Atlantic Gold

Appendix A.2b

Conceptual PAG Closure Options – Dec. 2021 as Completed for the Updated 2021 Beaver Dam Mine EIS

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December 1, 2020

Ms. Veronica Chisholm
Atlantic Gold
409 Billybell Way, Mooseland
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Dear Ms. Chisholm,

RE: BEAVER DAM PROJECT – CONCEPTUAL PAG CLOSURE OPTIONS

Wood Environment & Infrastructure Solutions, a Division of Wood Canada Limited (Wood), was requested by Atlantic Gold to provide conceptual level mitigation options for the potentially acid generating (PAG) waste rock stockpile as currently designed for the proposed Beaver Dam project. Potential options for closure of the PAG waste rock stockpile are presented below at a conceptual level, including capital cost estimates.

PAG CLOSURE OPTIONS

Four major options have been identified for closure of the PAG stockpile. These options are discussed briefly in the following sections and Attachment 1, which provides a summary of the pros, cons and estimated CAPEX and OPEX costs for each option at this conceptual level of design.

Assumptions

The comparison of options presented herein is based on the following assumptions:

- The site layout is as shown on the McCallum Environmental Ltd. figure "Beaver Dam Preliminary Property Boundary and Updated Infrastructure Layout" dated 4/6/2020 and .dxf files provided by Moose Mountain Technical Services to Wood on July 22, 2020.
- 1,958,000 tonnes of PAG is generated over the mine life and stored in the PAG stockpile.
- The bulk density of the PAG and NAG rock is assumed to be 2.2 t/m^3 and the till density is assumed to be 1.8 t/m^3.
- No clay source is available on-site and this material will need to be obtained from an offsite supplier (haul distance of 20 km assumed).
- Stockpiled soil/overburden material is available onsite for this application.

- The Open Pit will not be available for storage until mine closure.
- The overall PAG stockpile slopes of 2.6H:1V (individual lifts at 1.5H:1V) as per the EIS will need to be regraded for long-term stability if the PAG stockpile remains in place. If the stockpile is lined (Option 1 or 2), the maximum slope is anticipated to be in the range of 3H:1V to 4H:1V. For this preliminary assessment, it is assumed that 10% of the waste rock requires regrading.
- Water management (e.g., ditches) are in place for operations and closure costs include allowance for modifications only (e.g., directing runoff to the Open Pit).
- Cost estimates are present-day values.
- Costs for materials and cover layer thicknesses are based on typical requirements for similar applications but may be subject to change based on site-specific considerations at a later stage of design.

Option 1 (Base Case): Clay Cap with Vegetated Soil Cover

Option 1 (the Base Case identified by Atlantic Gold) is the placement of a clay cap with a vegetated soil cover. The clay cap will require assessment and approval of the properties of the clay source as well as specifications for compaction, along with field quality control (QC) and quality assurance (QA) testing to ensure the constructed clay liner performs as intended. While a properly constructed compacted clay cover will provide a low-permeability barrier to precipitation, compacted clay is prone to increases in permeability due to freeze/thaw cycles and desiccation. The cost estimate for this option includes a topsoil layer of 1.2 m over the 1 m compacted clay layer to minimize frost penetration into the clay. A heavy-duty separation geotextile is included above the regraded waste rock prior to clay placement as the clay will not be filter compatible with the waste rock, leading to migration of the fine-grained clay into void spaces in the rock. The topsoil will be hydroseeded to mirror the local topography and landscapes prior to mine development. The water management infrastructure in place during operations (i.e., ditches/berms) will be modified to direct runoff to the Open Pit.

> *Note: It is understood that there is no onsite source of clay material. If a clay source is not available within 20 km of the site, amendment of the available till material with bentonite should be considered as an alternative to provide a suitably low-permeability material. A laboratory testing program would be required in this case to determine the percentage of bentonite required based on the properties of the till (typical requirement of 5-10% bentonite by weight).*

Option 2: Geosynthetic Cover

Three sub-options have been identified for closure using geosynthetic covers (Option 2). All Option 2 sub-options consider the same regrading of the PAG stockpile slopes and water management modifications as noted for the Base Case.

Option 2a: High-Density Polyethylene (HDPE) Liner with Vegetated Soil Cover

Option 2a considers the use of a HDPE geomembrane liner as the low-permeability element of the PAG stockpile cover. While HDPE is a manufactured product with a finite service life, there is a significant body of research to support service life estimates and material behaviour. This option requires a heavy-duty protection geotextile to be placed over the stockpile to provide a suitable base for HDPE liner installation and limit the potential for puncture. Installation of the HDPE liner involves a field QA/QC program to be executed by qualified installers. The cost estimate assumes that a textured liner (for safety during installation) is provided on slopes and a smooth liner is installed on the stockpile crest. A 0.5 m layer of topsoil would be placed on the installed liner and hydroseeded.

Option 2b: Bituminous Liner with Vegetated Soil Cover

Option 2b assumes the use of a bituminous geomembrane liner as the low-permeability element. Bituminous liners are gaining wider acceptance in North America, although there is comparatively little available literature on their long-term performance compared to HDPE. While bituminous liners have greater resistance to puncture than HDPE liners, the maximum particle size in contact with bituminous liners is limited to approximately 75 mm. Therefore, a heavy-duty protection geotextile is assumed to be required beneath the bituminous liner. Topsoil and hydroseeding were assumed to be the same as for Option 2a.

Option 2c: Bituminous Liner with NAG Rockfill Cover

Option 2c considers use of the non-potentially acid generating (NAG) waste rock in place of the topsoil as a cover material for the bituminous liner considered in Option 2b. This option may be attractive if there is a need to lower or regrade the NAG stockpile at closure. Due to the anticipated gradation of the NAG rock, an additional geotextile overlying the bituminous liner would be required prior to placement of the NAG rock. It is assumed that a 1 m thickness of NAG would be placed based on typical mine waste rock gradation. This option does not include a vegetated cover, which may not be acceptable to environmental authorities in regard to mirroring the local topography and landscapes post-closure. Alternatively, bituminous liners may be left exposed without cover material, and this option could be further pursued but is subject to confirmation of resistance of the liner to wind uplift.

Option 3a and 3b: Subaqueous Disposal in Open Pit

Option 3 (3a and 3b) presents the options for relocation of the stockpiled PAG in the Open Pit at mine closure. A 0.5 m layer of till would be placed over the PAG surface as a cover to act as a diffusion barrier to minimize migration of acidity and metals into the overlying pit volume during flooding. The estimated PAG rock volume and cover material would be contained from the bottom of the Open Pit at 45 m below sea level (mbsl) to approximately 16 m above sea level (masl), with substantial remaining capacity in the pit for water storage (approximately 14 Mm^3). The footprint of the former stockpile would be regraded with soil and hydroseeded.

This option provides the benefit of eliminating any future stability concerns with the PAG stockpile and reducing the mine-affected areas of the site. Option 3a utilizes a Third Party (contractor) cost to haul the waste to the Open Pit, whereas Option 3b uses the Mine Fleet at the end of operations to complete that task.

Option 4: Water Treatment of Uncovered PAG Stockpile Drainage

Option 4 considers the use of water treatment to mitigate ARD impacted drainage from the PAG pile. The pile would remain uncovered following mine operations and runoff/seepage from the pile would be captured in the surrounding collection ditch for treatment prior to discharge in the Open Pit.

Option 4a: Lime addition

Under this scenario the addition of lime to the collected seepage is sufficient to mitigate any water quality impacts to the PAG pile seepage. Seepage would be routed to a small retention pond where lime would be added to the collected seepage before discharging the treated effluent via pumping to the Open Pit. The effluent would be discharged at depth below the pit lake surface to ensure settlement of the treatment sludge.

Option 4b: Additional Metals Treatment

Under this scenario lime dosing alone is not sufficient to mitigate certain metals in the effluent flow, and additional treatment steps are required. Based on some preliminary water treatment studies carried out on the project, use of a treatment method such as ion exchange could be required to treat for metals such as Co, Cd and Zn. Therefore, for this option the use of ion exchange has been included as a treatment step along with lime addition.

Operations and Maintenance Costs

Conceptual estimates of the (OPEX) costs to operate and maintain the different closure options were estimated based on the following assumptions:

1. During each 10-year period, 10% of each cover area would need to be replaced (e.g. ~1% per year).
2. During the first 10 years, additional hydroseeding and/or fertilization of the vegetated covers would be required multiple times (assumed in years 2, 3, 5, 7, 9) to ensure the development of a stable and self-sustaining biomass.
3. For the water treatment options, costs were based on high level estimates of reagent consumption and staffing requirements to manage the system.
4. For comparative purposes these OPEX costs were estimated for the first 10 years of each option.

Environmental monitoring related to the closure options was not included. It was assumed that this would be of a similar cost for any option and would be required for the mine site as a whole.

Options Comparisons

Attachment 1 summarizes the options and their estimated conceptual CAPEX and OPEX costs. CAPEX costs range from $0.92M (water treatment by lime addition) to approximately $13M (PAG relocation to Open Pit by Third Party contractor). Ten-year costs (CAPEX plus OPEX) range from $3.7M (water treatment by lime addition) to $16.9M (water treatment by lime addition and ion exchange).

These cost estimates are conceptual in nature and based on several simplifying assumptions and the current level of design for the mine site. Continued development of the mine plan and design of the site features could significantly influence and change the potential closure options and costs.

CLOSURE OPTIONS REVIEW MEETING

Following the submittal of the draft version of this memorandum, a review meeting was held on August 6, 2020 between Wood and Atlantic to assess the PAG pile closure options. After reviewing options including risks and costs, Atlantic concluded that for the EIS the option of a vegetated geosynthetic cover (Option 2a/2b) would be advanced with the contingency for in-pit or subaqueous disposal (Option 3). For the EIS, Atlantic will also include a commitment to undertake additional geochemical characterization / assessment of the PAG rock to assist in the engineering assessment and cover design.

CLOSING

Should you have any questions regarding the above report, please do not hesitate to contact Steve Sibbick at (905) 302-2680 (cell).

Sincerely,

Wood Environment & Infrastructure Solutions
a Division of Wood Canada Limited

Prepared by:	Reviewed by:
<Original signed by>	<Original signed by>
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ATTACHMENT 1

Option Comparison for Closure of PAG Stockpile

Attachment 1: Option Comparison for Conceptual Closure of PAG Stockpile

Option	Description	Pros	Cons	Capital Cost Estimate ($)[1]	Operating Cost Estimate ($)[2,3]	CAPEX plus 10 yrs of OPEX
1	Clay Cap with Vegetated Soil Cover	-transport of PAG stockpile not required -unlimited inherent service life of clay, although desiccation may reduce effectiveness of liner	-requirement for resloping of PAG stockpile expected for cover construction and long-term stability -clay expected to desiccate over time, resulting in significant increase in permeability -ongoing inspection and maintenance required to ensure vegetated cover remains intact -no onsite clay material available -clay placement restrictions (freezing temperatures and rain) -clay QA/QC and compaction testing requirements for material suitability	$7.8M	$0.12M	$9M
2a	HDPE Liner with Vegetated Soil Cover	-transport of PAG stockpile not required -extensive academic research to support HDPE service life expectations (>150 years for covered liner)	-requirement for resloping of PAG stockpile expected for cover construction and long-term stability -ongoing inspection and maintenance required to ensure vegetated cover remains intact -HDPE vulnerable to puncture from large particles or protrusions in underlying or overlying materials; geotextile protection required -HDPE installation restrictions require careful construction methods and extensive QA/QC testing requirements	$4.5M	$0.08M	$5.3M
2b	Bituminous Liner with Vegetated Soil Cover	-transport of PAG stockpile not required -bituminous liners more resistant to puncture than HDPE; geotextile protection may be required for larger protrusions (i.e., waste rock) -bituminous liner can be installed in any weather to as low as -20°C -minimal QA/QC testing requirements for bituminous liners	-requirement for resloping of PAG stockpile expected for cover construction and long-term stability -ongoing inspection and maintenance required to ensure vegetated cover remains intact -minimal academic studies to support bituminous liner service life (reported at >300 years)	$4.8M	$0.1M	$5.7M
2c	Bituminous Liner with NAG Rockfill Cover	-transport of PAG stockpile not required -reduces stockpiled NAG quantity -bituminous liners more resistant to puncture than HDPE; geotextile protection may be required for larger protrusions (i.e., waste rock) -bituminous liner can be installed in any weather to as low as -20°C -minimal QA/QC testing requirements for bituminous liners	-requirement for resloping of PAG stockpile expected for cover construction and long-term stability -minimal academic studies to support bituminous liner service life (reported at >300 years) -rockfill cover may not be acceptable to environmental authorities	$5.4M	$0.1M	$6.4M
3a	Subaqueous Disposal in Open Pit Third Party (haulage) costs	-no concern with liner service life -no ongoing maintenance requirements -removes long-term physical and chemical stability risks of PAG	-transport of PAG stockpile required	$13M		$13M
3b	Subaqueous Disposal in Open Pit Mine Fleet (haulage) costs	-no concern with liner service life -no ongoing maintenance requirements -removes long-term physical and chemical stability risks of PAG	-transport of PAG stockpile required	$6M		$6M
4a	Water Treatment of Uncovered PAG Simple lime addition	-transport of PAG stockpile not required -no concern with liner service life	-exposed PAG rock may not be acceptable to environmental authorities -ongoing water treatment costs	$0.92M	$0.28M	$3.7M
4b	Water Treatment of Uncovered PAG Lime addition and Ion Exchange treatment of waters for low-level metals	-transport of PAG stockpile not required -no concern with liner service life	-exposed PAG rock may not be acceptable to environmental authorities -ongoing water treatment costs	$1.58M	$1.53M	$16.9M

Notes
1 Present-day values.
2 Annual operating cost based on estimated 10 year operating and maintenance costs
3 Monitoring requirements will vary somewhat for each option, but are considered to be equivalent for the purposes of this study.