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"Technical Support for Grassroots Public Interest Groups"

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Cc: Dave Chambers, dchambers@csp2.org
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Re: Aquila Back Forty mine proposal

Dear Kathleen:

The Center for Science in Public Participation provides technical advice to public interest groups, nongovernmental organizations, regulatory agencies, mining companies, and indigenous communities on the environmental impacts of mining. CSP2 specializes in hard rock mining, especially with those issues related to water quality impacts and reclamation bonding.

This letter represents a brief review of issues that will likely require further attention during the permitting process. Materials reviewed include all or parts of the following:

> Aquila Resources Inc. 2015. Environmental Impact Assessment – Back Forty project, project ID 14A021. Report to Michigan Department of Environmental Quality. 340p.
>
> Chapters 1, 2 3, 5.1, 5.2, 5.3, 5.7, 5.8
> Appendix C – Geology of the Back Forty Polymetallic VMS deposit, 86p
>
> Aquila Resources Inc. 2015. Mining permit application – Back Forty project, project, ID 14A021. Report to Michigan Department of Environmental Quality. 112p.
>
> Chapters 1.1, 2, 3.1, 4, 5.3.3, 5.4, 5.5, 5.6, 5.7.9.5, 5.8, 6, 7, 8
> Appendix B – Geochemical investigation, report 1 of 3, 547p
> Appendix H – Treatment and containment of tailings and waste rock, 235p
> Appendix I – Reclamation plan, 36p
> Appendix K – Financial assurance plan, 45p
>
> Foth & Van Dyke. Flambeau Mining Company – Fall 1996 Backfilling plan for stockpiled Type II material. Report to Wisconsin Department of Natural Resources.
>
> Foth & Van Dyke. Flambeau Mining Company - 1997 Backfill plan for stockpiled Type II material. Report to Wisconsin Department of Natural Resources.
>
> May, ER. 1976? Flambeau – a Precambrian supergene enriched massive sulfide deposit.

A more comprehensive review of materials may find further issues or may find that some issues raised here have been addressed.

Introduction

The Aquila project proposes to mine a massive sulfide deposit for seven years using an open pit. Ore would be processed on site. Oxide ore, primarily containing silver and gold, would be processed by cyanide leach and tailings would be sent to an “oxide” tailings and waste rock management facility (TWRMF); sulfide ore, primarily containing copper, zinc, and lead, would be processed by flotation and tailings sent to the “flotation” TWRMF.

There are 13 rock lithologies (rock material with distinct crystal and/or chemical features). These are important to understanding the characteristics of waste rock and tailings. Virtually all (88%) of the rock material in the pit consists of six lithologies; the sulfide stringer zone (SFST) makes up 8% of the material and massive sulfide (MASU) makes up 6% (EIA Appendix B, Report 1, Section 2.1). It is important to note that the lithology that makes up most of the host rock, the “rhyolite crystal tuff” (RCTF), although mostly quartz and other silicate material (SiO_2) also contains pyrite (FeS_2), chalcopyrite (CuFeS), sphalerite ((Zn, Fe)S), and arsenopyrite (AsFeS) – all material that can produce acid; it contains no buffering material.

There are four ore “mineralizations” that will be processed: 1) MASU (zinc, copper, possibly gold), 2) SFST (zinc, copper, gold), 3) Low sulfide precious metal bearing mineralization, and 4) oxide-rich precious metal bearing gossan (EIA Appendix B, Report 1, Section 2.1). Gossan (GOSS) makes up 0.6% of the rock material in the Designed Pit. It is important to note that a single lithology, such as Gossan, will contain both oxide and sulfide material, which will need to be sorted to send the right ore to the right processing route.

Although MASU and SFST only make up 14% of the pit rock, virtually all lithologies have over 10% sulfide material. In the mining permit, the term “low sulfide” is used for material with less than 10% sulfide, but the geochemical testing indicated that material with over 0.3% sulfide was likely to go acid. Therefore, “low sulfide” material is still a high risk for acid rock drainage.

The oxide plant will process 0.24 Mt/year and the oxide TWRMF will take up 39 acres; the flotation plant will process 1.6 Mt/year and waste will take up 180 acres. At the end of mine life, 43 million tons (Mt) of flotation waste rock would be used to backfill the pit, interspersed with limestone to generate neutral pore water and minimize metal leaching. At closure, 16Mt of flotation waste rock and tailings would remain on the surface when the oxide and flotation facilities are merged.

Key findings

- The ARD risk is very high. Most material contains sulfides, and there is very little natural carbonate for buffering.
- There are important differences between closure at the Flambeau mine and closure at Aquila Back Forty. Most importantly, Flambeau had no tailings and left no waste rock on the surface post-closure.
- The water treatment plant design, including any necessary pre-treatment of wastewater prior to entering the plant, should be in place at this stage of permitting, but is not.
- Alkaline amendment of the tailings and waste rock facility should have a detailed design at this stage of mine permitting, but is not.
- Financial assurance has been significantly underestimated.

ARD risk

It appears that good work has been done to characterize the acid potential and metal release from waste material. In addition to several types of "static" testing, 40 humidity cell tests (HCTs) were set up to determine acid and metal leaching from 13 waste rock types, and 11 HCTs were set up to examine tailings chemistry (simulating the expected types of tailings by mining year).

The risk for acid drainage is very high. Testing suggests that **material with more than 0.3% sulfide will go acid**, because there is virtually no natural buffering material (such as calcium carbonate) present in the host rock. **All tailings are expected to generate acid**, with the exception of tailings produced in year 3 of mining. Additionally, over 75% of the waste rock is expected to generate acid.

The quartz feldspar porphyry (QFP) lithology is the only major lithology to have several samples that are net neutralizing, but it also has samples that will go acidic (Mining Permit Application, Appendix B, Report 1, Figure 4-26). Only the leached iron oxide "gossan" (GOSS), a minor lithology, appears to have relatively good carbonate buffering within it, and is net neutralizing; and sandstone (SS) material also has some minor neutralizing potential (Mining Permit Application, Appendix B, Report 1, Figure 4-3, Figure 4-4, Figure 4-27). Not surprisingly, the Massive Sulfide (MASU), Semi-massive sulfide (SMAS), and sulfide stringer (SFST) ore material have the least neutralizing potential.

Comparison with Flambeau

The Aquila project intends to mimic the Flambeau copper mine in Wisconsin. However, there are significant differences.

- At Flambeau, ore was processed off site. Therefore there were no tailings.

- No high sulfide material was left on the surface after closure – all was placed in the pit.

- The Flambeau mine was much smaller. About 4.5 million tons of waste rock was placed as pit backfill at Flambeau, over 43 million tons of waste rock will be placed in the Back Forty pit.

- Flambeau expected only copper, manganese, iron, and sulfate to be constituents of concern; the Back Forty will have metal leaching from trace elements like copper, but also from metalloids like selenium that will mobilize under the conditions that precipitate copper and zinc. This complicates the process of immobilizing dissolved elements.

These are important differences. Retaining acid-generating material on site at Aquila will likely require diligent water management of TWRMF leachate in perpetuity and may require in-perpetuity water treatment. This needs to be considered in financial assurance.

Tailings and Waste Rock Management facilities (TWRMF)

Tailings will be dewatered to 81% solids. Aquila considers this feasible, although it does not consider dewatering to 86% to be feasible because "filtering and placement costs would be high" (Mining Permit Application before 6.0). It does not seem that the expense of dewatering to an additional 5% would be that onerous. It may be more a matter of the cost of "placement" – pumping 81% solid tailings versus trucking 86% dewatered tailings to the management facility. I would question whether 81% solids is pumpable, particularly in cold weather.

- **Recommendation**. A comparison of the costs of a dry stack (86% dewatered) and the proposed 81% dewatering should be provided.

- **Recommendation.** Examples should be provided that indicate tailings that are 81% solids can be pumped in cold climates.

The leachate from the TWRMF will be acidic with high metals. Aquila suggests that they may need to amend the tailings and waste rock with alkaline material:

"The oxide TWRFM may have high constituent load that requires additional treatment ***prior to receiving at the CWBs.*** *The final description of the wastewater treatment process will be designed during final design of the project."* (Mining Permit Application Section 5.7.9.5)

*Aquila "**will generate a plan"** to improve water quality in both TWRMFs so that leachate that goes to sumps is circumneutral. "Various options" such as adding alkaline material will be considered.* (Mining Permit Application Section 6.0)

Some suggestions on methods are given in EIA Appendix D-5, one of which is to potentially line a drainage layer with alkaline material. This could lead to metals precipitating in the drainage layer itself and clogging it. Only a very cursory review was given to Appendix D-5; a more in-depth review of D-5 and D-6 might provide more information on the geochemistry of the TWRMF under various alkaline amendment scenarios.

- **Recommendation.** Proposed alkaline amendment strategies should be well-fleshed out at this stage, and details of the preferred method(s) provided, including geochemical reactions over time that could reduce the function of the drainage layer.

Waste rock will be used to build the embankments around the TWRMF. Given that less than 25% of the host rock has a neutral pH, and that even that rock has some risk of metal leaching – how will Aquila ensure that the embankment itself does not contribute to acid and metal leaching? It appears that most of the upper rock is quartz (QFP), RCTF, and sandstone (Mining Permit Application Figure 4-1), which indicates an acid drainage risk (EIA Appendix B, Report 1, Figures 4-26 and 4-27).

Leachate from the embankment will be captured in sumps and routed to the contact water ponds during operation.

- **Recommendation.** Monitoring wells need to be placed to ensure the tailings facility embankment is not contributing acid or metal leaching to groundwater.

The embankments will be in place post-closure. If the embankment rock is reactive, Aquila will need to ensure that an impermeable cover is in place. The plans to use a composite cover including geotextile with a clay layer below sandwiched between drainage layers may be adequate.

- **Recommendation.** An impermeable cap should be placed on the embankments at closure.

Water management

All runoff, contact water and leachate is to be directed to contact water ponds and/or sediment settling ponds. The sediment settling ponds will have one foot of freeboard and the contact water ponds 2.6 feet of freeboard. Although these are both sized for "24 hour, 100 year events", this level of freeboard could be inadequate (Mining Permit Application Section 5.8.2.1).

Consideration needs to be given to the amount of storage capacity that will be needed if the water treatment plant is down temporarily and to the contingency plans for moving water during major storm events.

If the contact water ponds fill up, water could have to be shunted to the TWRMF. I did not review the water management plan or the design of the TWRMF enough to determine the size of the embankments or the amount of freeboard they were designed to have, however, the cause of failure at most tailings facilities is heavy precipitation. Given the paste consistency of the tails, they are unlikely to move far downgradient, but poor quality water could be released if the embankment overtops, if the contact water ponds overtop, or if the sediment ponds release sediment-laden water.

- **Recommendation.** Ensure that water can be safely shunted between containment areas to be adequately contained during water treatment plant downtime, heavy precipitation, or rain on snow events.

Water treatment plant – during mine operations

The water treatment system (WTP) appears to be a basic lime treatment system to raise the pH and precipitate metals (Mining Permit Application Section 5.7.9.5). Some areas to consider with regards to the wastewater treatment plant: will the WTP adequately treat leachate, whether the expense of filtering and trucking out wastewater solids has been adequately considered, and whether the WTP will need to remain on site post-closure to treat TWRMF leachate.

The process will generate quite a large amount of sludge. Aquila proposes to put the sludge through a filter press to remove water, then truck the filter cakes off site. Running the filter press and trucking off tons of filtered sludge will likely be extraordinarily expensive. I did not review material on Aquila's cost estimate, but it could be important to verify the estimated costs. If material needs to be taken to a hazardous waste site, the expense will be higher than if it can go to a regular landfill.

- **Recommendation.** Ensure the costs of filtering wastewater and trucking waste solids material to a landfill and/or a hazardous waste landfill are accurately accounted for.

The contact water basins (CWB) will store water that is needed in the processing plant as well as the water that will be treated in the WTP.

- **Recommendation.** The wastewater treatment plant should have already been designed in detail by this stage of permitting, including any wastewater pre-treatment at the tailings facility sump or prior to entering the plant.

Pit backfill -- pH

Geochemistry tests determined that:

> *"Only trace amounts of carbonate were identified in this study (of waste rock samples). Carbonates occur mainly as thin veinlets along joints and fractures. The neutralizing of acid by carbonate will probably occur early and taper off quickly…"* (Appendix C "Mineralogical Report" of Appendix B "Geochemical Investigation Report" of the EIA)

Given that nearly all material is potentially acid generating (PAG), when material is backfilled into the pit it is to be layered with limestone. The plan will probably apply one mole of lime alkalinity to each mole of sulfide acidity, based on the equations (EIA Appendix B Section 3.1.2, 3.1.3, and 3.2):

$$FeS_2(s) + 7/2\ O_2 + H_2O \rightarrow Fe^{2+} + 2SO_4^{2-} + 2H+$$

$$CaCO_3\ (s) + 2H+ \rightarrow Ca^{2+} + H_2CO_3$$

Conservatively, higher amounts of material should be applied, considering:

- There will likely be preferential pockets of reaction that consume limestone (or lime or other buffering material) quickly, and other pockets that may not begin to react for several years.

- Enough buffering material needs to be placed that plenty is available for countering slow reacting pyrites.

- If there is a flux in the water table, it could cause an increase in the rate of acid reactions and cause minerals in "soft" secondary precipitates to re-dissolve

➢ **Recommendation.** Discuss how alkaline material will be introduced to the pit backfill after the pit has been capped and revegetated, if limestone is not adequate to consistently produce a neutral pH and precipitate metals.

Pit backfill - Metal leaching

Trace elements that are likely to be a concern due to mobilization from acid include: antimony (Sb), arsenic (As), cadmium (Cd), copper (Cu), lead (Pb), mercury (Hg), selenium (Se), silver (Ag) and zinc (Zn) (EIA, Appendix H, Section 4.7.4.1).

Trace elements that are likely to be a concern even with neutral pH pore water include: Sb, Se, and As. If there is dissolved iron in the pore water, it will help to precipitate dissolved arsenic, but if the iron is bound up as sulfides (in the deep pit where there is a reducing environment) or as siderite ($FeCO_3$, where limestone has been applied), there may not be enough dissolved iron to co-precipitate arsenic. Additionally, even co-precipitated arsenic may re-dissolve under reducing conditions, which will be expected throughout most of the pit. Currently arsenic is low in surface water and higher in groundwater – very likely due to reducing conditions that release arsenic from iron; this process could also occur in the backfilled pit or within the TWRMF. Appendix D5 of the EIA, which I have not reviewed, may have information on this.

- **Recommendation.** Given the potential for Sb, Se, and As to mobilize under neutral conditions, monitoring will need to occur at the TWRMF leachate sumps and at monitoring wells on and around the backfilled pit until hydrology and chemistry have stabilized.

Water treatment plant – Post Closure

It will take 22 years to flood the pit (EIA Section 3.4.3), but the wastewater treatment plant will only be on site through mine year 16 (about 8- 9 years post closure if the area is mined for 7 years) (EIA Appendix H, Section 1.2). The 22 years to flood presumes a 22.1 million m^3 sized pit (EIA Section 3.4.3); if 70 million tons of ore are processed, the pit will be 25.5 million m^3 (EIA Appendix B Section 2.2) and the pit presumably would take longer to flood.

Closure of the WTP is based on the assumption that "leachate generated by the (merged) TWRMF will be *de minimus*". This will depend on the permeability of the closure cap over the tailings facility.

There will certainly be some amount of pore water from exposure of the TWRMF to precipitation during the mining years; this will take some time to drain down. Backfilling flotation waste rock into the pit will occur in Mine Year 11; after that, the oxide and flotation facilities will be merged. If this occurs in Mine Year 12, there will only be four years of draindown before the expected decommissioning of the WTP.

The documents on closure (EIA Appendix H) did not specifically say if the cap was intended to be impermeable. It is designed to have vegetation, a drainage layer, a geomembrane, and a clay layer below the geomembrane that limits infiltration.

- **Recommendation.** The TWRMF cap is designed to reduce infiltration, but given the extremely acidic nature of the material that will be enclosed, the cost of a WTP should be included in financial assurance for at least the 20 year post closure monitoring period.

- **Recommendation.** It would be prudent to include the cost of a WTP until the pit has flooded and monitoring wells on show that there is no seepage into groundwater or surface water, and that pit backfill water chemistry has stabilized.

Financial Assurance

Indirect Cost Estimates

The indirect cost estimates made for the Back Forty financials assurance are less than that recommended by most sources. For indirect costs it is proposed to use:

- 5 percent (%) for Michigan Department of Environmental Quality administrative cost.
- 5% cost contingency. (Appendix K, p. 7)

There are a number of sources that address financial assurance calculations, and indirect costs. One of the often-quoted public sources of guidance is the US Forest Service's "Training Guide for Reclamation Bond Estimation and Administration."

USFS Reclamation Bond Estimation and Administration*

	Percentage of contract costs	
	Minimum	*Maximum*
Contingencies:		
POO Scope Contingency	4%	30%
Bid Contingency	10%	20%
Mobilization/Demobilization	0%	10%
Engineering Redesign	2%	10%
Contractor's Costs:		
Performance & Payment Bonds	3%	3%
Estimated State Sales Tax on direct costs	0%	5%
Profit & Overhead:	15%	30%
Agency Project & Contract Management	4%	14%
Inflation	1%	6%
	======	======
	39%	128%

* Training Guide for Reclamation Bond Estimation and Administration, For Mineral Plans of Operation Authorized and Administered Under 36 CFR 228A, USDA Forest Service, Minerals and Geology Management, April 2004.

As can be seen from the table the US Forest Service recommends indirect costs at a minimum of 39%, ranging up to 128% of the direct costs of reclamation and closure. The amount of indirect costs proposed for the Back Forty financial assurance is 10%. This amount is clearly inadequate. Lacking other guidance, indirect costs for the financial assurance at the Back Forty project should follow US Forest Service guidelines, with justification for the percentage chosen for each subcategory in the table.

Direct Costs

Calculation of direct costs for reclamation involve a significant amount of detailed analysis. While it is appropriate that the mine proponent offer its estimate of the financial assurance, it is incumbent upon the regulatory to carefully check these calculations for their appropriateness. There is significant financial incentive for the mine proponent to make optimistic assumptions about the cost of individual elements of the financial assurance in order to keep these costs to a minimum. However, it is always less expensive for the mine proponent to conduct reclamation activities that it is for regulatory agency to contract and oversee these same activities.

An example for the Back Forty project is that it has been assumed that mine trucks will be available to move the waste rock and tailings into the open pit as backfill. (see Appendix K, Appendix A Financial Assurance Cost Estimates, A-1 End of Construction Cost Estimate, p. 3 of 10; and, A-2 End of LOM Operating Period Cost Estimate, p. 3 of 12)

If Michigan DEQ does not have the expertise internally to check the assumptions and calculations made by the mine proponent in its financial assurance calculations, which most regulatory agencies do not have, then it should retain the services of qualified contractor to review the financial surety on its behalf. Such reviews can and often do result in millions of dollars in increases in the financial assurance, which is of major significance to the public since this is a potential financial liability.

- **Recommendation:** When reviewing the indirect and direct cost estimates for the Back Forty financial assurance, it is obvious that it has been significantly underestimated, especially with regard to the indirect cost calculations. At a minimum the indirect costs for the financial assurance at the Back Forty project should follow US Forest Service guidelines, and the direct costs should be reviewed by a qualified party to correct assumptions that underestimate the cost of reclamation that would need to be conducted by a regulatory agency.

Additional issues

Hydrology:

Upper weathered bedrock is said to be highly fractured and the lower fresh bedrock to be "too impermeable to store or transport groundwater" (EIA Section 3.4.1), yet the hydraulic conductivities fall in the same (wide) range – is upper more frequently in the fast conductivity range and lower more frequently in the low conductivity range, or does the variation go by different wall areas of the pit, different depths?

The hydraulic conductivities are: 10^{-5} to 10^{-11} for the highly weathered upper area (iron-stained oxide) and 10^{-6} to 10^{-12} for the lower "fresh" bedrock.

Surface water sampling:

Sampling was extremely minimal (eight "snapshots" over several years) and may not have covered water chemistry at high water and low water events (EIA Section 3.5.2). Monthly sampling should occur for at least a year to ensure a range of baseline chemistry has been captured.

Cyanide:

Aquila does not specifically say that they will sign the International Cyanide Management Code. The wording is "*The plan will be developed to meet the objectives of the International Cyanide Management Institute's International Cyanide Management Code….*" (Mining Permit Application Section 5.6.5).

Thank you for the opportunity to comment on the mining permit. Please feel free to contact us with questions or for further information.

Regards,

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