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Mt Todd Gold Project
50,000 tpd Feasibility Study Northern Territory, Australia

REFERENCE | ATTACHMENT R20

Reclamation Plan

PROJECT NO. 117-8348002

DATE: MARCH 2022

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LIST OF UNITS

g	acceleration of gravity
g/cm^3	grams per cubic centimeter
GPa	gigapascals
Ha-m	hectare-meters
Hz	Hertz
in	inches
km	kilometers
kN/m3	kilonewton per cubic meter
kPa	kilopascals
kWh	kilowatt hour
kWh/day	kilowatt hour per day
m/s	meters per second
m	meter
m^3	cubic meters
m^3/hr	cubic meters per hour
m^3/day	cubic meters per day
$m^3/day/m$	cubic meters per day per unit meter
mil	1/1000 inch
mm	millimeter
MPa	megapascals
Mtpy	Million tonnes per year
PN	Pressure Number
t/m^3	tonnes per cubic meter
tpd	tons per day

ACRONYMS, ABBREVIATIONS & SYMBOLS

ANFO	Ammonium nitrate fuel oil
ARD	Acid Rock Drainage
ARD/ML	Acid Rock Drainage and Metal-Laden Leachate
GCL	Geosynthetic Clay Liner
H	Horizontal
HDPE	High Density Polyethylene
HLP	Heap Leach Pad
hr	hour
$K_{(sat)}$	Saturated Hydraulic Conductivity
km	kilometer
LGO1	Existing low grade ore stockpile
LGO2	New low grade ore stockpile
LPM	low-permeability materials
m	meter
m^2	square meter
m^3	cubic meter
MDA	Mine Development Associates
Mt	Million tonnes
Mtpy	Million tonnes per year
MWH	Montgomery Watson Harza
NAF	Non-Acid Forming
NNP	Net Neutralizing Potential
NT	Northern Territory of Australia
O&M	Operations and Maintenance
PAF	Potentially Acid Forming
PEA	Preliminary Economic Assessment
Pegasus	Pegasus Gold Australia Pty Ltd
PFCP	Preliminary Feasibility Closure Plan
RP	Reclamation Plan
PGM	Plant Growth Medium
PFS	Preliminary Feasibility Study NI 43-101 Technical Report
RP	Retention Pond
RP1	Waste Rock Dump Pond
RP2	LGO Stockpile Pond
RP3	Batman Pit Lake
RP4	Run-of-Mine Pond
RP5	Process Plant Runoff Pond

RP6	Process Plant Pond
RP7	TSF1 Pond
RUSLE	Revised Universal Soil Loss Equation
SWCC	Soil Water Characteristic Curve
TDR	Time-Domain Reflectometers
TPD	tonnes per day
TSF1	Existing Tailings Storage Facility
TSF2	New Tailings Storage Facility
Vista	Vista Gold Corp.
WEPP	Water Erosion Prediction Project
WRD	Waste Rock Dump
WRMP	Waste Rock Management Plan
WTP	Water Treatment Plant

EXECUTIVE SUMMARY

Tetra Tech, Inc. (Tetra Tech) was retained by Vista Gold Corp. (Vista) to develop a Reclamation Plan (RP) for the Feasibility Study (FS) for the Mt Todd Project (Mt Todd) 50,000 (50K) tonne per day (TPD) mine. This RP assesses reclamation requirements and associated costs of resumed mining.

Mt Todd is located 56 kilometers (km) by road northwest of Katherine, and approximately 290 km southeast of Darwin in Northern Territory (NT), Australia. In March 2006, Vista gained the rights to explore and develop the mineral resources of Mt Todd. In January 2007, Vista assumed the obligation to operate, care for, and maintain assets held by the NT Government at Mt Todd. The rights and responsibilities assumed by Vista in 2006 and 2007 continue as of the authoring of this report.

This report focuses on the reclamation earthworks associated with closing existing and future mine features during and following mining operations. The reclamation plan included in this report incorporates elements from the reclamation cover designs presented in the June 2013 Mt Todd Gold Project Preliminary Feasibility Study Reclamation Plan prepared by Tetra Tech (referred to here as the '2013 PFS Reclamation Plan'). Vista is also conducting studies to address immediate environmental challenges for the Mt Todd site including management of acid rock drainage and metal-laden leachates (ARD/ML) currently contained in several water storage facilities. Current and future water treatment plans; residuals management; surface water management; and baseline studies and permitting are not covered in this report, as they are discussed in other sections of this FS. The costs of selective handling of waste rock and the haulage of waste rock to Tailings Storage Facility (TSF) 1 and 2 for reclamation purposes are not covered in this report, as they are included in the project mining costs.

The major facilities that are included in this RP are as follows:

- Batman Pit;
- Waste Rock Dump (WRD);
- Process Plant and Operations Area;
- Heap Leach Pad (HLP);
- Mine roads;
- Existing TSF (TSF1);
- Proposed TSF (TSF 2);
- Existing Low Grade Ore Stockpile (LGO1);
- Proposed LGO (LGO2); and
- Haul roads to new and expanded facilities.

Plans and strategies for the reclamation of these existing and proposed facilities are provided in this report.

Purpose and Scope

The primary goals of this RP are as follows:

1) Advance previous closure and reclamation plans by defining reclamation approaches, strategies, and estimated costs at an overall ± 30 percent level of accuracy.
2) Update reclamation cost estimates to reflect utilization of mine employees and mine-owned equipment in reclamation activities.
3) Provide an estimate of the Security Cost appropriate for this FS for the project using the Northern Territory's (NT) Security Cost estimate protocols.
4) Identify information and functional gaps pertaining to mine reclamation.
5) Summarize future investigations to address the information gaps identified.
6) Recommend actions to address the functional gaps identified.

Approach

This RP was developed based on input from Vista and their consultants; readily available data and information regarding Mt Todd; and Tetra Tech's technical experts who are familiar with Mt Todd mine and metallurgic planning. Additional technical support was provided by Tetra Tech geochemists, hydrogeologists, civil engineers, and vadose modeling experts.

Key issues and project drivers were identified during development of the June 2013 PFS Reclamation Plan, as well as a series of participatory meetings with Vista representatives, Mine Development Associates (MDA), and Tetra Tech staff. The concepts, strategies, and options developed and evaluated during these meetings and subsequent analyses were discussed with and endorsed by Vista and serve as the foundation for the previous PFS RPs and this RP.

The reclamation store and release covers for the TSFs and liner-based cover for the WRD presented in prior PFS RPs were confirmed for use in this RP. This RP is modified based on recent findings and analyses from ongoing investigations, and design and planning efforts.

This RP does not include in-depth analyses of surface water management and water treatment, as these and other components of mine closure are discussed elsewhere in the FS.

The reclamation plans developed and the estimated costs are based on the following:

1) 50K TPD Base Case mine plan and existing engineering and data presented in the FS;
2) Geochemical testing program and results;
3) Mine-life (i.e., pre-production phase, production phase, reclamation phase, and post-reclamation monitoring and maintenance phase);
4) Estimates of environmental conditions throughout the mine-life;
5) NT Government mine closure and environmental protection regulations and guidelines;
6) Published unit costing, and equipment specification and performance references;
7) Australian cost estimates provided by Tetra Tech and Vista employees in Australia;
8) Tetra Tech's recent mine closure costing experience; and
9) Best professional judgment.

Goals and Important Project Drivers

The reclamation goals for Mt Todd include:

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

The important project drivers by which the reclamation plan and strategies were developed are as follows:

1) Use standard reclamation practices with the knowledge that design details will be fine-tuned in the future;
2) Use previous investigations, studies, and available data and information;
3) Identify information gaps and future investigations necessary to improve the characterization of site conditions now and through reclamation;
4) Provide Vista with practical development and recommendations to facilitate:
5) Future closure and design efforts, and
6) Site-wide integration of closure designs.
7) Exploit "Mine for Closure" opportunities by reclaiming mine components simultaneously with mining (i.e., concurrent reclamation);
8) Identify strategies to reduce acid/metal loading to water management structures, and ground and surface water;
9) Handle materials and water efficiently; and
10) Emphasize low-maintenance or "walk away" reclamation where practical.

Major Reclamation Planning Results

The reclamation plans for each existing and proposed major facility at Mt Todd are summarized in Table ES-1. Additional remedial measures will be employed at each major facility as necessary.

Throughout the mine-life, Vista should anticipate, plan, design, and implement effective plans for:

1) Identification of potentially acid-forming (PAF) and non-acid forming (NAF) materials, as well as materials that have the potential to leach constituents in concentrations above applicable water quality-based effluent standards (metaliferous);
2) Selective handling of PAF and NAF material and potentially direct treatment of PAF materials throughout the mine-life to prevent or reduce the generation of ARD/ML;
3) Separation of unimpacted surface and ground water from PAF and metalliferous materials and ARD/ML;
4) Short- and long-term hydrologic isolation of PAF and metalliferous materials from ground and surface water;
5) Facility and site-wide closure; and
6) Control of stormwater to prevent excessive erosion and sedimentation.

Tetra Tech recommends the following specific closure investigations necessary to address the information gaps:

1) Complete an analysis of waste and cover material hydraulic properties;
2) Complete a tailings trafficability study;
3) Complete a precipitation-watershed yield study;
4) Complete a tailings management plan;
5) Complete a site-wide soils, closure cover, and reclamation material inventory and characterization study, including work to identify if a source of low permeability material can be located closer to the site than the currently identified borrow source; and
6) Complete a waste and closure cover erosion and sediment control study.

Based on the costing approach discussed in this report, Tetra Tech estimated reclamation costs. The FS cost estimate for implementing this reclamation plan is approximately **AUD 224,000,000**. This cost estimate includes reclamation of major facilities at Mt Todd, utilizes costs for performing reclamation activities with mine employees and mine-owned equipment, and includes costs for ongoing maintenance and monitoring costs throughout the mine life.

Table ES-1: Reclamation Approach

Task	FACILITY							
	Batman Pit	WRD	HLP	TSF1 & TSF2 Impounded Surface	TSF1 & TSF2 Dams (Embankments)	Process Plant and Pad	LGO 2	Mine Roads
Surface of Facility at Cessation of Production Composed of NAF		X			X			
Final Overall Slopes > 3H:1V*	X	X			X			
Final Overall Slopes ≤ 3H:1V*			X	X		X	X	X
Benches Created During Construction	X	X			X			
Install minimum 1.0 meter-Thick NAF Material		X		X				
Install 0.8 meter-Thick Store and Release Cover				X	X			
Install 0.2 meter-Thick Plant Growth Medium (PGM) Cover			X	X	X	X	X	X
Revegetate with Native Seed Mix			X	X	X	X	X	X
Install geosynthetic liner system as cover		X						
Install Erosion and Sediment Controls		X	X	X	X	X	X	X
Construct Access Restriction Bund	X							

** > and < indicates slopes are steeper and less steep, respectively.*
"X" indicates the reclamation approach task or characteristic listed under "Task" column applies to the facility listed in the subsequent columns

1. INTRODUCTION

Tetra Tech was retained by Vista to develop a RP for Mt Todd 50,000 (50K) TPD mine plan. This RP evaluates the reclamation liabilities that will transfer to Vista should a decision be made to restart mining operations at Mt Todd, and is primarily supported by information and data provided by the Geochemistry Program, prepared by Tetra Tech. The primary goals of this RP are as follows:

1) Advance previous closure and reclamation plans by defining reclamation approaches, strategies, and cost estimates at an overall ± 15 percent level of accuracy based on present value costs.
2) Update reclamation estimates to reflect utilization of mine employees and mine-owned equipment in reclamation activity.
3) Develop an estimate of security suitable for this FS using the Northern Territory's (NT) Security Cost estimate template.
4) Identify information and functional gaps pertaining to mine reclamation.
5) Summarize future investigations to address the information gaps identified.
6) Recommend actions to address the functional gaps identified.

To achieve these goals, Tetra Tech developed plans and estimated quantities (e.g., facility dimensions, material volumes, surface areas, and disturbance footprints) for the reclamation of major mine facilities at Mt Todd. These plans and estimates were based on the following:

1) 50K TPD FS mine plan;
2) Previously developed reclamation plans and strategies, including the 2013, 2018, and 2019 PFS Reclamation Plans, previously prepared by Tetra Tech;
3) Mine-life (including pre-production phase, production phase, reclamation phase, and post-reclamation monitoring and maintenance phase);
4) Estimates of environmental conditions throughout the mine-life;
5) NT Government mine closure and environmental protection regulations and guidelines; and
6) Best professional judgment.

Vista is conducting ongoing studies and activities to address environmental challenges for Mt Todd including management of ARD/ML currently contained in several water storage facilities. Current and future water treatment plans; residual management; surface water management; and baseline studies and permitting are not covered in this report. The costs of selective handling and the haulage of NAF waste rock to TSF 1 and 2 are not covered in this report as they are covered under the mining costs. This report focuses on the reclamation earthworks associated with closing existing and future mine features during and following the completion of mining operations. An emphasis in this reclamation plan has been placed on reclaiming features which contain PAF materials. PAF materials are currently located in TSF 1, WRD, Batman Pit, HLP, and other locations at Mt Todd, and will be present in TSF2 after its construction and operation. Both PAF and NAF waste rock and tailings will be produced during the production phase of the project (see Geochemistry Program for additional discussions regarding existing and future waste rock and tailings quality). It is Tetra Tech's opinion that the current and anticipated waste management, closure, and water management challenges at Mt Todd are significant but manageable. To manage these challenges, a concerted and well-coordinated effort will be necessary. This reclamation plan does not address water management issues, but rather focuses on the reclamation of facilities involving movement of earth and materials (e.g., TSF 1, TSF 2, WRD, HLP, roads, processing pad areas, and LGO2 stockpile), and high level estimate of costs associated with facilities removal and disposal.

The reclamation plan for existing and proposed major facilities at Mt Todd is summarized in Table 1 and includes:

1) General grading and capping designs, and estimates of cut/fill and cover volumes for the reclamation of mine wastes, roads, the processing area, ponds no longer used at closure, and other mine-related surface disturbance; and
2) Analysis and preliminary numeric modeling of long-term store and release cover hydrologic performance.

Throughout the mine-life, Vista should anticipate, design, plan, and implement effective plans for:

1) Identification of PAF and NAF materials, as well as materials that have the potential to leach metals in concentrations above applicable water quality-based standards;
2) Selective handling of PAF and NAF material and potentially direct treatment of PAF materials to prevent the generation of ARD/ML;
3) Continuous collection, containment, and treatment of ARD/ML prior to release;
4) Separation of unimpacted surface and ground water from ARD/ML;
5) Hydrologic isolation of acidic materials from ground and surface water; and
6) Control of stormwater to prevent excessive erosion and sedimentation.

Specific closure plans and strategies have not been developed in this document for the decommissioning, demolition, and removal of surface facilities. Geotechnical stability analyses of the closure grading and cover plans for mine roads were not completed. Instead, the assumption was made that cut and fill slopes with a maximum overall slope gradient of 3 horizontal (H):1 vertical (V) are adequate to ensure long-term geotechnical stability. An evaluation of the geotechnical stability of the TSF 1, TSF 2, and WRD is provided in other FS Appendices. Plans for the establishment of specific post-mining land uses and wildlife habitat were not completed for this RP.

Descriptions of the existing environment at Mt Todd, including the status of mining infrastructure, water management, and environmental monitoring and compliance are provided in the PEA (Gustavson, 2006) and the January 2011 PFCP.

The major existing and proposed facilities included in this RP are as follows:

1) Batman Pit;
2) WRD;
3) Process Plant and Operations Area (including RP2, RP5 and the Process Water Pond);
4) HLP;
5) Mine roads;
6) TSF 1;
7) TSF 2;
8) LGO1;
9) LGO2 located north of the Process Plant Area; and
10) Haul roads to all new and expanded facilities.

1.1 Report and Effective Date

The designs and costs used in the development of this reclamation plan are subject to variability. The reclamation plan costs are effective as of December 2021, and the narrative is effective as of February 2022.

2. RECLAMATION PLAN ANALYSIS

This RP was developed based on input from Vista and their consultants, review of readily available data and information regarding Mt Todd, and Tetra Tech's technical experts who are familiar with Mt Todd mining and mineral processing plans. Additional technical support was provided by Tetra Tech geochemists, hydrogeologists, civil engineers, and water balance modeling experts.

Key issues and project drivers were identified during development of previous Reclamation Plans and during a series of participatory meetings with Vista representatives, MDA, and Tetra Tech staff. The concepts, strategies, and options developed and evaluated during these meetings and subsequent analyses were discussed with and endorsed by Vista and serve as the foundation for this RP. Previous Reclamation Plans are the basis for this RP. This RP was developed by modifying and updating previous Reclamation Plans to reflect the current mining scenarios, recent findings and analyses from ongoing investigations, and design and planning efforts.

With the exception of matters such as surface water management, water treatment and other exclusions mentioned above (discussed in other Appendices of this FS) these findings and analyses were incorporated to the extent possible to support specific portions of this RP.

The reclamation plans for individual facilities of Mt Todd were based on predictions of site conditions during the mine-life phases. Available information, numeric modeling, and best professional judgment were used to estimate site conditions such as ARD/ML sources and flow volumes, annual precipitation and runoff variability, extreme flood events, and the hydrologic and physicochemical properties of the mine, tailings, waste rock, and potential closure cover materials.

This section of the report includes a summary of the important elements and approaches used to develop reclamation plans and strategies.

2.1 Reclamation Planning Goals and Important Drivers

The reclamation goals for Mt Todd include:

1) Control existing acid-generating conditions;
2) Minimize erosion of facilities containing mine waste;
3) Reduce or eliminate the acid and metal loads in seepage and runoff water;
4) Minimize adverse impacts to the surface and ground water systems surrounding Mt Todd;
5) Stabilize mine waste and other mine-related surface disturbances physically and chemically;
6) Protect public safety; and
7) Comply with NT Government regulations governing mine development and reclamation.

The important project drivers by which reclamation plans and strategies were developed are as follows:

1) Use standard reclamation practices with the knowledge that design details will be fine-tuned in the future;
2) Use previous investigations, studies, and available data and information;
3) Identify information gaps and future investigations necessary to improve the characterization of site conditions now and through closure;
4) Provide Vista with practical development and reclamation recommendations to facilitate site-wide integration of reclamation designs;
5) Exploit 'Mine for Closure' opportunities by reclaiming mine facilities simultaneously with mining (i.e., concurrent reclamation);

6) Identify strategies to reduce acid/metal loading to water management structures and ground and surface water by emphasizing hydrologic isolation of acidic materials from ground and surface water where plausible;
7) Handle materials efficiently; and
8) Emphasize low-maintenance "walk away" reclamation where practical.

2.2 General Reclamation Planning Strategies

The general planning strategies used in the development of the reclamation plans provided in this RP include the following:

1) Generate the lowest amount of ARD/ML feasible to minimize acid/metal loads that must be handled in the water conveyance and treatment system by:
    a) Isolating mine waste from precipitation and oxygen through the installation of store and release covers, liner covers, erosion control, rapid stormwater conveyance from the surface of graded and capped mine waste (surface water controls are not included in the scope of this reclamation plan, but are addressed in other appendices), and prevention of surface water ponding;
2) Demolish and remove unnecessary mining facilities and structures, (detailed decommissioning and demolition plans for facilities and structures are not included in the scope of this reclamation plan).
3) Create stable final configurations of features through regrading, placement of cover, and installation of stormwater drainage systems at closure (stormwater drainage systems are not included in the scope of this reclamation plan).

2.3 Major Reclamation Assumptions

A summary of the major assumptions used for the development of this RP is provided below. Estimated quantities (e.g., facility dimensions, material volumes, surface areas, and disturbance footprints) used for the development of this RP are discussed further in Sections 4 and 6, as well as in applicable sections of this RP. Future work should be conducted to verify the assumptions presented below.

2.3.1 Reclamation Assumptions

1) Sufficient quantities of NAF waste rock will be selectively handled during mining so as to be available for the reclamation of the WRD, TSF1, TSF2, roads, and other mine-related surface disturbance.
2) LGO2 and HLP reprocessing and targeted excavation will be sufficient to remove all PAF residuals from the footprints of these facilities.
3) LGO2 and process plant pad area design and construction methods will prevent PAF material that may be present during operations from impacting underlying materials.
4) NAF waste rock in combination with low-permeability materials (LPM) will be suitable as a store and release cover material.
5) LPM to be used in store and release covers will be imported from sources within 40 to 60 kilometers of Mt Todd to compensate for a lack of such material on-site.
6) Imported LPM will consist of non-expansive materials with a compacted hydraulic conductivity equal to or less than 1 x 10-6 cm/sec.
7) Plant growth medium (PGM) will be available on-site in existing stockpiles and from material salvage from new disturbance (TSF 2, expanded WRD etc.).
8) Material salvage from construction and expansion of facilities will yield an average PGM depth of 0.2 m, but no LPM material suitable for store and release covers.

9) Supplemental PGM may be provided through crushing of NAF waste rock into fines, but is not anticipated to be required.
10) Soil amendments will not be required to facilitate plant growth on the crushed NAF waste rock fines.
11) Installation of wick drains within the former pond area of TSF1 and TSF2 will rapidly dewater the tailings sufficiently to allow passage of equipment for placement of crowned cover material.
12) Thixotropic tailings can be bridged by installing a crowned cover of waste rock and sorter reject material.
13) The installation of the 0.8 m-thick store and release cover and 0.2 m-thick PGM cover over the TSF crowned cover will sufficiently control infiltration of precipitation through the cover.
14) Attaining final overall cut and fill slopes no steeper than approximately 2.5H:1V will be adequate to ensure long-term geotechnical stability of the TSF1 and TSF2 embankments and not steeper than n3H:1V at all other plant facilities, excluding the WRD.
15) A low permeability liner cover system in addition to placement of NAF waste rock around the perimeter of each bench will provide sufficient capping of the WRD to minimize seepage of ARD/ML.
16) LGO1 will be eliminated as a result of the Batman Pit expansion and will not require reclamation.
17) The safety bund installed around the perimeter of the Batman Pit will be offset 30 m to account for the minimum 10 m buffer beyond an assumed 20 m "potentially unstable pit edge zone" per the requirements outlined in the guidelines for "Safety Bund Walls around Abandoned Open Pit Mines" from the Department of Industry and Resources in Western Australia.
18) Vista will assume the responsibility to reclaim the HLP following the reprocessing of leached ore in the Mill.
19) Leached ore in the HLP will be removed and re-processed in the Mill.
20) Weak acid dissociable (WAD) cyanide levels in pore water and seepage from HLP and contaminated fill excavated from below the HLP are below maximum allowable concentration limits. Therefore, the liner or fill below the HLP will not require rinsing or treatment with oxidants following the reprocessing of leached ore in the Mill.
21) The equipment fleet used for mining will be used to conduct reclamation activities.
22) Mine-owned equipment and mine employees will be available during production to assist with concurrent reclamation activities.

Reclamation plans and strategies for each major facility at Mt Todd are summarized in Section **4**.

3. MINING SCENARIOS

The mining scenario for the 50K TPD FS is described in the FS technical report. The approximate mine-life schedule includes:

- 2 years pre-production
- 15 years pit ore processing with 2 years additional stockpile and HLP processing for 17 total years of production
- 2-3 years active reclamation
- 5 years of post-closure
- Continued long-term water management

The reclamation approach for the project is presented in the following section, with quantities as estimated for the 50K TPD Base Case.

4. RECLAMATION PLAN

This section of the report includes a summary of the important elements of the RP and recommendations regarding the practical approaches to reclamation at Mt Todd.

When mining is renewed at Mt Todd, the plans and designs contained here must be refined based on changes in mine plans and site conditions, unforeseen circumstances, acquisition of additional data, and advancements in site knowledge and closure technologies. Vista personnel should continue to work closely with engineers, technical experts and specialists, scientists, and agencies to implement practical and effective closure, reclamation, and water management programs at Mt Todd. These same staff should work to improve the designs and analyses provided in this report. The success of closure, reclamation, liability reduction, and mine and asset development will depend on these future efforts.

The major existing and proposed facilities included in this RP are as follows:

1) Batman Pit;
2) WRD;
3) Process Plant and Operations Area;
4) HLP;
5) Mine roads;
6) TSF 1;
7) TSF 2;
8) LGO 1;
9) LGO 2 located north of the Process Plant Area;
10) Haul roads to new and expanded facilities;
11) RP2; and
12) RP5.

Facilities not covered under this reclamation plan include:

1) RP1, RP3, RP4, RP6, RP7 and associated pumping systems;
2) HLP Ponds and pumping system;
3) Existing Water Treatment Plant (WTP) and sludge management facilities;
4) New WTP and sludge management facilities; and
5) Stormwater and surface water control facilities except as noted.

Reclamation approaches and strategies for each major facility at Mt Todd are discussed below were briefly summarized in **Table 1**. All recommendations for the advancement of reclamation to a design-level are provided in Section 5.0. The operational status and reclamation schedule of the Mt Todd facilities discussed within this plan is provided in **Table 2**.

4.1 Reclamation Materials

Limited materials suitable for reclamation are available at the Mt Todd project site. Reclamation materials utilized will include:

- Run-of mine NAF waste rock;
- Imported LPM;
- PGM from
  - existing PGM stockpiles;
  - salvaging from footprints of new facility construction and stockpiled until required for facility reclamation;
- Screened fine materials excavated from footprints of new facility construction; and
- Crushed rock (sorter reject) for bulk fill.

All materials used in reclamation will be NAF unless specifically approved, for instance, PAF containing materials may be used as bulk fill to construct the TSF crowned caps if adequately encapsulated with NAF material.

Run-of mine NAF waste rock will be used as material to create a crowned cap over the tailings impoundments, erosion control material on the WRD, and mixed with LPM for store and release covers. NAF waste rock will be handled during mining such that sufficient quantities will be available for concurrent reclamation of the HLP, WRD, TSF1, and TSF2. Additional NAF waste rock will be available at mine closure for final closure of the LGO2, WRD, TSF2, process plant and pad areas, roads and other mine-related disturbances.

The LPM is required for use in store and release reclamation covers. The requirements of this material are presented in Table 3. As sufficient quantities of suitable LPM have not been identified on-site, LPM material will be imported. A LPM inventory was conducted in October and November 2012 and preliminarily identified potential sources of LPM within 40 to 60 kilometers of the Project area. Samples of material within the potential sources of LPM were subject to laboratory testing to determine their physical properties. Based on preliminary evaluation of the lab and field inventory results the potential LPM source materials are non-expansive with compacted hydraulic conductivity equal to or less than 1×10^{-6} cm/sec and contain few coarse rock fragments. Additional investigations are necessary to confirm the quality and quantity of low-permeability materials within these and other potential sources. The LPM will be used in the reclamation of TSF1 and TSF2.

PGM will be used as the top layer of reclamation cover for vegetation establishment. PGM will be obtained from existing stockpiles at the Mt Todd site, as well as through salvaging surficial soils within the footprints of new facility construction, including but not limited to TSF 2 and expansion areas of the WRD. An average of 0.2 m of suitable PGM is assumed to be present beneath the footprints of the salvage areas. PGM suitability guidelines are presented in Table 3. As needed, NAF waste rock will be crushed and used as supplemental PGM for revegetation. It is assumed that PGM from existing stockpiles, new salvage, and crushed NAF waste rock will be of sufficient quality to facilitate plant growth and will not require any additional soil amendments. PGM will be used in the reclamation of the HLP, TSF1, TSF2, LGO2, process plant and pad area, roads, and other mine-related disturbances.

Material excavated from the footprints of new facility construction will be stockpiled and screened as necessary to generate WRD cover liner bedding and overlying material.

A portion of the ore material process through the mill is rejected at the sorter process. This material is anticipated to typically contain low sulfur content and is assumed to be NAF. The material is a poorly sorted gravel with few fines but may be used as bulk fill or mixed with run of mine NAF waste rock in the construction of the crowned surface for TSF1 and TSF2 reclamation.

4.2 Batman Pit

The Batman Pit will be significantly deepened and enlarged from its current depth of 114 m to a final planned elevation of -448m. Scaling and blasting of select pit benches and walls will be completed during the production phase to reduce the risk of human injury due to rock fall and improve pit wall stability and aesthetics.

A pit safety bund will be constructed around the entire perimeter of the Batman Pit to impede human access to the pit. The pit safety bund will be constructed with a 5 m base and 2 m height with a 10 m offset from the potentially unstable pit edge zone to ensure berm longevity and safety. As such, the pit berm will be approximately 4,900 m in length and utilize nearly 49,000 m^3 of NAF material from the Batman Pit. Key reclamation quantities are presented in Table 4**.**

Long-term pit water treatment is not anticipated under the project mining scenario, as the pit is predicted to be a terminal sink with net evaporation exceeding precipitation and runoff into the lake as described in the Predictive Geochemical Modelling Report for Batman Pit (Practical Geochemistry, 2020). The pit lake was modeled to reach equilibrium at approximately -15mAHD (179m below pit rim) approximately 1,200 years following cessation of mining (Practical Geochemistry, 2020). While geochemical modeling identified that an acidic pit lake (pH 3.1 to 3.7) was anticipated to develop and that sulfate, aluminum, arsenic, cadmium, cobalt, and zinc were likely to remain above guideline values, the terminal sink and low level of the pit lake relative to the ground surface reduce potentials for exposure and therefore render additional post closure water quality improvements unnecessary (Practical Geochemistry, 2020, Practical Geochemistry, 2019).

4.3 Waste Rock Dump

The existing WRD contains approximately 16 Mt of waste rock. The WRD will be significantly enlarged over the mine life. Based on the geochemical testing and analysis program conducted, (including the 2013 Geochemistry Program), approximately 37 percent of the waste rock excavated during renewed mining activities will be NAF. As part of the mine plan a Waste Rock Management Plan (WRMP) will be developed that specifies how waste rock is to be handled to minimize the potential for ARD/ML and maximize the beneficial use of NAF waste rock for closure. The WRMP will include:

1) Routine waste rock testing procedures such as collecting monthly samples for analysis of carbon and sulfur that can be used to confirm data from the blast hole database;
2) Staging dump construction to minimize the contact of PAF rock with air and water;
3) Selective handling and isolation of the highest sulfide material or blending PAF and NAF waste rock;
4) Contouring WRD surfaces to shed precipitation and runoff away from PAF materials during production and at closure; and
5) Concurrent reclamation of inactive dump areas and faces as mining progresses.

The results of this planning effort will include managing waste rock disposal so the outer layers of the WRD are composed of NAF waste rock at closure. The WRMP should also emphasize the implementation of operational techniques and dump designs that encourage clean water diversion, rapid internal surface runoff, and seepage control during operations and at closure.

From its current area of 69 hectares, the WRD will be constructed at an effective angle of 30 degrees with interbench slopes of 34 degrees and will expand to a planned 2D footprint area of 258 ha. As the WRD is constructed an 8m wide bench will be installed on the face of the WRD each 30m of vertical WRD height. The planned WRD will be benched appropriately to satisfy geotechnical stability constraints. These benches will function as stormwater drainages as practicable and as access for reclamation cover installation, reclamation activities, and maintenance. The WRD will be built to final grade and configuration, with a final 3D area of approximately 291ha.

The WRD design was completed by Respec and is shown on Figure 1 and Figure 2. This design:

- Overtakes the current footprint of RP1, requiring a new RP1 to be constructed;
- Avoids grading of waste rock at the end of the mine-life;
- Incorporates concurrent reclamation throughout the life of the WRD;
- Results in reclamation of the entire WRD by the end of Production Year 16; and
- Creates a 'geomorphic' final surface that includes:
  - Dissected, non-uniform, and complex slopes;
  - Opportunities for dispersing rather than concentrating runoff from the surface of the WRD; and
  - Final WRD configuration with similarities to the surrounding undisturbed topography.

Concurrent installation of a low-permeability geosynthetic liner cover system (i.e., LLDPE or GCL) following attainment of final grades is proposed for the closure of the WRD. This cover system design will include bedding layer followed by placement of the low permeability geosynthetic liner, and capped with a protecting layer. The under and over layers for a GCL liner would consist of a 0.3 m-thick fines where 80% of the material is finer than a #60 sieve (0.250 mm) and containing no sharp-edged rock fragments larger than 0.5 inches in diameter. The under and over layers for an LLDPE liner would consist of 0.3m thick layers of fines as described above, or a geotextile. The liner material will span approximately 52 m on top of each lift, covering the 8 m bench, and running below the subsequent lift. The liner material will be sloped at a 5 percent angle toward the outside of the WRD. The liner will be constructed with a 0.5 m berm made with 1:1 side slopes at the interior edge of the liner material layer. This cover will channel seepage toward the outer edge of the dump, toward the NAF material, mitigating generation of ARD/ML. A 1 m-thick layer of NAF waste rock will be placed on the top of all surfaces of the WRD to aid in erosion control. A closure cover trials design and monitoring procedure has been developed to provide direction on the installation of cover trials to prove the concept of the petticoat cover prior to full implementation of the cover, to collect data in the field to assess the effectiveness of the placed cover. This procedure has been included as **Attachment 1.**

In 2020 Tierra Group International (TGI), developed a Mt Todd Waste Rock Dump Closure Assessment Report (**Attachment 2**), to complete an independent review of the proposed WRD closure approach. While this review was based on the WRD proposed as part of the 2019 PFS, the closure cover components are generally consistent and the review applicable to the current cover design. TGI's review focused on possible failure modes of the closure approach and identified a selection of relevant failure modes for the Mt Todd WRD, specifically slope failure, differential settlement (liner grade reversal), and liner breach. To further assess these identified relevant failure modes, TGI identified some additional recommended studies and investigations for future phases of the project. These recommendations are appropriate for future phases of design and have been added to this report, as completing these evaluations was not included in the scope of this study. These recommendations are included in Section 5 of this Reclamation Plan. As part of this FS, Tetra Tech performed limited slope stability evaluations under static conditions to confirm that the use of geotextile, in lieu of fines, for liner under and overlayers would not introduce unacceptable factors of safety. The discussion of Tetra Tech's limited slope stability analysis is provided in **Attachment 3**. The static slope stability calculations confirmed that while use of geotextile as an under and over layer reduced factors of safety slightly, they remained adequately protective and above minimum requirements.

The estimated quantity of material necessary to close the WRD is approximately 2.8 million m^3 of NAF waste rock for erosion control, approximately 2.8 million m^2 of liner, and 5.7 million m^2 of geotextile (above and below the LLDPE liner). Key reclamation quantities are presented in Table 4.

Seepage through the WRD with a similar cover configuration (25 m sections of GCL on each bench) has been modeled in the software program VADOSE (**Attachment 4**). Initial modeling results indicate that the geosynthetic liner cover will sufficiently restrict seepage to allow for acceptable long-term passive water treatment. It is expected that implementation of 52 m liner covers on each bench will reduce the quantity of seepage beyond what was established in the modeling of the 25 m sections. Additional information regarding the seepage modeling is included as **Attachment 4**. Attachment 4 was originally developed in 2012 and was revised in 2018 to reflect updated WRD closure assumptions and strategies. In 2019 this closure cover modeling was reviewed to comment on applicability of the modeled configurations to the currently proposed cover configurations (including that it is anticipated that using a LLDPE liner will result in lower infiltration rate than a GCL liner). This review memorandum is included as **Attachment 5**.

4.4 Tailings Storage Facilities

Tailings will be produced at the Process Plant and disposed of in TSF1 and TSF2 as slurry with an average solids content of 42 percent by weight. The particle size of the tailings is anticipated to be fine, with 98 percent passing the #100 mesh sieve.

Prior to completion of the proposed TSF1 centerline raise, it is recommended that a visual inspection be completed to confirm if areas to be disturbed by the raise completion contain PGM. If PGM of suitable quality is identified, salvage of this material is recommended, however the site-wide PGM material balance does not require this area to contain suitable PGM. Additionally, prior to construction of TSF2, PGM will be salvaged from approximately 0.2 m to 1.0 m depth throughout the footprint of TSF2. Based on this range of excavation depths, approximately 1,200,000 m^3 of PGM will be salvaged from the TSF2 footprint. This salvaged material will be used in the closure of TSF1 and TSF2. Initiation of closure activities at TSF1 and TSF2 is anticipated to occur in Year 18.

Tetra Tech anticipates that the impounded tailings surface conditions in TSF1 and TSF2 at the end of tailings deposition activities will be similar to the current conditions. Currently, beach sands cover only a narrow strip near the inside crest of the existing TSF1 dam and slimes cover the remainder of the surface of TSF1. As such, Tetra Tech has assumed that at closure, the majority of the impounded surface of TSF1 and TSF2 will be primarily composed of thixotropic tailings (thick like a solid but flows like a liquid when a sideways force is applied) that will maintain a high degree of saturation for many years unless they are actively dewatered and consolidated, covered with material (i.e., increase surcharge), or are chemically treated to increase their strength. To address this, pumping of the supernatant pond to the water treatment plant and subsequent installation of wick drains in the supernatant pond footprint is proposed.

The final planned TSF1 3D surface area at closure will be approximately 250 hectares (including an impounded surface area of 194 hectares and dam embankment surface area of 56 hectares). The final planned TSF2 3D surface area at closure will be approximately 304 hectares (including an impounded surface area of 215 hectares and dam embankment surface area of approximately 89 hectares).

To close the impounded surfaces of TSF1 and TSF2 after pumping and wick drain installation has resulted in sufficiently dewatered tailings to allow for passage of equipment, bulk fill material will be placed on the tailing impoundment surface to create a crowned cover to drain surface water off to the sides. The estimated volume of material necessary to create a crown with minimum 1% slopes on the impounded surface of TSF1 and TSF2 is approximately 6.5 and 8.0 million m^3, respectively. This crown material will be covered with a 0.8 m-thick store and release cover composed of 66% imported LPM and 34% NAF waste rock, requiring approximately 1.6 and 1.7 million m^3 of store and release material to cover the TSF1 and TSF2 impoundment surfaces, respectively. The store and release cover will be topped with a 0.2 m-thick cover of PGM, requiring approximately 0.39 and 0.43 million m^3 of material for the TSF1 and TSF2 impoundment surfaces, respectively. A closure cover vadose model was developed for the TSFs and is included as **Attachment 6.**

The 0.8 m-thick store and release cover consisting of NAF waste rock and LPM will be installed on the outside slopes (embankments) of the main dams of TSF1 and TSF2, requiring approximately 0.45 and 0.71 million m^3 of material, respectively. This store and release cover will be capped with a 0.2 m-thick PGM cover. The embankment surfaces of TSF1 and TSF2 will require approximately 0.1 and 0.2 million m^3 of PGM, respectively. Following capping with PGM, TSF1 and TSF2 will be revegetated with native seed to increase the erosion resistance of the store and release cover. To the degree practicable, the store and release cover will be installed concurrently on the TSF1 and TSF2 dams. Figure 3 shows the TSF cover. Key reclamation quantities are presented in Table 4.

At closure, modifications will be made to the TSFs to manage seepage and precipitation. The spillways will be modified to suit the closure design and seepage collection ditches will be installed, routing seepage to a modified sump that will collect seepage via gravity feed. The seepage collection ditches will be designed to receive and convey seepage in a lined ditch to a central sump. A pump and pipeline system will then be installed to route the collected water away from the TSF sump to the active water treatment plant, or later on, to the passive water treatment systems. At closure of TSF2 seepage will be routed to the water treatment plant for approximately 5 years until flow rates decrease and flows can be treated using a passive water treatment system. Closure of TSF1 will also include modifications to the decant system to prevent short circuiting of fluids through the TSF at closure. Closure of TSF2 will include removal of the tailings delivery line spigot piping and on-site disposal.

TSF2 will be reclaimed concurrently as opportunity allows, with the impoundment surface reclamation starting in Year 18, following completion of the processing activities.

4.5 Process Plant and Pad Area

A new processing plant will be built at the existing Process Plant and Pad Area. The current plant and pad area is approximately 35 hectares. This area encompasses the Process Plant structures, crushing stockpile, RP2, RP5, and ancillary facilities such as the ammonium nitrate/fuel oil (ANFO) storage location. Tetra Tech anticipates that the area of disturbance for the construction of the new processing plant will increase only slightly, to approximately 38ha. Once mineral processing ceases the Process Plant will be decommissioned, decontaminated, demolished, and any reusable equipment and materials will be salvaged and resold. Removal of foundations and reclamation of Process Plant areas will occur after the plant has been removed.

The current operating assumption is that the Process Plant (or portions thereof) will be demolished (disassembled), removed (salvaged) or hauled to a solid waste landfill or other suitable locations on-site, capped, and reclaimed. Some buildings will remain to support reclamation operations and maintenance. Process Plant and WTP decontamination, decommissioning, demolition, and disposal assumes removal of building components above ground surface.

Concrete foundations, walls, bridges, and other non-reactive, non-combustive, non-corrosive and non-hazardous demolition waste will be broken up and either:

1) Placed in the WRD or TSFs prior to crowned cover placement; and/or
2) Buried in-place or backfilled against cutbanks and highwalls throughout the Process Plant and Pad Area, as well as other areas that will be reclaimed at Mt Todd.

The Process Plant and Pad Area will be graded to blend into the surrounding topography and drain towards Batman Creek. Closure grading will include pushing approximately 0.38 million m^3 of material. Stormwater drainage controls and erosion and sediment controls will be designed and constructed to minimize erosion and channel scour. The Process Plant Area and Pad will be covered with 0.2 m of PGM and revegetated and protected from erosion as described previously. The estimated volume of material necessary to close the Process Plant Area is approximately 77,000 m^3 of PGM. Tetra Tech assumes that the Process Plant and Pad Area will no longer be a source of ARD/ML following closure. Key reclamation quantities are presented in Table 4.

Reclamation of the Process Plant vicinity will also include closure of RP2 and RP5. The closure of these retention ponds will include removal of sediments, cutting, folding, and disposal of liners in place, and backfilling of the pond utilizing surrounding material. The pond surfaces will be covered and revegetated as described for the Process Plant area.

The Process Water Pond will be closed 5 years after production ceases, coinciding with the closure of the WTP. The Process Water Pond will be closed following the same methodology as described for RP2 and RP5.

The cost for Process Plant and Pad Area surface water management are not covered in this report as these costs are addressed in other appendices.

4.6 Heap Leach Pad and Moat

The HLP covers an area of 39 hectares and is 20 to 25 m thick with side slopes as steep as 1H:1.6V in isolated areas. These slopes are dissected by a dense network of rills and gullies. Due to the extent of exposure to precipitation, Tetra Tech assumes that the WAD cyanide concentration of HLP pore water and seepage meet applicable standards. As such, it is assumed that deliberate rinsing of the HLP or fill beneath the HDPE liner prior to initiation of re-processing of the leach ore is not required.

Material in the HLP will be removed and re-processed in the Mill in the final years of production. Subsequently, the underlying area will be reclaimed. Currently, no information is available on the subsurface conditions at the HLP. It is estimated that reclamation activities for the HLP footprint may include the following:

- Cut, fold, and dispose of liner either in place, or in TSF1 or TSF2 (a lined facility);
- Remove residual contaminated sediments for disposal in TSF1 or TSF2 (assumed excavated to a depth of 0.5m from the HLP footprint);
- Regrade the underlying area to promote drainage; and
- Place a 0.2m thick PGM cover and revegetate the area.

4.7 Low Grade Ore Stockpiles

LGO1 will be eliminated during the expansion of the Batman Pit. Consequently, no reclamation is required for the closure of this facility. LGO2 will be located northeast of the Process Plant Area (refer to Figure 1). PGM will be salvaged from approximately half of the LGO2 footprint prior to its construction. Salvage depths vary from 0.1 to 0.2 m over approximately 25 hectares yielding approximately 49,000 m^3 of PGM.

Tetra Tech assumed that no ore will remain at closure. In addition, Tetra Tech assumed that the surface drainage features designed for LGO2 would control and route surface water to ensure that no ARD/ML would impact the underlying soils. Any potential ARD/ML generated during operations reports to the process water pond, and therefore the WTP. Closure of LGO2 will include removal of 0.3m thick LGO2 foundation gravels ore from the stockpile area footprint, which would be hauled to the TSFs and used as part of the bulk fill for creating crowned covers on the TSFs.

A regrade depth of 0.2 m was assumed over the entire LGO2 area to estimate a regrade volume of approximately 102,000 m^3 for closure of LGO2. In addition, stormwater drainage, erosion, and sediment controls will be designed and constructed to minimize erosion and channel scour. A 0.2m thick PGM cover will then be placed over the LGO2 footprint and revegetated. The estimated total surface area of LGO2 is approximately 50 hectares. The estimated volume of material necessary to close LGO2 is approximately 102,000 m^3 of PGM. Key reclamation quantities are presented in Table 4. LGO2 is assumed to no longer be a source of ARD/ML following closure.

4.8 Mine Roads

Haul roads were assumed to be 35 m wide throughout the site. Light vehicle and access roads were assumed to be an average of approximately 14m wide. Roads were assumed to be reclaimed when no longer required to access active reclamation areas, for site monitoring, or for long-term access to select areas of the site, such as (but not limited to) the passive treatment systems and the RWD. Roads will be closed by grading into surrounding topography, ripping subgrade materials, placing 0.2 m of PGM, and revegetating the areas as described previously. Approximately 24 ha of haul roads will require closure.

Typical mine road reclamation and cover is shown in Figure 4. Key reclamation quantities are presented in Table 4.

5. RECOMMENDATIONS

Throughout the mine-life, Vista should anticipate, plan, design, and implement effective plans for:

1) Identification of PAF and NAF materials, as well as metaliferous materials;
2) Selective handling of PAF and NAF material and potentially direct treatment of PAF materials throughout the mine-life to prevent or reduce the generation of ARD/ML;
3) Identification and acquisition of suitable materials for use in closure covers, including NAF materials for liner bedding and overlayers (which if locally available may be a lower cost option to geotextile), NAF material for erosion control, low-permeability material, and plant growth medium;
4) Short- and long-term hydrologic isolation of PAF and metaliferous materials from ground and surface water; and
5) Control of stormwater to prevent excessive erosion and sedimentation.

Specific recommendations are provided below to address information gaps, advance the feasibility study, and improve the function and performance of on-site water management.

The following information is needed to progress reclamation planning to a design level. Completing these studies as early as practicable prior to or during mine life will aid in designing for closure and streamline the closure process. The recommended work should be performed strategically so that decisions about closure and reclamation can be made sequentially and at the appropriate phase of the project. The following work items are recommended to be conducted:

1) Waste and cover material hydraulic properties characterization and analysis;
2) WRD specific recommendations:
    a) Hydraulic properties characterization of WRD liner system components
    b) Liner bedding shear strength and liner to liner bedding interface shear strength testing (including residual interface strength analysis of liner system components and waste rock for use in slope stability analyses);
    c) Slope stability analyses for static (updated based on site-specific parameters) and pseudo-static conditions, focused on interlift stability and post-earthquake conditions based on stress-deformation modeling;
    d) Waste rock consolidation evaluation under 30-m waste rock load, to evaluate adequacy of 5% slope for maintaining positive drainage to outer bench of WRD and settlement impacts to liner system integrity;
    e) Seepage analyses for the WRD reflecting additional site-specific data (as available), closure designs (including LLDPE), and longer term climactic conditions & potential variations;
    f) Detailed quality control and monitoring plan for construction and operations of the WRD and cover placement, including assessing liner placement scheduling and necessary wet season considerations; and
    g) WRD liner longevity, long-term performance, and liner breach evaluations
3) TSF Specific Recommendations
    a) Tailings trafficability testing;
    b) Wick-drain efficacy testing;
    c) Development of a Tailings Management Plan;
    d) Seepage analyses for the TSFs reflecting additional site-specific data (as available), closure designs, and longer-term climactic conditions & potential variations;

4) Bench and pilot testing for passive water treatment;
5) Improvement of the watershed hydrologic data collection system to enable an update of precipitation-yield characteristics of the site;
6) Completion of the site-wide soils and closure cover materials inventory and characterization to identify material sources, properties, and balance; and
7) Erosion and sediment control analysis.

5.1 Waste and Cover Material Hydraulic Properties Characterization and Analysis

The hydraulic properties of waste rock, tailings, and potential cover materials require additional characterization as part of the feasibility study. These results should be used to improve:

1) Waste facility and site-wide water balance prediction; and
2) Evaluation of closure cover design alternatives and performance.

Samples of waste rock, tailings, and potential cover materials should be collected and analyzed to determine particle size distribution. These particle size distribution data should be compared with available computational databases (e.g., SoilVision) to estimate variably-saturated hydraulic properties (e.g., soil water characteristic curves [SWCC], saturated and unsaturated permeability). The SWCC describes the water content of a material as a function of soil suction or negative pore-water pressure. The particle size analyses and database query results should be used to select a wide range of samples for further empirical characterization of their saturated and unsaturated hydraulic properties.

Tetra Tech recommends that saturated hydraulic conductivity and SWCC of waste rock, tailings, and potential sources of soil cover materials be tested.

Samples should be collected as follows:

1) Waste Rock: 15 to 25 waste rock samples, each with a mass of 50 kilograms (kg), should be selected to represent the majority of the rock mass lithology anticipated to be deposited in WRDs. Samples should be collected from shallow trenches excavated in the existing waste rock facilities.
2) Tailings: Ten paired tailings material cores should be collected along transects from the tailings deposition zone to the far side of the impoundment or supernatant pond, as practicable. The cores should be collected using core barrels with clear plastic liners so that stratigraphy can be readily assessed. Cores should be collected to a minimum depth of 3 m. One of the paired cores should be used to visually assess stratigraphy. Areas of distinct sandy characteristics should be identified and evaluated for vertical continuity, with the goal of determining if there are large (e.g., greater than 0.5 m in depth) intervals composed solely of sandy material. Material from intervals of interest will be sampled and submitted to a laboratory for analysis (discussed below). This information will be used to assess the total porosity of beach tailings and geochemical properties of sands and slimes. This information may be of value in determining the trafficability of the beach tailings and efficacy of wick drains in helping to achieve trafficability.

   The second paired core will be sealed to prevent atmospheric oxygen from entering the sample and archived for possible future chemical analysis, depending on whether the particle size analysis indicates a significant possibility that ARD generation could be an issue.
3) Cover Material: 15 to 25 samples of potential cover material sources, each with a mass of 50 kg, should be selected to represent the range of possible cover materials. Samples should be collected from shallow trenches in areas that are representative of the majority of cover material by mass.

Particle size distributions should be determined using the sieve and hydrometer method, in accordance with American Society for Testing and Materials (ASTM) D 422. Material classification should be conducted according to

ASTM D 2487. Results will include percentages of cobbles, sand, silt and clay, and the material classification. Saturated hydraulic conductivity tests are most often completed using a triaxial permeameter. A falling head permeameter is more appropriate for coarse textured materials or for the determination of the saturated hydraulic conductivity of cover material following placement. SWCC tests are most often completed using a conventional or modified pressure plate apparatus.

Results of the field characterization should be incorporated into hydrologic models (e.g., GOLDSIM, VADOSE/W, SEEP/W, SOILCOVER, H-SAT) used to simulate the long-term water balance of tailings and waste rock facilities including the amount of meteoric water that infiltrates through closure covers. Detailed, stochastic models of waste facility and cover design alternatives should be developed using probabilistic analysis of precipitation to represent the range in wet, average, and dry year conditions.

Following the completion of the feasibility study, test plots and fills are recommended to be installed if material characteristics of materials proposed for use in covers differ significantly from the existing cover materials previously used and currently understood on the site. These test plots and fills would be monitored to evaluate and confirm the performance of alternative grading, stormwater drainage and cover designs, and erosion control and revegetation treatments. Conclusions regarding the performance of closure alternatives tested would be used, in part, for the development of final closure plans and designs at Mt Todd, and to validate vadose zone and water balance models to improve the prediction of long-term water treatment requirements and adverse impacts to surface and ground water in the vicinity of Mt Todd. Inclusion of test fills was not included in the cost estimate as the existing body of knowledge on cover material is assumed to be sufficient for closure planning purposes.

5.2 WRD-Specific Recommendations

5.2.1 Hydraulic Properties of Liner System Components

Assess hydraulic properties of liner system components (including geotextile, LLDPE, GCL, fines materials) and assess potential for saturated conditions near the liner system components.

5.2.2 Shear Strength Testing

Liner bedding shear strength and liner to liner bedding interface shear strength testing (including residual interface strength analysis of liner system components and waste rock for use in slope stability analyses) should be performed. These analyses should include evaluating geotextile and LLDPE components, as well as GCL and fines materials. Internal strength of GCL for use in slope stability analysis should also be assessed.

5.2.3 Geotechnical Stability Analyses

Slope stability analyses for static and pseudo-static conditions should be performed. Static slope stability analyses should be updated based on site-specific parameters and include interlift stability and post-earthquake conditions based on stress-deformation modeling. Pseudo-static conditions should also be evaluated.

5.2.4 Consolidation Analyses

The potential for differential settlement leading to liner grade reversal should be assessed through consolidation evaluation under 30m waste rock loads to determine if the 5% slope is adequate to maintain positive drainage to the outer bench of the WRD (assess if predicted settlement is greater than the 2.6m of grade drop between the start of the liner and the outer bench). The impact of settlement to liner system integrity should also be assessed.

5.2.5 Quality Control and Monitoring Plan

A detailed quality control and monitoring plan for construction and operations of the WRD and cover placement, including assessing liner placement scheduling and necessary wet season considerations

5.2.6 WRD Liner Longevity and Liner Breach Evaluations

Evaluations on the anticipated longevity of the liner system and potential for liner breaches to occur should be conducted, as effectiveness of the cover will be significantly impacted if permeability is increased due to liner deterioration or breach. Liner punctures, if present, will increase flow through the liner, and leakage through the liner due to defects (poor quality seems or holes) though anticipated to have a smaller impact, should be considered. The potential for liner breach due to long-term differential settlement impacts or potential seismic events should also be considered.

5.2.7 Seepage Analyses for the WRD

Update seepage flowrate analyses for the WRD based on improved site-specific information, as it becomes available, including but not limited to physical waste rock characteristics and results of cover trials. Update seepage analyses to reflect the design configuration and evaluate potential differences resulting from use of fines or geotextile under and overlayers paired with an LLDPE liner. Seepage analyses should also include an evaluation addressing potential longer term climactic conditions & potential climate variations.

5.3 TSF-Specific Recommendations

5.3.1 Seepage Analyses for TSF1 and TSF2

Specific TSF1 and TSF2 seepage analyses, including post-closure conditions, should be developed based on site-specific tailings consolidation and material properties of tailings and cover components. These seepage analyses should be developed independently for TSF1 and TSF2 based on the differing conditions between the two facilities (both in terms of design and deposited tailings). Seepage analyses should also include an evaluation addressing potential longer term climactic conditions & potential climate variations.

5.3.2 Tailings Trafficability Testing

The minimum cover that will be needed to bridge the thixotropic tailings located on the impounded surface of TSF1 and TSF2 and the trafficability and stability of saturated and dewatered slimes requires study and should be investigated to adequately define capping techniques and the quantity of cover needed to successfully reclaim TSF1 and TSF2 with a crowned cover. A tailings consolidation and loading study would be developed to report these findings.

5.3.3 Wick-drain Efficacy Testing

Use of wick-drains to efficiently dewater tailings, particularly in the area of the supernatant pond, should be investigated to adequately determine if wick drains can be effectively installed to achieve the desired dewatering results in a reasonable time period.

5.3.4 Development of a Tailings Management Plan

A Tailings Management Plan should be developed in future phases of study to specify how tailings are to be handled to minimize the potential for ARD and metals leaching, and facilitate closure and rapid dewatering and consolidation of tailings.

5.4 Bench and Pilot Testing for Passive Water Treatment

Bench scale and pilot scale testing of passive treatment system to treat seepage from the WRD and TSFs should be conducted early in the mine life to confirm these technologies will be appropriate to treat the seepages present on site to required water quality for discharge, to refine the specifications for substrates and other materials required within the passive treatment system, and to allow for site-specific information to be gathered necessary to progress the passive water treatment systems design to future phases.

5.5 Post-Closure Pit Lake Modeling

Optimize pit lake closure strategy based on site-specific information on pit wall rock reactivity as mining progresses.

5.6 Reclamation Material Inventory and Characterization

In order to maximize the use of on-site material over imported material for reclamation, Tetra Tech recommends that thorough site-wide inventories be developed for reclamation materials. Inventories (or continuance and completion of ongoing inventories) of the following materials are recommended:

1) NAF waste rock and other waste materials on site;
2) LPM;
3) Undisturbed or slightly disturbed soils, stockpiled soils, and regolith;
4) Durable rock riprap and gravels;
5) Acid-resistant drain rock; and
6) Organic wastes and other soil amendments.

These inventories should be followed by field-tests to determine the material suitability for the anticipated uses. The potential sources of closure materials at or near Mt Todd include, but are not limited to:

1) Production of waste covers, riprap, drain, liner bedding and overlayer, and low-permeability materials excavated from the pit during mining;
2) Production of waste covers, riprap, drain, liner bedding and overlayer, and low-permeability materials excavated from the borrow areas;
3) Production of organic soil amendments developed by composting organic waste such as feedlot manure, crop stubble, biosolids, wood waste from logging operations, etc.;
4) Uncontaminated fill material in materials storage yards, roads, and ancillary facilities;
5) Uncontaminated material excavated for creation of the WRD, RP1, TSF1, and TSF2 diversions; and
6) Soil salvage from the footprint of TSF1, TSF2, and the expansion of the WRD and Pit.

Inventories should define the location, volume, properties, uniformity, retrievability, and where necessary acid-resistance of potential sources of reclamation materials on or immediately adjacent to the site. Due to the significant cost associated with the excavation, processing (if necessary), transportation, and distribution of these reclamation materials, approximate haul distance and road grades between each potential closure material source and major closure area should be evaluated. This process will eliminate some potential sources from further consideration.

When the properties, volume, and viability of closure material sources are determined based on site inventories, material balance and costs should be improved and the results should be integrated into the closure planning process. The suitability of many of the existing on-site sources of durable rock riprap and gravels, acid-resistant drain rock, low-permeability clays, and other material have already been evaluated by Vista and others. However, the scope of these inventories will likely need to be expanded to address the volumes of materials needed for closure.

Material testing discussed previously and standard test references (e.g., ASTM) should be used to guide the analysis to assess the suitability of potential sources of durable rock riprap and gravels, acid-resistant drain rock, LPM, and other materials. Based on an initial assessment of materials contained in each potential cover source, representative material samples should be collected and the following material properties should be determined as appropriate for the intended use of the material.

Physical Parameters:

1) Particle size distribution (dry sieve and hydrometer for < 2-millimeter fraction);
2) Atterberg limits;
3) Specific gravity;
4) Compaction curve (i.e., Proctor curve);
5) Saturated hydraulic conductivity;
6) Consolidation – saturated hydraulic conductivity tests; and
7) SWCC (moisture release curves) tests.

Chemical Parameters:

1) pH (saturated paste and KCl);
2) Electrical Conductivity (saturated paste extract);
3) Bulk Density;
4) Organic Carbon;
5) Sodium absorption ratio;
6) Cation (Anion) Exchange Capacity;
7) Total Nitrogen;
8) Nitrate-Nitrogen;
9) Available Phosphorus;
10) Soluble cations (K, Ca, Mg, Na);
11) Exchangeable Bases (K, Ca, Mg, Na Fe, Mn, and Ti) and Aluminum; and
12) Acid Base Accounting (additional analysis may be necessary if net neutralization potential [NNP] < + 20 tonnes $CaCO_3$ equivalent/1,000 tonnes material or NPR (acid net neutralization potential) < 2).

Phase I of the LPM inventory was completed in late October and early November 2012 and included field work for the preliminary identification and characterization of LPM sources on-site and near Mt Todd. It is recommended that Phase II field work and associated analyses be completed in additional project study phases. Completion of Phase II would include estimates of the costs to deliver LPM to the mine and discussions regarding LPM material properties, estimated volumes, factors influencing the feasibility of accessing each source, and recommended LPM source selection.

5.7 Waste and Cover Material Erosion and Sedimentation Analysis

The erosion from tailings, waste rock, ancillary facilities, and closure covers should be evaluated to:

1) Predict soil loss from facilities during operations and following closure;
2) Develop and evaluate erosion and sediment control options; and
3) Predict the rate and magnitude of sediment loads to operational and closure stormwater drainage systems (ponds, channels, sumps, etc.).

Vegetation monitoring data should be collected for the existing reclamation test plots. These data and data from the characterization of waste and cover hydraulic properties may then be used as inputs to empirical or process-based erosion and sedimentation prediction models (RUSLE, Water Erosion Prediction Project (WEPP), Erodibility Index Method, SEDCAD, and others) for the evaluation of facility drainage designs, sediment management plans, and erosion and sediment control alternatives.

6. ESTIMATED CLOSURE COSTS

The estimated quantities (e.g., facility dimensions, material volumes, surface areas, disturbance footprints) for the reclamation of major facilities at Mt Todd are summarized in Table 4. Reclamation costs were estimated at a ± 15 percent level of accuracy based on present value costs based on the following:

1) Available mine plan and existing engineering and data presented in this Feasibility Study;
2) Geochemical testing and analysis program;
3) Estimates of environmental conditions throughout the mine-life;
4) NT Government mine closure and environmental protection regulations and guidelines;
5) Labor rates provided by Vista Gold;
6) Rawlinson's Australian Construction Handbook (2019 edition, costs scaled based on location factors);
7) Caterpillar Performance Handbook, Edition 40, January 2010;
8) Equipment Rates developed by RESPEC;
9) Vendor quotes;
10) Recent mine closure costing experience; and
11) Professional judgment.

Costs were also estimated for reclamation oversight, monitoring concurrent reclamation, monitoring final reclamation, maintenance, and contingency. Maintenance was estimated to be 10 percent of the direct costs by year and includes such costs as maintenance and rehabilitation of reclamation covers and vegetation, weed control, installation of additional erosion control devices, and maintenance of site roads during closure. Contingency was estimated to be 10 percent of the total project cost.

Based on the costing approach described above, the cost estimate for implementing this plan is summarized in Table 5, and includes closure of major facilities at Mt Todd. Additional information used to develop this cost estimate is provided in **Attachment 7**, including unit costs and quantities.

Passive water treatment installation and operation has been conceptually evaluated, as described in Appendix G to the Mt Todd Gold Project Prefeasibility Study Technical Report, and a provisional cost for construction and operations incorporated into this reclamation estimate.

No costs were included in this reclamation cost estimate for the following closure related items:

1) Selective handling of waste rock and the haulage of waste rock to the TSF 1 and 2 (covered under mining costs)
2) Construction of stormwater control structures (covered under stormwater costs);
3) Baseline studies and permitting (covered under environmental costs);
4) Security cost fees (covered under owners costs);
5) Active water treatment (during operations or during closure and post-closure) (covered under water treatment costs); and
6) Amendment of PGM with additional organic matter (not anticipated to be required).

A portion of the Project closure and reclamation has been addressed by others. Preliminary and provisional costs have been included in the financial model by others for each of these areas as follows:

1) Decontamination, decommissioning, and demolition of currently existing site structures, mills, processing areas, water treatment plants etc. down to the foundations, as well as disposal of all material and debris generated from these activities, has been evaluated and preliminary costs developed by

outside contractors. Demolition costs for facilities remaining following decontamination, decommissioning and superstructure demolition have been included and estimated in this Plan.

2) Operation of the water treatment plant during the closure period has not been evaluated in detail at this stage of study; however provisional costs have been developed based on the assumption that operations will continue for five years following cessation of operations. Annual operating costs during the five year period the plan will be run following operations have been assumed to equal annual operating costs during mine production.
3) Water treatment plant residuals handling or disposal has not been evaluated in detail at this stage of study; however a provisional cost has been included in the financial model.
4) Installation of surface water diversions and any site-wide surface water management has been evaluated and is discussed in detail in Appendix I (Water Balance Appendix).
5) Import of LPM has not been evaluated in detail at this stage of study; however a provisional cost has been included in the financial model based on preliminary investigations of nearby low-permeability borrow sources.
6) Handling of NAF waste rock and delivering NAF rock to features in quantities and at times required for reclamation has been evaluated by both Tetra Tech and RESPEC, and costs have been developed and included based on mine-owned equipment doing the work. These costs are presented as part of the operating costs for the pits, the two TSFs, and the WRD.

In accordance with regulatory requirements, a reclamation security will be required for the site. Calculation of security amounts will be conducted with the NT Security Calculation excel-based worksheet periodically throughout the mine life in accordance with regulatory requirements. Costs associated with reclamation security have been included as owners' costs in the technical economic model. As part of the RP, an estimate was developed of the Security Cost required for the project. In the NT, the government requires that a Security Cost calculation be performed prior to issuing a mining authorization to commence mining. This Security Cost calculation is used to assist in establishing the level of security required to ensure liabilities incurred by mining activities will be addressed. The NT government has specified that the Security Cost calculation must follow the excel workbook developed by the NT government and posted on the NT government website. The security that has been developed for the Mt Todd project has been developed in accordance with the NT Security workbook and associated guidance. The security calculation is reflective of the common mine site rehabilitation procedures and current rehabilitation costs included in the NT Security workbook as of the date of this document.

Security calculations developed include annual estimates for Yr -1 through Yr 17 based on the current 50K TPD Base Case mine plan and address activities required to close and rehabilitate each functioning facility planned for the Mt Todd project, including TSF1, TSF2, WRD, HLP, LGO2, Site Infrastructure and Process Plant area, Pit area, roads, decommissioning and post closure management, and post closure water management. The estimated annual security costs for project years -1 through 17 for the 50K TPD case Mt Todd project are summarized in Table 6. Additional information regarding the Security Cost estimate can be found in **Attachment 8**. The maximum liability occurs in project Yr 3, associated with full WRD footprint buildout and full TSF2 buildout. Liabilities generally decrease subsequently as the top surface areas of the WRD and TSFs requiring cover decrease as each of these facilities is constructed taller, and concurrent reclamation is completed (i.e., on WRD side slopes).

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TABLES

Table 1: Reclamation Approach

Task	Facility							
	Batman Pit	**WRD**	**HLP**	**TSF1 & TSF2 Impounded Surface**	**TSF1 & TSF2 Dams (Embankments)**	**Process Plant and Pad**	**LGO 2**	**Mine Roads**
Surface of Facility at Cessation of Production Composed of Non-PAF		X			X			
Final Overall Slopes > 3H:1V*	X	X			X			
Final Overall Slopes ≤ 3H:1V*			X	X		X	X	X
Benches Created During Construction	X	X			X			
Install minimum 1.0 meter-Thick NAF Material		X		X				
Install 0.8 meter-Thick Store and Release Cover				X	X			
Install 0.2 meter-Thick Plant Growth Medium (PGM) Cover			X	X	X	X	X	X
Revegetate with Native Seed Mix			X	X	X	X	X	X
Install geosynthetic liner system		X						
Install Erosion and Sediment Controls		X	X	X	X	X	X	X
Construct Access Restriction Bund	X							

** > and < indicates slopes are steeper and less steep, respectively.*
"X" indicates the reclamation approach task or characteristic listed under "Task" column applies to the facility listed in the subsequent columns
Additional Remedial Measures (as necessary) may be applied to each major facility.

Table 2: Reclamation Facility Status and Reclamation Schedule

Facility	Pre-Production (Years -2 and -1)	Production (Years 1 through 17)	Closure Phase (Years 18 through 20)	Post-Closure Phase (Years 21 through 24)	Post-Closure Phase (Years >24)
TAILINGS STORAGE FACILITY 1 (TSF1)					
TSF1 Top (Area of Impounded Tailings)	Inactive	Facility Active Begin Drain/ Install Wick Drains when tailings deposition complete	Continue dewatering and install cover/ reclaim facility till complete.	Reclaimed	Reclaimed
TSF1 Dam Face	Inactive/ Construct Dam Raise	Constructed Dam Raises / Reclaim as Practicable Final Reclamation when tailings deposition complete	Complete reclamation	Reclaimed	Reclaimed
TAILINGS STORAGE FACILITY 2 (TSF2)					
TSF2 Top (Area of Impounded Tailings)	Not yet constructed, no tails stored	Facility Active Begin Drain/ Install Wick Drains when tailings deposition complete	Continue dewatering and install cover/ reclaim facility till complete.	Reclaimed	Reclaimed
TSF2 Dam Face	Not yet constructed, no tails stored	Constructed Dam Raises / Reclaim as Practicable Final Reclamation when tailings deposition complete	Complete reclamation	Reclaimed	Reclaimed
HEAP					
Heap Leach Pad	Inactive	Leach Ore Re-Processed in Production Year 15 through 17	Footprint reclamation	Reclaimed	Reclaimed
PROCESSING PLANT AND PAD AREA					
Processing Plant	Constructed	Active	Demolish	Reclaimed	Reclaimed
Pad Area	Inactive / Upgraded	Active	Regrade / Install Cover / Reclaim	Reclaimed	Reclaimed
RP2 & RP5	Active	Active	Regrade / Install Cover / Reclaim	Complete reclamation	Reclaimed
Water Treatment Plant & Process Water Pond	Constructed	Active	Active	Demolish / Reclaim	Reclaimed

Facility	Pre-Production (Years -2 and -1)	Production (Years 1 through 17)	Closure Phase (Years 18 through 20)	Post-Closure Phase (Years 21 through 24)	Post-Closure Phase (Years >24)
BATMAN PIT					
Pit Access Berm	Nonexistent	Construct once pit excavated to full footprint	Reclaimed	Reclaimed	Reclaimed
WASTE ROCK DUMP					
Waste Rock Dump	Inactive	Active/ Concurrently Install geosynthetic liner and Reclaim Complete Final Cover Installation and Reclaim	WRD surface reclaimed	Reclaimed	Reclaimed
PASSIVE WATER TREATMENT					
WRD, TSF1 AND TSF2	Not yet constructed	Not yet constructed	Passive water treatment constructed concurrent with active water treatment	Passive water treatment ongoing	Passive water treatment ongoing
LOW GRADE ORE STOCKPILE 2 (LGO2)					
Low Grade Ore Stockpile	Not yet constructed	Active, processing completed by Year 16 / Reclaim as Practicable	Complete final reclamation	Reclaimed	Reclaimed
MINE ROADS					
Haul and Ancillary Roads	Inactive / Upgraded & Activated as Necessary	Active	Reclaim roads	Reclaim roads no longer used for active reclamation	Roads for monitoring and RWD access retained, other roads reclaimed

Table 3: Plant Growth Medium and Low Permeability Material Suitability Guidelines[1]

Suitability Parameter	Suitability Rating and Criteria			
	Good (G)	**Fair (F)**	**Poor (P)**	**Unacceptable (U)**
Saturation %	25 to 55	≥56 to 80	<25, >80	
pH	6.5 to 8.1	6.0 to 6.4, 8.2-8.5	5.5 to 6.0, 8.6 to 9.0	<5.5, >9.0
EC (mS/cm 25^0 C)	0 to 4	4 to 8	8 to 15	>15
SAR (Sodium Adsorption Ration)[a,b]	0 to 4	5 to 10	10 to 14	>14[a]
%$CaCO_3$	<15	15-30	>30	
Texture [c]	sl, l, sil, scl, sc, ls, lfs	cl, c, sicl, sc, ls, lfs	sic, s, sc, cos, fs, vfs	g, vcos
Total Organic Carbon	<10%			≥10%
Available Water Capacity[d]	>0.10, moderate	0.05 to 0.10, low	<0.05, very low	
K factor [e]	<0.37	0.37	>0.37	

[1] *Utah Oil Gas and Mining, October, 2005. Guideline for Management of Topsoil and Overburden R645-301-200 Soils - Table 4*
[a] *For clay textured soils unacceptable SAR > 14. For sandy textured soils unacceptable is >20.*
[b] *For most Western soils, the SAR to ESP relationship is usually 1:1, up to ESP ≈ 20. If SAR> 20, then determine ESP (Evangelou, 2000).*
[c] *s=sand, l=loam, si=silt, c=clay, v=very, f=fine, co=coarse, g=gravel*
[d] *Available Water Capacity is adjusted for texture and SAR*
[e] *K factor recommendations from the USDA Soil Conservation Service, 1978. National Soils Handbook Notice 24 (3/31/78). NSH Part II-403.6 (a). For prime farmland soils, the K factor times the percent slope should be a value of five or less for minimal erosion hazard.*

Low-Permeability Material Suitability Guidelines

Suitability Parameter	Suitability Criteria
Compacted Hydraulic Conductivity - $K_{(sat)}$	≤ 1 x 10^{-6} cm/second
Particles < 0.075 mm (i.e., very fine sand, silt and clay size particles)	> 20 percent by weight
Particles > 4.75 mm (i.e., gravel size particles)	< 10 percent by weight
Particles> 1 inch (i.e., coarse gravel size particles)	0 percent by weight

Table 4: 50K TPD Base Case Major Reclamation Quantities and Dimensions

Facility	Reclaimed Area (hectares)	Grading Volume (m^3)	Closure Cover Thickness (meters)	Total NAF Waste Rock and other Cover Material Volumes (m^3)	Total Store and Release Cover Volume (m^3)	Closure Cover LPM Volume (m^3)	Plant Growth Medium (PGM) (m^3)
TAILINGS STORAGE FACILITY 1 (TSF1)							
TSF1 Top (Area of Impounded Tailings)	194	0	Crowned cover variable thickness to create min 1% slopes, 0.8 m store and release cover, 0.2 m PGM	Crowned Cover: 6,520,000 Store and Release Cover: 528,000	1,554,000	1,025,000	388,000
TSF1 Dam Face (Embankment)	56	0	1.0 m (0.8 m store and release cover, 0.2 m PGM)	Store and Release Cover: 152,000	446,000	294,000	111,000
TAILINGS STORAGE FACILITY 2 (TSF2)							
TSF2 Top (Area of Impounded Tailings)	215	0	Crowned cover variable thickness to create min 1% slopes, 0.8 m store and release cover, 0.2 m PGM	Crowned Cover: 8,040,000 Store and Release Cover: 586,000	1,723,000	1,137,000	431,000
TSF2 Dam Face (Embankment)	89	0	1.0 m (0.8 m store and release cover, 0.2 m PGM)	Store and Release Cover: 241,000	709,000	468,000	177,000
HEAP							
Heap Leach Pad	39	195,000 m^3 materials removed 156,000 m^3 regraded	0.2 m PGM cover	-	-	-	78,000
PROCESSING PLANT AND PAD AREA							
Processing Plant Pad Area	38	380,000	0.2 m PGM cover		-	-	77,000
PWP, RP2 and RP5	1.4	146,000 m^3 to backfill ponds	0.2 m PGM cover (PWP only)	-	-	-	1,400
BATMAN PIT							
Pit Access Restriction Berm	-	49,000	-	-	-	-	-

Facility	Reclaimed Area (hectares)	Grading Volume (m^3)	Closure Cover Thickness (meters)	Total NAF Waste Rock and other Cover Material Volumes (m^3)	Total Store and Release Cover Volume (m^3)	Closure Cover LPM Volume (m^3)	Plant Growth Medium (PGM) (m^3)
WASTE ROCK DUMP							
Waste Rock Dump	291	0	Geosynthetic liner cover (Bedding Layer, Liner, Protective Layer, Erosion Control Layer)	NAF Waste Rock erosion cover: 2,800,000 Liner: 2,800,000 m^2 Liner under and overlayer geotextile: 5,700,000 m^2 (total)	-	-	-
LOW GRADE ORE STOCKPILE 2 (LGO2)							
LGO 2	51	153,000 m^3 gravels removed 102,000 m^3 regraded	0.2 m PGM cover	-	-	-	102,000
MINE ROADS							
Haul and Ancillary Roads	30	59,000	0.2 m PGM cover	-	-	-	59,000

Table 5: Reclamation Cost Estimate

Area	Cost[1]
Tailings Storage Facility 1 (TSF1)	$47,753,000
Tailings Storage Facility 2 (TSF2)	$61,361,000
Heap Leach Pad	$1,634,000
Process Plant and Pad Area	$17,156,000
Batman Pit	$369,000
Waste Rock Dump	$60,911,000
Low Grade Ore Stockpile 2 (LGO2)	$1,285,000
Soil Stockpiles	$473,000
Mine Roads	$674,000
Passive Water Treatment	$1,715,000
Maintenance and Monitoring	$11,046,000
Contingency	$20,049,000
Total Closure Cost	**$224,426,000**

[1] *Cost rounded to nearest $1,000 in current AUD.*

Table 6: Annual Security Cost Estimates (Base Case)

Year	Cost[1,2,3]
Year -1	$135,318,000
Year 1	$146,429,000
Year 2	$157,932,000
Year 3	$270,437,000
Year 4	$266,353,000
Year 5	$257,857,000
Year 6	$251,957,000
Year 7	$245,728,000
Year 8	$235,928,000
Year 9	$231,385,000
Year 10	$223,707,000
Year 11	$218,882,000
Year 12	$214,932,000
Year 13	$210,764,000
Year 14	$195,314,000
Year 15	$192,197,000
Year 16	$190,262,000
Year 17	$182,891,000

[1] *Cost rounded to nearest $1,000 in current AUD.*
[2] *Includes indirect costs associated with oversight of reclamation activities*
[3] *Cost excludes 10% discount and 1% levy discussed in NT Security Calculator*

FIGURES

TTP DOCUMENT CODE: 201645-DG-001

No	REF. DRG. No.	TITLE	REV	DRN	DATE	DESCRIPTION	CHK	DESN
			B	TMT	16.02.18	ISSUED FOR PFD - PGM STOCKPILE ADDED	ABS	BM
5	5200-DA-010	GATEHOUSE BUILDING FLOOR PLAN	C	MS	01.11.19	ISSUED FOR PRE-FEASIBILITY STUDY	TMT	BM
4	5200-DA-005	EMERGENCY SERVICES BUILDING FLOOR PLAN	D	CB	02.09.21	ISSUED FOR CLIENT REVIEW	SD	BM
3	5200-DA-001	ADMINISTRATION BUILDING FLOOR PLAN	E	SD	08.10.21	ISSUED FOR CLIENT REVIEW	SD	BM
2	2300-DA-003	HV WORKSHOP SITE PLAN	F	SD	20.12.21	ISSUED FOR FEASIBILITY STUDY	SD	DS
1	0000-XM-013	50KTPD PROCESS PLANT GA	G	SD	01.02.22	ISSUED FOR FEASIBILITY STUDY	SD	DS

CLIENT

VISTA GOLD

TETRA TECH PROTEUS
CONSULTING ENGINEERS • PROJECT MANAGERS
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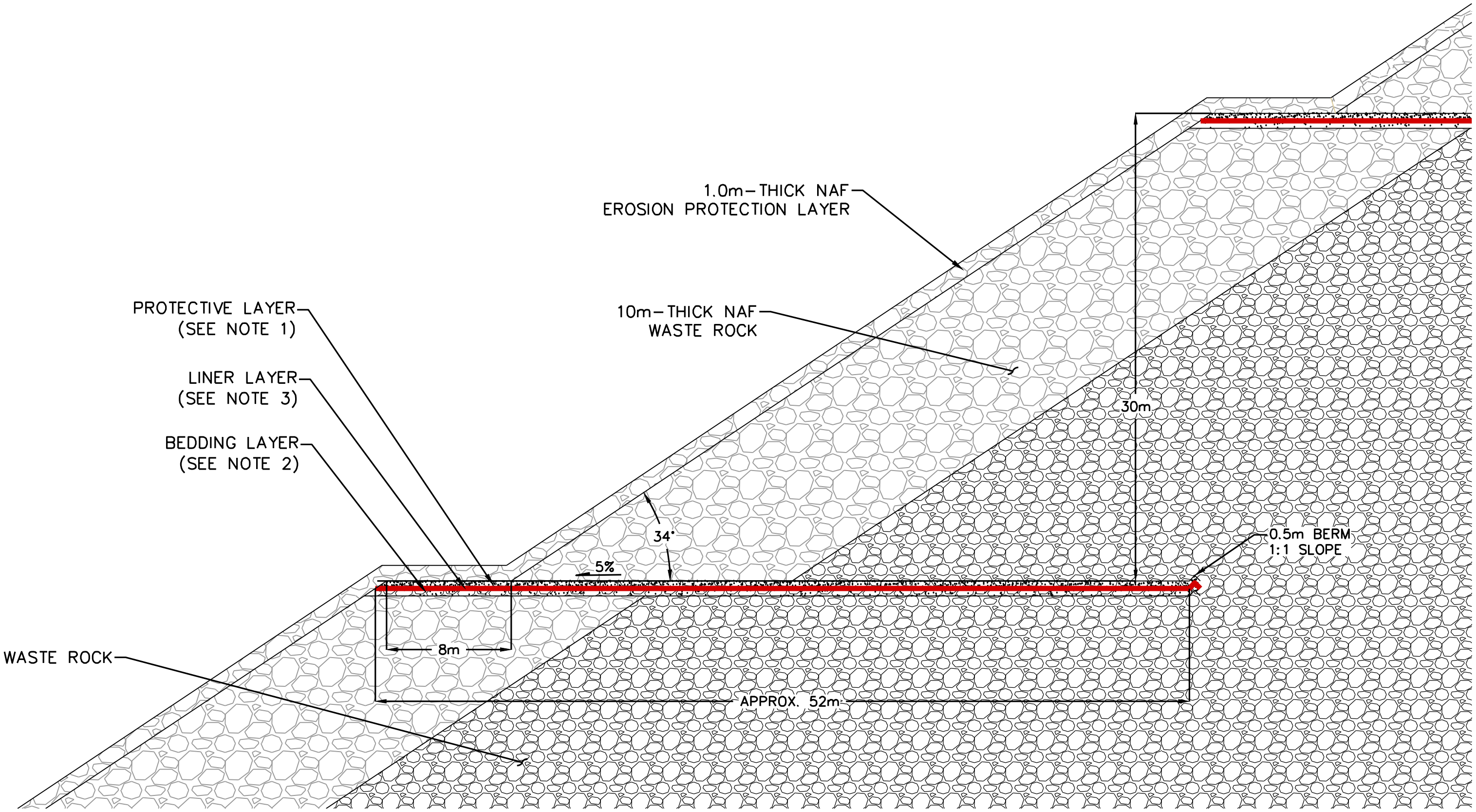
	BY	DATE
DRN	M.STENBECK	31.08.21
DCHK	S.DIXON	02.09.21
DESN	D.SCOTT	01.02.22
ECHK		
APP		

TITLE
VISTA GOLD AUSTRALIA PTY LTD
MOUNT TODD GOLD PROJECT
50 KTPD CASE
SITE PLAN

SCALE		DRG. No.		REV.
1:12500	A1	0000-XM-012	FIGURE 1	G

C:\ProjectWise\PW\CSWorking\230\309195_2\0000-XM-012.dgn
1/02/2022
1:18:00 PM



NOT TO SCALE

NOTES:

1. PROTECTIVE LAYER UNDER 1.0M THICK NAF EROSION PROTECTION LAYER TO BE A MINIMUM OF 0.3M THICK AND COMPOSED OF FINE-GRAINED NAF MATERIAL ADHERING TO THE LINER MATERIAL REQUIREMENTS OR GEOTEXTILE IF LINER MATERIAL IS LLDPE.

2. BEDDING LAYER UNDER THE LINER MATERIAL TO BE A MINIMUM OF 0.3M THICK AND COMPOSED OF FINE-GRAINED NAF MATERIAL ADHERING TO THE LINER MATERIAL BEDDING REQUIREMENTS OR GEOTEXTILE IF LINER MATERIAL IS LLDPE.

3. LINER MATERIAL LLDPE, GCL OR APPROVED EQUIVALENT. LINER MATERIAL PLACED ON EACH LIFT EXTENDING HORIZONTALLY TO A DISTANCE ADEQUATE TO REACH JUST BELOW OVERLYING BENCH.

Scale: As Shown
Designed by: AH
Drawn by: JS
Checked by: AH
Approved by: VS

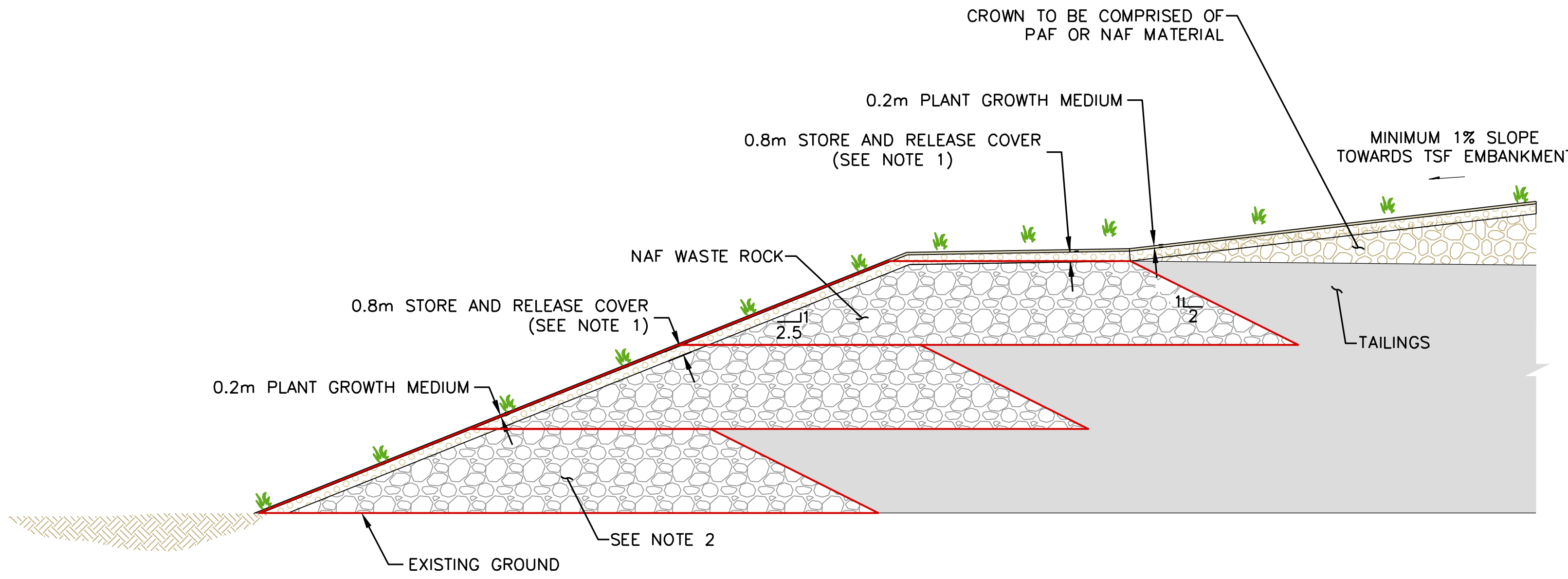
Issued for: VISTA GOLD

Issued by: TETRA TECH
350 Indiana Street, Suite 500
Golden, Colorado 80401
(303) 217-5700 (303) 217-5705 fax

FIGURE 2
WASTE ROCK DUMP GENERAL CLOSURE COVER DESIGN

REVISION 1

Project: MT. TODD GOLD PROJECT FEASIBILITY STUDY
Project no.: 117-8348002
Location: NORTHERN TERRITORY, AUSTRALIA
Date: 22/12/21
SHEET 2 OF 4



NOT TO SCALE

NOTES:

1. STORE AND RELEASE COVER COMPRISED OF A MIXTURE OF 66% CLAY-LIKE MATERIAL AND 34% NAF WASTE ROCK MATERIAL.
2. TSF2 DESIGN INCLUDES UPSTREAM EMBANKMENT RAISES. UPSTREAM RAISES SHOWN ARE CONCEPTUAL ONLY AND DO NOT REFLECT THE ACTUAL EMBANKMENT RAISE DIMENSIONS OR NUMBER OF RAISES.

Scale: As Shown
Designed by: AH
Drawn by: JS
Checked by: AH
Approved by: VS

Issued for:

VISTA GOLD

Issued by:

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Golden, Colorado 80401
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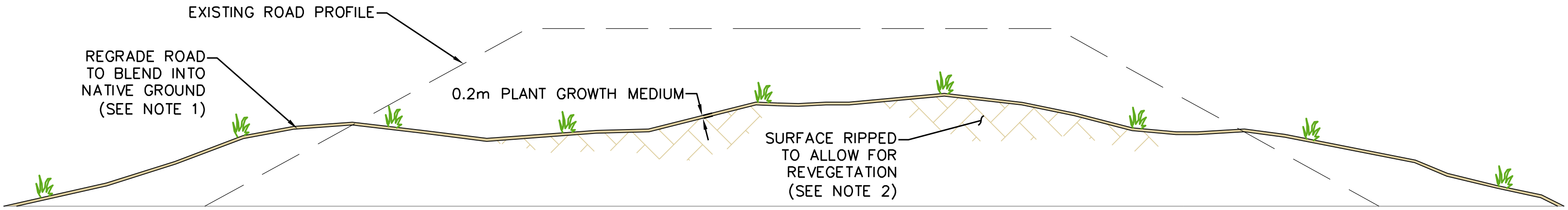
FIGURE 3
TAILINGS STORAGE FACILITY
GENERAL CLOSURE COVER DESIGN

1
REVISION

Project: MT. TODD GOLD PROJECT FEASIBILITY STUDY
Project no.: 117-8348002
Location: NORTHERN TERRITORY, AUSTRALIA
Date: 22/12/21
SHEET 3 OF 4



NOT TO SCALE

NOTES:
1. GRADING SHOWN REFLECTS ROAD CLOSURE IN PLACE. CUT SECTION AND FILL SECTION CLOSURES NOT SHOWN.

2. ROAD MATERIAL ASSUMED TO BE SUITABLE PLANT GROWTH MEDIUM FOLLOWING RIPPING OF MATERIAL TO REDUCE COMPACTION AND ENABLE ROOTING.

Scale: As Shown
Designed by: AH
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FIGURE 4
MINE ROADS GRADING AND GENERAL CLOSURE COVER DESIGN

REVISION 1

Project: MT. TODD GOLD PROJECT FEASIBILITY STUDY
Project no.: 117-8348002
Location: NORTHERN TERRITORY, AUSTRALIA
Date: 22/12/21

SHEET 4 OF 4

ATTACHMENT 1:
WRD Cover Trials Design and Monitoring Procedure

Cover Trials Design and Monitoring Procedure

Mt Todd Project – Waste Rock Dump

117-8348002

Revised for the Mt Todd Gold Project 50,000 TPD Feasibility Study – December 8, 2021

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ACRONYMS/ABBREVIATIONS

Acronyms/Abbreviations	Definition
ARD	Acid rock drainage
BPJ	Best professional judgment
DAS	Data acquisition system
dS/m	deciSiemens per meter
EIS	Environmental Impact Statement
GCL	Geosynthetic clay liner
GPS	Global positioning system
HDS	Heat dissipation sensors
LLDPE	Linear Low-Density Polyethylene
m	meter
m/s	meters per second
mg/L	milligrams per liter
mm	millimeter
MMP	Mine Management Plan
NAF	Non-Acid Forming
NTEPA	Northern Territory Environment Protection Authority
PAF	Potentially Acid Forming
QA	Quality assurance
QC	Quality control
SWCC	Soil Water Characteristic Curve
TDR	Time Domain Reflectometry
VWC	Volumetric water content
WRD	Waste rock dump

1. INTRODUCTION

This Cover Trial Procedure was originally developed in 2019 to provide Vista Gold Corp. (Vista) a plan to address a NTEPA recommendation by providing a cover trial design, instrumentation, and monitoring procedure for trial sections of the waste rock dump (WRD) where Vista's preferred WRD cover (i.e., petticoat cover) will be installed during concurrent reclamation.

This Cover Trial Procedure has been updated to reflect design updates to the waste rock dump (WRD) during the Mt Todd Gold Project 50,000 TPD Feasibility Study (2022). The locations of the WRD cover trials for the revised WRD design and monitoring equipment manufacturers, models and data acquisition systems (DAS) have been identified, which necessitated slight modifications to the layout of cover trial monitoring instrumentation. This procedure includes updates to trial design according to the modification discussed above, and descriptions of the methods used to estimate the cost of cover trial and instrument installation, which have been included as the last section of this report.

The Northern Territory Environment Protection Authority (NTEPA) Environmental Impact Statement (EIS) Recommendation No. 3 (reference http://www.mttodd.com.au/environmental-impact-statement.html) provided the following recommendation:

> "*The Proponent must undertake a rigorous evaluation of alternative WRD cover designs prior to authorisation of the Project. Modelling work underpinning the design of covers, and subsequent monitored trial covers, must demonstrate that the covers can meet the required cover objectives within the context of the wet- dry cycling environment of the Top End and other biophysical factors that have the potential to affect cover integrity in the long term. The modelling must be subject to rigorous peer review by an independent party with practical experience with the issues that affect the real world performance of the modelled cover system/s."*

Figure 1 shows the annual and final build-out configuration and layout of the WRD.

1.1 Preferred WRD Cover System

In previous studies, a series of WRD cover design alternatives were evaluated. The proposed steep side slopes of the WRD will prevent installation of a traditional cover, such as a store and release cover. It was determined that a cover system composed of a layer of synthetic liner (e.g., geosynthetic clay liner [GCL] or Linear Low Density Polyethylene [LLDPE]) placed on each 30 meter (m) bench was the preferred cover system approach to limit infiltration into the WRD. This cover system includes the following layers (from the bottom up):

- A bedding layer to protect overlying liner from puncture and damage (0.3 m thick fines for GCL, or 0.3m fines or geotextile for an LLDPE liner)
- Liner to act as a hydraulic barrier to limit percolation of meteoric water into underlying potentially acid forming (PAF) rock:
  - Typical GCL such as Elcoseal X1000 or Bentomat DN, or 1.5 millimeter (mm) LLDPE
  - Placed at 5% slope towards outer edge of WRD to direct drainage from interior areas to the outer edge of the WRD
  - Placed with 0.5 m high berm on interior edge of liner to prevent backflow of drainage into WRD
  - Approximate 52 m width of liner placed to provide liner overlap with liner coverage of overlying lift (wider in areas near the haul road)
- A liner protective layer to maintain the moisture content of and confining pressure on the underlying liner (if GCL) or to prevent puncture if LLDPE from overlying material or traffic (0.3 m thick fines for GCL, 0.3m fines or geotextile for LLDPE)

- 10 m thick non-acid forming (NAF) waste rock rind (placed on interbench slopes, not present on benches or WRD top) for the storage of meteoric water and generation of alkaline pore water to partially buffer acid generation and acidic pore water in underlying PAF waste rock
- 1.0 m thick NAF waste rock for erosion protection.

Figure 2 provides a conceptual typical section of the preferred WRD cover system.

1.2 Cover Trial Implementation – Proof of Concept

Through multiple engineering design and modeling exercises, the preferred cover design as described above was selected for the Project. This design is referred to as the petticoat option. As noted above the steep side-slope configuration of the WRD will prevent the installation of a more traditional cover design, such as a store and release cover over the entire waste rock surface, which has been tested over a wide range of wastes and environments. Therefore, the cover trial described in this report is intended to provide data that can be evaluated for the purpose of providing a proof of concept of the selected design.

The results of prior infiltration and seepage modeling work have shown that the petticoat design option resulted in a reduction in the infiltration rate compared to uncovered conditions. Runoff is also expected to increase by approximately 20% over the uncovered WRD. However, the WRD is predicted to produce seepage following closure. The quality of WRD seepage is predicted to be impacted by acid rock drainage (ARD). The preferred cover system is shown on **Figure 2** and is designed to limit the percolation of meteoric water into the WRD. The water that does enter the WRD is routed primarily through NAF rock material, thus limiting (but not eliminating) the ARD generated by the WRD that must be treated prior to release.

The cover trials will be monitored to determine how well the installed covers perform and how well the modelling simulated the field performance of the petticoat cover design. Over approximately three years of monitoring, the results from the cover trial will be compared to the modelling results and the performance of other covers placed over mine waste to support the proof of concept for the Mt Todd WRD closure cover.

2. COVER TRIAL PERFORMANCE OBJECTIVES

The primary goals of the cover trials at the Mt Todd Mine are:

1) Confirm the cover system performs in accordance with the WRD post-closure infiltration and seepage model simulations (Tetra Tech 2018); and

2) Support cover system design modifications if the cover system performance varies significantly from model simulations.

These goals will be met by collecting data regarding various components of the cover system water balance to compare with the results of the cover evaluation modeling. For example, the water content of the confining layer placed above the liner will be monitored as part of the cover trial. This data point will be compared to the water content results of the WRD modeling.

3. COVER TRIAL CONSTRUCTION PLAN

The siting, instrumentation, and additional sampling and monitoring planned for the cover trial areas are discussed in the sections below. Operational and construction managers at the Mt Todd mine will collaborate closely with the trial design engineers and monitoring team to ensure the cover trials are installed and monitored safely, early in the mine life, and in accordance with final cover trial design reports.

3.1 Siting

Cover trial locations on the WRD were selected to satisfy the siting objectives as follows:

1) Locate trials in areas which can be constructed early in the WRD life with minimal disturbance from ongoing WRD construction activities;
2) Locate trials in areas that represent the predominant topographic variability (e.g., slope face, bench, etc.) of the WRD following build-out;
3) Locate trials in areas that represent the range of climatic conditions expected to be encountered on the WRD; and
4) Locate trials in areas which allow for "nested" trials on slopes and benches for efficient use of instrumentation, worker effort, and to limit the potential for worker injury and instrument damage, which would increase if cover trials were installed at multiple locations across the WRD.

To select cover trial locations that satisfy these objectives the following information was assembled and evaluated:

1) WRD annual build-out plans – Construction Years -1 through Year 12 (**Figure 1**);
2) Area of dominant topography following WRD build-out – bench, slopes between benches (i.e. inter-bench slopes or inter-benches), and top surface (**Figure 1**);
3) Dominant WRD surface aspects (compass direction that a slope faces) following build-out **(Figure 3**); and
4) Wind rose (sum of wind speeds from any given direction) for the site (**Figure 4**).

Based on the evaluation of this information and consideration of trial instrumentations needs, worker effort and safety, and the potential instrument damage from waste rock disposal activities, the WRD cover trial locations were selected and are shown on **Figure 1.**

The cover trial locations selected allow trial construction and initiation of monitoring as soon as practicable. Construction and monitoring of the NW and SE cover trial locations can therefore begin during year 5 and 4, respectively, following initiation of renewed waste rock placement on the WRD, respectively. By initiating cover trial execution early in mining, opportunities will exist to modify WRD cover design based on trial monitoring results and to apply the modified design to unbuilt portions of the WRD (if necessary) (refer to Section 5.0).

Approximately 57, 29, 11 and 3 percent of the two-dimensional surface of the WRD following build-out will be comprised of inter-bench slopes, the WRD top, benches and access road, respectively (reference table on Figure 3). The cover trial locations selected, therefore represent the dominant surface topography of the WRD following build-out. As shown on **Figure 5,** the cover trial layouts at both the NW and SE cover trial locations will be "nested" or located in close proximity on inter-benches and adjacent downgradient benches.

As designed, the gradient of the inter-benches across the WRD is consistently 34^{o} (approximately 1.5(H):1(V)). This factor was therefore not considered an important siting factor as the majority of inter-benches will be at or near this slope gradient. In general, the geometry of inter-benches is rectilinear; however the WRD design does include concave and convex inter-bench slopes to a limited extent. These slope complexities may affect the potential for meteoric water to percolate through the preferred cover system; however, locating cover trials on complex slopes would confound placement of monitoring equipment and data interpretation, as well as require selection of an impractical number of cover trial locations. Locating trials on these complex inter-bench slopes was therefore consider impracticable and of limited value to the overall goal of a proof of concept of the overall cover design.

The cover trial locations on the northwest and southeast aspects of the WRD represent areas of the facility with the highest and lowest potential for net percolation of meteoric water through the cover system, respectively. As shown on the wind roses (**Figure 4**), the prevailing wind direction during the wet season at the Mt Todd Mine (i.e. October through March) are from the northwest. In addition, potential evaporation rates and relative humidity during the wet season are at their annual minimum and maximum, respectively (GHD 2013). The northwest aspect of the WRD is therefore expected to experience the greatest amount of precipitation during the wet season. In addition, the NW cover trial location will include construction and monitoring of a cover trial on a WRD bench. The benches are expected to receive runoff from the upgradient inter-bench slopes, thus increasing the potential for percolation of meteoric water though the cover systems. During the dry season, this location will also be subject to more intense solar radiation which is expected to result in a higher evaporation rate than other locations on the WRD.

Conversely, the prevailing wind direction during the dry season at the Mt Todd Mine (i.e. April through September) are from the southeast. In addition, potential evaporation rates and relative humidity during the dry season are at their annual maximum and minimum for the year, respectively (GHD 2013). The southeast aspect of the WRD is therefore expected to experience the least amount of precipitation during the period when potential evaporation rates and relative humidity are at their annual maximum and minimum, respectively. It is also expected to be the most protected location during the wet season, limiting the potential for percolation of meteoric water.

The combination of the northwest and southeast located cover trial areas provides a means to monitor the performance of the cover under the expected range of climatic conditions for the WRD. Locating a cover trial on top of the WRD is not proposed since the top surface of the WRD will not be complete until mining Year 16, however only minor amounts of waste rock are anticipated to be placed after Year 12. Adequate data should be obtained from the northwest and southeast cover trial locations to assess the performance of the preferred cover system placed on the top of the WRD.

3.2 Cover Trial Layouts

Cover trial layouts are shown in plan and profile on **Figures 5** and **6**. These figures also specify the number instruments to be installed and the approximate location, orientation, and dimensions of instruments and the DAS power supply and telemetry system to be installed. The locations, orientations and dimensions of each instrument are defined better than in previous versions of this report since instrument manufacturers, models and operating systems have been specified and costed, which are discussed in Section 6.0.

3.3 Instrumentation

Installation of cover trial instruments will occur simultaneously with waste rock disposal operations and installation of the cover system. The same instruments installed at the NW cover trial location will be installed at the SW cover trial location. Instrumentation will be installed to collect data on the temporal and spatial variability in volumetric water content (VWC) and matric suction above and below the interfaces of the preferred cover system layers as the contrasting material properties of these layers are expected to dramatically affect the vertical and lateral movement of meteoric water within the cover system. In addition, pore-water pressure at the top surface of the GCL or LLDPE liner will be monitored and the amount of meteoric water percolation below the preferred cover system (net percolation) will be monitored using lysimeters.

Instruments will be “nested” and co-located both inside and adjacent to the lysimeters to permit the measurement of multiple soil-water parameters at the same depths within the cover system and to assess the influences of the lysimeters on water content and movement within the cover system (if any). Surface runoff will also be measured from flumes located on inter-benches adjacent to where soil-water measurements are collected (i.e. Slope and

Bench Plots). This will limit the variability in climatic conditions encountered between the Slope and Bench Plots and surface runoff flume and also limit the amount of equipment needed to supply power to trial instruments and acquire data, as previously stated. A precipitation gauge will also be installed at each Bench Plot to monitor rainfall.

The locations of all instruments, including DAS, power and telemetry, surface runoff flumes, tipping buckets, and the alignment of connecting cables and drain pipes, etcetera will be recorded using a hand-held global positioning system (GPS). Warning signs will be installed at strategic locations on the WRD to notify workers and others of the location of trials plots and flumes to prevent damage to the cover trial plots. Signs will also be erected at and above the Slope and Bench Plots to define the lateral extent of underground and surficial instrument arrays and associated cables and lysimeter and flume drainage pipes.

The type and number of instruments used to measure the content and movement of meteoric water on and within the preferred cover system is briefly described below, along with instrument measurement principles, expected operational range, and accuracy or limitations. These descriptions were derived from commonly available literature sources, as well as scientific equipment manufacturers and distributors. The recommended manufacturers, models, and operating systems for the plot instrumentation is presented in Section 6.0. The frequency of soil-water and runoff measurements is discussed in Section 4.2.

Table 3-1: Cover Trial Instrumentation and Parameters to Monitor

Instrumentation	Parameter Monitored
Time Domain Reflectometry and Neutron Probe	Volumetric Water Content
Heat Dissipation Sensor	Matric Suction
Vibrating Wire Pressure Plate	Pore-Water Pressure
Lysimeter	Net Percolation (below the cover system)

3.3.1 Time Domain Reflectometry

In situ VWC of the fine-grained material layers within the preferred cover system will be measured indirectly using Time Domain Reflectometry (TDR). TDR is non-destructive automated method of measuring VWC that provides real-time results. The principles behind the measurement of VWC in soils and other fine-grained materials via TDR have been described in Zhan et al., (2001) as follows:

“An electromagnetic pulse discharged from the TDR travels along the rods and is reflected by the rod ends. The travel time, (T), to the end of the rods and back is dependent on the dielectric constant of the material surrounding the rods as follows:

$$T = \frac{2L}{V} = 2L * \frac{\sqrt{K}}{C}$$

*where L is the length of the wave guide, V is propagation velocity of the pulse, C is the velocity of light in free space (C=3*108 m/s), and K is the dielectric constant of the material. Water content is the principal contributor to the dielectric constant values. Topp et al. (1980) demonstrated that a relationship exists between the dielectric constant K and volumetric water content θ. It was found that K increases when θ increases. Nevertheless, solid constituents, such as clay and organic matter, and material bulk electric conductivity (EC) also affect the measurements. The manufactured TDR are quite uniform and do not need to be calibrated individually. However, sensor calibration must be conducted for each material because of constituent differences.”*

TDR will be calibrated by developing material-specific calibration curves in a laboratory that describes the relationship between dielectric constants and the VWC of each layer within the cover system (excluding the GCL or LLDPE liner). This will allow TDR measurements to be correlated to absolute values of VWC. The TDR s instrument specified (Campbell Scientific Model CS645) is not applicable for materials with electrical conductivities of greater than 5 deciSiemens per meter (dS/m) or dissolved solids in the soil water phase great than 100,000 milligrams per liter (mg/L) (MEND, 2004). The expected operational range of the TDR (assuming the aforementioned salinity and dissolved solids conditions are not exceeded) will vary according to calibration method; however, the accuracy of TDR measurements is expected to be within 1 or 2% of actual VWC (Sumner, 1999).

At each cover trial location, 16 TDR probes will be installed as shown on **Figures 5** and **6**. The probes will be connected via coaxial cables (that will be buried for protection and safety) to two DASs which include solar power supply, a cellular antenna and a mounting pole with a lighting protection kit . Data will be downloaded via an internet-based modem for web-based access.

3.3.2 Neutron Scatter

In situ VWC of the coarse-grained material layers within the cover system will be measured indirectly using the neutron scatter method, as TDR is not an appropriate for measuring VWC of coarse-grained materials such as the waste rock generated at the Mt Todd Mine. The VWC of the fine-grained material layers within the cover system will also be measured indirectly using the neutron scatter method. These data will be compared to VWC data measured via TDR, to assess the validity and accuracy of the TDR data.

The principles behind the measurement of VWC in soils via neutron scatter method have been described in Sumner, (1999) as follows:

> *"This (*neutron scatter*) is a nondestructive but indirect method commonly used for repetitive field measurement of volumetric water content. It is based on the propensity of* (hydrogen) *H nuclei to slow (thermalize) high energy fast neutrons. A typical neutron moisture meter consists of: (1) a probe containing a radioactive source that emits high energy (2-4 MeV) fast (1600 km* s^{-1}*) neutrons, as well as a detector of slow neutrons; (2) a scaler to electronically monitor the flux of slow neutrons; and optionally (3) a datalogger to facilitate storage and retrieval of data. The radioactive source commonly contains a mixture of* ^{241}*Am and Be at 10 to 50 mCi. The* ^{241}*Am emits β particles which strike the Be and cause emission of fast neutrons.*
>
> *When the probe is lowered into an access tube, fast neutrons are emitted radially into the soil where they collide with various atomic nuclei. Collisions with most nuclei are virtually elastic, causing only minor loss of kinetic energy by the fast neutrons. Collisions with H nuclei, which have similar mass to neutrons, cause a significant loss of kinetic energy and slow down the fast neutrons [consider a marble (neutron) colliding with a similarly sized ball bearing (H nucleus) versus a stationary bowling ball (larger atomic nucleus)]. When, as a result of repeated collisions, the speed of fast neutrons diminishes to those at ambient temperature (about 2.7 km* s^{-1}*), with corresponding energies of about 0.03 eV, they are called thermalized or slow neutrons. Thermalized neutrons rapidly form a cloud of nearly constant density near the probe, where the flux of the slow neutrons is measured by the detector. The average loss of the neutrons' kinetic energy, thus the relative number of slow neutrons, is therefore proportional to the amount of H nuclei in the surrounding soil. The primary source of H in soil is water; other sources of H in a given soil are assumed to be constant and are accounted for during calibration. Although several non H substances including C, Cd, Bo, Cl, and Li which may be present in trace amounts in some soils may also thermalize fast neutrons, these may generally also be effectively compensated through soil specific calibration.*
>
> *Calibration of the neutron probe is thus required to account for background H sources and other local effects (soil bulk density, trace neutron attenuators), and is conveniently achieved by paired measurements of soil water content and neutron probe counts."*

A single neutron probe dedicated to cover trial monitoring will be calibrated by developing material-specific calibration curves in a laboratory that describes the relationship between neutron count ratio and VWC of each layer within the cover system (excluding the GCL or LLDPE liner). VWC will be measured manually using a single neutron probe and recorded. As shown on Figure 6, each cover trial location will include four access tubes to allow the measurement of VWC at multiple depths, including at the depths and approximately locations where VWC will be measured by TDR. As the neutron scattering method is not appropriate for measuring VWC in near-surface soil due to neutron-escape (Sumner, 1999), the minimum depth within the cover system where accurate readings can be obtained must be determined. Other limitations or disadvantages of the neutron scatter method include the radiation hazard and associated licensing requirements and relatively poor (and uncertain) spatial resolution.

3.3.3 Heat Dissipation Sensors

In situ matric suction of the fine-grained material layers within the cover system will be measured indirectly using Heat Dissipation Sensors (HDS), however it is not practical to measure matric suction within coarse-grained materials such as the waste rock generated at the Mt Todd Mine. The principles behind the measurement of matric suction in soils via HDS have been described in Sumner, (1999) as follows:

> *"The rate of heat dissipation in a porous medium is dependent on specific heat capacity, thermal conductivity, and density. The heat capacity and thermal conductivity of a porous matrix are affected by its water content, and hence related to its matric potential. Heat dissipation sensors contain line- or point-source heating elements embedded in a rigid porous matrix with fixed pore space. The measurement is based on applying a heat pulse by passing a constant current through the heating element for a specified time, and analyzing the temperature response measured by a thermocouple fixed at a known distance from the heating source (Phene et al., 1971; Bristow et al., 1993). Sensors are individually or uniformly calibrated in terms of heat dissipation versus sensor wetness (i.e., matric potential). With the heat dissipation sensor buried in the soil, changes in soil matric potential result in a gradient between the soil and the porous matrix that induces a water flux between the two materials until a new equilibrium is established. The water flux changes the water content of the porous matrix which, in turn, changes the thermal conductivity and heat capacity of the sensor. In this manner, the measured thermal response of the sensor may be related to soil wetness. A typical useful matric potential range for such sensors is -10 to -1,000 kPa."*

A calibration curve will be developed for each HDS installed in the cover system as the rigid porous matrix (e.g. ceramic block) in each HDS is unique. Calibration of HDSs to the materials in which they will be installed is not necessary. While Sumner (1999) states the operation range of HDS at -10 to -1,000 kPa, others report a calibration range of -400 to -293,000 kilopascals (kPa) (MEND, 2004); therefore, matric suction measurements well below -1,000 kPa should be possible for the Mt Todd cover trials.

At each cover trial location 16 HDSs will be co-located with TDRs, as shown of Figures 5 and 6. The HDSs will be connected to the DASs and power supply in a manner that is similar to that described for the TDRs. As with the TDRs, data will be downloaded remotely via a modem.

3.3.4 Vibrating Wire Pressure Plate

The GCL or LLDPE liners within the preferred cover system are intended to function as a hydraulic barrier to limit percolation of meteoric water into underlying PAF rock. As such, vibrating wire pressure plate will be installed at the base of the protective layer above the GCL or LLDPE liner to continuously monitor the development of positive pressure on the liner. As most vibrating wire pressure plate are factory calibrated, no additional calibration is anticipated to be necessary.

At each cover trial location four vibrating wire pressure plates will be located on top of the GCL or LLDPE liner as shown on **Figure 6**. The pressure plates will be connected to the HDS DAS power supply and cellular antenna. As with the TDRs and HDSs, data will be downloaded remotely via a modem.

3.3.5 Lysimeters

Net percolation of meteoric water, also known as infiltration, will be monitored through the placement of lysimeters at the Slope and Bench Plots that will extend approximately three meters vertically from immediately above the GCL or LLDPE liner protective layer to the PAF waste rock below the GCL or LLDPE bedding layer (see **Figure 6**). Lysimeters are constructed such that the materials in the lysimeter are the same hydraulically as the surrounding material, but they are placed within a nonpermeable container, such as a barrel or tank. Water is able to enter the top portion of lysimeter, and as the water percolates downward through the rock contained in the lysimeter it is funneled to a drainage pipe located at the base of the structure. The water in the drainage pipe will flow to a monitoring station along the WRD slope face that contains a tipping bucket. The amount of water collected in the lysimeter will be measured and used to evaluate the amount of infiltration that is occurring above the liner and the amount of water passing through the liner into the underlying waste rock.

The hydraulic conductivities of undamaged GCL or LLDPE liners are on the order of 10^{-11} to 10^{-15} meters per second (m/s). Infiltration through these liners is therefore primarily related to manufacturing defects, poor connections between panels, and holes from sharp objects such as angular rocks or stretching and tearing due to differential settlement of subgrade materials. The rate of leakage through these defects and punctures is driven by the buildup of positive pressure (i.e. ponding) on damaged liner. The effects of liner punctures and pore-water pressure on liner leakage rates will therefore be tested empirically by deliberately puncturing the portions of the liner installed within the lysimeters. The frequency and size of these intentional punctures will be determined through discussions with liner manufacturers.

Pressure head on the liner within (and adjacent to) the lysimeters will be monitored by installing vibrating wire pressure plates and measuring pressure head on the liner as described previously. TDRs and HDSs will be located both inside and adjacent to the lysimeters to assess the influences of the lysimeters on water content and movement within the cover system (if any) as described earlier. The measured pressure head above the liner and measured leakage will assist in refining estimates of cover infiltration rates caused by over liner defects and punctures. Two lysimeters will be installed at both the NW and SE cover trial locations. One will be placed at the Slope Plot toward the interior of the WRD, so that it is under the inter-bench slope. This location will measure the infiltration that is occurring along the WRD slopes and passing through the protective NAF rind and encountering the liner at the base of the lift. The second location will be placed on the WRD bench (i.e. Bench Plot), where the travel distance through the protective NAF layer to the liner is the smallest. The two plot locations will provide information not only on the water that is percolating into the WRD, but also will provide some indication of the expected travel times and lags that may occur in different portions of the WRD.

The lysimeters and the tipping bucket measurements will be monitored continuously through a battery powered data logger. Data will be downloaded manually via direct connection to a datalogger. Percolation data will be downloaded according to precipitation monitored via the precipitation gauge located on the Bench Plots.

3.4 Additional Sampling and Monitoring

In addition to the monitoring of the cover trial area instrumentation, evaluation of the surface runoff, site meteorological data, and cover material properties will be required to comprehensively evaluate cover performance and compare actual cover performance to that predicted in the cover design models.

3.4.1 Surface Runoff

The volume of runoff from inter-bench slopes of the WRD will be measured by installing runoff flumes adjacent to the Slope and Bench Plots at the NW and SE cover trial locations. As shown on **Figures 5** and **6**, the runoff flumes will extend the entire WRD inter-bench slope. Large flumes such as these should capture the complex processes that affect runoff from WRD slopes, which will allow the data collected from these flumes to be compared to the WRD post-closure infiltration and seepage model simulations. In addition, it is anticipated that runoff data will be coupled with precipitation data collected over the trial period and analyzed to improve the design of the post-closure WRD stormwater management system.

Steel plates will be installed to extend vertically above and within the NAF erosion protection layer of the preferred cover system. The height to which the steel plates extend above the surface of the erosion protection layer and sizing of the runoff collection and measurement system will be determined by estimating runoff volumes and depths within the flumes based on protective layer runoff properties and the predicted probable maximum precipitation event at the Mt Todd property. Steel plates will be adequately welded to eliminate surface run-on from entering the flume. As such, the surface runoff volumes will be measured from a known surface area and slope gradient of the WRD. At the base of the flume a weir (or similar structure) will be install and connected to an adequately size drainage pipe, which will convey surface runoff from the flume to adequately-sized tipping buckets for measurement of surface runoff in a manner that is similar to that described for measuring net percolation of meteoric water reporting to the lysimeter.

At each cover trial location one surface runoff flume and runoff collection and conveyance system will be located on an inter-bench adjacent to the Slope and Bench Plots. In addition, one tipping bucket system and battery-powered data logger will be located on the bench down-gradient of the flume to measure runoff volumes. Data will be downloaded manually via direct connection to a datalogger. Surface water runoff data will be downloaded according to precipitation monitored via the precipitation gauge located on the Bench Plots.

3.4.2 Meteorological Data

Meteorological data will be collected throughout the trial period at an on-site meteorological station and precipitation data will be collected at each Bench Plot. Historically, meteorological stations have been located on site at RP1 and RP7. During the cover trial monitoring period, the existing meteorological station located on site at RP1 will be used to measure representative precipitation (total daily), temperature (maximum daily and minimum daily), wind speed (maximum daily and average daily), wind direction (daily), and pan evaporation (daily) and precipitation data collected at each Bench Plot will be correlated to precipitation data collected at RP1. These parameters are those used in the modeling. The meteorological data set developed for cover trial monitoring will be compared to the data set used in the cover modeling, as well as the site wide water balance. Significant differences between the measured dataset at the site and Bench Plots, and that used in the model may make it necessary to update the modeling after the cover trial is complete.

3.4.3 Cover Materials

Prior to and during trial construction, samples of the materials used to construct the cover system will be collected and subjected to laboratory analysis. The laboratory analysis performed on cover system materials may include one or more of the following: particle size distribution, specific gravity, slake-durability, saturated hydraulic conductivity, and soil water characteristic curve (SWCC). It may be necessary to crush samples collected from the waste rock portions of the preferred cover before testing can be completed as it is expected that these materials will have a large particle size. In addition, not all test methods mentioned above may be appropriate for the waste rock used in the cover trial; however, it is anticipated that these tests can readily be applied to the fines layers above and below the GCL or LLDPE. The test data will be used to refine the modeling input parameters for the cover design modeling during updates completed after the completion of the cover trial.

For TDR and neutron probes, and HDS to function properly material-specific calibration curves must be developed to accurately measure VWC and matric suction, respectively. Therefore, the LLDPE protective and bedding layers will be calibrated with the TDRs/HDSs, and these layers, as well as the NAF waste rock and erosion protection layer with be calibrated with the neutron probe.

3.5 Cover Trial Construction Reporting

Following installation of the cover trials, as-built drawings and a construction report will be prepared by Vista. Variations from the detailed design reports will be documented, as necessary, and the effects on the capacity to adequately measure water movement in and through the cover trials will be presented.

4. MONITORING PLAN

4.1 Monitoring Constituents

As described in Section 3.0, monitoring will be conducted for the following constituents:

1) Material properties
   a) Particle size distribution, specific gravity, slake-durability, saturated hydraulic conductivity, and SWCC, (as applicable) for the underlying PAF material, GCL or LLDPE liner underlayer and overlayer, NAF rind, and NAF erosion protection layer.
   b) VWC and matric suction calibration curves for LLDPE protective and bedding layers and the NAF waste rock and erosion protection layers (as applicable).

   Samples for these analyses and instrument calibration to specific materials will be collected during cover trial construction
2) Meteorological data (precipitation, temperature, etc.)
3) Surface runoff quantities and runoff test cell areas
4) *In situ* VWC
5) Matric Suction
6) Pore-water Pressure
7) Infiltration (net percolation)

4.2 Monitoring Frequency and Duration

VWC by TDR and matric suction and pore-water pressure will be collected at 15-minute time steps, while percolation through lysimeters and surface runoff from the flumes will be measure according to flow rates.; This frequency of data collection was selected because of the rapid time of runoff concentration in the area and the frequency of high intensity and long-duration precipitation events. As stated previously, automated DASs will be installed at each cover trial location. This will allow for monitoring of events and the cover performance as storms occur, as well as after the precipitation event cease. Ultimately, the frequency of data collection will need to be selected so the data set is dense enough to capture changes due to precipitation events.

The manual measurement of VWC using the neutron scattering method will be completed initially on a weekly basis. During the wet season manual VWC measurements will also be collected, when possible, immediately prior to and following precipitation events. VWC will likely be manually measured more frequent during the first one or two years following cover trial installation and according to VWC data collected via TDR. It is anticipated that as the characteristics of runoff from, infiltration into and percolation through the petticoat cover is better understood, the frequency of manual VWC measurement via neutron probe will gradually decrease.

Monitoring of the NW and SE cover trial locations will be conducted for a minimum of three years. The duration of monitoring may be extend depending on the data obtained from the trials.

4.3 Data Collection Plan

Vista's Environmental Quality Assurance / Quality Control (QA/QC) staff will collect data from the cover trial locations at the frequency defined in the Mine Management Plan (MMP). The data collection will be one of the core duties of the staff to ensure accurate and comprehensive data collection and to ensure data is not being lost. As part of operations and maintenance planning for the cover trial locations, following detailed design and in concert with construction, a detailed data collection plan will be developed to ensure the required data is collected at the appropriate frequency from the Slope and Bench Plots and runoff flumes, and the on-site meteorological station and Bench Plot precipitation gauge. The data collection plan will also identify data quality review steps that will be taken to ensure appropriate data quality for use in cover performance evaluations and to identify instrumentation issues (if any) are occurring that will require maintenance to address data quality issues.

4.4 Data Evaluation

The design of the WRD closure cover system was developed through modelling simulations of the cover performance under average climatic conditions. The results of the modelling provide a point of reference for the measurements being collected as part of the cover trials presented in this report. Data from monitoring the cover trial instrumentation is not expected to match up exactly to the modelling results, but should show a similar level of performance over time.

The moisture content and matrix suction of the fines layer above the GCL or LLDPE liner, GCL or LLDPE liner leakage rates, surface runoff rates, and the infiltration or percolation rate will be the key parameters used to evaluate the performance of the WRD cover system. If the data collected from the cover trials is significantly different than the modelling results, additional evaluation will be completed to determine what may be the source of the discrepancy. The differences are likely to be related to the construction of the cover trial testing configuration, the material properties used in the modelling, or significant differences in the climate conditions during the trial period of performance versus that used in the modelling.

4.5 Data Reporting

Cover trial data reporting will be conducted annually as part of the MMP reporting to regulatory agencies. Annual reporting is anticipated to include a summary of the critical findings from the cover trial monitoring over the year, including a comparison of actual cover performance to anticipated performance of the cover as identified in the cover model. Cover performance issues will be identified, and follow-up actions outlined to confirm findings and address deficiencies, if applicable.

5. CONTINGENCY COVER MODIFICATION OPPORTUNITIES

Vista plans to concurrently reclaim the WRD as each 30 m lift is added to the WRD height. This approach affords Vista the opportunity to adjust the WRD cover approach should the results of the cover trials indicate that the cover is not performing as anticipated. If the preferred cover does not limit infiltration of meteoric water as predicted or other issues are noted, subsequent covers installed on the WRD can be modified to address these issues to improve cover performance. Prior to implementing a modified cover approach, an analysis will be performed to identify the core reasons cover performance deviated from the anticipated performance (i.e., difference in material properties, issue with installation, issue with model calibration, etc.). Based on this analysis, the WRD post-closure infiltration and seepage model will be updated according to cover trial data, observations, and overall cover system performance. The updated model will be used to simulate the performance of alternative cover systems to develop a revised cover design(s) that address cover performance issues observed during the trials, if applicable.

Potential modifications to cover approach could include, but are not limited to:

- Adjust cover system installation procedures (if installation issues determined to be cause of issue)
- Use alternate liner material to provide increased resistance to infiltration
- Increase the length of GCL or LLDPE liner overlap between the 30 m lifts
- Modify GCL or LLDPE liner underlayer or overlayer material properties
- Increase the thickness of one or more liner system layers (underlayer, overlayer, NAF rind, NAF erosion control layer)

Additional cover trial locations could be installed to demonstrate that modified covers adequately address the cover performance issues identified during the initial cover trials.

6. COVER TRIAL COST ESTIMATION METHOD

Tetra Tech solicited informal (non-binding) price quotes (bids) from instrument and equipment suppliers located in Australia and the United States of America (USA). Instrument and equipment prices were also obtained via the worldwide web. Bidder solicitations were sent by Tetra Tech and bidders submit non-binding bids to Tetra Tech, via email, between October 11 and 19, 2021. During this same time, instrument and equipment information and prices available on the world wide web (Web) were accessed. The type, company and contact information, and date of non-binding bids submitted by the solicited suppliers and/or prices accessed via the web are summarized in **Table 6-1**.

Table 6-1. Non-binding Bid and Web Price Information

Instrument/ Equipment	Company	Location	Contact Name	Contact Phone	Contact Email or Web Address	Non-Binding Bid Submittal or Web Access Date
TDR System **HDS System (incl. Precipitation Gauge)**	Campbell Scientific Australia	Garbutt, QLD Australia	Grant Mathew	+61 (0)7 4401 7700	info@campbellsci.com.au	Nov 18, 2021
Lysimeter	Texas Metals Tanks	Dripping Springs, TX, USA			https://www.texasmetaltanks.com/sizes-pricing/	Nov 17, 2021
Vibrating Wire Pressure Plate	Geomotion	Yarraville,VIC Australia	Audrey Dussel	+61 447 859 066	Audrey.dussel@geomotion.com.au	Nov 17, 2021
Neutron Probe	Instrotek Companies	Research Triangle Park, NC USA	Anthony J Caito	919 875 8371	acaito@instrotek.com	Nov 16, 2021
Tipping Bucket Flow Gauge	Unidata Pty Ltd	O'Connor, WA Australia	Kevin Chung	+61 89331 8600	k.chung@unidata.com.au	Nov 17, 2021
Materials- Specific Sensor Calibration	GeoSystems Analysis Inc.	Tucson, AZ USA	Mike Yao	520 628 9330	myao@gsanalysis.com	Nov 18, 2021

Neutron probe access tube and steel plating for the surface water runoff flume were obtained from the RSMeans National Average Cost database for the 4th Quarter 2021.

Location, and shipping, GST, local tax and handling factors were applied to non-binding bids and Web prices. Currency conversions were applied as appropriate to non-binding bids obtained from suppliers to the USA. No other escalation factors or discounting were applied to bids or Web prices.

Tetra Tech's estimate of probable unit costs for the cover trial construction were based on the following:

Earthworks

- Civil unit rates provided by Tetra Tech Proteus in Document Number 201645-LC-001D, Unit Rate Codes: 4.6, 6.1, 6.2, 9.1, 12.7, and 14.1.
- Run-on Diversion Ditch Excavation and Installation - provided by Tetra Tech Proteus in Document Number 12240-LC-011A, Unit Rate Code 7.2.
- Specialty Earthworks and Productivity factors applied civil unit rates as follows:
  - Backfill lysimeter to avoid damage and dislodging of lysimeter and damage to neutron probe access tube. Five times backfilling base cost.
  - Place and spread liner underlayer fines to avoid damage and dislodging of lysimeter, damage to sensors access tube and their wiring. Five times liner underlayer placement base cost.
  - LLDPE liner overlap, welds in/outside of lysimeter, seam testing, and booting to prevent preferential flow and to avoid damage and dislodging of lysimeter, access tubes, sensors and their wiring. Five times liner placement base cost.
  - Place and spread overlayer fines to avoid damage and dislodging of lysimeter, damage to neutron probe access tube and TDRs, HDSs, pressure plates and their wiring. Four times liner overlayer placement base cost.
  - Place NAF Erosion Protection Layer on Bench Plot to avoid damage and dislodging of lysimeter, access tubes, and sensors and their wiring. Two times NAF Erosion Protection layer placement base cost.
  - Place NAF Waste Rock to avoid damage and dislodging of lysimeter, access tubes, sensors and their wiring. Four times NAF Waste Rock placement base cost.
  - Place NAF Erosion Protection Layer on Slope Plot to avoid damage and dislodging of access tube, and sensor wiring. Three times NAF Erosion Protection Layer placement base cost.

Pipe Work

- Lysimeter and Surface Water Runoff Flume – Rawlinson's Australian Construction Handbook, Edition 37, 2019. Page 500 see '*Drainage, stormwater drains, polyethylene, HDPE, steel reinforce polyethylene (SRP) pipe with rubber ring gasket joints. Prices for pipework include for laying and jointing in trench but exclude excavation and backfilling*'.

Trial Instrumentation and Equipment Installation

- Mined Owned Equipment & Labor Cost (based on equipment and labor costs provided by Respec, 2021)
- Specialty Activities and Derived Crews (based on Best Professional Judgement- BPJ) as follows:
- Control box stand and tower Crew: 0.2- Maintenance Foremen; 1- Servicemen; 0.1- Mine Surveyor.

Instrumentation Technical Support

- 80 hours of Systems Engineer support at $160 (AUD) (based on BPJ)

Tetra Tech's estimate of cover trial quantities were derived base on the dimensions identified on **Figures 5** and **6**, an assumed surface water runoff flume length and width of 16 and 10 meters, respectively and BPJ regarding the following:

- Additional trench excavation length and width necessary to permit worker safe access to install instrumentation;
- Lysimeter and drainage pipe sand bedding thicknesses;
- Thickness of lysimeter basal drain (sand bedding); and
- Area where specialty installation of liner underliner fines or geotextile, LLDPE liner, liner underliner fines or geotextile, NAF erosion protection layer within the Bench and Slope Plots, NAF waste rock would be necessary.

The percentages direct cost attributed to indirect cost were as follows:

- Mobilization / Demobilization = 10%
- Additional Contingency = Applied to overall Tetra Tech's reclamation and closure cost estimate
- Engineering = 10%
- Construction Administration and QA/QC = 15%

Tetra Tech assumed cover system monitoring, maintenance and reporting would be conducted by mine environmental personnel, therefore system monitoring, maintenance and reporting costs were not included in Tetra Tech's cost estimate for the WRD cover trials.

7. REFERENCES

GHD 2013. Mt Todd Gold Project, DRAFT ENVIRONMENTAL IMPACT STATEMENT, Volume I, GHD Group Pty Ltd, June 2013.

Mine Environment Neutral Drainage (MEND), 2004. Design, Construction and Performance Monitoring of Cover Systems for Waste Rock and Tailings, Volume 4 – Field Performance Monitoring and Sustainable Performance Of Cover Systems (Mend 2.21.4d), Prepared for MEND, Funded by INCO Ltd. Edited by: O'Kane Consultants Inc., July 2004.

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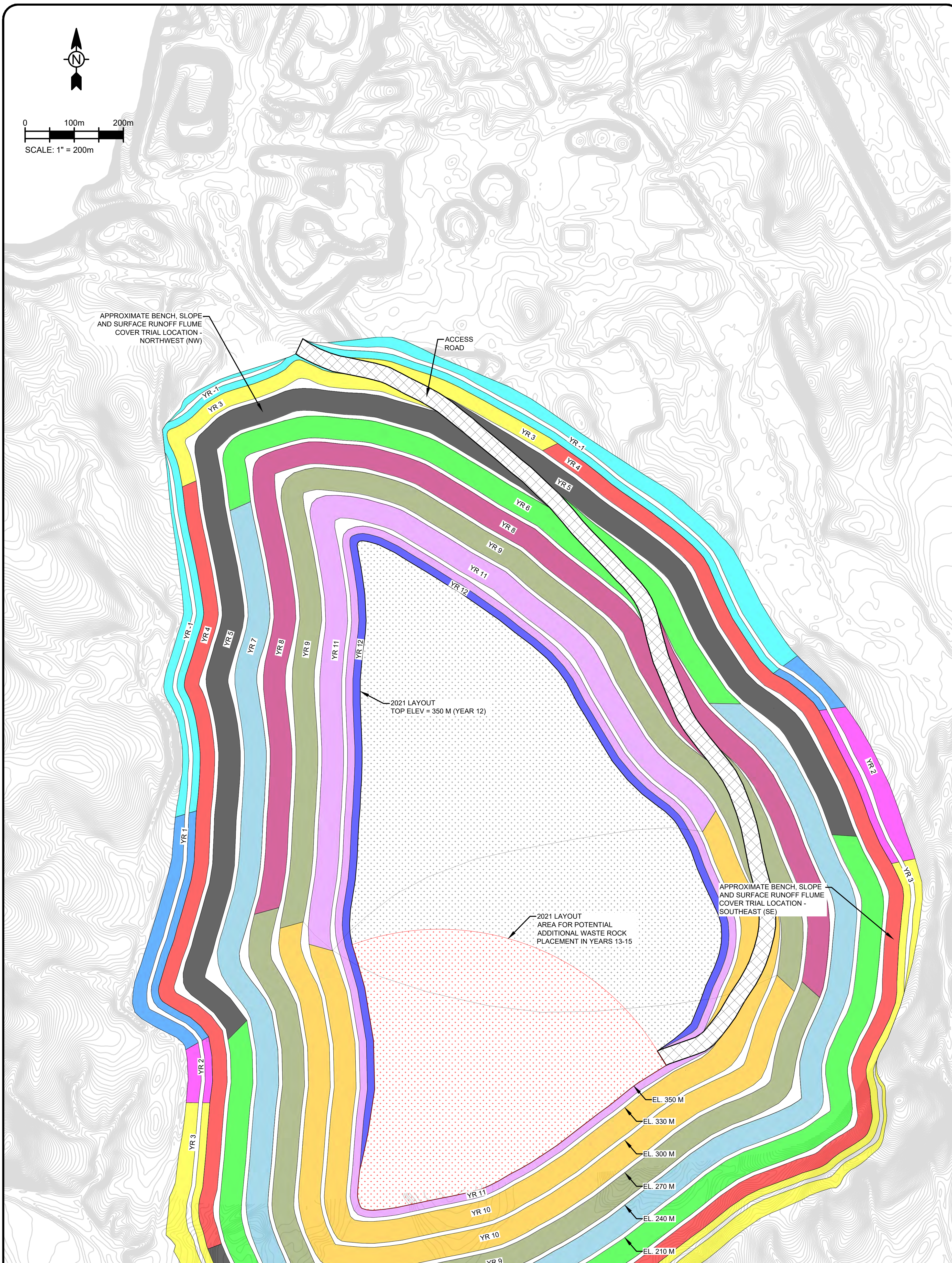
Zhan, G., M. Aubertin, A. Mayer, K. Burke and J. McMullen, 2001. Capillary Cover Design for Leach Pad Closure, *In Proceedings* – SME Annual Meeting, Denver, Colorado, February 26-28, 2001

FIGURES



LEGEND

- YEAR -1 INTER-BENCH
- YEAR 1 INTER-BENCH
- YEAR 2 INTER-BENCH
- YEAR 3 INTER-BENCH
- YEAR 4 INTER-BENCH
- YEAR 5 INTER-BENCH
- YEAR 6 INTER-BENCH
- YEAR 7 INTER-BENCH
- YEAR 8 INTER-BENCH
- YEAR 9 INTER-BENCH
- YEAR 10 INTER-BENCH
- YEAR 11 INTER-BENCH
- YEAR 12 INTER-BENCH
- WRD BENCH
- WRD TOP
- YEAR 13-15 ADD'L MATERIAL
- WRD ACCESS ROAD

NOTES

1. ANNUAL FINAL SLOPE COMPLETION AREAS BASED ON ANNUAL WRD BUILD-OUT DRAWINGS PROVIDED BY RESPEC, CURRENT AS OF OCTOBER 4, 2021.

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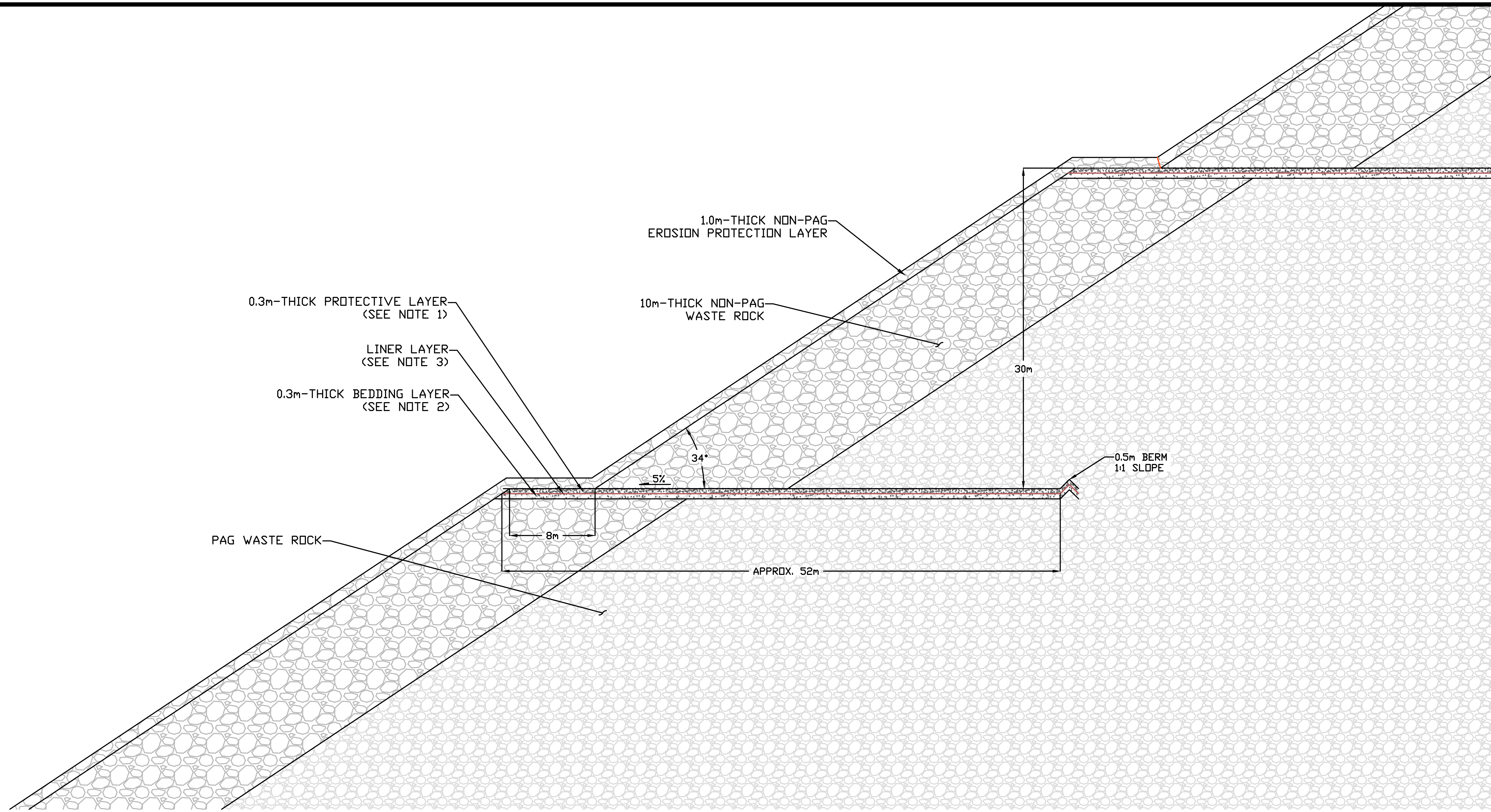
VISTA GOLD - MT TODD GOLD PROJECT

NORTHERN TERRITORY, AUSTRALIA

2021 WASTE ROCK DUMP (WRD) ANNUAL BUILD-OUT (YEAR -1 TO YEAR 12) AND FINAL PLAN VIEW

Project No.:	117-8348002
Date:	11/04/2021
Designed By:	KA
FIGURE	01

Bar Measures 1 inch



NOTES:

1. PROTECTIVE LAYER UNDER 1.0m THICK NON-PAG EROSION PROTECTION LAYER TO BE A MINIMUM OF 0.3m THICK AND COMPOSED OF FINE-GRAINED NON-PAG MATERIAL ADHERING TO THE LINER MATERIAL REQUIREMENTS

2. BEDDING LAYER UNDER THE LINER MATERIAL TO BE A MINIMUM OF 0.3m THICK AND COMPOSED OF FINE-GRAINED NON-PAG MATERIAL ADHERING TO THE LINER MATERIAL BEDDING REQUIREMENTS.

3. LINER MATERIAL LLDPE, GCL OR APPROVED EQUIVALENT. LINER MATERIAL PLACED ON EACH LIFT EXTENDING HORIZONTALLY TO A DISTANCE ADEQUATE TO REACH JUST BELOW OVERLYING BENCH.

NOT TO SCALE

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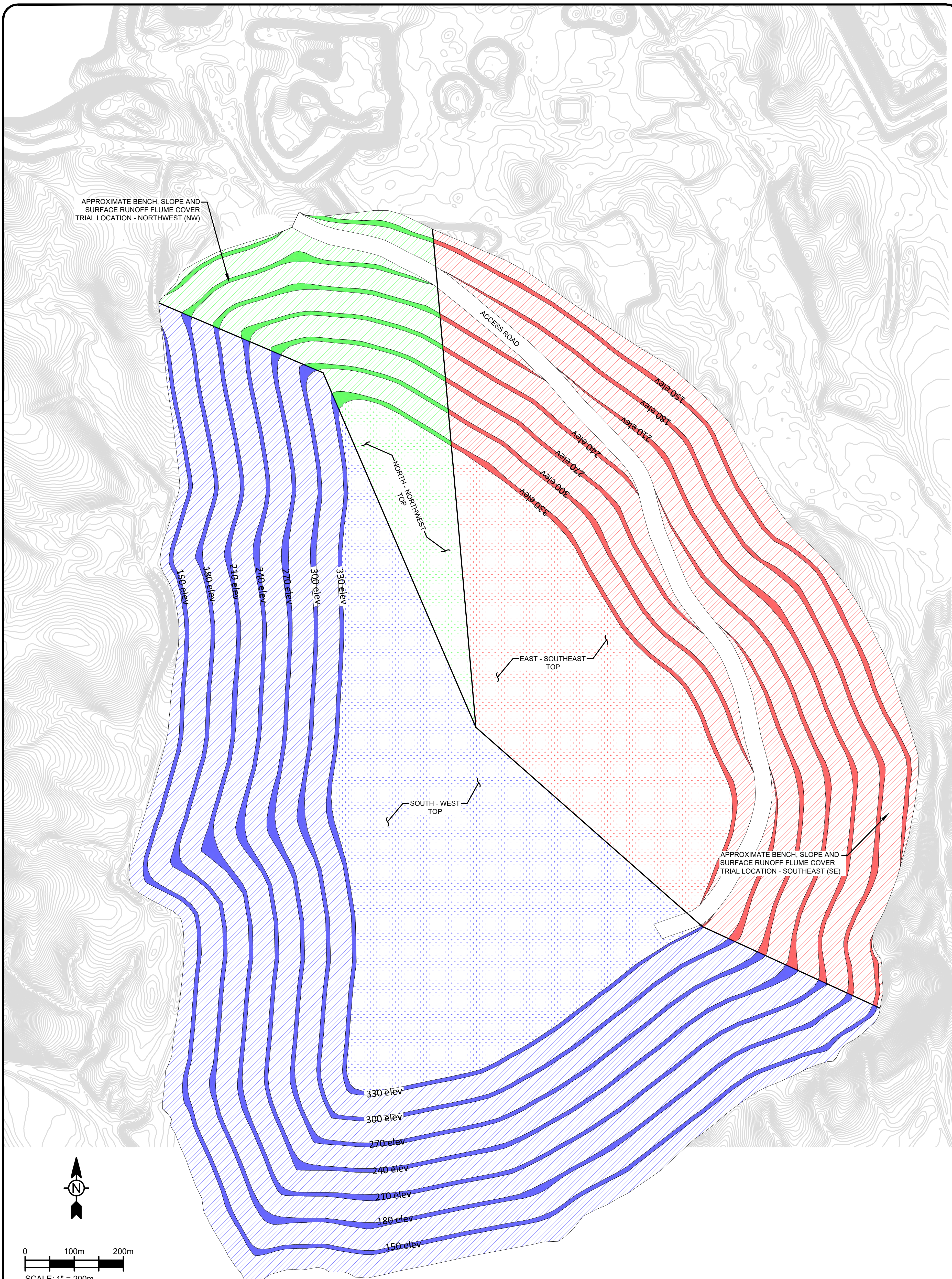
VISTA GOLD - MT TODD GOLD PROJECT

NORTHERN TERRITORY, AUSTRALIA

WASTE ROCK DUMP (WRD)
TYPICAL PREFERRED COVER SYSTEM
CROSS-SECTION

Project No.:	117-8348001
Date:	8/28/2019
Designed By:	AH/HH
FIGURE	02



NORTH - NORTHWEST ASPECT
- TOP
- BENCH
- INTER-BENCH

SOUTH - WEST ASPECT
- TOP
- BENCH
- INTER-BENCH

EAST - SOUTHEAST ASPECT
- TOP
- BENCH
- INTER-BENCH

ASPECT QUANTITIES

	NORTH - NORTHWEST	SOUTH - WEST	EAST - SOUTHEAST
DESCRIPTION	AREA* (m^2)	AREA* (m^2)	AREA* (m^2)
TOP	69,040	435,681	258,482
BENCH	26,247	174,168	89,539
INTER-BENCH	120,731	865,029	479,402
ACCESS-ROAD	10,488	2,578	53,377

*CALCULATED AREAS ARE 2-DIMENSIONAL

NOTES

1. WRD BUILD-OUT DRAWINGS PROVIDED BY RESPEC, CURRENT AS OF OCTOBER 4, 2021.

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VISTA GOLD - MT TODD GOLD PROJECT

NORTHERN TERRITORY, AUSTRALIA

WASTE ROCK DUMP (WRD)
SURFACE ASPECT DELINEATION
FOLLOWING BUILD-OUT (YEAR 12)

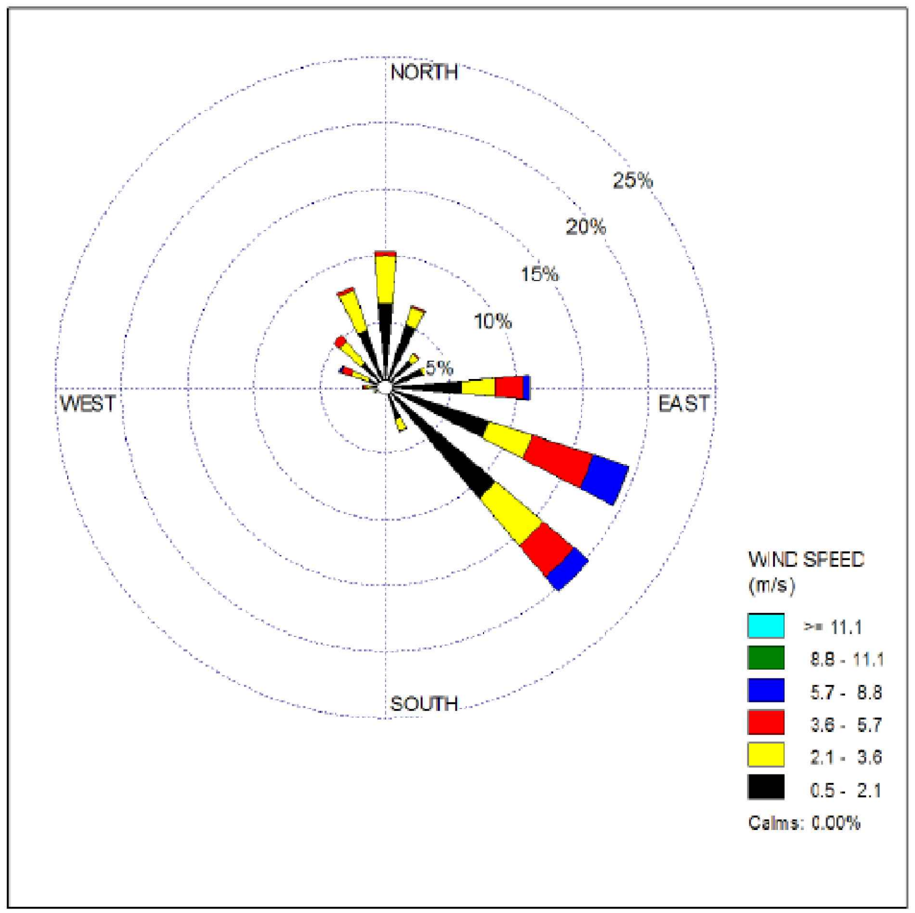
Project No.: 117-8348002
Date: 12/8/2021
Designed By: HS/SH

FIGURE
03

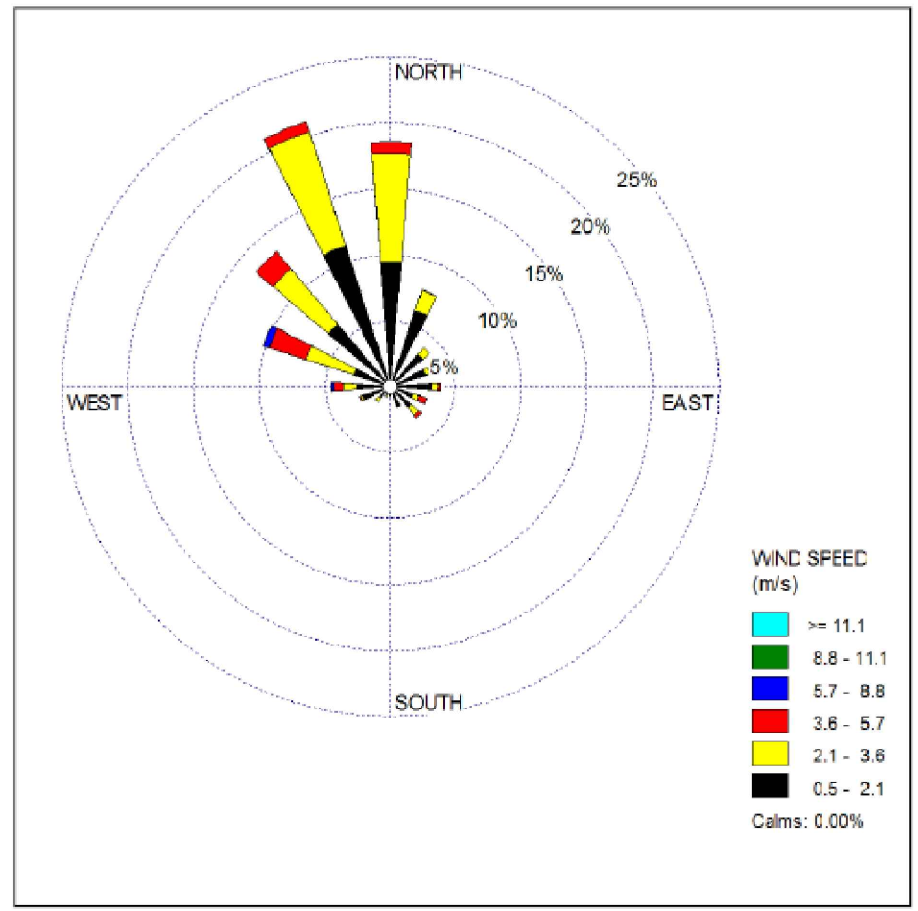
Bar Measures 1 inch

12/8/2021 9:09 AM - \\TT.LOCAL\GFS\US\VOLUME3\LEGACY\TTS232FS1\ECA\PROJECTS\T-Z\VISTA GOLD\117-8348002 - MT TODD 2021\07-CAD\SHEETFILES\WRD CLOSURE FIGURES\FIG-03_UPDATED WRD SURFACE ASPECT DELINEATION.DWG

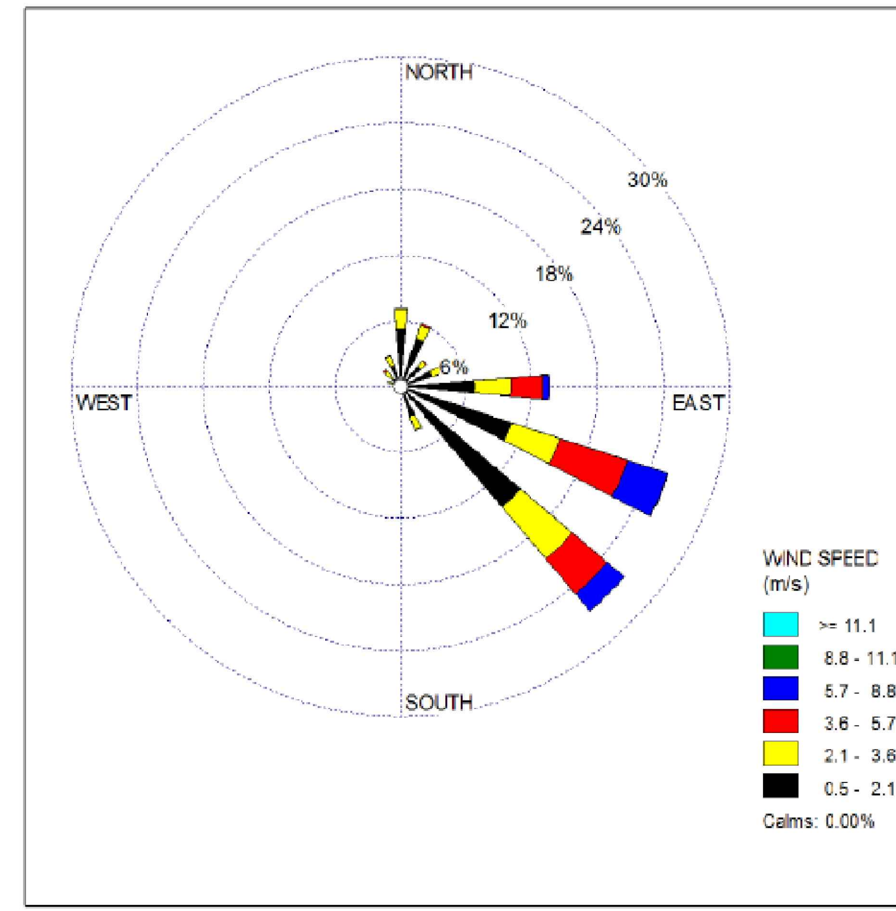
Annual



Wet Season



Dry Season



SOURCE: GHD 2013. Mt Todd Gold Project, DRAFT ENVIRONMENTAL IMPACT STATEMENT, Volume I, GHD Group Pty Ltd, June 2013.

ANNUAL AND SEASONAL WIND DISTRIBUTIONS FOR THE MINE SITE
SEPTEMBER 2007 TO AUGUST 2008

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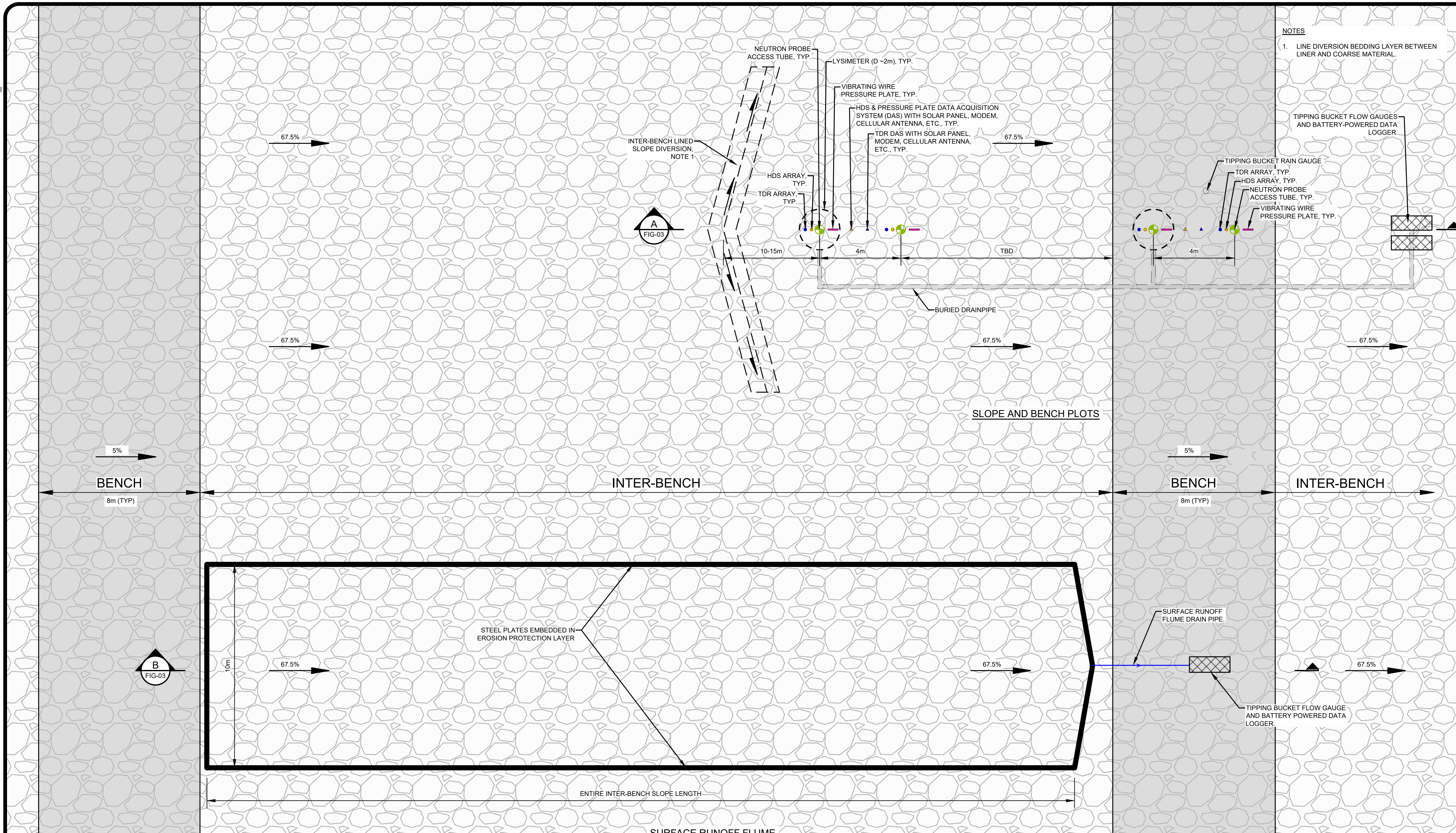
MT TODD MINE - SITE WIND ROSE

Project No.:	117-8348001
Date:	8/28/2019
Designed By:	AH/HH
FIGURE	04

8/29/2019 11:38:37 AM - Y:\T-Z\VISTA GOLD\117-8348001 - MT TODD PFS UPDATE 2019\07-CAD\SHEETFILES\FIGURES\FIG-04_MT TODD MINE - SITE WIND ROSE.DWG - HOLLEY, HARRISON



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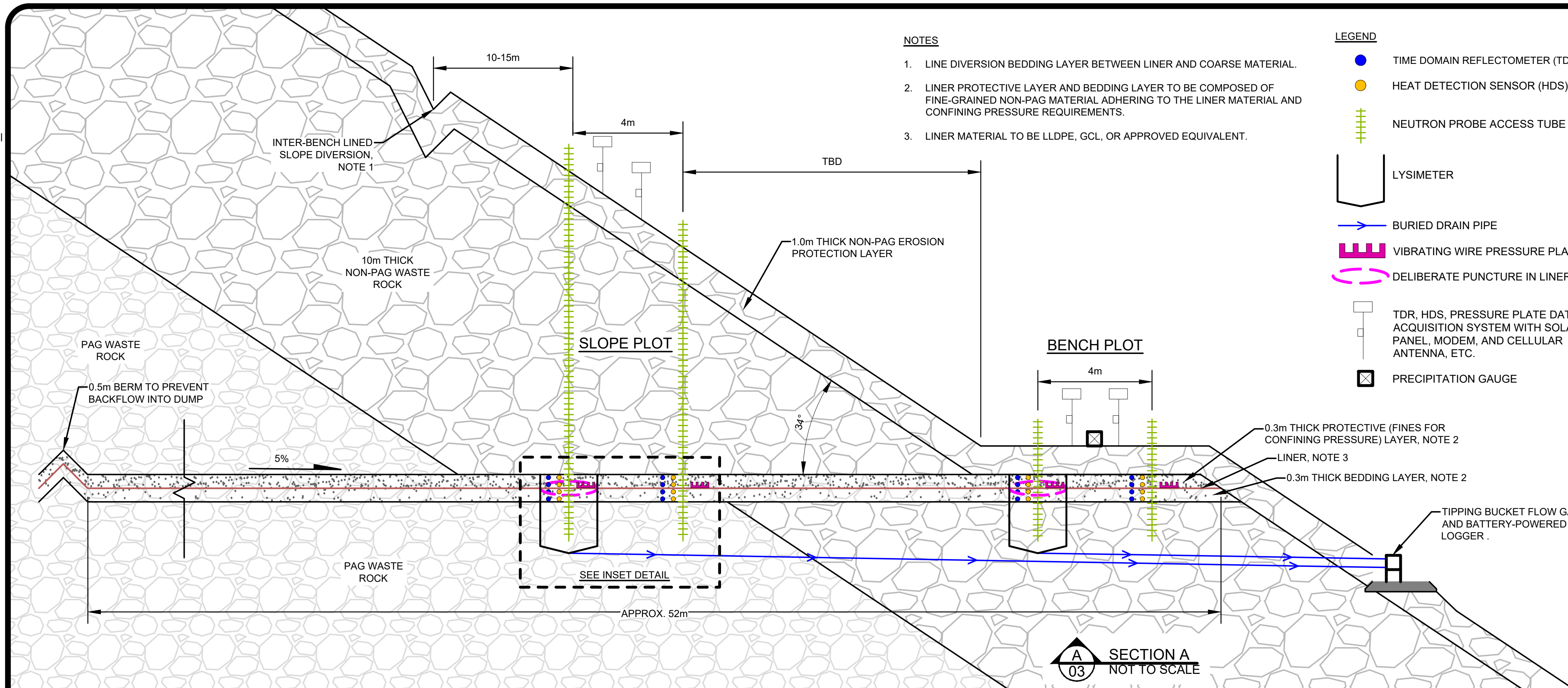
VISTA GOLD - MT TODD GOLD PROJECT

NORTHERN TERRITORY, AUSTRALIA

WASTE ROCK DUMP (WRD) SLOPE AND BENCH PLOTS AND SURFACE RUNOFF FLUME COVER TRIAL CONCEPT - PLAN VIEW

Project No.:	117-8348002
Date:	12/8/2021
Designed By:	HS/SH

FIGURE
05



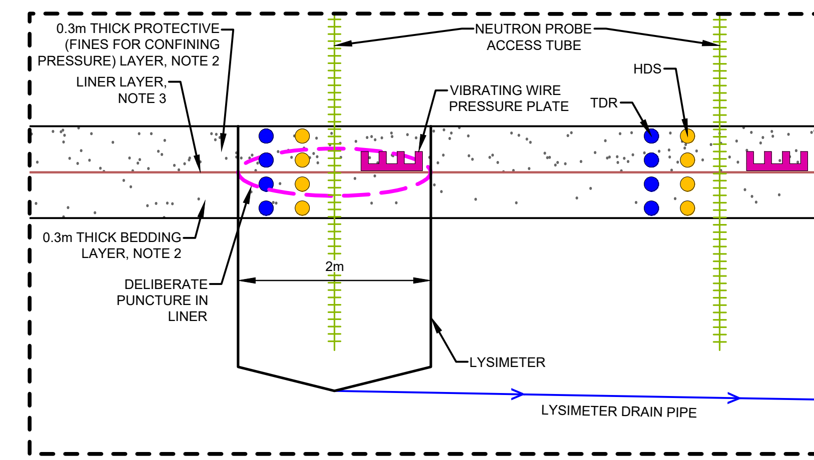
NOTES

1. LINE DIVERSION BEDDING LAYER BETWEEN LINER AND COARSE MATERIAL.
2. LINER PROTECTIVE LAYER AND BEDDING LAYER TO BE COMPOSED OF FINE-GRAINED NON-PAG MATERIAL ADHERING TO THE LINER MATERIAL AND CONFINING PRESSURE REQUIREMENTS.
3. LINER MATERIAL TO BE LLDPE, GCL, OR APPROVED EQUIVALENT.

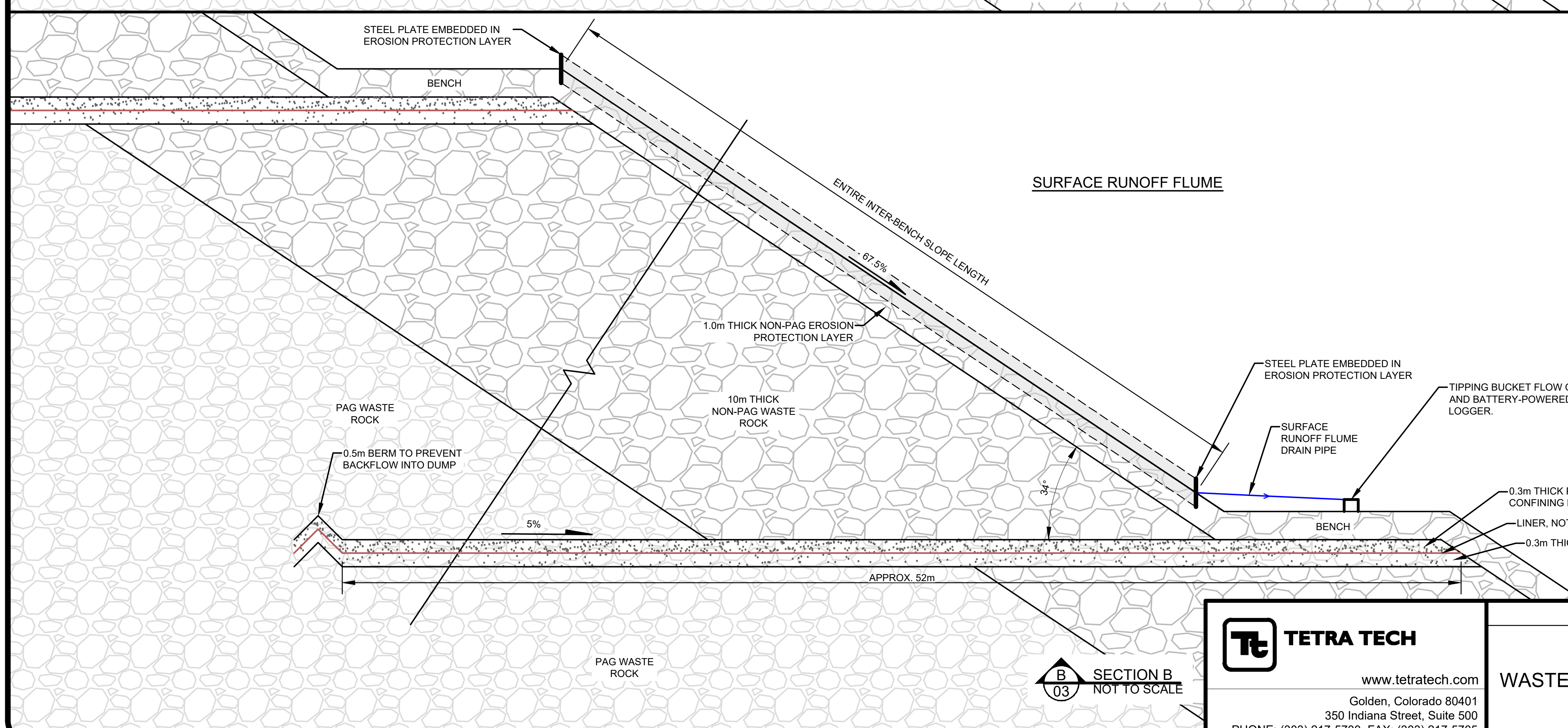
LEGEND

- TIME DOMAIN REFLECTOMETER (TDR) [Θ_W]
- HEAT DETECTION SENSOR (HDS) [Ψ]
- NEUTRON PROBE ACCESS TUBE
- LYSIMETER
- BURIED DRAIN PIPE
- VIBRATING WIRE PRESSURE PLATE
- DELIBERATE PUNCTURE IN LINER
- TDR, HDS, PRESSURE PLATE DATA ACQUISITION SYSTEM WITH SOLAR PANEL, MODEM, AND CELLULAR ANTENNA, ETC.
- PRECIPITATION GAUGE

DESCRIPTION	QUANTITY
TDR	15
HDS	15
NEUTRON PROBE ACCESS TUBE	4
LYSIMETER	2
LYSIMETER DRAIN PIPE	2
VIBRATING WIRE PRESSURE PLATE	4
DELIBERATE PUNCTURE IN LINER	2
TIPPING BUCKET FLOW GAUGE	3
PRECIPITATION GAUGE	1
DATA ACQUISITION SYSTEM (WITH POWER, TELEMETRY, AND MOUNTING TOWER	4



INSET DETAIL



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VISTA GOLD - MT TODD GOLD PROJECT

NORTHERN TERRITORY, AUSTRALIA

WASTE ROCK DUMP (WRD) SLOPE AND BENCH PLOTS AND SURFACE RUNOFF FLUME COVER TRIAL CONCEPT - PROFILE VIEW

Project No.:	117-8348002
Date:	12/8/2021
Designed By:	HS/SH
FIGURE	06

ATTACHMENT 2:
Tierra Group International –
2020 Mt Todd Waste Rock Dump Closure Assessment Report

Mt. Todd
Waste Rock Dump Closure

ASSESSMENT REPORT

PREPARED FOR:

VISTA GOLD

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P: 720.981.1185

PREPARED BY:

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Project Number: 613

July 2020

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LIST OF ACRONYMS

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).

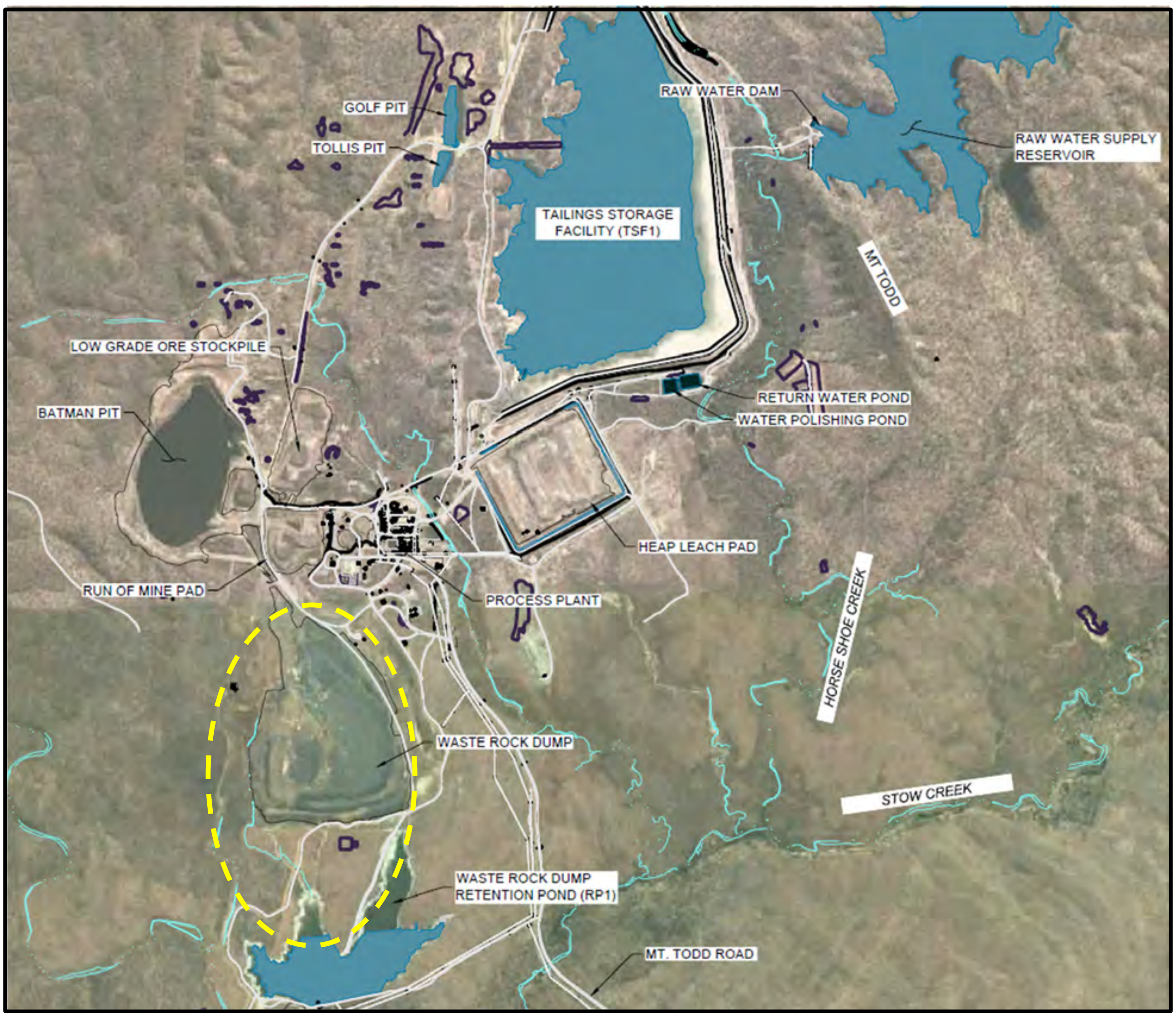


FIGURE 2.1: MT. TODD SITE – CURRENT CONDITIONS (TETRA TECH, 2018)

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).

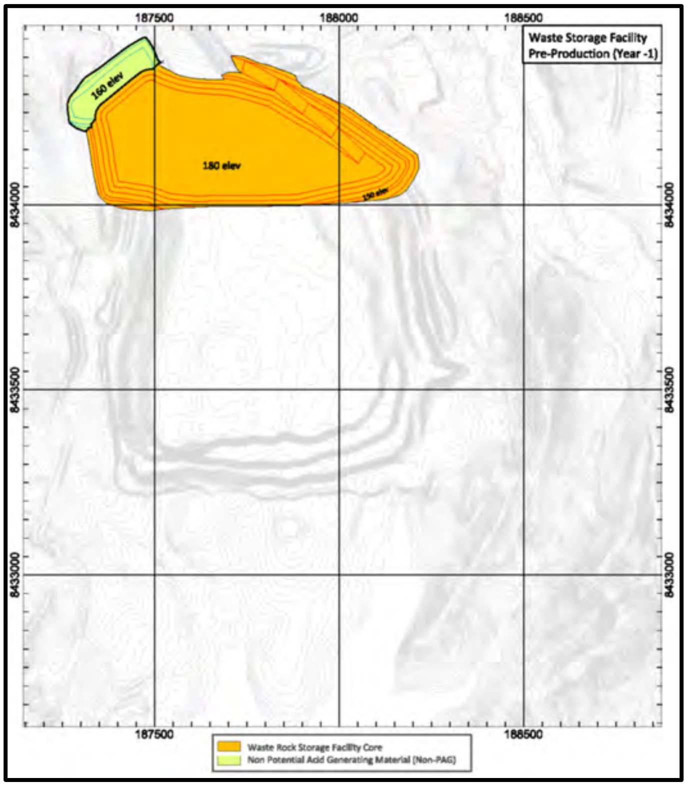


FIGURE 3.1: WRD EXPANSION IN PRE-PRODUCTION (YEAR-1) (VISTA GOLD, 2019)

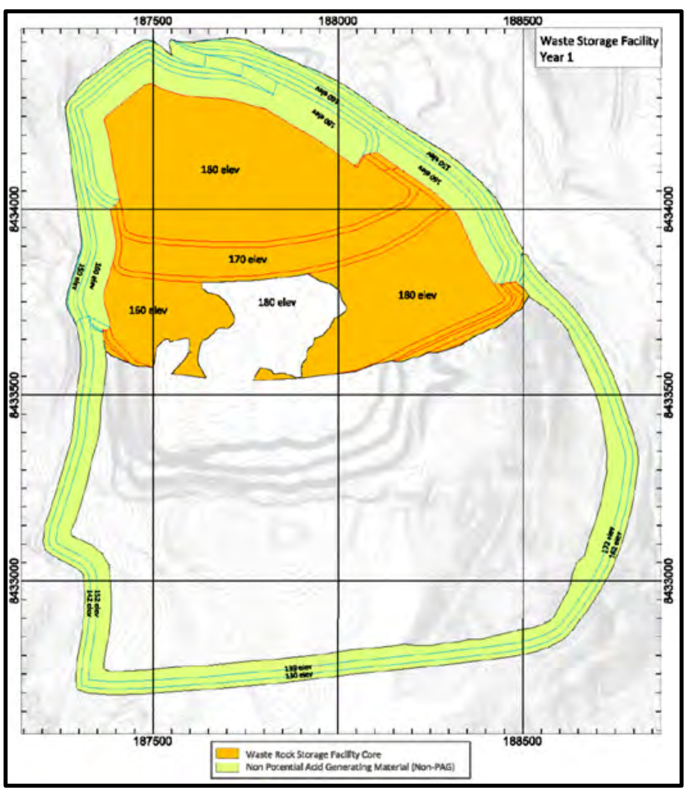


FIGURE 3.2: WRD EXPANSION IN YEAR 1 (VISTA GOLD, 2019)

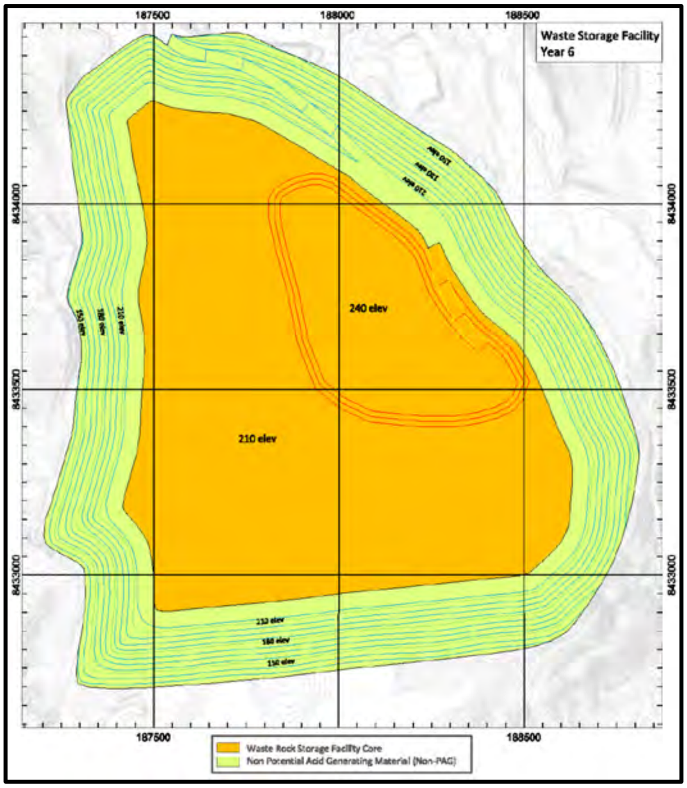


FIGURE 3.3: WRD EXPANSION IN YEAR 6 (VISTA GOLD, 2019)

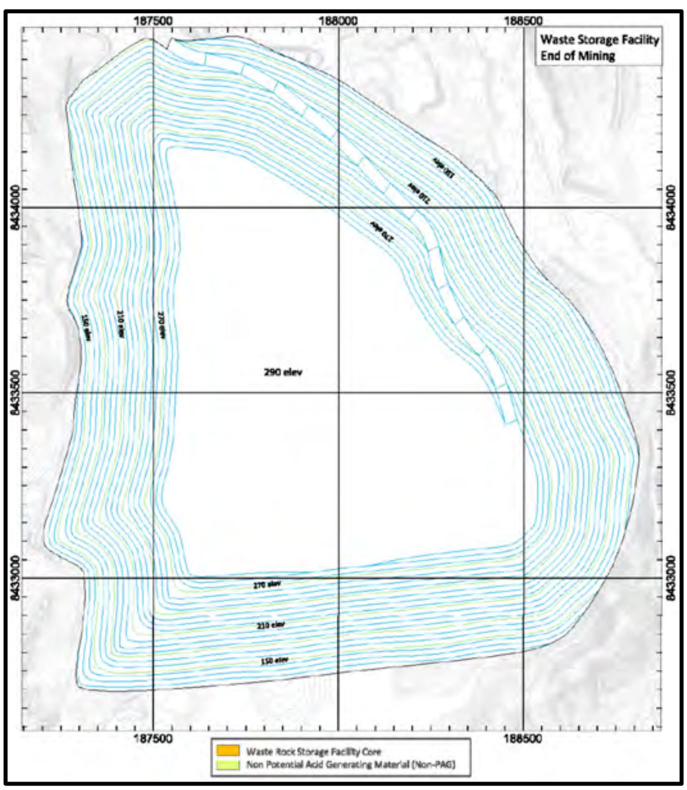


FIGURE 3.4: WRD AT COMPLETE BUILDOUT (VISTA GOLD, 2019)

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.

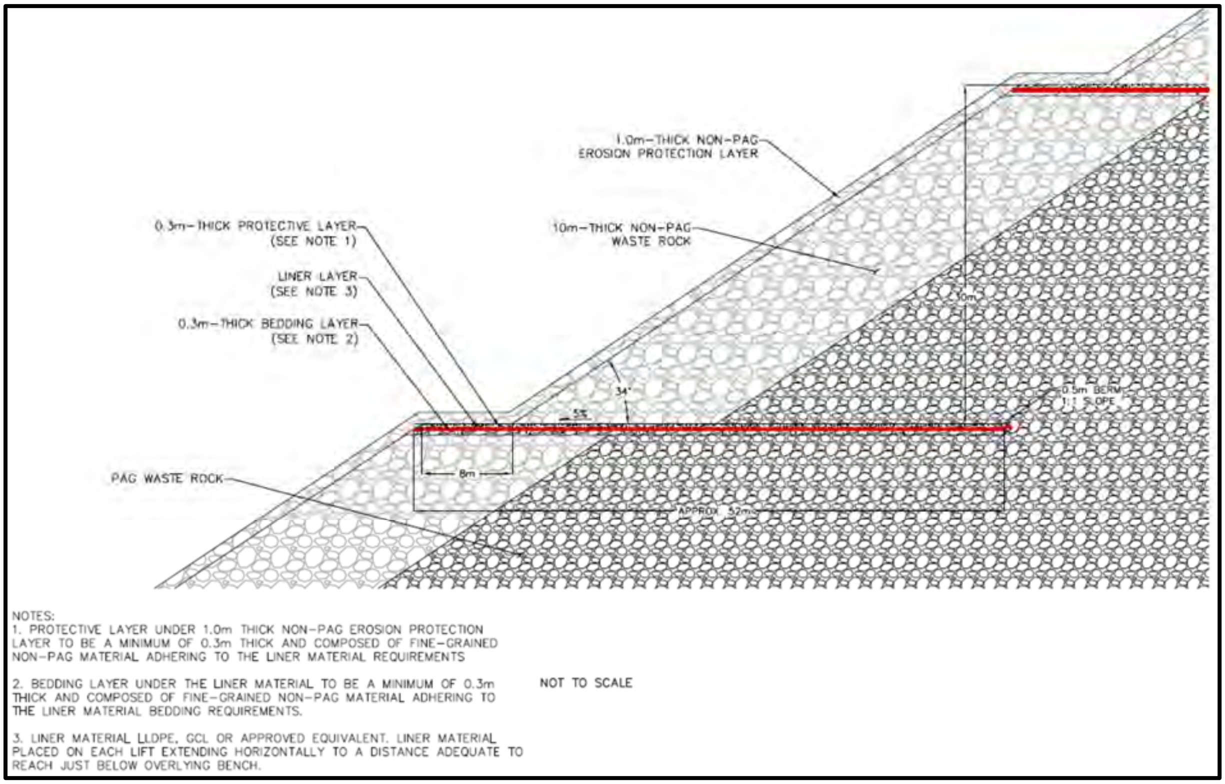


FIGURE 3.5: WRD INTERLIFT LINER CONFIGURATION (TETRA TECH, 2019B)

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.

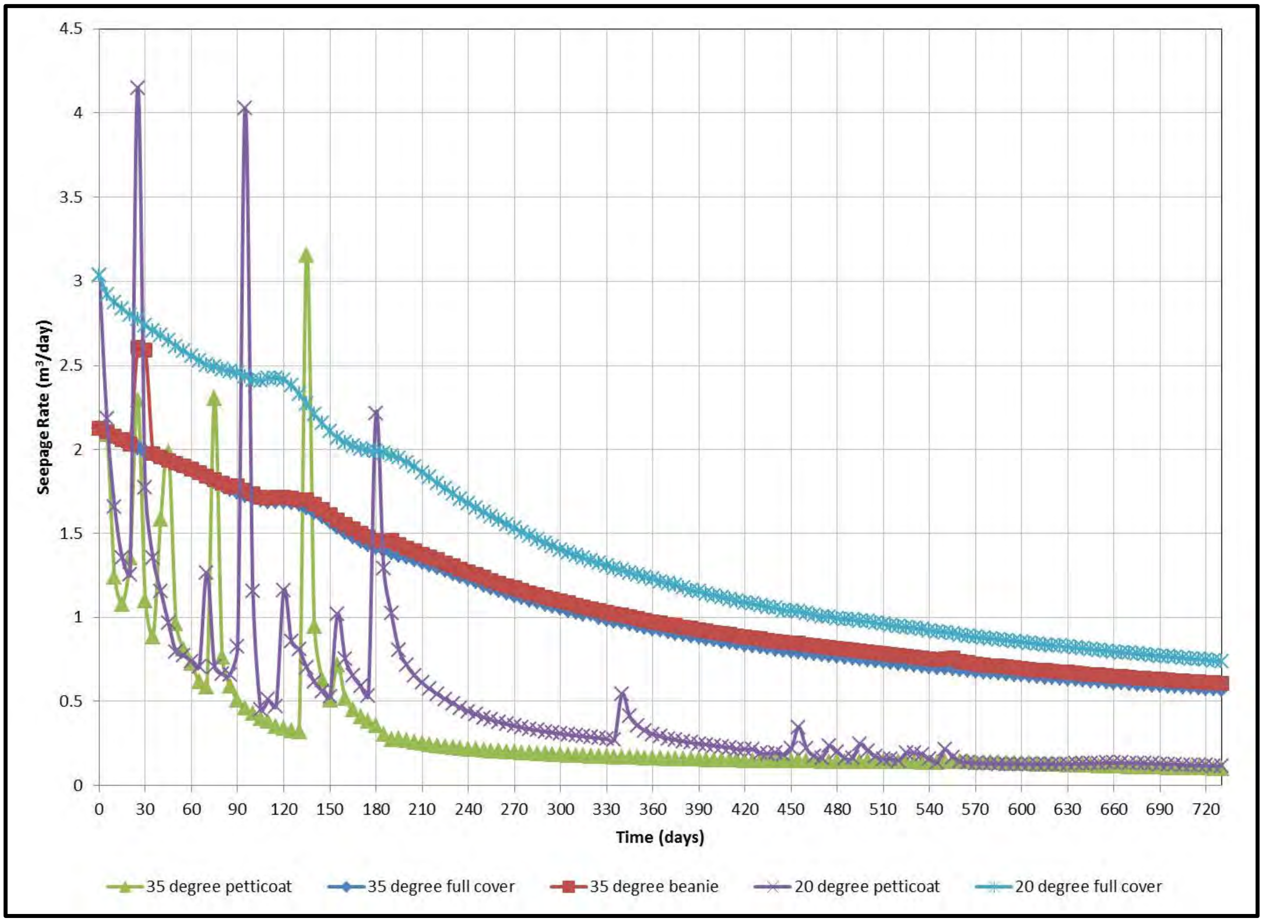


FIGURE 3.6: FLUX RATES FROM 2011 ALTERNATIVES ANALYSIS (TETRA TECH, 2018)

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

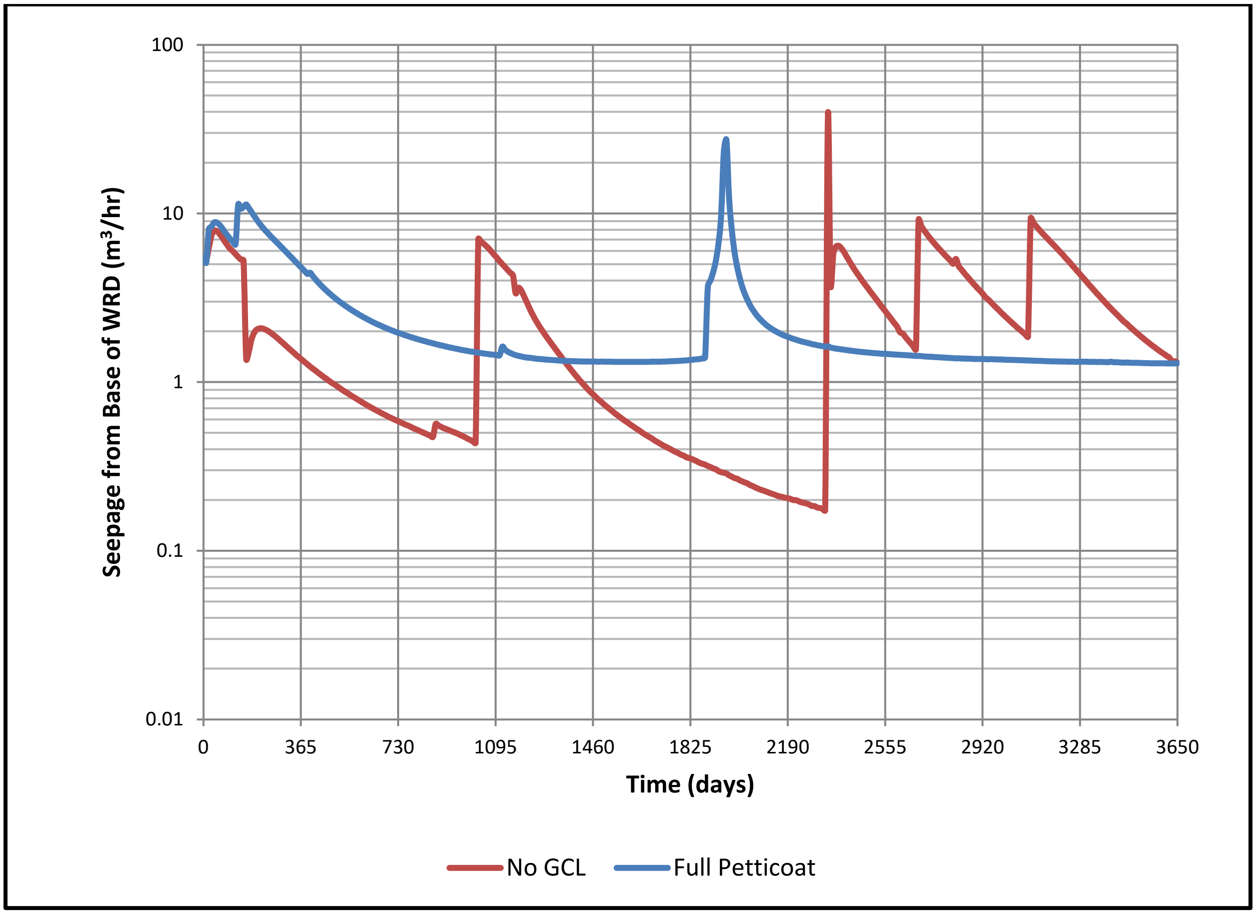


FIGURE 3.7: FLUX RATES FROM 2012 SEEPAGE ANALYSIS (TETRA TECH, 2018)

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.

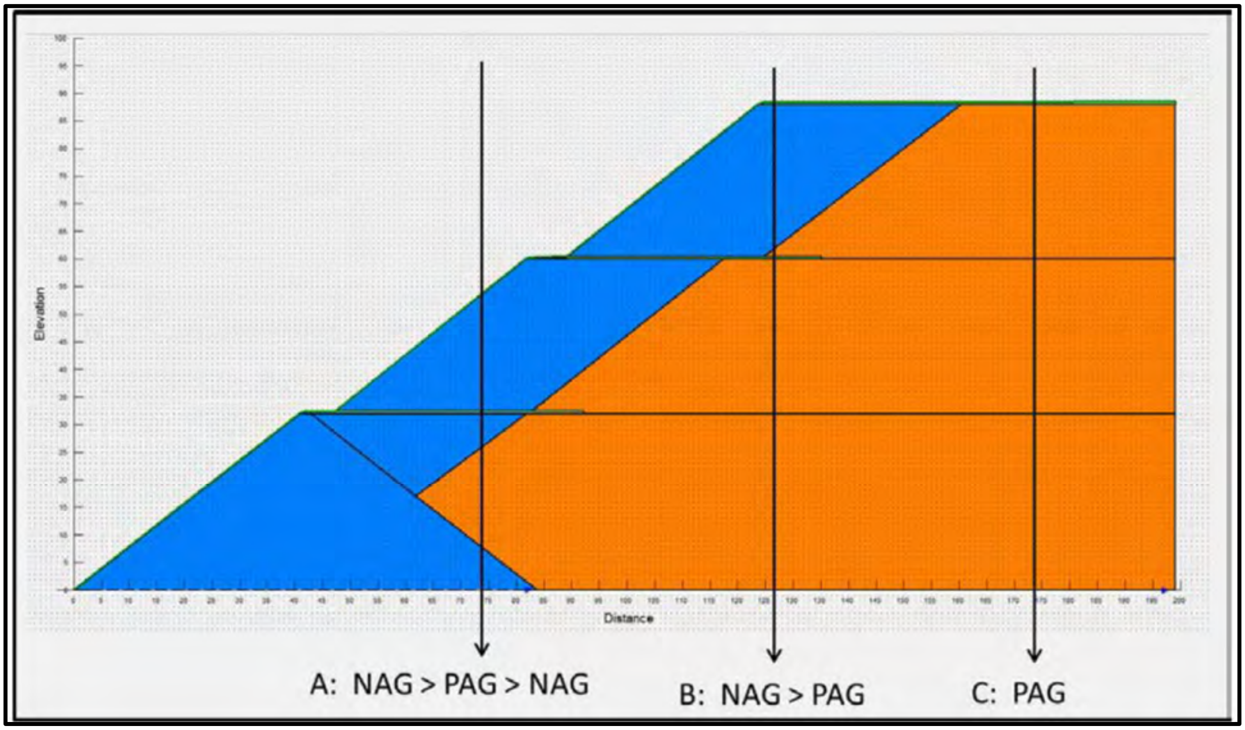


FIGURE 3.8: EXPECTED WRD FLOW PATHS AND MATERIAL CONTACTS (TETRA TECH, 2019a)

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.

Tetra Tech, 2019a. *NI 43-101 Technical Report Mt. Todd Gold Project 50,000 tpd Preliminary Feasibility Study*. Prepared for Vista Gold Corp., 7 October 2019.

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.

Vista Gold Australia Pty Ltd, 2019. *Mt Todd Project Area Mining Management Plan 2021 - 2025*. Report prepared by Vista Gold, 31 October 2019.

ATTACHMENT 3:
Mt Todd – Batman Pit Waste Rock Dump
Geosynthetic Liner System Stability Analysis

TETRA TECH

Tech Memo

To:	April Hussey, PE
From:	Caleb Stock, PE Jeremy Dierking, PE
Date:	December 10, 2021
Subject:	117-8348002 | Mt Todd – Waste Rock Dump Geosynthetic Liner System Stability Analysis

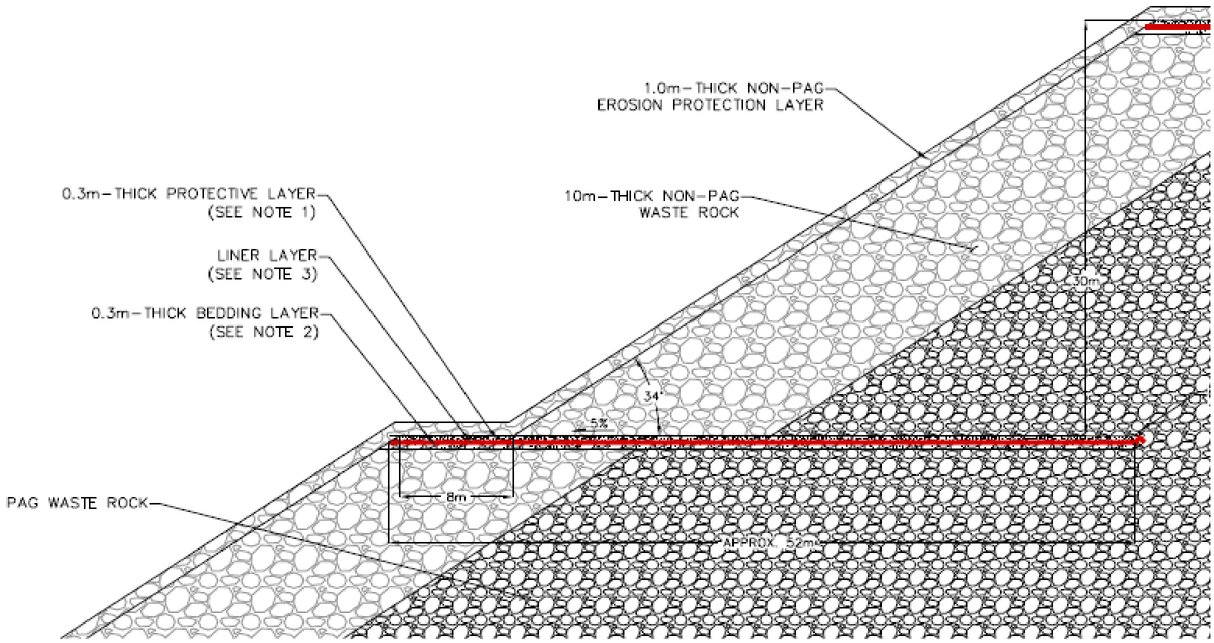
INTRODUCTION

Vista Gold is developing the Mount Todd Gold Project in Northern Territory, Australia. As part of Batman Pit Waste Dump (Waste Dump) feasibility design, Tetra Tech performed a preliminary stability analysis of the geosynthetic liner system that will be constructed on the exterior of the Waste Dump to limit infiltration. Previous stability analysis of the Waste Dump was performed by Golder Associates (Golder, 2012).

This technical memorandum is part of the feasibility design and will be included as one of several supporting documents therefore limited background and investigation data are presented. This technical memorandum does include the proposed Waste Dump geometry, stability analysis of the geosynthetic system, assumptions made in the design and analysis, descriptions and details of the methods used in the analysis, and results, conclusions, and recommendations for construction of the geosynthetic system.

BATMAN PIT WASTE DUMP GEOMETRY

The proposed geometry of the Waste Dump is 30-meter lifts at an inclination of 34 degrees (approximately 1.5 horizontal to 1 vertical). At the top of each lift an 8-meter wide bench will be constructed before the next lift is placed. At each bench a low permeability geosynthetic (linear low-density polyethylene [LLDPE] or geosynthetic clay liner [GCL] will be installed nearly horizontal for approximately 52 meters into the Waste Dump. Fine-grained material or a geotextile will be placed above and below the low permeability geosynthetic to provide cushioning and reduce penetrations of the low permeability geosynthetic. In this application "fine-grained material" is relative to the waste rock and is anticipated to be a granular sandy soil instead of the traditional use of "fine-grained material" representing a soil that has more than 50% by mass passing the #200 sieve resulting in a classification of silty or clay. The low permeability geosynthetic and cushioning material is herein referred to as the geosynthetic system. A schematic of the proposed geometry and materials is presented below. While this schematic notes fine grained material placed above and below the geosynthetic liner system, this analysis addresses stability related to use of either fine-grained material or geotextile material.



NOTES:
1. PROTECTIVE LAYER UNDER 1.0m THICK NON–PAG EROSION PROTECTION LAYER TO BE A MINIMUM OF 0.3m THICK AND COMPOSED OF FINE–GRAINED NON–PAG MATERIAL ADHERING TO THE LINER MATERIAL REQUIREMENTS

2. BEDDING LAYER UNDER THE LINER MATERIAL TO BE A MINIMUM OF 0.3m THICK AND COMPOSED OF FINE–GRAINED NON–PAG MATERIAL ADHERING TO THE LINER MATERIAL BEDDING REQUIREMENTS.

3. LINER MATERIAL LLDPE, GCL OR APPROVED EQUIVALENT. LINER MATERIAL PLACED ON EACH LIFT EXTENDING HORIZONTALLY TO A DISTANCE ADEQUATE TO REACH JUST BELOW OVERLYING BENCH.

NOT TO SCALE

STABILITY ANALYSES

Tetra Tech performed preliminary interface and global stability analyses of the proposed Waste Dump geometry with a focus on the geosynthetic system in relation to global stability analyses.

Design Guidelines

Tetra Tech's review of the 2011 Northern Territory of Australia Mineral Titles Regulations, 2010 Northern Territory of Australia Mineral Titles Act, and the 2001 Northern Territory of Australia Mining Management Act did not identify minimum required factors of safety for mining. In design of the Waste Dump Golder stated, *"Various published sources suggest that minimum safety factors for temporary and permanent slopes in mine waste dumps might lie in the ranges of 1.1 to 1.2 and 1.3 to 1.5 respectively. We assume that Vista will confirm appropriate limitations they consider acceptable for the Factors of Safety of this WRD."* Tetra Tech is in general agreement with these values for temporary and permanent slopes and as design progresses suggests that Vista Gold implements design criteria in accordance with Northern Territory or applicable regulatory agencies.

Interface Stability

Interface stability analysis involves evaluation of a potential failure plane at the contact between materials within the geosynthetic system. Typical interface friction angle values based on direct shear testing of geosynthetics against adjacent granular soil and nonwoven geotextile were obtained from the Geosynthetic Research Institute (GRI, 2005) for LLDPE and a commercial scale GCL manufacturer (CETCO). As design progresses direct shear testing of proposed materials under project normal loads should be performed to determine site specific values. The following tables present typical friction angles (apparent adhesion is omitted) obtained by direct shear testing between proposed materials:

LLDPE Smooth	Peak Friction (deg)	Residual Friction (deg)
Granular Soil	27	24
Nonwoven Geotextile	10	9

LLDPE Textured	Peak Friction (deg)	Residual Friction (deg)
Granular Soil	26	25
Nonwoven Geotextile	26	17

GCL	Peak Friction (deg)	Residual Friction (deg)
Granular Soil	29	16
Nonwoven Geotextile	27	20

Residual friction angles were used in design based on the anticipated strains and loading associated within the Waste Dump. Methodology from Koerner (2005) results in a simplified equation for calculating the factor of safety as:

$$FS = \tan(d) / \tan(b)$$

Where

FS = factor of safety,
d = inclination, and
b = interface friction angle

The proposed inclination of the geosynthetic system is 5% (2.9 degrees) towards the exterior but a steeper slope of 10% (5.7 degrees) was also evaluated. Calculated factors of safety for the different geosynthetic systems and inclinations indicate the minimum design criteria of 1.5 is exceeded for all scenarios. A permanent minimum factor of safety of 1.5 was selected because the geosynthetic system will be unchanged as it becomes a permanent part of the closed Waste Dump. Calculated factor of safety values at a 5% inclination ranged from 3.2 to 9.3 and the calculated values at a 10% inclination ranged from 1.6 to 4.7. The highest factor of safety was calculated for the scenario of a textured LLDPE adjacent to granular soil and the lowest factor of safety was calculated for the scenario of a smooth LLDPE adjacent to a geotextile. Factor of safety results for the different geosynthetic systems and inclinations are presented in the tables below:

5% Inclination

Interface Scenario 1	
Granular Soil	Smooth LLDPE
tan(d)	0.45
tan(b)	0.05
FS	8.9

Interface Scenario 2	
Geotextile	Smooth LLDPE
tan(d)	0.16
tan(b)	0.05
FS	3.2

Interface Scenario 3	
Granular Soil	Textured LLDPE
tan(d)	0.47
tan(b)	0.05
FS	9.3

Interface Scenario 4	
Geotextile	Textured LLDPE
tan(d)	0.31
tan(b)	0.05
FS	6.1

Interface Scenario 5	
Granular Soil	GCL
tan(d)	0.28
tan(b)	0.05
FS	5.6

Interface Scenario 6	
Geotextile	GCL
tan(d)	0.36
tan(b)	0.05
FS	7.3

10% Inclination

Interface Scenario 1	
Granular Soil	Smooth LLDPE
tan(d)	0.45
tan(b)	0.10
FS	4.5

Interface Scenario 2	
Geotextile	Smooth LLDPE
tan(d)	0.16
tan(b)	0.10
FS	1.6

Interface Scenario 3	
Granular Soil	Textured LLDPE
tan(d)	0.47
tan(b)	0.10
FS	4.7

Interface Scenario 4	
Geotextile	Textured LLDPE
tan(d)	0.31
tan(b)	0.10
FS	3.1

Interface Scenario 5	
Granular Soil	GCL
tan(d)	0.28
tan(b)	0.10
FS	2.8

Interface Scenario 6	
Geotextile	GCL
tan(d)	0.36
tan(b)	0.10
FS	3.6

Global Stability

To evaluate the potential for global slope instability as a result of the geosynthetic system, Tetra Tech utilized the finite element computer modeling program SLOPE/W (GeoStudio 2021 by Geo-Slope International, Ltd, 2021).

Input Parameters

Previous slope stability analysis performed by Golder calculated a factor of safety for the proposed geometry but did not specify input parameters used in the model. Discussion of the existing waste dump mentioned the side slope angles were observed to be up to 35 or 36 degrees and considered 34 degrees to be the angle of repose of tipped or pushed material.

SLOPE/W allows for geosynthetics to be modeled as a reinforcement element with user specified tensile capacity, interface shear angle, and interface adhesion. Values from Tensar Corporation for tensile capacity as well as the interface shear angle and adhesion (omitted) were used to model the reinforcement. Alternatively, the geosynthetic system was modeled as a material type so the thickness and material properties of the cushioning sand could be accounted for. The table below presents the engineering properties of the materials used in the model.

Model Material Parameters

Material Name	Total Unit Weight (kN/m^3)	Cohesion (kPa)	Phi (degrees)	Tensile Capacity (kN/m)	Interface Adhesion	Interface Shear Angle (degrees)
Waste Rock	22	0	34	N/A	N/A	N/A
Geosynthetic (reinforcement)	N/A	N/A	N/A	21	0	25
Geosynthetic and Cushion (material)	18	0	25	N/A	N/A	N/A

Analysis

The analyses were conducted using the SLOPE/W component of GeoStudio 2021. Static loading describes the normal, long term state of the Waste Dump. The Waste Dump was assumed to be dry because of the geosynthetic system and Waste Dump geometry thus pore water pressures were not included in the analysis. Global failure searches with broad potential failure surface entry and exit locations and localized intrabench failures were also analyzed. The Morgenstern-Price failure criteria model was selected because it satisfies both moment and force equilibrium. The Morgenstern-Price method was also used in the Golder stability analysis. Different failure envelope search criteria were utilized including: 1) specifying a range of potential entry and exit points with an optimized critical slip surface location feature that allows for a combination of both circular (rotational) and linear (block) failure surfaces, 2) block failure searches focused on the geosynthetic system, 3) fully specified failure surfaces focused on the geosynthetic system, and 4) grid and radius failure searches focused on the geosynthetic system. The failure searches were focused on the geosynthetic system because it represents a potential plane of weakness within the Waste Dump and is the focus of this analysis compared to the overall global stability. The block failure and fully specified failure surfaces were not considered realistic based on the model results and therefore are excluded from the results.

Modeling Results

Model results using the material properties and failure search criteria presented above are provided in the following section. The results of these analyses, summarized in the table below, show that the calculated factors of safety are equal to or greater than 1.1 required for temporary slopes. The Golder calculated factors of safety for non-earthquake conditions of individual benches was 1.1 and the global slope had a factor of safety of 1.25 to 1.3, indicating the geosynthetic system has minimal impact on stability of the Waste Dump. In the case of global stability analyses the failure surface penetrated through the geosynthetic system and did not appear to be affected by the geosynthetic system. Intrabench failure surfaces were at the face of the Waste Dump with just the toe of the failure surface at the geosynthetic system rather than sliding along a longer segment of the geosynthetic system. Visual model results of the slope stability analyses are presented in Attachment A.

Summary of Factors of Safety for Slope Stability

Scenario			Calculated Minimum Factor of Safety
Failure Search Limits	**Failure Search Method**	**Geosynthetic System Model Method**	
Global	Entry and Exit Points	Material	1.1
Global	Entry and Exit Points	Reinforcement	1.2
Intrabench	Entry and Exit Points	Material	1.1
Intrabench	Entry and Exit Points	Reinforcement	1.1
Intrabench	Grid and Radius	Material	1.1
Intrabench	Grid and Radius	Reinforcement	1.1

CONCLUSIONS AND RECOMMENDATIONS

Tetra Tech analyzed interface and global stability of a geosynthetic system at the benches of the proposed Waste Dump.

Based on the calculations herein a geosynthetic system of the analyzed materials at either a 5 or 10% inclination towards the exterior meets acceptable factors of safety and is not detrimental to the global stability performance of the Waste Dump. Cushioning to protect the low permeability geosynthetic with either sand or a geotextile is recommended. The sand cushion should not have any particles larger than 10 millimeters and have no more than 15% by mass passing a 0.075 millimeter (#200) sieve. If geotextile is used as a cushion the geotextile should have a mass per unit weight of at least 400 grams per square meter.

Global stability analyses resulted in calculated factors of safety meeting or exceeding the typical minimum factor of safety for temporary conditions of waste rock dumps. The geosynthetic system did not present a failure surface that impacted global stability or resulted in unacceptable factors of safety within benches. Further design iterations should incorporate pseudo-static loading conditions and closure design should be held to a higher required factor of safety.

Tetra Tech believes this analysis was conducted in a manner consistent with generally accepted geotechnical engineering principles and according to methods normally used in the vicinity of the project at this time. No warranty is made, express or implied. Should additional information become available that could alter the analyses, conclusions, or recommendations in this report, Tetra Tech should be contacted to review the analyses in the light of that information to determine if revisions are needed.

REFERENCES

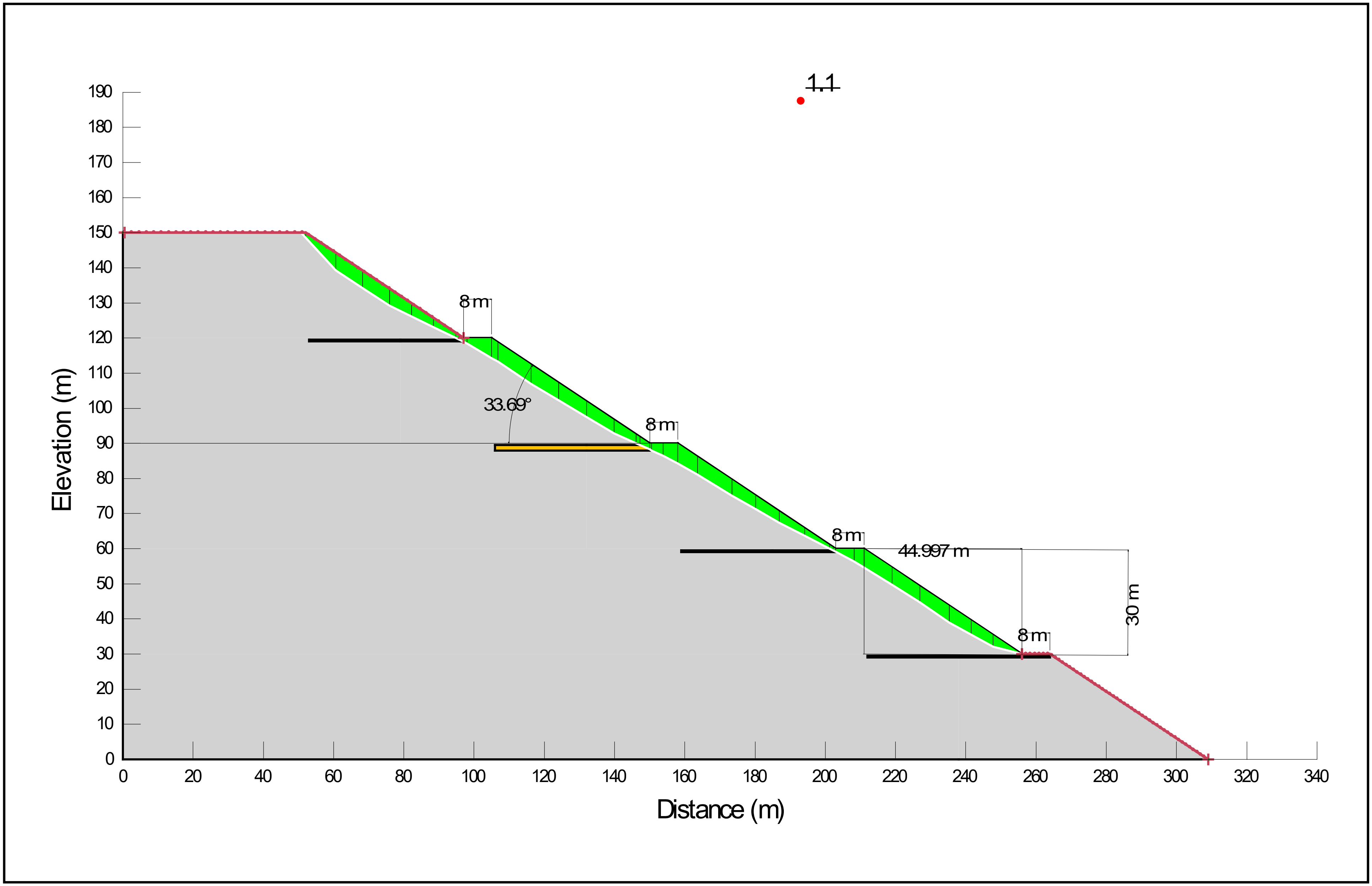
Geo-Slope International, Ltd, 2021. GeoStudio 2021 [Software].

Geosynthetic Research Institute, (GRI, 2005). Direct Shear Database of Geosynthetic-to-Geosynthetic and Geosynthetic-to-Soil Interfaces. GRI Report #30. June 14.

Golder Associates, (Golder, 2012). Batman Pit Waste Dump Design Review, Mt Todd, N.T., Australia. Report Number 117661009-007-R-Rev2. January 25.

Koerner, R.M., 2005. Designing with Geosynthetics, 5th edition. Pearson Education, Inc. Upper Saddle River.

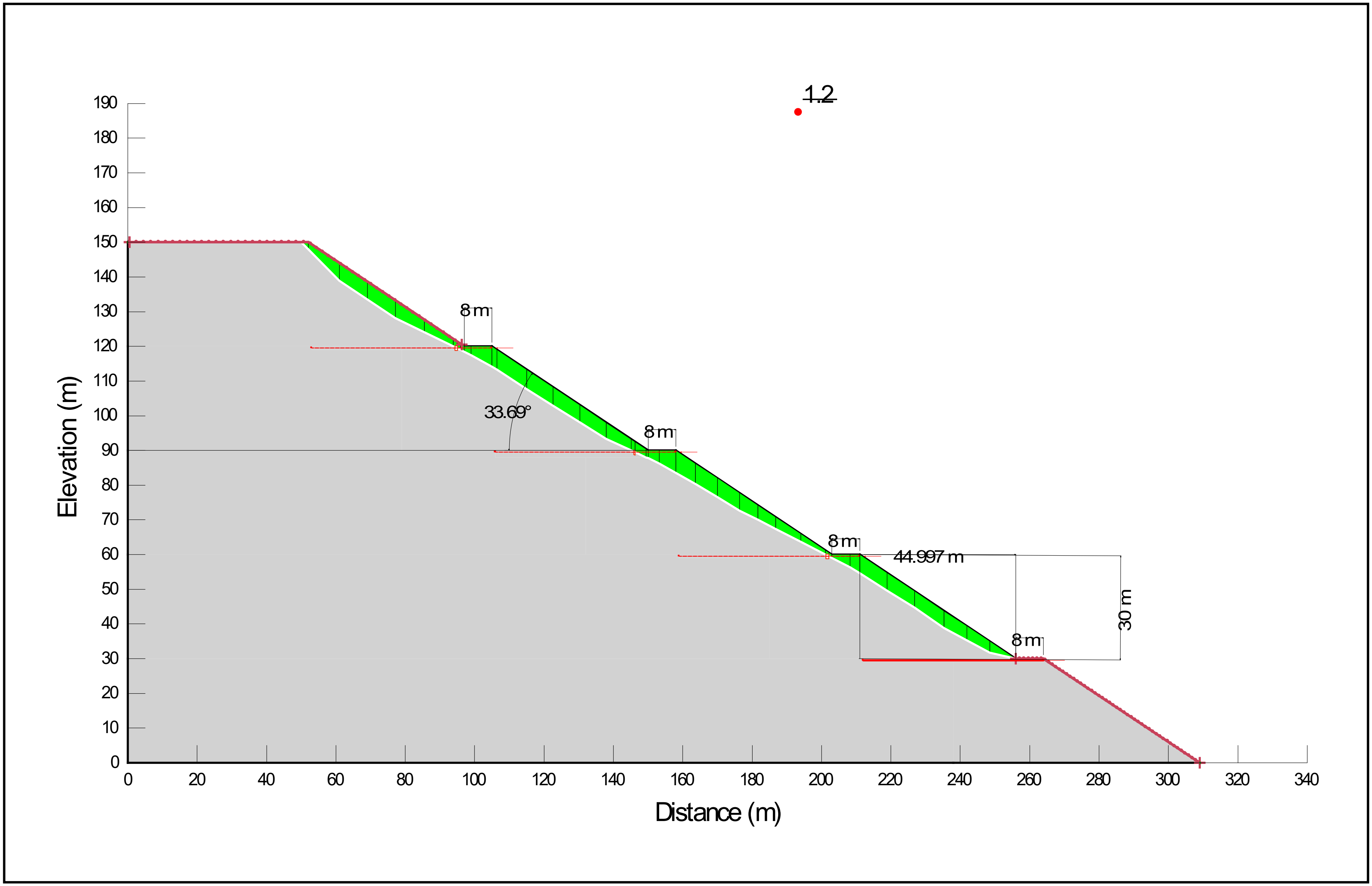
ATTACHMENT A:
Slope/W Modeling Results



Project No: 117-8348002

December 2021

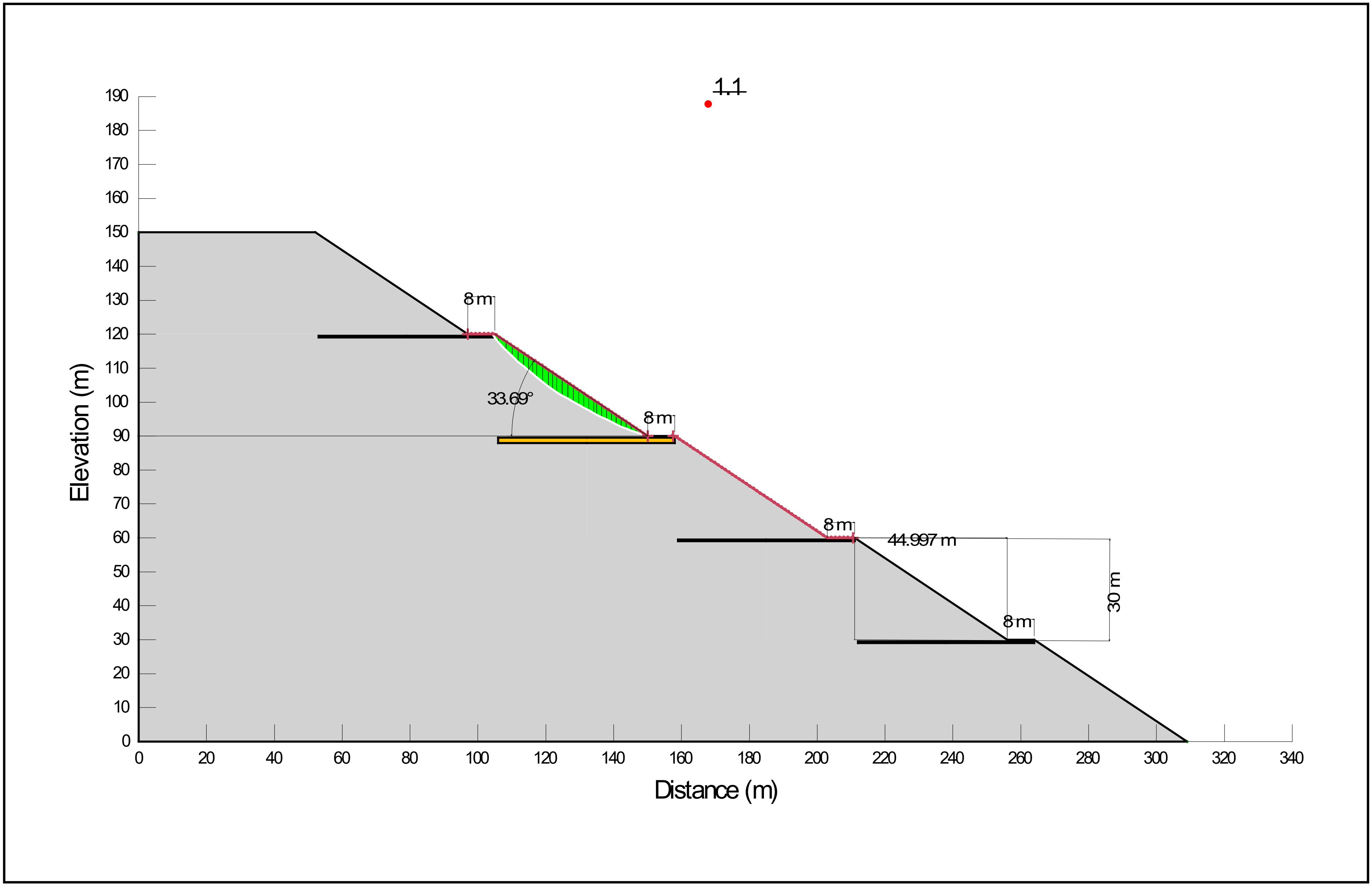
Attachment A-1
Vista Gold
Batman Pit Waste Dump
Global Stability Entry and Exit Point Optimized Failure Search (Geosynthetics Material Model)



Project No: 117-8348002

December 2021

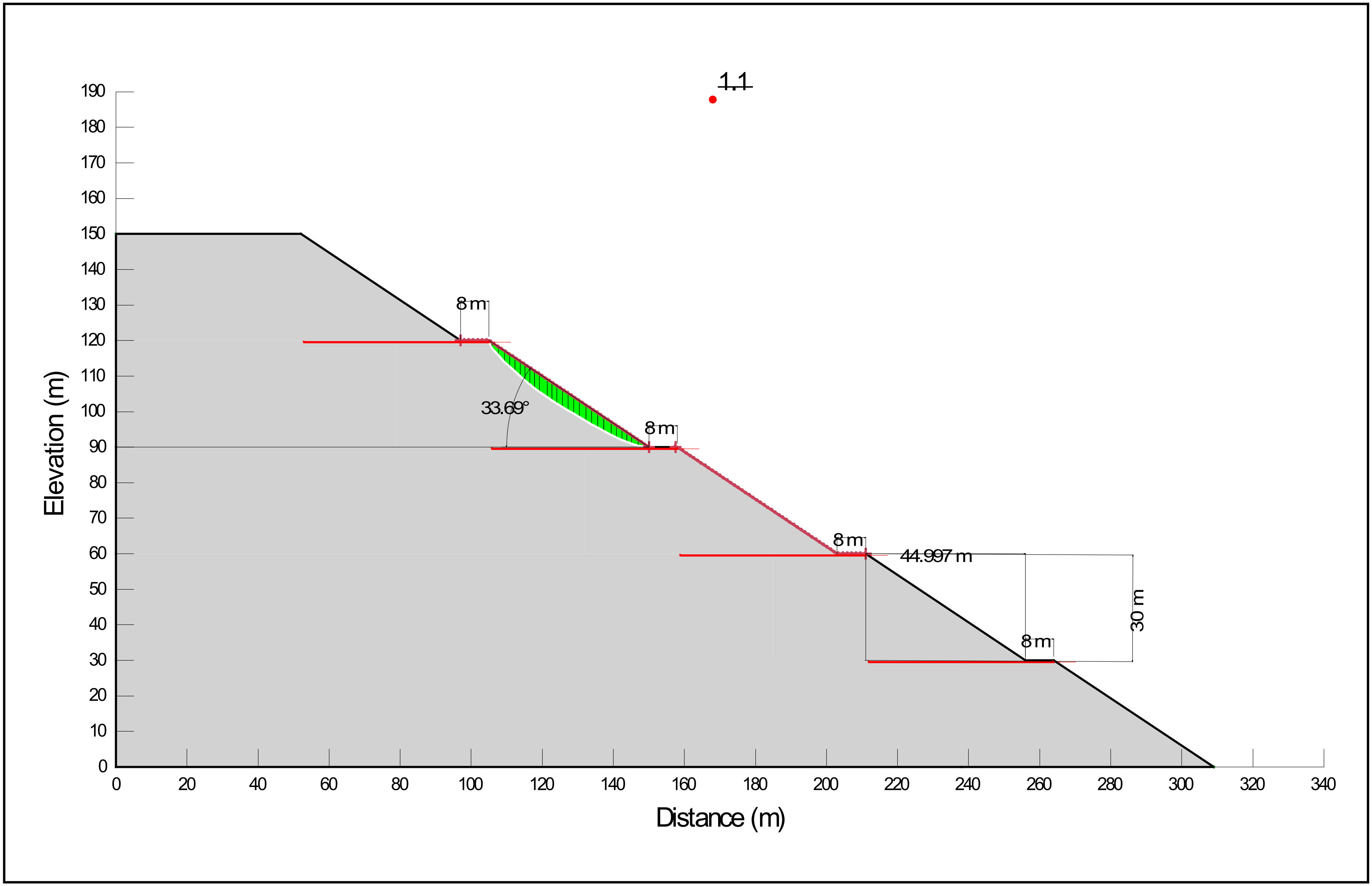
Attachment A-2
Vista Gold
Batman Pit Waste Dump
Global Stability Entry and Exit Point Optimized Failure Search (Geosynthetics Reinforcement Model)



Project No: 117-8348002

December 2021

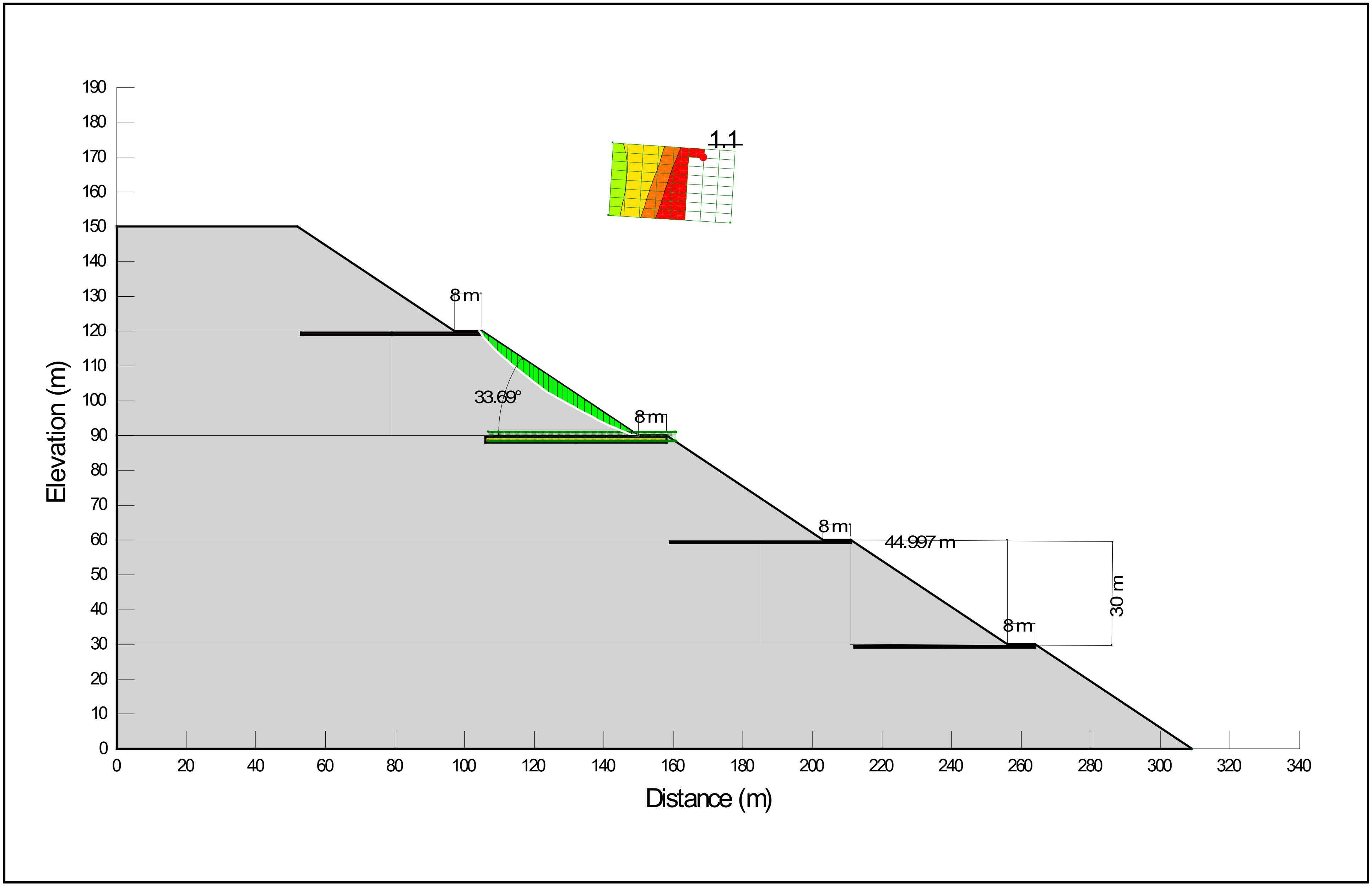
Attachment A-3
Vista Gold
Batman Pit Waste Dump
Intrabench Stability Entry and Exit Point Optimized Failure Search (Geosynthetics Material Model)



Project No: 117-8348002

December 2021

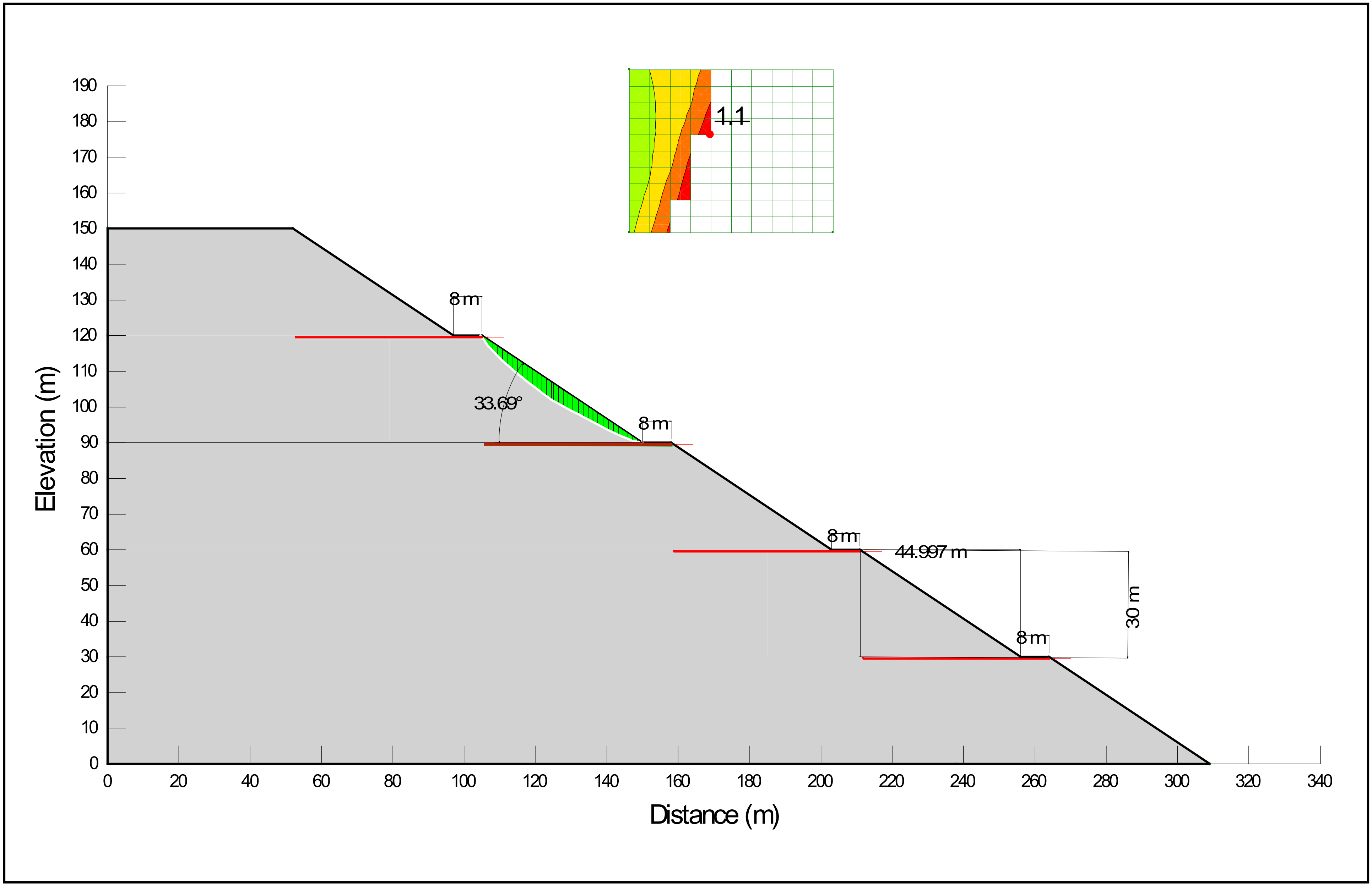
Attachment A-4
Vista Gold
Batman Pit Waste Dump
Intrabench Stability Entry and Exit Point Optimized Failure Search (Geosynthetics Reinforcement Model)



Project No: 117-8348002

December 2021

Attachment A-5
Vista Gold
Batman Pit Waste Dump
Intrabench Stability Grid and Radius Failure Search (Geosynthetics Material Model)



Project No: 117-8348002

December 2021

Attachment A-6
Vista Gold
Batman Pit Waste Dump
Intrabench Stability Grid and Radius Failure Search (Geosynthetics Reinforcement Model)

ATTACHMENT 4:
WRD GCL Cover Vadose Model

TETRA TECH

MEMO

To:	April Hussey, PE and Henry Sauer
From:	Amy L. Hudson, PhD, CPG
Date:	February 1, 2012 | Revised February 12, 2018
Subject:	117-8348002 | Mt Todd – Waste Rock Dump Design & Drainage Evaluation

1. INTRODUCTION

Vista Gold is proposing a waste rock dump (WRD) with steep side slopes for the Mt Todd Project Preliminary Feasibility Study (PFS). The proposed closure of the WRD includes a liner, so a review of the proposed WRD drainage closure conditions was conducted to provide a technical basis for the WRD design. The liner system will be composed of a low permeability liner like Linear Low-Density Polyethylene Liner (LLDPE) or Geosynthetic Clay Liner (GCL) which will be selected based on availability, implementability, and cost at the time of closure.

The WRD design presented in this memo and analyzed through infiltration and seepage analysis has nine 30-meter (m) lifts with eight meter catch benches, a 34 degree interbench slope, and an overall slope of approximately 29 degrees. The liner system presented in this memo uses GCL. The liner system would be placed on top of each of the catch benches, and under the next lift. The total width of the liner system would be approximately 24 m, which corresponds to three rolls of the material laid side-by-side. A one foot layer of fines material will be placed on the liner system to provide confining pressure on the material, and, if GCL is used, to maintain the GCL's moisture content. A one meter layer of Non-PAG material will be placed over the fines layer to prevent erosion and to prevent traffic from impacting liner system integrity.

The liner system using LLDPE would be constructed with a similar configuration to the GCL system simulated described above. Installation of the low-permeability geosynthtic liner cover (i.e., LLDPE) would be conducted concurrently with WRD development following attainment of final grades. This cover design will include a 0.3 m-thick bedding layer followed by placement of the LLDPE, and capped with a 0.3 m-thick protecting layer of fines. The liner bedding and overlayer shall consist of fines, where 80% of the material is finer than a #60 sieve (0.250 mm) and containing no sharp-edged rock fragments larger than 0.5 inches in diameter. The liner material will span approximately 52 m on top of each lift, covering the 8 m bench, and running below the subsequent lift. The liner material will be sloped at a 5 percent angle toward the outside of the WRD. The liner will be constructed with a 0.5 m berm made with 1:1 side slopes at the interior edge of the liner material layer. This cover will channel seepage toward the outer edge of the dump, toward the non-PAG material, mitigating generation of acid rock drainage/metals leaching (ARD/ML). A 1 m-thick layer of non-PAG waste rock will be placed on the top of all surfaces of the WRD to aid in erosion control and to prevent traffic from impacting liner system integrity. Seepage under the LLDPE design would be expected to be less than the GCL design because there is less chance for significant changes in the permeability of the protective layer after it is placed. Therefore, seepage modeling of the LLDPE performance was not completed and the simulation of the GCL design provides a conservative estimate of potential seepage rates.

This Technical Memorandum presents the modeling used to assess the drainage conditions and resulting water quality that would likely exist during closure and post-closure periods for the GCL design. It is anticipated that using a LLDPE liner will result in lower infiltration rates and will nearly eliminate the entrance of water into the WRD benches. The drainage modeling was completed using the VADOSE/W program from the GeoStudio 2007 software package (GEO-SLOPE, 2007). Modeling was performed on cross-section A-A’, which is oriented north-south and cuts through the south facing slope of the WRD (Figure 1). The focus of the modeling is on the interior flow dynamics that could affect the PAG material encapsulated within the interior portion of the facility, and the rate of seepage from the base of the WRD. The geochemical modeling was conducted using the computer code PHREEQC (Parkhurst and Appelo, 1999), a reaction path chemical equilibrium model supplied by the U.S. Geological Survey (USGS).

Proper closure of the WRD and seepage management is critical for preventing impacts to local waters, and to minimize long-term treatment and management costs. Acid rock drainage (ARD) commonly occurs in WRDs with sulphide-enriched mine waste through the oxidation of pyrite (or other sulphide minerals) as it is exposed to oxygen and water. The geochemical characterization program for Mt Todd has determined that 41% of the waste rock will be low sulphur and non-PAG, 18% of the waste rock is in the uncertain acid generating category, and 41% will be PAG; however, it should be noted that the non-PAG material may not provide excess neutralization capacity. WRDs with significant PAG material and minimal neutralization require further management and control of water to prevent environmental impacts.

2. CONCEPTUAL MODEL

The conceptual model provided as Figure 2, shows the system water balance components of the WRD including precipitation, evaporation (from soil surface), runoff, infiltration, and seepage. Seepage includes continued draindown of the residual water trapped in the waste rock, as well as any infiltration that reaches the waste rock through the internal and closure cover material. The internal and top closure covers are composed of a thin GCL layer covered by approximately 305 millimeters (mm) (12 inches) of fines material for confining pressure and moisture retention. Details of the GCL closure cover are shown as Figure 3. If LLDPE is used instead of the GCL, the installation will be similar to that shown in Figure 3 and will follow the same general configuration on each bench. The internal covers will be placed on top of each the catch bench of each 30 m lift of waste rock to limit the flow of water into the encapsulated PAG waste rock. The GCL will be placed from the outer edge of the bench along the horizontal surface, and will be under the buttress of non-PAG material for the next lift. The waste rock will be graded to a five degree slope towards the outside of the WRD to ensure drainage of water away from the PAG waste rock material.

Modeling was performed to simulate closure of the facility. The transient conditions simulated the closure and post-closure conditions and include only the fully stacked facility with the cover placed over the top surface of the waste rock. No operational conditions were correlated.

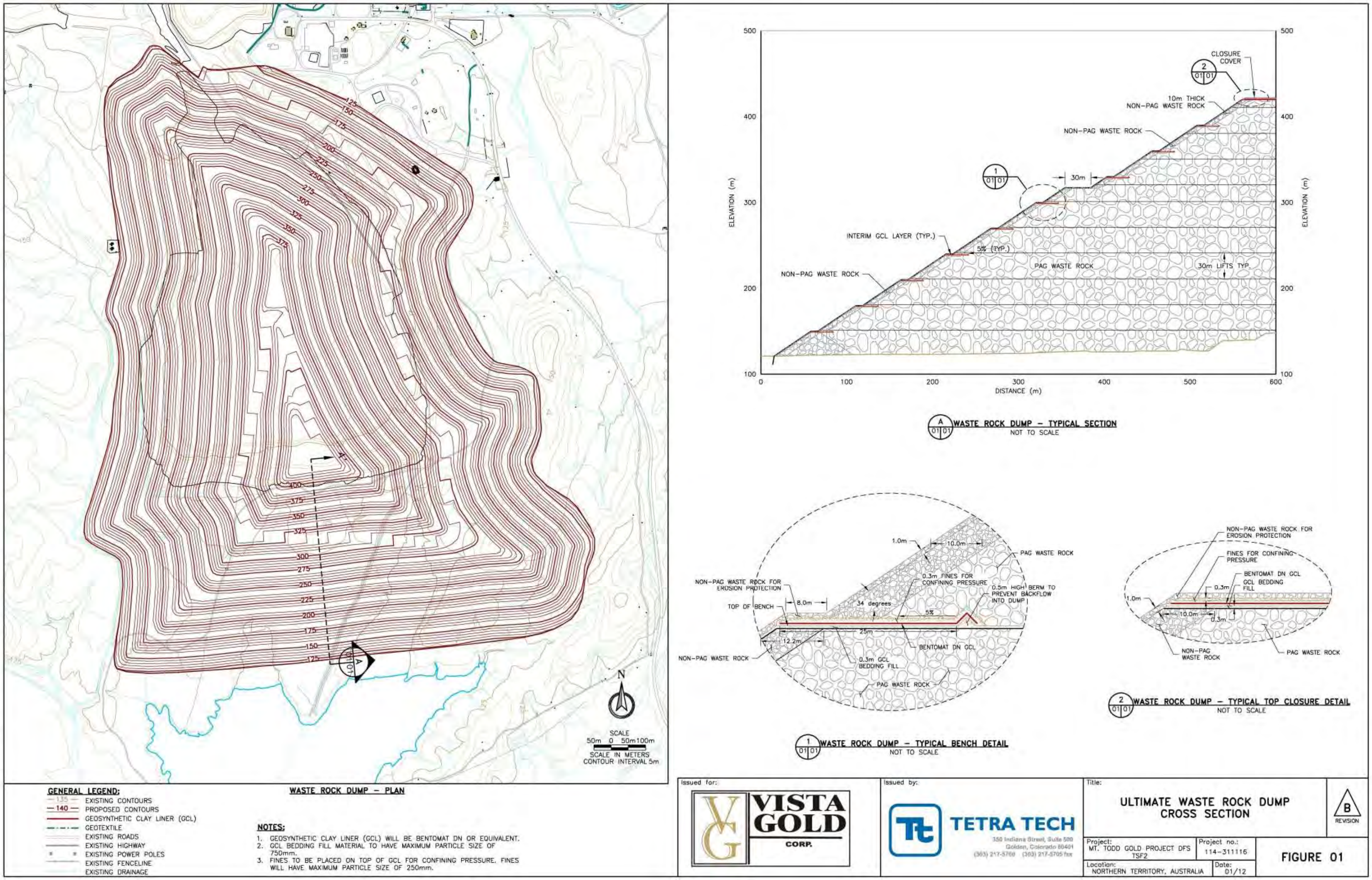


Figure 1 – 2012 Waste Rock Dump Conceptual Model

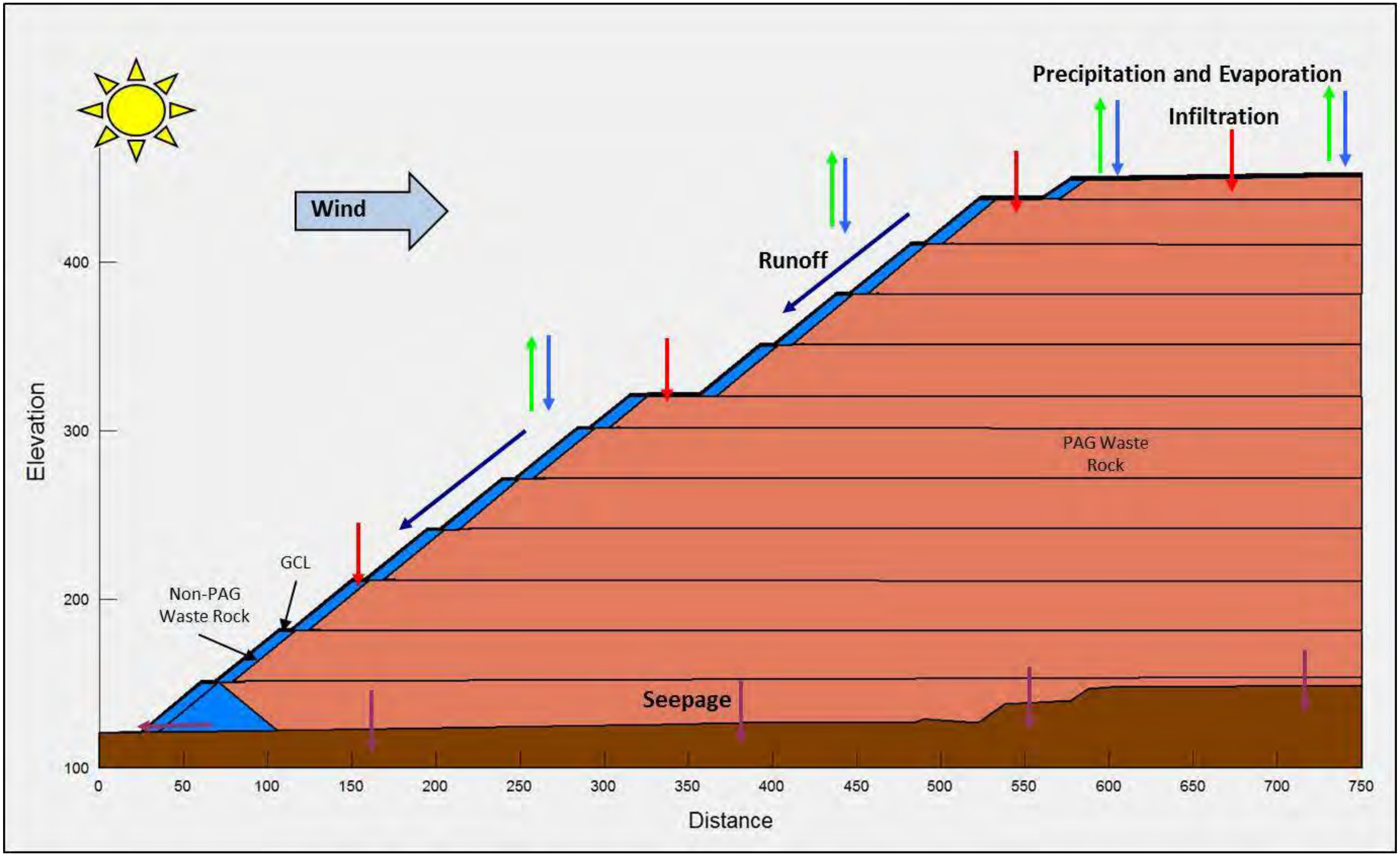


Figure 2 – Waste Rock Dump Conceptual Model

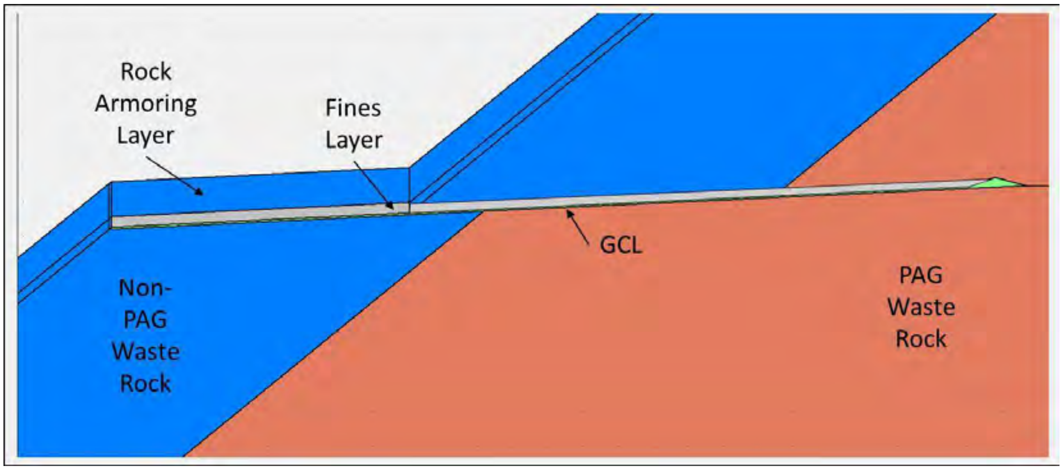


Figure 3 – GCL and Fine Layer Details

2.1 Model Input Parameters

The following subsections present the data that was used in the seepage assessment.

2.1.1 Climate Data

Climate data from the Australian Government Bureau of Meteorology Katherine Aviation Museum meteorological station (http://www.bom.gov.au/climate/averages/tables/cw_014903_All.shtml) was used in the model to evaluate the infiltration of precipitation and seepage from the waste rock. The parameters in the climate data file included:

- Minimum and maximum daily temperature;
- Daily precipitation;
- Minimum and maximum daily humidity;
- Daily evaporation or net radiation; and
- Average daily wind speed.

The Katherine Aviation Museum meteorological station is located approximately 50 kilometers south of the mine. The dataset applied to the modeling utilizes the daily data from October 2010 to September 2011. By applying actual daily data versus average data, a more realistic distribution of precipitation events can be applied to the modeling, including the distinct wet and dry seasons of the site. The water balance for the site is net negative (more evaporation than precipitation). The climate file used for the modeling has precipitation of approximately 1,652 mm and an annual pan evaporation of approximately 2,104 mm. The average annual precipitation for this meteorological station is 1,131 mm and the highest rainfall measured for a one year period is 1,773 mm. The data used for this modeling is above average and provides a conservative evaluation of the behavior of the WRD when conditions are most ideal for the formation of potential wetting fronts within the waste rock material. The same model was run three times, back-to-back, to minimize the "noise" in the model results and to be able to consider three full wet and dry season cycles.

2.2 Material Properties

The most significant difference between saturated and unsaturated flow is the hydraulic conductivity. The hydraulic conductivity in saturated media is a function of the material type. In unsaturated flow, the hydraulic conductivity is a function of the material properties and the moisture content of the material. The equation used to calculate water flow within unsaturated media is:

$$q = -K(\theta)\nabla H$$

Where:

q = water flow velocity (L^2/t)

K(θ) = hydraulic conductivity as a function of soil (or rock) moisture content (L/t)

∇H = hydraulic head (L)

The relationship between moisture content and hydraulic conductivity is non-linear, which further complicates the flow dynamics. In saturated material, the physics of flow are relatively simple and are driven by Darcy's Law where the flow is proportional to the saturated hydraulic conductivity, gravity, and pressure gradients. In simple terms, water flows downhill (downward pressure gradient) and flows faster through coarse material than fine material. However, in unsaturated flow, additional controlling forces include matric pressure (matric suction), absorption, and electrostatic forces.

Matric pressure (matric suction) is the suction created by capillary forces and the interaction of water, air, and solid surfaces. Matric pressure can be observed by placing a thin straw into a body of water. Driven by the surface tension forces, the water rises inside the straw, defying the force of gravity. The thinner the straw, the stronger the suction force will be and the higher the column of water will rise in the tube. The same process occurs in the voids between material particles in a WRD.

One of the most unusual properties of unsaturated zone flow is that different materials are preferentially conductive with varying moisture contents. Under high moisture conditions, pores are saturated and their suction decreases significantly. In this case, gravity is the strongest force and water will flow downhill from pore space to pore space. At low moisture conditions, the preferential flow changes, and the suction forces become stronger than gravitational forces. In this case, the tight materials are the most conductive with small voids that literally suck water through them. Under low moisture conditions, clay is more conductive than the sandy material.

The material properties used in the VADOSE/W (GEO-SLOPE, 2007) models were based on literature values and functions developed based on past experience of mined materials. The material property used to represent the waste rock was from a similar hard, competent waste rock with a limited amount of fine material. The GCL was simulated as a well graded high clay, and the fines layer was simulated as a uniform silt. Figure 4 presents the hydraulic conductivity functions of the waste rock, GCL, and fines layer materials. Figure 5 presents the water content functions of the same materials. The units used in these figures are those utilized by the modeling software.

The waste rock is expected to be very hard, competent material with a minimal amount of fines. This characterization is based on the current observations of an existing WRD for previous site operations. The function used to simulate this material has a saturated hydraulic conductivity of 4.2 centimeters per second (cm/sec) with a rapid, but smooth decrease with increased matrix suction. The hydraulic conductivity of the GCL layer was simulated as 10^{-6} cm/sec. This is higher than the specifications of this type of material, which is designed to be at 10^{-9} cm/sec. Work completed by Benson and Meer (2009) suggests that GCL that will be subjected to high levels of sodium and/or magnesium in solution will be subject to ion exchange processes. Their research showed that the GCL composition will be altered by exchanging sodium and/or magnesium for the calcium. When also subjected to multiple wetting and drying cycles, the hydraulic conductivity can increase by several orders of magnitude. The leachate from the non-PAG waste rock is estimated to have 20 milligrams per liter (mg/L) sodium (Na) and 200 mg/L magnesium (Mg). The saturated hydraulic conductivity value used in this modeling is higher than the design specs, but lower than the worst case observed by Benson and Meer (2009) and provides a conservative, but reasonable estimate of GCL conditions during closure and post-closure. For this modeling, the fines layer that will be placed over the GCL is assumed to be uniform silt with a saturated hydraulic conductivity of approximately 10^{-5} cm/sec.

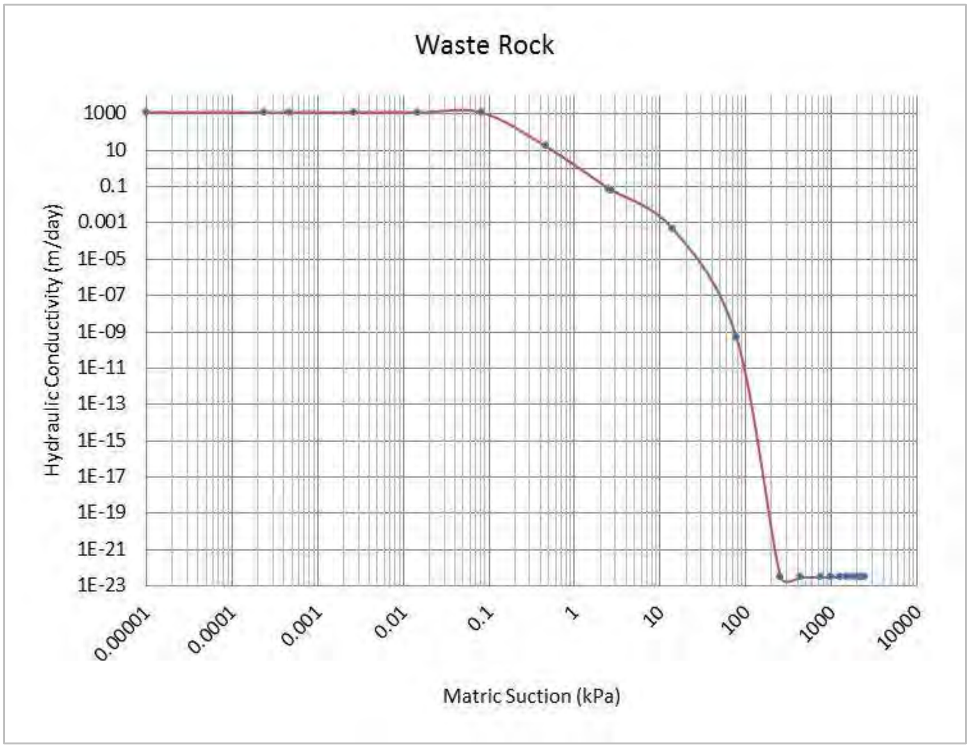
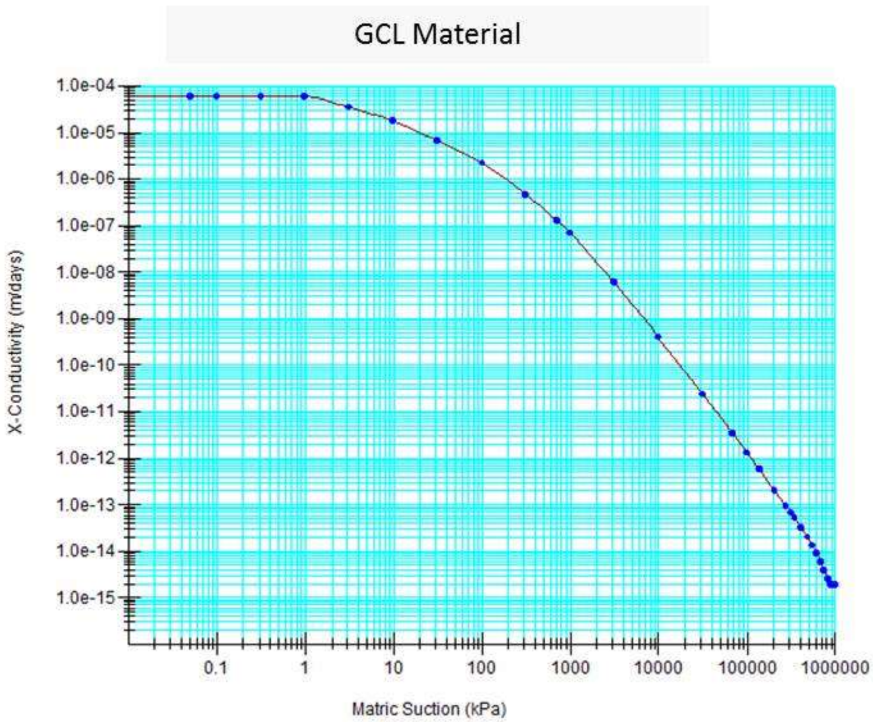


Figure 4 – Hydraulic Conductivity Functions



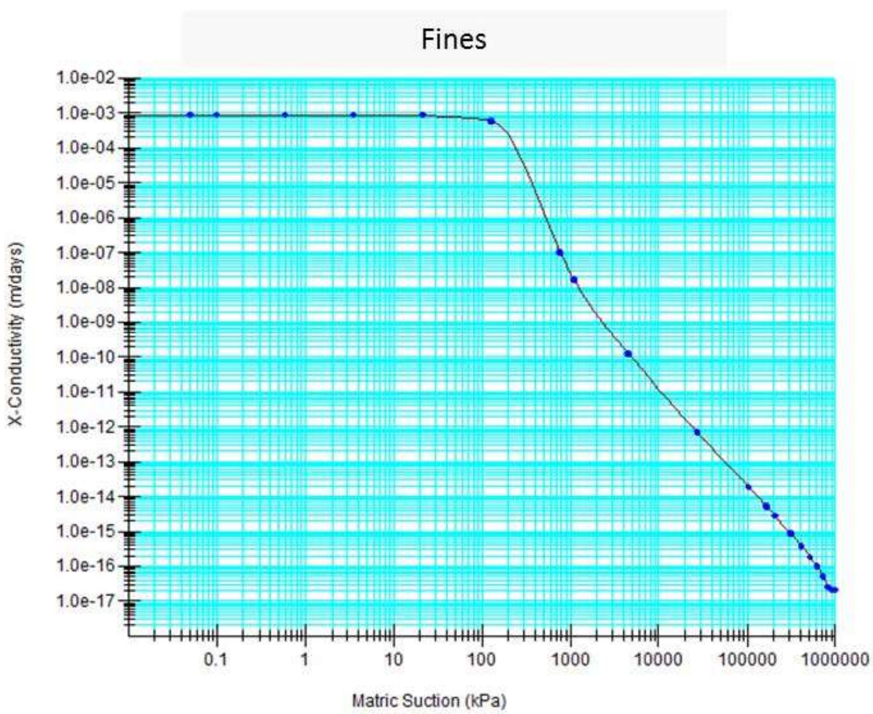
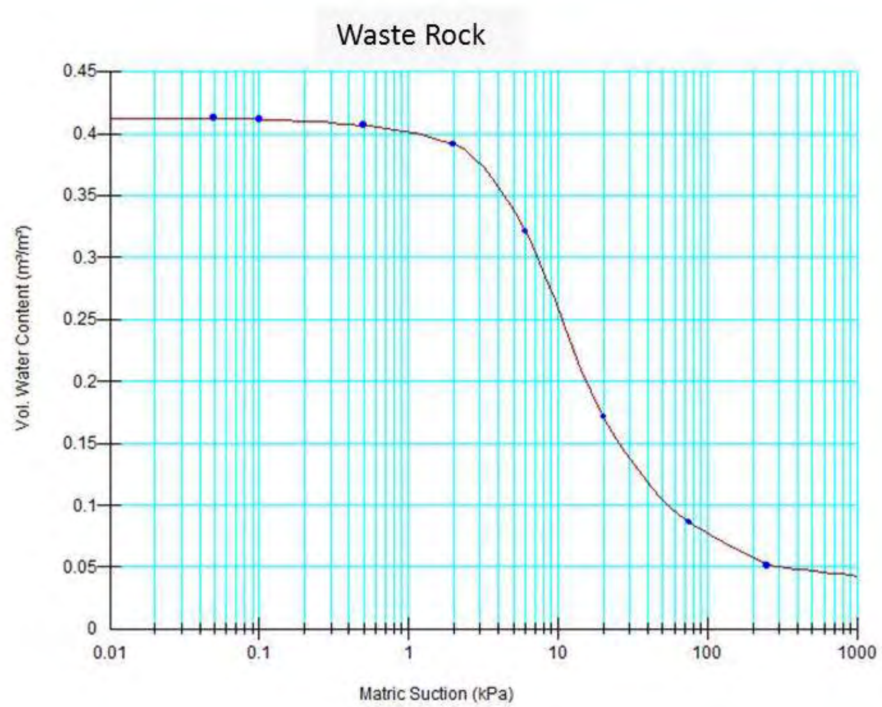


Figure 4 – Hydraulic Conductivity Functions (continued)



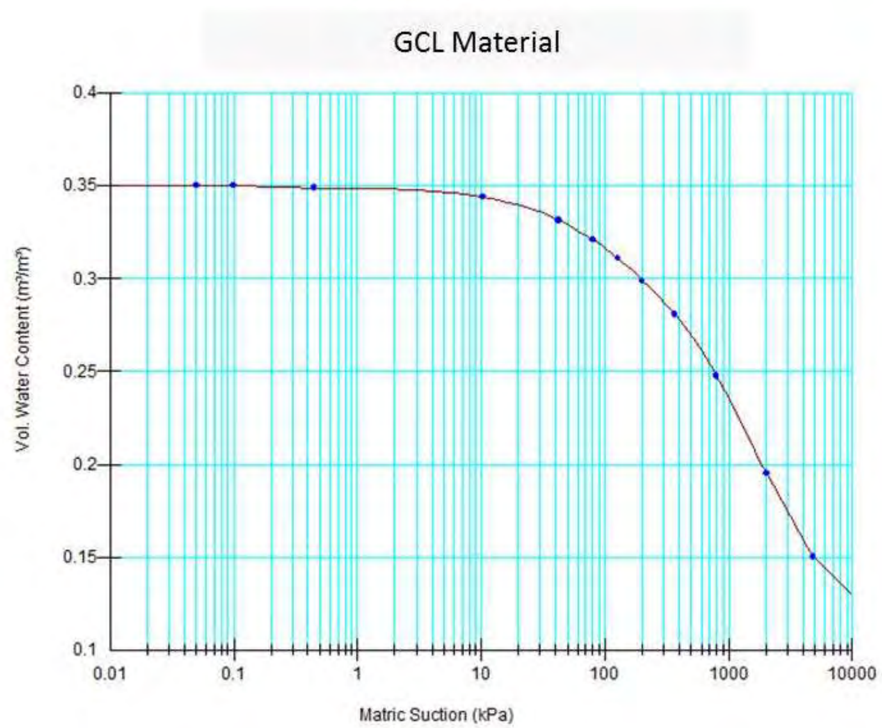


Figure 5 – Soil Water Characteristic Curves

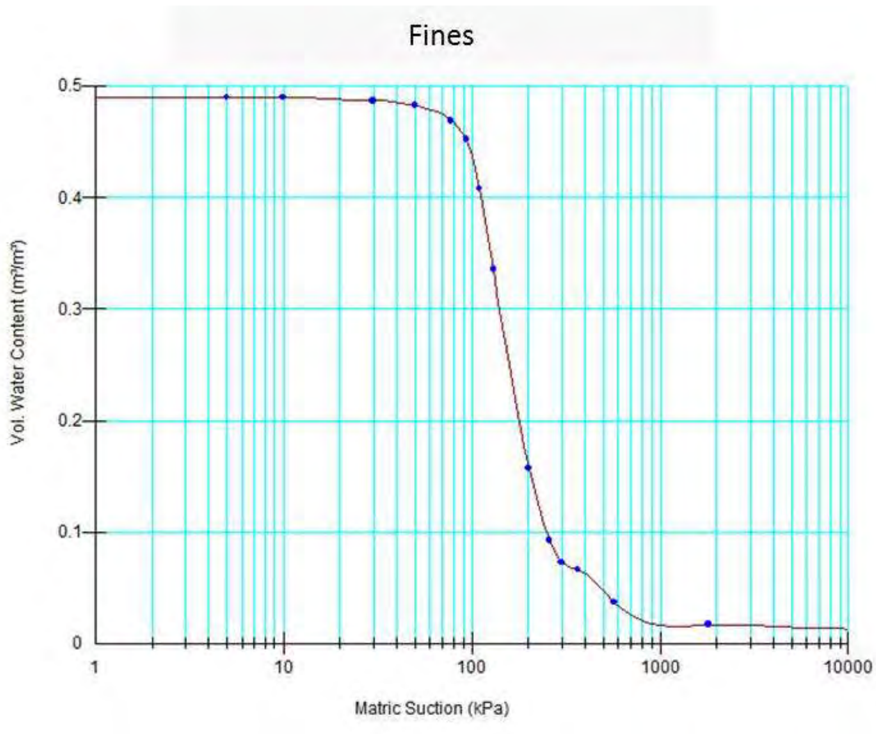


Figure 5 – Soil Water Characteristic Curves (continued)

2.2.1 Boundary Conditions

The boundary conditions used in this modeling were limited to a zero pressure boundary at the base of the model, initial moisture addition (establish non-zero starting conditions), and the climate file. A climate file was used in this modeling to ensure an evaluation of the long term behavior of the waste rock and the cover under actual climatic conditions.

2.3 Modeling Technique

The modeling was completed as a steady state model followed by transient models to simulate the climate conditions.

2.3.1 Steady State Modeling

Steady state modeling is challenging when analyzing mining sites because the facilities change quickly and do not reach true steady state conditions until mine closure. To account for this, the WRD was modeled using an initial non-zero moisture condition to define the starting point of the facility at the completion of mining. The moisture content of the steady state model was in the range of 5% to 15% by volume. The results of the steady state model have been generally calibrated to site conditions (flow rates observed at Weirs 1, 2, and 3), but are only intended to offer non-zero starting values for the subsequent transient modeling scenarios and to evaluate the seepage rate from the waste rock.

2.3.2 Transient Modeling

Transient modeling provides a reasonable simulation of flow conditions within the WRD material under climatic conditions. The upper most layer of these models is a surface region representing the top surface layer of the facility (the GCL, fines layer, and rock armor cover). It is in this part of the model that atmospheric conditions and soil come in contact, driving the water balance. The water within the facility then moves according to the rules of unsaturated flow physics through the waste rock material. Finally, and if applicable, the water reaches the base of the modeled region, where it moves to the model discharge point.

2.3.2.1 Transient Model Scenarios

This modeling study focused on one transient scenario that represents the construction and closure alternative. The WRD has interbench slopes of 34 degrees (overall slope of approximately 29 degrees) and the Petticoat cover option – GCL and fines layer on horizontal surfaces between the lifts of waste rock and on the top surface of the WRD.

2.3.2.2 Surface Layer

VADOSE/W (Geo-Slope, 2007) simulates the dynamics of the facility surface by considering climate and soil interactions. VADOSE/W (Geo-Slope, 2007) simulates precipitation using time increments with a maximum size of two (2) hours. The daily precipitation data is distributed according to a sinusoidal function that peaks at noon (normal distribution). This distribution pattern was compared with the constant averaged and the sloped averaged distribution patterns, and it was determined that the sinusoidal pattern resulted in the most mathematically stable calculation of the results. Potential evaporation or net radiation measurements are used to calculate the actual evaporation that is possible based on the conditions provided in the surface layer of the model. Evaporation is calculated from the following climate and soil factors:

- Air temperature;
- Soil temperature and thermal properties;
- Relative humidity;
- Solar intensity (from latitude);
- Soil moisture content;
- Wind speed; and
- Measured pan evaporation.

The combination of the factors listed above provides a reasonable estimate of water lost from the system through evaporative processes. Infiltration is based on the unsaturated hydraulic conductivity of the material at a given time. Excess precipitation that has not evaporated, transpired, or infiltrated is tabulated as runoff. The surface region for the model was constructed with three layers to simulate the materials of the petticoat cover design.

2.3.2.3 Transient Flow within the Facilities

The transient flow dynamics within the tailings material are simulated over time and space. The model accounts for transitions between material types and produces the following data sets:

- Water flux within the model domain;
- Moisture content;
- Water flow velocity; and
- Seepage discharge, if applicable (out of the model domain).

The following sections present the infiltration and seepage model results.

3. MODEL RESULTS

Table 1 presents the key components of the modeled facility water balance as a percentage of total annual precipitation. The petticoat closure cover limits the amount of precipitation that is able to infiltrate to approximately 25% of annual precipitation. The disadvantage with this design is that water infiltrates along the uncovered waste rock slopes. However, a closer investigation of the modeled results show that the precipitation that readily infiltrates into the waste rock slopes, is quickly evaporated back out of the WRD. Any water that infiltrates and is not quickly lost to evaporation travels vertically until it encounters the GCL and fines layer between the waste rock lifts. Once the infiltrated water reaches the GCL and fines layer, it travels laterally. Because the GCL layer is graded away from the center of the facility, the lateral flow is toward the outer edge of the facility and will prevent infiltration of some water into the PAG waste rock.

Table 1 – Water Balance of Model Scenarios

	Cumulative Boundary Fluxes	Cumulative Runoff Mesh	Cumulative Water Balance	Cumulative Surface Evaporation
34 degree – Petticoat cover	25%	8%	2%	65%

The draindown rate of the WRD was also considered and is presented in Figure 6. Because the catch bench GCL layers do not overlap from lift to lift, there is some potential for water to travel vertically from the slopes to the base of the facility. The amount of water that will travel through the facility is minimal (reaches a steady state rate of four to five cubic meters per hour [m^3/hr] in year three after closure), and will be captured and treated through a passive engineered wetland system. This type of treatment design requires that some moisture flow into the engineered wetland system on a continuous basis to prevent the system from drying out and to help maintain a healthy bacterial population.

During the wet season, the WRD could have a significant amount of water flushed from the waste rock in response to large storm events. This is illustrated by the spike in flows in Year 1 and a slight increase in Year 2 presented in Figure 6. By Year 3 the facility has reach a steady state condition and does not show any response to the wet season or large storm events.

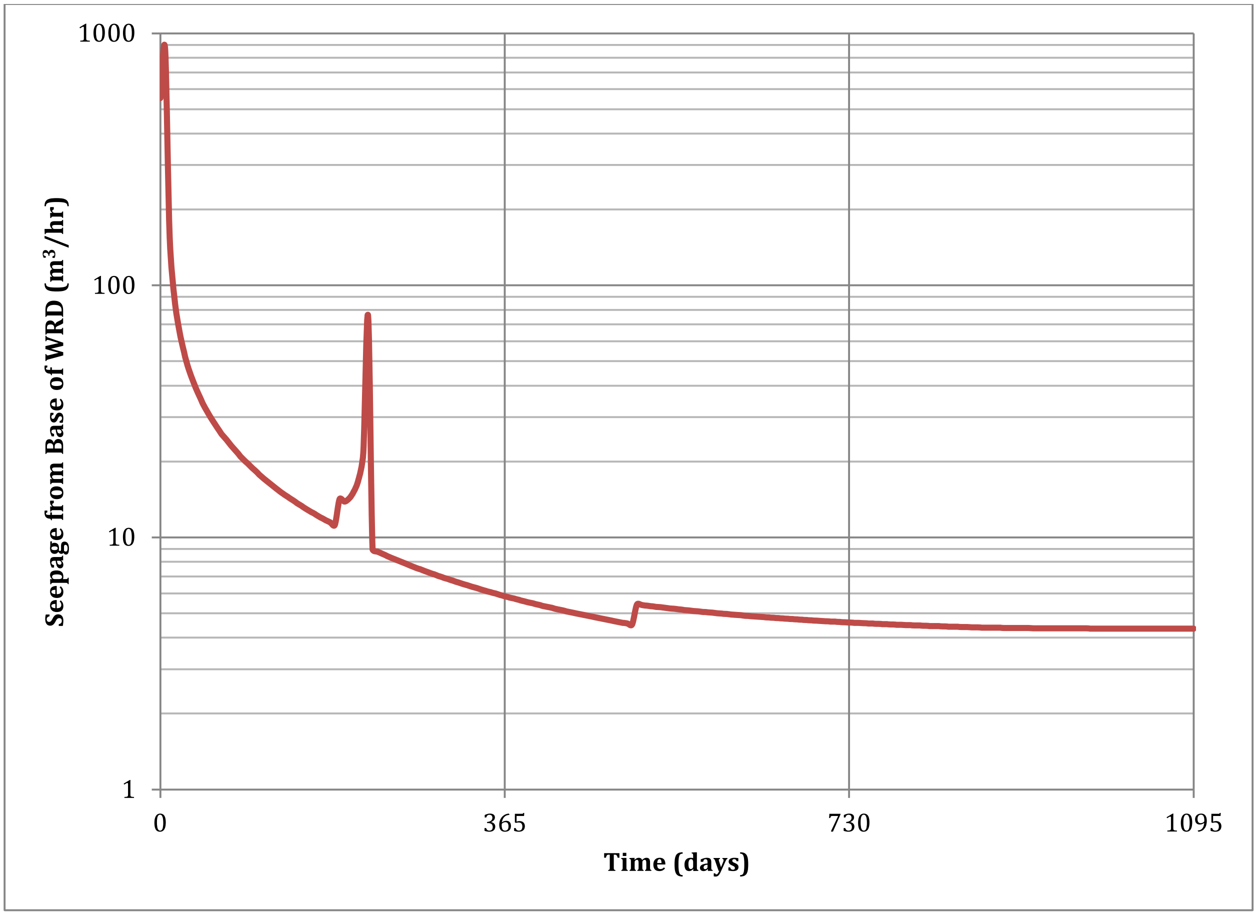


Figure 6 – Draindown Flux Rate of WRD

Even though the waste rock material is quite hard and competent, the WRD will still be a dual porosity system. The primary porosity is the spaces between the pieces of rock. The secondary source of porosity is the fractures present in the rock that will "relax" and potentially open once the confining pressure of overlying rocks is removed. The secondary porosity is difficult to define and could allow ARD to happen in isolated fractures, that could be flushed by a passing wetting front, creating significantly impacted drainage water. These conditions need to be further defined as additional data is collected and site observations are made.

4. WATER QUALITY ASSESSMENTS

The water quality modeling approach and results are provided in the following subsections. Input parameters are summarized in Attachment 1.

4.1 Modeling Code and Database

The geochemical modeling was conducted using the computer code PHREEQC (Parkhurst and Appelo, 1999), a reaction path chemical equilibrium model supplied by the U.S. Geological Survey (USGS). PHREEQC is able to process multiple equilibria and mixing reactions to produce the final chemical speciation of a system. In addition to a computer code, geochemical modeling requires a database of the thermodynamic and kinetic parameters. For this study, the MINTEQ.V5 database (Allison et al, 1991) was chosen. However, this database does not include all of the relevant metals; therefore, to obtain a broad range of metals, data for Ti, Th, Bi were added from the Lawrence Livermore National Laboratory database (llnl.dat).

4.2 Geochemical Conceptual Model

The water quality estimates are based on three probable vertical flow paths that the infiltration water is likely to take within the WRD (Figure 6). In summary:

- Flow Path A represents the optimal scenario with regard to limiting ARD formation such as the scenario that could be envisioned for the outer portion of the lower most lift where water will contact non-PAG rock first (~50%), interact with PAG/uncertain rock within the core (~35%) and contact non-PAG rock again (~15%) before reporting to RP1.
- The horizontal flow induced by the petticoat option would be similar to Flow Path B, and would result in contact with non-PAG rock (~33.3%), followed by PAG/uncertain rock (66.6%).
- Flow Path C represents percolation through the GCL and into the PAG/uncertain rock core only. This worst case scenario represents a scenario without flow through a non-PAG cover.

4.3 Modeling Approach

The geochemical models were constructed as a series of mixing and reaction steps that represent the flow paths shown in Figure 7. The percentages of each waste rock type to be placed in the WRD and the associated potential to generate acid are based on the geochemical characterization program described in Tetra Tech (2011a) and the sulphur cutoffs based on the sulfur block model described in Tetra Tech (2011b).

Tonnages are based on the feasibility study ultimate pit design provided by the project mine planner (Tom Dyer). Micromine software was utilized to cut the pit into the 18 lithologic codes within the block model. Non-PAG, uncertain and PAG criteria were based on the total sulphur concentrations as follows:

- Non-PAG waste rock contains up to 0.25 wt. % total sulphur;
- Uncertain waste rock contains from 0.25 to 0.4 wt. % total sulphur; and
- PAG waste rock contains greater than 0.4 wt. % total sulphur.

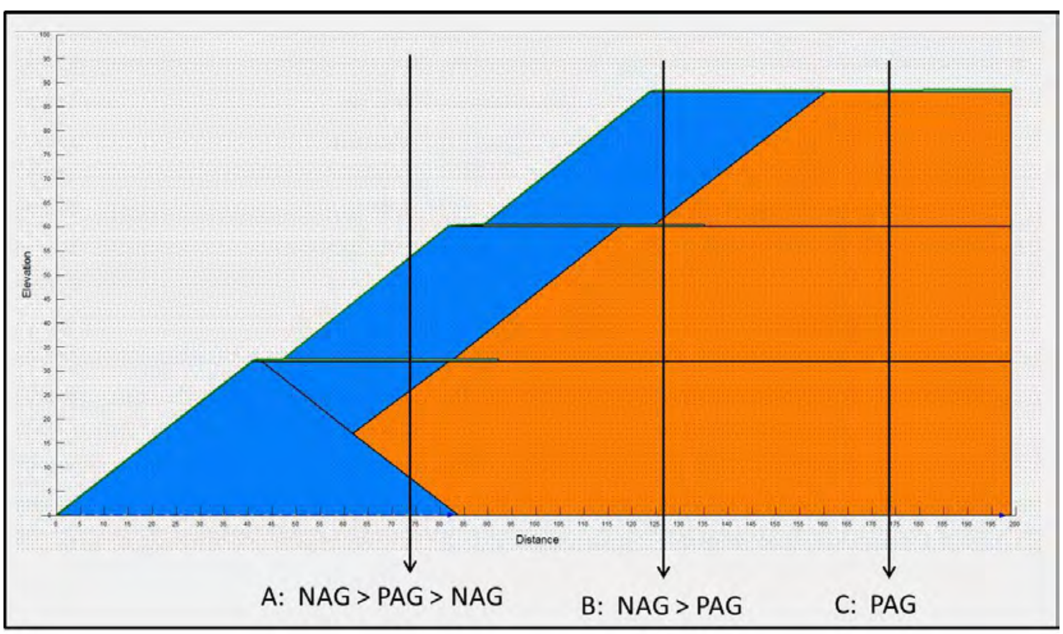


Figure 6 – Expected Flow Paths and Material Contacts

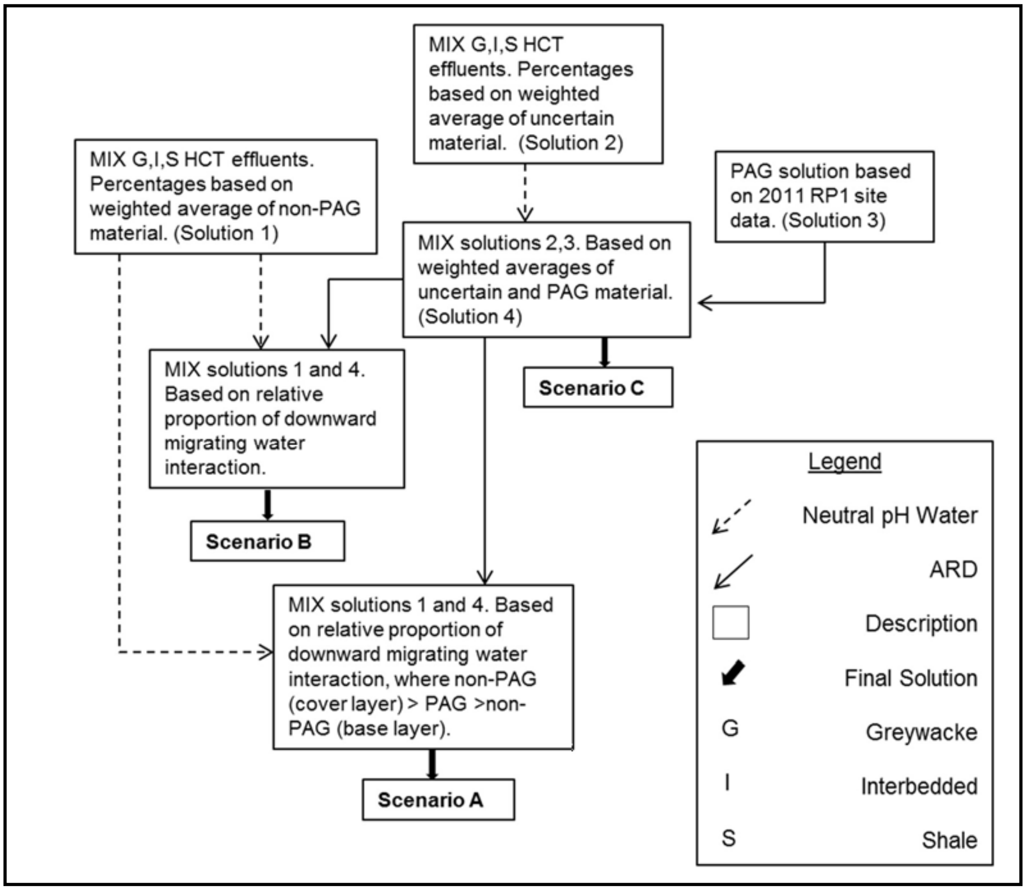


Figure 7 – Geochemical Conceptual Model

Tonnages were obtained by querying all waste rock blocks (< 0.4 ppm Au) with 50% in or out of the topographic surface and ultimate pit surface. Tonnages of each rock type were initially compiled based on the 18 lithologic codes and then grouped into the three larger rock types defined as greywacke, interbedded and shale. Finally, the tonnages of non-PAG, uncertain and PAG waste rock from each rock types were determined (Attachment 1, Table A-1). Blocks identified as felsic tuff (~ 2% of the total tonnages) are also presented in Table A-1 but were not included in the geochemical modeling.

Initial solutions (Attachment 1, Table A-2) were based on kinetic humidity cell test (HCT) results including stable long-term concentrations associated with non-PAG and uncertain waste rock samples that generated neutral to alkaline pH for over one year and "first flush" concentrations from uncertain samples that also did not generate acid during the testing period. Alkalinity values less than 30 mg $CaCO_3$/L are commonplace in the HCT leachates. These initial solutions were mixed together based on the percentages of each rock type with the same acid-generating potential characteristics (Attachment 1, Table A-3). For example, stable concentrations from the non-PAG greywacke, shale and interbedded HCT leachates were mixed at a ratio of 0.4:0.18:0.42, to make solution 1. Likewise, solution 2 is comprised of first flush HCT concentrations of greywacke, shale and interbedded HCT leachates at a ratio of 0.35:0.15:0.5. Solution 3 was based on results from the November 2011 RP1 sampling event and represents ARD from PAG rock without consideration of rock type.

The seepage quality is based on stable long-term and first flush concentrations from the laboratory kinetic testing or ARD from RP1. Therefore, the model is considered to approximate water quality at the onset of the wet season when flushing of constituents will be the highest. The water quality predictions to be conducted for the water balance study will include kinetic oxidation of pyrite.

4.4 Model Results

The geochemical model scenario results are summarized in Table 2. The results show that even partial encapsulation with non-PAG rock (scenario A) does not result in seepage with acceptable water quality as defined by the interim site specific trigger values (Table 3). The non-PAG rock primarily acts as a source of dilution of the regulated constituents. However, acidic pH remains because the alkalinity emanating from the non-PAG rock is insufficient to neutralize the acidity generated by the PAG rock. The model results show that acceptable pH (6 – 8) and associated decrease in constituent concentrations will require a source of neutralization potential (e.g., limestone).

Table 2 – Summary of Model Results

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

Table 3 – Proposed Interim Site Specific Trigger Values

Parameter	Units	Interim Trigger Values	Source (See GHD, 2011)
		Edith River	
pH	pH Units	6 - 8	ANZECC & ARMCANZ Table 3.3.4
Electrical Conductivity	uS/cm	20-250	ANZECC & ARMCANZ Table 3.3.5
Magnesium	mg/L	2.5	Van Dam et al 2010 Environ Toxicol Chem 29(2):410-421
Sulphate	mg/L	129	Elphick et al 2011 Environ Toxicol Chem 30 (1):247-253
Aluminum	mg/L	0.149	Site derived 80th %ile
Cadmium	mg/L	0.2	High reliability TV ANZECC & ARMCANZ Table 3.4.1
Cobalt	mg/L	0.09	Moderate reliability TV ANZECC & ARMCANZ pg 8.3 - 118
Chromium(III)	mg/L	0.0033	Low reliability TV ANZECC & ARMCANZ pg 8.3 - 116
Chromium(VI)	mg/L	0.001	High reliability TV ANZECC & ARMCANZ Table 3.4.1
Copper	mg/L	0.0027	ERISS (2005) NOEC Value
Manganese	mg/L	1.9	Moderate reliability TV ANZECC & ARMCANZ Table 3.4.1
Nickel	mg/L	0.011	High reliability TV ANZECC & ARMCANZ Table 3.4.1
Lead	mg/L	0.0034	High reliability TV ANZECC & ARMCANZ Table 3.4.1
Iron	mg/L	0.3	Canadian Guideline ANZECC & ARMCANZ pg 8.3-123
Mercury	mg/L	0.0006	High reliability TV ANZECC & ARMCANZ Table 3.4.1
Zinc	mg/L	0.0095	ERISS (2005) NOEC Value

5. CONCLUSIONS AND RECOMMENDATIONS

The primary conclusions that can be drawn from this preliminary assessment of the drainage conditions and the water quality associated with different configurations of stacking and covering include:

- The petticoat option for both the 35° and 20° slopes limits the amount of precipitation that is able to infiltrate; however, water that infiltrates along the uncovered waste rock slopes interacts with the PAG waste rock unless the GCL layer is graded away from the center of the WRD.
- The beanie option performed the worst of the scenarios considered because only the top surface of the WRD is cover and the uncovered slopes and benches receive a significant amount of infiltration.
- The most protective option investigated is to fully cover the WRD; however, this option does not appear technically feasible for the 35° slopes.
- The non-PAG rock largely acts to dilute the ARD from the PAG rock because it does not contribute much to the regulated constituent load (e.g., metals, sulphate) but also is not a significant source of alkalinity.
- All three scenarios produce acidic pH solutions due to the minimal available alkalinity in the non-PAG rock to neutralize the acidity generated by the PAG rock. Addition of a neutralization potential source will be needed to prevent/minimize ARD.

Based on the findings of this study, the following recommendations should be considered to advance the current understanding of the drainage conditions associated with Vista Gold's preferred WRD closure configuration:

- Confirm that the WRD design chosen for the feasibility study is geotechnically stable.

- Confirm the composition and hydraulic properties of the fines material that will be placed to obtain the confining pressures.
- Quantify the concentrations of sodium and magnesium associated with the fines material and rainwater due to the potential for elevated sodium and magnesium concentrations to increase the GCL permeability these ions to impact the hydraulic permeability of the GCL. The heap leach pad residues have high sodium and magnesium concentrations compared to the non-PAG waste rock.
- Confirm the viability of an engineered wetland to treat ARD emanating from the WRD and prevent impacts to local waters.

6. REFERENCES

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Tetra Tech, 2011b. Mt Todd Waste Rock Handling Criteria. Mt Todd Gold Project, Northern Territory, Australia. Prepared for Vista Gold Corp. September 26, 2011.

ATTACHMENT 5:
Vadose Model Review Memorandum

To:	Brent Murdoch & John Rozelle – Vista Gold
Cc:	Vicki Scharnhorst – Tetra Tech
From:	Amy Hudson & April Hussey – Tetra Tech
Date:	August 12, 2019
Subject:	**DRAFT**: Summary of Previous Modeling of Waste Rock Dump Cover Systems Mt Todd Project, NT Australia

1. INTRODUCTION

The Northern Territory Environment Protection Authority (NTEPA) Environmental Impact Statement (EIS) Recommendation No. 3 (http://www.mttodd.com.au/environmental-impact-statement.html) provided the following recommendation, "*The Proponent must undertake a rigorous evaluation of alternative WRD cover designs prior to authorisation of the Project. Modelling work underpinning the design of covers, and subsequent monitored trial covers, must demonstrate that the covers can meet the required cover objectives within the context of the wet- dry cycling environment of the Top End and other biophysical factors that have the potential to affect cover integrity in the long term. The modelling must be subject to rigorous peer review by an independent party with practical experience with the issues that affect the real world performance of the modelled cover system/s.*"

This Technical Memorandum provides support to Vista Gold Corp (Vista) in responding to this recommendation by providing a comprehensive summary of the extent of waste rock dump (WRD) cover system evaluation work conducted since 2010, and includes recommendations as to additional cover evaluation and modeling work that may be appropriate to respond to the EIS recommendation.

Initial closure planning completed as part of a Pre-Feasibility Study (PFS), including designing a WRD cover, was conducted in 2010 prior to the selection of the currently proposed petticoat GCL cover configuration. Additional cover designs were considered by Tetra Tech and Mine Development Associates (MDA) as the project progressed through engineering design and later PFS updates. A preliminary review of documents prepared during the project development indicate at least six configurations of closure covers were initially screened using modeling. The WRD closure cover configurations considered included:

1) Store and release cover
    a) Placed on WRD with 3H:1V regraded slopes
    b) Cover system consisting of 0.3 meters (m) of clay blended in-place with non-potentially acid generating (non-PAG) rock, 0.6 m non-PAG rock mixed with clay, and a thin layer of growth medium amended with organics
2) 35-degree outer slopes with petticoat liner – petticoat created from strips of geosynthetic clay liner (GCL) and fines layer placed on horizontal surfaces between the lifts of waste rock and on the top surface of the WRD;
3) 35-degree outer slopes with beanie cap liner – GCL and fines layer only on the final top surface of the WRD;

4) 35-degree outer slopes fully covered with liner – GCL and fines layer on the entire outer surface of the WRD;
5) 20-degree outer slopes with petticoat liner – petticoat created from strips of GCL and fines layer placed on horizontal surface and between the lifts of the waste rock and on the top surface of the WRD; and
6) 20 degree outer slopes fully covered with liner – GCL and fines layer on the entire outer surface of the WRD.

2. PREVIOUS WRD COVER MODELING EVALUATION

2.1 2010 Pre-Feasibility Study

The initial cover evaluation was reported as part of the proposed closure plan prepared as part of the PFS completed in 2010 (Tetra Tech, 2010). This cover design used a store and release design to manage water infiltration. The store and release design was proposed to be composed of two layers, one of clay and non-PAG rock blended in place on the WRD surface through deep ripping, with a second pre-blended clay/non-PAG layer placed over the blended in place layer. A thin layer of growth media that includes organic amendments was proposed for the outer surface to allow for revegetation of the cover. The same general design was proposed for both the WRD and the tailings storage facility (TSF).

Modeling to evaluate the performance of the store and release cover design was completed as a one dimensional VADOSE/W (GeoSlope Ltd., 2007) model under average climate conditions. The modeling was completed assuming tailings material under the cover, rather than waste rock; it is assumed that the performance of the cover will be similar over both types of waste material. A sample of greywacke rock from the geochemical testing program was used as the representative soil material in the cover. Grain size distribution analysis characterized the material as 65% gravel, 34% sand, and 1% silt/clay. This material was "improved" by increasing the silt/clay fraction of the material.

Five different scenarios were simulated using the store and release cover (Tetra Tech, 2010):

1) Non-vegetated cover constructed of greywacke material (Ksat = 1 x 10^{-3} cm/sec);
2) Non-vegetated cover constructed of improved greywacke material (Ksat = 1 x 10^{-5} cm/sec);
3) Vegetated cover constructed of greywacke material (Ksat = 1 x 10^{-3} cm/sec);
4) Vegetated cover constructed of improved greywacke material (Ksat = 1 x 10^{-5} cm/sec); and
5) Vegetated cover constructed of greywacke material (Ksat = 1 x 10^{-2} cm/sec).

For the modeling, each design included a one-meter thick cover layer. The model was run using three consecutive one-year simulation periods to attempt to reach approximate steady state conditions under the climate inputs. The results suggested that the more permeable greywacke cover performed the best due to the ability of the material to promote evaporation while providing storage of precipitation. The result was a net zero flux cover design that relied on well graded soils for holding water in tension while preventing erosion of the surface.

It was noted in the Closure Plan (Tetra Tech, 2010), that the design modelled had been superseded, but was not available in enough time to update the evaluation of the cover performance using the new design. The updated design was to be considered in future modeling studies completed for the project. It was also recommended that hydraulic testing be completed on the proposed soil cover material to refine the material properties being used in the modeling study. Extended modeling scenarios that use 10-20 years of climate data were also recommended at the time to determine the sensitivity of the cover to changes in conditions.

2.2 2011/2012 Updated WRD Design

Based on additional geotechnical work, it was determined that the WRD could be constructed with steeper slopes than those proposed and simulated as part of the PFS completed in 2010. The previously proposed store and release cover would be technically challenging to place and maintain on the proposed steeper WRD slopes, so covers using geosynthetic clay liner (GCL) were considered in an updated modeling study. The updated WRD design also included encapsulating the PAG rock in the center of the facility, with a layer of non-PAG rock placed on the outer surface of the dump to limit the water rock interaction between precipitation and the PAG material.

Figure 1 presents the general conceptual model of the WRD and the geometry of the modeling simulations completed to evaluate the closure cover performance. **Figure 2** presents a more detailed view of the GCL and fines layer proposed to be placed between the benches

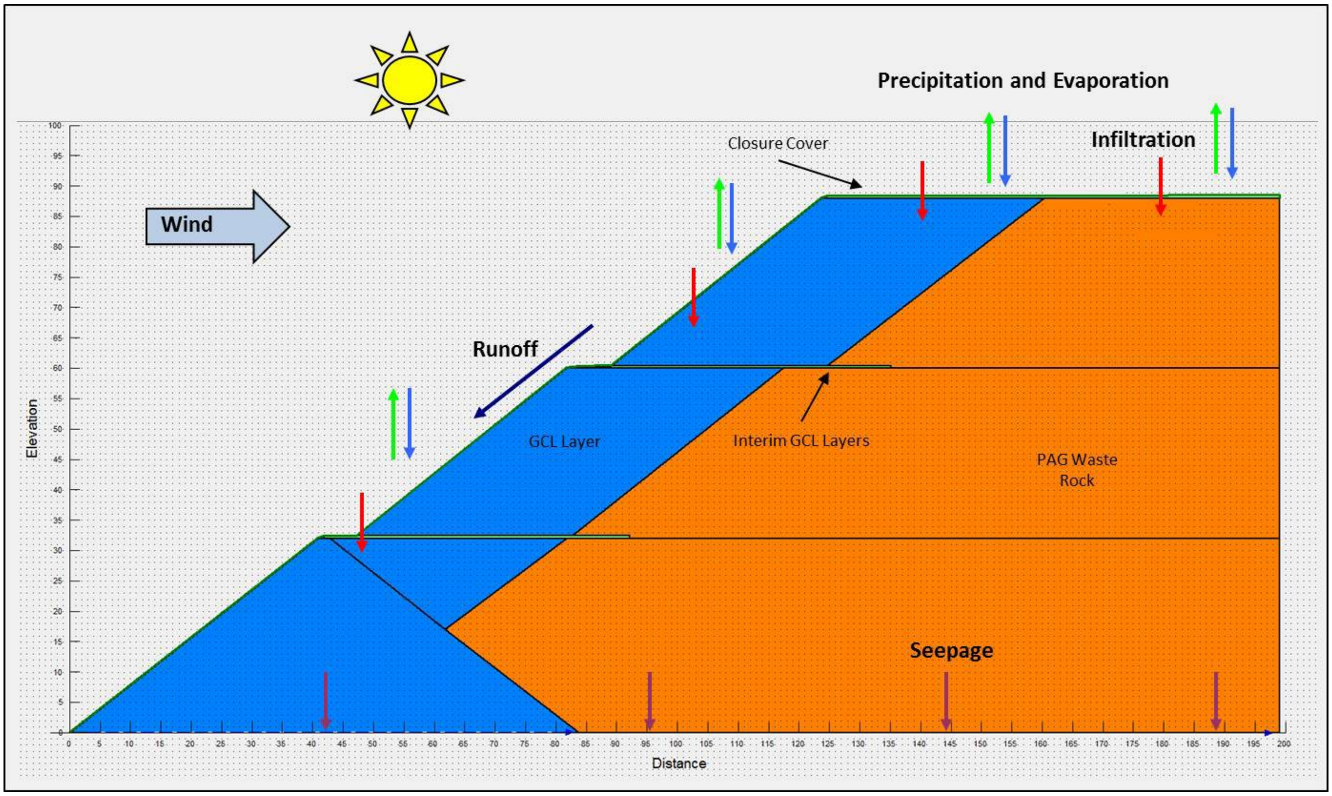

Figure 1: Waste Rock Dump Conceptual Model

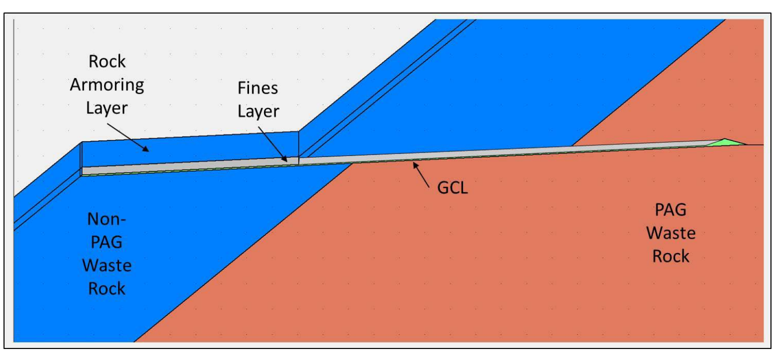

Figure 2: GCL and Fine Layer Details

A total of five different configurations of the cover were simulated during the 2011/2012 update of the WRD cover design:

- 35-degree outer slope of the WRD:
  - Petticoat – GCL and fines layer on horizontal surfaces between the lifts of waste rock and on the top surface of the WRD;
  - Beanie cap – GCL and fines layer only on the top surface of the WRD; and
  - Fully covered – GCL and fines layer on the entire outer surface of the WRD.
- 20-degree outer slope of the WRD:
  - Petticoat n – GCL and fines layer on horizontal surface and between the lifts of the waste rock and on the top surface of the WRD; and
  - Fully covered – GCL and fines layer on the entire outer surface of the WRD.

The internal and top closure covers were proposed to be composed of a thin GCL layer covered by approximately 305 millimeters (mm) (12 inches) of fines material for confining pressure and moisture retention. The internal covers will be placed on top of each 30 m lift of waste rock to limit the flow of water into the encapsulated PAG waste rock. The GCL was proposed to be placed from the outer edge of the bench along the horizontal surface, and under the buttress of non-PAG material for the next lift.

The modeling was completed as a two dimensional VADOSE/W (GeoSlope Ltd., 2007) model under daily measured climate conditions. The climate dataset applied to the modeling utilised the daily data from October 2010 to September 2011 from the Australian Government Bureau of Meteorology Katherine Aviation Museum meteorological station (http://www.bom.gov.au/climate/averages/tables/cw_014903_All.shtml). The same model was run twice, back-to-back, to reach approximate steady state conditions under the climate inputs and to be able to consider two full wet and dry season cycles.

The results of this modeling study were reported internally, but were not reported externally or presented as an appendix to another report. The petticoat option for both the 35° and 20° slopes limited the amount of precipitation able to infiltrate. The disadvantage with this design was that water can infiltrate along the uncovered waste rock slopes. The infiltrated water would be expected to travel vertically until it encounters the GCL and fines layer between the waste rock lifts. Once the infiltrated water reaches the GCL and fines layer, it travels laterally. If the GCL layer is graded away from the center of the facility, then the lateral flow is toward the outer edge of the facility and will prevent infiltration of this water into the PAG waste rock. If the GCL and fines layer is flat or grades inward, the lateral flow will cause the infiltrated water to contact the PAG rock.

The beanie option performed the worst of all of the scenarios considered because only the top surface of the WRD is covered and the side slopes and benches are not covered. This scenario confirmed the top GCL and fines layer is protective on the upper WRD surface even if it is subject to ion exchange; however, the uncovered slopes and benches receive a significant amount of infiltration. The most protective option for both the 35° and 20° slopes is a fully covered facility. This option is not technically feasible for the 35° slopes because the cover material could not be safely placed on the sloped surfaces and would be subject to significant physical erosion, impacting the long term effectiveness of the cover. This design is feasible for a 20° slope and performs the best of all of the scenarios. **Table 1** presents the key components of the facility water balance as a percentage of total annual precipitation resulting from the modeling completed as part of the 2011 study. The cumulative boundary flux represents the infiltration of precipitation into the WRD, the runoff is water shed from the WRD surface, the cumulative water balance is a measure of the model error, and the surface evaporation is the water lost through evaporative process at the WRD facility surface.

Table 1: Water Balance of 2011 Model Scenarios

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

The draindown rate of the WRD was also considered for each of the five modeled scenarios and is presented in **Figure 3**. It should be noted that the flux rates presented in **Figure 3** have not been calibrated to site conditions, but provide a comparative tool for assessing the performance of each of the cover configurations. The two petticoat options (green and purple lines) drain the quickest, but also have the greatest response to storms during the wet season. The fully covered options provide the greatest protection, which can be seen by the smooth and consistent draindown rate. Though it appears that the draindown is slower under these scenarios, it is primarily due to the limited amount of air flow and additional water being added to the WRD.

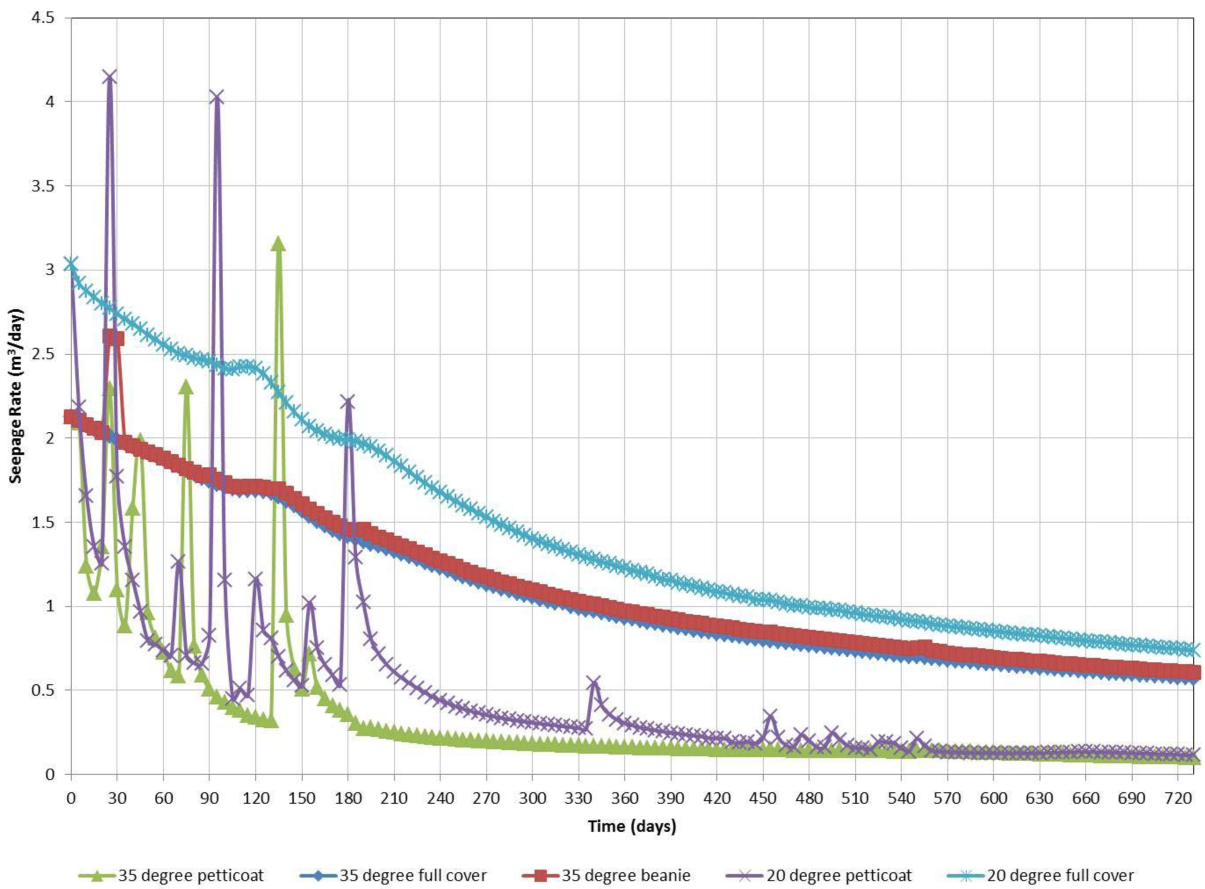

Figure 3: Draindown Flux Rate of 2011 Model Scenarios

Early in 2012, the petticoat liner cover placed over a 35-degree outer waste rock slope was selected as the preferred cover by Vista. It should be noted that early designs of the petticoat cover were such that there was not vertical overlap of the GCL layer from bench to bench. Following selection of the preferred cover option, it was decided to focus the modeling effort on the preferred cover alternative. Modeling of the preferred option was updated using three back-to-back simulations of actual climate data, to minimize the "noise" in the model results and to be able to consider three full wet and dry season cycles. The one year of actual climate data applied to this model simulation is the same as that used in the 2011 modeling study.

Table 2 presents the key components of the modeled facility water balance as a percentage of total annual precipitation for the 2012 simulation. The petticoat closure cover limited the amount of precipitation that is able to infiltrate to approximately 25% of annual precipitation. Because the catch bench GCL layers do not overlap from lift to lift, there is some potential for water to travel vertically from the slopes to the base of the facility. During the wet season, the WRD could have a significant amount of water flushed from the waste rock in response to large storm events. This is illustrated by the spike in flows in Year 1 and a slight increase in Year 2 presented in **Figure 4**. By Year 3 the facility has reach a steady state condition and does not show any response to the wet season or large storm events.

Table 2: Water Balance of 2012 Model Scenario

	Cumulative Boundary Fluxes	Cumulative Runoff	Cumulative Water Balance	Cumulative Surface Evaporation
35 degree - Petticoat cover	25%	8%	2%	65%

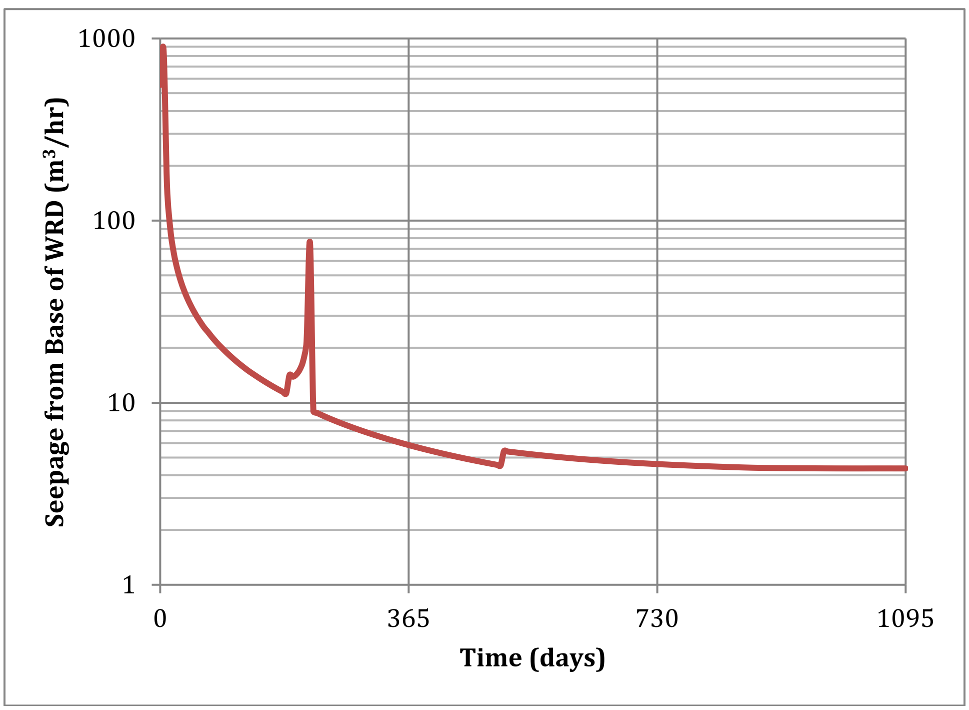

Figure 4: Draindown Flux Rate of 2012 Model Scenario

The next iteration of the modeling completed in 2012 considered a wider GCL placement that provides continuous coverage bench to bench. The total width of the GCL under this scenario would be approximately 52 m in width, which corresponds to the width required to provide full liner coverage with a small amount of overlap from bench to bench. A one-foot (0.3m) thick layer of fines material would be placed on the GCL to provide confining pressure on the material, and to maintain the GCL's moisture content. A one-meter layer of Non-PAG material will be placed over the fines layer to prevent erosion. The modeling study completed to evaluate this configuration of the cover design was run using VADOSE/W (GeoSlope Ltd., 2007) on a two-dimensional geometry. The model was run for a ten-year period with the climate file repeating each year, to minimize the "noise" in the model results and to be able to consider multiple full wet and dry season cycles. The same one year of actual daily measured data that was used in the prior 2011 and 2012 modeling was used for this study.

Table 3 presents the key components of the modeled facility water balance as a percentage of total annual precipitation. The petticoat closure cover limits the amount of precipitation that is able to infiltrate into the PAG waste rock to approximately 7% of annual precipitation compared to no cover, which allows approximately 21% of annual precipitation to infiltrate. Additionally, the petticoat design also increases the runoff by approximately 20% over the uncovered facility. A closer investigation of the modeled results shows that the precipitation that readily infiltrates into the waste rock slopes is quickly evaporated back out of the WRD. The amount of water that will travel through the facility is minimal (reaches a steady state rate of 1.5 cubic meters per hour [m^3/hr] at the end of year three after closure). **Figure 5** presents the draindown curves for these model simulations.

Table 3: Water Balance of Model Scenarios

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

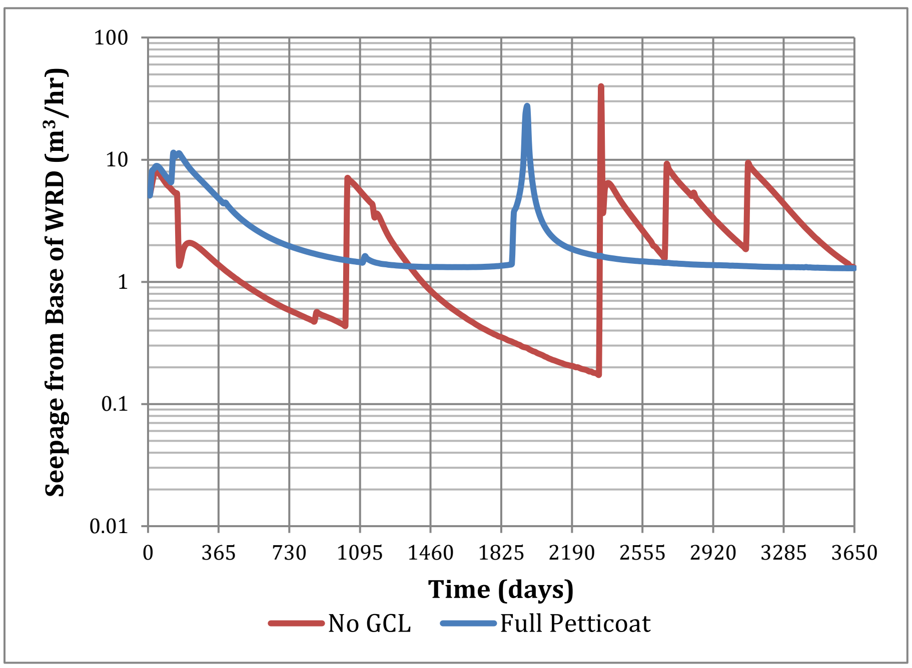

Figure 5: Draindown Flux Rate of WRD

3. CONCLUSIONS AND RECOMMENDATIONS

The model simulations completed for the Mt Todd project have developed iteratively as the development of the WRD design has advanced. The simulations completed early in the WRD design considered several design options, which were each simulated, though may not have been reported externally. As the design of the WRD changed to the steeper stacking plan, the closure cover options that could be feasibly constructed and maintained became more limited. Therefore, the modeling changed to focus on the closure cover designs that were practical for the overall WRD construction.

The simulations completed were comprehensive and considered actual climate data, allowing for the distinct characteristics of the wet and dry season to be simulated and considered. The final modeling also included the wider GCL placement, so the final design proposed has been simulated through modeling. It is therefore not recommended that additional modeling of the GCL covers be completed at this time. It has more recently been proposed to replace the GCL in the design with another liner option similar in configuration to the GCL system simulated, but using a low-permeability geosynthetic liner cover (i.e., LLDPE) following attainment of final grades on each bench. This cover design would include a 0.3 m-thick bedding layer followed by placement of the LLDPE, and capped with a 0.3 m-thick protecting layer of fines. The liner bedding and overlayer would need to consist of fines, where 80% of the material is finer than a #60 sieve (0.250 mm) and containing no sharp-edged rock fragments larger than 0.5 inches in diameter. While this option has been considered and it is anticipated that using a LLDPE liner will result in lower infiltration rate than the GCL, however, this WRD closure cover design configuration has not been modelled so this cannot be confirmed. The previous modeling could be updated to include a simulation of this cover configuration.

The modeling described in this report was all completed by Tetra Tech, though by multiple modelers. A peer review evaluation of the model was completed internally for each of the modeling studies described in this memo. If an independent, external review is desired, the model files and associated draft and final memos could be prepared for this purpose.

4. REFERENCES

GeoSlope Ltd., 2007. *Vadose Zone Modeling with VADOSE/W 2007: An Engineering Methodology*. GeoSlope International Ltd.: Calgary, Alberta, Canada.

Tetra Tech, 2010. Appendix J, Prefeasibility Study Proposed Closure Plan, Mt. Todd Project. September 2010.

ATTACHMENT 6:
TSF Cover Vadose Model

TETRA TECH

MEMO

To:	Henry Sauer & April Hussey
From:	Amy L Hudson, Ph.D., CPG, REM
Date:	March 8, 2022
Subject:	Mt Todd Tailings Storage Facility Closure Cover Design Modeling

1. INTRODUCTION

Vista Gold has prepared a Feasibility Study (FS) for the Mt Todd Project based on additional data collection and changes in the operation design. As a result, a review of the previously proposed Tailings Storage Facility (TSF) closure cover design and the modeling completed to support the effort was conducted.

The TSF closure plan includes the placement of a layer of waste rock over the tailings in order to provide a bridging layer to allow construction of a store and release cover over the entire facility. As detailed in the FS, the TSF closure cover is the same for both TSFs and consists of, from the top down, a 0.2 meter (m) layer of plant growth media (PGM), 0.8 m 66% low permeability material (LPM) (clay)/34% fine non-acid forming (NAF) rock mixture, and at least 1 m of sorter reject (over the tailings surface only). The cover will be placed over the bridging layer of coarser NAF waste rock. The waste rock will provide a surface on which to construct the closure cover and allow for the top surface of the facilities to be crowned (graded to drain). The bridging layer will be configured the same for both TSF1 and TSF2. The configuration of the closure cover for TSF is shown as Figure 1. In Figure 1, the brown region is the embankment, the gray region is the tailings, purple is the bridging layer, aqua is the sorter reject, blue is the LPM/NAF rock mixture, and green is the PGM.

This Technical Memorandum presents the modeling used to assess the closure conditions that will likely exist during closure and post-closure periods of the TSFs. The infiltration modeling was completed using the VADOSE/W program from the GeoStudio software package (GEO-SLOPE, 2014). Modeling was performed on a general cross-section through the TSF, including the outer embankment and a portion of the tailings mass. The focus of the modeling is on the performance of the waste rock placed over the tailings and the closure cover placed over the waste rock bridging layer. Proper closure of the TSFs and seepage management is critical for preventing impacts to local waters, and to minimize long-term treatment and management costs. The TSFs are expect to produce circum-neutral drainage that is impacted by metals leaching.

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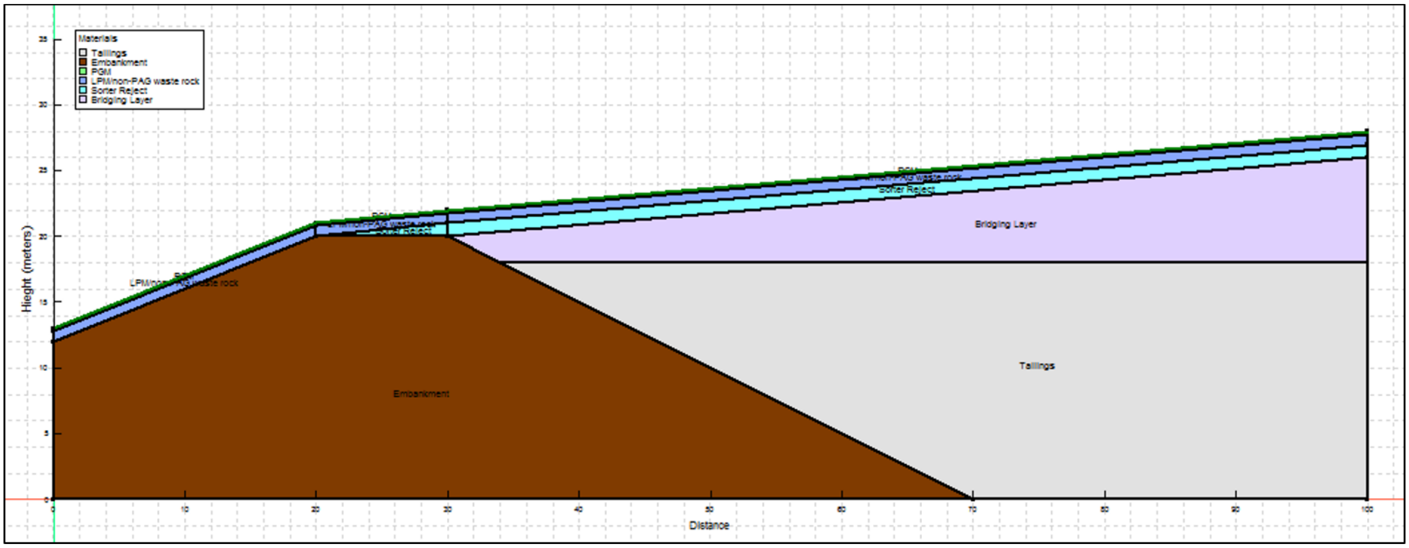


Figure 1 – Configuration of TSF Closure Cover

2. CONCEPTUAL MODEL

The conceptual model provided as Figure 2, shows the components of the TSF water balance including precipitation, evaporation (from soil surface), runoff, infiltration, and seepage. Seepage includes continued draindown of the residual water entrained in the tailings, as well as any infiltration that reaches the tailings through the closure cover material, if applicable. The waste rock placed over the tailings will be graded towards the outside of the TSFs to ensure drainage of water off the top surface of the facilities.

Modeling was performed to simulate closure of the facility. The transient conditions simulated the closure and post-closure conditions. No operational conditions were simulated.

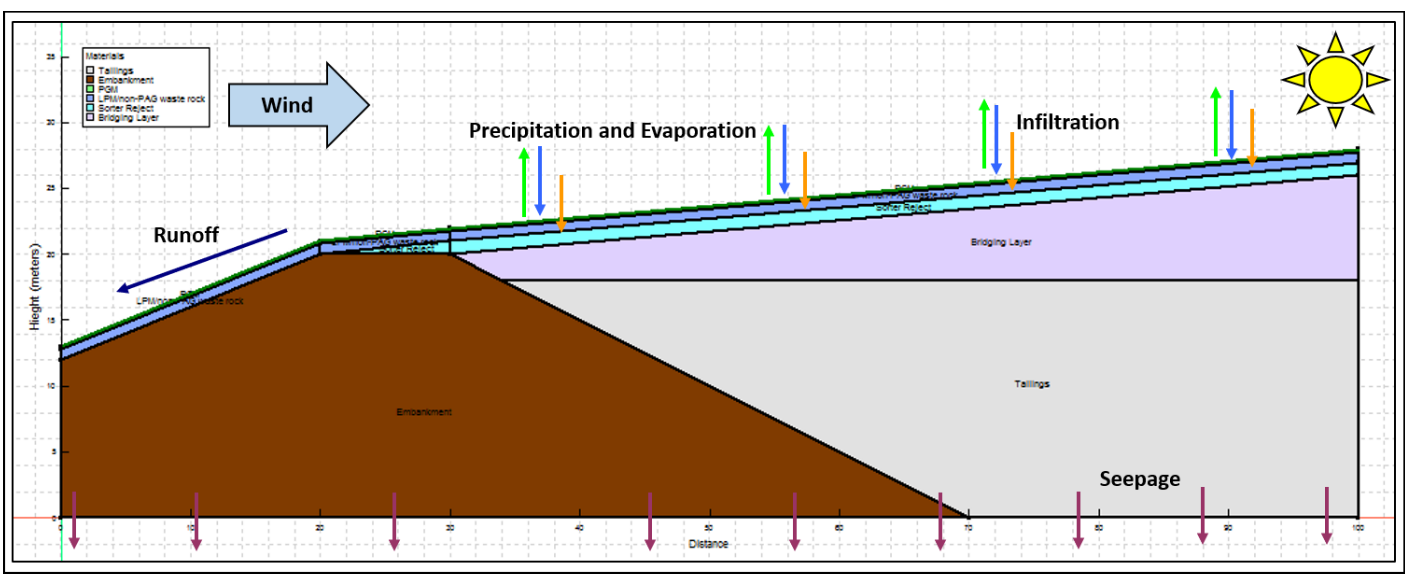


Figure 2 – Conceptual Model

2.1 Model Inputs

The following subsections present the data that was used in the seepage assessment.

2.1.1 Climate Data

Climate data from the Australian Government Bureau of Meteorology Katherine Aviation Museum meteorological station (http://www.bom.gov.au/climate/averages/tables/cw_014903_All.shtml) was used in the model to evaluate the infiltration of precipitation through the TSF closure covers. The parameters in the climate data file included:

- Minimum and maximum daily temperature;
- Daily precipitation;
- Minimum and maximum daily humidity;
- Daily evaporation or net radiation; and
- Average daily wind speed.

The Katherine Aviation Museum meteorological station is located approximately 50 kilometers south of the mine. The dataset applied to the modeling utilizes the daily data from October 2010 to September 2011. By applying actual daily data versus average data, a more realistic distribution of precipitation events can be applied to the modeling, including the distinct wet and dry seasons of the site. The water balance for the site is net negative (more evaporation than precipitation). The climate file used for the modeling has precipitation of approximately 1,652 mm and an annual pan evaporation of approximately 2,104 mm. The average annual precipitation for this meteorological station is 1,131 mm and the highest rainfall measured for a one year period is 1,773 mm. The data used for this modeling represents an above average precipitation year and provides a conservative evaluation of the behavior of the TSF closure covers when conditions are most ideal for the formation of potential wetting fronts. The model was run for a 20 year period with the climate file repeating each year, to minimize the "noise" in the model results and to be able to consider multiple full wet and dry season cycles.

2.1.2 Material Properties

The most significant difference between saturated and unsaturated flow is the hydraulic conductivity. The hydraulic conductivity in saturated media is a function of the material type. In unsaturated flow, the hydraulic conductivity is a function of the material properties and the moisture content of the material. The Richards Equation used to calculate water flow within unsaturated media is:

$$q = -K(\theta)\nabla H$$

Where:

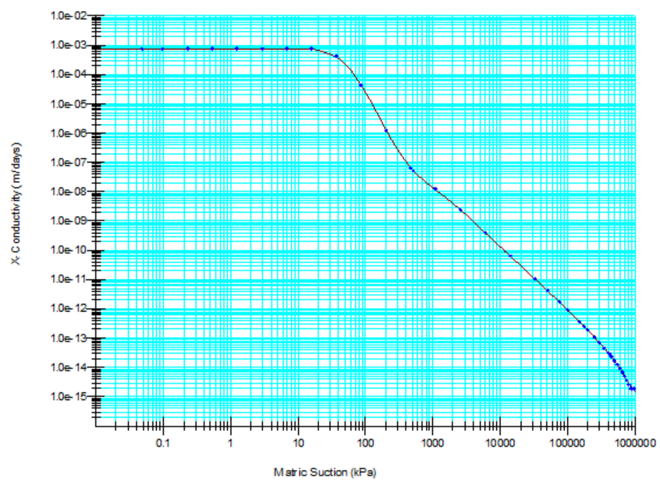
q = water flow velocity (L^2/t)

K(θ) = hydraulic conductivity as a function of soil (or rock) moisture content (L/t)

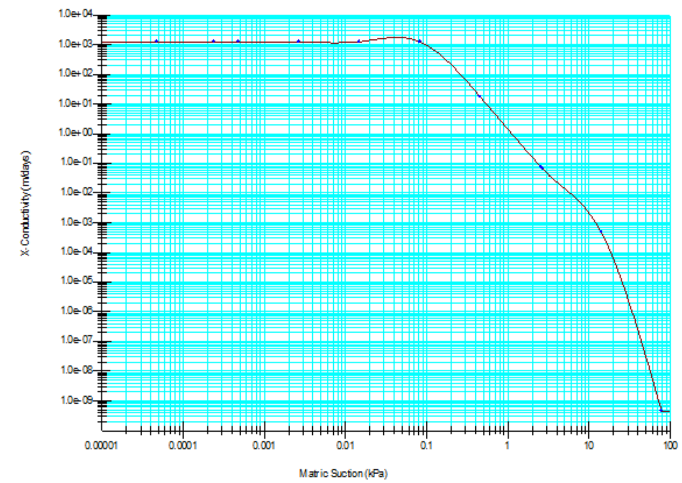
∇H = hydraulic head (L)

The relationship between moisture content and hydraulic conductivity is non-linear, which further complicates the flow dynamics. In saturated material, the physics of flow are relatively simple and are driven by Darcy's Law where the flow is proportional to the saturated hydraulic conductivity, gravity, and pressure gradients. In simple terms, water flows downhill (downward pressure gradient) and flows faster through coarse material than fine material. However, in unsaturated flow, additional controlling forces include matric pressure, absorption, and electrostatic forces.

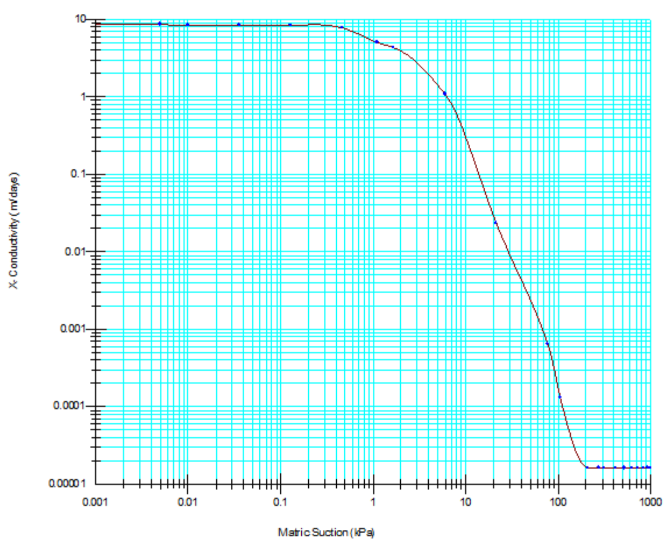
The material properties used in the VADOSE/W (GEO-SLOPE, 2014) models were based on library functions and past experience with simulation of similar facilities. The tailings are expected to have a saturated hydraulic conductivity in the range of 10^{-8} to 10^{-6} centimeters per second (cm/sec). A saturated hydraulic conductivity value of 8.4 x 10^{-7} cm/sec was used in these simulations as a representative estimate of the overall tailings permeability. The bridging layer is assumed to be composed of run of mine material and was simulated with a hydraulic conductivity of 1.4 cm/sec. The LPM/NAF mixture layer, was simulated as a have a broad range of particle sizes with a saturated hydraulic conductivity of 10^{-6} cm/sec and 10^{-5} cm/sec. The 10^{-6} cm/sec value represents the target permeability of the cover immediately after construction, while 10^{-5} cm/sec value represents the likely long term conditions within the cover due to degradation that will occur after the cover is placed due to wetting and drying cycles. The PGM conductivity was simulated as 5 x 10^{-5} cm/sec, which is equivalent to a silty loam. The sorter reject layer is expected to be a coarse sand sized material with generally uniform size. This layer will function as the capillary break of the cover and was simulated with a hydraulic conductivity of 10^{-2} cm/sec which is equivalent to a uniform sand. Figure 3 presents the hydraulic conductivity as a function of the matric suction for each of the materials simulated, and Figure 4 presents the water content as a function of the matric suction of the same materials. The functions described in these figures were those utilized by the modeling software, and are provided in the modeling units of meters per day (m/day).



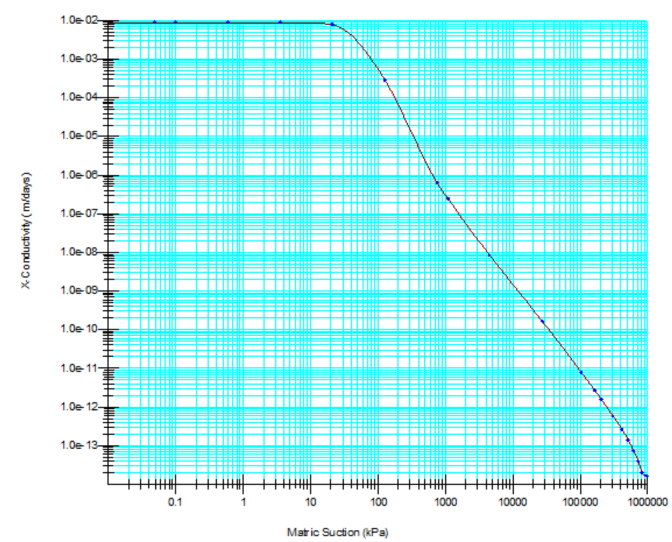
Tailings



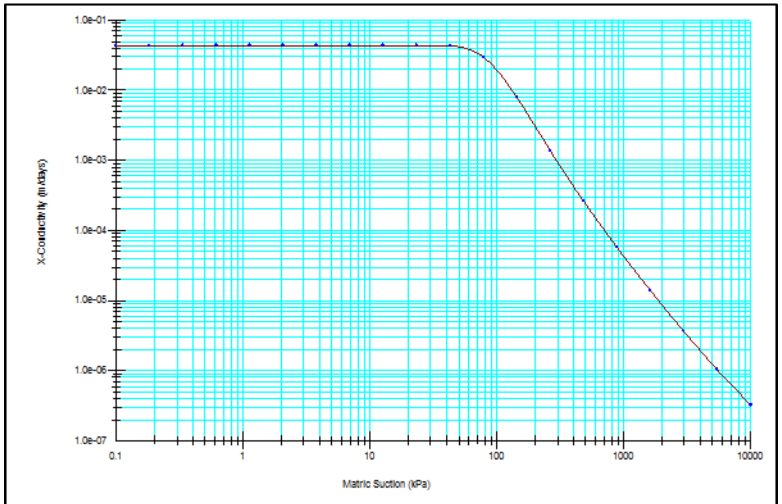
Bridging layer



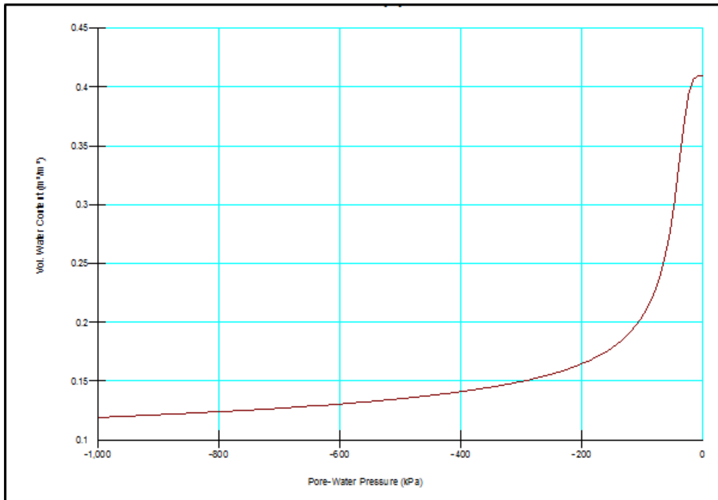
Sorter Reject



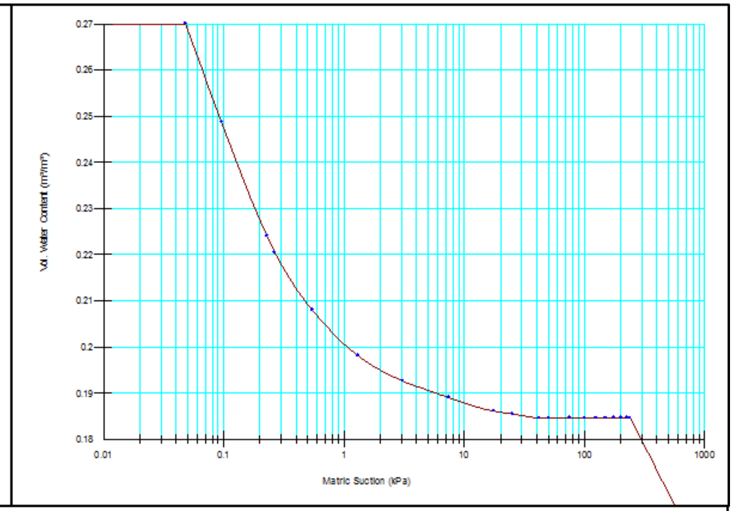
LPM/non-PAG mixture


1.0e-01
1.0e-02
1.0e-03
1.0e-04
1.0e-05
1.0e-06
1.0e-07
X-Conductivity (m/days)
0.1
1
10
100
1000
10000
Matric Suction (kPa)

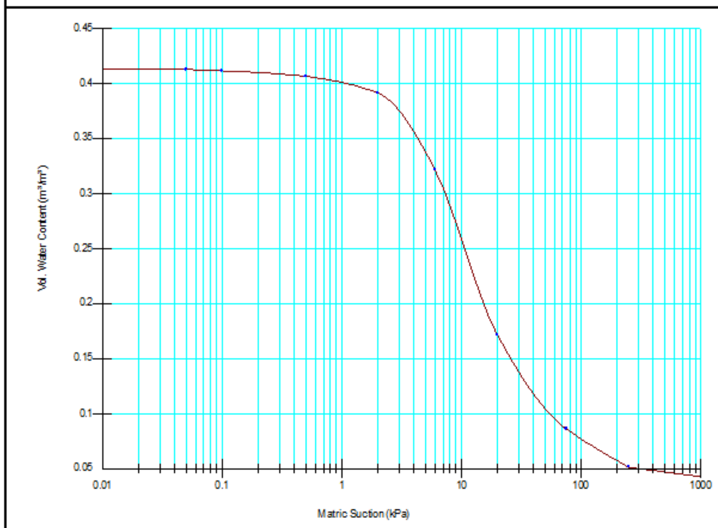
PGM



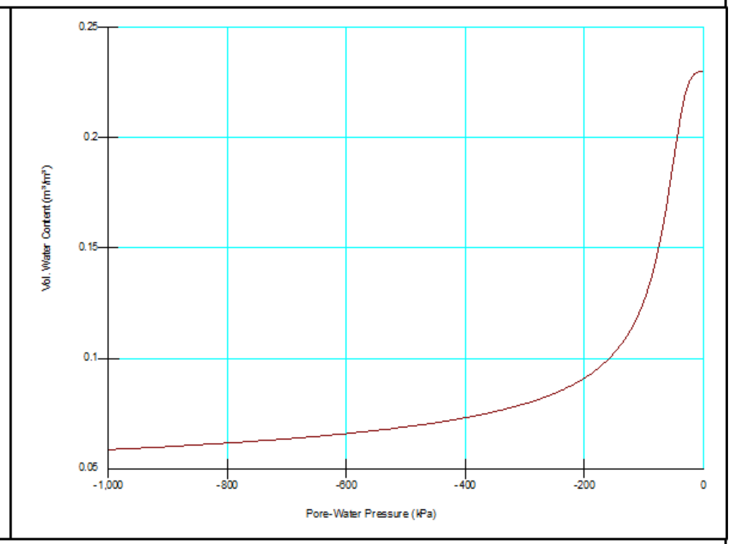
Tailings



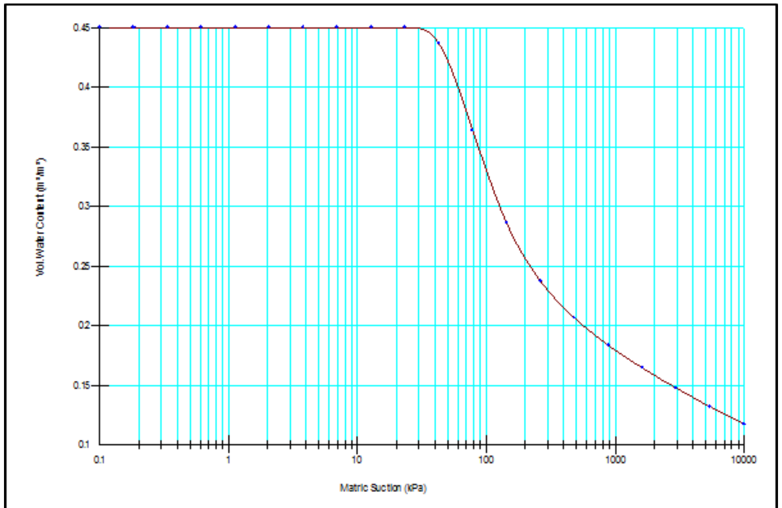
Bridging layer



Sorter Reject



LPM/non-PAG mixture


0.45
0.4
0.35
0.3
0.25
0.2
0.15
0.1
Vol. Water Content (m³/m³)
0.1
1
10
100
1000
10000
Matric Suction (kPa)

PGM

2.1.3 Boundary Conditions

The boundary conditions used in this modeling were limited to a zero pressure boundary at the base of the model, initial moisture addition (establish non-zero starting conditions), and the climate file. A climate file was used in this modeling to ensure an evaluation of the long term behavior of the waste rock and the cover under actual climatic conditions.

2.2 Modeling Approach

The modeling was completed as a steady state model followed by transient models to simulate the climate conditions.

2.2.1 Steady State

Steady state modeling is challenging when analyzing mining sites because the facilities change quickly and do not reach true steady state conditions until mine closure. To account for this, the TSF were modeled using an initial non-zero moisture condition to define the starting point of the facility at the completion of mining. These models provided the starting conditions for the transient modeling.

2.2.2 Transient

Transient modeling provides a reasonable simulation of flow conditions within the WRD material. The upper most layer of these models is a surface region representing the top surface layer of the facility (the PGM, LPM/NAF mixture, and sorter reject cover). It is in this part of the model that atmospheric conditions and soil come in contact, driving the water balance. The water within the facility then moves according to the rules of unsaturated flow physics through the bridging layer and tailings material. Finally, and if applicable, the water reaches the base of the modeled region, where it moves to the model discharge point.

2.2.2.1 Modeling Scenarios

This study focused on one transient scenario that represents the preferred construction and closure alternative for each TSF. A simulation using the bridging layer but not including a closure cover was also completed for comparison.

2.2.2.2 Surface Layer

VADOSE/W (Geo-Slope, 2014) simulates the dynamics of the facility surface by considering climate and soil interactions. VADOSE/W (Geo-Slope, 2014) simulates precipitation using time increments with a maximum size of two (2) hours. The daily precipitation data is distributed according to a sinusoidal function that peaks at noon (normal distribution). This distribution pattern results in the most mathematically stable calculation of the results. Potential evaporation or net radiation measurements are used to calculate the actual evaporation that is possible based on the conditions provided in the surface layer of the model. Evaporation is calculated from the following climate and soil factors:

- Air temperature;
- Soil temperature and thermal properties;
- Relative humidity;
- Solar intensity (from latitude);
- Soil moisture content;
- Wind speed; and
- Measured pan evaporation.

The combination of the factors listed above provides a reasonable estimate of water lost from the system through evaporative processes. Infiltration is based on the unsaturated hydraulic conductivity of the material at a given time. Excess precipitation that has not evaporated, transpired, or infiltrated is tabulated as runoff. The surface region for the model was constructed with three layers to simulate the materials of the cover design.

3. MODEL RESULTS

After the mining and deposition in the TSFs is complete, they will be closed by placing a bridging layer and soil cover over the tailings surface. The cumulative volumetric water balance from the 20 year simulation of TSFs with the 10^{-6} cm/sec cover is presented in Figure 5 and the water balance for TSFs with the 10^{-5} cm/sec cover simulation is presented as Figure 6. The values shown in Figures 5 and 6 are the cumulative volumetric flux over the entire model domain. Because the climate file is applied to the surface of the model, the water balance components provided in Figures 5 and 6 are representative of the surface of the model. For the tighter cover (10^{-6} cm/sec), runoff is a much more significant portion of the water balance that the 10^{-5} cm/sec cover simulation. As would be expected in the climate for this project, evaporation is the most significant remover of water from the system under both conditions. A summary of the water balance parameters as a percentage of precipitation from the simulations are summarized in Table 1.

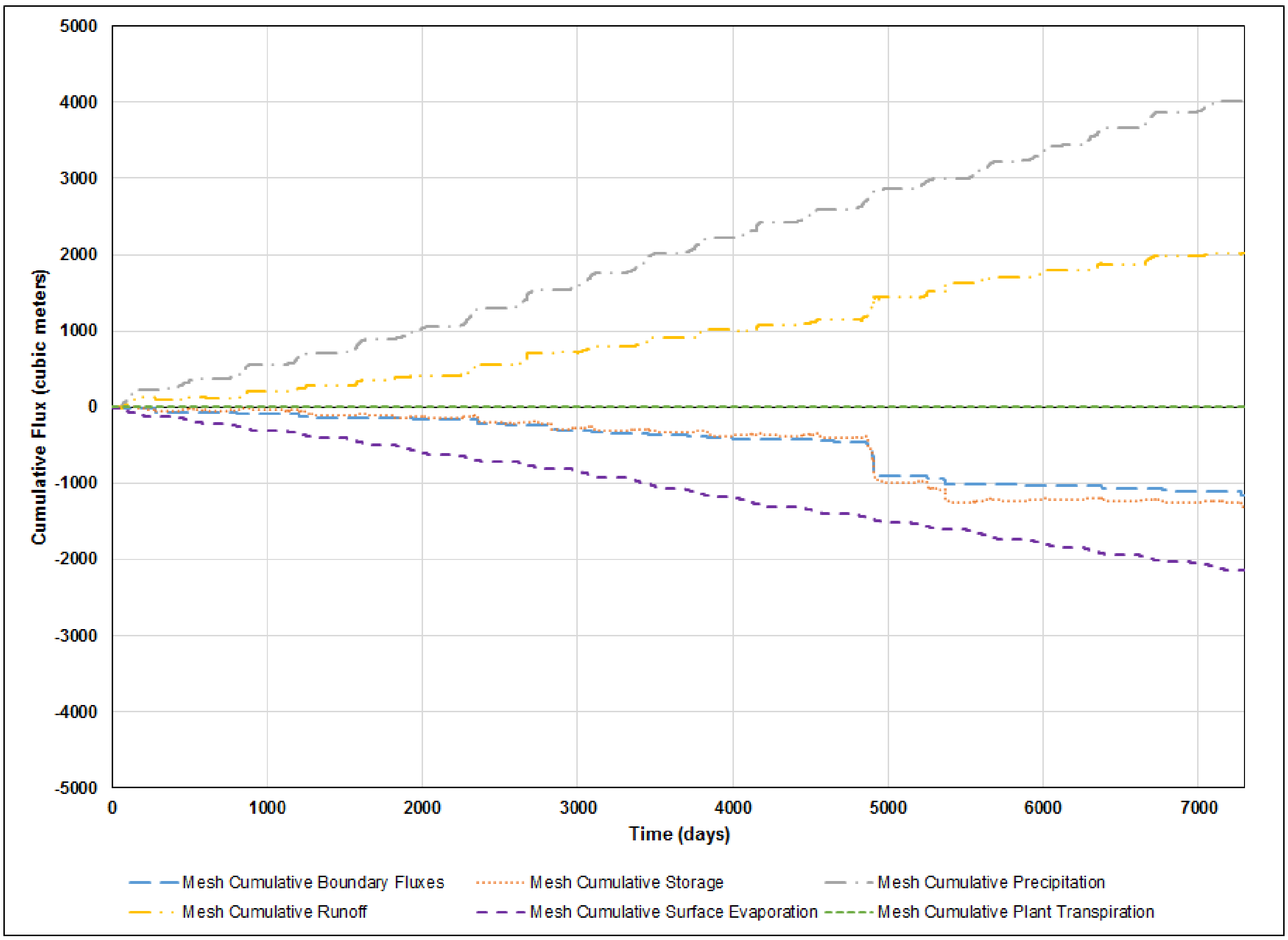


Figure 5 – TSF Simulation Water Balance - 10^{-6} cm/sec Cover

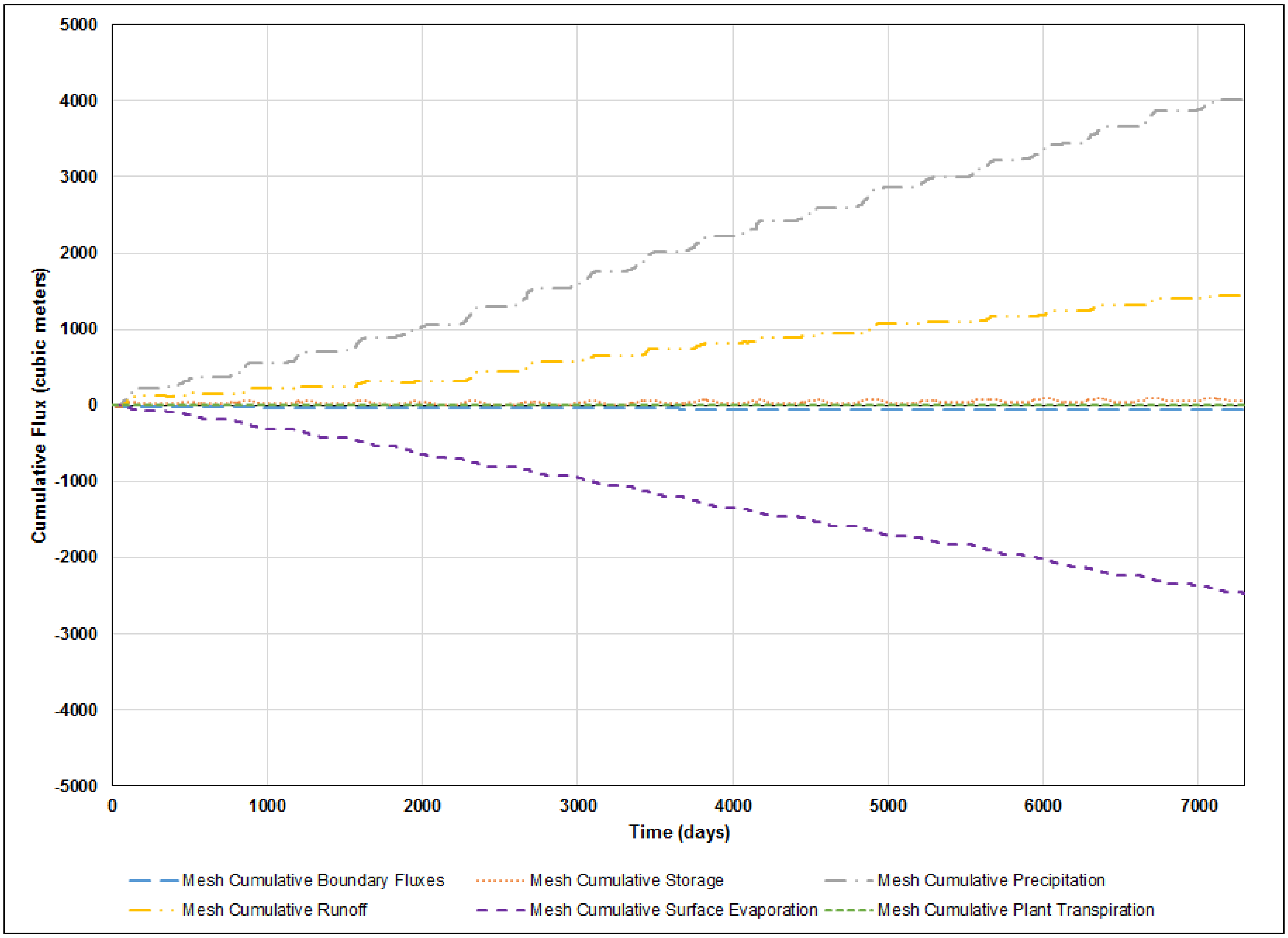


Figure 6 – TSF Simulation Water Balance - 10^{-5} cm/sec Cover

Table 1 – Model Results as a Percentage of Precipitation

	Cumulative Runoff	Cumulative Surface Evapotranspiration	Percolation into Cover	Infiltration through Cover
10^{-6} cm/sec	50%	-53%	27%	0.1%
10^{-5} cm/sec	36%	-61%	35%	2%

The 10^{-5} cm/sec is more representative of what the long term cover hydraulic conductivity value will be, and it still has a significant level of protection. As can be seen from the difference between the water that is able to get in the cover (percolation into cover) versus what actually water that moves through to the bridging layer (infiltration through cover), the cover design prevents the movement of water past the cover, and the added sorter reject only helps to slow down any water that percolates into the cover, allowing it to evaporate back out.

4. REFERENCES

Geo-Slope, 2014. Vadose Zone Modeling with VADOSE/W An Engineering Methodology, 2014 Edition. Geo-Slope International Ltd. Calgary, Alberta, Canada.

ATTACHMENT 7:
Reclamation Cost Information

Vista Gold Corp.
Mt. Todd Project - 2021 Feasibility Study
50K TPD Base Case
RECLAMATION
Version 001

					PPD	<<	Production															<<	Closure/Post Closure							
Description	**Qty**	**Unit Cost**	**Units**	**Total or Avg**	**2020** -2	**2021** -1	**2022** 1	**2023** 2	**2024** 3	**2025** 4	**2026** 5	**2027** 6	**2028** 7	**2029** 8	**2030** 9	**2031** 10	**2032** 11	**2033** 12	**2034** 13	**2035** 14	**2036** 15	**2037** 16	**2038** 17	**2039** 18	**2040** 19	**2041** 20	**2042** 21	**2043** 22	**2044** 23	**2045** 24
Reclamation (Developed by Tetra Tech)																														
Summary																														
Equipment	-	-	USD000s	**23,298**	0	2,957	687	19	98	204	155	149	146	109	175	105	63	0	321	0	0	125	507	2,430	14,766	146	0	0	137	0
Equipment Based Labor	-	-	USD000s	**7,625**	0	953	223	6	32	66	51	48	47	35	56	34	20	0	104	0	0	38	116	794	4,921	43	0	0	37	0
Non-Equipment Costs	-	-	USD000s	**139,588**	0	3,319	913	564	2,679	5,981	4,619	4,027	3,946	2,948	4,719	2,922	1,803	96	10,906	362	59	3,468	420	37,283	46,905	1,282	75	75	142	75
Reclamation	**-**	**-**	**USD000s**	**170,511**	**0**	**7,230**	**1,823**	**590**	**2,808**	**6,251**	**4,825**	**4,224**	**4,139**	**3,092**	**4,951**	**3,061**	**1,886**	**96**	**11,331**	**362**	**59**	**3,631**	**1,043**	**40,507**	**66,592**	**1,470**	**75**	**75**	**315**	**75**
Equipment																														
Dozer																														
Operating Hours	NA	-	hrs	**110,470**	0	14,090	3,317	87	439	915	720	670	655	488	785	470	283	0	1,443	0	0	493	1,093	11,716	71,783	574	0	0	450	0
Fuel Consumption	45.0	-	KL	**4,971**	0	634	149	4	20	41	32	30	29	22	35	21	13	0	65	0	0	22	49	527	3,230	26	0	0	20	0
Fuel Cost	-	$0.85	AUD000s	**4,225**	0	539	127	3	17	35	28	26	25	19	30	18	11	0	55	0	0	19	42	448	2,746	22	0	0	17	0
Lube & Oil	-	$8.78	AUD000s	**969**	0	124	29	1	4	8	6	6	6	4	7	4	2	0	13	0	0	4	10	103	630	5	0	0	4	0
Undercarriage	-	$0.00	AUD000s	**0**	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Wear Items & GET	-	$22.20	AUD000s	**2,452**	0	313	74	2	10	20	16	15	15	11	17	10	6	0	32	0	0	11	24	260	1,593	13	0	0	10	0
Parts/Marc	-	$82.24	AUD000s	**9,085**	0	1,159	273	7	36	75	59	55	54	40	65	39	23	0	119	0	0	41	90	963	5,903	47	0	0	37	0
Dozer	**-**	**-**	**AUD000s**	**16,731**	**0**	**2,134**	**502**	**13**	**66**	**139**	**109**	**101**	**99**	**74**	**119**	**71**	**43**	**0**	**219**	**0**	**0**	**75**	**166**	**1,774**	**10,872**	**87**	**0**	**0**	**68**	**0**
Loader																														
Operating Hours	NA	-	hrs	**24,008**	0	1,391	330	29	146	305	225	223	218	163	262	157	94	0	481	0	0	212	246	1,732	17,693	59	0	0	43	0
Fuel Consumption	150.0	-	KL	**3,601**	0	209	50	4	22	46	34	33	33	24	39	24	14	0	72	0	0	32	37	260	2,654	9	0	0	6	0
Fuel Cost	-	$0.85	AUD000s	**3,061**	0	177	42	4	19	39	29	28	28	21	33	20	12	0	61	0	0	27	31	221	2,256	8	0	0	6	0
Lube & Oil	-	$41.74	AUD000s	**1,002**	0	58	14	1	6	13	9	9	9	7	11	7	4	0	20	0	0	9	10	72	738	2	0	0	2	0
Tires	-	$86.34	AUD000s	**2,073**	0	120	29	2	13	26	19	19	19	14	23	14	8	0	42	0	0	18	21	150	1,528	5	0	0	4	0
Wear Items & GET	-	$13.16	AUD000s	**316**	0	18	4	0	2	4	3	3	3	2	3	2	1	0	6	0	0	3	3	23	233	1	0	0	1	0
Parts/Marc	-	$155.42	AUD000s	**3,731**	0	216	51	4	23	47	35	35	34	25	41	24	15	0	75	0	0	33	38	269	2,750	9	0	0	7	0
Loader	**-**	**-**	**AUD000s**	**10,183**	**0**	**590**	**140**	**12**	**62**	**129**	**95**	**95**	**93**	**69**	**111**	**67**	**40**	**0**	**204**	**0**	**0**	**90**	**104**	**734**	**7,505**	**25**	**0**	**0**	**18**	**0**
Haul Truck																														
Operating Hours	NA	-	hrs	**8,321**	0	2,597	582	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	885	1,531	2,341	178	0	0	208	0
Fuel Consumption	150.0	-	KL	**1,248**	0	390	87	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	133	230	351	27	0	0	31	0
Fuel Cost	-	$0.85	AUD000s	**1,061**	0	331	74	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	113	195	298	23	0	0	27	0
Lube & Oil	-	$55.44	AUD000s	**461**	0	144	32	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	49	85	130	10	0	0	12	0
Tires	-	$52.94	AUD000s	**441**	0	137	31	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	47	81	124	9	0	0	11	0
Wear Items & GET	-	$11.49	AUD000s	**96**	0	30	7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	10	18	27	2	0	0	2	0
Parts/Marc	-	$202.17	AUD000s	**1,682**	0	525	118	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	179	309	473	36	0	0	42	0
Loader	**-**	**-**	**AUD000s**	**3,741**	**0**	**1,167**	**261**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**398**	**688**	**1,052**	**80**	**0**	**0**	**93**	**0**
Equipment			**AUD000s**	**30,656**	**0**	**3,891**	**904**	**25**	**128**	**268**	**204**	**196**	**192**	**143**	**230**	**138**	**83**	**0**	**423**	**0**	**0**	**165**	**668**	**3,197**	**19,429**	**192**	**0**	**0**	**180**	**0**
	0.760		USD000s	23,298	0	2,957	687	19	98	204	155	149	146	109	175	105	63	0	321	0	0	125	507	2,430	14,766	146	0	0	137	0
Labor																														
Equipment Based Labor																														
Dozer Operator	-	-	hr	110,470	0	14,090	3,317	87	439	915	720	670	655	488	785	470	283	0	1,443	0	0	493	1,093	11,716	71,783	574	0	0	450	0
Loader Operator	-	-	hr	24,008	0	1,391	330	29	146	305	225	223	218	163	262	157	94	0	481	0	0	212	246	1,732	17,693	59	0	0	43	0
Haul Truck Operator	-	-	hr	8,321	0	2,597	582	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	885	1,531	2,341	178	0	0	208	0
		$/hr		**Total Labor**																										
Dozer Operator		$69	AUD000s	**7,662**	0	977	230	6	30	63	50	46	45	34	54	33	20	0	100	0	0	34	76	813	4,979	40	0	0	31	0
Loader Operator		$76	AUD000s	**1,821**	0	105	25	2	11	23	17	17	17	12	20	12	7	0	36	0	0	16	19	131	1,342	4	0	0	3	0
Haul Truck Operator		$66	AUD000s	**550**	0	172	38	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	59	101	155	12	0	0	14	0
Environmental Supervisor	-	-	AUD000s	**0**	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Labor			**AUD000s**	**10,033**	**0**	**1,254**	**294**	**8**	**42**	**87**	**67**	**63**	**62**	**46**	**74**	**45**	**27**	**0**	**137**	**0**	**0**	**50**	**153**	**1,045**	**6,475**	**56**	**0**	**0**	**48**	**0**
	0.760		USD000s	7,625	0	953	223	6	32	66	51	48	47	35	56	34	20	0	104	0	0	38	116	794	4,921	43	0	0	37	0

Vista Gold Corp.
Mt. Todd Project - 2021 Feasibility Study
50K TPD Base Case
RECLAMATION
Version 001

					PPD	<<	Production															<<	Closure/Post Closure						
Description	**Qty**	**Unit Cost**	**Units**	**Total or Avg**	**2020 -2**	**2021 -1**	**2022 1**	**2023 2**	**2024 3**	**2025 4**	**2026 5**	**2027 6**	**2028 7**	**2029 8**	**2030 9**	**2031 10**	**2032 11**	**2033 12**	**2034 13**	**2035 14**	**2036 15**	**2037 16**	**2038 17**	**2039 18**	**2040 19**	**2041 20**	**2042 21**	**2043 22**	**2044 23**	**2045 24**
Reclamation (Developed by Tetra Tech)																														
Non-Equipment Based Costs																														
Screen & Place WRD Cove	-	-	AUD000s	**0**	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
WRD Cover Liner geotextil	-	-	AUD000s	**33,680**	0	1,847	485	356	1,781	3,718	2,748	2,716	2,661	1,981	3,188	1,917	1,150	0	6,810	0	0	2,324	0	0	0	0	0	0	0	0
WRD Cover Liner Cover Pl	-	-	AUD000s	**22,230**	0	1,217	320	234	1,173	2,449	1,810	1,789	1,753	1,305	2,100	1,305	758	0	4,486	0	0	1,531	0	0	0	0	0	0	0	0
LPM Import	-	-	AUD000s	**43,957**	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	11,452	32,506	0	0	0	0	0
Compaction of Store and R	-	-	AUD000s	**20,605**	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5,368	15,237	0	0	0	0	0
Liner demo or install	-	-	AUD000s	**781**	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	738	10	10	0	0	22	0
Erosion Control	-	-	AUD000s	**682**	0	27	27	0	27	0	27	0	0	0	0	0	0	0	0	0	0	0	88	59	89	324	0	0	15	0
Pump water from TSFs	-	-	AUD000s	**274**	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	274	0	0	0	0	0	0
Install TSF wick drains	-	-	AUD000s	**7,643**	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	7,643	0	0	0	0	0	0
Revegetation	-	-	AUD000s	**3,510**	0	0	0	0	0	0	41	0	0	0	0	0	0	0	0	0	0	0	213	764	2,346	124	0	0	22	0
PTS	-	-	AUD000s	**1,715**	0	0	0	0	0	0	0	0	0	0	0	37	88	64	1,055	383	20	20	20	20	5	0	0	0	0	0
Staff vehicle	-	-	AUD000s	**0**	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Maintenance	-	-	AUD000s	**9,566**	0	412	101	31	158	354	272	238	233	174	280	170	101	0	593	0	0	203	56	2,302	3,808	80	0	0	0	0
Monitor	-	-	AUD000s	**1,480**	0	0	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	90	90	90	90	90	90	90
Contingency	-	-	AUD000s	**20,049**	0	865	218	71	336	748	577	505	495	370	592	366	226	11	1,355	43	7	434	125	4,845	7,626	169	9	9	38	9
Concrete work & closure co	-	-	AUD000s	**17,495**	0	0	0	0	0	552	552	0	0	0	0	0	0	0	0	0	0	0	0	15,500	0	891	0	0	0	0
Non-Equipment Costs			**AUD000s**	**183,668**	**0**	**4,367**	**1,201**	**742**	**3,524**	**7,870**	**6,078**	**5,299**	**5,192**	**3,879**	**6,210**	**3,845**	**2,372**	**126**	**14,350**	**476**	**77**	**4,563**	**552**	**49,056**	**61,717**	**1,687**	**99**	**99**	**187**	**99**
	0.760		USD000s	139,588	0	3,319	913	564	2,679	5,981	4,619	4,027	3,946	2,948	4,719	2,922	1,803	96	10,906	362	59	3,468	420	37,283	46,905	1,282	75	75	142	75
Total Cost			**AUD000s**	**224,357**	**0**	**9,513**	**2,398**	**776**	**3,694**	**8,225**	**6,349**	**5,558**	**5,446**	**4,068**	**6,514**	**4,028**	**2,482**	**126**	**14,909**	**476**	**77**	**4,778**	**1,373**	**53,298**	**87,622**	**1,935**	**99**	**99**	**415**	**99**

ATTACHMENT 8:
NT Security Calculation Summary

Tech Memo

To:	John Rozelle – Vista Gold
Cc:	Brad Bijold – Tetra Tech
From:	April Hussey
Date:	December 23, 2021
Subject:	117-8348002 | Mt Todd Gold Mine – Evaluation of Annual Security Cost Estimates

INTRODUCTION

At the request of Vista Gold, Tetra Tech has prepared annual security cost estimates for the closure of the surface features associated with the planned Mt Todd Gold Project. The security cost estimates have been developed using the Northern Territory (NT) Security Cost Estimate excel-based template for estimating security costs. Mine closure strategies forming the basis of the security cost estimates are based upon the Closure plan as developed in previous studies.

Similar NT Security costs (both annual and for end of project) for the closure of the project have been developed during previous permitting and study phases of this project. The general approaches and assumptions followed in these previous estimates were used as a basis for this update to the annual security cost estimates.

BASIS FOR ANNUAL QUANTITIES

The annual security cost estimates increase and decrease over time in accordance with the increase and decrease in land disturbances associated with the progression of mine development and completion of placement of cover on the waste rock dump (WRD) concurrent with operations. The 50K tpd mining scenario provided the basis for annual mine feature development and phasing including:

- Pit
- WRD
- Tailings storage facility (TSF) 1
- TSF 2

Annual quantities for the pit and WRD were derived from annual CAD drawings for the development of the pit and WRD provided by Respec. As the closure approach for the WRD includes placement of a liner and an overlying non-acid forming (NAF) material layer on the top surface of the WRD concurrently with each lift of the WRD, only the top surface of the newly developed WRD was assumed to required liner in this security estimate evaluation scenario. Underlying portions of the slopes would have received liner placement during buildout of the WRD in previous years. Liner placement over the top of the former WRD prior to placement of additional waste rock from the resumption of mining were not included in the security cost estimate.

TSF 1 and 2 periodic build-outs based on stages were developed for the express purpose of this analysis. The derivation of these periodic staged build-outs required several critical assumptions including:

- Build-outs are based on assumptions and extrapolations from available data for expected completion of different stages in different years.

- Drawings were developed for alternate stages (i.e., Stage 1, 3, 5, 7 etc.) and conservatively assumed that the larger cover volumes / areas calculated apply to subsequent stages i.e., Stage 1 volumes apply to years in which both Stage 1 and Stage 2 are active, Stage 3 volumes apply to years in which both Stage 3 and Stage 4 are active, etc.
- The construction buildout schedule for Stages was estimated to represent likely requirements based on tailings production, availability of raise construction material, and balancing rate of rise in both TSF1 and TSF2.
- Drawings do not indicate or provide expected completion for a schedule, rather are based on assumed completion as provided by construction schedule.
- For all drawings, existing topography is assumed to be accurate as provided by client/original drawings.
- Drawings assume no delays in construction stages occur.
- Elevations are assumed to follow straight lines, as required, for ease of sketching.

From the staged TSF1 and TSF2 drawings, quantities were derived for closure activities, including surface areas for application of a store and release cover and volumes required to create a crowned surface. These quantities reflect reasonable quantity estimates for these closure activities based on the level of study completed. The quantity of material required to create a crowned surface represents a key quantity in the security cost estimate, and TSF1 crowned surface volumes were estimated for Stages 1, 3, 5, 7, 9 and 11. TSF2 crowned surface volumes were estimated for Stages 1, 3, 5, 7 and 8. Final design phases can improve upon the annual crowned surface grading plans and may result in refined quantities, however that level of effort is beyond the scope of this evaluation.

Other features were maintained at the same size/quantity throughout the mine life. These included the low grade ore (LGO) stockpile, Heap leach pad (HLP), roads, and infrastructure. As the LGO stockpile and HLP would not be reprocessed until Yr 15, 16, and 17 closure of these facilities was assumed to include placement of a store and release cover. Yr 16 and 17 estimates assumed that as each facility is fully reprocessed, no store and release cover would be placed, but that excavation of 0.5m of contaminated material from under the HLP and 0.3m of gravels from beneath the LGO2 would be conducted as part of facility closure. These excavated materials would be hauled to TSF2 for use as crown material. Assumptions for long term water management, monitoring, and maintenance remained the same over the life of the project.

BASIS FOR UNIT COSTS

Once the quantities for mine closure activities associated with mine features were calculated for each year based on CAD drawings, these quantities were then input to their respective annual NT Security Cost Estimate spreadsheet. For each mine closure activity quantity, unit costs were applied. The NT Security Cost Estimate template includes typical ranges of unit costs, as well as default unit costs for various activities. Except for a few exceptions, the default costs were used to estimate costs. The following unit costs reflect key deviations from the NT Security Cost Estimate Spreadsheet defaults:

1. Source cart and spread suitable material for capping TSFs (cost range $2.00 - $5.00/m3): average cost in range used, based on haul distance.
2. Apply capping design treatment as required e.g. 'store and release' for TSFs, assumed to be no less than 2m thick (cost range $25,000 - $49,500): Low cost in range used, as store and release cover for TSFs is 0.8m thick.
3. Installation of Wick drains: Cost was added to the workbook for inclusion of costs associated with dewatering tailings for the placement of cap and was estimated at $9.33/m based on 2021 vendor quote.

4. Pumping surficial and wicked water from TSFs: Cost was added to the workbook for inclusion of costs associated with dewatering tailings and was estimated at $0.07/m3 resulting in a total of $130,000 for TSF1 and $144,000 for TSF2 for pump power and maintenance.
5. Installation of seepage collection ditches: Cost was added to the workbook for inclusion of costs associated with installation of tailings seepage collection ditches and was estimated at $170,000 for TSF1 and $70,000 for TSF2 based on nominal costs for excavation and lining with LLDPE.
6. Low Permeability Cover: Cost of $15.03/m3 used, based on cost derived during previous studies and escalated for use in the Feasibility Study. This cost was calculated to include the cost for borrow area development, importing material from off-site, and closure of the borrow area. It should be noted that the quality and quantity of low permeability material must be verified. If conditions are identified which deviate from current understanding, costs for this material may increase or decrease.
7. WRD apply capping design treatment ego 'store and release' (cost range $25,000 - $49,500/ha): This cost item was adjusted to reflect the cost of applying the liner cover on the WRD. The unit cost used of $196,400/ha was based on vendor estimates for the work, inclusive of an LLDPE liner and underlayer and overlayer geotextile.
8. WRD source cart and spread suitable material for capping (cost range $2.00-$5.00/m3). This cost is for hauling the NAF material for covering the WRD. The low cost in the range was used due to the short haul distance.
9. Active recovery treatment of problem leachate (cost range of $20,000-$2,000,000): Costs were estimate at $2,330,000 per year for 5 years based on operations costs estimated as part of the Feasibility Study.
10. Construct new wetland filter: A line item was added to the workbook for inclusion of costs associated with long-term passive water treatment and was estimated at $1,700,000 based on costs estimated as part of the Feasibility Study and anticipated wetland sizing.

SUMMARY OF ANNUAL SECURITY COST ESTIMATES

Table 1 summarizes the annual security cost estimates calculated in this evaluation. Additional detail for each estimate can be reviewed in the associated Excel workbooks for each year.

Table 1: Annual Security Cost Estimates

Project Year	Security Estimate
Year -1	$135,318,000
Year 1	$146,429,000
Year 2	$157,932,000
Year 3	$270,437,000
Year 4	$266,353,000
Year 5	$257,857,000
Year 6	$251,957,000
Year 7	$245,728,000
Year 8	$235,928,000
Year 9	$231,385,000
Year 10	$223,707,000
Year 11	$218,882,000

Project Year	Security Estimate
Year 12	$214,932,000
Year 13	$210,764,000
Year 14	$195,314,000
Year 15	$192,197,000
Year 16	$190,262,000
Year 17	$182,891,000

The maximum liability occurs in project Year 3, associated with full WRD footprint buildout and full TSF2 buildout. Liabilities decrease subsequently as the top surface areas of the WRD and TSFs requiring cover decrease as each of these facilities is constructed taller. Attachment 1 presents the summary of costs for each year which combine to total the amounts in Table 1.

	Year -1	Year 1	Year 2	Year 3	Year 4
Domains	Calculated Cost	Calculated Cost	Calculated Cost	Calculated Cost	Calculated Cost
1: Site Infrastructure	$14,122,427	$13,896,757	$13,896,757	$13,896,757	$13,896,757
2: Extractive Workings - Sand, Clay & Gravel	$0	$0	$0	$0	$0
3: Hard Rock Pits & Quarries	$77,992	$90,121	$117,632	$120,010	$120,010
4: Underground Workings	$0	$0	$0	$0	$0
5: Tailings Storage Facilities and Dams	$58,548,148	$58,548,148	$58,548,148	$139,313,686	$139,313,686
6: Stockpiles & Waste Rock Dumps	$40,589,078	$50,354,375	$60,218,992	$76,284,150	$72,771,478
7: Exploration	$0	$0	$0	$0	$0
8: Access and Haul Roads	$551,698	$551,698	$551,698	$551,698	$551,698
9: River Diversions	$0	$0	$0	$0	$0
Decommissioning & Post Closure Management	$3,778,538	$3,888,046	$3,998,668	$4,996,672	$4,957,281
Sub-Total - All Domains	$117,667,882	$127,329,145	$137,331,895	$235,162,973	$231,610,910
CONTINGENCY @15%	$17,650,182	$19,099,372	$20,599,784	$35,274,446	$34,741,636
TOTAL COST	$135,318,064	$146,428,517	$157,931,679	$270,437,419	$266,352,546

	Year 5	Year 6	Year 7	Year 8	Year 9
Domains	Calculated Cost	Calculated Cost	Calculated Cost	Calculated Cost	Calculated Cost
1: Site Infrastructure	$13,896,757	$13,896,757	$13,896,757	$13,896,757	$13,896,757
2: Extractive Workings - Sand, Clay & Gravel	$0	$0	$0	$0	$0
3: Hard Rock Pits & Quarries	$147,118	$147,435	$147,435	$147,946	$147,946
4: Underground Workings	$0	$0	$0	$0	$0
5: Tailings Storage Facilities and Dams	$139,313,686	$139,663,400	$139,663,400	$136,448,530	$136,448,530
6: Stockpiles & Waste Rock Dumps	$65,438,870	$60,019,499	$54,662,678	$49,414,671	$45,507,812
7: Exploration	$0	$0	$0	$0	$0
8: Access and Haul Roads	$551,698	$551,698	$551,698	$551,698	$551,698
9: River Diversions	$0	$0	$0	$0	$0
Decommissioning & Post Closure Management	$4,875,053	$4,814,280	$4,754,208	$4,695,357	$4,651,545
Sub-Total - All Domains	$224,223,181	$219,093,069	$213,676,176	$205,154,959	$201,204,288
CONTINGENCY @15%	$33,633,477	$32,863,960	$32,051,426	$30,773,244	$30,180,643
TOTAL COST	$257,856,658	$251,957,029	$245,727,602	$235,928,203	$231,384,931

	Year 10	Year 11	Year 12	Year 13	Year 14
Domains	Calculated Cost	Calculated Cost	Calculated Cost	Calculated Cost	Calculated Cost
1: Site Infrastructure	$13,896,757	$13,896,757	$13,896,757	$13,896,757	$13,896,757
2: Extractive Workings - Sand, Clay & Gravel	$0	$0	$0	$0	$0
3: Hard Rock Pits & Quarries	$147,946	$147,946	$147,946	$147,946	$147,946
4: Underground Workings	$0	$0	$0	$0	$0
5: Tailings Storage Facilities and Dams	$136,130,042	$136,130,042	$134,616,770	$130,992,389	$129,419,203
6: Stockpiles & Waste Rock Dumps	$39,220,190	$35,070,883	$33,171,201	$33,171,201	$21,440,591
7: Exploration	$0	$0	$0	$0	$0
8: Access and Haul Roads	$551,698	$551,698	$551,698	$551,698	$551,698
9: River Diversions	$0	$0	$0	$0	$0
Decommissioning & Post Closure Management	$4,581,036	$4,534,505	$4,513,202	$4,513,202	$4,381,655
Sub-Total - All Domains	$194,527,669	$190,331,831	$186,897,574	$183,273,193	$169,837,850
CONTINGENCY @15%	$29,179,150	$28,549,775	$28,034,636	$27,490,979	$25,475,677
TOTAL COST	$223,706,819	$218,881,606	$214,932,210	$210,764,172	$195,313,527

	Year 15	Year 16	Year 17
Domains	Calculated Cost	Calculated Cost	Calculated Cost
1: Site Infrastructure	$13,896,757	$13,896,757	$13,896,757
2: Extractive Workings - Sand, Clay & Gravel	$0	$0	$0
3: Hard Rock Pits & Quarries	$147,946	$147,946	$147,946
4: Underground Workings	$0	$0	$0
5: Tailings Storage Facilities and Dams	$126,709,563	$124,567,044	$124,567,044
6: Stockpiles & Waste Rock Dumps	$21,440,591	$21,900,491	$15,566,200
7: Exploration	$0	$0	$0
8: Access and Haul Roads	$551,698	$551,698	$551,698
9: River Diversions	$0	$0	$0
Decommissioning & Post Closure Management	$4,381,655	$4,381,655	$4,305,679
Sub-Total - All Domains	$167,128,210	$165,445,591	$159,035,324
CONTINGENCY @15%	$25,069,231	$24,816,839	$23,855,299
TOTAL COST	$192,197,441	$190,262,430	$182,890,623

Vista Gold Corp. - Mt Todd Year 3

Security Calculation

Security Summary

Details			
Contact Name	John Rozelle	**Authorisation #**	
Project	Vista Gold - Mt Todd FS	**Date**	12/22/2021
MMP			

NOTE: Operators may use DPIR Cost per Unit Of Measure as a guide or insert their own cost and UOM - adjust form as necessary. Justification of changes to UOM and cost should be provided if DPIR units area not used

New Authorisation	MMP Renewal/amendment	Audit Finding	Client Request
X	X	X	X

Domains	Calculated Cost
1: Site Infrastructure	$13,896,757
2: Extractive Workings - Sand, Clay & Gravel	$0
3: Hard Rock Pits & Quarries	$120,010
4: Underground Workings	$0
5: Tailings Storage Facilities and Dams	$139,313,686
6: Stockpiles & Waste Rock Dumps	$76,284,150
7: Exploration	$0
8: Access and Haul Roads	$551,698
9: River Diversions	$0
Decommissioning & Post Closure Management	$4,996,672
Sub-Total - All Domains	$235,162,973
CONTINGENCY @15%	$35,274,446
TOTAL COST	$270,437,419
10% Discount	$27,043,742

NORTHERN TERRITORY GOVERNMENT

DISTURBANCE AREA INVENTORY			
Whole of site summary	**Total Area (ha)**	**Progressively rehabilitated area**	**Remaining area**
Lease surface area			
Disturbed operational area			
Above grade landforms			
Waste rock dump #1	90.1		
Waste rock dump #2	256.9		
Waste rock dump #3			
Waste rock dump #4			
Waste rock dump #5			
Tailings Dam #1	553.9		
Tailings Dam #2			
Tailings Dam #3			
Tailings Dam #4			
Mining area #1			
Mining area #2			
Mining area #3			
Mining area #4			
Mining area #5			
Mining area #6			
Extractive areas	0.0		
haul roads	30.6		
access roads			
water ponds/dams			
Area of infrastructure	53.4		
camp area			
area of drill pads and sumps			
costeans/pits			
tracks/roads			
other			
TOTAL	**984.9**		

Domain 1: Infrastructure

Management Area	Technique	Unit of Measure (UOM)	Range per UOM ($)	Cost per UOM ($)	Estimated Quantity	Sub Total ($)	Technique Notes	Comment (eg when $/UOM differs from DPIR)
Process Plant, Mill, Crusher area	disconnect and terminate services	@	10000-27500	26700.00	1	26700.00	This item includes disconnecting all services such as power, water and sewer. This is a 'one off' cost for the area.	
	demolish and remove small buildings	m^2	70-90	90.00	1053	94770.00	enter the total area of small buildings and offices in the area, including demountables. It does not include workshops.	
	demolish and remove industrial workshops and sheds	m^2	160-210	210.00	5000	1050000.00	enter the total area of workshop facilities in the area.	
	demolish remove conveyor system	m	100-250	140.00	140	19600.00	Enter the total length of conveyors	
	demolish/remove crusher, process plant and mills	m^2	160-210	210.00	42000	8820000.00	enter the total surface area of process plant and mills etc. If multi-story the area should be the sum of the surface area of all floors.	
	remove concrete pads and footings	m^2	10-30	15.00	48193	722895.00	enter the total area of buildings, workshops etc. Cost dependent on thickness. Assume $10/m2 for <300mm thick, $30/m2 for >300mm thick. (default $15 if unknown)	
	remove mobile plant	hr	140-300	200.00		0.00	consider distance to remove all mobile plant to the nearest centre or to Darwin.	
	remove contaminated material	m^3	3.00-5.00	5.00		0.00	enter volume of spillage and other contamination for removal to pit or WRD.	
	deconstruct and remove large tanks - eg leach	@	35000-165000	35000.00	20	700000.00	enter the number of tanks	estimate
	deconstruct and remove small tanks	@	10000-30000	10000.00	20	200000.00	enter the number of tanks	estimate
						11,633,965.00		
Main Workshop and Stores area	disconnect and terminate services	@	5000-5500	5000.00	1	5000.00	This item includes disconnecting all services such as power, water and sewer. This is a 'one off' cost for the area.	
	demolish and remove small buildings	m^2	70-90	90.00	1986	178740.00	enter the total area of small buildings and offices in the area, including demountables. It does not include workshops.	
	demolish and remove industrial workshops and sheds	m^2	160-210	210.00	1640	344400.00	enter the total area of workshop facilities in the area. Are there any remote or field based workshops to include	
	remove concrete pads and footings	m^2	10-30	10.00	3626	36260.00	enter the total area of workshops and buildings. Include any areas of carpark and washdown pads, bulk fuel bunding and refuelling areas.	
	remove contaminated material	m^3	3.00-5.00	5.00		0.00	enter volume of spillage and other contamination for removal to pit or WRD.	
	underground tank removal - large hydrocarbon (>5000L)	@	48000-82500	60000.00		0.00	removal of underground tank and all pipework, bunds and any contamination	
	underground tank removal - small hydrocarbon (up to 5000L)	@	20000-21000	20000.00		0.00	removal of underground tank and all pipework, bunds and any contamination	
	above ground tank removal - hydrocarbon	@	200.00	200.00	10	2000.00	enter number of tanks	estimate
	remove hydrocarbon contamination	m^3	3.00-5.00	5.00		0.00	enter the volume to be removed to pit void for appropriate rehabilitation. If the volume is not known assume a volume of 3000m3 per fuel storage facility.	
	remediation on site of hydrocarbon contamination	m^3	30-55	40.00	9000	360000.00	enter the volume of material requiring onsite remediation. If the volume is not known assume a volume of 3000m3 per fuel storage facility.	
						926,400.00		
Administration	disconnect and terminate services	item	5000-5500	5000.00	2	10000.00	This item includes disconnecting all services such as power, water and sewer. This is a 'one off' cost for the area.	
	demolish and remove small buildings	m^2	70-90	75.00	590	44220.00	enter the total area of small buildings and offices in the area, including demountables. It does not include workshops.	
	demolish and remove industrial workshops and sheds	m^2	160-210	210.00		0.00	enter the total area of workshop facilities in the area.	
	remove bitumen from sealed carparks etc	m^2	12.00-17.00	17.00		0.00	enter total area of carparks. Includes removal offsite to appropriate facility	
	remove concrete pads, footings	m^2	10-30	10.00	590	5896.00	enter the total area of workshops and buildings. (concrete <300mm @ $10/m2, concrete >300mm @ $30/m2)	
	waste disposal offsite	@	650	650.00		0.00	assumes removal offsite to a waste disposal facility. Adjust if disposing at onsite facility	
						60116.00		
Sewerage/Water treatment plant	disconnect and terminate services	item	2500-5000	2500.00	4	10000.00	This item includes disconnecting all services such as power, water and sewer. This is a 'one off' cost for the area.	
	remove concrete pads and footings	m^2	10-30	10.00	40	400.00	enter the total area of workshops and buildings. Include any areas of carpark and washdown pads, bulk fuel bunding and refuelling areas.	
	demolish and remove small buildings	m^2	70-90	75.00	200	15000.00	enter the total area of small buildings and tanks.	
	remove contaminated soil	m^3	3.00-5.00	5.00		0.00	removal to pit void for appropriate rehabilitation	
						25400.00		
Accommodation Camp	disconnect and terminate services	item	5000-5500	5000.00	1	5000.00	This item includes disconnecting all services such as power, water and sewer. This is a 'one off' cost for the area.	
	remove concrete pads and footings	m^2	10-30	10.00	481	4814.00	enter the total area of workshops and buildings. Include any areas of carpark and washdown pads, bulk fuel bunding and refuelling areas.	
	demolish and remove small buildings	m^2	70-90	75.00	1173	87990.00	enter the total area of small buildings and tanks.	
						97804.00		
Airstrip, borefields, other	remove concrete pads footings and bitumen	m^2	10-30	10.00		0.00	enter total area (concrete <300mm @ $10/m2, concrete >300mm @ $30/m2)	
	demolish and remove sheds and storage tanks	m^2	70-90	75.00		0.00	enter area of sheds and tanks	
	production/dewatering bore closure	@	2000-3300	2000.00		0.00	sealing and rehabilitation	
	observation bore closure	@	500	500.00		0.00	includes sealing and rehabilitation to make safe.	
						0.00		
Revegetation Activities - all infrastructure areas	Deep rip	ha	550-1100	1100.00	53	58756.50	Enter all areas disturbed by infrasturcture from above, including laydown areas Assume highly disturbed and compacted areas - see assumptions.	
	source cart and spread topsoil	m^3	2.50-5.50	5.50	106830	587565.00	assume minimum of 10cm depth	
	revegetation by tubestock	ha	6000/ha (or 5/ea)	6000.00		0.00	enter total area for revegetation by tubestock. (or enter quantity of tubestock required (<15cm), and density/ha)	
	revegetation by direct seeding	ha	1200-2000	2000.00	53	106830.00	this rate includes acquiring a mix of native tree and shrub species appropriate for the area, mixing and treating the seed and applying by hand at a rate of 4-10kg/ha	
	feriliser application	ha	140-744	140.00		0.00	includes a single application of fertiliser during the initial seeding program - see assumptions	
						753151.50		
Other	remove powerlines	km	9800-15000	15000.00	25	375000.00	include dismantling and removal of lines and poles from the site	
	remove pipelines	km	1400-1800	1400.00	17.80	24920.00	remove polypipe >300mm diameter. Assumes removal by 3 persons via truck to nearest location.	
						399920.00		
DOMAIN 1 TOTAL						$13,896,756.50		

Domain 2: Extractive Workings - Sand, Clay & Gravel								
Management Area	Technique	Unit of Measure (UOM)	Range per UOM ($)	Cost per UOM ($)	Estimated Quantity	Sub Total ($)	Technique Notes	Comment (eg when $/UOM differs from DPIR)
Pits	Scaling, battering for stabilisation	m^2	1.21-3.00	3.00		0.00	this includes the area requiring reshaping for stabilisation and preparation for revegetation	
	backfilling of pits	m^3	4.00-5.00	5.00		0.00	enter volume of material to be backfilled into pit	
	abandonment bund and pit access closed	m	20.00-63.25	50.00		0.00	required where final pit includes steep faces. Includes bund around pit and closure of ramp. Bund assumed to be 2m high and 5m wide at base	
	structural works for drainage	ha	700-1500	1500.00		0.00	earthworks for banks and drains to manage surface water .	
	source cart and spread topsoil or growth medium	m^3	2.50-5.50	5.50		0.00	required if it has not been demonstrated that pit material is suitable as a growth medium	
	final trim, deep rip	ha	550-1600	1600.00	0.00	0.00	to enhance vegetation program as required, dependent on material to be ripped eg sand, gravel, clay. Assume low to medium level disturbance - see assumtpions	Reclamation of LPM borrow included in cost of LPM
	revegetation by tube stock	ha	6000/ha (or 5/ea)	6000.00		0.00	includes acquisition of tubestock, fertiliser and guarding as necessary	
	revegetation by direct seeding	ha	1200-2000	2000.00	0.0	0.00	includes acquiring and spreading a range of native seed by direct broadcast at a rate of 4-10kg/ha.	Reclamation of LPM borrow included in cost of LPM
	fertiliser application	ha	140-744	140.00	0.0	0.00	includes a single application of fertiliser during the initial seeding program - see assumptions	Reclamation of LPM borrow included in cost of LPM
	signage	@	50	50		0.00	enter number of warning signs as approriate	
						0.00		
Sediment Management	sediment traps/dams	m^3	2.50-2.90	2.90		0.00	enter volume of dam required for sediment traps	
	Rocks or coarse material lined sediment trap	m^3	1.00-5.00	5.00		0.00	condsider distance to cart material	
Other						0.00		
						0.00		
DOMAIN 2 TOTAL						$0.00		

NORTHERN TERRITORY GOVERNMENT

Domain 3: Hard Rock Pits and Quarries

Management Area	Technique	Unit of Measure (UOM)	Range per UOM ($)	Cost per UOM ($)	Estimated Quantity	Sub Total ($)	Technique Notes	Comment (eg when $/UOM differs from DPIR)
Stabilisation of Pits	Drill and blast faces to make safe OR	m^3	1.20-1.60	1.60		0.00	Volume is worked out be multiplying length of bench by width and height to reduce angle to make it safe.	
	scaling, battering, pushing walls	m^3	1.21-3.00	3.00		0.00	volume requiring reshaping	
	abandonment bund and pit access closed	m	19.00-63.25	30.00	3967	119009.85	required where final pit includes steep faces (>18o). Includes bund (2m high , 5m base) around pit and closure of ramp	
	final trim, deep rip	ha	550-1600	1600.00		0.00	to enhance vegetation program around pit and pit floors as required	
	structural works for drainage	ha	700-1540	1200.00		0.00	earthworks for banks and drains to manage surface water .	
	source cart and spread topsoil if appropriate	m^3	2.50-5.50	5.50		0.00	includes min of 10cm of topsoil to assist revegetation program.	
	revegetation by tube stock	ha	6000/ha (or 5/ea)	6000.00		0.00	includes acquisition of tubestock, fertiliser and guarding as necessary	
	revegetation by direct seeding	ha	1200-2000	2000.00		0.00	includes acquiring and spreading a range of native seed by direct broadcast at a rate of 4-10kg/ha.	
	fertiliser applicataion	ha	140-744	140.00		0.00	includes a single application of fertiliser during the initial seeding program	
	fencing	m	10.0-30.0	30.00		0.00	construct a standard stock fence around the site	
	signage	@	50	50	20	1000.00	enter number of warning signs as appropriate	
						120009.85		
Infill of pits	infill with tailings or waste rock	m^3	2.00-4.00	4.00		0.00	haul and dump of waste rock or tailings. Distance needs to be considered.	
	shaping or levelling	ha	550-1100	700.00		0.00	area requiring minor reshaping prior to deep ripping	
	source cart and spread suitable material for growth medium	m^3	2.00-5.00	5.00		0.00	required if it has not been demonstrated that infill material is suitable as a growth medium and only if does not require egineered capping design for ARD/metals mitigation. Assume min thickness of 0.5m	
	source cart and spread topsoil if appropriate	m^3	2.50-5.50	5.50		0.00	includes min of 10cm of topsoil to assist revegetation program.	
	final trim, deep rip	ha	550-1600	1600.00		0.00	to enhance vegetation program over infilled pit as required	
	structural works for drainage	ha	700-1540	1200.00		0.00	earthworks for banks and drains to manage surface water on top of capped pit area if required.	
	revegetation by tube stock	ha	6000/ha (or 5/ea)	6000.00		0.00	includes acquisition of tubestock, fertiliser and guarding as necessary	
	revegetation by direct seeding	ha	1200-2000	2000.00		0.00	includes acquiring and spreading a range of native seed by direct broadcast at a rate of 4-10kg/ha.	
	fertiliser applicataion	ha	140-744	140.00		0.00	includes a single application of fertiliser during the initial seeding program - see assumptions	
						0.00		
Sediment Management	sediment traps/dams	m^3	2.5-2.9	2.90		0.00	enter volume of dam required for sediment traps	
	Rocks or coarse material lined sediment trap	m^3	1.00-5.00	5.00		0.00	condsider distance to cart material	
Other						0.00		
						0.00		
DOMAIN 3 TOTAL						$120,009.85		

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Domain 4: Underground Workings

Management Area	Technique	Unit of Measure (UOM)	Range per UOM ($)	Cost per UOM ($)	Estimated Quantity	Sub Total ($)	Technique Notes	Comment (eg when $/UOM differs from DPIR)
Portals, Declines and Shafts	barricading portal/declines/adits	@	1500-2500	2500.00		0.00	barricading of portal with steel grill to make safe and ensure access cnnot be gained but will allow movement of bats	
	sealing portal/decline	@	15000-25000	25000.00		0.00	OR sealing portal with concrete and backfill to make safe and ensure access cannot be gained	
	capping/sealing shafts	@	10000-25000	10000.00		0.00	cap shafts using reinforced concrete slab. Dependent on size	
	shaft infilling	m^3	8.00-20.0	10.00		0.00	filling of shafts using onsite material	
	seal ventilation fans	@	27500	27500.00		0.00	seal and rehab ventilation fans to make safe.	
	final trim, deep rip	ha	550-1600	1600.00		0.00	to enhance vegetation program in area as required	
	revegetation by tube stock	ha	6000/ha (or 5/ea)	6000.00		0.00	includes acquisition of tubestock, fertiliser and guarding as necessary	
	revegetation by direct seeding	ha	1200-2000	2000.00		0.00	includes acquiring and spreading a range of native seed by direct broadcast at a rate of 4-10kg/ha.	
	fertiliser applicataion	ha	140-744	140.00		0.00	includes a single application of fertiliser during the initial seeding program - see assumptions	
						0.00		
DOMAIN 4 TOTAL						$0.00		

Domain 5: Tailings Storage Facilities and Dams

Management Area	Technique	Unit of Measure (UOM)	Range per UOM ($)	Cost per UOM ($)	Estimated Quantity	Sub Total ($)	Technique Notes	Comment (eg when $/UOM differs from DPIR)	
Water Dams, Ponds	clean water dams - stabilise and make safe	@	2000-2200	2000.00		0.00	minor earthworks		
	or backfill to natural surface	m^3	2.00-5.00	5.00		0.00	backfilled with onsite material. Haul distance sliding scale from $2/m3 for up to 1km, up to $5/m3 for up to 5km or greater.		
	dirty water dams - drain and remove sediment	m^3	5.00-7.50	7.50		0.00	includes draining the dam to the pit or other appropriate place, removing 500mm of potentially contaminated sediments to be buried in the pit or other disposal area. Must consider the distance from dam to disposal area.		
	shaping or levelling	ha	550-1100	700.00		0.00	area requiring minor reshaping prior to deep ripping		
	source cart and spread suitable material for capping/growth medium	m^3	2.00-5.00	5.00		0.00	required if it has not been demonstrated that infill material is suitable as a growth medium Assume min thickness of 0.5m		
	source cart and spread topsoil if appropriate	m^3	2.50-5.50	5.50		0.00	includes min of 10cm of topsoil to assist revegetation program.		
	final trim, deep rip	ha	550-1600	1600.00		0.00	to enhance vegetation program over infilled pit as required		
	structural works for drainage	ha	700-1540	1500.00		0.00	earthworks for banks and drains to manage surface water on top of capped dam area if required.		
	revegetation by tubestock	ha	6000/ha (or 5/ea)	6000.00		0.00	includes acquisition of tubestock, fertiliser and guarding as necessary		
	revegetation be direct seeding	ha	1200-2000	2000.00		0.00	includes acquiring and spreading a range of native seed by direct broadcast at a rate of 4-10kg/ha.		
	fertiliser application	ha	140-744	140.00		0.00	includes a single application of fertiliser during the initial seeding program		
						0.00			
Tailings Dams	source cart and spread suitable material for capping	m^3	2.00-5.00	3.50	20183036	70,640,627	volume of suitable material for capping the TSF. Must have appropriate chemical and physical properites. Required whether for engineered design or growth medium.	Source, cart, spread all NAF sub-base (crowning material), and NAF in Store & Release Cover, used average of costs in range. LPM material source, cart, and spread costs included in LPM unit cost below.	
	apply capping design treatment as required eg 'store and release'	ha	25000-49500	25000.00	554	13,847,710	required to manage AMD or metals leachate from TSF. Capping layer assumed to be no less than 2m thick.	Assume cost covers store and release blending and placement with compaction, includes Entire area of both TSF1 and TSF2 (rounded). Store and release cover 1m thick, therefore low range of cost used	
	source cart and spread topsoil if appropriate	m^3	2.50-5.50	5.50	1107817	6,092,992	includes min of 10cm of topsoil to assist revegetation program.	PGM on both TSF1 and TSF2, hauled 1km to 3km, depending on source area	default cost = $5.5/m3
	reshape walls and surrounds	ha	1400-5500	1400.00		-	area requiring stabilisation and reshaping works around the walls of the emplacement		
	fianl trim, deep rip	ha	550-1600	1600.00	554	886,253	to enhance vegetation program over infilled pit as required	Entire area of both TSF1 and TSF2 (rounded)	
	structural works for drainage	ha	700-1540	1500.00		-	earthworks for banks and drains to manage surface water on top of capped dam area if required.		
	revegetation by tubestock	ha	6000/ha (or 5/ea)	6000.00		-	includes acquisition of tubestock, fertiliser and guarding as necessary		
	revegetation be direct seeding	ha	1200-2000	2000.00	554	1,107,817	includes acquiring and spreading a range of native seed by direct broadcast at a rate of 4-10kg/ha.	Entire area of both TSF1 and TSF2 (rounded)	
	fertiliser application	ha	140-744	140.00		-	includes a single application of fertiliser during the initial seeding program - see assumptions		
	seepage management - recovery and treatment	@	20000-200000	20000.00		-	where seepage is at unacceptable levels and no wetland filter is in place and company has committed to recovery and treatment of seepage. Depends on size.		
	seepage management - wetland filter	ha	5500	5500.00		-	assumes wetland filter is in place and functioning		
Other	Wick drains	m		9.33	242980	2,267,002		Line item added to Security Calculation	
	Pump surficial and wicked water to WTP	LS		130000.00	1	130,000	cost for treatment of water included under WRD tab	TSF1- Line item added to Security Calculation	
	Pump surficial and wicked water to WTP	LS		144000.00	1	144,000		TSF2- Line item added to Security Calculation	
	Seepage Collection Ditches	LS		170000.00	1	170,000		TSF1-Line item added to Security Calculation	
	Seepage Collection Ditches	LS		70000.00	1	70,000		TSF2-Line item added to Security Calculation	
	Low Permeability Material Cost to	m3		15.03	2924636	43,957,284	Cost includes LPM borrow development, importing from off-site, and closure of borrow area.	Line item added to Security Calculation	
						139313686.32			
DOMAIN 5 TOTAL						$139,313,686.32			

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Domain 6: Stockpiles & Waste Rock Dumps

Management Area	Technique	Unit of Measure (UOM)	Range per UOM ($)	Cost per UOM ($)	Estimated Quantity	Sub Total ($)	Technique Notes	Comment (eg when $/UOM differs from DPIR)
Oxide waste rock dumps and extractive product stockpiles	Recontouring/battering for stabilisation	m^2	2.00-3.60	3.60		0.00	this includes the area requiring reshaping for stabilisation and preparation for revegetation	
	unshaped requiring minor earthworks, trim and deep rip	ha	550-1600	1600.00	90	144160.00	enter the area requiring minor reshaping to 12-18° slopes and deep ripping to enhance revegetation	HLP and LGO
	unshaped requiring major earthworks, trim and deep rip	m^3	1.21-4.00	4.00	0	-	include volume of material requiring major reshaping to achieve approriate grades (<18° Or as specified in MMP) and deep ripping	moved store and release cover costs to added rows at bottom of this section (rows 15, 16, 17, to be consistent with costs for store and release cover for TSFs)
	structural works for drainage	ha	700-1540	1500.00		0.00	earthworks for banks and drains to manage surface water on top of WRD.	
	source cart and spread topsoil or growth medium	m^3	2.50-5.50	5.50	180200	991100.00	required if it has not been demonstrated that WRD material is suitable as a growth medium	Topsoil cover (LGO and HLP)
	or removal of stockpiles	m3/bcm	3.00-5.00	3.00	0	-	carting of stockpiles offsite or WRD to pit. Consider carting distance	Material will be covered in place.
	trim, deep rip if required	ha	550-1600	1600.00		0.00	ripping stockpiles or surrounds if required.Assume ripping of waste rock dumps undertaken during reshaping.	
	revegetation by tube stock	ha	6000/ha (or 5/ea)	6000.00		0.00	includes acquisition of tubestock, fertiliser and guarding as necessary	
	revegetation by direct seeding	ha	1200-2000	2000.00	90	180200.00	includes acquiring and spreading a range of native seed by direct broadcast at a rate of 4-10kg/ha.	HLP and LGO
	fertiliser applicataion	ha	140-744	140.00		0.00	includes a single application of fertiliser during the initial seeding program - see assumptions	
	source cart and spread suitable material for capping	m^3	2.00-5.00	2.00	720800	1,441,600	volume of suitable material for capping. Must have appropriate chemical and physical properites. Required whether for engineered design or growth medium.	Line item added to Security Calculation Source, cart, spread all NAF in Store & Release Cover, used low costs in range due to short haul. LPM material source, cart, and spread costs included in LPM unit cost below.
	apply capping design treatment as required eg 'store and release'	ha	25000-49500	25000.00	90	2,252,500	required to manage AMD or metals leachate. Capping layer assumed to be no less than 2m thick.	Line item added to Security Calculation Assume cost covers store and release blending and placement with compaction, includes area of both HLP and LGO. Store and release cover 1m thick, therefore low range of cost used
	Low Permeability Material Cost to	m3		15.03	475728	7,150,192	Cost includes LPM borrow development, importing from off-site, and closure of borrow area.	Line item added to Security Calculation for HLP and LGO
						1315460.00		
Waste rock dumps with AMD or metals	unshaped requiring major earthworks, trim and deep rip	m^3	4.00-6.00	4.00		0.00	include volume of material requiring major reshaping to achieve approriate grades (<18° or as specified in MMP) and deep ripping	
	unshaped requiring minor earthworks, trim and deep rip	ha	550-1600	1600.00	0	0.00	enter the are requiring minor reshaping and deep ripping to enhance revegetation	
	source cart and spread suitable material for capping	m^3	2.00-5.00	5.00	2233694	11168471.39	volume of suitable material for capping the WRD. Must have appropriate chemical and physical properites.	NAF rock
	apply capping design treatment eg 'store and release'	ha	25000-49500	196400.00	257	50450218.94	required to manage AMD or metals leachate from WRD. Capping layer assumed to be no less than 2m thick.	LLDPE Liner, plus geotextile under and over layers, cost based on vendor estimate
	or removal of stockpiles	m3/bcm	3.00-5.00	5.00		0.00	removal to pit. Haulage distance needs to be considered at an additonal $1/km	
	source cart and spread topsoil if appropriate	m^3	2.50-5.50	5.50		0.00	required if it has not been demonstrated that capping material is suitable as a growth medium	
	final trim, deep rip	ha	550-1600	1600.00		0.00	to enhance vegetation program over infilled pit as required	
	structural works for drainage	ha	700-1540	700.00		0.00	earthworks for banks and drains to manage surface water on top of WRD area if required.	
	revegetation by tube stock	ha	6000/ha (or 5/ea)	6000.00		0.00	includes acquisition of tubestock, fertiliser and guarding as necessary	
	revegetation by direct seeding	ha	1200-2000	2000.00		0.00	includes acquiring and spreading a range of native seed by direct broadcast at a rate of 4-10kg/ha.	
	fertiliser applicataion	ha	140-744	140.00		0.00	includes a single application of fertiliser during the initial seeding program - see assumptions	
						61618690.33		
Leachate and sediment management	Active recovery treatment of problem leachate	item	20000-200000	2330000	5	11,650,000	where seepage is at unacceptable levels and no wetland filter is in place and company has committed to recovery and treatment of seepage. Depends on size.	Includes costs for treatment of TSF seepage/supernatant water pumped to WTP
	Construct New Wetland Filter	item	1,000,000 - 5,000,000	1700000	1	1,700,000	where seepage is at unacceptable levels and no wetland filter is in place and company has committed to recovery and treatment of seepage. Depends on size.	Line Item added to Security Estimate Workbook, Cost based on FS
	Wetland filter	ha	5500	5500.00		0.00	assumes wetland filter is in place and functioning	
	dams for sediment control	m^3	2.50-2.90	2.90		0.00	enter volume of dam required for sediment traps	
	Rocks or coarse material lined sediment trap	m^3	1.00-5.00	5.00		0.00	condsider distance to cart material	
Other						0.00		
						13350000.00		
DOMAIN 6 TOTAL						$76,284,150		

Domain 7: Exploration

Management Area	Technique	Unit of Measure (UOM)	Range per UOM ($)	Cost per UOM ($)	Estimated Quantity	Sub Total ($)	Technique Notes	Comment (eg when $/UOM differs from DME)
Drillholes, Pads, sumps, costeans	capping drillholes 30cm below ground	@	80-275	150.00		0.00	Cut collar, insert plug and backfill. Assume using, concrete or plastic cone plugs or bridge (no 'occy' plugs) Depends on number of holes	
	grout with concrete	@	1250	1250.00		0.00	Assume total grouting of drillhole	
	empty and remove plastic sample bags	hole	25-235	100.00		0.00	return cuttings to hole and remove plastic bags to a waste disposal facility. Bags cannot be disposed of on site.	
	ripping/scarifying pads	ha	440-2500	1600.00		0.00	Minor ripping/scarifying of pads to depth of 0.3m to assist vegetation in areas of flat/gentle terrain, includes sump infilling. Sumps should not remain open for extended periods of time.	
	reshape drill pads	@	320	320.00		0.00	Required in steep terrain where earthworks required with excavator/dozer to return pad to slope and establish erosion control, includes sump infilling. Using PC650 excavator or equivalent assumes one pad per hour @$320/hr.	
	infilling costeans	m^3	2.00-3.00	3.00		0.00	Backfilling of all costeans/trenches. Assumes material does not have to be carted.	
	bulk sample pits	m^3	2.00-8.00	2.00		0.00	dependent on depth of pit and if battering of walls required to form to 18° slope	
	contouring for erosion control	ha	700-1540	1500.00		0.00	minor pushing to construct water management structures such as contour banks and diversion drains as required.	
	topsoil replacement if applicable	m^3	2.50-5.50	5.50		0.00	includes min of 10cm of topsoil to assist revegetation program. **this may be carried out when reshaping pads	
	revegetation by tube stock	ha	6000/ha (or 5/ea)	6000.00		0.00	includes acquisition of tubestock, fertiliser and guarding as necessary	
	revegetation by direct seeding	ha	1200-2000	2000.00		0.00	includes acquiring and spreading a range of native seed by direct broadcast at a rate of 4-10kg/ha if required. Required where area of disturbance is significant.	
	fertiliser applicataion	ha	140-744	140.00		0.00	includes a single application of fertiliser during the initial seeding program	
						0.00		
Tracks and Gridlines	ripping/scarifying minor tracks and gridlines	km	120-500	500.00		0.00	assume using grader or equivalent to rip to 0.3m and no windrows, establishing erosion control measures (eg bunds) as required	
	ripping major tracks and roads	km	550-1000	1000.00		0.00	pushing in windrows and ripping track and establishing erosion control measures (ie bunds) across tracks as required	
	removal of gridpegs	item	1500	1500.00		0.00	includes removal offsite of all grid pegs in exploration area	
	topsoil replacement if applicable	m^3	2.50-5.50	5.50		0.00	includes min of 10cm of topsoil to assist revegetation program if required	
	revegetation by tube stock	ha	6000/ha (or 5/ea)	6000.00		0.00	includes acquisition of tubestock, fertiliser and guarding as necessary	
	revegetation by direct seeding	ha	1200-2000	2000.00		0.00	includes acquiring and spreading a range of native seed by direct broadcast at a rate of 4-10kg/ha.	
	fertiliser applicataion	ha	140-744	140.00		0.00	includes a single application of fertiliser during the initial seeding program	
						0.00		
DOMAIN 7 TOTAL						$0.00		

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Domain 8: Access and Haul Roads

Management Area	Technique	Unit of Measure (UOM)	Range per UOM ($)	Cost per UOM ($)	Estimated Quantity	Sub Total ($)	Technique Notes	Comment (eg when $/UOM differs from DME)
Haul Roads	remove ARD material from road	m3/bcm	2.50-5.50	5.50		0.00	where haul road has been constructed with waste rock material that is leaching ARD removal and disposal in pit or similar will be required	
	reshape and deep rip	ha	2000-5000	5000.00	31	153249.50	windrows are pulled back and edges battered, area is deep ripped (road 12mwide)	
	structural works for drainage	ha	700-1540	1500.00		0.00	pushing to construct water management structures such as contour banks and diversion drains as required.	
						153249.50		
Access Roads	breaking and removal of bitumen	m3	12.00-17.00	17.00		0.00	Includes area of bitument in roads car parks etc which needs to be removed and disposed of appropriately	
	reshape and deep rip	ha	2000-5000	2500.00		0.00	windrows are pulled back and edges battered, area is deep ripped	
	structural works for drainage	ha	700-1540	1500.00		0.00	pushing to construct water management structures such as contour banks and diversion drains as required.	
						0.00		
Revegetation activities - all roads	source cart and spread topsoil	m^3	2.50-5.50	5.50	61300	337148.90	assume minimum of 10cm depth	
	revegetation by tubestock	ha	6000/ha (or 5/ea)	6000.00		0.00	enter total area for revegetation by tubestock.(or enter quantity of tubestock required (<15cm), and density/ha)	
	revegetation by direct seeding	ha	1200-2000	2000.00	31	61299.80	this rate includes acquiring a mix of native tree and shrub species appropriate for the area, mixing and treating the seed and applying by hand at a rate of 4-10kg/ha	
	feriliser application	ha	140-744	140.00		0.00	includes a single application of fertiliser during the initial seeding program - see assumptions	
						398448.70		
DOMAIN 8 TOTAL						$551,698.20		

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Domain 9: River Diversions

Management Area	Technique	Unit of Measure (UOM)	Range per UOM ($)	Cost per UOM ($)	Estimated Quantity	Sub Total ($)	Technique Notes	Comment (eg when $/UOM differs from DME)
Creek/River	channel maintenance	m	165.00	165.00		0.00	Includes earthwork repairs and stabilisation following flow events.	
	vegetation by tubestock	ha	6000/ha (or 5/ea)	6000.00		0.00	enter total area for revegetation by tubestock.(or enter quantity of tubestock required (<15cm), and density/ha)	
	vegetation by direct seeding	ha	1200-2000	2000.00		0.00	this rate includes acquiring a mix of native tree and shrub species appropriate for th area, mixing and treating the seed and applying by hand at a rate of 4-10kg/ha	
	vegetation maintenance	ha	140-744	140.00		0.00	includes a single application of fertiliser during the initial seeding program	
						0.00		
DOMAIN 9 TOTAL						$0.00		

Decommissioning & Post Closure Management

Management Area	Technique	Unit of Measure (UOM)	Range per UOM ($)	Cost per UOM ($)	Estimated Quantity	Sub Total ($)	Technique Notes	Comment (eg when $/UOM differs from DME)
Decommissioning and Closure	mobilisation/demobilisation	km	10.00-15.00	15.00	290	21,750.00	determined based on distance to the mine and machinery used ($/km) Assume mob/demob from largest centre unless otherwise stipulated & supported by the operator. Calculation assumes 5 pieces of machinery required per site. Adjust formula if necessary.	
	Contaminated site assessment	@	35000	35000.00	1	35,000.00	has a contaminated site assessment been undertaken? If not this should be included for large metalliferous mines.	
	Pest and weed management, monitoring & assessment	ha	200 - 250	250.00	1970	492,474.07	Include total disturbed area , consider for minimum of 2 years during closure for larger sites only. Entry automated form 'Key Information' tab.	
	Contractor accommodation, messing and travel costs	man day	210-320	320.00	1000	320,000.00	Assume 5-9 people required for 2-10 weeks (or more) depending on size of site *quantity = number of days X number of people (eg 9 persons for 50 days = 450 man days)	
	Closure management	yr	110,000 - 300,000	110000.00	1	110,000.00	This includes project manaement team assuming 1 - 3 persons based on the magnitude of the process salaries, oncosts, tender preparation and closure report and coordination of works. Consider part of year only for small sites.	
Post Closure	mobilisation/demobilisation	km	10.00-15.00	15.00	2900	43,500.00	Determined based on distance to the mine and machinery used($/km) Assume mob/demob from largest centre unless otherwise stipulated & supported by the operator. Calculation assumes 1 piece of machinery required per site.	
	Post closure water monitoring	yr	adjust post closure worksheet - no entry required			1,833,900.00	Monitoring and measurement requirements that may be needed following the closure of the project - use the 'post closure worksheet' Estimated quanity refers to number of years required post closure	
	Pest and weed management, monitoring & assessment	ha	200 - 250	250.00	2955	738,711.11	Include total rehabilitated area , assumed for minimum of 3 years post closure Entry automated form 'Key Information' tab	
	Earthwork maintenance	ha	1,100	1100.00	360	396,388.63	Assume 20% failure rate for the total areas of contructed landforms (eg WRDS, TSF etc) for a period of 2 years (if not stipulated otherwise) Entry automated form 'Key Information' tab.	
	Revegetation maintenance, monitoring & assessment	ha	1,250 - 2,500	2500.00	394	984,948.14	Assume a 20% failure rate for all disturbed areas for a period of 2 years. (if not stipulated otherwise) Entry automated form 'Key Information' tab.	
	Project management	yr	20,000	20000.00	1	20,000.00	This includes tender preparation, financial reporting procurement, contractor management etc. Time frame assumed is 1-10 years depending upon the site & the complexity of the issues present	
	fire break maintenance	km	50-75	72.00		0.00	Grading of firebreaks during and after closure for a period of 1-10 years depending on site size *quantity = number km x number years	
						4,996,671.94		
POST CLOSURE TOTAL						4,996,671.94		

NORTHERN TERRITORY GOVERNMENT

POST CLOSURE WATER QUALITY MONITORING WORKSHEET

SUMMARY

NOTE:
Operators must enter numbers in the blue boxes, to the appropriate timeframes and reflecting the structures present on individual sites.

Item	Component	Cost ($)
1	Groundwater monitoring - Analytical	$1,050,000
2	Surface water monitoring - Analytical	$182,500
3	Field sampling and Expenses	$76,400
4	Water quality interpretation & reporting	$525,000
	TOTAL	**$1,833,900**

1 GROUNDWATER MONITORING - ANALYTICAL

Analytical & consumables
Assumptions: ICPMS, fields & laboratory consumables @ $250/sample

Mine site structures	Size (ha)	Enter the number of structures	Sampling points	Sampling per year	Enter the number of years 0-10	Subtotal cost ($)	
Whole of site	All		3	2	10	0	
Extraction bores for use after closure		0	1	2	10	0	
Discrete infrastructure areas		1	3	2	10	15,000	
Underground fuel storage areas		0	1	2	10	0	
Pit voids/declines	All	2	3	2	10	30,000	*Denotes sampling of bores adjacent to structures*
Waste rock dump - oxide	<5		2	1	10	0	
	5 - 20		3	2	10	0	
	>20		4	2	10	0	
Waste rock dump - mixed or sulfide	<5		2	2	10	0	
	5 - 20		4	2	10	0	
	>20	2	6	2	10	60,000	
Tailings dam / residue disposal ponds	0 -20		3	2	10	0	
	21 - 100		4	2	10	0	
	100 - 150		6	2	10	0	
	>150	15	10	2	10	750,000	
Heap leach pad	<10		3	2	10	0	
	>10	3	5	2	10	75,000	
Water containment/retention ponds	<10		2	1	10	0	
(water not suitable for passive release)	10 - 20		3	2	10	0	
	>20	4	4	2	10	80,000	
Waste disposal areas			2	1	10	0	
Other		4	1	2	10	20,000	
Other		4	1	2	10	20,000	
Other						0	
					sub total	***$1,050,000***	

2 SURFACE WATER MONITORING - ANALYTICAL

Analytical & consumables
Assumptions: ICPMS, fields & laboratory consumables @ $250/sample

Mine site features	Number of features	Sampling points	Sampling per year	Enter No. of years 1-10	Subtotal cost ($)
Water retaining structures with no discharge	2	1	1	10	5,000
Water retaining structures with possible discharge	1	1	2	10	5,000
Bioremediation structures	1	1	1	10	2,500

PLUS

Mine site features	Number of features	Sampling points	Sampling per year	Enter No. of years 0-10	Subtotal cost ($)
Perenial streams discharging from site	3	2	4	10	60,000
Ephemeral streams discharging from site	12	2	2	10	120,000

OR Please note: Fill out either the streams or the site operational complexity, size and climate section, but not both

Site operation complexity & size and climate	Default sampling sites	Sampling per year	Enter No. of years 0-10	Subtotal cost ($)
Arid zone site - small to medium	5	1		0
Arid zone site - large	10	2		0
Wet/dry tropics site - small size, simple issues	10	2		0
Wet/dry tropics site - small size, moderate -complex issues	10	4		0
Wet/dry tropics site - medium size, simple issues	15	2		0
Wet/dry tropics site - medium size, moderate -complex issues	15	4		0
Wet/dry topics site - large size, moderate -simple issues	25	4		0
Wet/dry topics site - large size, moderate -complex issues	30	4		0
			sub total	***$182,500***

3 FIELD SAMPLING & EXPENSES

Assumptions:
Road travel <200km = day trip , 2 people, no accommodation, fuel (300km return) & expenses
Road travel 200 - 500km = minimum of 1 nights accom , 1 day travel + 1 night for each additional sampling day, 2 people , fuel (av 800km return)
Road travel >500km = minimum of 2 nights accom, 2 days travel + 1 night for each additional sampling day, 2 people, fuel (av 1600km return)
Fuel = $1.20/L @ 6km/L Accommodation & meals = $130 per person /per night Personnel = $800 per person per day Air travel = $2000 per person return Expenses (e.g. vehicle/consumables etc) $100/day

Travel and expenses	Enter No. of years 0-10	Distance from nearest centre eg Darwin	Quantity	Enter est. days each sampling trip	Subtotal cost ($)
Field trips - Road travel		<200km	4	1	0
	5	200 - 500km	4	1	76,400
		> 500km	4	1	0
Field trip - Air travel (Proof of availability & suitability required)			4	1	0
				sub total	***$76,400***

4 WATER QUALITY INTERPRETATION AND REPORTING

Item	Site size& water mgmt challenges	Quantity	Enter No. of yrs 0-10	Unit cost ($)	Subtotal cost ($)
Quaterly data collation & interpretation	small	3		2,500	0
	medium	3		5,000	0
	large	3	10	10,000	300,000
Annual data collation & interpretation	small	1		1,000	0
	medium	1		5,000	0
	large	1	10	20,000	200,000
Other reporting		1	5	5,000	25,000
				sub total	***$525,000***

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