GEOTECHNICAL EVALUATION

REDBIRD SRA ACCESS ROAD IMPROVEMENTS
GREENE COUNTY, INDIANA

Prepared for

HWC ENGINEERING
135 NORTH PENNSYLVANIA STREET, SUITE 2800
INDIANAPOLIS, INDIANA 46204

By

EARTH EXPLORATION, INC.
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December 3, 2018

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December 3, 2018

Mr. Paul Lincks, P.E.
HWC Engineering
135 North Pennsylvania Street, Suite 2800
Indianapolis, IN 46204

Re: Geotechnical Evaluation
Redbird SRA Access Road Improvements
Greene County, Indiana
Earth Exploration, Inc. Project No. CJ185109
HWC Project No. 2017-276-S

Dear Mr. Lincks:

In accordance with your request, we have completed our geotechnical evaluation for the referenced project. This report presents the results of our subsurface exploratory and laboratory testing programs and provides geotechnical recommendations for design and construction of the proposed roadway improvements. The work for this project was authorized by HWC Engineering (HWC) via acceptance of Earth Exploration, Inc. (EEI) Proposal No. PCJ185109 dated September 25, 2018.

The opinions and recommendations provided herein are based, in part, on our interpretation of the subsurface information revealed at the exploratory locations as indicated on the attached Test Boring Location Plan (Drawing No. CJ185109.B1). Understandably, this report does not reflect variations in subsurface conditions between or beyond these locations. Therefore, variations in these conditions can be expected, and fluctuation of any groundwater level(s) will occur with time. A discussion of important limitations of a geotechnical report is attached for your information.

PROJECT DESCRIPTION

We understand that representatives of the Indiana Department of Natural Resources (IDNR) are planning to make improvements to an existing gravel haul road located in the Redbird State Forest. We understand that the existing gravel road is being used to access a recreational area which is an abandoned strip mine facility. We understand that the INDOT Standard Specifications (ISS) will be utilized for the design and construction of the proposed improvements. Based on our correspondence along with a review of the preliminary plans, the improvements are anticipated to include the construction of a new 24 ft in width asphaltic concrete (HMA) roadway from County Road 350 North to the Whitetail shelter house for a total length of about 1 mi. In addition, associated HMA parking areas are proposed along the roadway. Based on the plans, earth cuts and fill are generally not anticipated to exceed about 2 ft except near the southern portion of the alignment (i.e., near Sta. 11+50 to 13+00) where fill on the order of 4 to 11 ft is planned to achieve proposed grade with maximum side slopes of 2H:1V.

Additional project information such as construction schedule was not available at the time of this report. In the event that the nature, design or location of the proposed construction changes, the conclusions and recommendations obtained in this report shall not be considered valid unless the changes are reviewed, and the conclusions are modified or confirmed in writing by Earth Exploration, Inc. (EEI).

FIELD EXPLORATION AND LABORATORY TESTING

The subsurface conditions for the proposed improvements were explored by performing two borings near the highest fill area (designated B-1 and B-2) to depths ranging from about 19 to 30 ft below the existing ground surface, two roadway borings (designated RB-1 and RB-2) to a depth of 5 ft, and two parking area borings (designated P-1 and P-2) to a depth of 10 ft. The number, location, and depth of the exploratory locations were selected by EEI based on our understanding of the design and construction needs for the project. The exploratory locations were marked in the field by EEI personnel using a hand-held GPS. Furthermore, ground surface elevations at the boring locations were interpolated to the nearest 1-ft based on topographic information provided on the plans. The exploratory locations and elevations should be considered accurate only to the degree implied by the methods used.

The exploratory field activities were performed by EEI on November 1 and 2, 2018 using ATV-mounted equipment and 3¼-in I.D. hollow stem augers to advance the boreholes. Relatively disturbed samples of the soil strata were obtained using Standard Penetration Test (SPT) procedures. In addition, a relatively undisturbed sample was obtained using a thin-walled tube sampler (Shelby tube) near a depth of 5 to 7 ft from an offset location at Boring P-1. After obtaining groundwater observations, each borehole was backfilled with auger cuttings and a bentonite chip plug was placed near the surface.

Following the field activities, the soil/rock samples were visually classified by an EEI engineering technician and reviewed by an EEI geotechnical engineer. After visually classifying the soil and rock, representative samples were selected for index testing. The laboratory testing program included the following:

- Natural moisture content tests;
- Grain sized distribution;
- Atterberg limit determinations;
- Soil pH;
- Soluble sulfate concentration; and
- Hand penetrometer readings (q_p)

The results of these tests are provided on the attached boring logs and/or respective laboratory reports. Soil classifications on the boring logs are according to the Unified Soil Classification System (USCS). Further details regarding the classification system are provided in the Unified Soil Classification System/General Notes. The boring logs represent our interpretation of the individual samples, field logs, and results of the laboratory tests. The stratification lines on the boring logs represent the approximate boundary between soil types; although, the transition may actually be gradual.

SITE CONDITIONS

The following description of site conditions is derived from our site visit in association with the field exploration, and our review of readily available aerial photographs.

Item	Description
Parcel Information	The project site is located in the Redbird State Forest located at 15298 West County Road 350 North in Lizton, Indiana. See the Test Boring Location Plan (Drawing No. CJ185109.B1) in the attachments.
Existing Improvements	The area surrounding the existing gravel roadway generally consists of heavily wooded areas.
Current Ground Cover	Topsoil (5 to 11 in.) and crushed stone (6 in.)
Existing Topography	Per topographic information provided by HWC, ground surface elevations at the boring locations vary from about El. 569 to 596.

SUBSURFACE CONDITIONS

Roadway (Borings B-1, B-2, RB-1, and RB-2)

Based on our observations, the subsurface soils observed in the area of the proposed roadway generally consisted of cohesive soils (lean clay, sandy clay, and silty clay) to depths of about 5½ to 10 ft below the existing ground surface. Below these depths, weathered sandstone and shale was observed to the maximum depth explored in Borings B-1 and B-2. Note that the sandstone seam was observed above the shale at Boring B-1. An exception to this general profile was observed at Boring B-1, where silty sand was observed below the surficial materials.

The consistency of the cohesive soils was typically medium stiff to hard with hand penetrometer readings in the range of ½ to 4¼ tons/sq. ft (tsf), and moisture contents were on the order of about 8 to 16 percent. Atterberg limit tests performed on samples of lean clay and sandy clay indicated liquid limits (LL) in the range of 32 to 34 and plastic limits (PL) in the range of 20 to 23. The pH level (i.e., hydrogen-ion content) of the representative samples tested was determined to be in the range of 3.9 to 5, and soluble sulfate concentration in the range of 2,490 to 4,160 parts per million (ppm).

The relative density of the silty sand observed in Boring B-1 was medium dense with SPT N-values of 12 and 14 bpf. The weathered shale and weathered sandstone were described as soft based on the ability to scratch the samples recovered with a split-spoon sampler with a metallic object.

Parking Areas (Borings P-1 and P-2)

The subsurface soils in the proposed parking areas consisted of cohesive soils (lean clay and sandy clay) to depths of about 8½ to 10 ft. Note that coal was observed in Boring P-1 at depths of 8½ to 10 ft below the existing ground surface. An SPT N-value of 12 blows per foot (bpf) was observed within the coal.

The consistency of the cohesive soils was typically stiff to very stiff with hand penetrometer readings in the range of 1¼ to 3¾ tsf. Note that in Boring P-1, a layer of very soft to medium stiff

lean clay was observed at a depth range of 3 to 8½ ft below the existing ground surface. Hand penetrometer readings of less than ¼ to ½ tsf were observed in this stratum. An Atterberg limit test performed on a sample sandy clay indicated an LL of 32 and PL of 23. The pH level (i.e., hydrogen-ion content) of the representative samples tested was determined to be in the range of 3.6 to 5.3, and soluble sulfate concentration in the range of 560 to 5,570 parts per million (ppm).

GROUNDWATER CONDITIONS

Groundwater level observations made during, at completion of, and up to 6 hrs after the sampling process. The groundwater levels observed are noted on the boring lgos. Based on our observations, groundwater was observed at a depth of 4 ft below existing grades during drilling at Boring RB-2 and upon completion of the sampling process at Boring RB-2 and P-1 at depths of 1 to 7 ft below the existing ground surface. A review of the *Soil Survey of Greene County, Indiana* indicates that the groundwater level near the project alignment typically remains greater than 6½ ft below the surface. However, it should be recognized that groundwater levels of any kind will fluctuate due to changes in precipitation, infiltration, surface run-off, and other hydrogeological factors.

EARTHWORK

Subgrade and Foundation Preparation

In general, the subsurface conditions observed at the exploratory locations consisted mostly of cohesive soils exhibiting medium plasticity at shallow depths. Based upon our understanding of the improvements and information obtained from the exploratory locations, it is our opinion that the subsurface conditions are generally conducive for the support of the roadway improvements. The most critical aspect of this project, from a geotechnical perspective, will be preparation of the subgrades for support of these elements. Given the presence of soft to medium stiff cohesive soils near the area of Boring P-1, improvement of the subgrade will be required. Additional discussion and recommendations regarding these issues are provided in the following paragraphs.

We recommend that all topsoil, trees (via grubbing) and tree roots, soil containing organic matter, and wet or soft near-surface soils be removed per the ISS. Where tree removal is required, we recommend root masses be removed and any depressions be graded and compacted in accordance with the ISS so-as not to leave any soft conditions or areas where water is allowed to collect. Because otherwise stiff conditions will deteriorate when exposed to excessive moisture and repeated construction traffic, consideration should be given to the timing of the removal of these surface conditions relative to the preparation of the subgrade and sequencing of other activities. In addition, we recommend that consideration be given to access points and construction drives for moving construction equipment off the exposed subgrade, if possible, in order to avoid disturbing the subgrade.

Based on our observations of the shallow conditions at the test borings, the subgrade conditions in the area of the new roadway are anticipated to primarily consist of medium plasticity cohesive soils, as well as isolated instances of granular soil. Where granular soils are encountered at the subgrade, we recommend that they be compacted via several passes with a vibratory plate compactor. Once the subgrade is exposed, we recommend that the cohesive soils be proofrolled in accordance with the ISS. The purpose of proofrolling is to provide a first-order evaluation of how the subgrade is anticipated to react to construction traffic and gain an additional understanding of the conditions for support of the planned improvements. We recommend that the proofrolling be observed by an EEI geotechnical engineer or engineering technician.

Based on observations at our test borings, we anticipate that yielding subgrade conditions will be exposed during the proofroll observations particularly near the area of Boring P-1 due to the soft to medium stiff lean clay observed about 3½ to 8½ ft below the existing grade. Note that soft cohesive soils (similar to those observed in Boring P-1) are capable of exhibiting changes in volume in response to load that are detrimental to the performance of HMA pavement. We recommend an attempt be made to improve the conditions via aeriation (continuous discing and drying to reduce moisture content) and recompaction. In the event that continued difficult subgrade conditions are observed despite good faith efforts made by the contractor to correct the condition (i.e., discing and drying from recompaction), then improvement of the subgrade could be accomplished by undercutting a maximum depth of 2 ft and replacing with 6 in. of Indiana Department of Transportation (INDOT) No. 5 stone overlying geotextile Type 1B (INDOT Standard Specifications Section 918.02{c}) or equivalent and capped with 1½ ft of compacted INDOT No. 53 aggregate to achieve a stable base. Specifically, we anticipate that up to 2 ft of undercutting may be necessary near the area of Boring P-1 (parking area between approximate Sta. 48+00 to 51+00 “A”). We recommend additional quantities of common excavation, Type 1B geotextile, No. 5 stone, and No. 53 stone be included in the contract that is equal to the area of anticipated subgrade below embankment fill or pavement within those station limits. Note that the actual extent of undercutting will be dependent on field observations from a qualified person during construction. We recommend that EEI be retained during construction to observe the actual exposed subgrade soil conditions and provide guidance regarding the appropriate treatment.

Alternatively, additional subsurface exploration consisting of hand augers and Dynamic Cone Penetrometer (DCP) testing could be performed to further delineate the soft to medium stiff soil conditions observed near the area of Boring P-1.

As stated previously, soils with pH level in the range of 3.6 to 5.3 and soluble sulfate content greater than 1,000 ppm were observed near the existing ground surface. It is our opinion that the low pH values observed are likely due to mine spoils of the nearby mine. In addition, we anticipate subgrade improvement via chemical modification of the soil to be limited and is not recommended.

Fill Placement and Compaction

The maximum anticipated earth fill height on the project is anticipated to be about 11 ft. Standard embankment construction practices outlined in the ISS and with the ground prepared as discussed above should provide an adequate subgrade for earth fill placement.
We recommend that fill used to raise grades or backfill of undercut areas be placed in loose lifts thicknesses not exceeding 8 in. and be compacted to 95 percent of the maximum density obtained in accordance with AASHTO T 99 as specified in the ISS. Based on the anticipated earthwork requirements, we anticipate that new earth fill will be imported from off site. Verification of borrow from off site is a responsibility of the contractor. We recommend that benches be cut into any existing slopes steeper than 4H:1V before fill placement so as to key the new fill into the slope. In our opinion, benches having a minimum width of 10 ft should be cut into the slope before new fill is placed. Where 10 ft wide benches are not feasible due to shallow embankment heights and/or granular conditions, 6-ft wide benches (i.e., minimum) are recommended. Scarifying of the slope will also aide in keying the new fill into the slope.

As previously discussed, sideslopes as steep as 2H:1V are anticipated for the new embankment fill. We have selected the section at Sta. 11+50 for the stability analysis representing the highest fill section. An analysis was performed using GeoStudio's SLOPE/W software considering drained (i.e., long-term) conditions using the Spencer method of calculation. Soil and rock conditions were represented based on Borings B-1 and B-2. A traffic surcharge of 250 psf was assumed in the analysis. Provided the embankment fill is placed as recommend herein, the factor of safety against global stability of embankments with sideslopes as steep as 2H:1V is estimated to be about 1.4. However, there is a risk of surficial slope failures of embankments with sideslopes as steep as 2H:1V. As such, periodic maintenance of the surficial conditions along the embankment may be required. Furthermore, the performance of these slopes will be directly dependent on the subgrade preparation and quality of compaction achieved in the embankments. To minimize sloughing and erosion, it is important to provide adequate compaction and erosion and sloughing protection at the face of the embankment.

PAVEMENT CONSIDERATIONS

Based on or observations at the exploratory locations, the pavement subgrade is anticipated to consist of cohesive soils having medium plasticity. Based on the soils observed in the test borings and our experience with similar soils, we recommend that the information in Table 1 be considered for pavement design.

TABLE 1: PAVEMENT DESIGN PARAMETERS	
Resilient Modulus (M_r) for Improved Subgrade	7,000 psi
Resilient Modulus (M_r) for Natural Subgrade	3,000 psi
Design Soil Type	Lean/Silty Clay
Depth to Water	4 ft
Recommended Subgrade Treatment	Type IC

It should be noted that difficulty achieving compaction in implementing a Type IC subgrade treatment should be anticipated near the area of Boring P-1. As a result, additional subgrade stabilization in addition to the subgrade treatment may be necessary depending on the site conditions at the time of construction. We recommend including additional quantities for undercut and replacement with No. 5 and No. 53 stone in conjunction with a Type IB geogrid to address these areas.

CONCUDING REMARKS

We appreciate the opportunity to provide our services to you on this project. Feel free to contact our office if you have any questions or need further assistance with the project.

Sincerely,

EARTH EXPLORATION, INC.

Tanner Hill, E.I.
Staff Engineer

Gurkan Ozgurel, P.E.
Geotechnical Department Manager

Attachments –

Important Information About This Geotechnical Engineering Report
Test Boring Location Plan (Drawing No. CJ185109.B1)
Unified Soil Classification System/General Notes
Log of Test Boring (6)
Grain Size Distribution Curve (4)
Global Stability Model

Important Information about This

Geotechnical-Engineering Report

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

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

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

Geotechnical-Engineering Services Are Performed for Specific Purposes, Persons, and Projects

Geotechnical engineers structure their services to meet the specific needs of their clients. A geotechnical-engineering study conducted for a given civil engineer will not likely meet the needs of a civil-works constructor or even a different civil engineer. Because each geotechnical-engineering study is unique, each geotechnical-engineering report is unique, prepared *solely* for the client. *Those who rely on a geotechnical-engineering report prepared for a different client can be seriously misled*. No one except authorized client representatives should rely on this geotechnical-engineering report without first conferring with the geotechnical engineer who prepared it. *And no one – not even you – should apply this report for any purpose or project except the one originally contemplated.*

Read this Report in Full

Costly problems have occurred because those relying on a geotechnical-engineering report did not read it *in its entirety*. Do not rely on an executive summary. Do not read selected elements only. *Read this report in full.*

You Need to Inform Your Geotechnical Engineer about Change

Your geotechnical engineer considered unique, project-specific factors when designing the study behind this report and developing the confirmation-dependent recommendations the report conveys. A few typical factors include:

- the client's goals, objectives, budget, schedule, and risk-management preferences;
- the general nature of the structure involved, its size, configuration, and performance criteria;
- the structure's location and orientation on the site; and
- other planned or existing site improvements, such as retaining walls, access roads, parking lots, and underground utilities.

Typical changes that could erode the reliability of this report include those that affect:

- the site's size or shape;
- the function of the proposed structure, as when it's changed from a parking garage to an office building, or from a light-industrial plant to a refrigerated warehouse;
- the elevation, configuration, location, orientation, or weight of the proposed structure;
- the composition of the design team; or
- project ownership.

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

This Report May Not Be Reliable

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

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

Note, too, that it could be unwise to rely on a geotechnical-engineering report whose reliability may have been affected by the passage of time, because of factors like changed subsurface conditions; new or modified codes, standards, or regulations; or new techniques or tools. *If your geotechnical engineer has not indicated an "apply-by" date on the report, ask what it should be*, and, in general, *if you are the least bit uncertain* about the continued reliability of this report, contact your geotechnical engineer before applying it. A minor amount of additional testing or analysis – if any is required at all – could prevent major problems.

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

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

This Report's Recommendations Are Confirmation-Dependent

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

This Report Could Be Misinterpreted

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

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

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

Give Constructors a Complete Report and Guidance

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

Read Responsibility Provisions Closely

Some client representatives, design professionals, and constructors do not realize that geotechnical engineering is far less exact than other engineering disciplines. That lack of understanding has nurtured unrealistic expectations that have resulted in disappointments, delays, cost overruns, claims, and disputes. To confront that risk, geotechnical engineers commonly include explanatory provisions in their reports. Sometimes labeled "limitations," many of these provisions indicate where geotechnical engineers' responsibilities begin and end, to help others recognize their own responsibilities and risks. *Read these provisions closely*. Ask questions. Your geotechnical engineer should respond fully and frankly.

Geoenvironmental Concerns Are Not Covered

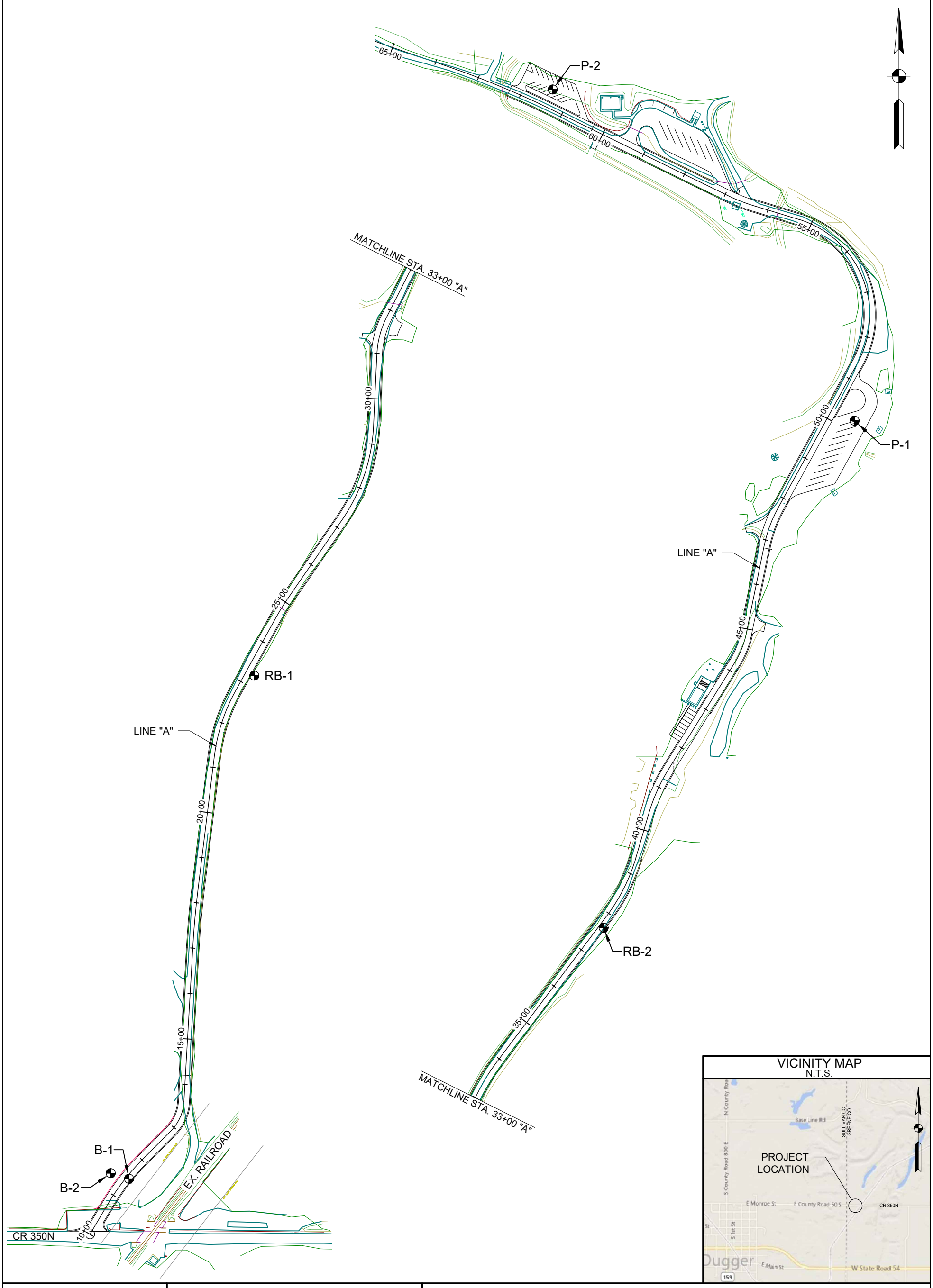
The personnel, equipment, and techniques used to perform an environmental study – e.g., a "phase-one" or "phase-two" environmental site assessment – differ significantly from those used to perform a geotechnical-engineering study. For that reason, a geotechnical-engineering report does not usually relate any environmental findings, conclusions, or recommendations; e.g., about the likelihood of encountering underground storage tanks or regulated contaminants. *Unanticipated subsurface environmental problems have led to project failures*. If you have not yet obtained your own environmental information, ask your geotechnical consultant for risk-management guidance. As a general rule, *do not rely on an environmental report prepared for a different client, site, or project, or that is more than six months old.*

Obtain Professional Assistance to Deal with Moisture Infiltration and Mold

While your geotechnical engineer may have addressed groundwater, water infiltration, or similar issues in this report, none of the engineer's services were designed, conducted, or intended to prevent uncontrolled migration of moisture – including water vapor – from the soil through building slabs and walls and into the building interior, where it can cause mold growth and material-performance deficiencies. Accordingly, ***proper implementation of the geotechnical engineer's recommendations will not of itself be sufficient to prevent moisture infiltration.*** Confront the risk of moisture infiltration by including building-envelope or mold specialists on the design team. ***Geotechnical engineers are not building-envelope or mold specialists.***

GEOPROFESSIONAL BUSINESS ASSOCIATION

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



VICINITY MAP
N.T.S.

LEGEND

B-1 ⊕ Test Boring Location and Designation

NOTES

1. Base map developed from an electronic file provided by HWC Engineering on November 8, 2018.
2. Vicinity map generated using imagery from bing.com/maps.
3. Borings were located in the field by Earth Exploration, Inc.
4. Ground surface elevation at the test boring locations were interpolated to the nearest 1 ft based on topographic information provided on the previously mentioned plan.
5. Boring locations are approximate.

TEST BORING LOCATION PLAN

PROJECT:	Redbird SRA Access Road Improvements
LOCATION:	Greene County, Indiana
CLIENT:	HWC Engineering
EEI PROJ. NO.:	CJ185109
SCALE:	1" = 200'

PROJECT ENG:	TJH
APPROVED BY:	GO
DRAWN BY:	JBF
DATE:	11/19/18
DRAWING NO.:	CJ185109.B1

EARTH EXPLORATION, INC. A Terracon company

EARTH EXPLORATION, LLC

UNIFIED SOIL CLASSIFICATION SYSTEM / GENERAL NOTES

FINE-GRAINED SOILS

CONSISTENCY	UNCONFINED STRENGTH (tsf)
Very Soft	<0.25
Soft	0.25 - 0.5
Medium	0.5 - 1.0
Stiff	1.0 - 2.0
Very Stiff	2.0 - 4.0
Hard	>4.0

COARSE-GRAINED SOILS

RELATIVE DENSITY	N-VALUE* (Blows/ft)
Very Loose	0 - 4
Loose	4 - 10
Medium Dense	10 - 30
Dense	30 - 50
Very Dense	50+

RELATIVE PROPORTIONS

TERM	DEFINING RANGE BY % OF WEIGHT
Trace	0 - 5
Little	5 - 12
Some	12 - 35
And	35 - 50

ORGANIC CONTENT BY COMBUSTION METHOD

SOIL DESCRIPTION	LOI
Trace Organic Matter	0 - 5%
Little Organic Matter	5 - 12%
Organic Silt/Clay	12 - 35%
Sedimentary Peat	35 - 50%
Fibrous and Woody Peat	50%±

UNIFIED SOIL CLASSIFICATION AND SYMBOL CHART

MAJOR DIVISIONS			SYMBOLS	DESCRIPTIONS
COARSE-GRAINED SOILS	GRAVEL AND GRAVELLY SOILS	CLEAN GRAVELS	GW	WELL GRADED GRAVELS, GRAVEL-SAND MIXTURES, LITTLE OR NO FINES
	More than 50% of coarse fraction retained on No. 4 sieve	Little or no fines	GP	POORLY GRADED GRAVELS, GRAVEL-SAND MIXTURES, LITTLE OR NO FINES
		GRAVELS WITH FINES	GM	SILTY GRAVELS, GRAVEL-SAND-SILT MIXTURES
		Appreciable amount of fines	GC	CLAYEY GRAVELS, GRAVEL-SAND-CLAY MIXTURES
More than 50% of material coarser than No. 200 sieve	SAND AND SANDY SOILS	CLEAN SANDS	SW	WELL GRADED SANDS, GRAVELLY SANDS, LITTLE OR NO FINES
		Little or no fines	SP	POORLY GRADED SANDS, GRAVELLY SANDS, LITTLE OR NO FINES
	More than 50% of coarse fraction passing No. 4 sieve	SANDS WITH FINES	SM	SILTY SANDS, SAND-SILT MIXTURES
		Appreciable amount of fines	SC	CLAYEY SANDS, SAND-CLAY MIXTURES
FINE-GRAINED SOILS	SILTS AND CLAYS	LIQUID LIMIT LESS THAN 50	ML	INORGANIC SILTS AND VERY FINE SANDS, ROCK FLOUR, SILTY OR CLAYEY FINE SAND OR CLAYEY SILTS WITH SLIGHT PLASTICITY
			CL	INORGANIC CLAYS OF LOW TO MEDIUM PLASTICITY, GRAVELLY CLAYS SANDY CLAYS, SILTY CLAYS, LEAN CLAYS
			OL	ORGANIC SILTS AND ORGANIC SILTY CLAYS OF LOW PLASTICITY
More than 50% of material finer than No. 200 sieve	SILTS AND CLAYS	LIQUID LIMIT GREATER THAN 50	MH	INORGANIC SILTS, MICACEOUS OR DIATOMACEOUS FINE SANDY OR SILTY SOILS, ELASTIC SILT
			CH	INORGANIC CLAYS OF HIGH PLASTICITY, FAT CLAYS
			OH	ORGANIC CLAYS OF MEDIUM TO HIGH PLASTICITY, ORGANIC SILTS
HIGHLY ORGANIC SOILS			PT	PEAT, HUMUS, SWAMP SOILS WITH HIGH ORGANIC CONTENT

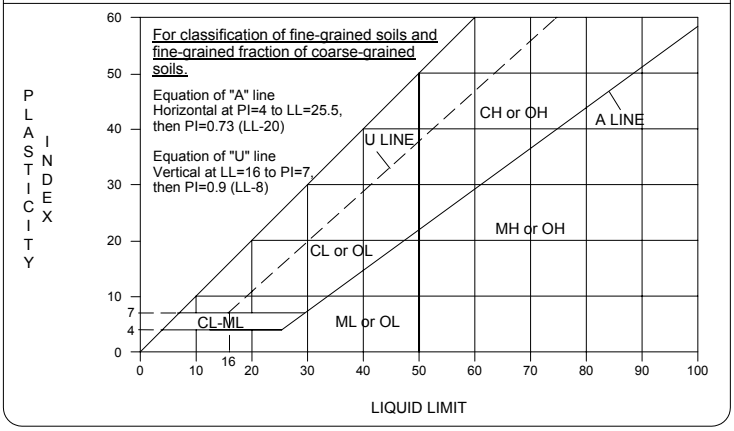
NOTE: DUAL SYMBOLS USED FOR BORDERLINE CLASSIFICATIONS

GRAIN SIZE TERMINOLOGY

SOIL FRACTION		PARTICLE SIZE	US STANDARD SIEVE SIZE
Boulders		Larger than 12-in.	Larger than 12-in.
Cobbles		3 to 12-in.	3 to 12-in.
Gravel	Coarse	3/4 to 3-in.	3/4 to 3-in.
	Fine	4.75 mm to 3/4-in.	#4 to 3/4-in.
Sand	Coarse	2.00 to 4.75 mm	#10 to #4
	Med	0.425 to 2.00 mm	#40 to #10
	Fine	0.075 to 0.425 mm	#200 to #40
Silt		0.005 to 0.075 mm	Smaller than #200
Clay		Smaller than 0.005 mm	Smaller than #200

Plasticity characteristics differentiate between silt and clay.

PLASTICITY CHART



EXPLORATORY SAMPLING ABBREVIATIONS

AS	- Auger Sample	PID	- Photo-Ionization Detector
BF	- Backfilled Upon Completion	PMT	- Borehole Pressuremeter Test
BS	- Bag Sample	PT	- 3-in. O.D. Piston Sample
C	- Casing: Size 2½-in., NW; 4-in., HW	PTS	- Peat Sample
COA	- Clean-Out Auger	RB	- Rock Bit
CS	- Continuous Sampler	RC	- Rock Core
CW	- Clear Water	REC	- Recovery
DC	- Driven Casing	RQD	- Rock Quality Designation
DM	- Drilling Mud	RS	- Rock Sounding
FA	- Flight Auger	S	- Soil Sounding
FT	- Fish Tail	SS	- 2-in. O.D. Split-Spoon Sample
HA	- Hand Auger	ST	- Thin-Walled Tube Sample
HSA	- Hollow Stem Auger	VS	- Vane Shear Test
NW	- No Water Encountered	WPT	- Water Pressure Test

LABORATORY TEST ABBREVIATIONS

qp	- Hand Penetrometer Reading, tsf
qu	- Unconfined Compressive Strength, tsf
W	- Moisture Content, %
LL	- Liquid Limit, %
PL	- Plastic Limit, %
PI	- Plasticity Index, %
SL	- Shrinkage Limit, %
LOI	- Loss on Ignition, %
γ_d	- Dry Unit Weight, pcf
pH	- Hydrogen-Ion Concentration
P_{200}	- Percent Passing a No. 200 Sieve

*The penetration resistance, N, is the summation of the number of blows required to effect two successive 6" penetrations of the 2" O.D. split-spoon sampler. The sampler is driven with a 140 lb weight falling 30" and is seated to a depth of 6" before commencing the standard penetration test.

EARTH EXPLORATION, Inc.

LOG OF TEST BORING

Project: **Redbird SRA Access Road Improvements**
Location: **Greene Co., IN**
Client: **HWC Engineering**

7770 West New York Street - Indianapolis, Indiana 46214
317-273-1690 / 317-273-2250 (Fax)

Boring No. **B-1**
Elevation **596**
Datum **NAVD 88**
EEI Proj. No. **CJ185109**
Sheet **1** of **1**

Project No.	2017-276-S	Station	11+50	Weather	Clear	Driller	B.N.
Struct. No.	---	Offset	7 ft Rt. "A"	Temp.	70° F	Inspector	---

SAMPLE No.	Type	Rec %	N Value	Depth ft	Elev	DESCRIPTION/CLASSIFICATION and REMARKS	q_p tsf	q_u tsf	γ_d pcf	W %	LL %	PL %	PI %
						CRUSHED STONE							
SS-1	X	90	14		595	**SM**, **SILTY SAND**, little gravel, medium dense, brown, with cobbles	---			---			
SS-2	X	90	12	5			---			---			
SS-3	X	90	14		590	**CL**, **LEAN CLAY with SAND**, trace gravel, stiff to very stiff, gray, with cobbles, SS-4 : P_{200} = 82 percent	1½			11.8			
SS-4	X	90	13	10			2½			12.4	32	20	12
SS-5	X	90	14		585	**WEATHERED SANDSTONE**, soft, gray	---			---			
SS-6	X	90	11	15			---			---			
SS-7	X	90	14		580		---			---			
SS-8	X	90	10	20			---			---			
					575	**WEATHERED SHALE**, soft, gray							
SS-9	X	90	10	25			---			---			
					570								
SS-10	X	90	16	30			---			---			
						End of Boring at 30 ft							

WATER LEVEL OBSERVATIONS

Depth ft	While Drilling	Upon Completion	After Drilling
To Water	NW	NW	BF
To Cave-in		21½	

The stratification lines represent the approximate boundary between soil/rock types and the transition may be gradual.

GENERAL NOTES

Start **11/1/18** End **11/1/18** Rig **CME 750**
Drilling Method **3¼" I.D. HSA** **ATV**
Remarks: **Backfilled with auger cuttings and a bentonite chip plug near the surface.**

EARTH EXPLORATION, Inc.

LOG OF TEST BORING

Project: **Redbird SRA Access Road Improvements**
Location: **Greene Co., IN**
Client: **HWC Engineering**

7770 West New York Street - Indianapolis, Indiana 46214
317-273-1690 / 317-273-2250 (Fax)

Boring No. **B-2**
Elevation **589**
Datum **NAVD 88**
EEI Proj. No. **CJ185109**
Sheet **1** of **1**

Project No.	2017-276-S	Station	11+35	Weather	Clear	Driller	B.N.
Struct. No.	---	Offset	33 ft Lt. "A"	Temp.	70° F	Inspector	---

SAMPLE No.	Type	Rec %	N Value	Depth ft	Elev	DESCRIPTION/CLASSIFICATION and REMARKS	q_p tsf	q_u tsf	γ_d pcf	W %	LL %	PL %	PI %
				0		**TOPSOIL**							
SS-1	X	90	7			**CL**, **SANDY CLAY**, some gravel, medium stiff to very stiff, brown, SS-2 : P_{200} = 60 percent	2½			13.5			
SS-2	X	90	8	5	585		½			15.7	34	23	11
SS-3	X	90	9				---			---			
SS-4	X	90	8	10	580		---			---			
SS-5	X	90	25			**WEATHERED SHALE**, soft, gray, with sandstone cobbles near 6 ft	---			---			
SS-6	X	90	21	15	575		---			---			
SS-7	X	90	100				---			---			
SS-8	X	95	50/.3		570		---			---			
						End of Boring at 19.3 ft							

WATER LEVEL OBSERVATIONS

Depth ft	▽ While Drilling	▼ Upon Completion	▼ After Drilling
To Water	NW	NW	BF
To Cave-in		14½	

The stratification lines represent the approximate boundary between soil/rock types and the transition may be gradual.

GENERAL NOTES

Start **11/2/18** End **11/2/18** Rig **CME 750**
Drilling Method **3¼" I.D. HSA** **ATV**
Remarks: **Backfilled with auger cuttings and a bentonite chip plug near the surface.**

Addendum No. 1 12-7-18

EARTH EXPLORATION, LLC

LOG OF TEST BORING

Project **Redbird SRA Access Road Improvements**
Location **Greene Co., IN**
Client **HWC Engineering**

7770 West New York Street - Indianapolis, Indiana 46214
317-273-1690 / 317-273-2250 (Fax)

Boring No. **P-1**
Elevation **578**
Datum **NAVD 88**
EEI Proj. No. **CJ185109**
Sheet **1** of **1**

Project No.	**2017-276-S**	Station	**50+24**	Weather	**Clear**	Driller	**B.N.**
Struct. No.	**---**	Offset	**55 ft Rt. "A"**	Temp.	**70° F**	Inspector	**---**

SAMPLE No.	Type	Rec %	N Value	Depth ft	Elev	DESCRIPTION/CLASSIFICATION and REMARKS	q_p tsf	q_u tsf	γ_d pcf	W %	LL %	PL %	PI %
						TOPSOIL							
SS-1		90	8			**CL**, **SANDY CLAY**, trace gravel, stiff, brown, SS-1 : pH = 5.3, P_{200} = 61 percent, soluble sulfate = 560 ppm	1½			25.0	32	23	9
					575								
SS-2		90	7				½			35.3			
				5		**CL**, **LEAN CLAY**, little sand, trace gravel, very soft to medium stiff, brown							
SS-3		90	1				<¼			32.7			
					570								
SS-4		90	12			**COAL**, soft, black	---			---			
				10									

End of Boring at 10 ft

Shelby tube pushed at offset location from 5 to 7 ft., W= 27.8, LL = 43, PL = 26. PI = 17, dry unit weight = 87.6 pcf, P_{200} = 90 percent, Q_p = <¼, CL, Lean clay

WATER LEVEL OBSERVATIONS

Depth ft	▽ While Drilling	▼ Upon Completion	⊻ After Drilling
To Water	**NW**	**7**	**BF**
To Cave-in		**7**	

The stratification lines represent the approximate boundary between soil/rock types and the transition may be gradual.

GENERAL NOTES

Start **11/2/18** End **11/2/18** Rig **CME 750**
Drilling Method **3¼" I.D. HSA** **ATV**
Remarks **Backfilled with auger cuttings and a bentonite chip plug near the surface.**

Addendum No. 1 12-7-18

EARTH EXPLORATION, Inc.

LOG OF TEST BORING

Project **Redbird SRA Access Road Improvements**
Location **Greene Co., IN**
Client **HWC Engineering**

7770 West New York Street - Indianapolis, Indiana 46214
317-273-1690 / 317-273-2250 (Fax)

Boring No. **P-2**
Elevation **570**
Datum **NAVD 88**
EEI Proj. No. **CJ185109**
Sheet **1** of **1**

Project No.	2017-276-S	Station	61+42	Weather	Clear	Driller	B.N.
Struct. No.	---	Offset	41 ft Rt. "A"	Temp.	70° F	Inspector	---

SAMPLE No.	Type	Rec %	N Value	Depth ft	Elev	DESCRIPTION/CLASSIFICATION and REMARKS	q_p tsf	q_u tsf	γ_d pcf	W %	LL %	PL %	PI %
						TOPSOIL							
SS-1	X	90	10				2½			19.3			
SS-2	X	90	8			**CL**, **LEAN CLAY**, little sand, little gravel, stiff to very stiff, brown, with coal near 1 ft, SS-1 : pH = 3.6, soluble sulfate = 5,570 ppm	3¾			20.3			
				5	565								
SS-3	X	90	6				1¼			24.7			
SS-4	X	90	6				2			18.1			
				10	560								
						End of Boring at 10 ft							

WATER LEVEL OBSERVATIONS

Depth ft	▽ While Drilling	▼ Upon Completion	▼ 6 hr After Drilling
To Water	NW	NW	NW
To Cave-in		7	6½

The stratification lines represent the approximate boundary between soil/rock types and the transition may be gradual.

GENERAL NOTES

Start **11/2/18** End **11/2/18** Rig **CME 750**
Drilling Method **3¼" I.D. HSA** **ATV**
Remarks **Backfilled with auger cuttings and a bentonite chip plug near the surface.**

LOG OF TEST BORING

Project **Redbird SRA Access Road Improvements**
Location **Greene Co., IN**
Client **HWC Engineering**

7770 West New York Street - Indianapolis, Indiana 46214
317-273-1690 / 317-273-2250 (Fax)

Boring No. **RB-1**
Elevation **569**
Datum **NAVD 88**
EEI Proj. No. **CJ185109**
Sheet **1** of **1**

Project No.	2017-276-S	Station	23+26	Weather	Clear	Driller	B.N.
Struct. No.	---	Offset	20 ft Rt. "A"	Temp.	70° F	Inspector	---

SAMPLE No.	Type	Rec %	N Value	Depth ft	Elev	DESCRIPTION/CLASSIFICATION and REMARKS	q_p tsf	q_u tsf	γ_d pcf	W %	LL %	PL %	PI %
						TOPSOIL							
SS-1	X	90	24			**CL-ML**, **SILTY CLAY**, some sand, little gravel, stiff to hard, brown, SS-1 : pH = 5.0, soluble sulfate = 4,160 ppm	4¼			11.9			
SS-2	X	90	14		565		1¼			11.8			
				5		End of Boring at 5 ft							

WATER LEVEL OBSERVATIONS

Depth ft	▽ While Drilling	▼ Upon Completion	⧩ After Drilling
To Water	NW	NW	BF
To Cave-in		2½	

The stratification lines represent the approximate boundary between soil/rock types and the transition may be gradual.

GENERAL NOTES

Start **11/2/18** End **11/2/18** Rig **CME 750**
Drilling Method **3¼" I.D. HSA** **ATV**
Remarks **Backfilled with auger cuttings and a bentonite chip plug near the surface.**

EARTH EXPLORATION, Inc.

LOG OF TEST BORING

Project: **Redbird SRA Access Road Improvements**
Location: **Greene Co., IN**
Client: **HWC Engineering**

7770 West New York Street - Indianapolis, Indiana 46214
317-273-1690 / 317-273-2250 (Fax)

Boring No. **RB-2**
Elevation **569**
Datum **NAVD 88**
EEI Proj. No. **CJ185109**
Sheet **1** of **1**

Project No.	**2017-276-S**	Station	**37+68**	Weather	**Clear**	Driller	**B.N.**
Struct. No.	**---**	Offset	**10 ft Rt. "A"**	Temp.	**70° F**	Inspector	**---**

SAMPLE No.	Type	Rec %	N Value	Depth ft	Elev	DESCRIPTION/CLASSIFICATION and REMARKS	q_p tsf	q_u tsf	γ_d pcf	W %	LL %	PL %	PI %
				0		**TOPSOIL**							
SS-1	X	90	21			**CL-ML**, **SILTY CLAY**, some sand, little gravel, very stiff, gray, SS-1 : pH = 3.9, soluble sulfate = 2,490 ppm	3			8.4			
SS-2	X	90	30		565		2¾			12.6			
				5		End of Boring at 5 ft							

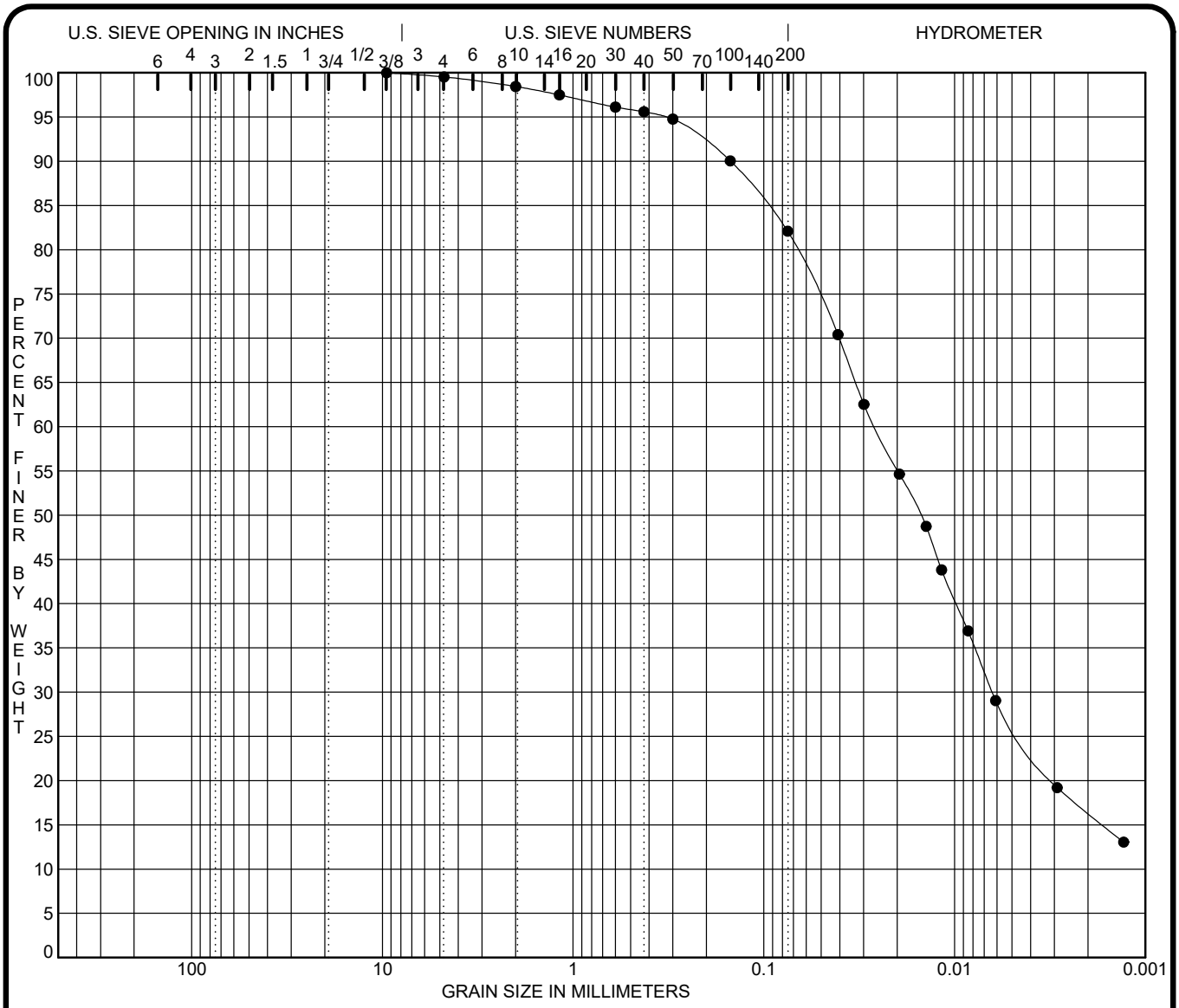
WATER LEVEL OBSERVATIONS

Depth ft	While Drilling	Upon Completion	After Drilling
To Water	4	1	BF
To Cave-in		3	

The stratification lines represent the approximate boundary between soil/rock types and the transition may be gradual.

GENERAL NOTES

Start **11/2/18** End **11/2/18** Rig **CME 750**
Drilling Method **3¼" I.D. HSA** **ATV**
Remarks: **Backfilled with auger cuttings and a bentonite chip plug near the surface.**



COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

Sample Identification	USCS Classification	MC%	LL	PL	PI	Cc	Cu
● B-1 SS-4	CL, LEAN CLAY with SAND	12.4	32	20	12		

% Gravel (>4.75mm)	% Sand (4.75 to .075mm)	% Silt (.075 to .005 mm)	% Clay (<.005mm)
0.5	17.4	55.7	26.4

Grain Size (mm)	% Passing	Grain Size (mm)	% Passing	Grain Size (mm)	% Passing
64.0		**0.5**	95.8	**0.016**	51.0
16.0		**0.25**	93.5	**0.008**	35.5
4.0	99.3	**0.125**	88.0	**0.005**	26.4
2.0	98.4	**0.075**	82.1	**0.002**	16.3
1.0	97.2	**0.050**	74.3		

EARTH EXPLORATION, Inc.

PROJECT Redbird SRA Access Road Improvements
LOCATION Greene Co., IN
CLIENT HWC Engineering **CLIENT ID NO.** 2017-276-S
EEI PROJECT NO. CJ185109 **DATE** 11/16/18

GRAIN SIZE DISTRIBUTION CURVE

Earth Exploration, Inc.
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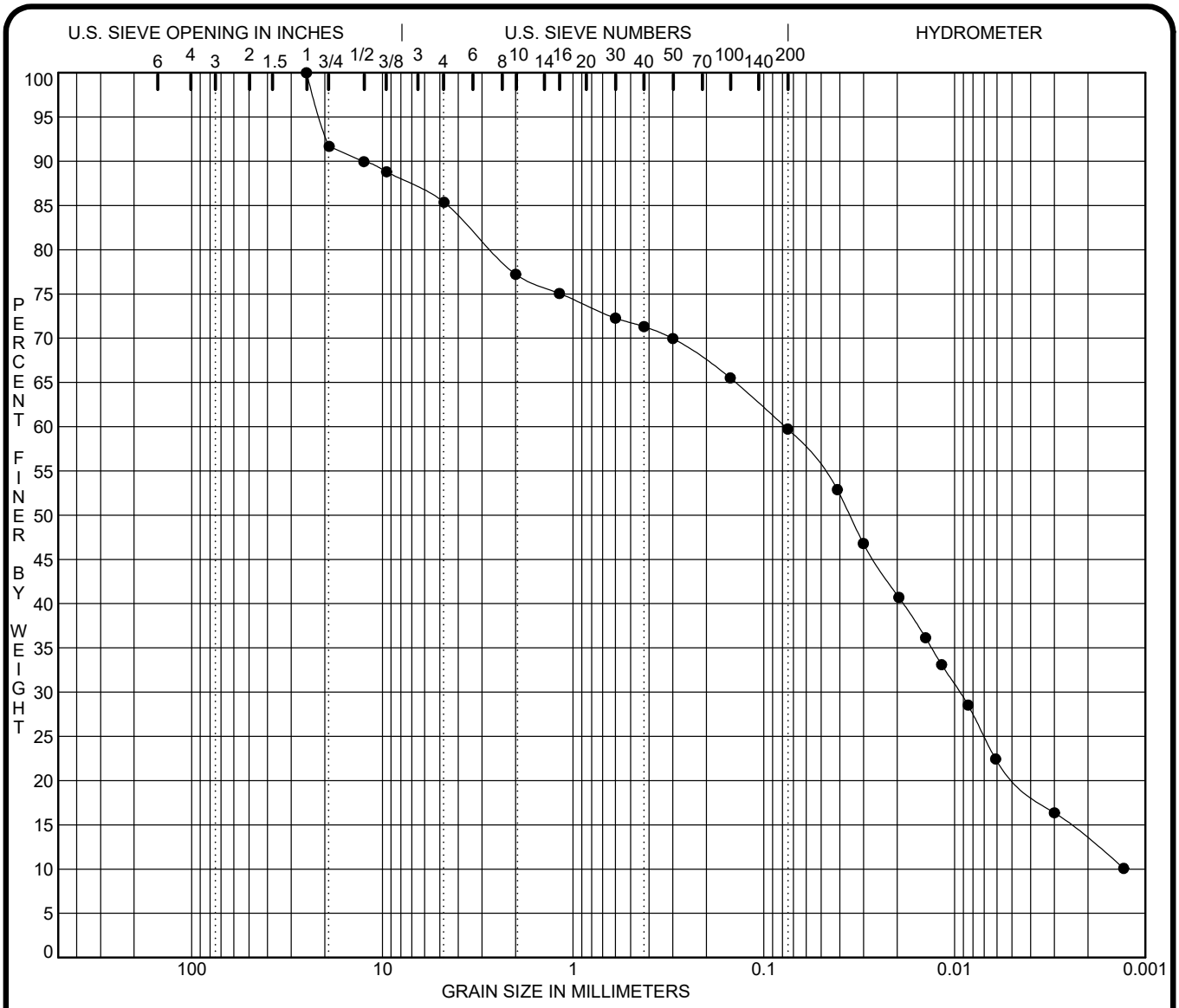
317-273-1690 / 317-273-2250 (Fax)



COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

Sample Identification	USCS Classification	MC%	LL	PL	PI	Cc	Cu
● B-2 SS-2	CL, SANDY CLAY	15.7	34	23	11		

% Gravel (>4.75mm)	% Sand (4.75 to .075mm)	% Silt (.075 to .005 mm)	% Clay (<.005mm)
14.6	25.6	39.0	20.7

Grain Size (mm)	% Passing	Grain Size (mm)	% Passing	Grain Size (mm)	% Passing
64.0		**0.5**	71.8	**0.016**	37.8
16.0	91.0	**0.25**	68.8	**0.008**	27.4
4.0	83.7	**0.125**	64.0	**0.005**	20.7
2.0	77.2	**0.075**	59.7	**0.002**	13.3
1.0	74.4	**0.050**	55.1		

EARTH EXPLORATION, Inc.

PROJECT Redbird SRA Access Road Improvements
LOCATION Greene Co., IN
CLIENT HWC Engineering **CLIENT ID NO.** 2017-276-S
EEI PROJECT NO. CJ185109 **DATE** 11/16/18

GRAIN SIZE DISTRIBUTION CURVE

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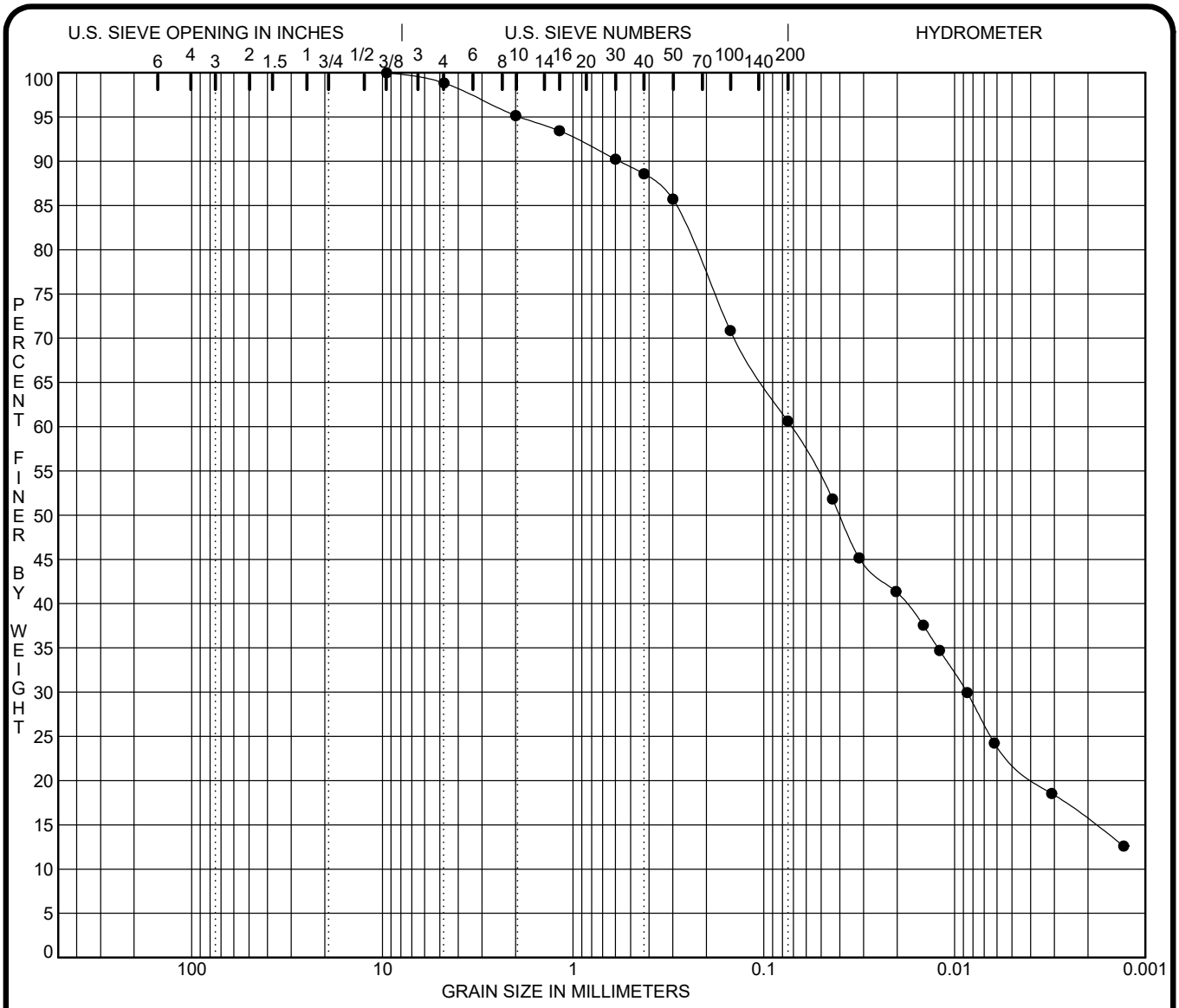

COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

Sample Identification	USCS Classification	MC%	LL	PL	PI	Cc	Cu
● P-1 SS-1	CL, SANDY CLAY	25.0	32	23	9		

% Gravel (>4.75mm)	% Sand (4.75 to .075mm)	% Silt (.075 to .005 mm)	% Clay (<.005mm)
1.2	38.2	38.2	22.5

Grain Size (mm)	% Passing	Grain Size (mm)	% Passing	Grain Size (mm)	% Passing
64.0		**0.5**	89.4	**0.016**	38.6
16.0		**0.25**	81.8	**0.008**	28.7
4.0	98.1	**0.125**	68.2	**0.005**	22.5
2.0	95.2	**0.075**	60.6	**0.002**	15.5
1.0	92.7	**0.050**	54.0		

EARTH EXPLORATION, Inc.

PROJECT Redbird SRA Access Road Improvements
LOCATION Greene Co., IN
CLIENT HWC Engineering **CLIENT ID NO.** 2017-276-S
EEI PROJECT NO. CJ185109 **DATE** 11/16/18

GRAIN SIZE DISTRIBUTION CURVE

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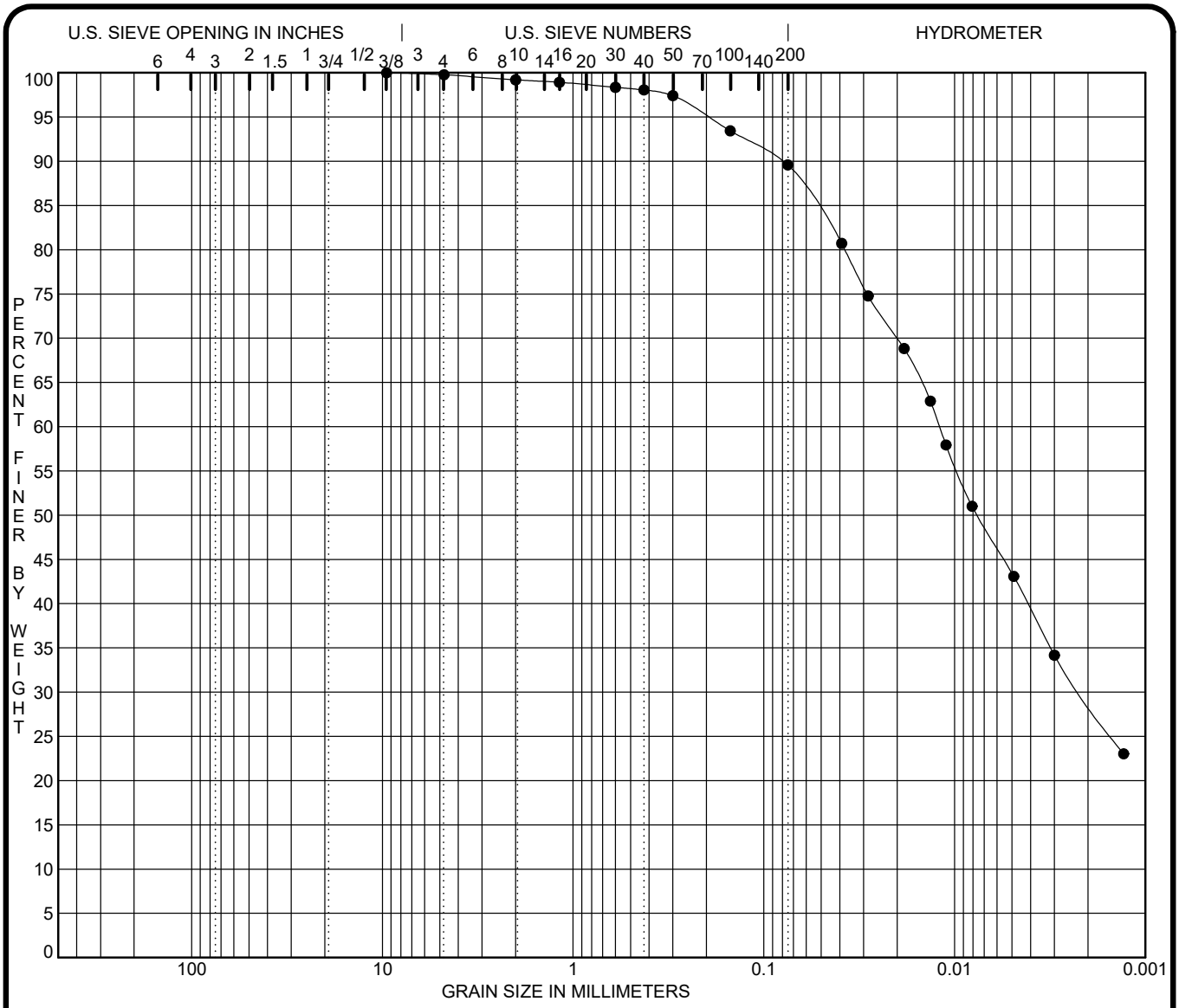


COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

Sample Identification		USCS Classification	MC%	LL	PL	PI	Cc	Cu
● P-1A	ST-1	CL, LEAN CLAY	27.8	43	26	17		

% Gravel (>4.75mm)	% Sand (4.75 to .075mm)	% Silt (.075 to .005 mm)	% Clay (<.005mm)
0.2	10.2	46.2	43.4

Grain Size (mm)	% Passing	Grain Size (mm)	% Passing	Grain Size (mm)	% Passing
64.0		**0.5**	98.2	**0.016**	66.2
16.0		**0.25**	96.4	**0.008**	50.8
4.0	99.7	**0.125**	92.4	**0.005**	43.4
2.0	99.2	**0.075**	89.6	**0.002**	28.8
1.0	98.8	**0.050**	84.1		

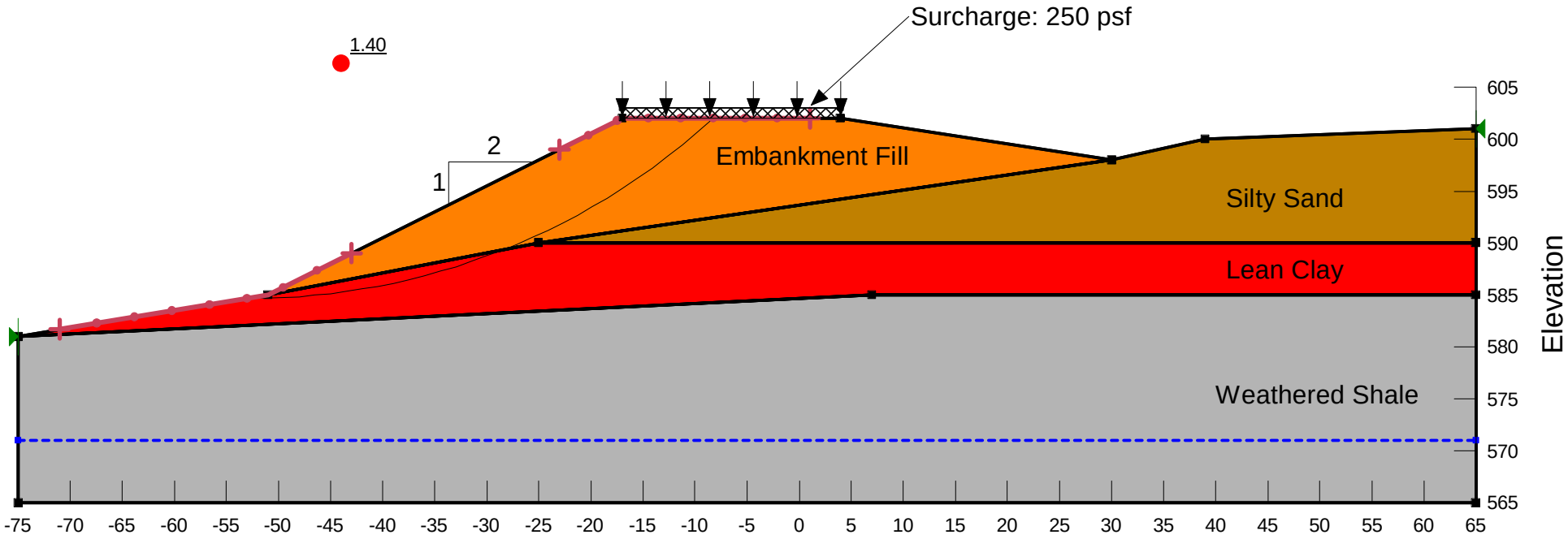
EARTH EXPLORATION, Inc.

PROJECT Redbird SRA Access Road Improvements
LOCATION Greene Co., IN
CLIENT HWC Engineering **CLIENT ID NO.** 2017-276-S
EEI PROJECT NO. CJ185109 **DATE** 11/16/18

GRAIN SIZE DISTRIBUTION CURVE

Earth Exploration, Inc.
7770 West New York Street, Indianapolis, IN 46214
317-273-1690 / 317-273-2250 (Fax)

Station 11+50



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Name: Silty Sand Unit Weight: 120 pcf Cohesion': 0 psf Phi': 32 °
Name: Lean Clay Unit Weight: 120 pcf Cohesion': 0 psf Phi': 31 °
Name: Weathered Shale Unit Weight: 135 pcf Cohesion': 0 psf Phi': 26 °