Field Test Evaluation Mine Remediation at Streets of West Pryor Lee's Summit, Missouri

Prepared for:

Streets of West Pryor, LLC
Overland Park, Kansas

Prepared by:

Geotechnology, LLC
Overland Park, Kansas

Date:

July 25, 2021

Geotechnology Project No.:

J035637.02

SAFETY
QUALITY
INTEGRITY
PARTNERSHIP
OPPORTUNITY
RESPONSIVENESS

July 25, 2021

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

Re: Field Test Evaluation
Mine Remediation at Streets of West Pryor
Lee's Summit, Missouri
Geotechnology Project No. J035637.02

Dear Mr. Olson:

Presented in this report are Geotechnology, LLC's (Geotechnology) observations, summary and conclusions regarding the initial field test of the mine remediation technique planned for the Streets of West Pryor development. This document was prepared based on field observations, discussions with Drill Tech Drilling and Shoring, Inc. (DTS) personnel, and engineering calculations and assessments. The summary and conclusions are related to the initial field test and should not be considered a comment on the process to date.

1.0 BACKGROUND AND PROJECT INFORMATION

Geotechnology was retained to evaluate a development over subsurface space in Lee's Summit, Missouri. Current plans are for an 11.2-acre surface development. Details can be found in our report "*Revised Mine Remediation Plan, Mine Filling at Streets of West Pryor*" (*Remediation Plan*) dated May 6, 2021.

Remediation Plan details included a discussion of anticipated production borings for rock placement and the specifications for backfill material. In addition, the *Remediation Plan* also provided details as to quality control and assurance for the mine backfill. As part of the *Remediation Plan*, a field test was proposed using an existing vent shaft that extends to the underground space. The vent shaft is approximately 19 inches in diameter and cased to a depth of 64 feet, which is within 1.5 feet of the mine roof. In addition, the plan also discussed the need to confirm the relationship between the surface survey and the subsurface; this was to verify that the surface staked locations correspond to the center of the mine rooms. This confirmation included advancement of three production borings. Field measurements would be taken at the mine level to verify the accuracy of the staked locations.

Per the *Remediation Plan*, backfill materials are to have a specific gradation. Deleterious materials within the backfill are not permitted. The backfill used in the field test generally consisted of crushed limestone from on-site stockpiles and some import material. The contractor providing crushing services is Industrial Demolition and Salvage (IDS).

Placement of backfill in the mine space is performed by DTS. The method described in the *Remediation Plan* includes mechanically dispersing the backfill via centripetal force using a proprietary tool (i.e., *rock slinger*).

Verification of the performance of the rock slinger and rock gradation was proposed. Verification includes entering mine space to observe the resultant backfill and laboratory testing of the mine backfill.

The field test was conducted July 12 through 15, 2021 at the location shown on the attached figure (provided by DTS). The existing shaft was offset approximately 5 feet south-southwest of the room center. The roof beam in this area measured approximately 30 feet from pillar to pillar. At the time of backfill placement, the room was inundated with approximately 2 feet of water.

The field test consisted of (1) lowering the rock slinger to a distance of 1 foot below the mine roof, (2) dumping crushed limestone down the vent shaft, and (3) mechanically spinning the rock slinger. Specifics of construction and operation of the device are included in Appendix A. During the test, adjustments to the position of the rock slinger, revolutions per minute (RPM), feed rate of the conveyor, and material gradation were performed to improve the backfill technique. Mine backfilling was observed from both the surface and the underground space. Backfilling was performed intermittently to allow further observation of the crushed limestone pile.

2.0 FIELD OBSERVATION

2.1 Prepared Aggregate

The prepared aggregate shall consist of 2-inch minus crushed limestone with less than 20% fines and free of organic matter. Existing on-site materials and some import were crushed at the site. Initially, two streams of material were produced. Bulk samples were collected and gradation tests were performed. Based on the results of the initial gradation tests, a screen was introduced as part of the crushing operation. This produced three stockpile streams, one being 2-inch minus, the second being ½-inch minus, and the third consisting of rock flour. One sample was collected prior to the introduction of the screen. Two other samples were obtained after re-processed to include the screen. Test results are included in Appendix B. While the test results did not meet all specifications, aggregate placement did perform in general accordance with the specifications. Refinement of the crushing process is being considered.

2.2 Rock Slinger Operation

The field test was observed from the underground space by Ms. Andrea Prince, P.G. and Mr. Kurt Porritt of Geotechnology from July 12 through 15, 2021. Site activities and observations were documented in Daily Field Reports (DFRs). Intermittent observations and measurements of the rock pile were made during the filling process. Documentation of variations of material placed, rotational speed, feed rate, and other modifications were noted on the DFR. For this field test, two different size slingers were used. The smaller diameter slinger was used to place the first approximately 75 cubic yards of fill. The larger diameter slinger was used to place the remainder of the backfill. Photographs and diagrams are included in Appendix C.

Mine filling activities commenced with the smaller diameter rock slinger. The smaller diameter slinger created a stockpile of material with a diameter of approximately 15 to 20 feet with an angle of repose of approximately 20 degrees. The second slinger was introduced and backfill placement continued. Use of the larger diameter slinger resulted in a stockpile of material with a diameter of approximately 30 feet or more with an angle of repose of 15 to 30 degrees. The resultant stockpile was bias to the southwest corner of the mine room. Observed higher clay content within the backfill created a steeper angle of the pile as expected. Materials placed ranged in size between 2 inches and 0.5 inches. Filling operations ceased when the fill pile extended to the roof and the slinger could no longer be rotated. The remainder of the shaft was gravity filled with 0.5 inch and 2 inch material. Settlement of the backfill was not observed as of July 23, 2021.

The resultant pile was measured and had a diameter of approximately 4 to 5 feet against the mine roof. The base of the fill pile extended to the approximate mid-point of the adjacent pillars. Average distance from the midpoint of the pile to the roof is approximately 5 to 10 feet. Based on observation of the rock slinger field test, it appears the rock slinger effectively spreads rock in a relatively uniform manner. The existing shaft did not did not clog nor "choke" during fill placement.

2.3 Survey

Three holes were advanced by means of rotary hammer to the mine level. These holes were designated A-7, A-11 and A-13 and were drilled at the locations the Figure. Measurements at the mine level were taken to evaluate the proximity of the boring to the center of the mine room. Field measurements were taken by Geotechnology and BHC, Inc. (BHC) (project surveyor). Field measurements and observations indicated that the borings were not drilled in the center of the rooms and were offset an approximate distance of 10 feet south, southwest. Two additional holes were advanced, designated as A-10 and A-12, to further establish the difference between the surface and subsurface survey.

2.0 ANALYSIS OF PERFORMANCE

The estimated volume of fill placement per room in the study area is approximately 500 cubic yards. Approximately 470 cubic yards of crushed limestone backfill was actually placed, which corresponds to 94 percent of the calculated volume. Calculations with intimate roof contact are included in Appendix D. The factor of safety against roof bean overstressing was increased since the unsupported distance of the beam was reduced by 50 percent. It is anticipated that the mine space will have an increase in long-term stability with an increase in room filling. Continued mine room filling operations will decrease the load on the roof beam.

BHC is currently evaluating the difference in the surveys. This report will be amended to include a discussion regarding the surveys once completed as results are to be determined.

3.0 CONCLUSIONS AND RECOMMENDATIONS

Based on the results of the field test, it is our opinion the rock slinger device is suitable for use in backfilling the mine space beneath the Streets of West Pryor development. While the initial test performance did not achieve the exact results anticipated, it is noted that this is the first time that this method has been employed. Refinements in the overall placement, fill materials, and methods are to be expected. Additional test fills should be performed to ensure repeatable results. We recommend that at least three additional test fills be conducted with the following rationale:

- The location of the additional test holes should correspond to the center of the mine rooms.
- Backfill placement should be conducted with production sized holes (14.5-inch ID) which are planned to be smaller in diameter than the existing shaft.
- Modifications of the feed rate and rotational speed of the rock slinger should be made to further evaluate the dispersion of the placed aggregate.
- Additional holes might be required to optimize fill placement.

4.0 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.

ENCLOSURES

The following attachments are included in and complete this report:

Figure	-	Field Test Location
Appendix A	-	Draft Memorandum (Prepared by Drill Tech Drilling & Shoring, Inc.)
Appendix B	-	Laboratory Test Results
Appendix C	-	Photographic Log
Appendix D	-	Calculations

* * * * *

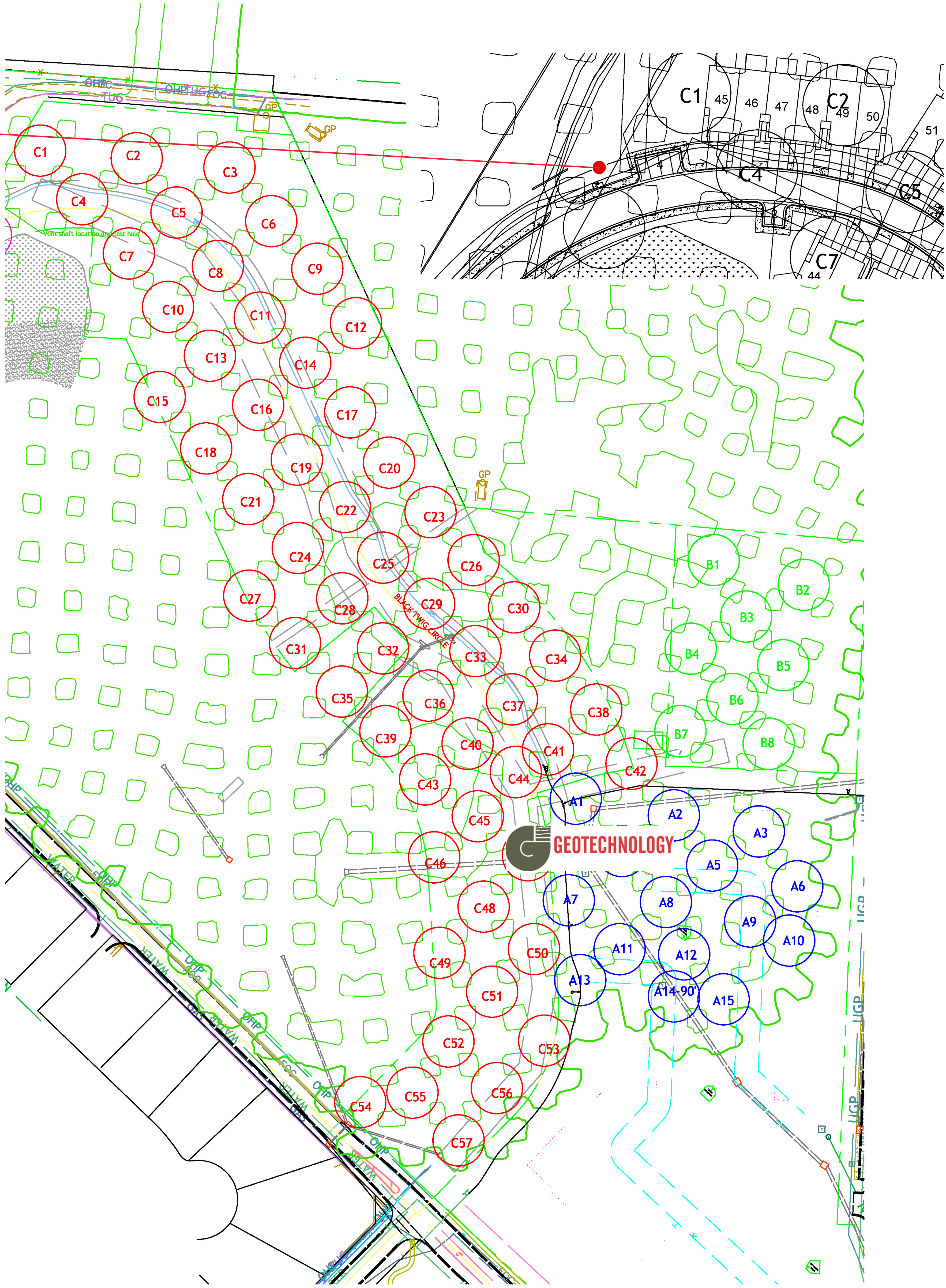
It has been our pleasure to provide geotechnical services to you, and we would welcome the opportunity to provide other services during the course of the project. Please contact the undersigned if you need further information about this document.

Respectfully submitted,

GEOTECHNOLOGY, LLC

Andrea Prince, P.G.
Senior Project Manager

ALP:MHM:alp\ljd



NOTES

1. Base map provided by BHC, 2021.

LEGEND

● Existing Vent Shaft Field Test Location

Drawn By: ALP	Ck'd By: ALP	App'vd By: MHM
Date: 7-17-21	Date: 7-17-21	Date: 7-21-21

GEOTECHNOLOGY

Streets of West Pryor
Lee's Summit, Missouri

MINE REMEDIATION
FIELD TEST LOCATION

Project Number J035637.01

FIGURE 1

APPENDIX A

Draft Memorandum (Prepared by Drill Tech Drilling & Shoring, Inc.)

DRAFT

7/15/21

By: Patrick Carr, P.E.
913-378-2575
Patrick.Carr@DrillTechDrilling.com

RE Test Hole, Streets of West Pryor Mine Stabilization

A test was performed to verify the performance of the crushed rock placement to improve the mine stability at the Streets of West Pryor site. The test was performed on an existing 19.5” ID vent shaft on the north end of the site. The floor of the mine was 78 feet below the surface and the room is ~12.5 feet tall.

Setup: Crushed rock was placed in the hole and distributed using a spinning disk with fold-out arms to increase the radius of the placed stone. The tool is referred to as a “slinger.” The tool was designed to operate on 3.5” OD drill steel in a 14.5” drill hole. There are two centralizer bearings to stabilize the drill string and slinger. The first bearing was installed 10 above the slinger and the 2nd bearing at a depth of 25 feet. The tool was lowered in the hole on a rotary drill with a variable speed drive. The drill is equipped with a tachometer to display rotation speed. The crushed rock was fed with a gated aggregate hopper equipped with a belt speed counter for placement rate and volume. The loader buckets of aggregate were counted as a determination of the volume placed. Rock was provided by others from on-site material stockpiled near the vent hole. The rock was segregated into 2” and ½- size. The rock was loaded into the gated hopper with a Hyundai 4 cy loader. The specifications for the loader bucket are 3.5 cy struck full and 4 cy heaped. 3.75 cy per bucket was used for the volume calculations.

Observation: Access was provided inside the mine through the Star Excavation quarry on the north side of I470. We were able to witness the performance of the equipment and process as well as the results. It was necessary to drive a portion of the way into the mine where it became flooded. A boat was then used to travel the rest of the way to and through the tunnel under 470 to access the vent shaft on the south side of I470. Safety protocols are established and are being utilized with Star Excavating.

We were able to talk between the mine and the surface with high-powered handheld radios with the signal presumably passing through the drill hole. This greatly improved our efficiency as the travel time between the surface and the mine is 20 minutes.

The vent hole was not centered in the room. It was offset about 7 feet to the southwest of the center.

Production: On 7/12/21 we lowered the tool into the hole and ran 7.5 cy (2 buckets) of rock to verify everything worked. On 7/13/21 we placed 135 CY of material. During the placement, we tried varying rotation speeds of the slinger and varying flow rates. In the test hole, we were unable to spin it more than 230 rpm due to the wobbling of the drill rod in the larger hole. The feed hopper worked best when it was run at a speed where we emptied a loader bucket with an average time of 1.3 minutes. Faster rpm speeds produced a larger radius of rock distribution. We tried the 2" and the ½"- rock to compare performance. The 2" rock was cleaner and distributed better than the smaller rock. Attached are photos of the equipment and process and videos are available. On 7/14/21 we placed 330 cy (88 buckets) until the cone reached the mine roof and choked the spinner. A total of 472 cy was placed in the hole.

Results: The goal was to place the majority of the rock in a 25 +/- foot diameter ring. We anticipated the fill would take the shape of an inverted W with the center filling somewhat slower. This was not the case and the material built up in the center more like rock was dropped and made a natural cone, though the angle of repose was much flatter due to the slinger distributing the stone. We ended up with 4 to 5-foot diameter contact with the roof and a cone of material with a 27 or 28-degree angle of repose measured midway up the pile, though it varied from shallower at the base to steeper at the top.

The volume of a truncated cone with a top radius of 2.5 and an angle of repose of 27 degrees gives a base diameter of 27 feet and a volume of 390 cy, which reasonably approximates the volume placed, considering the base is at a flatter angle.

Discussion: During placement of the rock it was obvious the cone was flatter at the north and west side of the pile. The slinger was biased to the NW side of the drill hole and from watching the process I am confident the slinger was able to distribute the rock better when the rock was dropped closer to the center of the slinger. The system was designed to work in a 14.5" diameter hole. The vent hole was 19.5" in diameter. I didn't anticipate the hole diameter would make a difference in the performance of the slinger or we would have cased the hole to match the production hole diameter. The extended diameter of the paddles on the slinger is 26" diameter. If centered the slinger would only be 3" larger than the hole diameter reducing its effectiveness.

Conclusions: This is the first time this process has been used and refinement is required. As with any process, the performance and production will improve with experience. It is our goal to provide stone fill with a sufficient volume to prevent mine roof failure from propagating to the surface. We had anticipated an approximate 10' diameter peak of the stone relatively close to the mine roof. Generally on mine stabilization projects verification of the results is by exploratory borings or with cameras lowered down inspection holes. We have an excellent opportunity to observe the results of this project and we will continue to improve the process.

The volume of a truncated cone with an upper radius of 5 feet, an angle of repose of 27 degrees would give a base dimension of 29.5 feet and a volume of 505 cy. We placed 472 cy on the test hole. We need only a 7% improvement in performance to achieve this volume. Based on our observations of the test hole we anticipate a 10 to 15% improvement in performance without operational changes.

We have an excellent opportunity to refine the rock placement and improve the results. Our plan to increase the volume placed per hole by 10 to 15% is as follows.

1. We expect the smaller drill hole will direct more of the material at the center of the slinger allowing more contact with the paddles which will impart more horizontal energy.
2. The smaller hole diameter may allow faster rotation speeds because the bearings will be better confined. It was demonstrated, as expected, the faster the rotation speed the further the distribution radius.
3. We will experiment with other placement sequences and processes to increase the volume placed at each location. These might include placing the smaller stone first without the use of the slinger

and placing the larger stone with the slinger or the use of a vibrating or percussion to flatten out the truncated cone near the top.

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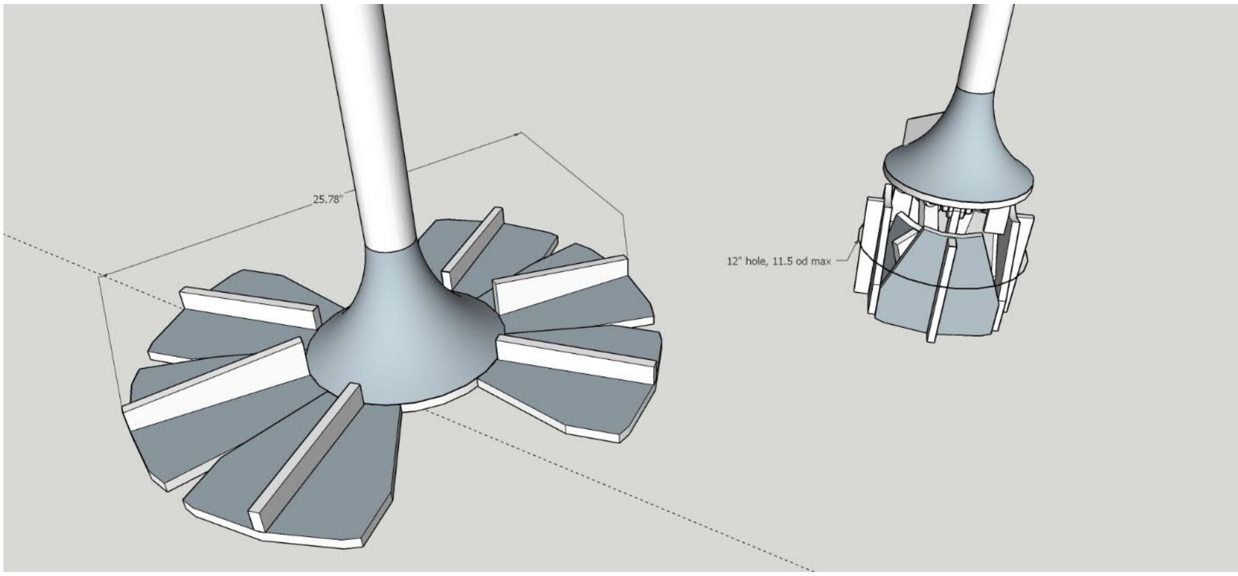
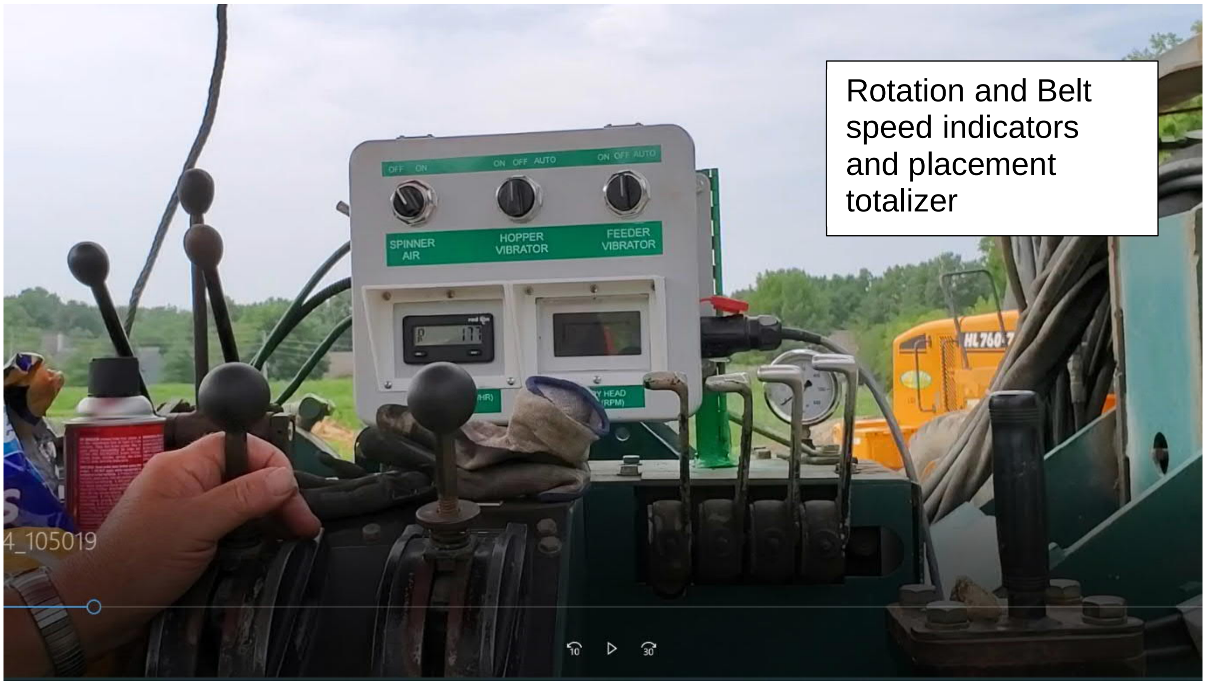
We recommend that we proceed with the process in the production holes in the 7C area and continue to observe and improve the results with experience and utilization of different methods.

2200 Wymore Way – Antioch, CA 94509-8548 – (925) 978-2060 – Fax: (925) 978-2063

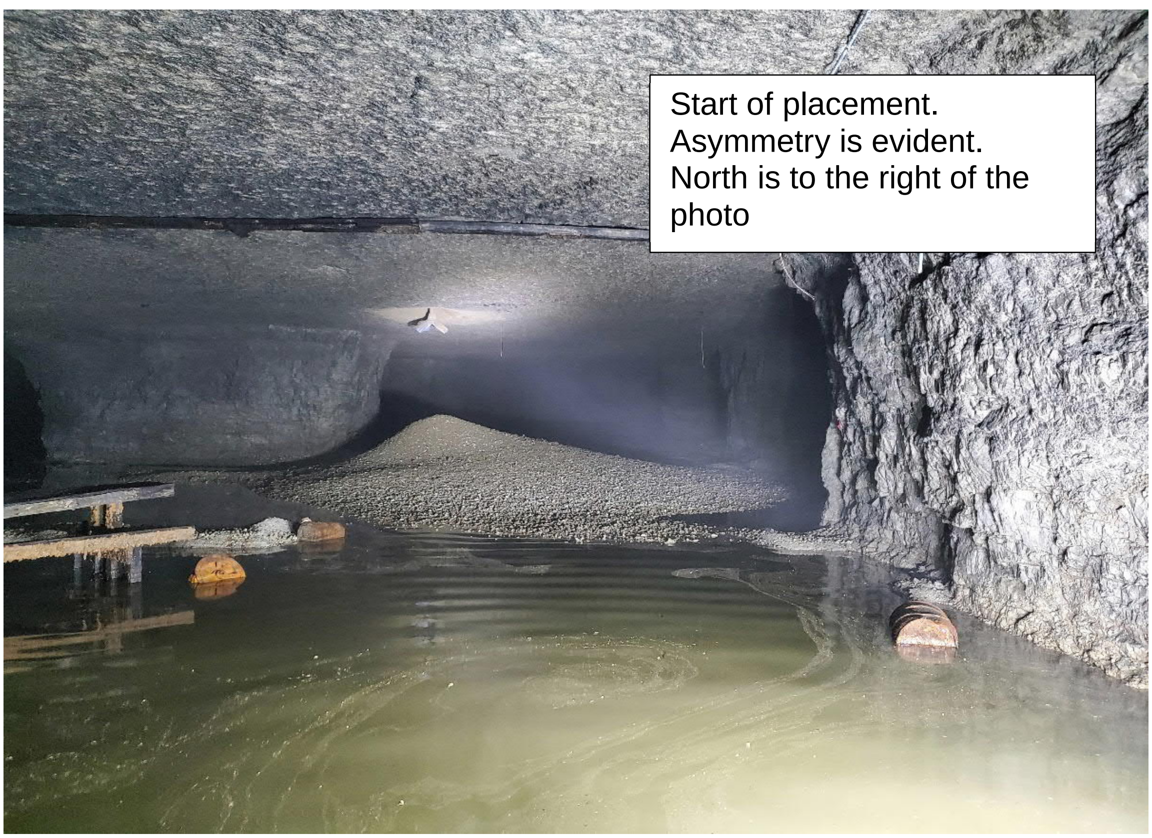

25.78"
12" hole, 11.5 od max


HYUNDAI


HYUNDAI
acker

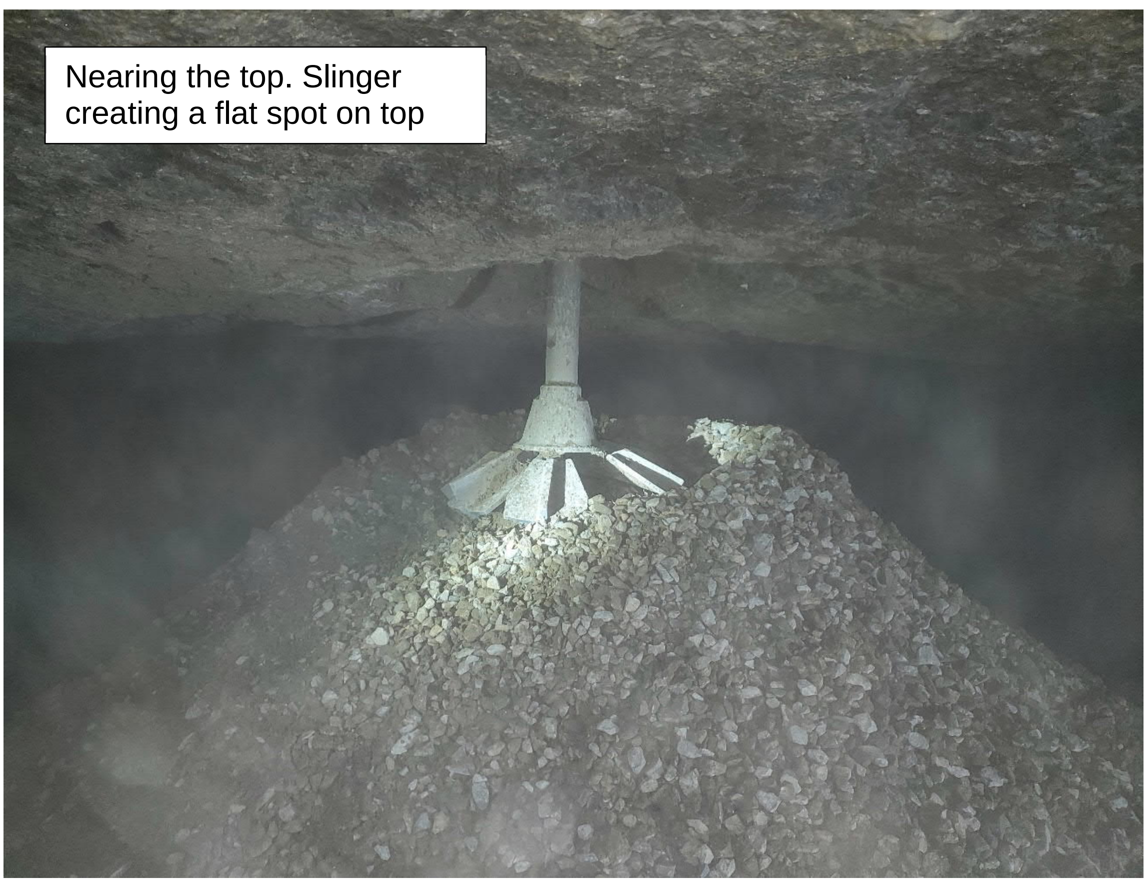


Rotation and Belt speed indicators and placement totalizer



Start of placement. Asymmetry is evident. North is to the right of the photo

Fines segregated from smaller rock and built up in the center

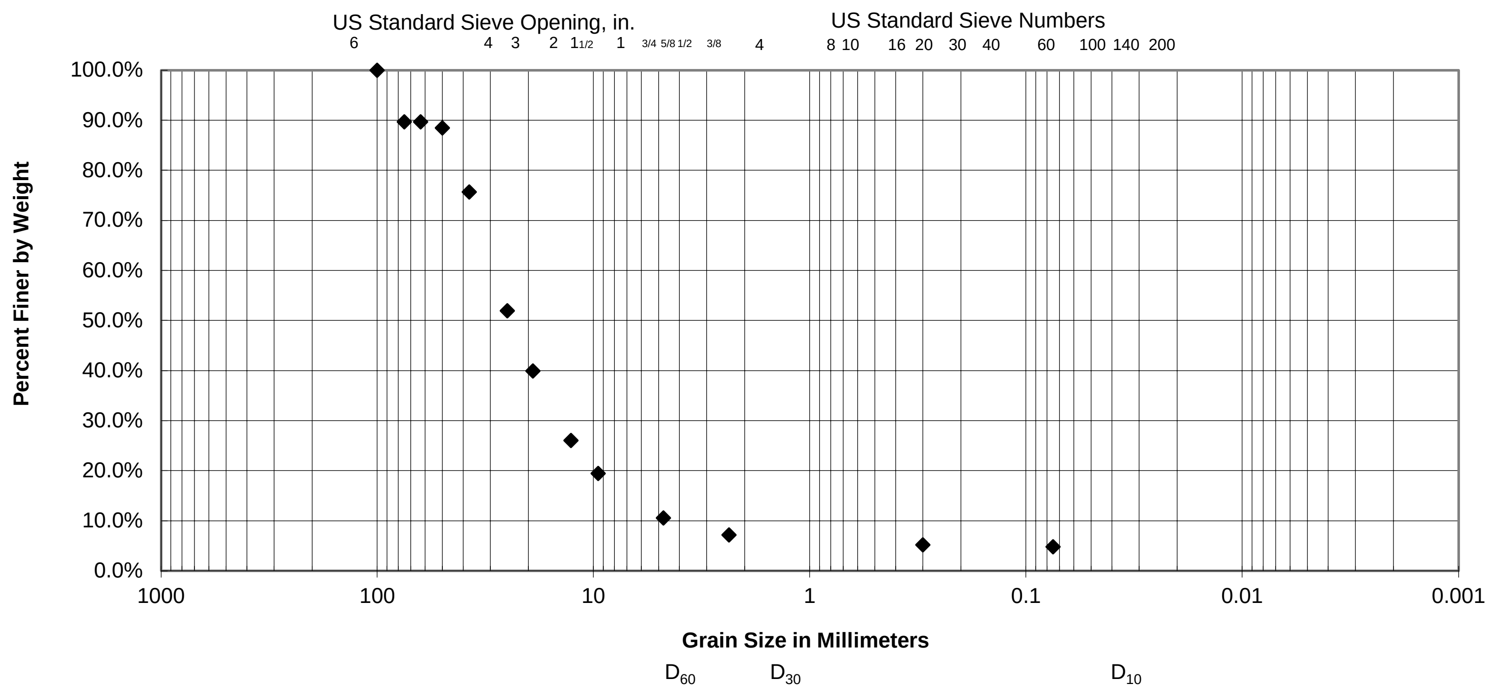


Nearing the top. Slinger creating a flat spot on top

APPENDIX B

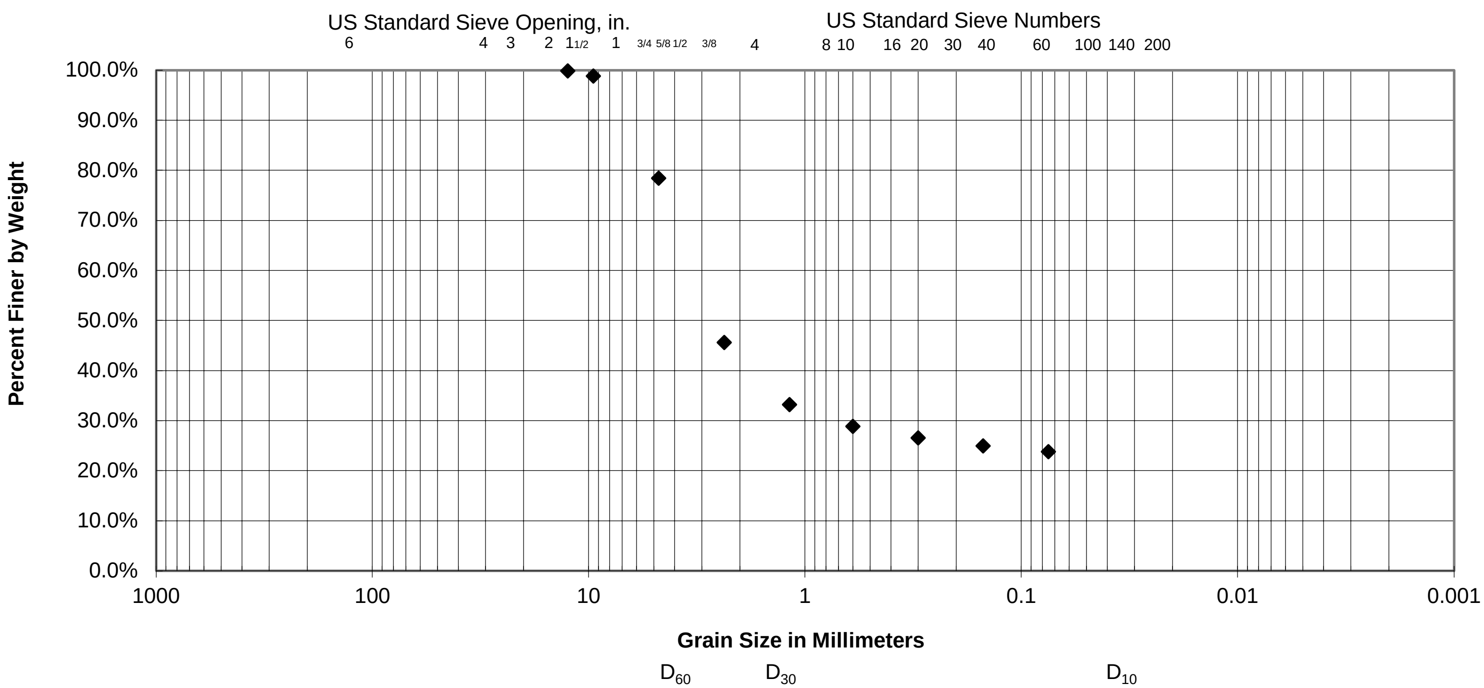
Laboratory Test Results

Mine Filling at Streets of West Pryor J035637.02
Streets of West Pryor, LLC
Grain Size Analysis ASTM D6913



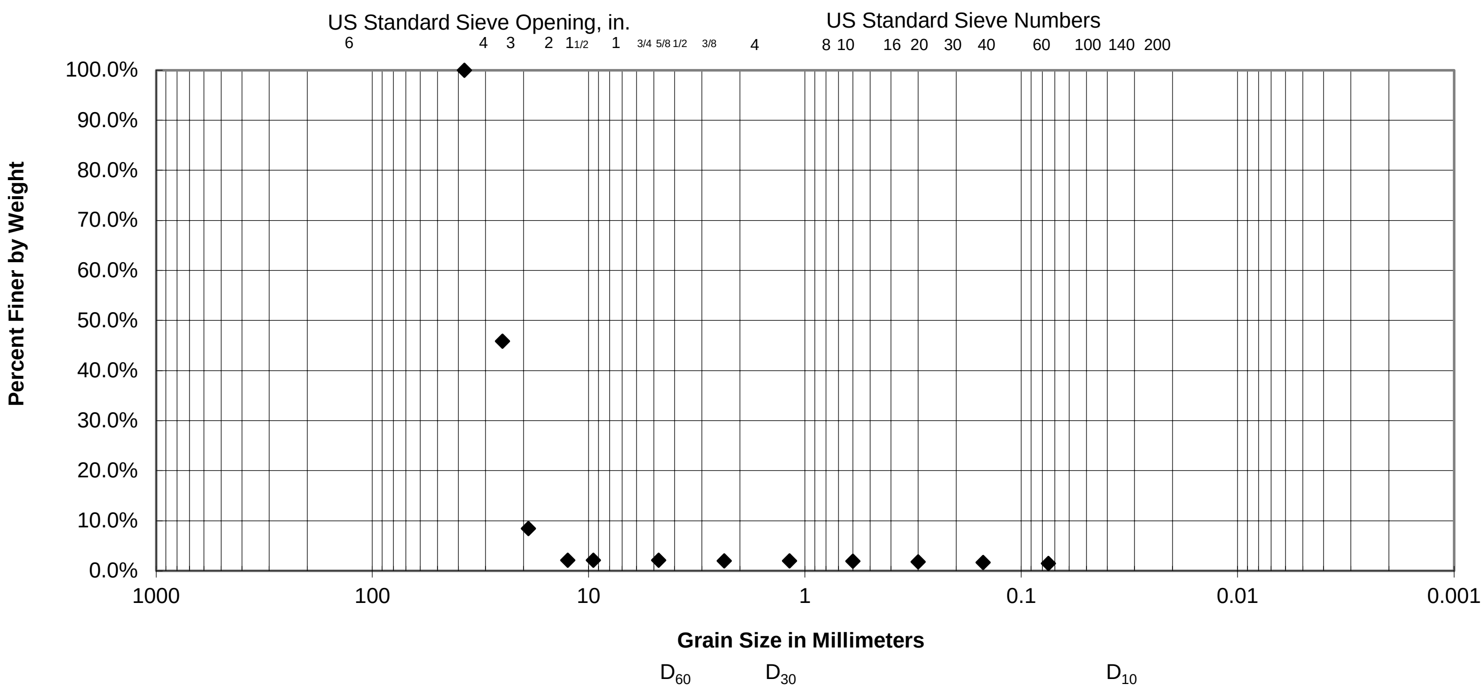
Sample Date:	**6/11/2021**	**Sampled By:**	ALP
Sample ID:	1185	**Tested By:**	DDW
Sample Description:	**Crushed Limestone**	**Calculated By:**	ADC
Sample Source:	**Stock Pile for Test Hole**	**Checked By:**	ADP
Material Contractor:	**Industrial Salvage & Wrecking**	**2" Minus: FAIL**	**Less than 20% Fines:** PASS

Mine Filling at Streets of West Pryor J035637.02
Streets of West Pryor, LLC
Grain Size Analysis ASTM D6913



Sample Date:	**6/22/2021**	**Sampled By:**	ALP
Sample ID:	1208	**Tested By:**	DDW
Sample Description:	**1/2 Inch**	**Calculated By:**	ADC
Sample Source:	**On-Site Stockpile**	**Checked By:**	ADP
Material Contractor:	**Industrial Salvage & Wrecking**	**2" Minus: FAIL**	**Less than 20% Fines:** FAIL

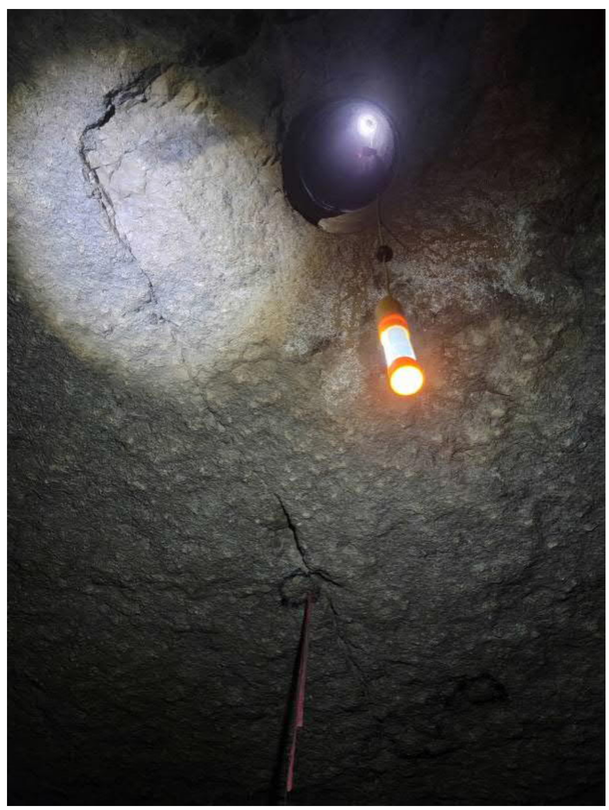
Mine Filling at Streets of West Pryor J035637.02
Streets of West Pryor, LLC
Grain Size Analysis ASTM D6913



Sample Date:	**6/22/2021**	**Sampled By:**	ALP
Sample ID:	1209	**Tested By:**	DDW
Sample Description:	**2 Inch**	**Calculated By:**	ADC
Sample Source:	**On-Site Stockpile**	**Checked By:**	ADP
Material Contractor:	**Industrial Salvage & Wrecking**	**2" Minus: FAIL**	**Less than 20% Fines:** PASS

APPENDIX C

Photographic Log

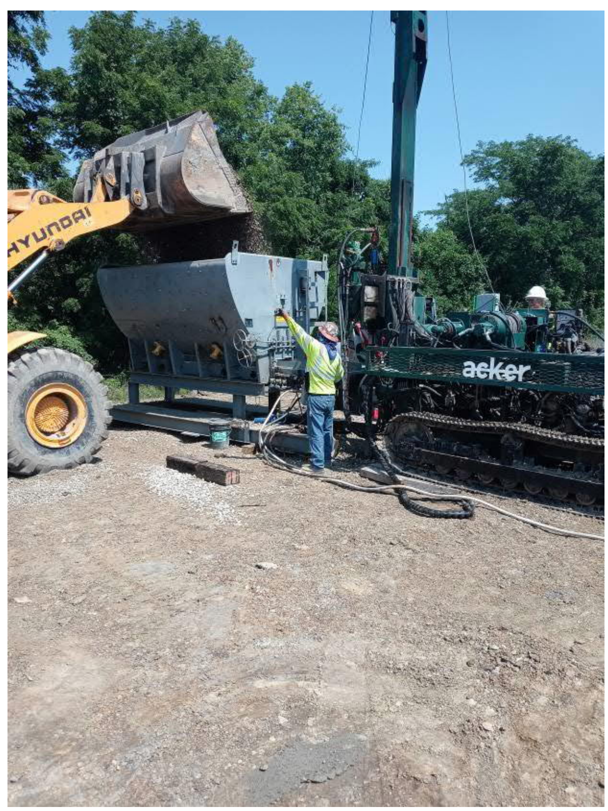
Description: Surface setup. Date: July 12, 2021	
Description: Bottom of the test hole. Date: July 12, 2021	

Description:
Stockpile – crushed aggregate.

Date:
July 13, 2021

Description:
Loading hopper.

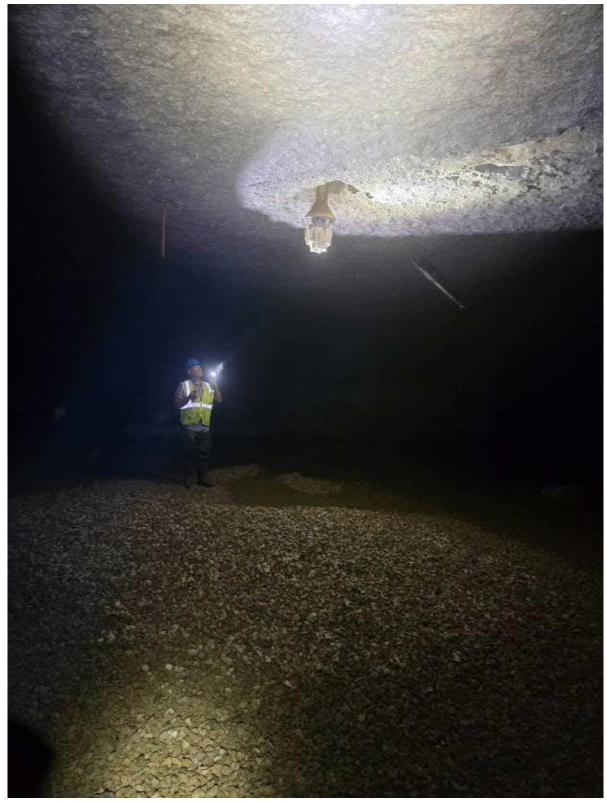
Date:
July 13, 2021



Description: Initial fill – note bias. Date: July 13, 2021	
Description: Initial fill. Date: July 13, 2021	

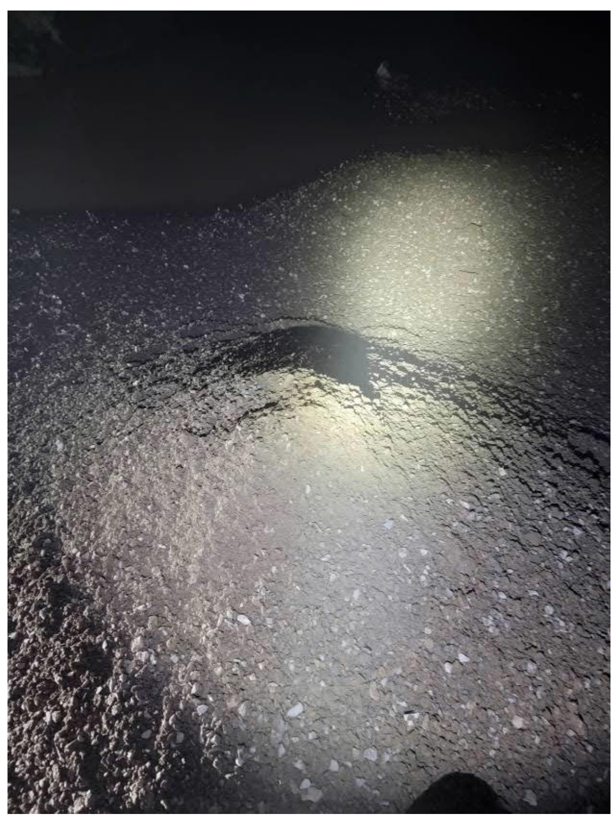
Description:
Test fill.

Date:
July 13, 2021



Description:
Test fill.

Date:
July 13, 2021



Description: Test fill – mid height. Date: July 14, 2021	

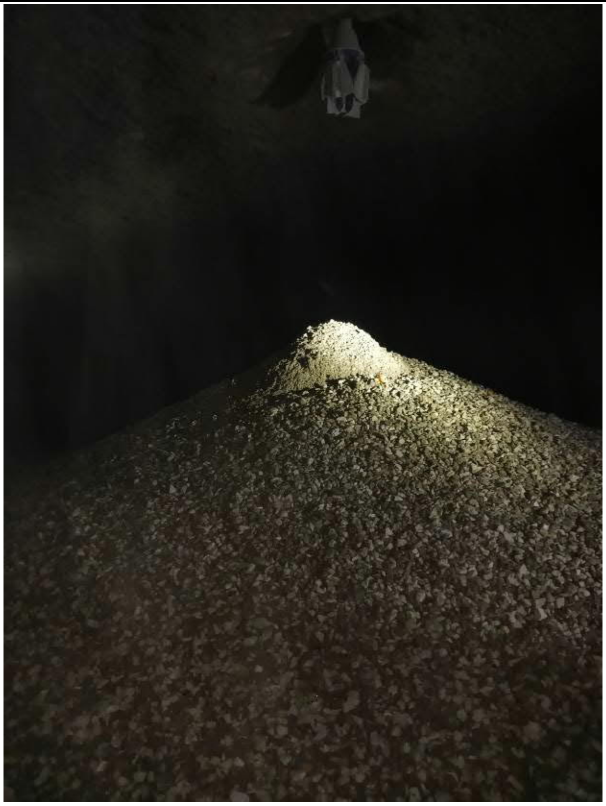
Description: Test fill – mid height. Date: July 14, 2021	

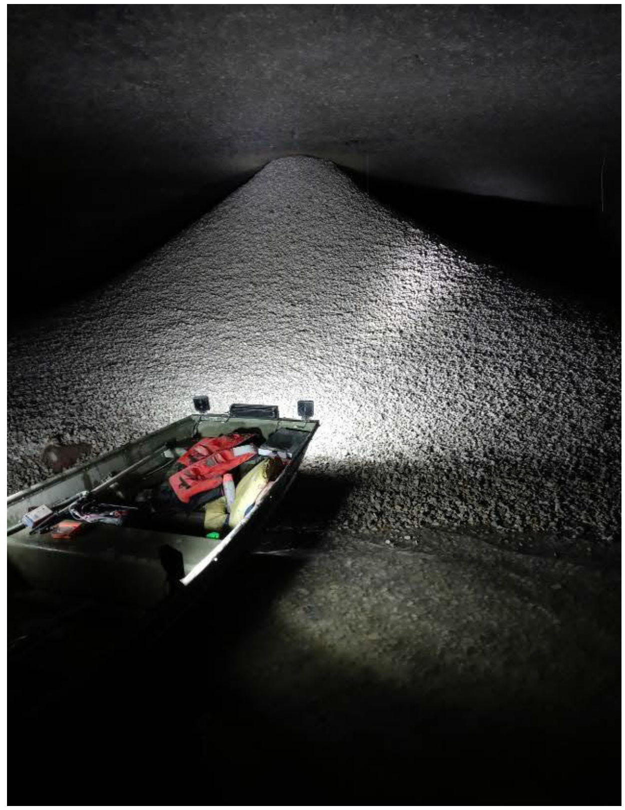
Description:
Test fill.

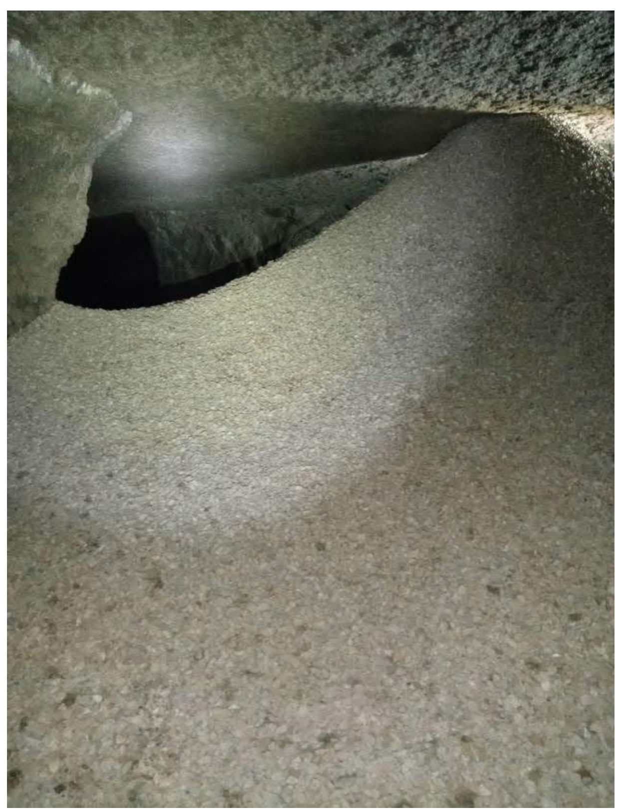
Date:
July 14, 2021

Description:
Test fill – completion.

Date:
July 14, 2021



Description: Test fill. Date: July 15, 2021	

Description: Test fill. Date: July 15, 2021	

Description:
Survey confirmation hole A-7.

Date:
July 15, 2021

Description:
Survey confirmation hole A-7.

Date:
July 15, 2021

APPENDIX D

Calculations

GEOTECHNOLOGY INC
FROM THE GROUND UP

JOB NO. J035637
SUBJECT Mine Remediation
BY ACP DATE 7-17-21 SHEET 1 of 1

Roof Beam Stress
- Limestone Roof Beam Assumed to be 4.5ft
  Average span is 35ft

- Roof Beam Carries self weight plus 1/2 assumed overburden

- From Mine Remediation Plan

Where
γ = Unit Weight 163 lb
L = Beam span 35' (as is)
t = Roof Beam Thickness 4.5ft
P = Overburden Pressure $\cong$ 1088 psf

$$\sigma_{t\,max} = \frac{\gamma L^2}{2t} + \frac{PL^2}{2(t)^2}$$

$$= \frac{163\,pcf\,(35ft)^2}{2(4.5)} + \frac{(1083\,psf)(35ft)^2}{2(4.5ft)^2} =$$

$$= 154\,psi + 114\,psi = 268\,psi$$

For a Remediated Room L=15.5ft

$$\sigma_{t\,max} = \frac{163\,pcf(15.5ft)^2}{2(4.5)} + \frac{(1083\,psf)(15.5ft)^2}{2(4.5ft)^2}$$

$$= 30.2\,psi + 44.6\,psi = 74.8\,psi$$

$$F.S. = \frac{\sigma_{TS}}{\sigma_{t\,max}}$$

From Remediation Plan
$\sigma_{ts} = 650\,psi$

$$F.S.\text{ for }35ft = \frac{650\,psi}{268\,psi} = 2.42$$

$$F.S.\text{ for }15.5ft = \frac{650\,psi}{74.8\,psi} = 8.71$$