Mt. Todd
Waste Rock Dump Closure

Assessment Report

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GCL	geosynthetic clay liner
H:V	horizontal:vertical
LLDPE	linear low-density polyethylene
NAG	non acid-generating
PAG	potentially acid-generating
Pegasus	Pegasus Gold Australia Pty. Ltd.
PFS	Pre-feasibility Study
RP1	Retention Pond No. 1
Tierra Group	Tierra Group International, Ltd.
Vista	Vista Gold Corp.
WRD	Waste Rock Dump

LIST OF UNITS

ha	hectare
m	meter
mm	millimeters
Mt	million tonnes
tpd	tonnes per day
%	percent

1.0 INTRODUCTION

Vista Gold Corp. (Vista) retained Tierra Group International, Ltd. (Tierra Group) to complete an independent review of the proposed approach to closing the Waste Rock Dump (WRD) at the Mt. Todd mine site in the Northern Territory, Australia. The Mt. Todd mine was operated by Pegasus Gold Australia Pty. Ltd. (Pegasus) from 1993 to 1997. Subsequently, the mine was operated under a joint venture between Multiplex Resources Pty. Ltd., General Gold Resources Ltd., and Pegasus from June 1999 through June 2000. Vista acquired the Mt. Todd project in 2006 and has been performing care and maintenance operations at the site while planning for mine reopening.

The most recent mining plan is described in a 2019 Pre-feasibility Study (PFS) (Tetra Tech, 2019a) that develops a production schedule for the planned processing rate of 50,000 tonnes per day (tpd). Vista intends to re-open and expand the existing WRD to provide waste rock storage for the proposed operation. The WRD footprint will expand from 70 hectares (ha) to 217 ha, providing a total waste rock storage capacity of up to 485 million tonnes (Mt). The WRD's height will increase from is current height of 24 meters (m) to approximately 160 m. The waste rock will be stacked at angle of repose (34 degrees or approximately 1.5H:1V [Horizontal:Vertical]) in 30-m vertical lifts within the WRD. The WRD will contain both potentially acid-generating (PAG) and non acid-generating (NAG) waste rock; PAG waste rock will be segregated within the interior of the WRD to minimize acidic or metals-laden seepage by minimizing oxygen and meteoric water infiltration exposure. Due to the steep waste rock slopes proposed at closure, traditional closure methods (capping with soil cover) will not be practical due to slope constraints (access and stability). Vista's consultants have developed an innovative closure approach incorporating the use of geosynthetic liners on top of each 30-m waste rock lift to minimize infiltration to the interior PAG waste rock.

This report provides an assessment of the analyses completed to date for the proposed WRD closure design and provides a discussion of issues that will need to be addressed prior to, and during, implementation of this proposed closure approach. Recommendations for future work by Tierra Group and Vista's consultants are summarized as well.

1.1 Documents Reviewed

The following documents were reviewed and data contained within these documents form the basis of the observations and recommendations presented herein:

- Vista Gold Australia Pty Ltd, 2019. *Mt Todd Project Area Mining Management Plan 2021 - 2025*. Report prepared by Vista Gold, 31 October 2019;
- Tetra Tech, 2018. *NI 43-101 Technical Report Mt Todd Gold Project Pr*eliminary *Feasibility Study*. Prepared for Vista Gold Corp., March 2018;

- Tetra Tech, 2019a. *NI 43-101 Technical Report, Mt Todd Gold Project, 50,000 tpd Preliminary Feasibility Study* Northern Territory, Australia. Report prepared by Tetra Tech for Vista Gold, October 2019; and
- Tetra Tech, 2019b. Draft Memo – Summary of Previous Modeling of Waste Rock Dump Cover Systems Mt Todd Project, NT Australia. Draft Memo to Brent Murdoch & John Rozelle, Vista Gold, 12 August 2019.

2.0 CURRENT CONDITIONS

2.1 WRD Construction and Operations

The existing WRD is located southeast of the Batman Pit and immediately north (upgradient) of the Waste Rock Dump Pond referred to as Retention Pond No. 1 (RP1). A diversion channel constructed along the western WRD toe diverts water around the WRD and into RP1 (Figure 2.1, Tetra Tech, 2018).

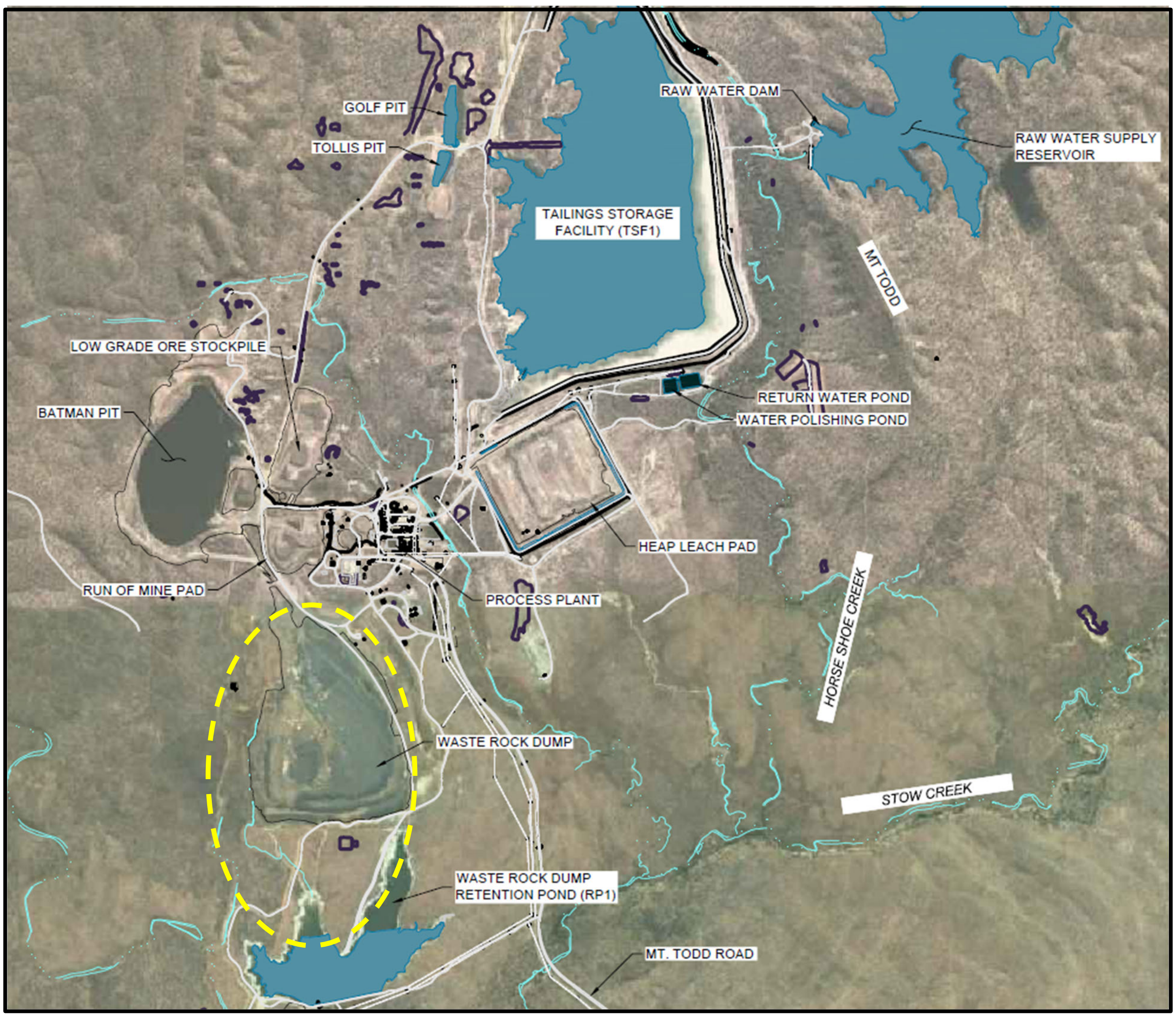

FIGURE 2.1: MT. TODD SITE – CURRENT CONDITIONS (TETRA TECH, 2018)

The existing WRD has a footprint area of 70 ha, a maximum constructed height of 24 m, and contains approximately 16 Mt of sulfidic waste rock. No significant reclamation activities were conducted at the WRD to limit infiltration into the reactive waste rock following cessation of mining. Seepage from the WRD reports to RP1, which is located immediately downstream (to the south) of the WRD. WRD seepage has a low pH and high metals content, requiring the water to be retained on-site or treated prior to discharge according to discharge permits regulating discharges from the site.

3.0 WASTE ROCK DUMP CLOSURE ASSESSMENT

3.1 Proposed WRD Expansion

The existing WRD will be expanded by stacking both NAG and PAG waste rock over the existing waste rock footprint as well as expanding the footprint to the south. Two cofferdams will be built at the upgradient (north) end of RP1 to prevent water from RP1 inundating waste rock stored in the WRD. The WRD will increase in height from approximately 24 m to 160 m at full buildout. The expanded WRD will have a storage capacity of 485 Mt, but the current mine plan only envisions requiring 440 Mt of storage.

Figures 3.1 through 3.4 show various time steps of the planned WRD expansion in plan view. The figures show the proposed segregation of PAG (orange) and non-PAG (yellow-green) waste rock during dump expansion.

During the proposed WRD expansion, waste rock will be stacked in 30 m lifts and left at angle of repose (1.5H:1V or 34 degrees) on the exterior slopes. An 8-m wide bench will be left on the dump’s exterior between each 30-m lift. A low permeability liner (either geosynthetic clay liner [GCL] or linear low-density polyethylene [LLDPE]) will be placed on the top of each completed lift to minimize meteoric infiltration and oxygen ingress to the PAG materials within the WRD. The liners will be extended approximately 52 m into the dump to intercept seepage within the WRD and route it to the external 8-m wide benches on the WRD exterior. The liners serve an integral function in WRD closure (Section 3.2).

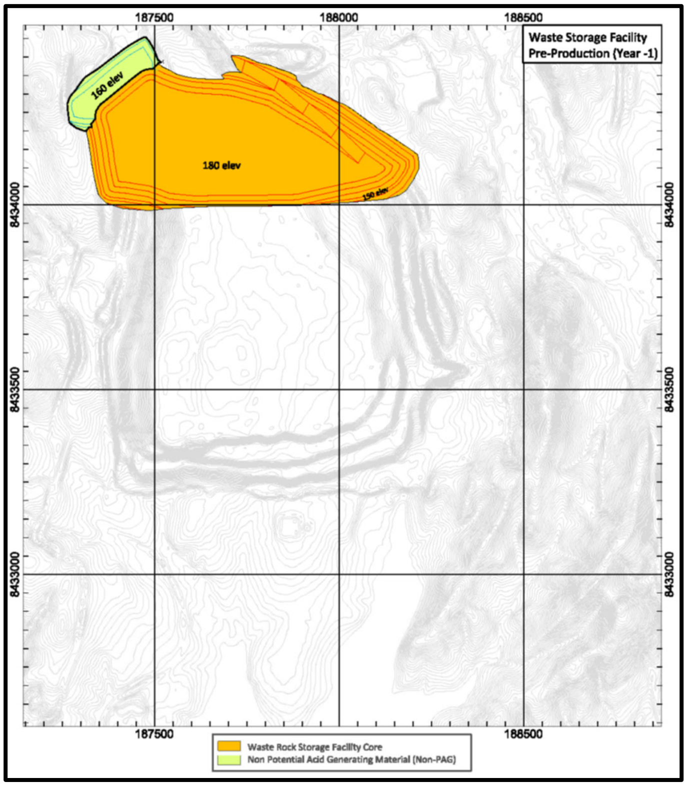

FIGURE 3.1: WRD EXPANSION IN PRE-PRODUCTION (YEAR-1) (VISTA GOLD, 2019)

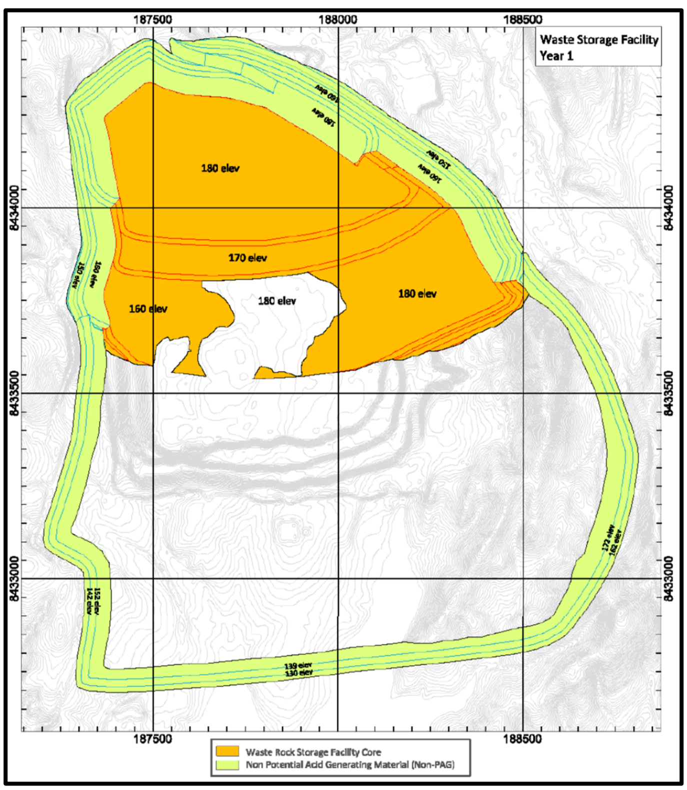

FIGURE 3.2: WRD EXPANSION IN YEAR 1 (VISTA GOLD, 2019)

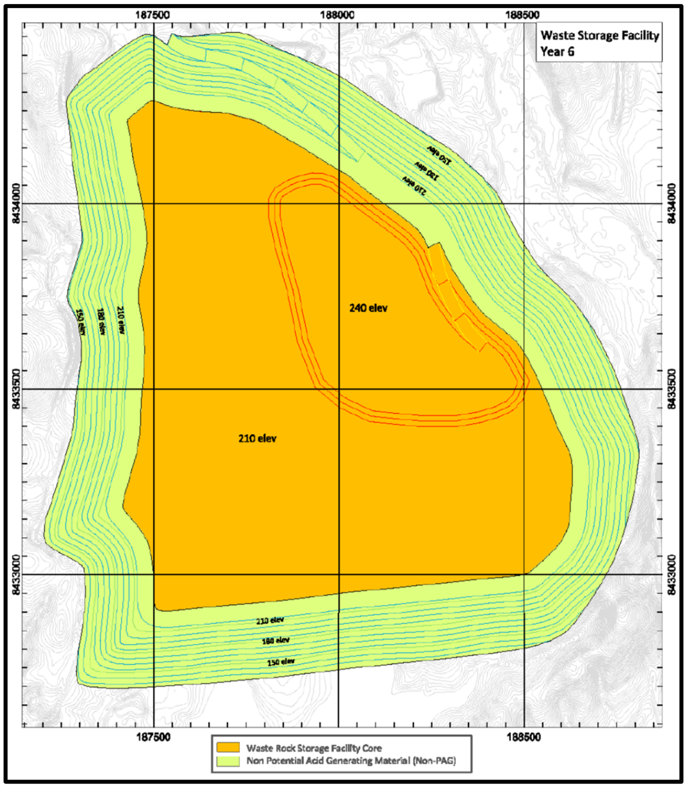

FIGURE 3.3: WRD EXPANSION IN YEAR 6 (VISTA GOLD, 2019)

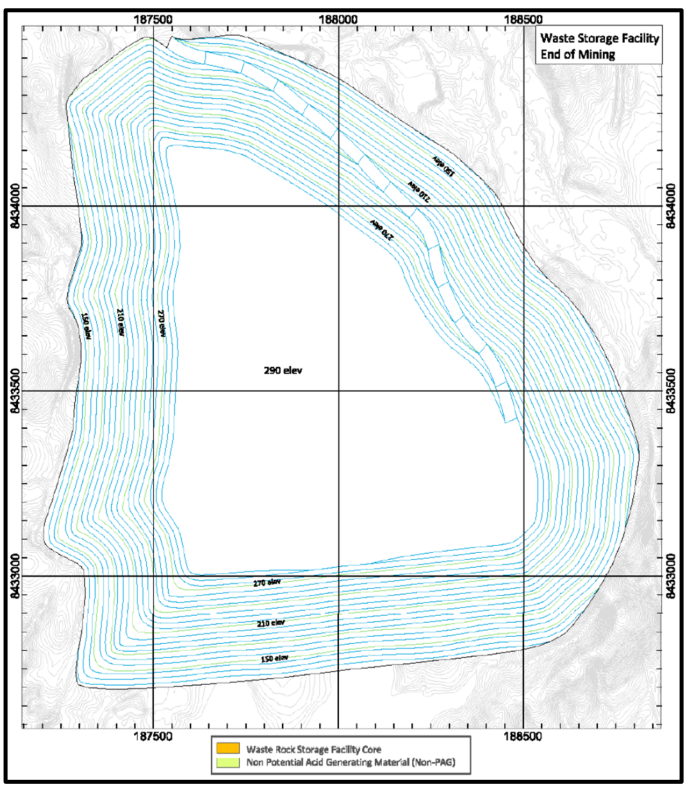

FIGURE 3.4: WRD AT COMPLETE BUILDOUT (VISTA GOLD, 2019)

3.2 Proposed WRD Closure Approach

The reclamation goals identified by Tetra Tech during the Mt Todd Reclamation Plan (Tetra Tech, 2019b) include the following:

- Control acid-generating conditions;
- Minimize erosion of facilities containing mine waste;
- Reduce or eliminate the acid and metal loads of seepage and runoff water;
- Minimize adverse impacts to the surface and groundwater systems surrounding Mt Todd;
- Stabilize physical and chemical characteristics of mine waste and other mine-related surface disturbances;
- Protect public safety; and
- Comply with NT Government regulations governing mine development and closure.

Approximately 40% of the waste rock contained in the WRD will be PAG. The approach to WRD Closure must include a means of isolating PAG from oxygen ingress and meteoric water infiltration to limit long-term generation of acidic or metal-laden seepage. Standard reclamation practices to limit oxygen and meteoric infiltration include construction of soil covers (ET or “store and release” covers) or incorporating a geosynthetic liner into the closure cover. However, due to the WRD’s steep slopes, construction of soil covers on the WRD at closure is not feasible.

The WRD will be constructed with an encapsulating NAG waste rock outer shell on each waste rock lift. A low permeability liner (GCL or LLDPE) will be installed on top of each 30-m lift (Figure 3.5) as it is completed to limit infiltration into the PAG at the WRD’s core. The liner system will include a 0.3 m thick bedding layer of fine soil to act as a liner cushion and an additional 0.3 m of fine soil will be placed over the liner to prevent damage during waste rock placement. The liner will extend 52 m on top of the completed lift into the dump interior. The waste rock/liner bedding will be graded at 5% to drain to the WRD outer face. At ultimate buildout, a liner will be placed over the regraded WRD top surface to shed water to the WRD perimeter and prevent infiltration into the PAG core.

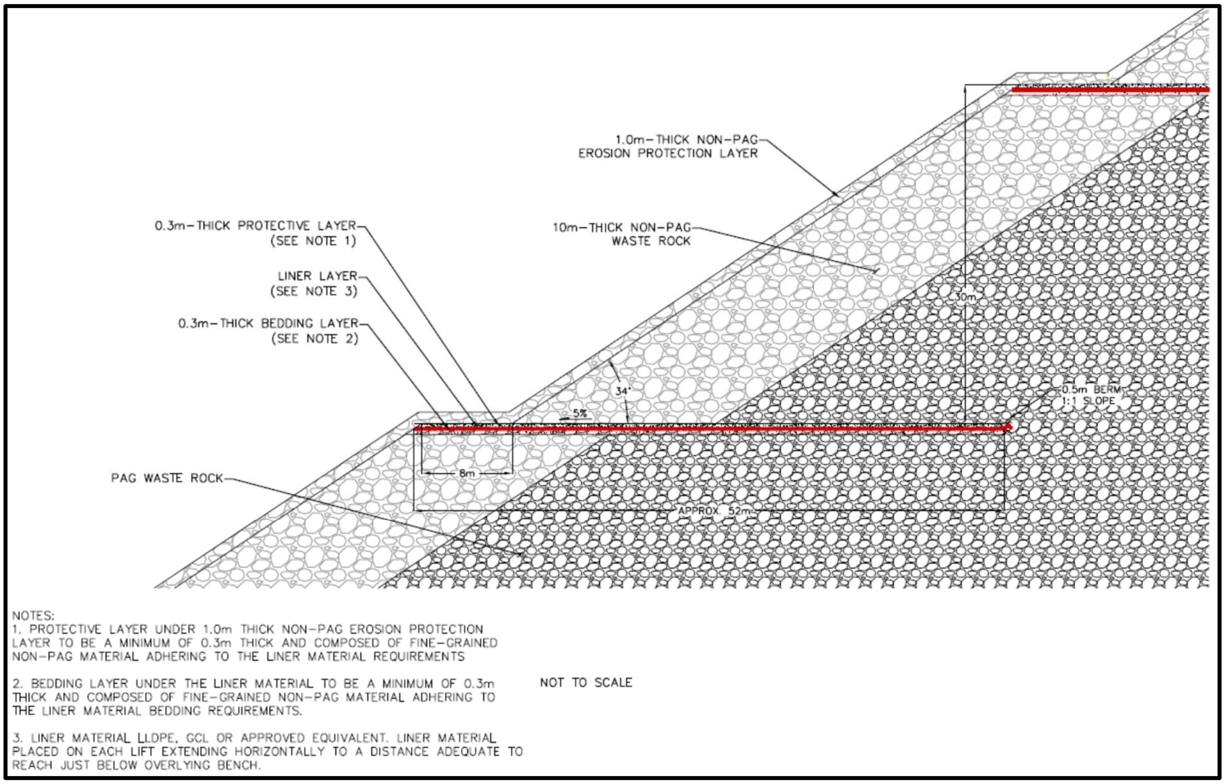

FIGURE 3.5: WRD INTERLIFT LINER CONFIGURATION (TETRA TECH, 2019B)

3.3 Analyses in Support of Closure Design

Vista's consultant (Tetra Tech) completed multiple engineering analyses in support of the WRD closure design, primarily focused on infiltration and water quality modeling. The infiltration modeling was completed to estimate seepage flow rates and volumes to support site-wide water balance calculations. Water quality modeling was used to predict resultant water quality due to seepage passing through, and reacting with, the NAG and PAG waste rock in the WRD. Analysis results were used to assess closure cover alternatives and ultimately identify a preferred WRD closure approach that met reclamation goals established for the Project.

3.3.1 Infiltration Modeling

Tetra Tech assessed multiple WRD configurations and closure covers using Geo-Slope's VADOSE/W model to complete both 1-D and 2-D modeling (work was performed between 2010 and 2012). Model input included 1 year of climate data from the Katherine Aviation Museum weather station (October 2010 through September 2011). Models were run for multiple years by looping through the 1 year of data. The climate data represented a wetter than normal year (annual total of 1652 millimeters (mm) versus long-term annual average of 1131 mm). Soil hydraulic properties used in the models were based on published literature values and not site-specific tested values. The use of published literature values (versus site-specific values) is appropriate for the preliminary feasibility-level analyses; soil hydraulic properties should be tested as the Project progresses to ensure modeling and analysis accuracy. VADOSE/W model output included calculation of the overall water balance for the WRD, including annual precipitation, infiltration, runoff, evaporation, and seepage exiting from the WRD base.

Table 3.1 presents a summary of the results obtained evaluating alternative WRD slope geometries and covers. Figure 3.6 provides a graphical summary of model output, focusing on the predicted seepage rate from the WRD base. Table 3.1 shows that modeling predicts the full cover option would result in the lowest seepage volume from the facility (measured as a percentage of annual precipitation); however, the full cover option has constructability limitations. GCL requires a soil cover providing confining pressure to resist bentonite swelling for optimal permeability performance. A GCL cannot be installed on a 35-degree slope and covered with a fine-grained fill, without significant erosion and soil loss occurring from the slopes. The 20-degree full cover option is limited due to the required footprint for the WRD cover. The 35-degree petticoat option provides the best performance without constructability limitations identified for the full cover options.

TABLE 3.1: FLUX RATES FROM 2011 ALTERNATIVES ANALYSIS (TETRA TECH, 2018)

Case	Cumulative Boundary Fluxes [4]	Cumulative Runoff [4]	Cumulative Water Balance [4]	Cumulative Surface Evaporation [4]
35 degree - Petticoat option [1]	13%	35%	4%	54%
35 degree - Beanie option [2]	32%	36%	0%	58%
35 degree - Full cover option [3]	11%	39%	2%	71%
20 degree - Petticoat option	14%	39%	17%	51%
20 degree - Full cover option	6%	39%	2%	64%

Notes: [1] "Petticoat" cover includes GCL liner and fines layer on top of each 30 m bench, extended 25 m into waste rock. 35 degrees references outer interlift waste rock slope angle.
[2] "Beanie" cover includes GCL liner and fines layer only on top of final waste rock lift. 35 degrees references outer interlift waste rock slope angle.
[3] "Full" cover includes GCL liner and fines on all exterior waste rock slopes. 35 degrees references outer interlift waste rock slope angle. Physical limitations exist for this option (unable to place fines over GCL and get them to stay on slope).
[4] All values presented as percentage of annual precipitation.

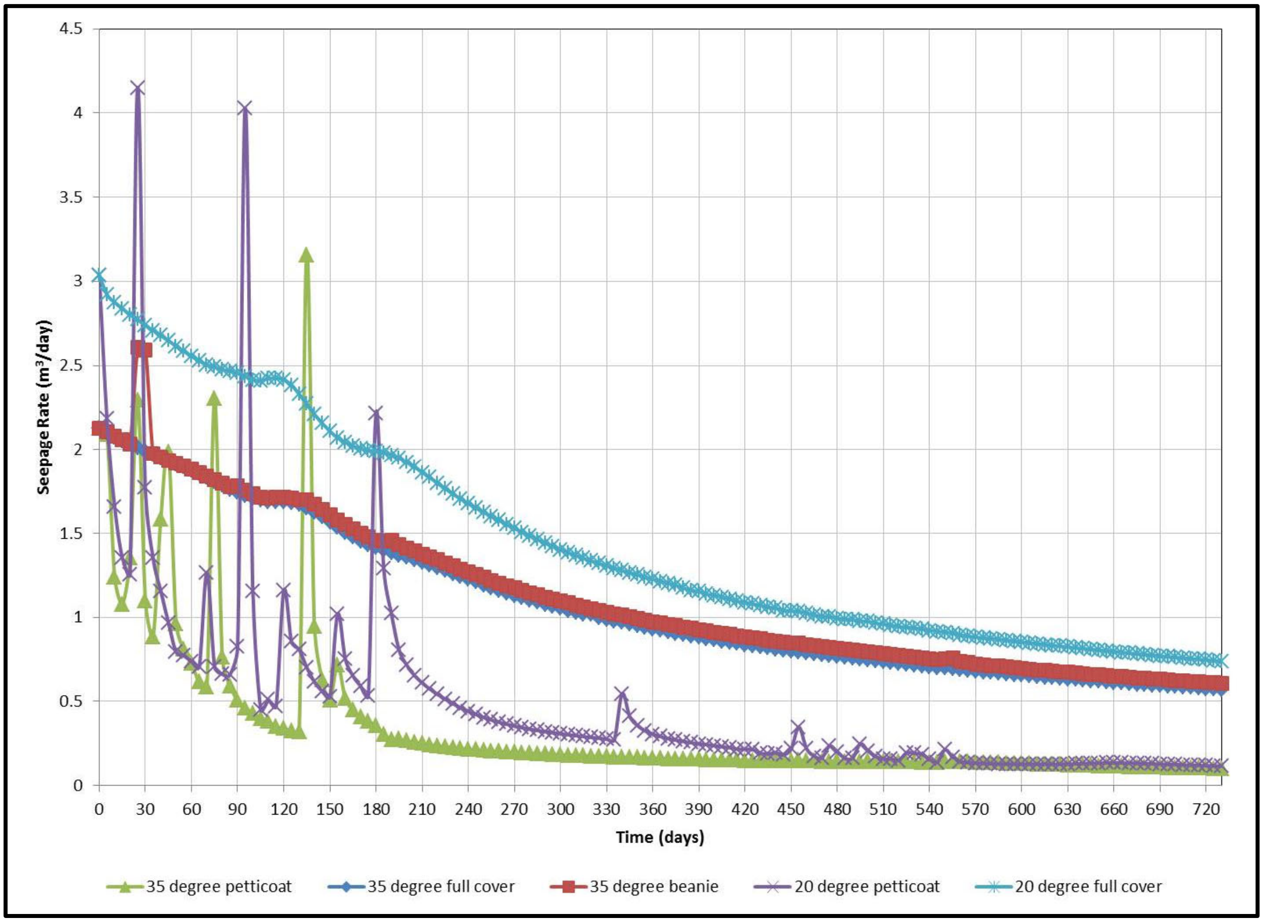

FIGURE 3.6: FLUX RATES FROM 2011 ALTERNATIVES ANALYSIS (TETRA TECH, 2018)

Tetra Tech revisited the petticoat design in 2012, extending the GCL further back along each bench from the outer edge into the waste rock a total of 52 m. The GCL length extends to a point vertically beneath the crest of the subsequent waste rock lift placed over the GCL. This configuration provides a more continuous measure to limit seepage along the outer waste rock shell and prevents contact with the PAG stored in the WRD interior. As can be seen in Table 3.2 and Figure 3.7, extending the length of the GCL significantly reduces the predicted amount of seepage from approximately 13% of annual precipitation down to approximately 7% of annual precipitation in the simulation. The 2012 modeling was completed using the same climate record (1 year of data from Katherine Aviation Museum meteorological station) as the previous modeling, but the model was run for a total of 10 years (as opposed to 3 years in previous modeling).

TABLE 3.2: FLUX RATES FROM 2012 ANALYSIS (TETRA TECH, 2018)

	Cumulative Infiltration [2]	Cumulative Runoff [2]	Cumulative Storage [2]	Cumulative Surface Evaporation [2]
No Closure Cover	21%	13%	9%	67%
35 degree - Petticoat cover [1]	7%	33%	-40%	61%

Notes: [1] Petticoat cover includes GCL liner on top of each 30-m bench, extended 52 m into waste rock. 35 degrees references outer interlift waste rock slope angle
[2] All values presented as percentage of annual precipitation

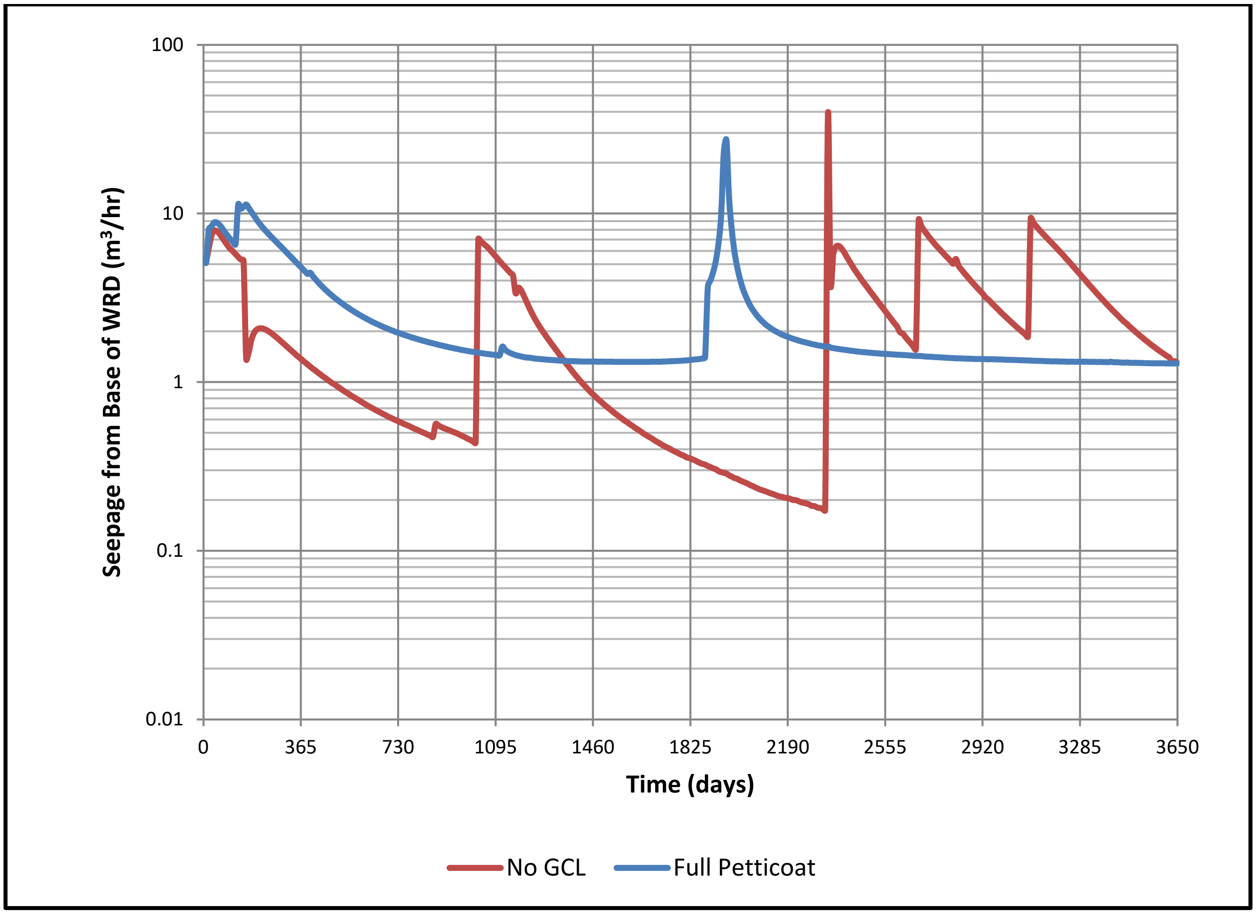

FIGURE 3.7: FLUX RATES FROM 2012 SEEPAGE ANALYSIS (TETRA TECH, 2018)

The VADOSE/W model files were not reviewed as part of this closure assessment. Summary input data, including soil hydraulic property graphs (soil water characteristic curves and unsaturated hydraulic conductivity functions) were provided and appeared to be reasonable for proposed closure design preliminary modeling.

3.3.2 Water Quality Modeling

Tetra Tech evaluated resultant seepage water quality using the computer code PHREEQC. The model was used to evaluate the resultant seepage water quality of three potential pathways through the WRD, each containing differing relative amounts of contact with PAG and NAG waste rock. The three paths described by Tetra Tech are presented in Figure 3.8.

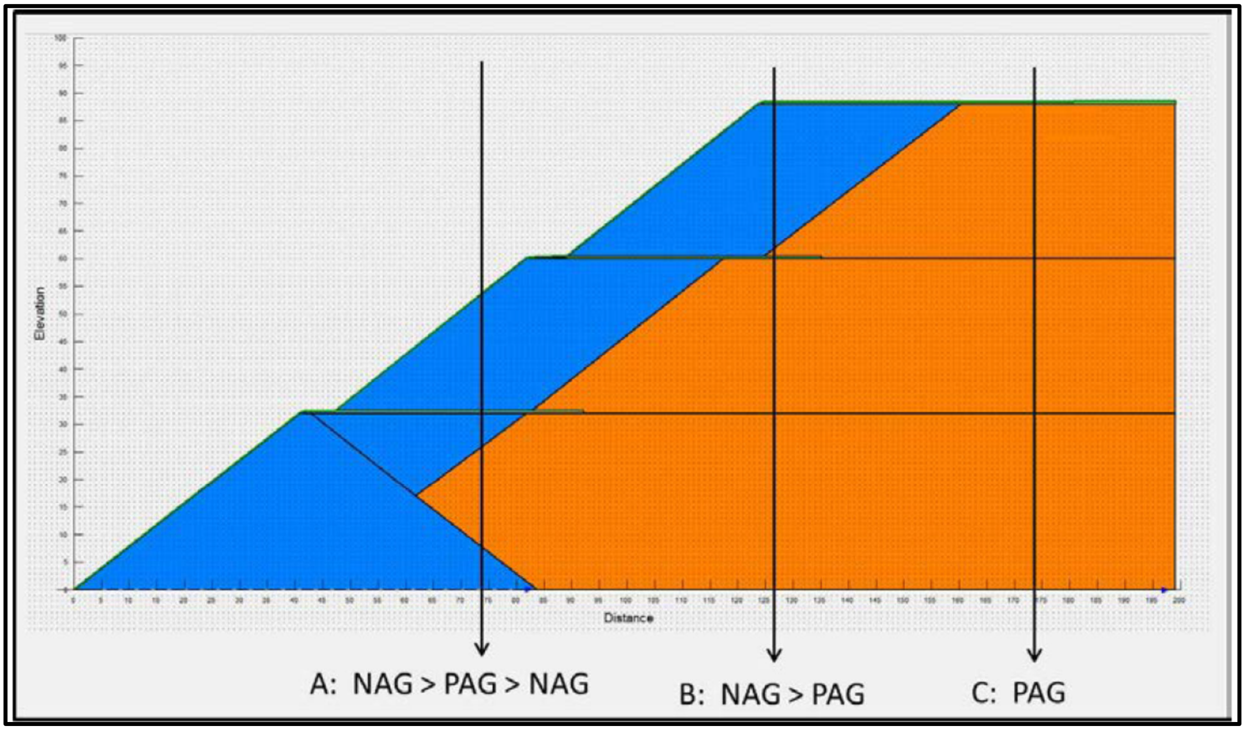

FIGURE 3.8: EXPECTED WRD FLOW PATHS AND MATERIAL CONTACTS (TETRA TECH, 2019a)

Table 3.3 is a summary of predicted water quality from the PHREEQC model. A detailed review of the PHREEQC modeling was not competed by Tierra Group. The results of the modeling appear to be reasonable and follow the anticipated outcome that seepage flowing through PAG resulted in lower pH, higher sulfate concentrations, and higher constituent (metals) loads.

TABLE 3.3: SUMMARY OF PHREEQC MODEL RESULTS (TETRA TECH, 2019a)

Description	Scenario C PAG/Uncertain Only (100%)	Scenario B Non-PAG>PAG/ Uncertain (33.3%, 66.6%)	Scenario A Non-PAG>PAG>Non-PAG (50%, 37%, 13%)
pH	3.79	3.83	3.95
Sulphate	1220	816	448
Al	38.83	22.33	6.73
As	0.0119	0.0097	0.0078
Ca	77.4	52.9	31.0
Cd	0.107	0.071	0.039
Cl	9.21	7.64	6.24
Co	1.52	1.02	0.56
Cr	0.00079	0.00061	0.00045
Cu	8.38	5.59	3.10
Fe	0.000060	0.000040	0.000022
K	5.26	3.68	0.60
Mg	191	127	71
Mn	0.0067	0.0045	0.0022
Mo	0.00025	0.00018	0.00012
Na	22.9	15.8	9.4
Ni	12.9	8.64	4.79
Pb	0.053	0.036	0.020
Zn	25.13	16.76	9.30

3.4 Possible Failure Modes

Tierra Group reviewed the proposed approach to WRD closure focusing on potential failure modes. Recommendations for further investigation, testing, and studies were then compiled to mitigate the identified potential failure modes. Failure modes considered relevant to the Mt. Todd WRD closure and recommended actions are discussed in the following sections.

3.4.1 Slope Failure

The proposed petticoat liner system proposed for the WRD introduces a liner (either GCL or LLDPE) into the WRD cross-section every 30 m (vertically). The liners will be installed on waste rock graded at 5% toward the outer WRD slope face. Generally, waste rock has a relatively high internal shear strength, as evidenced by the steep slopes (1.5H:1V of 35 degrees) proposed for the WRD. The introduction of a liner at the base of each 30m lift introduces a “slip plane” that can lead to slope instability. One of the key drivers to stability will be the interface friction angle achieved between the GCL (or LLDPE) and the fine-grained bedding material proposed to protect the liner. In the case of GCL, internal shear of the GCL itself must also be evaluated.

Tetra Tech recognized the need to assess the geotechnical stability of the proposed cover system in their Reclamation Plan recommendations (Tetra Tech, 2019a). Shear strengths, particularly interface shear strength of the liner and fine-grained bedding/protective material should be determined in the laboratory and used as input to a slope stability model to assess both static and pseudo-static (earthquake) stability. Post-earthquake and deformation modeling would also be appropriate in more detailed design stages to assess potential movement/settlement in the lined portion of the WRD cover. Slope instability and/or deformation could lead to liner tears and even large scale WRD slope failure.

3.4.2 Differential Settlement (Liner Grade Reversal)

The effectiveness of the petticoat liner system approach to the WRD closure is dependent upon the liner installed on top of each 30m lift to drain intercepted seepage to the WRD bench minimizing contact with PAG waste rock. The liners will be installed at a minimum 5% slope to promote flow to the WRD exterior slope. Truck-placed, end-dumped waste rock will settle over time as additional lifts of waste rock are placed over the initial lifts. A 5% slope over 52 m, provides 2.6 m of vertical relief from the liner initiation point to its end point. The magnitude of waste rock settlement will be driven by the thickness of additional waste rock placed over the liner; areas out near the face will have less coverage (and experience less settlement) than areas under the crest of the next lift. If excessive settlement were to occur, the slope of the liner could be reduced and potentially reversed, allowing collected seepage to flow into the PAG as opposed to avoiding contact. This is stated as an extreme case but is nonetheless possible.

Potential waste rock settlement should be evaluated to determine the magnitude of settlement that may be experienced beneath a 30-m waste rock lift to determine if grade reversal is a possibility. If excessive settlement is expected following settlement analysis, lift heights may be reduced in the outer “rind” of the WRD to obtain better waste rock compaction by loaded haul trucks thus minimizing settlement. Adjusting liner grade may also be necessary to compensate for potential grade reversal.

3.4.3 Liner Breach

The petticoat liner system relies on intercepting and conveying meteoric water away from PAG waste rock. The effectiveness of the system will be significantly reduced if any of the liner is breached or the permeability increased. GCL has “self-healing” ability due to bentonite swell. Tetra Tech identified the potential for GCL permeability increase due to cation exchange between the seepage water (high in calcium and magnesium) and bentonite in the GCL. The “self-healing” properties may reduce due to the cation exchange issue identified by Tetra Tech. Testing should be completed with site seepage water to determine the potential impact to GCL performance. If LLDPE liner is used in lieu of GCL, consideration must be given to liner puncture that will increase flow through the liner. Liner leakage due to defects (holes or poor quality seams) will likely be of relatively low magnitude due to the limited hydraulic head anticipated on the liners. Other considerations in future liner breach studies should consider liner longevity and potential seismic and/or differential settlement impacts.

4.0 SUMMARY AND RECOMMENDATIONS

4.1 Summary

The Mt Todd WRD will contain approximately 40% PAG and is proposed to be constructed, and reclaimed, with steep (1.5H:1V or 35-degree) inter-bench slopes. These steep slopes present technical challenges for installing traditional soil covers for facility closure. Vista's closure consultant, Tetra Tech, has developed an innovative approach to closing the facility that incorporates interlift liners around the WRD periphery to intercept vertical seepage and direct it to the outer edges where non-reactive waste rock will be strategically placed. Preliminary modeling and evaluation indicates that the petticoat liner system can significantly reduce seepage passing through the WRD requiring capture and treatment prior to discharge.

Infiltration and seepage modeling have been conducted at a preliminary level using literature and experience-based hydraulic properties. Additional sampling and testing of proposed construction materials (primarily NAG and PAG waste rock and liner bedding/protective material) should be completed to determine hydraulic properties such as each material's soil water characteristic curve and saturated hydraulic conductivity for use in the model. Following improved definition of material properties, modeling should be conducted using a longer, varied climate record to stress the WRD cover system and see how the cover responds in terms of limiting WRD seepage.

The proposed WRD design will require a significant amount of effort during operations to ensure liner installation is completed in advance of waste rock placement activities. Waste rock around the WRD perimeter will have to be graded to maintain the 5% slope to the exterior and fine-grained bedding material and liner will need to be deployed in advance of advancing waste rock lifts. Scheduling liner installation will be extremely important in light of the wet season experienced at the site that may impact the ability to deploy liner on a continuous basis. Waste rock placement will also need to be carefully monitored to ensure proper lift heights are maintained to avoid significant waste rock settlement.

4.2 Recommendations

The following studies and investigations are recommended for future phases of the project. Some recommendations are taken from Tetra Tech design reports and are noted as such. Tierra Group has recommendations in addition to those previously proposed. Results of these investigations and analyses may identify additional work items as detailed design progresses.

The current list of recommended work items includes the following:

- Determine liner bedding material hydraulic properties (Tetra Tech);
- Complete liner bedding shear strength and liner to liner bedding interface shear strength testing including residual interface strength and internal strength of GCL for use in slope stability analyses (Tierra Group);

- Slope stability analyses focused on interlift liner stability under static, pseudo-static, and post-earthquake conditions using appropriate parameters based on stress-deformation modeling (Tetra Tech);
- Evaluate waste rock consolidation under 30-m waste rock load to determine if 5% slope is adequate for positive drainage to WRD outer bench and settlement impacts to liner system integrity (Tierra Group);
- Update seepage modeling to reflect longer-term climatic condition variation – compare anticipated seepage using GCL (impacted due to cation exchange) versus LLDPE (pinholes due to loading) [Tierra Group];
- A detailed quality control and monitoring plan for construction and operations should be developed for the WRD. The installation of the interlift liners during WRD development will require deliberate scheduling and planned execution to avoid interactions between mine operations and the liner installation crews. Wet season construction will also need to be evaluated to determine how much liner will need to be installed ahead of time to prevent “running out of dump space” when additional liner cannot be deployed (Tierra Group);
- Evaluate or comment on the liner longevity and impacts to long-term performance of the system; and
- Confirm the viability of engineered wetland to passively treat impacted seepage from WRD (Tetra Tech).

5.0 REFERENCES

Tetra Tech, 2018. *NI 43-101 Technical Report Mt Todd Gold Project Preliminary Feasibility Study*. Prepared for Vista Gold Corp., March 2018.

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