HAUGO GEOTECHNICAL SERVICES

October 29, 2024 HGTS Project Number: 24-0721

Ms. Melissa Hanson
Housing and Redevelopment Authority
City of Northfield
801 Washington Street
Northfield, MN 55057

Re: Geotechnical Exploration Report, Northfield Development Project, Northfield, Minnesota

Dear Ms. Hanson:

We have completed the geotechnical exploration report for the proposed Northfield Development Project in Northfield, Minnesota. A brief summary of our results and recommendations is presented below. Specific details regarding our procedures, results and recommendations follow in the attached geotechnical exploration report.

Six (6) soil borings were completed for this project that encountered about 2 feet of topsoil underlain by native glacial till soils that extended to the termination depths of the borings. Groundwater was encountered in the borings at depths of about 10 to 20 feet below the ground surface corresponding to elevations of about 949 to 962 ½ feet above mean sea level.

The vegetation and topsoil are not suitable for building, roadway or utility support and will need to be removed and replaced, as needed, with suitable compacted engineered fill. It is our opinion that the underlying native glacial till soils are generally suitable for foundation support. However, portions of the clayey soil had a soft consistency and depending in part on final site grades or building grades some corrections to remove soft clayey soils could be required and should be anticipated.

With the building pads prepared as recommended it is our opinion that the foundations for the proposed buildings can be designed for a net allowable soil bearing capacity up to 2,000 pounds per square foot.

Thank you for the opportunity to assist you on this project. If you have any questions or need additional information, please contact Paul Gionfriddo at 612-729-2959.

Sincerely,

Haugo GeoTechnical Services

Nic Alfonso, G.I.T.
Project Geologist

Paul Gionfriddo, P.E.
Senior Engineer

GEOTECHNICAL EXPLORATION REPORT

PROJECT:

Northfield Development Project
Southbridge Drive & Aspen Street
Northfield, Minnesota

PREPARED FOR:

City of Northfield
801 Washington Street
Northfield, MN 55057

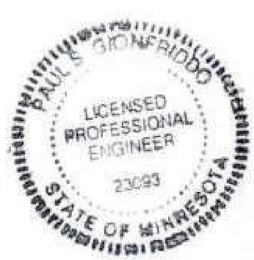
PREPARED BY:

Haugo GeoTechnical Services
2825 Cedar Avenue South
Minneapolis, Minnesota 55407

Haugo GeoTechnical Services Project: 24-0721

October 29, 2024

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.



Paul Gionfriddo, P.E.
Senior Engineer
License Number: 23093

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1.0 INTRODUCTION

1.1 Project Description

The City of Northfield is preparing for construction of the Southbridge HRA Site in Northfield, Minnesota and retained Haugo GeoTechnical Services (HGTS) to perform a geotechnical exploration to evaluate the suitability of site soil conditions to support the proposed development.

We understand the project will include 24 single-family homes, 38 multi-unit homes and 24 ADUs along with the associated streets and underground utilities.

1.2 Purpose

The purpose of this geotechnical exploration was to characterize subsurface soil and groundwater conditions and provide recommendations for foundation design and construction.

1.3 Site Description

The project site is located south of Aspen Street and west of Southbridge Drive in Northfield, Minnesota. It is located directly east of the property at 2351 Division Street S. At the time of this assessment, the project site existed as vacant land. However, portions of the project site appear to have been used for material storage related to construction on adjoining or nearby properties.

Further, based on a brief revie of historical aerial photographs available on Google Earth it appears that the project site was graded during the 2003 and 2004 construction seasons as part of an . It appears the roadway alignments were cut in but were not paved. It is unknown if underground utilities were installed at that time.

The site topography was generally flat with the elevations at the soil boring locations ranging from about 969 to 976 feet above mean sea level (MSL).

1.4 Scope of Services

Our services were performed in accordance with the Haugo Geotechnical Services proposal 24-0721 dated September 5, 2024. Our services were performed under the terms of our General Conditions and were limited to the following tasks:

- Calling in Gopher State One Call locate services
- Completing six (6) standard penetration test soil borings and extending to nominal depths of 20 feet.
- Sealing the boring in accordance with Minnesota Department of Health requirements.
- Obtaining GPS coordinates and ground surface elevations at the soil boring location.
- Visually/manually classifying samples recovered from the soil boring.
- Performing laboratory tests on selected samples.
- Preparing soil boring logs describing the materials encountered and the results of groundwater level measurements.

- Preparing an engineering report describing soil and groundwater conditions and providing recommendations for foundation design and construction.

1.5 Documents Provided

We were provided a Site Plan prepared by Rice County Habitat for Humanity and dated February 29, 2024. The Site Plan showed a proposed layout for the development.

Other than the provided plan, specific architectural, structural or civil documents were not provided at the time of this assessment.

1.6 Locations and Elevations

The soil boring locations were selected by HGTS based on the anticipate construction and site access. The approximate locations of the soil borings are shown on Figure 1, “Soil Boring Location Sketch,” in the Appendix. The sketch was prepared by HGTS using an aerial image from Google Earth as a base.

HGTS obtained the GPS coordinates and ground surface elevations at the soil boring locations using GPS technology based on the US State Plane Coordinate System. GPS coordinates and ground surface elevations are shown on Figure 2 in the Appendix.

2.0 FIELD PROCEDURES

The standard penetration test borings were advanced on September 26, 2024 by HGTS with a rotary drilling rig, using continuous flight augers to advance the boreholes. Representative samples were obtained from the borings, using the split-barrel sampling procedures in general accordance with ASTM Specification D-1586. In the split-barrel sampling procedure, a 2-inch O.D. split-barrel spoon is driven into the ground with a 140-pound hammer falling 30 inches. The number of blows required to drive the sampling spoon the last 12 inches of an 18-inch penetration is recorded as the standard penetration resistance value, or "N" value. The results of the standard penetration tests are indicated on the boring logs. The samples were sealed in containers and provided to HGTS for testing and soil classification.

A field log of each boring was prepared by HGTS. The logs contain visual classifications of the soil materials encountered during drilling, as well as the driller's interpretation of the subsurface conditions between samples and water observation notes. The final boring logs included with this report represent an interpretation of the field logs and include modifications based on visual/manual method observation of the samples.

The soil boring logs, general terminology for soil description and identification, and classification of soils for engineering purposes are also included in the appendix. The soil boring logs identify and describe the materials encountered, the relative density or consistency based on the Standard Penetration resistance (N-value, “blows per foot”) and groundwater observations.

The strata changes were inferred from the changes in the samples and auger cuttings. The depths shown as changes between strata are only approximate. The changes are likely transitions, variations can occur beyond the location of the borings.

3.0 RESULTS

3.1 Soil Conditions

At the surface, the soil borings encountered about 2 feet of topsoil consisting of sandy lean clay that was black and dark brown in color and contained traces of roots.

Below the topsoil, the soil borings encountered native glacial till soils that extended to the termination depths of the borings. The glacial till soils consisted of sandy lean clay, silty sand, poorly graded sand with silt, poorly graded sand and gravelly sand that was brown, grey or light grey in color.

Penetration resistance values (N-Values), shown as blows per foot (bpf) on the boring logs, within the sandy lean clay soils ranged from 2 to 14 bpf indicating a soft to stiff consistency. N-Values within the silty sand, poorly graded sand with silt, poorly graded sand and gravely sand soils ranged from 1 to 25 bpf indicating a very loose to medium dense relative density.

3.2 Groundwater

Groundwater was encountered in the soil borings while drilling and sampling at depths ranging from about 10 to 20 feet below the ground surface corresponding to elevations ranging from about 949 to 962 ½ feet above mean sea level (MSL). The observed water levels are summarized in Table 1.

Table 1. Summary of Groundwater Levels

Boring Number	Measured Surface Elevation (feet)	Estimated Depth to Groundwater (feet)*	Estimated Groundwater Elevation (feet)*
SB-1	969.1	14 ½	954 ½
SB-2	971.2	20	951
SB-3	972.5	10	962 ½
SB-4	968.8	20	949
SB-5	975.8	20	956
SB-6	973.3	20	953 ½

* = Depths and elevations were rounded to the nearest ½ foot.

Water levels were measured on the dates as noted on the boring logs and the period of water level observations was relatively short. Given the cohesive nature of the soils encountered in the borings it is possible there was insufficient time for groundwater to seep into the borings and rise to its hydrostatic level. Groundwater monitoring wells or piezometers would be required to more accurately determine water levels. Seasonal and annual fluctuations in the groundwater levels should be expected.

3.3 Laboratory Testing

Laboratory moisture content tests were performed on selected samples recovered from the soil borings. Laboratory soil moisture contents ranged from about 8 to 20 ½ percent indicating that the soils were likely near or above their assumed optimum moisture content based on the standard Proctor test. Laboratory tests results are summarized in Table 2 and are shown on the boring logs adjacent to the samples tested.

Table 2. Summary of Laboratory Tests

Boring Number	Sample Number	Depth (feet)	Moisture Content (%) *
SB-1	SS-43	5	18
SB-1	SS-45	10	12
SB-2	SS-34	2 ½	14 ½
SB-2	SS-36	7 ½	19
SB-3	SS-26	2 ½	12
SB-3	SS-28	7 ½	10 ½
SB-4	SS-18	2 ½	14
SB-4	SS-20	7 ½	15
SB-5	SS-10	2 ½	8
SB-5	SS-12	7 ½	20 ½
SB-6	SS-2	2 ½	13 ½
SB-6	SS-4	7 ½	19 ½

*Moisture content values rounded to the nearest ½ percent.

3.4 OSHA Soil Classification

The soils encountered in the borings consisted of sandy lean clay, silty sand, poorly graded sand with silt, poorly graded sand and gravelly sand corresponding to the ASTM Classifications of CL, SM, SP-SM, SP and GP. Soils classified as CL will generally be Type B soils under Department of Labor Occupational Safety and Health Administration (OSHA) guidelines, while soils classified as SM, SP-SM, SP and GP will generally be Type C soils under OSHA guidelines.

An OSHA-approved qualified person should review the soil classification in the field. Excavations must comply with the requirements of OSHA 29 CFR, Part 1926, Subpart P, "Excavations and Trenches." This document states excavation safety is the responsibility of the contractor. The project specifications should reference these OSHA requirements.

4.0 DISCUSSION AND RECOMMENDATIONS

4.1 Proposed Construction

We understand that the project will include preparing house pads for 24 single-family homes, 38 multi-family homes and 24 ADUs. We were not provided specific architectural, structural or civil construction plans, but we assume the homes will include one or two stories above grade and will likely be slab-on-grade structures but could include walkout, lookout or full basements. We anticipate below grade construction consisting of cast-in-place concrete foundation walls supported on concrete spread footings. The above grade construction is assumed to consist of wood framing, a pitched roof and asphalt shingles.

Based on the assumed construction we estimate wall loadings will range from about 2 to 3 kips (2,000 to 3,000 pounds) per lineal foot and column loads, if any, will be on the order of 75 kips (75,000 pounds).

We anticipate the buildings will be constructed at or near existing site grades so that cuts or fill for permanent grade changes will generally be on the order of 5 feet or less.

We have attempted to describe our understanding of the project. If the proposed loads exceed these values or if the design or location of the proposed development changes, we should be informed. Additional analyses and revised recommendations may be necessary.

4.2 Discussion

The vegetation and topsoil are not suitable for foundation, roadway or utility support and will need to be removed from below the building pads, pavements, utilities and oversize areas and replaced with suitable competed engineered fill, as needed, to attain design grades.

It is our opinion that the underlying native glacial till soils are generally suitable for foundation, pavement and utility support. However, portions of the clayey soil had a soft consistency and depending in part on final site grades or building grades some corrections could be required and should be anticipated. If the homes will have a basement level, then removal of some or all of the soft clays could be incidental to construction.

Groundwater was encountered in the soil borings while drilling and sampling at depths of about 10 to 20 feet below the ground surface, corresponding to an elevation of about 949 to 962 ½ feet above mean sea level. At those elevations, we do not anticipate that groundwater will be encountered and do not anticipate that dewatering will be required.

4.3 Site Grading Recommendations

Excavation We recommend that all vegetation, topsoil and any soft or otherwise unsuitable soils, if encountered, be removed from within the building, roadway, utility and oversize areas. Table 3 summarizes the anticipated excavation depths at the soil boring locations. Excavation depths may vary and could be deeper. It should be noted that the excavation depths presented in Table 3 do not account of foundation construction. Excavations for foundation construction could vary and could be deeper.

Table 3. Anticipated Excavation Depths

Boring Number	Measured Surface Elevation (feet)	Anticipated Excavation Depth (feet)*	Anticipated Excavation Elevation (feet)*	Approximate Groundwater Elevation (feet)*
SB-1	969.1	2 - 5	964 - 967	954 ½
SB-2	971.2	2	969	951
SB-3	972.5	2	970 ½	962 ½

Boring Number	Measured Surface Elevation (feet)	Anticipated Excavation Depth (feet)*	Anticipated Excavation Elevation (feet)*	Approximate Groundwater Elevation (feet)*
SB-4	968.8	2	967	949
SB-5	975.8	2 - 9	967 - 974	956
SB-6	973.3	2 – 12	961 ½ – 971 ½	953 ½

* = Excavation depths and elevations were rounded to nearest ½ foot.

Oversizing In areas where the excavations for soil corrections extend below the proposed footing elevations, the excavations require oversizing. We recommend the perimeter of the excavation be extended a foot outside the proposed footprint for every foot below footing grade (1H:1V oversizing). The purpose of the oversizing is to provide lateral support of the foundation.

Fill Material Additional fill required to attain design grades can consist of any mineral soil provided it is free of debris, organic soil and any soft or otherwise unsuitable materials. Except we recommend that fill or backfill placed in wet excavations or within 2 feet of the groundwater table, if encountered, consist of "clean coarse sand" with less than 5 percent passing the number 200 sieve and at least 50 percent retained on the number 40 sieve.

The on-site native glacial till soils appear to be suitable for reuse as structural fill or backfill provided it is free of debris, organic soils or other unsuitable materials. Laboratory soil moisture contents ranged from about 8 to 20 ½ percent indicating that the soils were likely near or above their assumed optimum moisture content based on the standard Proctor test. Soils that will be excavated and reused as fill and backfill could require some moisture conditioning either wetting or drying to achieve the recommended compaction levels.

Topsoil or other soils that are black in color are not suitable for reuse as structural fill or backfill.

Backfilling We recommend that backfill placed to attain site grades be compacted to a minimum of 95 percent of its standard Proctor density (ASTM D 698). Granular fill classified as SP or SP-SM should be placed within 65 percent to 105 percent of its optimum moisture content as determined by the standard Proctor. Other fill soils should be placed within 3 percentage points above and 1 percentage point below its optimum moisture content as determined by the standard Proctor. All fill should be placed in thin lifts and be compacted with a large self-propelled vibratory compactor operating in vibratory mode.

In areas where fill depths will exceed 10 feet, if any, we recommend that compaction levels be increased to a minimum of 100 percent of standard Proctor density. Even with the increased compaction levels a construction delay may be required to allow for post settlement of the fill mass.

Fill and backfill placed on slopes, if any, must be "benched" into the underlying suitable soils to reduce the potential for slip places to develop between the fill and underlying soil. We recommend "benching" or excavating into the slope at 5 feet vertical intervals to key the fill into the slope. We recommend each bench be a minimum of 10 feet wide.

Foundations We recommend the perimeter footings bear a minimum of 42 inches below the exterior grade for frost protection. Interior footings may be placed immediately below the slab provided construction does not occur during below freezing weather conditions. Foundation elements in unheated areas (i.e., deck or porch footings) should bear at least 5 feet below exterior grade for frost protection.

We anticipate the foundations and floor slabs will bear on compacted engineered fill or native glacial till soils. With the building pads prepared as recommended, it is our opinion the footings can be designed for a net allowable bearing pressure up to 2,000 pounds per square foot (psf).

We anticipate total and differential settlement of the foundations will be less than 1 inch and ½ inch, respectively, across a 30-foot span.

4.4 Dewatering

Groundwater was encountered in the borings at depths of about 10 to 20 feet below the ground surface, corresponding to elevations of about 949 to 962 ½ feet above mean sea level (MSL). We generally do not anticipate that groundwater will be encountered during foundation construction or soil corrections and do not anticipate that dewatering will be required.

4.5 Interior Slabs

The anticipated floor subgrade will consist of compacted clayey engineered fill or clayey native glacial till soils. It is our opinion a modulus of subgrade reaction, k, of 50 pounds per square inch per inch of deflection (psi) may be used to design the floor.

If floor coverings or coatings less permeable than the concrete slab will be used, we recommend that a vapor retarder or vapor barrier be placed immediately beneath the slab. Some contractors prefer to bury the vapor barrier or vapor retarder beneath a layer of sand to reduce curling and shrinkage, but this practice often traps water between the slab and vapor retarder or barrier. Regardless of where the vapor retarder or vapor barrier is placed, we recommend consulting the floor covering manufacturer regarding the appropriate type, use and installation of the vapor retarder or vapor barrier to preserve the warranty.

We recommend following all state and local building codes with regards to a radon mitigation plan beneath interior slabs.

4.6 Below Grade Walls

We recommend general waterproofing of the below grade walls. We recommend either placing drainage composite against the backs of the exterior walls or backfilling adjacent to the walls with sand having less than 50 percent of the particles by weight passing the #40 sieve and less than 5 percent of the particles by weight passing the #200 sieve. The sand backfill should be placed within 2 feet horizontally of the wall. We recommend the balance of the backfill for the walls consist of sand however the sand may contain up to 20 percent of the particles by weight passing the #200 sieve.

We recommend installing drain tile behind the below grade walls, adjacent to the wall footing and below the slab elevation. Preferably the drain tile should consist of perforated pipe embedded in gravel. A geotextile filter fabric should encase the pipe and gravel. The drain tile should be routed to a storm sewer, sump pump or other suitable disposal site.

Foundation walls or below grade (basement) walls will have lateral loads from the surrounding soil transmitted to them. Active earth pressures can be used to design the below grade walls if the walls are allowed to rotate slightly. If wall rotation cannot be tolerated, then below grade wall design should be based on at-rest earth pressures. It is our opinion that the estimated soil parameters presented in Table 4 can be used for below grade wall design. These estimated parameters are based on the assumptions that the walls are drained, there are no surcharge loads within a horizontal distance equal to the height of the wall and the backfill is level.

Table 4. Estimated Soil Parameters

Soil Type	Estimated Unit Weight (pcf)	Estimated Friction Angle (degrees)	At-Rest Pressure (pcf)	Active Soil Pressure (pcf)	Passive Soil Pressure (pcf)
Sand (SP & SP-SM)	120	32	55	35	390
Other Soils (CL, SM)	135	28	70	50	375

Resistance to lateral earth pressures will be provided by passive resistance against the wall footings and by sliding resistance along the bottom of the wall footings. We recommend a sliding coefficient of 0.35. This value does not include a factor of safety.

4.7 Retaining Walls

We are not aware of any retaining walls proposed for this project and were not provided any information regarding any proposed retaining walls. Retaining wall designers/installers should be aware that soil borings for any retaining walls were not completed as part of this evaluation. Because of that, additional geotechnical explorations (soil borings) could be required to determine and evaluate the suitability and/or stability of site soil conditions to support their design(s). Retaining wall designers and/or installers will be solely responsible to conduct additional geotechnical evaluation(s) as needed.

In addition, HGTS does not practice in retaining wall design. Retaining wall designers will be solely responsible for retaining wall design and construction.

4.8 Exterior Slabs

Exterior slabs will likely be underlain by clayey soils which are considered to be moderately to highly frost susceptible. If these soils become saturated and freeze, frost heave may occur. This heave can be a nuisance in front of doors and at other critical grade areas. One way to help reduce the potential for heaving is to remove the frost-susceptible soils below the slabs down to bottom of footing grades and replace them with non-frost-susceptible backfill consisting of sand having less than 5 percent of the particles by weight passing the number 200 sieve.

If this approach is used and the excavation bottoms terminate in non-free draining granular soil, we recommend a drain tile be installed along the bottom outer edges of the excavation to collect and remove any water that may accumulate within the sand. The bottom of the excavation should be graded away from the building.

If the banks of the excavations to remove the frost-susceptible soils are not sloped, abrupt transitions between the frost-susceptible and non-frost-susceptible backfill will exist along which unfavorable amounts of differential heaving may occur. Such transitions could exist between exterior slabs and sidewalks, between exterior slabs and pavements and along the slabs themselves if the excavations are confined to only the building entrances. To address this issue, we recommend sloping the excavations to remove frost-susceptible soils at a minimum 3:1 (horizontal:vertical) gradient.

An alternative method of reducing frost heave is to place a minimum of 2 inches of extruded polystyrene foam insulation beneath the slabs and extending it about 4 feet beyond the slabs. The insulation will reduce frost penetration into the underlying soil and reduce heave. Six to twelve inches of granular soil is typically placed over the insulation to protect it during construction.

Another alternative for reducing frost heave is to support the slabs on frost depth footings. A void space of at least 4 inches should be provided between the slab and the underlying soil to allow the soil to heave without affecting the slabs.

4.9 Site Grading and Drainage

We recommend the site be graded to provide positive run-off away from the proposed buildings. We recommend landscaped areas be sloped a minimum of 6 inches within 10 feet of the building and slabs be sloped a minimum of 2 inches. In addition, we recommend downspouts with long splash blocks or extensions.

We recommend the lowest floor grades be constructed to meet City of Northfield requirements with respect to groundwater separation distances. In the absence of city requirements, we recommend maintaining at least a 4-foot separation between the lowest floor slab and the observed groundwater levels and at least a 2-foot separation between the lowest floor slab and the 100-year flood level of nearby wetlands, storm water ponds or other surface water features.

4.10 Utilities

We anticipate that new utilities will be installed as part of this project. We further anticipate that new utilities will bear at depths ranging from about 7 to 10 feet below the ground surface. At these depths, we anticipate that the pipes will bear on compacted engineered fill or native glacial till soils, which in our opinion are suitable for pipe support.

We recommend removing all vegetation, topsoil and any soft or otherwise unsuitable soils, if any, beneath utilities prior to placement. We recommend bedding material be thoroughly compacted around the pipes. We recommend trench backfill above the pipes be compacted to a minimum of 95 percent beneath slabs and pavements, the exception being within 3 feet of the proposed pavement subgrade, where 100 percent of standard Proctor density is required. In landscaped areas, we recommend a minimum compaction of 90 percent.

Groundwater was encountered in the soil borings at about 10 to 20 feet below the ground surface. We generally do not anticipate that groundwater will be encountered during utility construction.

4.11 Bituminous Pavements

General The City of Northfield may have standard plates that dictate pavement design and if so, we recommend that the pavements be designed and constructed in accordance with the City of Northfield standard plates. The following paragraphs provide general pavement recommendations in the absence of city standard plates.

Traffic We were not provided any information regarding traffic volumes, such as Average Annual Daily Traffic (AADT) or vehicle distribution. We anticipate the streets will be used predominantly by automobiles, light trucks, school busses, garbage trucks and delivery vans (FEDEX, UPS etc.). Based on the anticipated number of homes in the development and assumed traffic types we estimate the roadways will be subjected to Equivalent Single Axle Loads (ESAL's) less than 50,000 over a 20-year design life. This does not account for any future growth.

Subgrade Preparation We recommend removing all vegetation, topsoil and any soft or otherwise unsuitable materials from beneath the pavement subgrade. Prior to placing the aggregate base, we recommend compacting and/or test rolling the subgrade soils to identify soft, weak, loose, or unstable areas that may require additional subcuts.

Backfill to attain pavement subgrade elevations can consist of any mineral soil provided it is free of organic material or other deleterious materials. We recommend placing and compacting fill and/or backfill as described in Section 4.3 except in paved areas where the upper 3 feet of fill and backfill should be compacted to a minimum of 100 percent of its standard Proctor maximum dry density.

R-Value R-Value testing was beyond the scope of this project. The near surface soils encountered in the soil borings consisted predominantly of sandy lean clay corresponding to the ASTM Classification of CL. It is our opinion an assumed R-Value of 10 can be used for pavement design.

Pavement Section Based on an estimated R-value of 10 and a maximum of 50,000 ESAL's we recommend pavement section consisting of a minimum of 3 ½ inches of bituminous (1 ½ inches of wear course and 2 inches of base course) underlain by a minimum of 8 inches of aggregate base.

If a heavy-duty section is required, we recommend pavement section consisting of a minimum of 4 inches of bituminous (2 inches of wear course and 2 inches of base course) underlain by a minimum of 9 inches of aggregate base.

4.12 Materials and Compaction

We recommend specifying aggregate base meeting MN/DOT Class 5 aggregate base. We recommend the aggregate base be compacted to 100 percent of its maximum standard Proctor.

We recommend that the bituminous wear and base courses meet the requirements of MN/DOT specification 2360. We recommend the bituminous pavements be compacted to at least 92 percent of the maximum theoretical density.

We recommend specifying concrete that has a minimum 28-day compressive strength of 4,500 psi, and a modulus of rupture of at least 600 psi. We recommend Type I cement meeting the requirements of ASTM C150. 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.

4.13 Stormwater Pond/Infiltration Basins

We anticipate that the project could potentially include constructing storm water ponds/infiltration basins on the project site. We were not provided any information regarding their potential locations, site grades or pond bottom elevations. The soil borings encountered sandy lean clay, silty sand, poorly graded sand with silt, poorly graded sand and gravelly sand corresponding to the ASTM classifications CL, SM, SP-SM, SP and GP. It is our opinion that the infiltration rates presented in Table 5, which were obtained from "Minnesota Storm Water Manual", can be used for stormwater pond design.

Table 5. Infiltration Rates

In-situ soils	Soil Description	Hydrologic Soil Group	Design Infiltration Rate (in/hr.)
CL	Sandy Lean Clay	D	0.06
SM	Silty Sand	B	0.45
SP & SP-SM	Poorly Graded Sand & Poorly Graded Sand with Silt	A	0.8
GP	Gravelly Sand	A	0.8

It should be noted that soil infiltration rates can vary due to; soil moisture content, soil compaction, the placement or introduction of fine-grained soils, topsoil or biofiltration media and changes or variations in local groundwater levels. These variations may result in additional construction costs and it is suggested that a contingency be provided for this purpose.

Field tests (double ring infiltrometer) can be performed within the proposed infiltration basin area to verify infiltration rates of the in-situ soils. We would be pleased to provide these services if required or requested.

5.0 CONSTRUCTION CONSIDERATIONS

5.1 Excavation

The soils encountered in the borings consisted of sandy lean clay, silty sand, poorly graded sand with silt, poorly graded sand and gravelly sand corresponding to the ASTM Classifications of CL, SM, SP-SM, SP and GP. Soils classified as CL will generally be Type B soils under Department of Labor Occupational Safety and Health Administration (OSHA) guidelines, while soils classified as SM, SP-SM, SP and GP will generally be Type C soils under OSHA guidelines.

Temporary excavations in Type B soils should be constructed at a minimum of 1 foot horizontal to every 1 foot vertical within excavations. Temporary excavations in Type C soils should be constructed at a minimum of 1 ½ foot horizontal to every 1 foot vertical within excavations. Slopes constructed in this manner may still exhibit surface sloughing. If site constraints do not allow the construction of slopes with these dimensions, then temporary shoring may be required.

5.2 Observations

A geotechnical engineer or a qualified engineering technician should observe the excavation subgrade to evaluate if the subgrade soils are similar to those encountered in the borings and adequate to support the proposed construction.

5.3 Backfill and Fills

We recommend moisture conditioning all soils that will be used as fill or backfill in accordance with Section 4.3 above. We recommend that fill and backfill be placed in lifts not exceeding 4 to 12 inches, depending on the size of the compactor and materials used.

5.4 Testing

We recommend density tests of backfill and fills placed for the proposed foundations. Samples of the proposed materials should be submitted to our laboratory prior to placement for evaluation of their suitability and to determine their optimum moisture content and maximum dry density (Standard Proctor).

5.5 Winter Construction

If site grading and construction is anticipated to proceed during cold weather, all snow and ice should be removed from cut and fill areas prior to additional grading and placement of fill. No fill should be placed on frozen soil and no frozen soil should be used as fill or backfill.

Concrete delivered to the site should meet the temperature requirements of ASTM and/or ACI. Concrete should not be placed on frozen soil. Concrete should be protected from freezing until the necessary strength is obtained. Frost should not be permitted to penetrate below the footings.

6.0 PROCEDURES

6.1 Soil Classification

The drill crew chief visually and manually classified the soils encountered in the borings in general accordance with ASTM D 2488, "Description and Identification of Soils (Visual-Manual Procedure)." Soil terminology notes are included in the Appendix. The samples were returned to our laboratory for review of the field classification by a soils engineer. Samples will be retained for a period of 30 days.

6.2 Groundwater Observations

Immediately after taking the final samples in the bottom of the boring, the hole was checked for the presence of groundwater. Immediately after removing the augers from the borehole the hole was once again checked and the depth to water and cave-in depths were noted.

7.0 GENERAL

7.1 Subsurface Variations

The analyses and recommendations presented in this report are based on data obtained from a limited number of soil borings. Variations can occur away from the boring, the nature of which may not become apparent until additional exploration work is completed, or construction is conducted. A reevaluation of the recommendations in this report should be made after performing on-site observations during construction to note the characteristics of any variations. The variations may result in additional foundation costs and it is suggested that a contingency be provided for this purpose.

It is recommended that we be retained to perform the observation and testing program during construction to 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, specifications and construction methods. This will allow correlation of the soil conditions encountered during construction to the soil borings and will provide continuity of professional responsibility.

7.2 Review of Design

This report is based on the design of the proposed structures as related to us for preparation of this report. It is recommended that we be retained to review the geotechnical aspects of the design and specifications. With the review, we will evaluate whether any changes have affected the validity of the recommendations and whether our recommendations have been correctly interpreted and implemented in the design and specifications.

7.3 Groundwater Fluctuations

We made water level measurements in the borings at the times and under the conditions stated on the boring log. The data was interpreted in the text of this report. The period of observation was relatively short and fluctuations in the groundwater level may occur due to rainfall, flooding, irrigation, spring thaw, drainage, and other seasonal and annual factors not evident at the time the observations were made. Design drawings and specifications and construction planning should recognize the possibility of fluctuations.

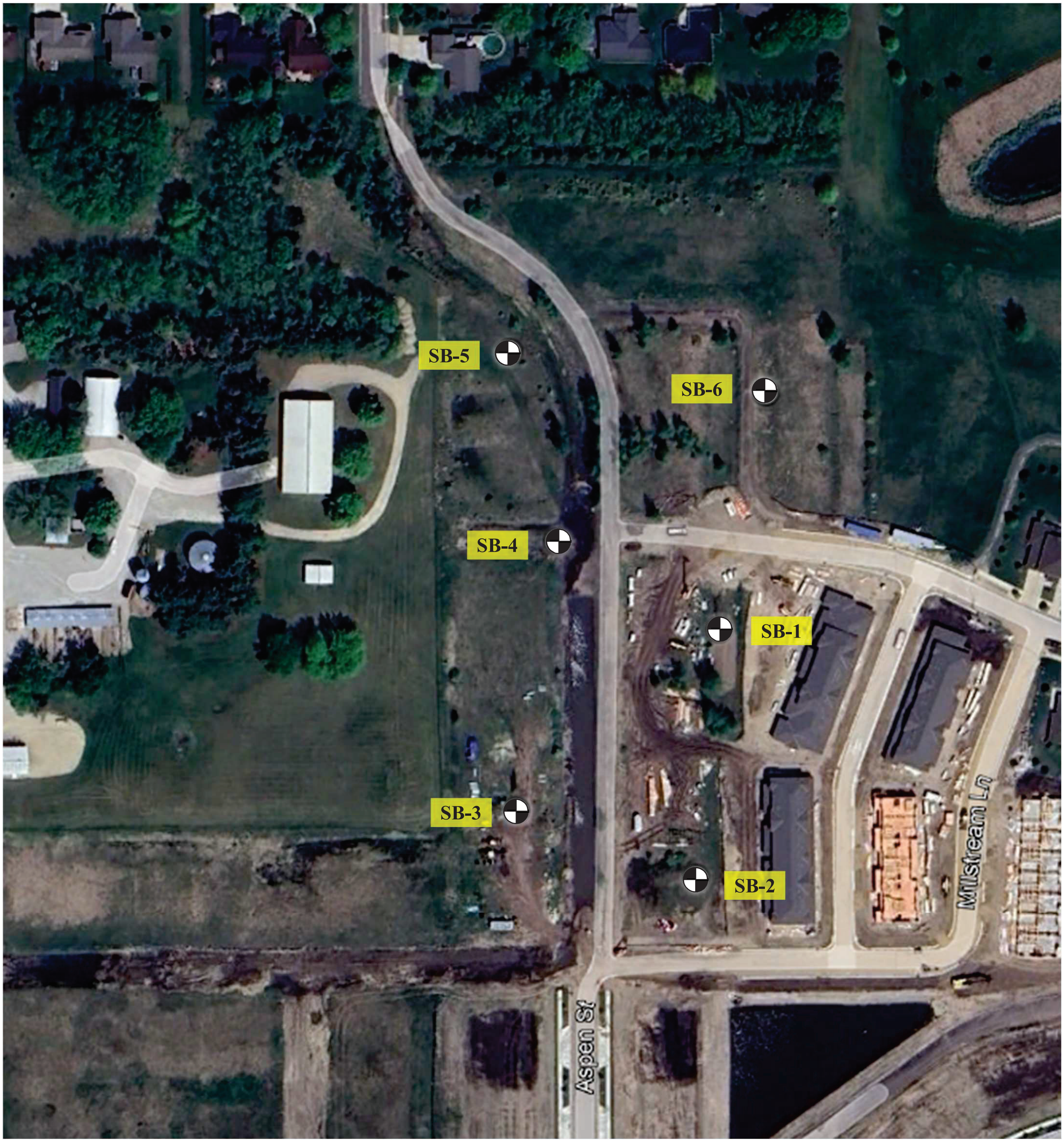
7.4 Use of Report

This report is for the exclusive use of City of Northfield and their design team to use to design the proposed structures and prepare construction documents. In the absence of our written approval, we make no representation and assume no responsibility to other parties regarding this report. The data, analysis and recommendations may not be appropriate for other structures or purposes. We recommend that parties contemplating other structures or purposes contact us.

7.5 Level of Care

Haugo GeoTechnical Services has used the degree of skill and care ordinarily exercised under similar circumstance by members of the profession currently practicing in this locality. No warranty expressed or implied is made.

APPENDIX



Legend

Approximate Soil Boring Location

Disclaimer: Map and parcel data are believed to be accurate, but accuracy is not guaranteed.
This is not a legal document and should not be substituted for a title search, appraisal, survey, or for zoning verification.

Haugo GeoTechnical Services, LLC 2825 Cedar Avenue S. Minneapolis, MN 55407	Soil Boring Location Sketch Southbridge HRA Site Northfield, Minnesota	Figure #: 1 Drawn By: AMH Date: 10-28-2024 Scale: None Project #: 24-0721

Figure 2: GPS Boring Locations

Boring Number	Elevation (US Feet)	Northing Coordinate	Easting Coordinate
SB-1	969.1	852047.986176663	2844968.3491257
SB-2	971.2	851771.376215197	2844944.31290233
SB-3	972.5	851843.11713347	2844744.61285083
SB-4	968.8	852144.564428905	2844786.8055638
SB-5	975.8	852351.562772347	2844730.64532341
SB-6	973.3	852311.934993663	2845014.86912341

Referencing US State Plane Coordinate System

Haugo GeoTechnical Services
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Telephone: 612-729-2959
Fax: 763-445-2238

BORING NUMBER SB-1

CLIENT City of NorthField
PROJECT NAME NorthField Development
PROJECT NUMBER 24-0721
PROJECT LOCATION Northfield, MN
DATE STARTED 9/26/24 **COMPLETED** 9/26/24
GROUND ELEVATION 969.1 ft **HOLE SIZE** 3 1/4 inches
DRILLING CONTRACTOR HGTS- 45
GROUND WATER LEVELS:
DRILLING METHOD Hollow Stem Auger/Split Spoon
▽ **AT TIME OF DRILLING** 14.50 ft / Elev 954.60 ft
LOGGED BY NC/MS **CHECKED BY** PG
AT END OF DRILLING ---
NOTES
AFTER DRILLING ---

DEPTH (ft)	MATERIAL DESCRIPTION	SAMPLE TYPE NUMBER	RECOVERY % (RQD)	BLOW COUNTS (N VALUE)	Moisture Content (%)
0	Sandy Lean Clay, trace Roots, black, moist (Topsoil)	AU 41			
	(CL) Sandy Lean Clay, trace Gravel, brown and light grey, moist to wet, rather soft to rather stiff (Glacial Till)	SS 42		2-3-4 (7)	
5		SS 43		2-2-2 (4)	18
		SS 44		2-4-4 (8)	
10		SS 45		2-2-5 (7)	12
		SS 46		3-5-6 (11)	
15	▽ (GP) Gravelly Sand, fine to coarse grained, brown, waterbearing, medium dense (Glacial Till)	SS 47		2-4-16 (20)	
20		SS 48		4-10-15 (25)	

▲ SPT N VALUE ▲ 20 40 60 80
PL MC LL 20 40 60 80
☐ FINES CONTENT (%) ☐ 20 40 60 80

Bottom of borehole at 21.0 feet.

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BORING NUMBER SB-2

CLIENT City of NorthField
PROJECT NAME NorthField Development
PROJECT NUMBER 24-0721
PROJECT LOCATION Northfield, MN
DATE STARTED 9/26/24 **COMPLETED** 9/26/24
GROUND ELEVATION 971.2 ft **HOLE SIZE** 3 1/4 inches
DRILLING CONTRACTOR HGTS- 45
GROUND WATER LEVELS:
DRILLING METHOD Hollow Stem Auger/Split Spoon
∇ **AT TIME OF DRILLING** 20.00 ft / Elev 951.20 ft
LOGGED BY NC/MS **CHECKED BY** PG
AT END OF DRILLING ---
NOTES
AFTER DRILLING ---

DEPTH (ft)	MATERIAL DESCRIPTION	SAMPLE TYPE NUMBER	RECOVERY % (RQD)	BLOW COUNTS (N VALUE)	Moisture Content (%)
0	Sandy Lean Clay, trace Grass and Roots, black, moist (Topsoil)	AU 33			
	(CL) Sandy Lean Clay, trace Gravel, brown, wet, rather soft to medium (Glacial Till)	SS 34		2-3-4 (7)	14.5
5		SS 35		1-3-4 (7)	
		SS 36		1-4-4 (8)	19
10		SS 37		1-3-2 (5)	
	(SP-SM) Poorly Graded Sand with Silt, fine grained, dark brown, wet to waterbearing, loose (Glacial Till)	SS 38		1-2-3 (5)	
	(CL) Sandy Lean Clay, trace Gravel, brown, wet, soft (Glacial Till)				
15		SS 39		1-1-2 (3)	
20	∇ (SM) Silty Sand with Gravel, dark brown, waterbearing, very loose (Glacial Till)	SS 40		0-0-1 (1)	

▲ SPT N VALUE ▲ 20 40 60 80
PL MC LL 20 40 60 80
☐ FINES CONTENT (%) ☐ 20 40 60 80

Bottom of borehole at 21.0 feet.

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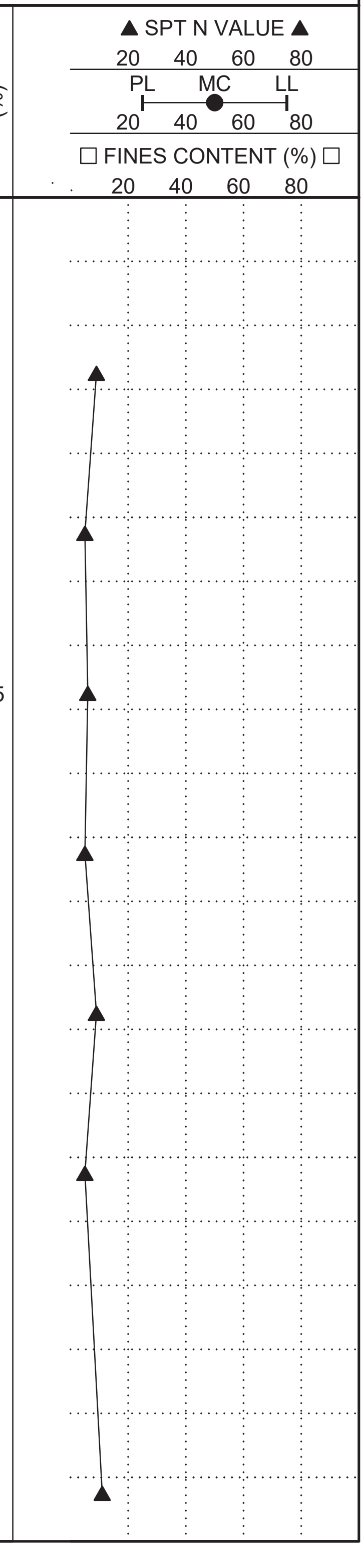
BORING NUMBER SB-3

CLIENT City of NorthField
PROJECT NAME NorthField Development
PROJECT NUMBER 24-0721
PROJECT LOCATION Northfield, MN
DATE STARTED 9/26/24 **COMPLETED** 9/26/24
GROUND ELEVATION 972.5 ft **HOLE SIZE** 3 1/4 inches
DRILLING CONTRACTOR HGTS- 45
GROUND WATER LEVELS:
DRILLING METHOD Hollow Stem Auger/Split Spoon
▽ **AT TIME OF DRILLING** 10.00 ft / Elev 962.50 ft
LOGGED BY NC/MS **CHECKED BY** PG
AT END OF DRILLING ---
NOTES
AFTER DRILLING ---

DEPTH (ft)	MATERIAL DESCRIPTION	SAMPLE TYPE NUMBER	RECOVERY % (RQD)	BLOW COUNTS (N VALUE)	Moisture Content (%)
0	Sandy Lean Clay, trace Grass and Roots, black, moist (Topsoil)	AU 25			
	(CL) Sandy Lean Clay, trace Gravel, brown, moist to wet, rather soft to rather stiff (Glacial Till)	SS 26		3-4-5 (9)	12
5		SS 27		2-2-3 (5)	
		SS 28		1-1-5 (6)	10.5
10 ▽		SS 29		0-2-3 (5)	
		SS 30		2-4-5 (9)	
15	(CL) Sandy Lean Clay, trace Gravel, grey, moist to wet, rather soft (Glacial Till)	SS 31		2-2-3 (5)	
20	(GP) Gravelly Sand, fine to coarse grained, brown, waterbearing, medium dense (Glacial Till)	SS 32		5-4-7 (11)	



Bottom of borehole at 21.0 feet.

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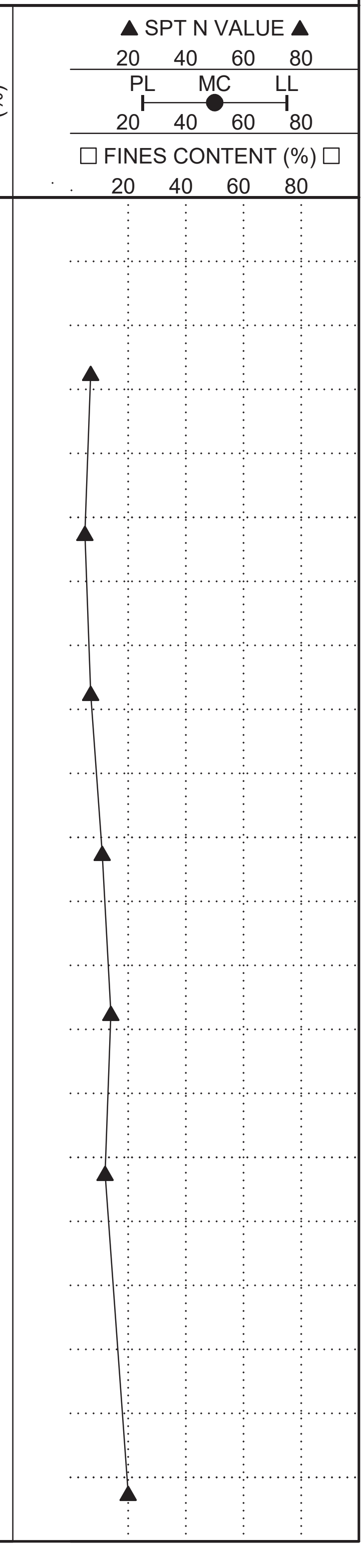
BORING NUMBER SB-4

CLIENT City of NorthField
PROJECT NAME NorthField Development
PROJECT NUMBER 24-0721
PROJECT LOCATION Northfield, MN
DATE STARTED 9/26/24 **COMPLETED** 9/26/24
GROUND ELEVATION 968.8 ft **HOLE SIZE** 3 1/4 inches
DRILLING CONTRACTOR HGTS- 45
GROUND WATER LEVELS:
DRILLING METHOD Hollow Stem Auger/Split Spoon
▽ **AT TIME OF DRILLING** 20.00 ft / Elev 948.80 ft
LOGGED BY NC/MS **CHECKED BY** PG
AT END OF DRILLING ---
NOTES
AFTER DRILLING ---

DEPTH (ft)	MATERIAL DESCRIPTION	SAMPLE TYPE NUMBER	RECOVERY % (RQD)	BLOW COUNTS (N VALUE)	Moisture Content (%)
0	Sandy Lean Clay, trace Gravel, trace Roots, dark brown, moist (Topsoil)	AU 17			
	(CL) Sandy Lean Clay, trace Gravel, brown, moist to wet, rather soft to rather stiff (Glacial Till)	SS 18		1-3-4 (7)	14
5		SS 19		1-2-3 (5)	
		SS 20		2-3-4 (7)	15
10		SS 21		5-5-6 (11)	
	(CL) Sandy Lean Clay, trace Gravel, grey, wet, rather stiff to stiff (Glacial Till)	SS 22		3-6-8 (14)	
15		SS 23		2-5-7 (12)	
20	▽ (GP) Gravelly Sand, fine to coarse grained, brown, waterbearing, medium dense (Glacial Till)	SS 24		12-10-10 (20)	



Bottom of borehole at 21.0 feet.

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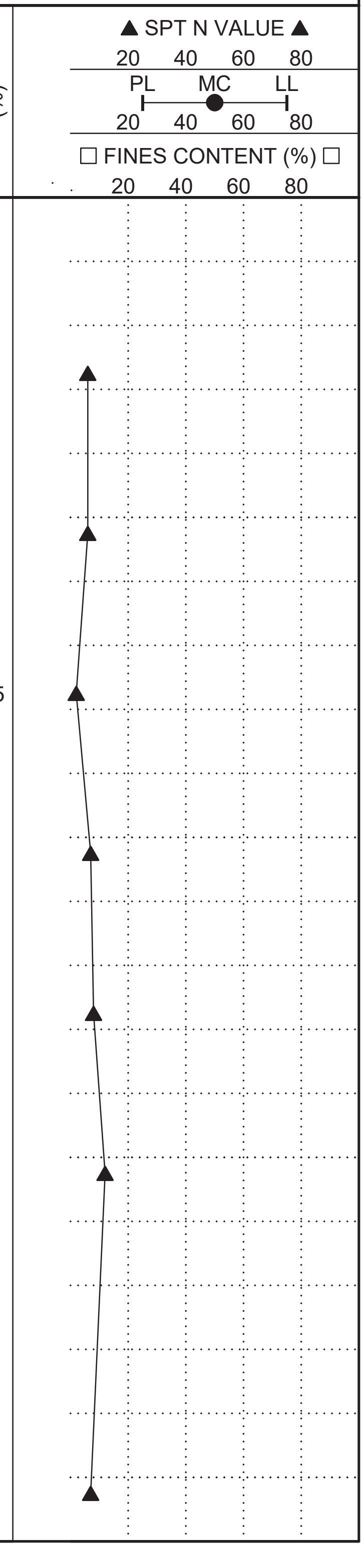
BORING NUMBER SB-5

CLIENT City of NorthField
PROJECT NAME NorthField Development
PROJECT NUMBER 24-0721
PROJECT LOCATION Northfield, MN
DATE STARTED 9/26/24 **COMPLETED** 9/26/24
GROUND ELEVATION 975.8 ft **HOLE SIZE** 3 1/4 inches
DRILLING CONTRACTOR HGTS- 45
GROUND WATER LEVELS:
DRILLING METHOD Hollow Stem Auger/Split Spoon
▽ **AT TIME OF DRILLING** 20.00 ft / Elev 955.80 ft
LOGGED BY NC/MS **CHECKED BY** PG
AT END OF DRILLING ---
NOTES
AFTER DRILLING ---

DEPTH (ft)	GRAPHIC LOG	MATERIAL DESCRIPTION	SAMPLE TYPE NUMBER	RECOVERY % (RQD)	BLOW COUNTS (N VALUE)	Moisture Content (%)
0		Sandy Lean Clay, trace Roots, black, moist (Topsoil)	AU 9			
		(SM) Silty Sand, fine grained, brown, moist (Glacial Till)	SS 10		3-3-3 (6)	8
5			SS 11		2-3-3 (6)	
		(CL) Sandy Lean Clay, trace Gravel, brown, wet, soft to medium (Glacial Till)	SS 12		1-1-1 (2)	20.5
10			SS 13		2-3-4 (7)	
		(CL) Sandy Lean Clay, trace Gravel, grey, wet, medium to rather stiff (Glacial Till)	SS 14		8-3-5 (8)	
15			SS 15		11-5-7 (12)	
20		▽ (CL) Sandy Lean Clay, with interbedded layers of fine grained sand, brown, moist to wet, medium (Glacial Till)	SS 16		2-2-5 (7)	



Bottom of borehole at 21.0 feet.

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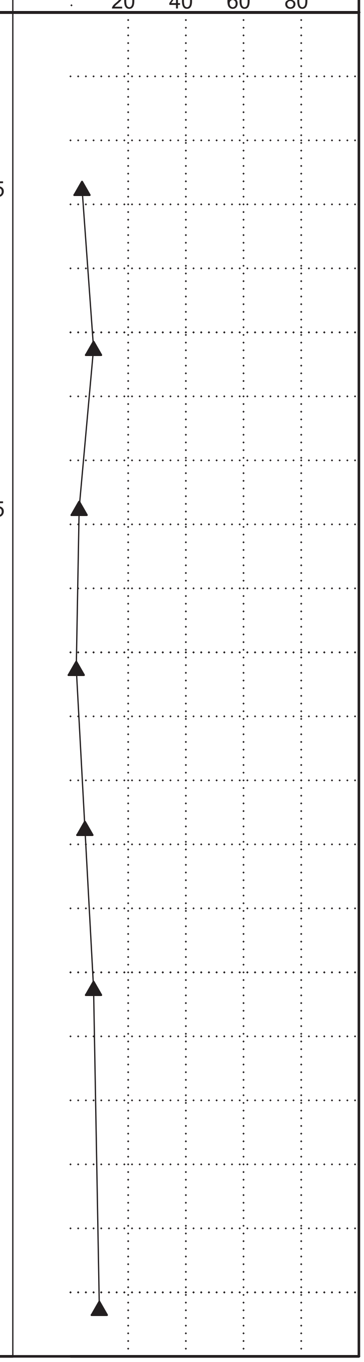
BORING NUMBER SB-6

CLIENT City of NorthField
PROJECT NAME NorthField Development
PROJECT NUMBER 24-0721
PROJECT LOCATION Northfield, MN
DATE STARTED 9/26/24 **COMPLETED** 9/26/24
GROUND ELEVATION 973.3 ft **HOLE SIZE** 3 1/4 inches
DRILLING CONTRACTOR HGTS- 45
GROUND WATER LEVELS:
DRILLING METHOD Hollow Stem Auger/Split Spoon
▽ **AT TIME OF DRILLING** 20.00 ft / Elev 953.30 ft
LOGGED BY NC/MS **CHECKED BY** PG
AT END OF DRILLING ---
NOTES
AFTER DRILLING ---

DEPTH (ft)	MATERIAL DESCRIPTION	SAMPLE TYPE NUMBER	RECOVERY % (RQD)	BLOW COUNTS (N VALUE)	Moisture Content (%)
0	Sandy Lean Clay, trace Roots, dark brown, moist (Topsoil)	AU 1			
	(CL) Sandy Lean Clay, trace Gravel, brown, moist to wet, soft to medium (Glacial Till)	SS 2		2-2-2 (4)	13.5
5		SS 3		3-3-5 (8)	
		SS 4		1-2-1 (3)	19.5
10		SS 5		0-1-1 (2)	
		SS 6		2-2-3 (5)	
15		SS 7		2-3-5 (8)	
20	▽ (SP) Poorly Graded Sand, fine to coarse grained, with Gravel, brown, waterbearing, loose (Glacial Till)	SS 8		4-4-6 (10)	

▲ SPT N VALUE ▲ 20 40 60 80
PL MC LL 20 40 60 80
☐ FINES CONTENT (%) ☐ 20 40 60 80



Bottom of borehole at 21.0 feet.

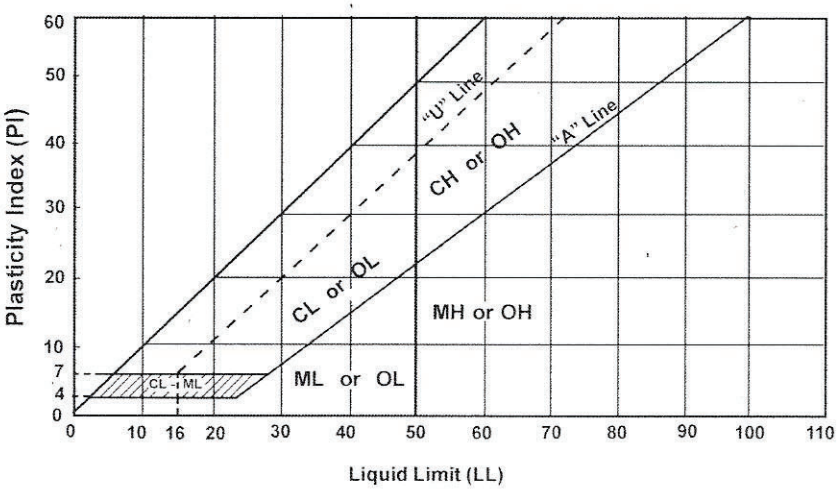
HAUGO GEOTECHNICAL SERVICES

Descriptive Terminology of Soil

Standard D 2487 - 00
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** 5% or less 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** 5% or less 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	< 0.75	OL	Organic clay [k l m n]
			Liquid limit - not dried		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	< 0.75	OH	Organic clay [k l m p]
			Liquid limit - not dried		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-in (75mm) sieve.
b. If field sample contained cobbles or boulders, or both, add "with cobbles or boulders or both" to group name.
c. $C_u = D_{60} / D_{10}$ $C_c = \frac{(D_{30})^2}{D_{10} \times D_{60}}$
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. Sands with 5 to 12% fines require dual symbols:
  SW-SM well-graded sand with silt
  SW-SC well-graded sand with clay
  SP-SM poorly graded sand with silt
  SP-SC poorly graded sand with clay
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" line.
q. PI plots below "A" line.



Laboratory Tests

DD	Dry density, pcf	OC	Organic content, %
WD	Wet density, pcf	S	Percent of saturation, %
MC	Natural moisture content, %	SG	Specific gravity
LL	Liqiuid limit, %	C	Cohesion, psf
PL	Plastic limit, %	∅	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 ≥ 4 and on or above "A" line

Relative Density of Cohesionless Soils

Very loose	0 to 4 BPF
Loose	5 to 10 BPF
Medium dense	11 to 30 BPF
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. Standard penetration test borings are designated by the prefix "ST" (Split Tube). All samples were taken with the standard 2" OD split-tube sampler, except where noted.

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

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. Hand auger borings are indicated by the prefix "H."

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 indicates thin-walled (undisturbed) tube sample.

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