Geotechnical Evaluation Report

Chamber Grove Park Recovery and Improvements
Minnesota Trunk Highway 23
Duluth, Minnesota

Prepared for

LHB, Inc.

Professional Certification:
I hereby certify that this plan, specification, or report was prepared by me or under my direct supervision and that I am a duly Licensed Professional Engineer under the laws of the State of Minnesota.

Joseph C. Butler, PE
Associate Principal / Senior Engineer
License Number: 47600
March 9, 2016

Project B1601111

Braun Intertec Corporation

BRAUN INTERTEC
The Science You Build On.

Braun Intertec Corporation
4511 West First Street, Suite 4
Duluth, MN 55807

Phone: 218.624.4967
Fax: 218.624.0196
Web: braunintertec.com

March 9, 2016 Project B1601111

Megan Goplin
LHB, Inc.
21 West Superior Street, Suite 500
Duluth, MN 55802

Re: Geotechnical Evaluation
Chamber Grove Park Recovery and Improvements
Minnesota Trunk Highway 23
Duluth, Minnesota

Dear Ms. Goplin:

We are pleased to present this Geotechnical Evaluation Report for the Chamber Grove Park Flood Recovery and Improvements project in Duluth, Minnesota. Please see the attached report for a detailed discussion of the field exploration results and our recommendations for design and construction. The report should be read in its entirety.

Thank you for making Braun Intertec your geotechnical consultant for this project. If you have questions about this report, or if there are other services that we can provide in support of our work to date, please contact Joe Butler at 218.624.4967or by email at dmorrison@braunintertec.com.

Sincerely,

BRAUN INTERTEC CORPORATION

David Morrison, EIT
Staff Engineer

Joseph C. Butler, PE
Associate Principal/Senior Engineer

AA/EOE

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BRAUN INTERTEC

A. Introduction

A.1. Project Description

The City of Duluth is planning improvements to Chambers Grove Park. The project will include the replacement of a bathroom building, installation of new playground equipment, relocation of the WWII Veteran's Memorial, storm water management improvements and construction of new or improved parking and drive areas. Included in the project is improvements and expansions to the pavements areas, landscaping and wetlands.

Chambers Park is located west of the intersection of Hwy 210 and MN-23 in Duluth, Minnesota.

A.2. Purpose

The purpose of our geotechnical evaluation will be to characterize subsurface geologic conditions at selected exploration locations and evaluate their impact on the design and construction of the building foundations and pavement areas.

A.3. Background Information and Reference Documents

To facilitate our evaluation, we were provided with or reviewed the following information or documents:

- Request for Proposal by LHB, Inc. dated January 28, 2016.
- Proposed boring location sketch, prepared by LHB, Inc. undated.
- Minnesota Geologic Map, "Geologic Map of Minnesota, Quaternary Geology", prepared by Hobbes and Goebel, dated 1982.
- Aerial photos from Google Earth©.

A.4. Site Conditions

Chambers Grove Park currently exists as a lawn covered city park with bituminous paved parking and drive areas. Included in the park is an existing picnic pavilion, bathroom building, gazebo and WWII Veteran's Memorial. The park is boarded on the southwest with a breakwater separating the park from the St. Louis River. The site generally slopes down to the southwest, toward the St. Louis River.

A.5. Scope of Services

Our scope of services for this project was originally submitted as a Proposal to Ms. Goplin of LHB, Inc. We received authorization to proceed from Ms. Goplin on February 9, 2016. Tasks performed in accordance with our authorized scope of services included:

- Staking and clearing exploration locations of underground utilities.
- Performing two penetration test borings for the parking and drive areas, to a nominal depth of 10 feet.
- Performing two penetration test borings for the bathroom and playground, to a nominal depth of 20 feet.
- Performing laboratory moisture content tests, and mechanical analysis (through a #200 sieve only) on selected penetration test samples.
- Preparing this report containing a CAD sketch, exploration logs, a summary of the geologic materials encountered, results of laboratory tests, and recommendations for structure subgrade preparation and the design of the pavements and building foundations.

Exploration locations and surface elevations at the exploration locations were determined using GPS (Global Positioning System) technology that utilizes the Minnesota Department of Transportation's (MnDOT's) permanent GPS Virtual Reference Network (VRN).

Our services will be provided under the terms of the Master Agreement for Professional Services dated June 26, 2012 between LHB, Inc. and Braun Intertec Corporation.

B. Results

B.1. Exploration Logs

B.1.a. Log of Boring Sheets

Log of Boring sheets for our penetration test borings are included in the Appendix. The logs identify and describe the geologic materials that were penetrated, and present the results of penetration resistance tests performed within them, laboratory tests performed on penetration test samples retrieved from them, and groundwater measurements.

Strata boundaries were inferred from changes in the penetration test samples and the auger cuttings. Because sampling was not performed continuously, the strata boundary depths are only approximate. The boundary depths likely vary away from the boring locations, and the boundaries themselves may also occur as gradual rather than abrupt transitions.

B.1.b. Geologic Origins

Geologic origins assigned to the materials shown on the logs and referenced within this report were based on: (1) a review of the background information and reference documents cited above, (2) visual classification of the various geologic material samples retrieved during the course of our subsurface exploration, (3) penetration resistance testing performed for the project, (4) laboratory test results, and (5) available common knowledge of the geologic processes and environments that have impacted the site and surrounding area in the past.

B.2. Geologic Profile

B.2.a. Geologic Materials

We completed 2 borings for the bathroom replacement and playground areas, extending them to a nominal depth of 20 feet. We performed 2 additional borings for the proposed parking and drive areas, extending them to a nominal depth of 15 feet.

Boring ST-02 was completed within an existing pavement area. The boring encountered 2 inches of bituminous pavement underlain with 8 inches of aggregate base. Below the pavements, the boring generally encountered silty sand fill to a depth of 2 feet. Native silty sand was encountered below the fill.

Borings ST-01, ST-03 and ST-04 were performed in the lawn area and generally encountered 1/2 foot of topsoil underlain with native silty sand to the termination depth of the borings. Borings ST-01 and ST-03 encountered 2 1/2 to 6 feet of organic clay at a depth of 11 1/2 feet

Penetration resistance values recorded in the silty sand ranged from 1 to 21 blows per foot (BPF), indicating they were very loose to medium dense.

Penetration resistance values recorded in the organic clays ranged from 1 to 3 BPF, indicating they were very soft to soft.

B.2.b. Groundwater

Groundwater was measured or estimated to be down approximately 6 to 11 feet as our borings were advanced. These depths correspond to elevations 603 to 611 1/2 feet.

The site is immediately adjacent the St. Louis River, we anticipate groundwater at the site will be correspond to the water surface elevation of the St. Louis River. Seasonal and annual fluctuations of groundwater should also be anticipated.

B.3. Laboratory Test Results

The moisture content of the silty sand was determined to vary from approximately 15.1 to 23.3 percent, indicating that the material was likely at or above its probable optimum moisture content.

Our mechanical analyses indicated that the silty sand contained 33 to 43 percent silt and clay by weight.

C. Basis for Recommendations

C.1. Design Details

C.1.a. Building Configuration and Loads

The project will include the demolition and replacement of the existing bathroom building. We have not been provided with building configuration at the time of this report. Based upon past experience with similar structures, we anticipate the building will be a single-story structure with concrete foundations and masonry or wood walls. Loads for the bathroom were reported as being less than 2.5 kips per linear for, column loads to be less than 20 kips. We have assumed the bathroom is not heated.

Interior areas are expected to consist of concrete slab-on-grade supported on compacted fill over native soils. Floor live loads are anticipated to be less than 100 pounds per square foot.

Additional site work is expected to include grading and gravel surfacing around the perimeter of the building. Bituminous paved sidewalks are also included in this project.

C.1.b. Monument Loads

We understand the existing WWII monument will be relocated to the lawn area of the north turn around. To facilitate the relocation, the monument will be deconstructed and reconstructed on a new concrete slab. Loads for the monument were reported as being 2,000 pounds per square foot (PSF).

C.1.c. Pavements and Traffic Loads

We understand that the existing pavements will be removed and replaced with new. We have assumed that the project will have a medium-duty pavement sections and will be subjected to no more than 75,000 equivalent 18-kip single axle loads (ESALs) over an assumed design life of 20 years.

C.1.d. Anticipated Grade Changes

We assume existing ground surface elevations are within approximately 1 foot of the proposed slab on grade and pavement elevations. Cuts and fills on the order of 1 foot are therefore anticipated.

C.1.e. Precautions Regarding Changed Information

We have attempted to describe our understanding of the proposed construction to the extent it was reported to us by others. Depending on the extent of available information, assumptions may have been made based on our experience with similar projects. If we have not correctly recorded or interpreted the project details, we should be notified. New or changed information could require additional evaluation, analyses and/or recommendations.

C.2. Design Considerations - Bathroom Building

Boring ST-01 was performed at the proposed bathroom building location. The boring encountered highly frost susceptible silty sands underlain with highly compressible organic clays at depth.

C.2.a. Compressible Soils

Boring ST-01 encountered organic clays between a depth of 11 ½ and 17 1/2 feet. If additional load, from new or heavier fill or from foundation loads are placed over the organic soils, settlement on the order of 3 inches or more will occur. We therefore recommend the organic soils not be relied upon for structural support of the building foundations. We recommend the design team consider helical piers for the support of the foundations and slabs. The helical pile will transfer load below the organic materials.

Helical pile are hollow tubes or solid square steel rods, which are typically 1 1/2 to 3 1/2 inches in diameter with several flights of steel plate augers. These augers are screwed into the ground until a specified torque criteria and minimum depth is met. Similar to the spread footings, the helical piers will move somewhat under structure loads, but typically to a lesser extent. The magnitude of this movement will be dependent upon helical pier type selected and the soil conditions. We recommend that a performance based specification be used to establish anchor performance and that the contractor be consulted as part of the design process.

We recommend the lead section of the helical pile be extended below the organic clay and extend into the native silty sand soil at depth. We would like to note that our boring for the bathroom foundation may not have been extended deep enough for the helical pile designer to accurately predict pile depth. If additional data is desired, we recommend the boring be extended past the glaciofluvium and into denser soils at depth.

C.2.b. Frost Susceptible Soils

The silty sand soils observed in Boring ST-01 is considered highly frost susceptible, frost heave on the order of 6 inches is possible. Removal of frost susceptible materials and replacement with non-frost susceptible materials and/or protection with insulation can be considered for frost protection of the foundations and slab. Because organic clays were encountered at depth, and helical pile are being considered for foundation and slab support, we recommend either a void be provided or a combination of insulation and non-frost susceptible materials be used.

We recommend a void be provided below the slab to accommodate heave. A minimum of 12 inches of clearance between the ground surface and the bottom of the structure should be provided. This void allows for soils to heave independent of the structure. We suspect design and construction of the underground plumbing will be difficult with the void. Alternatively, we recommend removing the native soils from below the bathroom building to a depth of 16 inches and replacing with 1 foot of non-frost susceptible materials and 4 inches of rigid insulation. The intent of the insulation and non-frost susceptible materials is for frost protection only, the slab should be structural and supported by helical pile.

We also recommend the final surface be graded so that surface water runs away from structure foundations, this will help minimize frost heave.

C.3. Design Considerations – Pavements, Exterior Slabs, and Utilities

C.3.a. Topsoil

Topsoil was observed across the site and varies in depth from 1/4 to 1/2 foot. Topsoil contains organic materials which readily absorb water and become weak and highly frost susceptible. We recommend completely removing the topsoil from below slabs and pavement.

C.3.b. Loose Wet Subgrade Materials

The borings encountered silty sands that were loose and wet of their optimum moisture content. We recommend a sand sub-base be included in the pavement section to enhance pavement strength and uniformity.

C.4. Construction Considerations

C.4.a. Groundwater

Groundwater was observed in all of the borings. Excavations can be dewatered using sumps and pumps. If groundwater cannot be completely removed prior to fill placement, we recommend initially backfilling over wet excavation bottoms with stone meeting the requirements of MnDOT Course Filter aggregate.

C.4.b. Construction Traffic

The silty sands present below the topsoil and at subgrade elevations are sensitive to disturbance. Haul roads and staging areas will be particularly sensitive to disturbance and strength loss. Subexcavation and replacement of subgrade soils can be limited if these traffic areas are protected.

D. Recommendations

D.1. Bathroom Building Subgrade Preparation

D.1.a. Excavations

We recommend removing topsoil from the proposed building area. Based on the boring, excavation depths are expected to be about 3 inches.

Excavation depths will vary away from the boring. Portions of the excavations may also be deeper than indicated by the boring. Contractors should also be prepared to extend excavations in wet or fine-grained soils to remove disturbed bottom soils.

To provide lateral support to replacement backfill, additional required fill and the structural loads they will support, we recommend oversizing (widening) the excavations 1 foot horizontally beyond the outer edges of the building perimeter footings, or pavement limits, for each foot the excavations extend below bottom-of-footing or pavement subgrade elevations.

D.1.b. Excavation Dewatering

We recommend removing groundwater from the excavations. Sumps and pumps can be considered for dewatering excavations.

D.1.c. Selecting Excavation Backfill and Additional Required Fill

On-site soils free of organic soil and debris can be considered for reuse as backfill and fill. The silty sand, however, being fine-grained, will be more difficult to compact if wet or allowed to become wet, or if spread and compacted over wet surfaces.

We recommend that imported material needed to replace excavation spoils or balance cut and fill quantities, consist of sand having less than 20 percent of the particles by weight passing a #200 sieve.

If groundwater cannot be completely removed prior to fill placement, we recommend initially backfilling over wet excavation bottoms with stone meeting the requirements of MnDOT Course Filter aggregate.

Where non frost susceptible materials are needed, we recommend they consist of sand with less than 50 percent of the particles by weight passing a #40 sieve, and less than 5 percent of the particles passing a #200 sieve.

D.1.d. Placement and Compaction of Backfill and Fill

We recommend spreading backfill and fill in loose lifts of approximately 6 to 12 inches depending on the size of the compactor used. We recommend compacting backfill and fill in accordance with the criteria presented below in Table 1. The relative compaction of utility backfill should be evaluated based on the structure below which it is installed, and vertical proximity to that structure.

Table 1. Compaction Recommendations Summary

Reference	Relative Compaction, percent (ASTM D 698 – standard Proctor)	Moisture Content Variance from Optimum, percentage points
Below foundations	95	+/- 3
Below slabs	95	+/- 3
Below pavements, within 3 feet of subgrade elevations	100	+/- 3
Below pavements, more than 3 feet below subgrade elevations	95	+/- 3

D.2. Bathroom Building Foundations

As discussed above we recommend the proposed bathroom building be supported by helical pile. Recommendations for design of the foundation are provided in the following sections.

D.2.a. Embedment Depth – Frost Depth Grade Beam

For frost protection, we recommend embedding grade beams and pile caps 72 inches below the lowest exterior grade.

D.2.b. Embedment Depth – Monolithic-Grade-Beam-Floor-Slab-System

As an alternative to placing grade beams at frost depth, it is our opinion the footings can be protected from frost with a combination of insulation and non-frost susceptible materials. If this option is pursued, we recommend 4 inches of insulation and 12 inches of non-frost susceptible sand.

We recommend perimeter grade beams be embedded a minimum of 12 inches for erosion protection.

D.2.c. Helical Pile Foundations

As discussed above, we recommend helical pile be considered for this project. We recommend that a performance based specification be used to establish anchor performance and that the contractor be consulted as part of the design process.

D.3. Interior Slabs

As discussed above, for frost protection in non-heated structures, we recommend interior slabs not be in contact with frost susceptible subgrade soils. We recommend a minimum of 12 inches of clearance be provided between slabs and subgrades. This void allows for soils to heave without affecting the structure. An alternative to constructing a void below the structural slab is to replace 16 inches of native soils with 1 foot of non-frost susceptible soils and 4 inches of rigid insulation.

We recommend insulation either extend down the frost depth foundation walls and below grade beams/pile caps placed above frost depth. If a monolithic grade beam slab system is used, we recommend the insulation and sand extend below the foundations and slabs, and extend out and away from the building 5 feet.

Regardless of which recommendation is followed for frost protection of interior slabs, subgrade soils should not be relied upon for support of interior slabs. We recommend that all interior slabs be structural slabs supported by foundation systems.

D.3.a. Moisture Vapor Protection

If floor coverings or coatings less permeable than the concrete slab will be used, consideration should be given to placing a vapor retarder or vapor barrier immediately beneath the slab. Some contractors prefer to bury the vapor retarder or barrier beneath a layer of sand to reduce curling and shrinkage, but this practice risks trapping water between the slab and vapor retarder or barrier.

Regardless of where the vapor retarder or barrier is placed, floor covering manufacturers should be consulted regarding the appropriate type, use and installation of the vapor retarder or barrier to preserve warranty assurances.

D.4. Monument

A boring was not performed at the proposed monument location however, compressible soils were observed on the site. Settlement of the monument due to compression of the organic soils is possible. Also, heave of the monument is likely due to the highly frost susceptible silty sands.

The monument is relatively lightly loaded, and we suspect it can be relatively easily re-leveled. If the project team accepts the risk of settlement due to buried organic deposits, we recommend the monument be supported by spread footings or a frost protected slab.

We recommend the monument be protected from frost heave similar to the proposed building, either with frost depth foundations or a combination of insulation and sand. Recommendations presented above for the bathroom building apply to the monument.

D.5. Pavements

D.5.a. Subgrade Preparation

We recommend completely removing existing pavements, topsoil and other organic materials from below the pavement areas.

We recommend compacting excavation backfill (including utility backfill) and additional required fill placed within 3 feet of pavement subgrade elevations to at least 100 percent of their maximum standard

Proctor dry densities (ASTM D 698). Backfill and fill placed more than 3 feet below pavement subgrade elevations should be compacted to at least 95 percent.

D.5.b. Subgrade Proofroll

Prior to placing aggregate base material, we recommend proofrolling pavement subgrades to determine if the subgrade materials are loose, soft or weak, and in need of further stabilization, compaction or subexcavation and recompaction or replacement. A second proofroll should be performed after the aggregate base material is in place, and prior to placing bituminous or concrete pavement.

D.5.c. Design Sections

Laboratory tests to determine an R-value or CBR value for pavement design were not included in the scope of this project. Based on our experience with similar projects in the area, however, it is our opinion that an R-value of 20 can be assumed for design purposes.

Based upon the aforementioned traffic loads and an R-value of 20, we recommend a medium duty pavement section consisting of 4 inches of bituminous pavement over 8 inches of aggregate base material over 12 inches of select granular borrow.

Where concrete pavements will be utilized, we recommend that at least 6 inches of aggregate base be placed over 12 inches of select granular borrow to provide more uniform support and subgrade drainage for the concrete, and to provide a more stable working platform for construction. We recommend a minimum 4-inch thick concrete slab in light-duty areas and a minimum 6-inch thick concrete slab in heavy-duty areas. These designs are based on a modulus of subgrade reaction (k) of 100 pci.

The above pavement designs are based upon a 20-year performance life. This is the amount of time before major reconstruction is anticipated. This performance life assumes maintenance, such as seal coating and crack sealing, is routinely performed. The actual pavement life will vary depending on variations in weather, traffic conditions and maintenance.

D.5.d. Materials and Compaction

We recommend specifying crushed aggregate base meeting the requirements of Minnesota Department of Transportation (MnDOT) Specification 3138 for Class 5. We recommend that the bituminous wear and base courses meet the requirements of Specifications 2360, Type SP.

We recommend that the aggregate base be compacted to a minimum of 100 percent of its maximum standard Proctor dry density. We recommend that the bituminous pavement be compacted to at least 92 percent of the maximum theoretical Rice density.

We recommend specifying concrete for pavements that has a minimum 28-day compressive strength of 4,000 psi, and a modulus of rupture (M_r) of at least 600 psi. We also recommend Type cement meeting the requirements of ASTM C 150. We recommend specifying 5 to 7 percent entrained air for exposed concrete to provide resistance to freeze-thaw deterioration. We also recommend using a water/cement ratio of 0.45 or less for concrete exposed to deicers.

D.5.e. Subgrade Drainage

We recommend installing perforated drainpipes throughout pavement areas at low points and about catch basins. The drainpipes should be placed in small trenches extended at least 8 inches below the granular subbase layer.

D.6. Frost Protection

D.6.a. General

All or some of the exterior slabs, as well as pavements, will be underlain with silty sand, which is considered to be moderately to highly frost-susceptible. Such soils can retain moisture and heave upon freezing. In general, this characteristic is not an issue unless these soils become saturated due to surface runoff or infiltration or are excessively wet in-situ. Once frozen, unfavorable amounts of general and isolated heaving of the soils and the surface structures supported on them could develop. This type of heaving could impact design drainage patterns and the performance of exterior slabs and pavements, as well as any isolated exterior footings and piers. To address most of the heave related issues, we recommend that general site grades and grades for exterior surface features be set to direct surface drainage away from buildings, across large paved areas and away from walkways to limit the potential for saturation of the subgrade and any subsequent heaving. General grades should also have enough “slope” to tolerate potential larger areas of heave which may not fully settle when thawed.

It should be noted that general runoff and infiltration from precipitation are not the only sources of water that can saturate subgrade soils and contribute to frost heave. Roof drainage and the irrigation of landscaped areas in close proximity to exterior slabs, pavements, and isolated footings and piers, contribute as well.

D.6.b. Exterior Slabs

Even small amounts of frost-related differential movement at walkway joints or cracks can create tripping hazards. Several subgrade improvement options can be explored to address this condition.

The most conservative and potentially most costly subgrade improvement option to help limit the potential for heaving, but not eliminate it, would be to remove any frost-susceptible soils present below the exterior slabs' "footprints" down to the bottom-of-footing grades or to a maximum depth of 6 feet below subgrade elevations, whichever is less. We recommend the resulting excavation then be refilled with sand or sandy gravel having less than 5 percent of the particles by weight passing a #200 sieve. The bottom of the excavation should be sloped toward one or more collection points so that any water entering the backfill can be collected and removed. A series of perforated drainpipes will need to be installed to collect and dispose of the infiltrating water and/or groundwater that could accumulate within the backfill. The piping should be connected to a storm sewer or a sump to remove any accumulated water, or "day lighted" if grades permit. If the water is not removed, it is our opinion this option will not be effective in controlling heave.

An important geometric aspect of the excavation and replacement approach described above is sloping the banks of the excavations to create a more gradual transition between the unexcavated soils considered to be frost-susceptible and the excavation backfill which is not, to attenuate differential movement that may occur along the excavation boundary. We recommend 3:1 (horizontal:vertical) banks along transitions between frost-susceptible and non-frost-susceptible soils.

Another option is to only protect critical areas, such as doorways and entrances, via stoops or localized excavations with sloped transitions between frost-susceptible and non-frost-susceptible soils as described above.

Regardless of what is done to the walkway or pavement area subgrade, it will be critical the end-user develop a detailed maintenance program to seal and/or fill any cracks and joints that may develop during the useful life of the various surface features. Concrete and bituminous will experience episodes of normal thermo-expansion and thermo-contraction during its useful life. During this time, cracks may develop and joints may open up, which will expose the subgrade and allow any water flowing overland to enter the subgrade and either saturate the subgrade soils or to become perched atop it. This occurrence increases the potential for heave due to freezing conditions in the general vicinity of the crack or joint. This type of heave has the potential to become excessive if not addressed as part of a maintenance program. Special attention should be paid to areas where dissimilar materials abut one another, where construction joints occur and where shrinkage cracks develop.

The on-going performance of pavements is impacted by conditions under which the pavement is asked to perform. These conditions include the environmental conditions, the actual use conditions and the level of ongoing maintenance performed. With regard to bituminous pavements in particular, because of normal thermo expansion and contraction, it is not unusual to have cracking develop within the first few years of placement and for the cracking to continue throughout the life of the pavement. A regular maintenance plan should be developed for filling cracks in bituminous pavements to lessen the potential impacts for cold weather distress due to frost heave or warm weather distress due to wetting and softening of the subgrade. It is also not unusual for bituminous pavements to require a seal coat within the first 5 to 10 years to increase the long-term performance.

D.6.c. Isolated Footing and Piers

Soils classifying as “silt” (USCS symbols ML or MH), “clay” (CL or CH), or as being “silty” or “clayey” (including but not limited to SP-SM, SC-SM, SM or SC), have the potential for adhering to poured concrete or masonry block features built through the normal frost zone. In freezing conditions, this soil adhesion could result in the concrete or masonry construction being lifted out of the ground. This lifting action is also known as heave due to adfreezing. The potential for experiencing the impacts of adfreezing increases with poor surface drainage in the area of below grade elements, in areas of poorly compacted clayey or silty soils and in areas of saturated soils. To limit the impacts of adfreeze, we recommend placing a low friction separation barrier, such as high density insulation board, between the backfill and the element. Extending isolated piers deeper into the frost-free zone, enlarging the bottom of the piers and then providing tension reinforcement can also be considered. Recommendations for specific foundation conditions can be provided as needed.

D.7. Utilities

D.7.a. Groundwater

We anticipate groundwater will be encountered at utility subgrade depths. Excavations can be dewatered using sumps and pumps. If groundwater cannot be completely removed prior to fill placement, we recommend initially backfilling over wet excavation bottoms with a clear rock meeting the requirements of MnDOT Course Filter Aggregate.

D.7.b. Subgrade Stabilization

We anticipate that utilities can be installed per manufacturer bedding requirements. If organic soils are encountered in excavations, we recommend the organic materials be sub-excavated 24 inches and replaced with course filter aggregate.

D.7.c. Selection, Placement and Compaction of Backfill

We recommend selecting, placing and compacting utility backfill in accordance with the recommendations provided above in Section D.1.

D.8. Infiltration

Infiltration basins are prosed for construction. We anticipate the subgrade soils will consist of silty sand. Based on the Minnesota Storm Water Manual, the silty sand is in Hydrologic Soil Group B, with an estimated infiltration rate of 0.45 inches per hour.

D.9. Corrosion Potential

The predominant silty sand soils encountered in the borings are considered corrosive. Therefore, we recommend corrosion protection be provided for ductile iron pipe or other metal conduits or tanks.

D.10. Construction Quality Control

D.10.a. Excavation Observations

We recommend having a geotechnical engineer observe all excavations related to subgrade preparation and spread footing, slab-on-grade and pavement construction. The purpose of the observations is to evaluate the competence of the geologic materials exposed in the excavations, and the adequacy of required excavation oversizing.

D.10.b. Materials Testing

We recommend density tests be taken in excavation backfill and additional required fill placed below spread footings, slab-on-grade construction, beside foundation walls behind basement walls, and below pavements.

We recommend Marshall tests on bituminous mixes to evaluate strength and air voids, and density tests to evaluate compaction.

We also recommend slump, air content and strength tests of Portland cement concrete.

D.10.c. Pavement Subgrade Proofroll

We recommend that proofrolling of the pavement subgrades be observed by a geotechnical engineer to determine if the results of the procedure meet project specifications, or delineate the extent of additional pavement subgrade preparation work.

D.10.d.Cold Weather Precautions

If site grading and construction is anticipated during cold weather, all snow and ice should be removed from cut and fill areas prior to additional grading. No fill should be placed on frozen subgrades. No frozen soils should be used as fill.

Concrete delivered to the site should meet the temperature requirements of ASTM C 94. Concrete should not be placed on frozen subgrades. Concrete should be protected from freezing until the necessary strength is attained. Frost should not be permitted to penetrate below footings.

E. Procedures

E.1. Penetration Test Borings

The penetration test borings were drilled with an all-terrain mounted core and auger drill equipped with hollow-stem auger. The borings were performed in accordance with ASTM D 1586. Penetration test samples were taken at 2 1/2- or 5-foot intervals. Actual sample intervals and corresponding depths are shown on the boring logs.

E.2. Material Classification and Testing

E.2.a. Visual and Manual Classification

The geologic materials encountered were visually and manually classified in accordance with ASTM Standard Practice D 2488. A chart explaining the classification system is attached. Samples were placed in jars or bags and returned to our facility for review and storage.

E.2.b. Laboratory Testing

The results of the laboratory tests performed on geologic material samples are noted on or follow the appropriate attached exploration logs. The tests were performed in accordance with ASTM or AASHTO procedures.

E.3. Groundwater Measurements

The drillers checked for groundwater as the penetration test borings were advanced, and again after auger withdrawal. The boreholes were then as noted on the boring logs.

F. Qualifications

F.1. Variations in Subsurface Conditions

F.1.a. Material Strata

Our evaluation, analyses and recommendations were developed from a limited amount of site and subsurface information. It is not standard engineering practice to retrieve material samples from exploration locations continuously with depth, and therefore strata boundaries and thicknesses must be inferred to some extent. Strata boundaries may also be gradual transitions, and can be expected to vary in depth, elevation and thickness away from the exploration locations.

Variations in subsurface conditions present between exploration locations may not be revealed until additional exploration work is completed, or construction commences. If any such variations are revealed, our recommendations should be re-evaluated. Such variations could increase construction costs, and a contingency should be provided to accommodate them.

F.1.b. Groundwater Levels

Groundwater measurements were made under the conditions reported herein and shown on the exploration logs, and interpreted in the text of this report. It should be noted that the observation periods were relatively short, and groundwater can be expected to fluctuate in response to rainfall, flooding, irrigation, seasonal freezing and thawing, surface drainage modifications and other seasonal and annual factors.

F.2. Continuity of Professional Responsibility

F.2.a. Plan Review

This report is based on a limited amount of information, and a number of assumptions were necessary to help us develop our recommendations. It is recommended that our firm review the geotechnical aspects of the designs and specifications, and evaluate whether the design is as expected, if any design changes have affected the validity of our recommendations, and if our recommendations have been correctly interpreted and implemented in the designs and specifications.

F.2.b. Construction Observations and Testing

It is recommended that we be retained to perform observations and tests during construction. This will allow correlation of the subsurface conditions encountered during construction with those encountered by the borings, and provide continuity of professional responsibility.

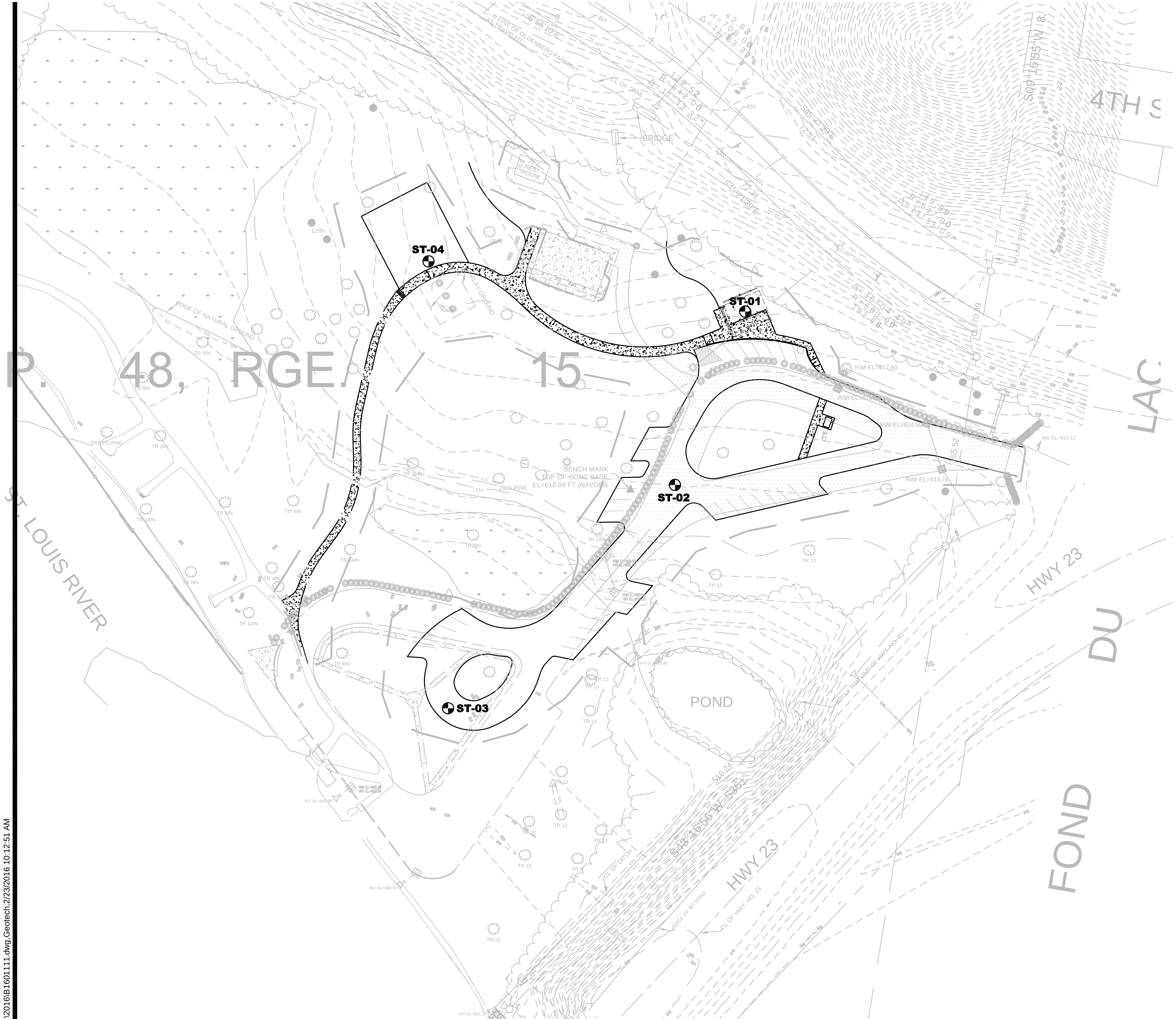
F.3. Use of Report

This report is for the exclusive use of the parties to which it has been addressed. Without written approval, we assume no responsibility to other parties regarding this report. Our evaluation, analyses and recommendations may not be appropriate for other parties or projects.

F.4. Standard of Care

In performing its services, Braun Intertec used that degree of care and skill ordinarily exercised under similar circumstances by reputable members of its profession currently practicing in the same locality. No warranty, express or implied, is made.

Appendix



DENOTES APPROXIMATE LOCATION OF STANDARD PENETRATION TEST BORING

40' 0 80'

SCALE: 1"= 80'

BRAUN INTERTEC

The Science You Build On.

11001 Hampshire Avenue S
Minneapolis, MN 55438
PH. (952) 995-2000
FAX (952) 995-2020

Base Dwg Provided By:
LHB

SOIL BORING LOCATION SKETCH

GEOTECHNICAL EVALUATION
CHAMBER GROVE PARK RECOVERY AND IMPROVEMENTS
MN 23 AND HIGHWAY 210
DULUTH, MINNESOTA

Project No:	B1601111
Drawing No:	B1601111
Scale:	1"= 150'
Drawn By:	JAG
Date Drawn:	2/11/16
Checked By:	DM
Last Modified:	2/23/16
Sheet: of	Fig:

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BRAUN INTERTEC

LOG OF BORING

Braun Project B1601111
Geotechnical Evaluation
Chamber Grove Park Recovery and Improvements
MN-23 and Highway 210
Duluth, Minnesota

BORING: **ST-01**

LOCATION: See attached sketch.

DRILLER: R. Granlund | METHOD: 3 1/4" HSA, Autohammer | DATE: **2/16/16** | SCALE: **1" = 4'**

Elev. feet 621.1	Depth feet 0.0	Symbol	Description of Materials (Soil-ASTM D2488 or D2487, Rock-USACE EM1110-1-2908)	BPF	WL	MC %	P200 %	Tests or Notes
620.5	0.6	SM	SILTY SAND, fine- to medium-grained, with roots, brown, moist. (Topsoil)					
		SM	SILTY SAND, fine-grained, reddish brown, moist to waterbearing, loose. (Glaciofluvium)	5		18.3	42.1	
				6		19.3	33.1	
				5				
					∇			An open triangle in the water level (WL) column indicates the depth at which groundwater was observed while drilling. Groundwater levels fluctuate.
				5				
609.6	11.5	OL	ORGANIC CLAY, with a trace of Sand, black, wet, very loose to soft. (Glaciofluvium)	3				
				2				
603.6	17.5	SM	SILTY SAND, fine-grained, reddish brown, wet, very loose. (Glaciofluvium)	3				
600.1	21.0		END OF BORING. Water observed at 9 1/2 feet while drilling. Boring immediately backfilled with auger cuttings.					

(See Descriptive Terminology sheet for explanation of abbreviations)

LOG OF BORING N:\GINT\PROJECTS\AX PROJECTS\2016\01111.GPJ BRAUN_V8_CURRENT.GDT 3/9/16 13:38

Braun Project B1601111
Geotechnical Evaluation
Chamber Grove Park Recovery and Improvements
MN-23 and Highway 210
Duluth, Minnesota

BORING: **ST-02**

LOCATION: See attached sketch.

DRILLER: R. Granlund	METHOD: 3 1/4" HSA, Autohammer	DATE: **2/16/16**	SCALE: **1" = 4'**

Elev. feet 612.4	Depth feet 0.0	Symbol	Description of Materials (Soil-ASTM D2488 or D2487, Rock-USACE EM1110-1-2908)	BPF	WL	MC %	P200 %	Tests or Notes
612.2	0.2	BIT	2 inches of bituminous surfacing.					
611.6	0.8	AGG	8 inches of aggregate base.					
610.4	2.0	FILL	FILL: Silty Sand, fine- to medium-grained, with a trace of Gravel, brown, moist.					
		SM	SILTY SAND, fine-grained, reddish brown, moist to waterbearing, very loose to medium dense. (Glaciofluvium)	21		15.1	41.7	
				8		23.3	43.7	
				3				
					▽			
				3				
				3				
596.4	16.0			6				
			END OF BORING.					
			Water observed at 9 1/2 feet while drilling.					
			Boring immediately backfilled with auger cuttings.					

(See Descriptive Terminology sheet for explanation of abbreviations)

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BRAUN INTERTEC

LOG OF BORING

Braun Project B1601111
Geotechnical Evaluation
Chamber Grove Park Recovery and Improvements
MN-23 and Highway 210
Duluth, Minnesota

BORING: **ST-03**

LOCATION: See attached sketch.

DRILLER: R. Granlund | METHOD: 3 1/4" HSA, Autohammer | DATE: **2/16/16** | SCALE: **1" = 4'**

Elev. feet 612.9	Depth feet 0.0	Symbol	Description of Materials (Soil-ASTM D2488 or D2487, Rock-USACE EM1110-1-2908)	BPF	WL	Tests or Notes
612.7	0.3	FILL	FILL: Silty Sand, fine-grained, with roots, brown, moist. (Topsoil)			
610.9	2.0	FILL	FILL: Silty Sand, fine-grained, with a trace of Gravel, brown, moist.			
608.9	4.0	SM	SILTY SAND, fine-grained, with a trace of Gravel and organics, grayish brown, moist. (Glaciofluvium)	12		
603.9	9.0	SM	SILTY SAND, fine-grained, with a trace of organics, grayish brown, moist, very loose. (Glaciofluvium)	7 1	▽	
601.4	11.5	SM	SILTY SAND, fine-grained, with a trace of organics, brown, waterbearing, very loose. (Glaciofluvium)	3		
598.9	14.0	OL	ORGANIC CLAY, gray, moist, very soft. (Glaciofluvium)	1		
596.9	16.0	SM	SILTY SAND, fine-grained, with a trace of organics, grayish brown, moist, very loose. (Glaciofluvium)	2		

END OF BORING.

Water observed at 6 feet while drilling.

Water observed at 6 feet immediately after withdrawal of auger.

Boring immediately backfilled with auger cuttings.

(See Descriptive Terminology sheet for explanation of abbreviations)

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LOG OF BORING

BRAUN INTERTEC

Braun Project B1601111
Geotechnical Evaluation
Chamber Grove Park Recovery and Improvements
MN-23 and Highway 210
Duluth, Minnesota

BORING: **ST-04**

LOCATION: See attached sketch.

DRILLER: R. Granlund | METHOD: 3 1/4" HSA, Autohammer | DATE: **2/16/16** | SCALE: **1" = 4'**

(See Descriptive Terminology sheet for explanation of abbreviations)

Elev. feet 619.5	Depth feet 0.0	Symbol	Description of Materials (Soil-ASTM D2488 or D2487, Rock-USACE EM1110-1-2908)	BPF	WL	Tests or Notes
619.2	0.3	SM	SILTY SAND, fine- to medium-grained, with roots, brown, moist. (Topsoil)			
		SM	SILTY SAND, fine-grained, reddish brown, moist to waterbearing, very loose to loose. (Glaciofluvium)	3		
				2		
				2		
				1	▽	
				2		
				1		
598.5	21.0			8		
			END OF BORING. Water observed at 11 feet while drilling. Boring immediately backfilled with auger cuttings.			

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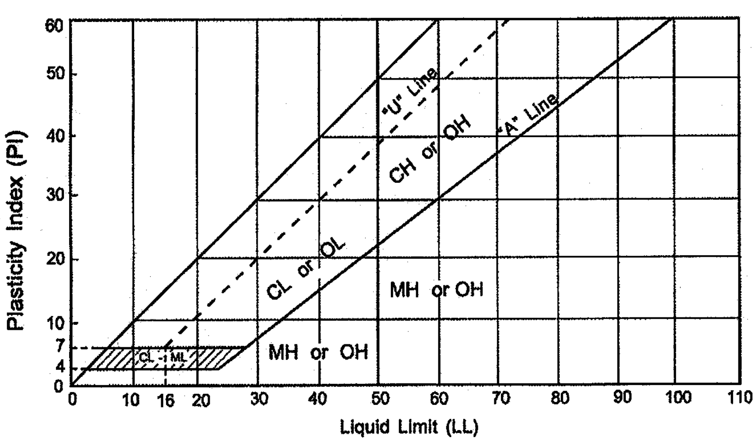
BRAUN INTERTEC

Descriptive Terminology of Soil

Standard D 2487
Classification of Soils for Engineering Purposes
(Unified Soil Classification System)

Criteria for Assigning Group Symbols and Group Names Using Laboratory Tests [a]				Soils Classification: Group Symbol	Soils Classification: Group Name [b]
Coarse-grained Soils more than 50% retained on No. 200 sieve	Gravels More than 50% of coarse fraction retained on No. 4 sieve	Clean Gravels Less than 5% fines [e]	$C_u \geq 4$ and $1 \leq C_c \leq 3$ [c]	GW	Well-graded gravel [d]
			$C_u < 4$ and/or $1 > C_c > 3$ [c]	GP	Poorly graded gravel [d]
		Gravels with Fines More than 12% fines [e]	Fines classify as ML or MH	GM	Silty gravel [d f g]
			Fines classify as CL or CH	GC	Clayey gravel [d f g]
	Sands 50% or more of coarse fraction passes No. 4 sieve	Clean Sands Less than 5% fines [i]	$C_u \geq 6$ and $1 \leq C_c \leq 3$ [c]	SW	Well-graded sand [h]
			$C_u < 6$ and/or $1 > C_c > 3$ [c]	SP	Poorly graded sand [h]
		Sands with Fines More than 12% [i]	Fines classify as ML or MH	SM	Silty sand [f g h]
			Fines classify as CL or CH	SC	Clayey sand [f g h]
Fine-grained Soils 50% or more passed the No. 200 sieve	Silts and Clays Liquid limit less than 50	Inorganic	PI > 7 and plots on or above "A" line [j]	CL	Lean clay [k l m]
			PI < 4 or plots below "A" line [j]	ML	Silt [k l m]
		Organic	Liquid limit - oven dried / Liquid limit - not dried < 0.75	OL	Organic clay [k l m n]
				OL	Organic silt [k l m o]
	Silts and clays Liquid limit 50 or more	Inorganic	PI plots on or above "A" line	CH	Fat clay [k l m]
			PI plots below "A" line	MH	Elastic silt [k l m]
		Organic	Liquid limit - oven dried / Liquid limit - not dried < 0.75	OH	Organic clay [k l m p]
				OH	Organic silt [k l m q]
Highly Organic Soils	Primarily organic matter, dark in color and organic odor			PT	Peat

a. Based on the material passing the 3-inch (75mm) sieve.
b. If field sample contained cobbles or boulders, or both, add "with cobbles or boulders or both" to group name.
c. $C_u = D_{60}/D_{10}$ $C_c = \frac{(D30)^2}{D_{10} \times D_{60}}$
d. If soil contains ≥15% sand, add "with sand" to group name.
e. Gravels with 5 to 12% fines require dual symbols:
   GW-GM well-graded gravel with silt
   GW-GC well-graded gravel with clay
   GP-GM poorly graded gravel with silt
   GP-GC poorly graded gravel with clay
f. If fines classify as CL-ML, use dual symbol GC-GM or SC-SM.
g. If fines are organic, add "with organic fines: to group name.
h. If soil contains ≥15% gravel, add "with gravel" to group name.
i. Sand with 5 to 12% fines require dual symbols:
   SW-SM well-graded sand with silt
   SW-SC well-graded sand with clay
   SP-SM poorly graded sand with silt
   SP-SC poorly graded sand with clay
j. If Atterberg limits plot in hatched area, soil is a CL-ML, silty clay.
k. If soil contains 10 to 29% plus No. 200, add "with sand" or "with gravel" whichever is predominant.
l. If soil contains ≥ 30% plus No. 200, predominantly sand, add "sandy" to group name.
m. If soil contains ≥ 30% plus No. 200, predominantly gravel, add "gravelly" to group name.
n. PI ≥ 4 and plots on or above "A" line.
o. PI < 4 or plots below "A" line.
p. PI plots on or above "A" lines.
q. PI plots below "A" line.



Laboratory Tests

DD	Dry density, pcf	**OC**	Organic content, %
WD	Wet density, pcg	**S**	Percent of saturation, %
MC	Natural moisture content, %	**SG**	Specific gravity
LL	Liquid limit, %	**C**	Cohesion, psf
PL	Plastic limits, %	**Ø**	Angle of internal friction
PI	Plasticity index, %	**qu**	Unconfined compressive strength, psf
P200	% passing 200 sieve	**qp**	Pocket penetrometer strength, tsf

Particle Size Identification

Boulders................. over 12"
Cobbles .... 3" to 12"
Gravel
   Coarse .... 3/4" to 3"
   Fine................ No. 4 to 3/4"
Sand
   Coarse .... No. 4 to No. 10
   Medium .... No. 10 to No. 40
   Fine................ No. 40 to No. 200
Silt .... <No. 200, PI< 4 or below "A" line
Clay .... <No. 200, PI $\geq$ 4 and on or about "A" line

Relative Density of Cohesionless Soils

Very Loose............ 0 to 4 BPF
Loose..................... 5 to 10 BPF
Medium dense .... 11 to 30 PPF
Dense .... 31 to 50 BPF
Very dense............ over 50 BPF

Consistency of Cohesive Soils

Very soft................ 0 to 1 BPF
Soft .... 2 to 3 BPF
Rather soft .... 4 to 5 BPF
Medium .... 6 to 8 BPF
Rather stiff .... 9 to 12 BPF
Stiff .... 13 to 16 BPF
Very stiff................. 17 to 30 BPF
Hard....................... over 30 BPF

Drilling Notes

Standard penetration test borings were advanced by 3 1/4" or 6 1/4" ID hollow-stem augers, unless noted otherwise. Jetting water was used to clean out auger prior to sampling only where indicated on logs. All samples were taken with the standard 2" OD split-tube samples, except where noted.

Power auger borings were advanced by 4" or 6" diameter continuous flight, solid-stern augers. Soil classifications and strata depths were inferred from disturbed samples augered to the surface, and are therefore, somewhat approximate.

Hand auger borings were advanced manually with a 1 1/2" or 3 1/4" diameter auger and were limited to the depth from which the auger could be manually withdrawn.

BPF: Numbers indicate blows per foot recorded in standard penetration test, also known as "N" value. The sampler was set 6" into undisturbed soil below the hollow-stem auger. Driving resistances were then counted for second and third 6" increments, and added to get BPF. Where they differed significantly, they are reported in the following form: 2/12 for the second and third 6" increments, respectively.

WH: WH indicates the sampler penetrated soil under weight of hammer and rods alone; driving not required.

WR: WR indicates the sampler penetrated soil under weight of rods alone; hammer weight, and driving not required.

TW: TW indicates thin-walled (undisturbed) tube sample.

Note: All tests were run in general accordance with applicable ASTM standards.