

Appendix A – The Cross-Media Analysis

During the section 401(a)(1) permitting process, the Minnesota Pollution Control Agency asked PolyMet to evaluate the combined water quality effects of the NorthMet Project’s air emissions, wastewater discharges, and other Project actions.¹ The result was the “[Cross-Media Analysis to Assess Potential Effects on Water Quality from Project-Related Deposition of Sulfur and Metal Air Emissions](#),” dated October 31, 2017.² As discussed below, the Cross-Media Analysis demonstrates that the Project will not cause or contribute to violations of any Fond du Lac Reservation water quality requirements or cause or contribute to any adverse impacts to human health from consuming fish taken from Fond du Lac waters.

A. Cross-Media Analysis background and purpose

The Cross-Media Analysis grew out of an extensive planning process led by the Minnesota Pollution Control Agency.

For more than a year, a working group of interdisciplinary experts from the MPCA, Minnesota Department of Natural Resources, and PolyMet evaluated the underlying science and assumptions for the Cross-Media Analysis, including the results of extensive modeling and data collection. The goal was a study that would comprehensively evaluate the Project’s potential impacts on water quality—not only direct effects from discharges to water, but also the indirect effects of air emissions, watershed changes, water withdrawals, and other Project actions. These findings would assist MPCA in evaluating the Project’s compliance with federal and state water quality requirements in Minnesota and at the Fond du Lac Reservation, 116 river miles downstream (as shown on Figure 1, below).

¹ These other Project actions included the operation of the tailings basin seepage capture systems to collect mine water and other process waters from the Project plant site and mine site; changes to watersheds as a result of the Project; and withdrawal of make-up water from Colby Lake, which has high mercury concentrations.

² This title is something of a misnomer. The study comprehensively evaluates all air and water impacts on downstream water quality. But because air emissions are not typically included in a section 401 water quality analysis, those emissions were highlighted in the title.

As a starting point, PolyMet evaluated the predicted effects of the Project’s wastewater discharges and other Project actions. That evaluation appeared in PolyMet’s NPDES antidegradation evaluation and its section 401 certification antidegradation assessment, as required by the MPCA rules. *See* Minn. R. ch. 7050 and 7052 (collectively referred to as “antidegradation analyses”).³ The Surface Water Antidegradation Evaluation demonstrated that the wastewater discharges and other Project actions will not cause or contribute to any exceedances of numeric water quality standards downstream of the Project (i.e., standards of either the State (Section 7.2) or the Band (Section 10.2)). That demonstration included no exceedance of the water quality standard for mercury in fish (Section 8.3.3) and no impairment of designated uses of any downstream waters (Section 7.1). In fact, the Surface Water Antidegradation Evaluation showed that the Project’s high level of wastewater treatment and other Project actions would actually reduce the amounts of mercury and sulfate loading entering the St. Louis River watershed as compared to the existing conditions. *Id.*⁴

The Cross-Media Analysis took the predicted water quality outcomes from the Surface Water Antidegradation Evaluation and added the potential contribution to water quality from Project air emissions to estimate the potential cumulative effects from the Project. Those results were then incorporated into PolyMet’s Section 401 Antidegradation Assessment, which concluded that “cumulative Project effects will not cause or contribute to a lowering of water quality within the [Fond du Lac] Reservation boundaries or to a violation of any water quality standards in waters within the Reservation, nor degrade or otherwise adversely affect any existing or designated uses of waters within the Reservation.” 401 Antidegradation Assessment § 6.2.

Building on the Surface Water Antidegradation Evaluation, the Cross-Media Analysis addressed three big-picture questions:

- Could Project air emissions, on their own or in combination with wastewater discharges and other Project actions, cause or contribute to violations of water quality standards?

³ The two antidegradation analyses are available on the MPCA website for the Project: [Antidegradation Assessment - NorthMet Project Section 401 Certification](#), December 2017 (401 Antidegradation Assessment); [Surface Water Antidegradation Evaluation – NorthMet Waste Water Treatment System Discharge](#), October 2017, Appendix A of Volume III (Surface Water Antidegradation Evaluation). The 401 Antidegradation Assessment incorporated the Surface Water Antidegradation Evaluation and also included other information.

⁴ The Project is expected to reduce sulfate loading by 1,400 metric tons per year and cause a small annual reduction in mercury loading as compared to existing conditions. *See* Surface Water Antidegradation Evaluation at 6, 8.

- In light of recent scientific studies showing that adding sulfate to wetlands sometimes stimulates biochemical methylation of mercury, how might sulfate deposition from Project air emissions affect methylmercury concentrations in the surrounding watersheds?
- What is the overall effect of the Project (air emissions plus wastewater discharges and other Project actions) on mercury, methylmercury, and sulfate loading and concentrations in the St. Louis River watershed?

As discussed below, for each of these three questions, the Cross-Media Analysis demonstrated that the Project will not cause or contribute to any violations of water quality standards, including both numeric criteria and use classifications, and will not cause any adverse impacts to human health.

B. Cross-Media Analysis methodology

To answer its three key questions, the Cross-Media Analysis used available modeling tools and made informed assumptions about the processes that occur from the time a particle is emitted into the air until some component of that particle ends up in a downstream wetland or waterbody. Because a majority of the sulfate and metals of potential significance are associated with sulfide mineral dust particles, the Cross-Media Analysis focused on sulfide dust emissions. It modeled the full geographic extent of lands expected to receive any meaningful air emissions (both stack and fugitive) from the Project, as shown in Figure 2 below. And, as shown in Figure 3, the Cross-Media Analysis's scope includes both the lower Embarrass and Partridge River watersheds, which drain into the St. Louis River.

Figure 2: Cross-Media Analysis Air Modeling Receptor Grid and Modeled Results



Figure 3: Geographic Scope of Cross-Media Analysis

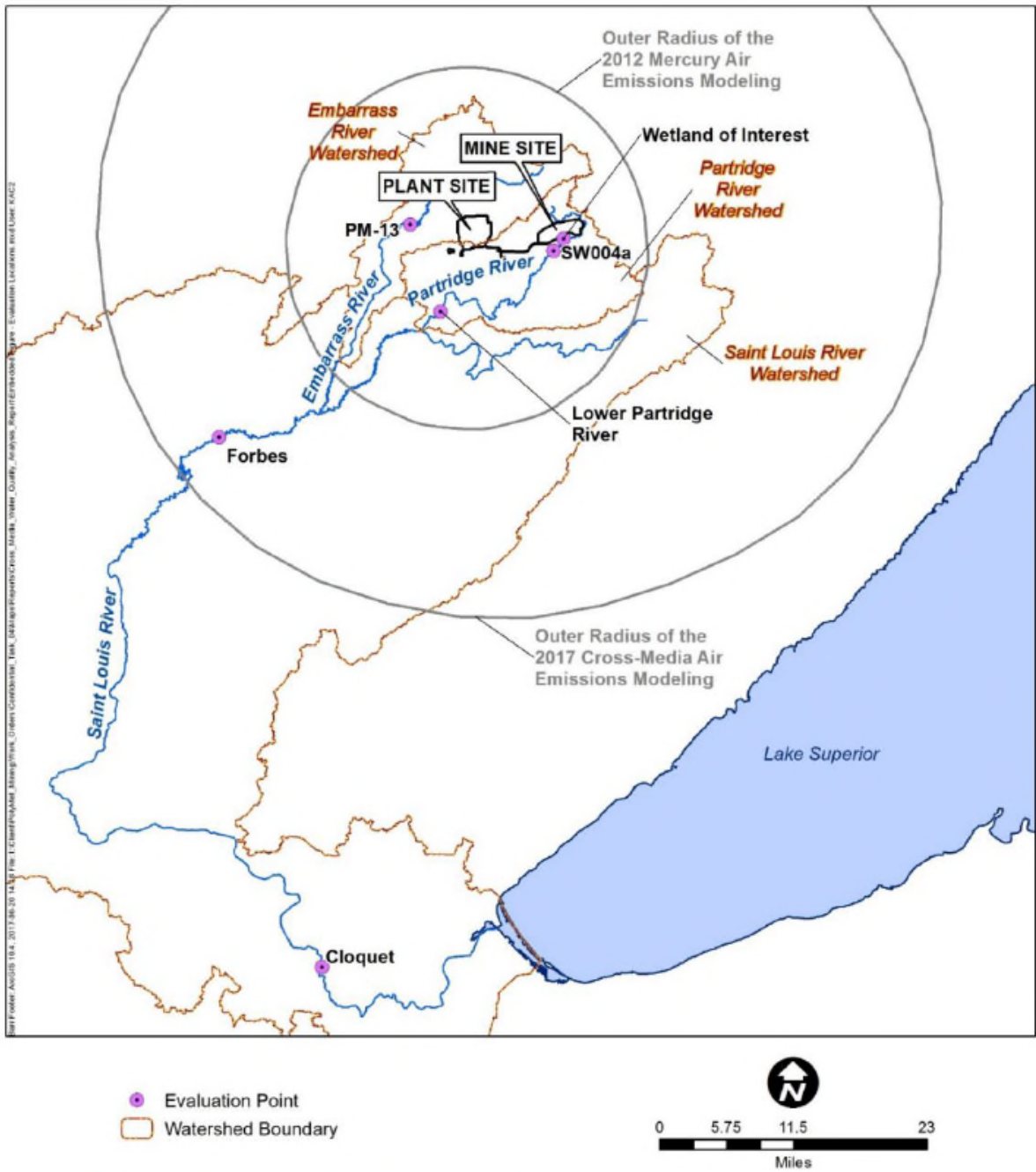


Figure 6-1 Geographic Scope of this Analysis

Deposition of a sulfide mineral particle into the environment does not necessarily result in release of sulfur or metals to surface water. Instead, release of sulfur and metals from a particle to a water body depends on the physical, chemical, and biological processes that act on the particle. The Cross-Media Analysis assessed these processes in five basic steps:

1. Project air emissions (from stacks, tailpipe emissions, and fugitive sources) relevant to sulfate and metals were modeled.⁵
2. The physical processes that affect air-emitted particles as they settle to the earth's surface and then move through the watershed (e.g., how far particles of different sizes travel before they settle to the surface) were accounted for.
3. Geochemical reactions of air-emitted particles in the environment, due to weathering and other factors, were estimated.
4. The amount of sulfur and metals that will enter downstream waters (loading) was estimated, as was the resulting effect (concentrations) on downstream water quality and mercury levels in fish.⁶
5. The effect on wetland water quality was calculated for the wetland that will receive the highest amount of sulfide mineral dust from Project air emissions—known as the “wetland of interest.”

The Cross-Media Analysis was designed to address the variability and uncertainty involved with interconnected natural systems by making informed assumptions about key physical, chemical, and biological processes. As already noted, a working group of interdisciplinary experts from MPCA, DNR, and PolyMet spent over a year discussing the underlying science and the appropriate assumptions for the Cross-Media Analysis. When the Cross-Media Analysis was nearly finished, MPCA submitted it for independent expert peer-review. Based on that review, MPCA asked PolyMet to adjust some of the study's assumptions. The final Cross-Media Analysis, which included MPCA's requested adjustments, was submitted to MPCA on October 31, 2017.

The Cross-Media Analysis incorporated protective assumptions that overestimated potential water quality effects into each part of its review. For example, its air emission modeling assumed that maximum emissions from all sources at the mine site and plant site occur simultaneously and continuously (24 hours a day, 365 days a year). Because not

⁵ The model design for the Cross-Media Analysis was consistent with PolyMet's emission modeling for its air permit application. To ensure consistency, it was reviewed and approved by the same MPCA staff involved in reviewing the air permit application and writing the air permit.

⁶ In addition to sulfate and mercury, the Cross-Media Analysis focused on arsenic, copper, and cobalt, based on their prevalence in PolyMet's ore, the applicable water quality standards, and the existing water quality in area waters.

all sources operate simultaneously all the time, actual emissions will be substantially less than the Cross-Media Analysis's estimates. The Cross-Media Analysis also assumed that all particles deposited over an entire watershed make their way into a wetland or stream. In fact, research demonstrates that most particles that fall in upland areas remain there and that sulfate and metals released from those particles are retained in the uplands.

In total, the Cross-Media Analysis included more than 25 different protective assumptions. See Cross-Media Analysis Table 3-3. Similar to human health and ecological risk assessments, these protective assumptions were multiplicative, not additive. The protective assumptions made in each part of the Analysis built on each other to amplify the overall protectiveness of the study's conclusions. As a result, the final findings of the Cross-Media Analysis—while still showing that the Project will comply with all applicable water quality standards—significantly overestimate the Project's potential effects on water quality. These overestimates account for any uncertainties in the Cross-Media Analysis's predicted outcomes.

The Cross-Media Analysis's findings were framed in terms of measurable change to water quality. But MPCA and PolyMet disagreed about how to define a "measurable change." The Analysis's modeling, because it is a mathematical exercise performed on a computer, can predict theoretical numeric changes that are too miniscule to be measurable in the field. Minnesota law recognizes this issue, providing that water quality will be considered degraded by a proposed activity only if it produces a "measurable change" in water quality—defined as "the *practical ability to detect a variation* in water quality, taking into account the limitations in analytical technique and sampling variability." Minn. R. 7050.0255, subp. 24 (emphasis added).

To decide whether a computer-modeled change would be "measurable," PolyMet recommended using the measure of variability in EPA-approved test methods for each of the parameters of concerns (mercury, methylmercury, sulfate, mercury in fish tissue, and the three indicator metals). These measures are the Laboratory Control Sample (LCS) acceptance criteria. Cross-Media Analysis at 30-32.⁷ MPCA staff preferred relative percentage difference (RPD) calculations as a way of determining measurable change relative to fish tissue mercury concentrations, and a different approach for determining measurable change in water concentrations. See MPCA [Conclusions and Recommendations Related to the Cross-Media Analysis](#), Jan. 5, 2018 (Cross-Media Analysis Conclusions and Recommendations) at 12-13.⁸ Regardless of which method was

⁷ Additional information regarding PolyMet's reliance on the LCS approach can be found in the company's surface water antidegradation evaluation, which was incorporated into both its NPDES/SDS permit application and its 401 certification application. In particular, Attachments B and C of [Appendix A of Volume III of the NPDES/SDS permit application](#) provided detailed rationales.

⁸ Application of the two methodologies did not create uniform results in terms of whether the "measurable change" threshold was higher or lower. Generally speaking, however,

used, the results were the same: no measurable changes in the St. Louis River. These results are documented in the Cross-Media Analysis for PolyMet’s “measurable change” methodology and in the Cross-Media Conclusions and Recommendations for the agency’s methodology.

C. Cross-Media Analysis results and MPCA conclusions

Using the methods and protective assumptions approved by MPCA, the Cross-Media Analysis reached the following conclusions:

- Neither the Project’s air emissions nor any other Project changes will cause measurable changes in water column methylmercury concentrations or in fish tissue mercury concentrations in the Partridge, Embarrass, or St. Louis Rivers.
- When mercury and sulfate loading from air emissions is added to mercury and sulfate loading changes from the Project’s wastewater discharge and other Project actions, the cumulative effect will be:
 - a *decrease* in sulfate loading to the St. Louis River watershed;⁹
 - a *measurable decrease* in sulfate concentration in the Embarrass River;
 - *no measurable change* in sulfate concentrations in the lower Partridge or St. Louis Rivers;
 - a *decrease* in mercury loading to the St. Louis River watershed;
 - *no measurable change* in mercury or methylmercury concentrations in the Partridge, Embarrass, or St. Louis Rivers; and
 - *no measurable change* in fish tissue mercury concentrations at any downstream locations on the Partridge, Embarrass, or St. Louis Rivers.
- The loading and concentration changes for sulfate, mercury, and methylmercury will not cause or contribute to any violations of water quality standards in Minnesota or Fond du Lac waters; nor will they cause any adverse health effects

PolyMet’s approach created lower thresholds, i.e., they were more likely to show a measurable change.

⁹ In particular, the Project will reduce sulfate loading to the St. Louis River watershed by approximately 1.38 million kilograms per year as compared to existing conditions. The Project will reduce mercury loading to the St. Louis River watershed by approximately 5.2 grams per year as compared to existing conditions. See Cross-Media Analysis Tables 5-5 and 5-6.

relating to mercury concentrations in fish, either in the vicinity of the Project or downstream.¹⁰

- The concentrations of arsenic, copper, and cobalt in the wetland of interest, which are currently below the numeric water quality standards, will stay below those standards after additions of metals from Project air emissions and other Project actions.
- The Project will not cause or contribute to any violations of water quality standards with respect to arsenic, copper, or cobalt, either in the wetland of interest or in any downstream waters.

Figure 4 shows the estimated cumulative effects of the Project air emissions, wastewater discharges, and other Project actions on sulfate and mercury concentrations, including the evaluation location at Forbes, about 60 miles upstream of the Fond du Lac Reservation.

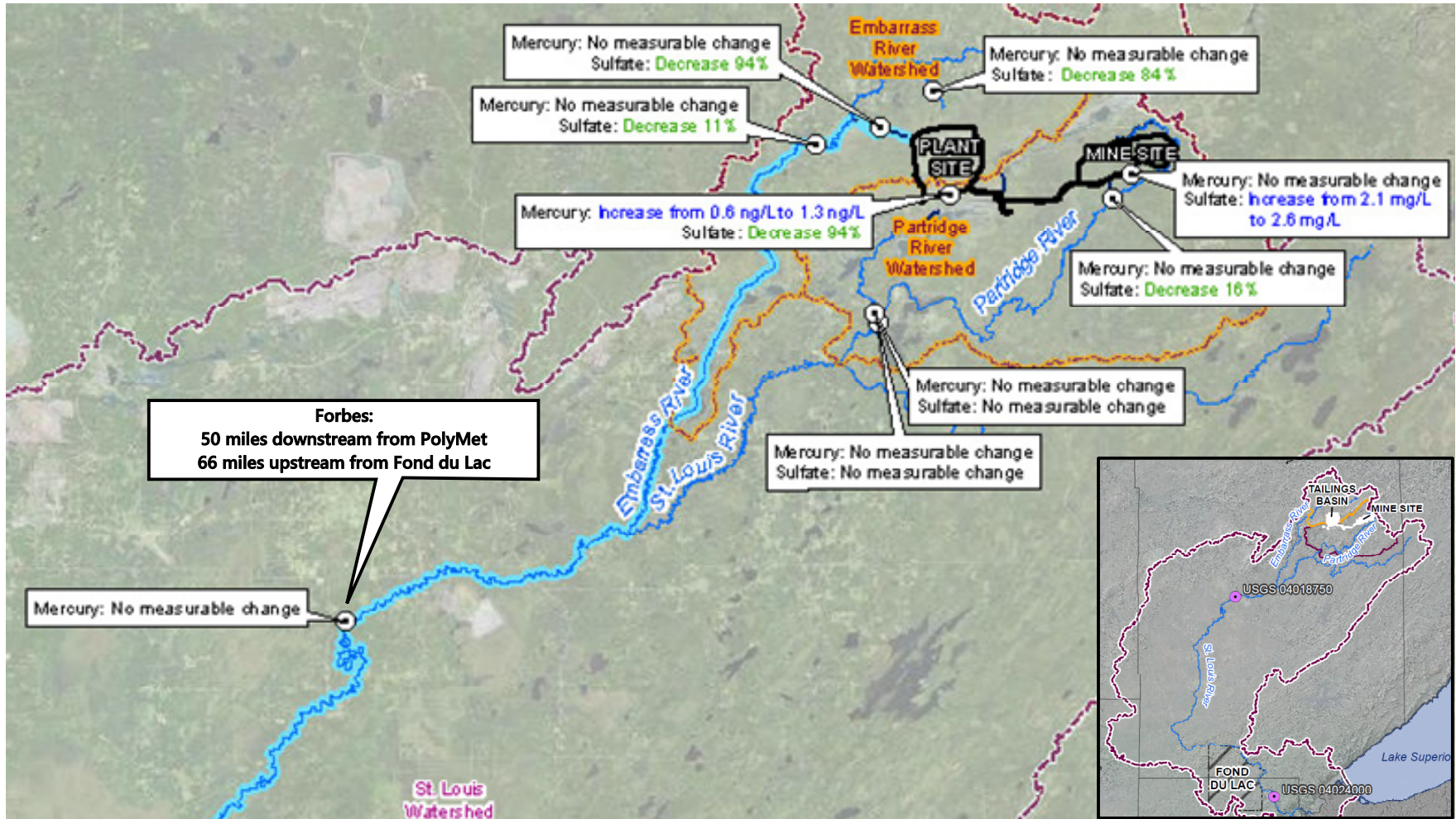
¹⁰ In Minnesota, MPCA and the Minnesota Department of Health have different health criteria for mercury concentrations in fish tissue. MPCA has a human-health based water quality standard of 0.2 kg/mg total mercury in edible fish. Minn. R. 7050.2020. Among other things, MPCA relies on this water quality standard to determine if a water body should be listed as impaired for purposes of the Clean Water Act Section 303(d) list. MDH uses different criteria for developing non-regulatory fish consumption advisories.

MPCA, for purposes of its section 401 certification, relied on the water quality standard in Minn. R. 7050.2030 rather than MDH's advisory criteria. MPCA explained its rationales in its Cross-Media Conclusions and Recommendations at II-12.

The Cross-Media Analysis reviewed both MPCA's water quality standard and MDH's advisory standard on fish consumption. It concluded that the Project would not cause any measurable changes in mercury in water concentrations or fish tissue in the St. Louis River within the Fond du Lac Reservation and accordingly that the Project would have no impacts under either MPCA's water quality standard or MDH's consumption advisory standard. MPCA consulted with MDH with respect to this evaluation in the Cross-Media Analysis, and MDH expressed no disagreement with the conclusions to be included within the Cross-Media Analysis or MPCA's review of the study.

MPCA's human health-based water quality standard for mercury in edible fish varies in some ways from EPA's fish tissue concentration for mercury, as MPCA explained in its Cross-Media Conclusions and Recommendations at pages II-12. The Minnesota standard requires lower levels of mercury in fish.

Figure 4: Cross-Media Analysis Results for Sulfate and Mercury Concentrations



Before issuing its section 401 certification, MPCA carefully considered the Project's potential impacts on downstream states, including the Fond du Lac Reservation. Based on the Cross-Media Analysis, as well as the other information collected during the NorthMet environmental review and permitting processes, the agency "determined there is reasonable assurance the activities proposed in the Revised Wetland Permit Application, the impacts of which were addressed in the Final Environmental Impact Statement, will be conducted in a manner that will not violate applicable water standards, and certifies the project with [numerous monitoring] conditions."¹¹ MPCA, [Section 401 Water Quality Certification](#) (Dec. 20, 2018 letter from MPCA Commissioner John Linc Stine to USACE and PolyMet).

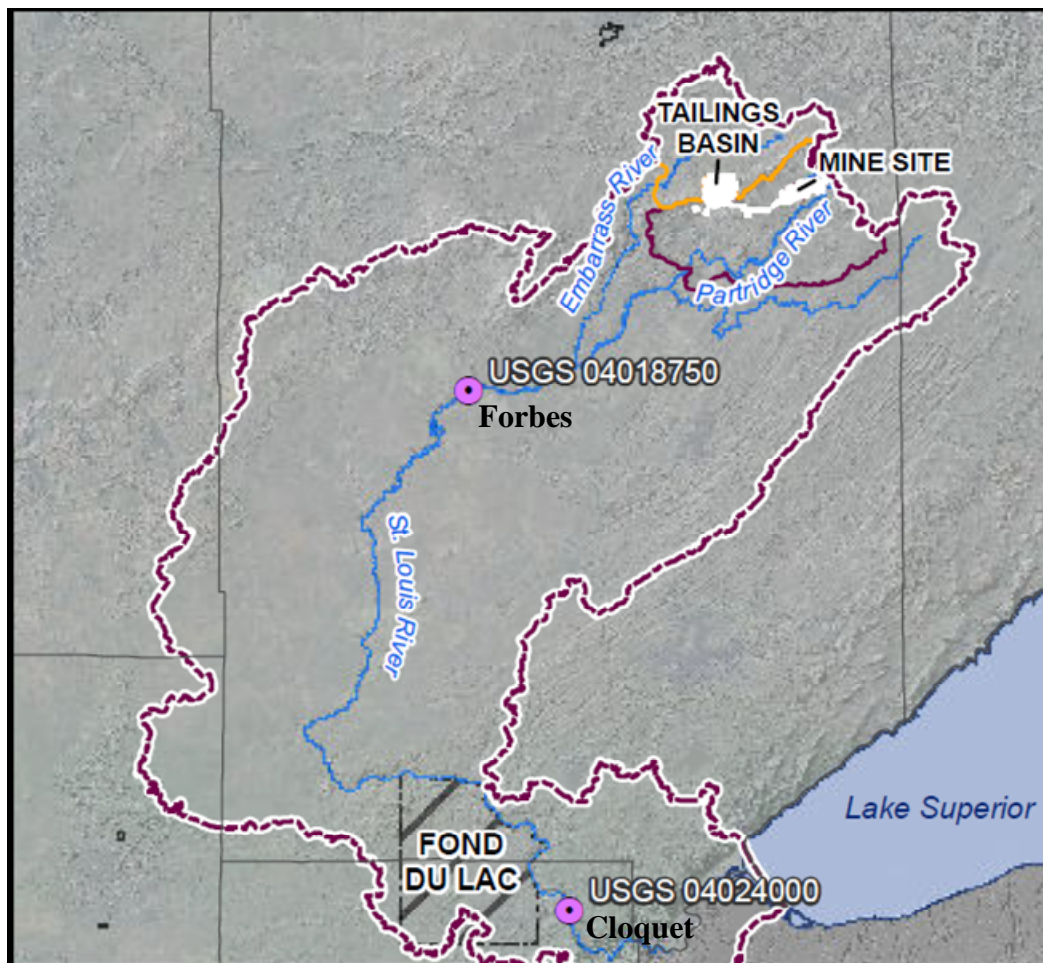
MPCA offered more detailed conclusions in its [Clean Water Act Section 401 Water Quality Certification Program Fact Sheet](#). As stated on page 14, MPCA found that:

1. The [Cross-Media] analysis developed a reasonable and protective scenario that showed no changes of mercury in water or fish from Project-related deposition of sulfur.
2. There will be no exceedances of copper, cobalt, and arsenic Class 2D water quality standards or to any other water quality criteria from Project-related air emissions or the cumulative impact of Project-related air emissions.
3. The Project will not result in any measurable changes to water quality downstream of the Project in the St. Louis River, including downstream locations at Forbes (upper St. Louis River).

Figure 5 shows that the USGS monitoring station at Forbes is approximately 50 river miles downstream of the Project, and approximately 60 river miles upstream of the Fond du Lac Reservation.

¹¹ MPCA's "reasonable assurance" language is from Minn. R. 7001.01470, subpt. 1(C). See *In the Matter of the Decision on the Approval for Submittal of a 401 Water Quality Certification to the U.S. Environmental Protection Agency for the Draft 2013 Vessel General Permit and the Draft 2013 Small Vessel General Permit*, 822 N.W.2d 676, 682-685 (Minn. App. 2012) (upholding MPCA's interpretation of the "reasonable assurance" standard as meeting requirements of CWA Section 401 and Minnesota law).

Figure 5: Cross-Media Analysis Evaluation Points on the St. Louis River



In reaching these conclusions, MPCA relied in part on its review of the Cross-Media Analysis, as documented in its Cross-Media Conclusions and Recommendations Memorandum. There, MPCA found that “the Project would not result in any measurable changes to water quality downstream of the Project in the St. Louis River at Forbes.” Cross-Media Conclusions and Recommendations at 2. That led MPCA to the “overall conclusion” that “there will be no measurable changes of mercury in water or fish nor exceedances of copper, cobalt, and arsenic Class 2d water quality standards from project related emissions.” *Id.* MPCA emphasized that these conclusions were its “best estimate” of the Project’s potential effects, made using the “best available data” and “best professional judgment.” *Id.*; *see id.* at 13.

MPCA’s Cross-Media Conclusions and Recommendations appended more detailed memos from the individual staff members who reviewed the Cross-Media Analysis. These materials offer even more support for the agency’s conclusion that PolyMet’s Project will have no downstream water quality effects. For example, the staff member responsible for

mercury and methylmercury review, Dr. Bruce Monson, noted that “[m]any of the assumptions [in the Cross-Media Analysis] were protective and most likely *overestimated* the effects of sulfate from the project.” Cross-Media Conclusions and Recommendations at 11 (emphasis added). The same expert wrote that the “potential changes in fish tissue mercury concentrations” calculated in the Cross-Media Analysis for the Embarrass River and Partridge River near the Project “are not measurable.” *Id.* at 12 (Monson). He then explained that “if there were no measurable changes [in fish tissue mercury concentrations] upstream, there is no reason to expect measurable changes” at Forbes or Cloquet. *Id.*¹²

That is not to say that each MPCA expert agreed with each element of the Cross-Media Analysis. But in the few areas where PolyMet’s and MPCA’s experts did not reach consensus on the assumptions to be included, the Cross-Media Analysis consistently used the more protective assumption.¹³ That meant that differences of opinion about methods did not lead to disagreements about Cross-Media Analysis’s conclusions, which were based on the most protective assumptions. See Cross-Media Analysis Table 3-3.

In sum, the science shows that PolyMet’s project will have no measurable impact on water quality in the St. Louis River upstream of the Fond du Lac Reservation at Forbes or downstream of the reservation at Cloquet. That means the Project can have no measurable impacts on reservation waters. Likewise, the science proves the project will have no measurable impacts on mercury concentrations in fish at Forbes, Cloquet, or within the reservation. Because there will be no project-related impacts to reservation waters, the Project cannot cause or contribute to any violations of the Band’s water

¹² See also, e.g., Cross-Media Conclusions and Recommendations at 5 (Sullivan) (“[T]he Data developed from the air quality modeling files is consistent with [the MPCA-approved] modeling protocol and is suitable for use in hydrological and geochemical analysis.”)

¹³ For example, Dr. Zach Wenz, the State’s specialist for geochemistry, who was detailed to MPCA from DNR, stated that “[i]n general, the [Cross-Media] analysis approach for estimating the overall metal and sulfur loading to the environment from dust particulates is well-defined and science-based,” but he noted a few areas of professional disagreement with certain assumption and methodologies used in the study. Cross-Media Conclusions and Recommendations at 6 (Wenz). Wenz explained his preferred approaches in the areas of disagreement, and acknowledged that the approaches used in the Cross-Media Analysis resulted in “overestimating the reaction rate and subsequent release of sulfate and copper from chalcopyrite.” *Id.* at 7-8. MPCA’s expert with regard to hydrology and other water quality-related factors, Richard Clark, explained a similar circumstance involving the calculation of metal concentrations in the wetland of interest, but he noted that the approach used by the Cross-Media Analysis resulted in a larger incremental increase in certain concentrations. *Id.* at 16-17 (Clark).

quality requirements or cause or contribute to any adverse human health impacts within the Fond du Lac Reservation.

The protectiveness of the Cross-Media Analysis's conclusions is reinforced by a supplemental evaluation that PolyMet conducted. In that "Representative Scenario" evaluation, PolyMet adjusted six of the Cross-Media Analysis's more than 25 protective assumptions to make them more representative of the actual conditions at the Project site.¹⁴ For example, the original analysis assumed that geochemical reactions would act on a particle for 365 days, but the Representative Scenario used a 30-day timeframe for the geochemical reaction, because research shows that within 30 days, a particle will be washed downward in the soil where oxygen is limited or absent and further particle weathering is extremely slow. Compared to the Cross-Media Analysis, the Representative Scenario analysis showed *70% less sulfate* and at least *94% less metals* will be released to the wetland of interest from Project air emissions. See Representative Scenario at 19-21. These results show the protectiveness of the Cross-Media Analysis, providing further support for MPCA's conclusion that the Project will not cause any downstream water quality impacts.

D. Monitoring requirements

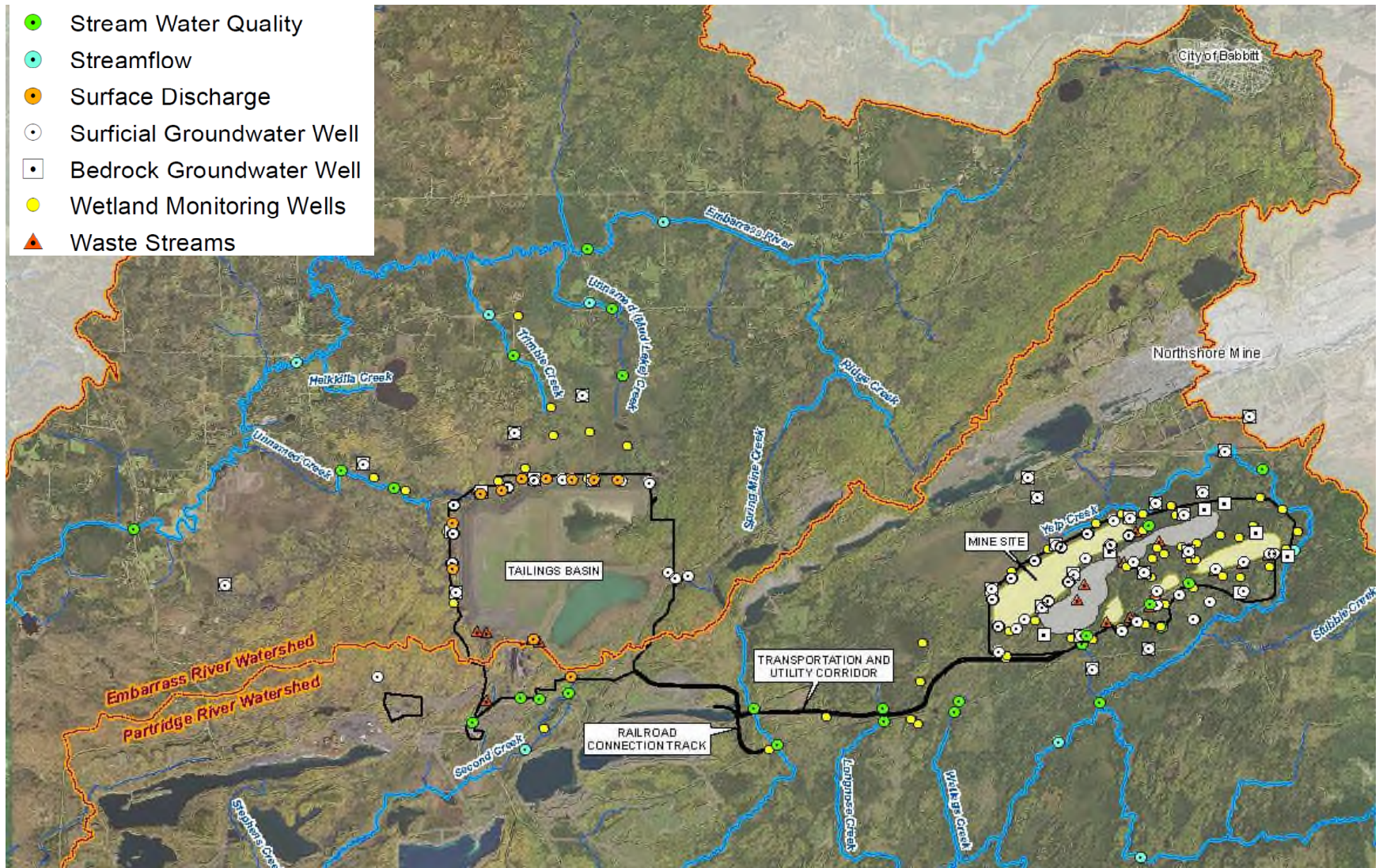
All of the scientists, engineers, modelers, and other experts involved in the Cross-Media Analysis recognized that there are some uncertainties inherent in their predictions. That is the nature of complex scientific analysis. But the agencies took multiple measures to address these uncertainties.

First, as discussed above, the Cross-Media Analysis included protective assumptions that lead to overestimates of the Project's effects on water quality. PolyMet's Representative Scenario shows the extent of that overestimate, reflecting the large margin of error included in the Cross-Media Analysis's predictions.

Second, MPCA's permits included extensive monitoring, both before Project construction starts and after operations begin. That monitoring will allow actual outcomes to be compared with the Cross-Media Analysis's predictions. Figure 6 shows the monitoring locations relevant to the section 401 certification, the NPDES/SDS permit, and the water appropriations permit, which include 31 surface water quality locations, 12 streamflow locations, 122 groundwater locations, 62 wetlands locations, 11 surface water discharge locations, and 25 waste stream locations—a total of 263 monitoring locations.

¹⁴ See Exhibit 2, Barr Engineering, Estimated Potential Concentrations of Arsenic, Cobalt, and Copper in a Wetland for a Representative Scenario for Sulfide Mineral Dissolution; Supplement to the Cross-Media Analysis to Assess Potential Effects on Water Quality from Project-Related Deposition of Sulfur and Metal Air Emissions (October 31, 2017) (Representative Scenario).

Figure 6: Permit-Required Monitoring Locations



The monitoring and related reporting, adaptive management, and mitigation requirements described in both MPCA's section 401 certification and section 401 certification fact sheet include:

- Part 1 – Water Quality Monitoring (to address potential air deposition)
- Part 2 – Wetland Hydrology Monitoring
- Part 3 – Wetland Vegetation Monitoring
- Part 4 – Reporting
- Part 5 – Stream Hydrology Monitoring
- Part 6 – Compensatory Mitigation

See 401 Water Quality Certification at 2-7. MPCA's section 401 certification fact sheet provides the agency's rationales for each of these monitoring categories. See 401 Certification Fact Sheet at 13-18; see also Cross-Media Analysis Conclusions and Recommendations at 13-14, 19-20.

The NorthMet Project section 401 certification, NPDES/SDS permit, permit to mine, and water appropriation permits require surface water, groundwater, and wetland monitoring across the project, in addition to requiring PolyMet to conduct various "true-up" analyses, including annual reviews in most cases.¹⁵ These "true-up" provisions require PolyMet to compare predicted water quality and quantity values against actual observed values for surface water, groundwater, and wastewater from major Project features and baseline data against observed values for groundwater levels, wetland water levels, and wetland boundaries, among other things. If there are significant departures from those modeled outcomes or baseline measurements, adaptive management measures may be required. These are a third layer of protection against any uncertainties associated with the Cross-Media Analysis's predictions.

¹⁵ See, e.g., 401 Water Quality Certification at 4-6; NPDES/SDS Permit at 101-106; Permit to Mine at 17.