Geotechnical Engineering Report

Preliminary Geotechnical Study
Harrison Hills City Schools – Site D
Cadiz, Ohio

June 22, 2015
Terracon Project No. N4155098

Prepared for:
Harrison Hills City Schools
c/o SHP Leading Design
Columbus, Ohio

Prepared by:
Terracon Consultants, Inc.
Columbus, Ohio

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June 22, 2015

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Re: Geotechnical Engineering Report
Preliminary Geotechnical Study
Harrison Hills City Schools – Site D
Cadiz, Ohio
Terracon Project No. N4155098

Dear Mr. Predovich:

Terracon Consultants, Inc. (Terracon) has completed the geotechnical engineering services for the above referenced project. This study was performed in general accordance with our proposal number PN4150208 and our agreement for services dated May 7, 2015. This report presents the findings of the subsurface exploration and provides preliminary geotechnical engineering recommendations regarding options for design and construction of the proposed school.

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,
Terracon Consultants, Inc.

M.S. FOR
Alma K. Baratta, P.E.
Senior Staff Engineer

Kevin M.
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Geotechnical Department Manager

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EXECUTIVE SUMMARY

Terracon Consultants, Inc. has completed a preliminary geotechnical exploration for the proposed Harrison City Schools "Site D" to be located on a parcel on the east side of State Route 9, south of Cadiz, Ohio. Four (4) test borings, designated B-1 through B-4, drilled to depths ranging from approximately 65 to 77 feet below the existing ground surface.

Based on the information obtained from our subsurface exploration, the site can be developed for the proposed project. The following geotechnical considerations were identified:

- The test borings at the site indicated variable depth fill consisting of mine spoils across the central portions of the site, with native cohesive soils on the western portion of the site. The mine spoil fill and native soils were underlain by sedimentary bedrock. Areas of fill encountered in the borings corresponded to available mapping of previous strip mining activities.

- Based on the subsurface conditions encountered in the recent test borings and available mine mapping, the site does not appear to be suitable for development of conventional building foundations and slab-on-grade floors without implementation of ground improvement of the fill to reduce potential adverse total and differential settlement response to proposed structure.

- From a geotechnical engineering perspective, one of the concerns associated with development of the site is the presence and considerable and variable depths of the mine spoil fill material. Volume reduction of the fill can occur owing to various processes, such as collapse compression from crushing of rock to rock contact points upon wetting or long-term creep associated with self-weight of the mine spoils. Hydrocompression settlement can also occur from the presence of water (saturating or percolating through the fill). Softening, squeezing, consolidation, and internal erosion of particles into open voids can also occur.

- Direct foundation support on the existing fill and mine spoils is not recommended, due to the potential for large total and differential settlements of the building foundations. Settlement will also continue to occur for a long period of time.

- Selection of the appropriate foundation system will depend on the level of risk to the structure and costs related to minimizing the risk potential. Constructing the proposed building at the proposed site will require transferring the foundation loads to the stable bedrock using deep foundations such as drilled shafts (least risk option) or by improving the uncontrolled fill/mine spoil material by using ground modification techniques such as proprietary Geopier® Rammed Aggregate Piers or by undercutting and replacement of mine spoils (higher risk options).

- Deep Dynamic Compaction (DDC) can also considered as a ground modification option, since in that it may provide for an economical alternative to the deep foundations, rammed aggregate piers or undercutting and replacement. A relatively complex, multiple phase compaction program that would be required for the predominantly clay fill/mine spoils encountered at this site.

- From a risk perspective, the deep foundation system with a structural type floor slab presents the least risk option relative to the potential distress to the building structure due to long term settlement/consolidation of the fill/mine spoil since the building loads are transferred to the underlying bedrock. The other options (Geopier® Rammed Aggegate Piers, partial undercut and replacement, dynamic compaction), reduce but do not eliminate the risk of damage/distress to the structure since these options replace or improve only a partial thickness of the existing fill/mine spoil, leaving unimproved fill/mine spoil material in place below the improved or replaced stratum.

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. Section **5.0 GENERAL COMMENTS** should be read for an understanding of the report limitations.

GEOTECHNICAL ENGINEERING REPORT
PRELIMINARY GEOTECHNICAL STUDY
HARRISON HILLS CITY SCHOOLS – SITE D
STATE ROUTE 9
CADIZ, OHIO

Terracon Project No. N4155098

June 22, 2015

1.0 INTRODUCTION

Terracon Consultants, Inc. has completed a geotechnical exploration for the proposed Harrison Hills City Schools "Site D" to be located on a parcel on the east side of State Route 9, south of Cadiz, Ohio. Four (4) test borings, designated B-1 through B-4, were drilled to depths ranging from approximately 65 to 77 feet below the existing ground surface. Test boring logs along with a boring location plan (Exhibit A-3) are attached to this report.

The purpose of this subsurface exploration is to evaluate the pertinent geotechnical conditions at the proposed building site in order to develop preliminary geotechnical parameters which will assist planners and designers in evaluation of the site with respect to design and construction of earthwork, building foundations, floor slabs and pavements.

2.0 PROJECT INFORMATION

2.1 Project Description

ITEM	DESCRIPTION
Proposed Facility	New school facility, with buildings, drives, play fields and associated utilities infrastructure.
Structural Loads	Structural loading information was not provided.
Site Grading	Due to the preliminary nature of this project, a site grading plan is not available.

2.2 Site Location and Description

ITEM	DESCRIPTION
Site Location	See Exhibit A-2: Site Location Map The site, identified as "Site D" is located in Harrison County, Ohio south of Cadiz, Ohio, on the east side of State Route 9.
Current Site Conditions	The site is currently reclaimed surface mine land, covered in grass

	and shrubs, with some wooded areas.
Existing Topography	The existing site is gently rolling and generally slopes downwards towards the edges of the site. Based on information from Google Earth, elevations across the site generally range from about elevation 1100 to 1260 feet.
Previous Mine Mapping	See Exhibits C-4 and C-5. Previous strip mining has occurred across the central portion of the site. Abandoned Underground Mining has occurred adjacent to, but not directly beneath, the project site.

Should any of the above information or assumptions be inconsistent with the planned construction, please let us know so that we may make any necessary modifications to this report.

3.0 SUBSURFACE CONDITIONS

3.1 Typical Profile

In general, the borings across the center of the site (B-1, B-3, and B-4) encountered fill (mine spoils) associated with prior surface mining, which corresponds to available information provided by ODNR. Boring B-2 on the western edge of the site did not encounter fill. The bottom of fill depths ranged from about elevation 1161 to 1176 feet, corresponding to fill depths ranging from about 28 to 35 feet.

In general, the mine spoil encountered was heterogeneous fill consisting predominantly of lean clay and fat clay, with varying amounts of sand and sandstone, limestone, shale and coal fragments. The coloration of the fill included brown, gray, and black materials. Because there is sampling bias associated with using relatively small diameter spilt spoon samplers, and the known mine reclamation activities, it is likely that cobble and boulder size materials are present throughout much of the fill. Native materials, encountered in Boring B-2, consisted of lean clay and fat clay materials with varying amounts of gravel and exhibited stiff to very stiff consistencies. No native soil deposits were encountered between the bottom of the mine spoil fill and the top of bedrock in Borings B-1, B-3, and B-4.

Sedimentary bedrock encountered below the overburden materials consisted of sandstone, shale, claystone, limestone, and siltstone. Rock hardness was generally very soft to medium hard layers of claystone and siltstone and medium hard to hard layers of sandstone and limestone.

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

3.2 Water Level Observations

Groundwater readings were obtained during drilling and prior to rock coring operations. Groundwater was encountered at a depth of 44.7 feet in Boring B-3, and at a depth of 38 feet in Boring B-4 during drilling, but was not observed in Borings B-1 or B-2. The water encountered in these borings appeared to be trapped at the bottom of the mine spoil fill, just above bedrock.

It should be noted that because of the heterogeneous fill at the site, the presence and levels of groundwater will be highly variable across the site with characteristics that would be difficult to generalize. Water is likely to be perched within granular fill deposits encountered at the site. Excavations into these deposits would yield significant groundwater seepage. Actual groundwater levels can also vary with rainfall and other seasonal changes.

4.0 RECOMMENDATIONS FOR DESIGN AND CONSTRUCTION

4.1 Geotechnical Considerations

The test borings at the site indicated variable depth fill consisting of mine spoils across the central portions of the site, with native cohesive soils on the western portion of the site. The mine spoil fill and native soils were underlain by sedimentary bedrock. Areas of fill encountered in the borings corresponded to available mapping of previous strip mining activities.

Based on the subsurface conditions encountered in the recent test borings and available mine mapping, the site does not appear to be suitable for development of conventional building foundations and slab-on-grade floors without implementation of ground improvement of the fill to reduce potential adverse total and differential settlement response to proposed structure.

Support of foundations, floor slab and pavements on or above existing fill soils is discussed in this report. However, even with the recommended construction testing, there is a risk that unsuitable materials within or buried by the fill will not be discovered. This risk cannot be eliminated without removing the fill but can be reduced by thorough exploration and testing during construction.

Soils prone to shrink/swell characteristics are present on this site. This report provides recommendations to help mitigate the effects of soil shrinkage and swell. However, even if these procedures are followed, some movement and cracking in the structure should be anticipated. The severity of cracking and other damage such as uneven floor slabs will probably increase if any modification of the site results in excessive wetting or drying of the shrink/swell prone soils. Eliminating the risk of movement and distress may not be feasible, but it may be possible to

further reduce the risk of movement if significantly more expensive measures are used during construction.

4.1.1 Mine Spoils

From a geotechnical engineering perspective, one of the concerns associated with development of the site is the presence and considerable and variable depths of the mine spoil fill material. From the borings and available mine mapping, deep mine spoils were encountered across the central portion of the site. Volume reduction of the fill can occur owing to various processes, such as collapse compression from crushing of rock-to-rock contact points upon wetting or long-term creep associated with the self-weight of the mine spoils. Hydrocompression settlement can also occur from the presence of water (saturating or percolating through the fill). Softening, squeezing, consolidation, and internal erosion of particles into open voids can also occur. Ground modification options will reduce the potential for settlement associated with these processes, but not necessarily eliminate them. It is differential settlement rather than the magnitude of total settlement that causes distortion and damage of buildings. Differential settlement can be attributed to a number of factors, including:

- variability of fill quality
- non-uniform distribution of loading
- variations in depth of fill

The significant issue with the encountered mine spoil material is that the mine spoils were placed with no compactive effort; therefore, building foundations placed on the existing mine spoil materials will be subjected to large total and differential settlement, due to the uncompacted nature of the mine spoils. All spoils settle regardless of placement procedures. The mine spoil depth is a major factor in the amount of settlement that occurs. Other important factors include moisture content during compaction, mix type, particle size distribution, groundwater conditions after placement, etc. In addition, the thickness of the mine spoils across the site currently varies, which can cause additional differential settlement of building foundations bearing in the mine spoils or within structural fill overlying the mine spoils due to foundation loads, self weight of the mine spoils and the weight of new fill. Since no compactive effort was used to place the mine spoils, voids likely exist in areas of the mine spoils which can cause further subsidence of the mine spoils. Based on available aerial photography, we estimate the mine spoils have been allowed to settle under their own weight for at least 20 years. Therefore, some of the settlement due to self-weight has likely already occurred. Mine spoil settlement diminishes with time. However, settlements can continue for many years, even decades, especially when aggravated by water infiltration.

Hydro-consolidation accounts for a large portion of the long-term settlements. Any site grading activities which increase the change of water build-up within the fill (construction of ponds or detention basins), can increase settlement potential. Surface drainage which can help to prevent a build-up of water in the fill should be considered in development of the site.

Finally, the mine spoils contain non-durable and unweathered shale fragments and possibly large intact pieces. If water enters the mine spoils and softens the shale constituents, subsidence can occur where nested structure exists between the shale fragments by weakening the point-to-point support of the shale fragments.

As a result, direct foundation support on the mine spoils is not recommended, due to the potential for large total, differential and sudden subsidence type settlement of the building foundations. Settlement will also continue to occur for a long period of time.

Selection of the appropriate foundation system will depend on the level of risk to the structure and costs related to minimizing the risk potential. Constructing the proposed building at the proposed site will require transferring the foundation loads to the stable bedrock using deep foundations such as drilled shafts (least risk option) or by improving the uncontrolled mine spoil material by using ground modification techniques such as proprietary Geopier® Rammed Aggregate Piers or by undercutting and replacement of mine spoils (higher risk options).

Deep Dynamic Compaction (DDC) (higher risk option) can also considered as a ground modification option, since in that it may provide for an economical alternative to the deep foundations, rammed aggregate piers or undercutting and replacement. A relatively complex, multiple phase compaction program that would be required for the predominantly clay mine spoils encountered at this site. DDC generally consists of dropping a weight repeatedly on the ground at regularly spaced intervals. The impact of the weight creates stress waves that densifies the existing mine spoils.

From a risk perspective, the deep foundation system with a structural type floor slab presents the least risk option relative to the potential distress to the building structure due to long term settlement/consolidation of the mine spoil fill since the building loads are transferred to the underlying bedrock. The other options (Geopier® Rammed Aggegate Piers, partial undercut and replacement, dynamic compaction), reduce but do not eliminate the risk of damage/distress to the structure since these options replace or improve only a partial thickness of the existing mine spoil fill, leaving unimproved mine spoil material in place below the improved or replaced stratum.

Even with ground improvement being undertaken, the building structure system should be designed to tolerate differential settlement.

4.1.2 Reuse of On-Site Materials as Structural Fill

With the exception of organic soils, coal refuse soils and large boulders, we believe that the majority of the excavated mine spoil material will generally be suitable for reuse as structural fill. All structural fill should be placed in loose lifts no greater than 8 inches thick. Durable rock pieces and slabs having a thickness greater than 4 inches or any plan dimension greater than

24 inches should be removed from the fill or broken down to a suitable size. Durable rock pieces and slabs should be dispersed evenly across the fill and not be allowed to nest. Large rock pieces and slabs should be excluded from the upper 5 feet of fill to aid in the excavation for footings and fine grading operations. If deeper underground utilities are planned, the larger rock pieces and slabs should be excluded from the invert elevation of the utilities to the proposed finished grades. A rock rake will likely be required to remove the larger rock pieces and slabs.

The anticipated problems in reusing the mine spoil material as structural fill include:

- Moisture conditioning to near optimum conditions per ASTM D 698 or ASTM D 1557, and
- Using the unweathered shale fraction of the mine spoils for structural fill. If large portions of unweathered shale are encountered, then they will need to be placed in accordance with shale placement guidelines and considerably more effort will be required.
- Fat clays have the potential for shrink-swell action, thus should not be allowed to be placed within the zone 18 inches below the floor slab subgrade. A Low Volume change material (e.g. lean clay, granular materials) should be present below all floor slabs designed and constructed for this project.
- Shale should not be used as structural fill within 18 inches of building floor slab or pavement subgrade elevation of due to potential for expansion or shink-swell behavior.

The mine spoil material may contain a large percentage of unweathered shale pieces and slabs and some pockets of shale fill. Shale is not considered a durable rock and can soften or disintegrate when exposed to water. When shale is compacted in a dry state and the pieces and slabs remain intact, the pieces and slabs can nest. When water is introduced to the shale fragments, the pieces and slabs lose their strength and become soft, which can result in subsidence of the fill. Therefore, when shale and rock pieces and slabs are encountered in the mine spoil excavations, special placement and compaction precautions will need to be taken to limit the collapse potential of the shale structural fill. Sufficient water needs to be added to the fill and the fill needs to be worked until the shale becomes a soil-like mass. In addition, the shale needs to be placed in thin lifts (8 inch maximum loose lifts) and compacted with several passes of heavy pad foot compaction equipment. Where the shale fragments are thoroughly mixed with clay in the excavated mine spoils, the material should be placed and compacted as a normal soil.

It is recommended that all structural fill be free of organics, debris, and other deleterious substances. The soil should have a liquid limit less than 40 and plasticity index of 22 or less and contain no inert constituents (rock pieces or cobbles) greater than 4 inches in maximum dimensions (except as described earlier concerning large rock pieces). If additional sources of structural fill are required, it is recommended that any off-site sources conform to these general

recommendations. Any materials proposed for reuse as structural fill should be subjected to laboratory testing to determine their suitability for reuse as structural fill.

4.1.3 Abandoned Underground Mines

Abandoned underground mines are mapped in the vicinity of, but not directly beneath, the subject property at an approximate mine elevation of 617 feet, or about 500 to 600 feet below the ground surface elevations across the site. Mine subsidence associated with deeper mines (overburden of more than 75 feet) is generally a "sag" type subsidence. Literature describes "sag" subsidence as a gentle, gradual settling of the surface that is associated with pillar crushing or pillar punching. The area of mine subsidence increases proportionally with the increasing width of the unsupported rock roof. The potential area of subsidence is equal to the extraction area plus an area surrounding the extraction measured by an angle up to 35 degrees, called the angle of draw, from the vertical edge of the extraction area. Thus, we would recommend the proposed structure be constructed beyond the anticipated angle of draw of the abandoned underground mines, or beyond a distance of 450 feet from the edge of the mine.

4.2 Foundation Options

The following options could be considered for support of the proposed building structures:

- Option 1: Deep Foundations consisting of a drilled shaft foundation system (least risk)
- Option 2: Ground improvement using Geopier® Rammed Aggregate Piers
- Option 3: A partial undercut and replacement with structural fill.
- Option 4: Deep Dynamic Compaction

From a risk perspective, the deep foundation system with a structural type floor slab presents the least risk option relative to the potential distress to the building structure due to long term settlement/consolidation of the fill since the building loads are transferred to the underlying bedrock. The other three options reduce, but do not eliminate, the risk of damage/distress to the structure since these options may replace or improve only a partial thickness of the existing fill, leaving unimproved fill material in place below the improved or replaced stratum.

In the following sections we have provided geotechnical engineering recommendations for each of these options.

4.2.1 Drilled Shaft Foundations

Drilled shafts penetrating the entire fill depth and bearing within the underlying bedrock can be considered for building support. The drilled shaft design will need to consider potential negative skin friction, due to the long-term settlement potential of the fill relative to the drilled shaft foundation. In lieu of drilled shafts, micropiles could be considered as a potential economical

deep foundation alternate. The microplie will require smaller diameter drilled holes and provided for high capacity deep foundation elements in situations where downdrag is an issue.

The constructability of the drilled shafts will have the largest impact on the economy of this foundation type. The presence of large boulders in the mine spoil material will slow drilling production significantly, since encountered boulders may have to be cored to allow further shaft excavation. The presence of cohesionless mine spoils would also likely require casing or slurry to support the open excavations during construction.

Supporting the building structure on drilled shafts would result in building settlement approximately equal to the elastic compression of the drilled shaft. For preliminary estimating purposes, an allowable end bearing capacity of 20 ksf can be used across the cross-sectional area of the drilled shaft. Additionally, for preliminary estimating purposes, it should be assumed that drilled shafts would bear within competent sedimentary bedrock at a minimum depth of at least one shaft diameter or 3 feet (whichever is greater) below the surface of the weathered bedrock in areas where the coal seam has been extracted completely by prior surface mining. Additional drilling and rock coring would be required to verify drilled shaft bearing capacity and bearing elevations. Minimum 30-inch diameters should be used for estimation purposes; however, the design diameters would depend on the estimated column and wall loads. Again, these capacities have not considered the impact of negative skin friction. Additional analyses would be required to develop detailed foundation design recommendations and measures to eliminate/reduce negative skin friction, if necessary.

Temporary casing of the drilled shafts should be anticipated since voids could be present in the mine spoils and some of the test borings encountered granular materials that may collapse without supporting the excavation with casing. Removal of boulders and existing voids in the mine spoils would increase the actual drilled pier concrete volumes well above the neat line volumes.

Using drilled shaft foundation support will support the building structure with little risk of total and differential building foundation settlement. However, drilled shafts will not eliminate or reduce the potential of floor slab-on-grade settlement due to floor load and long-term settlement of the mine spoils due to degradation and consolidation under its own weight.

The weight of any proposed new fill will cause settlement of the existing fill material, which could lead to differential settlement between portions of the building constructed on cut and fill. Settlement of the fill will also add downdrag loads to the drilled shafts. Therefore, any settlement due to new fill placement should be allowed to occur prior to constructing any drilled shafts, if they are used. A settlement monitoring program is recommended in areas of significant fill.

Additional drilling and geotechnical analyses would be required to further develop detailed drilled shaft design recommendations.

4.2.2 Geopier® Rammed Aggregate Piers

The patented Geopier® Rammed Aggregate Piers ground improvement option typically consists of 24 to 30-inch diameter drilled holes that are filled in thin lifts with highly compacted, well-graded aggregate to form very stiff, high density aggregate piers. The tamper is designed to produce significant lateral soil stress within the surrounding soil matrix, thereby stiffening the reinforced composite soil/aggregate mass. This type of ground improvement system could be used to improve the existing fill so as to allow for design and construction of conventional shallow spread footing type foundations and slab-on-grade floors for the proposed building structure. If the Geopier® Rammed Aggregate Piers option is chosen, we anticipate the spread footings could be designed for a net allowable bearing pressure of about 4,000 to 5,000 psf. The actual design bearing capacity would need to be further evaluated in consultation with the Geopier® design engineer.

Since design of these systems is proprietary, the design team should contact the Geopier® Company representative for additional design issues associated with this system.

The Geopier® Rammed Aggregate Piers would not only support the building foundations, but could also be designed and constructed to support the floor slab of the proposed building. Additionally, the designer could consider thickening the slab, providing additional reinforcing steel, and providing for closer than normal floor slab constructions joints. This type of floor slab should be design to “float” independently from the building structure so as to allow for differential settlements.

4.2.3 Partial Undercut and Replacement

Another method of improving the existing material is to perform a partial undercut and replacement of the upper 15 to 20 feet of existing fill material below the rough subgrade elevation of the building structure. Design undercuts would not be required in native soils unless areas of soft or loose soils were encountered. This undercutting scheme would involve stripping the building pad area of all vegetation and topsoil and then undercutting a minimum of 15 to 20 feet below existing grades in fill areas; and 15 to 20 feet below subgrade in cut areas as per a design undercutting plan. The lateral extent of this undercut should be to a distance of at least 10 feet beyond the perimeter of the proposed building footprint, measured at the bottom of the undercut. The bottom of the undercut would then need to be proofrolled using heavy pneumatic tired construction equipment, such as fully loaded tandem axle dump truck weighing at least 20 tons, to delineate any soft or highly disturbed areas in the presence of a geotechnical engineer. Soft areas would then need to be further undercut until firm soils are encountered or the exposed subgrade stabilized in place using geogrid and crushed No. 2 limestone. In areas where the bottom of the undercut is wet due to perched groundwater, stabilization may be needed before replacement with structural fill.

Once the subgrade is approved, structural fill should be used to fill to the desired grade. Structural fill may consist of borrow material or on-site materials, provided the material meets the structural fill requirements as recommended in section **4.1.2 Reuse of On-site Materials as Structural Fill**. On-site materials may require moisture conditioning prior to re-use as structural fill. Due to the shrink-swell potential of fat clay, on-site fat clay material it should not be used as structural fill within 18 inches of the floor slab subgrade level.

In addition, large boulders and floaters may be encountered within the existing materials. The actual distribution and volume of rock fragments and boulders is difficult to estimate based on test boring data. The rock pieces and slabs could be used in deeper portions of the replacement fill, up to 5 feet below finished grade or to the planned invert elevation of underground utilities, whichever is deeper. Large rock pieces and slabs will need to be laid out flat so that they cannot nest and will need to be well distributed throughout each lift. In addition, the thickness of the large pieces and slabs will need to be limited to 4 inches or less. Thicker pieces and slabs must first be broken up before incorporation into the fill or removed from the proposed fill materials. In the upper portion of the fill, rock rakes will need to be used to remove the large pieces and slabs having any dimension greater than 12 inches.

Perched water may be encountered within the mine spoil fill. Water seepage will likely need to be controlled using sumps and pumps. Perched water will also act to destabilize the temporary side slopes, possibly requiring flatter temporary slopes. If large volumes of seepage are encountered, more elaborate methods of dewatering may be required, such as well points or dewatering wells. The grading contractor, by his contract, is usually responsible for designing and constructing stable temporary excavations. Dewatering requirements are the responsibility of others.

Undercut and replacement of the existing fill occurring during winter and spring may be hindered by periods of heavy precipitation. Water will collect in the hole created by the undercut, causing the exposed soils to become unstable and possibly flood the excavation. Excavation and filling operations should be planned for the dry season. It is imperative for the partial undercut and replacement option that the structural backfill of the undercut be properly placed and compacted.

There are several unknowns if the partial undercut and replacement option is selected. The variability of groundwater (often perched within the fill) and its impact on a mass excavation need to be considered. Significant construction difficulties are anticipated due to the presence of perched groundwater and water softened soils. The success of this option is highly dependent on suitable weather conditions. The volume of large boulders and rock slabs, which will need to be processed, is not easily quantifiable using boring data.

Following undercut and replacement operations, building foundations and floor slabs designed to bear upon or within the structural fill would be constructed. For preliminary estimating purposes an allowable bearing capacity of 3000 psf can be used. The structural design should consider incorporation of appropriate design features to reduce the potential for distress due to differential settlement response of the structure, including thickened floor slabs, closer than normal construction joints and additional reinforcement of building foundations.

4.2.4 Deep Dynamic Compaction

The dynamic compaction technique of improving mine spoils would reduce the risk of long-term settlement, but not completely eliminate them. Dynamic compaction of the recently placed fill could also be considered if dynamic compaction of mine spoils in undertaken. The existing fill appears to be mostly clay soils, therefore a multiple pass/phase dynamic compaction program as described below would be needed for dynamic compaction of these fill materials.

Deep dynamic compaction (DDC) is a method of ground improvement that results from the application of high levels of energy at the ground surface. The energy is applied by repeatedly raising and dropping a tamper with a specified mass over a specified height. The tamper is lifted and dropped by a conventional crane with a single cable plus a winch that has a free spool attachment that allows the cable to unwind with minimal friction. The tamper energy of impact at the ground surface results in densification of the deposits to depths that are proportional to the energy applied. The main purpose of the DDC is to collapse voids in the upper portions of the mine spoil and compact the upper zone where foundation stresses are the greatest. Due to the fine grained nature of some of the existing fill/mine spoil, only minor compaction and densification will occur.

One of the additional merits of Deep Dynamic Compaction, particularly in mine spoil, is its inherent stiffness testing feature. Weak and strong areas are immediately identified during the field program by close monitoring of crater depths. When weaker areas (those that produce deeper craters) are noted, either additional energy or Dynamic Replacement is generally required. Dynamic Replacement involves backfilling of deeper craters with a rocky material and repounding this material into the crater until a noticeable decrease in crater formation is observed.

The existing fill/mine spoils at this site can likely be densified by means of dynamic compaction. Ordinarily wet clayey soils do not respond to dynamic compaction. However, the water table appears to be relatively deep. Even though the soil matrix consists of clayey soils, the upper portions of these deposits appear to be only partially saturated and capable of densification by impact. In addition, granular seams that are present within the clayey soil mass will aid in dissipation of pore water pressures as the soils are densified. There may be some locations where the perched water table is high and the densification methodology will need to be field modified by the specialty contractor based on their experience to achieve the desired compaction.

According to geotechnical literature, these materials would likely be considered "Intermediate Soil Deposits". Dynamic compaction works in these soils but because of the lower than desired permeability, the energy must be applied using multiple phases of multiple passes. A multiple pass/phase design will have implications related to cost and construction schedule and must be considered in evaluation of alternates. Typically, the time duration between beginning of the primary pass and the initiation of secondary pass is sufficient for the required dissipation of excess pore pressures.

Unfortunately, dynamic compaction will not be effective through the entire depth of the mine spoil. It has been found from measurements on other mine spoil project sites that densification with conventional dynamic compaction equipment will occur to depths on the order of about 20 feet below the ground surface. The soil improvement is not uniform within the entire 20 feet; the upper zones will show the greatest improvement with gradual reduction with depth. The upper zone of mine spoil is generally in the loosest condition since the deeper portions of the mine spoil have may become partially consolidated due to the overburden surcharge pressures. An approximate 20 foot thick zone of densified soil will act as a soil mat with enhanced stiffness to make the upper portion of the soil more uniform and spread the loads from the structure.

Additional design of the deep dynamic compaction program would need to be undertaken by a contractor who specializes in dynamic compaction. If this option is selected, we recommend that a test pad be performed at the site during the design phase to evaluate the effectiveness of the compaction and to provide information to optimize final design and construction.

Following dynamic compaction operations, building foundations and floor slabs designed to bear upon or within the structural fill would be constructed. For preliminary estimating purposes an allowable bearing capacity of 3000 psf can be used. The structural design should consider incorporation of appropriate design features to reduce the potential for distress due to differential settlement response of the structure, including thickened floor slabs, closer than normal construction joints and additional reinforcement of building foundations.

4.3 Other Considerations

4.3.1 Surface and Subsurface Drainage

Since subsidence of uncontrolled mine spoils can occur when water is introduced to the soil, control of subsurface and surface water is very important. Surface grades should be directed away from the building and pavement areas to suitable collection points (drainage swales and storm sewers) that are capable of removing the surface water from the site, so that infiltration into the mine spoils does not occur. In addition, water collected in roof scuppers or downspouts should also be directed away from the building and pavement areas and drained to a suitable outlet.

Where swales dissect the site, their throats should have a permanent subsurface drain (free-draining crushed stone wrapped in filter fabric) installed to intercept and remove any subsurface water that attempts to follow filled-in swales. The subsurface drains should gravity drain to a suitable outlet and be drained from the site. Allowances will also need to be made to collect the surface water currently carried by existing swales and carry it around the site or through the site in a manner that reduces infiltration that could add water to the mine spoils. Water in the mine spoils could result in subsidence of the soil due to piping of fine grained material into existing voids or softening the point to point contact of large non-durable rock pieces and slabs that are nested.

In addition, all utility connections at the building interface should be flexible, so that total and differential settlement of the building does not cause utility leaks. Leaking utilities could add water to the uncontrolled mine spoils and cause subsidence of the material.

4.3.2 Stormwater Ponds

Any stormwater pond will need to be lined to limit adding water to the uncontrolled mine spoils. If a clay liner is used, the material should consist of predominantly clay and silt size particles (minimum 70%), and no particles over 3 inches in any dimension should be allowed in the liner material. The minimum clay liner thickness should be 3 feet measured perpendicular from the slope face or the bottom of the pond. To reduce the permeability of the clay liner soil, we recommend that the clay liner be compacted to 98% Standard Proctor maximum dry density at +1 to +3% optimum moisture content. The clay liner should be placed in 8 inch thick maximum loose lifts and be compacted using a sheepsfoot or padded foot compactor. Consideration should be given to using HDPE liners for further reduction of water infiltration.

Retention ponds should be avoided, since ponds constantly holding water have a better chance of adding water to the mine spoils over the life of the structure. Any stormwater ponds should be constructed away from the pavement and building areas to limit collapse potential beneath building and pavement areas.

4.3.3 Underground Utilities

It is recommended that all footings adjacent to underground utility trenches be extended below the zone of influence of the trench; that is, below a 2H:1V slope extended upward from the base of the trenches. Preferably, all footings should bear at or below the elevation of the bottom of the utility trenches. Where utilities pass below foundations, the foundations should be bridged across the utility to prevent transfer of the foundation load onto the utility pipes.

We recommend that temporary excavations for the utilities be in accordance with OSHA Safety Regulations. The recommended temporary slopes were presented earlier. Note that there is a potential for some localized wet zones and sloughing, which may require flatter slopes or some localized bracing or remedial "dental" work or redressing.

Utility lines that connect to the building should incorporate flexible connections. Additionally consideration should be given to supporting critical utility lines upon structured fill placed within an undercut below the line.

4.3.4 Pavement Areas – Subgrade Preparation

Subgrades for new drives and parking areas in mine spoil should be developed by undercutting the mine spoils and backfilling the undercut exception with structured fill. For preliminary estimating purposes the depth of the undercut should extend to a depth of at least 3 feet below the design subgrade level of pavement sections. The undercut should extend at least 3 feet beyond the edge of paved areas.

4.4 Seismic Design

The Ohio Building Code (OBC) follows International Building Code (IBC) with regards to seismic guidelines. As part of the OBC, the seismic properties of the overburden soils and bedrock are utilized to determine the site seismic classification. The Seismic Site Class is determined by evaluation of the shear wave velocities of the overburden soil and bedrock to a depth of 100 feet.

Based on the soil conditions encountered at the site, a Site Class C is warranted. Additional site specific testing to determine shear wave velocity would be needed to further refine the Site Class.

5.0 GENERAL COMMENTS

Terracon should be retained to review the preliminary 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 additional geotechnical exploration required for final design and 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 construction or 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.

Support of foundations, floor slab and pavements on or above existing fill soils is discussed in this report. However, even with the recommended construction testing, there is a risk that unsuitable materials within or buried by the fill will not be discovered. This risk cannot be eliminated without removing the fill but can be reduced by thorough exploration and testing during construction.

Soils prone to shrink/swell characteristics are present on this site. This report provides recommendations to help mitigate the effects of soil shrinkage and swell. However, even if these procedures are followed, some movement and cracking in the structure should be anticipated. The severity of cracking and other damage such as uneven floor slabs will probably increase if any modification of the site results in excessive wetting or drying of the shrink/swell prone soils. Eliminating the risk of movement and distress may not be feasible, but it may be possible to further reduce the risk of movement if significantly more expensive measures are used during construction.

The scope of services for this project does not include either specifically or by implication any environmental or biological (e.g., mold, fungi, 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, either 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

Field Exploration Description

The subsurface exploration consisted of drilling and sampling four (4) borings at the site to depths of about 65 to 77 feet below existing grades. The approximate boring locations are indicated on the attached Boring Location Plan. The borings were staked in the field by Terracon personnel using a handheld GPS unit. Elevations of the ground surface at the boring locations were determined from Google Earth. Elevations indicated on the boring logs are rounded to the nearest ½ foot. The locations and elevations of the borings should be considered accurate only to the degree implied by the means and methods used to define them.

These borings were drilled with an ATV-mounted rotary drill rig 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 140-pound auto-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.

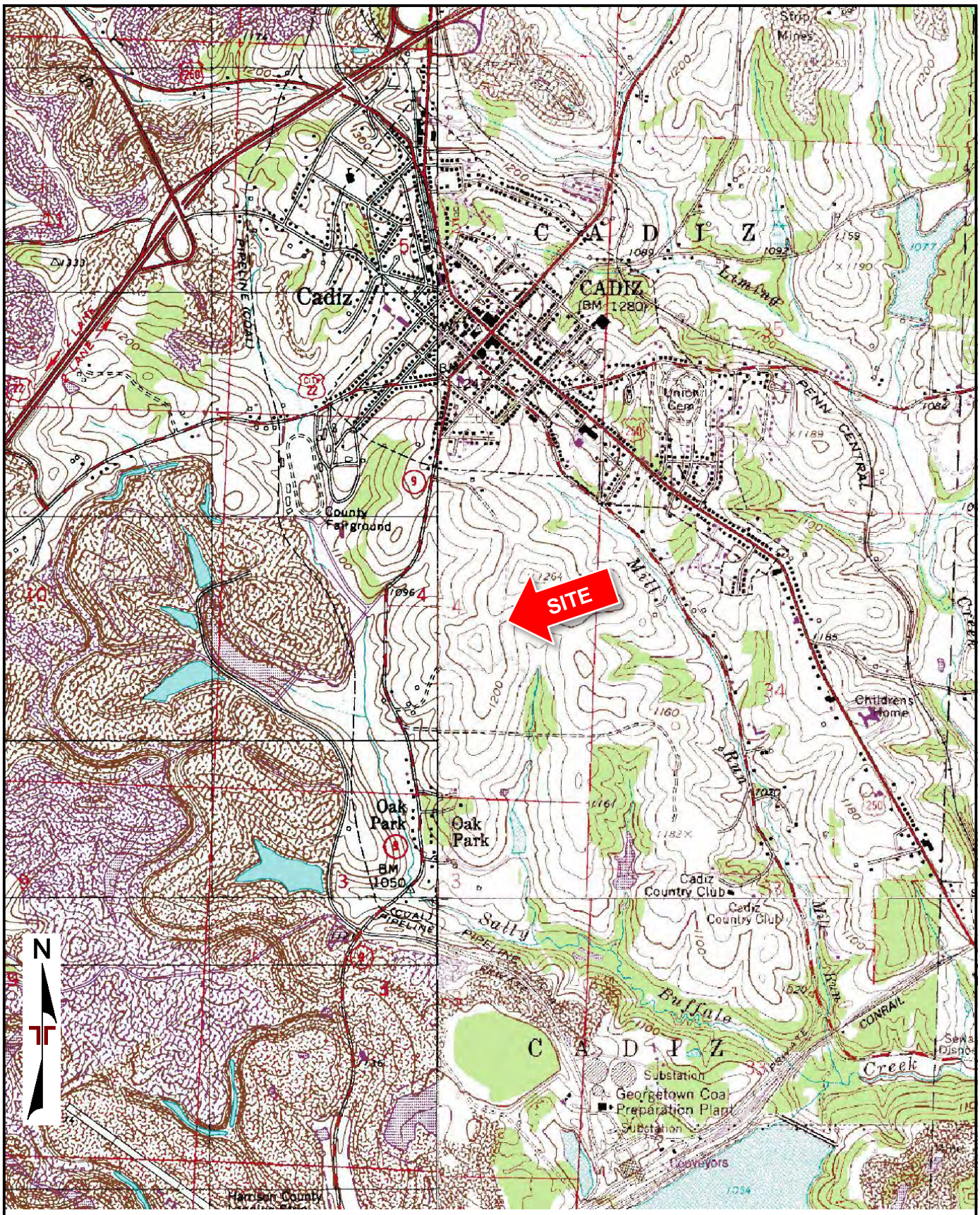
An automatic SPT hammer was used to advance the split-barrel sampler in the borings performed on this site. A significantly greater efficiency is achieved with the automatic hammer compared to the conventional safety hammer operated with a cathead and rope. This higher efficiency has an appreciable effect on the SPT-N value. The effect of the automatic hammer's efficiency has been considered in the interpretation and analysis of the subsurface information for this report.

Rock coring was performed using a NQ2-size double tube-swivel core barrel. Percent recovery and rock quality designation (RQD) were calculated for the core samples and are noted at their depths of occurrence on the boring logs. RQD is the percent of total length cored consisting only of rock pieces at least 4 inches or more in length and is a measure of the integrity of the rock mass in-situ. Rock quality, in terms of RQD, can generally be designated as excellent (90%-100%), good (75%-90%), fair (50%-75%), poor (25%-50%) and very poor (<25%). The recovered samples were sent to the laboratory for testing and classification.

The samples were tagged/marked 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 and bedrock descriptions, consistency evaluations, boring depths, sampling intervals, and any 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

interpretation of the field logs and include modifications based on laboratory observation and tests of the samples.



TOPOGRAPHIC MAP IMAGE COURTESY OF THE U.S. GEOLOGICAL SURVEY
QUADRANGLES INCLUDE: JEWETT, OH (1/1/1994), CADIZ, OH (1/1/1976), FLUSHING, OH (1/1/1994) and HARRISVILLE, OH (1/1/1985).

Project Manager: KME	Project No. N4155098	Terracon 800 Morrison Rd. Columbus, OH 43230	SITE LOCATION MAP	Exhibit
Drawn by: AKB	Scale: 1"=24,000 SF		Harrison Hills City Schools State Route 9 Cadiz, OH	A-2
Checked by: KME	File Name: N4155098			
Approved by: KME	Date: June 2015			

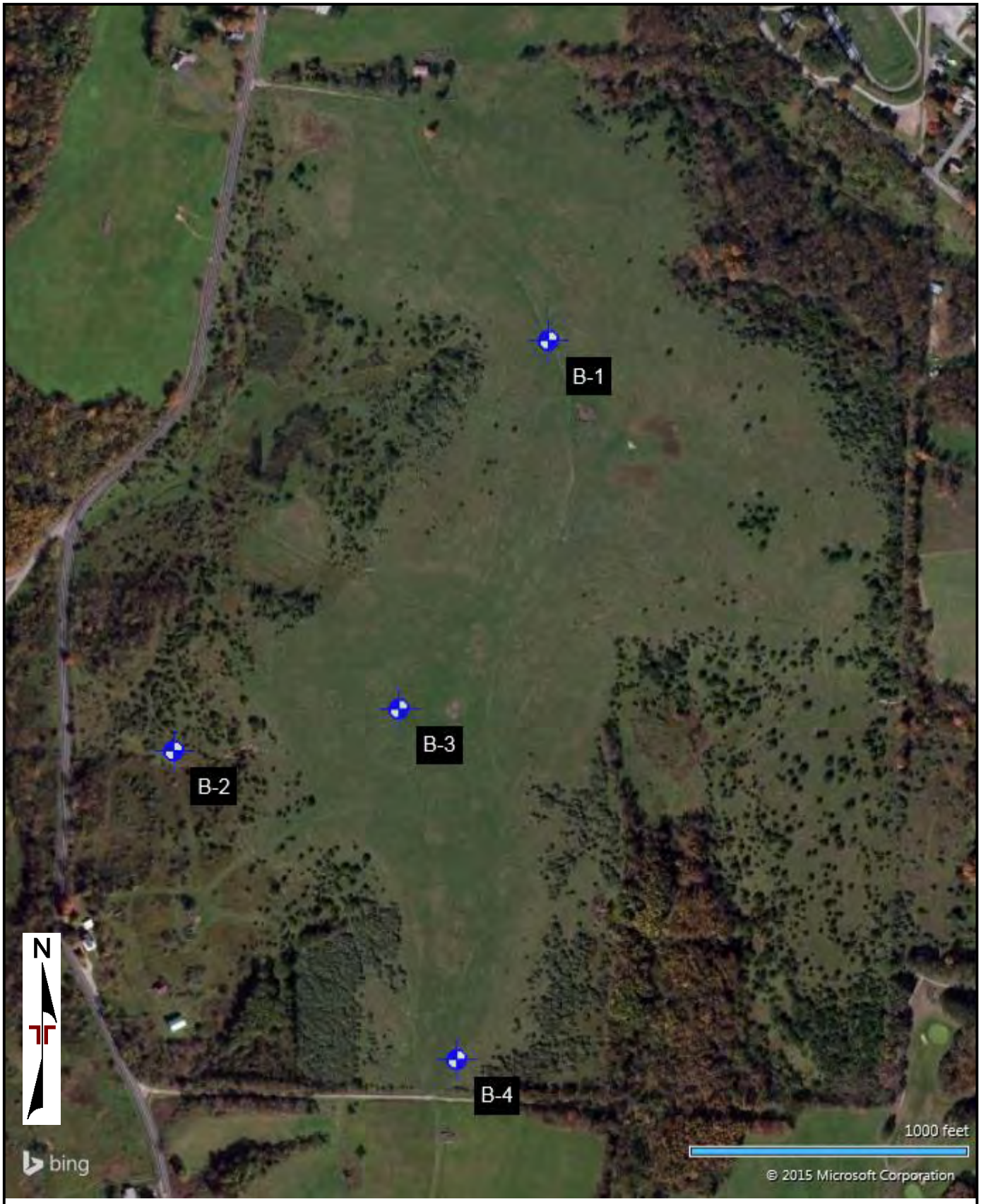


DIAGRAM IS FOR GENERAL LOCATION ONLY, AND IS NOT INTENDED FOR CONSTRUCTION PURPOSES

AERIAL PHOTOGRAPHY PROVIDED BY MICROSOFT BING MAPS

Project Manager: KME	Project No. N4155098	Terracon 800 Morrison Rd. Columbus, OH 43230	BORING LOCATION PLAN	Exhibit
Drawn by: AKB	Scale: AS SHOWN		Harrison Hills City Schools State Route 9 Cadiz, OH	A-3
Checked by: KME	File Name: N4155098			
Approved by: KME	Date: June 2015			

BORING LOG NO. B-1

PROJECT: Harrison Hills City Schools

CLIENT: Harrison Hills City Schools
Columbus, Ohio

SITE: Site D
Cadiz, Ohio

LOCATION See Exhibit A-3

Latitude: 40.264266° Longitude: -80.996277°

Approximate Surface Elev: 1211 (Ft.) +/-

DEPTH	ELEVATION (Ft.)	Description
0.4	1210.5+/-	**TOPSOIL (5")**
3.0	1208+/-	**FILL - LEAN CLAY WITH GRAVEL (CL)**, trace shale and coal fragments, brown
5.5	1205.5+/-	**FILL - LEAN CLAY WITH GRAVEL (CL)**, trace rock (limestone) fragments, gray
8.0	1203+/-	**FILL - FAT CLAY WITH GRAVEL (CH)**, (shale and limestone fragments), brown and gray
13.0	1198+/-	**FILL - LIMESTONE FRAGMENTS** , gray
23.0	1188+/-	**FILL - FAT CLAY (CH)**, trace coal and shale fragments, brown
		FILL - FAT CLAY (CH), trace limestone fragments, brown

DEPTH (Ft.)	SAMPLE TYPE	RECOVERY (In.)	FIELD TEST RESULTS
		18	6-6-7 N=13
		8	24-14-13 N=27
5		5	2-4-3 N=7
		8	14-6-9 N=15
10			
		10	3-2-4 N=6
15			
		6	3-4-6 N=10
20			
		8	8-8-9 N=17
25			

WATER LEVEL OBSERVATIONS | RQD (%) | LABORATORY TORVANE/HP (tsf)

Stratification lines are approximate. In-situ, the transition may be gradual.

Hammer Type: Automatic

Advancement Method:
3.25" Hollow Stem Auger

Abandonment Method:
Boring backfilled with cement/bentonite grout upon completion.

See Exhibit A-1 for description of field procedures

See Appendix B for description of laboratory procedures and additional data (if any).

See Appendix C for explanation of symbols and abbreviations.
Elevations obtained from Google Earth

Notes:

WATER LEVEL OBSERVATIONS

No water observed while drilling

Terracon
800 Morrison Road
Columbus, Ohio

Boring Started: 5/27/2015 | Boring Completed: 6/2/2015

Drill Rig: ATV | Driller: McMurray

Project No.: N4155098 | Exhibit: A-4

THIS BORING LOG IS NOT VALID IF SEPARATED FROM ORIGINAL REPORT. GEO LOG-DEPTH TO BOTTOM OF PAGE N4155098 HARRISON HILLS CITY SCHOOLS.GPJ TERRACON2012.GDT 6/22/15

BORING LOG NO. B-1

PROJECT: Harrison Hills City Schools

CLIENT: Harrison Hills City Schools
Columbus, Ohio

SITE: Site D
Cadiz, Ohio

LOCATION See Exhibit A-3

Latitude: 40.264266° Longitude: -80.996277°

Approximate Surface Elev: 1211 (Ft.) +/-

DEPTH	ELEVATION (Ft.)	Description	DEPTH (Ft.)	SAMPLE TYPE	RECOVERY (In.)	FIELD TEST RESULTS	RQD (%)
		FILL - FAT CLAY (CH), trace limestone fragments, brown *(continued)*					
28.0	1183+/-	**FILL - SHALE FRAGMENTS WITH CLAY**, trace coal fragments, dark brown					
					6	10-10-11 N=21	
			30				
					14	3-11-50/3"	
35.0	1176+/-	**SANDSTONE**, gray, moderately open to moderately wide joints, close joints, thin bedding, severely weathered, moderately hard	35				
37.2	1174+/-	**LIMESTONE**, gray, moderately open to open joints, close joints, thin bedding, severely weathered, moderately hard, argillaceous			58		43
38.0	1173+/-	**CLAYSTONE**, gray, open joints, very close to close, thin bedding, very severely weathered, soft					
40.2	1171+/-	**LIMESTONE**, gray, slight to open joints, close joints, medium bedding, severely weathered, moderately hard	40		57		58
			45				
46.0	1165+/-	**SHALE**, gray to brown, slightly open to open joints, very close joints, thin bedding, severely weathered, soft			60		33
49.0	1162+/-	**SANDSTONE**, gray, moderately open to open joints, close joints, thin to medium bedding, moderately severely weathered, moderately hard	50		60		

Stratification lines are approximate. In-situ, the transition may be gradual.

Hammer Type: Automatic

Advancement Method:
3.25" Hollow Stem Auger

Abandonment Method:
Boring backfilled with cement/bentonite grout upon completion.

See Exhibit A-1 for description of field procedures

See Appendix B for description of laboratory procedures and additional data (if any).

See Appendix C for explanation of symbols and abbreviations.
Elevations obtained from Google Earth

Notes:

WATER LEVEL OBSERVATIONS

No water observed while drilling

Terracon
800 Morrison Road
Columbus, Ohio

Boring Started: 5/27/2015 | Boring Completed: 6/2/2015
Drill Rig: ATV | Driller: McMurray
Project No.: N4155098 | Exhibit: A-4

THIS BORING LOG IS NOT VALID IF SEPARATED FROM ORIGINAL REPORT. GEO LOG-DEPTH TO BOTTOM OF PAGE N4155098 HARRISON HILLS CITY SCHOOLS.GPJ TERRACON2012.GDT 6/22/15

BORING LOG NO. B-1

PROJECT: Harrison Hills City Schools

CLIENT: Harrison Hills City Schools
Columbus, Ohio

SITE: Site D
Cadiz, Ohio

LOCATION See Exhibit A-3

Latitude: 40.264266° Longitude: -80.996277°

Approximate Surface Elev: 1211 (Ft.) +/-

DEPTH	ELEVATION (Ft.)	Description	RECOVERY (In.)	RQD (%)
		SANDSTONE, gray, moderately open to open joints, close joints, thin to medium bedding, moderately severely weathered, moderately hard *(continued)* 2" shale seam @ 52.5'	60	40
55.5	1155.5+/-	**CLAYSTONE**, gray, open to moderately wide joints, very close joints, thin bedding, very severely to completely weathered, very soft		
57.5	1153.5+/-	**LIMESTONE**, gray, mid open to open joints, close joints, thin bedding, severely weathered, moderately hard to hard	60	50
58.5	1152.5+/-	**CLAYSTONE**, gray, moderately open to open joints, very close to close joints, thin bedding, very severely weathered, very soft		
63.0	1148+/-	**LIMESTONE**, gray, open to moderately wide joints, very close joints, thin bedding, very severely weathered, moderately hard to hard	14	0
65.0	1146+/-	***Boring Terminated at 65 Feet***		

GRAPHIC LOG | DEPTH (Ft.) | WATER LEVEL OBSERVATIONS | SAMPLE TYPE | RECOVERY (In.) | FIELD TEST RESULTS | RQD (%) | LABORATORY TORVANE/HP (tsf)

55 60 65 70 75

Stratification lines are approximate. In-situ, the transition may be gradual.

Hammer Type: Automatic

Advancement Method:
3.25" Hollow Stem Auger

Abandonment Method:
Boring backfilled with cement/bentonite grout upon completion.

See Exhibit A-1 for description of field procedures

See Appendix B for description of laboratory procedures and additional data (if any).

See Appendix C for explanation of symbols and abbreviations.
Elevations obtained from Google Earth

Notes:

WATER LEVEL OBSERVATIONS

No water observed while drilling

Terracon
800 Morrison Road
Columbus, Ohio

Boring Started: 5/27/2015 | Boring Completed: 6/2/2015
Drill Rig: ATV | Driller: McMurray
Project No.: N4155098 | Exhibit: A-4

THIS BORING LOG IS NOT VALID IF SEPARATED FROM ORIGINAL REPORT. GEO LOG-DEPTH TO BOTTOM OF PAGE N4155098 HARRISON HILLS CITY SCHOOLS.GPJ TERRACON2012.GDT 6/22/15

BORING LOG NO. B-2

PROJECT: Harrison Hills City Schools

CLIENT: Harrison Hills City Schools
Columbus, Ohio

SITE: Site D
Cadiz, Ohio

LOCATION See Exhibit A-3

Latitude: 40.260216° Longitude: -81.001126°

Approximate Surface Elev: 1135 (Ft.) +/-

DEPTH	ELEVATION (Ft.)	Description
0.4	1134.5+/-	**TOPSOIL (5")**
1.5	1133.5+/-	**LEAN CLAY (CL)**, trace organics, brown, stiff
5.5	1129.5+/-	**LEAN CLAY (CL)**, trace gravel, brown, stiff
8.0	1127+/-	**SANDY LEAN CLAY WITH GRAVEL (CL)**, and sandstone fragments, brown, very stiff
13.0	1122+/-	**FAT CLAY (CH)**, (completely weathered shale), brown, very stiff
18.0	1117+/-	**SANDSTONE**, brown, very severely weathered, soft
23.0	1112+/-	**SHALE**, gray, very severely weathered, soft to medium hard
		CLAYSTONE, reddish-brown to maroon, very severely weathered, soft

DEPTH (Ft.)	SAMPLE TYPE	RECOVERY (In.)	FIELD TEST RESULTS	RQD (%)	LABORATORY TORVANE/HP (tsf)
		7	2-4-5 N=9		
		6	3-3-5 N=8		
5		6	4-5-6 N=11		2.5 (HP)
		14	7-14-24 N=38		1.5 (HP)
		13	3-5-9 N=14		
10					
		14	21-27-24 N=51		
15					
		2	50/2"		
20					
		5	50/5"		
25					

Stratification lines are approximate. In-situ, the transition may be gradual.

Hammer Type: Automatic

Advancement Method:
3.25" Hollow Stem Auger

Abandonment Method:
Boring backfilled with cement/bentonite grout upon completion.

See Exhibit A-1 for description of field procedures

See Appendix B for description of laboratory procedures and additional data (if any).

See Appendix C for explanation of symbols and abbreviations.

Elevations obtained from Google Earth

Notes:

WATER LEVEL OBSERVATIONS

No water observed

Terracon
800 Morrison Road
Columbus, Ohio

Boring Started: 6/4/2015 | Boring Completed: 6/5/2015

Drill Rig: ATV | Driller: McMurray

Project No.: N4155098 | Exhibit: A-5

THIS BORING LOG IS NOT VALID IF SEPARATED FROM ORIGINAL REPORT. GEO LOG-DEPTH TO BOTTOM OF PAGE N4155098 HARRISON HILLS CITY SCHOOLS.GPJ TERRACON2012.GDT 6/22/15

BORING LOG NO. B-2

PROJECT: Harrison Hills City Schools

CLIENT: Harrison Hills City Schools
Columbus, Ohio

SITE: Site D
Cadiz, Ohio

LOCATION See Exhibit A-3

Latitude: 40.260216° Longitude: -81.001126°

Approximate Surface Elev: 1135 (Ft.) +/-

DEPTH	ELEVATION (Ft.)	Description	DEPTH (Ft.)	RECOVERY (In.)	FIELD TEST RESULTS	RQD (%)
		CLAYSTONE, reddish-brown to maroon, very severely weathered, soft *(continued)*				
				4	26-26-38 N=64	
			30			
33.0	1102+/-					
		SHALE, gray, very severely weathered, soft to medium hard		2	50/2"	
			35			
39.0	1096+/-			1	50/1"	
		SANDSTONE, gray to dark gray, slightly open to open joints, close to moderately close joints, medium to thick bedding, moderately weathered, moderately hard	40	24		70
				60		58
			45			
				60		95
			50			
				60		

Stratification lines are approximate. In-situ, the transition may be gradual.

Hammer Type: Automatic

Advancement Method:
3.25" Hollow Stem Auger

Abandonment Method:
Boring backfilled with cement/bentonite grout upon completion.

See Exhibit A-1 for description of field procedures

See Appendix B for description of laboratory procedures and additional data (if any).

See Appendix C for explanation of symbols and abbreviations.

Elevations obtained from Google Earth

Notes:

WATER LEVEL OBSERVATIONS

No water observed

Terracon
800 Morrison Road
Columbus, Ohio

Boring Started: 6/4/2015 | Boring Completed: 6/5/2015

Drill Rig: ATV | Driller: McMurray

Project No.: N4155098 | Exhibit: A-5

THIS BORING LOG IS NOT VALID IF SEPARATED FROM ORIGINAL REPORT. GEO LOG-DEPTH TO BOTTOM OF PAGE N4155098 HARRISON HILLS CITY SCHOOLS.GPJ TERRACON2012.GDT 6/22/15

BORING LOG NO. B-2

PROJECT: Harrison Hills City Schools

CLIENT: Harrison Hills City Schools
Columbus, Ohio

SITE: Site D
Cadiz, Ohio

LOCATION See Exhibit A-3

Latitude: 40.260216° Longitude: -81.001126°

Approximate Surface Elev: 1135 (Ft.) +/-

DEPTH	ELEVATION (Ft.)	Description	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	RECOVERY (In.)	FIELD TEST RESULTS	RQD (%)	LABORATORY TORVANE/HP (tsf)
		SANDSTONE, gray to dark gray, slightly open to open joints, close to moderately close joints, medium to thick bedding, moderately weathered, moderately hard *(continued)*	55			60		87	
			60			60		88	
			65			60		68	
			70			60		88	
74.5	1060.5+/-		75			57		73	
		CLAYSTONE, gray, tight to open joints, close joints, thin bedding, severely to very severely weathered, soft to medium hard							
77.0	1058+/-								
		Boring Terminated at 77 Feet							

Stratification lines are approximate. In-situ, the transition may be gradual.

Hammer Type: Automatic

Advancement Method:
3.25" Hollow Stem Auger

Abandonment Method:
Boring backfilled with cement/bentonite grout upon completion.

See Exhibit A-1 for description of field procedures

See Appendix B for description of laboratory procedures and additional data (if any).

See Appendix C for explanation of symbols and abbreviations.
Elevations obtained from Google Earth

Notes:

WATER LEVEL OBSERVATIONS

No water observed

Terracon
800 Morrison Road
Columbus, Ohio

Boring Started: 6/4/2015 | Boring Completed: 6/5/2015

Drill Rig: ATV | Driller: McMurray

Project No.: N4155098 | Exhibit: A-5

THIS BORING LOG IS NOT VALID IF SEPARATED FROM ORIGINAL REPORT. GEO LOG-DEPTH TO BOTTOM OF PAGE N4155098 HARRISON HILLS CITY SCHOOLS.GPJ TERRACON2012.GDT 6/22/15

BORING LOG NO. B-3

PROJECT: Harrison Hills City Schools

CLIENT: Harrison Hills City Schools
Columbus, Ohio

SITE: Site D
Cadiz, Ohio

LOCATION See Exhibit A-3

Latitude: 40.260628° Longitude: -80.998212°

Approximate Surface Elev: 1205 (Ft.) +/-

DEPTH	ELEVATION (Ft.)	Description
0.5	1204.5+/-	**TOPSOIL (6")**
		FILL - LEAN CLAY (CL), trace organics, brown
3.0	1202+/-	
		FILL - SHALE FRAGMENTS, trace sand, dark gray
5.5	1199.5+/-	
		FILL - LEAN CLAY (CL), trace shale fragments, trace coal fragments, brown
13.0	1192+/-	
		FILL - LEAN CLAY WITH COAL FRAGMENTS (CL), dark brown to black
18.0	1187+/-	
		FILL - LEAN CLAY WITH ROCK FRAGMENTS (CL), brown
		noted cobble @ 20'
23.0	1182+/-	
		FILL - LEAN CLAY (CL), trace sand and shale fragments, gray

DEPTH (Ft.)	RECOVERY (In.)	FIELD TEST RESULTS
	7	3-7-11 N=18
	8	9-5-4 N=9
	10	2-6-4 N=10
5	6	0-2-3 N=5
	6	2-3-4 N=7
10		
	13	2-2-4 N=6
15		
	6	4-6-9 N=15
20		
	10	4-4-7 N=11
25		

GRAPHIC LOG | WATER LEVEL OBSERVATIONS | SAMPLE TYPE | RQD (%) | LABORATORY TORVANE/HP (tsf)

Stratification lines are approximate. In-situ, the transition may be gradual.

Hammer Type: Automatic

Advancement Method:
3.25" Hollow Stem Auger

Abandonment Method:
Boring backfilled with cement/bentonite grout upon completion.

See Exhibit A-1 for description of field procedures

See Appendix B for description of laboratory procedures and additional data (if any).

See Appendix C for explanation of symbols and abbreviations.

Elevations obtained from Google Earth

Notes:

WATER LEVEL OBSERVATIONS

Water observed at 44.7 feet while drilling

No water observed before coring

Terracon
800 Morrison Road
Columbus, Ohio

Boring Started: 6/2/2015 | Boring Completed: 6/3/2015

Drill Rig: ATV | Driller: McMurray

Project No.: N4155098 | Exhibit: A-6

THIS BORING LOG IS NOT VALID IF SEPARATED FROM ORIGINAL REPORT. GEO LOG-DEPTH TO BOTTOM OF PAGE N4155098 HARRISON HILLS CITY SCHOOLS.GPJ TERRACON2012.GDT 6/22/15

BORING LOG NO. B-3

PROJECT: Harrison Hills City Schools

CLIENT: Harrison Hills City Schools
Columbus, Ohio

SITE: Site D
Cadiz, Ohio

LOCATION See Exhibit A-3

Latitude: 40.260628° Longitude: -80.998212°

Approximate Surface Elev: 1205 (Ft.) +/-

DEPTH	ELEVATION (Ft.)	Description
		FILL - LEAN CLAY (CL), trace sand and shale fragments, gray *(continued)*
28.0	1177+/-	
		FILL - FAT CLAY (CL), trace shale fragments, gray
33.0	1172+/-	
		FILL - LEAN CLAY (CL), trace shale fragments, gray
38.0	1167+/-	
		FILL - LEAN CLAY WITH SHALE FRAGMENTS (CL), gray and dark brown
43.0	1162+/-	
		SHALE, trace root hairs, gray, completely weathered
45.0	1160+/-	
		LIMESTONE, gray, tight joints, close joints, thin bedding, moderately weathered, hard
46.4	1158.5+/-	
		CLAYSTONE, gray, tight joints, close joints, thin bedding, very severely weathered, soft
49.4	1155.5+/-	
50.0	1155+/-	**LIMESTONE**, gray, tight joints, close joints, thin bedding, severely weathered, hard
		SANDSTONE, gray, slightly open to open joints, close joints, medium bedding, severely weathered, moderately hard to hard

DEPTH (Ft.)	SAMPLE TYPE	RECOVERY (In.)	FIELD TEST RESULTS	RQD (%)
30		11	2-3-6 N=9	
35		12	4-5-7 N=12	
40		13	7-8-7 N=15	
			50/3"	
45		47		73
50		59		83

WATER LEVEL OBSERVATIONS: ▽ 45

Stratification lines are approximate. In-situ, the transition may be gradual.

Hammer Type: Automatic

Advancement Method:
3.25" Hollow Stem Auger

Abandonment Method:
Boring backfilled with cement/bentonite grout upon completion.

See Exhibit A-1 for description of field procedures

See Appendix B for description of laboratory procedures and additional data (if any).

See Appendix C for explanation of symbols and abbreviations.

Elevations obtained from Google Earth

Notes:

WATER LEVEL OBSERVATIONS

▽ *Water observed at 44.7 feet while drilling*

No water observed before coring

Terracon
800 Morrison Road
Columbus, Ohio

Boring Started: 6/2/2015	Boring Completed: 6/3/2015
Drill Rig: ATV	Driller: McMurray
Project No.: N4155098	Exhibit: A-6

THIS BORING LOG IS NOT VALID IF SEPARATED FROM ORIGINAL REPORT. GEO LOG-DEPTH TO BOTTOM OF PAGE N4155098 HARRISON HILLS CITY SCHOOLS.GPJ TERRACON2012.GDT 6/22/15

BORING LOG NO. B-3

PROJECT: Harrison Hills City Schools

CLIENT: Harrison Hills City Schools
Columbus, Ohio

SITE: Site D
Cadiz, Ohio

LOCATION See Exhibit A-3

Latitude: 40.260628° Longitude: -80.998212°

Approximate Surface Elev: 1205 (Ft.) +/-

DEPTH	ELEVATION (Ft.)	Description	RECOVERY (In.)	RQD (%)
		SANDSTONE, gray, slightly open to open joints, close joints, medium bedding, severely weathered, moderately hard to hard *(continued)*	59	
57.0	1148+/-		60	47
58.6	1146.5+/-	**SANDSTONE**, gray and brown, moderately open to open joints, very close joints, thin bedding, very severely weathered, moderately hard		
60.4	1144.5+/-	**SILTSTONE**, gray, slightly open joints, close joints, thin bedding, very severely weathered, soft		
61.2	1144+/-	**CLAYSTONE**, gray, open joints, very close joints, thin bedding, completely weathered, very soft	60	27
62.8	1142+/-	**LIMESTONE**, gray, slightly open joints, close joints, thin bedding, severely weathered, hard		
		CLAYSTONE, gray, slightly open joints, close joints, thin bedding, very severely to completely weathered, soft 6" very soft seam @ 64'	60	17
70.0	1135+/-			
72.4	1132.5+/-	**CLAYSTONE**, gray and maroon, slightly open to open joints, close joints, thin bedding, very severely weathered, very soft	60	47
75.0	1130+/-	**CLAYSTONE**, gray trace maroon, slightly open to moderately open joints, close joints, thin bedding, very severely weathered, very soft		
		Boring Terminated at 75 Feet		

DEPTH (Ft.): 55, 60, 65, 70, 75

WATER LEVEL OBSERVATIONS | SAMPLE TYPE | FIELD TEST RESULTS | LABORATORY TORVANE/HP (tsf)

Stratification lines are approximate. In-situ, the transition may be gradual.

Hammer Type: Automatic

Advancement Method:
3.25" Hollow Stem Auger

Abandonment Method:
Boring backfilled with cement/bentonite grout upon completion.

See Exhibit A-1 for description of field procedures

See Appendix B for description of laboratory procedures and additional data (if any).

See Appendix C for explanation of symbols and abbreviations.

Elevations obtained from Google Earth

Notes:

WATER LEVEL OBSERVATIONS

Water observed at 44.7 feet while drilling

No water observed before coring

Terracon
800 Morrison Road
Columbus, Ohio

Boring Started: 6/2/2015 | Boring Completed: 6/3/2015

Drill Rig: ATV | Driller: McMurray

Project No.: N4155098 | Exhibit: A-6

THIS BORING LOG IS NOT VALID IF SEPARATED FROM ORIGINAL REPORT. GEO LOG-DEPTH TO BOTTOM OF PAGE N4155098 HARRISON HILLS CITY SCHOOLS.GPJ TERRACON2012.GDT 6/22/15

BORING LOG NO. B-4

PROJECT: Harrison Hills City Schools

CLIENT: Harrison Hills City Schools
Columbus, Ohio

SITE: Site D
Cadiz, Ohio

LOCATION See Exhibit A-3

Latitude: 40.25717° Longitude: -80.997464°

Approximate Surface Elev: 1189 (Ft.) +/-

DEPTH	ELEVATION (Ft.)	Description
0.3	1188.5+/-	**TOPSOIL (4")**
1.5	1187.5+/-	**FILL - LEAN CLAY (CL)**, trace shale fragments, trace root hairs, brown
3.5	1185.5+/-	**FILL - LEAN CLAY (CL)**, trace rock fragments, trace root hairs, brown
5.5	1183.5+/-	**FILL - FAT CLAY WITH SHALE FRAGMENTS (CH)**, brown
13.0	1176+/-	**FILL - LEAN CLAY (CL)**, trace rock fragments, gray
18.0	1171+/-	**FILL - LEAN CLAY WITH SHALE FRAGMENTS (CL)**, brown
23.0	1166+/-	**FILL - LEAN CLAY (CL)**, trace shale fragments and rock fragments, brown
		FILL - LEAN CLAY WITH ROCK FRAGMENTS (CL), brown

DEPTH (Ft.)	SAMPLE TYPE	RECOVERY (In.)	FIELD TEST RESULTS	RQD (%)	LABORATORY TORVANE/HP (tsf)
	X	6	2-2-4 N=6		
	X	8	5-5-6 N=11		
	X	7	4-6-4 N=10		
5	X	12	8-9-12 N=21		
	X	9	4-20-16 N=36		
10					
	X	11	6-7-8 N=15		
15					
	X	6	5-7-7 N=14		
20					
	X	4	6-12-24 N=36		
25					

GRAPHIC LOG

WATER LEVEL OBSERVATIONS

Stratification lines are approximate. In-situ, the transition may be gradual.

Hammer Type: Automatic

Advancement Method:
3.25" Hollow Stem Auger

Abandonment Method:
Boring backfilled with cement/bentonite grout upon completion.

See Exhibit A-1 for description of field procedures

See Appendix B for description of laboratory procedures and additional data (if any).

See Appendix C for explanation of symbols and abbreviations.

Elevations obtained from Google Earth

Notes:

WATER LEVEL OBSERVATIONS

Water observed at 38 feet while drilling

No water observed before coring

Terracon
800 Morrison Road
Columbus, Ohio

Boring Started: 6/3/2015 | Boring Completed: 6/4/2015

Drill Rig: ATV | Driller: McMurray

Project No.: N4155098 | Exhibit: A-7

THIS BORING LOG IS NOT VALID IF SEPARATED FROM ORIGINAL REPORT. GEO LOG-DEPTH TO BOTTOM OF PAGE N4155098 HARRISON HILLS CITY SCHOOLS.GPJ TERRACON2012.GDT 6/22/15

BORING LOG NO. B-4

PROJECT: Harrison Hills City Schools

CLIENT: Harrison Hills City Schools
Columbus, Ohio

SITE: Site D
Cadiz, Ohio

LOCATION See Exhibit A-3

Latitude: 40.25717° Longitude: -80.997464°

Approximate Surface Elev: 1189 (Ft.) +/-

DEPTH	ELEVATION (Ft.)	Description
		FILL - LEAN CLAY WITH ROCK FRAGMENTS (CL), brown *(continued)*
28.0	1161+/-	
		SHALE, brown, completely weathered, soft
33.0	1156+/-	
		SHALE, gray, completely weathered, soft
38.0	1151+/-	
		SHALE, gray, completely weathered, soft
40.0	1149+/-	
		SANDSTONE, gray, slightly open to open joints, close joints, thin bedding, severely weathered, medium hard
41.8	1147+/-	
		SILTSTONE, gray, open joints, close joints, thin bedding, severely to very severely weathered, medium hard
43.5	1145.5+/-	
		CLAYSTONE, gray, slightly open to open joints, close joints, thin bedding, very severely weathered, soft
45.0	1144+/-	
		LIMESTONE, gray, moderately open joints, close joints, thin bedding, very severely weathered, moderately hard
		4" claystone seam @ 46.2'
47.5	1141.5+/-	2" claystone seam @ 47'
		CLAYSTONE, slightly open to moderately wide joints, close joints, thin bedding, very severely to completely weathered, soft
		2" limestone seam @ 50.4'
		6" limestone seam @ 51.2'

DEPTH (Ft.)	SAMPLE TYPE	RECOVERY (In.)	FIELD TEST RESULTS	RQD (%)
30		2	50/2"	
35		5	50/5"	
		3	50/3"	
40		60		30
45		60		43
50		58		

WATER LEVEL OBSERVATIONS: ▽ 38 feet

Stratification lines are approximate. In-situ, the transition may be gradual.

Hammer Type: Automatic

Advancement Method:
3.25" Hollow Stem Auger

Abandonment Method:
Boring backfilled with cement/bentonite grout upon completion.

See Exhibit A-1 for description of field procedures

See Appendix B for description of laboratory procedures and additional data (if any).

See Appendix C for explanation of symbols and abbreviations.
Elevations obtained from Google Earth

Notes:

WATER LEVEL OBSERVATIONS

▽ *Water observed at 38 feet while drilling*

No water observed before coring

Terracon
800 Morrison Road
Columbus, Ohio

Boring Started: 6/3/2015 | Boring Completed: 6/4/2015

Drill Rig: ATV | Driller: McMurray

Project No.: N4155098 | Exhibit: A-7

THIS BORING LOG IS NOT VALID IF SEPARATED FROM ORIGINAL REPORT. GEO LOG-DEPTH TO BOTTOM OF PAGE N4155098 HARRISON HILLS CITY SCHOOLS.GPJ TERRACON2012.GDT 6/22/15

BORING LOG NO. B-4

PROJECT: Harrison Hills City Schools

CLIENT: Harrison Hills City Schools
Columbus, Ohio

SITE: Site D
Cadiz, Ohio

LOCATION See Exhibit A-3

Latitude: 40.25717° Longitude: -80.997464°

Approximate Surface Elev: 1189 (Ft.) +/-

DEPTH	ELEVATION (Ft.)	Description	DEPTH (Ft.)	RECOVERY (In.)	RQD (%)
52.8	1136+/-	**LIMESTONE**, gray, moderately open to open joints, very close to close joints, thin bedding, very severely weathered, moderately hard to hard		58	30
55.0	1134+/-	6" claystone seam @ 54.5'	55		
58.3	1130.5+/-	**SILTSTONE**, gray, tight to open joints, close joints, thin to medium bedding, severely weathered, medium to moderately hard, calcareous		60	80
60.2	1129+/-	**LIMESTONE**, gray, open to moderately wide joints, close joints, medium bedding, very severely weathered, medium hard to hard	60		
65.0	1124+/-	2" siltstone seam @ 60' **SANDSTONE**, gray, moderately open to open joints, close to moderately close joints, medium bedding, severely to very severely weathered, moderately hard, calcareous, pyritic crystals @ 61' iron oxide staining @ 62' - 62.6' 2" claystone and 3" siltstone seams @ 62.6'		60	72
67.4	1121.5+/-	**LIMESTONE**, dark gray with maroon and olive staining, moderately open to open joints, close to moderately close joints, medium bedding, severely weathered, moderately hard	65		
69.0	1120+/-	**CLAYSTONE**, gray, slightly open to moderately open joints, close joints, thin bedding, very severely weathered, soft to medium hard		60	57
69.7	1119.5+/-	**SANDSTONE**, gray, tight joints, close joints, thin bedding, moderately weathered, medium hard			
70.0	1119+/-	**SILTSTONE**, gray, tight joints, close joints, thin bedding, very severely weathered, soft to medium	70		
75.0	1114+/-	**CLAYSTONE**, maroon, tight to moderately open joints, close joints, thin to medium bedding, severely weathered, soft to medium		60	67
		Boring Terminated at 75 Feet	75		

Stratification lines are approximate. In-situ, the transition may be gradual.

Hammer Type: Automatic

Advancement Method:
3.25" Hollow Stem Auger

Abandonment Method:
Boring backfilled with cement/bentonite grout upon completion.

See Exhibit A-1 for description of field procedures

See Appendix B for description of laboratory procedures and additional data (if any).

See Appendix C for explanation of symbols and abbreviations.
Elevations obtained from Google Earth

Notes:

WATER LEVEL OBSERVATIONS

Water observed at 38 feet while drilling

No water observed before coring

Terracon
800 Morrison Road
Columbus, Ohio

Boring Started: 6/3/2015 | Boring Completed: 6/4/2015

Drill Rig: ATV | Driller: McMurray

Project No.: N4155098 | Exhibit: A-7

THIS BORING LOG IS NOT VALID IF SEPARATED FROM ORIGINAL REPORT. GEO LOG-DEPTH TO BOTTOM OF PAGE N4155098 HARRISON HILLS CITY SCHOOLS.GPJ TERRACON2012.GDT 6/22/15

APPENDIX B
SUPPORTING DOCUMENTS

GENERAL NOTES

DESCRIPTION OF SYMBOLS AND ABBREVIATIONS

SAMPLING

Auger	Shelby Tube	Split Spoon
Rock Core	Macro Core	Modified California Ring Sampler
Grab Sample	No Recovery	Modified Dames & Moore Ring Sampler

WATER LEVEL

- Water Initially Encountered
- Water Level After a Specified Period of Time
- Water Level After a Specified Period of Time

Water levels indicated on the soil boring logs are the levels measured in the borehole at the times indicated. Groundwater level variations will occur over time. In low permeability soils, accurate determination of groundwater levels is not possible with short term water level observations.

FIELD TESTS

(HP)	Hand Penetrometer
(T)	Torvane
(b/f)	Standard Penetration Test (blows per foot)
N	N value
(PID)	Photo-Ionization Detector
(OVA)	Organic Vapor Analyzer

DESCRIPTIVE SOIL CLASSIFICATION

Soil classification is based on the Unified Soil 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.

LOCATION AND ELEVATION NOTES

Unless otherwise noted, Latitude and Longitude are approximately determined using a hand-held GPS device. The accuracy of such devices is variable. Surface elevation data annotated with +/- indicates that no actual topographical survey was conducted to confirm the surface elevation. Instead, the surface elevation was approximately determined from topographic maps of the area.

STRENGTH TERMS

RELATIVE DENSITY OF COARSE-GRAINED SOILS (More than 50% retained on No. 200 sieve.) Density determined by Standard Penetration Resistance Includes gravels, sands and silts.			CONSISTENCY OF FINE-GRAINED SOILS (50% or more passing the No. 200 sieve.) Consistency determined by laboratory shear strength testing, field visual-manual procedures or standard penetration resistance			
Descriptive Term (Density)	Standard Penetration or N-Value Blows/Ft.	Ring Sampler Blows/Ft.	Descriptive Term (Consistency)	Unconfined Compressive Strength, Qu, tsf	Standard Penetration or N-Value Blows/Ft.	Ring Sampler Blows/Ft.
Very Loose	0 - 3	0 - 6	Very Soft	less than 0.25	0 - 1	< 3
Loose	4 - 9	7 - 18	Soft	0.25 to 0.50	2 - 4	3 - 4
Medium Dense	10 - 29	19 - 58	Medium-Stiff	0.50 to 1.00	4 - 8	5 - 9
Dense	30 - 50	59 - 98	Stiff	1.00 to 2.00	8 - 15	10 - 18
Very Dense	> 50	≥ 99	Very Stiff	2.00 to 4.00	15 - 30	19 - 42
			Hard	> 4.00	> 30	> 42

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. (300 mm)
Cobbles	12 in. to 3 in. (300mm to 75mm)
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
Modifier	> 12

PLASTICITY DESCRIPTION

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

Terracon

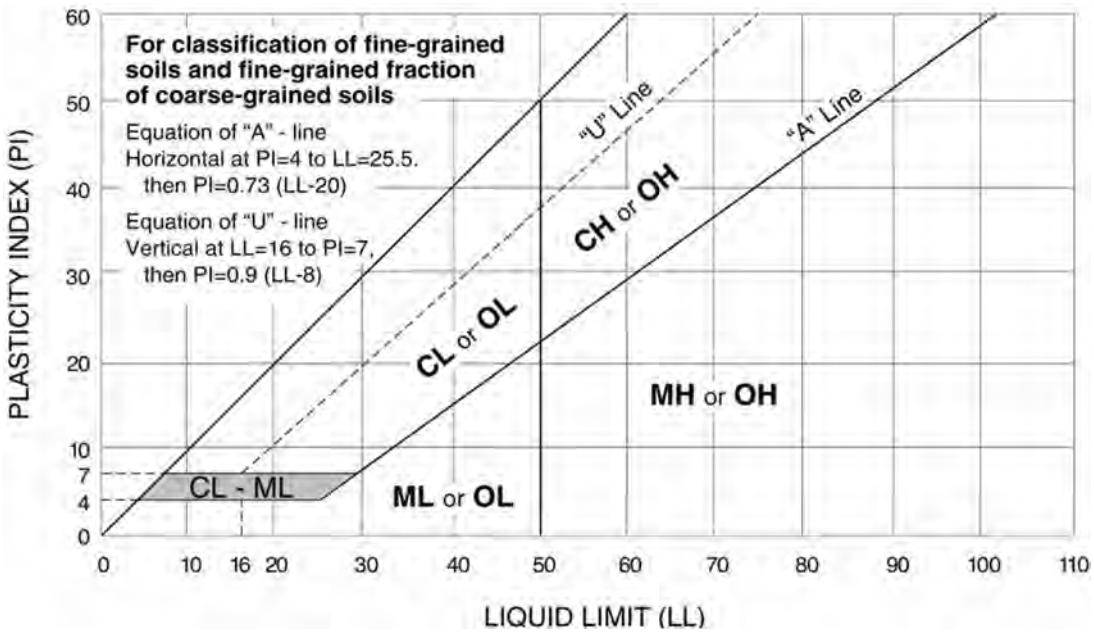
UNIFIED SOIL CLASSIFICATION SYSTEM

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 ≥ 4 and 1 ≤ Cc ≤ 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 ≥ 6 and 1 ≤ Cc ≤ 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-inch (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] $Cu = D_{60}/D_{10}$ $\quad Cc = \dfrac{(D_{30})^2}{D_{10} \times D_{60}}$

[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.



Terracon

Exhibit C-2

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

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

Rock Quality Designator (RQD) a

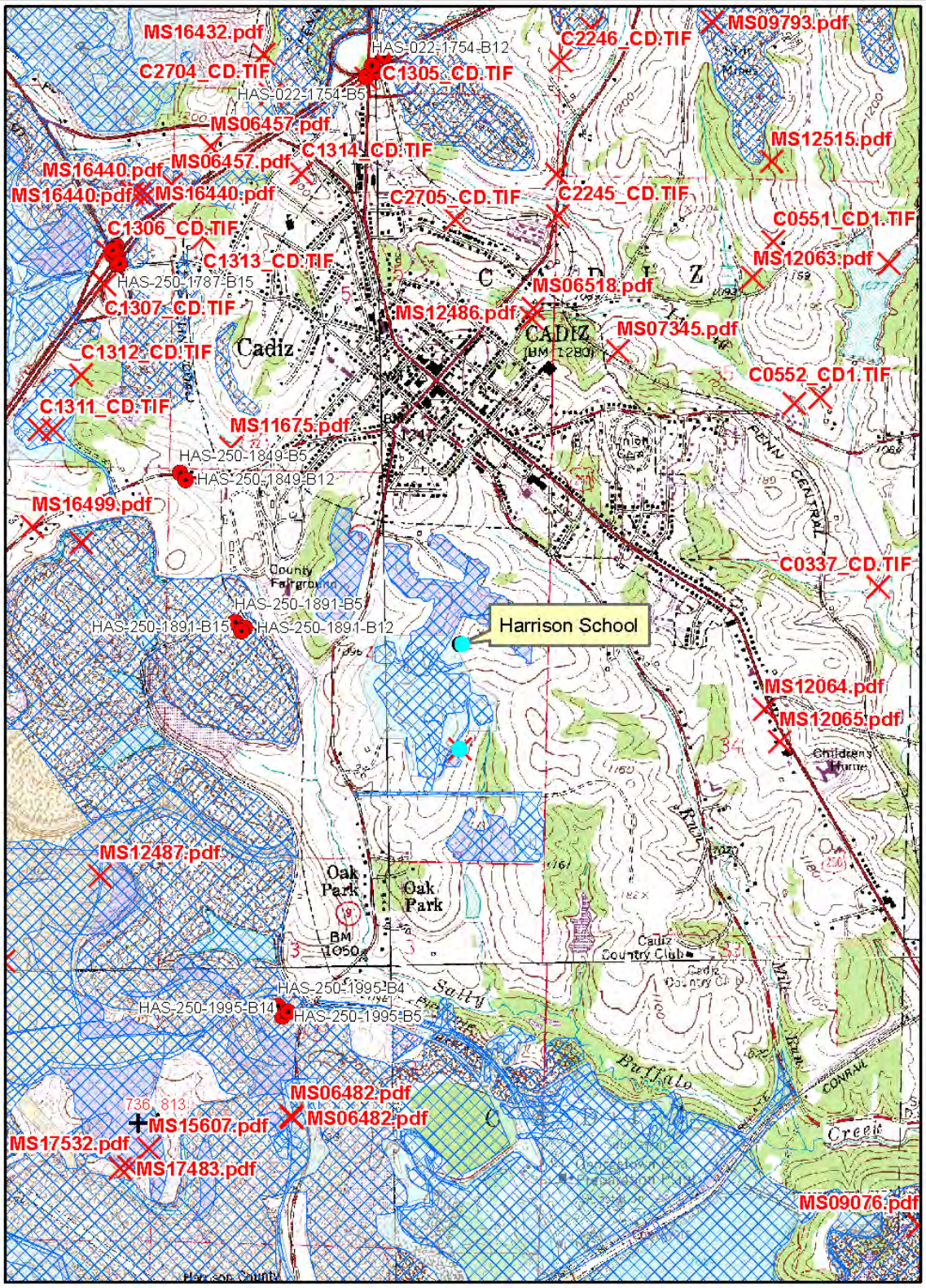
RQD, as a percentage	Diagnostic description
Exceeding 90	Excellent
90 – 75	Good
75 – 50	Fair
50 – 25	Poor
Less than 25	Very poor

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

Joint Openness Descriptors

Openness	Descriptor
No Visible Separation	Tight
Less than 1/32 in.	Slightly Open
1/32 to 1/8 in.	Moderately Open
1/8 to 3/8 in.	Open
3/8 in. to 0.1 ft.	Moderately Wide
Greater than 0.1 ft.	Wide

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.



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Note: surface mines are mapped across the middle of the site on this map provided by ODNR

Project Manager: KME	Project No. N4155098	Terracon Consulting Engineers & Scientists	SURFACE MINE MAP
Drawn by: AKB	Scale: N.T.S.	800 Morrison Road Columbus, Ohio 43230	HARRISON HILLS CITY SCHOOLS
Checked by: KME	File Name: N4155098	PH. (614) 863-3113 FAX. (614) 863-0475	STATE ROUTE 9
Approved by: KME	Date: June 2015		CADIZ, OHIO

Exhibit

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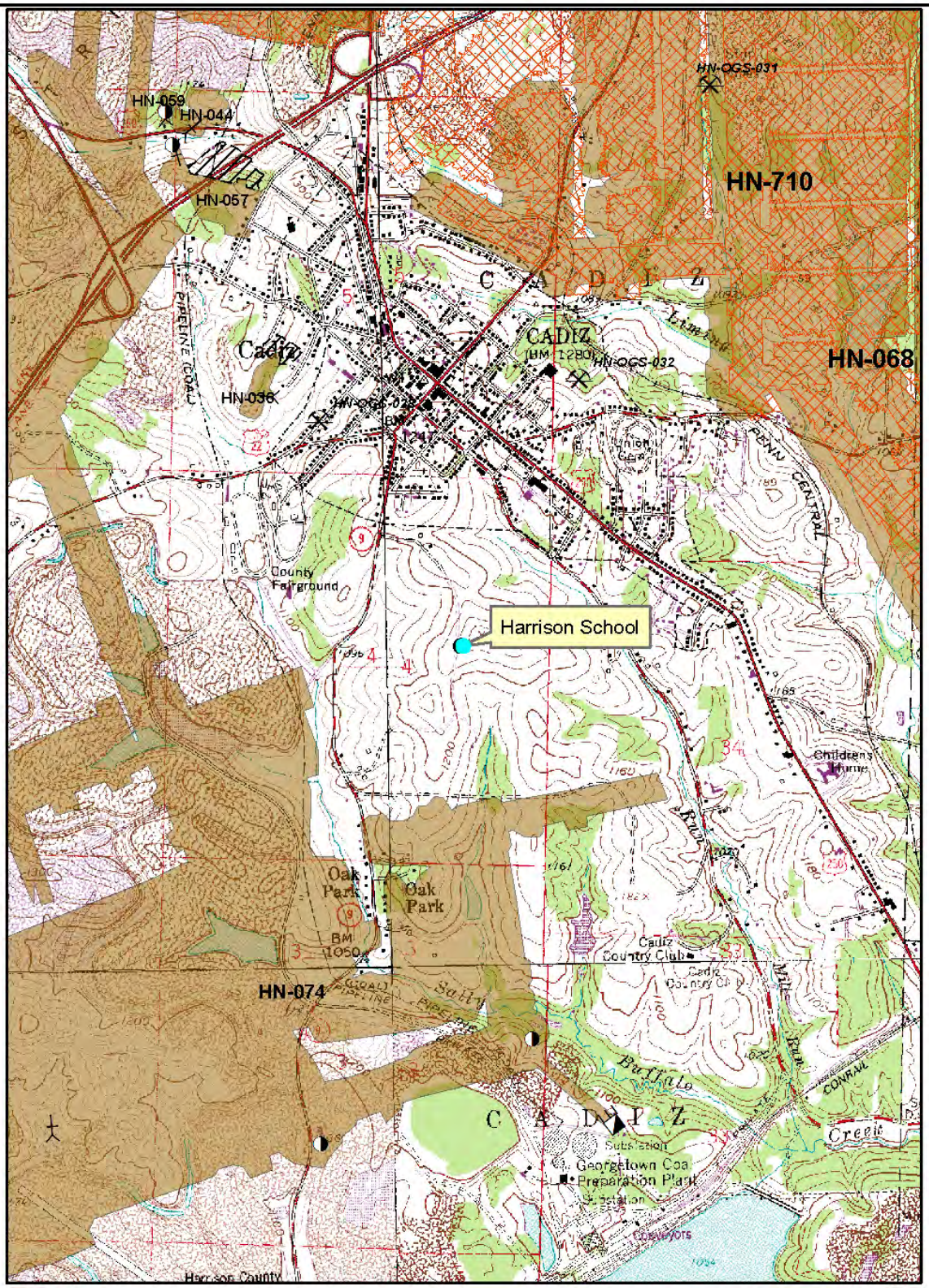

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N

Note: No underground mines are mapped beneath the site on this map provided by ODNR

Project Manager: KME	Project No. N4155098	Terracon Consulting Engineers & Scientists	ABANDONED UNDERGROUND MINES MAP
Drawn by: AKB	Scale: N.T.S.	800 Morrison Road, Columbus, Ohio 43230	HARRISON HILLS CITY SCHOOLS
Checked by: KME	File Name: N4155098	PH. (614) 863-3113, FAX. (614) 863-0475	STATE ROUTE 9
Approved by: KME	Date: June 2015		CADIZ, OHIO

Exhibit

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