COLORADO GEOLOGICAL SURVEY

1801 19th Street
Golden, Colorado 80401

Karen Berry
State Geologist

October 19, 2019

Hanna Van Nimwegan
Planning and Community Development
City of Colorado Springs
30 S. Nevada Ave, Suite 105
Colorado Springs, CO 80901

Location:
W NW ¼ of Section 13,
T14S, R67W of the 6th PM
38.8320°, -104.8492°

Subject: **Gold Hill Mesa Filing No. 10, Development Plan,**
City of Colorado Springs, El Paso County, CO;
City file number AR DP 17-00674; CGS Unique No. EP-20-20-0018

Dear Hanna:

We were asked to review the submittal for filing 10, an approximately 8.85-acre parcel that includes proposed construction along the dam edge of the mill tailings pile at Gold Hill Mesa. CGS has not previously reviewed this filing, the adjacent filings, the proposed construction along the crest of the dam, or the associated slope stability analysis. For this review we were provided a "Draft", unsigned report by CTL | Thompson, Inc. titled *"Geologic Hazards Evaluation Update and Preliminary Site Grading Recommendations Filings 8, 9, 10, and Dam Face Easterly One-Third of Gold Hill Mesa Colorado Springs, Colorado"*, CTL's Project No. CS18893.000-105 dated March 14, 2018. The city's geologic hazard ordinance requires that all submitted geologic hazard studies be signed and properly certified by the professional who prepared the study (City Ordinance 7.4.504). This document will be henceforth referred to in this letter as "the report".

We reviewed documents provided to us and submitted for this development plan as well as those available through the city web portal under city job number AR DP 17-00674, and available through the cities subdivision document viewer for the Gold Hill Mesa development. These included: city request for review (9.10.19), application (11.9.17), response to initial review comments (NES, 1.3.18), Filing 10 Final Irrigation Plan (NES, 5.19.18), Master Development Drainage Plan for Filing 9 & 10 (Terra Nova, 6.18), Development Plan (NES, 4.26.18), and various other documents. Additional background reports and previous reviews are discussed at the end of this letter. Based on the information provided, we offer the following comments and observations.

Planned Construction: The plans show fifty-five lots are planned for development as single-family residences. Lots 43-55 and Tract C and Tract B occur on or beyond the edge of the tailings dam. Significant site grading of the mill tailings dam is shown outside the limits of Filing 10 with fill placement expected to range from a few feet up to 20 feet as shown on the development plan and described in the report. Outside the limits of Filings 8 and 9, fill along the embankment dam and adjacent area is up to 40 feet.

Geologic Hazard Study: We have reviewed the geologic hazard study submitted to support Filing 10 as requested and per City Code 7.4.506: *Review of Geologic Hazard Studies.* No site-specific subsurface investigation is reported for Filing 10. The report apparently relies on previous subsurface investigations from CTL in 2004 and Dames and Moore in 1999. However, the specific subsurface data obtained during those investigations is not discussed in the report. Additional comments on this report are provided at the end of this letter.

Ground subsidence related to mill tailings and long-term settlement: New information since our reviews in 2004 calls into question basic assumptions about settlement on this mill-tailings waste pile. The new information is listed in the following table:

MWWAI, 2015a, Geotechnical Engineering Assessment, Hannah Polmer and William Robert Rudge v. Hi-Point Home Builders, LLC, et al., District Court, El Paso County, Colorado, Case Number: 2013CV30763, Division 15. MWWAI Project No. 141187: Michael W. West & Associates, Inc.
MWWAI, 2015b, Rebuttal Report, Geotechnical Engineering Assessment, Hannah Polmer and William Robert Rudge v. Hi-Point Home Builders, LLC, et al., District Court, El Paso County, Colorado, Case Number: 2013CV30763, Division 15. MWWAI Project No. 141187.: Michael W. West & Associates, Inc.
NHAZCA, 2019, A-DINSAR Historical Analysis of the Gold Hill Mesa Area (Colorado Springs, Colorado, USA): NHAZCA S.r.l., 21 p.

The **soil boring and engineering property tests** in the West reports show that both coarse and fine tailings within Gold Hill Mesa have variable saturation. In places, the water content of fine tailings is greater than the reported liquid limit. Where this occurs, the fine silt-sized particles, often called slimes, behave as a liquid. As such, slime deposits can significantly impact the potential for settlement and liquefaction.

A thorough understanding of the physical and engineering properties of the tailings is fundamental to understanding geologic hazard and geotechnical risks within and adjacent to Filing 10. This involves carefully considered laboratory and field test work to measure the relevant properties and performance of the materials. The successful design, construction, and performance of the proposed development relies on the appropriate identification and understanding of these properties.

The applicant's reports do not contain the information needed to demonstrate a thorough understanding of the physical and engineering properties of the tailings. For example, the reports do not include adequate laboratory and field data to determine the depth, thickness and extent of sand, silt and slime deposits.

Data in the West reports, and in the previous geotechnical reports indicate several things:

- The underlying mill tailings have a complicated stratigraphy between coarse tailings and fine tailings;
- These two types of tailings can be expected to have different engineering properties regarding settlement, yet their relative thickness and stratigraphy is not well characterized;
- The tailings have variable, partial saturation which will also impact settlement rates; and,
- The deep tailings below Filing 10 have not been sampled, tested or evaluated for settlement.

It appears the reports for Filing 10 do not include a detailed subsurface investigation with sampling and testing. The stratigraphy (horizontal and vertical thickness) of the coarse and fine tailings is apparently based on limited drilling in the area of Filing 10 by Dames and Moore in 1999, and a seismic study performed by Blackhawk Geophysics in 2004.

CTL has indicated in previous letters that the seismic study performed by Blackhawk Geophysics provided the stratigraphy of the coarse and fine tailings within Gold Hill Mesa and presumably for Filing 10. This study was able to clearly define the bedrock surface beneath the tailings. It makes a generalized attempt to define a vertical boundary between fine and coarse tailings. However, the applicant's engineer does not discuss or demonstrate that the geophysical study can be used to determine the needed physical and engineering properties of the tailings. In addition, the applicant's reports do not show or adequately discuss how the geophysical study was used to differentiate the tailings. The differentiation they provide for fine and coarse tailings is general and it is not clear how to interpret this work for Filing 10.

Slope stability: Slope stability is a balance of driving forces (i.e. gravity) versus resisting forces (i.e. soil strength). Slope failures occur when driving forces in a slope become greater than the resisting forces. Driving forces can increase and cause slope failure for a variety of reasons including:

- Loading (placing fill) along the top of the slopes;
- Increasing moisture content within the slopes;
- Removing support along the base of the slope.

Two of the basic parameters leading to slope failure occur at Filing 10. Proposed site grading adjacent to Filing 10 includes loading the slopes with fill (from several feet to up to 20-feet). Up to 40-feet of fill placement is proposed along the tailings dam nearby. Development is known to increase the moisture content of the underlying soils.

Soil saturation and slope stability: Mill-tailings piles, such as Gold Hill Mesa, are complex, man-made deposits comprised of a highly variable mixture of rock-flour, sand, silt and water. Tailings are placed in lifts that can vary significantly in thickness, lateral extent and content including amount of water. Fine-grained tailings, or slimes are saturated to partially saturated due to the method of placement resulting in wide variation in water content. The water in the slimes is different than typical groundwater encountered and reported in conventional drilling methods (such as those used for the investigations at Gold Hill Mesa). Extent of saturation within the underlying mill tailings should be expected to be irregular and site specific. There are minimal records to indicate how the mill tailing slimes were placed but we know of no compelling reason to expect the tailings were placed carefully or in the type of controlled conditions that would be conducive to residential development.

Zones of slimes with highly variable degrees of saturation and resulting soil strength should be expected throughout Gold Hill Mesa. Dames and Moore encountered zones below Filing 10 with high degrees of soil saturation not accounted for in the slope stability analysis provided. Specifically, Dames and Moore report water contents for Boring 14 of 41.4 to 73.2 percent in deep silts (80 to 100 feet). Atterburg limits (the moisture content of a soil where it will have engineering properties of a plastic or a liquid) were not reported for these materials in Boring 14. However, liquid limits are reported in Mike West's report on similar silts encountered in the tailings. Fine-grained materials and slimes from Mike West's report have moisture contents (36.5 to 68.2%) that are greater than the measured liquid limit (31 to 36%). Again, these measured values reflect soils with engineering properties of a liquid, an important condition not evaluated in the provided stability analysis. Saturated fine-grained tailings (slimes) are known to negatively impact stability of tailings dams and can occur nested within or closely adjacent to the coarser sand placed for the dam face.

Slope stability analysis: Four cross-sections in Filing 10 are used for slope stability analysis.

- There is no discussion on how these cross-sections were derived (i.e. what subsurface data supports their geometric depiction);
- There is limited subsurface data available to substantiate the subsurface assumptions for Filing 10;
- No subsurface investigation was conducted specifically for the residential construction proposed for Filing 10 or the slope stability analysis conducted for the tailings embankment adjacent to Filing 10; and,
- Groundwater is depicted in the analysis above the bedrock surface. While this groundwater condition is likely in this area, there is also a moisture component in the tailings due to variable saturation of the slimes. This has not been evaluated in the analysis.

For the slope stability analysis used to support Filing 10, we recommend:

- A sensitivity analysis be included for saturated soils (slimes);
- The stability evaluation considers the worst-case scenario, or, be based on site-specific drilling, sampling and testing (including Atterberg limits, moisture contents, etc.).

Site Drainage and Erosion: The drainage plans indicate that Basin J (1.25 acres) consist of the back half of single family lots along the north end of the mesa top. Runoff (Q5 = 4.1 cfs, Q100 = 8.4 cfs) sheet-flows north along the steep tailing dam across and down to the proposed extended detention basin 1. Basin F (1.14 acres) consists of the back half of single family lots the east end of the mesa top. Runoff (Q5 = 3.8 cfs, Q100 = 7.7 cfs) again appears to sheet-flow across the steep face of the tailing dam to pond 2.

As many are aware, the non-plastic silts and sands located on the face of the tailings dam are highly erodible. In addition, significant erosion can adversely impact slope stability. It will be important that no concentrated flows be allowed to discharge down the steep dam face without adequate protection. This includes discharge from downspouts, sumps or swales. It would be prudent to note such restrictions on the plat and HOA documents.

Fill: Areas of deep fill (up to 40-feet) are planned along the top of the tailing's embankment. Settlement calculations of these fills and the underlying material within the tailings dam have not been provided. For these areas the report states (p.8): *"We recommend installing survey monuments at the surface of completed fills to monitor consolidation."* No discussion or analysis is provided about consolidation rates or what is planned should they be different from what is anticipated. Apparently, development is planned at Filing 10 prior to determining the full extent of settlement of the deep fill and the tailing embankment or analyzing the potential impacts to adjacent ground in Filing 10 from this type of settlement. We recommend analysis and discussion of potential impacts on adjacent ground in Filing 10 from settlement, both in the deep fill and underlying dam embankment.

Liquefaction Study: CGS recommends that the city require a seismically-induced liquefaction study be conducted, based on measured engineering properties of the tailings that have been sampled from throughout the tailings. The results of the study should include factor-of-safety calculations on liquefaction for the soil conditions at Gold Hill Mesa.

To perform a liquefaction study, the underlying tailings must be thoroughly characterized in terms of stratigraphy and engineering properties. This would be done with subsurface sampling and testing, especially of the low strength tailings as encountered. Due to limited boring depths and limited sampling, the overall distribution of saturated fine-grained tailings beneath all of Gold Hill Mesa have been poorly defined. Additionally, it is not clear how liquefaction of the slimes at their present depth beneath the site might impact surface development (both in developed areas and Filing 10); additional geotechnical analysis appears warranted to ensure that existing and future residential structures can adequately withstand any stresses associated with liquefaction of the underlying fine-grained tailings. Liquefaction in other parts of the Gold Hill development can impact Filing 10.

CGS cannot recommend approval of Filing No. 10 until: the underlying mill tailings (at Filing 10) 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. 10; impacts to Filing 10 from settlement of adjacent deep fill and underlying dam embankment are analyzed; slope stability analysis accounts for variable saturation of the slimes; 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.

Sincerely,

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

Reviewed by:
Karen Berry
Director

Other Comments Regarding Geologic Hazard Report

- Filing 10 is underlain by up to 133 feet of mill tailings according to previous work. While depth to bedrock below Filing 10 can be estimated from previous geophysical investigations it is not precisely known nor is the actual depth of the tailings.
- There has been no site-specific subsurface investigation with sampling and testing to evaluate or confirm soil and groundwater conditions beneath Filing 10 or the tailings dam.
- This type of man-made deposit poses a significant risk of settlement, including differential settlement as well as a risk from liquefaction and slope instability of the dam face. There is no discussion of potential settlement or liquefaction at Filing 10. The slope stability analysis is not based on a site-specific subsurface investigation and does not account for variable saturation in the tailings.
- The borings from Dames and Moore's 1999 work near Filing 10 indicate that the fine tailings (silt tailings versus sand tailings) can be partially or completely saturated which has implications for the slope stability modeling of the embankment and for settlement of the overlying development. The slope stability evaluations presented in the report consider dry conditions for the mill tailings except for a groundwater table close to the bedrock surface.
- CTL's test fill site was used to develop assumptions of total settlement at Gold Hill Mesa. These results are graphically presented in the 2004 reports. It is indeterminate if the results from CTL's test fill site are applicable at Filing 10.
    - Of the four borings at the test site (TH-101 through 104) mill tailings are reported in only one boring (TH-103). The other three borings report fill. Groundwater is reported at or near the bedrock surface (at a reported depth of about 59 feet below the ground surface) in TH-103 and 104. No sampling or testing of the materials encountered in the borings is reported. Only one blow-count (measure of relative soil density) is reported in the mill tailings.
    - No subsurface investigation has been reported for Filing 10 to compare with the test fill site.
    - Tailings thickness is reported (CTL, 2004 Fig 8) to be greater than 133 feet beneath the general area of Filing 10 and from 46 to 74.5 feet thick at the test site. There is no discussion on any impacts to the settlement calculations or rates due to much thicker tailings beneath Filing 10 than at the test site.

Background reports and previous reviews

Background reports

The report states (p. 3): *The following is a list of past reports we believe are relevant to the Geological and Geotechnical conditions of the subject parcels."* We have reviewed the available supporting reports referenced by CTL in their March 14th report. These include:

- Dames & Moore (May 7, 1999). Preliminary Geotechnical Investigation, Gold Hill Mesa Property, Colorado Springs, Colorado, Job No. 38057-003-035.
- CTL|Thompson, Inc. (December 14, 2004). Geologic Hazards Evaluation and Preliminary Geotechnical Investigation, Gold Hill Mesa, Filings 1 & 2, Phase I Development, Colorado Springs, Colorado, Job No. CS-12,853.
- CTL|Thompson, Inc. (August 24, 2005). Slope Stability Evaluation, Gold Hill Mesa Phase III, Lower Gold Camp Rd. and 21st Street, Colorado Springs, Colorado, Project No. CS15280-145.

Several reports listed in the March 14th report are not available through the city web portal for AR DP 17-00674. While the October 9, 2002 report was reviewed by this office in October of 2002, we no longer have copies of it. We requested the missing reports from the city on September 12th, 2019. The requested reports include:

- CTLThompson, Inc. **(October 9, 2002).** Preliminary Geologic Hazards Evaluation and Preliminary Geotechnical Investigation, Residential 150 Acres of Gold Hill Mesa, Southeast of Highway 24 and 21st Street, Colorado Springs, Colorado, Job No. CS-12,853. (We emphasize the date as there are two later reports with the same job number).
- CTLThompson, Inc. (January 22, 2016). East Slope Failure Evaluation and Mitigation Recommendations, Gold Hill Mesa, West of Gardner St., Colorado Springs, Colorado, Project No. CS18733.002-145.

At the date of this letter we have not received copies of these reports.

Previous reviews

The report states (p.6): *"The Colorado Geological Survey apparently reviewed the report* (CTL's Slope Stability Evaluation report dated August 24, 2005) *and their primary comment related to the use of a seismic loading of 0.09g were (sic) they felt a more conservative value of 0.10g should be used. Ultimately the analysis was accepted."* The last review by CGS prior to 2019 was September 13, 2004. Our comments about seismic loading were directed at the liquefaction discussion in the 2004 CTL report. CGS has not previously reviewed the August 24, 2005 slope stability evaluation and has not accepted this analysis.