March 2016

Ajax Mine Application for Environmental Assessment Certificate/
Environmental Impact Statement

Working Group Comments from
Ministry of Energy and Mines

This document contains a compilation of review comments from the Ministry of Energy and Mines (MEM) on KGHM Ajax Mining Inc.'s (Proponent's) Application for an Environmental Assessment Certificate / Environmental Impact Statement. These comments are the "round one" Working Group comments from MEM.

For the purposes of documenting comments, EAO requires that the Proponent compile all written comments from Working Group members in a comment tracking table. The Proponent must provide responses to the Working Group submissions, in a table format or memo format as necessary. EAO reviews Working Group submissions to ensure that key issues in the environmental assessment are understood and addressed.

EAO's direction to the Proponent regarding Working Group comments is posted at http://a100.gov.bc.ca/appsdata/epic/html/deploy/epic_project_doc_list_362_r_com.html

Ministry of Energy and Mines

Mines and Mineral Resources Division

MEMORANDUM

March 4, 2016

To: Tracy James, EAO Project Assessment Manager

Re: Ajax Project – MEM Geochemistry/Water Quality Comments on the EA Certificate Application

The Ministry of Energy and Mines (MEM) has reviewed the Environmental Assessment Certificate Application for KGHM`s proposed Ajax Project. This review is intended to assess the adequacy of the following components of the application:

- Mine Development Plans;
- Geology and Geochemical Characterization;
- Source Terms and Water Quality Predictions, and
- Management Plans

The information that was assessed as part of this review was presented in the "Environmental Assessment Certificate Application: Ajax Project", prepared for KGHM by ERM Consultants Canada Ltd. with input from several consulting groups. This review is focused primarily on the information presented in Sections 2.2, 3.1, 3.3, 3.4, 3.5 3.6, 3.7, 3.8, 3.9, 3.10, 3.13, 3.14, 6.2 to 6.6, 11.5, 11.23, 11.24, 11.30 and associated Appendices.

This technical memorandum outlines MEM's understanding and assessment of the application, and identifies items requiring follow-up by the proponent. To facilitate tracking, review comments have been numbered and designated as: comment, clarification, EA information requirement or *Mines Act* permitting requirement. It is expected that detailed responses will be provided for all numbered items.

I. Geology and Mine Development

The geology for the Ajax Project is presented in Section 3.3 (Regional and Local Geology and Mineralization). The mine development plan is presented in Section 3.1.2. A single open pit is planned for the Ajax Project, which is divided into four time periods, Construction (year -2 to 1), Operation (year 1 to 23), Decommissioning (year 24 to 29) and post-closure.

The porphyry copper-gold Project is located in the South-Central Interior of BC within the Thompson Nicola Regional District on the site of the historic Afton Mine approximately 2 km south of the city of Kamloops, British Columbia. The major regional geology consists of three main rock types: Iron Mask Hybrid (IMH), Sugarloaf Diorite (SLD) and Nicola Volcanics. Locally, the Sugarloaf and Iron Mask Hybrid contact trends northwesterly and southwesterly through the project area.

The Sugarloaf and Nicola Group contact trends generally northwesterly through the project area, to the south of the IMH/SLD contact. There are two additional major waste rock units; Mafic Volcanics (MAFV), Picrite (PICR) and Sugarloaf Volcanic Hybrid (SVHYB). The economic mineralization in the Project area is associated with the Sugarloaf and Sugarloaf Hybrid phases, which extends over 2,000 m laterally and

600 m depth. The high-grade copper-gold mineralization is limited to the chalcopyrite veins, fracture fillings and isolated blebs within the SLD and SVHYB phases.

The deposit will be mined out using open pit methods over a 23 year mine life, producing approximately 438 million tonnes of ore. The ore is sub-divided into three categories, low, medium and high-grade ore. The high-grade ore will be immediately processed, while low and medium-grade ore will be stockpiled on site. Two ore stockpiles, low-grade and medium-grade, with a storage capacity of 45 Mt will be constructed with a similar level of design as the MRSF.

Over the life of mine, approximately 1,000 million tonnes of waste rock will be excavated, which will be stored on-site in four waste rock storage facilities (WRSF). The WRSFs will be built incrementally, optimized to the mine production schedule and progressively reclaimed over the life of mine. Additionally, a tailings storage facility will be constructed to handle the approximately 440 million tonnes (275 million cubic metres) of tailings anticipated to be produced over the life of mine.

MEM Comments:

1. There is a discrepancy between the life of mine and the associated yearly ore production amounts presented in Table 3.6-1 and Appendix 3A, Table 3.2. Please clarify the life of mine and provide the anticipated ore, waste rock and tailings production for each year [Clarification].

2. What geochemical parameters will be used to differentiate the low, medium and high-grade ores? [EA Information Requirement].

3. The Sugar Loaf Diorite (SLD) has been divided into three sub-categories, weakly, moderately and strongly albitized, which is carried through the geochemical characterization of the waste rock. How are the three degrees of SLD albitization defined in the classification system [EA Information Requirement].

II. Geochemical Characterization

The geochemical characterization of mine materials including ore, waste rock, tailings and overburden is summarized in Section 3.4 and detailed in Appendix 3-A. The following is a summary of the geochemical characterization of these materials as understood by MEM.

A. Waste Rock (referred to in the application as mine rock)

A total of 1048 waste rock samples were collected by Lorax Environmental from exploratory, geotechnical and ARD specific drill core in 2007 (n = 47), 2012 (n = 952) and 2014 (n = 49). The collected samples included 856 waste rock samples and 192 ore samples.

The waste rock has been classified into five major units, which correspond to the main geologic units; IMH, SLD, MAFV, PICR and SVHYB. The proportion of waste rock represented by each waste rock subgroup is approximately: IMH (60%), SLD (23%), MAFV (2%), PICR (10%) and SVHYB (1%). These units were further subdivided into nine grouped units as well as low, medium and high-grade ore, which were submitted for various combinations of static, kinetic and mineralogical testing. Static tests undertaken included; acid base accounting (ABA), elemental analysis (ICP-MS) after aqua-regia digest, net acid generation (NAG) and shake flask extractions (SFE). Kinetic testing included; humidity cell testing (HCT), unsaturated column testing and field bin weathering testing. Mineralogical testing included electron-microbeam/X-ray diffraction (EM/XRD), scanning electron microscopy (SEM), petrographic analyses and particle size distribution.

ABA testing included paste pH, sulphur speciation (total, sulphate and sulphide) and neutralization potential (NP). Characterization results indicate that the median pH for all materials was greater than 8.5 with minimum values greater than 7.7. Sulphur speciation indicated that sulphide-sulphur comprised a fraction of the total-sulphur content; therefore, acid potential (AP) values were conservatively calculated using non-sulphate values (i.e. total sulphur minus sulphate sulphur). Median non-sulphate values ranged between 0.010 and 0.22% and maximum values ranging between 0.30 and 5.0%. Neutralization Potentials were calculated using both carbonate-NP (CaNP), Sobek-NP (Bulk NP) and modified-Sobek-NP (modified NP) methods. Median CaNP results for all waste rock subgroups ranged between 5.0 and

63 kg $CaCO_3$/t, while median Bulk-NP results were substantially larger and ranged between 62 and 192 kg $CaCO_3$/t. Mineralogical analyses indicated that the presence of Fe-bearing carbonates was minimal; therefore, suggesting that CaNP values are a valid assessment of the carbonate mineral NP. Based on the CaNP results, the median neutralization potential ratio (NPR) for each waste rock subgroups varied between 2.3 and 64. Based on these results, the percentage of potentially acid generating (PAG) material, based on a CaNPR of greater than 2, for each waste rock group were; IMH (0%), SLD (27%), MAFV (43%), PICR (46%) and SVHYB (11%).

Comparison of CaNP and modified-NP indicated variable but systematically higher modified-NP values for MAFV and PICR waste rock samples, which suggested the presence of reactive silicate-NP phases. Initial investigations comparing CaNP and Bulk-NP method results had suggested that SLD was also characterized by silicate-NP phases; however, method refinement suggested that the Sobek-NP method included less reactive silicate phases that are not expected to significantly contribute to the overall available NP. The percentage of PAG material (NPR less than 2) for MAFV and PICR waste rock groups, based on the modified-NP results, were 18% and 11%.

Analysis of solid-phase elemental composition data indicated, based on the conservative comparison to three times the average crustal abundance, all waste rock is enriched in As, Cr, Cu, Mo, Ni, Se and V (using 90th percentile values). These values were exceeded for the waste rock subgroups; IMH (As, Cu, Se, V), SLD (As, Cu, Mo, Se), MAFV (Cr, Cu, Mo, Ni, Se), PICR (As, Cr, Cu, Mo, Ni, Se) and SVHYB (As, Cu, Se).

A total of 14 unsaturated column tests were conducted on samples of IMH (4), SLD (2), PICR (2), MAFV (1), SVHYB (1) and a mixture of PICR/MAFV (1). Additionally, three columns were initiated on ore samples. Unsaturated column testing was used to provide a more representative simulation of the arid climatic conditions prevalent in the Kamloops area than would be provided by conventional humidity cell methods. Results for six columns, representing SLD, IMH, MAFV/PICR and ore (> 100 weeks) remained circumneutral (pH > 7.5) and sulphate loading rates appeared to reach quasi steady-state between weeks 75 to 100. Relatively higher dissolved metal concentrations were associated with the MAFV/PICR column leachate, compared to the IMH and SLD results. The IMH, SVHYB, PICR and MAFV columns were not available as the experiments had not sufficiently progressed at the time of the report.

A total of 10 HCTs were initiated on splits of the SLD (6) and PICR (4) samples utilized for the column testing. The primary focus of the HCTs was to examine the contribution of silicate minerals to the effective-NP of the waste rock, which was achieved by pre-treating the samples to remove the CaNP. A comparison of untreated and pre-treated duplicate columns suggested that silicate minerals provided sufficient buffering capacity in the absence of carbonate phases to neutralize acid production. However, the results also indicated the possibility of slightly higher sulphate and metal leaching rates for pre-treated SLD samples. Only the results for the six SLD HCTs were presented as the PICR HCTs had not sufficiently progressed at the time of the report.

Field Bin weathering tests were initiated in 2007 on samples of IMH (2), SLD (2) and PICR waste rock, which was sourced from existing waste rock that had been weathering in place for 17 years. Results indicate that BC WQG have been regularly exceeded for median As (IMH, PICR, SLD), Cr (IMH, PICR, SLD) and Cu (SLD) values. Similarly, 30-day BC WQG criteria have been exceeded for median sulphate (SLD), nitrate (SLD), As (IMH, PICR, SLD), Cr (IMH, PICR), Cu (SLD), Se (IMH, SLD, SLD) and V (IMH, SLD) values. Overall, Field Bin loading rates were one to two orders of magnitude lower than rates calculated from the unsaturated column and HCT results.

MEM Comments:

4. Additional information is required on the historical waste rock located on the mine site. Please provide information on locations, volumes, available geochemistry information with a comparison to future mine waste geochemistry, as well as clarification of the re-handling and disposal plans as part of proposed future mining. This is required as a basis to understanding how historical waste has been considered in the water quality predictions [EA Information Requirement]

5. A robust investigation has provided clear evidence that iron carbonates contribute an insignificant amount to CaNP values. MEM agrees this method of NP determination is appropriate for use in the classification of waste rock and ore as PAG or NPAG [Comment].

6. The NP determination for operational management of waste rock and ore will be based on a calculation of CaNP from the total carbon content of a sample for the SLD, IMH and SLVH waste rock types. For the MAFV and PICR types, NP will be determined from CaNP and a correction factor based on the25th percentile non-carbonate NP value. Please provide MEM with an explanation of how the non-carbonate NP is calculated and how the fixed-NP value was derived for the MAFV and PICR waste rock types [EA Information Requirement].

7. The AP determination for the operation management of waste rock and ore will be based on the calculation of AP from the non-sulphate-sulphur content, which is calculated as the difference between total-sulphur and sulphate-sulphur. MEM agrees that the data supports deriving the waste rock and ore AP by this method [Comment].

8. The general setup for the unsaturated column experiments included 5kg of waste rock that is trickled leached weekly with 300-500mL of deionized water, which is then collected one day later. Please provide information on the rationale for employing unsaturated columns over HCTs, as well as the choice of modified column test procedures. Examples of the use of unsaturated columns in previous investigations should be provided [EA Information Requirement].

9. An updated summary of the results for unsaturated columns 2 to 6, collected since August 2015, will be required at permitting along with a detailed discussion of any implications to the project [*Mines Act* Permit Requirement].

10. A summary and discussion of the results for unsaturated columns 7 to 12 are required to provide MEM with a better understanding of the leaching characteristics of the PICR, MAFV and SVHYB waste rock. Additionally, these results should be carried through to determine the implications for the waste rock source terms and contribution to the site water quality model [EA Information Requirement].

11. An updated summary of the results for HC-1 to HC-6, collected since August 2015 will be required at permitting along with a detailed discussion of any implications to the project [*Mines Act* Permit Requirement].

12. A summary and discussion of the results for HC- 7 to HC-10 are required to provide MEM with a better understanding of the differences between normal and carbonate depleted leaching characteristics. Additionally, these results should be carried through to determine the implications for the waste rock source terms and contribution to the site water quality model [EA Information Requirement].

13. The report focuses on the results of the HCT results from the normal and carbonate-depleted (sodium acetate treated) SLD waste rock samples; however, duplicate HCTs were conducted for SLD treated with HOAc and H_2SO_4. Please provide a rationale for excluding the results of the SLD waste rock that was carbonate-depleted with HOAc and H_2SO_4 from the HCT discussion [EA Information Requirement].

14. The leaching behaviour of metals in the SLD waste rock HCTs are discussed in 6.1.1.5 (page 6-33); however, only the results for Cu and V are included. The difference in metal leaching behaviour between waste rock controlled by CaNP and silicate-NP is important to understanding the long-term implications of site water quality of the proposed reliance on silicate-NP. In order to assist MEM in understanding the potential for metal leaching in a silicate-NP controlled system, please provide a comparison and discussion of the leaching of metals between normal and

carbonate-depleted waste rock in the SLD (HC 1 to HC 6) and PICR (HC 7 to HC 10) HCT results [EA Information Requirement]

15. MEM is generally agreeable with the proposal to include silicate-NP in the determination of operational NP for the MAFV and PICR waste rock types. A substantial amount of laboratory analyses, including ABA, semi-quantitative mineralogy and kinetic testing was employed to demonstrate the presence and capacity of silicate mineral phases to buffer the waste rock acid potential. In addition, the relatively small proportion of the overall waste rock quantity represented by these waste rock types (approximately 12%) reduces the overall risk of the proposal. However, since the bulk of the assessment was conducted on SLD, additional characterization work will be will be required at permitting to strengthen the understanding of the phases controlling the silicate-NP of the MAFV and PICR waste rock types and the potential for neutral leaching of metals from these waste rock types[*Mines Act* Permit Requirement].

16. Field Bin weathering test results for the IMH, SLD, and PICR waste rock types indicate that BC WQG were exceeded for median dissolved Cr concentrations (Table 6-7); however, no discussion is provided on potential mechanisms or comparisons drawn with the unsaturated column and HCT results. Please provide this information [EA Information Requirement].

B. Tailings

A total of seven tailings test samples were included in the characterization study. Five of the tailings samples were produced during pilot plant testing in 2009 and 2013. The two remaining samples, produced in 2014, are considered more representative of the tailings product that will be produced during mine operations.

Results indicate circumneutral paste pH values for all samples. Sulphur speciation results for the more recent tailings samples are predominantly characterized by sulphate-sulphur phases. However, CaNPR values greater than 8.0 for earlier samples (T1 to T5) and greater than 30 for the more representative (T6 and T7) tailings samples.

Results from HCT, saturated column and Field Bin investigations are presented; however, results from the experiments conducted on the most recent and representative tailings were not available at the time of the report.

<u>*MEM Comments:*</u>

17. The Raw data for the static test analyses conducted on tailings samples produced in 2014 are missing from Appendix C-2.1 through C-2.4 [EA Information Requirement].

18. The 2014 tailings samples are indicated to be the most representative of tailings material composition that will be produced in years 6-10 and 11-21 (Page 3-25 and 5-51), but the application notes that as the metallurgical testwork is refined over time that the generated tailings are expected to become more representative of the final tailings material (pg 3-19, Appendix 3-A). Please provide additional information of the anticipated differences between the tailings used in this report and the final tailings and the implications of the evolution of the tailings geochemistry over the life of mine as it relates to the site water quality model [EA Information Requirement].

19. Further to the previous comment, please provide any relevant information and a discussion of the differences between the tailings expected to be produced in years 1-5 and those produced in years 6-21. Additionally, please provide an explanation for why the 2014 samples can be used to represent these two tailings groups in the geochemical assessment [EA Information Requirement].

20. It is unclear why loading rates for As, Cu, Cr, Mo, Ni, Se, V and Zn for tailings samples T1 to T4 are substantially higher in the HCT compared to the unsaturated column results. Please provide a more thorough discussion of these results and provide a rationale for why the unsaturated

dataset is appropriate for use as source terms in the water quality model [EA Information Requirement].

21. Please provide an updated summary of the results for the seven tailings HCTs collected since August 2015. This summary should focus on T-6 and T-7 and provide detailed discussion of the implications of the results on the conclusions drawn for the tailings in the EA [EA Information Requirement].

C. Ore Stockpile

A total of 192 samples were collected by Lorax Environmental from exploratory, geotechnical and ARD specific drill core. ABA testing included paste pH, sulphur speciation (total, sulphate and sulphide) and neutralization potential (NP). These samples included low (n = 94), medium (n = 28) and high-grade (n = 70) ore types.

Median non-sulphate sulphur values were 0.25, 0.35 and 0.58 % for the low, medium and high-grade ores. Median CaNP results for all waste rock subgroups ranged between 48 and 62 kg $CaCO_3$/t, while median Sobek-NP results were substantially larger and ranged between 79 and 143 kg $CaCO_3$/t. The median neutralization potential ratios, calculated with CaNP, (CaNPR) were 5.6, 4.2 and 3.5 for the low, medium and high-grade ores. There was only a small difference between CaNPR and modified-NPR results for the three ore types, suggesting the absence of reactive silicate-NP phases. The percentage of PAG material (NPR less than 2) for the low, medium and high-grade ores, based on the CaNP results, were 29%, 32% and 39%, respectively. Analysis of solid-phase elemental composition data indicated, based on the conservative comparison to three times the average crustal abundance, all ore is enriched in Ag, As, Cr, Cu, Mo, Ni, Sb and Se (using 90th percentile values).

Unsaturated columns, one containing high-grade ore (Col-1), one containing low-grade ore (Col-11) and a third containing a mixture of undefined ore (Col-12) were included in the kinetic testing program. Only Co1-1 had progressed sufficiently (~ 200 weeks) to provide representative results. The pH value remained circumneutral throughout the experiment duration and sulphate loading rates decreased by an order of magnitude between approximately week 75 and 150. Similarly, dissolved metal loading rates appear to reach quasi-steady states by approximately week 75, with only V showing a slight increase with time.

NP depletion calculations indicate that less than 10% of the ore material will be NP depleted within the 23 year life of mine, while approximately half will be NP depleted within 40 years. This calculation was based on the results of Col-14.

<u>*MEM Comments:*</u>

22. A summary and discussion of the results for unsaturated columns 2, 13 and 14, are required to provide MEM with a better understanding of the leaching characteristics of the low, medium and high-grade ore. Additionally, these results should be carried through to determine the implications for the waste rock source terms and contribution to the site water quality model [EA Information Requirement].

23. The NP depletion rates were calculated for most of the waste rock samples and one of the ore samples (Table 6.2, Appendix 3-A). Please provide the NP depletion rates for the unsaturated ore columns Col-1 and Col-13 and provide a discussion on how this affects the estimated amount of ore that will be NP depleted during the life of mine [EA Information Requirement].

D. Overburden

A series of soil samples were collected from both the previous (n = 7) and current (n = 13) proposed mine site footprints. Samples were characterized as non-PAG, with CaNPR values ranging between 21 and 413. Solid phase results indicated that As, Bi, Sb and S concentrations were elevated relative to three times the average crustal abundance. The SFE indicated that most species were at concentrations below contaminated site guidelines, with the exception of sulphate and Se in two samples collected from within the TSF footprint.

MEM Comments:

24. A detailed description of the solid phase geochemical characterization of the overburden is provided in Appendix 3-A. Additionally, Section 3.10 of the main report outlines the topsoil and overburden stockpiling plan. Please provide an estimate of the amount of overburden to be stockpiled and clarify where samples were collected in relation to the proposed borrow areas for the project [EA Information Requirement].

25. Overburden will be used in the construction of the TSF dams. Four overburden samples were collected from within the proposed TSF footprint, which are characterized by elevated sulphate and Se SFE concentrations (based on contaminated site WQG) relative to the remaining samples. To support *Mines Act* permitting, additional work will be required to more thoroughly characterize the overburden proposed for use in the construction of site features and overburden that will be stockpiled during mining operations [*Mines Act* Permit Requirement].

III. Waste Management Plans

Waste management plans for the Ajax project are presented in Section 11.5 (ML/ARD Management and Monitoring) and Appendix 3-D (TSF Design Report). The following provides a summary of MEMs understanding of the information.

Waste Rock

Over the expected 21 year life of Ajax approximately 1,000 Mt of uneconomical mine rock (waste rock) will be produced. Based on CaNP results, approximately 21% of the waste rock is classified as PAG, a percentage that decreases to 15% if modified-NP results are considered for the MAFV and PICR types. Waste rock will be permanently placed into one of four WRSF or four TSF embankments. NPAG waste rock will be blended with PAG waste rock to achieve an overall CaNPR of at least 3. The blending protocol involves mixing PAG MAFV, PICR and SVHYB with an equal amount of NPAG IMH or twice the amount of NPAG SLD. Similarly, PAG SLD waste rock can be blended with twice the amount of IMH or three times the amount of NPAG SLD. Blended waste rock will only be placed into the South WRSF, West WRSF or as backfill into the Pit. Waste rock reporting to the East WRSF and the bases of all WRSFs will consist entirely of NPAG material.

In-Pit identification of PAG waste rock will be guided by the spatial occurrence of PAG predicted by the ARD block model as well as assaying of PAG containing waste rock units. Additionally, Segregation procedure, involving GPS and dispatch, has been developed to ensure movement of PAG material from the Pit to the appropriate facility and placement with the appropriate amount of NPAG material. Confirmatory monitoring will involve regular sampling of waste rock that has been placed in each of the WRSFs, Embankments and Stockpiles. All samples will be analyzed at an on-site laboratory.

The TSF Embankments will be constructed entirely from non-blended NPAG waste rock, which will be determined by the production and placement schedules. The seepage rates through the TSF Embankments and foundations will be limited through the construction of seepage collection ponds. The Embankments will be constructed with a liner system and an underdrain system beneath each Embankment will collect and direct seepage towards the collection ponds. The seepage collection ponds will be sampled on a quarterly basis.

The South and West WRSFs will be progressively covered during mine operations and decommissioning and closing.

Tailings

Over the expected 21 year life of Ajax approximately 440 Mt of tailings will be generated. The TSF will consist of four earth-rockfill dams (Embankments), north, east, south and southeast. The West WRSF will buttress the north Embankment and the South WRSF will buttress the east Embankment.

Thickened tailings will be pumped at approximately 1,960 m^3/hr to the TSF at 60% solids. The tailings will quickly settle to approximately 77% solids with a dry density of 1.6 t/m^3 to form a beach from the upstream crest of the dyke with a slope of approximately 1.5%. A supernatant pond will develop, which will be used as a source of process water. The tailings reporting to the TSF are considered NPAG and will be deposited as a homogeneous, non-segregated tailings mass. A representative tailings sample will be collected for geochemical analyses on a weekly basis.

At closure, the existing TSF pond water will be moved to the open Pit and a dry cover consisting of 0.65 m of till or waste rock and 0.35 m of organic substrate will be constructed over the TSF.

MEM Comments:

26. MEM recognizes that KGHM has committed to constructing the East WRSF, all WRSF bases and the TSF Embankments from NPAG waste rock, thereby minimizing the generation of ML/ARD in storage facilities that cannot be easily relocated. Will there be enough NPAG waste rock available to meet the commitment of constructing the WRSF bases in the early stages of mine operation? [EA Information Requirement].

27. The estimation of PAG and NPAG waste rock (Section 11.5.3.4) uses NPRs derived from the modified-NP for each waste rock type. However, the geochemical characterization work presented in Appendix 3-A concluded that only the MAFV and PICR waste rock types would be classified using modified-NP and that for all other waste rock CaNP was the appropriate measure of available NP. Please provide a clear rationale as to why a modified-NP is considered appropriate for the other waste rock types. If appropriate, please provide a recalculation of the PAG and NPAG volumes that is based on the re-evaluated NPRs [EA Information Requirement].

28. The waste rock management plan indicates that PAG waste rock will be blended with NPAG waste rock in order to achieve a minimum NPR ratio of 3. MEM is in agreement with this approach as it increases the conservatism applied to the management of PAG waste rock [Comment].

29. All roadways, roadway embankments and any other mine site infrastructure incorporating waste rock in their construction should only use NPAG material. Appropriate confirmatory sampling protocols will be required at permitting [*Mines Act* Permit Requirement].

30. Section 11.5.5.1 indicates that In-Pit monitoring and classification of NPAG/PAG waste rock will be conducted by ABA assays for SLD, MAFV, PICR and SVHYB. IMH will only be identified visually as it is visually distinct and all characterized as NPAG. Detailed sampling and analytical programs will be required for Mines Act permitting. Analysis of both pre-blast samples from drill cuttings, and post depositional monitoring in the dumps will be required. [*Mines Act* Permit Requirement]

31. Detailed protocols and management plans will be required at the permitting stage for operational characterization, segregation and disposal of waste materials, including detailed sampling and analytical procedures. [*Mines Act* Permitting Requirement].

32. An on-site laboratory will conduct paste pH, sulphide sulphur (Leco furnace) and total carbon (Leco furnace) analyses on materials requiring segregation and on non-deposit rocks. Sulphide sulphur determinations will be conducted on samples that are leached with hydrochloric acid to remove any sulphate present. These on-site laboratory facilities will be required at the initiation of construction activities. MEM will require that all analytical results from the on-site lab are verified by an external accredited laboratory, until the lab is verified to be operating properly [*Mines Act* Permitting Requirement].

IV. Water Management Plans

Waste management plans for the Ajax project are presented in Section 3.14 (Site Water Management), Section 11.7 (Water Management and Hydrometric Monitoring). The following provides a summary of MEMs understanding of the information.

Water will be obtained from a variety of sources, including fresh, contact and recycled sources. Fresh water will be supplied from Kamloops Lake via pipeline. Process water from the tailings thickener overflow and concentrate thickener will be recycled and TSF pond water will be reclaimed. Contact water from the Open Pit, seepage from the WRSF and contact water from the Plant Site will also be collected and used.

During construction and operations, Peterson Creek will be diverted through the construction of the Peterson Creek Diversion System (PCDS). The PCDS will allow for outflows from Jacko Lake to be pumped around the mine site, via pipeline to the north of the Open Pit, and re-introduced to Peterson Creek downstream of the Central Pond. The Central Pond and Peterson Creek Downstream Pond (PCDP) would be constructed within the existing Peterson Creek (Lower) channel. The PCDP will consist of a dam and a storage pond lined with a low permeability barrier and the spillway will be armoured to prevent erosion. The PCDP will be actively managed as required. Jacko Lake will have four dams constructed to prevent the flooding of the Open Pit. A water intake system will be used to source fresh water from Kamloops Lake and pump it 16 km to the Ajax site at a maximum rate of 1,505 m^3/h.

<u>TSF</u>

During construction, Goose Lake will be connected to the TSF Pond via a trenched channel to provide room for the barge recycle system. A Seepage cut-off will be constructed along the upstream toe beneath the dam foundation and will be constructed of low permeability glacial till or geosynthetic material. Downstream, a series of collection ponds and drainage ditches will be constructed to manage the collected seepage. During operations, the trench will be infilled by deposited tailings. Slurried tailings will be pumped overland in an HDPE line within a bermed corridor from the process plant to the TSF along the embankments. Discharge to the TSF will be rotated as required for controlled development. As the TSF is developed the TSF Pond will develop in the southeast corner. All site runoff and process-affected water is recycled within the TSF Pond as part of the reclaim system. The supernatant will be pumped from a barge to a reclaim tank and gravity-fed to the process plant through an HDPE gravity pipeline. During decommissioning and closure, all TSF Pond water will be pumped to the Open Pit

<u>Water Management Ponds</u>

During operations, all sources of mine affected water (runoff and seepage) will be captured in a series of collection ponds and used in the process plant. This includes: runoff from the WRSFs and TSF Embankments, seepage from the TSF and Plant Site runoff. All of the collection ponds, with the exception of the Plant Site and SWRSF Ponds, are pumped or directed through drainage channels to the Central Pond along with water from the Open Pit. All collection ponds will be constructed of rockfill material and may include low permeability basin liners. Water levels in the ponds will be kept at minimum operating levels to provide storage for the design rainfall event.

Additional water management details include:

- During construction, water from the existing Ajax West East Pit will be treated and used as required and any remaining water will be pumped to the TSF;
- An emergency tailings pond will be constructed on the east of the Plant Site with sufficient volume to contain the volume present in the processing plant with a safety factor of 10%.

Decommissioning and Closure details include:

- Run-off from the reclaimed TSF and WRSFs is assumed to be of suitable quality for discharge to the environment;
- The PCDS will be decommissioned and the Peterson Creek closure channel constructed along the original channel;
- The TSF Pond will be pumped to the Open Pit;
- The Open Pit will then be allowed to passively fill;

- The EWRSF, SWRSF and North Embankment collection ponds will remain.

MEM Comments:

33. Water management plans for the project appear to have been developed with a good understanding of the site-specific climate, hydrologic, hydrogeologic and geographic conditions of the project area [Comment].

34. Water management structures are appropriately sized to manage 1:200 year flood events [Comment].

35. Dewatering of the existing West East and West West Pits is outlined in Section 11.7.4.4 including the requirement to treat the water before using during the construction phase. Please provide additional information on the location and type of treatment process, the geochemical characteristics and amounts of treatment waste that would be produced (if any), the disposal methods and locations for secondary wastes, and information on whether and how this has been considered in the water quality modelling for the project. [EA Information Requirement].

V. Water Quality Predictions

A mass balance water quality model (WQM) was developed to estimate the quality of mine contact water and the resulting concentrations within the receiving environment during operations, closure and reclamation and post-closure. The WQM builds on the results of the hydrologic, hydrogeologic, geochemical, air quality models developed for the project, in addition to the baseline water quality data for the site.

The following sections provide a summary of MEMs understanding of the source term development, model assumptions and estimates of future water quality at key points in the receiving environment.

A. Geochemical Source Terms

The geochemical source terms considered in the water quality model included: ore, waste rock, pit walls, tailings and overburden, which are summarized in Appendix 3-B. The following is a summary of the source term development as understood by MEM.

Waste rock Storage Facilities

The TSF Embankments containing waste rock are considered to be WRSFs. A total of 13 waste rock units, derived from the five major geologic units (SLD, IMH, MAFV, PICR, SVHYB) were considered in the source term development. In addition, three grades of ore (low, medium and high) were considered, with low and medium-grade ore considered for storage in temporary stockpiles.

Loading rates for waste rock and ore were determined using the geochemical characterization data provided in Appendix 3-A, scaling those results to field conditions, deriving mine facility specific concentrations and adjusting for secondary mineral controls using PHREEQC speciation modeling. Only loading rates developed from the unsaturated column experiments were used for the waste rock source terms. Where data from more than one column was available, the loading rates from each were combined in proportion to the percentage of each with a similar non-sulphate sulphur content determined in the static tests for that unit. Additionally, selected loading rates were based on early loading rates for modeling of the years during mine operation scenarios (short-term) and on the most recent loading rates for post-closure scenarios (long-term). Source terms were derived for one ore stockpile and six WRSFs including: West WRSF and North Embankment; South WRSF and East Embankment; East WRSF; South Embankment; Southeast Embankment and Backfill. The placement of each of the 13 waste rock units into each facility was estimated and the total waste rock tonnage and surface area was calculated. Scaling factors for grain-size and the amount of waste rock mass expected to be contacted by infiltrating water, which resulted in bulk correction factors that varied between 0.06 and 1% of the loading rates observed in the laboratory investigations.

Average annual pore water concentrations were determined by dividing the scaled loading rates by the volume of water predicted to infiltrate into each WRSF, which was 27 mm/yr for exposed and 8 mm/yr for covered waste rock. Selenium concentrations were calculated based on sulphate values as estimated concentrations were well below values observed in field leachate. The scaling of laboratory results to represent field loadings resulted in the super-saturation of some elements with respect to a series of secondary minerals. PHREEQC speciation modeling was incorporated to adjust for the precipitation of these secondary phases and the subsequent reduction in elemental concentration. Finally, the resulting concentrations were compared to measured site drainage, if the modeled value exceeded the observed 95^{th} percentile value it was capped at that concentration.

Tailings Loadings

The determination of tailings source terms was predicted for four sources; tailings beach runoff (active and inactive), tailings seepage during operations, tailings seepage runoff post-closure and process water.

During active tailings beach runoff the oxidation zone is assumed to be 1 cm thick, increasing to between 1 and 3 m post-deposition. An infiltration rate of 37 mm/yr was assumed and contact water (4%) and temperature (75%) scaling factors applied to the calculated loading rates scaled to a 1 m2 unit surface area of tailings. Similar to the waste rock source term development, secondary mineral controls on calculated tailings porewater concentrations were determined using PHREEQC and values were capped if values exceeded the 95^{th} percentile values in the unsaturated columns, field bin or historical TSF monitoring wells.

During operations it is assumed that the majority of the TSF will be saturated. Post-closure, the TSF is expected to fully drain within 300 years. The source terms for saturated tailings during operations were determined from the higher 95^{th} percentile value observed in the saturated tailings column testing or the tailings supernatant collected during pilot scale testing. Post-closure, the TSF will be characterized by a 1.5 to 2.5 m active sulphide zone, which will move progressively downwards and a cover infiltration rate of 8 mm/yr was applied. Additionally, the effect of applying a 2 m NPAG waste rock cover was simulated and the higher porewater concentration between the tailings and waste rock was applied as the post-closure source term.

The source terms for the process water that will represent a large proportion of the water balance in the TSF were calculated from the 95^{th} percentile values from the tailings supernatants analyzed during the tailings geochemical characterization program. Additionally, the accumulation of oxyanions in the process water as it is recycled through the mill was simulated by applying a per cycle load. The concentration per cycle load was determined from the maximum value of each species observed in either the supernatant; SFE tests or first rinses from the columns and HCTs. Values were capped if they exceeded the concentrations observed in a bench scale evaporation experiment or the 90^{th} percentile values of nearby evaporative lakes.

Pit Walls

The Pit wall source terms were estimated for the blast-damaged and blast-influenced zones, with penetration depths of 0.9 and 2.9 m, respectively. An average pit wall angle of 45° was used to calculate a tilted exposure factor of 1.41 per m^2, which was employed to determine the mass of exposed rock. The loading rates were calculated similar to those for the WRSFs for the four waste rock type's representative of the exposed Pit wall (IMH, SLD, MAFV, PICR). To account for the presence of exposed PAG waste rock, an acid factor was derived from the normal and carbonate-depleted SLD HCT results, which could be applied to the MAFV and PICR waste rock. Scaling factors for grain-size, temperature and contact water were applied to both Pit wall zones, resulting in bulk correction factors of 5.6 and 2.5% for the blast-damaged and blast-fractured zones, respectively. Source term concentrations were calculated from the scaled loading rates and annual Pit wall runoff and secondary mineral controls were modeled using PHREEQC. Similar to the WRSF source terms, cap values were derived for both neutral and acidic source terms.

Only a portion of the geochemical load produced from oxidation of the Pit wall waste rock will be flushed during rainfall events. The remaining stored load will accumulate on a yearly basis and will be released all at once when the Pit wall is inundated by the Pit Lake waters post-closure.

MEM Comments:

36. The low, medium and high-grade ore loading rates were determined from a combination of the unsaturated column (Col-1, Col-9, Col-13 and Col-13) results. Please provide additional discussion to assist MEM in understanding the selection of these results to represent each grade of ore [EA Information Requirement].

37. Please provide the secondary mineral controls employed and summarize the resulting changes to the waste rock, Pit wall and tailings source terms for each affected species. This will assist MEM in determining whether the secondary mineral controls were appropriately applied [EA Information Requirement].

38. Concentration maximums were derived for calculated species source terms for waste rock and tailings based on maximum values measured in field based sampling programs. These concentration maximums are included in the final geochemical source term summary (Appendix 3-B, Appendix D). However, the uncapped species source terms were not presented within Appendix 3-B for comparison. Please provide this information, including references for each concentration maximum. Additionally, please provide the rationale for choosing the source term concentrations that were capped [EA Information Requirement].

39. Porewater concentrations for samples collected from the historic Afton tailings were used to develop concentration limits for tailings porewater source terms in Section 2.2. Please provide additional information regarding how these concentrations were determined, including sample location, age, collection method, and analytical methods used. Additionally, please provide information that demonstrates these tailings are similar to the future Ajax tailings. This will assist MEM in evaluating the suitability of using these concentrations as source term concentration maximums [EA Information Requirement].

40. In several of the provided Appendices to the Appendix 3-B report, the geochemical units have been omitted. Units should be explicitly stated on all tables and figures [Comment].

41. Please provide additional information supporting the selection of the contact water scaling factors for each WRSF to assist MEM in evaluating their suitability and degree of conservatism appropriateness for these facilities [EA Information Requirement].

42. Infiltration rates for WRSFs were calculated assuming that the particle size distribution (PSD) determined for the waste rock used in the Field Bin investigations were representative of WRSF waste rock PSDs (Water Balance Model, Appendix 6.4-C). Please provide a sensitivity analysis that demonstrates the sensitivity of the source terms to a change in the PSD. This will assist MEM in understanding the implications of this assumption on the waste rock source terms and water quality predictions [EA Information Requirement].

43. A cover consisting of a 2m layer of NPAG waste rock is proposed for the TSF and included in the source term development. Please indicate what type of NPAG waste rock was used in the source term calculations. Will there be sufficient amounts of this material at the end of operations for use in cover construction? Which WRSF will it be sourced from? [EA Information Requirement].

44. Please provide information to demonstrate that the assumptions around infiltration into the TSF reasonable based on the application of the waste rock and till cover being proposed are reasonable [EA Information Requirement].

45. Is the water quality model sensitive to the amount and/or depth of the waste rock cover being used? [EA Information Requirement].

46. Were there any instances where the calculated waste rock or tailings source term for individual species were substantially (one or more orders of magnitude) lower than concentrations observed in field samples? If so, please provide discussion on the appropriateness of these calculated source term for those species [EA Information Requirement]

47. An acid factor was proposed and outlined for the conversion of source terms for MAFV and PICR derived from non-acidic loading rates to acidic loading rates (Section 2.3.1.2). A summary of the conversion factors for each species and discussion of the appropriateness of applying SLD results to MAFV and PICR waste rock should be provided so that MEM can assess this approach [EA Information Requirement].

48. For permitting, all source terms will need to be refined and updated as more recent static and kinetic testing results become available. [*Mines Act* Permit Requirement].

B. Model Assumptions

A number of key assumptions were incorporated into the WQM and the models on which it was developed from. These assumptions included:

- No chemical loads are associated with precipitation or evaporation;
- Mixing for each component was instantaneous and complete;
- Baseline WQ data that were below method detection levels were applied at concentrations equal to half the detection limit;
- Source terms were determined based on the full footprint of the mine facilities over entire life of mine;
- Source terms developed based on infiltration rates and source loadings expected under average precipitation conditions;
- Runoff source terms for historical waste rock were estimated using WQ data obtained from monitoring of the WR-Seep;
- Overburden stockpiled on the EWRSF was assumed to have loading rates equal to the EWRSF source terms;
- Baseline surface water quality data were used to represent background groundwater inputs within the regions of each mine facility on site;
- Baseline groundwater quality data were used to represent background groundwater inputs within the regions of each mine facility;
- Negative loads calculated between nodes were set to zero to prevent attenuation of mine loads in the WQM, and
- Fast, medium and slow groundwater seepage pathways were applied to seepage from each mine facility as informed by the Groundwater Flow Model (Appendix 6.6-D).

<u>*MEM Comments:*</u>

49. MEM believes that the simplifying assumptions included within the Water Quality Model are reasonable and generally conservative. At permitting and during mine operations, the assumptions incorporated into the Water Quality Model should be re-evaluated and updated as more information becomes available through ongoing testing and operational monitoring [*Mines Act* Permit Requirement].

C. Predicted Water Quality

Water quality predictions were computed on a monthly basis, as dictated by the Water Balance Model, by tracking all contact and non-contact sources reporting to Jacko Lake, and modeling stations PCDP, PC02.3, PC02 and Humphrey Creek. The water quality predictions were examined for these receptors at four different times, Operations (year 13), decommissioning and closure (year 25) and post-closure (year 43 and year 95).

A base case water quality model was initially assessed, which incorporates average conditions. Additionally, a series of 14 sensitivity scenarios, including the base case, were completed in order to assess the relative influence of climate, WRSF recharge, hydraulic conductivity, TSF seepage, dustfall, baseline water quality inputs and timing of seepage arrival and receptors on the site water quality. In total, 14 WQM scenarios were conducted, including:

- Base Case – average hydrologic, hydrogeologic, geochemical and air quality inputs;
- Variable Climate Case – stepping WQM through historic climate record on 5 year increments using the 95th, 75th, 50th, mean, 25th and 5th percentile values;
- Higher WRSF Recharge – assume that infiltration into the WRSFs is twice the base case amount;
- Higher Hydraulic Conductivity – increase and decrease the average hydraulic conductivity by five times;
- Higher TSF Conductance – increase the seepage rate from the TSF by ten times;
- Higher WRSF Seepage to Groundwater – assume that 40% of WRSF seepage bypasses collection ponds and reports to groundwater instead of 20%;
- Edith Lake Thrust Fault Zone –
- Insoluble Dustfall – assume that dustfall is not available for all constituents;
- Lower Dustfall Availability – decrease the area surrounding water bodies that dustfall is assumed to enter the system, and
- Variable Baseline Inputs – 95th Percentile, Median and 5th Percentile baseline inputs.

Results from the WQM sensitivity scenarios indicated that a majority of the SO_4, Cu and Se loads observed are from background/baseline sources. The WRSFs and TSF are responsible for an increase in the relative loading of SO_4, Fe, Cu, Mo and Se to the receiving environment. Dustfall is the main contributing source of Cu and Cr during operations, while seepage from the WRSF and TSF account for the majority of additional SO_4, Fe, Mo and Se observed in the model scenarios.

MEM Comments:

50. Historic waste rock was not included in the Water Quality Model. This site feature should be included in the water quality model in order to provide an understanding of its potential contribution to the overall site water quality [EA Information Requirement].

51. Please clarify the purpose of the Edith Lake Thrust Fault Zone water quality modelling sensitivity scenario [EA Information Requirement].

52. Seepage from the WRSFs and TSF during post-closure is potentially a measurable source of As, Mo and Se to the receiving environment. Please provide additional information that assesses the sensitivity of the Water Quality Model to variations in the source terms for these species? [EA Information Requirement].

53. Unprocessed ore that is not milled at the end of mine life is a liability that could adversely affect water quality in post-closure phase. What are the contingency plans in the event that low grade ore is not milled? How has this been incorporated into the Water Quality Model? [EA Information Requirement].

54. MEM notes that predicted concentrations for many parameters in the Pit Lake will continue to increase with time during the Post Closure period to levels that exceed water quality guidelines. While it is recognized there is not expected to be surface discharges at any time in the future,

would controls measures be required to restrict access to the Pit Lake by humans and wildlife? [Comment]

VI. Water Resource Monitoring Plans

Mitigation measures incorporated into the Ajax mine plan for the protection of water resources are discussed in Sections 11.23 (Surface Water Quality), 11.24 (Groundwater Quality). The potential effects of the Ajax project on water resources is mainly related to neutral ML and ML/ARD of waste rock and tailings materials stored in on-site facilities. Waste management plans for these facilities have already been addressed by MEM in Section III and IV. The following provides a summary of MEMs understanding of water resource monitoring plans proposed in the application.

Separate surface water and groundwater monitoring plans will be developed that provides feedback into the on-going efforts to mitigate surface water quality effects, identify and address were additional mitigation methods are required and measure and monitor water quality on site and in the receiving environment. Parameters that will be monitored include:

- In-situ parameters (temperature, DO, conductivity, redox potential and turbidity);
- Physical parameters (hardness, pH, TDS, TSS, TOC)
- Anions (alkalinity, Br, Cl, F, SO_4)
- Nutrients (NH_4-N, NO_3, NO_2, ortho- and total/dissolved PO_4)
- Total/Dissolved Metals (surface water), Dissolved Metals (groundwater)

All water quality monitoring data will be managed in an Environmental Management System (EMS) and reported on a regular basis.

Surface Water Sampling

The current baseline water sampling program will continue to be conducted monthly at all the existing sampling locations. New locations that will be added during the Construction phase of the project include:

- TSF Pond water (Reclaim Line)
- North Embankment Pond 1
- North Embankment Pond 2
- SWRSF Pond
- EWRSF Pond
- Central Pond

All of these locations will be monitored throughout the Construction, Operation, Decommissioning and Closure and Post Closure phases of the Ajax project. The exceptions to this schedule include PC02.5, PC03 and PC08, which will only be sampled during Post Closure. Additionally, the TSF Pond water will be sampled during Construction and Operations only. A series of Action Triggers will be developed to respond to observed increases in species and/or exceedances of water quality guidelines.

Groundwater Sampling

The monitoring program will include locations within the Peterson Creek watershed and will incorporate as many of the existing baseline monitoring locations as possible. Samples will be collected seasonally for water quality and groundwater levels, with four sampling events per year during the Construction, Operations, Decommissioning and Closure and Post Closure phases. A series of existing monitoring locations are proposed for the program including (Table 11.24.1):

- Background (five locations)
- Open Pit (nine locations)
- TSF (15 locations)
- SWRSF (11 locations)
- EWRSF (6 locations)

These locations could change depending on the final placement of mine facilities. Similar to surface water monitoring program, Action Triggers will be developed to respond to increases in species concentrations over multiple monitoring periods.

MEM Comments:

55. Given the large amount of water quality data that will be generated from operational surface and groundwater monitoring, MEM recommends that all Ajax monitoring data be included in one annual report that is made available to the appropriate permitting agencies [Comment].

56. The Open Pit Lake water should be included as a surface monitoring location for the Decommissioning and Closure and Post Closure Phases [Mines Act Permit Requirement].

57. MEM recommends that the following sites be included in the groundwater monitoring plan: historical WRSF; Ore Stockpile facility; down-gradient of the seepage collection ponds and down-gradient of the four TSF Embankments [Mines Act Permit Requirement]

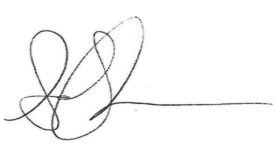
Conclusions

Overall, the Ajax application is well organized and provides a detailed level of geochemical testing and characterization. The overall water quality modeling approach appears reasonable. However, additional clarification is required to assist MEM's review of the water quality model and the evaluation of the project effects. The most significant additional information requirements include:

- Information to support the use of silicate-NP for classifying MAFV and PICR waste rock;
- Updating the datasets and interpretations of the on-going testwork for waste rock and tailings to validate the source terms used in water quality modelling;
- Strengthening and further development of waste rock and tailings source terms,
- Rationale for the application of modified-NP values to the NPR calculations for waste rock types beyond MAFV and PICR and a potential revision to the volumes of NPAG and PAG waste rock outlined in the ML/ARD Management and Monitoring Plan; and
- Contingency plans in the event that low/medium grade ore are not milled at the end of mine life.

Once MEM has reviewed the proponent's response to this memo, we will provide further comment on the water quality modeling and the overall evaluation of the project effects. Thank-you for the opportunity to review the Ajax EAC Application. If there are any questions regarding these review comments, please contact me at 250-952-0736.

Sincerely,



Sean Shaw, Ph.D., P. Geo.
Senior Environmental Geoscientist

cc. Diane Howe, MEM
Kim Bellefontaine, MEM
Jennifer McConnachie, MEM
Brent Beattie, MEM

Date: March 3, 2016

To: Krysia Zurakowski, EAO

cc: Diane Howe, Deputy Chief Inspector, MEM Victoria
Kim Bellefontaine, Manager, Environmental Geoscience and Permitting, MEM Victoria
Lowell Constable, A/Manager, Geotechnical Engineering

Re: Ajax Project EA Application - MEM Geotechnical Review Comments

Krysia,

The Ministry of Energy and Mines (MEM) has conducted a geotechnical review of the "*Ajax Project: Environmental Assessment Certificate Application / Environmental Impact Statement for a Comprehensive Study", a*ssembled for KGHM Ajax Mining Inc. (proponent) by ERM Consultants Canada Ltd., dated December 2015.

Specifically, I have reviewed:

- Chapters 1, and 3 of the application,
- Appendix 3-C Ajax Project Open Pit Geotechnical Slope Design Parameters, dated June 2014, by SRK Consulting (Australasia) Pty Ltd. **[Feasibility Level]**
- Appendix 3-D Tailings Storage Facility Design Report, dated August 26, 2015, by Norwest Corporation.
- Appendix 3-F Jacko Lake and Peterson Creek Downstream Pond Engineering – Preliminary Design, dated August 28, 2015, by Norwest Corporation. **[Preliminary Design]**
- Appendix 3-I Geotechnical Report – Mine Site Infrastructure, dated June 16, 2015, by Knight Piésold Ltd.
    i. Appendix F Mine Rock Storage Facility Geotechnical Stability Assessment
- Appendix 6.2-C Ajax Project Open Pit – Review of Open Pit Design Parameters for Updated Hydrogeological Conditions, dated November, 2014, by SRK Consulting (Australasia) Pty Ltd.

This review is more comprehensive than an "EA" level review. It is hoped that these comments will assist the proponent in understanding MEM geotechnical requirements as the project moves forward. Most of the issues that have been raised can be dealt with during the formal MA review process; however, there are some significant information requirements that will need to be addressed before a permit can be issued (discussed further below). Once you have had a chance to review these comments please share them with the proponent as you see fit.

The application has some deficiencies with respect to the level of geotechnical detail provided for the Ajax Open Pit, the Waste Rock Dumps, and the Tailings Storage Facility. No information was provided for the Ajax Open Pit Backfill design. It is understood the Jocko Lake site investigation will be completed at a later date and

MEM is looking for a commitment by the proponent that the key items to be addressed as outline in Section 7 of Appendix 3-F will be addressed so they can be reviewed as part of the Mines Act permitting process.

At the MA permitting stage, detailed designs are required for major infrastructure including TSF embankments, pit walls and waste rock spoils to show how they will be constructed. It is common for these designs to change over time as information is gathered during mining. Nonetheless, designs need to be detailed enough to provide confidence in the mine plan, and the mine plan needs to be flexible enough to accommodate changes that might become necessary as development proceeds.

I am sensitive to the fact that geotechnical and design work is ongoing; however, these reports need to be submitted early enough in the process to allow a meaningful review to be conducted before the granting of a Mine Act permit.

Portions of the application that were the subject of geotechnical review are referenced within this document. The following sections provide a description of the planned works, and relevant geotechnical review comments. Detailed descriptions are provided to facilitate future reviews and follow-up, and are provided in both paragraph and bullet form. These descriptions are for information purposes only and are followed by numbered comments.

Only the numbered comments require follow-up by the proponent. Some of the numbered comments include potential permit conditions. Note that reference to the “Code” means the “Health, Safety and Reclamation Code for Mines in British Columbia.”

Ajax Open Pit

The Ajax Open Pit will amalgamate the historic Ajax East and West open pits that were developed by Afton Mines from 1989 to 1997. The final Ajax Open Pit will be approximately 2.5 km long in the east-west direction and about 1.4 km wide in the north-south direction with wall heights of up to 425m. Pit walls are proposed with double benching (2x15m), with berm widths of between 17 m and 20 m, depending on the design sector. Pit walls are designed with bench face angles of between 65° and 75° and inter-ramp angles of between 44° and 50° for all design sectors. Geotechnical wall design criteria were developed by SRK Consulting (Australasia) Pty Ltd. Reference is made to the Guidelines for Open Pit Slope Design (Read & Stacy 2009). Other important aspects of design are:

- The Ajax Open Pit will be active from year -2 to year 23.
- The highest crest of the open pit is at approximately 987 masl while the deepest pit bottom is designed at 410 masl (Section 3.5.3).
- The geotechnical design is based on a review of an extensive collection of existing drilling records and 16 core holes drilled between 2006 and 2011 for a preliminary geotechnical assessment, as well as, about 3600 m of geotechnical drilling in 9 core holes from 2013. Fault and joint measurements were obtained from field mapping and photogrammetry within the existing pits, as well as, from discontinuities using ATV down hole orientation and structural core logging (SRK 2014, Appendix 3-C). The logging data was used to calculate the Rock Mass Rating (RMR) and Mining Rock Mass Rating (MRMR).
- Laboratory testing included confined and unconfined compression strength, point load testing, Brazilian tensile strength and direct shear strength testing.
- SRK identified 8 geotechnical domains based on lithology and major structure along with 19 slope design sectors. Slope angles and bench widths are provided for each design sectors in Table 8-1, Appendix 3-C.
- The latest wall design incorporates 20 m to 40 m wide geotechnical berms every 5 double benches and a maximum inter-ramp slope height of 150 m

- Design factors of safety of 1.1 (kinematic) and 1.3 (rock mass) were utilized. Overall factors of safety, taken as Strength Reduction Factors (SRF) at failure of 1.39 (Northern wall-Final Pit), 1.42 (Southern wall-Final Pit), 1.33 (Southeast wall-Final Pit), 1.75 (Eastern wall-Final Pit), 1.6 (Western wall-Final Pit), 1.43 (Stage 1 Pit), and >1.80 (Stage 2 Pit) were calculated.
- Stability analyses have been conducted using dewatered pit slopes, with secondary analyses completed using saturated pit slopes to illustrate the effect of recommended drainage behind the pit walls. In all design sectors, dewatering is required to achieve the required factors of safety (Section 7.4.4 of Appendix 3-C).
- Proposed pit slope depressurization includes 150 m long horizontal drainholes at 100 m lateral spacing for design sectors to achieve 125 m of groundwater pushback (Section 7.1 of Appendix 3-C).
- Impact of Jocko Lake hydrogeological conditions on the pit slope design has been analysed and confirms the importance of depressurization of the pit slopes.
- Slopes in overburden are designed with single 15 m high benches having a bench face angle of 45^{o}.

Geotechnical information relevant to the Ajax Open Pit slope design was found in Appendices A to I of Appendix 3-C, as well as, Appendix 6.2-C which documents the revised analysis of design sectors 1, 2 and 6 for a new pit design based on updated hydrogeological conditions. The analysis indicates the overall slope angle (OSA) can be increased provided depressurization of the pit slopes is achieved. The appendix documents a thorough analysis of kinematic and rock mass failure mechanisms through 2D and 3D finite element analysis. Further work is planned to finalize the design in specific areas, but it appears that the mine plan can accommodate the acquisition of this data during operations. Confirmation and clarification is requested in some instances (see numbered comments below). Geotechnical review comments as follows:

1. It is expected that the pit design will be reviewed, and if necessary refined, based upon an updated geological model and additional data collected prior to submission of the *Mines Act* permit application.**[Comment]**

2. In Section 7.1, Appendix 3-C, SRK indicates that, *"150 m long horizontal drainholes at 100m lateral spacing have been considered as a preliminary option to provide pit wall depressurisation."* and that the *"design can be changed based on the results of the current hydrogeological study".* In Section 8.4 of Appendix 3-C, SRK recommends that "*If the drainage measures will not be able to achieve a groundwater pushback of at least 125 m behind the slope face (as assumed in this report), the pit wall angles will need to be re-assessed taking into account the expected groundwater conditions*." A commitment to follow-up on this recommendation and to use this new information to check the Open Pit Slope Design stability analyses is required. **[MA Permitting Requirement]**

3. Dewatering measures are to be implemented in accordance with the design engineer's recommendations, and shall be modified only in accordance with the recommendations of a qualified professional geotechnical engineer, and only as needed to achieve the stability objectives outlined in the application. **[MA Permitting Requirement]**

4. Action point 3 on Page iv of Appendix 3-C states that "*There currently is not a good understanding of the detailed properties of the soil and/or highly weathered materials near surface. It may be advantageous that these materials are evaluated in more detail in the future to ensure that optimum slope design within them is identified*." This is fully endorsed by MEM and should include the Old Afton Waste Dump areas currently shown to be impacted by the Ajax Open Pit crest on Figure A1.3, Appendix 3-I. This information would be contained the Ajax Open Pit detailed design report. [**MA Permitting Requirement**]

5. In Section 8.3 of Appendix 3-C, SRK indicates that, "*The design recommendations provided in Table 8-1 should be coded into the block model for creation of the final mine design pit shells, using the pit sector wirefame solids provided by SRK and the existing latest geology model solids of KGHM.."* Optimizing the design during initial operations is not an uncommon approach, provided that the mine design is flexible enough to accommodate any required changes. It is understood that the current design has conservatively assumed worst case conditions, pending further investigations. The requirement for on-going wall mapping and other forms of data collection will form a permit condition. **[MA Permitting Requirement]**

6. Given the uncertainties that remain with respect to some aspects of the wall designs (including interim walls), and given that some final wall designs are dependent on future drilling, an annual pit slope review will be a permit condition. The annual review must be conducted by a qualified geotechnical engineer, and must consider all relevant aspects of pit slope performance, wall design, monitoring, pit wall depressurization, and recommendations with respect to controlled blasting. Any recommended measures relating to wall stability must be followed. **[MA Permitting Requirement]**

TAILINGS STORAGE AND WATER MANAGEMENT FACILITIES AND ORE PROCESSING

Tailing Storage Facility

Details with respect to the Tailing Storage Facility are predominantly found in Appendix 3-D. The TSF is designed to store 275 Mm^3 of tailings produced over a 23 year mine life. The TSF will be approximately 3.7 km long with a 541ha footprint and will be confined in a natural drainage basin bounded by topography and four embankments. The embankments will be constructed using a "downstream" method to an ultimate elevation of 1056m with an upstream till blanket over compacted mine rock slopes of 2.5:1 and downstream mine rock buttress slopes of 3:1. Other important aspects of the TSF include:

- Geotechnical design is based on information collected from 29 geotechnical drill holes in 2014, as well as, 182 test pits. Field testing consisted of SPT in soil and lugeon and falling head permeability tests in rock. Laboratory soil testing consisted of moisture contents, particle size distribution, Atterberg Limits and Proctor testing, as well as, unconfined compression testing, specific gravity, and young's modulus for rock testing.(Section 5.3 and 5.4)
- The ultimate North Embankment is approximately 3650 m long by 122 m high with a 1400 m long rockfill starter embankment constructed to elevation 971m. The ultimate crest width will be 39m.
- The ultimate East Embankment is approximately 1450 m long by 108 m high.
- The ultimate South Embankment is approximately 1550 m long by 42 m high.
- The ultimate Southeast Embankment is approximately 550 m long by 14 m high.
- North and East dams have been classified as "Very High" consequence while the South and Southeast TSF dams have been classified as "Significant" consequence category based on CDA "Dam Safety Guidelines" (2014); however the TSF dams have been designed for the most extreme events under the "Extreme" consequence category which is the highest design standard defined by the CDA Dam Safety Guidelines.
- The Inflow Design Flood (IDF) is the Probable Maximum Flood (PMF) which is estimated from the Probable Maximum Precipitation (PMP) event.
- The TSF will operate without an emergency spillway, therefore the recommended IDF is runoff from a 72 hour PMP+100year return period snowpack-average annual snowpack.
- Maximum Design Earthquake (MDE) uses Maximum Credible Earthquake (MCE) = 1 in 10,000 year, which corresponds to an PGA = 0.34g

- Integral to the embankment design will be the use of a mine rock buttress and/or mine rock storage facilities immediately downstream of the TSF, which are incorporated in the embankment designs to buttress these structures. The WMRSF will buttress the north embankment while the SMRF will buttress the east embankment.
- Seepage Control Measures include; upstream seepage control zone of the dam, Compacted till blanket, Rock drain to convey any seepage downstream to collection ponds.
- Thickened tailings will be deposited from spigots along the perimeter producing beaches with 1 to 2% overall slopes. The 60% solids content is expected to consolidate to 77% solids content.
- The key elements of the TSF water management plan are: seepage collection ponds and diversion ditches. There will be four seepage collection ponds: North Embankment Seepage Collection Pond #1 and #2, South and Southeast Embankment Seepage Collection Pond, and the Central Collection Pond. Contact Water Collection Ditches collect and carry contact water to the ponds, while the Non-contact Water Diversion ditches will direct water around the TSF towards the west. Diversions are designed to route the 200-year 24-hour peak flow.
- A site-specific seismic hazard assessment will be completed during the detailed design.
- A dry cover closure option was identified as a best alternative for the site. Upon final closure, surfaces of the tailings dams will be covered with a layer of earth fill to minimize ingress of surface water and to pass runoff into an engineered channel towards the south of the TSF and into Humphrey Creek.
- "Summary of Failure Modes and Effects Analyses (FMEA) Workshop "Memorandum for March 12, 2015 Workshop is included in Appendix 17.6-A. A Tailings Dam Failure Mode Assessment and Dam Breach Inundation Evaluation has been completed by Norwest Corporation on August 24, 2015 and is included in Appendix 17.6-B.
- The Best Available Technology (BAT) and Best Available Practices (BAP) for tailings technology, siting and water management and TSF closure strategy for the Ajax Project were completed. Results from these studies are provided in separate documents (Norwest, 2015 and KPL 2014) but are highlighted in Section 4.5 and 9.1 of this report.

Geotechnical review comments as follows:

7. I could not locate any information with respect to a Geotechnical Report: Knight Piésold Ltd. 2015. *Ajax Project – Geotechnical Report – Tailings Storage Facility and Mine Rock Storage Facilities*. C002-KA39-RPT-10-007 (VA101-246/26-11), Rev.0. Prepared for KGHM Ajax Mining Inc., March 23, 2015. Please send a copy of the report or **[Information Requirement]**

8. Site investigations at the TSF were conducted by Knight Piésold Ltd in 2014. To date the program has included reconnaissance and field geologic mapping, 29 geotechnical boreholes advanced into bedrock, 182 test pits, SPT, and various soil permeability and hydraulic conductivity testing. The proponent is asked to provide an assessment of remaining gaps in the subsurface investigation, including a description and schedule for any additional investigation or proposed testing, as well as any significant assumptions made in design. **[EA Information Requirement]**

9. The proponent is asked to clarify whether consolidation testing has been carried out, or is proposed to be carried out, for dam locations where fine-grained materials have been identified. In addition, the proponent is asked to indicate how consolidation has been accounted for in the current design? **[EA Clarification and Information Requirement]**

10. A system of rock drains will be installed at the base of the embankments to keep the water level depressed within the dam. The rock drains will facilitate drainage at the base of the embankments/buttresses along existing topographic lows and pre-mining surface drainage courses. The lowest point in the natural watercourse will be used as the center line of each of the drain

alignments. These drains will be constructed with processed non-reactive fluvial, colluvial or selected mine rock. In order to prevent the intrusion of fine soils (silt and clay) into the rock drain, fabric geotextiles, geosynthetics (HDPE) and a granular filter zone will be employed as necessary components of the design. The total flow capacity of the drainage system will be at least 10 times the expected normal seepage from the dam and underlying foundation soils. Has partial or full blockage of the drains been considered as well as associated mitigative measures that may be required if pore pressures increase? Were stability analyses based on long term performance of these drains? It is noted that artesian pressures are anticipated in the valley bottom**. [EA Clarification]**

11. The proponent will be required to provide anticipated key trench / cut-off wall depths and construction details for all dams. **[MA Permitting Requirement]**

12. The proponent will be required to provide comment on all mine site road designs as they relate to anticipated material conditions and stability analyses. **[MA Permitting Requirement]**

13. Table 8.1 of Appendix 3-D of the Application provides a summary of geotechnical instrumentation planned for the TSF. A typical instrumentation cross section proposed at the TSF is shown on Drawing C180-KA39-5000-70-001 and indicates vibrating wire piezometers, slope indicators and standpipe piezometers will be installed in the tailing dams. An assessment will be required during detailed design to consider if the proposed level of instrumentation is sufficient for the number and scale of dams and includes any redundancy for damage or instrument failure. **[MA Permitting Requirement**

14. In Section 5.3, Appendix 3-D Norwest states that "*Most of the high plastic clays identified to date are located at shallow depth (<5m) and it is planned to remove these materials as part of foundation preparation".* This recommendation will form a permit condition. **[MA Permitting Requirement]**

Seepage Recovery Dams

- Sediment pond design is consistent with the "Guidelines for Assessing the Design, Size and Operation of Sedimentation Ponds Used in Mining (Draft – MELP 2015).
- The seepage recovery dams will be constructed of earth fill/rockfill materials and will include low permeability HDPE basin liners, as required by site conditions. The ponds will be designed with emergency spillways to discharge to the environment if required.
- North Embankment Seepage Collection Pond #1: This seepage collection pond is located downstream of the north embankment along the natural valley drainage to the northwest of the downstream toe. The containment berm will be approximately 11m high dyke with a crest length of approximately 280m. The pond is sized for the area required for sediment removal during construction of the starter embankment. The elevation at which the required area can be met gives a storage volume of 119,000m3, which greatly exceeds the 1 in 200 year, 24-hour volume of 50,000m3.
- North Embankment Seepage Collection Pond #2: This seepage collection pond is located downstream of the north embankment along the natural valley drainage to the northeast of the downstream toe. The containment berm will be approximately 21m high dyke with a crest length of approximately 107m. The pond is sized for the area required for sediment removal during construction. The elevation at which the required area can be met gives a storage volume of 129,900m3, which greatly exceeds the 1 in 200 year, 24-hour volume of 10,000m3.
- South and Southeast Embankment Seepage Collection Pond: This seepage collection pond is contained within natural topography between the downstream toe of the South Embankment and the upslope terrain. No containment berm is proposed. A pond will form in the existing topography against the toe of the embankment.

- Central Collection Pond: Seepage from the East Embankment, as well as runoff from part of the WMRSF and SMSRF will be collected in an underdrain system that will discharge into the Central Collection Pond.
- The seepage dams are designed to provide storage of the 200-year 24-hour storm runoff event from the local undiverted catchment. Channels associated with each structure are designed to convey the 200-year event and no channel failures are assumed.

Geotechnical review comments as follows:

15. The proponent is asked to: indicate whether subsurface investigation has been carried out at the seepage recovery dams, provide the results of this investigation, or indicate where this information can be located in the Application (if included). **[EA Information Requirement]**

16. An assessment will be required during detailed design to consider if the proposed level of instrumentation is sufficient for the number and scale of dams and includes any redundancy for damage or instrument failure. **[MA Permitting Requirement]**

17. Pumping records from the seepage recovery ponds back to the tailings pond shall be kept to assess seepage rates from the tailing dams. This is considered to be an important aspect in monitoring seepage performance in the TSF and will form a permit condition. **[MA Permitting Requirement]**

18. The proponent is asked to describe any remaining gaps in the subsurface investigation, additional investigation or laboratory testing that is proposed, as well as any significant assumptions made in design. **[EA Information Requirement].**

The following requirements will apply to all major dams and major impoundments on the mine site:

19. All major impoundments, water management facilities and dams shall be designed in accordance with the criteria provided in the Canadian Dam Association (CDA), Dam Safety Guidelines as per Section 10.1.5 of the Health, Safety and Reclamation Code for Mines in BC (Code). "Major Dam" and "Major Impoundment" are defined on page 10-2 of the Code. Detailed designs will be required to be submitted prior to construction. **[MA Permitting Requirement]**

20. An "As-Built" report prepared by a professional engineer must be submitted to the Chief Inspector certifying that any major impoundments, water management facilities and dams were designed and constructed according to Section 10.1.5 of the Code prior to operation. **[MA Permitting Requirement]**

21. The report indicates that several of the project dams will be monitored by slope inclinometers, piezometers, survey monuments, monitoring wells etc. A conceptual monitoring plan for all dams will be required at the Mines Act Permitting stage. The plan should include the number, type and location of instrumentation, as well as a schedule for installation. **[MA Permitting Requirement].**

22. An Operation, Maintenance and Surveillance Manual is required as per Section 10.5.2 of the Code prior to operation of a major dam or major impoundment including any associated water diversion structures. The OMS should include instrumentation inspection schedule, monitoring procedures, and associated response trigger levels. **[MA Permitting Requirement]**

23. The mine manager shall submit an annual Dam Safety Inspection report to the Chief Inspector for all dams associated with major impoundments on the mine site as per Section 10.5.3 of the Code. Dam Safety Inspections will be due by March 31 of the year following the inspection. **[MA Permitting Requirement]**

24. Dam Safety Reviews must be carried out for all dams associated with major impoundments according to Section 5 of the Canadian Dam Association, Dam Safety Guidelines. **[MA Permitting Requirement]**

25. Any major impoundment classified as high, very high or extreme failure consequence will require an Emergency Preparedness and Response Plan during operation and closure as per Section 10.6.8 of the Code. **[MA Permitting Requirement]**

26. Any dams or impoundments not classified as "major dams" or "major impoundments" under the Health, Safety and Reclamation Code for Mines in BC will need to meet the design requirements of the "BC Dam Safety Regulations" including the requirements for OMS Manuals, Emergency Preparedness Plans, and Dam Safety Reviews outlined in the Regulations. "As-Built" reports and annual Dam Safety Inspections will also be required under the Code for these structures. **[MA Permitting Requirement]**

<u>MINE ROCK STORAGE FACILITY (MRSF)</u>

Four mine rock storage facilities are planned within the Project footprint: the South Mine Rock Storage Facility (SMRSF), East Mine Rock Storage Facility (EMRSF), West Mine Rock Storage Facility (WMRSF), and In-Pit Mine Rock Storage Facility (IPMRSF).

<u>In-Pit Mine Rock Storage Facility (IPMRSF)</u>

It is understood mine rock in the western area of the open pit will be placed in the In-Pit Mine Rock Storage Facility from year 13 to 18. Bottom up construction is planned for the lower portion of the IPMRSF and top down construction to finish the upper part. Few design details could be located in the application, though it is assumed this rock storage facility will have angle of repose slopes and will rest on relatively flat foundations.

<u>South Mine Rock Storage Facility (SMRSF)</u>

The SMRSF will have a maximum height of about 270m (Section 3.9.1) with the upper platform developed to the 1235m elevation. It will be developed at an overall slope angle of 2.4H:1V (with terraces) and resloped to 2H:1V at closure. PAG material will be placed in SMRSF and mixed with NPAG such that the resultant NPR is non-acid generating, to further reduce potential for ML/ARD. The SMRSF is located downstream of the East Embankment of the TSF, and will help to buttress that structure. Geotechnical stability analyses for the SMRSF were completed by Knight Piesold Limited (KPL) (Appendix 3-I, Appendix F). Other important aspects of design are:

- Bottom-up construction is planned utilizing 20m high lifts.
- A Dump Stability Rating of 900 or Moderate has been calculated for the SWRMF in accordance with the Interim Guidelines of the BC Mine Waste Rock Pile Research Committee (BCMWRPRC).
- The upstream portion of the SMRSF will ultimately be more than 50m higher than the East Embankment of the TSF (planned at 1056m elevation).
- Design factors of safety are in accordance with the Interim Guidelines of the BCMWRPRC. Provided that organics are stripped from the foundation as proposed, it is considered that adequate stability of both the upstream and downstream portions of the SMRSF has been demonstrated.
- The design earthquake adopted for the SMRSF is the 1:10,000 year earthquake. This is considered to be conservative. The designer indicates that potential deformations, predicted to be less than 0.10m, may occur during the design earthquake, and potential crest settlements under seismic loading were estimated to be less than 0.40m.
- The groundwater level utilized in the analyses was limited to a maximum of 5m below ground although the water table was generally encountered at the till-bedrock interface during site investigations. This is considered to be conservative.

West Mine Rock Storage Facility (WMRSF)

The WMRSF will have a maximum height of about 140m (Section 3.9.1) with the upper platform developed to the 1095m elevation. It will be developed at an overall slope angle of 2.4H:1V (with terraces) and resloped to 2H:1V at closure. PAG material will be placed in WMRSF and mixed with NPAG such that the resultant NPR is non-acid generating, to further reduce potential for ML/ARD. The WMRSF is located downstream of the North Embankment of the TSF, and will help to buttress that structure. Geotechnical stability analyses for the WMRSF were completed by Knight Piesold Limited (KPL) (Appendix 3-I, Appendix F). Other important aspects of design are:

- Bottom-up construction is planned utilizing 20m high lifts.
- A Dump Stability Rating of 800 or Moderate has been calculated for the WMRSF in accordance with the Interim Guidelines of the BC Mine Waste Rock Pile Research Committee (BCMWRPRC).
- The upstream portion of the WMRSF will ultimately be about 40m higher than the North Embankment of the TSF (planned at 1056m elevation).
- Design factors of safety are in accordance with the Interim Guidelines of the BCMWRPRC. Provided that organics are stripped from the foundation as proposed, it is considered that adequate stability of both the upstream and downstream portions of the WMRSF has been demonstrated.
- The design earthquake adopted for the WMRSF is the 1:10,000 year earthquake. This is considered to be conservative. The designer indicates that potential deformations, predicted to be less than 0.10m, may occur during the design earthquake, and potential crest settlements under seismic loading were estimated to be less than 0.40m.
- The groundwater level utilized in the analyses was assumed to be at ground surface. This is considered to be conservative.

East Mine Rock Storage Facility (EMRSF)

The EMRSF will have a maximum height of about 85m (Section 3.9.1) with the upper platform developed to the 980m elevation. It will be developed at an overall slope angle of 2.4H:1V (with terraces) and resloped to 2H:1V at closure. NAG material will be placed in EMRSF until after year 5 when the EMRSF capacity will be reached and then topsoil and overburden stockpiles will be placed on top. The EMRSF is located east of the Ajax Open Pit and north of the truck shop. Geotechnical stability analyses for the EMRSF were completed by Knight Piesold Limited (KPL) (Appendix 3-I, Appendix F). Other important aspects of design are:

- Bottom-up construction is planned utilizing 20m high lifts.
- A Dump Stability Rating of 550 or Low has been calculated for the EMRSF in accordance with the Interim Guidelines of the BC Mine Waste Rock Pile Research Committee (BCMWRPRC).
- The topsoil and overburden stockpiles covering the EMRSF are permanent and will be reclaimed.
- Design factors of safety are in accordance with the Interim Guidelines of the BCMWRPRC. Provided that organics are stripped from the foundation as proposed, it is considered that adequate stability of both the upstream and downstream portions of the WMRSF has been demonstrated.
- The design earthquake adopted for the WMRSF is the 1:10,000 year earthquake. This is considered to be conservative. The designer indicates that potential deformations, predicted to be less than 0.10m, may occur during the design earthquake, and potential crest settlements under seismic loading were estimated to be less than 0.40m.
- The groundwater level utilized in the analyses was limited to a maximum of 5m below ground although the water table was generally encountered at the till-bedrock interface during site investigations. This is considered to be conservative.

Information relevant to the MRSF design was found in Section 3 of the Application and Appendix 3-I, Appendix F. Geotechnical review comments as follows:

27. Are any special measures required to ensure that adequate drainage is maintained below the MRSF? **[Clarification and Information Requirement]**

28. In Section 3.2 of Appendix F, Appendix 3-I, instrumentation for the MRSF is discussed in general terms. A MRSF Monitoring Plan will need to be developed prior to active dumping. The plan is to include preliminary locations, installation schedules, monitoring frequency, and initial threshold response criteria for all proposed piezometers, surface monuments, and any other proposed instrumentation (i.e. criteria for establishing extensometers and threshold response values). This requirement will form a permit condition. The MRSF Monitoring Plan is to be updated periodically as required. **[MA Permitting Requirement]**

29. It is noted the SMRSF stability results for a slip surface towards the plant site has very robust factors of safety for all conditions analyzed. **[Comment]**

30. Section 6.1.10(7) of the Code prohibits extended activity below active dumps and requires a program of monitoring to allow work below inactive dumps. This Section of the Code is intended to protect the health and safety of mine personnel. This could have an influence on the timing/phasing of in-pit dumping and on the required IPWRMF monitoring plan. The proponent is asked to provide information with respect to the phasing of in-pit dumping that demonstrates compliance with this section of the Code. **[Information Requirement]**

<u>Low Grade/Medium Grade (Ore) Stockpiles</u>

Two ore stockpiles are proposed as discussed in Section 3.9.2 of the Application – a Low Grade Stockpile (LGS) and a Medium Grade Stockpile (MGS) for a combined 45 Mt ore storage. Some important aspects of design are:

- The stockpiles will be constructed in lifts based on the BC Mine Waste Rock Pile Research Committee Interim Guidelines.
- The stockpiles will be constructed on a platform to provide a flat working area for mining equipment.
- Stockpiles will be designed following the same principles/ level of design required for the MRSFs.

Geotechnical review comment as follows:

What is the proposed height of each the stockpiles? What is the maximum and typical foundation angle below these structures? **[Information Requirement]**

31. Drawing C180-KA39-5000-00-011 of the Application indicates that the LGS will be constructed on Anthropogenic Mine Rock which is denoted as Old Afton Waste Rock Dump material and designated as Borrow Source F. Will this area be used as a borrow source and has this been accounted for in the phasing of the LGS development? **[Clarification]**

32. An LGS and MGS Monitoring Plan will need to be developed prior to development of the stockpiles. The plan is to include preliminary locations, installation schedules, monitoring frequency, and initial threshold response criteria for all proposed instrumentation. This requirement will form a permit condition. The LGS/MGS Monitoring Plan is to be updated periodically as required. It may be appropriate to combine the LGS and WRMF Monitoring Plans (at the proponent's discretion). **[MA Permitting Requirement]**

<u>Overburden and Topsoil Stockpiles</u>

Prior to finalizing locations for overburden and topsoil stockpiles, a preliminary analysis was completed for overburden and topsoil stockpiles using typical foundation conditions and assuming typical material parameters. A 25m high overburden stockpile with slopes of 3H:1V and a 10m high topsoil stockpile with 4H:1V overall slopes were analyzed (Appendix 3-I, Appendix F). Geotechnical review comments as follows:

- Bottom-up construction is planned.

- A Dump Stability Rating of 600 or Moderate has been calculated for both the overburden and topsoil stock piles analyzed in accordance with the Interim Guidelines of the BC Mine Waste Rock Pile Research Committee (BCMWRPRC).
- Design factors of safety are in accordance with the Interim Guidelines of the BCMWRPRC. Provided that organics are stripped from the foundation as proposed, it is considered that adequate stability of both the upstream and downstream portions of both overburden and topsoil stock piles have been demonstrated.
- The pseudo-static analysis for seismic conditions (1 in 475 year earthquake event) also exceeded the minimum required factor of safety.
- The groundwater level utilized in the analyses was located midway between ground surface and the top of the stockpile. This is considered to be conservative.
- The stability analysis indicated that a toe berm is required to improve the stability.

Currently, the East Overburden 1 and East Overburden 2 (topsoil) stockpiles are proposed to be built on the EMRSF as discussed in Section 3.10 of the Application. Two other stockpiles, North Overburden 1 and North Overburden 2 are indicated on Drawing C180-KA39-5000-00-011. Few design details could be located in the Application, though it is assumed that these stockpiles will have less than angle of repose slopes, and will rest on relatively flat foundations.

Geotechnical review comment as follows:

33. The proponent is asked to provide information with respect to maximum foundation angle below the soil stockpiles, maximum stockpile heights and typical slope face angles (or indicate where this information can be located within the Application). **[Information Requirement]**
34. In Section 5.3, Appendix F, Appendix 3-I it is "*recommended to confirm the foundation conditions for the overburden and topsoil stockpiles, once their locations have been established*". Has this been done and was the stability of the stockpiles analyzed? **[Information Requirement]**

While every attempt has been made to glean relevant geotechnical information for major infrastructure, this review is general in nature and is not intended to consider all aspects of the project or to be a technical review. Rather, this memorandum is a starting point for ongoing regulatory geotechnical review that will continue to be refined throughout Mines Act Permitting and the life of mine. Items falling outside of MEM's mandate, and items outside of the reviewer's area of expertise have not been examined.

Thank you for the opportunity to comment on the Ajax Project EA Certificate / Mines Act Permit Application. Please feel free to contact me if you have any questions regarding these comments.

Regards,

Brent Beattie, P.Eng
Sr. Geotechnical Inspector, MEM

Environmental Assessment for the proposed Ajax Mine Project
WORKING GROUP ISSUES TRACKING TABLE
*Please refer to "**Instructions**" tab for directions

	For Working Group Use					
ID #	**Comment Date** (i.e., 5-Feb-16)	**Commenter Name/ Agency** (i.e., John Smith, MEM)	**Section of EA** (i.e., 6.1.2)	**Subject** (i.e., Surface Water Quality)	**Category of EA Comment**	**Comment** (include Memo ID as applicable)
	3-Mar-16	Liz Murphy, MEM	3.17.5.4	Detailed Overview - Reclamation and Closure	Clarification Required	Section 3.17.5.4 Soil Salvage, states that timber will be salvaged and debris will be chipped or burned. The Landscape Design and Restoration Plan mentions the use of large woody debris for natural barriers. Please comment on considerations for retaining coarse woody debris for use in future reclamation.
	3-Mar-16	Liz Murphy, MEM	3.17.6	Detailed Overview - Reclamation and Closure	Clarification Required	Section 3.17.6 Re-vegetaion, states that "Local experience indicates success using a dryland forage mix ("Stump" mix by Purity Feed Co. Ltd.) of crested wheatgrass, annual ryegrass, intermediate wheatgrass, smooth bromegrass, alfalfa and creeping red fescue. Pasture will be established using alfalfa, wheatgrass, fescue and ryegrass." The Wildlife Habitat Objectives for Reclamation Plan indicates that agronomics will be required to create conditions that are suitable for establishing native species. MEM believes that temporary revegetation prescriptions should consider operational requirements to discourage animal browse and prevent animal-human interactions. Species selection should exclude animal attractants in areas of the mine where animals should be deterred. For permanent revegetation, species selection should be intended to achieve site-specific end land use and land capability (e.g., site series) targets. If agronomics will be used, preference should be given to non-persistent species (short-lived). Viability and availability of native species should be expored as part of the reclamation research program. Please comment on any native seed mixes considered for site-wide use.
	3-Mar-16	Liz Murphy, MEM	3.17.10.2	Detailed Overview - Reclamation and Closure	Permitting Information Requirement	The application indicates the total reclamation cost will be $178 million. Full review of reclamation costing for the project will be evaluated in detail at the *Mines Act* application stage. Please note that all cost estimate details, including the assumptions made, must be provided for permitting.
	3-Mar-16	Liz Murphy, MEM	3.17	Detailed Overview - Reclamation and Closure	Clarification Required	Contingencies proposed specifically for reclamation could not be located in the application. This ties into monitoring of reclamation success. Details of reclamation monitoring and subsequent contingency planning would strengthen the position that reclamation will mitigate effects as proposed. Risk and contingency information with regard to reclamation was not found in Section 3.17 Closure and Reclamation, 11.28 Reclamation and Closure Plan, or in the Lanscape Design and Restoration Plan. Please comment on specific contingencies for Valued Components in which successful reclamation is listed as mitigation. This includes commenting on the probablity of reclamation success and specifically how success of reclamation will be measured for Valued Components.

			3.17	Detailed Overview - Reclamation and Closure	Clarification Required	In regard to the targeted end land use of seasonal cattle grazing and valuable wildlife habitat, MEM suggests the proponent considers whether the characteristics of "valuable habitat" are sufficiently outlined in the application in order to understand whether this end land use target has been met in future analysis. MEM only highlights this item because 'valuable' is a subjective term, therefore a clear definition may be important in the future. For example, are there particular habitat types that exist pre-mining that will not be targeted for restoration as part of the reclamation program?
	3-Mar-16	Liz Murphy, MEM	6.1.4.1	Greenhouse gas management	Clarification Required	Section 6.1.4.1 states, "Reclamation of disturbed area is anticipated to mitigate for some temporary loss of carbon sinks." Please clarify the timelines for the reclamation expected to mitigate temporary loss of carbon sinks. Is the assumption of this mitigation that establishing adequate vegetation will support carbon sequestration? That is, how will success of progressive reclamation as a mitigation for the greenhouse gas Valued Component be measured?
	3-Mar-16	Liz Murphy, MEM	6.2.4.3	Geology, Landforms and Soils	Clarification Required	Table 6.2-11. Expected Quantity of Soils Stockpiled, states the average topsoil replacement depth will be .35 metres which leads to a surplus of topsoil for reclamation. Later in the same section (page 6.2-42), it is stated that the topsoil at decommissioning and closure "will be placed at a thickness of 0.6 m; greater than the average baseline topsoil thickness of 0.35 m." Section 3.17.5.2 Materials Balance, states average topsoil replacement depth of .35 metres. The calculation of surplus soil seems to be based on .35 metres application depth. Please clarify the apparent discrepancy (.35 m or .6m).
	3-Mar-16	Liz Murphy, MEM	6.2	Geology, Landforms and Soils	Permitting Information Requirement	The *Mines Act* Permit Application will require soil replacement plans based on land capability requirements rather than on a backcalculation of predicted soil salvage volumes. That is, soil replacement planning must be tied to end land use and capability requirements for permitting purposes.
	3-Mar-16	Liz Murphy, MEM	6.3.7	Surface Water Quality	Permitting Information Requirement	In Section 6.3.7, reclamation of mine components is listed as mitigation for effects on water quality. Specifically, reduction of source metals through successful covers on WRSF and TSF. Please note that detailed cover designs, including design criteria, is required for a *Mines Act* permit application.
	3-Mar-16	Liz Murphy, MEM	6.1	Grasslands	Permitting Information Requirement	Please note that the *Mines Act* requires disturbances to be reclaimed to equivalent land capability as pre-mining conditions. The evaluation of equivalency is based on the mine footprint disturbance, not the RSA. If grasslands, wetlands or other important pre-mining ecosystems will be lost in the mine footprint, appropriate restoration/compensation plans should be developed. MEM notes that a Wetland Compensation Plan has been submitted with this application.
	3-Mar-16	Liz Murphy, MEM	6.10.4.3	Grasslands	Permitting Information Requirement	Please note that the *Mines Act* permit requirements of equivalent land capability pre- and post-closure must be based on the mine footprint, not the LSA or RSA. Ecosystem mapping at the site series level is required for the pre-mining and post-mining, with tabulated inventories for comparison. A reclamation research program to be developed early in mine life and conducted throughout life of mine should include provisions for evaluating strategies for reclaiming challenging habitats and ecosystems.

	3-Mar-16	Liz Murphy, MEM	10.1.5	Air Quality	Provincial EA Information Requirement	10.1.5 Residual Effects and Their Significance, states that " The predicted exceedance area northeast of the Plant Boundary is primarily undeveloped grassland and the primary contributor is the Project. The primary contributor to the predicted exceedance over the city of Kamloops is the Base Case (i.e., existing sources), not the Project. At the City Development Boundary the Project's contribution to the annual average PM2.5 concentration is 23.5% (1.3 μg/m3) and there is no exceedance of applicable regulatory criteria (8 μg/m3). The city of Kamloops is relatively unaffected by the Project. In the built-up urban area the predicted annual average PM2.5 concentration is 6.4 μg/m3 and the Project only contributes 0.15 μg/m3 to this region. This represents a 2.3% increase in annual average PM2.5 concentration attributable to the Project. This is insubstantial give the long-term year to year variability in annual average PM2.5 (± 0.92 μg/m3) concentrations. The primary contributor to the maximum predicted dustfall rate over Downtown Kamloops for the Application Case – Operation scenario is the Base Case (i.e., existing sources). " Further explanation of assumptions made in the modelling used to substantiate these predictions is required within the application. Please explain how the model has been tested. Please also explain contributions from different Project sources and the assumed options to mitigate dust from each source. MEM's understanding is that the model assumption for effectiveness of mitigation strategies is 95 %. A sensitivity analysis exercise conducted to model dust disperison extent and magnitude (and potential effects) for a range of effectiveness performance levels for proposed mitigation strategies is required for EA review.
	3-Mar-16	Liz Murphy, MEM	11.6.3	Air Quality	Clarification Required	Section 11.6.3.1 Design Criteria, lists a number of mitigation measures proposed to mitigate dust emissions. Specific monitoring of these criteria was not found in the monitoring section of this plan (Section 11.6.4). Please clarify how these proposed mitigation measures will be measured and monitored specifically. Further to the list of mitigation proposed, MEM believes mitigation measures should be tied to site specific plans with implementation triggers that are developed to ensure that the mitigation targets are met. No discussion of plans for where or when various mitigation measures will be implemented was found in the application.
	3-Mar-16	Liz Murphy, MEM	11.2	Management plans - Erosion and Sediment Control Plan	Permitting Information Requirement	Section 11.2.3.1 Design Criteria, contains provisions for soil sampling on site and use of Universal Soil Loss Equation for erosion and sediment control planning. For permitting, the results of this analysis, specific prescriptions and the reasoning behind the prescriptions will be required in the Erosion and Sediment Control Plan. Information on trigger, action, response will also be required.
	3-Mar-16	Liz Murphy, MEM	11.2	Management plans - Erosion and Sediment Control Plan	Permitting Information Requirement	Figure 11.2.1 Ajax Project - Erosion and Sedimentation Control Features, is an adequate overview of the site containing contours and major sediment control structures such as sediment ponds. For permitting purposes this map could be modified to include areas at higher risk for erosion and the prescriptions that may be applied for mitigation. More site specific detail would result in an operational plan suitable for permitting.

	3-Mar-16	Liz Murphy, MEM	11.2	Management plans - Erosion and Sediment Control Plan	Comment	Section 11.2.4 Monitoring, states that "Routine inspections, particularly **after** intensive rainfall events, will be undertaken to identify and prescribe site-specific BMP's to minimize soil loss." MEM believes on-site assessments of prescriptions should be conducted **during** rain fall whenever possible. Please note that event-based monitoring is required.
	3-Mar-16	Liz Murphy, MEM	11.2	Management plans - Erosion and Sediment Control Plan	Comment	Consideration of soil characteristics from the Baseline Soil Characterization Study conducted by VAST Resource Solutions (Appendix 3E) would help to inform appropriate prescriptions and further the site specific requirements of this plan for future permitting purposes. Erosion and and Sediment Control Plans submitted with *Mines Act* permit applications should include all calculations and a map of the erosion potential.
	3-Mar-16	Liz Murphy, MEM	11.3	Management plans - Soil Salvalge and Handling Plan	Clarification Required	Section 11.3.3.2 Construction, states that "Soils unsuitable for salvage (e.g., due to elevated concentrations of metals, etc.), if stripped, will not be mixed with suitable, clean soils but will be stockpiled separately and used for reclamation of the areas where the original baseline metal concentrations were naturally elevated." Please comment on how this is expected to effect overall soil volume avaialable for reclamation and how this may effect end land use objectives.
	3-Mar-16	Liz Murphy, MEM	11.3	Management plans - Soil Salvalge and Handling Plan	Permitting Information Requirement	Section 11.3.3.2 Construction, states that "Soils unsuitable for salvage (e.g., due to elevated concentrations of metals, etc.), if stripped, will not be mixed with suitable, clean soils but will be stockpiled separately and used for reclamation of the areas where the original baseline metal concentrations were naturally elevated." Please note that *Mines Act* permit conditions will require development of soil replacement strategies that provide sound reasoning for placement of soils with elevated metals in areas that are already elevated. A soil monitoring program will also be requried to track on-going results of the strategy.
	3-Mar-16	Liz Murphy, MEM	11.3	Management plans - Soil Salvalge and Handling Plan	Comment	Section 11.3.3.2 Construction, states "The term “soil” encompasses organic horizons (litter and humus) and mineral A, B and C horizons. The organic horizons and the mineral A and B horizons are termed “topsoil” whereas the C horizon (subsoil) is considered as part of “overburden”. Topsoil and overburden will be stripped and stored separately." MEM appreciates the committment to storing different quality reclamation materials seperately. This committment may form a permit condition in the future.
		Liz Murphy, MEM	11.3	Management plans - Soil Salvalge and Handling Plan	Permitting Information Requirement	For the *Mines Act* Permit Application, Standard Operating Procedures (SOPs) should be developed to ensure that appropriate controls are effectively implemented to protect soil resources during the salvage and stockpiling activities proposed. Development of of these SOPs may form permit conditions.
	3-Mar-16	Liz Murphy, MEM	11.3	Management plans - Soil Salvalge and Handling Plan	Clarification Required	This plan proposes to store soil salvaged from some roads, building areas and water management features in windrows adjacent to the development. These windrows will then be used in final reclamation. Please comment on how soil windrows will be identified to ensure the resource can be utilitzed in final reclamation, years after construction.
	3-Mar-16	Liz Murphy, MEM	11.3	Management plans - Soil Salvalge and Handling Plan	Comment	MEM notes the committment to monitor metal deposition (Section 11.3.4 Soil Salvage and Handling Plan) and metal uptake in plants (Section 11.26.8.2) of the Landscape Design and Restoration Plan. Monitoring committments may form future permit conditions.

	3-Mar-16	Liz Murphy, MEM	11.3.4	Management plans - Soil Salvalge and Handling Plan	Clarification Required	Section 11.3.4 Monitoring, states that "Soil contamination will be monitored before disturbance (as part of baseline program) and then every five years after soil salvage commences. The monitoring program will focus on detection of potential contaminant accumulation and metal deposition/mobility patterns. The program will involve a number of fixed sites located at established baseline sampling locations and in areas where project activities are anticipated to have the greatest impact on soils (e.g., near the mining pit, processing plant, tailing management facility, and main transportation corridors, where the levels of dust deposition/potential for spills could vary substantially)." Please clarify whether the monitoring proposed is site wide or specific to soil stockpiles. Is it expected that this monitoring will inform soil replacement depths to cover contaminated areas?
	3-Mar-16	Liz Murphy, MEM	6.8.4.3	Rare Plants	Permitting Information Requirement	Section 6.8 states, "Maps and a spatial database of known rare plant locations in the vicinity of Project facilities should be maintained and consulted to avoid impacts during Operations and maintenance activities. Ongoing monitoring by QEP or Project environmental manager will occur. The database should be actively updated as new information becomes available." Further to this committment, please note that comprehensive monitoring plans for rare plants should be developed as part of the Vegetation Management Plan. Reporting of results of rare plant monitoring will be required in Annual Reclamation Reports.
	3-Mar-16	Liz Murphy, MEM	6.8.4.3	Rare Plants	Clarification Required	Section 6.8, states, "Known rare plant occurrences will be used as inputs during the final design and Construction phase. Where feasible, Project IF will be placed so as to avoid direct impacts to these occurrences." Please comment on this concept of avoidance based on known rare plant occurances on site and conceptual mine plans to date. Please also comment on the how feasibility will be assessed (for example, on cost, topography etc.).
	3-Mar-16	LIz Murphy, MEM	6.1	Grasslands	Clarification Required	Section 6.10.4.3 Mitigation Measures for Grasslands, states that, "progressive reclamation will occur to recreate grassland habitat during operation and closure". Please provide information on the expected extent of grassland re-establishment during operations.
	3-Mar-16	Liz Murphy, MEM	11.8	Contaminated Site Management Plan	Permitting Information Requirement	The *Mines Act* Permit Application will require cost details for investigations and potential remediation of contaminated sites prior to permitting.
	3-Mar-16	Liz Murphy, MEM	11.17	Invasive Plant Management Plan	Clarification Required	The TOC indicates that an invasive plant inventory will be included in the application. This information could not be located in the Invasive Plant Management Plan nor the Wildlife and Vegetation Management Plan. Section 6.8 Rare Plants, contains a section on invasive plant occurances found during field surveys for rare plants. Please clarify if the field survey in Section 6.8 is the inventory listed in the TOC.
	3-Mar-16	Liz Murphy, MEM	11.17	Invasive Plant Management Plan	Comment	The plan lists resources and expertise that KGHM will utilize to design an appropriate operational plan for invasive species management. The detailed invasive plant managment plan required for permitting should consider that pre-distrubance conditions will inform employee training/awareness programs, monitoring targets, and management strategies. Activities conducted for all monitoring programs and management plans must be reported in the Annual Reclamation Report required for *Mines Act* permits.

	3-Mar-16	Liz Murphy, MEM	11.26	Landscape Design and Restoration Design	Clarification Required	The plan contains conceptual information on land capability and end land use objectives typically found in a reclamation and closure plan. Please clarify how this plan (11.26), the Reclamation and Closure Plan provided in Section 11.28 and the Mine Closure and Reclamation Plan provided in Section 3.17 (Project Description) of the application are intended to complement each other.
	3-Mar-16	Liz Murphy, MEM	11.26	Landscape Design and Restoration Design	Permitting Information Requirement	Please note that a *Mines Act* permit application will require pre- and post-mining details, including maps and inventories for land capability and land use go beyond a conceptual level of detail.
	3-Mar-16	Liz Murphy, MEM	11.26	Landscape Design and Restoration Design	Permitting Information Requirement	Reclamation research is *Mines Act* requirement. A program should be initially developed based on a gap analysis to ensure that site-specific information required for reclamation and closure planning will be effectvely collected based on identified timing requirements. Reclamation research will be considered in future permit conditions.
	3-Mar-16	Liz Murphy, MEM	11.26	Landscape Design and Restoration Design	Permitting Information Requirement	Section 11.26.9 Reclamation Research, lists a number of possible reclamation research areas being considered. At the permitting stage, such programs should be considered in closure cost evaluations.
	3-Mar-16	Liz Murphy, MEM	11.26 A	Wildlife Habitat Objectives for Reclamation Plan	Comment	This plan considers reclamation of habitats and ecosystems which are important for several Valued Components. The information in this plan will be useful as a reasonable basis for reclamation presciptions in the 5 Year Reclamation and Closure Plan required for a *Mines Ac* t permit. Reclamation research programs should be designed to test the reclamation and closure strategies and prescriptions in order to inform development of reclamation and closure plans that will succeed.