Western Science

May 29, 2026

To: J. Esmonde, Cavalluzzo LLP
From: Dr. Brian Branfireun, London, Canada (bbranfir@uwo.ca)

RE: Great Bear Project – Impact Statement
(https://iaac-aeic.gc.ca/050/evaluations/document/166124)

1) Introduction

I was asked to review the above Impact Statement documents for the Kinross/Great Bear Gold Pro ject and provide an expert opinion. I have also reviewed the report of Dr. K. Morin (May 2026) re lated to this same Impact Statement, as his expertise in geochemistry- and mine-related processes is relevant and complementary to mine. I have provided expert opinion on many submissions and memos related to dimensions of this project leading up to this Impact Statement, and this document largely relies on those prior submissions which will be referred to here where appropriate, in the in terest of brevity. Given the extensive technical scope of the IS documents I am unable to comment on many aspects as they are outside of my area of expertise. As such I am focussing on the compon ents of the Impact Statement which concern themselves with sulphate release from the Project, the evaluation of mercury methylation in receiving ecosystems, and the potential exposure to biota.

2) Summary of Opinions

1) Despite a substantial shift in the degree of acknowledgement of the sulphate – mercury methyla tion issue by the Proponent, the Proponent's ultimate conclusion of little to no impact on methylmercury levels in fish (or consumers) by the proposed Project is arrived at through a flawed conceptualization of the processes involved, flawed field methodologies, and oversimplified mod- elling that combine to minimize project effects.

2) The minimization of the Project impact on mercury methylation entirely hinges on the estimates of sulphate release into receiving waters by the Project. It is the opinion of other ANA Experts that the estimate of source water sulphate is flawed based on the opinion of other Experts, and the treat ment technology that is proposed is vague, with its efficacy entirely dependent on the source water sulphate concentrations. Even if the stated estimates of treatment efficiency and effluent chemistry are accepted, effluent sulphate concentrations would be 2-6 times higher than natural background concentrations, which by definition contribute to degradation of an already human-impacted water course.

3) Despite repeated presentation of evidence to the contrary in my prior memos, sulphate concen- trations in the receiving waters are neither 'low' nor 'typical' of other northern rivers as stated

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throughout the IS documents. As I have repeatedly opined about in prior memos (most recently Branfireun (May 6, 2026 - RE: Great Bear Project - Comments on the Great Bear Environmental Compliance Approval for Advanced Exploration, Number 5373-DEWHG7, dated April 17, 2026), the Great Bear Gold Project lacks a scientifically valid natural background site, and there is no new information in the IS to change this opinion. There is ample evidence that natural background con centrations are substantially lower than those measured at "reference" upstream locations, reflect cumulative impacts of industrial activities, and the use of these 'baseline' data is a license to pollute an already degraded watercourse.

3) Details of Opinions

3.1 Project Impacts on Mercury and Methylmercury is Minimized through Flaws, Errors, and Oversimplifications

Throughout the Impact Statement documents and in particular "Section 7: Analysis of Changes to Pathway Valued Components - Water pVCs (Section 7.5 to Section 7.7)" and "Appendix T: Mercury Bioaccumulation Study for Downstream English River to Wabigoon System Waterbodies", we find an even more fulsome consideration of the controls on mercury cycling in aquatic ecosystems than was found in the Proponents Mercury Study Plan (WSP, December 2024). As I indicated in my review of that document, the direct and indirect effects on mercury biogeochemistry of the proposed project were dismissed, downplayed or ignored in earlier submissions by the Proponent. Nearly unconditional acknowledgement of the link between sulphate loading and mercury methylation by the Proponents in this document is welcome and significant. It is also important to note that the Proponent's inappropriate fixation on the immediate downstream mixing zone with respect to sulphate concentrations in the Chukuni River has also softened, with the Proponent accepting assertions that I have made in prior memos that the greater concern lies in aquatic ecosystems downstream that will receive excess sulphate in effluent from the Project.

Despite these conceptual concessions, the document is still rife with an ultimate reliance on stated Water Quality Guidelines for the Protection of Aquatic Life (WQG-PAL), including the continued adherence to the BC WQG PAL for sulphate of 218 mg/L (Table 7-7.1). We find these statements throughout Section 7 and emphasized in particular in Section 7.7.7 Assessment of Effects, where levels less than "WQG PAL and / or equivalent to baseline conditions" is frequently stated (where baseline conditions are only considered when they are HIGHER than WQG PAL). The BC WQG PAL for sulphate is more than 100-fold higher than the best available natural background measure ments in the English River watershed and is not protective whatsoever against methylation and bioaccumulation of mercury.

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With respect to downstream impacts of the proposed Project it is interesting to note that the Proponent itself predicts a significantly measurable increase in sulphate in Pakwash Lake downstream of the Effluent discharge:

> Some water quality parameters in Pakwash Lake are predicted to be greater than baseline conditions, i.e. are at least 20% different from baseline concentrations. These parameters are ammonia, nitrate, nitrite, sulphate, thallium and tungsten. Note that the concentrations of these parameters are well below WQG PAL. The highest concentrations were predicted at the inlet of Pakwash Lake (node PAK-IN), directly downstream of the Chukuni River confluence. Note, while RPD is a useful screening tool for identifying key parameters, it should be interpreted alongside absolute concentrations. In this case, the predicted increases are minor in magnitude. For example, **baseline sulphate concentrations at the outlet of Pakwash Lake (node PAK-OUT) range from approximately 3.8 to 4.2 mg/L and are projected to increase to between 4.9 and 5.4 mg/L during the operations phase** (Table 7.7-21). (Section 7 p. 7-184). (emphasis mine).

Based on their own simplified modelling, this is a stunning 42% increase in sulphate in a downstream water body as a result of their own (problematic) estimates of effluent discharge. To say that this increase is "minor in magnitude" is an understatement, yet the reader is reassured that it is "well below WQG PAL", the value of which for sulphate is irrelevant in the context of mercury methylation potential. An increase in sulphate of this magnitude would be expected to cause a significant increase in mercury methylation.

On the same page in Section 7, we are then reassured that this increase in sulphate will not result in concerns related to mercury methylation because modelling "Results showed a non-detectable, maximum projected increase in methylmercury" in both the Chukuni River and Pakwash Lake. To arrive at this conclusion (and the subsequent obvious conclusions that there are similarly 'undetectable' changes in modelled fish mercury concentrations as a result of the project), the Proponent undertook a considerable effort to model enhancement of methylmercury production by increases in Project releases of sulphate (and subsequent bioaccumulation and biomagnification in biota) (Appendix T). Despite efforts to improve the appearance of technical rigour in the Mercury Bioaccumulation Study, we have the "house of cards" laid bare that I first referred to in my preliminary assessment of the proposed Projects Mercury Study Plan.

Flawed conceptualization of the processes involved: Appendix T provides evidence of some serious literature review on the part of the Proponent with respect to controls on mercury methylation in freshwater systems. Unfortunately, they have chosen to lean on a grossly oversimplified conceptualization of where methylmercury is produced in the environment, focussing on lake sediment and stratified hypolimnetic waters as primary locations. As I outlined in a relatively recent re

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view paper (Branfireun et al., 2020), co-authors and I laid out a path forward to consider this model (which had its origins in the early 1980s) merely a single case on a continuum of methylating envir onments in watersheds. In only focussing on these locations, particularly in a river-lake chain sys tem, other important sites of methylation (e.g. biofilm, periphyton, littoral and hyporheic sedi- ments) are completely ignored. Moreover, the timing of the short (but notably intense) field effort in late September 2025 variably captured stratification in different lakes, based on their own data.

Oversimplified Modelling: The assumption that diffusion (Fick's Law) is the only mechanism of transfer of sulphate into sediments, and methylmercury out of sediments, is both oversimpli- fied and assures an underestimation of exchanges. In flowing systems (such as those in this sys- tem), ***advection*** (the transport of a substance through the bulk movement of a fluid) of sulphate in, and methylmercury and sulphide out, biofilms and sediments would result in fluxes orders of magnitude greater than diffusion alone. Even if deeper lake sediments were an important source of methylmercury in these lakes, direct uptake by sediment biota, and exchange of lake and pore waters through ***bioturbation*** (the reworking or mixing of sediment by living organisms) would likely account for greater mass fluxes of methylmercury from sediments than diffusion alone. In order to even reasonably undertake these calculations, one needs to know the sediment layers where these reactions are occurring. Unfortunately, the sampling as described would completely fail to capture the most biogeochemically active layers of sediments and as such, also contribute to a minimization of the impacts of the project on mercury methylation.

Flawed field methodologies: Appendix T describes lake sediment sampling and sample hand- ling. The document states that "*The core sample was extruded to displace all recovered surface water, debris and periphyton such that only sediment and porewater remained. The biologically active layer of the core was removed section- wise to retain structure and porewater. The next layer down was extracted the same way, to provide a reference of deeper sediment conditions*." (p. 68).

Given that in lake sediments the strongest concentration gradient in all redox-reactive solutes are in the top few mm to maybe cm of the sediment layer, this approach would appear to show insight and rigour. Unfortunately, the depth of the sediment layers are not revealed until we review the data starting in Table 4-7 (p. 81) and we see that the Upper layer is 0-15 cm, and the Lower is 2-37 cm. First, I think it is reasonable to assume that the lower layer is probably a typo and it is 20-37 cm. Regardless, the homogenization of the top 15 cm of sediment would completely smear the zone of real bidirectional exchange with the water column, resulting in dramatically lower concentrations of all redox sensitive constituents, particularly methylmercury. The lower sediment characteristics (if truly 20-37 cm) are academically interesting, but irrelevant to the supply of methylmercury in any lake, in my opinion. This sampling minimizes the impacts of the project.

Secondly, pore waters were extracted from these sediment depths as described in Appendix T: "*Porewater was sampled from hypolimnetic and epilimnion sediment, at each location, by gently*

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agitating the collected sampled vigorously until pore water rose to the surface of the sediment for collection by syringe. The method liberated readily available porewater from the sediment intersti tial spaces, and the recovered porewater was a proxy for the porewater that can freely exchange with overlying surface water (in the case of biologically active sediment) or between sediment layers (in the case of legacy and biologically active." (p. 69).

This is a very non-standard approach to recovering pore waters from intact sediments (if the authors have a citation for this approach it should be included) and fails on several levels to appropriately characterize exchangeable waters with respect to methylmercury production. Firstly, even if the sample were representative of pore water, it would be subject to the same smearing of the thin zone of highest activity at the surface, significantly downward biasing concentrations. Secondly, in order to be even remotely representative, the sample would have had to have been kept under an inert gas, particularly when 'agitating' so that reduced species could be preserved. There is no discussion of sample handling or methodological details, but there are certainly hints that the data from these samples have little utility. Despite tables 4-3 and 4-4 indicating that both sulphate and sulph ide were analysed, only sulphate is reported. I speculate that this is because all sulphide data were below detection limits because of the challenges of field sampling and preserving for sulphide in porewaters and getting analyses conducted with a few days.

On Page 69, we find the interpretation:

> The summary statistics for the key porewater quality parameters related to methyl mercury prediction, are provided below (Table 4-8). The data indicate that in the fall of 2025, porewater was more enriched with methylmercury than epilimnetic surface water and a net gradient of methylmercury from porewater into the lake was occurring; the opposite was true in hypolimnetic water, where methylmercury was higher in surface water and net gradient into sediment was occurring. ***Sulphate was higher in porewater than epilimnetic and hypolimnetic waters, indicating no net gradient of sulphate into porewater. This is an important dynamic to identify, because it indicates that during some of the year no additional sulphate from surface water migrates to porewater and sulphate-related methylmercury stimulation occurs based on the sulphate sink in sediment, rather than from surface water inputs.*** (Emphasis mine).

A more parsimonious explanation is that the porewater data is wrong, and reduced sulphide in pore waters was oxidized to sulphate, which we would not expect to find in deeper lake sediments.

Morin (MDAG, May 2026) offers groundwater advection as another possible explanation, and I would agree with him that if this were the case, then this contribution to advective transport of methylmercury to the water column would far exceed diffusive flux.

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The reason why all of this is relevant is because the conclusion that the Project related increases in sulphate will not affect methylmercury production is almost entirely dependent on the lake sediment and pore water data to calculate diffusional exchange. Since these data are flawed, all subsequent analyses are moot, including all of the predictive calculations of fish mercury concentrations using bioaccumulation factors (BAFs). To see an increase in fish mercury levels by applying a water-based BAF formula, there would have to be a change in water concentrations for the formula to reveal changes. Indeed, to proceed with all of the extraordinarily in-depth technical work to model changes in fish mercury levels and human exposure was entirely pointless once the conclusion was reached that changes in methylmercury levels in water were non-detectable – no further analyses were required. The conclusion based on the "Mercury Bioaccumulation Study" that the project will not increase methylmercury in water, fish, or consumers is unsupportable based on these flaws alone. There is a long-standing scientific consensus that the addition of sulphate will stimulate the formation of additional methylmercury in suitable environmental conditions such as those that exist in the Chukuni River – Pakwash Lake system. Even if the measurements that were made were technically sufficient and rigorous, the failure of the Proponent's measurements to identify locations that exhibit the concentration gradients that support diffusional exchange of sulphate and methylmercury is only evidence that the sites of methylmercury production were not sampled since methylmercury is clearly produced in the aquatic system – it is **not** evidence that additional sulphate does not stimulate net methylation.

Ultimately the greatest weakness of the Mercury Bioaccumulation Study is not even these serious issues, but is the profound uncertainty in both the estimate of the sulphate source term, and the treatment technology that is to be relied upon to reduce sulphate levels in Effluent, elaborated upon in Section 3.2. below.

3.2. Estimate of Sulphate discharged to Receiving Waters is Incorrect/Highly Uncertain

I defer to other Grassy Narrows experts on the matter of source term estimation for sulphate in particular related to the proposed Project. Morin's Section 6 outlines his previously voiced concerns about dramatic underestimations of sulphate from acid rock drainage (ARD). Morin states that, "ML-ARD and water quality would very likely be substantially worse, by up to orders of magnitude, than estimated in the Impact Statement, which includes high-contaminant ARD likely within years of starting Operation." (p. 54).

The implications of this are found by following a trail of bread crumbs in both Section 7 and Appendix T that lead the reader to the voluminous Appendix K-3: Receiver Water Quality Modelling Report, which is the only document that makes anything remotely resembling specific reference to the Wastewater Treatment Plant (WTP) that is proposed to be put in place. Here we find the highly qualified statement that "Best available technologies that are economically achievable are being considered for the WTP to meet the protection requirements of local Indigenous Nations." (p.20),

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and that for water that is to be discharged to the Chukuni River, a "membrane filtration step" will be implemented to remove 95-98% of sulphate. The reader is referred to Appendix C, and in Table C-1 P. 193 we find an "Estimated Membrane Filtration Treated Water Quality" that uses a feed water sulphate concentration of 834 mg/L, and a resultant permeate concentration of 4-11 mg/L (a reduction of 98.7%). Table C-2 on pl. 194 is not discussed anywhere in the document as far as I can tell, but the title is "1:100 scenario Maximum of the average flow rates for year 2040; worst case scenario" and shows a treated water sulphate concentration of 504 mg/L with no removal. It is unclear what this table is but whatever the scenario, it clearly presents an effluent concentration that far exceeds even the ineffectively high 218 mg/L BC MOE WQG PAL, and warrants explanation by the Proponent.

Following his conclusion that ML-ARD is grossly underestimated, Morin writes, "The water-treatment plants discussed in the Impact Statement (see MDAG Section 7 below) could not successfully treat this worse ML-ARD with higher contaminant levels. The Impact Statement states in several places that higher-than-predicted contaminant concentrations in the inflow (feed) water will lead to higher- than-predicted contaminant concentrations in the treated effluent. As a minimum, this means the Chukuni River would become contaminated far worse than indicated in the Impact Statement." (p. 54). Indeed this is supported by the footnote in the table itself, which states clearly:

> **Note: The projection (Table 1 and 2) are estimates and do not reflect actual conditions. These values are subject to change depending on feed chemistry and temperature. Testwork and vendor input is required to verify the data." (Table C-1).**

This cautionary statement that the projections of water treatment efficacy do not reflect actual conditions and are subject to change suggests uncertainty around feed water chemistry and the treatment capacity of the WTP as recently as the revision date of this Table (March 27, 2025), and certainly contradicts the Proponent's assertion of 'high confidence' in these matters repeatedly stated in Section 7 and Appendix T projections.

Even if the values and removal efficiencies in Table C-1 are representative of the true case, then the treated effluent water would still be 2-6 times higher in sulphate than the likely true 'natural background' in the Chukuni River; a matter that I have repeatedly opined on, and would represent an additional mass loading of sulphate that could impact mercury methylation processes (see Section 3.3).

3.3 Sulphate concentrations in the receiving waters are neither 'low' nor 'typical' of other northern rivers

Despite repeated statements to this effect in the Impact Statement, sulphate levels in the Chukuni River are neither low, nor typical. I have commented extensively about this with respect to this projects Advanced Exploration proposal, but it similarly applies here.

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Environmental antidegradation frameworks, including that in the Province of Ontario, state that po tential impacts of a development such as the Great Bear Gold Project be evaluated against natural background conditions **unimpacted by human activity**. The Chukuni River is significantly impacted by upstream human activity (e.g. Evolution and Madsen Mines) both of which discharge large amounts of sulphate to Red Lake/Chukuni River upstream of the site that the ECA uses to es tablish 'Local Baseline." My previous comments noted consistently that this upstream sulphate pollution makes that site unfit for use as a background site, and I have recommended that Kinross establish an appropriate background site.

I have repeatedly stated that the average sulphate concentration in rivers in this region is ~1.8 mg/L, or lower, based on my own data. Even Kinross' own sampling of the English River upstream of the confluence with the Chukuni River, the best available local data to estimate background, had a con centration of 1.2 mg/L, confirming that the **local background criterion set in this document is over 5x higher than a natural background value** for an adjacent river that is not as impacted by human activity. The use of this inappropriate local background level of sulphate as a water quality guideline does not stand up to the test of the Ontario Ministry of Environment Conservation and Parks (MECP) own antidegradation requirements that potential impacts be evaluated against natur al background conditions unimpacted by human activity. The Great Bear Project will discharge ef fluent untreated for sulphate into an already sulphate-polluted water body.

Failing to establish a valid background site and true natural background concentration means that the project would impact downstream methylation indefinitely. The Proponent's own evaluation of downstream sulphate impacts show an **increase to between 4.9 and 5.4 mg/L during the operations phase from** 3.8 to 4.2 mg/L "baseline" (Table 7.7-21). (Section 7 p. 7-184). A measurable increase of this magnitude is cause for alarm if it were true, however this 42% increase would be even more dramatic if compared against what the natural background concentrations of sulphate in Pakwash Lake would be if it were not for significant prexisting upstream sulphate discharges.

If the true **natural background** levels of sulphate in Pakwash Lake were the same as the Chukuni River (which are likely similar to the English River's 1.2 mg/L) , and I use the Proponent's own model projections for potential project-related sulphate increase in Pakwash Lake (5.4-3.8 = 1.6 mg/L for a resultant total concentration of 2.8 mg/L), then the percentage increase in overall sulph ate concentration is an alarming 133%. This calculation lays bare the fact that when a higher impacted 'baseline' concentration is used instead of the appropriate natural background, the impacts of additional loading are inappropriately minimized. This is a particularly stark reality when sulph ate levels in the broader English-Wabigoon River system are considered in light of well-documented legacy and operational mines in the vicinity of Red Lake, numerous planned upstream developments, and the 10 to 20x documented increase in Wabigoon River sulphate levels from the current operations of the Dryden Mill (see Branfireun, 2024).

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It is simply not possible to reliably prevent, detect, and respond to impacts from industrial pollution when a valid background site has not been established.

4) Conclusion

Although this memo is not a comprehensive commentary on the entirety of the Impact Statement for the Great Bear Gold Project, the deficiencies in fundamentally core aspects of the analyses related to mercury methylation are readily visible through the thousands of pages, wall of data tables, and reams of boiler-plate statistical outputs. The contention that the Great Bear Gold Project will not have a measurable impact on downstream mercury methylation, fish mercury levels or exposure to fish consumers is wholly unsupported by the Impact Statement by virtue of modelling and measurement choices that can do nothing but minimize the impact of inevitable sulphate loading on mercury methylation by the proposed project. Even at the level of sulphate loading predicted by the Impact Statement, mercury methylation downstream is expected to increase significantly.

Respectfully,

Dr. Brian Branfireun, London, Ontario, Canada. May 29, 2026

Materials Referred

Branfireun, B; Cosio, C; Poulain, A; Riise, G; Bravo, A. (2020). Mercury cycling in freshwater systems – An updated conceptual model. Science of the Total Environment. 745: 140906.

Branfireun, B. Technical Report: Riverbank Mercury Methylation Dynamics Study May 14, 2024. (Riverbank Mercury Methylation Dynamics Study Technical Report May 14.pdf)

Branfireun B. Great Bear Project - Comments on the Great Bear Environmental Compliance Approval for Advanced Exploration, Number 5373-DEWHG7, dated April 17, 2026. May 6, 2026

Morin, K. Great Bear Gold Project - Review of the Impact Statement (IS). May 27, 2026

Kinross/WSP. Great Bear Gold Project Impact Statement Section 7: Analysis of Changes to Pathway Valued Components - Water pVCs Section 7.5 to Section 7.7 (undated)

Kinross/WSP. Great Bear Gold Project Impact Statement Appendix K-3: Receiver Water Quality Modelling Report (undated)

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Kinross/WSP. Great Bear Gold Project Impact Statement Appendix T: Mercury Bioaccumulation Study for Downstream English River to Wabigoon System Waterbodies (undated)

WSP. Great Bear Project Mercury Study Plan. Dec. 2024.

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