“GGM HARDROCK PROJECT - MERCURY IN SURFACE WATER, FISH TISSUE AND ASSOCIATED HUMAN HEALTH AND ECOLOGICAL RISK ASSESSMENT” MEMO

Stantec

Memo

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INTRODUCTION

Since the submission of the Final Environmental Impact Statement/Environmental Assessment (Final EIS/EA), several comments were submitted regarding the evaluation of potential ecological and human health effects related to the potential effect that the Project could have on mercury levels in surface water and fish tissue in Kenogamisis Lake. This memo provides additional information to clarify the baseline surface water sampling data for mercury in Kenogamisis Lake used in the assessment. It also identifies how non-detect samples were treated in the assessment and explains how the selected approach provides conservative over-estimates of future case mercury and methylmercury concentrations in surface water and fish tissue. This memo also clarifies how the approach used to estimate mercury levels in surface water and fish tissue results in over-estimations of potential exposures to mercury and methylmercury and the associated human health risks.

The surface water modelling results presented in the Hardrock Project Final EIS/EA incorporated 924 surface water samples and followed well established peer-reviewed methods to provide a conservative evaluation of the potential increase in mercury concentrations in Kenogamisis Lake. Based on this assessment, there is a high degree of confidence that the Project will make a negligible contribution to mercury and methylmercury concentrations in surface water in Kenogamisis Lake. Monitoring has been proposed to confirm these predictions. Based on the conservatism used in predicting mercury and methylmercury concentrations in surface water and fish tissue, there is also a high degree of confidence that the Project will make a negligible contribution to ecological and human health risks.

MERCURY IN SURFACE WATER

Mercury concentrations in surface water, under Baseline Case and Future Case conditions, are discussed in detail in Sections 10.2 through 10.4 of the Final EIS/EA. The following discussion provides an overview of the process used to determine baseline mercury concentrations in surface water bodies monitored by the Project and how these data were used to predict future mercury concentrations in surface water.

A total of 924 baseline surface water samples collected in support of the Project between 2013 and 2016 were submitted for metals analysis, including mercury. Mercury concentrations were below the original detection limit of 0.10 µg/L in the initial 45 water samples collected in late 2013. The detection limit of 0.10 µg/L is ½ the Provincial Water Quality Objective (PWQO) for mercury of 0.20 µg/L and is consistent with the MISA Protocol for the Sampling and Analysis of Industrial/Municipal Wastewater (MOECC 2016), which indicates that the analytical method detection limits and limits of characterization for mercury should be 0.10 µg/L.

To obtain measured mercury concentrations in surface water, an additional 297 samples were collected and submitted for analysis using a mercury detection limit of 0.01 µg/L. Mercury concentrations in all 297 samples were below the 0.01 µg/L detection limit. In the remaining 582 samples collected as part of the baseline surface water sampling program, the mercury detection limit was lowered to 0.005 µg/L. Mercury concentrations were below the 0.005 µg/L detection limit in 569 of these 582 samples. Detectable concentrations of mercury were found in only 13 of the 582 samples.

Although the data strongly indicate that mercury concentrations in surface water are typically below 0.005 µg/L, the water quality assessment adopted a conservative approach in predicting both Baseline Case and Future Case mercury concentrations in surface water in Kenogamisis Lake. In samples where mercury concentrations were below the detection limit, consistent with ECCC 2012, mercury was assumed to be present at ½ the detection limit as follows:

i. For the 45 samples below detection at 0.10 µg/L, a concentration of 0.05 µg/L was used.

ii. For the 297 samples below detection at 0.01 µg/L, a concentration of 0.005 µg/L was used.

iii. For the 569 samples below detection at 0.005 µg/L, a concentration of 0.0025 µg/L was used.

When this conservative approach is used, the mercury mean aggregate concentration is calculated as 0.006 µg/L

Most of the baseline surface water samples were collected monthly from up to 35 sample locations. Some locations were sampled quarterly rather than monthly. Thus, the 924 surface water samples reflect seasonal and annual mercury concentrations from fixed locations in the study area over a three-year period. The 13 samples where mercury was detected at concentrations greater than 0.005 µg/L represent 1.4% of the samples. These data show that mercury concentrations at most sampling locations are below detection limits over the 3-year period even though the detection limits were lowered over the course of the sampling program. The minor increase in detections identified in sample sets with lower detection limits suggests that if the lowest detection limit of 0.005 µg/L were applied over the entire surface water monitoring program since 2013, it is expected that only 2 – 3% of samples would have been above the detection limit. This suggests that mercury concentrations in surface water are typically below 0.005 µg/L in surface water in Kenogamisis Lake. Based on these results it is reasonable to assume that mercury concentrations are below 0.005 µg/L. Thus, it would be reasonable to apply a ½ detection limit of 0.0025 µg/L to the 911 of 924 samples where mercury concentrations were below the detection limits. Such an approach would result in an estimated mercury concentration of 0.0025 µg/L Although, there is sound rationale for using 0.0025 µg/L as the estimated Baseline Case mercury concentration in surface water, the assessment used 0.006 µg/l as the estimated mercury concentration to provide conservative estimates of both Baseline and Future Case mercury concentrations in surface water.

The conservative data handling of non-detects samples (i.e., assumed mercury was present at ½ the detection limit) has resulted in an over-estimation of baseline mercury concentrations in surface water in Kenogamisis Lake. The over-prediction of baseline conditions results in a corresponding over-prediction of future conditions. This over-prediction of Future Case conditions is discussed further in the following sections.

MASS BALANCE WATER QUALITY ASSESSMENT

Building on the mass balance assessment completed for baseline conditions, a mass balance assessment for operation and closure was completed to predict water quality changes in watercourses/waterbodies including Barton Bay, Southwest Arm, Central Basin and the Outlet Basin of Kenogamisis Lake. Mercury was among the parameters selected for further assessment due to regulatory agency and Aboriginal community comments. The predicted changes in mercury in water during operation and closure for Kenogamisis Lake are discussed below.

Table 1 provides a mercury-focused overview of baseline conditions and predicted concentrations during operation, active closure and post-closure for the basins of Kenogamisis Lake. The increases predicted in Central Basin East reflect the over-prediction of baseline mercury concentrations at a station in the Central Basin. Other predicted increases are an artifact of baseline overprediction described above by use of ½ of the detection limit.

Table 1: Mercury Surface Water Quality - Baseline, Operation, Active Closure and Post-Closure

Site	Table Referenced in Final EIS/EA	Unit	PWQO	CWQG -FAL	Baseline	Predicted Operation	Predicted Active Closure	Predicted Post-Closure
Barton Bay West	Table 10-39	µg/L	0.2	0.026	0.0105	0.0105	0.0105	0.0105
Barton Bay East	Table 10-41	µg/L	0.2	0.026	0.0089	0.0091	0.0091	0.0091
Southwest Arm of Kenogamisis Lake	Table 10-43	µg/L	0.2	0.026	0.006	0.0069	0.0068	0.0068
Central Basin East	Table 10-45	µg/L	0.2	0.026	0.025	**0.029**	**0.0293**	**0.0279**
Outlet Basin	Table 10-47	µg/L	0.2	0.026	0.0068	0.0077	0.0073	0.0074

Note:
Bold numbers are identified as exceedances of PWQO/Interim PWQO/CWQG-FAL

SUMMARY OF MERCURY CONCENTRATION PREDICTIONS

Although there is strong evidence that mercury concentrations in the water of Kenogamisis Lake and surrounding surface waters monitored in support of the Project are very low, and geochemical evidence that suggests the Project will not contribute mercury to the receiving environment, the water quality loading prediction method used in the EIS/EA conservatively predicts an increase in mercury concentrations in surface water at certain locations. The conservative data handling and modelling approaches used throughout the development of the EIS/EA have resulted in an over-estimation of Baseline conditions, resulting in a corresponding over-prediction of Future Case conditions.

METHYL MERCURY

As discussed in Section 10.4.2.2 of the Final EIS/EA, the Goldfield Creek diversion to the Southwest Arm Tributary will increase the flow in the Southwest Arm Tributary and result in an increase of the permanently inundated area by approximately 15 ha. This is the limited area where the potential for mercury methylation to occur exists. While this area is accustomed to periodic flooding under baseline conditions and is not expected to be an appreciable source of mercury, the Ministry of the Environment and Climate Change (MOECC) requested that this be evaluated in the Final EIS/EA.

The generation of methylmercury has been investigated through many studies at the Experimental Lakes Area of northern Ontario. The most applicable study was completed by St Louis et al. (2004) where it was reported that the net yield of methylmercury in the wetland complex increased from 1.7 mg/ha/yr under pre-flooding conditions to approximately 70 mg/ha/yr in the first year of loading. The net yield of methylmercury in the wetland complex declined (10 to 50 mg/ha/yr) during the subsequent flooding periods. The mercury methylation rates were observed to be the highest in the first 1 to 2 years of flooding and to decrease in subsequent years due to microbial demethylation.

Based on the studies discussed above, using the highest methylmercury net yield of 70 mg/ha/yr, the estimated methylmercury yield from the increased permanently inundated area around the Southwest Arm Tributary is approximately 1,050 mg/yr. Based on the mean annual flow estimated for the Southwest Arm Tributary after the diversion, the conservatively estimated increase in methyl-mercury concentration in the Southwest Arm Tributary is 0.0001 µg/L (0.1 ng/L). The CWQG-FAL limit for methylmercury is 0.004 µg/L, which is 40 times higher than the maximum predicted methylmercury concentration.

The findings presented by St Louis et al. (2004) were the result of a multi-disciplinary project undertaken at the Experimental Lakes Area (ELA) in northwestern Ontario to study how the construction of a reservoir over a wetland affects the surrounding ecosystem, including the reservoirs' cycling of mercury. To confirm the relevancy of the St Louis et al. (2004) study to the proposed work surrounding the Southwest Arm Tributary and Goldfield Creek diversion, a review of additional studies was undertaken. In addition to the St Louis et al. (2004) study, two additional studies resulting from this project (known as the Experimental Lakes Area Reservoir Project – ELARP) addressed the cycling of mercury and methylmercury in the constructed reservoir. Kelly et al. (1997) reported on fluctuations of methylmercury in the two years prior to and the two years following the reservoir's flooding. The St Louis et al. (2004) study was a follow up to the Kelly et al. (1997) study and analysed long-term (9-year) effects following reservoir flooding. The final study prepared by Paterson et al. (1998) studied the effects of methylmercury in zooplankton for a period of three years following the reservoir flooding for the ELARP.

While the ELARP project was carried out in a flooded wetland area because it was thought the high organic carbons in peat would present a worst-case scenario, researchers also wanted to study the various effects of reservoir construction, including methylmercury circulation, over boreal forest surfaces varying in stored organic carbon. The Flooded Upland Dynamics Experiment (FLUDEX) consisted of building dykes along low-lying contours at 3 sites with varying levels of stored organic carbon and ultimately flooding the sites. The operation of a reservoir at these sites was simulated through v-notch weirs acting as outfalls. The first study in FLUDEX prepared by Hall and St. Louis (2004) had a primary objective of observing among other variables, plant tissues' methylmercury concentrations, however the study was unable to identify impacts resulting from the varying levels of stored organic carbon between sites. A study by Hall et al. (2005) however, concluded that greater quantities of initial stored organic carbon generally coincided with greater yields of methylmercury in the water after flooding. Similar to findings from the various ELARP studies, methylmercury production in the FLUDEX study was highest in the first two years of the study, after which net demethylation began to reduce the water's methylmercury concentrations. Yields of methylmercury were found to be highest in the reservoir with medium quantities of initial organic carbon at 131 mg/ha/yr, which was nearly two times higher than the 70 mg/ha/yr peak found in the ELARP.

The proposed Goldfield Creek diversion to the Southwest Arm Tributary involves the inundation of an aggregate pit and Goldfield Creek to form the Goldfield Diversion Pond, the construction of a new diversion channel and the construction of low head weirs in the lower reaches of the Southwest Arm in areas dominated by riparian wetlands. As such, the proposed works are considered most comparable to the wetland inundation studies conducted in the ELARP research program. However, as some aspects of the FLUDEX study may also be relevant, the higher maximum mercury methylation rate observed in the FLUDEX study was also applied to the proposed Goldfield Creek diversion works. Based on the mean annual flow estimated for the Southwest Arm Tributary after the diversion, the conservatively estimated increase in methylmercury concentration in the Southwest Arm Tributary using the 131 mg/ha/yr FLUDEX maximum rate is <0.0002 µg/L (<0.2 ng/L). The CWQG-FAL limit for methyl mercury is 0.004 µg/L (4 ng/L), over 20 times higher than the maximum predicted methylmercury concentration.

In recognition of the possible effects on water quality from the construction of a new small hydro reservoir, the Ontario Waterpower Association, in consultation with the MOECC, developed a Best Management Practice (BMP) (Hutchinson 2016) for managing the uncertainties regarding methylmercury prediction. Referencing the previously mentioned studies, the BMP provides a descriptive explanation of possible factors affecting the presence of methylmercury and how to minimize its possible effects.

MERCURY MITIGATION

Despite negligible effects under a conservatively modelled scenario, the following proposed Project activities and mitigation measures are expected to reduce the potential for mercury release and methylation:

- Clearing and grubbing of organic vegetation prior to inundation to reduce potential mercury methylation. This is particularly relevant for the diversion aggregate pit area in the Goldfield Creek Diversion pond and the diversion channel from the pond to Lahtis Road.
- Removal and collection of organic soils, where feasible, for subsequent use in progressive rehabilitation to reduce potential mercury methylation. This is feasible where constructability and access permits in the upper section of the diversion channel and aggregate pit area in the Goldfield Creek Diversion Pond.
- The proposed inundation areas specifically reduce shoreline erosion, which is otherwise known to accelerate potential mercury methylation release.
- The proposed inundation zones are riverine in the upper diversion channel section and more lacustrine in the Southwest Arm Tributary lowland. The diversion increases the catchment area of Southwest Arm Tributary by more than 200% and will flush more water through the system than under baseline conditions reducing the potential for concentration increase over time under static or low flow conditions.
- Water quality monitoring of the streams and lakes in the local assessment area including the Goldfield Creek Tributary, Goldfield Creek diversion channel, Southwest Arm Tributary inflow to the Southwest Arm of Kenogamisis Lake and Mosher Lake.

MERCURY IN FISH TISSUE

Health concerns related to mercury in fish tissue are generally related to exposure to methylmercury, which is formed from mercury by microorganisms in waterbodies and can eventually accumulate in fish tissue. Methylmercury bioaccumulates in fish tissue resulting in the highest concentrations generally being found in large predatory fish (e.g., walleye) that prey on smaller fish.

For the characterization of baseline conditions in the Project area for the EIS/EA (i.e., Baseline Case), three species of fish were collected to determine concentrations of metals in fish tissue: Spottail Shiner, Trout-

Perch, and Walleye. In total, 31 samples of wholebody small fish (Spottail Shiner and Trout-Perch) from Goldfield Creek, Southwest Arm of Kenogamisis Lake, Kenogamisis Lake (historical Hardrock Tailings), and Kenogamisis Lake (historical MacLeod tailings) were analyzed for metals (including mercury and methylmercury). The data from the wholebody analysis of these small fish were used to estimate health risks in the ecological risk assessment (ERA) for piscivorous species because smaller fish rather than larger fish are expected to be a food source. In total, 55 samples of Walleye liver and Walleye fillet from Goldfield creek, Southwest Arm of Kenogamisis Lake and Kenogamisis River Outlet were analyzed for metals (including mercury and methylmercury) and the results were used in the human health risk assessment (HHRA). Walleye is a target species for fishing in Kenogamisis Lake.

The 95% upper confidence limit of the mean (UCLM) concentrations of total mercury and methylmercury in both whole body fish tissue and combined fillet and liver tissue are provided in Table 2. The concentration of methylmercury in tissue from large fish is approximately four times greater than in small fish (bioaccumulation). In both the HHRA and ERA, mercury in fish tissue was conservatively assumed to be 100% methylmercury. Based on the results provided in Table 2, this assumption results in an overestimation of the methylmercury concentration by approximately two times, which in turn results in an approximately two times overestimation of health risks for both human and ecological receptors exposed to methylmercury in fish tissue.

Table 2: Concentration of Mercury and Methylmercury in Fish Tissue.

Fish	Number of Samples	Parameter	95% UCLM Concentration (mg/kg wwt)	% Methylmercury
Large Fish (i.e., Walleye)- Analysis of Fillet and Liver	55	Total Mercury	0.586	44.4%
		Methylmercury	0.260	
Small Fish (i.e., Spottail Shiner, Trout-Perch)- Analysis of Wholebody	31	Total Mercury	0.151	44.5%
		Methylmercury	0.0672	

HHERA AND MERCURY

The baseline surface water sampling shows that mercury and methylmercury levels in surface water in Kenogamisis Lake are generally below the method detection limits as well as below the levels that represent an environmental concern for human or ecological receptors. The geochemical leach data supports the conclusion that the Project will not alter mercury or methylmercury levels in the lake or in the tissues of fish that reside in the lake. The conservative assumptions used in predicting the changes in mercury levels in the lake and those used in predicting the potential human health and ecological risks associated with these changes overestimate the potential Project-related risks associated with mercury. Potential health risks are further overestimated by assuming mercury in fish tissue is 100% methylmercury. Even with these over-predictions, the Project-related health risks associated with the methylmercury are considered negligible. The multiple conservative assumptions used in these predictions provide a high degree of confidence in this conclusion.

Reference: GGM Hardrock Project - Mercury in Surface Water, Fish Tissue and associated Human Health and Ecological Risk Assessment

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