Trunk Sewer Replacement

Geneva on the Lake, Ohio

Geotechnical Subsurface Investigation

Village of
Geneva on the Lake
Geneva on the Lake, Ohio

December 12, 2023

CT Project No. 231183

LEADING THROUGH THE NEXT 100 YEARS
www.ctconsultants.com

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December 12, 2023

CT Project No. 231183

Jeremy R. Shaffer
Village of Geneva on the Lake
4929 S Warner Dr
Geneva on the Lake, Ohio 44041

Geotechnical Subsurface Investigation
Trunk Sewer Replacement
Geneva on the Lake, Ohio

Dear Mr. Shaffer:

Following is the report of the geotechnical subsurface investigation performed by CT Consultants, Inc. for the referenced project. This investigation was performed in general accordance with CT Proposal No. P231183, authorized by you on April 27, 2023, with signature of Work Authorization No. 8.

This report contains the results of our study, our engineering interpretation of the results with respect to the project characteristics, design and construction recommendations for pavements, as well as our recommendations for installation and support of underground utilities.

Soil samples collected during this investigation will be stored at our laboratory for 90 days from the date of this report. The samples will be discarded after this time unless you request that they be saved or delivered to you.

Should you have any questions regarding this report or require additional information, please contact our office.

Sincerely,

CT Consultants, Inc.

Rawad J. Khawam
Geotechnical Staff

Christopher P. Iott, P.E.
Chief Geotechnical Engineer

STATE OF OHIO CHRISTOPHER P IOTT E-69734 REGISTERED PROFESSIONAL ENGINEER

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GEOTECHNICAL SUBSURFACE INVESTIGATION
TRUNK SEWER REPLACEMENT
GENEVA ON THE LAKE, OHIO

FOR

VILLAGE OF GENEVA ON THE LAKE
4929 S WANRNER DR
GENEVA ON THE LAKE, OHIO 44041

SUBMITTED

DECEMBER 12, 2023
CT PROJECT NO. 231183

CT CONSULTANTS, INC.
8150 STERLING COURT
MENTOR, OHIO 44060
(440) 951-9000

LEADING THROUGH the next 100 years

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1.0 INTRODUCTION

This geotechnical subsurface investigation report has been prepared for proposed trunk sewer replacement in Geneva on the Lake, Ohio. The general project area includes an approximate one mile of sewer alignment south of State Route 531, from just west of State Route 534 east to Sunset Drive, as shown on the Site Location Map (Plate 1.0).

This report describes the investigative and testing procedures, presents our findings and the results of the laboratory testing, provides our design and construction recommendations for pavements, as well as provides our recommendations for installation and support of the proposed underground utilities.

This investigation was performed in general accordance with CT Proposal No. P231183, and was authorized by Mr. Jeremy R. Shaffer, Administrator for Geneva on the Lake, on April 27, 2023 with signature of Work Authorization No. 8.

The purpose of this investigation was to evaluate the subsurface conditions and laboratory data, relative to the proposed pavement, as well as installation and support of the proposed underground utilities, at the referenced site. To accomplish this, CT performed four test borings, field and laboratory soil testing, and a geotechnical engineering evaluation of the test results.

This report includes:

- A description of the surface, subsurface soil and groundwater conditions encountered in the borings.
- Design recommendations related to the proposed pavements and underground utilities.
- Recommendations concerning soil- and groundwater-related construction procedures such as site preparation, earthwork, pavement subgrade preparation, and related field testing.

This investigation did not include an environmental assessment of the subsurface materials at the site.

2.0 INVESTIGATIVE PROCEDURES

This investigation included four test borings, which were performed by CT on October 25, 2023. The test borings were designated as Borings B-1 through B-4 and were located along the proposed sewer replacement. The locations of the test borings were established in the field by CT. Ground surface elevations at the boring locations were estimated from Google Earth. The approximate locations of the test borings are shown on the Test Boring Location Plans (Plate 2.1 for the west, and Plate 2.2 for the east).

The test borings were performed in accordance with geotechnical investigative procedures outlined in ASTM Standard D 6151. The test borings performed during this investigation were drilled with an ATV-mounted CME 550 drill rig with drilling capabilities utilizing 3¼-inch inside diameter hollow-stem augers. The borings were terminated upon encountering auger refusal, and the termination depths are summarized in Table 2.1.

Table 2.1 - Test Boring Data

Boring Number	Approximate Ground Surface Elevation (feet)	Termination Depth (feet)	Approximate Termination Elevation (feet)
B-1	584	14.5	569
B-2	582	21.5	560
B-3	593	18.5	574
B-4	596	20	576

During auger advancement, soil samples were collected at 2½-foot intervals to a depth of 10 feet and at 5-foot intervals thereafter. Split-spoon (SS) samples were obtained by the Standard Penetration Test (SPT) Method (ASTM D 1586), which consists of driving a 2-inch outside diameter split-barrel sampler into the soil with a 140-pound weight falling freely through a distance of 30 inches. The sampler was driven in three successive 6-inch increments and the number of blows per increment was recorded. The sum of the number of blows required to advance the sampler the second and third 6-inch increments is termed the Standard Penetration Resistance

(N-value) and is presented on the Logs of Test Borings. The samples were sealed in jars and transported to our laboratory for further classification and testing.

Soil conditions encountered in the test borings are presented in the Logs of Test Borings, along with information related to sample data, SPT results, water conditions observed in the borings, and laboratory test data. It should be noted that these logs have been prepared on the basis of laboratory classification and testing as well as field logs of the encountered soils.

All samples of the subsoils were visually or manually classified using the Unified Soil Classification System (USCS) via ASTM D 2487 and D 2488, as well as in accordance with the Ohio Department of Transportation (ODOT) system of soil classification. All samples were also tested for moisture content (ASTM D 2216). Unconfined compressive strength estimates were obtained for the intact cohesive samples using a calibrated hand penetrometer. Atterberg limits tests (ASTM D 4318) and particle size analyses (ASTM D 422) were performed on selected samples to determine soil classification and index properties. An Organic Content test by the loss-on-ignition (LOI) method (ASTM D 2974) was performed on a select sample. The results of these tests are presented on the Logs of Test Borings, Tabulation of Test Data sheet, Atterberg limits sheet, and Grain Size Distribution sheet attached to this report.

Experience indicates that the actual subsoil conditions at a site could vary from those generalized on the basis of test borings made at specific locations. Therefore, it is essential that a geotechnical engineer be retained to provide soil engineering services during the site preparation and excavation phases of the proposed project. This is to observe compliance with the design concepts, specifications, and recommendations, and to allow design changes in the event subsurface conditions differ from those anticipated prior to the start of construction.

3.0 PROPOSED CONSTRUCTION

We understand that the project will include the installation of a replacement sanitary sewer trunk line in Geneva on the Lake, Ohio. The proposed utilities installation alignment is approximated to be on the order of 5,100 lineal feet. Inverts are anticipated to range from approximately 8 to 15 feet below exiting grades.

The method of installation for the underground utilities is anticipated to be predominantly open-cut, but may also include bore-and-jack, and/or directional drilling methods.

Pavements may be constructed as part of this project. The pavements may consist of a flexible (asphalt) sections and/or rigid (concrete) sections. Final design grades are anticipated to approximate existing grades.

4.0 GENERAL SITE AND SUBSURFACE CONDITIONS

4.1 General Site Conditions

At the time of this investigation, the project area consisted of commercial, residential, and wooded areas. The surface materials encountered in the Borings B-1 through B-3 consisted of topsoil varying in thickness from 5 to 8 inches. The surface material encountered in Boring B-4 consisted of 4 inches of crushed stone. Ground surface elevations at the boring locations ranged from Elevs. 582± to 596±.

4.2 General Soil Conditions

Based on the conditions encountered in the test borings, the subsoils encountered underlying the surface materials can be generally described as one stratum of granular soils underlain by one stratum of cohesive soils, underlain by weathered shale bedrock. The granular stratum was encountered only in Borings B-2 and B-3, which were located in the wooded area.

Stratum I consisted of predominantly **very loose** to **loose** granular soils encountered underlying the topsoil in Borings B-2 and B-3, which are the borings that were located with the wooded area. Stratum I extended to depths ranging from 3½ to 6 feet below existing grades (Elevs. 589± to 576±). These granular soils consisted of silty sand (SM) and clayey sand (SC). SPT N-values ranged from 4 to 9 blows per foot (bpf). Moisture contents ranged from 11 to 22 percent. Due to gray/brown coloration of SS-2 in Boring B-2, an organic content test was performed that resulted in a value of 4.3 percent. Organic contents of 5 percent or less are considered trace, which should not be detrimental to the proposed development.

Stratum II consisted of predominantly medium stiff to stiff cohesive soils encountered underlying the surface materials in Borings B-1 and B-4, as well as underlying Stratum I in Borings B-2 and B-3. Stratum II extended to depths of 14 to 21 feet (Elevs. 561± to 577±). The Stratum II cohesive soils consisted of lean clay (CL) with varying amounts of sand and gravel. SPT N-values generally ranged from 5 to 14 bpf. Unconfined compressive strengths varied from 1,500 psf to more than 9,000 psf (maximum reading obtainable using a hand penetrometer), although some of the higher strengths in the upper soil profile may have been affected by desiccation. Moisture contents ranged from 17 to 30 percent. Zones of cohesive soils exhibiting very stiff consistency were found within Stratum II in Borings B-3 and B-4 as follows.

- In Boring B-3, from approximately 7 to 8½ feet (Elevs. 586± to 584±). SPT N-value of 16 bpf. Unconfined compressive strength of more than 9,000 pounds per square foot.
- In Boring B-4, from approximately 6 to 8 feet (Elevs. 590± to 588±). SPT N-value of 25 bpf. Unconfined compressive strength of more than 9,000 pounds per square foot.

Underlying Stratum II, an approximately half foot zone of weathered/augerable shale was encountered in each of the borings prior to encountering auger refusal.

Additional descriptions of the stratigraphy encountered in the borings and laboratory testing results are presented on the Logs of Test Borings.

4.3 Groundwater Conditions

Groundwater was not encountered during drilling nor observed upon completion of drilling operations in any of the borings. It should be noted that the boreholes were drilled and backfilled within the same day, and stabilized water levels may not have occurred over this limited time period.

Based on the limited data collected during this investigation, including the soil characteristics and the moisture conditions encountered in the borings, it is our opinion that the "normal" groundwater level will generally be encountered at depths on the order of 6 to 9 feet below existing grades. However, it should be noted that groundwater elevations can fluctuate with seasonal and climatic influences. In particular, "perched" groundwater may be encountered in stone subbase or granular soils that are underlain by relatively impermeable cohesive soils. Therefore, the groundwater conditions may vary at different times of the year from those encountered during this investigation.

5.0 DESIGN AND CONSTRUCTION RECOMMENDATIONS

The following recommendations are based on the data obtained during our field investigation as well as our understanding of the proposed construction and project design information furnished to date. If the project information as outlined herein is incorrect or should change significantly, a review of these recommendations should be made by CT.

5.1 Pipe Support

Underground utility installations may include installation using open-cut excavation techniques. Pipe support recommendations and open-cut installation recommendations are provided in Sections 5.1 and 5.2. If installation will include directional drilling and/or bore-and-jack methods, recommendations are provided in Section 5.3.

It is anticipated that underground utilities will be installed at varying depths on the order of 8 to 15 feet below existing grades.

Based on the borings performed for this investigation, the subsoils at the underground utility invert depths are anticipated to consist of Stratum II predominantly medium stiff to stiff cohesive soils. The medium stiff or better subsoils are considered generally suitable for support of the proposed underground utilities, provided that sufficient bedding and haunching is maintained below and above the proposed utility lines. Although not anticipated to be prevalent, if Stratum I very loose to loose granular soils are encountered, they will require in-place densification or over-excavation as discussed below.

If very loose to loose granular soils are encountered at the pipe invert elevation, they should be re-compacted in-place using a backhoe-mounted vibratory compactor (hoe-pac) or similar equipment to achieve at least medium dense compactness. If loose granular soils can not be suitably re-compacted in-place, or if soft cohesive soils are encountered, these materials should be over-excavated and replaced with new engineered fill. These unsuitable soils should be undercut to firm subgrade conditions. As a minimum, unsuitable soils should be undercut to a depth of one pipe diameter below invert, or 12 inches, whichever is greater. The undercut zones should be replaced with engineered fill, properly placed and compacted as outlined in Section 5.7 of this report prior to placement of the bedding and haunching material.

In any case, it will be critical to maintain a sufficient thickness of bedding and haunching to provide adequate support and protection for the underground utilities. Bedding and haunching materials should conform to pipe manufacturer specifications and recommendations. In the absence of specific criteria for bedding and haunching materials, we recommend the use of dense graded aggregate meeting Ohio Department of Transportation (ODOT) Item 304 specifications, or alternately, ODOT 703 coarse aggregate meeting No. 57 or No. 6 gradations.

We recommend that the trench excavation along the proposed underground utilities invert be inspected by a CT geotechnical engineer or qualified representative. This is to confirm that the encountered subsoils are consistent with those encountered in the test borings and that the exposed materials are capable of supporting the proposed underground utilities.

5.2 Open-Cut Installation Methods

The sides of the temporary excavations for underground utilities installation should be adequately sloped to provide stable sides and safe working conditions. If the proposed underground utilities alignment requires working in close proximity to existing underground utilities or other structures, this may not be possible. Where sloped excavations will not be used, the excavation must be properly braced against lateral movements. In any case, applicable OSHA safety standards must be followed. It is the responsibility of the installation contractor to develop appropriate installation methods and equipment prior to commencement of work, and to obtain the services of a geotechnical engineer to design or approve sloped or benched excavations and/or lateral bracing systems as required by OSHA criteria. While not anticipated, any excavations greater than 20 feet deep should be evaluated by a registered professional engineer.

If the excavation is to be performed with sloped banks, adequate stable slopes must be provided. Based on the borings drilled for this investigation, soils encountered in trench excavations may include one or more of the following:

- OSHA Type A soils (cohesive soils with unconfined compressive strengths of 3,000 pounds per square foot (psf) or greater),
- OSHA Type B soils (cohesive soils with unconfined compressive strengths greater than 1,000 psf but less than 3,000 psf), and
- OSHA Type C soils (cohesive soils with unconfined compressive strengths of 1,000 psf or less, or granular soils).

For temporary excavations in Type A, B, and C soils, side slopes must be constructed no steeper than ¾ horizontal to 1 vertical (¾H:1V), 1H:1V, and 1½H:1V, respectively. For situations where a higher strength soil overlies a lower strength soil and the excavation extends into the lower strength soil, the slope of the entire excavation is governed by that required for the lower strength soil. In all cases, flatter slopes may be required if lower strength soils or adverse seepage conditions are encountered during construction.

When a portable trench box or sliding trench shield system is utilized, vertical side slopes may be used up to 18 inches below the top of the shield. The sides should then be sloped back from that point to the ground surface.

Based on the conditions encountered in the test borings, invert depths are generally anticipated within soil. Depending on the final invert depths for the project, there may be some areas where utility installations approach the underlying bedrock. There was approximately a half foot of weathered augerable material encountered in the borings prior to encountering auger refusal on more intact rock. The weathered/augerable rock is likely to be removable with conventional excavation equipment such as a backhoe or track excavator, with some assistance from pneumatic chippers or jackhammers. Beyond the depth of auger refusal encountered in the borings, excavation into the bedrock is expected to be unproductive and uneconomical with conventional excavation equipment.

Excavations that must extend into the rock below the depth of auger refusal will likely require extensive use of hard rock removal methods, including pneumatic chippers, jackhammers, or hydraulic wedging equipment, as well as blasting or use of expansive chemicals to fracture and loosen the rock. Actual excavation ease or difficulty will depend on the required removal depth, location-specific fracture frequency, and variations in rock strength.

5.3 Directional Drilling and Bore-and-Jack Considerations

Directional drilling methods or bore-and-jack installation methods may be utilized for some underground utility installations associated with this project. Based on the conditions encountered in the borings, the soils encountered along the alignments of the underground utilities may consist of Stratum I very loose to loose granular soils, as well as Stratum II predominantly medium stiff to stiff cohesive.

It is presumed that directional drilling will be initiated from the ground surface. However, if access excavations for the directional drilling equipment are utilized, or in the case of using pits for bore-and-jack installation, they may be constructed with appropriate slope layback as presented in Section 5.2, or using bracing such as soldier piles with lagging or sheet piling as presented in Section 5.4.

Special care should be exercised during any boring or directional drilling operations to prevent "loss of ground" caused by the movement of excessive amount of soils out of the horizontal borehole. The movement of excessive amounts of soil during the boring operation could result in surface settlements along the boring alignment.

It should be noted that, although not encountered in the borings performed for this investigation, cobbles and boulders are not uncommon in glacial till soils. Should obstructions or boring/drilling penetration refusal/blockages occur during installation, cobbles or boulders may be indicated. Provisions must be made to remove any cobbles, boulders, or large obstructions encountered during the boring or directional drilling operations.

5.4 Support of Excavations

Where existing structures, underground utilities, and embankments are located within a distance from the excavation equal to approximately twice the depth of the excavation, an adequate system of sheet piling, lateral bracing, trench boxes, or an alternate construction procedure may be required to prevent lateral movements that may cause settlement of these entities. Sheet piling may also be used in combination with laid-back slopes limited to the upper portion of the profile to avoid an excessively large, open excavation.

Design of sheet-pile cutoff walls or H-pile and lagging systems should be the responsibility of the contractor, since their installation and performance is integrally tied to the contractor's means and methods of construction. In any case, applicable OSHA standards must be followed. It is the responsibility of the installation contractor to develop appropriate installation methods and equipment specifications prior to commencement of work, and to obtain the services of a qualified engineer to design or approve sloped or benched excavations and/or lateral bracing systems as required by OSHA criteria. In addition, OSHA requires that excavations with open-cut slopes higher than 20 feet, or braced excavation support systems such as sheetpiling or cofferdams be reviewed and designed by a registered professional engineer.

Retaining structures or walls that are not restrained at the top of the wall should be designed for active lateral earth pressure condition. An active earth pressure coefficient (k_a) of 0.33 may be used for design. A passive earth pressure coefficient (k_p) of 3.0 may be utilized for the portion of the wall that is below the excavation bottom. It should be noted that some wall movement or horizontal displacement is typically associated with active and passive earth pressure conditions. In particular, appreciable movements are needed to mobilize the full (theoretical) passive pressure of the soil. Specific bracing systems selected by the contractor may have variations of lateral earth pressure (and associated coefficients) that range between the active and passive cases.

A total unit weight of 130 pounds per cubic foot (pcf) may be utilized for lateral earth pressure evaluations. Below the groundwater table, an effective unit weight should be utilized by reducing the total unit weight by the unit weight of water (62.4 pcf). Additionally, hydrostatic pressures should be considered below the groundwater level. It should be noted that, where sewer installation involves invert depths in close proximity to bedrock, installation of sheet piling may not be feasible and other methods of braced excavation support maybe be provided.

It should also be noted that the above earth pressures are based on a level backfill condition behind the retaining wall. In areas where appreciable sloping materials will be present behind the top of the wall, surcharge loading or equivalent higher earth pressure coefficients should be evaluated, based on the sloping material, backfill slope, and proximity to the wall. In general, 50 percent of the vertical surcharge load should be used for lateral loading in the design of the wall.

Although not encountered during our exploration, cobbles and boulders may be present in the glacial till subsoils. Therefore, provisions should be made by the contractor to drive replacement piling if refusal is encountered shallower than anticipated.

5.5 Pavement Recommendations

5.5.1 Existing Subgrade

The subgrades that would result upon the satisfactory completion of the site preparation as described in Section 5.6 of this report are considered moderately suitable for support of the proposed pavements. Based on field and laboratory data developed during this investigation, the subgrade soils consist of native cohesive soils as well as native silty and clayey granular soils.

Based on laboratory testing as well as visual descriptions of the upper soil profile, the cohesive soils may generally be classified as Group A-6b in accordance with the Ohio Department of Transportation (ODOT) system of soil classification. The granular soils can be generally classified as Group A-4a in accordance with the ODOT system of soil classification. The granular soils are considered fair as subgrade materials. The cohesive soils are considered fair to poor as subgrade materials because they have relatively low permeabilities and a high percentage of silt and clay particles, which makes them susceptible to moisture, frost penetration, and frost heave. Therefore, the cohesive soils will dictate pavement design.

At the time of this investigation, moisture contents in the upper 5 feet of the cohesive subgrade soils were found to range from approximately 17 to 30 percent. Moisture contents in the upper 5 feet of the granular subgrade soils were found to range from approximately 11 to 22 percent. The in-situ moisture contents for the encountered subgrade soils are estimated to vary from near to significantly above the expected optimum moisture content for these soils. Therefore, remedial action should be anticipated to adjust the moisture contents of the existing materials and achieve proper compaction of the subgrade, particularly during wet seasonal periods. Additionally, subgrade modification should be anticipated based on the encountered near-surface loose granular soils in Borings B-2 and B-3, as well as the marginal medium stiff cohesive soils encountered in Boring B-1.

5.5.2 Modified Subgrade

If moisture contents are lower than optimum, water should be uniformly mixed into the subgrade. If moisture contents are higher than optimum, modification may consist of scarification and aeration (discing and exposure to sun and wind). However, this method may not be feasible if construction occurs during wet seasonal conditions or if the construction schedule must be expedited. Very moist to wet soils will "pump" under the operation of heavy equipment, resulting in deep rutting and perhaps rendering the operation of grading and paving equipment difficult or impossible.

Therefore, other methods of subgrade modification may be required in areas of high moisture content. Modification may be achieved by undercutting and replacement with granular subbase (possibly in combination with a geotextile separation layer or geogrid reinforcement), mixing stone into the subgrade, or treating the subgrade with lime or cement. The method of subgrade modification should be determined at the time of construction (See Section 5.6, "Site and Subgrade Preparation").

5.5.3 Pavement Drainage

Based on the poorly-drained nature of the encountered cohesive subgrade soils and silty/clayey granular soils, it is anticipated that surface water infiltration may collect in the aggregate base course. Without adequate drainage, water will remain in the base for extended periods of time, creating localized wet, soft pockets. The presence of these pockets will increase the likelihood that pavement distress (cracking, potholes, etc.) will develop. Drainage features may include grading the subgrade surface to slope downward to the outside edge of pavements and/or providing longitudinal edge drains connected to storm sewers or other outlets. A system of "finger drains" could also be installed near catch basins within the pavement areas to collect surface water infiltration, thus reducing the potential for adverse freeze-thaw effects on the pavement.

5.5.4 Flexible (Asphalt) Pavement Design

Based on the results of the laboratory testing and visual classifications, a subgrade CBR value of 6 percent may be utilized for design, considering the presence of Group A-6b or better site subgrade soils. This CBR value is based on subgrade compacted to at least 100 percent of the maximum dry density as determined by ASTM D 698 (Standard Proctor) or verified as stable through proof rolling.

It should be noted that we are not privy to the design traffic loads or intended design life. The subgrade support recommendations indicated herein should be reviewed by the site engineer in conjunction with the design traffic criteria to determine the required pavement sections. In any case, we recommend the roadway pavement cross-section consist of at least 4 inches of asphalt underlain by 8 inches of aggregate base based on our experience regarding environmental exposure and reasonable serviceability.

It is recommended that proof rolling/compaction, placement of aggregate base, and placement of asphalt be performed within as short a time period as possible. Exposure of the aggregate base to rain, snow, or freezing conditions may lead to deterioration of the subgrade and/or base due to excessive moisture conditions and to difficulties in achieving the required compaction. Additionally, pavement design and all paving operations should conform to Ohio Department of Transportation (ODOT) specifications.

5.5.5 Rigid (Concrete) Pavement Design

For properly prepared subgrade soils, a modulus of subgrade reaction (k) of 150 pounds per cubic inch (pci) may be used for rigid pavement design based on the A-6b or getter site soils. This section should consist of a minimum of 6 inches of reinforced, air-entrained concrete with a minimum compressive strength of 3,500 pounds per square inch (psi) underlain by a minimum of 6 inches of a dense-graded granular base such as ODOT Item 304. The pavement section should be supported on a subgrade compacted to not less than 100 percent of the maximum dry density as determined by ASTM D 698 (Standard Proctor) or verified as stable through proof rolling. All paving operations should conform to the Ohio Department of Transportation (ODOT) specifications.

5.6 Site and Subgrade Preparation

Prior to proceeding with construction operations, topsoil, root mat, vegetation, and other deleterious non-soil materials should be removed from the proposed construction areas. Suitable topsoil may be stockpiled for later use in landscaped areas. The surface materials encountered in the borings consisted of topsoil varying in thickness from 5 to 8 inches in Borings B-1 through B-3. The thickness of topsoil was based solely on visual estimation by the drillers considering soil texture and presence of root mat.

It is important to note that topsoil thicknesses referenced in the borings may vary across the site, particularly due to the wooded portions of the project site. Typically, soils with more than 5 percent organics are not recommended as subgrade soils in pavement areas, but dark colored soils having the appearance of topsoil with only trace “root hairs” may not necessarily require stripping. For these “transitional” soils, the actual moisture content and subgrade stability under proof-rolling operations is more critical than the color in determination of the amount of stripping or subgrade undercut.

Upon completion of stripping and clearing, the areas intended to support new fill and pavements should be carefully inspected by a geotechnical engineer. At the time of inspection, the engineer should observe proof rolling of the cohesive subgrade soils and silty/clayey granular soils utilizing a 20- to 30-ton loaded truck or other pneumatic-tired vehicle of similar size and weight. If there is uncertainty of suitability after proofrolling granular subgrade soils using a pneumatic-tired vehicle or truck, proof rolling/compaction of the granular subgrades may be completed utilizing a smooth-drum roller. The truck or roller should make a minimum of two passes in each of two perpendicular directions covering the proposed development area, with additional passes as necessary to achieve required compaction and/or subgrade stabilization.

The purpose of proof rolling the cohesive soil subgrades and silty/clayey granular soils is to locate any weak, soft, loose, or excessively wet materials that may be present at the time of construction. The purpose of the proof rolling/compaction of the granular soils is to densify zones of loose materials that are encountered in the upper portion of the soil profile, thereby providing more uniform subgrade support. We recommend a roller with a minimum dead weight on the drums of 8 tons, and traveling at speeds not exceeding approximately 4 feet per second (about 3 miles per hour). These operational criteria should provide sufficient dynamic compaction energy to alleviate loose soil conditions within the zone of influence for subgrade support.

Any unsuitable materials observed during the inspection and proof-rolling operations should be undercut and replaced with compacted fill or stabilized in place utilizing conventional remedial measures such as discing, aeration, and recompaction. Once the site has been proof rolled, inspected, and stabilized, the proof-rolled or inspected subgrades should not be exposed to wet conditions. It should be recognized that during periods of wet weather, the silty/clayey soils that will be exposed at design subgrades will tend to pond water for short periods of time, with the potential to deteriorate the prepared subgrade.

The results of the inspection and proof-rolling operations will be partially dependent on construction operations, the moisture content of the soil, and the weather conditions prevalent at the time. If pumping or rutting is encountered and difficulty is experienced in the operation of construction equipment, CT should be notified in order to determine which method of subgrade modification may be best suited for the conditions encountered. Should such conditions be experienced, we may recommend that a small test area be used to determine the necessary depth of undercutting and stone replacement or other remedial action necessary to achieve a stable subgrade condition.

5.7 Construction (General)

Construction traffic and excavated material stockpiles should be kept away from the excavation a minimum distance equal to the full depth of the excavation. In all cases, pertinent OSHA requirements must be followed, and adequate protection for workers must be provided.

Where existing buildings or structures, including underground utilities, are located within a distance from the excavation equal to approximately twice its depth, an adequate system of sheet piling and/or lateral bracing may be required to prevent lateral movements that could cause settlement. Any retaining system proposed by the contractor should be reviewed by a registered professional engineer prior to approval for installation and use.

It is also suggested that a condition survey (i.e., preconstruction documentation) of any existing structures and transportation infrastructure located in the vicinity of the proposed underground utilities alignment be completed. For general below-grade underground utilities installation, we recommend the condition survey extend a distance from the proposed installation extents equal to the depth of the excavation, but not less than 50 feet. The condition survey should be extended to 100 feet from the underground utility alignment in areas where driving of sheetpiling or H-piling will be performed for braced excavations. The condition survey should identify existing cracks and other forms of distress to the structures before the start of construction operations. This procedure will be helpful to evaluate possible effects the construction operations may have on nearby structures and to mitigate potential disputes with property owners.

The construction excavation should not be left open any longer than necessary. As soon as a section of the underground utilities is completed, the area should be backfilled to final grade. After the specified bedding material has been provided below and around the pipe, suitable excavated material may be used to backfill the trench, if located in non-structural and non-pavement areas. Fill required for backfill operations in non-structural and non-pavement areas may consist of any on-site soils that are free of organic matter, excessive moisture, and debris.

In general, backfill material placed above the pipes should be compacted sufficiently to achieve stable backfill and avoid undesirable settlements. Where underground utilities will be installed beneath pavement areas, future structure areas, or future pavement areas, the backfill material should be placed in uniform layers not more than 8 inches thick (loose measure) and compacted to 100 percent of the maximum dry density as determined by ASTM D 698 (Standard Proctor). Backfill placed in pavement areas should consist of dense-graded aggregate, such as ODOT Item 304 material. In order to achieve the desired compaction, the backfill material should be within 3 percent of the optimum moisture content.

Where underground utilities are installed in unpaved and non-structural areas, suitable excavated material from the underground utilities trench may be utilized as backfill. Based on the borings, the excavated material would consist of native cohesive soils and native silty/clayey granular soils. At the time of this investigation, moisture contents determined for these materials generally ranged from near to significantly above optimum moistures expected for these soils. Depending on seasonal conditions, it may not be practical to effectively scarify and aerate excavated soils that are wet of optimum, and imported granular backfill may be required.

We emphasize the need for placing the fill in lifts and compacting each lift to the specified density, especially where the trench will be directly beneath roadway pavement. The installation contractor should not be allowed to push or end-dump several feet of backfill into the trench as a single layer or lift, because the lower portion of a thick lift will not achieve proper densification from compaction equipment operating at the surface of that lift. If backfill is not properly placed and compacted, undesirable trench backfill settlement may occur.

It is recommended that all earthwork and site preparation activities be conducted under adequate specifications and properly monitored in the field by a CT geotechnical engineer or qualified representative.

Backfill for utility trenches in existing or proposed roadways is anticipated to consist of new granular engineered fill, which should be generally suitable for support of new pavements.

5.8 Construction Dewatering

Based on the soil characteristics and moisture conditions encountered in the borings, is our opinion that "normal" groundwater levels at the site will generally be encountered at depths on the order of 6 to 9 feet below existing grades. It should be noted that groundwater was not encountered at the time of drilling but does not eliminate the possibility of it being encountered.

Adequate control of groundwater seepage or surface water run-off into shallow excavations extending not more than a few feet below the water table in cohesive soils should be achievable by minor dewatering systems, such as pumping from prepared sumps. For deeper excavations, temporary sheeting may be required to extend into the underlying cohesive soils for a groundwater cutoff, particularly if sandier clays or sand seams are present. If excessive seepage is experienced, other means of groundwater control may be required. CT should be notified if such conditions are encountered in order to evaluate if other dewatering methods are needed.

6.0 QUALIFICATION OF RECOMMENDATIONS

Our evaluation of geotechnical-related pavement subgrade and underground utilities installation and support conditions has been based on the data obtained during our field investigation and our understanding of the furnished site and project information. The general subsurface conditions were based on interpretation of subsurface data obtained at specific boring locations. Regardless of the thoroughness of a subsurface investigation, there is the possibility that conditions between borings will differ from those at the boring locations, that conditions are not as anticipated by the designers, or that the construction process has altered the soil conditions. Therefore, experienced geotechnical engineers should observe earthwork and foundation construction to confirm that the conditions anticipated in design are noted. Otherwise, CT assumes no responsibility for construction compliance with the design concepts, specifications, or recommendations.

The design recommendations in this report have been developed on the basis of the previously described project characteristics and subsurface conditions. If project criteria or locations change, a qualified geotechnical engineer should be permitted to determine whether the recommendations must be modified. The findings of such a review will be presented in a supplemental report.

The nature and extent of variations between the borings may not become evident until the course of construction. If such variations are encountered, it will be necessary to reevaluate the recommendations of this report after on-site observations of the conditions.

Our professional services have been performed, our findings derived, and our recommendations prepared in accordance with generally accepted geotechnical engineering principles and practices. This warranty is in lieu of all other warranties either expressed or implied. CT is not responsible for the conclusions, opinions, or recommendations of others based on this data.

Plates

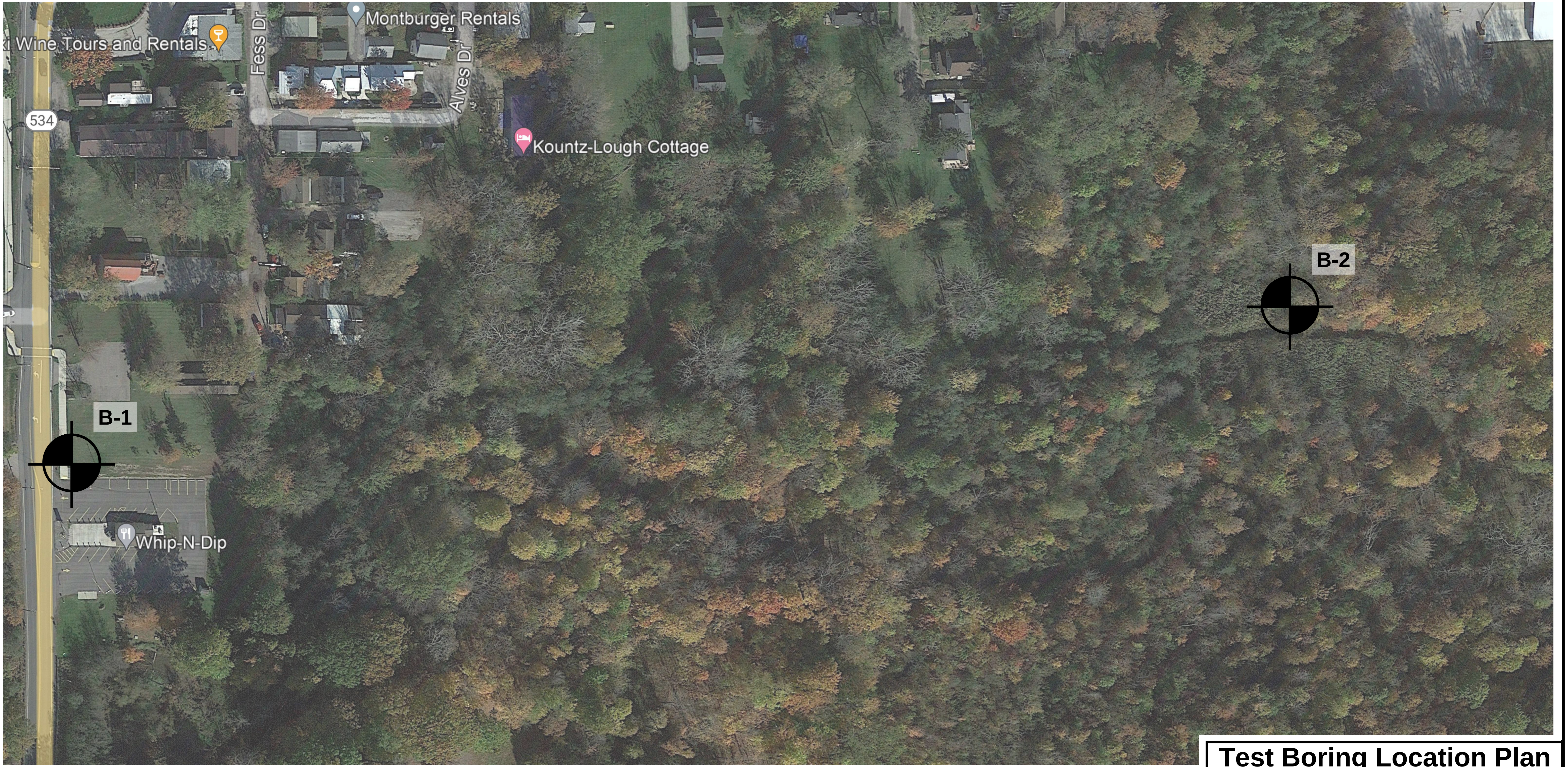
Site Location Map

Trunk Sewer Replacement
Geneva on the Lake, Ohio

Village of Geneva on the Lake

DRAWN:	RK 11/3/23
REVISED:	---
Project No.:	231183
Drawing No.:	Plate 1.0

Notes: Aerial Basemap obtained From Google Earth and dated 2023.



Legend:

B-1

Approximate Test Boring Location

0' 100' 200'

N

Notes: Aerial Basemap obtained From Google Earth and dated 2023

Test Boring Location Plan

Trunk Sewer Replacement
Geneva on the Lake, Ohio

Village of Geneva on the Lake

DRAWN:	RK 11/3/23
REVISED:	---
Project No.:	231183
Drawing No.:	Plate 2.1

Test Boring Location Plan

Trunk Sewer Replacement
Geneva on the Lake, Ohio

Village of Geneva on the Lake

Legend:

B-3 — Approximate Test Boring Location

0' 125' 250'

N

Notes: Aerial Basemap obtained From Google Earth and dated 2023

DRAWN:	RK 11/3/23
REVISED:	---
Project No.:	231183
Drawing No.:	Plate 2.2

100 YEARS
LEADING THROUGH the next 100 years
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APPENDIX A

Logs of Test Borings

CT Consultants, Inc.
1915 N 12th Street
Toledo Ohio 43604
Telephone: (419)324-2222

BORING NUMBER B-1

CLIENT Village of Geneva on the Lake
PROJECT NAME Trunk Sewer Replacement
PROJECT NUMBER 231183
PROJECT LOCATION Geneva on the Lake, OH
DRILLING CONTRACTOR CT Consultants Inc. JP DC
RIG NO. 550
GROUND ELEVATION 584 ft
DRILLING METHOD 3-1/4 in. HSA
GROUND WATER LEVELS:
DATE STARTED 10/25/23 **COMPLETED** 10/25/23
AT TIME OF DRILLING None
LOGGED BY KKC **CHECKED BY** RK
AT END OF DRILLING None
NOTES Auger refusal encountered at 14.5 feet.
0hrs AFTER DRILLING Backfilled w/Cuttings and Bentonite Chips

ELEVATION (ft)	DEPTH (ft)	MATERIAL DESCRIPTION	SAMPLE TYPE NUMBER	RECOVERY % (RQD)	BLOW COUNTS (N VALUE)	UNCONF. COMP. STR. (tsf)	DRY UNIT WT. (pcf)	MC (%)
	0	TOPSOIL - 5 Inches (0.4')						
		Moist Medium Stiff Brown SANDY LEAN CLAY w/Trace Gravel (CL) Moist Medium Stiff Brown SILTY CLAY, Some Sand, Little Gravel A-6b (8)	SS 1	100	2-4-4 (8)	3.00		23
580	5		SS 2	100	2-3-4 (7)	3.25		30
		(6.0') Moist Stiff Gray LEAN CLAY w/Sand and Trace Gravel (CL) Moist Stiff Gray SILT and CLAY (A-6a), Little Sand, Trace Gravel	SS 3	100	5-6-6 (12)	2.25		29
575	10	(8.0') Moist Medium Stiff Gray LEAN CLAY w/Trace Sand (CL) Moist Medium Stiff Gray SILT and CLAY (A-6a), Trace Sand	SS 4	100	2-3-3 (6)	1.25		28
570		(14.0') Gray WEATHERED SHALE	SS 5	100	50/2"	NP		5
		(14.5') Bottom of hole at 14.5 feet.						

PL MC LL: 20 40 60 80
▲ SPT N VALUE ▲: 20 40 60 80
>>▲

TTL_GEOTECH_STANDARD 231183.GPJ GINT US LAB.GDT 12/11/23

CT Consultants, Inc.
1915 N 12th Street
Toledo Ohio 43604
Telephone: (419)324-2222

BORING NUMBER B-2

CLIENT Village of Geneva on the Lake
PROJECT NAME Trunk Sewer Replacement
PROJECT NUMBER 231183
PROJECT LOCATION Geneva on the Lake, OH
DRILLING CONTRACTOR CT Consultants Inc. JP DC
RIG NO. 550
GROUND ELEVATION 582 ft
DRILLING METHOD 3-1/4 in. HSA
GROUND WATER LEVELS:
DATE STARTED 10/25/23 **COMPLETED** 10/25/23
AT TIME OF DRILLING None
LOGGED BY KKC **CHECKED BY** RK
AT END OF DRILLING None
NOTES Auger refusal encountered at 21.5 feet.
0hrs AFTER DRILLING Backfilled w/Cuttings and Bentonite Chips

ELEVATION (ft)	DEPTH (ft)	MATERIAL DESCRIPTION	SAMPLE TYPE NUMBER	RECOVERY % (RQD)	BLOW COUNTS (N VALUE)	UNCONF. COMP. STR. (tsf)	DRY UNIT WT. (pcf)	PL / MC / LL (20 40 60 80); ▲ SPT N VALUE ▲ (20 40 60 80)
	0	TOPSOIL - 5 Inches (0.4')						
580		Moist Loose Brown CLAYEY SAND w/Trace Gravel (SC) Moist Medium Stiff Brown SANDY SILT, Little Clay, Trace Gravel A-4a (3)	SS 1	100	4-4-3 (7)	NP		11
	5	@3.5': Very Loose, Gray/Brown, w/Trace Organics Organic Content = 4.3% (6.0')	SS 2	100	3-2-2 (4)	NP		17
575		Moist Stiff Brown LEAN CLAY w/Sand and Trace Gravel (CL) Moist Stiff Brown SILT and CLAY (A-6a), Little Sand, Trace Gravel	SS 3	100	3-4-5 (9)	3.25		21
	10	@9': Gray, w/Trace Iron Oxide Stain Seam (12.0')	SS 4	100	3-6-8 (14)	>4.5		19
570		Moist Medium Stiff Gray LEAN CLAY w/Trace Sand (CL) Moist Medium Stiff Gray SILT and CLAY (A-6a), Trace Sand	SS 5	100	2-2-3 (5)	1.25		29
565	15							
	20	@18': w/Sand and Trace Gravel @18': Little Sand, Trace Gravel (21.0')	SS 6	100	2-3-3 (6)	0.75		24
		Gray WEATHERED SHALE (21.5')	SS 7	100	50/1"	NP		4 >>
		Bottom of hole at 21.5 feet.						

BORING NUMBER B-3

CT Consultants, Inc.
1915 N 12th Street
Toledo Ohio 43604
Telephone: (419)324-2222

CLIENT Village of Geneva on the Lake
PROJECT NAME Trunk Sewer Replacement
PROJECT NUMBER 231183
PROJECT LOCATION Geneva on the Lake, OH
DRILLING CONTRACTOR CT Consultants Inc. JP DC
RIG NO. 550
GROUND ELEVATION 593 ft
DRILLING METHOD 3-1/4 in. HSA
GROUND WATER LEVELS:
DATE STARTED 10/25/23 **COMPLETED** 10/25/23
AT TIME OF DRILLING None
LOGGED BY KKC **CHECKED BY** RK
AT END OF DRILLING None
NOTES Auger refusal encountered at 18.5 feet.
0hrs AFTER DRILLING Backfilled w/Cuttings and Bentonite Chips

ELEVATION (ft)	DEPTH (ft)	MATERIAL DESCRIPTION	SAMPLE TYPE NUMBER	RECOVERY % (RQD)	BLOW COUNTS (N VALUE)	UNCONF. COMP. STR. (tsf)	DRY UNIT WT. (pcf)	MC (PL 20 40 60 80 LL) / SPT N VALUE
593	0	TOPSOIL - 8 Inches (to 0.7')						
		Moist Loose Brown SILTY SAND w/Trace Gravel (SM) Moist Loose Brown COARSE and FINE SAND (A-3a), Some Silt, Little Clay, Trace Gravel (0.7' to 3.5')	SS 1	100	3-4-5 (9)	NP		22
590								
		Moist Stiff Brown LEAN CLAY w/Sand and Trace Gravel (CL) Moist Stiff Brown SILT and CLAY (A-6a), Little Sand, Trace Gravel (3.5' to 18.0')	SS 2	100	3-5-6 (11)	>4.5		20
	5							
		@7': Very Stiff, Gray/Brown, w/Trace Calcite Stain Seam	SS 3	100	6-7-9 (16)	>4.5		25
585								
		@8.5': Stiff, Gray	SS 4	100	3-4-6 (10)	3.25		25
	10							
580								
		@13.5': Brown/Gray	SS 5	100	3-6-7 (13)	>4.5		22
	15							
575		Gray WEATHERED SHALE (18.0' to 18.5')	SS 6	100	50/1"	NP		4; SPT >>
		Bottom of hole at 18.5 feet.						

CT consultants

CT Consultants, Inc.
1915 N 12th Street
Toledo Ohio 43604
Telephone: (419)324-2222

BORING NUMBER B-4

CLIENT Village of Geneva on the Lake
PROJECT NAME Trunk Sewer Replacement
PROJECT NUMBER 231183
PROJECT LOCATION Geneva on the Lake, OH
DRILLING CONTRACTOR CT Consultants Inc. JP DC
RIG NO. 550
GROUND ELEVATION 596 ft
DRILLING METHOD 3-1/4 in. HSA
GROUND WATER LEVELS:
DATE STARTED 10/25/23 **COMPLETED** 10/25/23
AT TIME OF DRILLING None
LOGGED BY KKC **CHECKED BY** RK
AT END OF DRILLING None
NOTES Auger refusal encountered at 20.0 feet.
0hrs AFTER DRILLING Backfilled w/Cuttings and Bentonite Chips

ELEVATION (ft)	DEPTH (ft)	MATERIAL DESCRIPTION	SAMPLE TYPE NUMBER	RECOVERY % (RQD)	BLOW COUNTS (N VALUE)	UNCONF. COMP. STR. (tsf)	DRY UNIT WT. (pcf)	PL / MC / LL (20 40 60 80); ▲ SPT N VALUE ▲ (20 40 60 80)
	0	CRUSHED STONE - 4 Inches (0.3')						
595		Moist Stiff Gray/Brown LEAN CLAY w/Sand, Trace Gravel, and Iron Oxide Stain Seam (CL) Moist Stiff Gray/Brown SILT and CLAY (A-6a), Little Sand, Trace Gravel, Trace Iron Oxide Stain Seam	SS 1	100	4-4-5 (9)	>4.5		17
	5		SS 2	100	3-5-7 (12)	>4.5		20
590		@6': Very Stiff, Brown/Gray (8.0')	SS 3	100	8-11-14 (25)	>4.5		17
	10	Moist Medium Stiff Gray LEAN CLAY w/Trace Sand (CL) Moist Medium Stiff Gray SILT and CLAY (A-6a), Trace Sand	SS 4	100	2-3-3 (6)	2.50		27
585	15		SS 5	100	2-3-3 (6)	1.50		25
580		@18.5': Stiff to Very Stiff (19.5')	SS 6	100	7-9-50/3"	>4.5		17 >>
	20	Gray WEATHERED SHALE (20.0')						

Bottom of hole at 20.0 feet.

APPENDIX B

Legend Key

LEGEND KEY

Unified Soil Classification System Soil Symbols

GW - WELL GRADED GRAVEL Includes Gravel-Sand mixtures, little or no fines.

GP - POORLY GRADED GRAVEL Includes Gravel-Sand mixtures, little or no fines.

GM - SILTY GRAVEL Includes Gravel-Sand-Silt mixtures.

GC - CLAYEY GRAVEL Includes Gravel-Sand-Clay mixtures.

SW - WELL GRADED SAND Includes Gravelly Sands, little or no fines.

SP - POORLY GRADED SAND Includes Gravelly Sands, little or no fines.

SM - SILTY SAND Includes Sand-Silt mixtures.

SC - CLAYEY SAND Includes Sand-Clay mixtures.

ML - SILT Includes Silt with Sand and Sandy Silt.

CL - LEAN CLAY Includes Sandy Lean Clay and Lean Clay with Sand and Gravel.

MH - ELASTIC SILT Includes Sandy Elastic Silt and Elastic Silt with Sand.

CH - FAT CLAY Includes Sandy Fat Clay and Fat Clay with Sand.

CL-ML - SILTY CLAY Includes Clayey Silt of low plasticity.

OL - ORGANIC SILT and ORGANIC CLAY of low plasticity.

OH - ORGANIC SILT and ORGANIC CLAY of medium to high plasticity.

Pt - PEAT Includes humus, swamp and other soils with high organic content.

FILL MATERIAL - Includes controlled and non-controlled soil and non-soil materials.

TOPSOIL

ASPHALT - Bituminous Asphalt

CONCRETE - Includes broken concrete rubble.

Sample Symbols

SS - Split Spoon

ST - Shelby Tube

RC - Rock Core

GS - Geoprobe Sleeve

AU - Auger Cuttings

GB - Grab

Notes:

1. Exploratory borings were drilled on October 25, 2023, using 3¼-inch inside diameter hollow-stem augers.

2. These logs are subject to the limitations, conclusions, and recommendations in the report and should not be interpreted separate from the report.

3. The borings were located in the field by CT in accordance with the Proposed Boring Location Plan, attached to the proposal.

4. Ground Surface Elevations were estimated from Google Earth and reported to the nearest foot.

5. Unconfined Compressive Strength (tsf):
NP = Non Plastic

APPENDIX C

Tabulation of Laboratory Test Data

CT Consultants, Inc.
1915 N 12th Street
Toledo Ohio 43604
Telephone: (419)324-2222

SUMMARY OF LABORATORY RESULTS

CLIENT Village of Geneva on the Lake **PROJECT NAME** Trunk Sewer Replacement

PROJECT NUMBER 231183 **PROJECT LOCATION** Geneva on the Lake, OH

Borehole	Depth	Liquid Limit	Plastic Limit	Plasticity Index	Maximum Size (mm)	%<#200 Sieve	Class-ification	Water Content (%)	Dry Density (pcf)	Satur-ation (%)	Void Ratio
B-1	1.0	40	24	16	19	63	CL	23.1			
B-1	3.5							29.8			
B-1	6.0							29.3			
B-1	8.5							27.8			
B-1	14.0							4.6			
B-2	1.0	24	16	8	9.5	49	SC	10.7			
B-2	3.5							16.7			
B-2	6.0							21.1			
B-2	8.5							18.7			
B-2	13.5							29.3			
B-2	18.5							23.7			
B-2	21.0							4.5			
B-3	1.0							22.4			
B-3	3.5							19.6			
B-3	6.0							25.0			
B-3	8.5							25.3			
B-3	13.5							21.6			
B-3	18.0							4.4			
B-4	1.0							17.1			
B-4	3.5							19.8			
B-4	6.0							17.4			
B-4	8.5							27.3			
B-4	13.5							24.6			
B-4	18.5							17.3			

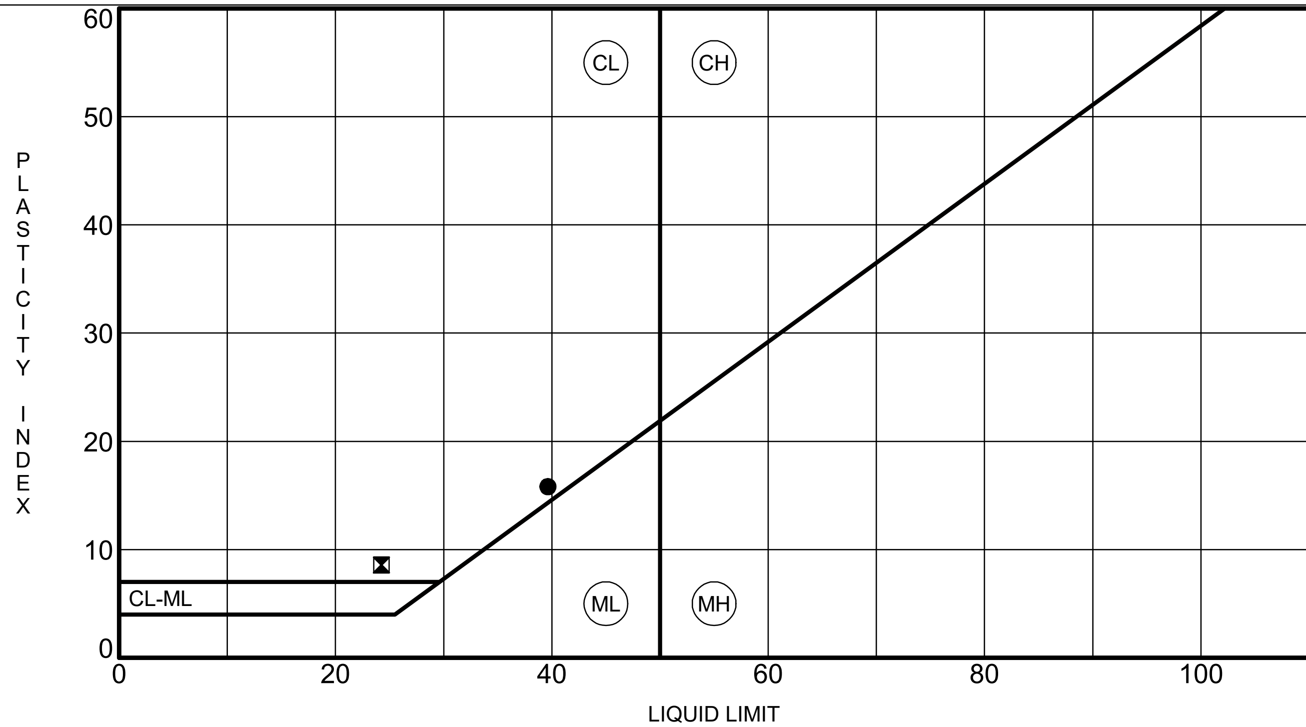
APPENDIX D

Laboratory Test Results

CT Consultants, Inc.
1915 N 12th Street
Toledo Ohio 43604
Telephone: (419)324-2222

ATTERBERG LIMITS' RESULTS

CLIENT Village of Geneva on the Lake
PROJECT NAME Trunk Sewer Replacement
PROJECT NUMBER 231183
PROJECT LOCATION Geneva on the Lake, OH



	Specimen Identification		LL	PL	PI	Fines	Classification
●	**B-1**	**1.0**	**40**	**24**	**16**	**63**	**SANDY LEAN CLAY (CL)**
⊠	**B-2**	**1.0**	**24**	**16**	**8**	**49**	**CLAYEY SAND (SC)**

CT Consultants, Inc.
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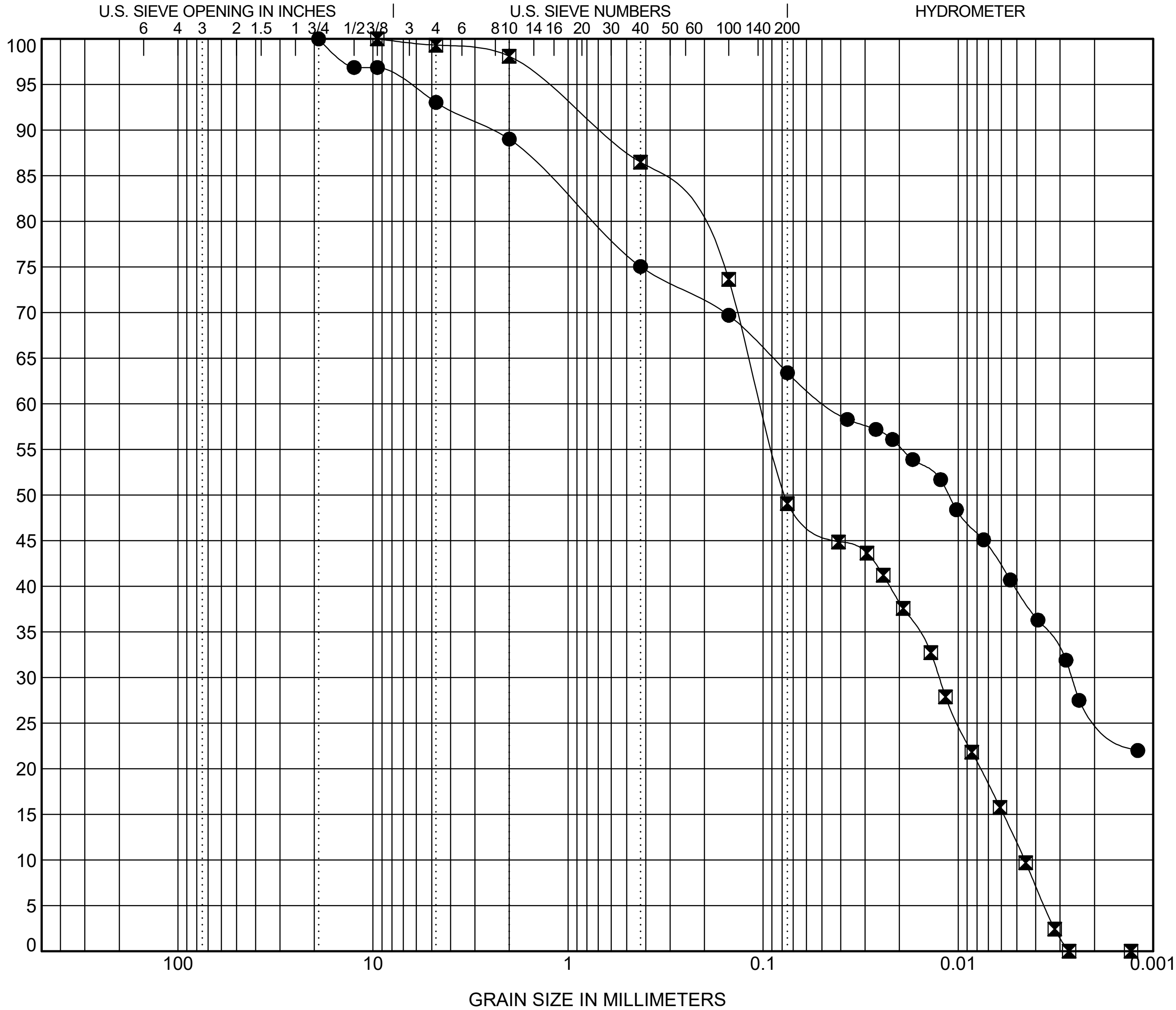
GRAIN SIZE DISTRIBUTION

CLIENT Village of Geneva on the Lake
PROJECT NAME Trunk Sewer Replacement
PROJECT NUMBER 231183
PROJECT LOCATION Geneva on the Lake, OH



COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

	Specimen Identification		USCS Classification	LL	PL	PI	Cc	Cu
●	**B-1**	**1.0**	**SANDY LEAN CLAY (CL)**	**40**	**24**	**16**		
⊠	**B-2**	**1.0**	**CLAYEY SAND (SC)**	**24**	**16**	**8**	**0.3**	**22.4**

	Specimen Identification		D100	D60	D30	D10	%Gravel	%Sand	%Silt	%Clay
●	**B-1**	**1.0**	**19**	**0.047**	**0.003**		**7.0**	**29.6**	**23.7**	**39.7**
⊠	**B-2**	**1.0**	**9.5**	**0.102**	**0.013**	**0.005**	**0.7**	**50.3**	**37.2**	**11.8**