DOWL

October 4, 2017

Ms. Andrea Beebout
Environmental Protection Specialist
Colorado Department of Public Health and Environment
4300 Cheer Creek Drive South
Denver, CO 80246

RE: SLAG FILTER AS-BUILT CERTIFICATION

SUBJ: GOLDEN WONDER MINE AMD FILTRATION PILOT STUDY, LAKE CITY COLORADO

Dear Andrea:

The installation of the Acid Mine Drainage (AMD) slag filtration system at the Golden Wonder Mine near Lake City has recently been completed. We certify that, as noted in the attached as-built drawing and variances noted below, the filtration system was installed in general conformance to the construction drawings, prepared under my signature and dated May 6, 2017 submitted to your office and subsequently approved for construction. I visited the site on the following date to inspect the third version of the slag filter installation and its design enhancements. My observations were as follows:

- September 19, 2017 – Attended site visit with the President of LKA Gold Inc., (mine owner) Kye Abraham, and DRMS staff members Tony Waldron, Travis Marshall and Russ Means to inspect the slag filter installation and operation. We visually estimated the drainage from the portal to be less than ½ gallon per minute and the slag filter was installed and operational. Photos from my visit are presented below.

Pilot Study - Preliminary Results

Based on our original approved design, Golden Wonder mine staff constructed and installed the initial filter arrangement in July and tested the system for suitability. To date, three trials with varying slag gradations and system components have been performed to optimize the water quality results as well as streamline the operations and maintenance of the filter system. A summary of those trials and the system modifications which resulted in improved results is:

Trial I (Version I completed prior to July 31)

- The "top-down" barrel filling system did not ensure that all water had the proper residence time in the slag. Once the barrel was full, nothing could prevent new water from exiting the top drain without treatment.

- A new 3-level valved distribution system (top, middle and bottom) was constructed in the barrel to better control residence time of mine water. We weren't sure just how effective treatment would be in raising pH levels.
- A 55 gallon barrel (barrel #1) was used instead of a 30 gallon barrel to ensure enough treatment if the slag was less effective in actual application than lab testing indicated.
- Two stock tanks (one for secondary containment and one flipped over to cover and secure the barrel) were substituted for the 36" CMP containment which did not accommodate the 55 gal barrel and the 3-valve PVC drainage system.
- A steel reinforced concrete slab was poured as a foundation for the stock tank containing the barrel per DRMS requirements.

Trial II (Version II completed during mid Aug)

- A secondary 55 gallon barrel (barrel #2) was added once we discovered that the slag was not flushing itself due to extremely low flow of mine water, less than a gallon a minute. This was preventing mine drainage from receiving proper treatment.
- A slag-filled sediment trap was added to provide a measure of pre-treatment prior to AMD reaching the barrels and to prevent sediments from reaching the treatment system.
- Barrel #1 inlet was redesigned and constructed to fill from the bottom and allow mine drainage the percolate up through the slag to ensure full treatment of all water entering the barrel.

Trial III (Version III completed during mid Sept)

- Both barrels were removed and barrel #1 was reloaded with uniformly crushed 5/8-inch slag. It was thought that the original material (over & undersized) as deliver from HARSCO was not reacting as expected. Barrel #2 was not installed until efficacy of the improved slag gradation could be determined.
- To prevent the slag from being "coated" with precipitate, due to "low flow" as was the case with the previous two trials, It was determined that a greater volume of water was required to properly flush the precipitate from the barrel(s) regardless of the number. A system for flushing the slag will be designed and installed prior to the spring snow melt to keep the slag flushed.
- A tighter and more secure sealing system was devised for both of the stock tanks to prevent wildlife from accessing the filter system.
- Excess crushed slag was used to replace limestone, and previously installed larger sized (original) slag in the lower sump to ensure proper reaction with lower seep.

Variances from Approved Construction Plans

During our site visit on September 19, 2017, the following items were found to differ from approved plans but are considered as improvements to the original design. These

variations are acceptable as they appear to improve overall performance of the on-site AMD treatment system and increase pH of the mine drainage as intended.

1. The AMD distribution pipe to the slag was modified from free flowing from above the slag to being introduced from the bottom. pH treatment occurs as the AMD travels up through the slag rather than down. This minimizes the channeling effect that Golden Wonder staff had observed during the first two trials.

2. Two additional valved outlets were installed at the bottom and midpoint of the slag filter to allow for multi-level flow for more treatment options. As pH is increased, having options for varying outlet levels may reduce filter clogging and provide greater control over AMD residence time.

3. The Harsco slag was advertised as a "3/4 inch" slag but was actually material that had been captured by a ¾" screen and, therefore, ranged from ¾" to 3 inches in diameter and was poorly graded. Golden Wonder staff crushed and screened the slag through a 5/8" screen to get a consistent filter material which was the intent of our design. See photo below for details of slag before and after on-site processing.

4. Golden Wonder staff located a 55-gallon HDPE barrel in lieu of the 30-gallon barrel we specified which allows for more slag and longer treatment time. Instead of housing the barrel in a vertical 36-inch CMP pipe section, at DRMS's staff request, the new filter was installed on a 3-inch concrete slab with secondary containment constructed of two galvanized, waterproofed stock tanks to create the filter housing.

5. After two trails by Golden Wonder staff, it was determined that the slag requires periodic flushing with fresh water to remain active and provide consistent treatment of the AMD. Therefore, a slag flushing system has been planned for installation prior to snow melt in 2018. AMD volume is currently too low to properly test flushing of the slag filter material to prolong its life and provide adequate pH increase.

Initial field tests indicate that the pH is increased from approximately 3 to 6.8 following exposure to the steel slag. Since the slag filter and its components (V-II) were not fully operational until September, we recommend that the pilot study continue in 2018 to provide enough test data to create a standard operating procedure (SOP) for a full season. During my inspection, DRMS staff expressed a level of cautious optimism about the potential for using steel slag in AMD treatment at other Colorado mine sites. They also seemed satisfied with the construction of the system but expressed a desire to be updated on its testing, development, and overall performance.

Please contact me at (970) 497-8852 or dquigley@dowl.com if you have any questions about this as-built certification.

Respectfully,
DOWL

Daniel C. Quigley, PE
Project Engineer
Colorado PE # 38334

Attachments: Photos 1-5 from September 19, 2017 site visit

Cc: Kye Abraham – President, LKA Gold, Inc.
Russ Means - CDRMS

Photo 1. View of slag as delivered from Harsco Industries in Pueblo, Colorado. Note varying size of slag particles. Dust broom is 7 inches wide for scale.

Photo 2. Slag material after processing on site by Golden Wonder staff and screened through 5/8-inch screen. Photo was taken looking into a bag of processed slag.

Photo 3. View looking down at slag filter. Note 2-inch PVC AMD distribution pipe which extends to the bottom of the 55-gallon HDPE drum filled with 5/8-inch screened slag. 3 outlets with valves (two are normally closed) are visible on the right side of the barrel.

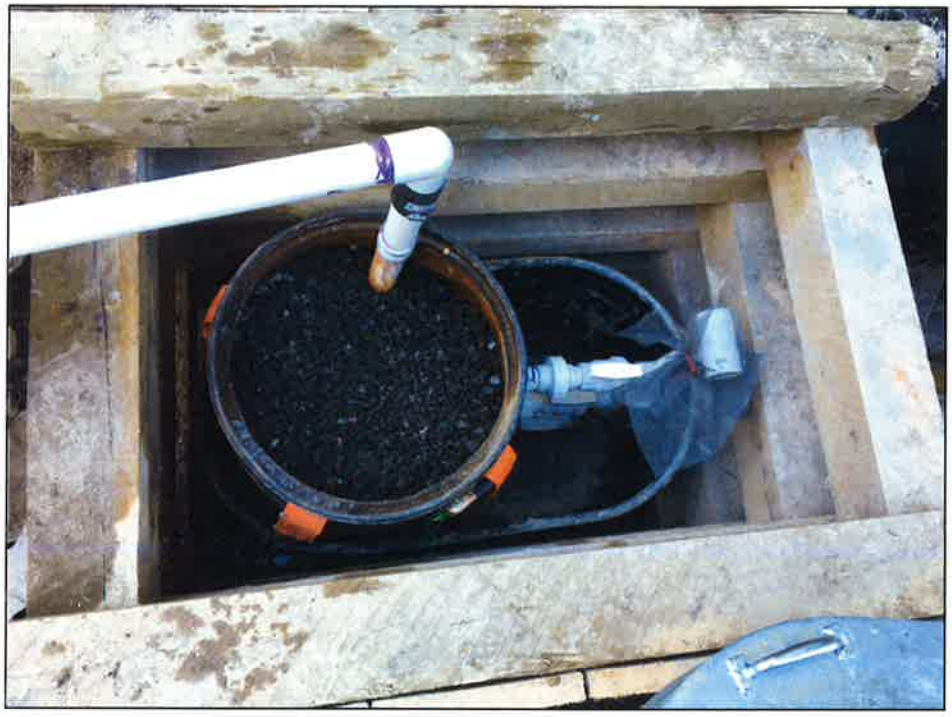

Photo 4. View of the portal at level 6 and the AMD interceptor trench and pre-filtration sediment basin. AMD is captured as it leaves the portal and is conveyed from left to right through 3-inch HDPE pipe to a 30-gallon pre-filtration sediment basin partially filled with 5/8" screened steel slag. From there the drainage is conveyed through 3-inch PVC pipe to the slag filter.

Photo 5. View looking upslope from the post-filtration sediment basin towards the slag filter. Outlet from sediment to basin to Deadman's Gulch and the lower sump is shown at the bottom of the photo.