VECTOR ENGINEERS, INC
GEOTECHNICAL · MATERIALS · GEOSCIENCES
A SUBSIDIARY OF CTL ENGINEERING, INC

January 13, 2023

Ms. Jennifer Linton
Office of the Secretary
200 Mero Street
Frankfort, KY 40622

Re: Report of Geotechnical Engineering Subsurface Charecterization
Evaluation of Mine Spoil Site for Residential and Commerical Development
Chestnut Ridge Site
Leburn (Knott County) Kentucky
Vector Project Number 22.05.0160 SHE

Dear Ms. Linton,

Vector Engineers, Inc. has completed a subsurface characterization of the Chestnut Ridge Site for development as a proposed residential and commerical development. This report outlines our exploration methods, our understanding of the development, the results of our exploration, our opinion on the risk of development and our recommendations for reducing that risk. Our services have been authorized by the Commonweallth of Kentucky Delivery Order Number 2300000522 dated November 21, 2022.

Background Information

Information concerning the proposed development was obtained from a meeting at the Kentucky Transportation Cabinet office and from several conversations with Mr. Jeffrey Conley of Western Pocahontas Properties. We also were provided with several drawings as follows:

1. Base Map, Chestnut Mountain by RMJE (RM Johnson Engineering Company) dated January 6, 2021.
2. Eastern Kentucky Floor Recovery general layout by Lord Aeck Sargent, undated.
3. Untitled topographic mapping of the area pre-mining, undated.
4. Untitled topographic mapping of the area post-mining, undated
5. Four untitled topographic maps showing the various mine permits, undated
6. A drawing showing the “solid base” of the mine benches, undated

The site is located off Highway 80 between Hazard and Hindman just east of the Perry/Knott County Line (Figure 1). The site was mined by mountaintop removal to a coal seam and contour mining around the mountain to obtain coal from a lower seam. The spoils (soil and bedrock from above the seam) are placed in the valley, on the side benches and overtop the mined top of the mountain. Similar sites have been developed in the area. From our experience with mine spoil fill sites, there are several factors that will impact a successful development. Typically, they are:

- Backfill placement Methods
- Age of the Fill
- Composition of the fill materials
- Thickness of the fill
- Water infiltration/hydrocompression

Based on conversations with Western Pocahontas Development, we understand that the placement methods of the mine spoil on this site consisted of end-dumping by using large dump trucks. The age is also important. Mine spoil fills less than about 10-year-old and less than about 100 feet thick will settle up to 1 to 2 percent of the fill height.

The composition is also important. If the fills are mostly shale, then the degradation of the shale can be excessive, causing large settlements. Sandstone is a more durable material. Therefore, determination of the spoil makeup is critical in evaluating a site.

Water infiltration is also a factor in detrimental settlement of mine spoil fills. Once the surface is broken up during construction, water infiltration will occur, causing the shale portion of the fill to degrade and cause settlement.

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Site and Geological Information

The site is located off Highway 80, in Leburn, KY, an unincorporated town in Knott County. The site is an old mine site that has been partially developed. There is an entry road, Chestnut Ridge Drive and Kenny Champion Loop. The Knott County Sportsplex is located on the west side of the site. The Sportsplex is experiencing detrimental settlement such that a portion of the building has been closed off to the public.

The old strip mine site has several tens of feet of mine spoil placed over top of several bedrock benches. The benches were created during past strip mining activity. We have been provided with a map of the approximate bench elevations.

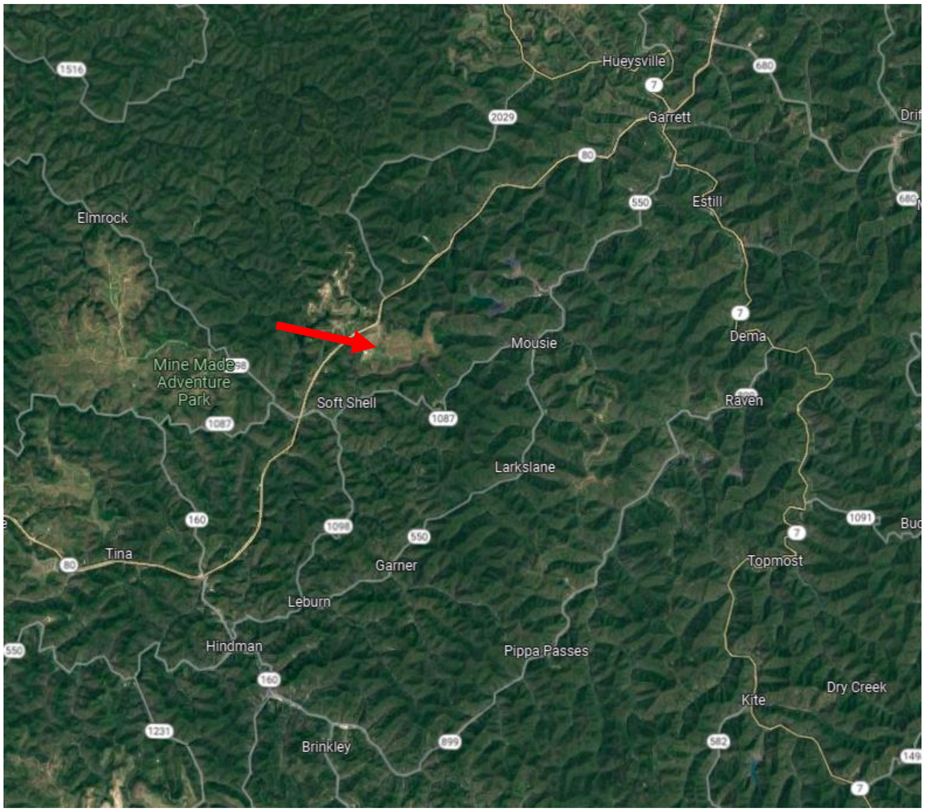


Figure 1: Site Location (Google Maps)

Figure 2: Aerial View of the site (Google Maps)

Figure 3: Preliminary Conceptual Plan of the Development (Lord Aeck Sargent)

An overlay of the conceptual plan to the aerial photograph gives a general indication of the site boundary.

Figure 4: Overlay of the conceptual plan on the aerial photograph of the site.

Review of the available published geological and mining data revealed that the site geology consists of two formations: the Princess Formation and the Four Corners Formation (Figure 5). The Princess Formation consists of sandstone, shale, coal, and underclay and is generally located at higher elevations. The Four Corners Formation is generally sandstone, siltstone, shale, coal, and limestone, encountered on the side slopes and in the valley bottoms.

Figure 5: Geological Map of the Site. The pink is the Princess Formation, and the blue is the Four Corners Formation

The Kentucky Geological Survey shows several coal seams that were/are located within the upper portions of the geologic column. Review of the geologic map for the area of the site indicate that three coal seems were probably mined. They are the Francis Coal (Hazard No. 8), the Hazard No. 7, and the Hazard seam (Figure 6). A review of the site topography would indicate that the Francis seam was about elevation 1480 ft msl, the Hazard #7 at about elevation 1280 ft msl and the Hazard seam about elevation 1200 ft msl. However, according to the mapping provided, the lowest seam mined on this site was about elevation 1420 feet msl. Therefore, the mining may have consisted of the Francis (Hazard #8) seam.

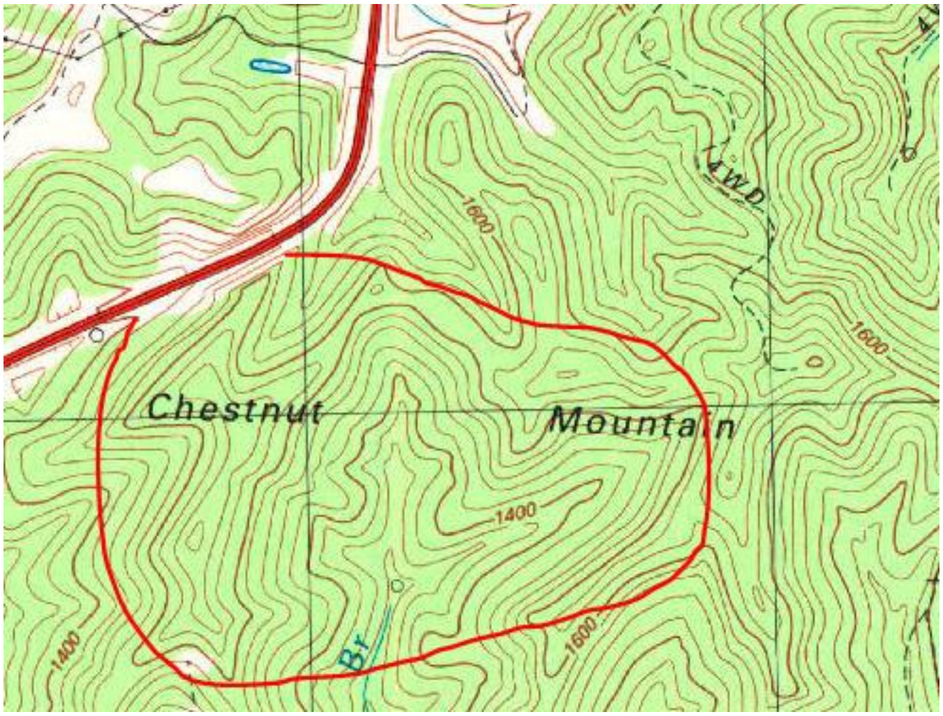


Figure 6: Pre-Mining contours (1992 USGS Mapping)

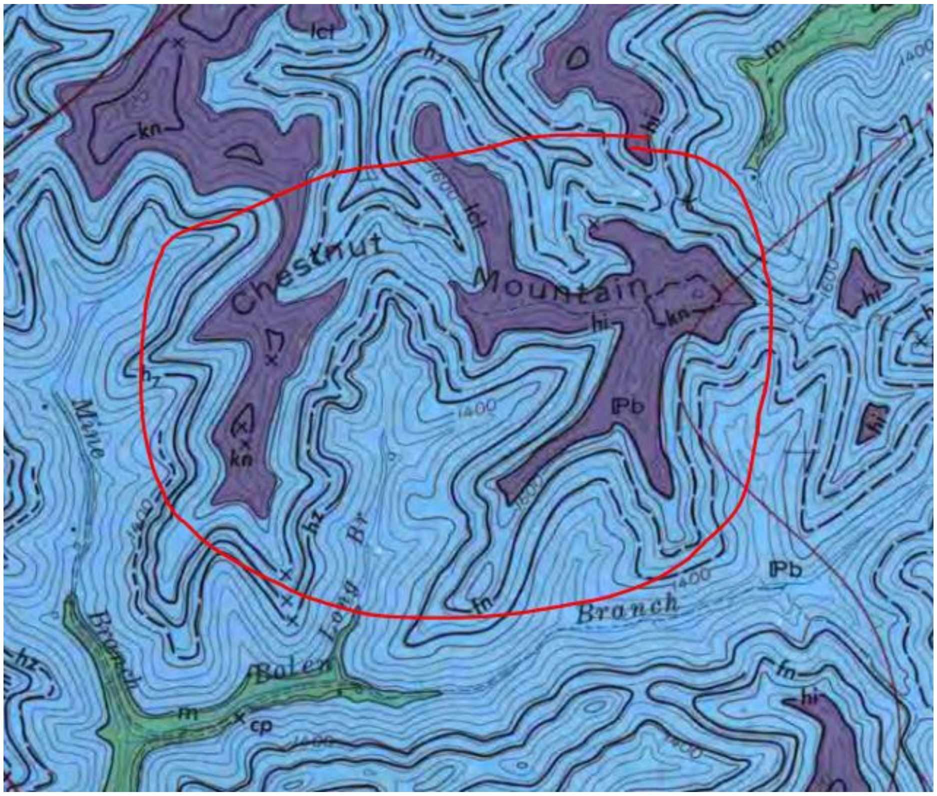


Figure 7: Geological Map showing coal seams.

Based on an interpretation from the geological maps and the provided topographic maps, the mining may have extended to about elevation 1420 ft msl. However, mapping may not be exact. As mentioned, we have received a map showing the approximate depth to the bottom of the mine excavation (solid base). The drawing indicates a bedrock solid base ranging from an elevation of 1420 feet to 1630 feet. Based on the top of ground elevations shown on the drawing and the indicated "solid base", the depth of mine spoil fill ranges from about 20 to up to 100 feet on the benches and probably deeper in the hollow fills.

According to the work pit model drawings, the mining was completed by 2002 with the majority of the backfill completed in 2003. We understand the Sportsplex building was started in 2006.

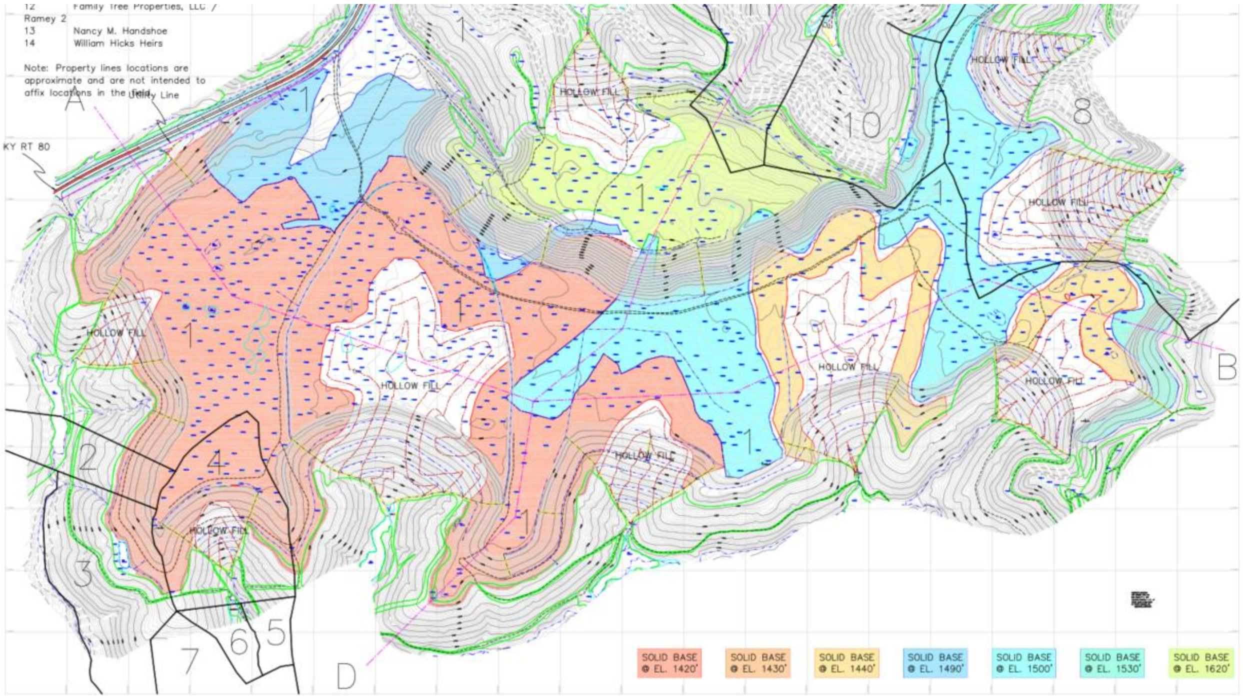


Figure 8: Drawing of the bottom of the mine excavation (solid base).

Existing Conditions

Based on the topographic mapping provided and our site observations, the site has been extensively graded and reclaimed during the reclamation process of the mine.

The site is partially developed with the Knott County Sports Complex, located on the southeast portion of the property. The property has generally level areas with steep slopes on the south side. A hill is located along the north side of the development. The surface cover is generally grass, weeds and brush. The following photographs illustrate the current site conditions.

Photograph No. 1: View looking west toward boring B-1 (pink flag) and toward Highway 80. The cut is on the west side of highway 80.

Photograph No. 2: View looking east toward Boring B-10.

Photograph No. 3: View looking North towards the upper plateau area.

The elevations at the toe of the slope from the upper ridge on the north side of the site is about 1525 feet and the top of the ridge at about 1660 to 1670 feet. The generally flatter areas on the majority of the site range in elevation from about 1500 to 1520 feet on the west side of the site to about 1540 to 1550 on the east side. Several hollow fills are located on the west side, near highway 80, the south side and the west sides. The toe of the hollow fills range from 1250 feet on the west side of the site to about 1300 feet on the south side and about 1150 feet on the far east end.

Detailed mining methods for the site have not been conveyed to us, however, from our conversation with Western Pocahontas Development and our experience on similar sized mines in the area would indicate that the site was mined using contour mining and mountain top removal mining methods. Typical contour mining consists of stripping and grubbing prior to constructing drill benches by bulldozers. The overburden is drilled and blasted to expose the coal seam. Bulldozers push the blasted rock to a front-end loader. The loader loads the overburden into haul trucks for transport to the deposition location.

Mountaintop or Ridge top removal mining removes the entire top of a mountain ridge creating a level surface at the coal seam. The same type of equipment used for contour mining is used in mountaintop removal. Mountaintop mining does affect much larger areas of land versus the relatively thin bands characteristic of contour mining.

Typically, the excavation begins along the deepest economically removable coal seam outcrop parallel to the ridgeline. To start the operation, the first cut is transferred by rock trucks to the hollow fill. After overburden drilling and blasting, front end loaders and rock trucks work progressively toward the center of the mountain. Concentrically circling the mountain, the lower benches advance ahead of the upper excavations. The excavation continues with rock trucks hauling material to the mine spoil storage area using ramps connecting the series of benches until a level surface remains. The bench heights are determined by ether the occurrence of a coal seam or by equipment limitations. Typically, the equipment used for placing the mine spoil consisted of bulldozers (most likely Caterpillar model D9's or similar) and Caterpillar model 777B (triple 7's) dump trucks. The dump trucks end dumped the mine spoil into the valley or onto the benches. The bulldozers were used to level the top of the mine spoil piles. No compactive effort was conducted in the hollow fills.

Based on our understanding of the site, the mine spoils were placed by end-dumping from the top of the mine bench into the valleys. The initial phase of the mining would have used the valleys to place spoil materials with later phases consisting of ridgetop removal and back stacking the spoils on against the highwalls created by contouring and on the plateau.

End dumping of the spoil creates a loose structure that has a tendency to consolidate thereby reducing the void space between particles over a long period of time. In addition, water infiltration can cause slaking of the shale portion of the mine spoil fills, which can lead to a condition called hydrocompression where settlement can occur from loss of strength from the once rock to rock contact points and the creation of conduits that can collapse over time. Due to the variability of the constituents, placement methods and thickness of the mine spoil, differential settlement can occur in these fills. The quantituy naa time for completing of the settlements can not be accurately predicted.

Subsurface Characterization

After researching the available information provided to us on the project, we developed a preliminary understanding of the subsurface conditions. The "Solid Base" map (Figure 8) provided a good indication of where the bedrock would be encountered. Therefore, we utilized the preliminary master planning drawing and compared the proposed structure locations to the solid base mapping. In conjunction with conducting soil test borings and bedrock coring, we also conducted geophysical testing. The geophysical testing allows a larger area to be evaluated to determine the general makeup of the subsurface where a soil boring yields information at a specific location.

The subsurface terrain consists of the base of a mountain ridge (Chestnut Mountain), several contour benches and the Long Branch Creek Valley to the south. The mining created several benches with elevations of 1420 feet msl, 1430 feet msl, 1440 feet msl, 1490 feet msl, 1500 feet msl, 1530 feet msl and 1620 feet msl. The 1620 feet bench is on the upper portions of the site where the master plan shows large homes will be built.

The depth of the mine spoil in the areas range considerably. The top of ground elevations are about 1515 feet to 1520 feet on the western section of the site (orange shading on Figure 8) where the bench elevation is reported to be 1420 feet, making the mine spoil depths about 100 feet thick.

The area on the northern section of the site near the development entrance road indicated by the blue shading in Figure 8 has top of ground elevations of about 1490 to about 1530 feet msl making the depth of mine spoil to the bench elevation of 1490 feet about a few feet to about 40 feet.

The area near the center of the site (light blue shading in Figure 8) has top of ground elevations ranging from about 1520 to about 1530 feet msl making the depth of fill to the mine bench (1500 feet msl) about 20 to 30 feet thick.

The area along the hollow fill perimeter shaded in yellow, has top of ground elevations ranging from 1525 to about 1530 feet msl. The bench elevation is reported to be 1440 feet msl making the spoil thickness about 85 to 90 feet.

The western portion of the site shaded in a lighter blue has top of ground elevations ranging from about 1540 feet msl to just under 1545 feet msl. With a bench elevation reported to be 1500 feet msl, the mine spoil thickness is expected to be about 401 to 45 feet.

The upper elevations of the site, where the proposed large homes will be located, have top of ground elevations ranging from 1630 on the lower ledge toward the main entrance road to 1655 to 1660 feet msl on the upper plateau. With a bench elevation reported to be 1620 feet msl the mine spoil thickness is expected to be 35 to 40 feet.

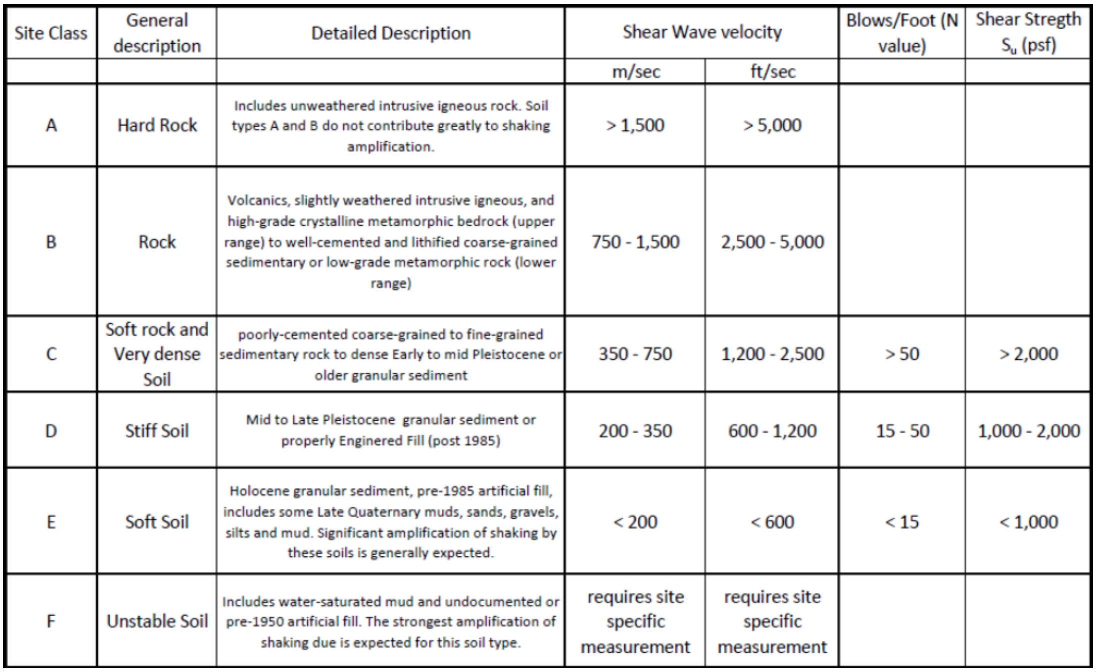
The slope along the upper plateau to the lower area is also mine spoil that has been back stacked against a highwall that was the edge of the contour mining bench.

To verify the accuracy of the mapping we conducted geophysical surveys and soil test borings at various locations as shown on the location plans in the appendix. We conducted 5 geophysical arrays and 10 soil test borings to evaluate the mine spoil consistency.

Geophysical Testing

Geophysical testing on the site utilized Multichannel Analysis of Surface Waves (MASW). MASW evaluates ground stiffness by measuring shear wave velocity (Vs) of the subsurface materials. The seismic waves are generated using a steel plate and sledgehammer with the waves collected using geophones spaced along a line. The shear wave velocity is a direct indicator of the soil and bedrock stiffness. A low shear wave velocity indicates a soil material, and a high velocity would represent bedrock. Table 1 illustrates typical ranges for the various materials.

Table 1: Shear Wave Velocities and Earth Material Type



Site Class	General description	Detailed Description	Shear Wave velocity		Blows/Foot (N value)	Shear Stregth S_u (psf)
			m/sec	ft/sec		
A	Hard Rock	Includes unweathered intrusive igneous rock. Soil types A and B do not contribute greatly to shaking amplification.	> 1,500	> 5,000		
B	Rock	Volcanics, slightly weathered intrusive igneous, and high-grade crystalline metamorphic bedrock (upper range) to well-cemented and lithified coarse-grained sedimentary or low-grade metamorphic rock (lower range)	750 - 1,500	2,500 - 5,000		
C	Soft rock and Very dense Soil	poorly-cemented coarse-grained to fine-grained sedimentary rock to dense Early to mid Pleistocene or older granular sediment	350 - 750	1,200 - 2,500	> 50	> 2,000
D	Stiff Soil	Mid to Late Pleistocene granular sediment or properly Engineered Fill (post 1985)	200 - 350	600 - 1,200	15 - 50	1,000 - 2,000
E	Soft Soil	Holocene granular sediment, pre-1985 artificial fill, includes some Late Quaternary muds, sands, gravels, silts and mud. Significant amplification of shaking by these soils is generally expected.	< 200	< 600	< 15	< 1,000
F	Unstable Soil	Includes water-saturated mud and undocumented or pre-1950 artificial fill. The strongest amplification of shaking due is expected for this soil type.	requires site specific measurement	requires site specific measurement		

Geophysical Survey

The purpose of our geophysical survey was to attempt to determine where the old subsurface mine benches are located. The bench locations will determine where the development should be constructed. Differing mine spoil thicknesses across the site will result in differential settlement which could be detrimental to the long-term performance of structures, buildings, roads and utilities.

Geophysical (seismic) data were collected along 5 survey lines to gather information about the density of subsurface materials. Specifically, a seismic refraction survey was conducted to evaluate the subsurface compressional-wave velocity variation along each survey line. Compressional-wave velocity is a function of the density, bulk modulus, and shear modulus of the material. The data were used in combination with boring data to estimate the characteristics of the geologic materials. The seismic refraction survey line locations are shown in Figure 9 and 10. Figure 10 illustrates the reported bench locations as well as the boring locations.

Seismic refraction data were collected between December 19 and December 22, 2022. The field procedures involved use of a 24-channel 4.5-Hz geophone array with a geophone spacing of twelve (Seismic Refraction Lines 1, 3, and 4) to fifteen (Seismic Refraction Lines 2 and 5) feet. The energy source used during the seismic refraction surveys was a sledgehammer striking a steel plate. The seismic data were recorded digitally directly on the laptop computer used to control the seismograph.

The seismic refraction data were processed using SeisImager software (copyright Geometrics, Inc.) to produce compressional-wave velocity models of the subsurface. Processing included manually picking first-arrival times of seismic energy and data inversion to produce smoothed velocity contours of the subsurface. One velocity model (profile) was produced for each geophysical survey line. The ground surface of each model was assigned a relative elevation of 100 feet.

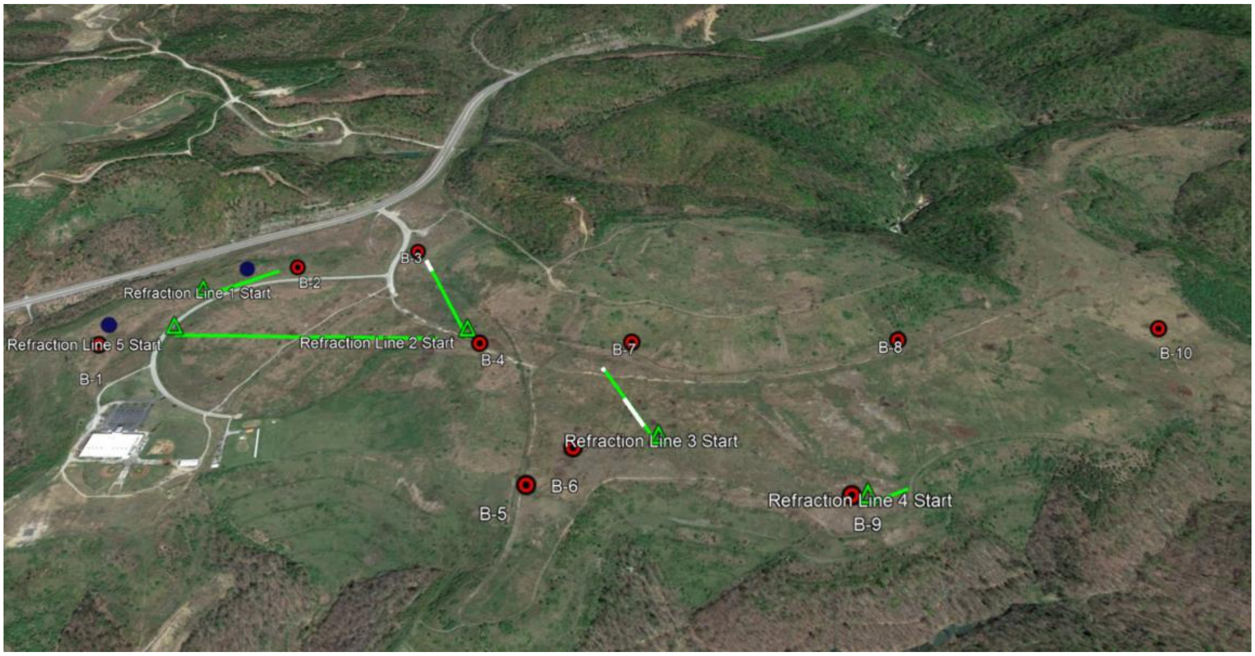


Figure 9: Seismic refraction lines and boring locations

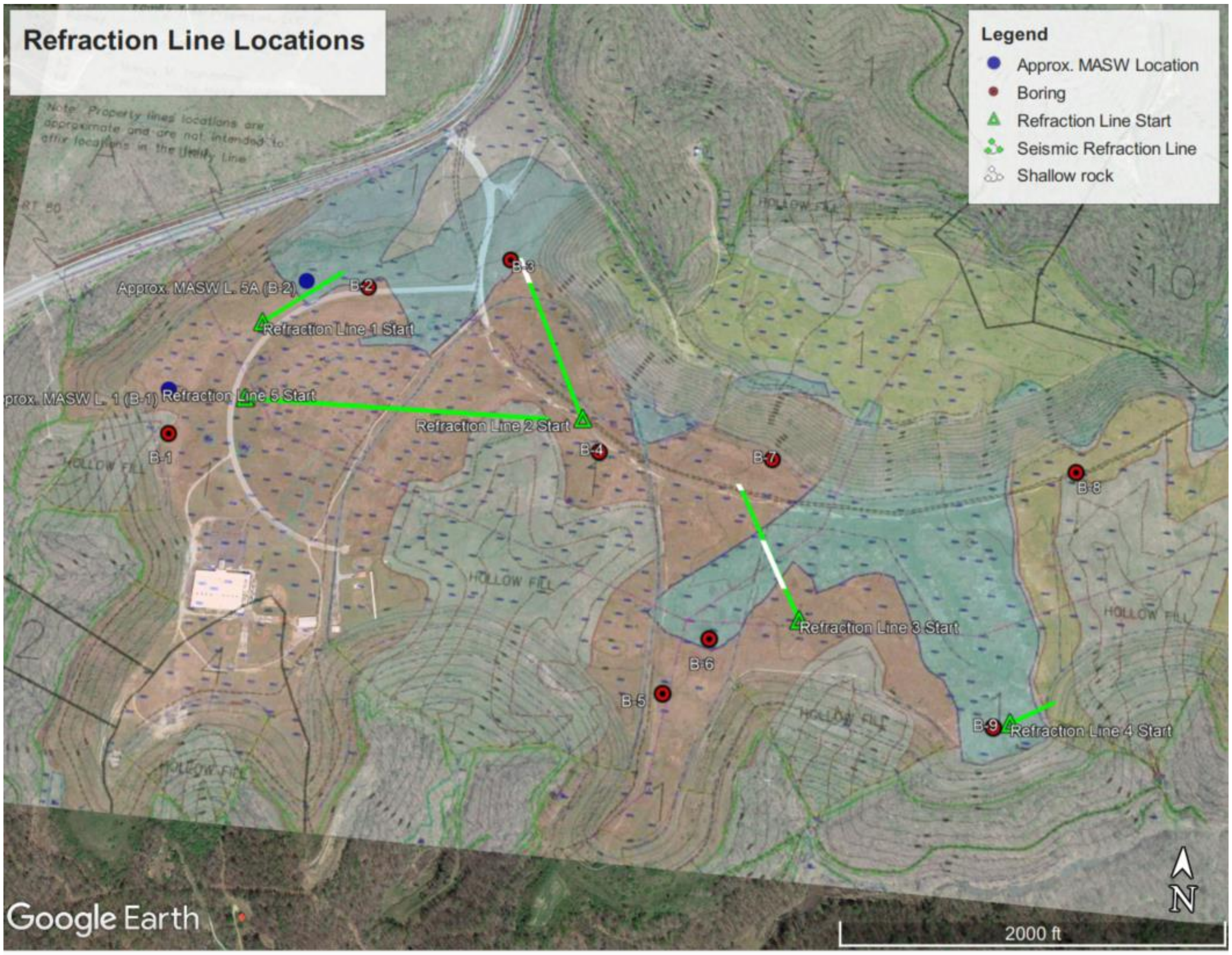


Figure 10: Seismic refraction line locations with respect to reported bench locations

Findings

Compressional-wave (i.e. P-wave) velocities varied laterally and with depth based on the materials encountered. Shallow soil, fill, and weathered rock generally exhibited lower velocity values than materials at greater depths, indicating a weaker soil/fill structure near the surface. The results (seismic refraction profiles) are shown in the *Appendix*. However, the results from line 1 are illustrated in Figure 10 for illustration. The seismic refraction shear wave velocities over about 5000 feet per second would generally indicate competent bedrock or in this case, the old mine bench.

Seismic Refraction (SR) Line 1 suggests competent bedrock exists at shallow depths (about 30 feet or more) beneath the line location. The dark blue to green transition is the area where we interpret the mine bench. Boring B-2 was drilled within

200 feet (to the southeast) of the northeastern end of SR Line 1. Boring B-2 encountered refusal at a depth of 33.4 feet from top of ground. This corresponds well to the seismic refraction data. The data collected along SR Line 1 do not show a clear bench feature (sharp increase in the interpreted depth to rock) at the documented boundary of a transition from solid base material at elevation 1,490 feet to solid base material at an elevation of 1,420 feet. This may represent a concentration of boulders that were back stacked against the old highwall from one bench to the other.

Seismic Refraction Line 2 suggests the depth to competent rock is deeper than our survey was able to record (more than 70 feet) at the southern end of the line. The SR Line 2 data show the depth to competent rock significantly decreases near the northern end of the line. The depth to rock at the northern end of the line is consistent with the materials encountered in boring B-3, which is located very close to the northern end of the line (approximately 50 feet west of the end of the line). Boring B-3 encountered refusal at 25 feet. Zones of shallow rock that were interpreted along SR Line 2 and SR Line 3 are shown by white sections of the survey lines (otherwise shown in green) that are shown in *Appendix*.

Seismic Refraction Line 3 suggests the depth to competent rock is deeper than our survey was able to record (more than 50 feet) near the southeastern and northwestern end of the line. The SR Line 3 data show a section of shallower rock near the center of the line that corresponds with a transition in documented base of solid material to elevation 1490 feet, with solid base material being near an elevation of 1420 feet closer to the start and end of the survey line. The SR Line 3 data also suggest shallow rock exists near the northern end of the line.

Seismic Refraction (SR) Line 4 suggests competent bedrock exists at depths of 45 to 55 feet beneath the line Seismic Refraction (SR) Line 5 suggests competent rock exists at depths below the base of the profile (more than 70 feet below ground surface). The SR Line 5 data show higher seismic velocities (potentially shallower weathered and/or soft rock) near the eastern end of the line. Boring B-9 was located just west of line 4 where refusal was encountered at a depth of 7 feet.

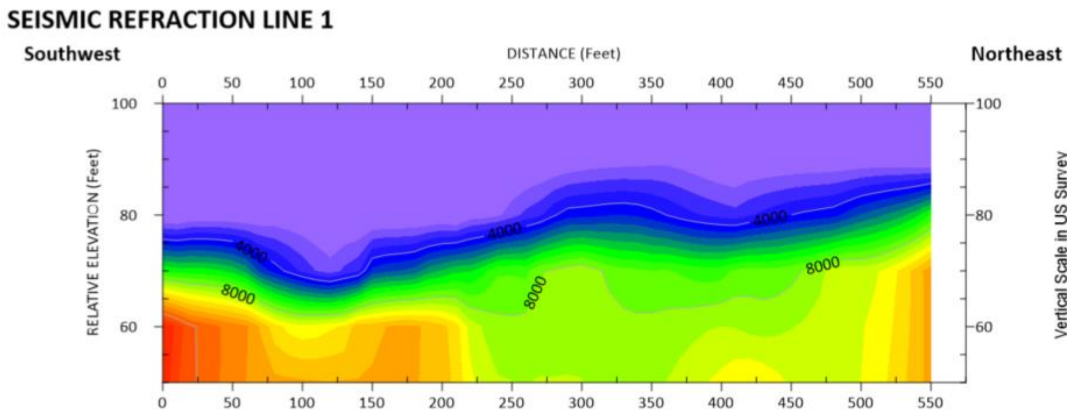


Figure 11: Results of Seismic Refraction Survey along line 1.
The green area is representative of suspected bedrock benching.

Comparing the results of the seismic refraction testing and the soil boring refusal depths, the data generally agrees with the “Solid Base” mapping provided to us.

Soil Borings

The borings generally encountered similar conditions across the site. The soil borings encountered a thin layer of topsoil, less than 3 inches thick, underlain by mine spoils consisting of a mixture of weathered shale, sand, sandstone pieces, silt and sandstone boulders. There were pockets of saturated weathered shale within the fill. Additionally, we encountered several layers of sand (assumed to be weathered sandstone). The standard penetration tests ranged from 2 blows per foot to in excess of 50 blows per inch. A statistical analysis of the N values indicate an average value of 24 blows per foot with a standard deviation of 16. The result of the statistical analysis matches well with penetration data from other sites in the area, therefore, we can incorporate our experience with the previous sites with this site.

The borings were located at specific bench locations to verify the depths indicated on the “Solid Base” Map. The borings generally encountered refusal within a reasonable depth that agreed with the mapping. Table 1 lists the interpreted depth to the bedrock bench based on our review of the soil and rock specimens. On the boring logs, some of the coring conducted through refusal material was judged to be large boulders within the fill and not actual bedrock bench depths.

Table 2: Depth to Estimated Bedrock from the Borings

Boring Number	Depth to "Solid Base" from drawing	Depth to Refusal (Feet)	Judged Bedrock Bench (Feet)
B-1	90 to 100	74.6	74.6
B-2	10 to 30	33.4	33.4
B-3	10 to 30	20	24.8
B-4	? (near top of hollow fill	20.5	80
B-5	? hollow fill	67.2	67.2
B-6	90 to 100	25	25
B-7	90 to 100	62	102+
B-8	35 to 40	10.6	48
B-9	35 to 40	7	7
B-10	35 to 40	54.5	54.5

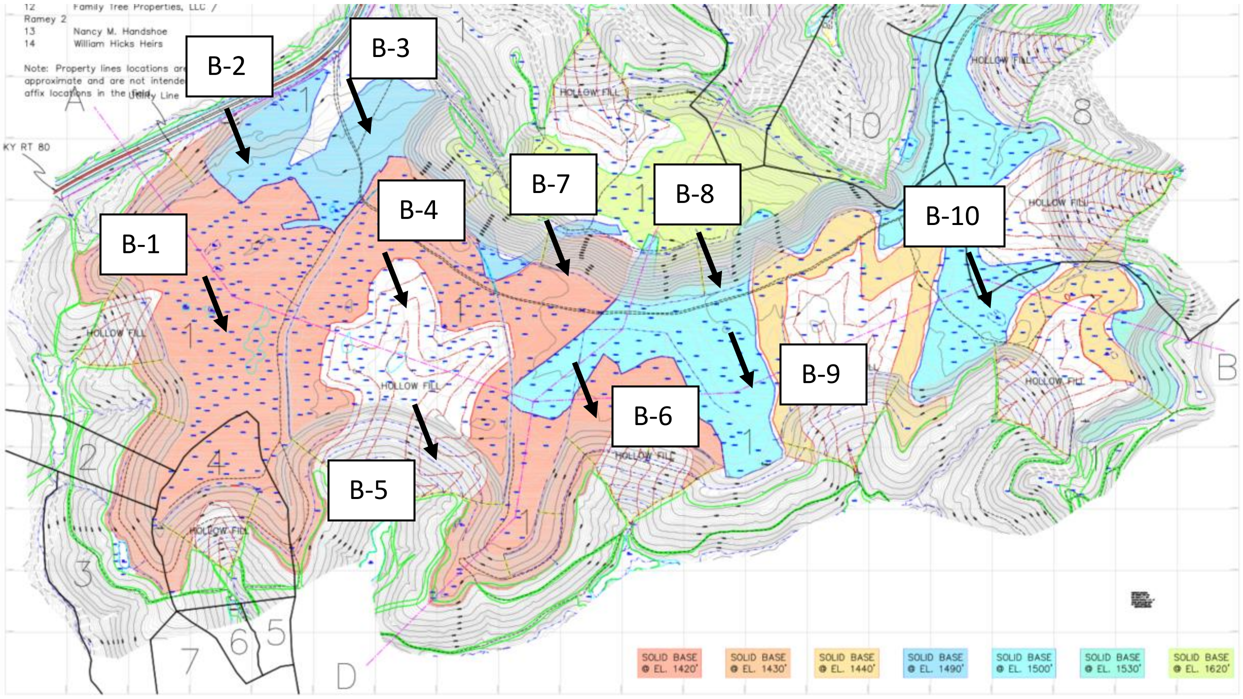


Figure 9: Approximate Borehole locations compared to bench map.

Our laboratory testing consisted of conducted several moisture contents tests on two select borings. The moisture contents ranged from 7.2 percent to 17.4 percent.

Groundwater

Groundwater was not encountered in the borings at the time of drilling. However, our experience indicates that groundwater does exist at the bottom of the mine spoil fill and within perched zones within the fill. Our previous experience on mine spoil fill sites and research conducted by the Kentucky Geological Survey suggests that groundwater typically enters the fill from infiltration of surface water and through buried coal seams. Typically, groundwater issues when working in mine spoil fills are related to trapped or perched water which occurs in irregular, discontinuous locations within the overburden, or near a bedrock/soil interface. When these water bearing strata are exposed in excavations, such as cut slopes, utility or footing trenches, they can produce widely varying seepage duration and rates depending on recent rainfall activity and other site-specific characteristics of the area.

Discussion

There have been several developments on mine spoil fill sites throughout the region ranging from residential, commercial, educational, and industrial. The primary concerns of building on mine spoil fill sites is the amount of differential settlement that can occur . Settlement will generally result from two primary processes: the consolidation settlement of the fill under its own weight and degradation of the shale portion of the fill over time due to water infiltration. The initial settlement of mine spoil fills is primarily due to a reduction in void space within the material from self weight. The amount of time for this primary initial settlement to occur will vary based on the individual site conditions. However, previous research indicates that for fills less than about 100 feet thick, the majority of the settlement occurs within the first 8 to 10 years after the mine spoil was placed Additionally, research conducted by the Kentucky Geological Survey also indicates that the initial settlement in mine spoil studied at an Eastern Kentucky mine had occurred within 8 years of placement. Once the void space reduction occurs, additional initial settlement results for short term compression as the fine-grained material is loaded. Short term compression will continue until the stresses are distributed uniformly throughout the fill at which time long term or secondary settlement begins.

After the initial settlement phase of mine spoil fills has occurred, the secondary settlement phase can produce significant magnitudes of settlement, although they are not as severe as the settlement for the initial phase. However, changes in water infiltration through subsurface groundwater recharge and/or surface water infiltration drastically affects the settlement of mine spoil fills.

Observations of numerous mine spoil sites in Eastern Kentucky generally indicate that on relatively new sites and sites that have been recently regraded, evidence of water infiltration from rainfall such as sinkholes and piping into the subsurface are common. On older sites large amounts of water infiltration into the surface of the mine spoil fill is not as prevalent. This is evidenced by the presence of ponds and wetland type vegetation. On established mine spoil fill sites, the surface will develop a crust. The weathering process of the upper materials results in voids within the upper portions of the mine spoil becoming filled by the downward migration of small particles and thus increasing the density of the spoil and prohibiting the infiltration of water. Desiccation of the surface layer of mine spoil may also contribute to the formation of a surface crust. Desiccation is a process where the soil moisture in clay is drawn to the surface and evaporated. During this process, the clay becomes stiffer. Since natural precipitation does not expel more than a small part of the air contained in the voids of surface soil, cohesion in the soil can survive wet periods of long duration. However, once a site is disturbed by construction activity, the crust is disturbed, and the weathering process is reinitiated.

The age, placement methods and type of mine spoil material would indicate that the primary consolidation period for the site has been achieved. However, as mentioned, there is a risk of secondary consolidation that could take many years. Based on our prior research on similar sites, we are anticipating secondary settlements over the next 10 to 20 years for the fills less than 50 feet thick to range from 1 to 2 inches. For fills over 50 feet and less than 100 feet, we anticipate additional long-term settlement over the next 10 to 20 years will range from 1 ½ to 3 inches. Therefore, to reduce the risk of differential settlements, individual buildings should be located on a generally uniform fill thickness. This will require adjusting the master plan to keep the proposed school from straddling two bench areas.

A higher risk concern is the amount of water infiltration that can occur soon after construction has been completed. Water infiltration can rapidly (within a few years) cause detrimental settlement issues. As previously mentioned, the weathering process of the upper materials results in voids within the mine spoil being filled eventually preventing infiltration of surface water. However, the process of regarding and developing a site for construction destroys this crust. Therefore, newly disturbed construction sites will allow the infiltration of water until the crusting process reestablishes itself. Therefore, it is imperative that any building or structure have adequate positive drainage away from the building. Additionally, all gutter downspouts should be directed away from the buildings such that any water infiltration will not impact the building.

Our previous experience and research suggests that the hydrocompression process is accelerated by introduction of water into the subsurface from the forementioned gutters, septic tank fields, poor site drainage and runoff from paved and landscaped areas.

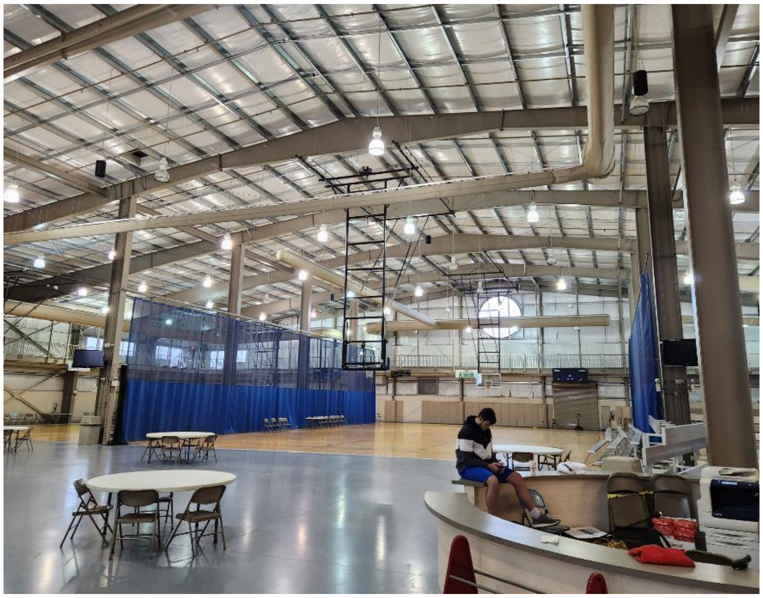
Existing Building on Site

The Knott County Sportscenter is located at the southeastern portion of the site. The building is a steel framed, metal sided, high bay structure with a glass and CMU block façade. The building has a lower masonry wall around the building. The structural cracking appears to be limited to the front two story section of the building. There is extensive structural damage to the front stairwell and upper floor of the front section of the building. The two-story office and classroom portion of the building has been closed off to the public due to the damage. The CMU block wall around the sides and back of the building did not show obvious settlement cracking. The following photographs illustrate the damage.

Photograph No. 4: Front View of the Sportsplex

Photographs No. 5 and 6: Cracks in upper floor of stairwell and storage room.

Photograph 7: Upper-level cracking in front room.



Photograph No. 8: Interior of the gymnasium portion of the building

The evaluation of the settlement of this building is not within our scope of evaluation. However, for a better understanding of the risks associated with this site, observations of the existing building were included. We understand that the Sportsplex building was built about 10 years ago. The foundation type is unknown; however, we are assuming conventional spread footings. Based on the mapping reviewed for this site, it appears that the building is partially underlain by a hollow fill and partially on the 1420 feet msl bench. If the fill was completed shortly before construction (within 5 years or so) then the primary consolidation of the fill due to self-weight was still occurring. This may explain the settlement. Additionally, there was evidence of water overflowing the gutters (water stains, wet blocks, and algae growth on the blocks) which may have contributed to hydrocompression.

Site Preparation Recommendations

The current state of practice for developments on mine spoil fill sites has been developed as a result of the numerous failures that have occurred. Due to the unknown risks associated with the inability to predict the long-term performance of structures founded on mine spoil fill sites, very conservative and costly site development methods have become typical. Due to the risk of settlement potential of mine spoil fill sites, site preparation for buildings with column loads of less than 100 kips typically consist of massive undercutting and replacement with engineered recompacted mine spoil, preloading the site and/or dynamic compaction. These methods are very expensive and cannot provide a higher than normal confidence that the building will not experience detrimental settlement.

From our experience with mine spoil sites and the information obtained on this site, we believe that this site is suitable for the proposed development of residential, commercial, and the proposed one to two story educational building(s). However, as previously mentioned, each proposed building or cluster of buildings should have additional subsurface information prior to design. The individual houses and small commercial buildings can be designed based on general subsurface information provided in this report. However, when the location of the proposed school is set, we recommend additional exploration be conducted. For planning purposes, we recommend the following:

1. The mine spoil fill must be relatively consistent in composition and relative density as determined by exploration of the site. Typical evaluations of the

mine spoil's relative density is from standard penetration testing. Statistical comparisons of the N-values obtained from the standard penetration tests provide an indication of the degree of compaction of the fill.

2. The mine spoil fill thickness must be consistent beneath the proposed building footprint. The risk of differential settlement due to varying mine spoil thickness under the building is not quantifiable. Therefore, to reduce the risk, the fill thickness should be consistent across the site.

3. The depth to bedrock must also be relatively consistent beneath the building location. The building must not straddle areas of large variations in bedrock depths between benches or be located over a site with a partially buried mine bench. We believe this condition has occurred under the Sportscenter.

4. To provide a uniform bearing surface for the building and the building foundations, a site is typically undercut to a depth of 5 to 20 feet below the bottom of the building foundations depending upon the experience of the engineer. The undercut area is backfilled with recompacted mine spoil fill placed in thin lifts of about 12 inches and recompacted using bulldozers and compactors. The recompacted mine spoil acts as a "mat" supporting the entire building within the uncompacted mine spoil. The type of equipment used for recompaction varies, however, typically consists of Caterpillar D-8 bulldozers or similar spreading the mine spoil and Caterpillar 825 sheepsfoot rollers or similar compacting the mine spoil. The compaction of the fill should be tested to at least 98 percent of the mine spoils maximum dry density as determined by the standard Proctor compaction test (ASTM D698). From previous research the maximum dry unit weight of mine spoil in this area ranges from about 120 pcf to 125 pcf with optimum moisture contents of 10 to 20 percent.

Due to the anticipated light loading conditions for the homes and commercial buildings, undercuts of no more than 3 feet below the bottom of the foundation should achieve an adequate uniform bearing surface for spread footings. For the proposed school, an undercut of 5 feet below the foundation bearing depth should be considered. The undercut should extend at least 5 feet beyond the house or commercial building footprint and at least 10 feet for the proposed school building.

5. In addition to the undercutting and replacement, surcharging a site to allow settlement of the building site prior to conducting the undercutting or using dynamic compaction to densify the subgrade after undercutting and prior to recompaction is often used. However, this is generally during the initial consolidation phase of the fill.

For heavy buildings with column loads of over 200 kips or settlement sensitive buildings, foundation systems consisting of drilled piers bearing on competent bedrock should be considered. However, on this site, heavy loads are not anticipated. Due to the rocky nature of mine spoil fill sites, driven piles are not generally feasible.

Dynamic compaction is often used to densify the upper several feet of the mine spoil surface providing a uniform subgrade for development, especially for the construction of the roadways. Dynamic compaction utilizes a weight to impart energy to the mine spoil fill surface causing it to densify. Heavy weights or tampers up to 20 tons are dropped from heights of up to 100 feet with a crane. Dynamic compaction can accelerate stabilization of mine spoil fill still in its initial settlement phase by quickly reducing the void space within the fill. The depth of densification from dynamic compaction is generally limited to 20 feet depending upon the composition of the fill.

Foundation Recommendations

The selection of the foundation type for the proposed development would typically consist of conventional shallow spread footings. However, considering the performance of the existing Sportsplex building, we recommend a modified spread footing consisting of an inverted "T" type footing that is rigid to allow for uniform movements and reduce the risk of cracking of masonry or brick walls. The foundation can be designed using a bearing capacity for the mine spoil of up to 3000 psf. The structural engineer should consider top and bottom reinforcement in all foundations as well as reinforcement in the stem wall.

Even though the computed footing dimensions may be less, column footings should be at least 24 inches wide and strip foots should be at least 18 inches wide. These dimensions facilitate hand cleaning and allow for proper placement of the reinforcement bars. All exterior footings should be at least 30 inches below the lowest adjacent grade to reduce the risk of frost heave during winter months. Due to the risk of settlement on this site, we recommend that buildings limit the use of masonry or ceramic.

Floor Recommendations

For residential buildings, we recommend the use of a crawl space floor system. Grade supported floor slabs can be used but will have a risk of cracking due to subgrade movements. Concrete slab on grade floors are less susceptible to settlement of mine spoil than building foundations. However, differential movements can result in cracks. If grade supported floors are used, some cracking of the floor slab should be anticipated. Slab on grade floors should be separated from the structure and placed on a crushed stone base of at least 4 inches.

Seismic Site Classification

The current seismic design procedures outlined in the NEHRP (National Earthquake Hazard Reduction Program) guidelines mandate structural design loads be based on the seismic coefficients of the site. Based on the results of our exploration and the geology of the area, we assigned a **site seismic classification of "D"**.

LIMITATIONS OF RECOMMENDATIONS

This report should be considered a general evaluation and not applicable to specific buildings or structures. Once specific building locations are determined, additional geotechnical information will be required. When building on old mine spoil sites, the owner must understand and accept that no matter how much evaluation and exploration is conducted, there will be a risk of unsuitable building and structure performance. There are numerous documented building settlement and distress issues when building on old mine sites. Therefore, the information provided in this report is to assist in understanding, but not eliminating, the risk of building on this site.

This report has been prepared for the exclusive use of the Commonwealth of Kentucky for specific application to the project site. Our recommendations have been prepared using generally accepted standards of geotechnical engineering practice in the Commonwealth of Kentucky. No other warranty is expressed or implied. This company is not responsible for the conclusions, opinions, or recommendations of others based on these data. Additionally, our conclusions and recommendations are based on the information provided to us, the data obtained from our subsurface exploration, and our experience. They do not reflect variations in the subsurface conditions which are likely to exist between borings and in unexplored areas of the site. These variations result from the geologic variability of the subsurface conditions. If conditions are different than those encountered in our exploration, it will be necessary for us to re-evaluate our conclusions and recommendations based upon on-site observation of the conditions.

If the overall design or location of any of the elements of the project is changed, the recommendations contained in this report for that element must not be considered valid unless our firm reviews the changes, and our recommendations are modified. When the design is finalized, we should be given the opportunity to provide the additional service of reviewing the grading plan and applicable portions of the project specifications. This review will allow us to check whether these documents are consistent with the intent of our recommendations.

We may recommend that a supplementary exploration be performed when significant design changes such as the movement of a project element are incorporated in the final design after the geotechnical exploration has been completed. This supplementary exploration may include obtaining additional soil data along the new alignment to provide specific recommendations.

Valediction

We appreciate your consideration of Vector for this work. We look forward to working with you on this and future projects.

Yours truly
Vector Engineers, Inc.

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Attachments:
- Important Information about your Geotechnical Engineering Report
- Field Testing Procedures
- Laboratory Testing Procedures
- Refraction Line Locations
- Seismic Refraction Line Data (1 through 5)
- Boring Location Plan
- Soil Test Borings (B-1 through B-10)
- Laboratory Data Summary

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