Impacts of the Line 5 Reroute Project on Mercury Cycling in the Bad River Watershed

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Section 401a2 Presentation – May 13, 2025

Outline of Presentation

1) **Qualifications and Summary of Opinion**
2) **Overview: The mercury cycle, sulfate and methylmercury**
3) **Is the Bad River Watershed sensitive to methylmercury contamination?**
4) **What are the impacts of the proposed project on methylmercury production and loading in the Bad River watershed?**

1) Statement of Qualifications

Area of Expertise:

Mercury biogeochemistry; mercury-sulfate interactions; wetland hydrology and biogeochemistry, climate change interactions.

Training and Employment

- PhD (1999) McGill University, Montreal, Canada
- 1999-2010: Professor, University of Toronto, Toronto, Canada
- 2010-current: Professor and Canada Research Chair, University of Western Ontario, London, Canada

Evidence of Qualifications

- 172 published papers, book chapters and reports (Google Scholar May 9/25)
- Expert contributions to State of California, US DOE, USFS, Canadian Federal and Provincial agencies.
- Extensive prior work relevant to this hearing in Minnesota (USFS Marcell Experimental Forest; Minnesota Power, Fond du Lac), and First Nations in Canada (Grassy Narrows).

Summary of Opinion

Hydrological and biogeochemical changes to wetlands as a result of the Line 5 Reroute Project will increase the amount of methylmercury produced in the Bad River watershed, violating the Band's water quality standards.

1) This impact is the result of the project intersection of over 2000 ac of hydrologically-connected wetlands, and subsequent changes to hydrological and ecological characteristics that will enhance the process of mercury methylation.
2) This increase in methylmercury production will cumulatively contribute to the methylmercury load of a mercury sensitive watershed with existing exceedances for mercury levels in fish.
3) Increases in methylmercury production will have more local impacts on other organisms that will affect their biological function.

2) Overview: The mercury cycle, sulfate and methylmercury

2) Overview: The mercury cycle, sulfate and methylmercury

Hg

- Mercury (Hg) is a high priority global pollutant
- Released to the environment through a range of natural and human sources
- Distributed globally in gaseous form in the atmosphere as well as discharged from point sources.
- Dominantly released in inorganic forms, but is most toxic in organic forms.

Some Terminology

Elemental Mercury: can exist both as a liquid (“quicksilver”) or as a gas.

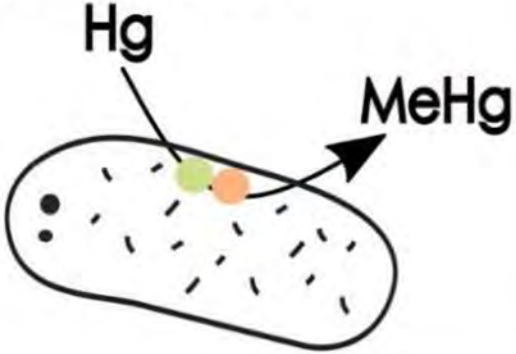
Inorganic Mercury (IHg): the ionic forms of mercury (e.g. Hg(II)) that are most abundant in water, soils and sediments.

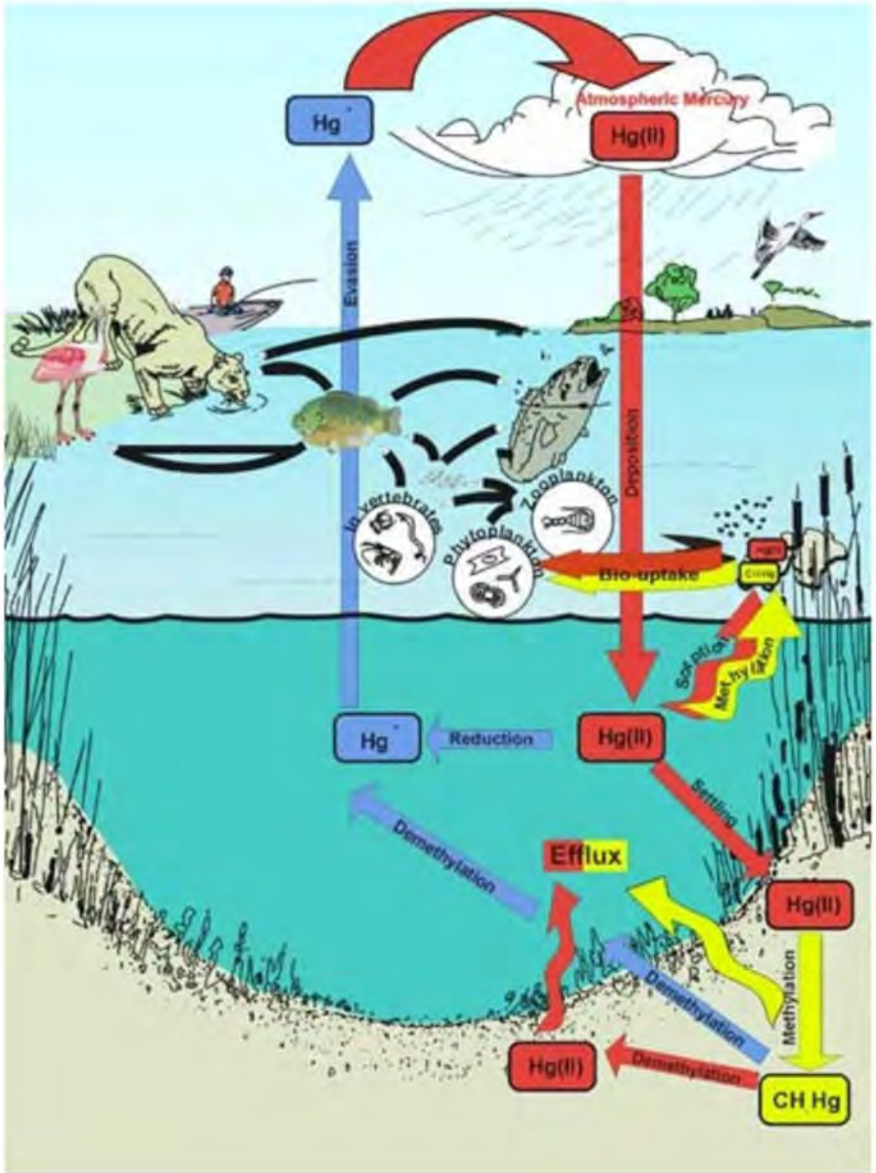
Methylmercury (MeHg): an organic form of mercury that bioaccumulates and is potently **neurotoxic**.

Total Mercury (THg): the sum of all forms mercury in a sample (IHg + MeHg). Is an operational term because of an analytical method.

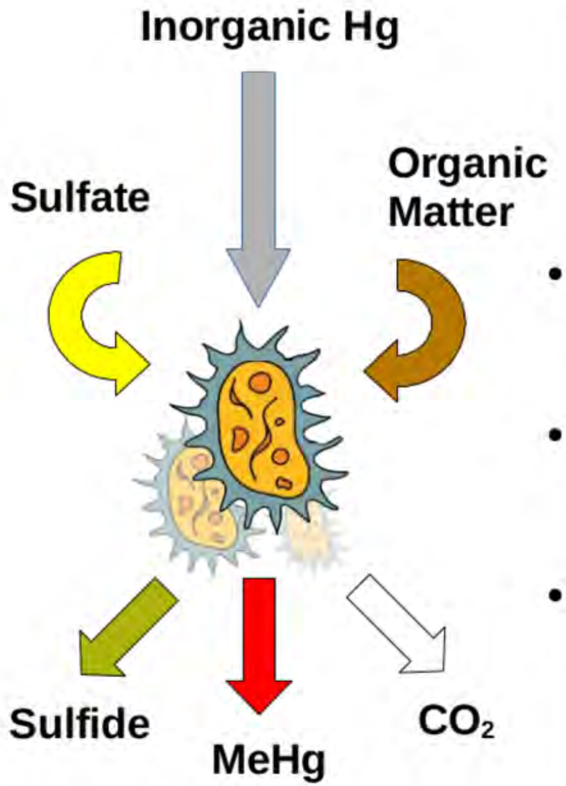
2) Overview: The mercury cycle

- Elemental Hg circulates in the atmosphere
- IHg is deposited to watersheds
- In **oxygen-free waters and sediments**, a very small fraction (usually <1%) of IHg is converted to MeHg
- MeHg is dominantly formed by bacteria in the environment (sulfate-reducing bacteria).

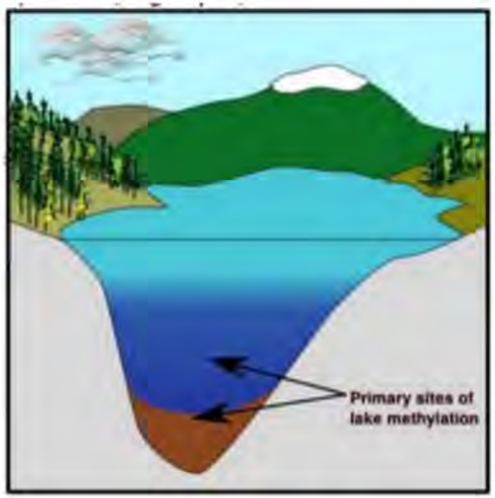


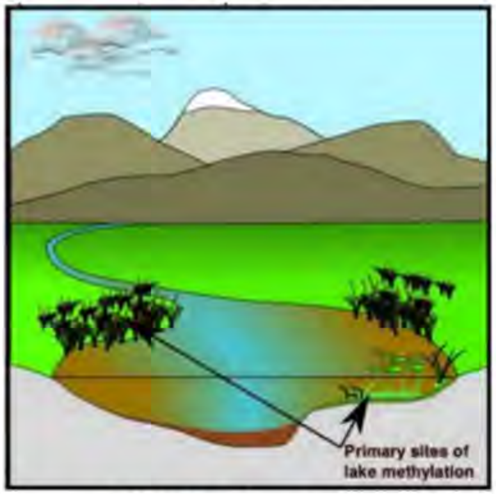


2) Overview: Where is methylmercury formed, and how?



- The bacteria (dominantly sulfate reducers in freshwaters) that convert mercury to methylmercury need **organic matter** (electron donor) and **sulfate** (electron acceptor) to function.
- They can only function in **oxygen-free** (anaerobic) environments.
- Activity is postively related to temperature.
- We have typically thought that these environments were in deep lake water and sediments, now know they are much more diverse (wetlands, riverbank sediments, wet forest soils).

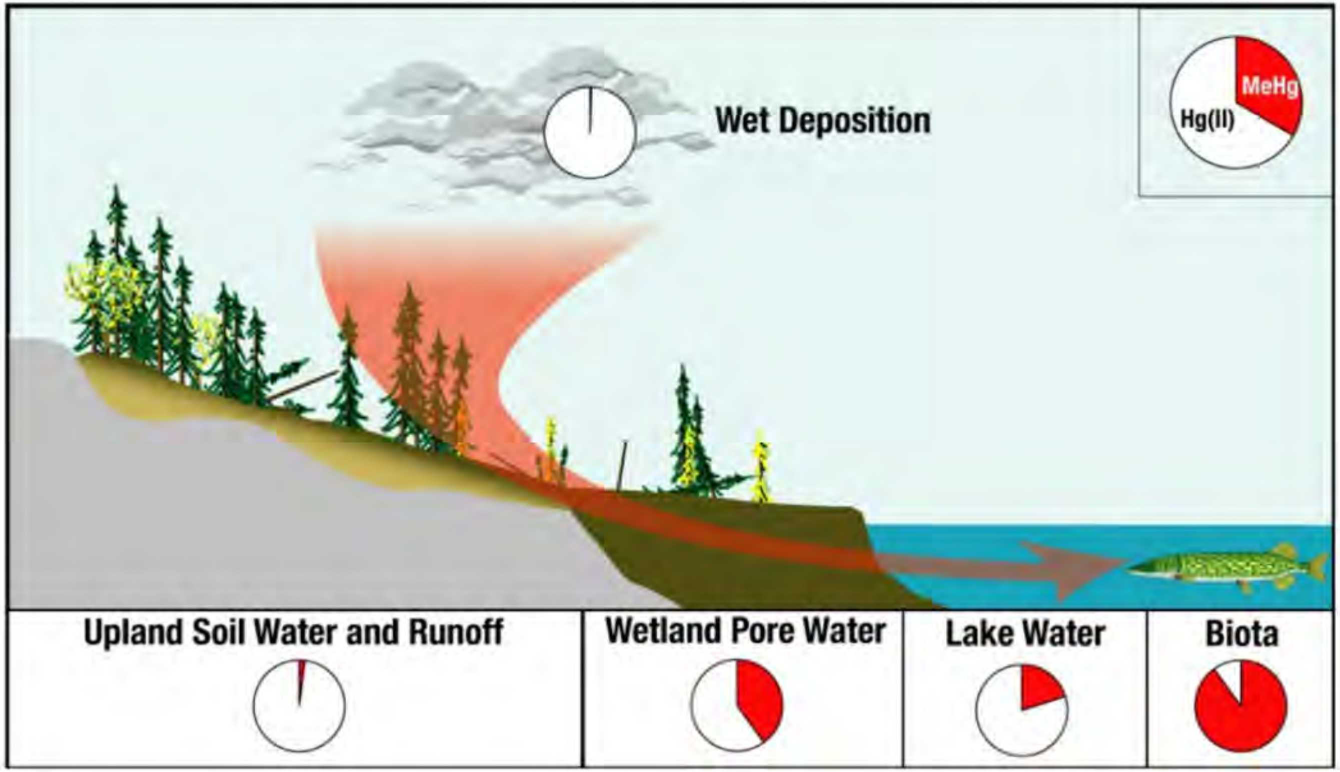


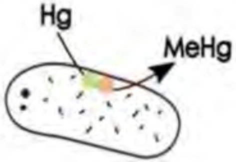


From Branfireun et al., 2020

2) Overview: Where is methylmercury formed, and how?

Wetland sediments are often the locations in watersheds that dominate MeHg formation and transport because they support the biogeochemical conditions that are required for Hg methylation.





From: Krabbenhoft, Branfireun and Heyes, 2005

2) Overview: Wetlands as Sites of Hg Methylation

- Wetlands are frequently characterized by permanent or transient anaerobic conditions, depending on wetland type and hydroperiod.
- Broadly speaking, any watershed that has significant wetland cover will be more mercury 'sensitive' because there is greater potential for MeHg formation.
- This is scientifically well-established, with some of the earliest work being done in Wisconsin.

MeHg Concentrations, Percent of Hg_T as MeHg and Watershed MeHg Yields

watershed type	range	mean	SD	med
Wetland and Forest				
fall				
MeHg concn (ng L^{-1})	0.020–0.870	0.291	0.284	0.200
% of Hg_T as MeHg	1.6–11.1	6.4	3.2	5.8
yield (mg km^{-2} d^{-1})	0.003–0.778	0.148	0.217	0.050
spring				
MeHg concn (ng L^{-1})	0.015–0.390	0.194	0.130	0.164
% of Hg_T as MeHg	0.4–6.7	3.2	1.9	3.1
yield (mg km^{-2} d^{-1})	0.010–1.242	0.507	0.426	0.388

Watershed Transfer Efficiencies for Hg_T and MeHg[a]

watershed type	$WTE_{Hg\,T}$ range	$WTE_{Hg\,T}$ mean	WTE_{MeHg} range	WTE_{MeHg} mean
wetland and forest				
fall	0.01–0.30	0.06	0.07–3.23	0.61
spring	0.029–5.38	0.90	0.04–5.15	2.11
spring[b]	0.029–1.06	0.49	0.04–5.15	2.04
agriculture and forest				
fall	0.03–0.25	0.08	0.02–0.62	0.18
spring	0.13–0.62	0.31	0.13–2.02	0.62
agricultural only				
fall	0.003–0.006	0.005	0.01–0.04	0.02
spring	0.12–0.64	0.29	0.14–0.84	0.52

Influences of Watershed Characteristics on Mercury Levels in Wisconsin Rivers

JAMES P. HURLEY,*,†,‡
JANINA M. BENOIT,‡
CHRISTOPHER L. BABIARZ,‡
MARTIN M. SHAFER,‡
ANDERS W. ANDREN,‡
JOHN R. SULLIVAN,§
RICHARD HAMMOND,§ AND
DAVID A. WEBB†

Hurley et al., 1995

Percent MeHg is important...

2) Overview: Overall Controls on Methylmercury Formation

- Like baking with a recipe, we need the ‘ingredients’ for the methylation process, and a place for the reaction to occur.

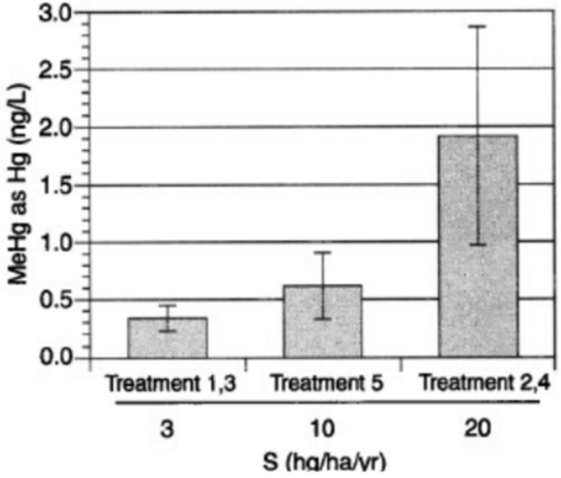
1) **Inorganic mercury**
   - Generally not limited.
2) **Organic matter**
   - Can be limited as a reactant and as a transport factor in some environments.
3) **Sulfate**
   - Can be limited as a reactant in some environments.
4) **Anaerobic environment** that supports SRB
   - Proportion of watershed as wetlands positively related to MeHg export (Hurley et al., 1995 and others).

2) Overview: Overall Controls on Methylmercury Formation

More MeHg will be formed and exported if:

- more of a limiting reactant (sulfate, organic matter) is supplied, and/or
- a greater proportion of the landscape has the conditions to support methylation.

Generally the amount of available inorganic Hg is **not limiting** in most environments due to atmospheric deposition. Changes in the amount of IHg have a small effect on MeHg formation relative to these other controls.



When there is more sulfate added to wetland soils, there is more MeHg (from Branfireun et al. 2001)

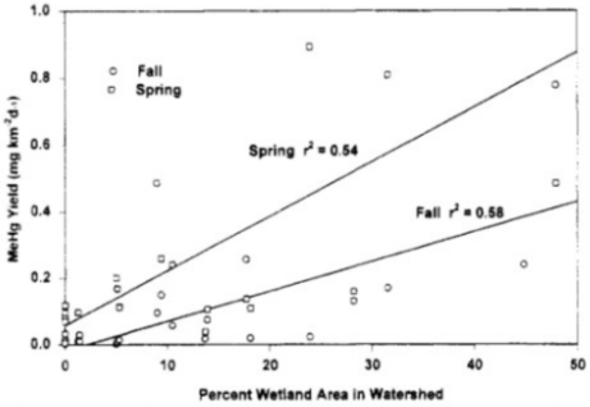
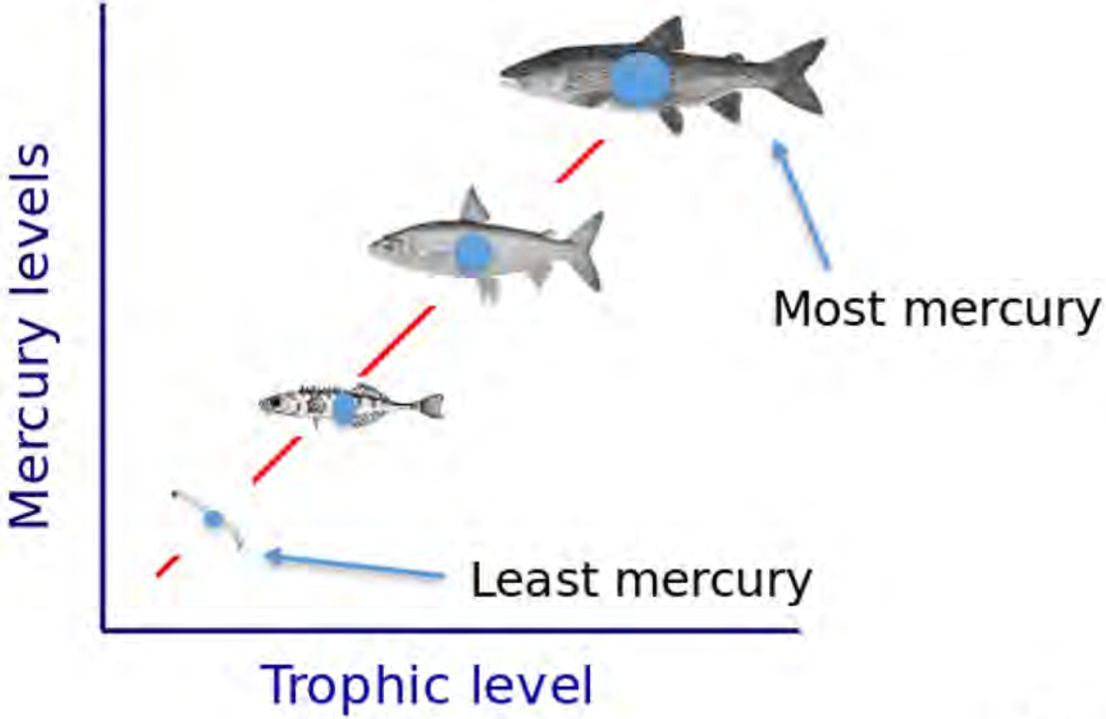


FIGURE 2. Methyl mercury yield vs percent wetland area for wetland/forest sites.

When there is more wetland area in a watershed, there is more MeHg exported.
(from Hurley et al. 1995)

2) Overview: Bioaccumulation and Biomagnification

- MeHg is the only form of mercury that **bioaccumulates** (is strongly retained in tissues) and **biomagnifies** (increases up the food chain through diet).
- MeHg in a high trophic level fish is typically about one million times higher than in the water where it lives.
- Top consumers (birds, mammals, humans) are exposed to elevated MeHg through a fish diet.
- If MeHg was not formed in the environment, there would not be a mercury problem.



2) Overview: Why does this matter?

- Increases in water MeHg are directly related to increases in MeHg in biota.
- MeHg is the only form of Hg that bioaccumulates and biomagnifies.
- MeHg impacts the behaviour, reproduction, and survival of wildlife (fish, **migratory songbirds**, piscivorous birds and mammals).
- The predominant pathway for human and fish-eating animal exposure to MeHg is from consuming fish contaminated with MeHg.
- Health effects of MeHg exposure on humans can be severe and life-long. **Biologically, there does not appear to be a safe level of methylmercury exposure for humans.**

Tomoko Kamimura, Minamata disease victim (https://en.wikipedia.org/wiki/Minamata_disease)

3) Is the Bad River Watershed sensitive to methylmercury contamination?

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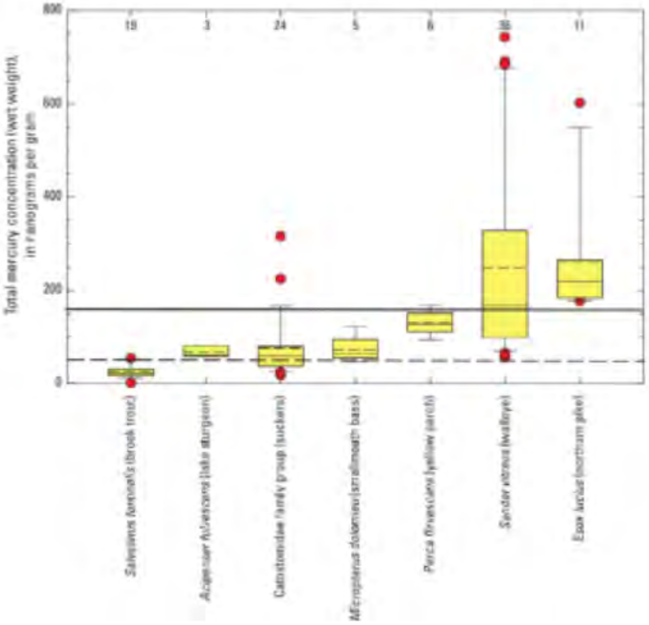
USGS/D. Burns, 2020

Although there is not extensive data available, there is clear evidence that the Bad River Watershed is sensitive to methylmercury contamination.

1) Fish Hg was above Great Lakes consumption guidelines
2) Bald Eagles and Otter had mercury levels high enough to cause impairment
3) Median %MeHg as THg was **10.9** (2.9 – 12.7% interquartile range).
4) Rule of thumb for surface waters is that **>3%** as MeHg is a mercury sensitive environment (i.e. efficient at Hg methylation).
5) When %MeHg is this high, the source of MeHg is **wetlands** draining into tributaries (Hurley *et al*., 1995 and subsequent scientific consensus).



3) Evidence points to wetlands as the dominant source of methylmercury in the Bad River Watershed.

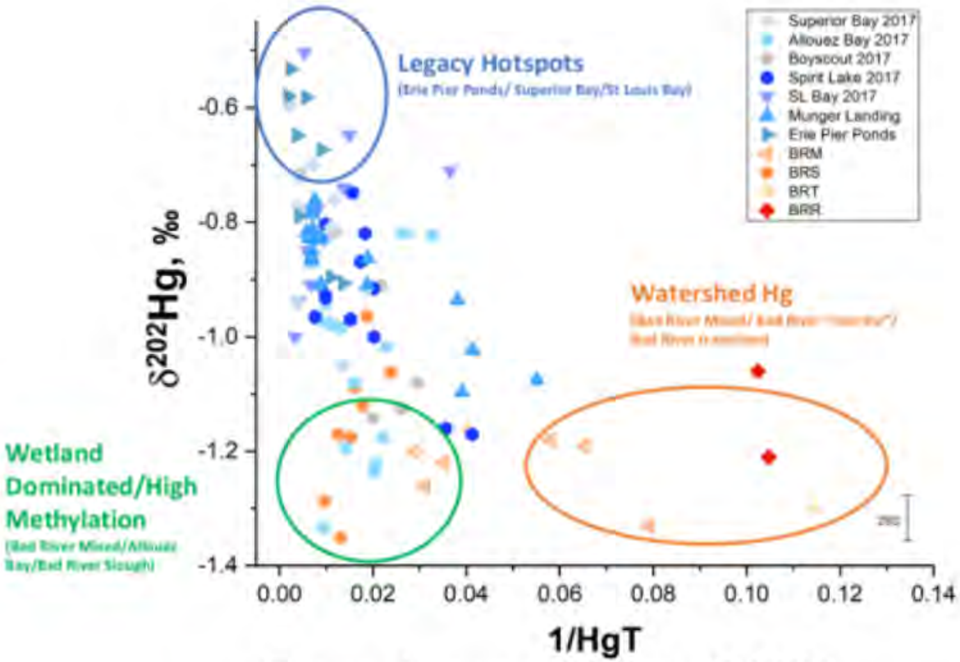
1) Percent wetland cover (between ROW and Reservation boundary) is high.

- Bad River watershed = 15.1%
- Potato River watershed = 22.6%
- **Tyler Forks watershed = 37.1%***

2) Dissolved organic carbon concentrations are high, and strongly correlated to dissolved (Me)Hg (Burns et al., 2020). Both are wetland derived.

3) Hg isotope ratios show importance of wetlands and watershed for Bad River (Janssen et al., (2020)

***Sampling locations where %MeHg was highest in entire watershed.**



From Janssen et al. (2020)

4) **What are the impacts of the proposed project on methylmercury production and loading in the Bad River watershed?**

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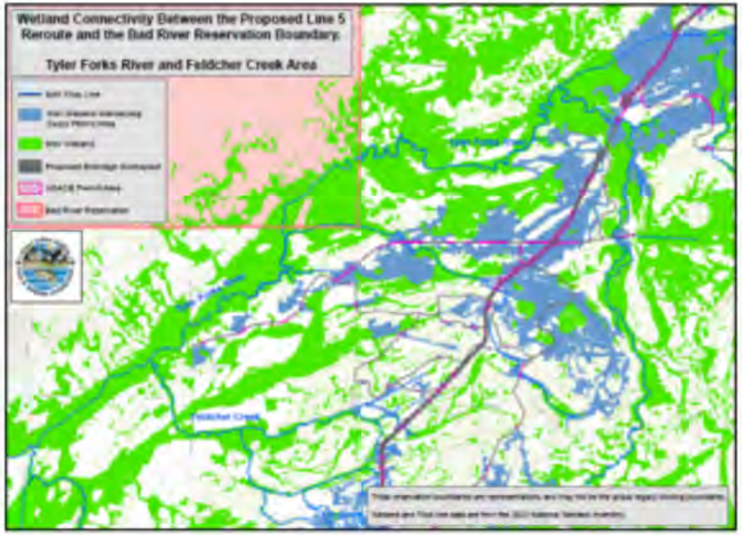
A) The Line 5 reroute project will impact the hydrology of substantial areas of wetlands in the headwaters of the Bad River and her tributaries.

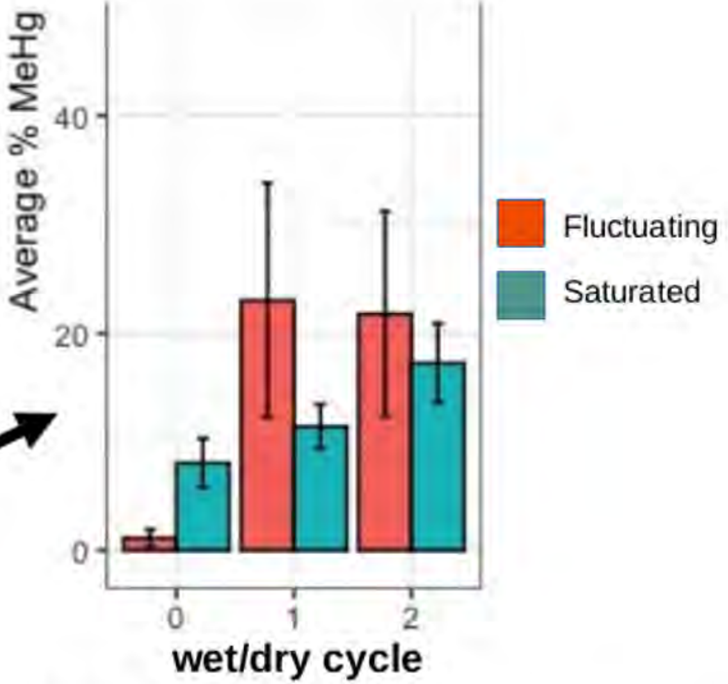
- The area of wetland impact of the project is not just the right of way/designated permit area since it is perpendicular to the hydrological flowpaths of extensive wetlands that control downstream flows and water quality.
- Estimates by GLIFWC based on recent surveys (2023-25) indicate that 426 wetlands are intersected by the project, with a total area of 2398 ac.
- The 20% 'success' criterion of down-gradient water table variation relative to up-gradient means down-gradient wetlands may be substantially wetter, drier, or more variable than natural conditions all of which impact mercury methylation in different ways.



Tyler Forks/Feldcher Watershed wetlands. NWI wetlands are green. NWI wetlands intersected by the permit area are blue (Map from GLIFWC).

4) **Wetland hydrologic changes will increase mercury methylation potential, which is already high.**

- **Wetter** conditions bring the saturated zone of the wetland closer to the ground surface, increasing the volume and temperature of the anaerobic zone.
- **Drier** conditions promote oxidation in surface organic soils, releasing dissolved organic matter, bound mercury, and sulfate, increasing methylmercury production in the saturated soils below.
- More **variable** water table fluctuations combine both of these mechanisms, alternately supplying the reactants for methylation, and the conditions required for methylation to occur.
- Effect may not just be down-gradient since the project will also change up-gradient hydrology.



From Pigeon and Branfireun (2024)

4) What are the impacts of the proposed project on methylmercury production and loading in the Bad River watershed?

B) Changes in wetland plant communities through wetland conversion will increase mercury methylation potential.

- Conversion of forested and shrub-scrub wetlands to emergent wetlands is a result of both the direct effect of the reroute project (land clearing), and indirect effects of changes in hydrology.
- The change in plant community changes microbial ecology (fungal → bacterial).
- Increased productivity → increased organic matter → increased microbial activity → increased mercury methylation
- Increased hydrologic connectivity will increase downstream export.

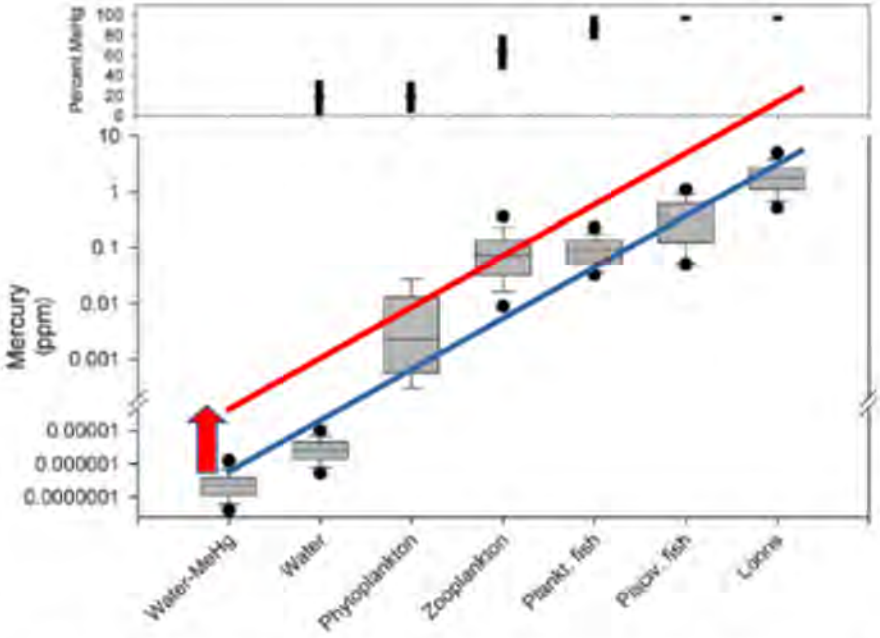
www.wisconsinwetlands.org

4) What are the impacts of the proposed project on methylmercury production and loading in the Bad River watershed?

The increase in methylmercury production in the mercury sensitive headwaters of the Bad River will result in:

1) the delivery of additional methylmercury to receiving waters (facilitated by high wetland derived Dissolved Organic Matter (DOM) concentrations).

2) Additional methylmercury will be bioaccumulated and biomagnified, **cumulatively** contributing to the mercury load of an already mercury-impaired downstream ecosystem.



Driscoll, C. T., Han, Y. J., Chen, C. Y., Evers, D. C., Lambert, K. F., Holsen, T. M., . . . Munson, R. K. (2007). Mercury contamination in forest and freshwater ecosystems in the Northeastern United States. Bioscience, 57(1), 17-28. doi: 10.1641/b570106

4) What are the impacts of the proposed project on methylmercury production and loading in the Bad River watershed?

The increase in methylmercury production in the mercury sensitive headwaters of the Bad River will result in:

Enhanced 'hot spots' of methylmercury production in headwater wetlands will contribute to increased exposure in song birds and piscivorous birds and animals, with magnified negative ecological effects, including reproduction and migration.

Environmental Pollution

Dietary exposure to methylmercury affects flight endurance in a migratory songbird

Yanju Ma, Cristina R. Perez, Brian A. Branfireun, Christopher G. Guglielmo

JOURNAL OF AVIAN BIOLOGY

Evidence of negative seasonal carry-over effects of breeding ground mercury exposure on survival of migratory songbirds

Effects of Environmental Methylmercury on the Health of Wild Birds, Mammals, and Fish

Authors: Scheuhammer, Anton M., Meyer, Michael W., Sandheinrich, Mark B., and Murray, Michael W.

Source: AMBIO: A Journal of the Human Environment, 36(1) : 12-19

Conclusion and Summary of Opinion

Hydrological and biogeochemical changes to wetlands as a result of the Line 5 Reroute Project will increase the amount of methylmercury produced in the Bad River watershed, violating the Band's Water Quality Standards.

1) *The presence of pollutants in quantities that result in bioaccumulation in aquatic organisms that may cause or contribute to an adverse effect to consumers of aquatic organisms shall be prohibited (refer to criterion E.6.ii.h.).*

2) *Pollutants or human-induced changes to waters, the sediments of waters, or area hydrology that results in changes to the natural biological communities and wildlife habitat shall be prohibited (refer to criterion E.6.ii.e.)*

Further, it is my opinion that there are no conditions that would prevent these violations of the Bands Water Quality Standards, given the nature and location of the reroute project.

Chi-Miigwech