Geotechnical Engineering Report

Sub-District H Water Main Extension Project – Phase 4

Pleasant Ridge Road, Maddox Road, and Cory Lane
Alexandria, Campbell County, Kentucky
Project No. N1095342
May 21, 2010 (Revised)
March 5, 2010 (Original)

Prepared for:

Northern Kentucky Water District
Erlanger, Kentucky

Prepared by:

HCN
A Terracon COMPANY
Cincinnati, Ohio

A Terracon COMPANY

May 21, 2010 (revised)
March 5, 2010 (original)

Northern Kentucky Water District
2835 Crescent Springs Road
P.O. Box 18640
Erlanger, Kentucky 41018

Attn: Mr. John Scheben
Design Supervisor
TEL: 859-426-2717
FAX: 859-578-7893
Email: jscheben@nkywater.org

Re: Geotechnical Engineering Report
Proposed Sub-District H Water Main Extension Project – Phase 4
Pleasant Ridge Road, Maddox Road, and Cory Lane
Alexandria, Campbell County, Kentucky
HCN/Terracon Project Number: N1095342

Dear Mr. Scheben:

H.C. Nutting, a Terracon Company (HCN) has completed the geotechnical engineering services for the above referenced project. This study was performed in general accordance with our proposal number PN1090210, dated March 10, 2009. This report presents the findings of the subsurface exploration and provides geotechnical recommendations concerning earthwork during the installation of water main. This report has been prepared as requested by NKWD and Viox & Viox to more specifically address the geotechnical aspects along the waterline alignment for incorporation onto the project plans.

We appreciate the opportunity to be of service to you on this project. If you have any questions concerning this report, or if we may be of further service, please contact us.

Sincerely,
H.C. NUTTING, A TERRACON COMPANY

Bobby Daita, P.E.
Senior Staff Engineer

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Geotechnical ■ Environmental ■ Construction Materials ■ Facilities

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EXECUTIVE SUMMARY

A geotechnical study was performed for the phase 4 portion of the proposed Sub-District H water main extension project in Campbell County, Kentucky. The project involves installation of an 8-inch water main along Pleasant Ridge Road, Maddox Road, and Cory Lane in Alexandria, Campbell County, Kentucky. Based on a review of provided plan and profile drawings the proposed water main invert elevations are generally about 4 to 7 feet below existing site grade, with the typical depth being about 5 feet.

A total of eight test borings were performed as part of the exploration program. The typical subsurface profile at the test borings consisted of natural cohesive soils underlain by shale and limestone bedrock. Existing fill was encountered at one boring location to a depth of 5 feet below existing grade.

The following key geotechnical related items are identified:

- Open cut excavations will penetrate a variety of materials ranging from medium stiff cohesive soil to very stiff to hard cohesive soil and weathered shale bedrock. The shale bedrock is typically soft to very soft in bedrock classification terms. There are also hard limestone layers within the bedrock formation and in residual soil zones above the bedrock.
- Materials anticipated at pipe invert elevation are generally expected to be compact cohesive materials and occasionally, bedrock.
- Based on review of the project plans, the use of pipe restraints and thrust blocks along portions of the alignment is proposed.

Close monitoring of the construction operations discussed herein will be critical in achieving the design subgrade support. We recommend that HCN/Terracon be retained to perform construction testing and inspection for this project.

This summary should be used in conjunction with the entire report for design purposes. It should be recognized that details were not included or fully developed in this section, and the report must be read in its entirety for a comprehensive understanding of the items contained herein. The section titled **GENERAL COMMENTS** should be read for an understanding of the report limitations.

GEOTECHNICAL ENGINEERING REPORT

SUB-DISTRICT H WATER MAIN EXTENSION PROJECT- PHASE 4
PLEASANT RIDGE ROAD, MADDOX ROAD, AND CORY LANE
ALEXANDRIA, CAMPBELL COUNTY, KENTUCKY
HCN/TERRACON PROJECT NO. N1095342
MAY 21, 2010 (REVISED)
MARCH 5, 2010 (ORIGINAL)

1.0 INTRODUCTION

A geotechnical engineering report has been completed for the Phase 4 portion of the proposed Sub-District H Water Main Extension project in Alexandria, Campbell County, Kentucky (Exhibit 1). A total of eight borings including three borings along Pleasant Ridge Road (designated at PR-1 to PR-3), four borings along Maddox Road (designated as MR-1 to MR-4), and one boring along Cory Lane (designated as CL-1) were drilled to approximate depths of 8.2 to 9 feet below existing grades. Logs of the borings along with site vicinity map, boring location plans are included in Appendix A of this report.

The purpose of these services is to provide information and geotechnical engineering recommendations relative to:

- subsurface soil conditions
- groundwater conditions
- earthwork recommendations
- slope stability considerations
- pipe subgrade recommendations

2.0 PROJECT INFORMATION

Item	Description
Project Purpose	Water main extension – Phase 4
Project Alignment	Pleasant Ridge Road, Maddox Road, and Cory Lane
Total Project Length	7,901 feet (2456 + 3845 + 1600)
Pipe Invert Elevation	4 to 7 feet (5 feet on average)
Existing Grades	• Grades slope down along Pleasant Ridge Road and vary between El. 835 and El. 730 feet • Maddox Road has rolling terrain with grades varying between El. 760 and El. 851 feet • Cory Lane is predominantly flat with grades varying between El. 850 and El. 837 feet.

3.0 SUBSURFACE CONDITIONS

3.1 Typical Profile

The surficial material at the test borings consisted of topsoil, gravel, concrete pavement, and asphalt pavement with granular base. Approximately 6 inches of topsoil was encountered at boring PR-3. Asphalt pavement with thickness varying between 5 and 6 inches was encountered at five test borings (PR-1, PR-2, MR-1, MR-3, and MR-4) and was underlain by 8 to 11 inches thick granular base. Six inches of gravel fill was encountered at MR-2 and six inches of concrete pavement was encountered at CL-1. Underlying these surficial materials were natural overburden soils and shale and limestone bedrock. An exception was existing fill that was encountered immediately below the pavement at test boring PR-3. The following table summarizes the encountered subsurface conditions:

Description	Approximate Depth to Bottom of Stratum (feet)	Material Encountered	Consistency/Density
Existing Fill	5	Lean Clay	Soft to Stiff
Natural Overburden Soils	7.5 to 9	Silty Clay, Lean Clay, Fat Clay, Silt	Soft to Very Stiff
Bedrock[2]	Bottom of Boring	Weathered Brown Shale with Limestone	Soft (rock hardness)

1. Existing fill extended to a depth of 5 ft. at boring PR-3. It appears that the existing fill was placed with some compactive effort. However, we have not reviewed any records showing its controlled placement as structural fill.
2. Bedrock was encountered at two test borings (PR-2 and MR-3). At boring MR-3, weathered shale was encountered immediately below the asphalt pavement and granular base. Based on the elevation at which bedrock was encountered, a review of published literature suggests that Ordovician Age bedrock along Pleasant Ridge Road and Maddox Road includes the Bellevue and Corryville members which belong to the McMillan formation under the Maysville Group. In general Bellevue bedrock members are rich in limestone and Corryville bedrock members are rich in shale.

Conditions encountered at each boring location are indicated on the individual boring logs. Stratification boundaries on the boring logs represent the approximate location of changes in soil types; the transition between materials may be gradual. Details for each of the borings can be found on the boring logs in Appendix A of this report.

3.2 Groundwater

Groundwater conditions were noted during and after drilling operations at each of the test boring locations. During drilling, groundwater was encountered at a depth of 5 feet below existing grade at boring MR-1. No groundwater or "dry" conditions were reported during and after drilling operations at the remaining test boring locations. A "dry" condition is reported when no water is observed in the borehole or on the sampling tools. Boreholes were backfilled immediately upon completion and patched at the roadway surface for safety reasons. Therefore, long-term groundwater conditions at the site were not obtained.

Perched water may be encountered at shallow depths within the existing fill, at the fill/natural soil interface or near the soil/bedrock interface, etc. Groundwater level fluctuations occur due to seasonal variations in the amount of rainfall, runoff and other factors not evident at the time the borings were performed. Therefore, groundwater levels during construction or later may be higher or lower than the levels indicated on the boring logs. The possibility of groundwater level fluctuations should be considered when developing the design and construction plans for the project.

4.0 RECOMMENDATIONS FOR DESIGN AND CONSTRUCTION

4.1 Geotechnical Considerations

Based on the provided water main alignment plans prepared by Viox & Viox, the proposed water main inverts are generally about 4 to 7 feet below existing site grades along the various roads planned within Phase 4. Based on the results of the test borings and the anticipated water main subgrade elevations, we anticipate that trench excavations in the area of the test boring locations will typically penetrate medium stiff to hard natural cohesive residual soils. Weathered shale and limestone bedrock may be encountered at pipe subgrade elevation at some locations along Maddox Road. Based on the project plans, the use of pipe restraints and thrust blocks along portions of the alignment is proposed. The use of thrust blocks/restraints are typically shown where horizontal and/or vertical grade changes cannot be accommodated by the inherent flex of the waterline. Recommendations for the use of thrust blocks/restraints or lowering the waterline into bedrock where stability is a concern has been provided for evaluation by the waterline designer and NKWD. Additional details regarding general water main construction are provided in the following sections, followed by a station-by-station overview of our recommendations.

4.2 Construction Assessment

We anticipate excavations could likely be completed using conventional trench box support or conventional trench box support incorporated with laid-back slopes (open-cut and cover). Open-cut and cover techniques (with/without trench box support) can be considered, provided that precautions are taken to protect any existing utilities, structures, roadways, or creeks within the construction area. The following table shows the proposed invert elevations and anticipated bearing materials at the soil test boring locations.

Boring Number	Approx. Ground Elevation (ft.)	Approx. Invert Elev. /Depth (ft.)	Estimated Depth to Bedrock (ft.)	Anticipated Material @ Pipe Invert (approx.)
Pleasant Ridge Road				
PR-1	834.5	830.5 / 4	>9	Very Stiff Fat Clay
PR-2	798.0	793.5 / 4.5	7.5[1]	Very Stiff Fat Clay
PR-3	726.0	722 / 4	>9	Soft Existing Fill to Stiff Lean Clay
Maddox Road				
MR-1	768.0	763.5 / 4.5	>9	Very Stiff Lean Clay to Loose Silt
MR-2	820.0	815.5 / 4.5	>9[2]	Medium Stiff Lean Clay to Very Stiff Fat Clay
MR-3	824.0	819.5 / 4.5	0.8	Soft Weathered Shale with Limestone
MR-4	850.0	845 / 5	>9	Stiff Lean Clay
Cory Lane				
CL-1	839.5	835 / 4.5	>9	Very Stiff Fat Clay

1. Residuum with limestone fragments and layers may be encountered above the bedrock depth.
2. Residuum with limestone fragments and layers may be encountered above the bedrock depth and is suspected at MR-2 below about 7.5 feet.

In general, the placement of the water main, hydrants, and valves within the soil profile will not add significant load on the underlying bearing material. However, it is important to have uniform and proper support, and to maintain proper line and grade of the pipe to prevent the pipe from becoming over-stressed in hoop compression or bending. Based on the proposed invert elevations and subsurface conditions encountered at the test borings, we anticipate the bearing material at invert elevations should generally consist of stiff to very stiff cohesive soils and/or weathered shale and limestone bedrock. Some of the cohesive materials within excavation limits may comprise "residuum" which can contain hard limestone fragments and layers.

Soft to medium stiff existing cohesive fill soil and medium stiff natural cohesive lean clay soil are anticipated to be encountered at proposed pipe invert elevation near borings PR-3 and MR-2, respectively. It is recommended that any such soft to medium stiff soils encountered at pipe subgrade elevation be undercut to expose suitable stiff to very stiff bearing materials. The undercut area may be brought up to design bearing levels with engineered fill as discussed in the Bedding and Backfill section of this report.

The water main alignment is generally located within the roadways or adjacent to the roadways within Phase 4. We have not identified any obvious signs of potential instability along the roadways within this phase of the project; however, we recommend that the water main generally be installed along the upslope side of the road when feasible. It generally appears that this condition is being followed in the proposed pipe alignment. Thrust blocks and pipe restraints should also be provided along the water main alignment in accordance with manufacturer's specifications.

4.3 Trench Excavations

All temporary cut slopes required for water main installation should be made in accordance with OSHA Safety Regulations. It is anticipated that the depths of excavation will range between about 4 and 7 feet below existing grades. We anticipate that trench boxes or other types of temporary shoring will be utilized within the existing roadway and in close proximity to existing physical features.

Where sufficient space is available, the excavation slope can be laid back, in accordance with OSHA criteria. It is recommended that temporary excavation slopes be examined periodically to evaluate any potential destabilizing effects.

Trench excavations are not anticipated to be deeper than about 7 feet below existing grade. It is our opinion that the overburden soils/weathered shale bedrock encountered in the test borings can typically be excavated using conventional rubber- tired backhoes and/or trackhoes. If excavations penetrate into bedrock (such as along Maddox Road and possibly Pleasant Ridge Road), the rock formation could include hard limestone layers in perhaps 30 to 50% (+/-) % of the mass. Hard limestone layers can also be encountered within residual clay overlying the weathered shale zone. No rock coring was performed as part of this study. The weathered bedrock typically breaks along the natural horizontal bedding planes. Excavation of narrow trenches in the shale and limestone can be difficult. A rock trencher or line drilling may be used to define the edge of the trench, with the rock being excavated with a large hydraulic hoe. Breaking with percussion tools will likely be advantageous to excavate some zones of limestone. The Contractor's "responsible person" should also establish a minimum lateral distance from the crest of the slope or excavation for all spoil piles and vehicles. Likewise, the contractor's "responsible person" should establish protective measures for exposed slope faces.

We recommend that the engineering specifications state that the contractor will be responsible for the temporary shoring, bracing, and sheeting design, if required, and the protection of roadways, utilities, and any other structures. We recommend that a pre-condition survey of all-adjacent structures, roadways, private driveways, etc., be performed prior to the start of construction.

Unless visually apparent, the location of private underground utilities and other manmade physical features cannot be easily identified during our site reconnaissance. Oftentimes, the subsurface soils adjacent to these underground features, whether in-use or abandoned, may not represent the subsurface conditions encountered in the soil test borings. Unless notified in advance, identifying and/or locating the presence of underground manmade features such as leach fields, septic systems, irrigation piping, drainage tile, vaults, privies, cisterns, wells, shelters, private utilities, etc. is beyond our scope of services. Interviewing individual home and property owners for the purposes of identifying/locating known underground physical features is also outside the range of our site reconnaissance activities.

These manmade features are often used to collect, store, and/or provide an avenue for transporting water/ liquid waste. Similarly, underground utilities bedded in granular soils and utility trenches that may be inadequately backfilled tend to "hold" water. As a result, the soils in the area of the underground features tend to be saturated or near saturation, resulting in "weakening" of the soil structure and increased susceptibility to failure if exposed and/or disturbed. Due to the proposed construction being within a developed area where manmade disturbances are likely, we recommend that the contractor carefully evaluate their excavation methods so that properly laid back slopes or sheeting/shoring/trench boxes can be readily utilized during construction. Additionally, if any suspicious surficial features (i.e., depressions, mounds, etc.) and/or seepage within the excavation are observed, further excavation should stop and the owner and geotechnical engineer should be notified.

4.4 Undercut and Replacement

The bottom of the excavations for the water main pipes and valves/hydrants must be stable so that no excessive settlement will occur. In some of the proposed pipe subgrade areas where existing fill or soft to medium stiff natural soils may be encountered or if excessive water seepage is encountered during excavation, the on-site cohesive fill or natural soil is highly susceptible to strength loss when wet and disturbed. Therefore, a limited undercut and replacement (or other stabilizing measures) could be required. The undercut depth or other stabilization measures can be decided in field during construction based on the encountered conditions. It is recommended that the undercut of existing fill or soft to medium stiff natural soils expose at least stiff to very stiff natural cohesive soils. The shallow undercuts to expose stiff to very stiff natural soils can be replaced with engineered granular fill like Dense Graded Aggregate (DGA) or with flowable fill if the pipeline is within the roadway easement; however, this does not preclude the use of proper bedding below and around the pipe.

4.5 Bedding and Backfill

It is recommended that pipe bedding material be used and consist of a "shaped" surface of well-graded sand and/or gravel (with a maximum size less than 1 inch) with no more than 10 percent passing the No. 200 sieve. This granular material should not be less than 3 inches in thickness below the bottom of the pipe and should extend to a height of at least 12 inches above the top of the pipe. This material should be placed in 4 to 6 inch thick lifts and be uniformly compacted to at least 95 percent (in non-pavement areas) of the Standard Proctor maximum dry density (ASTM D 698) at 2 percent below to 3 percent above of the optimum moisture content. Some pipe manufacturers provide backfill requirements pertaining to their particular brand or type of pipe. If this is the case for this project, the manufacturer's specifications could be adopted. If the manufacturer's specifications vary significantly from those provided herein, HCN/Terracon should be contacted to evaluate the appropriateness of the compaction specifications.

Within the roadway right-of-way, the trench backfill above the bedding fill should be in compliance with Northern Kentucky Water District and current KTC specifications. Flowable concrete fill (low strength mortar) should be used within roadway easements to reduce construction time and minimize the risk of future trench settlement. It is our experience that reduced labor costs associated with flowable fill backfill make the use of this material an attractive alternative. Flowable fill is a semi-rigid backfill, typically stronger than the soil that was removed.

In areas that are not within the roadway right-of-way, the remaining backfill above the granular zone previously described, can consist of on-site cohesive soils or high quality granular material unless specified otherwise. Excavated overburden soils from the water main alignment areas appear to be suitable for reuse as trench backfill, though likely wet of optimum. Some moisture adjustment may be necessary to achieve specified compaction. Material classifying as fat clay, such as the cohesive material encountered in majority of the test borings, should be placed wet of optimum to reduce swell potential. Any proposed backfill material (on-site or imported) should be properly tested to determine its optimum moisture content and moisture-density characteristics and pre-approved before use. All backfill material should be free of organics, topsoil, debris and other deleterious substances. Maximum solid particle size (rock fragments, etc.) should be less than about 4 inches in any dimension. If utility trenches are backfilled with relatively clean granular material, they should be capped with at least 18 inches of cohesive fill in non-pavement areas to reduce the infiltration and conveyance of surface water through the trench backfill. The following table provides property requirements for structural fill:

Fill Type [1]	USCS Classification	Acceptable Location for Placement
Lean clay	CL (LL<40)	All locations and elevations
Fat clay [2]	CH (LL >50)	In non-structural fill areas
Well graded granular	GW[3]	All locations and elevations
On-site soils	Varies	The on-site soils, including the existing uncontrolled fill material, typically appear suitable for use as fill. Appropriate moisture conditioning may be needed.

1. New structural fill should consist of approved materials that are free of organic matter and debris. Frozen material should not be used, and fill should not be placed on a frozen subgrade. A sample of each material type should be submitted to the geotechnical engineer for evaluation.

2. Delineation of fat clays should be performed in the field by a qualified geotechnical engineer or their representative.

3. Similar to KTC DGA stone or crushed limestone aggregate or granular material such as sand, gravel or crushed stone containing less than 8% low plasticity fines.

Compaction Requirements for Backfill	
Fill Lift Thickness	8-inches or less in loose thickness 6-inches or less if hand compaction equipment used
Compaction Requirements [1] (Pavement Areas)	Top 12" beneath pavement areas, 100% of the material's maximum Standard Proctor dry density (ASTM D 698); structural fill beneath the top 12" should be compacted to at least 98% of the material's maximum Standard Proctor dry density (ASTM D 698)
Compaction Requirements (Landscape Areas)	95% of maximum Standard Proctor dry density (ASTM D 698) provided long-term plans do not include paving or a structure in these areas
Moisture Content - Cohesive Soil (Low Plasticity)	Within ±3% of optimum moisture content (OMC) as determined by the Standard Proctor test at the time of placement and compaction
Moisture Content - Granular Material[2]	Within ±2% of OMC

1. Should the results of the in-place density tests indicate the specified moisture or compaction limits have not been met, the area represented by the test should be reworked and retested as required until the specified moisture and compaction requirements are achieved.

2. Specifically, moisture levels should be maintained low enough to allow for satisfactory compaction to be achieved without the cohesionless fill material pumping when proofrolled.

All materials to be used as structural fill should be tested in the laboratory to determine their suitability and compaction characteristics.

4.6 Drainage and Groundwater Considerations

Water should not be allowed to collect in the bottom of excavation or on prepared subgrades of the construction area. Undercut or excavated areas should be sloped toward one corner to facilitate removal of any collected rainwater, groundwater, or surface runoff.

Based on the predominately cohesive soil types and observed groundwater conditions during drilling, we do not anticipate significant seepage within the excavations. Any encountered water can most likely be removed with typical sump and pump methods. The presence and handling of groundwater should be further evaluated at the time of construction.

4.7 Slope Stability Considerations

Based on the relatively very stiff to hard cohesive overburden soils and relatively shallow brown shale bedrock in some areas, deep-seated (global) slope failure does not appear to be a concern (although detailed slope stability analyses were not performed). We have not identified any obvious areas of potential instability along the roadways within other portions of this phase of the project; however, we recommend that the water main generally be installed along the upslope side of the road when feasible. Due to the long-term nature of creep, slope movement may become evident in this area and along other portions of the alignment in the future. Therefore, we recommend that monitoring along the alignment be performed on a regular basis due to the potential for creep movement.

4.8 Thrust Block Recommendations

Thrust block or restrained joints are used to resist thrust forces that occur in waterlines when the pipeline changes directions, changes sizes, or stops. A thrust block may be constructed between the fitting and the undisturbed side or bottom of the trench. The base of the thrust block is designed to support the anticipated thrust loads by providing a bearing area through which the thrust forces can be transferred to the soil without exceeding the bearing capacity of the soil.

An alternative method of providing thrust restraint is the use of restrained joints. A restrained joint is a special type of push-on or mechanical joint that is designed to provide longitudinal restraint. Restrained joint systems function in a manner similar to thrust blocks; as the reaction of the entire restrained unit of piping with the soil balances the thrust forces. The objective in designing a restrained joint thrust restraint system is to determine the length of pipe that must be restrained on each side of the focus of a thrust force. This will be a function of the pipe size, the internal pressure, depth of cover, the characteristics of the soil surrounding the pipe, and whether the pipe is polyethylene encased.

The provided plans depicting the water main alignment along various roads shows several 22½° to 45° bends where thrust blocks are anticipated. Based on the invert elevations of the water main pipeline, natural cohesive soils and/or weathered shale bedrock are anticipated in the vicinity of the thrust blocks. The following table summarizes the recommended coefficient of friction values for the interface of thrust block concrete and insitu soil. These values are ultimate values (no safety factors applied).

Interface Material	Coefficient of Friction
Stiff to Very Stiff Natural Cohesive soils	0.35
Weathered Shale Bedrock	0.50

Note: It is anticipated that existing fill and soft to medium stiff soils will be undercut to expose competent natural soils.

The following earth pressure coefficients can be used in sizing the thrust blocks for horizontal and vertical bends:

Material	Angle of Internal Friction (ϕ)	Total Unit Weight (γ, pcf)	K_o (At-rest)	K_p (Passive)
Soft to Stiff Existing Fill	23°	120	0.61	2.28
Stiff to Very Stiff Natural Cohesive Soil	26°	125	0.56	2.56
Weathered Shale Bedrock	36°	135	0.41	3.85

The following allowable bearing capacities can be used in sizing the thrust block for downward directed thrust:

Bearing Material	Allowable Bearing Capacity
New Engineered Granular Fill (placed over stiff to very stiff natural soils)	3,000 psf
Stiff to Very Stiff Natural Cohesive soils	3,000 psf
Weathered Shale Bedrock	8,000 psf

It is recommended that the trench backfill in the areas of thrust blocks and restrained joints consist of granular backfill, flowable fill, or at least lean concrete fill.

4.9 Overview of Geotechnical Recommendations

The following table is being provided for use by the NKWD and the waterline designer to aid in waterline design, and development of the project plans. The table generally outlines our recommendations along the alignment in consideration of the geotechnical aspects outlined above and based on review of the plan and profile information provided to us. The actual design of the waterline and design methodology is the responsibility of the designer. We have not considered flowrates, pressures, valve/hydrant placement, etc., along the waterline, which may require the further use of thrust blocks/restraints, grade change, waterline relocation, in addition to the recommendations provided below. We request the opportunity to review such changes and/or meet with the NKWD/designer to discuss any of our recommendations, as deemed necessary. It should be further acknowledged that our test borings provide limited, widely-spaced information and that "ground truth" is only obtained in the field during construction at the time of excavation. Adjustments in the field at the time of construction based on actual field conditions should be anticipated. Additional exploration and/or long-term monitoring may be required.

Alignment	Approximate Station	Applicable Test Boring(s)	Geotechnical Consideration(s)	Remarks(2)
Pleasant Ridge Road	0+00 to 5+00	PR-1	None anticipated	Within Road
	5+00 to 7+00	PR-1	None anticipated	Bend in Alignment (Road Crossing); Use thrust blocks/restraints
	7+00 to 15+00	PR-2	None anticipated	Within road
	14+00 to 16+50	PR-2(1)	None anticipated	Bend in Alignment (Road Crossing); Use thrust blocks/restraints
	16+50 to 21+00	PR-2(1), PR-3(1)	Undercut of existing fill	Within road

Alignment	Approximate Station	Applicable Test Boring(s)	Geotechnical Consideration(s)	Remarks[(2)]
Pleasant Ridge Road	21+00 to 22+00	PR-3[(1)]	Possible undercuts of existing fill	Bend in alignment (Road Crossing); Use thrust blocks/restraints
	22+00 to 24+56	PR-3	Possible undercuts of existing fill	Within road
Maddox Road	0+00 to 1+00	MR-1[(1)]	None anticipated	Bend in Alignment (Road Crossing); Use thrust blocks/restraints
	1+00 to 18+00	MR-1, MR-2	None anticipated	(none)
	18+00 to 18+50	MR[(1)]	None anticipated	Bend in alignment (from shoulder into roadway); Use thrust blocks/restraints
	18+50 to 22+50	MR-2[(1)] ,MR-3[(1)]	Possible bedrock excavation	Within road
	22+50 to 24+00	MR-3[(1)]	Possible bedrock excavation	Bend in alignment (off road to avoid culvert)
	24+00 to 38+45	MR-3, MR-4	Possible bedrock excavation	None
Cory Lane	0+00 to 1+50	MR-4[(1)]	None anticipated	Bend in Alignment; Use thrust blocks/restraints
	1+50 to 16+00	CL-L	None Anticipated	(none)

(1) Boring drilled outside of station range.
(2) Thrust block/restraint use based on project plans.

5.0 GENERAL COMMENTS

Terracon should be retained to review the final design plans and specifications so comments can be made regarding interpretation and implementation of our geotechnical recommendations in the design and specifications. Terracon also should be retained to provide observation and testing services during grading, excavation, foundation construction and other earth-related construction phases of the project.

The analysis and recommendations presented in this report are based upon the data obtained from the borings performed at the indicated locations and from other information discussed in this report. This report does not reflect variations that may occur between borings, across the site, or due to the modifying effects of weather. The nature and extent of such variations may not become evident until during or after construction. If variations appear, we should be immediately notified so that further evaluation and supplemental recommendations can be provided.

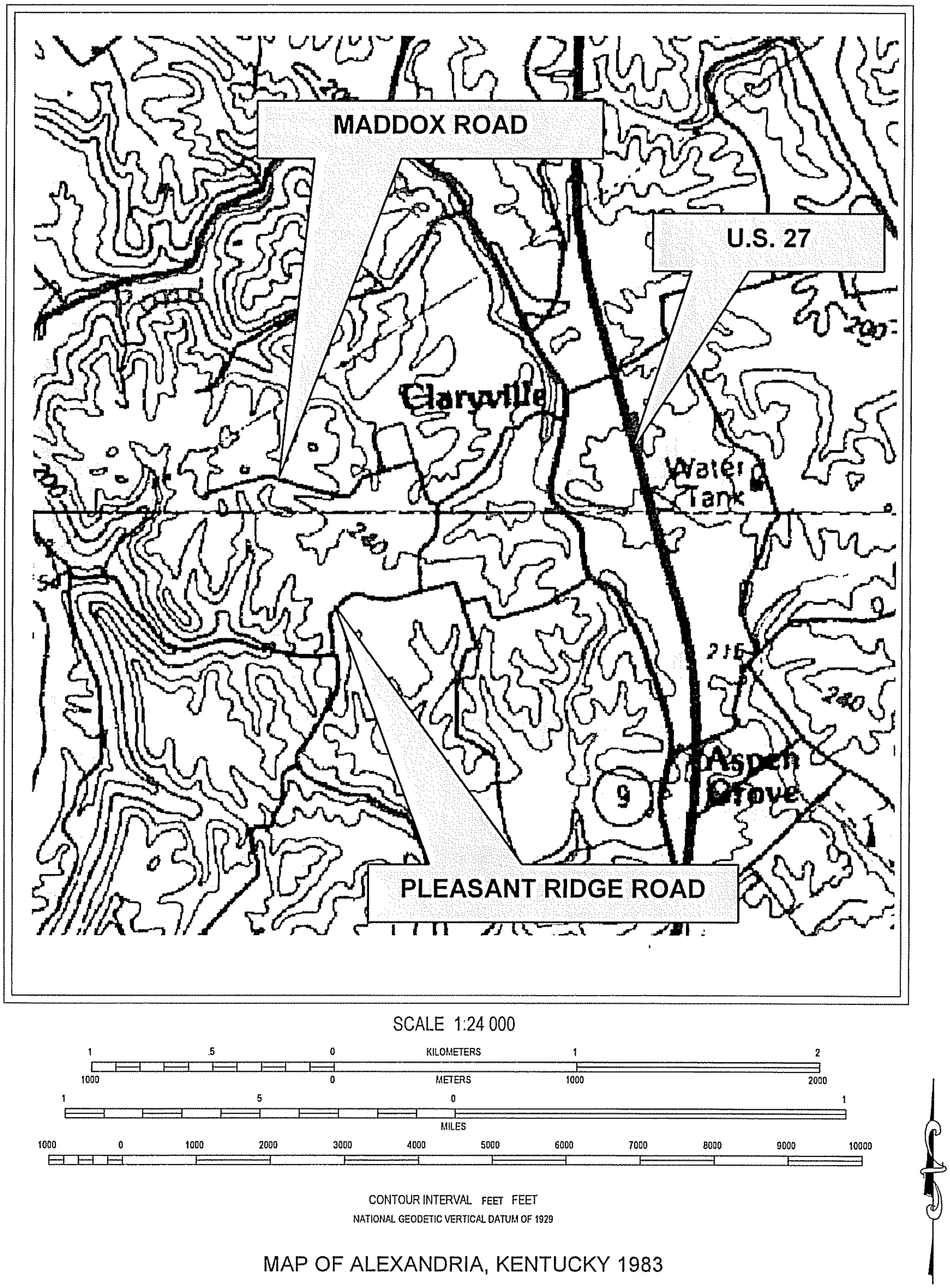
The scope of services for this project does not include either specifically or by implication any environmental or biological (e.g., mold, fungi, and bacteria) assessment of the site or identification or prevention of pollutants, hazardous materials or conditions. If the owner is concerned about the potential for such contamination or pollution, other studies should be undertaken.

This report has been prepared for the exclusive use of our client for specific application to the project discussed and has been prepared in accordance with generally accepted geotechnical engineering practices. No warranties, express or implied, are intended or made. Site safety, excavation support, and dewatering requirements are the responsibility of others. In the event that changes in the nature, design, or location of the project as outlined in this report are planned, the conclusions and recommendations contained in this report shall not be considered valid unless Terracon reviews the changes and either verifies or modifies the conclusions of this report in writing.

APPENDIX A

FIELD EXPLORATION

UNITED STATES – DEPARTMENT OF THE INTERIOR – GEOLOGICAL SURVEY



CONTOUR INTERVAL FEET FEET

NATIONAL GEODETIC VERTICAL DATUM OF 1929

MAP OF ALEXANDRIA, KENTUCKY 1983

7.5 MINUTE SERIES (TOPOGRAPHIC)

Note: Cory Lane is a side street off Maddox Road

Project Mngr:	AJM	Project No.	N1095342
Drawn By:	DRK	Scale:	AS SHOWN
Checked By:	AJM	File No.	FIGURE 1A
Approved By:	JAS	Date:	2/2/2010

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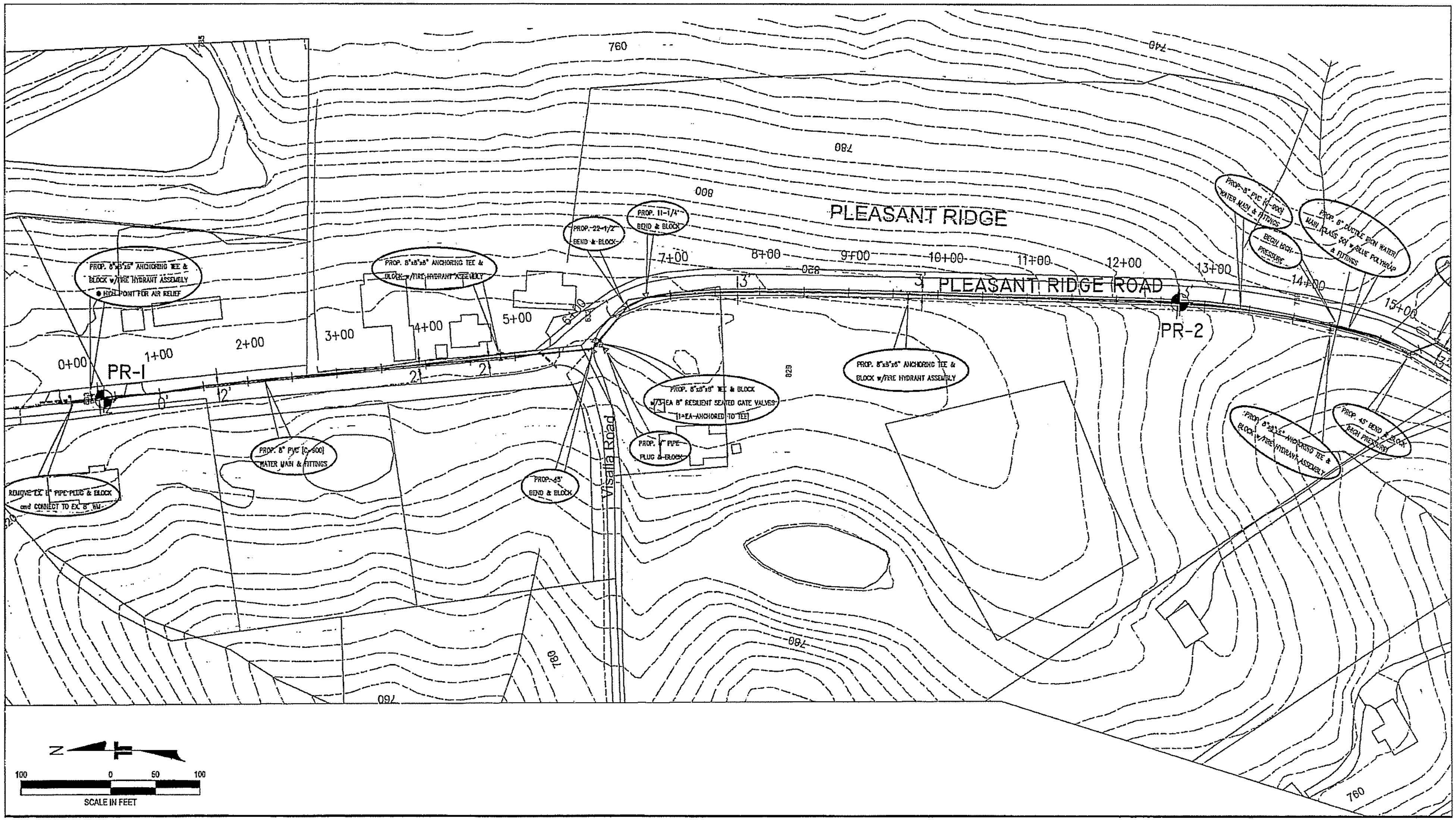
SITE VICINITY MAP
SUBDISTRICT H WATER MAIN EXTENSION – PHASE 4
NORTHERN KENTUCKY WATER DISTRICT
PLEASANT RIDGE ROAD, MADDOX ROAD, & CORY LANE
ALEXANDRIA, CAMPBELL COUNTY KENTUCKY

EXHIBIT
A-1



REV.	DATE	BY	DESCRIPTION

HCN
A Terracon COMPANY
611 LUNKEN PARK DRIVE CINCINNATI, OHIO 45226
PH. (513) 321-5816 FAX. (513) 321-4540

APPROXIMATE TEST BORING LOCATION PLAN

SUB-DISTRICT H, PROPOSED 8" WATER MAIN EXTENSION

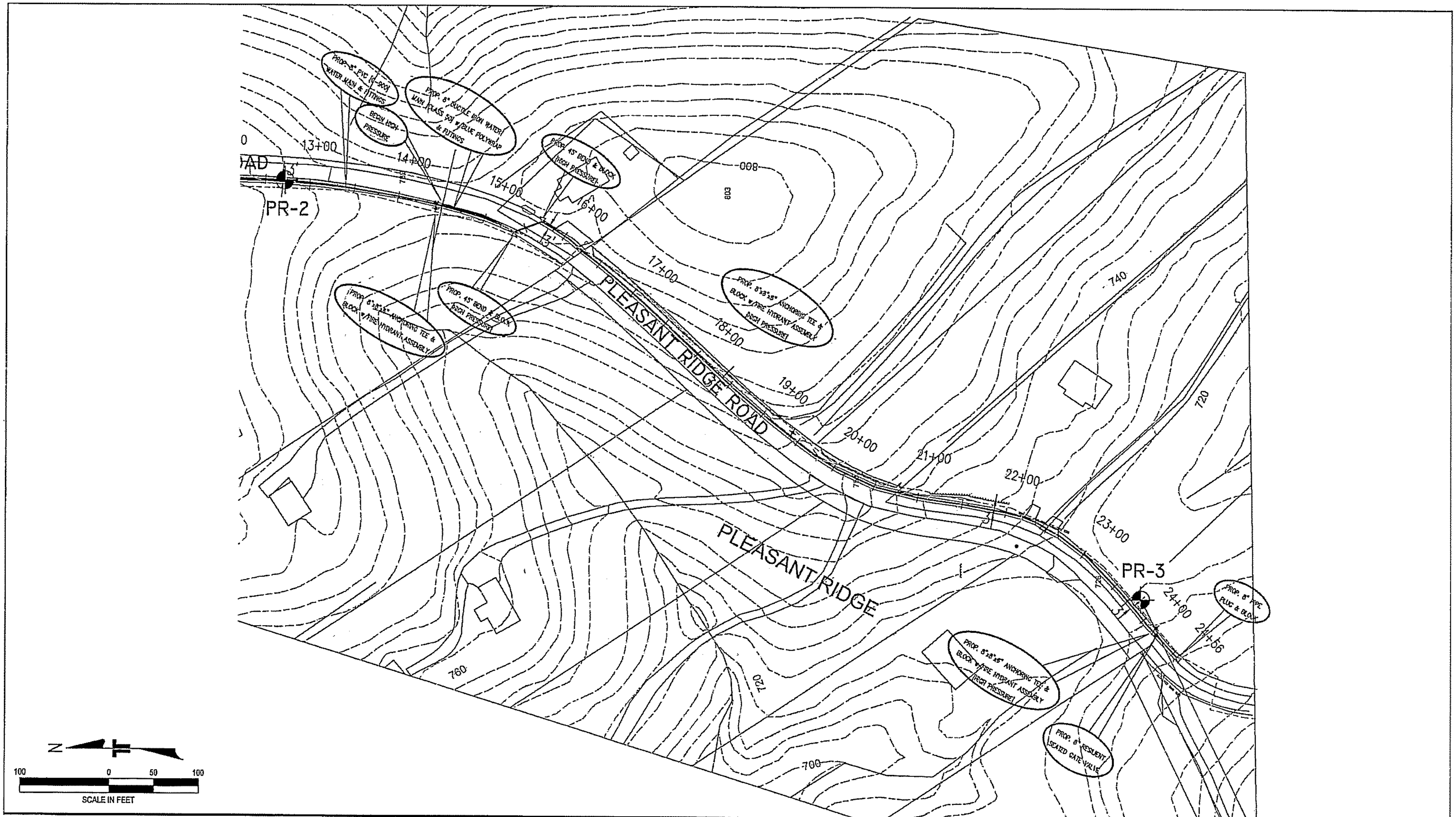
NORTHERN KENTUCKY WATER DISTRICT

PHASE 4

ALEXANDRIA, CAMPBELL COUNTY KENTUCKY

EXHIBIT A-2

DESIGNED BY:	BD
DRAWN BY:	KM
APPVD. BY:	BD
SCALE:	1" = 100'
DATE:	01/19/2010
JOB NO.	N1095342
ACAD NO.	NKWD PR BL.DWG
SHEET NO.:	A-2



REV.	DATE	BY	DESCRIPTION

A Terracon COMPANY
611 LUNKEN PARK DRIVE CINCINNATI, OHIO 45226
PH. (513) 321-5816 FAX. (513) 321-4540

APPROXIMATE TEST BORING LOCATION PLAN

SUB-DISTRICT H, PROPOSED 8" WATER MAIN EXTENSION

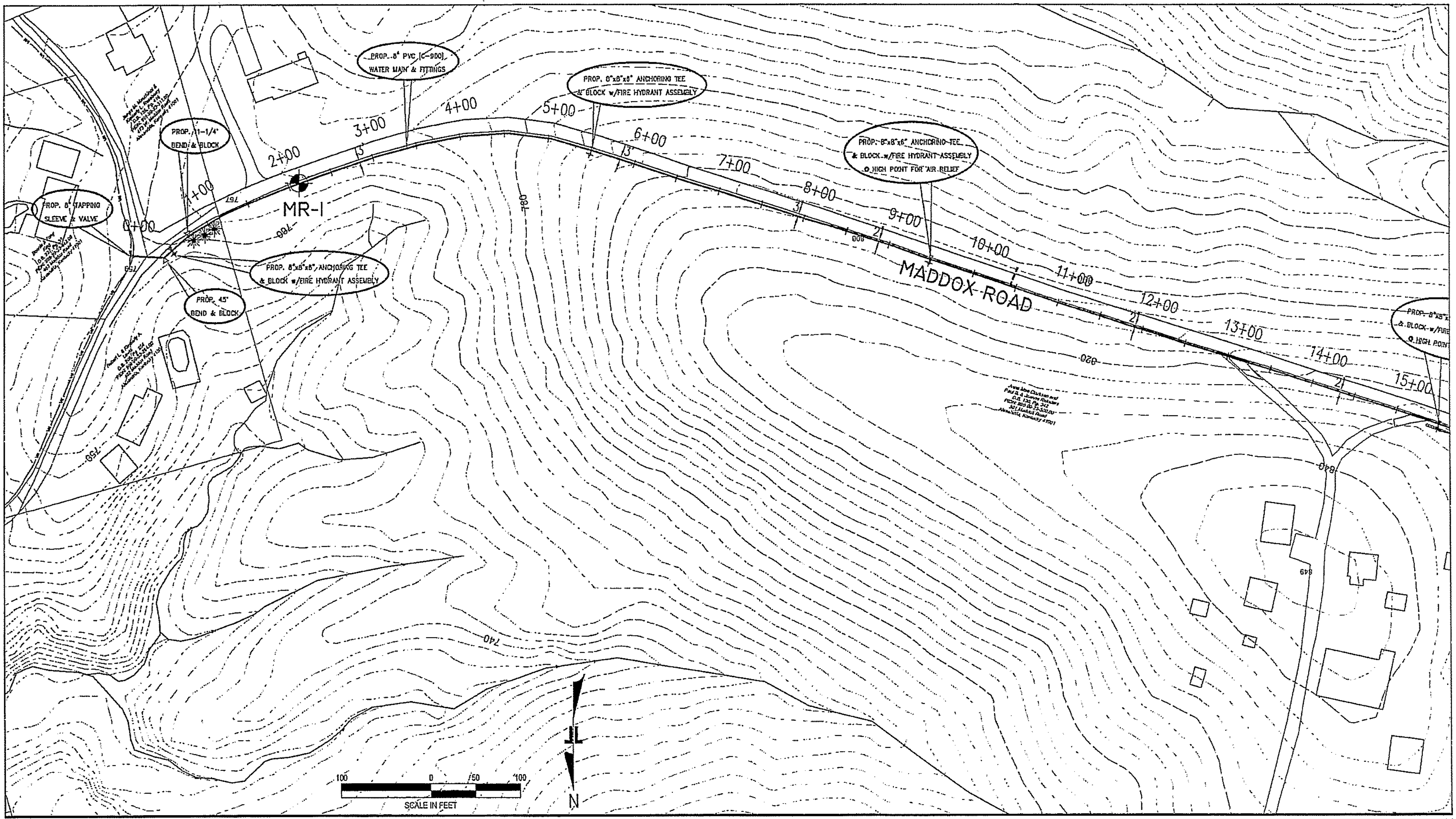
NORTHERN KENTUCKY WATER DISTRICT

PHASE 4

ALEXANDRIA, CAMPBELL COUNTY KENTUCKY

EXHIBIT A-3

DESIGNED BY:	BD
DRAWN BY:	KM
APPVD. BY:	BD
SCALE:	1" = 100'
DATE:	01/19/2010
JOB NO.	N1095342
ACAD NO.	NKWD PR BL.DWG
SHEET NO.:	A-3



REV.	DATE	BY	DESCRIPTION

HCN
A Terracon COMPANY
611 LUNKEN PARK DRIVE CINCINNATI, OHIO 45226
PH. (513) 321-5816 FAX. (513) 321-4540

APPROXIMATE TEST BORING LOCATION PLAN

SUB-DISTRICT H, PROPOSED 8" WATER MAIN EXTENSION

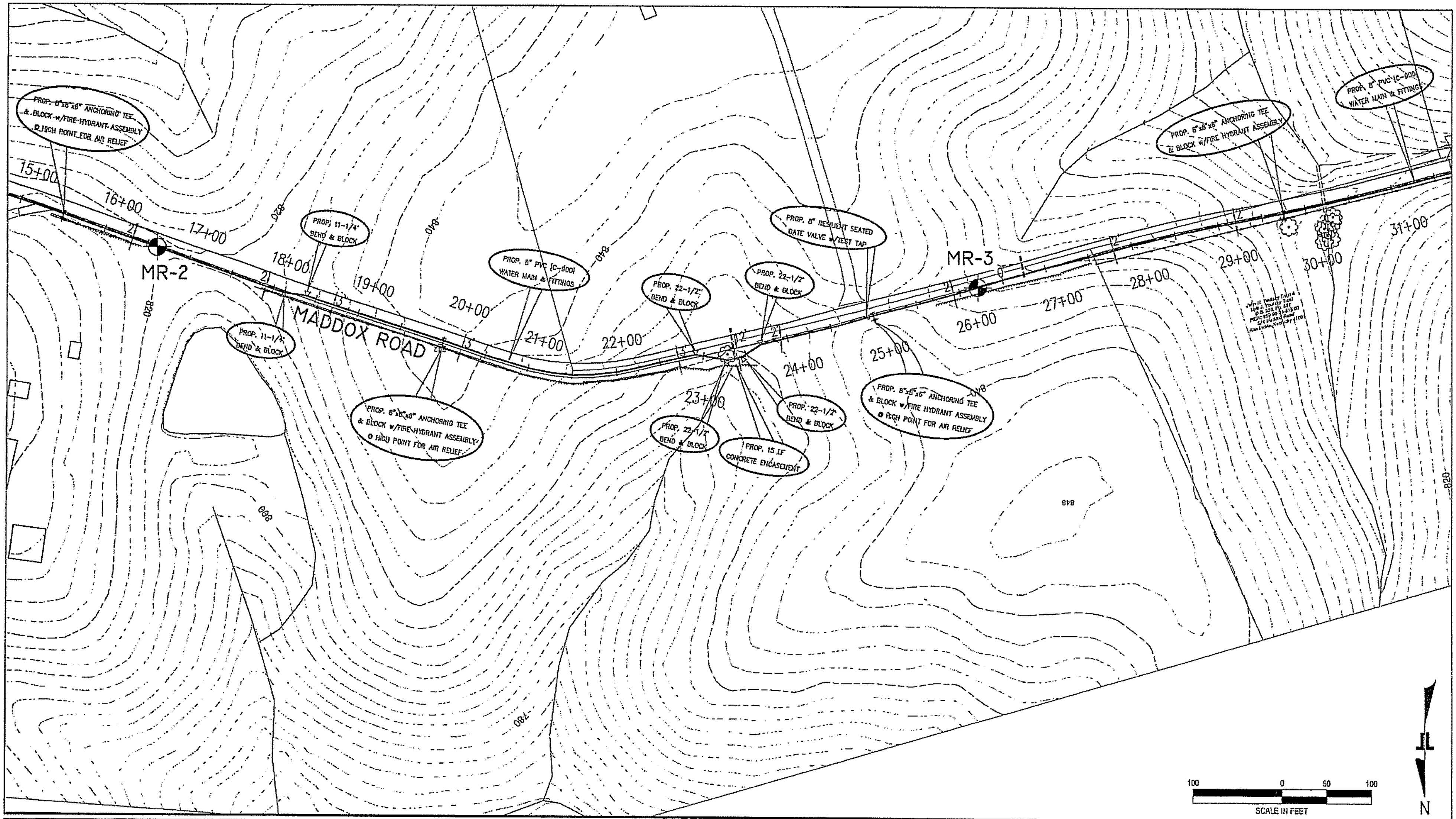
NORTHERN KENTUCKY WATER DISTRICT

PHASE 4

ALEXANDRIA, CAMPBELL COUNTY KENTUCKY

EXHIBIT A-4

DESIGNED BY:	BD
DRAWN BY:	KM
APP'VD. BY:	BD
SCALE:	1" = 100'
DATE:	01/19/2010
JOB NO.	N1095342
ACAD NO.	NKWD MR BL.DWG
SHEET NO.:	A-4



REV.	DATE	BY	DESCRIPTION

A Terracon COMPANY

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PH. (513) 321-5816 FAX. (513) 321-4540

APPROXIMATE TEST BORING LOCATION PLAN

SUB-DISTRICT H, PROPOSED 8" WATER MAIN EXTENSION

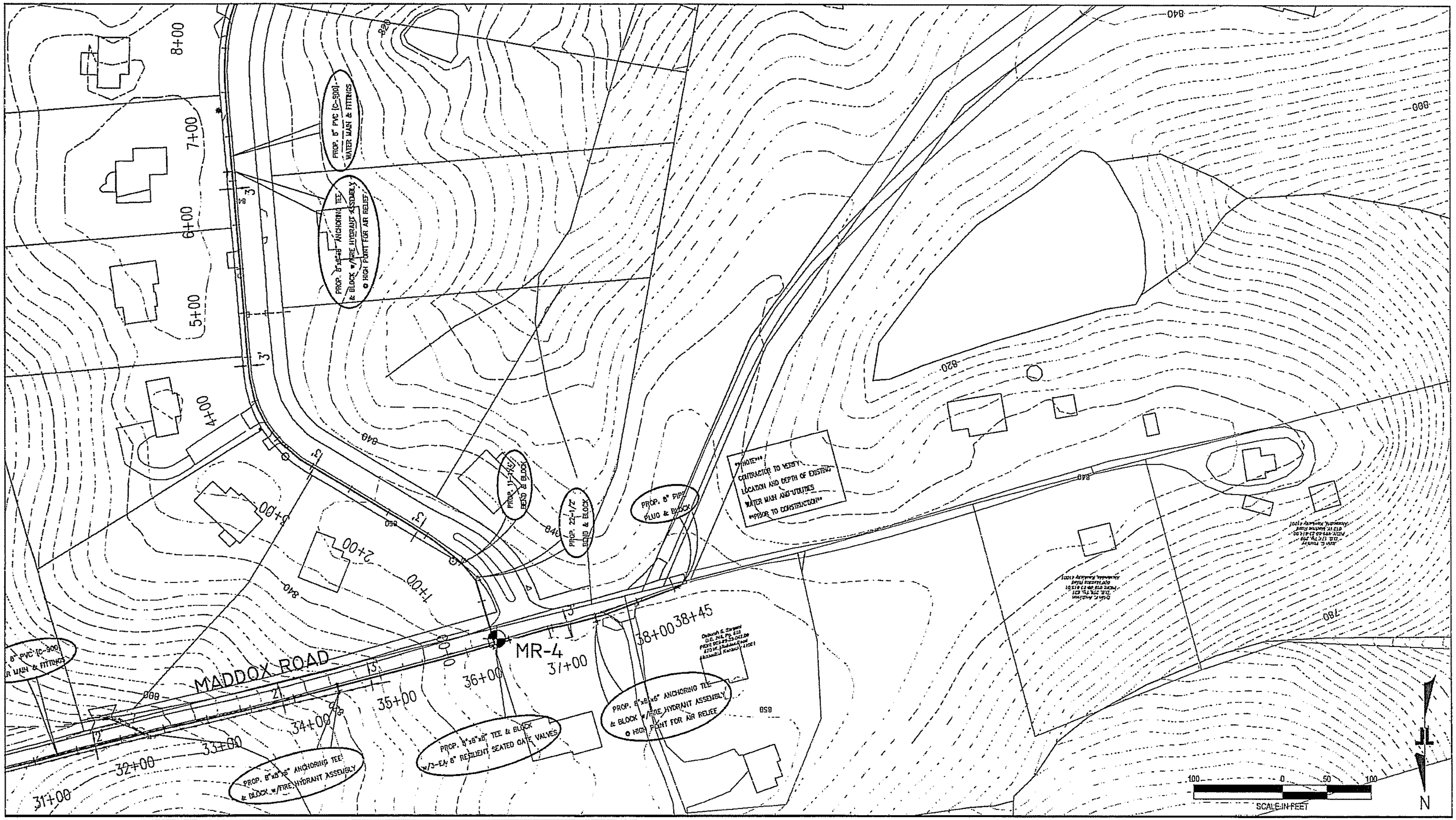
NORTHERN KENTUCKY WATER DISTRICT

PHASE 4

ALEXANDRIA, CAMPBELL COUNTY KENTUCKY

EXHIBIT A-5

DESIGNED BY:	BD
DRAWN BY:	KM
APPVD. BY:	BD
SCALE:	1" = 100'
DATE:	01/19/2010
JOB NO.	N1095342
ACAD NO.	NKWD MR BL.DWG
SHEET NO.:	A-5



REV.	DATE	BY	DESCRIPTION

HCN
A Terracon COMPANY
611 LUNKEN PARK DRIVE CINCINNATI, OHIO 45226
PH. (513) 321-5816 FAX. (513) 321-4540

APPROXIMATE TEST BORING LOCATION PLAN

SUB-DISTRICT H, PROPOSED 8" WATER MAIN EXTENSION

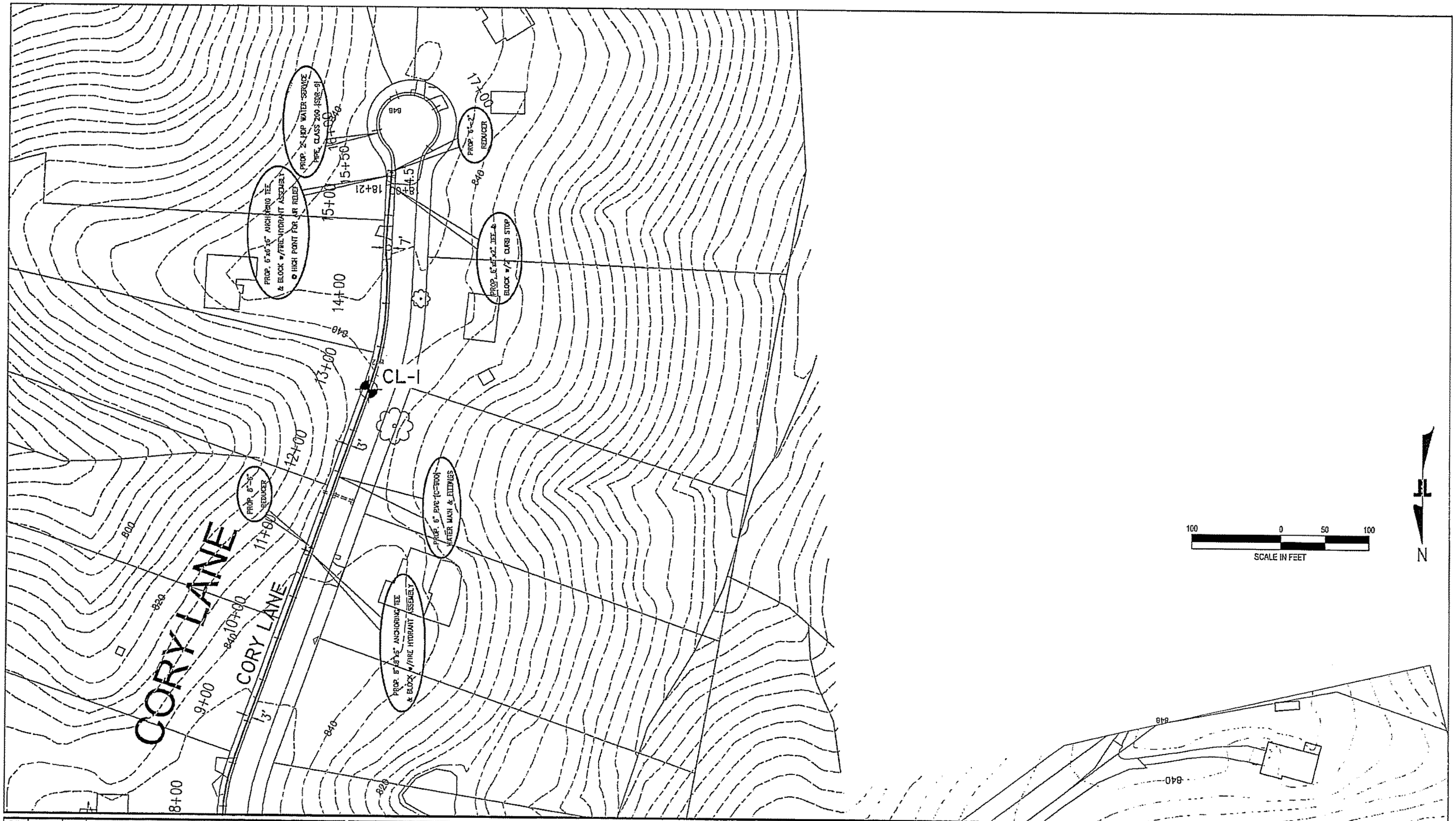
NORTHERN KENTUCKY WATER DISTRICT

PHASE 4

ALEXANDRIA, CAMPBELL COUNTY KENTUCKY

EXHIBIT A-6

DESIGNED BY:	BD
DRAWN BY:	KM
APPVD. BY:	BD
SCALE:	1" = 100'
DATE:	01/19/2010
JOB NO.	N1095342
ACAD NO.	NKWD MR BL.DWG
SHEET NO.:	A-6



REV.	DATE	BY	DESCRIPTION

A Terracon COMPANY

611 LUNKEN PARK DRIVE CINCINNATI, OHIO 45226
PH. (513) 321-5816 FAX. (513) 321-4540

APPROXIMATE TEST BORING LOCATION PLAN

SUB-DISTRICT H, PROPOSED 8" WATER MAIN EXTENSION

NORTHERN KENTUCKY WATER DISTRICT

PHASE 4

ALEXANDRIA, CAMPBELL COUNTY KENTUCKY

EXHIBIT A-7

DESIGNED BY:	BD
DRAWN BY:	KM
APPVD. BY:	BD
SCALE:	1" = 100'
DATE:	01/19/2010
JOB NO.	N1095342
ACAD NO.	NKWD MR BLDWG
SHEET NO.:	A-7

LOG OF BORING NO. MR-1

Page 1 of 1

CLIENT **Northern Kentucky Water District**	ELEVATION REFERENCE **Interpolated from Site Topographic Plan**
SITE **Alexandria, Kentucky**	PROJECT **Proposed Sub-District H Water Main Ext. Ph. 4**

Boring Location: As Shown on Test Boring Location Plan

GRAPHIC LOG	DESCRIPTION Approx. Surface Elev.: 768 ft	DEPTH, ft.	USCS SYMBOL	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES RECOVERY, %	SAMPLES BLOWS / 6in. (SPT - N)	TESTS WATER CONTENT, %	TESTS DRY UNIT WT pcf	TESTS UNCONFINED STRENGTH, psf
	0.4 ASPHALT PAVEMENT 767.6									
	0.7 GRANULAR BASE 767.3		CL	1	SS	67	7-4-4 (8)	26		4000*
	LEAN CLAY, little silt, brown, stiff to very stiff		CL	2	SS	100	6-8-9 (17)	21		8000*
	5 ▽ 763	5								
	SILT, brown, medium dense		ML	3	SS	100	4-5-5 (10)	25		
	7.5 760.5									
	LEAN CLAY, some silt, brown, very stiff		CL	4	SS	100	7-9-11 (20)	23		6000*
	9 759									
	-intermediate silt seams									
	Boring Completed at 9 ft.									

The stratification lines represent the approximate boundary lines between soil and rock types: in-situ, the transition may be gradual.

*Calibrated Hand Penetrometer

Exhibit A-8

WATER LEVEL OBSERVATIONS, ft			
WL	▽ 5.0	WD	▼
WL	▼ N/E	AB	▼
WL			

A Terracon COMPANY

BORING STARTED	1-23-10		
BORING COMPLETED	1-23-10		
RIG	Truck	FOREMAN	JM
LOGGED	DRK	JOB #	N1095342

LOG OF BORING NO. MR-2

Page 1 of 1

CLIENT Northern Kentucky Water District	ELEVATION REFERENCE Interpolated from Site Topographic Plan
SITE Alexandria, Kentucky	PROJECT Proposed Sub-District H Water Main Ext. Ph. 4

Boring Location: As Shown on Test Boring Location Plan

Approx. Surface Elev.: 820 ft

GRAPHIC LOG		DESCRIPTION		DEPTH, ft.	USCS SYMBOL	SAMPLES				TESTS			
						NUMBER	TYPE	RECOVERY, %	BLOWS / 6in. (SPT - N)	WATER CONTENT, %	DRY UNIT WT pcf	UNCONFINED STRENGTH, psf	
	0.5	GRAVEL	819.5			1	SS	89	4				
		LEAN CLAY, some silt, brown, soft to medium stiff			CL	1A	SS	89	2-3 (5)	28		1000*	
					CL	2	SS	78	3-4-3 (7)	25		2000*	LL=39% PI=19%
	5		815	5									
		FAT CLAY, brown and gray, very stiff			CH	3	SS	94	2-4-5 (9)	35		5000*	
	7.5		812.5										
	8.2	**FAT CLAY**, with limestone fragments, brown, medium stiff to stiff	811.8		CH	4	SS	33	7-50/3"	23			
		Boring Completed at 8.2 ft.											

The stratification lines represent the approximate boundary lines between soil and rock types: in-situ, the transition may be gradual.

*Calibrated Hand Penetrometer

Exhibit A-9

WATER LEVEL OBSERVATIONS, ft			
WL	▽ N/E	WD	▼
WL	▼ N/E	AB	▼
WL			

HCN

A Terracon COMPANY

BORING STARTED			1-23-10
BORING COMPLETED			1-23-10
RIG	Truck	FOREMAN	JM
LOGGED	DRK	JOB #	N1095342

LOG OF BORING NO. MR-3

Page 1 of 1

CLIENT **Northern Kentucky Water District**	ELEVATION REFERENCE **Interpolated from Site Topographic Plan**
SITE **Alexandria, Kentucky**	PROJECT **Proposed Sub-District H Water Main Ext. Ph. 4**

Boring Location: As Shown on Test Boring Location Plan

DESCRIPTION

Approx. Surface Elev.: 824 ft

GRAPHIC LOG	Depth	DESCRIPTION	Elev.
	~~0.5~~	ASPHALT PAVEMENT	~~823.5~~
	0.8	GRANULAR BASE	823.2
	8.9	**WEATHERED SHALE**, and limestone fragments, brown, soft	815.1
		Boring Completed at 8.9 ft.	

DEPTH, ft.	USCS SYMBOL	SAMPLES				TESTS		
		NUMBER	TYPE	RECOVERY, %	BLOWS / 6in. (SPT - N)	WATER CONTENT, %	DRY UNIT WT pcf	UNCONFINED STRENGTH, psf
		1	SS	89	7-20-20 (40)	13		
		2	SS	100	20-74-50/1"	16		
5		3	SS	83	26-22-49 (71)	16		
		4	SS	100	9-30-50/5"			

The stratification lines represent the approximate boundary lines between soil and rock types: in-situ, the transition may be gradual.

Exhibit A-10

WATER LEVEL OBSERVATIONS, ft			
WL	∇ N/E	WD	▼
WL	▼ N/E	AB	▼
WL			

HCN
A Terracon COMPANY

BORING STARTED			1-23-10
BORING COMPLETED			1-23-10
RIG	Truck	FOREMAN	JM
LOGGED	DRK	JOB #	N1095342

LOG OF BORING NO. MR-4

Page 1 of 1

CLIENT **Northern Kentucky Water District**	ELEVATION REFERENCE **Interpolated from Site Topographic Plan**
SITE **Alexandria, Kentucky**	PROJECT **Proposed Sub-District H Water Main Ext. Ph. 4**

Boring Location: As Shown on Test Boring Location Plan

GRAPHIC LOG	DESCRIPTION Approx. Surface Elev.: 850 ft	DEPTH, ft.	USCS SYMBOL	SAMPLES				TESTS		
				NUMBER	TYPE	RECOVERY, %	BLOWS / 6in. (SPT - N)	WATER CONTENT, %	DRY UNIT WT pcf	UNCONFINED STRENGTH, psf
■	0.5 ASPHALT PAVEMENT 849.5									
▨	0.9 GRANULAR BASE 849.1		CL	1	SS	78	2-2-5 (7)	25		6000*
▨	2.5 **LEAN CLAY**, little silt and sand, brown, very stiff 847.5									
▥	**SILTY CLAY**, brown, very stiff 5 845		CL ML	2	SS	100	6-8-12 (20)	17		8000*
▨	**LEAN CLAY**, some silt, dark brown to brown, stiff 7.5 842.5	5	CL	3	SS	100	5-7-8 (15)	22		4000*
▨	**LEAN CLAY**, some silt, brown, very stiff 9 841		CL	4	SS	100	8-4-10 (14)	16		8000*
	Boring Completed at 9 ft.									

The stratification lines represent the approximate boundary lines between soil and rock types: in-situ, the transition may be gradual.

*Calibrated Hand Penetrometer

Exhibit A-11

WATER LEVEL OBSERVATIONS, ft			
WL	⊻ N/E	WD	⊻
WL	⊻ N/E	AB	⊻
WL			

A Terracon COMPANY

BORING STARTED			1-23-10
BORING COMPLETED			1-23-10
RIG	Truck	FOREMAN	JM
LOGGED	DRK	JOB #	N1095342

LOG OF BORING NO. PR-1

Page 1 of 1

CLIENT **Northern Kentucky Water District**	ELEVATION REFERENCE **Interpolated from Site Topographic Plan**
SITE **Alexandria, Kentucky**	PROJECT **Proposed Sub-District H Water Main Ext. Ph. 4**

Boring Location: As Shown on Test Boring Location Plan

Approx. Surface Elev.: 834.5 ft

GRAPHIC LOG	DESCRIPTION	DEPTH, ft.	USCS SYMBOL	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES RECOVERY, %	SAMPLES BLOWS / 6in. (SPT - N)	TESTS WATER CONTENT, %	TESTS DRY UNIT WT pcf	TESTS UNCONFINED STRENGTH, psf
	0.5 ASPHALT PAVEMENT 834									
	0.9 GRANULAR BASE 833.6									
	2.5 **LEAN CLAY**, trace sand, brown, very stiff 832		CL	1	SS	67	10-5-5 (10)	22		5000*
	5 **FAT CLAY**, brown, very stiff 829.5		CH	2	SS	100	5-6-6 (12)	31		5000
	7.5 **LEAN CLAY**, some silt, brown, very stiff 827	5	CL	3	SS	100	3-4-8 (12)	22		6000*
	9 **LEAN CLAY**, little sand and silt, trace iron concretions, brown, very stiff 825.5		CL	4	SS	100	7-10-13 (23)	21		8000*
	Boring Completed at 9 ft.									

The stratification lines represent the approximate boundary lines between soil and rock types: in-situ, the transition may be gradual.

*Calibrated Hand Penetrometer

Exhibit A-12

WATER LEVEL OBSERVATIONS, ft			
WL	∇ N/E	WD	▼
WL	▼ N/E	AB	▼
WL			

HCN

A Terracon COMPANY

BORING STARTED			1-23-10
BORING COMPLETED			1-23-10
RIG	Truck	FOREMAN	JM
LOGGED	DRK	JOB #	N1095342

LOG OF BORING NO. PR-2

Page 1 of 1

CLIENT **Northern Kentucky Water District**	ELEVATION REFERENCE **Interpolated from Site Topographic Plan**
SITE **Alexandria, Kentucky**	PROJECT **Proposed Sub-District H Water Main Ext. Ph. 4**

Boring Location: As Shown on Test Boring Location Plan

Approx. Surface Elev.: 798 ft

	DESCRIPTION		DEPTH, ft	USCS SYMBOL	SAMPLES				TESTS			
					NUMBER	TYPE	RECOVERY, %	BLOWS / 6in. (SPT - N)	WATER CONTENT, %	DRY UNIT WT pcf	UNCONFINED STRENGTH, psf	
0.5	ASPHALT PAVEMENT	797.5										
0.8	GRANULAR BASE	797.2		CH	1	SS	83	6-8-4 (12)	23		5000*	
	FAT CLAY, trace limestone floaters, brown, very stiff			CH	2	SS	100	6-8-9 (17)	24		7000*	LL=52% PI=28%
			5	CH	3	SS	100	6-7-7 (14)	15		6000*	
7.5		790.5										
	HIGHLY WEATHERED SHALE, brown, soft				4	SS	100	7-10-16 (26)	17			
9		789										
	Boring Completed at 9 ft.											

The stratification lines represent the approximate boundary lines between soil and rock types: In-situ, the transition may be gradual.

*Calibrated Hand Penetrometer

Exhibit A-13

WATER LEVEL OBSERVATIONS, ft			
WL	∇ N/E	WD	▼
WL	▼ N/E	AB	∇
WL			

HCN

A Terracon COMPANY

BORING STARTED			1-23-10
BORING COMPLETED			1-23-10
RIG	Truck	FOREMAN	JM
LOGGED	DRK	JOB #	N1095342

LOG OF BORING NO. PR-3

Page 1 of 1

CLIENT **Northern Kentucky Water District**	ELEVATION REFERENCE **Interpolated from Site Topographic Plan**
SITE **Alexandria, Kentucky**	PROJECT **Proposed Sub-District H Water Main Ext. Ph. 4**

Boring Location: As Shown on Test Boring Location Plan

Approx. Surface Elev.: 726 ft

GRAPHIC LOG	DESCRIPTION	DEPTH, ft.	USCS SYMBOL	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES RECOVERY, %	SAMPLES BLOWS / 6in. (SPT - N)	TESTS WATER CONTENT, %	TESTS DRY UNIT WT pcf	TESTS UNCONFINED STRENGTH, psf
▨	0.5 TOPSOIL 725.5									
▨	**FILL**, lean clay, little sand and gravel, dark brown, stiff 2.5 723.5			1	SS	100	2-4-4 (8)	17		4000*
▨	**FILL**, lean clay, brown, soft to medium stiff 5 721			2	SS	100	5-3-3 (6)	33		1000*
▨	**LEAN CLAY**, trace sand and gravel, brown and gray, stiff 7.5 718.5	5	CL	3	SS	89	3-3-7 (10)	26		4000*
▨	**FAT CLAY**, little silt, brown and gray, very stiff 9 717		CH	4	SS	100	3-7-10 (17)	23		8000*
	Boring Completed at 9 ft.									

The stratification lines represent the approximate boundary lines between soil and rock types: in-situ, the transition may be gradual.

*Calibrated Hand Penetrometer

Exhibit A-14

WATER LEVEL OBSERVATIONS, ft			
WL	⊻ N/E	WD	⊻
WL	⊻ N/E	AB	⊻
WL			

HCN

A Terracon COMPANY

BORING STARTED			1-23-10
BORING COMPLETED			1-23-10
RIG	Truck	FOREMAN	JM
LOGGED	DRK	JOB #	N1095342

LOG OF BORING NO. CL-1

Page 1 of 1

CLIENT **Northern Kentucky Water District**	ELEVATION REFERENCE **Interpolated from Site Topographic Plan**
SITE **Alexandria, Kentucky**	PROJECT **Proposed Sub-District H Water Main Ext. Ph. 4**

Boring Location: As Shown on Test Boring Location Plan

GRAPHIC LOG	DESCRIPTION Approx. Surface Elev.: 839.5 ft	DEPTH, ft	USCS SYMBOL	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES RECOVERY, %	SAMPLES BLOWS / 6in. (SPT - N)	TESTS WATER CONTENT, %	TESTS DRY UNIT WT pcf	TESTS UNCONFINED STRENGTH, psf	
	0.5 CONCRETE PAVEMENT 839										
	LEAN CLAY, little sand, brown, very stiff 2.5 837		CL	1	SS	94	3-6-8 (14)	28		8000*	
	FAT CLAY, some silt, brown, very stiff		CH	2	SS	100	9-9-13 (22)	26		8000*	
		5	CH	3	SS	100	7-9-11 (20)	19		8000*	LL=63% PI=36%
	7.5 832										
	SILTY CLAY, trace sand, brown, very stiff 9 830.5		CL ML	4	SS	100	9-11-13 (24)	18		6000*	
	Boring Completed at 9 ft.										

The stratification lines represent the approximate boundary lines between soil and rock types: In-situ, the transition may be gradual.

*Calibrated Hand Penetrometer

Exhibit A-15

WATER LEVEL OBSERVATIONS, ft			
WL	▽ N/E	WD	▼
WL	▼ N/E	AB	▼
WL			

HCN
A Terracon COMPANY

BORING STARTED			1-23-10
BORING COMPLETED			1-23-10
RIG	Truck	FOREMAN	JM
LOGGED	DRK	JOB #	N1095342

BOREHOLE 99 BORING LOGS PH 4.GPJ TERRACON TEST.GDT 3/4/10

Field Exploration Description

The boring locations were laid out on the site by HCN/Terracon personnel using water main alignment plans provided by Viox & Viox Inc., (undated). Ground surface elevations at test boring locations were interpolated from the water main alignment plan drawings. The borings were drilled with truck-mounted rotary drill rigs using continuous flight hollow-stem augers to advance the boreholes. Samples of the soil encountered in the borings were obtained using the split-barrel sampling procedures.

In the split barrel sampling procedure, the number of blows required to advance a standard 2 inch O.D. split barrel sampler the last 12 inches of the typical total 18 inch penetration by means of a rope and cathead manual safety hammer with a free fall of 30 inches, is the standard penetration resistance value (SPT-N). This value is used to estimate the in-situ relative density of cohesionless soils and consistency of cohesive soils.

An automatic SPT hammer was used to advance the split-barrel sampler in the borings performed on this site. A greater efficiency is typically achieved with the automatic hammer compared to the conventional safety hammer operated with a cathead and rope. Published correlations between the SPT values and soil properties are based on the lower efficiency cathead and rope method. This higher efficiency affects the standard penetration resistance blow count (N) value by increasing the penetration per hammer blow over what would obtained using the cathead and rope method. The effect of the automatic hammer's efficiency has been considered in the interpretation and analysis of the subsurface information for this report.

The samples were tagged for identification, sealed to reduce moisture loss, and taken to our laboratory for further examination, testing, and classification. Information provided on the boring logs attached to this report includes soil descriptions, consistency evaluations, boring depths, sampling intervals, and groundwater conditions. The borings were backfilled with auger cuttings prior to the drill crew leaving the site.

A field log of each boring was prepared by the drill crew. These logs included visual classifications of the materials encountered during drilling as well as the driller's interpretation of the subsurface conditions between samples. Final boring logs included with this report represent the engineer's review of obtained soil samples, driller's field logs and include modifications based on laboratory tests of the samples.

APPENDIX B

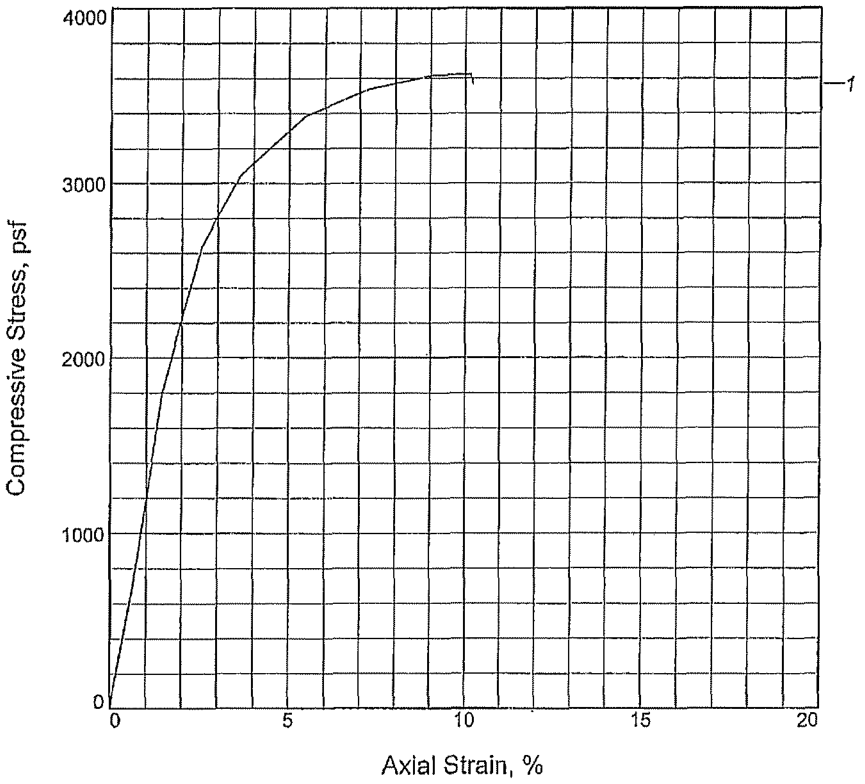
SUPPORTING INFORMATION

Laboratory Testing

Selected soil samples were tested in the laboratory to measure natural water content and Atterberg Limits. One unconfined compression strength test was performed on a sample obtained at test boring PR-1. A calibrated hand penetrometer was used to estimate the approximate unconfined compressive strength of some samples. The calibrated hand penetrometer has been correlated with unconfined compression tests and provides a better estimate of soil consistency than visual examination alone. The test results are provided on the boring logs included in Appendix A.

Descriptive classifications of the soils indicated on the boring logs are in accordance with the enclosed General Notes and the Unified Soil Classification System. Also shown are estimated Unified Soil Classification Symbols. A brief description of this classification system is attached to this report. All classification was by visual manual procedures. Selected samples were further classified using the results of Atterberg limit testing. The Atterberg limit test results are also provided on the boring logs.

UNCONFINED COMPRESSION TEST



Sample No.	1			
Unconfined strength, psf	3623.9			
Undrained shear strength, psf	1811.9			
Failure strain,	10.1			
Strain rate, in./min.	0.027			
Water content, %	31.1			
Wet density, pcf	120.2			
Dry density, pcf	91.6			
Saturation, %	99.7			
Void ratio	0.8463			
Specimen diameter, in.	1.390			
Specimen height, in.	2.760			
Height/diameter ratio	1.99			

Description: BROWN FAT CLAY

LL =	**PL =**	**PI =**	**Assumed GS=** 2.71	**Type:** SS

Project No.: N1095342
Date: 2-1-10
Remarks:
Lab No. 606

EXHIBIT B-2

Figure ______

Client: NORTHERN KENTUCKY WATER DISTRICT

Project: SUBDISTRICT H WATER MAIN EXT. PHASE 4

Source of Sample: PR-1 **Depth:** 2.5-4'
Sample Number: S-2

UNCONFINED COMPRESSION TEST

H. C. NUTTING COMPANY

Tested By: DR **Checked By:** GS

APPENDIX C

SUPPORTING DOCUMENTS

GENERAL NOTES

DRILLING & SAMPLING SYMBOLS:

SS: Split Spoon – 1-$^{3}/_{8}$" I.D., 2" O.D., unless otherwise noted
ST: Thin-Walled Tube - 2" O.D., unless otherwise noted
RS: Ring Sampler - 2.42" I.D., 3" O.D., unless otherwise noted
DB: Diamond Bit Coring - 4", N, B
BS: Bulk Sample or Auger Sample

HS: Hollow Stem Auger
PA: Power Auger
HA: Hand Auger
RB: Rock Bit
WB: Wash Boring or Mud Rotary

The number of blows required to advance a standard 2-inch O.D. split-spoon sampler (SS) the last 12 inches of the total 18-inch penetration with a 140-pound hammer falling 30 inches is considered the "Standard Penetration" or "N-value".

WATER LEVEL MEASUREMENT SYMBOLS:

WL: Water Level
WCI: Wet Cave in
DCI: Dry Cave in
AB: After Boring

WS: While Sampling
WD: While Drilling
BCR: Before Casing Removal
ACR: After Casing Removal

N/E: Not Encountered

Water levels indicated on the boring logs are the levels measured in the borings at the times indicated. Groundwater levels at other times and other locations across the site could vary. In pervious soils, the indicated levels may reflect the location of groundwater. In low permeability soils, the accurate determination of groundwater levels may not be possible with only short-term observations.

DESCRIPTIVE SOIL CLASSIFICATION: Soil classification is based on the Unified Classification System. Coarse Grained Soils have more than 50% of their dry weight retained on a #200 sieve; their principal descriptors are: boulders, cobbles, gravel or sand. Fine Grained Soils have less than 50% of their dry weight retained on a #200 sieve; they are principally described as clays if they are plastic, and silts if they are slightly plastic or non-plastic. Major constituents may be added as modifiers and minor constituents may be added according to the relative proportions based on grain size. In addition to gradation, coarse-grained soils are defined on the basis of their in-place relative density and fine-grained soils on the basis of their consistency.

CONSISTENCY OF FINE-GRAINED SOILS

Unconfined Compressive Strength, Qu, psf	Standard Penetration or N-value (SS) Blows/Ft.	Consistency
< 500	<2	Very Soft
500 – 1,000	2-3	Soft
1,001 – 2,000	4-6	Medium Stiff
2,001 – 4,000	7-12	Stiff
4,001 – 8,000	13-26	Very Stiff
8,000+	26+	Hard

RELATIVE DENSITY OF COARSE-GRAINED SOILS

Standard Penetration or N-value (SS) Blows/Ft.	Ring Sampler (RS) Blows/Ft.	Relative Density
0 – 3	0-6	Very Loose
4 – 9	7-18	Loose
10 – 29	19-58	Medium Dense
30 – 49	59-98	Dense
50+	99+	Very Dense

RELATIVE PROPORTIONS OF SAND AND GRAVEL

Descriptive Term(s) of other Constituents	Percent of Dry Weight
Trace	< 15
With	15 – 29
Modifier	> 30

GRAIN SIZE TERMINOLOGY

Major Component of Sample	Particle Size
Boulders	Over 12 in. (300mm)
Cobbles	12 in. to 3 in. (300mm to 75 mm)
Gravel	3 in. to #4 sieve (75mm to 4.75 mm)
Sand	#4 to #200 sieve (4.75mm to 0.075mm)
Silt or Clay	Passing #200 Sieve (0.075mm)

RELATIVE PROPORTIONS OF FINES

Descriptive Term(s) of other Constituents	Percent of Dry Weight
Trace	< 5
With	5 – 12
Modifiers	> 12

PLASTICITY DESCRIPTION

Term	Plasticity Index
Non-plastic	0
Low	1-10
Medium	11-30
High	30+

Exhibit C-1

UNIFIED SOIL CLASSIFICATION SYSTEM

Criteria for Assigning Group Symbols and Group Names Using Laboratory Tests[A]					Soil Classification	
					Group Symbol	Group Name[B]
Coarse Grained Soils: More than 50% retained on No. 200 sieve	**Gravels:** More than 50% of coarse fraction retained on No. 4 sieve	**Clean Gravels:** Less than 5% fines[C]	$Cu \geq 4$ and $1 \leq Cc \leq 3$ [E]		GW	Well-graded gravel[F]
			$Cu < 4$ and/or $1 > Cc > 3$ [E]		GP	Poorly graded gravel[F]
		Gravels with Fines: More than 12% fines[C]	Fines classify as ML or MH		GM	Silty gravel[F,G,H]
			Fines classify as CL or CH		GC	Clayey gravel[F,G,H]
	Sands: 50% or more of coarse fraction passes No. 4 sieve	**Clean Sands:** Less than 5% fines[D]	$Cu \geq 6$ and $1 \leq Cc \leq 3$ [E]		SW	Well-graded sand[I]
			$Cu < 6$ and/or $1 > Cc > 3$ [E]		SP	Poorly graded sand[I]
		Sands with Fines: More than 12% fines[D]	Fines classify as ML or MH		SM	Silty sand[G,H,I]
			Fines Classify as CL or CH		SC	Clayey sand[G,H,I]
Fine-Grained Soils: 50% or more passes the No. 200 sieve	**Silts and Clays:** Liquid limit less than 50	**Inorganic:**	PI > 7 and plots on or above "A" line[J]		CL	Lean clay[K,L,M]
			PI < 4 or plots below "A" line[J]		ML	Silt[K,L,M]
		Organic:	Liquid limit - oven dried	< 0.75	OL	Organic clay[K,L,M,N]
			Liquid limit - not dried			Organic silt[K,L,M,O]
	Silts and Clays: Liquid limit 50 or more	**Inorganic:**	PI plots on or above "A" line		CH	Fat clay[K,L,M]
			PI plots below "A" line		MH	Elastic Silt[K,L,M]
		Organic:	Liquid limit - oven dried	< 0.75	OH	Organic clay[K,L,M,P]
			Liquid limit - not dried			Organic silt[K,L,M,Q]
Highly organic soils:	Primarily organic matter, dark in color, and organic odor				PT	Peat

[A] Based on the material passing the 3-in. (75-mm) sieve

[B] If field sample contained cobbles or boulders, or both, add "with cobbles or boulders, or both" to group name.

[C] Gravels with 5 to 12% fines require dual symbols: GW-GM well-graded gravel with silt, GW-GC well-graded gravel with clay, GP-GM poorly graded gravel with silt, GP-GC poorly graded gravel with clay.

[D] Sands with 5 to 12% fines require dual symbols: SW-SM well-graded sand with silt, SW-SC well-graded sand with clay, SP-SM poorly graded *sand with silt, SP-SC poorly graded sand with clay*

[E] $$Cu = D_{60}/D_{10} \qquad Cc = \frac{(D_{30})^2}{D_{10} \times D_{60}}$$

[F] If soil contains ≥ 15% sand, add "with sand" to group name.

[G] *If fines classify as CL-ML, use dual symbol GC-GM, or SC-SM.*

[H] If fines are organic, add "with organic fines" to group name.

[I] If soil contains ≥ 15% gravel, add "with gravel" to group name.

[J] If Atterberg limits plot in shaded area, soil is a CL-ML, silty clay.

[K] If soil contains 15 to 29% plus No. 200, add "with sand" or "with gravel," whichever is predominant.

[L] If soil contains ≥ 30% plus No. 200 predominantly sand, add "sandy" to group name.

[M] If soil contains ≥ 30% plus No. 200, predominantly gravel, add *"gravelly" to group name.*

[N] PI ≥ 4 and plots on or above "A" line.

[O] PI < 4 or plots below "A" line.

[P] PI plots on or above "A" line.

[Q] PI plots below "A" line.

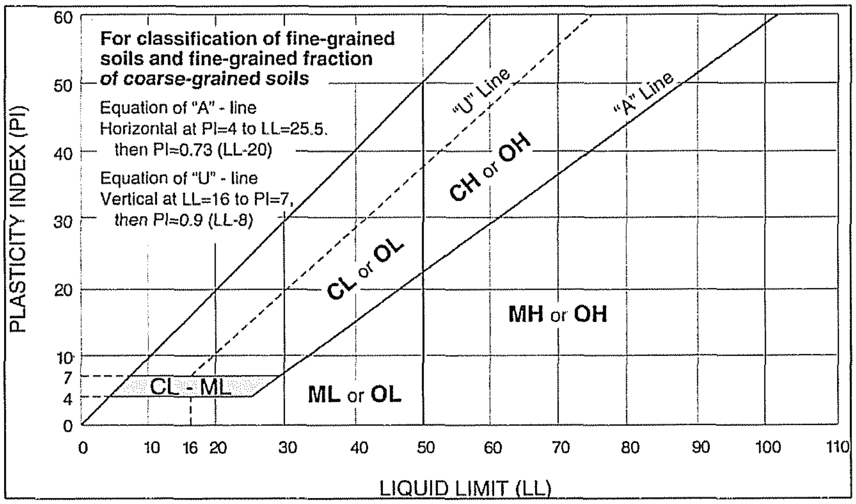


Exhibit C-2

GENERAL NOTES

Description of Rock Properties

WEATHERING

Fresh	Rock fresh, crystals bright, few joints may show slight staining. Rock rings under hammer if crystalline.
Very slight	Rock generally fresh, joints stained, some joints may show thin clay coatings, crystals in broken face show bright. Rock rings under hammer if crystalline.
Slight	Rock generally fresh, joints stained, and discoloration extends into rock up to 1 in. Joints may contain clay. In granitoid rocks some occasional feldspar crystals are dull and discolored. Crystalline rocks ring under hammer.
Moderate	Significant portions of rock show discoloration and weathering effects. In granitoid rocks, most feldspars are dull and discolored; some show clayey. Rock has dull sound under hammer and shows significant loss of strength as compared with fresh rock.
Moderately severe	All rock except quartz discolored or stained. In granitoid rocks, all feldspars dull and discolored and majority show kaolinization. Rock shows severe loss of strength and can be excavated with geologist's pick.
Severe	All rock except quartz discolored or stained. Rock "fabric" clear and evident, but reduced in strength to strong soil. In granitoid rocks, all feldspars kaolinized to some extent. Some fragments of strong rock usually left.
Very severe	All rock except quartz discolored or stained. Rock "fabric" discernible, but mass effectively reduced to "soil" with only fragments of strong rock remaining.
Complete	Rock reduced to "soil". Rock "fabric" not discernible or discernible only in small, scattered locations. Quartz may be present as dikes or stringers.

HARDNESS (for engineering description of rock – not to be confused with Moh's scale for minerals)

Very hard	Cannot be scratched with knife or sharp pick. Breaking of hand specimens requires several hard blows of geologist's pick.
Hard	Can be scratched with knife or pick only with difficulty. Hard blow of hammer required to detach hand specimen.
Moderately hard	Can be scratched with knife or pick. Gouges or grooves to ¼ in. deep can be excavated by hard blow of point of a geologist's pick. Hand specimens can be detached by moderate blow.
Medium	Can be grooved or gouged 1/16 in. deep by firm pressure on knife or pick point. Can be excavated in small chips to pieces about 1-in. maximum size by hard blows of the point of a geologist's pick.
Soft	Can be gouged or grooved readily with knife or pick point. Can be excavated in chips to pieces several inches in size by moderate blows of a pick point. Small thin pieces can be broken by finger pressure.
Very soft	Can be carved with knife. Can be excavated readily with point of pick. Pieces 1-in. or more in thickness can be broken with finger pressure. Can be scratched readily by fingernail.

Joint, Bedding and Foliation Spacing in Rock [a]

Spacing	Joints	Bedding/Foliation
Less than 2 in.	Very close	Very thin
2 in. – 1 ft.	Close	Thin
1 ft. – 3 ft.	Moderately close	Medium
3 ft. – 10 ft.	Wide	Thick
More than 10 ft.	Very wide	Very thick

Rock Quality Designator (RQD) [b]		Joint Openness Descriptors	
RQD, as a percentage	**Diagnostic description**	**Openness**	**Descriptor**
Exceeding 90	Excellent	No Visible Separation	Tight
90 – 75	Good	Less than 1/32 in.	Slightly Open
75 – 50	Fair	1/32 to 1/8 in.	Moderately Open
50 – 25	Poor	1/8 to 3/8 in.	Open
Less than 25	Very poor	3/8 in. to 0.1 ft.	Moderately Wide
		Greater than 0.1 ft.	Wide

a. Spacing refers to the distance normal to the planes, of the described feature, which are parallel to each other or nearly so.

b. RQD (given as a percentage) = length of core in pieces 4 in. and longer/length of run.

References: American Society of Civil Engineers. Manuals and Reports on Engineering Practice - No. 56. Subsurface Investigation for Design and Construction of Foundations of Buildings. New York: American Society of Civil Engineers, 1976.

U.S. Department of the Interior, Bureau of Reclamation, Engineering Geology Field Manual.

Exhibit C-2