VISTA GOLD

Cover Trials Design and Monitoring Procedure

Mt Todd Project – Waste Rock Dump

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ACRONYMS/ABBREVIATIONS

Acronyms/Abbreviations	Definition
amsl	Above mean sea level
ARD	Acid rock drainage
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
Non-PAG	Non-potentially acid generating
NTEPA	Northern Territory Environment Protection Authority
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

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.*"

This document provides support to Vista Gold Corp (Vista) in response to this recommendation by providing a cover trial design, and 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. **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):

- 0.3 m thick liner bedding layer to protect overlying liner from puncture and damage
- Liner to act as a hydraulic barrier to limit percolation of meteoric water into underlying PAG 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)
- 0.3 m thick liner protective layer to maintain the moisture content of and confining pressure on the underlying liner;
- 10 m thick non-potentially acid generating (Non-PAG) 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 PAG waste rock
- 1.0 m thick Non-PAG 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 non-PAG 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 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 11 (**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 4 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 52, 37, 9 and 2 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° (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 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, the data acquisition system, power supply, and telemetry systems to be installed. Exact locations, orientations and dimensions of each instrument are not located at this time.

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.

The locations of all instruments, including data loggers, power systems, data acquisition system (DAS), surface runoff flumes, tipping buckets and housing, 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 drain 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. It is beyond the scope of this document to specify the exact manufacturer, model, calibration, installation and operating system requirements for the instruments recommended. 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
Pressure Transducer	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. Standard TDR methods may not be 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 one central, tamper-proof solar power supply, and one data logger and DAS. Data will be downloaded via an internet-based modem for web-based access or manually via direct connection to the datalogger.

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 power supply, a data logger, and a DAS in a manner that is similar to that described for the TDRs. As with the TDRs, data may be downloaded remotely via a modem or manually via direct connection to a datalogger.

3.3.4. Pressure Transducers

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 PAG rock. As such, pressure transducers 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 pressure transducers are factory calibrated, no additional calibration is anticipated to be necessary.

At each cover trial location four (4) pressure transducers will be located on top of the GCL or LLDPE liner as shown on Figure 6. The transducers will be connected to the power supply, a data logger, and a DAS in a manner that is similar to that described for the TDRs and HDSs. As with the TDRs and HDSs, data may be downloaded remotely via a modem or manually via direct connection to a datalogger.

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 vertically from immediately above the GCL or LLDPE liner protective layer to the PAG 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 drain pipe located at the base of the structure. The water in the drain 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 pressure transducers 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 non-PAG 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 non-PAG 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 data logger and the DAS. The same collection timing for the lysimeter tipping buckets and the precipitation gauge should be used to correlate the percolation measured with the precipitation events happening at the site.

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 Figure 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 non-PAG 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 drain pipe, which will convey surface runoff from the flume to adequately-sized tipping buckets and housing for continuous measurement of surface runoff.

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 associated housing and data logger will be located on the bench down-gradient of the flume to measure runoff volumes. The data logger will be connected by cables to the central power supply and DAS dedicated to each cover trial location. As recommend for the lysimeters, the same collection timing for the surface runoff flume tipping buckets and the precipitation gauge should be used to correlate the surface runoff measurements with the precipitation events at the site.

3.4.2. Meteorological Data

Meteorological data will be collected throughout the trial period at an on-site meteorological station. 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). 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 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.

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 (particle size distribution, specific gravity, slake-durability, saturated hydraulic conductivity, and SWCC, as applicable) for the underlying PAG material, GCL or LLDPE liner underlayer and overlayer, Non-PAG rind, and Non-PAG erosion protection layer. Samples for analysis 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

Where possible, the monitoring data will be collected at one-minute time steps; however, this will depend on the storage and transmission capacity of the dataloggers, cables, and the DAS. 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, an automated DAS will be installed at each cover trial location. This will allow for monitoring of events and the cover performance as storms are happening, as well as after the precipitation event ceases. 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, while being sufficiently spaced to provide enough data storage capacity to store the data between data downloading/collection activities.

The manual measurement of VWC using the neutron scattering method will be completed weekly. During the wet season manual VWC measurements will also be collected, when possible, immediately prior to and following precipitation events.

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. 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 identify if instrumentation issues are occurring which 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 area data collection 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, non-PAG rind, non-PAG 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. REFERENCES

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

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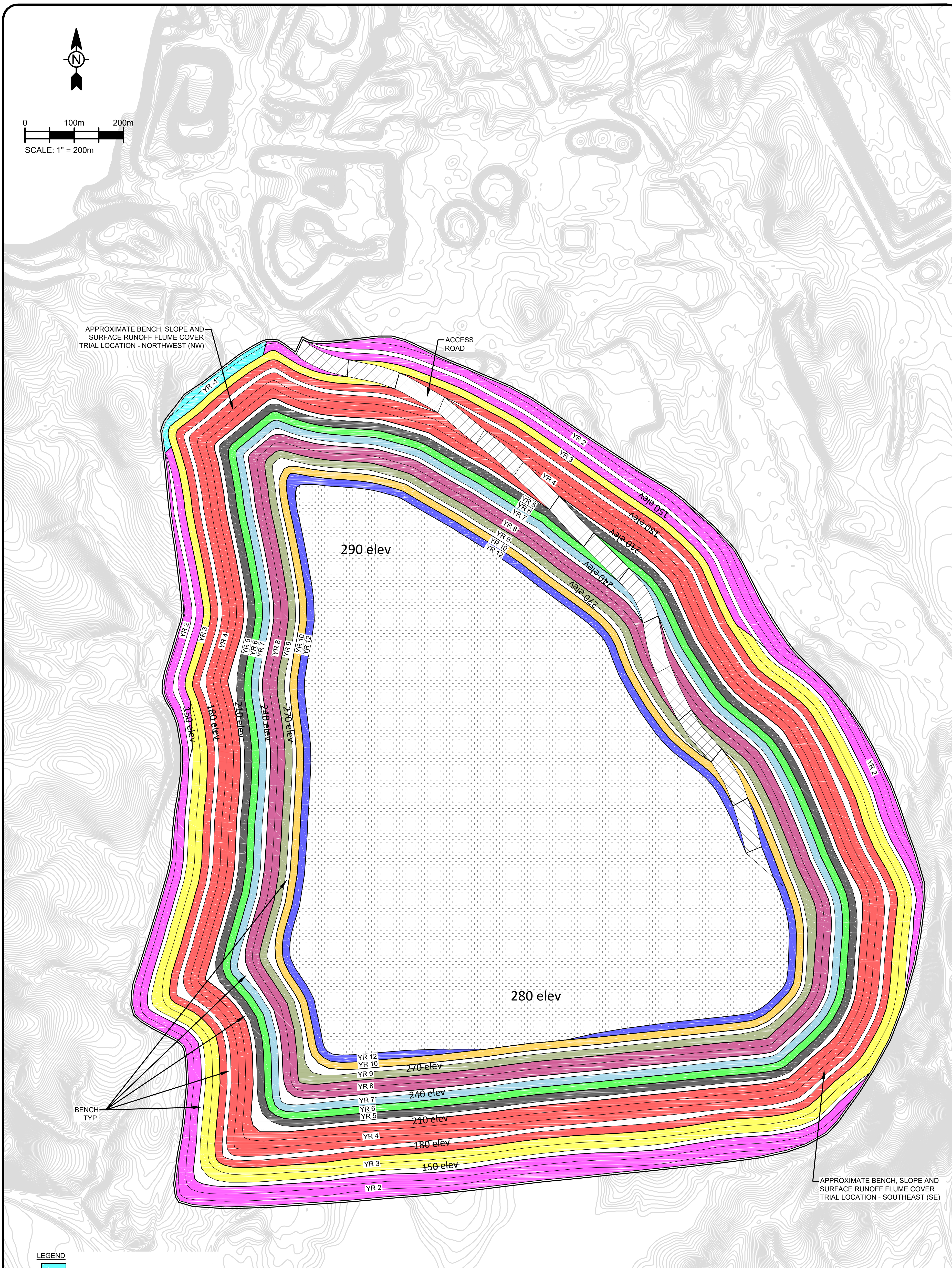
FIGURES



LEGEND

- 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 12 INTER-BENCH
- WRD BENCH
- WRD TOP
- WRD ACCESS ROAD

NOTES

1. ANNUAL FINAL SLOPE COMPLETION AREAS BASED ON ANNUAL WRD BUILD-OUT DRAWINGS PROVIDED BY MINE DEVELOPMENT ASSOCIATES (MDA) FOR THE 50K TPD MINE PLAN, CURRENT AS OF MAY 15, 2020.

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VISTA GOLD - MT TODD GOLD PROJECT

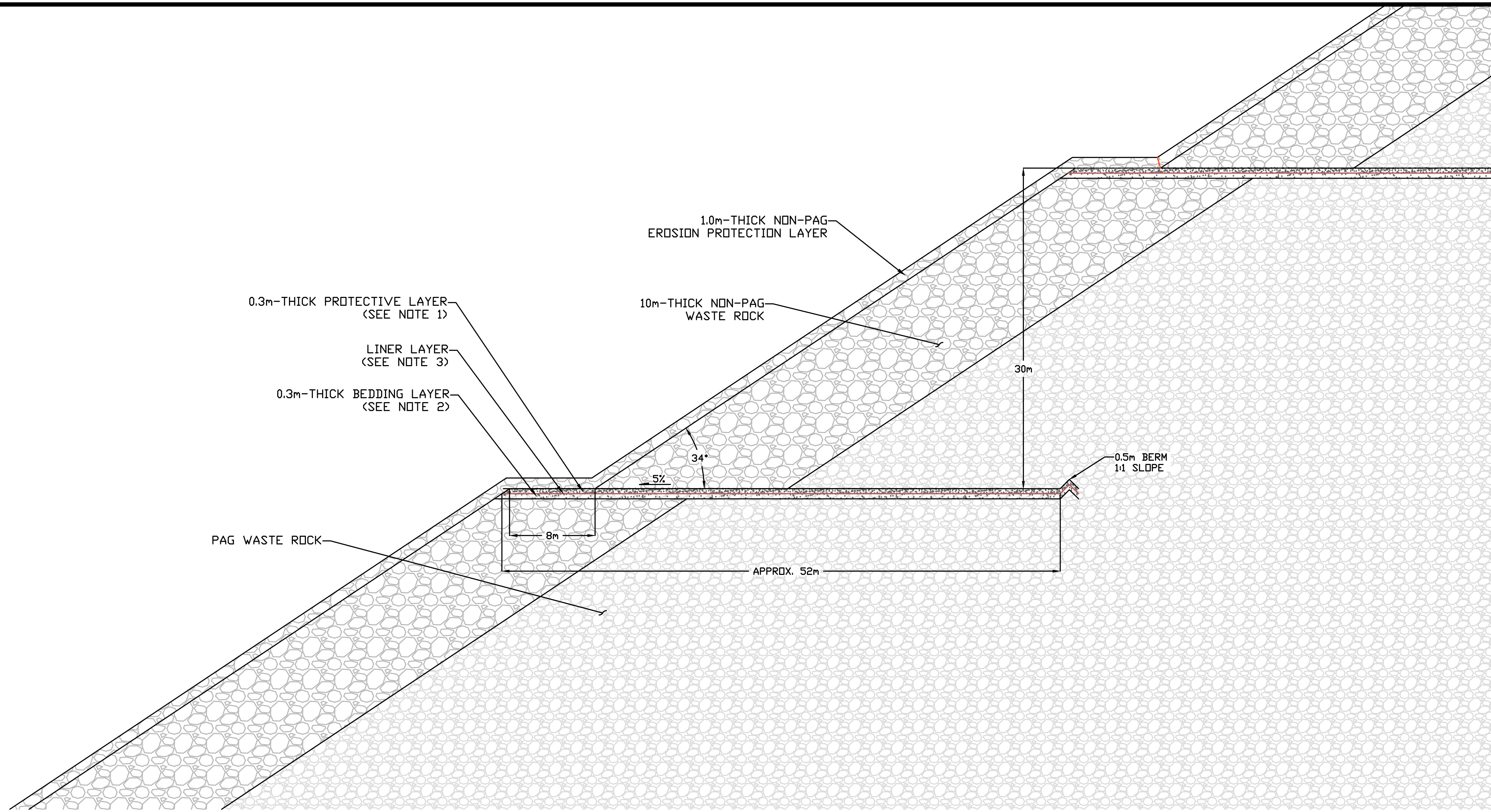
NORTHERN TERRITORY, AUSTRALIA

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

Project No.:	117-8348001
Date:	5/15/2020
Designed By:	AH/HH
FIGURE	01

Bar Measures 1 inch

5/15/2020 3:20 PM - C:\USERS\HARRISON.HOLLEY\DESKTOP\VISTA GOLD TEMP\117-8348001 - MT TODD PFS UPDATE 2019\07-CAD\SHEETFILES\FIGURES\FIG-01_UPDATED WRD ANNUAL BUILD-OUT.DWG



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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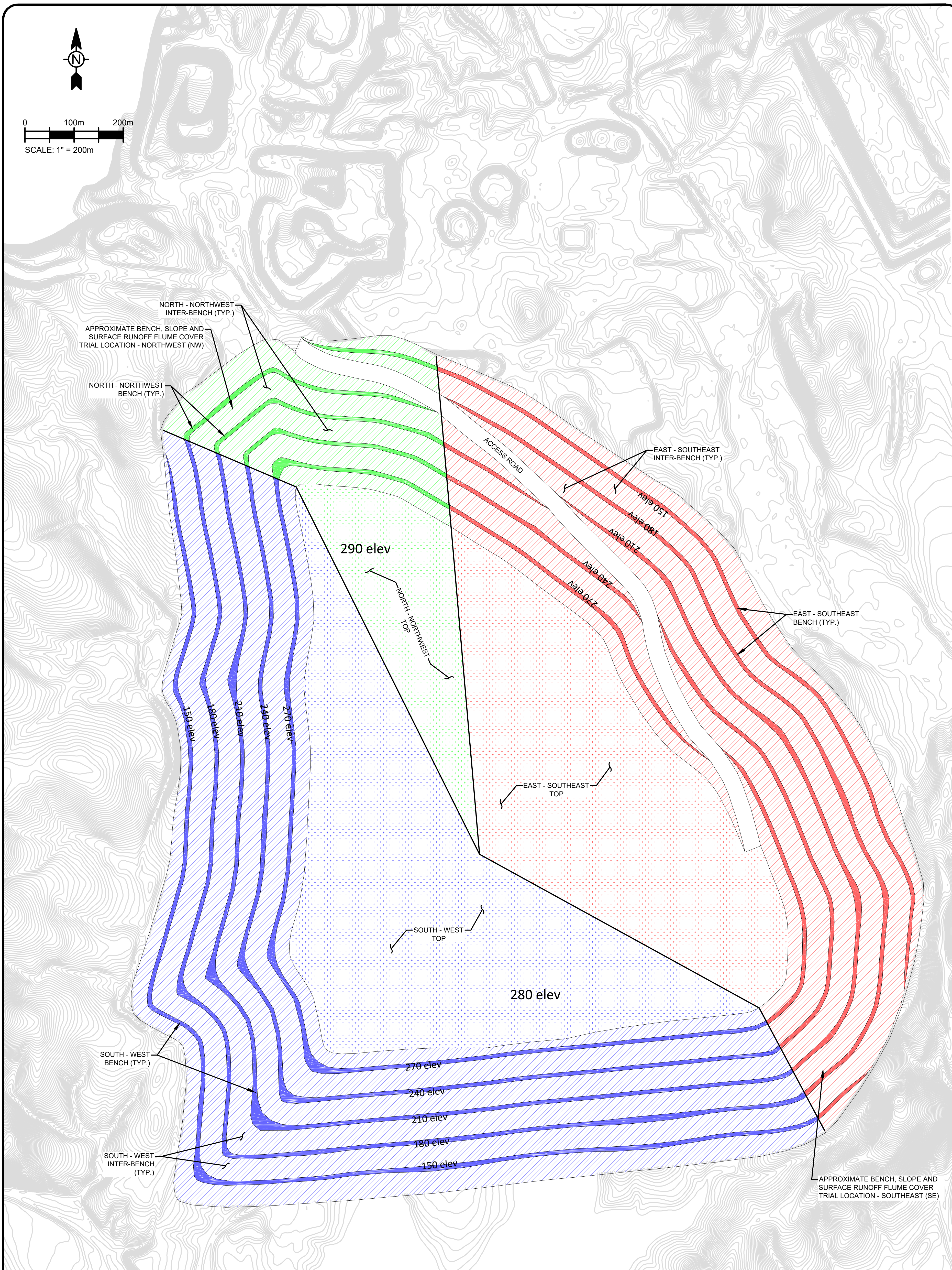
VISTA GOLD - MT TODD GOLD PROJECT

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	109,583	378,852	320,212
BENCH	18,659	109,686	66,171
INTER-BENCH	114,923	605,953	399,700
ACCESS-ROAD	10,680	0	38,208

*CALCULATED AREAS ARE 2-DIMENSIONAL

NOTES

1. WRD BUILD-OUT DRAWINGS PROVIDED BY MINE DEVELOPMENT ASSOCIATES (MDA) FOR THE 50K TPD MINE PLAN, CURRENT AS OF MAY 15, 2020.

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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.:	117-8348001
Date:	5/15/2020
Designed By:	AH/HH
FIGURE	03

Bar Measures 1 inch

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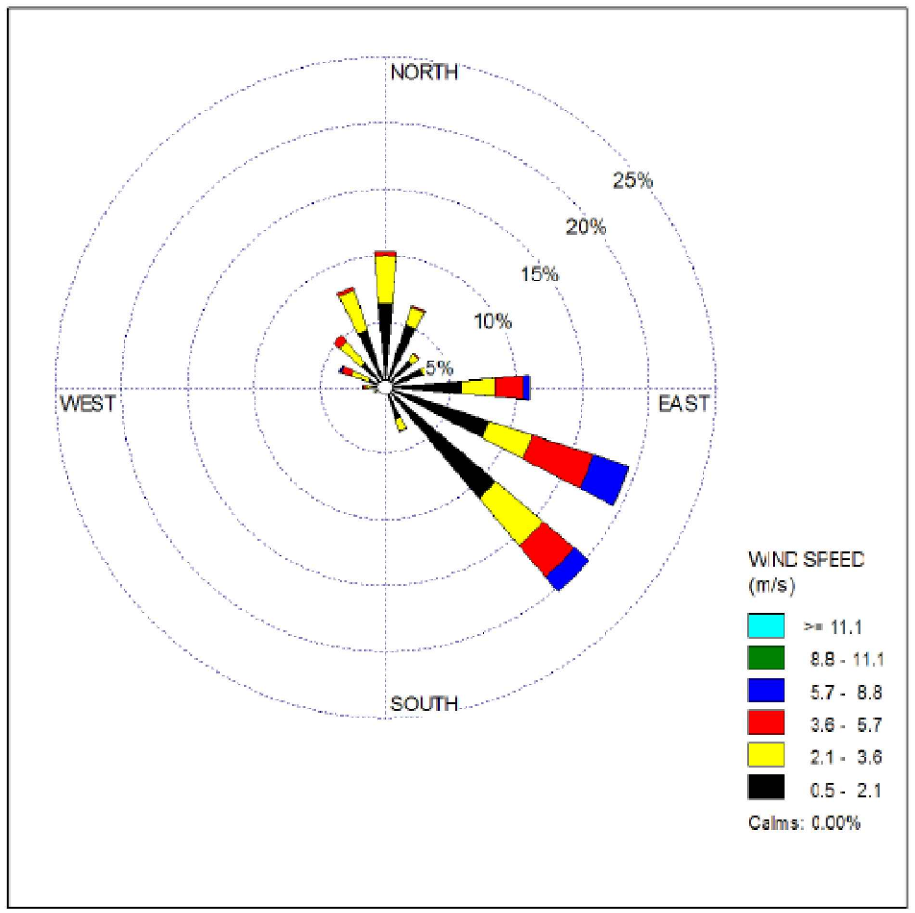
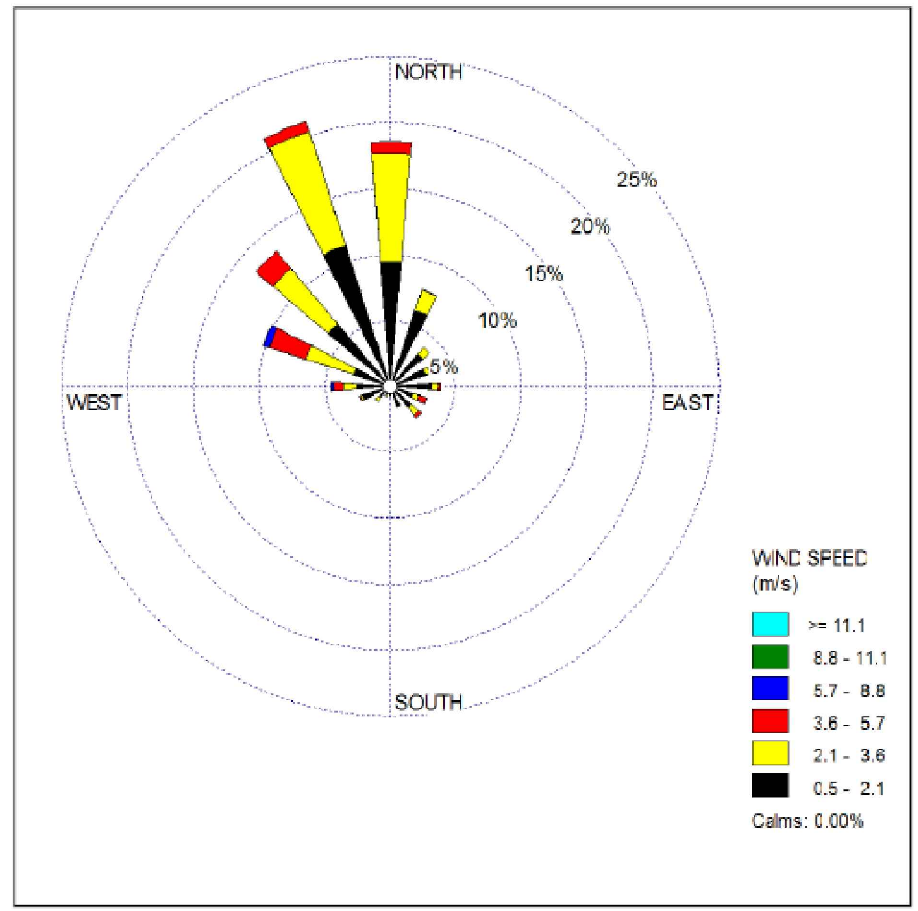
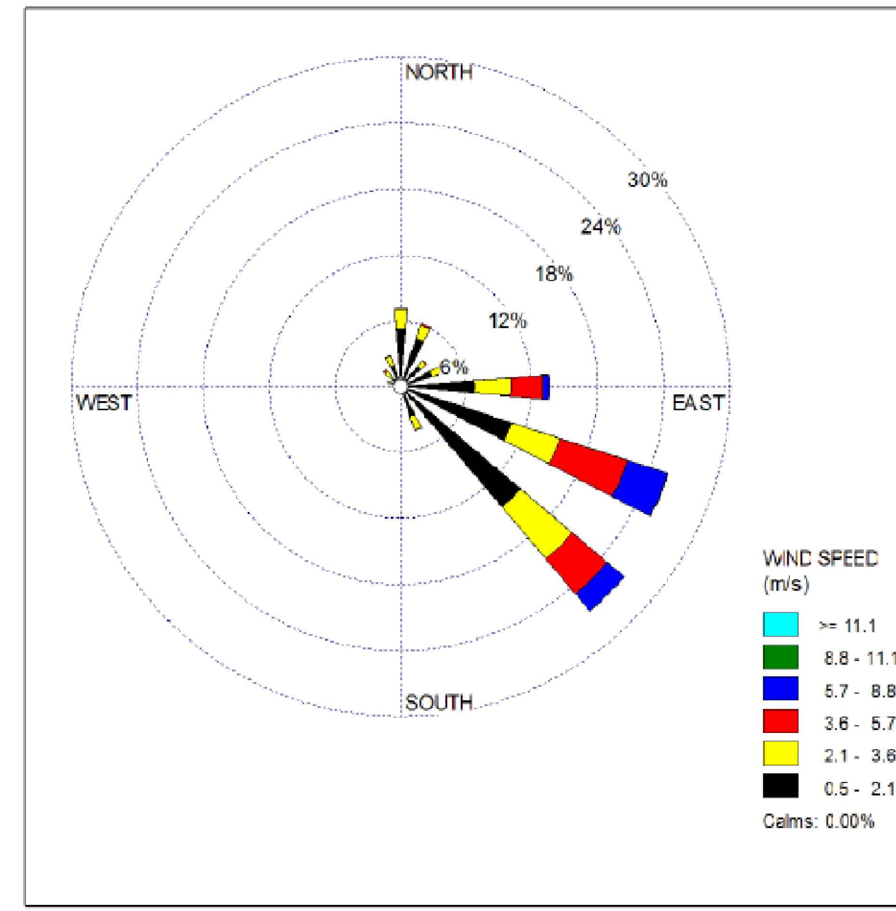
Annual



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
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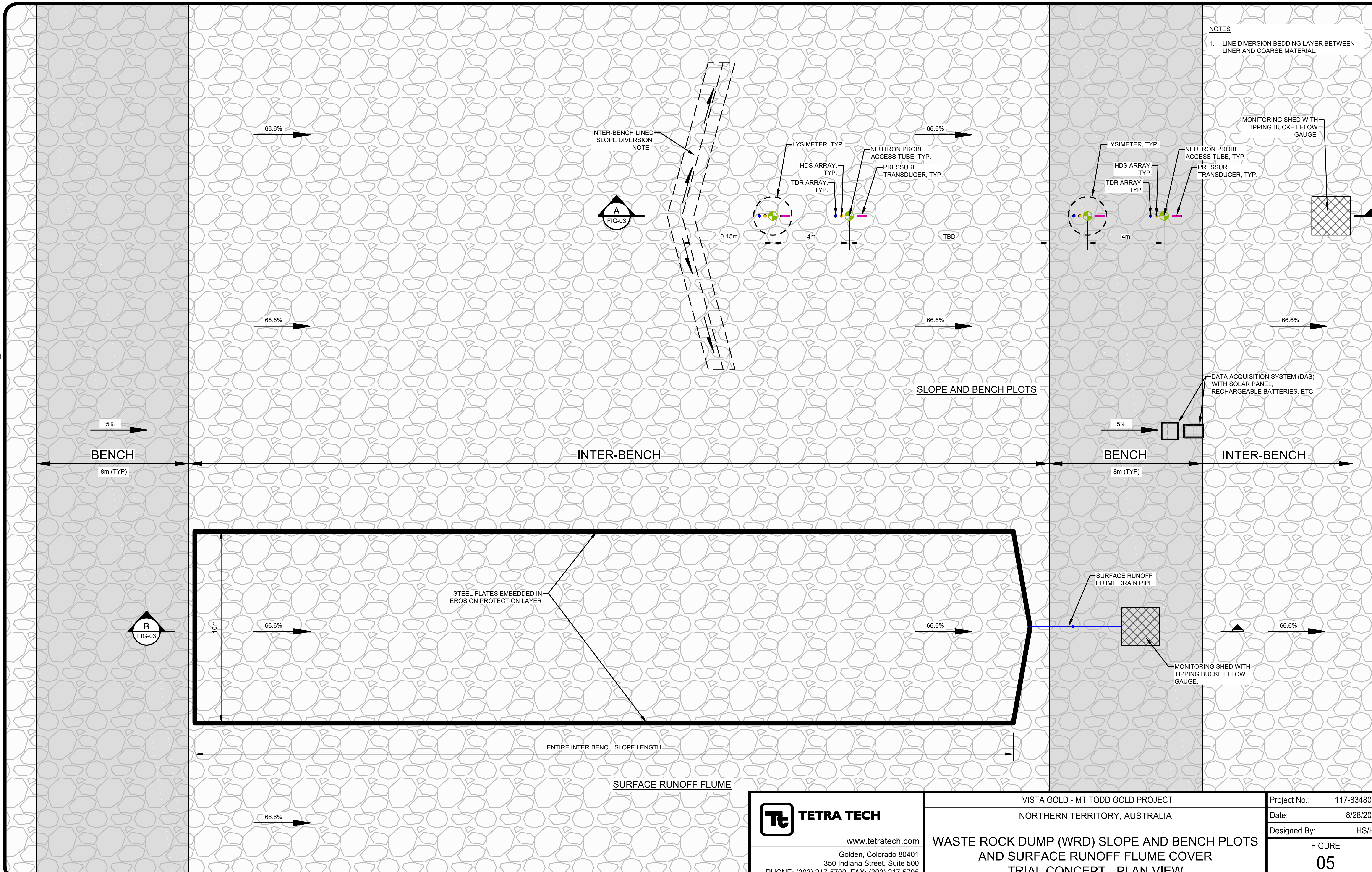
VISTA GOLD - MT TODD GOLD PROJECT
NORTHERN TERRITORY, AUSTRALIA

MT TODD MINE - SITE WIND ROSE

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



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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.:	117-8348001
Date:	8/28/2019
Designed By:	HS/HH
FIGURE	05

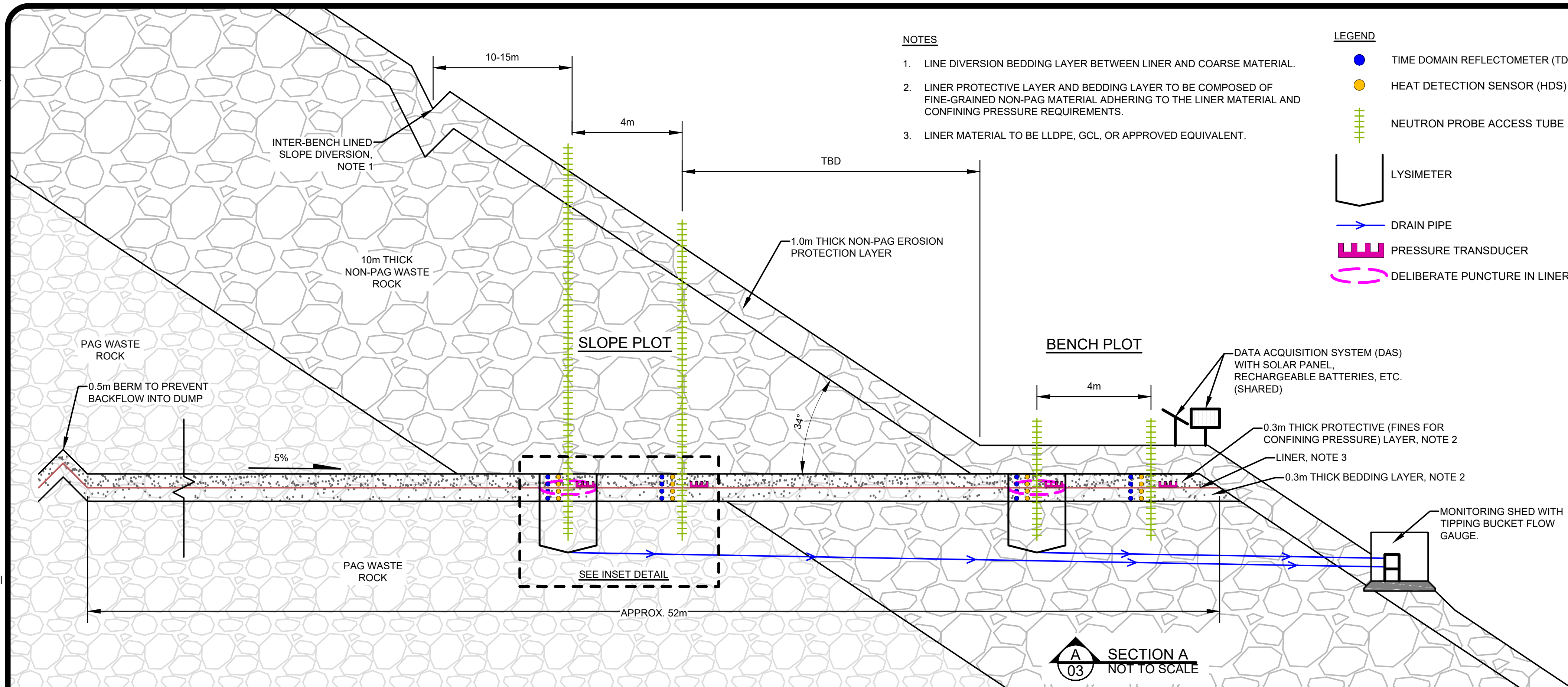
NOTES

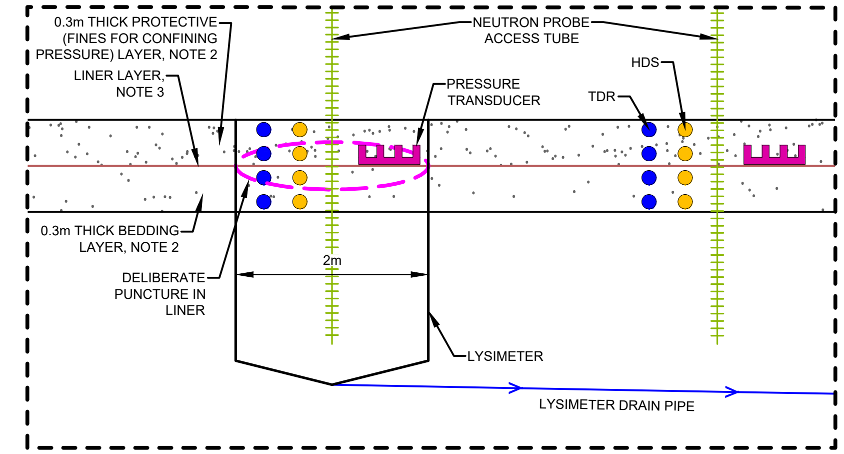
1. LINER DIVERSION BEDDING LAYER BETWEEN LINER AND COARSE MATERIAL.
2. LINER PROTECTIVE LAYER AND BEDDING LAYER TO BE COMPOSED OF FINE-GRAINED NON-PAG MATERIAL ADHERING TO THE LINER MATERIAL AND CONFINING PRESSURE REQUIREMENTS.
3. LINER MATERIAL TO BE LLDPE, GCL, OR APPROVED EQUIVALENT.

LEGEND

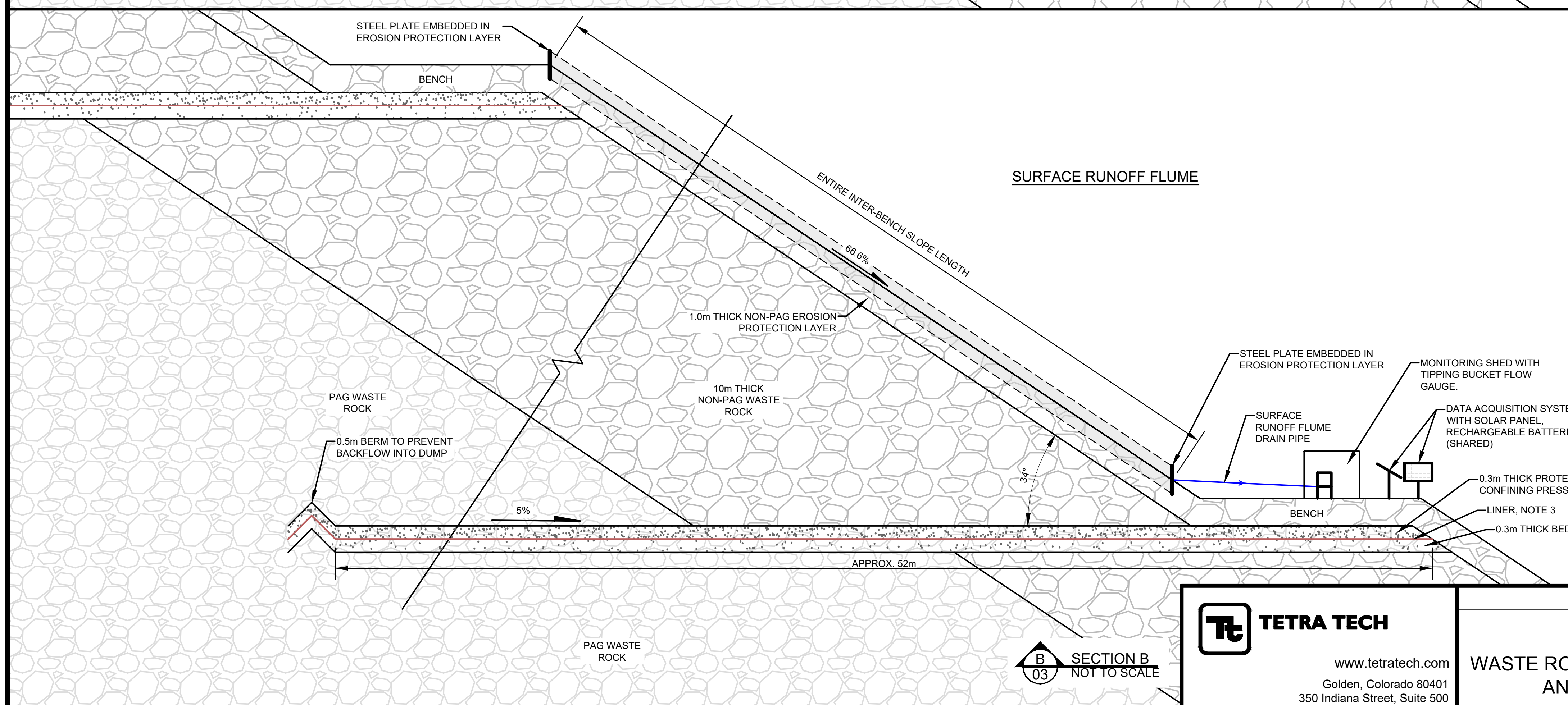
- TIME DOMAIN REFLECTOMETER (TDR) [Θ_W]
- HEAT DETECTION SENSOR (HDS) [Ψ]
- NEUTRON PROBE ACCESS TUBE
- LYSIMETER
- DRAIN PIPE
- PRESSURE TRANSDUCER
- DELIBERATE PUNCTURE IN LINER

DESCRIPTION	QUANTITY
TDR	16
HDS	16
NEUTRON PROBE ACCESS TUBE	4
LYSIMETER	2
LYSIMETER DRAIN PIPE	2
PRESSURE TRANSDUCER	4
DELIBERATE PUNCTURE IN LINER	2





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.:	117-8348001
Date:	8/28/2019
Designed By:	HS/HH
FIGURE	06