Foth

Memorandum

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May 2, 2022

Report for 401(a)(2) Public Hearing

TO: U.S. Army Corps of Engineers, St. Paul District
File No. MVP-1999-05528-TJH

FROM: Steve Donohue, PH, Foth Infrastructure & Environment, LLC[1]
Jack Gibbons, PG, Foth Infrastructure & Environment, LLC[1]
Andrea Martin, PE, Foth Infrastructure & Environment, LLC[1]

RE: 401(a)(2) Public Hearing on PolyMet's NorthMet Project Section 404 Permit:
Project-Related Effects on Specific Conductance and Salinity in the St. Louis River at the Fond du Lac Reservation

1. Summary

In this report, we document our review of claims by the Fond du Lac Band of Lake Superior Chippewa (Band) that the NorthMet Project (Project) by Poly Met Mining, Inc. (PolyMet) will affect the Band's water quality on its Reservation located 116 miles downstream from the Project. Specifically, the Band alleges that the treated effluent from the Project's Waste Water Treatment System (WWTS) will result in exceedances of the Band's water quality standard for specific conductance set at 300 microsiemens per centimeter (µS/cm) at 25 degrees Celsius (°C) in the St. Louis River at the upstream boundary of the FDL Reservation. The Band also alleges that elevated specific conductance values in the St. Louis River will result in elevated salinity that will inhibit spawning of lake sturgeon.

This memorandum (memo) analyzes these two Band allegations and concludes the following:

- At estimated peak Project operation, the treated wastewater effluent is conservatively estimated to decrease specific conductance by approximately 0.40 to 0.66 µS/cm at 25°C in the St. Louis River near Cloquet. This reduction in specific conductance in the St. Louis River is a direct result of the capture and treatment of tailings basin seepage via the WWTS.

- At estimated peak Project operation, the treated wastewater effluent is conservatively estimated to decrease the salinity by approximately 0.0007 to 0.0024 parts per thousand (ppt) at the low-head dam along the St. Louis River at Forbes, the farthest upstream extent of lake sturgeon spawning. This reduction in salinity in the St. Louis River is a direct result of the capture and treatment of tailings basin seepage via the WWTS.

[1] Resumes of all authors are provided in Attachment 1.

2. Methods for Estimating Specific Conductance

2.1 Specific Conductance Definition and the Miller and Russell Estimation Methods

The GoldSIM model for Project effluent was used to estimate the concentration of primary ions such as calcium (Ca), chloride (Cl), fluoride (F), potassium (K), magnesium (Mg), sodium (Na), bicarbonate (HCO_3^-), sulfate ($SO4^{-2}$) that affect specific conductance. Parameters such as specific conductance must be calculated from the estimate of major ion chemistry of Project effluent. The following section defines specific conductance and then describes how it may be calculated via two methods from the major ion composition of an aqueous solution.

Specific conductance is defined as the electrical conductance of 1 cubic centimeter of water at 25°C. If the electrical conductance is measured at another temperature, the value is corrected to what it would be at 25°C and reported as specific conductance at 25°C (USGS, 2019). In the NorthMet Project National Pollutant Discharge Elimination System (NPDES) permit application and within this memo, specific conductance was estimated based on calculated ionic strength using the Russell (Snoeyink and Jenkins, 1980) and Miller estimation methods (Miller et al., 1988).

Similar to specific conductance, ionic strength is an important property of an aqueous solution. Understanding how ionic strength is derived and relates to specific conductance highlights the nature of the relationship between an aqueous solution's ionic species and its specific conductance. Ionic strength, in milliequivalents per liter (mEq/L), is defined as follows:

$$Ionic\ Strength = \frac{1}{2}\sum_{i=1}^{i=n} C_i\, Z_i^2 \qquad \text{mEq/L}$$

C_i = molar concentration in moles per liter (mol/L) of species *i*.

Z_i = oxidation state of species *i* (unitless).

Ionic strength may then be used to approximate specific conductance with the Russell estimation method (Snoeyink and Jenkins, 1980):

$$Specific\ Conductance = \frac{Ionic\ Strength}{1.6\ x\ 10^{-5}\ (\frac{\mathrm{mEq/L}}{\mu\mathrm{S/cm}})} \qquad \text{µS/cm at 25°C}$$

Taken together, these two equations are the Russell Estimation Method and underscore the relationship between the concentration of ionic species in a solution and the specific conductance: the greater total concentration of ionic species, the greater the specific conductance of a solution.

The second method for calculating specific conductance is referred to as the Miller estimation method (Miller et al., 1988) as follows:

$$Specific\ Conductance = \sum_{i=1}^{i=n} (a_i \lambda^\circ_i C_i)^f \qquad \text{µS/cm at 25°C}$$

a_i = the fraction of the ith ionic species that occurs as the basis species (unitless).

λ_i° = the equivalent conductance of the ith ionic species (µS/cm per mEq/L).

C_i = concentration in milliequivalents per liter of the ith ionic species (mEq/L).

f = exponential correction factor that describes the relationship between ionic conductance and concentration (unitless).

$$f = 0.9687 + 0.01956 \times F_1$$

F_1 = the fraction of monovalent (i.e., +1 or -1) ions using concentrations in milliequivalents per liter (unitless value between 0 and 1).

The Russell and Miller methods provide two formulae for calculating specific conductance from the estimates of major ion chemistry for Project effluent. Calculating specific conductance via the Russell and Miller methods is presented in the following section.

3. Specific Conductance Will Not Violate the Band's Water Quality Standard at the FDL Reservation

To estimate the potential effect of peak Project effluent on specific conductance in the St. Louis River near the FDL Reservation, the Miller and Russell estimation methods were used to calculate specific conductance from pH and the major ionic species — e.g., Ca, Cl, F, K, Mg, Na, $HCO3^-$, and $SO4^{-2}$. Conversions, parameterizations, and assumptions used in this Russell and Miller specific conductance estimation methods include:

- For mine year (MY) 1, P50 concentration and pH values for tailings basin seepage were taken from GoldSIM model results presented in Barr, 2015.
- For MY10, concentration and pH values were provided in a personal communication with Christie Kearney (2022). These data are the same that were used to calculate specific conductance as part of the antidegradation evaluation (Barr, 2017a).
- All ionic species were treated as conservative, i.e., no attenuation of concentration was attributed to speciation, sorption, and/or mineral precipitation. It must be emphasized that this is a very protective assumption, and naturally occurring speciation, sorption, and/or mineral precipitation processes will attenuate the concentration of ionic species.
- No speciation models were run to assess ionic speciation.
- A value of 1.22 — molar conversion factor between bicarbonate alkalinity as calcium carbonate ($CaCO_3$) and bicarbonate alkalinity as HCO_3^- — was used to convert alkalinity in milligrams per liter (mg/L) of $CaCO_3$ to mg/L of HCO_3^-.
- A MY10 annual average stabilized effluent flow of 2,720 gallons per minute (gpm), i.e., 6.060 cubic feet per second (cfs) (Barr, 2017a) and an annual average flow of 2,294 cfs for the St. Louis River at Cloquet (Barr, 2017c) were used to calculate a dilution factor of 378.6.
- Exponential correction factor values (*f*) of 0.9766 and 0.9755 were calculated for MY1 and MY10, respectively, using the monovalent ion formula (Miller et al., 1988).
- Equivalence conductance values (λ°) for individual ions were taken from Table 5 of Miller et al. (1988).

Results of specific conductance modeling, which were conducted as part of this analysis, are presented in Table 1. The Russell and Miller Estimation methods for undiluted specific concentration agree well with each other and also agree well with prior estimations (Barr, 2017a). By these two methods, the capture and treatment of tailings basin seepage via the WWTS are conservatively estimated to decrease specific conductance by approximately 0.40 to 0.66 µS/cm at 25°C in the St. Louis River near Cloquet.

Table 1

Calculation of Project-related Reductions in Specific Conductance in the St. Louis River at Cloquet

Species-specific Model Parameters				MY1 Undiluted, Tailings Basin Seepage			MY10 Undiluted, Stabilized Effluent at Project Discharge			MY1 Diluted at USGS#0402400 Tailings Basin Seepage			MY10 Diluted at USGS#0402400 Stabilized Effluent			Reduction in Specific Conductance at USGS#0402400	
Ionic Species	**Molecular Weight (mg/mol)**	**Valence**	**λ°**	**mg/L**	**Miller Estimation**	**Miller Estimation**	**mg/L**	**Miller Estimation**	**Russell Estimation**	**mg/L**	**Miller Estimation**	**Russell Estimation**	**mg/L**	**Miller Estimation**	**Russell Estimation**	**Miller Estimation**	**Russell Estimation**
H+	1008	+1	349.80	3.19E-05	1.11E-02	3.16E-08	4.01E-06	1.39E-03	3.98E-09	8.42E-08	2.92E-05	8.35E-11	1.06E-08	3.68E-06	1.05E-11	--	--
OH-	17007	-1	197.80	5.38E-03	6.25E-02	3.16E-07	4.27E-02	4.97E-01	2.51E-06	1.42E-05	1.65E-04	8.35E-10	1.13E-04	1.31E-03	6.64E-09	--	--
Ca+2	40078	+2	59.50	3.78E+01	1.12E+02	3.78E-03	7.65E+01	2.27E+02	7.63E-03	1.00E-01	2.97E-01	9.98E-06	2.02E-01	6.00E-01	2.02E-05	--	--
Cl-	35453	-1	76.35	1.99E+01	4.29E+01	5.62E-04	2.04E+01	4.39E+01	5.75E-04	5.27E-02	1.13E-01	1.49E-06	5.38E-02	1.16E-01	1.52E-06	--	--
F-	18998	-1	55.32	3.73E+00	1.09E+01	1.96E-04	1.24E+00	3.62E+00	6.54E-05	9.85E-03	2.87E-02	5.18E-07	3.28E-03	9.56E-03	1.73E-07	--	--
K+	39098	+1	73.52	8.84E+00	1.66E+01	2.26E-04	1.77E+01	3.34E+01	4.54E-04	2.34E-02	4.39E-02	5.97E-07	4.69E-02	8.82E-02	1.20E-06	--	--
Mg+2	24305	+2	53.06	6.67E+01	2.91E+02	1.10E-02	7.65E+01	3.34E+02	1.26E-02	1.76E-01	7.69E-01	2.90E-05	2.02E-01	8.82E-01	3.33E-05	--	--
Na+	22990	+1	50.11	6.40E+01	1.40E+02	2.79E-03	6.28E+01	1.37E+02	2.73E-03	1.69E-01	3.69E-01	7.36E-06	1.66E-01	3.62E-01	7.22E-06	--	--
HCO3-	61017	-1	44.50	2.46E+02	1.79E+02	4.03E-03	1.01E+02	7.36E+01	1.65E-03	6.49E-01	4.74E-01	1.06E-05	2.67E-01	1.95E-01	4.37E-06	--	--
SO4-2	96062	-2	80.00	2.03E+02	6.76E+02	8.45E-03	1.00E+01	1.67E+01	4.16E-04	5.36E-01	8.93E-01	2.23E-05	2.64E-02	4.40E-02	1.10E-06	--	--
				Specific Conductance (µS/cm at 25°C):	**1238**[1]	**969**[1]	**Specific Conductance (µS/cm at 25°C):**	**737**[1]	**816**[1]	**MY1: Specific Conductance diluted at Cloquet (µS/cm at 25°C**	**2.91**[2]	**2.56**[2]	**MY10: Specific Conductance diluted at Cloquet (µS/cm at 25°C**	**2.25**[2]	**2.16**[2]	**0.66**	**0.40**

[1] These are undiluted discharge values that were calculated using the equations referenced in Section 2.1.

[2] These are discharge values that were diluted by the 378.6 dilution factor and represent a conservative estimation on the reduction in specific conductance.

Prepared by: JVG
Checked by: AKM

4. Project-related Specific Conductance Will Not Inhibit or Impede Lake Sturgeon Spawning in the St. Louis River

The Band also suggests that the specific conductance of Project discharge waters will inhibit spawning of lake sturgeon in the St. Louis River. The Band notes that lake sturgeon will not spawn in waters with a salinity greater than 23 ppt and implies that the specific conductance of Project discharge waters will contribute to a salinity that exceeds 23 ppt. The Band has documented that the upper reach of lake sturgeon spawning in the St. Louis River is the low-head dam at Forbes. Therefore, this analysis will use Forbes as an evaluation point for salinity. The following paragraphs describe the estimation of salinity from specific conductance values and indicate that Project capture and treatment of seepage from the tailings basin will reduce the salinity in the St. Louis River by 0.0007 to 0.0024 ppt.

Lake sturgeon spawn within a specific range of water depths, temperatures, and salinities. Lake sturgeon spawning has been observed at water depths from 0.3 to 23 meters (m), water temperatures from 8 and 21.5°C, and salinities up to 23 ppt (Mims et al., 2002; COSEWIC, 2017). To provide the most protective evaluation (i.e., temperature and depth at which a given electrical conductivity value would result in the greatest salinity), salinities were evaluated at a temperature of 8°C and depth of 0.3 m.

For the conversion of specific conductance of Project discharge water to electrical conductivity, a temperature conversion value (1.458) was taken from Table 4 of Miller et al. (1988). This facilitates the conversion of specific conductance values reported in the Project's NPDES permit application to electrical conductivity values at 8°C.

Salinity calculations from electrical conductivity were performed in R Studio using the *ec2pss* function of the *wql* package. The *ec2pss* function converts electrical conductivity to salinity using the Practical Salinity Scale 1978 (Fofonoff and Millard, 1983) and the extension of the Practical Salinity Scale (Hill et. al., 1986) for salinities below 2 practical salinity units (psu). PSUs are a unitless value that is approximately equivalent to ppt. Since the Band's allegation refers to a salinity of 23 ppt, discussion will reference salinity in terms of ppt. Calculated specific conductance values from Table 1 were used to evaluate the magnitude of the reduction in salinity in the St. Louis River at Forbes.

Calculated discharge salinities were diluted by a factor or 94, which represents the flow of the St. Louis River at Forbes (570 cfs) (Barr, 2017a) divided by the Project's effluent discharge (2,720 gpm or 6.06 cfs) (Barr, 2017b). The protective assumption that a reduction in salinity is wholly attributed to dilution (i.e., does not include speciation, sorption, and/or precipitation processes that would attenuate concentration) was made. Table 2 presents the calculation results. Using the Miller and Russell method estimates of specific conductance and the Practical Salinity Scale 1978, the capture and treatment of tailings basin seepage via the WWTS is conservatively estimated to decrease the salinity by approximately 0.0007 to 0.0024 ppt in the St. Louis River near Forbes.

Table 2

Calculation of Project-related Reductions in Salinity in the St. Louis River at Forbes

	MY1 Undiluted, Tailings Basin Seepage		MY10 Undiluted, Stabilized Effluent at Project Discharge		MY1 Diluted at USGS#04018750 Tailings Basin Seepage		MY10 Diluted at USGS#04018750 Stabilized Effluent		Reduction in Salinity at USGS#04018750	
	Miller Estimation	Russell Estimation	Miller Estimation	Russell Estimation	Miller Estimation	Russell Estimation	Miller Estimation	Russell Estimation	Miller Estimation	Russell Estimation
Electrical Conductivity (µS/cm at 8°C and 0.3 m water depth)1	849	665	505	560	9.03	7.06	5.38	5.95	--	--
Specific Conductance (µS/cm at 25°C)	1238	969	737	816	13.16	10.3	7.84	8.68	--	--
Salinity (parts per thousand)	0.6298	0.4878	0.3671	0.4083	0.0049	0.0036	0.0025	0.0029	**0.0024**	**0.0007**

Prepared by: JVG
Checked by: AKM

5. Conclusions

This memo addresses the Band's allegations that Project discharge: 1) will result in an exceedance of the Band's water quality standard for specific conductance of 300 µS/cm at 25°C in the St. Louis River at the upstream boundary of the Reservation; and 2) will result in elevated salinity values in the St. Louis River that will inhibit lake sturgeon spawning.

Key takeaways from this memo are:

- At estimated peak Project operation, the treated wastewater effluent is conservatively estimated to decrease specific conductance by approximately 0.40 to 0.66 µS/cm at 25°C in the St. Louis River near Cloquet. This reduction is a direct result of the capture and treatment of tailings basin seepage via the WWTS.

- At estimated peak Project operation, the treated wastewater effluent is conservatively estimated to decrease the salinity by approximately 0.0007 to 0.0024 ppt at the low-head dam along the St. Louis River at Forbes, the farthest upstream extent of lake sturgeon spawning. This reduction is a direct result of the capture and treatment of tailings basin seepage via the WWTS.

6. References

Barr Engineering, 2015. NorthMet Project Water Modeling Data Package Volume 2 - Plant Site (v11)

Barr Engineering, 2017a. NPDES/SDS Permit Application: Volume III – Waste Water Treatment System. 564 pp.

Barr Engineering, 2017b. Waste Water Treatment System: Design and Operation Report: Permit-Review Level, NorthMet Project. 1069 pp.

Barr Engineering Company, 2017c. *Cross-Media Analysis to Assess Potential Effects on Water Quality from Project-Related Deposition of Sulfur and Metal Air Emissions*. October 31, 2017.

Committee on the Status of Endangered Wildlife in Canada, 2017. COSEWIC Assessment and Status Report on the Lake Sturgeon *Acipenser fulvescens,* Western Hudson Bay populations, Saskatchewan-Nelson River populations, Southern Hudson Bay-James Bay populations and Great Lakes-Upper St. Lawrence populations in Canada. Committee on the Status of Endangered Wildlife in Canada. Ottawa. 183 pp.

Fofonoff, N.P. and Millard, R.C., 1983. Algorithms for Computation of Fundamental Properties of Seawater. UNESCO Technical Papers in Marine Science 44. UNESCO, Paris, 53 pp.

Hill K.D., Dauphinee T.M., and Woods D.J., 1986. The extension of the Practical Salinity Scale 1978 to low salinities. IEEE Journal of Oceanic Engineering 11, 109-112.

Kearney, C., personal communication, March 30, 2022.

Miller, Ronald L., Bradford, Wesley L. and Peters, Norman E, 1988. Specific Conductance: Theoretical Considerations and Application to Analytical Quality Control. Geological Survey Water-Supply Paper 2311.

Mims, S.D., Lazur, A., Shelton, W.L., Gomelsky, B. and Chapman, F., 2002. Species profile: production of sturgeon. Southern Regional Aquaculture Center, Publication, 7200, pp.1-8.

Snoeyink, V. L. and Jenkins, D., 1980. Water Chemistry. New York: John Wiley & Sons, Inc.

U.S. Geological Survey, 2019, Specific conductance: U.S. Geological Survey Techniques and Methods, book 9, chap. A6.3, 15 p.

Attachment 1

Resumes

Stephen V. Donohue, P.H.

Vice President - Mining

Education
M.S. University of Wisconsin-Madison
B.S. Natural Science, University of Wisconsin-Madison

Professional Registrations/Certifications
- Professional Hydrologist - WI
- Professional Soils Scientist - WI

Litigation Highlights
- 2007 – Contested Case Hearing: Flambeau Mine (Rio Tinto) Certificate of Completion for Reclamation.
- 2008 – Contested Case Hearing: Eagle Mine (Rio Tinto) Mining Permit/ Environmental Impact Assessment and Groundwater Discharge Permit.
- 2012 – Clean Water Act Citizens Lawsuit: Plaintiff Action in Federal Court Against Flambeau Mining Company (Rio Tinto) alleging water quality impairment of Flambeau River
- 2018 – Contested Case Hearing: Back Forty Mine (Aquila Resources) Mining Permit/Environmental Impact Assessment.
- 2019 – Contested Case Hearing: Back Forty Mine (Aquila Resources) Wetlands Permit. Case Pending.

Key Expertise
- 30 years of professional experience, much of it focused on permitting complex mining projects in the Great Lakes region

Steve Donohue, P.H., has over 30 years of experience with expertise in permitting complex metallic mining projects. Mr. Donohue has led project teams on high-profile projects integrating feasibility studies, environmental permitting, mine closure, compliance and environmental impact analyses. He has worked with his clients to develop mine development, regulatory, and permitting strategies that incorporate the technical, legal, and public relations needs of the project. Mr. Donohue has provided litigation support to his clients. Mr. Donohue served as Rio Tinto's Lead Witness for the Eagle Project Contested Case Hearing and served as Aquila Resources' lead witness in the Contested Case Hearing for the Back Forty Project. Part of his responsibilities to his clients includes significant public involvement through multiparty meetings with public interest groups and regulatory agencies. He is routinely involved in educating state and federal legislators on behalf of his clients. Mr. Donohue's expertise in his profession has been recognized through his appointment to the Board of Trustees for the American Exploration and Mining Association and through his three appointments by Wisconsin Governors Thompson, McCallum, and Doyle to the Wisconsin Examining Board of Professional Geologists, Hydrologists, and Soil Scientists. Mr. Donohue is a past Chairperson of the Hydrology Section and the Joint Board.

Relevant Experience

Rio Tinto/Kennecott Exploration Company, Tamarack Project. In 2017, Foth was retained to assist Rio Tinto in the completion of the Conceptual Study for the potential development of the Tamarack copper-nickel resource in northeastern Minnesota. Steve led the Foth team's work effort on this project which included an assessment of all regulatory requirements, critical data needs including hydrologic studies for subsequent stage-gated study phases, costing and a risk assessment related to water resources, regulatory, social, and developmental risks.

Highland Copper Company, Copperwood Project. In 2017, Foth was retained as a Lead Environmental Consultant to lead the effort to secure permit amendments for the Copperwood Project in the Upper Peninsula of Michigan. In 2018, Foth secured the Amended Mining Permit and Air Permit for the reconfigured/ optimized project.

Aquila Resources Inc., Back Forty Project. In 2015, Aquila Resources acquired ownership of the Back Forty Project and financing to support permitting and feasibility studies for the development of the project. Foth was awarded the prime contract to lead the engineering and science-based work for the permitting and environmental review effort. Steve is the principal in charge of this effort. Tasks completed under Steve's direction included completion of the Environmental Impact Assessment including all baseline reports, geochemical characterization of mine waste materials, completion of the tailings and waste rock storage facility design, completion of mine water management plan including process level engineering of the wastewater treatment plant, completion of hydrologic modeling, completion of the Mine Permit Application, Air Permit Application, NPDES Permit Application, and Wetlands Permit Application. Steve worked as a strategic business partner with Aquila on the planning of the project to aid in the securing of finance agreements to fund the project. Steve recently served as the lead expert witness for the contested case hearing challenging the Mine Permit. In this capacity, Steve provides testimony related to the Mine Permit and Environmental Impact Assessment and in particular testimony related to the adequacy of hydrologic baseline studies and groundwater modeling studies.

Stephen V. Donohue, cont.

Professional Affiliations & Organizations

- Past Chair of the Wisconsin Examining Board of Professional Geologists, Hydrologists, and Soil Scientists - Past Chair of the Hydrology Section
- Society for Mining, Metallurgy and Exploration
- Prospectors & Developers Association of Canada
- American Exploration & Mining Association – Great Lakes Mining Committee
- Board of Directors - Mining Minnesota
- Board of Trustees for the American Exploration and Mining Association

Publications/Presentations

- Donohue, S.V., 2018. Prospects for Renewal of the Mining Industry in Wisconsin. Society for Mining, Metallurgy & Exploration. Annual Conference & Expo. February 25 -28, 2018. Minneapolis, Minnesota.
- Donohue, S.V. and F. Ongaro, 2017. Policies, Politics, and Projects: Are the Midwest States Inviting Investment? American Exploration & Mining Association. 123rd Annual Conference. December 4 -8, 2017. Reno, Nevada.
- Eykholt, G.R., J.B. Manchester, S.V. Donohue & J.C. Cherry (2009), "Heat and Mass Balance Modeling of a Subaqueous Tailings Disposal Facility," Tailings and Mine Waste '08, Taylor & Francis Group, London, pp. 35-48.
- Manchester, J.B., G.R. Eykholt, S.V. Donohue & J.C. Cherry (2009), "Water Chemistry and Metal Cycling in a Subaqueous Tailings Disposal Facility," Tailings and Mine Waste '08, Taylor & Francis Group, London. Pp. 49-62.
- Council, G.W., P.F. Anderson, S.V. Donohue. Crandon Mine Permit Application: A Modeling Odyssey. Modflow 2001 and other Modeling Odysseys Conference September 11-14, 2001.
- Donohue, S.V. May 5, 2000. Development of a Surface Water Mitigation Strategy for the Proposed Crandon Mine in Forest County, Wisconsin. Upper Peninsula Section SME Meeting.

Twin Metals Minnesota (Antofagasta). Twin Metals Minnesota is seeking to develop a large underground copper-nickel mine near the Boundary Waters Canoe Area Wilderness in northern Minnesota. The regulatory process will involve oversite by numerous state and federal agencies including the MDNR, MPCA, USACE, BLM, USFS, and USEPA. In 2015 Foth was awarded the contract as the Lead Environmental Consultant and was also selected to lead the hydrogeologic and water resources studies. In these roles, Foth will serve as one of the primary consultants to TMM for NEPA, MEPA, and permitting efforts. Steve is the principal in charge of Foth's contract obligations and serves in an advisory capacity to TMM for project activities including hydrologic studies.

Flambeau Mining Company. Principal-in-Charge for the project to engineer and construct an improved stormwater management system for runoff from the Industrial Outlot including the construction of a passive treatment wetland for attenuation of copper.

Flambeau Mining Company Lawsuit. In January 2011, the Wisconsin Resources Protection Council and others filed a federal lawsuit against Flambeau Mining Company alleging violations of the Clean Water Act. Having worked with Flambeau Mining Company for more than 25 years, Foth was retained to provide expert witness testimony on behalf of Flambeau Mining Company. Steve served as a lead witness on behalf of Flambeau Mining Company on issues related to site hydrology, hydrogeology, and water chemistry. The federal judge's ruling found that the Flambeau Mine was an exemplary operation and had not impaired water in the Flambeau River as alleged by the plaintiffs.

PolyMet Mining, Inc. For the better part of a decade, PolyMet Mining Inc. has been working on securing a positive EIS and permitting decision on the proposed NorthMet Project in northern Minnesota. Adjacent to the iron range, the NorthMet Project represents the first copper-nickel development in the state of Minnesota. In January 2012, Foth was retained to provide input to the consulting team working to address agency concerns about the project. Foth has also been tasked with providing peer review of hydrologic modeling studies and assisting in the preparation of the Permit to Mine Application, analysis of Financial Assurance and other critical documents leading to a permissibility decision by the regulatory agencies. Steve serves as principal-in-charge of this effort.

Kennecott Eagle Project. Principal-in-Charge and project manager for the permitting effort for the Kennecott Eagle Project in Marquette County, Michigan. Tasks included the development of a permitting plan for the project and development of permitting documents including the Mine Permit Application, Environmental Impact Assessment, Groundwater Discharge Permit Application, Air Permit Application, State Surface Use Lease Application, Soil Erosion, and Sediment Control Permit, Storm Water Permits, Septic Permit, Potable Well Permit, and Local Permit Application. Permit applications included design of the development rock storage area, facility plan, stormwater management plan, contact water storage basins, wastewater treatment plant, treated water infiltration system, reclamation plan, and financial assurance requirements. Project permits were issued in December 2007. Worked as a consultant with Kennecott's legal team on the preparation of litigation strategy, and preparation of expert witness testimony in support of environmental permits issued by the state of Michigan. All environmental permits and the impact analysis were successfully defended in court.

Stephen V. Donohue, cont.

- Donohue, S.V., G.W. Sevick, G.J. Berg, G. Reid. 1999. "Development of a Surface Water Mitigation Strategy for the Proposed Crandon Mine in Forest County, Wisconsin." Sudburg '99 Mining and the Environmental II Conference.
- Anderson, P.F., G.W. Council, R.T. Hagemeyer, S.V. Donohue. 1998. "Numerical Simulation of the Effect on Groundwater and Surface Water of the Proposed Crandon Mine." Presented at the American Water Resources Association Wisconsin Section 22nd Annual Meeting, Green Lake, Wisconsin. March 5-6, 1998.
- Donohue, S.V., P.F. Anderson, G. W. Council. 1998. "Project Overview of Groundwater Studies for the Proposed Crandon Mine." Presented at the American Water Resources Association Wisconsin Section 22nd Annual Meeting, Green Lake, Wisconsin. March 5-6, 1998.
- Donohue, S.V. 1997. "Geographical Information Systems (GIS): Emergence of a Cost-effective Management Tool." Presented at the New World of Environmental Regulation...Challenges for the Future Conference sponsored by DeWitt, Ross & Stevens, S.C. and Foth & Van Dyke, De Pere, Wisconsin. April 9, 1997.
- Donohue, S.V., P.F. Anderson, G.W. Sevick. 1997. "Crandon Mining Groundwater Studies." Presented at the Society of Environmental Toxicology and Chemistry-Midwest Chapter 5th Annual Meeting, Green Bay, Wisconsin. April 2-4, 1997.
- Donohue, S.V., G.W. Sevick. 1997. "Studies on Groundwater Lake Interactions near the Proposed Crandon Mine Site in Forest County, Wisconsin." Presented at the Society of Environmental Toxicology and Chemistry-Midwest Chapter 5th Annual Meeting, Green Bay, Wisconsin. April 2-4, 1997.
- Cheng, X.X., S.V. Donohue, S.J. Laszewski, S.G. Lehrke. 1993. Temporal and Spatial Non-Uniformity of Recharge in Northern Illinois. American Geophysical Union Spring Meeting.

Kennecott Humboldt Project. Principal-in-Charge for the permitting effort for the Kennecott Humboldt Project in Marquette County, Michigan. Tasks included the development of a permitting plan for the project, baseline studies, and development of permitting documents including the Mine Permit Application, Environmental Impact Assessment, National Pollution and Discharge Elimination System Permit Application, Air Permit Application, Soil Erosion, and Sediment Control Permit, Stormwater Permits, Septic Permit, Potable Well Permit, and Local Permit Application. Mine Permit Application included evaluation of historic mine impacts, reclamation plan, and financial assurance requirements.

HudBay/Aquila Resources, Back Forty Project. Principal-in-Charge for the permitting and environmental impact analysis for the Back Forty Project in Stephenson County, Michigan. This work commenced in 2009 when Foth was retained as the Prime Consultant to lead the permitting process. Foth was tasked with developing permitting strategy in consultation with HudBay's outside legal counsel and participating in community education programs. Other tasks include subsurface geotechnical investigations for tailings facility design, bedrock hydrogeologic studies, reviewing commissioned baseline environmental reports, geochemical characterization of waste rock and tailings, preparation of mining permit application, preparation of environmental impact assessment, design of water treatment system, design of waste rock and tailings storage facilities, preparation of water discharge permit application, preparation of air permit application and coordination with regulatory agencies.

Twin Metals, Minnesota. Principal-in-Charge of Foth team that completed scoping study on the use of open-pit mine site for tailings management. Project effort evaluated environmental liabilities associated with various options for using the open pit for tailings disposal. Both subaqueous and dry stack placement methods were evaluated. Conceptual level cost estimates for construction, operation, and closure were prepared.

Confidential Client. Principal-in-Charge of Foth team that completed scoping study on the use of open-pit mine site for tailings management. Project effort evaluated environmental liabilities associated with various options for using the open pit for tailings disposal. Both subaqueous and dry stack placement methods were evaluated. Conceptual level cost estimates for construction, operation, and closure were prepared.

Centerra Gold (Mongolia). Principal-in-Charge for Foth team completing various tasks for Centerra Gold's mining operations in northern Mongolia. Tasks have included completion of a Detailed Environmental Impact Assessment for the proposed Gatsuurt mine and a Detailed Environmental Impact Assessment for modifications of the mill facility at the existing Boroo Mine. Other studies at Gatsuurt include geochemical characterization, hydrogeologic investigations, waste rock storage facility design, and reclamation and water treatment planning.

Confidential Client Legislative Assistance. Work for the confidential client to assist with drafting a new state mining law regulating metallic mining.

- Donohue, S.V., S.J. Laszewski, F.J. Doran. 1992. Risk of Increased Contamination of a Dolomite Aquifer from Pumping Induced Drawdown, Fifth International Solving Groundwater Problems with Models Conference, Association of Groundwater Scientists and Engineers, Dallas, Texas. February 11-13, 1992.
- Kung, K-J.S., and S.V. Donohue. 1991. Improved Solute Sampling Protocol in a Sandy Vadose Zone Using Ground-Penetrating Radar, Soil Science Society of America, J. 55: 1543-1545.
- Donohue, S.V., X.X. Cheng, K-J.S. Kung. 1990. Improving Solute Sampling Protocols in Sandy Soils by Using Ground-Penetrating Radar, Third International Conference on Ground-Penetrating Radar, U.S. Geological Survey, Denver, Colorado. May 14-18, 1990.

Kennecott Tamarack Project. Principal-in-Charge of the baseline studies for the Kennecott Tamarack Project in Aitkin County, Minnesota. The Tamarack Project is high-grade nickel and copper peridotite intrusion west of Duluth, Minnesota. In 2006, Foth was commissioned to begin environmental studies on the project in anticipation of future environmental review and permitting requirements. To date, Foth has initiated studies on surface water hydrology, groundwater hydrology, hydraulic characterization of the Quaternary deposits and bedrock system at the potential mine site, geochemical characterization of potential development rock and regulatory coordination.

Crandon Mine Project. Project Manager for the formerly proposed Crandon Mine Project in northeast Wisconsin. Responsible for management of the permitting budget and activities of Foth Infrastructure & Environment professional staff and numerous sub-consultants, and overall coordination and integration of technical studies into permitting documents. Key project elements included preparation of an environmental impact report, development of mitigation plan for mine dewatering impacts on lakes and streams, groundwater quality performance assessment for proposed tailings facility, development of management plan for reflooded underground mine, feasibility studies for tailings and development of rock storage areas, socioeconomic analysis and addressing complex regulatory issues for a project that experienced significant public opposition. Attended and participated in numerous meetings with the Wisconsin Department of Natural Resources, U.S. Army Corps of Engineers, U.S. Environmental Protection Agency, U.S. Geological Survey, Native American Tribes, legislative officials, concerned environmental organizations, and the Governor's Science Advisory Council on Metallic Mining.

Kennecott Flambeau Mine Project. Principal-in-Charge for ongoing environmental monitoring of the closed and reclaimed Flambeau Mine in Ladysmith, Wisconsin. The project received in 2007 a Certificate-of-Completion for reclamation of the main mine site. Recent work includes support for ongoing litigation.

Groundwater Quality Assessment for Mine Closure. Lead Groundwater Hydrologist for a project to evaluate future groundwater quality compliance after backfilling and reclamation of a copper mine operated by Flambeau Mining Company in Ladysmith, Wisconsin.

Renard Island Closure Plan. Project Manager for the development of a closure plan for a confined disposal facility in the Bay of Green Bay. The CDF is contaminated with heavy metals and PCBs. The closure plan assessed capping options and the contaminant flux from the island under different closure scenarios.

Cedar Creek. Principal-in-Charge for the Amcast Industrial Corporation Cedarburg Superfund Project in Cedarburg, Wisconsin. The project included site characterization of PCB-contaminated environmental media and feasibility study on remedial alternatives including dredging and capping of contaminated sediments.

RCRA Closure Plan. Project Manager for preparation of an RCRA closure plan for Modern Plating Corporation in Freeport, Illinois. The feasibility study included conceptual design plans for the disposal of metal plating sludge and contaminated soils in a double-lined and capped landfill referred to as a Corrective Action Management Unit or CAMU. The closure plan also addressed the development of site-specific soil and groundwater cleanup objectives.

North American Exploration Projects. Principal-in-Charge of hydrologic monitoring programs for clients conducting exploration projects in North America in support of Order-of-Magnitude studies at potential mine sites.

Andrea K. Martin, P.E.

Lead Environmental Engineer

Role:

Education
B.S., Chemical Engineering, Michigan Technological University, 1981
M.S., Environmental Science & Policy, University of Wisconsin Green Bay, 2005

Professional Registrations/Certifications
- Registered Member – Society for Mining, Metallurgy & Exploration
- Executive Committee Member and 2021-2022 Chair– Society for Mining, Metallurgy & Exploration Environmental Division
- Professional Engineer – Wisconsin, Illinois, Michigan, Minnesota

Honors/Awards
- 2013 Recipient of SME President's Citation Award for Local Section Service.

Previous Employment
- Years of previous experience: 16
- Chicago Bridge & Iron Company

Key Expertise
For Mining and Other Industrial Projects:
- Environmental and General Permitting
- Environmental Impact Assessment
- Air Quality Programs
- Water Management Programs
- Regulatory Documentation and Reporting
- Remediation and Superfund Permitting
- Process Safety Management/Risk Management Plan
- General Regulatory Strategy and Review

Ms. Martin has over 30 years of experience in engineering, with 25 years in the environmental regulatory arena. Andrea concentrates on environmental issues associated with industrial, mining, and remediation projects, including preparation of permit applications, reports for Environmental Impact Statements and Assessments, compliance program development and maintenance, and interfacing with regulatory agencies. Air and water related permitting for industrial, mining, and CERCLA sites have been a primary focus. Andrea specializes in analysis of air deposition impacts including evaluation of impacts to water, soils, and other comparative criteria. Andrea has provided expert testimony for several mining related permits. She has strong skills in comprehensive document development and technical writing. Besides preparing project deliverables, Andrea serves many projects in oversight role as a Technical and Overall Document Reviewer. Previously, Andrea worked for a construction company where she gained design, engineering, estimating, and plant start-up experience. Andrea received her Bachelor of Science degree in Chemical Engineering from Michigan Technological University and a Master of Science degree in Environmental Science & Policy from University of Wisconsin-Green Bay. She holds Professional Engineer's licenses in Wisconsin, Michigan, Illinois, and Minnesota. Andrea is active in Society for Mining, Metallurgy & Exploration (SME), Executive Committee Member of the Environmental Division, and is currently Wisconsin Section Chair. She is an SME Registered Member and a Qualified Person pertaining to NI 43-101 for the environmental sections.

Relevant Experience

Aquila Resources Back Forty Project (2010 to present). Lead on Environmental Impact Assessment and NPDES and Dam Safety Permit applications and amended permit applications; contributor to the Air Permit and Mine Permit Applications; lead on recent amended permit applications. Development of these applications included expertise in mill processes, emissions inventory, water balance, preliminary conceptual wastewater treatment design, and understanding of applicable regulations. As the Project permitting has advanced, Andrea testified in one successful contested case hearing resolving the 2016 Mining Permit; provided on-site support in the wetland permit contested case; and will continue involvement in ongoing litigation.

Tamarack Project, Mine Project Development. Oversight of quarterly and annual monitoring reports on groundwater and surface water baseline data collection. Involved in the miscellaneous reports supporting the project since 2008 including the 2017 Conceptual Study and wetland permit applications for drilling activities.

Served as Qualified Person for NI 43-101 reports in the environmental sections and provided additional support for mining clients.

PolyMet Mining, Inc. (2011 to 2015). Technical Lead on several significant documents including analysis of environmental impacts due to air emissions from the project. Performed overall technical review and coordination on large analyses and applications underway to permit the project. Provided ongoing strategic consulting on a variety of issues as the project team responds and substantiates its investigative studies, design, and operations planning.

Twin Metals Minnesota. Prepare miscellaneous alternative analyses assisting in navigating environmental review process and permitting.

Andrea K. Martin, cont.

Publications/Presentations

- Martin, Andrea. "Regulations: What's in Store for Aboveground Tank Management." Materials Evaluation. July 1994.
- Martin, Andrea, and John Badrock, Robert Coutu, Norman Johnson. "Bulk Heating Cleans Paraffinic Bottoms from Crude Tanks." Oil & Gas Journal. February 1995.
- Martin, Andrea. "A Perspective of Mining Emissions and Cumulative Impact Analysis". Society for Mining, Metallurgy & Exploration, 85th Annual Meeting of the SME Minnesota Section, Duluth Minnesota. April 17-18, 2012.
- Martin, Andrea. "Adaptive Environmental Management Plans and Practices". Responsible Mining: Case Studies in Managing Social & Environmental Risks in the Developed World (Chapter 25). 2015.
- Martin, Andrea. "Adaptive Environmental Management Plans and Practices: Managing Environmental Impacts at Mines". 2014 Society for Mining, Metallurgy & Exploration Annual Meeting & Exhibit, Salt Lake City, Utah.
- Martin, Andrea. "A Perspective on Mercury: Air Emissions, Water Discharges, the Environment, and Regulations". 2015 Society for Mining, Metallurgy & Exploration Annual Meeting and Exhibit, Denver, Colorado.
- Martin, Andrea. "Major Contributors to Mine Water Treatment Design for Nonferrous Mines." 2017 Society for mining, Metallurgy & Exploration Annual Meeting and Exhibit, Denver, Colorado.
- Martin, Andrea. "The Impact of Native American Concerns on Mine Development and Operation." 2018 Society for Mining, Metallurgy & Exploration Annual Meeting and Exhibit, Minneapolis, Minnesota.
- Martin, Andrea. "Litigation: Strategies to Strengthen the Case for Your Permit." 2019 Society for Mining, Metallurgy & Exploration Annual Meeting and Exhibit, Denver, Colorado.

Honors/Awards

- 2013 Recipient of SME President's Citation Award for Local Section Service

Kennecott Eagle Project, Copper Nickel Mine, New Project (2005 to 2009). Lead on air permit application, construction storm water application. Contributed to Mining Permit Application, Environmental Impact Assessment, and overseeing biological and archaeological study preparation. Testified at administrative hearing assisting in upholding the issuance of the permits. Assisted with state lease negotiations. Established and maintained productive relationships with regulatory agency personnel. Prepared many analyses and responses supporting various permit applications.

Kennecott Humboldt Mill Project, Ore Processing Mill, Brownfield Refurbishment (2007 to 2009). Lead on air permit application, NPDES permit application, construction storm water permit application. Contributed to Mining Permit Application, Environmental Impact Assessment, Cumulative Impact (Air Deposition) Analysis. Prepared many analyses and responses supporting various permit applications.

Antofagasta-Duluth Metals Joint Venture (2009 to 2010). Due diligence on property transaction. Provided technical information as part of due diligence efforts for a confidential international mining company that was considering a joint venture on a base metal mining project in the upper Midwest. Foth's tasks included reviewing ongoing environmental studies that have been commissioned by the current owner of the prospective mine site and review of conceptual mine plans, permitting requirements, and identification of potential fatal flaws in the project.

Copperwood Resources Inc., Mine Project Development. Amended permit applications were prepared by Foth. Co-lead the air permit application preparation.

Northern States Power of Wisconsin Permit and Compliance Lead on Superfund Remediation Project, Ashland Wisconsin. Provided permit equivalency evaluation and permit application preparation for miscellaneous permits pursued with the city of Ashland. Acted as liaison between the City and the Foth Envirocon Joint Venture. Lead air permit compliance of Medium Temperature Thermal Desorption system of subcontractor.

Confidential Client. Project Manager on Process Safety Management Program Development project. Provided coordination and management to the client-Foth team developing a PSM program for a newly constructed process. The process technology originates from outside the United States, presenting additional translation and regulatory challenges.

Wisconsin Storm Water Permitting for Nonmetallic Mining. Developed management tools and methods to address permitting and compliance requirements for industrial and non-industrial sand and aggregate facilities. Strategized on methods to manage multiple facilities efficiently and cost-effectively through standardization.

Canadian Pacific Railway Litigation Project. Part of a team tasked with reviewing legacy sites undergoing litigation. Researched historical documentation to evaluate each site's contamination status and assess the timeframe of activities pertinent to the law suit issues.

Illinois Manufacturing Facility. Reviewed regulatory and environmental status, updated, and obtained permits in a manufacturing facility under EPA scrutiny with potential lawsuits, violations, and severe penalties.

Andrea K. Martin, cont.

Memberships

- Chair of Wisconsin Section Society for Mining, Metallurgy & Exploration

Birds Eye Foods, Inc., Fruit Processing Facility (2011-2012). A Lead on groundwater discharge permit application for a major modification of facility wastewater treatment facility. Served as a permit liaison during the construction and startup of the facility. Developed the Discharge Management Plan.

Modern Plating Corporation, Plating Facility. Lead on RCRA Part B Permit Renewal Application. Oversaw preparation and certified the application.

Variety of Foth Clients, Lead Client Contact. Performed environmental compliance work including preparation of air permit applications and permitting management tasks in a variety of states, annual reporting, plan preparation for spill control and storm water pollution prevention, numerous environmental compliance evaluations.

Lead preparer and certifier of SPCC Plans.

John (Jack) Gibbons, Ph.D., P.G.

Project Environmental Scientist

Education
Ph.D. Geology – University of Arizona
M.S. Geology and Geological Engineering – Colorado School of Mines
B.A. Geology and Economics – Carleton College

Professional Registrations/Certifications
- Professional Geologist (P.G.), Minnesota, #59842, 2021

Membership
- Society of Economic Geologists
- Mesabi Range Geological Society (President 2021 to 2022, Vice President 2020 to 2021, and Treasurer 2019 to 2020)

Key Expertise
- Hydrogeochemical modeling in PHREEQC and Geochemist's Workbench.
- USEPA Stage 2A Data Validation.
- Statistical analysis.
- SQL database design and management.
- Scripting in R and Python.

Previous Employment
- MineraLogic LLC (October 1st, 2018 to September 30th, 2021)
- University of Arizona (September 1st, 2012 to August 30th, 2018)
- BHP Billiton (June 1st, 2013 to August 30th, 2013 and June 1st, 2015 to August 30th, 2015)
- Duluth Metals (February 1st, 2011 to August 30th, 2012)
- Colorado School of Mines (September 1st, 2008 to January 30th, 2011)
- Arcadis (July 1st, 2007 – December 31st, 2008)

Jack Gibbons is a professional geologist with over five years of hydrogeochemical modeling and quality control and data validation experience. His hydrogeochemical modeling expertise includes pit lake chemistry, baseline groundwater assessment, evaluation of amended pit backfill chemistry, seepage characterization, and mineral speciation of kinetic test leachate. He has designed and implemented surface and groundwater quality control programs and has supported data validation programs that adhere to the USEPA Stage 2A guidelines.

Relevant Experience

Modeling of groundwater at a proposed underground copper-nickel mine to support environmental permitting, Twin Metals Minnesota, Twin Metals project, Ely, Minnesota, 2021. The client was seeking to perform scoping of groundwater issues to identify key items that would further focus pre-permitting baseline characterization. Groundwater data was modeled in Geochemist's Workbench to both characterize different hydrogeochemical populations and to identify areas of potential mixing between discrete groundwater aquifers. The project's deep bedrock groundwater quality was also compared with groundwater monitoring records from similar underground mines, i.e., base metal mines located within the Canadian shield, to support development of a predictive groundwater quality model.

Hydrogeochemical modeling to confirm efficacy of limestone amendment to pit backfill at a closed copper-gold mine, Rio Tinto, the former Flambeau mine site, Ladysmith, Wisconsin, 2021. The client was seeking to confirm that the limestone amendment to a backfilled open pit copper-gold mine was continuing to function as a pH buffer. A hydrogeochemical model was developed in PHREEQC to verify that groundwater was continuing to remain saturated with respect to several magnesium and calcium carbonate phases. The model confirmed that slow dissolution of the limestone amendment was providing sufficient concentrations of cations and alkalinity to the groundwater to mitigate any potential future metal leaching and acid-rock drainage (ML/ARD).

Automate data validation workflow to rapidly screen historic groundwater datasets, US Department of Energy, various global nickel sulfide mines, 2020. The project needed to rapidly screen historic geochemical datasets of varying quality prior to incorporating them within a large, multi-project relational database. A script was developed in R to provide both quantitative and graphical means to automate data screening. The script incorporated quantile-quantile plots, Spearman's rank-order correlation charts, and Shewhart control plots into an R-markdown document to provide a rapid means to screen for common data quality issues. This high-level technique successfully identified unit conversion, incorrect parameter reporting, and data omission errors that were irregularly distributed across many of the datasets.