GEOTECHNICAL EVALUATION REPORT

NASON BASIN TO GROVE AVENUE STORM SEWER IMPROVEMENTS
PHASE 1
WILLOUGHBY, OHIO

SME Project No. 090029.00
November 18, 2022

SME

9375 Chillicothe Road
Kirtland, OH 44094-8501

T (440) 256-6500

www.sme-usa.com

November 18, 2022

Mr. Michael Cyvas, PE
CT Consultants, Inc.
8160 Sterling Court
Mentor, Ohio 44060

Via E-mail: mcyvas@ctconsultants.com

RE: Geotechnical Evaluation Report
Nason Basin to Grove Avenue Storm Sewer Improvements Phase 1
Willoughby, Ohio
SME Project No. 090029.00

Dear Mr. Cyvas:

We have completed the geotechnical evaluation and report for the Nason Basin to Grove Avenue Storm Sewer Improvements Phase 1 project in Willoughby, Ohio. This report presents the results of our observations and analyses, and our geotechnical recommendations based on the information disclosed by the borings.

We appreciate this opportunity to be of service. If you have questions or require additional information, please contact me.

Very truly yours,

SME

Brendan Lieske

Brendan P. Lieske, PE
Senior Project Engineer / Project Manager

Enclosure: SME Geotechnical Evaluation Report, Dated November 18, 2022

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1. INTRODUCTION

This report presents the results of the geotechnical evaluation performed by SME for Phase 1 of the Nason Basin to Grove Avenue Storm Sewer Improvements project in Willoughby, Ohio. We performed this assessment in accordance with the scope of services outlined in SME Proposal No. P02504.22 dated July 27, 2022. Boring B4 was terminated four feet above the planned termination depth due to the driller reporting a pocket of gas at a depth of 31 feet below the ground surface. Our services for this evaluation were authorized by Mr. Michael Cyvas, PE with CT Consultants.

To assist with our evaluation and the preparation of this report, SME was provided a PDF file of “Plan & Profile” Sheets 5 through 8, dated October 28, 2022, and prepared by CT Consultants for the Nason Basin to Grove Avenue Storm Sewer Improvements Phase 1” project.

1.1 PROJECT DESCRIPTION AND SITE CONDITIONS

The project consists of constructing a new storm sewer in Willoughby, Ohio. The proposed storm sewer will terminate at the existing Nason Basin, located on the north side of Lakeland Freeway (State Route 2). From Nason Basin, the proposed sewer will cross below State Route 2 and extend south along the east side of the State Route 2 eastbound on-ramp. The proposed sewer will turn east along the north side of Vine Street and continue east for about 1,150 feet. From there, the proposed sewer will turn south, and cross below Vine Street and the railroad tracks located along the south side of Vine Street. The final termination will be located along Grove Avenue approximately 300-feet south of Park Avenue.

The project has been divided into two phases. This evaluation only covers the portion of project designated as Phase 1. Phase 1 consists of the section of the storm sewer located along the north side of Vine Street and eventually terminating at the existing Nason Basin. The location of Phase 1 is depicted on the Location Map inset on the Boring Location Diagram (Figure No. 1) included in Appendix A.

The total Phase 1 alignment is about 2,100 feet long. The proposed storm sewer will be installed using open-cut methods outside of the crossing below State Route 2 and using trenchless installation methods below State Route 2. Within open cut areas, the proposed storm sewer will consist of an 84-inch diameter pipe, constructed at a 0.15% slope with invert elevations ranging from about 20 to 25 feet below the existing ground surface. Below State Route 2, the proposed storm sewer will consist of a 78-inch diameter pipe placed inside of an 84-inch diameter casing pipe and constructed at a 0.15% slope. The trenchless installation below State Route 2 will be 266 linear feet long.

2. EVALUATION PROCEDURES

2.1 FIELD EXPLORATION

SME completed eight borings (B1 through B8) at the site on August 26 and 29, and September 20, 2022. The borings extended to depths ranging from 30 to 35 feet below the existing ground surface for a total of 266 linear feet of drilling. The approximate locations of the borings are depicted on Figure No. 1.

SME determined the planned number, locations, and depths of the borings. SME staked the boring locations and measured ground surface elevations at the borings using a handheld GPS unit. However, the ground surface elevation at boring B2 was estimated by SME using the previously referenced drawings.

The borings were drilled using a rotary-type drill rig and were advanced using continuous-flight augers. These borings included soil sampling based upon the Split-Barrel Sampling procedure. Recovered split-barrel samples were sealed in glass jars by the driller.

Groundwater level observations were recorded during and immediately after completion of each boring. Except at borings B1, B2, B3, and B8, the boreholes were backfilled with auger cuttings after completion and collection of groundwater level observations. At boring B2, the borehole was backfilled with cement-bentonite grout and capped with asphalt cold patch.

Long-term groundwater levels were not obtained from the borings, except at borings B1, B3, and B8 where groundwater level observation wells WB1, WB3, and WB8 were constructed within those boreholes. The observation wells were constructed with a 3/4-inch-diameter PVC well screen with 0.010-inch slot openings, and 3/4-inch-diameter PVC well casing. The wells were finished with a stick-up riser pipe capped with a screw on cap at the top of the riser pipe.

Soil samples recovered from the field exploration were delivered to the SME laboratory for further observation and testing.

SME obtained supplemental groundwater elevation readings from the observation wells on October 26 and November 8, 2022. The groundwater levels in the observation wells were measured using an electronic water level indicator, which measures the depth to the water surface in the well from the top of the riser pipe.

2.2 LABORATORY TESTING

The laboratory testing program consisted of performing visual soil classification on recovered soil samples in accordance with ASTM D-2488. Moisture content and hand penetrometer shear strength tests were performed on portions of the recovered cohesive samples. Atterberg limits tests were performed on selected samples of cohesive soil from borings B1, B6, and B8. Based on the laboratory testing, we described the soils and assigned a Unified Soil Classification System (USCS) group symbol to each of the soil strata encountered.

Upon completion of the laboratory testing, boring logs were prepared that include information on materials encountered, the soil descriptions, penetration resistances, pertinent field observations made during the drilling operations, and the results of the laboratory testing. The boring logs also include the existing ground surface elevations measured by SME. The boring logs are included in Appendix A. Explanations of symbols and terms used on the boring logs are provided on the Boring Log Terminology sheet included in Appendix A.

The Standard Penetration Test (SPT) resistances (N-values) plotted on the boring logs were normalized to a 60 percent hammer efficiency (N_{60}) based on the correlation between the SPT value recorded in the field and the measured hammer efficiency of the testing equipment (also shown on the boring logs).

Soil samples are normally retained in our laboratory for 60 days and are then disposed of, unless instructed otherwise.

3. SUBSURFACE CONDITIONS

3.1 SOIL CONDITIONS

The soil conditions encountered at the borings generally consisted of 3 to 12-inches of surficial topsoil, with the exception of boring B2 where 13-inches of Portland cement concrete pavement was encountered at the surface. The surficial materials were underlain by sand fill extending to a depth of three feet below the existing ground surface at borings B2 and B8. Natural clays were generally encountered below the surficial materials or sand fill extending to the explored depths of the borings. Natural sands were encountered at boring B3 between the depths of 5.5 and 8 feet and 13.5 and 15 feet, and at boring B7 between the depths of 34.5 and 35 feet.

The soil profile described above and included on the boring logs is a generalized description of the conditions encountered. The stratification depths described above and shown on the boring logs are intended to indicate a zone of transition from one soil type to another. They are not intended to show exact depths of change from one soil type to another. The soil descriptions are based on visual classification of the soils encountered. Soil conditions may vary between or away from the boring locations. Please refer to the boring logs for the soil conditions at the specific boring locations.

Thickness measurements of surficial materials reported on the boring logs should be considered approximate since mixing of the surface materials with the underlying subgrade can occur in small-diameter boreholes. Therefore, if accurate thickness measurements are required for inclusion in bid documents or for quantity estimates, additional evaluations, such as shallow test pits in topsoil or fill areas and pavement cores in pavement areas, should be performed.

3.2 GROUNDWATER CONDITIONS

Groundwater levels were recorded at borings B3 and B7 during and after drilling, and at the observation wells WB1, WB3, and WB8 at the depths and elevations shown in Table 1 below.

TABLE 1: SUMMARY OF GROUNDWATER OBSERVATIONS FROM BORINGS & WELLS

BORING NUMBER	DURING DRILLING		AT END OF BORING		OBSERVATION WELL READINGS	
	DEPTH (FEET)	ELEVATION (FEET)	DEPTH (FEET)	ELEVATION (FEET)	10/26/2022 DEPTH (ELE.) (FEET)	11/8/2022 DEPTH (ELE.) (FEET)
B1	Groundwater was not observed				6.3 (622.9)	6.1 (623.1)
B2	Groundwater was not observed				NA	
B3	13	616.1	13	616.1	13.0 (616.1)	13.0 (616.1)
B4	Groundwater was not observed				NA	
B5	Groundwater was not observed				NA	
B6	Groundwater was not observed				NA	
B7	34.5	598.7	Not observed upon completion of drilling		NA	
B8	Groundwater was not observed				12.0 (620.1)	12.2 (619.9)

Based on the boring information, groundwater observed at the borings during or upon completion of drilling appeared to be associated with wet sand strata within the clay, as at borings B3 and B7. However, where observation wells were installed, and stabilized groundwater readings were obtained, groundwater levels ranging from about 6.1 to 13 feet below the existing ground surface, or between about elevations 623.1 feet and 616.1, feet were recorded.

Color change in soil, specifically a transition from brown to gray, can also be used as an indicator of long-term groundwater levels within a given area. Table 2 below lists the depth and elevation at which point a color change from brown to gray was observed. The observed clay soil color changes in the borings generally support the groundwater levels recorded in the wells, which ranged from about elevations 623 to 616 feet.

TABLE 2: SUMMARY OF BROWN TO GRAY SOIL COLOR CHANGE

BORING NUMBER	DEPTH (FEET)	ELEVATION (FEET)
B1	8	621.2
B2	15.5	616.5
B3	8	621.1
B4	8	620.9
B5	10.5	619.1
B6	10.5	620.1
B7	10.5	622.7
B8	12.5	619.6

Groundwater levels should be expected to fluctuate throughout the year, based on variations in precipitation, evaporation, run-off, and other factors. The groundwater levels reported on the boring and well logs and presented in this section represent conditions at the time the readings were taken. The groundwater level at the time of construction may vary from those conditions noted on the logs.

4. ANALYSIS AND RECOMMENDATIONS

This report includes recommendations for the portion of the project that consists of the design and installation of the proposed gravity storm sewer along the previously described Phase I alignment. The proposed storm sewer will be installed using a combination of both open-cut and trenchless installation methods as depicted in Image 1 below. Recommendations for both installation methods are provided in the following sections.

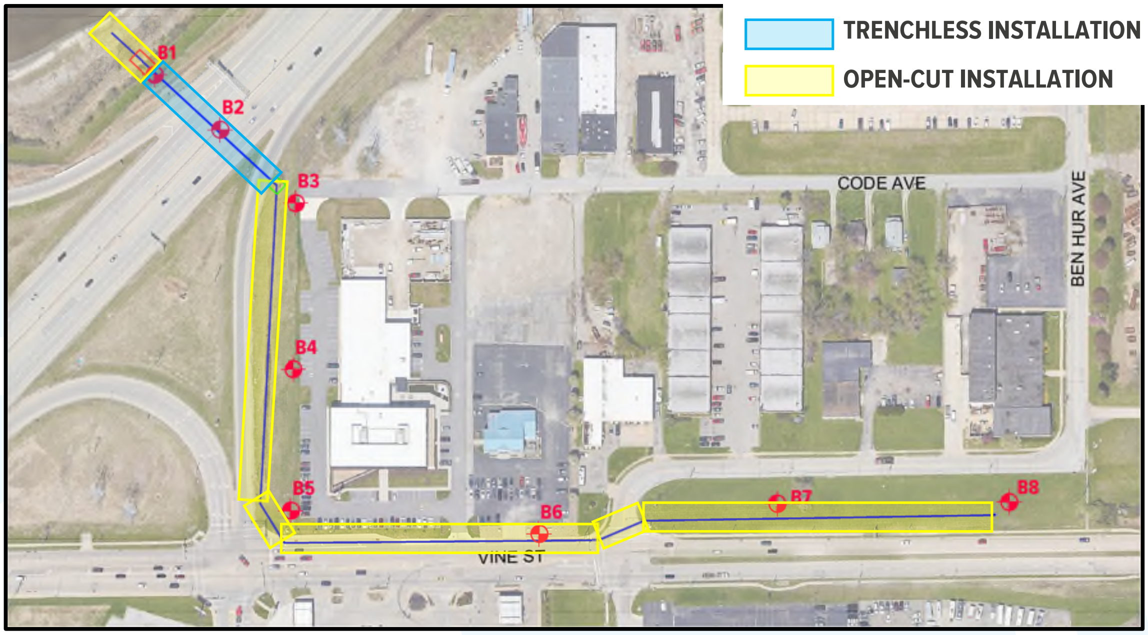

Image 1: Proposed Phase 1 Storm Sewer Alignment

4.1 OPEN-CUT UTILITY INSTALLATION

4.1.1 OPEN-CUT EXCAVATIONS

The contractor must provide a safely sloped excavation or an adequately constructed and braced shoring system in accordance with federal, state, and local safety regulations for individuals working in an excavation that may expose them to the danger of moving ground. If material is stored or heavy equipment is operated near an excavation, appropriate shoring must be used to resist the extra pressure due to the superimposed loads. Natural clays with occasional sand strata were generally encountered in the borings performed along proposed Phase 1 alignment. Fills were encountered at the surface at borings B2 and B8. The contractor should anticipate variations in soil and groundwater conditions along the alignment, which could include encountering varying depths and consistencies of existing fill, wet sand seams and/or strata, and other unanticipated conditions. Contact SME to review the field conditions during construction if they differ significantly from those encountered at the boring locations.

Where sloped and/or benched excavations are feasible, the proper OSHA classification for safe excavation slopes should be determined and followed by the contractor based on the specific soil and groundwater conditions encountered in the open-cut excavations at specific locations. At locations where multiple soil types or layers are present, use the flattest slope appropriate for the variable soil conditions. The effect of groundwater must also be considered when determining excavation slopes, per OSHA requirements. Perched groundwater conditions and seepage affecting excavation stability should be expected based on the stabilized groundwater readings obtained at the observation wells. The proper OSHA classification should be determined visually by the contractor’s competent person and supported using appropriate testing equipment (e.g., hand penetrometer or Torvane). In cases where sloughing or instability is observed, excavation side slopes will need to be flatter than identified by the OSHA guidelines and/or earth retention must be provided as discussed in Section 4.1.2.

4.1.2 SHEETING AND SHORING

Due to the lateral constraints along the majority of the project alignments (i.e., existing underground utilities, adjacent properties and structures, driveway entrances, and roadways), utilization of open cut, sloped, and/or benched excavations may not be feasible along a significant portion of alignments. At locations where adequate excavation slopes cannot be maintained during construction, a temporary earth retention system (TERS) comprised of steel sheeting or appropriately sized steel trench boxes will be necessary to support the excavation. Dewatering to control groundwater, if encountered, will be necessary in conjunction with the TERS.

Where sloped and/or benched excavations are not feasible, a double or triple-stacked trench box and/or a slide rail shoring system for protection of workers and the pipe system could be considered. The sidewalls should be cut close to vertical prior to placing the trench boxes in the excavations, to limit the amount of excavation spoils and required backfill volume. This type of shoring system is considered feasible in portions of the sewer alignment with a predominantly clay soil profile above the sewer invert depth that does not exhibit significant groundwater infiltration/seepage. A clay soil profile is generally able to temporarily maintain verticality during trench box installation. However, significant vertical and lateral soil movements can occur in some cases prior to installation of the trench box, and at either end of the trench box, due to the sloughing/caving of the excavation side-walls that may shift into the gap between the sides of the trench excavation and the trench box. The contractor must be prepared to handle these conditions with minimal effect on the surrounding area or on adjacent utilities or structures.

Trench box type shoring is better utilized for excavations that are outside the zone of influence of structures, and where there is less stringent subgrade movement criteria. Based on the boring information, it appears that trench box type shoring systems can be considered along portions of the alignment with predominantly clay soil profiles and near roadways and underground utility structures provided that any ground movement outside the trench box is minimized, and proper offset distances from the edges of the structures are maintained. An excavation plan should be prepared to detail the location(s) of adjacent structures and specific offset distances, and the trench box construction methods and sequence. The work must be performed by a contractor experienced with open cut excavation methods. We recommend the contractor minimize oversizing the excavation so that any sloughing/caving of the excavation side-walls is also minimized. At locations where it is critical to minimize soil movements, it may also be beneficial to partially fill the gaps outside the trench box with sand or peastone promptly after the trench box is in-place.

Ground movements outside of the trench box can also occur after removal of the trench box and during backfilling. We recommend minimizing the time that the excavation side-walls are exposed prior to backfilling. Utilizing trench box type shoring systems near structures can be difficult and requires coordination of the site specific risks with the proper installation and backfilling methods, along with the risk acceptance of subgrade movements of a magnitude that could adversely affect the nearby structures. For high-risk situations, we recommend properly underpinning/bracing/shoring and securing the existing structures prior to the sewer installation, as needed for the specific situation.

Steel sheet piles or other approved earth retention methods are options where excavations are close to critical or sensitive structures or utilities. Drilling to install soldier piles or other earth retention elements, rather than driving, may also be necessary to minimize vibrations. The design of the earth retention system and any required bracing will be based on performance, economy, and geometric site and ground conditions.

Temporary earth retention must be designed by a licensed professional engineer in the State of Ohio. In some cases, additional geotechnical information could be required, especially considering the current borings for this project may not have been performed at the specific location(s) where a TERS is needed. Consideration should be given to how the installation and extraction of the earth retention system will affect nearby structures and underground utilities. As indicated above, trench boxes can be used to support excavation sidewalls, but only in areas where predominantly clay soils were encountered and soil movements of the magnitude that is common to the use of trench boxes would not adversely impact nearby structures or utilities. Based on the anticipated excavation depths (and assuming the excavations are not significantly sloped back) we recommend reviewing the need for special support (earth retention, underpinning, bracing, etc.) on a case-by-case basis where the proposed sewer alignment is within 50 feet of any existing structures or critical utilities.

Pre-existing and post-construction condition surveys are recommended to document conditions of adjacent structures, roadways, and utilities prior to and after performing the work, particularly if there are nearby structures that are more susceptible to damage due to their age or the materials used in their construction. Vibration monitoring should also be considered if the work will be performed near sensitive structures or if relatively large magnitude vibrations are expected during construction. Critical utilities should be located using hydrovac or other physical methods prior to excavating.

4.1.3 PIPE SUPPORT

Based on the borings, very stiff to hard silty clays were typically encountered at the proposed pipe invert depths in open cut areas. Hard silty clays are generally considered suitable for utility pipe support. However, conditions may vary between boring locations. Undercutting of medium to soft cohesive soils could be necessary if those soils are encountered, and stabilization of the bottom of excavations could be necessary at locations that become disturbed due to seepage, construction traffic, or for other reasons. Undercuts should be backfilled with engineered fill consisting of crushed aggregate. Mechanical reinforcement (i.e., geogrid) can be considered to stabilize subgrades and reduce undercut depths for deep pipe infrastructure. We recommend an SME representative be onsite during the utility excavation to review and verify subgrade conditions at the bottom of the excavations and to provide field recommendations for subgrade improvements or removal and replacement, where required. Refer to Section 4.3 for pipe bedding and undercutting recommendations.

We recommend earthwork contractors provide bids with unit prices for removal and disposal of unsuitable or unstable soils, replacement with engineered fill, crushed aggregate and/or subgrade stabilization. The construction manager should include a contingency in the budget for removal of unsuitable or unstable soils and replacement with engineered fill, crushed aggregate and for subgrade stabilization, as needed.

4.1.4 TEMPORARY GROUNDWATER CONTROL AND UTILITY TRENCH BOTTOM INSTABILITY

Groundwater was observed at the well locations above the invert elevation of the proposed storm sewer, and within wet sand layers above the invert elevation at boring B3. Therefore, the contractor should be prepared to manage and control groundwater entering excavations for the proposed storm sewer. The actual groundwater levels and the amount of perched or trapped groundwater in granular soils (sand) at the time of construction could vary from the groundwater levels reported on the logs, depending on seasonal precipitation, time of year, and other environmental factors. In addition, variations should be expected at locations not evaluated by borings.

Excavations extending below the groundwater level will require dewatering to facilitate installation of the storm sewer at locations where seepage is encountered. For excavations extending below the anticipated groundwater levels and encountering wet sand seams or strata, we anticipate temporary, short-term dewatering, using standard sump pit and pumping methods, likely in conjunction with a layer of crushed aggregate at the bottom of the excavation, should be suitable to remove seepage accumulations. Multiple sumps pumping from casings in the gravel could be used in cases of more significant seepage. Deep wells or well points will likely be ineffective to provide temporary dewatering within the clay soils encountered at most of the borings, except for conditions such as at boring B3 where sand below the groundwater level was encountered at about 13.5 to 15 feet in depth, or at boring B7 where wet sand was encountered at the bottom of the boring at a depth of 34.5 feet. Conditions requiring higher capacity dewatering methods would not be consistent with the clays encountered in most of the borings and should be further evaluated if encountered.

Even after dewatering, the existing subgrade soils within an excavation can remain wet and unstable. Therefore, in those cases, a working surface of crushed aggregate should be used to protect and maintain the stability of the exposed subgrade where seepage is encountered or dewatering is performed, and to help facilitate pumping, as discussed above. Pipe bedding material should meet the specified requirements of the design and the appropriate governing agency.

Based on the stabilized groundwater level readings at the wells, which are in some cases above the design pipe invert elevation, the base of the excavation could be under hydrostatic pressure. Therefore, groundwater infiltration rates and the required capacity of dewatering operations could be higher than anticipated, particularly in cases where excavations encounter sand strata. Furthermore, dewatering of the lower sand strata may be necessary to relieve hydrostatic pressures and prevent instability or bottom heave of the soils at the base of excavations after removing the overburden soils, even when groundwater is not observed in the clay soils at the bottoms of those excavations. Contractors should closely review the groundwater level information from the boring logs and wells, prior to preparing their bids and prior to construction, and be prepared to conduct dewatering operations where necessary. Contractors should also obtain additional groundwater level readings from the wells if desired, install additional wells at critical locations, and be prepared to handle seepage and/or bottom instability, if encountered.

4.2 TRENCHLESS INSTALLATION

The proposed storm sewer will be installed using trenchless methods below State Route 2. The proposed crossing will consist of a 78-inch diameter pipe placed inside of an 84-inch diameter casing pipe and constructed at a 0.15 percent slope. The trenchless installation below State Route 2 will be 266 linear feet long. This report section summarizes our recommended trenchless technology construction methods for this project.

If a trenchless installation method is selected and used, the successful completion of the sewer installation using a trenchless method will depend on the skill and experience of the specialty contractor performing the work. This report does not provide engineering design or specific recommendations related to the means and methods to be used for the proposed sewer installation, as these are the responsibility of the installation contractor.

4.2.1 TRENCHLESS METHODS NOT CONSIDERED FEASIBLE

Based on our experience with trenchless technology, and our discussions with utility contractors specializing in trenchless utility installation, the following trenchless utility installation methods are not likely feasible for this project, for the reasons discussed below. Contact SME if additional information becomes available and to further discuss any of the following methods.

Horizontal Auger Bore (HAB)

HAB can typically be performed to within a grade accuracy of +/- 1% over the length of the bore. Due to the proposed sewer having a slope of 0.15%, HAB is not considered a viable trenchless method capable of maintaining the necessary piping grade. An oversized casing is sometimes installed so the grade and slope of the carrier pipe can be adjusted within the larger pipe. However, SME is not aware of a bore machine capable of installing an oversized casing pipe with the diameter required to achieve the design slope of the proposed storm sewer.

Pipe Ramming

The pipe ramming method offers little control over the line and grade of the installed pipe, aside from the initial set-up. Due to the 0.15 percent slope tolerance of the proposed gravity sewer and the size of the proposed storm sewer, pipe ramming is not considered a viable trenchless method for this project.

Horizontal Directional Drilling (HDD)

HDD methods are not suitable for the installation of a pipe of the proposed size over the short distance of the proposed crossing

Hand Mining/Shield Tunneling

Hand mining or shield tunneling can be performed as part of either the pipe jacking trenchless construction method (pipe segments are advanced via a hydraulic jacking frame located in the launching shaft) or the utility tunneling trenchless construction method (a two-stage process where a temporary tunnel liner is constructed as the tunnel is advanced). Based on borings B1 through B3, we generally expect to encounter very stiff to hard clays along the length and elevation of the proposed alignment. However, wet sand conditions were encountered within close proximity (about two feet) of the proposed storm sewer at boring B3. These two methods of trenchless construction can only be considered when there is a high level of confidence of stable ground conditions. Due to the possibility of encountering wet sand conditions during installation operations, we do not consider these methods suitable for this project.

4.2.2 MICROTUNNELING

The microtunneling (MT) method uses a microtunneling boring machine (MTBM) to provide continuous support to the excavation face while boring through the soil mass. MT simultaneously installs pipe behind the boring machine at the jacking pit as it is advanced and as spoils are excavated and removed. MT uses laser beam guidance systems targeted to the MTBM capable of installing pipelines while maintaining closer tolerances to line and grade than the other trenchless installation methods. MTBM up to 84-inches in diameter are available for procurement.

MT construction considerations for the proposed storm sewer include:

1. Commonly more expensive than other trenchless technologies.
2. A driving or launching shaft or excavation is required to install the needed jacking frame and a target or recovery shaft is required to remove the MTBM.
3. Typically, not as cost effective when installing pipelines over short distances due to the need to construct the required launching and recovery shafts, in addition to the cost of the MTBM.
4. Typical bore lengths range from 500 feet to 1,000 feet long. Shorter bore lengths can be achieved but reduces the cost effectiveness of this method.
5. Capable of installing pipes while maintaining relatively close tolerances online and grade.
6. Capable of installing pipes in a wide range of ground conditions without dewatering.
7. An oversized casing may be required to allow for adjustments of the storm sewer pipe inside of the larger casing to obtain the required slope tolerance. The production pipe installed would need to be designed to withstand the heat of hydration of the grout used to set the production pipe in place.
8. A closed face drilling system is recommended due to the risk of encountering wet sand soils along the proposed sewer alignment.
9. The type of pipe installed behind the MTBM will need to be designed to withstand the jacking pressures over the length of the planned bore.
10. Soils will be removed during boring operations as a slurry. A system can be incorporated to separate heavier soil particles from the overall slurry. The removed slurry is typically pumped to a large temporary aeration basin (e.g., 200 square-feet) where the material is dried and mixed to obtain a consistency suitable for trucking/disposal. The slurry is not anticipated to be suitable for reuse as part of this project and will need to be properly handled, transported, and disposed of in accordance with applicable regulations.
11. MT operations typically occur continuously (e.g., 24 hour/day) until completion of the run-length.

4.2.3 PIPE JACKING & UTILITY TUNNELING

Pipe jacking and utility tunneling is similar to MT as a tunnel boring machine (TBM) is used to provide continuous support to the excavation face while boring through the soil mass. The production pipe can either be simultaneously installed behind the boring machine at the jacking pit as it is advanced and as spoils are excavated and removed (pipe tunneling), or a tunnel support system, often consisting of a ring beam and wood lagging, can be erected behind the TBM (utility tunneling). When using a tunnel support system, the production pipe can be constructed inside, shimmed/leveled as required, and grouted into place. Pipe jacking and utility tunneling requires workers to be inside the constructed tunnel and is, therefore, most often used in cases where larger-diameter pipes are being installed.

Pipe jacking and utility tunneling construction considerations for the proposed sewer include:

1. Commonly more expensive than other trenchless technologies, but possibly less than MT under certain conditions.
2. A driving or launching shaft excavation is required to install the needed jacking frame and a target or recovery shaft is required to remove the TBM.
3. Typically, not as cost effective when installing pipelines over short distances due to the need to construct the required launching and recovery shafts, in addition to the cost of the TBM.

4. Typical bore lengths can range upwards of 2,000 feet in length and are often limited by the ability of the contractor to supply air to workers inside the tunnel. Pipe jacking is typically more cost effective when the amount of launching and recovery shafts over the length of the proposed alignment is minimized.
5. Capable of installing pipes while maintaining close tolerances online and grade.
6. Capable of installing pipes in a wide range of ground conditions without dewatering.
7. A tunnel support system can be used as an oversized casing to provide maneuvering room for the sewer pipe inside the support system to obtain the required slope tolerance with shimming/leveling as required. The production pipe to be installed would need to be designed to withstand the heat of hydration of the grout used to set the production pipe in place.
8. A closed face drilling system is recommended due to the risk of encountering wet sand soils along the proposed sewer alignment.
9. The type of pipe or tunnel support system installed behind the TBM will need to be designed to withstand the jacking pressures over the length of the planned bore.
10. Soils will typically be removed in their in-situ condition during boring operations.
11. Pipe jacking operations typically occur continuously (e.g., 24 hour/day) until completion of the run-length.

4.2.4 GENERAL TRENCHLESS DRILLING CONSIDERATIONS

Regardless of the selected trenchless pipe installation method, we recommend the following considerations be taken into account as part of preliminary project planning to reduce the risk of surface settlements and damage to existing utilities and infrastructure:

1. Plan for a temporary earth retention system to construct the launching and receiving pits required for the recommended trenchless installation methods.
2. Identify all utilities within the area of work prior to beginning drilling operations and use hydrovac excavation methods, as-needed, possibly in conjunction with GPR, to determine the location and the amount of ground cover over each utility.
3. Perform and submit a baseline, or pre-existing, condition assessment to record and document the existing condition of nearby buildings, utilities, pavements, and other improvements. The existing condition of the structures should also be reviewed at critical phases during construction, and a post-construction condition assessment should be performed. These assessments could assist in evaluating whether any perceived distress to existing structures or improvements occurred during construction, relative to the pre-existing conditions. We also recommend elevations be monitored at selected locations and vibration levels adjacent to the site be monitored at critical locations and during critical construction activities to verify the levels of vibrations generated do not exceed values that may be expected to cause cosmetic or structural distress.

4.3 ENGINEERED FILL REQUIREMENTS

Any fill placed within the construction area, including utility trench backfill, should be an approved material, free of frozen soil, organics, or other deleterious materials. Fill placed in structural areas (e.g., below roadways) should be compacted to a minimum of 98 percent of the maximum dry density as determined in accordance with the Standard Proctor (ASTM D 698) test. The upper two feet of the subgrade should be compacted to at least 100 percent of the Standard Proctor maximum density. Fill placed in non-structural areas should be compacted to at least 95 percent, to help prevent future subsidence. The fill should be spread in level layers with a loose thickness appropriate for the type of equipment used to obtain compaction. However, under no circumstances should the loose lift thickness exceed 10 inches.

In general, pipe bedding should consist of relatively clean, well-graded fine aggregate placed to or above the spring line/static groundwater elevation. Typically, pipe bedding should have a maximum particle size of 1/2-inch and less than 15 percent passing the No. 200 sieve. However, AASTHO No. 57 crushed aggregate is typically utilized for pipe bedding and can be utilized for this project if approved by the designer and appropriate agencies. The compaction requirement for testing presented above is for general excavation backfill and does not apply to pipe bedding which should be compacted to meet the requirements of the design specifications. A vibratory plate compactor should be utilized for compaction of pipe bedding and the contractor must exercise caution to avoid overstressing the pipe.

Clays (with a USCS group symbols of “CL” and “CL/ML”) are expected to be the predominant soil excavated during installation of the sanitary sewer. The inorganic site lean clays are generally suitable for reuse as structural fill above the pipe bedding, provided they do not contain miscellaneous debris or organics and that the soils can be properly compacted in the confined areas of the excavations. Sheepsfoot type rollers with overlapping passes should be used for compaction of the clayey soils (see Figure 1).

FIGURE NO. 1: Remote Controlled Sheepsfoot Trench Compactor

Coarse-crushed limestone aggregate consisting of No. 1’s or No. 2’s, can be used to stabilize subgrades or to backfill the base of undercuts, if soft or disturbed subgrade conditions are encountered. Alternatively, crushed concrete consisting of well-graded, nominal 1- to 3-inch diameter material with a maximum of 7 percent passing the No. 200 sieve can be utilized in-lieu of the recommended limestone gradations. The recommended crushed aggregate should be compacted using a steel-drum vibratory roller, a static roller (in the case of disturbed subgrades), a vibratory plate compactor mounted on an excavator or backhoe (i.e., hoepac), or by tamping the aggregate layers using a backhoe or excavator bucket, if the material is placed in deep trenches. The crushed aggregate should be compacted until it is stable.

Clay fill or clay subgrade should be compacted with sheepsfoot rollers at a moisture content +/- 2 percent of the optimum moisture content as determined by ASTM D 698, or as needed to achieve the recommended compaction requirement. Clay soils can be difficult to compact in confined areas and should only be reused in areas where suitable sized compaction equipment can operate (see image above), or may be used as backfill in shallow trenches above the pipe bedding (and above the static groundwater elevation). Moisture conditioning (i.e., discing and drying) of the clayey soils could be required to achieve suitable moisture levels to properly compact the on-site clays. The successful reuse of the on-site clayey soils for trench backfill will depend on the time of year and the care the earthwork contractor uses during construction. During cold and wet periods of the year, clayey and/or silty subgrade soils can become saturated and disturbed, and those soils can be difficult to dry so they can be properly compacted.

Imported granular fill may also be used for general backfill. Granular soils can be compacted with vibratory or impact compactors (vibrating plate compactors or tampers). Do not use vibratory compactors for clayey soils. Suitability of compaction methods for the various types of backfill should be verified with field testing before approval as general backfill for the project. If granular soils are used, the upper two feet of subgrade should consist of clay fill, to provide support of the pavement section that is similar to the adjacent subgrade conditions.

4.4 GENERAL CONSIDERATIONS

This report was prepared in accordance with generally accepted geotechnical engineering practices to assist with geotechnical considerations related to open cut and trenchless utility installations. If the scope of the project changes from that stated in this report, SME should review and confirm the conclusions and recommendations of this report.

Our recommendations are based on small diameter borings and limited sampling. Variations in soil and groundwater conditions commonly occur between boring locations and between sampling depths. The nature and extent of the variations may not become evident until the time of construction. An SME field representative should be on-site to verify the subsurface conditions encountered during construction are consistent with the anticipated subsurface conditions indicated by the boring. SME should be retained to assist during the construction process by reviewing contractor submittals, observing subsurface conditions, documenting the trenchless boring activities, observing surface conditions, and reviewing elevation data collected during construction. SME is not responsible for misinterpretation by others of our boring logs or recommendations, or for variations of conditions encountered in the field away from the boring locations at the time of construction.

The contractor must take precautions to protect nearby existing pavements, utilities, and structures during construction. Care must be exercised during the excavating and compacting operations so that excessive vibrations do not cause settlement of nearby existing pavements, utilities, or structures, and to avoid undermining existing utilities during excavation for the proposed storm sewer. Contact SME for additional information on monitoring vibrations during construction or conducting pre and post-construction condition surveys, if needed.

Handling, transportation and disposal of excavated materials and groundwater should be performed in accordance with applicable environmental regulatory requirements.

5. SIGNATURES

REPORT PREPARED BY:

Aaron Reed
Nov 18 2022 5:11 PM

Aaron J. Reed, PE (Michigan)
Senior Project Engineer
License #MI-6201063623

REPORT REVIEWED BY:

Tim Mitchell
Nov 18 2022 5:07 PM

Timothy J. Mitchell, PE
Principal Consultant
License #OH-PE82523

APPENDIX A

BORING LOCATION DIAGRAM
BORING LOG TERMINOLOGY
BORING LOGS (B1 THROUGH B8)
LIQUID LIMIT, PLASTIC LIMIT, & PLASTICITY INDEX REPORTS (3)

PLOT DATE: Nov 03, 2022 - 11:48am - cindy.rocha-ceron

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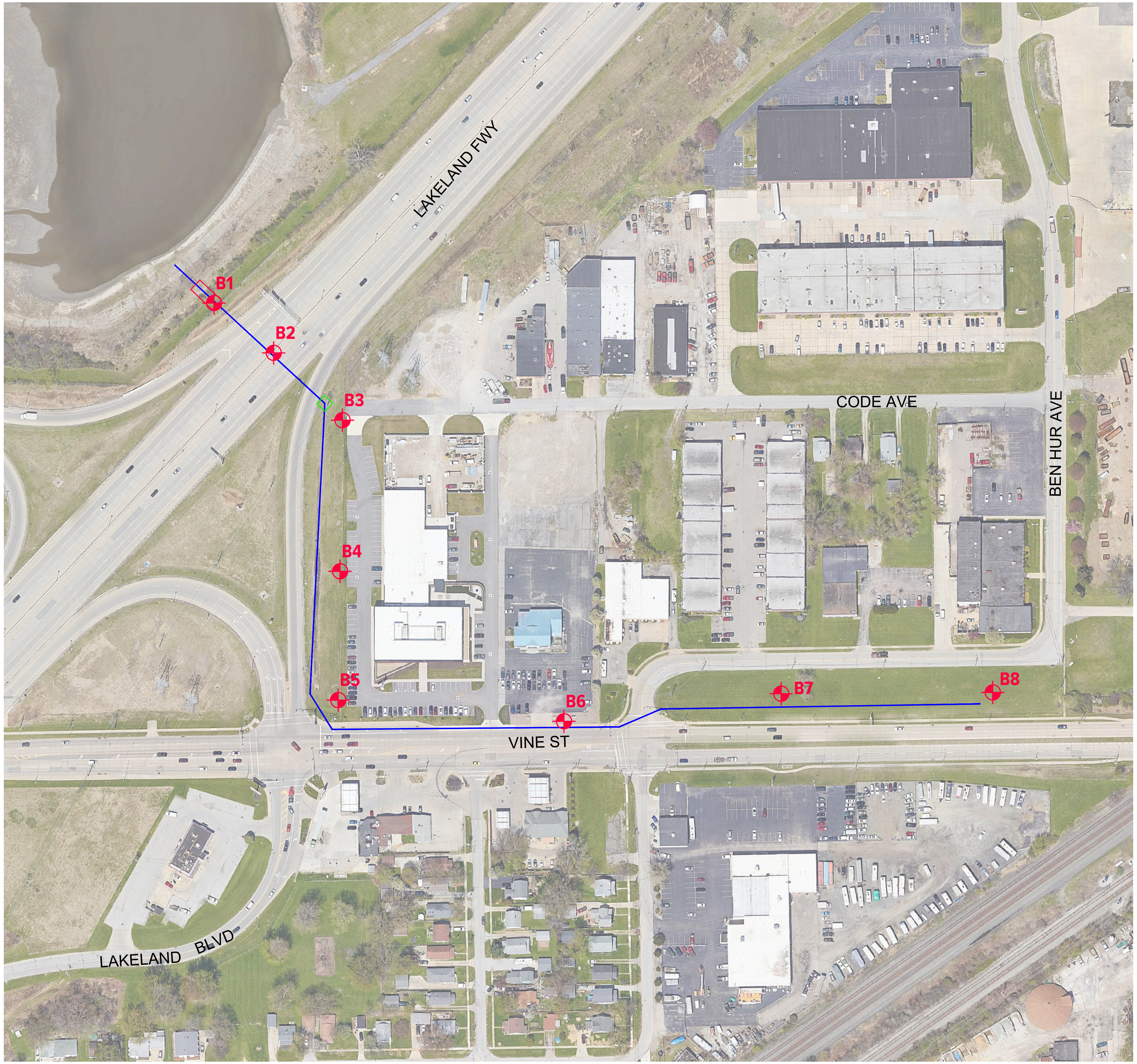
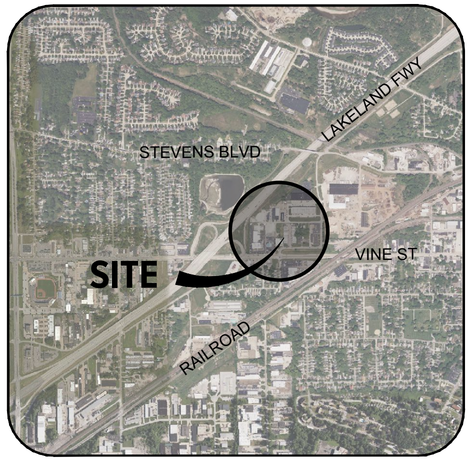


0' 200' 400'

GRAPHIC SCALE: 1" = 200'

LEGEND

⌖	APPROXIMATE BORING LOCATION
🟥	PROPOSED BORE PIT LIMITS
🟩	PROPOSED RECEIVING PIT LIMITS
🟦	APPROXIMATE LOCATION OF PROPOSED PHASE 1 STORM SEWER ALIGNMENT



LOCATION MAP

NOT TO SCALE

NOTES:

1. THE APPROXIMATE LOCATION OF THE PROPOSED ALIGNMENT WAS TAKEN FROM A PDF CONTAINING "PLAN & PROFILE" SHEETS 5 THROUGH 8, DATED OCTOBER 28, 2022, AND PREPARED BY CT CONSULTANTS FOR THE "NASON BASIN TO GROVE AVENUE STORM SEWER IMPROVEMENTS PHASE 1" PROJECT.

2. AERIAL IMAGE TAKEN FROM GOOGLE EARTH PRO WITH AN IMAGE DATE OF 04-27-2022.

SME

www.sme-usa.com

Project

NASON BASIN TO GROVE AVENUE STORM SEWER IMPROVEMENTS PHASE 1

Project Location

WILLOUGHBY, OHIO

Sheet Name

BORING LOCATION DIAGRAM

No.	Revision Date

Date 11-01-2022

CADD CRC

Designer AJR

Scale AS NOTED

Project 090029.00

Figure No. 1

DRAWING NOTE: SCALE DEPICTED IS MEANT FOR 11" X 17" AND WILL SCALE INCORRECTLY IF PRINTED ON ANY OTHER SIZE MEDIA

SME

BORING LOG TERMINOLOGY

UNIFIED SOIL CLASSIFICATION AND SYMBOL CHART

COARSE-GRAINED SOIL (more than 50% of material is larger than No. 200 sieve size.)			
GRAVEL More than 50% of coarse fraction larger than No. 4 sieve size	Clean Gravel (Less than 5% fines)		
	▨	GW	Well-graded gravel; gravel-sand mixtures, little or no fines
	▨	GP	Poorly-graded gravel; gravel-sand mixtures, little or no fines
	Gravel with fines (More than 12% fines)		
	▨	GM	Silty gravel; gravel-sand-silt mixtures
	▨	GC	Clayey gravel; gravel-sand-clay mixtures
SAND 50% or more of coarse fraction smaller than No. 4 sieve size	Clean Sand (Less than 5% fines)		
	▨	SW	Well-graded sand; sand-gravel mixtures, little or no fines
	▨	SP	Poorly graded sand; sand-gravel mixtures, little or no fines
	Sand with fines (More than 12% fines)		
	▨	SM	Silty sand; sand-silt-gravel mixtures
	▨	SC	Clayey sand; sand–clay-gravel mixtures
FINE-GRAINED SOIL (50% or more of material is smaller than No. 200 sieve size)			
SILT AND CLAY Liquid limit less than 50%	▨	ML	Inorganic silt; sandy silt or gravelly silt with slight plasticity
	▨	CL	Inorganic clay of low plasticity; lean clay, sandy clay, gravelly clay
	🟩	OL	Organic silt and organic clay of low plasticity
SILT AND CLAY Liquid limit 50% or greater	▨	MH	Inorganic silt of high plasticity, elastic silt
	▨	CH	Inorganic clay of high plasticity, fat clay
	▨	OH	Organic silt and organic clay of high plasticity
HIGHLY ORGANIC SOIL	▨	PT	Peat and other highly organic soil

OTHER MATERIAL SYMBOLS

■	Topsoil	□	Void	▨	Sandstone
▨	Asphalt Concrete	▨	Glacial Till	▨	Siltstone
▨	Aggregate Base	▨	Coal	▨	Limestone
▨	Portland Cement Concrete	▨	Shale	▨	Fill

LABORATORY CLASSIFICATION CRITERIA

GW	$C_U = \frac{D_{60}}{D_{10}}$ greater than 4; $C_C = \frac{D_{30}{}^2}{D_{10} \times D_{60}}$ between 1 and 3	
GP	Not meeting all gradation requirements for GW	
GM	Atterberg limits below "A" line or PI less than 4	Above "A" line with PI between 4 and 7 are borderline cases requiring use of dual symbols
GC	Atterberg limits above "A" line with PI greater than 7	
SW	$C_U = \frac{D_{60}}{D_{10}}$ greater than 6; $C_C = \frac{D_{30}{}^2}{D_{10} \times D_{60}}$ between 1 and 3	
SP	Not meeting all gradation requirements for SW	
SM	Atterberg limits below "A" line or PI less than 4	Above "A" line with PI between 4 and 7 are borderline cases requiring use of dual symbols
SC	Atterberg limits above "A" line with PI greater than 7	

Determine percentages of sand and gravel from grain-size curve. Depending on percentage of fines (fraction smaller than No. 200 sieve size), coarse-grained soils are classified as follows:

Less than 5 percent……………………….……..GW, GP, SW, SP
More than 12 percent…………………….……..GM, GC, SM, SC
5 to 12 percent…………….…..……..Cases requiring dual symbols

- SP-SM or SW-SM (SAND with Silt or SAND with Silt and Gravel)
- SP-SC or SW-SC (SAND with Clay or SAND with Clay and Gravel)
- GP-GM or GW-GM (GRAVEL with Silt or GRAVEL with Silt and Sand)
- GP-GC or GW-GC (GRAVEL with Clay or GRAVEL with Clay and Sand)

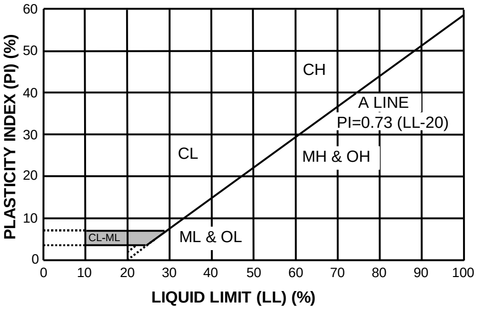
If the fines are CL-ML:

- SC-SM (SILTY CLAYEY SAND or SILTY CLAYEY SAND with Gravel)
- SM-SC (CLAYEY SILTY SAND or CLAYEY SILTY SAND with Gravel)
- GC-GM (SILTY CLAYEY GRAVEL or SILTY CLAYEY GRAVEL with Sand)

PARTICLE SIZES

Boulders		-	Greater than 12 inches
Cobbles		-	3 inches to 12 inches
Gravel-	Coarse	-	3/4 inches to 3 inches
	Fine	-	No. 4 to 3/4 inches
Sand-	Coarse	-	No. 10 to No. 4
	Medium	-	No. 40 to No. 10
	Fine	-	No. 200 to No. 40
Silt and Clay		-	Less than (0.074 mm)

PLASTICITY CHART



VISUAL MANUAL PROCEDURE

When laboratory tests are not performed to confirm the classification of soils exhibiting borderline classifications, the two possible classifications would be separated with a slash, as follows:

For soils where it is difficult to distinguish if it is a coarse or fine-grained soil:

- SC/CL (CLAYEY SAND to Sandy LEAN CLAY)
- SM/ML (SILTY SAND to SANDY SILT)
- GC/CL (CLAYEY GRAVEL to Gravelly LEAN CLAY)
- GM/ML (SILTY GRAVEL to Gravelly SILT)

For soils where it is difficult to distinguish if it is sand or gravel, poorly or well-graded sand or gravel; silt or clay; or plastic or non-plastic silt or clay:

- SP/GP or SW/GW (SAND with Gravel to GRAVEL with Sand)
- SC/GC (CLAYEY SAND with Gravel to CLAYEY GRAVEL with Sand)
- SM/GM (SILTY SAND with Gravel to SILTY GRAVEL with Sand)
- SW/SP (SAND or SAND with Gravel)
- GP/GW (GRAVEL or GRAVEL with Sand)
- SC/SM (CLAYEY to SILTY SAND)
- GM/GC (SILTY to CLAYEY GRAVEL)
- CL/ML (SILTY CLAY)
- ML/CL (CLAYEY SILT)
- CH/MH (FAT CLAY to ELASTIC SILT)
- CL/CH (LEAN to FAT CLAY)
- MH/ML (ELASTIC SILT to SILT)

DRILLING AND SAMPLING ABBREVIATIONS

2ST	–	Shelby Tube – 2" O.D.
3ST	–	Shelby Tube – 3" O.D.
AS	–	Auger Sample
GS	–	Grab Sample
LS	–	Liner Sample
NR	–	No Recovery
PM	–	Pressuremeter
RC	–	Rock Core diamond bit. NX size, except where noted
SB	–	Split Barrel Sample 1-3/8" I.D., 2" O.D., except where noted
VS	–	Vane Shear
WS	–	Wash Sample

OTHER ABBREVIATIONS

WOH	–	Weight of Hammer
WOR	–	Weight of Rods
SP	–	Soil Probe
PID	–	Photo Ionization Device
FID	–	Flame Ionization Device

DEPOSITIONAL FEATURES

Parting	–	as much as 1/16 inch thick
Seam	–	1/16 inch to 1/2 inch thick
Layer	–	1/2 inch to 12 inches thick
Stratum	–	greater than 12 inches thick
Pocket	–	deposit of limited lateral extent
Lens	–	lenticular deposit
Hardpan/Till	–	an unstratified, consolidated or cemented mixture of clay, silt, sand and/or gravel, the size/shape of the constituents vary widely
Lacustrine	–	soil deposited by lake water
Mottled	–	soil irregularly marked with spots of different colors that vary in number and size
Varved	–	alternating partings or seams of silt and/or clay
Occasional	–	one or less per foot of thickness
Frequent	–	more than one per foot of thickness
Interbedded	–	strata of soil or beds of rock lying between or alternating with other strata of a different nature

DESCRIPTION OF RELATIVE QUANTITIES

The visual-manual procedure uses the following terms to describe the relative quantities of notable foreign materials, gravel, sand or fines:

Trace –	particles are present but estimated to be less than 5%
Few –	5 to 10%
Little –	15 to 25%
Some –	30 to 45%
Mostly –	50 to 100%

CLASSIFICATION TERMINOLOGY AND CORRELATIONS

Cohesionless Soils

Relative Density	**N_{60} (N-Value) (Blows per foot)**
Very Loose	0 to 4
Loose	5 to 10
Medium Dense	11 to 30
Dense	31 to 50
Very Dense	51 to 80
Extremely Dense	Over 81

Cohesive Soils

Consistency	**N_{60} (N-Value) (Blows per foot)**	**Undrained Shear Strength (kips/ft^2)**
Very Soft	<2	0.25 or less
Soft	2 - 4	> 0.25 to 0.50
Medium	5 - 8	> 0.50 to 1.0
Stiff	9 - 15	> 1.0 to 2.0
Very Stiff	16 - 30	> 2.0 to 4.0
Hard	> 30	> 4.0 or greater

Standard Penetration 'N-Value' = Blows per foot of a 140-pound hammer falling 30 inches on a 2-inch O.D. split barrel sampler, except where noted. N60 values as reported on boring logs represent raw N-values corrected for hammer efficiency only.

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SME

BORING B1

PAGE 1 OF 2

BORING DEPTH: 35 FEET

PROJECT NAME: Nason Basin to Grove Ave Storm Sewer PH I

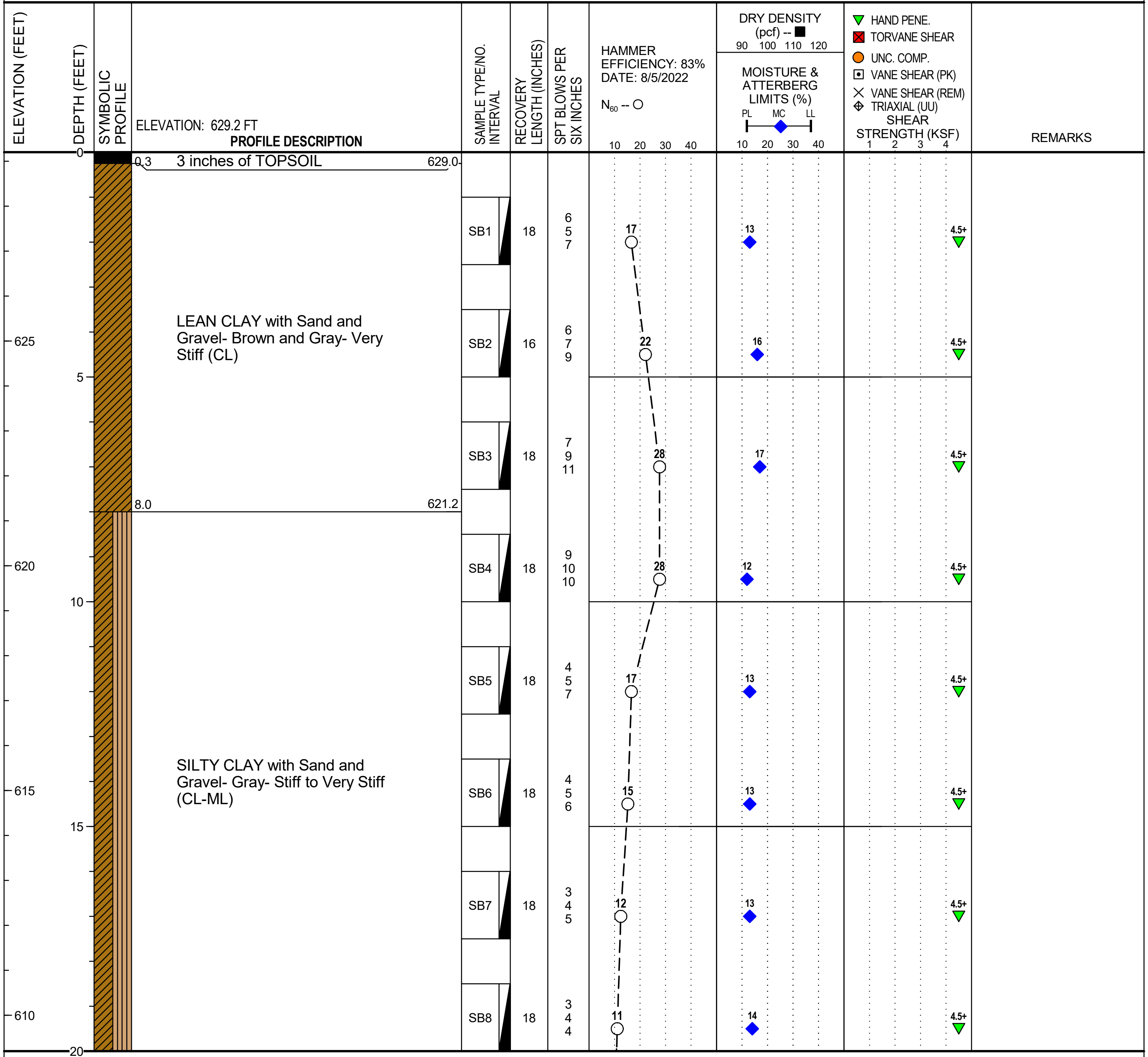
PROJECT NUMBER: 090029.00

CLIENT: CT Consultants, Inc.

PROJECT LOCATION: Willoughby, Ohio

DATE STARTED: 8/29/22 **COMPLETED:** 8/29/22 **BORING METHOD:** 3-3/4" Hollow-stem Auger

DRILLER: WI/RM **RIG NO.:** 635-CME55-RT ATV **LOGGED BY:** APP **CHECKED BY:** BPL



DEPTH (FEET)	PROFILE DESCRIPTION	ELEVATION (FEET)
0.3	3 inches of TOPSOIL	629.0
8.0	LEAN CLAY with Sand and Gravel- Brown and Gray- Very Stiff (CL)	621.2
	SILTY CLAY with Sand and Gravel- Gray- Stiff to Very Stiff (CL-ML)	

SAMPLE TYPE/NO. INTERVAL	RECOVERY LENGTH (INCHES)	SPT BLOWS PER SIX INCHES	N60	MC (%)	HAND PENE. (KSF)
SB1	18	6 5 7	17	13	4.5+
SB2	16	6 7 9	22	16	4.5+
SB3	18	7 9 11	28	17	4.5+
SB4	18	9 10 10	28	12	4.5+
SB5	18	4 5 7	17	13	4.5+
SB6	18	4 5 6	15	13	4.5+
SB7	18	3 4 5	12	13	4.5+
SB8	18	3 4 4	11	14	4.5+

GROUNDWATER & BACKFILL INFORMATION

GROUNDWATER WAS NOT ENCOUNTERED

BACKFILL METHOD: Refer to Well Lob WB1

NOTES:
1. The indicated stratification lines are approximate. The in-situ transitions between materials may be gradual.
2. The colors depicted on the symbolic profile are solely for visualization purposes and do not necessarily represent the in-situ colors encountered.

(Continued Next Page)

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SME

BORING B1

PAGE 2 OF 2

BORING DEPTH: 35 FEET

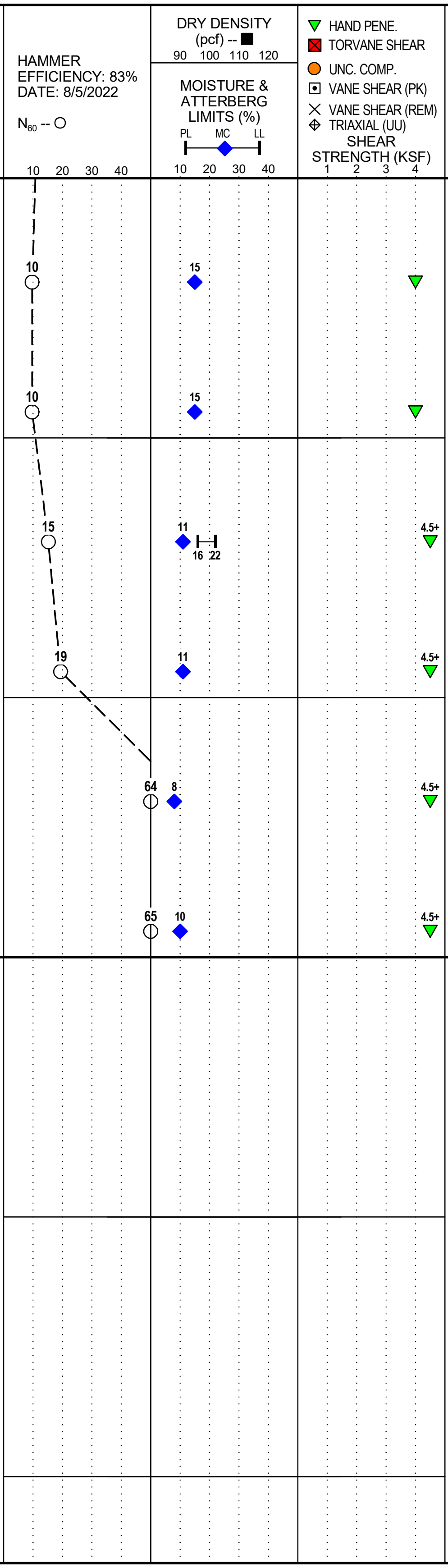
PROJECT NAME: Nason Basin to Grove Ave Storm Sewer PH I **PROJECT NUMBER:** 090029.00

CLIENT: CT Consultants, Inc. **PROJECT LOCATION:** Willoughby, Ohio

ELEVATION: 629.2 FT

HAMMER EFFICIENCY: 83%
DATE: 8/5/2022

ELEVATION (FEET)	DEPTH (FEET)	PROFILE DESCRIPTION	SAMPLE TYPE/NO. INTERVAL	RECOVERY LENGTH (INCHES)	SPT BLOWS PER SIX INCHES	N_{60}	MOISTURE (%)	ATTERBERG LIMITS PL / LL	HAND PENE. (KSF)	REMARKS
	20	SILTY CLAY with Sand and Gravel- Gray- Stiff to Very Stiff (CL-ML) *(continued)*								
			SB9	18	3 3 4	10	15			
605			SB10	18	3 3 4	10	15			
	25									
			SB11	18	4 5 6	15	11	16 / 22	4.5+	
600			SB12	16	5 6 8	19	11		4.5+	
	30									
			SB13	16	12 24 22	64	8		4.5+	
595		35.0 594.2	SB14	18	8 17 30	65	10		4.5+	
	35	END OF BORING AT 35.0 FEET.								
590										
	40									
585										
	45									

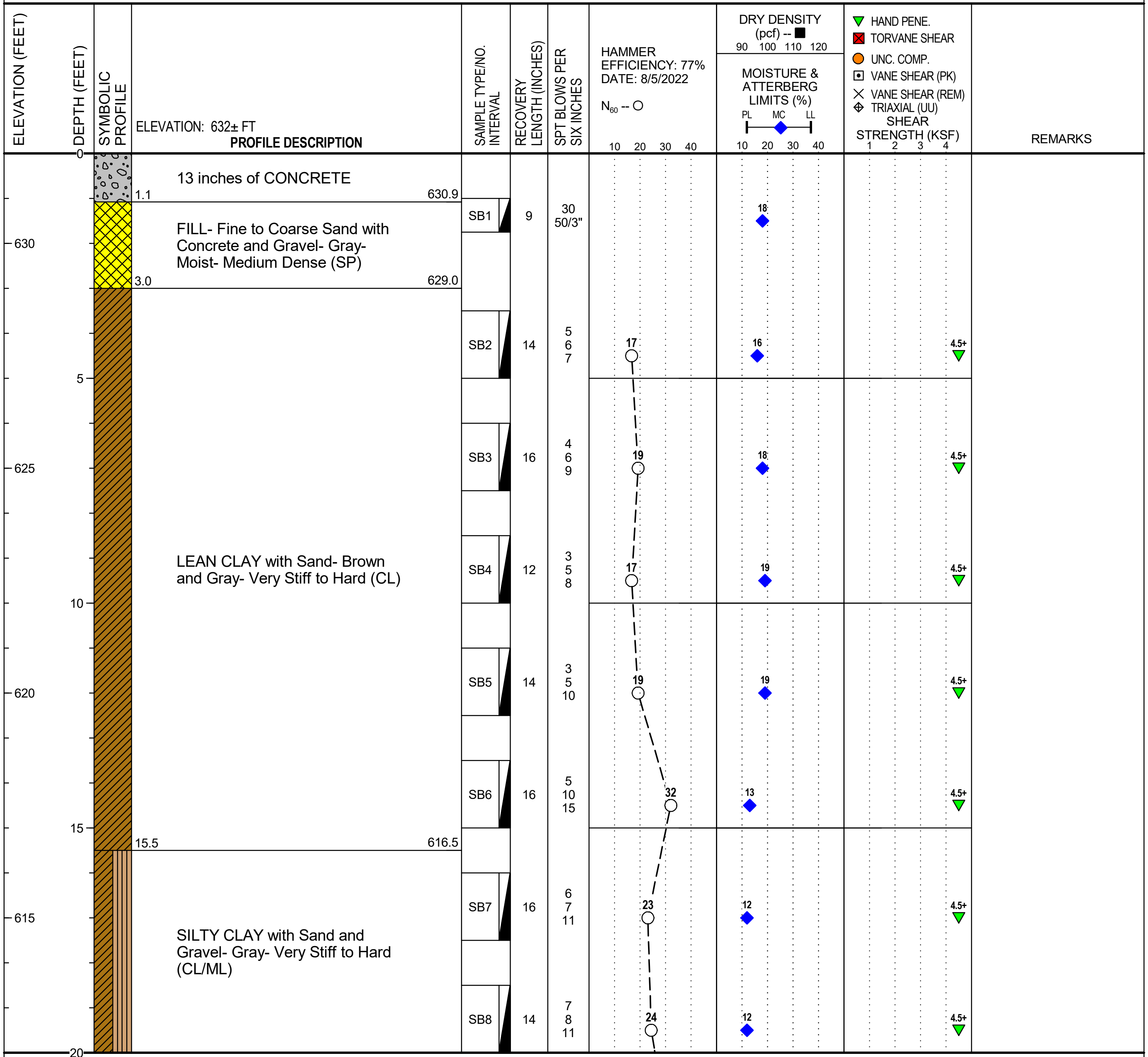


BORING B2

PAGE 1 OF 2

BORING DEPTH: 30 FEET

PROJECT NAME: Nason Basin to Grove Ave Storm Sewer PH I
PROJECT NUMBER: 090029.00
CLIENT: CT Consultants, Inc.
PROJECT LOCATION: Willoughby, Ohio
DATE STARTED: 9/20/22
COMPLETED: 9/20/22
BORING METHOD: 3-3/4" Hollow-stem Auger w/AW Rod
DRILLER: JH/WI
RIG NO.: 293 (CME 55)
LOGGED BY: APP
CHECKED BY: BPL



ELEVATION: 632± FT

DEPTH (FEET)	PROFILE DESCRIPTION	ELEVATION (FEET)
1.1	13 inches of CONCRETE	630.9
3.0	FILL- Fine to Coarse Sand with Concrete and Gravel- Gray- Moist- Medium Dense (SP)	629.0
15.5	LEAN CLAY with Sand- Brown and Gray- Very Stiff to Hard (CL)	616.5
	SILTY CLAY with Sand and Gravel- Gray- Very Stiff to Hard (CL/ML)	

HAMMER EFFICIENCY: 77%
DATE: 8/5/2022

SAMPLE TYPE/NO. INTERVAL	RECOVERY LENGTH (INCHES)	SPT BLOWS PER SIX INCHES	N_{60} -- ○	MOISTURE (%)	HAND PENE. (KSF)
SB1	9	30 50/3"		18	
SB2	14	5 6 7	17	16	4.5+
SB3	16	4 6 9	19	18	4.5+
SB4	12	3 5 8	17	19	4.5+
SB5	14	3 5 10	19	19	4.5+
SB6	16	5 10 15	32	13	4.5+
SB7	16	6 7 11	23	12	4.5+
SB8	14	7 8 11	24	12	4.5+

GROUNDWATER & BACKFILL INFORMATION

GROUNDWATER WAS NOT ENCOUNTERED

BACKFILL METHOD: Bentonite & Cement

NOTES:
1. The indicated stratification lines are approximate. The in-situ transitions between materials may be gradual.
2. The colors depicted on the symbolic profile are solely for visualization purposes and do not necessarily represent the in-situ colors encountered.
3. Surface capped with asphalt cold patch after backfilling the borehole.

(Continued Next Page)

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SME

BORING B2

PAGE 2 OF 2

BORING DEPTH: 30 FEET

PROJECT NAME: Nason Basin to Grove Ave Storm Sewer PH I

PROJECT NUMBER: 090029.00

CLIENT: CT Consultants, Inc.

PROJECT LOCATION: Willoughby, Ohio

ELEVATION: 632± FT

HAMMER EFFICIENCY: 77%
DATE: 8/5/2022
N_{60} -- ○

DRY DENSITY (pcf) -- ■ 90 100 110 120

MOISTURE & ATTERBERG LIMITS (%) PL MC LL 10 20 30 40

▼ HAND PENE.
☒ TORVANE SHEAR
● UNC. COMP.
⊡ VANE SHEAR (PK)
× VANE SHEAR (REM)
⊕ TRIAXIAL (UU)
SHEAR STRENGTH (KSF) 1 2 3 4

ELEVATION (FEET)	DEPTH (FEET)	PROFILE DESCRIPTION	SAMPLE TYPE/NO. INTERVAL	RECOVERY LENGTH (INCHES)	SPT BLOWS PER SIX INCHES	N_{60}	MOISTURE (%)	SHEAR STRENGTH (KSF)	REMARKS
610		SILTY CLAY with Sand and Gravel- Gray- Very Stiff to Hard (CL/ML) *(continued)*	SB9	14	9 11 14	32	12	4.5+	
			SB10	18	5 6 7	17	13	4.5+	
605	25		SB11	18	5 7 8	19	13	4.5+	
602.0	30.0		SB12	18	4 5 6	14	14	4.5+	
		END OF BORING AT 30.0 FEET.							

Depth scale: 20, 25, 30, 35, 40, 45
Elevation scale: 610, 605, 600, 595, 590

11/18/22 2:55:37 PM

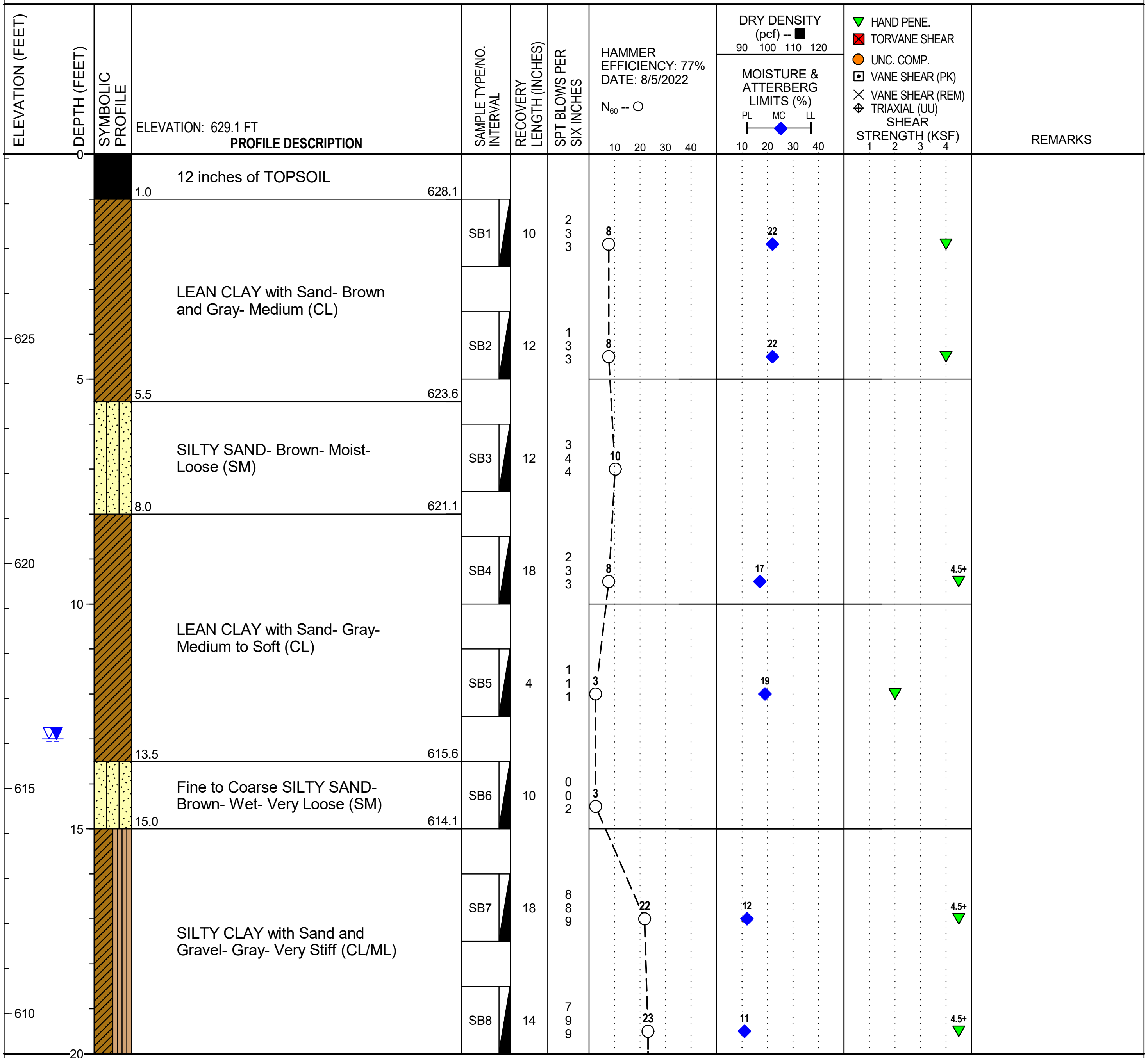
SME

BORING B3

PAGE 1 OF 2

BORING DEPTH: 30 FEET

PROJECT NAME: Nason Basin to Grove Ave Storm Sewer PH I
PROJECT NUMBER: 090029.00
CLIENT: CT Consultants, Inc.
PROJECT LOCATION: Willoughby, Ohio
DATE STARTED: 9/20/22
COMPLETED: 9/20/22
BORING METHOD: 3-3/4" Hollow-stem Auger w/AW Rod
DRILLER: JH/WI
RIG NO.: 293 (CME 55)
LOGGED BY: APP
CHECKED BY: BPL



DEPTH (FEET)	ELEVATION (FEET)	PROFILE DESCRIPTION
0 – 1.0	628.1	12 inches of TOPSOIL
1.0 – 5.5	623.6	LEAN CLAY with Sand- Brown and Gray- Medium (CL)
5.5 – 8.0	621.1	SILTY SAND- Brown- Moist- Loose (SM)
8.0 – 13.5	615.6	LEAN CLAY with Sand- Gray- Medium to Soft (CL)
13.5 – 15.0	614.1	Fine to Coarse SILTY SAND- Brown- Wet- Very Loose (SM)
15.0 –		SILTY CLAY with Sand and Gravel- Gray- Very Stiff (CL/ML)

SAMPLE TYPE/NO.	RECOVERY LENGTH (INCHES)	SPT BLOWS PER SIX INCHES	N60	MC (%)	HAND PENE. (KSF)
SB1	10	2 3 3	8	22	
SB2	12	1 3 3	8	22	
SB3	12	3 4 4	10		
SB4	18	2 3 3	8	17	4.5+
SB5	4	1 1 1	3	19	
SB6	10	0 0 2	3		
SB7	18	8 8 9	22	12	4.5+
SB8	14	7 9 9	23	11	4.5+

GROUNDWATER & BACKFILL INFORMATION

	DEPTH (FT)	ELEV (FT)
▽ **DURING BORING:**	13.0	616.1
▼ **AT END OF BORING:**	13.0	616.1

BACKFILL METHOD: Refer to Well Log WB3

NOTES:
1. The indicated stratification lines are approximate. The in-situ transitions between materials may be gradual.
2. The colors depicted on the symbolic profile are solely for visualization purposes and do not necessarily represent the in-situ colors encountered.

(Continued Next Page)

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SME

BORING B3

PAGE 2 OF 2

BORING DEPTH: 30 FEET

PROJECT NAME: Nason Basin to Grove Ave Storm Sewer PH I
PROJECT NUMBER: 090029.00

CLIENT: CT Consultants, Inc.
PROJECT LOCATION: Willoughby, Ohio

HAMMER EFFICIENCY: 77%
DATE: 8/5/2022
N_{60} -- ○

DRY DENSITY (pcf) -- ■ 90 100 110 120

MOISTURE & ATTERBERG LIMITS (%) PL MC LL 10 20 30 40

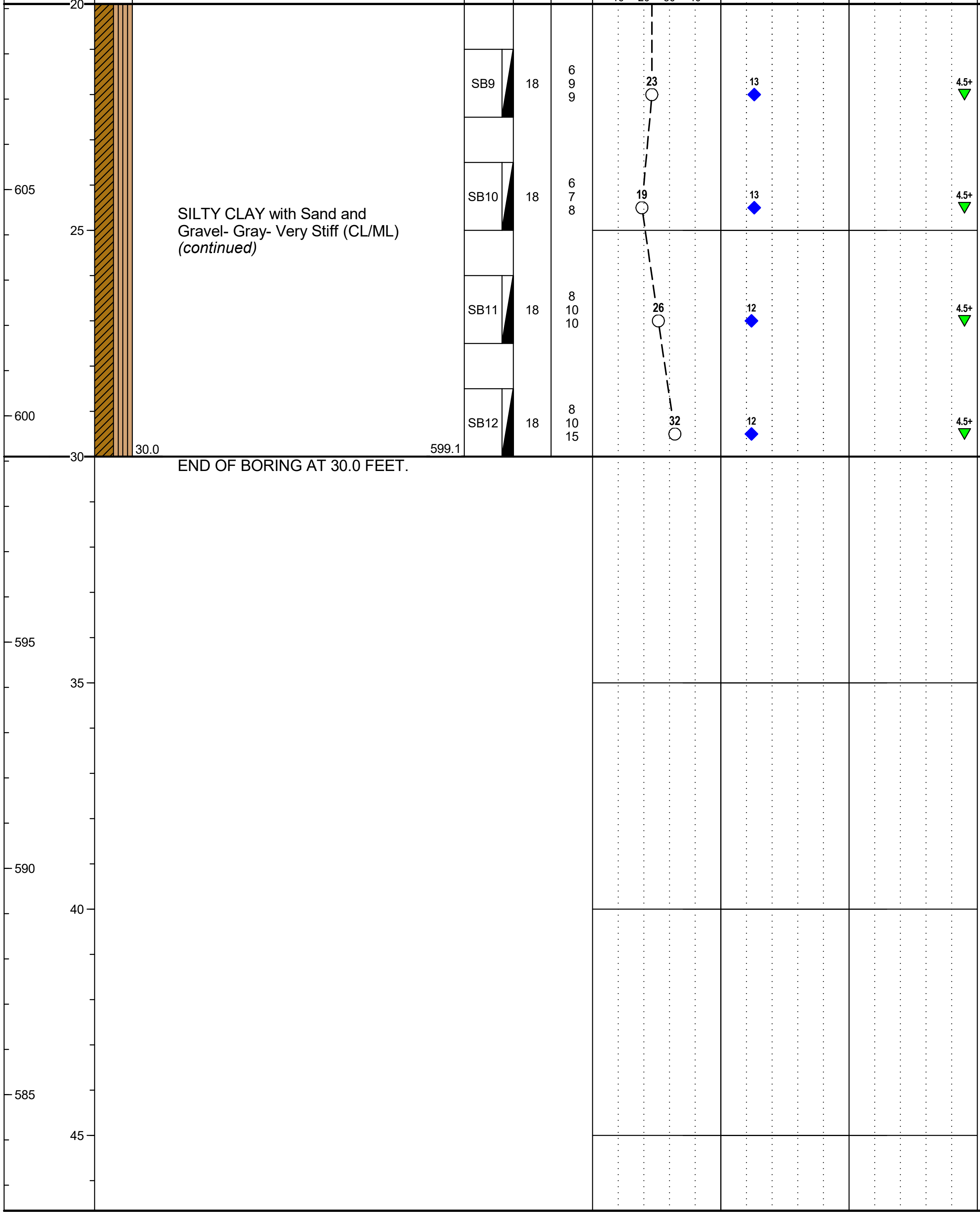
▽ HAND PENE.
☒ TORVANE SHEAR
● UNC. COMP.
⊡ VANE SHEAR (PK)
× VANE SHEAR (REM)
◈ TRIAXIAL (UU)

SHEAR STRENGTH (KSF) 1 2 3 4

ELEVATION: 629.1 FT

ELEVATION (FEET)	DEPTH (FEET)	PROFILE DESCRIPTION	SAMPLE TYPE/NO. INTERVAL	RECOVERY LENGTH (INCHES)	SPT BLOWS PER SIX INCHES	N_{60}	MC (%)	HAND PENE. (KSF)	REMARKS
	20–30	SILTY CLAY with Sand and Gravel- Gray- Very Stiff (CL/ML) *(continued)*	SB9	18	6 9 9	23	13	4.5+	
			SB10	18	6 7 8	19	13	4.5+	
			SB11	18	8 10 10	26	12	4.5+	
599.1	30.0		SB12	18	8 10 15	32	12	4.5+	

END OF BORING AT 30.0 FEET.



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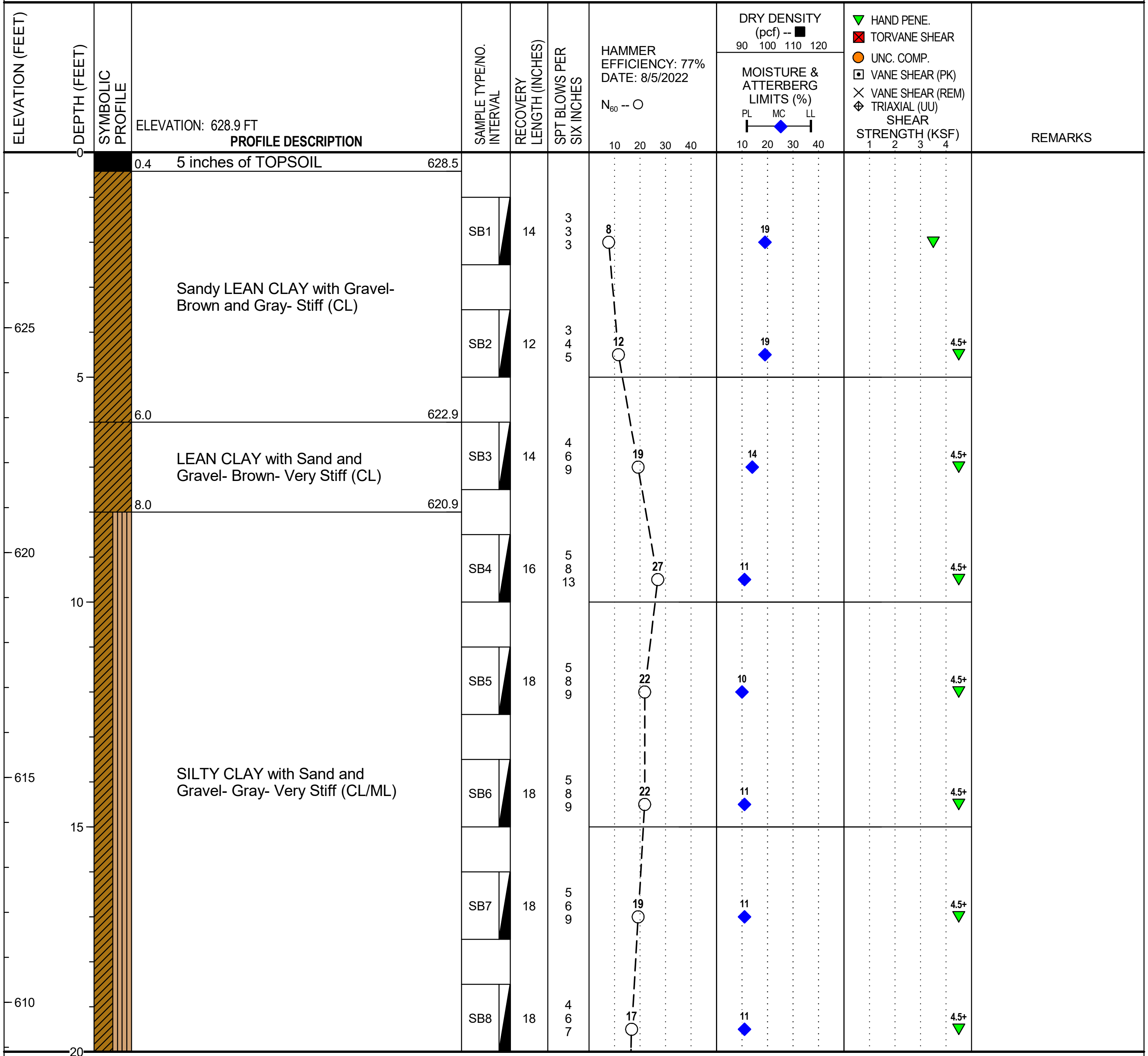
BORING B4

PAGE 1 OF 2

BORING DEPTH: 31 FEET

PROJECT NAME: Nason Basin to Grove Ave Storm Sewer PH I
PROJECT NUMBER: 090029.00
CLIENT: CT Consultants, Inc.
PROJECT LOCATION: Willoughby, Ohio

DATE STARTED: 8/26/22
COMPLETED: 8/26/22
BORING METHOD: 3-3/4" Hollow-stem Auger
DRILLER: WI/JH
RIG NO.: 293 (CME 55)
LOGGED BY: APP
CHECKED BY: BPL



Depth (ft)	Elevation (ft)	Profile Description
0.4	628.5	5 inches of TOPSOIL
6.0	622.9	Sandy LEAN CLAY with Gravel- Brown and Gray- Stiff (CL)
8.0	620.9	LEAN CLAY with Sand and Gravel- Brown- Very Stiff (CL)
		SILTY CLAY with Sand and Gravel- Gray- Very Stiff (CL/ML)

Sample	Recovery (in.)	SPT Blows	N60	MC (%)	Hand Pene. (KSF)
SB1	14	3 3 3	8	19	
SB2	12	3 4 5	12	19	4.5+
SB3	14	4 6 9	19	14	4.5+
SB4	16	5 8 13	27	11	4.5+
SB5	18	5 8 9	22	10	4.5+
SB6	18	5 8 9	22	11	4.5+
SB7	18	5 6 9	19	11	4.5+
SB8	18	4 6 7	17	11	4.5+

GROUNDWATER & BACKFILL INFORMATION

GROUNDWATER WAS NOT ENCOUNTERED

BACKFILL METHOD: Auger Cuttings

NOTES:
1. The indicated stratification lines are approximate. The in-situ transitions between materials may be gradual.
2. The colors depicted on the symbolic profile are solely for visualization purposes and do not necessarily represent the in-situ colors encountered.
3. Stopped drilling at a depth of 18 feet due to yellow plastic ribbon in cuttings, potentially indicating an unmarked adjacent gas line. Boring was offset 10 feet south, blind drilled to 18 feet, and drilled to the explored depth.

(Continued Next Page)

BORING B4

PAGE 2 OF 2

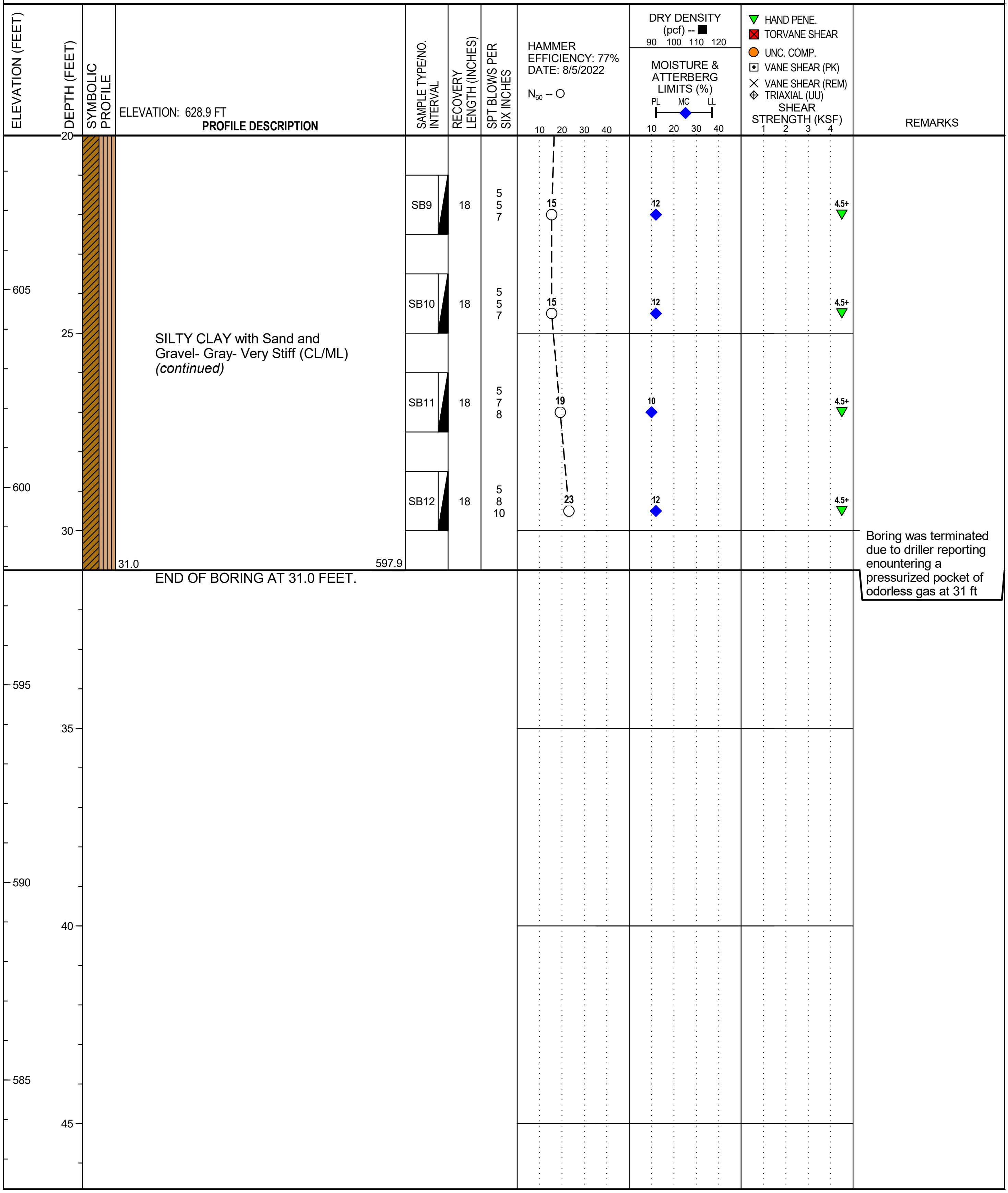
BORING DEPTH: 31 FEET

PROJECT NAME: Nason Basin to Grove Ave Storm Sewer PH I

PROJECT NUMBER: 090029.00

CLIENT: CT Consultants, Inc.

PROJECT LOCATION: Willoughby, Ohio



ELEVATION: 628.9 FT

PROFILE DESCRIPTION	SAMPLE TYPE/NO. INTERVAL	RECOVERY LENGTH (INCHES)	SPT BLOWS PER SIX INCHES	N_{60}	MOISTURE (%)	SHEAR STRENGTH (KSF)	REMARKS
SILTY CLAY with Sand and Gravel- Gray- Very Stiff (CL/ML) *(continued)*	SB9	18	5 5 7	15	12	4.5+	
	SB10	18	5 5 7	15	12	4.5+	
	SB11	18	5 7 8	19	10	4.5+	
	SB12	18	5 8 10	23	12	4.5+	Boring was terminated due to driller reporting enountering a pressurized pocket of odorless gas at 31 ft
31.0 597.9							

END OF BORING AT 31.0 FEET.

SME

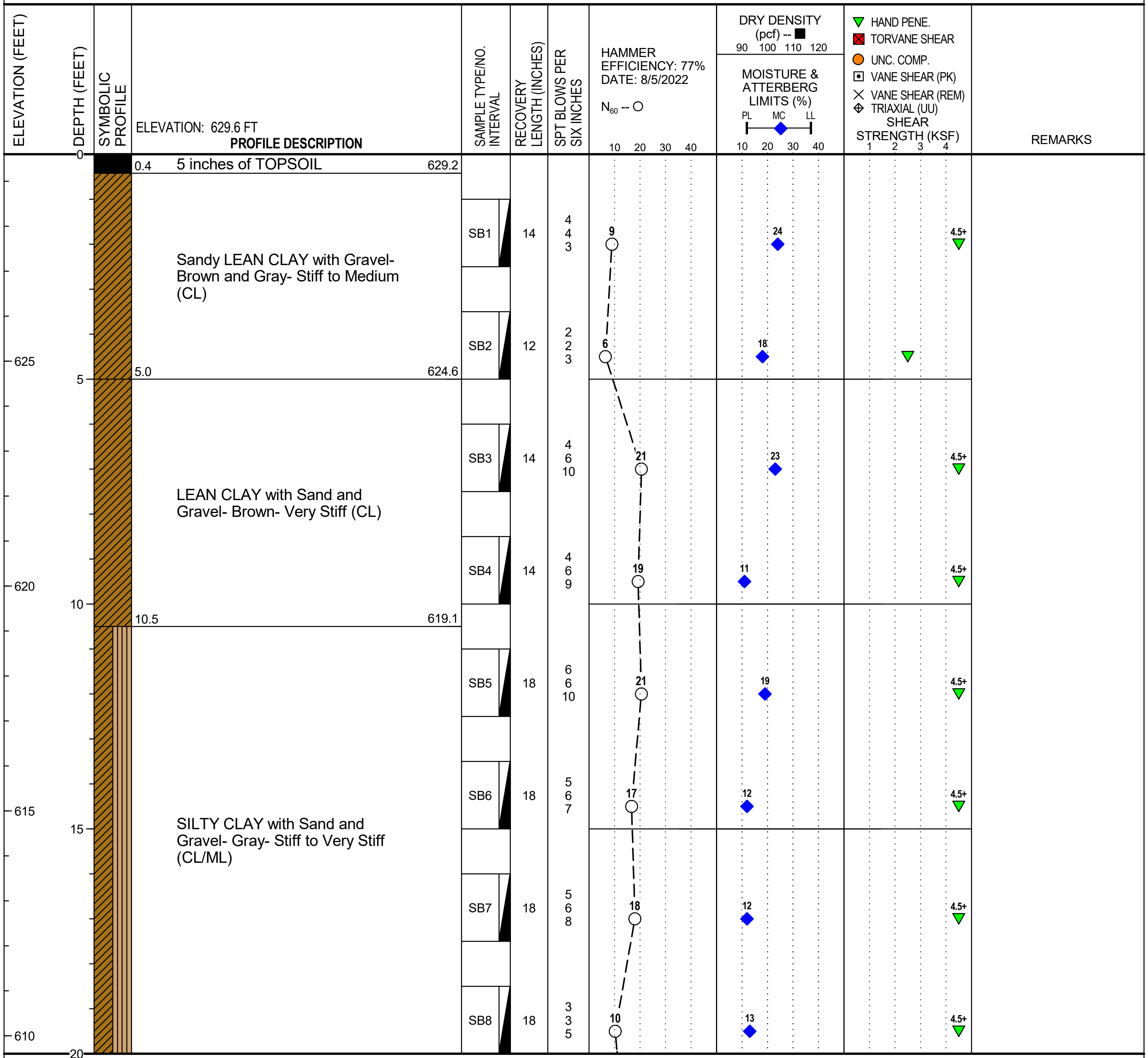
BORING B5

PAGE 1 OF 2

BORING DEPTH: 35 FEET

PROJECT NAME: Nason Basin to Grove Ave Storm Sewer PH I
PROJECT NUMBER: 090029.00
CLIENT: CT Consultants, Inc.
PROJECT LOCATION: Willoughby, Ohio

DATE STARTED: 8/26/22
COMPLETED: 8/26/22
BORING METHOD: 3-3/4" Hollow-stem Auger
DRILLER: WI/JH
RIG NO.: 293 (CME 55)
LOGGED BY: APP
CHECKED BY: BPL



Depth (ft)	Profile Description	Elevation	Sample	Recovery (in)	SPT Blows	N_{60}	MC (%)	Hand Pene. (ksf)
0.4	5 inches of TOPSOIL	629.2						
5.0	Sandy LEAN CLAY with Gravel- Brown and Gray- Stiff to Medium (CL)	624.6	SB1	14	4 4 3	9	24	4.5+
			SB2	12	2 2 3	6	18	
10.5	LEAN CLAY with Sand and Gravel- Brown- Very Stiff (CL)	619.1	SB3	14	4 6 10	21	23	4.5+
			SB4	14	4 6 9	19	11	4.5+
	SILTY CLAY with Sand and Gravel- Gray- Stiff to Very Stiff (CL/ML)		SB5	18	6 6 10	21	19	4.5+
			SB6	18	5 6 7	17	12	4.5+
			SB7	18	5 6 8	18	12	4.5+
			SB8	18	3 3 5	10	13	4.5+

GROUNDWATER & BACKFILL INFORMATION

GROUNDWATER WAS NOT ENCOUNTERED

BACKFILL METHOD: Auger Cuttings

NOTES:
1. The indicated stratification lines are approximate. The in-situ transitions between materials may be gradual.
2. The colors depicted on the symbolic profile are solely for visualization purposes and do not necessarily represent the in-situ colors encountered.

(Continued Next Page)

SME

BORING B5

PAGE 2 OF 2

BORING DEPTH: 35 FEET

PROJECT NAME: Nason Basin to Grove Ave Storm Sewer PH I
PROJECT NUMBER: 090029.00
CLIENT: CT Consultants, Inc.
PROJECT LOCATION: Willoughby, Ohio

ELEVATION: 629.6 FT

HAMMER EFFICIENCY: 77%
DATE: 8/5/2022

N_{60} -- ○

DRY DENSITY (pcf) -- ■

MOISTURE & ATTERBERG LIMITS (%): PL, MC ◆, LL

- ▼ HAND PENE.
- ☒ TORVANE SHEAR
- ● UNC. COMP.
- ⊡ VANE SHEAR (PK)
- × VANE SHEAR (REM)
- ⊕ TRIAXIAL (UU)

SHEAR STRENGTH (KSF)

ELEVATION (FEET)	DEPTH (FEET)	PROFILE DESCRIPTION	SAMPLE TYPE/NO. INTERVAL	RECOVERY LENGTH (INCHES)	SPT BLOWS PER SIX INCHES	N_{60}	MOISTURE (%)	SHEAR STRENGTH (KSF)	REMARKS
	20	SILTY CLAY with Sand and Gravel- Gray- Stiff to Very Stiff (CL/ML) *(continued)*	SB9	18	3 4 7	14	13	4.5+	
605	25		SB10	16	3 4 8	15	13	4.5+	
			SB11	18	5 6 10	21	12	4.5+	
601.6	28.0	Sandy SILTY CLAY with Gravel- Gray- Hard (CL-ML)							
600	30		SB12	16	5 9 14	30	11	4.5+	
			SB13	18	8 10 12	28	8	▼	
595			AS14	18	15 18 14	41	10	4.5+	
594.6	35.0	END OF BORING AT 35.0 FEET.							
590	40								
585	45								

BORING B6

PAGE 1 OF 2

BORING DEPTH: 35 FEET

PROJECT NAME: Nason Basin to Grove Ave Storm Sewer PH I
PROJECT NUMBER: 090029.00
CLIENT: CT Consultants, Inc.
PROJECT LOCATION: Willoughby, Ohio

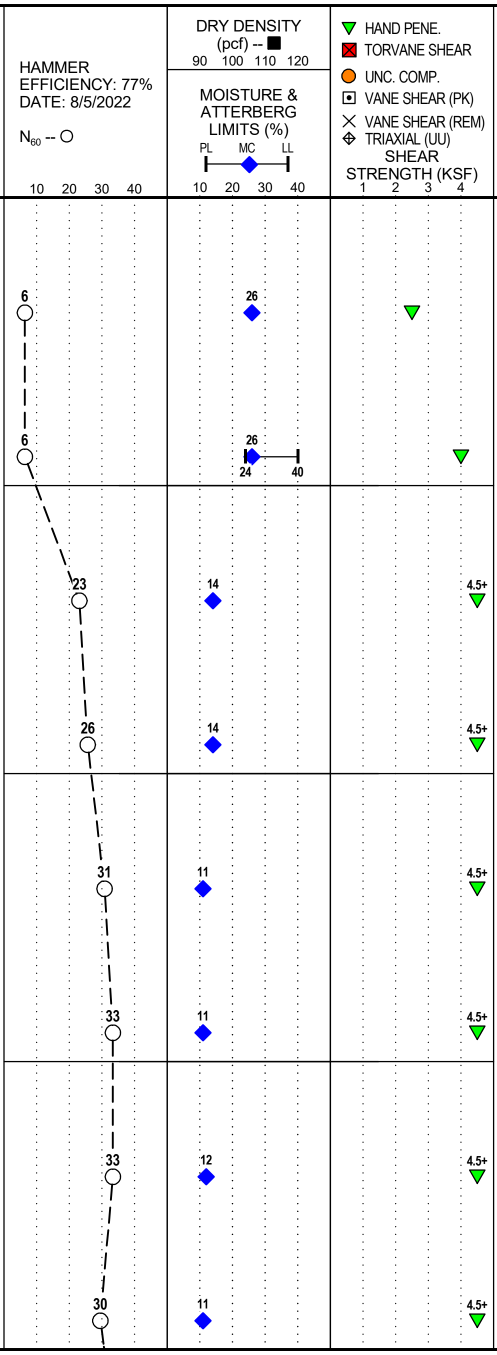
DATE STARTED: 8/26/22
COMPLETED: 8/26/22
BORING METHOD: 3-3/4" Hollow-stem Auger
DRILLER: WI/JH
RIG NO.: 293 (CME 55)
LOGGED BY: APP
CHECKED BY: BPL

ELEVATION: 630.6 FT

HAMMER EFFICIENCY: 77%
DATE: 8/5/2022

DEPTH (FEET)	ELEVATION (FEET)	PROFILE DESCRIPTION
0.3	630.4	3 inches of TOPSOIL
5.5	625.1	Sandy LEAN CLAY with Gravel- Brown- Medium (CL)
10.5	620.1	LEAN CLAY with Sand and Gravel- Brown- Very Stiff (CL)
		SILTY CLAY with Sand and Gravel- Gray- Very Stiff to Hard (CL/ML)

SAMPLE TYPE/NO. INTERVAL	RECOVERY LENGTH (INCHES)	SPT BLOWS PER SIX INCHES	N_{60}	MOISTURE (%)	SHEAR STRENGTH (KSF)	REMARKS
SB1	14	2 2 3	6	26		
SB2	14	2 2 3	6	26 (PL 24, LL 40)		
SB3	12	5 7 11	23	14	4.5+	
SB4	16	7 9 11	26	14	4.5+	
SB5	18	5 10 14	31	11	4.5+	
SB6	18	8 11 15	33	11	4.5+	
SB7	18	9 12 14	33	12	4.5+	
SB8	18	9 10 13	30	11	4.5+	



GROUNDWATER & BACKFILL INFORMATION

GROUNDWATER WAS NOT ENCOUNTERED

BACKFILL METHOD: Auger Cuttings

NOTES:
1. The indicated stratification lines are approximate. The in-situ transitions between materials may be gradual.
2. The colors depicted on the symbolic profile are solely for visualization purposes and do not necessarily represent the in-situ colors encountered.

(Continued Next Page)

BORING B6

PAGE 2 OF 2

BORING DEPTH: 35 FEET

PROJECT NAME: Nason Basin to Grove Ave Storm Sewer PH I

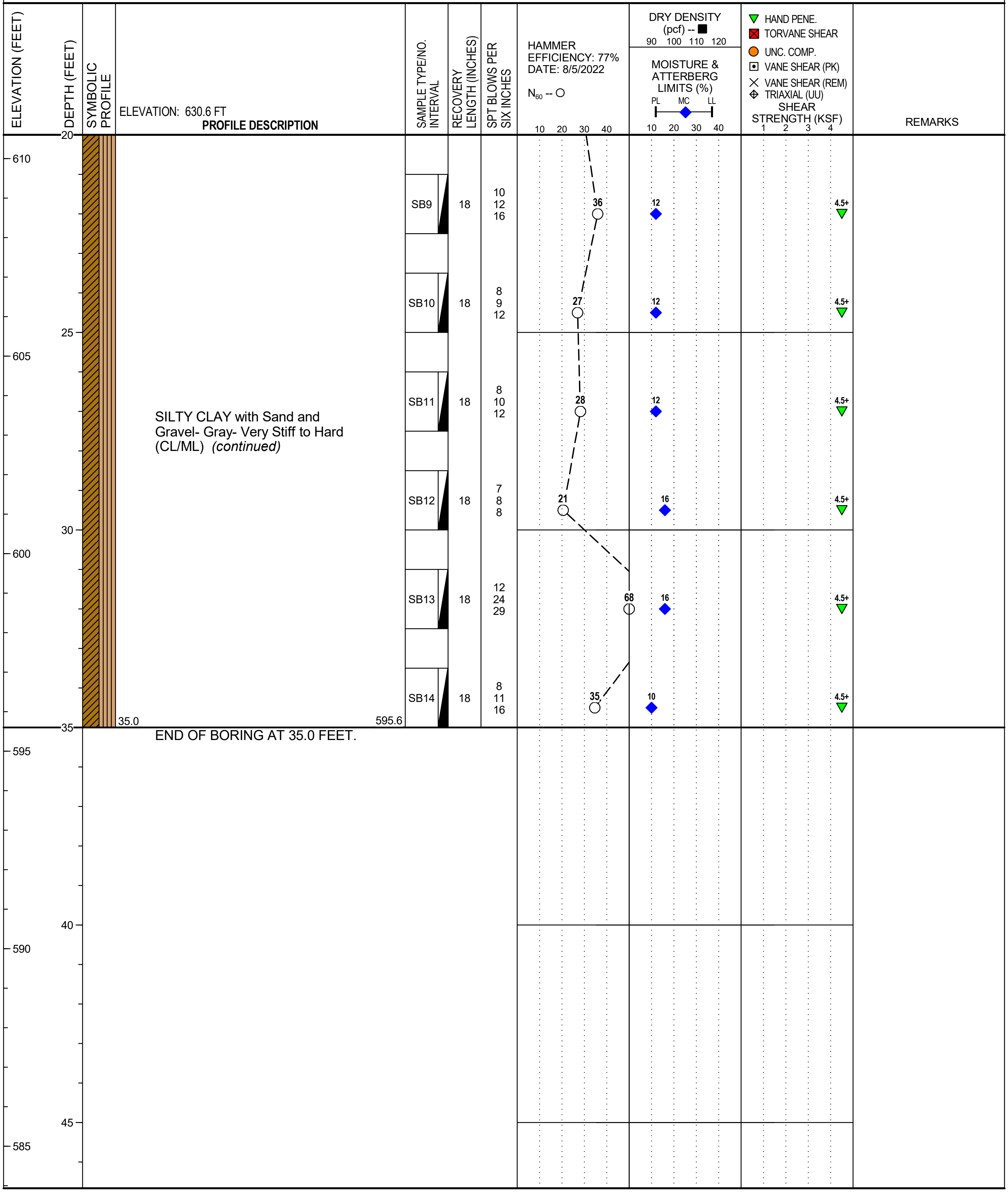
PROJECT NUMBER: 090029.00

CLIENT: CT Consultants, Inc.

PROJECT LOCATION: Willoughby, Ohio

HAMMER EFFICIENCY: 77%
DATE: 8/5/2022

ELEVATION: 630.6 FT



SAMPLE TYPE/NO. INTERVAL	RECOVERY LENGTH (INCHES)	SPT BLOWS PER SIX INCHES	N_{60}	MC (%)	HAND PENE. (KSF)
SB9	18	10 12 16	36	12	4.5+
SB10	18	8 9 12	27	12	4.5+
SB11	18	8 10 12	28	12	4.5+
SB12	18	7 8 8	21	16	4.5+
SB13	18	12 24 29	68	16	4.5+
SB14	18	8 11 16	35	10	4.5+

SILTY CLAY with Sand and Gravel- Gray- Very Stiff to Hard (CL/ML) *(continued)*

35.0 595.6

END OF BORING AT 35.0 FEET.

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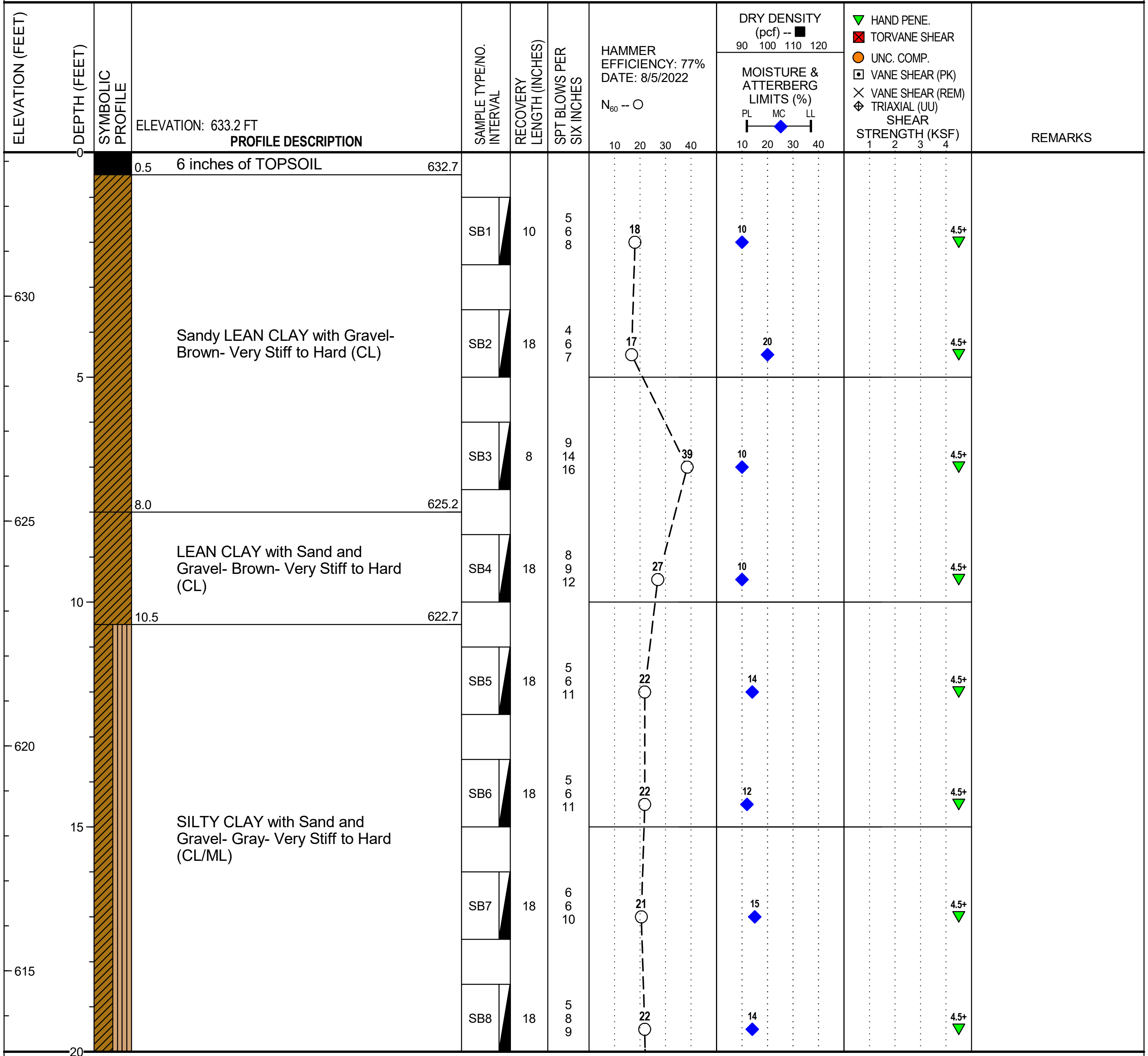
BORING B7

PAGE 1 OF 2

BORING DEPTH: 35 FEET

PROJECT NAME: Nason Basin to Grove Ave Storm Sewer PH I
PROJECT NUMBER: 090029.00
CLIENT: CT Consultants, Inc.
PROJECT LOCATION: Willoughby, Ohio

DATE STARTED: 8/26/22
COMPLETED: 8/26/22
BORING METHOD: 3-3/4" Hollow-stem Auger w/AW Rod
DRILLER: JH/LP
RIG NO.: 293 (CME 55)
LOGGED BY: APP
CHECKED BY: BPL



ELEVATION: 633.2 FT

DEPTH (FT)	PROFILE DESCRIPTION	ELEVATION (FT)
0.5	6 inches of TOPSOIL	632.7
8.0	Sandy LEAN CLAY with Gravel- Brown- Very Stiff to Hard (CL)	625.2
10.5	LEAN CLAY with Sand and Gravel- Brown- Very Stiff to Hard (CL)	622.7
	SILTY CLAY with Sand and Gravel- Gray- Very Stiff to Hard (CL/ML)	

SAMPLE TYPE/NO. INTERVAL	RECOVERY LENGTH (INCHES)	SPT BLOWS PER SIX INCHES	N_{60}	MOISTURE (%)	HAND PENE. (KSF)
SB1	10	5 6 8	18	10	4.5+
SB2	18	4 6 7	17	20	4.5+
SB3	8	9 14 16	39	10	4.5+
SB4	18	8 9 12	27	10	4.5+
SB5	18	5 6 11	22	14	4.5+
SB6	18	5 6 11	22	12	4.5+
SB7	18	6 6 10	21	15	4.5+
SB8	18	5 8 9	22	14	4.5+

GROUNDWATER & BACKFILL INFORMATION

	DEPTH (FT)	ELEV (FT)
▽ **DURING BORING:**	34.5	598.7
▼ **AT END OF BORING:**	Note 3	

BACKFILL METHOD: Auger Cuttings

NOTES:
1. The indicated stratification lines are approximate. The in-situ transitions between materials may be gradual.
2. The colors depicted on the symbolic profile are solely for visualization purposes and do not necessarily represent the in-situ colors encountered.
3. Groundwater was not encountered upon completion of drilling.

(Continued Next Page)

BORING B7

PAGE 2 OF 2

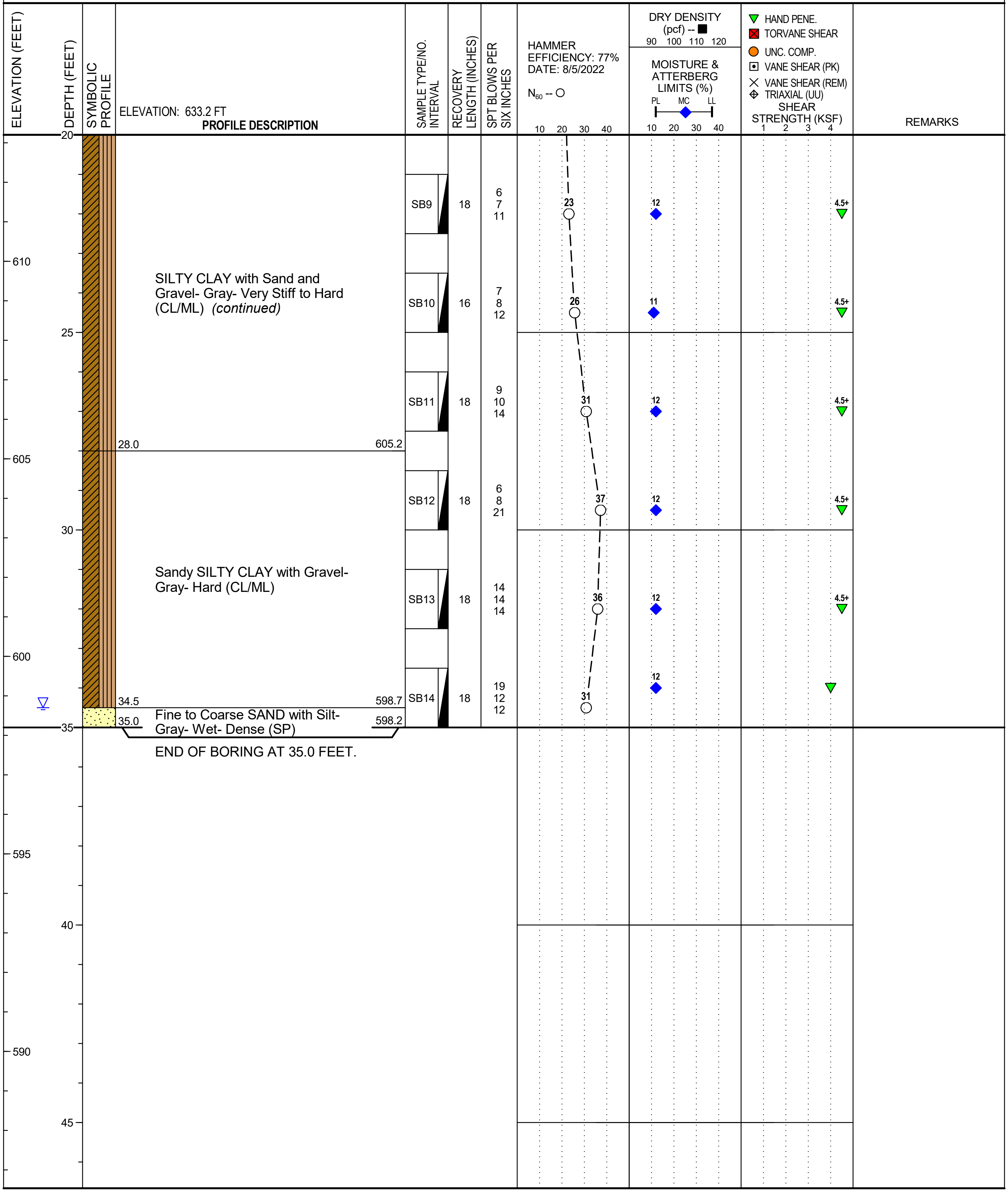
BORING DEPTH: 35 FEET

PROJECT NAME: Nason Basin to Grove Ave Storm Sewer PH I

PROJECT NUMBER: 090029.00

CLIENT: CT Consultants, Inc.

PROJECT LOCATION: Willoughby, Ohio



Depth (ft)	Elevation (ft)	Profile Description
20.0–28.0	605.2	SILTY CLAY with Sand and Gravel- Gray- Very Stiff to Hard (CL/ML) *(continued)*
28.0–34.5	598.7	Sandy SILTY CLAY with Gravel- Gray- Hard (CL/ML)
34.5–35.0	598.2	Fine to Coarse SAND with Silt- Gray- Wet- Dense (SP)

END OF BORING AT 35.0 FEET.

Sample	Recovery (in)	SPT Blows	N60	MC (%)	Hand Pene. (ksf)
SB9	18	6 7 11	23	12	4.5+
SB10	16	7 8 12	26	11	4.5+
SB11	18	9 10 14	31	12	4.5+
SB12	18	6 8 21	37	12	4.5+
SB13	18	14 14 14	36	12	4.5+
SB14	18	19 12 12	31	12	

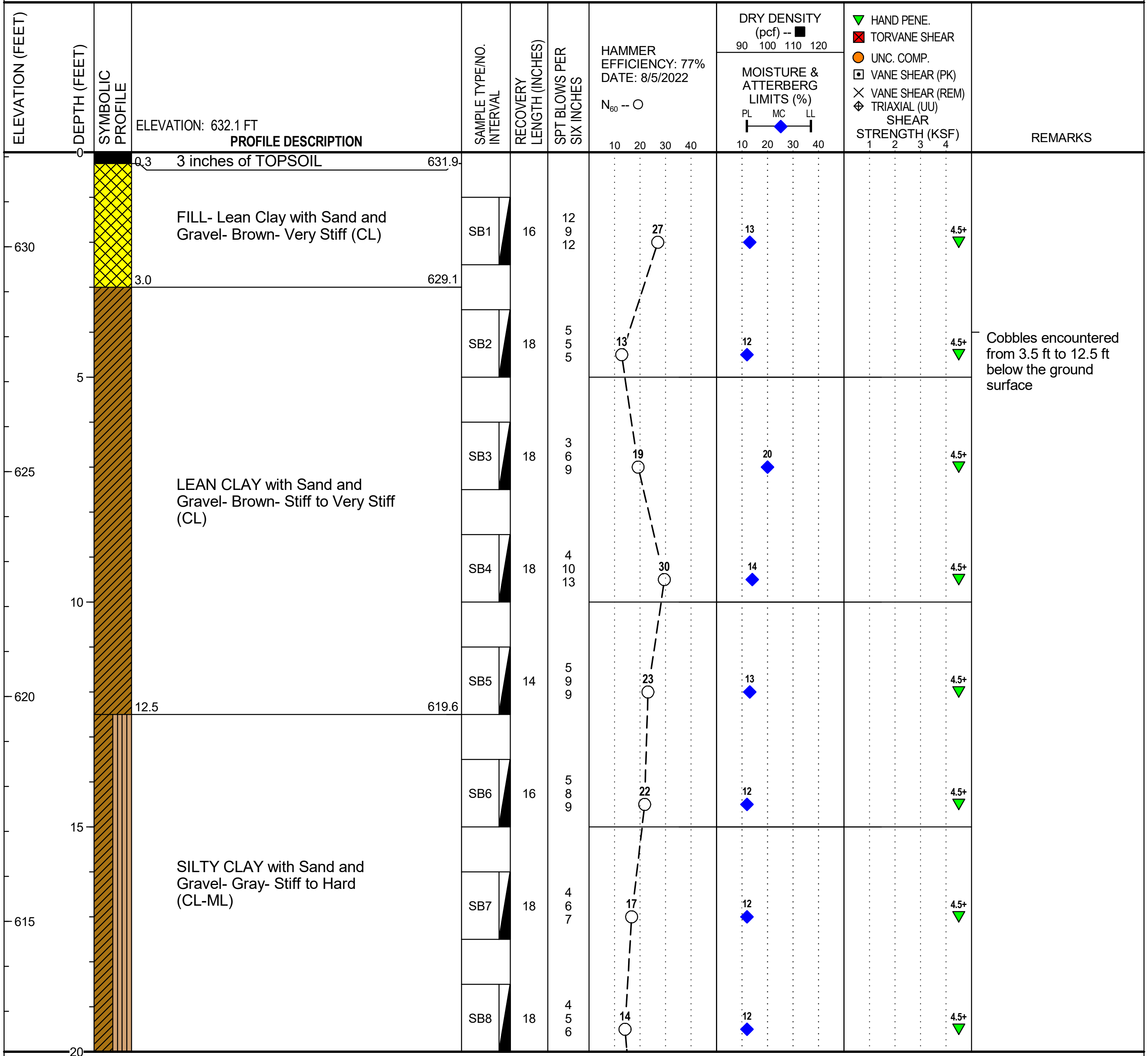
SME

BORING B8

PAGE 1 OF 2

BORING DEPTH: 35 FEET

PROJECT NAME: Nason Basin to Grove Ave Storm Sewer PH I
PROJECT NUMBER: 090029.00
CLIENT: CT Consultants, Inc.
PROJECT LOCATION: Willoughby, Ohio
DATE STARTED: 8/26/22
COMPLETED: 8/26/22
BORING METHOD: 3-3/4" Hollow-stem Auger w/AW Rod
DRILLER: JH/LP
RIG NO.: 293 (CME 55)
LOGGED BY: APP
CHECKED BY: BPL



DEPTH (FEET)	ELEVATION (FEET)	PROFILE DESCRIPTION
0.3	631.9	3 inches of TOPSOIL
3.0	629.1	FILL- Lean Clay with Sand and Gravel- Brown- Very Stiff (CL)
12.5	619.6	LEAN CLAY with Sand and Gravel- Brown- Stiff to Very Stiff (CL)
		SILTY CLAY with Sand and Gravel- Gray- Stiff to Hard (CL-ML)

SAMPLE TYPE/NO.	RECOVERY LENGTH (INCHES)	SPT BLOWS PER SIX INCHES	N_{60}	MC (%)	HAND PENE. (KSF)
SB1	16	12 9 12	27	13	4.5+
SB2	18	5 5 5	13	12	4.5+
SB3	18	3 6 9	19	20	4.5+
SB4	18	4 10 13	30	14	4.5+
SB5	14	5 9 9	23	13	4.5+
SB6	16	5 8 9	22	12	4.5+
SB7	18	4 6 7	17	12	4.5+
SB8	18	4 5 6	14	12	4.5+

REMARKS: Cobbles encountered from 3.5 ft to 12.5 ft below the ground surface

GROUNDWATER & BACKFILL INFORMATION

GROUNDWATER WAS NOT ENCOUNTERED

BACKFILL METHOD: Refer to Well Log WB8

NOTES:
1. The indicated stratification lines are approximate. The in-situ transitions between materials may be gradual.
2. The colors depicted on the symbolic profile are solely for visualization purposes and do not necessarily represent the in-situ colors encountered.

(Continued Next Page)

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BORING B8

PAGE 2 OF 2

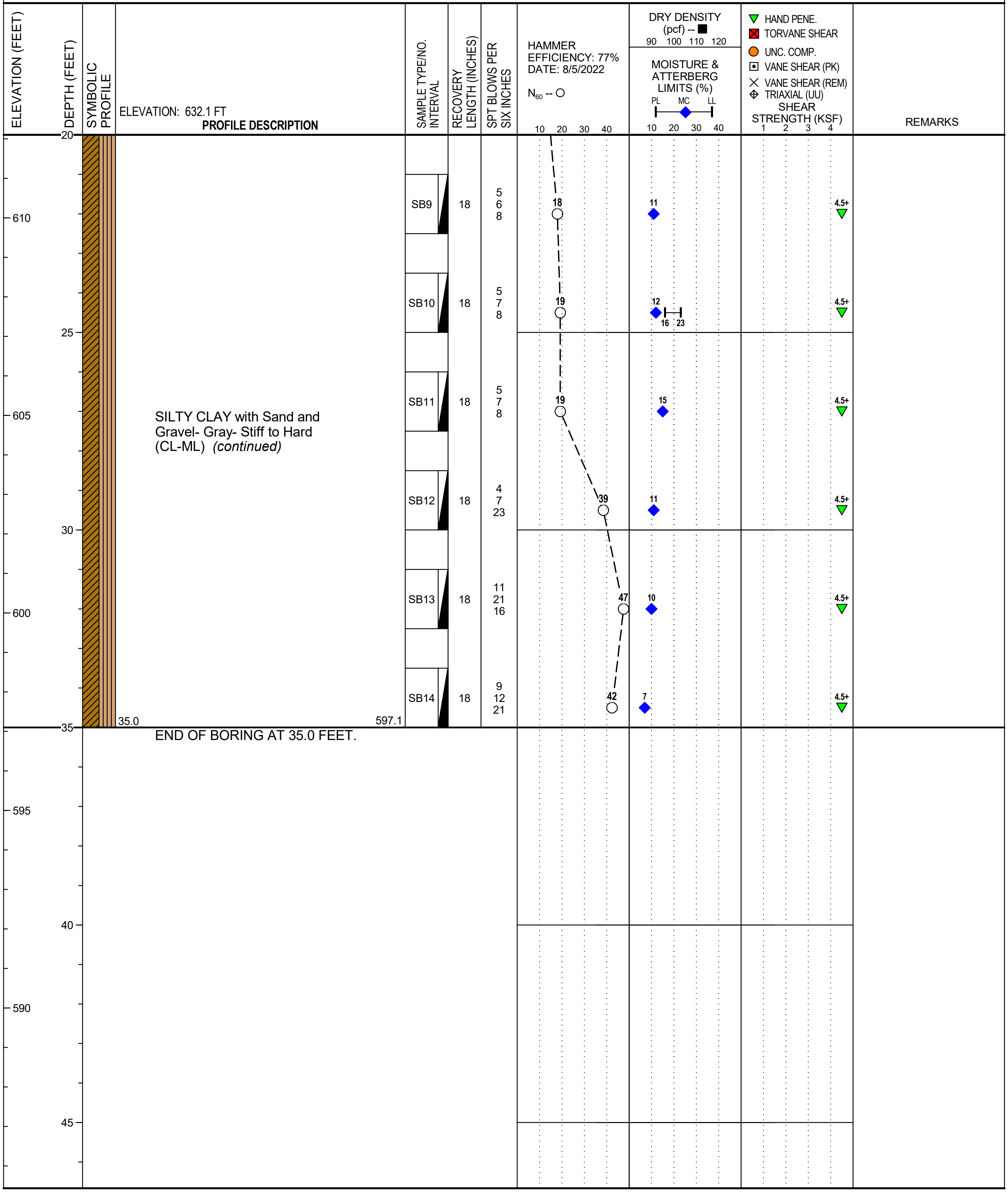
BORING DEPTH: 35 FEET

PROJECT NAME: Nason Basin to Grove Ave Storm Sewer PH I

PROJECT NUMBER: 090029.00

CLIENT: CT Consultants, Inc.

PROJECT LOCATION: Willoughby, Ohio



SILTY CLAY with Sand and Gravel- Gray- Stiff to Hard (CL-ML) *(continued)*

END OF BORING AT 35.0 FEET.

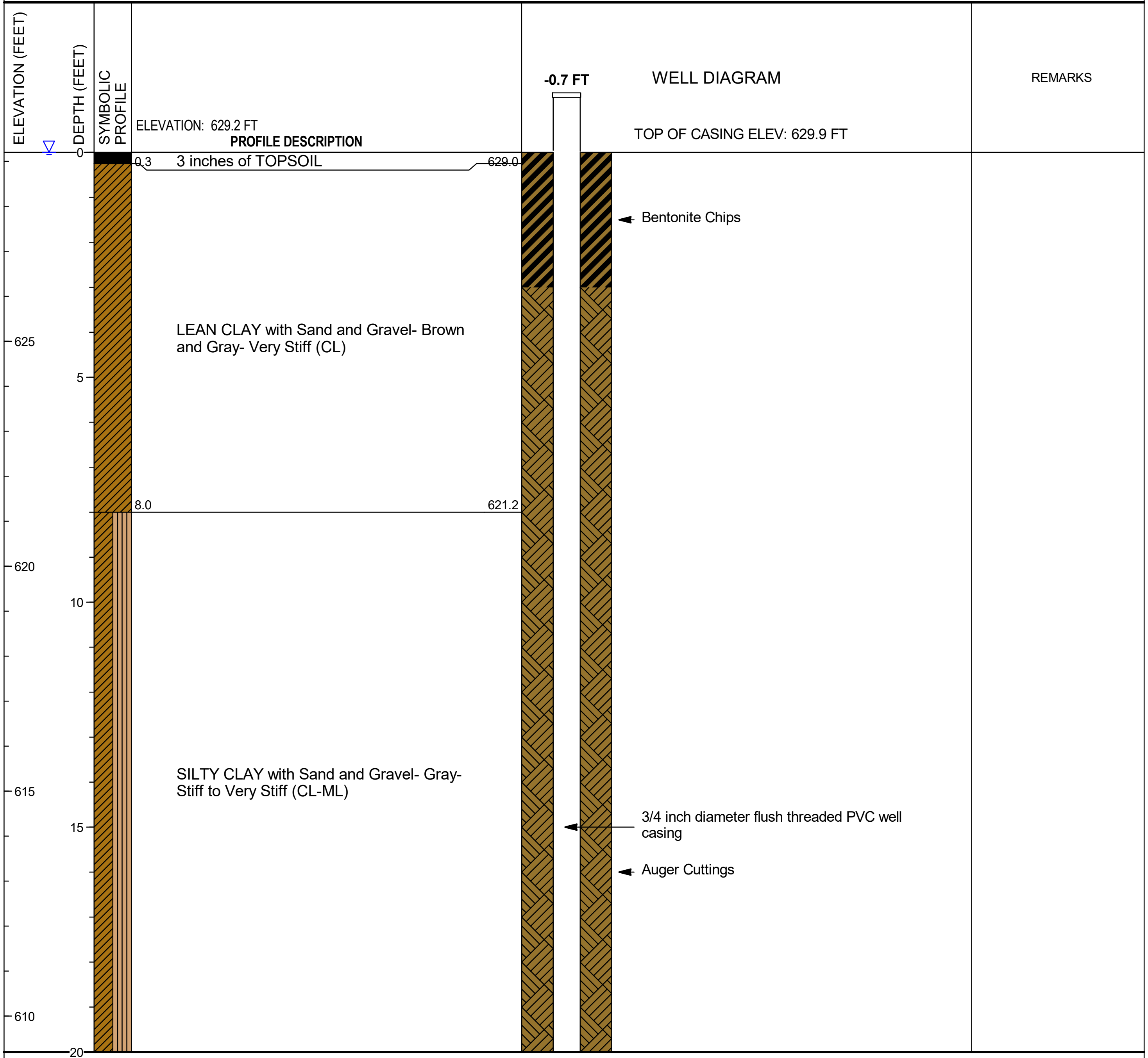
SAMPLE TYPE/NO. INTERVAL	RECOVERY LENGTH (INCHES)	SPT BLOWS PER SIX INCHES	N60	MOISTURE & ATTERBERG LIMITS (%)	SHEAR STRENGTH (KSF)
SB9	18	5 6 8	18	11	4.5+
SB10	18	5 7 8	19	12 16 23	4.5+
SB11	18	5 7 8	19	15	4.5+
SB12	18	4 7 23	39	11	4.5+
SB13	18	11 21 16	47	10	4.5+
SB14	18	9 12 21	42	7	4.5+

WELL WB1

PAGE 1 OF 2

WELL DEPTH: 35 FEET

PROJECT NAME: Nason Basin to Grove Ave Storm Sewer PH I
PROJECT NUMBER: 090029.00
CLIENT: CT Consultants, Inc.
PROJECT LOCATION: Willoughby, Ohio
DATE STARTED: 8/29/22
COMPLETED: 8/29/22
BORING METHOD: 3-3/4" Hollow-stem Auger
DRILLER: WI/RM
RIG NO.: 635-CME55-RT ATV
LOGGED BY: APP
CHECKED BY: BPL



3 inches of TOPSOIL

LEAN CLAY with Sand and Gravel- Brown and Gray- Very Stiff (CL)

SILTY CLAY with Sand and Gravel- Gray- Stiff to Very Stiff (CL-ML)

GROUNDWATER INFORMATION

	DEPTH (FT)	ELEV (FT)

WELL WATER LEVEL DATA

DATE	DEPTH (FT)	ELEV (FT)
10/26/2022	6.3	622.9
11/8/2022	6.1	623.1

NOTES: 1. The indicated stratification lines are approximate. The in-situ transitions between materials may be gradual.
2. The colors depicted on the symbolic profile are solely for visualization purposes and do not necessarily represent the in-situ colors encountered.

(Continued Next Page)

WELL WB1

WELL DEPTH: 35 FEET

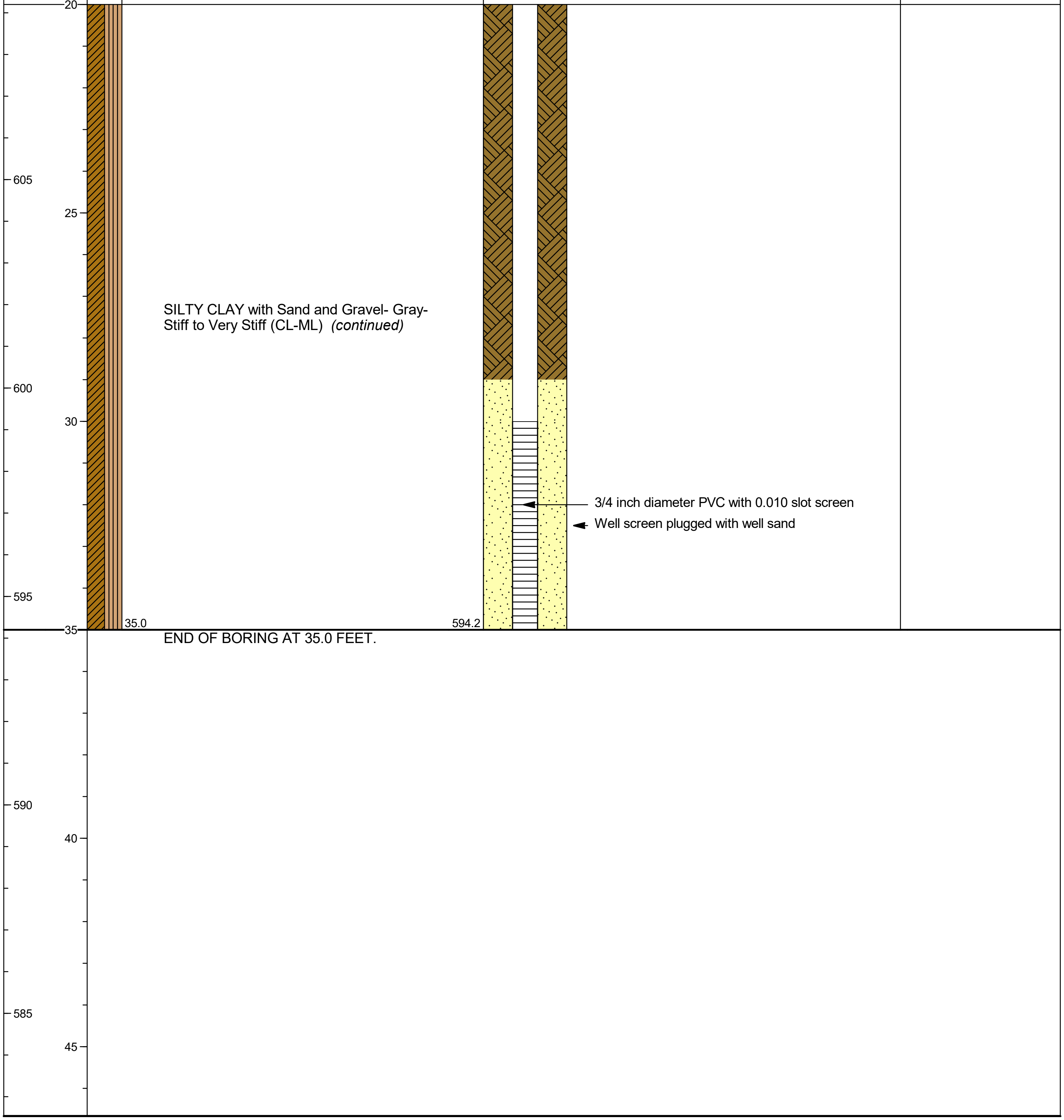
PROJECT NAME: Nason Basin to Grove Ave Storm Sewer PH I

PROJECT NUMBER: 090029.00

CLIENT: CT Consultants, Inc.

PROJECT LOCATION: Willoughby, Ohio

ELEVATION (FEET) | DEPTH (FEET) | SYMBOLIC PROFILE | ELEVATION: 629.2 FT | **PROFILE DESCRIPTION** | WELL DIAGRAM | REMARKS



SILTY CLAY with Sand and Gravel- Gray- Stiff to Very Stiff (CL-ML) *(continued)*

END OF BORING AT 35.0 FEET.

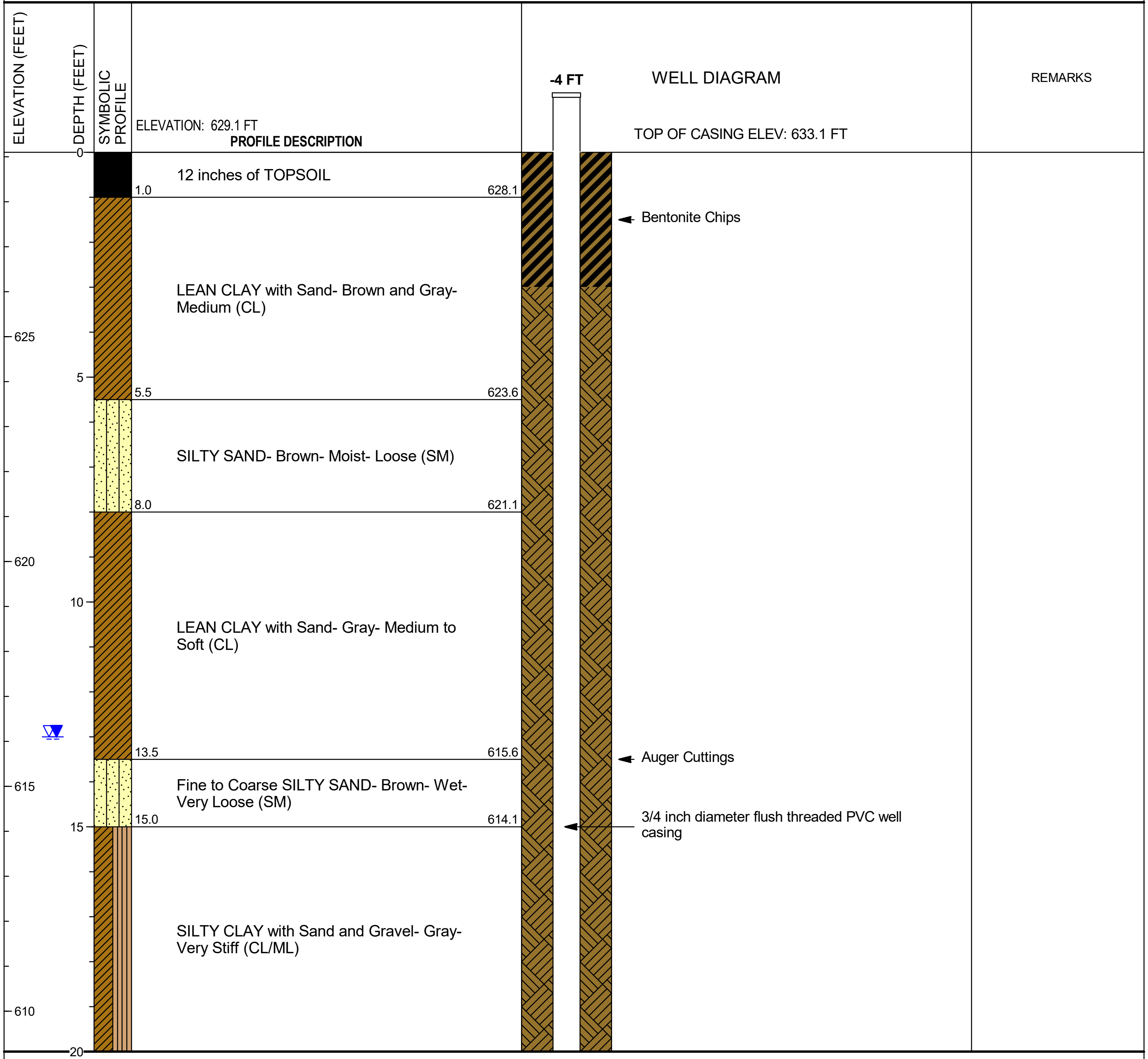
SME

WELL WB3

PAGE 1 OF 2

WELL DEPTH: 30 FEET

PROJECT NAME: Nason Basin to Grove Ave Storm Sewer PH I
PROJECT NUMBER: 090029.00
CLIENT: CT Consultants, Inc.
PROJECT LOCATION: Willoughby, Ohio
DATE STARTED: 9/20/22
COMPLETED: 9/20/22
BORING METHOD: 3-3/4" Hollow-stem Auger w/AW Rod
DRILLER: JH/WI
RIG NO.: 293 (CME 55)
LOGGED BY: APP
CHECKED BY: BPL



ELEVATION: 629.1 FT

Depth (ft)	PROFILE DESCRIPTION	Elev (ft)
1.0	12 inches of TOPSOIL	628.1
5.5	LEAN CLAY with Sand- Brown and Gray- Medium (CL)	623.6
8.0	SILTY SAND- Brown- Moist- Loose (SM)	621.1
13.5	LEAN CLAY with Sand- Gray- Medium to Soft (CL)	615.6
15.0	Fine to Coarse SILTY SAND- Brown- Wet- Very Loose (SM)	614.1
	SILTY CLAY with Sand and Gravel- Gray- Very Stiff (CL/ML)	

GROUNDWATER INFORMATION

	DEPTH (FT)	ELEV (FT)
▽ **DURING BORING:**	13.0	616.1
▼ **AT END OF BORING:**	13.0	616.1

WELL WATER LEVEL DATA

DATE	DEPTH (FT)	ELEV (FT)
11/8/2022	6.3	622.8

NOTES:
1. The indicated stratification lines are approximate. The in-situ transitions between materials may be gradual.
2. The colors depicted on the symbolic profile are solely for visualization purposes and do not necessarily represent the in-situ colors encountered.

(Continued Next Page)

WELL WB3

WELL DEPTH: 30 FEET

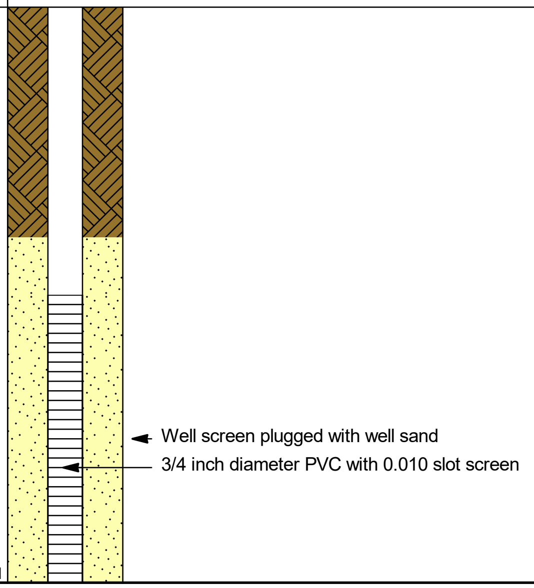
PROJECT NAME: Nason Basin to Grove Ave Storm Sewer PH I

PROJECT NUMBER: 090029.00

CLIENT: CT Consultants, Inc.

PROJECT LOCATION: Willoughby, Ohio

ELEVATION (FEET)	DEPTH (FEET)	SYMBOLIC PROFILE	ELEVATION: 629.1 FT PROFILE DESCRIPTION	WELL DIAGRAM	REMARKS
	20	▨			
605	25	▨	SILTY CLAY with Sand and Gravel- Gray- Very Stiff (CL/ML) *(continued)*		
600	30	▨	30.0 599.1		
595	35		END OF BORING AT 30.0 FEET.		
590	40				
585	45				



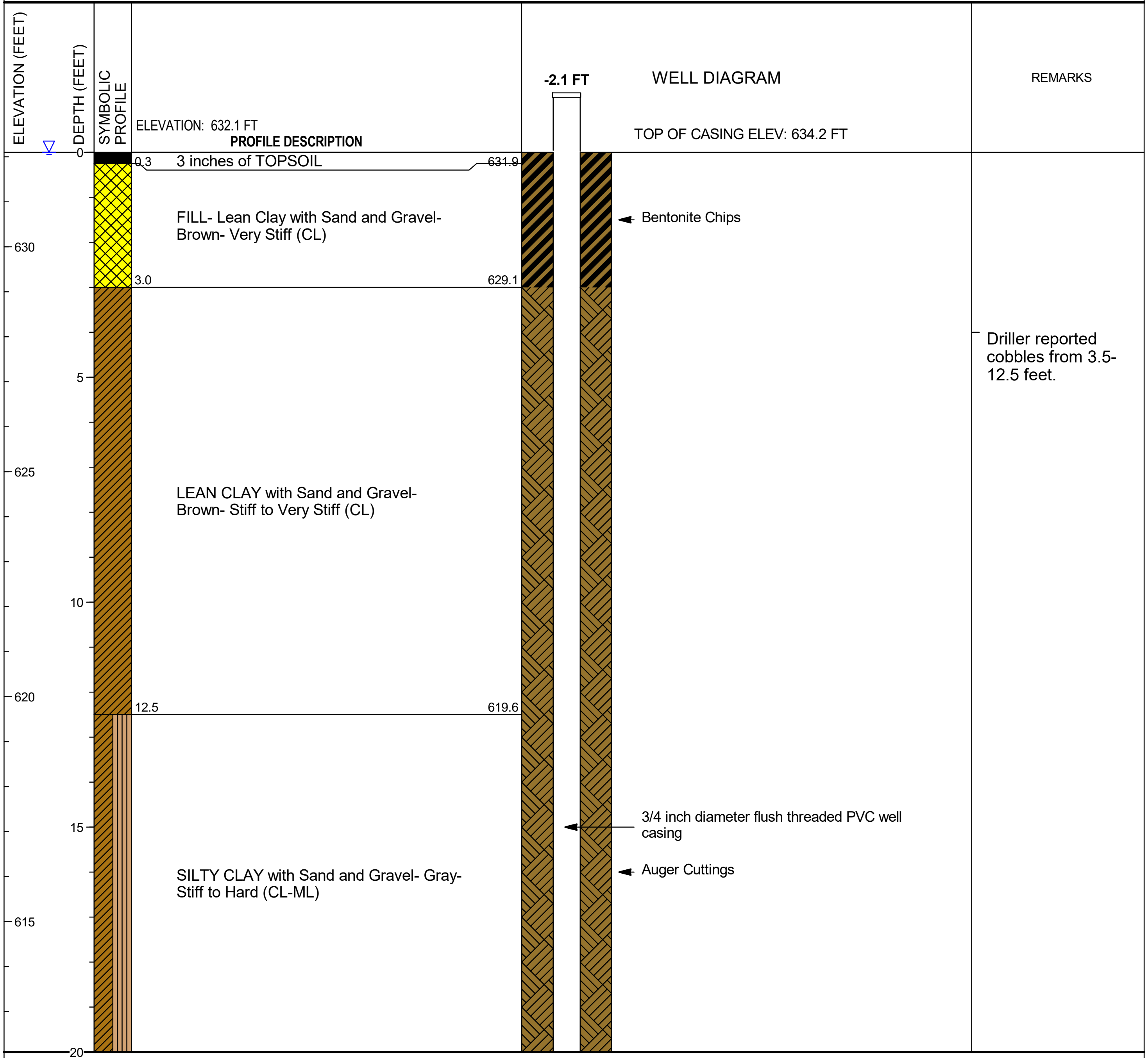
WELL WB8

PAGE 1 OF 2

WELL DEPTH: 35 FEET

PROJECT NAME: Nason Basin to Grove Ave Storm Sewer PH I
PROJECT NUMBER: 090029.00
CLIENT: CT Consultants, Inc.
PROJECT LOCATION: Willoughby, Ohio

DATE STARTED: 8/26/22
COMPLETED: 8/26/22
BORING METHOD: 3-3/4" Hollow-stem Auger w/AW Rod
DRILLER: JH/LP
RIG NO.: 293 (CME 55)
LOGGED BY: APP
CHECKED BY: BPL



3 inches of TOPSOIL

FILL- Lean Clay with Sand and Gravel- Brown- Very Stiff (CL)

LEAN CLAY with Sand and Gravel- Brown- Stiff to Very Stiff (CL)

SILTY CLAY with Sand and Gravel- Gray- Stiff to Hard (CL-ML)

Driller reported cobbles from 3.5-12.5 feet.

GROUNDWATER INFORMATION

	DEPTH (FT)	ELEV (FT)

WELL WATER LEVEL DATA

DATE	DEPTH (FT)	ELEV (FT)
10/26/2022	12	620.1
11/8/2022	12.2	619.9

NOTES:
1. The indicated stratification lines are approximate. The in-situ transitions between materials may be gradual.
2. The colors depicted on the symbolic profile are solely for visualization purposes and do not necessarily represent the in-situ colors encountered.

(Continued Next Page)

SME

WELL WB8

PAGE 2 OF 2

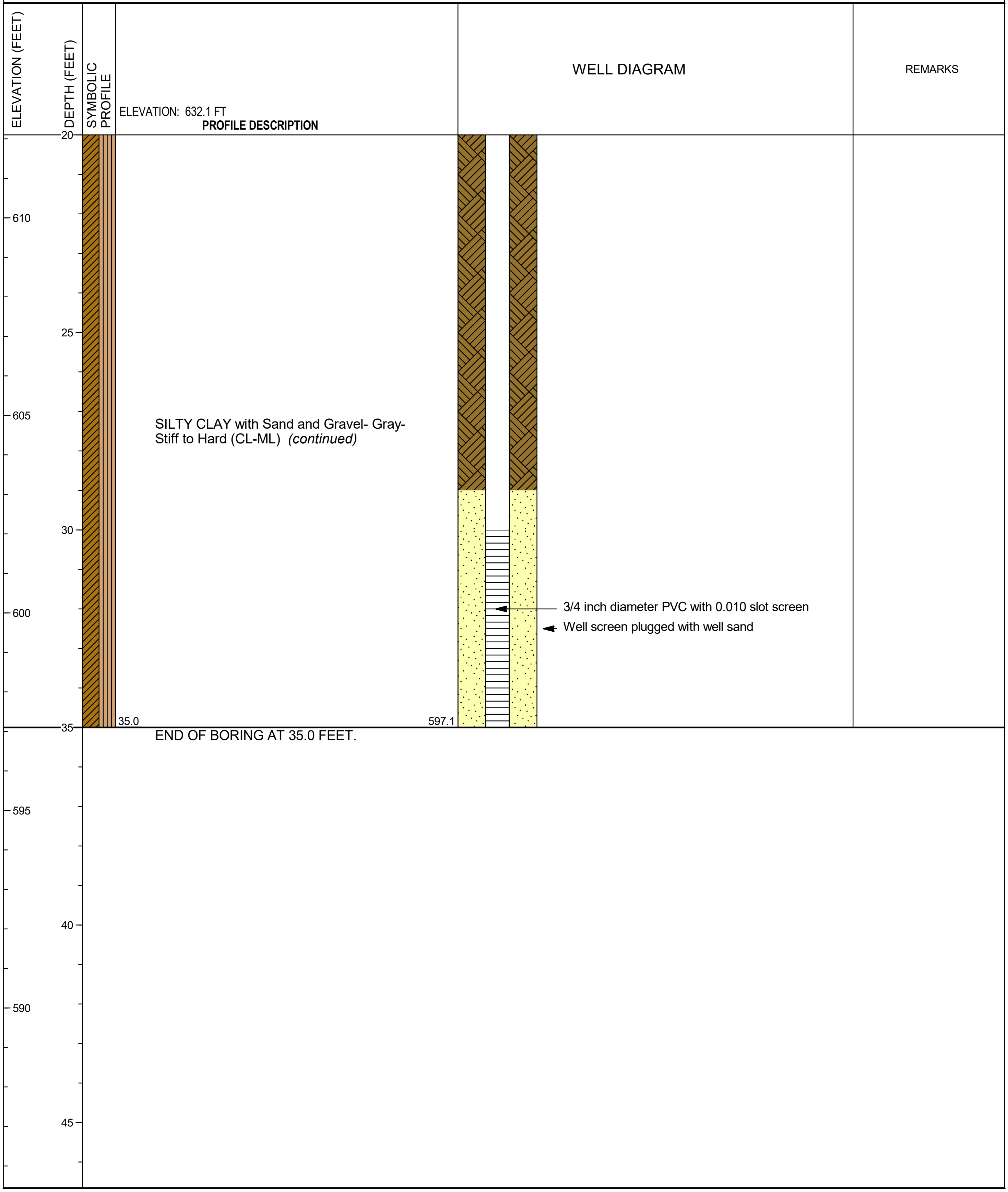
WELL DEPTH: 35 FEET

PROJECT NAME: Nason Basin to Grove Ave Storm Sewer PH I

PROJECT NUMBER: 090029.00

CLIENT: CT Consultants, Inc.

PROJECT LOCATION: Willoughby, Ohio



SILTY CLAY with Sand and Gravel- Gray- Stiff to Hard (CL-ML) *(continued)*

3/4 inch diameter PVC with 0.010 slot screen

Well screen plugged with well sand

END OF BORING AT 35.0 FEET.

LIQUID LIMIT, PLASTIC LIMIT & PLASTICITY INDEX
ASTM D4318 - A

SME
9375 CHILLICOTHE ROAD, KIRTLAND, OH 44094
PHONE: 440-256-6500   FAX: 440-256-6507

PROJECT: Nason Basin to Grove Avenue Storm Sewer Impr.
LOCATION: Willoughby, OH
PROJECT#: 090029.00
DATE: September 12, 2022

DATE OBTAINED: August 29, 2022
SAMPLE NUMBER: SB11 (26'-27.5')
SAMPLE LOCATION: B1
SAMPLE DESCRIPTION: SILTY CLAY with Sand and Gravel- Gray
TECHNICIAN: DG

TEST METHOD: ASTM D4318
METHOD - A

TEST DATA:

LIQUID LIMIT

Point #:	1	2	3
Wet Wt + Tare, g:	42.72	42.37	42.35
Dry Wt + Tare, g:	41.07	40.71	40.79
Tare Wt.:	34.03	33.26	33.57
Water Content:	23.44	22.28	21.61
Number of Blows:	16	25	34

Water Content corrected for method B:	22

PLASTIC LIMIT TEST

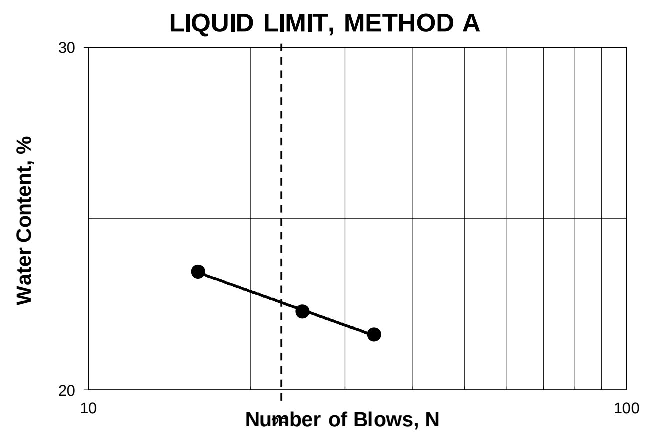
Wet Wt + Tare, g:	39.73	40.16
Dry Wt + Tare, g:	38.80	39.27
Tare Wt, g:	33.06	33.58
Water Content:	16.20	15.64

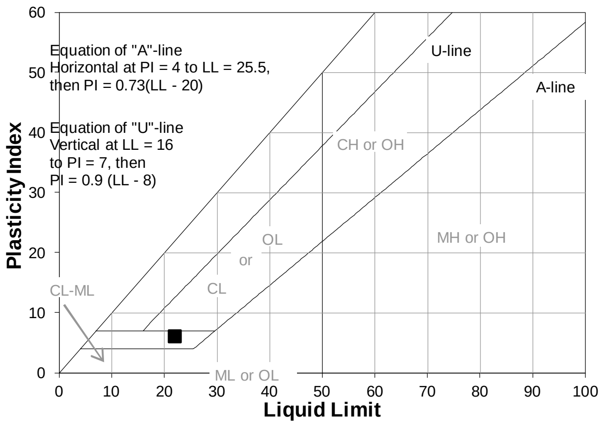
PLASTICITY INDEX

LIQUID LIMIT:	22
PLASTIC LIMIT:	16
PLASTICITY INDEX:	6

CLASSIFICATION: CL-ML

REMARKS: Sample air dried prior to testing





SME
9375 CHILLICOTHE ROAD, KIRTLAND, OH 44094
PHONE: 440-256-6500 FAX: 440-256-6507

LIQUID LIMIT, PLASTIC LIMIT & PLASTICITY INDEX
ASTM D4318 - A

PROJECT: Nason Basin to Grove Avenue Storm Sewer Impr.
LOCATION: Willoughby, OH
PROJECT#: 090029.00
DATE: September 12, 2022

DATE OBTAINED: August 26, 2022
SAMPLE NUMBER: SB2 (3.5'-5')
SAMPLE LOCATION: B6
SAMPLE DESCRIPTION: Sandy LEAN CLAY with Gravel- Brown
TECHNICIAN: DG

TEST METHOD: ASTM D4318
METHOD - A

TEST DATA:

LIQUID LIMIT

Point #:	1	2	3
Wet Wt + Tare, g:	42.48	46.02	42.03
Dry Wt + Tare, g:	39.83	43.29	39.62
Tare Wt.:	33.52	36.39	33.31
Water Content:	42.00	39.57	38.19
Number of Blows:	15	24	35

Water Content corrected for method B:	39

PLASTIC LIMIT TEST

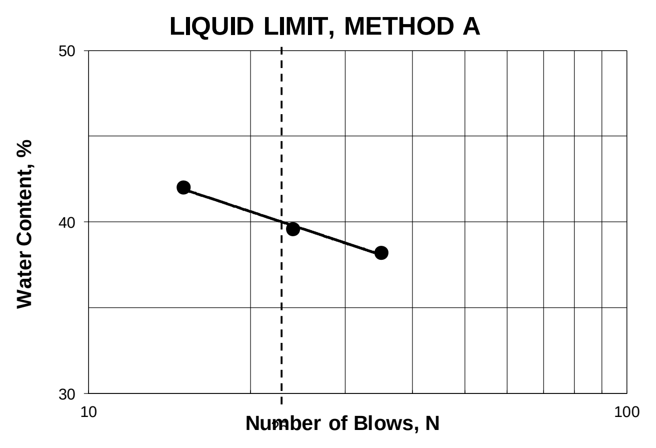
Wet Wt + Tare, g:	40.20	40.39
Dry Wt + Tare, g:	38.85	39.02
Tare Wt, g:	33.30	33.43
Water Content:	24.32	24.51

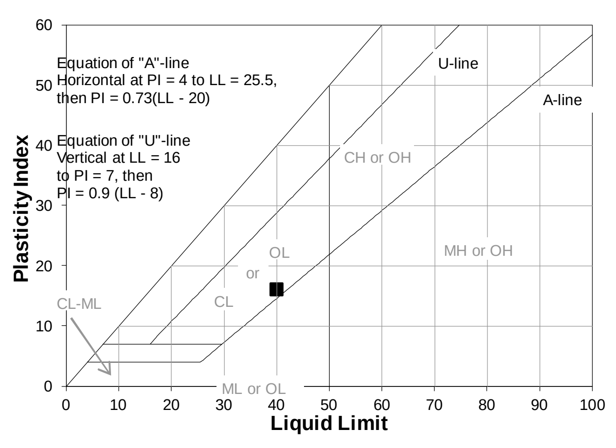
PLASTICITY INDEX

LIQUID LIMIT:	40
PLASTIC LIMIT:	24
PLASTICITY INDEX:	16

CLASSIFICATION: CL

REMARKS: Sample air dried prior to testing





9375 CHILLICOTHE ROAD, KIRTLAND, OH 44094
PHONE: 440-256-6500   FAX: 440-256-6507

LIQUID LIMIT, PLASTIC LIMIT & PLASTICITY INDEX
ASTM D4318 - A

PROJECT: Nason Basin to Grove Avenue Storm Sewer Impr.
LOCATION: Willoughby, OH
PROJECT#: 090029.00
DATE: September 12, 2022

DATE OBTAINED: August 26, 2022
SAMPLE NUMBER: SB10 (23.5'-25')
SAMPLE LOCATION: B8
SAMPLE DESCRIPTION: SILTY CLAY with Sand and Gravel- Gray
TECHNICIAN: DG

TEST METHOD: ASTM D4318
METHOD - A

TEST DATA:

LIQUID LIMIT

Point #:	1	2	3
Wet Wt + Tare, g:	43.99	45.33	44.01
Dry Wt + Tare, g:	42.03	43.25	42.20
Tare Wt.:	33.98	34.18	34.01
Water Content:	24.35	22.93	22.10
Number of Blows:	15	24	34

Water Content corrected for method B:	23

PLASTIC LIMIT TEST

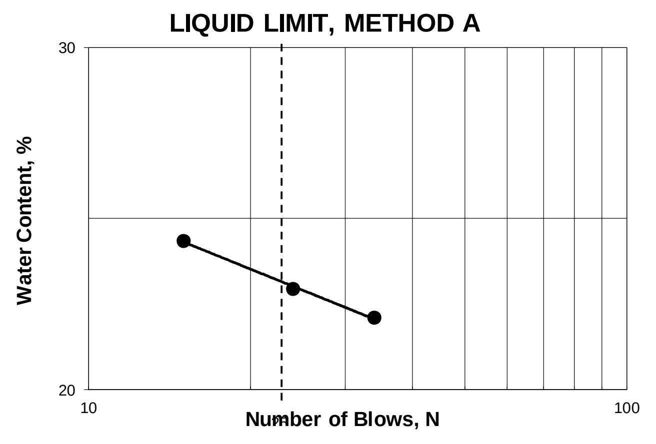
Wet Wt + Tare, g:	40.93	40.92
Dry Wt + Tare, g:	39.95	39.94
Tare Wt, g:	34.07	33.81
Water Content:	16.67	15.99

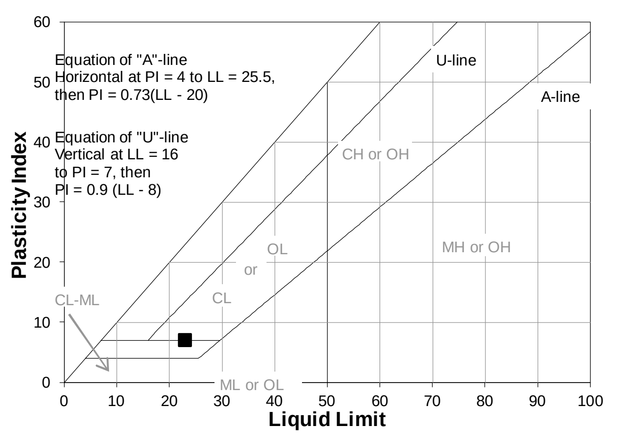
PLASTICITY INDEX

LIQUID LIMIT:	23
PLASTIC LIMIT:	16
PLASTICITY INDEX:	7

CLASSIFICATION: CL-ML

REMARKS: Sample air dried prior to testing





APPENDIX B

IMPORTANT INFORMATION ABOUT THIS GEOTECHNICAL-ENGINEERING REPORT
GENERAL COMMENTS
LABORATORY TESTING PROCEDURES

Important Information about This

Geotechnical-Engineering Report

Subsurface problems are a principal cause of construction delays, cost overruns, claims, and disputes.

While you cannot eliminate all such risks, you can manage them. The following information is provided to help.

The Geoprofessional Business Association (GBA) has prepared this advisory to help you – assumedly a client representative – interpret and apply this geotechnical-engineering report as effectively as possible. In that way, you can benefit from a lowered exposure to problems associated with subsurface conditions at project sites and development of them that, for decades, have been a principal cause of construction delays, cost overruns, claims, and disputes. If you have questions or want more information about any of the issues discussed herein, contact your GBA-member geotechnical engineer. Active engagement in GBA exposes geotechnical engineers to a wide array of risk-confrontation techniques that can be of genuine benefit for everyone involved with a construction project.

Understand the Geotechnical-Engineering Services Provided for this Report

Geotechnical-engineering services typically include the planning, collection, interpretation, and analysis of exploratory data from widely spaced borings and/or test pits. Field data are combined with results from laboratory tests of soil and rock samples obtained from field exploration (if applicable), observations made during site reconnaissance, and historical information to form one or more models of the expected subsurface conditions beneath the site. Local geology and alterations of the site surface and subsurface by previous and proposed construction are also important considerations. Geotechnical engineers apply their engineering training, experience, and judgment to adapt the requirements of the prospective project to the subsurface model(s). Estimates are made of the subsurface conditions that will likely be exposed during construction as well as the expected performance of foundations and other structures being planned and/or affected by construction activities.

The culmination of these geotechnical-engineering services is typically a geotechnical-engineering report providing the data obtained, a discussion of the subsurface model(s), the engineering and geologic engineering assessments and analyses made, and the recommendations developed to satisfy the given requirements of the project. These reports may be titled investigations, explorations, studies, assessments, or evaluations. Regardless of the title used, the geotechnical-engineering report is an engineering interpretation of the subsurface conditions within the context of the project and does not represent a close examination, systematic inquiry, or thorough investigation of all site and subsurface conditions.

Geotechnical-Engineering Services are Performed for Specific Purposes, Persons, and Projects, and At Specific Times

Geotechnical engineers structure their services to meet the specific needs, goals, and risk management preferences of their clients. A geotechnical-engineering study conducted for a given civil engineer will not likely meet the needs of a civil-works constructor or even a different civil engineer. Because each geotechnical-engineering study is unique, each geotechnical-engineering report is unique, prepared *solely* for the client.

Likewise, geotechnical-engineering services are performed for a specific project and purpose. For example, it is unlikely that a geotechnical-engineering study for a refrigerated warehouse will be the same as one prepared for a parking garage; and a few borings drilled during a preliminary study to evaluate site feasibility will not be adequate to develop geotechnical design recommendations for the project.

Do not rely on this report if your geotechnical engineer prepared it:

- for a different client;
- for a different project or purpose;
- for a different site (that may or may not include all or a portion of the original site); or
- before important events occurred at the site or adjacent to it; e.g., man-made events like construction or environmental remediation, or natural events like floods, droughts, earthquakes, or groundwater fluctuations.

Note, too, the reliability of a geotechnical-engineering report can be affected by the passage of time, because of factors like changed subsurface conditions; new or modified codes, standards, or regulations; or new techniques or tools. *If you are the least bit uncertain* about the continued reliability of this report, contact your geotechnical engineer before applying the recommendations in it. A minor amount of additional testing or analysis after the passage of time – if any is required at all – could prevent major problems.

Read this Report in Full

Costly problems have occurred because those relying on a geotechnical-engineering report did not read the report in its entirety. Do not rely on an executive summary. Do not read selective elements only. *Read and refer to the report in full.*

You Need to Inform Your Geotechnical Engineer About Change

Your geotechnical engineer considered unique, project-specific factors when developing the scope of study behind this report and developing the confirmation-dependent recommendations the report conveys. Typical changes that could erode the reliability of this report include those that affect:

- the site's size or shape;
- the elevation, configuration, location, orientation, function or weight of the proposed structure and the desired performance criteria;
- the composition of the design team; or
- project ownership.

As a general rule, *always* inform your geotechnical engineer of project or site changes – even minor ones – and request an assessment of their impact. *The geotechnical engineer who prepared this report cannot accept* *responsibility or liability for problems that arise because the geotechnical engineer was not informed about developments the engineer otherwise would have considered.*

Most of the "Findings" Related in This Report Are Professional Opinions

Before construction begins, geotechnical engineers explore a site's subsurface using various sampling and testing procedures. *Geotechnical engineers can observe actual subsurface conditions only at those specific locations where sampling and testing is performed.* The data derived from that sampling and testing were reviewed by your geotechnical engineer, who then applied professional judgement to form opinions about subsurface conditions throughout the site. Actual sitewide-subsurface conditions may differ – maybe significantly – from those indicated in this report. Confront that risk by retaining your geotechnical engineer to serve on the design team through project completion to obtain informed guidance quickly, whenever needed.

This Report's Recommendations Are Confirmation-Dependent

The recommendations included in this report – including any options or alternatives – are confirmation-dependent. In other words, they are not final, because the geotechnical engineer who developed them relied heavily on judgement and opinion to do so. Your geotechnical engineer can finalize the recommendations *only after observing actual subsurface conditions* exposed during construction. If through observation your geotechnical engineer confirms that the conditions assumed to exist actually do exist, the recommendations can be relied upon, assuming no other changes have occurred. *The geotechnical engineer who prepared this report cannot assume responsibility or liability for confirmation-dependent recommendations if you fail to retain that engineer to perform construction observation.*

This Report Could Be Misinterpreted

Other design professionals' misinterpretation of geotechnical-engineering reports has resulted in costly problems. Confront that risk by having your geotechnical engineer serve as a continuing member of the design team, to:

- confer with other design-team members;
- help develop specifications;
- review pertinent elements of other design professionals' plans and specifications; and
- be available whenever geotechnical-engineering guidance is needed.

You should also confront the risk of constructors misinterpreting this report. Do so by retaining your geotechnical engineer to participate in prebid and preconstruction conferences and to perform construction-phase observations.

Give Constructors a Complete Report and Guidance

Some owners and design professionals mistakenly believe they can shift unanticipated-subsurface-conditions liability to constructors by limiting the information they provide for bid preparation. To help prevent the costly, contentious problems this practice has caused, include the complete geotechnical-engineering report, along with any attachments or appendices, with your contract documents, *but be certain to note conspicuously that you've included the material for information purposes only.* To avoid misunderstanding, you may also want to note that "informational purposes" means constructors have no right to rely on the interpretations, opinions, conclusions, or recommendations in the report. Be certain that constructors know they may learn about specific project requirements, including options selected from the report, *only* from the design drawings and specifications. Remind constructors that they may perform their own studies if they want to, and *be sure to allow enough time* to permit them to do so. Only then might you be in a position to give constructors the information available to you, while requiring them to at least share some of the financial responsibilities stemming from unanticipated conditions. Conducting prebid and preconstruction conferences can also be valuable in this respect.

Read Responsibility Provisions Closely

Some client representatives, design professionals, and constructors do not realize that geotechnical engineering is far less exact than other engineering disciplines. This happens in part because soil and rock on project sites are typically heterogeneous and not manufactured materials with well-defined engineering properties like steel and concrete. That lack of understanding has nurtured unrealistic expectations that have resulted in disappointments, delays, cost overruns, claims, and disputes. To confront that risk, geotechnical engineers commonly include explanatory provisions in their reports. Sometimes labeled "limitations," many of these provisions indicate where geotechnical engineers' responsibilities begin and end, to help others recognize their own responsibilities and risks. *Read these provisions closely.* Ask questions. Your geotechnical engineer should respond fully and frankly.

Geoenvironmental Concerns Are Not Covered

The personnel, equipment, and techniques used to perform an environmental study – e.g., a "phase-one" or "phase-two" environmental site assessment – differ significantly from those used to perform a geotechnical-engineering study. For that reason, a geotechnical-engineering report does not usually provide environmental findings, conclusions, or recommendations; e.g., about the likelihood of encountering underground storage tanks or regulated contaminants. *Unanticipated subsurface environmental problems have led to project failures.* If you have not obtained your own environmental information about the project site, ask your geotechnical consultant for a recommendation on how to find environmental risk-management guidance.

Obtain Professional Assistance to Deal with Moisture Infiltration and Mold

While your geotechnical engineer may have addressed groundwater, water infiltration, or similar issues in this report, the engineer's services were not designed, conducted, or intended to prevent migration of moisture – including water vapor – from the soil through building slabs and walls and into the building interior, where it can cause mold growth and material-performance deficiencies. Accordingly, ***proper implementation of the geotechnical engineer's recommendations will not of itself be sufficient to prevent moisture infiltration. Confront the risk of moisture infiltration*** by including building-envelope or mold specialists on the design team. ***Geotechnical engineers are not building-envelope or mold specialists.***

GEOPROFESSIONAL
BUSINESS
ASSOCIATION

Telephone: 301/565-2733
e-mail: info@geoprofessional.org www.geoprofessional.org

GENERAL COMMENTS

BASIS OF GEOTECHNICAL REPORT

This report has been prepared in accordance with generally accepted geotechnical engineering practices to assist in the design and/or evaluation of this project. If the project plans, design criteria, and other project information referenced in this report and utilized by SME to prepare our recommendations are changed, the conclusions and recommendations contained in this report are not considered valid unless the changes are reviewed, and the conclusions and recommendations of this report are modified or approved in writing by our office.

The discussions and recommendations submitted in this report are based on the available project information, described in this report, and the geotechnical data obtained from the field exploration at the locations indicated in the report. Variations in the soil and groundwater conditions commonly occur between or away from sampling locations. The nature and extent of the variations may not become evident until the time of construction. If significant variations are observed during construction, SME should be contacted to reevaluate the recommendations of this report. SME should be retained to continue our services through construction to observe and evaluate the actual subsurface conditions relative to the recommendations made in this report.

In the process of obtaining and testing samples and preparing this report, procedures are followed that represent reasonable and accepted practice in the field of soil and foundation engineering. Specifically, field logs are prepared during the field exploration that describe field occurrences, sampling locations, and other information. Samples obtained in the field are frequently subjected to additional testing and reclassification in the laboratory and differences may exist between the field logs and the report logs. The engineer preparing the report reviews the field logs, laboratory classifications, and test data and then prepares the report logs. Our recommendations are based on the contents of the report logs and the information contained therein.

REVIEW OF DESIGN DETAILS, PLANS, AND SPECIFICATIONS

SME should be retained to review the design details, project plans, and specifications to verify those documents are consistent with the recommendations contained in this report.

REVIEW OF REPORT INFORMATION WITH PROJECT TEAM

Implementation of our recommendations may affect the design, construction, and performance of the proposed improvements, along with the potential inherent risks involved with the proposed construction. The client and key members of the design team, including SME, should discuss the issues covered in this report so that the issues are understood and applied in a manner consistent with the owner's budget, tolerance of risk, and expectations for performance and maintenance.

FIELD VERIFICATION OF GEOTECHNICAL CONDITIONS

SME should be retained to verify the recommendations of this report are properly implemented during construction. This may avoid misinterpretation of our recommendations by other parties and will allow us to review and modify our recommendations if variations in the site subsurface conditions are encountered.

PROJECT INFORMATION FOR CONTRACTOR

This report and any future addenda or other reports regarding this site should be made available to prospective contractors prior to submitting their proposals for their information only and to supply them with facts relative to the subsurface evaluation and laboratory test results. If the selected contractor encounters subsurface conditions during construction, which differ from those presented in this report, the contractor should promptly describe the nature and extent of the differing conditions in writing and SME should be notified so that we can verify those conditions. The construction contract should include provisions for dealing with differing conditions and contingency funds should be reserved for potential problems during earthwork and foundation construction. We would be pleased to assist you in developing the contract provisions based on our experience.

The contractor should be prepared to handle environmental conditions encountered at this site, which may affect the excavation, removal, or disposal of soil; dewatering of excavations; and health and safety of workers. Any Environmental Assessment reports prepared for this site should be made available for review by bidders and the successful contractor.

THIRD PARTY RELIANCE/REUSE OF THIS REPORT

This report has been prepared solely for the use of our Client for the project specifically described in this report. This report cannot be relied upon by other parties not involved in the project, unless specifically allowed by SME in writing. SME also is not responsible for the interpretation by other parties of the geotechnical data and the recommendations provided herein.

LABORATORY TESTING PROCEDURES

VISUAL ENGINEERING CLASSIFICATION

Visual classification was performed on recovered samples. The appended General Notes and Unified Soil Classification System (USCS) sheets include a brief summary of the general method used visually classify the soil and assign an appropriate USCS group symbol. The estimated group symbol, according to the USCS, is shown in parentheses following the textural description of the various strata on the boring logs appended to this report. The soil descriptions developed from visual classifications are sometimes modified to reflect the results of laboratory testing.

MOISTURE CONTENT

Moisture content tests were performed by weighing samples from the field at their in-situ moisture condition. These samples were then dried at a constant temperature (approximately 110º C) overnight in an oven. After drying, the samples were weighed to determine the dry weight of the sample and the weight of the water that was expelled during drying. The moisture content of the specimen is expressed as a percent and is the weight of the water compared to the dry weight of the specimen.

HAND PENETROMETER TESTS

In the hand penetrometer test, the unconfined compressive strength of a cohesive soil sample is estimated by measuring the resistance of the sample to the penetration of a small calibrated, spring-loaded cylinder. The maximum capacity of the penetrometer is 4.5 tons per square-foot (tsf). Theoretically, the undrained shear strength of the cohesive sample is one-half the unconfined compressive strength. The undrained shear strength (based on the hand penetrometer test) presented on the boring logs is reported in units of kips per square-foot (ksf).

TORVANE SHEAR TESTS

In the Torvane test, the shear strength of a low strength, cohesive soil sample is estimated by measuring the resistance of the sample to a torque applied through vanes inserted into the sample. The undrained shear strength of the samples is measured from the maximum torque required to shear the sample and is reported in units of kips per square-foot (ksf).

LOSS-ON-IGNITION (ORGANIC CONTENT) TESTS

Loss-on-ignition (LOI) tests are conducted by first weighing the sample and then heating the sample to dry the moisture from the sample (in the same manner as determining the moisture content of the soil). The sample is then re-weighed to determine the dry weight and then heated for 4 hours in a muffle furnace at a high temperature (approximately 440º C). After cooling, the sample is re-weighed to calculate the amount of ash remaining, which in turn is used to determine the amount of organic matter burned from the original dry sample. The organic matter content of the specimen is expressed as a percent compared to the dry weight of the sample.

ATTERBERG LIMITS TESTS

Atterberg limits tests consist of two components. The plastic limit of a cohesive sample is determined by rolling the sample into a thread and the plastic limit is the moisture content where a 1/8-inch thread begins to crumble. The liquid limit is determined by placing a ½-inch thick soil pat into the liquid limits cup and using a grooving tool to divide the soil pat in half. The cup is then tapped on the base of the liquid limits device using a crank handle. The number of drops of the cup to close the gap formed by the grooving tool ½ inch is recorded along with the corresponding moisture content of the sample. This procedure is repeated several times at different moisture contents and a graph of moisture content and the corresponding number of blows is plotted. The liquid limit is defined as the moisture content at a nominal 25 drops of the cup. From this test, the plasticity index can be determined by subtracting the plastic limit from the liquid limit.

Passionate People Building
and Revitalizing our World

SME