Appendix C
Geotechnical Evaluation

January 7, 2020
GMU Project No. 19-230-00

Mr. Steve Davis
Applied Medical
22872 Avenida Empresa
Rancho Santa Margarita, California 92688

RE: GEOTECHNICAL INVESTIGATION
APPLIED MEDICAL EQUIPMENT ROOM
BRIDGE AND BUILDING ADDITION
LAKE FOREST, CALIFORNIA

Dear Mr. Davis:

We are pleased to present the results of our Geotechnical Evaluation for the proposed Applied Medical equipment room bridge between the 20162 and 20202 Windrow Drive buildings and a proposed addition to the east side of the 20202 Windrow Drive structure. Our report includes a description of the geotechnical and seismic aspects of the site along with our conclusions and geotechnical recommendations for subgrade remediation and foundation design for the proposed Applied Medical Equipment Room Bridge and Building Addition.

We refer you to the text of the report for detailed recommendations. To help us continue to add value to your projects, please feel free to contact us and provide feedback. Your opinion is important to us. If you have any questions concerning our findings, please call and we will be glad to discuss them with you.

Very truly yours,

Ali Bastani PhD, F. ASCE, PE, GE 2458
Director of Engineering

AB/ABM

Copies: Emailed to Addressee

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GMU

Geotechnical Investigation

Applied Medical Equipment Room Bridge and Building Addition

Lake Forest, California

Prepared for:

Applied Medical

22872 Avenida Empresa

Rancho Santa Margarita, California 92688

January 7, 2020

Project No. 19-230-00

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LAKE FOREST, CALIFORNIA

1.0 INTRODUCTION

In this report, we present the results of our geotechnical investigation for the proposed Applied Medical equipment room bridge between the 20162 and 20202 Windrow Drive buildings and an addition to the east side of the 20202 Windrow Drive structure in the City of Lake Forest, California. The location of the site is shown on the Location Map, Plate 1. The purpose of our investigation was to evaluate the subsurface conditions and site seismic hazards and perform geotechnical engineering for the design and construction of the proposed building foundation. As part of this work, we reviewed a geotechnical investigation report prepared by Associated Soils Engineering, Inc. (ASE, 2012) which was prepared for the tenant improvements between 20161 and 20162 Windrow Drive buildings.

1.1 Project Description

Applied Medical is planning to connect the two buildings with a bridge structure between them. The new bridge will partially serve as an equipment room. The bridge structure will have an approximate footprint of 80 feet by 170 feet. Vehicle access is expected to be maintained beneath the structure.

The building addition will have approximate dimensions of 25 feet by 175 feet east of 20202 Windrow Drive.

1.2 Scope of Services

Our scope of services was presented in detail in our proposal and an addendum to Applied Medical dated November 18 and December 5, 2019. To accomplish this work, we provided the following services:

- Reviewed existing background information pertaining to the site, including an earlier report by ASE (2012) for the bridge connecting 20161 and 20162 Windrow Drive buildings and published geologic maps and the referenced plans and documents (Appendix A).

- Performed a field investigation program to characterize the soils within the building footprints. The investigation consisted of three 50-foot-deep hollow-stem auger drill holes. Two of the drill holes were excavated for the proposed bridge and the third boring was performed for the proposed addition. The drill holes were logged by one of our staff geologists. The groundwater conditions were noted at the time of drilling. Bulk, Standard Penetration Test (SPT), and relatively undisturbed samples of the typical soil materials were obtained for laboratory testing. Drill hole locations are shown on Plate 2.

- Performed laboratory testing to evaluate the engineering properties of the on-site soil materials.

- Compiled data and performed geotechnical analysis to evaluate site geology, groundwater conditions, geological hazards (liquefaction potential, lateral spreading, earthquake-induced settlement, fault rupture, and ground shaking), design lateral earth pressures for retaining walls, wall foundation design, settlement, earthwork, corrosion, and then develop geotechnical recommendations for design of the proposed improvements.

- Prepared this report summarizing the results of our research, exploration, testing, and analysis, and presenting our conclusions and recommendations related to the design of the proposed improvements.

This effort did not include environmental services.

2.0 SITE CONDITIONS

2.1 Historic Site Use

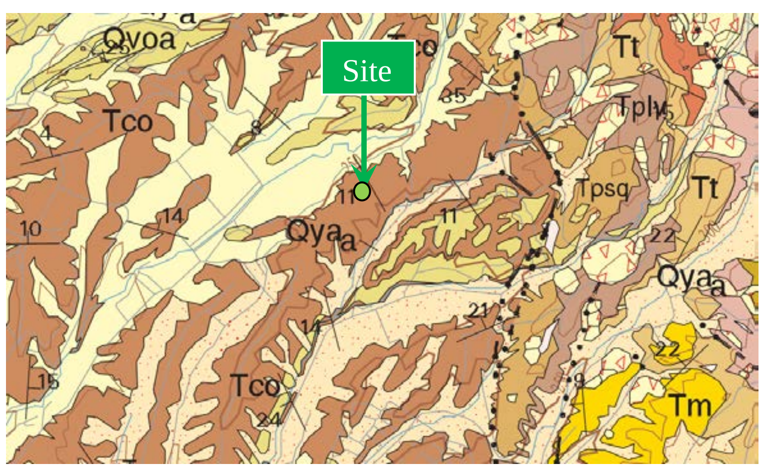
The site was in its natural condition in the early 1900s. Trees were planted at the site during the 1960s through 1980. The area was graded and streets were constructed in the 1990s. The area adjacent to the site, Parkside Homes, was an active sand mine until mid-2000. The aerial photos indicate that the sand mine was extended to the east side of the 20202 Windrow Drive lot, but was never extended under the subject building areas. The subject area was developed in the second half of the 1990s.

2.2 Exploration Program

As part of our investigation, three 50-foot drill holes were excavated at the site. The approximate locations of GMU's field exploration are shown on the Geotechnical Map, Plate 2.

Boring logs and details from our investigation, along with those from earlier field investigations, are included in Appendix A of this report. The laboratory tests are included in Appendix B.

2.3 Geologic Setting



The site is situated along the western flank of the Santa Ana Mountains. Underlying the site at depth are Mesozoic crystalline and sedimentary rocks associated with the Peninsular Ranges geomorphic province. The marine origin, late Miocene to early Pliocene Oso member of the Capistrano

Formation mantles the site and has a maximum thickness of approximately 300 feet. This sedimentary arkosic sandstone is tilted and forms a portion of the broad southeast-plunging Capistrano Syncline. Located approximately one mile east of the site is the Cristianitos fault, which is a high angle normal fault having a roughly north to south strike alignment. There are no conclusive documented exposures of Holocene (recent) displacements along the fault alignment; therefore, the Cristianitos fault is classified as an inactive fault. Numerous field investigations have been performed to classify this fault due to the proximity to the San Onofre nuclear power plant.

Geologic structure was not observed during our exploration. Where documented adjacent to the site, the geologic structure consists of generally continuous, gently to moderately bedding surfaces which generally dip to the south and southwest.

2.3.1 Surface Conditions

Both building sites are over existing paved areas with parking stalls, planters, and occasional planter islands between the parking stalls. The pavement section contains 3 inches of asphalt over 4 to 5 inches of aggregate base. There are some utility line cuts through the pavement; otherwise, the existing pavement is in good condition.

2.3.2 Subsurface Conditions

The project site was underlain by a thin layer of engineered fill underlain by Capistrano Formation.

<u>Engineered Fill:</u> Based on our exploration, engineered fill was present within the upper 2 feet of the site. The fill materials were generally a fine grain, silty sand which was probably extracted from the underlying bedrock.

<u>Capistrano Formation (Tco):</u> The Oso Member of the Capistrano Formation underlies the project site. The Oso Member consists primarily of a fine-grain, uncemented sandstone. The weathered materials typically have well-developed joint patterns. The unweathered sandstone is more massive.

In general, the Capistrano Formation consists of a thick layer of silty sand with occasional thin clayey sand layers. A graphical summary of exploratory boring field data (i.e., soil penetration resistance) and index laboratory test data (i.e., soil classification and index properties) of selected soil specimens versus depth is provided in Plate 3. The soil profile specifically includes a side-by-side plot of the following data versus depth:

- Soil penetration resistance (SPT or equivalent SPT N-values).
- In situ dry density, moisture content, and degree of saturation; and
- Particle size characteristics, namely percent of fine-grained soils (minus No. 200 sieve).

The subsurface bedrock materials have moisture contents between 5 and 17 percent and dry densities ranged from 113 to 120 pounds per cubic feet (pcf). In general, the subsurface soils below the bridge site were representative of the native bedrock with an average blow count of 66.5 blows per foot (bpf) for DH-1 and DH-2.

However, the average blow count for the drilled hole DH-3 was estimated at 32 bpf indicating a softer subsurface soils response at the new building addition.

2.3.3 Groundwater

Groundwater was not encountered in any of our borings nor the previous borings to the explored depth of 50 feet below ground surface (bgs) at the site. The high groundwater level was considered to be deeper than 40 feet per the CGS seismic hazard report (2000).

2.4 Expansion Potential

The Expansion Index was tested between 1 and 9 for surficial soils (i.e., existing fill and the upper part of bedrock). According to the 2019 CBC, soils meeting all four of the following provisions shall be considered expansive, except that tests for compliance with Items 1, 2, and 3 will not be required if the test prescribed in Item 4 is conducted:

1. Plasticity Index (PI) of 15 or greater (ASTM D4318).
2. More than 10 percent of the soil particles pass the #200 sieve (ASTM D422).
3. More than 10 percent of the soil particles are less than 5 micrometers in size (ASTM D422).
4. Expansion index greater than 20 (ASTM D4829).

Based on our review of the data (Expansion Index), the encountered soils may be considered non-expansive.

3.0 SEISMICITY

The site is located in a seismically active region of Southern California. The San Joaquin Hills Blind Trust and the Elsinore fault are located about 3 miles west and 7 miles east of the site, respectively. These faults may produce an earthquake with a maximum moment magnitude (M_{max}) of 7.7 in the area. 2019 CBC parameters, as presented below, were used to evaluate the seismic hazards at the site.

3.1 CBC Site Coefficient

The average blowcount for the upper 100 feet of subsurface soils (Average N) was estimated to be 70 and 63 at Drill Holes DH-1 and DH-2, respectively. Based on the site geology and the Average N, Table 20.3-1 of the ASCE 7-16 indicates that the site has a soft rock profile which corresponds to a Site Class S_C. The seismic design coefficients based on ASCE 7-16 and 2019 CBC are listed in the following Table 1.

Table 1. 2019 CBC Site Categorization and Site Coefficients

Categorization/Coefficient	Design Value
Soil Profile Type (Table 20.3-1 of ASCE 7-16)	S_C
Short Period Spectral Acceleration S_s	1.279
1-sec. Period Spectral Acceleration S_1	0.455
Site Coefficient F_a (Table 1613A.2.3(1) of CBC 2019)	1.2
Site Coefficient F_v (Table 1613A.2.3(2) of CBC 2019)	1.5
Short Period MCE* Spectral Acceleration S_{MS}**	1.535
1-sec. Period MCE Spectral Acceleration S_{M1}**	0.683
Short Period Design Spectral Acceleration S_{DS}**	1.024
1-sec. Period Design Spectral Acceleration S_{D1}**	0.455
MCE Peak Ground Acceleration (PGA) *	0.53g
Site Coefficient F_{PGA} (Table 11.8-1)**	1.2
MCE Peak Ground Acceleration (PGA_M) *	0.64g
Modal Contributing Magnitude to MCE Event	6.6

* MCE: Maximum Considered Earthquake

** Values Obtained from USGS Earthquake Hazards Program website, http://earthquake.usgs.gov/research/hazmaps/design/, based on the ASCE7-16 and 2019 California Building Code and site coordinates of N33.66975º and W117.65762º.

The Maximum Considered Earthquake (MCE) Peak Ground Acceleration (PGA_M) is 0.64g as determined in accordance with the 2019 CBC. This PHGA is primarily dominated by earthquakes with a mean magnitude of 6.6 at a mean distance of about 10 miles from the site using the USGS 2014 Interactive De-aggregation website.

It should be recognized that much of southern California is subject to some level of damaging ground shaking as a result of movement along the major active (and potentially active) fault zones that characterize this region. Design utilizing the 2019 CBC is not meant to completely protect against damage or loss of function. Therefore, the preceding parameters should be considered as minimum design criteria.

4.0 GEOLOGIC HAZARDS

A site-specific evaluation of geologic hazards was made during this investigation. Our comments concerning these hazards are presented below.

4.1 Fault Rupture Hazard

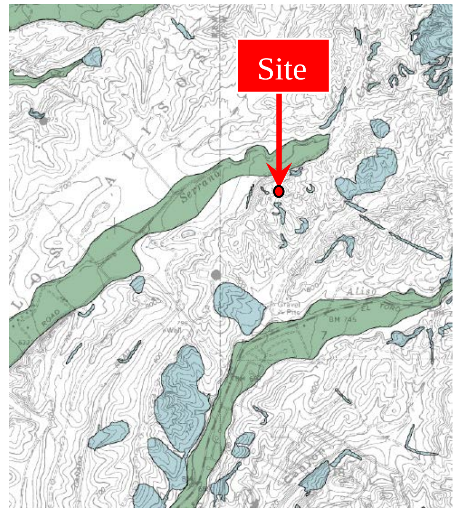
The site is not located within a currently designated Alquist-Priolo Earthquake Fault Zone (known formerly as a Special Studies Zone, Hart and Bryant, 2007).

4.2 Ground Shaking

Strong ground shaking can be expected at the site during moderate to severe earthquakes in the general region. This is common to virtually all developments in Southern California.

4.3 Liquefaction

4.3.1 General Background



The site is not located within the State of California Seismic Hazard Zone for liquefaction for this area (CGS, 2000 – El Toro Quadrangle). Soil liquefaction results from loss of strength during cyclic loading, such as imposed by earthquakes. Soils most susceptible to liquefaction are loose to moderately dense, saturated granular soils with poor drainage, such as silty sands or sands and gravels capped by or containing seams of impermeable sediment.

The project site is underlain by bedrock and the groundwater table is deep; therefore, the liquefaction potential is considered negligible.

4.4 Earthquake-Induced Settlements and Differential Densification

Earthquake-induced settlements are a function of many parameters such as consistency and thickness of liquefiable layers, overburden pressure, liquefaction depth, soil stratification, and effect of soft non-liquefiable layers on the blowcount/CPT tip resistance. Earthquake-induced settlements will include both liquefaction-induced settlements and compaction of unsaturated granular soils under dynamic loads.

Pradel (1998) procedure was used to estimate the EQ-induced settlements based on the SPT data. Cetin et al. (2009) recommended applying weighting factors to EQ-induced settlement with depth to limit the influence of liquefaction at great depth since the deeper deposits' settlement may not propagate to the surface as much as the shallow deposits. The rationale behind the use of a depth weighting factor is based on the following: i) upward seepage, triggering void ratio redistribution, and resulting in unfavorably higher void ratios for the shallower sublayers of soil layers; ii) reduced induced shear stresses and number of shear stress cycles transmitted to deeper soil layers due to initial liquefaction of surficial layers; and iii) possible arching effects due to non-liquefied soil layers. Since the site was underlain by bedrock and loose layers were isolated, Cetin et al. (2009) weighting factors were applied in our analyses.

The earthquake-induced settlements were evaluated for all three drill holes. The total and differential earthquake-induced settlements were estimated at ½-inch and ¼-inch, respectively, at the equipment room bridge. The total and differential earthquake-induced settlements were estimated at 1-inch and ½-inch, respectively, for the new building addition at the east side of 20202 Windrow.

4.5 Lateral Spreading

Since the liquefaction potential is considered negligible at this site, the probability of lateral spreading occurring at the site during a seismic event is also negligible.

4.6 Tsunamis, Inundation, Seiches, and Flooding

The site is at an elevation of approximately 790 feet above mean sea level. Therefore, tsunamis (seismic sea waves) are not considered a significant hazard at the site.

The site is located in an area of 0.2% annual chance flood (Zone X) as designated by the Federal Emergency Management Association. Therefore, the potential for flooding to affect the site is considered low.

The closest dam to the site is the Upper Oso Dam (ID CA01145) owned by Santa Margarita Water District. Based on the Division of Safety of Dams (DSOD) Inundation Maps, the site is not located in the potentially inundated areas due to the local dam failures.

5.0 CORROSION EVALUATION

To evaluate the corrosion potential of the subsurface soils at the site, two representative surficial soil samples collected during our subsurface investigation were tested for soluble sulfate and chloride content, pH, and resistivity. The results of the tests are summarized in Table 2 below.

Table 2. Results of Corrosivity Testing

Boring No.	Depth (feet)	Chloride (mg/kg)	Sulfate (mg/kg)	pH	Resistivity (ohm-cm)	Estimated Corrosivity Based on Resistivity	Estimated Corrosivity Based on Sulfates
DH-1	0-5	600	5	7.8	4,174	Moderate	Negligible
DH-3	0-5	696	10	6.7	3,684	Moderate	Negligible

Note: mg/kg = milligrams per kilogram

Many factors can affect the corrosion potential of soil including soil moisture content, resistivity, permeability and pH, as well as chloride and sulfate concentration. In general, soil resistivity, which is a measure of how easily electrical current flows through soils, is the most influential factor. Based on the findings of studies presented in ASTM STP 1013 titled “Effects of Soil Characteristics on Corrosion” (February, 1989), the approximate relationship between soil resistivity and soil corrosiveness was developed as shown in Table 3 below.

Table 3. Relationship Between Soil Resistivity and Soil Corrosivity

Soil Resistivity (ohm-cm)	Classification of Soil Corrosiveness
0 to 900	Very Severe Corrosion
900 to 2,300	Severely Corrosive
2,300 to 5,000	Moderately Corrosive
5,000 to 10,000	Mildly Corrosive
10,000 to >100,000	Very Mildly Corrosive

Chloride and sulfate ion concentrations and pH appear to play secondary roles in affecting corrosion potential. High chloride levels tend to reduce soil resistivity and break down otherwise protective surface deposits, which can result in corrosion of buried metallic improvements or reinforced concrete structures. Sulfate ions in the soil can lower the soil resistivity and can be highly aggressive to Portland cement concrete by combining chemically with certain constituents of the concrete, principally tricalcium aluminate. This reaction is accompanied by expansion and eventual disruption of the concrete matrix. A potentially high sulfate content could also cause corrosion of the reinforcing steel in concrete. The 2019 CBC, referring to ACI 318, provides requirements for concrete exposed to sulfate-containing solutions as summarized below in Table 4.

Table 4. Relationship Between Sulfate Concentration and Sulfate Exposure (ACI 318 Table No. 4.3.1)

Water-Soluble Sulfate (SO_4) in soil, ppm	Sulfate Exposure
0 to 1,000	Negligible
1,000 to 2,000	Moderate[1]
2,000 to 20,000	Severe
over 20,000	Very Severe

[1] Seawater

Acidity is an important factor of soil corrosivity. The lower the pH (the more acidic the environment), the higher the soil corrosivity with respect to buried metallic structures. As soil pH increases above 7 (the neutral value), the soil is increasingly more alkaline and less corrosive to buried steel structures due to protective surface films which form on steel in high pH environments. A pH between 5 and 8.5 is generally considered relatively passive from a corrosion standpoint.

As shown in Table 2, soil resistivity results range from 3,684 to 4,174 ohm-centimeters. In our opinion, based on the field resistivity results shown in Table 2 and the resistivity correlations presented in Table 3, it appears that the corrosion potential to buried metallic improvements may be characterized as moderately corrosive. Based on our previous experience, in our opinion, sulfate exposure to Portland Cement Concrete (PCC) may be considered negligible for the native subsurface materials sampled. As a good engineering practice, we recommend using Type II/V cement, a maximum water-cement ratio of 0.50, and a minimum compressive strength of 4,000 psi for structural concrete.

We recommend that a corrosion engineer be consulted regarding corrosion protection measures for any underground metallic pipelines or improvements in contact with soil for the project.

6.0 CONCLUSIONS AND DEVELOPMENT CONSIDERATIONS

6.1 Conclusions

From a geotechnical engineering viewpoint, the proposed facilities may be constructed as planned, provided design and construction is performed in accordance with the recommendations presented in this report.

The primary geologic and geotechnical concerns at the site are:

- High ground motion at the site due to the site seismicity; and
- EQ-induced settlements.

There is no mitigation for site seismicity; therefore, the proposed structure(s) should, at minimum, be designed to resist the dynamic loads per the building code requirements. Groundwater is not expected to impact the proposed improvements.

Detailed recommendations are presented in the following sections of this report.

6.2 Plans, Specifications, and Construction Review

Because subsurface conditions may vary from those predicted by relatively small diameter borings, and to check that our recommendations have been properly implemented, we recommend GMU be retained to: 1) review final construction plans and specifications, and 2) observe the earthwork and foundation construction. Also, geotechnical conditions can be affected by the construction process. For the above reasons, our geotechnical recommendations are contingent upon our firm providing geotechnical observation and testing services during construction.

7.0 EARTHWORK

7.1 General

Major grading or major remedial grading is not expected for the proposed improvements. The proposed building foundations may be placed 6 inches into neatly cut bedrock. Twelve inches of the slab-on-grade subgrade should be removed and recompacted (R&R) as engineered fill. The engineered fill should be compacted to 90% relative compaction at a minimum of 2% above optimum moisture content per ASTM D1557, latest release.

7.2 Temporary Slopes and Trench Excavations

Excavations for utility trenches will need to be laid back at an angle no greater than 1:1 up to a depth of 20 feet and/or shored per OSHA requirements.

The above verbiage regarding excavation stability is presented for general guidance only. All aspects of construction stability are the responsibility of the contractor. All governing regulations in regards to excavation stability (i.e., OSHA, City of Lake Forest, etc.) should be followed.

7.3 Construction Observation

All earthwork should be performed under the observation of our representative to check that the site is properly prepared, selected fill materials are satisfactory, and that placement and compaction of fills is performed in accordance with our recommendations and the project specifications. Sufficient notification to us prior to earthwork is essential. The project plans and specifications should incorporate all recommendations contained in this report.

8.0 FOUNDATION AND SLAB-ON-GRADE DESIGN AND CONSTRUCTION

8.1 General

The criteria contained in the following section may be used for the design and construction of the proposed equipment room bridge and building addition as follows:

- As discussed previously, based on the provided conceptual plans, it is our understanding that the proposed equipment room bridge and building addition will be supported by shallow foundations.
- The proposed shallow spread/continuous footings may bear on neatly cut bedrock surface.

8.2 Foundation Design Parameters

Shallow spread/continuous footings foundation system recommendations provided in this section are based on corrective grading performed below the bottom of footings as discussed above. The design parameters are presented below may be used for foundation structural design.

- Bearing Material: Bedrock
- Minimum Footing Size:
  - Width: 24 inches
  - Depth: 18 inches embedment below lowest adjacent soil grade (depth)
- Allowable Bearing Capacity: 3,000 psf for the minimum footing size given above.
  - May be increased by 500 psf for each additional foot of footing depth, and by 200 psf for each additional foot of footing width to a maximum of 4,500 psf
  - Above value may be increased by 1/3 for temporary loads such as wind or seismic
- Settlement:
  - Static Settlement:
    - Total: 1.0 inch
    - Differential: ½-inch over a span of 40 feet
  - Seismic Settlement:

    Bridge:
    - Total: ½-inch
    - Differential: ¼-inch

Addition:
- Total: 1 inch
- Differential: ½-inch

- Lateral Foundation Resistance:
  - Allowable passive resistance: 250 psf/ft (disregard upper 6 inches, max 2,500 psf)
  - Allowable friction coefficient: 0.35
  - Above values may be combined without reduction and may be increased by 1/3 for temporary loads such as wind or seismic

8.3 Slab-on-Grade Subsection and Slab Design

The slab thickness and reinforcement shall be designed by the project structural engineer for the design dead and live loads.

Minimum Thickness: The minimum slab thickness shall be 5 inches.

Minimum Slab Reinforcement: Minimum slab reinforcement shall not be less than No. 3 bars placed at 18 inches on center. Welded wire mesh is not recommended. Care should be taken to position the reinforcement bars in the center of the slab.

Slab Subgrade:
- The upper 12 inches of the on-site soils and subgrade soil should be moisture conditioned to 2% above the optimum moisture content, and compacted to a minimum relative compaction of 90% in accordance with the latest version of ASTM D1557.
- A 4-inch-thick section of compacted ¾-inch crushed rock shall be provided directly below the slab.
- A moisture vapor retarder should be placed per the recommendations provided in the ***Moisture Vapor Transmission*** section of this report (see Section 10.0 below).
- Sand above the moisture retarder/barrier (i.e., directly below the slab) is not a geotechnical issue. This should be provided by the structural engineer

9.0 CONCRETE

As a good engineering practice, we recommend using Type II/V cement, a maximum water-cement ratio of 0.50, and a minimum compressive strength of 4,000 psi for structural concrete.

10.0 MOISTURE VAPOR TRANSMISSION

10.1 Moisture Vapor Retarder

A vapor retarder, such as a 15-mil-thick moisture vapor retarder that meets the requirements of ASTM E1745 Class C (Stego Wrap or equivalent) should be placed directly over the prepared soil subgrade to provide protection against vapor transmission through concrete floor slabs that are anticipated to receive carpet, tile, or other moisture sensitive coverings. The use of a moisture vapor retarder should be determined by the project architect. At minimum, the vapor retarder should be installed as follows:

- Per the manufacture's specifications as well as with the applicable recognized installation procedures such as ASTM E1643;
- Joints between the sheets and the openings for utility piping should be lapped and taped. If the barrier is not continuously placed across footings/ribs, the barrier should, at minimum, be lapped into the side of the footing/rib trenches down to the bottom of the trench; and
- Punctures in the vapor retarder should be repaired prior to concrete placement.

It should be noted that the moisture retarder is intended only to reduce moisture vapor transmissions from the soil beneath the concrete and is consistent with the current standard of the industry in building construction in southern California. It is not intended to provide a "waterproof" or "vapor proof" barrier or reduce vapor transmission from sources above the retarder (i.e., concrete). The evaluation of water vapor from any source and its effect on any aspect of the proposed building space above the slab (i.e., floor covering applicability, mold growth, etc.) is beyond our purview and the scope of this report.

11.0 UTILITY TRENCH BACKFILL CONSIDERATIONS

11.1 General

New utility line pipelines should be backfilled with both select bedding materials beneath, around, and above the pipes (pipe zone), and compacted soil above the pipe bedding/shading. Recommendations for the types of the materials to be used and the proper placement of these materials are provided in the following sections.

11.2 Pipe Zone

The pipe bedding and shading materials should extend from at least 6 inches below the pipes to at least 12 inches above the crown of the pipes. Pipe bedding should consist of either clean sand with a sand equivalent (SE) of at least 30, or crushed rock. If crushed rock is used, it should consist of ¾-inch crushed rock that conforms to Table 200-1.2.1 (A) of the 2018 "Greenbook." Pipe bedding should also meet the minimum requirements of the County of Orange and the City of Lake Forest. If the requirements of the County or City are more stringent, they should take precedence over the geotechnical recommendations. Sufficient laboratory testing should be performed to verify the bedding meets the minimum requirements of the Greenbook and the County and City grading codes.

Based on our subsurface exploration and knowledge of the onsite materials, the soils that will be excavated from the pipeline trenches will not meet the recommendations for pipe bedding materials; therefore, imported materials will be required for pipe bedding.

Granular pipe bedding material having a sand equivalent of 30 or greater should be properly placed in thicknesses not exceeding 3 feet, and then sufficiently flooded or jetted in place.

11.3 Trench Backfill

All existing soil material within the limits of the site are considered suitable for use as trench backfill above the pipe bedding zone if care is taken to remove all significant organic and other decomposable debris, moisture condition the soil materials as necessary, and separate and selectively place and/or stockpile any inert materials larger than 6 inches in maximum diameter.

Imported soils are not anticipated for backfill since the on-site soils are suitable. However, if imported soils are used, the soils should consist of clean, granular materials with physical and chemical characteristics similar to or better than those described herein for on-site soils. Any imported soils to be used as backfill should be evaluated and approved by GMU prior to placement.

Soils to be used as trench backfill should be moistened, dried, or blended as necessary to achieve a minimum of 2% over optimum moisture content (i.e., if the optimum moisture content is 10.5%, the compacted fill's moisture content shall be at least 12.5%), placed in loose lifts no greater than 8 inches thick, and mechanically compacted/densified to at least 90% relative compaction as determined by ASTM Test Method D 1557. Jetting is not permitted in this trench zone.

No rock or broken concrete greater than 6 inches in maximum diameter should be utilized in the trench backfills.

12.0 PAVEMENT

12.1 Asphalt Concrete Pavement Engineering Analysis

Asphalt concrete (AC) pavement thickness analysis was performed in accordance with the Caltrans Highway Design Manual. This design methodology considers the relationship between the subgrade soil strength, as measured by the R-value test, as well as the design traffic index (TI). "Composite" pavement consists of an AC section constructed on top of properly constructed aggregate base (AB) section on top of properly prepared subgrade. Full-depth AC pavement consists of an AC section constructed on top of properly prepared subgrade.

We have assumed that traffic indices (TI) of 5.0 to 7.0 are representative of the anticipated traffic volume and loading conditions. The Project Traffic Engineer should review and assign the appropriate TI to the road.

R-value testing (CTM 301) of the subgrade soil was performed in GMU's in-house Caltrans-certified soils and pavement laboratory resulting in one R-value of 55. A design R-value of 50 was used in our analysis. The final R-value of the subgrade shall be checked if the roadway is rough graded.

12.2 Asphalt Concrete Pavement Recommendations

We have developed the following pavement thickness recommendations for the proposed access road and parking lots for a 20-year design life per Caltrans Highway Design Manual. The actual service life of the pavement can be extended through proper maintenance and rehabilitation (i.e., slurry seal every 7 years, mill-and-overlay every 12-16 years, etc.)

The following table summarizes the recommended minimum AC thicknesses.

Table 6. Conventional AC Pavement Thickness Recommendations

Assumed Traffic Index	Composite Pavement (AC/AB)	Full-Depth AC (AC over subgrade)
5.0	4.0" AC over 4.0" AB over Properly Prepared Subgrade	4.5" AC over Properly Prepared Subgrade
6.0	4.0" AC over 4.0" AB over Properly Prepared Subgrade	5.5" AC over Properly Prepared Subgrade
7.0	4.0" AC over 5.0" AB over Properly Prepared Subgrade	6.5" AC over Properly Prepared Subgrade

Implementing any of these recommendations involves:

- Grading the existing site to create sufficient depth for the recommended AC or AC/AB sections;
- Processing and re-compacting the exposed subgrade material to a depth of at least 12 inches in accordance with Greenbook Sections 301-1.2 and 301-1.3. The required relative compaction of the subgrade is 90% minimum with a moisture content of at or above the optimum moisture content. Maximum density and optimum moisture content of the subgrade should be determined by ASTM D1557;
- Installing the aggregate base section to at least 95% relative compaction and moisture conditioning to near optimum moisture content. Maximum density and optimum moisture content of the aggregate base should be determined by ASTM D1557; and
- Constructing the asphalt concrete (AC) section in two lifts.

All materials used and work performed should meet the current edition of the Standard Specifications for Public Works Construction (Greenbook) with all supplements, unless superseded by the recommendations provided within this report.

Aggregate base may be Crushed Miscellaneous Base (CMB) or Crushed Aggregate Base (CAB) meeting Greenbook Section 200-2.

We recommend using the Greenbook Type IIIC3 AC mix with PG 64-10 asphalt binder for both the AC surface and AC base course sections.

13.0 FUTURE SERVICES

It is recommended that geotechnical observation and testing be performed during the following stages of precise grading and construction.

- During site clearing and grubbing.
- During removal of any buried irrigation lines or other subsurface structures.
- During all phases of precise grading including over-excavation, temporary excavations, removals, scarification, ground preparation, moisture conditioning, proof-rolling, over-excavation, and placement and compaction of all fill materials.
- During installation of foundations.
- During backfill of structure walls and underground utilities.
- During hardscape subgrade and base placement and compaction.
- During pavement section placement and compaction.
- When any unusual conditions are encountered.

Given that the above services are an extension of the geotechnical design, if GMU does not provide observation and testing services during site grading and construction, then the consultant performing the above services would assume all duties and responsibilities of the Geotechnical Engineer of Record (GER), and GMU would no longer be responsible for any of the recommendations contained herein as well as any related performance of any aspect of the project.

14.0 LIMITATIONS

This report has been prepared for the sole use by Applied Medical and its design team, specifically for design of Applied Medical Equipment Room Bridge and Building Addition in Lake Forest, California. The opinions presented in this report have been formulated in accordance with accepted geotechnical engineering practices that exist in Southern California at the time this report was written. No other warranty, expressed or implied, is made or should be inferred.

The opinions, conclusions, and recommendations contained in this report are based upon the information obtained from our investigation, which includes data from widely separated discrete locations, visual observations from our site reconnaissance, and review of other geotechnical data provided to us, along with local experience and engineering judgment. The recommendations presented in this report are based on the assumption that soil and geologic conditions at or between borings do not deviate substantially from those encountered or extrapolated from the information collected during our investigation. We are not responsible for the data presented by others.

GMU should be retained to review the geotechnical aspects of the final plans and specifications for conformance with our recommendations. The recommendations provided in this report are based on the assumption that we will be retained to provide observation and testing services during construction to confirm that conditions are similar to that assumed for design and to form an opinion as to whether the work has been performed in accordance with the project plans and specifications. If we are not retained for these services, GMU cannot assume any responsibility for any potential claims that may arise during or after construction as a result of misuse or misinterpretation of GMU's report by others. Furthermore, GMU will cease to be the Geotechnical-Engineer-of-Record if we are not retained for these services.

The opinions presented in this report are valid as of the date of this report for the property evaluated. Changes in the condition of the property will likely occur with the passage of time due to natural processes and/or the works of man. In addition, changes in applicable standards of practice can occur as a result of legislation and/or the broadening of knowledge. Furthermore, geotechnical issues may arise that were not apparent at the time of our investigation. Accordingly, the opinions presented in this report may be invalidated, wholly or partially, by changes outside of our control. Therefore, this report is subject to review and should not be relied upon after a period of three years, nor should it be used, or is it applicable, for any other properties.

15.0 REFERENCES

15.1 Site Reports

Associated Soils Engineering, Inc., 2012, "Report of Geotechnical Investigation, Proposed Tenant Improvements and Additions, 20161 and 20162 Windrow Drive, Lake Forest, California," Prepared for TD Architects, Project No. 12-6359, Dated October 31, 2012.

15.2 Literature

California Building Code, 2019, "*California Code of Regulations*," Title 24, Part 2, Vol. 2.

California Geological Survey (CGS, formerly known as California Division of Mines and Geology, CDMG) (2001), "*Seismic Hazard Zones, El Toro Quadrangle*".

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Pradel, D. (1998), "*Procedure to Evaluation Earthquake-Induced Settlements in Dry Sandy Soils,"* ASCE Journal of Geotechnical and Geoenvironmental Engineering, Vol 124, No. 4, April 1998.

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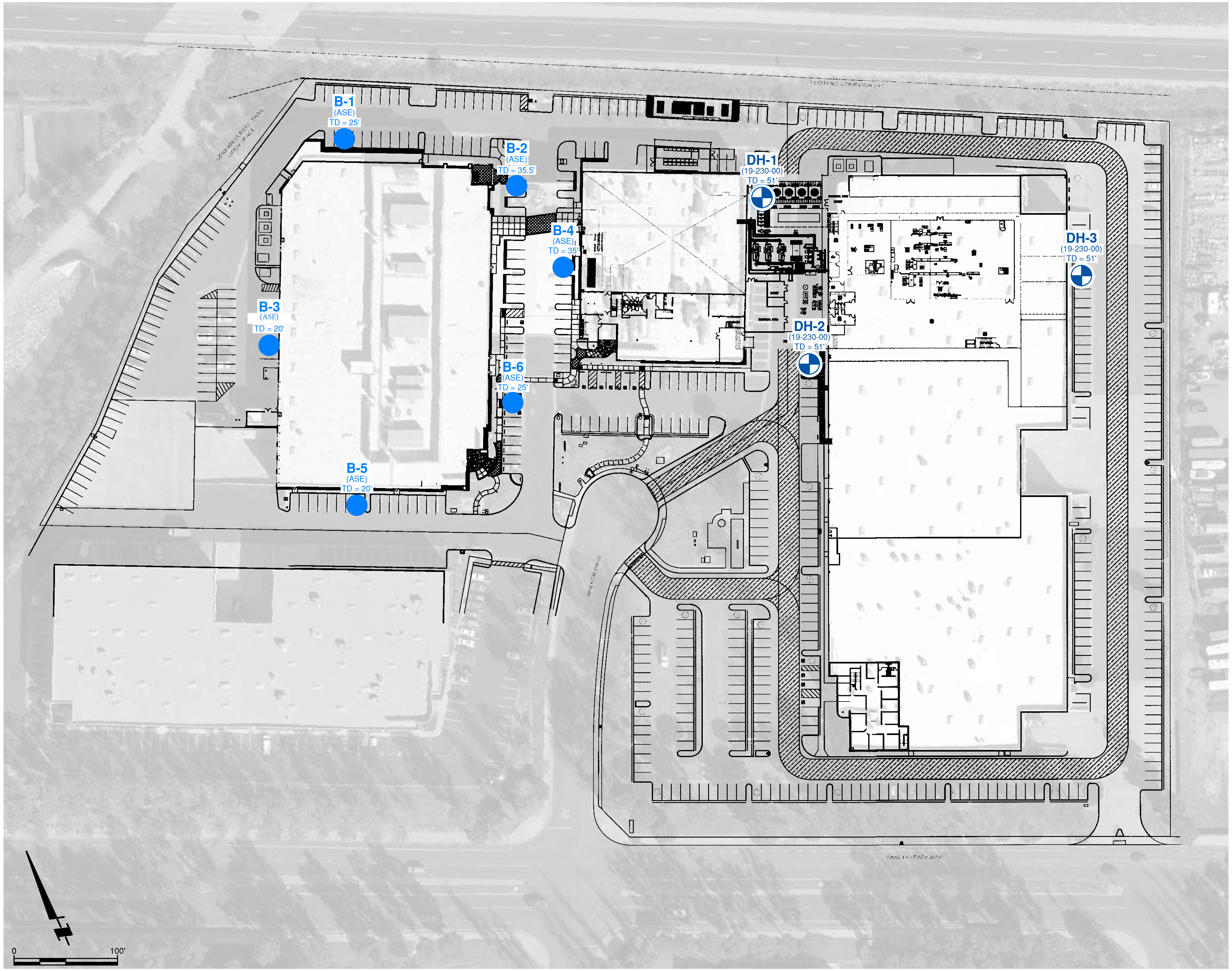
GMU

Location Map

Date: January 10, 2020

Project No.: 19-230-00

Plate 1



LEGEND

DH-3 (19-230-00) — APPROXIMATE LOCATION OF DRILL HOLE BY GMU GEOTECHNICAL, INC. (PROJECT NO. 19-230-00)

B-6 (ASE) — APPROXIMATE LOCATION OF BORING BY ASSOCIATED SOILS ENGINEERING, INC., (ASE)

Geotechnical Map

GMU

Date: January 10, 2020		Plate 2
Project No.: 19-230-00		

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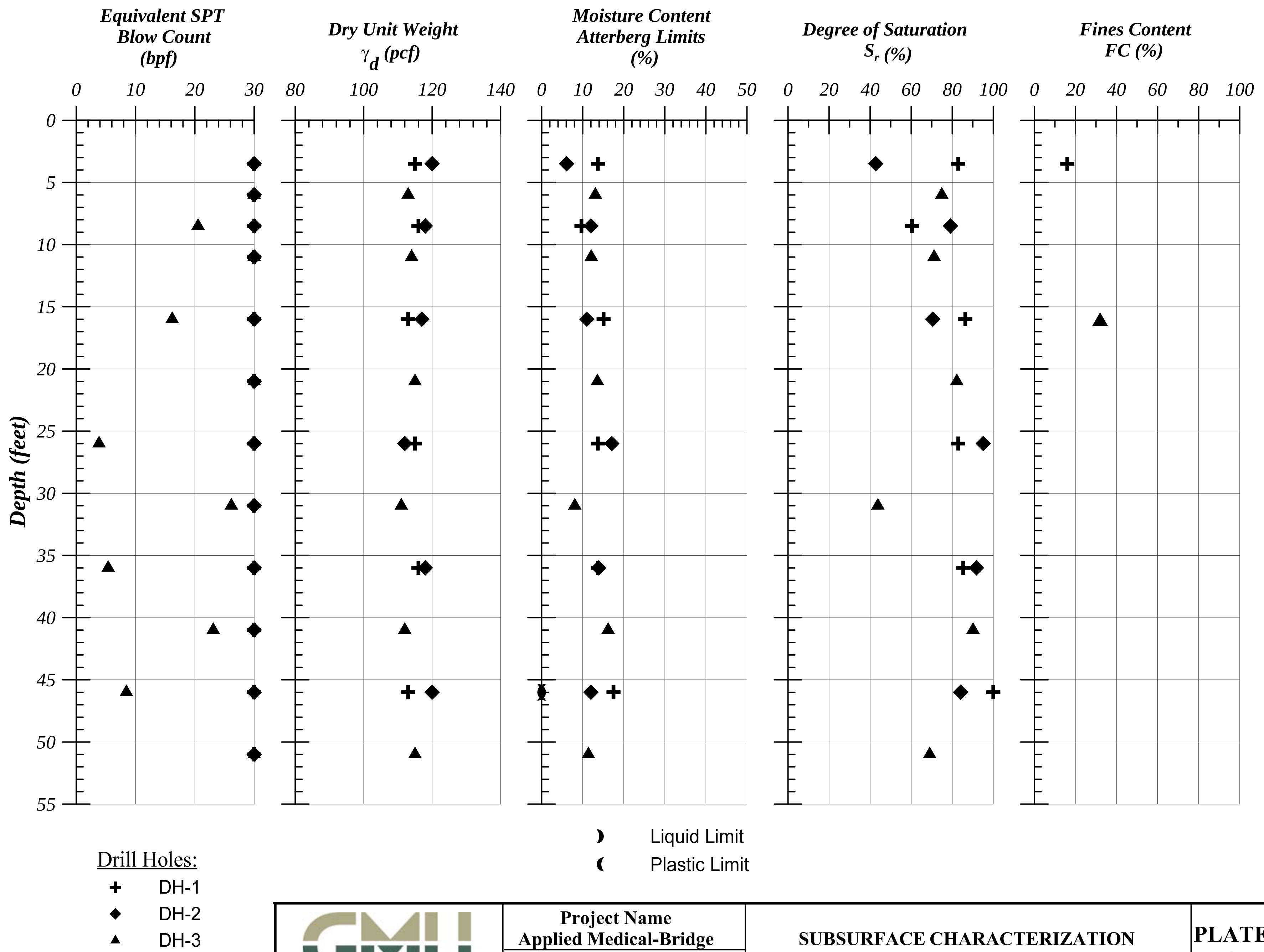


	Project Name Applied Medical-Bridge Project No. 19-230-00	SUBSURFACE CHARACTERIZATION INDEX SOIL PROPERTIES VERSUS DEPTH	PLATE 3

APPENDIX A

Geotechnical Exploration Procedures and Logs

APPENDIX A

GMU GEOTECHNICAL EXPLORATION PROCEDURES AND LOGS

Our exploration at the subject site consisted of three (3) drill holes. The estimated locations of the explorations are shown on Plate 2 – Geotechnical Map. Our drill holes were logged by a Staff Engineer and drive, bulk, and SPT samples of the excavated soils were collected. "Undisturbed" samples were taken using a 3.0-inch, thin-walled outside-diameter drive sampler which contains a 2.416-inch-diameter brass sample sleeve 6 inches in length. Standard penetration testing (SPT) with a 2.0-inch outside diameter split spoon sampler without liners was performed in the borings during advancement. Blow counts recorded during sampling from the drive and SPT are shown on the drill hole logs. The logs of each drill hole are contained in this Appendix A, and the Legend to Logs is presented as Plates A-1 and A-2.

The geologic and engineering field descriptions and classifications that appear on these logs are prepared according to Corps of Engineers and Bureau of Reclamation standards. Major soil classifications are prepared according to the Unified Soil Classification System as modified by ASTM Standard No. 2487. Since the descriptions and classifications that appear on the Log of Drill holes are intended to be that which most accurately describe a given interval of a drill hole, discrepancies do occur in the Unified Soil Classification System nomenclature between that interval and a particular sample in that interval. For example, an 8-foot-thick interval in a log may be identified as silty sand (SM) while one sample taken within the interval may have individually been identified as sandy silt (ML). This discrepancy is frequently allowed to remain to emphasize the occurrence of local textural variations in the interval.

MAJOR DIVISIONS			Group Letter	Symbol	TYPICAL NAMES
COARSE-GRAINED SOILS More Than 50% Retained On No.200 Sieve Based on The Material Passing The 3-Inch (75mm) Sieve. Reference: ASTM Standard D2487	GRAVELS 50% or More of Coarse Fraction Retained on No.4 Sieve	Clean Gravels	GW		Well Graded Gravels and Gravel-Sand Mixtures, Little or No Fines.
			GP		Poorly Graded Gravels and Gravel-Sand Mixtures Little or No Fines.
		Gravels With Fines	GM		Silty Gravels, Gravel-Sand-Silt Mixtures.
			GC		Clayey Gravels, Gravel-Sand-Clay Mixtures.
	SANDS More Than 50% of Coarse Fraction Passes No.4 Sieve	Clean Sands	SW		Well Graded Sands and Gravelly Sands, Little or No Fines.
			SP		Poorly Graded Sands and Gravelly Sands, Little or No Fines.
		Sands With Fines	SM		Silty Sands, Sand-Silt Mixtures.
			SC		Clayey Sands, Sand-Clay Mixtures.
FINE-GRAINED SOILS 50% or More Passe The No.200 Sieve Based on The Material Passing The 3-Inch (75mm) Sieve. Reference: ASTM Standard D2487	SILTS AND CLAYS Liquid Limit Less Than 50%		ML		Inorganic Silts, Very Fine Sands, Rock Flour, Silty or Clayey Fine Sands or Clayey Silts With Slight Plasticity.
			CL		Inorganic Clays of Low To Medium Plasticity, Gravelly Clays, Sandy Clays, Silty Clays, Lean Clays.
			OL		Organic Silts and Organic Silty Clays of Low Plasticity
	SILTS AND CLAYS Liquid Limit 50% or Greater		MH		Inorganic Silts, Micaceous or Diatomaceous Fine Sandy or Silty Soils, Elastic Silts.
			CH		Inorganic Clays of High Plasticity, Fat Clays.
			OH		Organic Clays of Medium To High Plasticity, Organic Silts.
HIGHLY ORGANIC SOILS			PT		Peat and Other Highly Organic Soils.

The descriptive terminology of the logs is modified from current ASTM Standards to suit the purposes of this study

ADDITIONAL TESTS

DS = Direct Shear
HY = Hydrometer Test
TC = Triaxial Compression Test
UC = Unconfined Compression
CN = Consolidation Test
(T) = Time Rate
EX = Expansion Test
CP = Compaction Test
PS = Particle Size Distribution
EI = Expansion Index
SE = Sand Equivalent Test
AL = Atterberg Limits
FC = Chemical Tests
RV = Resistance Value
SG = Specific Gravity
SU = Sulfates
CH = Chlorides
MR = Minimum Resistivity
pH
(N) = Natural Undisturbed Sample
(R) = Remolded Sample
CS = Collapse Test/Swell-Settlement

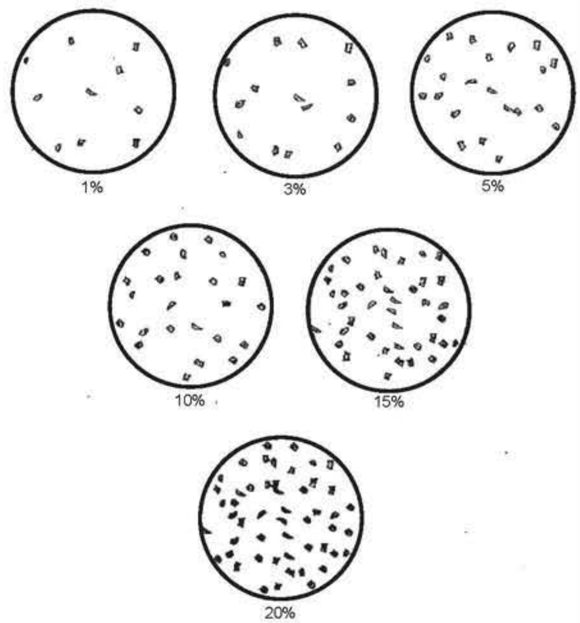
GEOLOGIC NOMENCLATURE

B = Bedding C = Contact J = Joint
F = Fracture Flt = Fault S = Shear
RS = Rupture Surface ○～ = Seepage
▼ = Groundwater

SAMPLE SYMBOLS

Undisturbed Sample (California Sample)
Undisturbed Sample (Shelby Tube)
Bulk Sample
Unsuccessful Sampling Attempt
SPT Sample

5 10 15 Blows per 6-Inches Penetration
10: 10 Blows for 12-Inches Penetration
6/4": 6 Blows for 4-Inches Penetration
P: Push
(13): Uncorrected Blow Counts ("N" Values) for 12-Inches Penetration- Standard Penetration Test (SPT)



GMU

LEGEND TO LOGS
ASTM Designation: D 2487
(Based on Unified Soil Classification System)

Plate
A-1

SOIL DENSITY/CONSISTENCY

FINE GRAINED

Consistency	Field Test	SPT (#blows/foot)	Mod (#blows/foot)
Very Soft	Easily penetrated by thumb, exudes between fingers	<2	<3
Soft	Easily penetrated one inch by thumb, molded by fingers	2-4	3-6
Firm	Penetrated over 1/2 inch by thumb with moderate effort	4-8	6-12
Stiff	Penetrated about 1/2 inch by thumb with great effort	8-15	12-25
Very Stiff	Readily indented by thumbnail	15-30	25-50
Hard	Indented with difficulty by thumbnail	>30	>50

COARSE GRAINED

Density	Field Test	SPT (#blows/foot)	Mod (#blows/foot)
Very Loose	Easily penetrated with 0.5" rod pushed by hand	<4	<5
Loose	Easily penetrated with 0.5" rod pushed by hand	4-10	5-12
Medium Dense	Easily penetrated 1' with 0.5" rod driven by 5lb hammer	10-30	12-35
Dense	Dificult to penetrat 1' with 0.5" rod driven by 5lb hammer	31-50	35-60
Very Dense	Penetrated few inches with 0.5" rod driven by 5lb hammer	>50	>60

BEDROCK HARDNESS

Density	Field Test	SPT (#blows/foot)
Soft	Can be crushed by hand, soil like and structureless	1-30
Moderately Hard	Can be grooved with fingernails, crumbles with hammer	30-50
Hard	Can't break by hand, can be grooved with knife	50-100
Very Hard	Scratches with knife, chips with hammer blows	>100

MODIFIERS

Trace	1%
Few	1-5%
Some	5-12%
Numerous	12-20%
Abundant	>20%

GRAIN SIZE

Description		Sieve Size	Grain Size	Approximate Size
Boulders		>12"	>12"	Larger than a basketball
Cobbles		3-12"	3-12"	Fist-sized to basketball-sized
Gravel	Coarse	3/4-3"	3/4-3"	Thumb-sized to fist-sized
	Fine	#4-3/4"	0.19-0.75"	Pea-sized to thumb-sized
Sand	Coarse	#10-#4	0.079-0.19"	Rock-salt-sized to pea-sized
	Medium	#40-#10	0.017-0.079"	Sugar-sized to rock salt-sized
	Fine	#200-#40	0.0029-0.017"	Flour-sized to sugar-sized
Fines		passing #200	<0.0029"	Flour-sized and smaller

MOISTURE CONTENT

Dry- Very little or no moisture
Damp- Some moisture but less than optimum
Moist- Near optimum
Very Moist- Above optimum
Wet/Saturated- Contains free moisture

GMU

LEGEND TO LOGS
ASTM Designation: D 2487
(Based on Unified Soil Classification System)

Plate
A-2

Project: Applied Medical - Equipment Room Bridge
Project Location: 20162-20202 Windrow Drive
Project Number: 19-230-00

Log of Drill Hole DH-1

Date(s) Drilled	12/6/19	Logged By	RVC	Checked By	AB
Drilling Method	Hollow Stem Auger	Drilling Contractor	2R Drilling	Total Depth of Drill Hole	51.0 feet
Drill Rig Type	CME 75	Diameter(s) of Hole, inches	8 Inches	Approx. Surface Elevation, ft MSL	780.0
Groundwater Depth [Elevation], feet	N/A []	Sampling Method(s)	California Modified Sampler with 6-inch sleeve/SPT	Drill Hole Backfill	Native
Remarks	No groundwater encountered, no caving			Driving Method and Drop	140 lb hammer, 30" drop

ELEVATION, feet	DEPTH, feet	GRAPHIC LOG	GEOLOGICAL CLASSIFICATION AND DESCRIPTION	ORIENTATION DATA	ENGINEERING CLASSIFICATION AND DESCRIPTION	SAMPLE DATA: SAMPLE	SAMPLE DATA: NUMBER OF BLOWS / 6"	SAMPLE DATA: DRIVING WEIGHT, lbs	TEST DATA: MOISTURE CONTENT, %	TEST DATA: DRY UNIT WEIGHT, pcf	TEST DATA: ADDITIONAL TESTS
			3" ASPHALT, 4" BASE								CP, DS, EI, FC
			ARTIFICIAL FILL (Qaf)		SILTY SAND (SM), olive brown, damp, dense, fine to medium grained sand, orange patches						
			CAPISTRANO FORMATION (OSO MEMBER) (Tco)		SILTY SAND (SM), olive brown, damp, dense, fine to medium grained sand, orange patches		13 21 30		14	115	
775	5						7 9 12				PS
							13 25 37		10	116	
770	10				Becomes olive with fine grained sand		7 9 15				
765	15						12 20 33		15	113	

ELEVATION, feet	DEPTH, feet	GRAPHIC LOG	GEOLOGICAL CLASSIFICATION AND DESCRIPTION	ORIENTATION DATA	ENGINEERING CLASSIFICATION AND DESCRIPTION	SAMPLE	NUMBER OF BLOWS / 6"	DRIVING WEIGHT, lbs	MOISTURE CONTENT, %	DRY UNIT WEIGHT, pcf	ADDITIONAL TESTS
					SILTY SAND (SM), olive brown, damp, dense, fine grained sand		9 16 20				
					CLAYEY SAND (SC), dark brown, damp, dense, fine grained sand						
755	25				SILTY SAND (SM), olive brown, damp, dense, fine grained sand		18 32 50		14	115	
750	30				Becomes olive gray with orange and brown patches fine to medium grained sand		12 16 50/6"				
745	35				Becomes Grayish brown with fine grained sand		10 16 50/6"		14	116	
740	40						12 15 18				

ELEVATION, feet	DEPTH, feet	GRAPHIC LOG	GEOLOGICAL CLASSIFICATION AND DESCRIPTION	ORIENTATION DATA	ENGINEERING CLASSIFICATION AND DESCRIPTION	SAMPLE DATA: SAMPLE	SAMPLE DATA: NUMBER OF BLOWS / 6"	SAMPLE DATA: DRIVING WEIGHT, lbs	TEST DATA: MOISTURE CONTENT, %	TEST DATA: DRY UNIT WEIGHT, pcf	TEST DATA: ADDITIONAL TESTS
					SILTY SAND (SM); olive gray, damp, very dense, very fine to fine grained sand, dark brown clay pockets		30 50/6"		18	113	AL
730	50				SILTY SAND (SM), light brown, moist to wet, dense fine to medium grained sand		19 24 30				
					Total Depth - 51 feet No Groundwater encountered No caving						

DH_REV3 19-230-00.GPJ GMULAB.GPJ 12/18/19

Project: Applied Medical - Equipment Room Bridge	**Log of Drill Hole DH-2**
Project Location: 20162-20202 Windrow Drive	Sheet 1 of 3
Project Number: 19-230-00	

Date(s) Drilled	**12/6/19**	Logged By	**RVC**	Checked By	**AB**
Drilling Method	**Hollow Stem Auger**	Drilling Contractor	**2R Drilling**	Total Depth of Drill Hole	**51.0 feet**
Drill Rig Type	**CME 75**	Diameter(s) of Hole, inches	**8 Inches**	Approx. Surface Elevation, ft MSL	**780.0**
Groundwater Depth [Elevation], feet	**N/A []**	Sampling Method(s)	**California Modified Sampler with 6-inch sleeve/SPT**	Drill Hole Backfill	**Native**
Remarks	**No groundwater encountered, no caving**			Driving Method and Drop	**140 lb hammer, 30" drop**

ELEVATION, feet	DEPTH, feet	GRAPHIC LOG	GEOLOGICAL CLASSIFICATION AND DESCRIPTION	ORIENTATION DATA	ENGINEERING CLASSIFICATION AND DESCRIPTION	SAMPLE DATA: SAMPLE	SAMPLE DATA: NUMBER OF BLOWS / 6"	SAMPLE DATA: DRIVING WEIGHT, lbs	TEST DATA: MOISTURE CONTENT, %	TEST DATA: DRY UNIT WEIGHT, pcf	TEST DATA: ADDITIONAL TESTS
			3" ASPHALT, 5" BASE								FC
			ARTIFICIAL FILL (Qaf)		SILTY SAND (SM), light brown dry to damp, dense, very fine to fine grained sand						
			CAPISTRANO FORMATION (OSO MEMBER) (Tco)		SILTY SAND (SM), light brown, damp, dense, very fine to fine grained sand Becomes damp		27 36 15		6	120	DS
775	5						14 14 16				
					Continues to be silty sand with orange patches		30 26 15		12	118	CN, (T)
770	10						14 18 23				
765	15						20 40 50/5"		11	117	

ELEVATION, feet	DEPTH, feet	GRAPHIC LOG	GEOLOGICAL CLASSIFICATION AND DESCRIPTION	ORIENTATION DATA	ENGINEERING CLASSIFICATION AND DESCRIPTION	SAMPLE DATA: SAMPLE	SAMPLE DATA: NUMBER OF BLOWS / 6"	SAMPLE DATA: DRIVING WEIGHT, lbs	TEST DATA: MOISTURE CONTENT, %	TEST DATA: DRY UNIT WEIGHT, pcf	TEST DATA: ADDITIONAL TESTS
					SILTY SAND (SM), light brown, damp to moist, dense, very fine to fine grained sand		12 16 23				
755	25						22 50/6"		17	112	
750	30				Becomes olive brown with orange patches, fine to medium grained sand		12 20 22				
745	35						25 50/6"		14	118	
740	40						10 15 26				
					CLAYEY SAND (SC), dark brown, damp, fine grained sand , few clay pockets						

DH_REV3 19-230-00.GPJ GMULAB.GPJ 12/18/19

ELEVATION, feet	DEPTH, feet	GRAPHIC LOG	GEOLOGICAL CLASSIFICATION AND DESCRIPTION	ORIENTATION DATA	ENGINEERING CLASSIFICATION AND DESCRIPTION	SAMPLE DATA: SAMPLE	SAMPLE DATA: NUMBER OF BLOWS / 6"	SAMPLE DATA: DRIVING WEIGHT, lbs	TEST DATA: MOISTURE CONTENT, %	TEST DATA: DRY UNIT WEIGHT, pcf	TEST DATA: ADDITIONAL TESTS
					Becomes dark brown and olive, moist to wet		26 37 33		12	120	
730	50				Becomes dark brown and light brown, very fine grained sand		8 9 11				PS
					Total Depth - 51 feet No Groundwater encountered No caving						

DH_REV3 19-230-00.GPJ GMULAB.GPJ 12/18/19

Project: Applied Medical - Equipment Room Bridge	**Log of Drill Hole DH-3**
Project Location: 20162-20202 Windrow Drive	Sheet 1 of 3
Project Number: 19-230-00	

Date(s) Drilled	**12/11/19**	Logged By	**RVC**	Checked By	**AB**
Drilling Method	**Hollow Stem Auger**	Drilling Contractor	**2R Drilling**	Total Depth of Drill Hole	**51.0 feet**
Drill Rig Type	**CME 75**	Diameter(s) of Hole, inches	**8 Inches**	Approx. Surface Elevation, ft MSL	**780.0**
Groundwater Depth [Elevation], feet	**N/A []**	Sampling Method(s)	**California Modified Sampler with 6-inch sleeve/SPT**	Drill Hole Backfill	**Native**
Remarks	**No groundwater encountered, no caving**			Driving Method and Drop	**140 lb hammer, 30" drop**

ELEVATION, feet	DEPTH, feet	GRAPHIC LOG	GEOLOGICAL CLASSIFICATION AND DESCRIPTION	ORIENTATION DATA	ENGINEERING CLASSIFICATION AND DESCRIPTION	SAMPLE DATA: SAMPLE	SAMPLE DATA: NUMBER OF BLOWS / 6"	SAMPLE DATA: DRIVING WEIGHT, lbs	TEST DATA: MOISTURE CONTENT, %	TEST DATA: DRY UNIT WEIGHT, pcf	TEST DATA: ADDITIONAL TESTS
			3" ASPHALT, 5" BASE								EI, FC
			ARTIFICIAL FILL (Qaf)		SILTY SAND (SM); olive, damp to moist, very dense, fine grained sand						
			CAPISTRANO FORMATION (OSO MEMBER) (Tco)		SILTY SAND (SM); olive, damp to moist, very dense, fine grained sand						
775	5						13 25 41		13	113	DS
							6 6 10				
770	10						9 20 30		12	114	
765	15				Becomes olive brown with orange specles, very fine to fine grained sand		5 9 12				PS

DH_REV3 19-230-00.GPJ GMULAB.GPJ 12/18/19

GMU

Drill Hole DH-3

Project: Applied Medical - Equipment Room Bridge
Project Location: 20162-20202 Windrow Drive
Project Number: 19-230-00

Log of Drill Hole DH-3

ELEVATION, feet	DEPTH, feet	GRAPHIC LOG	GEOLOGICAL CLASSIFICATION AND DESCRIPTION	ORIENTATION DATA	ENGINEERING CLASSIFICATION AND DESCRIPTION	SAMPLE DATA: SAMPLE	SAMPLE DATA: NUMBER OF BLOWS / 6"	SAMPLE DATA: DRIVING WEIGHT, lbs	TEST DATA: MOISTURE CONTENT, %	TEST DATA: DRY UNIT WEIGHT, pcf	TEST DATA: ADDITIONAL TESTS
					SILTY SAND (SM); light brown, damp to moist, very loose to loose, fine grained sand		18 28 44		14	115	
755	25				Becomes medium dense		3 2 3				
750	30				Becomes loose		7 7 10		8	111	
745	35				CLAYEY SAND (SC); dark brown, damp to moist, medium dense, fine grained sand		3 3 4				
740	40				SILTY SAND (SM); olive brown, damp to moist, loose, fine grained sand		5 7 8		16	112	

GMU

ELEVATION, feet	DEPTH, feet	GRAPHIC LOG	GEOLOGICAL CLASSIFICATION AND DESCRIPTION	ORIENTATION DATA	ENGINEERING CLASSIFICATION AND DESCRIPTION	SAMPLE DATA: SAMPLE	SAMPLE DATA: NUMBER OF BLOWS / 6"	SAMPLE DATA: DRIVING WEIGHT, lbs	TEST DATA: MOISTURE CONTENT, %	TEST DATA: DRY UNIT WEIGHT, pcf	TEST DATA: ADDITIONAL TESTS
					SILTY SAND (SM); olive brown, damp to moist, medium dense, fine grained sand		3 5 6				
730	50						9 11 15		11	115	
					Total depth - 51 feet No groundwater encountered No caving						

DH_REV3 19-230-00.GPJ GMULAB.GPJ 12/18/19

APPENDIX B

Geotechnical Laboratory Procedures and Test Results

APPENDIX B

GMU GEOTECHNICAL LABORATORY PROCEDURES AND TEST RESULTS

MOISTURE AND DENSITY

Field moisture content and in-place density were determined for each 6-inch sample sleeve of undisturbed soil material obtained from the drill holes. The field moisture content was determined in general accordance with ASTM Test Method D 2216 by obtaining one-half the moisture sample from each end of the 6-inch sleeve. The in-place dry density of the sample was determined by using the wet weight of the entire sample.

At the same time the field moisture content and in-place density were determined, the soil material at each end of the sleeve was classified according to the Unified Soil Classification System. The results of the field moisture content and in-place density determinations are presented on the right-hand column of the Log of Drill Hole and are summarized on Table B-1. The results of the visual classifications were used for general reference.

PARTICLE SIZE DISTRIBUTION

As part of the engineering classification of the materials underlying the site, samples were tested to determine the distribution of particle sizes. The distribution was determined in general accordance with ASTM Test Method D 422 using U.S. Standard Sieve Openings 3", 1.5", 3/4, 3/8, and U.S. Standard Sieve Nos. 4, 10, 20, 40, 60, 100, and 200. In addition, on some samples a standard hydrometer test was performed to determine the distribution of particle sizes passing the No. 200 sieve (i.e., silt and clay-size particles). The results of the tests are contained in this Appendix B. Key distribution categories (% gravel; % sand, etc.) are contained on Table B-1.

ATTERBERG LIMITS

As part of the engineering classification of the soil material, samples of the on-site soil material were tested to determine relative plasticity. This relative plasticity is based on the Atterberg limits determined in general accordance with ASTM Test Method D 4318. The results of these tests are contained in this Appendix B and also Table B-1.

EXPANSION TESTS

To provide a standard definition of one-dimensional expansion, a test was performed on typical on-site materials in general accordance with ASTM Test Method D 4829. The result from this test procedure is reported as an “expansion index”. The results of this test are contained in this Appendix B and also Table B-1.

CHEMICAL TESTS

The corrosion potential of typical on-site materials under long-term contact with both metal and concrete was determined by chemical and electrical resistance tests. The soluble sulfate test for potential concrete corrosion was performed in general accordance with California Test Method 417, the minimum resistivity test for potential metal corrosion was performed in general accordance with California Test Method 643, and the concentration of soluble chlorides was determined in general accordance with California Test Method 422. The results of these tests are contained in this Appendix B and also Table B-1.

COMPACTION TESTS

Bulk sample representatives of the on-site materials were tested to determine the maximum dry density and optimum moisture content of the soil. These compactive characteristics were determined in general accordance with ASTM Test Method D 1557. The results of this test are contained in this Appendix B and also Table B-1.

CONSOLIDATION TESTS

The one-dimensional consolidation properties of “undisturbed” samples were evaluated in general accordance with the provisions of ASTM Test Method D 2435. Sample diameter was 2.416 inches and sample height was 1.00 inch. Water was added during the test at various normal loads to evaluate the potential for hydro-collapse and to produce saturation during the remainder of the testing. Consolidation readings were taken regularly during each load increment until the change in sample height was less than approximately 0.0001 inch over a two-hour period. The graphic presentation of consolidation data is a representation of volume change in change in axial load. In addition, time rate tests were performed for a sample. The results of this test are contained in this Appendix B.

DIRECT SHEAR STRENGTH TESTS

Direct shear tests were performed on typical on-site materials. The general philosophy and procedure of the tests were in accord with ASTM Test Method D 3080 - "Direct Shear Tests for Soils Under Consolidated Drained Conditions".

The tests are single shear tests and are performed using a sample diameter of 2.416 inches and a height of 1.00 inch. The normal load is applied by a vertical dead load system. A constant rate of strain is applied to the upper one-half of the sample until failure occurs. Shear stress is monitored by a strain gauge-type precision load cell and deflection is measured with a digital dial indicator. This data is transferred electronically to data acquisition software which plots shear strength vs. deflection. The shear strength plots are then interpreted to determine either peak or ultimate shear strengths. Residual strengths were obtained through multiple shear box reversals. A strain rate compatible with the grain size distribution of the soils was utilized. The interpreted results of these tests are shown in this Appendix B.

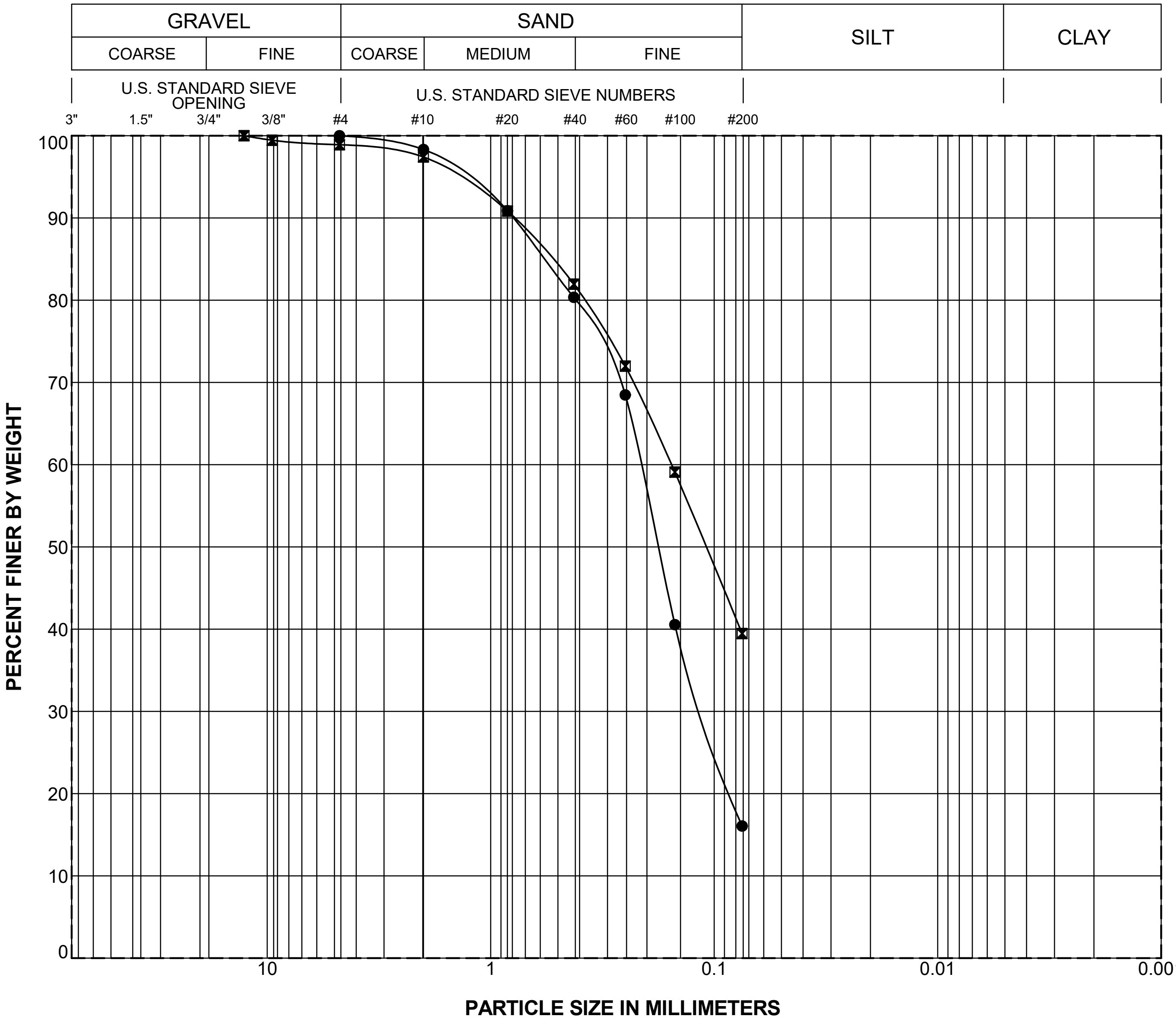
R-VALUE TESTS

Bulk samples representative of the underlying on-site materials were tested to measure the response of a compacted sample to a vertically applied pressure under specific conditions. The R-value of a material is determined when the material is in a state of saturation such that water will be exuded from the compacted test specimen when a 16.8 kN load (2.07 MPa) is applied. The results from these test procedures are reported in this Appendix B.

TABLE B-1
SUMMARY OF SOIL LABORATORY DATA

Sample Information			Geologic Unit	USCS Group Symbol	In Situ Water Content, %	In Situ Dry Unit Weight, pcf	In Situ Satur-ation, %	Sieve/Hydrometer				Atterberg Limits			Compaction		Expansion Index	R-Value	Chemical Test Results			
Boring Number	Depth, feet	Elevation, feet						Gravel, %	Sand, %	<#200, %	<2μ, %	LL	PL	PI	Maximum Dry Unit Weight, pcf	Optimum Water Content, %			pH	Sulfate (ppm)	Chloride (ppm)	Min. Resistivity (ohm/cm)
DH-1	0	780.0	Qaf	SM				0	84	16					121.5	10.0	9		7.8	5	600	4174
DH-1	2.5	777.5	Tco	SM	13.7	115	83															
DH-1	7.5	772.5	Tco	SM	9.7	116	61															
DH-1	15	765.0	Tco	SM	15.1	113	86															
DH-1	25	755.0	Tco	SM	13.7	115	82															
DH-1	35	745.0	Tco	SM	13.7	116	84															
DH-1	45	735.0	Tco	SM	17.5	113	100					NP	NP	NP								
DH-2	2.5	777.5	Tco	SM	6.1	120	43											55				
DH-2	7.5	772.5	Tco	SM	12.0	118	79															
DH-2	15	765.0	Tco	SM	11.0	117	69															
DH-2	25	755.0	Tco	SM	17.1	112	95															
DH-2	35	745.0	Tco	SM	13.9	118	91															
DH-2	45	735.0	Tco	SC/SM	12.0	120	83															
DH-2	50	730.0	Tco	SC				1	59	39												
DH-3	0	780.0	Qaf	SM													1		6.7	10	696	3684
DH-3	5	775.0	Tco	SM	13.1	113	76															
DH-3	10	770.0	Tco	SM	12.1	114	70															
DH-3	15	765.0	Tco	SM				0	68	32												
DH-3	20	760.0	Tco	SM	13.6	115	82															
DH-3	30	750.0	Tco	SM	8.1	111	44															
DH-3	40	740.0	Tco	SC	16.2	112	91															
DH-3	50	730.0	Tco	SC	11.4	115	69															

Project: Applied Medical - Equipment Room Bridge
Project No. 19-230-00



Boring Number	Depth (feet)	Geologic Unit	Symbol	LL	PI	Classification
DH-1	0.0	Qaf	●			SILTY SAND (SM)
DH-2	50.0	Tco	⊠			CLAYEY SAND (SC)

GMU_GRAIN_SIZE 19-230-00.GPJ 1/2/20

PARTICLE SIZE DISTRIBUTION

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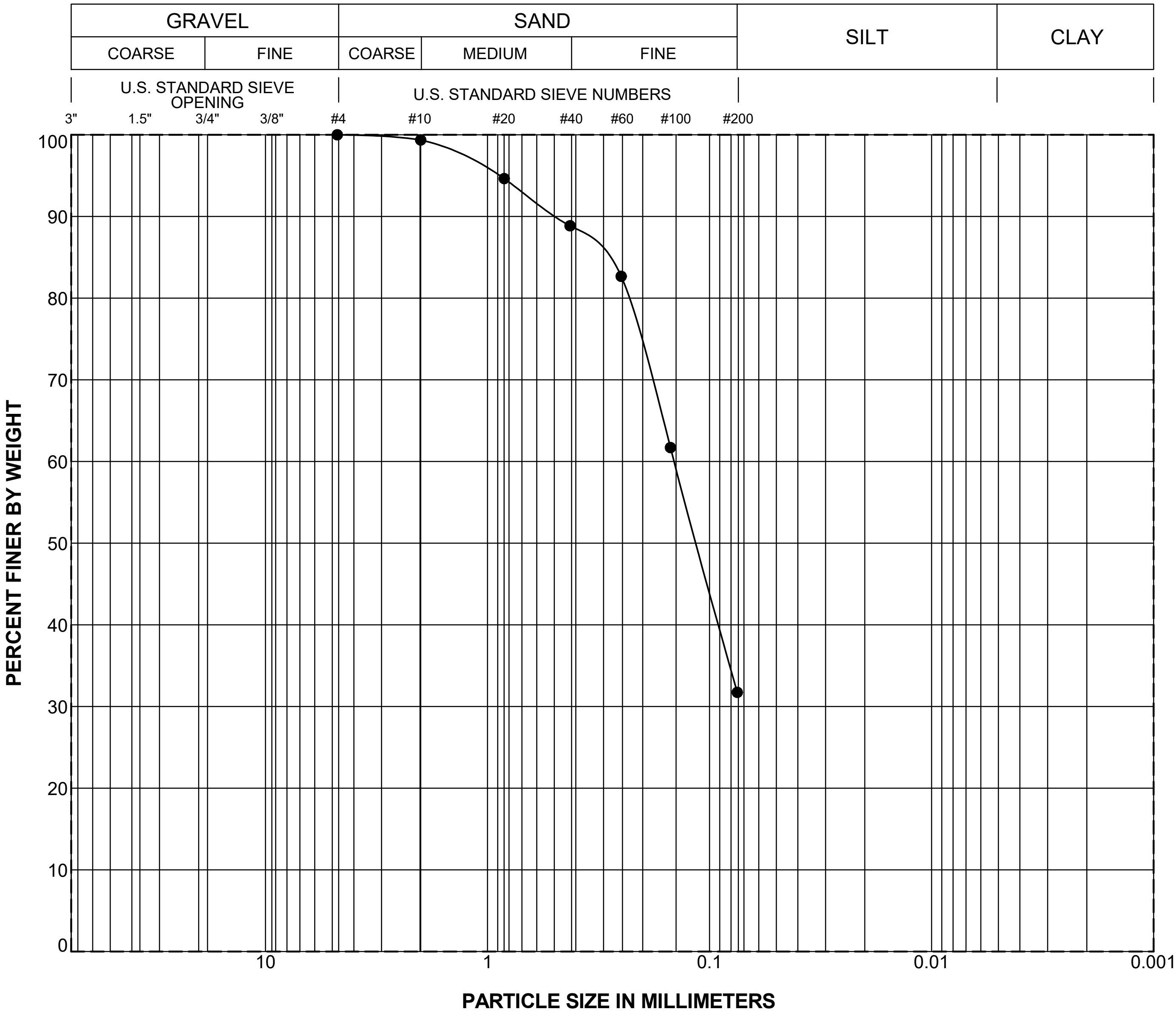

Boring Number	Depth (feet)	Geologic Unit	Symbol	LL	PI	Classification
DH-3	15.0	Tco	●			SILTY SAND (SM)

GMU_GRAIN_SIZE 19-230-00.GPJ 1/2/20

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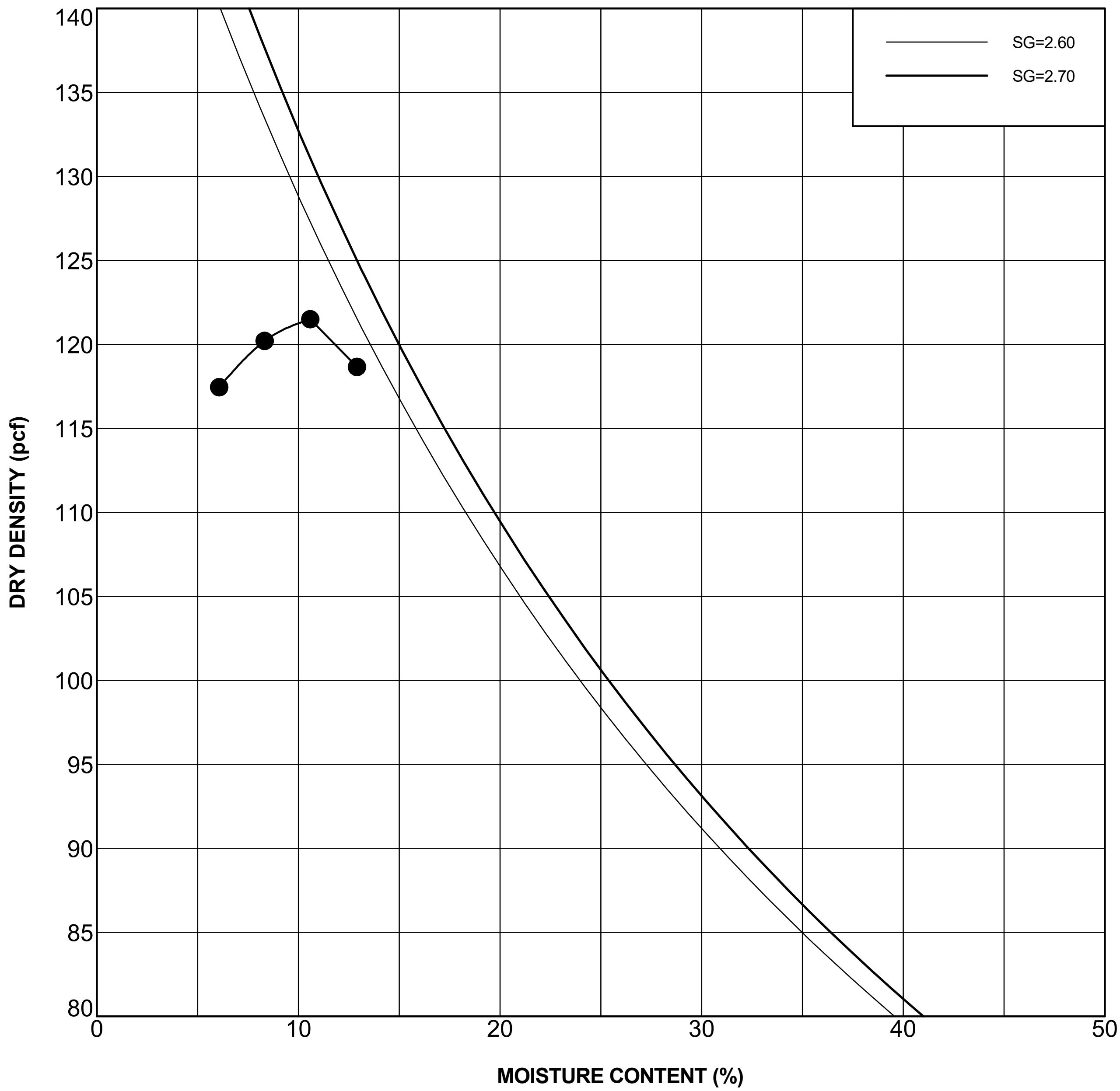
Project No. 19-230-00

GMU



Boring Number	Depth (feet)	Geologic Unit	Symbol	Maximum Dry Density, pcf	Optimum Moisture Content, %	Classification
DH-1	0.0	Qaf	●	121.5	10	SILTY SAND (SM)

DVTCOMP 19-230-00.GPJ 12/17/19

COMPACTION TEST DATA

Project: Applied Medical - Equipment Room Bridge

Project No. 19-230-00

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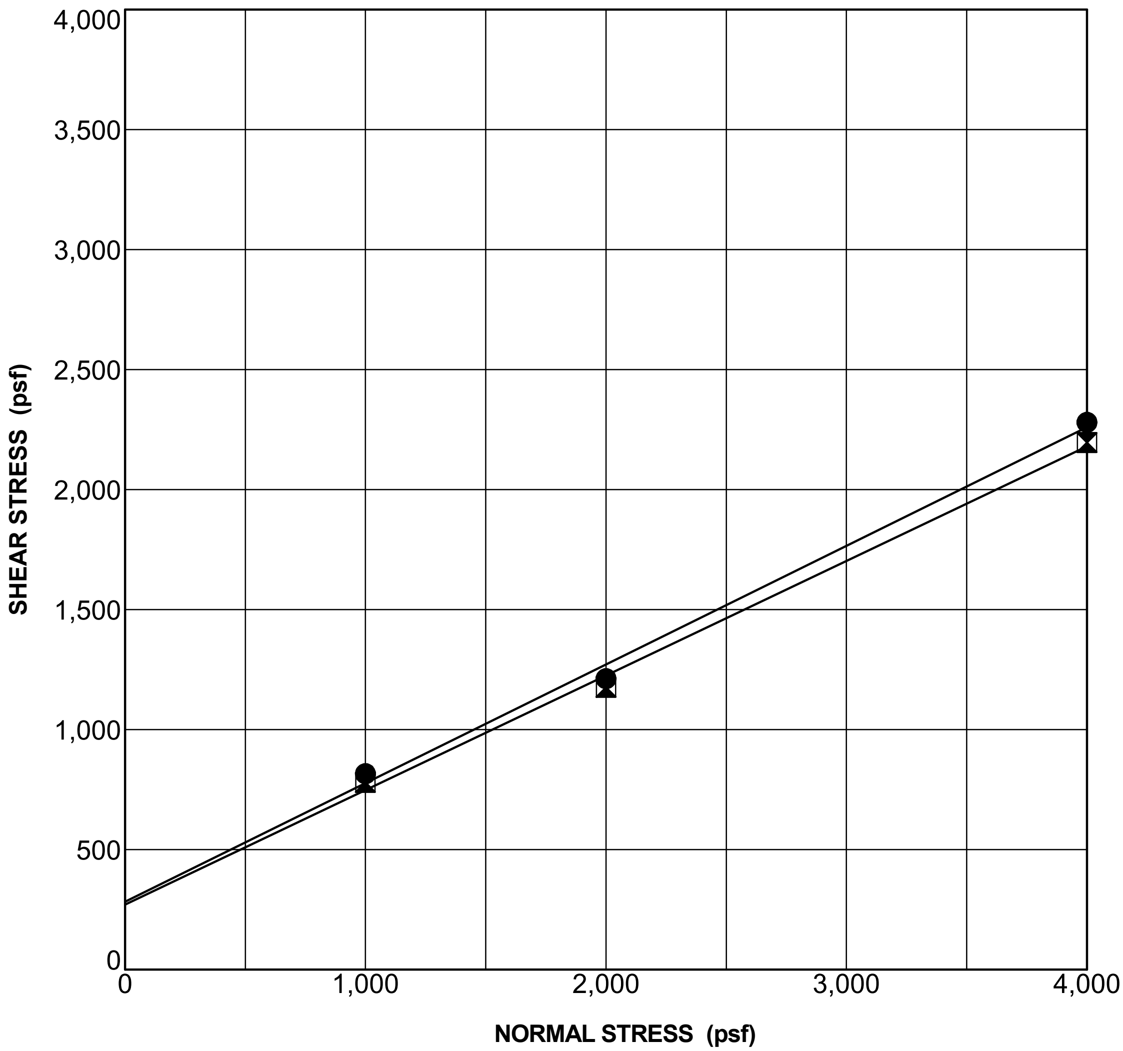


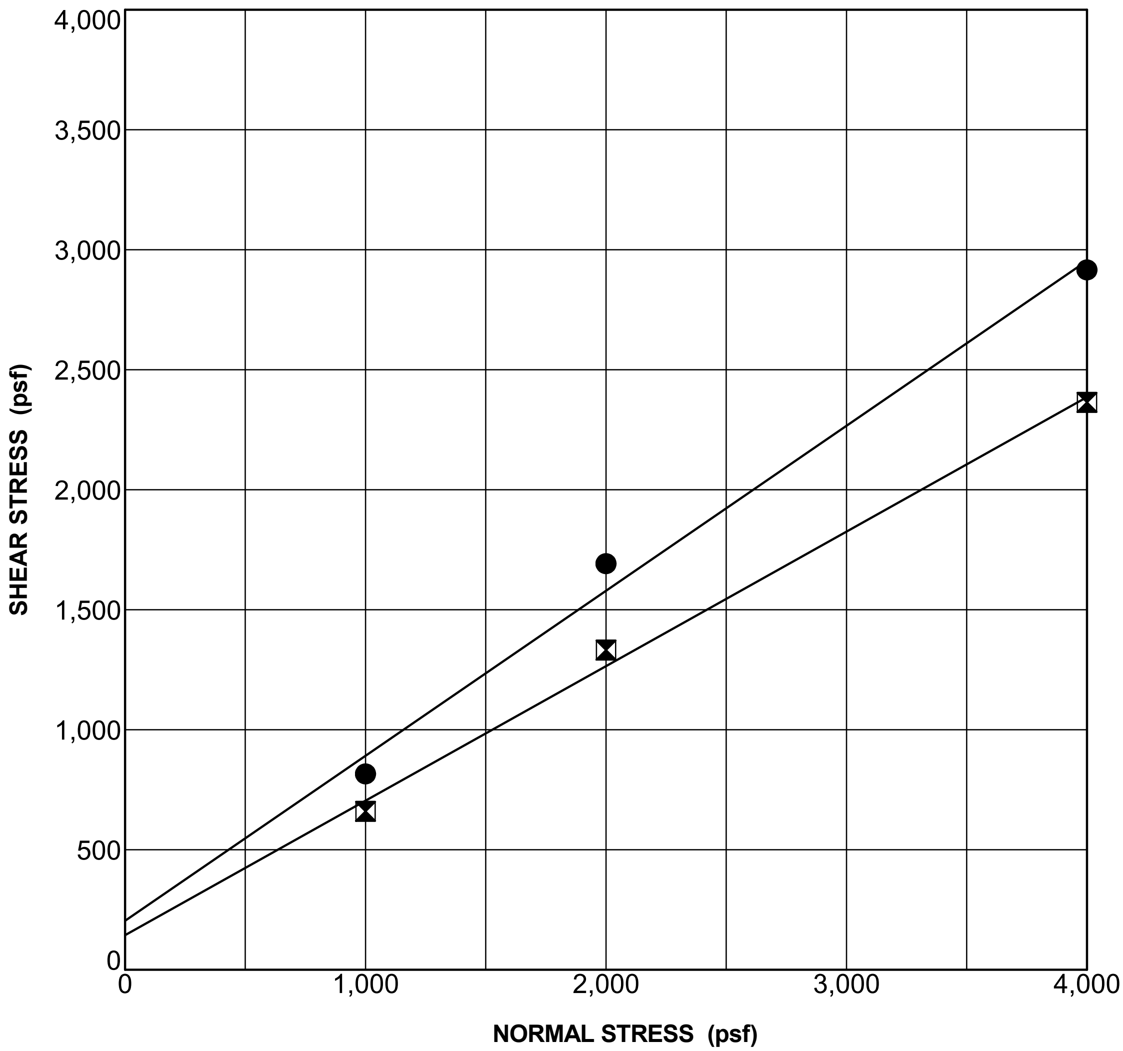
SAMPLE AND TEST DESCRIPTION
Sample Location: DH-1 @ 0.0 ft **Geologic Unit:** Qaf **Classification:** SILTY SAND (SM)
Strain Rate (in/min): 0.005 **Sample Preparation:** Remolded
Notes: 90% compaction at optimum

STRENGTH PARAMETERS		
STRENGTH TYPE	**COHESION (psf)**	**FRICTION ANGLE (degrees)**
● Peak Strength	282	26.3
⧗ Ultimate Strength	270	25.5

SHEAR TEST DATA

Project: Applied Medical - Equipment Room Bridge

Project No. 19-230-00



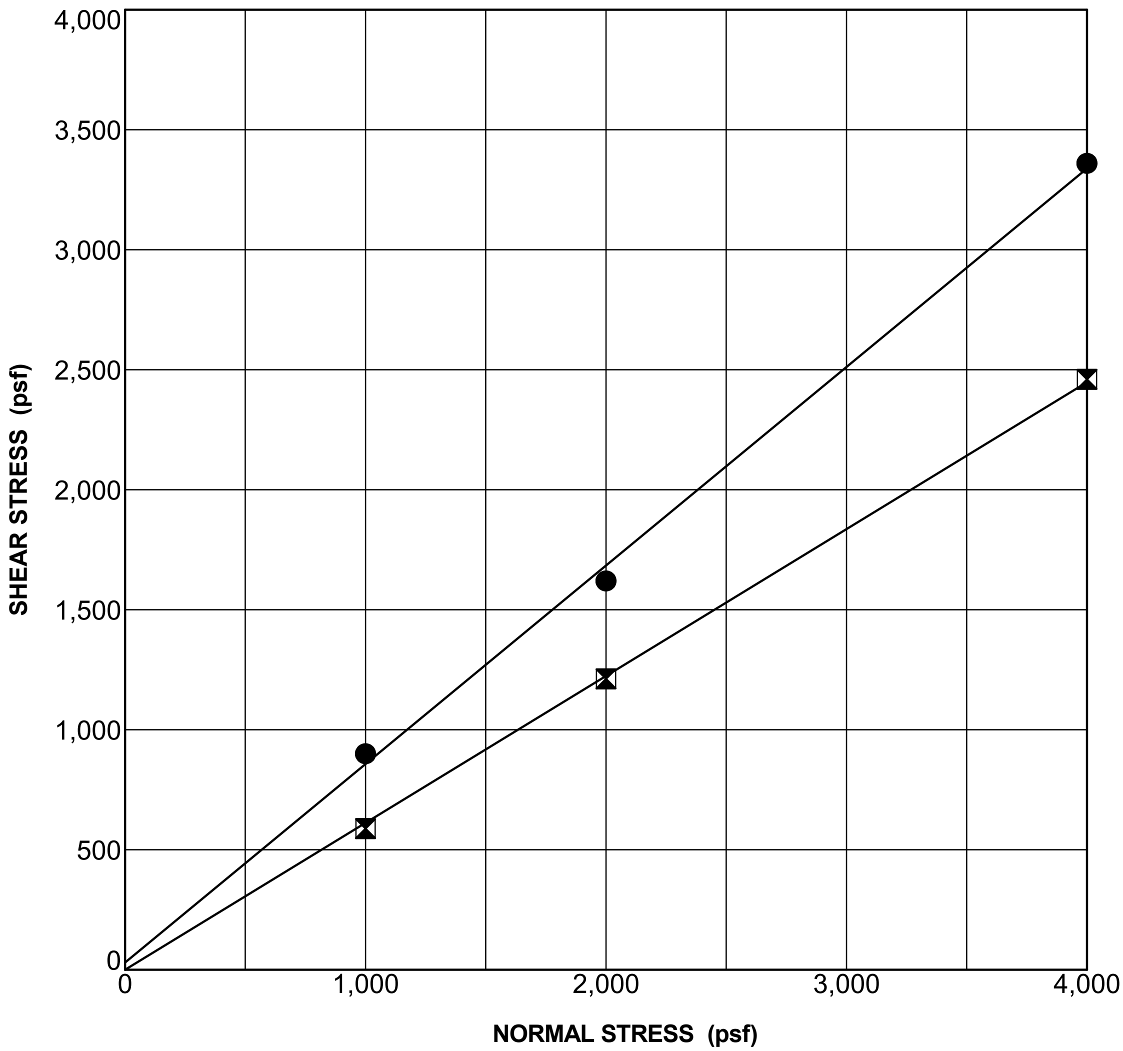
SAMPLE AND TEST DESCRIPTION
Sample Location: DH-2 @ 2.5 ft **Geologic Unit:** Tco **Classification:** SILTY SAND (SM)
Strain Rate (in/min): 0.005 **Sample Preparation:** Undisturbed
Notes: Sample saturated prior and during shearing

STRENGTH PARAMETERS		
STRENGTH TYPE	**COHESION (psf)**	**FRICTION ANGLE (degrees)**
● Peak Strength	204	34.5
⧗ Ultimate Strength	144	29.3

SHEAR TEST DATA

Project: Applied Medical - Equipment Room Bridge
Project No. 19-230-00

GMU



SAMPLE AND TEST DESCRIPTION
Sample Location: DH-3 @ 5.0 ft **Geologic Unit:** Tco **Classification:** SILTY SAND (SM)
Strain Rate (in/min): 0.005 **Sample Preparation:** Undisturbed
Notes: Sample saturated prior and during shearing

STRENGTH PARAMETERS		
STRENGTH TYPE	**COHESION (psf)**	**FRICTION ANGLE (degrees)**
● Peak Strength	30	39.6
⧗ Ultimate Strength	0	31.4

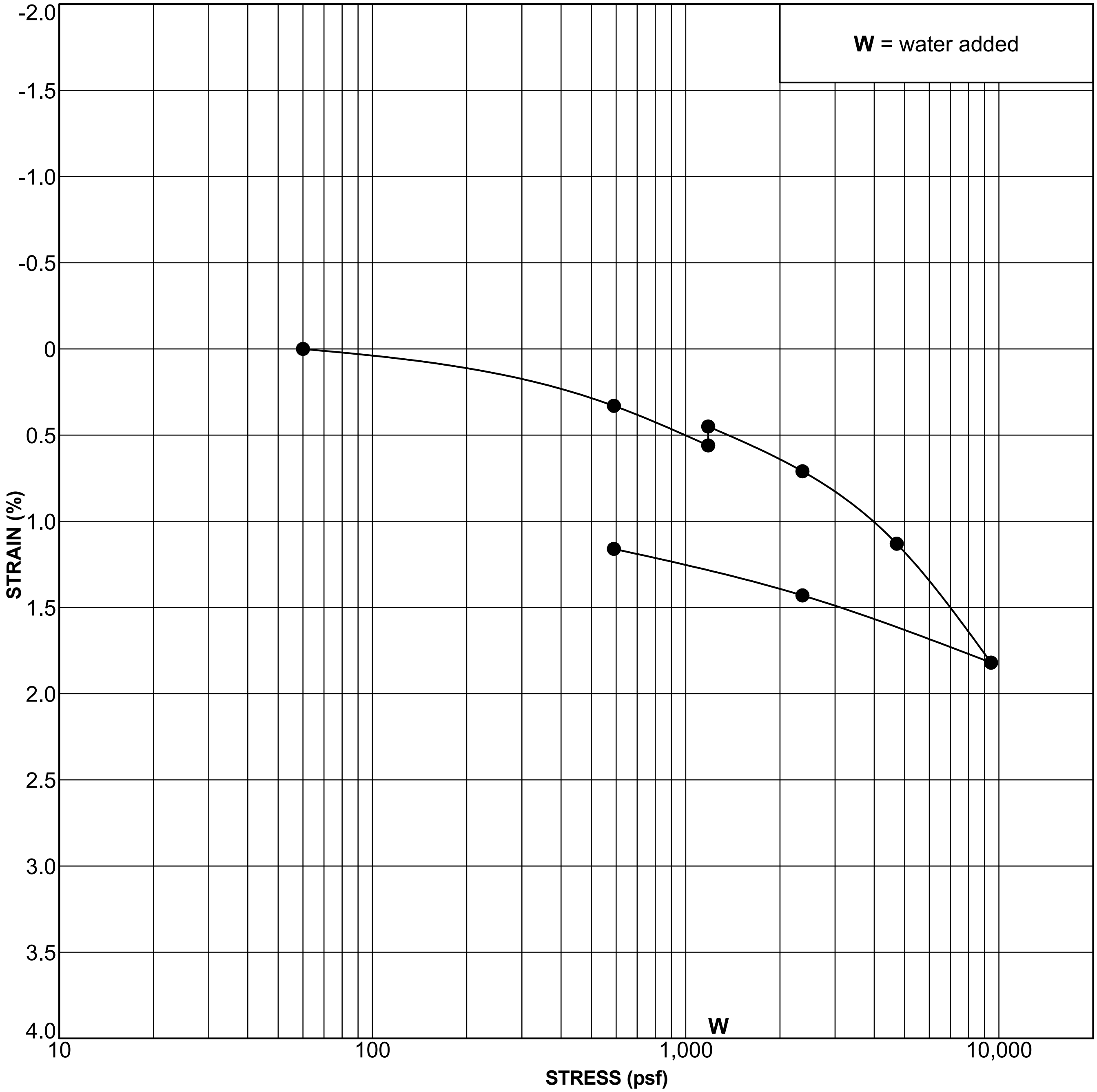
GMU_DIRECT_SHEAR 19-230-00.GPJ GM&U.GDT 1/2/20

SHEAR TEST DATA

Project: Applied Medical - Equipment Room Bridge

Project No. 19-230-00

GMU



Boring Number	Depth (feet)	Geologic Unit	Symbol	In Situ or Remolded Sample	% Hydro-Collapse	Classification
DH-2	7.5	Tco	●	In Situ	-0.11	SILTY SAND (SM)

CONSOLIDATION TEST DATA

Project: Applied Medical - Equipment Room Bridge
Project No. 19-230-00

GMU

Addendum Report of Preliminary
Percolation Testing and Geotechnical Engineering,
Infiltration Feasibility,
Applied Medical,
20162 and 20202 Windrow Drive,
Lake Forest, California

Prepared for
APPLIED MEDICAL

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Percolation Testing and Geotechnical Engineering,
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Lake Forest, California

Prepared for
APPLIED MEDICAL

February 26, 2021

GMU Project No. 21-017-00

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TRANSMITTAL

APPLIED MEDICAL
22872 Avenida Empresa
Rancho Santa Margarita, CA 92688

DATE: February 26, 2021

PROJECT: 21-017-00

ATTENTION: Mr. Steve Davis

SUBJECT: Addendum Report of Preliminary Percolation Testing and Geotechnical Engineering, Infiltration Feasibility, Applied Medical, 20162 and 20202 Windrow Drive, Lake Forest, California

DISTRIBUTION:

Addressee (electronic copy)

Adams Streeter Civil Engineers
Attn: Omar Maciel (electronic copy)

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TABLE OF CONTENTS

INTRODUCTION

PURPOSE

This report presents the results of our infiltration feasibility investigation for the proposed stormwater infiltration system improvements for the Applied Medical buildings at 20162 and 20202 Windrow Drive in the City of Lake Forest (Applied Medical Buildings L202 and L203, respectively). The location of the site is shown on the Location Map, Plate 1. The purpose of this investigation was to determine if infiltration would be feasible based site infiltration rates and other construction considerations. In addition, a rigid pavement structural section is also provided per your request. This infiltration investigation report serves as an addendum report to our reference (2) Geotechnical Investigation Report for the Applied Medical Equipment Room Bridge and Building Addition (references listed on Page 11).

SCOPE

The scope of our services, as outlined in our proposal dated January 18, 2021, is as follows:

1. Coordinate drill hole locations with Adams Streeter Civil Engineers based on their WQMP Exhibit.

2. Perform a site visit to stake three (3) drill hole locations and notify Underground Service Alert (USA).

3. Coordinate private utility locations with Applied Medical in conjunction with their subcontracted private utility locator.

4. Completed our infiltration feasibility field investigation which consisted of three locations tested at 10 feet below ground surface (bgs).

    The first day of the infiltration feasibility investigation consisted of drilling all three locations with a hollow-stem auger, truck-mounted drill rig. Our Field Engineer logged the drill holes and collected bag samples of the bottom 5 feet for laboratory testing if deemed necessary. The infiltration testing locations were set up and pre-saturated per the referenced infiltration test method. The second day of the infiltration feasibility investigation consisted of the infiltration testing followed by backfill and clean-up of all three locations.

5. Interpreted and evaluated the field data obtained during our infiltration feasibility investigation and compared it to the data obtained during our original geotechnical investigation (reference (2)).

6. Prepared this report presenting infiltration rates to support the design and construction of the proposed stormwater infiltration system.

SITE LOCATION AND DESCRIPTION

The site currently consists of Applied Medical Buildings L202 and L203, adjacent parking lots, flatwork, and small landscaped areas. The referenced WQMP Exhibit provided by Adam Streeter Civil Engineers outlines drainage areas DMA-A and DMA-B which flow to the three infiltration locations investigated. Drainage area DMA-A corresponds to Infiltration Testing Locations 1 and 2, and drainage area DMA-B corresponds to the Infiltration Testing Location 3. The infiltration test locations are shown on the Infiltration Testing Location Map, Plate 2, which uses the reference WQMP Exhibit as a base map.

PROPOSED STORMWATER INFILTRATION SYSTEM

Based on our correspondence with Adams Streeter, it is our understanding that the proposed stormwater infiltration system will consist of a pretreatment unit combined with a series of 72-inch-diameter horizontal corrugated metal stormwater detention and infiltration pipes which will be installed below the parking lot area on the east side of Applied Medical Building L-203 at approximately 9 feet bgs.

SUBSURFACE EXPLORATION

GMU performed a subsurface investigation on December 6 and December 11, 2019, as a part of our original geotechnical investigation utilizing a hollow-stem auger drill rig on the east and west sides of Applied Medical Building L-203 (reference (2)). On February 17 and 18, 2021, GMU performed a subsurface investigation to evaluate the feasibility of infiltration at the site. A hollow-stem auger drill rig was utilized to drill on the east and west sides of Applied Medical Building L-203, near the locations of the proposed infiltration systems. A total of three 10-foot-deep exploratory drill holes and infiltration tests were performed. The drill holes were logged by our Staff Engineer, and samples were collected in each of the drill holes for further laboratory testing.

The infiltration test (IT) locations are shown on Plate 2 – Geotechnical Map. The IT test locations were obtained from the WQMP Exhibit provided by Adams Streeter Civil Engineers. Logs of the drill holes are contained in Appendix A.

GROUNDWATER

Groundwater was not observed during our December 2019 geotechnical investigation (reference (2)) to the maximum explored depth of 51 feet bgs. Furthermore, the historical high depth to groundwater is reportedly greater than 40 feet bgs at the project site per the referenced CGS Seismic Hazard Report. Groundwater conditions may vary across the site due to stratigraphic and hydrologic conditions and may change over time as a consequence of seasonal and meteorological fluctuations, or activities by humans at this site and nearby sites. However, based on the above findings, groundwater is unlikely to impact the proposed infiltration structures.

GEOTECHNICAL ENGINEERING FINDINGS

SOIL EXPANSION

Based on our classification and laboratory testing of the onsite fill and bedrock soils, the existing near surface materials at the subject site are anticipated to have a negligible expansion potential.

SOIL CORROSION

To evaluate the corrosion potential of the subsurface soils at the site, two representative surficial soil samples collected during our December 2019 geotechnical investigation were tested for soluble sulfate, chloride content, pH, and resistivity. The results of the tests are summarized below.

Table 1 - Results of Corrosivity Testing

Boring No.	Depth (feet)	Chloride (mg/kg)	Sulfate (mg/kg)	pH	Resistivity (ohm-cm)	Estimated Corrosivity Based on Resistivity	Estimated Corrosivity Based on Sulfates
DH-1	0 – 5	600	5	7.8	4,174	Moderate	Negligible
DH-3	0 – 5	696	10	6.7	3,684	Moderate	Negligible

- Elevated chloride levels indicating conditions that are corrosive to ferrous metals.
- A negligible sulfate exposure to concrete per the ACI 318 Table 4.3.1 (Class S0).
- A moderate resistivity indicating conditions that are moderately corrosive to ferrous metals.

PERCOLATION TESTING

Three preliminary percolation tests were performed in general conformance with the Orange County Technical Guidance Document (OCTGD) for northern Orange County. Deep Percolation Tests (10 feet to 40 feet) were completed at each of the three 8-inch-diameter boreholes. The boreholes were excavated to a depth of 10 feet bgs using a hollow-stem auger, truck-mounted drill rig. Following the drilling, the holes were set up in accordance with the OCTGD and were presoaked overnight. The tests were then performed the following day using a water source at the site and a water level sounder taking measurements in 30-minute intervals, topping off the water level at the beginning of each interval accordingly. The results of our percolation testing are summarized below in Table 2. The table includes the measured stabilized percolation rate (K_{obs}) and the screening level percolation rate (K_{screen}). K_{screen} incorporates the OCTGD required factor-of-safety of 2. The design stabilized percolation rate (K_{design}) will need to incorporate a two-part factor-of-safety and will be based on the observed percolation rate (K_{obs}) below. The worksheet used to calculate this two-part factor-of-safety is included in Appendix B of this report. The percolation data is presented in its entirety in Appendix B. The first portion of this factor-of-safety has been completed on the document (SA = 1.75), and the second portion (SB) will need to be calculated by the design Civil Engineer based on several design factors including the tributary area and the level of pretreatment.

Table 2 - Preliminary Percolation Rates Summary

Infiltration Test Location	Depth Below Existing Grade (feet)	Observed Percolation Rate, (Kobs) (inches/hour)	Screen Level Percolation Rate, (Kscreen)* (inches/hour)	Infiltration Feasible Based on Rate
IT-1	10	0.08	0.04	No
IT-2	10	0.03	0.01	No
IT-3	10	1.70	0.85	Yes

*Incorporates OCTGD minimum factor-of-safety of 2.

The preliminary infiltration test locations are shown on the attached Geotechnical Map, Plate 2. The results of the percolation testing are provided in Appendix B of this report, and site percolation recommendations are presented in a subsequent section of this report.

CONCLUSIONS AND RECOMMENDATIONS

DEVELOPMENT FEASIBILITY

Based on the site infiltration rates obtained from Infiltration Test Locations 1 and 2 (IT-1 and IT-2), infiltration will not be feasible for drainage area DMA-A and an alternative location will be required.

Based on the geologic and geotechnical findings, it is our opinion that the proposed stormwater infiltration system is feasible and practical from a geotechnical standpoint for drainage area DMA-B, which corresponds with Infiltration Test Location #3 (IT-3) if constructed in accordance with the Orange County requirements and the recommendations presented herein. It is also the opinion of GMU that the proposed construction will not adversely affect the geologic stability of adjoining properties provided that the construction is performed in accordance with the recommendations provided in this report.

INFILTRATION SYSTEM SUITABILITY

Based on: 1) our review of available geologic information, 2) our recent infiltration feasibility investigation, 3) our laboratory testing from our reference (2) geotechnical report, 4) our review of available data for the site vicinity, and 5) our evaluation, we note the following:

- Groundwater was not encountered during our December 2019 geotechnical investigation to the maximum depth explored (51 feet bgs), and the historic high groundwater level is deeper than 40 feet below the existing grade. Therefore, groundwater is not anticipated to be within 10 feet of the invert of the proposed stormwater infiltration system.
- Due to the historic depth of groundwater being deeper than 40 feet bgs and the dense nature of the subsurface bedrock materials, the potential for increase of seismic settlement due to percolation of water into the site soils is considered low.
- Due to the absence of basement walls and that no retaining walls are at a lower elevation than the proposed stormwater infiltration system, the potential for increased surcharge on such structures due to percolation of water into the site soils is considered negligible.
- Due to the lack of slopes on the site and the site not being located within a designated hillside grading area, the potential for slope instability and saturation is considered negligible.
- The potential for increase of static settlement for structures on or adjacent to the site is considered low based on the dense nature of the subsurface bedrock materials.

INFILTRATION SYSTEM DESIGN AND CONSTRUCTION RECOMMENDATIONS

Stormwater Infiltration System Design

Based on our percolation testing and findings, it is our opinion that the installation of the proposed infiltration system within the subject property is feasible for drainage area DMA-B from a geotechnical standpoint, provided that recommendations presented in this section are incorporated into the design and construction.

- We recommend that the design stabilized percolation rate be based on the observed percolation rate of 1.7 inches per hour that will be reduced by the factor-of-safety which will be calculated based on the Technical Guidance Document Worksheet 3, *Factor of Safety and Design Infiltration Rate Worksheet* provided in Appendix B of this report. SA of 1.75 has been completed by GMU, and SB will need to be completed by an infiltration system designer.
- The design stabilized percolation rate should be considered for the bedrock materials encountered around Infiltration Test Location #3 (IT-3) for drainage area DMA-B encountered at approximately 7.5 feet and greater bgs.
- The proposed infiltration system should be designed and constructed in accordance with the minimum requirements presented below, the requirements of the Orange County Technical Guidance Document (OCTGD), and the City of Lake Forest New Development/ Significant Redevelopment Treatment Control Requirements.

Table 3 - Minimum Setback Requirements

Property lines and public right of way	• A minimum 10-foot setback.
Any foundation	• A minimum 15-foot setback or within a 1:1 plane drawn up from the bottom of foundation, whichever is greater.
Water wells used for drinking water	• A minimum 100-foot setback.

Stormwater Infiltration System Construction Considerations

- The infiltration system should be constructed in accordance with the recommendations provided herein, the project plans, and the specifications and manufacturer details included as Appendix C of this report.
- We recommend that two double ring infiltration tests be performed at the excavation bottom during construction of the proposed large-diameter corrugated metal detention and

infiltration pipes in order to determine the as-built percolation rate in accordance with the OCTGD. The testing should be performed by a representative of GMU during construction.
- The final stormwater infiltration system design and specifications should be reviewed by GMU prior to construction to verify compliance with the recommendations of this report and/or provide additional recommendations/revisions if needed.

Concrete Pavement Recommendations

We have developed the following concrete pavement thickness recommendations for the proposed site improvements.

Table 4 - Conventional Concrete Pavement Thickness Recommendations

Assumed Traffic Index	Composite Concrete Pavement and Aggregate Base
6.0	7.0” Concrete over 4.0” AB over Properly Prepared Subgrade

Implementing these recommendations involves:

- Grading the existing site to create sufficient depth for the recommended concrete and aggregate base sections.
- Processing and re-compacting the exposed subgrade material to a depth of at least 12 inches in accordance with Greenbook Sections 301-1.2 and 301-1.3. The required relative compaction of the subgrade is 90% minimum with a moisture content of at or above the optimum moisture content. Maximum density and optimum moisture content of the subgrade should be determined by ASTM D1557.
- Installing the aggregate base section to at least 95% relative compaction and moisture conditioning to near optimum moisture content. Maximum density and optimum moisture content of the aggregate base should be determined by ASTM D1557.
- No steel reinforcement is recommended.
- Max. joint spacing is 12 feet, both longitudinal and transverse directions.
- Concrete pavement edge thickness to be thickened by 6 to 13 inches where concrete pavement terminates at driveway panels or other asphalt concrete sections.

TEMPORARY EXCAVATION STABILITY

Temporary excavations ranging from 8 to 12 feet bgs will be required to construct the planned infiltration system. The sidewalls of these temporary excavations are expected to expose approximately 2 feet of fill at the surface over bedrock of the Capistrano Formation (Oso Member), (Tco).

Based on the anticipated engineering characteristics of these materials, temporary excavations will need to be laid back at an angle no greater than 1:1 up to a depth of 20 feet and/or shored per OSHA requirements.

The above guidelines regarding excavation stability are presented for general guidance only. All aspects of excavation stability are the responsibility of the contractor. All governing regulations in regards to excavation stability (i.e., OSHA, City of Lake Forest, etc.) should be followed.

FILL MATERIAL AND PLACEMENT

Suitability of On-Site Soils

All on-site soils are considered suitable for use as compacted fill from a geotechnical perspective if care is taken to remove all significant organics (roots) and other decomposable debris, and separate and stockpile rock or broken concrete materials larger than 6 inches in maximum diameter.

Import Soils

Although not expected to be required, import soils should be predominately granular soil material and have an expansion index (E.I.) of less than 20. Prior to allowing soil materials to be imported to the site, a field representative of the Geotechnical Engineer of Record should sample and test the source of the planned import and provide their approval of the soil materials.

Compaction Standard and Methodology

All soil material used as compacted fill, or material processed in-place or used for backfill, should be moistened, dried, or blended as necessary and densified to at least 90% relative compaction. It is recommended that fills be placed at 2% above the optimum moisture content, as determined in accordance with the latest addition of ASTM D1557.

STRUCTURAL CONCRETE

As a good engineering practice, we recommend using Type II/V cement, a maximum water-cement ratio of 0.50, and a minimum compressive strength of 4,000 psi for structural concrete.

CORROSION PROTECTION OF METAL STRUCTURES

The results of the laboratory chemical tests performed on soil samples collected in the upper 5 feet during our December 2019 geotechnical investigation within the site indicate that the on-site soils are moderately corrosive to ferrous metals. Consequently, metal structures which will be in direct contact with the soil (i.e., underground metal conduits, pipelines, etc.) may be subject to corrosion. The use of special coatings or cathodic protection around buried metal structures has been shown to be beneficial in reducing corrosion potential. Corrosion of ferrous metal reinforcing elements in structural concrete should be reduced by increasing the thickness of concrete cover and the use of the recommended maximum water/cement ratio for concrete. The results of the laboratory chemical tests performed within the site are presented in Table 1 (Page 3).

The above discussion is provided for general guidance in regards to the corrosiveness of the on-site soils to typical metal structures used for construction. Detailed corrosion testing and recommendations for protecting buried ferrous metal and/or copper elements are beyond our purview. If detailed recommendations are required, a corrosion engineer should be consulted to develop appropriate mitigation measures.

LIMITATIONS

All parties reviewing or utilizing this report should recognize that the findings, conclusions, and recommendations presented represent the results of our professional geological and geotechnical engineering efforts and judgements. Due to the inexact nature of the state of the art of these professions and the possible occurrence of undetected variables in subsurface conditions, we cannot guarantee that the conditions actually encountered during grading and stormwater infiltration system installation will be identical to those observed and sampled during our subsurface investigations, or that there are no unknown subsurface conditions which could have an adverse effect on the use of the property. We have exercised a degree of care comparable to the standard of practice presently maintained by other professionals in the fields of geotechnical engineering and engineering geology, and believe that the findings present a reasonably representative description of geotechnical conditions and their probable influence on the grading and use of the property.

Because our conclusions and recommendations are based on a limited amount of previous geotechnical exploration and analysis, all parties should recognize the need for possible revisions to our conclusions and recommendations during construction of the proposed project. As with all preliminary geotechnical reports, there is a need to review field conditions for conformance to those contained in the geotechnical report and to assess the need to revise or amend the recommendations as necessary.

Detailed corrosion testing and recommendations for protecting buried ferrous metal and/or copper elements are beyond our purview.

This report has not been prepared for use by other parties or projects other than those named or described herein. This report may not contain sufficient information for other parties or other purposes.

CLOSURE

We are pleased to present the results of our infiltration feasibility investigation for this project. The Plates and Appendices that complete this report are listed in the Table of Contents.

If you have any questions concerning our findings or recommendations, please do not hesitate to contact us and we will be happy to discuss them with you.

Respectfully submitted,

Matthew T. Farrington, M.Sc., PE 90349
Project Engineer

Reviewed by:

S. Ali Bastani, PhD, F. ASCE, PE, GE 2458
Director of Engineering

mtf/21-017-00 (02-24-21)

REFERENCES

SITE-SPECIFIC REFERENCES

(1) WQMP Exhibit, L202 and L203 Bridge Building, 20162 and 20202 Windrow Drive, Pre-Construction Plan, prepared by Adams Streeter Civil Engineers, dated November 20, 2020.

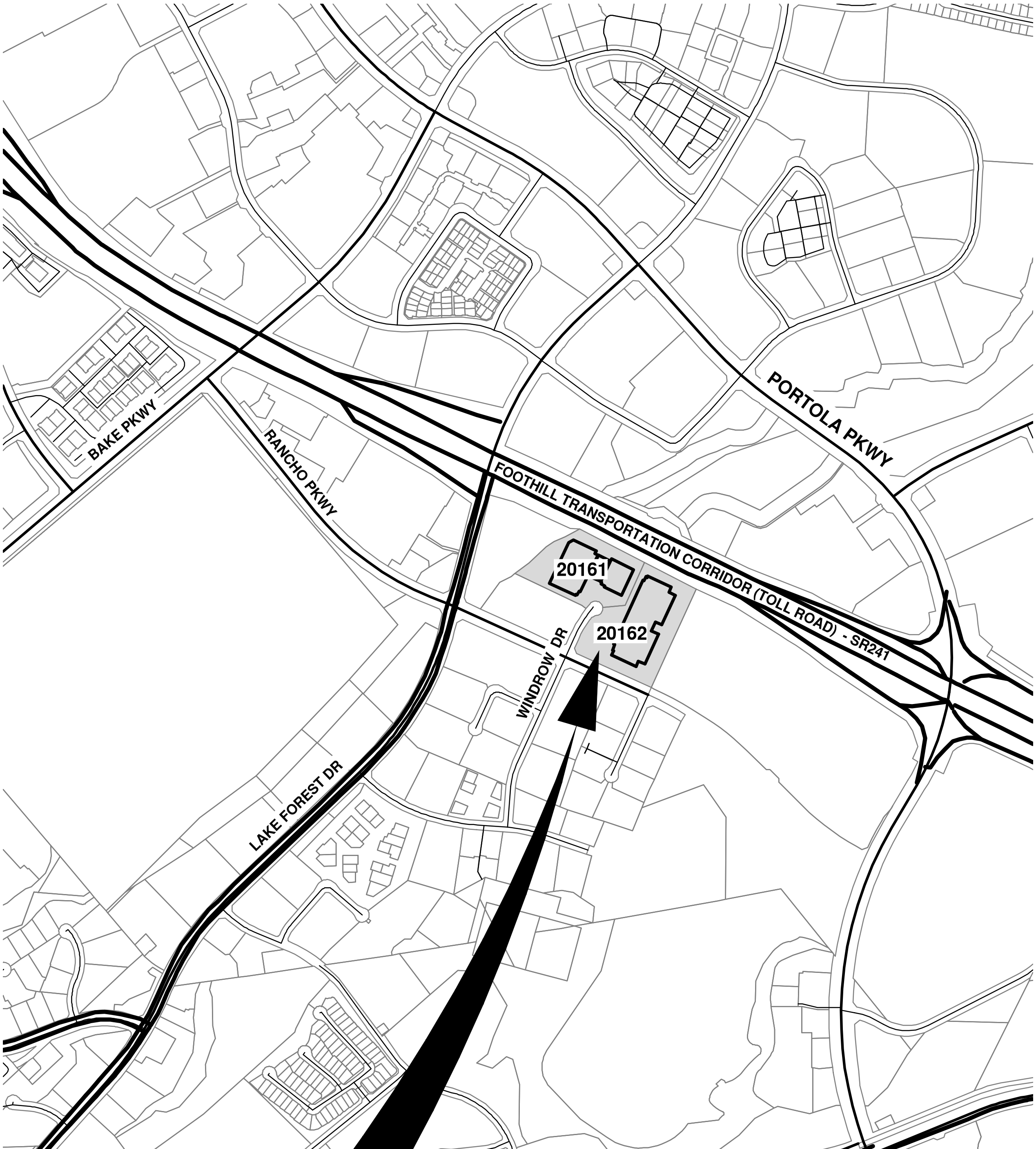
(2) GMU's "Geotechnical Investigation, Applied Medical Equipment Room, Bridge and Building Addition, Lake Forest, California," dated January 7, 2020 (Project 19-230-00).

TECHNICAL REFERENCES

California Geologic Survey (CGS formerly known as California Division of Mines and Geology, CDMG) (2001) "*Seismic Hazard Zones, El Toro Quadrangle*".

Technical Guidance Document (TGD) for the Preparation of Conceptual/Preliminary and/or Project Water Quality Management Plans (WQMPs), dated December 20, 2013.

Standard Specifications for Public Works Construction, by Public Works Standards, Inc., 2018, *The Greenbook 2018 Edition*.



PROJECT SITE
20161 & 20162 WINDROW DR.
LAKE FOREST, CALIFORNIA

0 1000'

Location Map

GMU

Date:	February 26, 2021	Plate 1
Project No.:	21-017-00	

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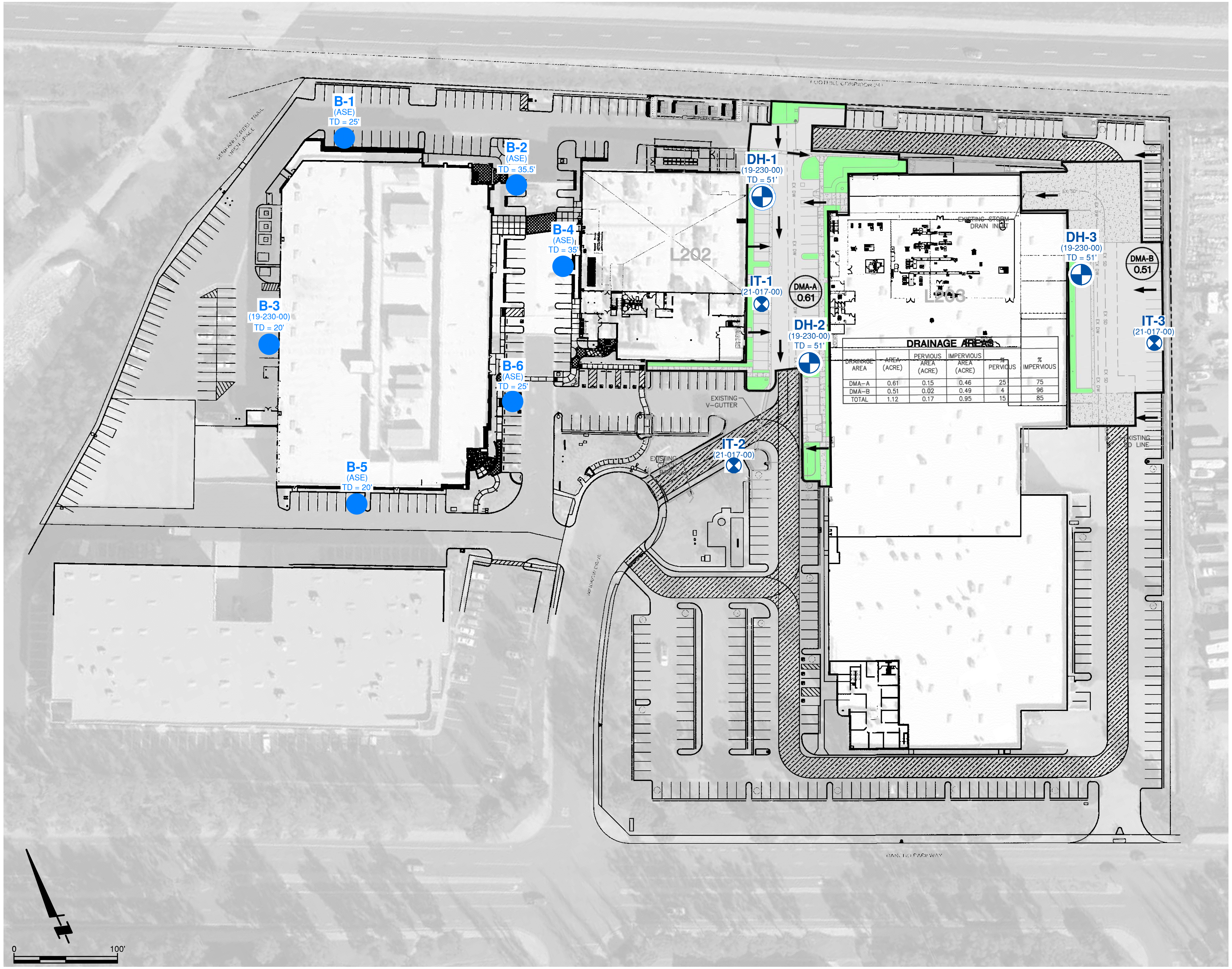

DRAINAGE AREAS

DRAINAGE AREA	AREA (ACRE)	PERVIOUS AREA (ACRE)	IMPERVIOUS AREA (ACRE)	% PERVIOUS	% IMPERVIOUS
DMA-A	0.61	0.15	0.46	25	75
DMA-B	0.51	0.02	0.49	4	96
TOTAL	1.12	0.17	0.95	15	85

LEGEND

- **DH-3** (19-230-00) — APPROXIMATE LOCATION OF DRILL HOLE BY GMU GEOTECHNICAL, INC. (PROJECT NO. 19-230-00)
- **IT-3** (21-017-00) — APPROXIMATE LOCATION OF INFILTRATION TESTS BY GMU GEOTECHNICAL, INC., (PROJECT NO. 21-017-00)
- **B-6** (ASE) — APPROXIMATE LOCATION OF BORING BY ASSOCIATED SOILS ENGINEERING, INC., (ASE)

Geotechnical Map

GMU		Plate
Date:	February 26, 2021	2
Project No.:	21-017-00	

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APPENDIX A

Geotechnical Exploration Procedures and Drill Hole Logs

MAJOR DIVISIONS			Group Letter	Symbol	TYPICAL NAMES
COARSE-GRAINED SOILS More Than 50% Retained On No.200 Sieve. Based on The Material Passing The 3-Inch (75mm) Sieve. Reference: ASTM Standard D2487	**GRAVELS** 50% or More of Coarse Fraction Retained on No.4 Sieve	Clean Gravels	GW		Well Graded Gravels and Gravel-Sand Mixtures, Little or No Fines.
			GP		Poorly Graded Gravels and Gravel-Sand Mixtures Little or No Fines.
		Gravels With Fines	GM		Silty Gravels, Gravel-Sand-Silt Mixtures.
			GC		Clayey Gravels, Gravel-Sand-Clay Mixtures.
	SANDS More Than 50% of Coarse Fraction Passes No.4 Sieve	Clean Sands	SW		Well Graded Sands and Gravelly Sands, Little or No Fines.
			SP		Poorly Graded Sands and Gravelly Sands, Little or No Fines.
		Sands With Fines	SM		Silty Sands, Sand-Silt Mixtures.
			SC		Clayey Sands, Sand-Clay Mixtures.
FINE-GRAINED SOILS 50% or More Passe The No.200 Sieve. Based on The Material Passing The 3-Inch (75mm) Sieve. Reference: ASTM Standard D2487	**SILTS AND CLAYS** Liquid Limit Less Than 50%		ML		Inorganic Silts, Very Fine Sands, Rock Flour, Silty or Clayey Fine Sands or Clayey Silts With Slight Plasticity.
			CL		Inorganic Clays of Low To Medium Plasticity, Gravelly Clays, Sandy Clays, Silty Clays, Lean Clays.
			OL		Organic Silts and Organic Silty Clays of Low Plasticity
	SILTS AND CLAYS Liquid Limit 50% or Greater		MH		Inorganic Silts, Micaceous or Diatomaceous Fine Sandy or Silty Soils, Elastic Silts.
			CH		Inorganic Clays of High Plasticity, Fat Clays.
			OH		Organic Clays of Medium To High Plasticity, Organic Silts.
HIGHLY ORGANIC SOILS			PT		Peat and Other Highly Organic Soils.

The descriptive terminology of the logs is modified from current ASTM Standards to suit the purposes of this study

ADDITIONAL TESTS

- DS = Direct Shear
- HY = Hydrometer Test
- TC = Triaxial Compression Test
- UC = Unconfined Compression
- CN = Consolidation Test
- (T) = Time Rate
- EX = Expansion Test
- CP = Compaction Test
- PS = Particle Size Distribution
- EI = Expansion Index
- SE = Sand Equivalent Test
- AL = Atterberg Limits
- FC = Chemical Tests
- RV = Resistance Value
- SG = Specific Gravity
- SU = Sulfates
- CH = Chlorides
- MR = Minimum Resistivity
- pH
- (N) = Natural Undisturbed Sample
- (R) = Remolded Sample
- CS = Collapse Test/Swell-Settlement

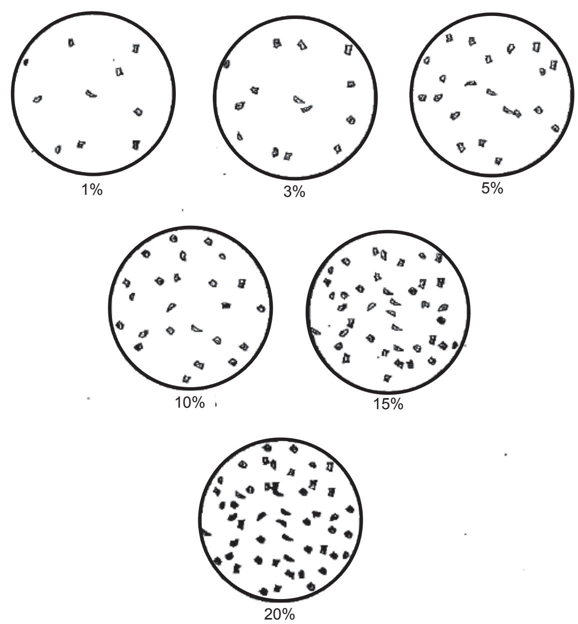
GEOLOGIC NOMENCLATURE

B = Bedding C = Contact J = Joint
F = Fracture Flt = Fault S = Shear
RS = Rupture Surface = Seepage
= Groundwater

SAMPLE SYMBOLS

- Undisturbed Sample (California Sample)
- Undisturbed Sample (Shelby Tube)
- Bulk Sample
- Unsuccessful Sampling Attempt
- SPT Sample

10: 10 Blows for 12-Inches Penetration
6/4: 6 Blows Per 4-Inches Penetration
P: Push
(13): Uncorrected Blow Counts ("N" Values) for 12-Inches Penetration- Standard Penetration Test (SPT)



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LEGEND TO LOGS
ASTM Designation: D 2487
(Based on Unified Soil Classification System)

Plate **A-1**

P8-11/16/2012

SOIL DENSITY/CONSISTENCY

FINE GRAINED

Consistency	Field Test	SPT (#blows/foot)	Mod (#blows/foot)
Very Soft	Easily penetrated by thumb, exudes between fingers	<2	<3
Soft	Easily penetrated one inch by thumb, molded by fingers	2-4	3-6
Firm	Penetrated over 1/2 inch by thumb with moderate effort	4-8	6-12
Stiff	Penetrated about 1/2 inch by thumb with great effort	8-15	12-25
Very Stiff	Readily indented by thumbnail	15-30	25-50
Hard	Indented with difficulty by thumbnail	>30	>50

COARSE GRAINED

Density	Field Test	SPT (#blows/foot)	Mod (#blows/foot)
Very Loose	Easily penetrated with 0.5" rod pushed by hand	<4	<5
Loose	Easily penetrated with 0.5" rod pushed by hand	4-10	5-12
Medium Dense	Easily penetrated 1' with 0.5" rod driven by 5lb hammer	10-30	12-35
Dense	Dificult to penetrat 1' with 0.5" rod driven by 5lb hammer	31-50	35-60
Very Dense	Penetrated few inches with 0.5" rod driven by 5lb hammer	>50	>60

BEDROCK HARDNESS

Density	Field Test	SPT (#blows/foot)
Soft	Can be crushed by hand, soil like and structureless	1-30
Moderately Hard	Can be grooved with fingernails, crumbles with hammer	30-50
Hard	Can't break by hand, can be grooved with knife	50-100
Very Hard	Scratches with knife, chips with hammer blows	>100

MODIFIERS

Trace	1%
Few	1-5%
Some	5-12%
Numerous	12-20%
Abundant	>20%

GRAIN SIZE

Description		Sieve Size	Grain Size	Approximate Size
Boulders		>12"	>12"	Larger than a basketball
Cobbles		3-12"	3-12"	Fist-sized to basketball-sized
Gravel	Coarse	3/4-3"	3/4-3"	Thumb-sized to fist-sized
	Fine	#4-3/4"	0.19-0.75"	Pea-sized to thumb-sized
Sand	Coarse	#10-#4	0.079-0.19"	Rock-salt-sized to pea-sized
	Medium	#40-#10	0.017-0.079"	Sugar-sized to rock salt-sized
	Fine	#200-#40	0.0029-0.017"	Flour-sized to sugar-sized
Fines		passing #200	<0.0029"	Flour-sized and smaller

MOISTURE CONTENT

Dry- Very little or no moisture
Damp- Some moisture but less than optimum
Moist- Near optimum
Very Moist- Above optimum
Wet/Saturated- Contains free moisture

GMU GEOTECHNICAL, INC.

LEGEND TO LOGS

Plate **A-2**

Project: Applied Medical Infiltration **Project Location: 20162 & 20202 Windrow Drive, Lake Forest** **Project Number: 21-017-00**	**Log of Drill Hole DH-1** Sheet 1 of 1

Date(s) Drilled	**2/17/2021**	Logged By	**RC**	Checked By	**MF**
Drilling Method	**Hollow Stem Auger**	Drilling Contractor	**Geoboden**	Total Depth of Drill Hole	**10.0 feet**
Drill Rig Type	**CME 75**	Diameter(s) of Hole, inches	**8**	Approx. Surface Elevation, ft MSL	**780.0**
Groundwater Depth [Elevation], feet	**N/A []**	Sampling Method(s)	**N/A**	Drill Hole Backfill	**Native, Concrete patch**
Remarks				Driving Method and Drop	**N/A**

ELEVATION, feet	DEPTH, feet	GRAPHIC LOG	GEOLOGICAL CLASSIFICATION AND DESCRIPTION	ORIENTATION DATA	ENGINEERING CLASSIFICATION AND DESCRIPTION	SAMPLE DATA: SAMPLE	SAMPLE DATA: NUMBER OF BLOWS / 6"	SAMPLE DATA: DRIVING WEIGHT, lbs	TEST DATA: MOISTURE CONTENT, %	TEST DATA: DRY UNIT WEIGHT, pcf	TEST DATA: ADDITIONAL TESTS
					3.5" AC, 3.5" Base						
			ARTIFICIAL FILL (Qaf)		CLAYEY SAND (SC); olive brown, moist, medium dense, fine to medium grained sand, trace clay						
			CAPISTRANO FORMATION (OSO MEMBER) (Tco)		CLAYEY SAND (SC); olive brown, moist, medium dense, fine to medium grained sand, trace clay						
775	**5**					X					
					SILTY SAND (SM); brown, moist, medium dense, fine to medium grained sand Becomes olive brown	X					
770	**10**				Total Depth: 10ft No groundwater						

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Drill Hole DH-1

Project: Applied Medical Infiltration **Project Location: 20162 & 20202 Windrow Drive, Lake Forest** **Project Number: 21-017-00**	**Log of Drill Hole DH-2** Sheet 1 of 1

Date(s) Drilled	**2/17/2021**	Logged By	**RC**	Checked By	**MF**
Drilling Method	**Hollow Stem Auger**	Drilling Contractor	**Geoboden**	Total Depth of Drill Hole	**10.0 feet**
Drill Rig Type	**CME 75**	Diameter(s) of Hole, inches	**8**	Approx. Surface Elevation, ft MSL	**778.0**
Groundwater Depth [Elevation], feet	**N/A []**	Sampling Method(s)	**N/A**	Drill Hole Backfill	**Native**
Remarks				Driving Method and Drop	**N/A**

ELEVATION, feet	DEPTH, feet	GRAPHIC LOG	GEOLOGICAL CLASSIFICATION AND DESCRIPTION	ORIENTATION DATA	ENGINEERING CLASSIFICATION AND DESCRIPTION	SAMPLE DATA: SAMPLE	SAMPLE DATA: NUMBER OF BLOWS / 6"	SAMPLE DATA: DRIVING WEIGHT, lbs	TEST DATA: MOISTURE CONTENT, %	TEST DATA: DRY UNIT WEIGHT, pcf	TEST DATA: ADDITIONAL TESTS
			ARTIFICIAL FILL (Qaf)		SILTY SAND (SM); olive brown, moist, medium dense, fine to medium grained sand, trace clay						
775			**CAPISTRANO FORMATION (OSO MEMBER) (Tco)**		SILTY SAND (SM); olive brown, moist, medium dense, fine to medium grained sand, trace clay						
	5										
770											
	10				Total Depth: 10ft No groundwater						

DH_REV3 21-017-00.GPJ GMULAB.GPJ 2/24/21

GMU

Drill Hole DH-2

Project: Applied Medical Infiltration Project Location: 20162 & 20202 Windrow Drive, Lake Forest Project Number: 21-017-00	**Log of Drill Hole DH-3** Sheet 1 of 1

Date(s) Drilled	**2/17/2021**	Logged By	**RC**	Checked By	**MF**
Drilling Method	**Hollow Stem Auger**	Drilling Contractor	**Geoboden**	Total Depth of Drill Hole	**10.0 feet**
Drill Rig Type	**CME 75**	Diameter(s) of Hole, inches	**8**	Approx. Surface Elevation, ft MSL	**782.0**
Groundwater Depth [Elevation], feet	**N/A []**	Sampling Method(s)	**N/A**	Drill Hole Backfill	**Native, Concrete patch**
Remarks				Driving Method and Drop	**N/A**

ELEVATION, feet	DEPTH, feet	GRAPHIC LOG	GEOLOGICAL CLASSIFICATION AND DESCRIPTION	ORIENTATION DATA	ENGINEERING CLASSIFICATION AND DESCRIPTION	SAMPLE DATA: SAMPLE	SAMPLE DATA: NUMBER OF BLOWS / 6"	SAMPLE DATA: DRIVING WEIGHT, lbs	TEST DATA: MOISTURE CONTENT, %	TEST DATA: DRY UNIT WEIGHT, pcf	TEST DATA: ADDITIONAL TESTS
					2" AC, 5" Base						
			ARTIFICIAL FILL (Qaf)		SILTY SAND (SM); olive brown, moist, medium dense, fine to medium grained sand, trace clay						
780			**CAPISTRANO FORMATION (OSO MEMBER) (Tco)** Some cobble		SILTY SAND (SM); olive brown, moist, medium dense, fine to medium grained sand, trace clay						
	5					X					
775						X					
	10				Total Depth: 10ft No groundwater						

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GMU

Drill Hole DH-3

APPENDIX B

Infiltration Test Results

Falling Head Borehole Infiltration Test

Project Name:	Applied Medical, L203	**Date:**	2/19/2021
Project Number:	21-017-00	**Tested By:**	RC
Test Hole Number:	IT-1	**USCS Soil Classification:**	Clayey Sand (SC)
Total Depth :	7.42 feet	**Water Temperature:**	62 °F
Test Hole Diameter:	8.00 inches	radius=	4 inches

Test No.	Start Time	End Time	ΔT (min)	Total Time (min)	Initial Depth of Water (ft)	Final Depth of Water (ft)	H_0 (in)	H_f (in)	ΔH (in)	H_{avg} (in)	Unfactored Percolation Rate (in/hour)
1	7:34	8:04	30.0	30.0	4.43	4.74	35.88	32.16	3.72	34.02	0.41
2	8:04	8:34	30.0	60.0	4.42	4.59	36.00	33.96	2.04	34.98	0.22
1	8:34	9:04	30.0	90.0	4.31	4.42	37.32	36.00	1.32	36.66	0.14
2	9:04	9:34	30.0	120.0	4.40	4.48	36.24	35.28	0.96	35.76	0.10
3	9:34	10:04	30.0	150.0	4.42	4.50	36.00	35.04	0.96	35.52	0.10
4	10:04	10:34	30.0	180.0	4.40	4.45	36.24	35.64	0.60	35.94	0.06
5	10:34	11:04	30.0	210.0	4.40	4.46	36.24	35.52	0.72	35.88	0.08
6	11:04	11:34	30.0	240.0	4.40	4.46	36.24	35.52	0.72	35.88	0.08
7	11:34	12:04	30.0	270.0	4.40	4.48	36.24	35.28	0.96	35.76	0.10
8	12:04	12:34	30.0	300.0	4.40	4.46	36.24	35.52	0.72	35.88	0.08
9	12:34	13:04	30.0	330.0	4.4	4.44	36.24	35.76	0.48	36.00	0.05
10	13:04	13:34	30.0	360.0	4.40	4.50	36.24	35.04	1.20	35.64	0.13

WATER TEMPERATURE CORRECTION FACTOR:	0.98
SAFETY FACTOR*:	2
UNFACTORED INFILTRATION RATE (IN/HR):	0.08
FACTORED INFILTRATION RATE (IN/HR):	0.04

Factor Category	Factor Description	Assigned Weight (w)	Factor Value (v)	Product (p) = w x v
Suitability Assessment	Soil assessment methods	0.25	3	0.75
	Predominant soil texture	0.25	2	0.5
	Site soil variablity	0.25	1	0.25
	Depth to groundwater	0.25	1	0.25
		Geotechnical Factor of Safety (SA):		1.75

Concern Level	Factor Value (v)
Low	1
Medium	2
High	3

Factor Description	High Concern	Medium Concern	Low Concern
Soil assessment methods	Use of borhole methods to estimate vertical infiltration rate (not recommended, but may be necessary at a planning level). Less than 2 tests per BMP	At least 2 tests per BMP. Use of borehole tests for dry wells or infiltration trenches. Use of infiltrometer or small scale PIT methods for vertical infiltration BMPs.	Extensive infiltration testing such as: PIT testing or infiltrometer testing at 3+ locations per BMP, and/or commitment to construction phase testing and design adaption if necessary.
Predominant soil texture	Silty and clayey soils with significant fines	Finer sandy soils with some loam content	Clean, granular soils (sands)
Site soil variablity	Highly variable soils indicated from site assessment or limited soil borings collected during site assessment.	Soil borings/test pits indicate moderately homogeneous soils.	Multiple soil borings/test pits indicate relatively homogeneous soils.
Depth to groundwater	Groundwater conditions or movement not well understood.	Seasonal high GW at least 10 ft below facility bottom.	Seasonal high GW at least 15 ft below facility bottom.

***Factor of safety should not be less than 2. Additional factor of safety in accordance with Table D-7 of the South Orange County Technical Guidance Document should be applied by the project civil engineer.**

Falling Head Borehole Infiltration Test

Project Name:	Applied Medical, L203		**Date:**	2/19/2021	
Project Number:	21-017-00		**Tested By:**	RC	
Test Hole Number:	IT-2		**USCS Soil Classification:**	Clayey Sand (SC)	
Total Depth :	5.16	feet	**Water Temperature:**	62	°F
Test Hole Diameter:	8.00 inches	radius= 4	inches		

Test No.	Start Time	End Time	ΔT	Total Time	Initial Depth of Water	Final Depth of Water	H_0	H_f	ΔH	H_{avg}	Unfactored Percolation Rate
			(min)	*(min)*	*(ft)*	*(ft)*	*(in)*	*(in)*	*(in)*	*(in)*	*(in/hour)*
1	7:28	7:58	30.0	30.0	2.10	2.40	36.72	33.12	3.60	34.92	0.39
2	7:58	8:28	30.0	60.0	2.12	2.31	36.48	34.20	2.28	35.34	0.24
1	8:28	8:58	30.0	90.0	2.16	2.25	36.00	34.92	1.08	35.46	0.12
2	8:58	9:28	30.0	120.0	2.09	2.10	36.84	36.72	0.12	36.78	0.01
3	9:28	9:58	30.0	150.0	2.10	2.12	36.72	36.48	0.24	36.60	0.02
4	9:58	10:28	30.0	180.0	2.10	2.10	36.72	36.72	0.00	36.72	0.00
5	10:28	10:58	30.0	210.0	2.10	2.10	36.72	36.72	0.00	36.72	0.00
6	10:58	11:28	30.0	240.0	2.10	2.13	36.72	36.36	0.36	36.54	0.04
7	11:28	11:58	30.0	270.0	2.10	2.15	36.72	36.12	0.60	36.42	0.06
8	11:58	12:28	30.0	300.0	2.10	2.12	36.72	36.48	0.24	36.60	0.02
9	12:28	12:58	30.0	330.0	2.1	2.12	36.72	36.48	0.24	36.60	0.02
10	12:58	13:28	30.0	360.0	2.10	2.13	36.72	36.36	0.36	36.54	0.04

WATER TEMPERATURE CORRECTION FACTOR:	0.98
SAFETY FACTOR*:	2
UNFACTORED INFILTRATION RATE (IN/HR):	0.03
FACTORED INFILTRATION RATE (IN/HR):	0.01

Factor Category	Factor Description	Assigned Weight (w)	Factor Value (v)	Product (p) = w x v
Suitability Assessment	Soil assessment methods	0.25	3	0.75
	Predominant soil texture	0.25	2	0.5
	Site soil variablity	0.25	1	0.25
	Depth to groundwater	0.25	1	0.25
		Geotechnical Factor of Safety (SA):		1.75

Concern Level	Factor Value (v)
Low	1
Medium	2
High	3

Factor Description	High Concern	Medium Concern	Low Concern
Soil assessment methods	Use of borhole methods to estimate vertical infiltration rate (not recommended, but may be necessary at a planning level). Less than 2 tests per BMP	At least 2 tests per BMP. Use of borehole tests for dry wells or infiltration trenches. Use of infiltrometer or small scale PIT methods for vertical infiltration BMPs.	Extensive infiltration testing such as: PIT testing or infiltrometer testing at 3+ locations per BMP, and/or commitment to construction phase testing and design adaption if necessary.
Predominant soil texture	Silty and clayey soils with significant fines	Finer sandy soils with some loam content	Clean, granular soils (sands)
Site soil variablity	Highly variable soils indicated from site assessment or limited soil borings collected during site assessment.	Soil borings/test pits indicate moderately homogeneous soils.	Multiple soil borings/test pits indicate relatively homogeneous soils.
Depth to groundwater	Groundwater conditions or movement not well understood.	Seasonal high GW at least 10 ft below facility bottom.	Seasonal high GW at least 15 ft below facility bottom.

***Factor of safety should not be less than 2. Additional factor of safety in accordance with Table D-7 of the South Orange County Technical Guidance Document should be applied by the project civil engineer.**

Falling Head Borehole Infiltration Test

Project Name:	Applied Medical, L203	**Date:**	2/19/2021
Project Number:	21-017-00	**Tested By:**	RC
Test Hole Number:	IT-3	**USCS Soil Classification:**	Clayey Sand (SC) - Silty Sand (SM)
Total Depth :	10.13 feet	**Water Temperature:**	62 °F
Test Hole Diameter:	8.00 inches	radius= 4 inches	

Test No.	Start Time	End Time	ΔT	Total Time	Initial Depth of Water	Final Depth of Water	H_0	H_f	ΔH	H_{avg}	Unfactored Percolation Rate
			(min)	*(min)*	*(ft)*	*(ft)*	*(in)*	*(in)*	*(in)*	*(in)*	*(in/hour)*
1	7:38	8:08	30.0	30.0	6.85	9.00	39.30	13.50	25.80	26.40	3.63
2	8:08	8:38	30.0	60.0	7.07	8.73	36.66	16.74	19.92	26.70	2.78
1	8:38	9:08	30.0	90.0	7.17	8.70	35.46	17.10	18.36	26.28	2.60
2	9:08	9:38	30.0	120.0	7.13	8.45	35.94	20.10	15.84	28.02	2.11
3	9:38	10:08	30.0	150.0	7.05	8.24	36.90	22.62	14.28	29.76	1.80
4	10:08	10:38	30.0	180.0	7.00	8.25	37.50	22.50	15.00	30.00	1.88
5	10:38	11:08	30.0	210.0	7.10	8.25	36.30	22.50	13.80	29.40	1.76
6	11:08	11:38	30.0	240.0	7.10	8.27	36.30	22.26	14.04	29.28	1.80
7	11:38	12:08	30.0	270.0	7.00	8.10	37.50	24.30	13.20	30.90	1.60
8	12:08	12:38	30.0	300.0	7.10	8.17	36.30	23.46	12.84	29.88	1.61
9	12:38	13:08	30.0	330.0	7.05	8.18	36.90	23.34	13.56	30.12	1.69
10	13:08	13:38	30.0	360.0	7.00	8.26	37.50	22.38	15.12	29.94	1.89

WATER TEMPERATURE CORRECTION FACTOR:	0.98
SAFETY FACTOR*:	2
UNFACTORED INFILTRATION RATE (IN/HR):	1.70
FACTORED INFILTRATION RATE (IN/HR):	0.85

Factor Category	Factor Description	Assigned Weight (w)	Factor Value (v)	Product (p) = w x v
Suitability Assessment	Soil assessment methods	0.25	3	0.75
	Predominant soil texture	0.25	2	0.5
	Site soil variablity	0.25	1	0.25
	Depth to groundwater	0.25	1	0.25
			Geotechnical Factor of Safety (SA):	1.75

Concern Level	Factor Value (v)
Low	1
Medium	2
High	3

Factor Description	High Concern	Medium Concern	Low Concern
Soil assessment methods	Use of borhole methods to estimate vertical infiltration rate (not recommended, but may be necessary at a planning level). Less than 2 tests per BMP	At least 2 tests per BMP. Use of borehole tests for dry wells or infiltration trenches. Use of infiltrometer or small scale PIT methods for vertical infiltration BMPs.	Extensive infiltration testing such as: PIT testing or infiltrometer testing at 3+ locations per BMP, and/or commitment to construction phase testing and design adaption if necessary.
Predominant soil texture	Silty and clayey soils with significant fines	Finer sandy soils with some loam content	Clean, granular soils (sands)
Site soil variablity	Highly variable soils indicated from site assessment or limited soil borings collected during site assessment.	Soil borings/test pits indicate moderately homogeneous soils.	Multiple soil borings/test pits indicate relatively homogeneous soils.
Depth to groundwater	Groundwater conditions or movement not well understood.	Seasonal high GW at least 10 ft below facility bottom.	Seasonal high GW at least 15 ft below facility bottom.

***Factor of safety should not be less than 2. Additional factor of safety in accordance with Table D-7 of the South Orange County Technical Guidance Document should be applied by the project civil engineer.**

Worksheet 3: Factor of Safety and Design Infiltration Rate and Worksheet

Factor Category		Factor Description	Assigned Weight (w)	Factor Value (v)	Product (p) $p = w \times v$
A	Suitability Assessment	Soil assessment methods	0.25	3.0	0.75
		Predominant soil texture	0.25	2.0	0.5
		Site soil variability	0.25	1.0	0.25
		Depth to groundwater / impervious layer	0.25	1.0	0.25
		Suitability Assessment Safety Factor, $S_A = \Sigma p$			1.75
B	Design	Tributary area size	0.25		
		Level of pretreatment/ expected sediment loads	0.25		
		Redundancy/contingency plan	0.25		
		Compaction during construction	0.25		
		Design Safety Factor, $S_B = \Sigma p$			
Combined Safety Factor, $S_{Total} = S_A \times S_B$					
Observed Infiltration Rate, inch/hr, K_{obs} (corrected for test-specific bias)					
Design Infiltration Rate, in/hr, $K_{design} = K_{obs} / S_{Total}$					
Supporting Data					
Briefly describe infiltration test and provide reference to test forms:					

Note: The minimum combined adjustment factor shall not be less than 2.0 and the maximum combined adjustment factor shall not exceed 9.0.

APPENDIX C

Contech Engineered Solutions, Corrugated Metal Pipe Specifications

CONTECH®
ENGINEERED SOLUTIONS

Corrugated Metal Pipe
Detention & Infiltration

The experts you need to solve your stormwater challenges

Your Contech Team

Contech is the leader in stormwater solutions, helping engineers, contractors and owners with infrastructure and land development projects throughout North America.

With our responsive team of stormwater experts, local regulatory expertise and flexible solutions, Contech is the trusted partner you can count on for stormwater management solutions.

STORMWATER CONSULTANT

It's my job to recommend the best solution to meet permitting requirements.

STORMWATER DESIGN ENGINEER

I work with consultants to design the best approved solution to meet your project's needs.

REGULATORY MANAGER

I understand the local stormwater regulations and what solutions will be approved.

SALES ENGINEER

I make sure our solutions meet the needs of the contractor during construction.

Contech is your partner in stormwater management solutions

Subsurface Infiltration as a Stormwater Management Strategy

CMP Infiltration is used at Long Beach City College in Long Beach, California.

The only sure way to eliminate stormwater pollution is to eliminate stormwater runoff. In recognition of this fact, Green Infrastructure and Low Impact Development based stormwater management regulations prioritizing runoff reduction have proliferated throughout the United States.

Where site conditions allow, infiltration is typically the most cost effective and reliable runoff reduction approach. In urban environments where there are competing demands for land, subsurface infiltration can provide many of the benefits of landscape based systems but without requiring dedicated land area.

Infiltration systems are commonly comprised of a pretreatment component designed to remove sediment, trash, and oil, followed by plastic, metal or concrete storage units surrounded by permeable stone creating a high voids storage gallery.

Infiltration systems are typically designed to support vehicular loading and to withstand lateral pressures from surrounding soil that allows the overlying land to be used for virtually any non-building application.

Corrugated Metal Pipe
The "Go To" Material for Stormwater Detention

For the majority of applications, corrugated metal pipe (CMP) is the "go to" material for stormwater detention and infiltration. With its low cost, a wide variety of diameters, layout configurations and coatings, no other material can match CMP's flexibility and versatility.

- NCSPA service life guidance of 75+ years for certain materials in recommended environments. Please refer to the Corrugated Metal Pipe Detention Design Guide for additional information.
- Various pipe coatings and materials are available to accommodate site-specific needs: Aluminized Steel Type 2 (ALT2), Galvanized, CORLIX® Aluminum, and Polymeric.
- Wide range of gages, corrugations, and shapes, diameters 12"– 144"
- Pipe can be fully or partially perforated for infiltration or groundwater recharge applications
- Custom risers and manifolds provide direct access for maintenance
- Outlet control devices can be incorporated within the system, eliminating the need for a separate structure
- Customizable - a variety of fittings allow CMP to match most layout configurations
- May be designed for heavy loading and high maximum cover
- Contributes to LEED points
- Available locally; quick turnaround time
- The most economical installed solution

No other material can match the flexibility and versatility of CMP

Service Life for Corrugated Metal Pipe

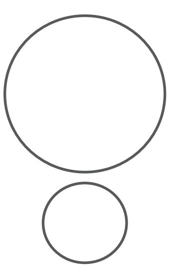
The durability of steel ...

Some engineers are hesitant to use corrugated metal pipe (CMP) for infiltration because they have heard about CMP drainage culverts that have corroded due to abrasion. Factors affecting longevity differ between culvert and infiltration applications. Culverts experience high velocity flows carrying abrasive sediment, which can wear off galvanized coatings used in older CMP culverts. Infiltration systems are designed for storage rather than conveyance, so velocity and abrasive forces are minimized. In addition, improved CMP coatings, such as Aluminized Type 2 (ALT2), are more abrasion resistant and have demonstrated superior in-ground performance against abrasion in long-term durability studies. Field studies also have indicated that ALT2 coating may extend service life in wider pH and resistivity ranges than galvanized coatings. Confirming and maintaining recommended environmental conditions helps ensure system longevity projected by the long term studies. Finally, properly designed infiltration systems include pretreatment, flow control and a stone backfill envelope that can reduce exposure to abrasion

Learn More:
www.ncspa.org

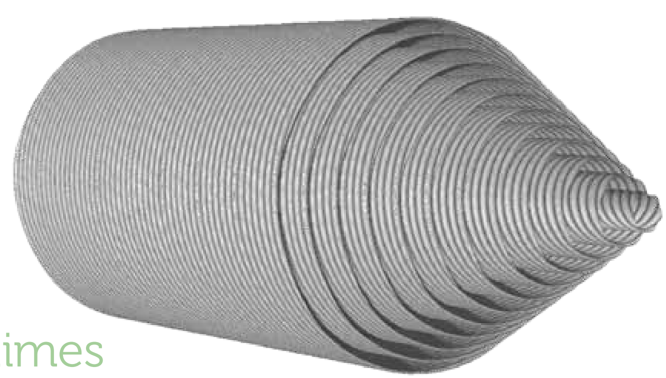
Maximizing Vertical Space: Every Inch Counts

One of the most overlooked advantages of CMP is its ability to maximize vertical storage space. Increasing the depth of a CMP infiltration system allows for more water storage in the same footprint. For example, doubling the diameter of pipe yields four times as much storage volume in the pipe. This provides a significant cost savings per cubic foot of storage. In addition, more vertical storage space means a smaller footprint, less excavation, and lower project costs.



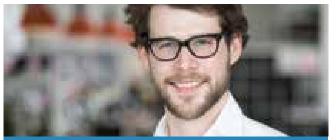
96" diameter - 50.2 ft^3/ft

48" diameter - 12.5 ft^3/ft



Twice the diameter provides four times the storage space.

System Sizing



APPLICATION TIPS

- Use the largest diameter pipe possible to maximize vertical storage space and minimize the overall footprint. Doing so will reduce material, excavation, and backfill costs.
- Single manifold systems are most cost effective as they reduce the amount of fabrication needed.
- Incorporating flow controls into the CMP system can reduce costs by eliminating the need for additional concrete structures.
- The Contech MOBILE PIPE® mill can be delivered to remote locations and assembled on-site for fast and cost effective steel pipe manufacturing.

DIAMETER (IN)	VOLUME (FT^3/FT)	MIN. COVER HEIGHT
6	0.20	12”
8	0.35	12”
10	0.55	12”
12	0.78	12”
15	1.22	12”
18	1.76	12”
21	2.40	12”
24	3.14	12”
30	4.90	12”
36	7.10	12”
42	9.60	12”
48	12.60	12”
54	15.90	12”
60	19.60	12”
66	23.80	12”
72	28.30	12”
78	33.20	12”
84	38.50	12”
90	44.20	12”
96	50.30	12”
102	56.80	18”
108	63.60	18”
114	70.90	18”
120	78.50	18”
126	86.60	18”
132	95.00	18”
138	103.90	18”
144	113.10	18”

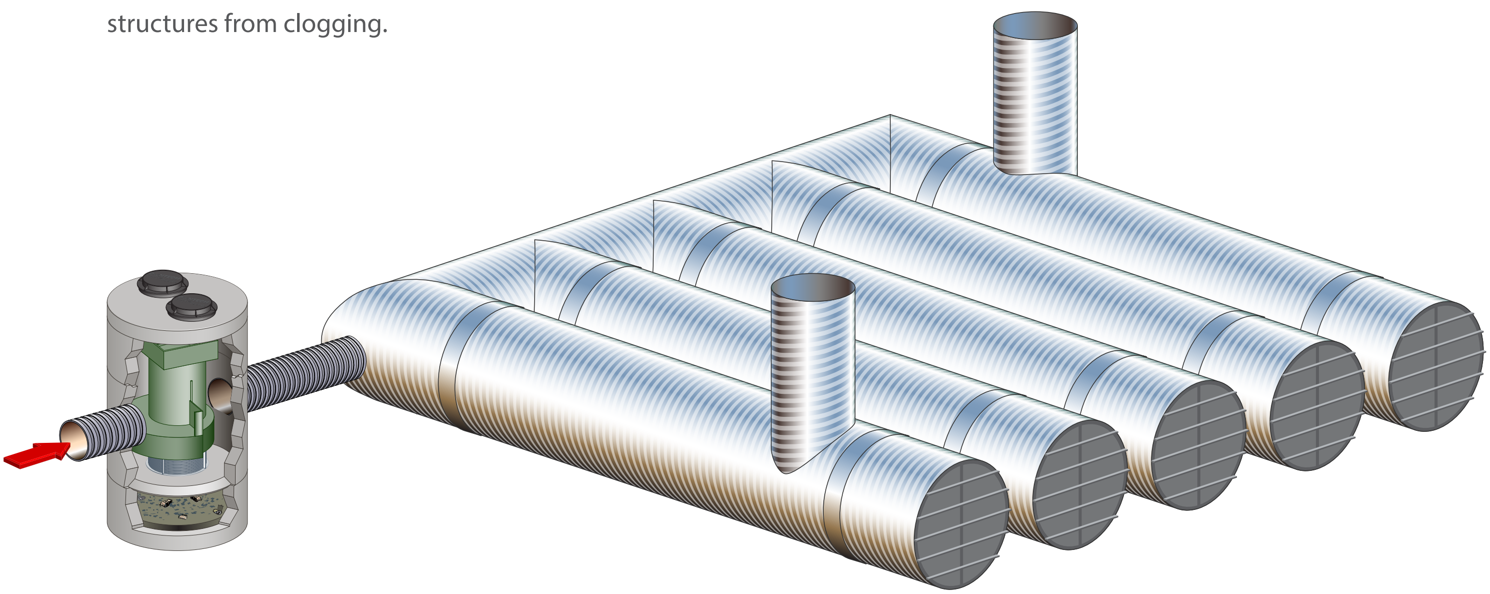
Because of its low cost and flexible configurations, CMP is the ‘go to’ material for stormwater detention and filtration.

Contech’s CMP Detention systems maximize vertical storage space

The Need for Effective Pretreatment

Infiltration systems have multiple components, and one of the most important is pretreatment. The purpose of a pretreatment device is to prolong the life of the infiltration system by removing debris and sediment that can collect on the invert and within the stone backfill voids. Pretreatment will maintain the efficiency of an infiltration system as well as extend the life cycle, therefore preventing a premature replacement. Pretreatment also offers these additional benefits:

- Easier to clean and maintain compared to the infiltration system itself.
- Cost savings due to the extended service life of the system.
- Removing trash and debris protects downstream outlet control structures from clogging.



Pretreatment systems that are easy to maintain and do not rely on the use of geotextile fabric are preferred.

Pretreatment Design Considerations

When choosing a pretreatment system, consider the following ...

- Downstream outlet control structures may require protection from a pretreatment device that screens trash and debris.
- Pretreatment system selection depends on pollutant targets. Trash, debris, and larger particles can be removed with hydrodynamic separators. Removing high percentages of fine particles and associated heavy metals and nutrients requires filtration.
- Reduced long term maintenance or replacement cost of the infiltration system can help justify pretreatment construction costs.
- Inlet and pipe layout will influence the number and type of pretreatment systems used. A combination of different systems may be appropriate for the various inlet locations and flows.

The CDS® provides direct access to cleaning, using a combination of swirl concentration and indirect screening.

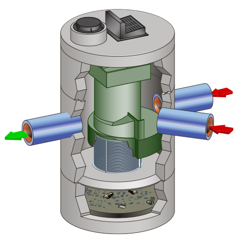
Learn More:
www.ContechES.com/cmp-detention

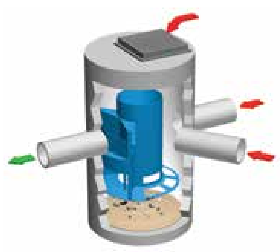
Reduce long term maintenance of an infiltration system with pretreatment.

Pretreatment options extend the life of subsurface infiltration

Pretreatment Options

Contech offers a number of pretreatment options, all of which will extend the life of subsurface infiltration systems and improve water quality. The type of system chosen will depend on a number of factors including footprint, soil conditions, local regulations, and the desired level of pretreatment.





Hydrodynamic Separation

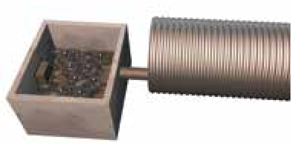
Hydrodynamic Separation (HDS) provides a basic level of pretreatment by capturing and retaining trash and debris, sediment, and oil from stormwater runoff.

CDS®

CDS provides superior trash and sediment removal, and is much easier to clean and maintain compared to the infiltration system itself.

Cascade Separator™

The Cascade Separator uses advanced sediment capture technology to provide the highest sediment removal efficiency to protect the stone backfill voids of infiltration systems, thus extending the life of the system.



Filtration

Filtration provides a higher level of pretreatment and improved water quality by removing trash and debris, oil, fine solids, and dissolved pollutants such as metals, hydrocarbons, and nutrients.

Filterra® Bioretention System

Filterra is an engineered bioretention system that has been optimized for high volume/flow treatment and high pollutant removal.

The Stormwater Management StormFilter®

The StormFilter system is comprised of a structure that houses rechargeable, media-filled cartridges. The media can be customized to target site-specific pollutants.

Jellyfish® Filter

The Jellyfish filter uses membrane filtration in a compact footprint to remove a high level and a wide variety of stormwater pollutants such as fine particulates, oil, trash and debris, metals, and nutrients.

Alternative Materials for Subsurface Infiltration

There may be instances where alternative materials are needed for subsurface infiltration due to site specific needs ...

Plastic Chambers

Plastic chambers are best suited to shallow depth applications; minimum cover is 18 inches, and maximum cover is 96 inches. Some benefits of chambers are:

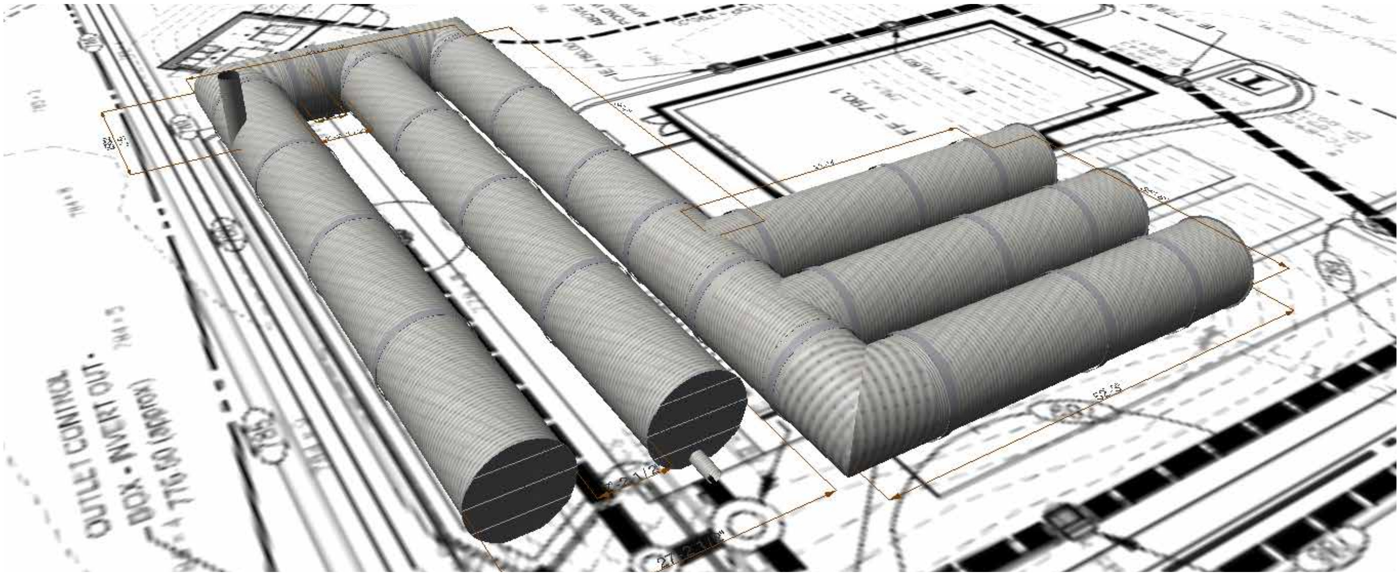
- Chambers may be beneficial for sites with limited vertical storage.
- Lightweight and installed by hand.
- Heavy equipment is not required to set units into place.
- Centralized stocking locations for short lead times.

Concrete Structures/Vaults

Some concrete structures and vaults are best suited for high loading applications such as railroads or airports. Concrete units are also ideal in corrosive environments or areas with high salinity. Some benefits of concrete structures are:

- Wide range of spans and heights.
- Greater underground infiltration storage in a smaller footprint.
- Ample and easy maintenance access.
- Fast installation.

Design Your Own Detention System (DYODS®)



Learn More:
www.ContechES.com/dyods

Quickly prepare designs for estimates and project meetings ...

Engineers are always looking for new ways to quickly prepare designs for estimates and project meetings. We have a tool that does just that… the Design Your Own Detention System (DYODS®) tool.

This free, online tool fully automates the layout process for stormwater detention and infiltration systems. You can create multiple systems for each project while saving all project information for future use.

The tool's draft board feature allows you to edit the layout of your system. The unique "drag and drop" feature allows users to add stubs and risers while customizing the site's layout to meet site specific conditions while optimizing the design.

After you submit your design, you'll receive an email that contains your customized drawings in both PDF and CAD format, storage volume calculations, and specifications.

- "Drag and drop" feature allows users to customize layout
- A 2D/3D design environment with high-resolution graphics including BIM model output
- Optimize designs for the storage requirement or maximize storage for a given footprint
- Import a PDF site plan, scale and design a system over the plan and view the overlay in 2D
- Instant access to customized, project specific drawings, and CAD files
- Ability to co-workers or Contech design engineers to your project with the new Collaborator feature

A free, online tool that fully automates the layout process for stormwater detention systems.

A partner you can rely on

STORMWATER SOLUTIONS

PIPE SOLUTIONS

STRUCTURES SOLUTIONS

Few companies offer the wide range of high-quality stormwater resources you can find with us — state-of-the-art products, decades of expertise, and all the maintenance support you need to operate your system cost-effectively.

THE CONTECH WAY

Contech® Engineered Solutions provides innovative, cost-effective site solutions to engineers, contractors, and developers on projects across North America. Our portfolio includes bridges, drainage, erosion control, retaining wall, sanitary sewer and stormwater management products.

TAKE THE NEXT STEP

For more information: www.ContechES.com

CONTECH®
ENGINEERED SOLUTIONS

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