FOR REVIEW PURPOSES
NOT TO BE CONSIDERED A FINAL DOCUMENT

MINE MITIGATION STUDY
MINE FILLING AT PRYOR CROSSING
LEE'S SUMMIT, MISSOURI

Prepared for:

STREETS OF WEST PRYOR, LLC
OVERLAND PARK, KANSAS

Prepared by:

GEOTECHNOLOGY, INC.
OVERLAND PARK, KANSAS

Date:

DECEMBER 22, 2020

Geotechnology Project No.:

J035637.02

SAFETY
QUALITY
INTEGRITY
PARTNERSHIP
OPPORTUNITY
RESPONSIVENESS

December 22, 2020

Mr. David Olsson
Streets of West Pryor, LLC
7200 W 132nd Street, #150
Overland Park, Kansas 66213

Re: Mine Mitigation Study
Mine Filling at Pryor Crossing
Lee's Summit, Missouri
Geotechnology Project No. J035637.02

Dear Mr. Olsson:

This document is for informational purposes only and subject to change on the basis of the City of Lee's Summit third-party reviewers. Presented in this report are Geotechnology's observations and recommendations regarding the mitigation of the portion of the Union Quarry Mine which underlies the referenced project. It is our understanding this document will be provided to the City of Lee's Summit and a third-party consultant for review.

This report includes three parts: project and background review; review of industry mitigation practices and the selection of the proposed mitigation practice; and a technical specifications manual for implementation of the chosen methodology. Reports by others for the subject area and academic papers pertinent to the project are provided in the Appendices.

Our services were performed in general accordance with Geotechnology's Proposal P035637.02 dated December 19, 2020. We appreciate the opportunity to provide underground services for this project. If you have questions regarding this report, or if we may be of additional service to you, please contact the undersigned.

Respectfully submitted,

GEOTECHNOLOGY, INC.

Andrea Prince, P.G.
Senior Project Manager

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1.0 BACKGROUND AND PROJECT INFORMATION

1.1 Streets of West Pryor Development

Streets of West Pryor, LLC (SWP, LLC) is currently developing a parcel in Lee's Summit, Missouri. The triangular parcel is bounded by NW Lowenstein Drive, NW Pryor Road and Interstate 470 (I-470) as shown in Figure 1. Portions of the property are underlain by mine space. Presently, the Streets of West Pryor development has been limited to the east side of the property in an area not underlain by mine space. It is our understanding SWP, LLC would like to further develop the parcel by constructing Pryor Crossing subdivision (which consists of single and multifamily residential homes) over the undermined property.

Several reports have been prepared by others over the past 20 years in the vicinity for surface development. A selection of reports written for the subject area and adjacent parcels have been reviewed for the preparation of this report and are included as Appendix A.

1.2 Geologic Conditions

The regional geology generally consists of lower formations of the Kansas City Group, which is characterized by alternating layers of limestone and shale. Geotechnical borings have been performed at multiple locations on the site within the past 17 years. Approximate locations of previous geotechnical borings drilled by others is included as Figure 2. The following stratigraphic descriptions (from the mined unit up to the surface) were excerpted from a URS report[1] for the subject area.

> <u>Bethany Falls Limestone</u> – *This is the rock unit that has been mined extensively in the Kansas City area. The Bethany Falls is typically a 20 to 25+ foot thick limestone unit that is quite thick bedded in the majority of the lower portion of the unit. The lower 12 +/- feet of this unit is typically mined. The location that normally forms the roof of the mine consists of a thin shale parting that is easy for the drillers to identify. The limestone above this shale seam is often a relatively thick (4 to 6 feet) zone of massive limestone that forms a solid "roof beam" for the mine. The upper 2 to 5 feet of the Bethany Falls consists of a nodular limestone in a greenish gray shale matrix. This zone, called the "peanut rock" by the local miners is a relatively weak zone.*

[1] *Lee's Summit, Missouri Mine Evaluation*. Prepared for Lakewood Business Park by URS, dated February 7, 2003.

<u>Galesburg/Stark Shales</u> – The Galesburg Shale transitions from the "peanut rock" and it is often difficult to determine the exact location of this contact. This unit ranges from approximately 3 to 5 feet thick and is often a gray to dark gray clayey material. The overlying Stark Shale is typically a black platy (fissile) shale that ranges from about 2 to 4 feet in thickness. This unit can transmit water horizontally and where fractured, or penetrated by rock bolts drilled into the roof of the mine, can also transmit water vertically. Both the upper and lower contact of this rock unit is quite apparent, due to the unique bedding characteristics.

<u>Winterset Limestone</u> – This unit is one of the thicker limestone units in the Kansas City area. The average thickness ranges from approximately 25 to 35+ feet. The unit consists of two limestone beds, separated by a 1- to 3-foot-thick dark gray shale seam which is located near the central portion. Both upper and lower limestone can contain noduled and seams of blue gray chert.

<u>Fontana Shale</u> – The Fontana Shale is a thin, dark gray clayey unit that ranges in thickness from approximately 1 to 10+ feet. It may have a black zone near the middle, and in some locations may be quite calcareous.

<u>Block Limestone</u> – The Block Limestone is a thin (1 to 7+/- feet thick) limestone which may have a very thin shale seam. The unit may consist of a lower consistent limestone overlain by a variable thickness upper zone. We note that the boring log, discussed below, did not identify this limestone as being present.

<u>Wea Shale</u> – This relatively thick shale was the highest unit identified at the subject site. The Wea can vary from approximately 15 to greater than 30 feet in thickness in the Kansas City area. This shale can vary in color from a light gray to very dark gray to greenish gray, with an occasional maroon zone in the middle portion.

<u>Overburden</u> – A thin veneer of residual clay soils overlies the bedrock units. The thickness of the soils is unknown, but expected to be relatively thin (5 to 15 feet).

According the core hole log, the following rock units were present at this location:

Bethany Falls Limestone	*Base Elevation 884.7*	*Thickness 20.5 feet*
Stark/Galesburg Shale	*Base Elevation 905.2*	*Thickness 6.2 feet*
Winterset Limestone	*Base Elevation 911.4*	*Thickness 36.1 feet*
Wea/Fontana Shale	*Base Elevation 947.5*	*Thickness 8.7 feet*
Soil Overburden	*Base Elevation 956.2*	*Thickness 10.1 feet*

1.3 Mine History

The Bethany Falls Limestone was mined by the Union Quarry company in the subject area starting in 1959. The mine space has been owned and operated by multiple entities during and after completion of underground mining in 1981. For simplicity, the mine space will be herein referred to as the Union Quarry Mine[2]. At completion of underground mining operations, the mine spanned from East Bannister Road to the north to NW Lowenstein Drive. The Union Quarry Mine is bisected by I-470; the mine space will be herein referred to as the north and south sides, respectively. The north and south mine spaces are joined by a series of tunnels (four) which run beneath I-470. Portals were constructed only on the north side of the mine and access to the south side of the mine is from the north side.

The surface over the north and south sides of the mine are currently owned by different parties. Star Excavation operates a quarrying operation on the north side of the mine. The quarrying operation exposed the roof beam on the north side of the mine and excavated portions of the roof beam and pillars for aggregate. The original portal has been excavated and the mine is now accessed through the exposed mine rooms on the edges of the open quarry pit.

Based on reports by others, the north side of the mine appears to have been excavated using random pillar spacing and the pillars have various diameters. The south side was generally mined on a grid pattern and appears to have more uniform pillar dimensions. It is our understanding instabilities reaching the surface have occurred on the north side of the mine. Mine failure does not appear to extend to the ground surface on the south side.

1.4 Mine Failure Modes

Based on our experience with room-and-pillar limestone mines in the Greater Kansas City area, the following issues are common.

Pillar Distress. Good pillar design leaves enough width to transfer the load of the roof beam and overlying rock and soil to the mine floor, while still extracting the maximum amount of aggregate. Pillars become distressed when the present width is too small or too fractured to provide enough strength to carry the load of the roof beam and overburden. Pillar failure generally occurs in two modes:

- Crushing – a pillar with an insufficient diameter may begin to spall (the "sloughing off" of the outermost layer of the pillar) or to fracture vertically. As stresses continue to accumulate the pillar becomes narrower in the middle, taking on an hourglass shape, before finally being crushed under the load of the mine roof and overlying material.

- Punching – results when the pillar detaches from either the floor or the roof. This mode of failure occurs when the pillar is significantly stiffer than the floor or roof. With roof punching, the pillar and underlying floor remain in place while the weaker roof moves downward, likewise with floor punching the roof and pillar together move downward into the softer, weaker floor. Punching is especially a risk when shales in the mine floor or roof swell and/or lose strength due to water infiltration.

[2] Not to be confused with the other Union Quarry mine located in Lenexa, Kansas.

Roof Distress. The two forces of concern in the roof beam span between two pillars are (1) the shear stress that develops between the rock directly above the pillar and the "unsupported" span of the roof beam and (2) the tensile stress experienced by the unsupported beam span as it supports its own weight and a portion of the overburden between the pillars. The ability of the roof to "resist" these stresses depends on the thickness of the roof beam, the presence and condition of the layers comprising the roof beam, the tensile and compressive strength of the rock, and the spacing between pillars. Failure occurs when a change in one or more of these conditions results in a reduction of either the shear or tensile strength. A change in rock strength could be due to one or more of the following:

- Thin beds in the roof beam
- Delamination of the roof beam
- Joints or fractures
- Solutioning of the roof beam
- Weakness in the rock caused by variation in composition, weathering, or swelling in the presence of water
- Increases in the length of the beam span (as a result of further excavation of the mine face or pillar or the loss of a pillar)

Changes to the surface over the mine space (such as development, the placement of fill, significant cuts during grading, or the build-up of either surface or subsurface water) could lead to increased stress and roof failure.

Roof distress can cause joints to open up. Small pockets of rock can break out of the roof. Stress conditions that continue to build can lead to a larger rock fall. Generally, roof failures continue to propagate both laterally and vertically until a more stable stress configuration can be reached, generally an arch. These arches can extend between the pillars and result in the appearance of a dome. This kind of large-scale failure is known as a 'dome-out.' On occasion, when the overlying rock is weak, the dome-out does not resolve the stress condition and failure continues at the precipice of the dome towards the surface. This is called a "chimney" failure and, if the stresses are not resolved, can result in a sinkhole on the surface.

2.0 PRESENT MINE CONDITIONS

2.1 Mine Observation

In late April 2020, a cursory inspection of the mine space was made by Ms. Andrea Prince, R.G. by boat during the lidar survey performed by BHC Rhodes. During this limited mine observation dome-outs were noted in several areas of the mine and the water was observed to be up to 8 feet deep.

After receiving preliminary survey information from BHC Rhodes, a second trip was made to the subsurface. Representatives of Geotechnology were escorted by BHC Rhodes through the mine to confirm the location and extent of dome-outs, as depicted on Figure 3, provided by BHC Rhodes. Photographs of the mine entrance and underground space are included in Appendix B.

The mine was accessed through the north side of the mine at the edge of the Star Excavation quarry pit as shown in Photo #1. The western tunnels, as shown on Figure 3, which were used to enter the south side of the mine, were relatively dry at the time. In general, along the mine face to the west and southwest, the mine floor was relatively dry. Due to deeper water towards the center of the south mine space it was difficult to determine the height of underwater rock piles. The perimeter of the dome-outs is characterized by 4 to 12 inches of roof break-out in the one to three rooms surrounding the dome-outs.

2.2 Stability Analysis

Analyses for stability of the mine space were performed using the assumptions shown in the calculations in Appendix C. Based on our calculations, with the application of engineering controls the surface over the mine is viable for development.

3.0 MINE MITIGATION

3.1 Mine Mitigation Goals

Based on the project requirements, engineering controls will limit both existing and future instability and require minimal maintenance or mine observation. Reinforcement of the mine space, using rock bolts and pillar improvements, would require semi-annual to bi-annual inspection to verify the continued performance of engineering controls and to identify areas which require improvement. In addition, continued inspection could require dewatering of the mine. We recommend (1) backfilling of the mine area beneath the subject development to limit the need for regular observation and (2) that access to the mine be maintained in the event of future need of observation.

3.2 General Overview of Backfilling

In the case of Kansas City area limestone mines, backfilling has been utilized to limit liability and facilitate redevelopment. Backfilling of portions of mine space has been used to reinforce highways and roadways over mine space. General information regarding mine backfilling methodology is included in Appendix D**.** Supporting documents regarding the use of backfill for limiting surface damage are included in Appendix E.

Backfill is used to translate the load of the roof beam and overburden back down to the mine floor. Complete filling of the mine void laterally and/or vertically is not required in order to achieve effective load distribution. More information about the specific needs of this subject mine space will be discussed in a subsequent section.

Based on our experience in the Kansas City area, backfilling from the mine level using conveyors and dozers is the preferred methodology. However, backfilling is also accomplished from the surface by pumping backfill into the mine space using either hydraulic or pneumatic methods via large diameter holes. This method is commonly referred to as "blind" backfilling. Backfilling materials vary based on the specific engineering needs, material availability, and methodology chosen. Some applications require high strength flowable fill, while other conditions allow the use of waste rock from the mining operation.

3.3 Pryor Crossing Backfilling Challenges

Presented below is a discussion of mine backfilling challenges.

- The only mine opening for the subject property is located on the north side of I-470 in an active quarry.
- The presence of high-water levels in the mine.
- Blind backfilling utilizing hydraulic methods would introduce a substantial volume of water into the mine space. Introduction of additional water and at high volumes could cause water levels to rise such that the mine entrance would become flooded and the mine unpassable. At present, we believe there is enough capacity within the mine space such that the displacement of water by fill is not a concern.
- There is not enough information on pneumatic blind backfilling methods at this time. In addition, backfill suitable for use in pneumatic filling is not economically feasible.
- Traditional blind backfill methodology precludes observation of backfill performance from the underground space. The use of hydraulic or pneumatic methods requires the insertion of a large tube for pumping of material which is difficult to control directionally.

3.4 Non-Traditional Approach.

The proposed mine backfilling contractor, Drill Tech Drilling & Shoring, Inc. (Drill Tech), has worked with Ms. Andrea Prince for 15 years. They have many years of experience filling mine spaces across the country. In response to the aforementioned project challenges, Drill Tech has proposed the use of a proprietary device referred to as a "rock slinger". The proposal for the development of the rock slinger and filling of the mine is included in Appendix F. Together, Geotechnology and Drill Tech are proposing the following approach utilizing the rock slinger.

The mine space would be backfilled through 12- to 15-inch diameter boreholes drilled into the mine space on a checkerboard pattern across the footprint and extending two rooms laterally beyond the development footprint. A prepared backfill would be placed into the mine space using casing fitted with the rock slinger. The rock slinger, in theory, would place material in a wider arc than could be accomplished via dumping, potentially eliminating the need to drill into every mine room, as illustrated in Figure 4.

An analysis was performed to determine the volume of rubble-debris generated during dome-out failure. In order to self-arrest the dome-out failure and prevent chimney failure, the load of the remaining overburden must be transferred to the mine floor. Based on the assumptions presented in the calculations presented in Appendix G, filling of the mine to within 12 inches of the mine ceiling will self-arrest the dome-out, preventing the formation of a chimney failure.

It should be understood Drill Tech's rock slinger concept has not been used in the Greater Kansas City area and no documentation can be found on similar devices. We recommend test holes be completed with the rock slinger and available prepared aggregate in order to define the geometry of the fill piles created by the rock slinger and finalize the mine filling methodology.

4.0 QUALITY ASSURANCE/QUALITY CONTROL

Sources regarding industry practice have been included in Appendix H. In general, quality assurance/control measures can be difficult to assign. Recommendations for quality assurance/control measures are outlined below and are included in the Project Manual attached as Appendix I.

Surveying. The project surveyor should tie the existing surveys for the surface and subsurface to the same control point. The project surveyor should mark the boring locations as selected by Geotechnology. The boreholes should be numbered and the numbering scheme should be consistent throughout the project.

Borehole Filling. Boreholes should be sized such that casing can be lowered down into the mine. Casing diameter should be selected and the rate of filling controlled such that the pipe does not become clogged with backfill.

Surface Observation. We recommend a representative of Geotechnology be employed on a full-time basis throughout project phases. The representative of Geotechnology should observe the drilling, noting the borehole number, location, date, a general description of the stratigraphy encountered, and the depths of the mine roof and floor.

Aggregate. It is our understanding the prepared backfill is available locally, but could vary in composition. Geotechnology should be notified of upcoming material variations. Samples should be collected from each variable source and tested for gradation. At this time material specifications have not been finalized. Material volumes should be recorded for each borehole and a sample collected for gradation testing. Where samples do not adhere to the gradation requirements, the associated fill pile should be flagged for review.

Mine Filling. The mine space should be filled to within 12 inches of the mine roof, as verified by depth measurements. A representative of Geotechnology should observe the top of the fill with a borehole camera. Fill piles with visual flaws in geometry should be flagged for review.

Fill Pile Observation. Each fill pile should be observed from underground. We anticipate observation approximately once every 10 to 15 borehole completions, but more frequent observation will be required during the initial filling. A Geotechnology team should enter the mine space and observe the spread and shape of the fill piles. Piles which have previously been flagged for changes in gradation or irregular geometry via borehole camera should be reviewed. Additional room filling might be required if large portions (more than two connecting rooms) are not filled in accordance with specifications.

Reporting. Field notes and laboratory test results shall be shared with the client throughout mine filling operations. Upon completion of the project the quality assurance/quality control documents shall be compiled into a single document for record keeping.

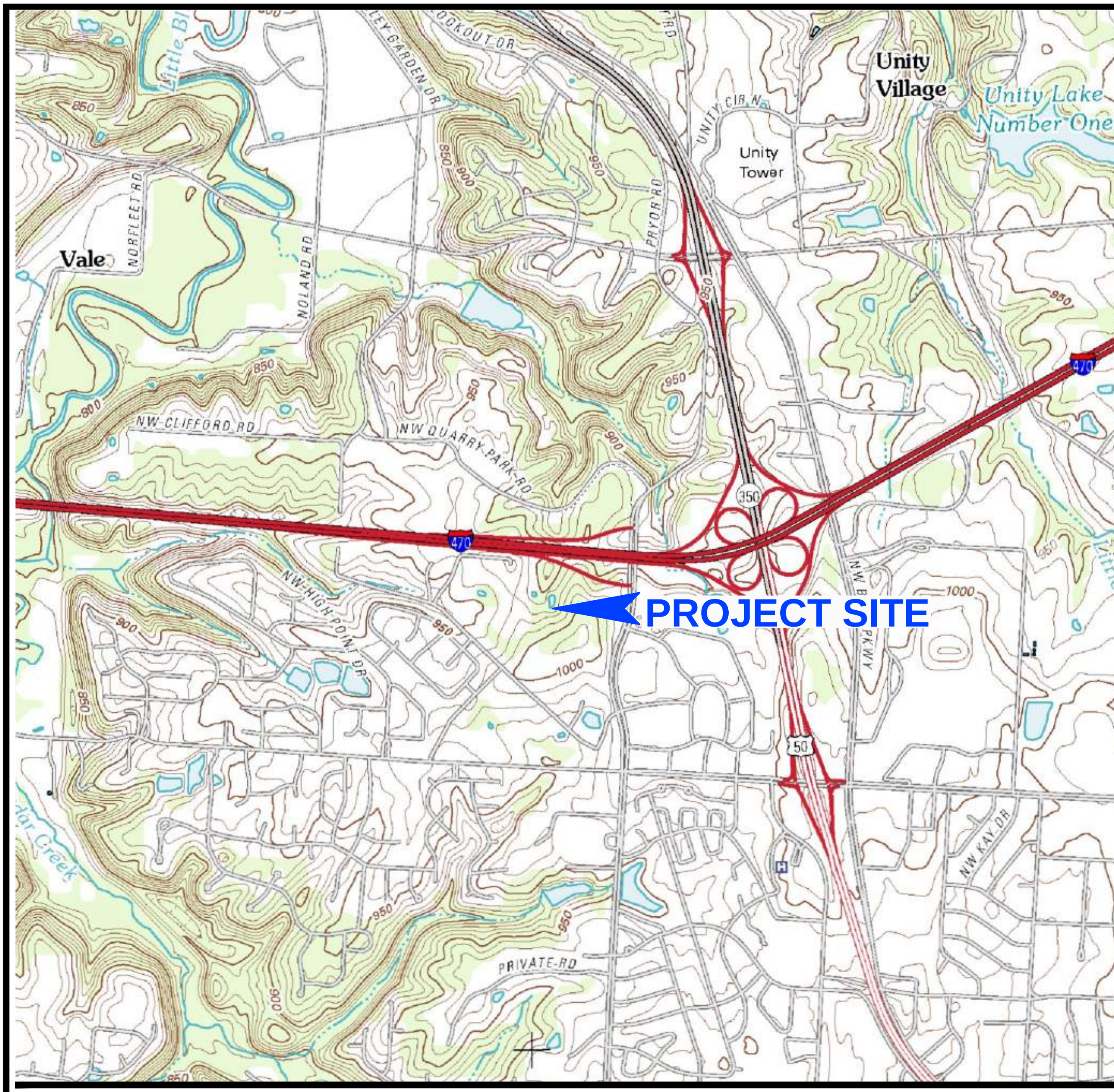
5.0 MINE ACCESS

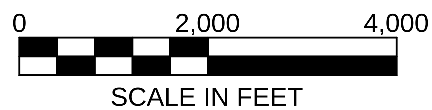
After backfilling of the mine space beneath the subject developed, we recommend access to the mine space be maintained. While backfilling will have reduced the risks associated with the mine space, access to the mine for observation should be maintained.

6.0 LIMITATIONS

This report has been prepared on behalf of, and for the exclusive use of, the client for specific application to the named project as described herein. If this report is provided to other parties, it should be provided in its entirety with all supplementary information. In addition, the client should make it clear that the information is provided for factual data only, and not as a warranty of subsurface conditions presented in this report.

Geotechnology has attempted to conduct the services reported herein in a manner consistent with that level of care and skill ordinarily exercised by members of the profession currently practicing in the same locality and under similar conditions. The recommendations and conclusions contained in this report are professional opinions. The report is not a bidding document and should not be used for that purpose.





NOTES

1. Plan adapted from 7.5 minute U.S.G.S. maps for Mound City and Dotham, Missouri quadrangles, last revised in 2014.

Drawn By: ALY	Ck'd By: ALP	App'vd By: MHM
Date: 12-2-20	Date: 12-2-20	Date: 12-18-20

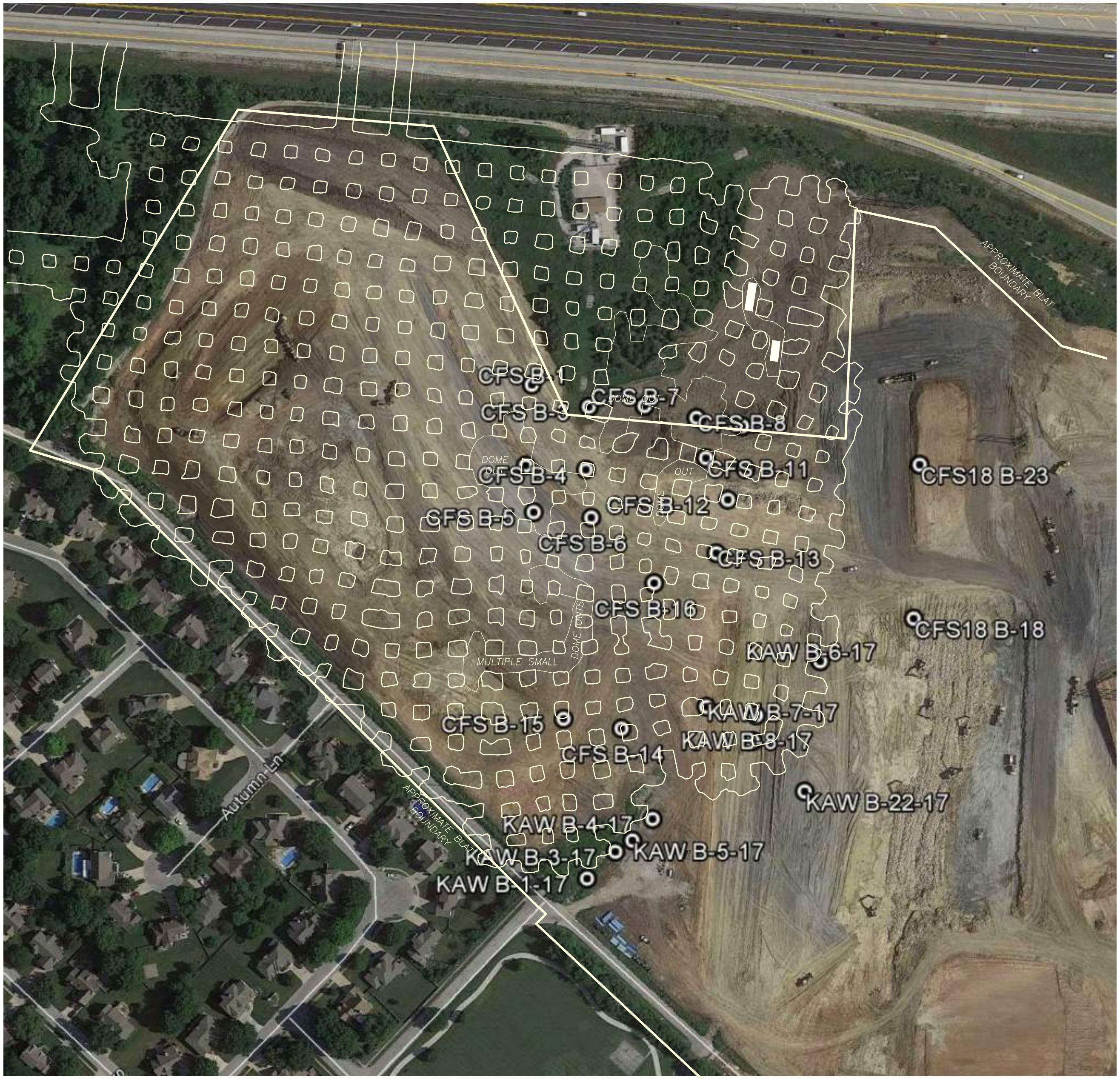
GEOTECHNOLOGY INC
FROM THE GROUND UP

Mine Mitigation Study
Mine Filling at Pryor Crossing
Lee's Summit, Missouri

SITE LOCATION AND TOPOGRAPHY

Project Number J035637.02

FIGURE 1



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NOTES

1. Aerial photograph courtesy of Google Earth

2. Boring locations approximated from previous reports prepared by others.

Drawn By: ALY	Ck'd By: ALP	App'vd By: MHM
Date: 12-17-20	Date: 12-18-20	Date: 12-18-20

GEOTECHNOLOGY INC
FROM THE GROUND UP

Mine Mitigation Study
Mine Filling at Pryor Crossing
Lee's Summit, Missouri

AERIAL PHOTOGRAPH OF SITE, LOCATIONS OF BORINGS DRILLED BY OTHERS, AND MINE OUTLINE

Project Number J035367.02	FIGURE 2

MINE COLUMN AND EXTENTS EXHIBIT

PART OF THE SOUTH HALF, SECTION 35, TOWNSHIP 48 NORTH, RANGE 32 WEST, CITY OF LEE'S SUMMIT, JACKSON COUNTY, MISSOURI

Notes by Geotechnology included in blue

GRAPHIC SCALE

100 0 100

1 inch = 100 feet

LEGEND

- Columns
- Wall of Mine
- Dome Out

GENERAL NOTES

1. This is **not** meant to be a geological report or to represent anything other than what we show on the face of this document. Dome out limits are approximate limits based on the fieldwork completed on April 21, 2020. These limits are not meant to indicate areas of the mine that are unstable, only to show areas as indicated. There may be other areas of dome out activity that are not represented on this document.

2. The columns and limits of the mine have been applied an elevation of zero due to a large portion of the mine inundated with water that does not allow for a floor elevation to be obtained with the data collection method used.

3. The aerial image shown on the exhibit is for **informational purposes only.** The image might not represent the actual conditions on the surface. Additional information needs to be obtained to show actual conditions on the surface.

4. The plat boundary show on the exhibit is for **informational purposes only.** This is not a signed and sealed boundary survey.

Rev.	Date	Description	Drawn	Checked

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Project:
MINE COLUMN AND EXTENTS EXHIBIT
PART OF THE SOUTH HALF,
SECTION 35,
TOWNSHIP 48 NORTH, RANGE 32 WEST,
LEE'S SUMMIT, JACKSON COUNTY, MISSOURI

Project No:	028440
Field Crew:	MS,TH,ZL
Field Date:	04.21.20
Drawn By:	TAR
Issue Date:	04.27.20

Sheet: 1 OF 1

FIGURE 3