GEOTECHNICAL ENGINEERING REPORT

Thomas J. Slocum Memorial Skate Park
2211 Eppinger Boulevard
Thornton, Colorado

Prepared for:
Team Pain Enterprises, Inc.
890 Northern Way, Suite D-1
Winter Springs, Florida 32708

Prepared by:
Cole Garner Geotechnical
CGG Project No.: 20.22.056

April 14, 2020

Cole Garner Geotechnical
1070 W. 124th Ave, Ste. 300
Westminster, CO 80234
303.996.2999

April 14, 2020

Team Pain Enterprises, Inc.
890 Northern Way, Suite D-1
Winter Springs, Florida 32708

Attn: Ms. Jaclyn Asencio

Re: Geotechnical Engineering Report
Thomas J. Slocum Memorial Skate Park
2211 Eppinger Boulevard
Thornton, Colorado
CGG Project No. 20.22.056

Cole Garner Geotechnical (CGG) has completed a geotechnical engineering investigation for the proposed skate park to be reconstructed at the referenced address in Thornton, Colorado. This study was performed in general accordance with our proposal number P20.22.042, executed March 3, 2020.

This geotechnical summary should be used in conjunction with the entire report for design and/or construction purposes. The report must be read in its entirety for a comprehensive understanding of the items contained herein. The section titled General Comments should be read for an understanding of the report limitations.

- **Subsurface Conditions:** The subsurface materials encountered at the site generally consisted of consisted of approximately 4 to 13 feet of man-placed fill soils comprised primarily of lean clay with varying amounts of sand. Native soils below the fill were visually classified as clayey to silty sand with some gravel. Sedimentary interbedded claystone/sandstone bedrock (predominantly claystone) was encountered at depths ranging from about 8 to 16 feet below existing site grades and extended to the full depth of exploration. Groundwater was encountered during drilling at depths ranging from about 19 to 25 feet below existing site grades in Boring Nos. 2 and 3. When checked four days later, wet sandy soils had caved-in to a depth of about 6-½ feet below existing site grades in Boring No. 4 and groundwater was encountered at depths ranging from about 10 to 17.25 feet below existing site grades in the other three borings. Other specific information regarding the subsurface conditions is shown on the attached Boring Logs.

- **Existing Fill Soils:** As discussed, approximately 4 to 13 feet of existing man-made fill was encountered in our borings and may be present on other portions of the site and may extend to deeper depths. ***We do not possess any information regarding whether the fill was placed under the direction and observation of a geotechnical engineer.*** Field and laboratory data indicate that the fill is variable and is relatively dry and loose in areas.

Undocumented fills can present a greater than normal risk of post-construction movement of concrete slabs-on-grade and other on grade structures supported on these materials. There is also inherent uncertainty and greater risk that zones or layers of poorly compacted fill may be encountered on the site or unsuitable materials (such as organics and construction debris, or soft/loose/expansive layers) may be present within or buried by the fill. This risk cannot be eliminated without completely removing and replacing/recompacting the fill, but can generally be reduced to a reasonable level by thorough proper testing and observation during construction.

- **Expansive Soils and Bedrock:** The clay fill soils and claystone bedrock encountered at and near proposed subgrade elevations exhibited low to moderate expansive potential at existing moisture contents. ***Post-construction wetting of these materials can potentially result in excessive or uneven movement (settlement) of concrete flatwork. In order to reduce, but not eliminate, this risk (and that presented by the existing fill), we recommend that all foundation elements, thickened slab edges, and other critical site flatwork bear on a minimum of 3 feet of recompacted onsite soils.*** These on-site soils should be processed, moisture-conditioned and recompacted as engineered fill.

  Provided this process is properly performed, we believe that conventional slab-on-grade concrete flatwork should provide acceptable performance for the planned site improvements. ***Movement associated with properly designed concrete slabs-in-grade bearing on approved soils is expected to be within generally accepted tolerances for exterior flatwork.***

- **Surface Drainage:** The amount of movement associated with foundations, flatwork, pavements, etc. will be related to the wetting of underlying supporting soils. Therefore, it is imperative the recommendations outlined in the "Grading and Drainage" section of this report be followed to reduce potential movement.

We appreciate being of service to you in the geotechnical engineering phase of this project, and are prepared to assist you during the construction phases as well. Please do not hesitate to contact us if you have any questions concerning this report or any of our testing, inspection, design and consulting services.

Sincerely,

Cole Garner Geotechnical

Patrick Maloney, G.I.T.
Project Manager

Andrew J. Garner, P.E.
Principal, COO

COLORADO REGISTERED PROFESSIONAL ENGINEER
ANDREW J. GARNER
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4/14/2020

Copies to: Addressee (1 PDF copy)

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GEOTECHNICAL ENGINEERING REPORT

THOMAS J. SLOCUM MEMORIAL SKATE PARK
2211 EPPINGER BOULEVARD
THORNTON, COLORADO

CGG Project No. 20.22.056
April 14, 2020

INTRODUCTION

This report contains the results of our geotechnical engineering exploration for the proposed skate park to be reconstructed at the referenced address in Thornton, Colorado (see Figure 1 - Site Vicinity Map included in Appendix A).

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

- Subsurface soil and bedrock conditions
- Groundwater conditions
- Earthwork
- Drainage
- Concrete flatwork design and construction
- Below-grade construction

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

PROJECT INFORMATION

We understand that the project will include demolition and removal of the existing concrete skate park at the referenced address in Thornton, Colorado. Proposed redevelopment will include the design and construction of a new 25,000 square feet concrete skate park with above-grade street skating elements, in-ground skating elements such as bowls or snake runs, and paved parking areas/access drives.

Detailed grading (finished floor elevations) or design plans were not available for review at the time of this proposal. However, based on the site conditions and the anticipated construction, we estimate that cut/fill thicknesses of generally less than 3 feet will be required to bring the site to construction grade. We estimate maximum excavation depths of about 5 to 8 feet for construction of in-ground skate park elements and underground utilities. Development will also include installation of site landscaping and accessory flatwork. Since the site is located in an existing Community Center development, we assume that no new site pavements will be required. If our understanding of the project, or assumptions above, is incorrect, or if you have any additional information that may be relevant to this proposal, please notify us as soon as possible.

SITE EXPLORATION PROCEDURES

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

Field Exploration: We investigated the subsurface conditions on the site with a total of four (4) test boring, as shown on the attached Figure 2 - Boring Location Diagram in Appendix A. The borings were advanced with a track-mounted drilling rig utilizing 4-inch diameter, solid-stem auger to depths ranging from about 20 to 35 feet below existing site grades.

A lithologic log of each boring was recorded by our field personnel during the drilling operations. At selected intervals, samples of the subsurface materials were obtained by driving modified California barrel samplers. Penetration resistance measurements were obtained by driving the sample barrel into the subsurface materials with a 140-pound automatic hammer falling 30 inches. The penetration resistance value is a useful index to the consistency, relative density or hardness of the materials encountered.

Groundwater measurements were made in the borings at the time of site exploration and again approximately four days later. Borings were loosely backfilled with the auger cuttings upon completion of follow-up groundwater measurements.

Laboratory Testing: Samples retrieved during the field exploration were returned to the laboratory for observation by the project engineer, and were classified in general accordance with the Unified Soil Classification System described in Appendix C. Bedrock materials were classified according to the noted on Rock Classification in that same appendix. At that time, an applicable laboratory-testing program was formulated to determine engineering properties of the subsurface materials. Following the completion of the laboratory testing, the field descriptions were confirmed or modified as necessary, and Boring Logs were prepared. These logs are presented in Appendix A.

Laboratory test results are presented in Appendix B. These results were used for the geotechnical engineering analyses and the development of foundation and earthwork recommendations. Laboratory tests were performed in general accordance with the applicable local or other accepted standards.

Selected soil samples were tested for the following engineering properties:

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

SITE CONDITIONS

The project site is located north of the Thornton Community Center at the subject address. The area of the proposed improvements is currently occupied by the existing Thomas J. Slocum Memorial Skate Park and existing sod landscaping.. Existing improvements at the site include paved parking and access drives, landscaping, concrete sidewalks, and the concrete flatwork skate park. At the time of our field exploration, the ground surface was covered with irrigated sod and other landscaping. Based on review of project plans, the site has a slight downward slope to the north and west, with an elevation drop of about 20 feet across the site and surrounding area.

SUBSURFACE CONDITIONS

Geology: Surficial geologic conditions at the site, as mapped by the United States Geological Survey (CGS) ([1]Lindvall, 1980), consist of Piney Creek Alluvium (Qp) and Loess (Ql) of Holocene and Pleistocene Age. Piney Creek Alluvium soils are reported to generally include well-stratified sand, silt, and clay with some gravel. The thickness of this deposit is reported to range from 5 to 10 feet. The Loess deposit isi reported to generally include sandy silt with a significant amount clay and silty clay. The thickness of this deposit is generally less than 10 feet, but may be as much as 25 feet in areas.

Bedrock underlying the surface units mapped nearby consists of the Denver and Arapahoe Formations (TKda) of Paleocene to Upper Cretaceous Age. This formation in this area typically includes interbedded claystone, sandstone, siltstone, shale, and conglomerate. Thickness is reported to be on the order of 785 feet.

Mapping completed by the Colorado Geological Survey ([2]Hart, 1972) indicates the site is located in an area of "Very High Swell Potential." Potentially expansive materials mapped in this area include bedrock, weathered bedrock and colluvium (surficial units).

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[1] Lindvall, R.M., 1980, ***Geologic Map of the Commerce City Quadrangle, Adams and Denver Counties, Colorado.*** United States Geological Survey, Geologic Quadrangle Map GQ-1541.

[2] Hart, Stephen S., 1972, ***Potentially Swelling Soil and Rock in the Front Range Urban Corridor, Colorado***, Colorado Geological Survey, Sheet 2 of 4.

No other geologic hazards were identified at the site. Seismic activity in the region is anticipated to be low. With proper site grading around proposed structures, erosional problems at the site should be reduced.

Soil and Bedrock Conditions: The subsurface materials encountered at the site generally consisted of consisted of approximately 4 to 13 feet of man-placed fill soils comprised primarily of lean clay with varying amounts of sand. Native soils below the fill were visually classified as clayey to silty sand with some gravel. Sedimentary interbedded claystone/sandstone bedrock (predominantly claystone) was encountered at depths ranging from about 8 to 16 feet below existing site grades and extended to the full depth of exploration. Other specific information regarding the subsurface conditions is shown on the attached Boring Logs.

Field and Laboratory Test Results: Field test results indicated that the clay fill soils ranged from soft to very stiff in relative consistency. The native sand soils varied from loose to medium dense in relative density. The interbedded claystone and sandstone bedrock ranged from weathered to very hard in density.

The clayey fill soils are considered moderately plastic and select samples exhibited low to moderate expansive potential at existing moisture contents. The silty sand soils are considered non-plastic and non-expansive. Testing of select soil samples for the presence of water-soluble sulfates indicated concentrations ranging from 1,400 to 2,800 parts per million (ppm).

Groundwater Conditions: Groundwater was encountered during drilling at depths ranging from about 19 to 25 feet below existing site grades in Boring Nos. 2 and 3. When checked four days later, wet sandy soils had caved-in to a depth of about 6-½ feet below existing site grades in Boring No. 4. Groundwater was encountered at depths ranging from about 10 to 17.25 feet below existing site grades in the other three borings.

Based upon review of mapping completed in relatively close geologic proximity to the site, U.S. Geological Survey Maps ([3]Hillier, et al, 1980), regional groundwater beneath the project area is anticipated to occur in the Denver Aquifer at depths generally more than 20 feet and commonly more than 100 feet below the ground surface.

SITE DEVELOPMENT RECOMMENDATIONS

Geotechnical Considerations: The site appears suitable for the proposed construction as long as the recommendations included herein are incorporated into the design and construction aspects of the project. In our opinion, the primary geotechnical concern with respect to the proposed development

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[3] Hillier, Donald E.; and Hutchinson, E. Carter, 1980, ***Depth to Water Table (1976-1977) in the Colorado Springs – Castle Rock Area, Front Range Urban Corridor, Colorado***, United States Geological Survey, Map I-857-H.

includes the presence of moderately expansive clayey fill soils and claystone bedrock at and near proposed subgrade elevations.

- **Existing Fill Soils:** As discussed, approximately 4 to 13 feet of existing man-made fill was encountered in our borings and may be present on other portions of the site and may extend to deeper depths. ***We do not possess any information regarding whether the fill was placed under the direction and observation of a geotechnical engineer.*** Field and laboratory data indicate that the fill is variable and is relatively dry and loose in areas.

  Undocumented fills can present a greater than normal risk of post-construction movement of concrete slabs-on-grade and other on grade structures supported on these materials. There is also inherent uncertainty and greater risk that zones or layers of poorly compacted fill may be encountered on the site or unsuitable materials (such as organics and construction debris, or soft/loose/expansive layers) may be present within or buried by the fill. <u>This risk cannot be eliminated without completely removing and replacing/recompacting the fill</u>, but can generally be reduced to a reasonable level by thorough proper testing and observation during construction.

- **Expansive Soils and Bedrock:** The clay fill soils and claystone bedrock encountered at and near proposed subgrade elevations exhibited low to moderate expansive potential at existing moisture contents. ***Post-construction wetting of these materials can potentially result in excessive or uneven movement (settlement) of concrete flatwork. In order to reduce, but not eliminate, this risk (and that presented by the existing fill), we recommend that all foundation elements, thickened slab edges, and other critical site flatwork bear on a minimum of 3 feet of recompacted onsite soils.*** These on-site soils should be processed, moisture-conditioned and recompacted as engineered fill.

  Provided this process is properly performed, we believe that conventional slab-on-grade concrete flatwork should provide acceptable performance for the planned site improvements. ***Movement associated with properly designed concrete slabs-in-grade bearing on approved soils is expected to be within generally accepted tolerances for exterior flatwork.***

- **Surface Drainage:** The amount of movement associated with foundations, flatwork, pavements, etc. will be related to the wetting of underlying supporting soils. Therefore, it is imperative the recommendations outlined in the "Grading and Drainage" section of this report be followed to reduce potential movement.

Design and construction recommendations for the foundation system and other earth-connected phases of the project are outlined below.

Earthwork:

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

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

- **Demolition and Site Preparation:** Strip and remove any existing landscaping, vegetation and any other deleterious materials. Stripped materials consisting of vegetation and organic materials should be wasted from the site or used to revegetate landscaped areas or exposed slopes after completion of grading operations.

  Demolition of existing skate park elements and other flatwork should include removal of any foundation elements and abandoned utility lines, including any loose/soft backfill associated with these elements. Existing flatwork and pavements may be crushed (maximum size of 4 inches) and re-used on-site, especially to utilize in stabilizing the soft and unstable soil conditions described below.

  Based upon our borings, and depending on site irrigation and seasonal conditions, we anticipate that the near-surface soils may be unstable. The stability of the site subgrade may also be affected by precipitation, repetitive construction traffic, or other factors. We recommend that contractors consider the use of tracked earthwork equipment to minimize rutting and disturbance during site preparations.

  Where unstable conditions, if any, are encountered or develop during construction, workability may be improved by scarifying and aeration during warmer periods. In some areas, removal and recompaction (or replacement with other on-site soils) may be suitable to build a stable base for placement of new fills.

  In areas where subgrade soils are very soft/yielding (if any), gravel augmentation (mechanically compacting/kneading crushed rock into the subgrade soils) may be cost-effective. In our experience, crushed rock or recycled concrete materials on the order of 3 to 6 inches in size would be effective in most situations. As an alternative, chemical treatment by blending fly ash, lime or Portland cement into the subgrade could also be considered. The actual mitigation methods used should be based on observation of exposed conditions by the geotechnical engineer.

- **Subgrade Preparation:** Field and laboratory data indicate that the existing fill is variable and is contains expansive soils. Undocumented fills and expansive soils can present a greater than normal risk of post-construction movement of concrete slabs-on-grade and other on grade structures supported on these materials. ***Post-construction wetting of these materials can potentially result in excessive or uneven movement (settlement) of concrete flatwork. In order to mitigate this risk (and that presented by the existing fill), we recommend that <u>all foundations, thickened edges, and critical site flatwork associated with skating areas bear on a minimum of 3 feet of recompacted on-site soils.</u>***

  These on-site soils should be processed, moisture-conditioned and recompacted as engineered fill. Subexcavation should also extend at least 3 feet horizontally beyond the outside edge of all bearing elements and critical concrete flatwork slabs-on-grade.

  Prior to construction, evaluation of the subgrade conditions should also include a proofroll of the existing subgrade by a heavily loaded, tandem water-truck or dump truck just prior to construction of concrete slabs-on-grade. ***If unstable soils are observed during this evaluation, some additional recompaction and stabilization of the on-site soils should be completed.*** At a minimum, all subgrade soils below new fill, concrete slabs-on-grade, exterior PCC flatwork, and pavements should be scarified to a minimum depth of 12 inches, moisture conditioned and compacted as discussed below just prior to construction of these elements.

- **Fill Materials:** Clean on-site soils or approved imported materials may be used as fill material. Imported soils (if required) should conform to the following:

Gradation	**Percent finer by weight (ASTM C136)**
6”	100
3"	70-100
No. 4 Sieve	50-100
No. 200 Sieve	60 maximum

  - Liquid Limit .... 35 (max)
  - Plasticity Index .... 20 (max)
  - Maximum expansive potential (%)* 0.5

  *Measured on a sample compacted to approximately 95 percent of the ASTM D698 maximum dry density at about optimum water content. The sample is confined under a 500 psf surcharge and submerged.

- **Compaction Requirements:** Engineered fill for site development and grading should be placed and compacted in horizontal lifts, using equipment and procedures that will produce recommended moisture contents and densities throughout the lift. Fill soils should be placed and compacted according to the following criteria:

Criteria	**Recommended values**
Fill Materials	On-site soils, free of vegetation are acceptable (3 to 4 inch fragments max) Imported fill, if required, should meet the specifications above
Lift Thickness	8 to 12 inches or less in loose thickness
Moisture Content Range	• Clayey soils: +1% to +4% above optimum moisture content • Non-plastic granular soils: -2% below to +2% above optimum
Compaction	Clayey soils: 95% minimum ASTM D698 standard Proctor dry density Non-plastic granular soils: 95% minimum ASTM D1557 modified Proctor dry density

At a minimum, fill soils placed for any sub-excavation fill, site grading, utility trench backfill and foundation backfill should be tested to confirm that earthwork is being performed according to our recommendations and project specifications. Subsequent lifts of fill should not be placed on previous lifts if the moisture content or dry density is determined to be less than specified.

- **Excavation and Trench Construction:** It is anticipated that excavations for the proposed construction can be accomplished with conventional, heavy-duty earthmoving equipment. ***Caving sand soils are present at the site.*** The individual contractor(s) should be made responsible for designing and constructing stable, temporary excavations as needed to maintain stability of both the excavation sides and bottom. All excavations should be sloped or shored in the interest of safety following local and federal regulations, including current OSHA excavation and trench safety standards.

All excavations should be sloped or shored in the interest of safety following local and federal regulations, including current OSHA excavation and trench safety standards. An excavation side slope configuration of 1-½ to 1 (horizontal to vertical) should be used for the Type C overburden soils unless the contractor's OSHA competent personnel allow for steeper side slopes.

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

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

SKATE PARK STRUCTURAL CONSIDERATIONS

Concrete Flatwork and Exterior Structures: Ground-supported flatwork, such as the skate park facilities, will be subject to soil-related movements resulting from heave/settlement, frost, etc. The amount of movement will be related to the compactive effort used when the fill soils are placed and future wetting of the subgrade soils. The potential for damage would be greatest where exterior slabs are constructed adjacent to buildings or other structural elements. Thus, where these types of elements abut rigid building foundations or isolated/suspended structures, differential movements should be anticipated.

We recommend that exterior concrete flatwork for the skate part facilities be supported on improved subgrade as described in the Earthwork – Subgrade Preparation Section of this report. ***However, even after this mitigation, we estimate slab movement of 1 to 2 inches is possible when bearing on properly placed and compacted engineered fill.*** Movements could be further reduced if substantially deeper subexcavation and recompaction is performed. If the movement outlined above cannot be tolerated, we should be contacted to provide alternatives for additional subgrade preparation.

Movements will be directly related to wetting of the supporting soils, therefore, it is imperative to establish and maintain positive drainage away from structures and critical flatwork. Water should not be allowed to pond on flatwork.

For structural design of concrete slabs-on-grade, a modulus of subgrade reaction of 100 pounds per cubic inch (pci) may be used for floors supported on compacted engineered fill soils at the site. Additional flatwork design and construction recommendations are as follows:

- Positive separations and/or isolation joints should be provided between slabs and all foundations, columns or utility lines to allow independent movement in accordance with The City of Thornton Standards.

- Placement of effective control joints on relatively close centers and isolation joints between slabs and other structural elements to control the location and extent of cracking.

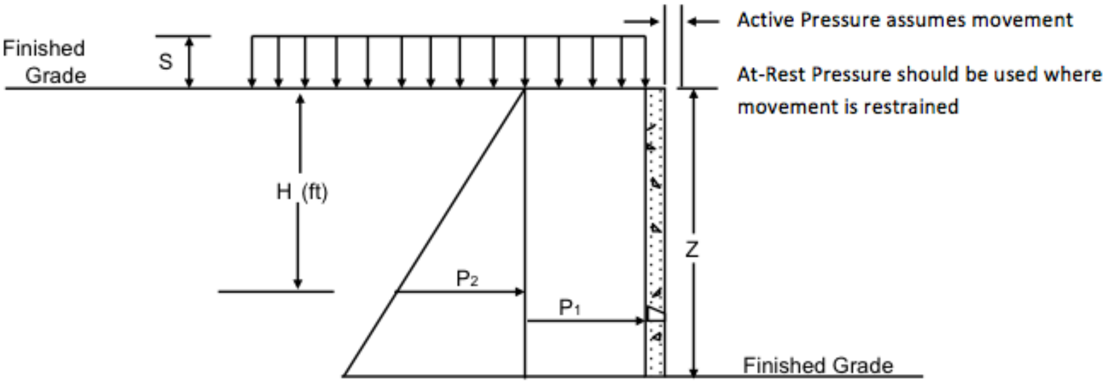
- provision for adequate drainage in areas adjoining the slabs.

- Trench backfill placed beneath slabs should be compacted in accordance with recommended specifications outlined in the *Earthwork* section of this report.

- Concrete slabs-on-grade should not be constructed on frozen subgrade.

Other design and construction considerations, as outlined in Section 302.1R of the *ACI Design Manual*, are recommended.

Lateral Earth Pressures: Earth pressures will be influenced by structural design of the walls, conditions of wall restraint, methods of construction, wetting of backfill materials, and/or compaction and the strength of the materials being restrained. Loads that should be considered by the structural engineer on walls are shown below.



Active earth pressure is commonly used for design of freestanding cantilever retaining walls and assumes wall movement. The "at-rest" condition assumes no wall rotation. Walls with unbalanced backfill levels on opposite sides (i.e. basement walls) should be designed for earth pressures at least equal to those indicated in the following table. The recommended design lateral earth pressures do not include a factor of safety and do not provide for possible hydrostatic pressure on the walls.

EARTH PRESSURE COEFFICIENTS

Earth pressure conditions	Coefficient for backfill type	Equivalent fluid pressure, pcf	Surcharge pressure P_1, psf	Earth pressure P_2, psf
Active (Ka)	On-site clay soils - 0.42	50	(0.42)S	(50)H
At-Rest (Ko)	On-site clay soils - 0.59	70	(0.59)S	(70)H
Passive (Kp)	On-site clay soils – 2.1	250	---	---

Conditions applicable to the above conditions include:

- for active earth pressure, wall must rotate about base, with top lateral movements 0.01 Z to 0.02 Z, where Z is wall height
- for passive earth pressure, wall must move horizontally to mobilize resistance
- uniform surcharge, where S is surcharge pressure

- in-situ soil backfill weight a maximum of 120 pcf
- horizontal backfill, compacted to at least 95 percent of standard Proctor maximum dry density
- loading from heavy compaction equipment not included
- no groundwater acting on wall
- no safety factor included
- ignore passive pressure in frost zone

Any backfill placed against structures should consist of on-site soils processed to a soil-like consistency with a maximum size of about 4 to 6 inches. Backfill should be moisture conditioned to near optimum, placed in relatively thin lifts appropriate for the compaction equipment used. Care should be used during the backfill process not to over-compact backfill and cause damage to structural walls and other features.

Seismic Considerations: Based on the soil/bedrock conditions encountered in the test holes drilled on the site, we estimate that a Site Class D is appropriate for the site according to the 2015 International Building Code (Section 1613.3.2 referencing Table 20.3-1 of ASCE 7, Chapter 20). This parameter was estimated based on extrapolation of data beyond the deepest depth explored, using methods allowed by the code. Actual shear wave velocity testing/analysis and/or exploration to 100 feet was not performed.

Below-Grade (In-Ground) Construction and Subsurface Drainage: We understand that in-ground skate park elements will be included in the project and that they will bear approximately 5 to 8 feet below finished site grades. While design plans have not been provided, we assume that these elements will consist of precast concrete/gunnite shells or will be cast-in-place against existing ground using shotcrete/gunnite techniques.

Provided that the sides of these in-ground elements are placed directly against on-site soils, we believe there is low risk of infiltration of irrigation or precipitation water causing excessive lateral pressures or “floating” of the in-ground elements. However, we believe it is prudent to include drainage systems for relieving subsurface “perched” water that may infiltrate around the elements from the ground surface. We understand that these systems typically include installing drain boards behind shotcrete walls, gravel lenses below the base of in-ground elements, and drains at the base of skate bowls.

Subsurface drainage systems are also recommended behind any site walls that retain more than 2 feet of soil.

Final Grading, Surface Drainage and Landscaping: All grades must be constructed to provide positive drainage away from structures during construction, and it is imperative that grades be maintained throughout the life of the proposed improvements. ***Water permitted to pond near or adjacent to the perimeter of exterior flatwork (either during or post-construction) can result in significantly higher soil movements than those discussed in this report. As a result, any estimations of potential movement described in this report cannot be relied upon if positive drainage is not constructed and maintained, and water is allowed to infiltrate the supporting subgrade.***

We recommend exposed ground around the proposed skate park be sloped at a minimum of 10 percent grade for at least 10 feet beyond the perimeter of the structures, where possible. Flatter slopes may be appropriate in areas where site constraints require. The use of swales, chases and/or area drains may be required to facilitate drainage in unpaved areas around the perimeter of the skate park. After construction and prior to completion of landscaping, we recommend that verification of final grading be performed to document that positive drainage, as described above, has been achieved. A review of grading should also be performed after landscaping to assure grades have been maintained. Areas where earthwork and/or backfill has settled should be repaired immediately to prevent ponding of water adjacent to structures. ***In all cases, the grade should slope a minimum of 5 percent away from structures in accordance with the applicable building code.***

Downspouts, if present, should discharge on pavements or be extended away from the structure(s) a minimum of 5 to 10 feet through the use of splash blocks or downspout extensions. Drains may also be designed to discharge to storm sewers by solid, rigid PVC pipe or daylighted to a detention pond or other appropriate outfall, however, a Civil Engineer should be consulted to design the system if this option is considered. We do not recommend discharging flow below the ground surface using flexible pipe, as pipe grades and pipe integrity are difficult to maintain using this product. Outfalls should be protected from damage, blockage, and small animals.

Landscaped irrigation adjacent to flatwork should be minimized to timed, drip irrigation systems or eliminated altogether. Planters located adjacent to the structure(s) should preferably be self-contained. Sprinkler mains and spray heads should be located a minimum of 5 feet away from the skate park footprint, if possible. Trees or other vegetation whose root systems have the ability to remove excessive moisture from the subgrade soils should not be planted next to the structure(s). Trees and shrubbery should be kept away from the exterior edges of flatwork, a distance at least equal to 1.5 times their expected mature height.

Backfill against flatwork, exterior walls, and in utility and sprinkler line trenches should be well compacted and free of all construction debris to reduce the possibility of moisture infiltration.

Additional Design and Construction Considerations:

- **Underground Utility Systems:** All underground piping within or near the proposed structure(s) should be designed with flexible couplings, so minor deviations in alignment do not result in breakage or distress.

  It is strongly recommended that a representative of the geotechnical engineer provide full-time observation and compaction testing of trench backfill within flatwork and pavement areas.

- **Concrete Corrosion Protection:** Select samples were tested for the presence of water-soluble sulfates outlined in the table below.

Boring	Depth (ft)	Material	Water-Soluble Sulfates (ppm)	ACI Sulfate Exposure Class
1	2	Fill – Sandy Lean Clay	2,800	S2
3	2	Fill - Sandy Lean Clay	1,400	S1

The select samples, likely to be in contact with project concrete, were tested for the presence of water-soluble sulfates in order to determine corrosion characteristics and the appropriate concrete mixture. Testing results indicate the samples are within the American Concrete Institute (ACI) Sulfate Exposure Class S2 in accordance with Chapter 19 of the ACI design manual, *Building Code Requirements for Structural Concrete (ACI 318-14). W**e recommend project concrete be designed utilizing ACI Sulfate Exposure Class S2, as summarized in the table below.***

ACI Sulfate Exposure Class	Portland Cement Type (ASTM C150)	Maximum Water/Cement Ratio	Minimum Concrete Compressive Strength (psi)
S2	V (or equivalent)	0.45	4,500

GENERAL COMMENTS

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

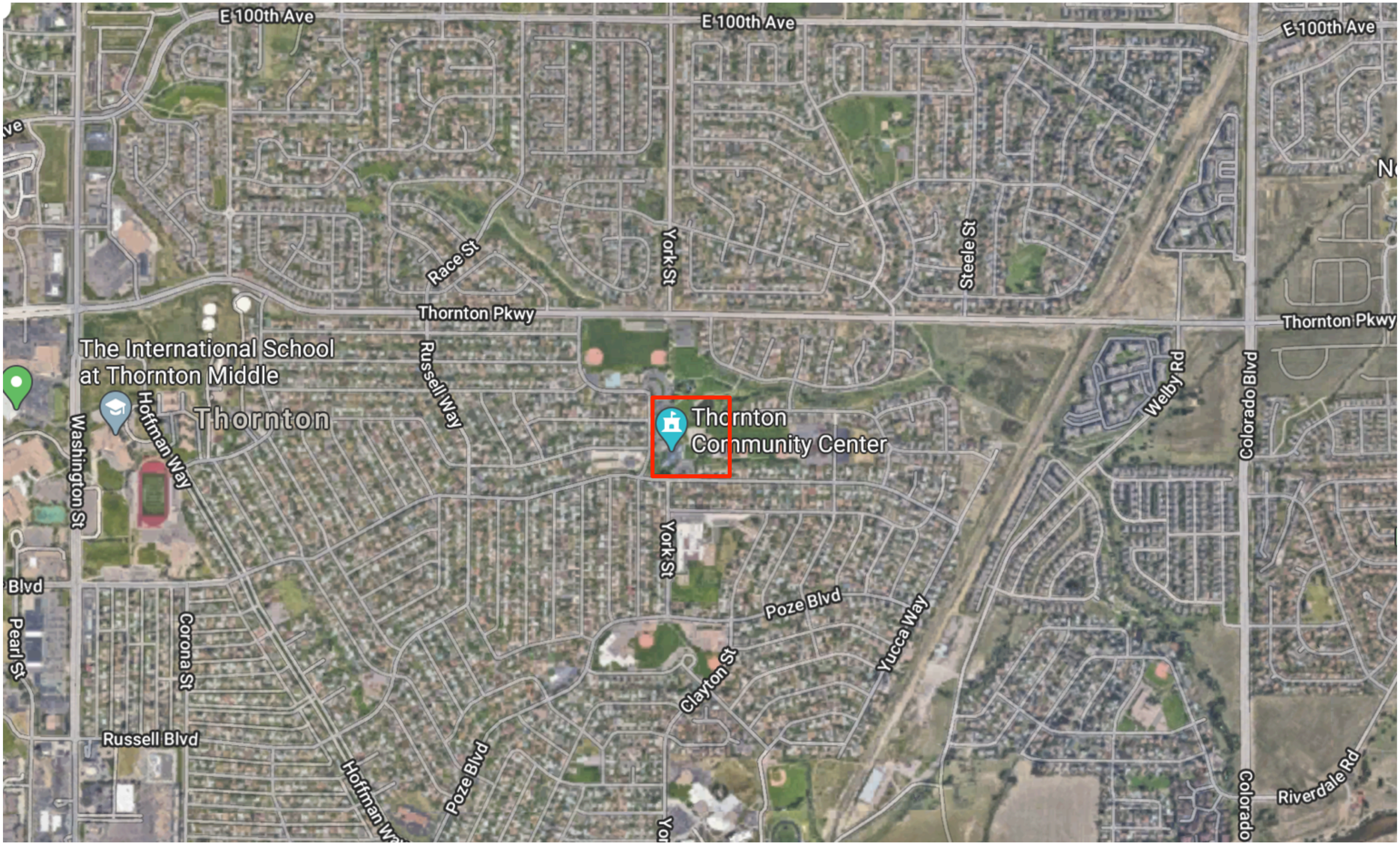
The analysis and recommendations presented in this report are based upon the data obtained from the borings performed at the indicated locations and from other information discussed in this report. This report does not reflect variations that may occur between borings, across the site, or due to the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

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

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

APPENDIX A

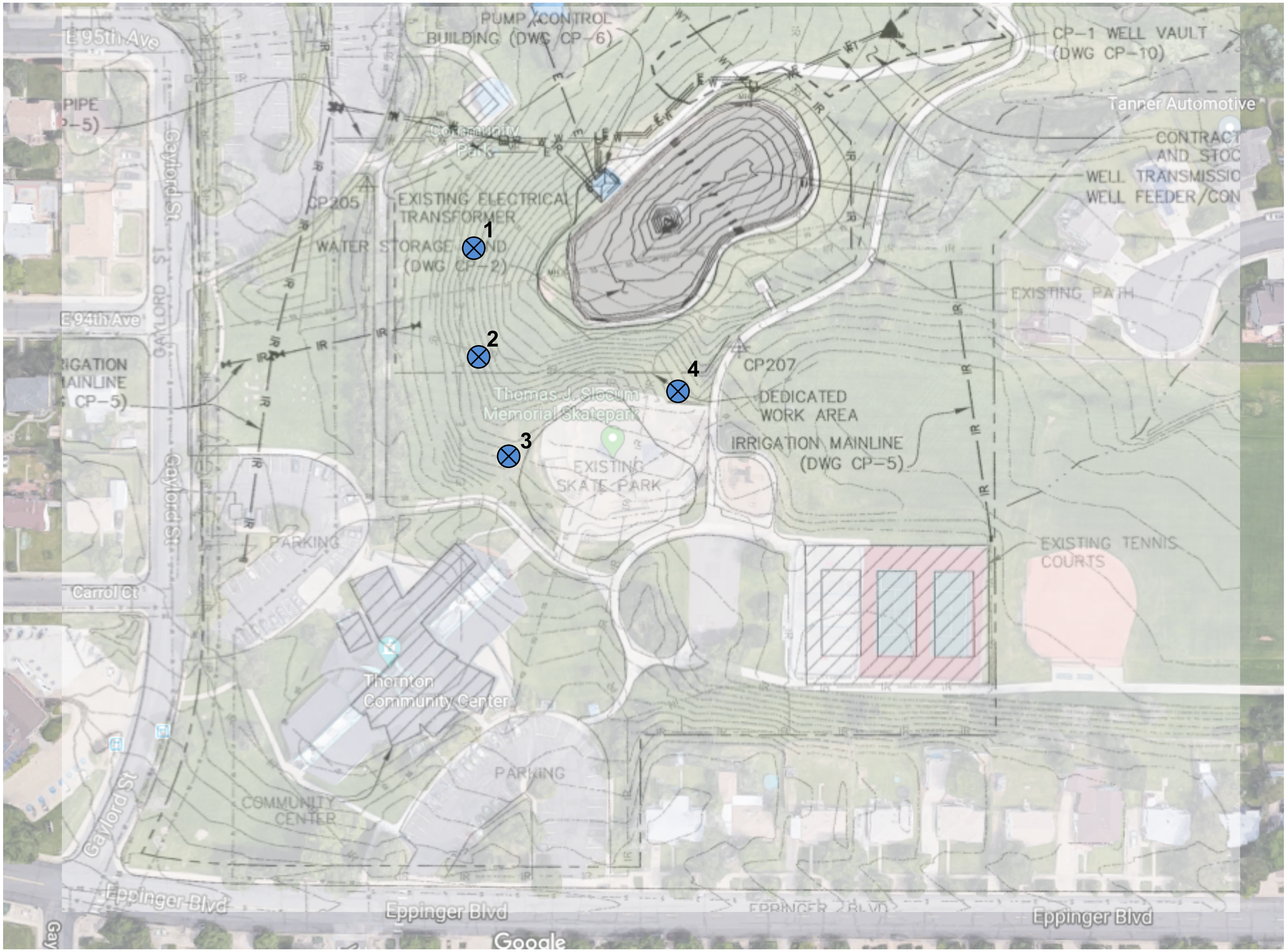
SITE VICINITY MAP
BORING LOCATION DIAGRAM
BORING LOGS



🟥 **APPROXIMATE PROJECT LOCATION**

FIGURE 1 – SITE VICINITY MAP
THOMAS J. SLOCUM MEMORIAL SKATE PARK
2211 EPPINGER BOULEVARD
THORNTON, COLORADO
CGG PROJECT NO. 20.22.056

Cole Garner Geotechnical
1070 W. 124th Ave., Suite 300
Westminster, CO 80234
(303) 996-2999



⊗ 1 **APPROXIMATE BORING LOCATIONS**

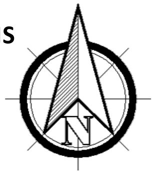


FIGURE 2 - BORING LOCATION DIAGRAM
THOMAS J. SLOCUM MEMORIAL SKATE PARK
2211 EPPINGER BOULEVARD
THORNTON, COLORADO
CGG PROJECT NO. 20.22.056

Cole Garner Geotechnical
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Westminster, CO 80234
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1070 W 124th Ave Suite 300
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Telephone: 303-996-2999

BORING NUMBER 1

PAGE 1 OF 1

CLIENT Team Pain Enterprises, Inc.

PROJECT NAME Thomas J Slocum Memorial Skate Park - Reconstruction

PROJECT NUMBER 20.22.056

PROJECT LOCATION 2211 Eppinger Blvd - Thornton, CO

DATE STARTED 3/12/20 **COMPLETED** 3/12/20

GROUND SURFACE ELEV. Not Provided **PROPOSED ELEV.** Not Provided

DRILLING CONTRACTOR Vine Laboratories

SURFACE CONDITIONS Sod landscaping

DRILLING METHOD CME-55 Track-rig/Solid Stem Auger

GROUND WATER LEVELS:

HAMMER TYPE Automatic

▽ **DURING DRILLING** None

LOGGED BY TMC **CHECKED BY** AG

▼ **AFTER DRILLING** 12.00 ft - 3/16/2020

GRAPHIC LOG	MATERIAL DESCRIPTION	DEPTH (ft)	USCS SYMBOL	SAMPLE TYPE	RECOVERY %	PENETRATION blows/in	MOISTURE CONTENT (%)	DRY UNIT WT. (pcf)	SWELL-CONSOL /SURCHARGE LOAD, %psf
	FILL - SANDY LEAN CLAY, with some gravel, varies to clayey sand dark brown to light brown, tan, iron-stained, dry to moist, medium stiff to very stiff	0	CL/SC	CB	100	12 / 12	23.3	91	
			CL	CB	100	9 / 12	11.5	108	+3.1/500
		5	CL	CB	100	29 / 12	2.5	126	
	▼	10	CL	CB	100	6 / 12	8.2	91	
13	**CLAYEY to SILTY SAND**, fine-grained, tan, light brown, moist to wet, loose	15	SC/SM	CB	100	6 / 12	31.5	87	
16	**CLAYSTONE to SANDSTONE BEDROCK**, interbedded, olive-brown, light brown, grey, iron-stained, moist, medium hard	20	-	CB	100	36 / 12	19.5	107	
20									

Approximate bottom of borehole at 20.0 feet.

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BORING NUMBER 2

PAGE 1 OF 1

CLIENT Team Pain Enterprises, Inc.

PROJECT NAME Thomas J Slocum Memorial Skate Park - Reconstruction

PROJECT NUMBER 20.22.056

PROJECT LOCATION 2211 Eppinger Blvd - Thornton, CO

DATE STARTED 3/12/20 **COMPLETED** 3/12/20

GROUND SURFACE ELEV. Not Provided **PROPOSED ELEV.** Not Provided

DRILLING CONTRACTOR Vine Laboratories

SURFACE CONDITIONS Sod landscaping

DRILLING METHOD CME-55 Track-rig/Solid Stem Auger

GROUND WATER LEVELS:

HAMMER TYPE Automatic

▽ **DURING DRILLING** 19.00 ft

LOGGED BY TMC **CHECKED BY** AG

▼ **AFTER DRILLING** 10.00 ft - 3/16/2020

GRAPHIC LOG	MATERIAL DESCRIPTION	DEPTH (ft)	USCS SYMBOL	SAMPLE TYPE	RECOVERY %	PENETRATION blows/in	MOISTURE CONTENT (%)	DRY UNIT WT. (pcf)	SWELL-CONSOL /SURCHARGE LOAD, %psf
	FILL - SANDY LEAN CLAY, dark brown to brown, iron-stained, moist, medium stiff	0	CL	CB	100	9 / 12	24.7	94	-0.2/500
			CL	CB	100	9 / 12	27.3	92	
		5	CL	CB	100	10 / 12	25.6	94	+0.2/500
8	**CLAYEY SAND to SILTY SAND**, fine-grained, brown, moist to wet, loose ▼	10	SC/SM	CB	100	6 / 12	29.9	88	
12	**CLAYSTONE to SANDSTONE BEDROCK**, interbedded, light brown to brown, grey, iron-stained, moist, firm to hard	15	-	CB	100	35 / 12	17.8	115	
20	▽	20	-	CB	100	50 / 8	20.1	108	

Approximate bottom of borehole at 20.0 feet.

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BORING NUMBER 3

PAGE 1 OF 1

CLIENT Team Pain Enterprises, Inc.
PROJECT NAME Thomas J Slocum Memorial Skate Park - Reconstruction
PROJECT NUMBER 20.22.056
PROJECT LOCATION 2211 Eppinger Blvd - Thornton, CO
DATE STARTED 3/12/20 **COMPLETED** 3/12/20
GROUND SURFACE ELEV. Not Provided **PROPOSED ELEV.** Not Provided
DRILLING CONTRACTOR Vine Laboratories
SURFACE CONDITIONS Sod landscaping
DRILLING METHOD CME-55 Track-rig/Solid Stem Auger
GROUND WATER LEVELS:
HAMMER TYPE Automatic
▽ **DURING DRILLING** 25.00 ft
LOGGED BY TMC **CHECKED BY** AG
▼ **AFTER DRILLING** 17.00 ft - 3/16/2020

GRAPHIC LOG	MATERIAL DESCRIPTION	DEPTH (ft)	USCS SYMBOL	SAMPLE TYPE	RECOVERY %	PENETRATION blows/in	MOISTURE CONTENT (%)	DRY UNIT WT. (pcf)	SWELL-CONSOL /SURCHARGE LOAD, %psf
▨	**FILL - SANDY LEAN CLAY**, with claystone fragments, brown, grey, iron-stained, moist to wet, medium stiff	0							
			CL	CB	100	10 / 12	20.8	99	+0.3/500
		5	CL	CB	100	7 / 12	30.8	85	
8 ▤	**CLAYSTONE to SANDSTONE BEDROCK**, with interbedded sandstone with depth olive-brown, grey, iron-stained, moist to wet, firm to very hard								
		10	-	CB	100	36 / 12	19.5	106	+2.1/1000
		15	-	CB	100	26 / 12	24.2	98	
	▼								
		20	-	CB	100	32 / 12	20.8	107	
	▽	25	-	CB	100	43 / 12	21.0	106	
		30	-	CB	100	50 / 3	24.0		
35		35	-	CB	100	50 / 5	14.8	121	

Approximate bottom of borehole at 35.0 feet.

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BORING NUMBER 4

PAGE 1 OF 1

CLIENT Team Pain Enterprises, Inc.
PROJECT NAME Thomas J Slocum Memorial Skate Park - Reconstruction
PROJECT NUMBER 20.22.056
PROJECT LOCATION 2211 Eppinger Blvd - Thornton, CO
DATE STARTED 3/12/20 **COMPLETED** 3/12/20
GROUND SURFACE ELEV. Not Provided **PROPOSED ELEV.** Not Provided
DRILLING CONTRACTOR Vine Laboratories
SURFACE CONDITIONS Sod landscaping
DRILLING METHOD CME-55 Track-rig/Solid Stem Auger
GROUND WATER LEVELS:
HAMMER TYPE Automatic
▽ **DURING DRILLING** None
LOGGED BY TMC **CHECKED BY** AG
▼ **AFTER DRILLING** MCI @ 7' - 3/26/2020

GRAPHIC LOG	MATERIAL DESCRIPTION	DEPTH (ft)	USCS SYMBOL	SAMPLE TYPE	RECOVERY %	PENETRATION blows/in	MOISTURE CONTENT (%)	DRY UNIT WT. (pcf)	SWELL-CONSOL /SURCHARGE LOAD, %psf
	FILL - LEAN CLAY with SAND, with claystone fragments, brown, grey, iron-stained, moist, soft	0							
			CL	CB	100	5 / 12	20.7	95	-0.2/500
4	**CLAYEY SAND to SILTY SAND**, fine-grained, tan, brown, iron-stained, moist, medium dense	5	SC/SM	CB	100	25 / 12	20.6	102	
9	**CLAYSTONE BEDROCK**, varies sandy, olive-brown, olive-grey, brown, grey, iron-stained, moist, weathered to hard	10	-	CB	100	16 / 12	25.4	97	+3.3/500
		15	-	CB	100	50 / 11	20.4	108	
		20	-	CB	100	50 / 10	18.5	113	
		25	-	CB	100	49 / 12	20.6	109	
		30	-	CB	100	50 / 7	20.3	110	
35		35	-	CB	100	50 / 7	19.2	112	

Approximate bottom of borehole at 35.0 feet.

APPENDIX B

LABORATORY TEST RESULTS

Cole Garner Geotechnical
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Westminster, CO 80234
Telephone: 303-996-2999

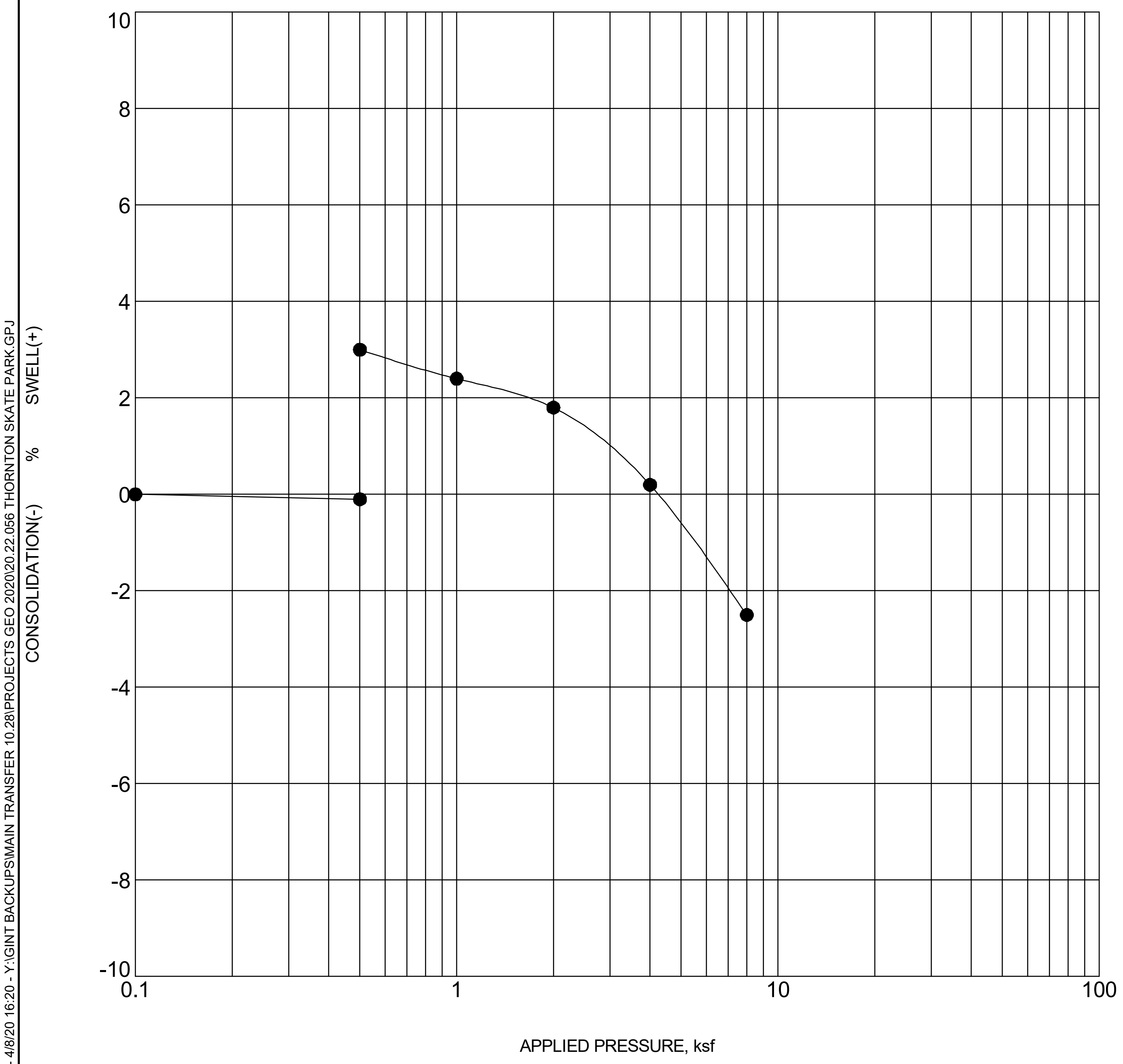
SWELL/CONSOLIDATION TEST

CLIENT Team Pain Enterprises Inc

PROJECT NAME Thomas J Slocum Memorial Skate Park - Proposed Reconstruction

PROJECT NUMBER 20.22.056

PROJECT LOCATION 2211 Eppinger Blvd - Thornton, CO



BOREHOLE	DEPTH	Classification	γ_d	MC%
● **1**	**2.0**	**SANDY LEAN CLAY(CL)**	**108**	**11**

Note: Water Added to Sample at 500 psf.

Date: 3/23/20

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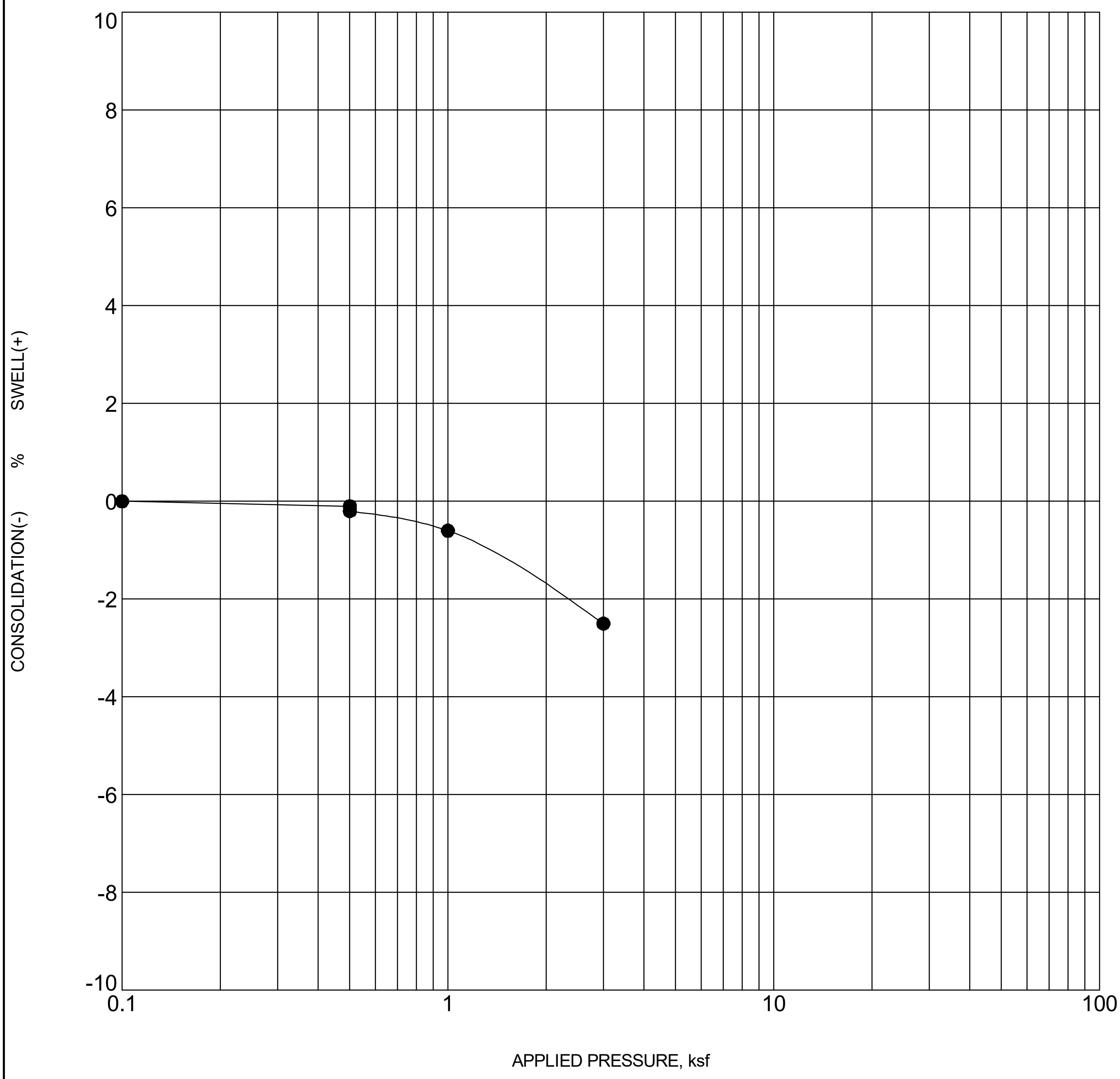
SWELL/CONSOLIDATION TEST

CLIENT Team Pain Enterprises Inc

PROJECT NAME Thomas J Slocum Memorial Skate Park - Proposed Reconstruction

PROJECT NUMBER 20.22.056

PROJECT LOCATION 2211 Eppinger Blvd - Thornton, CO



BOREHOLE	DEPTH	Classification	γ_d	MC%
● **2**	**0.0**	**FILL - SANDY LEAN CLAY**	**94**	**25**

Note: Water Added to Sample at 500 psf.

Date: 3/23/20

Cole Garner Geotechnical
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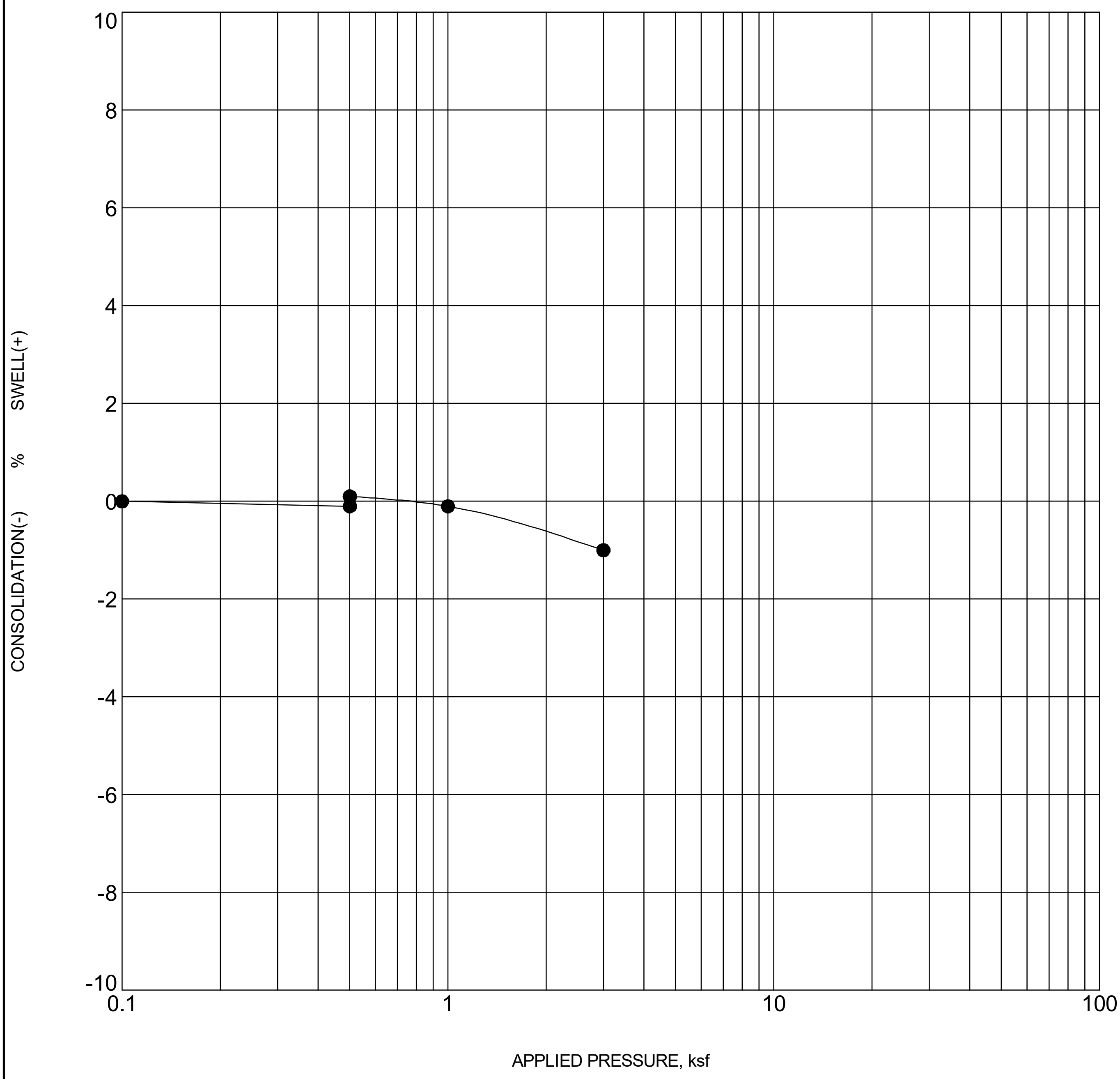
SWELL/CONSOLIDATION TEST

CLIENT Team Pain Enterprises Inc

PROJECT NAME Thomas J Slocum Memorial Skate Park - Proposed Reconstruction

PROJECT NUMBER 20.22.056

PROJECT LOCATION 2211 Eppinger Blvd - Thornton, CO



BOREHOLE	DEPTH	Classification	γ_d	MC%
● **2**	**4.0**	**FILL - SANDY LEAN CLAY**	**94**	**26**

Note: Water Added to Sample at 500 psf.

Date: 3/23/20

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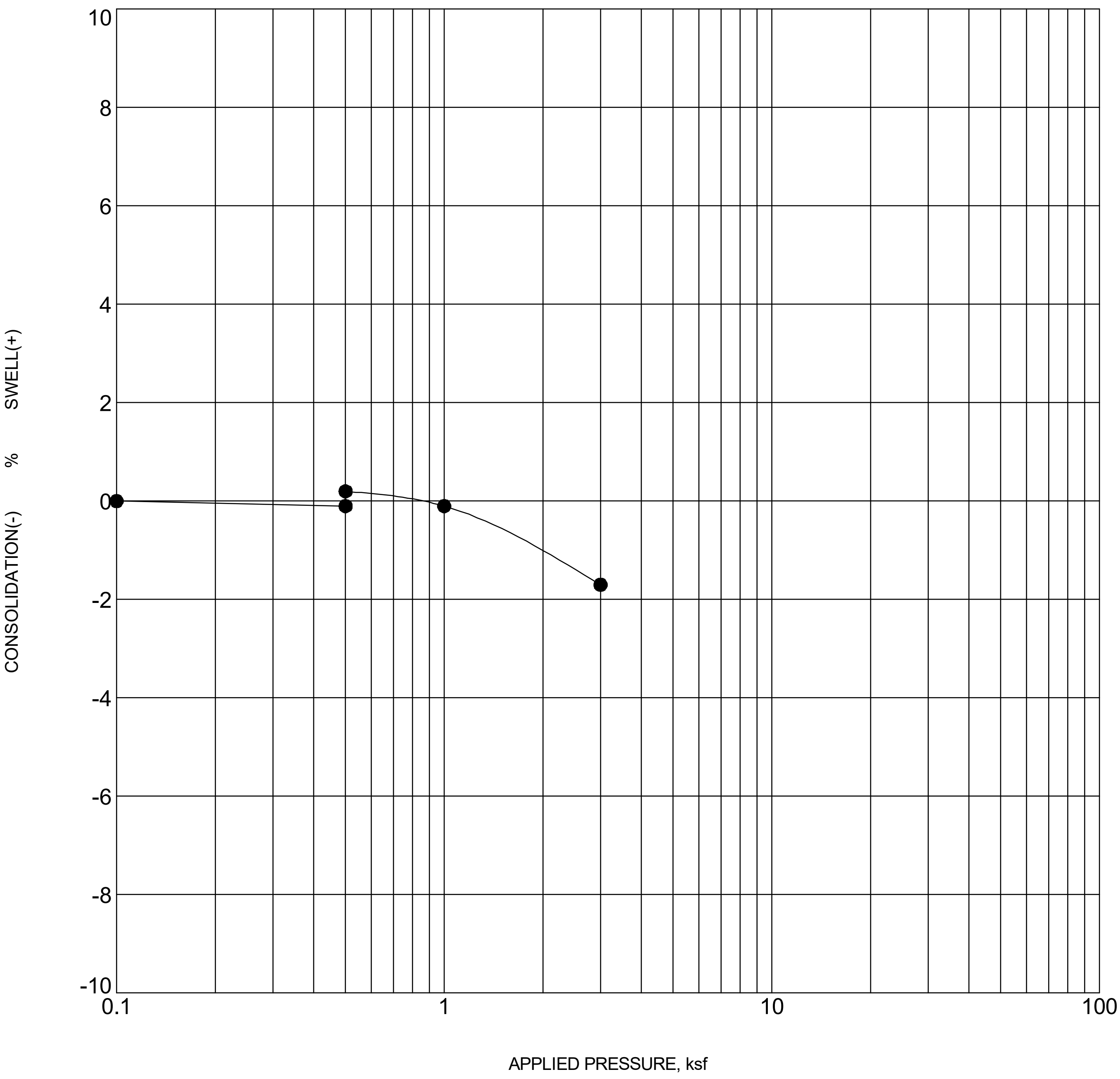
SWELL/CONSOLIDATION TEST

CLIENT Team Pain Enterprises Inc

PROJECT NAME Thomas J Slocum Memorial Skate Park - Proposed Reconstruction

PROJECT NUMBER 20.22.056

PROJECT LOCATION 2211 Eppinger Blvd - Thornton, CO



BOREHOLE	DEPTH	Classification	γ_d	MC%
● **3**	**2.0**	**SANDY LEAN CLAY(CL)**	**99**	**21**

Note: Water Added to Sample at 500 psf.

Date: 3/23/20

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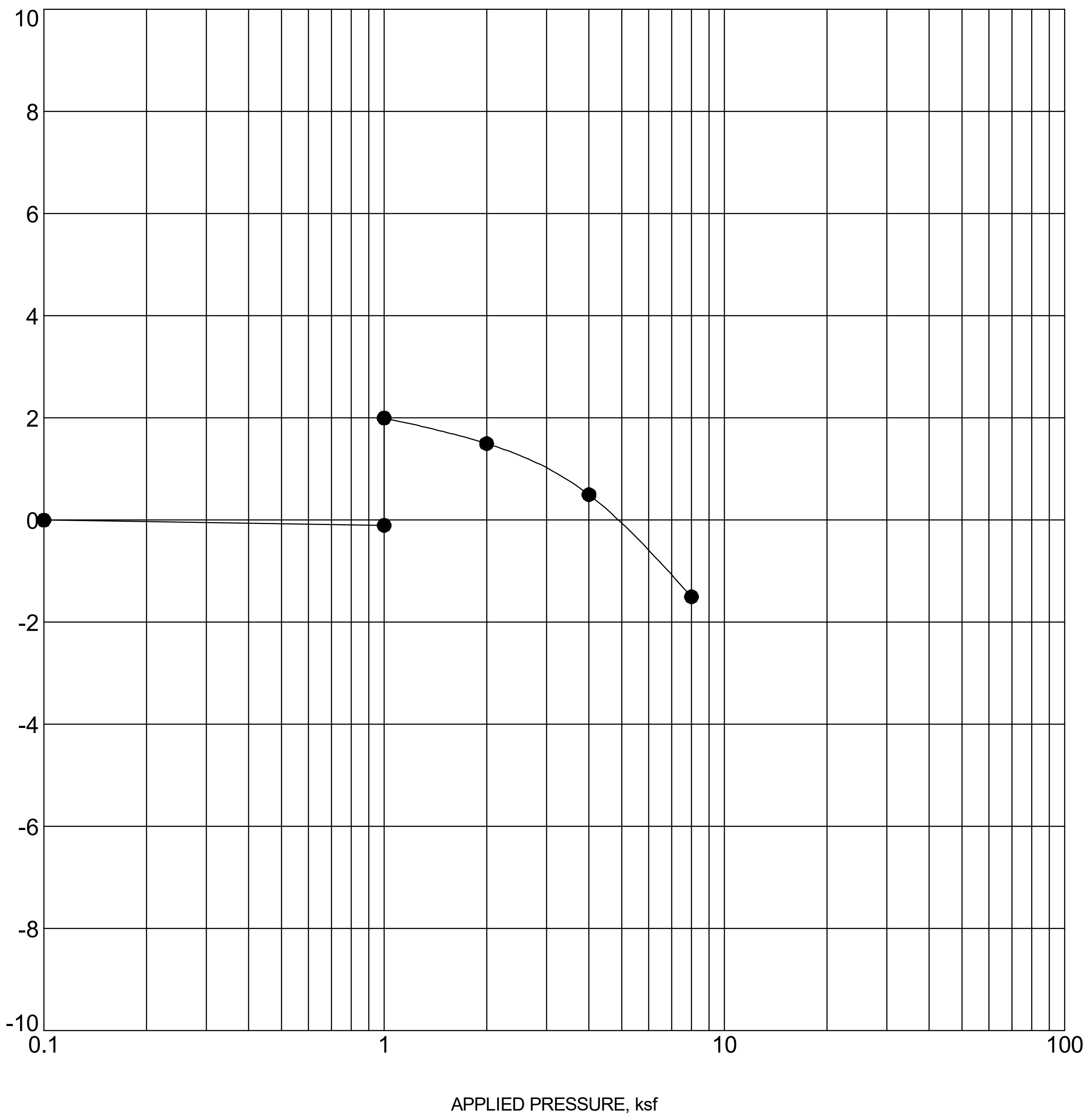
SWELL/CONSOLIDATION TEST

CLIENT Team Pain Enterprises Inc

PROJECT NAME Thomas J Slocum Memorial Skate Park - Proposed Reconstruction

PROJECT NUMBER 20.22.056

PROJECT LOCATION 2211 Eppinger Blvd - Thornton, CO



BOREHOLE	DEPTH	Classification	γ_d	MC%
● 3	14.0	**CLAYSTONE BEDROCK**	98	24

Note: Water Added to Sample at 1000 psf.

Date: 3/23/20

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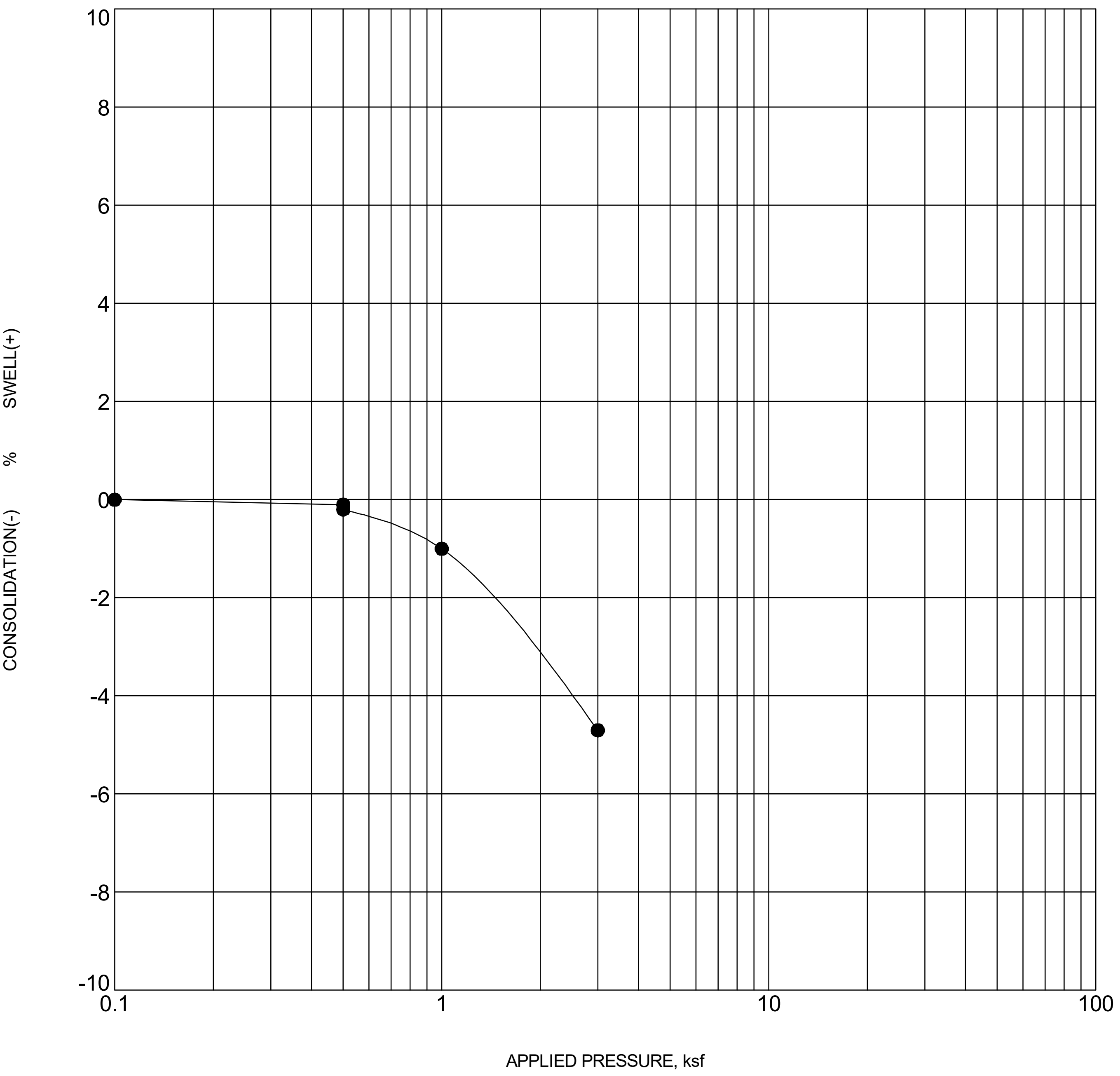
SWELL/CONSOLIDATION TEST

CLIENT Team Pain Enterprises Inc

PROJECT NAME Thomas J Slocum Memorial Skate Park - Proposed Reconstruction

PROJECT NUMBER 20.22.056

PROJECT LOCATION 2211 Eppinger Blvd - Thornton, CO



BOREHOLE	DEPTH	Classification	γ_d	MC%
● **4**	**2.0**	**LEAN CLAY with SAND(CL)**	**95**	**21**

Note: Water Added to Sample at 500 psf.

Date: 3/23/20

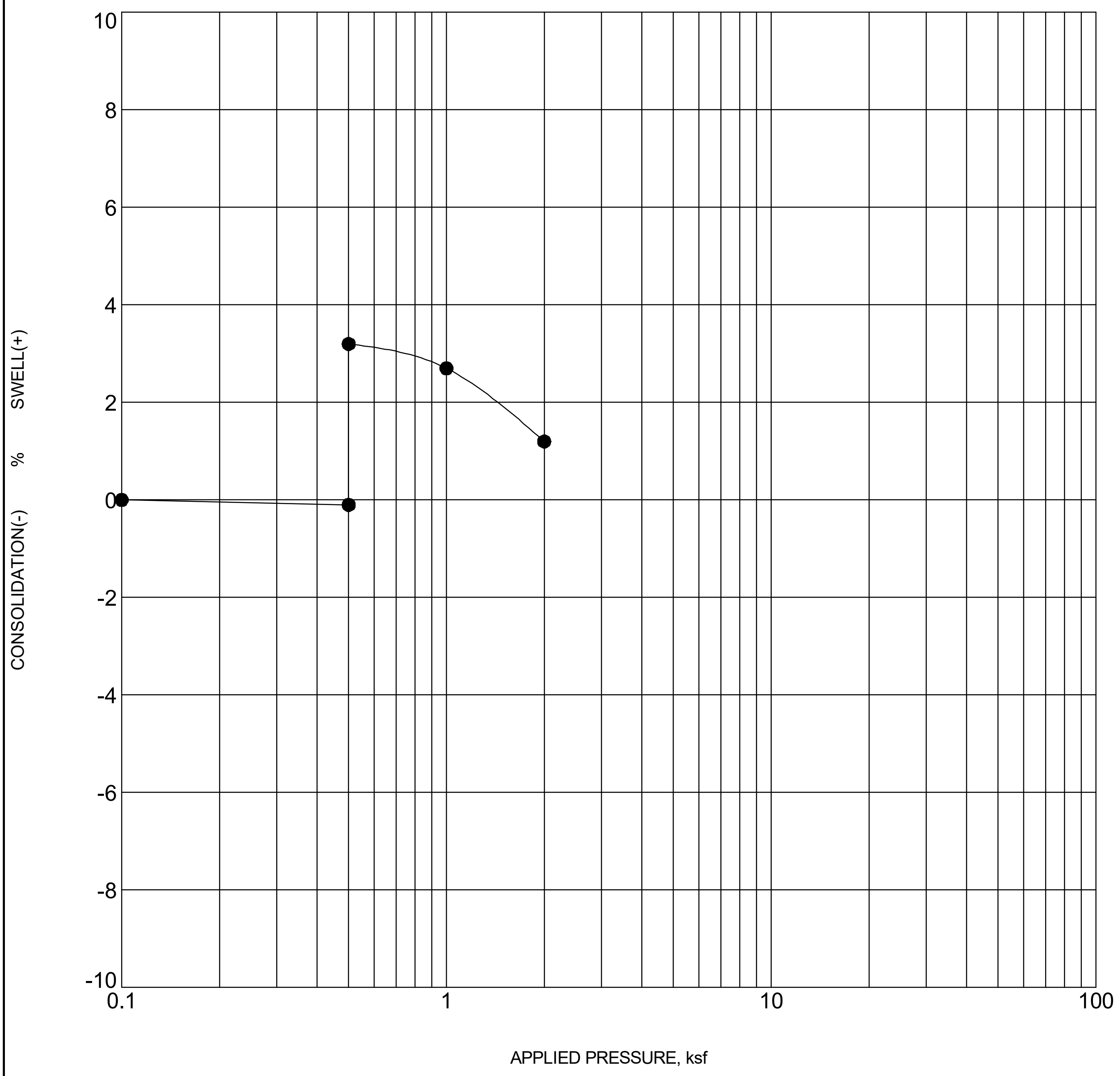
SWELL/CONSOLIDATION TEST

CLIENT Team Pain Enterprises Inc

PROJECT NAME Thomas J Slocum Memorial Skate Park - Proposed Reconstruction

PROJECT NUMBER 20.22.056

PROJECT LOCATION 2211 Eppinger Blvd - Thornton, CO



BOREHOLE	DEPTH	Classification	γ_d	MC%
● **4**	**9.0**	**CLAYSTONE BEDROCK**	**97**	**25**

Note: Water Added to Sample at 500 psf.

Date: 3/23/20

Cole Garner Geotechnical
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Westminster, CO 80234
Telephone: 303-996-2999

SUMMARY OF LABORATORY RESULTS

CLIENT Team Pain Enterprises, Inc.

PROJECT NAME Thomas J Slocum Memorial Skate Park - Reconstruction

PROJECT NUMBER 20.22.056

PROJECT LOCATION 2211 Eppinger Blvd - Thornton, CO

Borehole	Depth	Soil Description	Water Content (%)	Dry Density (pcf)	Swell (+) or Consolidation (-)/ Surcharge (%/psf)	Water Soluble Sulfates (ppm)	Passing #200 Sieve (%)	Atterberg Limits		
								Liquid Limit	Plastic Limit	Plasticity Index
1	0	FILL - SANDY LEAN CLAY	23.3	91.3						
1	2	FILL - SANDY LEAN CLAY	11.5	108.4	+3.1/500	2800	53	36	21	15
1	4	FILL - SANDY LEAN CLAY	2.5	125.8						
1	9	FILL - SANDY LEAN CLAY	8.2	91.0						
1	14	CLAYEY to SILTY SAND	31.5	87.1						
1	19	CLAYSTONE to SANDSTONE BEDROCK	19.5	106.6						
2	0	FILL - SANDY LEAN CLAY	24.7	94.4	-0.2/500					
2	2	FILL - SANDY LEAN CLAY	27.3	92.3						
2	4	FILL - SANDY LEAN CLAY	25.6	94.3	+0.2/500					
2	9	CLAYEY to SILTY SAND	29.9	87.5						
2	14	CLAYSTONE to SANDSTONE BEDROCK	17.8	114.7						
2	19	CLAYSTONE to SANDSTONE BEDROCK	20.1	108.2						
3	2	FILL - SANDY LEAN CLAY	20.8	98.7	+0.3/500	1400	59	39	19	20
3	4	FILL - SANDY LEAN CLAY	30.8	84.8						
3	9	CLAYSTONE BEDROCK	19.5	106.5	+2.1/1000					
3	14	CLAYSTONE BEDROCK	24.2	97.6						
3	19	CLAYSTONE BEDROCK	20.8	107.0						
3	24	CLAYSTONE BEDROCK	21.0	106.3						
3	29	SANDSTONE BEDROCK	24.0							
3	34	CLAYSTONE to SANDSTONE BEDROCK	14.8	120.9						
4	2	FILL - LEAN CLAY with SAND	20.7	95.0	-0.2/500		75	42	19	23
4	4	CLAYEY SAND to SILTY SAND	20.6	101.5						
4	9	CLAYSTONE BEDROCK	25.4	96.8	+3.3/500		95	53	19	34
4	14	CLAYSTONE BEDROCK	20.4	108.4						
4	19	CLAYSTONE BEDROCK	18.5	113.2						
4	24	CLAYSTONE BEDROCK	20.6	109.2						
4	29	CLAYSTONE BEDROCK	20.3	110.0						
4	34	CLAYSTONE BEDROCK	19.2	111.6						

LAB SUMMARY - GINT STD US LAB.GDT - 4/13/20 15:35 - Y:\GINT BACKUPS\MAIN TRANSFER 10.28\PROJECTS GEO 2020\20.22.056 THORNTON SKATE PARK.GPJ

APPENDIX C

GENERAL NOTES

GENERAL NOTES

DRILLING & SAMPLING SYMBOLS:

SS: Split Spoon - 1⅜" I.D., 2" O.D., unless otherwise noted
ST: Thin-Walled Tube – 2.5" O.D., unless otherwise noted
RS: Ring Sampler - 2.42" I.D., 3" O.D., unless otherwise noted
CB: California Barrel - 1.92" I.D., 2.5" O.D., unless otherwise noted
BS: Bulk Sample or Auger Sample

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

The number of blows required to advance a standard 2-inch O.D. split-spoon sampler (SS) the last 12 inches of the total 18-inch penetration with a 140-pound hammer falling 30 inches is considered the “Standard Penetration” or “N-value”. For 2.5” O.D. California Barrel samplers (CB) the penetration value is reported as the number of blows required to advance the sampler 12 inches using a 140-pound hammer falling 30 inches, reported as “blows per inch,” and is not considered equivalent to the “Standard Penetration” or “N-value”.

WATER LEVEL MEASUREMENT SYMBOLS:

WL: Water Level
WCI: Wet Cave in
DCI: Dry Cave in
AB: After Boring

WS: While Sampling
WD: While Drilling
BCR: Before Casing Removal
ACR: After Casing Removal

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

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

FINE-GRAINED SOILS

(CB) Blows/Ft.	(SS) Blows/Ft.	Consistency
< 3	0-2	Very Soft
3-5	3-4	Soft
6-10	5-8	Medium Stiff
11-18	9-15	Stiff
19-36	16-30	Very Stiff
> 36	> 30	Hard

COARSE-GRAINED SOILS

(CB) Blows/Ft.	(SS) Blows/Ft.	Relative Density
0-5	< 3	Very Loose
6-14	4-9	Loose
15-46	10-29	Medium Dense
47-79	30-50	Dense
> 79	> 50	Very Dense

BEDROCK

(CB) Blows/Ft.	(SS) Blows/Ft.	Consistency
< 24	< 20	Weathered
24-35	20-29	Firm
36-60	30-49	Medium Hard
61-96	50-79	Hard
> 96	> 79	Very Hard

RELATIVE PROPORTIONS OF SAND AND GRAVEL

Descriptive Terms of Other Constituents	Percent of Dry Weight
Trace	< 15
With	15 – 29
Modifier	> 30

GRAIN SIZE TERMINOLOGY

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

RELATIVE PROPORTIONS OF FINES

Descriptive Terms of Other Constituents	Percent of Dry Weight
Trace	< 5
With	5 – 12
Modifiers	> 12

PLASTICITY DESCRIPTION

Term	Plasticity Index
Non-plastic	0
Low	1-10
Medium	11-30
High	30+

UNIFIED SOIL CLASSIFICATION SYSTEM

Criteria for Assigning Group Symbols and Group Names Using Laboratory Tests[A]				**Soil Classification**	
				Group Symbol	**Group Name**[B]
Coarse Grained Soils More than 50% retained on No. 200 sieve	Gravels More than 50% of coarse fraction retained on No. 4 sieve	Clean Gravels Less than 5% fines[C]	$Cu \geq 4$ and $1 \leq Cc \leq 3$[E]	GW	Well graded gravel[F]
			$Cu < 4$ and/or $1 > Cc > 3$[E]	GP	Poorly graded gravel[F]
		Gravels with Fines More than 12% fines[C]	Fines classify as ML or MH	GM	Silty gravel[F,G,H]
			Fines classify as CL or CH	GC	Clayey gravel[F,G,H]
	Sands 50% or more of coarse fraction passes No. 4 sieve	Clean Sands Less than 5% fines[D]	$Cu \geq 6$ and $1 \leq Cc \leq 3$[E]	SW	Well graded sand[I]
			$Cu < 6$ and/or $1 > Cc > 3$[E]	SP	Poorly graded sand[I]
		Sands with Fines More than 12% fines[D]	Fines classify as ML or MH	SM	Silty sand[G,H,I]
			Fines classify as CL or CH	SC	Clayey sand[G,H,I]
Fine-Grained Soils 50% or more passes the No. 200 sieve	Silts and Clays Liquid limit less than 50	Inorganic	$PI > 7$ and plots on or above "A" line[J]	CL	Lean clay[K,L,M]
			$PI < 4$ or plots below "A" line[J]	ML	Silt[K,L,M]
		Organic	$\frac{\textbf{Liquid limit - oven dried}}{\textbf{Liquid limit - not dried}} < 0.75$	OL	Organic clay[K,L,M,N]
					Organic silt[K,L,M,O]
	Silts and Clays Liquid limit 50 or more	Inorganic	PI plots on or above "A" line	CH	Fat clay[K,L,M]
			PI plots below "A" line	MH	Elastic silt[K,L,M]
		Organic	$\frac{\text{Liquid limit - oven dried}}{\text{Liquid limit - not dried}} < 0.75$	OH	Organic clay[K,L,M,P]
					Organic silt[K,L,M,Q]
Highly organic soils	Primarily organic matter, dark in color, and organic odor			PT	Peat

[A] Based on the material passing the 3-in. (75-mm) sieve

[B] If field sample contained cobbles or boulders, or both, add "with cobbles or boulders, or both" to group name.

[C] Gravels with 5 to 12% fines require dual symbols: GW-GM well graded gravel with silt, GW-GC well graded gravel with clay, GP-GM poorly graded gravel with silt, GP-GC poorly graded gravel with clay.

[D] Sands with 5 to 12% fines require dual symbols: SW-SM well graded sand with silt, SW-SC well graded sand with clay, SP-SM poorly graded sand with silt, SP-SC poorly graded sand with clay

[E] $Cu = D_{60}/D_{10} \qquad Cc = \frac{(D_{30})^2}{D_{10} \times D_{60}}$

[F] If soil contains ≥ 15% sand, add "with sand" to group name.

[G] If fines classify as CL-ML, use dual symbol GC-GM, or SC-SM.

[H] If fines are organic, add "with organic fines" to group name.

[I] If soil contains ≥ 15% gravel, add "with gravel" to group name.

[J] If Atterberg limits plot in shaded area, soil is a CL-ML, silty clay.

[K] If soil contains 15 to 29% plus No. 200, add "with sand" or "with gravel," whichever is predominant.

[L] If soil contains ≥ 30% plus No. 200 predominantly sand, add "sandy" to group name.

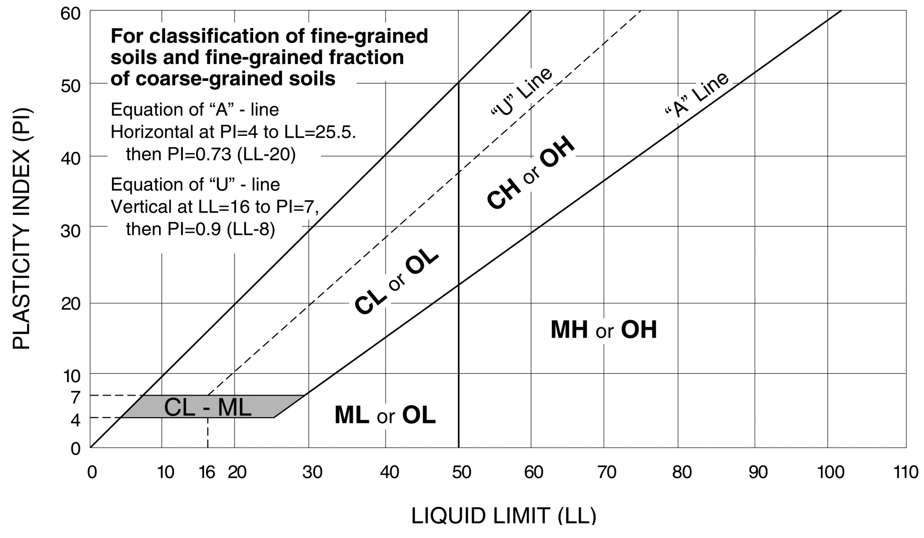
[M] If soil contains ≥ 30% plus No. 200, predominantly gravel, add "gravelly" to group name.

[N] $PI \geq 4$ and plots on or above "A" line.

[O] $PI < 4$ or plots below "A" line.

[P] PI plots on or above "A" line.

[Q] PI plots below "A" line.



ROCK CLASSIFICATION
(Based on ASTM C-294)

Sedimentary Rocks

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

Chert	Very fine-grained siliceous rock composed of micro-crystalline or cyrptocrystalline quartz, chalcedony or opal. Chert is various colored, porous to dense, hard and has a conchoidal to splintery fracture.
Claystone	Fine-grained rock composed of or derived by erosion of silts and clays or any rock containing clay. Soft massive and may contain carbonate minerals.
Conglomerate	Rock consisting of a considerable amount of rounded gravel, sand and cobbles with or without interstitial or cementing material. The cementing or interstitial material may be quartz, opal, calcite, dolomite, clay, iron oxides or other materials.
Dolomite	A fine-grained carbonate rock consisting of the mineral dolomite [$CaMg(CO_3)_2$]. May contain noncarbonate impurities such as quartz, chert, clay minerals, organic matter, gypsum and sulfides. Reacts with hydrochloric acid (HCL).
Limestone	A fine-grained carbonate rock consisting of the mineral calcite ($CaCO_3$). May contain noncarbonate impurities such as quartz, chert, clay minerals, organic matter, gypsum and sulfides. Reacts with hydrochloric acid (HCL).
Sandstone	Rock consisting of particles of sand with or without interstitial and cementing materials. The cementing or interstitial material may be quartz, opal, calcite, dolomite, clay, iron oxides or other material.
Shale	Fine-grained rock composed of or derived by erosion of silts and clays or any rock containing clay. Shale is hard, platy, of fissile may be gray, black, reddish or green and may contain some carbonate minerals (calcareous shale).
Siltstone	Fine grained rock composed of or derived by erosion of silts or rock containing silt. Siltstones consist predominantly of silt sized particles (0.0625 to 0.002 mm in diameter) and are intermediate rocks between claystones and sandstones and may contain carbonate minerals.

LABORATORY TEST
SIGNIFICANCE AND PURPOSE

TEST	SIGNIFICANCE	PURPOSE
California Bearing Ratio	Used to evaluate the potential strength of subgrade soil, subbase, and base course material, including recycled materials for use in road and airfield pavements.	***Pavement Thickness Design***
Consolidation	Used to develop an estimate of both the rate and amount of both differential and total settlement of a structure.	***Foundation Design***
Direct Shear	Used to determine the consolidated drained shear strength of soil or rock.	***Bearing Capacity, Foundation Design, and Slope Stability***
Dry Density	Used to determine the in-place density of natural, inorganic, fine-grained soils.	***Index Property Soil Behavior***
Expansion	Used to measure the expansive potential of fine-grained soil and to provide a basis for swell potential classification.	***Foundation and Slab Design***
Gradation	Used for the quantitative determination of the distribution of particle sizes in soil.	***Soil Classification***
Liquid & Plastic Limit, Plasticity Index	Used as an integral part of engineering classification systems to characterize the fine-grained fraction of soils, and to specify the fine-grained fraction of construction materials.	***Soil Classification***
Permeability	Used to determine the capacity of soil or rock to conduct a liquid or gas.	***Groundwater Flow Analysis***
pH	Used to determine the degree of acidity or alkalinity of a soil.	***Corrosion Potential***
Resistivity	Used to indicate the relative ability of a soil medium to carry electrical currents.	***Corrosion Potential***
R-Value	Used to evaluate the potential strength of subgrade soil, subbase, and base course material, including recycled materials for use in road and airfield pavements.	***Pavement Thickness Design***
Soluble Sulfate	Used to determine the quantitative amount of soluble sulfates within a soil mass.	***Corrosion Potential***
Unconfined Compression	To obtain the approximate compressive strength of soils that possess sufficient cohesion to permit testing in the unconfined state.	***Bearing Capacity Analysis for Foundations***
Water Content	Used to determine the quantitative amount of water in a soil mass.	***Index Property Soil Behavior***

REPORT TERMINOLOGY
(Based on ASTM D653)

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

REPORT TERMINOLOGY
(Based on ASTM D653)

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