February 14, 2023

Mr. S. Bradford Rives
Long Run Creek Properties, LLC
3911 Wilderness Trail
Louisville, Kentucky 40299

c/o Mr. David Mindel
Mindel Scott
5151 Jefferson Boulevard
Louisville, Kentucky 40219

Reference: **Slope Evaluation and Karst Survey – 2405 Echo Trail – Revision I**
2405 Echo Trail
Louisville, Jefferson County, Kentucky 40245
ECS Project No. 61-2863RI

Dear Mr. Rives:

ECS Southeast, LLP (ECS) conducted a combined evaluation, consisting of a limited subsurface exploration and site reconnaissance, for the referenced site in accordance with ECS Proposal No. 61-P2890, dated October 10, 2022. This evaluation included the following elements: a review of provided drawings; a review of soil survey information; a review of geologic maps; a review of topographic maps; a review of current and historical aerial photographs; a visual reconnaissance of site conditions for the karst geologic features defined in the Metro Louisville Land Development Code (LDC); a visual reconnaissance of indicated steeper slope areas that would be disturbed by new construction; a limited subsurface evaluation to explore the materials along slopes greater than 30% that will be disturbed during construction; and evaluate the reviewed information and prepare a report of our findings and recommendation.

**Purpose**

The purpose of the subsurface evaluation was to explore the materials along slopes greater than 30% that will be disturbed during construction, the depth to bedrock and the shear strength of the soils in these areas are required to be analyzed by a geotechnical engineer per the county development code (Section 4.7.4 of the LDC). A visual reconnaissance of the site was completed concurrently with the subsurface evaluation to identify potential karst geologic features and document the condition of steeper slope areas not evaluated during the subsurface evaluation, per the LDC (Section 4.9.3).

The drawing "22-ZONEPA-0110 – 22-09-12 (FILED)" provided by Allison Hicks of Mindel Scott via email, dated September 12, 2022, was used as a reference during the subsurface evaluation and site reconnaissance and for creation of the attached maps and diagrams. A reduced copy of this drawing is attached to this report. Slopes identified as greater than 30%, and slopes between 20% and 30%, were reported on this drawing, as well as the location of planned construction.

**Project Information**

The proposed development on-site includes 103 single-family residential lots and associated roadways. The site undulates across the proposed development footprint with approximately 75 feet of fall across the entire site, with up to approximately 20 feet of fall across a single proposed residential development lot. The site includes approximately 36.67 acres of rolling hills which are mostly wooded, with isolated open areas. Two existing streams are located in the northeastern portion of the site. A third stream was observed in the southern portion of the site in the proposed open space located in Lot 106, which extended towards the southern property boundary of the site.

The existing topography generally sloped down from north to south, with areas of steeper slopes generally occurring within the eastern portions of the site and sloped towards the existing streams.

**Geology**

The following geologic information is based on the review of: the Fisherville, 24K Quadrangle, Geologic Map, Kentucky, published by the United States Geological Survey (USGS); information (aerial photos, geologic maps, and topographic maps, etc.) obtained from the Kentucky Geological Survey (KGS) Geologic Information Service website; and Google Earth satellite imaging.

The Kentucky Geologic Map Information Service website indicated that the majority of the proposed development area (roughly above ~EL 605 to ~EL 620) was underlain by the Drakes Formation. Lower elevation areas roughly between ~EL 600 to ~EL 620 were underlain by Grant Lake Limestone. The southeastern-most portion of the proposed development area between elevations of roughly ~EL 605 to ~EL 610 were underlain by Alluvium.

| | | |
|---|---|---|
| Above | ~EL 605 – 620 | Drakes Formation |
| | ~EL 600 – 620 | Grant Lake Limestone |
| Below | ~EL 605 – 610 | Alluvium |

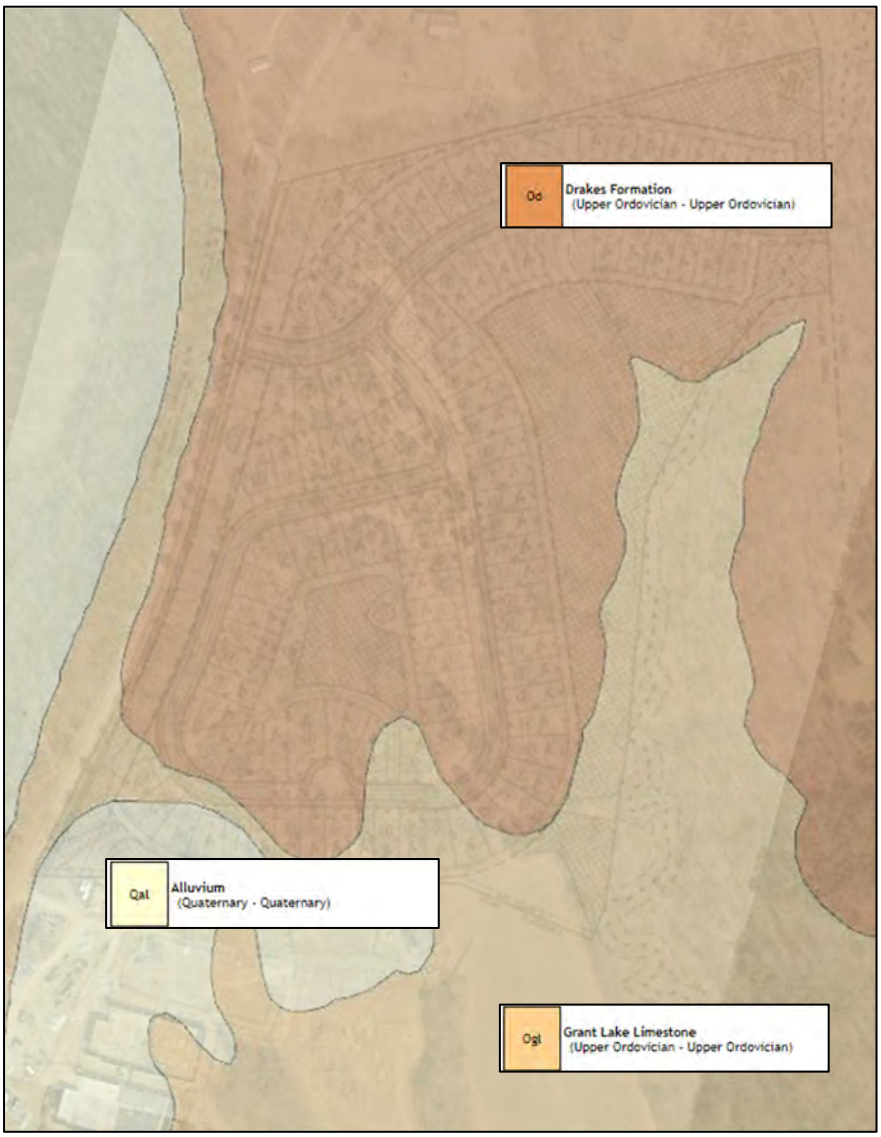



**Figure 1: Reported Site Geology**

**Drakes Formation**
Total Reported Thickness: ± 140 feet
Karst Potential: Low
Primary Lithology: Dolomite and Limestone
Members: Hitz Limestone Bed; Saluda Dolomite Member; Bardstown Member; and Rowland Member.

*Hitz Limestone Bed:* Primarily limestone, dolomite, and shale. Limestone and dolomite are dark gray to olive gray, weathers light gray to grayish orange, locally with a reddish brown cast; very fine to medium grained, silty; laminated in part; hackly to blocky fracture; inter-bedded and inter-tongued. Shale is grayish black to dusky brown, carbonaceous, calcareous, and strongly fissile, commonly appears in two beds, one about 0.5 feet thick near base and one 0.2 foot thick near the top.

*Saluda Dolomite Member:* Primarily dolomite, dolomitic mudstone, shale, and limestone. Dolomite is greenish gray, light to medium gray, grayish yellowish green, and light olive gray in distinct color bands, weathers same to yellowish gray and grayish orange. Dolomite in the upper three fourths of the unit is laminated. Weathers blocky in steep ravines, shaly to flaggy on weathered slopes. Lower one-fourth of the unit is dolomitic mudstone and lacks prominent lamination, weathers shaly or to blocky prisms. Limestone is bluish gray, weathers olive gray to brownish gray; dense, micritic; conchoidal fracture; commonly as one or two beds 0.1 to 0.6 feet thick in lower part of laminated dolomite sequence. Shale is light gray to olive black, locally carbonaceous; as persistent parting 0.1 to about 1 foot thick in lower part of laminated dolomite.

*Bardstown Member:* Primarily limestone, mudstone, and shale. Limestone is of three main types: Most common limestone is medium to dark gray, weathers yellowish brown, micritic to fine grained in very thin beds, laminated and continuous with fossils common. Second type is medium light gray to olive gray, weathers light gray to dark yellowish orange, micritic to coarse grained in very thin and/or discontinuous beds, with abundant whole fossils. Third type is muddy limestone, blueish to olive gray, weathers greenish gray to yellowish green, and resembles limestone of underlying Rowland Member (see below). Mudstone and shale appear as inter-beds in limestone, are olive gray, somewhat calcareous, light olive gray to light gray; locally grayish to brownish black, weathers medium gray. All shale is fossiliferous.

*Rowland Member:* Primarily limestone and shale. Dominant limestone is medium and greenish gray to medium bluish gray calcisiltite; weathers pale olive to yellowish gray; dolomitic and argillaceous; streaked with irregular burrows filled with dusky yellowish-green glauconitic material which weathers out readily to form holes and pitted bed surfaces; thin to thick bedded in continuous but poorly defined planar beds. Dominant shale is olive gray, light olive gray, greenish gray, and dark greenish gray; weathers yellowish gray to light gray; clayey and calcareous; prominent in two persistent beds 5 to 7 feet thick near upper and basal contacts. Small ponds for livestock and recreation are common in areas underlain by the Waldron Shale and by shale of the Osgood Formation and the Bardstown and Rowland Members of the Drakes Formation.

**Grant Lake Limestone**
Total Reported Thickness: + 100 feet
Karst Potential: Medium
Primary Lithology: Limestone and Shale

Grant Lake Limestone is of three main types. Dominant limestone type is medium gray, contains abundant coarse fossil fragments and whole fossils in a greenish gray calcareous mudstone or a medium to very coarse grained calcarenite cemented by sparry calcite; beds uneven to nodular, some continuous, commonly less than 0.2 foot thick. Less abundant limestone type is medium gray, fossil fragmental, poorly sorted calcarenite with sparry cement; weathers with abundant brown specks; in crossbeds 0.1 to 1.3 feet thick with smooth to undulating surfaces. Cross-bedded limestone common about 10 feet below top of unit; forms 15 foot thick sequence underlying bench capped

with alluvial gravel along east side of Floyds Fork between the mouths of Pope Lick and Cane Run 45 to 60 feet below top of unit. Least abundant limestone type is medium gray, micro-grained to medium grained, well-sorted, planar laminated calcarenite to calcisiltite in smooth surfaced, even, continuous inter-beds 0.1 to 0.4 foot thick; fossils not conspicuous; this limestone type presents only in upper part of unit. Inter-beds of planar-laminated calcisiltite and shale were well exposed at the time of mapping. Shale is olive gray to dark greenish gray, weathers light olive gray and dusky yellow; calcareous; in partings and beds 0.1 to 1.2 feet thick, commonly less than 0.6 foot thick; sparsely fossiliferous. Base of unit not exposed.

**Alluvium**
Total Reported Thickness: 0 - 20 feet
Karst Potential: Non-Karst
Primary Lithology: Silt, clay, sand, and gravel

Alluvium consists of silt, clay, sand, and gravel. Along Floyds Fork, silty clay, olive gray in root zone, grades downward to moderate brown to grayish brown clayey silt with blocky structure, then to moderate brown, calcareous, sandy, silty clay containing thin-shelled pelecypods, in turn underlain by as much as 3.5 feet of limestone gravel containing abundant cobbles and pebbles. In smaller stream valleys alluvium is brown to dark grayish brown silty clay and clayey silt, sand, and gravel. Gravel ranges in size from granules to boulders. Most granules and sand are limonite derived from soil; pebbles, cobbles, and slabs are from local bedrock. Older alluvium on limestone bench 30 to 45 feet above Floyds Fork is 15 to 20 feet thick; alluvium beneath modern floodplain is 8 to 10 feet thick. Basal gravel in older alluvium contains pebbles as much as 0.2 foot long; consists of brown chert, quartz geodes, silicified corals, and limonite cemented siltstone; overlain by grayish orange to moderate yellowish orange silty clay. Locally completely removed by stream erosion.

**Karst Potential**
According to the KGS Karst Potential Classification definitions, formations designated with a "Medium" karst potential are "Limestone units and coarse-grained, or siliciclastic units with limestone interbeds. Limestone units may contain a high percentage of insoluble minerals. Siliciclastic units will only be karst-prone where limestone beds occur in the near surface. Development of karst features in this category is variable and dependent on site-specific conditions." Formations designated with a "Low" karst potential are where the development of karst features are poorly developed or absent with the formations described as "siliciclastic units with minor limestone beds or units primarily composed of dolomite". Formations designated with a "Non-Karst" karst potential are described as "Consolidated or unconsolidated siliclastic units. Karst features are rare or absent." The karst potential is based on the tendency for the site to develop or have karst features as shown on the Kentucky Geologic Map Information Service and is not necessarily indicative of the actual presence or absence of karst activity at the site.

No sinkholes were mapped on the site by the Kentucky Geologic Map Information Service. However, several karst features were reported approximately 500 to 1,000 feet east and northwest of the site. Refer to attached **Karst Potential Map** for approximate location of mapped features.

**Soil Conservation Service Soil Survey**
The USDA Natural Resources Conservation Service "Web Soil Survey" website indicated 5 general soil types at the site as shown in **Figure 2**. Descriptions of these soil types are summarized below.

| NRCS CUSTOM SOIL RESOURCE REPORT | | | | |
|---|---|---|---|---|
| **Map Unit Symbol** | **Map Unit Name** | **Parent Material** | **Acres in AOI (Approximate)** | **Percent of AOI (Approximate)** |
| **BeC** | Beasley silt loam, 6 to 12 percent slopes. | Clayey residuum weathered from calcareous shale and/or calcareous siltstone. | 11.3 | 29.7% |
| **NhB** | Nicholson silt loam, 2 to 6 percent slopes | Fine-silty noncalcareous loess over clayey residuum weathered from limestone. | 5.3 | 13.9% |
| **ShD3** | Shrouts silt loam, 12 to 25 percent slopes, severely eroded, very rocky | Clayey residuum weathered from calcareous shale and/or siltstone | 15.6 | 41.3% |
| **UkC** | Urban land-Alfic Udarents-Beasley complex, 0 to 12 percent slopes | Clayey residuum weathered from calcareous shale and/or calcareous siltstone. | 4.0 | 10.6% |
| **UwC** | Urban land-Alfic Udarents-Shrouts complex, 0 to 12 percent slopes | Clayey residuum weathered from calcareous shale and/or siltstone. | 1.8 | 4.6 % |

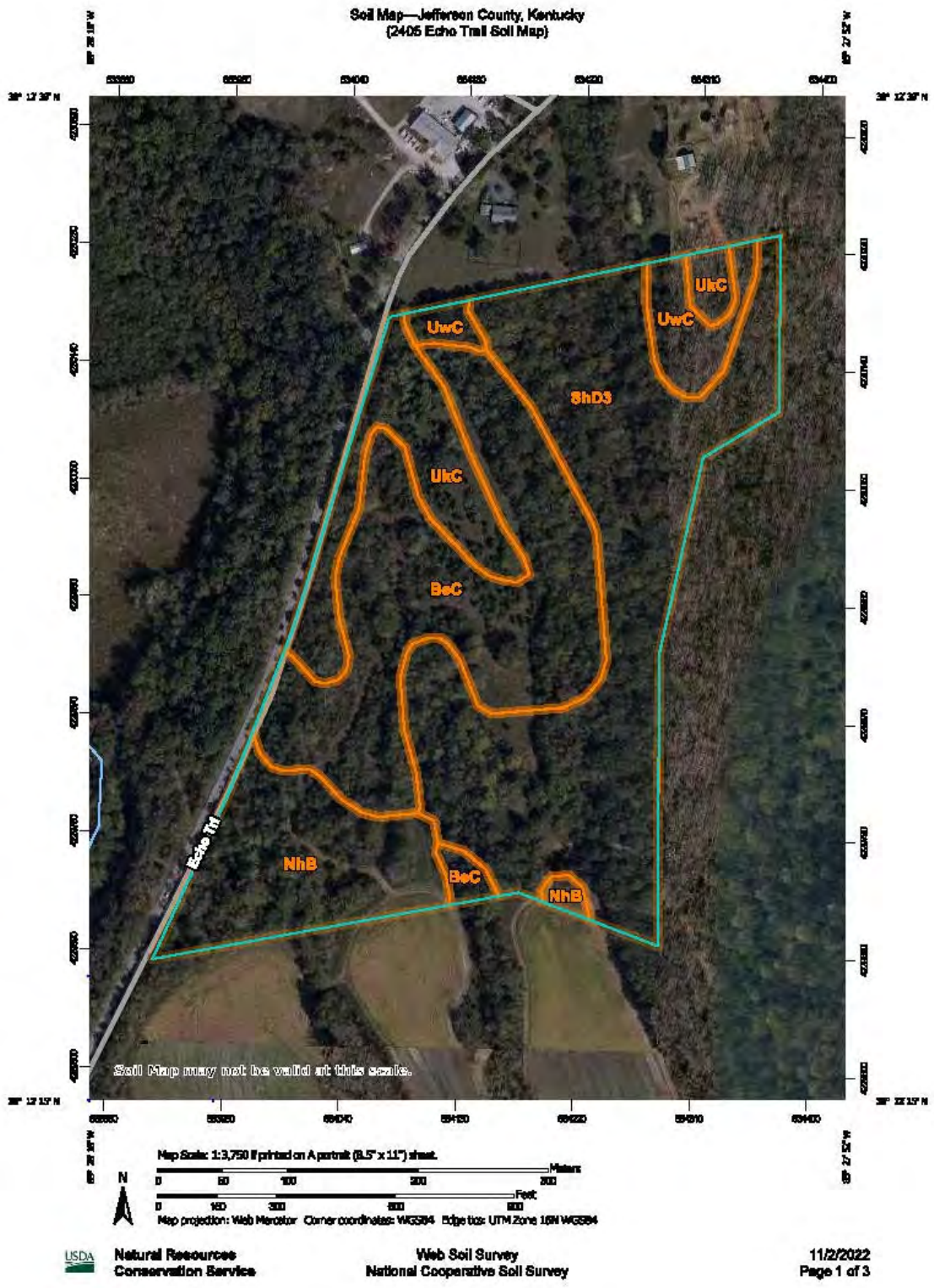



**Figure 2: Reported Soil Data**

**Site Reconnaissance**

A site reconnaissance was conducted over several days beginning November 3, 2022 through November 9, 2022 by Bryn Kabbes, E.I.T. of ECS. The purpose of the site reconnaissance was to observe and record site conditions for karst geologic features defined in the LDC as well as observe indicated steeper slope areas that would be disturbed by new construction.

Several remnant structures were observed in the southwestern portion of the site, including a small wooden storage building, a silo, and several isolated piles of rubble and debris. Remnant structures were observed in close proximity to one another along the southern boundary of the site and were typically encountered along existing cleared access paths. Several fill mounds and man-made berms, typically 1-3' in height were observed around the remnant structures and cleared access paths, and generally consisted of crushed pavement and stone.

In general, the surface drainage appeared to be directed from the northern portion of the property and away from Echo Trail towards the eastern and southern portions of the property. Two (2) existing streams were observed in the northeastern portion of the site, which conjoin in the northern portion of proposed open space Lot 105. A third existing stream was observed in the southern central portion of the site, in proposed open space Lot 106, which extended southward towards an existing drainage inlet on the southern property boundary. All three existing streams observed extend southward through the property towards Long Run Creek, located approximately 1,300 feet south of the southern property boundary. Drainage swales and associated shallow tributaries were observed throughout the site typically extending downslope towards the existing streams on the site. Swales ranged from 10 to 100 feet long, 1 to 10 feet wide, and 0.5 to 4 feet deep. Evidence of erosion was primarily observed along the drainage swales and typically consisted of areas of bare or loose soil, exposed tree roots, and displaced rock fragments (gravel, cobbles, and/or boulders). No apparent springs or rock outcroppings typical of karst terrain were observed at the time of the site reconnaissance.

Steeper slopes, as identified on the provided drawing, were generally observed adjacent to drainage swales and the existing streams. Steep slopes with numerous displaced gravel, cobbles, and/or boulder-sized rock, eroded/mounded soil, and various indications of minor slope instability and soil creep were observed in the northern and eastern portions of the site and typically became prevalent within 100 feet of the existing streams. Gentle slopes were encountered throughout most of the southern and western portions of the site, typically within the dense wooded areas. The central portion of the site consisting of open space was relatively flat and slope instability was not observed in the area. No indications of large, wide-scale or deep seated slope movements were noted. However, minor slope movements (wedge, bowl, or fan shaped failures) were observed in isolated areas (typically near slope areas approaching 20%), and specifically in failure areas SF-01 and SF-02, which are noted on the attached **Site Reconnaissance Plans**. For the remainder of the site, the slopes appeared to be relatively stable (excluding stream and drainage swale banks).

Two (2) minor slope failure areas were observed in isolated areas on the eastern portion of the site. Both failure areas were fan-shaped which narrowed to form drainage swales directed towards the existing stream located in the eastern portion of the property. Evidence of soil instability in these areas included bowed and fallen trees, erosion, mounded soil, and exposed tree roots. SF-01, located in the northeastern portion of proposed open space Lot 105, was approximately 50 feet long, 40 feet wide, and 3 to 5 feet deep which narrowed to a drainage swale approximately 2 to 5 feet wide and 0.5 feet deep. SF-02, located in the eastern portion of proposed open space Lot 105, was approximately 10 to 20 feet long, 8 to 10 feet wide, and 1 to 3 feet deep which narrowed to a drainage swale approximately 0.5 to 1.0 feet wide and 0.5 feet deep. Photos of each area observed are included in this letter. See the attached **Site Reconnaissance Plans** for the approximate locations, and **Site Photos** for conditions observed.

Thirty-one (31) possible karst-related features were identified onsite during the site reconnaissance. Refer to the attached **Site Reconnaissance Plans** and **Site Photos** for the approximate location of observed site features and pictures of selected features. Brief descriptions of the features are provided in the table on the following page. Areas

and/or features with multiple designations (A, B, C, etc.) represent a series of features which appeared to be related to a common joint or similar lineation.

| Feature | | Description | Approximate Dimensions | Approximate Depth |
|---|---|---|---|---|
| **F-01** | | Large, shallow closed depression with soil sidewalls and contained three (3) smaller closed depressions. Observed near remnant storage shed which could have obscured additional closed depressions from view. | 20' Diameter | 1' |
| | A | Bowl-shaped closed depression with soil sidewalls. | 2' Diameter | 1' |
| | B | Oblong-shaped closed depression with soil sidewalls. | 2' Long<br>1' Wide | 0.5' |
| | C | Bowl-shaped closed depression with soil sidewalls. | 1' Diameter | 0.5' |
| **F-02** | | Oblong-shaped closed depression with soil sidewalls. | 6-7' Long<br>2-5' Wide | 1' |
| **F-03** | | Large closed depression with soil/rock sidewalls and contained slot-shaped features, closed depressions, and several small openings. | 50' Long<br>50' Wide | 6' |
| | A | Bowl-shaped closed depression with soil sidewalls. Probe rod extended 2' below the bottom of the feature. | 5' Diameter | 2' |
| | B | Slot-shaped feature with soil/rock sidewalls. May tie in to existing creek. Probe rod extended 2-3' below slot feature in two small openings at the bottom of the feature. | 15-20' Long<br>3-5' Wide | 3-6' |
| | C | Bowl-shaped closed depression with soil/rock sidewalls. | 10' Diameter | 4' |
| **F-04** | | Large, closed depression with soil sidewalls and contained two (2) oval shaped closed depressions. | 50’ Long<br>30’ Wide | 3’ |
| | A | Closed depression with soil sidewalls. | 20' Long<br>3-4' Wide | 1-2' |
| | B | Closed depression with soil sidewalls. | 20' Long<br>4-5' Wide | 2-3' |
| **F-05** | | Crescent-shaped closed depression. Evidence of apparent human disturbance with sidewalls lined with boulders and debris. | 12-14' Long<br>10-12' Wide | 1-3' |
| **F-06** | | Oval-shaped closed depression with soil/rock sidewalls and a partially closed throat at the bottom of the depression. Evidence of apparent human disturbance with sidewalls lined with boulders and rusted metal debris. | 10' Long<br>5-7' Wide | 1-3' |

| Feature | | Description | Approximate Dimensions | Approximate Depth |
|---|---|---|---|---|
| **F-07** | | Oval-shaped closed depression with soil/rock sidewalls and a partially closed throat at the bottom of the depression. Probe rode extended 3 feet below the feature to an apparent rock bottom. | 6' Long<br>5' Wide | 4' |
| **F-08** | | Large-closed depression with soil/rock sidewalls and contained slot shaped features, closed depressions, and several small openings. | 80' Diameter | 4' |
| | A | Bowl-shaped closed depression with soil sidewalls. | 5' Diameter | 2' |
| | B | Bowl-shaped closed depression with soil/rock sidewalls and a partially closed throat at the bottom of the depression. | 8' Diameter | 2-3' |
| | C | Slot-shaped feature with soil/rock sidewalls. | 20' Long<br>3-4' Wide | 2-4' |
| | D | Oval-shaped closed depression with soil sidewalls. | 5' Long<br>3-4' Wide | 2-3' |
| **F-09** | | Large, closed depression with soil/rock sidewalls and contained four (4) smaller closed depressions. | 30' Long<br>20' Wide | 4' |
| | A | Oblong-shaped closed depression with soil sidewalls. | 2-3' Long<br>1-2' Wide | 1' |
| | B | Bowl-shaped closed depression with soil sidewalls. | 4' Diameter | 3' |
| | C | Bowl-shaped closed depression with soil sidewalls. | 3' Diameter | 2' |
| | D | Bowl-shaped closed depression with soil/rock sidewalls. | 6' Diameter | 4' |
| **F-10** | | Large, closed depression with soil sidewalls and contained two (2) smaller closed depressions separated by a large tree. | 20' Diameter | 3' |
| | A | Oval-shaped closed depression with soil sidewalls. | 10' Long<br>5' Wide | 1' |
| | B | Bowl-shaped closed depression with several partially closed throats (approximately 2-4 inches in diameter) encountered at the bottom of the depression. Probe rod extended 2 feet below the feature. | 5' Diameter | 2-3' |
| **F-11** | | Clover-shaped closed depression with soil sidewalls and a partially closed throat at the bottom of the depression. Probe rod extended 2 feet below the base of the feature. | 15-20' Long<br>5-10' Wide | 1' |
| **F-12** | | Bowl-shaped closed depression with soil sidewalls. | 4' Diameter | 1' |

| Feature | Description | Approximate Dimensions | Approximate Depth |
|---|---|---|---|
| **F-13** | Shallow, clover-shaped closed depression with soil sidewalls and large trees growing around the perimeter. | 5' Long<br>6' Wide | 6" |
| **F-14** | Clover-shaped closed depression with soil sidewalls. | 3-4' Long<br>2-4' Wide | 2-6' |
| **F-15** | Bowl-shaped closed depression with soil sidewalls and a partially closed throat encountered at the bottom of the depression. | 5' Diameter | 2' |
| **F-16** | Oblong-shaped closed depression with soil sidewalls. | 3-5' Long<br>3-4' Wide | 1' |
| **F-17** | Shallow, oval-shaped closed depression with soil sidewalls and a 3 inch partially closed opening at the bottom of the depression. Probe rod extended 3.5' below the feature. | 2' Long<br>3' Wide | 1' |
| **F-18** | Bowl-shaped closed depression with soil/rock sidewalls and a partially closed throat at the bottom of the depression. Probe rod extended 2 feet below the feature to an apparent rock bottom. | 4' Diameter | 1' |
| **F-19** | Bowl-shaped closed depression with soil/rock sidewalls. | 3' Diameter | 1-3' |
| **F-20** | Oval-shaped closed depression with soil sidewalls near bed of creek. | 6' Long<br>4' Wide | 0.5' |
| **F-21** | Bowl-shaped closed depression with soil sidewalls. | 4' Diameter | 2.5' |
| **F-22** | Bowl-shaped closed depression with soil sidewalls and a partially closed throat encountered at the bottom of the depression. Probe rod extended 1 foot below the feature to an apparent rock bottom. | 7' Diameter | 2-3' |
| **F-23** | Bowl-shaped closed depression with soil/rock sidewalls and a partially closed throat at the bottom of the depression. Probe rod extended 1 feet below the feature. | 3' Diameter | 1' |
| **F-24** | Bowl-shaped closed depression with soil sidewalls. Probe rod extended 2' below the bottom of the feature to an apparent rock bottom. | 1' Diameter | 0.5' |
| **F-25** | Bowl-shaped closed depression. Evidence of apparent human disturbance with sidewalls lined with boulders. A large tree is located at the center of the depression. | 10' Diameter | 1-3' |

| Feature | Description | Approximate Dimensions | Approximate Depth |
|---|---|---|---|
| **F-26** | Closed depression with soil sidewalls. | 4' Wide<br>6' Long | 1' |
| **F-27** | Small opening with soil/rock sidewalls. Probe rod extended approximately 1-2 feet below the feature. | 1' | 2-3' |
| **F-28** | Oval-shaped closed depression with soil sidewalls and a partially closed throat at the bottom of the depression. | 6-7' Long<br>3-4' Wide | 2' |
| **F-29** | Oblong shaped closed depression with soil sidewalls and a partially closed throat at the bottom of the depression. Probe rod extended to apparent rock approximately 3 feet below the feature. | 6-7' Long<br>4-5' Wide | 1-3' |
| **F-30** | Bowl shaped closed depression with soil sidewalls. | 10' Long<br>5' Wide | 1' |
| **F-31** | Oval shaped closed depression with soil sidewalls. The southern wall of the closed depression was approximately 3 feet above the northern wall of the closed depression. | 10' Long<br>4-6' Wide | 1-2' |

The observed closed depressions may have been caused by removal of a tree rootball, previous land use, or could be indicative of the presence of a karst feature. No other karst features were identified during the site reconnaissance. However, the existing remnant structures, debris, and man-made fill piles and berms located on the property potentially could have obscured indications of karst features at the time of this site reconnaissance. Additionally, fallen leaves and trees due to seasonal transition, especially in densely wooded areas, can also obscure such observations. Refer to the attached **Site Reconnaissance Plans** for the approximate locations of each possible karst-feature and the **Site Photos** for conditions observed.

**Karst Feature Remediation Guidelines**

Typically, karst features in this vicinity and similar to those identified in this survey can be stabilized for development, as needed, for the planned future use of the site. Remediation methods vary based on planned use of the specific area where a karst feature is located and the characteristics of each feature. Treatment methods may vary for features where buildings or other improvements are located, in contrast to features in non-sensitive areas. For this project the typical objective of the treatment of a feature will be to reduce the risk of future subsidence and to decrease surface water infiltration in and around the active karst feature(s).

An experienced and qualified geotechnical engineer or geologist should be present during remediation to evaluate the characteristics as the feature is excavated, and to recommend specific treatment methods for each feature. Remediation of most karst features identified is anticipated to consist of excavation of the closed depression or slot-features to identify the active feature(s) and determine the appropriate stabilization method. Once the active karst throat or weathered apparent rock area is stabilized, an inverted filter (see attached **Typical Sinkhole Remediation Diagram**) should be constructed within and over the feature(s).

The filter will reduce future loss of soil into the feature, reducing the risk of subsidence. The area can then be backfilled with clay, with the fill mounded above adjacent grade to reduce surface water infiltration. Clay fill placed in above the filter constructed in the karst features should meet the requirements for “CL” or “CH” according to the Unified Soil Classification System. The fill should be placed in one-foot lifts and compacted to at least 95% of the

Standard Proctor maximum dry density, within 2% of the optimum moisture content. Placement and compaction of the fill in limited horizontal lifts will reduce porosity and surface water infiltration. Periodic observations and compaction testing are recommended to confirm the character and continuity of the clay caps. Grading the site to promote surface drainage in all areas and avoiding ponding water is also important in reducing future subsidence of existing karst features (including sinkholes) and reducing the development of additional karst features.

Existing buildings, debris, and brush piles located on the property potentially could have obscured indications of slope instability and/or karst features at the time of this evaluation. Additionally, fallen leaves and trees due to the seasonal transition can also obscure such observations.

**Subsurface Summary**

Three (3) borings were extended on November 3, 2022, using a hand auger and Dynamic Cone Penetrometer (DCP). The approximate boring locations were established with a consumer-grade GPS device. A drive rod was extended in each boring, below the encountered hand auger refusal, to determine approximate refusal depths at each location. Refusal was encountered approximately 1.0 to 3.8 feet below existing grades. Materials encountered at each location were documented. Brief descriptions are provided in the following **Boring Summary**. Refer to the **Boring Location Diagram** for the approximate boring locations, and the **Boring Records** for the depths of materials encountered at each location.

**Boring Summary**

| APPROXIMATE DEPTH (FT) | STRATUM | DESCRIPTION | N-VALUES BLOWS PER FOOT (BPF)[2] |
|---|---|---|---|
| 0.0 – 0.3 | I | **TOPSOIL –** Approximately 2 to 4 inches of topsoil encountered at the surface materials in all borings. Rock fragments were encountered within topsoil in Boring B-01. | NA |
| 0.3 – 3.5 | **II** | **CLAY (CL) –** Orange brown to brown, low to moderate plasticity, firm to stiff, dry to slightly moist, silty clay (CL), with trace black oxide nodules and root fibers. Encountered below Stratum I in all borings. Weathered rock fragments and cobbles were encountered within silty clay in Borings B-01 and B-02 from approximately 0.8 to 1.6 feet to drive rod refusal. | 5 – 25/1" |
| 1.0 – 3.8 | **III** | **CLAY (CH) –** Orange brown to medium brown, moderate to high plasticity, hard, dry to slightly moist, silty clay (CL), with few root fibers. Encountered below Stratum II in Boring B-03. Weathered rock fragments and cobbles were encountered within silty clay from approximately 1.8 feet to drive rod refusal. | 18 |
| **REFUSAL[3]** | Refusal was encountered approximately 1.0 to 3.8 feet below existing grades. | | |
| **GROUNDWATER** | Groundwater was not encountered at the time of boring. However, groundwater seepage at the soil/rock interface and within the underlying bedrock onsite is common and should be anticipated. | | |

Notes:

(1) This summary is generalized and does not describe the actual conditions in each boring. These zones also may not occur at each location. Depths are approximate. Detailed descriptions of the encountered materials are listed on the **Boring Records** in the **Appendix**.

(2) Number of blows to drive the dynamic cone penetrometer 1.75 inches has been empirically correlated to the Standard Penetration Test value "N" in blows per foot.

(3) Refusal is the term applied to material that cannot be penetrated with augers or has a Dynamic Penetration resistance exceeding 25 blows per 1.75-inch increment. Refusal may be encountered on continuous bedrock, discontinuous floaters, cemented soil, weathered rock, debris, buried structures, or other hard subsurface materials.

**Laboratory Test Summary**

| STRATUM | MOISTURE CONTENT | LIQUID LIMIT | PLASTIC LIMIT | PLASTICITY INDEX | UNCONFINED COMPRESSIVE STRENGTH (ksf) | UNDRAINED SHEAR STRENGTH (psf) | UNIFIED SOIL CLASSIFICATION |
|---|---|---|---|---|---|---|---|
| **II** | **14.6** | 46 | 20 | 26 | 3.0 – 9.0 | 1,500 – 4,500 | CL |
| **III** | **23.1** | 76 | 27 | 49 | 2.0 – 8.0 | 1,000 – 4,000 | CH |

Notes:

(1) A more detailed summary of the laboratory test results is included on the **Boring Records** and **Laboratory Reports** in the **Appendix.** Detailed descriptions of the laboratory test methods are listed in the **Laboratory Procedures** section of the **Appendix.**

(2) Atterberg Limits test results were not complete at the time the report was issued. Once completed, an updated report will be issued.

**Findings**

Based on our review of the above referenced observations and information, and on our past experience with site development for similar conditions in Jefferson County, our opinion is that most of the on-site slopes (excluding small, localized erosion features along swales) in the observed areas were generally stable at the time of our site reconnaissance. Evidence of minor instability was observed in isolated areas in the northeast and east portions of the site (identified as SF-01 and SF-02 in this report).

The current, on-site localized slope instability observed likely is related to the following factors:

- Relatively thin depths of soil in slope areas
- Cohesive (clayey) soil matrix
- Rocky soil texture
- Limestone, dolomite, and or shale bedrock
- Numerous trees and other vegetation
- Groundwater seepage from shallow bedrock

Based on the conditions observed, our opinion is that additional geotechnical exploration/analyses including soil/rock test borings/coring, shear strength tests of soils, etc. are not required for most of the evaluated on-site slopes, provided that the planned subdivision is designed and constructed utilizing the guidelines included in this report.

The northeast and east portions of the site, particularly in areas identified as “existing slopes > 20-30%” and “existing slopes >30%” as shown on the provided drawing, and including the shaded “Minor Failure Areas”, where minor instability was observed should be further evaluated during the construction phase of the project once the location and planned elevation of the proposed structures and related improvements are known.

The following guidelines should be used to help maintain the stability of the existing and planned slopes during the design and construction of the new subdivision, and over the life of the new homes. These guidelines include:

- All foundations should bear entirely on competent rock (sound and continuous).
- Groundwater seepage should be anticipated. Plan to install foundation and sub-floor drainage systems for structures bearing entirely on rock or near the soil/rock interface.
- Plan grading to minimize changes to existing topography along slopes.
- Minimize disturbance to slopes and vegetation outside new construction areas.
- Avoid significant transverse cuts along face or at the toe of existing slopes.
- Avoid significant embankments on the face, or along or at the crest of existing slopes.
- Avoid placing new construction at or within 10 feet of the crest of existing slopes.
- Maintain the following limits for new embankments without additional geotechnical exploration and analysis:
  - 3:1 (horizontal: vertical) or flatter slopes.
  - Properly strip all vegetation, topsoil, etc. where fill will be placed.

  - Construct embankments with controlled fill compacted to at least 98 percent of the Standard Proctor maximum dry density and within 2 percent of the optimum moisture content.
  - Maximum fill embankment height of 5 feet.
  - Horizontally bench new fill into existing slopes in maximum one-foot vertical steps.
- Maintain the following limits for new cuts in soil without additional geotechnical exploration and analysis:
  - 3:1 (horizontal: vertical) or flatter slopes.
  - Maximum cut height of 5 feet.
- Provide adequate erosion and surface water drainage control during construction and over the life of the subdivision.
- Establish permanent vegetative cover as soon as practical.

**Closing**

We appreciate the opportunity to serve as your geotechnical consultants for this project. We look forward to future association with you on this and other projects.

Respectfully submitted,
**ECS Southeast, LLP**

**Bryn Kabbes, E.I.T**
*Project Engineer*
*bkabbes@ecslimited.com*

**Liz Blandford Newcomb, P.E.**
*Principal Engineer*
*lnewcomb@ecslimited.com*

**APPENDICES**

Appendix A – Drawings
- Site Location Diagram
- Geology Location Map
- Karst Potential Map
- Provided Drawing : 22-ZONEPA-0110 – 22-09-12 (FILED)

Appendix B – Site Reconnaissance
- Site Reconnaissance Plans – 3 pages
- Site Photos – 18 pages
- Typical Sinkhole Remediation Diagram

Appendix C – Slope Exploration
- Boring Location Diagram
- Soil & Rock Classification
- Boring Legend
- Boring Records
- Boring Composite
- Field and Laboratory Procedures

# APPENDIX A – Drawings

Site Location Diagram
Geology Location Diagram
Karst Potential Diagram
Provided Drawing: 22- ZONEPA-0110 – 22-09-12 (FILED)

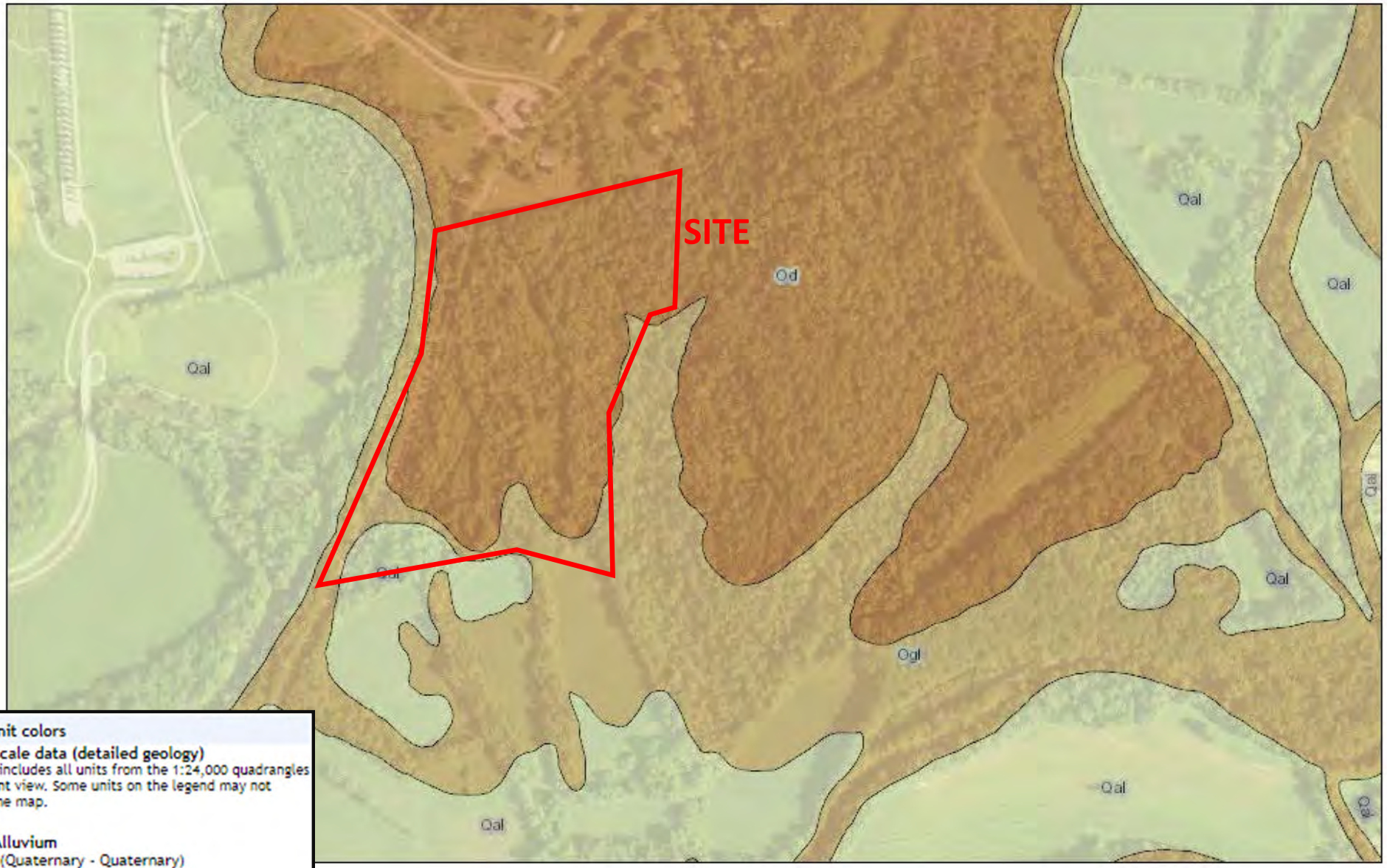

# SITE LOCATION DIAGRAM

## PRELIMINARY SLOPE EVALUATION AND KARST SURVEY - 2405 ECHO TRAIL

**2405 ECHO TRAIL, LOUISVILLE, KENTUCKY 40245**
**LONG RUN CREEK PROPERTIES**

| | |
|---|---|
| ENGINEER | BEK |
| SCALE | AS NOTED |
| PROJECT NO. | 61-2863 |
| FIGURE | 1 OF 1 |
| DATE | 11/10/2022 |

# Kentucky Geologic Map Information Service – Geology Location Diagram




map unit colors

1:24,000 scale data (detailed geology)

This legend includes all units from the 1:24,000 quadrangles in the current view. Some units on the legend may not appear on the map.

| | |
|---|---|
| Qal | Alluvium (Quaternary - Quaternary) |
| Od | Drakes Formation (Upper Ordovician - Upper Ordovician) |
| Ogl | Grant Lake Limestone (Upper Ordovician - Upper Ordovician) |

1:9,028

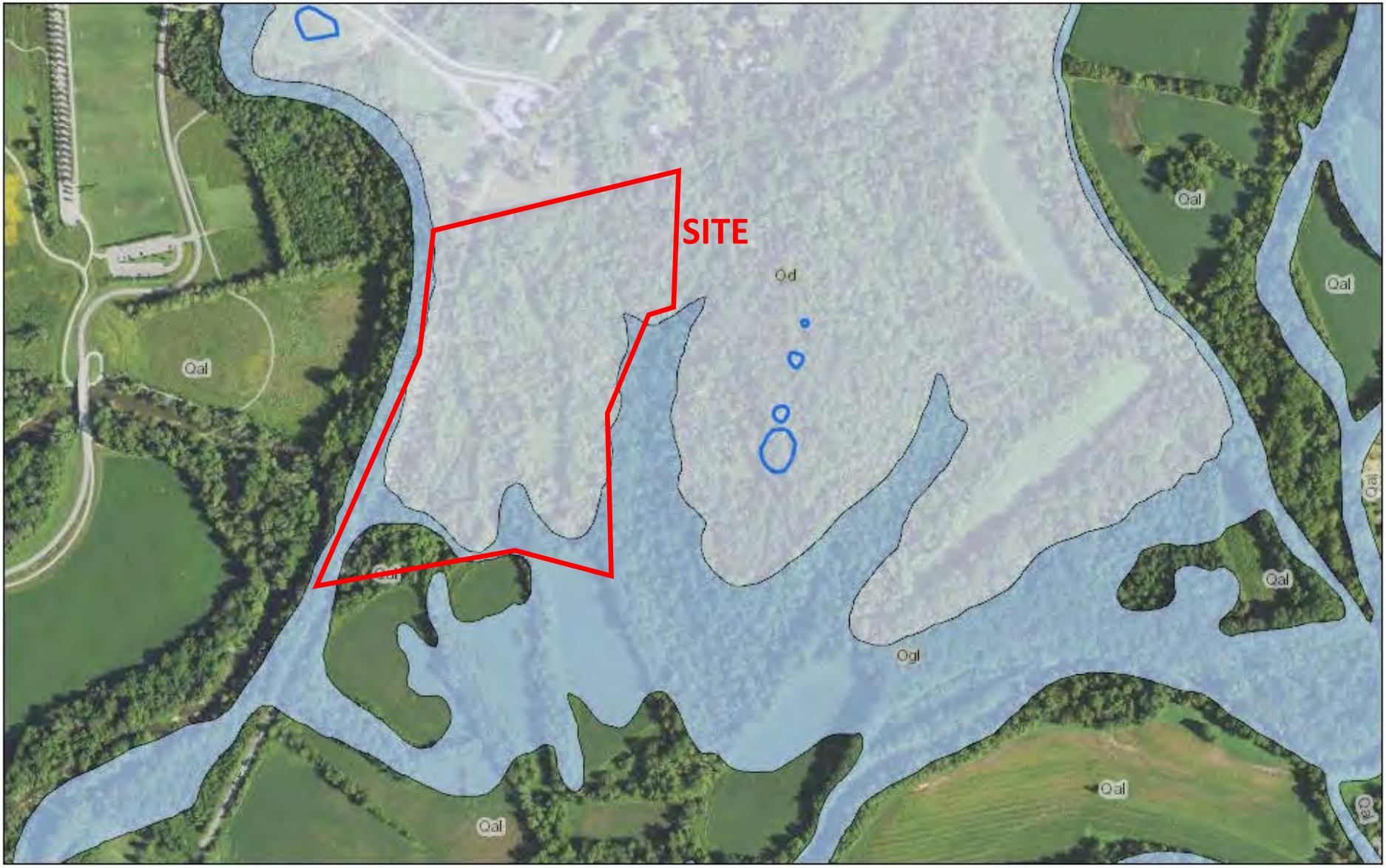
0 0.075 0.15 0.3 mi

0 0.1 0.2 0.4 km

Kentucky Geological Survey

author: Kentucky Geological Survey
copyright Kentucky Geological Survey

# Kentucky Geologic Map Information Service – Karst Potential Map




Karst Potential Units
- very high
- high
- medium
- low
- non-karst

LiDAR Sinkholes

KGS Sinkholes

Kentucky Sinkhole Outlines
- Sinkhole

1:9,028

0 0.075 0.15 0.3 mi

0 0.1 0.2 0.4 km

Kentucky Geological Survey

author: Kentucky Geological Survey
copyright Kentucky Geological Survey

Received Feb. 27, 2023

Planning & Design

22-ZONE-0131



LOCATION MAP
NO SCALE

**SITE DATA:**

| | |
|---|---|
| FORM DISTRICT | NEIGHBORHOOD |
| EXISTING ZONING | R-R |
| PROPOSED ZONING | R-4 DEVELOPMENT POTENTIAL TRANSFER |
| EXISTING LAND USE | VACANT |
| PROPOSED LAND USE | SINGLE-FAMILY RESIDENTIAL |
| GROSS LAND AREA | 36.67± AC (1,597,331 SF) |
| NET LAND AREA | 31.71± AC (1,381,432 SF) |
| BUILDABLE LOTS | 103 |
| NON-BUILDABLE LOTS | 3 |
| GROSS DENSITY | 2.81 D.U./AC |
| NET DENSITY | 3.25 D.U./AC |
| OPEN SPACE PROVIDED | 684,925 SF (49%) |

**DIMENSIONAL STANDARDS**

| | |
|---|---|
| FRONT/STREET SIDE YARDS | 15'/(25' IF GARAGE) |
| SIDE YARD MIN. | 5' |
| REAR YARD MIN. | 25' |
| MINIMUM LOT WIDTH | 50' |

**TREE CANOPY DATA:**

| | |
|---|---|
| GROSS SITE AREA | 36.67± AC (1,597,331 SF) |
| LAND USE | SINGLE-FAMILY RESIDENTIAL |
| EX. TREE CANOPY | 1,039,580± SF (65%) |
| EX. TREE CANOPY TO BE PRESERVED | 396,491± SF (38%) |
| TOTAL TREE CANOPY REQUIRED | 638,932± SF (40%) |

*TREE CANOPY DEPICTED ON PLAN PER MSD LOJIC MAPPING, AERIAL PHOTO OR FIELD SURVEY. TREE CANOPY CALCULATIONS BASED UPON TREE AREAS SHOWN.

**MAXIMUM BALANCE TRANSFER LOT CALCULATION**

MLP = MAXIMUM LOTS PERMITTED
TA = TOTAL LAND AREA (36.67± AC)
SS = STEEP SLOPES AREA/SLOPES >20% 1.06 AC)
IA = INFRASTRUCTURE AREA (4.97 AC)

$MLP = [(TA - SS - IA)\ 4.84] + \frac{SS \times 4.84}{2}$

$MLP = [(36.67 - 1.06 - 4.97)\ 4.84] + \frac{1.06 \times 4.84}{2}$

$MLP = [(30.64)\ 4.84] + 2.56$

$MLP = 151$

NOTE: ONLY THE AREAS OF STEEP SLOPES WITHIN OPEN SPACE LOTS ARE USED FOR THE BALANCE TRANSFER AREA CALCULATION.

**LEGEND**

- EXISTING CONTOUR
- EXISTING TREE MASS
- EXISTING TREE
- EXISTING FENCE
- EXISTING CATCH BASIN & YARD DRAIN W/PIPE
- EXISTING HEADWALL W/PIPE
- EXISTING SANITARY MANHOLE W/PIPE
- PROPOSED TREE MASS
- PROPOSED CATCH BASIN & YARD DRAIN W/PIPE
- PROPOSED HEADWALL W/PIPE
- PROPOSED SANITARY MANHOLE W/PIPE
- PROPOSED DITCH/SWALE
- ZONING LINE
- EXISTING SLOPES >20-30%
- EXISTING SLOPES >30%
- PROPOSED TREE CANOPY CREDIT AREA (TCCA)
- LIMITS OF DISTURBANCE

**GENERAL NOTES:**

1. DOMESTIC WATER SUPPLY:
   SUBJECT SITE CAN BE SERVED BY THE LOUISVILLE WATER COMPANY. THE NECESSARY WATER SYSTEM IMPROVEMENTS REQUIRED TO SERVICE THE DEVELOPMENT SHALL BE AT THE OWNER/DEVELOPER'S EXPENSE.
2. TREE PRESERVATION:
   A TREE PRESERVATION PLAN SHALL BE PROVIDED TO THE PLANNING COMMISSION'S STAFF LANDSCAPE ARCHITECT FOR APPROVAL PRIOR TO BEGINNING ANY CONSTRUCTION ACTIVITIES ON THE SITE.
3. PROTECTION OF TREES TO BE PRESERVED:
   CONSTRUCTION FENCING SHALL BE ERECTED PRIOR TO ANY GRADING OR CONSTRUCTION ACTIVITIES-PREVENTING COMPACTION OF ROOT SYSTEMS OF TREES TO BE PRESERVED. THE FENCING SHALL ENCLOSE THE AREA BENEATH THE DRIP LINE OF THE TREE CANOPY AND SHALL REMAIN IN PLACE UNTIL ALL CONSTRUCTION IS COMPLETE. NO PARKING, MATERIAL STORAGE OR CONSTRUCTION ACTIVITIES SHALL BE PERMITTED WITHIN THE FENCED AREA.
4. A LANDSCAPE AND TREE CANOPY PLAN PER CHAPTER 10 OF THE LDC SHALL BE PROVIDED AS REQUIRED PRIOR TO ISSUANCE OF BUILDING PERMIT.
5. THE DEVELOPMENT LIES IN THE EASTWOOD FIRE DISTRICT.
6. IF PROPOSED, SIGNATURE ENTRANCE WALLS SHALL BE SUBMITTED TO AND APPROVED BY THE PLANNING STAFF PRIOR TO CONSTRUCTION PLAN APPROVAL AND THEY SHALL MEET THE REQUIREMENTS OF CHAPTER 4.4.3 OF THE LDC.
7. ALL LUMINAIRES SHALL BE AIMED, DIRECTED OR FOCUSED SUCH AS TO NOT CAUSE DIRECT LIGHT FROM THE LUMINAIRE TO BE DIRECTED TOWARDS RESIDENTIAL USES OR PROJECTED OPEN SPACES (IE. CONSERVATION EASEMENTS, GREENWAYS OR PARKWAYS) ON ADJACENT OR NEARBY PARCEL'S, OR TO CREATE GLARE PERCEPTIBLE ON PUBLIC STREETS AND RIGHT-OF-WAYS PER CHAPTER 4.1.3. OF THE LDC.
8. MITIGATION MEASURES FOR DUST CONTROL SHALL BE IN PLACE DURING CONSTRUCTION TO PREVENT FUGITIVE EMISSIONS REACHING EXISTING ROADS AND NEIGHBORHOODS.
9. ALL EXISTING STRUCTURES AND EXISTING ENTRANCES SHALL BE REMOVED, EXCEPT AS NOTED ON THE PLAN.
10. IN ACCORDANCE WITH CHAPTER 4.9 OF THE LDC, A KARST SURVEY WAS PERFORMED BY TRAVIS A. BROWN, P.E. ON 08/23/18 AND KARST TOPOGRAPHY WAS FOUND. A REVIEW OF PUBLISHED GEOLOGIC INFORMATION FROM THE KY GEOLOGICAL SURVEY CONTAINED INDICATION OF SINKHOLES ON THE SUBJECT PROPERTY, WHICH HAVE BEEN VISUALLY CONFIRMED. THERE WILL BE A NEED TO REMEDIATE SINKHOLES DURING CONSTRUCTION OF THIS SITE AND IT IS RECOMMENDED TO HAVE A GEOTECHNICAL CONSULTANT FAMILIAR WITH THE SITE ON-HAND TO CALL WHEN SINKHOLES ARE ENCOUNTERED. CARE SHOULD BE TAKEN TO PROPERLY REMEDIATE SINKHOLES, PER THE GEOTECHNICAL ENGINEER'S RECOMMENDATIONS, CARE SHOULD ALSO BE TAKEN DURING EARTHWORK TO INVESTIGATE AND REMEDIATE ANYTIME A POTENTIAL KARST FEATURE IS ENCOUNTERED. IT WILL BE IMPORTANT TO PROOFROLL THOROUGHLY BEFORE PLACING FILL AND AFTER CUTTING.
11. STREET TREES TO BE PROVIDED IN ALL ADJACENT RIGHTS-OF-WAY. FINAL LOCATION AND TYPE TO BE SHOWN ON THE APPROVED LANDSCAPE PLAN.

**MSD NOTES:**

1. CONSTRUCTION PLANS & DOCUMENTS SHALL COMPLY WITH LOUISVILLE AND JEFFERSON COUNTY METROPOLITAN SEWER DISTRICT'S DESIGN MANUAL AND STANDARD SPECIFICATIONS.
2. WASTEWATER:
   SANITARY SEWER WILL CONNECT TO THE FLOYDS FORK WASTEWATER TREATMENT PLANT BY LATERAL EXTENSION AGREEMENT, SUBJECT TO FEES. SANITARY SEWER CAPACITY TO BE APPROVED BY METROPOLITAN SEWER DISTRICT.
3. DRAINAGE/STORMWATER DETENTION:
   DETENTION TO BE PROVIDED ON ADJACENT SITE #18SUBDIV1023. POST-DEVELOPMENT PEAK FLOWS WILL NOT EXCEED PRE-DEVELOPED PEAK FLOWS FROM DEVELOPMENT FOR THE 2, 10, 25, AND 100 YEAR STORMS OR TO DOWNSTREAM CAPACITY, WHICH IS MORE RESTRICTIVE. DRAINAGE PATTERN (DEPICTED BY FLOW ARROWS) IS FOR THE CONCEPT PURPOSES ONLY. FINAL CONFIGURATION AND SIZE OF DRAINAGE PIPES AND CHANNELS SHALL BE DETERMINED DURING THE CONSTRUCTION PLAN DESIGN PROCESS. DRAINAGE FACILITIES SHALL CONFORM TO MSD REQUIREMENTS.
4. EROSION AND SILT CONTROL:
   A SOIL AND SEDIMENTATION CONTROL PLAN SHALL BE DEVELOPED AND IMPLEMENTED IN ACCORDANCE WITH MSD AND THE USDA NATURAL RESOURCES CONSERVATION SERVICE RECOMMENDATIONS.
5. A PORTION OF THE SUBJECT PROPERTY LIES WITHIN A FLOOD HAZARD AREA PER FEMA'S FIRM MAPPING (21111C0067F & 21111C0066F).
6. THE FINAL DESIGN OF THIS PROJECT MUST MEET ALL MS4 WATER QUALITY REGULATIONS ESTABLISHED BY MSD. SITE LAYOUT MAY CHANGE AT DESIGN PHASE DUE TO PROPER SIZING OF GREEN BEST MANAGEMENT PRACTICES.
7. ANY PROPOSED LOTS ENCROACHING INTO THE REQUIRED 25' BUFFER AREAS SHALL BE SHOWN AND NOTED ON THE RECORD PLAT.

**PUBLIC WORKS AND KTC NOTES:**

1. NO LANDSCAPING AND COMMERCIAL SIGNS SHALL BE PERMITTED IN METRO WORKS RIGHT-OF-WAY.
2. RIGHT-OF-WAY DEDICATION BY DEED OR MINOR PLAT MUST BE RECORDED PRIOR TO SITE CONSTRUCTION APPROVAL BY PUBLIC WORKS OR WITH ASSOCIATED RECORD PLAT AS REQUIRED BY METRO PUBLIC WORKS.
3. COMPATIBLE UTILITY LINES (ELECTRIC, PHONE, CABLE) SHALL BE PLACED IN A COMMON TRENCH UNLESS OTHERWISE REQUIRED BY APPROPRIATE AGENCIES.
4. STREET TREES SHALL BE PLANTED IN A MANNER THAT DOES NOT AFFECT PUBLIC SAFETY AND MAINTAINS PROPER SIGHT DISTANCE. FINAL LOCATION WILL BE DETERMINED DURING CONSTRUCTION APPROVAL PROCESS.
5. AN ENCROACHMENT PERMIT AND BOND MAY BE REQUIRED BY METRO PUBLIC WORKS FOR ROADWAY REPAIRS ON ALL SURROUNDING ACCESS ROADS TO THE SITE DUE TO DAMAGES CAUSED BY CONSTRUCTION TRAFFIC ACTIVITIES.
6. THE DEVELOPER IS RESPONSIBLE FOR ANY UTILITY RELOCATION ON THE PROPERTY.
7. TREES AND SHRUBBERY SHALL BE TRIMMED OR REMOVED TO PROVIDE SIGHT DISTANCE AS REQUIRED PER METRO PUBLIC WORKS STANDARDS.
8. ALL SIDEWALK RAMPS SHALL CONFORM TO A.D.A. STANDARD SPECIFICATION, THE "SPECIAL NOTE FOR DETECTABLE WARNING FOR SIDEWALK RAMPS" PER KTC STANDARD DRAWING FOR SIDEWALKS AND PER "KENTUCKY STANDARD SPECIFICATIONS FOR ROAD AND BRIDGE CONSTRUCTION," LATEST EDITION.

GRAPHIC SCALE 1"=100'
0 50 100 200

CASE# 22-ZONEPA-0110
RELATED PROJECTS: #18SUBDIV1023, #21-CFR-0002
MSD WM # 9674

MINDEL SCOTT
ENGINEERING ▶ SURVEYING ▶ PLANNING ▶ LANDSCAPE ARCHITECTURE
5151 Jefferson Blvd. Louisville, KY 40219
502-485-1508 ▶ MindelScott.com

OWNER/DEVELOPER
LONG RUN CREEK PROPERTIES, LLC
3911 WILDERNESS TRAIL
LOUISVILLE, KY 40299

CHANGE OF ZONNING PLAN
# ECHO TRAIL RESIDENTIAL
(DEVELOPMENT POTENTIAL TRANSFER)
(FLOYD'S FORK DRO)
2405 ECHO TRAIL, LOUISVILLE, KY 40245
TAX BLOCK 0041, LOT 0199
DEED BOOK 11728, PAGE 341

Revisions

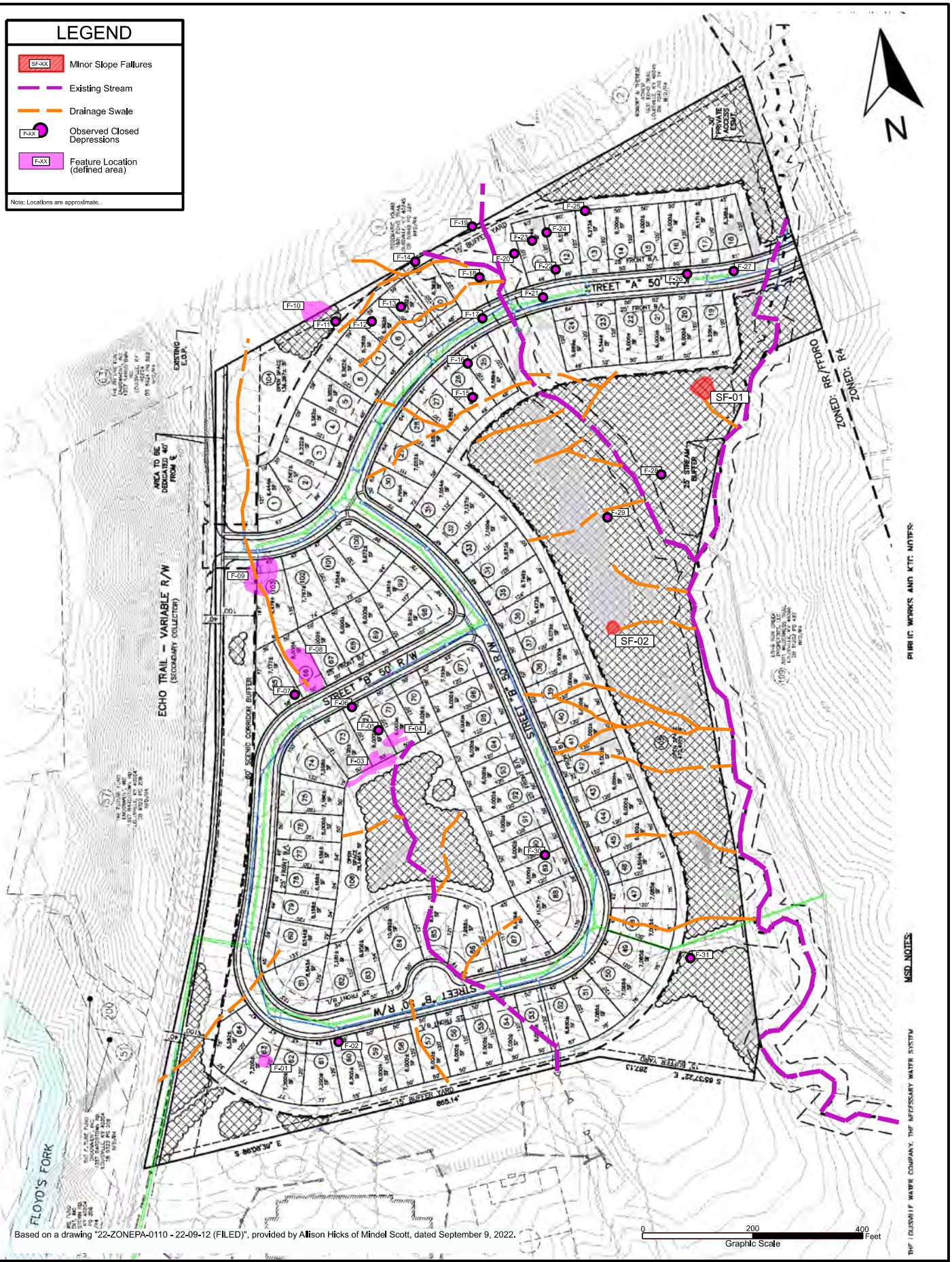
Vertical Scale: N/A
Horizontal Scale: 1"=100'
Date: 09/12/2022
Job Number: 3334-002

Sheet 1 of 1

L:\land projects-2\3334\3334-002 - Echo Trail Residential Balance Transfer\DWG\PLANNING\3334-002 - 22-ZONEPA-0110 - dp-12-22.dwg, 9/12/2022 12:16:20 PM, ahicks, 1:1

# APPENDIX B – Site Reconnaissance

Site Reconnaissance Plans
Site Photos
Typical Sinkhole Remediation Diagram

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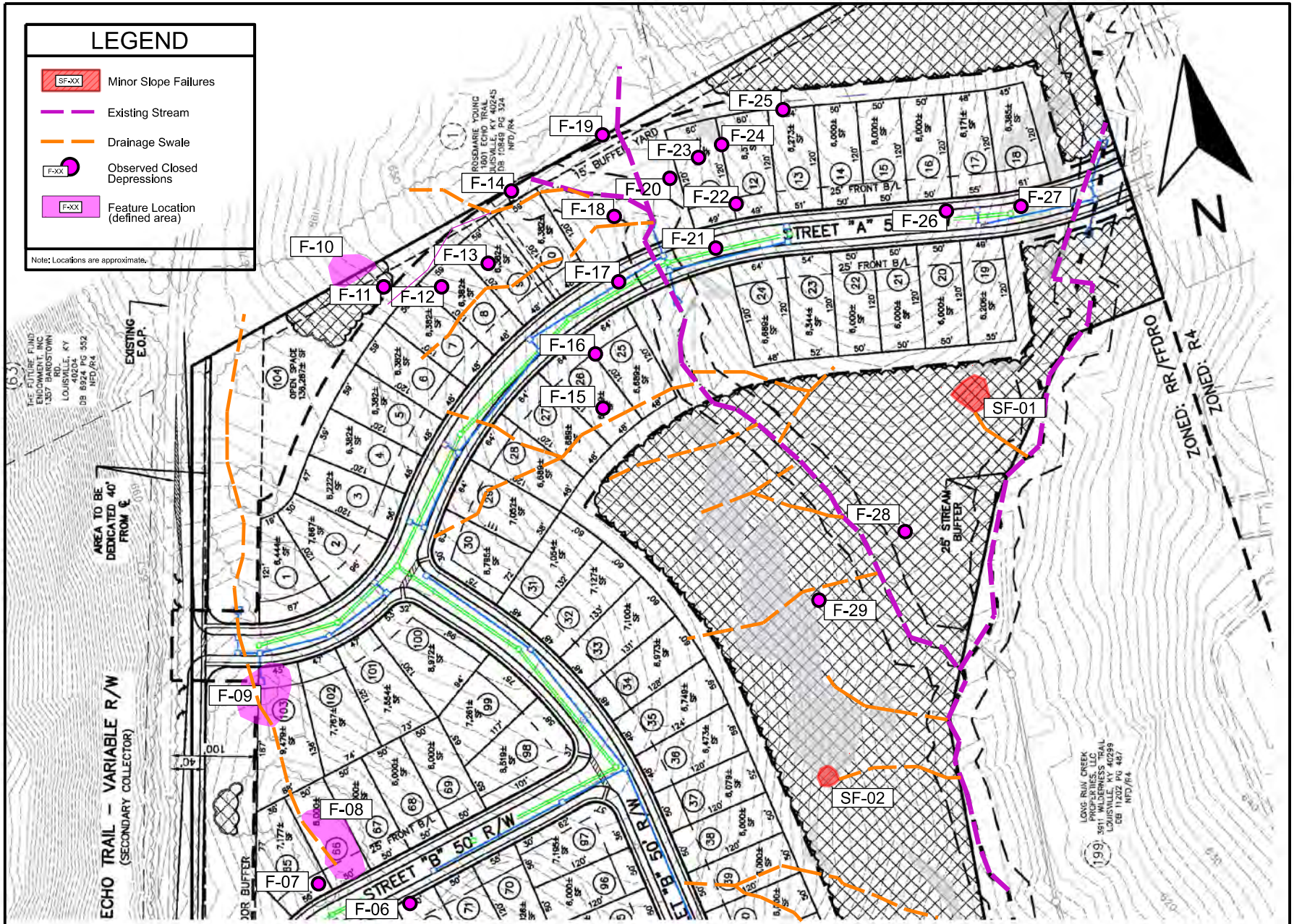
Louisville, Kentucky 40299
Tel. (502) 493-7100

# Site Reconnaissance Plan

Slope Evaluation and Karst Survey - 2405 Echo Trail

2405 Echo Trail
Louisville, Jefferson County, Kentucky 40245

| | |
|---|---|
| DRAWN BY | BEK |
| APPROVED BY | FEN |
| PROJECT NO. | 61-2863 |
| DATE | 11-14-2022 |




Based on a drawing "22-ZONEPA-0110 - 22-09-12 (FILED)", provided by Allison Hicks of Mindel Scott, dated September 9, 2022.

0 200 400 Feet
Graphic Scale

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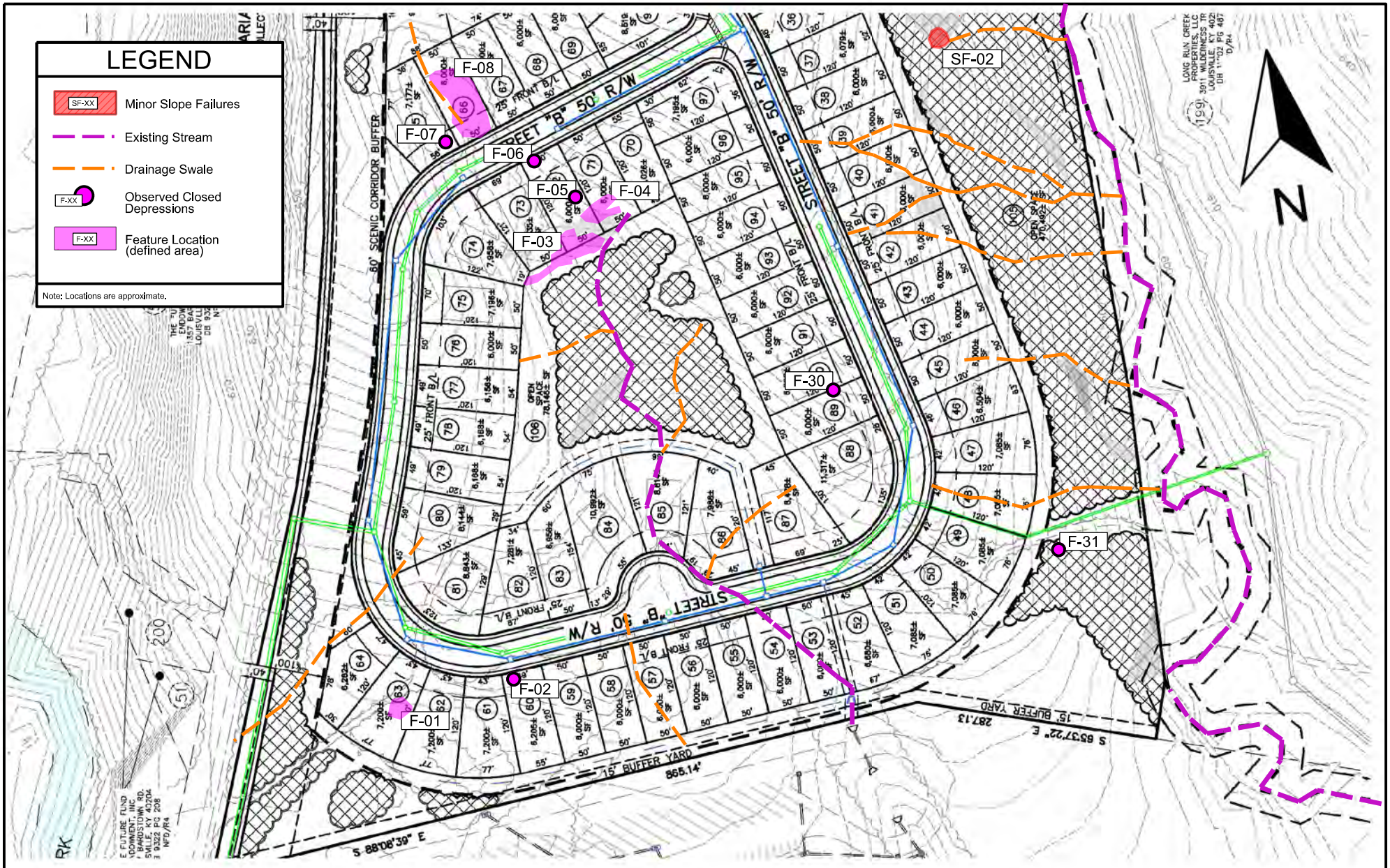
1762 Watterson Trail
Louisville, Kentucky 40299
Tel. (502) 493-7100

# Site Reconnaissance Plan - North Area

Slope Evaluation and Karst Survey - 2405 Echo Trail

2405 Echo Trail
Louisville, Jefferson County, Kentucky 40245

| | |
|---|---|
| DRAWN BY | BEK |
| APPROVED BY | FEN |
| PROJECT NO. | 61-2863 |
| DATE | 11-14-2022 |




Based on a drawing "22-ZONEPA-0110 - 22-09-12 (FILED)", provided by Allison Hicks of Mindel Scott, dated September 9, 2022.

0 200 400 Feet
Graphic Scale

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Louisville, Kentucky 40299
Tel. (502) 493-7100

# Site Reconnaissance Plan - South Area

## Slope Evaluation and Karst Survey - 2405 Echo Trail

2405 Echo Trail
Louisville, Jefferson County, Kentucky 40245

| | |
|---|---|
| DRAWN BY | BEK |
| APPROVED BY | FEN |
| PROJECT NO. | 61-2863 |
| DATE | 11-14-2022 |

Photo 1: View of remnant shed located adjacent to F-01.

Photo 2: View of F-02.

Photo 3: View of one of several throats located in F-03.

Photo 4: View of F-03.

Photo 5: View of F-04.

Photo 6: View of F-05.

Photo 7: View of F-06 containing rusted debris and a partially closed throat.

Photo 8: View of probe rod in partially closed throat in F-07.

Photo 9: View of multiple partially closed throats located in F-08.

Photo 10: View of multiple closed depressions located in F-09.

Photo 11: View of probe rod extended in partially closed throat located in F-11.

Photo 12: View of probe rod extended in partially closed throat located in F-12.

Photo 13: View of probe rod extended in partially closed throat located in F-15.

Photo 14: View of probe rod extended in partially closed throat located in F-17.

Photo 15: View of probe rod extended in partially closed throat located in F-18.

Photo 16: View of stream located in northeastern portion of the site.

Photo 17: View of stream sidewalls located in northeastern portion of the site.

Photo 18: View of F-21.

Photo 19: View of probe rod extended in partially closed throat located in F-22.

Photo 20: View of probe rod extended in partially closed throat located in F-23.

Photo 21: View of F-25.

Photo 22: View of possible human disturbance and partially closed throat located in F-25.

Photo 23: View of F-26.

Photo 24: View of probe rod extended in partially closed throat located in F-28.

Photo 25: View of probe rod extended in partially closed throat located in F-29.

Photo 26: View of F-31.

Photo 27: View of large fan-shaped slope failure area SF-01.

Photo 28: View of bowed trees and mounded soil encountered in SF-01.

Photo 29: View of drainage swale directed downslope of slope failure area SF-01.

Photo 30: View of fan-shaped slope failure area SF-02.

Photo 31: View of slope downslope of slope failure area SF-02.

Photo 32: View of a shallow drainage swale typically encountered throughout the northeastern and eastern portions of the site, directed towards the eastern creek.

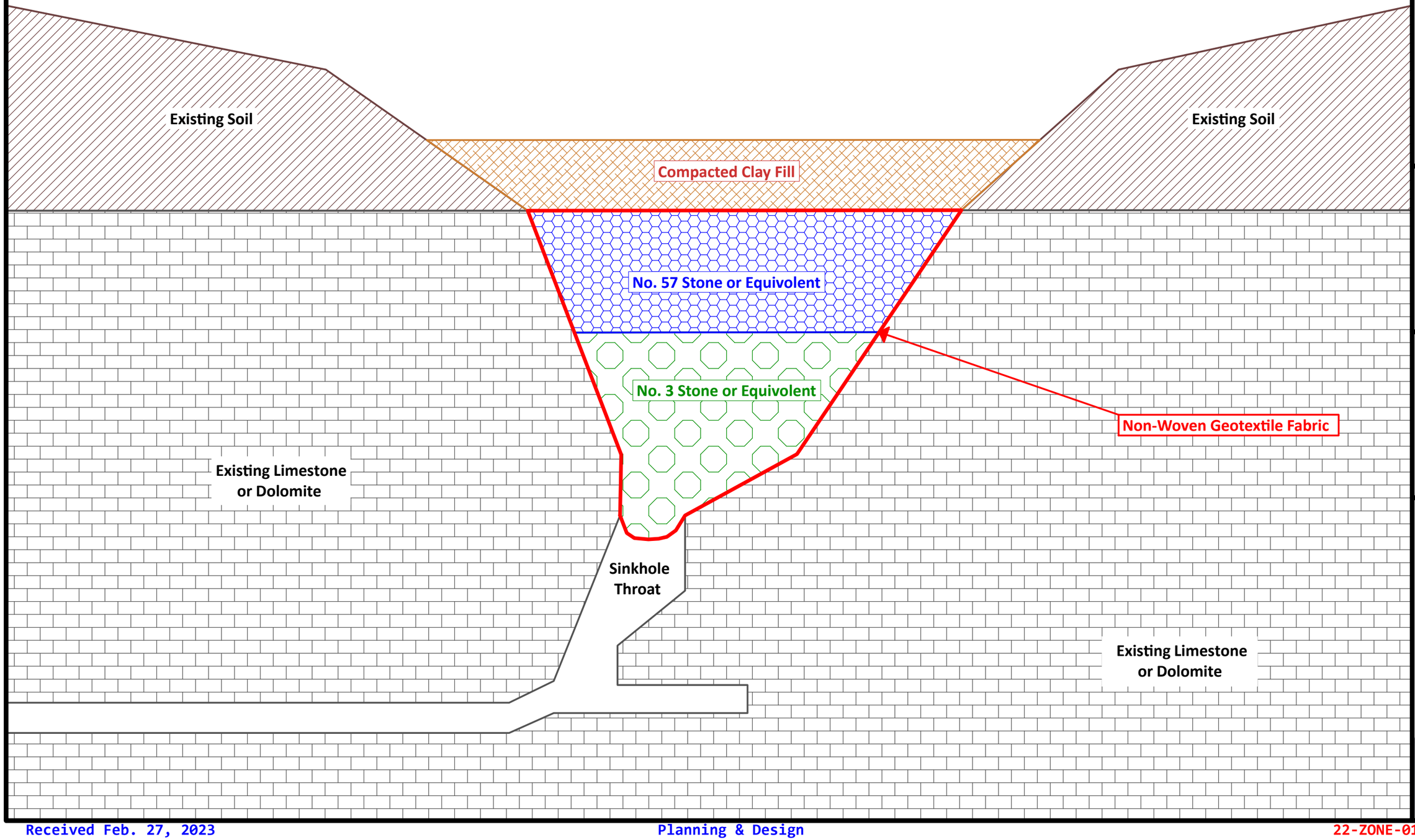
Photo 33: View of a drainage swale typically encountered throughout the southern portion of the site, directed towards the central stream directed south.

Photo 34: View of the central stream from the southern property boundary.

Photo 35: View of debris piles typically encountered in the southern portion of the site, near the existing cleared access paths.

Photo 36: View of dense brush encountered throughout the site that could obscure potential karst features or indications of slope instability from view.

Note: Not for construction - specific remediation for each sinkhole must be recommended by ECS Southeast, LLP at the time of remediation. See "Sinkhole Remediation Guidelines" in the report.




Typical Sinkole Remediation Diagram
Slope Evaluation and Karst Survey - 2405 Echo Trail
2405 Echo Trail
Louisville, Jefferson County Kentucky 40425

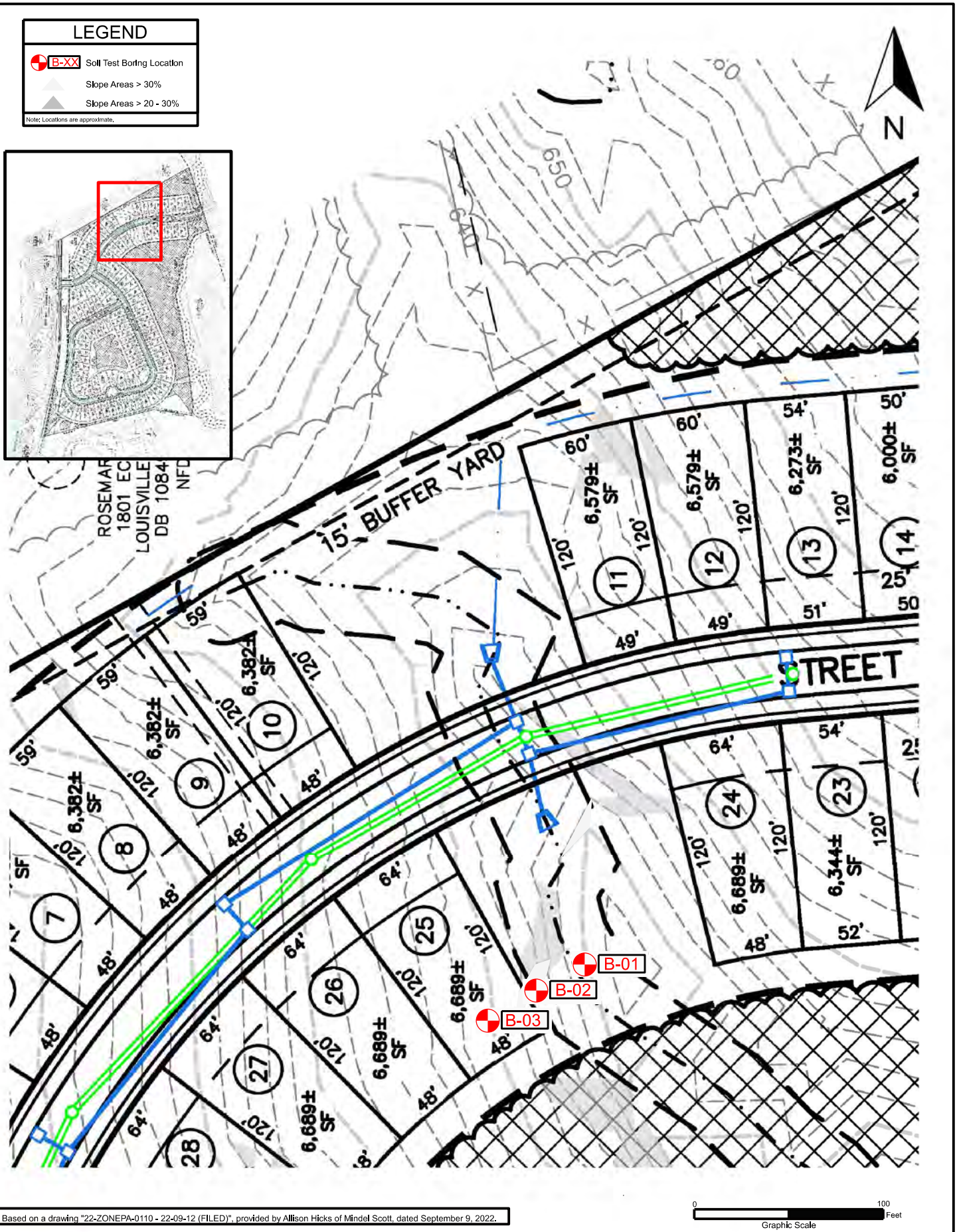
Drawn By: BEK
Checked By: FEN
Scale: As Shown

Project No.: 61-2863
Drawing No.: 2863 BLP
Date: 11/21/2022

ECS Southeast, LLP
1762 Watterson Trail
Louisville, Kentucky 40299
Tel. (502) 493-7100

# APPENDIX C – Slope Exploration

Boring Location Diagram
Soil & Rock Classification
Boring Legend
Boring Records
Boring Composite
Field Procedures
Laboratory Procedures

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Louisville, Kentucky 40299
Tel. (502) 493-7100

# Boring Location Diagram

Preliminary Slope Evaluation and Karst Survey - 2405 Echo Trail

2405 Echo Trail
Louisville, Jefferson County, Kentucky 40245

| | |
|---|---|
| DRAWN BY | BEK |
| APPROVED BY | FEN |
| PROJECT NO. | 61-2863 |
| DATE | 11-14-2022 |

# ECS Southeast, LLP

# SOIL & ROCK CLASSIFICATION

## SOIL CLASSIFICATION

| MAJOR DIVISIONS | | | SYMBOLS | TYPICAL DESCRIPTIONS |
|---|---|---|---|---|
| COARSE GRAINED SOILS<br>MORE THAN 50% OF MATERIAL IS LARGER THAN NO. 200 SIEVE | GRAVEL AND GRAVELLY SOILS | Clean Gravels | GW | Well graded gravels, gravel-sand mixtures, 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 |
| | | | GC | Clayey gravels, gravel-sand-clay mixtures |
| | SAND AND SANDY SOILS | Clean Sands | SW | Well graded sands, gravelly sands, little or no fines |
| | | | SP | Poorly graded sands, gravelly sand, little or no fines |
| | | Sands with fines | SM | Silty sands, sand-silt mixtures |
| | | | SC | Clayey sands, sand-clay mixtures |
| FINE GRAINED SOILS<br>MORE THAN 50% OF MATERIAL IS SMALLER THAN NO. 200 SIEVE | SILTS AND CLAYS | Liquid Limit less than 50 | ML | Inorganic silts, silty or clayey fine sands or clayey silts with slight plasticity |
| | | | CL | Inorganic clays of low to moderate plasticity, gravelly clays, sandy clays, silty clays, lean clays |
| | | | OL | Organic silts and organic silty clays of low plasticity |
| | SILTS AND CLAYS | Liquid Limit greater Than 50 | MH | Inorganic silts, micaeceous or diatomaceous fine sand or silty soils |
| | | | CH | Inorganic clays of high plasticity |
| | | | OH | Organic clays of moderate to high plasticity, organic silts |
| HIGHLY ORGANIC SOILS | | | PT | Peat, humus, swamp soils with high organic contents |

## SOIL CONSISTENCY

SPT N: Standard Penetration Test N-Value  $N^1$ – Manual Hammer (Rope & Pulley - 60% Efficiency)  $N^2$ – Automatic Hammer (Free-Fall - 96% Efficiency)

| COARSE GRAINED SOILS | | |
|---|---|---|
| SPT $N^1$ | SPT $N^2$ | Relative Density |
| 0-4 | 0-3 | Very loose |
| 4-10 | 3-6 | Loose |
| 10-30 | 6-19 | Medium dense |
| 30-50 | 19-31 | Dense |
| > 50 | > 31 | Very dense |

| FINE GRAINED SOILS | | |
|---|---|---|
| SPT $N^1$ | SPT $N^2$ | Field Identification |
| 0-2 | 0-1 | Very soft – Easily penetrated several inches by fist |
| 3-4 | 2-3 | Soft – Easily penetrated several inches by thumb |
| 5-7 | 3-4 | Firm – Can be penetrated several inches by thumb with moderate effort |
| 8-15 | 5-9 | Stiff – Readily indented by thumb but penetrated only with great effort |
| 16-30 | 10-19 | Very stiff – Readily indented by thumbnail |
| > 30 | > 19 | Hard – Indented with difficulty by thumbnail |

## SOIL PARTICLE SIZES

| Description | Size Limits | Familiar Example |
|---|---|---|
| Boulder | 12 inches or more | Larger than basketball |
| Cobble | 3 - 12 inches | Orange to basketball |
| Coarse gravel | ¾ - 3 inches | Grape to orange |
| Fine gravel | 4.75 mm (No. 4 sieve) - ¾ inch | Pea to grape |
| Coarse sand | 2-4.75 mm (No. 10 to 4 sieve) | Rock Salt |
| Medium sand | 0.42-2 mm (No. 40 to 10 sieve) | Table Salt |
| Fine sand | 0.075-0.42 mm (No. 200 to 40 sieve) | Powdered sugar |
| Silt/Clay/Fines | Less than 0.075 mm (No. 200) | Not visible to naked eye |

## RELATIVE PROPORTIONS

| Description | Percent |
|---|---|
| Trace | 1-5 |
| Few | 5-15 |
| Little | 15-30 |
| Some | 30-50 |
| Mostly | 50-100 |

## ROCK CONTINUITY

| Description | Core Recovery (%) |
|---|---|
| Incompetent | 0-40 |
| Competent | 40-70 |
| Fairly Continuous | 70-90 |
| Continuous | 90-100 |

## ROCK QUALITY DESIGNATION

| Description | RQD (%) |
|---|---|
| Very Poor | 0-25 |
| Poor | 25-50 |
| Fair | 50-75 |
| Good | 75-90 |
| Excellent | 90-100 |

## ROCK BEDDING

| Description | Thickness (in) |
|---|---|
| Parting | < 0.3 |
| Band | 0.3-2.5 |
| Thin Bed | 2.5-6.0 |
| Medium bed | 6.0-12.0 |
| Thick bed | 12.0-36.0 |
| Massive | > 36.0 |

## ROCK HARDNESS (Descriptions for rock core samples)

| Description | Definition |
|---|---|
| Very soft | Can be broken with fingers |
| Soft | Can be scratched with fingernail; only edges can be broken with fingers |
| Moderately hard | Can be easily scratched with knife; cannot be scratched with fingernail |
| Hard | Difficult to scratch with knife; hard hammer blow to break specimen |
| Very hard | Cannot be scratched with knife; several hard hammer blows to break specimen |

## ROCK WEATHERING (Descriptions for rock core samples)

| Description | Definition |
|---|---|
| Completely | Rock decomposed to soil; rock fabric and structure completely destroyed |
| Highly | Most minerals are decomposed; texture indistinct but fabric preserved; strength greatly reduced |
| Moderately | Discoloration throughout and weaker minerals decomposed; texture preserved but strength less than unweathered rock |
| Slightly | Discoloration around open fractures; strength preserved |
| Unweathered | No sign of decomposition |

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# BORING RECORD LEGEND

| Scale, ft. | Elevation, ft. | Soil Symbol | Material Description and Classification | Depth, ft. | Sample Type | Sample Depth, ft. | Recovery, % | DCP Penetration Test Blows | Ne Value | Water Content, % | Uc, tsf | Comments |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | TOPSOIL | | | | | | | | | |
| | | | | 1.0 | | | | | | | | |
| | | | Low Plasticity Clay (CL) | | | | | | | | | |
| | | | | 2.0 | | | | | | | | |
| | | | Moderate to High Plasticity Clay (CH) | | | | | | | | | |
| 2.5 | | | | | | | | | | | | |
| | | | | 3.0 | | | | | | | | |
| | | | Abbreviations<br>ATD - At the Time of Drilling<br>HA - Hand Auger<br>DCP - Dynamic Cone Penetrometer | | | | | | | | | |
| | | | Notes<br>Dashed lines indicate an estimated or gradual strata change.<br>Solid lines indicate a more precise, measured depth value. | | | | | | | | | |
| 5.0 | | | | | | | | | | | | |
| | | | Dynamic Cone Penetrometer | | | 5.5 - 6.5 | | | | | | |
| | | | Shelby Tube | | | 7.0 - 8.0 | | | | | | |
| 7.5 | | | | | | | | | | | | |

**Scale** - Proportional distance below the surface.

**Elevation** - Vertical distance above or below a benchmark.

**Soil Symbol** - Graphic representation of subsurface material.

**Material Description** - Account of encountered materials based on ASTM D-2488.

**Depth** - Distance below the surface to a strata as measured in the field.

**Sample Type** - Method for collecting soil or rock specimens.

**Sample Depth** - Collected specimen interval.

**Recovery** - Percentage of recovered sample material.

**DCP Penetration Test Blows** - Number of blows to drive a dynamic cone penetrometer three 1.75" increments with a 15-lb. hammer falling 20".

**Ne Value** - Number of blows to drive the dynamic cone penetrometer the final foot. These blow counts have not been corrected for hammer efficiency or other applicable factors. The manual hammer, if used, has an estimated efficiency of 60%. The automatic hammer, if used, has an estimated efficiency of 96%.

**Water Content** - The weight of water divided by the weight of oven dried soil, expressed as a percentage.

**Uc** - Unconfined compressive strength, as determined by a pocket penetrometer.

**Comments** - Pertinent comments about the conditions encountered.

Remarks: Additional infomation about the surface, subsurface, or other conditions that could impact the exploration results.

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# BORING RECORD

| | | | | | |
|---|---|---|---|---|---|
| Project Name | **Slope Evaluation and Karst Survey - 2405 Echo Trail** | | | Boring No. | B-01 |
| Location | **2405 Echo Trail, Louisville, KY 40425** | | | Project No. | 61-2863RI |
| Client | **Long Run Creek Properties, LLC** | | | Elevation | 618 (a) |
| Driller | B. Emery/B. Kabbes | Rig Type | DCP | Started | 11/03/2022 |
| Drill Method | Hand Auger | Hammer Type | Manual | Completed | 11/03/2022 |
| Groundwater | Not Encountered ATD | | | Logged By | B. Kabbes |
| | | | | Weather | 60s, Sunny |

| Scale, ft. | Elevation, ft. | Soil Symbol | Material Description and Classification | Depth, ft. | Sample Type | Sample Depth, ft. | Recovery, % | DCP Penetration Test Blows | Ne Value | Water Content, % | Uc, tsf | Comments |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | TOPSOIL (4 inches), with trace rock fragments | | | 0.0 - 0.4 | | 4-4-6 | 5 | | | |
| | | | | 0.3 | | | | | | | | |
| | | | CLAY, silty, sandy, orange to medium brown, low plasticity, firm, very moist to wet, (CL), with trace root fibers | | | | | | | | | |
| | | | - mostly rock fragments below 0.8 feet | | | | | | | | | Hand Auger Refusal encountered approximately 0.8 feet below existing grade. |
| 1 | 617 | | | 1.0 | | 1.0 - 1.0 | | 25/1" | 25/1" | | | |
| | | | Boring Terminated at Drive Rod Refusal | | | | | | | | | |
| 2 | 616 | | | | | | | | | | | |
| 3 | 615 | | | | | | | | | | | |
| 4 | 614 | | | | | | | | | | | |

Remarks: (a) Ground surface elevations interpolated to ± 1.0 feet based on a drawing "22-ZONEPA-0110 - 22-09-12 (FILED)", provided by Allison Hicks of Mindel Scott, dated September 9, 2022.

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# BORING RECORD

| | | | | | |
|---|---|---|---|---|---|
| Project Name | **Slope Evaluation and Karst Survey - 2405 Echo Trail** | | | Boring No. | B-02 |
| Location | **2405 Echo Trail, Louisville, KY 40425** | | | Project No. | 61-2863RI |
| Client | **Long Run Creek Properties, LLC** | | | Elevation | 623 (a) |
| Driller | B. Emery/B. Kabbes | Rig Type | DCP | Started | 11/03/2022 |
| Drill Method | Hand Auger | Hammer Type | Manual | Completed | 11/03/2022 |
| Groundwater | Not Encountered ATD | | | Logged By | B. Kabbes |
| | | | | Weather | 60s, Sunny |

| Scale, ft. | Elevation, ft. | Soil Symbol | Material Description and Classification | Depth, ft. | Sample Type | Sample Depth, ft. | Recovery, % | DCP Penetration Test Blows | Ne Value | Water Content, % | Uc, tsf | Comments |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | TOPSOIL (2 inches) | | | | | | | | | |
| | | | | 0.2 | | | | | | | | |
| | | | CLAY, silty, yellow to medium brown, low plasticity, firm, dry, (CL), with few root fibers | | | 0.0 - 0.4 | | 7-4-6 | 5 | | | Two borings were extended at approximately 1 foot spacing. DCP testing was performed in one boring while an undisturbed sample was collected in the adjacent boring. A drive rod was offset an additional 1 foot and driven to refusal. |
| 1 | 622 | | | | | | | | | | | |
| | | | | | | 1.0 - 1.5 | 66 | 10-25/1" | 25/1" | 14.6 | | DCP Refusal was encountered at approximately 1.2 feet below existing grade. |
| | | | - mostly weathered rock fragments below 1.6 feet | | | | | | | | | Undisturbed sample was obtained from approximately 1.0 to 1.5 feet below existing grade. |
| 2 | 621 | | | | | | | | | | | |
| | | | | | | | | | | | | Hand Auger Refusal was encountered at approximately 1.5 feet below existing grade. |
| | | | | | | | | | | | | Liquid Limit: 46<br>Plastic Limit: 20<br>Plasticity Index: 26 |
| 3 | 620 | | | | | | | | | | | |
| | | | | 3.5 | | | | | | | | |
| | | | Boring Terminated at Drive Rod Refusal | | | | | | | | | |
| 4 | 619 | | | | | | | | | | | |

Remarks: (a) Ground surface elevations interpolated to ± 1.0 feet based on a drawing "22-ZONEPA-0110 - 22-09-12 (FILED)", provided by Allison Hicks of Mindel Scott, dated September 9, 2022.

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# BORING RECORD

| | | | | | |
|---|---|---|---|---|---|
| Project Name | **Slope Evaluation and Karst Survey - 2405 Echo Trail** | | | Boring No. | B-03 |
| Location | **2405 Echo Trail, Louisville, KY 40425** | | | Project No. | 61-2863RI |
| Client | **Long Run Creek Properties, LLC** | | | Elevation | 630 (a) |
| Driller | B. Emery/B. Kabbes | Rig Type | DCP | Started | 11/03/2022 |
| Drill Method | Hand Auger | Hammer Type | Manual | Completed | 11/03/2022 |
| Groundwater | Not Encountered ATD | | | Logged By | B. Kabbes |
| | | | | Weather | 60s, Sunny |

| Scale, ft. | Elevation, ft. | Soil Symbol | Material Description and Classification | Depth, ft. | Sample Type | Sample Depth, ft. | Recovery, % | DCP Penetration Test Blows | Ne Value | Water Content, % | Uc, tsf | Comments |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | TOPSOIL (4 inches) | | | | | | | | | |
| | | | | 0.3 | | 0.0 - 0.4 | | 6-8-11 | 9 | | | Two borings were extebded at approximately 1 foot spacing. DCP testing was performed in one boring while an undisturbed sample was collected in the adjacent boring. A drive rod was offset an additional 1 foot and driven to refusal. |
| | | | CLAY, silty, yellow to medium brown, low plasticity, stiff, dry, (CL), with few root fibers | | | | | | | | | |
| 1 | 629 | | | 1.0 | | | | | | | | |
| | | | CLAY, silty, orange to medium brown, moderate to high plasticity, hard, dry to slightly moist, (CH), with few root fibers and weathered rock fragments | | | | | | | | | Undisturbed sample was obtained from approximately 1.0 to 2.0 feet below existing grade. |
| | | | | | | 1.0 - 2.0 | 88 | 10-15-21 | 18 | 23.1 | | Hand Auger Refusal was encountered at approximately 1.8 to 1.9 feet below existing grades. |
| 2 | 628 | | - mostly weathered rock fragments below 1.8 feet | | | | | | | | | Liquid Limit: 76<br>Plastic Limit: 27<br>Plasticity Index: 49 |
| 3 | 627 | | | | | | | | | | | |
| | | | | 3.8 | | | | | | | | |
| 4 | 626 | | Boring Terminated at Drive Rod Refusal | | | | | | | | | |

Remarks: (a) Ground surface elevations interpolated to ± 1.0 feet based on a drawing "22-ZONEPA-0110 - 22-09-12 (FILED)", provided by Allison Hicks of Mindel Scott, dated September 9, 2022.

# ECS Southeast, LLP

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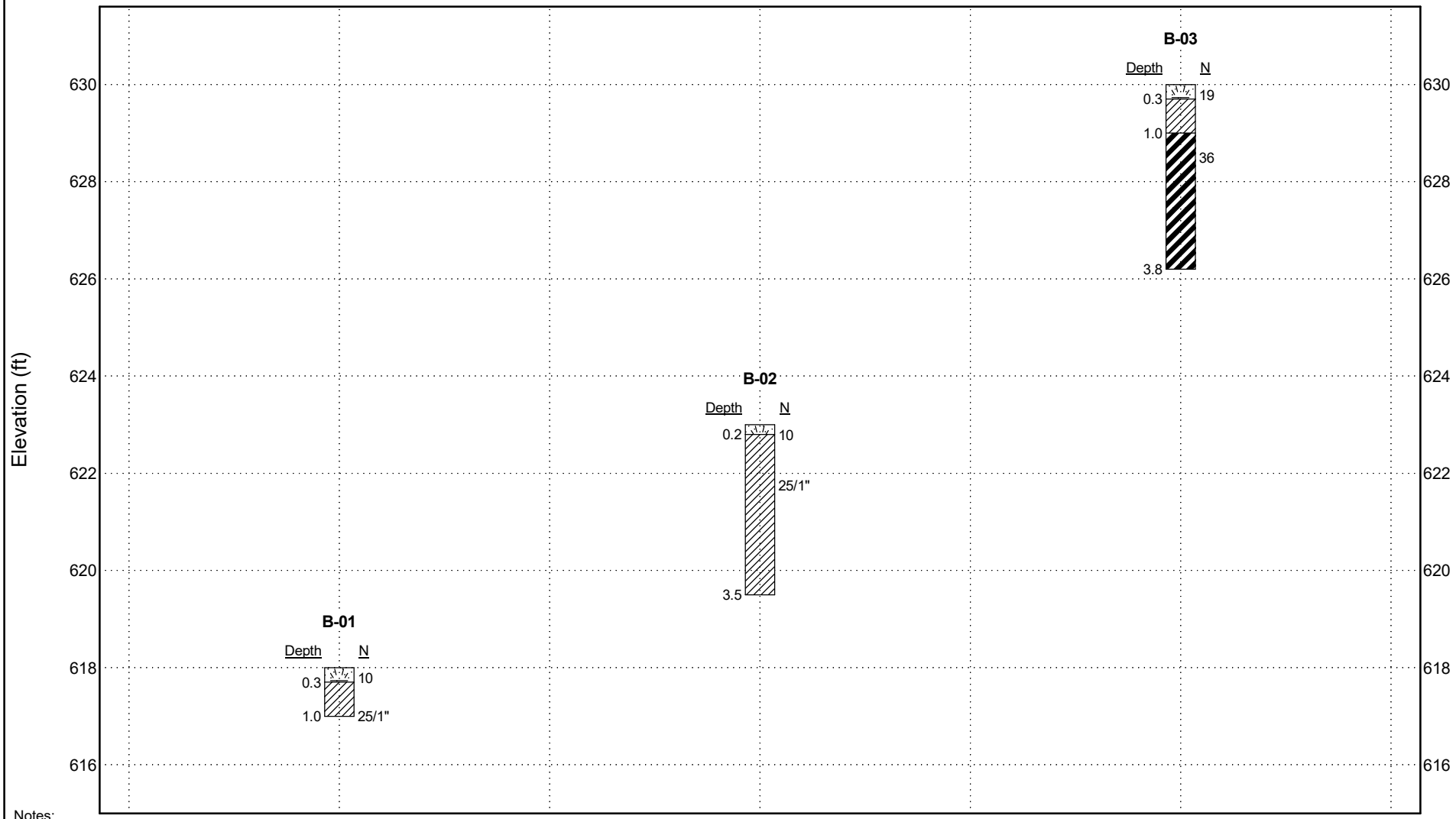
## BORING COMPOSITE - Revision I

**CLIENT** Long Run Creek Properties, LLC

**PROJECT NAME** Slope Evaluation and Karst Survey - 2405 Echo Trail

**PROJECT NUMBER** 61-2863RI

**PROJECT LOCATION** 2405 Echo Trail, Louisville, KY 40425




Notes:
Ground surface elevations interpolated to ± 1.0 feet based on a drawing "22-ZONEPA-0110 - 22-09-12 (FILED)", provided by Allison Hicks of Mindel Scott, dated September 9, 2022.

Location of borings along the horizontal axis are not indicative of actual spacing

# Field Procedures

**General**

ECS conducts field sampling and testing procedures in general accordance with methods of the American Society for Testing Materials (ASTM) and widely accepted geotechnical engineering standards. A brief description of the procedures we utilize is provided in the following paragraphs.

**Boring Locations and Elevations**

Boring locations typically are selected by our project manager. The project manager establishes the boring locations in the field by pacing or measuring distances and estimating angles relative to existing site landmarks. When topographic plans of the site are provided, the project manager estimates the surface elevation of the boring locations using available information. Surveying to determine the locations and elevations of the borings is beyond the scope of typical geotechnical studies; therefore, the boring locations and elevations should be considered approximate.

**Dynamic Cone Penetrometer Tests (ASTM STP-399)**

The Dynamic Cone Penetrometer (DCP) uses a 15 lb (6.8 kg) steel mass falling 20 in (50.8 cm) that strikes an anvil to cause penetration of a 1.5 in (3.8 cm) diameter cone (45° vertex angle) that has been seated in the bottom of a hand augered hole. The blows required to drive the embedded cone a depth of 1-3/4 in have been correlated to N values derived from the Standard Penetration Test (SPT). Experience has shown that the DCP can be used effectively in augered holes to depths of 15 to 20 ft. (4.6 to 6.1 m).

**Boring Records**

Our interpretation of the conditions encountered at each location is indicated on the **Boring Records**, which are prepared from the observations of the ECS field engineer or geologist during drilling or excavation, our engineering review of the soil samples obtained, the results of laboratory testing on selected samples, and our experience with similar subsurface conditions. Soil descriptions are made using the Unified Soil Classification System and/or ASTM D-2488 as guides. The depths designating strata changes are estimations and only representative of depths at that specific boring location. In many geologic settings, the transition between strata is gradual. A **Boring Legend**, which defines the symbols and other pertinent information presented on the **Boring Records**, is provided with this report. The subsurface conditions indicated on our **Boring Records** represent only the conditions encountered at the specific boring location at the time of our exploration. The groundwater observations were made at the time of drilling and may vary with changes in the season and weather.

**Refusal**

Refusal is the term applied to material that cannot be penetrated with augers or has a standard penetration resistance exceeding 50 blows per 6-inch increment. Refusal may be encountered on continuous bedrock, discontinuous floaters, cemented soil, weathered rock, debris, buried structures, or other hard subsurface materials. Refusal materials can be evaluated only by obtaining a core of the material. This limitation must be considered when evaluating refusal depths where coring is not conducted.

# Laboratory Procedures

**General**

Laboratory tests are generally conducted to satisfy one or more of the following objectives: (1) confirmation of visual-manual soil identification; (2) determination of index values used to estimate soil engineering properties (i.e., strength, compressibility and permeability); or (3) direct measurement of specific soil properties. The tests selected for a given project are dependent on the subsurface conditions encountered, as well as specific project requirements, such as structural loads and planned grade changes. The results of the laboratory tests conducted for this project are listed on the **Boring Records**, Laboratory Test Data Summary, or laboratory data curves in the **Appendix**. Brief descriptions of the test procedures are provided below.

**Description and Identification of Soils (Visual-Manual Procedure) (ASTM D 2488)**

The Visual-Manual Procedure provides a general guide to the engineering properties of soils and enables the engineer to apply past experience to current situations. Samples obtained during the field exploration are examined and visually described and identified by a geotechnical engineer or geologist. The soils are typically identified according to predominant particle size (clay, silt, sand, etc.), consistency (based on apparent stiffness and the number of blows from standard penetration tests), color, moisture and group symbol (CL, CH, SP, SC, etc.). Unless otherwise indicated, the soil descriptions in this report are based on the Visual-Manual Procedure.

**Classification of Soils for Engineering Purposes (Unified Soil Classification System) (ASTM D 2487)**

The Visual-Manual Procedure described above is primarily qualitative. The Unified Soil Classification System (USCS) is used when precise soil classification is required. The USCS is based on laboratory determination of particle-size characteristics, liquid limit, and plasticity index. Using these test results, the soil can be classified according to the Unified Classification System, which provides an index for estimating soil behavior.

**Water (Moisture) Content of Soil (ASTM D 2216)**

Moisture content is one of the most important index properties used in establishing a correlation between soil behavior and soil properties such as strength and compressibility. The moisture content, along with the liquid and plastic limits, are used to express the relative consistency or liquidity index of a soil. Increasing moisture contents typically reflect lower strengths for a given soil. The soil moisture content is the ratio, expressed as a percentage, of the mass of “pore” or “free” water in a given mass of soil to the mass of the solid soil. Moisture content samples are taken from the sealed container obtained during the field exploration phase of a project. Each sample is weighed, and then placed in an oven set to 110°C + 5°C. Each sample remains in the oven until the free moisture evaporates. Each dried sample is removed from the oven, allowed to cool, and then weighed. The moisture content is computed by dividing the weight of evaporated water by the weight of the dry sample.

**Liquid Limit, Plastic Limit, and Plasticity Index of Soils (ASTM D 4318)**

Depending upon the relative moisture content, a fine-grained soil may occur in a liquid, plastic, or solid state. In current usage, the liquid limit (LL) and plastic limit (PL) of a soil are referred to as the “Atterberg Limits”, which establish the approximate moisture contents at which the soil changes state. This test method is an integral part of several engineering classification systems to characterize the fine grained fractions of soils. It is also used with other soil properties to correlate with engineering behavior such as compressibility, permeability, compactability, shrink-swell, and shear strength. The liquid limit is the moisture content at which a soil becomes sufficiently "wet" to behave as a heavy viscous fluid (i.e., transition from plastic to liquid state). It is defined as the moisture content at which the soil, when placed in a standard brass bowl, makes a 1/2-inch closure in a groove cut through the soil after the bowl is dropped 25 times at a specified height and rate. The plastic limit is the moisture content at which the soil begins to lose its plasticity (i.e., transition from plastic to semi-solid state). It is defined as the lowest moisture content

at which the soil can be rolled into 1/8-inch diameter threads without crumbling. The plasticity index (PI) is the difference between the liquid limit and the plastic limit, and is the range of moisture content over which a soil deforms as a plastic material.

**Pocket Penetrometer**

The pocket penetrometer is a hand-held, spring-loaded rod that measures the penetration resistance of soil. It is used to gauge the approximate unconfined compressive strength of cohesive soils. The strength is measured by applying pressure to the end of the penetrometer thereby pushing the rod tip a prescribed distance into the soil. The unconfined compressive strength is read directly from a scale or gauge on the device.