TECHNICAL MEMO

TO: Mai-Linh Hunyh, Canadian Environmental Assessment Agency
Ann Riemer, Saskatchewan Ministry of Environment
FROM: Ethan Richardson, Shore Gold Inc.

DATE: November 27, 2013

SUBJECT: Response to Federal Question NRCan #12

On October 3, 2013, the Canadian Environmental Assessment Agency provided an additional question (NRcan #12) to Shore Gold Inc. as part of the review of the proposed Star-Orion South Diamond Project. This memo provides a response to these questions, which are reproduced below for reference.

NRCan Submission

Additional information required. During the mine operational phase, most of the seepage from thePKCF would exit through the containment dams to the perimeter collection ditches. Vertical downward seepage flow through the deposited PK fines after approximately 2 years of deposition would be extremely slow and take approximately 117 years to arrive at Duke Ravine based on vertical hydraulic conductivity of $1x10^{-9}$ m/s. With the buildup of fines on the upstream sides of the containment dams, the PKCF would only be able to dewater its standing free water through the upper sections of the containment dyke and the bulk of the deposited PK may remain permanently saturated which may not dewater any further. This likelihood of occurrence may have important implications on the effectiveness of post mining PKCF reclamation and decommissioning as the site may remain too wet to support any heavy equipment for cover application purposes. This likelihood of occurrence may also have consequential effects on the predicted water quality of receiving water bodies post-closure.

Questions:

1) Does the predictive water quality model of the seepage consider occurrences described above (i.e. sensitivity in reclamation effectiveness of the PKCF)? If no, explain why. If yes, describe the sensitivity analysis used in the model.

2) If any, what water quality parameters are predicted to exceed guidelines at its arrival at Duke Ravine 100 years post closure, and how will these exceedances affect aquatic biota in the Duke Ravine and the overall water quality in the Saskatchewan River?

Response to Question #1

Reclamation effectiveness of the PKCF has low levels of uncertainty due to the nature of the fine PK and water management during operations and closure. Fine PK is defined as material less than 1 mm, and as such, is a relatively coarse grained material. Other operations define 'fine tailings' in different ways, with mines in Alberta defining the fine fractions as material less than 44 µm. For the proposed project, even the cycloned fine PK would be coarser (less than 0.25 mm or 250 µm) than most other mines 'fine tailings'. In addition, the fine PK is created only by crushing and washing of the kimberlite. No heat or chemicals are used in the proposed process that have the potential to change the chemistry of the clay particles in ways that could affect their settling. Consolidation and settling characteristics are described in the April 2013 response to the Provincial Industrial Branch IR#11. In these reports, significant differences were described between the settling characteristics of the 'ultra fine' fraction of ore from Star and Orion South due to the different clay mineralogy at the two ore bodies. Fine PK from Star settled rapidly, while Orion South fine PK did not. Within the PKCF, only fine PK from Star will be managed. Once mining begins at Orion South, all fine PK and process water will be managed in the Star Pit.

The proposed Project does not contemplate the use of flocculants or coagulants during operation as results of specific studies (see response to Provincial Industrial Branch IR#11), operation of the exploration processing facility (which produced PK with particle sizes less than 0.5 mm, i.e., finer than the proposed Project) and associated fines management area, and observations from other diamond operations do not indicate potential issues with closure of the PKCF. Even so, reclamation and water management at closure is designed to facilitate development of a trafficable surface.

The PCKF will be decommissioned upon completion of mining at Star, and not used during the mining of Orion South. As such, progressive reclamation will begin about 8 years prior to overall site closure. Once the PKCF berms are constructed to their final height (i.e., in year 17), a 1 metre overburden cap would be placed on it and the site would be revegetated. On the interior of the PKCF, the first reclamation step would be to pump any standing free water from the PKCF to the Star pit, which would minimize the amount of saturated fine material, and facilitate internal drainage of the fines. This pumping would also remove whatever fine material remained in suspension in the free standing water. Reclamation material (1 metre depth) would then be placed on the unsaturated fine material as it dries out and becomes trafficable. Internal drainage and seepage would continue to be managed by the Star Pit until the facility is fully reclaimed. As Shore would actively drain and manage this facility for 8 years of operation prior to Closure, and would continue to manage PKCF water until such time as the facility is reclaimed, the water quality model does not consider the events described in NRCan#12.

Response to Question #2

Water quality of shallow groundwater from under the PKCF was estimated using a modified exposure/pathway assessment. The assessment modeled the resultant water quality as shallow groundwater moves under the PKCF and receives input from seepage through the bottom of the PKCF. Using the 2-D analytical method used by Arcadis to respond to Federal Comment NRCan#10 in April 2013, seepage and travel time under the PKCF was calculated using the values contained in Table 1 and the following assumptions:

- Horizontal gradient across the PKCF in the sand is constant in time and space;
- Inputs due to precipitation are intercepted by the PKCF and must infiltrate through the fine PK;
- Precipitation on the PKCF berms or onto bare sand between the PKCF and the Duke Ravine are assumed to run-off (i.e., does not infiltrate into the sand). This is conservative as precipitation inputs would improve groundwater quality;
- Assume no interception of groundwater by the drainage ditches;
- Assume no loss through the first silt/clay layer; and
- Assume groundwater is fully mixed upon discharge to Duke Ravine.

Table 1. Parameters Used in the Pathway Assessment

Parameter	Value
Horizontal Gradient (upper sand)	0.025
Horizontal conductivity in the upper sand	$2.0*10^{-4}$ m/s
Vertical gradient through the fine PK	1
Vertical conductivity in the fine PK	$1*10^{-9}$ m/s
Porosity of the sand	0.3
Saturated thickness of the sand	6.5 metres
Maximum pathway under the PKCF	3,500 metres

This analysis calculated that it would take 11.1 years for groundwater to move through the surficial sand, under the entire length of the PKCF. Also, seepage through the bottom of the PKCF was calculated to be 0.0315 m/yr. Water quality was calculated using this input, over time, to the shallow groundwater to estimate water quality.

Baseline Shallow Groundwater and Duke Ravine water quality were taken from Tables 3.7 to 3.9 of Appendix 6.2.7-A of the Revised EIS. Seepage water quality (Table 2) was estimated from kenetic testing presented in Section 5.3.2 of the Revised EIS. As the kenetic testing results vary considerably with time (as the material weathers) a short term (corresponding to the initial, and often worst case results of the kenetic testing), medium term (corresponding roughly to the mean value of the transient portion of the testing) and long term (corresponding to the steady state results of the testing). Note that these estimates are conservative, as the fines in the PCKF would not be subjected to the same weathering factors as those simulated in the lab testing. Fine PK in the PKCF would be initially exposed to oxygen and freeze-thaw cycles, however, once buried, the PK would remain saturated with water, limiting further weathering. Relevant water quality guidelines are also presented in Table 2.

Discussion of Water Quality

Water quality parameters that exceed CCME guidelines are bolded in Table 2. No seepage water quality estimates exceed existing MMER limits, however natural baseline arsenic levels in the Duke Ravine exceed MMER. Bolded values are discussed below.

Predicted total Aluminum levels exceed the CCME objective for all three time periods, and naturally in the Duke Ravine. Short term modeled groundwater is about twice baseline, and has the potential to alter water quality in the Duke Ravine, however any effect is unlikely as this input is within the range of natural variability presented in the Revised EIS (Section 5.2.8). Medium and long term inputs are equal to or lower than baseline levels and will not affect water quality.

Total Arsenic in the modeled groundwater water quality exceeds the CCME objectives, however this exceedance is due to high naturally occurring levels in the shallow groundwater and in Duke Ravine. As a result, modeled groundwater will not negatively affect water quality.

Modeled groundwater and baseline levels in the Duke Ravine for total Chromium exceed the CCME objective for hexavalent chromium, but fall well below the MMER limit. The use of total Chromium, and the slightly basic pH of the seepage, is extremely conservative. The short term levels in modeled groundwater may affect water quality in the Duke Ravine, however any effects are very unlikely due to the speciation of Chromium in the seepage. Medium and long term modeled groundwater are similar to baseline levels in the Duke Ravine

Short term total Copper levels in the modeled groundwater exceed the CCME objective but are well below the MMER limit. Short term, there is the potential for copper levels to rise incrementally in Duke Ravine, however due to large seasonal fluctuations in total copper in the Duke Ravine, any effect on the aquatic environment would be negligible.

Short term total Iron levels in the modeled groundwater exceed CCME objectives, but are less that the mean concentration in the Duke Ravine. As such, any modeled groundwater will not negatively affect water quality in Duke Ravine.

Zinc levels in the modeled groundwater are greater than the CCME objective, but are lower than the naturally occurring levels in the baseline shallow groundwater. As such, modeled groundwater slightly improves water quality in the output to Duke Ravine as compared to the baseline scenario.

Table 2. Modeled Seepage Water Quality in Shallow Groundwater from the PKCF

Parameter	Units	CCME (2011)	MMER (1996)	Duke Ravine	Shallow Ground water	Seepage water quality			Modeled Ground Water Quality at Duke Ravine		
						Short Term [1]	Medium Term[1]	Long Term [1]	Short Term [1]	Medium Term [1]	Long Term[1]
pH	pHunit	-		8.3	7.95	9	8.6	8.5	8.11	8.04882	8.03361
Specific conductivity	uS/cm	-		403	382	10000	2500	800	1844	704	446
Sum of Ions	mg/L	-		352	330	1050	1050	600	439	439	371
Sulfate	mg/L	-		7.9	5.4	1000	400	250	156.6	65.4	42.6
Aluminum-T	mg/L	0.1		**0.213** [2]	0.0005	3	1.5	1	**0.46**	**0.23**	**0.15**
Arsenic-T	µg/L	0.005	0.5	**2.8**	**0.2**	0.1	0.04	0.02	**0.18**	**0.175**	**0.17**
Cadmium-T	mg/L	0.00006		0.00006	0.00005	0.00002	0.00001	0.000005	0.00005	0.00004	0.00004
Chromium-T	mg/L	0.001 (hexavalent)		**0.00167**	**0.0005**	0.07	0.01	0.008	**0.01107**	**0.00194**	**0.00164**
Cobalt-T	mg/L	-		0.00039	0.0001	0.01	0.004	0.0002	0.00161	0.00069	0.00012
Copper-T	mg/L	0.004	0.3	0.00129	0.0002	0.05	0.02	0.01	**0.00777**	0.00321	0.00169
Iron-T	mg/L	0.3		**1.08**	0.001	4	2	1	**0.61**	0.30	0.15
Lead-T	mg/L	0.007	0.2	0.00051	0.0001	0.004	0.003	0.002	0.00069	0.00054	0.00039
Molybdenum-T	mg/L	0.073		0.0032	0.001	0.15	0.05	0.005	0.02365	0.00845	0.00161
Nickel-T	mg/L	0.15	0.5	0.00148	0.0001	0.015	0.09	0.05	0.00237	0.01377	0.00769
Selenium-T	mg/L	0.001		0.00019	0.0001	0.00025	0.00025	0.00025	0.00012	0.00012	0.00012
Thallium-T	mg/L	0.0008		0.0001	0.0002	0.004	0.001	0.001	0.00078	0.00032	0.00032
Zinc-T	mg/L	0.03	0.5	0.0073	**0.069**	0.01	0.007	0.004	**0.06003**	**0.05957**	**0.05912**

1. Note that for Cadmium, Chromium and Iron, kenetic testing results showed high variability in these parameters over the test period. For these parameters, reported numbers correspond to low, medium and high estimates of water quality
2. Bolded numbers indicate an exceedance of the CCME water quality guidelines.

Conclusion

Estimates of long term, medium term and short term water quality in the shallow groundwater after closure were estimated using a conservative exposure/pathway assessment.

Results show some exceedances of CCME objects as described above. These exceedances will not translate into effects on the aquatic environment due to the naturally high levels of some parameters, and the high degree of natural variability in the receiving waters. No parameters are predicted to be higher than MMER limits.

Estimated water quality in the surficial sand aquifer discharging to the Duke Ravine 100 years post closure is conservatively estimated as values contained in the ‘medium term’ column in Table 2.

Please do not hesitate to contact me with any questions or comments about the attached information.

Sincerely,

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