave. Ice jacking can develop relatively rapidly. A portion of this movement typically is recovered when the soils thaw, but due to loss of soil density, some degree of displacement will remain. This can result even where the subgrade soils were prepared properly.

Where hardscape movements are a design concern, e.g., at doorways, replacement of the subgrade soils with 3 or more feet of clean, coarse sand or gravel should be considered or supporting the element on foundations similar to the building and spanning over a void. A detailed discussion in this regard can be provided upon request. It should be noted that where such open graded granular soils are placed, water can infiltrate and accumulate in the subsurface relatively easily, which can lead to increased settlement or heave from factors unrelated to ice formation. Therefore, where a section of open graded granular soils are placed, a local underdrain system should be provided to discharge collected water. GROUND will be available to discuss these concerns upon request.

UTILITY PIPE INSTALLATION AND BACKFILLING

The parameters and opinions below are based on GROUND's evaluation of the local, geotechnical conditions. Where our parameters or opinions differ from applicable municipal or agency standards for public utilities, the latter should be considered to take precedence.

Pipe Support The bearing capacity of the site soils appeared adequate, in general, for support of anticipated water lines. The pipe + water are less dense than the soils which will be displaced for installation. Therefore, GROUND anticipates no significant pipe settlements in these materials where properly bedded.

Excavation bottoms may expose soft, loose or otherwise deleterious materials, including debris. Firm materials may be disturbed by the excavation process. All such unsuitable materials should be excavated and replaced with properly compacted fill. Areas allowed to pond water will require excavation and replacement with properly compacted fill. The contractor should take particular care to ensure adequate support near pipe joints which are less tolerant of extensional strains.

Where thrust blocks are needed, they may be designed utilizing the values provided in the *Lateral Loads* section of this report.

Trench Backfilling Some settlement of compacted soil trench backfill materials should be anticipated, even where all the backfill is placed and compacted correctly. Typical settlements are on the order of 1 to 2 percent of fill thickness. However, the need to compact to the lowest portion of the backfill must be balanced against the need to protect the pipe from damage from the compaction process. Some thickness of backfill may need to be placed at compaction levels lower than specified (or smaller compaction equipment used together with thinner lifts) to avoid damaging the pipe. Protecting the pipe in this manner can result in somewhat greater surface settlements. Therefore, although other alternatives may be available, the following options are presented for consideration:

Controlled Low Strength Material: Because of these limitations, we suggest backfilling the entire depth of the trench (both bedding and common backfill zones) with "controlled low strength material" (CLSM), i.e., a lean, sand-cement slurry, "flowable fill," or similar material along all trench alignment reaches with low tolerances for surface settlements.

We suggest that CLSM used as pipe bedding and trench backfill exhibit a 28-day unconfined compressive strength between 50 to 150 psi so that re-excavation is not unusually difficult.

Placement of the CLSM in several lifts or other measures likely will be necessary to avoid 'floating' the pipe. Measures also should be taken to maintain pipe alignment during CLSM placement.

Compacted Soil Backfilling: Where compacted soil backfilling is employed, using the site soils or similar materials as backfill, the risk of backfill settlements entailed in the selection of this higher risk alternative must be anticipated and accepted by the Client/Owner.

We anticipate that the on-site soils excavated from trenches will be suitable, in general, for use as common trench backfill within the above-described limitations. Backfill soils should be free of vegetation, organic debris and other deleterious materials. Fragments of rock, cobbles, and inert construction debris (e.g., concrete or asphalt) coarser than 3 inches in maximum dimension should not be incorporated into trench backfills.

If it is necessary to import material for use as backfill, the imported soils should conform to the characteristics set forth in the *Project Earthworks* section of this report. Representative samples of the materials proposed for import should be tested and approved prior to transport to the site.

Soils placed for compaction as trench backfill should be conditioned to a relatively uniform moisture content, placed and compacted in accordance with the *Project Earthwork* section of this report.

Pipe Bedding Pipe bedding materials, placement and compaction should meet the specifications of the pipe manufacturer and applicable municipal standards. Bedding should be brought up uniformly on both sides of the pipe to reduce differential loadings.

As discussed above, we suggest the use of CLSM or similar material in lieu of granular bedding and compacted soil backfill where the tolerance for surface settlement is low. (Placement of CLSM as bedding to at least 12 inches above the pipe can protect the pipe and assist construction of a well-compacted conventional backfill although possibly at an increased cost relative to the use of conventional bedding.)

If a granular bedding material is specified, it is our opinion that with regard to potential migration of fines into the pipe bedding, design and installation follow ASTM D2321. If the granular bedding does not meet filter criteria for the enclosing soils, then non-woven filter fabric (e.g., Mirafi® 140N, or the equivalent) should be placed around the bedding to reduce migration of fines into the bedding which can result in severe, local surface settlements. Where this protection is not provided, settlements can develop/continue several months or years after completion of the project. In addition, clay or concrete cut-off walls should be installed to interrupt the granular bedding section to reduce the rates and volumes of water transmitted along the sewer alignment which can contribute to migration of fines.

If granular bedding is specified, some volume of native materials may be suitable for that use. Materials proposed for use as pipe bedding should be approved prior to use. Imported materials should be approved prior to transport to the site.

SURFACE DRAINAGE

The site soils are relatively stable with regard to moisture content – volume relationships at their existing moisture contents. Other than the anticipated, post-placement settlement of fills, post-construction soil movement will result primarily from the introduction of water into the soil underlying the proposed structure, hardscaping, and pavements. Based on the site surface and subsurface conditions encountered in this study, we do not anticipate a rise in the local water table sufficient to approach grade beam or floor elevations. Therefore, wetting of the site soils likely will result from infiltrating surface waters (precipitation, irrigation, etc.), and water flowing along constructed pathways such as bedding in utility pipe trenches.

The following drainage measures should be incorporated as part of project design and during construction. The facility should be observed periodically to evaluate the surface drainage and identify areas where drainage is ineffective. Routine maintenance of site drainage should be undertaken throughout the design life of the project. If these measures are not implemented and maintained effectively, the movement estimates provided in this report could be exceeded.

1) Wetting or drying of the foundation excavations and underslab areas should be avoided during and after construction as well as throughout the improvements' design life. Permitting increases/variations in moisture to the adjacent or supporting soils may result in a decrease in bearing capacity and an increase in

volume change of the underlying soils, and increased total and/or differential movements.

2) Positive surface drainage measures should be provided and maintained to reduce water infiltration into foundation soils.

The ground surface surrounding the exterior of each building should be sloped to drain away from the foundation in all directions. A minimum slope of 12 inches in the first 10 feet should be incorporated in the areas not covered with pavement or concrete slabs, or a minimum 2 percent in the first 10 feet in the areas covered with pavement or concrete slabs to comply with ADA requirements. Increasing slopes to 3 percent where possible will reduce the risks associated with moisture infiltration.

In no case should water be allowed to pond near or adjacent to foundation elements, hardscaping, utility trench alignments, etc.

3) Drainage should be established and maintained to direct water away from sidewalks and other hardscaping as well as utility trench alignments. Where the ground surface does not convey water away readily, additional post-construction movements and distress should be anticipated.

4) In GROUND's experience, it is common during construction that in areas of partially completed paving or hardscaping, bare soil behind curbs and gutters, and utility trenches, water is allowed to pond after rain or snow-melt events. Wetting of the subgrade can result in loss of subgrade support and increased settlements / increased heave. By the time final grading has been completed, significant volumes of water can already have entered the subgrade, leading to subsequent distress and failures. The contractor should maintain effective site drainage throughout construction so that water is directed into appropriate drainage structures.

5) On some sites, slopes may descend toward buildings locally. Such slopes can be created during grading even on comparatively flat sites. In such cases, even where the slopes as described above are implemented effectively, water may flow toward and beneath a structure or other site improvements with resultant

additional, post-construction movements. Where the final site configuration includes graded or retained slopes descending toward the improvements, surface drainage swales and/or interceptor drains should be installed between the improvements and the slope.

In addition, where site slopes, including retained slopes, descend toward a building, and the toe-of-slope (-wall) is less than 3 times the total slope (wall) height from the building, then an interceptor drain should be installed between the building and the slope. Ideally, the interceptor drain should be installed at least 10 feet from the building or along the axis of the swale between the building and the toe-of-slope (-wall). Geotechnical parameters for an interceptor drain system are provided in the *Subsurface Drainage* section of this report.

Where irrigation is applied on or above slopes, drainage structures commonly are needed near the toe-of-slope to prevent on-going or recurrent wet conditions.

6) Roof downspouts and drains should discharge well beyond the perimeter of the structure foundations (minimum 10 feet) and backfill zones and be provided with positive conveyance off-site for collected waters.

7) Based on our experience with similar facilities, the project may include landscaping/watering near site improvements. Irrigation water – both that applied to landscaped areas and over-spray – is a significant cause of distress to improvements. To reduce the potential for such distress, vegetation requiring watering should be located 10 or more feet from building perimeters, flatwork, or other improvements. Irrigation sprinkler heads should be deployed so that applied water is not introduced near or into foundation/subgrade soils. Landscape irrigation should be limited to the minimum quantities necessary to sustain healthy plant growth.

8) Use of drip irrigation systems can be beneficial for reducing over-spray beyond planters. Drip irrigation can also be beneficial for reducing the amounts of water introduced to foundation/subgrade soils, but only if the total volumes of applied water are controlled with regard to limiting that introduction. Controlling rates of moisture increase beneath the foundations, floors, and other improvements should take higher priority than minimizing landscape plant losses.

Where plantings are desired within 10 feet of a building, it is GROUND's opinion that the plants be placed in water-tight planters, constructed either in-ground or above-grade, to reduce moisture infiltration in the surrounding subgrade soils. Planters should be provided with positive drainage and landscape underdrains. As an alternative involving a limited increase in risk, the use of water-tight planters may be replaced by local shallow underdrains beneath the planter beds. Colorado Geological Survey – Special Publication 43 provides additional guidelines for landscaping and reducing the amount of water that infiltrates into the ground.

GROUND understands many municipalities and or developments require landscaping within 10 feet of building perimeters. Provided that positive, effective surface drainage is initially implemented and maintained throughout the life of the facility and the Owner understands and accepts the risks associated with this requirement, vegetation that requires controlled minimal amounts of irrigation may be located within 10 feet of the building perimeter.

9) Regular inspections should be made by facility representatives to make sure that the landscape irrigation is functioning properly throughout operation and that excess moisture is not applied.

10) Maintenance as described herein may include complete removal and replacement of site improvements in order to maintain effective surface drainage.

11) Detention ponds commonly are incorporated into drainage design. When a detention ponds fills, the rate of release of the water is controlled and water is retained in the pond for a period of time. Where in-ground storm sewers direct surface water to the pond, the granular pipe bedding also can direct shallow groundwater or infiltrating surface water toward the pond. Thus, detention ponds can become locations of enhanced and concentrated infiltration into the subsurface, leading to wetting of foundation soils in the vicinity with consequent heave or settlement. Therefore, unless the pond is clearly down-gradient from the proposed buildings and other structures that would be adversely affected by wetting of the subgrade soils, including off-site improvements, GROUND recommends that the detention pond should be provided with an effective, low permeability liner. In addition, cut-off walls and/or drainage provisions should be

provided for the bedding materials surrounding storm sewer lines flowing to the pond.

SUBSURFACE DRAINAGE

Building Perimeter Foundation Drains and Laterals As a component of project civil design, properly functioning, subsurface drain systems (underdrains) can be beneficial for collecting and discharging subsurface waters where the soil is saturated. In GROUND's opinion the proposed building does not specifically need to be protected with a perimeter underdrain system in the absence of below-grade / basement levels.

However, if a below-grade or partially below-grade level is added to the building, then a local underdrain system should be included to protect that area. Damp-proofing should be applied to the exteriors of below-grade elements. The provision of Tencate MiraFi® G-Series backing (or comparable wall drain provisions) on the exteriors of (some) below-grade elements may be appropriate, depending on the intended use.

Collected surface waters should not be routed into an underdrain.

Each underdrain system should be tested by the contractor after installation and after placement and compaction of the overlying backfill to verify that the system functions properly. Like other components of the structure, periodic maintenance of an underdrain system after completion should be anticipated to keep it functioning as intended.

Geotechnical Parameters for Underdrain Design Where an underdrain system is included in project drainage design, it should be designed in accordance with the recommendations below. The actual underdrain layout, outlets, and locations should be developed by a civil engineer.

1) An underdrain system for a building should consist of perforated, rigid, PVC collection pipe at least 4 inches in diameter, non-perforated, rigid, PVC discharge pipe at least 4 inches in diameter, free-draining gravel, and filter fabric, as well as a waterproof membrane or drain board product.

2) The free-draining gravel should contain less than 5 percent passing the No. 200 Sieve and more than 50 percent retained on the No. 4 Sieve, and have a maximum particle size of 2 inches.

Each collection pipe should be surrounded on the sides and top (only) with 6 or more inches of free-draining gravel.

3) The gravel surrounding the collection pipe(s) should be wrapped with filter fabric (Tencate MiraFi 140N® or the equivalent) to reduce the migration of fines into the drain system.

4) The collection and discharge pipes should be 12 or more inches from grade beam margin and 6 or more inches below the bottom of the grade beam

5) The underdrain system should be designed to discharge at least 10 gallons per minute of collected water.

6) The high point(s) for the collection pipe flow lines should be below the foundation or grade beam bearing elevation. Multiple high points can be beneficial to reducing the depths to which the system would be installed.

   Pipe gradients also should be designed to accommodate at least 1 inch of differential movement after installation along a 50-foot run.

7) Underdrain 'clean-outs' should be provided at intervals of no more than 200 feet to facilitate maintenance of the underdrains. Clean-outs also should be provided at collection and discharge pipe elbows of 60 degrees or more.

8) The underdrain discharge pipes should be connected to one or more sumps from which water can be removed by pumping, or to outlet(s) for gravity discharge. We suggest that collected waters be discharged directly into the storm sewer system, if possible.

PAVEMENT SECTIONS

A pavement section is a layered system designed to distribute concentrated traffic loads to the subgrade. Performance of the pavement structure is directly related to the physical properties of the subgrade soils and traffic loadings. The standard care of practice in pavement design describes the flexible pavement section as a "20-year" design pavement: however, most flexible pavements will not remain in satisfactory condition without routine maintenance and rehabilitation procedures performed throughout the life of the pavement. Pavement designs for the private pavements were developed in general accordance with the design guidelines and procedures of the American Association of State Highway and Transportation Officials (AASHTO). The pavement designs for the public roadways (Prospect Road and County Road 5) were developed in general accordance with the Larimer Count Urban Area Street Standards (LCUASS).

Subgrade Materials Based on the results of our field exploration and laboratory testing, the likely pavement subgrade materials vary from A-1-a to A-6 soil in accordance with the American Association of State Highway and Transportation Officials (AASHTO) classification system. These materials are anticipated to have elevated moisture content and be unstable based on the existing condition of the pavement. These materials will need to be stabilized prior to placing asphalt.

Laboratory results indicated an R-value of 36 for the materials obtained from the public roadways adjacent to the project site. Due to the inclusion of some amounts of asphalt and road base within the bulk sample utilized for testing, an R-Value of 20 was utilized for design of the project pavements. An R-Value of 20 converts to a resilient modulus of 4,940 psi based on CDOT correlation tables. It is important to note that significant decreases in soil support have been observed as the moisture content increases above the optimum. Pavements that are not properly drained may experience a loss of the soil support and subsequent reduction in pavement life.

Anticipated Traffic Based on our experience with similar projects and conversations with the client equivalent 18-kip daily load application (EDLA) values of 5, 10, and 30 were assumed for the general parking lots, vehicle drive lanes, and heavy vehicle drive paths/bus lanes, respectively. The EDLA values of 5, 10, and 30 were converted to equivalent 18-kip single axle load (ESAL) values of 36,500; 73,000; and 219,000 respectively for a 20-year design life.

The Fort Collins Master Street Plan labels the portion of Prospect and County Road 5 as 4-lane Arterial Roadways. These roadways are currently constructed as 2-lay roadways therefore, pavement designs for a 2-lane and 4-lane Arterial Roadway are provided below. The EDLA values provided by LUCASS for a 2-lane and 4-lane arterial are 100 and 200 respectively. These EDLA values convert to 730,000 and 1,460,000 ESAL's. If anticipated traffic loadings differ significantly from these assumed values, GROUND should be notified to re-evaluate the pavement thicknesses provided below.

Pavement Sections The soil resilient modulus and the ESAL values were used to determine the required design structural number for the project pavements. The required structural number was then used to develop the pavement sections. Pavement designs were based on the DARWin™ computer program that solves the 1993 AASHTO pavement design equations. A Reliability Level of 80 percent was utilized to develop the private pavement sections, together with a Serviceability index loss of 2.5. An overall standard of deviation of 0.44 also was used.

A structural coefficient of 0.44 was used for hot bituminous asphalt and 0.11 for aggregate base course, respectively. The resultant minimum pavement sections that should be used at the facility are tabulated below.

Minimum Private Pavement Sections

Location	***Composite Asphalt Section*** *(inches Asphalt / inches ABC)*	***Full Depth Asphalt Section*** *(inches Asphalt)*	***Rigid Pavement*** *(inches PCCP / inches ABC)*
Parking Areas	4.0 / 4	5.0	-
Light Vehicle Drive Lanes	4.0 / 6	5.5	-
Heavy Vehicle / Bus Lane	5.0 / 6	6.5	6.5 / 6

ABC = Aggregate Base Course, PCCP= Portland Cement Concrete Pavement

Minimum Public Pavement Sections

Location	***Roadway Classification***	***Composite Asphalt Section*** *(inches Asphalt / inches ABC)*
Prospect Rd and County Road 5	2-Lane Arterial	7.0 / 6.0
Prospect Rd and County Road 5	4-Lane Arterial	7.5 / 8.0

ABC = Aggregate Base Course, PCCP= Portland Cement Concrete Pavement

Heavy traffic areas/routes serving the facility that impose high stress on the pavement such as trash collection areas and trash truck turn arounds should be provided with rigid pavements consisting of **6.5 or more inches of Portland cement concrete underlain by at least 6 inches of Aggregate Base Course materials**. (An equivalent flexible section for these areas would not perform as well as the concrete section where heavy vehicles are parked, stop suddenly, turn repeatedly, etc.)

Pavement Materials Asphalt pavement should consist of a bituminous plant mix composed of a mixture of aggregate and bituminous material. Asphalt mixture(s) should meet the requirements of a job-mix formula established by a qualified engineer and applicable municipality design requirements.

Aggregate base material should meet the criteria of CDOT Class 5 or 6 Aggregate Base Course. Base course should be placed in and compacted in accordance with the standards in the *Project Earthwork* section of this report.

Concrete pavements should consist of a plant mix composed of a mixture of aggregate, Portland cement and appropriate admixtures meeting the requirements of a job-mix formula established by a qualified engineer and applicable municipality design requirements. Concrete should have a minimum modulus of rupture of third point loading of 650 psi. Normally, concrete with a 28-day compressive strength of 4,500 psi should develop this modulus of rupture value. The concrete should be air-entrained with approximately 6 percent air and should have a minimum cement content of 6 sacks per cubic yard. Maximum allowable slump should be 4 inches for hand-placed concrete. Machine-placed concrete may require a lower slump.

These concrete mix design criteria should be coordinated with other project requirements including any criteria for sulfate resistance presented in the *Water-Soluble Sulfates* section of this report. To reduce surficial spalling resulting from freeze-thaw cycling, we suggest that pavement concrete meet the requirements of CDOT Class P concrete. In addition, the use of de-icing salts on concrete pavements during the first winter after construction will increase the likelihood of the development of scaling. Placement of flatwork concrete during cold weather so that it is exposed to freeze-thaw cycling before it is fully cured also increases its vulnerability to scaling. Concrete placing during cold weather conditions should be blanketed or tented to allow full curing.

Depending on the weather conditions, this may result in 3 to 4 weeks of curing, and possibly more.

Concrete pavements should contain sawed or formed joints. CDOT and various industry groups provide guidelines for proper design and concrete construction and associated jointing. In areas of repeated turning stresses the concrete pavement joints should be fully tied and doweled. Example layouts for joints, as well as ties and dowels, that may be applicable can be found in CDOT's M standards, found at the CDOT website: http://www.dot.state.co.us/DesignSupport/. PCA, ACI and ACPA publications also provide useful guidance in these regards.

Subgrade Preparation Shortly before paving, the pavement subgrade should be excavated and/or scarified to a minimum depth of **12 inches**, moisture-conditioned and properly re-compacted. Although subgrade preparation to a depth of 12 inches is typical in the project area, pavement performance commonly can be improved by a greater depth of moisture-density conditioning of the soils.

Based on samples taken from the test holes man-made fill exists onsite. Over-excavation to greater depths may need to be performed on localized areas depending on the conditions exposed during construction.

Subgrade preparation should extend the full width of the pavement. The subgrade for sidewalks and other project hardscaping also should be prepared in the same manner (moisture density treatment to a depth of 12-inches).

Criteria and standards for fill placement and compaction are provided in the *Project Earthwork* section of this report. The contractor should be prepared either dry the subgrade materials or moisten them, as needed, prior to compaction.

Where adequate drainage cannot be achieved or maintained, excavation and replacement should be undertaken to a greater depth, in addition to the edge drains discussed below.

Proof Rolling Immediately prior to paving, the subgrade should be proof rolled with a heavily loaded, pneumatic tired vehicle. Areas that show excessive deflection during proof rolling should be excavated and replaced and/or stabilized as discussed above. Areas allowed to pond prior to paving will require significant re-working prior to proof-rolling. Establishment of a firm paving platform (as indicated by proof rolling) is an additional requirement beyond proper fill placement and compaction. It is possible for soils to be compacted within the limits indicated in the *Project Earthwork* section of this report and fail proof rolling, particularly in the upper range of specified moisture contents.

Temporary Fire Access Routes Commonly, construction sites are required by local fire departments to provide temporary access for emergency response. It has been GROUND's experience these access drives are to provide support for trucks weighing up to 90,000 pounds and are typically desired to be gravel/aggregate-surfaced.

Based on our experience, a temporary section consisting of at least 12 inches of material meeting the requirements of CDOT Class 5 or Class 6 Aggregate Base Course or at least 8 inches of CDOT Class 5 or Class 6 Aggregate Base Course over a layer of stabilization geotextile/geofabric, such as Mirafi® RS380*i* or the equivalent, could be utilized provided the Owner understands that this section is for temporary access during construction only and is not a replacement or an equal alternate to the pavement section(s) that were indicated previously. The aggregate base course placed for this purpose should be compacted to at least 95 percent of the maximum modified Proctor dry density. It should be noted that the aggregate base course sections indicated above are not intended to support fire truck outriggers without cribbing or similar measures.

It should be understood that with any aggregate surface, shoving and displacement of the granular materials should be expected during repetitive vehicular/equipment loading. Therefore, regular maintenance should be implemented to ensure proper surface and subsurface drainage, repair distressed/damaged areas, and re-establish grades. Application of additional aggregate may be required in this regard. Additionally, the ability of the aggregate temporary access drive to accommodate loads as indicated above is directly related to the quality of the subgrade materials on which the aggregate is placed, not only on the aggregate section. If water infiltrates these areas, additional rutting and other distress, including a reduction in capacity, will result, requiring additional maintenance.

Additional Considerations The collection and diversion of surface drainage away from paved areas is extremely important to satisfactory performance of the pavements. The subsurface and surface drainage systems should be carefully designed to ensure removal of the water from paved areas and subgrade soils. Allowing surface waters to pond on pavements will cause premature pavement deterioration. Where topography, site constraints or other factors limit or preclude adequate surface drainage, pavements should be provided with edge drains to reduce loss of subgrade support. The long-term performance of the pavement also can be improved greatly by proper backfilling and compaction behind curbs, gutters, and sidewalks so that ponding is not permitted and water infiltration is reduced.

Landscape irrigation in planters adjacent to pavements and in "island" planters within paved areas should be carefully controlled or differential heave and/or rutting of the nearby pavements will result. Drip irrigation systems are recommended for such planters to reduce over-spray and water infiltration beyond the planters. Enclosing the soil in the planters with plastic liners and providing them with positive drainage also will reduce differential moisture increases in the surrounding subgrade soils.

In our experience, infiltration from planters adjacent to pavements is a principal source of moisture increase beneath those pavements. This wetting of the subgrade soils from infiltrating irrigation commonly leads to loss of subgrade support for the pavement with resultant accelerating distress, loss of pavement life and increased maintenance costs. This is particularly the case in the later stages of project construction after landscaping has been emplaced but heavy construction traffic has not ended. Heavy vehicle traffic over wetted subgrade commonly results in rutting and pushing of flexible pavements, and cracking of rigid pavements. Where the subgrade soils are expansive, wetting also typically results in increased pavement heave. In relatively flat areas where design drainage gradients necessarily are small, subgrade settlement or heave can obstruct proper drainage and yield increased infiltration, exaggerated distress, etc. (These considerations apply to project flatwork, as well.)

Also, GROUND's experience indicates that longitudinal cracking is common in asphalt-pavements generally parallel to the interface between the asphalt and concrete structures such as curbs, gutters or drain pans. This of this type is likely to occur even where the subgrade has been prepared properly and the asphalt has been compacted properly.

The anticipated traffic loading does not include excess loading conditions imposed by heavy construction vehicles. Consequently, heavily loaded concrete, lumber, and building material trucks can have a detrimental effect on the pavement. GROUND recommends that an effective program of regular maintenance be developed and implemented to seal cracks, repair distressed areas, and perform thin overlays throughout the life of the pavements.

Most pavements will not remain in satisfactory condition and achieve their "design lives" without regular maintenance and rehabilitation procedures performed throughout the life of the pavement. Maintenance and rehabilitation measures preserve, rather than improve, the structural capacity of the pavement structure. Therefore, GROUND recommends that an effective program of regular maintenance be developed and implemented to seal cracks, repair distressed areas, and perform thin overlays throughout the lives of the pavements. The greatest benefit of pavement overlaying will be achieved by overlaying sound pavements that exhibit little or no distress.

Crack sealing should be performed at least annually and a fog seal/chip seal program should be performed on the pavements every 3 to 4 years. After approximately 8 to 10 years after construction, patching, additional crack sealing, and asphalt overlay may be required. Prior to overlays, it is important that all cracks be sealed with a flexible, rubberized crack sealant in order to reduce the potential for propagation of the crack through the overlay. If actual traffic loadings exceed the values used for development of the pavement sections, however, pavement maintenance measures will be needed on an accelerated schedule.

CLOSURE AND LIMITATIONS

Geotechnical Review The author of this report or a GROUND principal should be retained to review project plans and specifications to evaluate whether they comply with the intent of the measures discussed in this report. The review should be requested in writing. GROUND should be provided preliminary grading plans, building layout, and foundation elevation details as soon as practical so that the criteria in this document can be verified and any required adjustments be addressed and documented.

The geotechnical conclusions and parameters presented in this report are contingent upon observation and testing of project earthwork by representatives of GROUND. If another geotechnical consultant is selected to provide materials testing, then that consultant must assume all responsibility for the geotechnical aspects of the project by concurring in writing with the parameters in this report, or by providing alternative parameters.

Materials Testing Poudre School District should consider retaining a geotechnical engineer to perform materials testing during construction. The performance of such testing or lack thereof, however, in no way alleviates the burden of the contractor or subcontractor from constructing in a manner that conforms to applicable project documents and industry standards. The contractor or pertinent subcontractor is ultimately responsible for managing the quality of his work; furthermore, testing by the geotechnical engineer does not preclude the contractor from obtaining or providing whatever services that he deems necessary to complete the project in accordance with applicable documents.

Limitations This report has been prepared for the Poudre School District as it pertains to design of the proposed New Prospect 6-12 School as described herein. It should not be assumed to contain sufficient information for other parties or other purposes. The Client has agreed to the terms, conditions, and liability limitations outlined in our agreement between Poudre School District and GROUND. Reliance upon our report is not granted to any other potential owner, contractor, or lender. Requests for third-party reliance should be directed to GROUND in writing; granting reliance by GROUND is not guaranteed.

In addition, GROUND has assumed that project construction will commence by Spring/Summer of 2020. Any changes in project plans or schedule should be brought to the attention of a geotechnical engineer, in order that the geotechnical conclusions in this report may be re-evaluated and, as necessary, modified.

The geotechnical conclusions in this report were based on subsurface information from a limited number of exploration points, as shown in Figure 1, as well as the means and methods described herein. Subsurface conditions were interpolated between and extrapolated beyond these locations. It is not possible to guarantee the subsurface conditions are as indicated in this report. Actual conditions exposed during construction may differ from those encountered during site exploration. In addition, a contractor who obtains information from this report for development of his scope of work or cost estimates does so solely at his own risk and may find the geotechnical information in this report to be inadequate for his purposes or find the geotechnical conditions described herein to be at variance with his experience in the greater project area. The contractor should obtain the additional geotechnical information that is necessary to develop his workscope and cost estimates with sufficient precision. This includes, but is not limited to, information regarding excavation conditions, earth material usage, current depths to groundwater, etc.

If during construction, surface, soil, bedrock, or groundwater conditions appear to be at variance with those described herein, a geotechnical engineer should be retained at once, so that our conclusions for this site may be re-evaluated in a timely manner and dependent aspects of project design can be modified, as necessary.

The materials present on-site are stable at their natural moisture content, but may change volume or lose bearing capacity or stability with changes in moisture content. Performance of the proposed structure and pavement will depend on implementation of the conclusions and information in this report and on proper maintenance after construction is completed. Because water is a significant cause of volume change in soils and rock, allowing moisture infiltration may result in movements, some of which will exceed estimates provided herein and should therefore be expected by the Poudre School District.

ALL DEVELOPMENT CONTAINS INHERENT RISKS. It is important that ALL aspects of this report, as well as the estimated performance (and limitations with any such estimations) of proposed improvements are understood by Poudre School District. Utilizing the geotechnical parameters and measures herein for planning, design, and/or construction constitutes understanding and acceptance of the conclusions with regard to risk and other information provided herein, associated improvement performance, as well as the limitations inherent within such estimates. Ensuring correct interpretation of the contents of this report by others is not the responsibility of GROUND. If any information referred to herein is not well understood, it is imperative that the Poudre School District contact the author or a GROUND principal immediately. We will be available to meet to discuss the risks and remedial approaches presented in this report, as well as other potential approaches, upon request.

Current applicable codes may contain criteria regarding performance of structures and/or site improvements which may differ from those provided herein. Our office should be contacted regarding any apparent disparity.

GROUND makes no warranties, either expressed or implied, as to the professional data, opinions or conclusions contained herein. Because of numerous considerations that are beyond GROUND's control, the economic or technical performance of the project cannot be guaranteed in any respect**.**

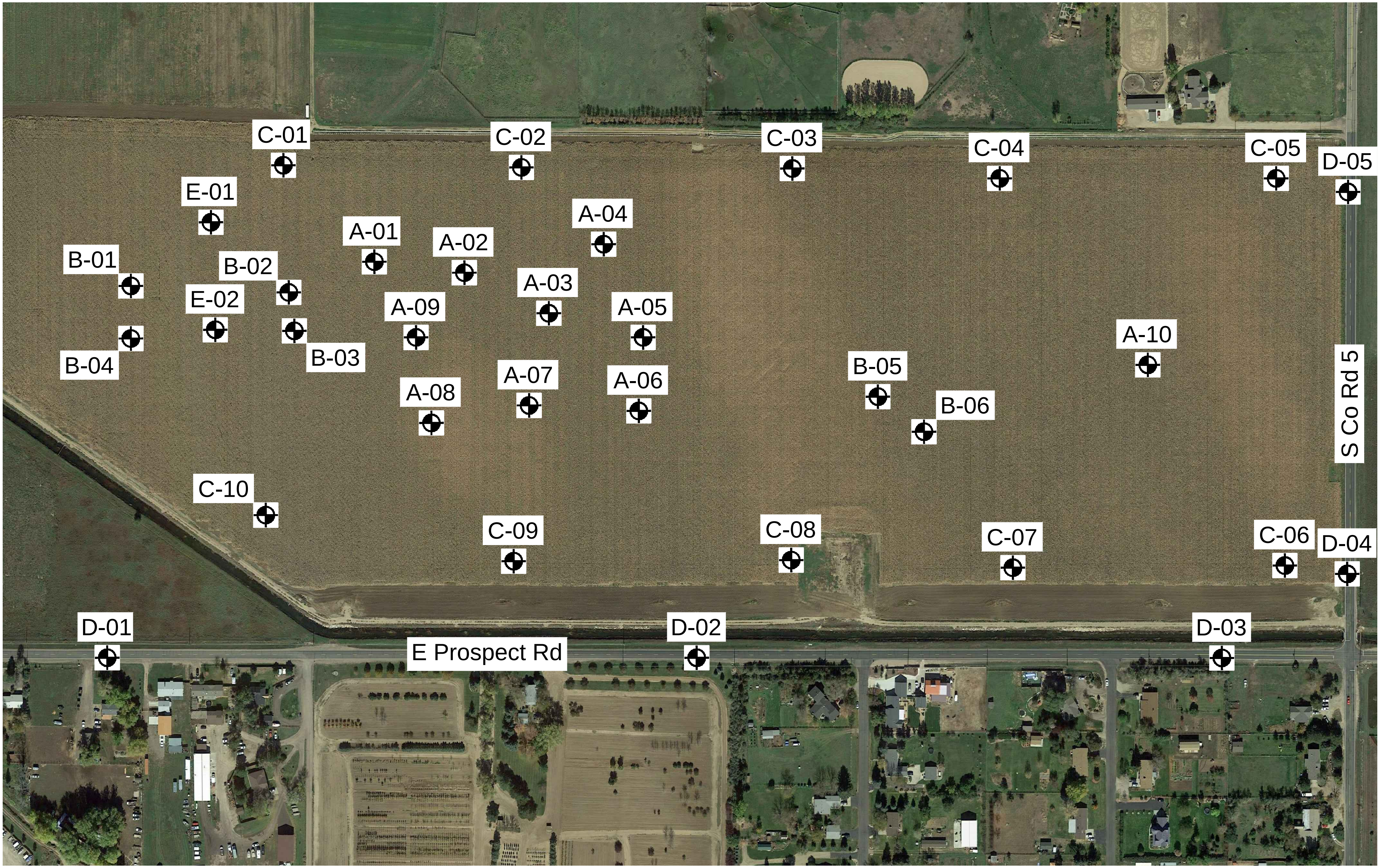
This document, together with the concepts and conclusions presented herein, as an instrument of service, is intended only for the specific purpose and client for which it was prepared. Re-use of, or improper reliance on this document without written authorization and adaption by GROUND Engineering Consultants, Inc., shall be without liability to GROUND Engineering Consultants, Inc.

GROUND appreciates the opportunity to complete this portion of the project.

Sincerely,
GROUND Engineering Consultants, Inc.

Kelsey Van Bemmel
Digitally signed by Kelsey Van Bemmel
DN: cn=Kelsey Van Bemmel, o=Ground Engineering Consultants, Inc., ou=Loveland Office, email=kelsey.vanbemmel@groundeng.com, c=US
Date: 2019.06.17 11:25:30 -06'00'

Kelsey Van Bemmel, P.E. Reviewed by Brian H. Reck, P.G., C.E.G., P.E.



GOOGLE EARTH AERIAL IMAGE (DATE UNKNOWN)

1

⊕ Indicates test hole number and approximate location.

(Not to Scale)

GROUND
ENGINEERING CONSULTANTS

LOCATION OF TEST HOLES

JOB NO.: 19-0013	FIGURE: 1
CADFILE NAME: 0013SITE.DWG	

SUBSURFACE DIAGRAM

GROUND ENGINEERING

CLIENT: Poudre School District

JOB NO.: 19-0013

PROJECT NAME: PSD: New Prospect 6-12 School - Final

PROJECT LOCATION: Fort Collins, CO

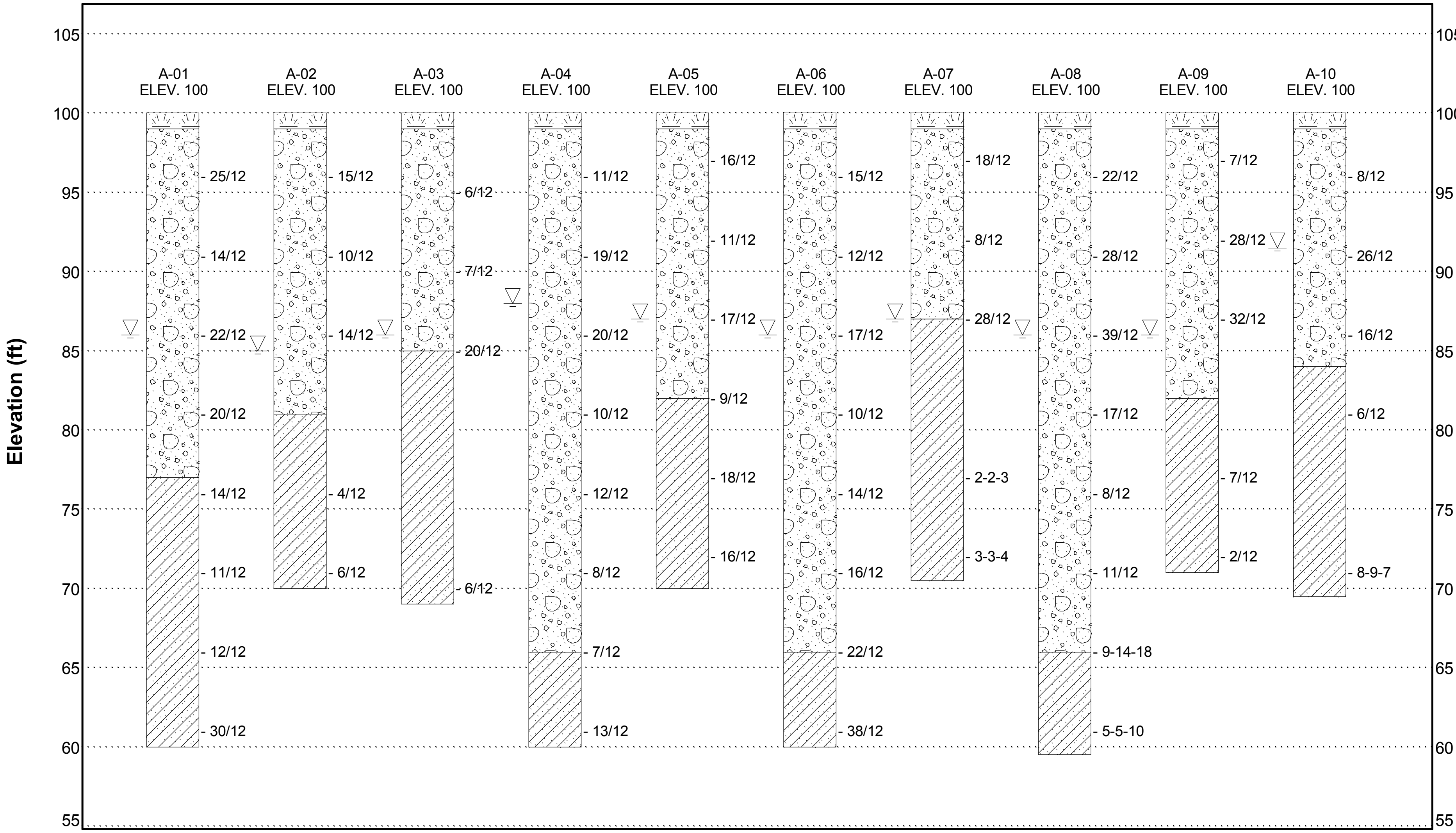


FIGURE #2

GROUND ENGINEERING

SUBSURFACE DIAGRAM

CLIENT: Poudre School District

JOB NO.: 19-0013

PROJECT NAME: PSD: New Prospect 6-12 School - Final

PROJECT LOCATION: Fort Collins, CO

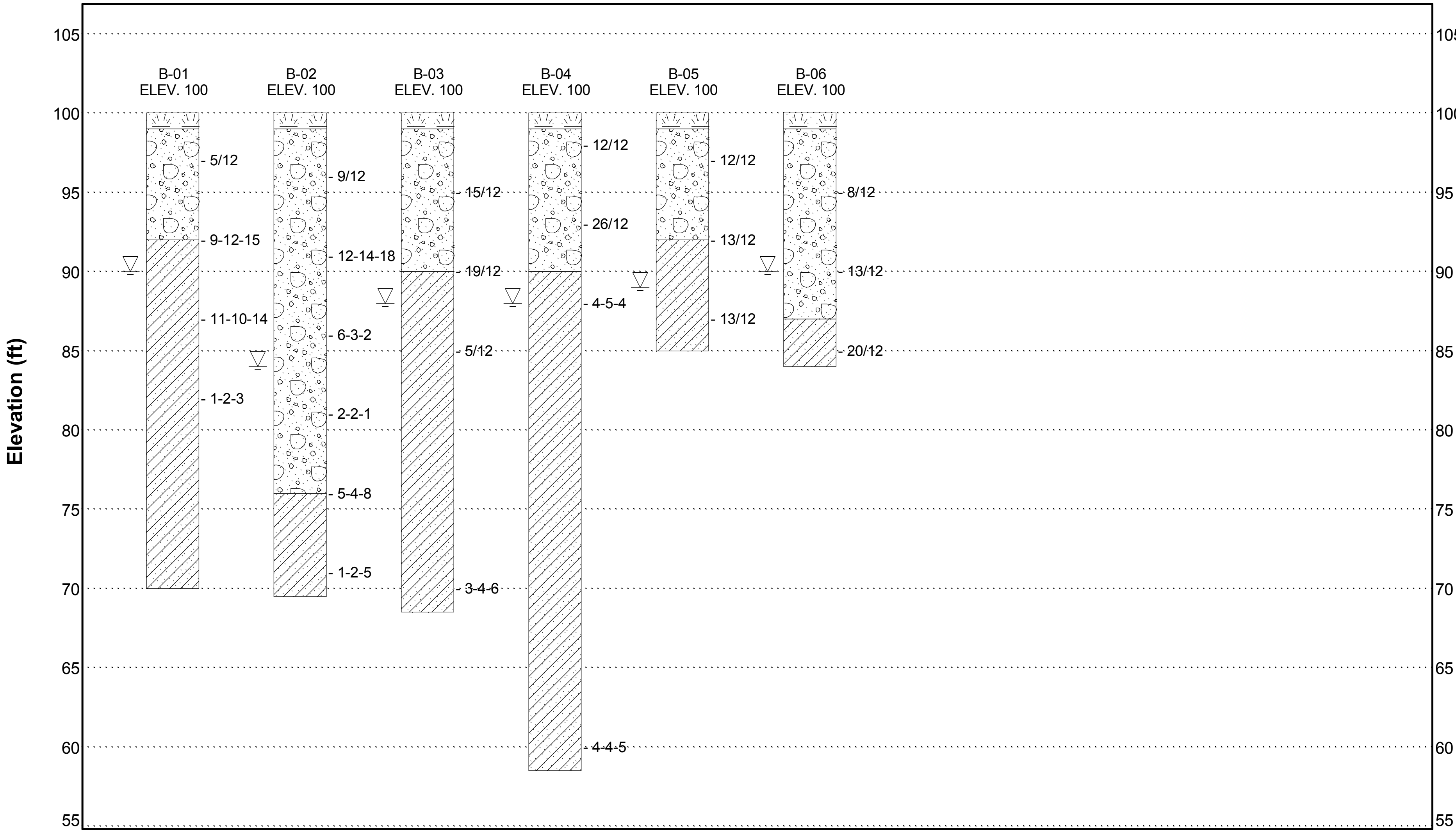


FIGURE #3

SUBSURFACE DIAGRAM

CLIENT: Poudre School District

JOB NO.: 19-0013

PROJECT NAME: PSD: New Prospect 6-12 School - Final

PROJECT LOCATION: Fort Collins, CO

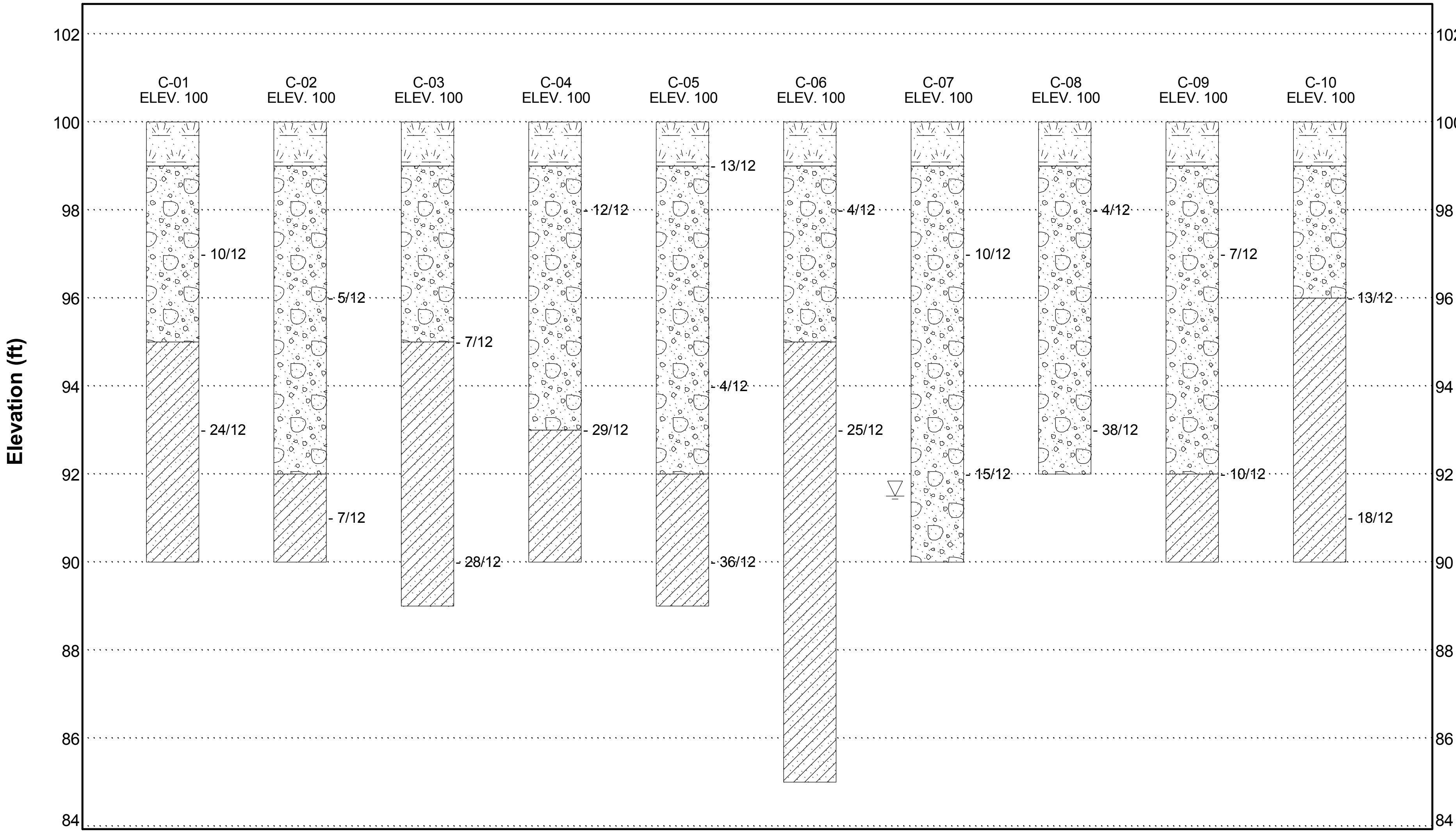


FIGURE #4

GROUND ENGINEERING

SUBSURFACE DIAGRAM

CLIENT: Poudre School District

JOB NO.: 19-0013

PROJECT NAME: PSD: New Prospect 6-12 School - Final

PROJECT LOCATION: Fort Collins, CO

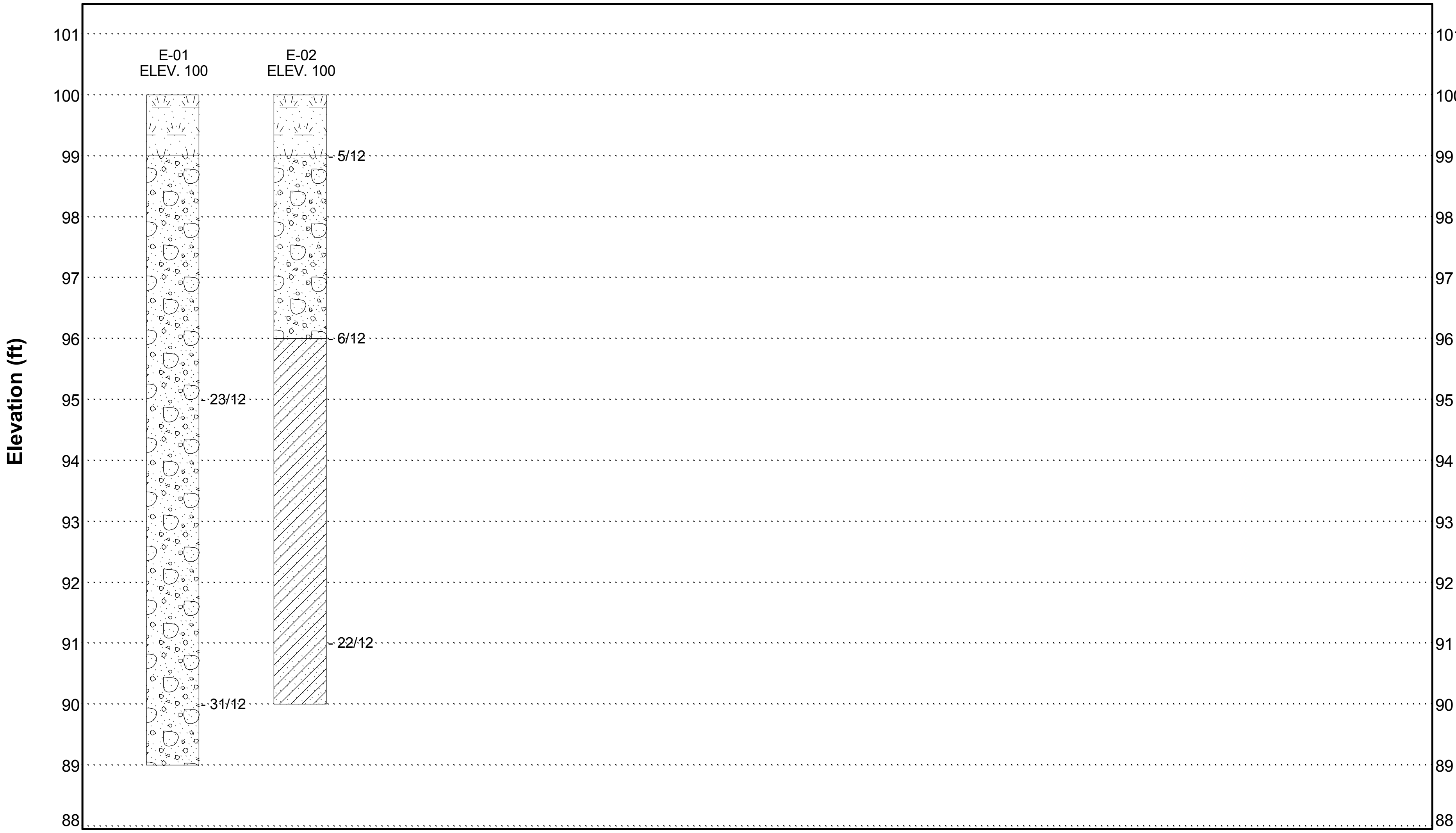


FIGURE #5

SUBSURFACE DIAGRAM

GROUND ENGINEERING

CLIENT: Poudre School District

JOB NO.: 19-0013

PROJECT NAME: PSD: New Prospect 6-12 School - Final

PROJECT LOCATION: Fort Collins, CO

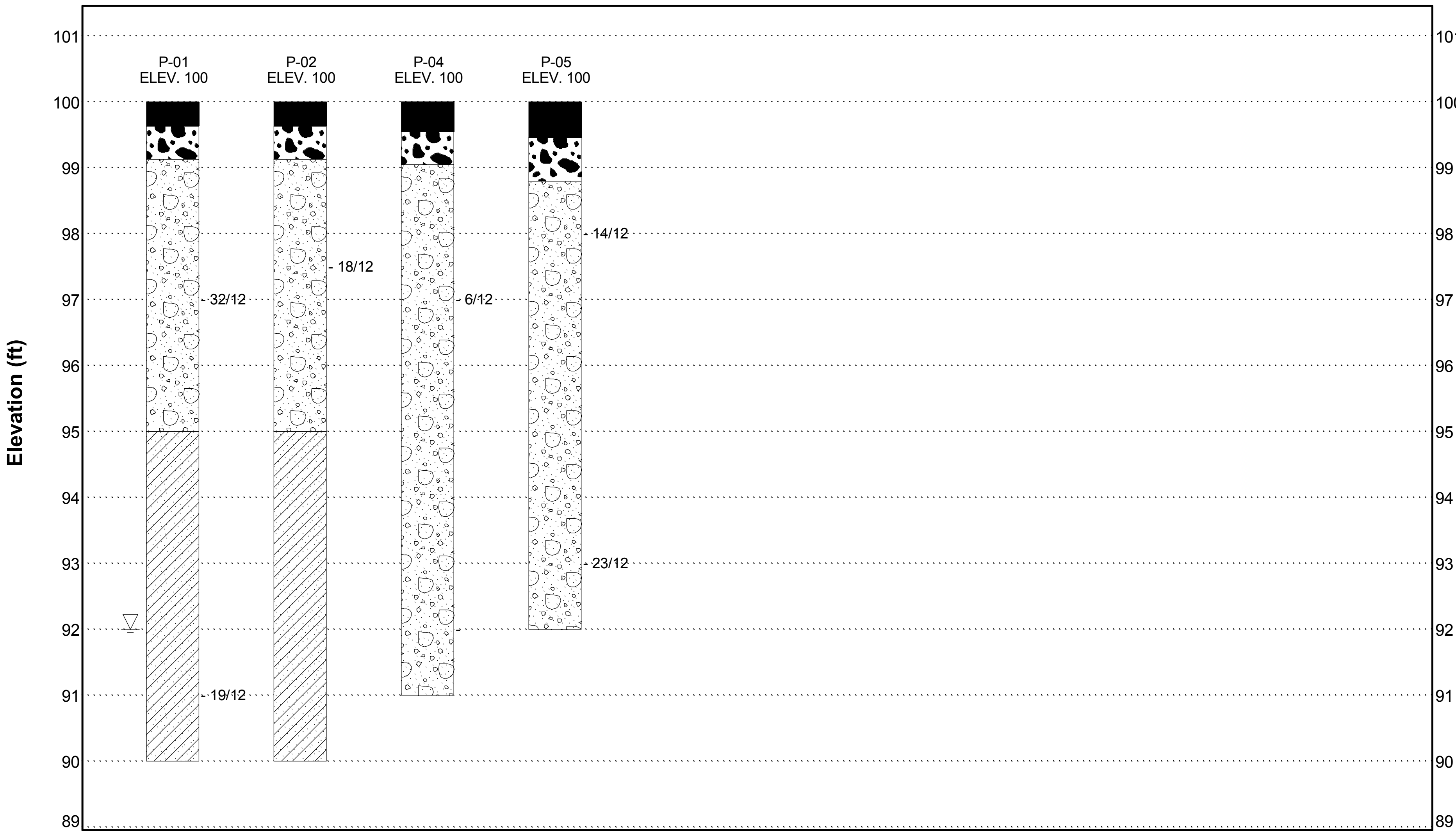


FIGURE #6

KEY TO SYMBOLS

GROUND ENGINEERING

CLIENT: Poudre School District

PROJECT NAME: PSD: New Prospect 6-12 School - Final

JOB NO.: 19-0013

PROJECT LOCATION: Fort Collins, CO

LITHOLOGIC SYMBOLS

ASPHALT

ROAD BASE

TOPSOIL

SAND AND CLAY

SAND AND GRAVEL

NOTE: See Detailed Logs for Material descriptions.

SAMPLER SYMBOLS

California Sampler
23 / 12 Drive sample blow count indicates 23 blows of a 140 pound hammer falling 30 inches were required to drive the sampler 12 inches.

Small Disturbed Sample

Split Spoon

NOTES:

1. Test holes were drilled on 5/6/2019, 5/7/2019, 5/13/2019, 5/14/2019 and 5/29/2019 with 4-inch, 5-inch and 8-inch Diameter Continuous Flight Auger.

2. Locations of the test holes were measured approximately by pacing from features shown on the site plan provided.

3. Elevations of the test holes were not measured and the logs of the test holes are drawn to depth.

4. The test hole locations and elevations should be considered accurate only to the degree implied by the method used.

5. The lines between materials shown on the test hole logs represent the approximate boundaries between material types and the transitions may be gradual.

6. Groundwater level readings shown on the logs were made at the time and under the conditions indicated. Fluctuations in the water level may occur with time.

7. The material descriptions on these logs are for general classification purposes only. See full text of this report for descriptions of the site materials & related information.

8. All test holes were immediately backfilled upon completion of drilling, unless otherwise specified in this report.

ABBREVIATIONS

Water Level at Time of Drilling, or as Shown

Water Level at End of Drilling, or as Shown

Water Level After 24 Hours, or as Shown

NV No Value
NP Non Plastic

FIGURE #7

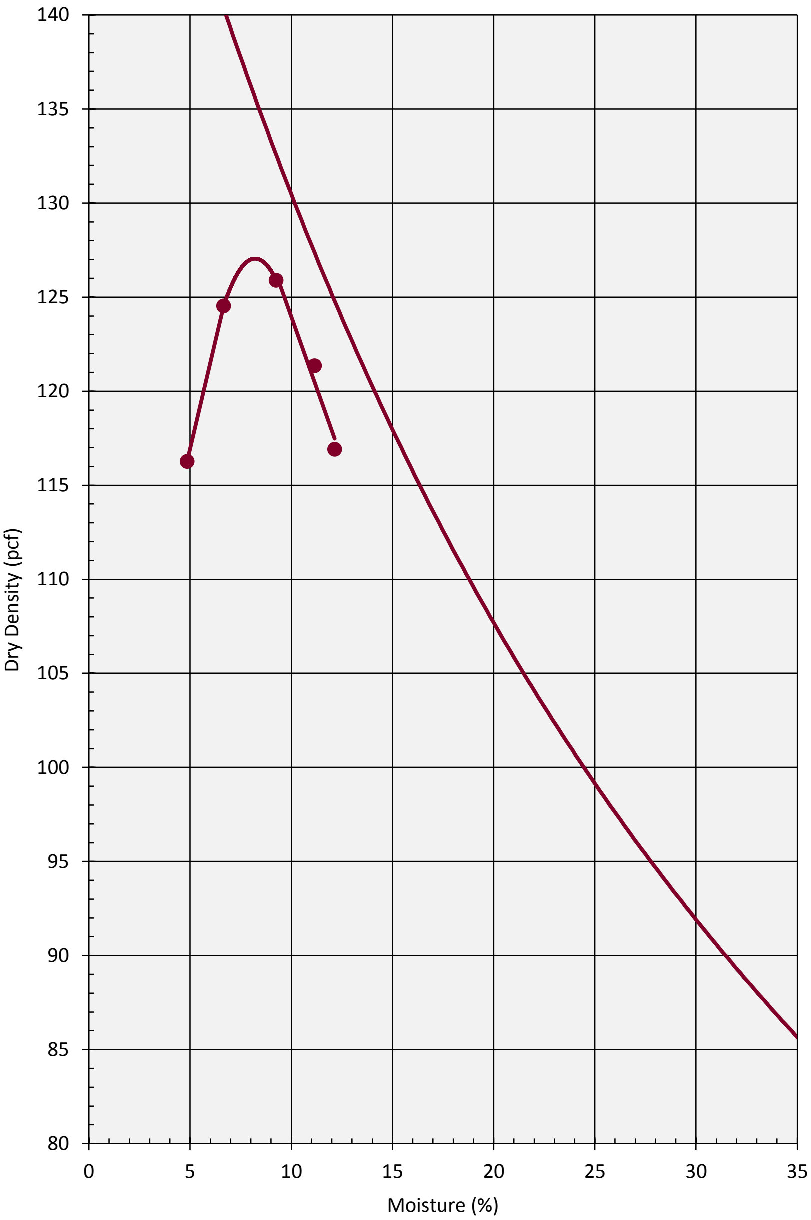
GROUND ENGINEERING

Client: Poudre School District

Project No.: 19-0013

New Prospect 6-12 School

Standard Proctor (ASTM D698)



Method	Preparation	Hammer
Method B	Moist	Manual

Maximum Dry Density (pcf)	Optimum Moisture (%)	Oversize Corrected	
		Maximum Dry Density (pcf)	Optimum Moisture (%)
127.0	**8.0**	-	-

Oversize Sieve: 3/8 in
Coarse Fraction (%): -
Fine Fraction (%): -
Coarse Specific Gravity: -
Coarse Absorption (%): -
Fine Specific Gravity: 2.65 Estimated

Location: D-1 to D- 5, 1 to 5', Bulk
Description: Light brown, clayey SAND

Classification: SC/A-2-4 (0) *< No. 200 (%):* 30.0
Liquid Limit: 27
Plasticity Index: 9

Client: Poudre School District

Project No.: 19-0013

New Prospect 6-12 School

TABLE 2: SUMMARY OF SOIL CORROSION TEST RESULTS

Sample Location		Water Soluble Sulfates	pH	Redox Potential	Sulfide Reactivity*	Resistivity	USCS Equivalent Classification	AASHTO Equivalent Classification (Group Index)	Sample Description
Test Hole No.	Depth *(feet)*	*(%)*		*(mV)*		*(ohm-cm)*			
A-1	4	0.05	8.3	-69.0	Positive	10790	SC-SM	A-4 (0)	Silty Clayey SAND
A-8	4	< 0.01	8.5	-95.0	Positive	2287	SC	A-6 (5)	Clayey SAND
B-5	3	< 0.01	-	-	-	-	SW	A-1-a(0	Well graded SAND
C-1	3	0.01	-	-	-	-	SM	A-2-4(0)	Silty SAND

*Performed by eAnalytics Laboratory.

GROUND ENGINEERING

TABLE 1
SUMMARY OF LABORATORY TEST RESULTS

Sample Location		Natural Moisture Content	Natural Dry Density	Gradation		Percent Passing No. 200 Sieve	Atterberg Limits		Percent Swell (Surcharge Pressure)	USCS Classification	AASHTO Classification (GI)	Soil or Bedrock Type
Test Hole No.	Depth *(feet)*	*(%)*	*(pcf)*	Gravel *(%)*	Sand *(%)*		Liquid Limit	Plasticity Index				
A-1	4	9.9	113.0			47	24	6		SC-SM	A-4 (0)	Silty Clayey SAND
A-2	9	15.2	106.5			56	34	20		SC-CL	A-6(8)	SAND and CLAY
A-3	10	3.2	118.1			14	-	NP		(SM)	A-2-4(0)	Silty SAND
A-3	15	20.9	103.5			19	-	NP		(SM)	A-2-4(0)	Silty SAND
A-4	4	1.0	SD	39	57	4	-	NP		(SW)	A-1-a(0)	Well graded SAND
A-4	19	24.0	101.9			83	29	12		(CL)s	A-6(8)	CLAY with sand
A-5	8	25.2	96.8			89	14	34		(CL)	A-6(17)	CLAY
A-5	13	12.7	114.5			13	-	NP		(SM)	A-2-4(0)	Silty SAND
A-6	4	2.1	SD	39	55	6	-	NP		(SW-SM)	A-1-a(0)	Well graded silty SAND and GRAVEL
A-6	34	15.9	104.8	0	97	3	-	NP		(SP)	A-1-b(0)	Poorly graded SAND
A-7	13	7.7	110.0	25	68	7	-	NP		(SW-SM)	A-1-a(0)	Well graded silty SAND
A-7	23	23.6	SD			85	38	21		A-6(17)	(CL)s	CLAY with sand
A-8	4	14.7	109.8			48	34	18		SC	A-6 (5)	Clayey SAND
A-9	13	9.3	123.6			38	-	NP		(SM)	A-4(0)	Silty Sand
A-10	4	5.6	117.1			16	-	NP		(SM)	A-2-4(0)	Silty Sand
B-1	3	6.2	120.9			28	22	6		(SC-SM)	A-2-4(0)	Clayey Silty SAND
B-2	4	12.8	112.7			55	21	3		s(ML)	A-4(0)	Sandy SILT
B-3	10	5.3	SD			4	-	NP		(SP)	A-2-4(0)	Poorly Graded SAND
B-4	7	1.6	SD	14	71	15	-	NP		(SM)	A-1-b(0)	Silty SAND with gravel

GROUND ENGINEERING

TABLE 1
SUMMARY OF LABORATORY TEST RESULTS

Sample Location		Natural Moisture Content	Natural Dry Density	Gradation		Percent Passing No. 200 Sieve	Atterberg Limits		Percent Swell (Surcharge Pressure)	USCS Classification	AASHTO Classification (GI)	Soil or Bedrock Type
Test Hole No.	Depth *(feet)*	*(%)*	*(pcf)*	Gravel *(%)*	Sand *(%)*		Liquid Limit	Plasticity Index				
B-5	3	1.0	SD	31	62	7	-	NP		(SW)	A-1-a(0)	Well graded SAND
B-5	8	5.6	SD			15	-	NP		(SM)	A-2-4(0)	Silty SAND
B-6	5	1.6	SD			9	-	NP		(SP-SM)	A-2-4(0)	Poorly graded Silty SAND
C-1	3	7.2	115.8			35	-	NP		(SM)	A-2-4(0)	Silty SAND
C-2	9	22.8	98.7			94	33	17		(CL)	A-6(15)	CLAY
C-3	5	4.2	SD	34	56	10	-	NP		(SP-SM)	A-1-b(0)	Poorly graded Silty SAND
C-4	2	2.8	SD			9	-	NP		(SM)	A-2-4(0)	Silty SAND
C-5	1	11.1	118.6			55	27	13		s(CL)	A-6(4)	Sandy CLAY
C-6	2	5.7	111.2	4	68	28	24	6		(SC-SM)	A-2-4(0)	Clayey Silty SAND
C-8	2	5.9	113.1	3	73	24	-	NP		(SM)	A-2-4(0)	Silty SAND
C-10	4	5.2	SD			21	-	NP		(SM)	A-2-4(0)	Silty SAND
E-1	5	3.4	SD			55	-	NP		s(ML)	A-4(0)	Sandy SILT
E-2	1	6.7	119.6			31	20	3		(SM)	A-2-4(0)	Silty SAND
D-1	3	7.0				41	26	10		(SC)	A-4(1)	Clayey SAND
D-2	2.5	14.2	115.0			48	29	12	0.0 (150 psf)	(SC)	A-6(3)	Clayey SAND
D-4	3	8.6	112.5			53	25	9		s(CL)	A-4(2)	Sandy CLAY
P-5	2	2.7	122.0			15	NP	-		(SM)	A-2-4(0)	Silty SAND

SD = Sample Disturbed, NV = Non-Viscous, NP = Non-Plastic

Job No. 19-0013

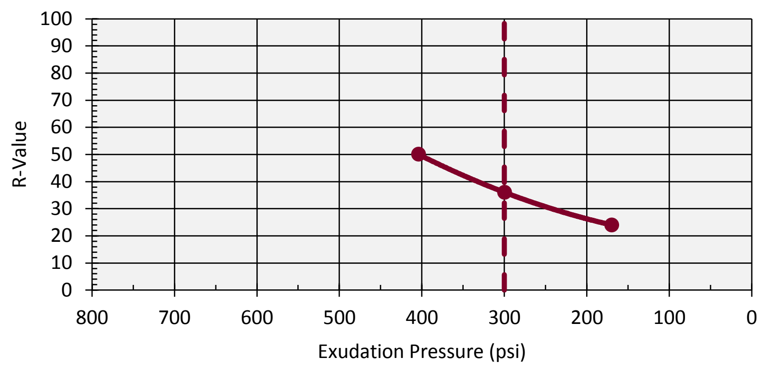
GROUND ENGINEERING

Client: Poudre School District

Project No.: 19-0013

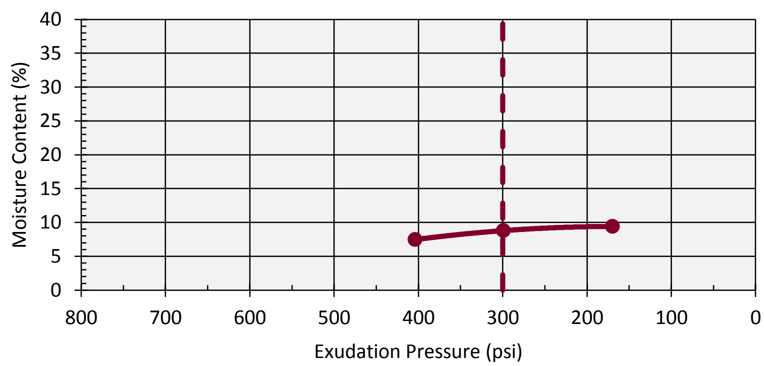
New Prospect 6-12 School

R-Value (ASTM D2844 / AASHTO T190)



Test Point	Moisture (%)	Exudation Pressure (psi)	R-Value
1	8.8	299	36
2	9.4	170	24
3	7.5	404	50
4	-	-	-

R-Value at 300 psi Exudation Pressure
36



Location: D-1 to D- 5, 1 to 5', Bulk
Description: Light brown, clayey SAND

Classification: SC/A-2-4 (0) *< No. 200 (%):* 30.0
Liquid Limit: 27
Plasticity Index: 9

APPENDIX A

Detailed Drilling Logs

TEST HOLE A-01

GROUND ENGINEERING

CLIENT: Poudre School District
PROJECT NAME: PSD: New Prospect 6-12 School - Final
JOB NO.: 19-0013
PROJECT LOCATION: Fort Collins, CO

Elevation (ft)	Depth (ft)	MATERIAL DESCRIPTION	Sample Type	Blow Count	Natural Moisture Content (%)	Natural Dry Density (pcf)	Percent Passing No. 200 Sieve	ATTERBERG LIMITS Liquid Limit	Plasticity Index	% Swell at Surcharge (psf)	Unconfined Strength (ksf)	USCS
100	0	**TOPSOIL**										
		SAND and GRAVEL: Silty to clayey, non- to low plastic, fine to coarse grained with gravel, moist to wet, loose to dense, and light brown to pink to dark brown in color.										
95	5			25/12	9.9	113.0	47	24	6			SC-SM
90	10			14/12								
85	15			22/12								
80	20			20/12								
		CLAY and SAND: Moderately plastic, fine to coarse grained, moist, medium to very stiff, and light brown to brown in color.										
75	25			14/12								
70	30			11/12								
65	35			12/12								

(Continued Next Page)

GROUND ENGINEERING

CLIENT: Poudre School District

PROJECT NAME: PSD: New Prospect 6-12 School - Final

JOB NO.: 19-0013

PROJECT LOCATION: Fort Collins, CO

Elevation (ft)	Depth (ft)	Graphic Log	MATERIAL DESCRIPTION	Sample Type	Blow Count	Natural Moisture Content (%)	Natural Dry Density (pcf)	Percent Passing No. 200 Sieve	ATTERBERG LIMITS: Liquid Limit	ATTERBERG LIMITS: Plasticity Index	% Swell at Surcharge (psf)	Unconfined Strength (ksf)	USCS
65	35		**CLAY and SAND**: Moderately plastic, fine to coarse grained, moist, medium to very stiff, and light brown to brown in color. *(continued)*										
60	40				30/12								

Bottom of borehole at Approx. 40 feet.

GROUND ENGINEERING

TEST HOLE A-02

CLIENT: Poudre School District
PROJECT NAME: PSD: New Prospect 6-12 School - Final
JOB NO.: 19-0013
PROJECT LOCATION: Fort Collins, CO

Elevation (ft)	Depth (ft)	Graphic Log	MATERIAL DESCRIPTION	Sample Type	Blow Count	Natural Moisture Content (%)	Natural Dry Density (pcf)	Percent Passing No. 200 Sieve	ATTERBERG LIMITS Liquid Limit	ATTERBERG LIMITS Plasticity Index	% Swell at Surcharge (psf)	Unconfined Strength (ksf)	USCS
100	0		**TOPSOIL**										
			SAND and GRAVEL: Silty to clayey, non- to low plastic, fine to coarse grained with gravel, moist to wet, loose to dense, and light brown to pink to dark brown in color.										
95	5				15/12								
90	10				10/12	15.2	106.5	56	34	20			SC
85 ▽	15				14/12								
			Test hole caved at 18 feet.										
80	20		**CLAY and SAND**: Moderately plastic, fine to coarse grained, moist, medium to very stiff, and light brown to brown in color.										
75	25				4/12								
70	30				6/12								

Bottom of borehole at Approx. 30 feet.

TEST HOLE A-03

GROUND ENGINEERING

CLIENT: Poudre School District

PROJECT NAME: PSD: New Prospect 6-12 School - Final

JOB NO.: 19-0013

PROJECT LOCATION: Fort Collins, CO

Elevation (ft)	Depth (ft)	MATERIAL DESCRIPTION	Sample Type	Blow Count	Natural Moisture Content (%)	Natural Dry Density (pcf)	Percent Passing No. 200 Sieve	ATTERBERG LIMITS Liquid Limit	ATTERBERG LIMITS Plasticity Index	% Swell at Surcharge (psf)	Unconfined Strength (ksf)	USCS
100	0	**TOPSOIL**										
		SAND and GRAVEL: Silty to clayey, non- to low plastic, fine to coarse grained with gravel, moist to wet, loose to dense, and light brown to pink to dark brown in color.										
95	5			6/12								
90	10			7/12	3.2	118.1	14		NP			SM
85	15	**CLAY and SAND**: Moderately plastic, fine to coarse grained, moist, medium to very stiff, and light brown to brown in color.		20/12	20.9	103.5	19		NP			SM
		Test hole caved at 18 feet.										
80	20											
75	25											
70	30			6/12								

Bottom of borehole at Approx. 31 feet.

TEST HOLE A-04

GROUND ENGINEERING

CLIENT: Poudre School District

PROJECT NAME: PSD: New Prospect 6-12 School - Final

JOB NO.: 19-0013

PROJECT LOCATION: Fort Collins, CO

Elevation (ft)	Depth (ft)	MATERIAL DESCRIPTION	Sample Type	Blow Count	Natural Moisture Content (%)	Natural Dry Density (pcf)	Percent Passing No. 200 Sieve	ATTERBERG LIMITS: Liquid Limit	ATTERBERG LIMITS: Plasticity Index	% Swell at Surcharge (psf)	Unconfined Strength (ksf)	USCS
100	0	**TOPSOIL**										
		SAND and GRAVEL: Silty to clayey, non- to low plastic, fine to coarse grained with gravel, moist to wet, loose to dense, and light brown to pink to dark brown in color.										
95	5			11/12	1.0	SD	4		NP			SW
90	10			19/12								
85	15			20/12								
80	20			10/12	24.0	101.9	83	29	12			CL
75	25			12/12								
70	30			8/12								
65	35			7/12								

(Continued Next Page)

GROUND ENGINEERING

CLIENT: Poudre School District **PROJECT NAME:** PSD: New Prospect 6-12 School - Final

JOB NO.: 19-0013 **PROJECT LOCATION:** Fort Collins, CO

Elevation (ft)	Depth (ft)	Graphic Log	MATERIAL DESCRIPTION	Sample Type	Blow Count	Natural Moisture Content (%)	Natural Dry Density (pcf)	Percent Passing No. 200 Sieve	ATTERBERG LIMITS Liquid Limit	ATTERBERG LIMITS Plasticity Index	% Swell at Surcharge (psf)	Unconfined Strength (ksf)	USCS
65	35		**CLAY and SAND**: Moderately plastic, fine to coarse grained, moist, medium to very stiff, and light brown to brown in color. *(continued)*										
60	40				13/12								

Bottom of borehole at Approx. 40 feet.

TEST HOLE A-05

CLIENT: Poudre School District
PROJECT NAME: PSD: New Prospect 6-12 School - Final
JOB NO.: 19-0013
PROJECT LOCATION: Fort Collins, CO

Elevation (ft)	Depth (ft)	Graphic Log	MATERIAL DESCRIPTION	Sample Type	Blow Count	Natural Moisture Content (%)	Natural Dry Density (pcf)	Percent Passing No. 200 Sieve	ATTERBERG LIMITS: Liquid Limit	ATTERBERG LIMITS: Plasticity Index	% Swell at Surcharge (psf)	Unconfined Strength (ksf)	USCS
100	0		**TOPSOIL**										
			SAND and GRAVEL: Silty to clayey, non- to low plastic, fine to coarse grained with gravel, moist to wet, loose to dense, and light brown to pink to dark brown in color.										
				⧓	16/12								
95	5												
				⧓	11/12	25.2	96.8	89	14	34			CL
90	10												
	▽												
				⧓	17/12	12.7	114.5	13		NP			SM
85	15												
			CLAY and SAND: Moderately plastic, fine to coarse grained, moist, medium to very stiff, and light brown to brown in color.	⧓	9/12								
80	20												
				⧓	18/12								
75	25												
				⧓	16/12								
70	30												

Bottom of borehole at Approx. 30 feet.

GROUND ENGINEERING

TEST HOLE A-06

CLIENT: Poudre School District

PROJECT NAME: PSD: New Prospect 6-12 School - Final

JOB NO.: 19-0013

PROJECT LOCATION: Fort Collins, CO

Elevation (ft)	Depth (ft)	Graphic Log	MATERIAL DESCRIPTION	Sample Type	Blow Count	Natural Moisture Content (%)	Natural Dry Density (pcf)	Percent Passing No. 200 Sieve	ATTERBERG LIMITS Liquid Limit	ATTERBERG LIMITS Plasticity Index	% Swell at Surcharge (psf)	Unconfined Strength (ksf)	USCS
100	0		**TOPSOIL**										
			SAND and GRAVEL: Silty to clayey, non- to low plastic, fine to coarse grained with gravel, moist to wet, loose to dense, and light brown to pink to dark brown in color.										
95	5				15/12	2.1	SD	6		NP			SW-SM
90	10				12/12								
85	15				17/12								
80	20				10/12								
75	25				14/12								
70	30				16/12								
65	35				22/12	15.9	104.8	3		NP			SP

(Continued Next Page)

TEST HOLE A-06

GROUND ENGINEERING

CLIENT: Poudre School District

PROJECT NAME: PSD: New Prospect 6-12 School - Final

JOB NO.: 19-0013

PROJECT LOCATION: Fort Collins, CO

Elevation (ft)	Depth (ft)	Graphic Log	MATERIAL DESCRIPTION	Sample Type	Blow Count	Natural Moisture Content (%)	Natural Dry Density (pcf)	Percent Passing No. 200 Sieve	ATTERBERG LIMITS		% Swell at Surcharge (psf)	Unconfined Strength (ksf)	USCS
									Liquid Limit	Plasticity Index			
65	35		**CLAY and SAND**: Moderately plastic, fine to coarse grained, moist, medium to very stiff, and light brown to brown in color. *(continued)*										
60	40				38/12								

Bottom of borehole at Approx. 40 feet.

TEST HOLE A-07

GROUND ENGINEERING

CLIENT: Poudre School District | **PROJECT NAME:** PSD: New Prospect 6-12 School - Final

JOB NO.: 19-0013 | **PROJECT LOCATION:** Fort Collins, CO

Elevation (ft)	Depth (ft)	MATERIAL DESCRIPTION	Sample Type	Blow Count	Natural Moisture Content (%)	Natural Dry Density (pcf)	Percent Passing No. 200 Sieve	ATTERBERG LIMITS: Liquid Limit	ATTERBERG LIMITS: Plasticity Index	% Swell at Surcharge (psf)	Unconfined Strength (ksf)	USCS
100	0	**TOPSOIL**										
		SAND and GRAVEL: Silty to clayey, non- to low plastic, fine to coarse grained with gravel, moist to wet, loose to dense, and light brown to pink to dark brown in color.										
				18/12								
95	5											
				8/12								
90	10											
		CLAY and SAND: Moderately plastic, fine to coarse grained, moist, medium to very stiff, and light brown to brown in color.		28/12	7.7	110.0	7		NP			SW-SM
85	15	Test hole caved at 15 feet.										
80	20											
				2-2-3	23.6	SD	85	38	21			CL
75	25											
				3-3-4								

Bottom of borehole at Approx. 30 feet.

GROUND ENGINEERING

TEST HOLE A-08

CLIENT: Poudre School District

PROJECT NAME: PSD: New Prospect 6-12 School - Final

JOB NO.: 19-0013

PROJECT LOCATION: Fort Collins, CO

Elevation (ft)	Depth (ft)	Graphic Log	MATERIAL DESCRIPTION	Sample Type	Blow Count	Natural Moisture Content (%)	Natural Dry Density (pcf)	Percent Passing No. 200 Sieve	ATTERBERG LIMITS Liquid Limit	ATTERBERG LIMITS Plasticity Index	% Swell at Surcharge (psf)	Unconfined Strength (ksf)	USCS
100	0		**TOPSOIL**										
			SAND and GRAVEL: Silty to clayey, non- to low plastic, fine to coarse grained with gravel, moist to wet, loose to dense, and light brown to pink to dark brown in color.										
95	5				22/12	14.7	109.8	48	34	18			SC
90	10				28/12								
85	15				39/12								
80	20				17/12								
75	25				8/12								
70	30				11/12								
65	35				9-14-								

(Continued Next Page)

GROUND ENGINEERING

TEST HOLE A-08

CLIENT: Poudre School District

PROJECT NAME: PSD: New Prospect 6-12 School - Final

JOB NO.: 19-0013

PROJECT LOCATION: Fort Collins, CO

Elevation (ft)	Depth (ft)	Graphic Log	MATERIAL DESCRIPTION	Sample Type	Blow Count	Natural Moisture Content (%)	Natural Dry Density (pcf)	Percent Passing No. 200 Sieve	ATTERBERG LIMITS: Liquid Limit	ATTERBERG LIMITS: Plasticity Index	% Swell at Surcharge (psf)	Unconfined Strength (ksf)	USCS
65	35												
			CLAY and SAND: Moderately plastic, fine to coarse grained, moist, medium to very stiff, and light brown to brown in color. *(continued)*		18								
60	40				5-5-10								

Bottom of borehole at Approx. 41 feet.

TEST HOLE A-09

GROUND ENGINEERING

CLIENT: Poudre School District

PROJECT NAME: PSD: New Prospect 6-12 School - Final

JOB NO.: 19-0013

PROJECT LOCATION: Fort Collins, CO

Elevation (ft)	Depth (ft)	Graphic Log	MATERIAL DESCRIPTION	Sample Type	Blow Count	Natural Moisture Content (%)	Natural Dry Density (pcf)	Percent Passing No. 200 Sieve	ATTERBERG LIMITS Liquid Limit	ATTERBERG LIMITS Plasticity Index	% Swell at Surcharge (psf)	Unconfined Strength (ksf)	USCS
100	0		**TOPSOIL**										
			SAND and GRAVEL: Silty to clayey, non- to low plastic, fine to coarse grained with gravel, moist to wet, loose to dense, and light brown to pink to dark brown in color.										
					7/12								
95	5												
					28/12								
90	10												
					32/12	9.3	123.6	38		NP			SM
85	15												
			Test hole caved at 16 feet.										
			CLAY and SAND: Moderately plastic, fine to coarse grained, moist, medium to very stiff, and light brown to brown in color.										
80	20												
					7/12								
75	25												
					2/12								

Bottom of borehole at Approx. 29 feet.

TEST HOLE A-10

GROUND ENGINEERING

CLIENT: Poudre School District
PROJECT NAME: PSD: New Prospect 6-12 School - Final
JOB NO.: 19-0013
PROJECT LOCATION: Fort Collins, CO

Elevation (ft)	Depth (ft)	Graphic Log	MATERIAL DESCRIPTION	Sample Type	Blow Count	Natural Moisture Content (%)	Natural Dry Density (pcf)	Percent Passing No. 200 Sieve	ATTERBERG LIMITS Liquid Limit	ATTERBERG LIMITS Plasticity Index	% Swell at Surcharge (psf)	Unconfined Strength (ksf)	USCS
100	0		**TOPSOIL**										
			SAND and GRAVEL: Silty to clayey, non- to low plastic, fine to coarse grained with gravel, moist to wet, loose to dense, and light brown to pink to dark brown in color.										
95	5				8/12	5.6	117.1	16		NP			SM
90	10				26/12								
85	15				16/12								
			CLAY and SAND: Moderately plastic, fine to coarse grained, moist, medium to very stiff, and light brown to brown in color.										
80	20				6/12								
75	25												
70	30				8-9-7								

Bottom of borehole at Approx. 31 feet.

TEST HOLE B-01

GROUND ENGINEERING

CLIENT: Poudre School District

PROJECT NAME: PSD: New Prospect 6-12 School - Final

JOB NO.: 19-0013

PROJECT LOCATION: Fort Collins, CO

Elevation (ft)	Depth (ft)	MATERIAL DESCRIPTION	Sample Type	Blow Count	Natural Moisture Content (%)	Natural Dry Density (pcf)	Percent Passing No. 200 Sieve	ATTERBERG LIMITS: Liquid Limit	ATTERBERG LIMITS: Plasticity Index	% Swell at Surcharge (psf)	Unconfined Strength (ksf)	USCS
100	0	**TOPSOIL**										
		SAND and GRAVEL: Silty to clayey, non- to low plastic, fine to coarse grained with gravel, moist to wet, loose to dense, and light brown to pink to dark brown in color.		5/12	6.2	120.9	28	22	6			SC-SM
95	5											
		CLAY and SAND: Moderately plastic, fine to coarse grained, moist, medium to very stiff, and light brown to brown in color.		9-12-15								
90	10											
				11-10-14								
85	15											
				1-2-3								
		Test hole caved at 19 feet.										
80	20											
75	25											
70	30											

Bottom of borehole at Approx. 30 feet.

TEST HOLE B-02

GROUND ENGINEERING

CLIENT: Poudre School District

PROJECT NAME: PSD: New Prospect 6-12 School - Final

JOB NO.: 19-0013

PROJECT LOCATION: Fort Collins, CO

Elevation (ft)	Depth (ft)	MATERIAL DESCRIPTION	Sample Type	Blow Count	Natural Moisture Content (%)	Natural Dry Density (pcf)	Percent Passing No. 200 Sieve	ATTERBERG LIMITS: Liquid Limit	ATTERBERG LIMITS: Plasticity Index	% Swell at Surcharge (psf)	Unconfined Strength (ksf)	USCS
100	0	**TOPSOIL**										
		SAND and GRAVEL: Silty to clayey, non- to low plastic, fine to coarse grained with gravel, moist to wet, loose to dense, and light brown to pink to dark brown in color.										
95	5			9/12	12.8	112.7	55	21	3			ML
90	10			12-14-18								
85	15			6-3-2								
		Test hole caved at 16 feet.										
80	20			2-2-1								
75	25	**CLAY and SAND**: Moderately plastic, fine to coarse grained, moist, medium to very stiff, and light brown to brown in color.		5-4-8								
70	30			1-2-5								

Bottom of borehole at Approx. 31 feet.

TEST HOLE B-03

GROUND ENGINEERING

CLIENT: Poudre School District

PROJECT NAME: PSD: New Prospect 6-12 School - Final

JOB NO.: 19-0013

PROJECT LOCATION: Fort Collins, CO

Elevation (ft)	Depth (ft)	MATERIAL DESCRIPTION
100	0	**TOPSOIL**
		SAND and GRAVEL: Silty to clayey, non- to low plastic, fine to coarse grained with gravel, moist to wet, loose to dense, and light brown to pink to dark brown in color.
90	10	**CLAY and SAND**: Moderately plastic, fine to coarse grained, moist, medium to very stiff, and light brown to brown in color.

Elevation (ft)	Depth (ft)	Sample Type	Blow Count	Natural Moisture Content (%)	Natural Dry Density (pcf)	Percent Passing No. 200 Sieve	ATTERBERG LIMITS Liquid Limit	ATTERBERG LIMITS Plasticity Index	% Swell at Surcharge (psf)	Unconfined Strength (ksf)	USCS
95	5		15/12								
90	10		19/12	5.3	SD	4		NP			SP
85	15		5/12								
70	30		3-4-6								

Bottom of borehole at Approx. 32 feet.

GROUND ENGINEERING

CLIENT: Poudre School District

PROJECT NAME: PSD: New Prospect 6-12 School - Final

JOB NO.: 19-0013

PROJECT LOCATION: Fort Collins, CO

Elevation (ft)	Depth (ft)	Graphic Log	MATERIAL DESCRIPTION	Sample Type	Blow Count	Natural Moisture Content (%)	Natural Dry Density (pcf)	Percent Passing No. 200 Sieve	ATTERBERG LIMITS: Liquid Limit	ATTERBERG LIMITS: Plasticity Index	% Swell at Surcharge (psf)	Unconfined Strength (ksf)	USCS
100	0		**TOPSOIL**										
			SAND and GRAVEL: Silty to clayey, non- to low plastic, fine to coarse grained with gravel, moist to wet, loose to dense, and light brown to pink to dark brown in color.										
					12/12								
95	5												
					26/12	1.6	SD	15		NP			SM
90	10		**CLAY and SAND**: Moderately plastic, fine to coarse grained, moist, medium to very stiff, and light brown to brown in color.										
					4-5-4								
			Test hole caved at 14 feet.										
85	15												
80	20												
75	25												
70	30												
65	35												

(Continued Next Page)

CLIENT: Poudre School District
PROJECT NAME: PSD: New Prospect 6-12 School - Final
JOB NO.: 19-0013
PROJECT LOCATION: Fort Collins, CO

Elevation (ft)	Depth (ft)	Graphic Log	MATERIAL DESCRIPTION	Sample Type	Blow Count	Natural Moisture Content (%)	Natural Dry Density (pcf)	Percent Passing No. 200 Sieve	ATTERBERG LIMITS Liquid Limit	ATTERBERG LIMITS Plasticity Index	% Swell at Surcharge (psf)	Unconfined Strength (ksf)	USCS
65	35		**CLAY and SAND**: Moderately plastic, fine to coarse grained, moist, medium to very stiff, and light brown to brown in color. *(continued)*										
60	40				4-4-5								

Bottom of borehole at Approx. 42 feet.

TEST HOLE B-05

GROUND ENGINEERING

CLIENT: Poudre School District

PROJECT NAME: PSD: New Prospect 6-12 School - Final

JOB NO.: 19-0013

PROJECT LOCATION: Fort Collins, CO

Elevation (ft)	Depth (ft)	Graphic Log	MATERIAL DESCRIPTION	Sample Type	Blow Count	Natural Moisture Content (%)	Natural Dry Density (pcf)	Percent Passing No. 200 Sieve	ATTERBERG LIMITS		% Swell at Surcharge (psf)	Unconfined Strength (ksf)	USCS
									Liquid Limit	Plasticity Index			
100	0		**TOPSOIL**										
			SAND and GRAVEL: Silty to clayey, non- to low plastic, fine to coarse grained with gravel, moist to wet, loose to dense, and light brown to pink to dark brown in color.										
				⧓	12/12	1.0	SD	7		NP			SW
95	5												
			CLAY and SAND: Moderately plastic, fine to coarse grained, moist, medium to very stiff, and light brown to brown in color.	⧓	13/12	5.6	SD	15		NP			SM
90	10												
				⧓	13/12								
85	15												

Bottom of borehole at Approx. 15 feet.

TEST HOLE B-06

GROUND ENGINEERING

CLIENT: Poudre School District

PROJECT NAME: PSD: New Prospect 6-12 School - Final

JOB NO.: 19-0013

PROJECT LOCATION: Fort Collins, CO

Elevation (ft)	Depth (ft)	Graphic Log	MATERIAL DESCRIPTION	Sample Type	Blow Count	Natural Moisture Content (%)	Natural Dry Density (pcf)	Percent Passing No. 200 Sieve	ATTERBERG LIMITS: Liquid Limit	ATTERBERG LIMITS: Plasticity Index	% Swell at Surcharge (psf)	Unconfined Strength (ksf)	USCS
100	0		**TOPSOIL**										
			SAND and GRAVEL: Silty to clayey, non- to low plastic, fine to coarse grained with gravel, moist to wet, loose to dense, and light brown to pink to dark brown in color.										
95	5				8/12	1.6	SD	9		NP			SP-SM
90	10				13/12								
			CLAY and SAND: Moderately plastic, fine to coarse grained, moist, medium to very stiff, and light brown to brown in color.										
85	15				20/12								

Bottom of borehole at Approx. 16 feet.

TEST HOLE C-01

CLIENT: Poudre School District

PROJECT NAME: PSD: New Prospect 6-12 School - Final

JOB NO.: 19-0013

PROJECT LOCATION: Fort Collins, CO

Elevation (ft)	Depth (ft)	Graphic Log	MATERIAL DESCRIPTION	Sample Type	Blow Count	Natural Moisture Content (%)	Natural Dry Density (pcf)	Percent Passing No. 200 Sieve	ATTERBERG LIMITS Liquid Limit	ATTERBERG LIMITS Plasticity Index	% Swell at Surcharge (psf)	Unconfined Strength (ksf)	USCS
100	0		**TOPSOIL**										
			SAND and GRAVEL: Silty to clayey, non- to low plastic, fine to coarse grained with gravel, moist to wet, loose to dense, and light brown to pink to dark brown in color.										
				⋈	10/12	7.2	115.8	35		NP			SM
95	5		**CLAY and SAND**: Moderately plastic, fine to coarse grained, moist, medium to very stiff, and light brown to brown in color.										
				⋈	24/12								
90	10												

Bottom of borehole at Approx. 10 feet.

TEST HOLE C-02

GROUND ENGINEERING

CLIENT: Poudre School District

PROJECT NAME: PSD: New Prospect 6-12 School - Final

JOB NO.: 19-0013

PROJECT LOCATION: Fort Collins, CO

Elevation (ft)	Depth (ft)	Graphic Log	MATERIAL DESCRIPTION	Sample Type	Blow Count	Natural Moisture Content (%)	Natural Dry Density (pcf)	Percent Passing No. 200 Sieve	ATTERBERG LIMITS: Liquid Limit	ATTERBERG LIMITS: Plasticity Index	% Swell at Surcharge (psf)	Unconfined Strength (ksf)	USCS
100	0		**TOPSOIL**										
			SAND and GRAVEL: Silty to clayey, non- to low plastic, fine to coarse grained with gravel, moist to wet, loose to dense, and light brown to pink to dark brown in color.										
95	5				5/12								
			CLAY and SAND: Moderately plastic, fine to coarse grained, moist, medium to very stiff, and light brown to brown in color.										
90	10				7/12	22.8	98.7	94	33	17			CL

Bottom of borehole at Approx. 10 feet.

GROUND ENGINEERING

TEST HOLE C-03

CLIENT: Poudre School District

PROJECT NAME: PSD: New Prospect 6-12 School - Final

JOB NO.: 19-0013

PROJECT LOCATION: Fort Collins, CO

Elevation (ft)	Depth (ft)	Graphic Log	MATERIAL DESCRIPTION	Sample Type	Blow Count	Natural Moisture Content (%)	Natural Dry Density (pcf)	Percent Passing No. 200 Sieve	ATTERBERG LIMITS Liquid Limit	ATTERBERG LIMITS Plasticity Index	% Swell at Surcharge (psf)	Unconfined Strength (ksf)	USCS
100	0		**TOPSOIL**										
			SAND and GRAVEL: Silty to clayey, non- to low plastic, fine to coarse grained with gravel, moist to wet, loose to dense, and light brown to pink to dark brown in color.										
95	5		**CLAY and SAND**: Moderately plastic, fine to coarse grained, moist, medium to very stiff, and light brown to brown in color.		7/12	4.2	SD	10		NP			SP-SM
90	10				28/12								

Bottom of borehole at Approx. 11 feet.

GROUND ENGINEERING

TEST HOLE C-04

CLIENT: Poudre School District

PROJECT NAME: PSD: New Prospect 6-12 School - Final

JOB NO.: 19-0013

PROJECT LOCATION: Fort Collins, CO

Elevation (ft)	Depth (ft)	Graphic Log	MATERIAL DESCRIPTION	Sample Type	Blow Count	Natural Moisture Content (%)	Natural Dry Density (pcf)	Percent Passing No. 200 Sieve	ATTERBERG LIMITS Liquid Limit	ATTERBERG LIMITS Plasticity Index	% Swell at Surcharge (psf)	Unconfined Strength (ksf)	USCS
100	0		**TOPSOIL**										
			SAND and GRAVEL: Silty to clayey, non- to low plastic, fine to coarse grained with gravel, moist to wet, loose to dense, and light brown to pink to dark brown in color.										
				⧓	12/12	2.8	SD	9		NP			SM
95	5												
			CLAY and SAND: Moderately plastic, fine to coarse grained, moist, medium to very stiff, and light brown to brown in color.	⧓	29/12								
90	10												

Bottom of borehole at Approx. 10 feet.

GROUND ENGINEERING

TEST HOLE C-05

CLIENT: Poudre School District

PROJECT NAME: PSD: New Prospect 6-12 School - Final

JOB NO.: 19-0013

PROJECT LOCATION: Fort Collins, CO

Elevation (ft)	Depth (ft)	Graphic Log	MATERIAL DESCRIPTION	Sample Type	Blow Count	Natural Moisture Content (%)	Natural Dry Density (pcf)	Percent Passing No. 200 Sieve	ATTERBERG LIMITS: Liquid Limit	ATTERBERG LIMITS: Plasticity Index	% Swell at Surcharge (psf)	Unconfined Strength (ksf)	USCS
100	0												
			TOPSOIL										
			SAND and GRAVEL: Silty to clayey, non- to low plastic, fine to coarse grained with gravel, moist to wet, loose to dense, and light brown to pink to dark brown in color.		13/12	11.1	118.6	55	27	13			CL
95	5												
					4/12								
			CLAY and SAND: Moderately plastic, fine to coarse grained, moist, medium to very stiff, and light brown to brown in color.										
90	10												
					36/12								

Bottom of borehole at Approx. 11 feet.

ENGINEERING

TEST HOLE C-06

CLIENT: Poudre School District

PROJECT NAME: PSD: New Prospect 6-12 School - Final

JOB NO.: 19-0013

PROJECT LOCATION: Fort Collins, CO

Elevation (ft)	Depth (ft)	Graphic Log	MATERIAL DESCRIPTION	Sample Type	Blow Count	Natural Moisture Content (%)	Natural Dry Density (pcf)	Percent Passing No. 200 Sieve	ATTERBERG LIMITS Liquid Limit	ATTERBERG LIMITS Plasticity Index	% Swell at Surcharge (psf)	Unconfined Strength (ksf)	USCS
100	0		**TOPSOIL**										
			SAND and GRAVEL: Silty to clayey, non- to low plastic, fine to coarse grained with gravel, moist to wet, loose to dense, and light brown to pink to dark brown in color.										
				Sampler	4/12	5.7	111.2	28	24	6			SC-SM
95	5		**CLAY and SAND**: Moderately plastic, fine to coarse grained, moist, medium to very stiff, and light brown to brown in color.										
				Sampler	25/12								
90	10												

Bottom of borehole at Approx. 10 feet.

ENGINEERING

TEST HOLE C-07

CLIENT: Poudre School District

PROJECT NAME: PSD: New Prospect 6-12 School - Final

JOB NO.: 19-0013

PROJECT LOCATION: Fort Collins, CO

Elevation (ft)	Depth (ft)	Graphic Log	MATERIAL DESCRIPTION	Sample Type	Blow Count	Natural Moisture Content (%)	Natural Dry Density (pcf)	Percent Passing No. 200 Sieve	ATTERBERG LIMITS Liquid Limit	ATTERBERG LIMITS Plasticity Index	% Swell at Surcharge (psf)	Unconfined Strength (ksf)	USCS
100	0		**TOPSOIL**										
			SAND and GRAVEL: Silty to clayey, non- to low plastic, fine to coarse grained with gravel, moist to wet, loose to dense, and light brown to pink to dark brown in color.										
				⧓	10/12								
95	5												
	▽			⧓	15/12								
90	10												

Bottom of borehole at Approx. 10 feet.

TEST HOLE C-08

GROUND ENGINEERING

CLIENT: Poudre School District

PROJECT NAME: PSD: New Prospect 6-12 School - Final

JOB NO.: 19-0013

PROJECT LOCATION: Fort Collins, CO

Elevation (ft)	Depth (ft)	Graphic Log	MATERIAL DESCRIPTION	Sample Type	Blow Count	Natural Moisture Content (%)	Natural Dry Density (pcf)	Percent Passing No. 200 Sieve	ATTERBERG LIMITS: Liquid Limit	ATTERBERG LIMITS: Plasticity Index	% Swell at Surcharge (psf)	Unconfined Strength (ksf)	USCS
100	0		**TOPSOIL**										
			SAND and GRAVEL: Silty to clayey, non- to low plastic, fine to coarse grained with gravel, moist to wet, loose to dense, and light brown to pink to dark brown in color.		4/12	5.9	113.1	24		NP			SM
95	5												
					38/12								

Bottom of borehole at Approx. 8 feet.

TEST HOLE C-09

GROUND ENGINEERING

CLIENT: Poudre School District

PROJECT NAME: PSD: New Prospect 6-12 School - Final

JOB NO.: 19-0013

PROJECT LOCATION: Fort Collins, CO

Elevation (ft)	Depth (ft)	MATERIAL DESCRIPTION	Sample Type	Blow Count	Natural Moisture Content (%)	Natural Dry Density (pcf)	Percent Passing No. 200 Sieve	ATTERBERG LIMITS: Liquid Limit	ATTERBERG LIMITS: Plasticity Index	% Swell at Surcharge (psf)	Unconfined Strength (ksf)	USCS
100	0	**TOPSOIL**										
		SAND and GRAVEL: Silty to clayey, non- to low plastic, fine to coarse grained with gravel, moist to wet, loose to dense, and light brown to pink to dark brown in color.										
			Sampled	7/12								
95	5											
		CLAY and SAND: Moderately plastic, fine to coarse grained, moist, medium to very stiff, and light brown to brown in color.	Sampled	10/12								
90	10											

Bottom of borehole at Approx. 10 feet.

TEST HOLE C-10

GROUND ENGINEERING

CLIENT: Poudre School District
PROJECT NAME: PSD: New Prospect 6-12 School - Final

JOB NO.: 19-0013
PROJECT LOCATION: Fort Collins, CO

Elevation (ft)	Depth (ft)	Graphic Log	MATERIAL DESCRIPTION	Sample Type	Blow Count	Natural Moisture Content (%)	Natural Dry Density (pcf)	Percent Passing No. 200 Sieve	ATTERBERG LIMITS: Liquid Limit	ATTERBERG LIMITS: Plasticity Index	% Swell at Surcharge (psf)	Unconfined Strength (ksf)	USCS
100	0		**TOPSOIL**										
			SAND and GRAVEL: Silty to clayey, non- to low plastic, fine to coarse grained with gravel, moist to wet, loose to dense, and light brown to pink to dark brown in color.										
95	5		**CLAY and SAND**: Moderately plastic, fine to coarse grained, moist, medium to very stiff, and light brown to brown in color.		13/12	5.2	SD	21		NP			SM
90	10				18/12								

Bottom of borehole at Approx. 10 feet.

TEST HOLE E-01

CLIENT: Poudre School District

PROJECT NAME: PSD: New Prospect 6-12 School - Final

JOB NO.: 19-0013

PROJECT LOCATION: Fort Collins, CO

Elevation (ft)	Depth (ft)	Graphic Log	MATERIAL DESCRIPTION	Sample Type	Blow Count	Natural Moisture Content (%)	Natural Dry Density (pcf)	Percent Passing No. 200 Sieve	ATTERBERG LIMITS Liquid Limit	ATTERBERG LIMITS Plasticity Index	% Swell at Surcharge (psf)	Unconfined Strength (ksf)	USCS
100	0		**TOPSOIL**										
			SAND and GRAVEL: Silty to clayey, non- to low plastic, fine to coarse grained with gravel, moist to wet, loose to dense, and light brown to pink to dark brown in color.										
95	5				23/12	3.4	SD	55		NP			ML
90	10				31/12								

Bottom of borehole at Approx. 11 feet.

TEST HOLE E-02

GROUND ENGINEERING

CLIENT: Poudre School District

PROJECT NAME: PSD: New Prospect 6-12 School - Final

JOB NO.: 19-0013

PROJECT LOCATION: Fort Collins, CO

Elevation (ft)	Depth (ft)	Graphic Log	MATERIAL DESCRIPTION	Sample Type	Blow Count	Natural Moisture Content (%)	Natural Dry Density (pcf)	Percent Passing No. 200 Sieve	ATTERBERG LIMITS: Liquid Limit	ATTERBERG LIMITS: Plasticity Index	% Swell at Surcharge (psf)	Unconfined Strength (ksf)	USCS
100	0		**TOPSOIL**										
			SAND and GRAVEL: Silty to clayey, non- to low plastic, fine to coarse grained with gravel, moist to wet, loose to dense, and light brown to pink to dark brown in color.		5/12	6.7	119.6	31	20	3			SM
95	5		**CLAY and SAND**: Moderately plastic, fine to coarse grained, moist, medium to very stiff, and light brown to brown in color.		6/12								
90	10				22/12								

Bottom of borehole at Approx. 10 feet.

TEST HOLE P-01

GROUND ENGINEERING

CLIENT: Poudre School District **PROJECT NAME:** PSD: New Prospect 6-12 School - Final

JOB NO.: 19-0013 **PROJECT LOCATION:** Fort Collins, CO

Elevation (ft)	Depth (ft)	Graphic Log	MATERIAL DESCRIPTION	Sample Type	Blow Count	Natural Moisture Content (%)	Natural Dry Density (pcf)	Percent Passing No. 200 Sieve	ATTERBERG LIMITS: Liquid Limit	ATTERBERG LIMITS: Plasticity Index	% Swell at Surcharge (psf)	Unconfined Strength (ksf)	USCS
100	0		Approximately 4 1/2 inches of asphalt.										
			Approximately 6 inches of road base.										
			SAND and GRAVEL: Silty to clayey, non- to low plastic, fine to coarse grained with gravel, moist to wet, loose to dense, and light brown to pink to dark brown in color.		32/12								
95	5		**CLAY and SAND**: Moderately plastic, fine to coarse grained, moist, medium to very stiff, and light brown to brown in color.										
90	10				19/12								

Bottom of borehole at Approx. 10 feet.

GROUND ENGINEERING

TEST HOLE P-02

CLIENT: Poudre School District

PROJECT NAME: PSD: New Prospect 6-12 School - Final

JOB NO.: 19-0013

PROJECT LOCATION: Fort Collins, CO

Elevation (ft)	Depth (ft)	Graphic Log	MATERIAL DESCRIPTION	Sample Type	Blow Count	Natural Moisture Content (%)	Natural Dry Density (pcf)	Percent Passing No. 200 Sieve	ATTERBERG LIMITS Liquid Limit	ATTERBERG LIMITS Plasticity Index	% Swell at Surcharge (psf)	Unconfined Strength (ksf)	USCS
100	0		Approximately 4 1/2 inches of asphalt.										
			Approximately 6 inches of road base.										
			SAND and GRAVEL: Silty to clayey, non- to low plastic, fine to coarse grained with gravel, moist to wet, loose to dense, and light brown to pink to dark brown in color.		18/12								
95	5		**CLAY and SAND**: Moderately plastic, fine to coarse grained, moist, medium to very stiff, and light brown to brown in color.										
90	10												

Bottom of borehole at Approx. 10 feet.

TEST HOLE P-03

GROUND ENGINEERING

CLIENT: Poudre School District **PROJECT NAME:** PSD: New Prospect 6-12 School - Final

JOB NO.: 19-0013 **PROJECT LOCATION:** Fort Collins, CO

Elevation (ft)	Depth (ft)	Graphic Log	MATERIAL DESCRIPTION	Sample Type	Blow Count	Natural Moisture Content (%)	Natural Dry Density (pcf)	Percent Passing No. 200 Sieve	ATTERBERG LIMITS		% Swell at Surcharge (psf)	Unconfined Strength (ksf)	USCS
									Liquid Limit	Plasticity Index			
100	0												
			Test hole not drilled due to utility conflict.										

Bottom of borehole at Approx. 1 feet.

TEST HOLE P-04

GROUND ENGINEERING

CLIENT: Poudre School District

PROJECT NAME: PSD: New Prospect 6-12 School - Final

JOB NO.: 19-0013

PROJECT LOCATION: Fort Collins, CO

Elevation (ft)	Depth (ft)	Graphic Log	MATERIAL DESCRIPTION	Sample Type	Blow Count	Natural Moisture Content (%)	Natural Dry Density (pcf)	Percent Passing No. 200 Sieve	ATTERBERG LIMITS: Liquid Limit	ATTERBERG LIMITS: Plasticity Index	% Swell at Surcharge (psf)	Unconfined Strength (ksf)	USCS
100	0		Approximately 5 1/2 inches of asphalt.										
			Approximately 6 inches of road base.										
			SAND and GRAVEL: Silty to clayey, non- to low plastic, fine to coarse grained with gravel, moist to wet, loose to dense, and light brown to pink to dark brown in color. Test hole caved at 3 feet.										
					6/12								
95	5												
			Test hole caving from 7-9 feet.										

Bottom of borehole at Approx. 9 feet.

TEST HOLE P-05

GROUND ENGINEERING

CLIENT: Poudre School District

PROJECT NAME: PSD: New Prospect 6-12 School - Final

JOB NO.: 19-0013

PROJECT LOCATION: Fort Collins, CO

Elevation (ft)	Depth (ft)	Graphic Log	MATERIAL DESCRIPTION	Sample Type	Blow Count	Natural Moisture Content (%)	Natural Dry Density (pcf)	Percent Passing No. 200 Sieve	ATTERBERG LIMITS Liquid Limit	ATTERBERG LIMITS Plasticity Index	% Swell at Surcharge (psf)	Unconfined Strength (ksf)	USCS
100	0		Approximately 6 1/2 inches of asphalt.										
			Approximately 8 inches of road base.										
			SAND and GRAVEL: Silty to clayey, non- to low plastic, fine to coarse grained with gravel, moist to wet, loose to dense, and light brown to pink to dark brown in color.		14/12								
95	5		Test hole caved at 5 feet.										
					23/12								

Bottom of borehole at Approx. 8 feet.

APPENDIX B

Pavement Section Calculations

1993 AASHTO Pavement Design

DARWin Pavement Design and Analysis System

A Proprietary AASHTOWare
Computer Software Product
Network Administrator

Rigid Structural Design Module

Poudre School District
Prospect 6-12 School
Prospect Rd and County Rd 5
Fort Collins, Colorado
Concrete Apron

Rigid Structural Design

Pavement Type	JPCP
18-kip ESALs Over Initial Performance Period	219,000
Initial Serviceability	4.5
Terminal Serviceability	2
28-day Mean PCC Modulus of Rupture	650 psi
28-day Mean Elastic Modulus of Slab	3,400,000 psi
Mean Effective k-value	15 psi/in
Reliability Level	80 %
Overall Standard Deviation	0.34
Load Transfer Coefficient, J	4.2
Overall Drainage Coefficient, Cd	1
Calculated Design Thickness	6.42 in

1993 AASHTO Pavement Design

DARWin Pavement Design and Analysis System

A Proprietary AASHTOWare
Computer Software Product
Network Administrator

Flexible Structural Design Module

Poudre School District
Prospect 6-12 School
Prospect Rd and County Rd 5
Fort Collins, Colorado
General Parking Full Depth Asphalt Section

Flexible Structural Design

18-kip ESALs Over Initial Performance Period	36,500
Initial Serviceability	4.5
Terminal Serviceability	2
Reliability Level	80 %
Overall Standard Deviation	0.44
Roadbed Soil Resilient Modulus	4,940 psi
Stage Construction	1
Calculated Design Structural Number	2.13 in

Specified Layer Design

Layer	Material Description	Struct Coef. (Ai)	Drain Coef. (Mi)	Thickness (Di)(in)	Width (ft)	Calculated SN (in)
1	Hot Mix Asphalt	0.44	1	5	-	2.20
Total	-	-	-	5.00	-	2.20

1993 AASHTO Pavement Design

DARWin Pavement Design and Analysis System

A Proprietary AASHTOWare Computer Software Product

Network Administrator

Flexible Structural Design Module

Poudre School District
Prospect 6-12 School
Prospect Rd and County Rd 5
Fort Collins, Colorado
General Parking Composite Asphalt Section

Flexible Structural Design

18-kip ESALs Over Initial Performance Period	36,500
Initial Serviceability	4.5
Terminal Serviceability	2
Reliability Level	80 %
Overall Standard Deviation	0.44
Roadbed Soil Resilient Modulus	4,940 psi
Stage Construction	1
Calculated Design Structural Number	2.13 in

Specified Layer Design

Layer	Material Description	Struct Coef. (Ai)	Drain Coef. (Mi)	Thickness (Di)(in)	Width (ft)	Calculated SN (in)
1	Hot Mix Asphalt	0.44	1	4	-	1.76
2	Aggregate Base Course	0.11	1	4	-	0.44
Total	-	-	-	8.00	-	2.20

1993 AASHTO Pavement Design

DARWin Pavement Design and Analysis System

A Proprietary AASHTOWare
Computer Software Product

Network Administrator

Flexible Structural Design Module

Poudre School District
Prospect 6-12 School
Prospect Rd and County Rd 5
Fort Collins, Colorado
Private Drive Composite Asphalt Section

Flexible Structural Design

18-kip ESALs Over Initial Performance Period	219,000
Initial Serviceability	4.5
Terminal Serviceability	2
Reliability Level	80 %
Overall Standard Deviation	0.44
Roadbed Soil Resilient Modulus	4,940 psi
Stage Construction	1
Calculated Design Structural Number	2.81 in

Specified Layer Design

Layer	Material Description	Struct Coef. (Ai)	Drain Coef. (Mi)	Thickness (Di)(in)	Width (ft)	Calculated SN (in)
1	Hot Mix Asphalt	0.44	1	6.5	-	2.86
Total	-	-	-	6.50	-	2.86

1993 AASHTO Pavement Design

DARWin Pavement Design and Analysis System

A Proprietary AASHTOWare Computer Software Product

Network Administrator

Flexible Structural Design Module

Poudre School District
Prospect 6-12 School
Prospect Rd and County Rd 5
Fort Collins, Colorado
Private Drive Composite Asphalt Section

Flexible Structural Design

18-kip ESALs Over Initial Performance Period	219,000
Initial Serviceability	4.5
Terminal Serviceability	2
Reliability Level	80 %
Overall Standard Deviation	0.44
Roadbed Soil Resilient Modulus	4,940 psi
Stage Construction	1
Calculated Design Structural Number	2.81 in

Specified Layer Design

Layer	Material Description	Struct Coef. (Ai)	Drain Coef. (Mi)	Thickness (Di)(in)	Width (ft)	Calculated SN (in)
1	Hot Mix Asphalt	0.44	1	5	-	2.20
2	Aggregate Base Course	0.11	1	6	-	0.66
Total	-	-	-	11.00	-	2.86

1993 AASHTO Pavement Design

DARWin Pavement Design and Analysis System

A Proprietary AASHTOWare
Computer Software Product
Network Administrator

Flexible Structural Design Module

Poudre School District
Prospect 6-12 School
Prospect Rd and County Rd 5
Fort Collins, Colorado
Private Drive Full Depth Asphalt Section

Flexible Structural Design

18-kip ESALs Over Initial Performance Period	73,000
Initial Serviceability	4.5
Terminal Serviceability	2
Reliability Level	80 %
Overall Standard Deviation	0.44
Roadbed Soil Resilient Modulus	4,940 psi
Stage Construction	1
Calculated Design Structural Number	2.38 in

Specified Layer Design

Layer	Material Description	Struct Coef. (Ai)	Drain Coef. (Mi)	Thickness (Di)(in)	Width (ft)	Calculated SN (in)
1	Hot Mix Asphalt	0.44	1	5.5	-	2.42
Total	-	-	-	5.50	-	2.42

1993 AASHTO Pavement Design

DARWin Pavement Design and Analysis System

A Proprietary AASHTOWare
Computer Software Product

Network Administrator

Flexible Structural Design Module

Poudre School District
Prospect 6-12 School
Prospect Rd and County Rd 5
Fort Collins, Colorado
Private Drive Composite Asphalt Section

Flexible Structural Design

18-kip ESALs Over Initial Performance Period	73,000
Initial Serviceability	4.5
Terminal Serviceability	2
Reliability Level	80 %
Overall Standard Deviation	0.44
Roadbed Soil Resilient Modulus	4,940 psi
Stage Construction	1
Calculated Design Structural Number	2.38 in

Specified Layer Design

Layer	Material Description	Struct Coef. (Ai)	Drain Coef. (Mi)	Thickness (Di)(in)	Width (ft)	Calculated SN (in)
1	Hot Mix Asphalt	0.44	1	4	-	1.76
2	Aggregate Base Course	0.11	1	6	-	0.66
Total	-	-	-	10.00	-	2.42

1993 AASHTO Pavement Design

DARWin Pavement Design and Analysis System

A Proprietary AASHTOWare Computer Software Product

Network Administrator

Flexible Structural Design Module

Poudre School District
Prospect 6-12 School
Prospect Rd and County Rd 5
Fort Collins, Colorado
Public Rigth of Way Composite Asphalt Section

Flexible Structural Design

18-kip ESALs Over Initial Performance Period	1,460,000
Initial Serviceability	4.5
Terminal Serviceability	2.5
Reliability Level	90 %
Overall Standard Deviation	0.44
Roadbed Soil Resilient Modulus	4,940 psi
Stage Construction	1
Calculated Design Structural Number	4.12 in

Specified Layer Design

Layer	Material Description	Struct Coef. (Ai)	Drain Coef. (Mi)	Thickness (Di)(in)	Width (ft)	Calculated SN (in)
1	Hot Mix Asphalt	0.44	1	7.5	-	3.30
2	Aggregate Base Course	0.11	1	8	-	0.88
Total	-	-	-	15.50	-	4.18

1993 AASHTO Pavement Design

DARWin Pavement Design and Analysis System

A Proprietary AASHTOWare
Computer Software Product

Network Administrator

Flexible Structural Design Module

Poudre School District
Prospect 6-12 School
Prospect Rd and County Rd 5
Fort Collins, Colorado
Public Right of Way Composite Asphalt Section

Flexible Structural Design

18-kip ESALs Over Initial Performance Period	730,000
Initial Serviceability	4.5
Terminal Serviceability	2.5
Reliability Level	90 %
Overall Standard Deviation	0.44
Roadbed Soil Resilient Modulus	4,940 psi
Stage Construction	1
Calculated Design Structural Number	3.71 in

Specified Layer Design

Layer	Material Description	Struct Coef. (Ai)	Drain Coef. (Mi)	Thickness (Di)(in)	Width (ft)	Calculated SN (in)
1	Hot Mix Asphalt	0.44	1	7	-	3.08
2	Aggregate Base Course	0.11	1	6	-	0.66
Total	-	-	-	13.00	-	3.74