Response to Lydian review of Bronozian-Commissioned Reports

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Executive Summary

We have reviewed Lydian's response to our evaluation of the Amulsar Project.

Our key recommendation is that Lydian must strengthen their ARD Management Plan immediately and that the Government of Armenia insist on receiving such a plan before allowing mining to proceed. At a minimum, this plan should include improved separation and handling of potentially acid generating materials and development of a water treatment plant that treats all the contaminated waters produced at the mine. Both measures should be implemented before pit dewatering and mining operations begin.

We agree that this project could potentially benefit Armenia and its citizens, but we believe that the proposed mine, as currently planned, will lead to the long-term environmental degradation of one of the most beautiful parts of the country. In our view, Lydian takes an overly optimistic view of the risks associated with this project, especially regarding the release of acidic, metal-contaminated waters from this site. We firmly believe that a more conservative approach is justified in light of existing site conditions and the potential long-term environmental damage associated with acid rock drainage (ARD) and contaminant leaching.

Our main disagreement with Lydian falls into five key points:

1. The risk of ARD and contaminant leaching at Amulsar is very high
2. The plans to mitigate contaminant release are insufficient
3. Lydian needs to identify and manage every potential source of contaminated water during construction, operation, closure and post-closure
4. Lydian's wording occasionally minimizes apparent risk and confuses issues
5. Lydian has not made available some key documents needed to fully evaluate this project

Lydian reviewers state in their summary that "independent studies show that ARD risks at Amulsar are very low." We disagree. Most of their evidence indicates that the risk of acid generation and contaminant leaching is very high. This evidence includes:

- Several naturally acidic seeps exist at the site, indicating that acid generation in this area already occurs
- Waste rock that was mined during the Soviet era generates acidic drainage
- Acid-base accounting results show that rocks that will be mined at the site have a high potential to acidify water. Additionally, there is virtually no rock on site that can neutralize acidic water
- Humidity cell tests show that nearly every rock unit mined at this site will generate ARD
- Additional tests identify several metals and metalloids that these rocks may release, including antimony, arsenic, cadmium, chromium, cobalt, copper, lead, mercury, selenium and zinc

The small acidic seeps in the Amulsar area and the Soviet-era waste rock only have localized effects. However, mining will unearth vast quantities of rock that will generate much larger volumes of acid water. Without proper measures to mitigate this, these acidic waters will travel much farther and affect far greater areas.

Lydian's plans to mitigate contaminant release are inadequate. The ARD mitigation plan should already be in place, so that Potentially-Acid Generating (PAG) rock is managed from the start of construction. The planned management of acidic waters generated from pit dewatering and other sources during mining is problematic. It assumes that metal loads will be low and sludge management will be unnecessary. We feel this is very optimistic and believe that it is both prudent and necessary to build a lime-based treatment plant to manage these waters and the resulting sludges.

The proposed passive treatment system will deal with some, but not all of the contaminants identified above. More importantly, it is not designed to treat large volumes of acid drainage with elevated metal concentrations. Given the uncertainty in predicted water chemistry during operations and at closure, we are not confident that the proposed passive treatment system will function properly and produce an acceptable discharge.

We indicated that thiocyanate is likely to be produced in the HLF for decades, yet no measure has been proposed to control this toxic contaminant. Similarly, ammonia and nitrate, as well as metals and metalloids, may be present at elevated concentrations in heap rinsate or drain down water, but no credible measure to control these contaminants has been presented.

The proposed encapsulation of barren rock and capping of the spent HLF could decrease the release of contaminants, but will not eliminate them. Potentially, this could result in release of acid drainage for many decades. In our opinion, a better practice is to segregate sulfide minerals during mining operations and backfill them into one or more of the mined-out pits to ensure that they do not generate acid drainage. This practice has been advocated for the past 15 years and is becoming the norm for mining projects with high risk of ARD (MEND 2015).

Lydian takes an optimistic approach to the management of surface and groundwater flows into the pits. Several model predictions have high uncertainty, and measures to mitigate the discharge of contaminated pit water are not based on a reliable water balance calculation. Given that these waters could flow into the Kechut Reservoir, we believe it is more prudent to assume that water treatment will be needed before Year 4 of mining and prepare for increased storage and treatment before pit dewatering and mining operations begin.

Lydian uses terminology that confounds issues. Their reference to mining wastes being resistant to “ferric iron oxidation” is unusual and irrelevant. The more relevant fact is that humidity cell tests show that every rock unit is likely to generate acid drainage. Similarly, they refer to “passive treatment as an industry-standard method for controlling ARD.” This statement is true for ARD from coal mines in Eastern Appalachia, but not for base and precious metal mines. More importantly, their discussion sidesteps the key issue that the passive treatment system design that they put forward is inappropriate for the drainage that will be generated at Amulsar.

Finally, we hear a recurrent criticism that our review omitted important reports, as though our conclusions would change significantly if we had all the necessary information. Our reviews are based on the most recent available information, but not all the pertinent information has been made publicly available. In the name of transparency and to remove any uncertainty in our conclusions about this project, we urge Lydian to make publicly available all the documents relevant to this project.

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Introduction

We thank Lydian International and its consultants for responding to our reviews of the Amulsar Gold Project. We agree that this project could potentially benefit Armenia and its citizens, but disagree that these benefits will outweigh the long-term drawbacks in the project's current form. Our primary concern is that the proposed mine, as currently planned, will lead to long-term environmental degradation of one of the most beautiful parts of the country. It is our view that Lydian takes an overly optimistic view of the risks associated with this project and that a more conservative approach is justified in light of existing site conditions and the long-term impacts associated with acid rock drainage (ARD) and contaminant leaching.

We present below our main concerns regarding the current plans and present our recommendations for addressing these problems. We would welcome the opportunity to discuss these issues in an open forum with Lydian and its consultants, representatives of the Armenian government and international stakeholders. Ultimately, we believe that the environmental performance could be markedly improved once a number of key issues have been addressed.

Risk of ARD and contaminant leaching at Amulsar is high

Reviewers of our reports state in their summary that that independent studies show that ARD risks at Amulsar are "very low." However, the potential to generate acid is considered a risk, and the available data demonstrate that the acid generation potential of the site is not low. Reviewers also state that naturally acidic conditions already exist at the site, especially as evidenced by the seeps, and mining would not worsen the existing water quality conditions.

a. ***Baseline water quality in the Amulsar Project area is generally high and does not appear to be notably affected by natural acid drainage.***

Using the available data, springs identified in the ESIA (Wardell Armstrong, 2016; Chapter 4.8) as being acidic are not, and naturally acidic baseline conditions in the springs is questionable.

The following statement is not correct, based on the data provided (ESIA, 2016, p. 4.8.82): "The locations where a slightly alkali pH was measured are SP32, GA2, GA3, GA4 and AW035." (note: statement says alkali rather than alkaline). Instead, as shown in Table 1, these springs are acidic, with pH values <4; all but one spring was sampled only once. Sulfate concentrations are low, even though the pH is acidic; it is not clear that these springs represent natural acid drainage from weathering of sulfide minerals.

Table 1. The pH and sulfate values for springs declared to be alkaline in the 2016 ESIA.
Source: ESIA, 2016, Appendix 4.8.5 Groundwater Quality.

Spring ID	# Samples	pH Value (SU)	SO_4 (mg/L)
SP32	No data		
GA2	1	3.96	21.5
GA3	1	3.82	27
GA4	1	4.21	20.2
AW035	4	3.45 – 3.74	36.3 – 49.2

The following statement is also incorrect based on the data provided (ESIA, 2016, p. 4.8.82): "The locations where a naturally lower pH was measured in April/May 2014 include SP29, SP33, ERW3, ERW5, Spring 1, Spring 6, Spring 7, Spring 8, Spring 9 and Spring 10." Instead, as shown in Table 2, these springs have pH values >6 and low sulfate concentrations, indicating that they are not representative of natural acid drainage.

Table 2. The pH and sulfate values for springs declared to be acidic in the 2016 ESIA.
Source: ESIA, 2016, Appendix 4.8.5 Groundwater Quality.

Spring ID	# Samples	pH (SU)	SO_4 (mg/L)
SP29	No data		
SP33	No data		
ERW3	1 (pH) 2 (SO_4)	6.43	11.9 – 18.1
ERW5	1 (pH) 2 (SO_4)	6.18	18 – 38.1
Spring 1	3 (pH) 1 (SO_4)	6.21 - 6.57	5
Spring 6	2 (pH) 1 (SO_4)	6.52, 6.64	5
Spring 7	1	6.47	5
Spring 8	1	6.62	5
Spring 9	1	6.95	5
Spring 10	1	4.38	29.1

As shown in Figure 1a and b, most springs have a neutral pH. The acidic springs are downgradient of the NE corner of the Artavazdes Pit area (Figure 1b) with the exception of Spring 10 (acidic, not shown in Figure 1) which is located south of the Artavazdes Pit and appears to be upgradient of the pit.

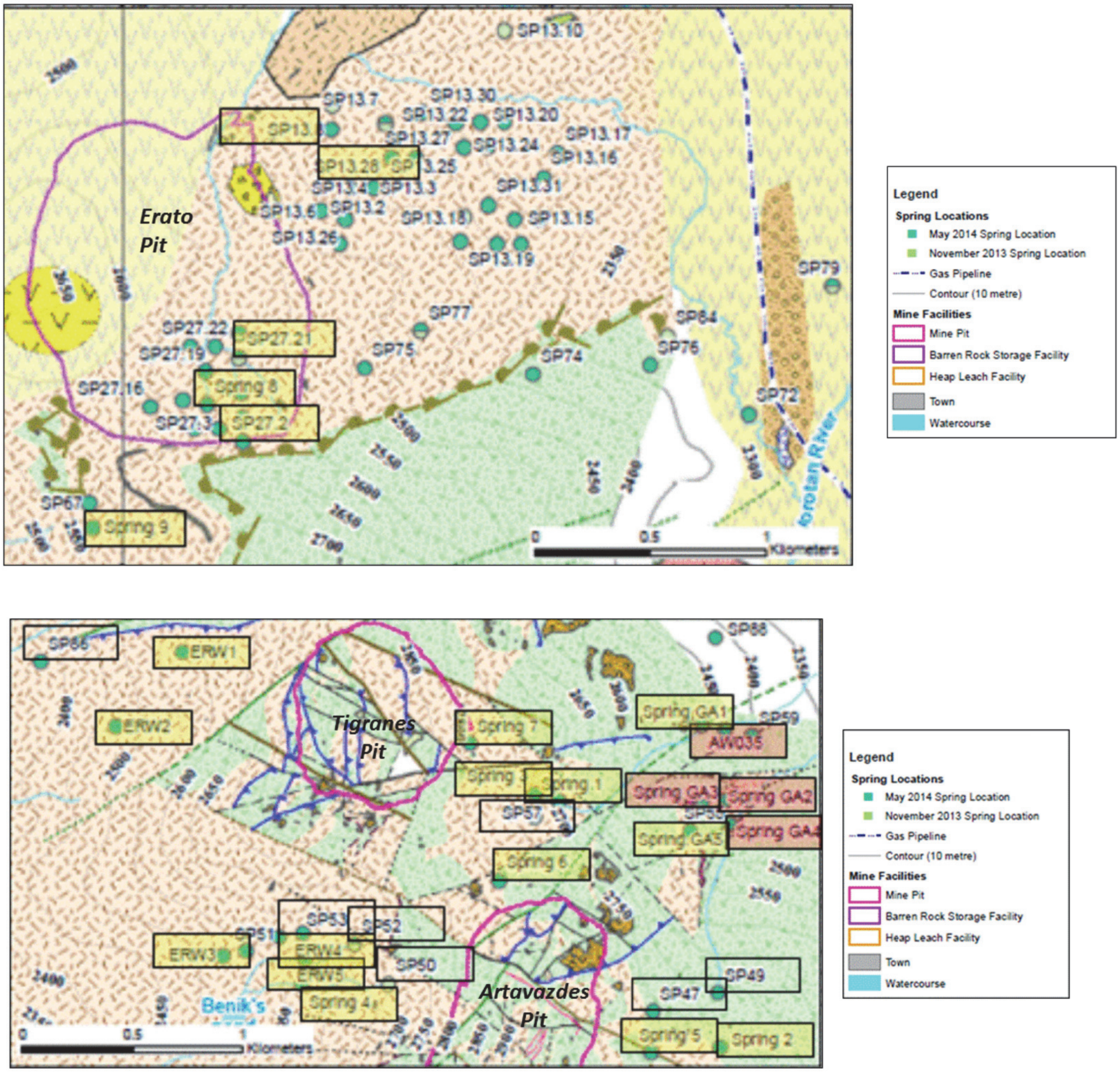

Figure 1a, b. Spring pH values for areas around the (a) Erato Pit and (b) Tigranes and Artavazdes pits. Yellow = pH <4.5; pink = pH >6; no color = no data (Note that all other springs around the Erato Pit in Figure 1a do not have available pH values.) *Source: Modified from Drawing 4.8.3, ESIA, 2016, using data from Appendix 4.8.5, ESIA, 2016.*

The representativeness of the acidic well samples is questioned in the ESIA: "Groundwater samples collected from wells in the GSA (Groundwater Study Area) are typically circum-neutral (pH 6.5 to 9). Mildly acidic pH values below 6.5 are only recorded on two occasions in field pH measurements of groundwater well samples (Appendix 4.8.5), in well DDGW003 on the Cenozoic Flow Basalts east of the Vorotan River in March 2014, and in well GGDW016a in the Lower Volcanic Andesites south-west of the HLF in March 2014. The flush of water in springs arising from snow melt infiltration may cause temporary acid conditions as the products of sulphide oxidation that has accumulated over the Winter period are 'washed through'. However, given the sporadic nature of the observed acidity, it is equally probable that these are anomalous pH recordings." (ESIA, 2016, Chapter 4.8, p. 4.8.83)

b. ***Many statements and results in the ESIA and other documents confirm that the site will generate acid and require treatment. The short-term metal and other contaminant leaching potential of the mined materials is underestimated due to the types of short-term leach tests selected.***

The humidity cell test (HCT) results show that all but two samples produced acid (pH <6), and the test duration of those two samples was cut short. The HCTs were conducted on materials expected to become waste rock. As shown in Figure 2, all five Lower Volcanic HCT samples produced acid (pH <6). Only three Upper Volcanic HCT samples were tested. One produced acid after about 30 weeks of testing; the other two samples were cut short at 20 weeks, even though pH values had decreased by about 1 pH unit before testing was prematurely stopped. Additional testing has been committed to and could be under way, but these limited results indicate that the Lower Volcanic material is highly acid generating and the Upper Volcanic material, while likely less acid generating, may nonetheless produce acid as well.

It is stated that "…three of the five LV kinetic cells showed strong resistance to the formation of ferric iron oxidized ARD. These samples produce consistently mild (pH greater than 4.5) ARD, with low sulfate, nearly zero cumulative acidity, and low iron concentrations despite long-duration testing." (Appendix 4.6.2, ESIA 2016). This sentiment is also reiterated in the reply by the reviewers "Ferric iron oxidation has not occurred in old mine waste piles despite the presence of abundant unoxidized sulphides." However, this understanding is based on

(a) HCT tests 72C, 75C and 77C (see Figure 1) that contained relatively low sulfide S at 0.8, 0.2 and 0.3 wt.%, and

(b) Historic Soviet waste rock piles also containing low levels of sulfide S of 0.75, 0.2, 0.14, and 0.37 wt.%.

Hence the leach behavior observed reflects the low pyrite content and not any unusual geochemical resistance. In contrast, the mean sulfide S values of the Tig/Art and Erato Lower Volcanic barren rock samples were 1.31 and 0.88 wt.%, respectively.

It is also stated in the reply "Jarosite and Alunite have been assessed in detail with static testing and humidity cells and been identified as non-acid generating and have therefore not been included in the discussion on ARD management." The highest sulfate S value of the nine samples subjected to HCT examination was 0.2 wt.%. The mean sulfate S values in the Tig/Art and Erato Lower Volcanics waste rock samples were 0.36 and 0.28 wt.%, respectively. . These tests therefore cannot be considered an evaluation of potential acid generation from these minerals. In addition, static testing does not distinguish between acid generated from sulfide minerals versus - slowly dissolving sulfate sources. Even more so than alunite, wastes with substantial amounts of jarosite require on-going ARD management, as now acknowledged by major mining companies (Linklater et al., 2012).

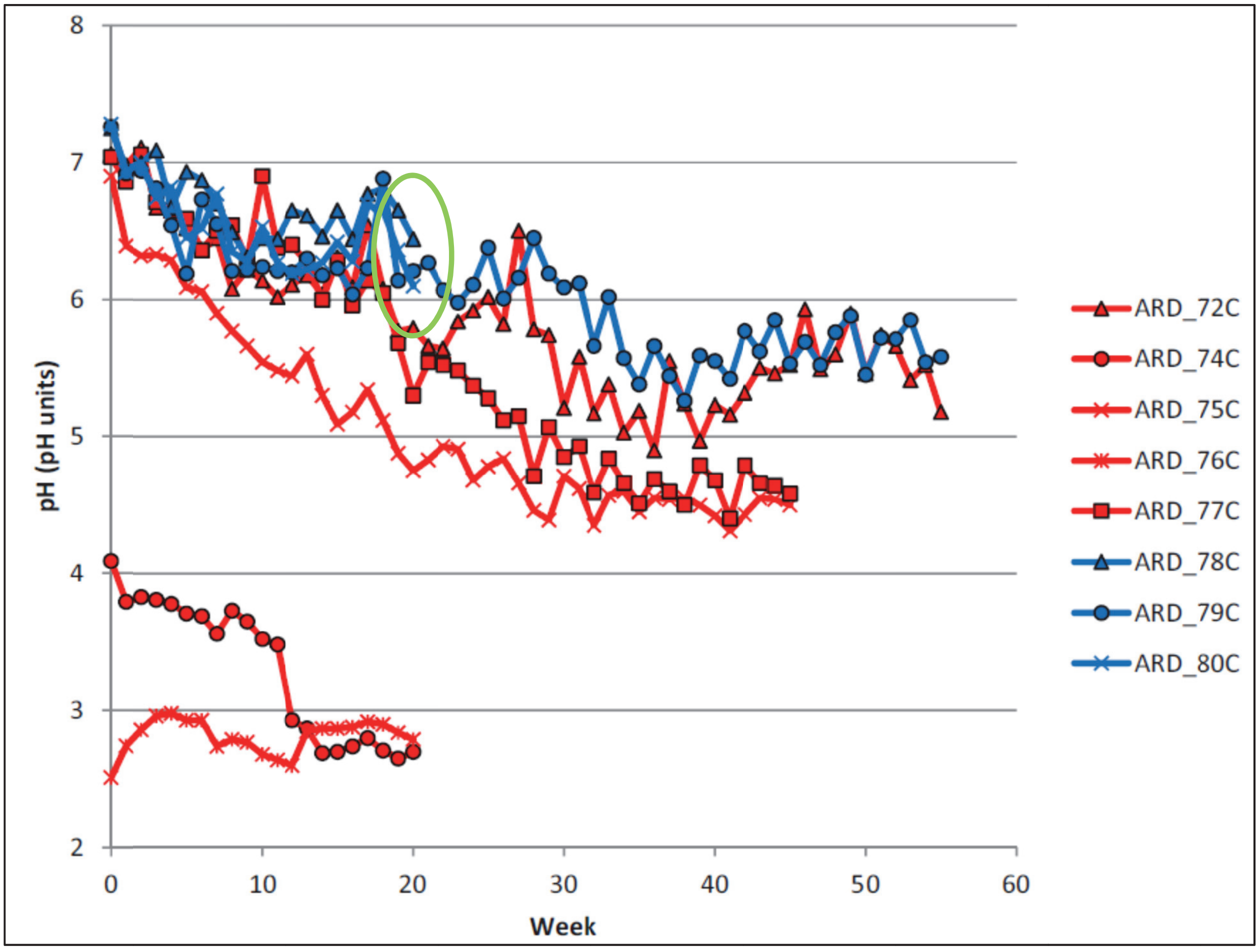

Figure 2. Humidity cell test results for eight samples from the Upper and Lower Volcanics.
The red test results are for Lower Volcanic samples, and the blue results are for Upper Volcanic samples. The green oval shows where two of the Upper Volcanic sample tests were terminated prematurely. *Source: ESIA, 2015, Appendix 4.6.2, Figure 24.2.*

The ESIA (2016) states that the Lower Volcanic materials are "highly acid generating": "Geochemical characterization completed to date for the Amulsar project (Golder Associates, 2013b) indicates that the high pyrite/jarosite materials from the Lower Volcanics lithologic group are highly acid generating due to sulphide oxidation and produce acidic leachates with pH as low as 2.5." (ESIA, 2016, Chapter 4.8, p. 4.8.82)

Appendix 4.6.2 of the 2015 ESIA (GRE, 2014, p. 1) states: "It is accepted that the residual sulfides present in portions of the mineralized areas to be mined have a potential of oxidizing, and the resulting oxidation products would result in an acidic leachate and elevated salt and dissolved metal values." This statement indicates that mining will produce a classic acid drainage solution with low pH and elevated metal and sulfate concentrations. No mention is made of a low acid drainage potential.

GRE (2014, p. 7) also notes that the ability of waste rock ("barren rock") to neutralize any acid produced is nearly non-existent. "Table 5-1 shows that the barren rocks have little to no acid neutralization potential. This is not unusual for a high sulfidation epithermal deposit, where extensive acid leaching during deposit formation frequently removes any original carbonate or aluminosilicate minerals that might have provided neutralization potential." Therefore, the HCT results demonstrate that the waste rock will produce acid, and the acid-base accounting results indicate that the waste will have little to no ability to neutralize the acid produced. While the Upper Volcanic samples had a lower acid production potential than the Lower Volcanics, they also had a lower neutralization potential.

As the reviewers noted, it is true that the short-term leach tests show low concentrations of leached contaminants in the wastes, the spent ore, and the borrow materials. The problem with the selected short-term leach tests is that they both used a high liquid:solid ratio (measured as mL/g or L/kg), which will dilute leached concentrations. The SPLP test has a liquid:solid ratio of 20:1, and the NAG testing method used a 100:1 liquid:solid ratio. In addition, only average concentrations were reported in GRE (2014); maximum values should have been presented as well, but more importantly, lower liquid:solid ratios should be used. As noted in the Buka Environmental report, results from the HCTs, which use a 1:1 liquid:solid ratio, and the barren leach solution indicate a potential to leach antimony, arsenic, copper, and zinc from the spent ore and arsenic, cadmium, chromium, cobalt, copper, lead, selenium, and zinc from the waste rock (ESIA, 2015, Appendix 4.6.2). As an alternative, the Meteoric Water Mobility Procedure (MWMP), which uses a 1:1 liquid:solid ratio, or leach tests at a variety of liquid:solid ratios, could be used (see Maest et al., 2005 for descriptions and pros and cons of geochemical tests). Short-term leach tests must be applied to weathered materials because the tests are designed to capture releases of quickly soluble constituents during or shortly after a rainstorm or snowmelt event. The extent of weathering of the samples used for testing was not discussed in the documents.

GRE (2014, p. 12) summarized the results of acid potential testing of the Erato wastes as follows: "NAG pH values are available for 50 Erato barren rock samples. As expected, NAG pH values are consistently lower than paste pH values. The results indicate that complete sulfide oxidation would result in all lithologies being net acid-generating, with LV samples generating an effluent pH slightly above 4 and UV samples an effluent pH slightly below 5." The results indicate that not only is Lower Volcanic waste rock expected to generate acid, but Upper Volcanics and colluvium is as well.

These statements and results strongly indicate that the acid drainage/contaminant leaching risk at the Amulsar site is high. Absolutely rigorous waste and water management is needed at the site to avoid short and long term environmental contamination. The following section addresses issues with planned mitigation and suggested improvements.

Planned mitigation is insufficient to prevent long-term contaminant release

a. Timing of mitigation measures

The mine is already under construction, and acid drainage and contaminant leaching can begin now without adequate mitigation measures, such as careful control of construction materials and blasting agents, separation of potentially acid generating (PAG) materials, and shotcreting of long-term exposed PAG wall rock. Waiting to develop these measures until after operation begins is not best practice. In addition, an Adaptive Management Plan (AMP) should be in place now.

The reviewers suggest that the likelihood of acid generation peaking after post-closure is an "unsupported prediction." It is correct that this prediction is unsupported in terms of this specific site, as no attempts have been made to date to predict the evolution of rates and amounts of acid generation. However, acid generation from mine wastes can peak after mine closure, if not appropriately remediated during operations, with environmentally damaging drainage continuing for decades Ziemkiewicz et al., 1991, Hart et al., 1991). Therefore, mitigation must start on commencement of mining and be implemented over a likely time frame of decades or longer.

b. An active treatment system is needed to handle large flows and metal loads of mine-influenced waters.

The passive treatment system (PTS) planned for the project is designed to handle low flows generated as seepage from the heap leach facility (HLF) and the barren rock storage facility (BRSF). At high flows and/or metal loads, the rapid accumulation of solid residues (metal sludges) requires significantly more management that a PTS can offer. In fact, rapid sludge accumulation is one of the main causes of PTS failures. By contrast, an active treatment system, such as a High-Density Sludge (HDS) treatment plant, uses clarifiers to manage rapid sludge accumulation. This is one of the reasons why it is required at Amulsar instead of a PTS.

The plan to control contact waters in Ponds PD-7 and PD-8 during operations assumes that neutralization of ARD and solids settling will happen easily and will not impact gold extraction and recovery operations. On the contrary, metal sludges are not expected to settle easily in these ponds and this may result in clogging of pumps and pipes. Better control of these sludges will be necessary and will only be achieved reliably by operating a lime plant with a proper clarifier.

The design of a PTS during the mine planning stage should be conservative and supported by examples of relevant systems operating at existing mines. The PTS design memo provides examples of PTSs used at hardrock mines. Two of these examples appear to be relevant. The first Gusek (2011a) report describes a PTS installed at an historic, abandoned underground base metal mine. The water source was mine adit discharge that contained high metal concentrations, had a low pH, and had flows of 0.9 gpm (3.6 L/min). The 2013 Gusek report discusses effectively treating flows from an historic underground mine that also had high metal and sulfate concentrations and low pH. The system was designed to treat only 7 gpm (26.5 L/min), and peak flows were only 6.3 gpm (23.8 L/min).

The PTS proposed for the Amulsar project has similar flows and is predicted to have better inflow water quality than these two examples. However, we have raised concerns about the predicted water quality and anticipate that it will contain higher metal concentrations than those shown in the design document (Sovereign Consulting, 2015). The humidity cell test results (Figure 2) showed that acid generation and metal release from mined rock was likely to be rapid. It is reasonable to expect that there will be a high buildup of acidity and metal loads during the development of the BRSF and these will have to be treated early during mining operations.

The Amulsar PTS is designed to treat 11.1 L/sec (~15 gpm) (ESIA, 2016, Appendix 3.3) and is predicted to be installed after Year 4 of mining to treat low flows from the waste rock pile (BRSF). However, we expect these flows to contain high loads of acidity and dissolved metals. The PTS design incorporates no front-end unit to neutralize acidic pH and to control sludges resulting from aluminum and iron precipitation. This omission will result in the plugging of the initial nitrate BCRs and failure of the system.

A PTS is also planned to treat draindown water from the HLF. As we indicated in our review, arsenic and thiocyanate (among other contaminants) are likely to be present in HLF rinsate and draindown, and the proposed PTS has no provisions to treat these constituents. While Wardell-Armstrong (2017) argues that previously-discussed examples demonstrate that passive treatment of HLF draindown is achievable, they have not shown that these examples are relevant to Lydian’s Amulsar project, i.e., that the draindown chemistry or climate in these examples are comparable to those anticipated at Lydian. In fact, significant differences in the geology of the ore body assure that draindown chemistry will be different.

Low flows expected from these the BRSF and HFL assume that the vast majority of draindown water from both facilities is captured, and flows remain low. The lack of a synthetic liner under the BRSF makes effective capture uncertain. Uncertainties in the water balance, the groundwater model, and a lack of understanding of groundwater inflow to the pits add large uncertainties in the predicted flows and chemistry of waters feeding the planned PTSs. The use of a PTS becomes a risky proposition, especially if metal loads are significantly higher than those predicted in the design document. It is far more prudent to install a conservatively-designed active treatment system before mining begins. The system should be capable of treating large volumes of mine-influenced waters with elevated levels of metals, sulfate, and acidity.

Lydian needs to manage and plan for every potential source of contaminated water during construction, mining, closure, and post-closure

a. *Water balance assumptions and effects*

Reviewers of the Bronozian-commissioned reports state that the ESIA and the groundwater model do assess groundwater inflow to the open pits during mining. However, the results of the modeling and groundwater assessment are highly uncertain, and the ESIA (2016) does not accurately or adequately incorporate findings from the modeling or assessments. Our conclusions remain that the basis for only needing treatment and discharge starting at Year 4 of mining is not substantiated and that a lime treatment or reverse osmosis plant should be built as a contingency, given the available geochemical testing results and close proximity to water resources.

Golder admits there are large uncertainties in their groundwater model (ESIA, 2016, Appendix 6.9.1. Groundwater Modeling Study, p. 39): "The regional groundwater flow model is not able to represent the hydrogeological regime surrounding the ore bodies with sufficient accuracy to predict rates of permanent groundwater inflow during mining. Similarly, the occurrence of isolated permanent and semi-permanent perched water bodies within the faulted geological sequence cannot be readily predicted and must be dealt with as an operational issue."

The 2016 ESIA still states that no groundwater will enter the pit, even though the Groundwater Modeling Study (above) indicates otherwise: ESIA, p. 3.67: "Groundwater modelling indicates that the pit floor will not intersect with the groundwater table, and so there will be no water ingress to the pit via groundwater sources."

The water balance appendix that was not included in the 2016 ESIA also used an assumption that no groundwater would enter the pit (ESIA, 2015, Appendix 6.10.1 Site Wide Water Balance and Water Management Plan (2014), p. 12: "All pit water comes from meteoric water (snow and rain). Perched groundwater is not a significant long-term source of groundwater."

According to Appendix 6.10.1 in the 2015 ESIA (missing in 2016 ESIA), the cumulative excess water is predicted to exceed the available storage capacity in all three scenarios examined during an extremely wet period (starting on p. 22). The first scenario where excess water would exceed available storage is very early in mine development, at the peak of cumulative excess water during pre-production (ESIA, 2015, Appendix 6.10.1, Section 6.4). That would be during Year 1 of mining, yet no treatment is proposed until Year 5 of mining. The report states that the pits could be used for water storage during those time, but this would preclude mining. Statements such as "Because two such storms are not expected in the same year, a factor of safety is maintained." (p. 19) indicate that climate change has not been seriously considered in the site-wide water balance.

The FS (2015, NI-43-101), p. 187, makes it clear that the only dewatering considered is in-pit dewatering, not pumping of perimeter dewatering wells, which will very likely be needed to establish hydrologic control, improve stability of the pit walls, and ensure that the materials being mined are dry. These positive effects will reduce mining costs and improve safety and environmental performance in the medium and long term. The maximum in-pit dewatering pumping capacity is 160 L/s. Dewatering of wells will likely produce much more water, yet no contingency plans exist for installing perimeter dewatering wells and adding an active treatment system.

The detention pond (designed to store all contact water from pits and the BRSF) is sized for the 100-yr, 24-hr storm (FS, p. 205), and the HLF Storm Ponds (1 and 2) are designed for a "typical wet year" (FS, p. 203). Extreme storms possible under climate change conditions have apparently not been incorporated into the design.

Updates to the water balance are in process, but what is needed is a series of diagrams showing water inflows, outflows, on-site management and storage under different climate scenarios, with uncertainties. An example would be Figure 18.2 from Lydian (2017), but with numbers. This kind of information is critical for understanding the need for treatment during operations. Also, no mention is made of whether the contact water ponds will be lined or if water released to the environment, including to the Gndevaz Reservoir (see Lydian, 2017, p. 275), will be monitored for contaminants and treated if necessary before discharge. Non-contact water can contain contaminants and should be part of the site monitoring program.

The problem with the statements and assumptions highlighted above is that they provide the basis for not needing treatment until Year 4 of mining. The lack of treatment for four years of large-scale mining relies upon a highly uncertain water balance and groundwater hydrogeologic assessment. If in-pit dewatering sumps cannot adequately dewater the pit or create a cone of depression for hydrologic control of mine-influenced water, perimeter dewatering wells will need to be installed. Water pumped from perimeter dewatering wells will likely require treatment because of the high volume of water and the increased nitrate and other contaminant concentrations in the pumped water resulting from blasting. Additional studies are underway, but it is not acceptable to be in construction of a large-scale mine and have NO water treatment available, especially when the water balance is so uncertain. A reverse osmosis or lime treatment plant must be build and be fully operational before mine dewatering begins.

Lydian's wording confounds issues, minimizes apparent risk

Lydian uses terminology that confounds issues. Their reference to minerals wastes being resistant to "ferric iron oxidation" is unusual and irrelevant. The more relevant fact is that humidity cell tests show that every rock unit is likely to generate acid drainage.

Similarly, they refer to "passive treatment… rapidly becoming the industry-standard for all but the most severe ARD." As an expert in the field and a world authority, one of us knows that this is a wildly optimistic, indefensible statement. It is only true for ARD from coal mines in Eastern Appalachia, but not for ARD or most drainages from base and precious metal mines. More importantly, this statement sidesteps the key issue that the passive treatment system design put forward for this project is inappropriate for the drainage that will be generated at Amulsar.

Lydian has not been transparent with its most data-rich reports and appendices.

One of the comments from the reviewers was that the most recent reports were not reviewed. Our reviews are based on the most recent available information, but not all the pertinent information has been made publicly available. Under the IFC's Performance Standard 1: Assessment and Management of Environmental and Social Risks and Impacts (IFC, 2012), consultation with stakeholders should "be based on the prior disclosure and dissemination of relevant, transparent, objective, meaningful and easily accessible information." Lydian's intent to meet international standards should certainly include transparency of information.

a. ***The Feasibility Study and other documents, including the ESIA (2016) refer to results from an updated geochemical testing report that is not available without making a trip to the Channel Islands.***

Buka Environmental stated that the numeric results for the geochemical testing program are not included in the current ESIA (2016). Comments to the Buka Environmental report responded that "Numerical results are included in the Geochemical Characterization Report which is included as an appendix to the FS." However, no reference or link was provided. Lydian (2017), p. 351 states: "The characterization of the Acid Rock

Drainage (ARD) properties of the Amulsar site was first reported by Golder Associates (Golder, 2013c). This report has been fully-updated by GRE (Appendix 15 found in ESIA version 10, found on the Lydian website at http://www.lydianinternational.co.uk/reponsibility/esia) to include the results of additional geochemical testing, and to report predictive modeling associated with the up-to-date mine planning and ARD mitigation measures." This link leads to the 2016 ESIA. Appendix 15 does not exist. The Feasibility Study (FS) and a mention of Appendix 15 can be found on the Lydian *International* website (SGS, 2015). In fact, Appendix 15 is not included in the Feasibility Study. A statement at the beginning of the FS makes it clear that Lydian does not want to transparently release the information contained in the FS appendices:

> **"With the exception of Appendix 1 - AMC Appendices A, B and C, all other documents and drawings can be viewed and are available In the Lydian International Ltd. offices in Helier Jersey, Channel Islands, United Kingdom after signing a confidentiality agreement."**

The updated geochemical characterization report was completed by the publication date of the ESIA and should have been included as an appendix in the 2016 ESIA and made easily available on the Lydian website for the project. Making documents difficult to find does not foster trust in the ability of Lydian to be transparent with its stakeholders.

b. The Independent Environmental and Social Consultants (IESC) report is mentioned many times in Lydian documents, but it is not available to the public.

The reviewers of the reports stated that testing, the EMSP, and other Lydian documents or studies have been determined as sufficient by Independent Environmental and Social Consultants (IESC, Knight Piésold, April/May 2017). A Knight Piésold report from 2016 was found online (Knight Piesold and Co., 2016), but the 2017 report was not available.

c. In addition to the appendices not available in the Feasibility Study, five appendices with important information about the mine's environmental performance and visual appearance that were available in the 2015 ESIA are not included in the 2016 ESIA.

The following appendices were available electronically in the 2015 ESIA, which is no longer available on the Lydian Armenia website. The 2015 ESIA is still available on the Lydian *International* website, but the question remains: why were these key appendices excluded from the updated 2016 ESIA?

Lydian should upload these and all other missing appendices to their website for the project (Table 3).

Table 3. Appendices missing from the Amulsar 2016 ESIA.

2015 ESIA Appendix # and Title	**Notes**
3.1 Feasibility Design of BRSF	2016 Appendix 3.1 is titled BRSF design but is instead a report on the passive treatment system (PTS). Appendix A of Appendix 8.1.9 also addresses the PTS for the BRSF.
3.4 Feasibility Design of HLF	The feasibility design for the HLF and the BRSF are not included in the 2016 ESIA.
4.6.2 Geochemical Characterization and Prediction Report	This report contains critical information on the contaminant leaching characteristics of Amulsar mined materials.

2015 ESIA Appendix # and Title	Notes
6.5.1 Figures	Contains 103 pages of maps and drawings showing the visibility of the mine throughout the years of mining from various vantage points in the area, including Jermuk and Gndevez Village.
6.10.1 Site Wide Water Balance and Water Management Plan (2014)	The 2015 site wide water balance ESIA appendix contained no numeric information on flows at the mine site during operations and references to reports without providing links. The referenced reports are not available on the Lydian website. The 2016 ESIA eliminated Appendix 6.10.1.

Recommendations

- Statements in the ESIA about the acidity of springs should be compared to the water quality data and corrected.
- Short-term leach tests with lower or variable liquid:solid ratios should be conducted on representative mined materials.
- It is stated in several places in the reply from the reviewers that considerably more geochemical testing will be undertaken during 2017 and thereafter. This should serve to address such issues as stored acidity (i.e. the presence of jarosite and alunite) and rate and degree of acid generation due to pyrite oxidation. However, the test samples need to be properly representative – those chosen for HCT previously were not – and sufficient in number and duration.
- Based on further testing and planned rates of waste rock accumulation, the evolution of acid generation should be modelled and mitigation measures should be planned to specifically address the time scale of this evolution.
- The current Best practice to identify sulfides at the wall face and segregate waste containing sulfides (above a cut-off grade) from non-sulfide waste should be implemented. Sulfide waste that is likely to generate acidity should be dumped near one of the pits, and eventually backfilled and flooded to prevent long-term acid generation (MEND, 2015).
- An Adaptive Management Plan (AMP) to address changes in water quality, streamflows, and groundwater elevations should be in place now. The plan should identify trigger levels, mitigation measures to be taken, responsibilities, and evaluation of mitigation effectiveness.
- The basis for only needing treatment starting in Year 4 of operation is not substantiated. Given the geochemical testing results indicting a strong potential to develop acid drainage, the acknowledged uncertainties in the site water balance, and the close proximity to water resources, an active treatment system should be installed before mining begins. The system should be designed conservatively and be capable of treating large volumes of mine-influenced waters with elevated levels of metals, sulfate, and acidity.
- The site-wide water balance should be recalculated assuming the need for perimeter dewatering wells and taking more extreme events (>100-yr storm) into account.

- Lydian's intent to meet international standards should include transparency of information. All previous documents and data should be placed on the same Lydian website as ESIA 2016 and be clearly named in chronological order. It would confer credibility if the availability of these documents were not subject to a confidentiality agreement.

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