Re: Polymet NorthMet 401(a)(2) Certification Remand

Prepared for: The Fond du Lac Band of Lake Superior Chippewa
Prepared by: Dr. Brian Branfireun, PhD
Date: April 28, 2021

1) Introduction

Based on prior review and recent re-review of documents pertaining to the environmental impacts of the PolyMet NorthMet project, I maintain my professional opinion that the weight of the scientific evidence indicates that the NorthMet project would create a substantial risk of ecologically significant increases in water column and fish methylmercury concentrations in downstream waters (including the St. Louis River) due to project-driven changes in hydrology to headwater streams and wetlands, and the release of excess sulfate which stimulates the process of mercury methylation. The enhanced production of methylmercury both adjacent to the project site as well as more distal locations in the St. Louis River watershed will contribute to the watershed-level burden of methylmercury that will subsequently bioaccumulate in biota and impair designated uses such as subsistence fishing. This memo relies on substantive content from prior Opinions that I have provided on the project SDEIS (Branfireun, 2014), FEIS (Branfireun, 2015) and the certification of the CWA Section 401 by the Minnesota Pollution Control Agency (Branfireun, 2019) as well as other scientific literature that relates to the fate and transport of (methyl)mercury, sulfate and dissolved organic matter.

There are three primary lines of evidence that draw me to these conclusions:

1. Direct and seepage discharges of sulfate and mercury to surface waters and wetlands will enhance methylmercury production. Increasing methylmercury is neither accounted for in existing mass balances, nor is there adequate monitoring plans to detect irreparable harm.

2. Changes in regional wetland hydrology in the area of groundwater impact in the vicinity of the project site will have indirect effects that will enhance mercury, sulfate and methylmercury release in an area that data clearly indicate is already naturally susceptible to enhanced methylmercury production. These increases are neither accounted for in existing mass balances, nor are there adequate monitoring plans to detect irreparable harm.

3. Methylmercury, inorganic mercury, excess sulfate, and dissolved organic matter released due to the direct and indirect effects of the project may be transported downstream, cumulatively impairing designated uses in the Fond du Lac Band's waters in downstream reaches of the St. Louis River.

2) Background on Mercury Cycling in Watersheds

Anthropogenic activities have resulted in anywhere from 150 to 300% more inorganic mercury being released to the atmosphere and deposited to ecosystems since ca. 1850. This is not the mercury that ultimately presents the direct risk to ecosystems and consumers. This inorganic mercury is converted to methylmercury (typically only a few percent of all mercury forms in the environment) in oxygen-free environments such as the sediments of lakes and slow-moving waters, and in wetlands (in particular peatlands) that support the activity of sulfate-reducing bacteria, principle methylators of mercury in

freshwaters. The methylation process is an enzymatic by-product of the sulfate-reduction reaction. Thus, nutrient-limited anaerobic environments that have a supply of inorganic mercury, sulfate, and organic matter (required for microbial metabolism) are likely net sources of methylmercury, with sulfate and organic matter being limiting (in that order). The primary mechanism of methylmercury loss in aquatic systems is through photodegradation by UV light. Methylmercury is the only form of mercury that bioaccumulates and biomagnifies in aquatic systems that then can present a serious risk to consumers of higher trophic level fish.

3) Direct and seepage discharges of sulfate and mercury to surface waters and wetlands will enhance methylmercury production

In prior Opinions, I have provided a detailed analysis of the mechanisms by which NorthMet project discharges of sulfate and mercury will enhance methylmercury production in the Partridge and Embarrass watersheds (tributaries of the St. Louis River) and that this methylmercury production presents an environmental risk that is completely unaccounted for in permitting associated with the PolyMet NorthMet mine proposal. Headwater tributaries that have proposed discharges from the project are low in sulfate, and already elevated in the percentage of total mercury that is present as methylmercury (up to nearly 10%) indicating a high methylmercury production potential in their watersheds. Additional sulfate loading to tributaries (even if limited to 10 mg/L by unproven and unchallenged water treatment strategies proposed for the project) will very likely increase methylmercury production either in the stream channel or floodplain wetlands (see Branfireun, 2015; Section 2.1.1). Monitoring of post-development wetland water quality is explicitly excluded from the 401 Certification, prevent discovery of any impacts on wetland biogeochemistry - particularly methylmercury production – during NorthMet project mine and processing operations.

The subsequent cross-media analysis undertaken to ostensibly address uncertainties in the projects impacts on mercury cycling was so narrowly drawn that more profound mechanisms impacting mercury and methylmercury in waters downstream of the NorthMet project were fully disregarded, despite their identification in previous reviews and opinions. By focusing exclusively on air deposition of sulfate and other elements to an inconsequential "Wetland of Interest", the direct and seepage discharges of sulfate and inorganic mercury to extensive headwater wetlands of the Embarrass River Watershed are completely unaccounted for. Seven direct waste water outfalls will discharge to the headwater wetlands of a single tributary (Trimble Creek) increasing water loading by several million gallons per day, and supplying hundreds of pounds of sulfate per year (based on PolyMet's own data), affecting ecological and biogeochemical function of these wetlands. These loads (in addition to any seepage that is not contained by the proposed unproven capture system) would result in an increase in methylmercury production precisely at a location in the watershed that would result in the greatest environmental harm – a headwater wetland that then supplies water and solutes to downstream (Branfireun 2019; Section 2.1.2). In the final 401 Certification, the MPCA ultimately requires only two monitoring locations upstream of the proposed development, and only three downstream (potentially impacted) sites where change might be detected. Downstream monitoring sites are only on larger channels and considerable distance from potential locations of direct operational impact such as the Embarrass River wetlands discussed previously. The specification for sampling the streams only four times annually is scientifically indefensible – detection and confirmation of systematic change above natural variability will be impossible over any reasonable time period (Branfireun 2019; Section 2.2).

4) Changes in Regional Wetland Hydrology and Methylmercury Production

The proposed project will have a significant impact on the regional water table due to substantial dewatering of the open mine pit and the development of a cone of depression. Although a groundwater model was implemented for mine development, it was curiously never applied to evaluate the hydrological impacts on the extensive wetlands adjacent to the proposed development area; this despite significant concerns raised about hydrology and wetland function (see Report by Price, 2017), and the potential for enhanced mercury release and methylmercury production (see Branfireun, 2014, 2015, 2019). PolyMet contended that the complexity of bedrock configuration precluded its use for impact assessment, despite it being sufficiently rigorous to develop the engineering requirements of a substantial open pit.

PolyMet suggested that "the potential export of SO_4 [sulfate] and MeHg [methylmercury] is expected to be the same as background wetlands and likely no different with the Project in operations as occurs now in existing conditions" (Cross-Media Analysis Appx. F, p. 12). This claim is strictly opinion and without substantiation. Indeed, the scientific literature points quite strongly in the opposite direction, with the potential for amplified wetting and drying cycles and increased peat soil oxidation during drought, leading to pulses of high concentrations of dissolved organic matter (DOM), sulfate (from oxidized reduced sulfide), and inorganic mercury during rewetting (Coleman-Wasik et al., 2015). <u>These releases are unaccounted for in mass balance estimates and will contribute to increased downstream loading far beyond the calculations used to conclude *de minimus* loadings.</u> Once oxygen-free conditions re-restablish, these pulses of sulfate, DOM and mercury fuel sulfate reduction and mercury methylation. The overall implication being that the proposed operation may increase mercury release and methylmercury production over the entire area of groundwater influence that is significantly larger than the directly disturbed wetlands within the site boundary. The lack of consideration of these potential impacts in loading estimates and complete absence of any monitoring of wetland water quality over the operation of the mine means that not only are these loads unaccounted for in the mass balances used to justify meeting permitting thresholds, but that downstream loads will almost certainly exceed those declared, and cannot be detected nor mitigated, resulting in irreparable harm.

5) Downstream Impacts on Water Quality and Designated Use of Natural Resources

PolyMet has relied exclusively on a mass-balance model to predict the potential impacts of project development and operations on sulfate, mercury and other solutes, concluding from it that water quality will not be impaired as a result of the mine. This approach is fatally-flawed. Aside from the fact that a mass-balance model is inappropriate to apply to reactive solutes and does not account for mercury release from any of the indirect effects identified above, the model does not include methylmercury at all. There was no uncertainty or sensitivity analyses conducted for sulfate or mercury concentrations; the lack of such a standard model inclusion would result in such a study not meeting even the lowest bar for scientific publication. There will be substantial variability associated with the range of concentrations of sulfate and mercury, and uncertainty in the estimates of mass released, yet these ranges and uncertainties are never revealed.

Technical documents submitted to dispel concerns about both the potential for exceedences in the release of mercury and sulfate (see Barr, 2018) lay bare the complete reliance on unconstrained mass balance estimates, unproven storm and waste water capture techniques, and the avoidance of the quantification of indirect releases of mercury and sulfate outlined above in order to draw the conclusion of *de*

minimus impacts. The appearance of rigorous consideration of the literature to discount the impacts on landscape methylmercury production is accomplished through an egregiously selective use of the scientific literature that is either inappropriate or misdirecting (e.g. citing a nearly 20 year old review paper about the cycling of mercury in terrestrial/forested ecosystems (Grigal et al., 2002) as evidence to support the contention that mercury in outflow water will be removed by a variety of "loss mechanisms". Perhaps most deliberately misleading is the statement that sulfate loadings only lead to increases in methylmercury production in "certain limited circumstances" (Barr, 2018) supported by citing one paper from an important experiment conducted in Minnesota (Coleman-Wasik et al., 2015). As search of the ISI Web of Science Database (April 27, 2021) for "sulfate and methylmercury" results in 618 citations, many of which are related to the link between environmental sulfate availability and mercury methylation. Indeed one of the most recent citations by Brigham et al. (2021) concludes that long-term data from four lakes in Voyageurs National Park in northern Minnesota shows that lake methylmercury concentrations are declining as a result of the "decline in atmospheric Hg deposition as well as a decline in **sulfate deposition, which is an important driver of mercury methylation in the environment** (emphasis mine). Results from this case study suggest that regional- to continental-scale decreases in both mercury and sulfate emissions have benefitted aquatic resources." Considerable literature exists that shows that changes in sulfate loading changes mercury methylation at the landscape scale. To cite one paper as proof of "limited" evidence is guilt by omission, and indeed, the "limited circumstances" are when sulfate loading and methylmercury production are **not** related, not vice-versa. The conclusions by PolyMet and consultants working on their behalf that the proposed development will not have appreciable impacts on water quality are unsupported by data, scientific consensus in the literature, or even a sound conceptual model.

PolyMet has not even met the burden of scientifically demonstrating that its direct discharges will not impair receiving water quality, let alone account for processes affecting mercury release and methylmercury production in the vicinity of the mine and elsewhere in the larger watershed. I contend that the combination of both direct and indirect effects on mercury release and methylmercury production will have impacts that could reach far downstream. <u>All</u> of the discharges and impacts identified above (which are beyond those currently considered in the PolyMet application) will influence downstream waters, including the St. Louis River. Headwater wetlands and streams such as the Partridge and Embarrass Rivers and their smaller tributaries that will be directly impacted by the proposed development strongly regulate the downstream water quality of the larger rivers that they supply (Bishop et al., 2008; Klaminder et al., 2006); to such a degree that the headwater stream chemistries can be predicted from the mixed chemistry of the downstream river (see Temnerud et al., 2010). Thus, there can be no scientific disconnection made between the mercury, methylmercury and sulfate loading to the source waters impacted by the NorthMet development and the larger rivers that they supply.

Sulfate is often treated as a quasi-conservative solute (i.e. it moves with surface waters in a relatively unreactive way) in the context of hydrological studies (e.g. Christopherson and Hooper, 1992), and as such additional loading to the headwaters of the St. Louis River will contribute to the cumulative sulfate load. Under high flow conditions, this additional sulfate will be delivered to extensive riparian wetlands associated with the lower reaches of the St Louis River, contributing to enhanced sulfate reduction and methylmercury production far from the proposed NorthMet site.

High concentrations of high molecular weight natural dissolved organic matter (DOM) in surface waters is associated with runoff from wetlands and peatlands and is responsible for the tea color that is characteristic of streams and rivers in north central Minnesota. Inorganic mercury and methylmercury

form very strong chemical bonds with DOM (Ravichandran, 2004), to such a degree that inorganic mercury is preserved in the dissolved form protected from particle binding and precipitation with sulfides enhancing transport and methylation potential (Graham et al., 2017). Methylmercury is similarly chemically bound, and is also shielded from photodegradation by UV light which is the main mechanism of methylmercury loss in freshwaters (Klapstein et al., 2018). The naturally high DOM environment in the headwaters creates the ideal conditions for the excess inorganic mercury released by the proposed project to be transported downstream where it may be methylated in riparian wetlands of the St. Louis River, contributing to resource impairment far from the point of release. Methylmercury formed by sulfate release by the project may be transported in the dissolved form long distances associated with, and protected by DOM, with the potential for bioaccumulation far from where it was formed, including in the St. Louis River (and beyond).

The potential for transport of either methylmercury or inorganic mercury considerable distances from the development site to downstream locations where they contribute to ecosystem impairments is no longer in the realm of speculation. A very recent published paper used natural abundance stable isotopes of mercury to trace the origins of mercury in biota in the St. Louis River Estuary (Janssen et al., 2021), and shows unequivocally that SLRE sediment mercury showed significant proportions attributed to industrial sources likely associated with in the estuary. Importantly, some locations well upstream of the estuary also had significant proportions of industrial Hg, indicating the long-distance river transport of industrially-derived mercury from unidentified upstream sources. The mercury in biota and fish was a more complex pattern but also reflected these differences, clearly demonstrating that the locations of mercury release, methylation, and bioaccumulation need not be spatially contiguous.

In conclusion, it is my opinion that the releases of mercury, methylmercury and sulfate from the headwater region of the St. Louis River that are likely to be broadly impacted by the NorthMet development will far exceed estimates provided by PolyMet in support of the projects 401 Certification. These releases may affect water quality standards, downstream ecosystem function, and designated uses of aquatic resources by the Fond du Lac Band of Lake Superior Chippewa and other downstream aquatic resource stakeholders.

Sincerely,

Dr. Brian Branfireun
London, Ontario, Canada

6) MATERIALS REFERRED

BARR Engineering (2018). Technical Memoradum: Potential for Mercury Loading to the St. Louis River Associated with the Construction Stormwater General Permit. November 9, 2018.

Bishop, K, I Buffam, M. Erlandsson, J. Folster, H. Laudon, J. Seibert, Temnerud, J (2008). Aqua Incognita: the unknown headwaters, Hydrological Processes, 22, 1239-1242.

Branfireun, B.A. Final Expert Review of the NorthMet Mining Project and Land Exchange Supplemental Draft Environmental Impact Statement, March 10, 2014 and Referenced Materials

Branfireun, B.A. Final Expert Review of the NorthMet Mining Project and Land Exchange Final Environmental Impact Statement, Dec. 12, 2015 and Referenced Materials

Branfireun, B.A. Final Expert Review of the Minnesota Pollution Control Agency Clean Water Act Section 401 Certification for the NorthMet Project, January 20, 2019 and Referenced Materials

Christopherson, N, RP Hooper (1992) Multivariate analysis of stream water chemical data: The use of principal components analysis for the end-member mixing problem. Water Resources Research, 28(1), 99-107.

Coleman Wasik, J.K., D.R. Engstrom, C.P.J. Mitchell, E.B. Swain, B. A. Monson, S.J. Balogh, J.D. Jeremiason, B. A. Branfireun, R.K. Kolka, J.E. Almendinger (2015) Hydro- logic fluctuations and sulfate regeneration increase methylmercury in an experimental peatland, Journal of Geophysical Research – Biogeosciences, 120: 10.1002/2015JG00299

Graham, A.M., Cameron-Burr, K.T., Hajic, H.A., Lee, C., Msekela, D., Gilmour, C.C., 2017. Sulfurization of Dissolved Organic Matter Increases Hg-Sulfide-Dissolved Organic Matter Bioavailability to a Hg-Methylating Bacterium. Environ. Sci. Technol. https://doi.org/10.1021/acs.est.7b02781

Janssen SE, , JC Hoffman, RF Lepak, DP. Krabbenhoft, D Walters, CA. Eagles-Smith, G Peterson, JM. Ogorek, JF. DeWild, A Cotter, M Pearson, MT. Tate, RB. Yeardley, MA. Mills (2021) Examining historical mercury sources in the Saint Louis River estuary: How legacy contamination influences biological mercury levels in Great Lakes coastal regions. Science of the Total Environment. doi.org/10.1016/j.scitotenv.2021.146284

Klaminder J, Bindler R, Laudon H, Bishop K, Emteryd O, Renberg I. 2006. Flux rates of atmospheric lead pollution within soils from a small catchment in northern Sweden and their implication for future stream water quality. Environmental Science and Technology 40(15): 4639– 4645. DOI: 10·1021/es0520666.

Klapstein, SJ, SE Ziegler, NJ O'Driscoll (2018). Methylmercury photodemethylation is inhibited in lakes with high dissolved organic matter. Environmental Pollution, 232, 392-401.

Ravichandran, M. (2004). Interactions between mercury and dissolved organic matter--a review. Chemosphere, 55(3), 319-331.

Temnerud, J, J. Folster, I Buffam, H. Laudon, M. Erlandsson, K. Bishop (2010). Can the distribution of headwater stream chemistry be predicted from downstream observatsions? Hydrological Processes, 24, 2269-2276.

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Dr. Brian Andrew Branfireun

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Dr. Brian Branfireun

Language Skills

Language	Read	Write	Speak	Understand	Peer Review
English	Yes	Yes	Yes	Yes	Yes

Degrees

- 1999/6 — Doctorate, Geography, McGill University
  Supervisors: N. Roulet, 1995/1 - 1999/6
- 1994/6 — Master's Thesis, Geography, York University
  Supervisors: N. Roulet, 1992/9 - 1994/8
- 1992/6 — Bachelor's Honours, Geography, University of Western Ontario
  Supervisors: P. Ashmore, 1991/9 - 1992/4

Recognitions

2015/7 - 2020/6
Canada Research Chair (Tier II) - 500,000
Canada Research Chair Program
Prize / Award
CRC renewal nomination by Univ of Western Ontario

User Profile

Research Specialization Keywords: hydrology, biogeochemistry, wetland, mercury

Employment

2016/7
Professor
Biology and Centre for Environment and Sustainability, Science, University of Western Ontario
Full-time, Professor
Tenure Status: Tenure
In this position I am responsible for maintaining an active research program, teach at the undergraduate and graduate level, and commit service to the institution and my scientific community. As a Canada Research Chair, I had an alternative workload arrangement (60/25/15).

2015/7 - 2020/6 Adjunct Professor (Graduate Committee)
Biology, University of Waterloo
Part-time, Adjunct, Associate Professor
Tenure Status: Non Tenure Track
Official graduate **committee** status appointment.

2016/7 - 2019/6 Associate Chair (Research)
Biology, University of Western Ontario
Part-time
Tenure Status: Tenure
Terms of reference for the Associate Chair for the department of Biology are to enhance research productivity and outcomes in the department, and reduce barriers to research funds, graduate students and collaborative opportunities.

2015/7 - 2018/6 Adjunct Professor (Graduate Supervision)
Geography, Nipissing University
Part-time, Adjunct, Associate Professor
Tenure Status: Non Tenure Track
Official graduate **co-supervisory** status appointment (MSc Germain, with A. James).

2014/7 - 2018/6 Adjunct Professor (Graduate Supervision)
Department of Aquatic Sciences and Assessment, Swedish Univ Agric Sciences
Part-time, Adjunct, Associate Professor
Tenure Status: Non Tenure Track
Official graduate **co-supervisory** status appointment (PhD Candidate Wu) in collaboration with Dr. Kevin Bishop.

2012/7 - 2018/6 Director
Biotron Centre for Experimental Climate Change Research, University of Western Ontario
Part-time
Tenure Status: Non Tenure Track
Oversee the operation and scientific mission of an institutional research centre with 6 staff and annual operating budget of ~$0.75M. Centre includes an analytical facility, microscopy unit and experimental chambers that support the research of over 200 faculty and graduate researchers each year.

2013/7 - 2016/6 Associate Professor
Biology and Centre for Environment and Sustainability, Science, University of Western Ontario
Full-time, Associate Professor
Tenure Status: Tenure
In this position I was responsible for maintaining an active research program, teach at the undergraduate and graduate level, and commit service to the institution and my scientific community. As a Canada Research Chair, I had an alternative workload arrangement (60/25/15).

2011/1 - 2015/12 Adjunct Professor (Graduate Supervision)
Geography, Queen Mary, University of London
Part-time, Adjunct, Associate Professor
Tenure Status: Non Tenure Track
Official graduate **co-supervisory** status appointment (PhD Morris) with K. Spencer.

Research Funding History

Awarded [n=9]

2020/7 - 2023/7
Co-applicant

How shrubification influences hydrology, permafrost, and mercury mobilization: a cross-disciplinary approach to landscape change to support community resilience in Old Crow Flats, YT, Grant

Funding Sources:
Canadian Polar Commission (Ottawa, ON)
Polar Knowledge Canada
Total Funding - 448,360
Portion of Funding Received - 80,000
Funding Competitive?: Yes

Co-applicant : Basiliko, Nathan; Calmels, Fabrice; Turner, Kevin;

Principal Applicant : Leveillee, Pascale

2018/5 - 2023/4
Principal Investigator

Climate change and catchment controls on the mercury cycle of northern lakes, Grant

Funding Sources:
Natural Sciences and Engineering Research Council of Canada (NSERC)
Individual Discovery Grant
Total Funding - 215,000
Portion of Funding Received - 215,000
Funding Competitive?: Yes

2017/7 - 2022/6
Co-investigator

Wetland Ecosystem Terrain System Simulator (WETSyS), Grant

Funding Sources:
Canada Foundation for Innovation (CFI)
Innovation Fund
Total Funding - 1,083,524
Portion of Funding Received - 0
Funding Competitive?: Yes

Co-applicant : Macrae, Merrin; Petrone, Richard; Rezanezhad, Fereidoun; Rooney, Rebecca; Stone, Michael; Strack, Maria; Van Cappelen, Phillippe; Waddington, James Michael;

Principal Applicant : Price, Jonathan

2017/1 - 2022/1
Co-investigator

Wetland Ecosystem Terrain System Simulator (WETSyS), Grant

Funding Sources:
Ontario Research Fund (ORF)
CFI Matching Program
Total Funding - 1,083,524
Portion of Funding Received - 0
Funding Competitive?: Yes

Co-applicant : Macrae, Merrin; Petrone, Richard; Rezanezhad, Fereidoun; Rooney, Rebecca; Stone, Michael; Strack, Maria; Van Cappellen, Phillipe; Waddington, James Michael;

Principal Applicant : Price, Jonathan

2019/5 - 2021/4
Principal Investigator

The role of peatlands in boreal forest land use carbon management under climate change, Grant

Funding Sources:
Natural Resources Canada - Univ of Western Ontario

Total Funding - 111,000
Portion of Funding Received - 60,000
Funding Competitive?: Yes

Co-investigator : Emilson, Erik; Lindo, Zoe

2019/4 - 2021/3
Co-investigator

Development of new analytical methods for speciation of chromium in subsistence fish from northern Ontario, Grant

Funding Sources:
Natural Sciences and Engineering Research Council of Canada (NSERC)
Collaborative Research and Development Grant
Total Funding - 140,000
Portion of Funding Received - 0
Funding Competitive?: Yes

Principal Investigator : Gunn J

2019/6 - 2020/6
Principal Investigator

Trackdown of fugitive mercury release from groundwater from the former Chlor-Alkali Mill in Dryden, ON, Grant

Funding Sources:
Government of Ontario
Grassy Narrows Mercury Remediation Trust
Total Funding - 444,545
Portion of Funding Received - 100
Funding Competitive?: Yes

2015/7 - 2020/6
Principal Applicant

Canada Research Chair in Environment and Sustainability (Tier 2), Research Chair

Funding Sources:
Canada Research Chairs (CRC)
Tier 2
Total Funding - 500,000
Portion of Funding Received - 72,500
Funding Competitive?: Yes

2019/6 - 2020/5
Principal Investigator

Postdoctoral Research Associate in Peatland Ecosystem Modeling, Grant

Funding Sources:
Ontario Ministry of Natural Resources (ON)
Total Funding - 80,000
Portion of Funding Received - 100
Funding Competitive?: No

Completed [n=17]

2015/10 - 2019/9
Principal Applicant

Northern Peatland Ecosystem Responses to Climate Change, Grant

Funding Sources:
Natural Sciences and Engineering Research Council of Canada (NSERC)
Strategic Partnership Grant
Total Funding - 516,281
Portion of Funding Received - 170,372
Funding Competitive?: Yes

Co-applicant : Basiliko, Nathan; Lindo, Zoë; Petrone, Richard; Roulet, Nigel;

Co-investigator : Charron, Chris; McLaughlin, James

2018/5 - 2019/4
Co-applicant

Solid phase CHNS analyser for plant, soil and sediments from aquatic and terrestrial ecosystems, Grant

Funding Sources:
Natural Sciences and Engineering Research Council of Canada (NSERC)
Research Tools and Instruments
Total Funding - 102,872
Portion of Funding Received - 0
Funding Competitive?: Yes

Co-applicant : Henry, Hugh; Macfie, Sheila;

Principal Applicant : Lindo, Zoe

2017/5 - 2018/4
Co-applicant

Variable fish mercury concentrations in the Dehcho: effects of catchment control and invertebrate community composition, Grant

Funding Sources:
Aboriginal Affairs and Northern Development Canada (AANDC)
Northern Contaminants Program
Total Funding - 25,703
Portion of Funding Received - 11,450
Funding Competitive?: Yes

Principal Investigator : Low, George; Swanson, Heidi

2017/5 - 2018/4
Principal Applicant

An autonomous underwater vehicle for the study of remote lakes, Grant

Funding Sources:
Natural Sciences and Engineering Research Council of Canada (NSERC)
Research Tools and Instruments
Total Funding - 150,000
Portion of Funding Received - 150,000
Funding Competitive?: Yes

Co-applicant : Swanson, Heidi

2009/1 - 2018/4
Principal Applicant

Hydrology and mercury biogeochemistry of the Hudson Bay lowland (extension due to NSERC Committee Service), Grant

Funding Sources:
Natural Sciences and Engineering Research Council of Canada (NSERC)
Individual Discovery Grant
Total Funding - 320,000
Portion of Funding Received - 320,000
Funding Competitive?: Yes

2016/5 - 2018/3
Co-applicant

An investigation of variable fish mercury concentrations in Dehcho lakes, Grant

Funding Sources:
Government of The Northwest Territories
Cumulative Impacts Monitoring Program
Total Funding - 102,000
Portion of Funding Received - 41,550
Funding Competitive?: Yes

Co-investigator : Baker, Leanne; Canadien, Priscilla; Chief Norwegian, Gladys; Homan, Dean; Low, Mike;

Principal Applicant : Low, George; Swanson, Heidi

2017/1 - 2018/1
Principal Applicant

A spectrophotometer for the rapid characterization of natural organic matter in water, Grant

Funding Sources:
The University of Western Ontario

SERB Accelerate
Total Funding - 49,688
Portion of Funding Received - 49,688
Funding Competitive?: Yes

2016/7 - 2017/12
Co-applicant

Speciation of Arsenic and Mercury in Volunteers, Traditional Foods and the Environment at Walpole Island First Nation Complemented with Three Repeated 24-Hour Dietary Recall Surveys and a Food Frequency Questionnaire, Grant

Funding Sources:
Health Canada
Exposure Assessment & Human Biomonitoring
Total Funding - 99,500
Portion of Funding Received - 0
Funding Competitive?: Yes

Co-applicant : Darnell, Regna; Koren, Gideon; McKinley, Gerald; Rieder, Michael;

Co-investigator : Jacobs, Dean; Peters, Judy; Williams, Naomi; Williams, Rosemary;

Principal Applicant : Bend, Jack

2012/12 - 2017/12
Co-applicant

NSERC Canadian Network for Aquatic Ecosystem Services, Grant

Funding Sources:
Natural Sciences and Engineering Research Council of Canada (NSERC)
Total Funding - 4,416,625
Portion of Funding Received - 220,831
Funding Competitive?: Yes

Co-applicant : Bennett, Elena; Buttle, James; Creed, Irena; Fortin, Marie-Josee; Gergel, Sarah; Gunn, John; James, April; Kidd, Karen; Lenher, Bernard; Peres-Neto, Pedro; Price, Jonathan; Richardson, John; Sibley, Paul;

Co-investigator : Keller, Bill; Kreutzweiser, David; Shuter, Brian;

Principal Applicant : Jackson, Donald

2015/12 - 2017/12
Principal Applicant

Mercury cycling and bioaccumulation in fluctuating hydroelectric reservoirs, Grant

Funding Sources:
Ontario Ministry of the Environment
Sportfish Monitoring Program
Total Funding - 60,000
Portion of Funding Received - 60,000
Funding Competitive?: No

2016/5 - 2017/4
Co-applicant

A field-portable ultra-trace mercury analysis system, Grant

Funding Sources:
Natural Sciences and Engineering Research Council of Canada (NSERC)
Research Tools and Instruments
Total Funding - 92,000
Portion of Funding Received - 23,000
Funding Competitive?: Yes

Co-applicant : Laird, Brian; Power, Michael;

Principal Applicant : Swanson, Heidi

2016/5 - 2017/3
Co-applicant

Variable fish mercury concentrations in the Dehcho: effects of catchment control and invertebrate community composition, Grant

Funding Sources:

Aboriginal Affairs and Northern Development Canada (AANDC)
Northern Contaminants Program
Total Funding - 23,978
Portion of Funding Received - 10,250
Funding Competitive?: Yes

Co-investigator : Canadien, Priscilla; Chief Norwegian, Gladys; Homan, Dean; Low, Mike;

Principal Applicant : Low, George; Swanson, Heidi

2015/4 - 2016/5
Co-applicant

Understanding contaminant levels in commonly consumed fish of Kluane Lake, Yukon, Grant

Funding Sources:
Aboriginal Affairs and Northern Development Canada (AANDC)
Northern Contaminants Program
Total Funding - 22,025
Portion of Funding Received - 2,000
Funding Competitive?: Yes

Co-applicant : Friendship, Katelyn; Hik, David; Kassi, Norma; Liard, Brian; Southwick, Grace; Swanson, Heidi; Walker, Jody;

Co-knowledge User : Roach, Pat; Williams, Sian;

Decision Maker : Hanley, Brendan;

Principal Applicant : Alatini, Chief Mathieya

2015/5 - 2016/4
Co-applicant

Biological (biofilm and zooplankton) indicators to monitor aquatic ecosystem health with communities across the NWT, Grant

Funding Sources:
Canadian High Arctic Research Station
Science and Technology Program
Total Funding - 60,650
Portion of Funding Received - 18,500
Funding Competitive?: Yes

Co-applicant : Cott, Peter; Gregory, Ryan; Somers, Gila; Trembath, Katherine; Vandermeer, Jennie;

Principal Applicant : Kelly, Erin

2014/12 - 2015/12
Co-applicant

Bioavailability of mercury in aquatic food webs, Grant

Funding Sources:
Nordic Council
Nordic Cooperation Grant
Total Funding - 50,000
Portion of Funding Received - 25,000
Funding Competitive?: Yes

Principal Applicant : Bishop, Kevin

2014/12 - 2015/12
Co-applicant

A field-based experimental system for the evaluation of the effects of elevated temperature and CO2 on peatlands, Grant

Funding Sources:
Natural Sciences and Engineering Research Council of Canada (NSERC)
Research Tools and Instruments
Total Funding - 148,612
Portion of Funding Received - 74,306
Funding Competitive?: Yes

Co-applicant : Basiliko, Nathan; Petrone, Richard; Roulet, Nigel; Schincariol, Robert;

Principal Applicant : Lindo, Zoe

2010/7 - 2015/6
Principal Applicant

Canada Research Chair in Environment and Sustainability (Tier 2), Research Chair

Funding Sources:
Canada Research Chairs (CRC)
Tier 2
Total Funding - 500,000
Portion of Funding Received - 92,500
Funding Competitive?: Yes

Student/Postdoctoral Supervision

Bachelor's Honours [n=9]

2020/9 - 2021/4
Principal Supervisor

Grove, Rachael (In Progress) , University of Western Ontario
Student Degree Expected Date: 2021/6
Thesis/Project Title: Mercury total daily intake (TDI) and fish meal consumption calculations: a critical review and sensitivity analysis
Present Position: in progress

2019/5 - 2020/4
Principal Supervisor

White, Amy (Completed) , University of Western Ontario
Thesis/Project Title: Controls on water-particle partitioning of mercury in contaminated sediments
Present Position: In Progress

2017/1 - 2020/6
Principal Supervisor

Blythe, Jennifer (Completed) , University of Western Ontario
Thesis/Project Title: Methylmercury production in boreal peat soils
Present Position: MSc, University of Western Ontario

2016/5 - 2017/4
Principal Supervisor

Ayushi Shah (Completed) , University of Western Ontario
Thesis/Project Title: Mercury and Arsenic in sediments water and biota near the Walpole Island First Nation, Ontario, Canada
Present Position: Contract employee, Ontario Ministry of Natural Resources and Forestry

2015/9 - 2016/4
Principal Supervisor

Warner, Jeffery (Completed) , University of Western Ontario
Thesis/Project Title: Effects of wetting and drying cycles on mercury methylation and sulphate regeneration in boreal peat soils
Present Position: Laboratory Analyst, University of Western Ontario

2014/9 - 2015/4
Co-Supervisor

Edgar, Nikita (Completed) , University of Western Ontario
Thesis/Project Title: Crayfish as bioindicators of mercury contamination in an urbanized river
Present Position: unknown

2014/9 - 2015/4
Principal Supervisor

O'Brien, Meghan (Completed) , University of Western Ontario
Thesis/Project Title: Using fluorescence and absorbance measures as proxies for dissolved organic carbon and mercury in northern streams and rivers
Present Position: Environmental Consulting

2013/9 - 2014/4
Principal Supervisor

Evans, Christopher (Completed) , University of Western Ontario
Thesis/Project Title: Effects of temperature and root exudates on mercury methylation in boreal peats
Present Position: Unknown

2013/9 - 2014/4 Craig, Aaron (Completed) , University of Western Ontario
Principal Supervisor Thesis/Project Title: Effect of climate change on peatland dissolved organic carbon quality and quantity
Present Position: University Research Laboratory Technician

Master's non-Thesis [n=1]

2017/9 - 2018/8 Ibe, Generosa (Completed) , University of Western Ontario
Principal Supervisor Thesis/Project Title: Mercury sorption-desorption kinetics on suspended mineral particulate in freshwaters
Present Position: seeking employment

Master's Thesis [n=14]

2018/9 - 2020/8 Anderson, Madelaine (Completed) , University of Western Ontario
Co-Supervisor Thesis/Project Title: Carbon and mercury dynamics in decomposing forest litter in boreal ecosystems
Present Position: PhD, Sherbrooke

2018/9 - 2020/8 James, Ericka (Completed) , University of Western Ontario
Principal Supervisor Thesis/Project Title: Climate change impacts on greenhouse gas fluxes in northern peatlands
Present Position: staff, Ontario Ministry of Transportation

2017/9 - 2019/12 Genier, Corrine (Completed) , University of Western Ontario
Co-Supervisor Thesis/Project Title: Habitat controls on diet, fitness and mercury burdens in bank swallows
Present Position: PhD, Western

2017/5 - 2019/2 Simone, Kyra (Withdrawn) , University of Western Ontario
Principal Supervisor Thesis/Project Title: Role of Natural Dissolved Organic Matter on Mercury Partitioning from Water to Phytoplankton
Present Position: unknown

2015/9 - 2017/8 Twible, Lauren (Completed) , University of Western Ontario
Principal Supervisor Thesis/Project Title: Mercury and sulphur redox biogeochemistry in northern peatland watersheds
Present Position: PhD Candidate, University of Toronto

2015/5 - 2017/7 Mack, Mikhail (Completed) , University of Western Ontario
Principal Supervisor Thesis/Project Title: Climate change impacts on peatland carbon and mercury biogeochemistry
Present Position: PhD Candidate, Wilfrid Laurier University

2014/9 - 2017/5 Germain, Brittany (Completed) , Nipissing University
Co-Supervisor Thesis/Project Title: Applying a hydrologic classication approach to low gradientboreal watersheds
Present Position: unknown

2013/12 - 2015/8 Smofsky, Alexandra (Completed) , University of Western Ontario
Co-Supervisor Thesis/Project Title: Soil biochemical indicators of early Mayan settlement, Central America
Present Position: unknown

2012/9 - 2014/12 Goacher, James (Completed) , University of Western Ontario
Principal Supervisor Thesis/Project Title: Geochronology of Mercury Accumulation in Far North Peatlands, Hudson Bay Lowlands
Present Position: Lawyer, Blake, Cassels & Graydon LLP Toronto

2012/9 - 2016/4 Principal Supervisor	Despault, Tara (Completed) , University of Western Ontario Thesis/Project Title: Dissolved Organic Matter in Natural Waters of streams and rivers of the Hudson Bay Lowlands Present Position: Authorizations Specialist - Groundwater, Ministry of Forests, Lands, and Natural Resource Operations,BC
2011/9 - 2014/9 Principal Supervisor	Liznick, Kaylin (Completed) , University of Western Ontario Thesis/Project Title: Mercury in the Lake Erie Foodweb Present Position: Coordinator, Aquatic Habitat Toronto
2011/9 - 2014/9 Principal Supervisor	Kline, Meghan (Completed) , University of Western Ontario Thesis/Project Title: Hydrology and biogeochemistry of a fen-stream complex, Hudson Bay Lowlands Present Position: Hydrologist, Credit Valley Conservation Authority
2010/9 - 2015/6 Principal Supervisor	Warnock, Ashley (Completed) , University of Western Ontario Thesis/Project Title: Small-bodied fish as sentinels of ecosystem mercury sensitivity Present Position: unknown
2010/9 - 2014/9 Principal Supervisor	Ulanowski, Thomas (Completed) , University of Western Ontario Thesis/Project Title: Hydrology of bog-fen ecosystems in the Hudson Bay Lowlands Present Position: President, NextLeaf Solutions

Doctorate [n=9]

2017/9 - 2020/1 Principal Supervisor	Ng, Kevin (Withdrawn) , University of Western Ontario Thesis/Project Title: Mercury Methylation in Thermokarst Environments Present Position: unknown
2016/9 - 2021/5 Principal Supervisor	Ting Sun (In Progress) , The University of Western Ontario Student Degree Expected Date: 2021/5 Thesis/Project Title: Climate Change effects on mercury cycling in boreal fen peatlands Present Position: in progress
2014/9 - 2019/6 Principal Supervisor	Tian, Jing (Completed) , University of Western Ontario Thesis/Project Title: Carbon cycling and peatland ecosystems Present Position: Research Engineer, National Forestry and Grassland Administration - China
2013/9 - 2017/9 Co-Supervisor	Wu, Pianpian (Completed) , Swedish Agricultural University, Uppsala Thesis/Project Title: Mercury bioaccumulation in forested catchments Present Position: Postdoctoral Fellow, Swedish Agricultural University
2013/9 - 2018/4 Co-Supervisor	Ma, Yanju (Completed) , University of Western Ontario Thesis/Project Title: The effect of mercury on terrestrial migratory songbird migration and fitness Present Position: PDF, Southern University of Science and Technology, Shenzen China
2012/12 - 2016/7 Co-Supervisor	Dieleman, Catherine (Completed) , University of Western Ontario Thesis/Project Title: Climate change impacts on above-belowground processes in northern peatlands Present Position: Postdoctoral Fellow, University of Guelph
2012/9 - 2018/12 Co-Supervisor	Krynak, Edward (Completed) , University of Western Ontario Thesis/Project Title: Bioindicators of Aquatic Ecosystem Health in Agriculturally Impacted Streams Present Position: PDF, University of Nevada - Reno

2011/9 - 2015/12 Co-Supervisor	Morris, Michelle (Completed) , Queen Mary University of London Thesis/Project Title: Mercury biogeochemistry in natural and restored saltmarsh ecosystems Present Position: Chemical Fate and Behaviour Specialist, Enviro Services, Health and Safety Executive, UK
2009/9 - 2014/8 Principal Supervisor	Farrick, Kegan (Completed) , University of Western Ontario Thesis/Project Title: The hydrology of a subtropical dry forest watershed Present Position: Assistant Professor, University of the West Indies, Trinidad

Post-doctorate [n=2]

2019/6 - 2020/5 Principal Supervisor	Kononen, Mari (Completed) , University of Western Ontario Thesis/Project Title: Modlelling peatland carbon cycling with DNDC Present Position: in progress
2013/5 - 2014/6 Principal Supervisor	Columbus, Melanie (Completed) , University of Western Ontario Thesis/Project Title: Microbial community structure and function in disturbed northern peatlands Present Position: Research Coordinator, Victoria Hospital, London ON

Research Associate [n=1]

2019/6 - 2020/5 Principal Supervisor	Klemt, Wynona, University of Western Ontario Thesis/Project Title: Trackdown study of fugitive mercury from a former Chlor-alkali mill, Dryden ON Present Position: unknown

Technician [n=1]

2012/7 - 2017/9 Principal Supervisor	Craig, Aaron (Completed) , University of Western Ontario Thesis/Project Title: Laboratory Research Technician Present Position: Unknown, Unknown

Event Administration

2017/7 - 2019/12	Local Organizing Committee Member, International Union for Geodesy and Geophysics Quadrennial Meeting, 2019 (Montreal QC), Conference, 2019/6 - 2019/7

Expert Witness Activities

2015/8 - 2016/12	Expert Opinion, Polymet - Northmet Mine Environmental Impact Assessment, United States, St. Paul Expert opinion was solicited from me by legal counsel for the not for profit organization WaterLegacy concerning the scientific merit of the revised final draft of the Environmental Impact Assessment with respect to sulphate release, changes in hydrology, and impacts on mercury cycling. My consultation on this matter is ongoing.

2013/11 - 2014/8 Expert Opinion, Polymet - Northmet Mine Environmental Impact Assessment, United States, St. Paul
Expert opinion was solicited from me by legal counsel for the not for profit organization WaterLegacy concerning the scientific merit of the draft Environmental Impact Assessment with respect to sulphate release, changes in hydrology, and impacts on mercury cycling. My written opinion formed a part of the public comment submission made by WaterLegacy to the US Environmental Protection Agency.

Organizational Review Activities

2012/6 - 2018/12 Technical Review/Advisory Committee Member, US State and Federal Agencies
I have participated in a number of reviews of US State and Federal scientific programs since 2012. These are both reviews of organizational programs as well as knowledge transfer activities. These review activities are detailed in the Knowledge and Technology Transfer module of the CCV.

2018/1 - 2018/4 Reviewer, Simon Fraser University
Served as external program reviewer for department of Earth Sciences.

Knowledge and Technology Translation

2012/1 - 2018/12 Technical Review Committee, Policy/Regulation Development
Group/Organization/Business Serviced: California Central Valley Regional Water Quality Control Board Technical Advisory Committee (Mercury
Target Stakeholder: Government Personnel
Outcome / Deliverable: Development and implementation of Total Maximum Daily Load regulations for methyl mercury for the California Central Valley.
Evidence of Uptake/Impact: Approvals and implementations of pilot projects by wide range of agencies under the jurisdiction of the Central Valley Water Board.
Activity Description: Asked by State of California to serve as technical advisor on binding TMDL development for methyl mercury. Reviewed, commented, and approved pilot control projects for ~20 agencies. Met several times in California. Review panel is engaged until 2018 when final TMDLs and control measures are approved.

2017/7 - 2018/6 Technical Advisor, Policy/Regulation Development
Group/Organization/Business Serviced: Province of Ontario
Target Stakeholder: Government Personnel
Outcome / Deliverable: Development or provincial regulatory strategies with respect to mercury in the environment and the impacts of climate change
Evidence of Uptake/Impact: The "Mercury Community of Practise" is a new initiative of the recently departed Minister of Environment and Climate Change, the Honorable Glen Murray. As a new initiative there is no evidence of uptake at this time.
Activity Description: At the request of Minister Murray, I agreed to serve as a technical advisor to the Minister and staff on this issue of mercury and climate change. The Mercury Community of Practice has not yet met, and the activities beyond consultation on expert issues are not yet defined.

2016/7 - 2017/7 Technical Advisor, Policy/Regulation Development
Group/Organization/Business Serviced: Ontario Ministry of Environment and Climate Change
Target Stakeholder: General Public
Outcome / Deliverable: Development of an appropriate data collection and remediation plan to address the mercury contamination issues in the English-Wabigoon River
Evidence of Uptake/Impact: The development of the remediation plan is ongoing.
Activity Description: regular teleconference with stakeholders. Review of technical plans and data collection.

2017/3 - 2017/3 Panel Member, Community Engagement
Group/Organization/Business Serviced: Lakehead University Research Innovation Week
Target Stakeholder: General Public
Outcome / Deliverable: Increased public awareness of mercury issues in northern Ontario, particularly focussed on the communities of Grassy Narrows/White Dog First Nations.
Evidence of Uptake/Impact: Attendance by approximately 75 members of the public at a forum hosted by Lakehead University resulted in strong pre and post event media coverage (local to regional incl CBC Radio Interview).
References / Citations / Web Sites: http://infosuperior.com/blog/2017/03/14/roundtable-discussions-what-can-we-do-about-mercury-in-our-water/ https://www.lakeheadu.ca/about/news-and-events/events/events-archive/2015/node/41279
Activity Description: Public open house on mercury in the environment hosted by Lakehead University. Deliverable was public information session on mercury in the environment spurred by recent heightened media coverage of the Grassy Narrows ON mercury contamination issue. Co-presentation with Judy Da Silva, Grassy Narrows Community Member/Advocate

2016/12 - 2016/12 Workshop Participant, Community Engagement
Group/Organization/Business Serviced: Mushkegowuk Council
Target Stakeholder: General Public
Outcome / Deliverable: The outcome of the two day science summit was direction for the Mushkegowuk Council on their approach to developing a collaborative framework for supporting research and managing traditional lands in the face of climate change.
Evidence of Uptake/Impact: The planners were expecting about 80 community members to attend. Over 200 people registered for the event, with people flying in from very remote communities. There was very free speech from many Elders on day 2, something that is unusual in a meeting setting, indicating a high level of interest and a desire to communicate concerns. The Council is striking a science advisory committee which will move these plans forward.
References / Citations / Web Sites: http://www.mushkegowuk.com/?page_id=4722
Activity Description: The Mushkegowuk Council organized a two day "Climate Summit" on December 7-8, 2016 in Timmins ON to bring Elders, community members, community leaders, government and scientists together to discuss priorities for a climate 'action plan' for the traditional territories in the Far North of Ontario. As a researcher participant, I led on of the "talking tables" about climate change and water quality, where we had open discussion about any questions that Elders, community members and leaders had about our area of science. We also participated in open discussion about the vision for the science action plan, as well as how best to implement new research relationships among the council, communities, government, and universities.

2016/3 - 2016/3

Facilitator and Educator, Community Engagement
Group/Organization/Business Serviced: Kluane First Nation
Target Stakeholder: General Public
Outcome / Deliverable: Two Indigenous youth and a youth councillor from Kluane FirstNation, YT, travelled to University of Waterloo and Western University for a three-dayexchange that included training in the laboratory. The youth were accompanied by anelder and an Aboriginal Filmmaker. Youth learned how to run fish samples they hadcollected on their traditional fishing lakes the previous summer (2015) for total mercuryanalysis. They also learned how to age fish using otoliths, and prepare samples forstable isotope and mercury analysis. University personnel learned traditional uses andpreparation and fishes, and traditional stories and lessons about fish harvest.
Evidence of Uptake/Impact: This unique and high-profile event was profiled in theWaterloo Record daily newspaper, on the University of Waterloo homepage, and on theWestern University Homepage. Youth were interviewed by CBC Yukon upon returning totheir community, and presented results to elders and community members at a communitylunch. A tweet containing a video clip of the training was retweeted to 14,598 people.
References / Citations / Web Sites: http://m.therecord.com/news-story/6408238-first-nations-students-to-help-uw-test-yukon-fish http://news.westernu.ca/2016/04/western-helps-unlock-secrets-to-food-security/
Activity Description: I helped coordinate the Western University portion of the visit. I arranged for the analytical laboratory training and visit, coordinated activities with Westerns Indigenous Student Centre, and a field trip to an Archeological Museum.

2013/1 - 2015/12

Science Advisory Panel Member, Policy/Regulation Development
Group/Organization/Business Serviced: Sensing the Americas' Freshwater Ecosystem Risk (SAFER) from Climate Change
Target Stakeholder: Academic Personnel
Outcome / Deliverable: Oversight of an international network to ensure scientifically rigorous outcomes. Ultimately outcomes may inform policy concerning the implications of climate change on freshwater ecosystems across the Americas.
Evidence of Uptake/Impact: Annual review of science outcomes of the program, and solicited for recommendations for changes or improvements to program.
Activity Description: I was asked to serve on this Panel as a result of my internationally recognized expertise in wetlands, aquatic systems and environmental change and oversee the scientific direction of a lake monitoring network that spans all of the Americas from Argentina to northern Canada.

2015/11 - 2015/11

Facilitator and Educator, Community Engagement
Group/Organization/Business Serviced: Attawapiskat First Nation
Target Stakeholder: General Public
Outcome / Deliverable: The deliverable was a public presentation/information session, filming a community TV channel program, and a presentation to Chief and Council about current information on mercury in the Attawapiskat River. The outcome was greater awareness of the current state of the ecosystem through the presentation of objective data.
Evidence of Uptake/Impact: Difficult to measure, other than the presentation was very well attended (~25 community members and Elders) which is unusual. Chief and Council called a special meeting to speak with the visiting science team,
Activity Description: Over 2 days I participated in a public presentation/information session, filming a community TV channel program, and a presentation to Chief and Council about current information on mercury in the Attawapiskat River.

2012/4 - 2015/7 Technical Review Committee, Policy/Regulation Development
Group/Organization/Business Serviced: US Department of Energy Oak Ridge National Laboratory (ORNL) Mercury Science Focus Area (SFA) Review
Target Stakeholder: Government Personnel
Outcome / Deliverable: Ultimately on the guidance of the Technical Review Panel, the outcome is the renewal of ~$30M worth of US DOE funding for a Oak Ridge National Lab mercury research program.
Evidence of Uptake/Impact: US DOE does not approve project funding without input from expert panel.
Activity Description: My involvement in federal and state review programs pertaining to mercury in the environment has been ongoing since the early 2000s. My invitations to serve on this US DOE review committee for two consecutive bi-annual reviews involved the review of science progress and plans for the Oak Ridges National Lab. This activity involved the review of significant reports and proposals, and multi-day review sessions in Washington DC in both 2012 and 2015.

2012/1 - 2014/12 Scientific Advisory Panel Member, Policy/Regulation Development
Group/Organization/Business Serviced: CALFED Yolo Bypass Mercury Project
Target Stakeholder: Government Personnel
Outcome / Deliverable: The research and regulatory community in the State of California has recognized my expertise in mercury and wetland ecosystems. I have served on numerous advisory and grant review panels for California since the mid-2000s and have had decision-making influence over the trajectory of funding programs valued in excess of $25M.
Activity Description: The research and regulatory community in the State of California has recognized my expertise in mercury and wetland ecosystems. I have served on numerous advisory and grant review panels for California since the mid-2000s and have had decision-making influence over the trajectory of funding programs valued in excess of $25M.

International Collaboration Activities

2015/7 - 2019/12 Co-Investigator, United States
I am a collaborator on a research project "Biological Responses to Increasing Water Temperatures in Lakes in the Barrow/Atquasuk Focus Watershed: An interdisciplinary Bioenergetics and Contaminants Study" by PIs Dr. C. Zimmerman (US Geological Survey) and Dr. H. Swanson (UWaterloo) and funded by the Arctic Landscape Conservation Cooperative (~$0.5M USD). My role as collaborator is to bring expertise in mercury biogeochemistry to the project (Hg methylation and bioavailability) and to contribute to training.

2014/1 - 2017/12 Co-Investigator, Sweden
As part of a research program funded by the Nordic Council of Ministers, I am co-funded with colleague Kevin Bishop and co-supervising a PhD Student Pianpian Wu at the Swedish Agricultural University (SLU) examining bioavailability of mercury in boreal lakes. This collaboration included a visit by Kevin and Pianpian in fall 2014 to Western to work on research questions, and I will be visiting Uppsala again in the next 4 months to continue working on research papers with this group.

Committee Memberships

2017/10 - 2018/3	Committee Member, Canada Research Chair Adjudication Committee, Natural Sciences and Engineering Research Council of Canada (NSERC) One year of service on CRC adjudication committee in Ottawa. Declined invitation to continue for a three year term for procedural reasons.
2013/1 - 2017/3	Committee Member, NSERC Discovery Grant Evaluation Group 1506 Geosciences, NSERC Discovery Grant Evaluation Group 1506 Geosciences As part of the NSERC DG review process, committee members are provided access to ~250 proposals and CCVs in the fall, review for comfort level, are assigned ~60 as a first to fifth level reviewer, provides full reviews and rankings of these, along with any from other cognate committees (in my case additional ~5 per year from Engineering, Chemistry and Ecology & Evolution). The review process is ~300 hours of effort from Sept – February. Additionally, a full week is committed to the review panel meeting in Ottawa in February. For the 2016-17 competition I was been asked by NSERC to serve as a Group Co-Chair for the second year (4th year of service) which means that in addition to my reviews I assist the Program Officer with decisions concerning group membership, cross committee review files, and will co-ordinate and oversee approximately 1/3 of the review process in Ottawa.
2015/5 - 2016/4	Committee Member, City of London Advisory Committee on the Environment, City of London Advisory Committee on the Environment University representative on advisory committee to the City of London
2013/5 - 2016/4	Committee Member, Department of Biology Research Committee, University of Western Ontario
2014/1 - 2014/12	Committee Member, Internal Research Tools and Instruments Screening Review Panel, University of Western Ontario

Presentations

1. Branfireun, B; Lindo, Z, Tian, J, James, E, Emilson E, Petrone, R, McLaughlin, J. (2019). Experimental climate warming leads to increasing carbon gas fluxes in boreal peatlands. British Ecological Society Annual Meeting, Belfast, Ireland
   Main Audience: Researcher
   Invited?: No, Keynote?: No
2. Branfireun BA. (2017). Mine-derived sulphate and mercury methylation in pristine northern peatlands: A little goes a long way...Workshop on Advances in Catchment Mercury Science, Uppsala, Sweden
   Main Audience: Researcher
   Invited?: Yes, Keynote?: No
3. Branfireun B, Zabel N, Swanson H. (2017). Mercury and methylmercury in tributary inputs to Kluane Lake, Yukon Territory, Canada. International Conference on Mercury as a Global Pollutant, Providence, United States
   Main Audience: Researcher
   Invited?: No, Keynote?: No
4. Branfireun B, Gunn G. (2017). From microbes to migratory fishes: a synthesis of far north research from the NSERC Canadian Network for Aquatic Ecosystem Services (CNAES). Canadian Conference For Fisheries Research/Society for Canadian Limnologists, Montreal, Canada
   Main Audience: Researcher
   Invited?: Yes, Keynote?: No

5. Branfireun B, Zabel N, Swanson H. (2017). Mercury in Water, Sediments and Fish in Kluane Lake, Yukon Territory, Canada. Canadian Geophysical Union Annual Assembly, Vancouver, Canada
   Main Audience: Researcher
   Invited?: No, Keynote?: No
6. Branfireun B. (2016). Climate and Land Use Change Impacts in Far North Peatlands: Implications for Carbon and Mercury Cycling. Laurentian University - Earth Science Speakers Series, Sudbury, Canada
   Main Audience: Researcher
   Invited?: Yes, Keynote?: No
7. Branfireun B. (2015). When the Arctic Isn't Cold. TEDx: The Human Condition, London, Canada
   Main Audience: General Public
   Invited?: Yes, Keynote?: Yes
8. Branfireun B. (2015). Natural and anthropogenically-induced hydrological connectivity produces methylmercury hotspots in the Hudson Bay Lowlands, Canada. Joint Assembly of the American Geophysical Union, Canadian Geophysical Union, Geological Association of Canada, Montreal, Canada
   Main Audience: Researcher
   Invited?: Yes, Keynote?: No

Broadcast Interviews

2017/03/06 - 2017/03/06	How do you clean up mercury contamination?, Up North, CBC Radio http://www.cbc.ca/player/play/891362371602
2014/07/10 - 2014/07/10	"Warming will change wetlands, release CO2: study", The Link, Radio Canada International http://www.rcinet.ca/en/2014/07/10/warming-will-change-wetlands-release-co2-study/

Text Interviews

2017/03/14	"What Can we Do About Mercury in Our Water?", InfoSuperior.com
2017/03/01	"Report shows mercury still leaking into river system", KenoraOnline
2017/02/28	"Study claims mercury still leaking from mill near Grassy Narrows: Chief", The Globe and Mail
2017/02/28	"Site near Grassy Narrows likely leaking mercury, study finds", The Toronto Star
2017/01/12	"Mercury-tainted soil found upstream from Grassy Narrows First Nation", The Toronto Star
2016/11/23	"Grassy Narrows residents eating fish with highest mercury levels in province", Toronto Star
2016/06/20	"Province ignores information about possible mercury dumping ground: Star Investigation" (expert advice and fact checking on article), The Toronto Star
2016/05/30	It’s possible to safely remove mercury from Wabigoon River, report says, The Toronto Star
2014/07/10	"Warming will change wetlands, release CO2: study", Radio Canada International (online web article) http://www.rcinet.ca/en/2014/07/10/warming-will-change-wetlands-release-co2-study/

Publications

Journal Articles

1. Bottini, C; MacDougall-Shackleton, S; Branfireun, B; Hobson, K. (2021). Feathers accurately reflect blood mercury at time of feather growth in a songbird. Science of the Total Environment.
Accepted
Refereed?: Yes, Open Access?: No

2. Blanchfield P, Rudd J, Hrenchuk L, Amyot M, Babiarz C, Bodaly R, Branfireun B, Gilmour C, Graydon J, Hall B, Harris R, Heyes A, Hintelmann H, Hurley J, Kelly C, Krabbenhoft D, Lindberg S, Mason R, Paterson M, Podemski C, Sandilands K, Southworth G, St. Louis V, Tate L, Tate M. (2021). Rapid recovery of contaminated fish following experimental mercury controls. Nature.
Submitted
Refereed?: Yes, Open Access?: No

3. Zabel, N; Hall, R; Branfireun B and Swanson, H. (2021). Mercury Accumulation in Sediments of Lhù'ààn Mān' (Kluane Lake, YT): Response To Past Hydrological Change. Manuscript submitted for publication.Arctic, Antarctic, and Alpine Research.
Submitted
Refereed?: Yes, Open Access?: No

4. Ma, Y*, Hobson, K; Kardynal, K; Guglielmo, C; Branfireun, B. (2021). Inferring spatial patterns of mercury exposure in migratory boreal songbirds: Combining feather mercury and stable isotope (delta H-2) measurements. Science of the Total Environment. 762: 143109.
Published
Refereed?: Yes, Open Access?: No

5. Tian, J*; Branfireun, B, Lindo, Z. (2020). Global change alters peatland carbon cycling through plant biomass allocation. Plant and Soil. 455(1-2): 53-64.
Published
Refereed?: Yes, Open Access?: No

6. Denkenberger, L, Fakhraei, H; Branfireun, B; Montesdeoca, M; Driscoll, C. (2020). Watershed influences on mercury in tributaries to Lake Ontario. Ecotoxicology. 29(10): 1614-1626.
Published
Refereed?: Yes

7. Gustin, M; Bank, M; Bishop, K; Bowman K; Branfireun, B; Chetelat, J; Eckley, C; Hammerschmidt, C; Lamborg, C; Lyman, S; Martinez-Cortizas, A; Sommar, J; Tsui, M; Zhang, T. (2020). Mercury biogeochemical cycling: A synthesis of recent scientific advances. Science of the Total Environment. 737: 139619.
Published
Refereed?: Yes, Open Access?: No

8. Grives, L; Bottini, C; Branfireun, B; Bernards, M; MacDougall-Shackleton, S; MacDougall-Shackleton, E. (2020). Food stress, but not experimental exposure to mercury, affects songbird preen oil composition. Ecotoxicology. 29(3): 275-285.
Published
Refereed?: Yes, Open Access?: No

9. Lescords, G; Johnston, T; Heeschap, M; Keller, W; Southee, F; O'Connor, C; Dyer, R; Branfireun, B; Gunn, J. (2020). Arsenic, chromium, and other elements of concern in fish from remote boreal lakes and rivers: Drivers of variation and implications for subsistence consumption. Environmental Pollution. 259: 113878.
Published
Refereed?: Yes

10. Sumner A; Johnston, T; Lescord, G; Branfireun, B; Gunn, J. (2020). Mercury Bioaccumulation in Lacustrine Fish Populations Along a Climatic Gradient in Northern Ontario, Canada. Ecosystems. 23(6): 1206-1226.
Published
Refereed?: Yes, Open Access?: No

11. Lyons, C; Branfireun, B; McLaughlin, J; Lindo, Z. (2020). Simulated climate warming increases plant community heterogeneity in two types of boreal peatlands in north-central Canada. Journal of Vegetation Science. 31(5): 908-919.
Published
Refereed?: Yes

12. 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.
Published
Refereed?: Yes, Open Access?: No

13. Bhavsar, S, Knight A, Branfireun B, Drouin, P, Prashad, R, Petro, S, Oke, M. (2019). A comparison of fish tissue mercury levels from homogenized fillet and nonlethal biopsy plugs. Journal of Environmental Science. 80: 137-145.
Published
Refereed?: Yes, Open Access?: No

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