

# COLORADO GEOLOGICAL SURVEY

1801 19<sup>th</sup> Street  
Golden, Colorado 80401



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April 19, 2019

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**Location:**  
SW ¼ of NE ¼ of Section 14,  
T14S, R67W of the 6<sup>th</sup> PM  
38.8333°, -104.8581°

**Subject: Gold Hill Mesa Filing No. 11,  
Final Plat-AR FP 19-00201; and Development Plan-AR DP 19-00198;  
City of Colorado Springs, El Paso County, CO; CGS Unique No. EP-19-0132**

Hanna:

As requested, we have reviewed the submittal consisting of: application (3.26.19), drainage report (Terra Nova, 1.19), development plan drawings (NES, 3.14.19), final plat drawings (Barron Land, 3.13.19), and geologic hazard report (CTL, 3.14.19). The applicant plans to develop 32 lots on 3.755 acres. We offer the following comments and observations.

Mill Tailings: Gold Hill Mesa is a tailings pile resulting from the processing of gold and silver ore by mills that operated south of Old Colorado City from the 1890's to the late 1940's. Ore rock was brought to the location from Cripple Creek and Victor by rail. The mills were located here due to ready access to local coal deposits for the coking part of the milling process. The milling process resulted in a slurry of water and pulverized rock varying in size from sand to fine silt and clay. These materials were conveyed from the mill into the tailings impoundment via a tailings pipe. The coarser tailings (sand) settle near the spigot while the finer silt and clay particles remain suspended in the slurry that settles out in the pond (referred to as a decant pond) forming within the impoundment. The tailing fines are often referred to as slimes.

No recorded borings have drilled through the deepest portions of the tailings, estimated to be 130 feet deep. Both sand and slimes are located within Gold Hill Mesa. The volume of slimes in the sands, or their stratigraphy (vertical and horizontal layering) are unknown.

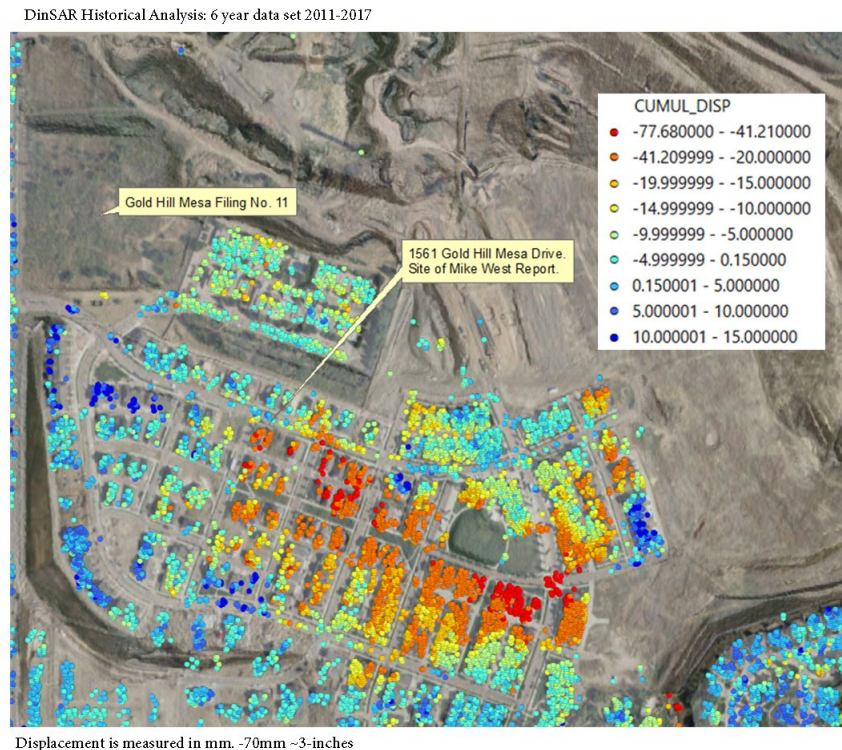
Settlement: Mill tailings resulting from gold ore processing, such as at Gold Hill Mesa, are known to have significant differential settlement issues. Concerns about long term settlement have been expressed by geotechnical engineers and the Colorado Geological Survey (CGS) in the history of the recent residential development of Gold Hill Mesa. A settlement study at one location on the tailings was conducted by CTL in the early phases of development of Gold Hill Mesa.

In 2015 the City of Colorado Springs asked CGS to visit a newly constructed residence with visible settlement problems. We were provided with reports by Mike West and Associates. The reports discuss the history of subsurface investigations at Gold Hill Mesa and the subsequent site characterization and conclusions about settlement that led to the construction of the home in question. The reports demonstrate that the overall subsurface characterization of the mill-tailings was insufficient to support the conclusions about long-term settlement used in the construction of the home and the Gold Hill Mesa development in general. Specifically, the tailings vary in consistency (fines versus sands) and water content and therefore engineering properties and settlement potential. CGS recommends that the City provide the applicant and their consultants with the two

Mike West reports. These reports provide the geotechnical basis for concluding that estimates of potential settlement remain difficult to calculate accurately, as the subsurface of the tailings has not been sufficiently characterized.

A-DinSAR Historical Analysis of the Gold Hill Mesa Area: A-DinSAR is an acronym for “*Advanced Differential Interferometric Synthetic Aperature Radar*”. This term groups several processing techniques based on analysis of “stacks” of satellite images. “Stacks” are a dataset of satellite images acquired with the same feature template (i.e. resolution, orbit geometry, incidence angle) for a specific location in a given time interval. The satellite image stack is the raw data input for analysis in the A-DinSAR approach. The analysis is capable of measuring (on the level of millimeters) relative movement over time.

Following concerns raised by the city and local residents CGS commissioned this type of satellite study for Gold Hill Mesa. The study was performed on a stack of 162 images covering the period from June 24<sup>th</sup>, 2011 to October 14<sup>th</sup>, 2017. This work shows 3-inches of cumulative vertical settlement around the area of concern in the Mike West reports. This area generally corresponds with some of the deep, saturated slime deposits outlined in the reports. The cumulative movement recorded in the Satellite study is shown in the following figure. (The data is collected on fixed points associated with houses, streets, etc., so no points are in the undeveloped areas. The movement is relative movement and may not be exact at specific locations.)



Three-inches of movement can result in cracking of walls, floors, and hard finishes such as tile or rock. Doors and windows can stop operating properly and floors can become uneven. We observed external and internal evidence of structural distress on each floor and throughout the subject house of the Mike West reports at the time of our visit. This included cracks; in the concrete basement floor, around doors and window openings, along ceiling panels and within exterior finishes. The first floor above basement level was noticeably out-of-level throughout the house. Additionally, evidence of differential movement was observed in the street and sidewalk adjacent to the structure.

The geotechnical reports on file for Gold Hill Mesa do not fully characterize the slimes versus the sands, but typically treat the mill tailings as a relatively homogenous unit. The area of greatest measured settlement as depicted in the DinSAR image corresponds to deep saturated slimes beneath tailing sands. Borings historically drilled in this area tend to be shallow and not drilled to bedrock. Minimal or no sampling and testing of the slimes was done.

The geologic hazard report submitted for Filing 11 has not fully characterized the tailings beneath the site. There has been limited sampling, testing and analysis of the tailings. Two of the borings (TH-7 and 9) end in very loose material (as indicated by blow counts of 3/12) that is below groundwater levels and neither boring extends into bedrock. It is difficult to accurately analyze settlement potential at or near these borings based on the subsurface data collected.

Liquefaction: Soil liquefaction occurs when soil loses strength during an earthquake. When intense shaking occurs, wet soil loses its solid structure and behaves like a liquid. Research following past earthquakes shows liquefaction is more likely to occur in loose deposits of sand or silt. The West report shows the Gold Hill Mesa tailings contains deposits that may be prone to liquefaction or increased earthquake risk.

Liquefaction evaluation is typically recommended for areas with seismic and ground conditions like those located at Gold Hill Mesa. There are two nearby faults capable of producing maximum credible earthquakes of 6.0 to 6.75. Damaging shaking can occur far from the fault producing the earthquake.

Soil liquefaction is known to increase the impacts of an earthquake (compared to more stable deposits) often causing building collapse or buildings sinking into wet loose soil. The degree of such risk at Gold Hill Mesa is dependent on knowing the extent, depth, and engineering properties of the tailings deposit. As previously discussed, Gold Hill Mesa has not been sufficiently characterized to determine liquefaction risks to homes, roads, and infrastructure.

CGS expressed concerns about earthquake related liquefaction in our review letters for Gold Hill Mesa and especially in our last review for Gold Hill Mesa (2004). We are not aware of any liquefaction analysis that has been done for Gold Hill Mesa. We continue to recommend that a liquefaction analysis of the entire Gold Hill Mesa be performed.

**CGS cannot recommend approval of Filing No. 11 until: the underlying mill tailings are fully characterized in terms of fines versus sands both laterally and vertically; sampling and testing is completed of the fines and saturated fines, to their full depth; settlement calculations are performed for the actual materials located beneath Filing No. 11; a liquefaction analysis for the entire Gold Hill Mesa is conducted.**

Thank you for the opportunity to comment on this project. If you have questions or require further review, please call me at 303-384-2654, or e-mail [jlovekin@mines.edu](mailto:jlovekin@mines.edu).

Sincerely,



Jonathan R. Lovekin, P.G.  
Senior Engineering Geologist

Reviewed by:  
Karen Berry  
Director