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March 13, 2026

Montgomery County Engineering (MCE)
c/o Mr. Jordan Wyman
Commonwealth Development Group, Inc. (CDG)
25 Jefferson Street, Suite 200-F
Clarksville, Tennessee 37075

RE: Report of Consulting Engineering Services
Dunlop Lane Geophysical Study
Clarksville, Montgomery County, Tennessee
TTL Project No. 26-08-00220

TTL, Inc. (TTL) is pleased to submit this report summarizing our consulting engineering services for the evaluation of a sinkhole located near Dunlop Lane in Clarksville, Tennessee. These services were performed in general accordance with our proposal dated January 27, 2026, and authorized by Mr. Wyman on behalf of MCE on February 1, 2026.

The purpose of this report is to document our understanding of the site conditions and to summarize our field observations and non-invasive geophysical testing. Our conclusions and opinions are based on site observations, seismic refraction testing results, available background information, and our experience with similar sinkhole features in karst terrain.

We appreciate the opportunity to be of service to Montgomery County Engineering during this phase of the project. Please contact us if you have any questions regarding this report or if additional services are needed.

Respectfully submitted,

TTL, Inc.

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REGISTERED ENGINEER
AGRICULTURE
COMMERCE
No. 00106627
STATE OF TENNESSEE
3/13/2026

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Attachments

CONTENTS

1.0 PROJECT INFORMATION

1.1 Project Description

The project consists of consulting engineering services for the evaluation of an existing stormwater management area located southeast of an intersection with Rollow Lane and Dunlop Lane in Clarksville, Montgomery County, Tennessee. The study area (site) consists of the stormwater management area (pond) part of an existing development which is about 3 acres in size. We understand plans are being considered to construct a new injection well within the limits of the stormwater management area to assist with drainage.

1.2 Authorization and Scope

The project was authorized by Montgomery County Engineering and performed in general accordance with our proposal dated January 27, 2026. The scope of services included geophysical exploration within the limits of the existing stormwater management pond, consisting of observations of site conditions and performing non-invasive seismic refraction testing, interpreting the results to infer the approximate boundaries between soil overburden and bedrock below the arrays and preparing supporting drawings.

The scope of services did not include invasive exploration, laboratory testing, or the preparation of detailed plans and specifications for remedial repairs.

2.0 EXPLORATION FINDINGS

2.1 Site Conditions

Item	Description
Site Location	The site is located southeast of Dunlop Lane and Grace Community Church and northeast of the Farmington subdivision (single family residential development) in Clarksville Tennessee. Access to the site is provided from Bluebriar Trace (road) east part of the site. A Site Location Map is provided in the Appendix for reference.
Existing Conditions	Ground cover consisted primarily of dried grass, bare soil, and weeds, along the margins, with scattered medium-diameter trees. Our site visits were completed during winter months and snow and ice were sometimes present. Standing water was present within a ponded area on the northern portion of the study area and in a depression near the access road on the east of the site.
Existing Topography	The ground surface was relatively flat through the central portion of the study area, with about 4 feet of local relief. Additional relief occurs along the hillsides on the north and northeast margins, bringing the total change in elevation to roughly 12 feet with those areas included.
Other	Three potential karst features, depressions, were encountered at the site during our field activities (reference Section 2.2 below).

Photographs of the site during our visit are provided below.

View looking northwest from near the southeast part of the study area

View looking south from near the northwest part of the study area

View looking west from east part of the study area. Depression SH-01 also visible on the right

2.2 Karst Features

We observed features possibly related to karst in three low areas within the study area. The table below includes a brief description of the features. Photographs of some of the features are provided after the table. The approximate location of the features are included on the Exploration Location Plan (ELP) in Appendix A.

Feature ID	Approximate Coordinates[1]	Description
SH-01	36.5751 N, 87.2263 W	approximately 5 feet by 10 feet with no obvious open throat observed. The feature was approximately 3 feet deep and contained about 2 feet of water.
SH-02	36.5753 N, 87.2265 W	approximately 30 feet in diameter and 2-to 3-foot deep, containing about 6 inches of water at the time of observation. No open throat was visible.
SH-03	36.5753 N, 87.2268 W	approximately 4 feet in diameter about 2 feet deep, with no open throat observed. Water was not present.
[1] Coordinates obtained using a recreational grade hand-held GPS unit and should be considered approximate		

View looking at depression SH-01

View looking at depression SH-02

View looking at depression SH-03

2.3 Site Geology

The Geologic Map of the Sango Quadrangle (Tennessee Division of Geology, dated 1985) shows the site is underlain by the St. Louis Limestone Formation. This formation is typically a light olive to dark gray, very fine to medium grained, medium to thick bedded, fossiliferous limestone containing numerous chert stringers and nodules. Residual soil formed by the in-place solution weathering of the parent limestone formation normally consists of reddish-brown silty clay of low to moderate plasticity with occasional zones of high plasticity. Often bands of partially and unweathered chert exist within the overburden soil. The soil/bedrock contact is often irregular with soil slots extending into the bedrock unit and more resistant rock pinnacles protruding into the soil zone. This formation is susceptible to solution weathering and sinkhole development.

Limestone is susceptible to solution weathering and sinkhole development. The site is found within a series of closed mapped topographic depressions, which may be associated with sinkholes. In addition, we encountered three depressions possibly related to karst on the site during our field activities as discussed above (Section 2.2).

2.4 Seismic Refraction Profiles

We used a grid of seismic refraction tests to check for indications of subsurface anomalies across the property. This geophysical method is described in ASTM D5777 and is a noninvasive means of gathering information about the depth of soil overburden and the relative competency of the underlying bedrock directly below the test arrays. We performed eight individual refraction tests across the site. The arrays overlapped with one another and were processed into six lines. The approximate locations, orientations, and identifying labels for the array lines are shown on the ELP in the Appendix.

The lines were comprised of at least one or two individual arrays aligned colinearly in either north or east directions. The arrays overlapped at least 40 feet with adjacent arrays to provide some redundancy in the measurement and assist with interpretation of subsurface conditions along the array lines.

Each test consisted of measuring the travel times of seismic compression waves, called P-waves, emanating from impact locations on the ground surface to 12 vibration sensors, called geophones, arranged along a linear array. After setting up 12 geophones, a sledgehammer was used to impact a strike-plate on the ground surface at seven strike-point locations within and beyond the ends of the linear array of geophones. At least five impacts were recorded and averaged for each strike point to reduce noise and enhance the seismic signals at the geophones. The geophone spacing was 20 feet, resulting in an overall array length of 240 feet (includes distance between strike points and the ends of the array). This configuration of geophones should be capable of resolving subsurface features as small as about 20 feet, or larger, but smaller features could exist that may not be resolved.

The measured field data for each array were analyzed to pick first-arrival times of seismic energy at each geophone in an array for every strike location. A computer model of the two-dimensional subsurface P-wave velocity profile was created and adjusted until the arrival times predicted by the model closely matched the measured arrival times. The subsurface velocity profile producing the best match, in terms of least squares of error, was selected as the representative velocity profile for the array. The subsurface velocity profile for each array is therefore not unique, and there could be other velocity profiles producing arrival times matching the measured data. Processing refraction array data also assumes the P-wave velocity of subsurface materials stays the same or increases with increasing depth below the array, such that refraction testing cannot identify zone of lower-velocity materials (like soil) below higher-velocity materials (like rock). Consequently, refraction cannot necessarily identify layers of less weathered bedrock or layers of denser chert stringers within a soil zone and it cannot identify open or partly-filled voids (like caves or slots) within the bedrock below the site (unless, perhaps, the features are very large).

Seismic refraction testing produced subsurface profiles of variable seismic velocities below the arrays. The seismic velocities represented on the profiles, which are shown in the Appendix, are velocities of P-waves moving through the subsurface. The P-wave velocity of a material can be correlated with material type. In general, soil materials have slower P-wave velocities than harder, denser materials like bedrock. The transitional materials between soil and bedrock have intermediate P-wave velocities. The correlation between velocity and material type varies and is affected by many factors, including consistency (strength, stiffness, density of the material), unit weight, and presence or absence of groundwater. We interpreted the refraction profiles using the approximate correlation between P-wave velocity and generalized subsurface material type shown in the table below. This correlation is based on our experience, but actual depths of soil, weathered rock, and bedrock may vary because we did not have site-specific boring data with which to refine our interpretations.

Color Range	P-Wave Velocity Range (ft/s)	Inferred Subsurface Material
Violet to Green	1,000 to 5,000	Soil Overburden
Green	5,000 to 6,000	Transitional Soil/Weathered Bedrock Zone
Green to Red	> 6,000	Competent Bedrock

The velocity profile for each array line is included in the Appendix. We used a P-wave velocity of 5,000 fps to represent the approximate boundary between soil/weathered rock and competent bedrock on each of the array lines measured. Using this criterion, the refraction profiles show the depths of soil and weathered rock overburden above competent bedrock appear irregular and vary between about 15 feet and 40 feet below existing grades. The arrays were surveyed, and we interpolated the ground surface elevations along each array based on available 2-foot topographic contours across the site from publicly available Tennessee LiDAR and used the interpolated elevations to approximate the elevations of the inferred top of rock along each array line. Depending on location across the site, the top of rock elevations indicated by the refraction results ranged from about 430 feet to about 464 feet.

2.5 Interpretation of Refraction Profiles

We overlaid the apparent bedrock elevations indicated by individual velocity profiles according to their colinear alignments and orientations to compare the inferred bedrock elevations along the profile lines. In some places the bedrock elevations inferred for intersecting array lines were in good agreement, while in other locations the bedrock elevations were more than several feet (up to 5 feet) apart. We resolved these differences by first reviewing data from each array line and removing outlier bedrock elevations that were not consistent with data from adjacent array lines and then by averaging remaining individual rock elevations that appeared reasonable. We then used these interpreted data points to define the bedrock surface below the site and generated a plan view showing a topographic contour drawing representing the top of bedrock below the site. The contour drawing used contour intervals of 2 feet. The topographic contour drawing representing our interpretation of the competent bedrock surface below the site is shown on the “Bedrock Surface” drawing in the Appendix.

We compared the Bedrock Surface topographic contours with the ground surface topographic contours to generate a plan view showing the inferred depths to competent bedrock below the ground surface. The illustration is called “Bedrock Depths” in the Appendix and provides a “heat map” of approximate bedrock depths. This drawing allows the following generalized conclusions regarding the apparent bedrock surface below the site.

- Bedrock depths are closer to the surface approaching the berm on the north part of the study area and bedrock depths drop to their lowest points towards the north central part of the study area
- In general, bedrock appears to be less than 50 feet below grade, but not shallower than about 15 feet. The boundary between the yellow color and the green color on the “Bedrock Depths” in the Appendix drawing represents a depth of about 40 feet below ground surface.

- The bedrock surface appears to be undulated across the site. Line-04 appears to be especially undulated and dips lowest between Line-02 and Line-06 where nearby surface depressions were observed.

3.0 INJECTION WELL CONSIDERATIONS

Based on the geophysical results and observed site conditions, we understand the Client intends to install one or more injection wells to help manage stormwater at the site. While final placement should be confirmed through supplemental invasive exploration and regulatory review, the middle portion of the study area appears to offer favorable conditions for an injection well. This area corresponds to relatively shallow inferred bedrock and more defined topographic relief, which may promote more effective conveyance into the underlying limestone formation. Alternatively, installation within or near one of the existing depressions noted on the ELP may also be viable options. These options should be reviewed by a licensed contractor experienced in installation of injection wells for consideration. Additional subsurface exploration may also be required.

4.0 LIMITATIONS

This report has been prepared for the exclusive use of our Client for specific application to this project. The report was prepared in accordance with generally accepted geotechnical engineering practices using that level of care and skill ordinarily exercised by licensed members of the engineering profession currently practicing under similar conditions in the same locale. No warranties, expressed or implied, are intended or made.

TTL understands this report will be used by the Client and various designers and contractors involved with the project. Any party other than the Client who receives a copy of this report shall understand the copy is for information only and cannot be relied on by the third-party without first entering into a secondary-client agreement with TTL. We should be invited to attend project meetings (in person or virtually) or be contacted in writing to address applicable issues relating to the geotechnical engineering aspects of the project. TTL should also be retained to review the final construction plans and specifications to evaluate if the information and recommendations in this geotechnical engineering report have been properly interpreted and implemented in the design and specifications. This report has not been prepared as, and should not be used as, a design or specification document to be directly implemented by the contractor. The contractor and applicable subcontractors should familiarize themselves with this report prior to the start of their construction activities, contact TTL for any interpretation or clarification of the report, retain the services of their own consultants to interpret this report, or perform additional geotechnical testing prior to bidding and construction.

This report is based on the information provided to us by the Client and various other professionals associated with the project, subsurface conditions inferred from results of seismic refraction tests, and our engineering evaluation and judgement. Our inferences of depths to bedrock were developed without data from test pits, soil borings, CPT soundings, or other invasive explorations that might otherwise confirm or modify our conclusions. The Client and readers of this report should realize that subsurface variations and anomalies could and may exist across the site and such anomalies may not be consistent with conditions inferred from the refraction tests performed. The refraction method implemented for this study cannot resolve small subsurface features or voids of any size, so it is possible for such small features or voids to be present but undetected. Additional exploration using invasive methods, such as test pits, borings, CPT soundings, or similar techniques, should be performed to further evaluate the site before the start of design or construction.

The Client and readers should realize that site conditions can change over time due to the modifying effects of seasonal and climatic conditions such that different conditions could be encountered at times after this report. The nature and extent of such site or subsurface variations may not become evident until construction commences or is in progress. If site and subsurface anomalies or variations exist or develop, TTL should be contacted immediately so we can be authorized to evaluate such conditions and, if necessary, address the situation with applicable recommendations.

Unless stated otherwise in this report or in the contract documents between TTL and the Client, our scope of services for this project did not include, either specifically or by implication, any environmental or biological assessment of the site or buildings, or any identification or prevention of pollutants, hazardous materials or conditions at the site or within buildings. If the Client is concerned about the potential for such contamination or pollution, TTL should be contacted to provide a scope of additional services to address the environmental concerns. Also, permitting, site safety, excavation support, and dewatering requirements are the responsibility of others.

Should the nature, design, or location of the project, as outlined in this geotechnical engineering report, be modified, the geotechnical engineering recommendations and guidelines provided in this document will not be considered valid unless TTL is authorized to review the changes and either verifies or modifies the applicable project changes in writing.

Additional information about the use and limitations of a geotechnical report is provided within the Geoprofessional Business Association document included at the end of this report.

ATTACHMENTS

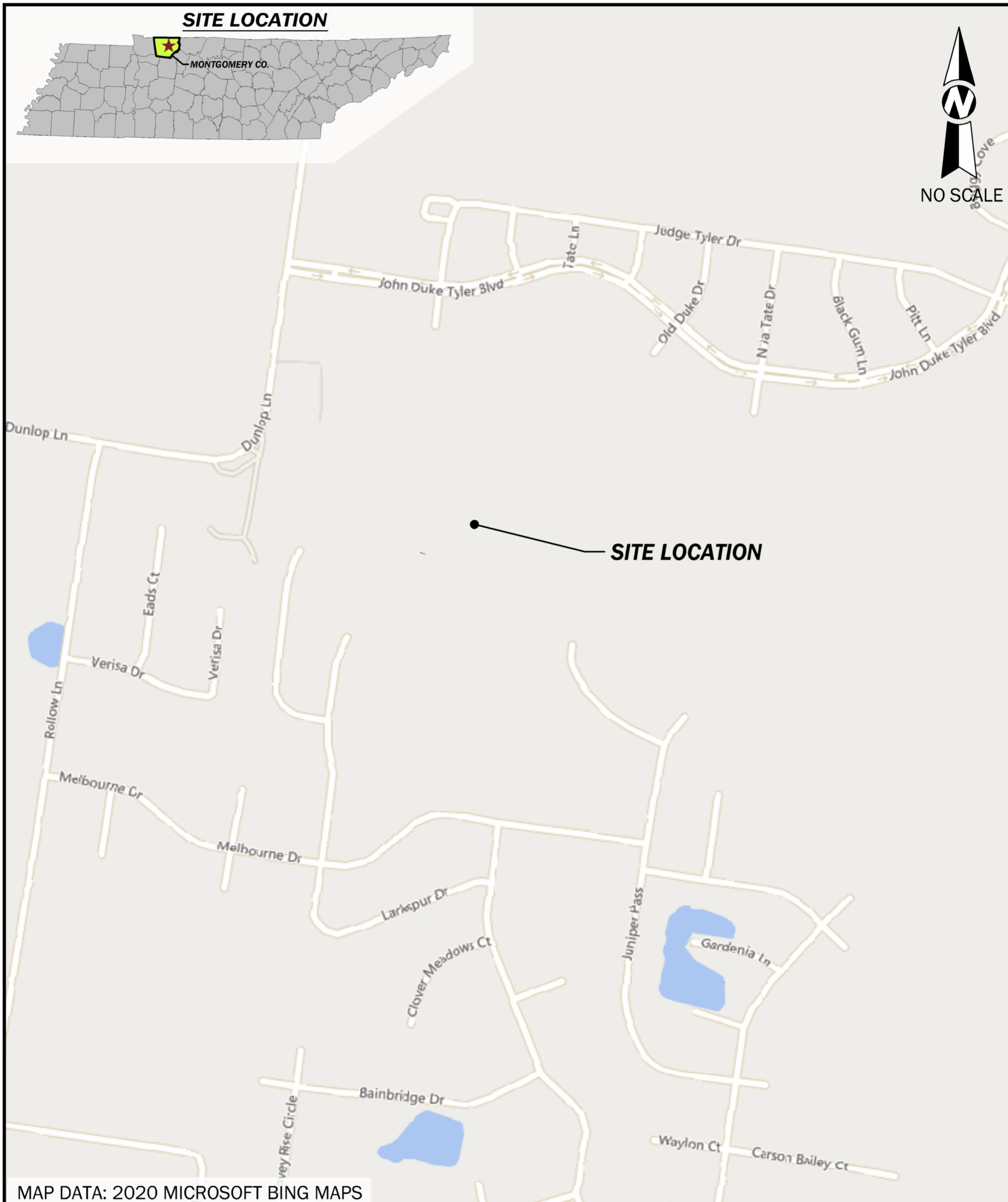
Site Location Map

Exploration Location Plan

Bedrock Surface

Bedrock Depths

Seismic Refraction Array Profiles



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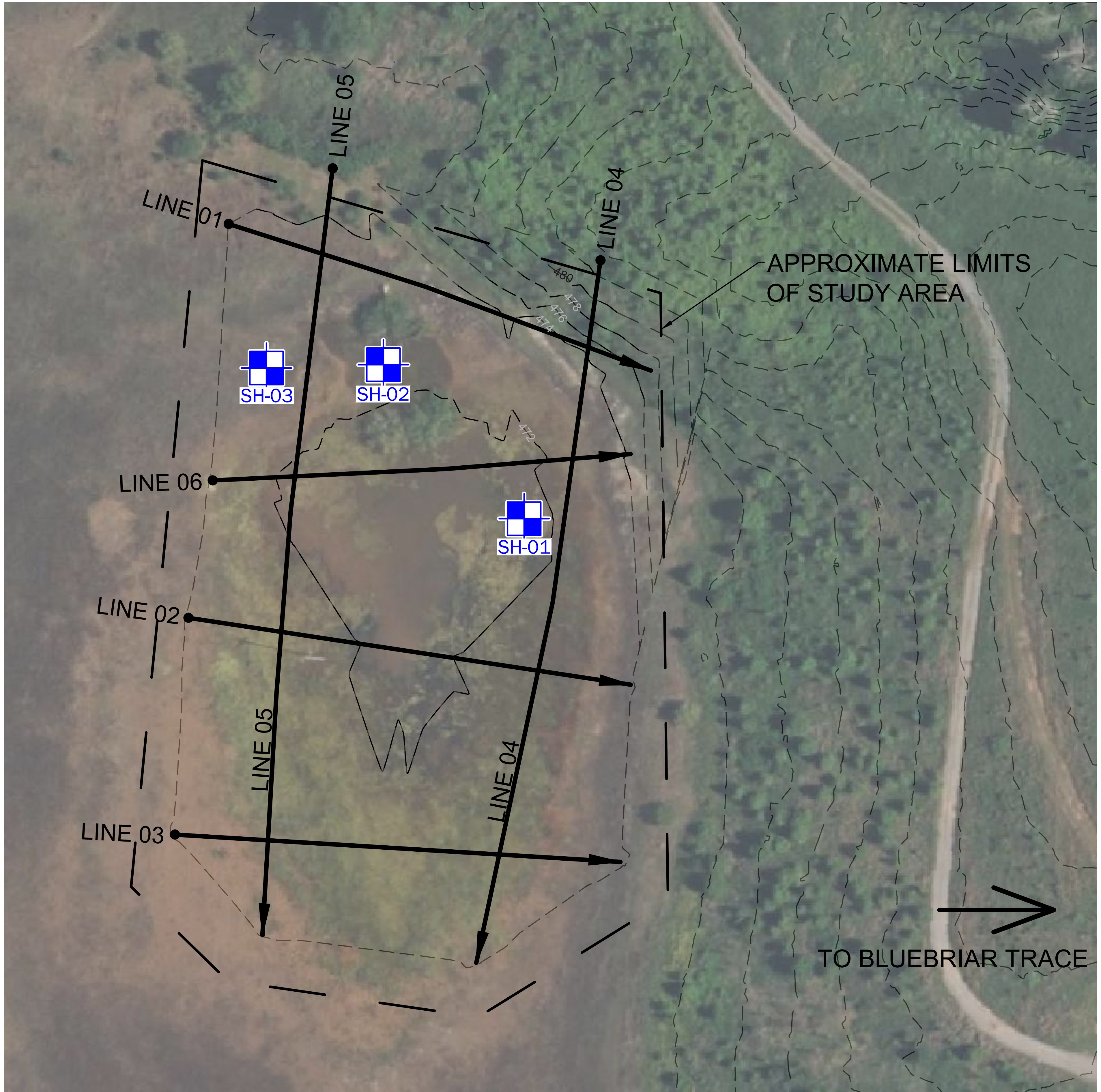
DUNLOP LANE - SEISMIC REFRACTION TESTING

MONTGOMERY COUNTY ENGINEERING

CLARKSVILLE, MONTGOMERY COUNTY, TENNESSEE

Drawn By: AVM
Checked By: CJF
Date: 03/10/2026
Proj. No.: 25-08-00220
File Name:
25-08-00220.00 SLM.dwg

Sheet Title
SITE LOCATION MAP



0 60 120 180

SCALE: 1" = 60'

LEGEND

LINE 01 — SEISMIC LINE (APPROXIMATE LOCATION)

SH-01 — SURFACE DEPRESSION LOCATION AND IDENTIFIER

NOTES

THE SYMBOLS ONLY REPRESENT THE LOCATION, BUT DO NOT REPRESENT THE SIZE OR SHAPE OF THE ACTUAL TEST.

SOURCE - GOOGLE EARTH MAPS & TN. STATE LIDAR

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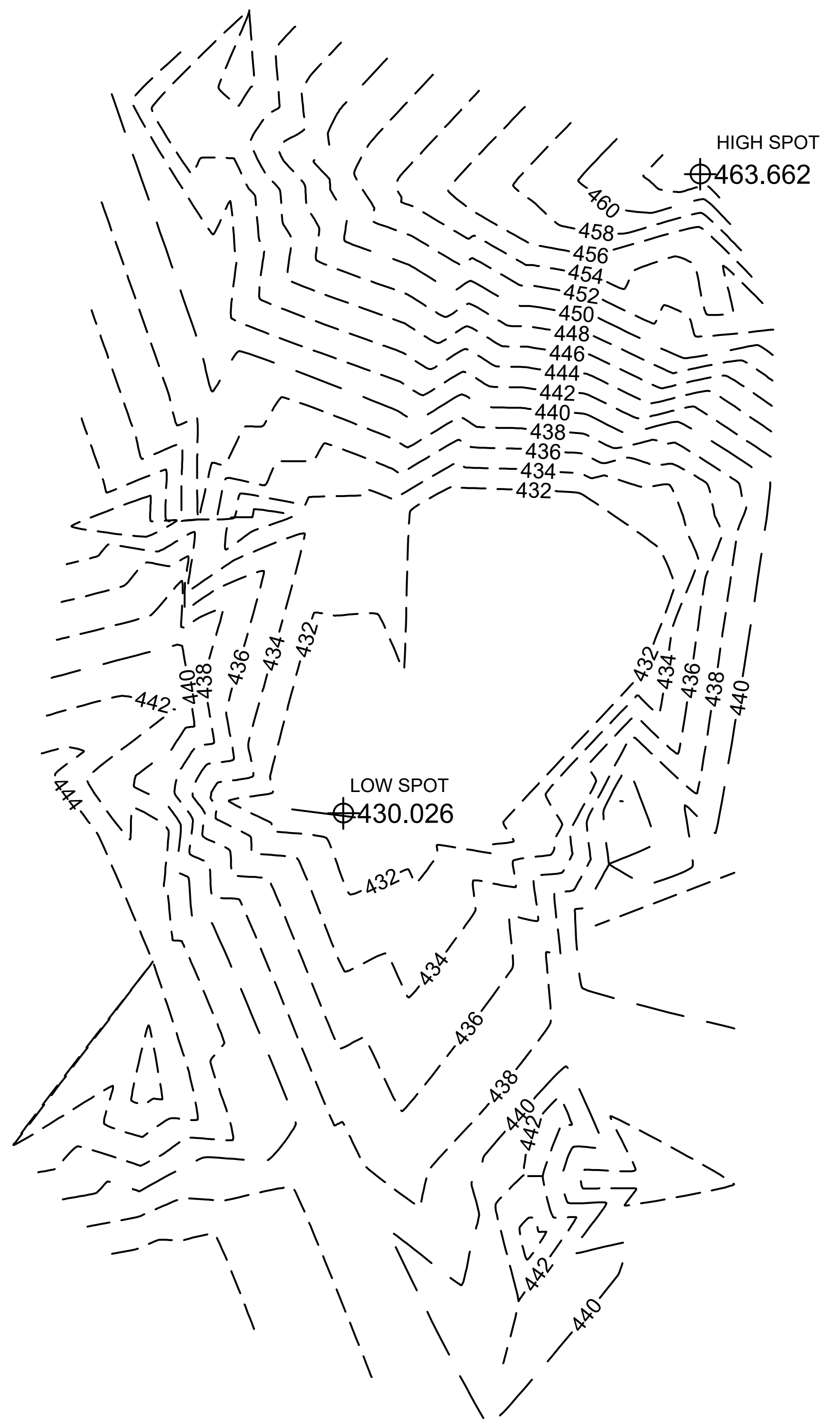
MONTGOMERY COUNTY ENGINEERING

CLARKSVILLE, MONTGOMERY COUNTY, TENNESSEE

Drawn By: NTH
Checked By: LSW
Date: 03-02-2026
Proj. No.: 26-08-00220
File Name: CDG - DUNLAP LANE TOPO WITH GEO.dwg

Sheet Title
EXPLORATION LOCATION PLAN



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SCALE: 1" = 60'

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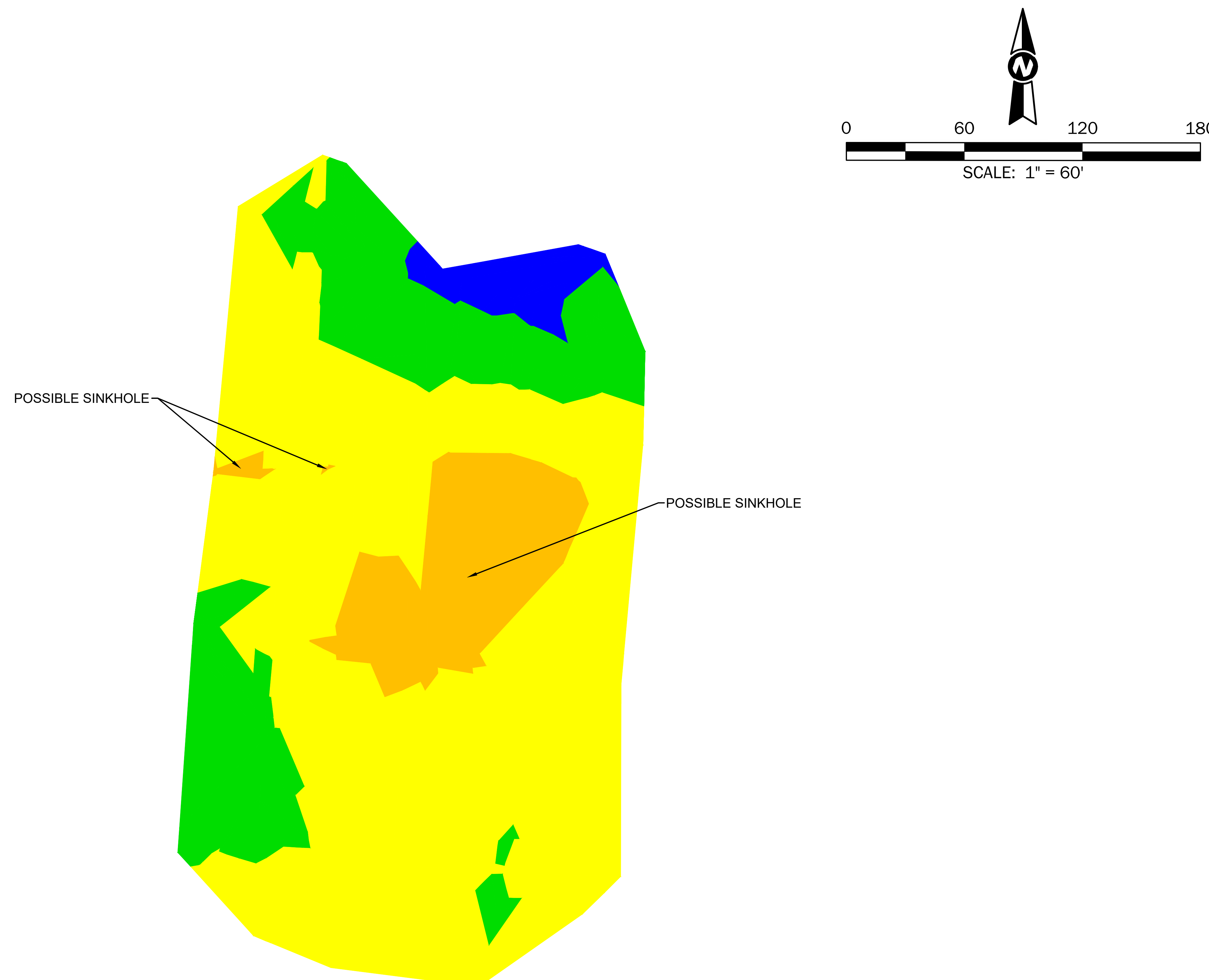
Proj. No.: 26-08-00220

File Name:

CDG - DUNLAP LANE BEDROCK SURFACE.dwg

Sheet Title

BEDROCK SURFACE



Approximate Rock Depth Below Existing Grade, Feet			
Number	Color	From	To
1	(orange)	40	50
2	(yellow)	30	40
3	(green)	20	30
4	(blue)	10	20
5	N/A	0	10

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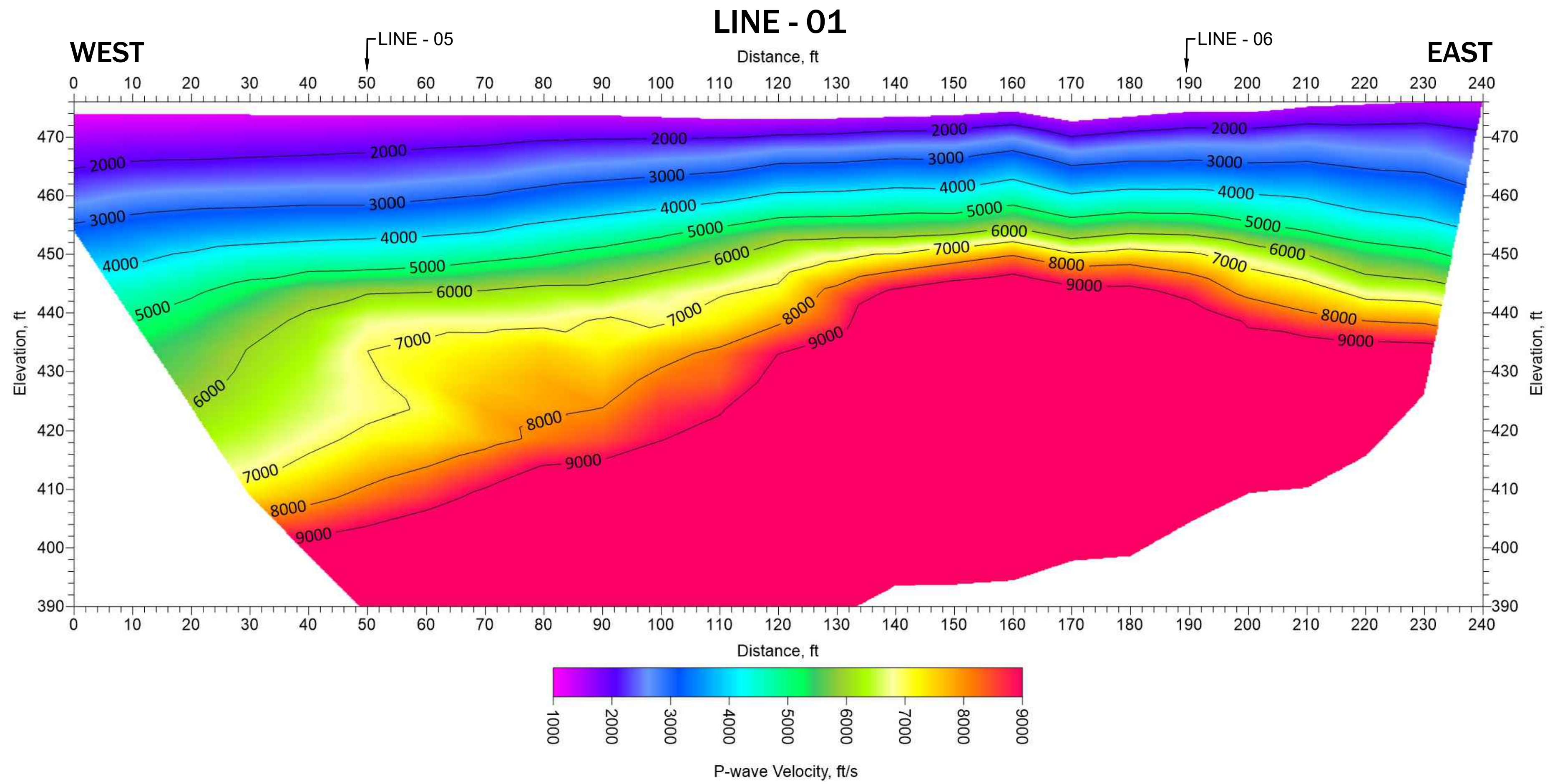
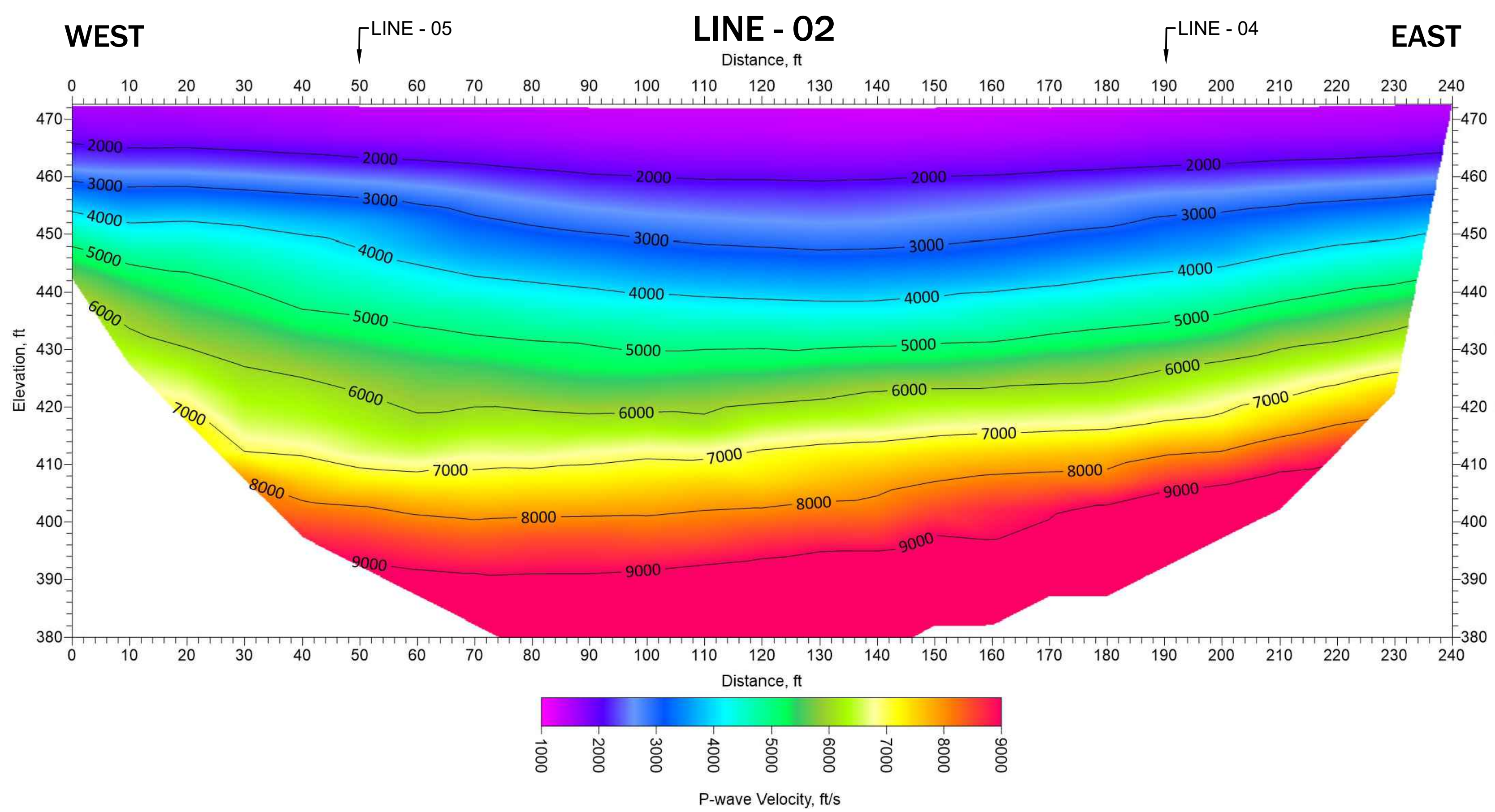
File Name:
CDG - DUNLAP LANE SURFACE COMPARISONS.dwg

Sheet Title

BEDROCK DEPTHS





NOTE: VELOCITY 5000 FT/S REPRESENTS THE APPROXIMATE TOP OF BEDROCK.

NOT TO SCALE

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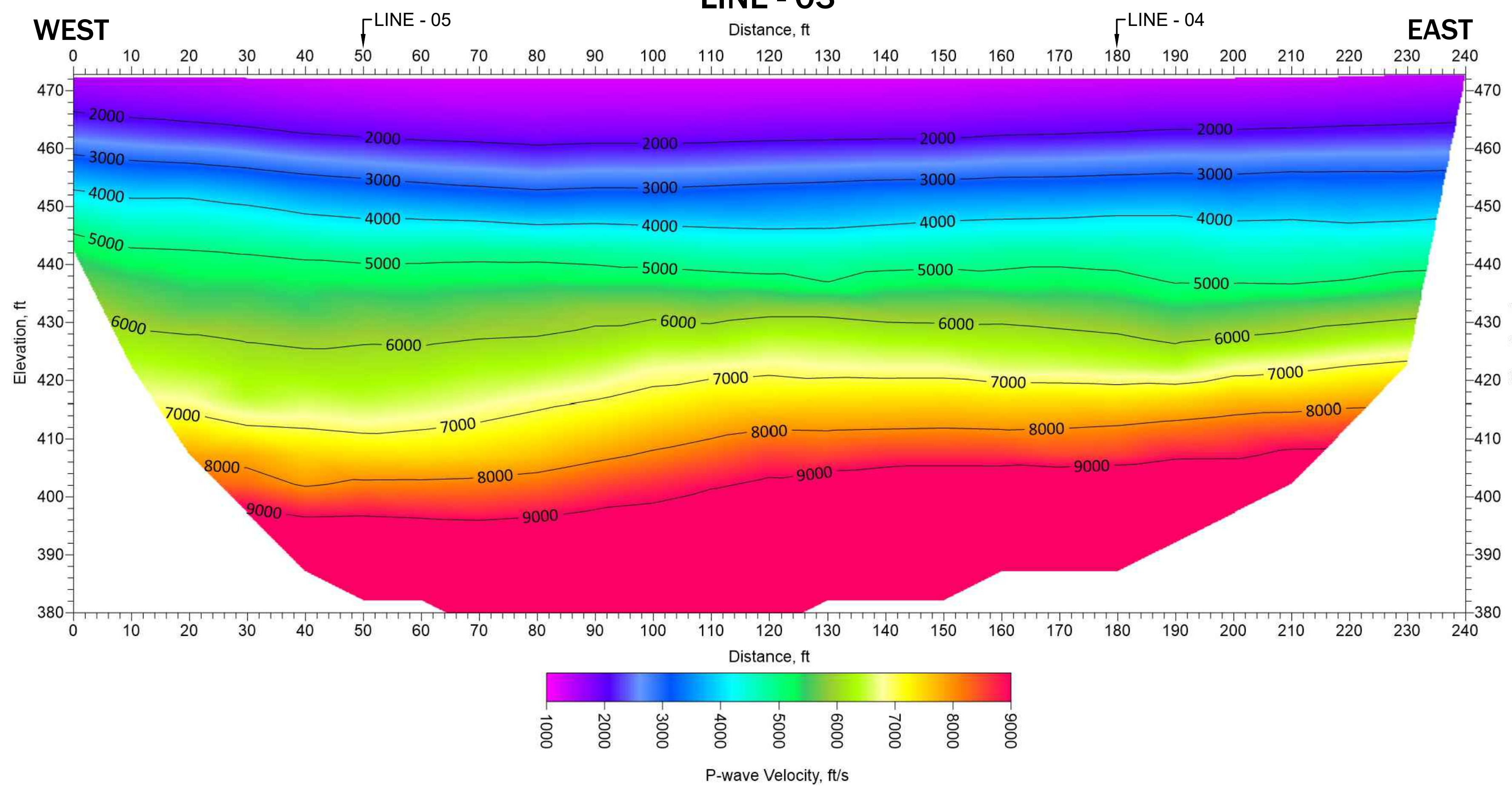
CDG - DUNLAP LANE SURFACE COMPARISONS.dwg

Sheet 1 of 3

SEISMIC ARRAYS

LINE - 03



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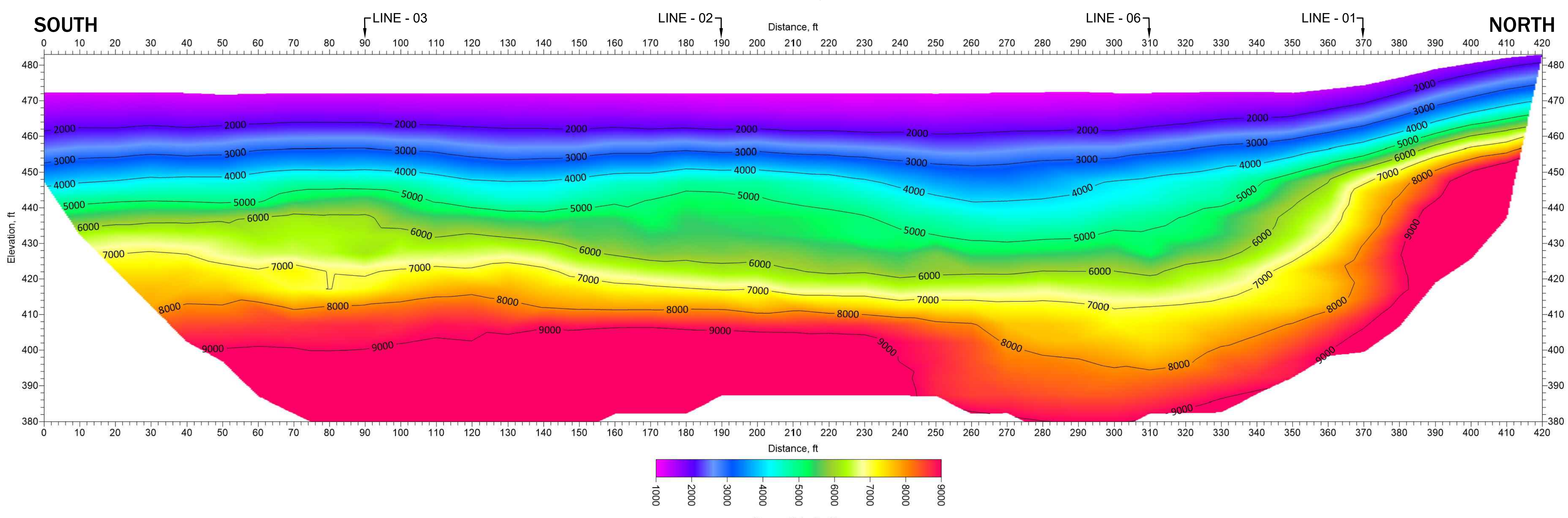

NOTE: VELOCITY 5000 FT/S REPRESENTS THE APPROXIMATE TOP OF BEDROCK.

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CLARKSVILLE, MONTGOMERY COUNTY, TENNESSEE

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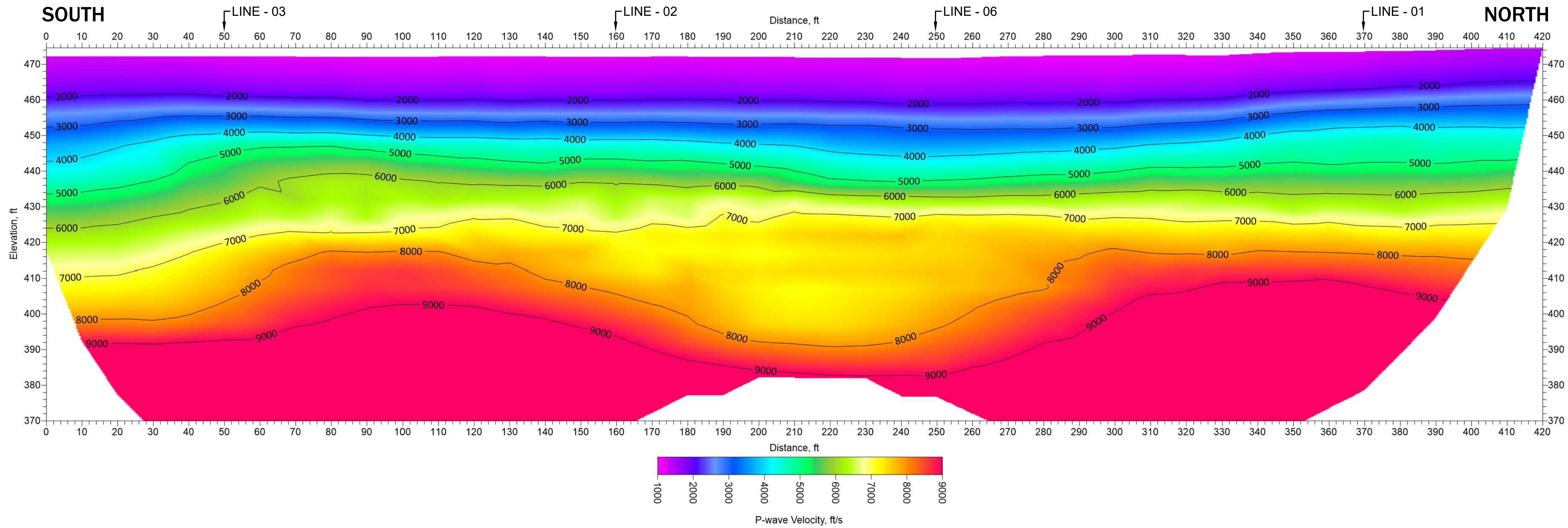
SEISMIC ARRAYS

LINE - 05



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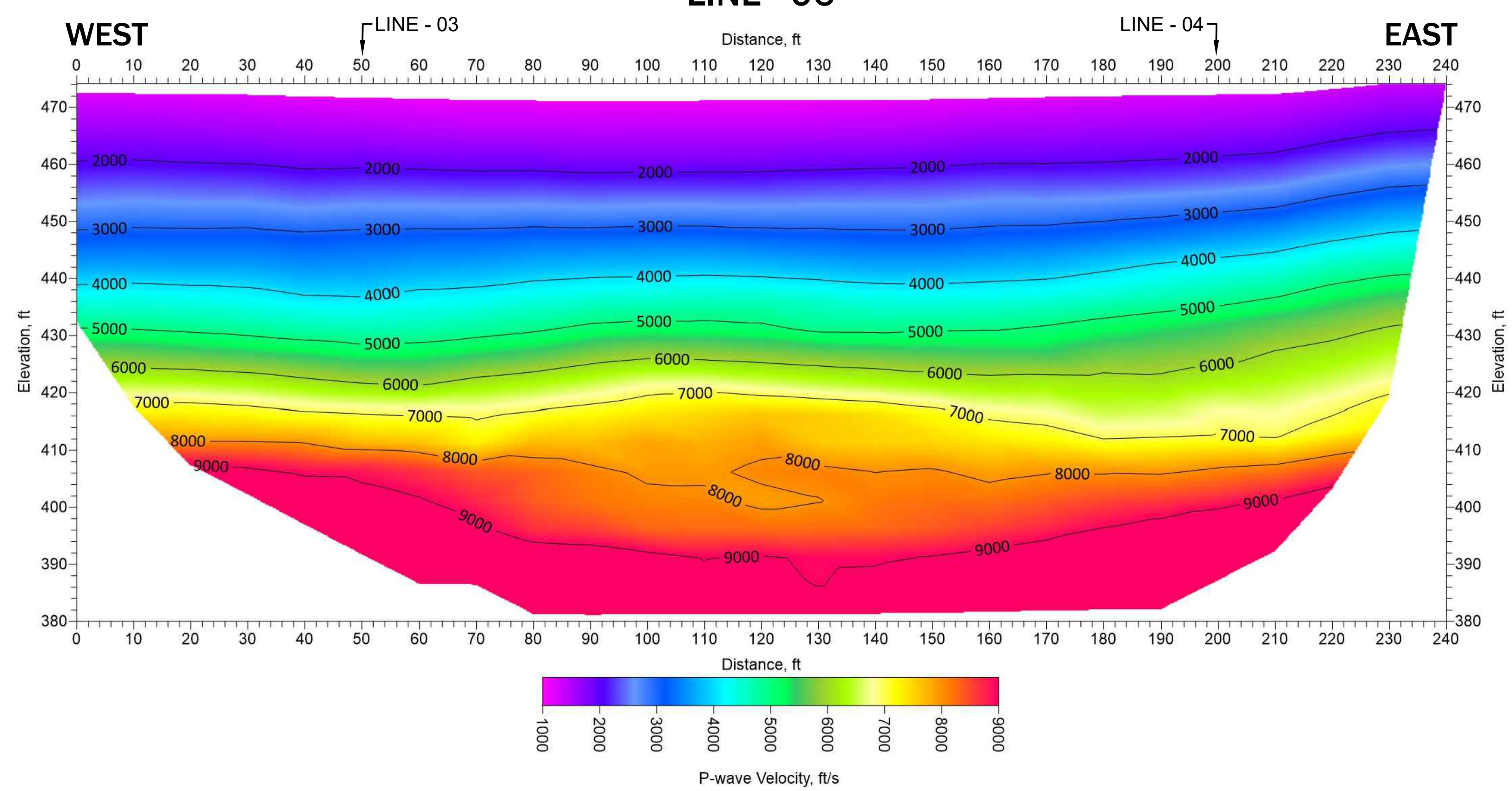

NOTE: VELOCITY 5000 FT/S REPRESENTS THE APPROXIMATE TOP OF BEDROCK.

NOT TO SCALE

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MONGOMERY COUNTY ENGINEERING

CLARKSVILLE, MONTGOMERY COUNTY, TENNESSEE

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SEISMIC ARRAYS