

**Proposed River Street
8-inch Waterline
Replacement**

**River Street
Willoughby, Ohio**

Geotechnical Subsurface Investigation

**Lake County
Department of Utilities
105 Main Street
Painesville, Ohio**

February 21, 2024

CT Project No. 231956

CT Consultants, Inc.

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February 21, 2024

CT Project No. 231956

Randell J. Rothlisberger, P.E.
County Sanitary Engineer
Lake County Department of Utilities
105 Main Street
Painesville, Ohio 44077

**Geotechnical Subsurface Investigation
River Street 8-inch Waterline Replacement
Willoughby, Ohio**

Following is the report of the geotechnical subsurface investigation performed by CT Consultants, Inc. (CT) for the referenced project. This study was conducted for the Lake County Department of Utilities to support design services for the Proposed River Street Utilities and Pavement Improvement Project.

This report contains the results of our study, our engineering interpretation of the results concerning the project characteristics, design and construction recommendations for pavements, and our recommendations for installation and support of the proposed underground utilities.

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

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

Sincerely,
CT Consultants, Inc.

Negoslav Tosanovic, P.E.
Geotechnical Project Manager



Curtis E. Roupe, P.E.
Vice President

GEOTECHNICAL SUBSURFACE INVESTIGATION
RIVER STREET 8-INCH WATERLINE REPLACEMENT
RIVER STREET, WILLOUGHBY, OHIO

FOR

LAKE COUNTY DEPARTMENT OF UTILITIES
105 MAIN STREET
PAINESVILLE, OHIO 44077

SUBMITTED

FEBRUARY 21, 2024
CT PROJECT NO. 231956

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1.0 INTRODUCTION

This geotechnical subsurface investigation report was performed for the Lake County Department of Utilities in support of design services for the Proposed River Street Utilities and Pavement Improvement Project. The general project area is shown on the Site Location Map (Plate 1.0). This report summarizes our understanding of the proposed construction, describes the investigative and testing procedures, presents the findings, discusses our evaluations and conclusions, and provides our design and construction recommendations for pavements, as well as provides our recommendations for installation and support of the proposed underground utilities.

The purpose of this investigation was to evaluate the subsurface conditions and laboratory data relative to the design and construction of the utilities and pavements at the referenced site. This investigation included four (4) test borings, field and laboratory soil testing, and a geotechnical engineering evaluation of the test results. This report includes:

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

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

2.0 INVESTIGATIVE PROCEDURES

This subsurface investigation included four (4) test borings; two of them (B-3 and B-4) were drilled by CT consultants on November 30, 2023, and remaining borings B-1 and B-2 were drilled by subcontractor Ridgeway Drilling on December 7, 2023, under CT direction. All four borings were performed to a depth of 10 feet below the existing grade. The test borings were located in the field by CT personnel in accordance with a proposed boring location plan submitted with the proposal for this study. The approximate locations of the borings are shown on the Test Boring Location Plan (Plate 2.0).

The test borings were performed in general accordance with geotechnical investigative procedures outlined in ASTM Standard D 1452. The test borings performed during this investigation were drilled with a Truck- and an ATV-mounted drill rigs with utilizing 2¼-inch diameter hollow-stem augers. The approximate ground surface elevations obtained by Google Earth software, termination depths, and elevations for the borings are summarized in Table 1.0 at the end of this section.

During auger advancement, soil samples were collected at 2½-foot throughout explored depths of 10 feet. Split-spoon (SS) samples were obtained by the Standard Penetration Test (SPT) Method (ASTM D 1586), which consists of driving a 2-inch outside diameter split-barrel sampler into the soil with a 140-pound weight falling freely through a distance of 30 inches. The sampler was driven in three successive 6-inch increments with the number of blows per increment being recorded. The sum of the number of blows required to advance the sampler the second and third 6-inch increments is termed the Standard Penetration Resistance (N-value) and is presented on the Logs of Test Borings attached to this report. The samples were sealed in jars and shipped to our laboratory for further classification and testing.

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

All of the recovered samples of the subsoils were visually or manually classified in accordance with the Ohio Department of Transportation (ODOT) soil classification system and were tested in our laboratory for moisture content (ASTM D 2216). Unconfined compressive strength estimates were obtained for the intact cohesive samples using a calibrated hand penetrometer. A particle size analysis (ASTM D 6913 and D 7928) and an Atterberg limits test (ASTM D 4318) were performed on representative samples from Boring B-2 (SS-2), B-3 (SS-1) to determine soil classification and soil index properties. The test results are presented on the Logs of Test Borings, Tabulation of Test Data sheets, and Grain Size Distribution and Atterberg Limits sheets attached to this report.

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

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

Test boring data is provided in the following table.

Table 1.0 - Test Boring Data		
Boring Number	Approximate Boring Termination Depth (Ft)	Approximate Ground Elevation (Ft)
B-1	10	674
B-2	10	685
B-3	10	688
B-4	10	699

3.0 PROPOSED CONSTRUCTION

The proposed project consists of proposed underground utility improvements in Willoughby, Ohio. We understand that the improvements consist of the replacement of an 8-inch iron cast waterline planned on the 2,535-foot-long section starting from the intersection with Union Street and extending up to 485± feet south of South Street in vicinity of the house number 4594 on River Street.

We also understand that these underground utilities will be installed using an open-cut excavation technique.

Pavements at the backfilled, repaired trenches, if utility installation is performed within the road, are anticipated to coincide with the existing pavement, which is flexible (asphalt) pavement over brick pavement at the time of exploration. Final design grades are assumed to approximate existing roadway grades. Traffic loads and volumes were not available at the time of preparing this proposal.

4.0 GENERAL SITE AND SUBSURFACE CONDITIONS

4.1 General Site Conditions

At the time of our investigation, the project area consisted primarily of single-family home residential properties with business and apartment complex buildings on the northern end of the improvement area. The area on the section along and close to the Chagrin River on the southern portion of the improvement is vacant with sporadic mature trees along the street. There is a 90± feet tall cliff in this area along the road starting approximately from Wilson Avenue and proceeding south throughout the improvement area. Topographically, the road pavement is gently and gradually sloping down from the south improvement limit, which is at elevation 700, and going south, reaching elevation 674 at the intersection with Union Street.

Borings B-1 through B-4 penetrated asphalt at the surface with thicknesses ranging from 2.0 to 6.5 inches underlain by approximately 5.5 to 10.0 inches of brick pavement over approximately 3.0 to 6.0 inches of aggregate base. Combined asphalt and brick pavements together with aggregate base thicknesses are summarized in the following table. It should be noted that pavement thicknesses were generally measured to the nearest ¼ inch.

Table 2.0 – Pavement Thickness (inch)			
Boring Number	Asphalt	Brick	Aggregate Base
B-1	2	6	*6+
B-2	2	6	*6+
B-3	6.5	5.5	3
B-4	4	10	6

*The aggregate base and underlying granular fill materials of similar composition, thickness is estimated.

4.2 General Soil and Rock Conditions

Based on the results of our field and laboratory tests, the subsurface profile in northern portion of the improvement area (Borings B-1 and B-2) is primarily

composed of granular, cohesionless materials extending 6.0 to 8.5 feet below existing grade. Strata of cohesive clay soils were encountered in Boring B-1, samples SS-3 and SS-4 and in Boring B-2, sample SS-2. The upper six feet of these materials are classified as either fill or possible fill. The subsurface profile on southern portion of the improvement area (Borings B-3 and B-4) is primarily composed of fine-grain cohesive clay soils with granular material detected in B-3, sample SS-3 and in B-4, sample SS-1. Granular soils consisted of silty sand or poorly graded sand with varying amounts of silt and gravel; shale fragments were noted in Boring B-3, sample SS-3. Within the cohesive soils consisting of lean clay, silty clay, and sandy silt, variable amounts of sand and gravel were noted, and trace root hairs were noted in Boring B-2 sample SS-2. All borings except B-1 were terminated in weathered shale rock detected in sample SS-4; Boring B-1 was terminated in naturally deposited cohesive clay material. Unconfined compressive strength test results on the cohesive samples generally ranged from 1.75 to 4.5 tons per square foot (tsf). One sample, SS-2 at boring B-2, had an unconfined compressive strength test result of 0.75 tsf. Moisture contents ranged from approximately 7 to 23 percent. All materials appear to be naturally deposited except for the near-surface 3.5 feet thick layer at the location of boring B-1 and B-2, which is classified as a fill. Underlying fill at these two locations, materials extending to 6 feet of depth are classified as a possible fill. SPT N-values for cohesive soils ranged from 4 to 32, and soil consistency was determined in the range between soft to hard. Soft and hard cohesive soils were detected in Boring B-3 samples SS-1 and SS-3, respectively. SPT N-values for granular soils are in the range of 6 to 21, and relative compactness is medium dense; loose soil with an SPT N-value of 6 was encountered in Boring B-4 sample SS-1. The soil color is brown, brown to gray, and gray at deeper depths. Rock hardness for encountered shale bedrock is determined to be soft to medium hard.

Two soil samples obtained from borings B-2 (SS-2) and B-3 (SS-1) were tested for Atterberg Limits with respective results of 34 and 36 for Liquid Limit (LL), 19 and 20 for Plastic Limit (PL) and 15 and 16 for Plasticity Index (PI). The percent passing the #200 sieve are determined to be 83 and 79 percent, respectively. In accordance with Unified Soil Classification System (USCS), these values along with gradation results, are indicative of Lean Clay with sand (CL). Following Ohio Department of Transportation (ODOT) Soil Classification System the soils are classified as A-6a and

A-6b material. Rock was encountered in three of four performed borings. Additional descriptions of the stratigraphy encountered in the borings are presented on the Logs of Test Borings.

4.3 Groundwater Conditions

No groundwater was encountered either during or after the completion of the drilling process. It should be noted all the boreholes were drilled and backfilled within the same day, and stabilized water levels are not likely to have occurred over this limited time period. Instrumentation was not installed to observe long-term groundwater levels.

Based on the soil characteristics and groundwater conditions encountered in the borings, it is our opinion that the static, long-term groundwater table is below the explored depths. However, we cannot rule out the possibility for perched groundwater on the site (water held in the pockets or layers of granular soil that are underlain or surrounded by relatively impermeable cohesive soil deposits). In particular, “perched” groundwater may be encountered within the pavement base materials and fill materials. If water bearing soils deposits are penetrated during construction excavations, water will be released; however, it is our experience that perched groundwater can typically be controlled by pumping from shallow sumps or by gravity drainage. Also, groundwater elevations can fluctuate with seasonal and climatic influences. Therefore, the groundwater conditions may vary at different times of the year from those encountered during this exploration.

5.0 DESIGN RECOMMENDATIONS

The following conclusions and recommendations are based on our understanding of the proposed construction and on the data obtained during the field investigation. If the project information or location as outlined is incorrect or should change significantly, a review of these recommendations should be made by CT. These recommendations are subject to the satisfactory completion of the recommended site and subgrade preparation and fill placement operations described in Section 6.0, "Construction Recommendations".

5.1 Pipe Support

We understand that the underground utility improvements for this project will include the replacement of the existing 8-inch iron cast water pipe. The current stage of design has not determined the type of the new pipe and depth of the installation, but it is expected to be within 10 feet below existing grades. We also understand that these underground utilities will be installed using an open-cut excavation technique.

Based on our project understanding, and based on the future design details, the proposed waterline is anticipated to be supported on either cohesive or granular materials encountered in subsurface exploration at assumed depth of installation. However, we cannot rule out possibility of encountering shale bedrock at the bottom of the trench in some sections depending on the designed water line depth and changes in top of the bedrock elevations in between the borings. Difficult excavation of rock may be encountered during construction depending upon installation depths.

Based on the subsurface exploration findings, laboratory, and field-testing results, it is our professional opinion that the soils within explored depths are capable of sufficiently support planned piping system and structures planned for the improvements.

It will be critical to maintain a sufficient thickness of bedding and haunching to provide adequate support and protection for the underground utilities. Bedding and haunching materials should conform to pipe manufacturer specifications and recommendations.

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

5.2 Open-Cut Installation Methods

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

If the excavation is to be performed with sloped banks, adequate stable slopes must be provided. Based on the general OSHA rules and the borings drilled for this investigation, soils encountered in trench excavations should predominately include OSHA Type A and B soils (cohesive soils), however Type C soils were encountered near the surface of Boring B-5. OSHA soil types are described as follows:

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

- OSHA Type C soils (existing fill materials, granular soils, and cohesive soils with unconfined compressive strengths less than 1,000 psf).

For temporary excavations in Type A, B, and C soils, side slopes must be no steeper than $\frac{3}{4}$ horizontal to 1 vertical ($\frac{3}{4}$ H:1V), 1H:1V, and 1½H:1V respectively. For situations where a higher strength soil is underlain by a lower strength soil and the excavation extends into the lower strength soil (including excavation through cohesive soils that are underlain by granular soils or bedrock), the slope of the entire excavation is governed by that required for the lower strength soil. In all cases, flatter slopes may be required if lower strength soils or adverse seepage conditions are encountered during construction.

For permanent excavations and slopes, we recommend that grades be no steeper than 3H:1V without a more extensive geotechnical evaluation of the proposed construction plans and site conditions.

Based on the conditions encountered in the test borings, the probable method of excavation within the medium stiff to very stiff cohesive soils is expected to consist of conventional excavation equipment such as a backhoe or track excavator and metal trench box which is very common practice. However, sloping or benching the sides of the trench excavation is also applicable if found practical and feasible. We highly recommend using a grading bucket for final excavation close to the designed bearing elevation (bottom of the trench) to reduce disturbance of the natural soils.

5.3 Braced Excavations

Braced excavations constructed using soldier piles with wood lagging or sheetpiling may be considered in areas of restricted access or proximity to structures. The method employed will depend on the construction sequencing, required access size and area, and economic considerations. Braced excavations are typically the responsibility of the contractor to design. Any retaining system proposed by the contractor should be reviewed by a registered professional engineer prior to approval for installation and use.

5.4 Construction (General)

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

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

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

The construction excavation should not be left open any longer than necessary. As soon as a section of the underground utilities is completed, the area should be backfilled to final grade. After the specified bedding material has been provided below and around the pipe, backfill material placed above the pipes should be compacted sufficiently to achieve stable backfill and avoid undesirable settlements.

Where underground utilities will be installed beneath pavement areas, future structure areas, or future pavement areas, the backfill material should be placed in uniform layers not more than 8 inches thick and compacted to 100 percent of the maximum dry density as determined by ASTM D 698 (Standard Proctor). Backfill placed in pavement areas should consist of dense-graded aggregate, such as ODOT Item 304 material. In order to achieve the desired compaction, the backfill material should be within 3 percent of the optimum moisture content. Alternatively, flowable controlled-density fill could be used to backfill the excavated trenches.

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

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

5.5 Construction Dewatering

Based on the soil characteristics and groundwater conditions encountered in the borings, it is our opinion that the static, long-term groundwater table is below the planned excavation depths. However, groundwater elevations can fluctuate with seasonal and climatic influences. In particular, “perched” groundwater may be encountered within, the pavement base materials, fill materials, granular soils as well as at the soil/bedrock interface. Therefore, the groundwater conditions may vary at different times of the year from those encountered during this exploration.

If excavations below the groundwater table are required (e.g., site utilities, foundations, etc.), or if seasonally elevated groundwater conditions are prevalent at the time of construction, diligent dewatering using point wells will be required for

groundwater management during construction. In the event excessive seepage is encountered during construction, CT may be notified to evaluate whether other dewatering methods are required. Installation of the proposed site utilities is expected to require excavation above the “normal” groundwater level and groundwater seepage into excavations shouldn’t be anticipated. However, seepage perched water cannot be ruled out; if encountered, it will be manageable by shallow sump pumps or gravity drainage.

5.6 Flexible (Asphalt) Pavement

Based on the results of subsurface exploration, subgrade soils encountered at tested locations are either granular or cohesive in nature. The lower values of design parameters for cohesive soils will govern. Based on the results of the plasticity and gradation testing for the upper profile cohesive subgrade soil samples, we recommend a subgrade California Bearing Ratio (CBR) value of 6 percent for the Group A-6a or better soils. This CBR value is based on subgrade compacted to at least 100 percent of the maximum dry density as determined by ASTM D 698 (Standard Proctor) or verified as stable through proof rolling.

It should be noted that we are not privy to the design traffic loads or intended design life. The subgrade support recommendations indicated herein should be reviewed by the site engineer in conjunction with the design traffic criteria to determine the required pavement sections. In any case, we recommend the light-duty pavement cross-section consist of at least 3 inches of asphalt underlain by 6 inches of aggregate base for even the lightest-duty pavements based on our experience regarding environmental exposure and reasonable serviceability. For the same reason, we recommend the heavy-duty pavement cross-section consist of at least 4 inches of asphalt underlain by 8 inches of aggregate base.

All paving operations should conform to the State of Ohio Department of Transportation (ODOT) specifications. The pavement and subgrade preparation procedures outlined in this report should result in a reasonably workable and satisfactory pavement. It should be recognized, however, that all flexible pavements

need repairs or overlays from time to time as a result of progressive yielding under repeated traffic loads for a prolonged period of time, as well as exposure to freeze-thaw conditions.

5.7 Pavement Drainage

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

Note that the above paragraph is a general recommendation for Pavement Drainage mostly applicable for larger pavement areas (e.g., all-width street pavement or pavement on the larger parking lot areas), but it can be used as a general guidance for the narrow, strip-shaped streets’ pavement repair on the backfilled sewer trenches.

6.0 QUALIFICATION OF RECOMMENDATIONS

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

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

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

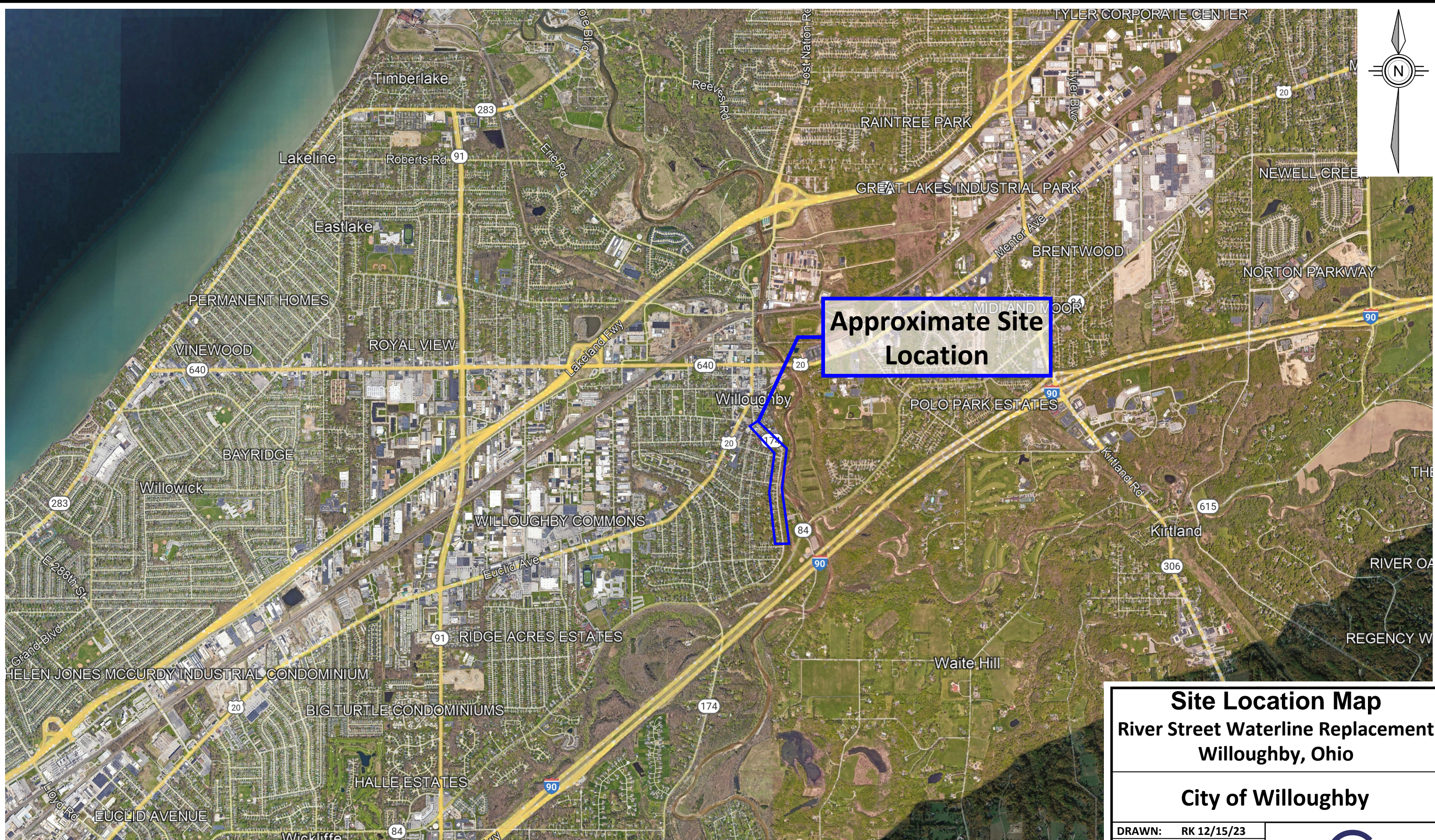
Our professional services have been performed, our findings derived, and our recommendations prepared in accordance with generally accepted geotechnical engineering principles and practices. This warranty is in lieu of all other warranties either expressed or implied. CT is not responsible for the conclusions,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

Plates

Plate 1.0 Site Location Map

Plate 2.1 Test Boring Location Plan with Borings B-1, B-2, and B-3

Plate 2.2 Test Boring Location Plan with Boring B-4



Approximate Site Location

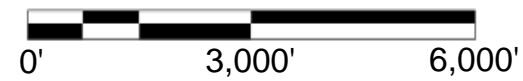
Site Location Map
River Street Waterline Replacement
Willoughby, Ohio

City of Willoughby

DRAWN: RK 12/15/23
 REVISED: ---
 Project No.: 231956
 Drawing No.: Plate 1.0



Notes: Aerial Basemap obtained From Google Earth and dated 04/27/2022.

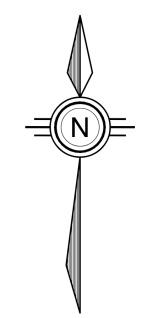




Legend:

B-1

 Approximate Test Boring Location



0' 30' 60'

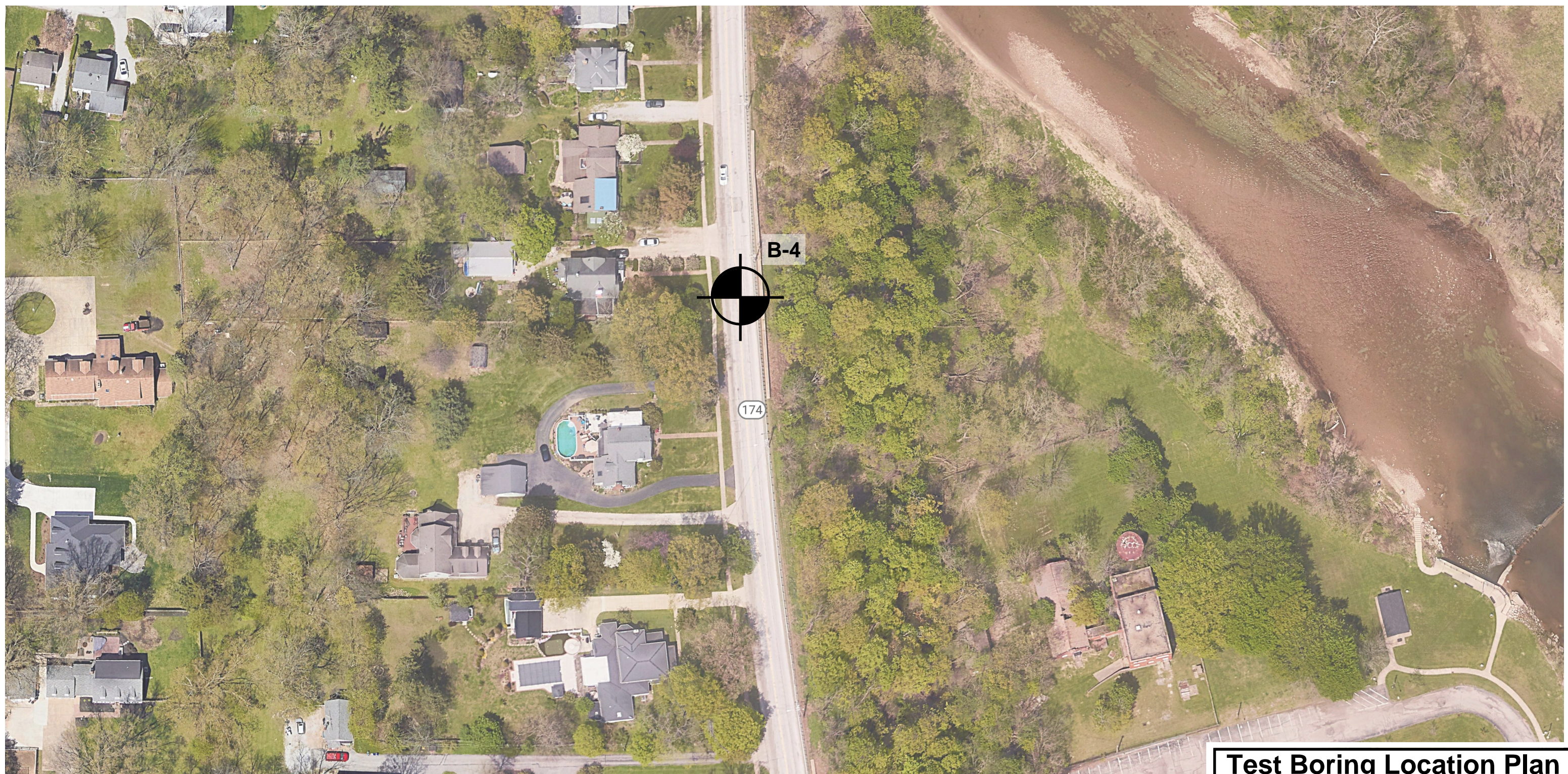
Notes: Aerial Basemap obtained From Google Earth and dated 06/03/2022

**Test Boring Location Plan
 River Street Waterline Replacement
 Willoughby, Ohio**

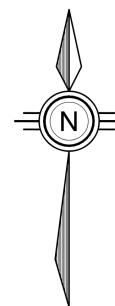
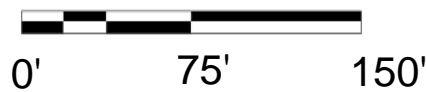
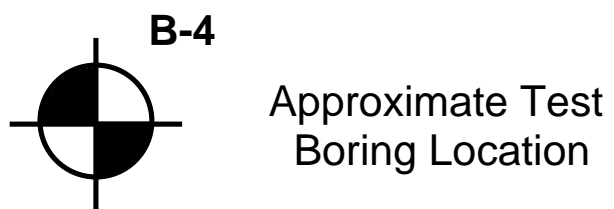
City of Willoughby

DRAWN:	RK 12/15/23
REVISED:	---
Project No.:	231956
Drawing No.:	Plate 2.1





Legend:



**Test Boring Location Plan
River Street Waterline Replacement
Willoughby, Ohio**

City of Willoughby

DRAWN:	RK 12/15/23
REVISED:	---
Project No.:	231956
Drawing No.:	Plate 2.2



Notes: Aerial Basemap obtained From Google Earth and dated 04/27/2022

APPENDIX A

Logs of Test Borings B-1 through B-4



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

BORING NUMBER B-1

CLIENT Lake County Department of Utilities	PROJECT NAME River Street 8-Inch Waterline Replacement
PROJECT NUMBER 231956	PROJECT LOCATION Willoughby, OH
DRILLING CONTRACTOR Ridgeway Drilling, Inc. Kevin Pete	RIG NO. D50 GROUND ELEVATION _____
DRILLING METHOD HSA	GROUND WATER LEVELS:
DATE STARTED 12/7/23 COMPLETED 12/7/23	AT TIME OF DRILLING None
LOGGED BY KKC CHECKED BY _____	AT END OF DRILLING None
NOTES _____	0hrs AFTER DRILLING Backfilled w/Cuttings

ELEVATION (ft)	DEPTH (ft)	GRAPHIC LOG	MATERIAL DESCRIPTION	SAMPLE TYPE NUMBER	RECOVERY % (RQD)	BLOW COUNTS (N VALUE)	UNCONF. COMP. STR. (tsf)	DRY UNIT WT. (pcf)	PL MC LL			
									20	40	60	80
0.0			ASPHALT - 2 Inches									
			BRICK - 6 Inches									
			FILL - Moist Medium Dense Brown SILTY SAND w/Trace Gravel (SM)	SS 1	33	14-12-10 (22)	NP					12 ▲
2.5			FILL - Moist Medium Dense Brown POORLY GRADED SAND w/Trace Silt (SP)	SS 2	56	3-8-8 (16)	NP					7 ▲
5.0			Moist Stiff Brown LEAN CLAY w/Sand and Gravel (CL)	SS 3	56	2-4-6 (10)	1.75					18 ▲
7.5			Moist Stiff Gray SILTY CLAY w/Trace Sand (CL-ML)	SS 4	100	4-6-8 (14)	4.50					15 ●
10.0			Bottom of hole at 10.0 feet.									

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 Toledo Ohio 43604
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BORING NUMBER B-2

CLIENT Lake County Department of Utilities **PROJECT NAME** River Street 8-Inch Waterline Replacement
PROJECT NUMBER 231956 **PROJECT LOCATION** Willoughby, OH
DRILLING CONTRACTOR Ridgeway Drilling, Inc. Kevin Pete **RIG NO.** D50 **GROUND ELEVATION** _____
DRILLING METHOD HSA **GROUND WATER LEVELS:**
DATE STARTED 12/7/23 **COMPLETED** 12/7/23 **AT TIME OF DRILLING** None
LOGGED BY KKC **CHECKED BY** _____ **AT END OF DRILLING** None
NOTES _____ **0hrs AFTER DRILLING** Backfilled w/Cuttings

ELEVATION (ft)	DEPTH (ft)	GRAPHIC LOG	MATERIAL DESCRIPTION	SAMPLE TYPE NUMBER	RECOVERY % (RQD)	BLOW COUNTS (N VALUE)	UNCONF. COMP. STR. (tsf)	DRY UNIT WT. (pcf)	PL MC LL			
									20	40	60	80
	0.0		ASPHALT - 2 Inches									
			BRICK - 6 Inches									
			FILL - Moist Medium Dense Brown POORLY GRADED SAND w/Gravel and Trace Silt (SP)	SS 1	44	6-10-5 (15)	NP					9
	2.5											
			POSSIBLE FILL - Moist Medium Stiff Brown LEAN CLAY w/Sand, Trace Gravel, and Root Hairs (CL)	SS 2	67	3-2-5 (7)	0.75					23
	5.0											
			Moist Very Stiff Brown/Gray SANDY SILT w/Trace Gravel (ML)	SS 3	67	6-7-14 (21)	4.50					14
	7.5											
			Moist Very Dense Gray WEATHERED SHALE	SS 4	88	10-27-50/4"	NP					10
	8.5'											
	9.8'											
	10.0		Bottom of hole at 10.0 feet.									

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BORING NUMBER B-3

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CLIENT Lake County Department of Utilities **PROJECT NAME** River Street 8-Inch Waterline Replacement
PROJECT NUMBER 231956 **PROJECT LOCATION** Willoughby, OH
DRILLING CONTRACTOR CT Consultants Inc. TB **RIG NO.** D70 **GROUND ELEVATION**
DRILLING METHOD 2-1/4 in. HSA **GROUND WATER LEVELS:**
DATE STARTED 11/30/23 **COMPLETED** 11/30/23 **AT TIME OF DRILLING** None
LOGGED BY KKC **CHECKED BY** **AT END OF DRILLING** None
NOTES Split spoon refusal encountered at a depth of 9.4 feet. **0hrs AFTER DRILLING** Backfilled w/Cuttings, Chips, and Patch

ELEVATION (ft)	DEPTH (ft)	GRAPHIC LOG	MATERIAL DESCRIPTION	SAMPLE TYPE NUMBER	RECOVERY % (RQD)	BLOW COUNTS (N VALUE)	UNCONF. COMP. STR. (tsf)	DRY UNIT WT. (pcf)	PL MC LL			
									20	40	60	80
0.0			ASPHALT - 6.5 Inches									
			BRICK - 5.5 Inches									
			CRUSHED STONE - 3 Inches									
			Moist Soft Brown LEAN CLAY w/Sand (CL)	SS 1	83	3-1-3 (4)	1.25					▲ 21
2.5			Moist Very Stiff Brown SILTY CLAY w/Trace Sand (CL-ML)	SS 2	89	5-8-10 (18)	4.50					● 18
5.0			Moist Hard Brown SANDY SILT w/Shale Fragments (ML)	SS 3	100	14-19-25 (44)	4.50					● 15
7.5			Moist Very Dense Gray WEATHERED SHALE	SS 4	100	20-50/5"	NP					● 7
			Bottom of hole at 9.4 feet.									▲ >>

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BORING NUMBER B-4

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CLIENT Lake County Department of Utilities **PROJECT NAME** River Street 8-Inch Waterline Replacement
PROJECT NUMBER 231956 **PROJECT LOCATION** Willoughby, OH
DRILLING CONTRACTOR CT Consultants Inc. TB **RIG NO.** D70 **GROUND ELEVATION** _____
DRILLING METHOD 2-1/4 in. HSA **GROUND WATER LEVELS:**
DATE STARTED 11/30/23 **COMPLETED** 11/30/23 **AT TIME OF DRILLING** None
LOGGED BY KKC **CHECKED BY** _____ **AT END OF DRILLING** None
NOTES Split spoon refusal encountered at a depth of 9.8 feet. **0hrs AFTER DRILLING** Backfilled w/Cuttings, Chips, and Patch

ELEVATION (ft)	DEPTH (ft)	GRAPHIC LOG	MATERIAL DESCRIPTION	SAMPLE TYPE NUMBER	RECOVERY % (RQD)	BLOW COUNTS (N VALUE)	UNCONF. COMP. STR. (tsf)	DRY UNIT WT. (pcf)	PL MC LL			
									20	40	60	80
0.0			ASPHALT - 4 Inches									
			BRICK - 10 Inches									
			CRUSHED STONE - 6 Inches									
			Moist Loose Brown CLAYEY SAND w/Trace Gravel (SC)	SS 1	89	4-3-3 (6)	NP					▲ 15 ●
2.5			Moist Very Stiff Brown SILTY CLAY w/Sand and Trace Gravel (CL-ML)									
				SS 2	100	5-10-12 (22)	4.25					● 18 ▲
5.0												
			Moist Hard Brown SILTY CLAY w/Sand and Shale Fragments (CL-ML)	SS 3	100	10-12-20 (32)	4.50					● 14 ▲
7.5												
			Moist Very Dense Gray WEATHERED SHALE	SS 4	100	18-39-50/4"	NP					● 9 >>▲
			Bottom of hole at 9.8 feet.									


























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APPENDIX B







Legend Key

LEGEND KEY

Unified Soil Classification System Soil Symbols

 GW - WELL GRADED GRAVEL Includes Gravel-Sand mixtures, little or no fines.	 GP - POORLY GRADED GRAVEL Includes Gravel-Sand mixtures, little or no fines.	 GM - SILTY GRAVEL Includes Gravel-Sand-Silt mixtures.	 GC - CLAYEY GRAVEL Includes Gravel-Sand-Clay mixtures.
 SW - WELL GRADED SAND Includes Gravelly Sands, little or no fines.	 SP - POORLY GRADED SAND Includes Gravelly Sands, little or no fines.	 SM - SILTY SAND Includes Sand-Silt mixtures.	 SC - CLAYEY SAND Includes Sand-Clay mixtures.
 ML - SILT Includes Silt with Sand and Sandy Silt.	 CL - LEAN CLAY Includes Sandy Lean Clay and Lean Clay with Sand and Gravel.	 MH - ELASTIC SILT Includes Sandy Elastic Silt and Elastic Silt with Sand.	 CH - FAT CLAY Includes Sandy Fat Clay and Fat Clay with Sand.
 CL-ML - SILTY CLAY Includes Clayey Silt of low plasticity.	 OL - ORGANIC SILT and ORGANIC CLAY of low plasticity.	 OH - ORGANIC SILT and ORGANIC CLAY of medium to high plasticity.	 Pt - PEAT Includes humus, swamp and other soils with high organic content.
 FILL MATERIAL - Includes controlled and non-controlled soil and non-soil materials.	 TOPSOIL	 ASPHALT - Bituminous Asphalt	 CONCRETE - Includes broken concrete rubble.
 Shale	 Weathered Shale	 Sandstone	 Weathered Sandstone
 Coal			

Sample Symbols

 SS - Split Spoon	 ST - Shelby Tube	 RC - Rock Core	 GS - Geoprobe Sleeve
	 AU - Auger Cuttings	 GB - Grab	

Notes:

1. Exploratory borings were drilled on November 30 and December 7, 2023, using 2¼- inch inside diameter hollow-stem augers.
2. These logs are subject to the limitations, conclusions, and recommendations in the report and should not be interpreted separately from the report.
3. The borings were located in the field by CT Consultants in accordance with boring location plans submitted with our proposal.
4. Unconfined Compressive Strength (tsf):
NP = Non-Plastic
NI = Not Intact

APPENDIX C

Tabulation of Laboratory Test Data



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SUMMARY OF LABORATORY RESULTS

CLIENT Lake County Department of Utilities

PROJECT NAME River Street 8-Inch Waterline Replacement

PROJECT NUMBER 231956

PROJECT LOCATION Willoughby, OH

Borehole	Depth	Liquid Limit	Plastic Limit	Plasticity Index	Maximum Size (mm)	%<#200 Sieve	Classification	Water Content (%)	Dry Density (pcf)	Saturation (%)	Void Ratio
B-1	1.0							11.8			
B-1	3.5							7.0			
B-1	6.0							17.5			
B-1	8.5							15.0			
B-2	1.0							9.1			
B-2	3.5	34	19	15	9.5	83	CL	23.3			
B-2	6.0							14.3			
B-2	8.5							10.0			
B-3	1.0	36	20	16	9.5	79	CL	20.9			
B-3	3.5							18.0			
B-3	6.0							15.1			
B-3	8.5							6.9			
B-4	1.0							14.5			
B-4	3.5							18.0			
B-4	6.0							14.5			
B-4	8.5							9.3			

APPENDIX D
Laboratory Test Results



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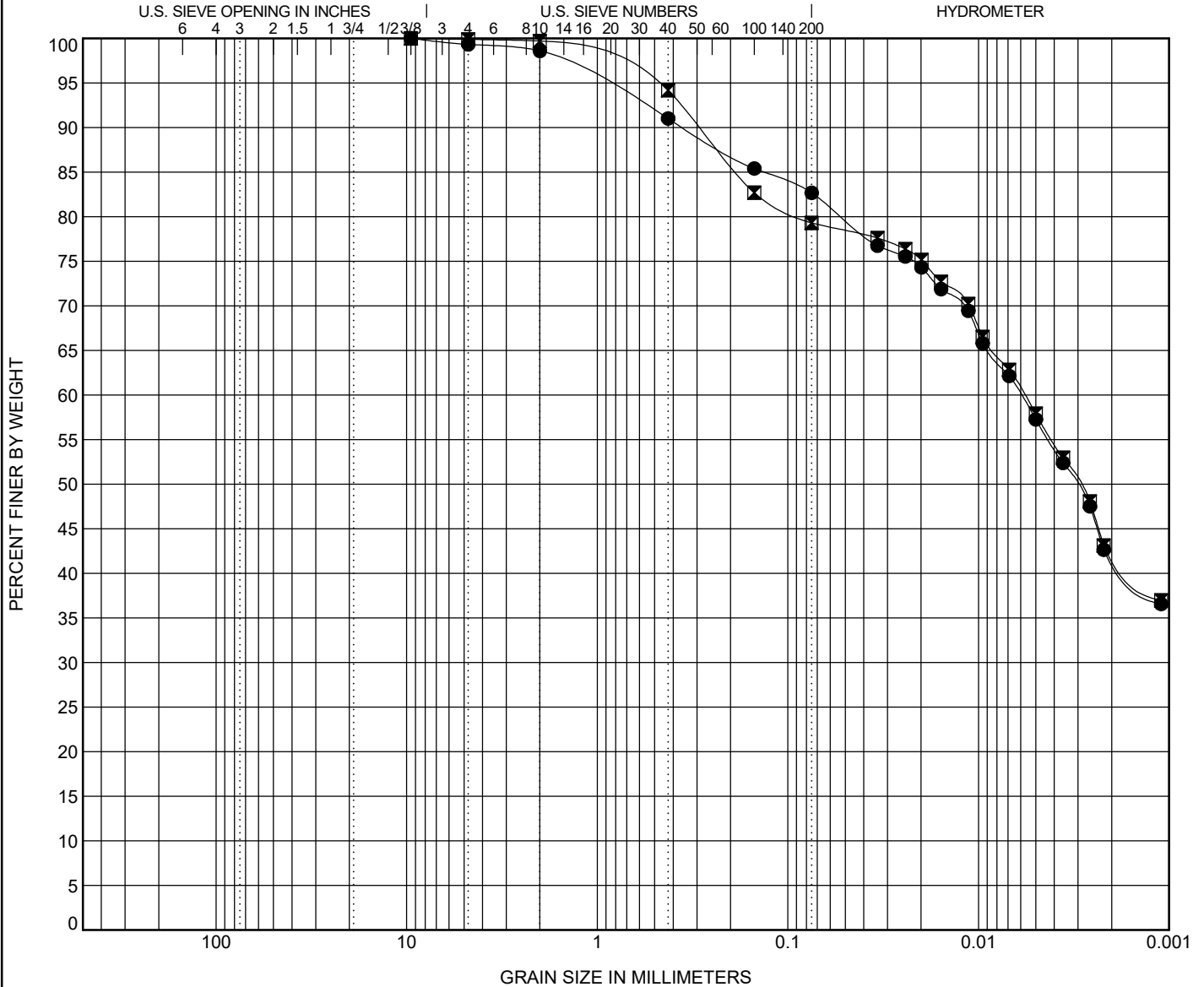
GRAIN SIZE DISTRIBUTION

CLIENT Lake County Department of Utilities

PROJECT NAME River Street 8-Inch Waterline Replacement

PROJECT NUMBER 231956

PROJECT LOCATION Willoughby, OH



COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

Specimen Identification	USCS Classification	LL	PL	PI	Cc	Cu
● B-2 3.5	LEAN CLAY with SAND (CL)	34	19	15		
■ B-3 1.0	LEAN CLAY with SAND (CL)	36	20	16		

Specimen Identification	D100	D60	D30	D10	%Gravel	%Sand	%Silt	%Clay
● B-2 3.5	9.5	0.006			0.7	16.7	25.4	57.3
■ B-3 1.0	9.5	0.006			0.1	20.6	21.4	57.9

GRAIN SIZE 231956.GPJ GINT US LAB.GDT 12/27/23

