1.0 INTRODUCTION

NRCan has indicated that there are two outstanding technical issues related to hydrogeology and hydrochemistry, as follows:

1) Incorporation of the Gypsum Line in the numerical groundwater flow model.

2) Investigation of the sensitivity of groundwater seepage estimates to the type of boundary conditions used to represent the TSF, specifically reconciling groundwater seepage estimates obtained by numerical flow modeling with the estimates reported in the annual water budget for mine components.

This memorandum responds to these outstanding technical issues. In each case the NRCan concerns are repeated to provide background prior to presenting the response.

2.0 TECHNICAL ISSUE: INCORPORATION OF GYPSUM LINE

2.1. NRCan Concerns

NRCan registered comment #111 in ITT:

NRCan recommends that the proponent incorporate the Gypsum Line in the numerical groundwater flow model, and attempt to relate hydraulic conductivity measurements to the deposit geologic model, possibly using block COMBO codes (EA, Vol. 3 p. 7-45).
NRCan Comment of July 29th on Proponent Response

NRCan disagreed with the initial response for the following reasons:

The proponent states that “the gypsum dissolution zone associated with the gypsum line is restricted to the vicinity of the ore body. This area is of limited regional extent with respect to the area simulated by the numerical hydrogeologic model and thus the effect of not explicitly defining it is not expected to have a large impact on the model predictions at a regional scale.” In NRCan’s view, the gypsum dissolution zone is indeed likely restricted to the alteration halo associated with the orebody. While this area may be of limited extent compared to the area of the numerical hydrogeologic model, it is also the area of greatest interest for effects predictions given the proximity of key project components (pit lake, water collection pond, tailings storage facility).

The proponent states that “estimates of hydraulic conductivity obtained to date do not suggest any significant spatial trends (Figure 5 modelling report).” In NRCan’s view, this statement is unsupported by any attempt at relating hydraulic conductivity measurements to their elevation with respect to the gypsum line – and not simply to depth. As recognized by the proponent, hydraulic conductivities in the broken rock above the gypsum line must be considerably higher than in the competent rock below and this, in itself, is a spatial trend.

The proponent states that “it is common for pit geologic and pit structural zonation to be different from hydrogeologic zonation due to the different properties that control the different aspects of their respective analyses.” In NRCan’s opinion, geologic, structural and hydrogeological zonations are clearly related at the Prosperity site: Structurally-controlled (viz. discussion of QD fault, EA. Vol. 3, sec. 7.1.6.8, p. 7-41) groundwater flow has dissolved gypsum veins in the alteration zone associated with the ore deposit resulting in broken rock above the “gypsum line.” This is an example of self-organized preferential groundwater flow in which the gypsum dissolution process creates “feed-back” couplings between geologic, structural and hydrogeologic properties of the host rocks. In NRCan’s opinion, it seems inconsistent that the gypsum line not be recognized as a key feature of the conceptual groundwater flow model when its significance was recognized in the development of a deposit block model (EA Vol.3, sec 7.1.6.9, pp.7-42 to 7-45).

NRCan Conclusion of July 29th:

In NRCan’s opinion the proponent has not addressed this comment in a satisfactory manner. To do so will require the proponent to revise the numerical groundwater flow model. Incorporating the “gypsum line” and associated zones of enhanced hydraulic conductivity in the groundwater flow model is important because this is likely to have a profound impact on flow patterns in the upper bedrock layer in the vicinity of the pit, Fish Lake and the TSF. This in turn will affect all seepage estimates related to these project components.

NRCan Conclusion of September 16th in response to additional information:

The proponent has not provided any additional information pertaining to this comment. As a result, NRCan’s conclusion and rationale of July 29th are unchanged: To address NRCan’s
comment will require the proponent to conduct additional numerical groundwater flow modeling which considers zones of enhanced hydraulic conductivity above the “gypsum line.” This information is required in order for NRCan to have confidence in the proponent’s groundwater seepage estimates related to the proposed pit, the Water Collection Pond and the Tailings Storage Facility. Reliable estimates of these fluxes are important for assessing impacts to water quality because of their chemical loads and because they represent significant components of the site water balance during operations and the post closure period.

2.2. Response to NRCan Concerns

BGC respectfully maintains its position that zones of rock with potentially enhanced hydraulic conductivity above the gypsum line are not likely to have a profound effect on flow patterns in the upper bedrock layer in the vicinity of the pit, Fish Lake, the Water Collection Pond and the TSF. We offer the following additional explanation to support this position.

NRCan agrees that the zone of gypsum dissolution “is indeed likely restricted to the alteration halo associated with the orebody” and suggests that “this is the area of greatest interest for effects predictions given the proximity of key project components (pit lake, water collection pond, tailings storage facility). BGC agrees that this zone of potentially enhanced hydraulic conductivity may have an effect on groundwater inflow rates to the pit during mining, and the final design of the pit depressurization system will need to account for zones of more heavily fractured or broken rock from which higher inflow rates may occur. However, it is very unlikely that seepage rates, and therefore mass loading rates, from the water collection pond and tailings storage facility will be controlled by zones of higher hydraulic conductivity in the upper bedrock because these facilities are underlain by thick deposits of glacial till, and the zone of gypsum dissolution has not currently been interpreted to extend much outside of the ore-body.

In general, geotechnical and exploration drilling results indicate that the till is 50 m thick or greater in most of the areas lying between the open pit and Fish Lake and the TSF (EA Vol. 3 sec. 7.1.6.3, Figures 7-8 OVB Surficial Geology and 7-9 Overburden Isopach). Based on available test results, the geometric mean hydraulic conductivity of the till was calculated to be $5 \times 10^{-8}$ m/s (EA Vol. 4. Appendix 4-4B, Table C-7), the same value was used in the calibrated numerical groundwater flow model (EA Vol. 4. Appendix 4-4C, Table 2). The geometric mean hydraulic conductivity of the till is almost an order of magnitude lower than that of the upper bedrock zone and as such, the till unit will limit the seepage from Fish Lake and the TSF into the open pit to de minimus levels during operations and closure.

While it is likely that more conductive areas of the bedrock underlying the till may serve to collect this seepage (once it crosses the till unit) and drain it into the pit, the overall rates of seepage from the Water Collection Pond (i.e. deepest part of Fish Lake) and the TSF will ultimately be controlled by the hydraulic conductivity of the till. In other words, the rate of mass loading to the open pit from these facilities will be limited by the rate at which water from the TSF or Water Collection Pond can seep through the till. Thus, while certain
conductive areas of the upper rock zone may supply more water to the pit, and lower conductivity areas will supply less, the average or total rate of mass loading will still be controlled by the till. From an environmental effects perspective, the potential presence of more conductive features in the upper bedrock zones is of limited significance in this context.

Concern over the potential effect of these more conductive zones, if present, is further diminished when the gypsum dissolution and alteration pattern is examined. As described in the EA (Vol. 3. Sec. 6.3.2 Open Pit Design p. 6-11 Alteration), the zone of gypsum dissolution is limited to areas within the potassic alteration zone. This zone of alteration is generally contained within the limits of the pit outline at grade except for a lobe that extends beyond the pit towards the west (EA, Vol. 3. sec. 7.1.6.6, Figures 7-21 Alteration at the Overburden Bedrock Interface, Figure 7-22 Alteration Level Plan 1402.5m, Figure 7-23 Alteration Level Plan 1207.5 m, Figure 7-24 Alteration Level plan 997.5 m).

Review of the spatial distribution of the “gypsum line” is described in the EA (Vol. 3. sec. 7.1.6.8), and represented conceptually in Figure 7-28; the spatial distribution of the “gypsum line” is summarized as follows:

- In the northwestern portion of the deposit, gypsum occurs at elevation 1340 m;
- in the southwestern portion, gypsum occurs between elevations 1250 and 1280;
- in the central portion of the deposit area, the gypsum line is described as more irregular and gypsum dissolution may have occurred down to elevation 1130 m;
- in the eastern part of the deposit gypsum occurs from 1260 to 1350 m elevation.

The approximate surface of the “gypsum line” intersection with the open pit is shown in EA Vol. 3. Appendix 3-6-C Figure 3.7.

Careful review of the pit outline and the extent of potassic alteration above elevation 1250 m in the western portion, above elevation 1130 in the central portion, and above elevation 1260 in the eastern portion of the pit indicates that the majority of the zones affected by gypsum dissolution are removed during mining. Zones that will remain after mining generally extend westward a distance of less than about 300 m into the ridge that divides Fish Creek from the Taseko River. Remaining zones of rock potentially affected by gypsum dissolution along fractures and joint surfaces are therefore not likely to extend under Fish Lake (and the Water Collection Pond) or under the TSF. It is also important to note that these zones do not appear to extend down-gradient along Fish Creek Valley, and so should not be of concern from a pit lake seepage perspective during closure.

It is also important to understand that the degree of significance assigned to alteration, and in this particular case gypsum dissolution, with respect to the different goals and modeling parameters associated with deposit mining, open pit slope stability design and groundwater flow modeling is quite often different. In other words, while alteration patterns may be very important to understanding the dissemination of precious metals within the deposit from a mining economics perspective, or gypsum dissolution may be an important indicator of pit...
wall material strengths and stability, it need not have a significant effect on the bulk hydraulic conductivity of the fractured rock mass. To support this statement, a plot showing the distribution of hydraulic conductivity test results versus depth below bedrock surface and position relative to the “gypsum line” is provided as Figure 1. As shown by this plot, the geometric mean hydraulic conductivity (3.5 x 10^{-7} m/s) for tests completed in the upper rock zone (0-100 m below grade) and above the “gypsum line” is very close to, but slightly greater than the hydraulic conductivity assigned to this zone during model calibration (2 x 10^{-7} m/s), and is well within the parameter reassignment used to investigate model sensitivity to the hydraulic conductivity of this layer. Similar conclusions can be made for the 100-200 m and 200+ m hydraulic conductivity zonations of the bedrock.

Based on the data available and given the only slight differences in hydraulic conductivity above and below the gypsum line from those applied in the calibrated numerical groundwater flow model, it remains BGC’s opinion that including zones of enhanced hydraulic conductivity above the “gypsum line” and completing additional numerical simulations is unnecessary. However, we note that the proponent has committed to completing additional hydrogeologic investigations in the vicinity of the open pit if a project development decision is made. Any significant findings from these investigations related to fractures or enhanced zones of hydraulic conductivity above (or below) the gypsum line would be incorporated to the model at that time.

3.0 TECHNICAL ISSUE: SEEPAGE RECONCILIATION

3.1. NRCan Concerns

NRCan registered comment #45 in ITT:

NRCan questions the validity of the proponent’s seepage estimates from the TSF in the closure period and the way in which they were determined.

NRCan registered comment #43 in ITT:

NRCan recommends that the proponent investigate the sensitivity of groundwater seepage estimates to the type of boundary conditions used to represent the TSF. The proponent should also reconcile groundwater seepage estimates obtained by the numerical flow modeling with estimates reported in the annual water budget for mine components.

NRCan Comment of July 29th on Proponent Response:

The proponent’s response does little to inspire confidence in estimates of (undifferentiated) groundwater seepage from the tailings storage facility or the proponent’s ability to ensure that a water cover is maintained in the post-closure period. It is not clear if either the KP 2D simulation or the BGC 3D groundwater model yield rigorous estimates of groundwater seepage from the TSF. It is also not clear which model, if any, yields the results deemed most authoritative by the proponent.
NRCan’s Conclusion of July 29th

NRCan's original conclusions are unchanged. NRCan questions the validity of the proponent's seepage estimates from the TSF in the post-closure period and the way in which they were determined. In particular, NRCan questions the proponent’s estimated groundwater seepage rate from the TSF of only 63 m³/day (0.7 L/s). Estimates of groundwater seepage from the TSF are important because contamination from tailings-impacted groundwater is the most likely residual impact to Big Onion lake, and because it is essential to maintain a water cover over PAG material contained in the facility. NRCan recommends that the proponent investigate the sensitivity of groundwater seepage estimates to the type of boundary conditions used to represent the TSF. This will require revisiting the groundwater flow model. The proponent should also provide a more rigorous reconciliation of in the annual water budget for mine components.

NRCan Conclusion of September 16th in response to additional information:

In [Taseko, July 9, 2009], the proponent discusses plans for further baseline hydrological and hydrogeological characterization in the Big Onion Lake basin. These plans are being developed in response to EA review concerns related to seepage from the Tailings Storage Facility (TSF) in the West Embankment area. In this memorandum, the proponent also summarizes primary and secondary mitigation measures to minimize seepage from the TSF toward Big Onion Lake. In [Taseko, August 2, 2009], the proponent responds to Information Request (I.R.) 3.1 from the Federal Review Panel related to "Site Water Balance for Prosperity Lake and Tailings Storage Facility". The response describes results from a sensitivity analysis performed using the site water balance model. The sensitivity analysis investigated the effects of climate uncertainty, climate variability and additional PAG waste rock on the water balance for Prosperity Lake and the TSF.

The sensitivity analysis makes no reference to uncertainty in estimates of seepage from the TSF which is the issue of concern to NRCan.

While the proponent’s sensitivity analysis and plans for further baseline characterization and seepage mitigation are commendable, they do not address NRCan's expressed concerns related to deficiencies in current predictive seepage modeling from the TSF. As a result, NRCan's conclusion and rationale of July 29th are unchanged: To address NRCan's comment will require the proponent to a) conduct additional numerical groundwater flow modeling using a more realistic boundary condition to represent the TSF; b) reconcile seepage estimates from the groundwater flow model and the site water balance model; c) conduct a sensitivity analysis on seepage from the TSF using the site water balance model.

This additional information is important for assessing impacts to water quality because chemical loading from TSF seepage is the most likely residual impact to Big Onion Lake, and because long-term ARD mitigation requires that a water cover be maintained over the TSF in perpetuity.
3.2. Response to NRCan Concerns

The additional information provided in [Taseko, July 9, 2009] and in [Taseko, August 2, 2009] were not intended to provide responses to the NRCan concerns relating to estimates of seepage from the TSF. These submissions were made in response to other issues raised during the review.

The following approaches were taken to estimate seepage rates from the TSF:

Knight Piésold conducted 2-dimensional (2D) simulations using SEEP/W to estimate steady state seepage rates from the TSF. The results of this work are provided in EA Vol. 3, Appendix 3-JJ, which documents the linkage of the seepage analyses with the water balance. These analyses, which considered seepage through (and under) the Main Embankment using the maximum design section and through (and under) the West Embankment using two cross-sections, were used throughout the feasibility design of the TSF and the supporting site water balance. The predicted seepage flows from this modeling were incorporated into a water quality model for the TSF Lake and Pit Lake at closure. SRK Consulting (SRK) utilized these predicted flows to predict water quality in these two water bodies starting at the cessation of operations and onward for an additional 80 years.

Based on the results of this seepage modeling and significant design and operations experience with tailings storage facilities, Knight Piésold estimated a net seepage rate of 40 L/s from the TSF, divided as follows (EA Vol. 3, Appendix 3-JJ, Table 3.2):

- 27 L/s through Main Embankment and recovered by natural drainage to the Water Collection Pond or Open Pit
- 9 L/s through the West Embankment, approximately 50% (4-5 L/s) intercepted by embankment toe drains (and the rest reporting as seepage under the dam)
- 4 L/s into the TSF basin foundation.

The net seepage rate from the facility predicted to infiltrate to the groundwater system therefore, is between 8 and 9 L/s as indicated above.

The 2D analyses included the embankment materials, seepage cutoff key and drains and considered seepage flow in the horizontal and vertical directions. Because only maximum embankment sections were considered, this estimate of seepage from the TSF is expected to be on the conservative side, as it does not consider the gradual rise of the phreatic surface underlying and surrounding the TSF with time, nor the lower embankment heights bordering large portions of the facility and so over time generally overestimates the hydraulic gradient driving seepage for much of the facility. This methodology also does not permit an assessment of groundwater discharge into the TSF basin from the surrounding uplands which will limit the area of pond infiltration to the groundwater system and reduce the overall seepage rate.

BGC conducted 3-dimensional (3D) simulations using MODFLOW. The specific objectives of this work were to evaluate pre-development hydrogeologic conditions at the site, including...
the distribution of hydraulic head, regional groundwater flow directions, and discharge rates to rivers, creeks and lakes in the study area, and to predict changes to this system during mine operations and mine closure. The boundary condition used to simulate the effects of the TSF on the regional hydrogeologic system was the River Package. The pond and tailings elevations were set using TSF configurations provided by Knight Piésold and the site water balance. The River Package permits the infiltration of water to underlying cells in the vertical direction. The rate at which this seepage water is introduced to the model is controlled by the area of an individual cell and a conductance value set to be the vertical hydraulic conductivity of the tailings (1x10⁻⁸ m/s) or the permeability of the underlying till (5x10⁻⁸ m/s) depending on the relative elevations of the pond and tailings to the basin topography. Thus seepage from the tailings is considered in the vertical direction only and horizontal flow from the tailings into embankment materials and drains is not considered by this approach. The rate at which water seeping in the vertical direction from the tailings into the underlying groundwater system was provided in EA Vol.4 sec. 4 Figure 4-51. Pond seepage to groundwater is seen to decrease from about 400 m³/day at year 16 to about 63 m³/day at year 100 in response to the equilibration of the pond during closure and post-closure with the underlying groundwater system.

This transient vertical seepage flux from the TSF is not directly comparable to the conservative estimate generated by the 2D simulation. However, to reconcile the 2D estimate with the 3D estimate, the 3D flux from the TSF to groundwater at the end of year 16 (400 m³/day or about 4.6 L/s) was compared to the 2D steady state results (8-9 L/s) on the basis that the gradients driving the simulations in each case are most similar at this point in time. Given the inherently different methods of simulation used to derive these estimates, a factor of 2 difference is considered acceptable.

As noted above, the 2D seepage results were used in the effects assessment for Pit Lake and TSF Lake water quality and the seepage rates used are considered to be conservative for this purpose.

The results of the 3D model were used to guide the mixing model used to assess potential TSF seepage impacts to Big Onion Lake assuming no mitigation was applied to control seepage of unacceptable quality. Given the acknowledged uncertainty associated with the 3D simulation results in this area (EA Vol. 4, Appendix 4-4C Sec. 8.8 Summary and Conclusions and Sec. 9. Recommendations) the potential concentrations of seepage affected groundwater discharging to Big Onion Lake were bracketed by the results of transport sensitivity runs (concentration loads of 1-5% pore water dissolved in groundwater), and the percentage of groundwater as a function of total water influx to Big Onion Lake was varied between 8.5% (using 1% TSF pore water – Best Case), 23% (using 5% pore water – Average Case) and 39% (using 5% TSF pore water – Worst Case).

This methodology is considered appropriately conservative for the effects assessment given the information available. It is also noteworthy that the proponent has committed to completing additional hydrological and hydrogeological investigations in the ridge underlying
the West Embankment and in the Big Onion Lake catchment to address the uncertainty in predictions in this area prior to commencement of operations.

Finally, it is our opinion that any additional modeling effort will not significantly reduce uncertainty in simulation results for TSF seepage or flows to Big Onion Lake unless it also incorporates the results of the recommended additional investigations in the west ridge. We note that the proponent has committed to undertaking these investigations as soon as practicable once a development decision is made. Deferral of additional modeling efforts until these investigations are completed will also permit implementation of final design Main Embankment sections into the model if this will be an NRCan requirement.

4.0 CLOSURE

BGC Engineering Inc. (BGC) prepared this document for the account of Taseko Mines Limited. The material in it reflects the judgment of BGC staff in light of the information available to BGC at the time of document preparation. Any use which a third party makes of this document or any reliance on decisions to be based on it is the responsibility of such third parties. BGC accepts no responsibility for damages, if any, suffered by any third party as a result of decisions made or actions based on this document.

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Yours sincerely,

BGC ENGINEERING INC.

per: Reviewed by:

Senior Hydrogeological Engineer Senior Hydrogeological Engineer
Prosperity Gold-Copper Project

Comparison of K above and below the Gypsum Line

Hydraulic Conductivity (m/s)

Depth below Bedrock Surface (m)

- Bedrock K Calibrated Model
- Geometric Mean K Above "Gypsum Line"
- Geometric Mean K Below "Gypsum Line"
- Bedrock K Sensitivity Runs

Legend:
- Bedrock 0-100 m below grade and above gypsum line
- Bedrock 100-200 m below grade and above gypsum line
- Bedrock 100-200 m bg and below gypsum line
- Bedrock 200 m+ bg all below gypsum line