Michigan Department of Environmental Quality

Air Quality Division

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Air Deposition Impact Analysis for the Aquila Back Forty Project

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The purpose of this report is to assess the deposition impacts of particles released to the air from the open pit mine called, "The Back Forty Project". Aquila Resources proposes to operate the mine located on approximately 580 acres in Lake Township in Michigan's western Upper Peninsula. The deposition of dust particles, including four metals and sulfate from the mine, was evaluated for both soil and water impacts. The results of this evaluation indicate that the deposition of dust particles emitted from the Back Forty mine is not expected to harm public health or the environment.

Deposition Impact Methodology

Emission rates for four metals and sulfate were calculated and used as input in the United States Environmental Protection Agency (EPA) AERMOD air dispersion model to determine the annual deposition rates to areas outside the proposed mine's fence line. Based on the air emission rates and previous Air Quality Division (AQD) deposition assessments, copper, lead and zinc were chosen as most likely to pose a potential environmental and public health concern. Although the estimated potential emission rate is low (2.25 lbs/yr), mercury was included because mercury levels in many Michigan waters are known to be elevated and pose a concern (MDEQ, 2008 and 2016; MDHHS, 2016). A detailed description of the methodology is described in Foth (2016).

Metal and sulfate deposition impact were evaluated in three ways:

1. Soil metal concentration for human and wildlife health effects;
2. Acid sulfur deposition rate for ecological effects; and
3. Water impacts due to direct deposition and run-off.

Fifteen locations around the proposed mine perimeter were modeled to find the deposition rate of the metals and sulfate. Soil metal and sulfate concentrations were calculated assuming that the mass of substance deposited would mix homogeneously in the top one centimeter (cm) of soil. Note that EPA (2005; Table B-1) recommends a two cm soil mixing zone depth for untilled soil. The worst-case conservative assumption of one cm soil mixing depth was used as a screening level for the initial evaluation, and is intended to overestimate chemical impacts to the soil. A more refined model with more realistic assumptions can be used if the proposed mine's impacts exceed environmental and health based standards. For this assessment, substances deposited to the soil were conservatively assumed to remain in the topsoil compartment and continue to accumulate over time. A density of the soil of 1.3 grams per cubic meter (g/cm^3) (as determined from measurements around the mine; Foth 2016) was used to calculate the weight of the top one cm of soil for a one meter by one meter square (1 m^2). The value of 1.3 g/cm^3 is similar to the recommended value of 1.5 g/cm^3 used by EPA (2005; Table B-1). Deposition impacts for one and seven years[1] were calculated. The resulting soil concentrations for each metal deposited were compared to soil cleanup criteria established by the Michigan Department of Environmental Quality's (MDEQ's) Remediation and Redevelopment Division (RRD) pursuant to Part 201, and the Risk Management Criteria for metals at the U.S. Bureau of Land Management (BLM) mining sites (United States Dept. of Interior, 2004). RRD's soil cleanup

[1] Aquila Resources stated that the anticipated duration of mining activity is 7 years.

criteria are designed to be protective of human health for specific exposure situations, whereas the BLM soil impact benchmarks are protective of wildlife health.

Sulfate deposition impacts (acid rain concentrations) were determined and compared to background levels of sulfate deposition for the region, as well as a standard of 11 kilograms per hectare per year (kg/ha/yr), designed to be protective of sensitive aquatic and terrestrial ecosystems (Minnesota, 1985). Another concern, albeit impossible to quantitate at this time, is that sulfate deposition can increase methyl mercury production in wetlands (Jeremiason et al., 2006; Ed Swain, 2016).

Two waterbodies were evaluated for water impacts: the Menominee River and Spring Lake. These were chosen based on their proximity to the facility and relatively high importance to the local citizenry. The surface areas of these waterbodies and their drainage basins were determined from digital map data including the Michigan Geospatial Data Library and the National Hydrography Dataset. The mass deposited to the two waterbodies and their terrestrial watersheds was calculated. The annual water volume of the Menominee River at the location of the mine was calculated as a flow rate of 2510 cubic feet per second or 2.2E+12 liters/year (50% value; Foth 2016). The annual drought water flow for Spring Lake was estimated by using the annual flow rate for the Shakey River (note: Spring Lake is part of the Shakey River system). The annual water flow for Spring Lake was estimated to be 27 cubic feet per second or 2.4E+10 liters/year (Foth, 2016). Using recommendations and methodology from Minnesota Pollution Control Agency (MPCA) Mercury Risk Estimation Method (MMREM), as well as a personal communication with Ed Swain of MPCA, it was assumed that 26% of the mass of mercury depositing from the air onto the terrestrial watershed is either washed into the waterbody from surface runoff or from groundwater seepage of the dissolved metal (MMREM, 2016; Swain, 2016). The 26% run-off value for mercury transport from the terrestrial watershed to the waterbody was based on experimental results (Ed Swain, 2016). It was conservatively assumed that 100% of copper, lead, zinc and sulfate falling on the watershed were fully dissolved in the water and washed into the waterbodies.

Results

1. Deposition of Metals to Soil

A summary of the maximum modeled soil impacts from Back Forty operations is shown in Table 1.

Table 1. Soil Impacts Plus Background Soil Concentrations Compared to Health Protective Standards (all values are in milligrams per kilogram, mg/kg, soil concentrations)

	Facility Impact	Background plus Facility* impact after 1 year	Background plus Facility* impact after 7 years	Most Stringent Health Criterion**	Are Impacts less than the Criteria?
Copper	0.193	4.7	5.9	7[a]	Yes
Lead	0.176	3.9	4.9	6[a]	Yes
Mercury	0.0256	0.011	0.027	0.05[b]	Yes
Zinc	2.46	20.8	35.5	43[a]	Yes
Sulfate	19.6	153	271	5000[c]	Yes

* Highest facility impact + background concentration (mean + two standard deviations.

** The most stringent health criteria of three criteria: footnotes a, b and c (below). Direct contact was never the most stringent criteria for a metal or sulfate, therefore, it was not included in the table.

[a] US Dept. of Interior. 2004. Risk Management Criteria for Metals at BLM Mining Sites, Technical Note 390 rev. October 2004.

[b] MDEQ Part 201 cleanup criteria for Groundwater Surface Water Interface Protection Criteria and Risk Based Screening Level.

[c] MDEQ Part 201 cleanup criteria for Drinking Water Protection Criteria and Risk Based Screening Level.

2. Sulfur Acid Deposition

The deposition of sulfate was evaluated and compared to a standard to protect sensitive aquatic and terrestrial ecosystems from acidification. Minnesota is the only state or U.S. federal agency known to have set a sulfate deposition standard. The basis of this standard is described in the report: *The Effects of Acid Deposition on Minnesota's Forests: Information Update* (Minnesota, 1985). Although repealed in 2013 (Minnesota Administrative Rules, 2013), the Minnesota standard is the only science-based standard available for sulfate deposition effects. It was repealed because it was no longer being used to evaluate sulfate emissions, which have fallen in recent years, and because sensitive lakes have not been impacted by acid rain (Swain, 2016). The sulfate standard of 11 kg/ha/yr addresses the total amount of sulfate in wet deposition (called acid rain). The total deposition of sulfate for both wet and dry deposition was used as an over estimate of deposition impacts. The total wet plus dry deposition rate of sulfate from the proposed Back Forty Project was found to be 2.6 kg/ha/yr. The background deposition rate of sulfate is 5.8 kg/ha/yr (wet[2] of 5.4 kg/ha/yr plus dry[3] of 0.4 kg/ha/yr), for a total of background plus incremental rate of 8.5 kg/ha/yr. Because this value is less than the previous Minnesota standard of 11 kg/ha/yr, there are no anticipated adverse acidification impacts to aquatic or terrestrial ecosystems.

3. Water Impacts

The air deposition impacts to water were evaluated by assuming that the substances deposited to the soil within the watershed would wash into two nearby waterbodies: Menominee River and Spring Lake (closest lake to the mine). Table 2 shows the proposed mine's metal and sulfate impacts to the water concentrations in the Menominee River. Table 3 shows the proposed mine's metal and sulfate impacts to the water concentrations in Spring Lake. Tables 2 and 3 also show the standards used to evaluate water quality using MDEQ water Rule 57 (Lipsey, 2016). According to Rule 57, each lake can have different standards based on the chemical composition of the water.

Table 2. Menominee River Deposition Impacts (in micrograms per liter; µg/L)

	Background Water Concentration	Proposed Mine's Water Impact	Water Quality Std. or Final Chronic Value	Proposed Mine's Impact as % of Background Concentration
Copper	1.063	0.0007	15	0.07%
Lead	1	0.0006	104	0.06%
Mercury	0.009*	0.00000286	0.0013	0.032%
Zinc	52	0.01	227	0.019%
Sulfate	38386	0.09	na	0.00023%

*The background concentration is above the water quality standard for mercury of 0.0013 µg/L.

[2] The long-term trend in the western Upper Peninsula and northeastern Wisconsin area wet deposition rate of sulfate is approximately 5.4 kg/ha/yr; National Atmospheric Deposition Program (NADP, 2016).
[3] The dry deposition of sulfate is 0.43 kg/ha/yr; CASTNET 2016.

Table 3. Spring Lake Deposition Impacts (in micrograms per liter; µg/L)

	Background Water Concentration	Proposed Mine's Water Impact	Water Quality Std. or Final Chronic Value	Proposed Mine's Impact as % of Background Concentration
Copper	1	0.11	22	11%
Lead	1	0.09	149	9%
Mercury	0.011*	0.000345	0.0013	3%
Zinc	51.8	1.2	408	2%
Sulfate	29387	13	na	0.04%

*The background concentration is above the water quality standard for mercury of 0.0013 µg/L.

Conservative assumptions contribute to the mercury incremental impact estimate. These include: the potential emission rate assumption of 2.25 lbs/yr is a conservative estimate (Drury, 2016); and the incremental water impacts were calculated using a drought flow rate for dilution of the loading, while a long-term average flow rate would be more appropriate for the evaluation of any bioaccumulation concern.

The mercury deposition background rate (wet plus dry) is estimated to be 10 to 13 µg/m²-yr (Depa and Sills, 2013). The 2.25 lbs/yr conservative emission rate estimate was modeled to be associated with a Spring Lake water body estimated incremental impact of 3.8 µg/m²-yr, representing 29–38% of this background rate.

Conclusion

Particle emissions from the proposed Back Forty Project were calculated and used as input for dispersion modeling and air deposition. Deposition rates of four metals (copper, lead, mercury and zinc) and sulfate were evaluated for soil and water impacts. The metals' impacts to soils as well as the sulfate rate of deposition were below standards protective of human and environmental health. Except for mercury, all resultant metal water concentrations were below the Rule 57 water quality standards. As seen in Table 2, the metal and sulfate impacts to the Menominee Rivers show an increase to background water concentration that was in the range of 0.07% to 0.00023%. For Spring Lake (Table 3), the percentage increase of metals to the background concentrations were higher than those calculated for the Menominee River.

The background water concentrations of mercury for both waterbodies were higher than the water quality standard of 0.0013 µg/L. The percentage of incremental impact to background water mercury concentration was 0.032% and 3% for Menominee River and Spring Lake, respectively. The significance of the 3% incremental increase (0.00034 µg/L incremental impact) to the background water concentration (0.011 µg/L) of mercury may be considered as a minimal increase. The conservative estimated mercury emission rate of 2.25 lbs/yr is a small amount compared to other regulated air emission facilities in Michigan (MDEQ, 2008). The estimated potential mercury impact was conservatively derived (due to a conservative emission rate and a drought water flow assumption), and pertains to a limited time period (the anticipated mining activity is seven years). In addition, Michigan has been making significant progress toward the goal of reducing mercury use and releases (MDEQ, 2008), and there have been large decreases from 1990 to 2016 in mercury emissions and atmospheric mercury concentrations and deposition in North America (Zhang et al., 2016). Taken together, these factors indicate that the proposed project would not significantly change the current mercury concentrations in the Menominee River or Spring Lake.

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