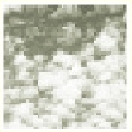

STRATUS CONSULTING

Comments on the Taseko Mines Ltd. Hydrometeorology Plan for the Proposed Prosperity Copper-Gold Project

Prepared for:

Chief Bernie Elkins
Director, Tsilhqot'in National Government

and

Chief Anne Louie
Williams Lake Indian Band

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1. Introduction

Taseko Mines Ltd. (Taseko) has proposed a plan for the Prosperity Gold-Copper Mine Project outside of Williams Lake, BC. The Canadian Environmental Assessment Agency (CEAA) Review Panel (Panel) issued two sets of comments, dated October 6, 2009 and October 16, 2009, related to the sufficiency of information contained in the environmental impact statement (EIS) and supplemental information submitted by Taseko. Among other things, both sets of comments reflected ongoing concerns related to the site hydrology and the hydrometeorology model. In the comments dated October 6, 2009, the Panel was concerned about the potential need for up to 7,000,000 cubic meters (m^3) of additional water each year to maintain the tailings storage facility (TSF) in years 2 through 12 of operations. The comments dated October 16, 2009 reflected additional concerns related to the sources of water identified by the proponents to meet any potential water deficits during mine operations. This memorandum provides additional comments regarding the suitability of the Taseko Mines hydrometeorology model for predicting site hydrology.

1.1 Background

The Prosperity Gold-Copper Project is a proposed open pit mine with an approximately 4 km × 6 km TSF, a concentrator facility, and an anticipated 70,000 tpd production. As proposed in the EIS, the projected mine life is 20 years. No active treatment or long-term site management or maintenance is proposed after production is complete, even though the mined materials are known to generate acid and metal-rich leachate. The mine is located in an area with abundant and important natural resources, including resident trout, migratory salmon, and other wildlife that provide important economic, recreational, and cultural benefits. Because of the potentially severe consequences of hardrock mining projects on natural resources – particularly at sites with the potential for generation of acid drainage – it is important for project developers to perform a careful evaluation of potential environmental consequences of operations, both during the operating lifetime of the mine, as well during and after mine closure.

Potential environmental consequences associated with the Prosperity project include:

- Discharge of acid mine drainage into Fish Creek and the Taseko River
- Infiltration of contaminated tailings seepage to groundwater
- Permanent production of acid drainage from the surface of the TSF and exposure to wildlife

- Flow of contaminated water through fractured bedrock and the pit to groundwater and ultimately to downgradient surface water
- Insufficiency of proposed mitigation habitat (Prosperity Lake) to support native fisheries and uses
- Changes in water balance, especially decreased flows in streams currently downgradient of the proposed tailings impoundment and pit areas
- Tailings dam breaks and spills and input of contaminated sediment to surface water.

Proper evaluation of potential environmental consequences should include projections of expected future conditions (both during operation and post-closure), as well as an evaluation of the probability of adverse effects given environmental variability and uncertainty.

Based on our review of documents prepared by Taseko, available information provided to date does not permit a reasoned evaluation of potential adverse effects to water quality, water quantity, fish, and wildlife under variable environmental conditions. Because of the known impacts of hardrock mining (Kuipers et al., 2006), it is critical that reasonable potential effects are identified and short-term and long-term mitigation and management measures and monitoring are included in the mine proposal.

A full evaluation of the uncertainties associated with the proposed project is beyond the scope of this current memorandum. Rather, we focus on several issues related to site hydrology and hydrometeorology.

1.2 Summary of Opinions Related to Hydrology/ Hydrometeorology

We concur with the Panel that the site water balance is a topic of particular concern for the successful maintenance of the TSF. The proponent’s responses to the Panel’s information requests imply a level of certainty in the site water balance calculations that is not justified by the data available. Especially because of the lack of available hydrologic and meteorologic data, we do not believe that the proponents can reliably predict site hydrological impacts or adequately control water levels in the proposed TSF.

Based on our review of the water balance model as detailed in the EIS (Taseko Mines, 2009), the hydrometeorology report (Knight Piésold, 2007), the numerical hydrogeologic analysis (BGC Engineering, 2009), and the report on tailings storage facility seepage assessment (Knight Piésold, 2009), as well as subsequent comments and responses, we conclude that the data underlying these models are insufficient for adequately predicting the hydrologic impacts of this proposed mine. The water balance modeling methods used by Taseko are reported only as tables with annual water budgets; as a result, we have not been able to reproduce the results of the model simulations or the hydrologic probability assessments that resulted from the model. However, we have examined the conceptual model and the input data and concluded that some facets of a proper water balance are ignored entirely, and other facets are based on weak correlations using short-term records. The results of the model are therefore unlikely to adequately represent the range of potential outcomes of the proposed project.

As described below, it does not appear that Taseko fully incorporated the effect of uncertainty in model inputs on the water balance model outputs. These uncertainties of the model inputs and outputs should be explicitly stated (Maest et al., 2005). Taseko also did not evaluate the effect of uncertainty in their conceptual model, including missing elements such as sublimation and transpiration. Alternative conceptual models should be considered and included in model runs (Bredehoeft, 2005).

We are also concerned that the proponents may not have enough data to predict or prepare for extreme weather events. After operations, they propose leaving their mine waste in place with no active controls. One extreme weather event at any point in the future could lead to an uncontrolled release of mine waste, which could have severe adverse consequences for the trout and salmon fishery of the Taseko River. In this review, we emphasize both the shortcomings of the inputs to the hydrometeorology model, and the potential consequences if their assumptions are incorrect.

1.3 Document Organization

In Section 2, we discuss the elements that should be included in a robust hydrometeorological water balance model. Next we discuss the extent to which Taseko has addressed each of these elements, including an examination of the potential uncertainties in each element of their model (Section 3). In Section 4, we summarize data shortcomings and the potential impacts on the environment if their site water balance is incorrect. Finally, Section 5 presents the qualifications of the authors of this report.

2. Hydrometeorology Conceptual Model

A hydrometeorology or water balance model is intended to mathematically describe the inflows and outflows of water to the catchment in which the proposed mine lies. A water balance model is only as good as the data used to estimate the relevant inflows and outflows. The elements of a water balance model include seasonal and annual incoming precipitation; loss of precipitation to the atmosphere from evaporation, transpiration, and sublimation; infiltration and transport of water via groundwater flow; and surface water runoff to streams (Figure 1).

In the context of planning for water use for a mine of this scale, the water balance must not only model the average conditions likely to occur in the area, it also must adequately represent climatic extremes. At the proposed Prosperity Mine, water shortfalls would result in exposure of potentially acid generating (PAG) mine waste in the TSF to the atmosphere, which would generate acid mine drainage. Water surpluses could require discharge and /or treatment of contaminated mine water and/or result in erosion, sedimentation, or increased contaminant fluxes to the environment. If these extreme climatic events are not accurately represented, the nature and severity of potential ecological effects would not be captured.

In the following sections, we discuss how Taseko has addressed each element in the site water balance (Figure 1). Specifically, we discuss the underlying data that were used as inputs to their model. Because their modeling methods were not well documented, we have not been able to discern exactly how their model produced the estimated probability of water shortfalls or surpluses. However, Taseko's underlying meteorological and hydrologic data suggest that they vastly underestimate the uncertainties in the site water balance.

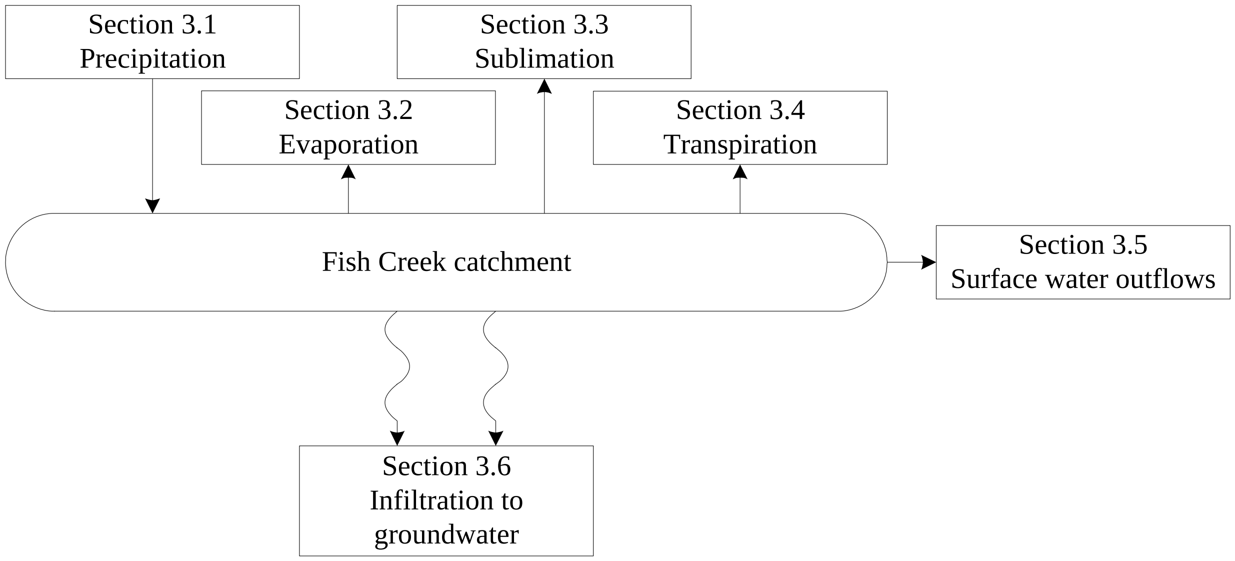

Figure 1. Elements of water balance model, and the section of this report in which we address each element.

3. Data Underlying Taseko's Model

3.1 Precipitation

Despite investigating this site for 15 years prior to releasing the EIS, Taseko collected precipitation data at the site for only six years (1993–1998), and only two of those years (1993 and 1994) contain complete data for the entire year. Recognizing the lack of suitability of these data for modeling the full range of possible influent precipitation for any given year during the 25-year operation of the mine and hundreds of years of post-closure, Taseko relies on correlations between these site-specific data and a longer-term record of precipitation data from a meteorological station 40 kilometers (km) away. The remote station, Big Creek, has a precipitation record of 69 years.

Based on the available data, the *total* cumulative precipitation at the proposed mine site over six years of (incomplete) record (1993–1998) is 40% higher than the *total* precipitation at Big Creek over the same six years (Knight Piésold, 2007). Taseko used this relationship in their model, simplistically assuming that the long-term average precipitation at the base of the Fish Creek watershed (445 millimeters, mm) is 40% higher than the long-term average for Big Creek (318 mm). However, when one examines the two years for which complete records exist for both Fish Creek and Big Creek, one finds that the annual site precipitation total in Fish Creek was 10% *lower* than Big Creek in 1993 and 82% *higher* than Big Creek in 1994 (Figure 2). With this level of uncertainty in just the two years for which they collected complete Fish Creek precipitation data, there is clearly no validity in assuming that precipitation in Fish Creek is simply 40% higher than precipitation in Big Creek.

Precipitation is commonly higher at higher elevations than at lower elevations, due to the effects of topography on atmospheric dynamics (orographic effects). However, the available site-specific meteorology data do not indicate that such an effect is present in the Fish Creek catchment:

> Due to the higher elevation of station M4, it was expected that orographic influences would produce higher rainfall there than at Stations M1 or M2. While the August 1996 and 1997 values indicate that Station M4 receives more rainfall, the July 1997 values indicate that it receives less rainfall, and the September 1996 and May 1997 values indicate approximately the same rainfall amounts at all three locations (Knight Piésold, 2007, p. 6).

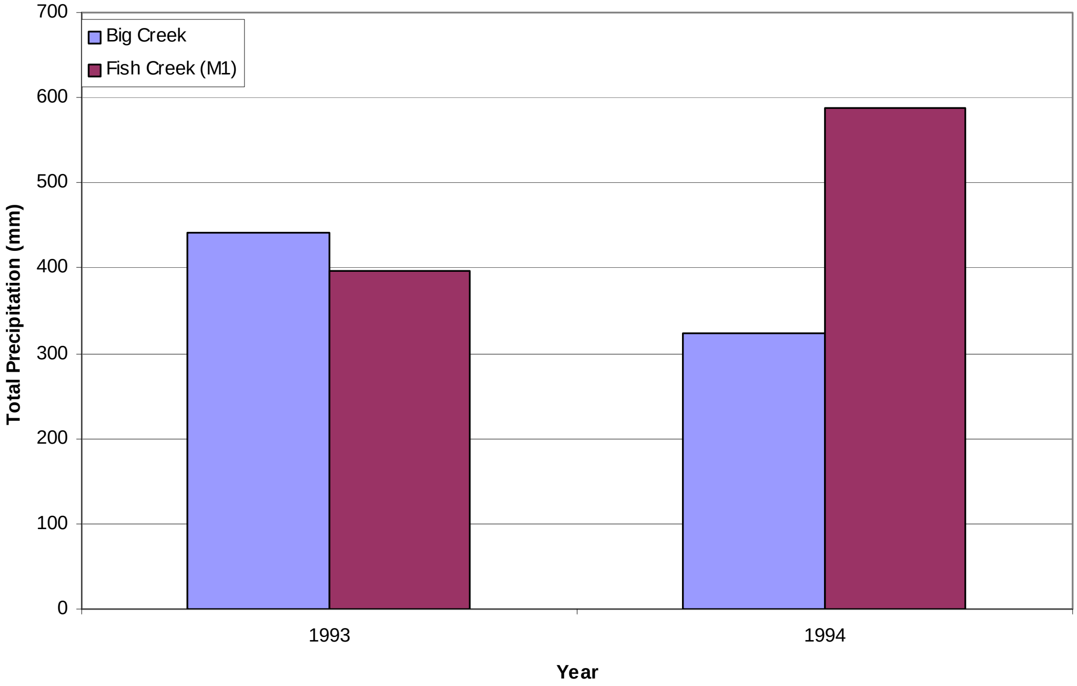

Figure 2. Comparison of measured precipitation at Big Creek and Fish Creek in 1993 and 1994.

Data source: Knight Piésold, 2007.

Even though the data do not support an orographic effect on precipitation, Taseko included the effect in their model: "The data collected at station M4 do not conclusively demonstrate an orographic effect, but it is believed that one does exist" (Knight Piésold, 2007, p. 7). To estimate the precipitation throughout the Fish Creek catchment based on the precipitation at the bottom of the catchment, they add an orographic correction factor of 12% per 100 meters of elevation gain. Thus, they estimate that the annual precipitation at the site (527 mm) is nearly 20% higher than the annual precipitation estimated at the lowermost monitoring station (445 mm), which was itself based on poorly correlated records from Big Creek. The Taseko water balance model does not appear to account for the high level of uncertainty in their annual precipitation estimate for the Fish Creek catchment.

In summary, Taseko has very little site-specific precipitation data, and the two complete years of site-specific data that they do have do not correlate at all with the data from the long-term weather station that they used for their model. In addition, they added an orographic correction factor that does not appear to exist based on available data. The impact of the first assumption

(40% higher precipitation at the proposed site) cannot be evaluated due to a lack of data. However, the unsupported orographic correction factor will lead to a systematic overestimate of the amount of water available for TSF management. This overestimate is likely to lead to water shortfalls, and potentially acid-generating conditions in the TSF.

3.2 Evaporation

Taseko collected site-specific evaporation data from the Project area in 1998 (Knight Piésold, 2007). However, these data did not demonstrate the expected correlation between temperature and evaporation that would allow calibration of a simple empirical model of evaporation. Consequently, Taseko abandoned the site-specific data and instead used evaporation estimates from a site approximately 250 km to the southeast, collected between 1972 and 1983. There are no overlapping data from the two sites that would allow one to correlate the remote site to the Fish Creek catchment. Thus, there is no way to estimate whether the input evaporation data in the Taseko model is in any way representative of actual evaporation rates at the site.

3.3 Sublimation

Snowfall in the Fish Creek catchment can melt and contribute to runoff or groundwater recharge, or it can return directly to the atmosphere through sublimation. During the two years for which complete data are available for the site (1993 and 1994), snowfall represents 23% and 63% of total precipitation (Knight Piésold, 2007). Sublimation losses from mature northern forests have been shown to return between 13% and 40% of seasonal snowfall directly to the atmosphere (King et al., 2008, as cited in Armstrong and Brun, 2008). These data suggest a possible loss of up to 25% (63% × 40%) of annual precipitation to sublimation. Rather than account for possible sublimation losses and the large variability in percent snowfall in consecutive years, Taseko simply assumes that sublimation is negligible without providing corroborating data:

> It was also assumed that sublimation losses are negligible, which is reasonable given the small magnitude of sublimation and the uncertainties associated with the estimates of precipitation and evaporation (Knight Piésold, 2007, p. 9).

By ignoring sublimation in their model, Taseko assumes that all of the water that falls as snow in the catchment returns as runoff in the spring. If 13%–40% of this water is lost to sublimation, Taseko’s model will overestimate the quantity of water available for water management, including control of the water level in the TSF. The consequences of such an overestimate could be generation of acid drainage in the upper portions of the TSF.

3.4 Transpiration

Even after construction of the mine facilities, including the pit, waste rock storage, processing facilities and the TSF, the Fish Lake catchment will remain primarily forested. Trees and other vegetation intercept precipitation directly and transpire water that falls to the forest floor. Transpiration can emit multiple liters of water per day into the atmosphere for a single coniferous tree (Granier, 1987), and forest-scale transpiration in moist, cool settings can account for the loss of as much as a third of incoming precipitation (Running and Coughlan, 1988). The Taseko model does not appear to account for any transpiration of influent precipitation. This again results in a potentially substantial overprediction of the amount of water that will be available for controlling the water level of the TSF. Having less water available for management could result in drying of the upper portions of the tailings in the TSF and creation of acid drainage.

3.5 Surface Water Outflows

Streamflow has been gauged at 17 sites in and around the project area over the course of site investigations. However, as noted in the hydrometeorology report, “these installations were active for varying periods of time, and with varying degrees of success” (Knight Piésold, 2007, p. 10). Furthermore, rather than reporting actual flow data from stream gauging stations, Taseko reports “mean annual unit runoff” data, which are average monthly flows normalized to the drainage area at each gauging station. This presentation makes it difficult for us to assess the actual behavior of the surface water hydrology. Nonetheless, we have identified a number of issues with Taseko’s representation of surface water flows in their hydrometeorology model.

First, the streamflow data indicate a broad range of hydrologic responses to precipitation within the catchment that do not appear to be accurately represented in the model. For each gauging station record, Taseko compares total streamflow to modeled precipitation to calculate the percentage of precipitation that exits the catchment in surface water. These “effective runoff coefficients” vary on the site from 5% to 52% (Knight Piésold, 2007). Taseko chose an effective runoff coefficient of 25% as input to their water balance model, but acknowledged that this runoff coefficient is “slightly greater than the average of the ‘period of record’ values” from Fish Creek gauging stations. It is not clear that the variability of their calculated effective runoff coefficients has been adequately incorporated into their model. Using a runoff coefficient that is too high suggests that the water balance will overpredict the amount of water available for TSF management (since the majority of this water appears to come from streamflow). Again, the possible outcome would be drying of acid-generating wastes and creating acid conditions in the TSF.

Second, their data indicated substantial losses of streamflow to groundwater in the Fish Creek catchment, a fact that Taseko originally acknowledged, then recanted. In the hydrometeorology report, Knight Piésold (2007, p. 10) stated, "recorded flows on some creeks are higher near the midpoint of their basins than further downstream, which is likely due to localized infiltration losses." This can be seen in gauging station H2 (Figure 3), located directly downstream from Fish Lake, which commonly has a higher mean monthly unit discharge than station H3 immediately downstream from it. In July 1993, unit monthly discharge was nearly six times lower at H3 than at H2 (Figure 3). The implication from Figure 3, which shows monthly averaged flows in stream gauging stations, is that water is being lost somewhere between monitoring stations H3 and H2.

Recently, Knight Piésold concluded that "the surface flow loss pattern suggested by [Figure 3 in this report] is almost certainly an artifact of data error" (Thompson and Crozier, 2009, Appendix A). They justify this statement by claiming that there are no consistent trends, particularly in data collected more recently, and they state that data collected in the 2000s are more accurate than data collected in the 1990s.[1] As discussed previously, they provide discharge data only in units of discharge per unit drainage area, preventing reviewers from comparing actual streamflow data between gauging stations. If surface water in the stream is in fact lost to groundwater, the ultimate fate of this water needs to be known. If their calculated 80% decrease in mean monthly unit discharge between H2 and H3 in July 1993 (Figure 3) is merely a "data error," this data deficiency needs to be remedied, and one has to wonder what other input "data errors" may be incorporated into this hydrometeorology model. If Fish Creek becomes contaminated, there is the potential for more widespread contamination of groundwater from the losing reach or reaches.

In summary, surface water gauging records have a number of problems, which have a variety of impacts on the site water balance and the proponents' ability to predict the environmental consequences of the proposed mine. The choice of an effective runoff coefficient that is "slightly greater than the average of the 'period of record' values" will systematically overestimate the amount of water available for TSF management, increasing the likelihood of creating acid generating conditions in the TSF. The potential loss of streamflow from Fish Creek to groundwater highlights the potential for uncontrolled releases of contaminants to the environment via subsurface pathways. Alternatively, if these unusual gauging records are indeed an artifact of "data error," this further underscores the proponents' inability to fully evaluate the potential impacts of the proposed mine.

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[1] If they conclude that data collected before the 2000s are unreliable, they invalidate the majority of data used as input to their model.

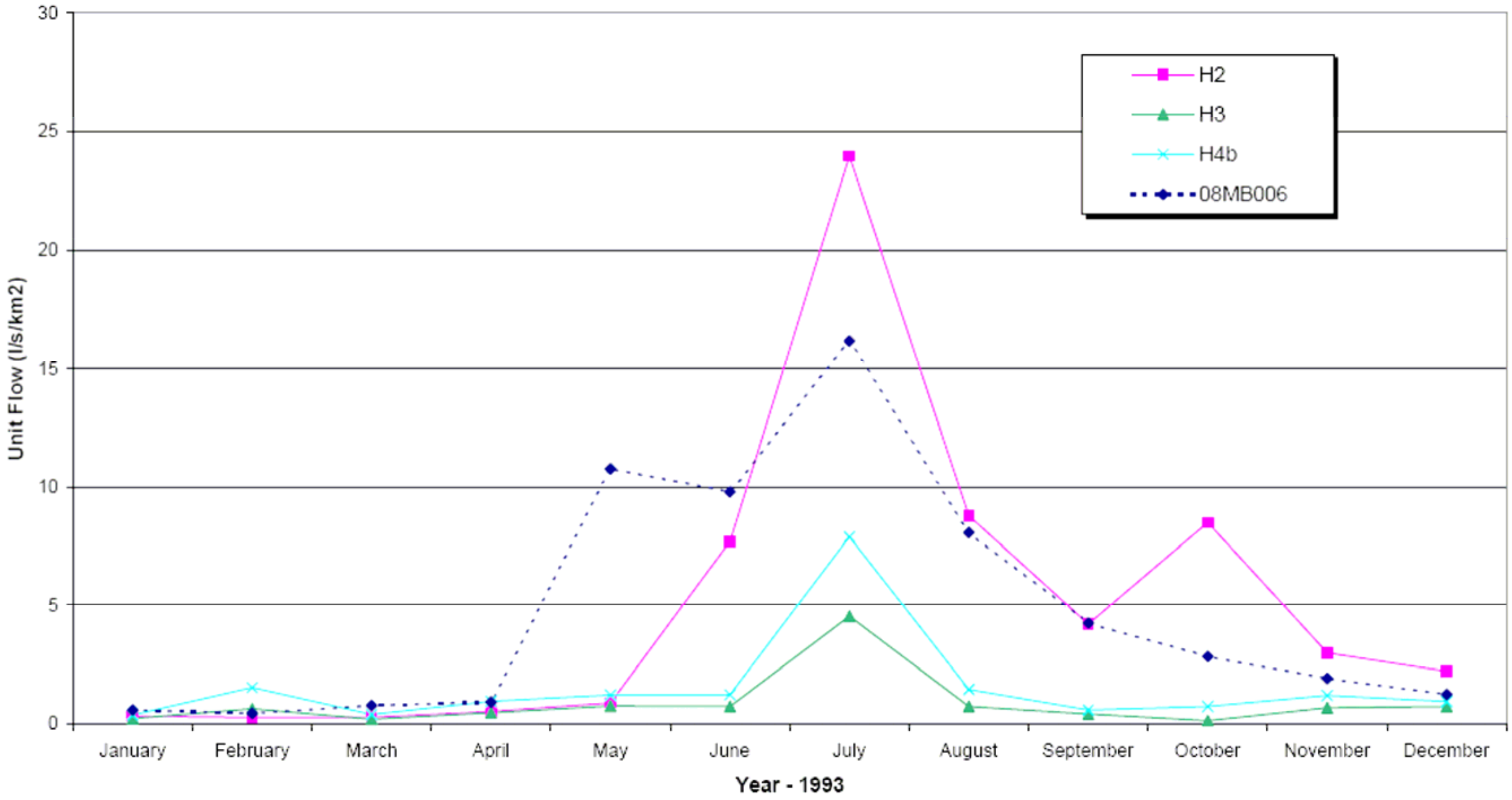

Figure 3. Mean monthly hydrographs from Fish Creek gauging stations, 1993. Note that H2 is upstream of H3.

Source: Knight-Piésold, 2007, Figure C9.

3.6 Infiltration to Groundwater

The final component of a water balance is infiltration to groundwater. An accurate estimate of infiltration and groundwater flow depends on an adequate characterization of both hydraulic conductivities and hydraulic gradients. We focus our comments here on the characterization of hydraulic parameters in and around the mine area, recognizing that the water balance also depends on the infiltration of water in other parts of the watershed.

3.6.1 Glacial till

Most of the proposed TSF is underlain by a glacial till layer, the hydraulic conductivity of which appears to be characterized based on a total of three permeability tests (Taseko Mines, 2009). The geometric mean hydraulic conductivity based on these three tests is 5×10^{-6} cm/s. Three permeability tests is insufficient to estimate infiltration to glacial till across many square kilometers of the tailings storage facility. Compounding the problem, Knight Piésold (2009) chose a hydraulic conductivity five times lower than the geometric mean:

> "The glacial till foundation was assigned a permeability of 1×10^{-6} cm/s, based on in situ test results carried out during previous site investigations. Some of the in situ tests resulted in higher permeabilities, but a value of 1×10^{-6} cm/s was chosen because the unit generally acts as an aquitard and is underlain by an aquifer in the model" (Knight Piésold, 2009, p. 6)

Other than this qualitative statement, no other justification is provided for selecting a hydraulic conductivity that does not correspond with the actual data in those previous site investigations. Using a hydraulic conductivity value that is too low will underestimate the potential for migration of contaminated leachate from the TSF to groundwater.

Again, Taseko has failed to address the amount of uncertainty in their input data. The Taseko water balance model relies on estimates of seepage rates through the proposed TSF in order to predict the water needs to keep PAG tailings submerged. If more water is lost from the TSF to groundwater than their model predicts, their water needs will correspondingly increase. If their water balance underpredicts these needs, the tailings could become exposed to the atmosphere and generate acid conditions. In addition, faster than predicted losses to groundwater could result in more contamination of shallow groundwater than predicted by the numerical hydrogeologic modeling (BGC Engineering, 2009).

3.6.2 Bedrock

The bedrock beneath the glacial till comprises Tertiary basalt flows. Importantly, the basalts locally outcrop at the ground surface, indicating that the till layer does not always prevent direct groundwater inflows to bedrock (Knight Piésold, 2009). As shown in Figure 4, the hydraulic conductivity of the basalts ranges across four orders of magnitude, from approximately $1x10^{-3}$ to $1x10^{-7}$ cm/s (Taseko Mines, 2009). Most of these conductivity values are higher than the conductivity of the glacial till.

In the report on tailings storage facility seepage assessment, Knight Piésold (2009) chose $1x10^{-4}$ centimeters per second (cm/s) to represent the fractured/vesicular basalt and $1x10^{-5}$ cm/s to represent the massive basalt flows. Their model does not appear to account for the wide range of potential hydraulic conductivities illustrated by single-well hydraulic tests shown in Figure 4. In addition, along the western ridge of the Fish Creek valley where seepage losses are likely to be most important due to the lack of till in this area, the basalt is characterized by columnar jointing (Taseko Mines, 2009). The bulk hydraulic conductivity of the basalt may therefore be considerably higher than implied by localized single-well tests because of the network of fractures in this type of bedrock (see following section). However, Taseko lacks the necessary data to evaluate this possibility.

The Taseko water balance model relies on estimates of seepage rates through the proposed TSF in order to predict the amount of water needed to keep PAG tailings submerged. The fact that basalt outcrops directly to the surface in the western part of the TSF, and the possibility that the bulk conductivity of the basalt due to fractures may be higher than the estimates from single-well tests, will each cause the water balance to overpredict the amount of water remaining on the surface of the TSF. The result could be underprediction of the extent of acid generation on the surface of the TSF. In addition, using a too-low hydraulic conductivity value will underestimate the potential for groundwater contamination and groundwater transport from the tailings materials.

3.6.3 Faults and fractures

Fractures in bedrock provide preferential pathways for groundwater flow. Bulk hydraulic conductivity in fractured bedrock can be orders of magnitude higher than hydraulic conductivity in the unfractured matrix. Volcanic basalt flows frequently contain networks of fractures and preferential flow pathways, and modeling groundwater flows in these systems is complicated. The Idaho National Engineering and Environmental Laboratory and the Hanford Nuclear Site in the U.S. are both located atop Columbia River basalt flows. Scientists and engineers have tried for decades to understand groundwater and contaminant transport in these areas, with limited

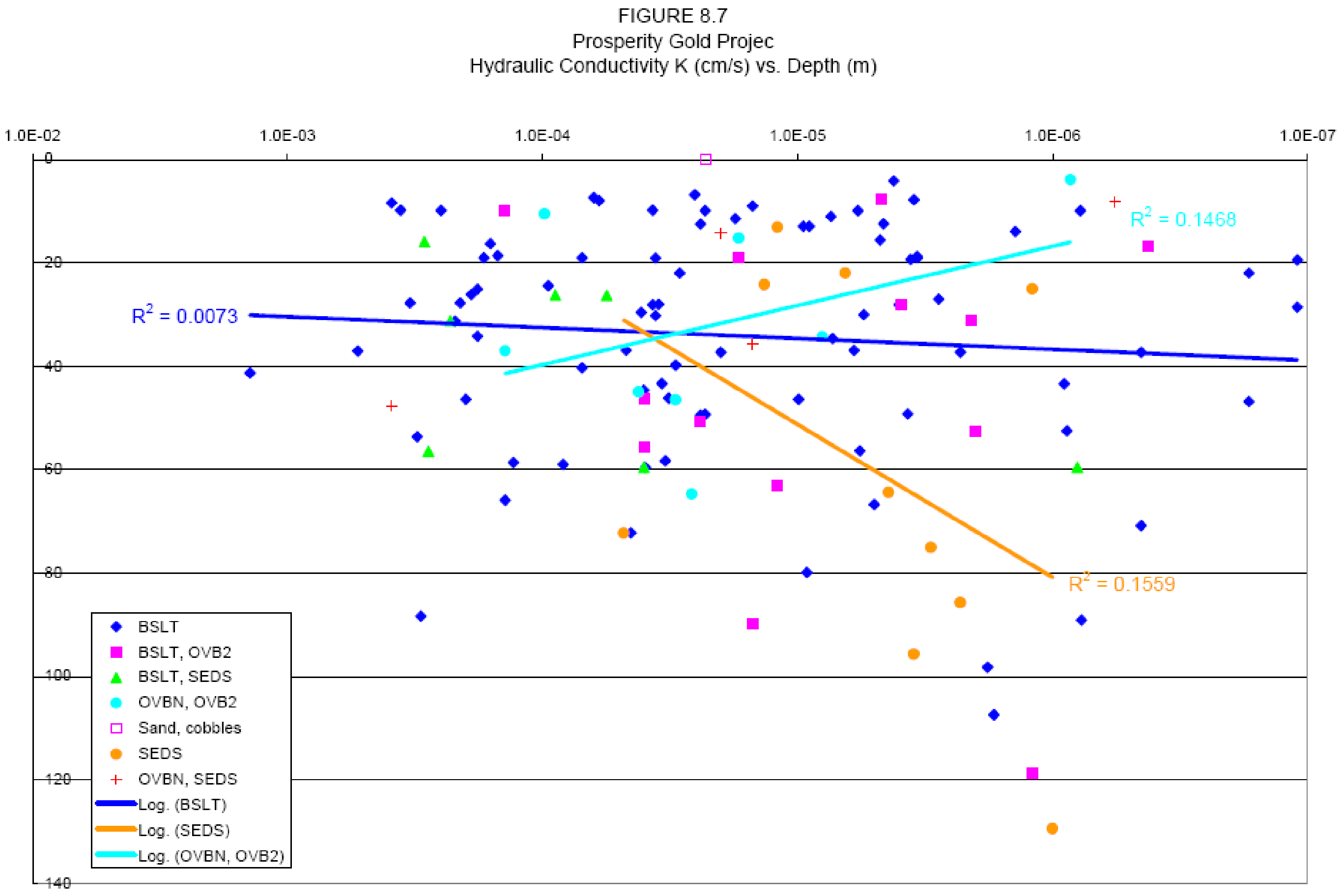

Figure 4. Hydraulic conductivity in bedrock. Depth (in meters) is on the vertical axis, and hydraulic conductivity (in cm/sec) is on the horizontal axis.

Source: Taseko Mines, 2009, Appendix 4-4B, Figure 8.7.

success. Taseko does not acknowledge preferential pathways in columnar basalt flows, let alone attempt to model groundwater transport scenarios should these pathways exist. This may be a significant gap in the site conceptual model, with implications for both the TSF water balance as described above and the fate of contaminants from the TSF.

Like fractures, faults can also provide preferential flow pathways for groundwater. Maps of the project area show two sets of faults that could potentially influence groundwater flow. One of these faults passes approximately between streamflow gauging stations H3 and H2, suggesting that faults could be responsible for the localized streamflow losses observed in this area (see Figure 3). Another of these faults is co-located with a groundwater seep at the base of the western escarpment, again suggesting localized control of faults on groundwater flow.

In its report on hydrogeology, BGC Engineering (2009) recommends that the role of these faults on groundwater flow be investigated:

> Future hydrogeologic investigations should try to target fault structures in order to develop a better understanding of their role in the hydrogeologic regime of the site and to evaluate assumptions made to date (BGC Engineering, 2009, p. 2).

Given the spatial coincidence between faults and areas of localized infiltration and groundwater seepage, we concur that an additional evaluation of faults on groundwater flow needs to be undertaken before permits are granted. Groundwater infiltration through this fractured and faulted bedrock is poorly understood, and the range of potential infiltration scenarios has not been addressed in the modeling undertaken to date. This could again result in far more loss to groundwater than the water balance predicts, which would result in both water shortfalls for managing water levels in the TSF, and potentially a far larger and faster plume of contaminated groundwater leaving the mine property.

3.6.4 Deep groundwater

In its response to the October 6, 2009 information request from the Panel, Taseko indicates that “advanced dewatering” of the deep bedrock aquifer can supply enough make-up water to maintain the TSF during the early years of mine operation (Cathcart and Brouwer, 2009b).

However, when pressed by the panel to provide additional information on the ability of this aquifer to supply this make-up water, Taseko states that the “full capacity [of this aquifer] to supply a given amount of make-up water is not known or needed” (Cathcart and Brouwer, 2009a).

These statements imply that maintaining the water levels in the TSF can be achieved by using pumped water from an aquifer about which little is known. While Taseko acknowledges the lack of information on water supply from the deep aquifer, the fact that they believe data are not necessary for approval of this mine project underscores the insufficiency of their modeling approach.

If the deep groundwater aquifer cannot provide the water they predict, the result would again be insufficient water for maintaining the tailings storage facility, and potential generation of acid conditions. In addition, the aquifer that the proponents admit to knowing little about is the same aquifer that will intersect the open pit once the pit has been established. This suggests that pit inflows, a major component of the water balance during operations, are yet another unknown in the overall site water balance. Lack of information on the deep aquifer will also add uncertainty to predictions of pit dewatering and filling rates.

4. Summary and Potential Impacts

In the preceding sections we have summarized some of the uncertainties associated with Taseko's water balance model. Although the proponents claim that their model enables them to predict the likelihood of TSF shortfalls, our review of their water balance indicates that neither the inputs nor the outputs to the water balance model have been adequately characterized. In general, the uncertainties in each of the elements of the site water balance suggest that the current model systematically overpredicts the amount of water available for site operations. In particular, precipitation seems to be overpredicted, and losses through sublimation, transpiration, and infiltration are all underpredicted. Here we briefly summarize the potential impacts on the environment if these estimates are incorrect.

4.1 Potential Impacts of Water Shortfalls

Among other arguments, the proponents justify their projected water balance shortfalls by reiterating that for any given year, a 7,000,000 m^3 water shortfall has "only a 5% probability of occurring in that particular year." Even if the proponents had enough information to ensure that this 5% probability were an accurate representation of risk, this risk is not currently weighed against the potential environmental impacts of such a shortfall. In particular, water shortages could lead to the generation of acid conditions in the tailings storage facility as PAG wastes become exposed to the atmosphere. Given that the proponents currently have no plans for water treatment on the mine site, any acid generated would presumably remain in the TSF, with the potential to infiltrate to groundwater or seep through the main embankment. Upon closure, the TSF is designed to allow overflows to the pit lake and ultimately to lower Fish Creek and the Taseko River. Given the large uncertainties and documented variability in precipitation and streamflow, it is not reasonable to conclude that Taseko could cease operations and simply expect the tailings impoundment to maintain itself in perpetuity. Instead, long-term water treatment should be included as an alternative in the final EIS.

4.2 Potential Impacts of Water Surpluses

Although the proponents and the Panel primarily focus on the possibility of water shortfalls, there may also be a probability of water surpluses given the paucity of data available. Under the current water management plan, these surpluses would primarily flow to Wasp Creek and then overflow down the steep embankment southeast of Wasp Lake to Beece Creek. In their memorandum dated August 4, 2009, the proponents indicate that the additional discharge to Beece Creek would be a relatively minor contribution relative to the typical flows in that creek.

This analysis misses one of the main potential problems of a water surplus: the effects of an increased water discharge on the steep gully between Wasp Lake and Beece Creek. Available topographic maps and imagery from Google Earth indicate that this gully is already actively eroding, even with the relatively small drainage area that currently feeds it. The water management plan calls for the drainage area reporting to this creek to increase by as much as ~ 22 km^2 (Knight Piésold, 2009), which represents at least a tripling of the current drainage area feeding this gully. Increased discharge would increase the rates of erosion in this gully, potentially feeding large pulses of excess sediment into Beece Creek.

If potential water excesses are not directed to this Beece Creek tributary, they must be directed to the TSF, which would either increase seepage rates through the embankments and bedrock or lead to overflows. Given the current lack of plans for water treatment, the ultimate result could be a discharge of potentially contaminated surface water to trout and salmon habitat in the Taseko River and Big Onion Lake. Again, this possibility highlights the importance of including an alternative for long-term treatment of mine water.

We emphasize again that Taseko must have a water management plan that accommodates low probability events. They consider a modeled 5% risk of occurrence to be acceptably low, with no plan to accommodate the consequences should the low probability event occur (other than a plan to pump groundwater from a deep aquifer they know nothing about should there be less water for TSF management than they predict). While it is important to model water management in an average year, it is perhaps even more important to model water management in an atypical year. As has been proven at most mine sites worldwide, droughts and large storm events happen, and it takes only a single event with a corresponding uncontrolled release of mine contamination to devastate downstream fisheries.

5. Qualifications of the Authors

Cameron Wobus, PhD, is a geomorphologist and surface and groundwater hydrologist. His areas of specialty include surface water and groundwater hydrology, sediment transport, climate change science, geographical information systems, and numerical modeling. Dr. Wobus has developed and implemented watershed-scale hydrologic monitoring and models, quantified the effects of climate change on coastal erosion along a permafrost-rich coastline in northern Alaska, developed numerical models of sediment transport and river incision, and evaluated contaminant fate and transport pathways in surface and groundwaters. His publications have appeared in journals including *Nature, Earth and Planetary Science Letters, Geology,* and the *Journal of Geophysical Research*. Dr. Wobus holds a PhD in earth sciences from the Massachusetts Institute of Technology, an MS in earth sciences (hydrogeology) from Dartmouth College, and an AB in economics and geology from Bowdoin College.

Ann Maest, PhD, is an aqueous geochemist with expertise in the fate and transport of natural and anthropogenic contaminants in groundwater, surface water, and sediment. She has over 20 years of research and professional experience as a geochemist and has worked on natural systems as well as on systems that have been impacted by industrial activities, especially hardrock mining and petroleum exploration. Dr. Maest's research includes studies of metal-organic interactions, metal and metalloid speciation, water-rock interactions, and redox geochemistry in surface water and groundwater. The results of her research have been published as numerous articles in peer-reviewed journals including *Applied Geochemistry, Canadian Journal of Fisheries and Aquatic Sciences, Chemical Geology, Applied and Environmental Microbiology,* and *Environmental Science and Technology*. Dr. Maest has served on a number of national and international committees, including several National Academy of Sciences committees related to mining and minerals research issues and international committees on mining and sustainable development. She was recently elected to a three-year term on the National Academy of Sciences Committee on Earth Resources. Dr. Maest holds a PhD in geochemistry and water resources from Princeton University and an undergraduate degree in geology from Boston University.

James Holmes, MS, is a hydrologist with expertise in contaminant fate and transport, acid mine drainage, and water quality modeling. Over the past 18 years, he has worked at numerous hard rock mining sites an employee of Stratus Consulting, Stratus Consulting's predecessor company, and as an employee of the U.S. Army Corps of Engineers. His research has included hydrograph separation in stormflow, geochemical mixing models, and sources of acid mine drainage. He has extensive field experience in flow measurement and water quality sampling and has evaluated environmental impacts at several large mining operations, including the Clark Fork Complex in Montana, the Bunker Hill/Coeur d'Alene Complex in Idaho, the Upper Blackbird Mining District in Montana, the Ray Mine in Arizona, and the Tri-State Mining District in Missouri, Kansas, and Oklahoma. Mr. Holmes holds an MS in earth sciences from Dartmouth College and a BA in environmental biology from Middlebury College.

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