Appendix 6.6-F

Aquifer Compressibility below TSF and MRSF

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Project Memorandum

To:	**KGHM Ajax Mining Inc.**	**Doc. No.:**	**1125-009-M06-2015**
Attention:	**Nettie Ore**	**cc:**	
From:	**Randi Thompson**	**Date:**	**November 16, 2015**
Subject:	**Screening request AIR0491: Aquifer compressibility below TSF and MRSF**		
Project No.:	**1125-009-04**		

1.0 INTRODUCTION

BGC Engineering Inc. (BGC) was retained by KGHM Ajax Mining Inc. (KAM) to complete a baseline groundwater hydrology, or hydrogeology, study for the Ajax Project (the Project) near Kamloops, British Columbia; the results of this work are documented in BGC (2015). This memorandum summarizes BGC's response to information request AIR0491, related to groundwater quantity reported in BGC (2015).

2.0 REQUEST AND RESPONSE

2.1. Request AIR0491

In the updated Application, please include additional discussion on potential for aquifer compaction beneath the Tailings Storage Facility (TSF) and Mine Rock Storage Facilities (MRSFs). Additional follow-up may be required pending comments from Working Group (WG) members.

2.2. Response

Mapped bedrock and sand and gravel aquifers in the regional study area (RSA) are presented in Drawing 02 of BGC (2015). The drawing shows that the planned TSF, West MRSF and South MRSF do not overly any mapped overburden or bedrock aquifers. The footprint of the East MRSF, however, is located over mapped bedrock aquifer No. 0276 – the Sugar Loaf Hill Aquifer.

The TSF and each MRSF will increase the total stress and the effective stress on the natural materials below the storage facilities. The degree of compaction that may result will depend on the compressibility of the natural materials. Sand and gravel aquifers with small amounts of silt and clay are of low compressibility and would be expected to experience little compaction and negligible changes in thickness. Bedrock, similar to sand and gravel, is of low compressibility, and therefore limited aquifer compaction is expected in these units. Typical aquifer compressibility, α, from the literature are presented in Table 1 below.

Table 1. Aquifer Compressibility Values (after Freeze and Cherry, 1979 and Maidment, 1992)

Material	Compressibility, α (m^2/N or Pa^{-1})
Clay	10^{-6} to 10^{-8}
Sand	10^{-7} to 10^{-9}
Gravel	10^{-8} to 10^{-10}
Compacted sediments	10^{-9} to 10^{-11}
Jointed Rock	10^{-8} to 10^{-10}
Sound Rock	10^{-9} to 10^{-11}
Igneous and metamorphic rocks	10^{-9} to 10^{-11}
Water (β)	$4.4x10^{-10}$

The foundation soils of the East MRSF are primarily glacial till (up to 30 m, often silty sand or sandy silt) underlain by the Iron Mask Batholith (Cherry Creek Unit and Hybrid Unit), which is mapped as part of bedrock aquifer 0276. Based on literature values presented in Table 1, 10^{-10} Pa^{-1} would be an appropriate value for aquifer compressibility (α) for this bedrock unit.

The potential compaction of the bedrock aquifer below the East MRSF can be estimated from aquifer compressibility (α) as follows:

$\alpha = (-dH/H)/d\sigma_e$; $dH = -\alpha H d\sigma_e$ (Freeze and Cherry, 1979)

Where H = aquifer thickness, dH = change in aquifer thickness (or compaction), and $d\sigma_e$ is equal to the change in effective stress, resulting from the load of the mine facility in question. For a maximum height of 100 m for the East MRSF, and a typical unit weight of 21 kN/m^3 for drained mine rock (Knight Piésold Consulting, 2015), the resulting change in stress over the facility would be 2,100 kPa. The estimated bedrock aquifer compaction for the upper 100 m of bedrock would therefore be:

$dH = -\alpha H d\sigma_e = - 10^{-10}$ Pa^{-1} x 100m x 2,100,000 Pa = 0.02 m

The estimated bedrock aquifer compaction below the East MRSF of 0.02 m is negligible and is therefore not expected to change the hydraulic capacity of the aquifer.

3.0 CLOSURE

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Yours sincerely,

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REFERENCES

BGC Engineering Inc., 2015. Ajax Project Environmental Assessment Baseline Groundwater Hydrology Assessment. Document 1125-007-R03-2015 prepared for KGHM Ajax Mining Inc. August 26, 2015.

Maidment, D.R., 1992. Handbook of Hydrology. McGraw Hill, Inc.

Freeze, R.A. and Cherry, J.A., 1979. Groundwater. Prentice Hall Inc., Englewood Cliffs, New Jersey.

Knight Piésold Consulting, 2015. Geotechnical Report – Mine Site Infrastructure. Report C002-KA39-RPT-10-008 prepared for KGHM Ajax Mining Inc. June 16, 2015.