Klohn Crippen Berger

January 30, 2020

Seabridge Gold Inc.
106 Front Street, Suite 400
Toronto, Ontario
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Brent Murphy
Vice President, Environmental Affairs

Dear Mr. Murphy:

KSM Project
Comparison of the KSM Tailings Management Facility to Feijão Tailings Dam

This letter compares the design of the KSM Tailings Management Facility (TMF) to that of the Feijão Tailings Dam I (Feijão) in Brazil, which failed on January 25, 2019. There are stark differences between the two designs, and Seabridge Gold and relevant stakeholders should be aware that the conditions that led to the failure of Feijão are not applicable to the KSM TMF.

Compared to Feijao, the KSM TMF has a robust design with a centreline-constructed compacted cycloned sand shell, underdrains, and a compacted till core (KCB 2012[1], KCB 2016[2]), whereas Feijão, was an upstream-constructed dam which relied on the strength of the saturated uncompacted tailings for the dam stability.

A forensic investigation into the failure of Feijão was completed by an Expert Panel (Robertson et. al 2019). The Panel found that the failure was[3] the result of flow liquefaction within the tailings. The Feijão dam was composed of mostly loose, saturated, heavy, and brittle tailings that had high shear stresses within the downstream slope, resulting in a dam that was close to failure in undrained conditions. (Robertson et. al 2019). The Panel concluded that the sudden strength loss and resulting failure were due to a critical combination of ongoing internal strains due to creep, and a strength reduction due to loss of suction in the unsaturated zone caused by the intense rainfall towards the end of 2018 (Robertson et. al 2019).

[1] Klohn Crippen Berger Ltd. (KCB). 2012. 2012 Engineering Design Update of Tailing Management Facility. Report to Seabridge Gold Inc. dated October 6.

[2] Klohn Crippen Berger Ltd. (KCB). 2016. KSM Project - 2016 Pre-Feasibility Study Update - Addendum Report - Tailing Management Facility Design Rev. 1. Report to Seabridge Gold Inc. dated October 6.

[3] Robertson P.K., De Melo L., Williams D., and Wilson G.W. 2019. Report of the Expert Panel on the Technical Causes of the Failure of Feijão Dam I. Dated December 12.

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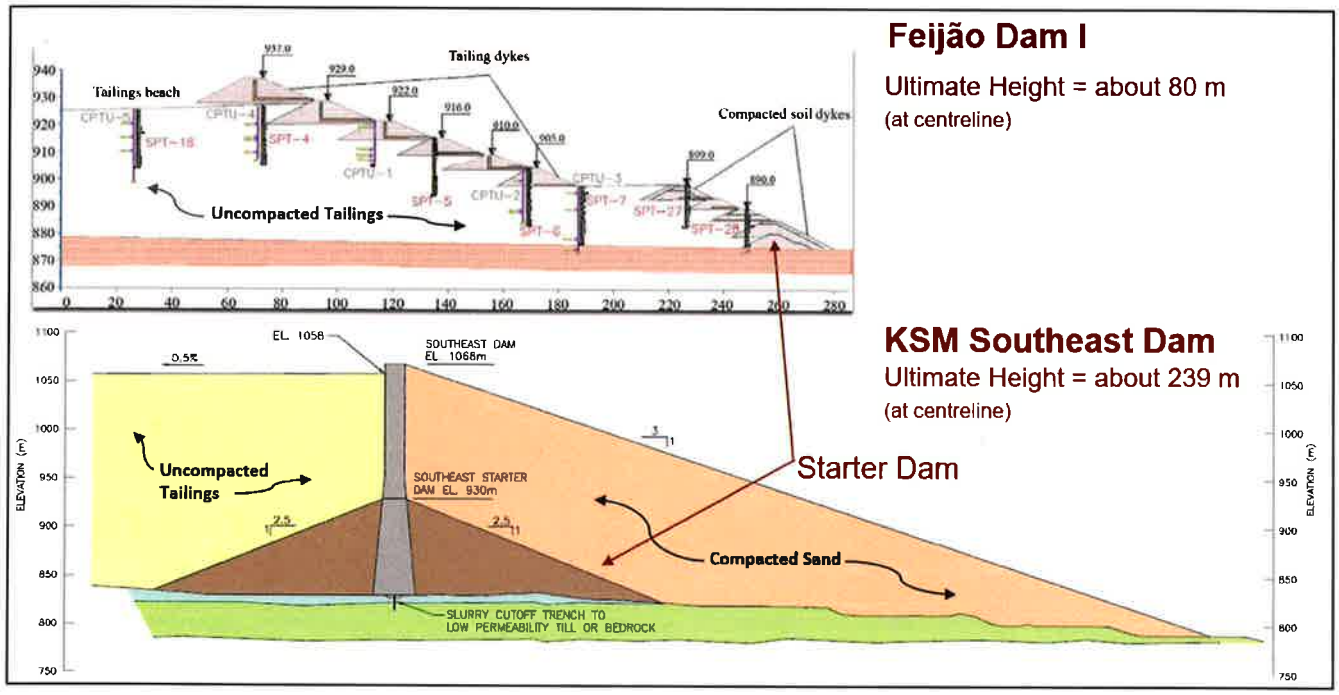
The factors that created the conditions for the Feijão failure would not occur for the KSM TMF as further summarized in Table 1. For reference, a comparison of the cross sections is shown in Figure 1.

Table 1 Comparison of Conditions between Feijão and KSM

Conditions Leading to the Failure of Feijão Dam I (Robertson et. al 2019)	Comparison with the KSM TMF
An upstream constructed dam that relied on the strength of uncompacted tailings for the integrity of the dam. The Feijiao dam had a static factor of safety (FoS) for undrained loading close to FoS = 1.0, prior to failure.	The KSM TMF is a centerline constructed dam that relies on the strength of compacted sand for the integrity of the dam. The dam has a static factor of safety FoS > 1.5 for both undrained and drained loading conditions. This means that the dam is more than 1.5 times stronger than its expected loading.
A design that included a steep dam slope.	The KSM TMF design has downstream slope of 3H:1V as shown in Figure 1 compared with Feijão which had internal slopes of about 2H:1V and an overall slope of about 2.75H:1V.
Water management within the tailings impoundment that at times allowed ponded water to get close to the crest of the dam, resulting in the deposition of weak tailings near the crest.	The KSM TMF is designed with a wide beach to prevent ponding against the dam. In addition, due to the centerline-construction, the stability is not sensitive to the strength of the tailings deposited near the crest as it does not rely on the strength of tailings for stability.
A setback in the design that pushed the upper portions of the slope over weaker fine tailings	The KSM TMF design does not include a setback (Figure 1), and is not constructed over tailings due to the centerline design. As the dam is raised the compacted shell gets larger and wider to maintain the FoS.
A lack of significant internal drainage that resulted in a persistently high-water level in the dam, particularly in the toe region;	The KSM TMF has a continuous, low permeability till core in the center of the dam that limits seepage through the dam. Underdrains below the downstream sand shell promote drained conditions in this part of the dam that provides stability.
High iron content, resulting in heavy tailings with bonding between particles. This bonding created stiff tailings that were potentially very brittle if triggered to behave undrained.	The KSM tailings does not have a high iron content and is not anticipated to have a brittle behavior. Additionally, as stated above, the integrity of the dam does not rely on the properties of the tailings.
High and intense regional wet season rainfall that can result in a loss of suction, producing a small loss of strength in the unsaturated loose tailings above the water level.	KSM has a moderately wet climate, but the design does not rely on suction or the strength of the upstream tailings. The cycloned sand downstream shell is compacted, dense, and well drained.

Figure 1 Comparison of Cross Sections



Klohn Crippen Berger has prepared this letter for Seabridge Gold in a manner consistent with the level of care, skill and diligence ordinarily provided by members of the same profession for projects of a similar nature at the time and place the services were rendered.

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Principal

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