Workers' Safety and Compensation Board
Yukon

An Investigation into the causes of the Heap Leach Failure at Victoria Gold's Eagle Mine, Yukon

December 2024

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STATEMENT ON POTENTIAL CONFLICT OF INTEREST

In preparing this report the authors do not perceive that there exists any actual, potential or perceived conflict of interest. With respect to this statement and to provide full disclosure, the following is noted.

Mr. Charles Hunt P.Eng., was employed by Tetra Tech between 2006 and 2019. On the basis that Tetra Tech had a significant involvement with the project during development and latterly with respect to construction quality assurance services, the following statement is made. Mr. Hunt was not involved with the Victoria Gold project whilst employed by Tetra Tech.

Mr. Ricky Collins C.Eng., is employed by SLR Consulting Limited. It is noted that BGC assessed the use of Coletanche Bituminous Liner in the Heap Leach Facility Spillway. BGC presented several items from manufacturer of the Bituminous Liner, one of the items was a letter completed by SLR Consulting. The letter was prepared by Mr. Hadj-Hamou who is based in SLR's Irvine California office, and dated December 2018. On the basis that the product was rejected by BGC and not used, and furthermore that SLR Consulting were not engaged by Stratagold / Victoria Gold or BGC and had no further involvement with the project, it is not believed a conflict of interest exists. As a note Mr. Ricky Collins is employed by SLR Consulting, but based in the United Kingdom and has had no involvement with the project.

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Executive Summary

At around 5:40 am on the 24th of June 2024 a substantial slope failure occurred at the Eagle Gold Mine heap leach facility (HLF) that involved the mass movement of an estimated 3.5 million cubic metres of ore. The failure did not lead to any loss of life but did cause ore to be transported several hundred metres down the Dublin Gulch Valley and led to the mine ceasing operational production. Delve Underground were retained by Yukon Workers' Safety and Compensation Board (YWSCB) to carry out a detailed study of the failure and to comment on the possible underlying causes. This report summarizes the findings of the study.

Following a review of the development of the heap leach design and construction, the report highlights a number of changes that were made during operational practices. The report reviews these changes, and a number of other potential factors that might have influenced the conditions that contributed to the failure. The report describes observations made during a site visit in early August 2024 by representatives from Delve Underground and an account by a witness to the event as it occurred.

This report has systematically assessed both typical failure mechanisms that might occur in heap leach facilities as well as unique failure mechanisms given the cold climate and design / construction practices. From the results of these analyses the report has identified both minor and major contributory factors, as well as identifying factors that are not considered to play a role in the failure. The authors contend that the initiating mechanism of the failure was the lining system constructed on a steep slope forming the north-west part of the HLF. Three main issues have been highlighted as contributory factors to the failure; i) damage during construction leading to a post peak shear strength between the GCL and the LLDPE textured geomembrane, ii) a hydrated GCL with a reduced internal shear strength, and, iii) placement of frozen ore which in combination with other minor contributory factors led to a potentially and partially frozen lining system and constituent interfaces.

A fourth contributory factor (that has also been identified as a potential stand-alone mechanism) is that the widespread placement of frozen ore and operation of the HLF throughout the winter led to a number of unique conditions that were not anticipated by the designers or operators. As ore was placed in freezing conditions we believe that expansion of pore fluid within the near surface layers occurred as the fluid froze. Without enough overburden pressure to control swelling due to freezing, the void ratio of the ore is increased. The increase in void ratio could have resulted in the ore being in a contractive state once the frozen fluid thawed out. An undrained response of such thawed-out soils could lead to liquefaction-type behaviour, either induced by changes in effective stresses (static liquefaction) or large strains (e.g. as might result from movement down a weak side slope geosynthetic interface). The report notes that this was a very rapid failure, which does suggest a brittle response of the ore that would indicate at least some degree of undrained contractive behaviour. Further, a large release of fluid/leachate was noted during the immediate failure.

While we believe that the side slope lining system was the initiating mechanism there remains the possibility it could have been the thawing of more apparently extensive frozen layers that could have led to sufficient changes in effective stress that resulted in static liquefaction. However, to robustly demonstrate that this could be equally important as the lining system hypothesis much more detailed testing and advanced analysis would need to be undertaken.

In carrying out this review and at the request of Yukon Workers Safety and Compensation Board, the report has identified a number of potential deficiencies in terms of the construction specifications and operation of the HLF. An assessment of the key factors leading to the failure with examination of the responsibility of the designers and operator in terms of compliance and causation has been undertaken in the report. This shows a shared responsibility for the failure between the designer and the operator, but with slightly more onus on the operator.

The report makes a number of recommendations in terms of outstanding issues, additional analysis and the investigation of the HLF which includes installation of in-situ monitoring devices to help detect further mass movement. A ten staged plan of remediation and repair is outlined within the report and recommendations made in terms of the assumed current shear strength of the lining system which should govern any repair design.

In carrying out this work, Delve Underground have engaged SLR Consulting as a subconsultant to provide an external review of Delve Underground's work throughout the analytical and reporting process.

List of Abbreviations

AASHTO	American Association of State Highway and Transportation Officials
ADR plant	Processing plant
ADS	Advanced Drainage Systems
ASTM	American Society for Testing and Materials
BGC	BGC Engineering
CQA	Construction Quality Assurance
CSA	Canadian Standards Association
Forte	Forte Dynamics Inc.
FoS	Factor of safety
GCL	Geosynthetic clay liner
HDPE	High Density Polyethylene
HLF	Heap Leach Facility
InSAR	Interferometric Synthetic-Aperture Radar
KCA	Kappes, Cassiday & Associates
LDRS	Leakage detection recovery system
LiDAR	Light Detection and Ranging
LLDPE	Linear low-density polyethylene
LDPE	Low-density polyethylene
NRCAN	Natural Resources Canada
ODF	Over-liner Drainage Fill
PLS	Pregnant Leach Solution
QA/QC	Quality Assurance / Quality Check
RT	Rough texture
SDR	Standard dimension ratio
SWE	Snow water equivalent
UCS	Uniaxial compressive strength
UMV	Underdrain monitoring vault
VGC	Victoria Gold Corp.
VWP	Vibrating Wire Piezometer
XRT	Extra rough texture
YWSCB	Yukon Workers Safety and Compensation Board

1.0 Introduction

A slope failure occurred at the Heap Leach Facility (HLF) of the Eagle Gold Mine in Yukon, Canada on 24th June 2024 between 5:40 and 5:50am. Delve Underground was retained by Yukon Workers' Safety and Compensation Board (YWSCB) to carry out a detailed study of the failure and to comment on the underlying causes. Delve Underground engaged SLR Consulting as a subconsultant to provide an external technical review of Delve Underground's work throughout the analytical and reporting process.

This report summarizes key findings of the study and is outlined as follows. Section 1.0 provides background information on the mine and the failure and discusses the scope of this study. Section 2.0 summarizes information reviewed related to the failure in a chronological order, and then assesses the data reviewed, highlighting pertinent issues and unknowns. Section 3.0 sets out observations of the HLF pre and post failure some of which were noted on site by the authors.

Section 4.0 sets out a number of potential failure mechanisms, some of which were screened out and not analysed further. Those which were analysed are discussed further in Section 5.0 in terms of model set up, and Section 6.0 which presents results.

Section 7.0 of the report discusses the implications of the analytical results and sets out the main factors which are thought to have contributed to the failure. Section 8.0 then presents what the authors contend is the most probable causation.

Delve Underground were asked specifically to set out if there were any design or operational practices that might have contributed to the failure or could have been improved upon, and this is set out in Section 9.0. In Section 12.0 a number of recommendations to assess and monitor the future stability are made and in Section 11.0 conclusions are provided, summarizing the work.

1.1 Project Background

The Eagle Gold Mine, owned by Victoria Gold Corp. (VGC) and located about 85 km north-northeast (NNE) of Mayo, Yukon, extracts gold with heap leaching. This is a process where crushed ore (referred to as heap), transported from the crusher, is stacked onto the heap leach pad (i.e., the HLF), where a diluted cyanide solution is passed through from the top, drained by gravity and flows over a lined surface to an internal pond (in-heap pond). From the in-heap pond the pregnant solution is pumped to a processing plant (ADR plant) to extract gold. A layout plan of location of the HLF is shown on Figure 1.

Construction of the HLF began in 2017 and ore stacking was ongoing to the point of the failure on June 24, 2024.

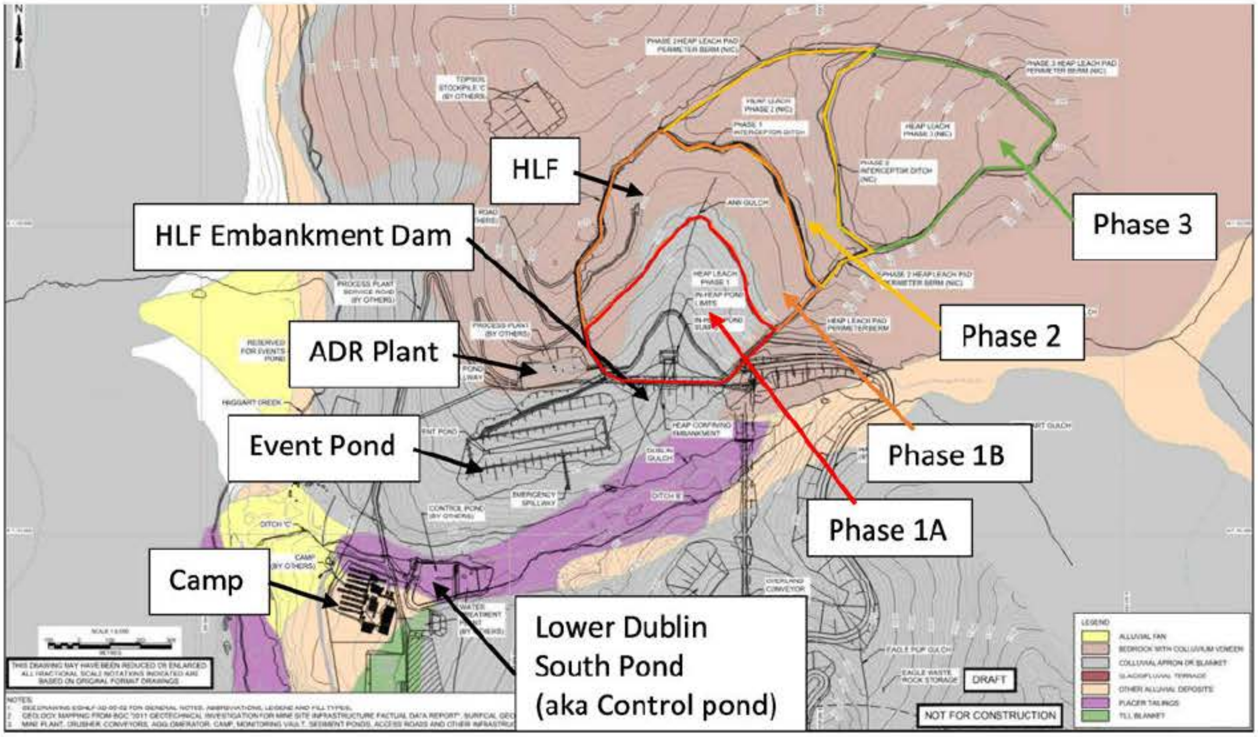


Figure 1: Layout plan of mine facilities near the HLF (extracted from drawing EGHLF-XD-01-03 in 2017 design report for HLF Phase 1A by BGC Engineering Inc. (BGC) (BGC, 2018))

1.2 Overview Development of the Heap Leach Facility

The HLF was designed in phase 1A, 1B, 2, 3. Phase 1A was designed by BGC, while phases from 1B onwards were designed by Forte Dynamics, Inc. (Forte). Construction of Phase 1A, including the embankment dam at 940m elevation, started in 2017. As part of this construction a side slope liner was installed to contain the barren and pregnant solution. From the base upward the lining system was composed of; prepared sub-grade, a geosynthetic clay liner (GCL), a 2 mm thick low-density polyethylene (LLDPE) (textured on both sides), and a 0.6 m thick over-drainage fill (ODF) layer. On top of this lining system ore was placed. Figure 2 below shows the lining system.

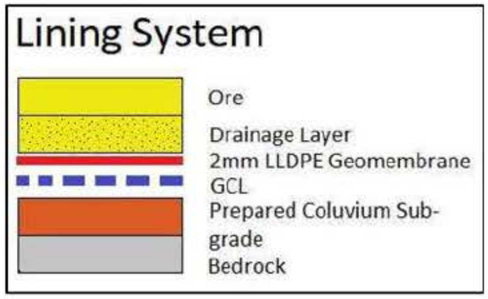


Figure 2: Graphical Representation of the lining system

By the end of 2023, the construction of liners at Phase 2 was completed. On 23rd June, 2024, ore was stacked up to approx. 1065m elevation. Figure 3 below shows the development of the facility. Aerial photos from 2019 to 2023 were taken from Physical Stability Assessment Report by Allnorth Consultants Limited (2023).

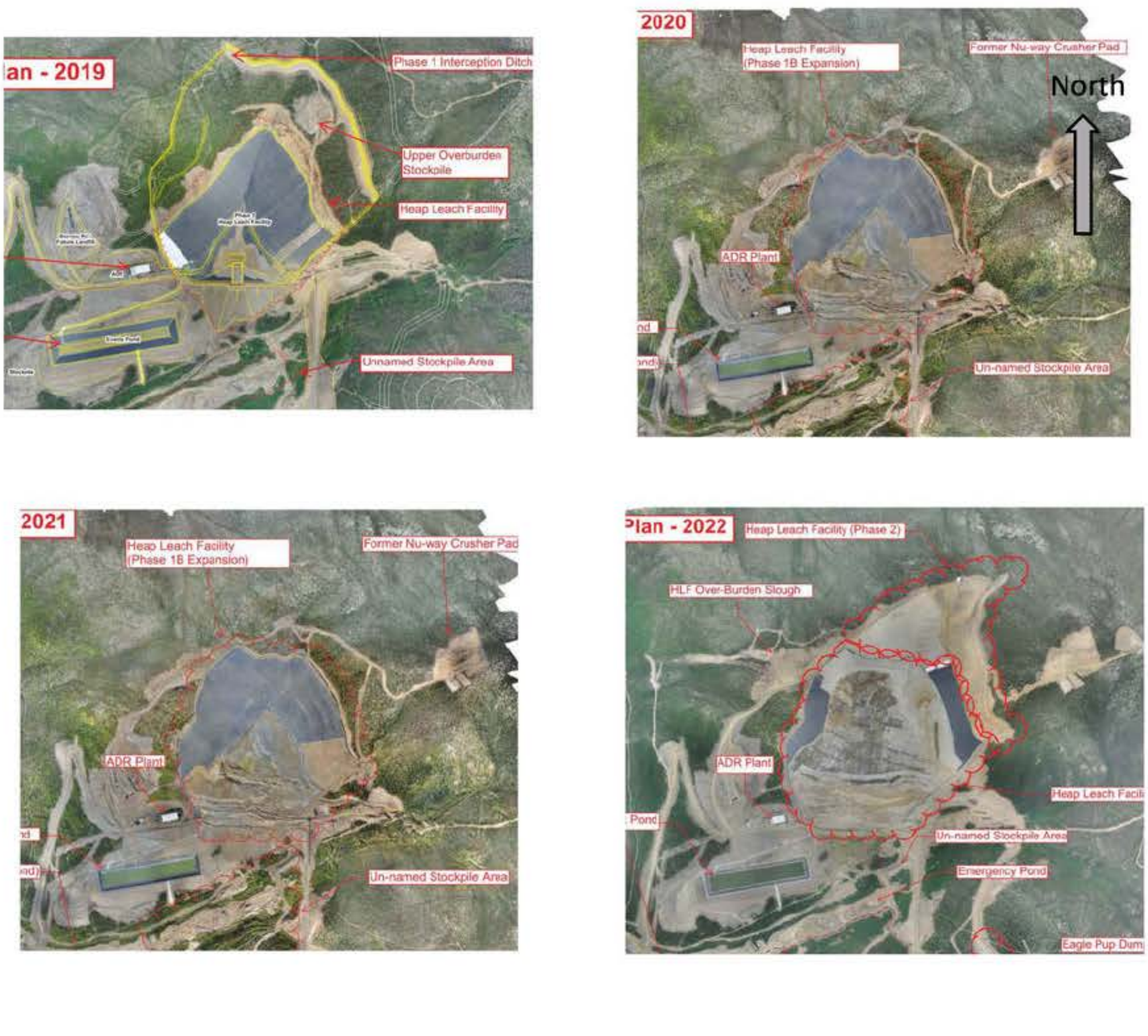


Figure 3: Development of the HLF between 2019 and 2024

1.3 Overview of Failure

Between 05:40 and 05:50 on 24th June, 2024 a failure of the heap leach occurred involving an estimated 4,000,000 cubic metres of ore. At the base of the slide, the material partially fluidized and flowed down the Dublin Gulch valley towards the control pond. At the top of the slide a backscarp was formed that was over 50 m high. The slide moved towards the south-south-east direction and is a deep-seated failure. The failure occurred at shift change, although a dozer operator was carried in his vehicle tens of metres, no injuries were reported. Photograph 1 and 2 were taken shortly after the failure.

Photograph 1: Overview of the slide failure shortly after the event, taken from the south looking north (photo provided by YWSCB).

Photograph 2: Overview of the slide failure shortly after the event, taken from the east looking west (photo provided by YWSCB).

1.4 Scope of Work

YWSCB retained Delve Underground to carry out an investigation into the most probable causes of the failure. YWSCB requested that any poor practices, negligence, omissions or errors be highlighted in the Delve Underground review and assessment of the slide. Delve Underground have therefore conducted a systematic review of the information made available to assess any potential poor practices in design or operation, and carried out analyses to determine the most probable cause of failure. This report presents the findings of these assessments.

Within this report the term ‘leachate’ has been used as a common term for barren solution distributed onto the HLF pad and pregnant solution pumped from the in-heap pond.

2.0 Background Review and Historical Development of the Heap Leach Facility

This section of the report presents a background review and describes the development of the Heap Leach Facility (HLF) in terms of design, construction and operational performance. Appendix A presents a table of the some fifty key reports reviewed to describe this historical development (amounting to over 20,000 pages of information). It was noted during the review that occasionally several versions of the same document exist, as a consequence the number of pdf pages has been added to the table presented in Appendix A ostensibly for document and file identification purposes.

Within the review of the historical development and construction, aspects that are considered pertinent to the stability of the HLF, or which are referenced and discussed within later sections of this report are highlighted. Where appropriate to provide direct quotations from a reviewed report, parenthesis have been added.

2.1 Chronological Background Review

Prior to 2009 StrataGold were developing and investigating the Dublin Gulch area and what was to become the Eagle Gold Project. In early 2009 StrataGold merged with Victoria Gold (on friendly terms; Northern Miner, 2009) and essentially co-owned the project from that time. The majority of the reports prior to 2020 are addressed to or prepared for / by StrataGold. After 2020 the reports are mostly prepared for, or by Victoria Gold Corp.

The initial studies on Victoria Gold Corp Eagle Gold project in the Yukon Territory were carried out to a pre-feasibility level in April of 2010 (Scott Wilson et al., 2010). The pre-feasibility study was prepared by Scott Wilson Roscoe Postle Associates Inc. in association with Kappes, Cassidy & Associates and BGC Engineering Inc. This report examined six potential heap leach pad sites, and identified the Ann Gulch pad as the best (based on factors such as geotechnical conditions, favorable geometry for pad engineering, haulage distance from the pit, and environmental considerations). Ore stacking operations on the HLF were scheduled within the report for 250 days per year, with a switch to winter stockpiling from early November to end of February when no ore was planned to be stacked on the HLF. The rationale was as stated in the report; "*… avoid creation of permanent ice lenses within the heap...*".

The pre-feasibility report noted that preliminary agglomeration tests indicated that a minor amount of cement may be required in the lower lifts of the multi-lift heap leach operation (it was estimated that up to 2 kg/t of cement might be required during the first few years of operation). It is considered that the purpose of the cement agglomeration was to ensure better hydraulic conductivity of the ore placed on the heap leach.

In February of 2012 Tetra Tech prepared a report titled Heap Leach Facility Feasibility Design (Tetra Tech 2012). This report was issued just prior to the full feasibility level report for the entire mine. The report sets out the initial stability analysis on the HLF. The parameters used are outlined in Section 5.3 of this report.

In 2012 a feasibility study was prepared for the Eagle Gold project by Wardrop (Wardrop, 2012). This report presents details about the heap leach such as; agglomeration being required (using cement and lime), stacking would be within a 250 day window with 10 m lifts. To insulate the drip emitter system the leach lines were intended to be ripped into the ore to a depth of 3 m. The report notes that a total of 21,644 oz of gold is delayed in recovery to the rinsing stage (following heap leaching). Section 17.4.5 of the feasibility study report details cold weather considerations, such as;

- Selected an in-valley heap configuration to create a heat sink.
- Selected a south facing valley.
- Use of an in-heap solution pond for PLS storage.
- Sizing of the fine ore crushing operation to allow increased production rate during warm months.
- Incorporation of 100-day ore storage pad.
- Provision for a D9 track dozer equipped with a ripper assembly to rip frozen ore prior to resuming leaching in the spring.
- Heating of barren solution.
- In-heap temperature monitoring.
- Burying drip emitter lines with 3 m of ore.
- Heat-tracing and insulating the barren tank.

In April 2014 Tetra Tech prepared the detailed design of the HLF (Tetra Tech, 2014). This report sets out the design criteria such as: ore gradation P_{80} is 6.5 mm; 10 m lifts for a 250-day stacking schedule; overall outer stacked ore slope of 1V:2.5H, 365-day leach schedule with buried emitters for cold weather. This report designed the containment dam in the base of Dublin Gulch (not on the valley side, just to the south of where it was eventually constructed) with the Dubin Gulch creek diverted round the base of the prosed heap leach to the south. Appendix J of this report presents the stability analyses, but it should be noted that this is for a differing configuration, for the reasons noted above, than was actually constructed some 4 years later.

One of the aspects that was set out in the Tetra Tech detailed design report and remained unchanged through to construction was the analysis of the above liner collection system. Tetra Tech used an approach developed by Burns & Richards (1964) to assess the 400-, 250- and 100-mm diameter pipes used in the collection system. A number of other consultants, most recently Forte Dynamics Inc. repeated the use of this approach during the staged design and development of the HLF.

In 2016 the heap leach was designed to a feasibility level by Dowl (Dowl, 2016). It is believed that moving the containment dam to the northern side of the Dublin Gulch (vs within it as per Tetra Tech detailed design report), was the basis for a feasibility reassessment. The report presents details in terms of the ore processing and placement on the HLF, in particular; i) a 275-

day stacking season, ii) final ore crushing gradation was based on a P_{80} of 6.5mm, iii) 10 m lifts with an overall slope angle of 22 degrees (1V:2.5H), and, iv) solution application rate of 10 litres per hour per m^2. This report also noted that the liner drainage design details would be drain pipes consisting of 100-mm, 250-mm and 450-mm diameter corrugated dual-wall, perforated ADS N-12 pipes (similar to those originally designed by Tetra Tech). The moisture content of the ore was set out to be 5.84%, with a specific retention of 8.6% by weight, and an active leachate moisture content of 13.3% by weight. The report makes recommendations with respect to geotechnical instrumentation in particular the use of vibrating wire piezometers at strategic locations (within the foundation materials, foundation drains, embankment fill materials, over-liner, and at critical locations within the collection piping and sumps). The report makes a number of provisions for seasonal stacking as a result of: "*…Frozen ore on a heap leach pad is generally detrimental to the operation due to the loss of percolation resulting in reduced recovery and possible heap instability from lateral solution flows to the heap slopes…*". The report (Dowl, 2016) also contains the first formal slope stability analysis undertaken on the HLF (as it was eventually constructed) and describes the parameters adopted (these are reviewed in this report under Section 5.3).

In June of 2017 StrataGold prepared the document Heap Leach Facility Foundation Improvement Plan (StrataGold 2017). This plan sets out that where permafrost occurs, it will be identified, removed and replaced with a suitable compacted fill. The foundation of the Heap Leach was further assessed in October of 2017 by StrataGold (StrataGold, 2017), and an underdrainage system was set out in some initial design drawings.

Prior to finalization of the HLF lining system, a review was undertaken by AB Engineering Inc. (AB, 2017) in a memorandum dated 9th November, 2017. The review was tasked with assessing the viability of using a geosynthetic clay liner (GCL) for the HLF in a cold climate. The memorandum sets out some of the practical risks and mitigations to be considered in using a GCL where sub-zero temperatures are prevalent.

The December 2017 report by StrataGold titled: Heap Leach Process Facilities Plan (StrataGold, 2017) summarized both the HLF construction aspects as well as the processing and operational facilities. The report sets out concordance with the stipulations as outlined by the April 2013 Yukon Government Decision regulatory terms and conditions. The design criteria for the ore and placement of the ore are the same as Dowl (Dowl, 2016) with one difference that the barren solution application rate was reduced to 7 L/hr/m^2 from 10 L/hr/m^2. A section within this report on cold weather considerations and mitigation states the heating of barren solution will occur, with in-heap temperature monitoring. A number of the other cold weather considerations originally outlined in the feasibility report (Wardrop, 2012) are essentially repeated.

In October of 2017 BGC (BGC, 2017) prepared the Technical Specifications for the Heap Leach facility. These specifications set out the clearing and grubbing of the sub-grade, removal of ice rich soils, installation of the lining systems and pipework (both of underdrainage and liner drainage). Section 4.1.7.2 of this specification states that seaming (plastic welding to connect linear low-density polyethylene (LLDPE) lining elements) will not be conducted if the temperature is lower than 5°C (without written acceptance of the engineer, and using pre-heating of the welded zone). The procedure and placement of ore on top of the liner is not covered by these specifications.

In June 2017, BGC reported on a geotechnical investigation of the HLF (BGC, 2017). This report presented the results of 23 test pits and six HTW-sized cored boreholes (HTW core size is 81.5 mm in diameter). The report described that the site consists of overburden (organic veneers and colluvium), underlain by a moderately weathered to fresh bedrock that is metasedimentary in composition. Frozen ground was encountered in six test pits and one borehole (the deepest depth of frozen ground being 6.7 m in borehole BH-BGC16-088).

In January of 2018, BGC finalized the HLF design and prepared a report detailing the Heap Leach Facility detailed design (BGC, 2018; a report first issued in November of 2017). This report updated the stability analysis of the HLF (Dowl, 2016) and used slightly differing parameters in the geotechnical analysis (as described in Section 5.0 of this report). The detailed design report by BGC recommends the use of two vibrating wire piezometers (VWP's) in the in-heap pond and three VWP's located in the Phase 1 leach pad over liner layer (also known as over-liner drainage fill – ODF), up-gradient of the in-heap pond. The design report does not mention thermistor instrumentation.

BGC further updated the stability analysis of the Heap Leach in April of 2018 (BGC, 2018) to incorporate results from recent laboratory strength tests on the crushed ore and the liner system. The results of the analysis were similar to those presented and appended to HLF detailed design report.

Within the Heap Leach Facility detailed design report (BGC, 2018) a pipe deflection analysis was undertaken by BGC (BGC, 2017). This memorandum states that; "*…solid wall HDPE* (High Density Polyethylene) *pipe is specified for the PLS (sic. Pregnant Leach Solution) collector and header pipes and the underdrain system header pipes…"*. It should be noted that solid wall pipe was not used during the construction but replaced with perforated collection pipes. The memorandum continues:

"…Generally, yielding and/or buckling of a polyethylene pipe will take place between 20 and 30 percent deflection, yet the pipe will still function for its intended purpose of providing reliable drainage to the heap leach facility (Smith et al, 2005). A deflection limitation of 15 percent is considered reasonable and conservative for this type of application (Lupo, 2005). A minimum safety factor of at least 2 against buckling is also recommended (AWWA, 2006). The effects of the heap on the PLS and underdrain pipe deformation were analyzed using the Culvert Analysis and Design (CANDE) finite element software which requires the user to input pipe, soil, and load properties….". This report has commented upon the above liner PLS drainage in Section 2.12 of this report.

In January 2018 the water balance between the containment pond, event pond and dynamic storage was modelled through the life of the HLF (The Mines Group, 2018). This report was further updated on October 24th, 2018, to include a weekly basis for the water balance (Mines Group, 2018). The key parameters in terms of moisture content of the ore were unchanged from that noted above in Dowl, 2016.

In an undated report (thought to have been prepared around the Q3/Q4 of 2018, StrataGold) non agglomeration testing was summarized. The report concludes that an ore hydraulic conductivity of 0.038 cm/s reduced by a factor of 50 for infield performance, is well beyond the required conductivity to support the target application rate of 7 L/hr/m^2. The report also states that reducing the target application rate from 10 L/hr/m^2 to 7 L/hr/m^2 will reduce the potential for mobilization of fines. In summary, adding cement to agglomerate particles and therefore derive a coarser gradation (increasing hydraulic conductivity) was not required, as the crushed rock was sufficiently coarse with little clay or silt fraction.

The hydraulic conductivity of the ore was tested in a memorandum prepared by Forte Dynamics (Forte, 2018). The memorandum sets out hydraulic conductivity at different ore heights with the following results for 70 m loading; P_{80} 6.5 mm = 0.022 to 0.58 cm/s; P_{80} 12 mm = 0.13 to 0.17 cm/s; and, P_{80} 16 mm = 0.13 to 0.17 cm/s. In order to achieve a 55 to 65% saturation of the ore, application of barren solution is estimated in the range of 6 to 8 L/hr/m^2. The memorandum also concludes that agglomeration (by adding cement) is not required.
A second undated report by Stratagold (considered to be sometime in 2018) titled ore stability test plan - investigation and recommendations, makes a key conclusion with respect to the mobilization of fines within the ore; "*…Based on the low percentage of fines (less than 10% passing #200 sieve) and the very low flux rate, migration of fines potential will be extremely low and thus the stability of the Eagle Zone crushed ore is expected to be stable under the compressive loads and wetted conditions within the heap leach facility…*".

In January of 2019 StrataGold Corp. prepared a design report for the waste rock storage areas (StrataGold, 2019). Appendix 1 of this report presents a very detailed map of the permafrost distribution within the Dublin Gulch Area (Tetra Tech, 2017) located to the south of the HLF area. Although this is a generally north facing slope, we question if such detailed permafrost mapping was undertaken on the slopes forming the HLF.

The Phase 1A heap leach facility pad (confinement embankment, in-heap pond, HLF under-drainage & monitoring vault) were constructed between September 2017 and July 2019. A six-thousand-page report setting out the construction was prepared by BGC (BGC, 2019). The underdrainage system was constructed as a series of four 150 mm dia. SDR 11 HDPE pipes. The overall drain installation and connection with lateral drains and an artesian well is presented on Drw. No. 184110-010 (signed by Daniel Granda of BGC). In constructing the Event Pond, ice-rich permafrost was encountered. However, BGC instructed JDS (BGC-RFI-018) that only where excess ice is present (and thaw unstable >15% ice content) was it required to be removed. In the sub-grade of the HLF, frozen ground (soil) was removed back to frozen bedrock, but only if when thawed, it exhibited instability (exampled by BGC Inspection No. FND11, May 8th, 2018).

One of the very few plans showing the location of frozen ground encountered is on the day shift report from 14th August, 2018 and depicts frozen ground to the north-west above the in-heap pond.

Photograph 3 below was taken from 7th September, 2018 Dayshift report and shows the location of frozen ground (annotations are from the original daily report).

Photograph 3: Depiction of frozen ground from 7th September, 2018 dayshift report.

Following test pit construction as reported in the daily site report from 23rd October, 2018 the plan presented in Figure 4, sets out where frozen ground had been found (annotations are from the original).

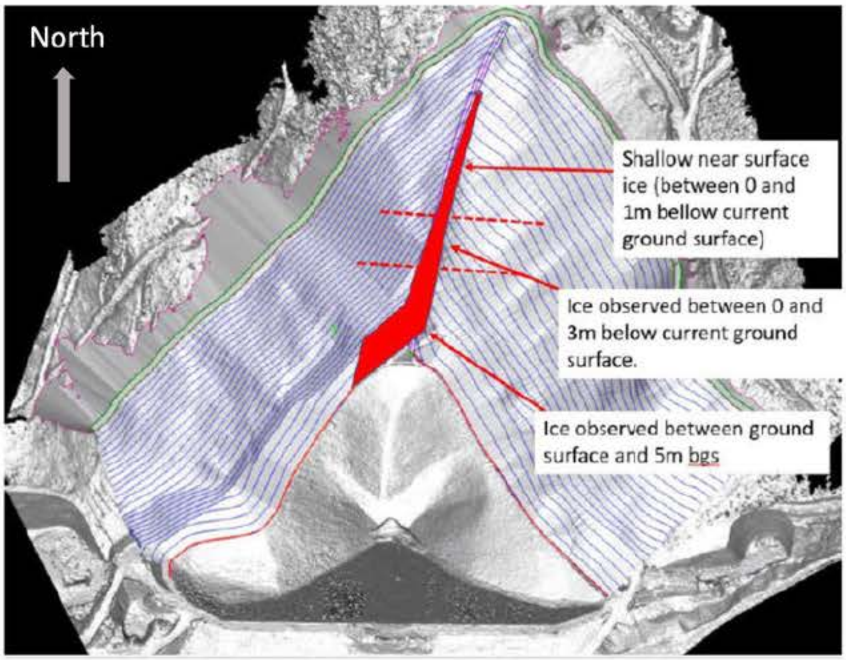


Figure 4: Plan of frozen ground from 23rd October dayshift report.

It should be noted that the location of the frozen ground is also where the under-drainage pipes were located and constructed. From the daily report of 3rd November, 2018, it was noted that over-liner drain fill (ODF) was frozen in some locations following placement on top of the liner. The temperatures on this day were -15°C to -23°C, yet the geomembrane LDPE liner was being placed. Based on a review of the membrane welding (seaming) records from Layfield, welding of the membrane in sub-zero temperatures was common practice and on one occasion 16 seam panels were welded in air temperatures of -25°C.

It should be noted that this is contrary to the construction specifications prepared by BGC. In BGC-RFI-014 included in the same construction completion report by BGC (2019), although BGC had given permission to JDS to perform placement of the ODF and seaming of geomembrane in subzero temperatures down to a minimum temperature of -10°C, this was on the basis that detailed work procedures at low temperatures were submitted to owner's representatives (Tetra Tech and BGC) for approval. In this regard we assume the Engineer of Record had given permission for welding to occur in temperatures less than +5°C as per the specification.

An overview of the liner construction undertaken in Phase 1B on the steep western slope is shown in Photograph 4 below, taken on 4th June, 2019.

Photograph 4: Liner installation on subgrade from 4th June, 2019 on western slope, Phase 1B.

On 4th December it was reported that the ODF required ripping prior to replacement with unfrozen ODF. It was also reported on this day by Pelly Construction that the Event Pond underdrainage system was frozen and not conveying water.

Within the construction report for the Phase 1A HLF (BGC, 2019), Appendix 7 contains Tetra Tech's Construction Quality Assurance (CQA) report on the geosynthetics installation (originally presented to JDS Energy and Mining in September 2019), this contains Figure 5 below which presents the as-built gradient of the lining system.

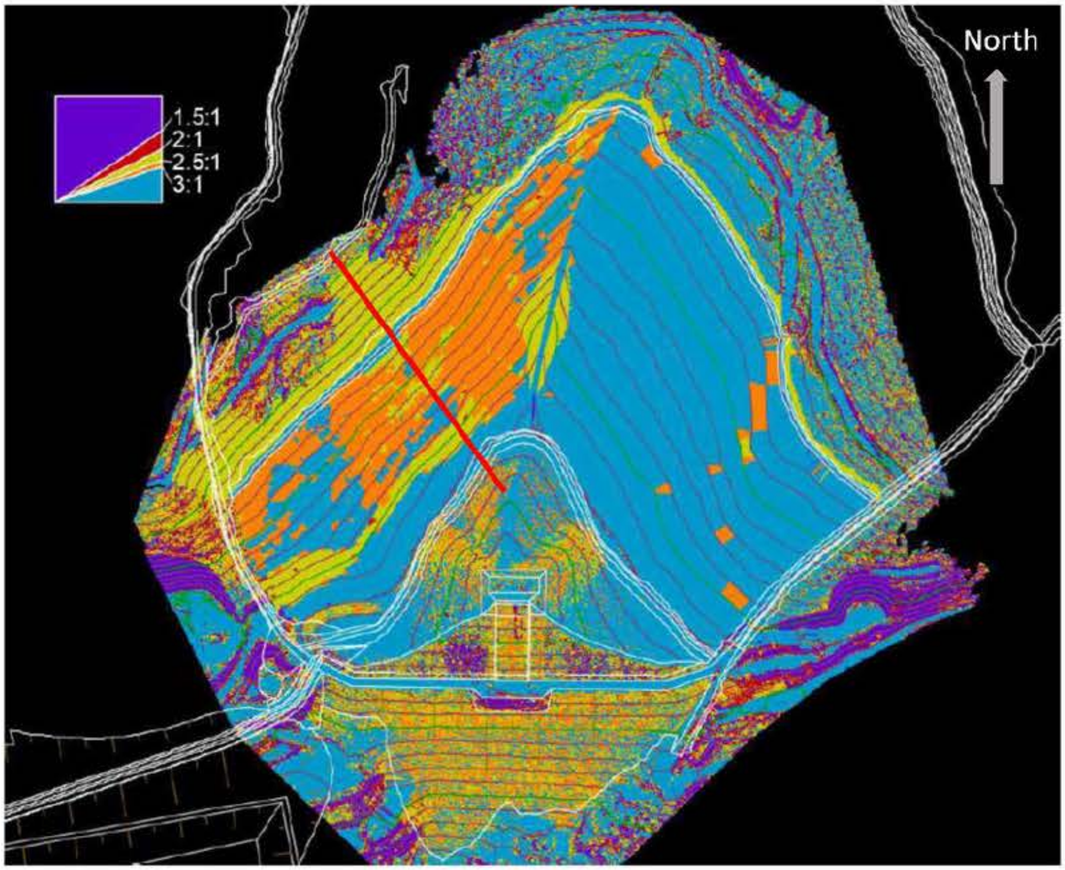


Figure 5: As built gradients of the lining system (taken from Figure 4 in Appendix 7 of (BGC, 2019)). Red line depicts steepest gradient.

The figure shows that the side slope and liner to the north-west above the in-heap containment pond was constructed at an angle of between 1V:2.5H (22.5°) to 1V:2H (26.5°). The red line on this figure depicts this steepest angle. Under Appendix B of the same report by Tetra Tech (2019), an email conversation between BGC and Tetra Tech showed the approval of liner installation on the aforementioned steep slopes.

Another email conversation between BGC, Layfield and JDS Mining on liner installation and testing was also attached under the same Appendix. It was understood from the conversation that JDS Mining was deciding between two manufacturers, Solmax or Layfield, for the LLDPE geomembrane given the tight construction schedule. Initial testing by BGC concluded that Solmax geomembrane did not meet the project requirements, which was set out by BGC. Yet, the procurement of this Solmax geomembrane continued. A Layfield geomembrane was used for the Event Pond and the In-Heap Pond after clarification by BGC that such requirements were only applicable to Heap Leach Pads (i.e., the area above the In-Heap Pond).

BGC then expressed that the testing data from the Layfield geomembrane could be used as the minimum project requirements for the Heap Leach Pad. It was then found out that the Layfield sample tested was a non-stock, high asperity sample that Layfield had no confidence in manufacturing in a large-quantity order given the short timeframe. It was then decided that the following products from Solmax were tested: RT (rough texture) 40mil LLDPE and XRT (extra rough texture) 80mil HDPE.

The difference in thickness (40mil vs 80mil) and the difference between HDPE and LLDPE were regarded by Solmax as irrelevant and had minimal impact on the testing results. This option was then approved by BGC for testing. The testing results were then reviewed, accepted by BGC as meeting the design criteria, and used by BGC in their stability analyses. Solmax LLDPE geomembrane was then used for the construction of Phase 1A of the HLF.

In terms of assessing liner damage post-construction, BGC noted, in BGC-RFI-020, also attached under the same Appendix, to StrataGold and JDS mining that with the project schedule at that time, placement of over-liner drain fill (ODF) was made the priority to cover and protect the liner from freezing temperatures in the winter. This subsequently restricted the area of liner available for VALID testing, a vacuum test to detect post-installation damage in the liner, as an alternative to the spark testing set out in the specifications approved by BGC in EPCM-RFI-022. In Section 3.10.5 of Tetra Tech's Heap Leach Facility Geosynthetics Installation CQA Report (Tetra Tech, 2019), it was noted that no VALID testing was performed as of August 2019. It was unclear to the authors of this report whether the integrity of the liner was compromised during construction.

Table 10 within this report presents where Layfield and Solmax geosynthetics were used.

BGC undertook the HLF annual inspection in 2019 (BGC, 2019). This report makes a number of recommendations for instrumentation and monitoring of the HLF. Following construction of the Phase 1A HLF it is apparent that BGC were replaced on site and prepared a project handover document (BGC, 2019). BGC had identified a low factor of safety within the Phase 1A ore pile based on a 3-D stability assessment using updated shear strength test data (BGC, 2019), and had advised on mitigation measures to improve stability. BGC outline several mitigation measures in the handover report as follows: 1) revising the planned overall 2.5H:1V ore pile slope to 2.8H:1V (or flatter), and 2) revising the design setback between east perimeter berm and ore pile toe from 7.5m to 30m. The report also notes that a geomembrane sheet temperature of minus 10 °C is the lower limit that ODF should be placed on the geomembrane. Furthermore, the report continues that any liner left exposed over the winter should be thoroughly inspected by qualified personnel prior to covering with ODF. Based on a review of the construction records, ODC was placed on top of the geomembrane liner in temperatures less than -10 °C, at least in Phases 1A and 1B. From 2021 onwards placement of ODF in sub-zero temperatures was less common (as described in Section 2.4 of this report).

In January 2020 Victoria Gold Corp. prepared the Heap Leach Facility Operation, Maintenance and Surveillance Manual (Victoria Gold, 2020). This report sets out the proposed operation of the HLF including ore placement, solution circulation and maintenance. The design criteria are unchanged from previous reports in that 10 m lifts are noted with 1V:2.5H ore side slopes, 275-day ore placement and 7 L/hr/m^2 application rate. Provisions were noted for year-round operation including as required heating of the barren solution, burying emitters to a depth of 1 m and calculating the snow water equivalent (SWE) on the HLF on a monthly basis for water balance management. It was noted that three pairs of VWP's would be located within the Phase 1B leach pad and record pressure and temperature data. The report also notes that independent annual inspections should be carried out of the physical stability of the HLF.

Following on from the completion of Phase 1A, the detailed design of Phase 1B was completed by Forte Dynamics on the 1st June, 2020 (Forte, 2020). This report sets out the HLF design criteria (without change from that noted above; Victoria Gold, 2020) and sets out the technical specifications. The specifications re-iterate that only where visible ice occurs in the sub-grade (or volume is >10%) should the sub-grade be removed and replaced with compacted fill. It was noted that due to the heterogeneous nature of the subgrade investigation test pits on a 100m x 100m pattern would be completed. The specifications also notes that the ODF shall be placed in a single 0.6 m minimum lift thickness by suitable dozer, at temperatures greater than -10 °C. It is stated that haul truck speeds, braking and turning during drain cover fill placement should be strictly controlled by the Contractor to prevent damage to the underlying geomembrane and pipework. The specifications note that seaming (welding) of geomembrane should not occur when the temperature is below 0 °C, unless tests show that the project specifications can be met. No geomembrane sheets were allowed to be unrolled and set out in temperatures less than minus 10°C. The specifications set out the type and design criteria of the pipe work used for drainage on top of the liner in the ODF. Drawings are appended to the report that set out the location of the Phase 1B over-drains and sub-grade elevations / gradients.

In May 2021 Forte Dynamics prepared a memorandum outlining the performance of the Phase 1 HLF (Forte, 2021). Within this report the leakage detection recovery system (LDRS) is reviewed as are pumping records from the underdrain monitoring vault (UMV). This shows that following Phase 1 perhaps 500 m^3 of water per day is derived from seasonal rainfall and snow melt events, with a spring base flow of 100 m^3 per day. The drainage to the UMV is commented upon in Section 2.11 of this report

In August 2021 Forte Dynamics prepared a detailed design report for the Phase 2 Heap Leach (Forte, 2021). This document states that in the absence of published international standards for the design and construction of a HLF, Nevada State guidelines have been adopted as they provide minimum standards. This report does not change any of the design details from Phase 1 (similar lining system with underdrainage, over lining drains to be perforated ADS N-12 pipes, maximum ore slope gradient is 1V:2.5H etc.). In 2020 Forte completed additional direct shear test work on the ore material and updated the slope stability analysis (enclosed in the design report in Appendix E). The stability analysis used was based on 3-dimensional analysis, with minor changes to the ore shear strength and that adopted for the interface considered to be the weakest (GCL to LLDPE textured geomembrane). The 3-D analysis was compliant with the Nevada state guidelines on stability of heap leach pads (these guidelines have been enclosed within Appendix B of this report).

Within the design report (Forte, 2021) specifications for the construction of the Phase 2 HLF are presented. A cursory review did not note any changes in the specifications from that discussed above with respect to the detailed design of Phase 1B (Forte 2020).

A risk assessment was carried out on the HLF Phase 2 by Victoria Gold Corp. (Victoria Gold, 2021). A panel was formed from four employees of Forte Dynamics and Mr. Troy Meyer from Strata-Geo, the six other panel members were from Victoria Gold. The report describes the assessment of Risk Priority Numbers (RPN's) with the highest RPN's attributed to; i) Confining embankment failure (during a seismic event), ii) Confining embankment failure (due to over-topping), iii) HLF liner system damage during ore placement, and iv) ore heap failure due to elevated phreatic levels. The mitigation associated with the ore heap failure was noted to follow procedures in OMS manual including instrumentation monitoring.

In December of 2021 Allnorth Consultants undertook a visual physical stability assessment of the mine including the HLF (Allnorth, 2021). No major observations of the HLF were made, although the overburden slope to the north of the HLF had failed. A similar visual physical stability assessment report undertaken in 2023 reached a similar conclusion with respect to the HLF (Allnorth, 2023).

In March of 2022 Forte reported on the 2021 annual inspection of Eagle Gold HLF (Forte, 2022). This report reviews the HLF design criteria, instrumentation and levels within the in-heap containment pond. The daily pumped volumes from the UMV (underdrain monitoring vault) are set out, the data continues from April 2021 to October 2021 and appears to show an increase in the base flow (not from seasonal events) to be 180 m^3 per day. It is considered that this base flow is a result of Phase 1B completion and Phase 2 initiation.

In August of 2022 Forte Dynamics verified through pumping tests the storage capacity of the in-heap pond (Forte, 2022). In summary the as-built volume of the in-heap pond of 57,763 m^3 was proven to be consistent with what was observed during testing.

The Phase 2A expansion was constructed in 2022 between March and October, as reported by Forte (2023). Construction activities were completed under the supervision of JDS Energy and Mining. During the construction of Phase 2A there were no major changes from the design. The report does present detailed records of the sub-grade drainage and trenching, within which ice lenses were found. The installation and seam welding of the LLDPE was carried during the summer in temperatures above zero.

In March 2024 the annual report for 2023 was published by Victoria Gold (Victoria Gold, 2024). This report presents temperature data from two piezometers (P2 and P3) located above the heap leach in-pond containment. To October 2023 there was a general downward trend in the temperature of leachate to just below 4 °C. Data is presented from a thermistor within the ODF (Phase 1B Horizontal ODF Piezometer levels), this shows that between March and May 2023 the temperature was around 1 °C. Figure 6 is taken from the 2023 annual report that presents the thermistor data, arrows have been added for emphasis.

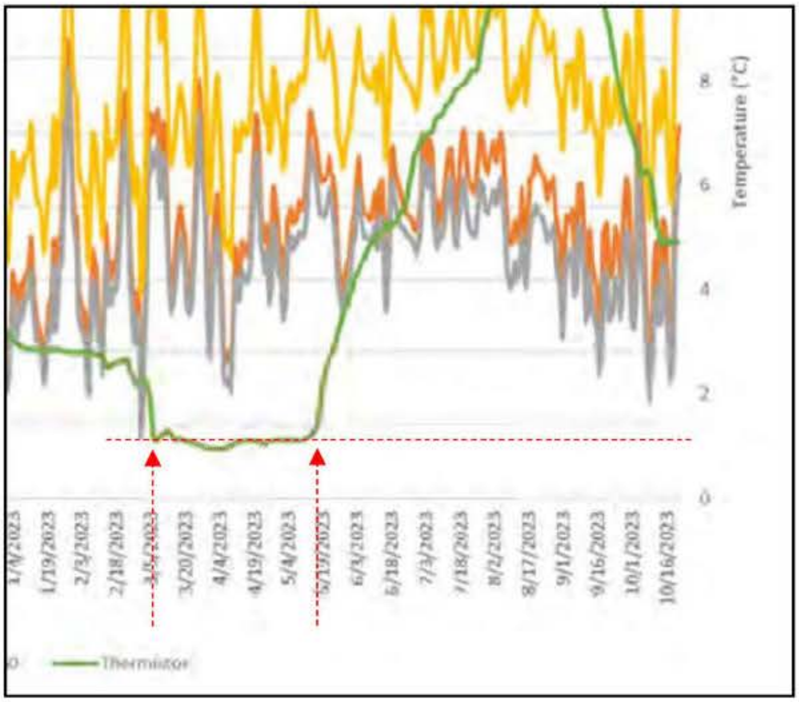


Figure 6: Thermistor Data from Phase 1B Horizontal ODF Piezometer levels

A layout plan of all monitoring instruments (inclinometers and piezometers) is shown on Figure 7. It is understood each piezometer was paired with a thermistor. It should be appreciated from Figure 7 that the vast majority of the heap leach was uninstrumented.

Figure 7: Location of Monitoring Instruments Installed

Regrettably in the ODF thermistor data we have been given, these results can not be repeated, in that the temperature data from the ODF thermistor is missing from 2022 onwards. It should be noted that these piezometers in the ODF did not show a high or elevated leachate surface, in fact the ODF piezometric level was generally less than 0.6 m from the installation point of the piezometers (considered to be on top of the liner). At the time of failure these ODF piezometers also did not show any elevated readings.

2.1.1 HLF Slope Failure – January 2024

On 6th January, 2024, a slope failure occurred on the heap leach pad where the crest was at lift 1065. On 22nd January in a response to Workers' Safety and Compensation Board order (Order Number 2 – IR No. 73-2024012-0587), Victoria Gold prepared a memo (Victoria Gold, 2024) describing the failure and appending a preliminary assessment of the failure by Forte. The technical memo prepared by Forte within Appendix C of (Victoria Gold, 2024) is titled: PHLF January 2024 Internal Ore Bench Slide Preliminary Assessment and Recommendations. This memo does not speculate or assess the causes of the failure, although it notes that a portion of the lift was up to 33 m in height. Rather, the memo provides recommendations to remediate the area and assess if damage to the liner has occurred.

The location of the failure was in the southeastern part of the HLF. A figure presented in an HLF-ADR meeting of 15th September, 2023, shows an over-high lift at the location of the failure some 3 months after this meeting. Figure 8 below shows this figure and the location of the failure, the dates shown are ore placement dates through the last quarter of 2023.

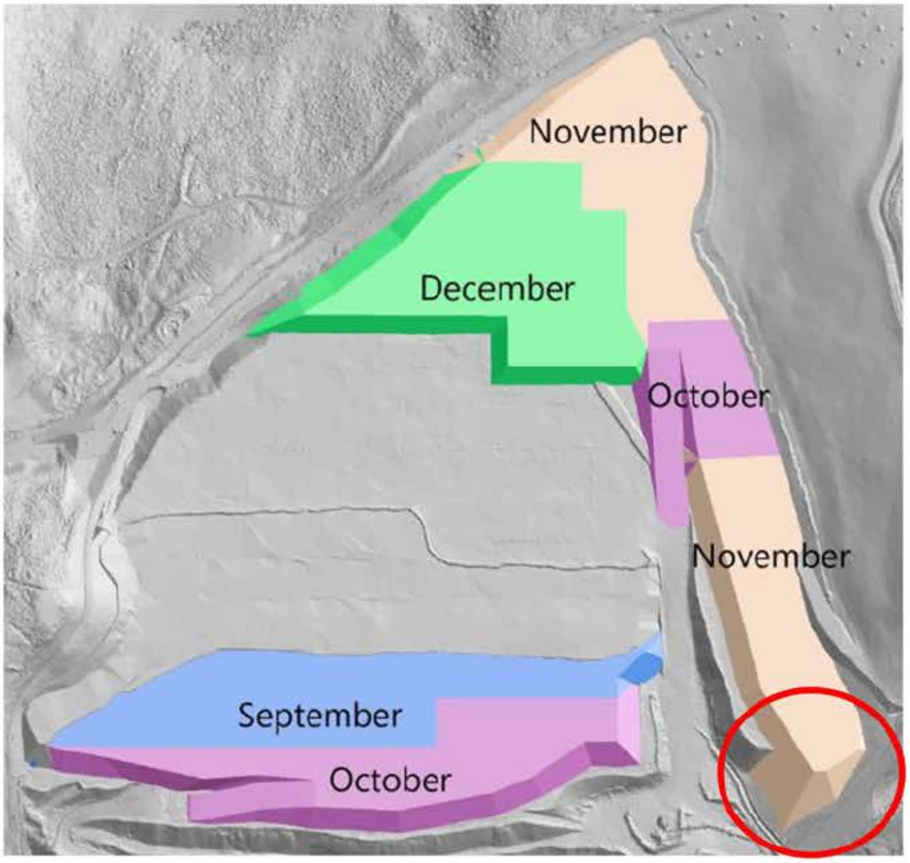


Figure 8: Planned ore stacking on the HLF (from 15th September, 2023 meeting). Location of failure highlighted.

Photograph 5 below shows the slide (note truck for scale on right side of photo).

Photograph 5: Failure of the heap leach ore on 6th January, 2024.

The heap leach slide area was repaired as reported by Forte (2024). During the repair several inter-panel tears were noted and repaired in the geomembrane, only one welded seam had torn. On the daily Forte's Observation Report from 14th March, 2024, photograph 4 (shown as Photograph 6 below) observes; *"...buried frost and ice within the ODF...".* Furthermore, excavation of the slide mass on the 15th March noted within Forte's daily Observation Report; *"...Lenses of solid ice have been found in the slide mass frozen to the top of the ODF (max thickness measures 5 cm) ...".*

The photograph below is from Forte's daily Observation Report on 15th March and was labelled as; *"...Buried snow and frost observed in the slide mass being excavated mostly found on top of frozen ODF...".*

Photograph 6: From Forte's Daily Observation Report on 15th March; frozen ODF and ice (spelling error per original document)

It was perhaps initially considered that this failure was due to an ore slope constructed higher than the design i.e. 33 m height, not a 10 or 12 m lift. However, the observations during remediation and repair show that this was a failure that involved the side slope lining and the ore. It is regrettable that investigation of the cause of the failure was not carried out. Notwithstanding this comment, the fact that an over high ore slope was constructed should have been recognized at least 3 months prior to the failure.

2.2 Discussion on the Background Information Reviewed

This section of the report discusses the background information reviewed, and other data provided (a complete list is set out in Appendix C), and also assess, analyses and interprets some of the data provided.

2.2.1 Overview of Changes from Design during Construction and Operation

There are some slight but noticeable differences in approach from the 2020 HLF OMS manual (Victoria Gold 2020), and the Heap Leach and Process Facilities Plan (StrataGold 2017a). In that the process facilities plan included a number of mitigation measures with respect to winter stacking. Firstly, there was a provision for a D9 track dozer equipped with a ripper assembly to rip frozen ore prior to resuming leaching in the spring. YWSCB who have interviewed the dozer operators have confirmed anecdotally that ripping of ore placed during the winter did not occur, and leaching did not 'resume in the spring' as it occurred throughout the winter. Secondly, a mitigation measure noted was to heat the barren solution, again this did not occur.

It should be noted that ore stacking on the heap leach pad occurred throughout the year. As a result, storage of ore during the winter season was not required.

The Heap Leach and Process Facilities Plan (StrataGold 2017a) also notes that crushing the ore to a P_{80} size of 6.5 mm will lead to (sic) optimal gold recovery. The design and actual ore crushing gradation is commented separately within this report (refer to Section 2.5).

Forte Dynamics in December 2017 made a number of heap leach facility operational changes (Forte Dynamics, 2017a).

- Due to final calculations regarding ore stability, the ultimate configuration of the pad was modified affecting the stacking and leaching plans. This change included a mid-slope bench on the pad. As a note it is considered that the access road up the HLF face formed this bench.
- Detailed analysis based on lab testing resulted in the application rate being reduced from 10 L/hr/m^2 to 7 L/hr/m^2. This was based on using an analytical unsaturated flow conditions (Brooks-Corey model) as reported in Forte Dynamics (2018). Based on a review of the records an application rate lower than 7 L/hr/m^2 was rarely if ever adhered to. In the 16 weeks before failure the average application rate was 8.4 L/hr/m^2.
- The report noted that for the 6.5 mm crush size (P_{80}) to be used for the majority of the ore in the pad, the bulk density from the testing was found to be 1.72 tonne/m^3.

With respect to heating the barren solution Sinha and Smith (2015) report a summary of the anticipated heap leaching procedures at Victoria Gold. This summary is repeated here as it potentially shows some form of disconnect between the early designers of the HLF and the latter operators.

- Crushed ore will be stacked on the leach pad in 10 m lifts for 250 days per year and leaching will continue year-round with a leach cycle averaging 150 days. Drip lines will be buried 3 m deep in the heap and barren solution will be heated in the winter "as required".

As a note the barren solution was never heated, 12 m lifts were constructed (not 10 m) 365 days of the year.

Frozen ground as discontinuous permafrost was encountered within the footprint of the HLF footprint in about 6 of 30 test pits in the Ann Gulch basin. When observed in a plan view, the test pits with frozen ground are scattered in the Phase 1 HLF pad area and in the area of the proposed Events Pond. During construction permafrost was encountered sporadically throughout the sub-grade of the Phase 1A and 1B. There is not a consistent record or map of where permafrost was found, but based on Figure 4 and

Photograph **3** its apparent that it was discontinuous across the original slopes forming the Ann Gulch valley.

Based on a review of site photographs it is apparent that the drip lines (referred to as orchard lines in some documents) were only buried by 300 to 500 mm on top of the ore. During winter these emitters were not buried to the originally envisaged depth of 3 m. Operators on the HLF described frequent cases where the drip lines would 'blow out' from the larger 2-inch emitter lines. The operators describe that ponding of the barren solution on top of the heap leach pad was a common occurrence and led to icing issues in the winter.

It was noted that layout of LLDPE geomembrane panels occurred during sub-zero temperatures and on occasion temperatures below -20 °C. This practice occurred during construction of Phase 1A and 1B of the HLF. We have not reviewed in detail the individual LLDPE geomembrane weld tests to establish the performance of welds undertaken at these temperatures in comparison to the specification. It was noted from BGC-RFI-016, included in the Phase 1A Construction Completion Report (BGC, 2019), that BGC relaxed the lower limit of temperature allowed for ODF and geomembrane placement. Though Layfield demonstrated, through email conversation (attached in the Construction Completion Report (BGC, 2019)) that installation and welding below 0 degrees would be possible if it was above the low temperature brittleness at -70 °C stated in American Society for Testing and Materials (ASTM) D746 and the practical handling temperature at -25 °C as limited by welding. The effect on the performance and stability of the liner is open to some conjecture but LLDPE in cold conditions is known to behave in a more brittle manner. It is considered that the LLDPE specified and welded at -20 °C would thermally expand following installation, but we are uncertain if this would cause a continuous structural failure of the weld. It is noted that Phase 2 geomembrane was welded in temperatures above zero.

The specification of the HLF defines the material requirement of the Overliner Drain Fill (ODF) as having a maximum of 5% passing the No. 200 ASTM sieve (0.075 mm) and operational permeability (considered to be hydraulic conductivity) of 2×10^{-4} m/s or higher (BGC, 2017). Within Phase 1A and 1B Record of Construction (Forte, 2022) ODF gradation curves are presented showing the percentage passing a #200 Sieve, and average percolation rates. This was based on testing during construction which was a minimum of 1 test per 5000 m^3 of ODF material placed. The results show that of the 37 gradation results reviewed 27 have a higher value than 5 % passing a #200 sieve. Some 12 results are 9% or higher, the average was 7%. The geometric mean of the hydraulic conductivity was 5.7×10^{-4} m/s, with 8 out of 37 tests having a lower hydraulic conductivity than specified. The fact that some of the results are non-conforming (which usually triggers a non-conformance and rectification QA/QC (Quality Assurance / Quality Check) process is not mentioned in the construction report). A review of the ore gradation calculates (refer to Section 2.5) the approximate hydraulic conductivity of the ore based on 'Hazens rule' as 0.0086 m/s. If this is compared to the ODF at 0.00057 m/s, then potentially the ODF was one order of magnitude less permeable than the ore.

2.3 Review of Temperature Data

Annual climate reports were prepared by Victoria Gold, the most recent one issued was dated March 2024 (Appendix M of the 2023 Annual report (Victoria Gold, 2024)). This report sets out the climate data recorded at the camp and snow depth indicators on the HLF. The temperature at the camp is reasonably consistent in that the average daily temperature between 2019 and 2023 was below zero Celsius from October to April (inclusive). The maximum daily temperature is below zero Celsius from November to March inclusive between 2019 to 2023. Most years have 3 or 4 successive months where the average daily temperature is less than minus 30 degrees Celsius on a particular day.

Snow data have been collected at three snow courses at the Project site since 2009. Furthermore, the annual maximum snow water equivalent (SWE) value generally occurs in late March or early-April at the Project site. Field measurements from site show that snow density is generally lower earlier in the season, corresponding to colder temperatures, but increases through winter as the snowpack deepens, consolidates and as snow melt progresses.

The HLF Snow Survey 2023 maximum SWE (267 mm) was highest on record (2019 – 2023) and well above average annual maximum SWE (180 mm), noting that the record period is shorter for this station.

A review of the weather data for 2024 shows a generally negative temperature with the first warm period around 19th April. Precipitation in May and June historically averages at 27.4 mm for May and 40.9 mm for June. The total for May 2024 was just above this average at 38.6 mm, whereas the total for June was very dry at 2.3 mm. A check was made of the rainfall data for Mayo airport which received 38.6 mm of rain in June 2024 (18.2 mm occurring on one single day).

As a consequence of this review of climate data, a significant rainfall event did not occur immediately preceding the slide on 24th June, 2024.

Table 1 below presents the total days the temperature measured at base camp was less than zero degrees Celsius to less than 30 degrees Celsius in five-degree increments. Figure 9 below presents the daily and 10 day rolling average of temperatures measured at the camp. Based on this information the temperature in the winter of 2023/2024 was not longer than previous years or more intense. However, the lowest temperature was recorded on 13th January, 2024 and at the end of January the biggest swing to warm temperatures occurred with the temperature being +4°C on 29th January, 2024 and -38°C some 6 days later.

Table 1: Total days less than zero degrees over the three winters measured

Period	Total Days less than temperature stated (°C)						
	≤ 0	≤ -5	≤ -10	≤ -15	≤ -20	≤ -25	≤ -30
Sept 2021 to May 2022	204	158	128	93	62	33	19
Sept 2022 to May 2023	189	158	116	78	45	27	12
Sept 2023 to May 2024	180	141	109	79	52	31	14

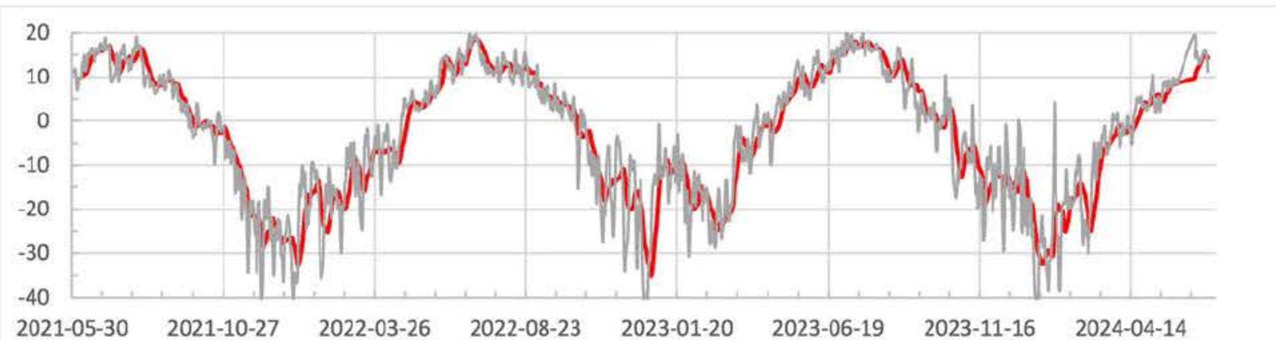


Figure 9: Daily (grey line) and ten-day rolling average (red line) temperatures measured at the mine camp.

2.4 Placement of Ore and ODF during Sub-Zero Temperatures

A review was undertaken of the ore and ODF (over drainage fill) placement plans on a monthly basis when sub-zero ore stacking was carried out between mid 2021 and May 2024. Appendix C presents the ore placement plans on a month-by-month basis with a note on the average temperature on site and snow depth at the camp. Figure 10 below presents a summary of the ore deposited in months where the average temperature was below zero, by level.

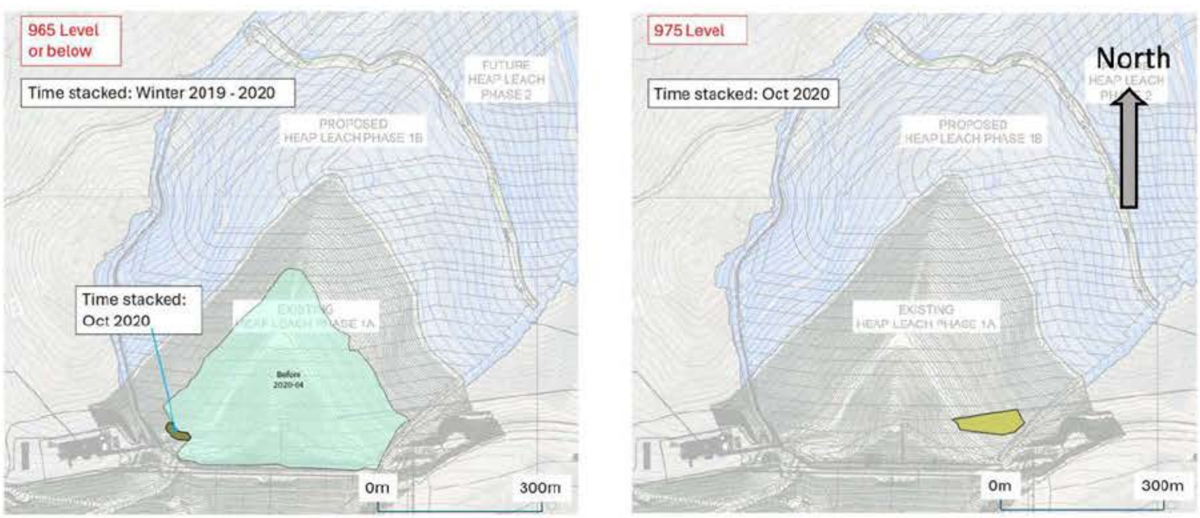


Figure 10: Placement of ore in sub-zero temperatures by level

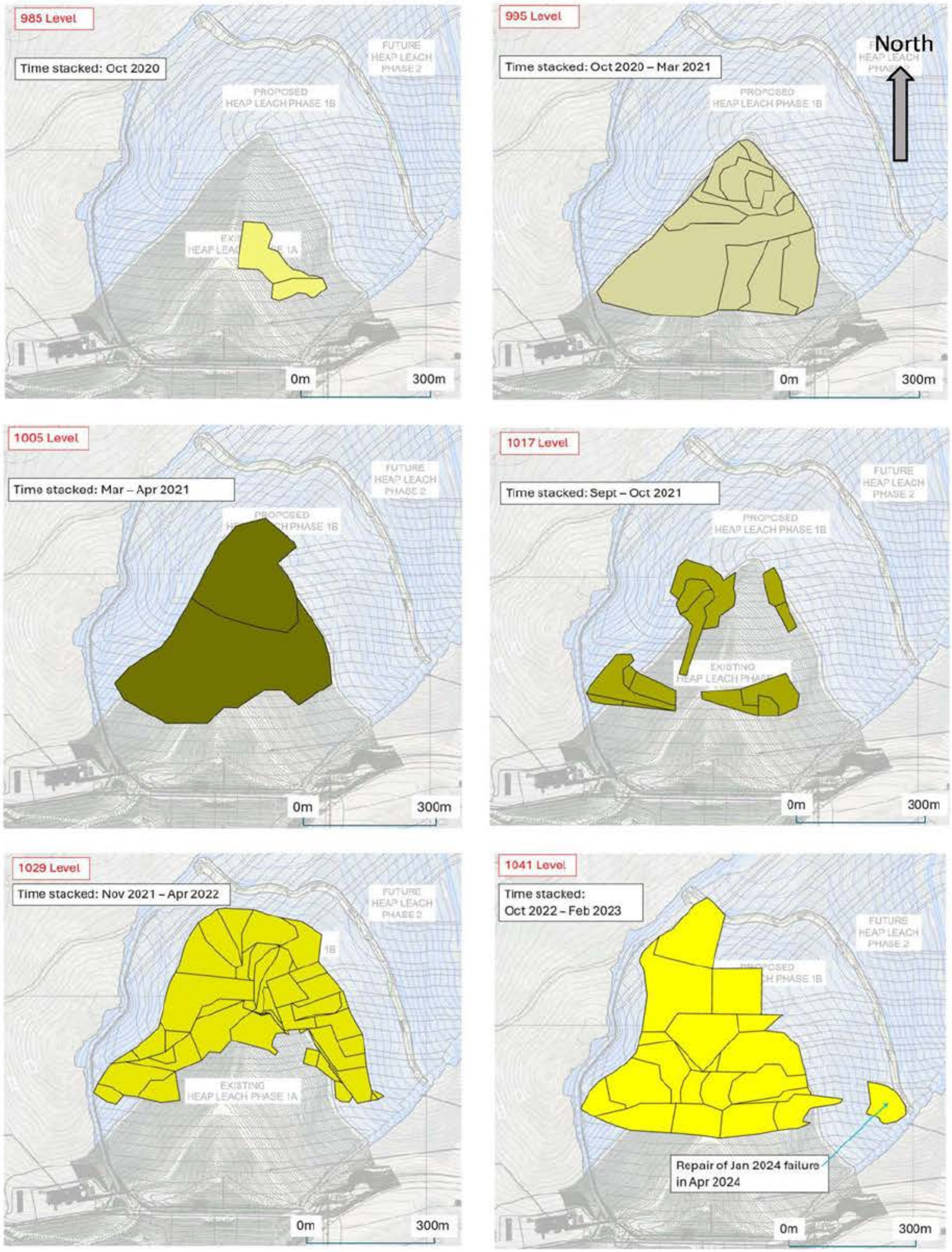


Figure 10: Placement of ore in sub-zero temperatures by level

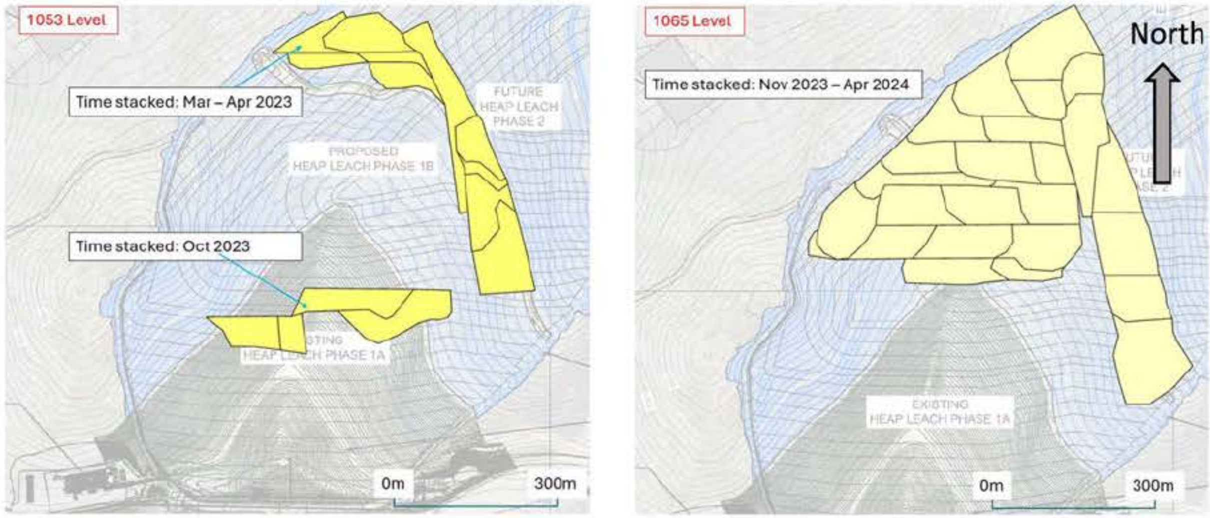


Figure 10: Placement of ore in sub-zero temperatures by level

It should be apparent from Figure 10Figure 10 that a substantial part of the western side of the Phase 1A and Phase 1B heap leach pad was placed in sub-zero temperatures particularly the 24 m thickness between 985 and 1005 & 1017 and 1041. Based on this analysis Delve Underground contend that parts of the ore remained frozen, even though barren solution was being irrigated on surface.

There are two additional effects of placing frozen ore that should be considered. The first is that frozen ore with partial or complete freezing of pore water interstitial space (and on the basis that such ore is not submerged), is heavier by unit weight than either unfrozen ore, or submerged unfrozen ore (the latter where a buoyant unit weight might be applied). The unit weight varies depending on the saturation and pore space available, but might be as high as 22 to 24 kN/m^3. This effect has been considered further in the analyses section of this report.

The second effect that should be considered is the expansion of pore fluid within the near surface layers as the fluid freezes. Without enough overburden pressure to control swelling due to freezing, the void ratio of the ore is increased. Evidence of expansion of pore fluids has frequently been witnessed on site with 'eruptions' of ice stacks occurring on the top surface. The increase in void ratio could result in the ore being in a contractive state once the frozen fluid thaws out. It is often not appreciated that coarse granular soils can exhibit contractive behaviour in a similar manner to finer grained soils such as silty sands (a key focus area for tailings). As such, a case could be made for assigning undrained behaviour for at least some of the ore layers, or even part of the ODF layer, within stability models that are known to have been placed in frozen conditions. An undrained response of such thawed-out soils could lead to liquefaction-type behaviour, either induced by changes in effective stresses (static liquefaction) or large strains (e.g. as might result from movement down a weak side slope geosynthetic interface). The very rapid nature of the failure does suggest a brittle response of the ore that would indicate at least some degree of undrained contractive behaviour. Further, a large release of fluid/leachate was noted during the immediate failure (discussed further in Section 3.0), possibly indicating the release of thawed (previously frozen) fluid.

On the basis that; i) there are a significant number of unknowns in relation to the potential for contractive layers to exist, ii) assessment of such behaviour requires advanced laboratory testing to derive parameter values for the appropriate constitutive models, and iii) complex numerical modelling is required to establish the potential contribution of this phenomenon, we have not attempted to model it for the purposes of this report. Notwithstanding this, we do provide a commentary on this potential contributary factor within the final sections of this report.

2.5 Gradation of Ore Placed in the HLF

A review of the design documents revealed that the designed gradation of the ore to be placed in the HLF changed insignificantly prior to mining. Within a spreadsheet provided by Victoria Gold the results of 1,340 sieve tests were presented. This spreadsheet also depicted the designed gradation. The designed gradation as presented was defined as D_{10} = 0.5 mm; D_{25} = 2.4 mm; D_{50} = 6.15 mm and D_{75} = 11 mm.

A review of the 1340 sieve samples undertaken between September 2019 and February 2024 is set out in Table 2 below. For this assessment we have summarized the ore gradation into four categories. It should be noted that the smallest seized sieve is 1.25 mm. As a consequence, the values of D_{10} were found by fitting a Rosin-Rammler distribution to each of the samples and then using this curve fitting technique to predict the 10% passing value.

Table 2: Ore gradation between September 2019 and February 2024

Date and Quarter		Percentage passing in mm				Number of Samples
		D_{10}	D_{25}	D_{50}	D_{75}	
2019	Q3/4	0.52	1.77	5.49	14.09	20
2020	Q1/2	0.63	1.68	4.17	8.73	171
	Q3/4	0.7	1.94	4.87	10.23	216
2021	Q1/2	1.0	2.59	6.08	12.04	122
	Q3/4	0.79	2.21	5.50	11.37	152
2022	Q1/2	0.87	2.43	6.10	12.76	155
	Q3/4	0.89	2.43	5.98	12.29	131
2023	Q1/2	1.01	2.86	7.25	15.31	169
	Q3/4	1.27	3.46	8.47	17.36	156
2024	Q1/2	2.48	5.32	10.7	18.92	48
	Overall Average	0.93	2.51	6.15	12.67	---
	Standard Deviation	0.96	1.75	3.1	5.1	---
Designed Gradation		0.5	2.4	7	11	---

From these results we infer that the gradation of the ore as placed in the heap leach is slightly coarser than designed. By applying (the simplistic) 'Hazens rule' to estimate a hydraulic conductivity from the D_{10} value it appears that the designed hydraulic conductivity might have been 0.0025 m/s, whereas the actual value based on the average D_{10} is 0.0086 m/s (ie. three times greater than the designed hydraulic conductivity).

Examining the results it also appears that there are three occasions when the ore has coarsened during the life of the mine. The first was in Q1/2 2021, secondly Q3/4 in 2023 and finally Q1/2 in 2024. The rationale for these three coarsening events is unknown, i.e., if by design for processing reasons, or due to mechanical reasons related to the crusher.

2.6 GCL Placement and Potential Hydration

Based on a review of the construction records, it is recognized that during installation and construction of the lining system, proactive measures were undertaken to ensure that the GCL did not become hydrated. The lining system was constructed during the day shift and at the end of each day the geomembrane covered the GCL that had been laid out on the same day. There is at least one instance of GCL becoming hydrated and being removed prior to re-installation of new un-hydrated GCL. Preventing hydration of the GCL is very important as the force of bentonite hydration can break the stitching that holds the GCL geotextile layers together. This can result in a very low shear strength layer within the lining system. A hydrated bentonite has a shear strength represented by an internal angle of shearing resistance of 6 to 8 degrees.

It is noted that covering the GCL with the geomembrane provides a protection from precipitation that might hydrate the GCL. However, this provides no protection from either sub-grade soil moisture or seepages within the subgrade. Had the geomembrane been routinely covered with the ODF as construction of the lining system progressed, then this hydration from the sub-grade might have been impeded due to a normal force preventing vertical expansion as the bentonite hydrates.

To test this theory on site three samples of the GCL were taken by cutting through the geomembrane at a location where ODF had not been placed. The location of the samples was in the northern part of the HLF where the lining system had been constructed in July of 2023 but ODF has to date not been placed. In all three cases the GCL was found to be hydrated, although the needle stitching was found to be reasonably intact. Photograph 7 below shows the location of the sampling and the hydrated GCL.

Photograph 7: Sampling of GCL not covered with ODF. Note hydration of bentonite in GCL core and frost on inside of geomembrane (photo provided by YWSCB).

Photograph 7 also shows the presence of frost on the inside of the geomembrane. If the GCL were partially hydrated, then any moisture between the GCL and trapped by the geomembrane should be absorbed by the bentonite in the GCL. The observation of the frost potentially shows that the bentonite was fully hydrated at this location. The excess moisture in freezing temperatures then turned to frost. We also question the interface shear strength with this frost or ice on the inside of the membrane; such ice it if were present might have reduced the effectiveness of the asperities forming the texture to the geomembrane. This issue is commented upon further in this report.

It should be noted that the GCL at this location has not been subject to significant stresses imparted by significant thicknesses of ore on the HLF liner slope. At other locations within the HLF the GCL has been exposed to such stresses that might have damaged the internal needle stitching, and led to a reduced shear strength of the GCL lining component.

Given the foregoing observations that the GCL had become hydrated, the timing of geomembrane installation and ODF placement were reviewed from the construction reports (Phase 1A: BGC (2019); Phase 1B: Forte (2021); Phase 1A and 1B: Forte (2022)) and are compared in Figure 11 and Figure 12 respectively.

It was noted by Forte (2022) that Phase 1A ODF placement did not complete by the time BGC demobilized in the end of June 2019. The responsibility of ODF production, placement and quality control of such work was then passed onto VGC. It was also understood from Forte (2022) that the placement of the remaining ODF would occur lift by lift depending on the schedule of ore placement.

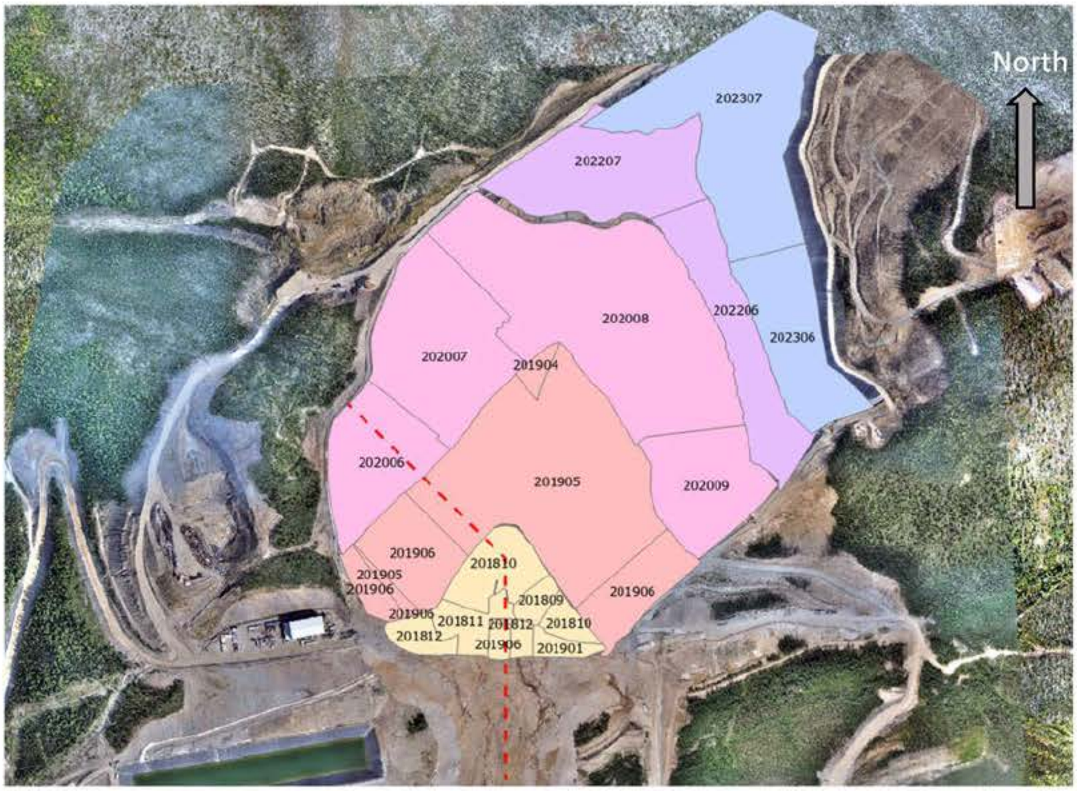


Figure 11: Timing of geomembrane completion and installation locations shown (highlighted dashed line is Section 1A).

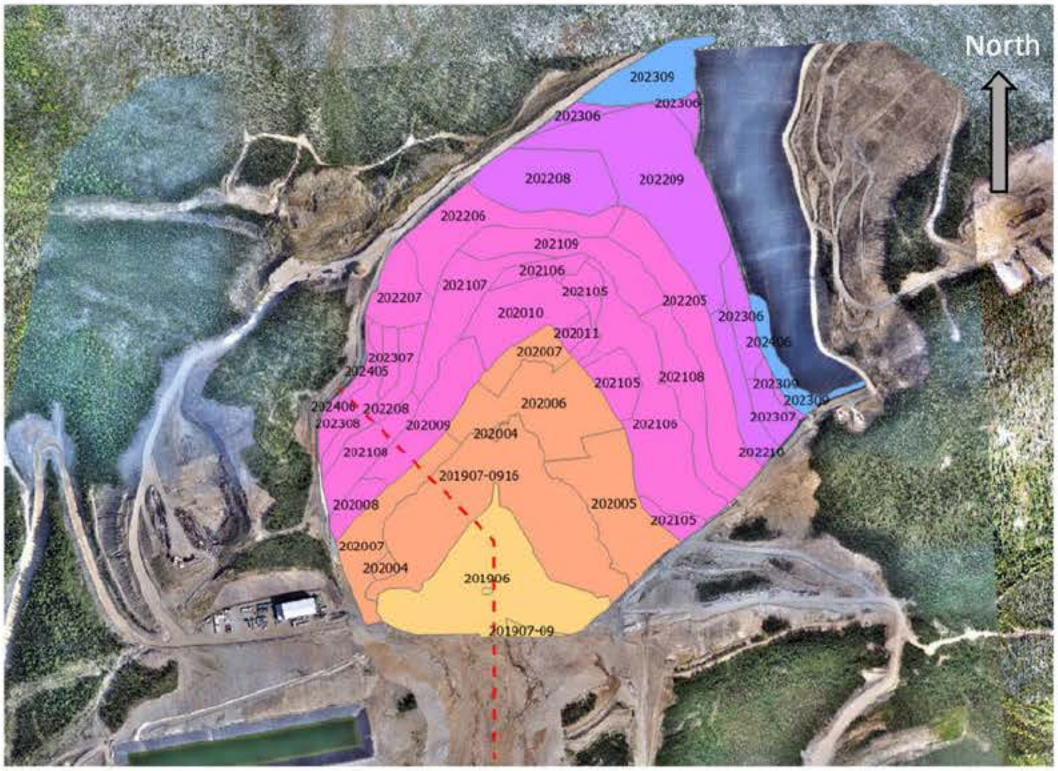


Figure 12: Timing of ODF placement (approximate placement location shown with Section 1A).

From this review, it appears that large parts of the geomembrane were left exposed for a prolonged period before ODF was placed. As such, the time lag between ODF placement and geomembrane installation was then assessed along Section 1A, a critical composite cross section encompassing the steepest side slope of the HLF and the in-heap pond. The time lag between geomembrane and ODF placement along this critical section is summarized in Table 3 below.

Table 3: Summary of Time Lag Between Geomembrane Completion and ODF Placement

Length along Section 1A (m)	Month of GCL & geomembrane completion	Month of ODF placement	Time lag in months
0 - 1.68	Edge of section, unlined		NA
1.68 - 9.33	June, 2020	None (ODF not placed at the time of failure)	52
9.33 - 23.91	June, 2020	May, 2024	47
23.91 - 60.72	June, 2020	August, 2023	38
60.72 - 88.38	June, 2020	August, 2022	26
88.38 - 133.15	June, 2020	August, 2021	14
133.15 - 180.97	June, 2020	September, 2020	3
180.97 - 186.65	May, 2019	September, 2020	16

Length along Section 1A (m)	Month of GCL & geomembrane completion	Month of ODF placement	Time lag in months
186.65 - 222.58	May, 2019	July, 2020	14
222.58 - 329	May, 2019	July, 2019	2
329 - 432.89	October, 2018	June, 2019	8
432.89 - 483.24	November, 2018	June, 2019	7
483.24 - 491.29	December, 2018	June, 2019	6
491.29 - 552.79	June, 2019	June, 2019	0

As highlighted in Table 3, significant portions of the lining system, formed by a layer of GCL covered by geomembrane, were left exposed for more than three months before ODF was placed. Along this section the weighted average time following liner emplacement to ODF backfill was 10.9 months. It is therefore questioned whether hydration of the GCL underneath the geomembrane might have occurred due to sub-grade soil seepages and sub-grade moisture. As noted above, hydrated bentonite has a significantly reduced shear strength, possibly as low as 6 degrees.

This potential failure mechanism has been evaluated within this report.

2.7 Damage to Liner During Installation

With the specifications prepared by BGC and Forte there is an acknowledgement that heavy equipment running on top of the lining system could have an impact on the integrity and stability of the geosynthetics. The specifications note that the ODF should be placed as an initial 0.6 m thick layer pushed out with suitable equipment. In practice, a D6 bulldozer was used to push out the ODF. To prevent damage to the underlying geosynthetics (LLDPE geomembrane and GCL) the specification made specific recommendations with regard to equipment usage on top of the HLF as follows; "*…Haul truck speeds, braking and turning during drain cover fill placement shall be strictly controlled by the Contractor to prevent damage to the underlying geomembrane and pipework…*". It has been recognized that if the bulldozer slews, twists and turns whilst placing fill on geosynthetics then these may be irreparably damaged (Kerkes, 1999). Specifications for the placement of the ODF on top of the HLF liner system did not fully elaborate and consider these issues. Typically, bulldozers are only allowed to run parallel with the slope with pre-determined slew angles to prevent damage.

An analysis was undertaken using the formula by Kerkes (1999) to assess placement of the 0.6 m ODF layer on the geomembrane using a D6 Bulldozer and based on the liner gradients shown in Figure 5. This showed that the factor of safety against tensional failure was marginal (1.01) at a slope inclination of 1V:2.5H (refer to Figure 13) and if on the steeper slopes (1V:2H) the factor of safety is calculated to be 0.9 i.e. tensional failure of the geomembrane is indicated.

SLIDING BLOCK ANALYSIS WITH SURFACE LOADS (P & S) AND GEOTEXTILE TENSILE FORCE (Tg)
Method of Kerkes, D.J. (1999), "Analysis of equipment loads on geocomposite liner systems", Proc Geosynthetics 99, pp.1043-1
BULLDOZER SPREADING SOIL UPSLOPE
Spreadsheet and associated VB macros, Version 2003.02

1. STEP 1. PARAMETER SPECIFICATION

Unit weight of soil cover	18.00	kN/cu.m
Depth of soil cover (1st lift, D)	0.60	m
Dozer type	CAT D6D LGP	
Total dozer weight	205	kN
Track length (L)	3.25	metres
Track width (W)	0.91	metres
Width of dozer blade (Wb)	3.99	metres
Height of soil pile (Hb)	1.00	metres
Length in front of blade (Lb)	1.00	metres
Weight of soil being spread	71.82	kN
Slope angle, alpha	21.80	degrees
Soil cover friction angle	32	degrees
Interface friction angle	28	degrees
Interface adhesion	0	kN/sq.m
Unit tension (geosynthetic)	0	kN/m

2. STEP 2. ITERATION

Select trial values for beta and theta. Press the button to calculate the factor of safety. Then select new trial values and try again.

Beta (Passive wedge)	10	degrees (minus alpha to 90d)
Theta (Active wedge)	70	degrees (slope angle to 90d)

Calculate for trial values

Iterate to find the minimum factor of safety for this calculation method.

Results		Infinite slope
Factor of safety	1.01	1.33
Mobilized soil friction angle	31.7	25.2
Mobilized interface friction angle	27.7	21.8
Moblized interface adhesion	0.0	0.0
Notes		(interface)

Figure 13: Factor of Safety Against Tensional Failure of LLDPE (Kerkes, 1999)

Jones, Dixon and Connell (2000) assessed the effect of landfill construction activities on mobilized interface shear strength. The authors concluded that "*…residual shear strengths can be mobilized if heavy plant (e.g. a D6 dozer) is used…*", (Note: the authors example bulldozer is taken verbatim from the Jones et al., paper) and that such mobilization of post peak conditions is more likely on steep slopes greater than 1V:2.5H. The authors also note that "*…If the movement of the Construction Plant over the entire slope is considered, it is likely that significant areas of the interface will have mobilized shear strengths at or close to residual…*".

There was no detailed recorded procedure regarding the placement of ore with the exception of the specification noting; "*fill placement shall be strictly controlled by the Contractor to prevent damage to the underlying geomembrane and pipework*". There was no elaboration on the term "*strictly controlled*" within the specification. We therefore question if during emplacement of the ODF how much care and attention to detail was manifested by the operators of the D6 Bulldozers to prevent such a condition developing between the geosynthetics used.

Although a more subtle point, the textured asperities on the LLDPE geomembrane have slightly differing strength conditions depending on the quality of the manufacturer. The three general types of textured surface manufacture are; i) co-extrusion (a three-layer extrusion process that injects nitrogen gas into the molten polymer to create a roughened surface, ii) spray on (where the texture is sprayed on my hand or machine), and, iii) embossing (using profile rollers or similar).

On the basis that the construction equipment used to place the ODF may have been working close to the integrity limit of the geomembrane, the quality of manufacture of the textured surface becomes an increasingly important point. In short, the asperities might have sheared off, delaminated or become damaged more easily depending on the quality of manufacture. A comparison of the Layfield textured geomembrane (used on site) and a geomembrane with high quality asperity manufacture is shown in Figure 14 below. The scale is considered to be approximately the same.

Figure 14: Comparison of Layfield (left) and high quality textured geomembrane (right)

Based on this comparison it appears that the textured geomembrane used on site was of a poorer quality than might have been the case.

2.8 Water Balance Observations Prior to Failure

An assessment was made of the water balance within the heap leach in the four years prior to failure. This was undertaken by examining:

- In-heap pond parameters [5th October, 2019 – failure]:
  - Elevation of in-heap pond.
  - Pumpable volume (i.e. amount of fluid).
  - Fraction of HLF pond filled.
- In-heap flow of pregnant solution from HLF to ADR (12th August, 2019 – failure).
- Flow of barren solution from ADR to HLF (19th February, 2020 – failure).

- Flow of fresh water from ADR to HLF (7th May, 2022 – failure).
- Flow out of HLF through UMV (1st May, 2020 (effective 19th May, 2020) – failure).
- Moisture from placed ore (1st January, 2023 – 31st December, 2023).

The graph below (Figure 15) shows the daily change in in-heap pond volume as a yellow line. The orange line shows this in-heap pond volume normalized to a 7-day moving average. The blue line shows the flow of barren solution minus the flow of pregnant solution from the HDR. One might expect these to balance out, but due to precipitation the flow to the in-heap pond and thence to the pregnant solution pumped out will be higher. As a consequence, there is a deficit averaging around 2000 m^3 per day. On the basis that the area of the HLF was around 300,000 m^2, this deficit equates to 6 to 7 mm of precipitation per day, however over a year this is 4 times the rainfall that actually occurs. Only around 500 m^3 of this deficit can be accounted for by precipitation. Another contributing factor is the moisture of the ore placed and this contributing to the volume seen in the in-heap pond. The moisture of the ore equates to around 470 m^3. In summary there is still about 1000 m^3/day of liquid coming into the system from either an unknown source (for example from a breach in the liner) or from an equipment (pump) error or mis-calibration of an instrument. From a review of the UMV flow data and the quantity of water, we believe the latter hypothesis (instrument error) is more probable than a liner breach.

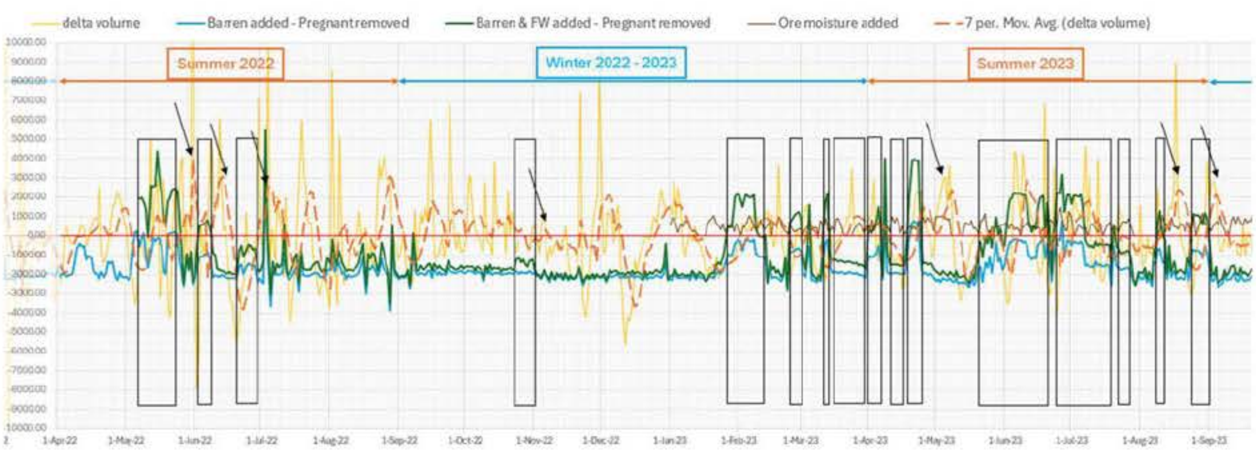


Figure 15: Analysis of the HLF Water Balance Prior to Failure.

Figure 15 also shows when water was added to the HLF system as a green line. The black boxes in Figure 15 show when significant water was added to the heap leach system (green lines on graph). Following these water additions an increase in the in-heap pond can be seen some 2 to 3 weeks after the addition. In other words, it takes 2 to 3 weeks for the water added to make its way through the heap leach to the in-heap pond. Based on this time interval and considering the average thickness of the ore, one is able to calculate a global average hydraulic conductivity in the unsaturated condition as 3.4×10^{-5} m/s.

2.9 Water Balance Observations at the Time of Failure

The monthly reporting by Victoria Gold (Victoria Gold, 2024) presents the elevations and water stored within the three ponds or containment facilities on site, namely: i) the Lower Dublin South Pond (also known as the containment pond), ii) the events pond, and iii) the in-heap pond (behind the containment dam). The day before the failure the following elevations and storage are noted:

- Lower Dublin South Pond water elevation = 810.21 m asl; stored volume = 17,889 m^3; available storage = 42,214 m^3.
- Events pond water elevation = 887.79 m asl; stored volume = 92,108 m^3; available storage = 199,948 m^3.
- In-heap pond storage = approx. 22,000 m^3; available storage = 35,658 m^3.

In an interview with Victoria Gold management staff on site (dated 7th August, 2024) we were informed that the total volume of water in circulation (processing plant, ponds and heap leach) was in the range of 450,000 m^3 to 500,000 m^3. Based on the above storage figures it is inferred that some 318,000 to 368,000 m^3 of water were within or on the heap leach pad at the time of failure.

Based on a pad stacking plan within the Heap Leach and Process Facilities Plan report (StrataGold 2017a), lift number 13 with a top elevation of 1065 m was being constructed at the time of failure. The cumulative volume of ore placed to this elevation was 19,240,048 m^3.

The Forte Technical Memorandum (Forte Dynamics, 2017a) noted that the top surface area of Lift 13 was 295,000 m^2. In the 16 weeks prior to the failure the average application rate was 8.4 litres per hour per m^2, over an average area under leach of 218,000 m^2 and would have had a total flow rate of barren solution of 1,830 m^3 per hour (figures from weekly HLF summary reports).

2.10 Temperature of Barren and Pregnant Leachate

At the ADR processing plant, the temperature of the barren solution going to the HLF pad is measured as well as the temperature of the pregnant solution returning from the in-heap pond. Generally, the pregnant solution is slightly warmer than the barren solution, possibly due to the cooling effect of adding water from the event pond (prior to sending the barren solution to the HLF). Figure 16 presents this comparison from April 2020 to the time of the failure on 24th June, 2024.

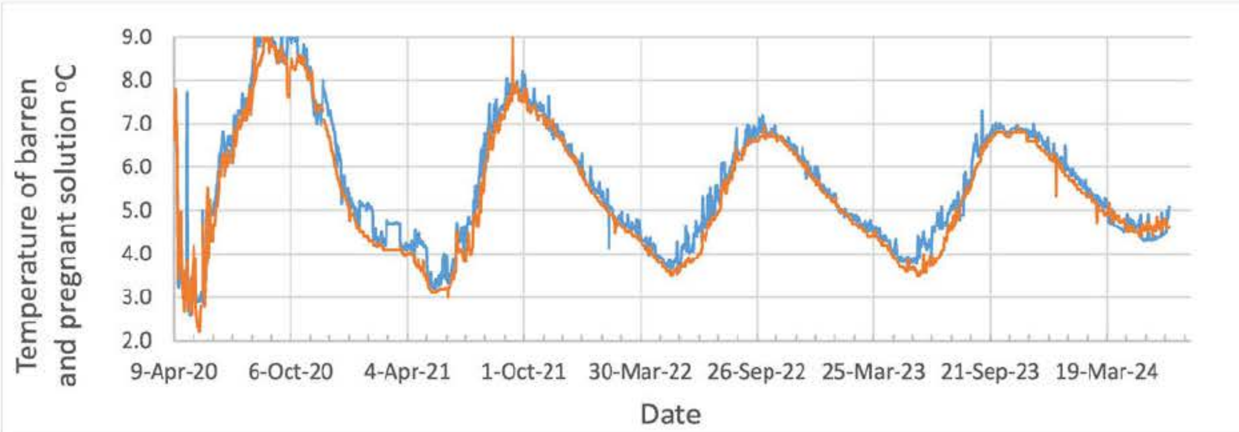


Figure 16: Temperature vs time of Pregnant (Blue) vs Barren (orange) solutions at ADR Plant

From Figure 16 it can be seen that in May of 2021, 2022 and 2023 there is a greater difference in temperature difference. This is thought to be caused by the lower temperature of the makeup water from the control and event ponds following winter. The difference reduces over the course of 2 months, this 'lag' is considered to be due to the water in the ponds slowly 'warming up' following winter.

Contrary to this generalization are the temperatures during March to June of 2024. Figure 17Figure 17 below shows the trend between October 2023 and 24th June, 2024.

Figure 17: Temperature vs time of Pregnant (Blue) vs Barren (orange) solutions at ADR Plant

The inversion first occurs around 20th March, around 15th April the trend goes back to 'normal' but reverts again on 12th May. Based on a review of the Heap Leach weekly presentations it is noted that between week ending 17th May and 21st June that some 50,0000 cubic metres of water was added to the Heap Leach from (we presume) from the event pond and control pond, and that this might have cooled the barren solution. However, the leachate or pregnant solution from the base of the heap leach is colder than the barren solution. This is a unique occurrence in the four years of records. Although the difference between the two temperatures is only slight this is considered a significant observation.

The quantity of water added to the heap leach between 17th May and 21st June (approximately 1 month) amounted to the same quantity that was added between week ending 9th February and 10th May (approximately 3 months). It is unclear why such an increase in added water occurred.

2.11 Drainage to the Underdrainage Monitoring Vault (UMV)

The pumping rates from the underdrainage monitoring vault (UMV) were recorded daily from May 2020 to the time of the failure on 24th June, 2024 when the vault was destroyed by the failure. Figure 18Figure 18 below presents the daily flow rates in cubic metres. The flow to the UMV was managed by two 150 mm HDPE pipes at a typical minimum gradient of 10%. As the subgrade was prepared for liner installation, seepages or springs of groundwater were directed and connected to the under-drainage system and thence connected to these two main HDPE pipes. There was a natural small creek called Ann Gulch that ran down the valley where the HLF was constructed. As a consequence, water entered the underdrainage system as a result of springs in the sub-grade and precipitation. As the HLF was built and the geomembrane placed across the pre-existing Ann Gulch valley, the contribution to the underdrainage system from precipitation events (and snowmelt) reduced. As a consequence, the timing of geomembrane construction has been added to the UMV graph.

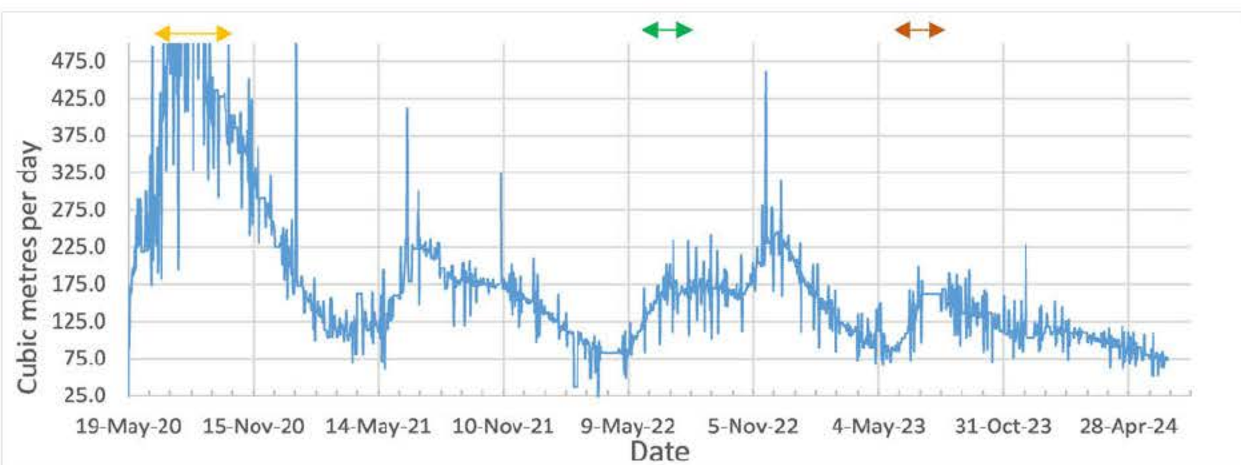


Figure 18: UMV drainage in m^3/day. Arrows indicate construction of the geomembrane liner. Yellow: Phase 1B; June to September 2020. Green: Phase 2A; June & July 2022; Brown: Phase 2B; June & July 2023.

The data shows that there is a cyclic nature to the drainage under the HLF. During winter the flow is supressed and reduces to a base-flow in April and May. During the summer the flow rebounds to a peak around July and august. The exception to this is increased flow between November 2022 and January 2023 when a second peak in addition to the summer peak occurred (the cause of this is unknown).

A significant observation is that by 24th June, 2024 the flow had not rebounded from the winter reduction and was still trending downwards. Had the UMV reported more typical results then the flow should have been around 150 m^3 per day, when in the week before failure the average was 74 m^3/day, approximately half of what might be considered normal flow.

Based on this observation we must question if there was some form of impedance to the flow through the under-drainage system. If such an impedance existed, then it might have built up a pressure in the sub-grade underneath the liner and caused an instability in the form of a basal heave. This mode of failure is discussed further later in Section 4.0 of this report. An alternative hypothesis is that reduced flow from natural groundwater seepages occurred due to a partial re-establishment of permafrost in part of the sub-grade that previously contributed water to the under-drainage system. Both these hypotheses are conjectural as the reason for lack of rebound in flow to the UMV is unknown.

2.12 Assessment of Under-Drainage and Over-Drainage Piping

Both the under-drainage and over-liner leachate collection system used HDPE piping to convey respectively groundwater and pregnant leachate. The pregnant leachate collection system used a system of 150 and 250 mm perforated corrugated pipes to convey leachate to the base of the HLF where larger 400 mm pipes directed the fluid into the in-heap pond. These pipes were placed on top of the geomembrane and then backfill in the form of ODF was bull-dozed over them. We understand that no special measures of ODF compaction were taken around the pregnant leachate collection pipes. With respect to the underdrainage these were two 150 mm HDPE pipes (with a standard dimension ratio (SDR) of 11). These were installed into trenches and gravel material compacted around the pipes.

The pipe manufacturer was Advanced Drainage Systems (ADS) for both the underdrainage and the pregnant leachate collection system. On the ADS website (ADS.com) a technical notice has been prepared titled “TN 2.01C Canada Minimum and Maximum Burial Depth for Corrugated HDPE Pipe per CSA (Canadian Standards Association) B182.8”. This document specifies that the maximum cover for 150 mm pipe (ore being a Class II material) is 6.1 m (akin to the case of the leachate collections system). With respect to compacted fill in a trench this depth increases to 13.4 m (Class I material; for the case of the underdrainage).

It is noted that in both cases the manufacturer’s recommendations for maximum cover has been greatly exceeded. The depth of the ore was well over 50 m in the majority of the HLF with a maximum ore depth of 100 m (the average is estimated at 65 m depth). Based on this comparison the integrity of both the leachate collection system and the under-drainage should be questioned. Our own calculations using an ADS spreadsheet based on Burns and Richards

(1964) show that the circumferential shortening and compressive stress does not achieve American Association of State Highway and Transportation Officials (AASHTO) design criteria for a depth over 55 m (for the 150 mm pipe).

With respect to the under-drainage piping, it is noted that if this pipe is full of water, then an internal pressure (not accounted for in the calculations used) would aid stability. The leachate collection system is not thought to benefit from such an internal pressure. Burns and Richards also do not account for the lateral perforations within the pipe which can lead to localized high stress in the pipe material around such perforations (Krushelnitzky, 2006).

We therefore question the effectiveness of the leachate collection system and if some of the poorly installed 150 mm pipe has partially buckled, impeding flow of the leachate collection. Although the collection of the leachate might have been hampered by potential pipe buckling, as noted in Section 2.1 of this report the piezometric level measured within the ODF (at the instrument location) is generally under 0.6 m and does not appear to have been affected.

2.13 Seismic Activity at Time of Failure

A review of the Alaska Earthquake Centre Seismic activity database and the Natural Resources Canada (NRCAN) Earthquake database for the month of June revealed that there were no seismic events in the vicinity of Victoria Gold on the morning of 24th June. Several earthquakes were recorded in early June around the confluence of the Peel and Wind Rivers some 200 km to the north (one of which was a magnitude 4.9). In 2024 there were five earthquakes noted within a 100 km radius of the site. The nearest seismic event was a magnitude 2.6 event some 2.8 km south of the site and at a depth of 5 km on the 17th of February 2024.

Figure 19 below shows the site and the recorded earthquake events during June 2024.

Figure 19: Earthquakes in the vicinity of the Victoria Gold Mine during June 2024.

A review was undertaken of the Earthquake record from the Natural Resources Canada database (NRCAN, 2024). In 2024 there were five recorded earthquakes within 100 km radius of the site. The location and magnitudes are set in Table 4, below:

Table 4: Location and magnitude of Earthquakes in 2024 within 100 km of HLF

Date/Time (UTC)	Latitude (°)	Longitude (°)	Depth (km)	Magnitude	Description
2024-03-30	64.074	-136.037	1.0	2.1 ML	11.1 km NW of HLF
2024-02-19	63.225	-136.398	15.8	2.6 ML	22 km SE of Stewart; (94 km South of HLF
2024-02-17	64.013	-135.837	5.0	2.6 ML	2.8 km South from HLF (Depth = 5km)
2024-02-12	64.286	-135.425	5.0	2.8 ML	41 km N of Keno, YT; (34 km NE of HLF)
2024-01-24	64.533	-134.338	10.0	2.8 ML	83 km NE of Keno; (90 km NE of HLF)

It was also noted from the NRCAN database that between 2000 to 31st December, 2018 in a 30 km vicinity of the Victoria Gold, there were five recorded earthquakes. From 1st January, 2019 to the time of failure on the 24th June, 2024 there was a period of more intense seismic activity. This period of more intense seismic activity is outlined in Table 5 below.

Table 5: Magnitude of Recorded Earthquakes from 2019 to 2024 within 30 km of the HLF

Year	Number of Recorded Earthquakes	Magnitude Range
2019	9	1.1 to 2.5
2020	9	1.6 to 2.2
2021	4	2.0 to 2.8
2022	5	2.1 to 2.6
2023	1	1.9
2024	2	2.1 & 2.6*

*The event of 17th February, 2024 was the closest to the site at 2.8 km south of the HLF at a depth of 5 km.

In total there were 30 recorded seismic events in the vicinity of the HLF since the start of 2019. In the documents and records we have reviewed these events are not highlighted as being detrimental to the site (observed instability) or are acknowledged as being 'felt' on site.

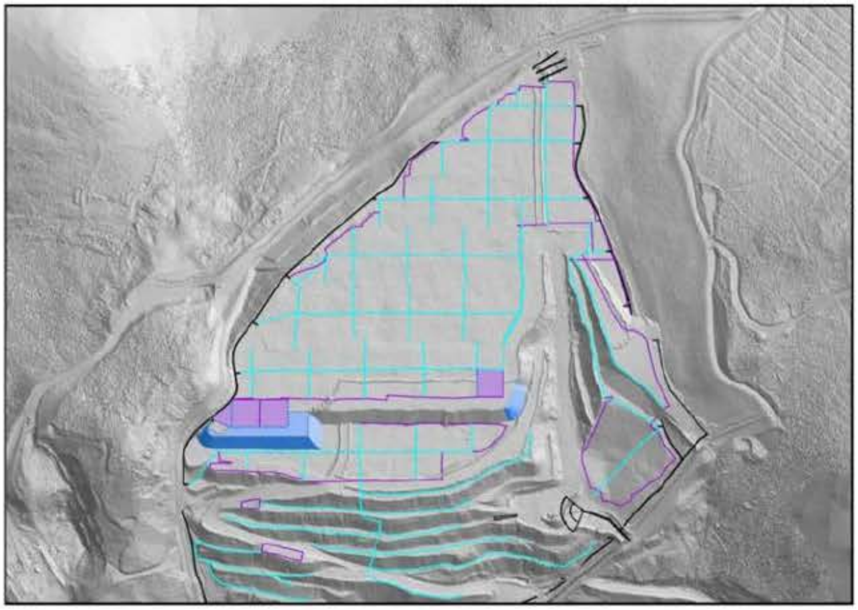
In summary, based on the Alaska Earthquake Centre Database and the NRCAN Earthquake database, it is not believed that the slope failure at the HLF was initiated by seismic activity.

Whether such events caused minor displacement or a post peak condition to be created in one or more of the geosynthetic interfaces is unknown. However, the magnitudes are below 3, it is noted that earthquakes less than magnitude 3.5 are generally not felt but are recorded on seismographs. As a consequence, the seismic activity in the area might have been a minor contributory factor, not in the event initializing instability, but possibly in weakening a geosynthetic interface however slightly.

It should be noted that the peak ground acceleration for the site based on the 2020 National Building Code of Canada Seismic Hazard Tool, is a PGA of 0.147 for a 1-in-500-year event. We contend that given the frequency of earthquakes (some 18 over 2 years), although minor in magnitude, this should have instigated a discussion on seismic performance and evaluation. Consideration should have been given to a site specific probabilistic or deterministic seismic hazard assessment. This should have been used to assess the final configuration of the HLF and the stability thereof.

3.0 Observations of the HLF Pre and Post Failure

In the days prior to the failure, ore was being placed on the pad where the failure occurred on 24th June. Figure 20 below shows the HLF stacking one week look ahead between 21st June and 27th June, 2024.



- Assumptions:
  - Continue 1065 Advancement
  - North ODF Leaching

Tonnes Stacked:
- **Week 1: 168,000 t**

Area Online:
- **Cells: 6,800 m^2**

Area Offline: 6,700 m^2

Figure 20: HLF Stacking plan between 21st and 27th June, 2024.

A review of piezometer instrumentation shows that the failure occurred on Monday 24th June sometime between 05:40 and 05:50 am. The piezometers were set at 10-minute recording intervals and did not record the 05:50 reading. Video footage of the slide exists and has been reviewed by the authors. There is also eyewitness testimony by [redacted] who was carried in the D6 bulldozer that he was operating that has been formally recorded in two interviews by YWSCB. [redacted] described 'millions of spider cracks' suddenly appearing around his vehicle and then felt the machine moving. Based on this evidence the slide occurred as a sudden and very quick movement at a high speed, and on the basis of where [redacted] was working and where his bulldozer ended up, the direction of movement was towards the south-east. Photograph 8 below was taken by [redacted] very shortly after he exited his bulldozer and was walking to escape the area. [redacted] described a 'hole' highlighted in the photo as being a black pond (with liquid), and was initially afraid that his bulldozer would go into this pond. It is noted that such a pond can not be seen in the photo.

As a consequence, and trusting on [redacted] testimony, it appears that from the time he exited his bulldozer and walked up the slope to the location where he took the photograph that the pond had drained away. Although open to conjecture, we contend that this is potentially evidence of perched leachate within the HLF that formed as a result of frozen ore layers.

Photograph 8: Taken by [redacted] immediately after the slide event.

A site visit was conducted on 7th August, 2024 to review the site and interview staff about the slide and possible causes. The visit included a review of the failure and a walk around the perimeter of the failure on the western side. This section of the report presents observations from this site visit as well as photographs taken on the day the slide occurred. Where relevant, photographs from previous site visits have been presented.

1) Barren solution drip lines on the 1065 level were reviewed. These show that only partial and shallow burial of the drip lines from the larger distribution pipes has been carried out (refer to Photograph 9 below).

Photograph 9: Distribution of the drip lines for barren solution on the 1065 level.

2) Photograph 10 shows an overview of the backscarp to the failure where a 60 m high slope has formed. The upper 30 m of this backscarp is at an average inclination of 45 degrees oriented towards a bearing of 210 degrees from North. The highlighted area shows 'blocks' of ore that appear to be boulder in size based on the diameter of nearby pipes. These 'blocks' are thought to be the remains of the access road up the side of the heap leach pad, where compaction was greater leading to an apparently cohesive ore forming blocks. Further evidence for this conclusion is highlighted in Photograph 11.

Photograph 10: Detail of failure backscarp, a 60 m high slope face. Area highlighted shows boulder sized 'blocks' or ore, considered to be more compacted sand from a remanent access road.

Photograph 11: Detail of failure backscarp and drip lines on the 1053 level.

3) Photograph 12 shows a tear in the liner with movement between the 2mm textured LLDPE and the GCL. The slope at this location was measured at 1V:2H.

Photograph 12: Detail of failure tear in geomembrane.

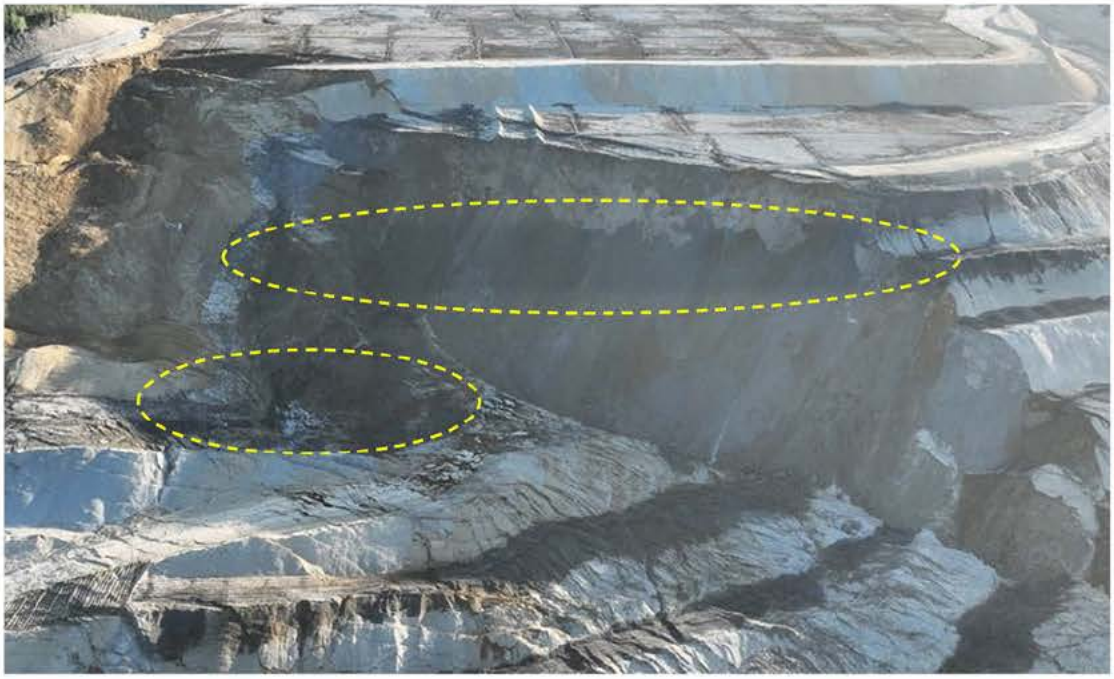
4) Photograph 13 shows the middle part of the slide, note a sinuous strip of more cohesive ore that in failing has formed 'blocks' of ground. This is thought to be the location of the access road up the heap leach face where compaction potentially led to a higher shear strength.

Photograph 13: Detail of middle part of failure and remanent of access road (white dashed line).

5) An aerial photograph was taken the day the slide occurred that shows the lower part of the slide mass below the containment berm. It appears that the lower part of the slide mass essentially "fluidized" and ran down the valley following the fall line towards the control pond. Immediately following the slide, significant quantities of leachate issued through the failed slide material just downslope of the containment berm. We understand that leachate is still issuing from this location in the slope (at time of preparing this report) and steep sided erosional gullies have formed at the points of seepage. The aerial photograph is presented below as Photograph 14.

Photograph 14: Photograph taken on the day of the slide showing run out down the Dublin Gulch drainage.

6) Photograph 15 below was taken the day of the failure of the backscarp. We believe that this photograph demonstrates that the ore was not just partially saturated from the percolation of barren solution. We contend that the dark bands, dark areas of the ore in the backscarp and the area downslope of [redacted] bulldozer (as marked in yellow dashed lines), demonstrate that the ore was significantly saturated.



Photograph 15: Detail of backscarp on the day of the failure

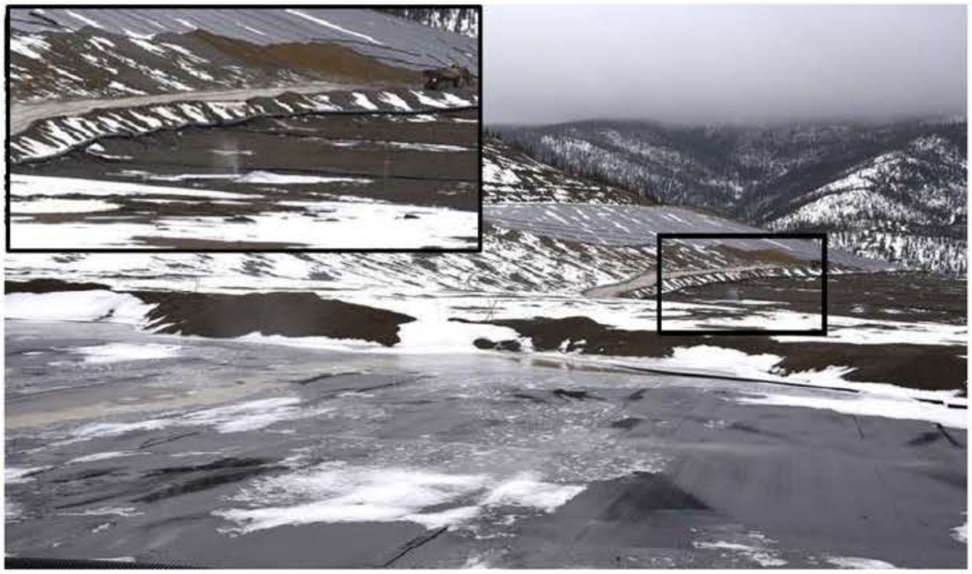
7) The observed ODF used on site appeared to have a high fines concentration. It is understood that this gravel is sourced from a nearby borrow pit. The ODF in this case does not appear to have been washed or screened. Refer to Photograph 16.

Photograph 16: Detail of the over-drainage fill (ODF) as placed.

8) Photograph 17 from September 2023 shows ore placement in the final part of the 1053 level. Note minor ponds of barren leachate across the HLF pad and location of haul road.

Photograph 17: Placement of ore on the 1053 level (September 2023). Red arrows show ponding.

9) Photograph 18 shows the heap leach pad in October 2022 (ore placement at 1041 level). Note ice on geomembrane, and ponding around junction with ODF. In background spray from a leak in the barren distribution system can be observed. The haul road appears 'muddy'.



Photograph 18: Heap leach pad in October 2022 (ore placement at 1041 level). Insert shows 'blow out' of barren distribution line.

10) A site visit was made by YWSCB following the failure on 26th October, 2024. Photograph 19 shows one of several locations where frozen brine was spilling and freezing. This photo was taken when the temperature on site was reported as -12°C. Testimony recorded by YWSCB from the site operators indicates this was a common occurrence throughout the winter. We therefore contend that ice lenses were formed within the HLF during winter stockpiling.

Photograph 19: Ice formation from brine leak on 26th October, 2024.

3.1 Post Ore Breach HLF Embankment Observations by Forte Dynamics

Forte Dynamics prepared a memorandum titled Post Ore Breach HLF Embankment Observations (Forte, 2024). This memorandum presents a number of observations from site and review of the gullies and failed ore downslope of the containment embankment. These locations were not reviewed by Delve Underground during our own site visit due to safety concerns. The memorandum also presents geophysical investigation that was carried out by DMT Geoscience Inc. of the HLF containment embankment and the event pond.

The Forte memo splits the drainage at the base of the slide into seven main gully or drainage paths. Due to erosion, the drainage gullies allow visualization of the failed slide material at greater depths than might otherwise be the case including random construction debris, GCL, liner drainage layers, LLDPE liner, and HDPE pipes. The observations also indicate that a potential loss of up to 3 to 4 m of containment embankment fill may have occurred in the crest area due to scour during the landslide movement.

It was noted that at the location of the monitoring vault that although the vault has been destroyed, it appears that Anne Gulch seepage typically caught by the under drains is flowing below the ore slide mass and has resulted in an increase in moisture content in this area.

3.2 Post Failure Topographic Review

A review was undertaken of the pre- and post-failure topography of the slide, Figure 21 presents this comparison. This figure shows that the slide propagated back as far north as the 1065.5 level. The backscarp can be seen to trend from the central part of the HLF across the 1053 level towards the north-west. The eastern half of the HLF is relatively intact with little sign of movement. The access road that ran up the HLF face cannot be seen on the contours (although as noted the remnants of the access road can be seen on site as shown in Photograph 13). The 60 m high main backscarp face trends towards a bearing of 210 degrees (from North), the upper 30 m at an average inclination of 45 degrees. The overall direction of movement appears to be in a south-easterly direction, essentially in the same direction as the underlying sub-grade and liner installation (refer to Figure 21). Whereas the base of the failure just above the containment dam has moved directly south, and as noted in Photograph 1 trended around to the west towards the Control Pond.

Figure 21: Pre- and Post- HLF slide contours.

Based on the pre and post failure contours an assessment was made of the elevation difference at particular locations and to contour these to form an isopachyte plan. The results of this assessment are presented in Figure 22 below which shows the contours of thickness difference (isopachytes) portrayed on top of the pre and post failure contours.

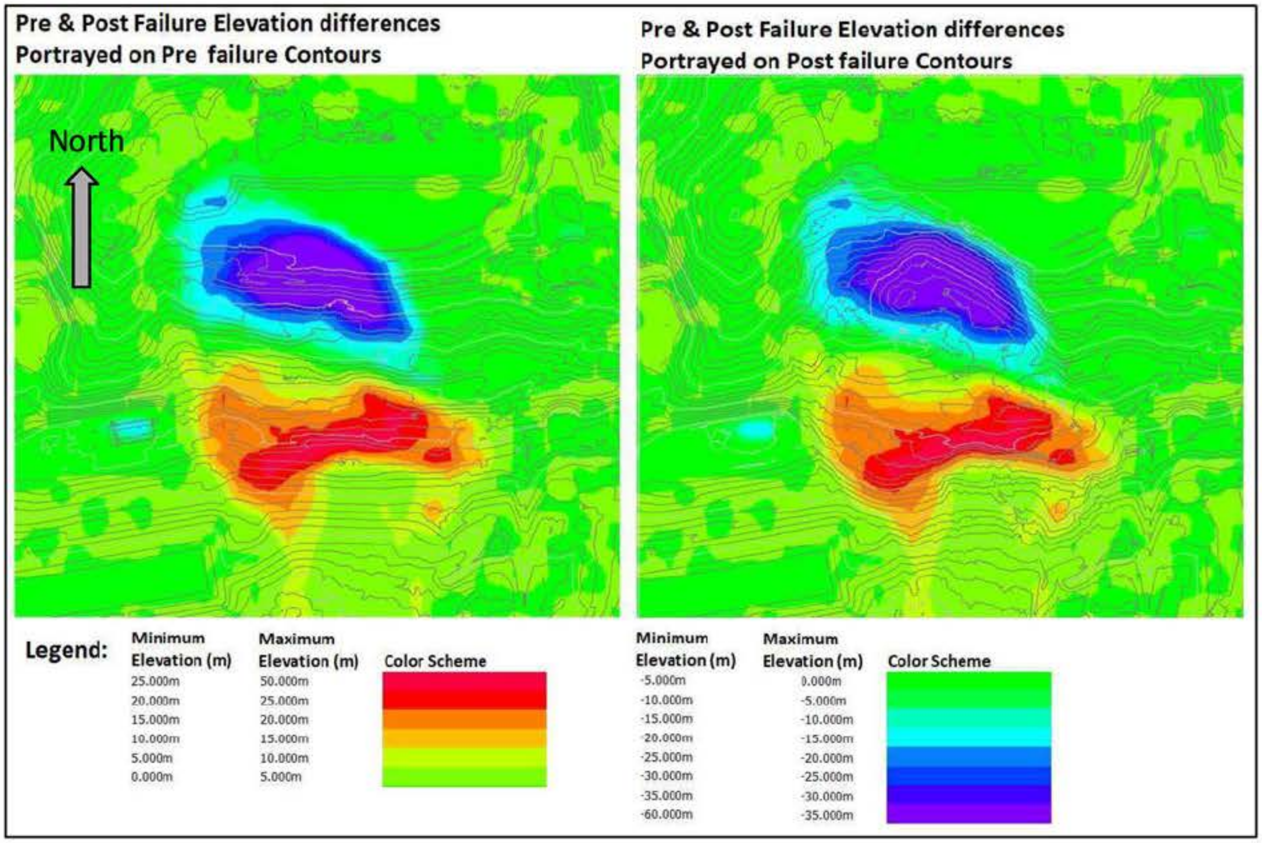


Figure 22: Isopachyte contours portrayed on pre- and post-failure contours

Figure 22 shows a displaced slide mass moving in volume from the north and backscarp towards the south-southeast. There is also movement towards the southeast as the red contour showing maximum thickening from the failure is aligned at an east-northeast to west-southwest direction and elongated towards the east. It is apparent from these contours that the failure was complex and in more than one stage following the initiating event. These observations have been interpreted later within this report to help define the failure mechanism.

On the basis that the upper part of the backscarp trends at 45 degrees from vertical to a bearing of 210 degrees, an assessment was made to determine that if this trend continued, where on the base of the HLF liner would the slide have occurred. It was considered that this might help determine roughly where movement initiated. This is considered a rough approximation as the backscarp slide surface might not have a consistent linear trend but could be curved.

Figure 23 below presents this assessment, with an overlay of the backscarp contours (yellow) on top of the as-built sub-grade plan. This assessment shows the approximate northern extent of the slide surface and by implication that the main slide mass and movement was down the steepest area of the sub-grade.

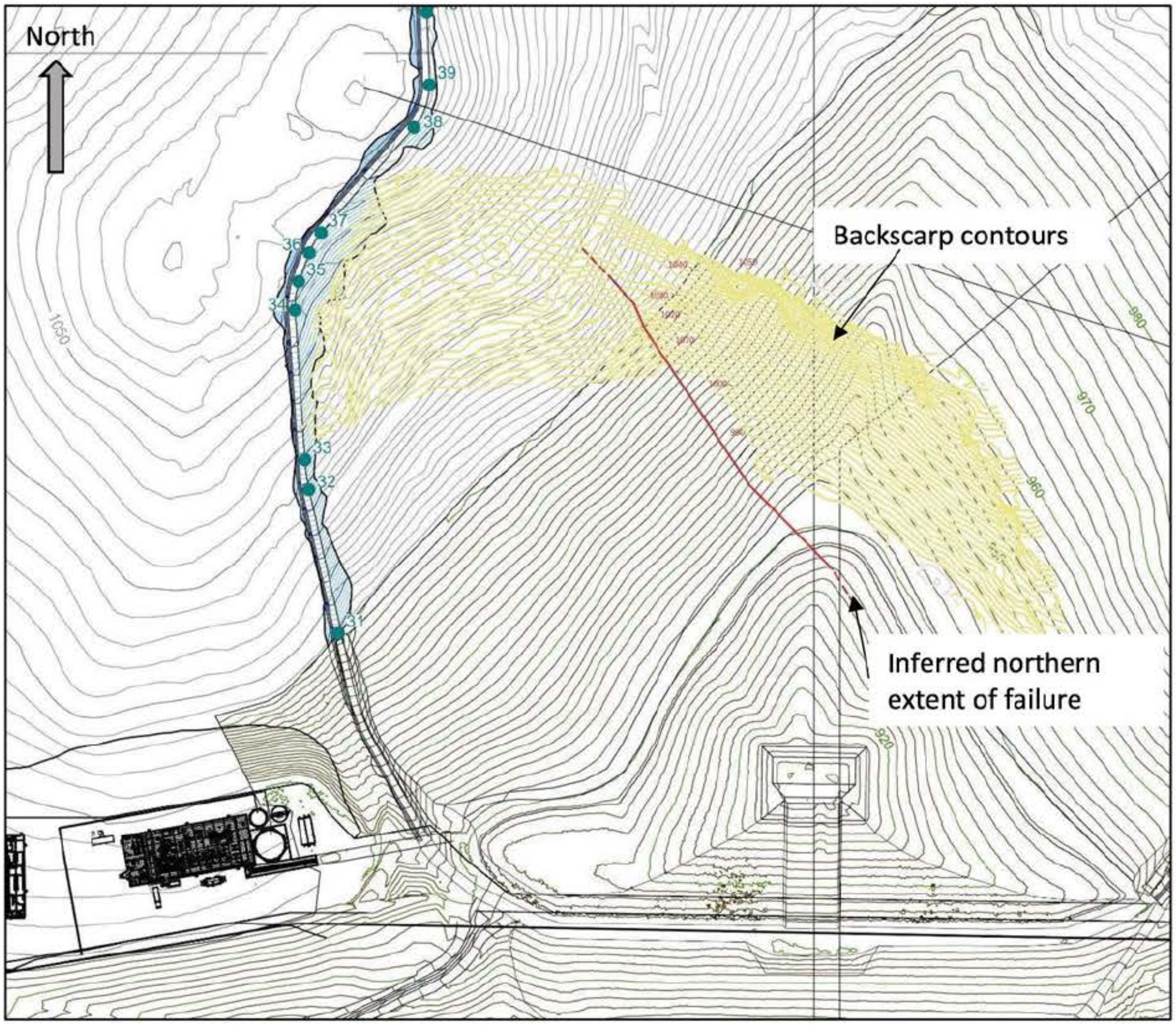


Figure 23: Overlay of backscarp contours onto underlying sub-grade to show northern extent of slide movement.

4.0 Potential Failure Modes – Screening

This section of the report discusses the potential modes of failure of the heap leach, and which modes of failure are viable and considered to require more formal analysis. In considering a systematic approach to assess the component parts of the HLF, we have considered four main components, namely; i) subgrade, ii) lining system, iii) ore and, iv) the containment berm. These components are shown in Figure 24 below.

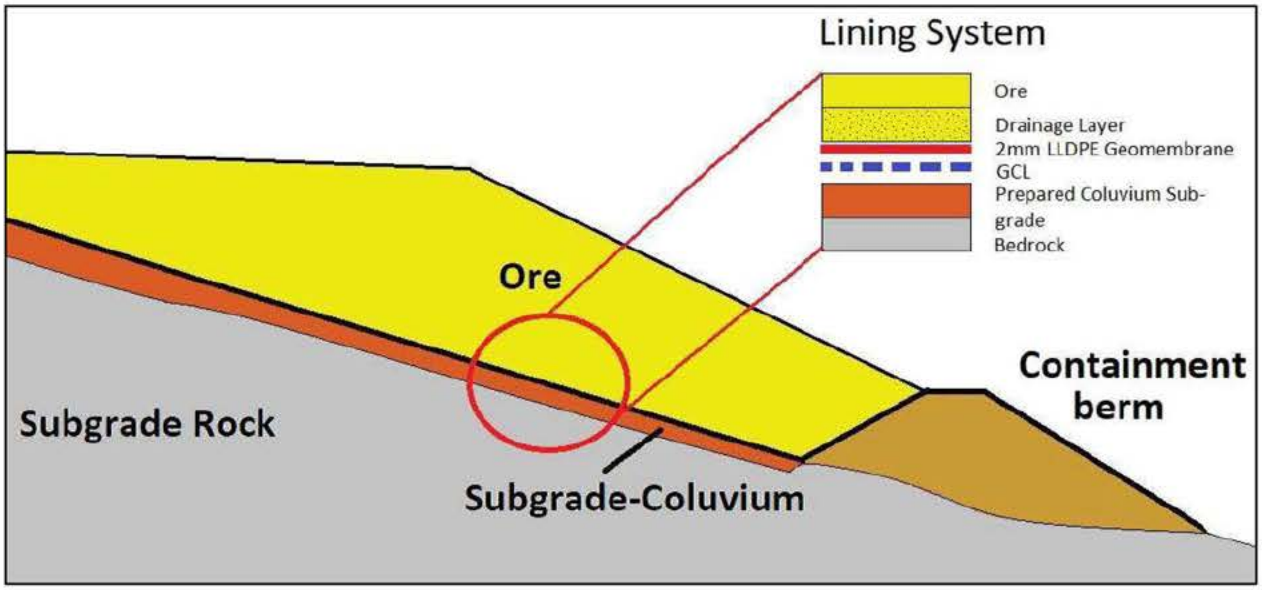


Figure 24: Overview of HLF component parts considered for analysis.

The sections below outline and describe the conceivable failure modes in each of the component parts of the HLF.

4.1 Mode 1 - Subgrade Failure

Failure Mode: **Mode 1A** – Subgrade – Bedrock Instability

Description: Failure of the rock mass forming the foundation of the HLF leads to instability of the heap leach. Such a failure could occur as a result of kinematic instability, through rock mass failure or bearing capacity.

Assessment: Notwithstanding that the bedrock is confined by the HLF, the following observations are made. The metasedimentary rocks forming the base of the heap leach pad were investigated by BGC in 2016 when 23 test pits and six HTW sized (81.5 mm diameter) cored boreholes were undertaken within the Ann Gulch basin (BGC, 2017). During this investigation samples were taken for uniaxial compressive strength (UCS) testing with the reported average UCS of 32.26 MPa. Given this relatively high UCS strength it is considered that a bearing capacity failure is unlikely to occur. The side slopes of the subgrade were regraded to between 1V:3H and 1V:2H (18 to 26 degrees), on this basis for a persistent joint to daylight and potentially create a kinematic planar instability the joint would need to dip less than this. However, the friction angle of joints within the metasedimentary rock is thought be higher than 26 degrees, as a result kinematic instability is considered unlikely.

Failure Mode: **Mode 1B** – Subgrade – Colluvium Instability

Description: Instability of the colluvium due to loading from the slope leads to instability of the ore.

Assessment: Notwithstanding that the colluvium soil is confined by the HLF, the following observations are made. Colluvium varied from 0.0 to 7.6 m below ground surface in test pits and boreholes (BGC, 2017). Colluvium included a mixture of greyish to reddish brown silt, sand and gravel. Failure of the colluvium forming the foundation of the HLF leads to instability of the heap leach. Such a failure could occur as a result of semi-circular or circular instability derived from slope failure. Further analysis is warranted.

4.2 Mode 2 - Lining Failure

Failure Mode: **Mode 2A** – Lining Instability due to high groundwater pressure.

Description: Instability along the base of the lining system due to failure of the underliner drainage system with subsequent build-up of high pressures below the liner.

Assessment: It should be appreciated that both the LDPE liner and the GCL form an extremely low permeability barrier. As a consequence, groundwater which might have arisen on the sides of Ann Gulch prior to HLF construction could cause an under-lining pressure if not dissipated. This mode of failure is addressed by the under-drainage system constructed during HLF phased development. As noted within Section 2.1 of this report the under-drain vault has water flowing to it perennially from the under-drain system. As a consequence, it appears that the system of underdrains appears to be functioning, and groundwater pressure is assumed to be dissipated. This failure mode is therefore considered to be unlikely, but is discussed further in Section 6.2.4.

Failure Mode: **Mode 2B** – Lining instability due to slip failure within lining system (LLDPE to GCL interface)

Description: As a result of the ore thickness and the gradient of the slope, the shear strength of the interface between the textured, 2 mm thick LLDPE liner and the underlying outer geotextile on the GCL, is exceeded leading to a slip failure. Such a failure could run through the ore (either at the toe or crest) or from the exposed surface at the HLF boundary crest underneath the ore. The failure surface considered is both along the lining system interface and within the ore.

Assessment: Requires assessment within this report.

Failure Mode: **Mode 2C** – Lining instability due to slip failure within lining system (Gravel (ODF) to LLDPE interface)

Description: As a result of the ore and the gradient of the slope, the shear strength of the interface between the gravel drainage layer (ODF) and textured LLDPE could be exceeded leading to failure. This interface in 'normal conditions' is not considered as critical as the one outlined in Mode 2B. However, if the leachate running down the drainage layer on top of the liner were to freeze, the interface could become the weakest layer in the lining system. The failure surface is both along the lining system interface and within the ore.

Assessment: Requires assessment within this report.

Failure Mode: **Mode 2D** – Lining instability due to internal slip failure within the GCL of the lining system

Description: As a result of the bentonite within the GCL becoming hydrated the stitching to improve the GCL strength is torn, and the GCL shear strength can ultimately be equivalent to hydrated bentonite (6 to 8 degrees).

Assessment: The GCL used on site is a Solmax Bentoliner (a needle punched GCL). The needle punching results in 'cross-stitching' through the bentonite layer sandwiched between the two GCL geotextile layer. This increases the apparent internal shear strength of the GCL. Hydrated bentonite without cross stitching has a very low residual shear strength, of the order of 6 to 8^{o}. Under normal conditions the internal shear strength of hydrated GCL is sufficient for design purposes. However, if the GCL became hydrated without a nominal normal pressure to confine the material prior to hydration, then the force of hydration and expansion of the bentonite might tear the needle punched stitching. It is well recognised that placement of a nominal thickness of soils (such the ODF) immediately after deployment of a GCL provides sufficient normal force to constrain hydration-related expansion and prevent the stitching from breaking. During phased liner construction significant areas (several hectares) of GCL were covered with the geomembrane to prevent hydration from precipitation, but this would not have prevented hydration from groundwater seepages and subgrade soil moisture. As a consequence, further analysis is warranted.

4.3 Mode 3 – Ore Failure

Failure Mode: **Mode 3A** – Failure of ore (phreatic conditions).

Description: Failure of the ore due to an increased piezometric level.

Assessment: The stability models reviewed in Section 5.0 assume a groundwater (or leachate) piezometric surface 1 m above the liner (the thickness of the over drainage fill - ODF layer). This assessment is on the basis that the ore is partially saturated (ideally 55 to 65%), but free draining. The gradation analysis confirms that particle size should have provided free draining ore down to the ODF layer. This failure mode requires further assessment to analyze the piezometric levels that could create a failure in the ore, and therefore assess the sensitivity of the designed HLF to a differing piezometric level than assumed. The potential for perching is largely related to the presence of frozen layers.

Failure Mode: **Mode 3B** – Failure of ore due to the presence of perched water tables

Description: Perched water tables within the ore create a complex hydrogeological condition, such that failure occurs through the ore.

Assessment: As a significant volume of the ore was placed during sub-zero temperatures there is the possibility that the frozen ore has created lenses of impermeable ground that creates perched water tables, possibly stacked on top of one another within the HLF. This complex groundwater regime could lead to a failure of the ore (possibly partially involving the lining system). Assessment is required.

Failure Mode: **Mode 3C** – Failure of the ore due to hydrostatic uplift pressures.

Description: Heterogeneous and unusual drainage of the leachate from ore deposition levels higher up in HLF to the base, create uplift forces towards the toe of the HLF causing a failure.

Assessment: The significant volume of ore that has been deposited in a frozen condition may have created perched leachate tables above the frozen ground that drain down the ODF towards the base of the HLF. On the basis that the drainage pipe system may have buckled (at the lower elevations where surcharge mass is highest) this may have led to high pore pressures in the ore at the base of the HLF creating an uplift hydrostatic pressure below frozen layers at depth and potential failure. Figure 25 below attempts to graphically display this mode of failure, which the authors acknowledge is somewhat unique. Assessment is required.

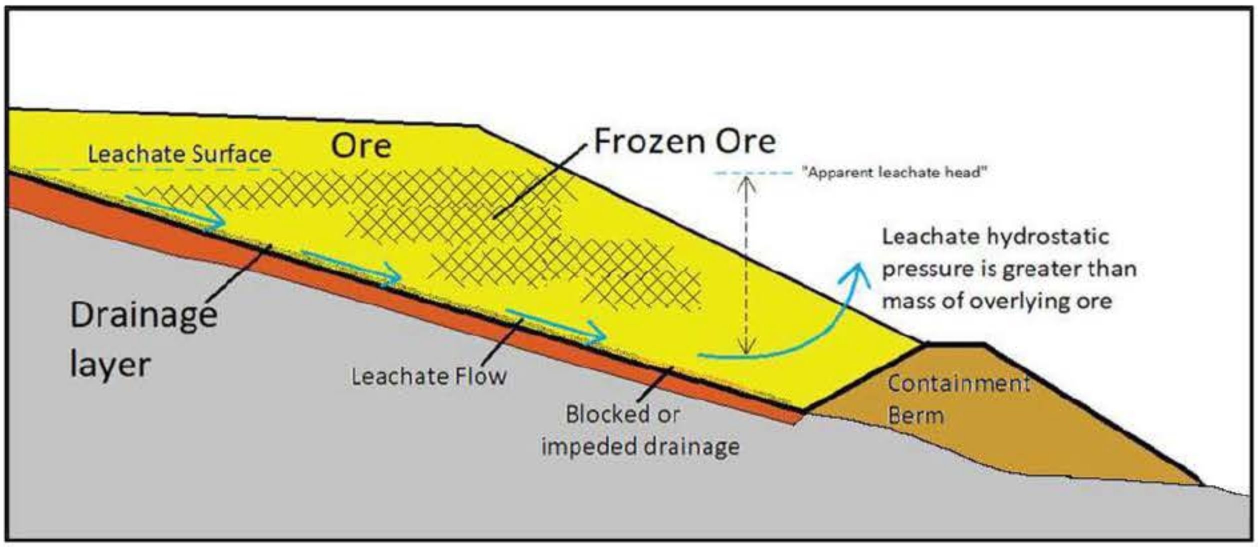


Figure 25: Sketch of Mode 3C – Failure of the ore due to hydrostatic uplift pressures.

4.4 Mode 4 – Embankment Dam

Failure Mode: Mode 4A – Failure of the Embankment Dam

Description: Failure of the containment berm leading to a more massive failure of the HLF.

Assessment: The containment and in-heap pond were a registered dam and therefore subject to perhaps more scrutiny than the other parts of the HLF since the time of construction. Inspection of the downstream side of the berm (beneath a road that ran along the dam crest) was routinely undertaken and showed no signs of seepage or piping cavitation. Instrumentation installed in the containment berm also showed no historical movement (data was not collected in 2024). Furthermore, Forte (2024) have undertaken a number of site observations within the gullies downstream of the containment berm, these observations appear to show that only 3 to 4 m of the embankment might have scoured during the failure, but that the embankment is still in place. Notwithstanding these observations this report has assessed the stability of the embankment dam.

5.0 Slope Stability Modelling Set Up

Based on the information reviewed in Section 2.0, and the mode of failure screening assessment carried out in Section 4.0, a series of limit equilibrium slope stability analyses were carried out. These analyses used the Rocscience Slide2 software (Build 9.034 64bit) for assessing a factor of safety for a given scenario. Details of the analyses including key assumptions, sections analysed, and parameters adopted are described in this section.

5.1 Key Assumptions

Based on the review of Section 2.13, it was considered unlikely that the HLF failure was induced by seismic activity. Thus, in all analyses outlined in this report, only static slope stability was assessed. No pseudo-static or post-earthquake stability analyses were carried out.

Given that the failure is deep-seated in nature, modelled failure surfaces with depth <25 m were filtered and neglected, as shallow ravelling failure was not considered the focus of this investigation. Entries of the failure surfaces were constrained to where the failure initiated and exits were constrained to around the embankment dam, such that the modelled failure surfaces resemble the failure surface observed (and described in Section 1.3) as closely as possible.

5.2 Sections Analysed

Based on the review of the HLF geometry, and the pre- and post-failure slope geometry captured by LiDAR drone flights on site, three critical sections were selected for analysis.

Figure 26 shows an overlay of the location of the three sections on a layout plan (extracted from drawing 109005-51100-03 GA-F003 included in Detail Design Report for Eagle HLF Phase 1B (Forte, 2020)) showing the contours of the lining system before ore placement. Figure 26 shows the location of the sections overlaid on post-failure orthophoto taken on 26th June. It should be noted that Section 1 aligns parallel with the inferred sliding surface along the steepest gradient of the liner slope shown on Figure 5.

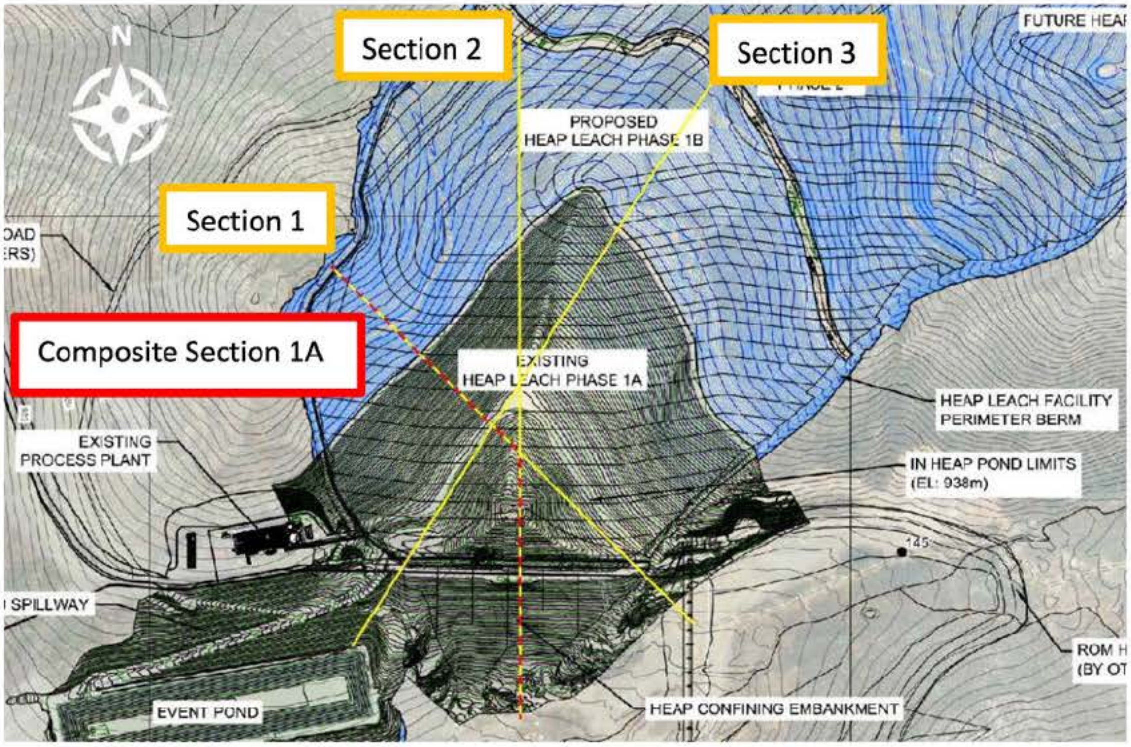


Figure 26: Sections overlaid on HLF layout plan.

Figure 27: Sections overlaid on post-failure site orthophoto on 26th June

Section 1 was selected within the failed slope where the lining system was the steepest on the west side of the HLF. Section 2 was selected through the center of the embankment dam. Section 3 was selected where the lining system was the steepest on the east side of the HLF, perpendicular to the exposed upper head scarp, extending to the slope adjacent to the Event Pond.

It is recognized that the stability of the HLF may be governed by a 3-dimensional aspect, for this reason a composite section 1A was introduced into the modelling as set out on Figure 27 above. This composite section 1A follows the steepest section of the side slope lining and sub-grade, but also follows part of Section 2 with the steepest outer slope face of the HLF.

5.2.1 Ground Profile

Generalized geological profiles were used to develop the modelled sections in the three sections. Ground surface profiles were extracted from a pre-failure LiDAR scan taken on 21st June, 2024. The LiDAR scan from 28th July was referred for post-failure profile, which shows the approximate extents of the actual failure surface. Profiles of the liner were drawn based on contours shown on drawing 109005-51100-03 GA-F003 (shown in Figure 26). Extents and depth of the embankment dam at the section was inferred from drawings in the 2017 HLF Design Report (BGC, 2018). Within the limit equilibrium program, the lining system was modelled as a 2 m-thick layer on the basis of initial sensitivity analysis and given the thickness of the overlying ore.

Based on site-wide geotechnical investigations completed by BGC in 2011 (BGC, 2011), colluvium was commonly found on sloping ground throughout the site with typical thickness of 0 to more than 3 m (up to 7 m). Thus, it was assumed in all models that a 5 m-thick colluvium exists below the basal lining, on the balance this is considered a reasonably conservative assumption. As failure through the subgrade bedrock is not considered likely (refer to Section 4.1) a layer of bedrock with infinite strength was assumed below the colluvium. Based on a review of the Phase 1A construction summary report (BGC, 2019), soil at the foundation of the embankment dam was removed and competent bedrock was exposed and approved by BGC. As such, it was assumed that the embankment dam overlies bedrock in all models.

5.2.2 Groundwater Level

Unless otherwise specified in the analysis, it was assumed that a 1 m phreatic head existed above the lining system to simulate the presence of leachate which flowed to the in-heap pond.

The level of pregnant leachate within the in-heap pond was monitored by a piezometer. Data from the piezometer was reviewed, and the in-heap pond level was found to be fluctuating in annual cycles (between 925 and 938 m elevation) with lows in summer months and highs in winter months. Although the in-heap pond level before the failure was recorded at around 932 m elevation, the in-heap pond was assumed to be full at 938 m elevation in the analyses undertaken.

The groundwater settings were generally applied to the ore and the colluvium subgrade, but not to the lining system and the embankment dam (unless otherwise specified).

5.2.3 Analysis Methods

Given the complex geometry of this failure, non-circular particle swarm search with optimization was used to search for slip surfaces with a global minimum factor of safety (FoS).

The General Limit Equilibrium (GLE) / Morgenstern-Price method, which considers both force and moment equilibrium, was used, while three other methods (Bishop simplified, Janbu corrected and Spencer) were also checked if a substantially lower FoS was achieved.

5.3 Parameters Values Adopted for Analyses

The parameters values adopted for the analyses are discussed in detail and compared with those values adopted by others in this section of the report. The following parameter values are discussed in detail:

- Embankment dam fill.
- Colluvium (subgrade).
- Ore in heap
- Liner system (and respective interfaces from base to top; prepared sub-grade, GCL, 2 mm thick textured LLDPE, ODF drainage layer).

5.3.1 Embankment Dam

In BGC's 2019 investigation for monitoring instruments at the embankment dam (BGC, 2019), the compacted site grading fill used for the construction of the embankment dam was described as "sand and gravel, some cobbles, some silt, well graded, brown, dry to moist". Table 6 below presents a comparison of the parameters used for embankment dam between the analysis presented in BGC (2019), and previous analyses.

Table 6: Parameters Adopted for Embankment Dam

Analyses	Unit Weight (kN/m^3)	Model	Cohesion (kPa)	Friction Angle (°)	Notes
Tetra Tech (2012, 2014)	22	Mohr-Coulomb	0	36	Sand and gravel (SW, SM, GW, GM), 30-50% fines
Dowl Engineering (2016)	24	Mohr-Coulomb	0	28	Estimated based on grain size

Analyses	Unit Weight (kN/m³)	Model	Cohesion (kPa)	Friction Angle (°)	Notes
BGC (2018)	21.5	Mohr-Coulomb	0	38.3	Based on laboratory testing
BGC (3D) (2019)	Modelled as infinite strength as considered not the focus of the study				
Forte Dynamics (3D) (2021)	Modelled as infinite strength as considered not the focus of the study				
Delve Underground (2024)	21.5	Mohr-Coulomb	0	38.3	Adopted parameters suggested by BGC

It was noted that Tetra Tech and Dowl Engineering assumed a phreatic surface through the embankment dam to model a 'worst-case' scenario where the liner on the upstream side of the embankment dam ruptured. This scenario was commented as unlikely (Tetra Tech, 2014; Dowl, 2016). Based on the comparison between LiDAR scans pre- and post-failure, it was believed that the embankment dam remained mostly intact (refer to Section 3.1 of this report). Thus, in the model analyses under this report, such worst-case scenario was not considered and the piezometric surface was not applied to the embankment dam and the liner.

Six consolidated undrained triaxial tests were carried out on the borrow material used for the embankment fill. Zero cohesion and the lowest effective friction angle of 38.3° was selected by BGC as a conservative estimate (BGC, 2018). Subsequent 3D analyses by BGC and Forte Dynamics did not consider failure through the embankment dam and modelled it as a material with infinite strength. The friction angle selected in BGC's 2018 analysis was adopted in the analysis undertaken in preparation of this report.

5.3.2 Colluvium

According to Sections 6.3.1 and 6.3.2 of Eagle Gold HLF Phase 1B Record of Construction (Forte, 2021) and the attached reports prepared by Tetra Tech (2020), the subgrade for Phase 1A and 1B of the HLF was inspected by Tetra Tech. Subgrade that was; organic, ice-rich, and soft, or composed of 'yielding soils' (per Tetra Tech 2020 report) was replaced with compacted rock fill, while the remaining areas were left in-situ.

During the 2011 site investigation by BGC, the colluvium was described as loose to compact, highly variable, boulders and cobbles with some silt and sand with gravel (BGC, 2011). A friction angle of 40 degrees was adopted by Dowl Engineering (2016) and BGC (2018) based on one Consolidated Undrained Triaxial Compression Test by Golder Associates in 2012.

Given this high variability in the subgrade underneath the liner, for the purpose of stability analysis, the shear strength of the in-situ colluvium was used in lieu of the higher strength compacted rock fill. Thus, a conservative friction angle of 28 degrees was adopted for the analysis undertaken by Delve Underground. Table 7 below presents a comparison of the parameters used for colluvium, and previous analyses.

Table 7: Parameters Adopted for Colluvium

Analyses	Unit Weight (kN/m³)	Model	Cohesion (kPa)	Friction Angle (°)	Notes
Tetra Tech (2012, 2014)	14	Mohr-Coulomb	38	28	Gravelly silt (ML), 30-50% fines
Dowl Engineering (2016)	22	Mohr-Coulomb	0	40	Based on 1 triaxial test by Golder (2012)
BGC (2018)	22	Mohr-Coulomb	0	40	
BGC (3D) (2019)	Not modelled as considered not the focus of the study				
Forte Dynamics (3D) (2021)	Not modelled as considered not the focus of the study				
Delve Underground (2024)	22	Mohr-Coulomb	0	28	Conservative estimate

5.3.3 Ore in Heap

In the absence of laboratory testing, the crushed ore was modelled as cohesionless with a friction angle of 32 degrees in Tetra Tech's analysis for the choice of embankment materials in 2012 (Tetra Tech 2012). Following this assessment when laboratory testing data by Kappes, Cassiday & Associates (KCA) became available, an increased friction angle was used by Tetra Tech in 2014. Subsequent analysis by BGC (2018) adopted the testing data directly as a shear-normal function, which significantly increased the strength of the ore in the model. Further testing was carried out by Victoria Gold Corp. (VGC) with 9 and 11% water content in the ore. Forte (2021) then adopted an updated shear-normal function for ore strength. At normal stress range below 691 kPa, the lowest among the tests by KCA and VGC (at 9% water content) was used, and at normal stress range above 691 kPa, a shear-normal function parallel to and lower than the function proposed by BGC was used (see Figure 28 below).

The shear-normal function approaches by BGC and Forte Dynamics did not consider the uncertainty of the ore strength due to its variable nature and ignore the fact that the actual strength of the ore may be noticeably lower. Thus, a conservative estimate of 0 cohesion and friction angle of 32 degrees was adopted in the analysis under this report. Table 8 below presents a comparison of the parameters used for the ore between the analysis presented in this report and previous analyses.

Table 8: Parameters Adopted for Ore

Analyses	Unit Weight (kN/m³)	Model	Cohesion (kPa)	Friction Angle (°)	Notes
Tetra Tech (2012)	18	Mohr-Coulomb	0	32	Based on pre-feasibility study in 1996
Tetra Tech (2014)	18	Mohr-Coulomb	0	38	Unit weight based on loaded column percolation laboratory tests by KCA
Dowl Engineering (2016)	18	Mohr-Coulomb	0	38	
BGC (2018), BGC (3D) (2019)	18	Shear-normal function, see plot below			Based on direct shear test results from KCA

Analyses	Unit Weight (kN/m^3)	Model	Cohesion (kPa)	Friction Angle (°)	Notes
Forte Dynamics (3D) (2021)	18	Shear-normal function, see plot below			Adjusted based on testing by VGC
Delve Underground (2024)	18	Mohr-Coulomb	0	32	Conservative estimate based on grain size distribution of ore

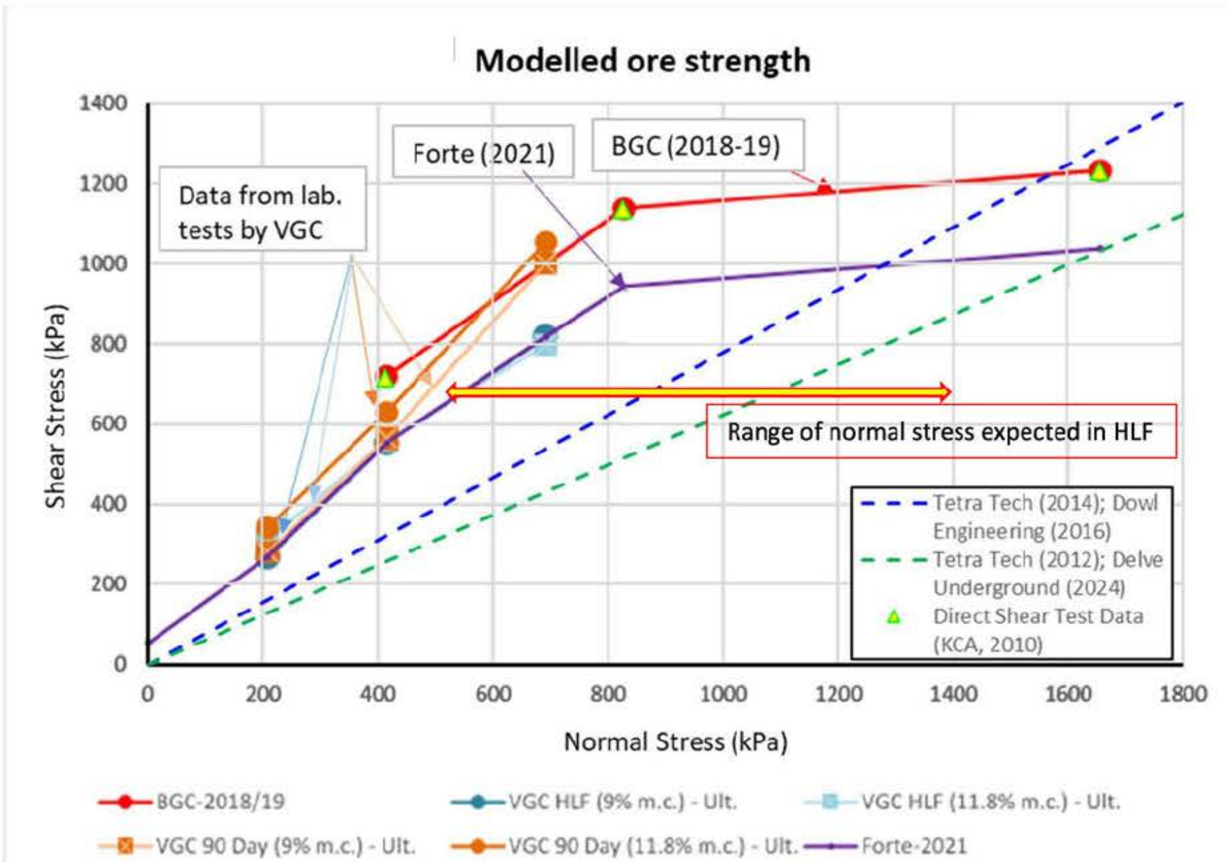


Figure 28: Plot of modelled ore strength in previous analyses

5.3.4 Liner interface

Several of the reviewed reports have noted that the weakest interface within the lining system is between the GCL and the overlying double textured 2 mm thick LLDPE geomembrane. A series of tests and studies were conducted on the liner interface of the HLF between the considered critical interface and other interfaces (GCL to sub-grade and textured HDPE to ODF). Prior to laboratory tests, Tetra Tech (2012) modelled a cohesionless interface with 22 degrees of friction angle.

Golder Associates performed a direct shear test on a GCL sandwiched between 1.5-inch minus gravel below and remolded silt underliner fill above (presented in Tetra Tech, 2014). GCL/silt interface was found to be the weakest layer, with peak and residual friction angles of 33.2° and 14.3° respectively. These values were then used in a bilinear function of shear strength in Tetra Tech's (2014) and Dowl Engineering's (2016) analyses.

In 2018 and 2019, BGC performed 2 rounds of further testing on a 4-layer liner system with poorly graded gravel (GP) overliner fill interface with LLDPE geomembrane, and furthermore the GCL (manufactured by GSE) interface with silt sand with gravel (SM) subgrade (BGC, 2018 & 2019). The weakest interface was determined to be between GCL and geomembrane. Between these 2 rounds of testing, the Solmax geomembrane used in the 2019 testing was found to have a lower interface strength with GSE GCL than when compared to the geomembrane manufactured by Layfield. BGC (2019) believed that the difference was due to rougher texture on the Layfield Environliner. It was noted that at 800 and 1600 kPa normal stress, failure within the GCL was observed (the double stitching failed).

In subsequent reporting by Forte (2021), BGC's testing data in 2019 was used as the modelled liner interface shear strength for Phase 1A of the HLF. Testing with Environliner geomembrane in lieu of Solmax geomembrane against GSE CGL was also performed for Phase 1B, giving slightly higher shear strength at lower normal stress; and lower shear strength at higher normal stress. It was understood from Forte Dynamic's reporting that the testing results were used as shear-normal functions in the slope stability models.

In reviewing all laboratory testing data, the shear strength between non-woven geotextile and geomembrane suggested by Dixon and Jones (2003) appeared to be applicable at low normal stress below 400 kPa. A bilinear strength envelope with friction angle of 12 degrees for normal stress higher than 400 kPa was considered conservative based on the tested peak strengths. Although it was observed in the 2019 BGC testing that GCL failed in addition to the GCL to geomembrane interface, it was unsure whether the low internal shear strength of bentonite within the GCL, as reported in the conformance tests, would be mobilized. Nevertheless, it was considered shearing of the GCL to geomembrane interface would occur prior to the rupture of the GCL and subsequently shearing of the bentonite within the GCL. Thus, a friction angle of 12 degrees was considered above a normal stress of 400 kPa. Details of liner interface used in each analysis was summarised in Table 9 and plotted on Figure 29 below. Brands of interface material tested and used for construction was also compared in Table 10 and Table 11. It was noted that none of the combinations tested reflected what was installed on site (i.e., a Layfield manufactured 2 mm thick LLDPE geomembrane to a Solmax manufactured GCL).

Table 9: Parameters Adopted for Liner Interface

Analyses	Unit Weight (kN/m³)	Model	Cohesion (kPa)	Friction Angle (°)	Notes
Tetra Tech (2012)	12	Mohr-Coulomb	0	22	Considered conservative based on Leps (1970) before testing data was available
Tetra Tech (2014) Dowl Engineering (2016)	12	Bilinear function, see plot below			Based on large displacement (post-peak residual) test results by Golder (2013)
BGC (2018), BGC (3D) (2019)	12	Peak: Mohr-Coulomb with cohesion of 35 kPa and friction angle of 26.6° Residual: Bilinear function, see plot below			Design envelopes based on direct shear test results from BGC
Forte Dynamics (3D) (2021)	12	Shear-Normal function following laboratory testing data for both peak and residual, see plot below			Directly adopted testing data: Phase 1A: Based on 2019 BGC testing Phase 1B: Further testing with Enviroliner geomembrane
Delve Underground (2024)	12	Peak: Bilinear function, see below: For normal stress lower than 400 kPa: cohesion of 6.9 kPa and friction angle of 25.8° For normal stress higher than 400 kPa: Friction angle of 12° Residual: Mohr-coulomb; Cohesion of 3.6 KPa and friction angle of 13°.			Peak: For normal stress lower than 400 kPa: Recommendations from Dixon and Jones For normal stress higher than 400 kPa: Based on laboratory testing data Residual: Based on Dixon and Jones.

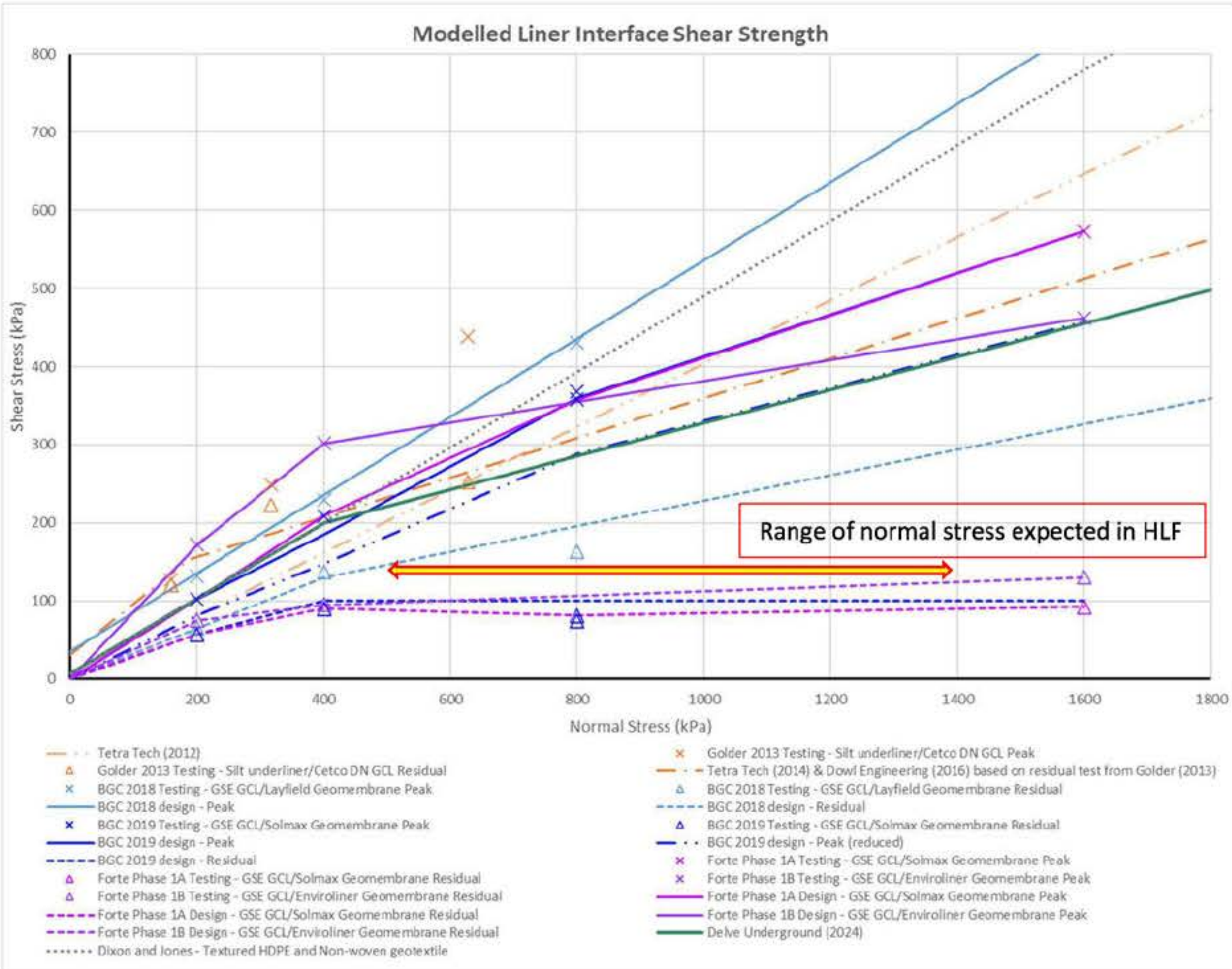


Figure 29: Modelled Liner Interface Shear Strength

Table 10: Brands of interface material used for construction

Interface Component	Phase 1A (1) (below 990 level)	Phase 1B (2) (above 990 level)	Phase 2 (2) (planned)
Geomembrane	Solmax LLDPE	Layfield Enviroliner LLDPE	Layfield Enviroliner LLDPE
GCL	Solmax Bentoliner NW Peel 60		

Note:
(1) from Construction Summary Report for HLF Phase 1A (BGC, 2019)
(2) from Detail Design Report for Eagle HLF Phase 2 (Forte, 2021)

Table 11: Brands of interface material used during testing

Interface Component	2013 Golder	2018 BGC	2019 BGC	Forte 1A	Forte 1B
Geomembrane	N/A (silt) (1)	Layfield Enviroliner LLDPE (2)	Solmax HDPE (3)	Solmax HDPE (4)	Layfield Enviroliner LLDPE (4)
GCL	Cetco DN (1)	GSE BentoLiner NWL-60 (2, 3, 4)			

Note:
(1) Heap Leach Facility Detailed Design (Tetra Tech, 2014)
(2) Eagle Gold Heap Leach Facility Slope Stability Analysis Update (BGC, 2018)
(3) Eagle Gold Heap Leach Facility – Ore Pile Stability Analysis Update (BGC, 2019)
(4) Detail Design Report for Eagle HLF Phase 2 (Forte, 2021)

5.4 Summary of Shear Strength Parameters Used

The parameters adopted in the analyses performed for the purposes of this report are presented in Table 12 below.

Table 12: Summary of Parameters Adopted

Unit	Unit Weight (kN/m³)	Model	Normal Stress Range (kPa)	Cohesion (kPa)	Friction Angle (°)	Notes
Embankment Dam	21.5	Mohr-Coulomb	(all)	0	38.3	Adopted parameters suggested by BGC
Colluvium	22	Mohr-Coulomb	(all)	0	28	Conservative estimate
Ore	18	Mohr-Coulomb	(all)	0	32	Conservative estimate based on grain size distribution of ore
Liner Interface	12	Shear/Normal Function	0 – 400	6.9	25.8	Based on Dixon and Jones (2003)
			>400	-	12	Based on peak values from interface shear strength testing

Unit	Unit Weight (kN/m^3)	Model	Normal Stress Range (kPa)	Cohesion (kPa)	Friction Angle (°)	Notes
Liner Interface	12	Mohr-Coulomb	(all)	3.6	13	Residual Conditions based on Dixon and Jones (2003)
Subgrade bedrock	Infinite strength					Failure through bedrock not assessed

6.0 Slope Stability Analysis

6.1 Mode 1 - Subgrade Failure

6.1.1 Mode 1A – Subgrade – Bedrock Instability

Failure of the subgrade in rock (Mode 1A) was considered unlikely in Section 4.1. As no assessment of failure through the bedrock was considered necessary, the strength of the bedrock layer below colluvium was set to infinite in each of the models assessed.

6.1.2 Mode 1B – Subgrade – Colluvium Instability

Based on the failure geometry, it was considered that the failure surface did not initiate at the colluvium layer. This was supported by observation on site that part of the liner remained and was observed on site post-failure.

However, it could not be ruled out that the failure surface may propagate through subgrade colluvium. Instead of assessing the stability of the colluvium layer as a stand-alone failure mode with a failure surface purely through the colluvium layer, a 5 m thick layer of colluvium was modelled in each of the models assessed as described in Section 5.2.1.

It was observed in some of the models that the base of some of the failure surfaces modelled reached the colluvium layer when the liner above was modelled with a similar strength. Yet, this was considered as a slide slope lining failure (to be discussed in Section 6.3.2 below) that propagates through colluvium, rather than a failure due to insufficient strength of the prepared subgrade or in-situ colluvium.

6.2 Mode 2 – Lining Failure

Lining instability due to slip failure along the interface between LLDPE and GCL (Mode 2B), and the interface between over-drain gravel and LLDPE (Mode 2C), and slip failure within GCL (Mode 2D) are discussed in subsections 6.2.1 to 6.2.3 respectively. Based on the discussion in Section 4.2, lining Instability due to hydraulic uplift (Mode 2A) is considered unlikely. Nevertheless, an assessment was performed and is presented in subsection 6.2.4.

6.2.1 Mode 2B – Lining Failure along the interface between LLDPE Geomembrane and GCL

Failure along the LLDPE Geomembrane/GCL interface was assessed in all 3 sections (refer to Figure 26) with assumptions laid out in Section 5.0. Results are summarized in Table 13. All analysis methods showed similar calculated FoS, and FoS calculated from GLE / Morgenstern-Price method were presented thereafter unless otherwise specified.

Table 13: Summary of Results for Mode 2B - Failure Along LLDPE/GCL Interface

Modelled Section	Section 1	Section 2	Section 3	Section 1A
Min. FoS achieved (Peak conditions)	1.66	1.35	1.71	1.39
Min. FoS achieved (Residual conditions)	1.14	1.11	1.47	1.01

With an overall minimum FoS of 1.35, it was demonstrated that the side slope lining system would not fail under normal conditions. It was considered that failure along the LLDPE/GCL interface alone was not the cause of the HLF failure based on the peak shear strength conditions assumed. However, some observations regarding the failure geometry were made in these analyses.

In Section 2, the critical failure surface was observed to pass through the liner interface entirely. In Section 1 & 3, the critical failure surfaces were observed to pass through the liner interface, and then through the colluvium underneath the liner. These indicated that the failures along the side slopes may have ruptured the liner and reached the subgrade colluvium locally and scoured part of the embankment dam on the west side. These observations coincided with that torn liners were observed on site, and that the embankment dam was partly scored as concluded from the post-failure geophysics survey near the embankment dam (Forte, 2024).

It is noted that if residual conditions are used in some cases a factor of safety just above unity is found.

The sensitivity of this model was tested with respect to the ore unit weight, acknowledging that frozen ore above the saturation surface might have a slightly higher unit weight depending on the interstitial space volume occupied by frozen pore water pressure. It was noted that in peak conditions if the ore was assumed to be frozen (with a unit weight of 22 kN/m^3) then on average the factor of safety decreased by 5%. We therefore consider the effect of frozen ore as a contributing factor to stability, but not a major one.

6.2.2 Mode 2C – Lining Failure along the interface between LLDPE Geomembrane and Drainage Gravel (ODF)

As discussed in Section 4.2, Mode 2C was considered likely if the liner interface were to freeze. Based on observations concluded in Section 2.4, the possibility of the interface being frozen due to ore stacking in cold temperatures could not be ruled out. The effects of freezing temperatures on the interface shear strength between GCL and geomembrane was found to be negligible by Paruchuri (2011) through 66 direct shear tests. Thus, this was not discussed in Section 6.2.1. Though it was believed that repeated freeze-thaw cycles could reduce the shear strength of soil, the effect of cold temperatures on soil/geomembrane interface was not vastly studied.

Under normal conditions, the friction angle of the interface between LLDPE geomembrane and the drainage gravel layer is considered to be about 30 degrees (i.e. a few degrees less than the internal angle of shearing resistance of a gravel). A series of analyses were performed to understand what reduction in shear strength at this interface would lead to a failure if this interface were to freeze.

In this series of analyses, the liner interface was assumed to be saturated with leachate, as the drainage capacity of the drainage gravel layer would be reduced when frozen. A 10 m phreatic head above the liner instead of 1 m was used to reflect reduced leachate drainage, while the in-heap pond level remained unchanged at 938 m elevation. The friction angle of the interface was decreased from 30 degrees until an FoS close to 1 was achieved. Results are summarized in Table 14.

Table 14: Summary of Results for Mode 2C - Failure Along LLDPE/drainage gravel interface

Modelled Section	Section 1	Section 2	Section 3	Section 1A
Min. friction angle (degrees) required for failure	12	15	8	15

Sensitivity analysis was also performed with 30 m and 2 m phreatic head above the liner at Section 1. It was concluded that the maximum friction angle for failure would lie between 10 (2 m phreatic head) and 16 (30 m phreatic head) degrees. Sensitivity analysis was also performed a higher unit weight of the ore (21 instead of 18 kN/m^3), but no significant change in the results was observed.

It was concluded that in the condition where the drainage was partly impeded by a frozen drainage layer, an interface with friction angle of about 8-15 degrees would lead to failure of the ore above. However, further testing is needed to confirm whether the shear strength of such interface between frozen gravelly soil and LLDPE geomembrane would fall in a similar range.

6.2.3 Mode 2D - Lining instability due to slip failure within lining system (GCL)

As discussed in Section 2.2 and 4.2, the presence of normal pressure above the GCL would be crucial in determining whether slippage along the GCL would be feasible.

A model was set up as described in Section 5.0, with the shear strength of the lining system reduced at the locations indicated by Table 3. The modelled section is shown in Figure 30.

A cohesionless interface with a friction angle of 10 degrees was set at the locations shown in red, representing locations where the GCL has been left for a significant time prior to covering with the ODF. It is recognized that without needle stitching a fully hydrated GCL would have a shear strength represented by an angle of internal shearing resistance of between 6 and 8 degrees. By modelling this interface at 10 degrees it is acknowledged that some needle stitching might still be intact.

A FoS of 1.03 resulted, indicating that the HLF would be marginally stable if all of the GCL along these exposed sections were hydrated. It was concluded that hydration in the GCL could be one of the factors contributing to the failure.

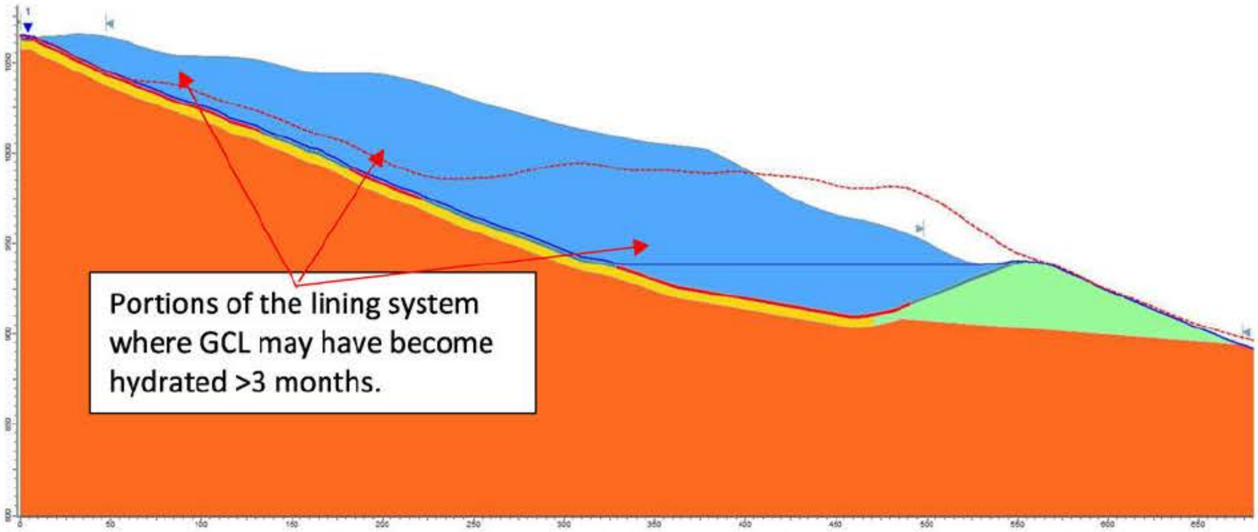


Figure 30: Portions of the lining system exposed for >3 months along Section 1A

6.2.4 Mode 2A – Lining instability due to high groundwater pressure

Despite being unlikely in the initial assessment as discussed in Sections 2.12 and 4.2, build-up of groundwater pressure resulting from a failure in the under-liner drainage system was assessed through a series of analyses.

A pore pressure grid with pressure head was used to model heterogeneous phreatic conditions above and below the lining system: the undissipated groundwater pressure underneath the lining system, and a lower phreatic head above the lining system. The pore pressure grid consists of 4 arrays of pore pressure grid points. Array 1 sets a gradual build-up of the undissipated groundwater pressure underneath the lining system from mid-slope to the lower part of the slope, while array 2 sets a constant (1 m) phreatic head above the lining system. Arrays 3 and 4 models the phreatic conditions of the in-heap pond such that the pore pressure modelled is equivalent to that described in Section 5.2.2. Kriging was adopted as the interpolation method between the pore pressure grid points. An example setup of the arrays is shown in Figure 31.

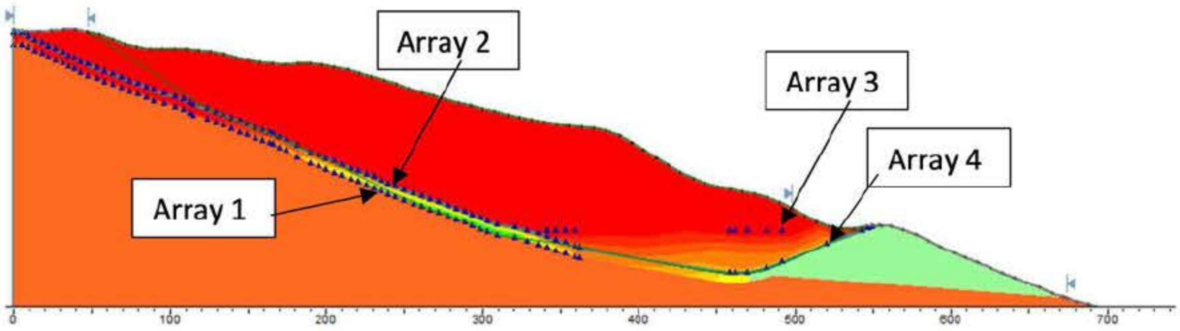


Figure 31: Example of pore pressure grid points in Section 1A

A groundwater pressure build-up of 75 m was assumed and Sections 1A, 1 and 2 were analyzed and the results are summarised in Table 15 below.

Table 15: Summary of Results for Mode 2A - Lining instability due to hydraulic uplift (basal heave)

Modelled Section	Section 1	Section 2	Section 1A
Min. FoS achieved	1.62	1.36	1.42

It appears from the results that such phreatic conditions alone would not be sufficient to cause failure in the HLF. A sensitivity test was performed at Section 1A using a triangular loading applied to where maximum pore pressure was anticipated underneath the lining system, pointing upwards to simulate the uplift force from the pore pressure. However, though the FoS achieved was reduced to around 1.37, a failure in such condition would still not be anticipated. An additional sensitivity test was performed with increasing the magnitude of the pore pressure build-up from 75 m to 100 m and 125 m. Although a failure could result with a pore pressure build-up of 125 m, it was considered that such a high pore pressure build-up is unlikely on the basis that flow was still recorded by the UMV as discussed in Section 2.11 and that under drainage piezometers did not show pressure build up.

6.3 Mode 3 – Ore Failure

Based on the discussion in Section 4.3, all three modes of failure in the ore are considered likely and should be assessed. This section details observations from the analysis of each failure mode in the ore.

6.3.1 Mode 3A – Ore failure due to increased piezometric level

With the knowledge that the leachate drainage system might not be functioning at its full capacity, it was investigated whether a failure could be initiated with elevated piezometric levels. A series of analysis was performed to understand what would be the piezometric level required to lead to a failure.

In this series of analyses, models were set up as described in Section 5.0, except for the piezometric levels. The phreatic head above the liner was increased from 1 m to 60 m, while the in-heap pond level remained unchanged at 938 m elevation, until an FoS close to 1 was achieved. Results are summarized in Table 16.

Table 16: Summary of Results for Mode 3A - Failure due to Increased Piezometric Level

Modelled Section	Section 1	Section 2	Section 3	Section 1A
Min. piezometric level (m above liner) required for failure	>60	83	>100	>70

Based on the results presented in Table 16, a high piezometric level of 60 to 100 m, which is almost equivalent to the entire HLF being saturated, would be required for the HLF to fail. Given that the leachate circulation was monitored daily, and that the ODF piezometer did not show elevated readings, such conditions are considered unlikely. Thus, it was concluded that elevated piezometric level alone would not be sufficient to cause the HLF to fail.

6.3.2 Mode 3B – Ore failure due to perched water tables

Based on the observations in Section 2.4 and discussions in Section 4.3, it was investigated whether a complex groundwater regime, caused by placement of ore in winter, would lead to a failure. Locations of where ore was placed in sub-zero temperatures between June 2021 and June 2024 (down to 1017 level) were plotted onto the 3 analysis sections and are presented in Figure 32 to Figure 34 below. Yellow lines on the section represent the base of the ore lift placed in sub-zero temperatures.

Perched water tables were created at these locations, sloping 6 degrees from 0 m phreatic head on the sides up to a maximum height of 2/3 of the height of the ore lift. These perched water tables were then applied to the ore lift at the same elevation and were repeated for each ore lift. Results from the models with perched water tables were then compared to a control model without perched water tables (i.e., with groundwater conditions set out in Section 5.2.2). Similar FoS was observed in both models.

Since the locations presented in Figure 32 to Figure 34 did not include ore placement prior to June 2021 (i.e., below 1017 level), a sensitivity analysis was performed on whether the existence of perched water tables in the 4 previous levels (1005, 994, 984, 974 levels) would lead to a failure. The factor of safety found for the three sections differed less than 6% from those reported under 'normal' conditions and presented in Table 13 for Mode 2B. On the basis that similar results were found, this indicates that the HLF stability is not sensitive to a series of perched water tables and complex groundwater regime.

It should be noted that these analyses assumed that the shear strength of the ore placed in sub-zero temperatures would be equivalent to that placed under normal conditions, discounting the potential beneficial effect of increased shear strength in the ore due to freezing.

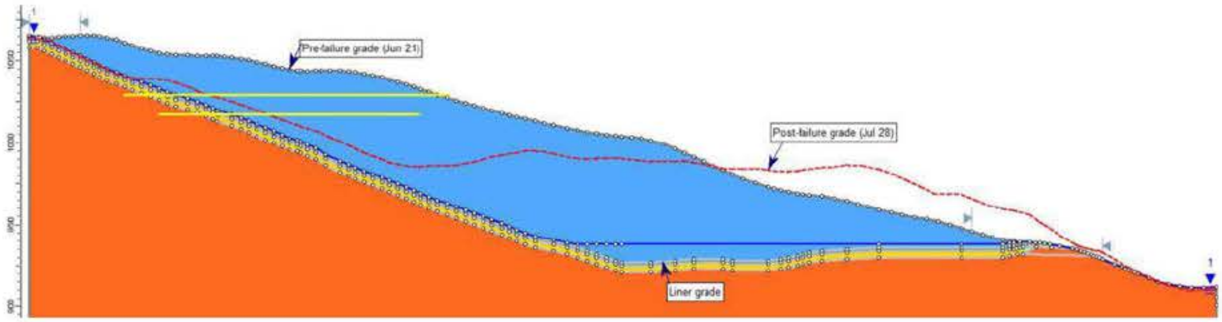


Figure 32: Location of ore placed in sub-zero temperatures on Section 1

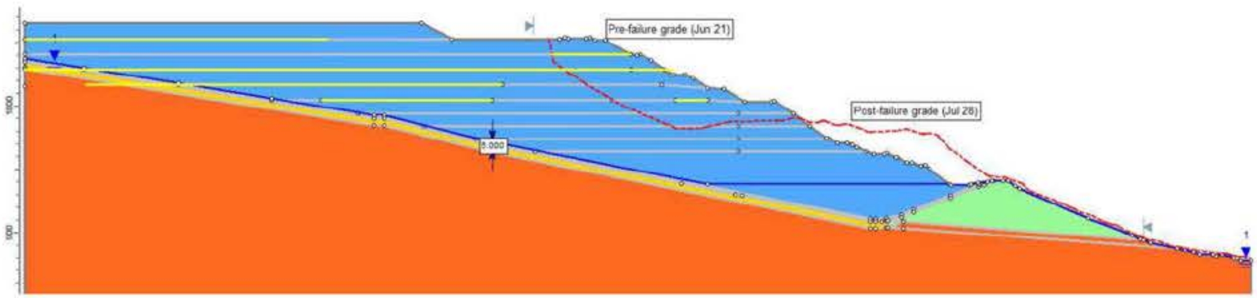


Figure 33: Location of ore placed in sub-zero temperatures on Section 2

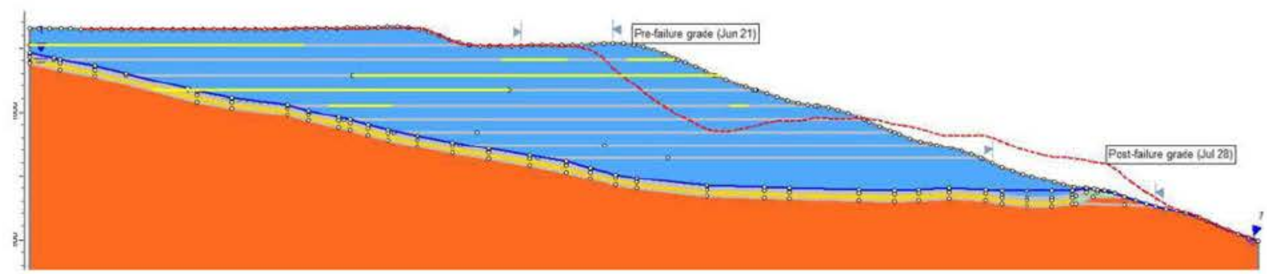


Figure 34: Location of ore placed in sub-zero temperatures on Section 3

6.3.3 Mode 3C – Ore failure due to hydrostatic uplift pressures

Based on the discussion in Section 4.3, it was assessed whether hydraulic uplift would possibly lead to a failure in the HLF. As previously mentioned, the authors of this report acknowledge that this mechanism is somewhat unique.

Similar to the setup as described in Section 6.2.4, pore pressure grid with pressure head and kriging interpolation between grid points was used to simulate such unique phreatic conditions in the ore. Instead of a gradual build-up of groundwater pressure beneath the lining system, a constant groundwater pressure (5 m pressure head) was applied to the base of the colluvium subgrade layer. In order to model an impeded drainage within the ore due to frozen ore, an impermeable block was assumed mid-slope (using grid points with 0 pressure head). Build-up of pore pressure was modelled by arrays of pore pressure grid points up-gradient of the impermeable block. It was then assumed that such build-up of pore pressure remained constant between the impermeable block and the lining system, until the pore pressure was released downslope in the ore. Such a pore pressure regime was illustrated in Section 4.3 and an example of the pore pressure setup is shown in Figure 35 below.

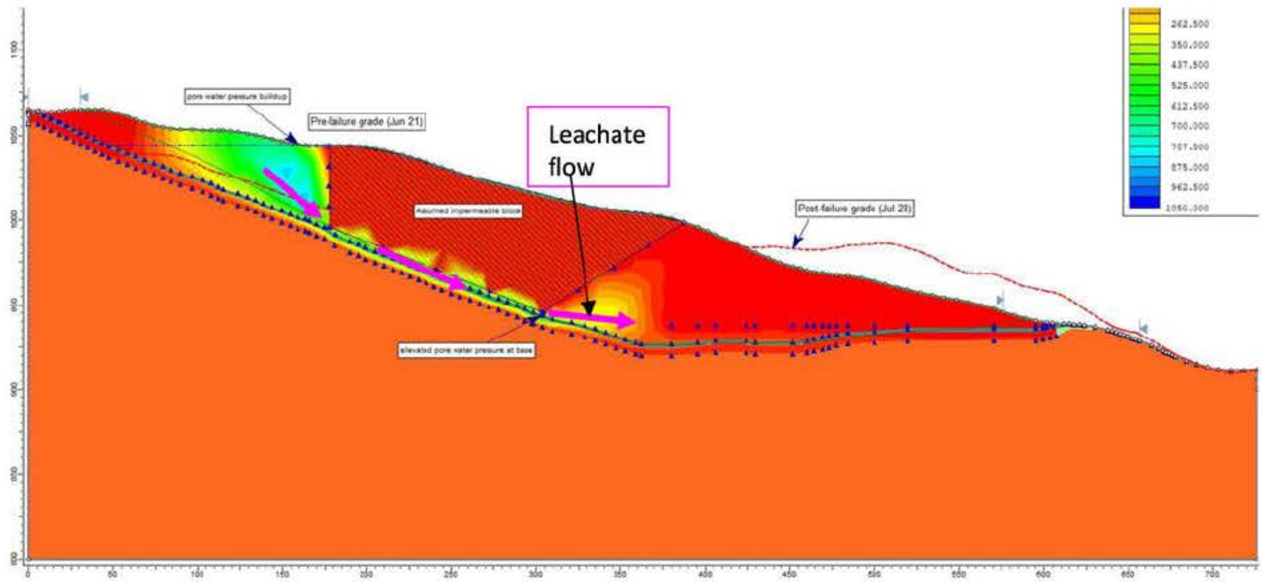


Figure 35: Example model setup for Failure Mode 3C in Section 1

Sections 1A, 1 and 2 were first analyzed with an assumed 70 m pore pressure build-up. It was observed that marginal stability (FoS ≈ 1) was achieved at Section 1A. The pore pressure build-up at Section 1 & 2 were then increased to assess what pore pressure build-up would be needed for the section to achieve marginal stability. Results are summarised in Table 17 below.

Table 17: Summary of Results for Mode 3C - Ore failure due to hydrostatic uplift pressures

Modelled Section	Section 1	Section 2	Section 1A
Min. FoS achieved with 70m pressure build-up	1.23	1.09	1.01
Pore pressure build-up needed for failure	>100 m	85 m	70 m

Similar to Mode 3A, it was concluded that a pore pressure build-up of 70-100 m in the ore would be needed for the HLF to fail. This would be comparable to the entire thickness of ore upstream being saturated. Such conditions were considered unlikely.

6.4 Mode 4 – Containment Berm Failure

6.4.1 Mode 4A – Failure of the containment berm

Despite the observations by Forte (2024) on the embankment dam, the stability of the embankment dam was assessed by including the embankment dam in the ground profile of the model discussed in Modes 2 and 3 and allowing failure surfaces to pass through it during analyses. In all models, none of the failure surfaces which pass through the embankment dam were found to be the critical failure surface as a higher FoS was calculated. Thus, it was concluded that failure of the embankment dam was unlikely the cause of the HLF failure.

6.5 Pseudo – 3-Dimensional Analysis

Section 5.0 of this report notes that a three-dimensional aspect to the HLF stability setting might exist and as a consequence Section 1A was prepared to partially verify this conclusion. In order to further verify the three-dimensional aspect recommendations for further analysis using a limit equilibrium-based 3D approach, or a 3D finite element modelling method, have been made (refer to Section 11.0).

In the interim and to further understand the global three-dimensional forces within the slope prior to failure, the program S-Wedge (Build 7.023 64bit) was used. In this case the north-west steeply dipping lined slope was modelled as a joint plane, the failure along the backscarp (trending as a planar feature, steeply dipping towards 210°) was modelled as a second joint plane. A basal plane essentially formed the base of the failure. Although simplistic, extensive sensitivity analyses were undertaken to assess differing shear strengths and application of pore water pressures on the various planes potentially forming the 3D wedge failure. Unfortunately, this approach did not result in a combination of factors that adequately replicated in a satisfactory manner either the 2D analysis nor the observations on site (physical and instrumentation).

While it must be appreciated that S-Wedge is not an ideal tool for assessing the HLF failure in 3 dimensions (it is normally applied to jointed rock masses) it was considered necessary to test the potential for a 3D influence on the failure using a simplistic approach. , It is still recommended that three-dimensional analysis (for example, using Slide 3) is used to assess the stability of the HLF, to assist in further validating the conclusions made in this report.

6.6 Supplementary Analyses

6.6.1 Background

It was considered important to undertake additional illustrative analyses to perform a preliminary assessment of:

- The potentially complex pore water pressure regime within the ore body as a result of the presence of frozen layers. This was achieved via high-level finite element seepage analyses with infiltration of barren solution into the ore body. The analyses above adopted assumptions with regard to pore water pressures conditions at boundary edges (with Kriging being applied to interpolate between those boundary conditions).

- The potential role of co-variations of multiple parameter values (shear strengths and pore water pressures). This was achieved via a single model adopting probabilistic ranges of variables.

The illustrative analyses were undertaken using the package GeoStudio V2024.2.0 (GEOSLOPE International Limited, 2024) and were carried out on Section 2.

6.6.2 Illustrative Seepage Analyses

As previously noted, there is evidence that both the ore and the ODF have frozen zones because of placement in sub-zero temperatures. Without extensive intrusive investigation works across the top surface of the HLF, the positions of these frozen layers are open to conjecture, but it may be valid to assume that they may occur more extensively i) at relative shallow depths below the top surface and ii) towards the outer slope of the structure. However, it is possible that permanently frozen layers will exist deeper and further back into the ore mass - there is evidence of frozen layers within tailings dams at significant depths within cold climate zones.

Figure 36 presents the illustrative seepage model that includes the following elements (adopted hydraulic conductivity values, k, are presented for each element):

- The ore and ice layers within this material coincide with ore lift elevations. The horizontal extent of the ice layers can be varied within the model to examine variability in proximity to the front face (i.e. downstream slope of the HLF) and the rear boundary where the lining system is present. k=

- The ODF layer.

- A row of interface elements representing the LLDPE/GCL very low permeability composite liner.

- The colluvium.

- The bedrock.

- The hydraulic boundary condition infiltration rate (equivalent to the application rate of the barren solution).

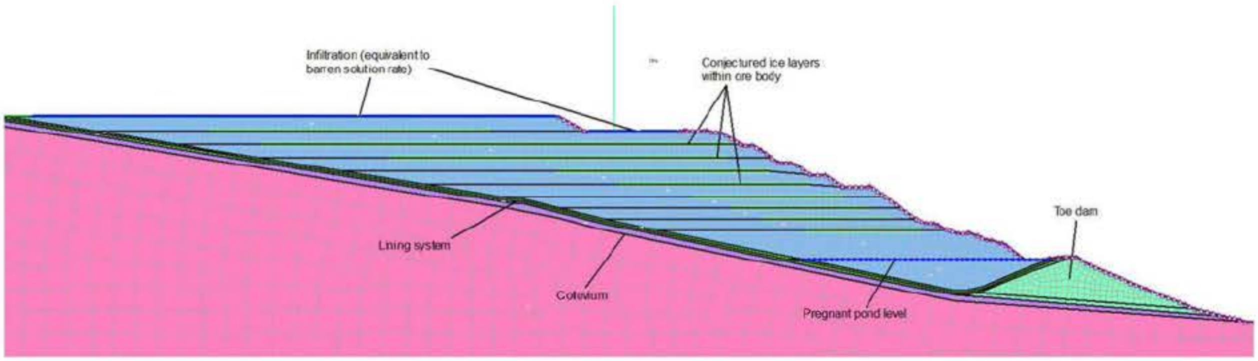


Figure 36: Seepage model with conjectured frozen layers within the ore, Section 2

For the purposes of the illustrative analyses, a simplistic steady state, as opposed to transient, seepage model was adopted. Figure presents the pore water pressure contours and confirms:

- The derivation of a complex pore water pressure regime with perching on ice layers.
- The development of a zone of high pressure at the rear of the lining system, with the highest pressures being present towards the top of the slope.

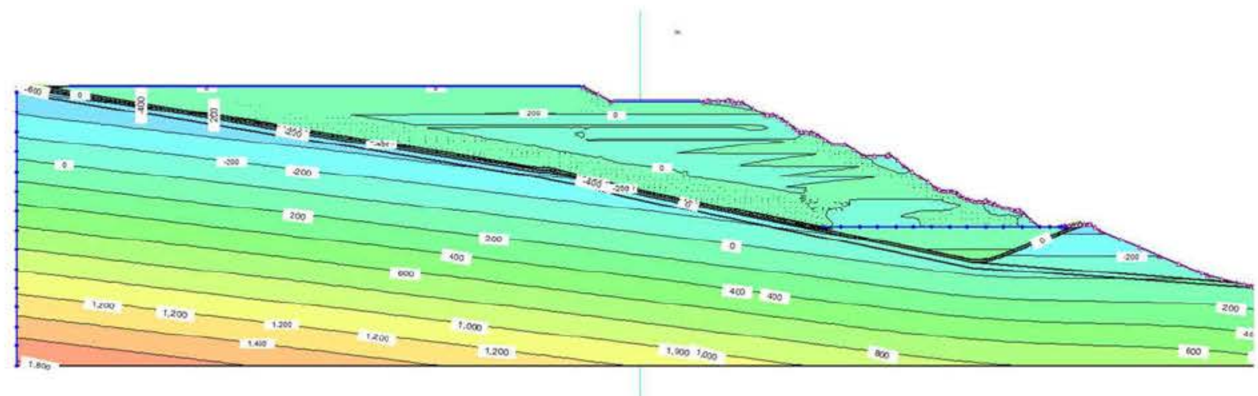


Figure 37: Pore water pressure contours from illustrative seepage analysis, Section 2

6.6.3 Illustrative Probabilistic Stability Analyses

In common with other failures of mine waste storage facilities, it is sometimes difficult to define a single definitive factor that initiated the failure. Section 7 of this report categorises contributory factors as being minor, potential or major. However, it is recognised that there are potential combinations of factors that may have tipped the balance towards the failure condition, and that without such interactions the facility might not have failed i.e. a single major factor might not have been sufficient to initiate the failure.

An illustrative probabilistic analysis on stability Section 2 has been undertaken. It is important to emphasise here that this does not imply that we believe the failure initiated along that section line - it has been selected for illustrative purposes only.

The analysis allows concurrent variations to be made in shear strength and pore water pressure conditions using the Monte-Carlo approach. The number of simulations was set at 20,000, each trial having a unique set of shear strengths and pore water pressure values within the ranges of credible values assigned to those variables.

The following factors were varied within what were estimated to be credible ranges for the purposes of the analysis:

- The pore water pressure regime derived from the illustrative seepage analysis summarised above. Maximum and minimum deviations from the baseline results were +300kPa and -100kPa.
- The friction angles applied to the various materials and/or interfaces present within the stability model. The minimum and maximum values adopted were as follows:
    - Colluvium: 22° to 32°.
    - GCL internal friction angle (taking into account the potential for hydrations and destruction of stitching): 10° to 22°.
    - ODF to LLDPE: 23° to 30°.
    - Heap leach ore: 24° to 34°.

The variations in values were defined by probabilistic sampling functions based upon; i) the estimated mean values for each variable, and, ii) deviations from the estimated mean values according to estimated standard deviations from the mean in accordance with a normal distribution profile.

Based upon the foregoing ranges in values, the probability of failure of the structure was determined to be 11.3% - i.e. there was a greater than 1 in 10 probability that failure would occur. Figure 38 provides a summary of the probabilistic analysis results.

It is important to note that the probabilistic analysis was undertaken for illustrative purposes only. Back-up to the adopted ranges in values for specific variables would need to be determined via field and laboratory testing.

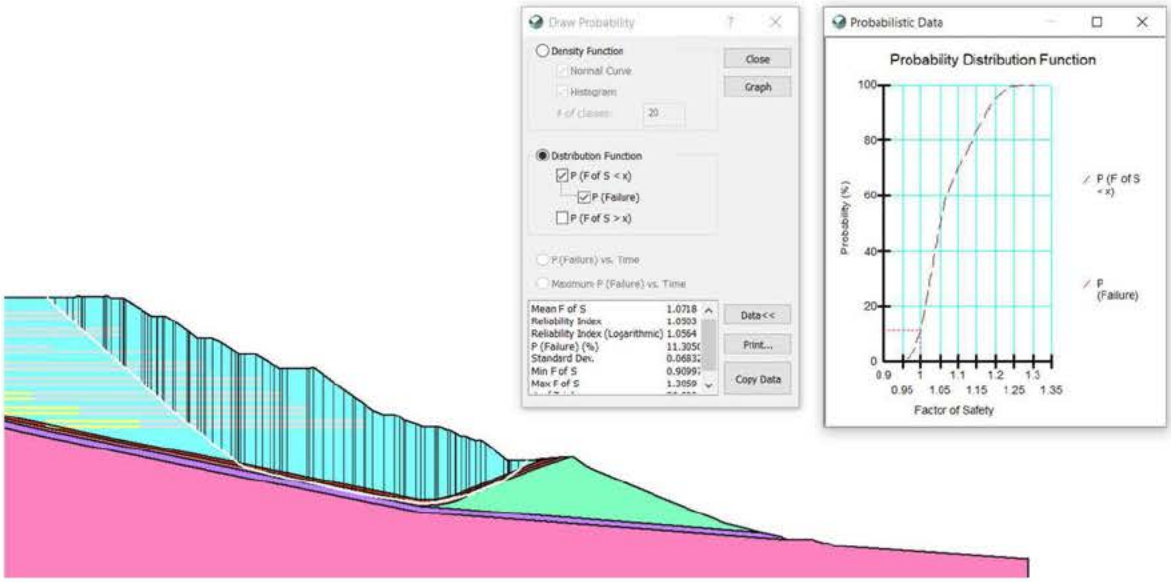


Figure 38: Critical slip surface and probability distribution function

7.0 Discussion of Results

This section of the report discusses the results of both the analysis and the assessment and implications of the background review. We have split this section into factors or issues that are not considered to contribute to the HLF failure, factors and issues that might have had a minor contribution and finally the factors that we consider have directly contributed to the failure.

7.1 Non-Contributory Factors and Issues

The following key points summarize the analysis results:

- A sub-grade failure within the bedrock has been ruled out as a result of the preliminary screening process.

- A sub-grade failure within the colluvium was initially screened out but was subsequently analyzed as a precautionary approach.

- Failure of the containment berm did not occur based on our analysis and observations on site by Forte within the gullies formed within the slide mass material.

- A seismic induced failure has been ruled out as there were no earthquakes at the time. Minor earthquakes less than magnitude 2.8 have been reported in the area in the years prior to the failure.

- Delve Underground have purposefully used more conservative parameters in terms of the expected design ore shear strength and the interface shear strength parameter values, yet the HLF is stable under various sensitivity analyses within these reasonably expected ranges.

- The leachate level assumed in the design report models is 1 m above the liner at the base of the HLF. Our modelling showed that this would need to be increased to an elevation of 60+ m before a factor of safety of less than 1 might occur. Such a high elevation would probably have been observed either in the Phase 1B horizontal ODF piezometer, possibly as an increase in the level of the in-heap pond and possibly with a surface expression of seepages towards the toe of the HLF. These indications of a high leachate level were not observed.

- Placement of frozen ore might have led to various perched water tables within the HLF that led to a lower stability. This hypothesis of failure was tested in the modelling and showed that even with 5 or 6 such perched water tables the HLF was stable. However, a high-level approach was necessarily adopted since knowledge of potential contractive behavior, possibly induced by an increase in void ratio due to freezing conditions, is not available. This possible phenomenon has been discussed previously within this report and remains an unknown that warrants further attention.

- A failure induced by confined groundwater pressures alone has been ruled out on the basis that under-drainage appeared to be working, and a review of the under-drain piezometer data showed nothing unusual. It is acknowledged that the piping forming the underdrainage might have been under-designed but was apparently functioning, and that the gravel within the under-drainage trench would also function as a drain. Furthermore, very little rain was experienced in June that might have led to the under-drainage system being at an over-capacity. Historically the underdrainage system was able to manage 600 m^3/day at the peak flow which occurred in August 2020.

  We observe that the post slide failure topography differs from one which might occur if a sub-grade excess pore water pressure failure had occurred due to under-drain blockage. Although conjectural by the authors, the shape of the backscarp in such that a confirmed excess groundwater regime might have been in an east-west direction and possibly semi-circular. This report has demonstrated that, based on the linear and extensive backscarp, the location of the failure is down the western side slope (refer to Figure 23).

In overview, the results of the limit equilibrium analysis show that the HLF was stable under normal conditions in respect of any single contributory factor listed above alone. On the basis of the foregoing assessment of the most probable and logical HLF failures, the conclusion reached is that the failure at Victoria Gold was somewhat unique to the site and the condition and construction of the HLF.

7.2 Minor Contributing Factors

This section of the report therefore uses the assessments and analyses undertaken and discusses a number of potential contributing factors.

7.2.1 Ore lifts and outer slope

The original designers suggested 10 m lifts of ore not the 12 m lifts that were actually undertaken. BGC also recommended the outer slope be graded at 1V:2.8H not the steeper gradient of 1V:2.5H that was constructed. We note that these changes have an almost insignificant effect on the stability, but note it is a detrimental effect and potential very minor contributing factor.

7.2.2 Water balance modelling

The report has also shown that based on water balance modelling (and the time taken for the barren solution to run down to the in-heap pond through the mass of ore), the unsaturated hydraulic conductivity of the ore is on average around 5 x 10^{-5} m/s. The water balance modelling has also highlighted an unknown quantity of 1,000 m^3 per day of water is 'seemingly' being added to the HLF (after taking into account precipitation and ore moisture content). The source of this water is unknown although it may be due to instrumentation flow meter error.

7.2.3 Irrigation by barren solution

In the year prior to failure, the irrigation of the ore by the barren solution generally occurred at an average rate of 8.3 L/hr/m^2. The lowest irrigation value recorded was 7.3 L/hr/m^2 in the week ending 29th December, 2023, and as much as 9.4 L/hr/m^2. These values are considered well above the designed irrigation rate of 7 L/hr/m^2 and equate on average to approximately 300 m^3 of 'extra' (above the designed rate) leachate going into the HLF on an hourly basis. It is noted that the stability analyses are not sensitive to the level of leachate as a height above the liner system. Nevertheless, we have to question if this over application of barren solution was a contributing factor to the stability.

7.2.4 ODF gradation

Typically, drainage material should have a maximum of 6% fines (defined as the portion of material grading under 0.075 microns). The ODF gradation curves showed that this was only being achieved for some 12 out of the 37 samples taken for Phases 1A and 1B and that the geometric mean of hydraulic conductivity was 5.77 x 10^{-4} m/s (based on the percolation tests). In summary this was not a clean, free draining gravel and the assumed distribution of pregnant leachate lines might have been under-designed (or over-spaced) relative to the actual, placed conductivity of the ODF. The gradation makes the ODF more susceptible to freezing. This is unfortunate as the authors consider that simple screening at the borrow pit might have significantly reduced the amount of fines.

7.2.5 Failure of leachate collection system

This report has demonstrated that the corrugated 150 and 250 ABS HDPE pipes might have buckled and constricted the flow at the base of the heap leach above the geomembrane. Such a constriction or at least impediment to flow at the base of the heap leach is more likely to have resulted in higher pore pressures and the potential for both ore and ODF to have frozen. The stability analyses have almost all been based on a piezometric surface 1 m above the liner. On the basis that the leachate collection system might have failed, and given the ODF was potentially less hydraulically conductive than previously assumed, this is considered an under-estimate of the actual piezometric surface within parts of the ODF. Towards the base of the HLF, piezometers installed in the ODF were showing a piezometric head below that of 1 m. We therefore acknowledge that the majority of the collection pipework was probably functioning.

7.3 Potentially Contributory Factors

The authors of this report have struggled with the issue of placing ore in frozen conditions, the temperature of the ODF thermistor / piezometer (in 2023), the back analysis of the January 2024 failure, and on the balance how much of a contributory factor frozen conditions might have been to the failure. Our analyses have shown that if the interface between the ODF and the geomembrane was frozen then this could have had an impact on the integrity of the interface shear strength and on that basis failure for this reason may have occurred. Additional evidence might be forthcoming during restoration and remediation of the failure. A review of the ODF thermistor data showed that for two months in 2023 that the ODF was around 1 degree Celsius, a review of 2024 data has not occurred (as it is not available). If during remediation significant areas of frozen ODF and ore are found, with the potential observation that permafrost has become re-established within the sub-grade, then a re-evaluation of the frozen conditions will be warranted.

However, we have balanced these observations on the frozen ground conditions with those of known and well documented failure mechanisms involving geosynthetics. On balance, it is therefore considered that, without further evidence, the frozen interface conditions described above are a minor contributor to the failure. However, the frozen ore conditions, as described below, are considered to represent a potential major contributory factor in the overall failure.

7.3.1 Placement of the ore in freezing conditions

The review in this report documents the placement of ore in frozen conditions. We consider that the placement of the ore in such conditions could have led to frozen layers within the heap leach pad. Based on our review of the background documents very little is stated regarding the design and operation of the HLF during a cold climate. A review of the paper on cold climate heap leach facilities (Sinha & Smith, 2015) shows that the HLF at Victoria Gold was one of the coldest in North America in terms of average temperatures.

From a review of design documentation, it is implied that the initial placement of the ore would have created a thermal mass that in combination with heated barren leachate distribution and percolation, essentially warms any ore placed in freezing conditions. Having reviewed the timing of ore placement, we have to question if such a thermal mass ever existed. During remediation of the failure of January 2024, frozen ore and ODF were found, one therefore has to question where else frozen ore and ODF might exist.

Mode 3C assessed this type of failure and assumes that essentially there was an impermeable block of ore in the HLF (representing the frozen conditions). This failure hypothesizes that barren leachate distributed on top of this block would run down the drainage layer and cause high pore and groundwater pressures in the underlying unfrozen ore. Our analyses demonstrate that this is a substantiated potential failure mechanism.

7.3.2 Observations of the failure in January during remediation

The observations of the failure and damaged liner system following the January 2024 slide event showed that the failure was not superficial and just through the ore. The failure had propagated through the over-high slope and had connected with the liner system. It is unclear from the remediation construction records which interface of the liner system that the failure propagated along. What was observed at the time was frozen ODF and damage to the textured LLDPE and GCL liner. On the basis that the ODF was observed to be frozen we contend that the interface between the LLDPE and the frozen ODF was the weakest interface in terms of shear strength. A back analysis of this location shows that the interface (frozen ODF to LLDPE textured membrane) friction angle was potentially 20 to 22 degrees.

The observations of this failure show that the ore and the ODF were frozen, we therefore have to question how widespread such conditions were throughout the HLF. It has been noted elsewhere that both ore and ODF were placed in freezing conditions. It appears that the underlying assumption from the operators was that placement of ore could occur irrespective of freezing conditions (and the severity thereof), and that the barren solution and thermal mass of the HLF would thaw any moisture in the ore and allow successful percolation of the leachate. We contend that this was not the case and that layers of frozen ore were formed within the HLF.

7.3.3 Temperature of ODF piezometer

The temperature of the piezometer (albeit one single instrument) shows a very low temperature in the spring of each year, at 1 to 2 degrees above freezing. On the basis this instrument was in the lower part of the HLF where mass leachate flow through the drainage system was greater, it is considered more likely that the instrument remained unfrozen. In areas of the HLF where such mass flow was reduced (akin to the outer edges of the geomembrane cone which in this analogy drains the HLF down to the in-heap pond or the base of the cone), we have to question if the temperature remained above zero. On the balance, it is considered that the ODF in lower flow locations would have frozen. Evidently at the location of the failure in January 2024 frozen ODF occurred and is considered partly responsible for this smaller failure.

The analyses have shown that if one of the interfaces did freeze and reduced the shear strength to 15 degrees or less, failure of the north-west side slope would have occurred. Freezing of the ODF gravel against the textured geomembrane might have created such a low shear strength.

7.3.4 Latent re-establishment of permafrost

An unknown factor that should be considered is if permafrost removed during sub grade construction became re-established in the ground (colluvium and man-made fill) adjacent to the liner. If as stated elsewhere the ODF and ore was placed in a frozen condition, then certainly re-establishment of permafrost in the sub grade is considered more likely. If this was the case, then certainly the interface between the ODF and the textured LLDPE would also have been frozen.

7.3.5 Observation of frost on the inside of the geomembrane

Photograph 7 shows the presence of frost on the inside of the geomembrane. If the GCL were partially hydrated, then any moisture between the GCL and trapped by the geomembrane should be absorbed by the bentonite in the GCL. The observation of the frost potentially shows that the bentonite was fully hydrated at this location. The excess moisture in freezing temperatures then turned to frost. We question the interface shear strength with this frost or ice on the inside of the membrane, such ice if it were present might have reduced the effectiveness of the asperities forming the texture to the geomembrane. On the basis that for two months the ODF thermistor showed very low temperatures (1 to 2 degrees above freezing), and as concluded above might have frozen in lower flow locations, frost or ice might have formed underneath parts of the geomembrane on the north-west slope. The reduced shear strength might have been akin to a smooth geomembrane against a geotextile which in peak conditions is 10 degrees.

Although open to conjecture, the presence of this water as the HLF warmed in June and melted this interface of frost and ice, might have created localized areas where the GCL was not in contact with the geomembrane, and in combination with other factors initiated the failure.

7.4 Major Contributory factors

7.4.1 Interface shear strength

This report has commented upon the sensitive nature of geosynthetic interfaces to equipment loading. Based on the analysis, the integrity of the geomembrane should be questioned where ODF was placed in the planned lifts of 0.6 m thick on the steeper slopes. Without care and attention, the D6 bulldozer operator may have inadvertently reduced the interface shear strength to a post peak condition. This report has demonstrated that if a residual condition (or a condition where the interface reduced to 15 degrees or less) existed between the GCL and the textured geomembrane then failure would occur. We consider this an important and contributing factor to the instability.

The quality of manufacture of the texture forming the outer surface of the LLDPE geomembrane is not considered to be optimal for the geomembrane used at Victoria Gold. The fact that the liner was subject to severe cold temperatures, and on the slope where we contend failure originated the liner was on average not covered with ODF for 10.9 months, exposing the membrane to weather and climate, this might have contributed to a reduced interface shear strength.

The anecdotal evidence from [redacted] and others on site recount that the failure occurred very rapidly, this would suggest a brittle-type failure where peak to post peak strength and failure occurs. There is also the observation from the isopachyte comparison of pre and post failure contours, that appears to show an elongation towards the east and that although the backscarp propagated parallel to the slope the initial failure, we contend, was down the side slope. Such observations are indicative of an interface lining failure, and as a consequence, we consider that the interface shear strength of the lining system played a crucial part in the failure of the HLF.

7.4.2 Bentonite hydration

There is a significant amount of data and research in scientific literature with respect to geosynthetic clay liners (GCLs). As has been described in this report the GCL used as part of the lining system at Victoria gold was a Solmax, needle punched GCL (Bentoliner NW Peel 60). One of the considerations with respect to the GCL is hydration of the bentonite within the GCL which could essentially lead to a splitting of the GCL and ripping apart the needle punched stitching. If this were to occur then the shear strength of the GCL would be governed by the hydrated bentonite, which is considered to be a friction angle of 6 to 8 degrees.

To prevent this failure mechanism, the GCL is typically covered by a geomembrane and a nominal loading applied (such as a layer of gravel, or in this case, an ODF layer). This loading acts as a normal force to the GCL and prevents over hydration of the GCL. A review of the construction records of Phase 2 reveals that hydration of the GCL did occur during construction and at such locations the GCL was removed and replaced. The specifications used during construction do not detail the remediation of hydrated GCL. The specifications seemingly allow the LLDPE geomembrane to be placed on top of the GCL which is considered sufficient to prevent hydration from precipitation. Typically, specifications also state the timely application of the nominal thickness of gravel / ODF to be placed on top, but the specifications are silent on this issue. We contend that hydration of the geomembrane occurred as a result of moisture from the ground beneath the liner and from the subgrade. This moisture could have partially or completely hydrated the bentonite, which with no overlying pressure (or normal force) could have swelled and ripped the confinement stitching.

Samples taken from site showed that the GCL had hydrated. We therefore believe that such hydration occurred over significant areas of the heap leach where the ODF was not placed in a timely manner. The performance of the GCL stitching when subsequently loaded and stressed by thick ore deposits on the steeper slopes, should be questioned. A recommendation has been made to assess the integrity of this hydrated GCL through testing.

On the slope where we contend failure originated (the north-western slope facing south-east) records show that the ODF was not placed on top of the geomembrane for an average or 10.9 months, and for the top 90 m (parallel with the slope gradient) over 24 months. The slope in question can be seen in Photograph 4, and it is inconceivable that on such a high slope natural seepages did not potentially hydrate the GCL. Given the membrane is black it would have heated up in the summer months and condensation could have formed on the GCL side further hydrating the GCL.

Any moisture that the bentonite took in became frozen during the shoulder and winter months. Ice crystals on a microscopic scale would have formed, thawed and reformed numerous times. We contend that this might have overworked both the bentonite and the needle-stitching.

The key issue is that with a lack of stitching or needle-punched fabric, and with a hydrated bentonite the interface shear strength might have been reduced to between 6 and 8 degrees. The analyses undertaken and presented in this report substantiate that this failure mechanism might have occurred. In this case the analysis has shown that with the side slope liner interface reduced to 10 degrees, and only at the locations where ODF covering was delayed, this leads to a marginal factor of safety.

7.4.3 Shear Strength Characteristics of the Ore

The potential for the ore to be in a contractive state, owing to placement during freezing conditions with subsequent expansion of pore water fluids, has been discussed earlier in this report. An undrained response in gravelly sandy soils is eminently possible:

- From: SEYED ABOLHASSAN NAEINI, "The ultimate shear behavior of loose gravelly sandy soils", The Geological Society of London 2006, AEG2006 Paper number 526:
    - *From the present series of experimental results it can be observed that, very loose specimens of gravelly soil show contractive behaviour. Since the specimens that were consolidated to an initial confining pressure were sheared in an undrained condition this produces pore water pressure increases. As the pore pressure increases, the mean effective stress decreases. The stress-strain behaviour showed that the shear strength showed a peak at relatively small strains and thereafter it decreased to an ultimate strength.*
- From Gabriele Chiaro *et al*, "Site characterisation and liquefaction potential of Blenheim gravelly sandy deposits", New Zealand Natural Hazards Commission, EQC grant reference number 18/760 (undated):
    - *Contrary to the general belief that gravelly soils do not liquefy, case histories from at least 27 earthquakes worldwide have indicated that liquefaction can actually occur in gravelly soils (either natural deposits and manmade reclamations) causing severe damage to land and civil infrastructures.*

Hence, coarse granular soils can exhibit contractive behaviour in a similar manner to finer grained soils. An undrained response of such thawed-out soils could lead to liquefaction-type behaviour, either induced by changes in effective stresses (static liquefaction) or sufficient shear strain (e.g. as might result from movement down a weak side slope geosynthetic interface). The very rapid nature of the failure does suggest a brittle response of the ore that would indicate at least some degree of undrained contractive behaviour. Further, a large release of fluid/leachate was noted during the immediate failure, supporting the hypothesis that thawing of previously frozen ore had occurred.

8.0 Proposed and Most Probable Failure Mechanism

The isopachyte analysis very clearly shows the change in contours around the backscarp. However, our analysis has shown that the failure did not initiate at this location. The eastern protuberance demonstrates a failure originating from the north-west steeply dipping side slope. We believe that as the side slope failed and displaced then the backscarp formed as a second stage almost concurrently. The bulldozer driver and his vehicle were displaced in a south-easterly direction. This report has therefore focused on the causation of this initiating failure, but acknowledged that the initiating displacement might of led to an undrained response in thawed out soils leading to a liquefaction-type behaviour. The large strains as might result from movement down a weak side slope geosynthetic interface essentially led to this liquefaction-type behaviour. The very rapid nature of the failure does suggest a brittle response of the ore that would indicate at least some degree of undrained contractive behaviour. Further, a large release of fluid/leachate was noted during the immediate failure.

The most probable initiating failure mechanism is one that involves the interface of the geosynthetics. We consider at this time that the interface between the ODF and the geomembrane being frozen is a minor contributory factor to the most probable failure mechanism. Equally the observation that frost or moisture was present between the GCL and the geomembrane. We recognize and acknowledge that there were a number of factors that could have led to either of these interfaces being partially frozen and initiating the slide. We have reviewed the placement of ore in sub-zero temperatures, the potential buckling of leachate collection pipes being overloaded, observations from the January 2024 failure, the fines content of ore and re-establishment of permafrost under the liner. However, we have tempered these factors with the lack of thermistor data from the ODF in the spring of 2024 and the current lack of site observations indicating the ODF / geomembrane interface was frozen. In short there are more probable failure mechanisms, although a frozen interface might have been a minor contributory factor.

In examining other potential causes, we are cognizant of recognized and published failures involving geosynthetics. Analysis has shown that on the steep HLF liner slopes at Victoria Gold, placement of the ODF in a controlled manner was critical. This criticality was not fully recognized during the design and preparation of specifications regarding the lining system, and the calculation by Kerkes (1999) which is considered common practice in designing with geosynthetics in some industries was not applied. As a result, portions of the lining system interface on the slopes could have been displaced and been over-stressed resulting in at best a post peak condition, potentially a residual condition.

We contend that hydration of the GCL due to sub-grade moisture, seepages and condensation did occur based on the GCL sampling undertaken post failure. The lack of overlying ODF would have meant that such hydration would have been unconfined (standard practices set out in Appendix E should of have been undertaken to prevent this). In this condition, as the bentonite hydrated damage or failure of the critical needle stitching holding the GCL together could have occurred. The fact that the GCL was left in an unconfined condition for almost 11 months (on average for the considered critical north-west lining slope section) meant that the bentonite was also subject to re-working as micro ice crystals froze and thawed. The effect of this re-working on the stitching and the bentonite is open to some conjecture, but is considered an unfavorable factor exacerbating degradation of the GCL. Without the stitching holding the GCL together, or with this stitching in a partially damaged condition, the shear strength of the GCL is greatly reduced. Modelling has shown if only the portions of the critical slope where ODF placement was delayed are reduced to 10 degrees, a failure could have occurred. In theory a complete lack of GCL stitching reduces the strength between 6 and 8 degrees.

On the basis that a portion of the interface formed by geosynthetics was overstressed, we contend that movement to a post peak and residual condition would have occurred. As soon as this happened other parts of the slope where needle-stitching in the GCL were potentially still intact or where the GCL to geomembrane interface was still at a peak condition would then become overloaded, displaced to post peak or a residual condition, and failed. This is akin to a failure in a room and pillar mine. One or several pillars failing is not necessarily an issue, but as soon as a critical number fail, a domino effect occurs, and all the pillars are overloaded. In the same way a small portion of the slope interfaces within the geosynthetics being in a residual condition, does not cause failure, but if enough areas are over stressed and displace to this condition then mass slope failure occurs.

We therefore contend that failure occurred in part through the GCL and partly along sliding between the GCL to the geomembrane interface. We recognize that there are a number of other factors that would have contributed to this failure mechanism as discussed and outline in this report.

9.0 Practices in Design, Construction and Operation Potentially Contributing to the Failure

We have been asked specifically by YWSCB to comment on any fault, error or poor practices on behalf of any party involved that might have led to, or contributed to the failure. This section of the report sets out and reports upon this request, in summary;

i) The operation of the HLF without any of the prescribed cold climate operational considerations.
ii) Incentivization of ore placement.
iii) Operating the HLF with a higher than designed barren solution application rate.
iv) The under-design of the leachate collection system.
v) The under design of the sub-grade under-liner groundwater collection system.
vi) Installation of the geomembrane in very low temperatures.
vii) Poor installation practices with respect to the GCL and lack of timely cover using the ODF which led to hydration of the GCL and subsequent potential degradation by freeze / thaw processes.
viii) Use of an ODF with a fines content that was higher than specified, and placement of ODF using heavy vehicles on steep slopes without direction from specifications.
ix) The absence of meaningful evaluation of the in-heap data be it leachate levels, temperature of ODF or monitoring of the under drainage.
x) Lack of documented assessment of the failure which occurred in January 2024.
xi) Lack of non-conformance documentation with respect to deviation from the specifications used to construct the HLF.

9.1 Cold Climate Operational Considerations

The review of the design reports showed that prior to commencement of operations, thought had been applied to the operational practices given the cold climate. The stockpiling of ore in the winter months and limiting placement of ore in the HLF to 250 days per year was prescribed. This allowed a 3.5-month window for winter and the coldest temperatures. The heating of barren solution was recommended in the initial design reports and placement of the barren distribution lines to a depth of 3 m to avoid freezing was also recommended. In practice none of these prescribed or recommended practices were undertaken in operating the HLF in a cold climate. Victoria Gold ran and operated the HLF no differently than that of a HLF in a temperate climate, seemingly ignoring the cold climate conditions or being ignorant that the cold climate might lead to unusual conditions and a higher risk of instability.

We are not aware of any correspondence between Victoria Gold and the original designers (or their successors) regarding this issue. As has been noted within this report, frozen ore and/or frozen ODF was a contributory factor to the failure.

9.2 Incentivization of Ore Placement

We understand that the mining personnel on site were directly incentivized to place ore on the heap leach pad in terms of a volume or mass of ore placed (based on interviews conducted by YWSCB with mine staff). We understand that monthly targets were set and if achieved a financial bonus was rewarded for productivity. It is suggested that Yukon Workers further investigate this aspect and assess if the additional time placing ore throughout the winter was as a result of site management trying to achieve a bonus.

9.3 Barren Solution Application Rate

The authors of this report contend that if the original designers knew that ore would be placed year-round, with the application of barren solution at a higher distribution rate, then at least additional monitoring might have been recommended to verify the in-heap conditions (in terms of both thermistors and piezometer installations).

We have not reviewed any correspondence that demonstrates that the higher barren application rates were reviewed and verified by the original designers or their successors. It appears Victoria Gold simply increased the application rate by 20% to facilitate efficient production.

9.4 Pipe Design

The leachate collection system and the under-drainage system appears to be under designed with respect to standard codes of practice. Although both drainage systems appear to function, we question if any pipes have buckled, reducing flow in the ODF and contributing to the failure. Reduced flow in the ODF would have made the ODF more susceptible to freezing.

9.5 Liner Installation Practices

The installation of the liner system in some parts of the HLF did not adhere to good practice. Cold climate welding of the geomembrane occurred in the first phase of the HLF development. The specifications do not set out any measures for cold climate LLDPE welding and we are unsure what practices did occur to ensure its success. Reference to the industry standard for cold weather installation published by the Geosynthetic Research Institute should have been made namely; GRI-GM9 "Cold Weather Seaming of Geomembranes" (presented in Appendix E). It is not considered that this had a detrimental effect on stability but might have led to leaks in the geomembrane due to poor weld quality.

The potential for, and observations with respect to GCL hydration, have been highlighted and discussed in this report, such hydration and freeze/thaw could tear the needle stitching and create a weak interface. This issue is highlighted in GRI-GCL5 "Design Considerations for Geosynthetic Clay Liners (GCLs) in Various Applications" and ASTM D 6102 "Guide for Installation of Geosynthetic Clay Liners" (both documents are presented in Appendix E). This is considered one of the key contributory factors to initiating the failure. The designers should have specified that a confining layer of ODF or drainage material should be placed on top of the geomembrane liner as it was constructed, to provide a load to prevent premature hydration of the bentonite within the GCL. In practice large areas in excess of several hectares of geomembrane were left uncovered without a confining layer. This we contend, allowed sub-grade groundwater seepages, moisture and condensation to hydrate the bentonite.

The 2021 Victoria Gold risk assessment (Victoria Gold, 2021) was carried out for Phase 2 and identified two of the top four risks as being a damage to system components during ore placement and elevated phreatic levels. The risk of damage to system components during ore placement noted in the risk assessment, was not addressed either in terms of the liner being left exposed or from vehicle damage placing the ore. With respect to a high phreatic level which was identified as being a risk, no additional mitigation measures were put in place to monitor the phreatic levels in Phase 2. Our analysis shows that the phreatic levels need to be raised by 60 m for there to be an issue. In short there were higher risks that were not identified by the risk assessment, but should have been.

Missing from such a risk assessment is the hydration of the GCL, monitoring of the UMV and basal heave issues, placement of ore in frozen conditions leading to stability issues. As a consequence of these deficiencies, we believe the risk assessment process lacked detail and was not comprehensive.

9.6 ODF Placement

The ODF had a fines content that was higher than specified. Simple screening at the borrow pit would have provided an acceptable ODF. This may have contributed to the failure as the higher fines content made the ODF less hydraulically conductive with a greater potential for freezing. We have not reviewed or seen any non-conformance QA/QC reports with respect to this issue. Such documentation is considered good practice.

The placement of the ODF using a D6 bulldozer in 0.6 m lifts should have been carefully controlled and detailed within the specifications prepared. An analysis of the loads from the plant and equipment used to place the ODF up the perimeter slope should have been undertaken to assess whether or not the proposed methodology could potentially damage the lining system. The analyses undertaken using the method proposed by Kerkes, (1999) “Analysis of Equipment loads on geocomposite liner systems”, have shown that the use of a D6 bulldozer on the steeper slopes may have impacted the integrity of the geomembrane. Furthermore, if turning and slewing of the bulldozer were not specified and undertaken in a careful manner then the interface between the geosynthetics may have reduced to a post peak or even residual condition. The steeper the slope of the lining system the more likely vehicle damage is to occur. The specifications are virtually silent on the placement of the ODF on top of the lining system (only the gradation and thickness are noted). This is considered a failing, as within other industries that design and construct using geosynthetics (for example landfill design and construction) such assessments and specified equipment practices are commonplace. It is also noted that within the Canadian Foundation and Engineering Manual (4th edition being relevant at the time, CGS (2008)) construction survivability for geosynthetics is noted as being an issue requiring assessment.

9.7 Instrumentation and Water Balance Assessment

We have not reviewed any detailed assessment of the instrumentation around the plant and HLF. Our review of the instrumentation has highlighted by a number of questions, which we contend should have been asked and evaluated at a site level, ideally with external or senior review by others. Site staff should be questioned if they were aware or concerned about the following:

i) In the year prior for a two-month period the ODF thermistor showed that the temperature of the leachate was at 1 °C. We question if this raised a concern and if it was being monitored in 2024. From our review of the uncalibrated data provided to Delve Underground we are unable to resolve the temperatures of the ODF in 2024.

ii) Our review of the water balance data shows that there is a deficit of approximately 1000 m^3 per day of liquid coming into the system. This deficit is based on the barren solution added minus the pregnant solution taken out, having normalized the volume of the in-heap pond. The deficit of approximately 1000 m^3 also takes into account precipitation and moisture content of the ore. We question if staff from Victoria Gold are aware of this deficit and if it is a result of gross error and miss-calibration of instrumentation equipment. On the basis that it is a seemingly unrecognized equipment malfunction, we have to question the reliability of the data and the quality management practices that are potentially revealed by this assessment.

iii) Four and a half years of record show that the water flow into the under-drainage monitoring vault (UMV) rebounds from winter depressed values in late May. Such a rebound did not occur in the spring of 2024. We question if the operators at Victoria Gold had recognized this in the data, and if discussions or conversations at site had been had regarding this issue. We have not reviewed any documented concerns regarding this data. The 2021 Victoria Gold risk assessment (Victoria Gold, 2021) notes that the UMV has separate collection pipes for each phase of the HLF that allows each area to be monitored independently. Had the monitoring data been studied then there may have been investigatory avenues that Victoria Gold might have pursued.

iv) There is a slight temperature inversion of the barren vs the pregnant leachate. Although only a slight inversion occurs, we question if this raised any concerns in the operation of the HLF and if it was detected. Such an inversion in the spring of 2024 almost up to the time of failure was a unique occurrence, based on our review of the temperature data.

9.8 Assessment of Failure in January 2024

In September of 2023 it should have been recognized that an overly high ore slope resulted from the planned placement schedule. The presentation minutes of the HLF meeting on 15th September, 2023 shows the over high slope. This non-conformance to the HLF design should have been communicated to the designers for their review and evaluation. We have not seen any documentation or review by the designers of this issue.

Following the failure and during remediation it should have been apparent to the designers that this was not a superficial failure just within the ore, but involved the side slope lining system. Our back analysis shows that the interface which failed (somewhere within the lining system) was represented by an angle of internal shearing resistance of 20 to 22 degrees. The observation that the ODF was frozen and assessment of how this might have contributed to the failure should have occurred. We contend that had a thorough and documented assessment of this failure occurred, then it would have raised a number of questions specifically in regard to the frozen ODF, the assumed liner shear strength. Although open to conjecture, such conclusions might then have led to additional scrutiny of the instrumentation available. We are not suggesting that these assessments would have prevented the larger scale failure from occurring, but might have led to some pro-active additional monitoring.

9.9 Non-Conformance Documentation

With the exception of proposed substitutions of materials during the initial phase of construction, there does not appear to be any non-conformance documentation. Although it is recognized that the work was partly self-performing, documented occurrences of non-conformance to the specifications were not observed in the records. A construction quality management plan was also not reviewed, and Delve Underground are unsure if one exists for the HLF. We would expect documented cases of non conformance related to; Geomembrane placement in sub zero temperatures, ODF gradation, geomembrane welding tests that failed and hydrated GCL removal.

9.10 Summary of Compliance and Causation

In order to summarize the practices in design, construction and operation potentially contributing to the failure, an assessment was made of the main contributory factors. For each of these contributory factors the responsibility or obligation of the designer, contractor (building the HLF lining system) or operator has been described in Table 19. Table 19 also describes if the obligation, direction or responsibility was fulfilled, and for each factor provides a proportion of responsibility in numeral percentage terms. It should be appreciated that this percentage is a global estimate not intended to be precise, but a relative proportion of responsibility and estimate levels of shared responsibility.

On this basis a score was then applied as a compliance rating with a value of 1 being compliant to directions / specifications or best practice, a value of 2 being partially compliant, and 3 being non-compliant. For each of the factors considered to contribute to the failure a score was also assigned to indicate if a particular factor had a negligible contribution (score of 1), minor contribution (score of 2), or major contribution (score of 3). These scores were then combined to evaluate a compliance causation rating. Table 18 below sets out this rating.

Table 18: Compliance and causation Scoring matrix

Compliance and Causation scoring system		**Compliance Rating**		
		1 (compliant)	**2** (partial compliance)	**3** (non-compliant)
Causation Rating	**1** Negligible contribution	**1**	**2**	**3**
	2 Minor contribution	**2**	**4**	**6**
	3 Major Contribution	**3**	**6**	**9**

Table 19 then uses the responsible proportion percentage and the compliance / causation score to develop a weighted average of responsibility and compliance causation for each factor. The total score of the responsibility and compliance causation is 16.6 for the designer and 23.3 for the operator. This shows a shared responsibility for the failure between the designer and the operator, but with slightly more onus on the operator.

Table 19: Summary Table Causation & Compliance

Contributory Factor	Causation Description	Description of responsibility / obligation	Was responsibility / obligation fulfilled	Responsible Party: Designer	Responsible Party: Lining Contractor	Responsible Party: Operator	(Compliance x Causation) Score	Comments
Winter stockpiling	Placing frozen ore; Increased void ratio; Contractive soil formation; Perched water tables	Designer stated 250 day placement.	Operator placed ore year round.	10%	0%	90%	3x3=9	No discussion by designer on potential to create a collapsible soil, or implications of frozen layers in heap. Designer specified minimal instrumentation to monitor the performance of the HLF. Operator did not comply.
			Weighted average of responsibility and compliance causation =	0.9	0	8.1		
Heating Barren Solution	Barren soultion less likely to freeze on pad	Initial designer stated heating barren solution to be considered.	Operator did not heat barren solution	10%	0%	90%	3x2=6	Barren solution was not heated. The emphasis of heating the barren solution appears to have been lost in the trnsfer of design responsibility from BGC to Forte Dynamics. No discussion by designer on impact if solution was not heated.
			Weighted average of responsibility and compliance causation =	0.6	0	5.4		
Barren Application Rate	Over-application creates increased saturation of heap.	Designer specified application rate.	Barren application rate was generally over 7 l / m2 / hr	10%	0%	90%	3x2=6	Application rate of barren solution was higher than specified.
			Weighted average of responsibility and compliance causation =	0.6	0	5.4		
GCL Hydration	ODF not placed in timely manner allowing GCL to hydrate	Designer to recognize issue and to develop mitigation plan.	Not recognized as issue	100%	0%	0%	3x2=6	Hydration of GCL did occur. ODF placement not recognized as an issue by designer.
			Weighted average of responsibility and compliance causation =	6	0	0		
Damage to geosynthetics	Damage to geosynthetics by construction vehicles	Designer to recognize issue and to specify vehicle loading / turning requirements.	Not recognized as issue	90%	0%	10%	3x2=6	We contend placement of ODF should have been specified as part of the lining contractors responsibilities. Careful ODF placement was not recognized as an issue by designers.
			Weighted average of responsibility and compliance causation =	5.4	0	0.6		
ODF Gradation	ODF source had too many fines; lower conductivity	Designer specifed maximum fines content.	Operator sourced ODF but did not adequately screen fines	10%	0%	90%	2x1=2	Possibly a minor contributory factor but desogner specified gradation and operator did not adhere to it.
			Weighted average of responsibility and compliance causation =	0.2	0	1.8		
Piping Design in HLF	Pipes underdesigned and might have had reduced capacity if buckled	Designer to specify pipes of appropriate specification.	Pipes under-designed in some parts of HLF	100%	0%	0%	2x1=2	Parts of HLF were in compliance
			Weighted average of responsibility and compliance causation =	2	0	0		
Ore lifts and outer slope angle	Ore lifts were thicker than designer intended and outer slope was steeper	Designer to specifiy ore lift height and outer slope angle; Operator to adhere to these dimensions.	Operator placed ore in 12 m lifts not 10 m and at a steeper gradeint.	0%	0%	100%	2x1=2	Lifts increased in height and ore was steeper but only a very minor contributory factor
			Weighted average of responsibility and compliance causation =	0	0	2		
Latent re-establishment of permafrost	Permafrost found in sub-grade and removed re-establishes underneath the liner.	Contractor to remove, designer to instrument locations where prevalent.	Contractor did remove permafrost. No additional instrumentation was used to verify conditions post liner installation where permafrost was found.	90%	10%	0%	1x1=1	Permafrost re-establishment has yet to be proven hence low score.
			Weighted average of responsibility and compliance causation =	0.9	0.1	0		
			Total Score of Responsibility and Compliance Causation =	**16.6**	**0.1**	**23.3**		

10.0 Future Stability Considerations

We understand that staged remediation of the HLF will be carried out starting in 2025. We assume that this work will commence with the regrading of the 60 m high backscarp and hauling of ore to the northern part of the HLF or onto the liner that is exposed along the north-eastern perimeter. Following re-grading of the backscarp the excavation can continue to expose the lining system on the north-western slope and start to assess the damage and repair that will be required.

In carrying out what will be substantial excavation and re-grading possibly over several years we believe that staged plans should be developed of each phase and the stability of the HLF assessed. In carrying out these assessments the interface shear strength of the lining system should be assumed to be in a residual condition not greater than an angle of shearing resistance of 15 degrees.

This is considered an interim recommendation subject to interface shear strength testing of the hydrated GCL. This testing has been presented in the recommendations section and will help to verify that complete degradation of the needle punched stitching has not occurred, and as a result the interface is not at the friction angle of hydrated bentonite (6 to 8 degrees), but at some higher strength.

Recommendations are made to further understand the geotechnical conditions of the HLF in Section 11.0 prior to carrying out extensive and multi-year remediation and repair. As part of the investigation of the geotechnical conditions, focus should be on the state of the ore (in terms of void ratio) and its potential to exhibit contractive behaviour in the undrained loading condition.

11.0 Conclusions

The failure of the Victoria Gold heap leach facility on June 24th 2024 resonated around the world in terms of the scale of the failure and the potential environmental consequences. It is estimated that some 3.5 million cubic meters of ore displaced as a result of the failure. The time of the failure between shifts was fortuitous as no one was severely injured during the event. Had the failure initiated during the working shift, multiple fatalities may have occurred. Understanding the root cause of this failure is considered fundamental to guide the remediation efforts and the future design / operation of this heap leach facility and potentially other cold climate heap leach facilities.

This report has reviewed the design, development and construction of the heap leach facility at the Eagle Mine and described the development of the site from the time of the feasibility study through to the as-built construction reports. In reviewing these documents, it has been noted that there is an apparent disconnect between the initial design and the construction and operations in terms of cold climate considerations. The initial designers made allowance and changes to practices for the cold conditions, and the operators seemingly disregarded such practices. In short, the mine operators ran and constructed the facility without due consideration of the specific climatic conditions at the site, and not, based on a 2015 study (Sinha & Smith, 2015) one of the top ten coldest heap leach operations in the world.

This report has systematically assessed both typical failure mechanisms that might occur in heap leach facilities as well as unique failure mechanisms given the cold climate and design / construction practices. From the results of these analyses the report has identified both minor and major contributory factors, as well as identifying factors that are not considered to play any significant role in the failure. The authors contend that a possible initiating mechanism of the failure was the lining system constructed on a steep slope forming the north-west part of the HLF. In association with this hypothesis, three main issues have been highlighted as contributory factors to the failure; i) damage during construction leading to a post peak shear strength between the GCL and the LLDPE textured geomembrane, ii) a hydrated GCL with a reduced internal shear strength, and, iii) placement of frozen ore which in combination with other minor contributory factors led to a potentially and partially frozen lining system and constituent interfaces.

An alternative (or complimentary) hypothesis is that the initiating mechanism was associated with the widespread placement of frozen ore and operation of the HLF throughout the winter, thereby leading to a number of unique conditions that were not anticipated by the designers or operators. This is considered a possible fourth contributory (i.e. complimentary) factor to the failure or even a standalone factor. As ore was placed in freezing conditions, we believe that expansion of pore fluid within the near surface layers occurred as the fluid froze. Without enough overburden pressure to control swelling due to freezing, the void ratio of the ore would have increased. The increase in void ratio could have resulted in the ore being in a contractive state once the frozen fluid thawed out. Coarse granular soils can exhibit contractive behaviour in a similar manner to finer grained soils. An undrained response of such thawed-out soils could lead to liquefaction-type behaviour, either induced by changes in effective stresses (static liquefaction) or sufficient shear strain (e.g. as might result from movement down a weak side slope geosynthetic interface). The very rapid nature of the failure does suggest a brittle response of the ore that would indicate at least some degree of undrained contractive behaviour. Further, a large release of fluid/leachate was noted during the immediate failure.

In carrying out this review and at the request of Yukon Workers Safety and Compensation Board, the authors have identified a number of potential deficiencies in terms of the construction specifications and operation of the HLF. Design and construction using geosynthetics requires specialist knowledge and consideration of failure mechanisms that are unique in mining or geotechnical engineering. We contend that Victoria Gold relied upon their designated engineers of record for such knowledge, but that with respect to the three main issues identified as initiating the failure in the context of a liner failure, the designers or Victoria Gold apparently did not comment or assess these factors. The designers did specify a number of cold climate considerations for the HLF, aspects that to the detriment of the HLF were ignored by the mine operators. However, the designers did not set out or describe the risks to the HLF, if these cold climate considerations were not undertaken in a systematic manner. At a risk assessment workshop in 2021 none of the main contributory factors were recognized as a risk, and most of the minor contributory factors were equally not recognized. Whether the actions of the operators and / or consulting engineers constitutes negligence we will leave for others to decide. We have identified a number of practices in the operation and design of the HLF that potentially contributed to the failure. An assessment of the responsibility compliance and causation resulted in a shared responsibility for the failure between the designer and the operator, but with slightly more onus on the operator.

We acknowledge from the stability analysis undertaken that the factors of safety reported are similar if slightly lower for Section 2. While we believe that the side slope lining system was the initiating mechanism there remains the possibility it could have been the thawing of more apparently extensive frozen layers that could have led to sufficient changes in effective stress that resulted in static liquefaction. However, to robustly demonstrate that this could be equally important as the lining system hypothesis much more detailed testing and advanced analysis would need to be undertaken.

There are a number of operational and design deficiencies that could have led to a failure in either case. We therefore believe that the same lack of understanding and compliance, led to a failure in both potential instances.

We understand that a similar study to that undertaken by Delve Underground is being initiated by the Yukon Government (Mines Dept.) using a three-person expert panel. We hope that this report is made available to this other team so that a consensus on the initiating mechanism can be determined, with the dual intent that going forward remediation and repair can occur safely, and that that key lessons learned can be publicized to the industry.

12.0 Recommendations

The following recommendations have been made and are split into four different categories; i) outstanding issues, ii) 3D limit equilibrium (and possibly numerical) analysis, iii) investigation, testing & instrumentation, and, iv) other recommendations.

12.1 Outstanding Issues

This report has highlighted a number of outstanding issues that we have yet to resolve. The first issue is to understand the temperature variation of the thermistor installed in the ODF during the first half of 2024. We believe such data may exist but the readings we have seen appear not to have been calibrated. Understanding the ODF temperature may help to resolve the extent that frozen ground conditions played in the failure.

We ask that the flowmeters to and from the HLF are checked and calibrated (noting that the flowmeters from the in-heap pond are currently redundant). We believe that the discrepancy in barren solution pumped to the HLF, and pregnant solution pumped from the HLF is in part due to instrument error. This assumption should be confirmed.

The method of manufacture of the LLDPE textured geomembrane should be confirmed. We believe it to be by the co-extrusion method and not by spraying the texture, but this should be clarified through the manufacturer.

One issue that should be considered to further assess the failure is that of acquiring InSAR data of the heap leach for the weeks and days prior to the failure. However, on the basis that the failure was a sudden displacement of the lining system there might have not been any noticeable movement in the days prior to failure. Under such circumstances, InSAR data would be of limited value – this method is used primarily to identify non-brittle type failures. However, it is recommended that this information is acquired and studied so as to provide a comprehensive assessment of this issue and possibly screen out the potential that movements had been developing progressively over the preceding weeks, rather than the currently adopted hypothesis of a brittle failure mode.

12.2 3D Analysis

This report has recognized that the failure of the HLF is a three-dimensional problem. We contend that the initiating failure mechanism was the side slope lining interface, however following this initial displacement down the slope and towards the south-east, the subsequent displacement was in more of a southerly direction. Three-dimensional analysis is likely to give a more definitive evaluation of the factor of safety and through sensitivity analysis better assess the minor and major contributory factors set out in this report.

A major benefit of 3D analysis is that the stability results can be interrogated to determine the mobilised shear strengths along selected cross sections. This allows the opportunity to determine which potential slip surface orientations were more critical to the overall stability in 3D space.

12.3 Investigation, Testing & Instrumentation

In order to safely commence any remediation of the HLF, including repairing the lining and re-grading the slopes we consider that it is important to resolve how extensive the potential damage is to the GCL. We therefore recommend that interface shear strength testing be carried out of the GCL in a hydrated condition. The testing may prove that the GCL bentonite interface is critical and lower than 15 degrees which it is assumed to be the residual friction angle of the geomembrane liner to the GCL. Understanding the strength of the weakest interface is critical to developing staged construction plans that are safe and do not result in additional failures.

Once this issue is resolved then we recommend that at least ten locations are drilled both to assess if frozen layers exist within the HLF and to install Measurand Shape-Array SAAV inclinometers. One of the main purposes of the drilling would be to retrieve undisturbed samples for the purposes of assessing the in-situ state (void ratio) of the ore, both for non-frozen and frozen layers. The main purpose of the instrumentation would be to ensure safety for the remediation and return to operation of the facility.

Understanding if layers of ore are frozen in the HLF is important from a stability perspective and in terms of practical construction. The shape-array inclinometers give real time instantaneous monitoring and should be able to determine if displacement in the ore mass is detected back from the outer slope. Such instrumentation in the HLF ore is important so as to undertake safe excavation and regrading.

The inclinometer instrumentation recommended is considered in addition to existing and continuation of the monitoring provided by the Sentry Device and drone LiDAR survey comparisons. We recognize that displacement of the ore may initiate as a relatively deep-seated movement with potential minor surface movement that might not be noticeable from the sentry system or the LiDAR drone. Hence the need for both types of monitoring.

12.4 Other Recommendations

On the basis that the lining system is likely to have been largely destroyed during the HLF failure, re-circulation of the leachate that is currently being undertaken (so called active storage) has undoubtedly led to additional cyanide seeping into the sub-grade and from there potentially into the environment. It is recommended that as soon as the cyanide recovery and extraction circuit is completed, active storage is reduced or stopped. The active storage or recirculation of any leachate will undoubtedly exacerbate any latent stability issues that have yet to be manifested in actual displacement and failure.

During the repair and remediation of the HLF we consider it would be valuable to install additional instrumentation in the form of piezometers and possibly strain gauges on exposed sections. The actual instrumentation plan to be developed is contingent on the scale and staged nature of the regrading and repair work. However, as part of this work installing target pads for instrumentation should be carried out at discrete locations. Target pads are essentially surveyed 300 mm thick concrete pads (roughly 3 x 3 m), that can be drilled down to and instrumentation installed retro-actively (or following ore replacement) without damaging the liner.

It is recommended that a staged remediation plan be developed that allows work to be undertaken as safely as practicable using real time instrumentation that alerts workers in case of movement. In outline we consider this staged plan to include:

1) 3-Dimensional analysis and testing of the hydrated GCL interface.

2) Investigation of the HLF and installation of shape-array inclinometers.

3) Excavation of the backscarp potentially using remotely operated equipment in the initial stages. Ore removed to be placed back in pit or other suitable area.

4) Excavation of the failed material in Dublin Gulch back to sub-grade, and up the failed ore to the location of the containment dam. During this phase of the work the integrity of the under-drainage system that previously directed water to the UMV can be assessed.

5) Re-installation of Dublin Gulch either in culverts or similar so as not to cause water in the creek to infiltrate the ground.

6) Excavation of the north west slope liner and interface down to the containment dam.

7) Excavation of the in-heap pond to assess the damage to the liner at this location.

8) Repair of the liners that are damaged.

9) Replacement of some of the ore that has been transported to the open pit.

10) Undertake a final flush of the HLF in order to recover remanent gold to help with the costs associated with the previous stages.

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Appendix A Summary of Reports Reviewed

Appendix A - Summary of Reports Reviewed

Document Date	Title	Main Author	Relevance and notes	PDF Page Numbers for Doc. Identifiction
23-Apr-2010	Pre-feasibility Study of the Eagle gold project, Yukon territory.	Scott Wilson Roscoe Postle Associates	Identified Ann Gulch as HLF location and winter stockpiling of the ore.	242
1-Sep-2011	Report On Seismic Refraction and Downhole Seismic Investigation Proposed Mine Site Facilities Eagle Gold Project Yukon	Frontier Geophysics	Geophysical report at the foundations of various structures.	52
10-Feb-2012	Heap Leach Facility Feasibility Design.	Tetra Tech	Presents the initial design criteria for the heap leach and sets out initial stability analysis.	52
5-Apr-2012	Technical Report – Feasibility Study Eagle Gold Project, Yukon	Wardrop (A Tetra Tech Company).	Feasibility report.	419
23-Apr-2014	Heap Leach Facility Detailed Design.	Tetra Tech	This is for a differing configuration with the containment pond in the base of the Dublin Gulch valley.	2317
1-Nov-2016	Heap Leach Facility Feasibility Design at the Eagle Gold Project	Dowl	Design criteria and stability assessment of the HLF is presented. Possibly the first report to develop geotechnical parameters and use these in limit equilibrium analysis.	3451
1-Jun-2017	Heap Leach Facility Foundation Improvement Plan	StrataGold	Where permafrost occurs it will be identified, removed and replaced with a suitable compacted fill.	22
20-Jun-2017	2016 Heap Leach Facility Geotechnical investigation.	BGC Engineering Inc.	Results of 23 test pits and six HTW sized cored boreholes	256
21-Aug-2017	Dublin Gulch Flood Inundation Assessment – Revised	BGC Engineering Inc.	Flood assessment of Dublin Gulch	13
1-Oct-2017	Stage 1 Heap Leach Facility Preparatory Works Plan.	StrataGold	Underdrainage system was set out in some initial design drawings	24
1-Oct-2017	Permafrost Distribution Mapping within the Dublin Gulch Area	Tetra Tech	Presents a very detailed map of the permafrost distribution within the Dublin Gulch Area	7
16-Oct-2017	Technical Specifications - Heap Leach Facility.	BGC Engineering Inc.	Specifications for subgrade preparation, liner and pipework.	49
9-Nov-2017	Primary Heap Leaching Pad GCL Liner Review	AB Engineering Inc.	Reviews the use of the GCL on site and risk / mitigations associated with its use.	11
1-Dec-2017	Heap Leach Process Facilities Plan.	StrataGold	Summarizes both the HLF construction aspects as well as the processing and operational facilities.	188
11-Dec-2017	Eagle Gold In-Heap Pond and Events Pond Dam Breach Inundation Modelling - Final	BGC Engineering Inc.	Dam breach inundation analysis and modelling carried out in 2D flow.	20
8-Jan-2018	Heap Leach Facility Detailed Design	BGC Engineering Inc.	Updated stability analysis from Dowls report. Slightly differing parameters adopted from Dowl.	2652
26-Jan-2018	Water Balance Modeling for the Eagle Gold Mine Proposed Heap Leach Pad Facility, Final Design.	The Mines Group Inc	Water balance between the containment pond, event pond and dynamic storage was modelled	170
20-Apr-2018	Eagle Gold Heap Leach Facility Slope Stability Analysis Update	BGC Engineering Inc.	Incorporates updated results based on recent laboratory strength tests on the crushed ore and the liner system	103
2018	Agglomeration Feasibility Test Plan; Non-Agglomeration Testing and Recommendations.	StrataGold	Reasons for non agglomeration are set out.	2
2018	Ore Stability Test Plan - Investigation and Recommendations	StrataGold	States mobilization of fines is unlikely.	2
15-Jun-2018	Hydraulic Conductivity Testing Review.	Forte Dynamics Inc.	Presents the design ore gradation and hydraulic testing of the ore.	10
24-Oct-2018	Weekly Water Balance Modeling for the Eagle Gold Mine Heap Leach Pad Facility.	The Mines Group Inc	Updated water balance on weekly basis.	233
1-Jan-2019	Design Report for Waste Rock Storage Areas.	StrataGold	Presents investigations, design and analysis of the waste rock storage areas.	368
31-May-2019	Ditches A, B & C Construction Report	JDS Energy and Mining	Construction and piping report.	133
27-Jul-2019	2019 Eagle Gold HLF Dam Instrumentation	BGC Engineering Inc.	Inclinometer and borehole drilling logs from dam instrumentation.	12
24-Sep-2019	Heap Leach Facility Construction Summary Report for Phase 1A.	BGC Engineering Inc.	Heap leach facility pad (confinement embankment, in-heap pond, HLF under-drainage & monitoring vault) construction details. Detailed drawings of the vault and pipes running to and from the vault.	6081
27-Sep-2019	Eagle Gold Heap Leach Facility – Ore Pile Stability Analysis Update.	BGC Engineering Inc.	Contains 3d analysis undertaken by BGC based on new shear strength testing.	45
19-Nov-2019	Project Handover Report.	BGC Engineering Inc.	Recommendations for incresed slope stability were made.	26
19-Nov-2019	Eagle Gold Heap Leach Facility – Annual Inspection	BGC Engineering Inc.	Annual inspection report.	49

Appendix A - Summary of Reports Reviewed

Document Date	Title	Main Author	Relevance and notes	PDF Page Numbers for Doc. Identifiction
1-Jan-2020	Heap Leach Facility Operation, Maintenance and Surveillance Manual.	Victoria Gold Corp.	Reports sets out the proposed operation of the HLF including ore placement, solution circulation, maintenance	63
1-Jan-2020	Heap Leach Facility Contingency Water Management Plan	Victoria Gold Corp.	Sets out total potential dynamic storage and emergency storage in ponds.	20
6-Jan-2020	Detail Design Report for Eagle HLF Phase 1B.	Forte Dynamics Inc.	Specs for HLF Phase 1B construction on pipes,ODF and subgrade.	86
1-Nov-2020	Ditch A Improvement Construction Report	Victoria Gold Corp.	Sets out Construction and as-built design of Ditch A.	106
19-Mar-2021	Eagle Gold HLF Phase 1B Record of Construction	Forte Dynamics Inc.	Detailed construction report and record drawings for HLF Phase 1B, including daily reports showing liner installation and testing, Phase 1A/1B stability memo (3-D stability analysis results presented), BGC's interface shear strength testing, and test pit logs and photos.	1964
20-May-2021	Phase 1 Performance Review.	Forte Dynamics Inc.	Sets out performance of the leakage detection system and underdrainage going to the vault.	21
15-Jul-2021	Ditch B Construction Report	Victoria Gold Corp.	Sets out Construction and as-built design of Ditch B.	243
30-Aug-2021	Detail Design Report for Eagle HLF Phase 2.	Forte Dynamics Inc.	Set out design of the Phase 2 heap leach pad. 3-D stability analysis is reported in Appendix E.	164
1-Oct-2021	Eagle Gold Mine HLF Phase 2 Risk Assessment.	Victoria Gold Corp.	Identified ore failure as 4th highest risk.	31
8-Dec-2021	Annual Physical Stability Assessment Report – Victoria Gold – Eagle Gold Project	Allnorth Consultants	Some photos of the HLF.	60
1-Mar-2022	Environmental characterization report	Victoria Gold Corp.	Provides annual data on rainfall monitoring.	116
25-Mar-2022	2021 Annual Inspection of Eagle Gold HLF.	Forte Dynamics Inc.	Reviews the HLF design criteria, instrumentation and levels within the in-heap containment pond. The daily pumped volumes from the UMV (underdrain monitoring vault) are set out	90
1-Apr-2022	Eagle HLF Phase 1A and 1B-2021 Record of Construction	Forte Dynamics Inc.	Summary of ODF test results: percolation rate and percentage passing	74
1-Jul-2022	Eagle Gold Heap Leach Facility And Cyanide Management Review	Piteau Associates	Assessment of HLF practices and mangement review on site.	61
3-Aug-2022	In heap pond pumping test results.	Forte Dynamics Inc.	Verified through pumping tests the storage capacity of the in-heap pond.	44
22-Aug-2022	Independent Third-Party Audit and Approval of Verification Test (in-heap pond test)	Hydrogeologica, Inc.	3rd party review of test.	1
21-Apr-2023	Eagle HLF Phase 2A Record of Construction Report	Forte Dynamics Inc.	Detailed construction report of under-drainage and liner of Phase 2A	1443
20-Nov-2023	Annual Physical Stability Assessment Report – Victoria Gold – Eagle Gold Project	Allnorth Consultants	Some photos of the HLF.	59
22-Jan-2024	Response to Order No. 2 (IR No. 73-2024012-0587) with respect to a fall of ground in the HLF on January 6th 2024.	Victoria Gold Corp.	Investigation into the heap leach ore failure on 6th January, 2024. Includes appendix C (PHLF January 2024 Internal Ore Bench Slide Preliminary Assessment and Recommendations)	12
1-Mar-2024	2023 Annual Report.	Victoria Gold Corp.	A wide range of data summarized from 2023 is presented.	248
21-Jun-2024	Eagle PHLF ROC Report Rev A - All Appendices	Forte Dynamics Inc.	Appendices of a construction report of under-drainage and liner of Phase 2B	710
6-Jul-2024	Eagle PHLF Ore Slide Repair 2024 Record of Construction	Forte Dynamics Inc.	Contains photos of frozen ice lenses within the daily reports of the repairs.	355

Appendix B Nevada State Heap Leach Guidelines

Bureau of Mining Regulation and Reclamation

STABILITY REQUIREMENTS FOR HEAP LEACH PADS

Heap leach pads are mining operation process components that provide for environmentally safe, fully contained, placement of ore to be leached with process solution, primarily cyanide. Information from the items listed below is required for the Bureau of Mining Regulation and Reclamation (BMRR) to adequately review the environmental concerns related to stability of heap leach pads. At a minimum, all stability analysis submittals shall include the following:

1. Identify the stability analysis computer model or equations used.
2. Submit all inputs and assumptions used in the derivation of the stability results. Provide a short justification for each of these values.
3. Identify the seismic region and Peak Ground Acceleration (PGA) values used in the pseudostatic model, and the reference from which they were taken, and provide a short justification for each. Generally, a PGA defined by a seismic event with a maximum 10% probability of exceedance in 50 years shall be used.
4. Provide heap leach pad design to include overall height, lift height, lift setback, and containment berm size, or reference this information contained in another report submitted to BMRR.
5. Evaluate the heap stability considering these modes of failure:
   - Infinite Slope Failure
   - Rotational Failure
   - Translational Failure (Block and/or Wedge)

   These evaluations should consider sliding/rotating through ore only, sliding/rotating through foundation soils and/or a containment dike, sliding along a liner interface, and entire heap mass instability involving sliding entirely or mostly along a liner interface, or any appropriate combination of one or more of these scenarios.
6. Results shall be presented in terms of Factors of Safety for each evaluation. Minimum recommended Factors of Safety are 1.30 (static) and 1.05 (pseudostatic – using the PGA identified in step 3 above).
7. Pseudostatic analyses may use a reduced PGA (up to 50% reduction) if technical justification is provided. However, any pseudostatic analysis using a reduced PGA, or any analysis for which the pseudostatic factor of safety result is less than 1.05, shall be accompanied by a deformation analysis, based on the full PGA, to determine the maximum potential movement of heap material in a seismic event.
8. Analysis results shall be submitted by a Professional Engineer licensed in the State of Nevada in an appropriate discipline.

Although not required with the stability analysis submittal, the actions required by the Permittee if a failure occurs must be addressed in the operating plan. Additionally, when designing heap leach facilities, consideration should be given to the post-closure/reclamation slope stability, slope steepness, and heap configuration.

Appendix C Monthly Ore Placement Plans

Summary of weekly HLF Ore Stacking Plans reviewed

From	To	Status	Notes
2019-09-16	2020-06-15	Missing	inferred between 2019-09-16 drone flight and 2020-06-16 leach cell map
2020-06-16	2020-06-22	Available	Inferred from schedule
2020-06-23	2020-06-29	Available	Inferred from schedule
2020-06-30	2020-07-06	Available	Inferred from schedule
2020-07-07	2020-07-13	Available	Inferred from schedule
2020-07-14	2020-07-20	Available	Inferred from schedule
2020-07-21	2020-07-27	Available	Inferred from schedule
2020-07-28	2020-08-03	Available	Inferred from schedule
2020-08-04	2020-08-10	Available	Inferred from schedule
2020-08-11	2020-08-17	Available	
2020-08-18	2020-08-24	Available	Inferred from schedule
2020-08-25	2020-08-31	Available	Inferred from schedule
2020-09-01	2020-09-07	Available	Inferred from schedule
2020-09-08	2020-09-14	Available	
2020-09-15	2020-09-21	Available	Inferred from schedule
2020-09-22	2020-09-28	Available	
2020-09-29	2020-10-05	Missing	Inferred from schedule
2020-10-06	2020-10-12	Available	
2020-10-13	2020-10-19	Available	
2020-10-20	2020-10-26	Available	
2020-10-27	2020-11-02	Available	
2020-11-03	2020-11-09	Available	
2020-11-10	2020-11-16	Missing	Inferred from schedule
2020-11-17	2020-11-23	Available	
2020-11-24	2020-11-30	Available	
2020-12-01	2020-12-07	Available	
2020-12-08	2020-12-14	Missing	Inferred from schedule
2020-12-15	2020-12-21	Available	
2020-12-22	2020-12-28	Available	
2020-12-29	2021-01-04	Available	
2021-01-05	2021-01-11	Available	
2021-01-12	2021-01-18	Available	
2021-01-19	2021-01-25	Available	
2021-01-26	2021-02-01	Available	
2021-02-02	2021-02-08	Available	
2021-02-09	2021-02-15	Available	
2021-02-16	2021-02-22	Available	
2021-02-23	2021-03-01	Available	
2021-03-02	2021-03-08	Available	
2021-03-09	2021-03-15	Available	
2021-03-16	2021-03-22	Available	
2021-03-23	2021-03-29	Available	
2021-03-30	2021-04-05	Available	
2021-04-06	2021-04-12	Missing	Inferred from schedule
2021-04-13	2021-04-19	Available	
2021-04-20	2021-04-26	Available	
2021-04-27	2021-05-03	Available	
2021-05-04	2021-05-10	Available	
2021-05-11	2021-05-17	Available	

From	To	Status	Notes
2021-05-18	2021-05-24	Available	
2021-05-25	2021-05-31	Available	
2021-06-01	2021-06-07	Available	
2021-06-08	2021-06-14	Available	
2021-06-15	2021-06-21	Missing	Inferred from schedule
2021-06-22	2021-06-28	Available	
2021-06-29	2021-07-05	Available	
2021-07-06	2021-07-12	Available	
2021-07-12	2021-07-18	Available	
2021-07-19	2021-07-25	Available	Inferred from schedule
2021-07-26	2021-08-01	Available	Inferred from schedule
2021-08-02	2021-08-16	Missing	Inferred from schedule
2021-08-17	2021-08-23	Available	
2021-08-24	2021-08-30	Available	
2021-08-31	2021-09-06	Available	
2021-09-07	2021-09-13	Available	
2021-09-14	2021-09-20	Available	
2021-09-21	2021-09-27	Available	
2021-09-28	2021-10-04	Available	
2021-10-05	2021-10-11	Available	
2021-10-12	2021-10-18	Available	
2021-10-19	2021-10-25	Available	
2021-10-26	2021-11-01	Available	
2021-11-02	2021-11-08	Available	
2021-11-09	2021-11-15	Available	
2021-11-16	2021-11-22	Available	
2021-11-23	2021-11-29	Available	
2021-11-30	2021-12-06	Available	
2021-12-07	2021-12-13	Available	
2021-12-14	2021-12-20	Available	
2021-12-21	2021-12-27	Available	
2021-12-28	2022-01-03	Available	
2022-01-04	2022-01-10	Available	
2022-01-11	2022-01-17	Available	
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2022-01-25	2022-01-31	Available	
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2022-02-08	2022-02-14	Available	
2022-02-15	2022-02-21	Available	
2022-02-22	2022-02-28	Available	
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2022-03-08	2022-03-14	Available	
2022-03-15	2022-03-21	Available	
2022-03-22	2022-03-28	Available	Inferred from schedule
2022-03-29	2022-04-04	Available	Inferred from schedule
2022-04-05	2022-04-11	Available	Inferred from schedule
2022-04-12	2022-04-18	Available	Inferred from schedule
2022-04-19	2022-04-25	Available	Inferred from schedule
2022-04-26	2022-05-02	Available	Inferred from schedule
2022-05-03	2022-05-11	Available	Inferred from schedule
2022-05-12	2022-05-18	Available	

From	To	Status	Notes
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2022-05-26	2022-06-01	Available	
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2022-06-16	2022-06-22	Available	
2022-06-23	2022-06-29	Available	
2022-06-30	2022-07-06	Available	
2022-07-07	2022-07-13	Available	
2022-07-14	2022-07-20	Available	
2022-07-21	2022-07-27	Available	
2022-07-28	2022-08-03	Available	
2022-08-04	2022-08-10	Available	
2022-08-11	2022-08-17	Available	
2022-08-18	2022-08-24	Available	
2022-08-25	2022-08-31	Available	
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2022-09-15	2022-09-21	Available	
2022-09-22	2022-09-28	Available	
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2022-10-04	2022-10-10	Available	Inferred from schedule
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2022-10-18	2022-10-24	Available	Inferred from schedule
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2022-11-08	2022-11-14	Missing	Inferred from schedule
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2022-12-06	2022-12-12	Missing	Inferred from schedule
2022-12-13	2022-12-19	Available	Inferred from schedule
2022-12-20	2022-12-21	Available	Inferred from schedule
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2023-01-05	2023-01-11	Available	
2023-01-12	2023-01-18	Available	
2023-01-19	2023-01-25	Available	
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2023-02-02	2023-02-08	Available	
2023-02-09	2023-02-15	Available	
2023-02-16	2023-02-22	Available	
2023-02-23	2023-03-01	Available	
2023-03-02	2023-03-08	Available	
2023-03-09	2023-03-15	Available	
2023-03-16	2023-03-22	Available	
2023-03-23	2023-03-29	Available	
2023-03-30	2023-04-05	Available	
2023-04-06	2023-04-11	Available	
2023-04-12	2023-04-17	Available	
2023-04-18	2023-04-24	Available	Inferred from schedule
2023-04-25	2023-04-27	Available	Inferred from schedule

From	To	Status	Notes
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2023-06-02	2023-06-08	Available	
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2023-06-16	2023-06-22	Available	
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2023-07-07	2023-07-13	Available	
2023-07-14	2023-07-20	Available	
2023-07-21	2023-07-27	Available	
2023-07-28	2023-08-03	Available	
2023-08-04	2023-08-10	Available	
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2023-09-22	2023-09-28	Available	
2023-09-29	2023-10-05	Available	
2023-10-06	2023-10-12	Available	
2023-10-13	2023-10-19	Available	
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2024-02-16	2024-02-22	Available	
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2024-03-08	2024-03-14	Available	
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2024-03-29	2024-04-04	Available	
2024-04-05	2024-04-11	Available	
2024-04-12	2024-04-18	Available	

From	To	Status	Notes
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2023-06-02	2023-06-08	Available	
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2023-06-16	2023-06-22	Available	
2023-06-23	2023-06-29	Available	
2023-06-30	2023-07-06	Available	
2023-07-07	2023-07-13	Available	
2023-07-14	2023-07-20	Available	
2023-07-21	2023-07-27	Available	
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2023-09-08	2023-09-14	Available	
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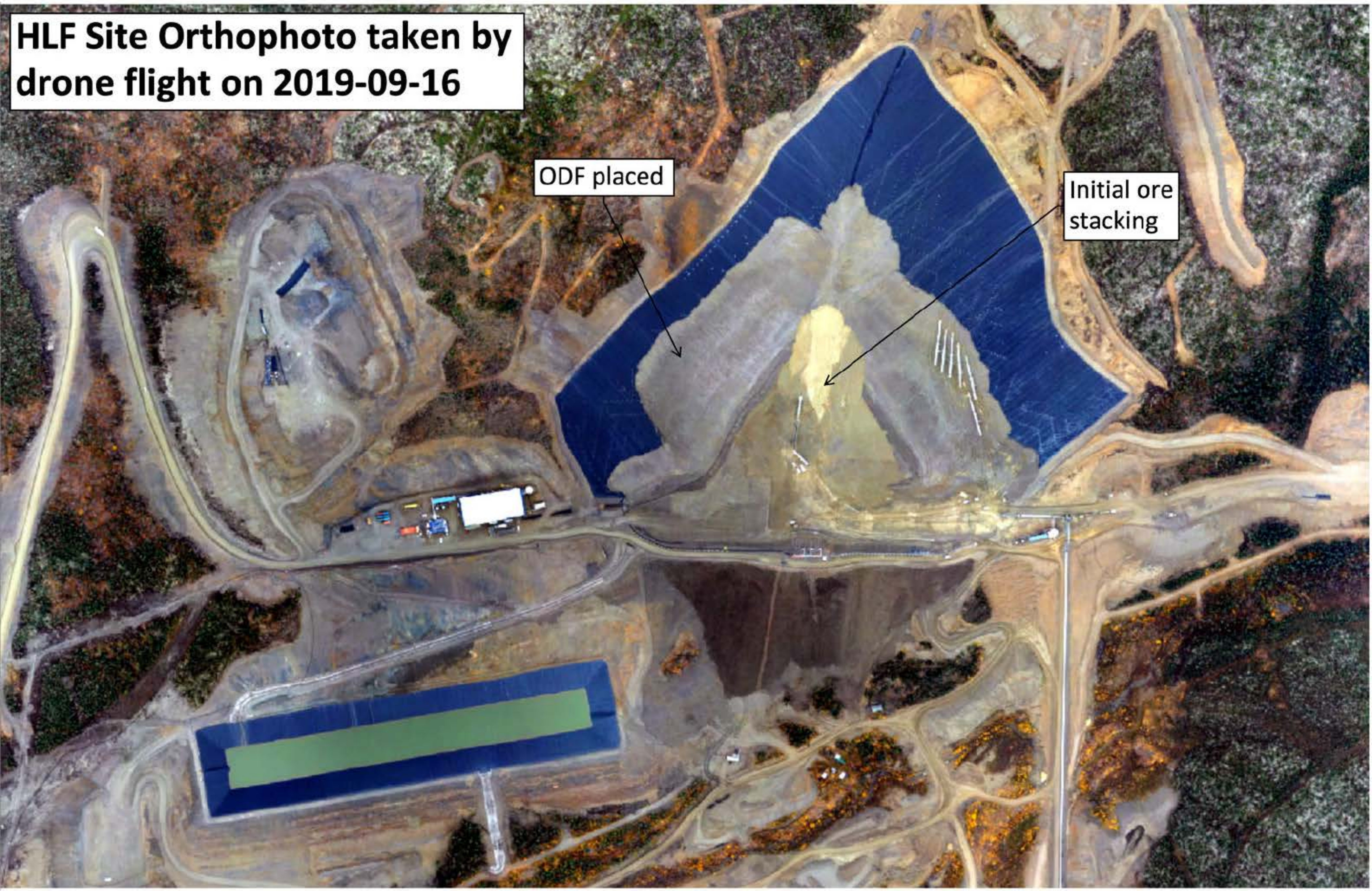
2023-09-22	2023-09-28	Available	
2023-09-29	2023-10-05	Available	
2023-10-06	2023-10-12	Available	
2023-10-13	2023-10-19	Available	
2023-10-20	2023-10-26	Available	
2023-10-27	2023-11-02	Available	
2023-11-03	2023-11-09	Available	
2023-11-10	2023-11-16	Available	
2023-11-17	2023-11-23	Available	
2023-11-24	2023-11-30	Available	Inferred from schedule
2023-12-01	2023-12-07	Available	
2023-12-08	2023-12-14	Available	
2023-12-15	2023-12-21	Available	
2023-12-22	2023-12-28	Available	
2023-12-29	2024-01-04	Available	
2024-01-05	2024-01-11	Available	
2024-01-12	2024-01-18	Available	
2024-01-19	2024-01-25	Available	
2024-01-26	2024-02-01	Available	
2024-02-02	2024-02-08	Available	
2024-02-09	2024-02-15	Available	
2024-02-16	2024-02-22	Available	
2024-02-23	2024-02-29	Missing	Inferred from schedule
2024-03-01	2024-03-07	Available	
2024-03-08	2024-03-14	Available	
2024-03-15	2024-03-21	Available	
2024-03-22	2024-03-28	Available	
2024-03-29	2024-04-04	Available	
2024-04-05	2024-04-11	Available	
2024-04-12	2024-04-18	Available	
2024-04-19	2024-04-25	Available	
2024-04-26	2024-05-02	Available	
2024-05-03	2024-05-09	Available	
2024-05-10	2024-05-16	Available	
2024-05-17	2024-05-23	Available	
2024-05-24	2024-05-30	Available	
2024-05-31	2024-06-06	Available	
2024-06-07	2024-06-13	Available	
2024-06-14	2024-06-20	Available	
2024-06-21	2024-06-23	Available	


HLF Site Orthophoto taken by
drone flight on 2019-09-16
ODF placed
Initial ore
stacking

Leach Cells Currently Online

All years shown are interpreted as typo;
should be 2020, not 2019

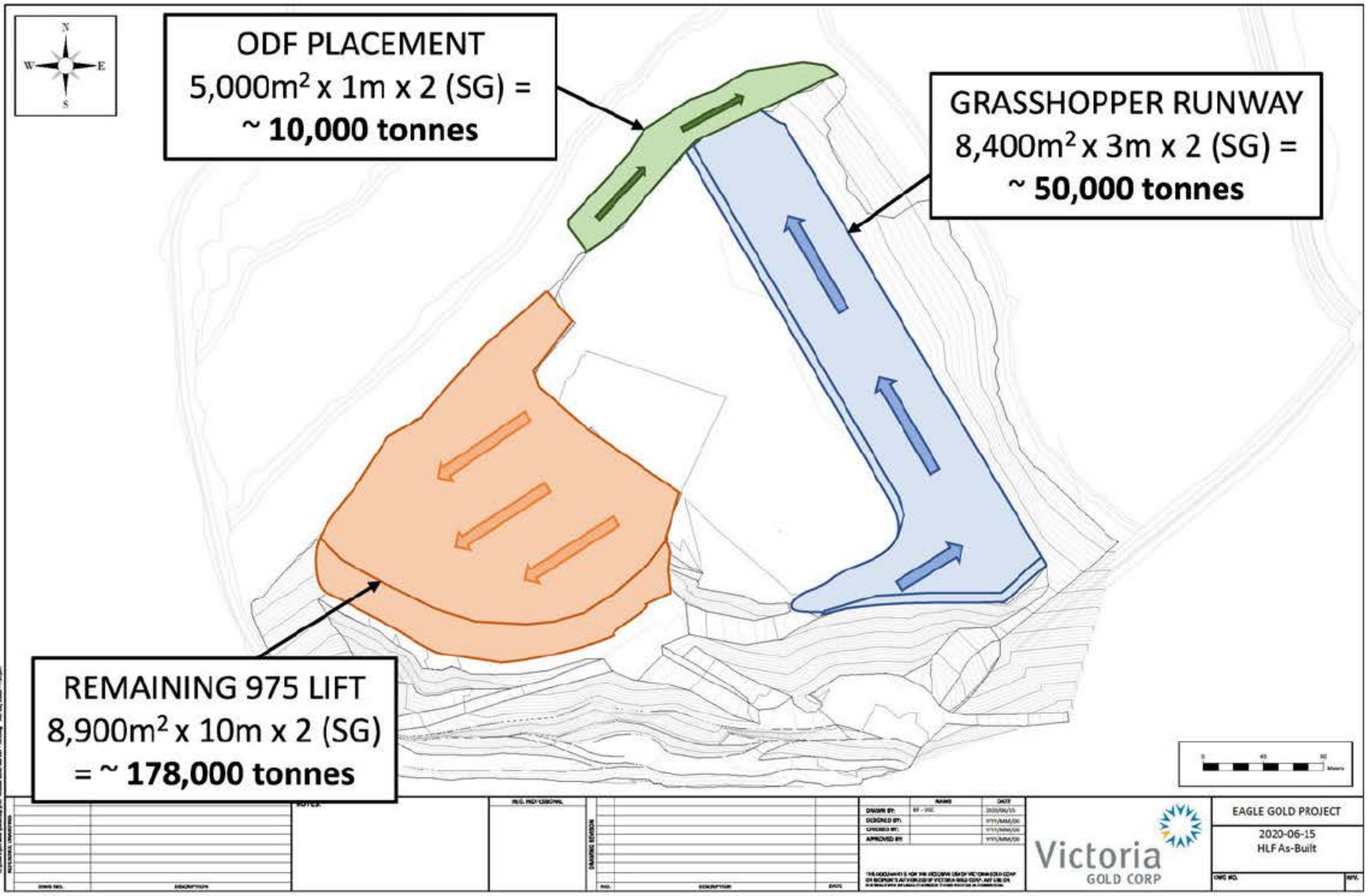
VICTORIA GOLD CORP

HLF Ore Stacked before 2020-06-15

HLF Ore Stacking Plan 2020-06-16 to 2020-06-22 (inferred from plan)

Placement Priorities This Week

VICTORIA GOLD CORP

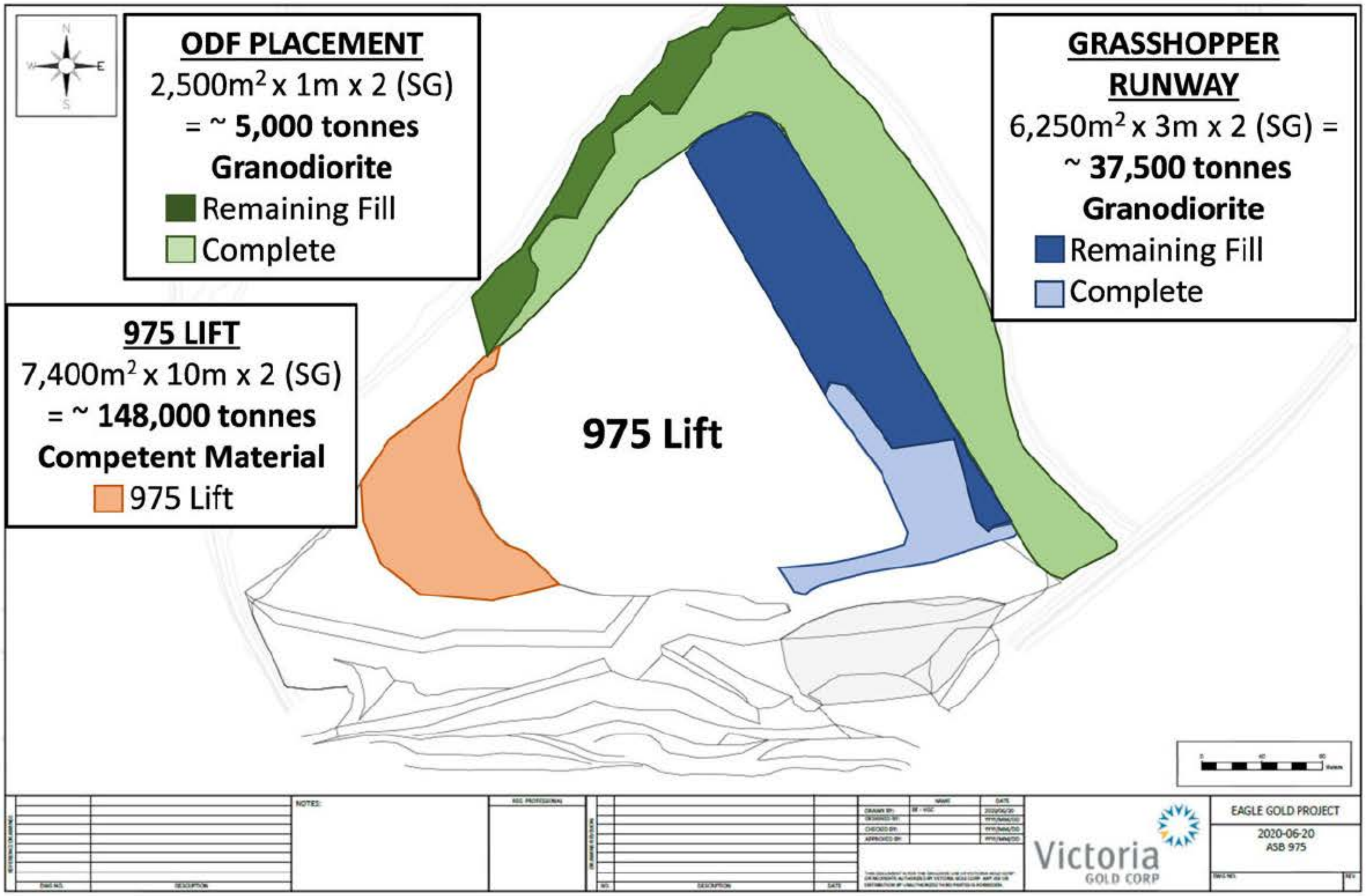


TSX : VGCX | vitgoldcorp.com

HLF Ore Stacking Plan 2020-06-23 to 2020-06-29 (inferred from plan)

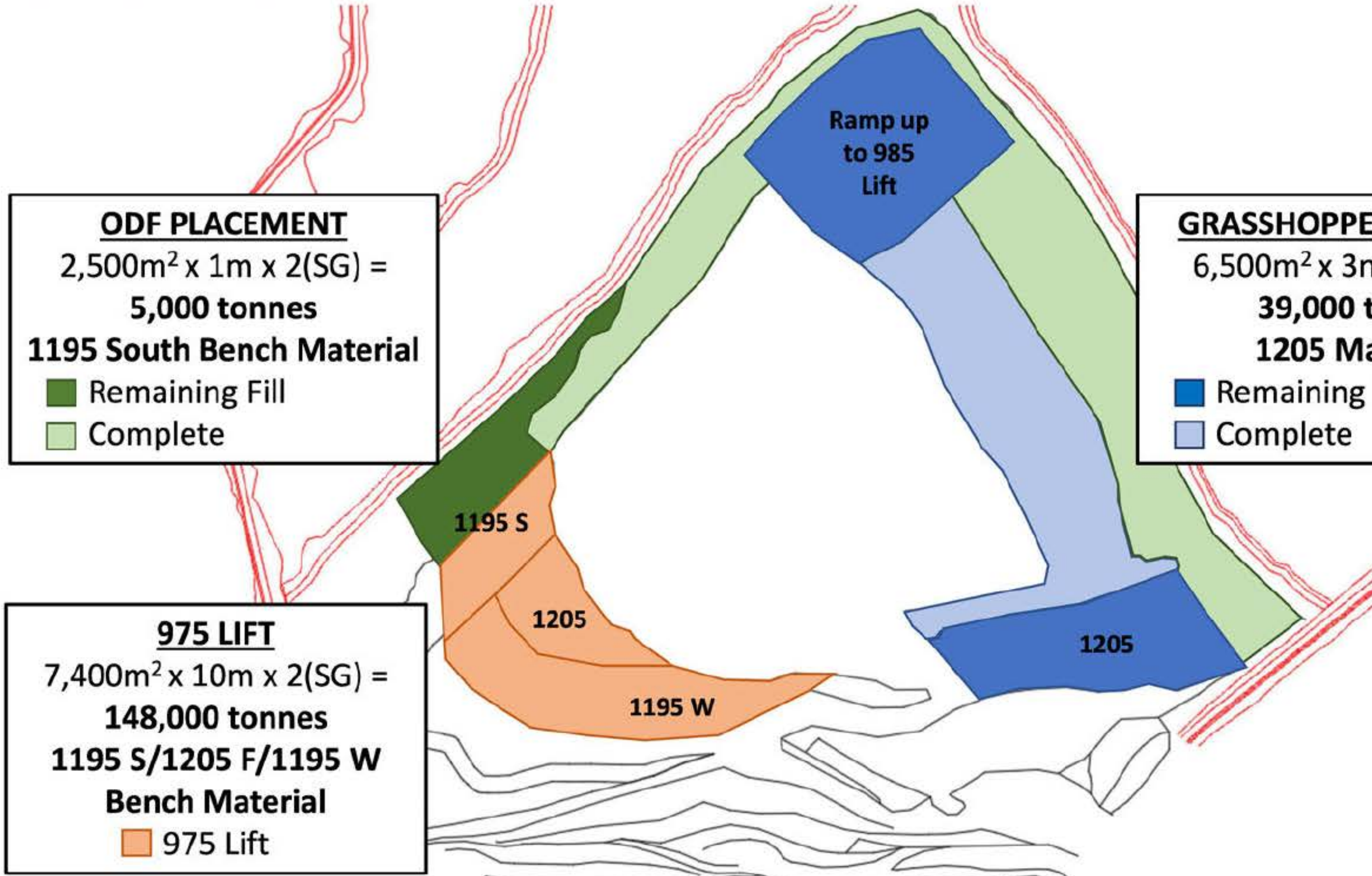
Placement Priorities This Week

VICTORIA GOLD CORP



HLF Ore Stacking Plan 2020-06-30 to 2020-07-06 (inferred from plan)

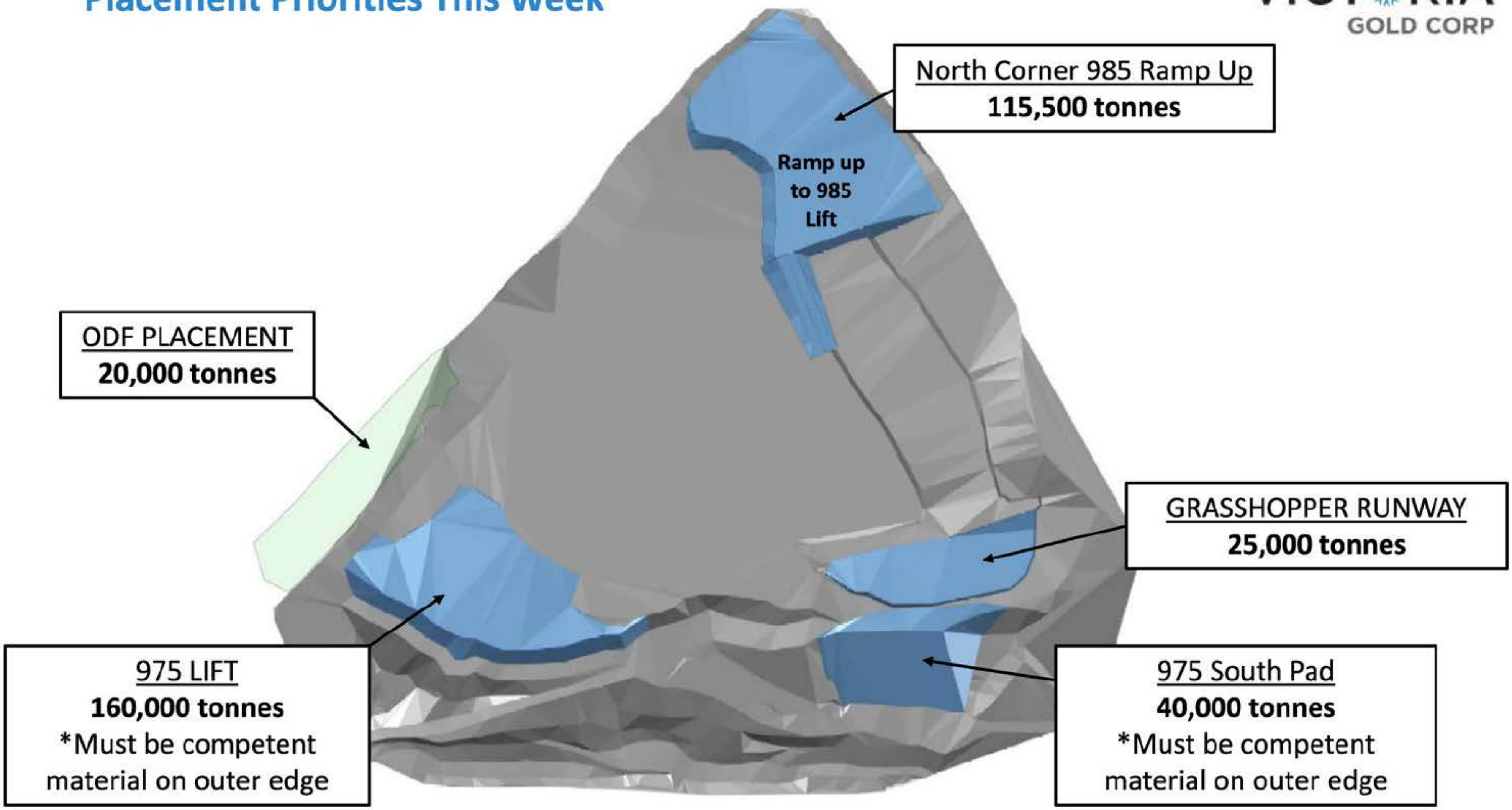
Placement Priorities This Week



HLF Ore Stacking Plan 2020-07-07 to 2020-07-13 (inferred from plan)

Placement Priorities This Week

VICTORIA GOLD CORP

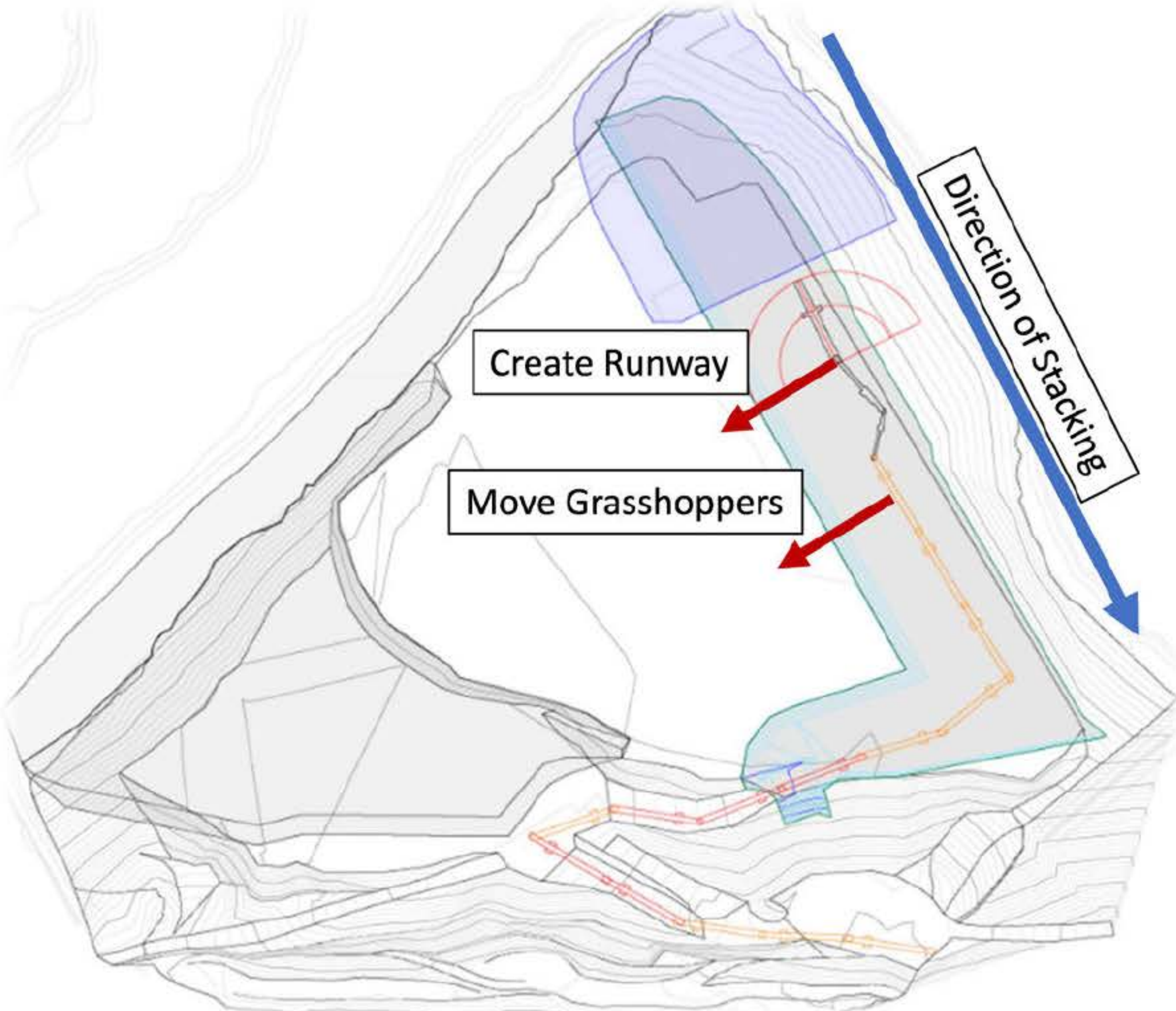


TSX : VGCX | vitgoldcorp.com

HLF Ore Stacking Plan 2020-07-14 to 2020-07-20 (inferred from plan)

Stacking 985 Lift with Grasshoppers

VICTORIA GOLD CORP



55m Wide by 3m Deep Runway Placed on Active Leach Area

Retreat Stacking Strip Widths Equal to Stacker Feed Extents

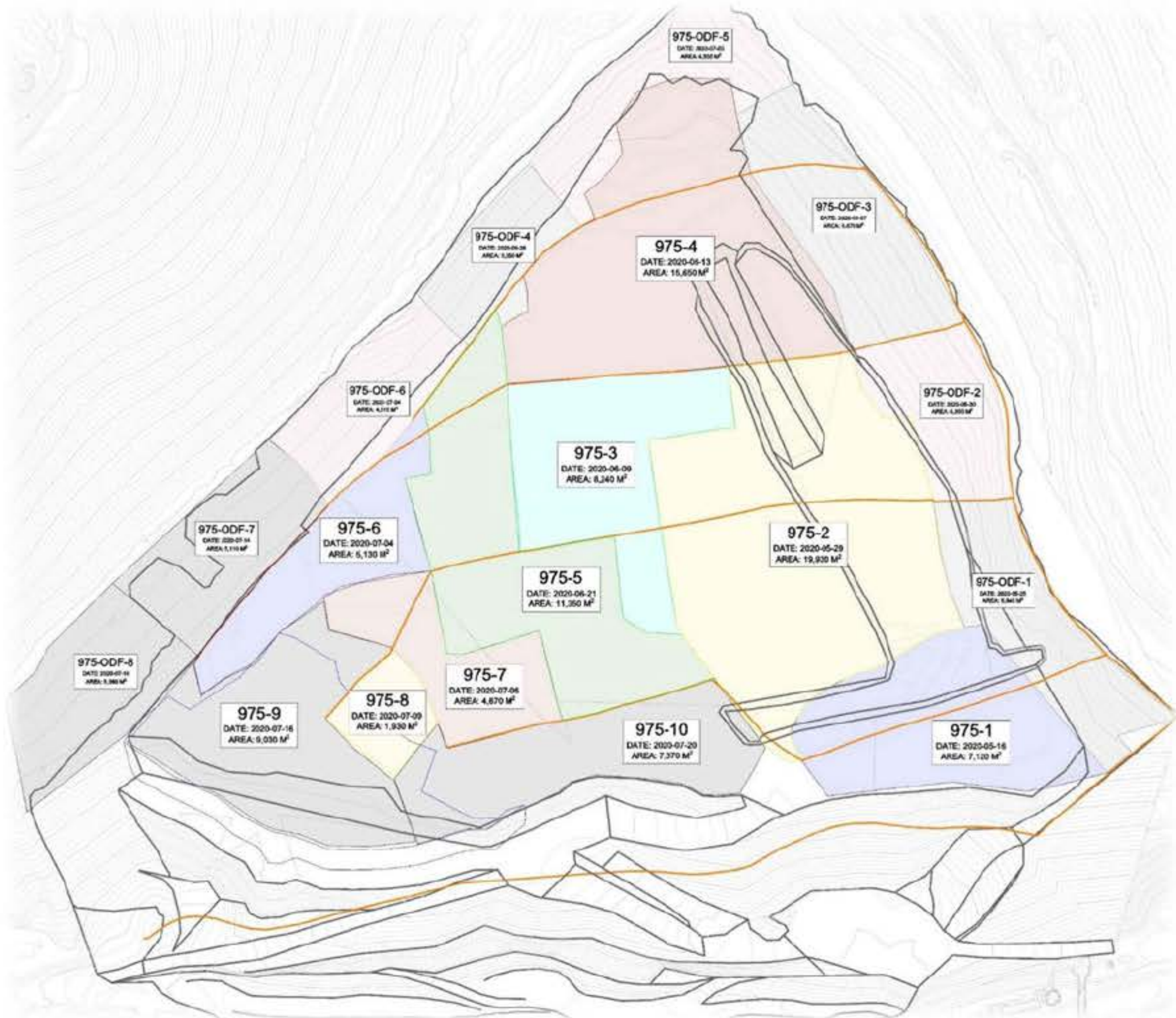
Dozers Create Next 3m Runway to West of Arrangement Off Main Pile

Grasshoppers Moved to West for Next Strip as Stacker System Retreats

TSX : VGCX | vitgoldcorp.com

HLF Ore Stacking Plan 2020-07-14 to 2020-07-20 (inferred from plan)

Finished 975 Lift (July 20)



16,400m² of Ore Remaining to Leach on 975 Elevation

Pre-Leaching ODF (1-3m):
29,170m² Under Leach
10,470m² To Be Added

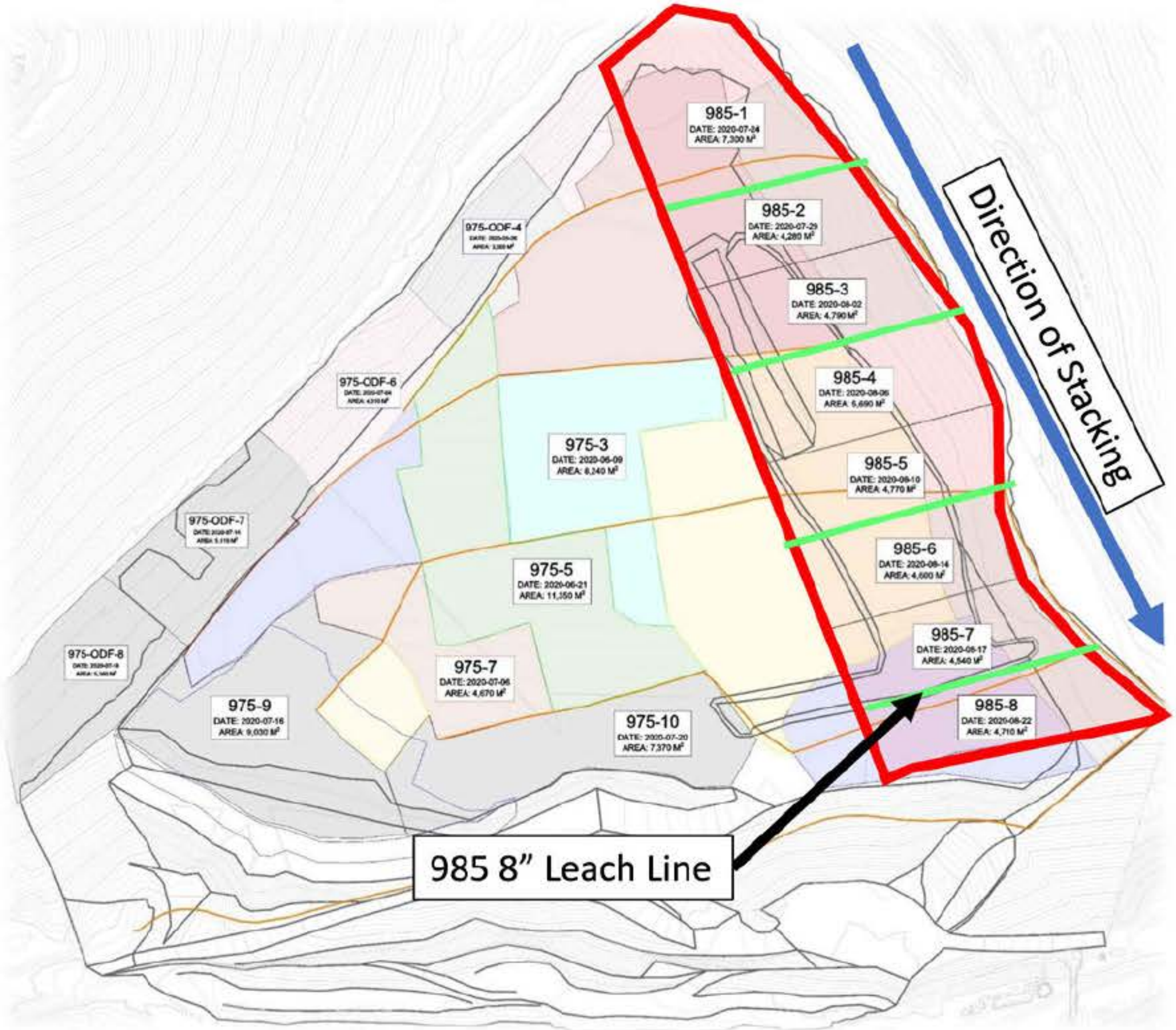
Stacking Production Based on Budget Numbers: ~33,000 Tonnes Per Day

Cells Put Under Leach Day After Stacking

HLF Ore Stacking Plan 2020-07-14 to 2020-07-20 (inferred from plan)

985 Lift Strip 1 (August 22)

VICTORIA GOLD CORP



Y-Type Fittings for 24" to 8", Leaching 975 & 985 Simultaneously

Strip 1 Adds 40,680m² Under Leach

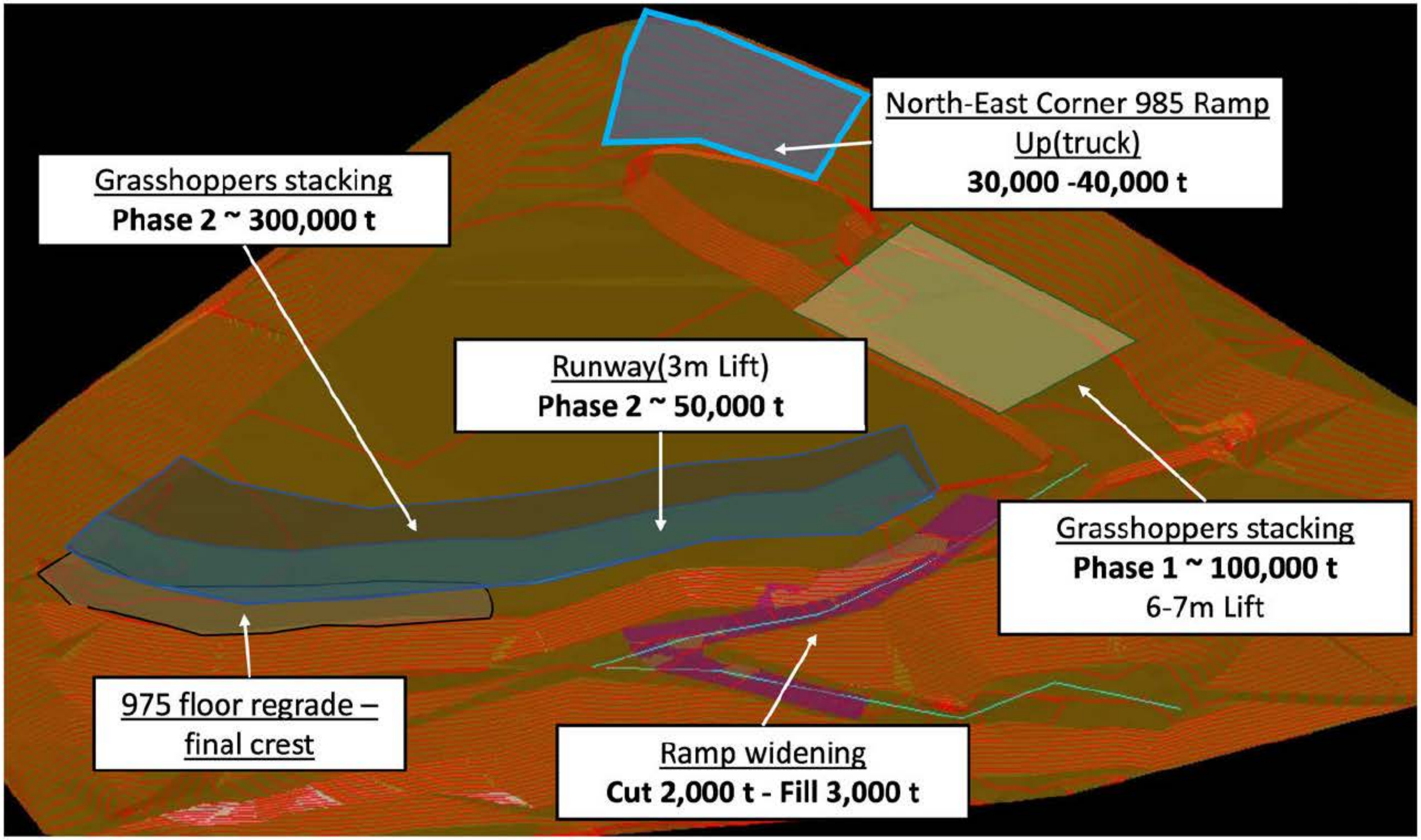
Bring 8" East to West as Stacker Retreats South

TSX : VGCX | vitgoldcorp.com

HLF Ore Stacking Plan 2020-07-21 to 2020-07-27 (inferred from plan)

Production Plan

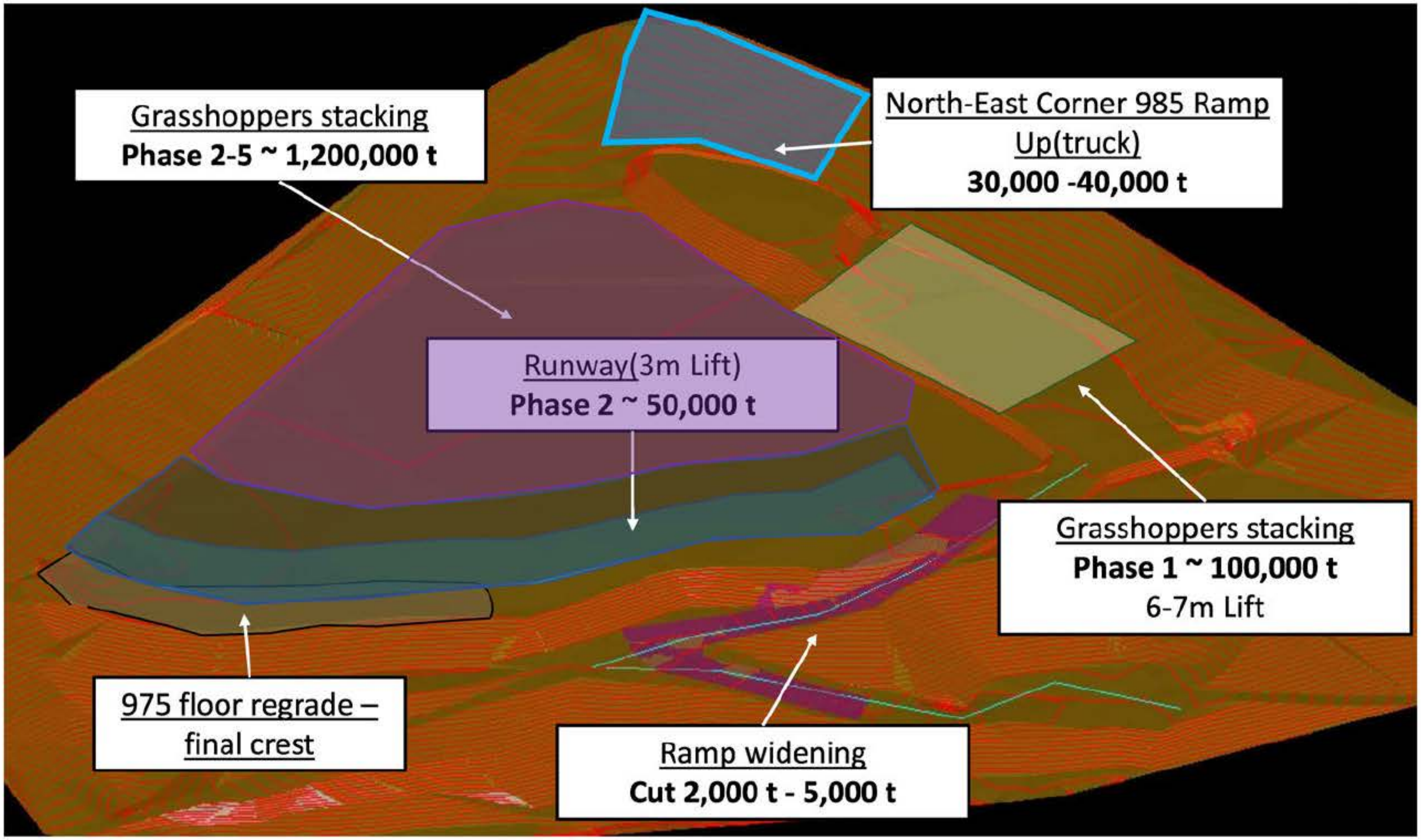
VICTORIA GOLD CORP



HLF Ore Stacking Plan 2020-07-28 to 2020-08-03 (inferred from plan)

Production Plan End July – 2 weeks August

VICTORIA GOLD CORP

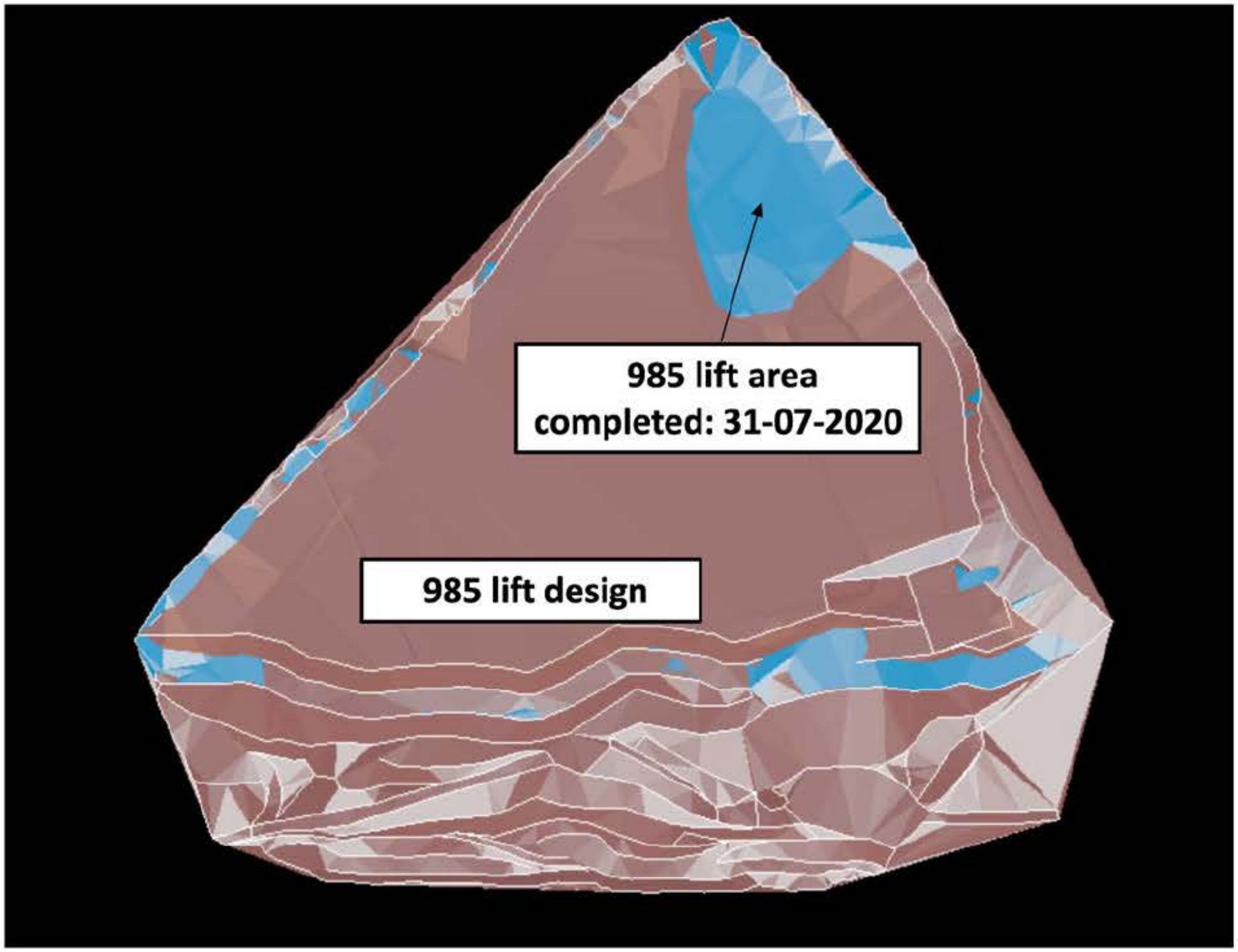


TSX : VGCX | vitgoldcorp.com

(Progress as of 2020-07-31 included for reference)

As-built 31-07-2020 vs 985 lift design

VICTORIA GOLD CORP



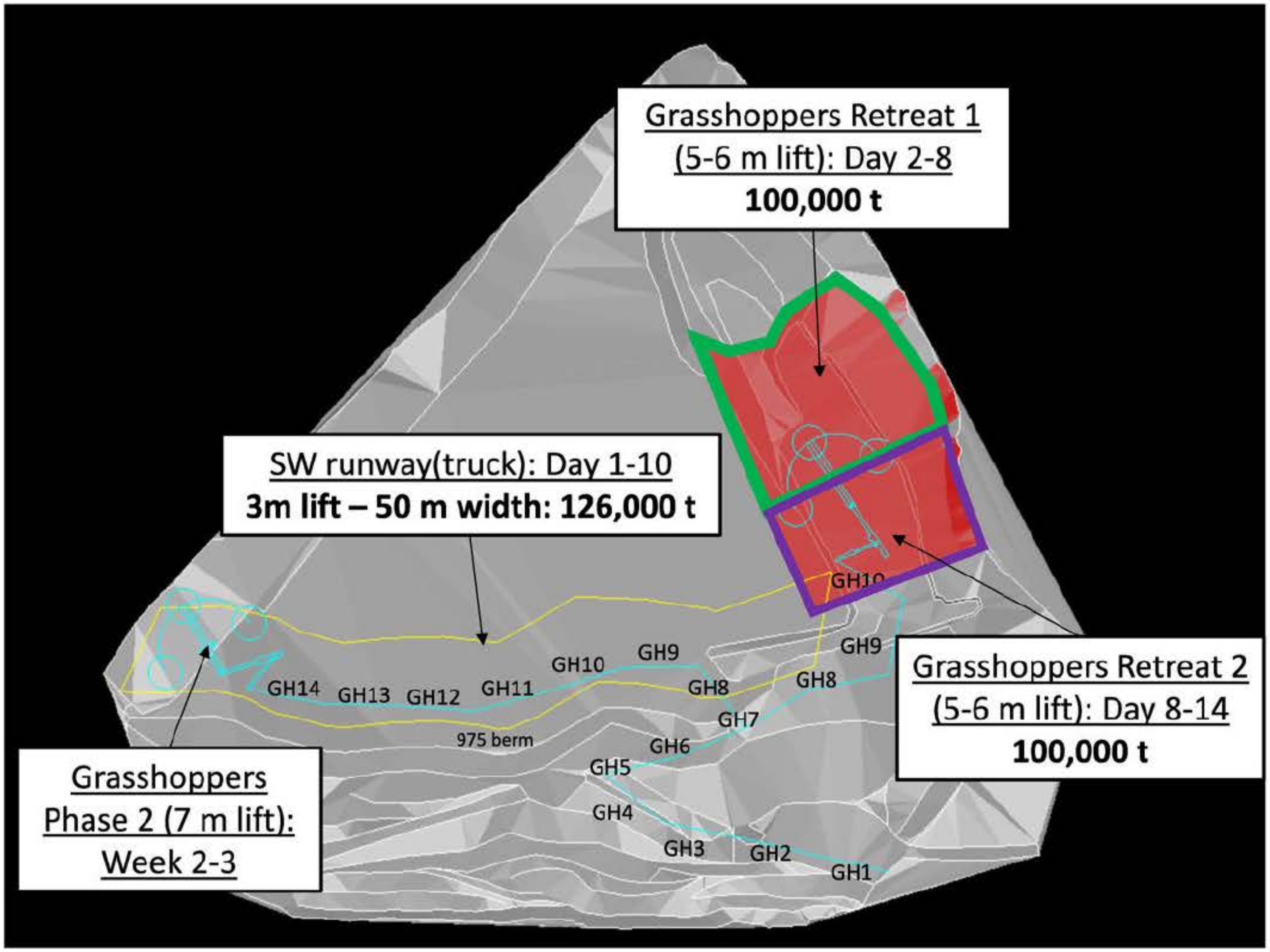
TSX : VGCX | vitgoldcorp.com

HLF Ore Stacking Plan 2020-08-04 to 2020-08-10 (inferred from plan)

Stacking Plan: 985 Lift (Week 1-2)

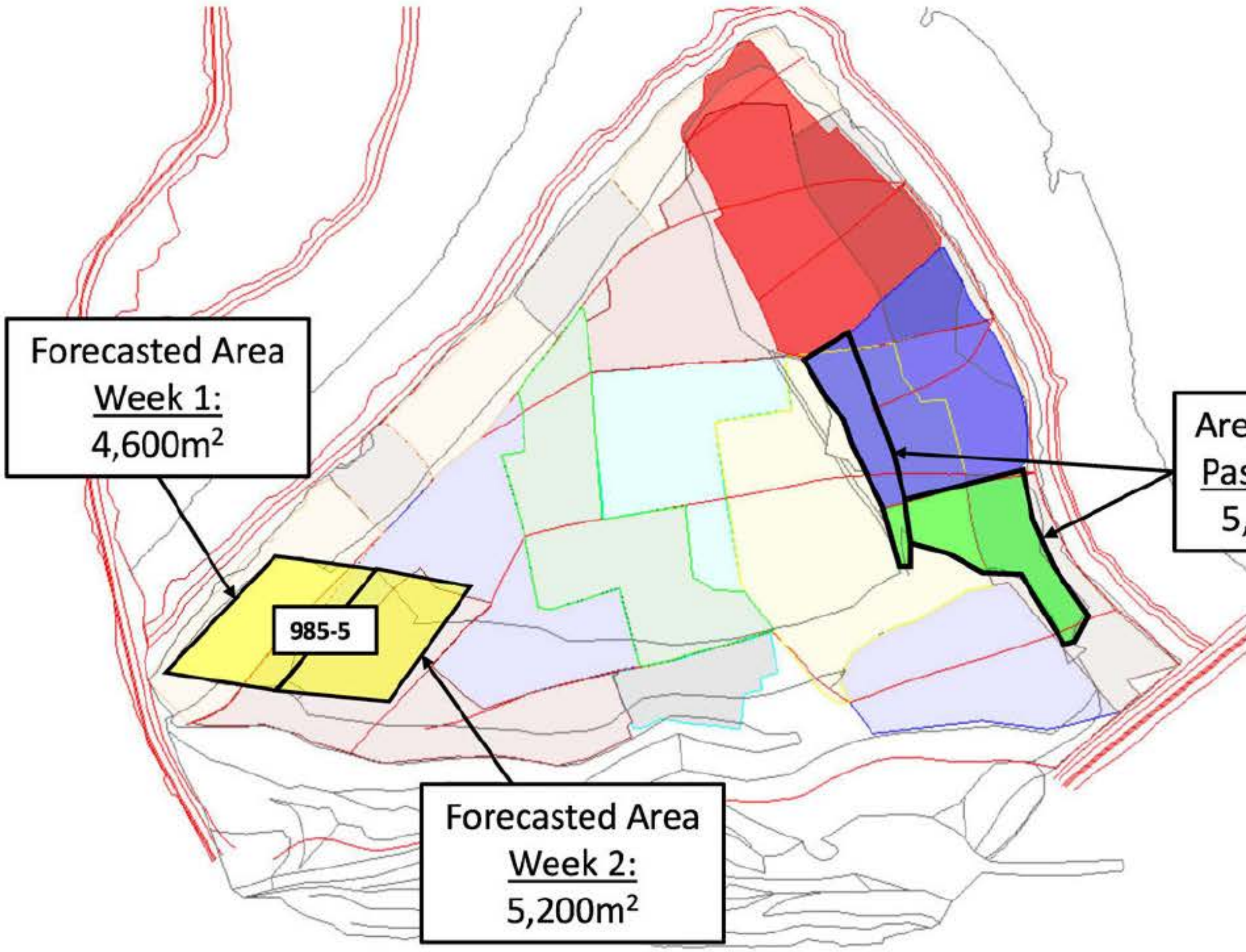
VICTORIA GOLD CORP

TSX : VGCX | vitgoldcorp.com



HLF Ore Stacking Plan 2020-08-11 to 2020-08-17

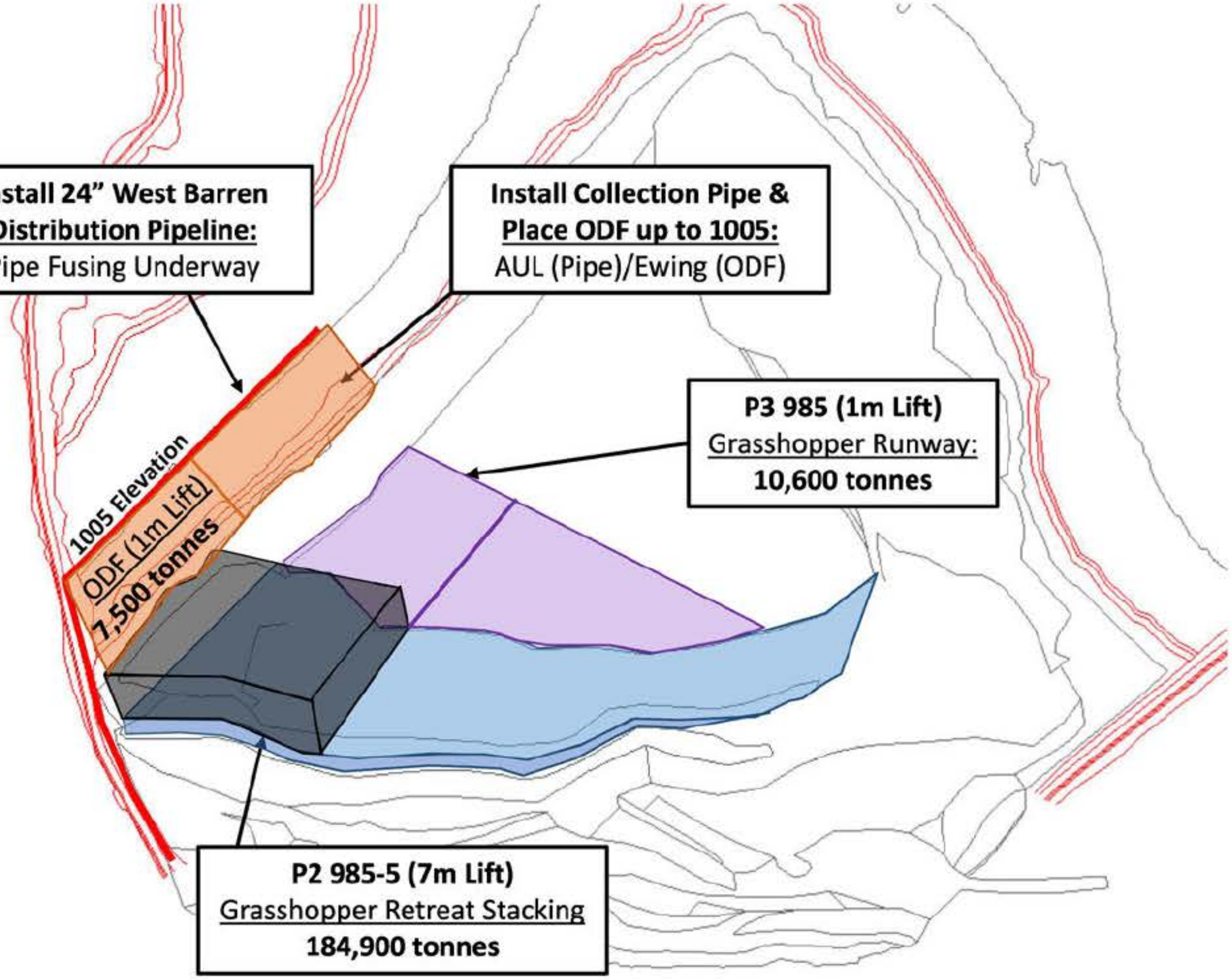
Leach Cells Online Aug 18 = 119,324 m²



HLF Ore Stacking Plan 2020-08-18 to 2020-08-24 (inferred from plan)

VICTORIA GOLD CORP

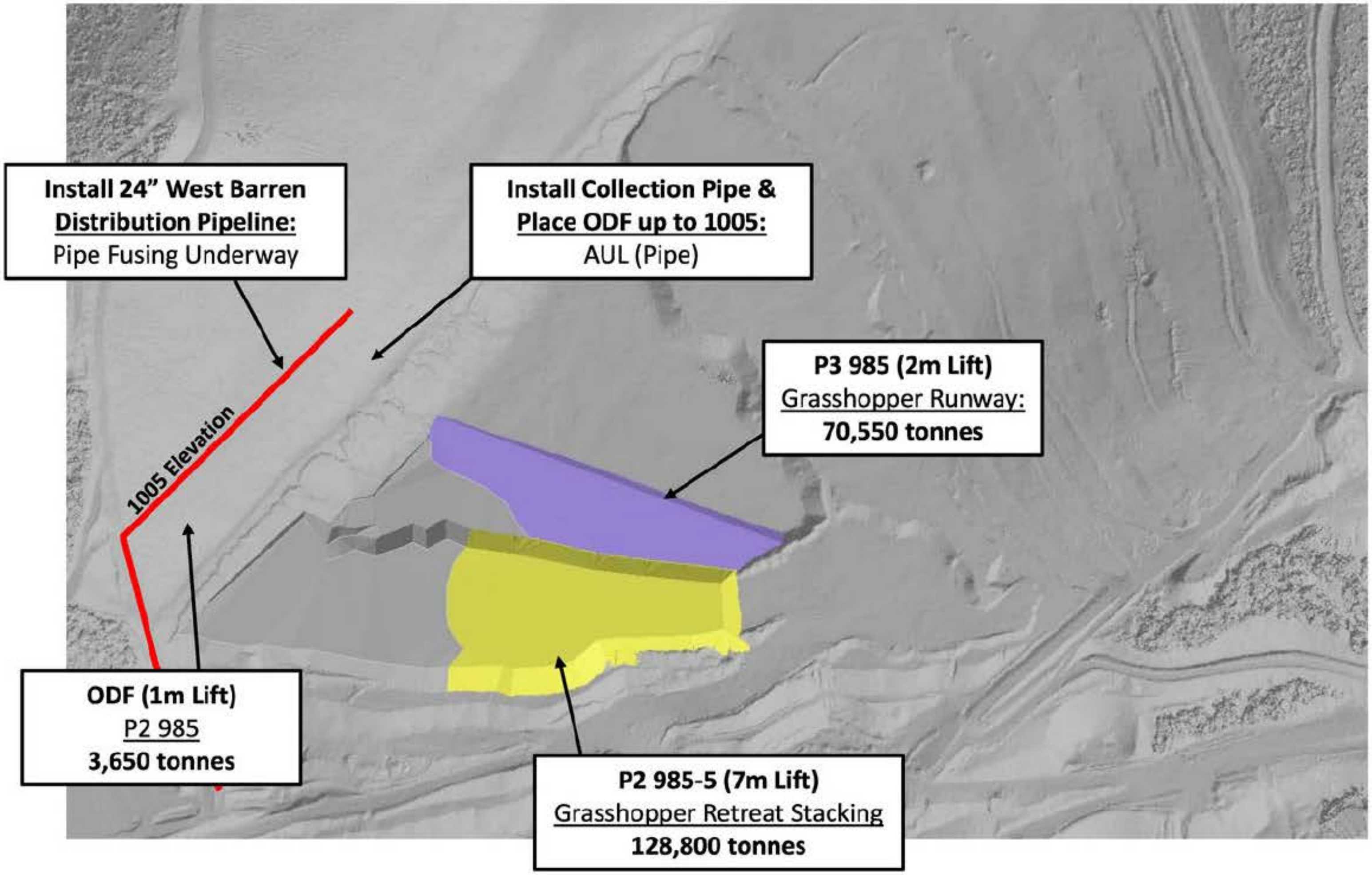
Placement Priorities Week 1 (Aug 18-24)



HLF Ore Stacking Plan 2020-08-25 to 2020-08-31 (inferred from plan)

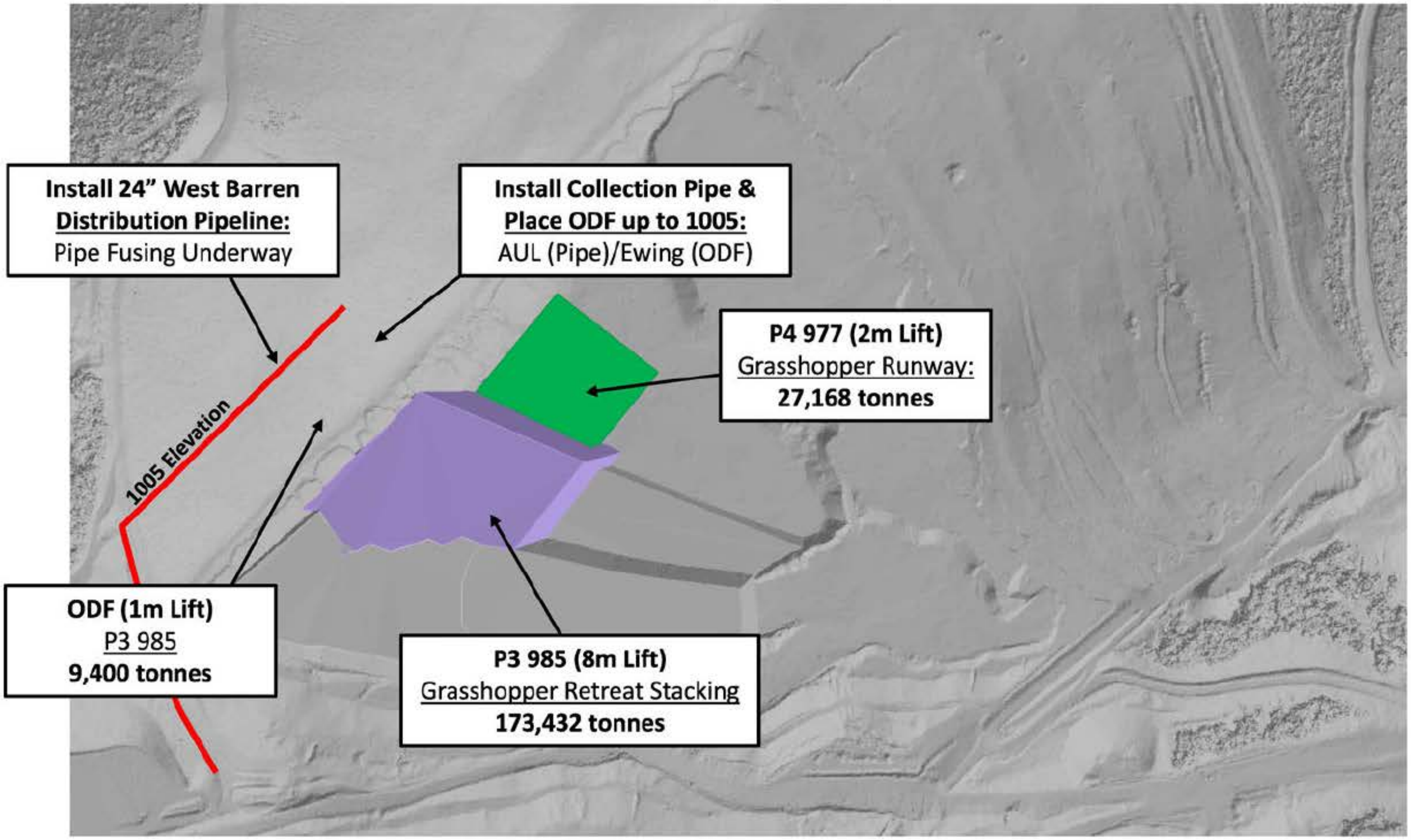
VICTORIA GOLD CORP

Placement Priorities Week 1 (Aug 25-31)



HLF Ore Stacking Plan 2020-09-01 to 2020-09-07 (inferred from plan)

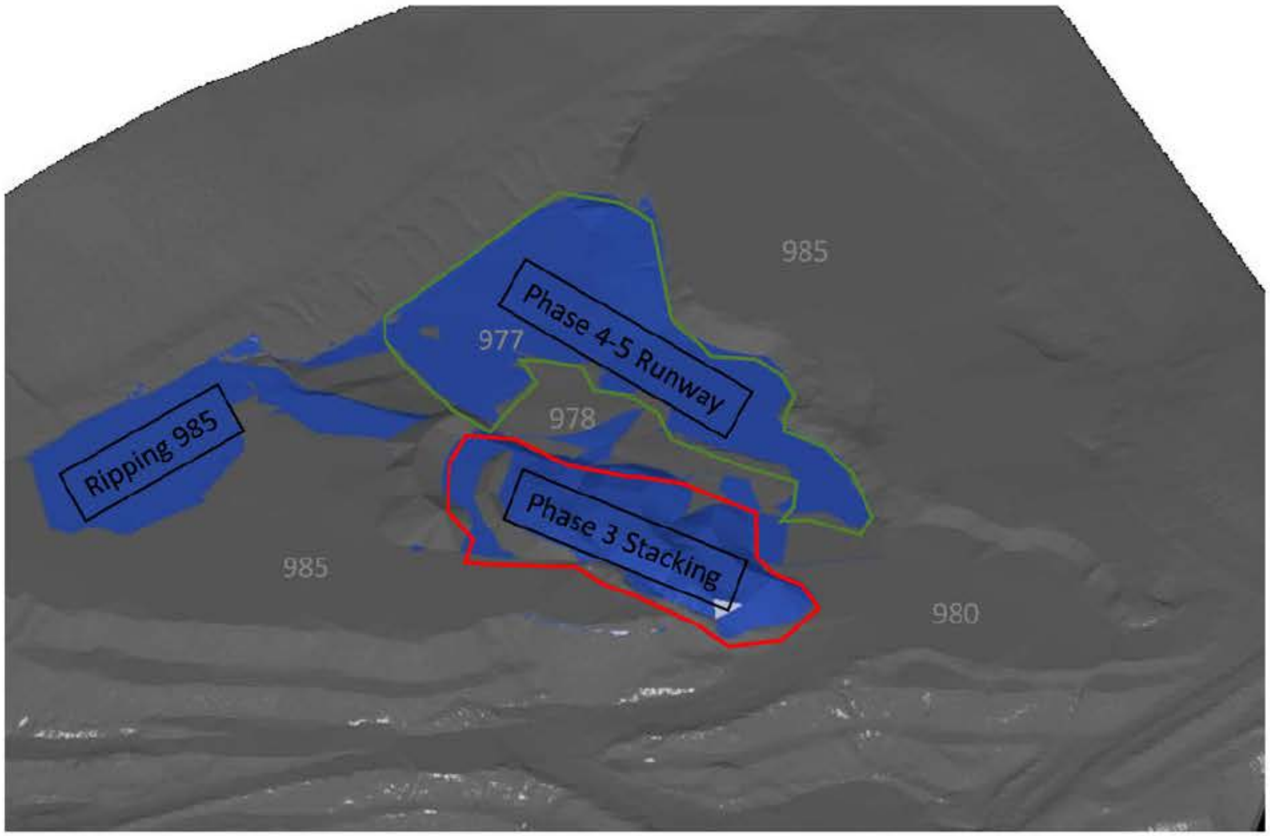
Placement Priorities Week 2 (Sep 1-7)



HLF Ore Stacking Plan 2020-09-08 to 2020-09-14

Lift - 985 Past Week – September 8th to September 14th

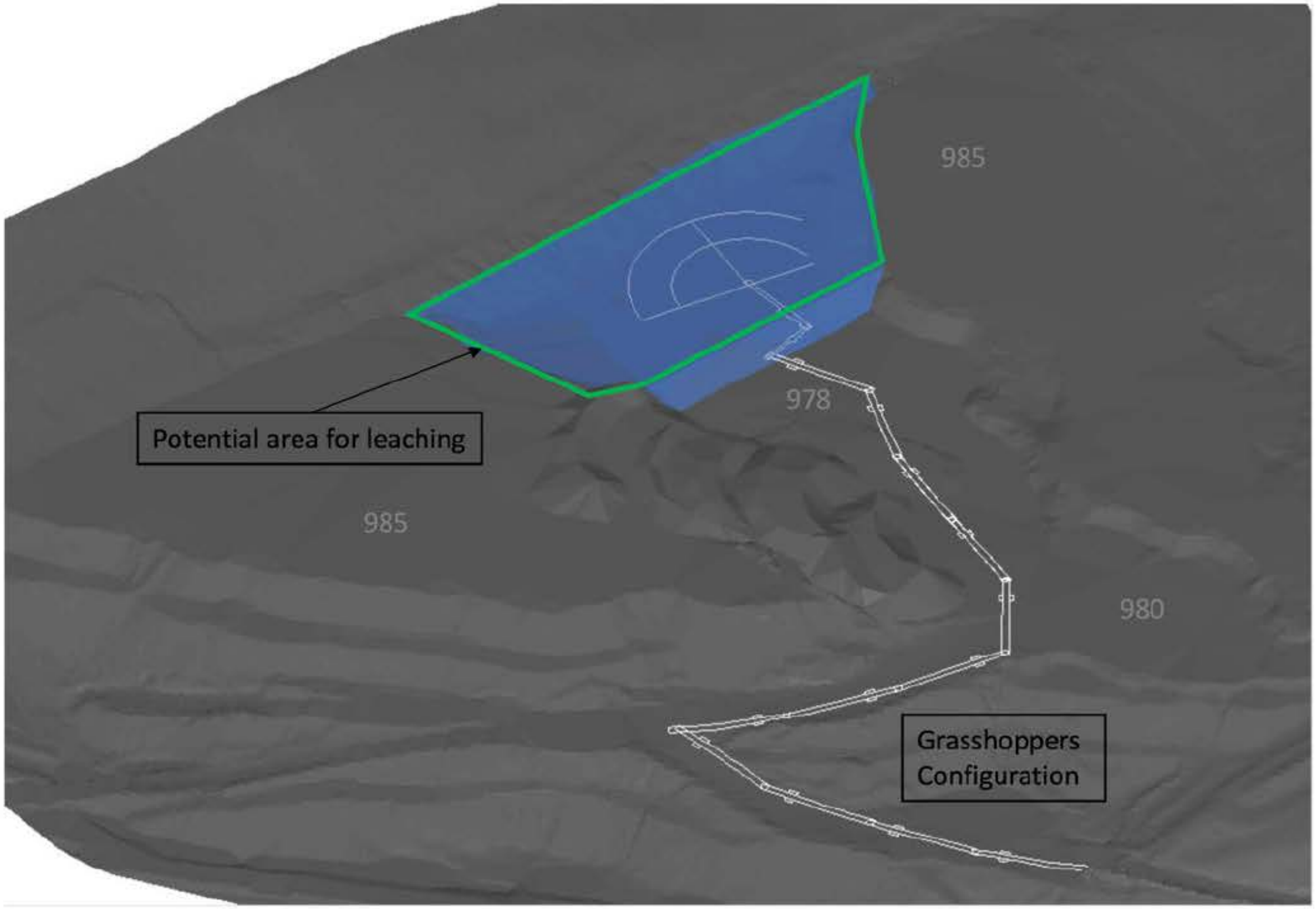
Previous Week Variance		08-Sep (Tue)	09-Sep (Wed)	10-Sep (Thu)	11-Sep (Fri)	12-Sep (Sat)	13-Sep (Sun)	14-Sep (Mon)	Daily Avg	Total
Planned Tonnes Stacked	(T)	30,000	30,000	30,000	30,000	30,000	30,000	30,000	**30,000**	**210,000**
Actual Tonnes Stacked	(T)	**21,345**	**21,681**	**29,735**	**24,677**	**23,353**	**21,567**	**25,901**	**24,037**	**168,259**
Variance		*-8,655*	*-8,319*	*-265*	*-5,323*	*-6,647*	*-8,433*	*-4,099*	-20%	-20%



HLF Ore Stacking Plan 2020-09-15 to 2020-09-21 (inferred from plan)

VICTORIA GOLD CORP

Stacking Plan Week 1 - September 15th to September 21st



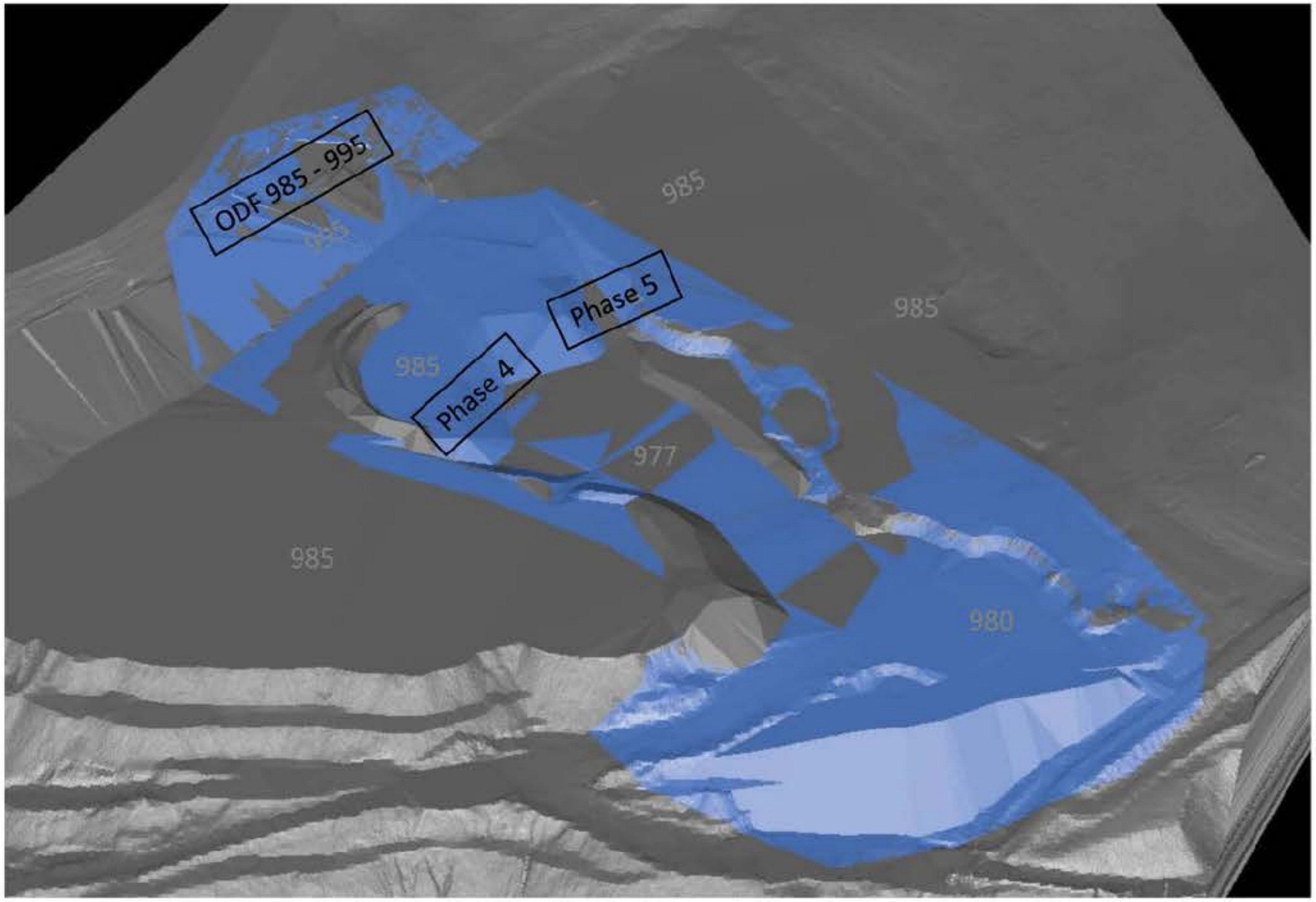
165,000 tonnes P4-P5 985 Lift (8m lift)

14,000 m^2 as potential available area for leaching

TSX : VGCX OTC: VITFF VGCX.com

HLF Ore Stacking Plan 2020-09-22 to 2020-09-28

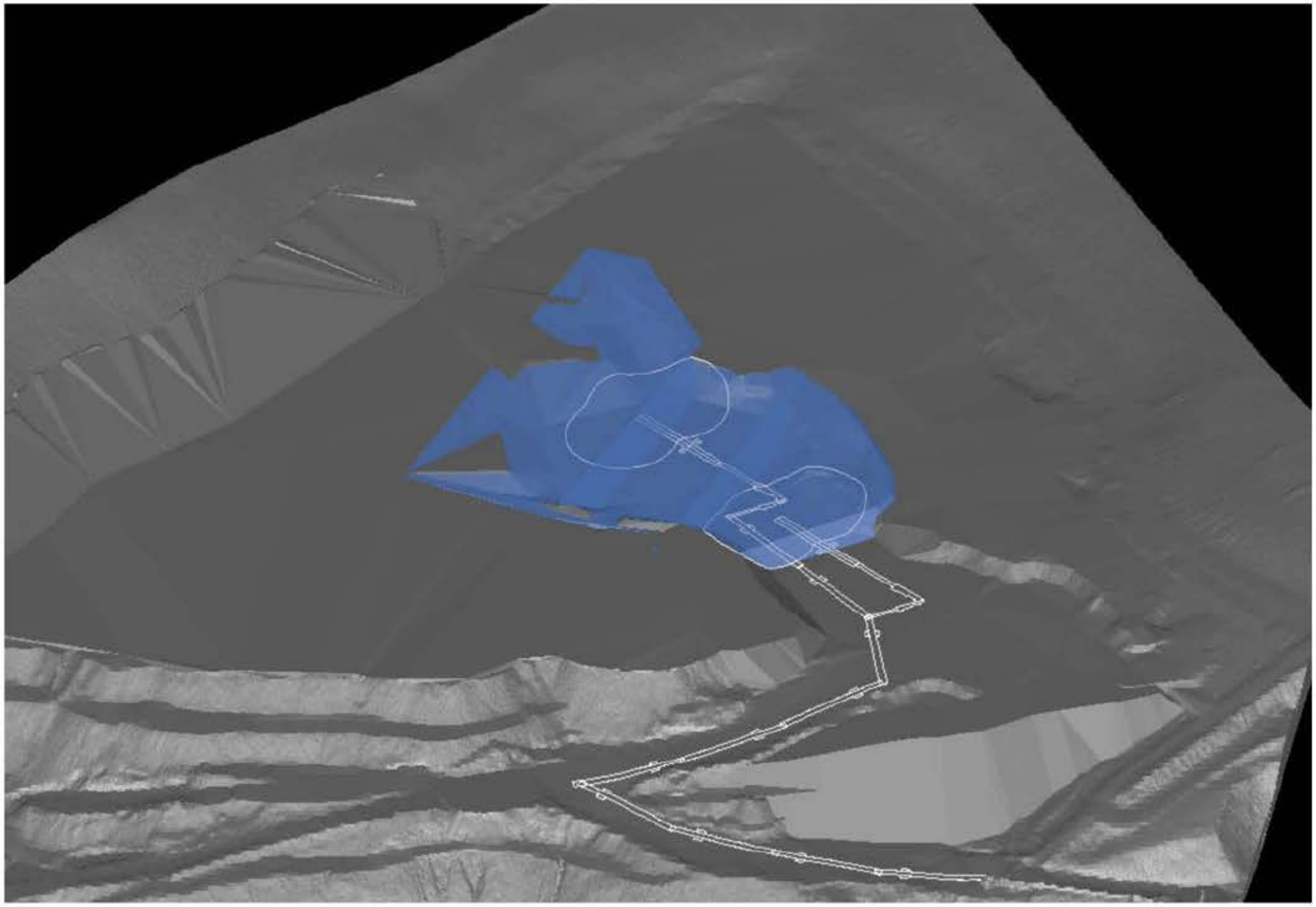
Lift - 985 Past Week – September 22nd to September 28th



HLF Ore Stacking Plan 2020-09-29 to 2020-10-05 (inferred from plan)

VICTORIA GOLD CORP

Stacking Plan Week 1 - September 29nd to October 5th



205,000 tonnes P4-P5 985 Lift (8m lift)

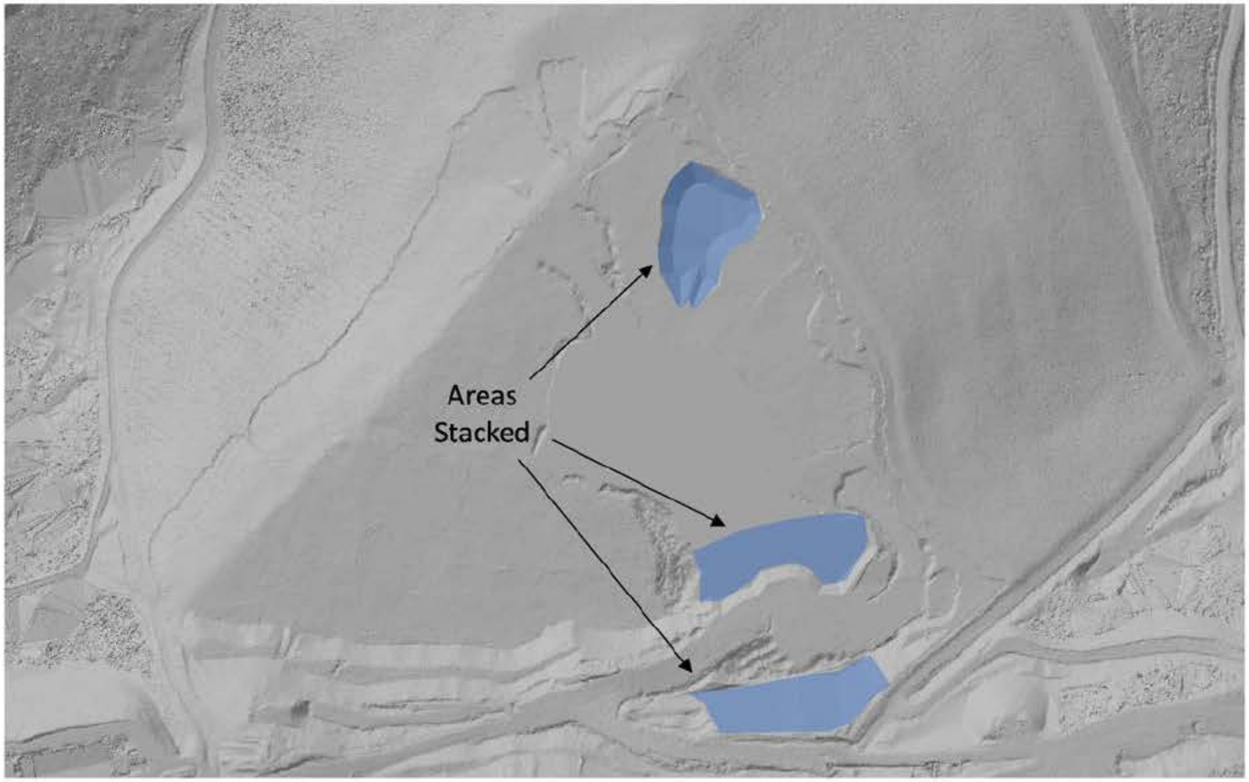
26,000 tonnes ODF Lift (1m lift)

TSX : VGCX OTC: VITFF VGCX.com

HLF Ore Stacking Plan 2020-10-06 to 2020-10-12

Previous Week Stacking: 985/995 – Oct 6th – Oct 12th

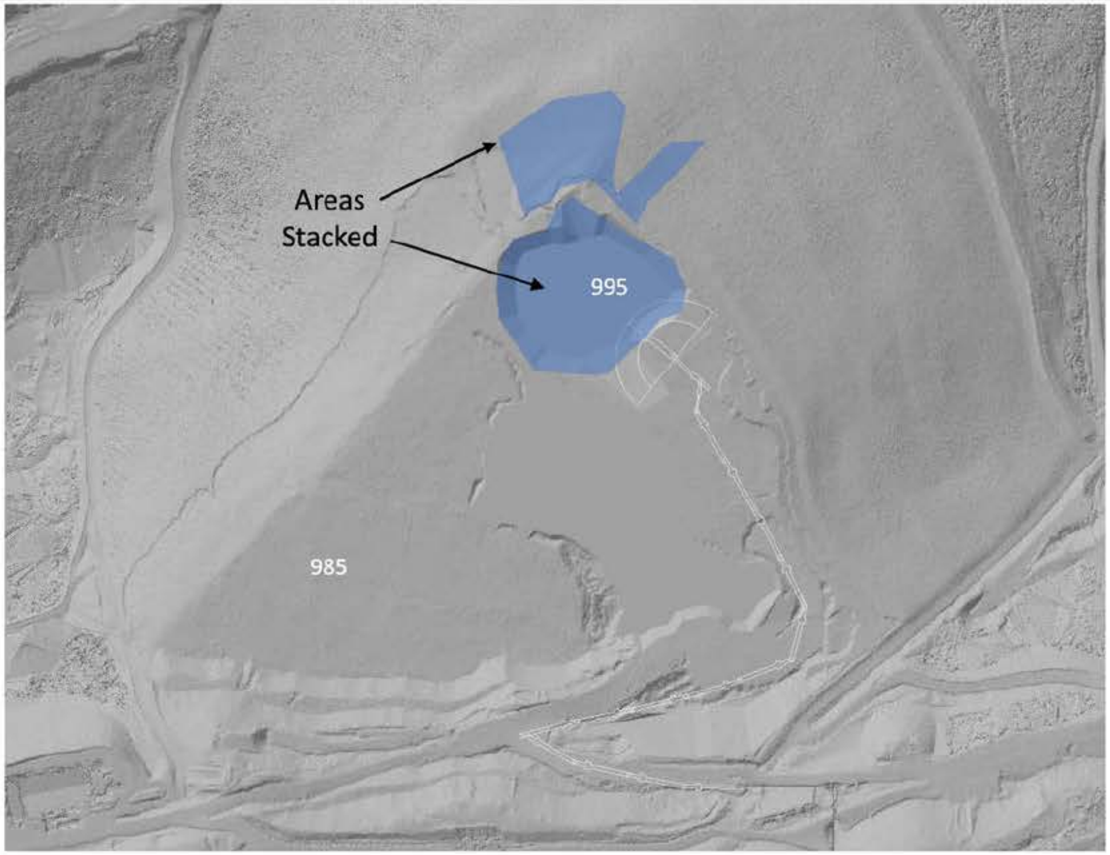
Previous Week Variance		06-Oct (Tue)	07-Oct (Wed)	08-Oct (Thu)	09-Oct (Fri)	10-Oct (Sat)	11-Oct (Sun)	12-Oct (Mon)	Total	Variance
HLF										
Planned Tonnes Stacked	(T)	30,645	30,645	30,645	30,645	30,645	30,645	30,645	**214,515**	
Actual Tonnes Stacked	**(T)**	**23,274**	**27,363**	**23,808**	**3,682**	**37,202**	**33,330**	**34,260**	**182,919**	**-15%**
Variance		*-7,371*	*-3,282*	*-6,837*	*-26,963*	*6,557*	*2,685*	*3,615*		



HLF Ore Stacking Plan 2020-10-13 to 2020-10-19

Previous Week Stacking: 985/995 – Oct 12th – Oct 18th

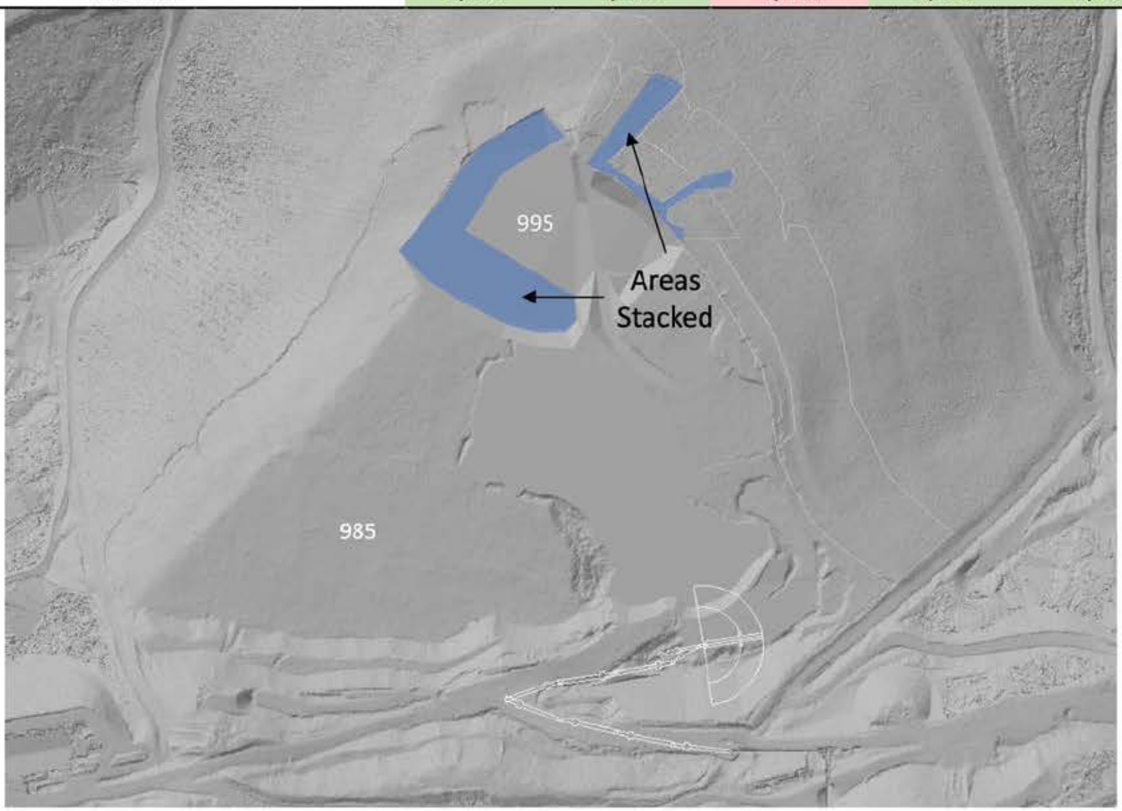
Previous Week Variance		12-Oct (Mon)	13-Oct (Tue)	14-Oct (Wed)	15-Oct (Thu)	16-Oct (Fri)	17-Oct (Sat)	18-Oct (Sun)	Total	Variance
HLF			Primary 8HR				SecTer 12HR			
Planned Tonnes Stacked	(T)	30,645	30,645	30,645	30,645	30,645	30,645		**183,870**	
Actual Tonnes Stacked	**(T)**	**34,260**	**31,810**	**32,048**	**28,501**	**21,952**	**12,630**		**161,201**	**-12%**
Variance		*3,615*	*1,165*	*1,403*	*-2,144*	*-8,693*	*-18,015*	*0*		



HLF Ore Stacking Plan 2020-10-20 to 2020-10-26

Previous Week Stacking: 995/ODF Oct 20th – Oct 26th

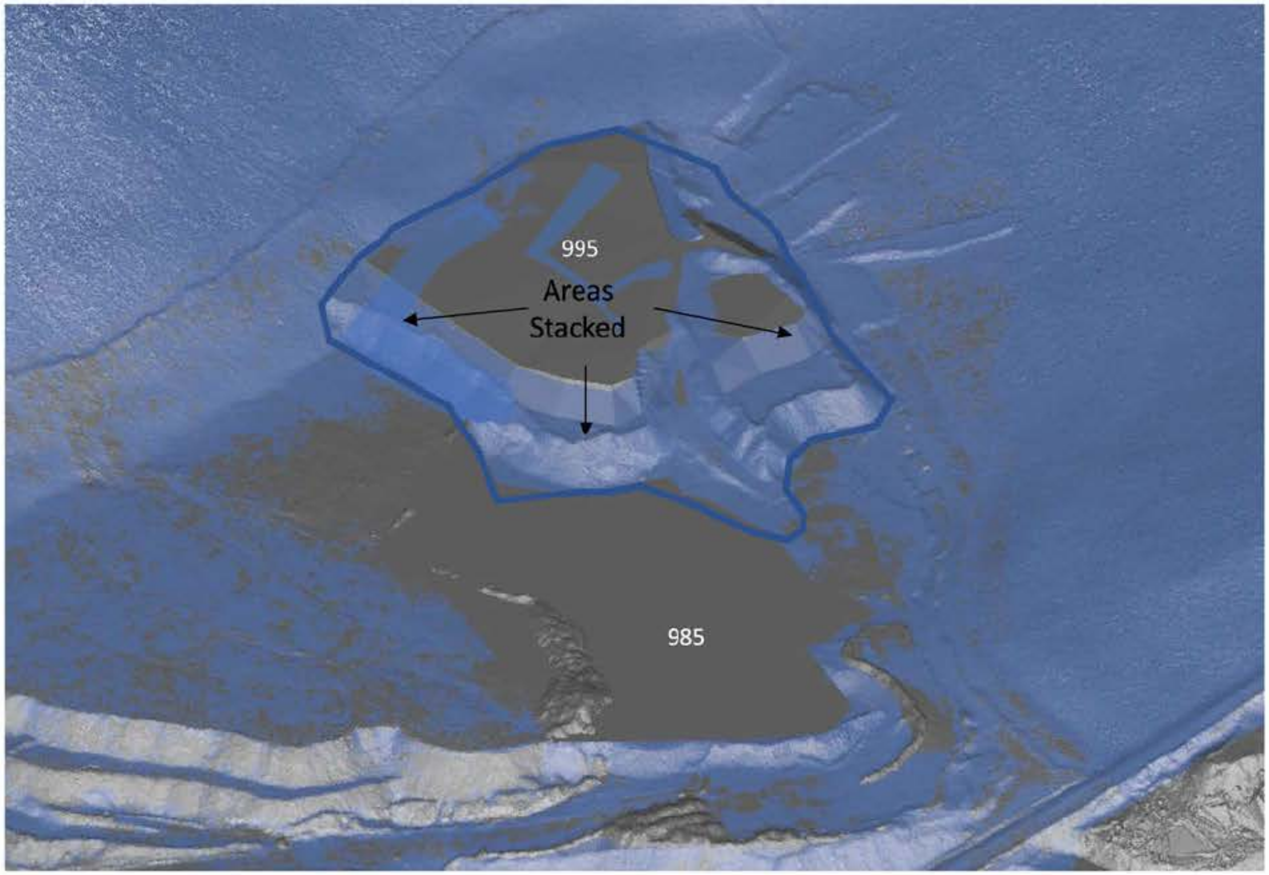
Previous Week Variance		20-Oct (Tue)	21-Oct (Wed)	22-Oct (Thu)	23-Oct (Fri)	24-Oct (Sat)	25-Oct (Sun)	26-Oct (Mon)	Total	Variance
HLF								SecTer 16Hr		
Planned Tonnes Stacked	(T)	30,645	30,645	30,645	30,645	30,645	30,645	30,645	**214,515**	
Actual Tonnes Stacked	**(T)**	**32,242**	**32,181**	**29,161**	**33,780**	**36,098**	**25,896**	**10,215**	**199,573**	-7%
Variance		*1,597*	*1,536*	*-1,484*	*3,135*	*5,453*	*-4,749*	*-20,430*		



HLF Ore Stacking Plan 2020-10-27 to 2020-11-02

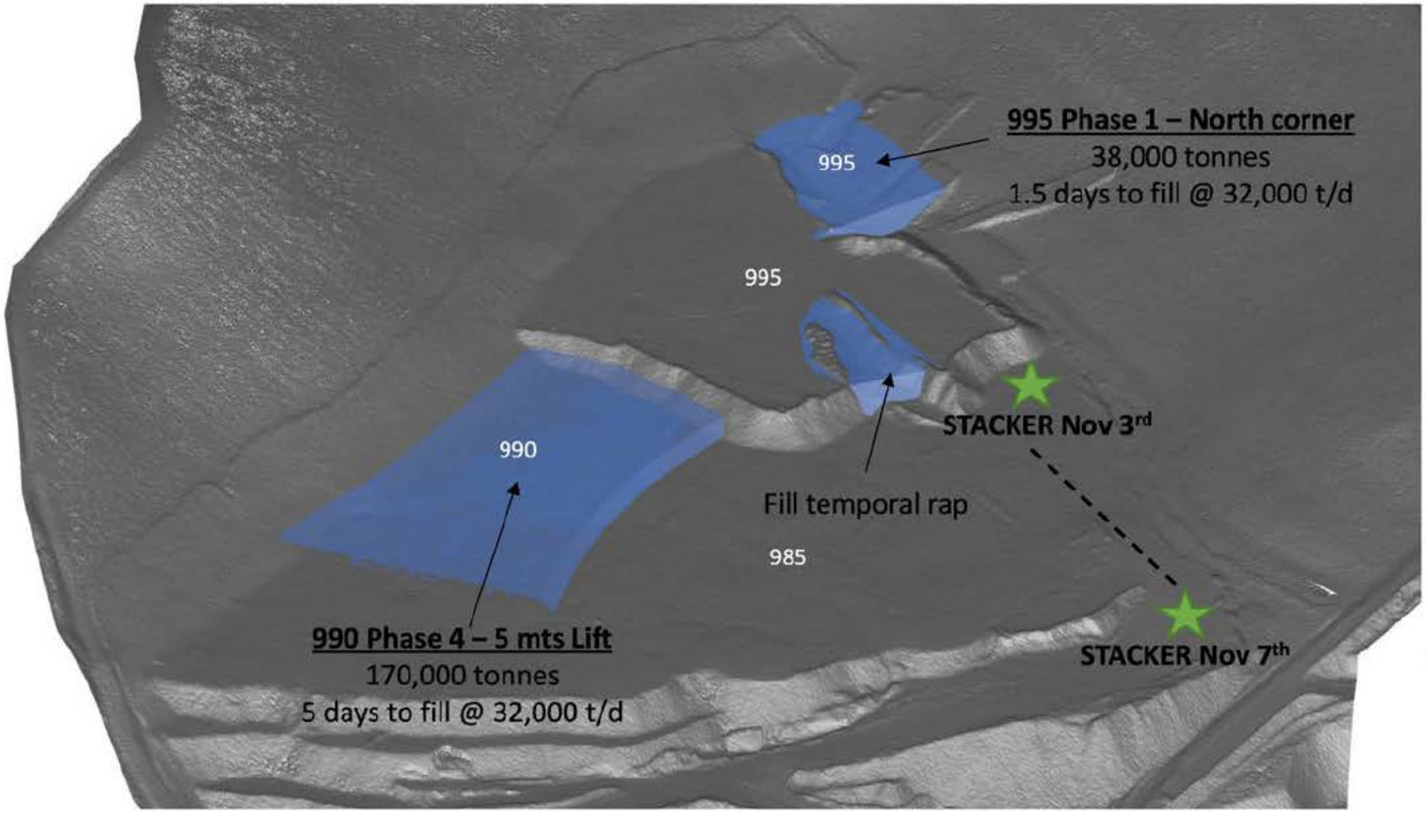
Previous Week Stacking: Oct 27th – Nov 2nd

Previous Week Variance		27-Oct (Tue)	28-Oct (Wed)	29-Oct (Thu)	30-Oct (Fri)	31-Oct (Sat)	01-Nov (Sun)	02-Nov (Mon)	Total
Planned Tonnes Stacked	(T)	30,900	30,900	30,900	30,900	30,900	30,900	30,900	**216,300**
Actual Tonnes Stacked	(T)	**22,011**	**10,351**	**7,890**	**17,402**	**18,533**	**14,744**	**23,631**	**114,562**
Variance		*-8,889*	*-20,549*	*-23,010*	*-13,498*	*-12,367*	*-16,156*	*-7,269*	**-47%**



Stacking Plan Week 1: November 3rd – November 9th

HLF Ore Stacking Plan 2020-11-03 to 2020-11-09 (inferred from plan)

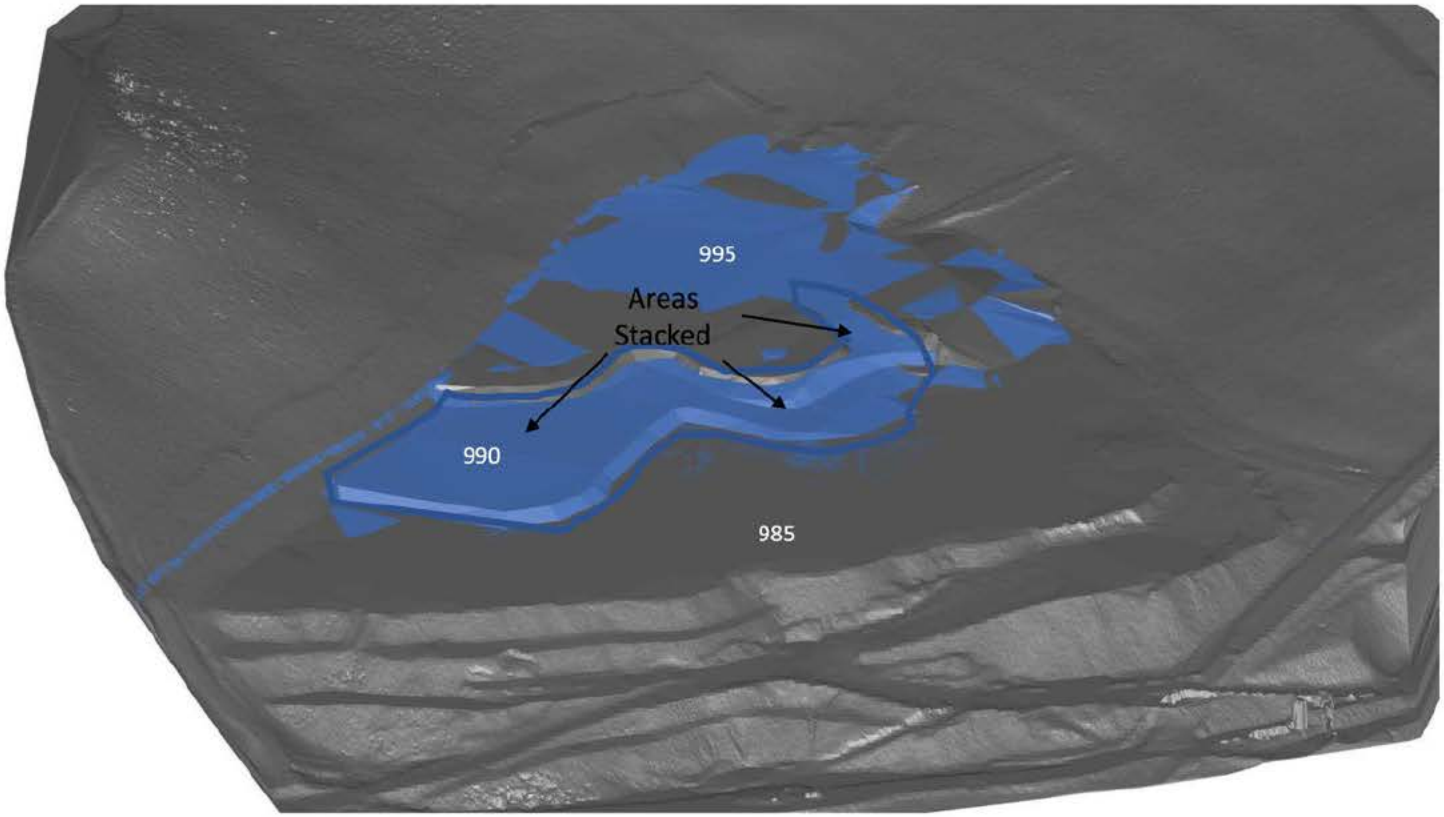


- Filling P1 & P4 will take ~ 7 days at budgeted tonnage.
- During the down, we will remove the 75hp grasshoppers and move the stacker to the staging area on the 985 bench.
- Utilize Cobalt Truck fleet for Phase 4 placement.
- Total Placement 208,000 tonnes

HLF Ore Stacking Plan 2020-11-10 to 2020-11-16

Previous Week Stacking: Nov 10th – Nov 16th

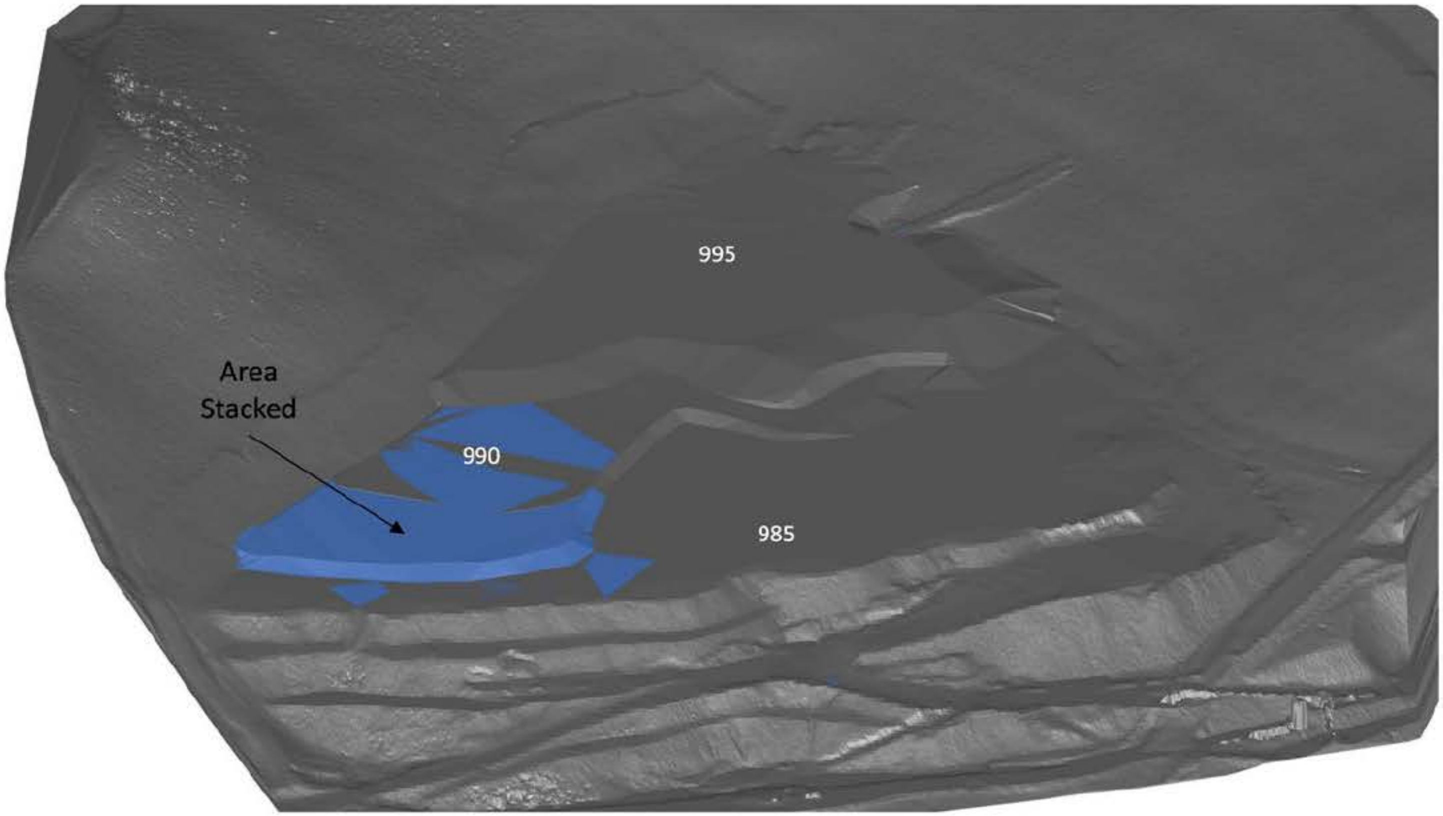
Previous Week Variance		10-Nov (Tue)	11-Nov (Wed)	12-Nov (Thu)	13-Nov (Fri)	14-Nov (Sat)	15-Nov (Sun)	16-Nov (Mon)	Total
Planned Tonnes Stacked	(T)	32,000	32,000	32,000	32,000	32,000	16,000	32,000	**208,000**
Actual Tonnes Stacked	(T)	**21,910**	**25,726**	**11,387**	**24,151**	**12,876**	**21,448**		**117,499**
Variance		*-10,090*	*-6,274*	*-20,613*	*-7,849*	*-19,124*	*5,448*	*-32,000*	**-44%**



HLF Ore Stacking Plan 2020-11-17 to 2020-11-23

Previous Week Stacking: Nov 17th – Nov 23rd

Previous Week Variance		17-Nov (Tue)	18-Nov (Wed)	19-Nov (Thu)	20-Nov (Fri)	21-Nov (Sat)	22-Nov (Sun)	23-Nov (Mon)	Total
Planned Tonnes Stacked	(T)	32,000	32,000	32,000	32,000	32,000	16,000	32,000	**208,000**
Actual Tonnes Stacked	(T)	**8,237**	**19,403**	**9,822**	**23,196**	**8,175**	**18,290**	**32,450**	**119,573**
Variance		*-23,763*	*-12,597*	*-22,178*	*-8,804*	*-23,825*	*2,290*	*450*	**-43%**

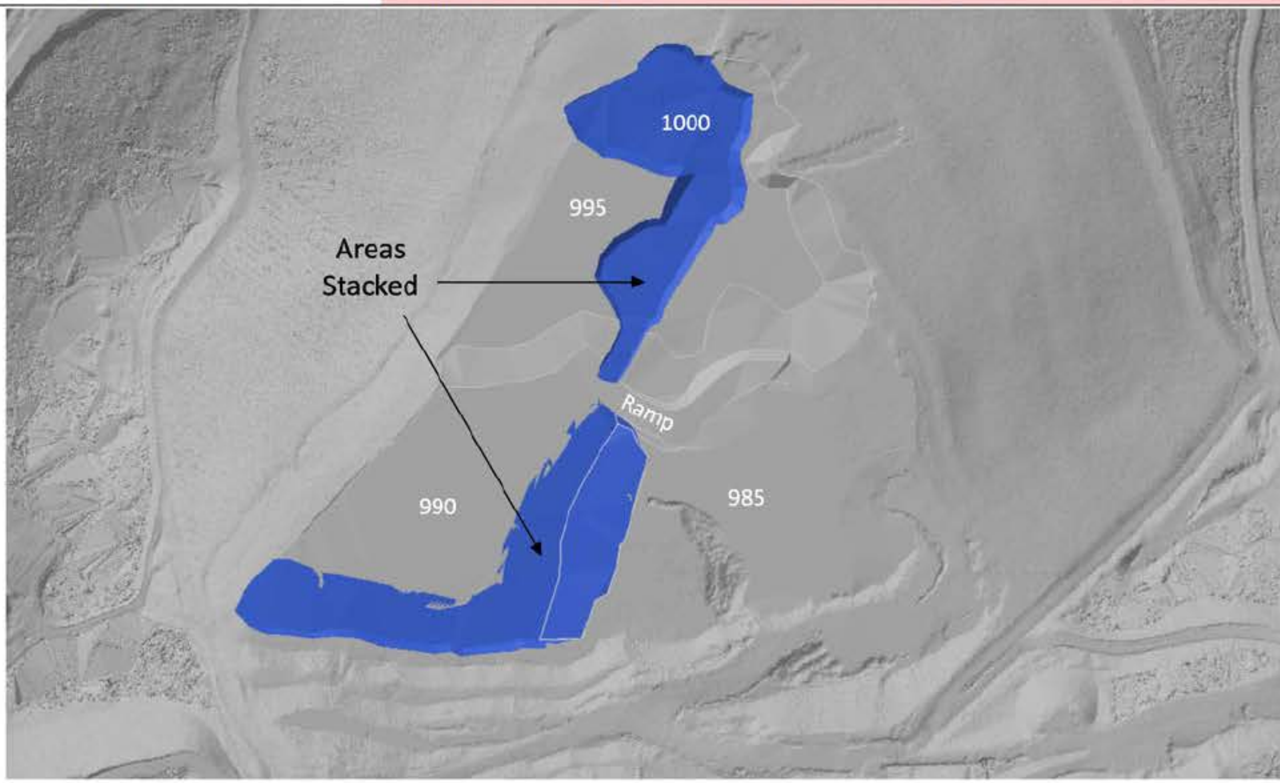


TSX : VGCX OTC: VITFF VGCX.com

HLF Ore Stacking Plan 2020-11-24 to 2020-11-30

Previous Week Stacking: Nov 24th – Nov 30th

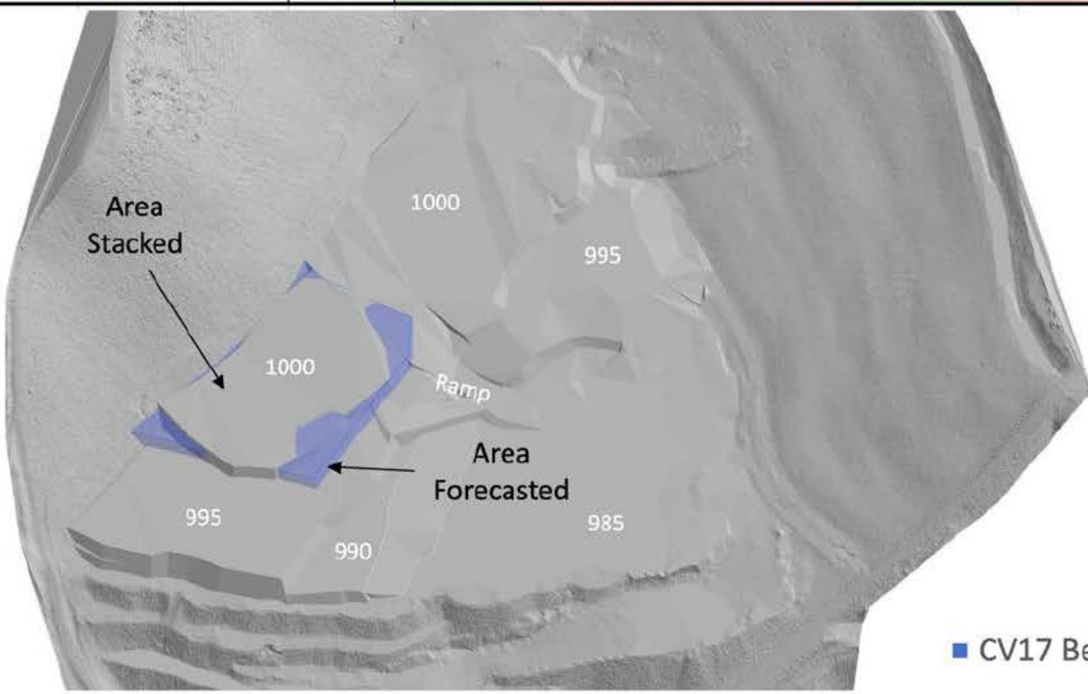
Previous Week Variance		24-Nov (Tue)	25-Nov (Wed)	26-Nov (Thu)	27-Nov (Fri)	28-Nov (Sat)	29-Nov (Sun)	30-Nov (Mon)	Total	Variance
HLF										
Planned Tonnes Stacked	(T)	31,667	31,667	31,667	31,667	31,667	31,667	31,667	**221,669**	
Actual Tonnes Stacked	**(T)**	**23,553**	**23,961**	**20,933**	**13,544**	**22,942**	**31,372**	**31,384**	**167,689**	-24.4%
Variance		*-8,114*	*-7,706*	*-10,734*	*-18,123*	*-8,725*	*-295*	*-283*		

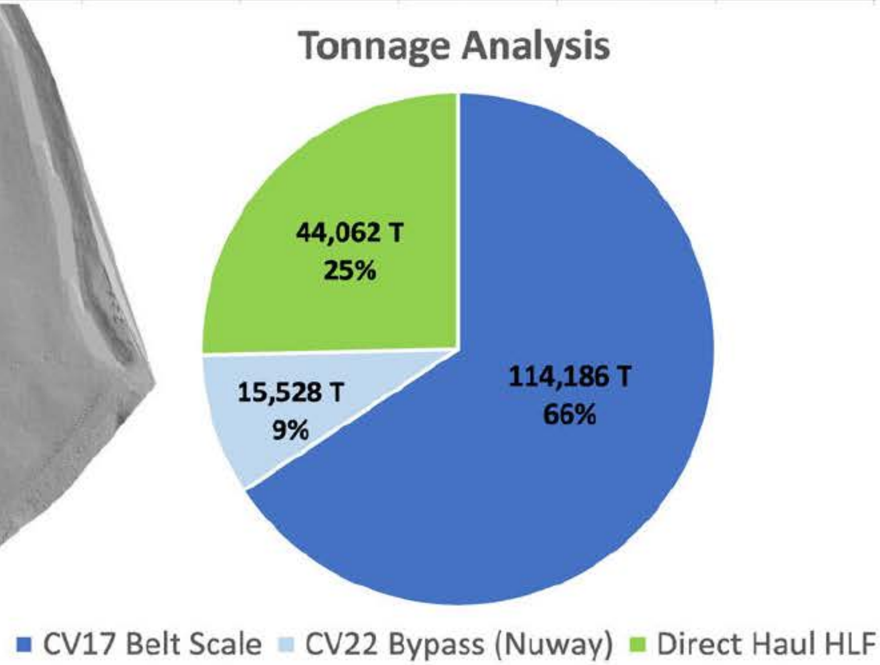


HLF Ore Stacking Plan 2020-12-15 to 2020-12-21

Previous Week Stacking: Dec 15th – Dec 21st

Previous Week Variance		15-Dec (Tue)	16-Dec (Wed)	17-Dec (Thu)	18-Dec (Fri)	19-Dec (Sat)	20-Dec (Sun)	21-Dec (Mon)	Total	Variance
HLF							Primary/SecTer			
Forecast Tonnes Stacked	**(T)**	**30,645**	**30,645**	**30,645**	**30,645**	**30,645**	**30,645**	**30,645**	**214,515**	
CV17 Belt Scale	(T)	25,135	11,279	16,958	24,830	22,637	13,347		**114,186**	
CV22 Bypass (Nuway)	(T)	4,042	4,501	1,517	1,262	1,064	3,142		**15,528**	**-5.49%**
Direct Haul HLF	(T)	8,108	7,723	7,940	7,310	6,896	6,085		**44,062**	
Actual Tonnes Stacked	**(T)**	**37,285**	**23,503**	**26,415**	**33,402**	**30,597**	**22,574**	**0**	**173,776**	
Variance		*6,640*	*-7,142*	*-4,230*	*2,757*	*-48*	*-8,071*	*-30,645*	-40,739	



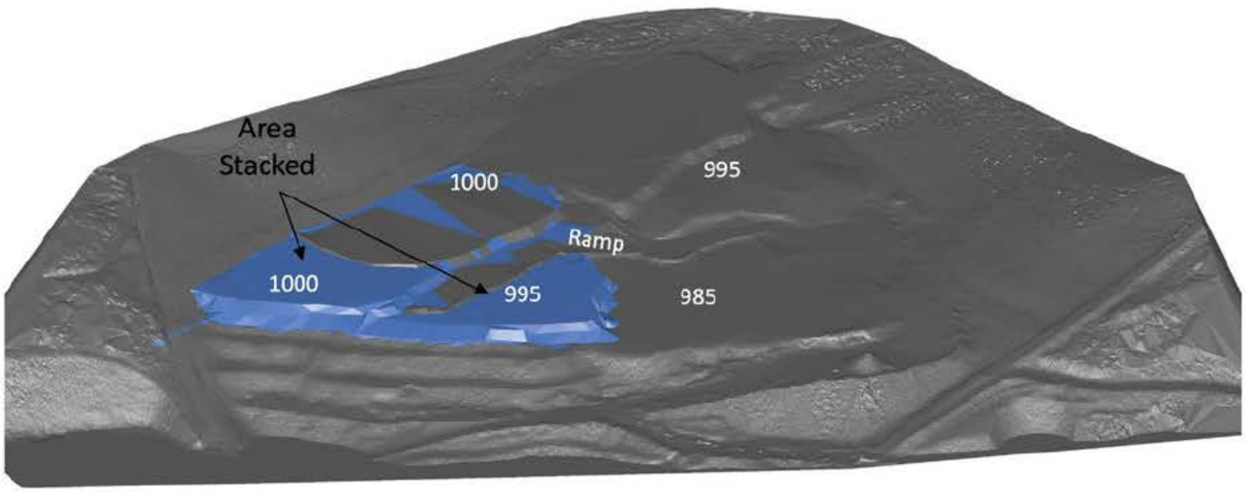


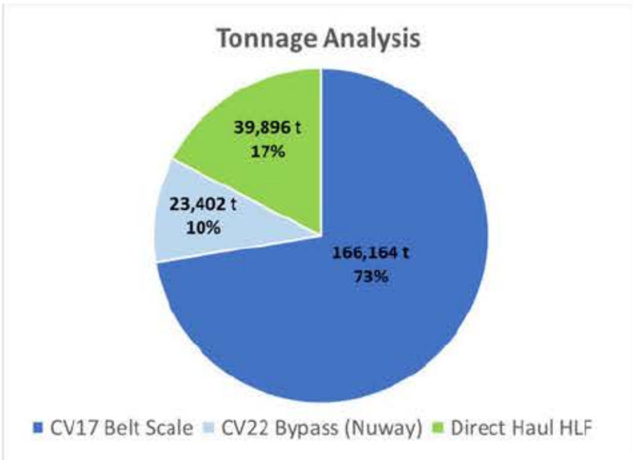
TSX : VGCX OTC: VITFF VGCX.com

HLF Ore Stacking Plan 2020-12-22 to 2020-12-28

Previous Week Stacking: Dec 22nd – Dec 28th

Previous Week Variance		22-Dec (Tue)	23-Dec (Wed)	24-Dec (Thu)	25-Dec (Fri)	26-Dec (Sat)	27-Dec (Sun)	28-Dec (Mon)	Total	Variance
HLF										
Forecast Tonnes Stacked	**(T)**	**30,645**	**30,645**	**30,645**	**30,645**	**30,645**	**30,645**	**30,645**	**214,515**	**6.97%**
CV17 Belt Scale	(T)	24,780	13,586	14,458	24,557	31,840	24,926	32,017	**166,164**	
CV22 Bypass (Nuway)	(T)	1,529	4,883	9,397	6,098	93	1,401	0	**23,402**	
Direct Haul HLF	(T)	5,841	3,918	6,486	6,393	6,380	4,506	6,373	**39,896**	
Actual Tonnes Stacked	**(T)**	**32,150**	**22,387**	**30,341**	**37,047**	**38,314**	**30,833**	**38,390**	**229,462**	
Variance		*1,505*	*-8,258*	*-304*	*6,402*	*7,669*	*188*	*7,745*	14,947	



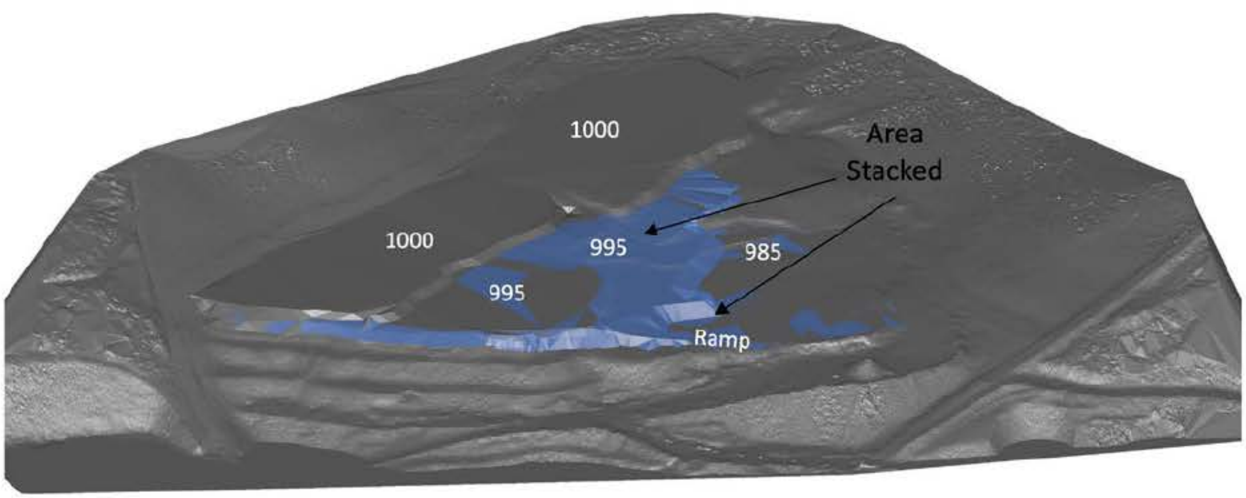


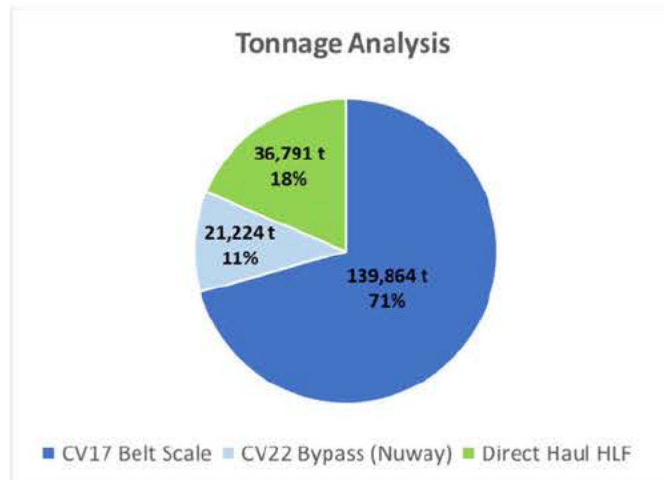
TSX : VGCX OTC: VITFF VGCX.com

HLF Ore Stacking Plan 2020-12-29 to 2021-01-04

Previous Week Stacking: Dec 29th – Jan 4th

Previous Week Variance		29-Dec (Tue)	30-Dec (Wed)	31-Dec (Thu)	01-Jan (Fri)	02-Jan (Sat)	03-Jan (Sun)	04-Jan (Mon)	Total	Variance
HLF										
Forecast Tonnes Stacked	**(T)**	**32,000**	**32,000**	**32,000**	**32,000**	**32,000**	**32,000**	**16,000**	**208,000**	
CV17 Belt Scale	(T)	20,719	23,440	30,224	11,649	21,493	27,539	4,800	**139,864**	
CV22 Bypass (Nuway)	(T)	505	1,915	238	9,661	1,241	537	7,127	**21,224**	**-5.29%**
Direct Haul HLF	(T)	7,023	7,097	7,018	5,924	3,537	3,844	2,348	**36,791**	
Actual Tonnes Stacked	**(T)**	**28,247**	**32,452**	**37,480**	**27,234**	**26,271**	**31,920**	**14,275**	**197,879**	
Variance		*-3,753*	*452*	*5,480*	*-4,766*	*-5,729*	*-80*	*-1,725*	-10,121	



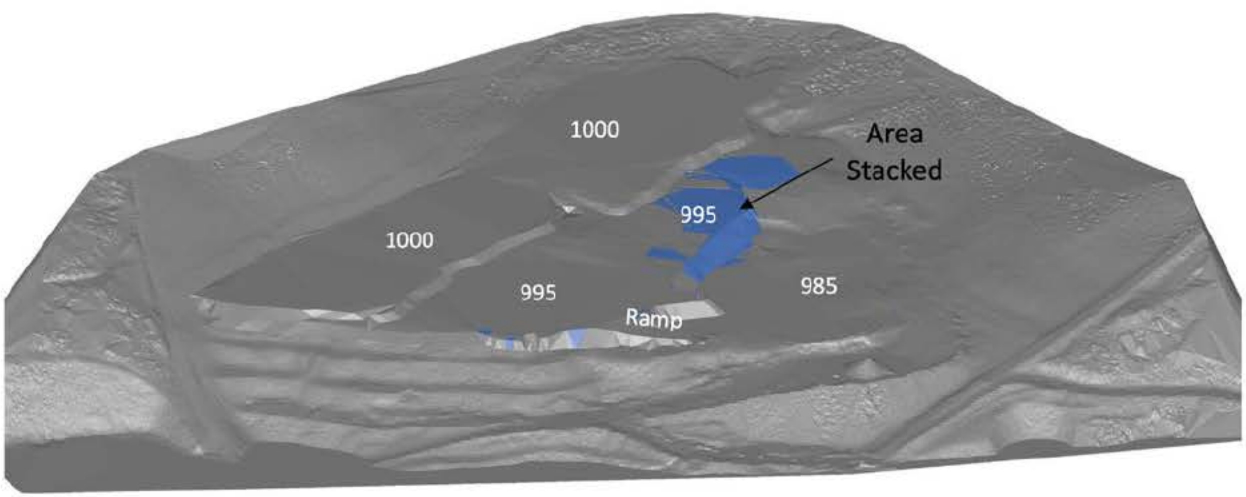


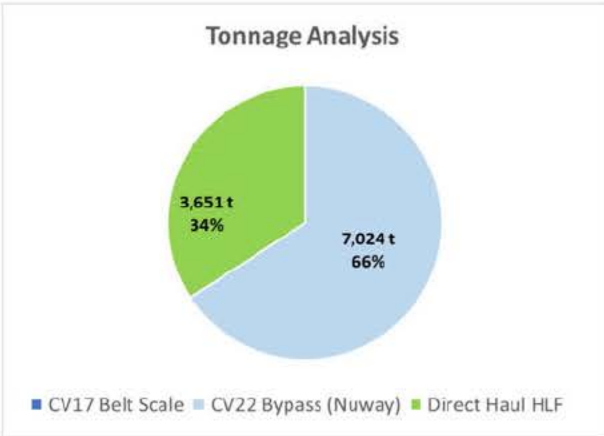
TSX : VGCX OTC: VITFF VGCX.com

HLF Ore Stacking Plan 2021-01-05 to 2021-01-11

Previous Week Stacking: January 5th – 11th

Previous Week Variance		05-Jan (Tue)	06-Jan (Wed)	07-Jan (Thu)	08-Jan (Fri)	09-Jan (Sat)	10-Jan (Sun)	11-Jan (Mon)	Total
HLF									
Forecast Tonnes Stacked	**(T)**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
CV17 Belt Scale	(T)								**0**
CV22 Bypass (Nuway)	(T)	6,664	360						**7,024**
Direct Haul HLF	(T)	3,651							**3,651**
Actual Tonnes Stacked	**(T)**	**10,315**	**360**	**0**	**0**	**0**	**0**	**0**	**10,675**
Variance		*10,315*	*360*	*0*	*0*	*0*	*0*	*0*	10,675



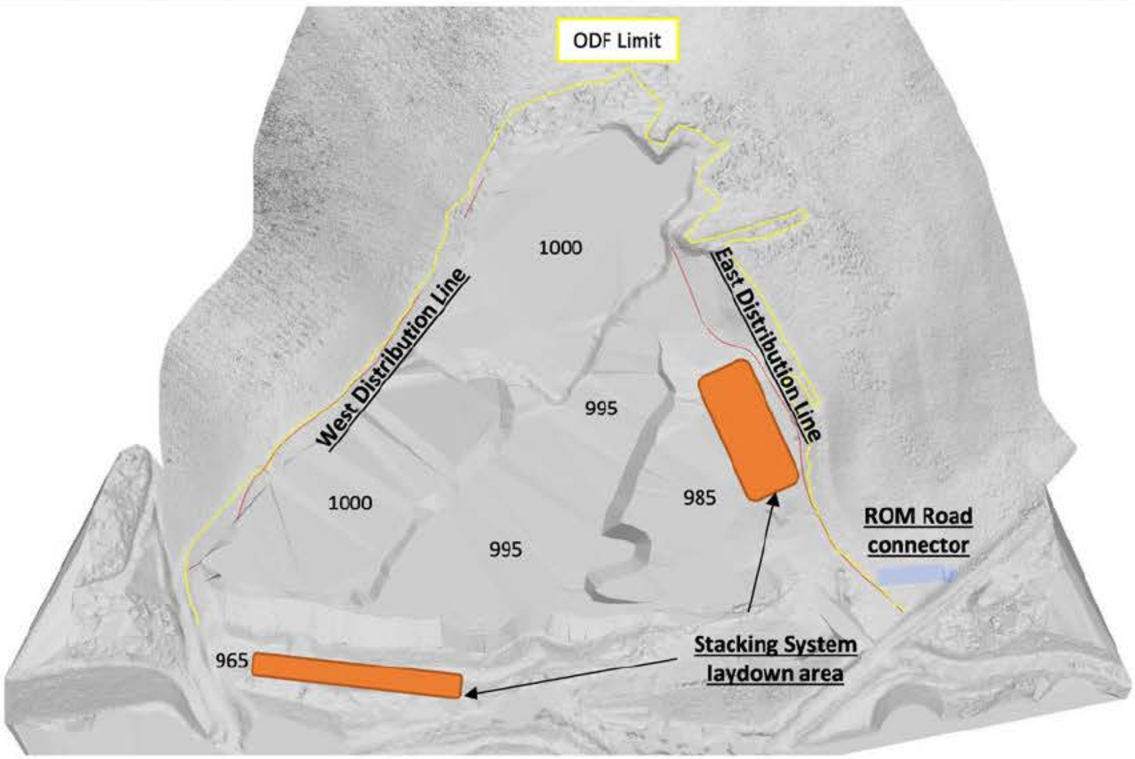


TSX : VGCX OTC: VITFF VGCX.com

HLF Ore Stacking Plan 2021-01-12 to 2021-01-18

Previous Week Stacking: January 12th – 18th

Previous Week Variance		12-Jan (Tue)	13-Jan (Wed)	14-Jan (Thu)	15-Jan (Fri)	16-Jan (Sat)	17-Jan (Sun)	18-Jan (Mon)	Total
HLF									
Forecast Tonnes Stacked	**(T)**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
CV17 Belt Scale	(T)								**0**
CV22 Bypass (Nuway)	(T)								**0**
Direct Haul HLF	(T)	1,386	1,723	1,805					**4,914**
Actual Tonnes Stacked	**(T)**	**1,386**	**1,723**	**1,805**	**0**	**0**	**0**	**0**	**4,914**
Variance		*1,386*	*1,723*	*1,805*	*0*	*0*	*0*	*0*	4,914

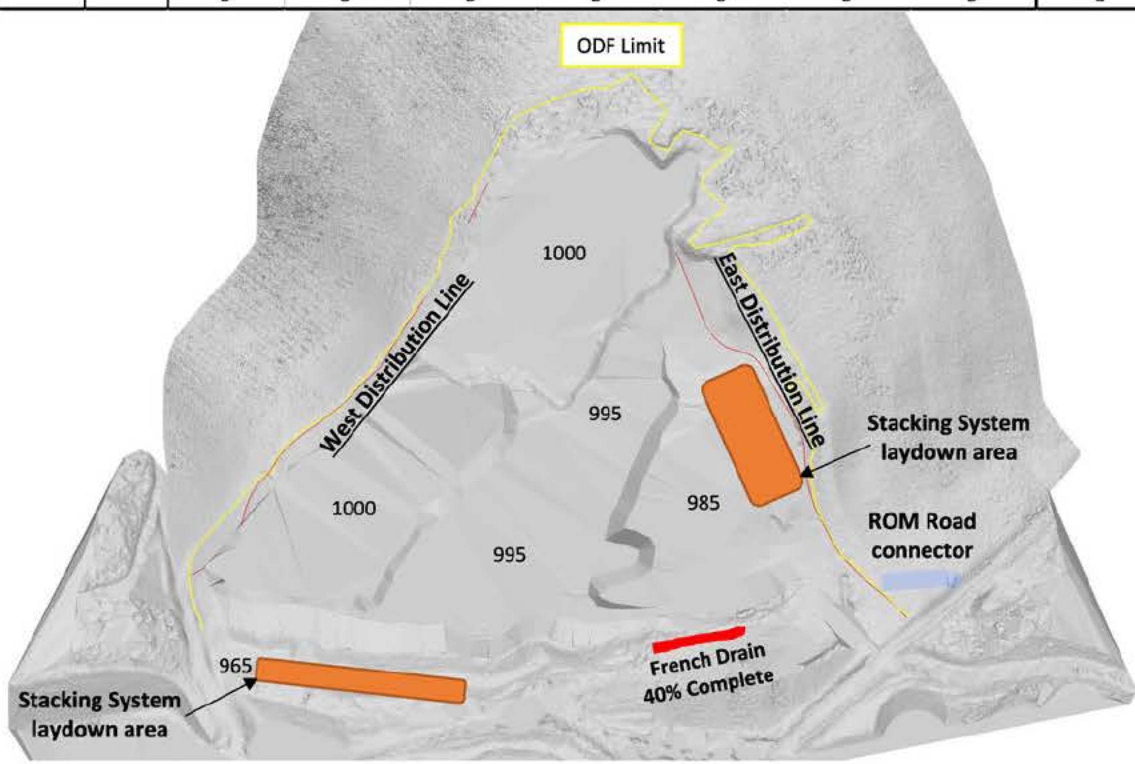


Location	Grasshopper	200 HP	75 HP
985 level	CV214	X	
	CV215	X	
	CV216	X	
	CV217	X	
	CV218	X	
	CV219	X	
	CV220	X	
	CV104		X
965 catch bench	CV105		X
	CV106		X
	CV108		X
	CV211	X	
	CV212	X	
Total	**13**	**9**	**4**

HLF Ore Stacking Plan 2021-01-19 to 2021-01-25

Previous Week Stacking: January 19th – 25th

Previous Week Variance		19-Jan (Tue)	20-Jan (Wed)	21-Jan (Thu)	22-Jan (Fri)	23-Jan (Sat)	24-Jan (Sun)	25-Jan (Mon)	Total	Variance
HLF										
Forecast Tonnes Stacked	**(T)**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	
CV17 Belt Scale	(T)								**0**	
CV22 Bypass (Nuway)	(T)								**0**	**0.00%**
Direct Haul HLF	(T)								**0**	
Actual Tonnes Stacked	**(T)**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	
Variance		*0*	*0*	*0*	*0*	*0*	*0*	*0*	0	



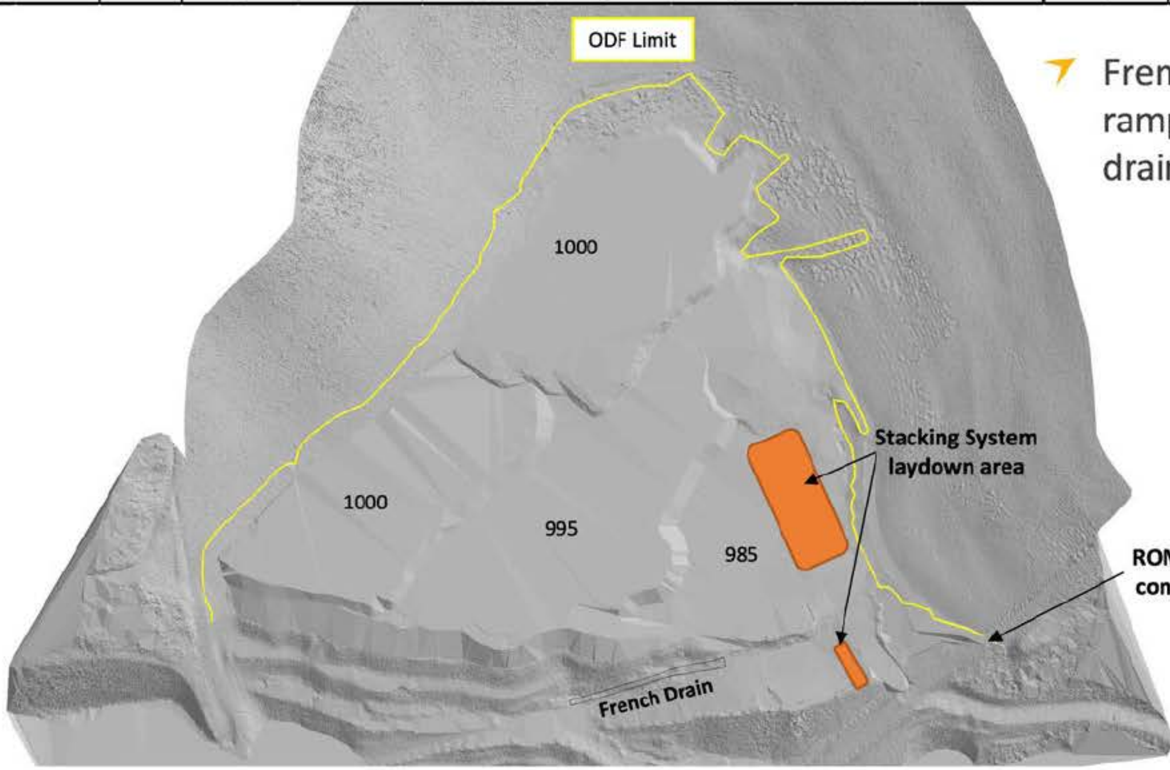
Location	Grasshopper	200 HP	75 HP
985 level	CV214	X	
	CV215	X	
	CV216	X	
	CV217	X	
	CV218	X	
	CV219	X	
	CV220	X	
	CV104		X
965 catch bench	CV105		X
	CV106		X
	CV108		X
	CV211	X	
	CV212	X	
Total	**13**	**9**	**4**

HLF Ore Stacking Plan 2021-01-26 to 2021-02-01

VICTORIA GOLD CORP X

Previous Week Stacking: January 26th – February 1st

Previous Week Variance		26-Jan (Tue)	27-Jan (Wed)	28-Jan (Thu)	29-Jan (Fri)	30-Jan (Sat)	31-Jan (Sun)	01-Feb (Mon)	Total	Variance
HLF										
Forecast Tonnes Stacked	**(T)**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0.00%**
CV17 Belt Scale	(T)								**0**	
CV22 Bypass (Nuway)	(T)								**0**	
Direct Haul HLF	(T)								**0**	
Actual Tonnes Stacked	**(T)**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	
Variance		*0*	*0*	*0*	*0*	*0*	*0*	*0*	0	

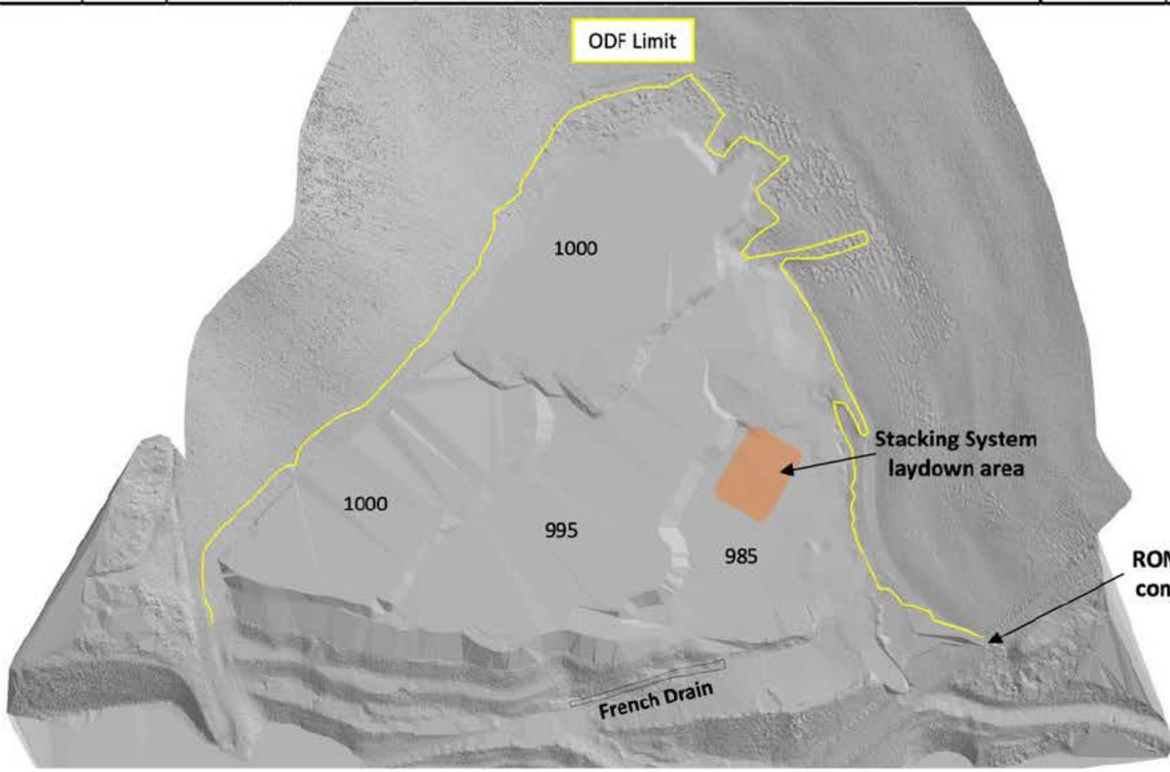


- French Drain (964-978) on main ramp is complete for permanent drainage

HLF Ore Stacking Plan 2021-02-02 to 2021-02-08

Previous Week Stacking: February 1st – February 7th

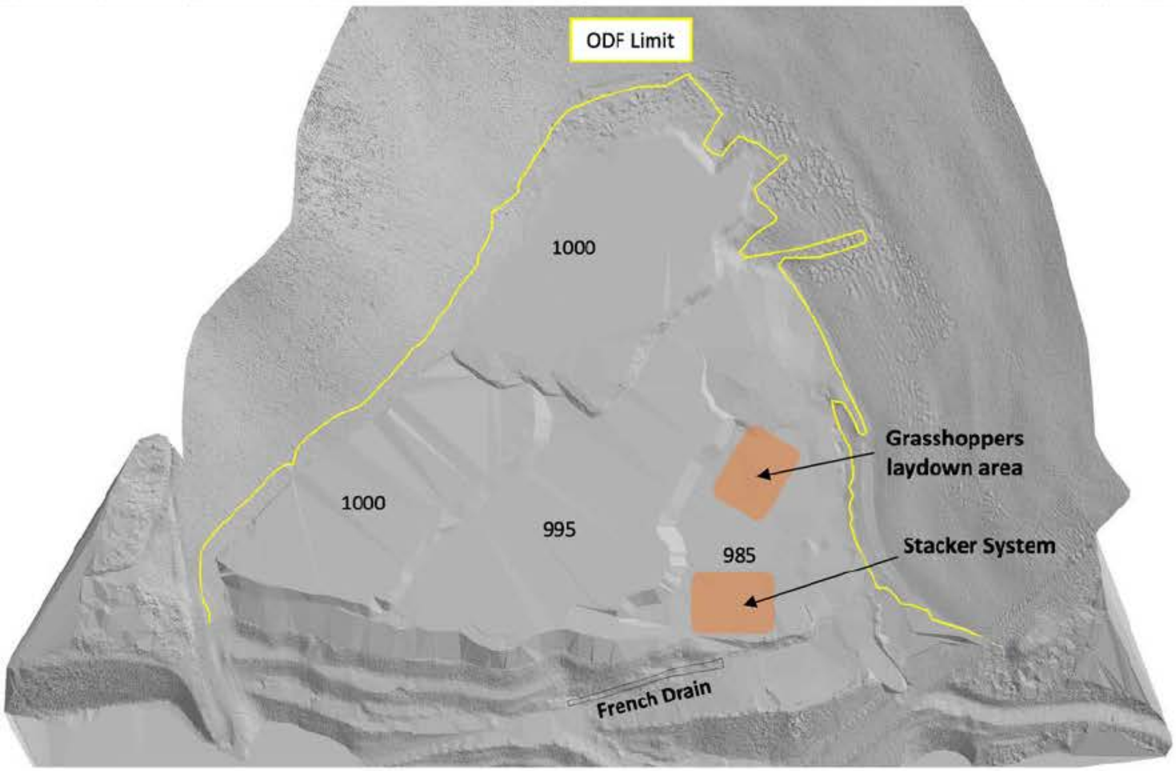
Previous Week Variance		01-Feb (Mon)	02-Feb (Tue)	03-Feb (Wed)	04-Feb (Thu)	05-Feb (Fri)	06-Feb (Sat)	07-Feb (Sun)	Total	Variance
HLF										
Forecast Tonnes Stacked	**(T)**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	
CV17 Belt Scale	(T)								0	
CV22 Bypass (Nuway)	(T)								0	**0.00%**
Direct Haul HLF	(T)								0	
Actual Tonnes Stacked	**(T)**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	
Variance		*0*	*0*	*0*	*0*	*0*	*0*	*0*	0	



HLF Ore Stacking Plan 2021-02-09 to 2021-02-15

Previous Week Stacking: February 9th – February 15th

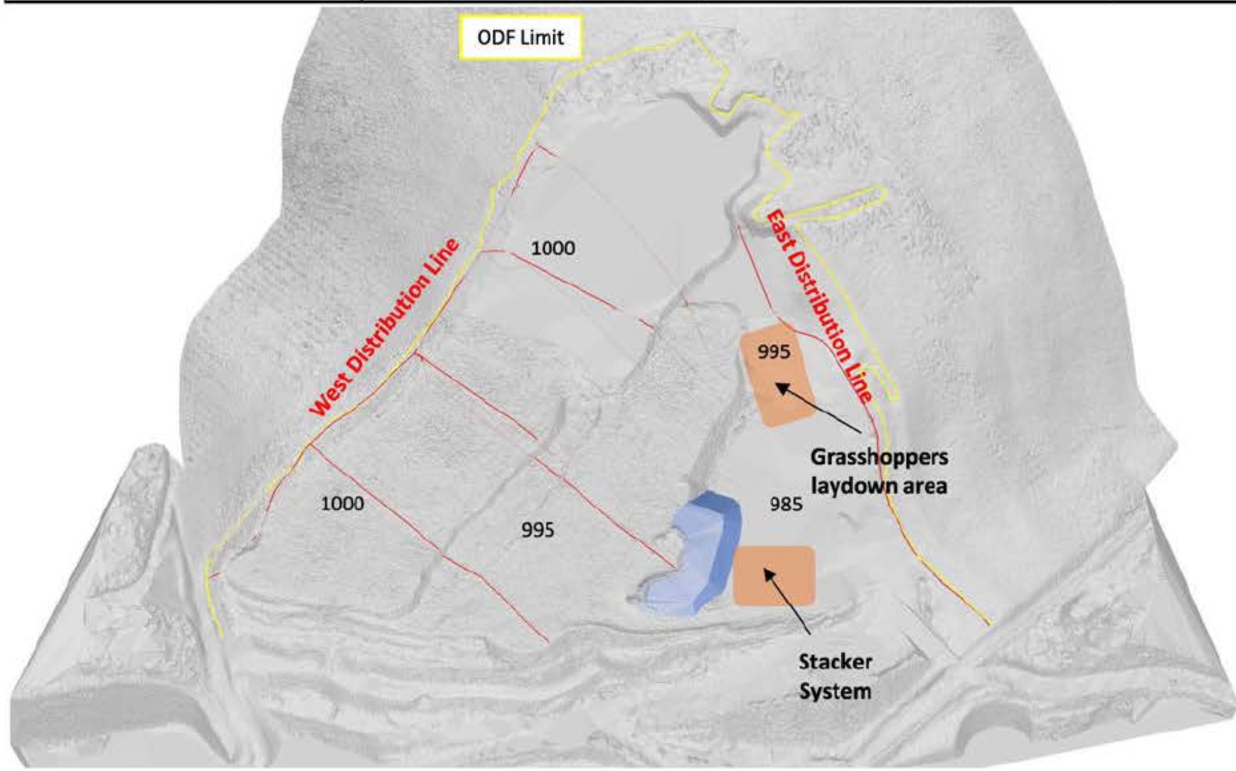
Previous Week Variance		09-Feb (Tue)	10-Feb (Wed)	11-Feb (Thu)	12-Feb (Fri)	13-Feb (Sat)	14-Feb (Sun)	15-Feb (Mon)	Total	Variance
HLF										
Forecast Tonnes Stacked	**(T)**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	0.00%
CV17 Belt Scale	(T)								**0**	
CV22 Bypass (Nuway)	(T)						2,285	3,293	**5,578**	
Direct Haul HLF	(T)								**0**	
Actual Tonnes Stacked	**(T)**	**0**	**0**	**0**	**0**	**0**	**2,285**	**3,293**	**5,578**	
Variance		*0*	*0*	*0*	*0*	*0*	*2,285*	*3,293*	5,578	

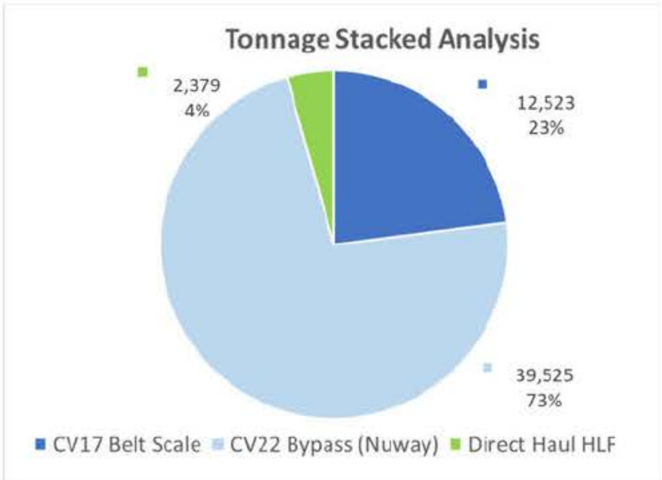


HLF Ore Stacking Plan 2021-02-16 to 2021-02-22

Previous Week Stacking: February 16th – February 22nd

Previous Week Variance		16-Feb (Tue)	17-Feb (Wed)	18-Feb (Thu)	19-Feb (Fri)	20-Feb (Sat)	21-Feb (Sun)	22-Feb (Mon)	Total
Heap Leach Facility									
Forecast Tonnes Stacked									**0**
CV17 Belt Scale	(t)	0	0	0	364	10,788	1,371		**12,523**
CV22 Bypass (Nuway)	(t)	0	10,010	15,793	9,727	3,795	200		**39,525**
Direct Haul HLF	(t)	469	469	547	0	195	352	347	**2,379**
Actual Tonnage Stacked		**469**	**10,479**	**16,340**	**10,091**	**14,779**	**1,922**	**347**	**54,427**
Variance		*469*	*10,479*	*16,340*	*10,091*	*14,779*	*1,922*	*347*	54,427

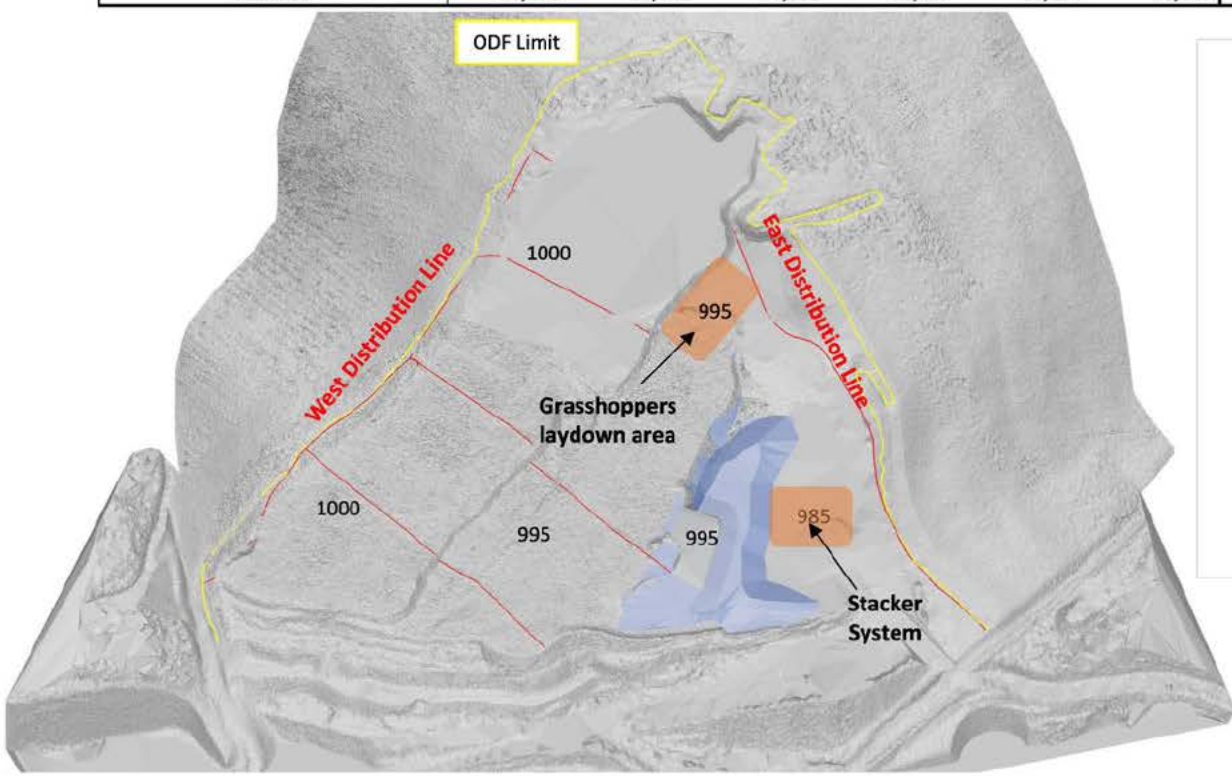


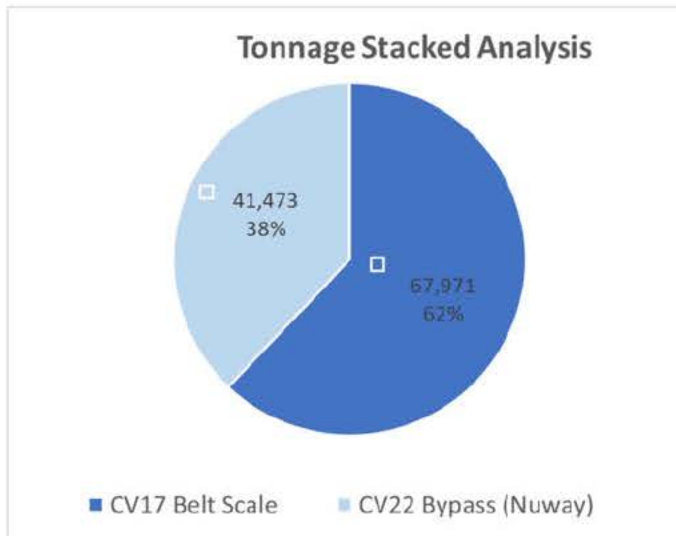


HLF Ore Stacking Plan 2021-02-23 to 2021-03-01

Previous Week Stacking: February 23rd – February 28th

Previous Week Variance		23-Feb (Tue)	24-Feb (Wed)	25-Feb (Thu)	26-Feb (Fri)	27-Feb (Sat)	28-Feb (Sun)	Total
Heap Leach Facility								
Forecast Tonnes Stacked								**0**
CV17 Belt Scale	(t)	12,444	14,228	11,625	3,279	10,179	16,215	**67,971**
CV22 Bypass (Nuway)	(t)	7,832	6,794	3,614	8,148	8,094	6,992	**41,473**
Direct Haul HLF	(t)							**0**
Actual Tonnage Stacked		**20,276**	**21,022**	**15,239**	**11,427**	**18,274**	**23,207**	**109,444**
Variance		*20,276*	*21,022*	*15,239*	*11,427*	*18,274*	*23,207*	109,444



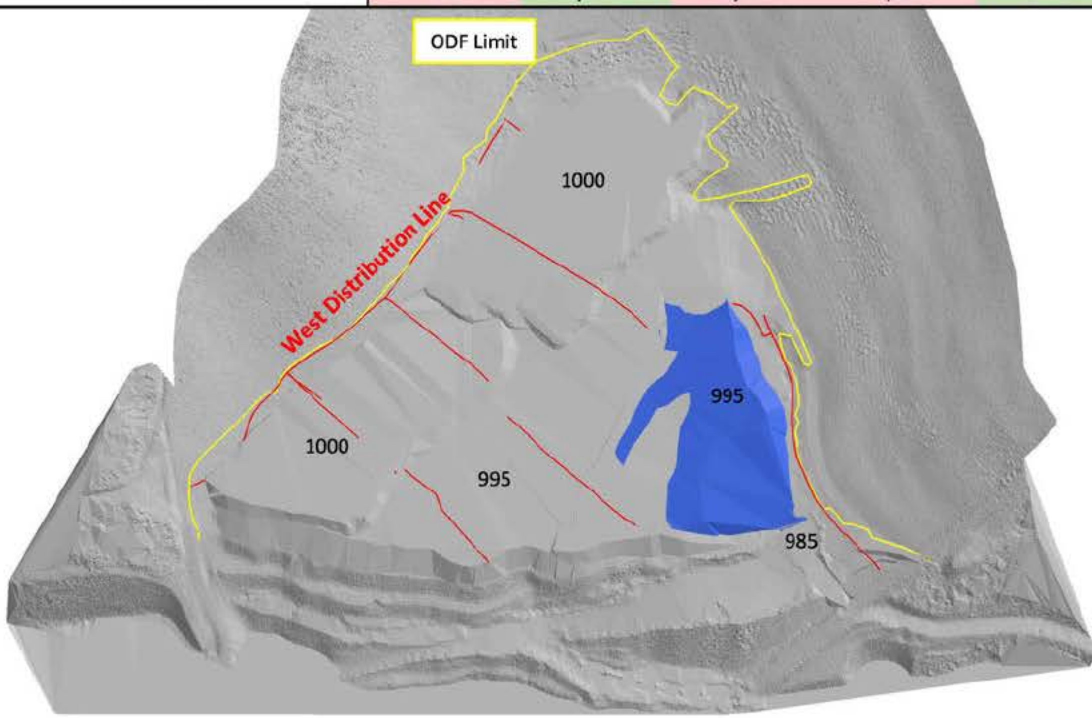


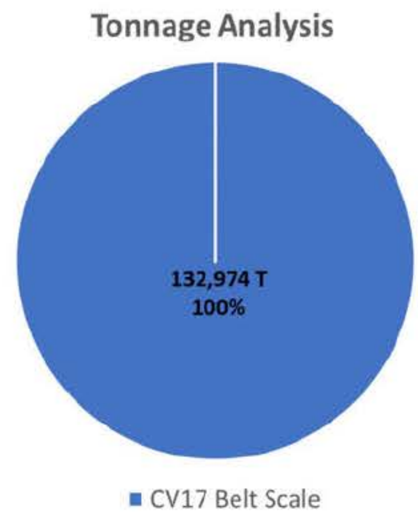
TSX : VGCX OTC: VITFF VGCX.com

HLF Ore Stacking Plan 2021-03-02 to 2021-03-08

Previous Week Stacking: March 3rd – 9th

Previous Week Variance		03-Mar (Wed)	04-Mar (Thu)	05-Mar (Fri)	06-Mar (Sat)	07-Mar (Sun)	08-Mar (Mon)	09-Mar (Tue)	Total	Variance
Heap Leach Facility								12HR		
Forecast Tonnes Stacked		**20,968**	**20,968**	**20,968**	**20,968**	**20,968**	**20,968**	**20,968**	**146,776**	**-2.82%**
CV17 Belt Scale	(t)	20,006	27,241	13,884	16,693	21,914	33,236	0	**132,974**	
CV22 Bypass (Nuway)	(t)		0	0	0	0	0	0	**0**	
Direct Haul HLF	(t)	0	0	0	0	0	0	1,006	**1,006**	
Actual Tonnage Stacked		**20,006**	**27,241**	**13,884**	**16,693**	**21,914**	**33,236**	**1,006**	**133,980**	
Variance		*-962*	*6,273*	*-7,084*	*-4,275*	*946*	*12,268*	*-19,962*	-12,796	

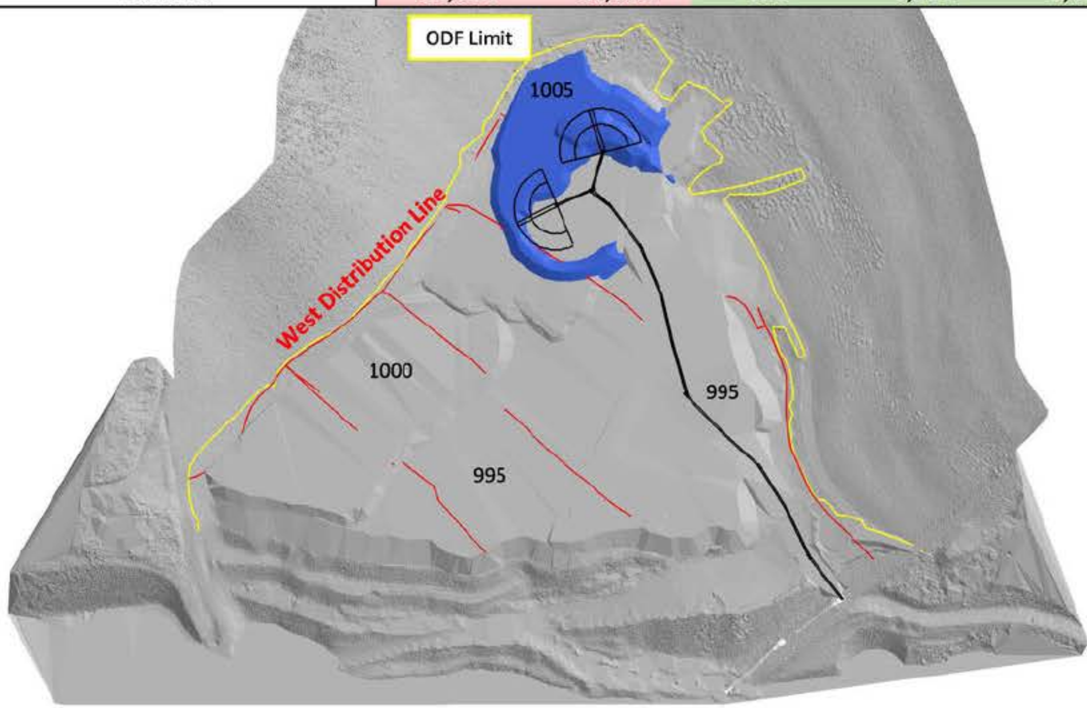


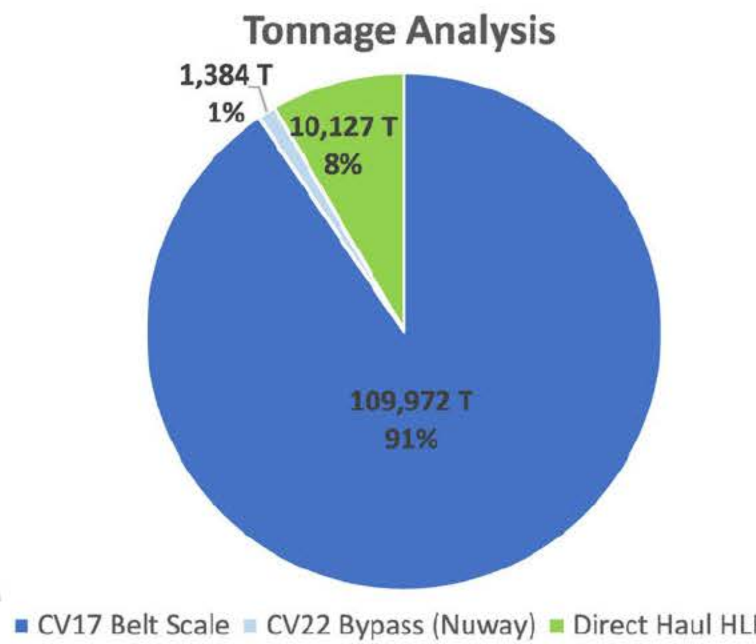


HLF Ore Stacking Plan 2021-03-09 to 2021-03-15

Previous Week Stacking: March 9th – 15th

Previous Week Variance		09-Mar (Tue)	10-Mar (Wed)	11-Mar (Thu)	12-Mar (Fri)	13-Mar (Sat)	14-Mar (Sun)	15-Mar (Mon)	Total	Variance
Heap Leach Facility		**12 Hr Down**								
Forecast Tonnes Stacked		**20,968**	**20,968**	**20,968**	**20,968**	**20,968**	**20,968**	**20,968**	**146,776**	**-17.2%**
CV17 Belt Scale	(t)	0	469	21,119	22,085	21,109	27,623	17,567	**109,972**	
CV22 Bypass (Nuway)	(t)	0	0	0	0	0	322	1,062	**1,384**	
Direct Haul HLF	(t)	1,006	1,775	447	2,097	2,055	1,523	1,224	**10,127**	
Actual Tonnage Stacked		**1,006**	**2,244**	**21,566**	**24,182**	**23,164**	**29,468**	**19,853**	**121,483**	
Variance		*-19,962*	*-18,724*	*598*	*3,214*	*2,196*	*8,500*	*-1,115*	-25,293	

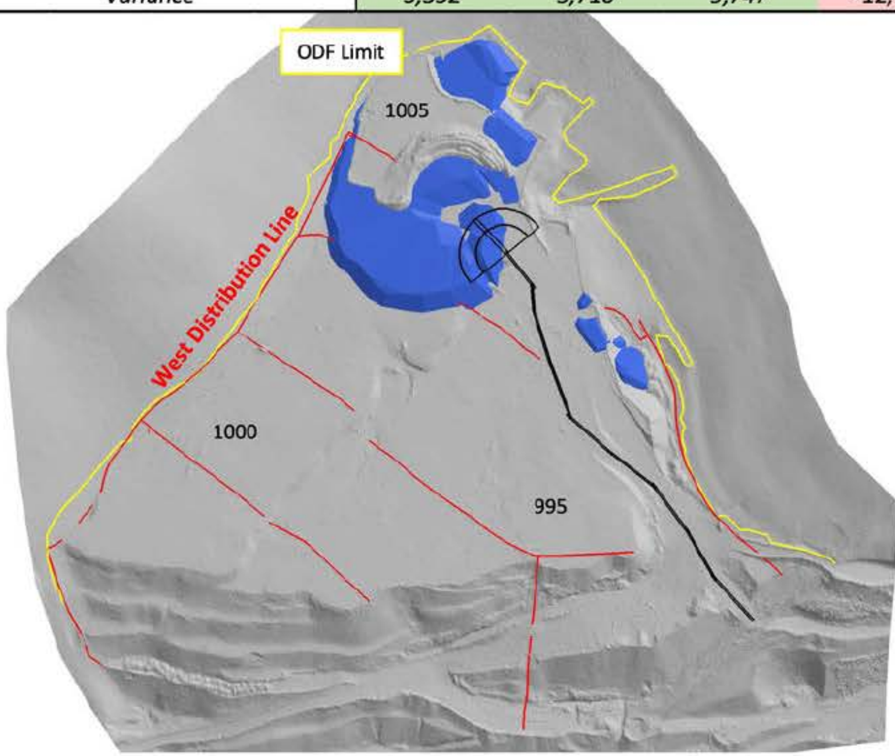


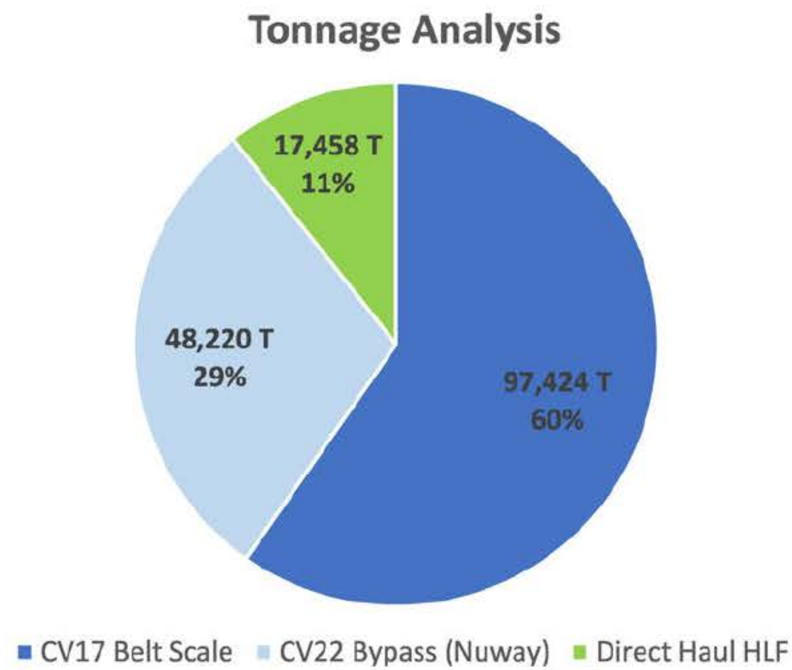


HLF Ore Stacking Plan 2021-03-16 to 2021-03-22

Previous Week Stacking: March 15th – 22nd

Previous Week Variance		16-Mar (Tue)	17-Mar (Wed)	18-Mar (Thu)	19-Mar (Fri)	20-Mar (Sat)	21-Mar (Sun)	22-Mar (Mon)	Total	Variance
Heap Leach Facility					**8 Hr Down**			**SecTer 10 Hr**		
Forecast Tonnes Stacked		**20,968**	**20,968**	**20,968**	**20,968**	**20,968**	**20,968**	**20,968**	**146,776**	**11.1%**
CV17 Belt Scale	(t)	22,048	16,848	11,830	5,141	15,973	14,486	11,098	**97,424**	
CV22 Bypass (Nuway)	(t)	0	7,096	15,398	1,259	7,794	10,150	6,523	**48,220**	
Direct Haul HLF	(t)	2,272	2,734	3,487	1,865	0	2,521	4,579	**17,458**	
Actual Tonnage Stacked		**24,320**	**26,678**	**30,715**	**8,265**	**23,767**	**27,157**	**22,200**	**163,102**	
Variance		*3,352*	*5,710*	*9,747*	*-12,703*	*2,799*	*6,189*	*1,232*	16,326	



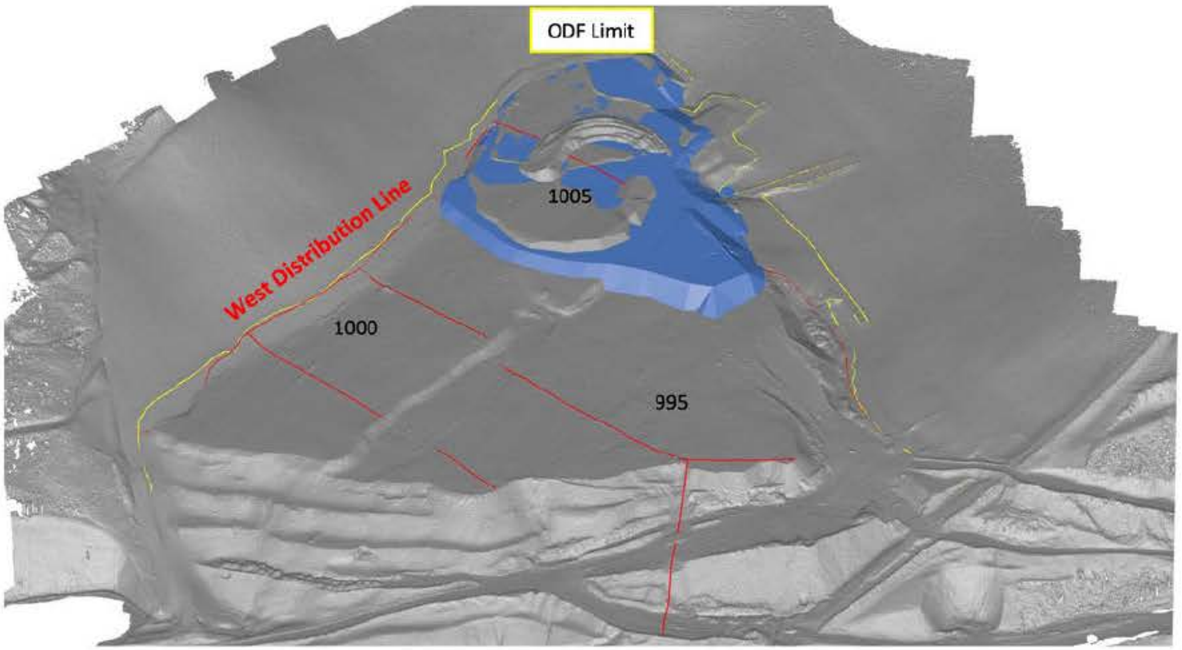


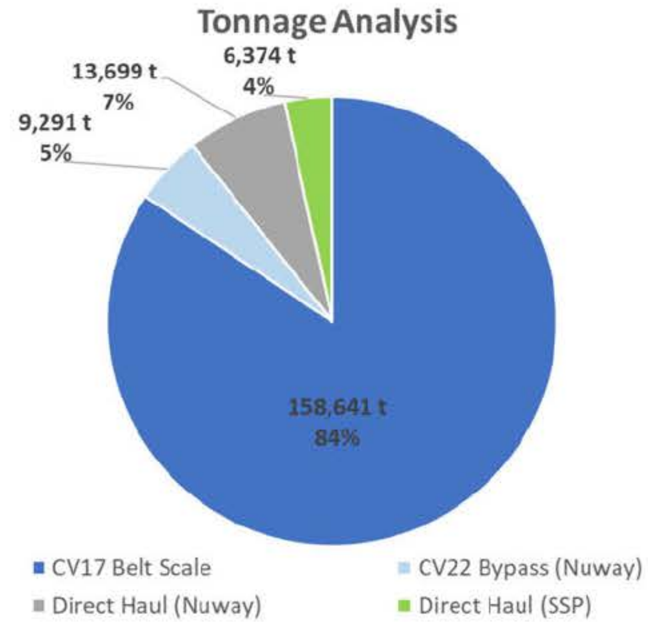
HLF Ore Stacking Plan 2021-03-23 to 2021-03-29

Previous Week Stacking: March 22nd – 29th

VICTORIA GOLD CORP

Previous Week Variance		23-Mar (Tue)	24-Mar (Wed)	25-Mar (Thu)	26-Mar (Fri)	27-Mar (Sat)	28-Mar (Sun)	29-Mar (Mon)	Total	Variance
Heap Leach Facility										
Forecast Tonnes Stacked		**21,000**	**21,000**	**21,000**	**21,000**	**21,000**	**21,000**	**21,000**	**147,000**	
CV17 Belt Scale	(t)	26,468	18,905	22,618	23,432	22,420	24,829	19,969	**158,641**	
CV22 Bypass (Nuway)	(t)	1,178	646	538	621	3,683	2,347	279	**9,291**	
Direct Haul (Nuway)	(t)	7,871	1,708	3,601	520	0	0	0	**13,699**	**27.9%**
Direct Haul (SSP)	(t)	0	168	97	1,931	2,363	891	924	**6,374**	
Actual Tonnage Stacked		**35,516**	**21,427**	**26,853**	**26,504**	**28,467**	**28,067**	**21,172**	**188,006**	
Variance		*14,516*	*427*	*5,853*	*5,504*	*7,467*	*7,067*	*172*	41,006	



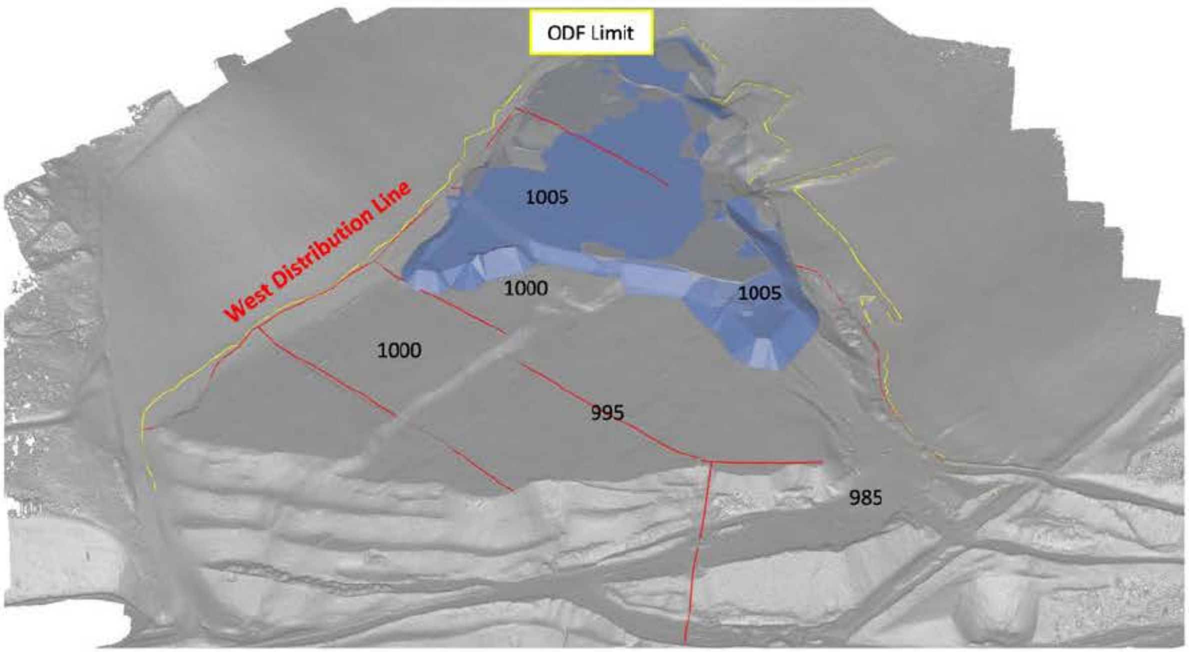


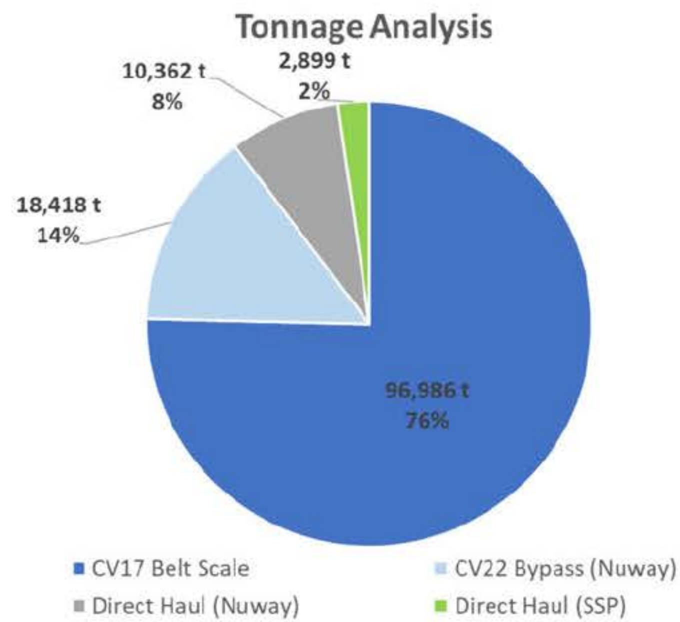
TSX : VGCX OTC: VITFF VGCX.com

HLF Ore Stacking Plan 2021-03-30 to 2021-04-05

Previous Week Stacking: March 30th – April 5th

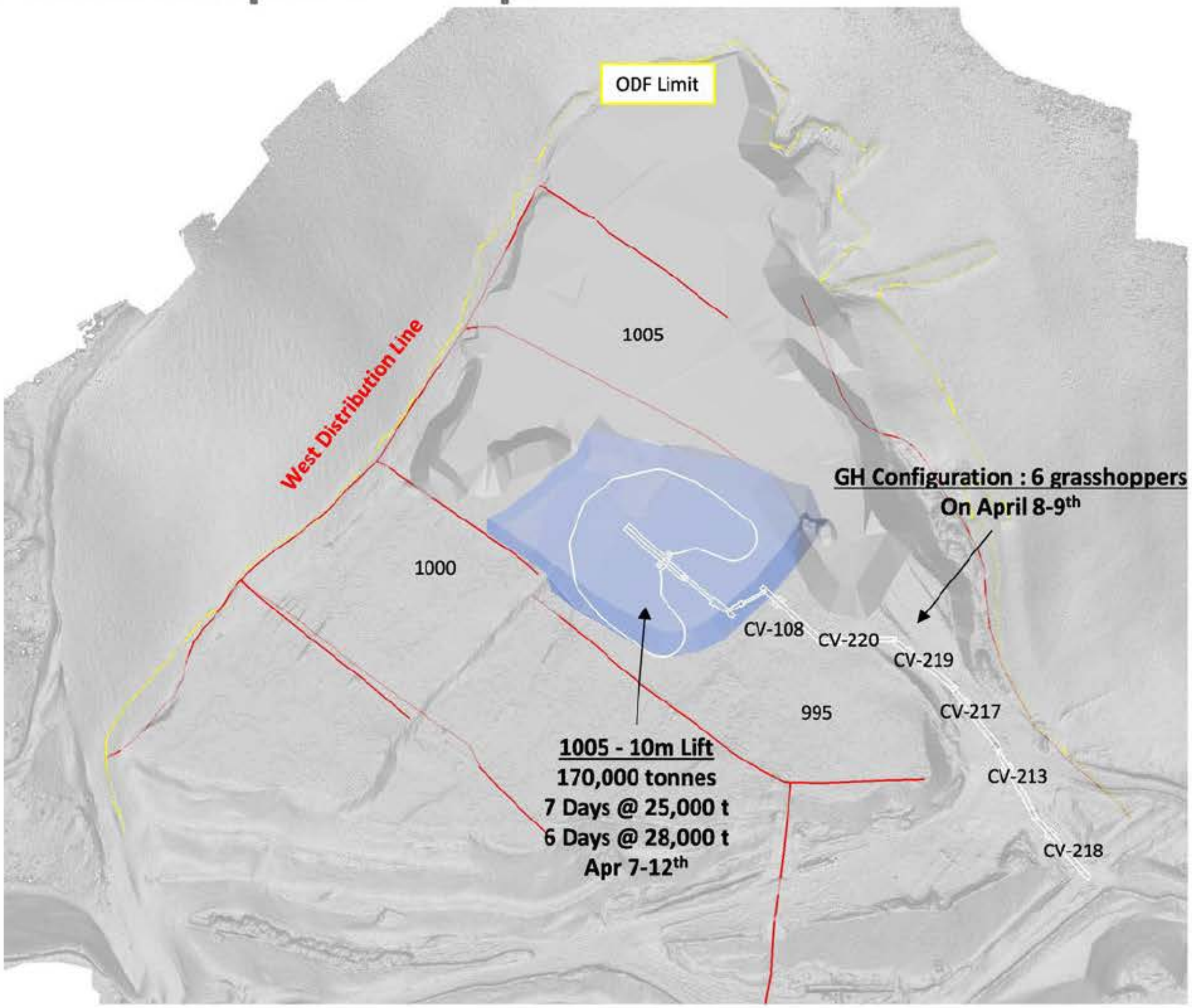
Previous Week Variance		30-Mar (Tue)	31-Mar (Wed)	01-Apr (Thu)	02-Apr (Fri)	03-Apr (Sat)	04-Apr (Sun)	05-Apr (Mon)	Total	Variance
Heap Leach Facility			12 Hour Down							
Forecast Tonnes Stacked		**21,000**	**10,500**	**25,000**	**25,000**	**25,000**	**25,000**	**25,000**	**156,500**	
CV17 Belt Scale	(t)	19,758	0	6,541	8,041	21,470	17,682	23,495	**96,986**	
CV22 Bypass (Nuway)	(t)	3,198	0	0	1,922	2,931	8,313	2,055	**18,418**	
Direct Haul (Nuway)	(t)			504	2,380	1,764	2,899	2,815	**10,362**	**-17.8%**
Direct Haul (SSP)	(t)	378	1,176	1,092	0	252	0		**2,899**	
Actual Tonnage Stacked		**23,334**	**1,176**	**8,137**	**12,342**	**26,417**	**28,894**	**28,364**	**128,664**	
Variance		*2,334*	*-9,324*	*-16,863*	*-12,658*	*1,417*	*3,894*	*3,364*	-27,836	





HLF Ore Stacking Plan 2021-04-06 to 2021-04-12 (inferred from plan)

Stack Plan Phase 2: April 6th - April 12th

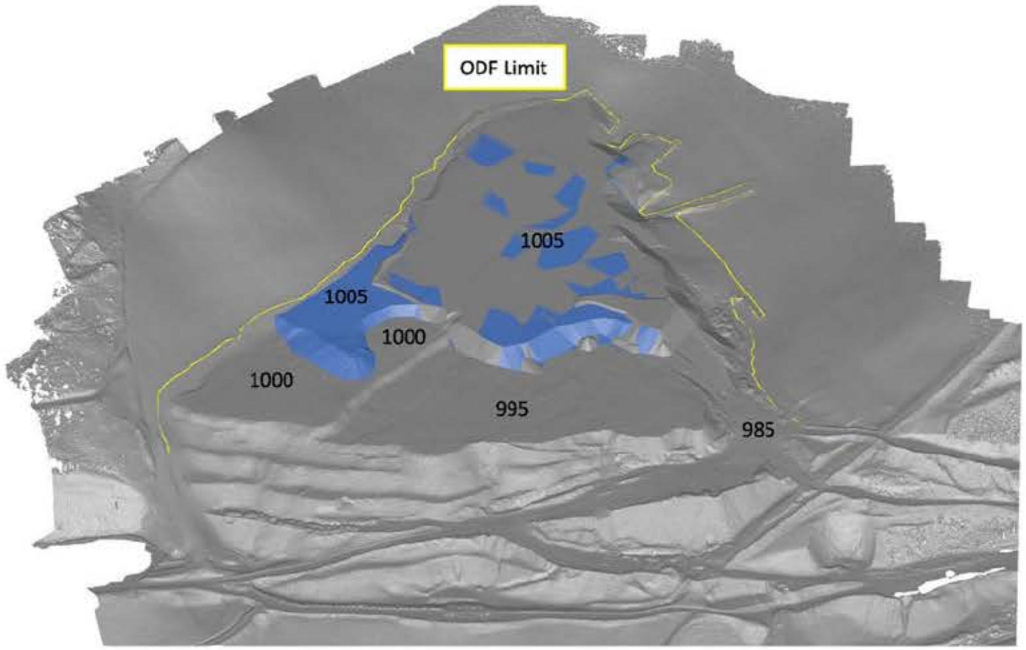


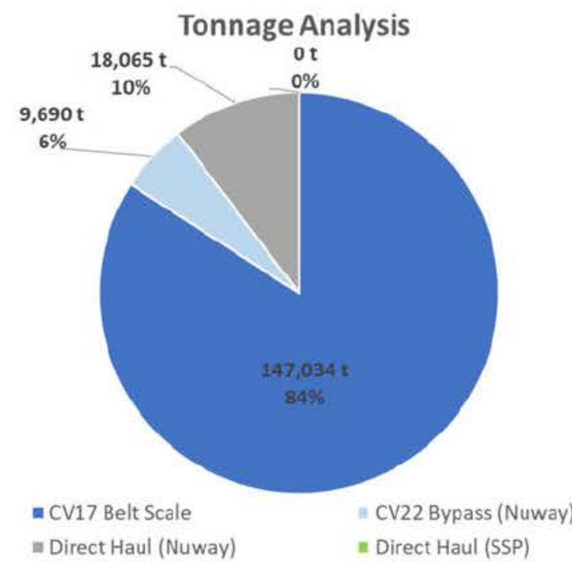
VICTORIA GOLD CORP

HLF Ore Stacking Plan 2021-04-13 to 2021-04-19

Previous Week Stacking: April 13th – 19th

Previous Week Variance		13-Apr (Tue)	14-Apr (Wed)	15-Apr (Thu)	16-Apr (Fri)	17-Apr (Sat)	18-Apr (Sun)	19-Apr (Mon)	Total	Variance
Heap Leach Facility										
Forecast Tonnes Stacked		**25,000**	**25,000**	**25,000**	**25,000**	**25,000**	**25,000**	**25,000**	**175,000**	**-0.1%**
CV17 Belt Scale	(t)	16,739	6,989	11,032	24,191	29,377	25,283	33,422	**147,034**	
CV22 Bypass (Nuway)	(t)	0	0	0	3,321	3,422	2,382	564	**9,690**	
Direct Haul (Nuway)	(t)	0	1,512	3,571	2,017	5,131	4,734	1,100	**18,065**	
Direct Haul (SSP)	(t)								**0**	
Actual Tonnage Stacked		**16,739**	**8,502**	**14,603**	**29,528**	**37,931**	**32,399**	**35,087**	**174,788**	
Avg Crushing Circuit TPH		**728**	**304**	**480**	**1,052**	**1,277**	**1,099**	**1,453**	**913**	
Variance		*-8,261*	*-16,498*	*-10,397*	*4,528*	*12,931*	*7,399*	*10,087*	-212	

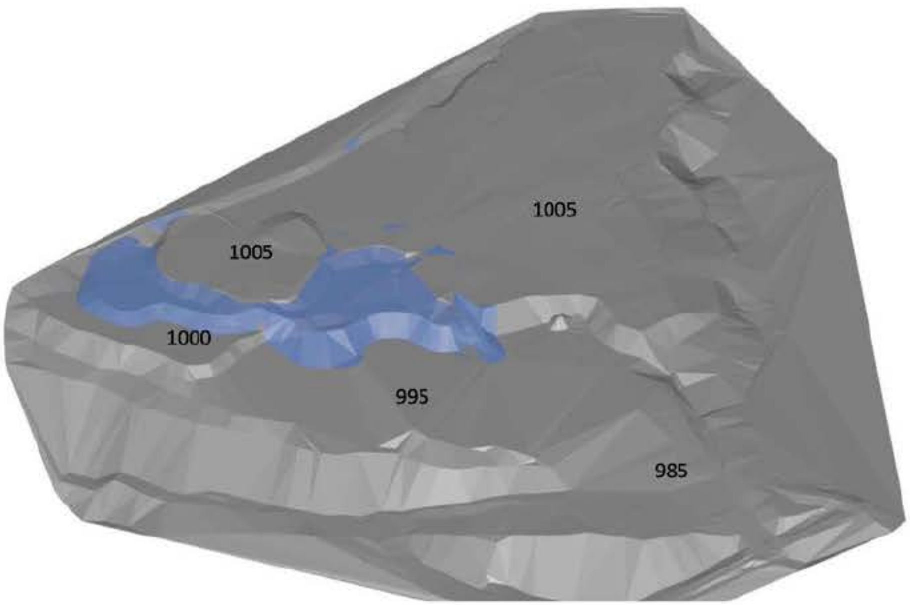


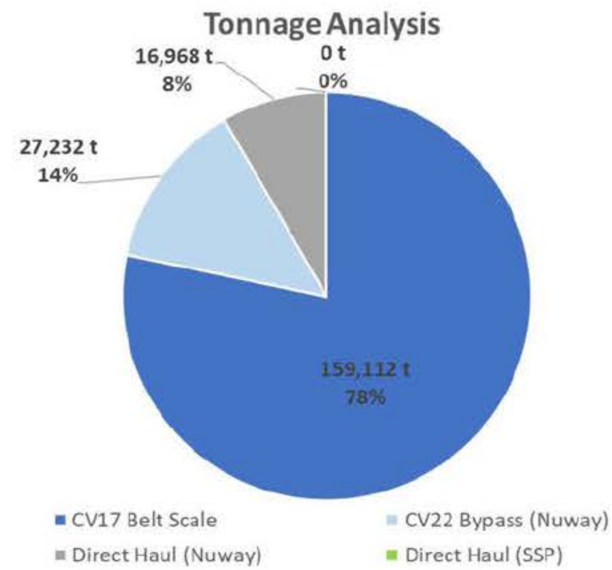


HLF Ore Stacking Plan 2021-04-20 to 2021-04-26

Previous Week Stacking: April 20th – 26th

Previous Week Variance		20-Apr (Tue)	21-Apr (Wed)	22-Apr (Thu)	23-Apr (Fri)	24-Apr (Sat)	25-Apr (Sun)	26-Apr (Mon)	Total	Variance
Heap Leach Facility										
Forecast Tonnes Stacked		**25,000**	**25,000**	**25,000**	**25,000**	**25,000**	**25,000**	**12,500**	**162,500**	
CV17 Belt Scale	(t)	17,708	31,821	26,199	13,966	21,470	25,762	22,187	**159,112**	
CV22 Bypass (Nuway)	(t)	0	821	6,627	6,598	6,208	4,607	2,370	**27,232**	
Direct Haul (Nuway)	(t)	2,605	2,017	4,327	3,739	877	1,092	2,311	**16,968**	**25.1%**
Direct Haul (SSP)	(t)								**0**	
Actual Tonnage Stacked		**20,313**	**34,658**	**37,154**	**24,304**	**28,555**	**31,461**	**26,867**	**203,311**	
Avg Crushing Circuit TPH		**770**	**1,384**	**1,139**	**607**	**933**	**1,120**	**965**	**988**	
Variance		*-4,687*	*9,658*	*12,154*	*-696*	*3,555*	*6,461*	*14,367*	40,811	

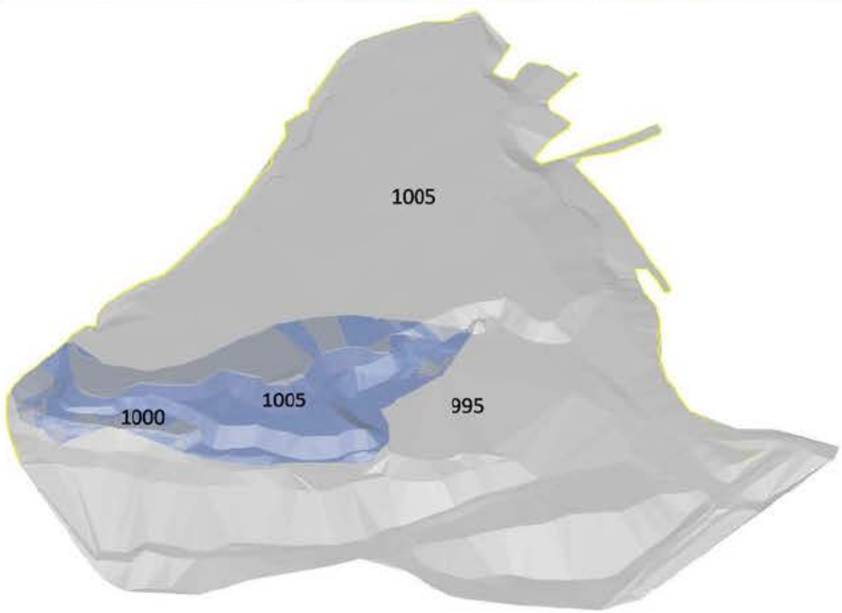


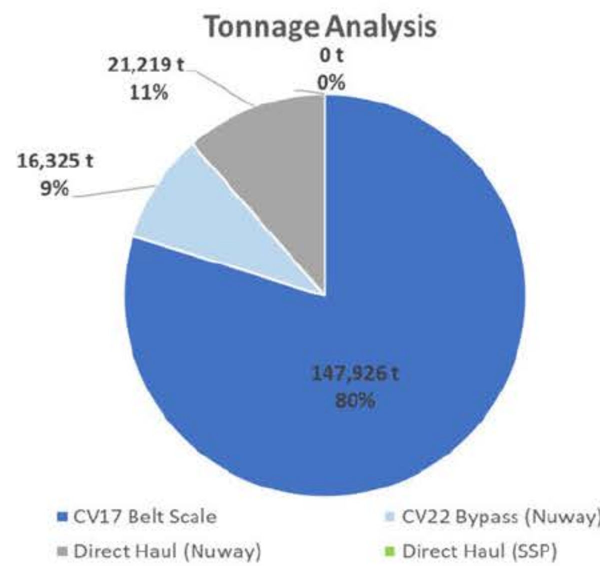


HLF Ore Stacking Plan 2021-04-27 to 2021-05-03

Previous Week HLF Stacking: April 27th – May 3rd

Previous Week Variance		27-Apr (Tue)	28-Apr (Wed)	29-Apr (Thu)	30-Apr (Fri)	01-May (Sat)	02-May (Sun)	03-May (Mon)	Total	Variance
Heap Leach Facility										
Forecast Tonnes Stacked		**12,500**	**25,000**	**25,000**	**25,000**	**34,000**	**17,000**	**34,000**	**172,500**	
CV17 Belt Scale	(t)	7,047	33,662	16,229	27,791	26,358	15,171	21,669	**147,926**	
CV22 Bypass (Nuway)	(t)	352	1,000	9,399	734	1,024	0	3,816	**16,325**	
Direct Haul (Nuway)	(t)	2,840	4,201	3,339	4,285	3,151	2,899	504	**21,219**	**7.5%**
Direct Haul (SSP)	(t)								**0**	
Actual Tonnage Stacked		**10,239**	**38,863**	**28,967**	**32,810**	**30,532**	**18,070**	**25,989**	**185,471**	
Avg Crushing Circuit TPH		**306**	**1,464**	**706**	**1,208**	**1,146**	**660**	**942**	**919**	
Variance		*-2,261*	*13,863*	*3,967*	*7,810*	*-3,468*	*1,070*	*-8,011*	12,971	



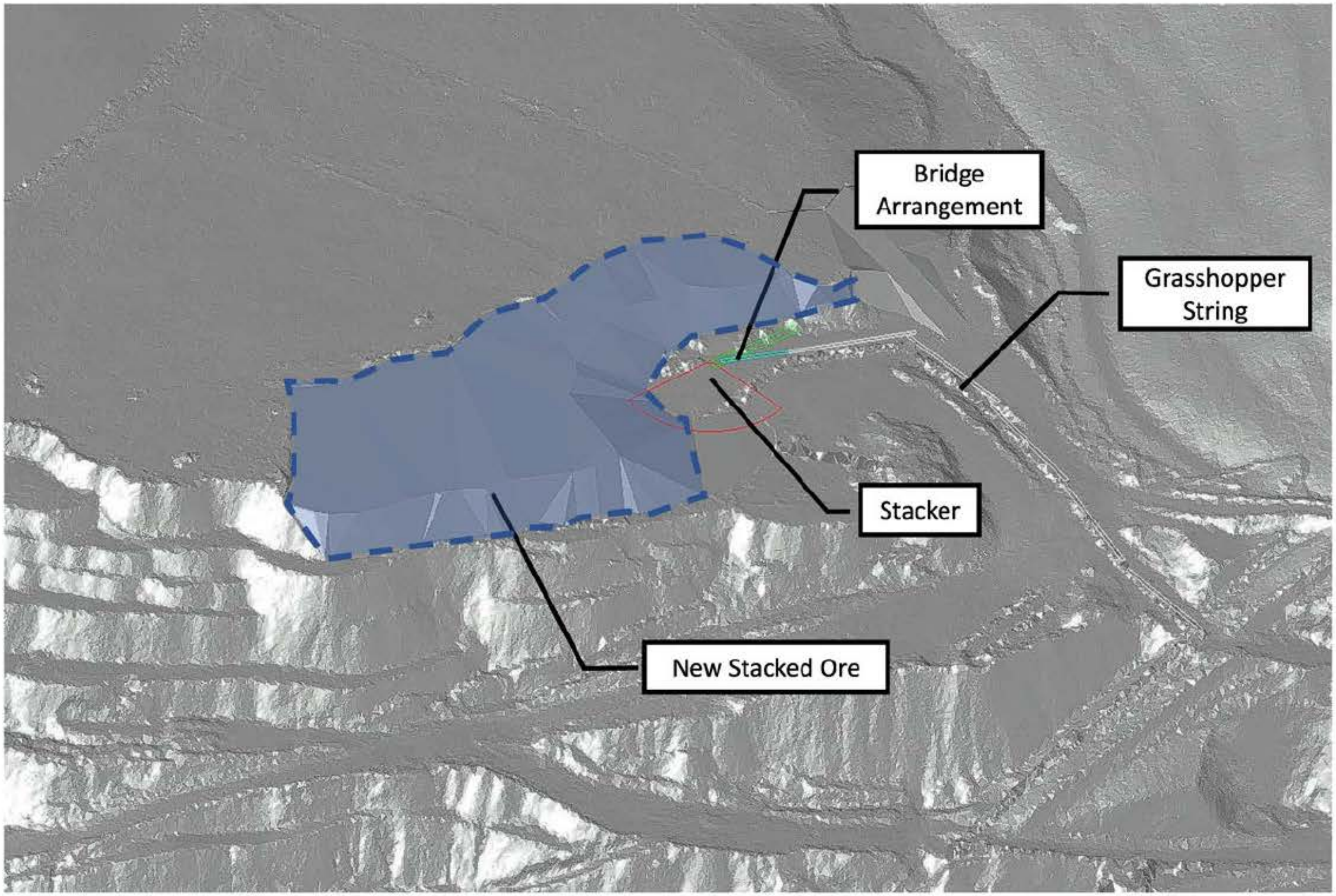


HLF Ore Stacking Plan 2021-05-04 to 2021-05-10

Previous Week: May 4th – May 10th Stacking

VICTORIA GOLD CORP

1005 Stacking
Tonnes Stacked: 215,000
Two Grasshopper Moves

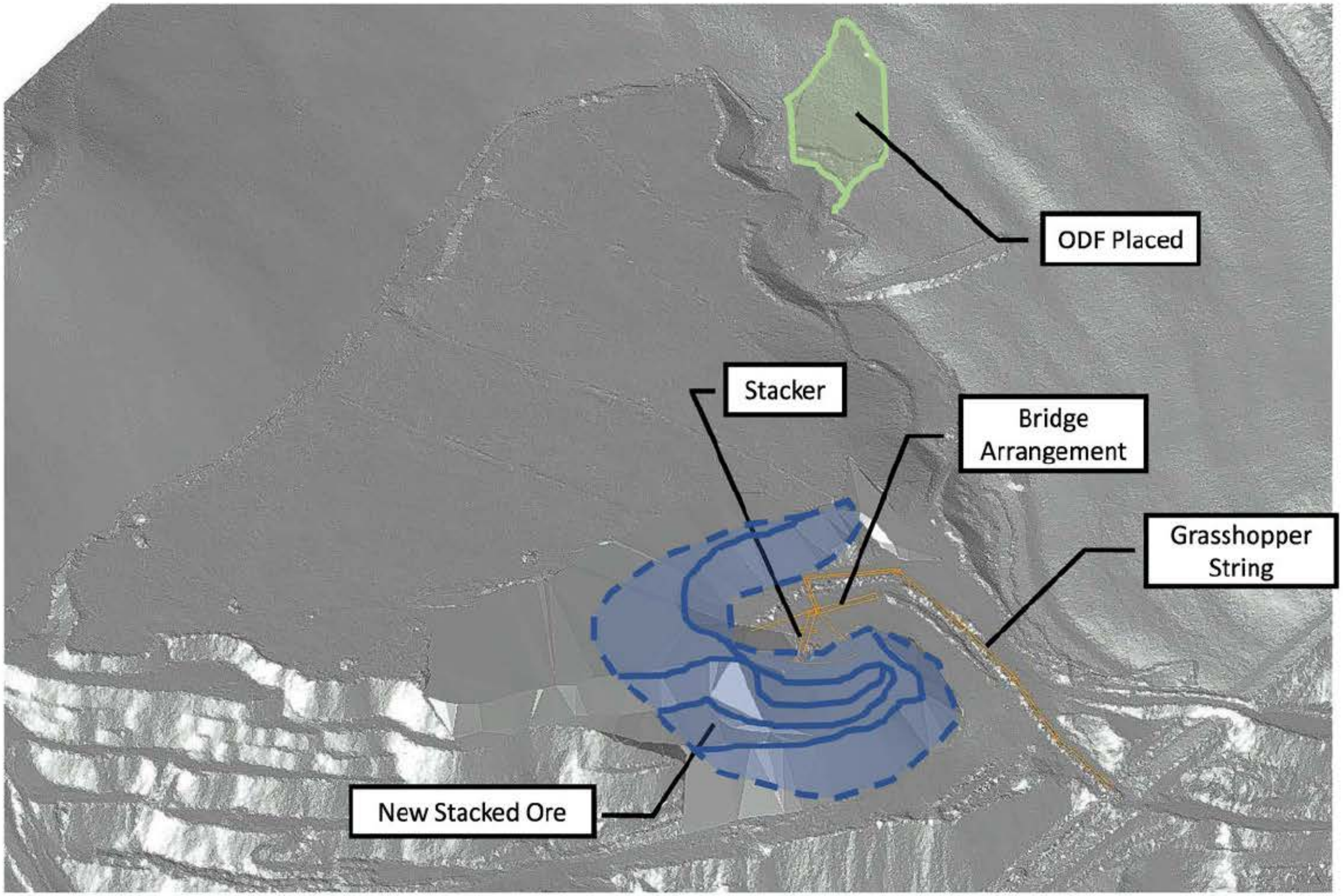


TSX : VGCX OTC: VITFF VGCX.com

HLF Ore Stacking Plan 2021-05-11 to 2021-05-17

Previous Week: May 11th – May 17th Stacking

1005 Stacking
Tonnes Stacked: 173,540
Multiple Bridge & Stacker Moves in Tight Space

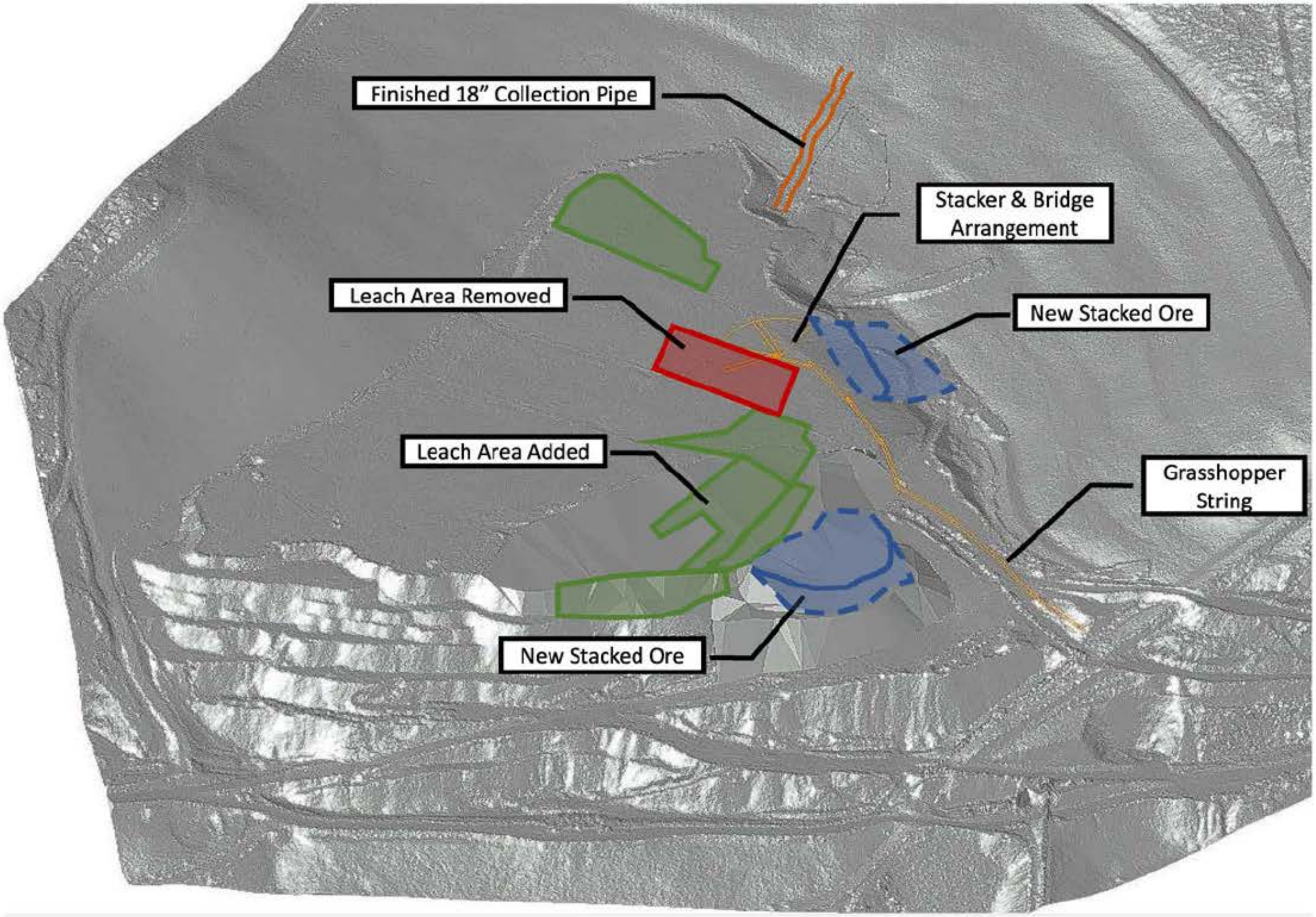


HLF Ore Stacking Plan 2021-05-18 to 2021-05-24

Previous Week: May 18th – May 24th

1005 Stacking
Tonnes Stacked: 170,938
Cobalt trucks filled southeast 1005.
Remaining tonnes towards eastern advance fill.

1005 Leaching
Added: 14,248 m²
Removed: 3,086 m²

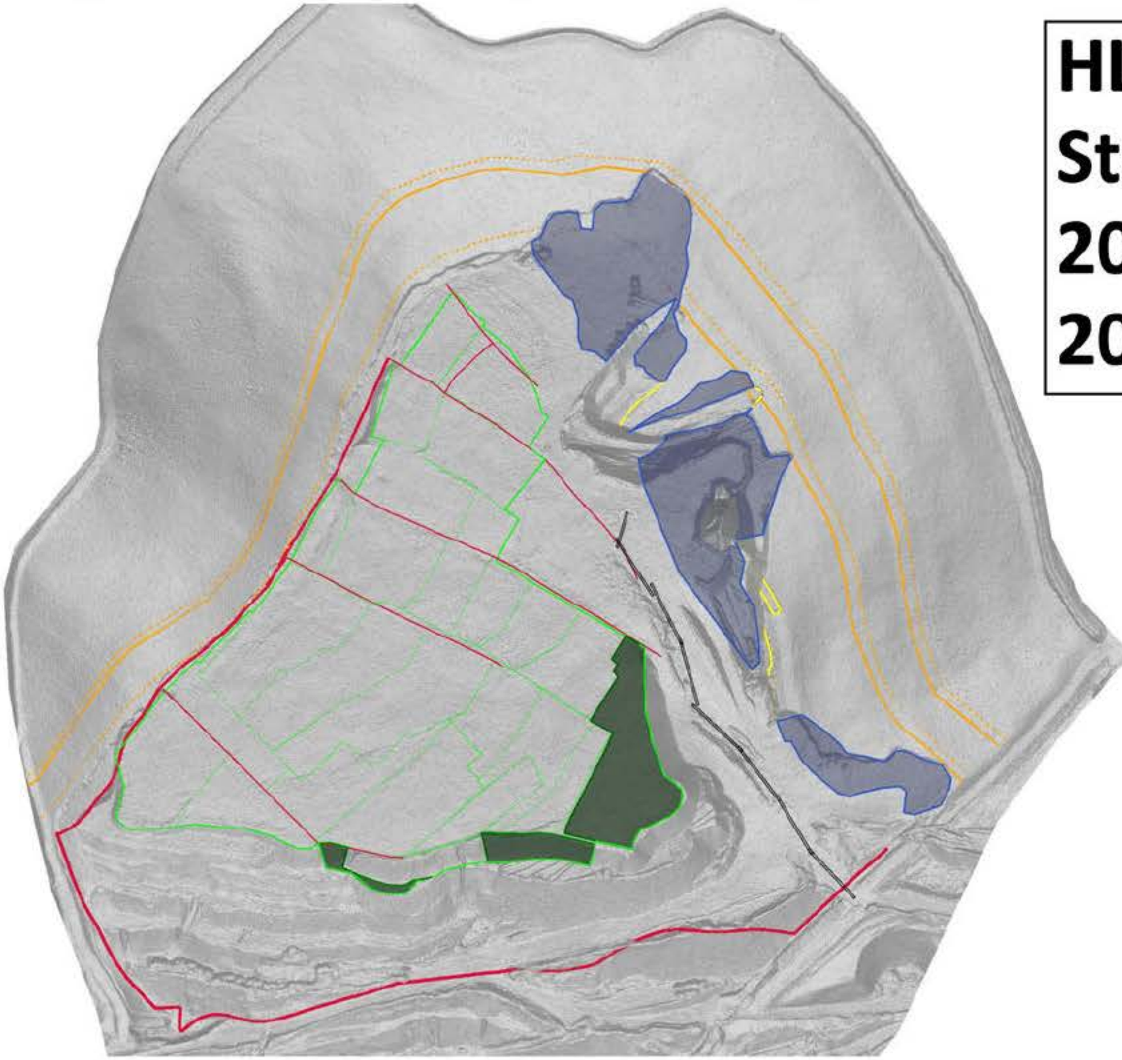


Past Week Stacking & Leaching: May 25th – May 31st

1005 Stacking
Tonnes Stacked: 189,253

Cobalt trucks and wiggle wagon filled North corner 1005\ODF advance on East wall

1005 Leaching
Online: 85,599 m²
Added: 6,055 m²
Removed: 0 m²



HLF Ore Stacking Plan 2021-05-25 to 2021-05-31

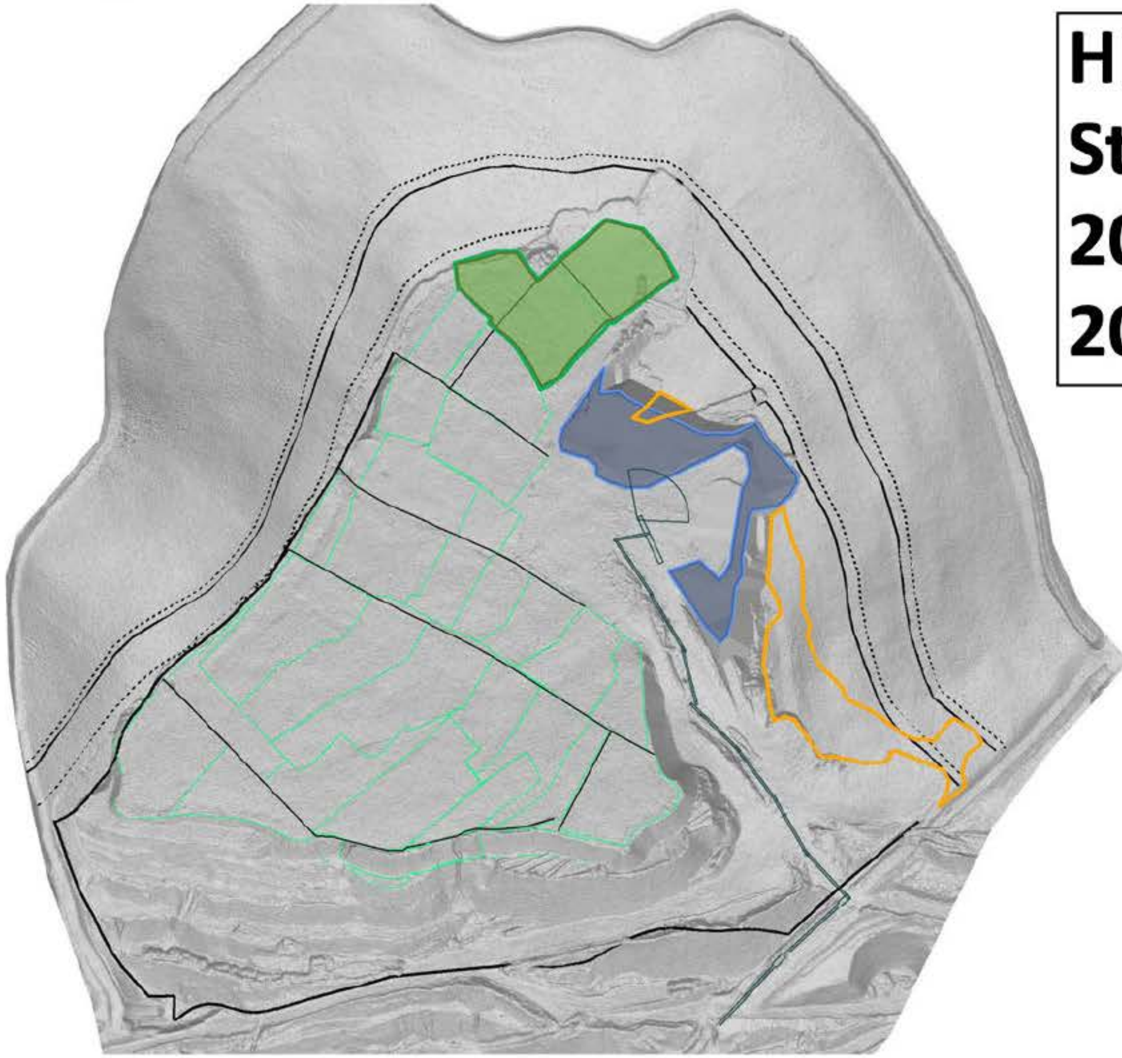
Past Week Stacking & Leaching: June 1st – June 7th

Stacking
1005 & ODF: 179,595 T

Cobalt trucks and wiggle wagon filled East wall 1005\ODF advance on East wall

Leaching
Online: 94,961 m²
Added: 9,362 m²
Removed: 0 m²

Infrastructure
24" Barren Line Extended under ROM Road installed



HLF Ore Stacking Plan 2021-06-01 to 2021-06-07

TSX : VGCX OTC: VITFF VGCX.com

HLF Ore Stacking Plan 2021-06-08 to 2021-06-14

HLF – Past Week – June 8th to June 14th

Stacking

1. ODF = 14,000t
2. 1005 E = 144,507t
3. -

Leaching

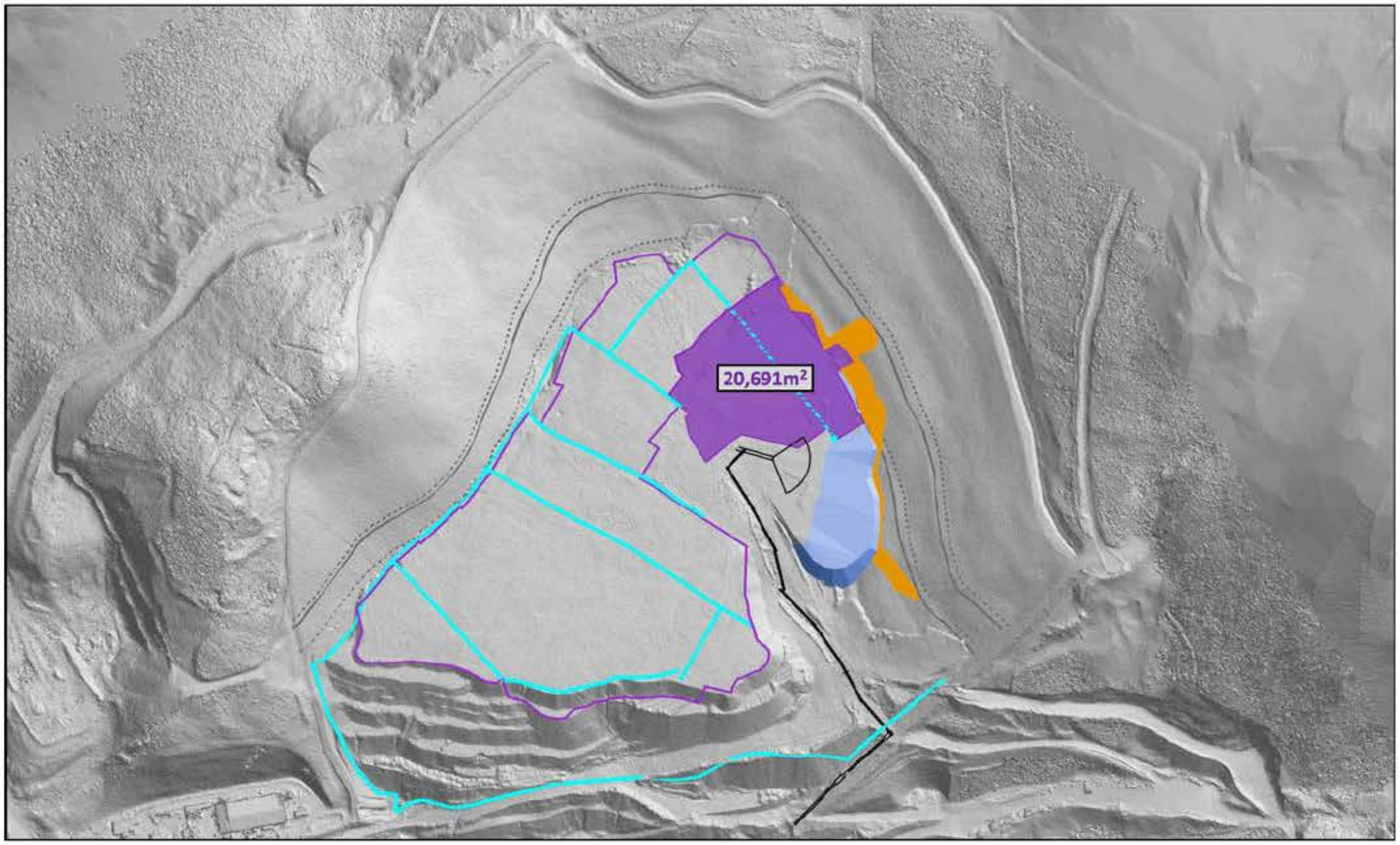
1. Added = 20,691m²
2. Removed = 0m²
3. Total = 115,652m²

Infrastructure

1. Collection Pipe N
2. -
3. -

Legend

- Leach Cells
- Distribution / Leach Line
- Stacking
- ODF



HLF Ore Stacking Plan 2021-06-22 to 2021-06-28

HLF – Past Week – June 22nd to June 28th

Stacking

1. 1017 Lift = 202,400t
2. ODF = 25,600t
3. -

Leaching

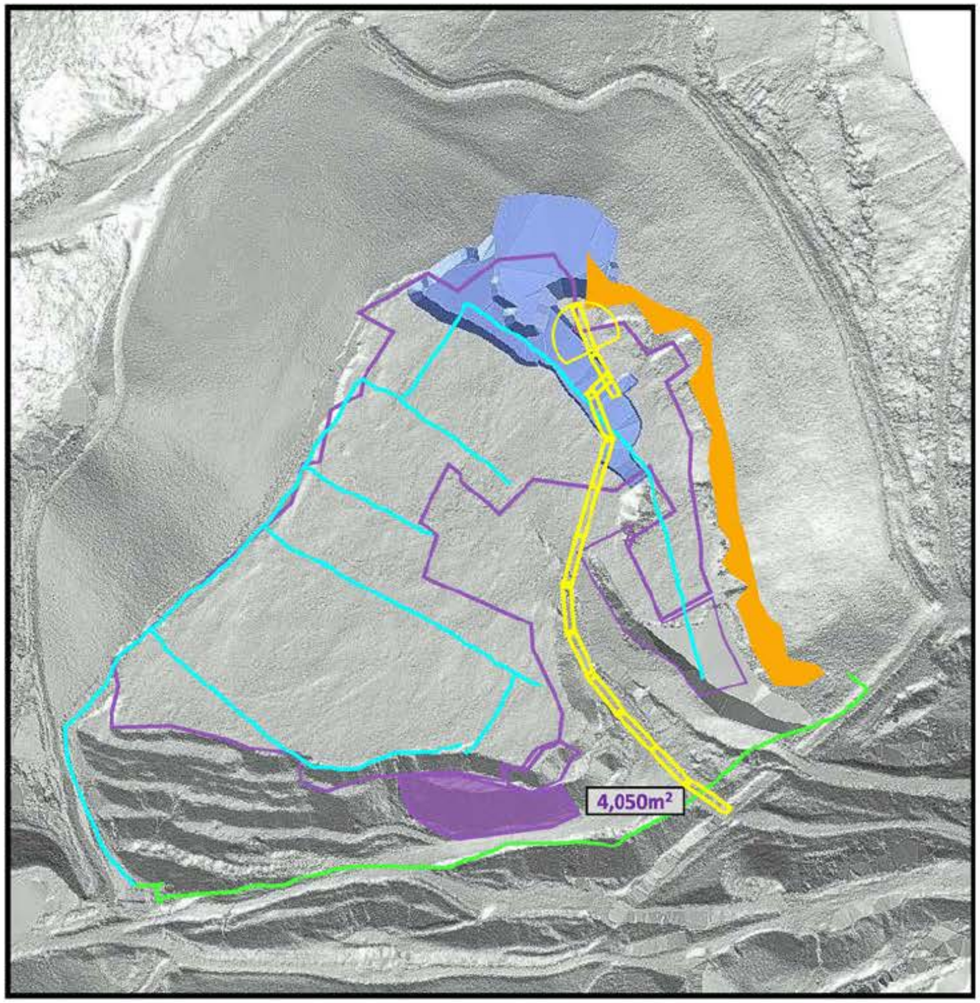
1. Add = 4,050m²
2. Remove = 0m²
3. Total = 132,592m²

Infrastructure

1. Eastern Distribution Line
2. -
3. -

Legend

- Leach Cells
- Distribution / Leach Line
- Stacking
- ODF



HLF Ore Stacking Plan 2021-06-29 to 2021-07-05

HLF – Past Week – June 29th to July 5th

Stacking

1. 1017 Lift = 220,000t
2. -
3. -

Leaching

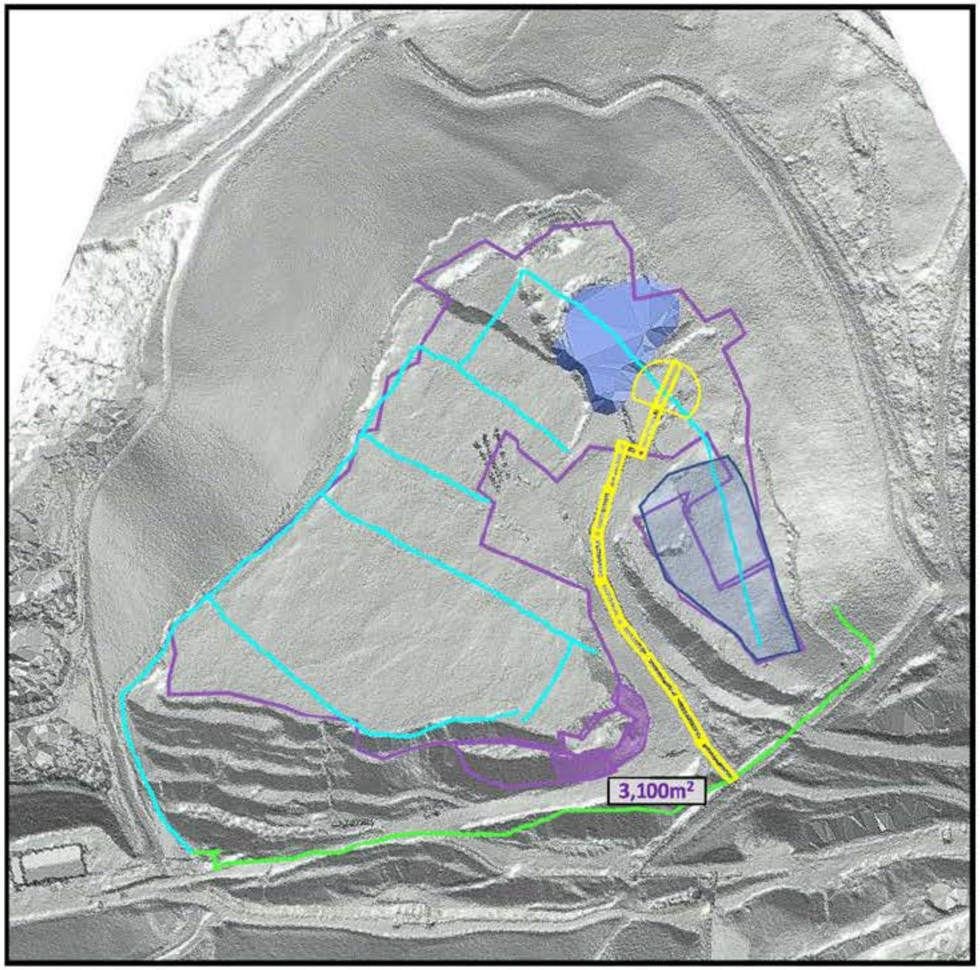
1. Add = 3,100m²
2. Remove = 0m²
3. Total = 135,665m²

Infrastructure

1. Eastern Distribution Line
2. Side Slope Leaching
3. -

Legend

- Leach Cells
- Distribution / Leach Line
- Stacking
- ODF



HLF Ore Stacking Plan 2021-07-06 to 2021-07-12

HLF – Past Week – July 6th to July 12th

Stacking

1. ODF = 8,000t
2. P1-1017 = 191,225t
3. Truck Haul = 98,961t

Leaching

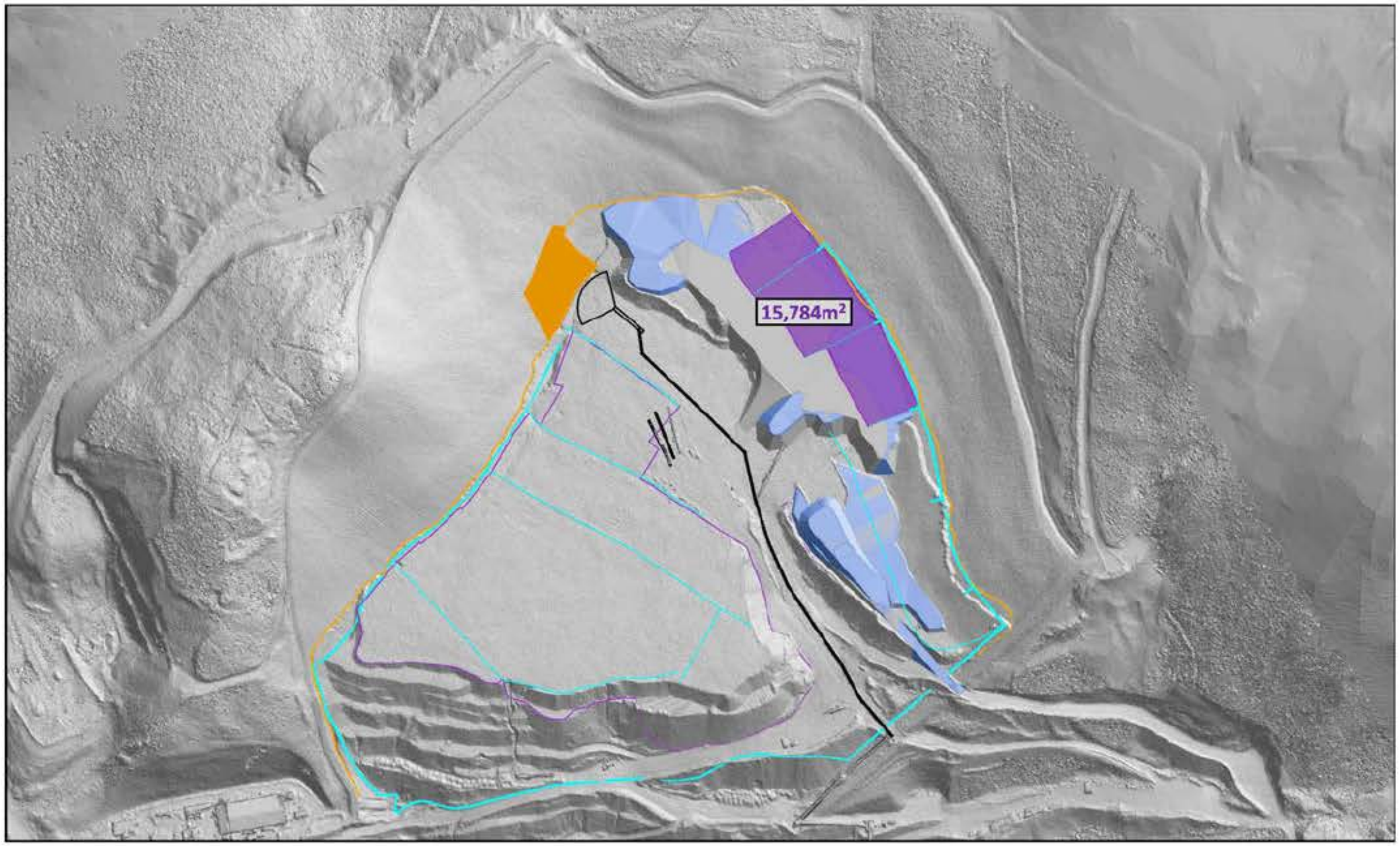
1. Added = 15,784m²
2. Removed = 0m²
3. Total = 151,449m²

Infrastructure

1. 24" E Dist. Line Install
2. Collection Pipe W
3. -

Legend

- Leach Cells
- Distribution / Leach Line
- Stacking
- ODF



TSX : VGCX OTC: VITFF VGCX.com

HLF Ore Stacking Plan 2021-07-12 to 2021-07-18

HLF – Past Week – July 12th to July 18th

Stacking

1. ODF = 20,000t
2. P2-1017 = 190,016t
3. ROM = 90,837t

Leaching

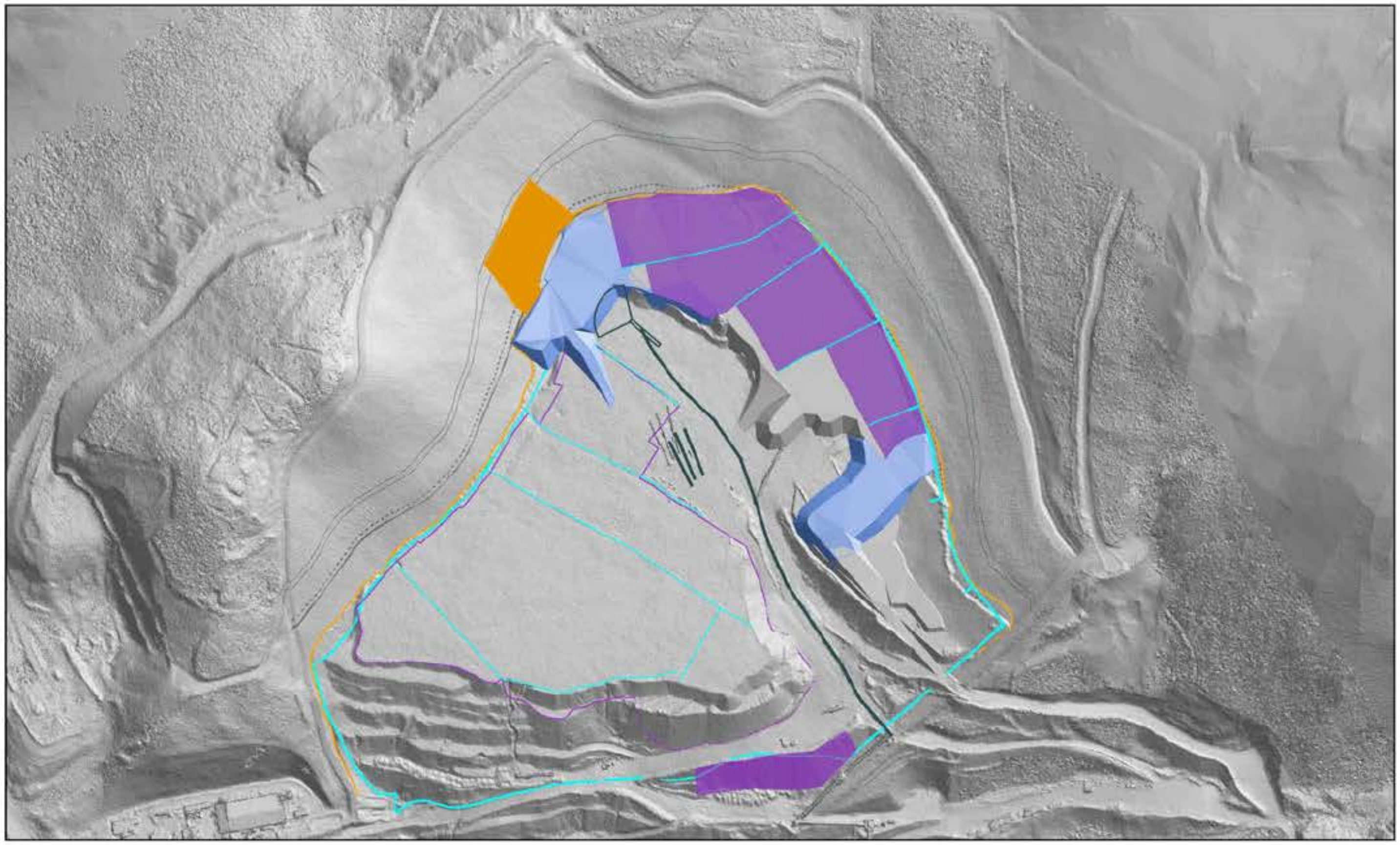
1. Added = 35,480m²
2. Removed = 42,157m²
3. Total = 124,573m²
4. Side Slope = 6,019m²

Infrastructure

1. Collection Pipe W
2. Piezometer Install
3. 8" E Lines Extended
4. Liner Patch Complete

Legend

- Leach Cells
- Distribution / Leach Line
- Stacking
- ODF



HLF Ore Stacking Plan 2021-07-19 to 2021-07-25

HLF – Week 1 – July 19th to July 25th

Stacking

1. ODF = 20,000t
2. P2-1017 = 138,550t
3. Trucks = 100,000t

Leaching

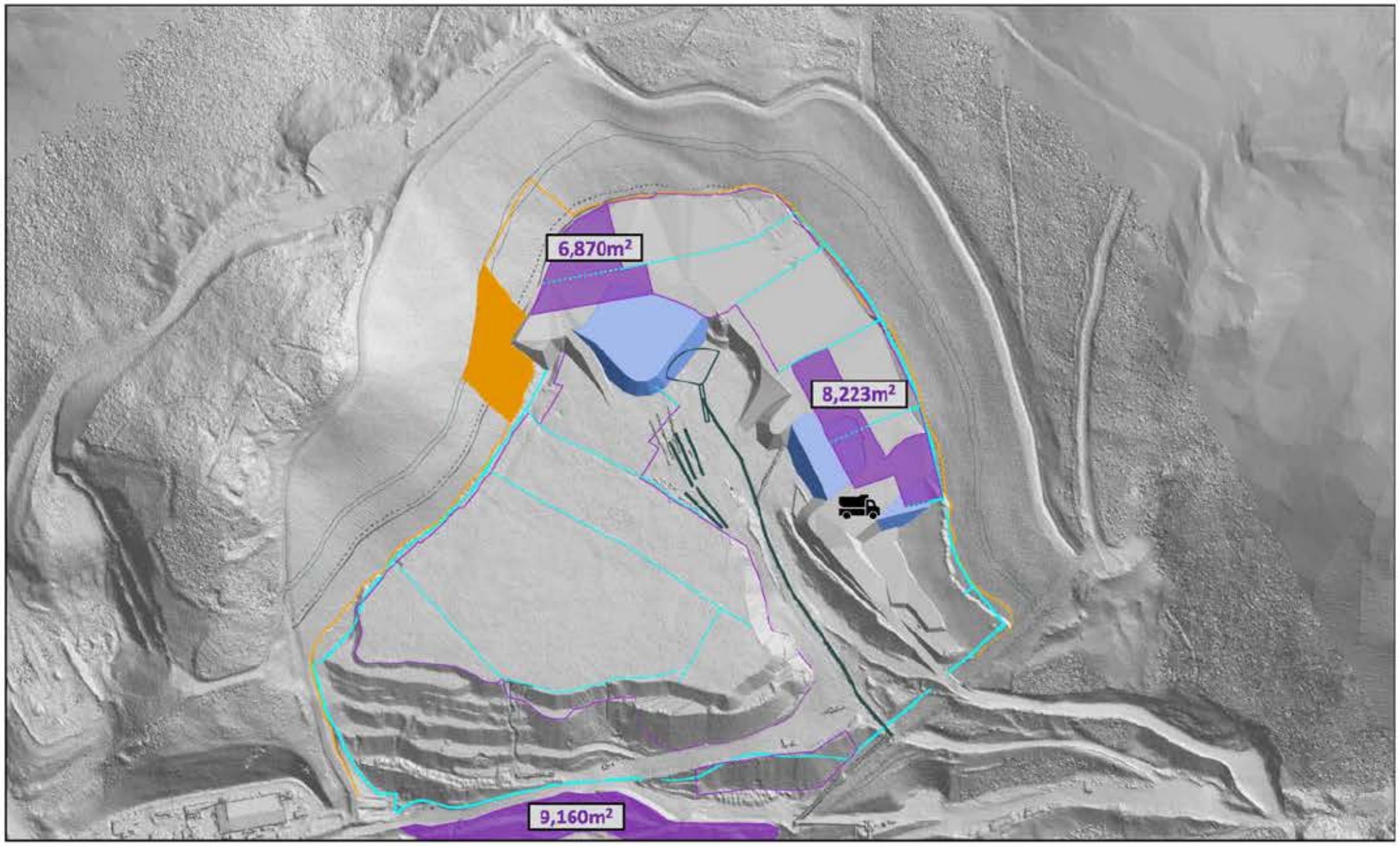
1. Add = 15,093m²
2. Remove = Side Slope
3. Total = 137,605m²
4. Side Slope = 9,160m²

Infrastructure

1. Collection Pipe W
2. 8" E Lines Extended
3. South Ramp

Legend

- Leach Cells
- Distribution / Leach Line
- Stacking
- ODF



TSX : VGCX OTC: VITFF VGCX.com

HLF Ore Stacking Plan 2021-07-26 to 2021-08-01

HLF – Week 2 – July 26th to August 01st

Stacking

1. ODF = 10,000t
2. P2-1017 = 148,550t
3. Trucks = 100,000t

Leaching

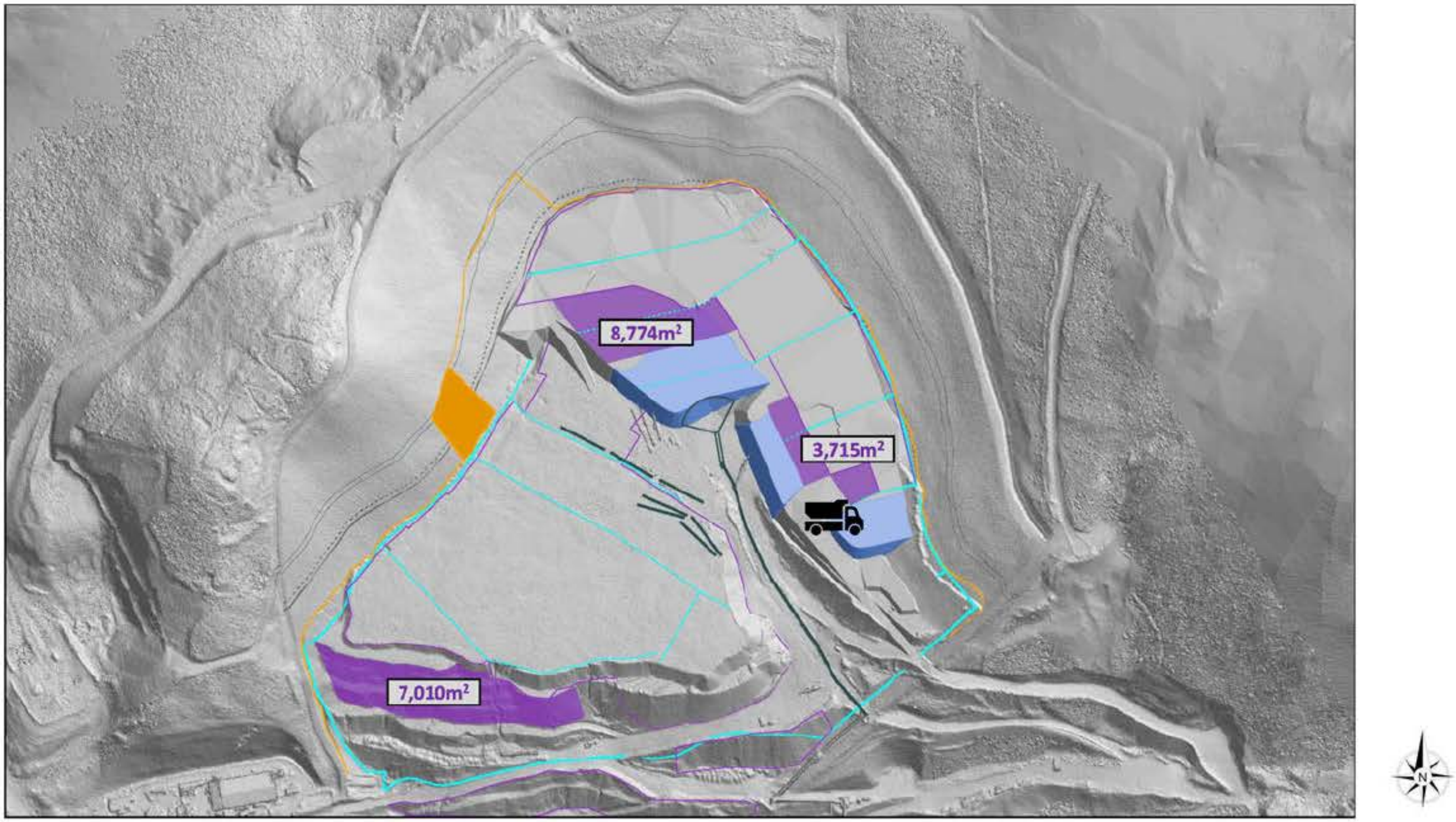
1. Add = 12,489m²
2. Remove = NA
3. Total = 150,094m²
4. Side Slope = 7,010m²

Infrastructure

1. Collection Pipe W
2. 8" E Lines Extended
3. South Ramp

Legend

- Leach Cells
- Distribution / Leach Line
- Stacking
- ODF



TSX : VGCX OTC: VITFF VGCX.com

HLF Ore Stacking Plan 2021-08-17 to 2021-08-23

HLF – Past Week – August 17th to August 23rd

Stacking

1. ODF = 5,100t
2. P3-1017 = 134,060t
3. ROM = 146,814t

Leaching

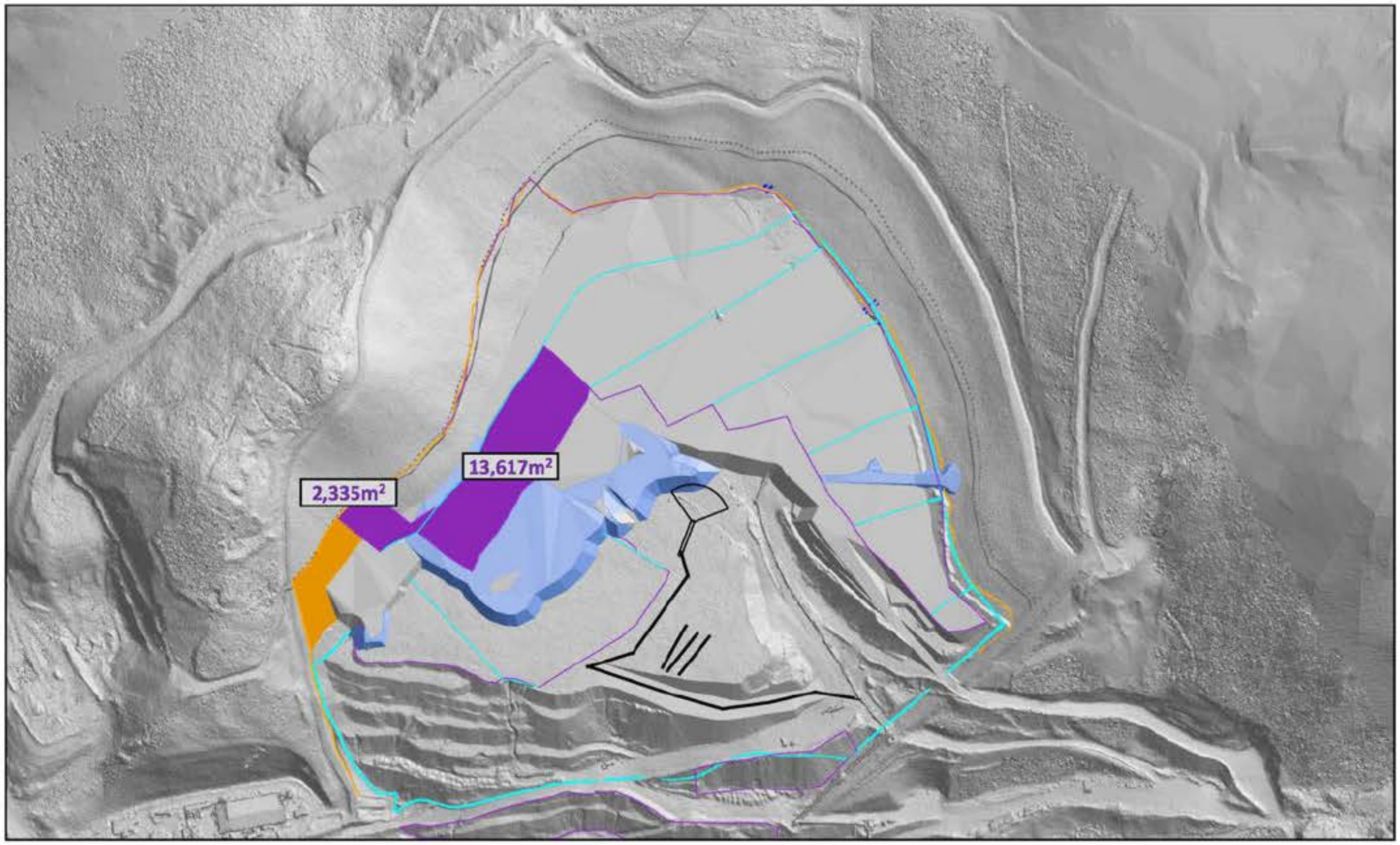
1. Added = 13,617m²
2. Removed = 10,290m²
3. Total = 152,228m²
4. Side Slope = Sprinkler
5. ODF = 2,335m²

Infrastructure

1. Collection Pipe W
2. 8" E Line Extended
3. -

Legend

- Leach Cells
- Distribution / Leach Line
- Stacking
- ODF



TSX : VGCX OTC: VITFF VGCX.com

HLF Ore Stacking Plan 2021-08-24 to 2021-08-30

HLF – Past Week – August 24th to August 30th

Stacking

1. ODF = 41,293t
2. P4-1017 = 97,381t
3. P4-995 = 15,900
4. ROM = 61,664t

Leaching

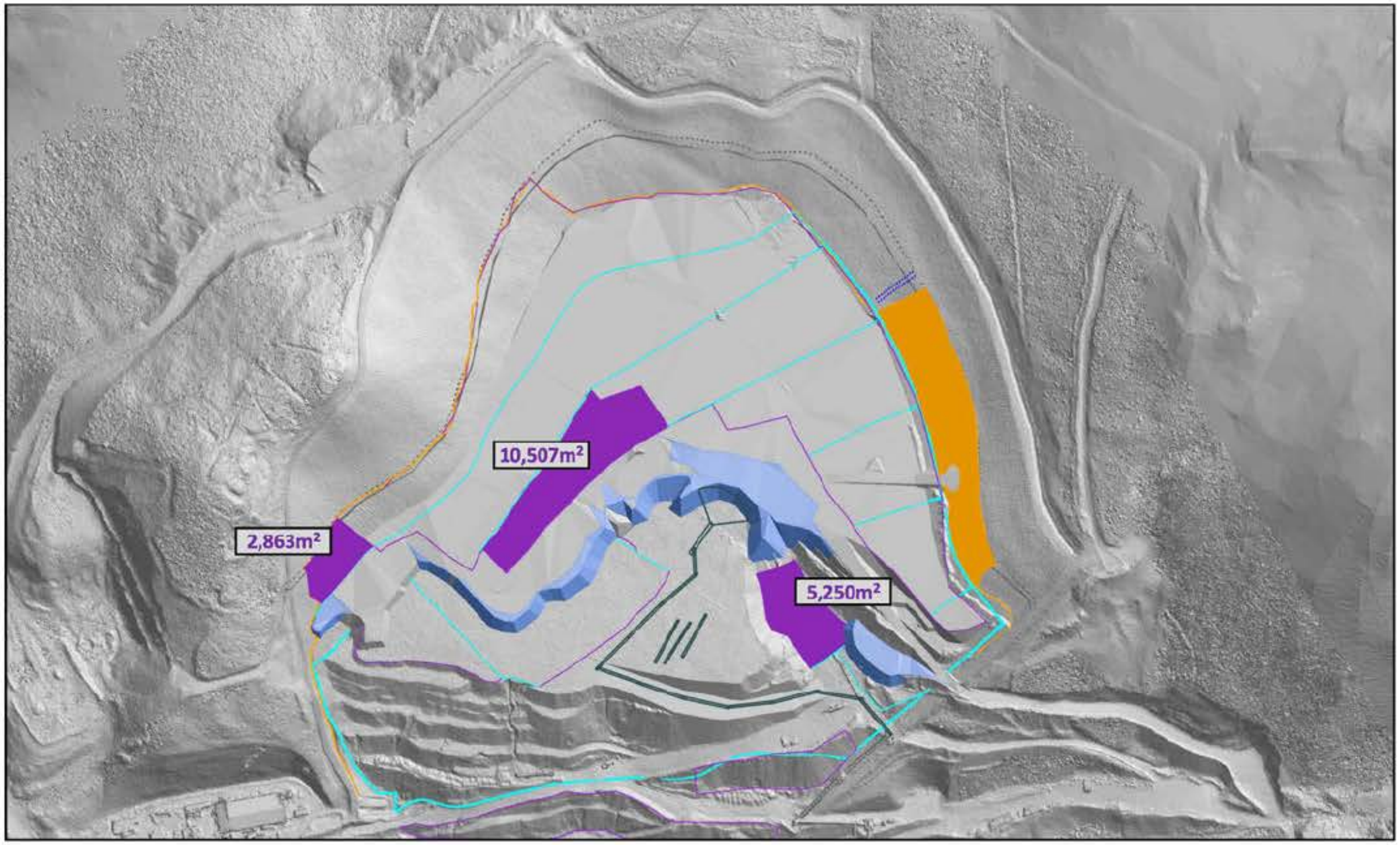
1. Added = 15,757m²
2. ODF = 2,863m²
3. Side Slope = 0m²
4. Removed = 0m²
5. Total = 177,716m²

Infrastructure

1. Collection Pipe E
2. 8" E Line Extension
3. CV23 Ditching
4. 18" Line E Extension

Legend

- Leach Cells
- Distribution / Leach Line
- Stacking
- ODF



TSX : VGCX OTC: VITFF VGCX.com

HLF Ore Stacking Plan 2021-08-31 to 2021-09-06

HLF – August 31st to September 6th

Stacking

1. ODF = 31,941t
2. P4-1017 = 24,825t
3. P4-995 = 81,007t
4. P4-1005 = 10,867t
5. ROM = 67,076t

Leaching

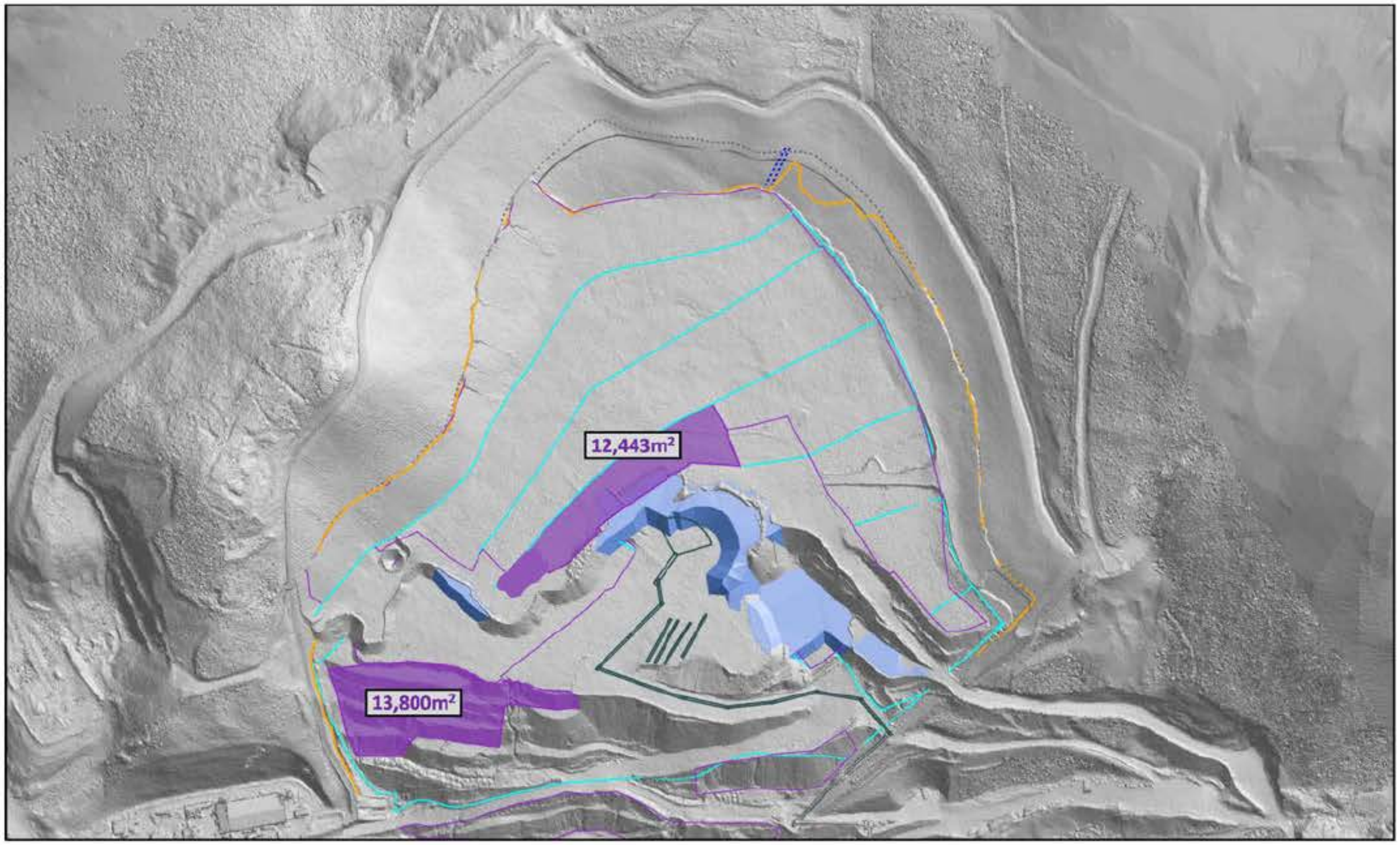
1. Added = 12,443m²
2. Side Slope = 13,800m²
3. Removed = 0m²
4. Total = 182,109m²

Infrastructure

1. Collection Pipe E
2. 8" E Line Extension
3. CV23 Ditching
4. N 18" Trunk Lines

Legend

- Leach Cells
- Distribution / Leach Line
- Stacking
- ODF



HLF Ore Stacking Plan 2021-09-07 to 2021-09-13

Last Week – HLF – September 7th to September 13th

Stacking

1. ODF = 5,002t
2. 1015 Stacker = 167,288t
3. 1005 ROM = 50,780t

Leaching

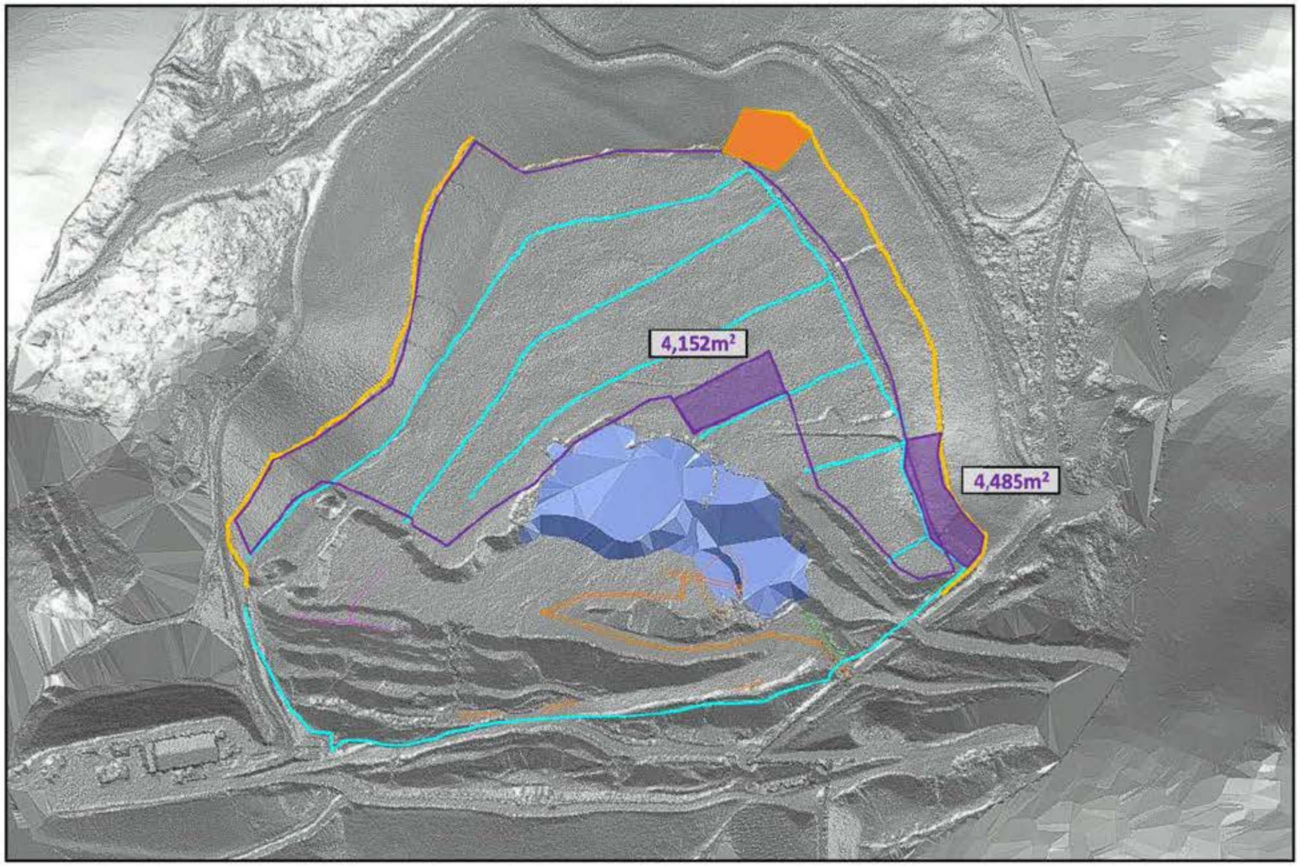
1. Added = 8,637m²
2. Removed = 33,038m²
3. Total = 157,711m²

Infrastructure

1. Western Trunk Line
2. 950 Pad Drain Ditch
3. ODF Collection Pipe

Legend

- Leach Cells
- Distribution / Leach Line
- Stacking
- ODF



TSX : VGCX OTC: VITFF VGCX.com

HLF Ore Stacking Plan 2021-09-14 to 2021-09-20

Last Week – HLF – September 14th to September 20th

Stacking

1. ODF = 10,002t
2. 1015 Stacker = 153,124t
3. 1005 ROM = 88,674t

Leaching

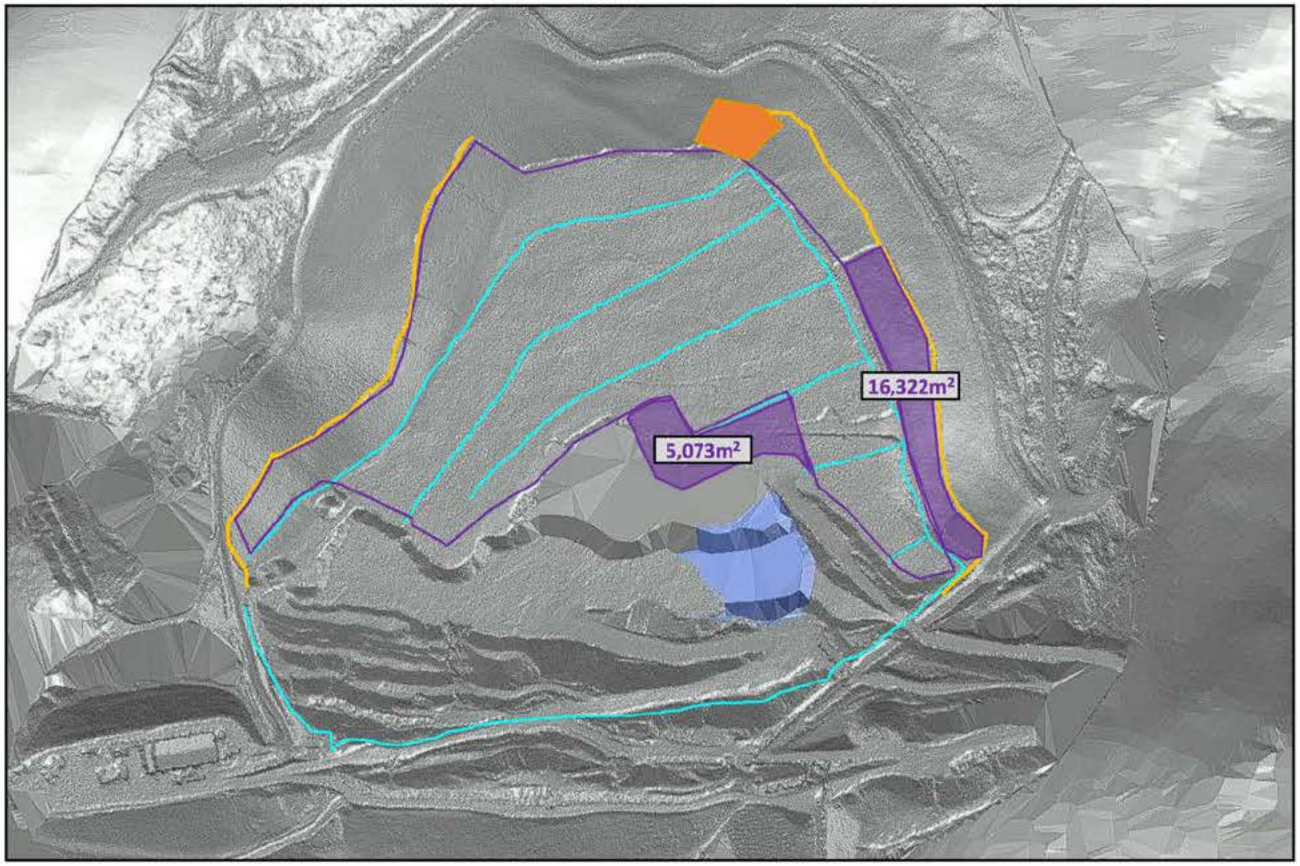
1. Added = 21,395m²
2. Removed = 10,468m²
3. Total = 168,638m²

Infrastructure

1. Western Trunk Line
2. 950 Pad Drain Ditch
3. ODF Collection Pipe

Legend

- Leach Cells
- Distribution / Leach Line
- Stacking
- ODF



TSX : VGCX OTC: VITFF VGCX.com

HLF Ore Stacking Plan 2021-09-21 to 2021-09-27

Last Week – HLF – September 21st to September 27th

Stacking

1. ODF = 10,002t
2. 1015 Stacker = 153,124t
3. 1005 ROM = 88,674t

Leaching

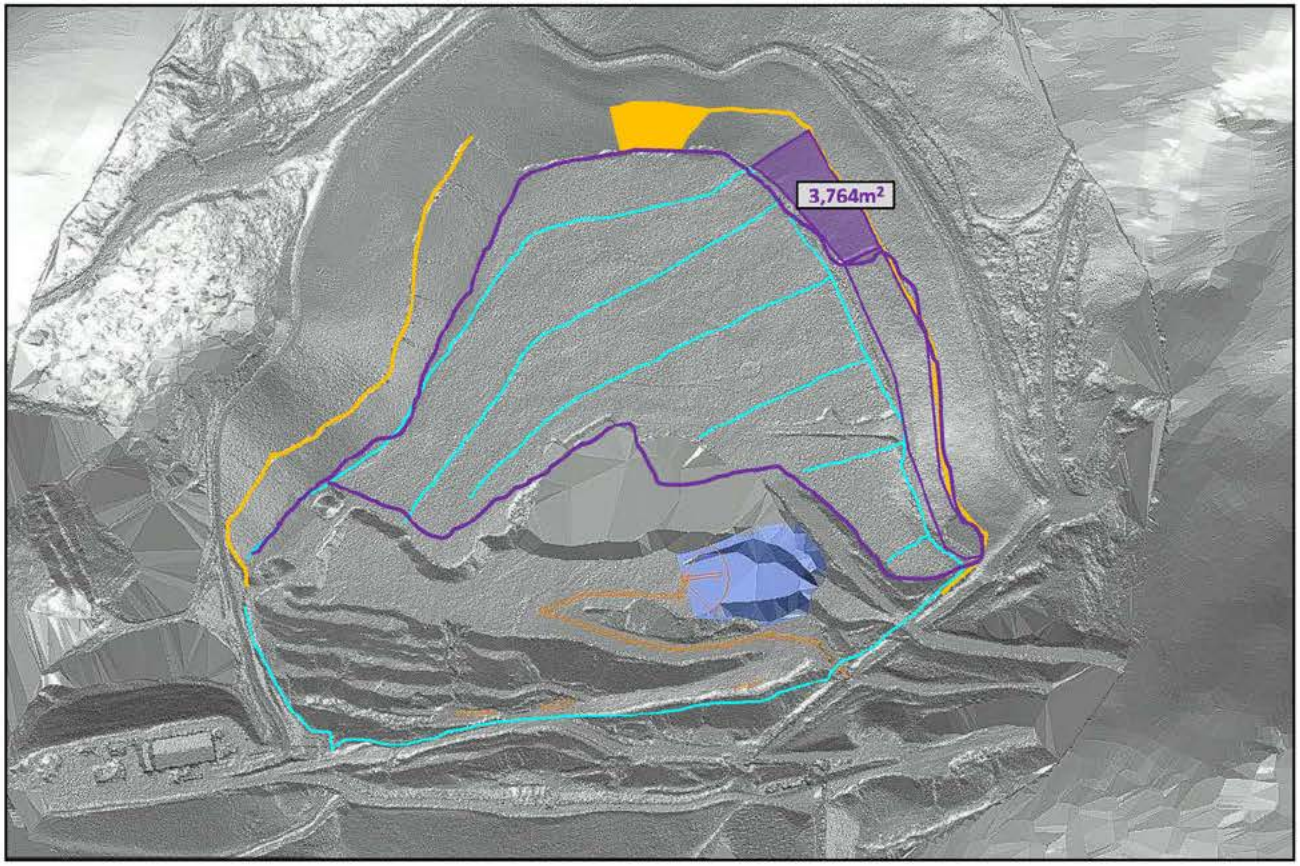
1. Added = 3,764m²
2. Removed = 10,016m²
3. Total = 154,719m²

Infrastructure

1. Western Trunk Line
2. 950 Pad Drain Ditch
3. ODF Collection Pipe

Legend

- Leach Cells
- Distribution / Leach Line
- Stacking
- ODF



HLF Ore Stacking Plan 2021-09-28 to 2021-10-04

HLF – Past Week Actual – September 28th to October 4th

Stacking

1. ODF North = 20,000t
2. P5-1017 = 137,505t
3. ROM = 30,232t

Leaching

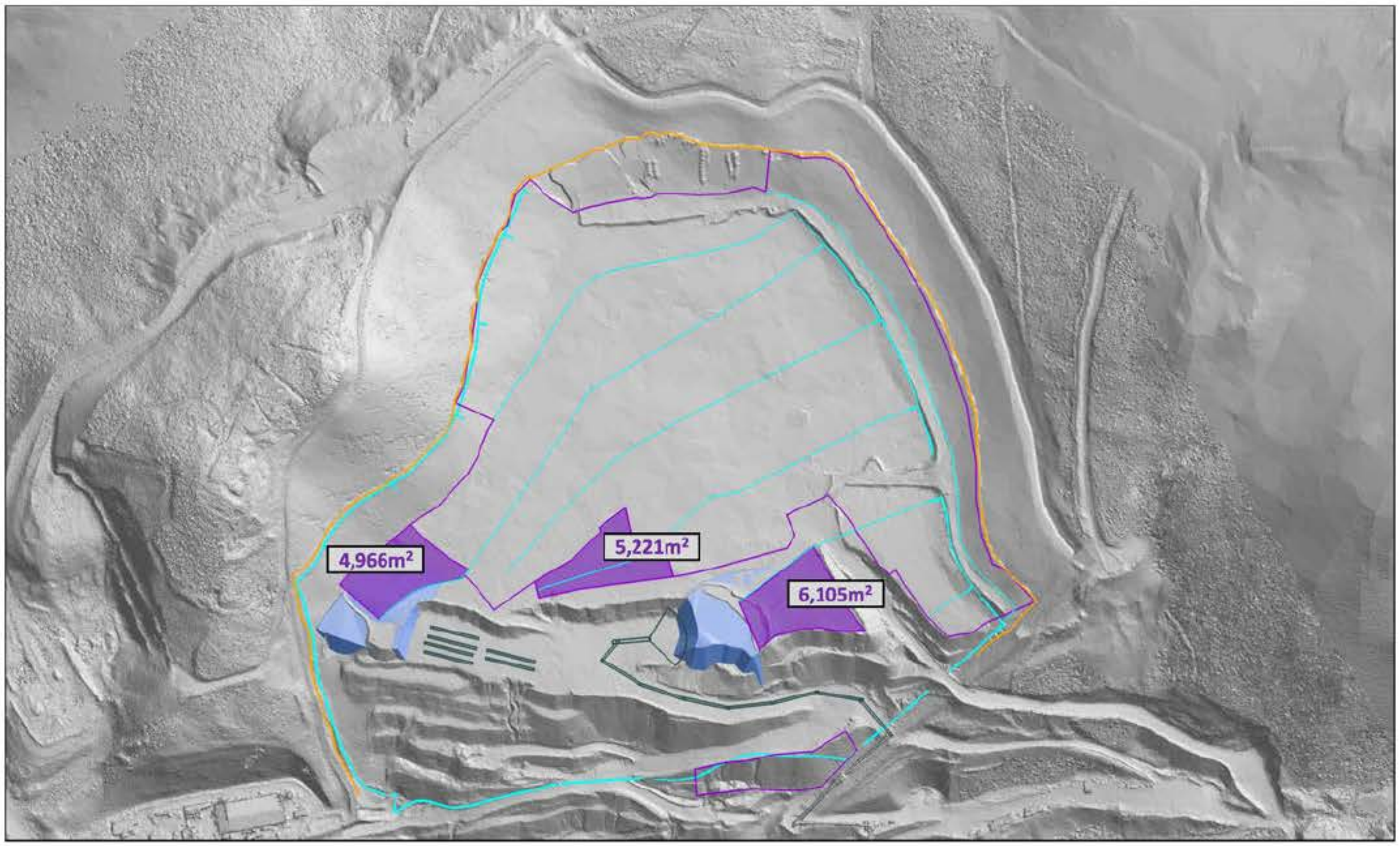
1. Added = 16,025m²
2. Remove = 0m²
3. Total = 175,536m²

Infrastructure

1. 8" North Trunk Lines
2. 8" E5-A Line Extended
3. 8" E2 Line Extended
4. 8" E3 Line Extended

Legend

- Leach Cells
- Distribution / Leach Line
- Stacking
- ODF



TSX : VGCX OTC: VITFF VGCX.com

HLF Ore Stacking Plan 2021-10-05 to 2021-10-11

HLF – Past Week Actual – October 5th to October 11th

Stacking

1. P6-1017 = 117,742t
2. GH Pad = 24,883t
3. ROM = 80,149t

Leaching

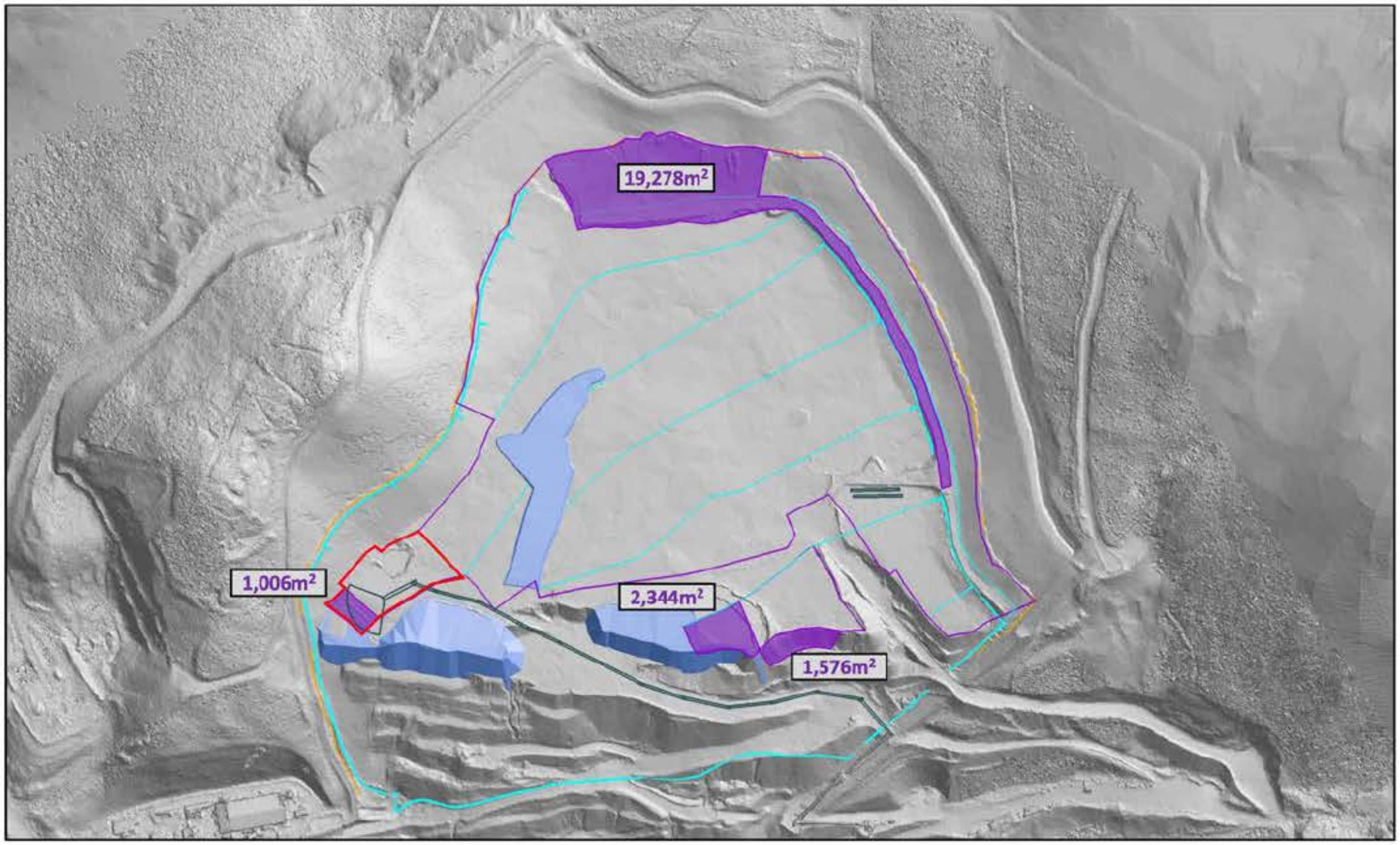
1. Added = 4,926m²
2. ODF = 19,278m²
3. **Removed = 5,972m²**
4. Total = 174,490m²

Infrastructure

1. 8" E5A Line Shortened
2. 8" E2 Line Extended

Legend

- Leach Cells
- Distribution / Leach Line
- Stacking
- ODF



HLF Ore Stacking Plan 2021-10-12 to 2021-10-18

HLF – Past Week Actual – October 12th to October 18th

Stacking

1. P6-1017 = 103,526t
2. GH Pad = 15,000t
3. 955 Road = 0t
4. ROM 1029 = 30,908t
5. P1-1029 = 31,164t

Leaching

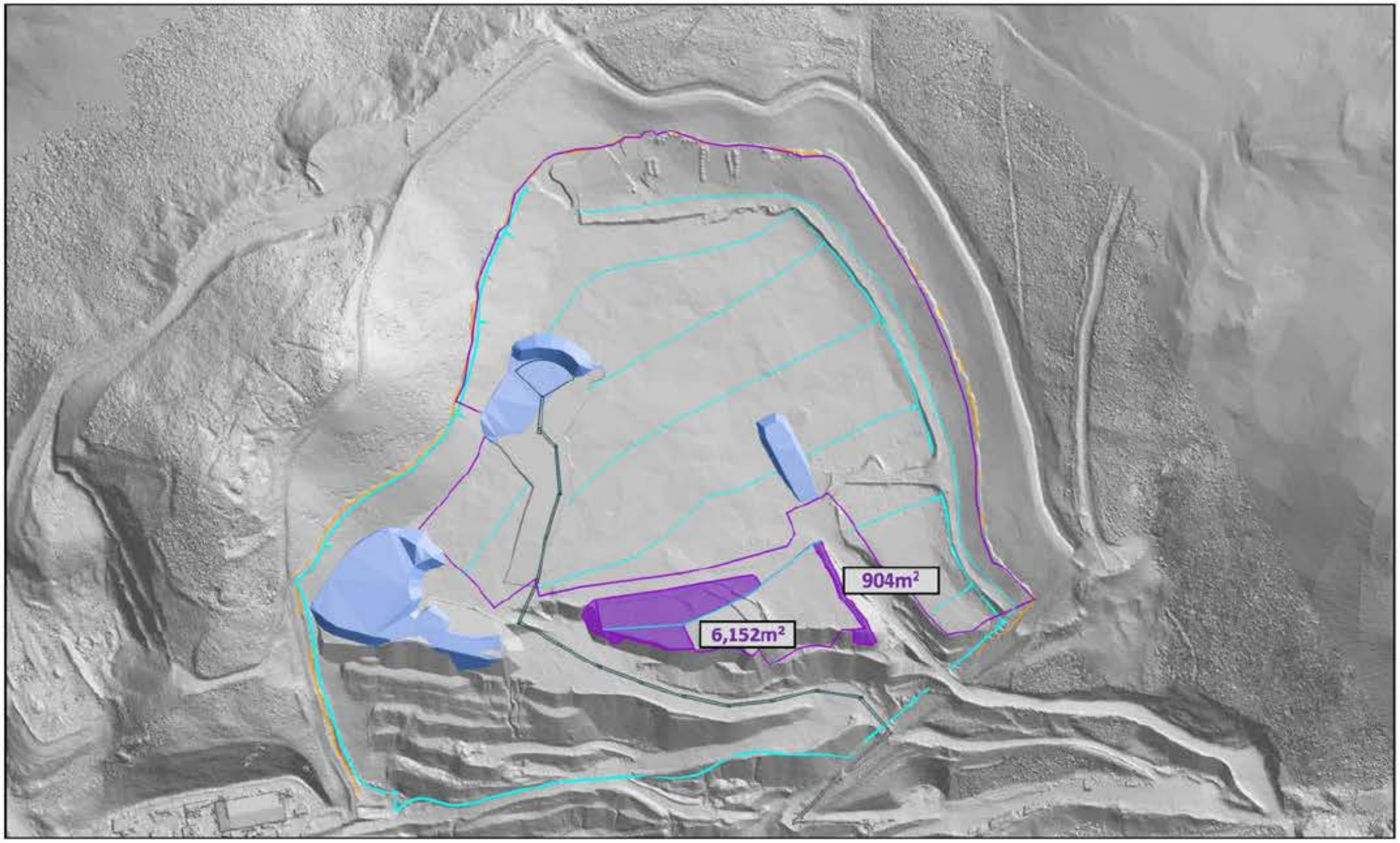
1. Added = 7,056m²
2. Removed = 0m²
3. Total = 160,982m²

Infrastructure

1. 8" E5A Line (0m)
2. 8" E2 Line (82m)

Legend

- Leach Cells
- Distribution / Leach Line
- Stacking
- ODF

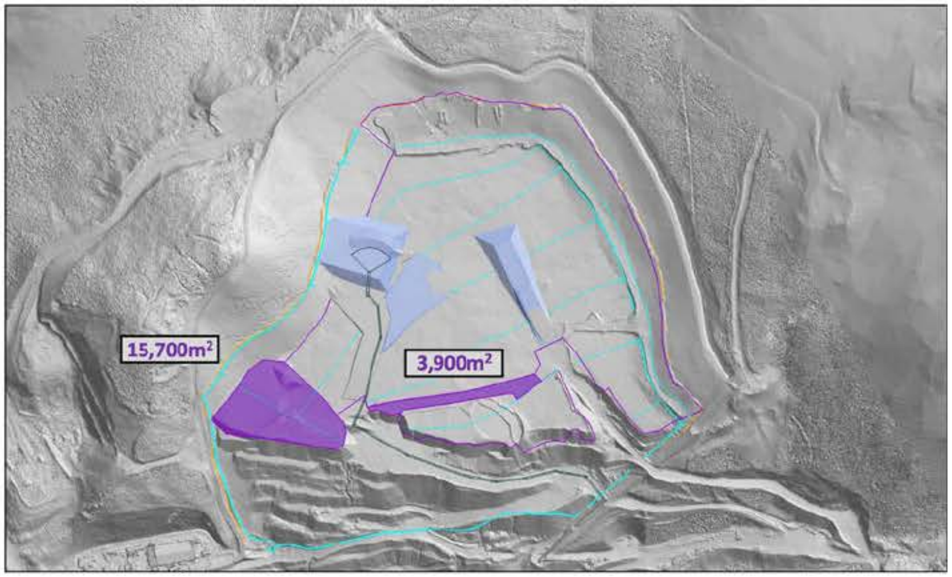


TSX : VGCX OTC: VITFF VGCX.com

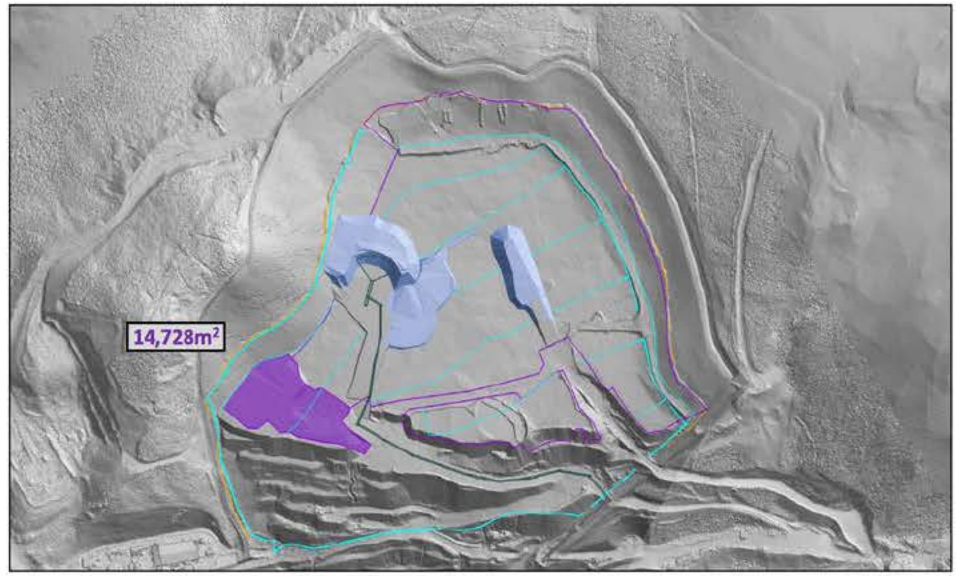
HLF Ore Stacking Plan 2021-10-19 to 2021-10-25

HLF – Past Week – October 19th to October 25th

Plan



Actual



Legend
- Leach Cells
- Distribution / Leach Line
- Stacking
- ODF

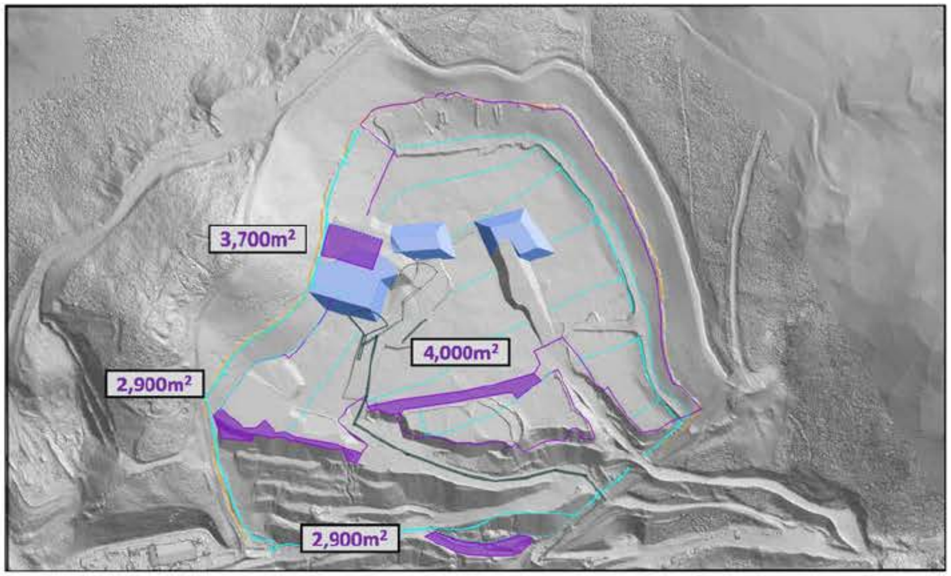
Previous Week HLF Production		19-Oct (Tue)	20-Oct (Wed)	21-Oct (Thu)	22-Oct (Fri)	23-Oct (Sat)	24-Oct (Sun)	25-Oct (Mon)	Daily Avg	Total	Week Plan Forecast	Variance
Actuals												
CV17 Belt Scale	(t)	27,363	21,437	29,746	27,268	14,432	22,979	22,933	23,737	166,158	175,371	95%
ROM	(t)	9,220	10,556	16,422	16,264	16,543	15,037	13,924	13,995	97,965	61,229	160%
Leach Area Added	(m^{2})	-	-	-	2,385	4,673	2,696	4,974	2,104	14,728	19,600	75%
Leach Area Removed	(m^2)	-	-	4,150	-	-	-	-	593	4,150	-	

TSX : VGCX OTC: VITFF VGCX.com

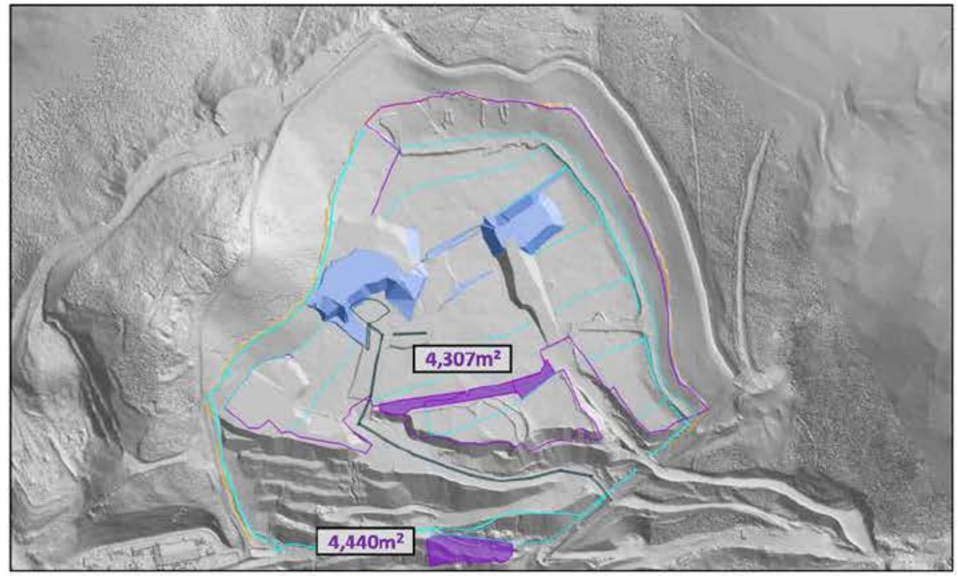
HLF Ore Stacking Plan 2021-10-26 to 2021-11-01

HLF – Past Week – October 26th to November 1st

Plan



Actual



Legend

- Leach Cells
- Distribution / Leach Line
- Stacking
- ODF

Previous Week HLF Production		26-Oct (Tue)	27-Oct (Wed)	28-Oct (Thu)	29-Oct (Fri)	30-Oct (Sat)	31-Oct (Sun)	01-Nov (Mon)	Daily Avg	Total	Forecast	Variance
Actuals												
CV22 + Bypass	(t)	29,338	12,434	25,292	11,075	24,088	30,589	24,320	22,448	157,136	198,000	-21%
ROM + Nuway	(t)	14,616	22,402	19,222	21,026	22,095	5,719	8,462	16,220	113,542	62,321	82%
Leach Area Added	(m^2)	1,549	-	-		4,440	1,351	1,407	1,250	8,747	11,500	-24%
Leach Area Removed	(m^2)	-	-	-	-	-	-	-	-	-	-	

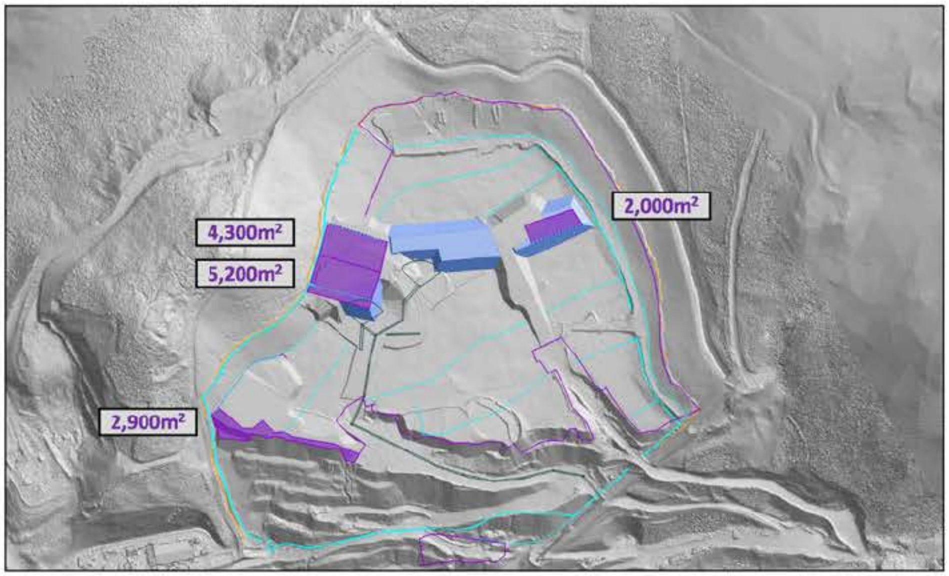
TSX : VGCX OTC: VITFF VGCX.com

HLF Ore Stacking Plan 2021-11-02 to 2021-11-08

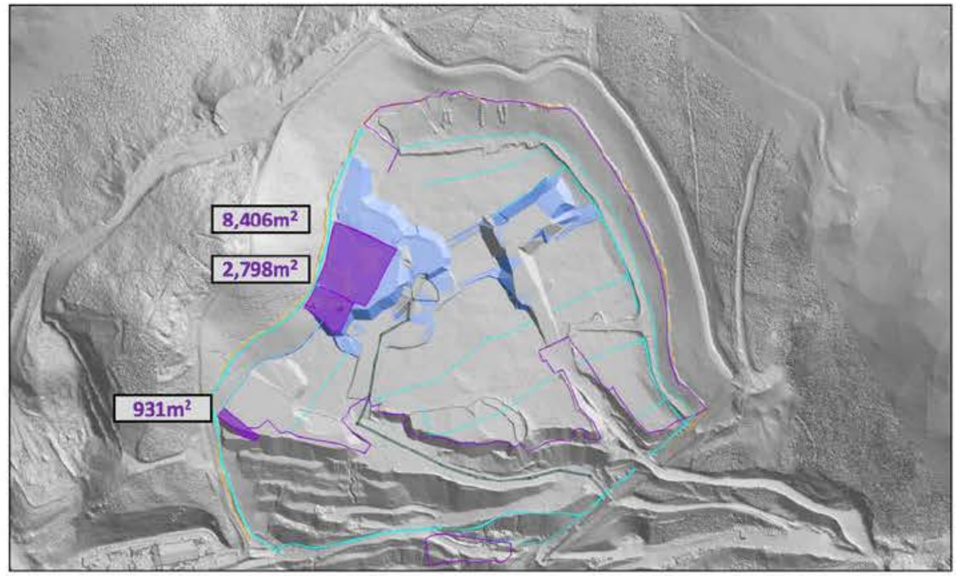
VICTORIA GOLD CORP

HLF – Past Week – November 2nd to November 8th

Plan



Actual



Legend

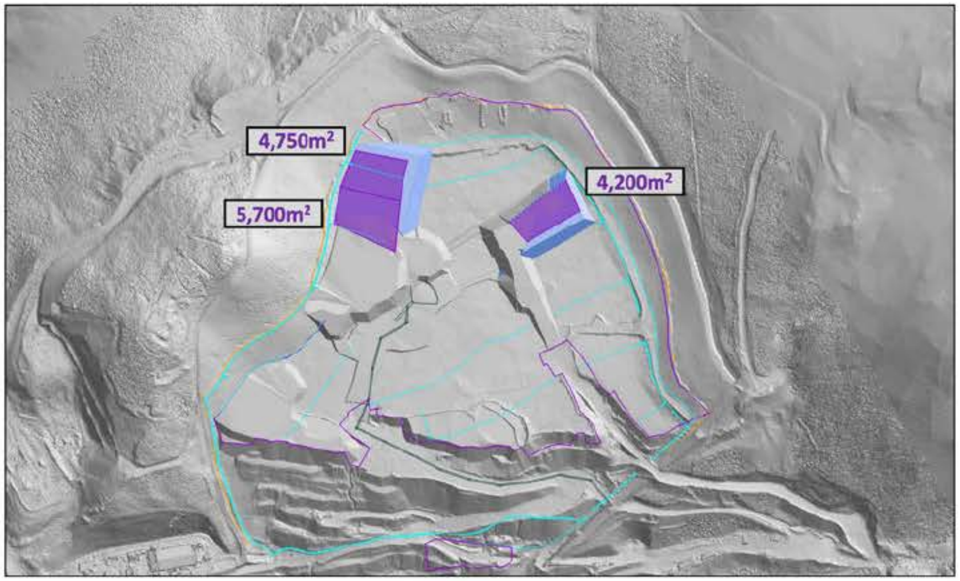
- Leach Cells
- Distribution / Leach Line
- Stacking
- ODF

Previous Week HLF Production		02-Nov (Tue)	03-Nov (Wed)	04-Nov (Thu)	05-Nov (Fri)	06-Nov (Sat)	07-Nov (Sun)	08-Nov (Mon)	Daily Avg	Total	Forecast	Variance
Actuals												
CV22 + Bypass	(t)	30,198	29,209	7,456	34,118	27,549	25,222	15,943	24,242	169,696	196,000	-13%
ROM + Nuway	(t)	7,435	12,895	12,311	5,604	4,260	3,820	8,710	7,862	55,034	62,321	-12%
Leach Area Added	(m^2)		8,406	2,798				931	1,734	12,135	14,400	-16%
Leach Area Removed	(m^2)								-	-	-	-

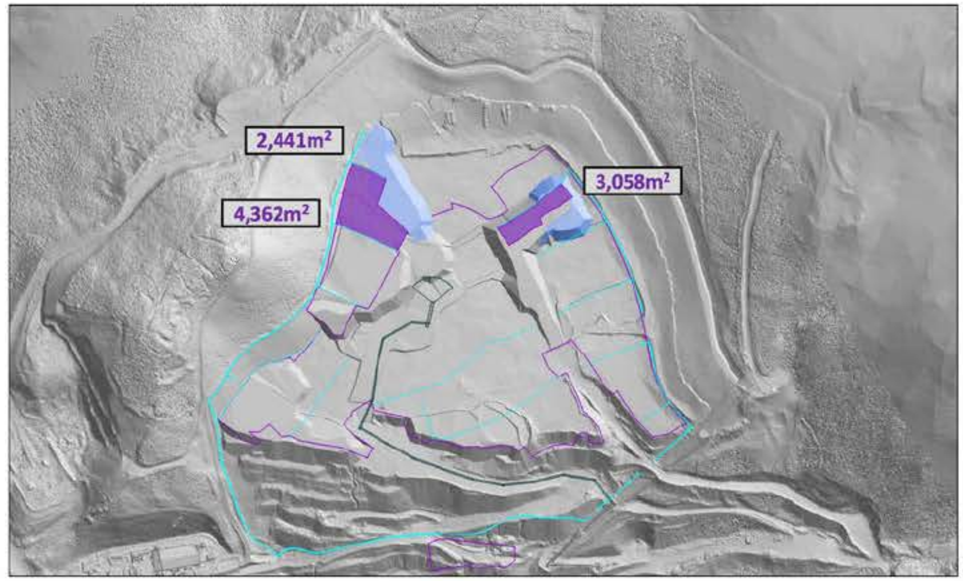
HLF Ore Stacking Plan 2021-11-09 to 2021-11-15

HLF – Past Week – November 9th to November 15th

Plan



Actual



Legend

- Leach Cells
- Distribution / Leach Line
- Stacking
- ODF

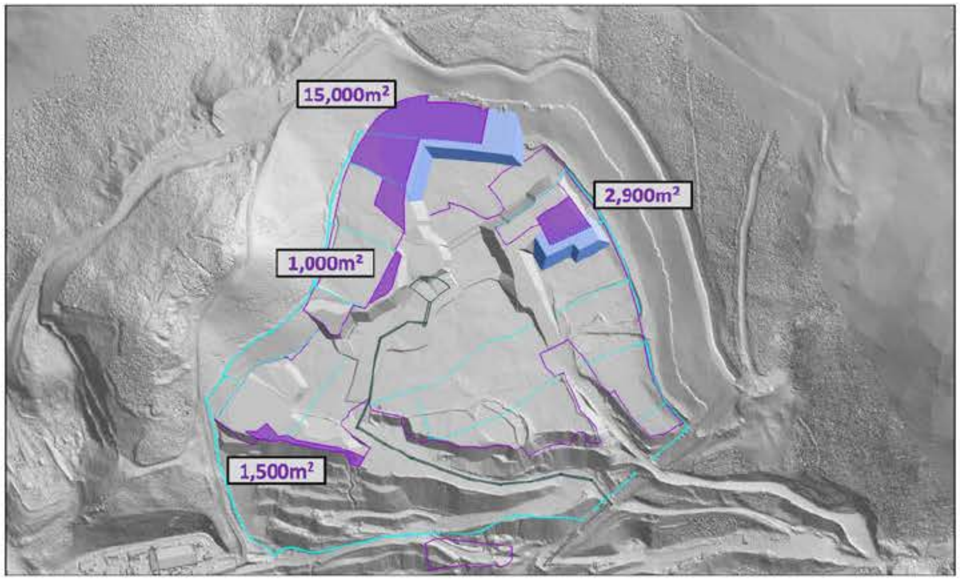
Previous Week HLF Production		09-Nov (Tue)	10-Nov (Wed)	11-Nov (Thu)	12-Nov (Fri)	13-Nov (Sat)	14-Nov (Sun)	15-Nov (Mon)	Daily Avg	Total	Forecast	Variance
Actuals												
CV22 + Bypass	(t)	30,999	26,519	31,842	27,453	6,255	18,221	11,170	21,780	152,459	196,000	-22%
ROM + Nuway	(t)	13,398	376	2,307	1,923	8,515	15,129	7,845	7,070	49,493	62,321	-21%
Leach Area Added	(m^2)		2,196	2,166	3,058		2,441		1,409	9,861	14,400	-32%
Leach Area Removed	(m^2)						17,803		2,543	17,803	-	-

TSX : VGCX OTC: VITFF VGCX.com

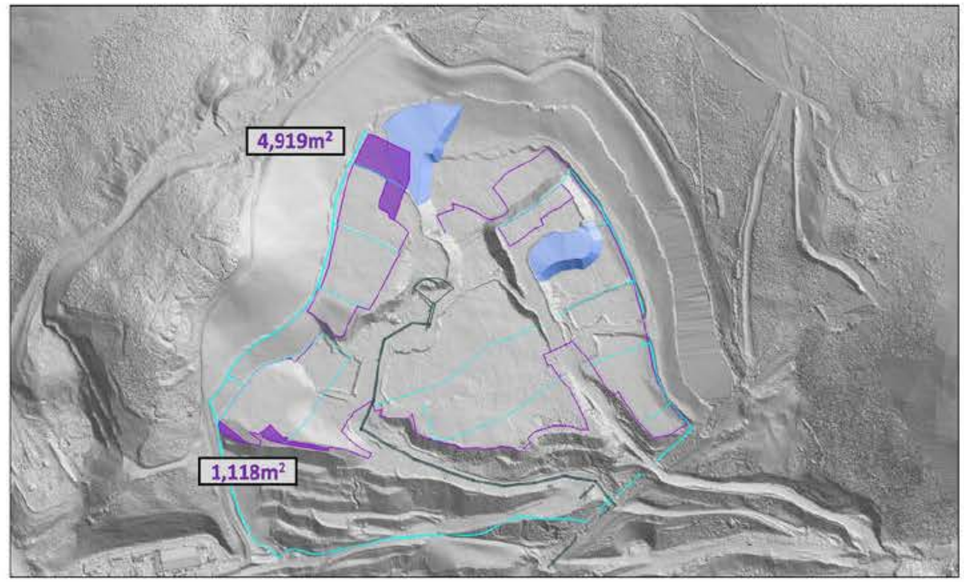
HLF Ore Stacking Plan 2021-11-16 to 2021-11-22

HLF – Past Week – November 9th to November 15th

Plan



Actual



Legend

- Leach Cells
- Distribution / Leach Line
- Stacking
- ODF

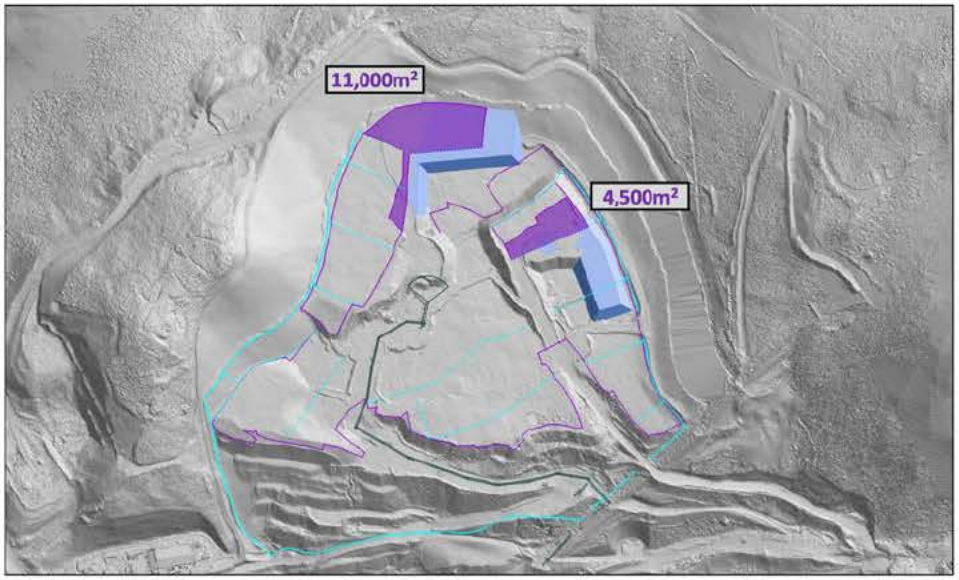
Previous Week HLF Production		16-Nov (Tue)	17-Nov (Wed)	18-Nov (Thu)	19-Nov (Fri)	20-Nov (Sat)	21-Nov (Sun)	22-Nov (Mon)	Daily Avg	Total	Forecast	Variance
Actuals												
CV22 + Bypass	(t)	12,745	8,286	5,286	11,917	14,205	19,830	25,309	13,940	97,578	196,000	-50%
Direct Haul	(t)	14,650	19,210	16,278	13,148	6,295	3,778	9,442	11,829	82,801	62,321	33%
Leach Area Added	(m^2)			1,118			4,919		862	6,037	20,400	-70%
Leach Area Removed	(m^2)			11,654		24,393			5,150	36,047	-	-

TSX : VGCX OTC: VITFF VGCX.com

HLF Ore Stacking Plan 2021-11-23 to 2021-11-29

VICTORIA GOLD CORP

HLF – Past Week Comparison– *November 23rd to November 29th



*Plan

Stacking

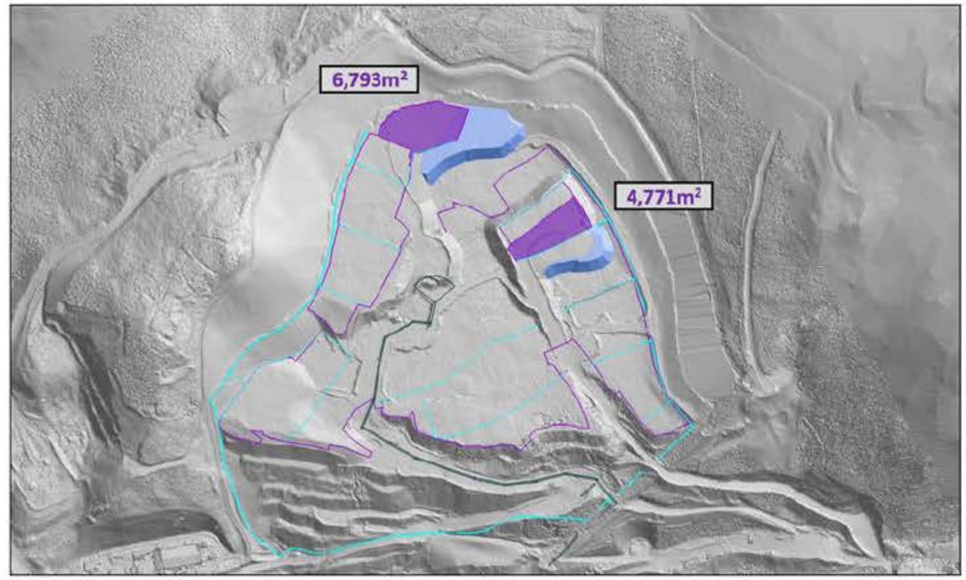
1. 1029 = 196,000t
2. ROM = 62,231t
3. -

Leaching

1. Add = 15,500m²
2. Remove = 0m²
3. Total = 170,071m²

Infrastructure

1. 8" W5 Line Extended
2. 8" W6 Line Extended
3. 8" E4 Line Extended



Nov 23 - 28 Actual

Stacking

1. 1029 = 139,689t
2. ROM = 26,701t
3. -

Leaching

1. Added = 13,916m²
2. Removed = 0m²
3. Total = 168,406m²

Infrastructure

1. 8" W5 Line Extended
2. W6 Header Frozen
3. 8" E4 Line Extended

Legend

Leach Cells | Distribution / Leach Line
Stacking | ODF

HLF Ore Stacking Plan 2021-11-30 to 2021-12-06

HLF – Past Week Comparison– November 30th to December 6th

Plan

Actual

Legend
- Leach Cells
- Distribution / Leach Line
- Stacking
- ODF

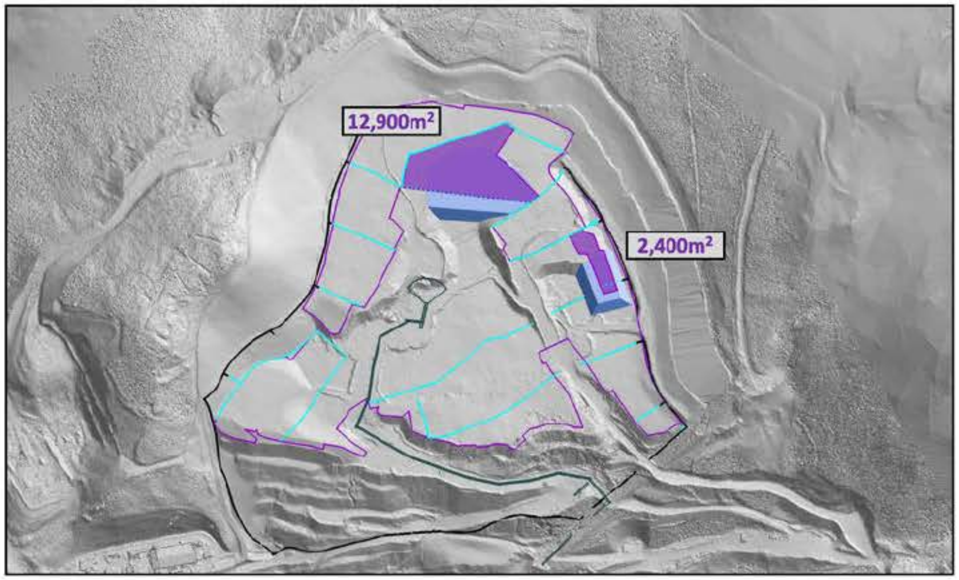
Previous Week HLF Production		30-Nov (Tue)	01-Dec (Wed)	02-Dec (Thu)	03-Dec (Fri)	04-Dec (Sat)	05-Dec (Sun)	06-Dec (Mon)	Daily Avg	Total	Week Target	Variance
Actuals												
CV22 + Bypass	(t)	26,079	25,245	28,893	20,707	14,126	7,441	17,359	19,978	139,849	196,000	-29%
Direct Haul	(t)	-	3,256	76	-	114	674	-	589	4,120	62,321	-93%
Leach Area Added	(m^2)	-	2,058	-	-	924	1,943	2,687	1,087	7,612	13,750	-45%
Leach Area Removed	(m^2)	18,523	-	-	-	-	-	-	2,646	18,523	-	-

TSX : VGCX OTC: VITFF VGCX.com

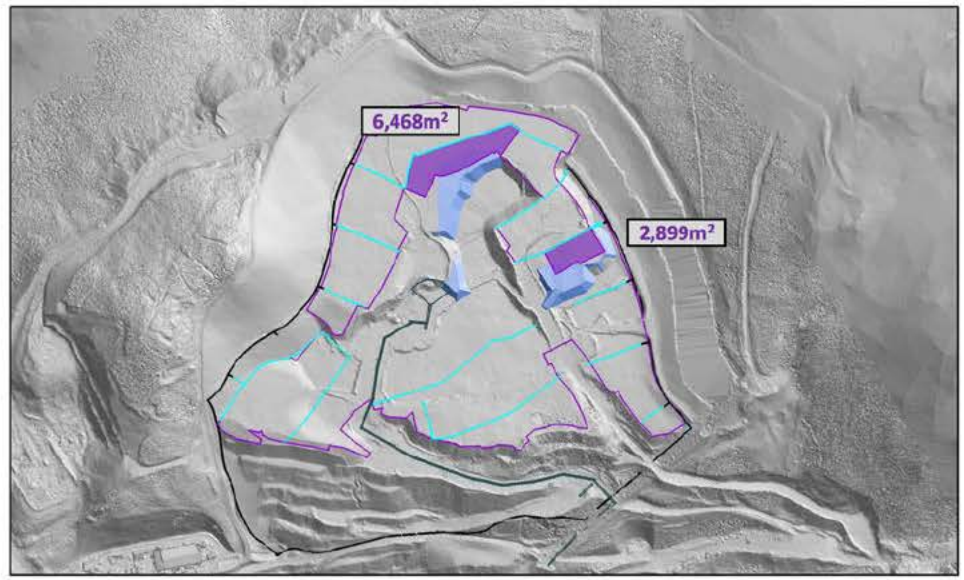
HLF Ore Stacking Plan 2021-12-07 to 2021-12-13

HLF – Past Week Comparison– December 7th to December 13th

Plan



Actual



Legend

- Leach Cells
- Distribution / Leach Line
- Stacking
- ODF

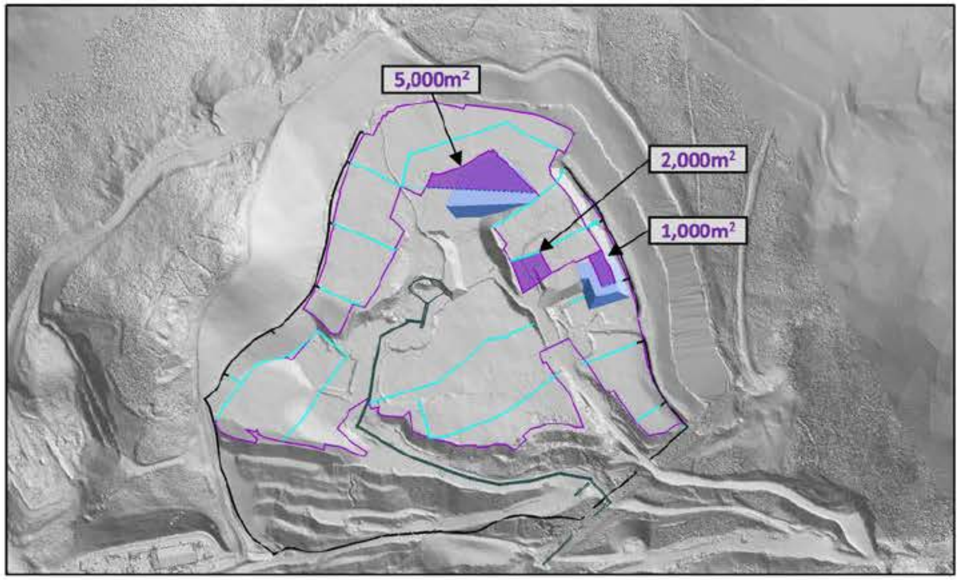
Previous Week HLF Production		07-Dec (Tue)	08-Dec (Wed)	09-Dec (Thu)	10-Dec (Fri)	11-Dec (Sat)	12-Dec (Sun)	13-Dec (Mon)	Daily Avg	Total	Week Target	Variance
Actuals												
CV22 + Bypass	(t)	16,319	15,369	1,611	10,092	9,735	23,319	18,341	13,541	94,787	196,000	-52%
Direct Haul	(t)	511	18,890	8,807	5,744	13,912	7,403	8,296	9,080	63,563	62,321	2%
Leach Area Added	(m^2)	1,736	1,632	-	-	2,833	1,270	1,896	1,338	9,367	15,800	-41%
Leach Area Removed	(m^2)	-	-	-	8,081	-	-	-	1,154	8,081	-	-

HLF Ore Stacking Plan 2021-12-14 to 2021-12-20

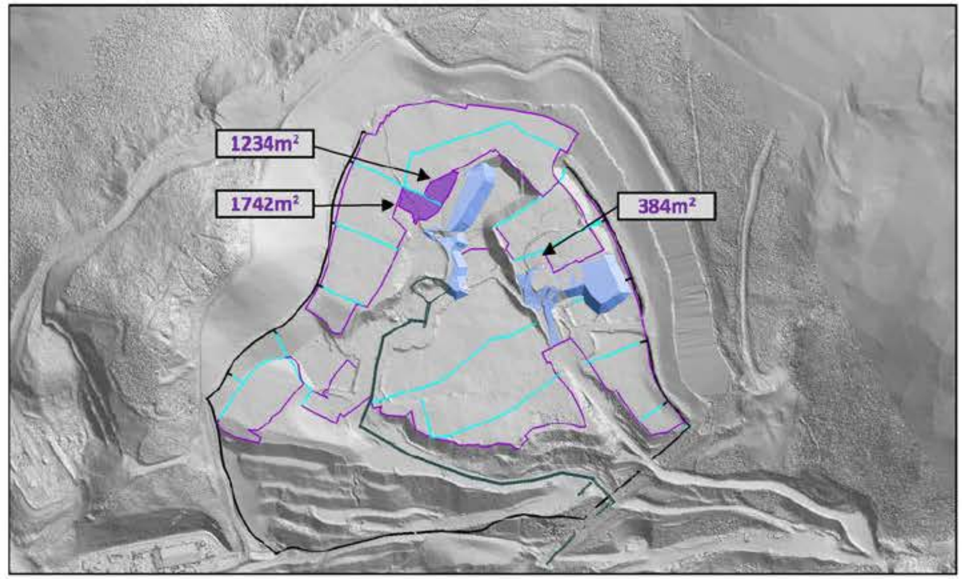
VICTORIA GOLD CORP

HLF – Past Week Comparison– December 14th to December 20th

Plan



Actual



Legend

- Leach Cells
- Distribution / Leach Line
- Stacking
- ODF

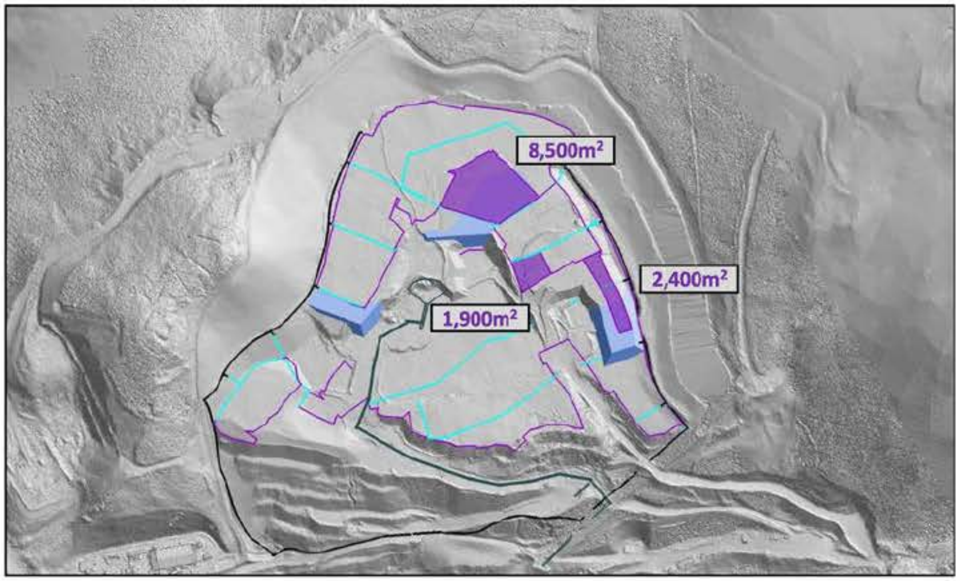
Previous Week HLF Production		14-Dec (Tue)	15-Dec (Wed)	16-Dec (Thu)	17-Dec (Fri)	18-Dec (Sat)	19-Dec (Sun)	20-Dec (Mon)	Daily Avg	Total	Week Target	Variance
Actuals												
CV22 + Bypass	(t)	14,928	13,761	-	6,432	14,394	2,261	22,261	10,577	74,036	126,000	-41%
Direct Haul	(t)	7,786	3,574	18,635	24,123	6,892	18,635	13,019	13,238	92,664	56,000	65%
Leach Area Added	(m^2)				1,234	1,742		384	480	3,360	8,000	-58%
Leach Area Removed	(m^2)	-	-	-		-	-	-	-	-	-	-

TSX : VGCX OTC: VITFF VGCX.com

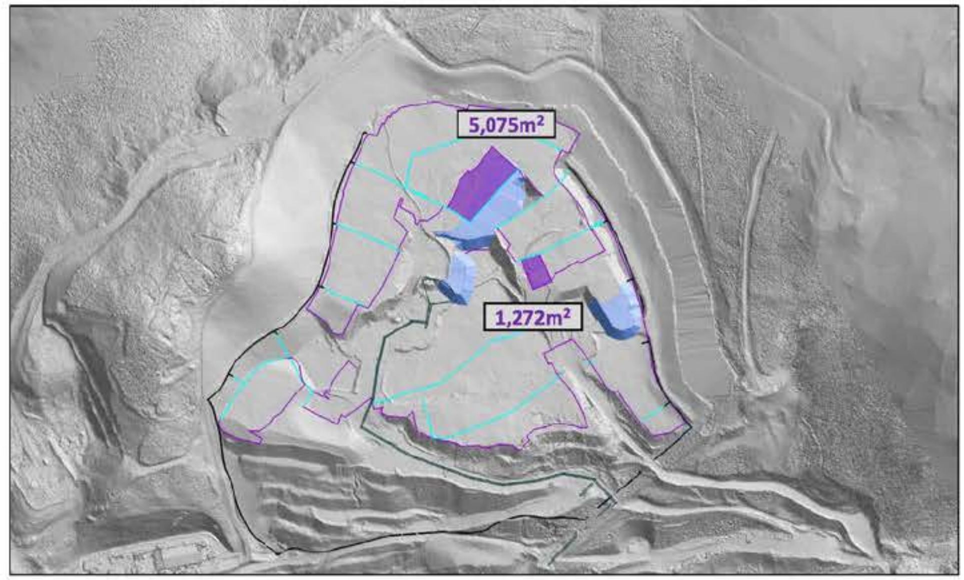
HLF Ore Stacking Plan 2021-12-21 to 2021-12-27

HLF – Past Week Comparison– December 14th to December 20th

Plan



Actual



Legend

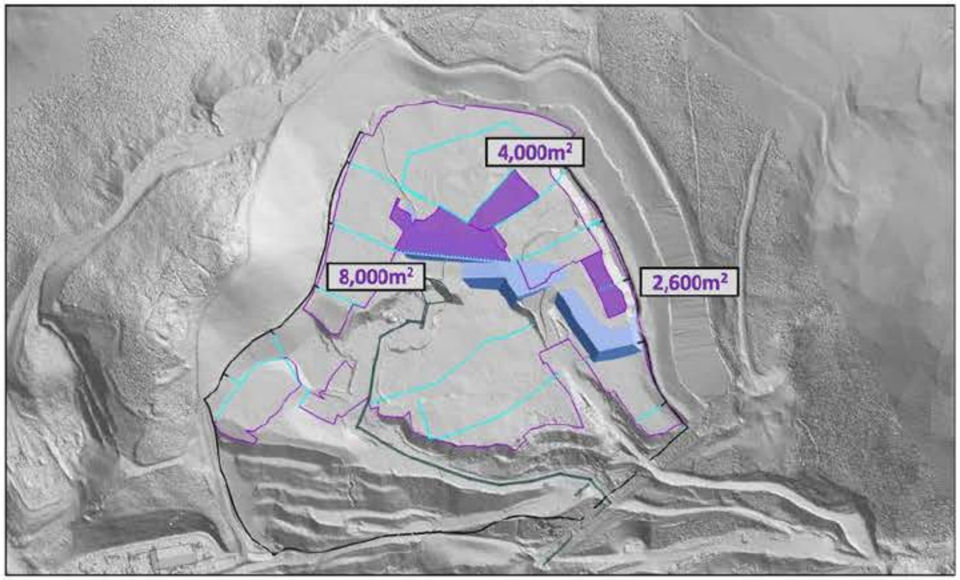
- Leach Cells
- Distribution / Leach Line
- Stacking
- ODF

Previous Week HLF Production		21-Dec (Tue)	22-Dec (Wed)	23-Dec (Thu)	24-Dec (Fri)	25-Dec (Sat)	26-Dec (Sun)	27-Dec (Mon)	Daily Avg	Total	Week Target	Variance
Actuals												
CV22 + Bypass	(t)	15,830	13,627	15,165	12,915	14,101	11,797	2,863	12,328	86,298	126,000	-32%
Direct Haul	(t)	10,083	7,913	7,275	4,595	4,467	1,532	2,936	5,543	38,801	84,000	-54%
Leach Area Added	(m^2)	1,272			5,075				907	6,347	12,800	-50%
Leach Area Removed	(m^2)	-	-	-	-	-	-	-	-	-	-	-

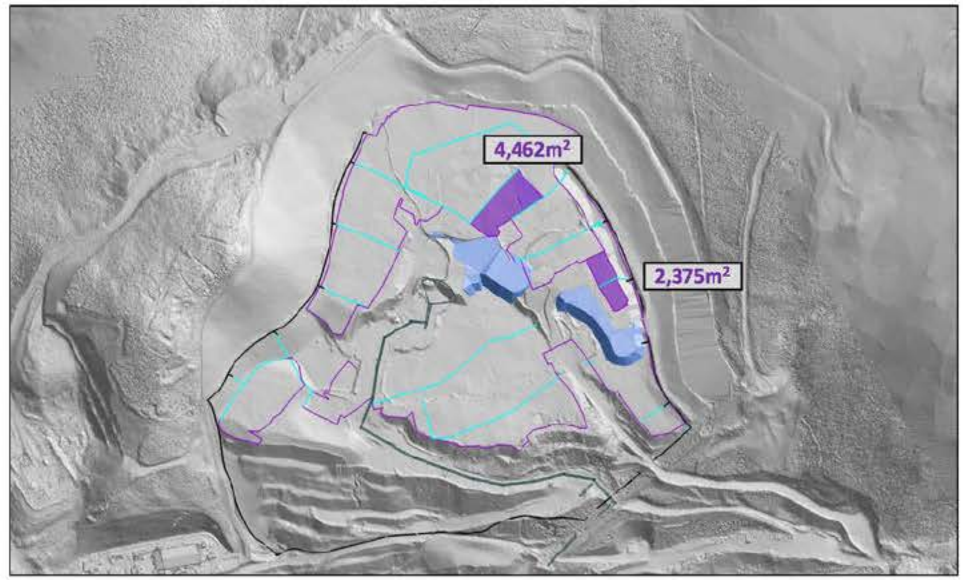
HLF Ore Stacking Plan 2021-12-28 to 2022-01-03

HLF – Past Week Comparison– December 28th to January 03rd

Plan



Actual



Legend

- Leach Cells
- Distribution / Leach Line
- Stacking
- ODF

Previous Week HLF Production		28-Dec (Tue)	29-Dec (Wed)	30-Dec (Thu)	31-Dec (Fri)	01-Jan (Sat)	02-Jan (Sun)	03-Jan (Mon)	Daily Avg	Total	Week Target	Variance
Actuals												
CV22 + Bypass	(t)	2,768	1,272	15,034	20,986	7,279	12,394	15,442	10,739	75,175	126,000	-40%
Direct Haul	(t)	6,509	7,148	18,380	14,295	13,274	15,189	1,915	10,959	76,710	84,000	-9%
Leach Area Added	(m²)	1,237		4,462		1,138			977	6,837	12,800	-47%
Leach Area Removed	(m²)	-	-	-	-	-	-	-	-	-	-	-

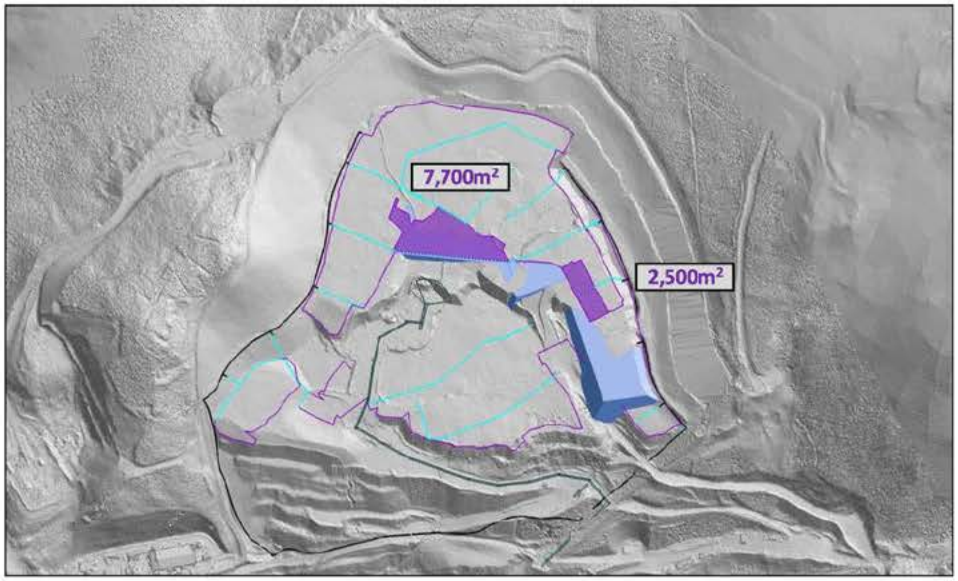
TSX : VGCX OTC: VITFF VGCX.com

HLF Ore Stacking Plan 2022-01-04 to 2022-01-10

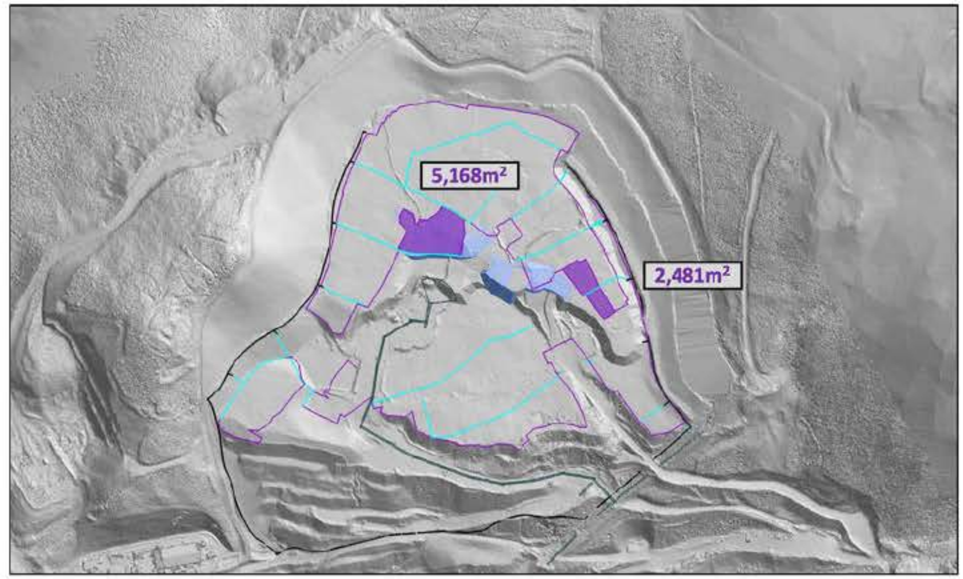
VICTORIA GOLD CORP

HLF – Past Week Comparison– January 4th to January 10th

Plan



Actual



Legend

- Leach Cells
- Distribution / Leach Line
- Stacking
- ODF

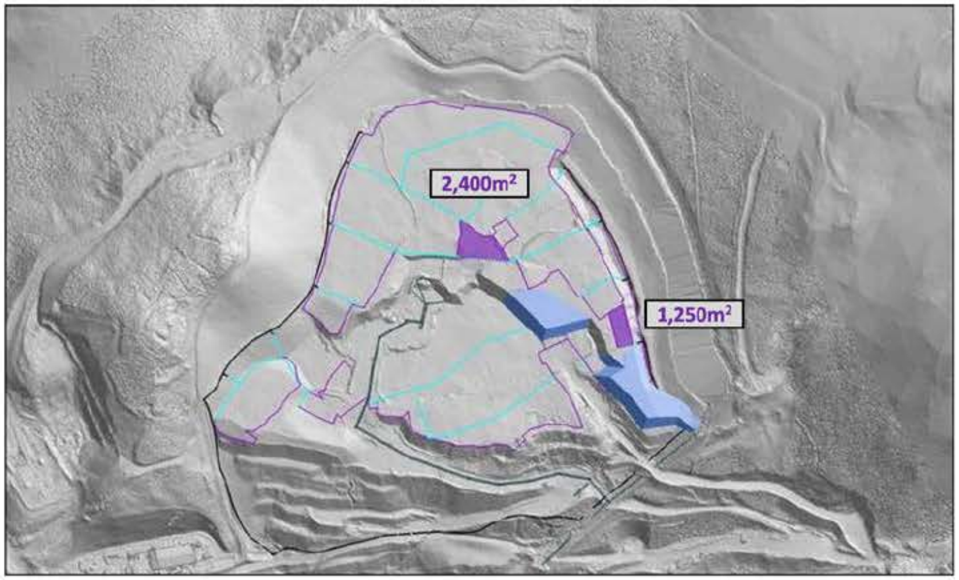
Previous Week HLF Production		04-Jan (Tue)	05-Jan (Wed)	06-Jan (Thu)	07-Jan (Fri)	08-Jan (Sat)	09-Jan (Sun)	10-Jan (Mon)	Daily Avg	Total	Week Target	Variance
Actuals												
CV22 + Bypass	(t)	-	-	6,215	11,977	4,336	9,297	10,237	6,009	42,062	151,242	-72%
Direct Haul	(t)								-	-	-	-
Leach Area Added	(m^2)	2,481					5,168		1,093	7,649	10,200	-25%
Leach Area Removed	(m^2)	-	-	-	-	-	-	-	-	-	-	-

TSX : VGCX OTC: VITFF VGCX.com

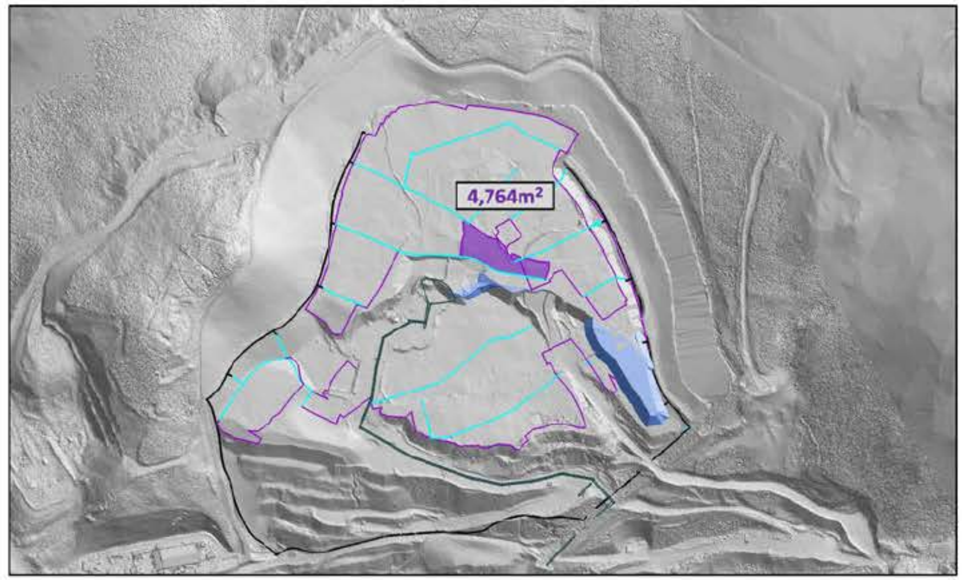
HLF Ore Stacking Plan 2022-01-11 to 2022-01-17

HLF – Past Week Comparison– January 11th to January 17th

Plan



Actual



Legend

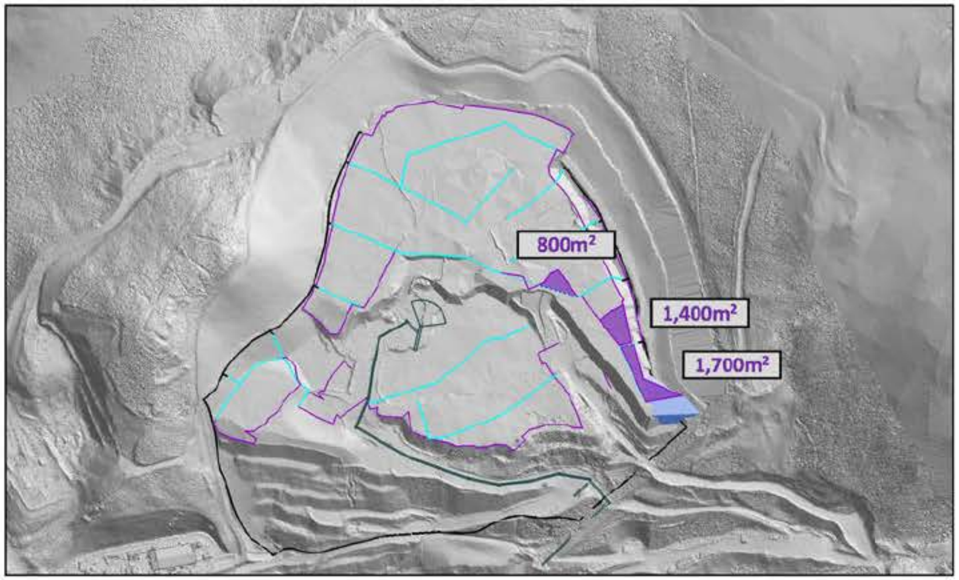
- Leach Cells
- Distribution / Leach Line
- Stacking
- ODF

Previous Week HLF Production		11-Jan (Tue)	12-Jan (Wed)	13-Jan (Thu)	14-Jan (Fri)	15-Jan (Sat)	16-Jan (Sun)	17-Jan (Mon)	Daily Avg	Total	Week Target	Variance
Actuals												
CV22 + Bypass	(t)	-	8,991	12,831	27,436	25,520	30,814	19,897	17,927	125,489	175,322	-28%
Direct Haul	(t)	-	-	74	-	-	-	-	11	74	-	-
Leach Area Added	(m^2)			2,268		2,223			642	4,491	3,650	23%
Leach Area Removed	(m^2)	-	-	-	4,513	-	-	-	645	4,513	-	-

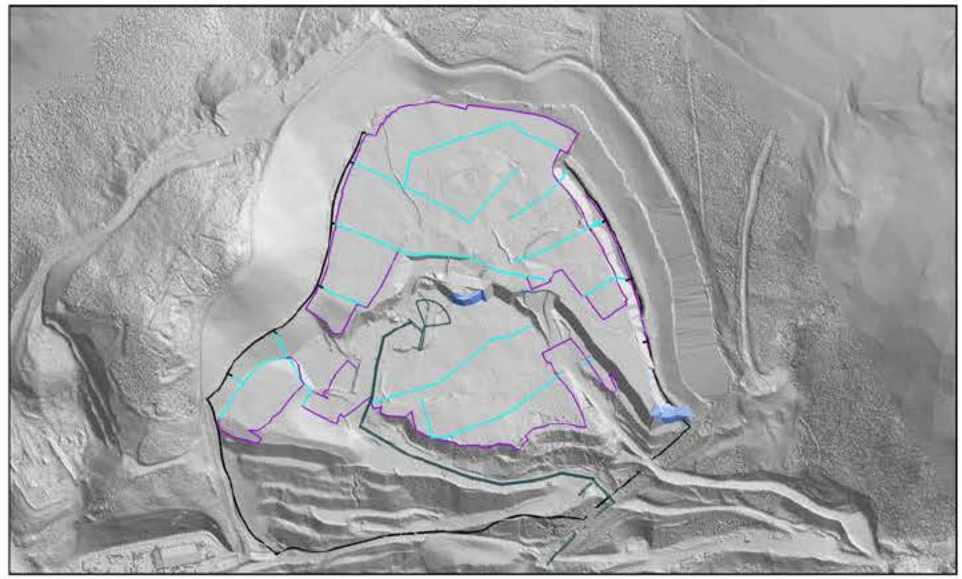
HLF Ore Stacking Plan 2022-01-18 to 2022-01-24

HLF – Past Week Comparison– January 18th to January 25th

Plan



Actual



Legend

- Leach Cells
- Distribution / Leach Line
- Stacking
- ODF

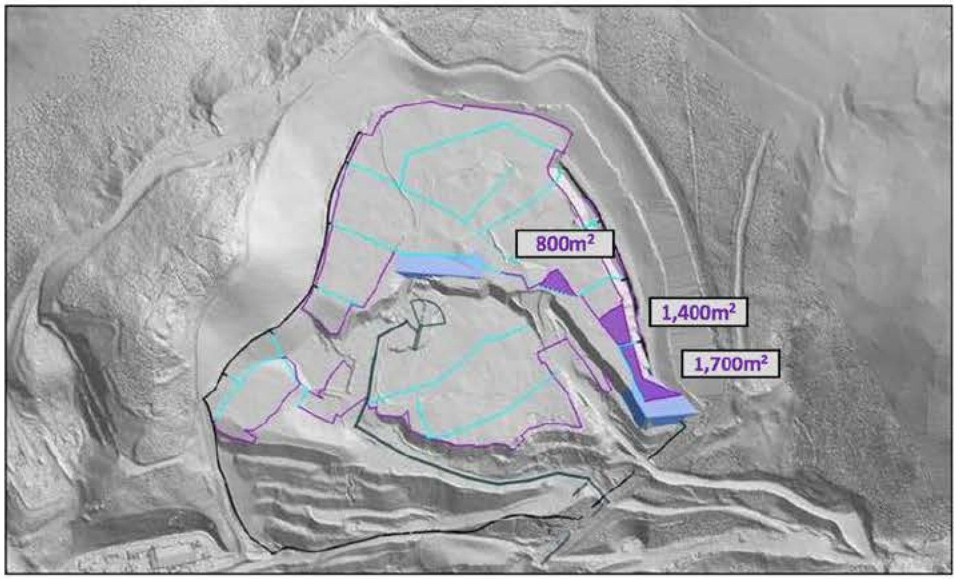
Previous Week HLF Production		18-Jan (Tue)	19-Jan (Wed)	20-Jan (Thu)	21-Jan (Fri)	22-Jan (Sat)	23-Jan (Sun)	24-Jan (Mon)	Daily Avg	Total	Week Target	Variance
Actuals												
CV22 + Bypass	(t)	2,935	-	-	477	-	-	-	487	3,412	-	100%
Direct Haul	(t)	521	781	1,228	707	930	-	-	595	4,167	21,000	-80%
Leach Area Added	(m^2)	-	-	-	-	-	-	-	-	-	3,900	-100%
Leach Area Removed	(m^2)	-	-	-	-	-	-	-	-	-	-	-

TSX : VGCX OTC: VITFF VGCX.com

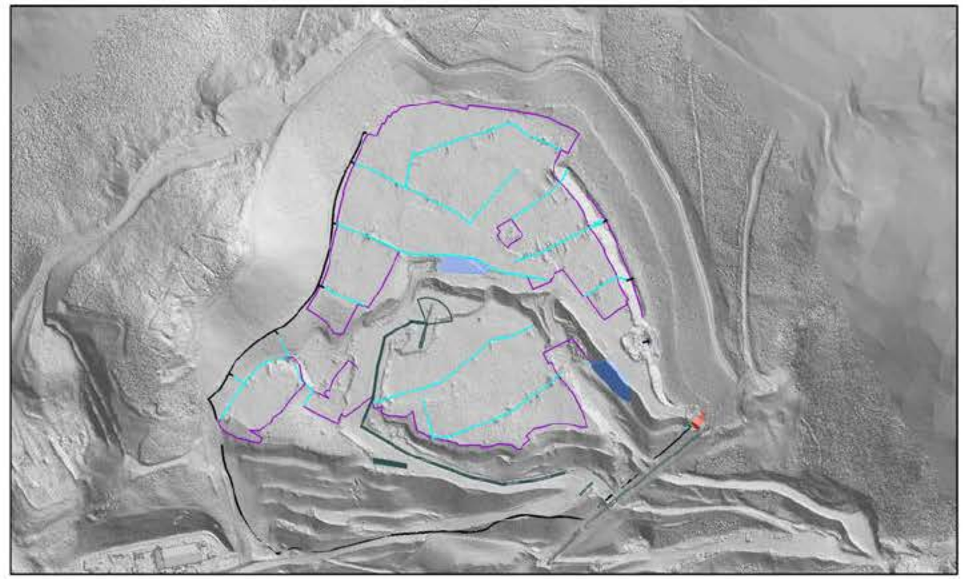
HLF Ore Stacking Plan 2022-01-25 to 2022-01-31

HLF – Past Week Comparison– January 18th to January 25th

Plan



Actual



Legend
- Leach Cells
- Distribution / Leach Line
- Stacking
- ODF

Previous Week HLF Production		25-Jan (Tue)	26-Jan (Wed)	27-Jan (Thu)	28-Jan (Fri)	29-Jan (Sat)	30-Jan (Sun)	31-Jan (Mon)	Daily Avg	Total	Week Target	Variance
Actuals												
CV22 + Bypass	(t)	-	-	-	-	-	-	-	-	-	-	100%
Direct Haul	(t)	1,004	-	-	-	1,897	3,050	3,943	1,413	9,894	21,000	-53%
Leach Area Added	(m^2)	-	-	-	-	-	-	-	-	-	3,900	-100%
Leach Area Removed	(m^2)	-	-	-	-	-	-	-	-	-	-	-

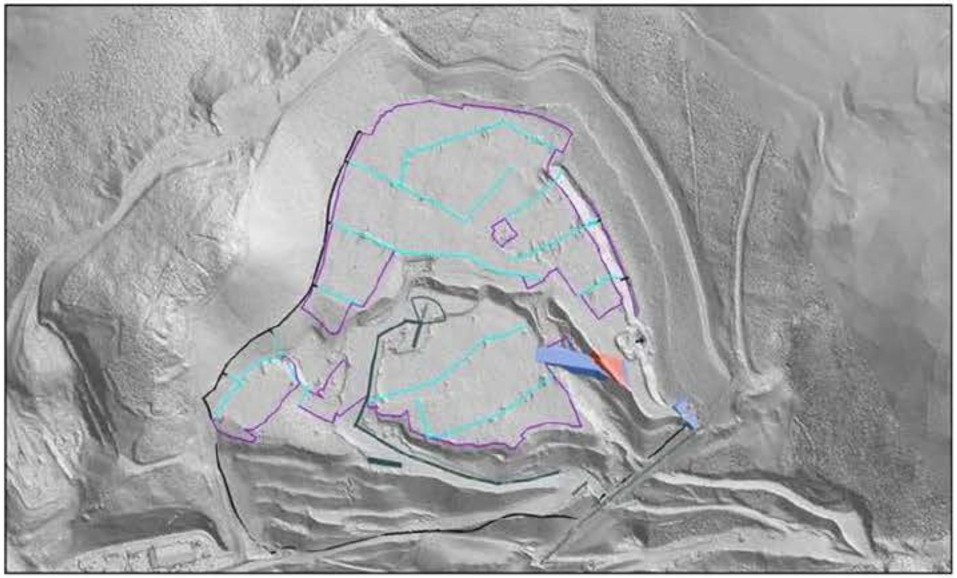
TSX : VGCX OTC: VITFF VGCX.com

VICTORIA GOLD CORP

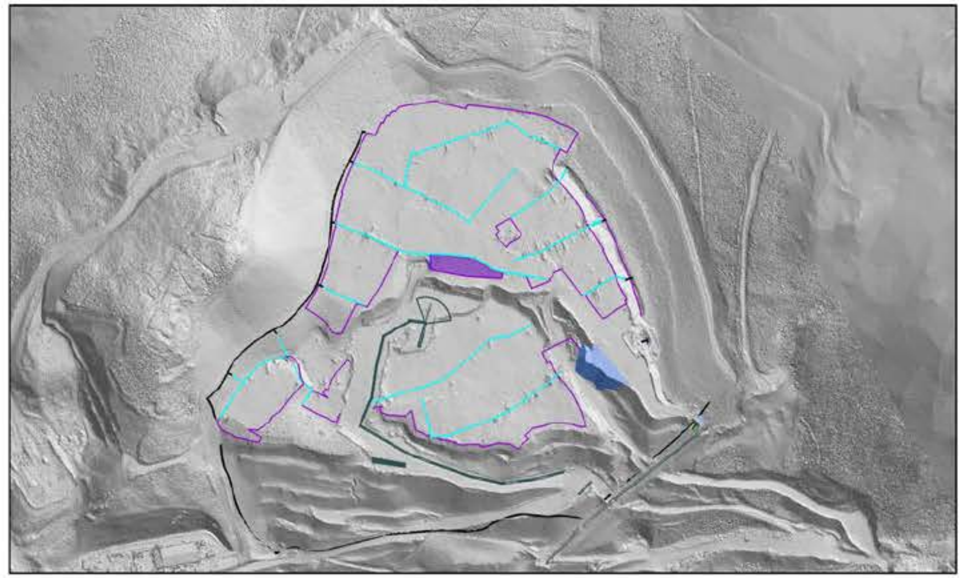
HLF Ore Stacking Plan 2022-02-01 to 2022-02-07

HLF – Past Week Comparison– February 1st to February 7th

Plan



Actual



Legend

- Leach Cells
- Distribution / Leach Line
- Stacking
- ODF

Previous Week HLF Production		01-Feb (Tue)	02-Feb (Wed)	03-Feb (Thu)	04-Feb (Fri)	05-Feb (Sat)	06-Feb (Sun)	07-Feb (Mon)	Daily Avg	Total	Week Target	Variance
Actuals												
CV22 + Bypass	(t)	-	-	-	-	-	-	-	-	-	-	100%
Direct Haul	(t)	2,678	3,869	3,943	4,910	3,720	1,488	-	2,944	20,608	14,000	47%
Leach Area Added	(m^{2})	-	-	-	-	-	-	2,450	350	2,450	-	-
Leach Area Removed	(m^2)	-	-	-	-	-	-	-	-	-	-	-

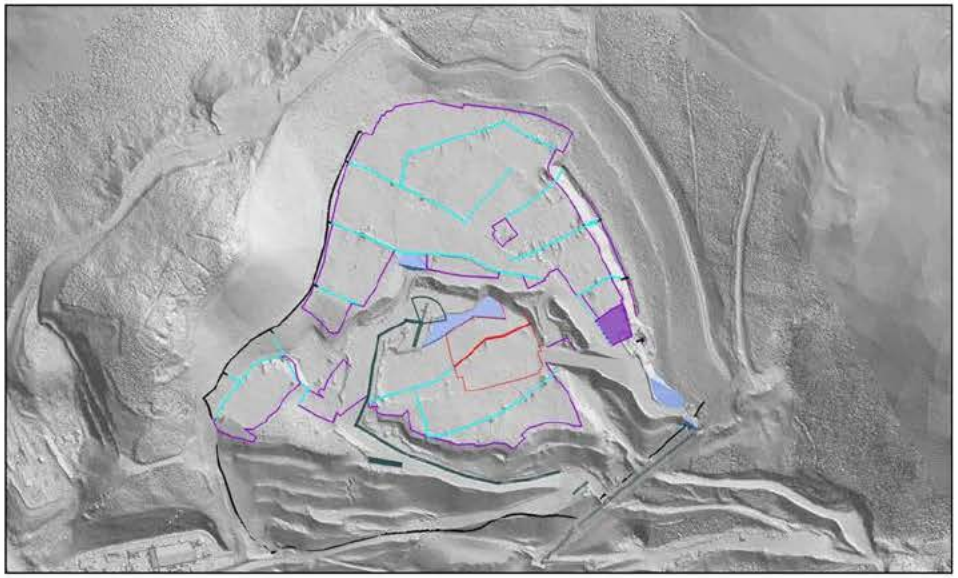
TSX : VGCX OTC: VITFF VGCX.com

VICTORIA GOLD CORP

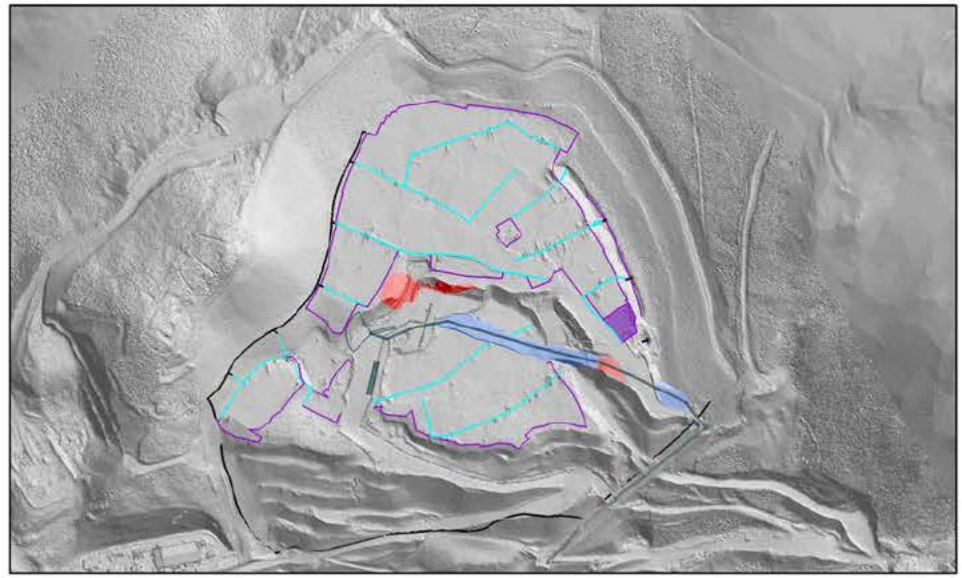
HLF Ore Stacking Plan 2022-02-08 to 2022-02-14

HLF – Past Week Comparison– February 8th to February 14th

Plan



Actual



Legend

- Leach Cells
- Distribution / Leach Line
- Stacking
- ODF

Previous Week HLF Production		15-Feb (Tue)	16-Feb (Wed)	17-Feb (Thu)	18-Feb (Fri)	19-Feb (Sat)	20-Feb (Sun)	21-Feb (Mon)	Daily Avg	Total	Week Target	Variance
Actuals												
CV22 + Bypass	(t)	-	-	-	-	-	-	-	-	-	12,000	-100%
Direct Haul	(t)	-	-	-	-	-	-	-	-	-	11,400	-100%
Leach Area Added	(m^2)		-	-	3,390	2,344	-	-	819	5,734	7,100	-19%
Leach Area Removed	(m^2)	141	815	3,275	2,879	1,646	5,221	-	1,997	13,977	12,605	-11%

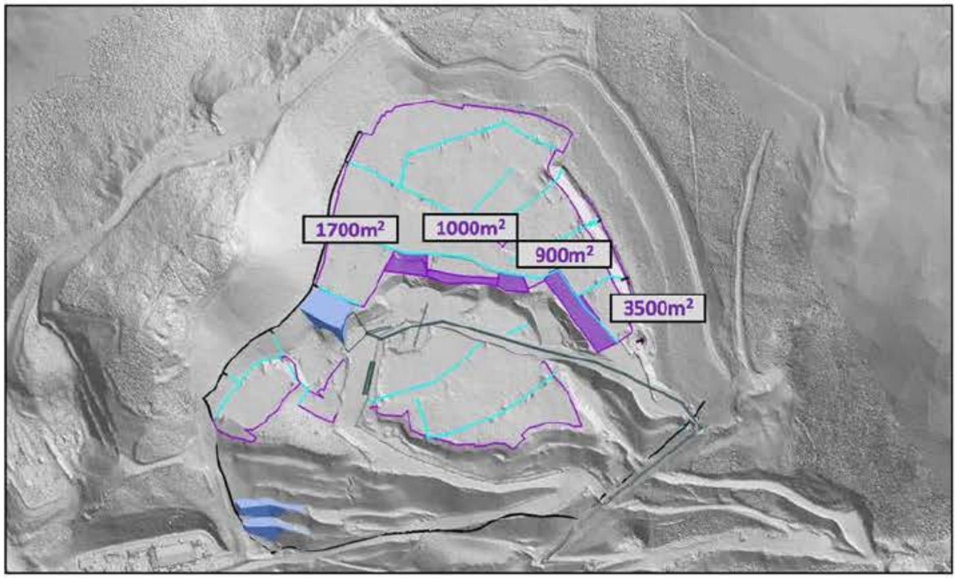
TSX : VGCX OTC: VITFF VGCX.com

VICTORIA GOLD CORP

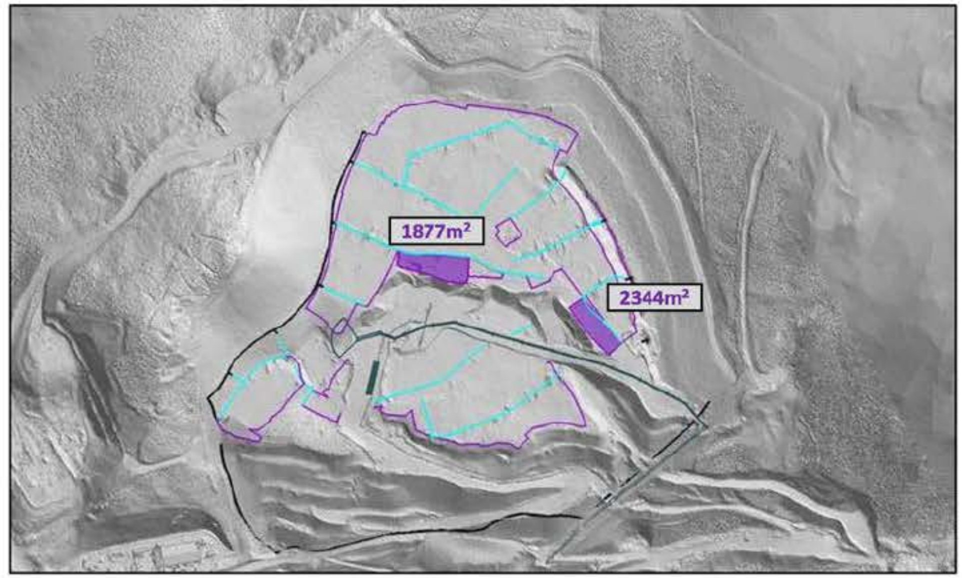
HLF Ore Stacking Plan 2022-02-15 to 2022-02-21

HLF – Past Week Comparison– February 15th to February 21st

Plan



Actual



Legend

- Leach Cells
- Distribution / Leach Line
- Stacking
- ODF

Previous Week HLF Production		15-Feb (Tue)	16-Feb (Wed)	17-Feb (Thu)	18-Feb (Fri)	19-Feb (Sat)	20-Feb (Sun)	21-Feb (Mon)	Daily Avg	Total	Week Target	Variance
Actuals												
CV22 + Bypass	(t)	-	-	-	-	-	-	-	-	-	12,000	-100%
Direct Haul	(t)	-	-	-	-	-	-	-	-	-	11,400	-100%
Leach Area Added	(m^2)		-	-	1,877	2,344	-	-	603	4,221	7,100	-41%
Leach Area Removed	(m^2)	141	815	3,275	2,879	1,646	5,221	-	1,997	13,977	-	-

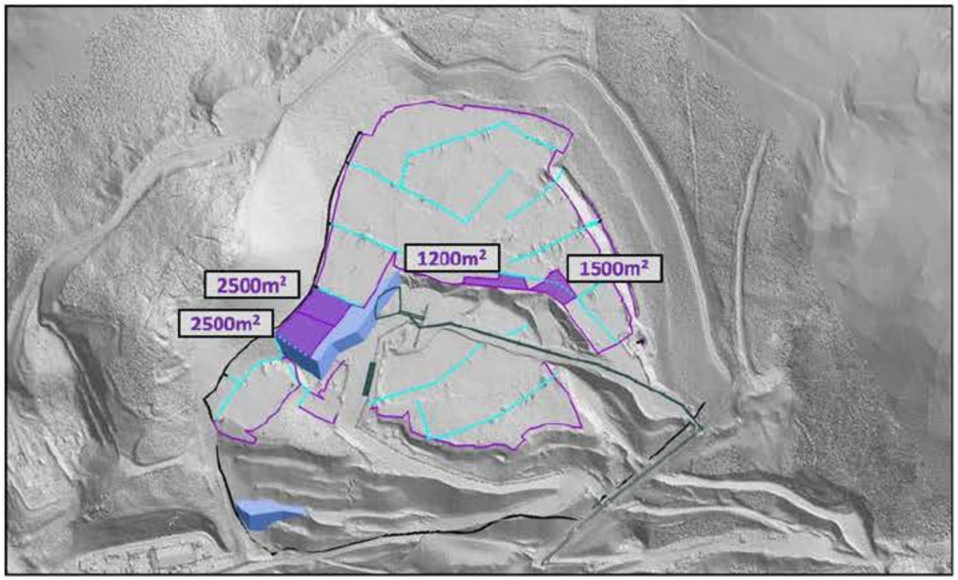
TSX : VGCX OTC: VITFF VGCX.com

VICTORIA GOLD CORP

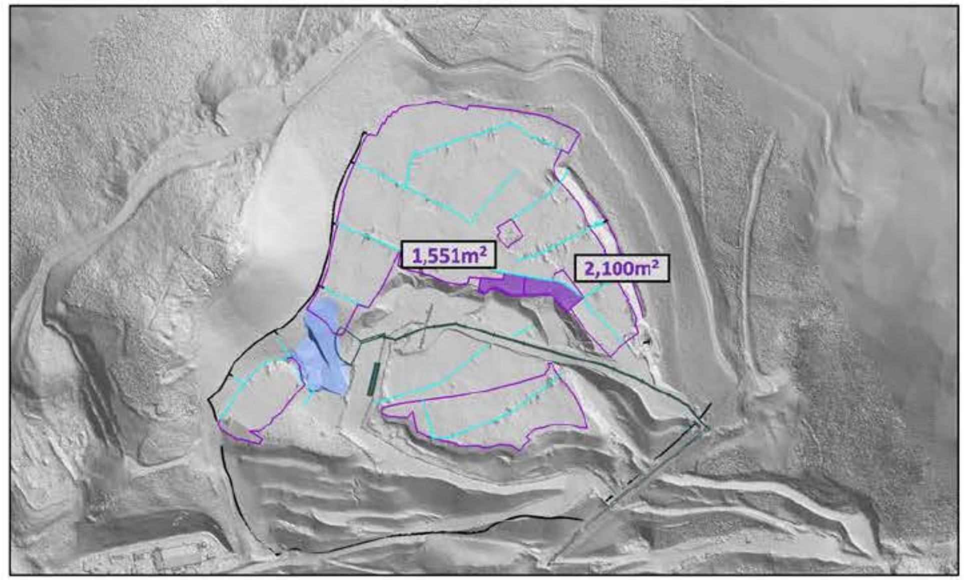
HLF Ore Stacking Plan 2022-02-22 to 2022-02-28

HLF – Past Week Comparison– February 22nd to February 28th

Plan



Actual



Legend

- Leach Cells
- Distribution / Leach Line
- Stacking
- ODF

Previous Week HLF Production		22-Feb (Tue)	23-Feb (Wed)	24-Feb (Thu)	25-Feb (Fri)	26-Feb (Sat)	27-Feb (Sun)	28-Feb (Mon)	Daily Avg	Total	Week Target	Variance
Actuals												
CV22 + Bypass	(t)	-	-	66	7,906	10,935	16,604	6,509	6,003	42,020	148,000	-72%
Direct Haul	(t)	-	-	-	-	1,004	3,348	595	707	4,947	-	-
Leach Area Added	(m^2)		2,100	1,551			-	-	522	3,651	7,700	-53%
Leach Area Removed	(m^2)								-	-	5,218	100%

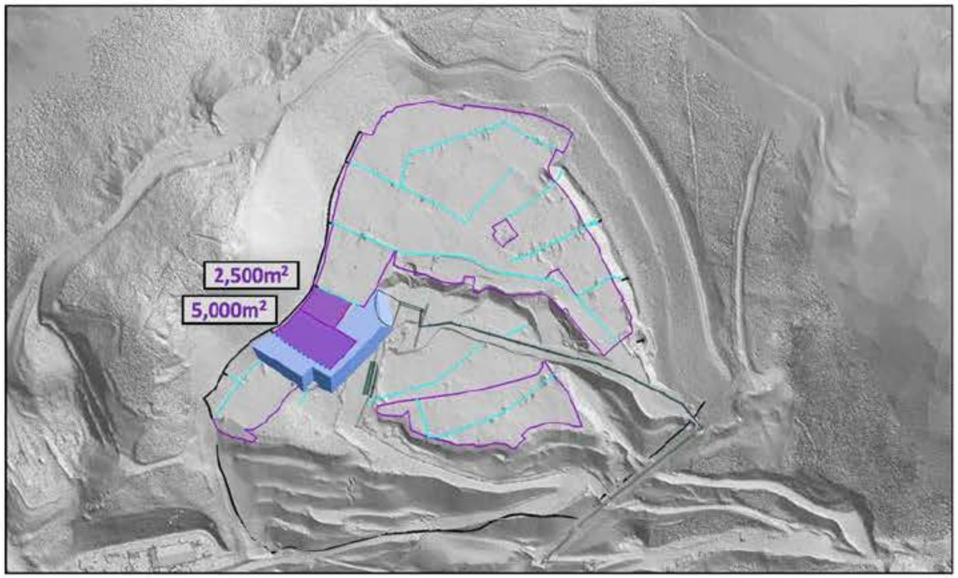
TSX : VGCX OTC: VITFF VGCX.com

VICTORIA GOLD CORP

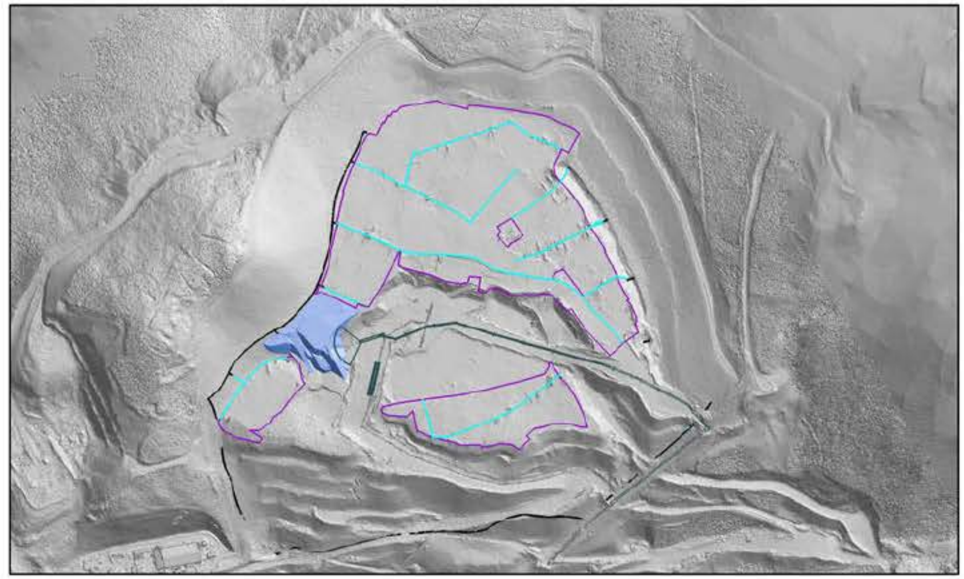
HLF Ore Stacking Plan 2022-03-01 to 2022-03-07

HLF – Past Week Comparison– March 01st to March 07th

Plan



Actual



Legend

- Leach Cells
- Distribution / Leach Line
- Stacking
- ODF

Previous Week HLF Production		01-Mar (Tue)	02-Mar (Wed)	03-Mar (Thu)	04-Mar (Fri)	05-Mar (Sat)	06-Mar (Sun)	07-Mar (Mon)	Daily Avg	Total	Week Target	Variance
Actuals												
CV22 + Bypass	(t)	4,053	7,145	11,151	12,354	21,353	19,797	15,070	12,989	90,923	256,494	-65%
Direct Haul	(t)	-	-	-	-	-	-	-	-	-	-	-
Leach Area Added	(m^{2})						-		-	-	7,500	-100%
Leach Area Removed	(m^2)						5,360		766	5,360	5,360	0%

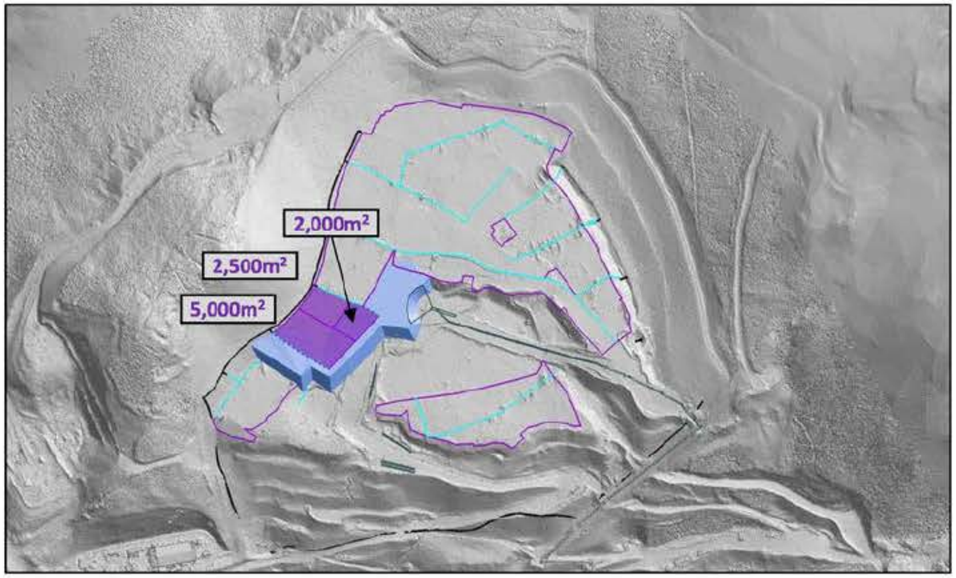
TSX : VGCX OTC: VITFF VGCX.com

VICTORIA GOLD CORP

HLF Ore Stacking Plan 2022-03-08 to 2022-03-14

HLF – Past Week Comparison– March 8th to March 14th

Plan



Actual

Legend

- Leach Cells
- Distribution / Leach Line
- Stacking
- ODF

Previous Week HLF Production		08-Mar (Tue)	09-Mar (Wed)	10-Mar (Thu)	11-Mar (Fri)	12-Mar (Sat)	13-Mar (Sun)	14-Mar (Mon)	Daily Avg	Total	Week Target	Variance
Actuals												
CV22 + Bypass	(t)	26,466	25,719	15,614	13,338	17,134	9,957	23,201	18,775	131,428	256,494	-49%
Direct Haul	(t)	-	-	-	-	-	-	-	-	-	-	-
Leach Area Added	(m²)	3,253			2,851		1,217		1,046	7,321	9,500	-23%
Leach Area Removed	(m²)								-	-		-

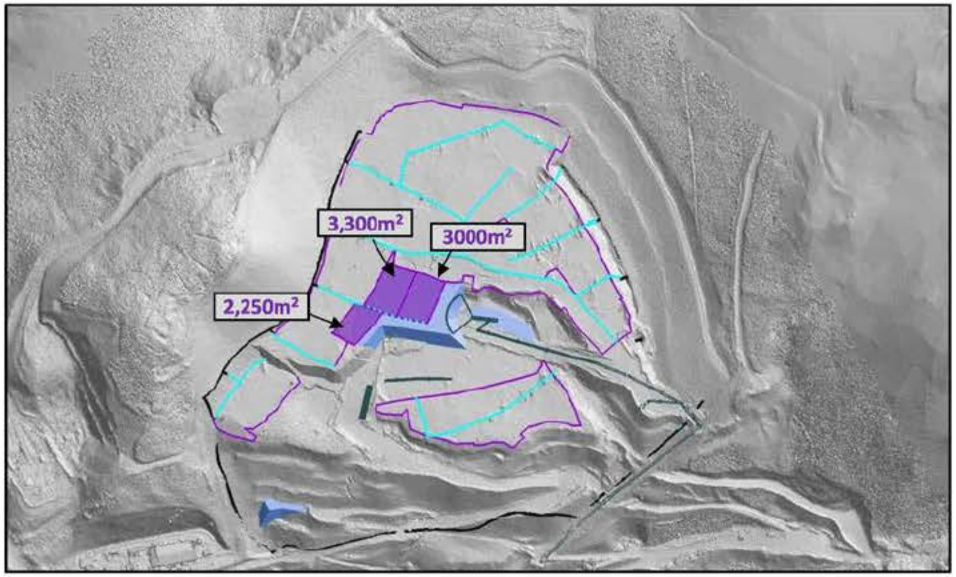
TSX : VGCX OTC: VITFF VGCX.com

VICTORIA GOLD CORP

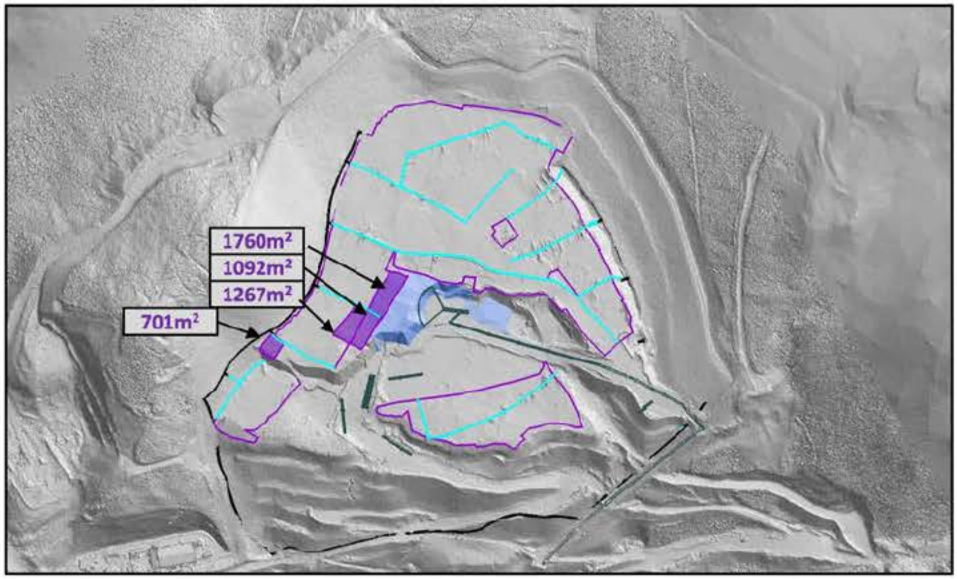
HLF Ore Stacking Plan 2022-03-15 to 2022-03-21

HLF – Past Week Comparison– March 15th to March 21st

Plan



Actual



Legend
- Leach Cells
- Distribution / Leach Line
- Stacking
- ODF

Previous Week HLF Production		15-Mar (Tue)	16-Mar (Wed)	17-Mar (Thu)	18-Mar (Fri)	19-Mar (Sat)	20-Mar (Sun)	21-Mar (Mon)	Daily Avg	Total	Week Target	Variance
Actuals												
CV22 + Bypass	(t)	16,375	25,430	20,532	30,606	26,730	12,957	27,241	22,839	159,872	238,173	-33%
Direct Haul	(t)	-	-	-	-	-	-	-	-	-	-	-
Leach Area Added	(m²)	1,267			1,092	2,461			689	4,820	5,850	-18%
Leach Area Removed	(m²)								-	-		-

TSX : VGCX OTC: VITFF VGCX.com

VICTORIA GOLD CORP

HLF – Week 1 – March 22nd to March 28th

HLF Ore Stacking Plan 2022-03-22 to 2022-03-28

Stacking

1. 1029-R1 = 192,600t
2. 1029-R2 = 63,600t
3. 975 = 8,725t

Leaching

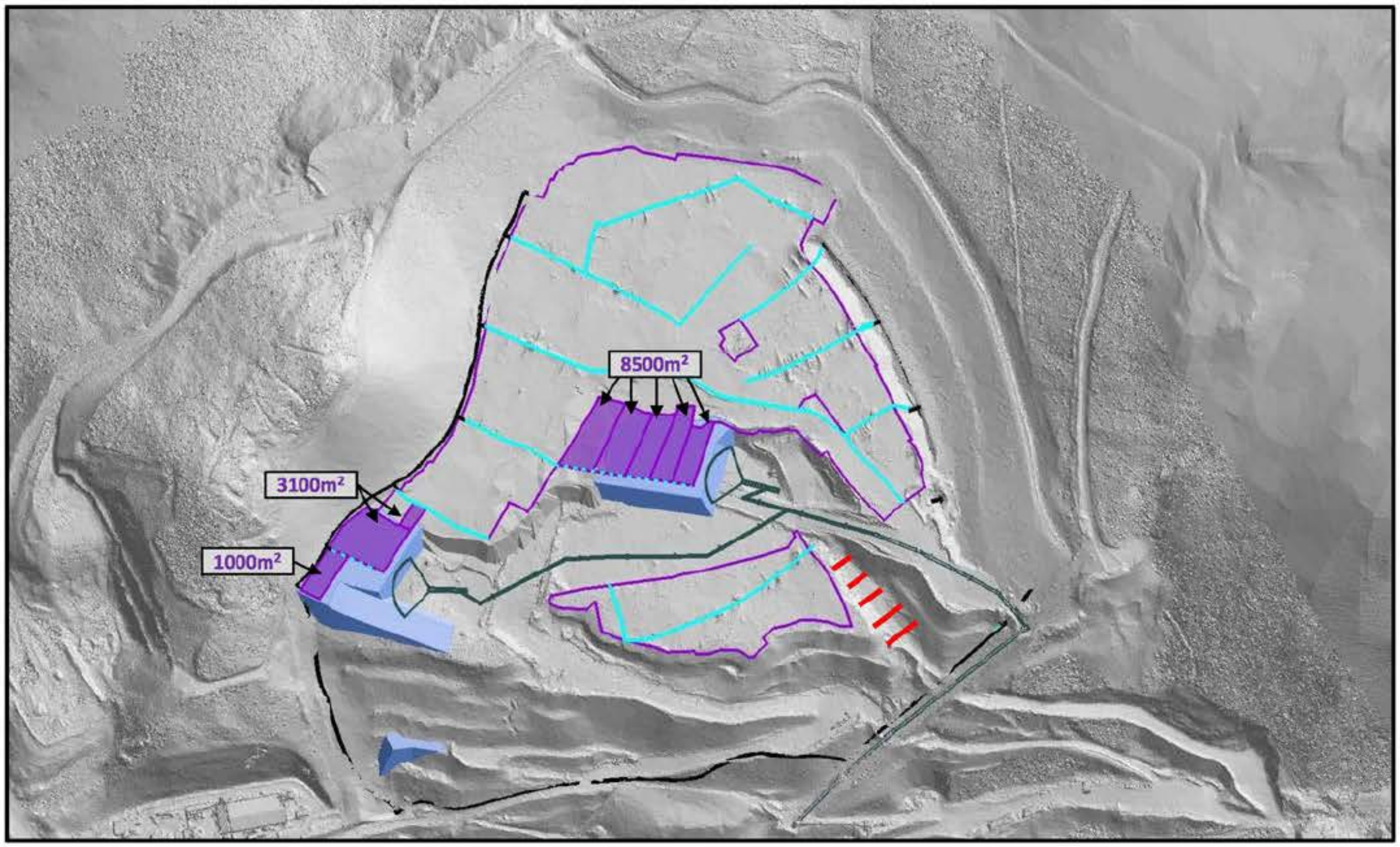
1. Add = 12,600m²
2. Remove = 8,377m²

Infrastructure

1. W3 8" Extension
2. W1 8" Extension
3. ROM Trenching

Legend

- Leach Cells
- Distribution / Leach Line
- Stacking
- ODF



HLF – Week 2 – March 29th to April 4th

HLF Ore Stacking Plan 2022-03-29 to 2022-04-04

Stacking

1. 1029-R2 – 256,600t
2. 975 = 8,725t
3. -

Leaching

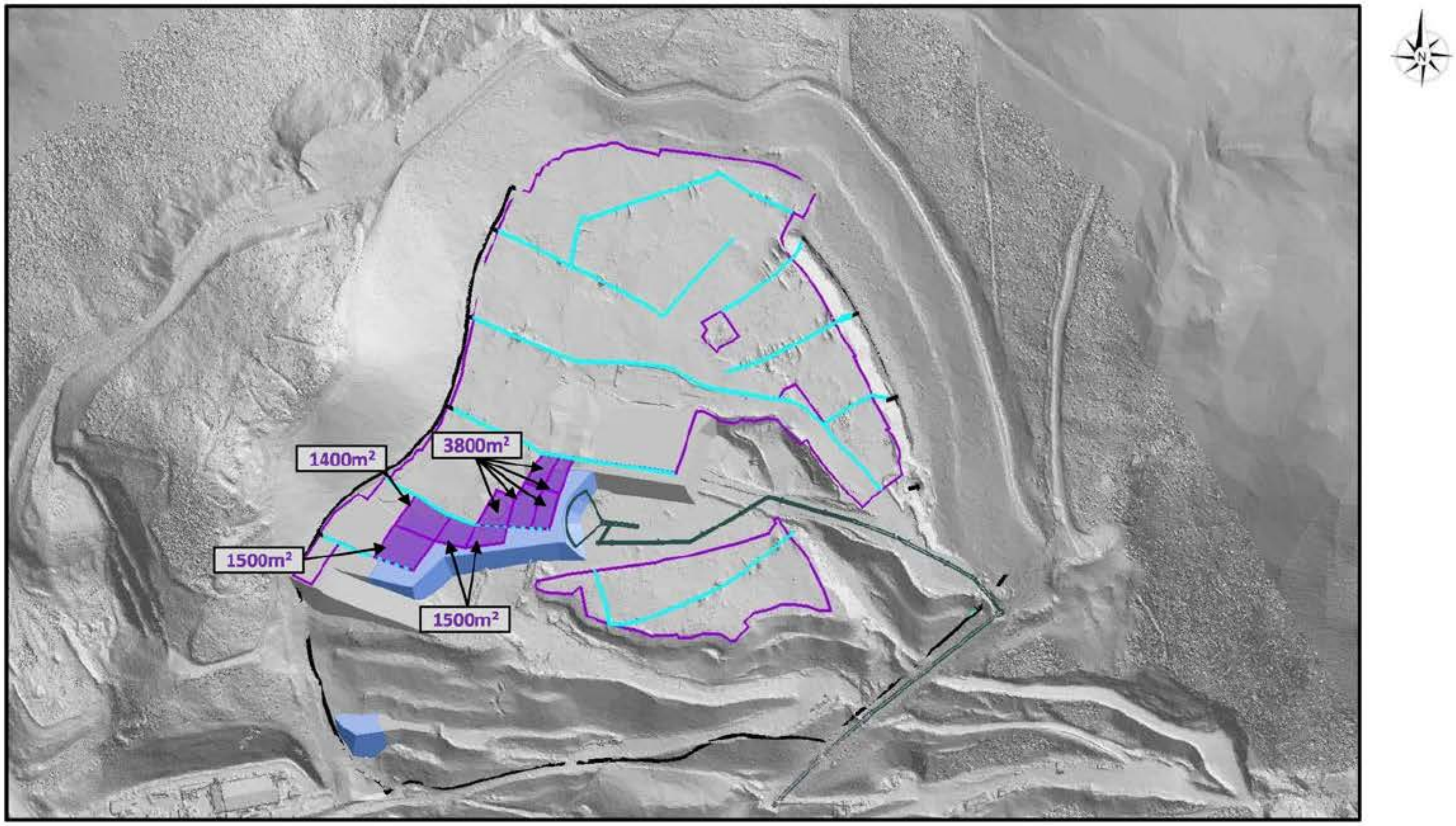
1. Add = 8200m²
2. Remove = 8,377m²

Infrastructure

1. W3 8" Extension
2. W1 8" Extension
3. -

Legend

- Leach Cells
- Distribution / Leach Line
- Stacking
- ODF



HLF Ore Stacking Plan 2022-03-22 to 2022-03-28

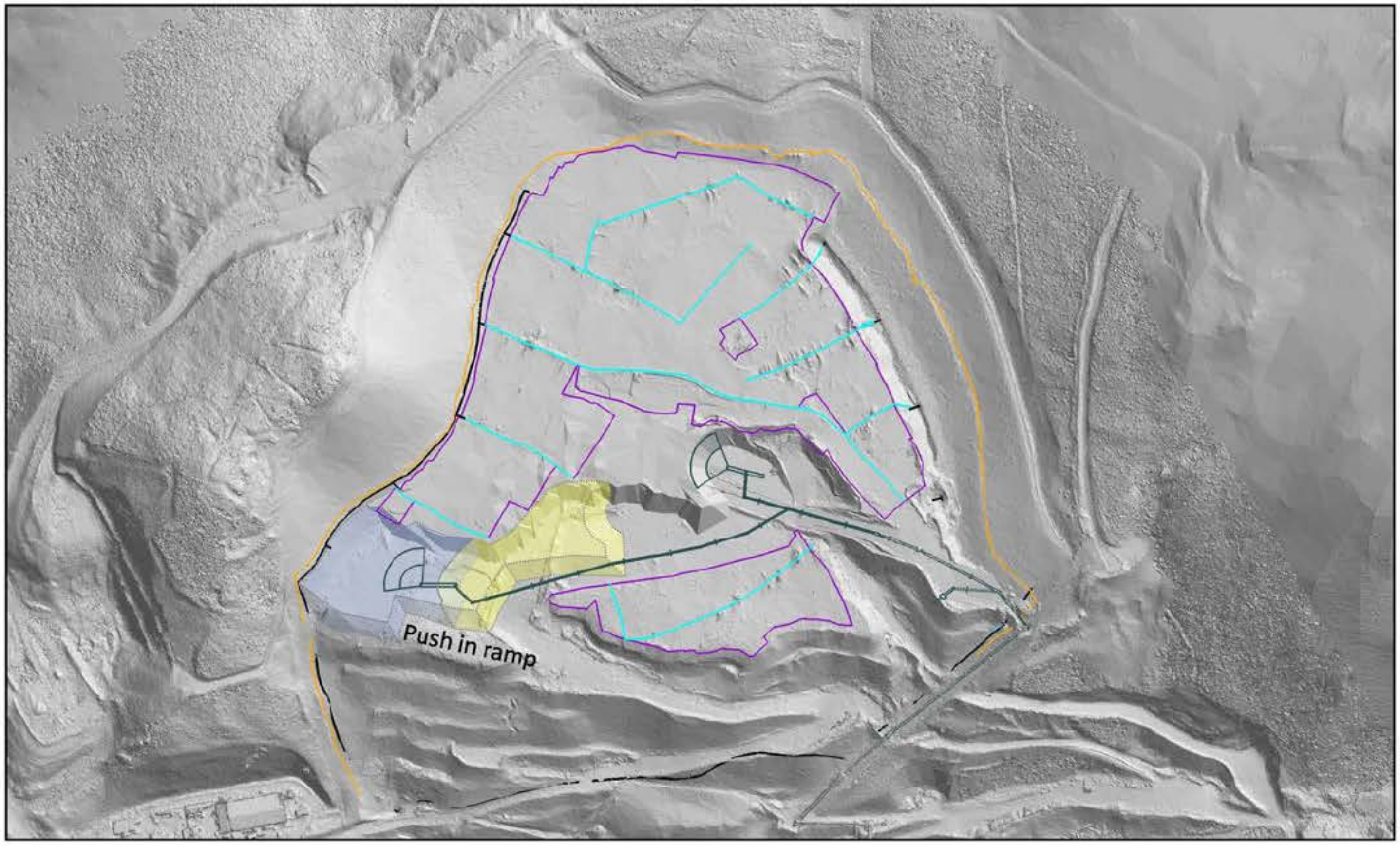
HLF – March 29th – April 11th

Stacking
1. Week 1 = 225,000t
2. Week 2 = 225,000t
3. 975 = 8,725t

Material Type
1. SW 1029 = Competent
2. 975 = ROM

Tonnes to pull GH
1. 140,000t Stationary
2. 45,000t Pull 1st GH
   - **April 4th**
3. 90,000t Pull 2nd GH
   - **April 7th**
4. 45,000t Pull 3rd GH
   - **April 9th**
5. 105,000 Pull 4th GH
   - **April 12th**

Legend
- Leach Cells
- Distribution / Leach Line
- W1 Stacking
- W2 Stacking



TSX : VGCX OTC: VITFF VGCX.com

VICTORIA GOLD CORP

HLF Ore Stacking Plan 2022-04-05 to 2022-04-11

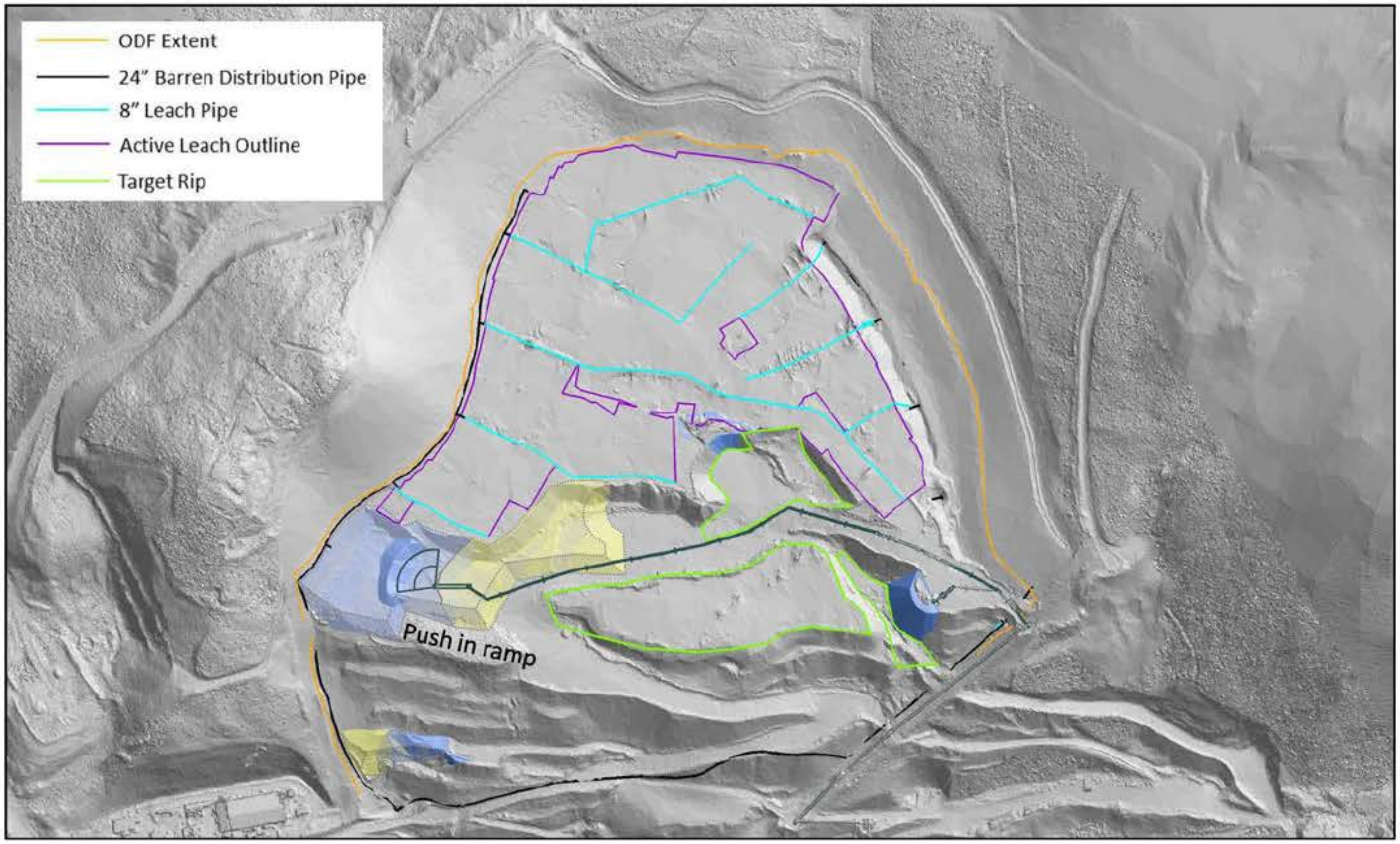
HLF – April 5th – April 18th

Stacking
1. Week 1 = 158,000t
2. Week 2 = 225,000t
3. 975 = 12,000t

Material Type
1. SW 1029 = Competent
2. 975 = ROM

Tonnes to pull GH
1. 109,000t Stationary
2. 45,000t Pull 1st GH
   - **April 15th**
3. 90,000t Pull 2nd GH
   - **April 18th**
4. 45,000t Pull 3rd GH
   - **April 20th**
5. 105,000 Pull 4th GH
   - **April 23rd**

Legend
- Leach Cells
- Distribution / Leach Line
- W1 Stacking
- W2 Stacking



TSX : VGCX OTC: VITFF VGCX.com

VICTORIA GOLD CORP

HLF Ore Stacking Plan 2022-04-12 to 2022-04-18

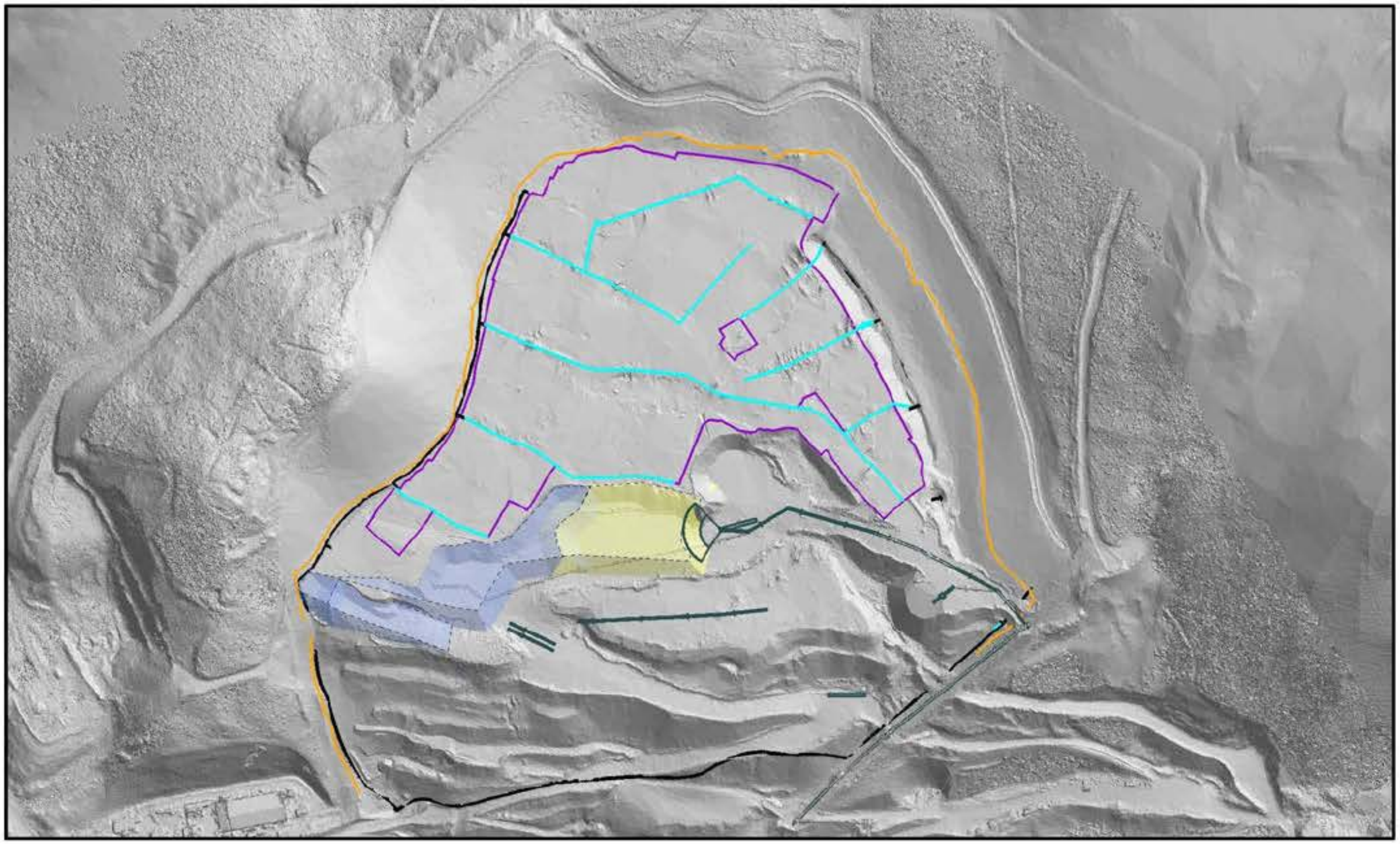
HLF – April 12th – April 25th

Stacking
1. Week 1 = 224,000t
2. Week 2 = 224,000t
3. 975 = 8,725t

Material Type
1. SW 1029 = Competent
2. 975 = ROM/Tert Bin

GH Moves Schedule
1. 125,000t Rotate BF
   - **April 15th**
2. 80,000t Pull GH211
   - **April 17th**
3. 95,000t Pull GH216
   - **April 21st**
4. 75,000t Pull GH213/217
   - **April 23rd**

Legend
- Leach Cells
- Distribution / Leach Line
- W1 Stacking
- W2 Stacking



TSX : VGCX OTC: VITFF VGCX.com

VICTORIA GOLD CORP

HLF Ore Stacking Plan 2022-04-19 to 2022-04-25

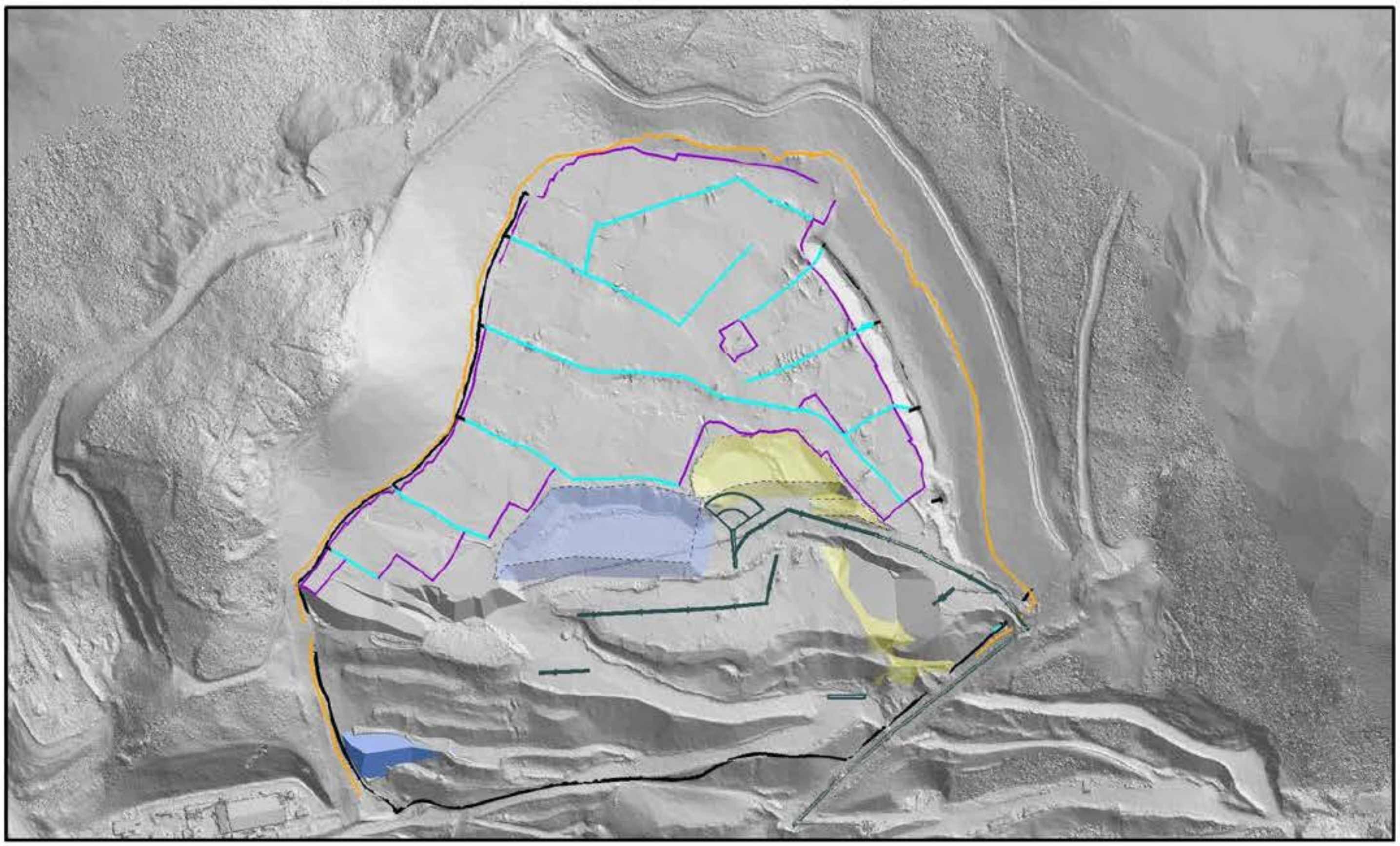
HLF – April 19th – May 2nd

Stacking
1. Week 1 = 215,275t
2. Week 2 = 215,275t
3. 975 = 17,450t

Material Type
1. 1029 = Fresh/altered granodiorite
2. 975 = ROM/Tert Bin

GH Moves
1. 65kt pull GH216
2. 75kt pull GH106
3. 80kt pull GH213/217

Legend
- Leach Cells
- Distribution / Leach Line
- W1 Stacking
- W2 Stacking



TSX : VGCX OTC: VITFF VGCX.com

VICTORIA GOLD CORP

HLF Ore Stacking Plan 2022-04-26 to 2022-05-02

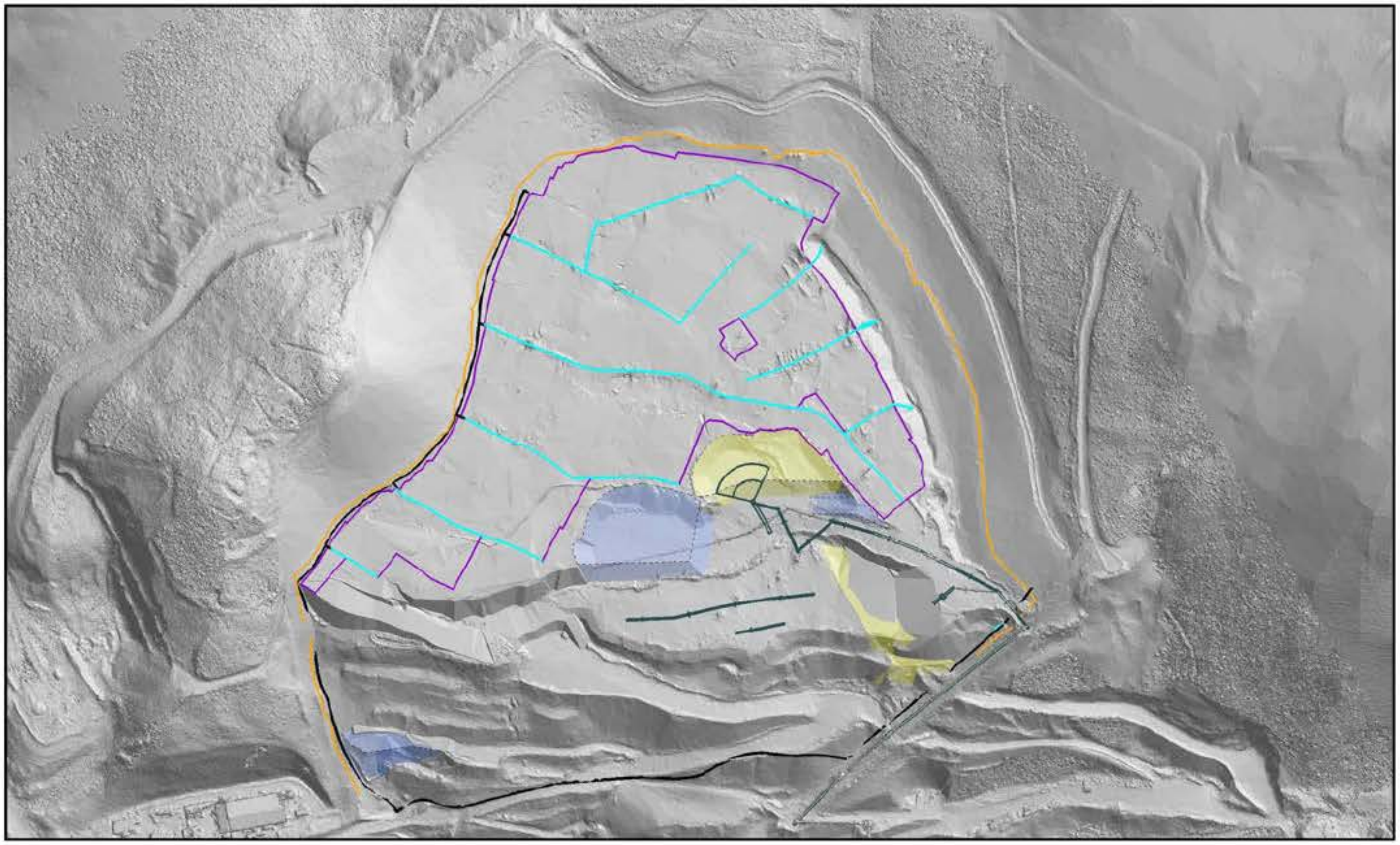
HLF – April 26th – May 8th

Stacking
1. Week 1 = 215,275t
2. Week 2 = 215,275t
3. 975 = 17,450t

Material Type
1. 1029 = Fresh/altered granodiorite
2. 975 = ROM

GH Moves
1. 80kt pull GH213
2. 60kt pull GH217
3. 55kt pull GH108

Legend
- Leach Cells
- Distribution / Leach Line
- W1 Stacking
- W2 Stacking



TSX : VGCX OTC: VITFF VGCX.com

HLF Ore Stacking Plan 2022-05-03 to 2022-05-11

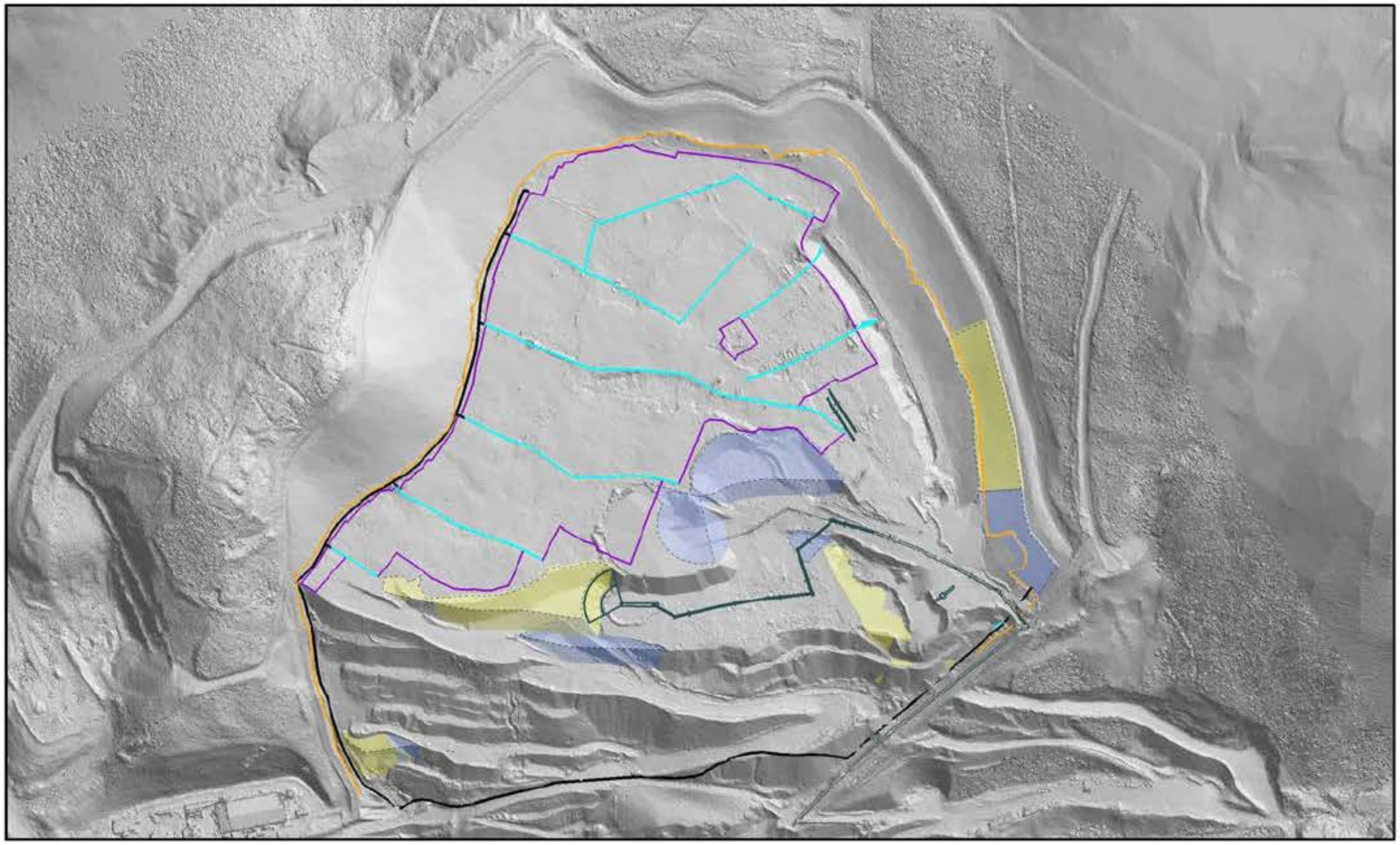
HLF – May 03rd – May 16th

Stacking
1. Week 1 = 195,000t
2. Week 2 = 195,000t
3. ODF Placed = 30,000t
4. 975 = 17,450t

Material Type
1. 1029 = Fresh/altered granodiorite
2. 975 = ROM
3. ODF = High permeability

GH Moves
1. 20kt pull GH
2. 60kt pull GH
3. 50kt pull GH

Legend
- Leach Area
- Distribution / Leach Line
- W1 Stacking
- W2 Stacking



VICTORIA GOLD CORP

HLF Ore Stacking Plan - planned stacking on 2022-05-10 (for reference)

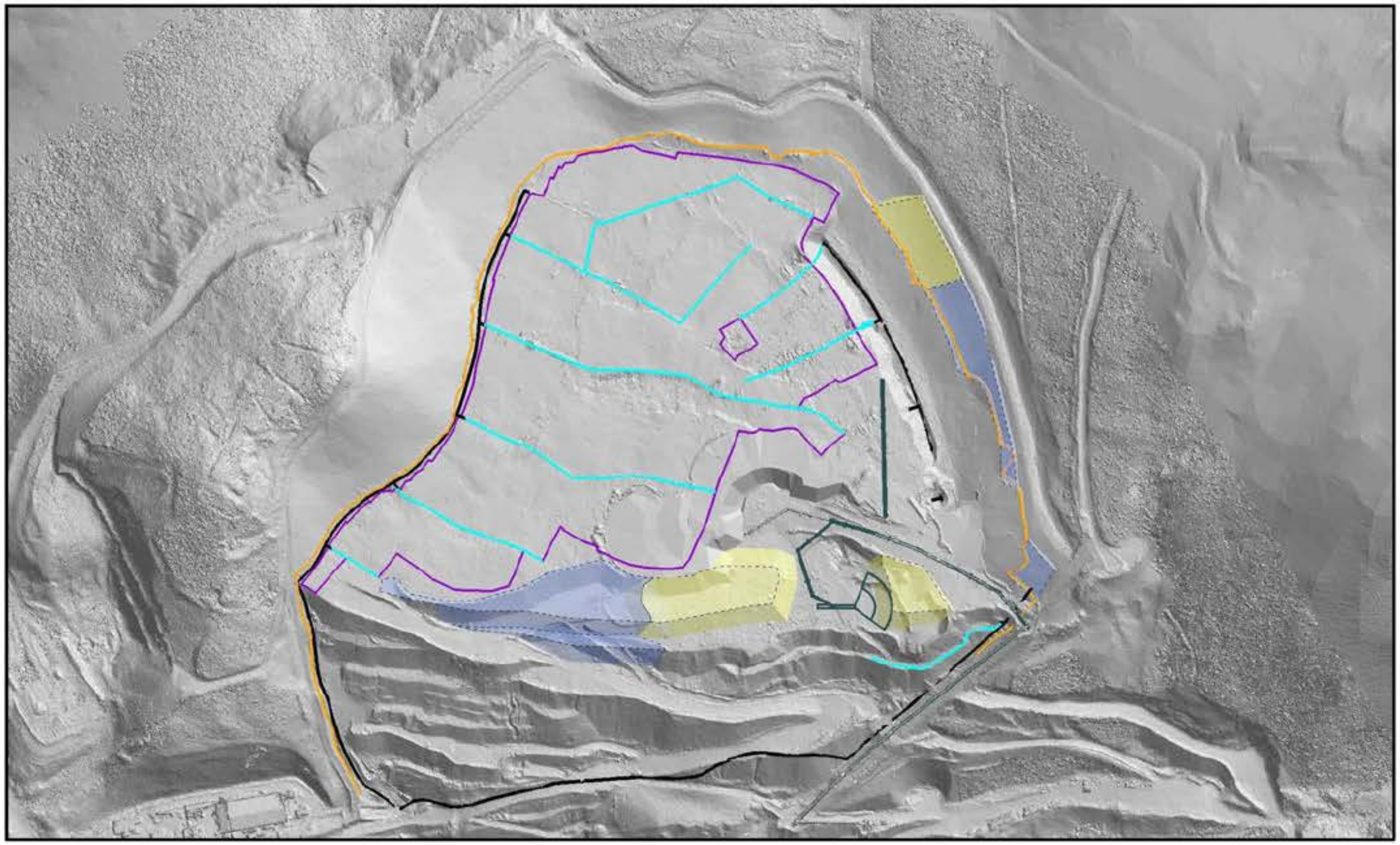
HLF – May 10rd – May 23th

Stacking
1. Week 1 = 200,000t
2. Week 2 = 200,000t
3. ODF Placed = 44,800t

Material Type
1. 1029 = Fresh/altered granodiorite
2. ODF = High permeability

GH Moves
1. 35kt pull GH
2. 72kt pull GH
3. 75kt pull GH
4. 50kt pull GH

Legend
- Leach Area
- Distribution / Leach Line
- W1 Stacking
- W2 Stacking



TSX : VGCX OTC: VITFF VGCX.com

VICTORIA GOLD CORP

HLF Ore Stacking Plan - planned stacking on 2022-05-10 (for reference)

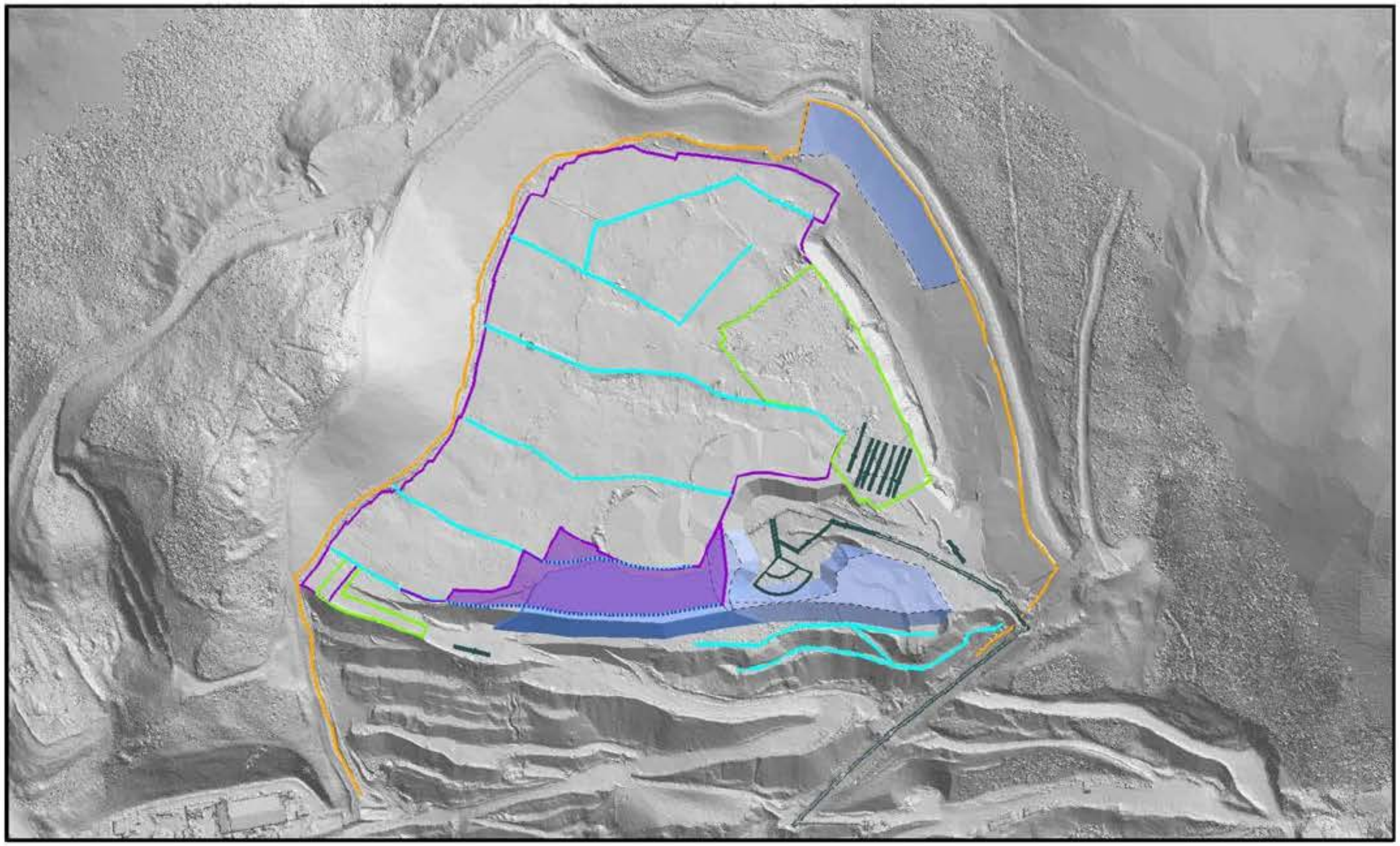
HLF – May 17th – May 30th

Stacking
1. Week 1 = 200,000t
2. Week 2 = 200,000t
3. ODF Placed = 44,800t

Material Type
1. 1029 = Fresh/altered granodiorite
2. ODF = High permeability

GH Moves
1. 45kt pull GH
2. 55kt pull GH
3. 45kt pull GH
4. 45kt pull GH

Legend
- Leach Area
- Distribution / Leach Line
- W1 Stacking
- W2 Stacking

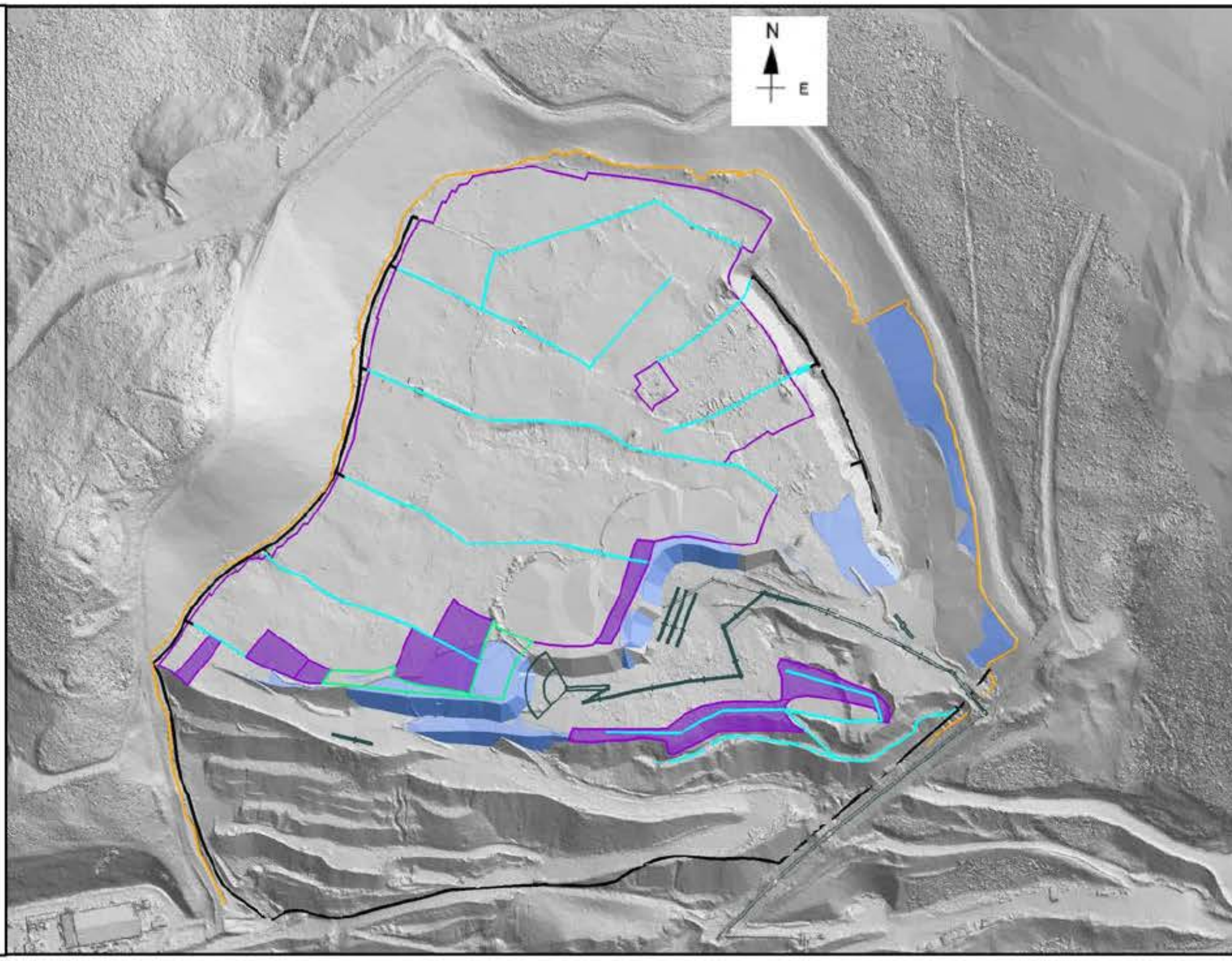


HLF Ore Stacking Plan 2022-05-12 to 2022-05-18

HLF Stacking: Past Week Performance

Previous Week Statistics

- **Stacked Target: 32,000 tpd**
  - Actual = 21,804 tpd
- **7 Day Leach Added**
  - Actual = 7,587 m^2
  - Sprinklers = 5,800 m^2
- **30 Day Leach Added:**
  - Actual = 34,279 m^2
- **Leach Area in Prep:**
  - Actual = 3,000 m^2
    - ETA online = 05/19, 05/21
  - Sprinklers ~ 5,000 m^2



Legend

- Leach Online
- 24" HDPE
- 8" HDPE
- Stacking
- ODF
- Ripped Area
- Leach Offline

TSX : VGCX OTC: VITFF VGCX.com

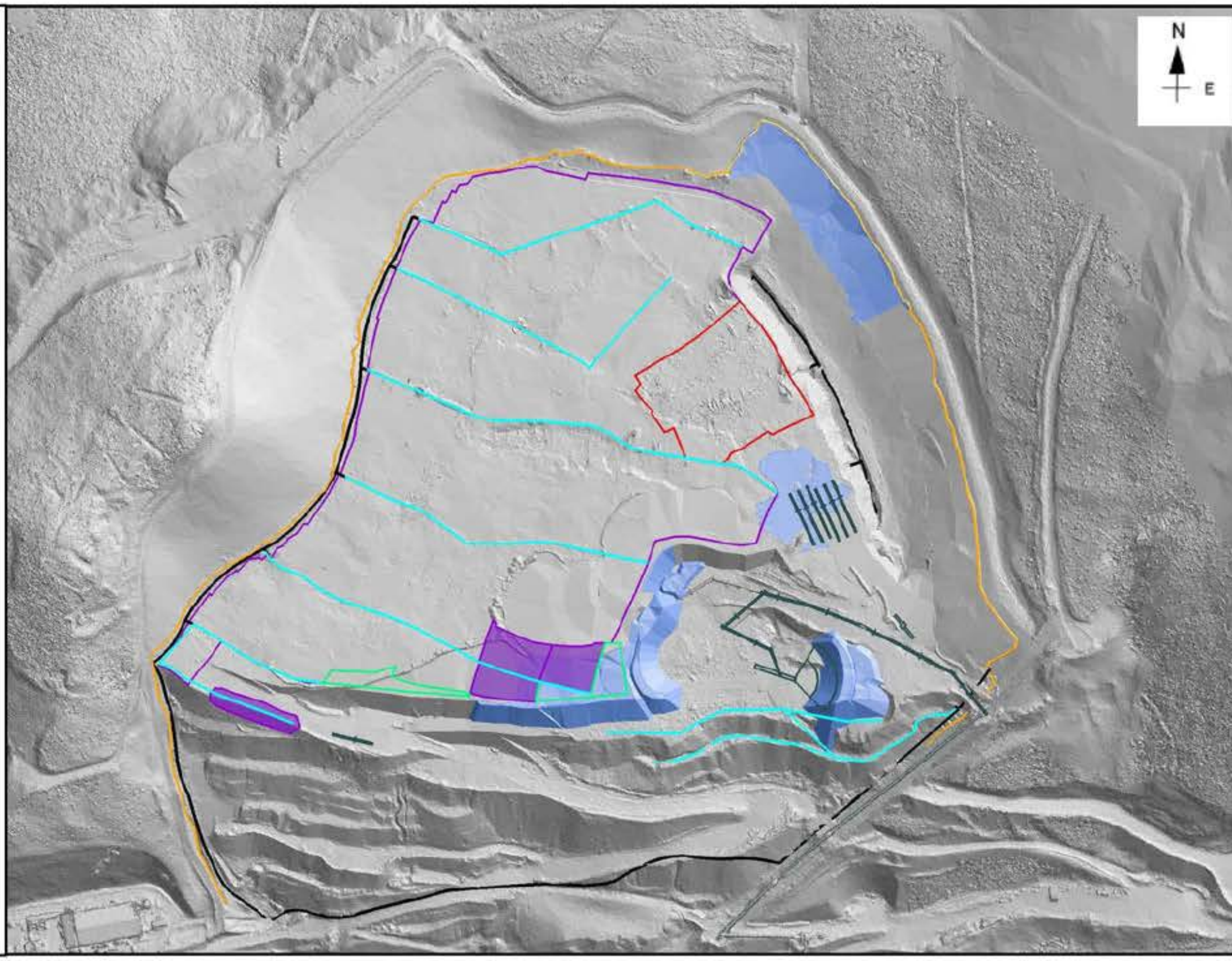
VICTORIA GOLD CORP

HLF Ore Stacking Plan 2022-05-19 to 2022-05-25

HLF Stacking: Past Week Performance

Previous Week Statistics

- **Stacked Target: 32,000 tpd**
  - Actual = 30,467 tpd
- **7 Day Leach Added**
  - Actual = 4,900 m^2
  - Sprinklers = 1,307 m^2
- **30 Day Leach Added:**
  - Actual = 36,593 m^2
- **Leach Area in Prep:**
  - Actual = 2,669 m^2
    - ETA online = 05/26, 05/28
  - Sprinklers ~2,000 m^2



Legend

- Leach Online
- 24" HDPE
- 8" HDPE
- Stacking
- ODF
- Ripped Area
- Leach Offline

TSX : VGCX OTC: VITFF VGCX.com

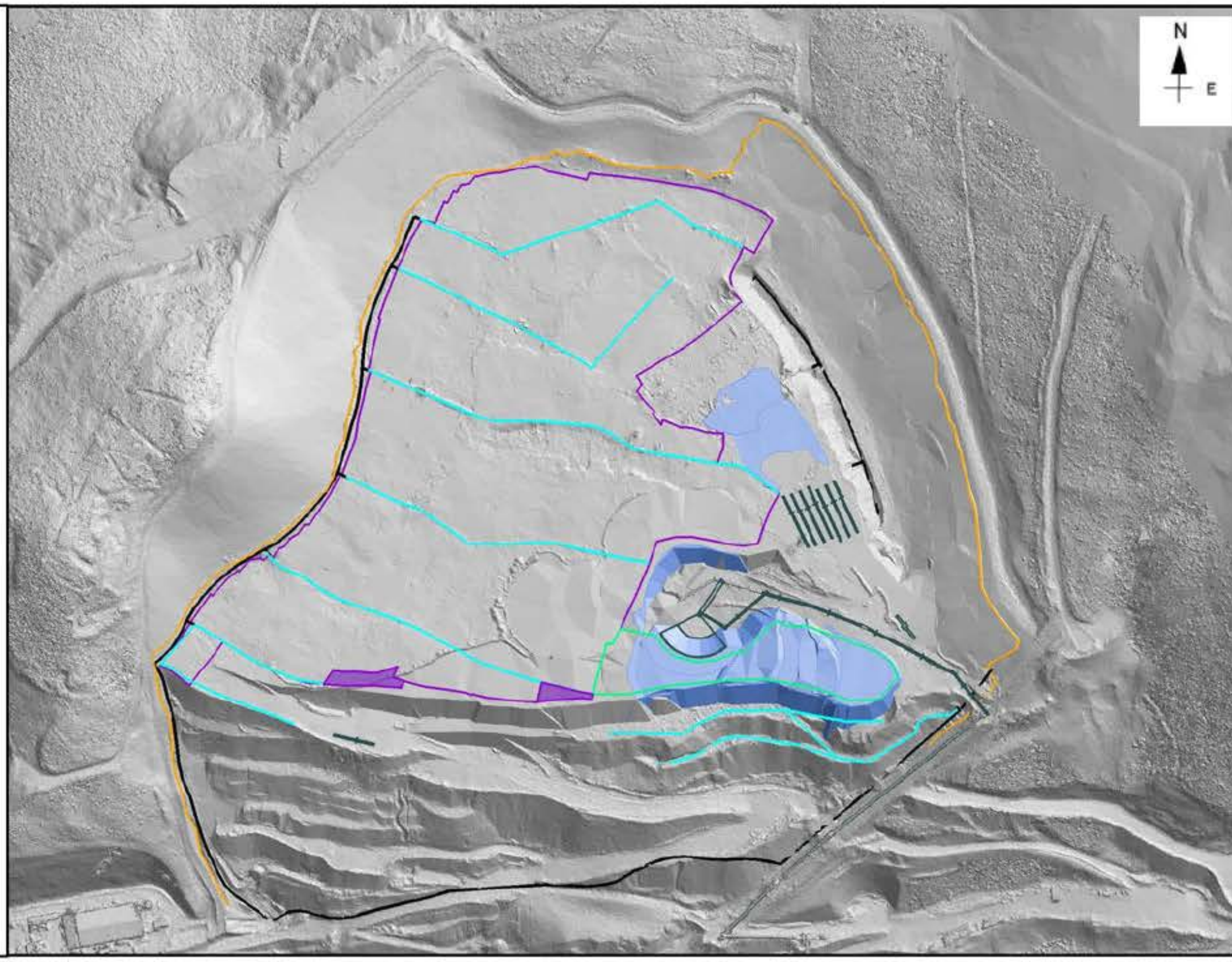
VICTORIA GOLD CORP

HLF Ore Stacking Plan 2022-05-26 to 2022-06-01

HLF Stacking: Past Week Performance

Previous Week Statistics

- **Stacked Target: 36,000 tpd**
  - Actual = 24,317 tpd
- **7 Day Leach Added**
  - Actual = 1,200 m^2
  - Sprinklers = 0 m^2
- **30 Day Leach Added:**
  - Actual = 30,445 m^2
- **Leach Area in Prep:**
  - Actual = 10,200 m^2
    - ETA online = 06/03, 06/08
  - Sprinklers ~2,000 m^2



Legend

- Leach Online
- 24" HDPE
- 8" HDPE
- Stacking
- ODF
- Ripped Area
- Leach Offline

TSX : VGCX OTC: VITFF VGCX.com

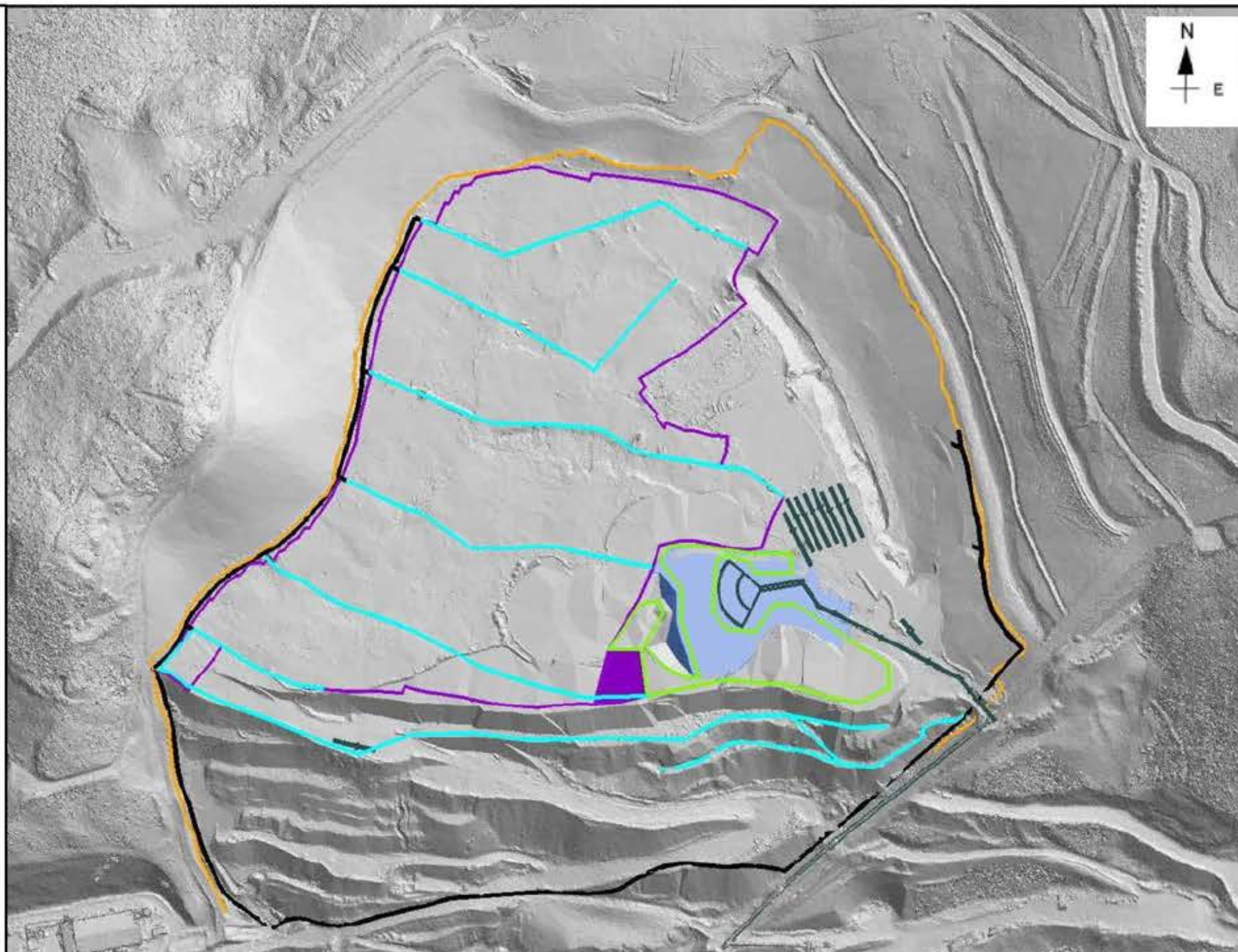
VICTORIA GOLD CORP

HLF Ore Stacking Plan 2022-06-02 to 2022-06-08

HLF Stacking: Past Week Performance

Previous Week Statistics

- **Stacked Target: 36,000 tpd**
  - Actual = 24,317 tpd
- **7 Day Leach Added**
  - Actual = 2,120 m^2
  - Sprinklers = 0 m^2
- **30 Day Leach Added:**
  - Actual = 23,697 m^2
- **Leach Area in Prep:**
  - Actual = 19,400 m^2
    - ETA online = June 11/12/13



Legend

- Leach Online
- 24" HDPE
- 8" HDPE
- Stacking
- ODF
- Ripped Area

TSX : VGCX OTC: VITFF VGCX.com

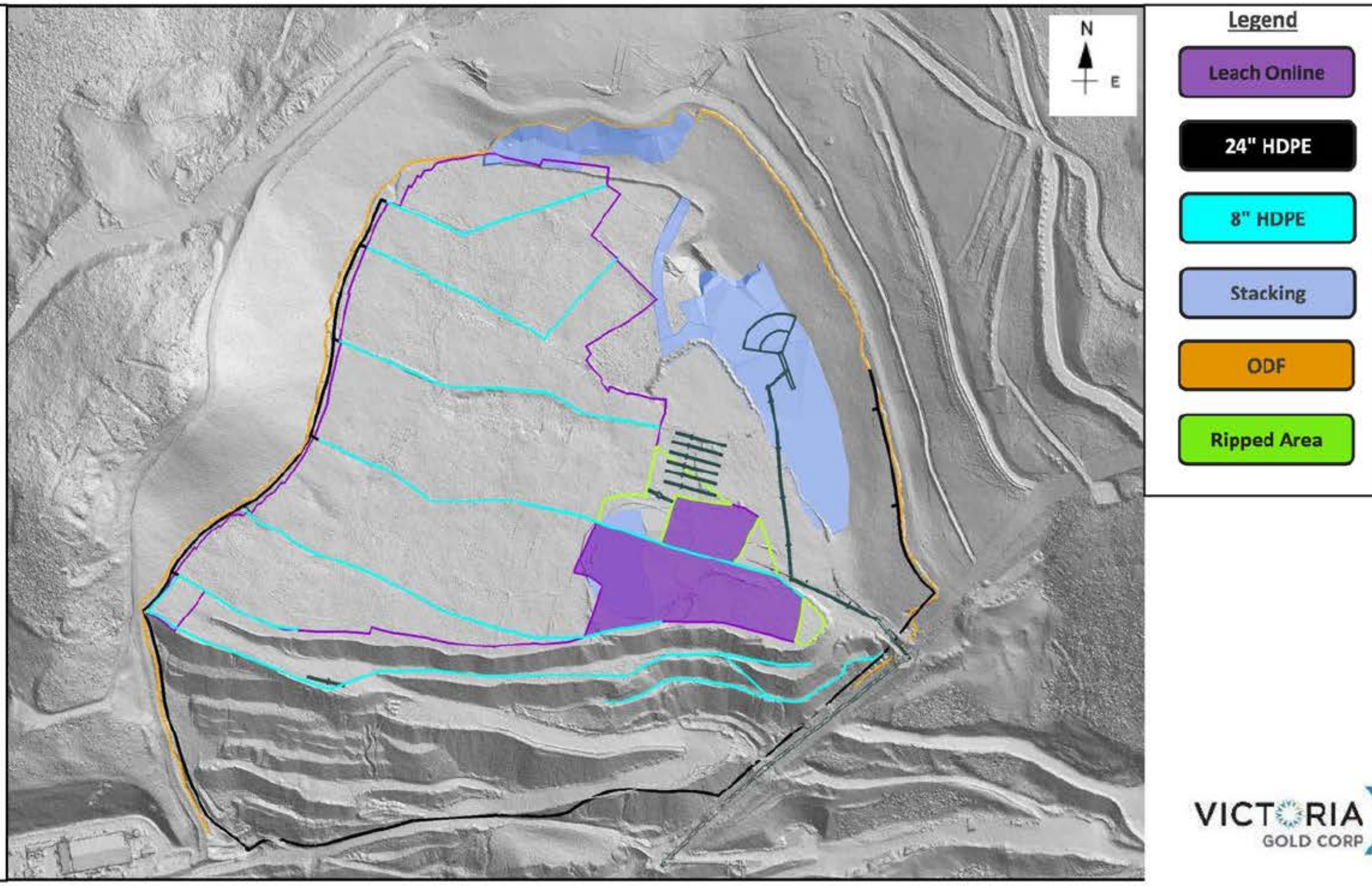
VICTORIA GOLD CORP

HLF Ore Stacking Plan 2022-06-09 to 2022-06-15

HLF Stacking: Past Week Performance

Previous Week Statistics

- **Stacked Target: 36,000 tpd**
  - Actual = 28,625 tpd
- **7 Day Leach Added**
  - Actual = 17,915 m²
  - Sprinklers = 0 m²
- **30 Day Leach Added:**
  - Actual = 32,150 m²
- **Leach Area in Prep:**
  - Actual = 5,700 m²
    - ETA online = June 18/19/21



TSX : VGCX OTC: VITFF VGCX.com

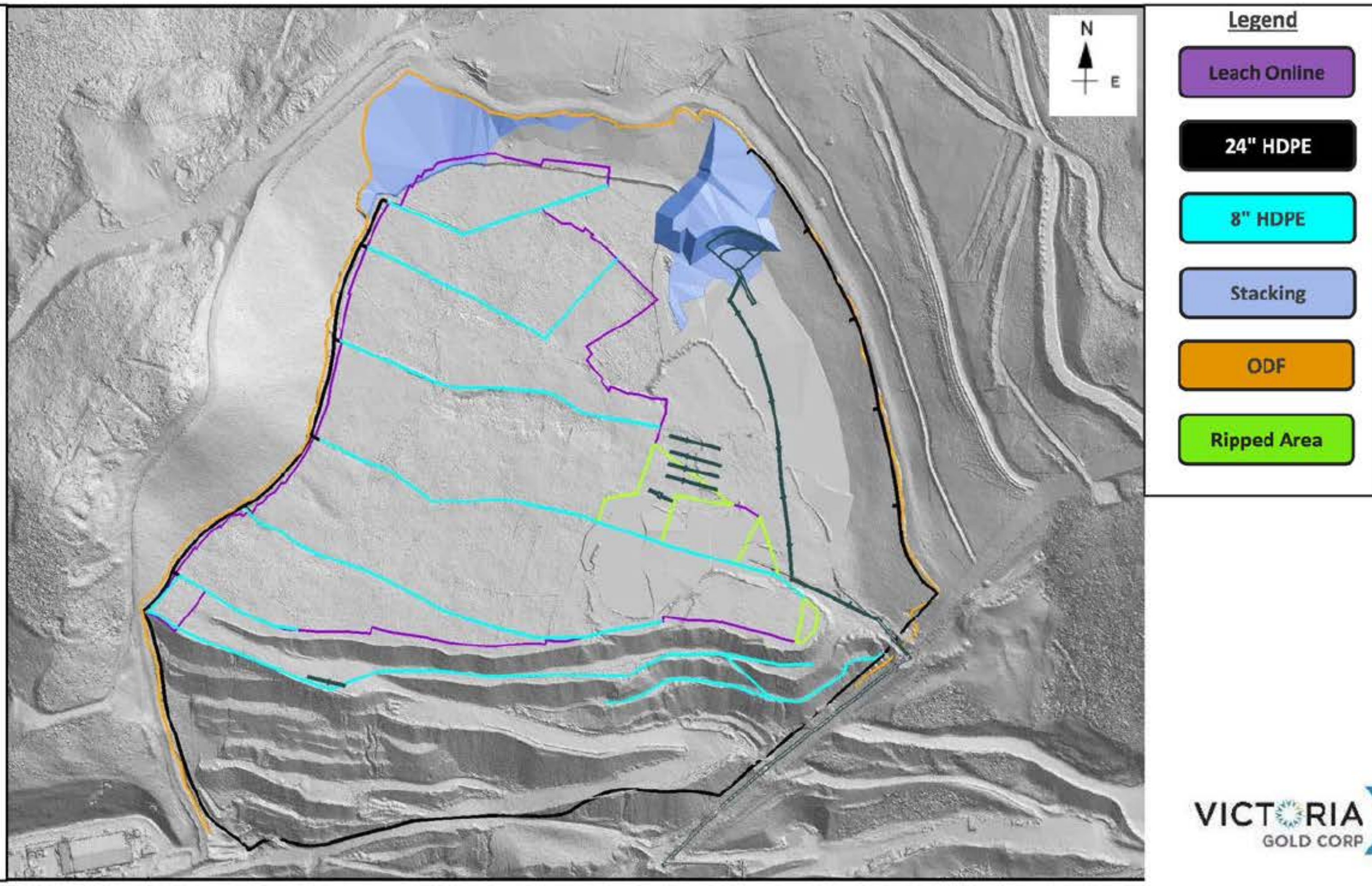
VICTORIA GOLD CORP

HLF Ore Stacking Plan 2022-06-16 to 2022-06-22

HLF Stacking: Past Week Performance

Previous Week Statistics

- **Stacked Target: 36,000 tpd**
  - Actual = 28,013 tpd
- **7 Day Leach Added**
  - Actual = 0 m^2
  - Sprinklers = 0 m^2
- **30 Day Leach Added:**
  - Actual = 22,977 m^2
- **Leach Area in Prep:**
  - Actual = 5,700 m^2
    - ETA online = June 24/26



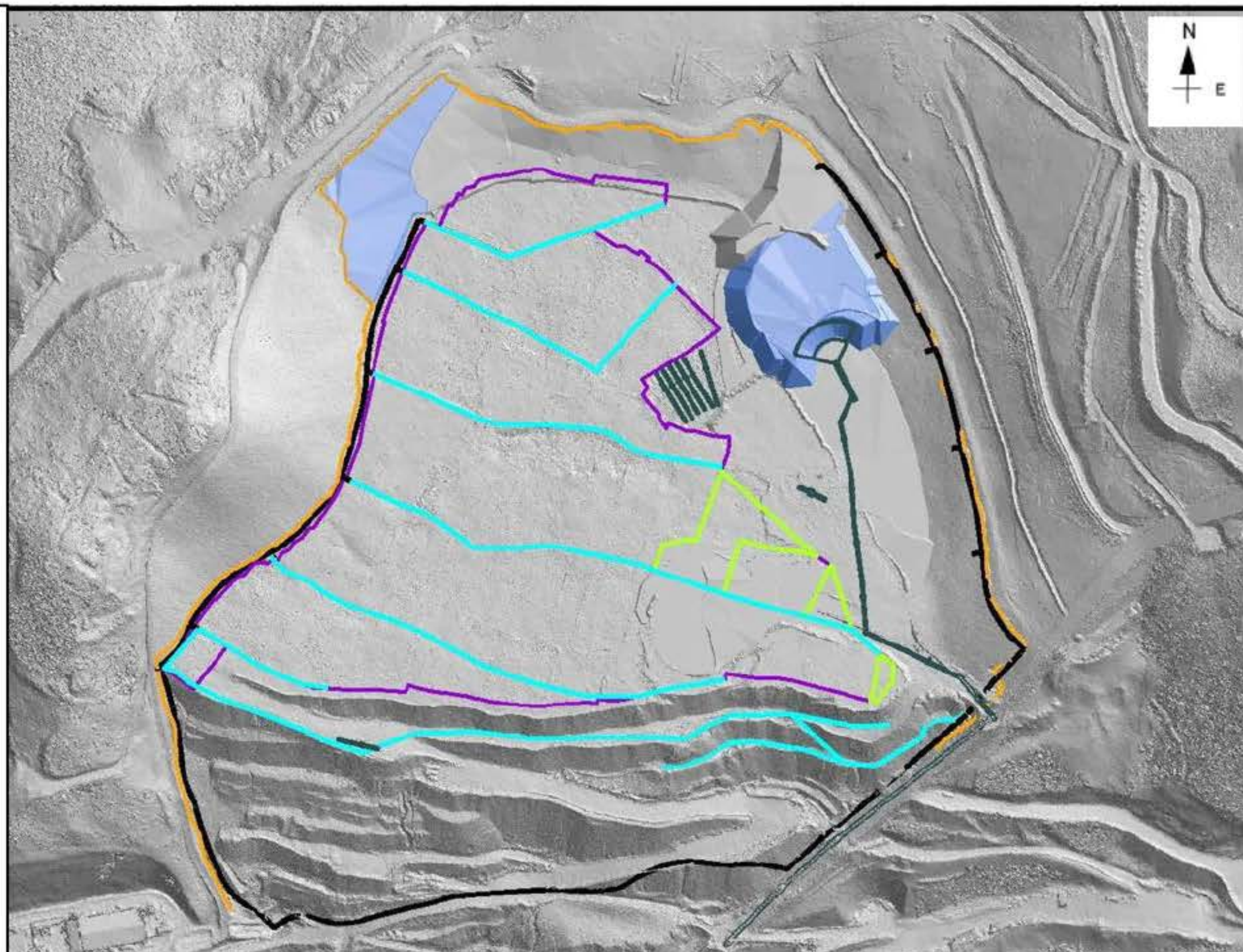
TSX : VGCX OTC: VITFF VGCX.com

VICTORIA GOLD CORP

HLF Ore Stacking Plan 2022-06-23 to 2022-06-29
HLF Stacking: Past Week Performance

Previous Week Statistics

- **Stacked Target: 36,000 tpd**
  - Actual = 31,928 tpd
- **7 Day Leach Added**
  - Actual = 0 m²
  - Sprinklers = 0 m²
- **30 Day Leach Added:**
  - Actual = 20,035 m²
- **Leach Area in Prep:**
  - Actual = 6,000 m²
    - ETA online = July 1/2



Legend

- Leach Online
- 24" HDPE
- 8" HDPE
- Stacking
- ODF
- Ripped Area

TSX : VGCX OTC: VITFF VGCX.com

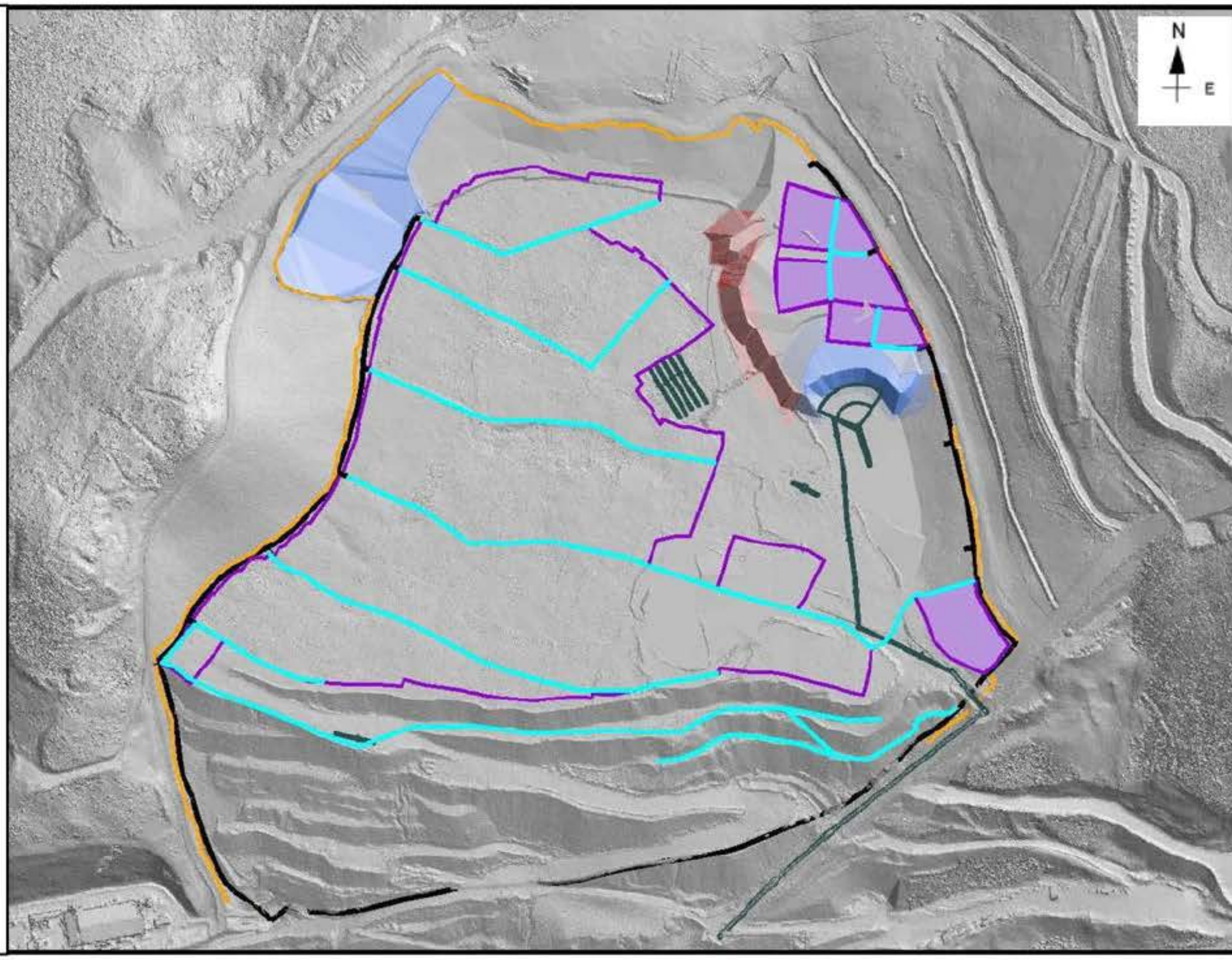
VICTORIA GOLD CORP

HLF Ore Stacking Plan 2022-06-30 to 2022-07-06

HLF Stacking: Past Week Performance

Previous Week Statistics

- **Stacked Target: 36,000 tpd**
  - Actual = 13,052 tpd
- **ODF Stacked Target 4500 tpd**
  - Actual = 6400 tpd
- **7 Day Leach Added**
  - Actual = 10,606 m²
  - Sprinklers = 5,341 m²
- **30 Day Leach Added:**
  - Actual = 28,521 m²
- **Leach Area in Prep:**
  - Actual = 11,500 m² ODF
  - Actual = 1,500 m² 1041
    - ETA online = July 8/9/10



Legend

- Leach Online
- 24" HDPE
- 8" HDPE
- Stacking
- ODF
- Ripped Area

TSX : VGCX OTC: VITFF VGCX.com

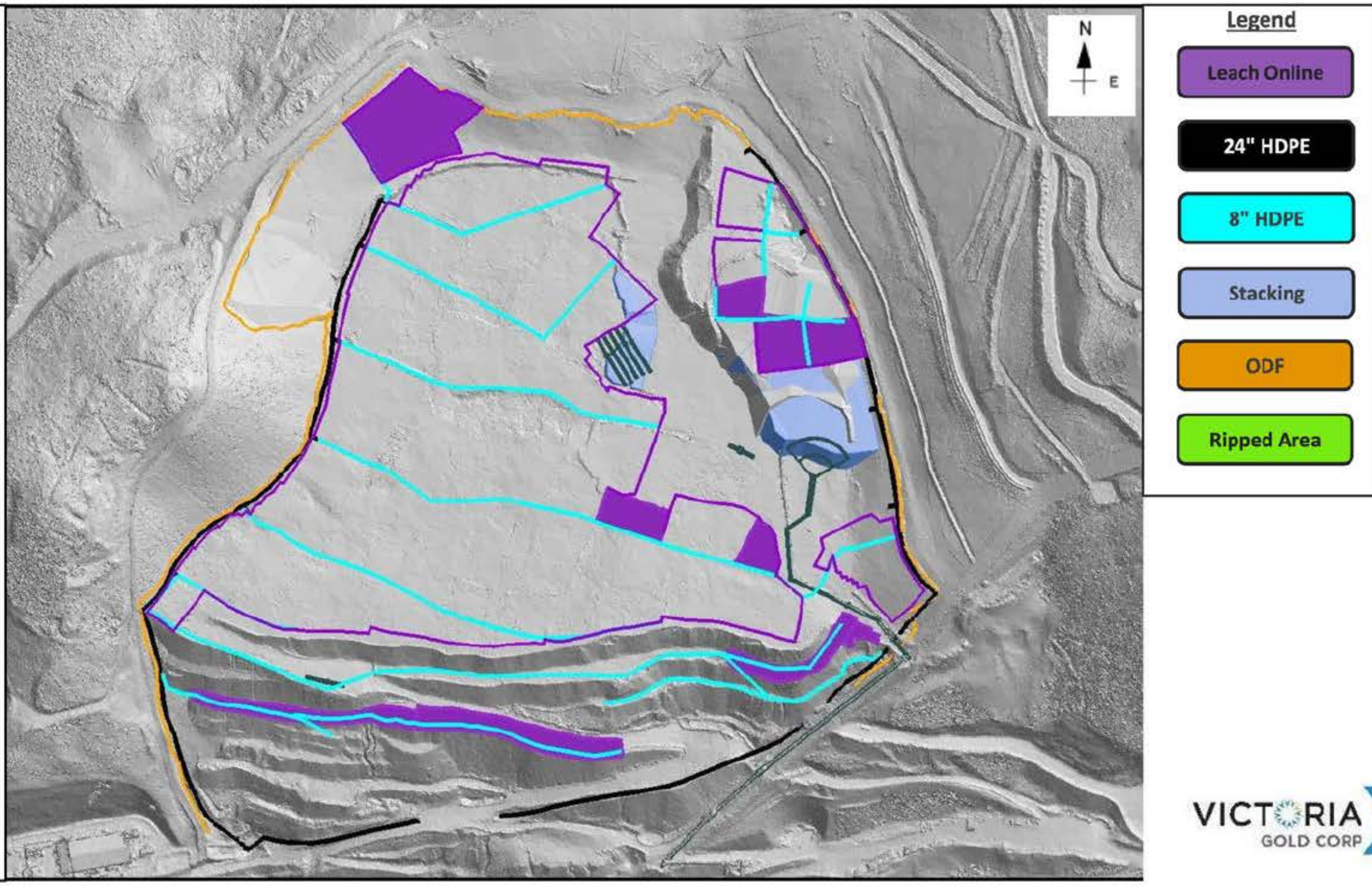
VICTORIA GOLD CORP

HLF Ore Stacking Plan 2022-07-07 to 2022-07-13

HLF Stacking: Past Week Performance

Previous Week Statistics

- **Stacked Target: 36,000 tpd**
  - Actual = 13,052 tpd
- **7 Day Leach Added**
  - Actual = 12,609 m²
  - Sprinklers = 5,603 m²
  - ODF = 7,615
- **30 Day Leach Added:**
  - Actual = 53,378 m²
- **Leach Area in Prep:**
  - Actual = 11,500 m² ODF
  - Actual = 1,500 m² 1041
    - ETA online = July 8/9/10

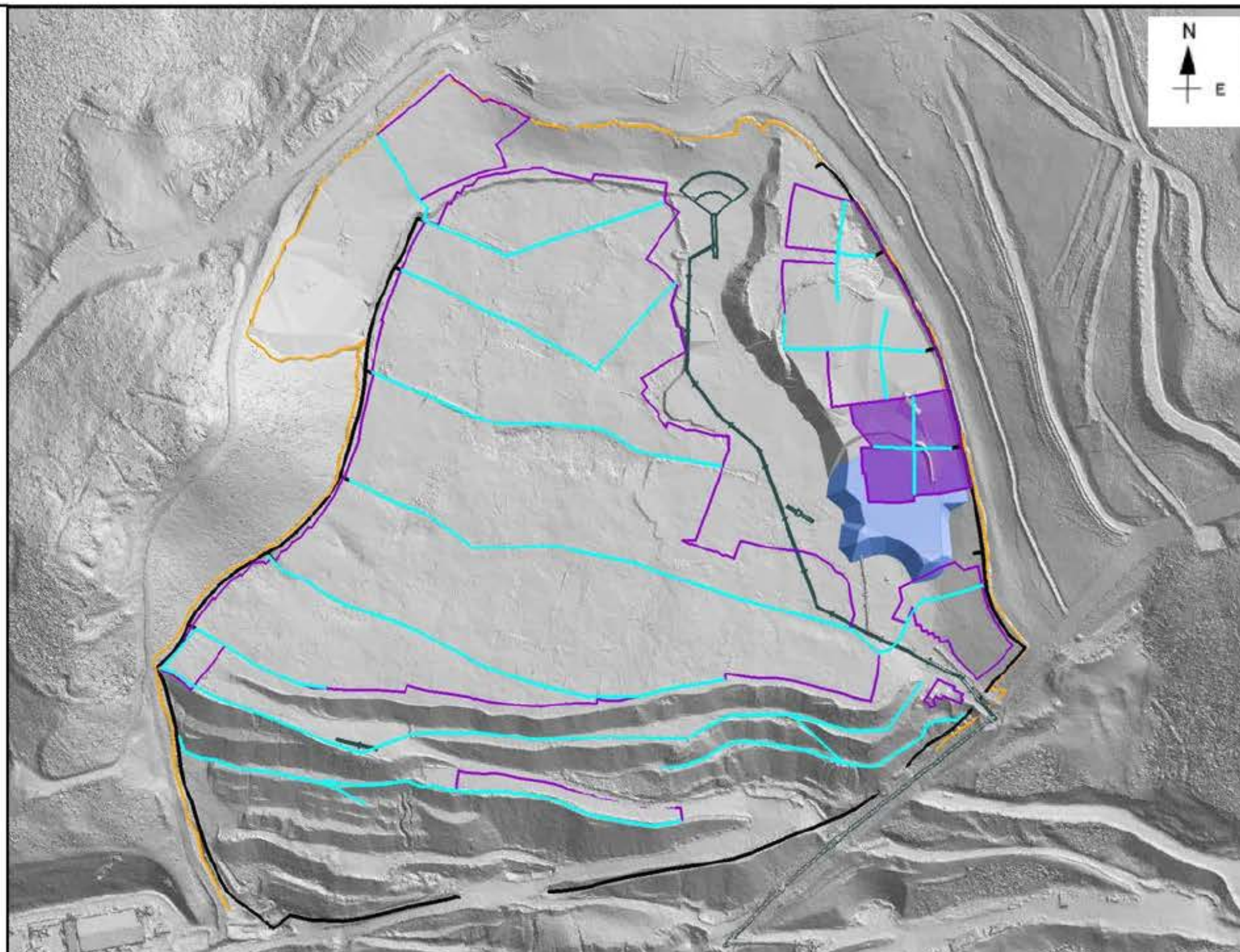


HLF Ore Stacking Plan 2022-07-14 to 2022-07-20

HLF Stacking: Past Week Performance

Previous Week Statistics

- **Stacked Target: 36,000 tpd**
  - Actual = 17,217 tpd
- **7 Day Leach Added**
  - Actual = 7,454 m²
  - Sprinklers = 0 m²
  - ODF = 0 m²
- **30 Day Leach Added:**
  - Actual = 43,750 m²
- **Leach Area in Prep:**
  - ODF = TBD
  - 1041 = 4,000 m² 1041
    - ETA online = July 24/25



Legend

- Leach Online
- 24" HDPE
- 8" HDPE
- Stacking
- ODF
- Ripped Area

TSX : VGCX OTC: VITFF VGCX.com

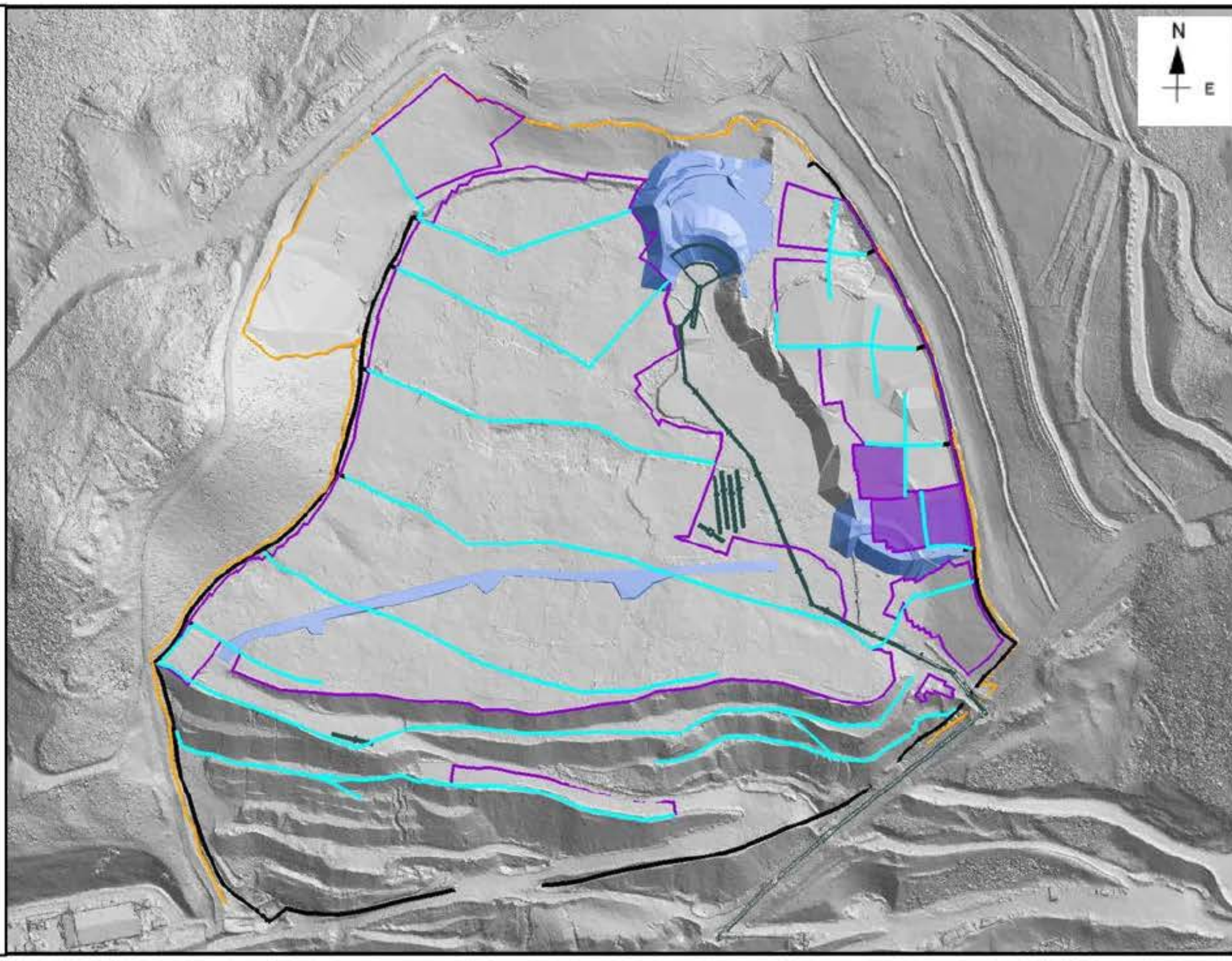
VICTORIA GOLD CORP

HLF Ore Stacking Plan 2022-07-21 to 2022-07-27

HLF Stacking: Past Week Performance

Previous Week Statistics

- **Stacked Target: 36,000 tpd**
  - Actual = 31,072 tpd
- **7 Day Leach Added**
  - Actual =6,049 m²
  - Sprinklers = 5,553 m²
  - ODF = 0 m²
- **30 Day Leach Added:**
  - Actual = 53,320 m²
- **Leach Area in Prep:**
  - 1041 = 4,000 m² 1041
    - ETA online = July 29



Legend

- Leach Online
- 24" HDPE
- 8" HDPE
- Stacking
- ODF
- Ripped Area

TSX : VGCX OTC: VITFF VGCX.com

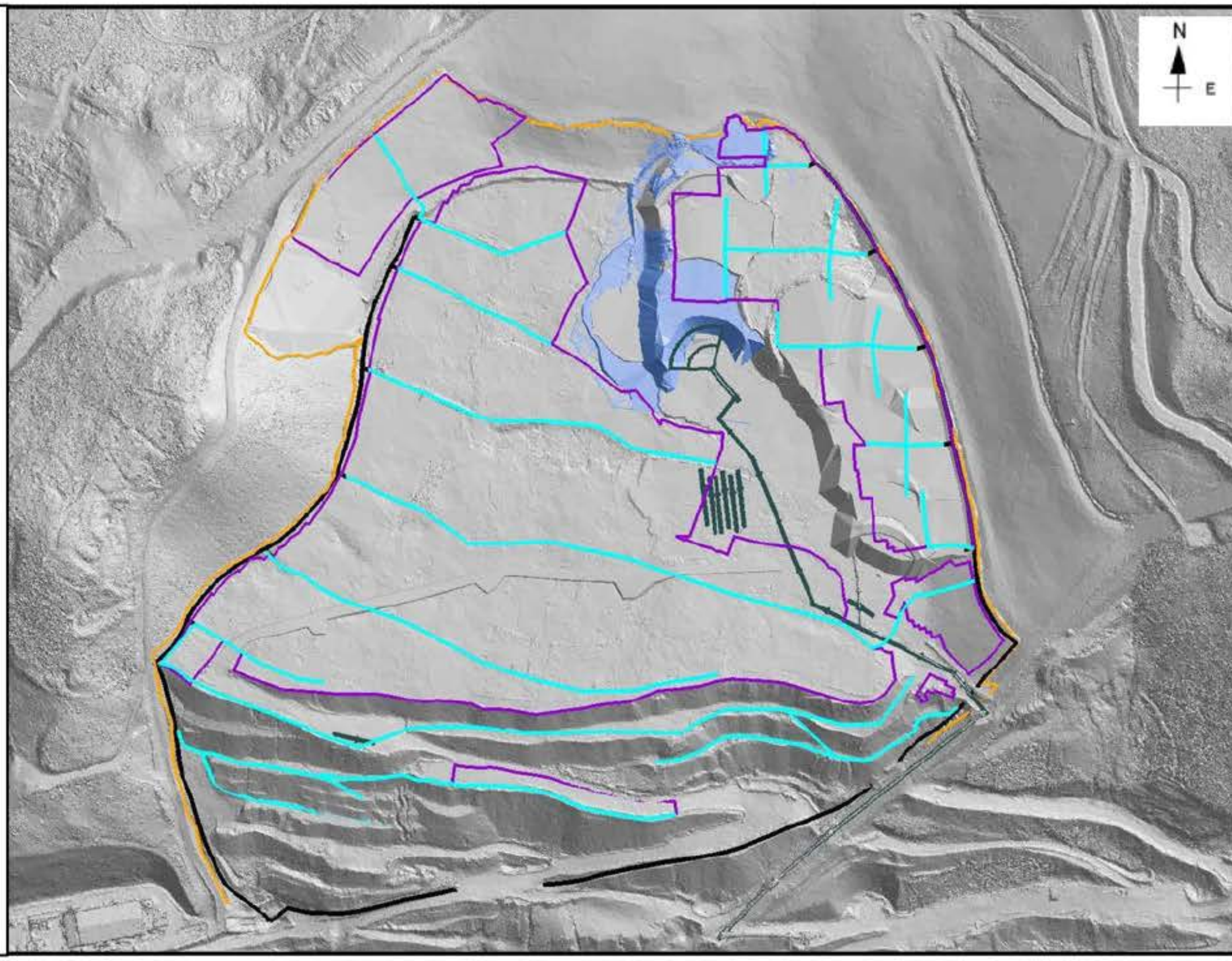
VICTORIA GOLD CORP

HLF Ore Stacking Plan 2022-07-28 to 2022-08-03

HLF Stacking: Past Week Performance

Previous Week Statistics

- **Stacked Target: 36,000 tpd**
  - Actual = 19,892 tpd
- **7 Day Leach Added:**
  - Actual =13,551 m²
  - Sprinklers = 0 m²
  - ODF = 0 m²
- **30 Day Leach Added:**
  - Actual = 93,780 m²
- **Leach Area in Prep:**
  - 1041 = 0 m2



Legend

- Leach Online
- 24" HDPE
- 8" HDPE
- Stacking
- ODF
- Ripped Area

TSX : VGCX OTC: VITFF VGCX.com

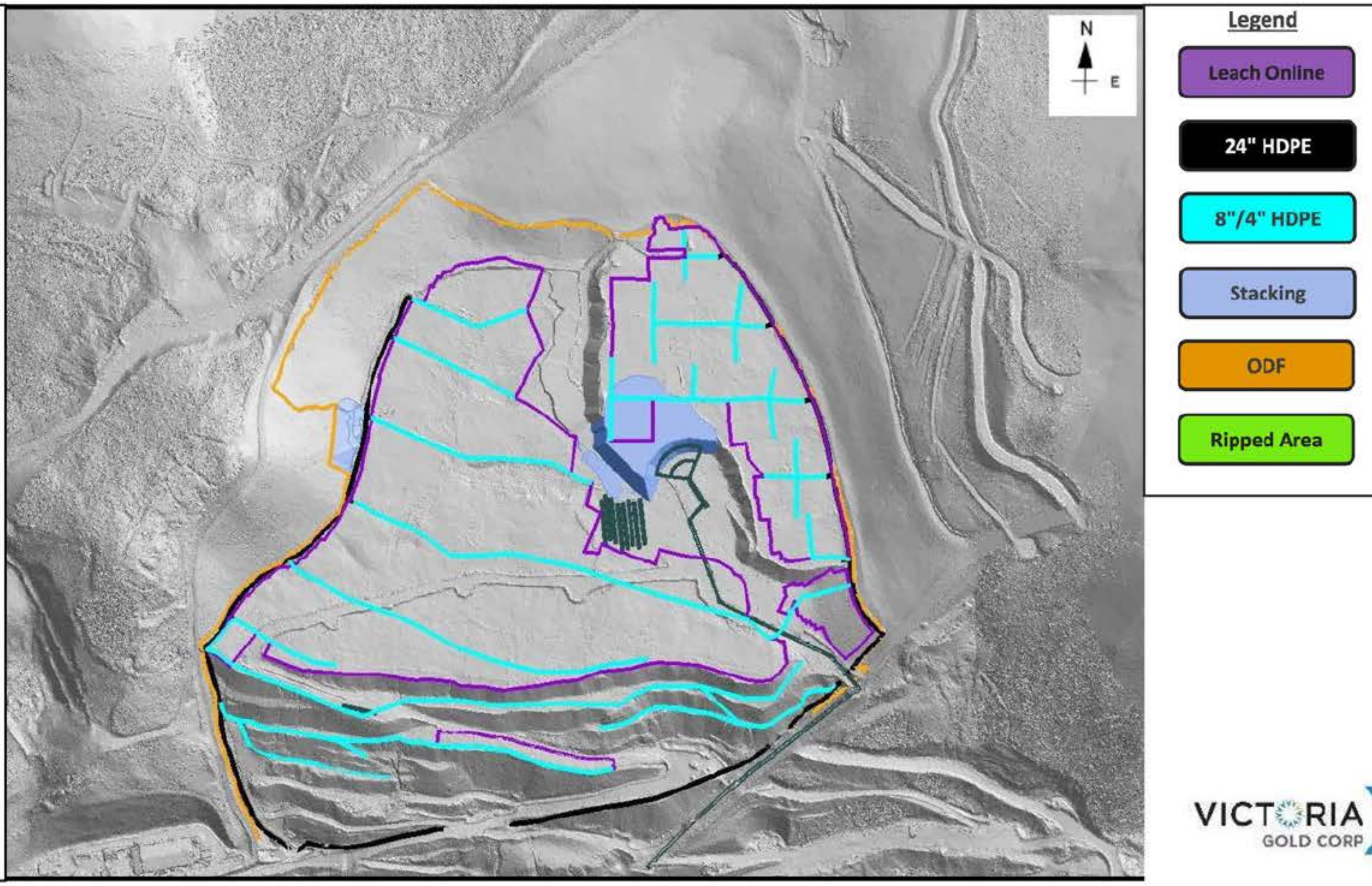
VICTORIA GOLD CORP

HLF Ore Stacking Plan 2022-08-04 to 2022-08-10

HLF Stacking: Past Week Performance

Previous Week Statistics

- **Stacked Target: 36,000 tpd**
  - Actual = 25,223 tpd
- **7 Day Leach Added:**
  - Actual = -16,490 m^2
  - Sprinklers = 0 m^2
  - ODF = 0 m^2
- **30 Day Leach Added:**
  - Actual = 38,638 m^2
- **Leach Area in Prep:**
  - 1041 = 3,000 m2



TSX : VGCX OTC: VITFF VGCX.com

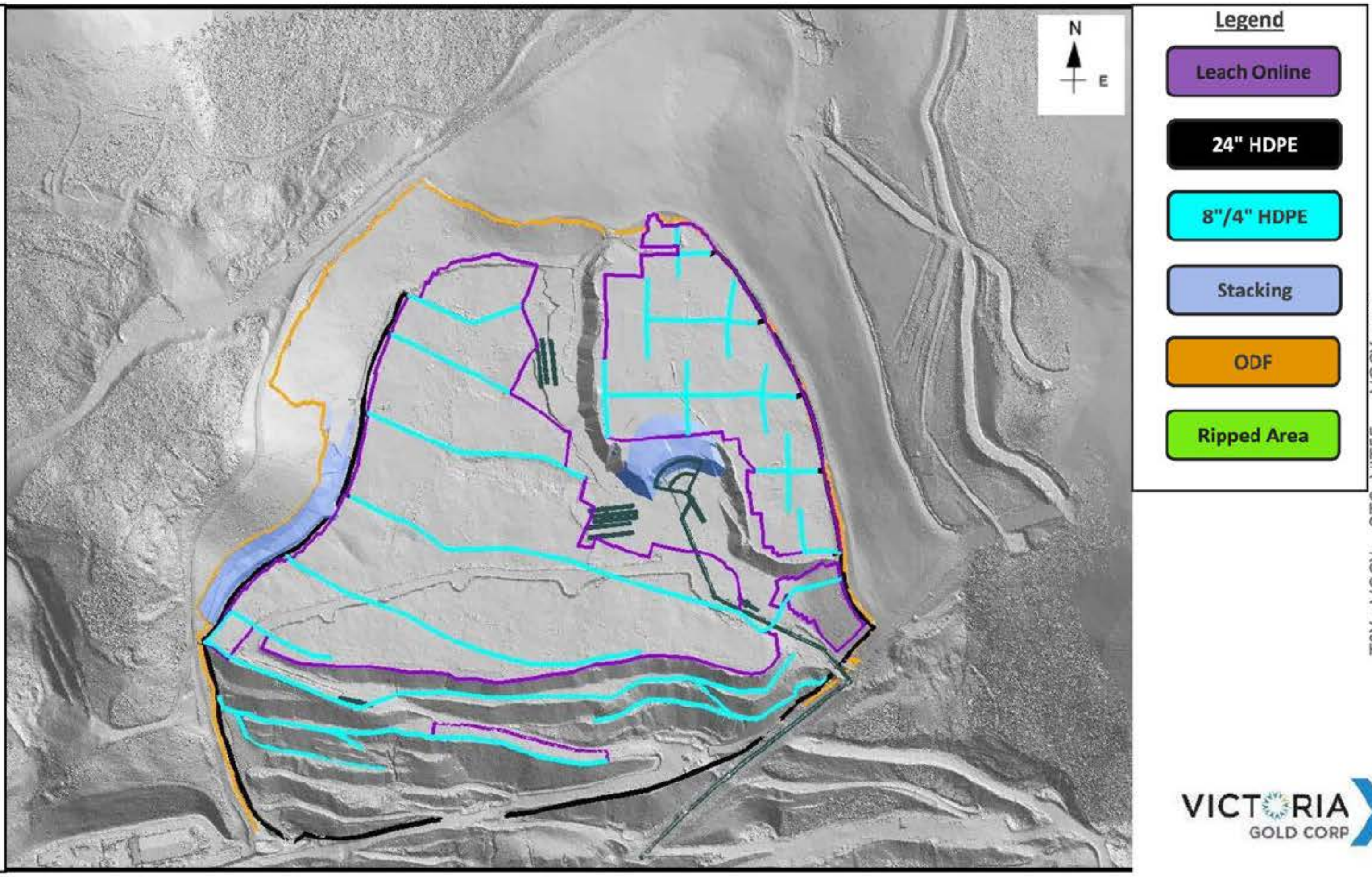
VICTORIA GOLD CORP

HLF Ore Stacking Plan 2022-08-11 to 2022-08-17

HLF Stacking: Past Week Performance

Previous Week Statistics

- **Stacked Target: 10,300 tpd**
  - Actual = 9,512 tpd
- **7 Day Leach Added:**
  - Actual = 5,990 m^2
  - Sprinklers = 0 m^2
  - ODF = 14,490 m^2
- **30 Day Leach Added:**
  - Actual = 43,426 m^2
- **Leach Area in Prep:**
  - 1041 = 0 m2



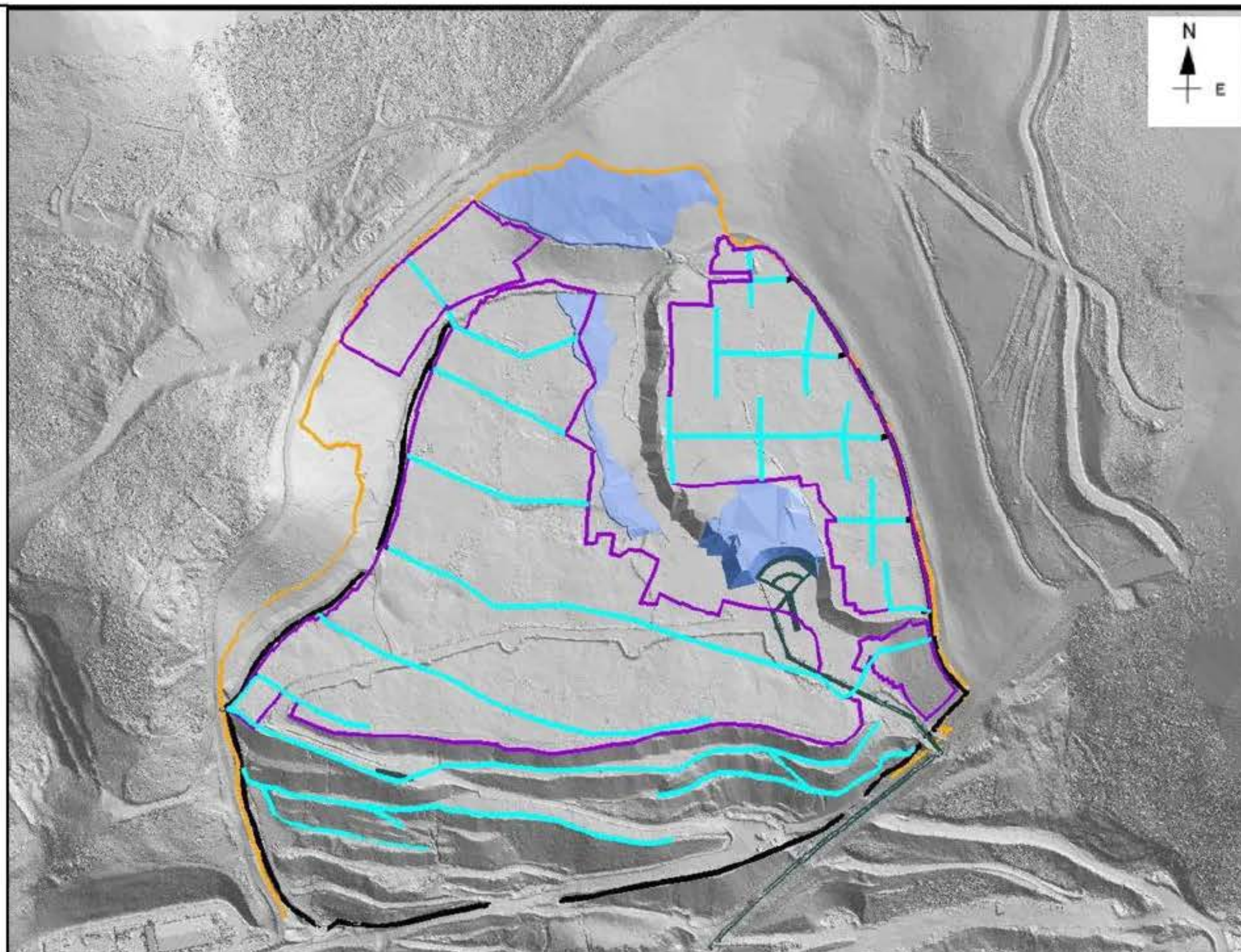
VICTORIA GOLD CORP

HLF Ore Stacking Plan 2022-08-18 to 2022-08-24

HLF Stacking: Past Week Performance

Previous Week Statistics

- **Stacked Target: 30,850 tpd**
  - Actual = 22,904 tpd
- **7 Day Leach Added:**
  - Actual = 0 m^2
  - ODF = 2,800 m^2
- **30 Day Leach Added:**
  - Actual = 34,081 m^2
- **Leach Area in Prep:**
  - 1041 = 4,500 m2



Legend

- Leach Online
- 24" HDPE
- 8"/4" HDPE
- Stacking
- ODF
- Ripped Area

TSX : VGCX OTC: VITFF VGCX.com

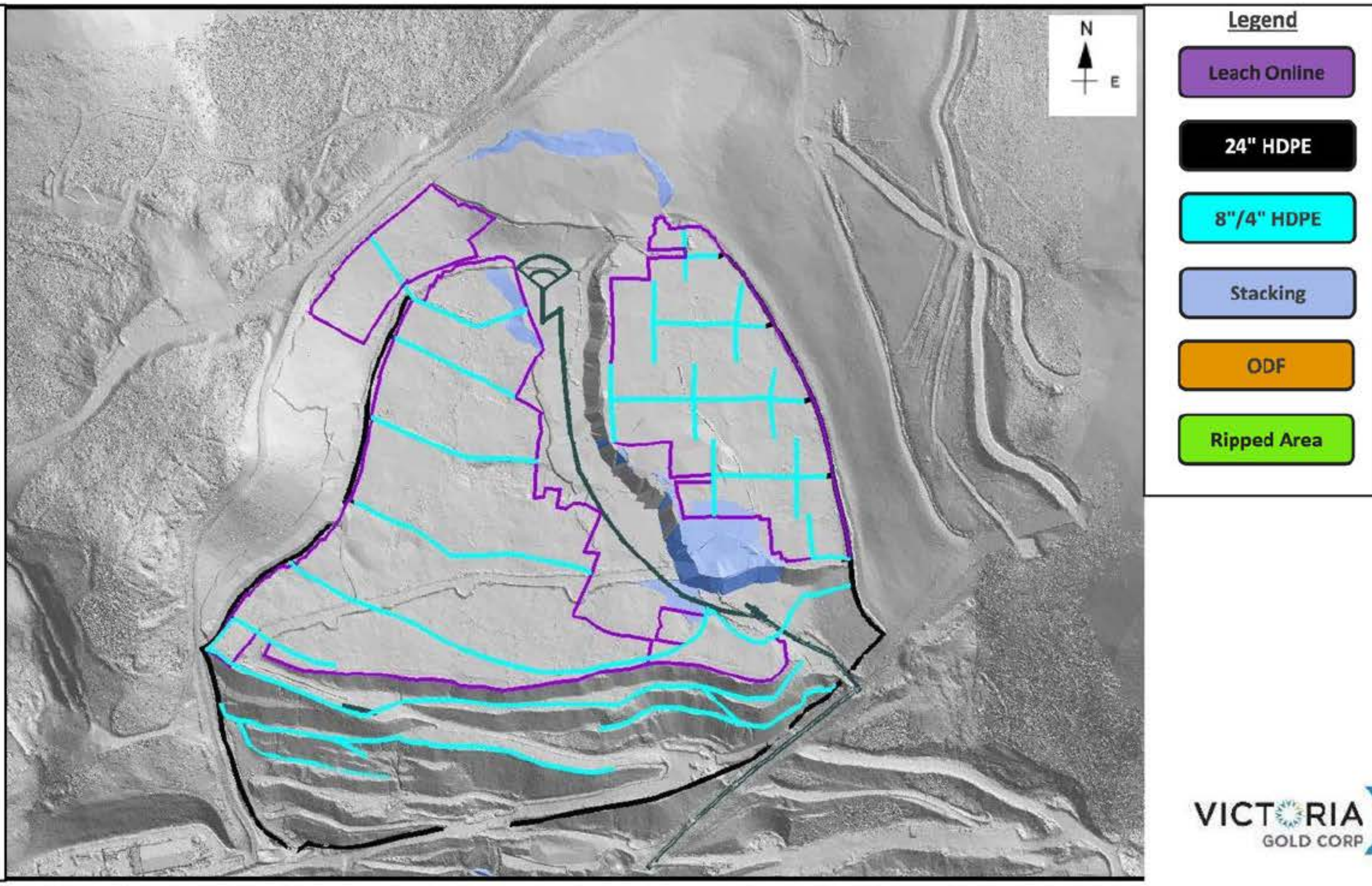
VICTORIA GOLD CORP

HLF Ore Stacking Plan 2022-08-25 to 2022-08-31

HLF Stacking: Past Week Performance

Previous Week Statistics

- **Stacked Target: 33,420 tpd**
  - Actual = 30,465 tpd
- **7 Day Leach Added:**
  - Actual = 8,775 m^2
  - ODF = 5,658 m^2
- **30 Day Leach Added:**
  - Actual = 48,514 m^2
- **Leach Area in Prep:**
  - 1041 = 4,000 m2



TSX : VGCX OTC: VITFF VGCX.com

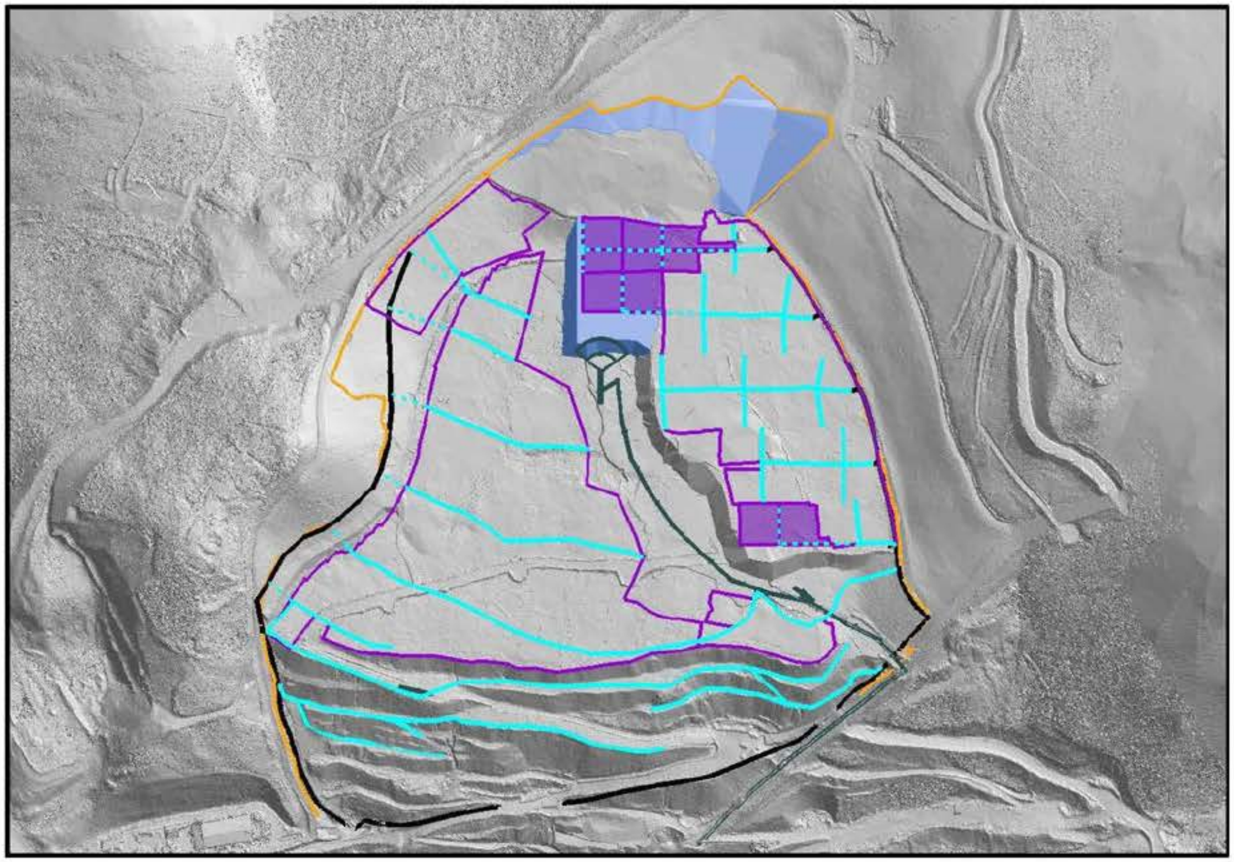
VICTORIA GOLD CORP

HLF Ore Stacking Plan 2022-09-01 to 2022-09-07

HLF Stacking: Past Week Performance

Previous Week Statistics

- **Stacked Target: 33,420 tpd**
  - Actual = 28,070 tpd
- **7 Day Leach Added:**
  - Actual = 12,623 m²
- **30 Day Leach Added:**
  - Actual = 36,694 m²
- **Leach Area in Prep:**
  - 1041 = 0 m2



Legend

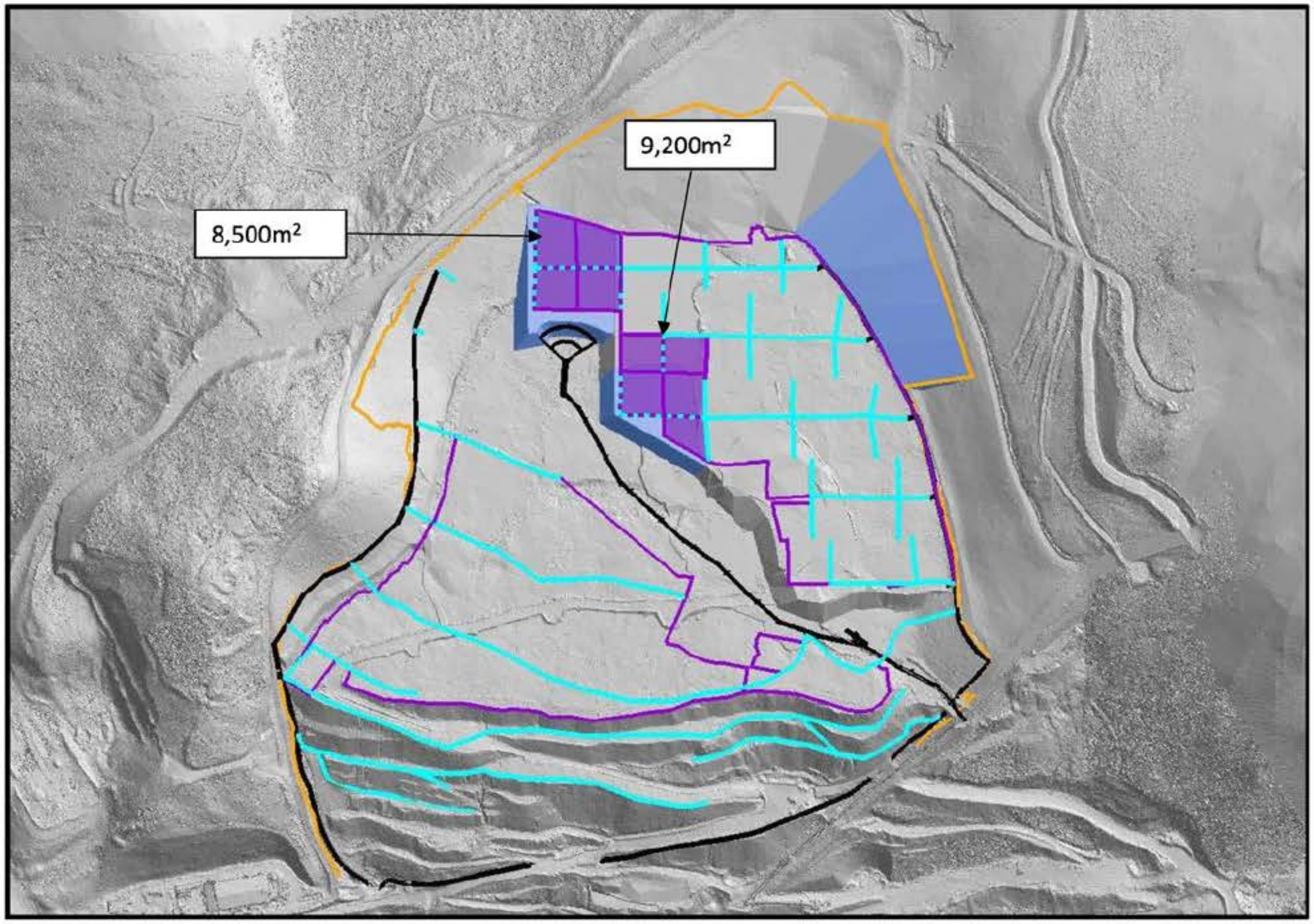
- Leach Online
- 24" HDPE
- 8"/4" HDPE
- Stacking
- ODF
- Ripped Area

TSX : VGCX OTC: VITFF VGCX.com

VICTORIA GOLD CORP

HLF Ore Stacking Plan 2022-09-08 to 2022-09-14 (inferred from plan)

HLF Stacking: Three week look-ahead



Path forward Requirements:

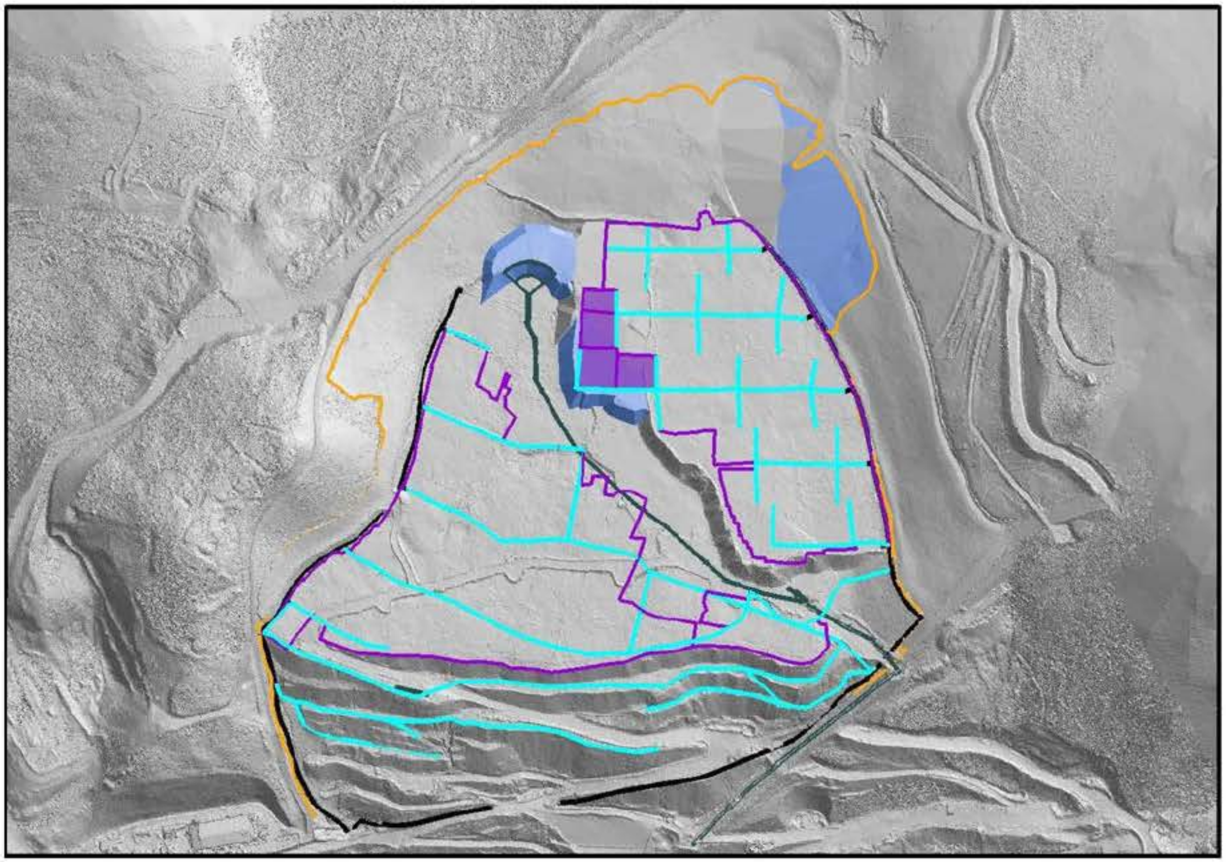
- Continued focus on 1041 grid leaching system
- GH realignment estimated Sept 13 – require 14 GH
- Reconnect 1029 to WDL
- Proper realignment prep works
- Maintaining 300' stacking width to align with leaching schedule
- Fusing for the EDL lift plan
- Minimum 5ktpd ODF

HLF Ore Stacking Plan 2022-09-15 to 2022-09-21

HLF Stacking: Past Week Performance

Previous Week Statistics

- **Stacked Target: 33,420 tpd**
  - Actual = 28,846 tpd
- **7 Day Leach Added:**
  - Actual = 6,497 m²
- **30 Day Leach Added:**
  - Actual = 37,003m²
- **Leach Area in Prep:**
  - 1041 = 0 m2



Legend

- Leach Online
- 24" HDPE
- 8"/4" HDPE
- Stacking
- ODF
- Ripped Area

TSX : VGCX OTC: VITFF VGCX.com

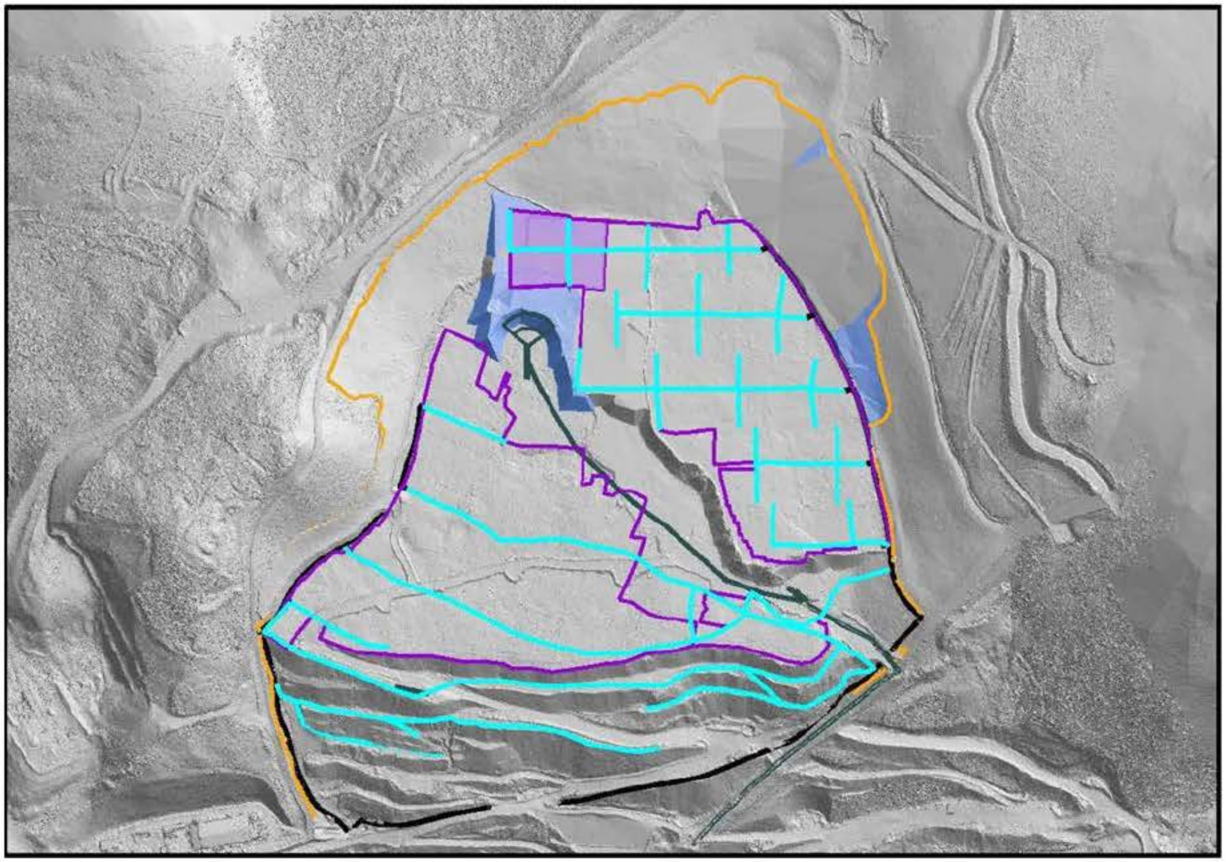
VICTORIA GOLD CORP

HLF Ore Stacking Plan 2022-09-22 to 2022-09-28

HLF Stacking: Past Week Performance

Previous Week Statistics

- **Stacked Target: 33,420 tpd**
  - Actual = 28,623 tpd
- **7 Day Leach Added:**
  - Actual = 8,743 m^2
- **30 Day Leach Added:**
  - Actual = 34,340 m^2
- **Leach Area in Prep:**
  - 1041 = 2,500 m^2

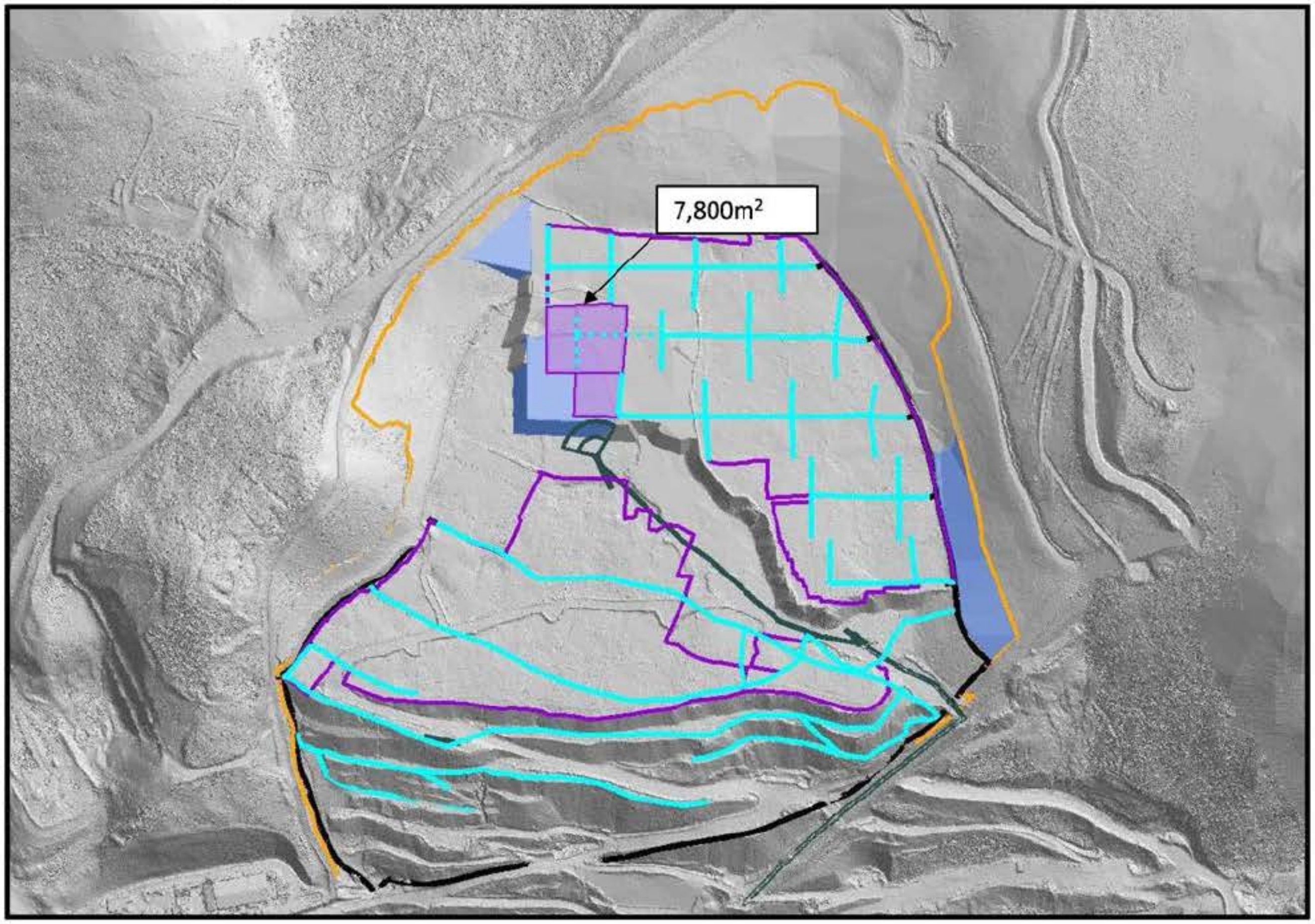


Legend

- Leach Online
- 24" HDPE
- 8"/4" HDPE
- Stacking
- ODF
- Ripped Area

HLF Ore Stacking Plan 2022-09-29 to 2022-10-03 (inferred from plan)

HLF Stacking: One week look-ahead



- Assumptions:
  - Stacking the 1041 at a rate of 36ktpd
  - Minimum 6ktpd ODF placement to the 1053 el. Based on arrival of 4"
  - Continued collection lines to the 1053 el.
  - Rehandle material to North portion of next retreat to push realignment to Oct. 6 down day
  - Remove W3-W4 and place at 1043 el.
- Follow-up on Key Issues:
  - 4" Collection lines

HLF Ore Stacking Plan 2022-10-04 to 2022-10-10 (inferred from plan)

HLF – October 4th – October 17th

Stacking
1. Week 1 = 62,000t
2. W1 ODF = 20,000t
3. Week 2 = 172,000t
4. W2 ODF = 32,000t

Material Type
1. 1041 = Fresh/altered granodiorite
2. ODF = High permeability

GH Moves
1. 35kt Pull GH211
2. 100kt Realignment

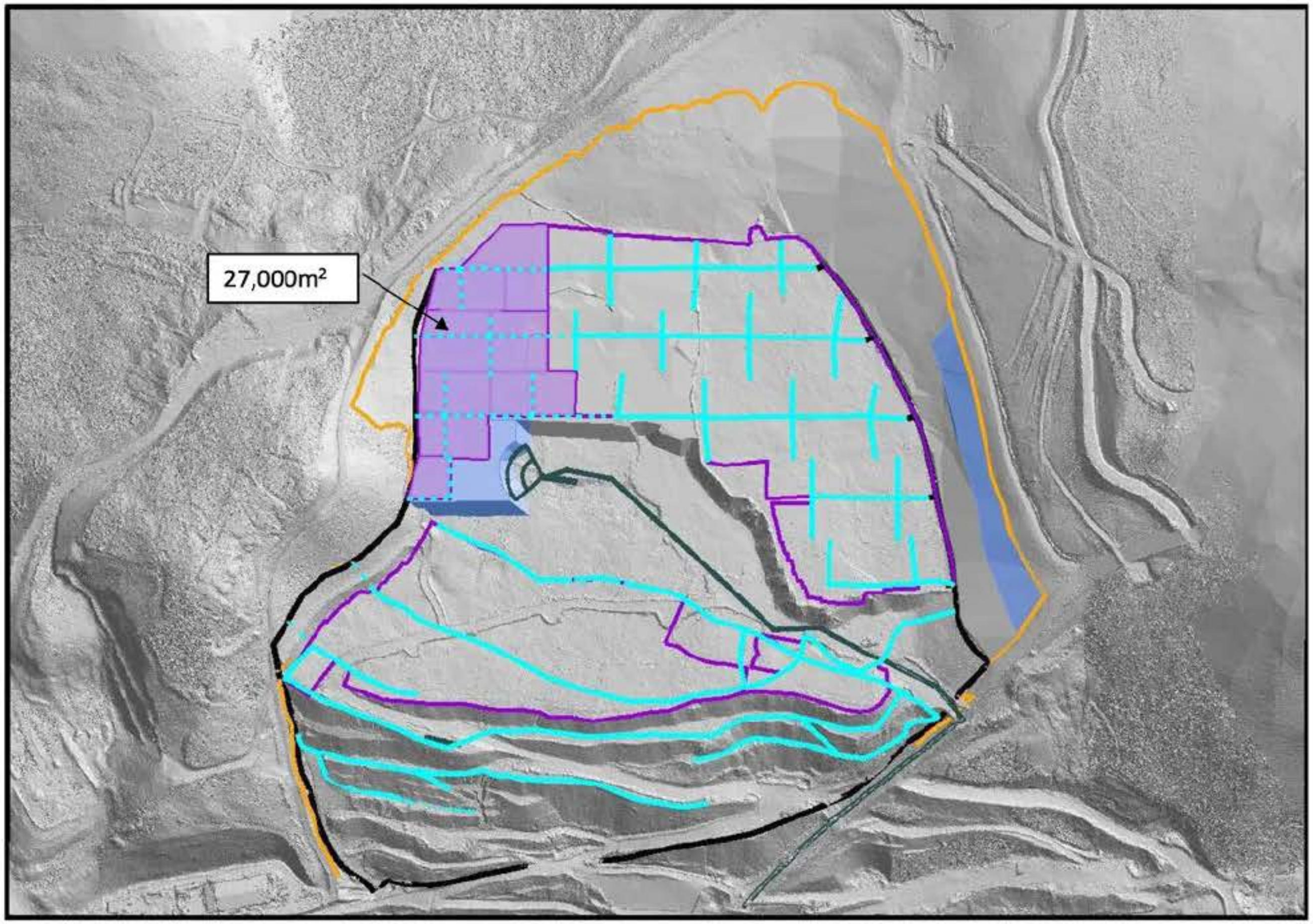
Legend
- Leach Area
- Distribution / Leach Line
- W1 Stacking
- W2 Stacking

TSX : VGCX OTC: VITFF VGCX.com

VICTORIA GOLD CORP

HLF Ore Stacking Plan 2022-10-11 to 2022-10-17 (inferred from plan)

HLF Stacking: Three week look-ahead



- Path forward Requirements:
  - Move full WDL to 1041 el.
  - Connect 12" laterals to WDL
  - Reconnect 1029 to WDL
  - Fusing for the EDL lift plan
  - Finish ODF to the 1065 extent

HLF Ore Stacking Plan 2022-10-18 to 2022-10-24 (inferred from plan)

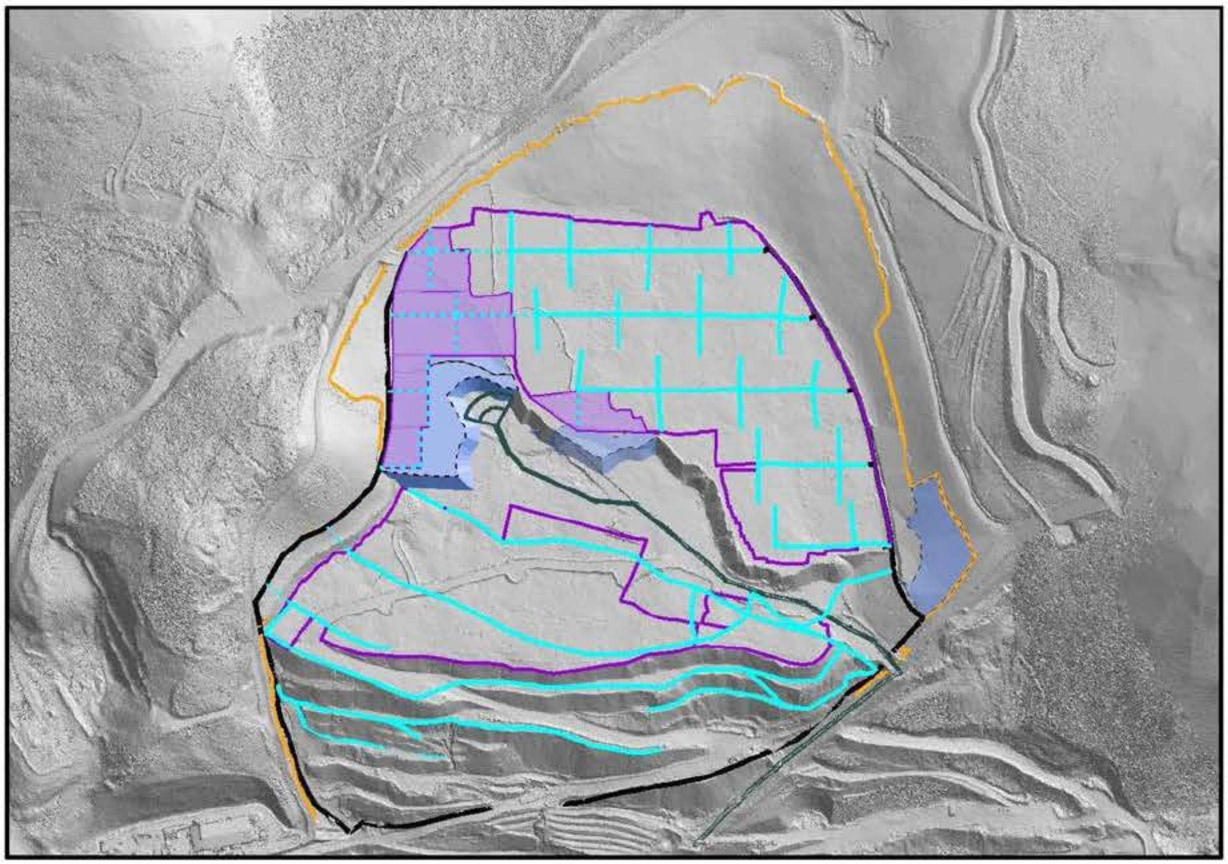
HLF – October 25th – November 7th

Stacking
1. Week 1 = 208,000t
2. W1 ODF = 20,000t
3. Week 2 = 228,000t

Material Type
1. 1041 = Fresh/altered granodiorite
2. ODF = High permeability

GH Moves
1. Oct 27th Realignment
2. 98kt Pull GH220

Legend
- Leach Area
- Distribution / Leach Line
- W1 Stacking
- W2 Stacking



TSX : VGCX OTC: VITFF VGCX.com

VICTORIA GOLD CORP

HLF Ore Stacking Plan 2022-10-25 to 2022-10-31 (inferred from plan)

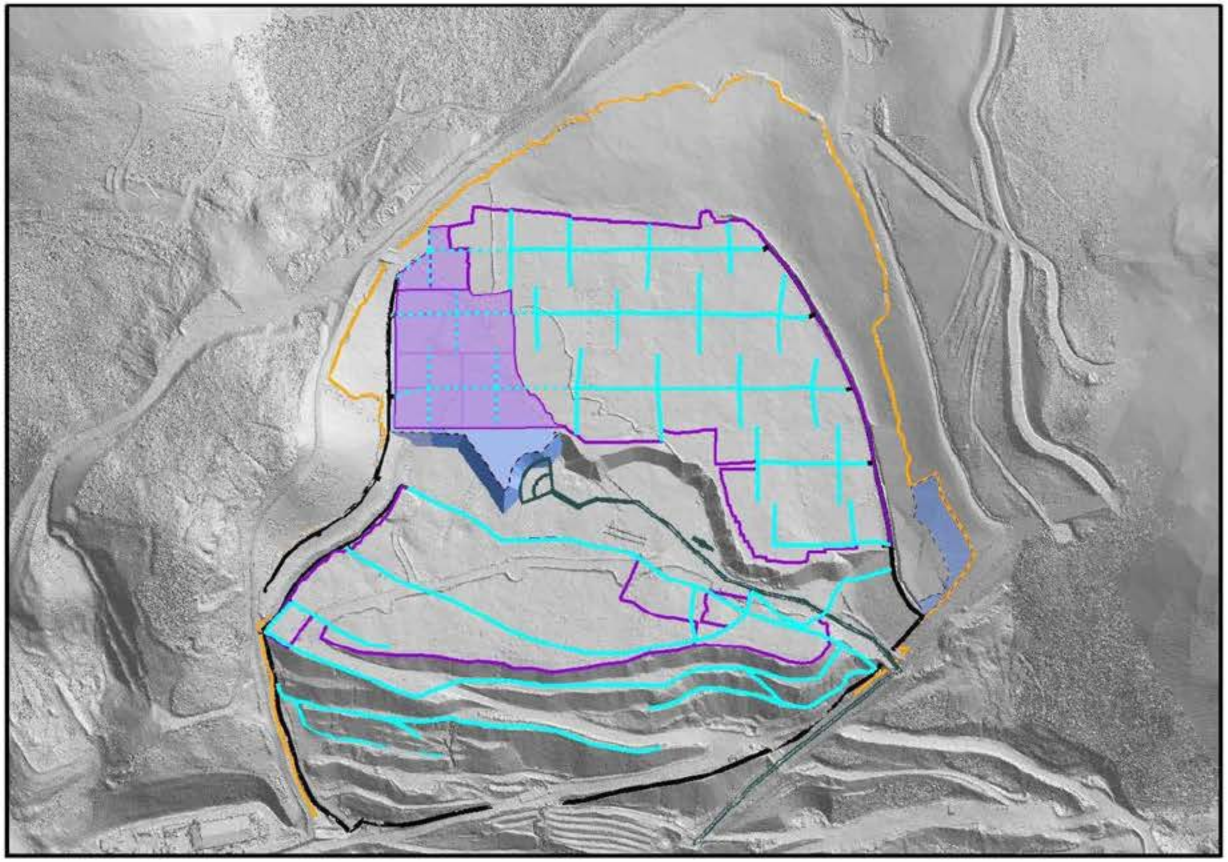
HLF – November 1st – November 14th

Stacking
1. Week 1 = 220,000t
2. W1 ODF = 8,000t
3. Week 2 = 228,000t

Material Type
1. 1041 = Fresh/altered granodiorite
2. ODF = High permeability

GH Moves
1. Nov 3rd rotate BF
2. Nov 6th pull GH220

Legend
- Leach Area
- Distribution / Leach Line
- W1 Stacking
- W2 Stacking



TSX : VGCX OTC: VITFF VGCX.com

VICTORIA GOLD CORP

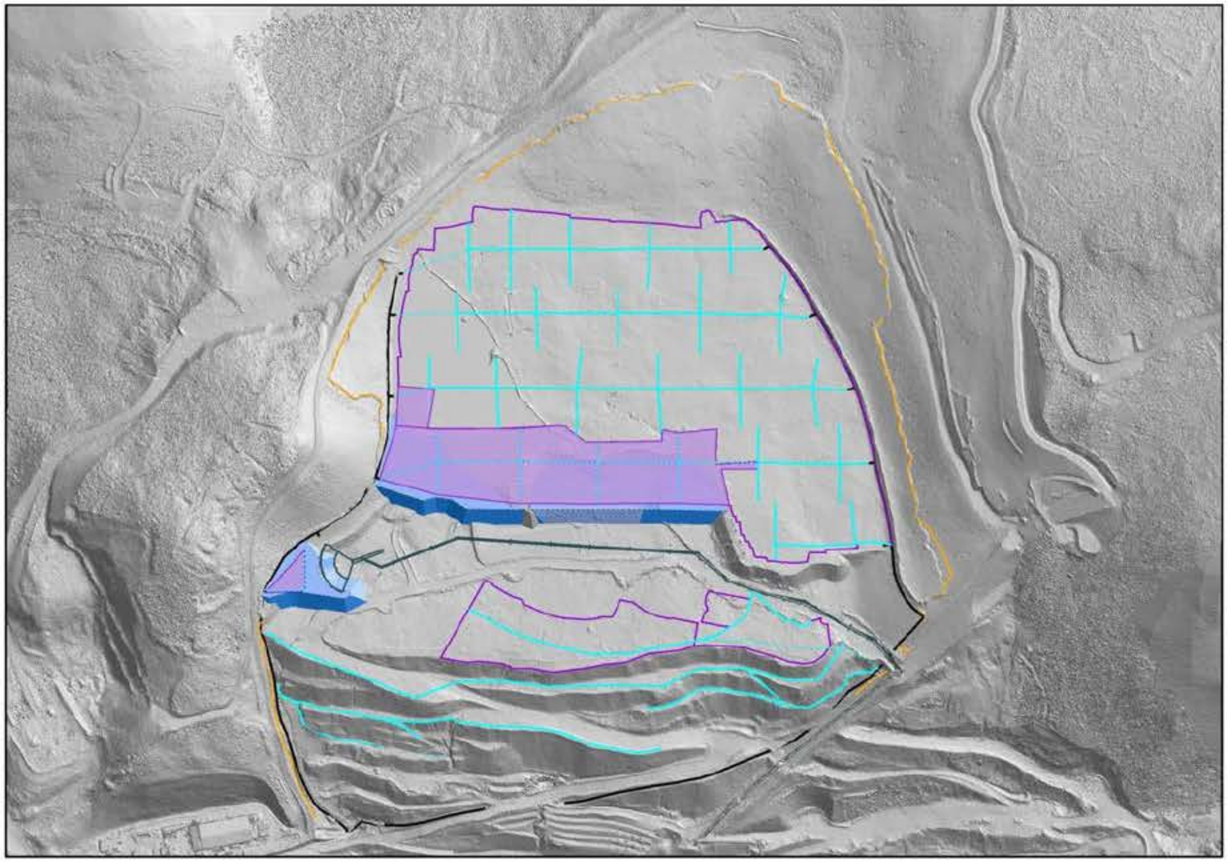
HLF Ore Stacking Plan 2022-11-15 to 2022-11-21 (inferred from plan)

HLF – November 22nd – December 5th

Stacking
1. Week 1 = 202,666t
2. Week 2 = 202,666t

GH Moves
1. Nov 24th pull GH212
2. Nov 26th pull GH218
3. Dec 1st realignment

Legend
- Leach Area
- Distribution / Leach Line
- W1 Stacking
- W2 Stacking



TSX : VGCX OTC: VITFF VGCX.com

VICTORIA GOLD CORP

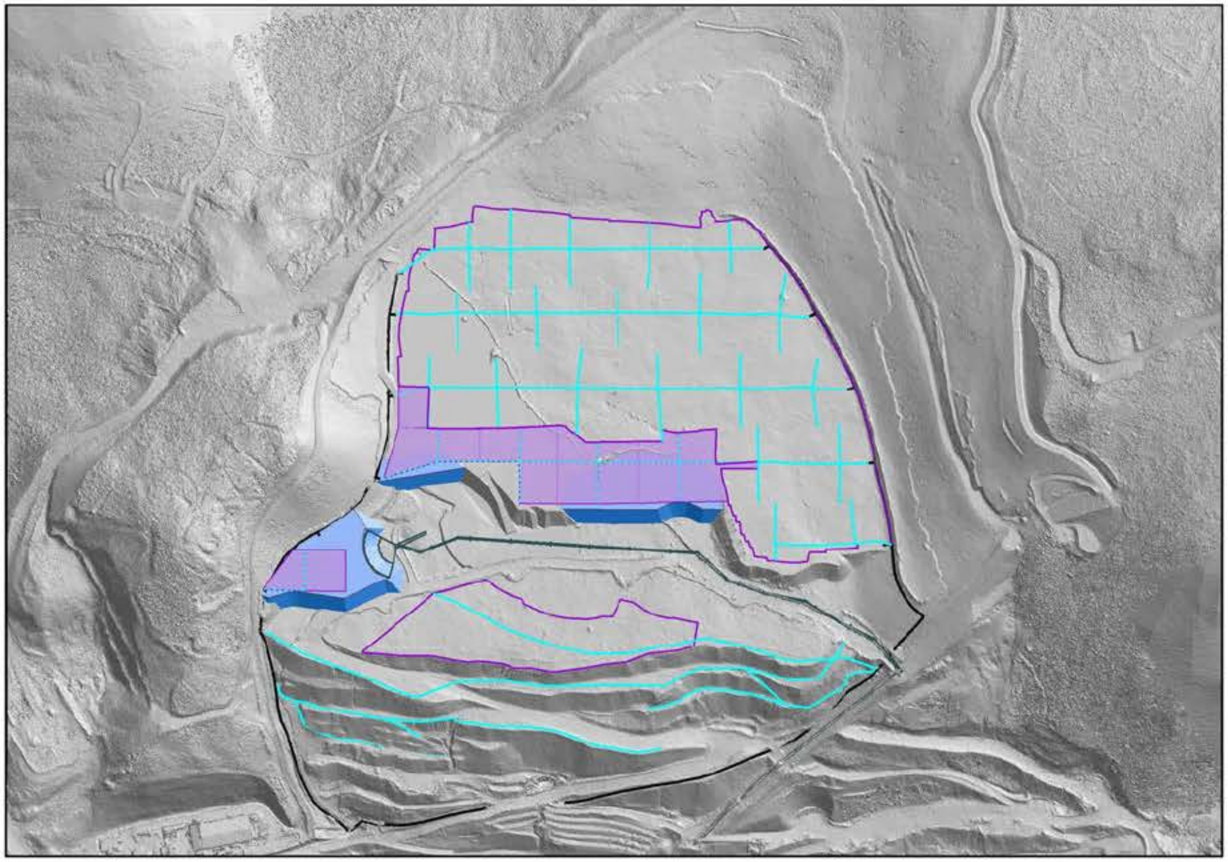
HLF Ore Stacking Plan 2022-11-22 to 2022-11-28 (inferred from plan)

HLF – November 22nd – December 5th

Stacking
1. Week 1 = 186,560t
2. Week 2 = 202,560t

GH Moves
1. 89kt pull GH218
2. 98kt realignment

Legend
- Leach Area
- Distribution / Leach Line
- W1 Stacking
- W2 Stacking



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VICTORIA GOLD CORP

HLF Ore Stacking Plan 2022-12-13 to 2022-12-19 (inferred from plan)

HLF – December 20th 2022 – January 2nd 2023

Stacking

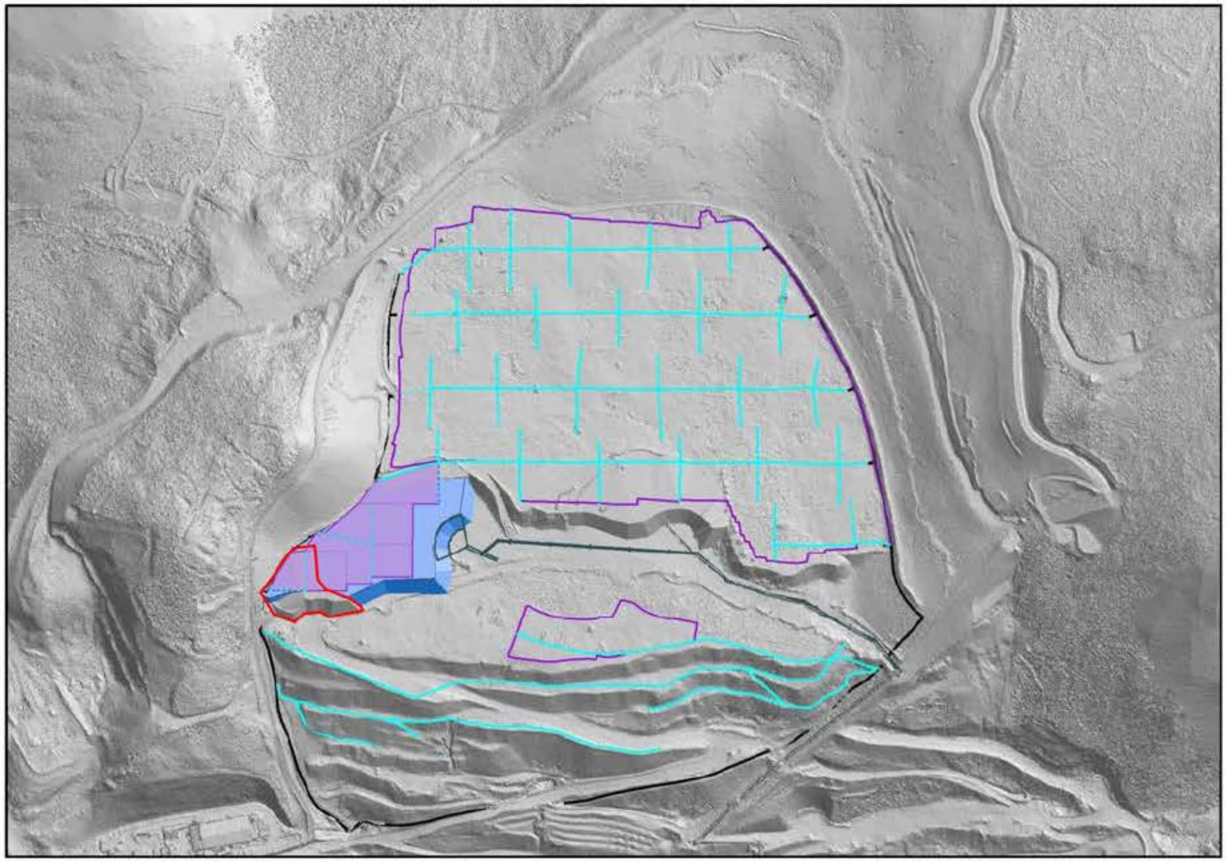
1. Week 1 = 158,333t
2. Week 2 = 158,333t

GH Moves

1. 13kt Pull GH219
2. 75kt Pull GH212
3. 135kt Pull GH211
4. 85kt Pull GH214
5. 130kt Pull GH213

Legend

- Leach Area
- Distribution / Leach Line
- Stacking



TSX : VGCX OTC: VITFF VGCX.com

VICTORIA GOLD CORP

HLF Ore Stacking Plan 2022-12-20 to 2022-12-21 (inferred from plan)

HLF – December 27th 2022 – January 9th 2023

Stacking

1. Week 1 = 100,000t
2. Week 2 = 158,333t

GH Moves

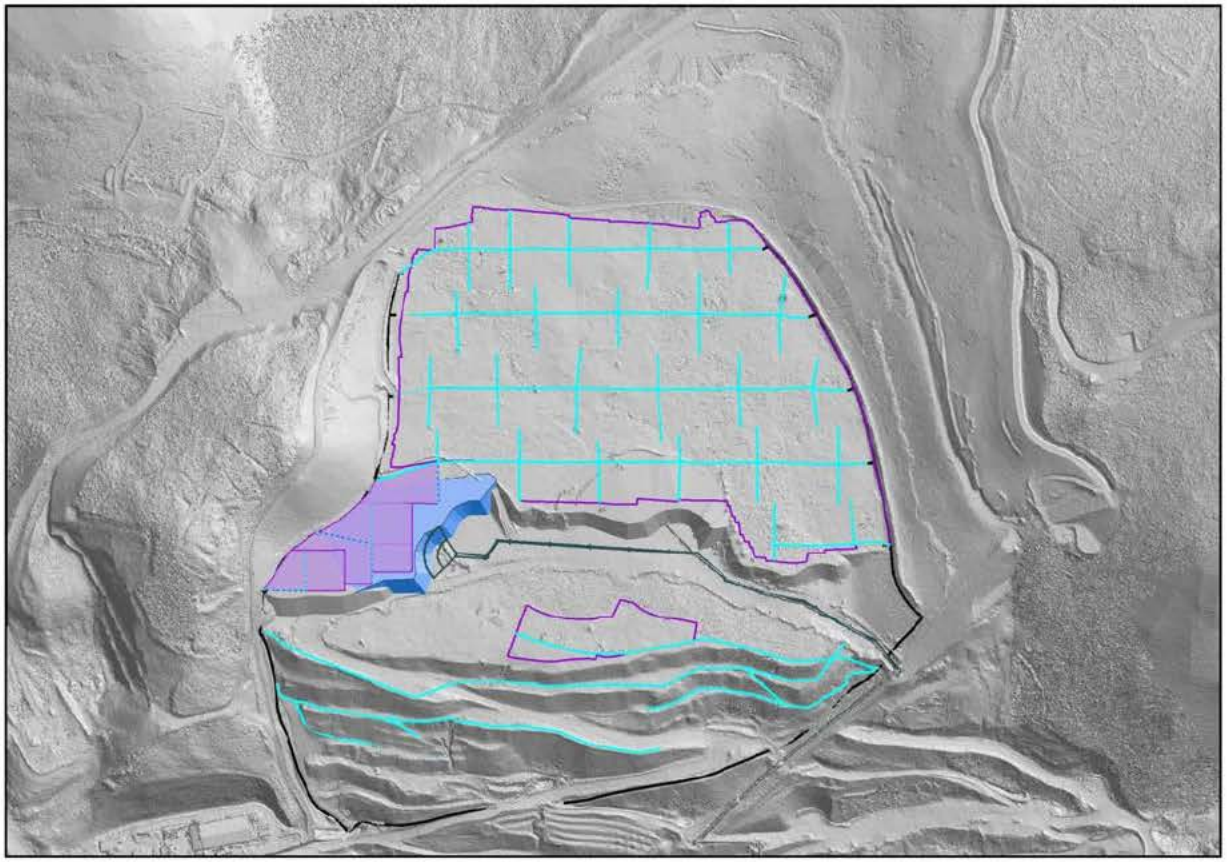
1. 55kt Pull GH212
2. 130kt Pull GH211
3. 146kt Pull GH214
4. 98kt Pull GH213

Legend

Leach Area

Distribution / Leach Line

Stacking



TSX : VGCX OTC: VITFF VGCX.com

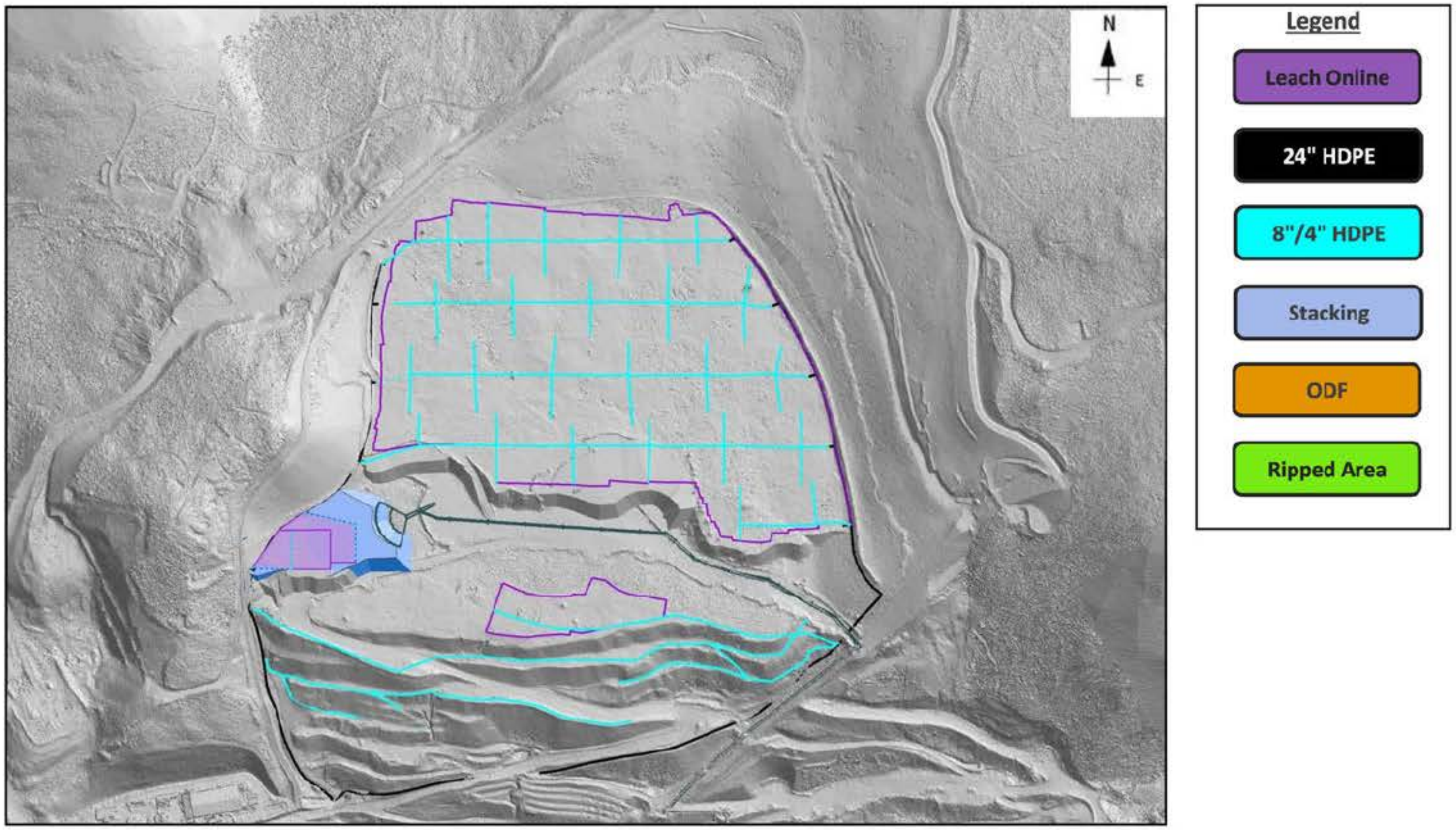
VICTORIA GOLD CORP

HLF Ore Stacking Plan 2022-12-22 to 2022-12-28

HLF Stacking: Past 7 Day Performance

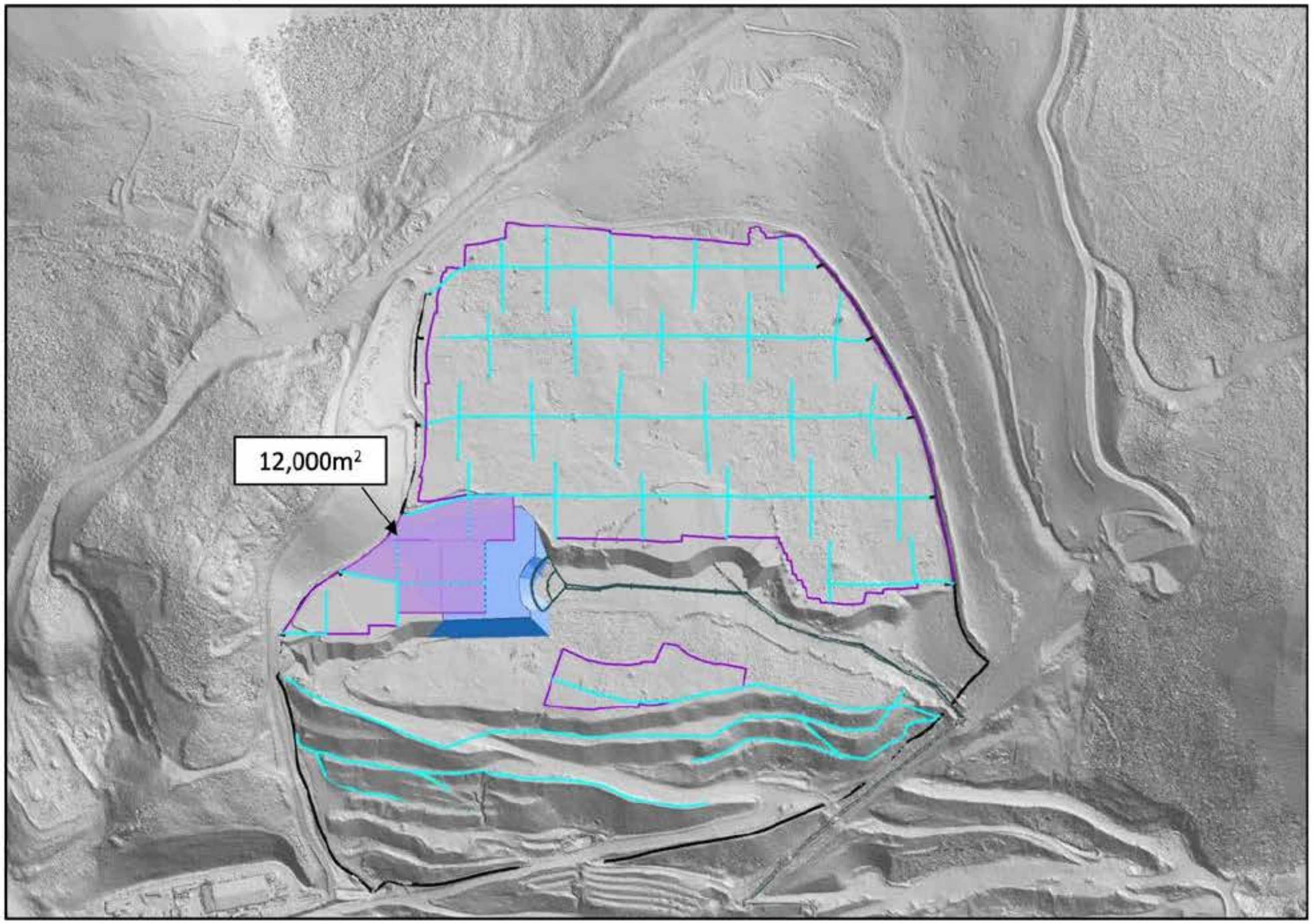
Previous Week Statistics

- **Stacked Target: 32,500 tpd**
  - Actual = 23,642 tpd
- **7 Day Leach Added:**
  - Actual = 2,300 m^2
- **30 Day Leach Added:**
  - Actual = 26,676 m^2
- **Area in Prep:**
  - Actual = 0 m^2



HLF Ore Stacking Plan 2022-12-29 to 2023-01-04 (inferred from plan)

HLF Stacking: Three week look-ahead



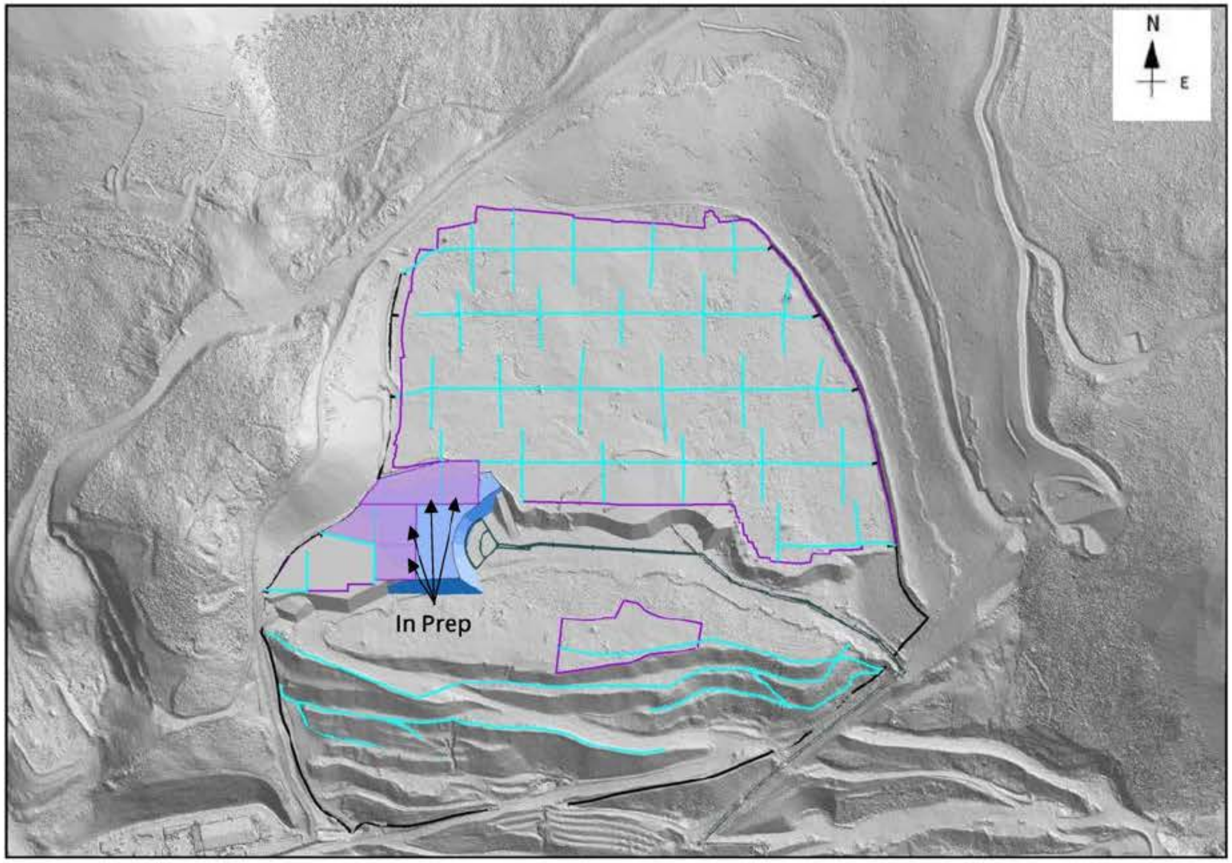
- Assumptions:
  - Stacking width widens past 300' normal design retreat due to North Void
  - 12" extents to follow survey guidance based on future connections to EDL
  - Small down for EDL valve tie ins for the 1053 installation in January
  - 1053 EDL installation in early January

HLF Ore Stacking Plan 2023-01-05 to 2023-01-11

HLF Stacking: Past 7 Day Performance

Previous Week Statistics

- **Stacked Target: 26,600 tpd**
  - Actual = 28,383 tpd
- **7 Day Leach Added:**
  - Actual = 4,302 m^2
- **30 Day Leach Added:**
  - Actual = 13,237 m^2
- **Area in Prep:**
  - Actual ~ 6000 m^2



Legend

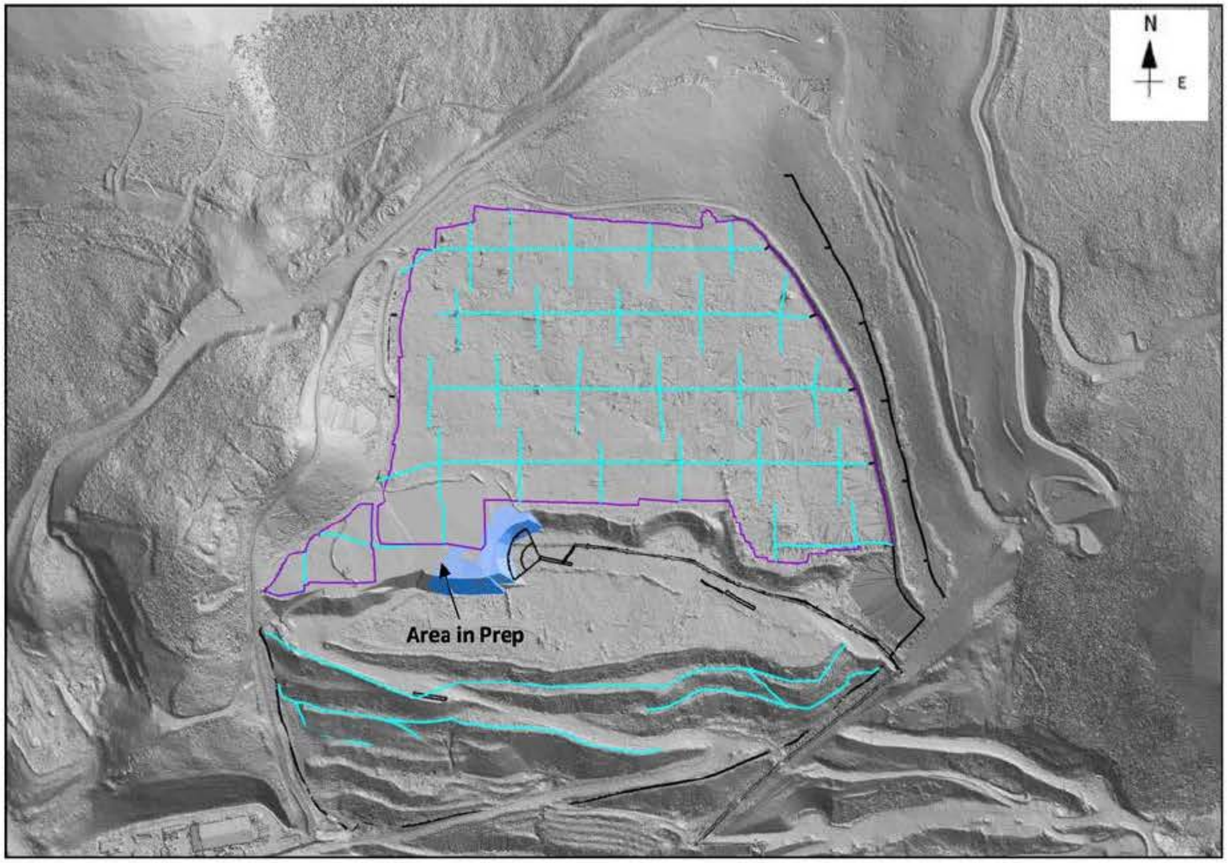
- Leach Online
- 24" HDPE
- 8"/4" HDPE
- Stacking
- ODF
- Ripped Area

HLF Ore Stacking Plan 2023-01-12 to 2023-01-18

HLF Stacking: Past 7 Day Performance

Previous Week Statistics

- **Stacked Target: 26,600 tpd**
  - Actual = 13,540 tpd
- **7 Day Leach Added:**
  - Actual = 10,145 m^2
- **30 Day Leach Added:**
  - Actual = 17,309 m^2
- **Area in Prep:**
  - Actual ~ 3000m^2



Legend

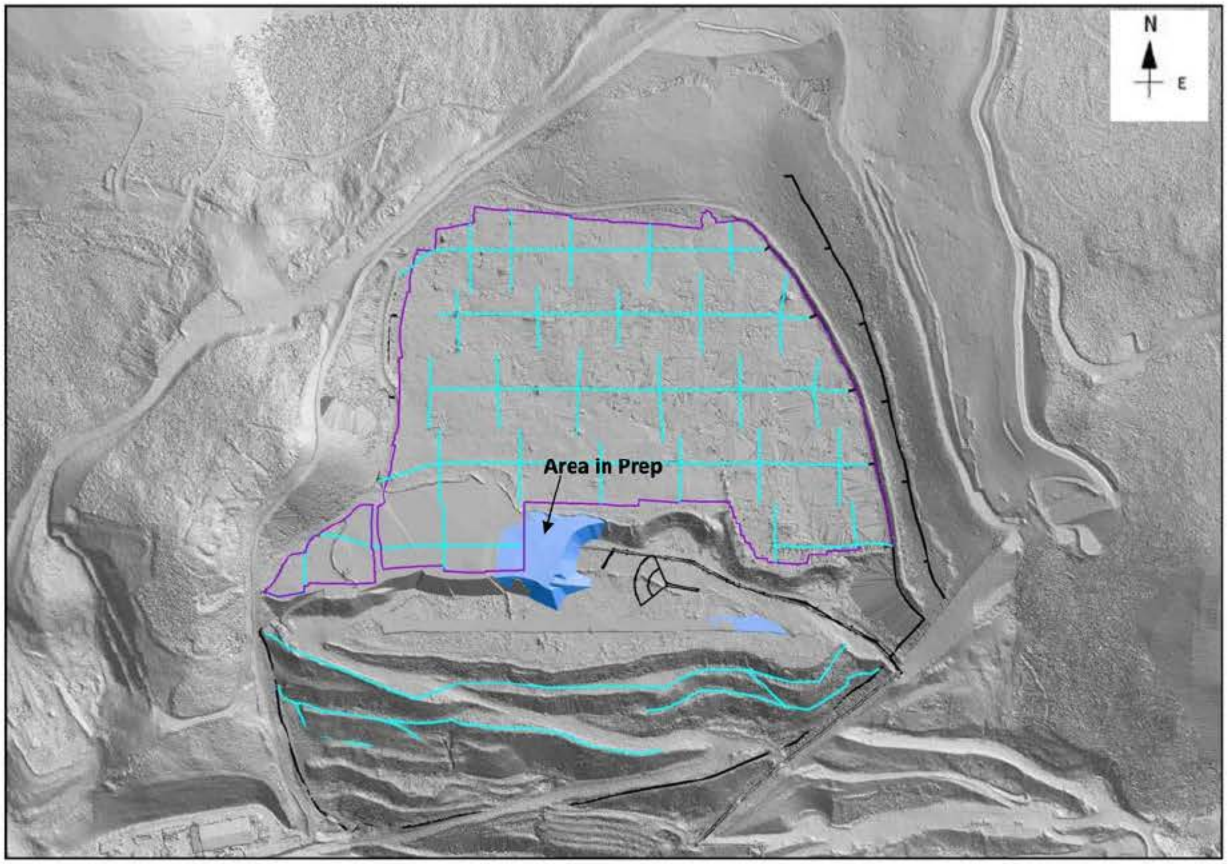
- Leach Online
- 24" HDPE
- 8"/4" HDPE
- Stacking
- ODF
- Ripped Area

HLF Ore Stacking Plan 2023-01-19 to 2023-01-25

HLF Stacking: Past 7 Day Performance

Previous Week Statistics

- **Stacked Target: 26,600 tpd**
  - Actual = 26,638 tpd
- **7 Day Leach Added:**
  - Actual = 8053 m²
- **30 Day Leach Added:**
  - Actual = 25,332 m²
- **Area in Prep:**
  - Actual ~ 2100m²



Legend

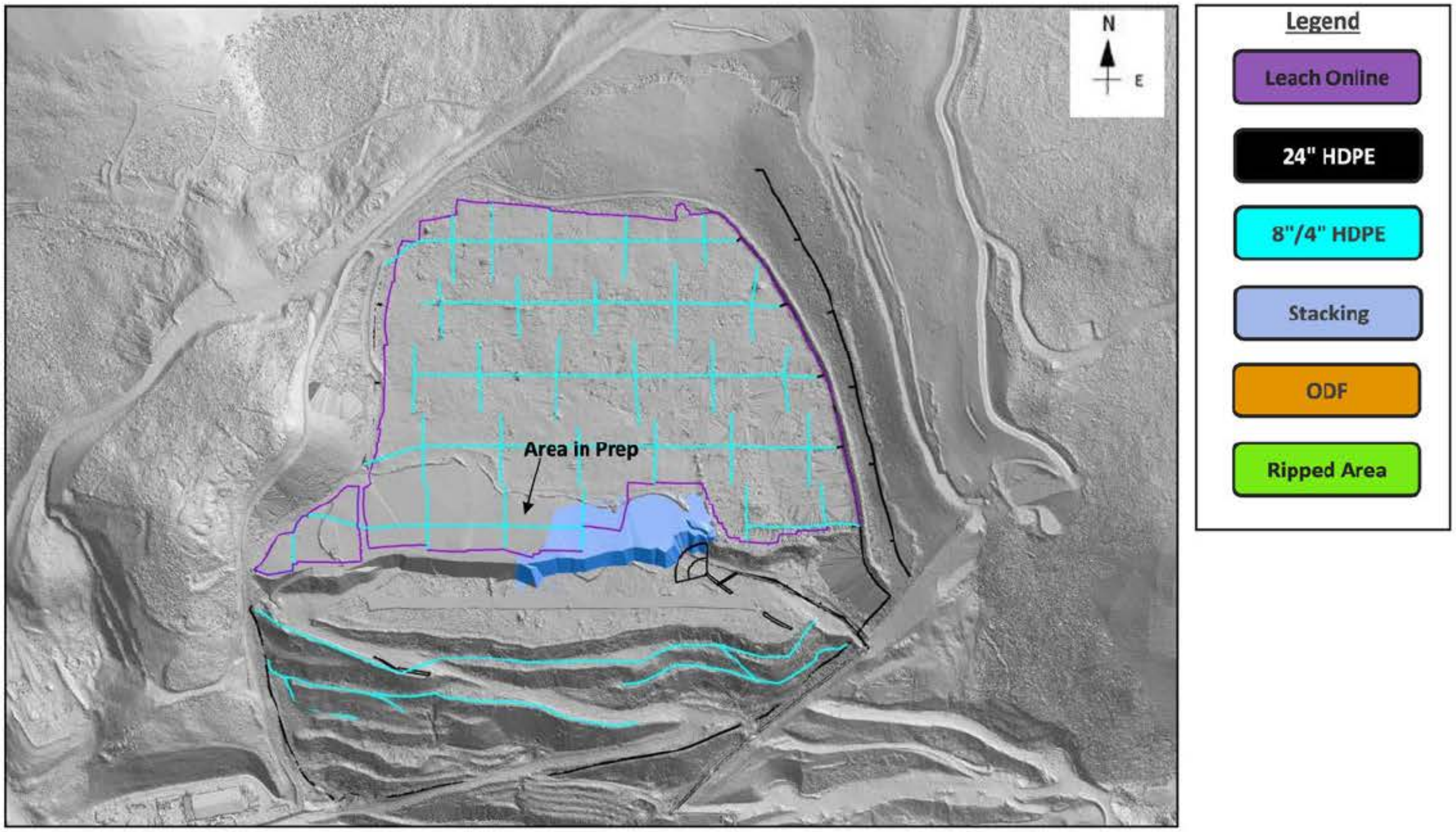
- Leach Online
- 24" HDPE
- 8"/4" HDPE
- Stacking
- ODF
- Ripped Area

HLF Ore Stacking Plan 2023-01-26 to 2023-02-01

HLF Stacking: Past 7 Day Performance

Previous Week Statistics

- **Stacked Target: 26,600 tpd**
  - Actual = 24,830 tpd
- **7 Day Leach Added:**
  - Actual = 7,859 m^2
- **30 Day Leach Added:**
  - Actual = 33,248 m^2
- **Area in Prep:**
  - Actual ~ 5100m^2

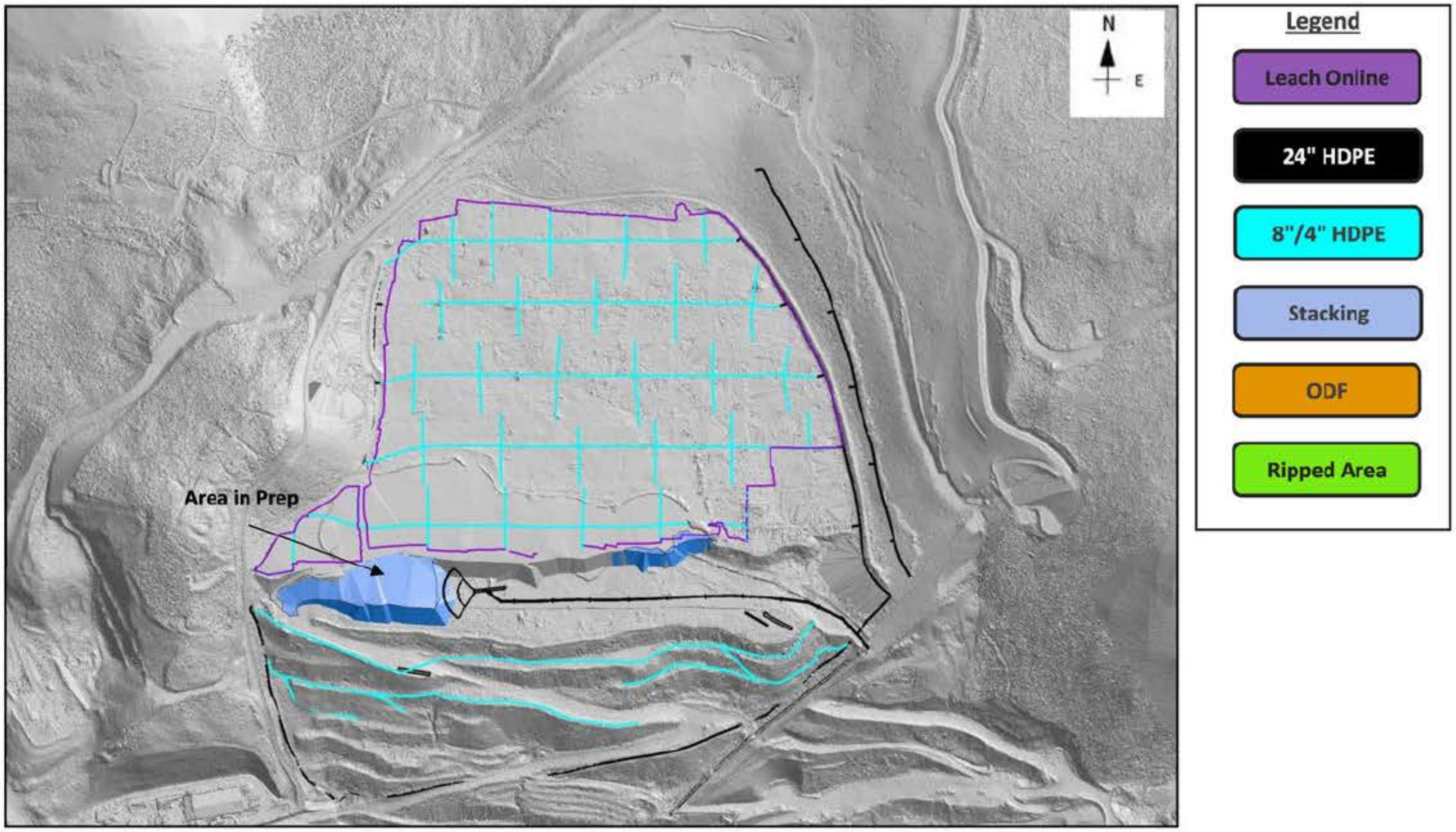


HLF Ore Stacking Plan 2023-02-02 to 2023-02-08

HLF Stacking: Past 7 Day Performance

Previous Week Statistics

- **Stacked Target: 27,000 tpd**
  - Actual = 24,727 tpd
- **7 Day Leach Added:**
  - Actual = 7,063 m^2
- **30 Day Leach Added:**
  - Actual = 35,962 m^2
- **Area in Prep:**
  - Actual ~ 2700m^2

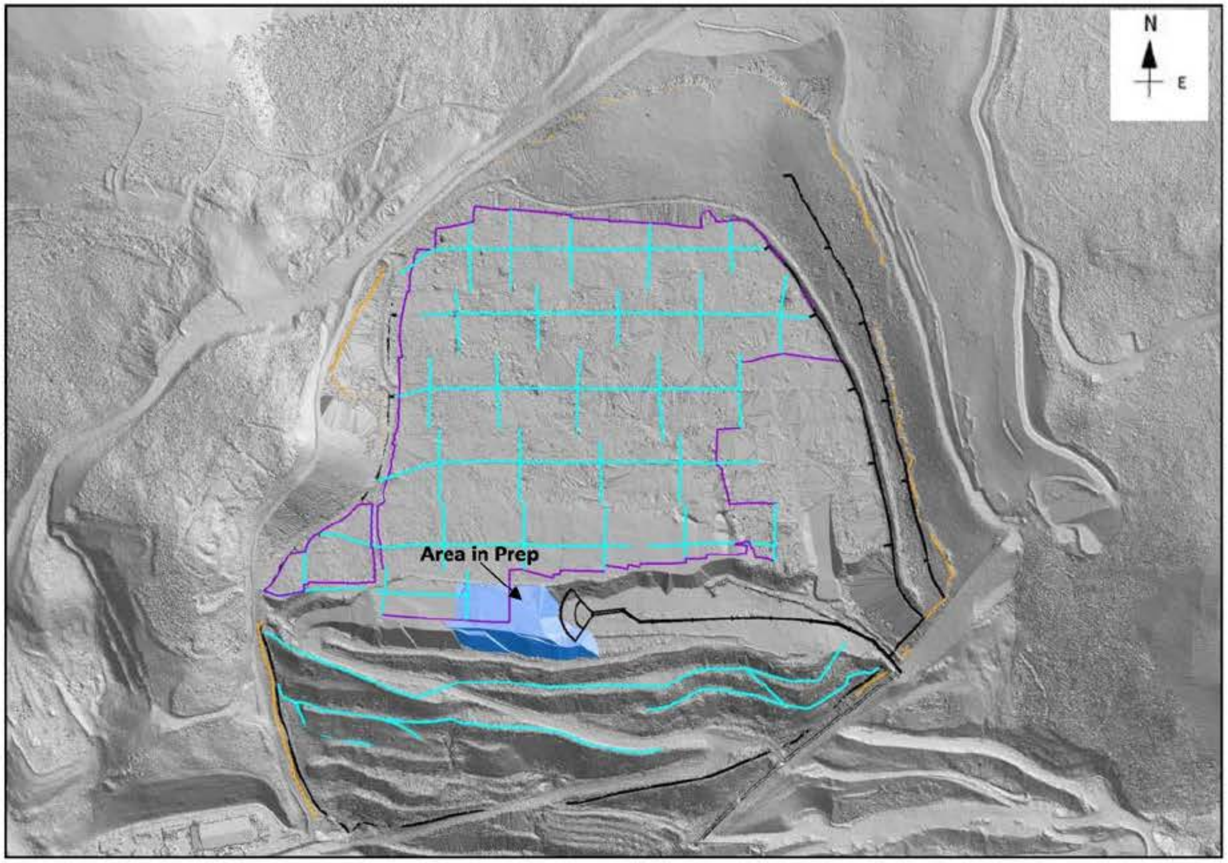


HLF Ore Stacking Plan 2023-02-09 to 2023-02-15

HLF Stacking: Past 7 Day Performance

Previous Week Statistics

- **Stacked Target: 27,000 tpd**
  - Actual = 26,099 tpd
- **7 Day Leach Added:**
  - Actual = 7,847 m^2
- **7 Day Leach Added:**
  - Actual = 21,120m^2
- **30 Day Leach Added:**
  - Actual = 34,153m^2
- **Area in Prep:**
  - Actual ~ 2600m^2



Legend

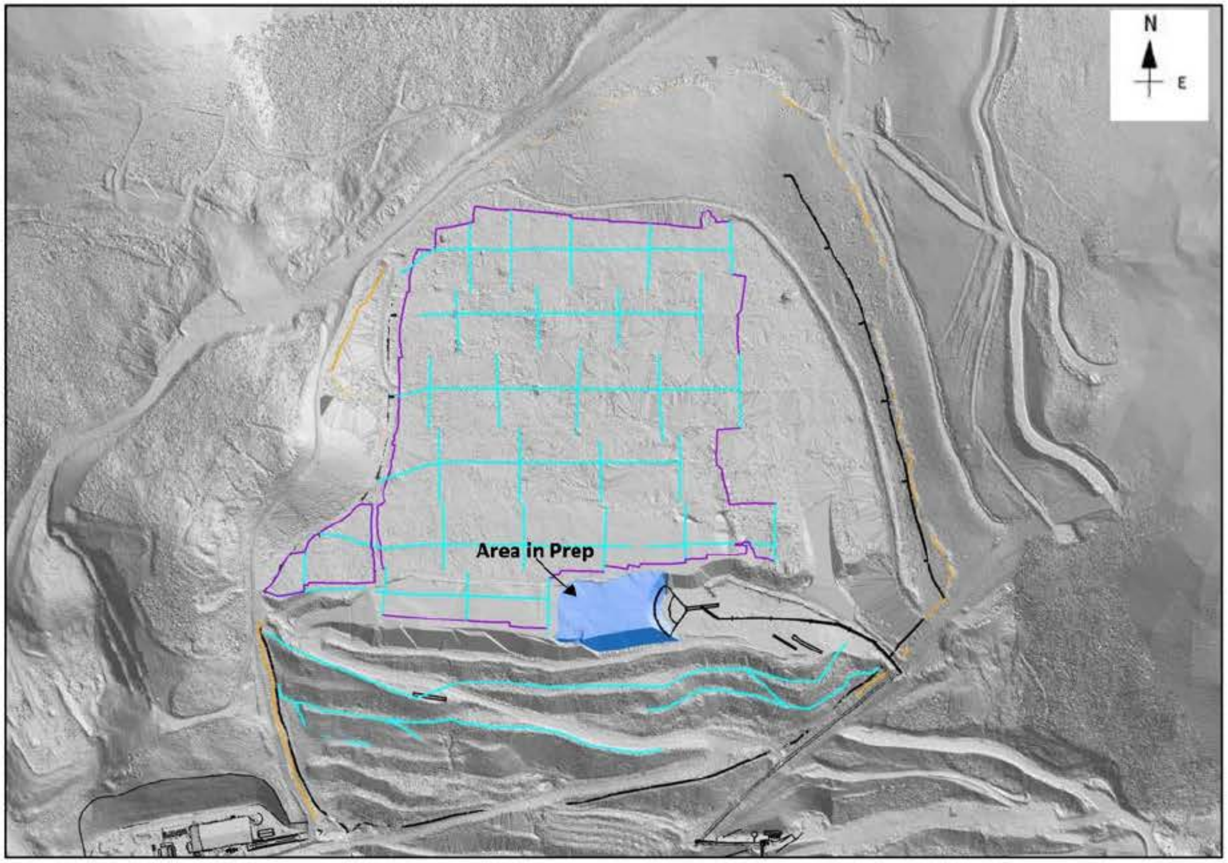
- Leach Online
- 24" HDPE
- 12"/4" HDPE
- Stacking
- ODF
- Ripped Area

HLF Ore Stacking Plan 2023-02-16 to 2023-02-22

HLF Stacking: Past 7 Day Performance

Previous Week Statistics

- **Stacked Target: 27,000 tpd**
  - Actual = 21,152 tpd
- **7 Day Leach Added:**
  - Actual = 5,331 m^2
- **7 Day Leach Removed:**
  - Actual = 10,903m^2
- **30 Day Leach Added:**
  - Actual = 30,552m^2
- **Area in Prep:**
  - Actual ~ 5800m^2



Legend

- Leach Online
- 24" HDPE
- 12"/4" HDPE
- Stacking
- ODF
- Ripped Area

HLF Ore Stacking Plan 2023-02-23 to 2023-03-01

HLF Stacking: Past 7 Day Performance

Previous Week Statistics

- **Stacked Target: 27,000 tpd**
  - Actual = 15,415 tpd
- **7 Day Leach Added:**
  - Actual = 2,739 m^2
- **7 Day Leach Removed:**
  - Actual = 1,572m^2
- **30 Day Leach Added:**
  - Actual = 28,782m^2
- **Area in Prep:**
  - Actual ~ 2000m^2

Legend

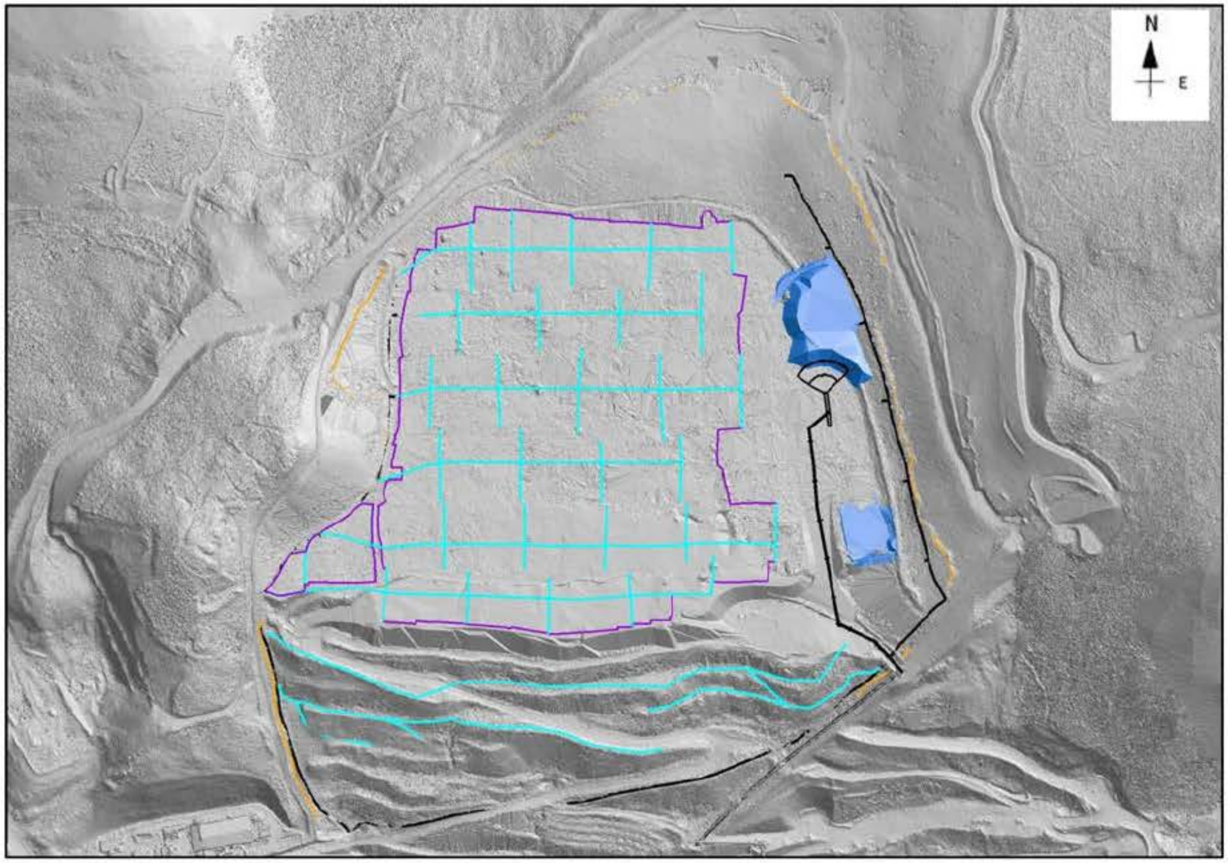
- Leach Online
- 24" HDPE
- 12"/4" HDPE
- Stacking
- ODF
- Ripped Area

HLF Ore Stacking Plan 2023-03-02 to 2023-03-08

HLF Stacking: Past 7 Day Performance

Previous Week Statistics

- **Stacked Target: 27,000 tpd**
  - Actual = 23,791 tpd
- **7 Day Leach Added:**
  - Actual = 9,534 m^2
- **30 Day Leach Added:**
  - Actual = 23,953m^2
- **Area in Prep:**
  - Actual ~ 0m^2



Legend

- Leach Online
- 24" HDPE
- 12"/4" HDPE
- Stacking
- ODF
- Ripped Area

HLF Ore Stacking Plan 2023-03-09 to 2023-03-15

HLF Stacking: Past 7 Day Performance

Previous Week Statistics

- **Stacked Target: 27,000 tpd**
  - Actual = 25,243 tpd
- **7 Day Leach Added:**
  - Actual = 0 m^2
- **30 Day Leach Added:**
  - Actual = 16,842m^2
- **Area in Prep:**
  - Actual ~ 3600m^2

Legend

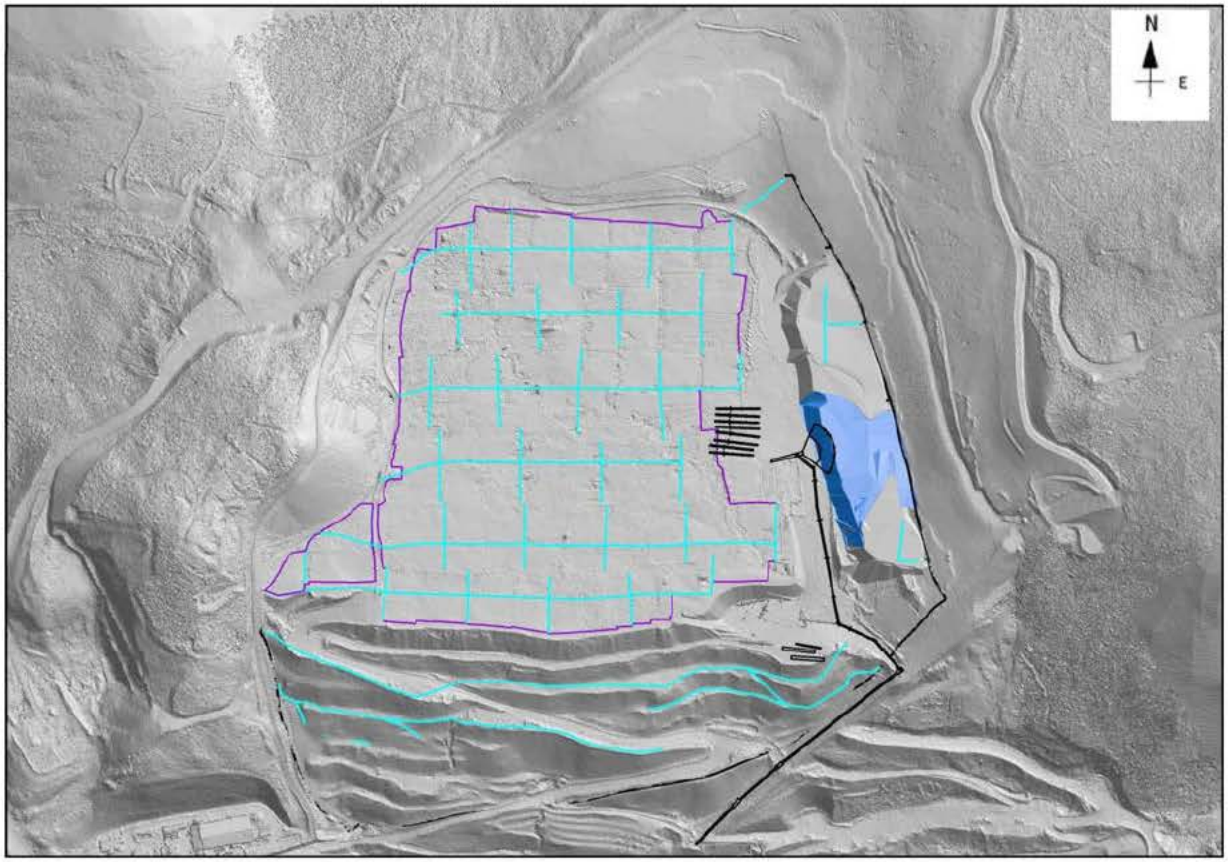
- Leach Online
- 24" HDPE
- 12"/4" HDPE
- Stacking
- ODF
- Ripped Area

HLF Ore Stacking Plan 2023-03-16 to 2023-03-22

HLF Stacking: Past 7 Day Performance

Previous Week Statistics

- **Stacked Target: 27,000 tpd**
  - Actual = 20,947 tpd
- **7 Day Leach Added:**
  - Actual = 0 m^2
- **30 Day Leach Added:**
  - Actual = 12,003 m^2
- **Area in Prep:**
  - Actual ~ 5000m^2



Legend

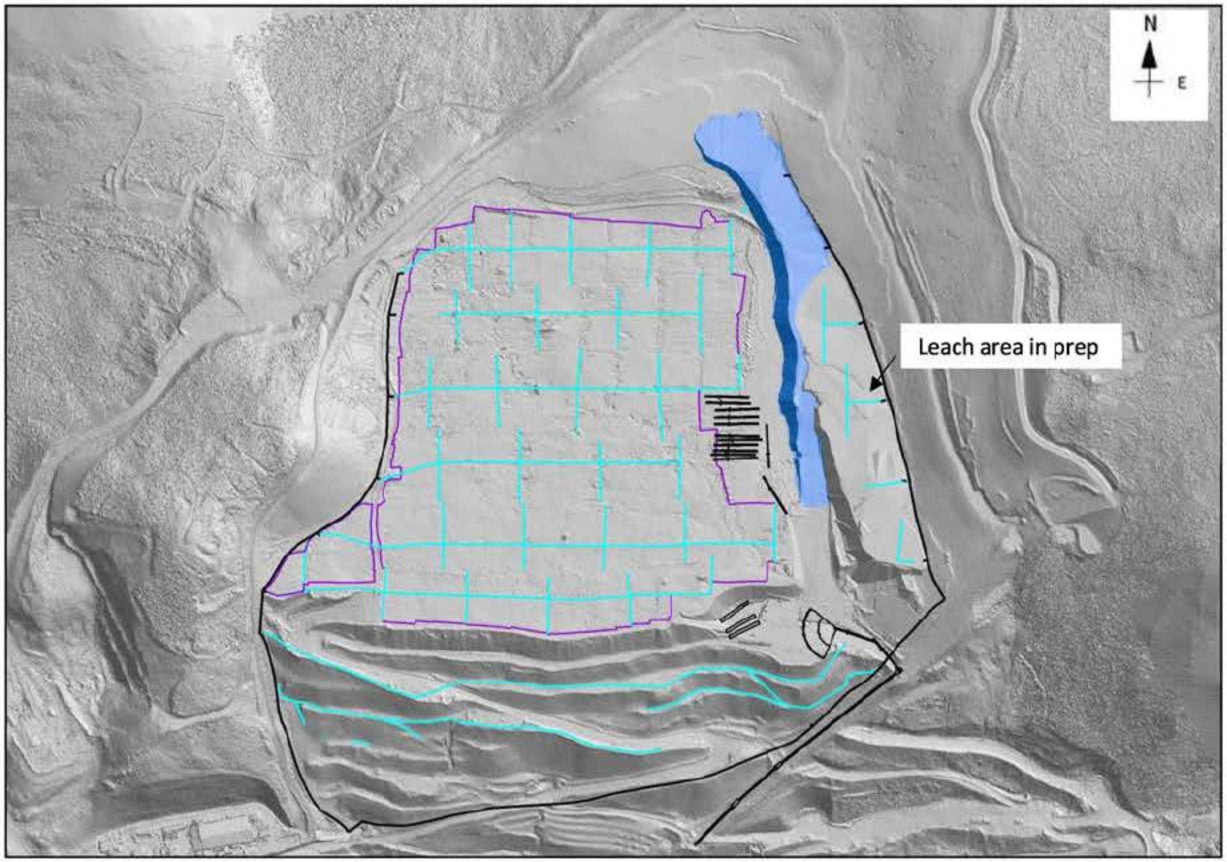
- Leach Online
- 24" HDPE
- 12"/4" HDPE
- Stacking
- ODF
- Ripped Area

HLF Ore Stacking Plan 2023-03-23 to 2023-03-29

HLF Stacking: Past 7 Day Performance

Previous Week Statistics

- **Stacked Target: 27,000 tpd**
  - Actual = 21,888 tpd
- **7 Day Leach Added:**
  - Actual = 0 m^2
- **30 Day Leach Added:**
  - Actual = 9,534 m^2
- **Area in Prep:**
  - Actual ~16,000m^2



Legend

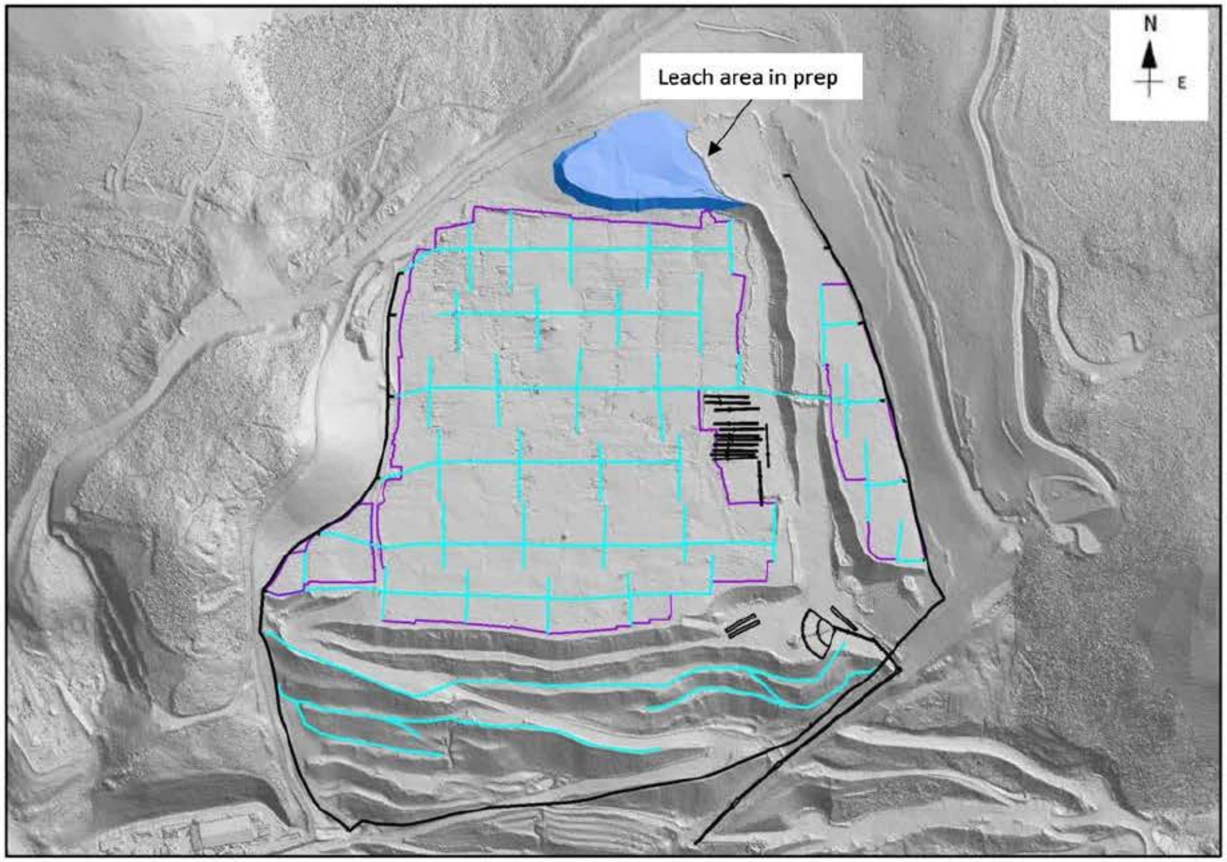
- Leach Online
- 24" HDPE
- 12"/4" HDPE
- Stacking
- ODF
- Ripped Area

HLF Ore Stacking Plan 2023-03-30 to 2023-04-05

HLF Stacking: Past 7 Day Performance

Previous Week Statistics

- **Stacked Target: 27,000 tpd**
  - Actual = 29,461 tpd
- **7 Day Leach Added:**
  - Actual = 17,736 m²
- **30 Day Leach Added:**
  - Actual =26,658 m²
- **Area in Prep:**
  - Actual ~9800 m²



Legend

- Leach Online
- 24" HDPE
- 12"/4" HDPE
- Stacking
- ODF
- Ripped Area

HLF Ore Stacking Plan 2023-04-06 to 2023-04-11

HLF Stacking: Past 7 Day Performance

Previous Week Statistics

Stacked Target: 29,000 tpd

- Actual = 28,352 **tpd**

7 Day Leach Added:

- Actual = 13,726 m²

7 Day Leach Added:

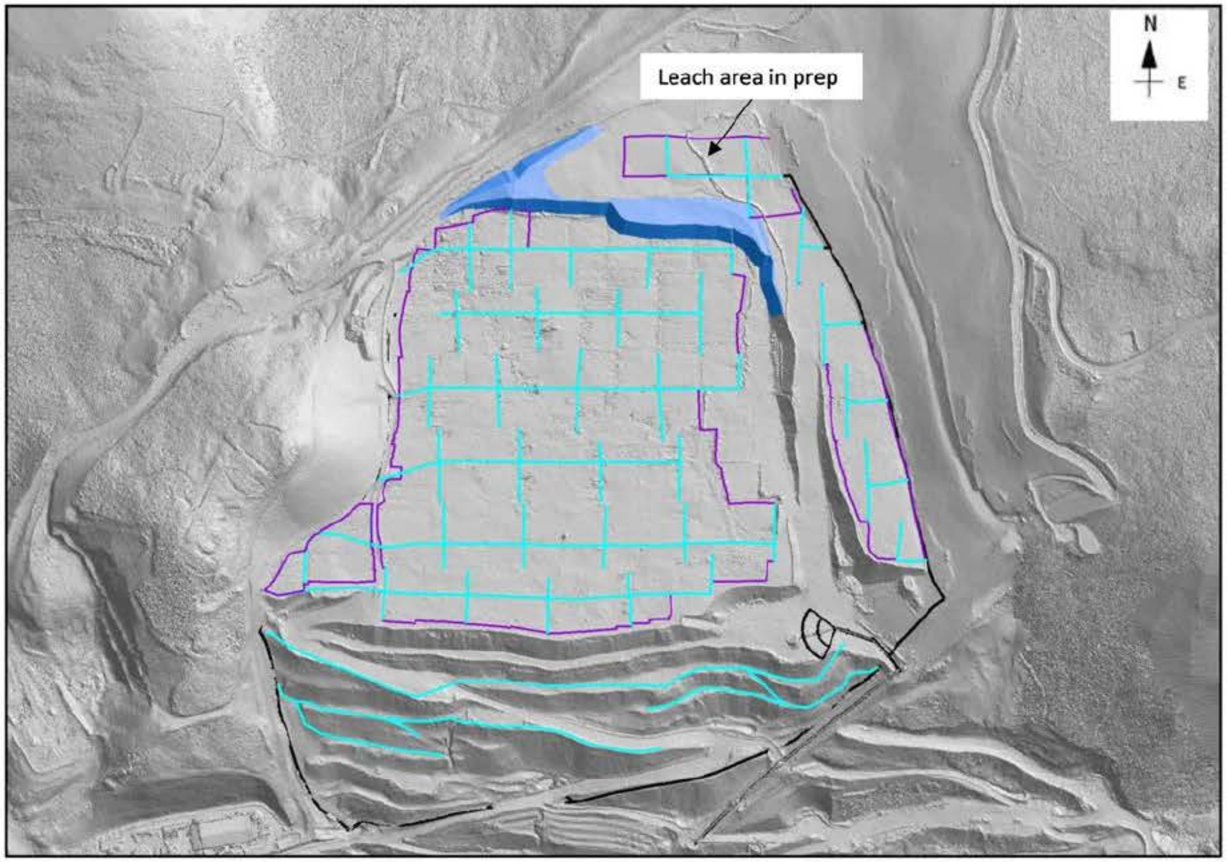
- Actual = 13,726 m₂

30 Day Leach Added:

- Actual = 31,461 m²

Area in Prep:

- Actual ~9800 m²

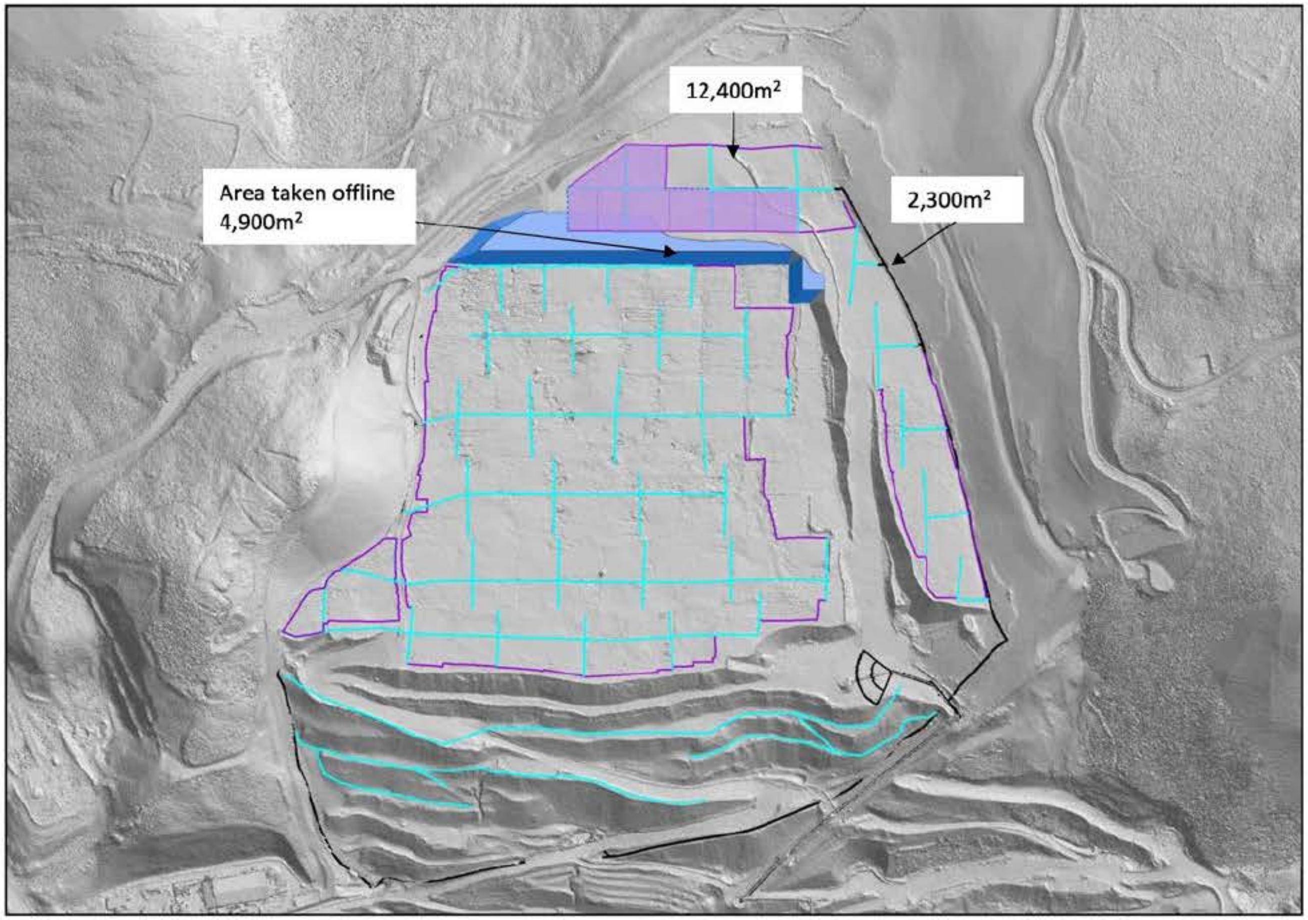


Legend

- Leach Online
- 24" HDPE
- 12"/4" HDPE
- Stacking
- ODF
- Ripped Area

HLF Ore Stacking Plan 2023-04-12 to 2023-04-17 (inferred from plan)

HLF Stacking: One week look-ahead



- Assumptions:
  - EDL is operational
  - Staged approach to taking areas offline
  - 2x 785D and 1x 993 Loader
  - Remove W4-E3 connection once EDL operational

- Follow-up on Key Issues:
  - GH long-term storage
  - Trucks PMs (Saturdays) - Backup options
  - Maintain haul access road from 1B
  - Stacking close to the liner
  - Freshet & ongoing snow removal

Tonnes: 201 Kt stacked

Area available online: 14,700 m^2

Area taken offline: 4,900 m^2

HLF Ore Stacking Plan 2023-04-18 to 2023-04-24 (inferred from plan)

HLF – April 18th – May 1st 2023

Stacking

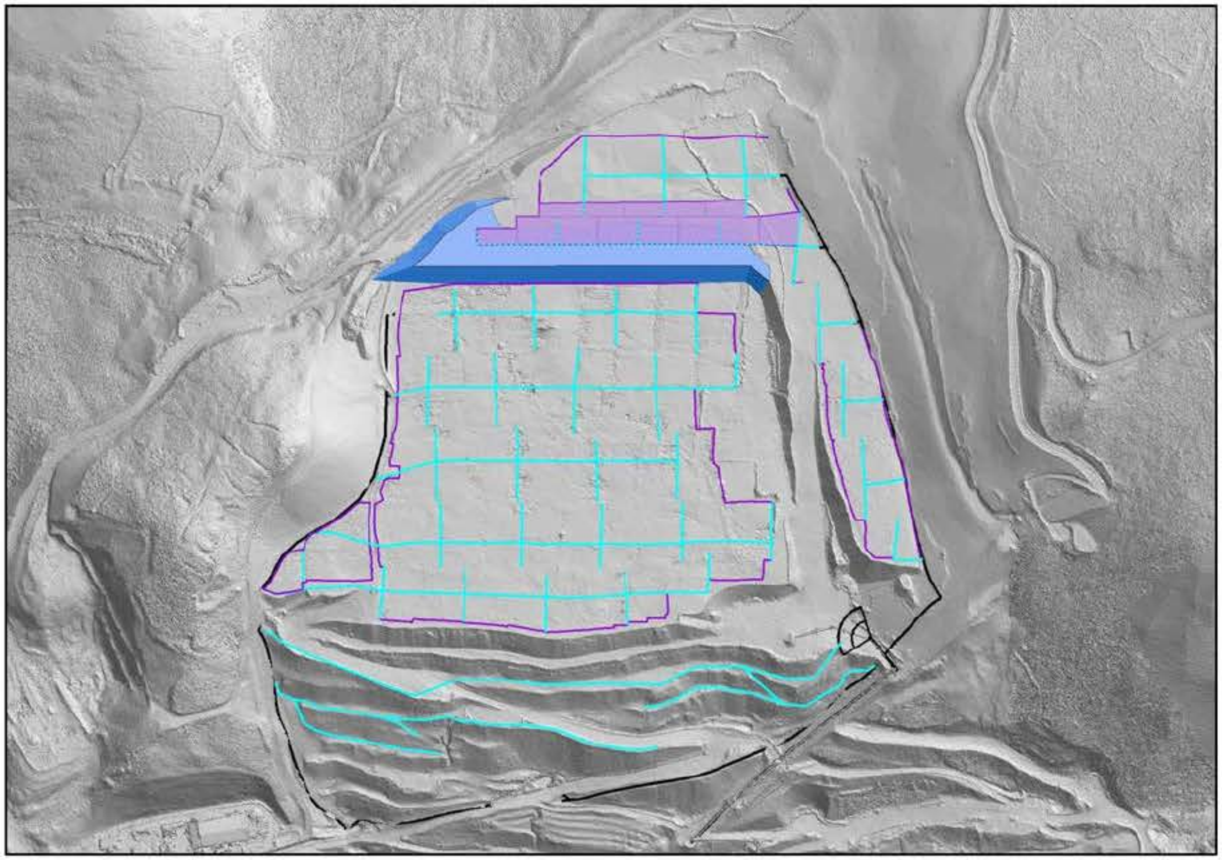
1. Week 1 = 204,800t
2. Week 2 = 204,800t

GH Moves
Remove GH 102 – April 22

Infrastructure
Remove W6-W5 – April 29

Load & Haul Equipment
785D (x2) Haul Truck
993K (x1) Wheel Loader

Legend
Leach Area
Distribution / Leach Line
Stacking



TSX : VGCX OTC: VITFF VGCX.com

VICTORIA GOLD CORP

HLF Ore Stacking Plan 2023-04-25 to 2023-04-27 (inferred from plan)

HLF – April 25th – May 8th 2023

Stacking

1. Week 1 = 204,800t
2. Week 2 = 180,000t

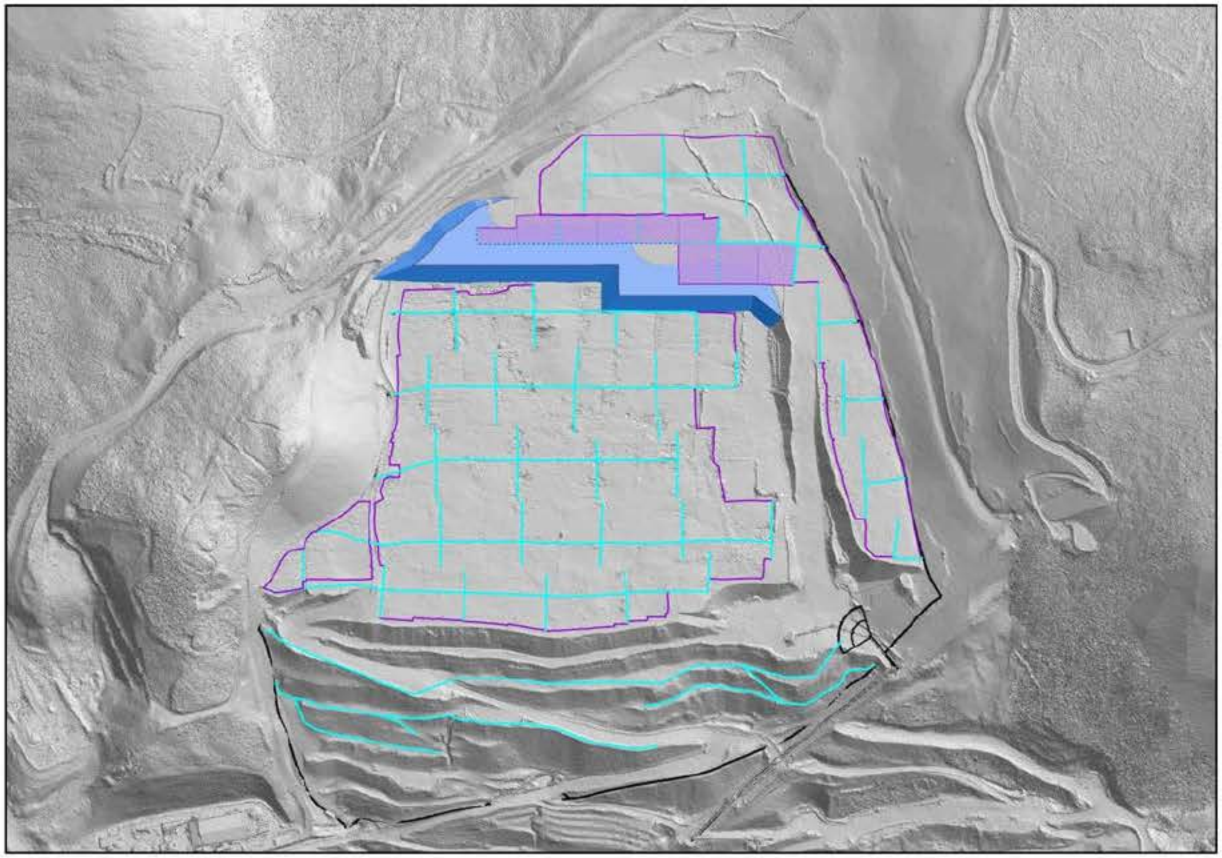
GH Moves
N/A

Infrastructure
Remove W6-W5 – May 2nd

Load & Haul Equipment
785D (x2) Haul Truck
993K (x1) Wheel Loader

Legend

- Leach Area
- Distribution / Leach Line
- Stacking



TSX : VGCX OTC: VITFF VGCX.com

(Progress up to 2023-05-02 included for reference)

HLF – May 2nd – May 15th 2023

Stacking

1. Week 1 = 207,000t
2. Week 2 = 77,000t

GH Moves
N/A

Infrastructure
N/A

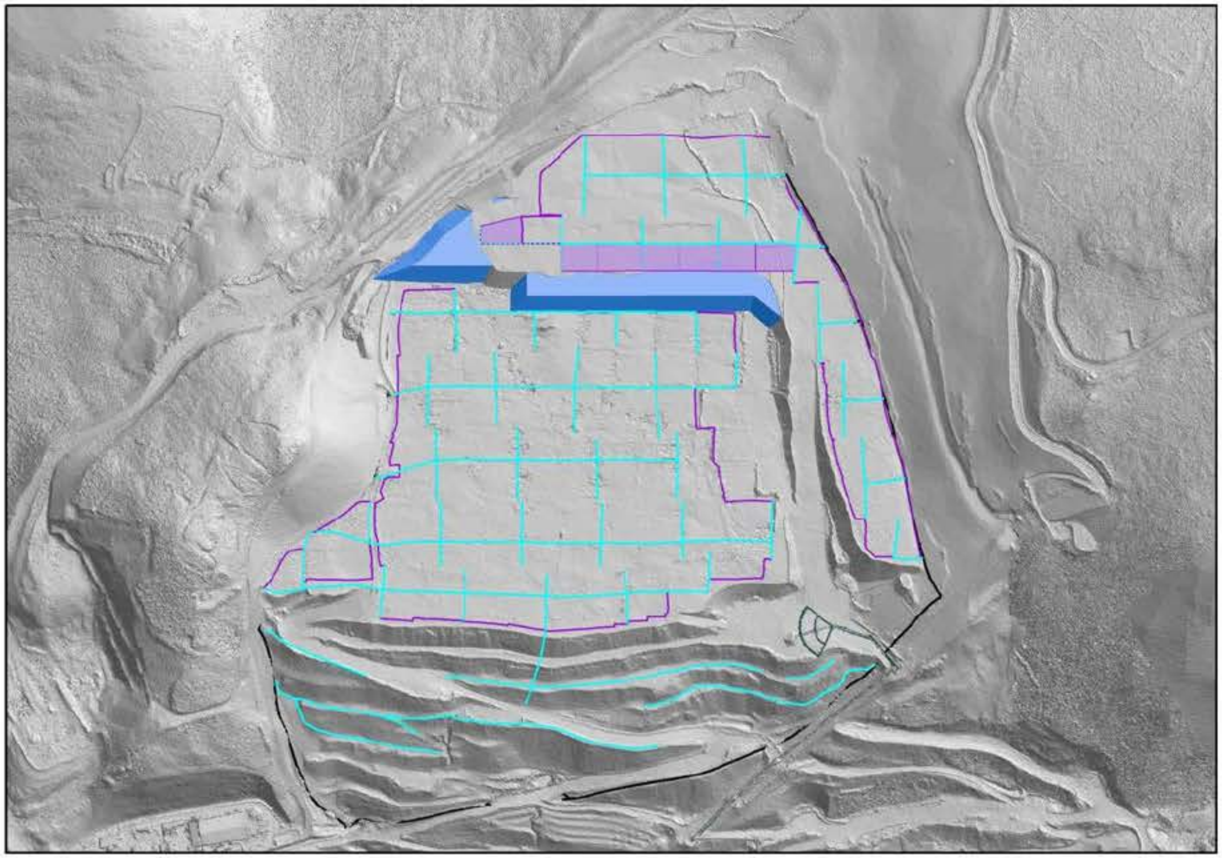
Load & Haul Equipment
785D (x2) Haul Truck
993K (x1) Wheel Loader

Legend

Leach Area

Distribution / Leach Line

Stacking



TSX : VGCX OTC: VITFF VGCX.com

HLF Ore Stacking Plan 2023-04-28 to 2023-05-04

HLF Stacking: Past 7 Day Performance

Previous Week Statistics

Stacked Target: 29,000 tpd

- Actual = 32,281 tpd

7 Day Leach Added:

- Actual = 5,6974 m^2

7 Day Leach Removed:

- Actual = 6,231 m^2

30 Day Leach Added:

- Actual = 37,802 m^2

Area in Prep:

- Actual ~1500 m^2

Legend

- Leach Online
- 24" HDPE
- 12"/4" HDPE
- Stacking
- ODF
- Ripped Area

HLF Ore Stacking Plan 2023-05-05 to 2023-05-11

HLF Stacking: Past 7 Day Performance

Previous Week Statistics

Stacked Target: 29,000 tpd

- Actual = 27,388 tpd

7 Day Leach Added:

- Actual = 12,989 m^2

7 Day Leach Removed:

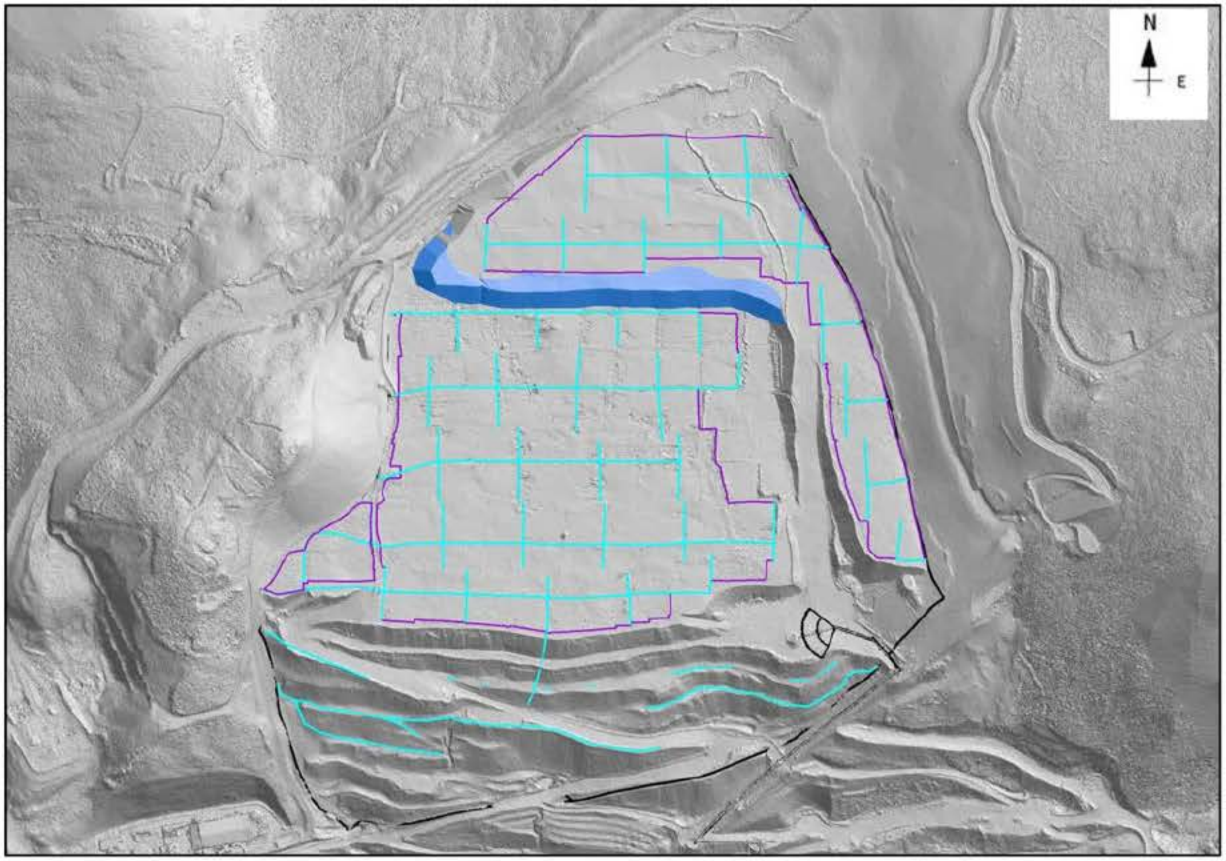
- Actual = 9,276 m^2

30 Day Leach Added:

- Actual = 39,415 m^2

Area in Prep:

- 0 m^2



Legend

- Leach Online
- 24" HDPE
- 12"/4" HDPE
- Stacking
- ODF
- Ripped Area

HLF Ore Stacking Plan 2023-05-12 to 2023-05-18

HLF Stacking: Past 7 Day Performance

Previous Week Statistics

Stacked Target: 29,000 tpd

- Actual = 23,020 tpd

7 Day Leach Added:

- Actual = 0 m²

7 Day Leach Removed:

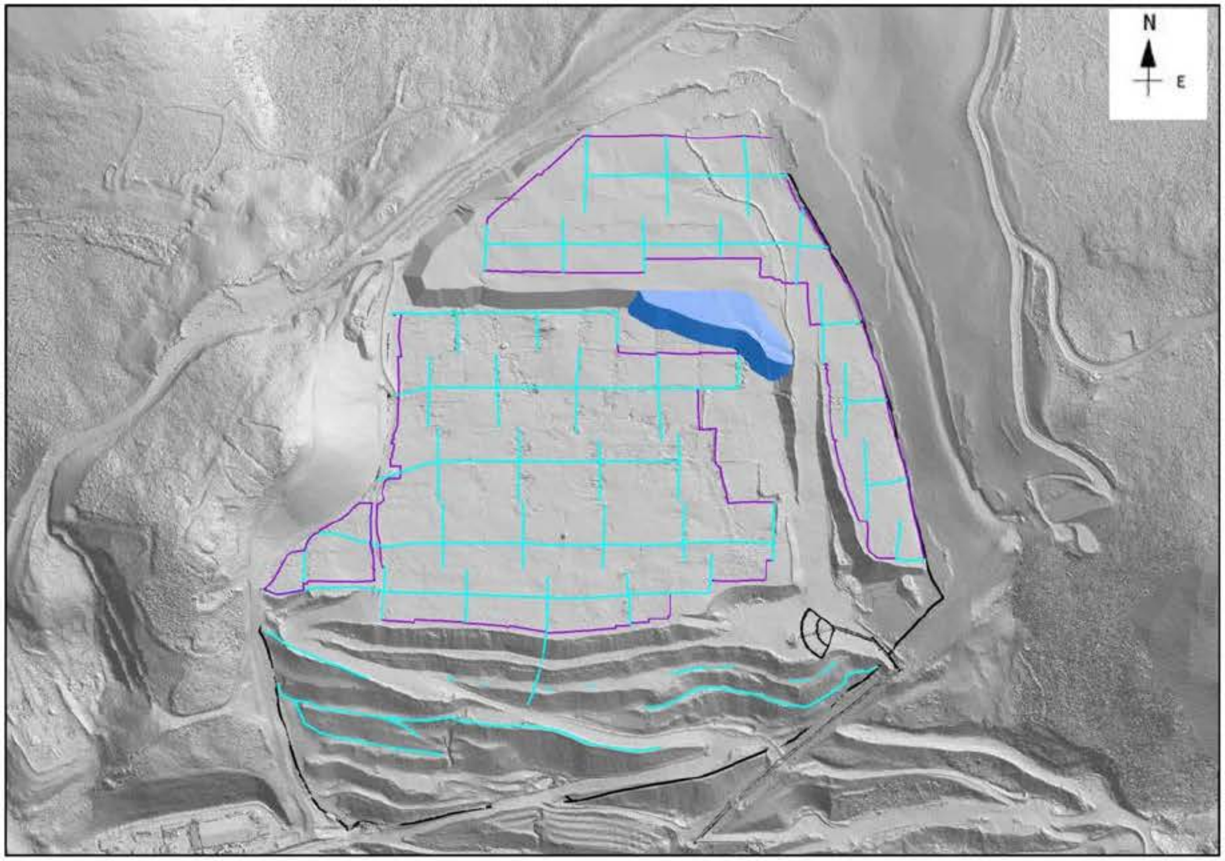
- Actual = 6,170 m²

30 Day Leach Added:

- Actual = 26,830 m²

Area in Prep:

- 8,200 m²



Legend

- Leach Online
- 24" HDPE
- 12"/4" HDPE
- Stacking
- ODF
- Ripped Area

HLF Ore Stacking Plan 2023-05-19 to 2023-05-25

HLF Stacking: Past 7 Day Performance

Previous Week Statistics

Stacked Target: 29,000 tpd

- Actual = 28,748 **tpd**

7 Day Leach Added:

- Actual = 12,071 m^2

7 Day Leach Removed:

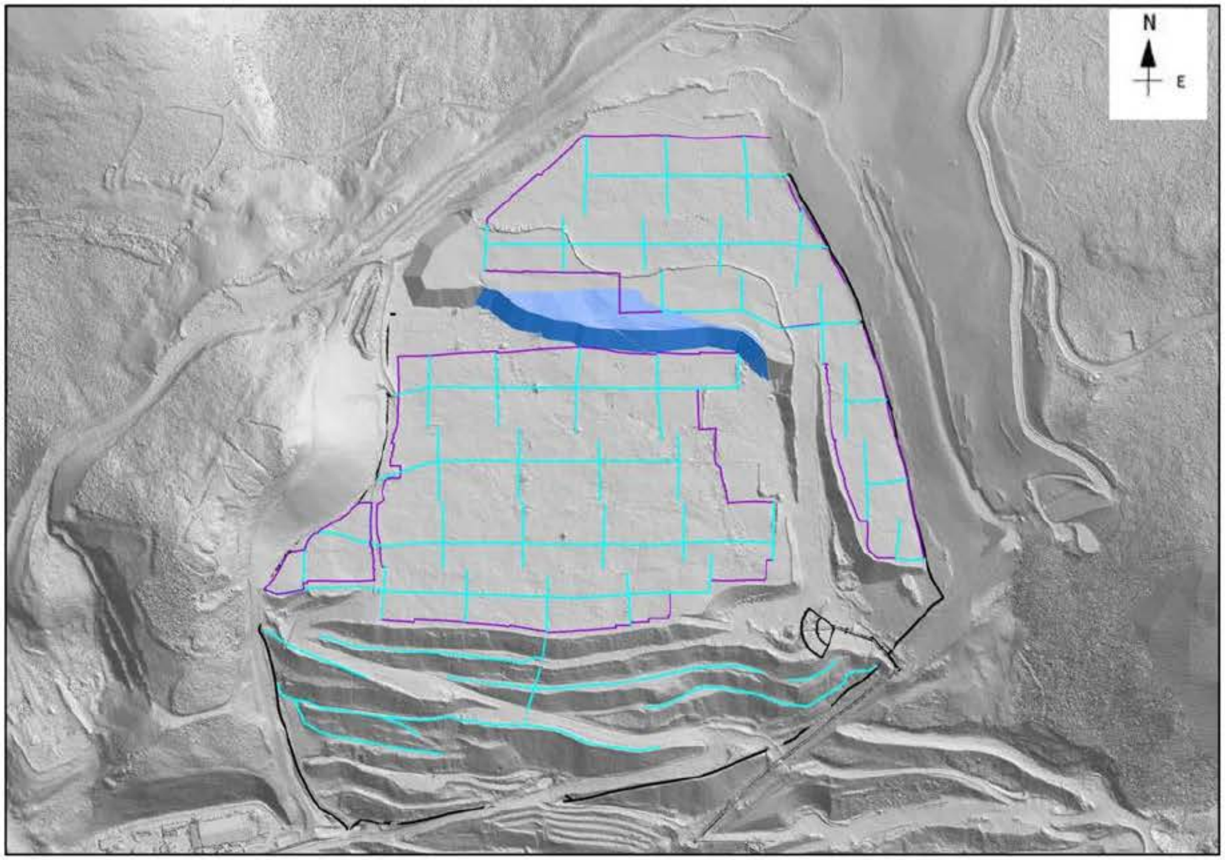
- Actual = 5,794 m^2

30 Day Leach Added:

- Actual = 30,757 m^2

Area in Prep:

- 4,000 m^2



Legend

- Leach Online
- 24" HDPE
- 12"/4" HDPE
- Stacking
- ODF
- Ripped Area

HLF Ore Stacking Plan 2023-05-26 to 2023-06-01

HLF Stacking: Past 7 Day Performance

Previous Week Statistics

Stacked Target: 29,000 tpd

- Actual = 28,176 **tpd**

7 Day Leach Added:

- Actual = 11,043 m^2

7 Day Leach Removed:

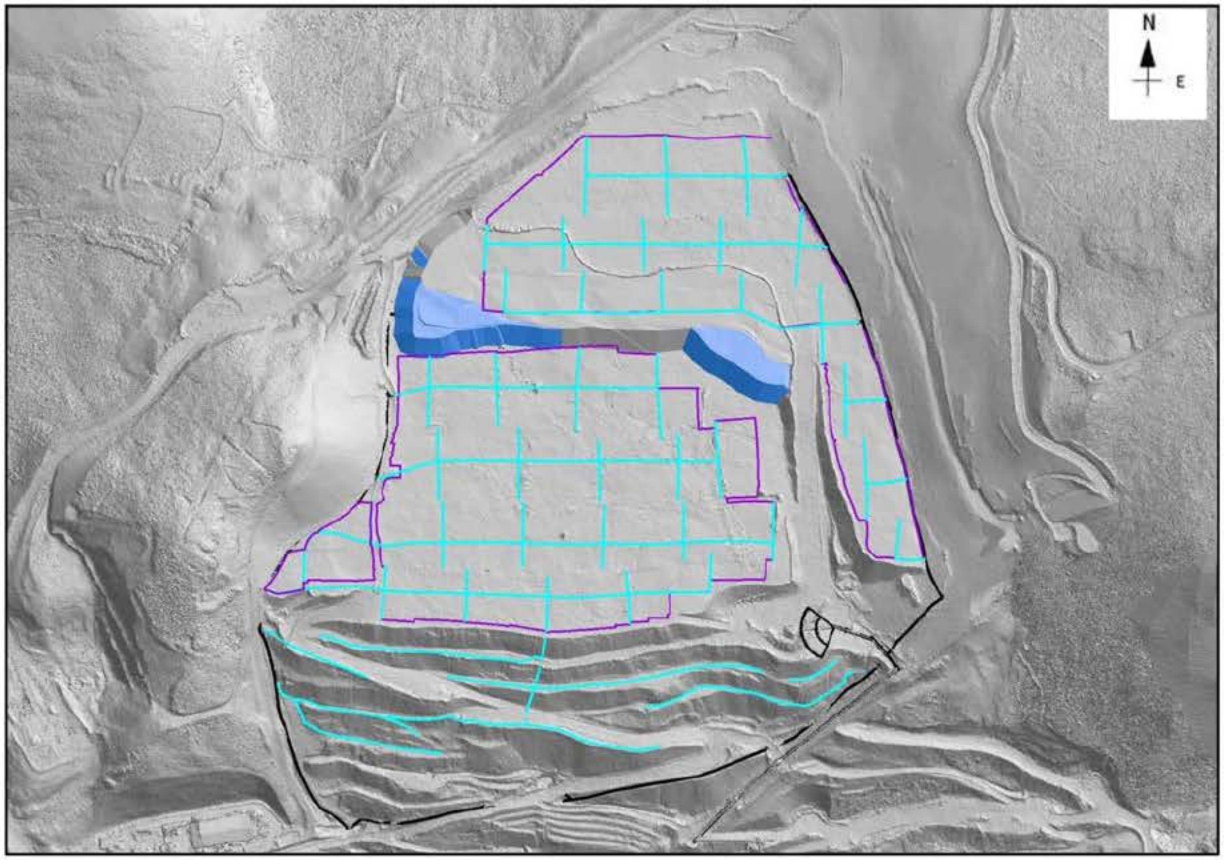
- Actual = 3,648m^2

30 Day Leach Added:

- Actual = 36,104 m^2

Area in Prep:

- 1,800 m^2



Legend

- Leach Online
- 24" HDPE
- 12"/4" HDPE
- Stacking
- ODF
- Ripped Area

HLF Ore Stacking Plan 2023-06-02 to 2023-06-08

HLF Stacking: Past 7 Day Performance

Previous Week Statistics

Stacked Target: 29,250 tpd

- Actual = 26,521 tpd

7 Day Leach Added:

- Actual = 5,075 m^2

7 Day Leach Removed:

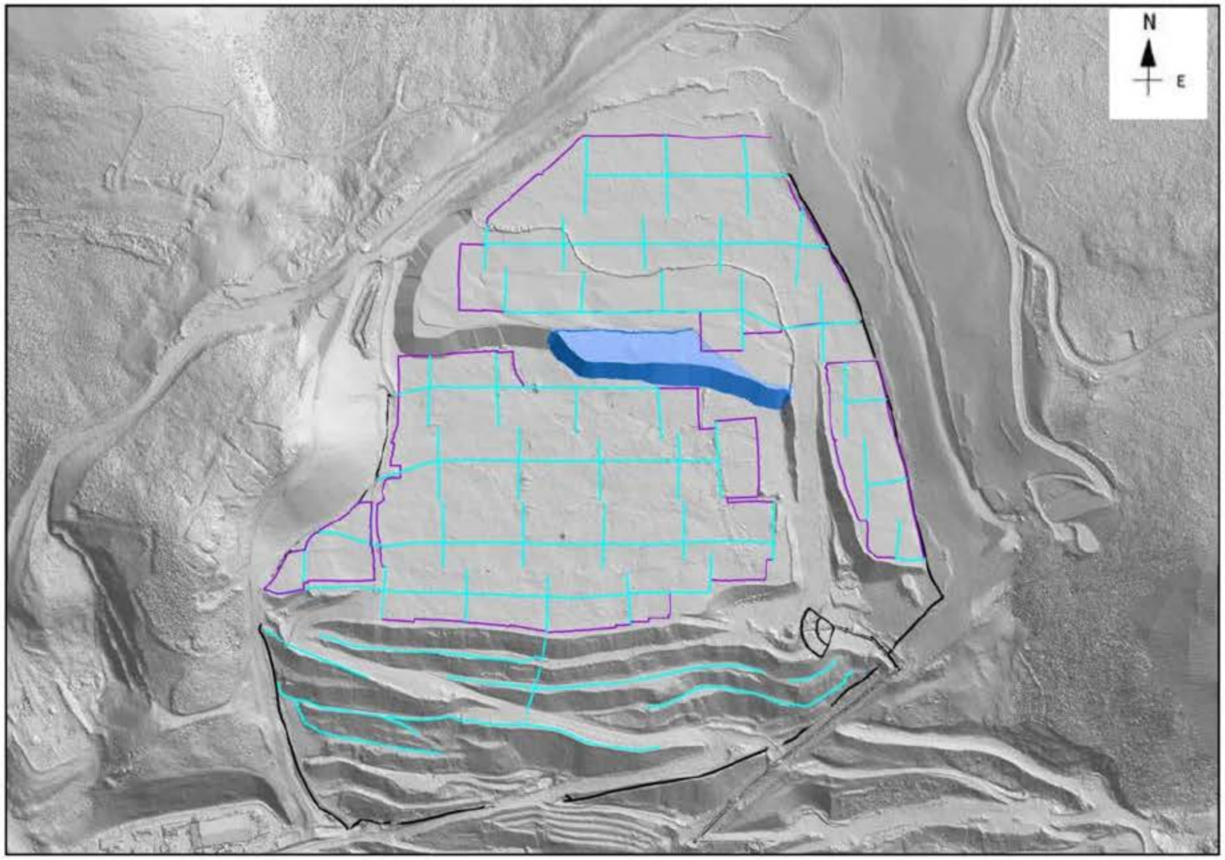
- Actual = 9,572m^2

30 Day Leach Added:

- Actual = 31,731m^2

Area in Prep:

- 2,900 m^2



Legend

- Leach Online
- 24" HDPE
- 12"/4" HDPE
- Stacking
- ODF
- Ripped Area

HLF Ore Stacking Plan 2023-06-09 to 2023-06-15

HLF Stacking: Past 7 Day Performance

Previous Week Statistics

Stacked Target: 29,250 tpd

- Actual = 27,469 tpd

7 Day Leach Added:

- Actual = 7,695 m^2

7 Day Leach Removed:

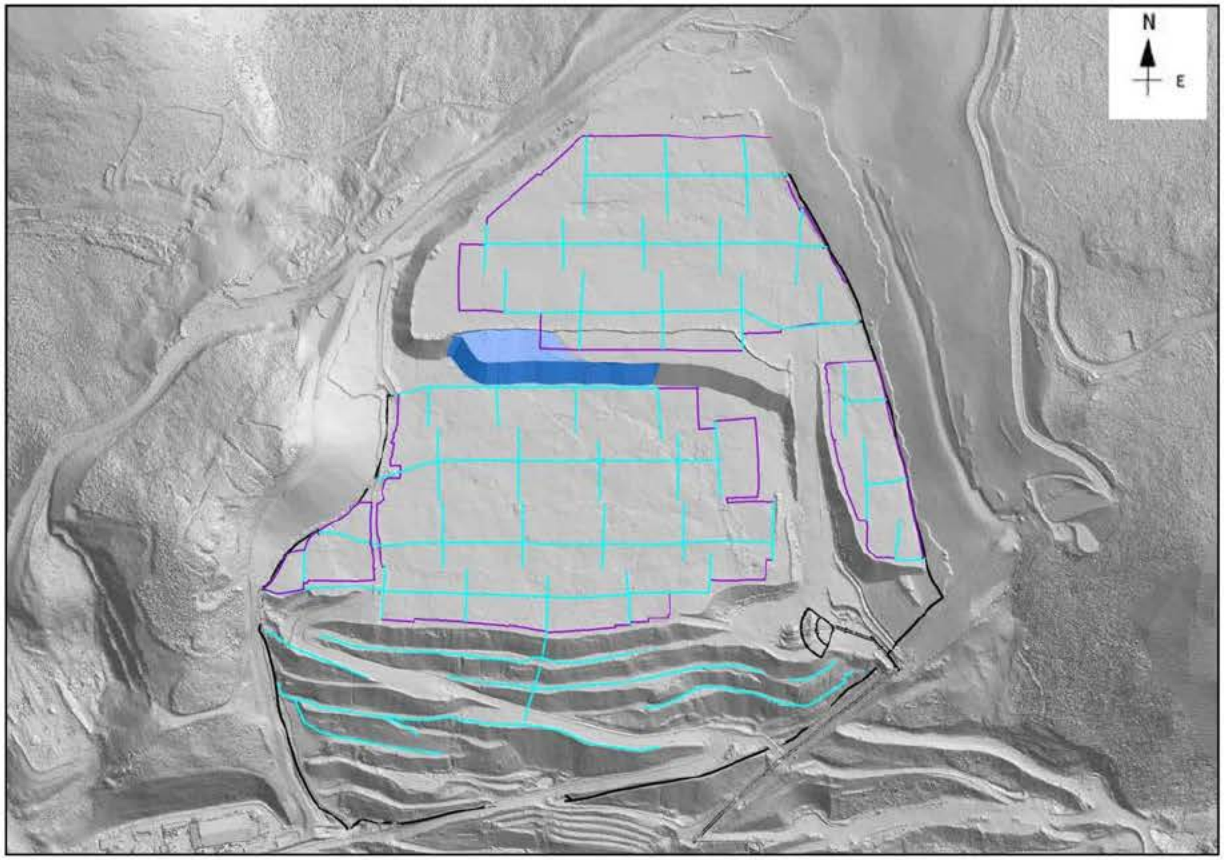
- Actual = 5,144 m^2

30 Day Leach Added:

- Actual = 35,884 m^2

Area in Prep:

- 3,500 m^2



Legend

- Leach Online
- 24" HDPE
- 12"/4" HDPE
- Stacking
- ODF
- Ripped Area

HLF Ore Stacking Plan 2023-06-16 to 2023-06-22

HLF Stacking: Past 7 Day Performance

Previous Week Statistics

Stacked Target: 29,250 tpd

- Actual = 26,395 **tpd**

7 Day Leach Added:

- Actual = 13,336 m²

7 Day Leach Removed:

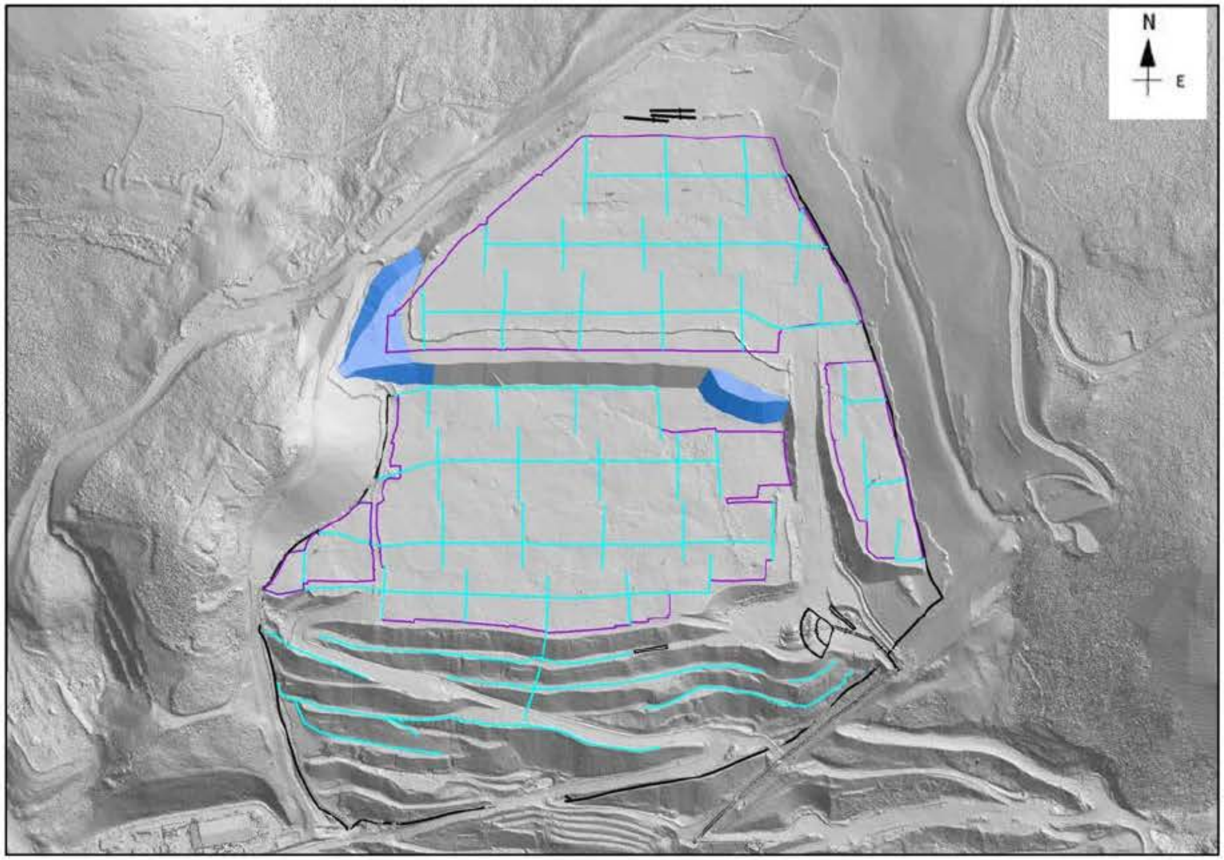
- Actual = 2,175 m²

30 Day Leach Added:

- Actual = 40,605 m²

Area in Prep:

- 4,000 m²



Legend

- Leach Online
- 24" HDPE
- 12"/4" HDPE
- Stacking
- ODF
- Ripped Area

HLF Ore Stacking Plan 2023-06-23 to 2023-06-29

HLF Stacking: Past 7 Day Performance

Previous Week Statistics

Stacked Target: 29,250 tpd

- Actual = 27,124 tpd

7 Day Leach Added:

- Actual = 4,066 m²

7 Day Leach Removed:

- Actual = 6,664 m²

30 Day Leach Added:

- Actual = 33,527 m²

Area in Prep:

- 4,000 m²

Legend

- Leach Online
- 24" HDPE
- 12"/4" HDPE
- Stacking

HLF Ore Stacking Plan 2023-06-30 to 2023-07-06

HLF Stacking: Past 7 Day Performance

Previous Week Statistics

Stacked Target: 30,097 tpd

- Actual = 27,264 **tpd**

7 Day Leach Added:

- Actual = 3,870 m²

7 Day Leach Removed:

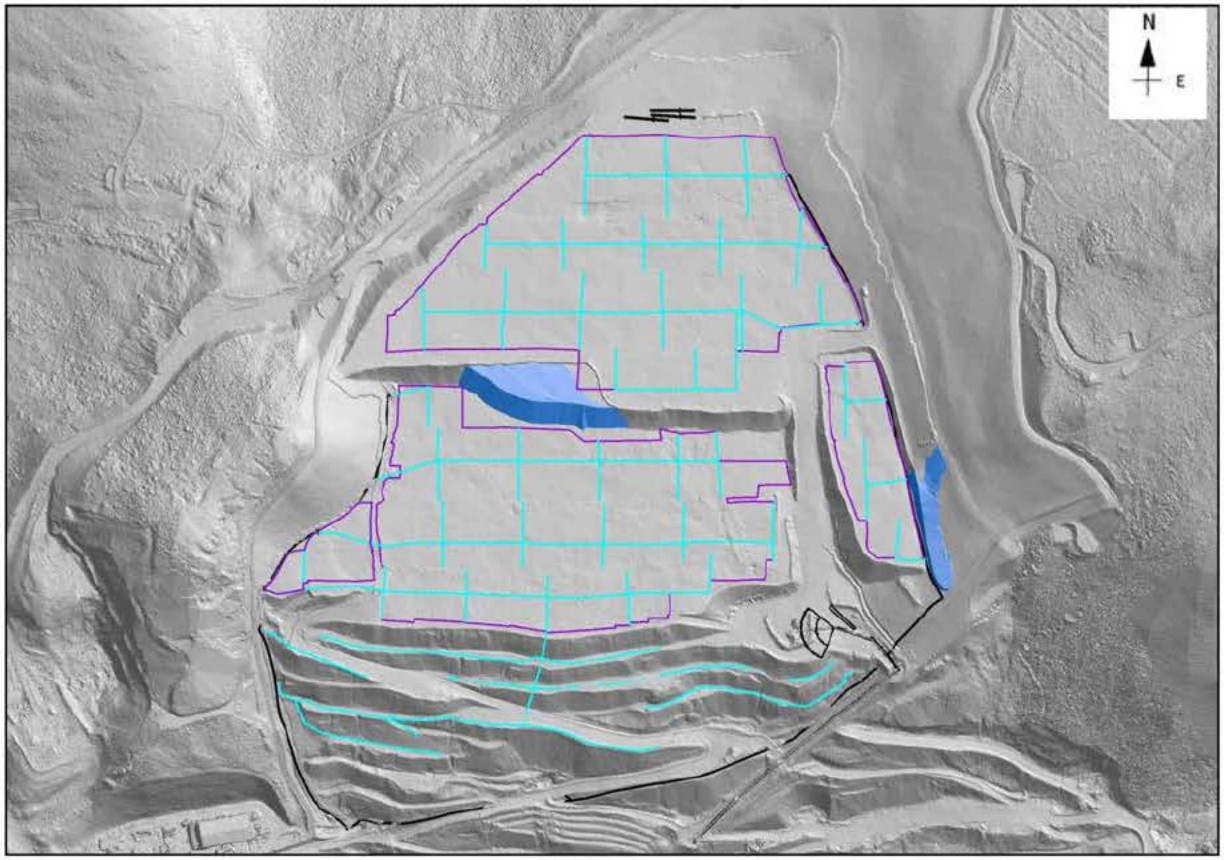
- Actual = 7,575 m²

30 Day Leach Added:

- Actual = 30,833 m²

Area in Prep:

- 2,000 m²



Legend

- Leach Online
- 24" HDPE
- 12"/4" HDPE
- Stacking

HLF Ore Stacking Plan 2023-07-07 to 2023-07-13

HLF Stacking: Past 7 Day Performance

Previous Week Statistics

Stacked Target: 30,097 tpd

- Actual = 26,360 tpd

7 Day Leach Added:

- Actual = 6,219 m^2

7 Day Leach Removed:

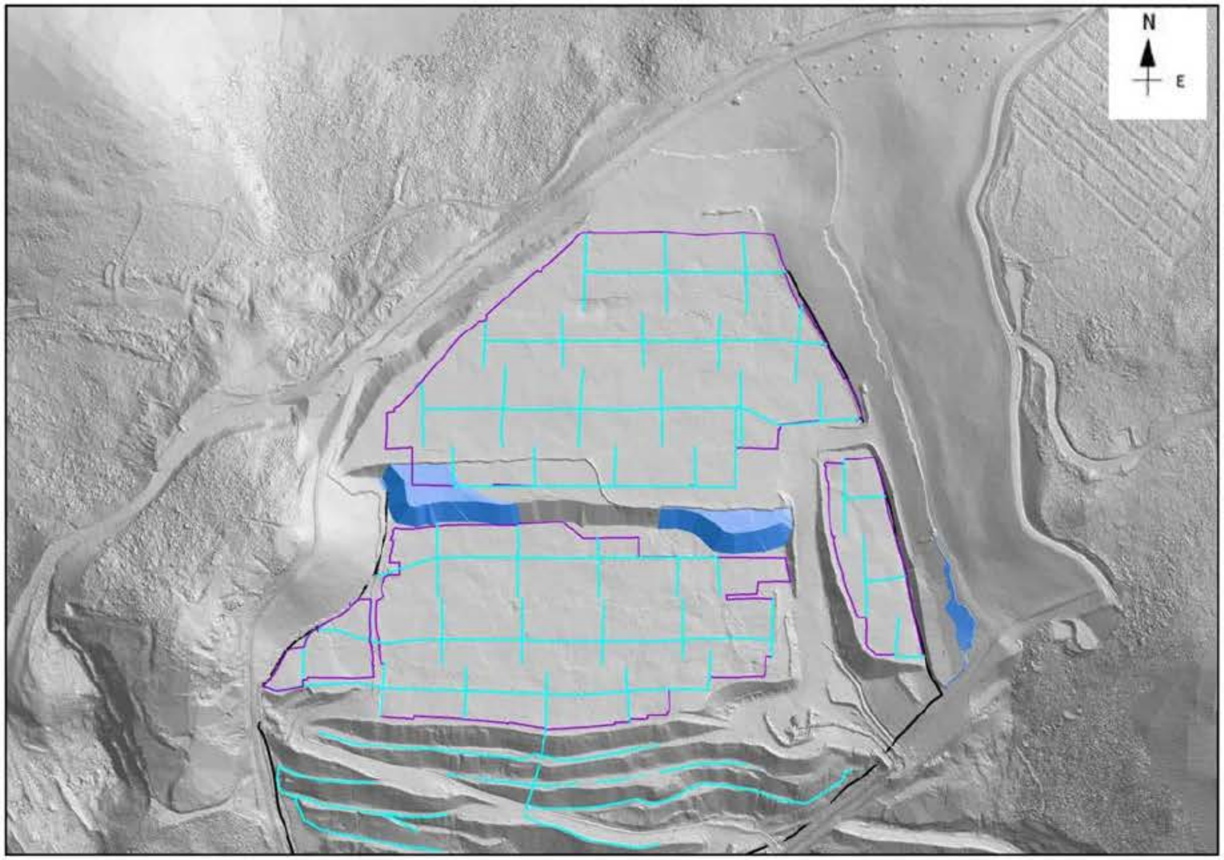
- Actual = 3,763 m^2

30 Day Leach Added:

- Actual = 28,712 m^2

Area in Prep:

- 0 m^2



Legend

- Leach Online
- 24" HDPE
- 12"/4" HDPE
- Stacking

HLF Ore Stacking Plan 2023-07-14 to 2023-07-20

HLF Stacking: Past 7 Day Performance

Previous Week Statistics

Stacked Target: 30,097 tpd

- Actual = 23,691 tpd

7 Day Leach Added:

- Actual = 4,745 m^2

7 Day Leach Removed:

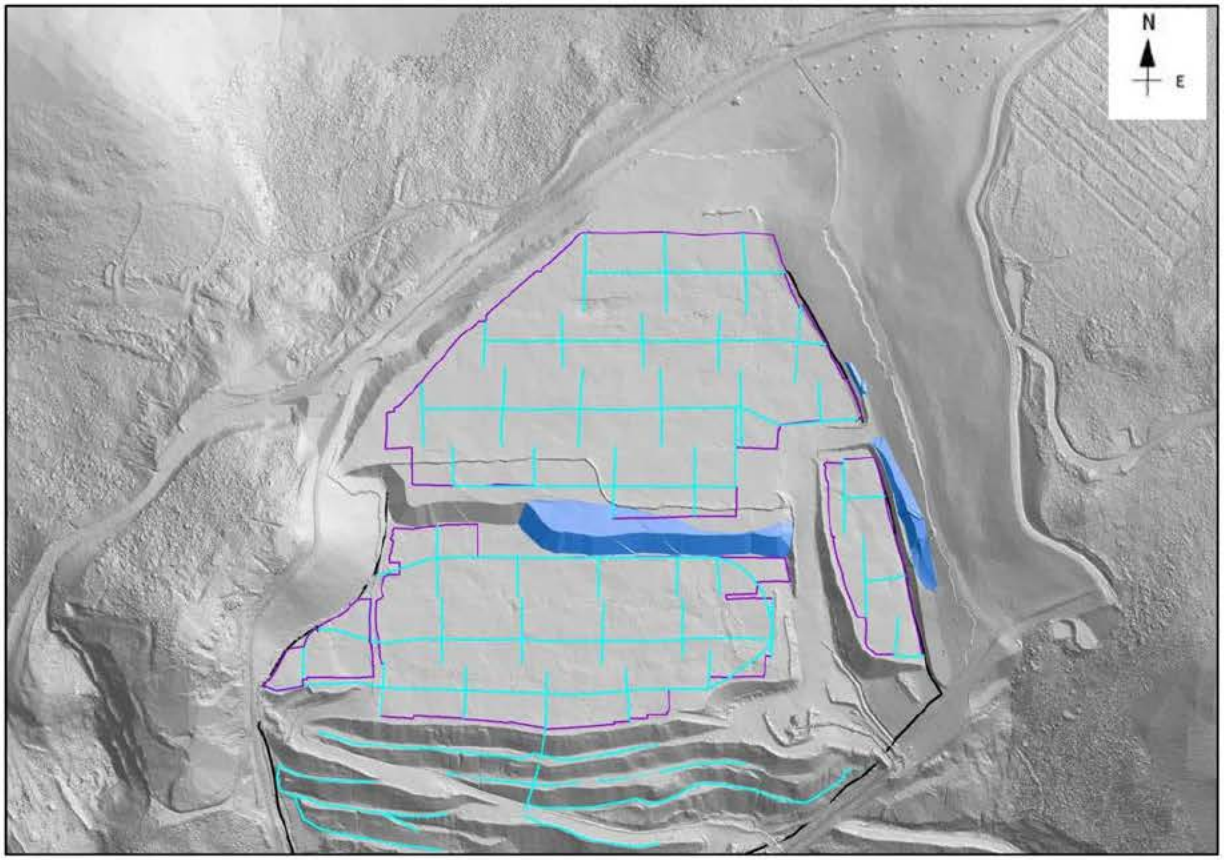
- Actual = 5,835 m^2

30 Day Leach Added:

- Actual = 25,423 m^2

Area in Prep:

- 4,000 m^2



Legend

- Leach Online
- 24" HDPE
- 12"/4" HDPE
- Stacking

HLF Ore Stacking Plan 2023-07-21 to 2023-07-27

HLF Stacking: Past 7 Day Performance

Previous Week Statistics

Stacked Target: 30,097 tpd

- Actual = 32,172 tpd

7 Day Leach Added:

- Actual = 6,753 m^2

7 Day Leach Removed:

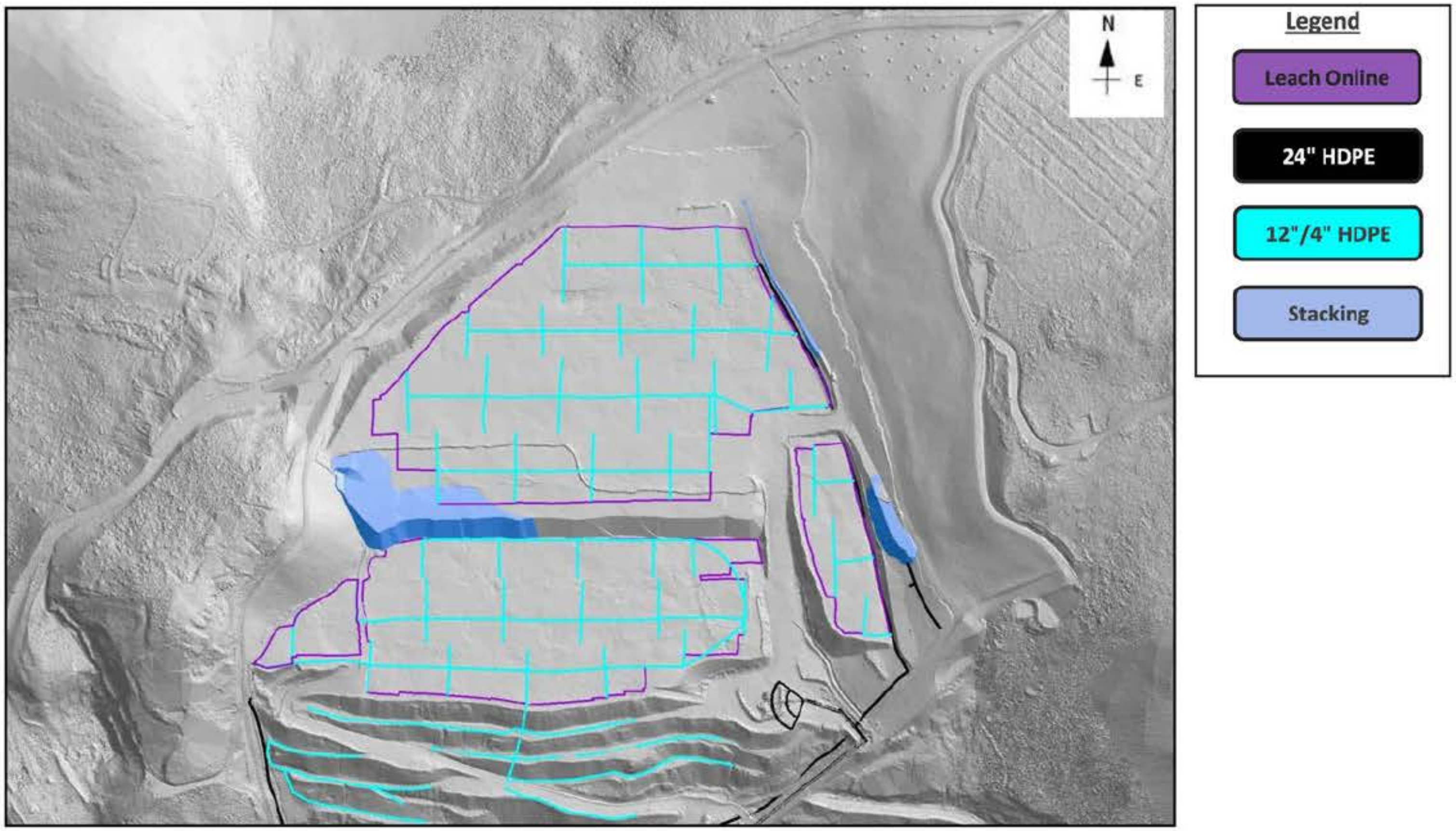
- Actual = 5,893 m^2

30 Day Leach Added:

- Actual = 25,861m^2

Area in Prep:

- 4,000 m^2



HLF Ore Stacking Plan 2023-07-28 to 2023-08-03

HLF Stacking: Past 7 Day Performance

Previous Week Statistics

Stacked Target: 30,097 tpd

- Actual = 8,885 tpd

7 Day Leach Added:

- Actual = 1,945 m^2

7 Day Leach Removed:

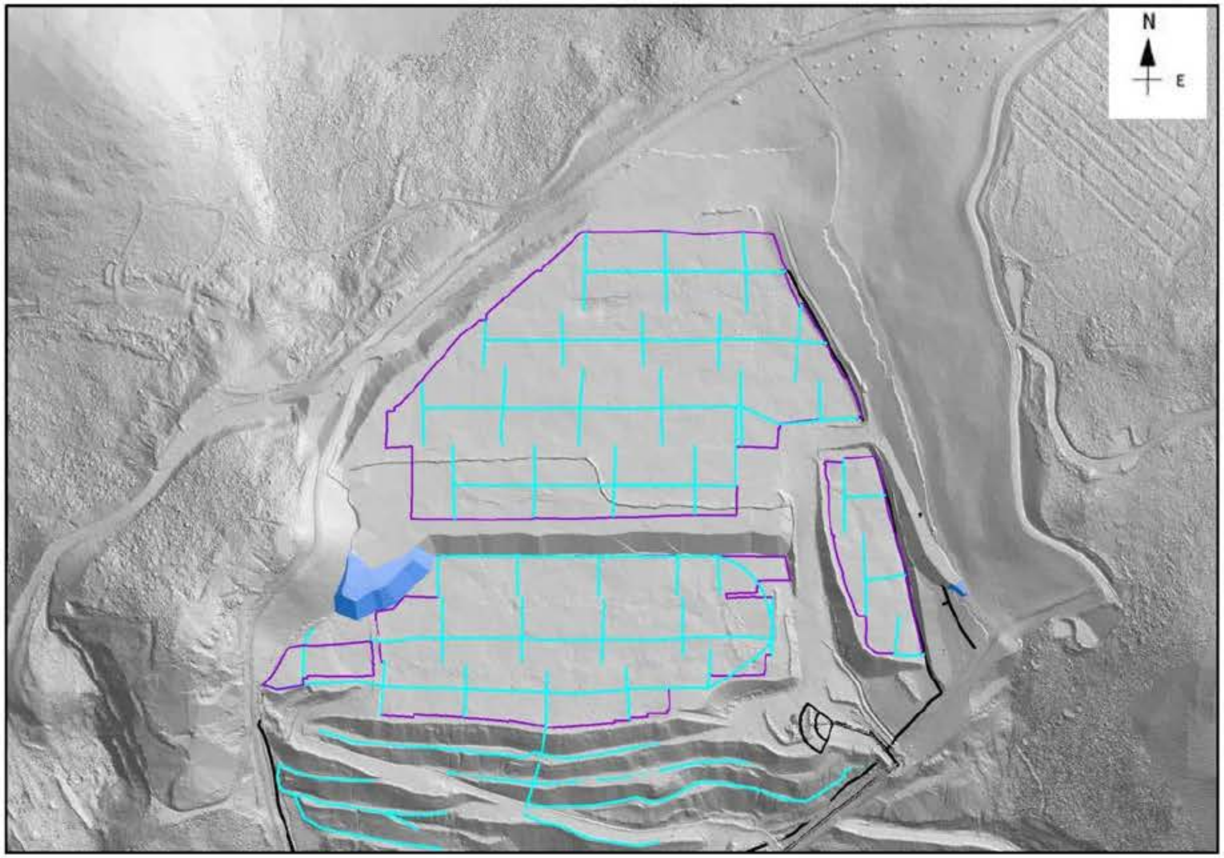
- Actual = 2,456 m^2

30 Day Leach Added:

- Actual = 21,935m^2

Area in Prep:

- 4,000 m^2



Legend

- Leach Online
- 24" HDPE
- 12"/4" HDPE
- Stacking

HLF Ore Stacking Plan 2023-08-04 to 2023-08-10

HLF Stacking: Past 7 Day Performance

Previous Week Statistics

Stacked Target: 30,097 tpd

- Actual = 8,885 tpd

7 Day Leach Added:

- Actual = 1,945 m^2

7 Day Leach Removed:

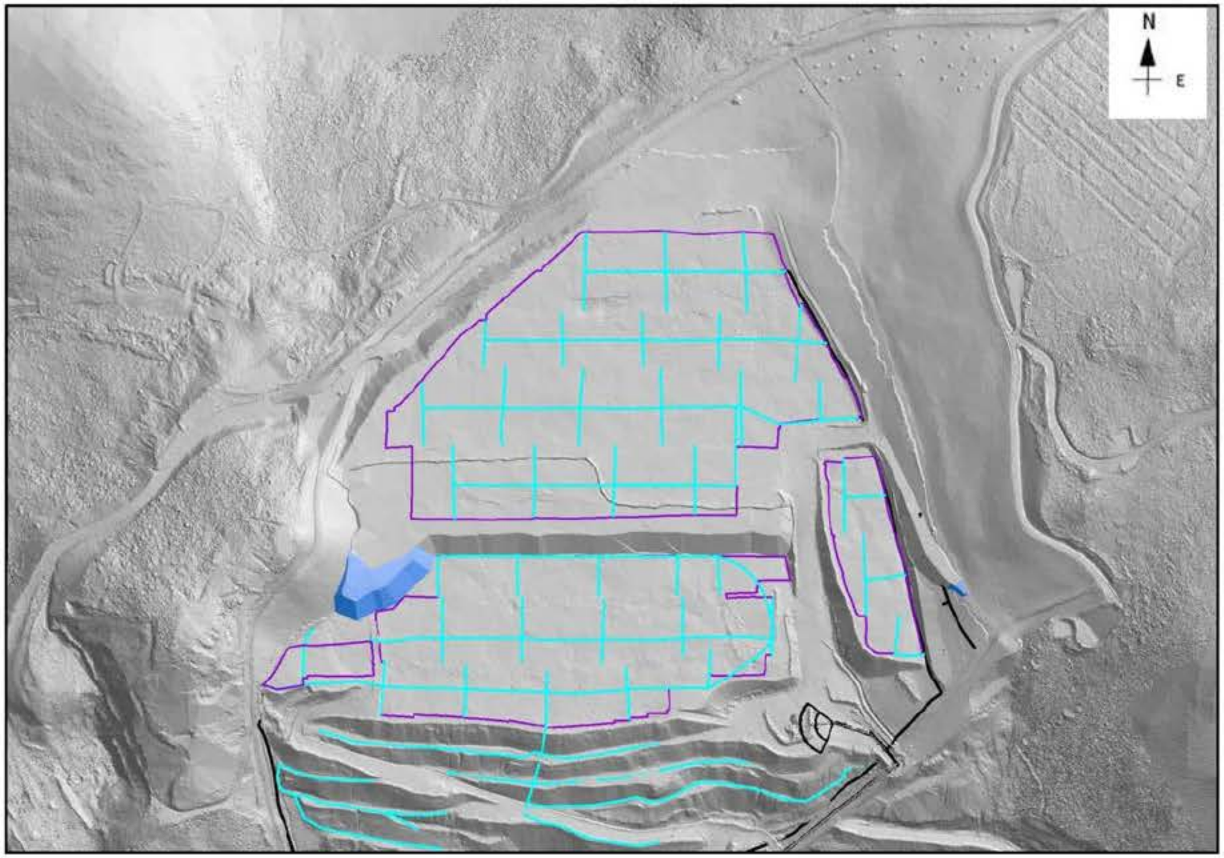
- Actual = 2,456 m^2

30 Day Leach Added:

- Actual = 21,935m^2

Area in Prep:

- 4,000 m^2



HLF Ore Stacking Plan 2023-08-11 to 2023-08-17

HLF Stacking: Past 7 Day Performance (199,092t)

Previous Week Statistics

Stacked Target: 29,465 tpd

- Actual = 28,442 tpd

7 Day Leach Added:

- Actual = 2,987 m²

7 Day Leach Removed:

- Actual = 4,101 m²

30 Day Leach Added:

- Actual = 13,232 m²

Area in Prep:

- 6,000 m²

Legend

- Leach Online
- 24" HDPE
- 12"/4" HDPE
- Stacking

HLF Ore Stacking Plan 2023-08-17 to 2023-08-24

HLF Stacking: Past 7 Day Performance (215,712t)

Previous Week Statistics

Stacked Target: 29,465 tpd

- Actual = 30,816 tpd

7 Day Leach Added:

- Actual = 2,987 m²

7 Day Leach Removed:

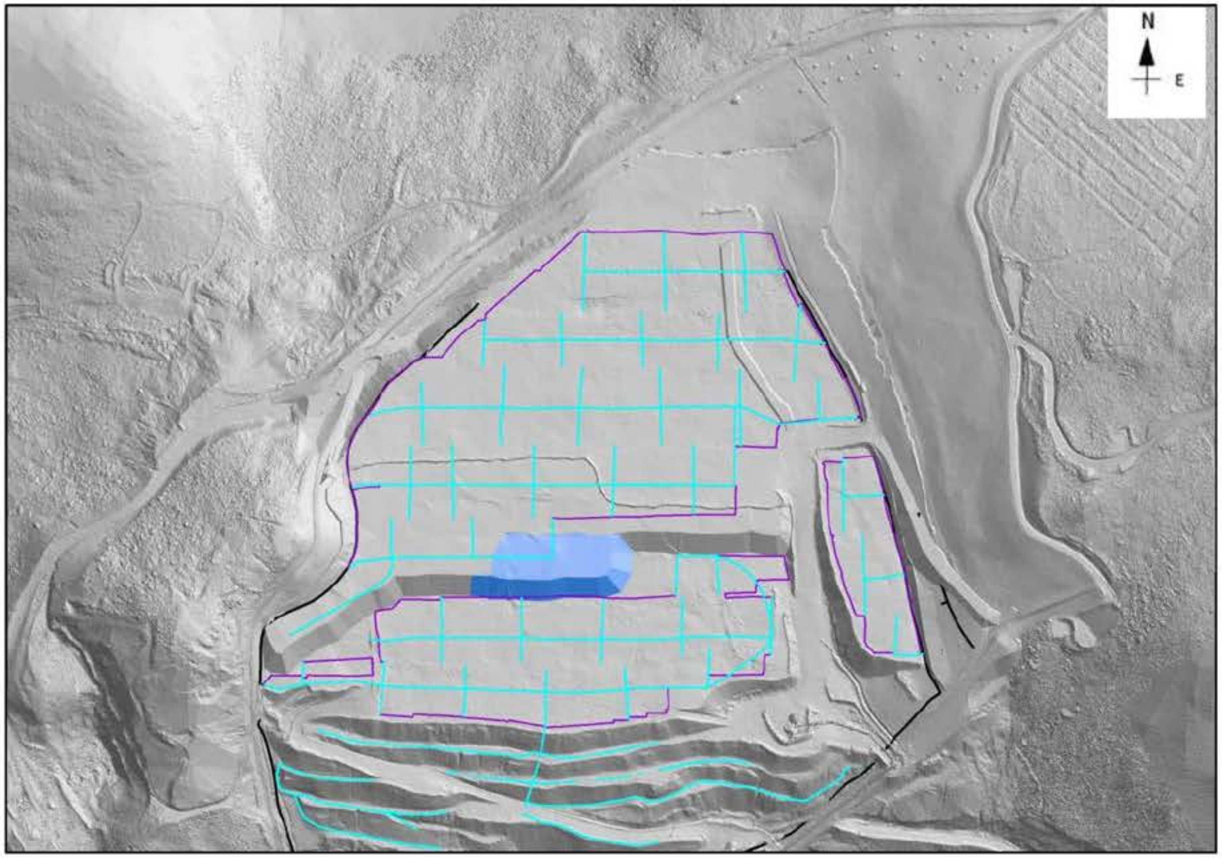
- Actual = 15,825 m²

30 Day Leach Added:

- Actual = 20,361 m²

Area in Prep:

- 3,000 m²



Legend

- Leach Online
- 24" HDPE
- 12"/4" HDPE
- Stacking

HLF Ore Stacking Plan 2023-08-25 to 2023-08-31

HLF Stacking: Past 7 Day Performance (208,965t)

Previous Week Statistics

Stacked Target: 29,465 tpd

- Actual = 30,852 **tpd**

7 Day Leach Added:

- Actual = 16,164m^2

7 Day Leach Removed:

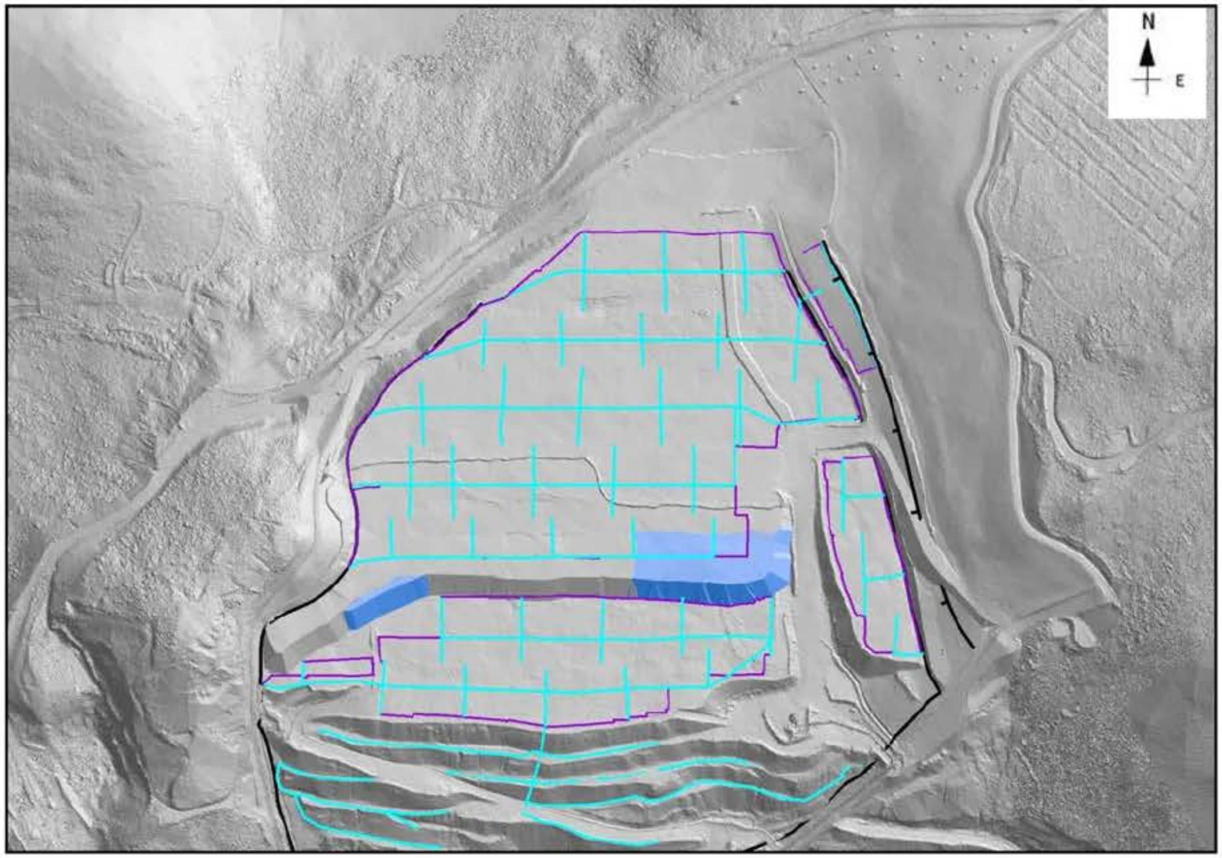
- Actual = 7,568 m^2

30 Day Leach Added:

- Actual = 30,738 m^2

Area in Prep:

- 0 m^2



Legend

- Leach Online
- 24" HDPE
- 12"/4" HDPE
- Stacking

HLF Ore Stacking Plan 2023-09-01 to 2023-09-07

HLF Stacking: Past 7 Day Performance (233,387t)

Previous Week Statistics

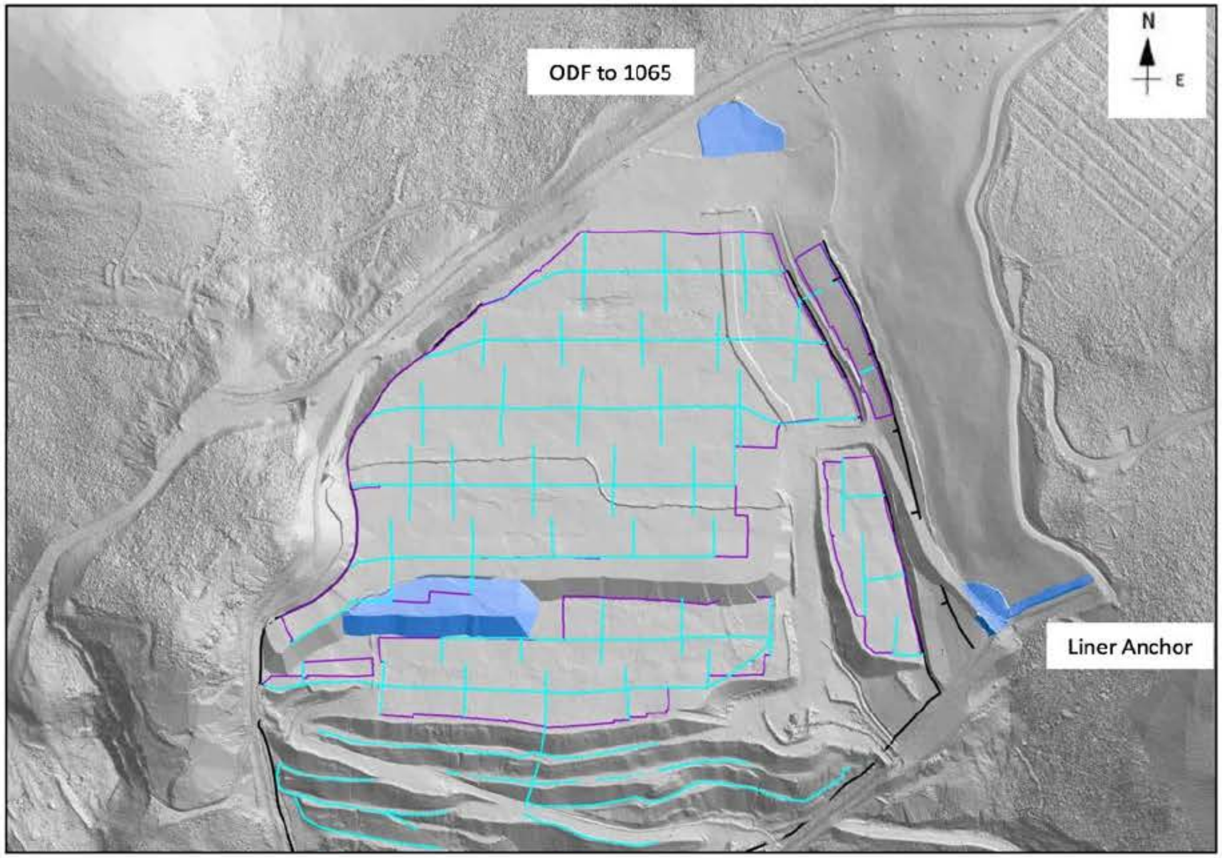
Stacked Target: 30,120 tpd
- Actual = 33,341 tpd

7 Day Leach Added:
- Actual = 8,020 m^2

7 Day Leach Removed:
- Actual = 6,018 m^2

30 Day Leach Added:
- Actual = 42,880 m^2

Area in Prep:
- 2,000 m^2



Legend
- Leach Online
- 24" HDPE
- 12"/4" HDPE
- Stacking

HLF Ore Stacking Plan 2023-09-08 to 2023-09-14

HLF Stacking: Past 7 Day Performance (183,341t)

Previous Week Statistics

Stacked Target: 30,120 tpd

- Actual = 26,192 tpd

7 Day Leach Added:

- Actual = 8,158 m^2

7 Day Leach Removed:

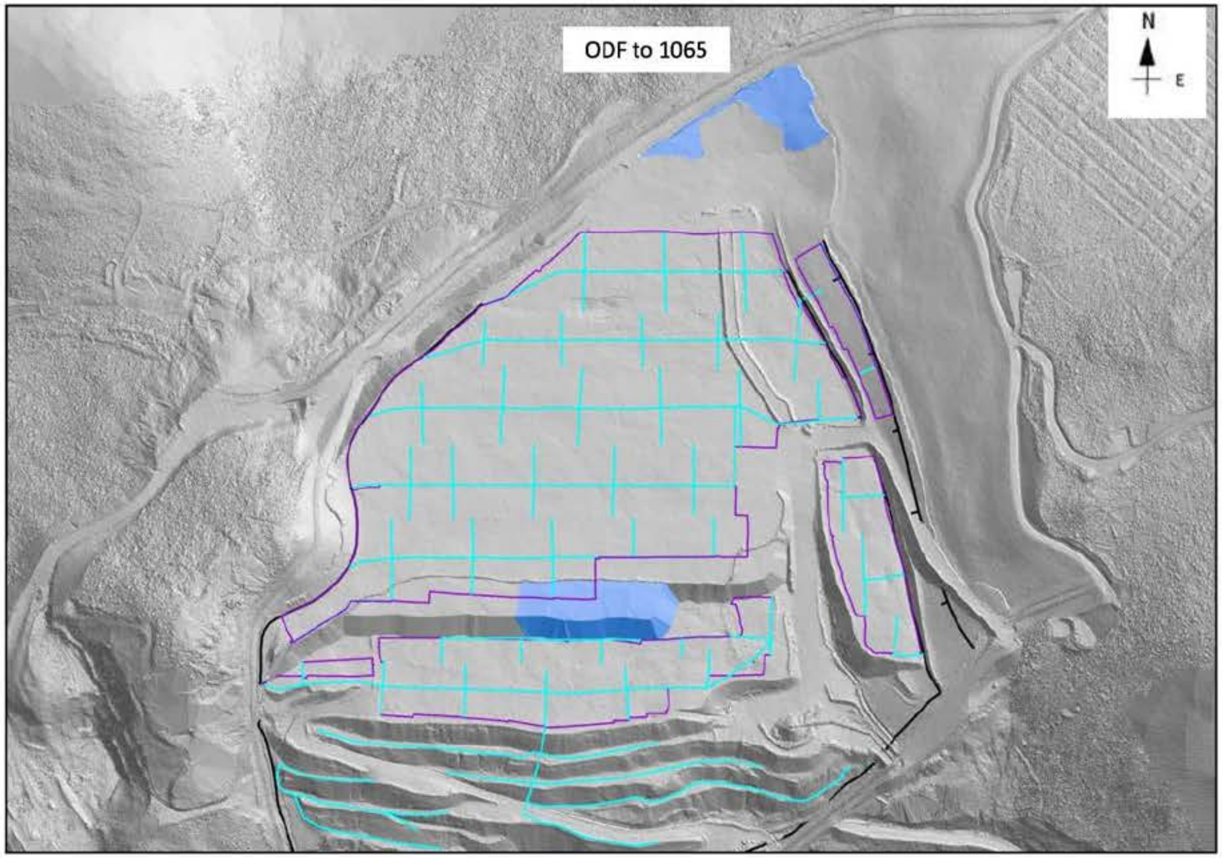
- Actual = 10,129 m^2

30 Day Leach Added:

- Actual = 48,051 m^2

Area in Prep:

- ODF: 25,000 m^2



Legend

- Leach Online
- 24" HDPE
- 12"/4" HDPE
- Stacking

HLF Ore Stacking Plan 2023-09-15 to 2023-09-21

HLF Stacking: Past 7 Day Performance (232,448t)

Previous Week Statistics

Stacked Target: 30,120 tpd

- Actual = 33,207 tpd

7 Day Leach Added:

- Actual = 27,337 m^2

7 Day Leach Removed:

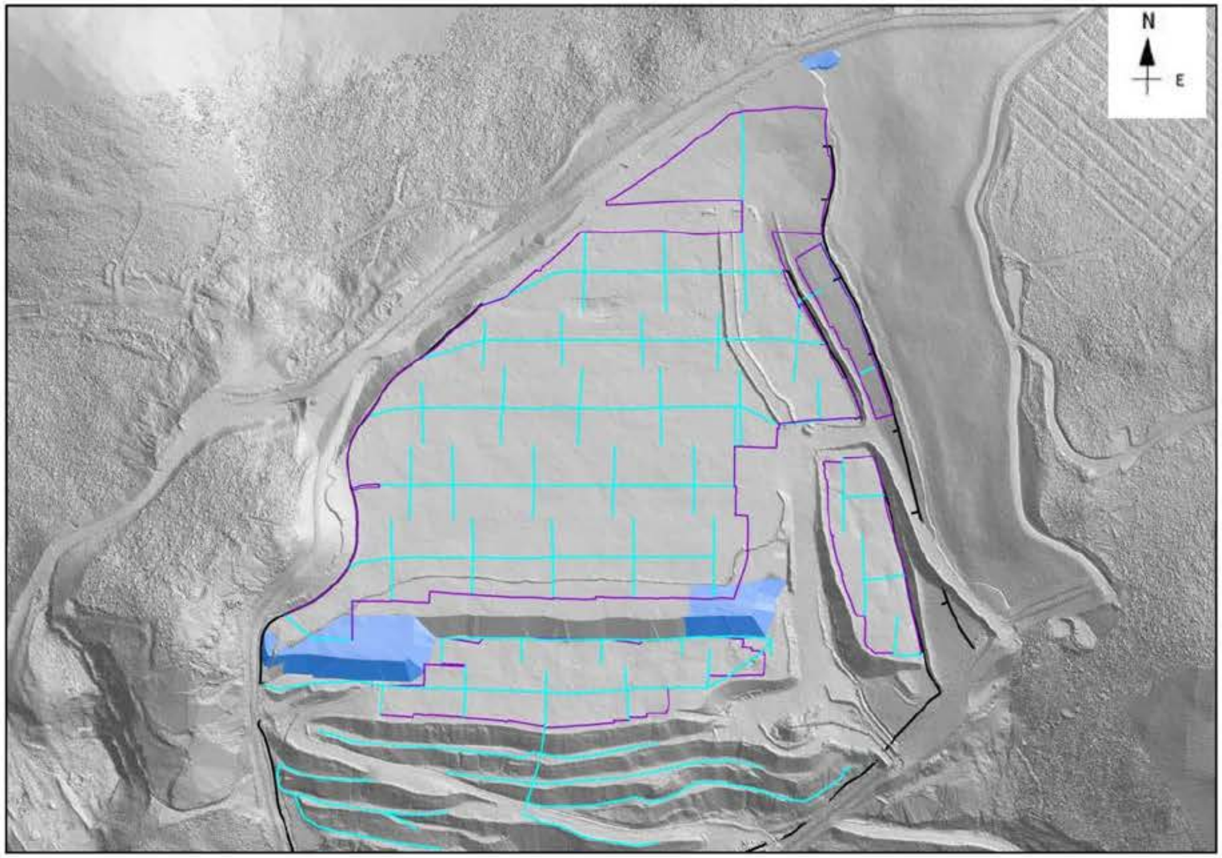
- Actual = 9,014 m^2

30 Day Leach Added:

- Actual = 65,657 m^2

Area in Prep:

- ODF: 2,000 m^2



Legend

- Leach Online
- 24" HDPE
- 12"/4" HDPE
- Stacking

HLF Ore Stacking Plan 2023-09-22 to 2023-09-28

HLF Stacking: Past 7 Day Performance (**169,294t**)

Previous Week Statistics

Stacked Target: 30,120 tpd

- Actual = 24,185 **tpd**

7 Day Leach Added:

- Actual = 5,451 m^2

7 Day Leach Removed:

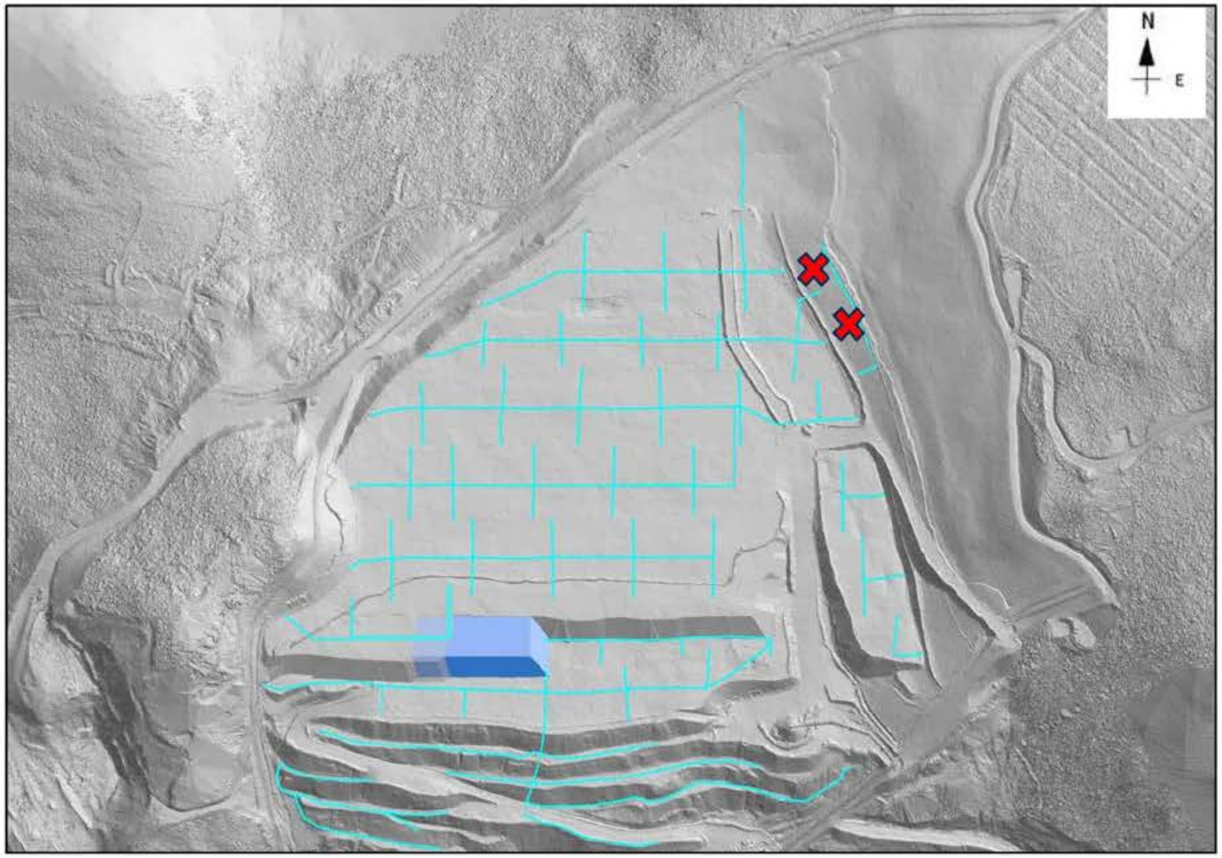
- Actual = 9,715 m^2

30 Day Leach Added:

- Actual = 59,948 m^2

Area in Prep:

- ODF: 2,200 m^2



Legend

- Leach Online
- 24" HDPE
- 12"/4" HDPE
- Stacking

HLF Ore Stacking Plan 2023-09-29 to 2023-10-05

HLF Stacking: Past 7 Day Performance (**182,144t**)

Previous Week Statistics

Stacked Target: 20,613 tpd

- Actual = 26,021 **tpd**

7 Day Leach Added:

- Actual = 9,873 m^2

7 Day Leach Removed:

- Actual = 11,920 m^2

30 Day Leach Added:

- Actual = 56,402 m^2

Area in Prep:

- 2,200 m^2

Legend

- Leach Online
- 24" HDPE
- 12"/4" HDPE
- Stacking

HLF Ore Stacking Plan 2023-10-06 to 2023-10-12

HLF Stacking: Past 7 Day Performance (**144,614t**)

Previous Week Statistics

Stacked Target: 20,613 tpd

- Actual = 20,659 **tpd**

7 Day Leach Added:

- Actual = 15,227 m^2

7 Day Leach Removed:

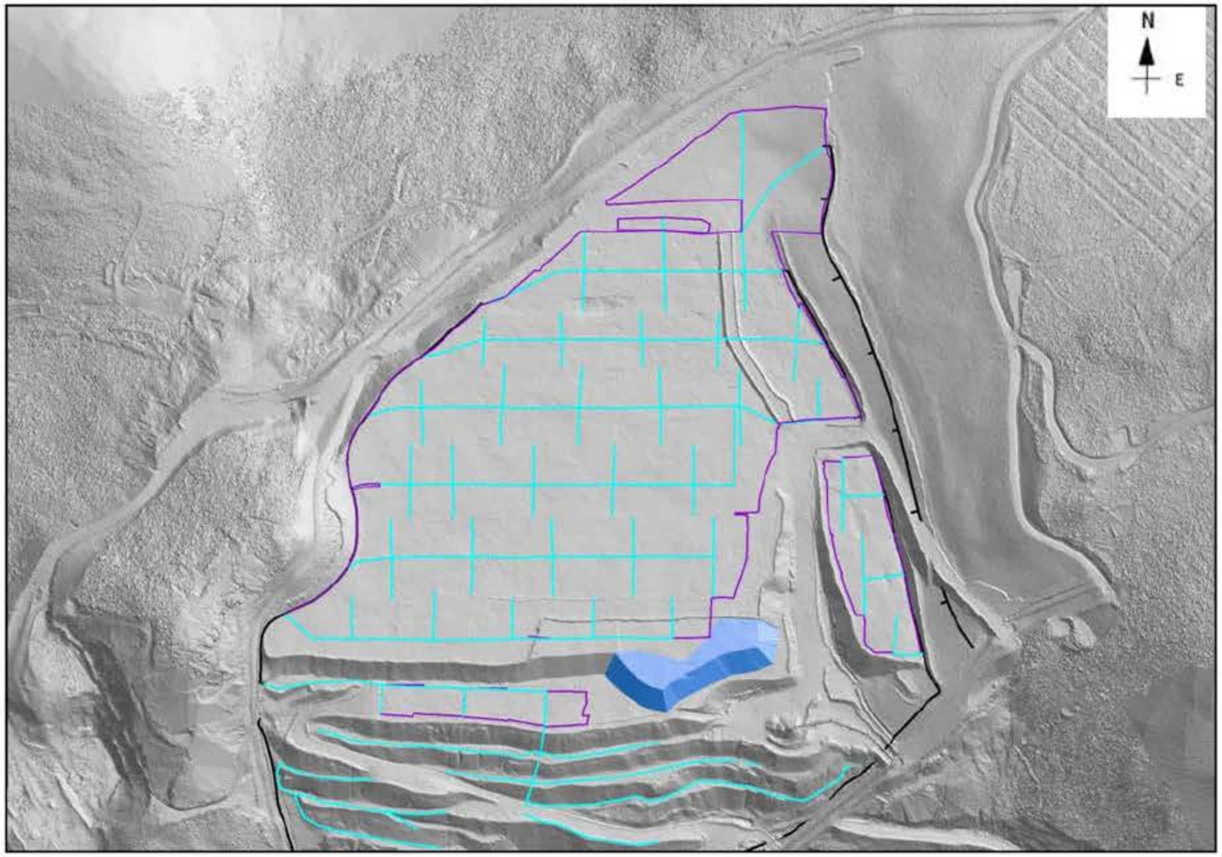
- Actual = 5,080 m^2

30 Day Leach Added:

- Actual = 57,073 m^2

Area in Prep:

- 2,200 m^2



Legend

- Leach Online
- 24" HDPE
- 12"/4" HDPE
- Stacking

HLF Ore Stacking Plan 2023-10-13 to 2023-10-19

HLF Stacking: Past 7 Day Performance (**146,424t**)

Previous Week Statistics

Stacked Target: 20,613 tpd

- Actual = 20,917 **tpd**

7 Day Leach Added:

- Actual = 11,388 m^2

7 Day Leach Removed:

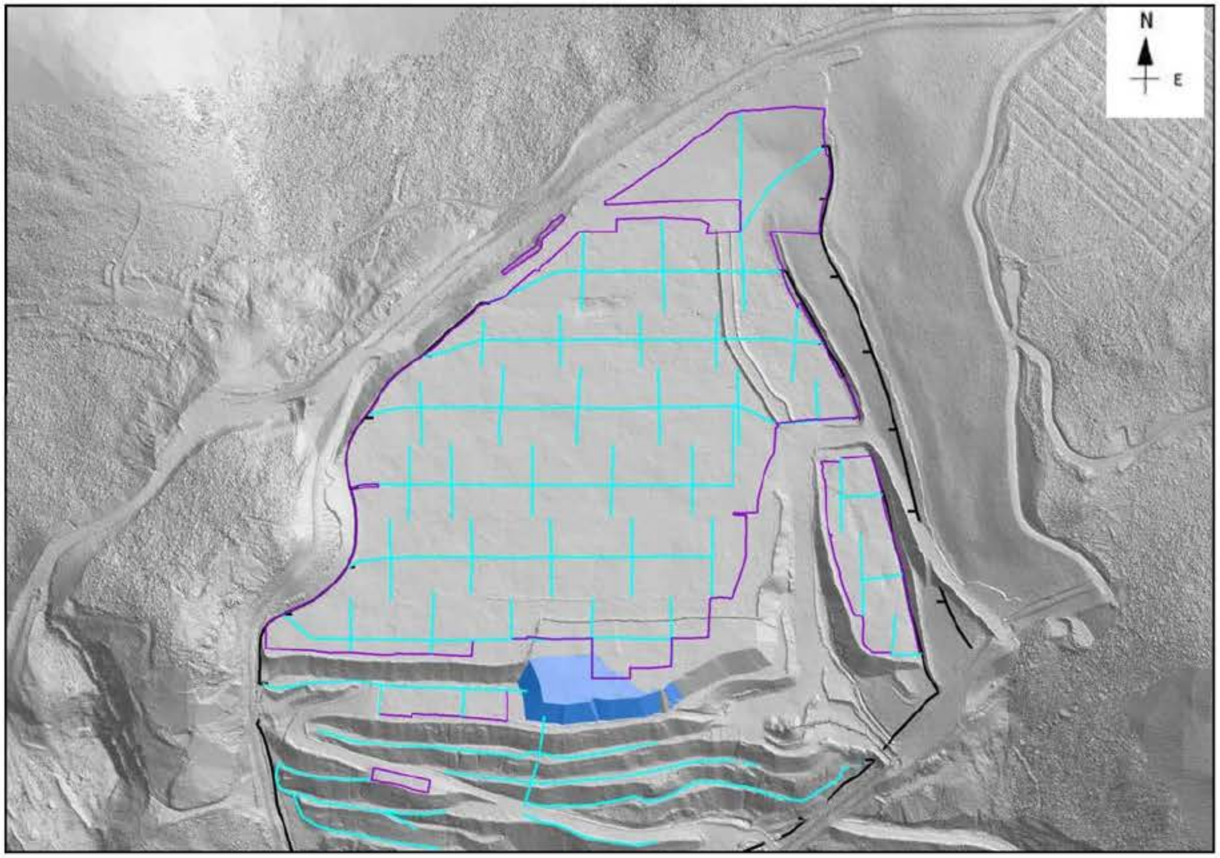
- Actual = 1,769 m^2

30 Day Leach Added:

- Actual = 36,986 m^2

Area in Prep:

- 2,000 m^2



Legend

- Leach Online
- 24" HDPE
- 12"/4" HDPE
- Stacking

HLF Ore Stacking Plan 2023-10-20 to 2023-10-26

HLF Stacking: Past 7 Day Performance (**32,487t**)

Previous Week Statistics

Stacked Target: 8,571 tpd

- Actual = 4,641 **tpd**

7 Day Leach Added:

- Actual = 1,706 m^2

7 Day Leach Removed:

- Actual = 1,691 m^2

30 Day Leach Added:

- Actual = 38,692 m^2

Area in Prep:

- 2,000 m^2

Legend

- Leach Online
- 24" HDPE
- 12"/4" HDPE
- Stacking

HLF Ore Stacking Plan 2023-10-27 to 2023-11-02

HLF Stacking: Past 7 Day Performance (**205,178t**)

Previous Week Statistics

Stacked Target: 20,613 tpd

- Actual = 29,311 **tpd**

7 Day Leach Added:

- Actual = 9,435 m^2

7 Day Leach Removed:

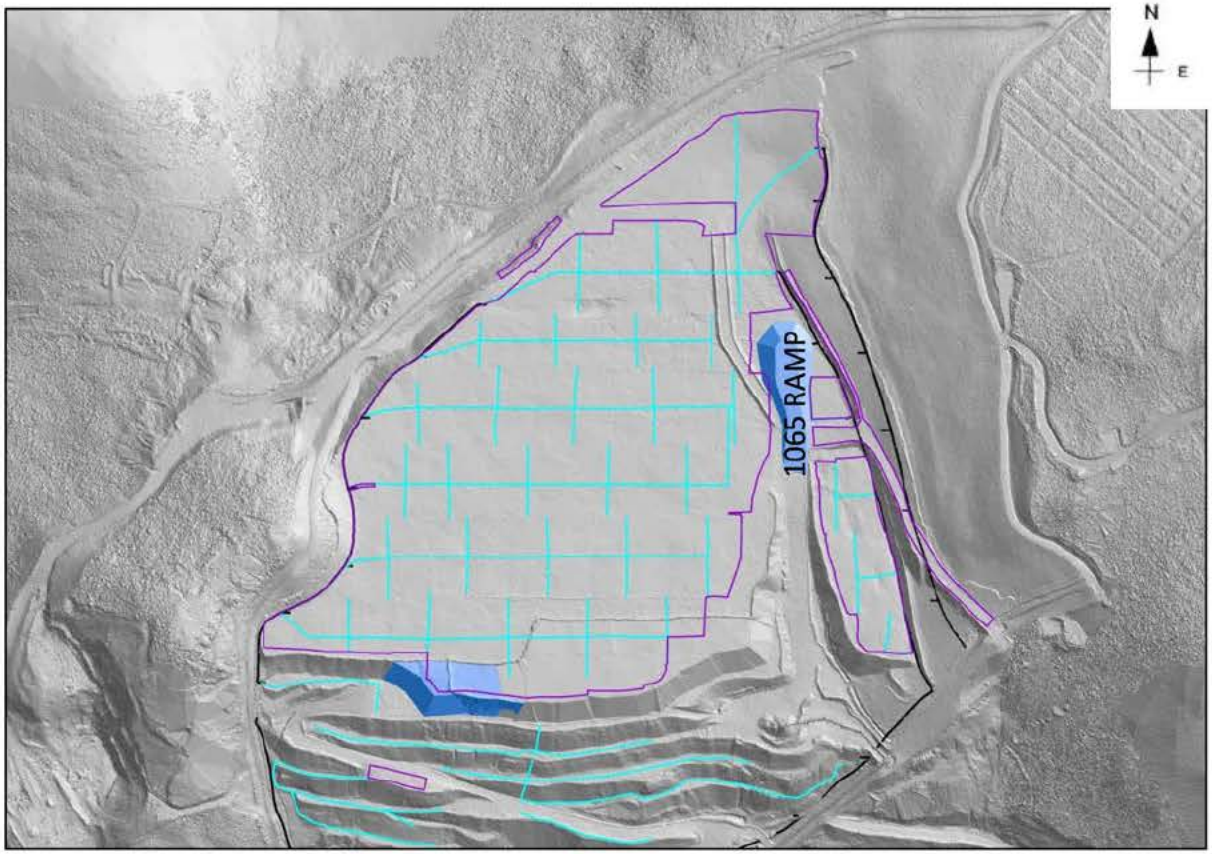
- Actual = 12,868 m^2

30 Day Leach Added:

- Actual = 41,460 m^2

Area in Prep:

- Scavenge 2,000 m^2



Legend

- Leach Online
- 24" HDPE
- 12"/4" HDPE
- Stacking

HLF Ore Stacking Plan 2023-11-03 to 2023-11-09

HLF Stacking: Past 7 Day Performance (210,158t)

Previous Week Statistics

Stacked Target: 28,720 tpd

- Actual = 30,023 tpd

7 Day Leach Added:

- Actual = 2,849 m^2

7 Day Leach Removed:

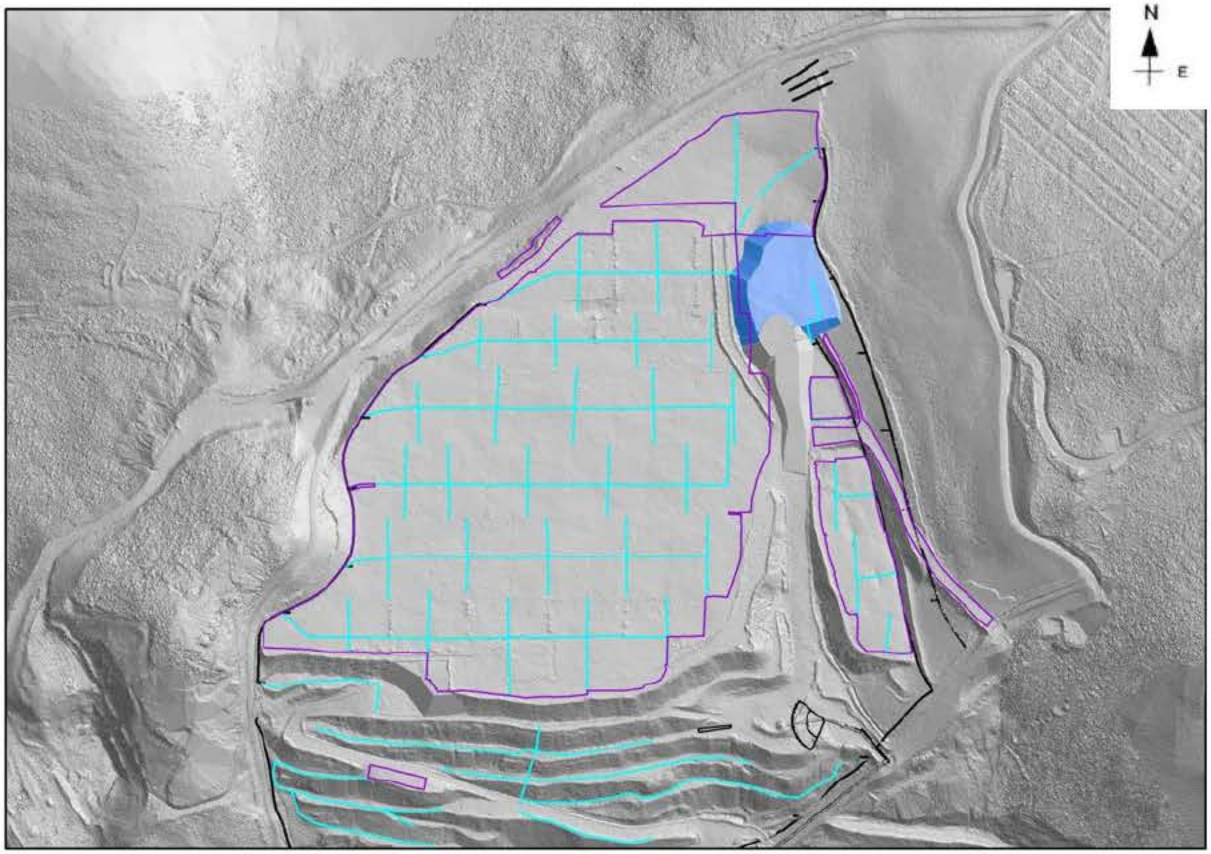
- Actual = 2,350 m^2

30 Day Leach Added:

- Actual = 31,839 m^2

Area in Prep:

- 2,000 m^2



Legend

- Leach Online
- 24" HDPE
- 12"/4" HDPE
- Stacking

HLF Ore Stacking Plan 2023-11-10 to 2023-11-16

HLF Stacking: Past 7 Day Performance (**144,335t**)

Previous Week Statistics

Stacked Target: 28,720 tpd

- Actual = 20,620 **tpd**

7 Day Leach Added:

- Actual = 7,500 m^2

7 Day Leach Removed:

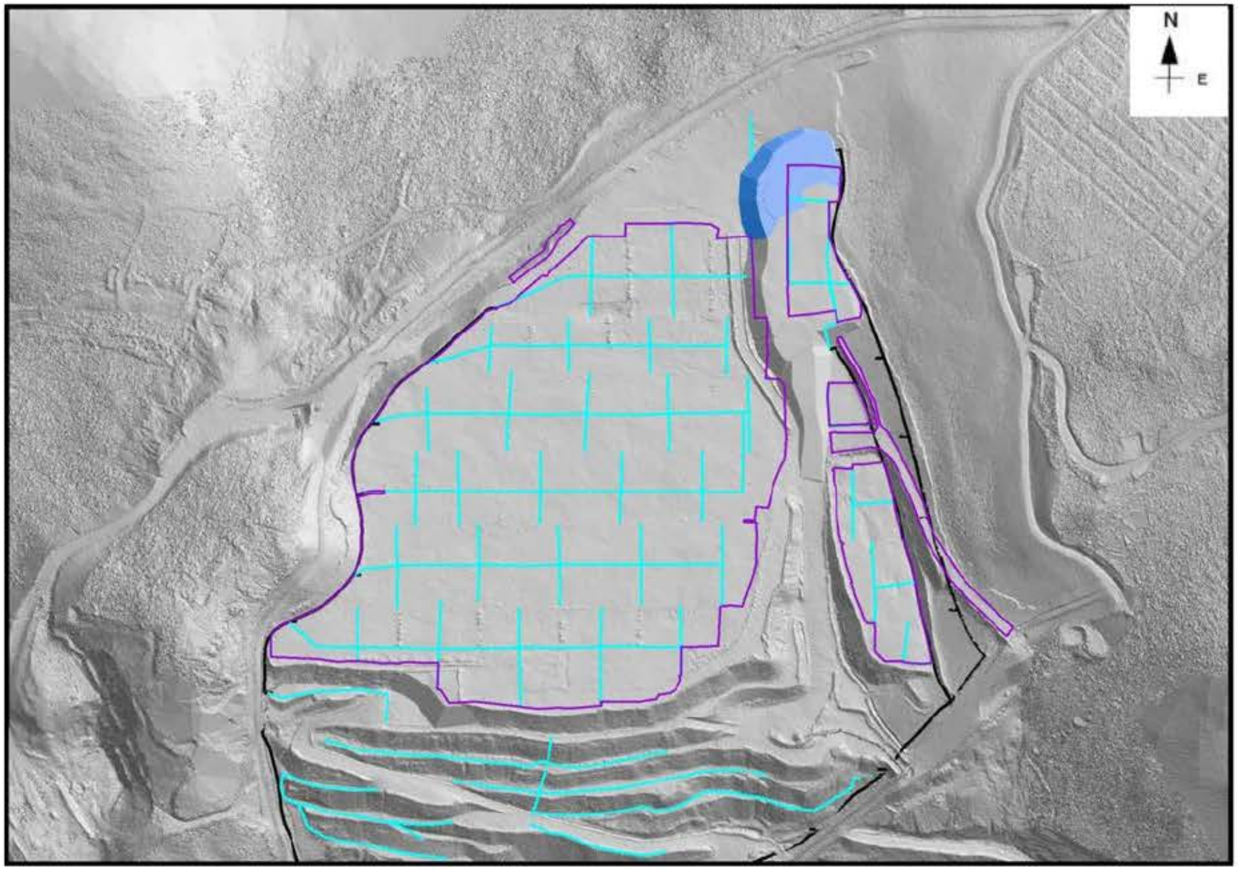
- Actual = 0 m^2

30 Day Leach Added:

- Actual = 39,700 m^2

Area in Prep:

- 7,600 m^2



Legend

- Leach Online
- 24" HDPE
- 12"/4" HDPE
- Stacking

HLF Ore Stacking Plan 2023-11-17 to 2023-11-23

HLF Stacking: Past 7 Day Performance (**164,773t**)

Previous Week Statistics

Stacked Target: 34,600 tpd

- Actual = 23,500 **tpd**

7 Day Leach Added:

- Actual = 13,000 m^2

7 Day Leach Removed:

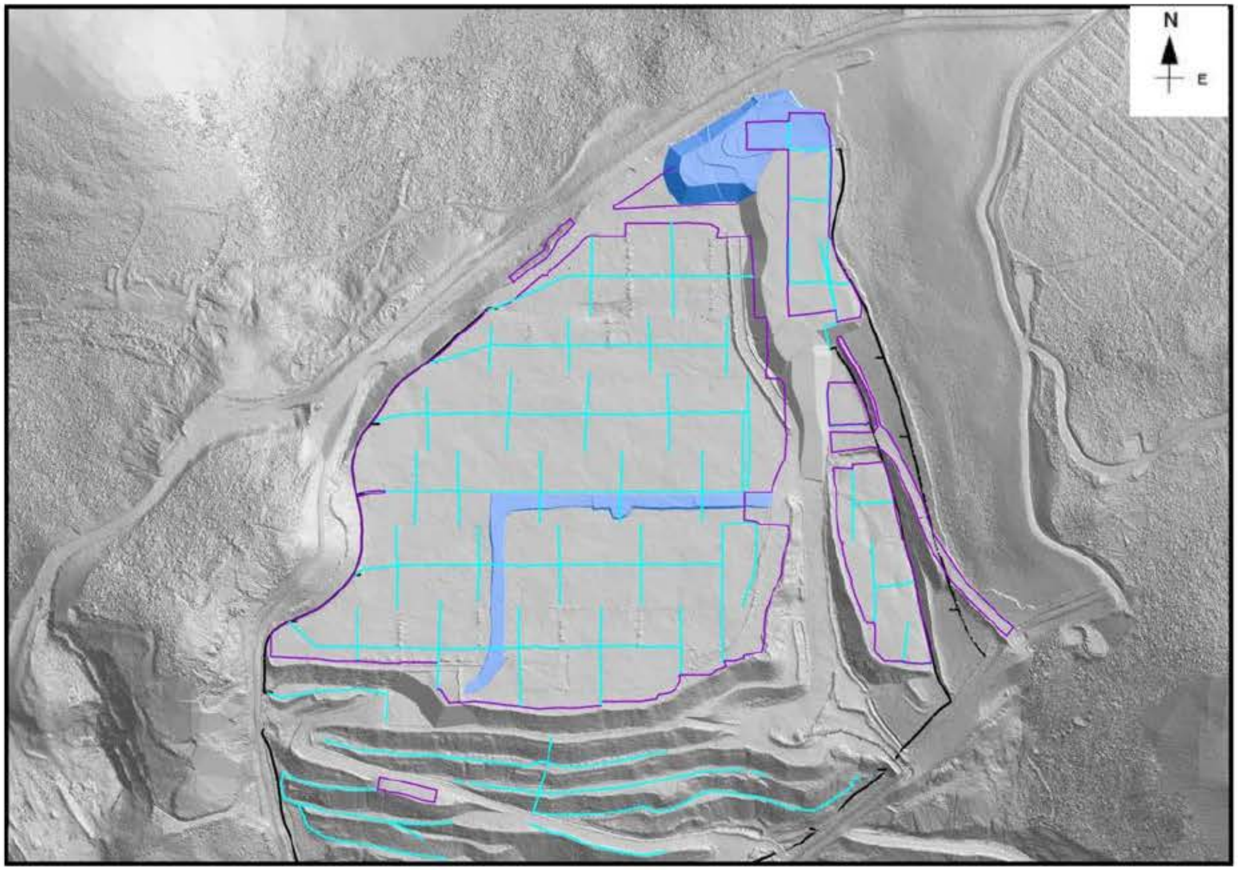
- Actual = 0 m^2

30 Day Leach Added:

- Actual = 31,800 m^2

Area in Prep:

- 900 m^2

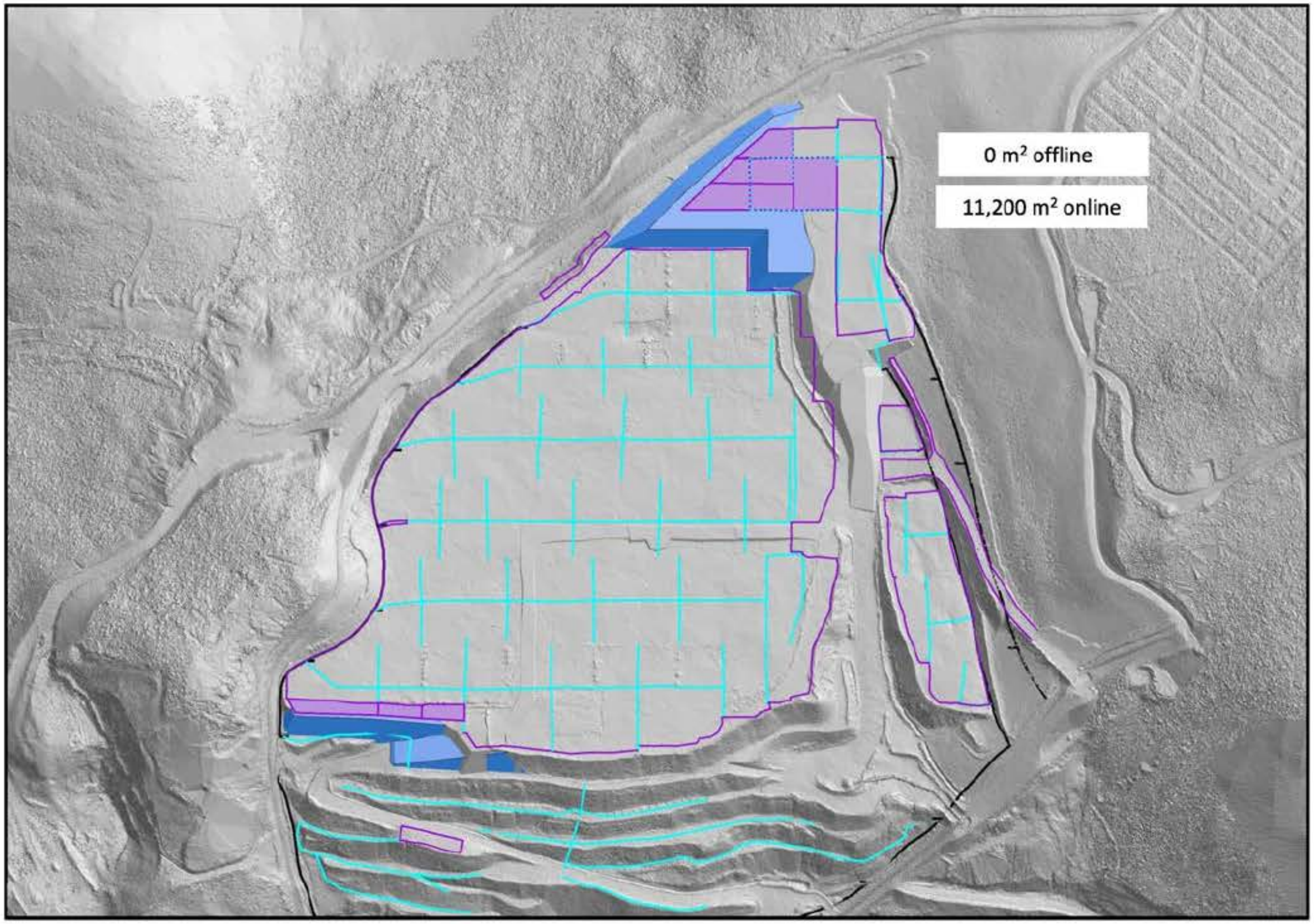


Legend

- Leach Online
- 24" HDPE
- 12"/4" HDPE
- Stacking

HLF Ore Stacking Plan 2023-11-24 to 2023-11-30 (inferred from plan)

~~HLF Stacking: One week look-ahead (Nov 25th – Dec 1st)~~



- Assumptions:
  - E6 1053 Header feeding 1065
  - Build 1053 Ramp and push out material and leach remaining area on 1053
- Follow-up on Key Issues:
  - Charge 1065 EDL on Dec 2nd

Tonnes Stacked: 230,000 t

Area Online: 11,200 m²

Area Offline: 2,200 m²

Area Offline ODF: 9,700 m²

HLF Ore Stacking Plan 2023-12-01 to 2023-12-07

HLF Stacking: Past 7 Day Performance (196,028t)

Previous Week Statistics

Stacked Target: 28,561 tpd

- Actual = 28,004 tpd

7 Day Leach Added:

- Actual = 6,573 m²

7 Day Leach Removed:

- Actual = 12,411 m²

30 Day Leach Added:

- Actual = 36,393 m²

Area in Prep:

- ~2,000 m²

Legend

- Leach Online
- 24" HDPE
- 12"/4" HDPE
- Stacking

HLF Ore Stacking Plan 2023-12-08 to 2023-12-14

HLF Stacking: Past 7 Day Performance (**159,332t**)

Previous Week Statistics

Stacked Target: 28,561 tpd

- Actual = 22,800 **tpd**

7 Day Leach Added:

- Actual = 7,559 m^2

7 Day Leach Removed:

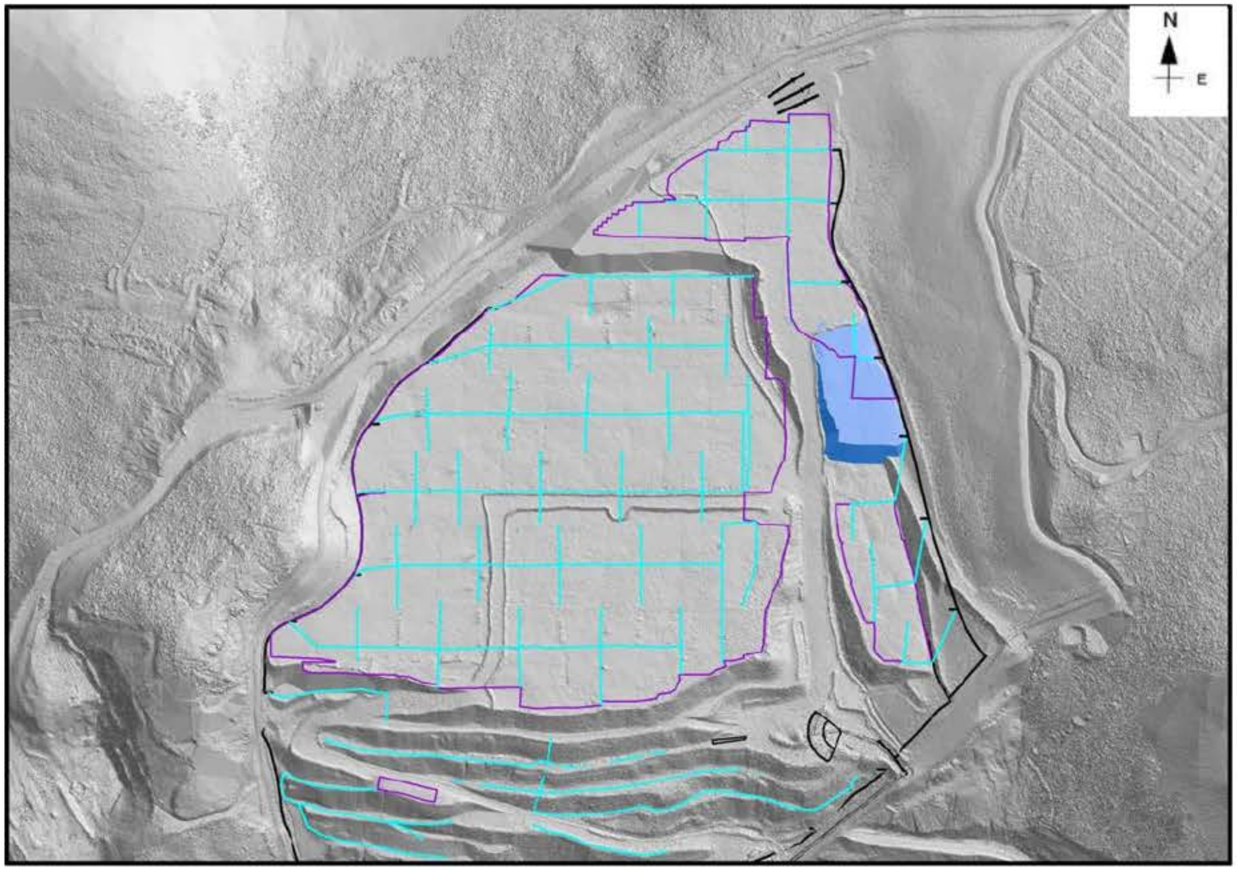
- Actual = 4,446m^2

30 Day Leach Added:

- Actual = 42,026 m^2

Area in Prep:

- ~2,500 m^2



Legend

- Leach Online
- 24" HDPE
- 12"/4" HDPE
- Stacking

HLF Ore Stacking Plan 2023-12-15 to 2023-12-21

HLF Stacking: Past 7 Day Performance (**144,167t**)

Previous Week Statistics

Stacked Target: 28,561 tpd

- Actual = 20,595 tpd

7 Day Leach Added:

- Actual = 5,269 m^2

7 Day Leach Removed:

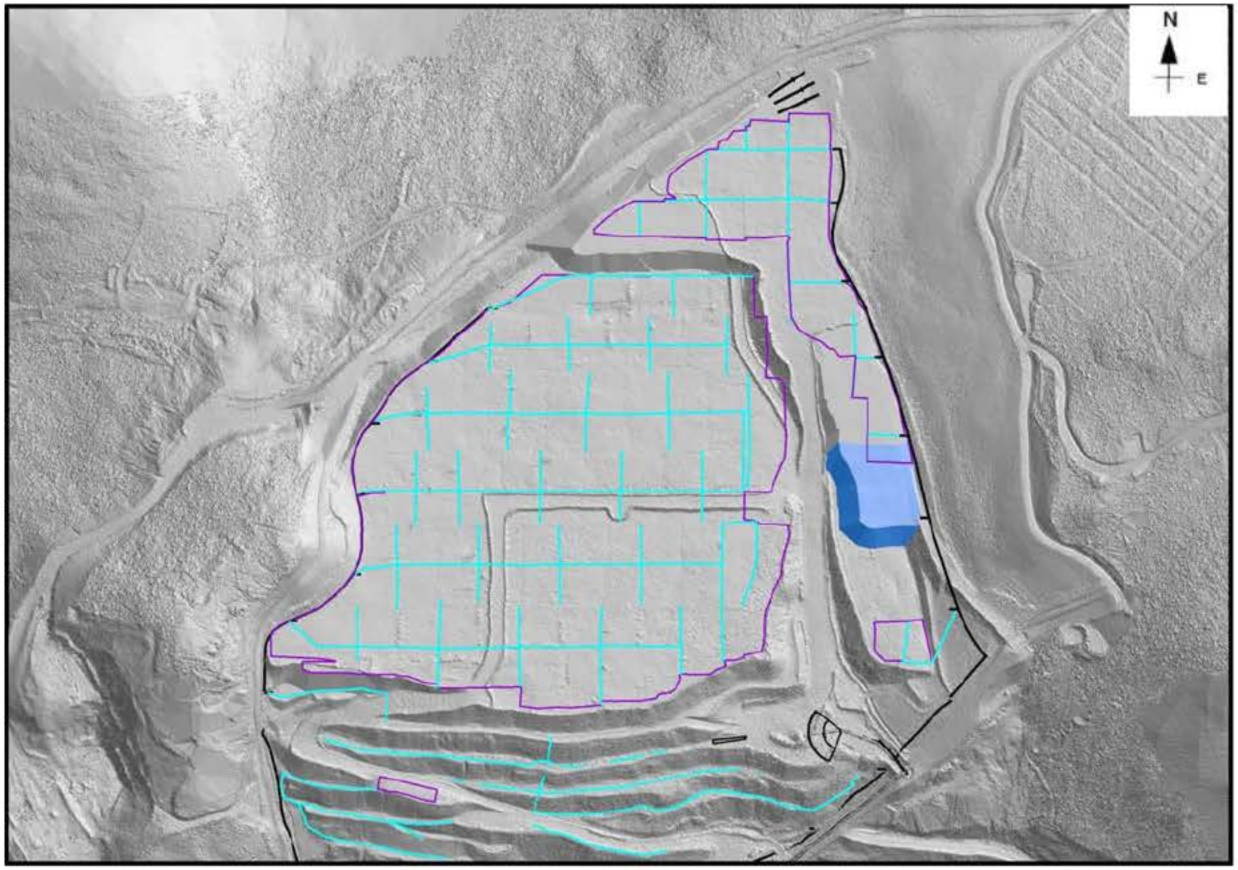
- Actual = 9,317m^2

30 Day Leach Added:

- Actual = 35,795 m^2

Area in Prep:

- ~3,000 m^2



Legend

- Leach Online
- 24" HDPE
- 12"/4" HDPE
- Stacking

HLF Ore Stacking Plan 2023-12-22 to 2023-12-28

HLF Stacking: Past 7 Day Performance (125,536t)

Previous Week Statistics

Stacked Target: 28,561 tpd

- Actual = 17,934 tpd

7 Day Leach Added:

- Actual = 2,414 m^2

7 Day Leach Removed:

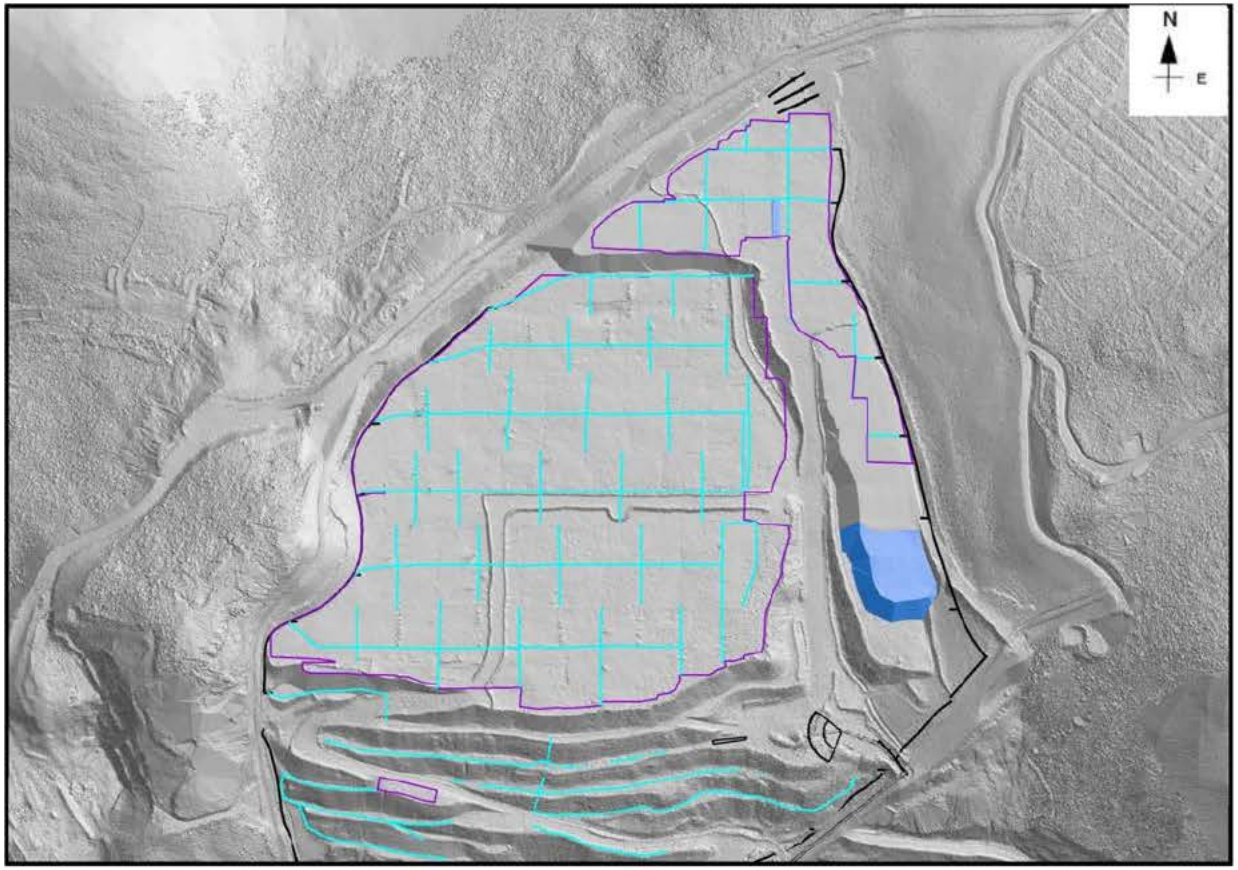
- Actual = 2,609 m^2

30 Day Leach Added:

- Actual = 31,453 m^2

Area in Prep:

- ~4,000 m^2



Legend

- Leach Online
- 24" HDPE
- 12"/4" HDPE
- Stacking

HLF Ore Stacking Plan 2023-12-29 to 2024-01-04

HLF Stacking: Past 7 Day Performance (**133,507t**)

Previous Week Statistics

Stacked Target: 28,561 tpd

- Actual = 17,934 **tpd**

7 Day Leach Added:

- Actual = 3,951 m^2

7 Day Leach Removed:

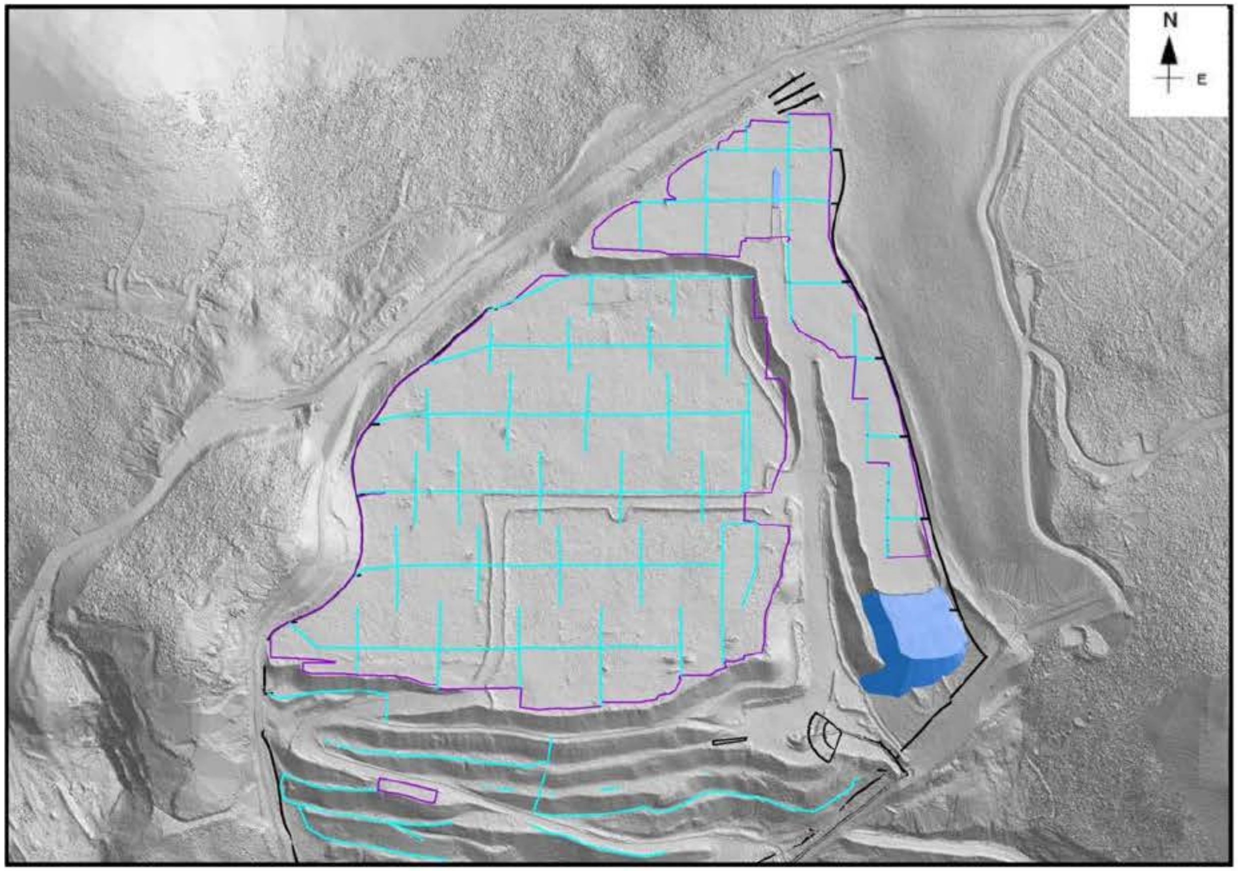
- Actual = 0 m^2

30 Day Leach Added:

- Actual = 29,115 m^2

Area in Prep:

- ~4,000 m^2



Legend

- Leach Online
- 24" HDPE
- 12"/4" HDPE
- Stacking

HLF Ore Stacking Plan 2024-01-05 to 2024-01-11

HLF Stacking: Past 7 Day Performance (**198,083t**)

Previous Week Statistics

Stacked Target: 27,837 tpd

- Actual = 28,297 **tpd**

7 Day Leach Added:

- Actual = 8,060 m²

7 Day Leach Removed:

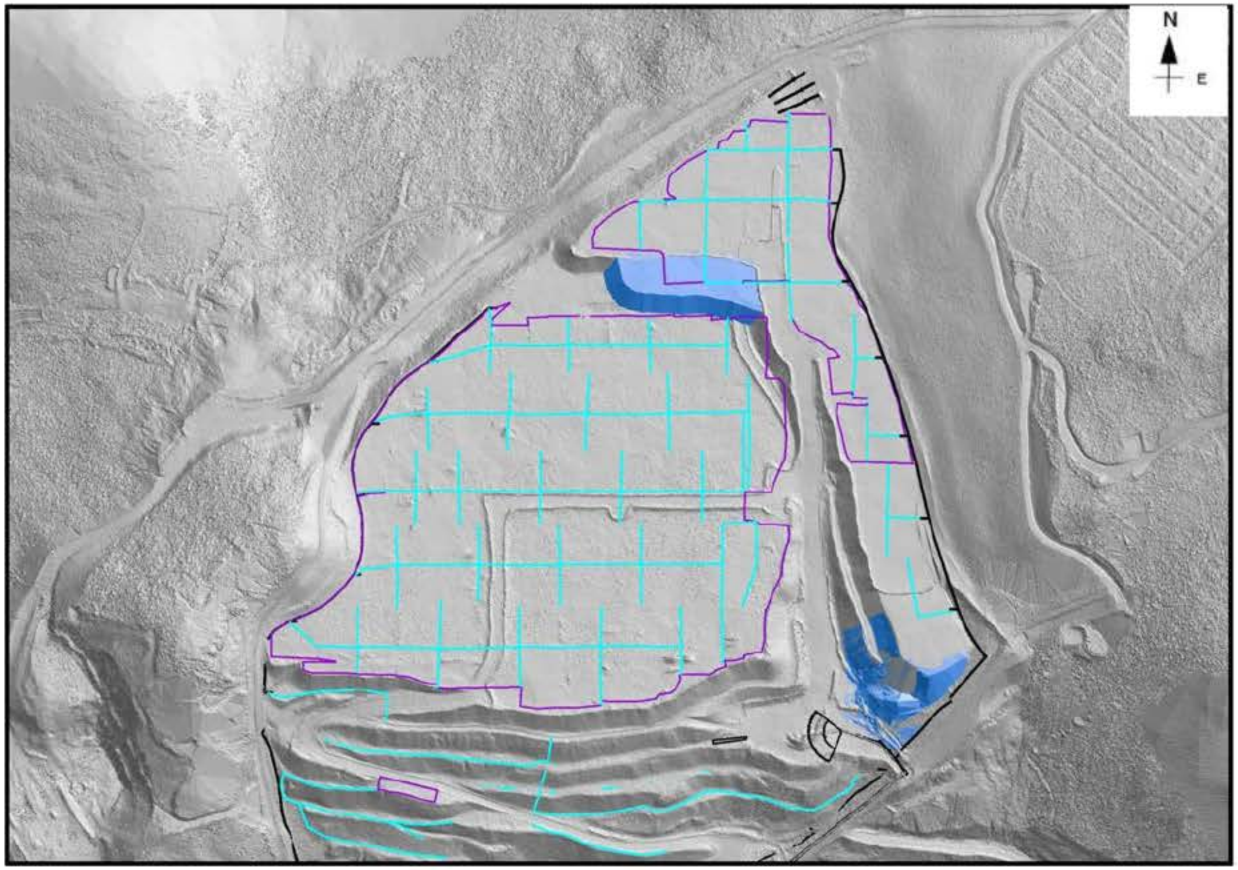
- Actual = 16,666 m²

30 Day Leach Added:

- Actual = 17,628 m²

Area in Prep:

- ~2,000 m²



Legend

- Leach Online
- 24" HDPE
- 12"/4" HDPE
- Stacking

HLF Ore Stacking Plan 2024-01-12 to 2024-01-18

HLF Stacking: Past 7 Day Performance (**167,734t**)

Previous Week Statistics

Stacked Target: 27,837 tpd

- Actual = 23,962 **tpd**

7 Day Leach Added:

- Actual = 6,899 m²

7 Day Leach Removed:

- Actual = 12,021 m²

30 Day Leach Added;

- Actual = 14,956 m²

Area in Prep:

- ~2,100 m²

Legend

- Leach Online
- 24" HDPE
- 12"/4" HDPE
- Stacking

HLF Ore Stacking Plan 2024-01-19 to 2024-01-25

HLF Stacking: Past 7 Day Performance (**186,578t**)

Previous Week Statistics

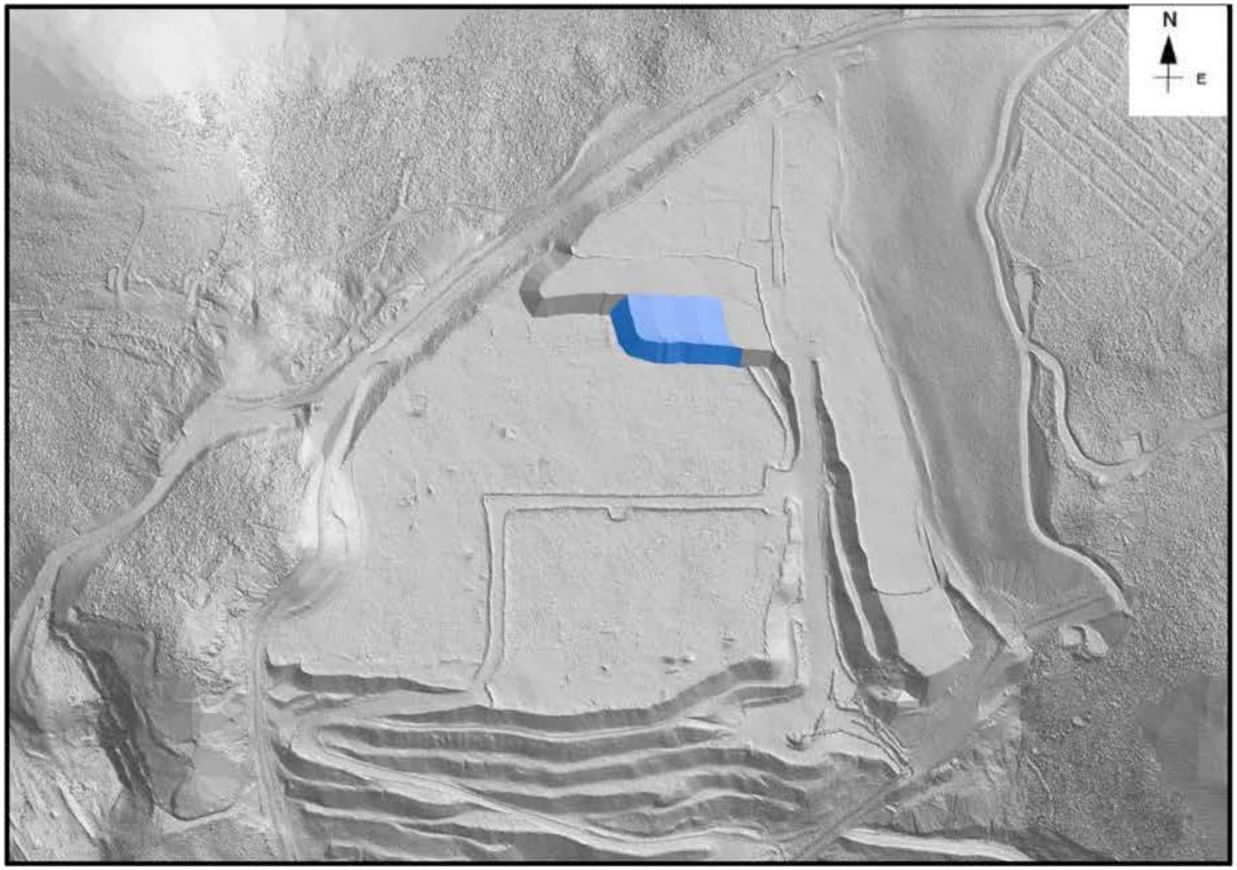
Stacked Target: 27,837 tpd
- Actual = 26,654 **tpd**

7 Day Leach Added:
- Actual = 6,596 m^2

7 Day Leach Removed:
- Actual = 8,609 m^2

30 Day Leach Added;
- Actual = 26,654 m^2

Area in Prep:
- ~2,100 m^2



Legend
- Leach Online
- 24" HDPE
- 12"/4" HDPE
- Stacking

HLF Ore Stacking Plan 2024-01-26 to 2024-02-01

HLF Stacking: Past 7 Day Performance (**142,787t**)

Previous Week Statistics

Stacked Target: 30,000 tpd

- Actual = 20,398 **tpd**

7 Day Leach Added:

- Actual = 7,780 m^2

7 Day Leach Removed:

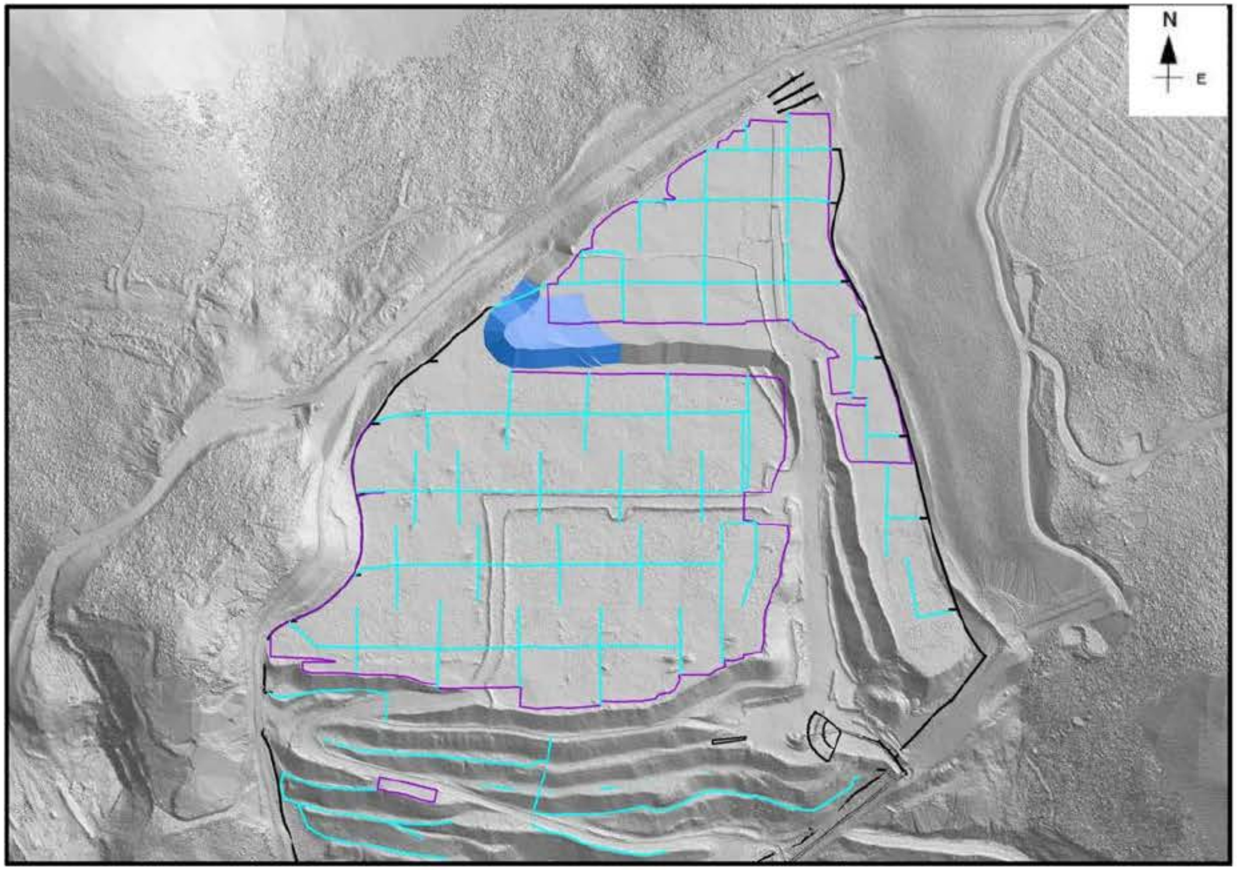
- Actual = 11,974 m^2

30 Day Leach Added;

- Actual = 23,502 m^2

Area in Prep:

- ~500 m^2



Legend

- Leach Online
- 24" HDPE
- 12"/4" HDPE
- Stacking

HLF Ore Stacking Plan 2024-02-02 to 2024-02-08

HLF Stacking: Past 7 Day Performance (**179,847t**)

Previous Week Statistics

Stacked Target: 28,619 tpd

- Actual = 25,692 **tpd**

7 Day Leach Added:

- Actual = 5,547 m^2

7 Day Leach Removed:

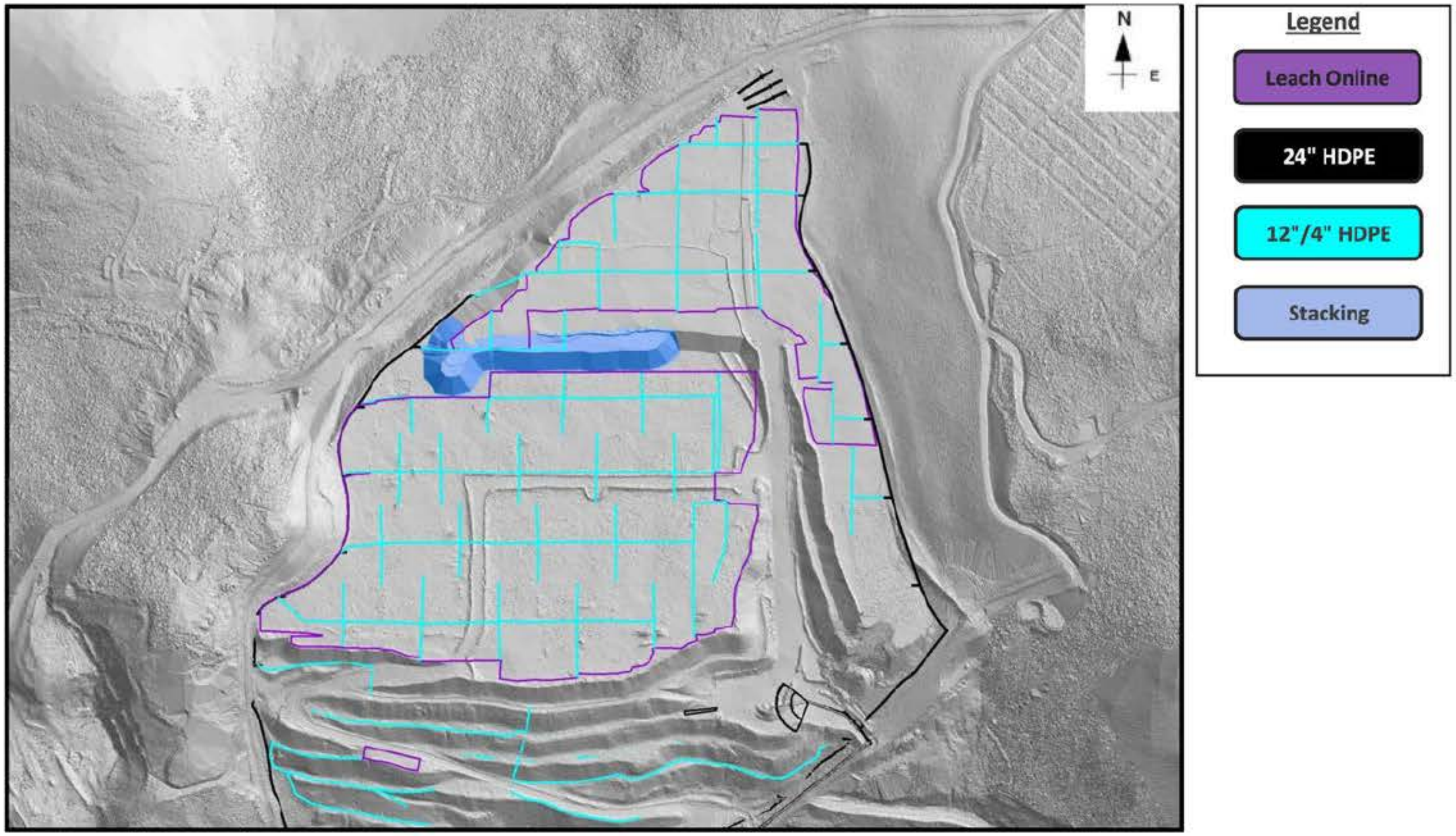
- Actual = 4,307 m^2

30 Day Leach Added;

- Actual = 27,339 m^2

Area in Prep:

- ~4000 m^2



HLF Ore Stacking Plan 2024-02-09 to 2024-02-15

HLF Stacking: Past 7 Day Performance (**150,949t**)

Previous Week Statistics

Stacked Target: 28,619 tpd

- Actual = 21,564 **tpd**

7 Day Leach Added:

- Actual = 9,618 m^2

7 Day Leach Removed:

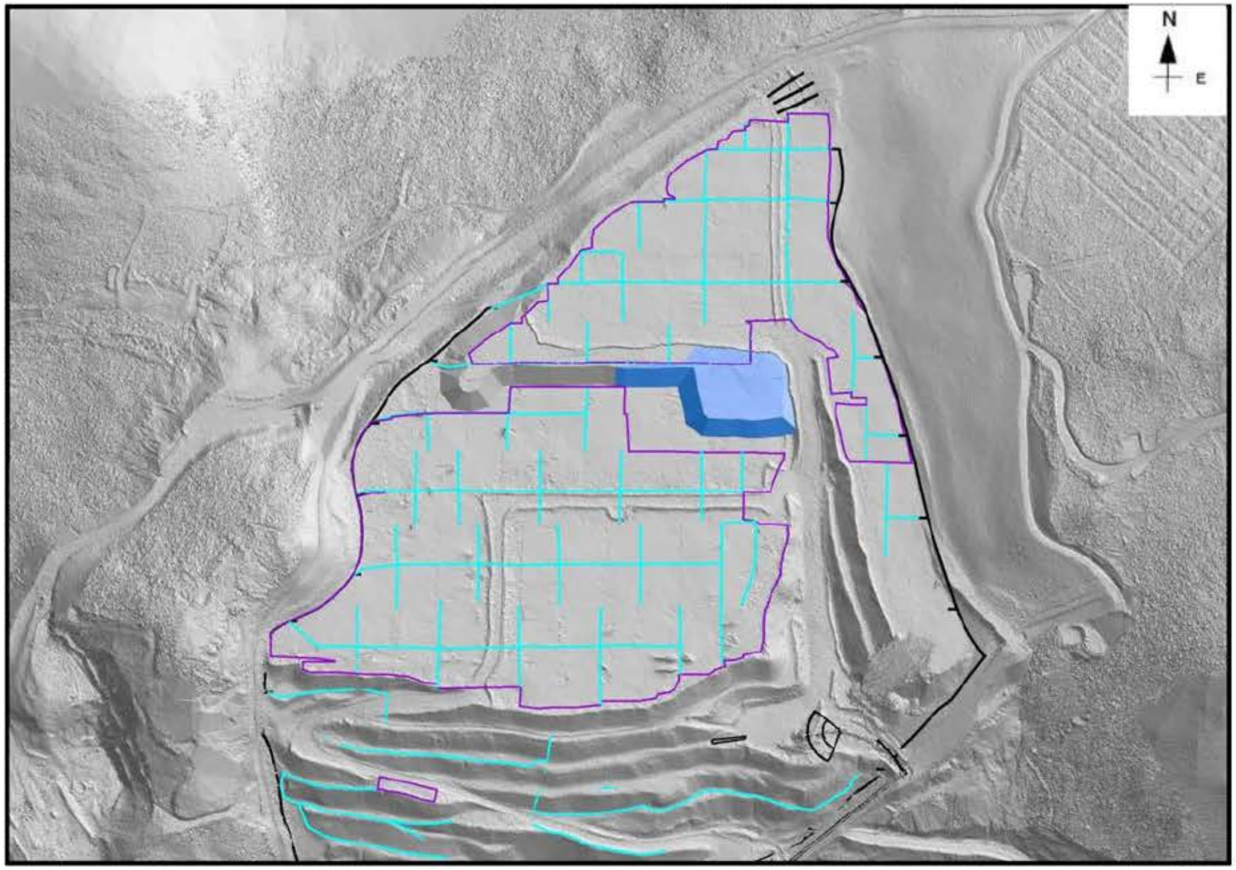
- Actual = 13,298 m^2

30 Day Leach Added;

- Actual = 27,439 m^2

Area in Prep:

- ~2100 m^2



Legend

- Leach Online
- 24" HDPE
- 12"/4" HDPE
- Stacking

HLF Ore Stacking Plan 2024-02-16 to 2024-02-22

HLF Stacking: Past 7 Day Performance (**149,428 t + 45,528 t**)

Previous Week Statistics

Stacked Target: 32,336 tpd

- Actual = 21,347 tpd

7 Day Leach Added:

- Actual = 6,293 m^2

7 Day Leach Removed:

- Actual = 15,070 m^2

30 Day Leach Added;

- Actual = 27,529 m^2

Area in Prep:

- ~2100 m^2

Leach Area Change:

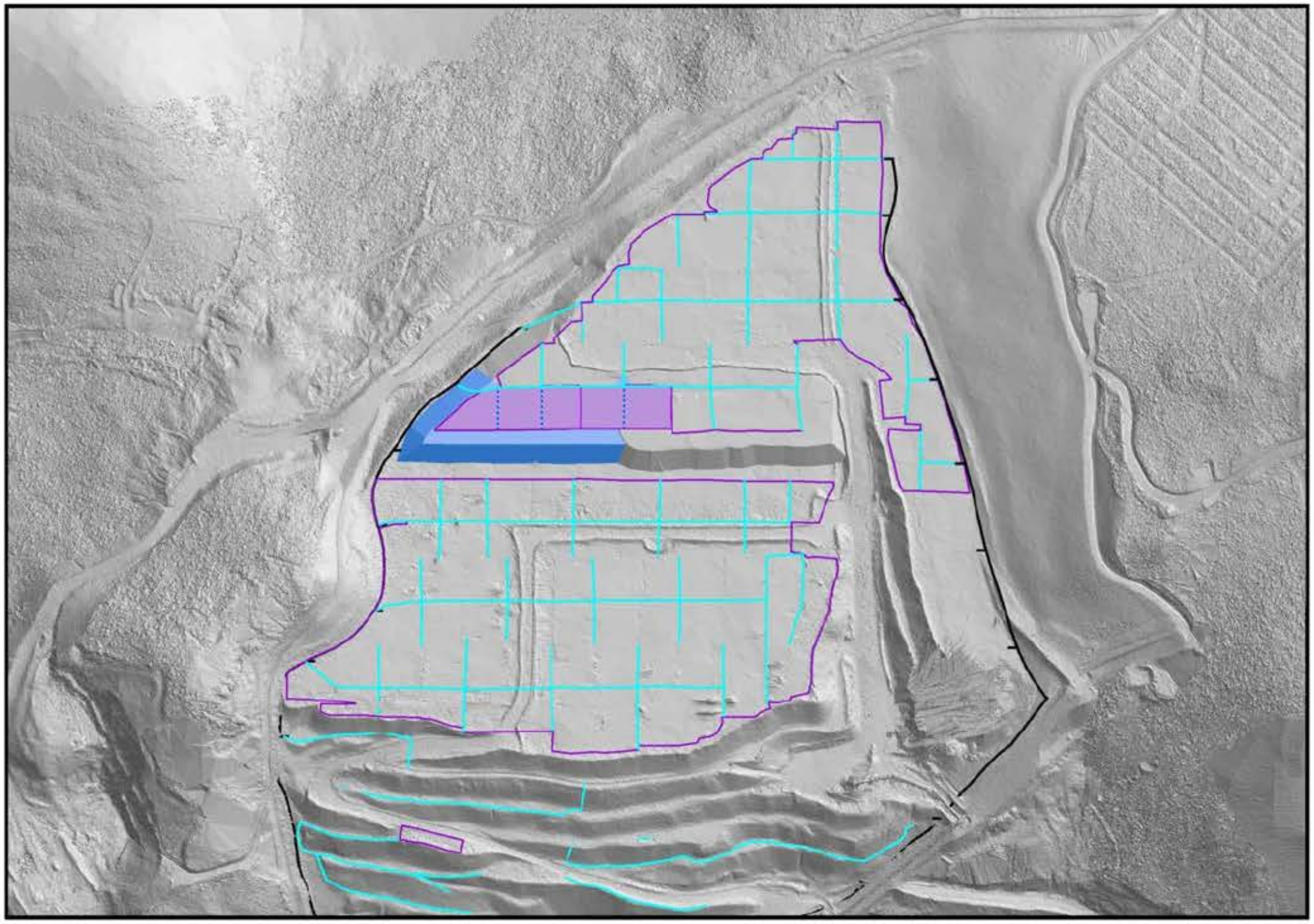
- **219,455m^2 today**
- **226,909m^2 last week**

Legend

- Leach Online
- 24" HDPE
- 12"/4" HDPE
- Stacking

HLF Ore Stacking Plan 2024-02-23 to 2024-02-29 (inferred from plan)

~~HLF Stacking: One week look-ahead~~



- Assumptions:
  - 45kT stacked from remediation
  - Continue advancement to the west.
- Pipework:
  - 3 x 150 ft 4" Line

Tonnes Stacked:

- **Week 1: 210,000 t**
- **Remediation: 45,000 t**

Area Online: 10,000 m^2

Area Offline: 4,400 m^2

HLF Ore Stacking Plan 2024-03-01 to 2024-03-07

HLF Stacking: Past 7 Day Performance (141,884 t + 22,279t)

Previous Week Statistics

Stacked Target: 25,937 tpd

- Actual = 20,269 tpd

7 Day Leach Added:

- Actual = 3,568 m^2

7 Day Leach Removed:

- Actual = 5,737 m^2

30 Day Leach Added;

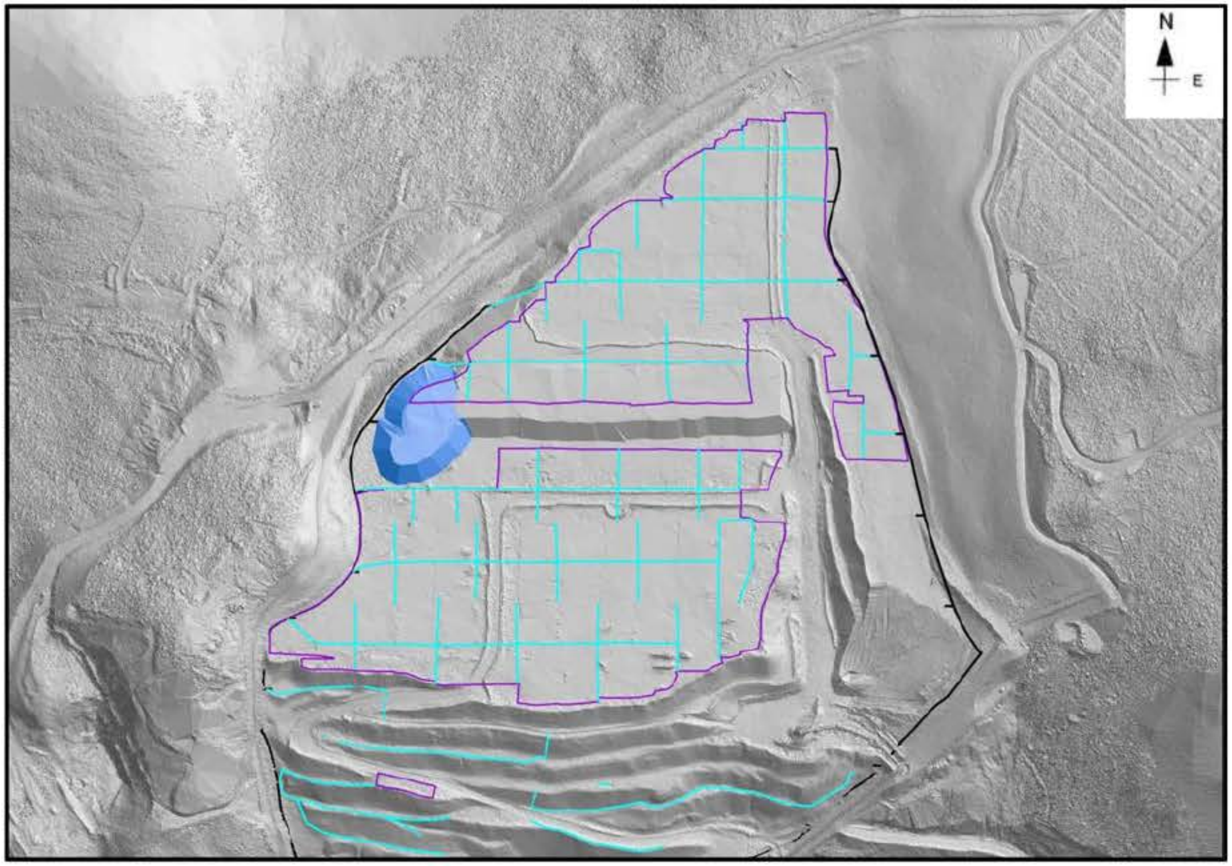
- Actual = 29,255 m^2

Area in Prep:

- ~1000 m^2

Leach Area Change:

- **217,440m^2 today**
- **221,180m^2 last week**



Legend

- Leach Online
- 24" HDPE
- 12"/4" HDPE
- Stacking

HLF Ore Stacking Plan 2024-03-08 to 2024-03-14

HLF Stacking: Past 7 Day Performance (71,686 t + 55,150t)

Previous Week Statistics

Stacked Target: 25,937 tpd

- Actual = 10,241 tpd

7 Day Leach Added:

- Actual = 5,688 m^2

7 Day Leach Removed:

- Actual = 10,039 m^2

30 Day Leach Added;

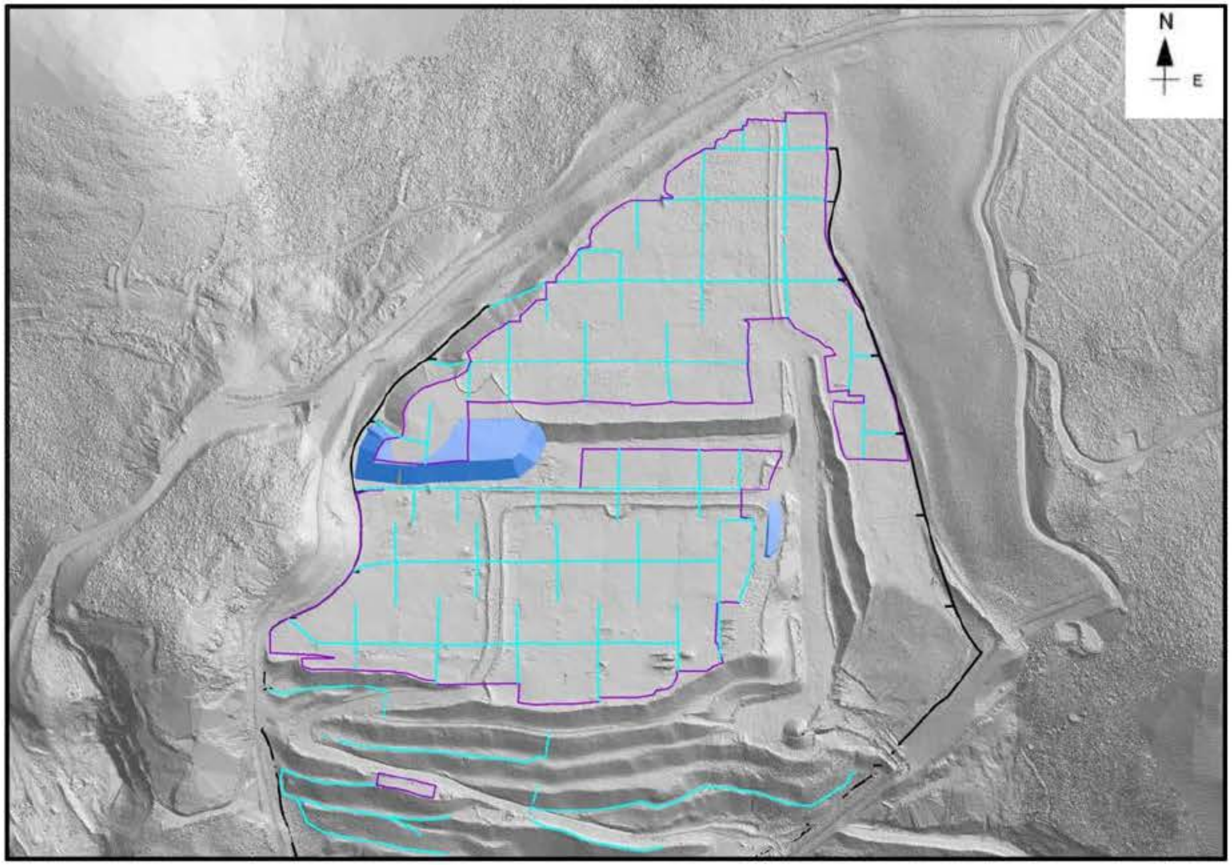
- Actual = 22,018 m^2

Area in Prep:

- ~3000 m^2

Leach Area Change:

- **213,090m^2 today**
- **217,440m^2 last week**



Legend

- Leach Online
- 24" HDPE
- 12"/4" HDPE
- Stacking

HLF Ore Stacking Plan 2024-03-15 to 2024-03-21

HLF Stacking: Past 7 Day Performance (180,901 t + 46,800t)

Previous Week Statistics

Stacked Target: 25,937 tpd
- Actual = 25,843 tpd

7 Day Leach Added:
- Actual = 9,762 m^2

7 Day Leach Removed:
- Actual = 12,908 m^2

30 Day Leach Added;
- Actual = 25,496 m^2

Area in Prep:
- ~2000 m^2

Leach Area Change:
- **209,943m^2 today**
- **213,090m^2 last week**

Legend
- Leach Online
- 24" HDPE
- 12"/4" HDPE
- Stacking

HLF Ore Stacking Plan 2024-03-22 to 2024-03-28

HLF Stacking: Past 7 Day Performance (172,397 t)

Previous Week Statistics

Stacked Target: 25,937 tpd

- Actual = 24,628 tpd

7 Day Leach Added:

- Actual = 10,169 m²

7 Day Leach Removed:

- Actual = 6,838 m²

30 Day Leach Added;

- Actual = 31,374 m²

Area in Prep:

- ~1400 m²

Leach Area Change:

- **210,598 m² today**
- **206,220 m² last week**

Legend

- Leach Online
- 24" HDPE
- 12"/4" HDPE
- Stacking

HLF Ore Stacking Plan 2024-03-29 to 2024-04-04

HLF Stacking: Past 7 Day Performance (**49,137 t**)

Previous Week Statistics

Stacked Target: 30,789 tpd

- Actual = 7,020 tpd

7 Day Leach Added:

- Actual = 2,271 m²

7 Day Leach Removed:

- Actual = 3,112 m²

30 Day Leach Added;

- Actual = 29,363 m²

Area in Prep:

- ~1,300 m²

Leach Area Change:

- **209,758 m² today**
- **210,598 m² last week**

Legend

- Leach Online
- 24" HDPE
- 12"/4" HDPE
- Stacking

HLF Ore Stacking Plan 2024-04-05 to 2024-04-11

HLF Stacking: Past 7 Day Performance (161,216 t)

Previous Week Statistics

Stacked Target: 30,789 tpd

- Actual = 23,030 tpd

7 Day Leach Added:

- Actual = 5,024 m²

7 Day Leach Removed:

- Actual = 8,549 m²

30 Day Leach Added;

- Actual = 30,225 m²

Area in Prep:

- ~1,200 m²

Leach Area Change:

- **206,233 m² today**
- **209,758 m² last week**

Legend

- Leach Online
- 24" HDPE
- 12"/4" HDPE
- Stacking

HLF Ore Stacking Plan 2024-04-12 to 2024-04-18

HLF Stacking: Past 7 Day Performance **(38,555 t)**

Previous Week Statistics

Stacked Target: 23,593 tpd

- Actual = 5,507 tpd

7 Day Leach Added:

- Actual = 0 m²

7 Day Leach Removed:

- Actual = 0 m²

30 Day Leach Added;

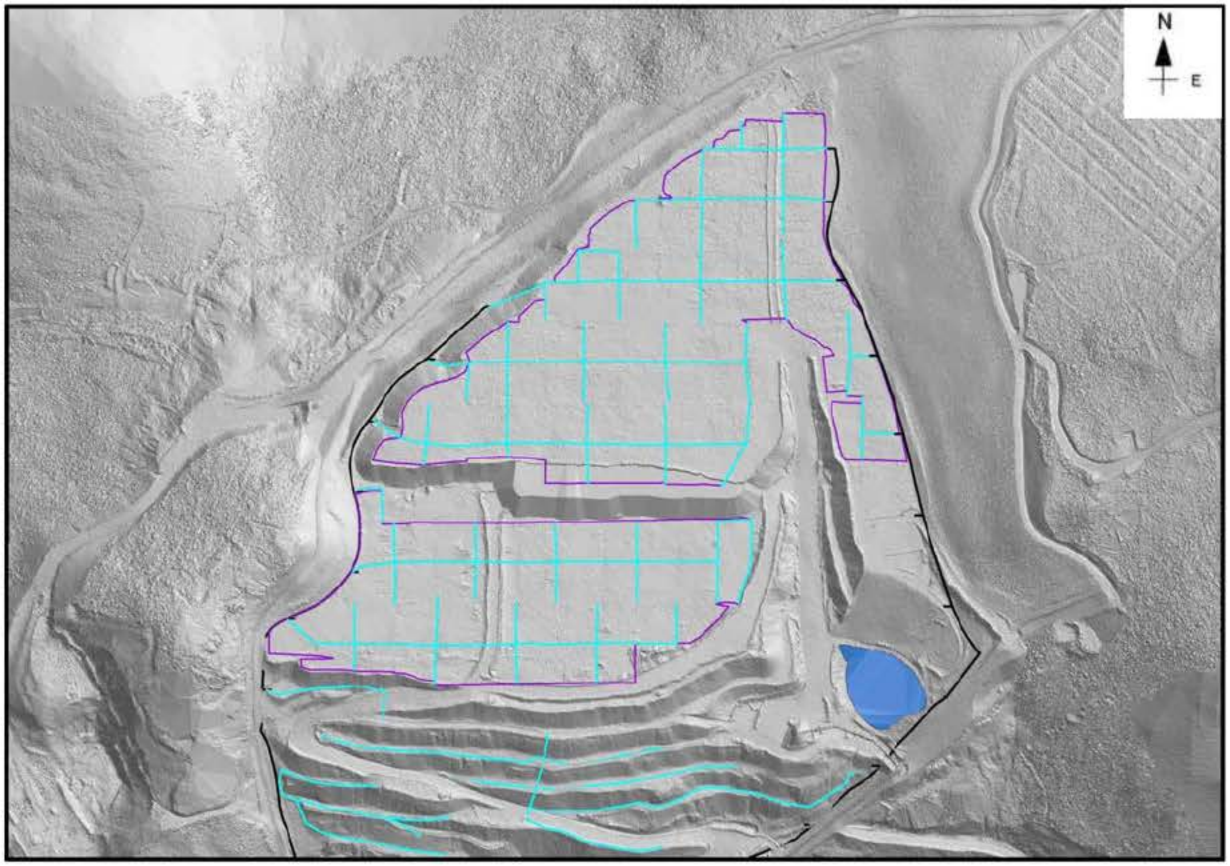
- Actual = 21,643 m²

Area in Prep:

- ~10,500 m²

Leach Area Change:

- **206,233 m² today**
- **206,233 m² last week**



Legend

- Leach Online
- 24" HDPE
- 12"/4" HDPE
- Stacking

HLF Ore Stacking Plan 2024-04-19 to 2024-04-25

HLF Stacking: Past 7 Day Performance (200,479 t)

Previous Week Statistics

Stacked Target: 23,593 tpd

- Actual = 28,640 tpd

7 Day Leach Added:

- Actual = 21,921 m²

7 Day Leach Removed:

- Actual = 5,098 m²

30 Day Leach Added;

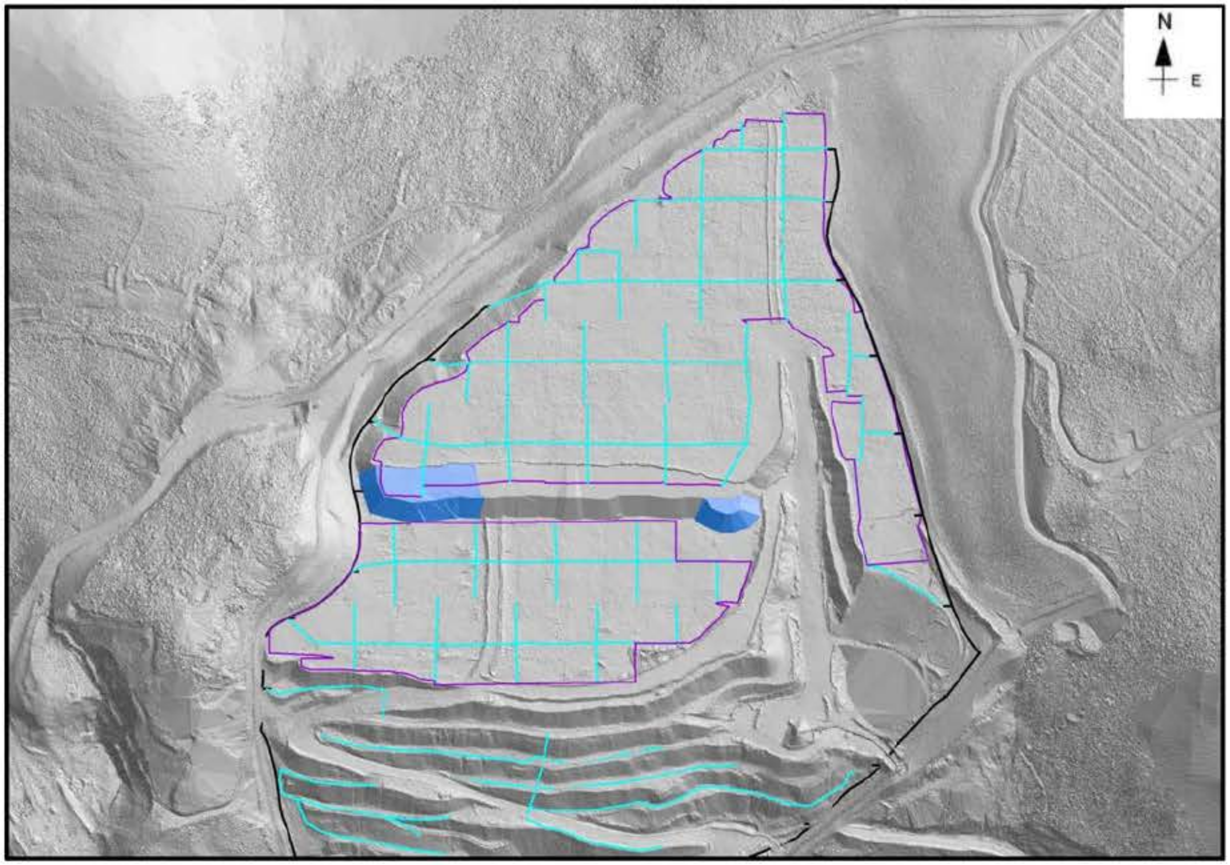
- Actual = 35,356 m²

Area in Prep:

- ~2,000 m²

Leach Area Change:

- **223,055 m² today**
- **206,233 m² last week**



Legend

- Leach Online
- 24" HDPE
- 12"/4" HDPE
- Stacking

HLF Ore Stacking Plan 2024-04-26 to 2024-05-02

HLF Stacking: Past 7 Day Performance **(242,453 t)**

Previous Week Statistics

Stacked Target: 31,020 tpd

- Actual = 34,636 tpd

7 Day Leach Added:

- Actual = 10,087 m²

7 Day Leach Removed:

- Actual = 13,017 m²

30 Day Leach Added;

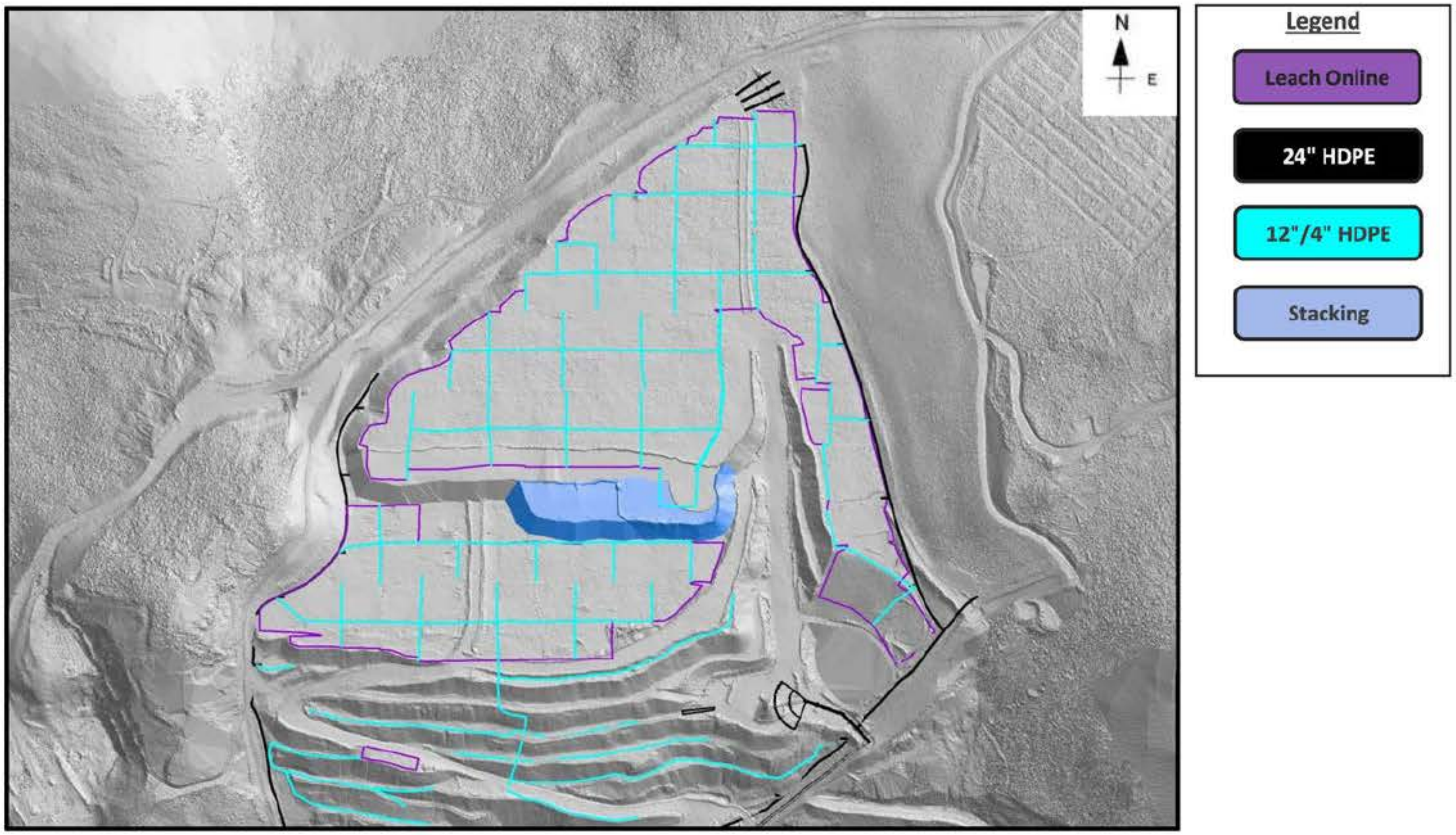
- Actual = 29,912 m²

Area in Prep:

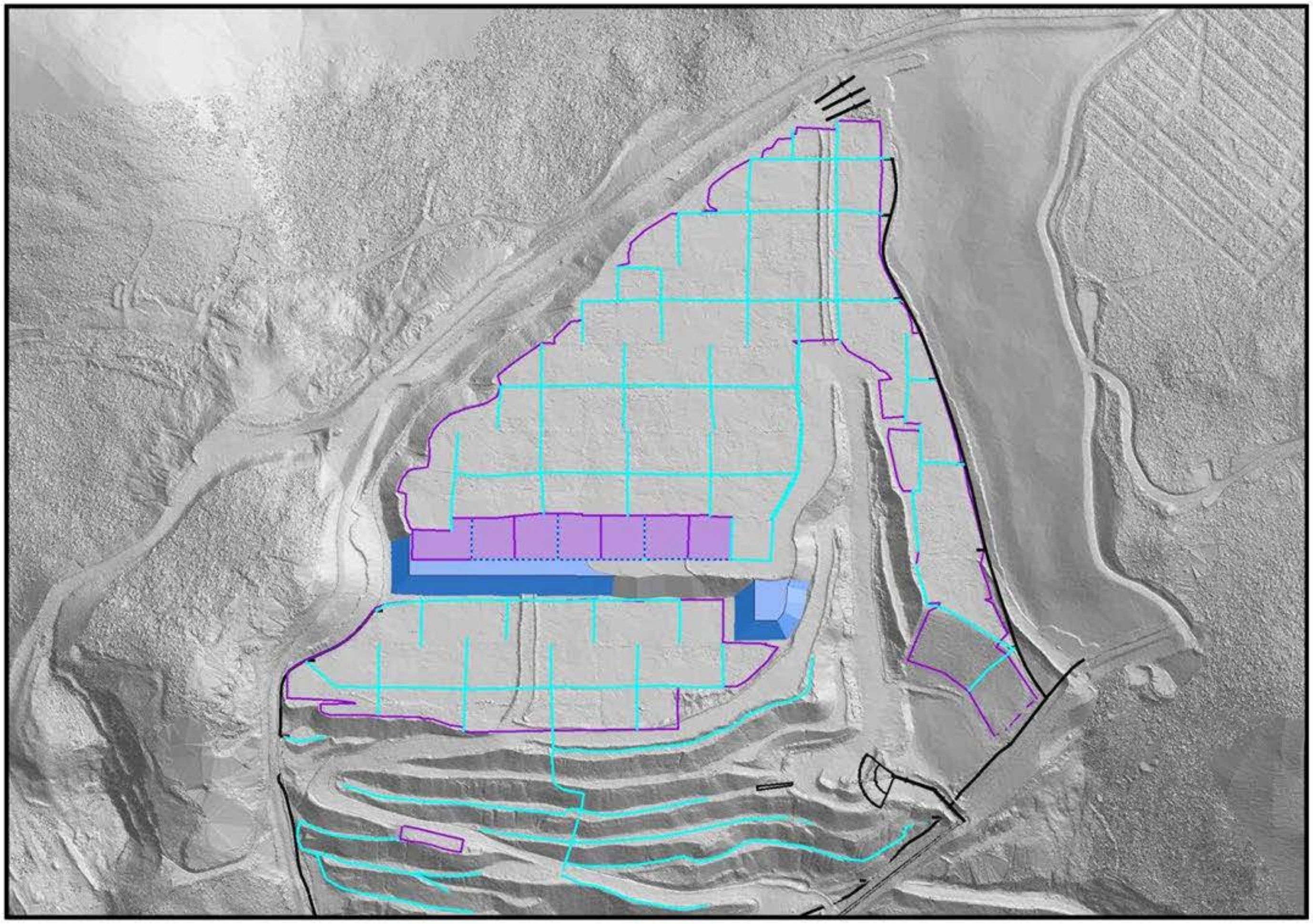
- ~6,400 m²

Leach Area Change:

- **212,961 m² today**
- **223,055 m² last week**



HLF Stacking: One week look-ahead (May 4th - May 9th)



- Assumptions:
  - Continue stacking current advancement to the west.
  - Regular pressure checks on 1065 and 1053 lift of the pad
  - Installing sprinklers in 1041 South bench of the Pad
  - EDL providing solution supply to 1065 lift.
  - WDL providing solution supply to 1053 lift.

Tonnes Stacked:

- **Week 1: 235,000 t**

Area Online: 15,000 m²

Area Offline: 7,500 m²

HLF Ore Stacking Plan 2024-05-03 to 2024-05-09

HLF Stacking: Past 7 Day Performance (216,379 t)

Previous Week Statistics

Stacked Target: 31,020 tpd

- Actual = 30,911 tpd

7 Day Leach Added:

- Actual = 10,855 m²

7 Day Leach Removed:

- Actual = 11,000 m²

30 Day Leach Added;

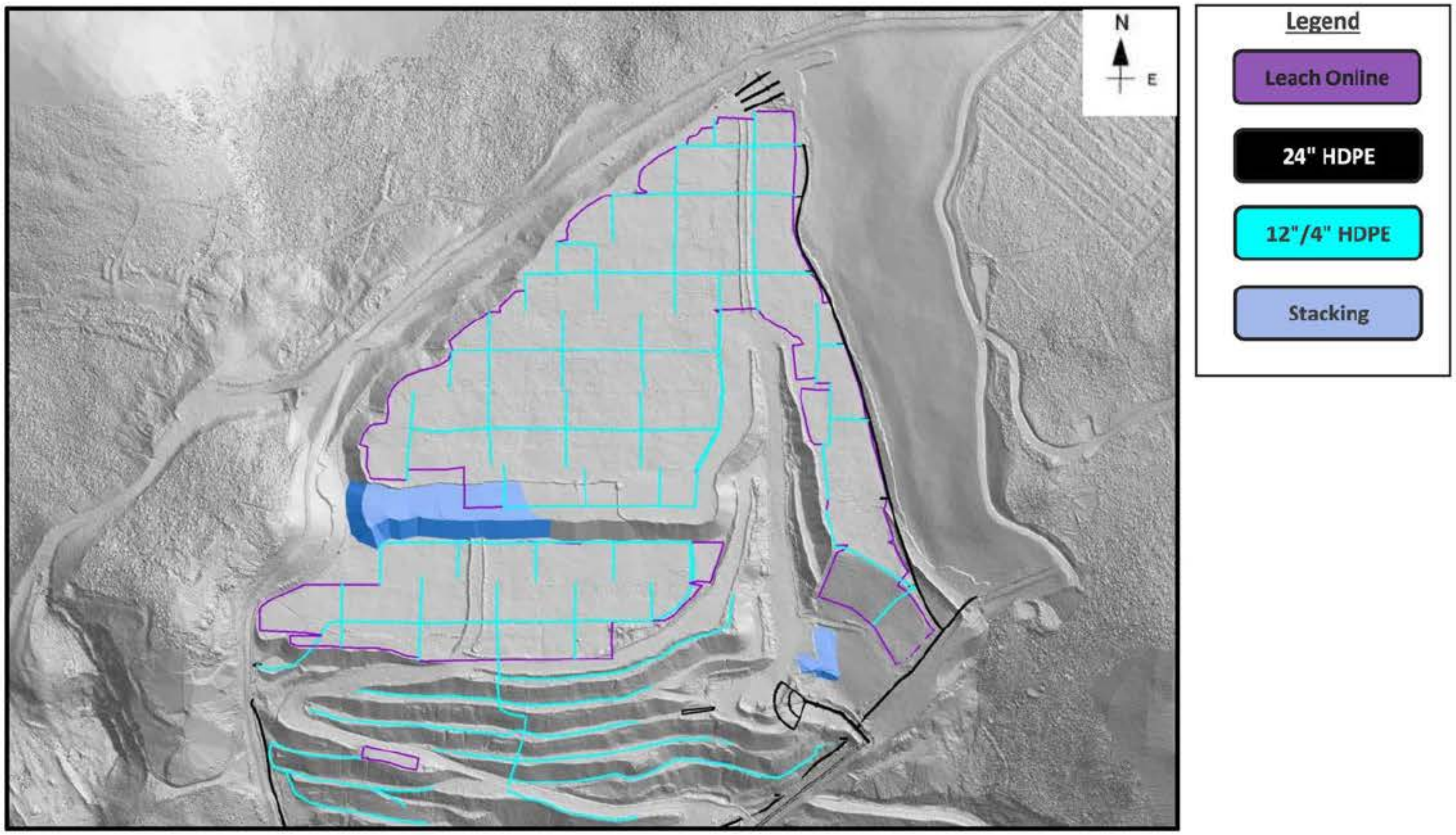
- Actual = 37,276 m²

Area in Prep:

- ~3,900 m²

Leach Area Change:

- **216,052 m² today**
- **212,961 m² last week**



HLF Ore Stacking Plan 2024-05-10 to 2024-05-16

HLF Stacking: Past 7 Day Performance **(191,647 t)**

Previous Week Statistics

Stacked Target: 31,020 tpd

- Actual = 27,378 tpd

7 Day Leach Added:

- Actual = 3,197 m²

7 Day Leach Removed:

- Actual = 2,143 m²

30 Day Leach Added;

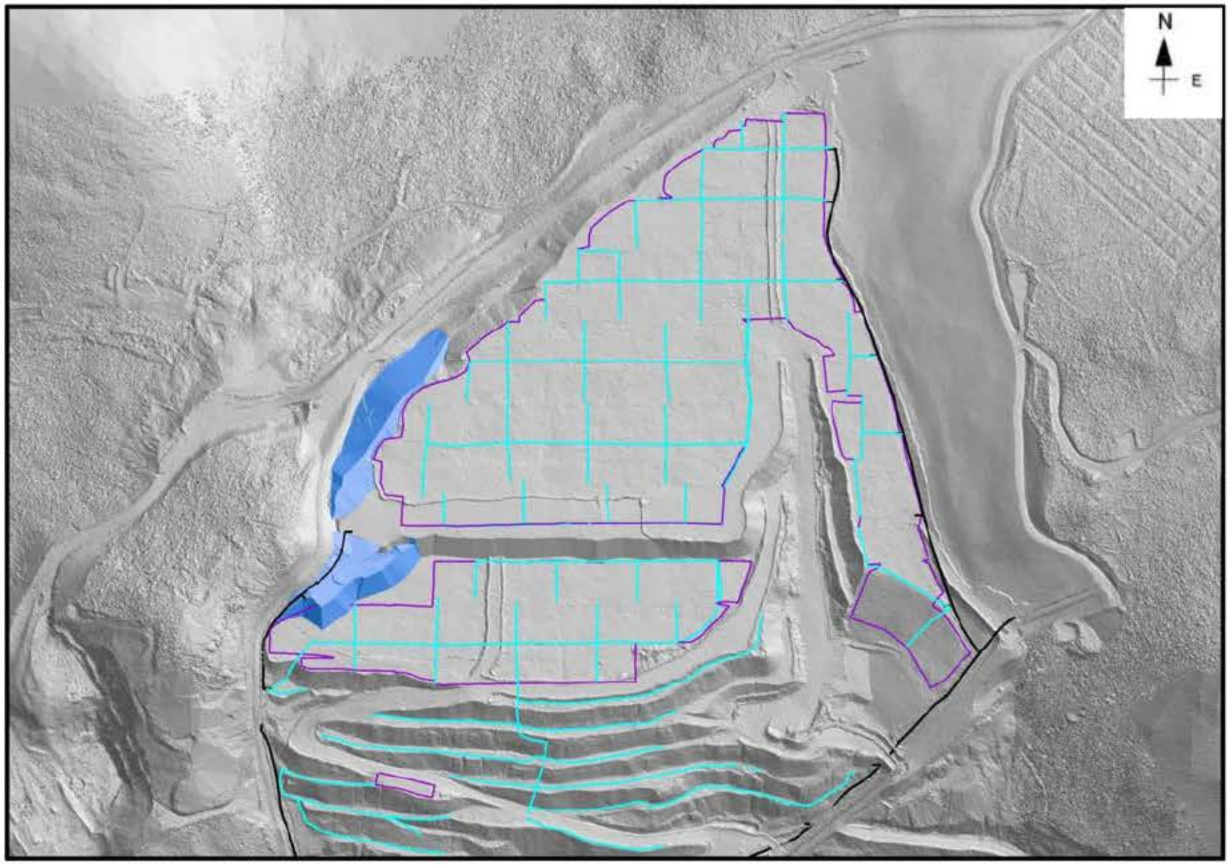
- Actual = 37,974 m²

Area in Prep:

- ~7,100 m²

Leach Area Change:

- **217,107 m² today**
- **216,052 m² last week**



Legend

- Leach Online
- 24" HDPE
- 12"/4" HDPE
- Stacking

HLF Ore Stacking Plan 2024-05-17 to 2024-05-23

HLF Stacking: Past 7 Day Performance (72,517 t)

Previous Week Statistics

Stacked Target: 31,020 tpd
- Actual = 10,360 tpd

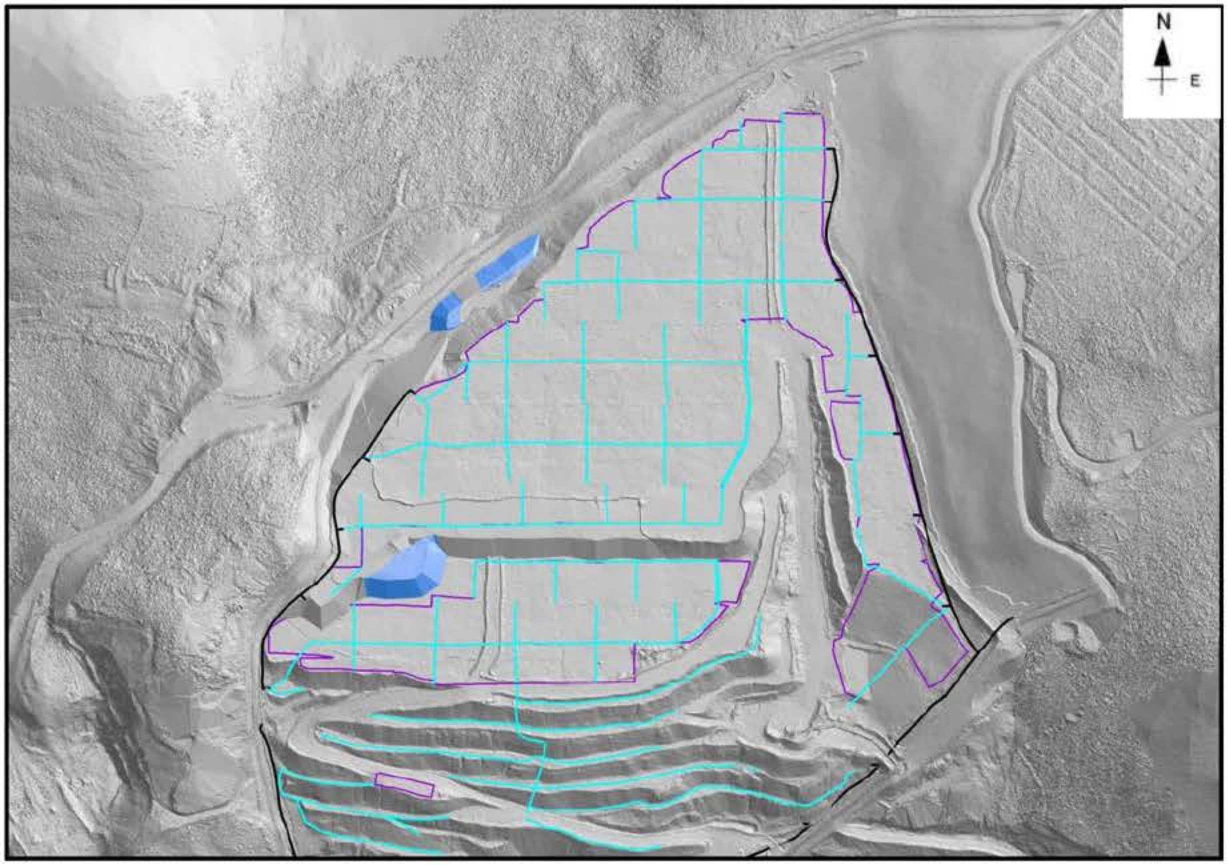
7 Day Leach Added:
- Actual = 5,454 m²

7 Day Leach Removed:
- Actual = 4,050 m²

30 Day Leach Added;
- Actual = 39,139 m²

Area in Prep:
- ~2,100 m²

Leach Area Change:
- **225,423 m² today**
- **217,107 m² last week**



Legend
- Leach Online
- 24" HDPE
- 12"/4" HDPE
- Stacking

HLF Ore Stacking Plan 2024-05-24 to 2024-05-30

HLF Stacking: Past 7 Day Performance (223,581 t)

Previous Week Statistics

Stacked Target: 31,020 tpd
- Actual = 31,940 tpd

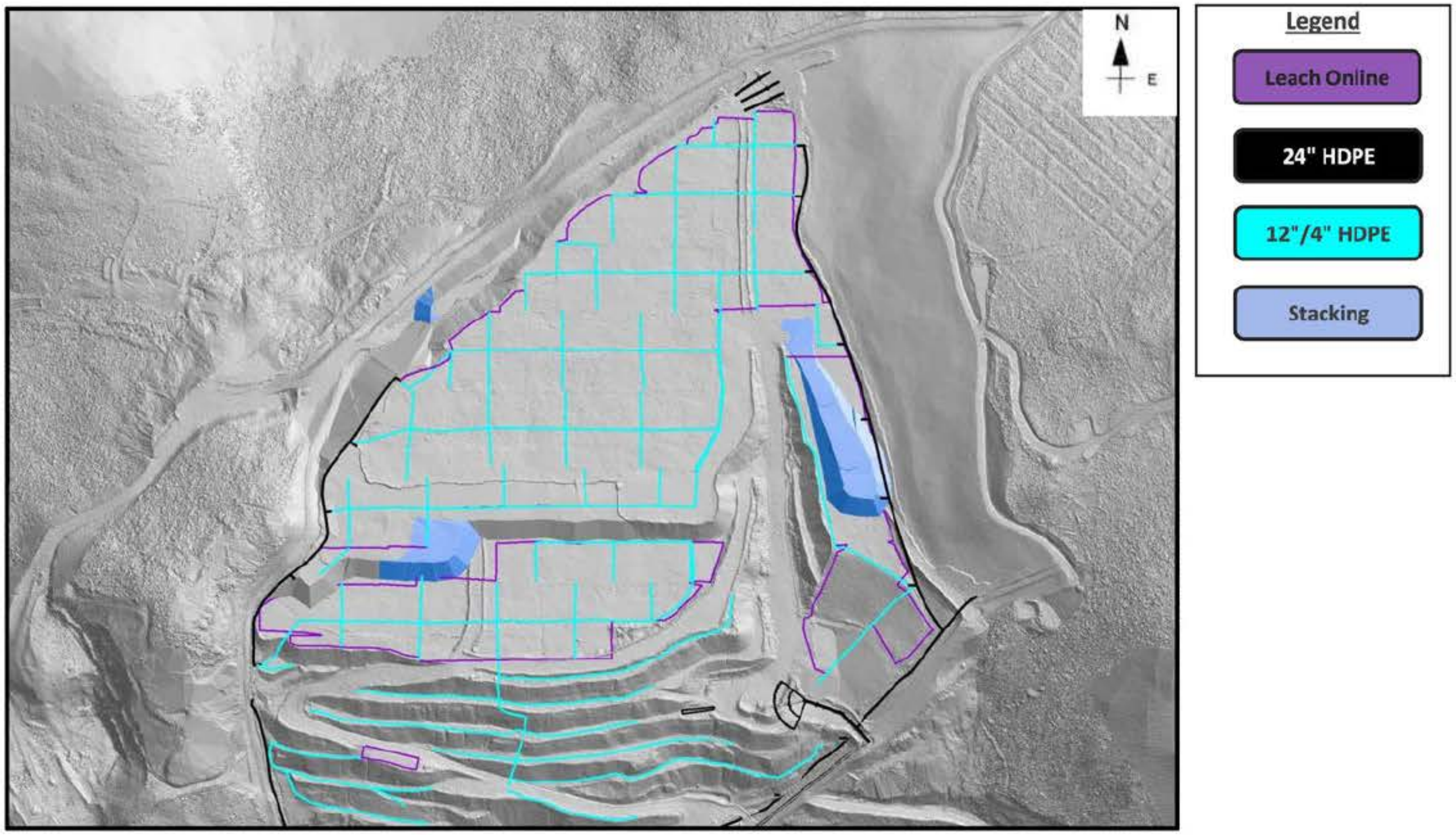
7 Day Leach Added:
- Actual = 4,152 m^2

7 Day Leach Removed:
- Actual = 4,109 m^2

30 Day Leach Added;
- Actual = 23,659 m^2

Area in Prep:
- ~2,100 m^2

Leach Area Change:
- **225,466 m^2 today**
- **225,423 m^2 last week**



HLF Ore Stacking Plan 2024-05-31 to 2024-06-06

HLF Stacking: Past 7 Day Performance **(222,584 t)**

Previous Week Statistics

Stacked Target: 31,286 tpd

- Actual = 31,798 tpd

7 Day Leach Added:

- Actual = 5,019 m²

7 Day Leach Removed:

- Actual = 6,229 m²

30 Day Leach Added;

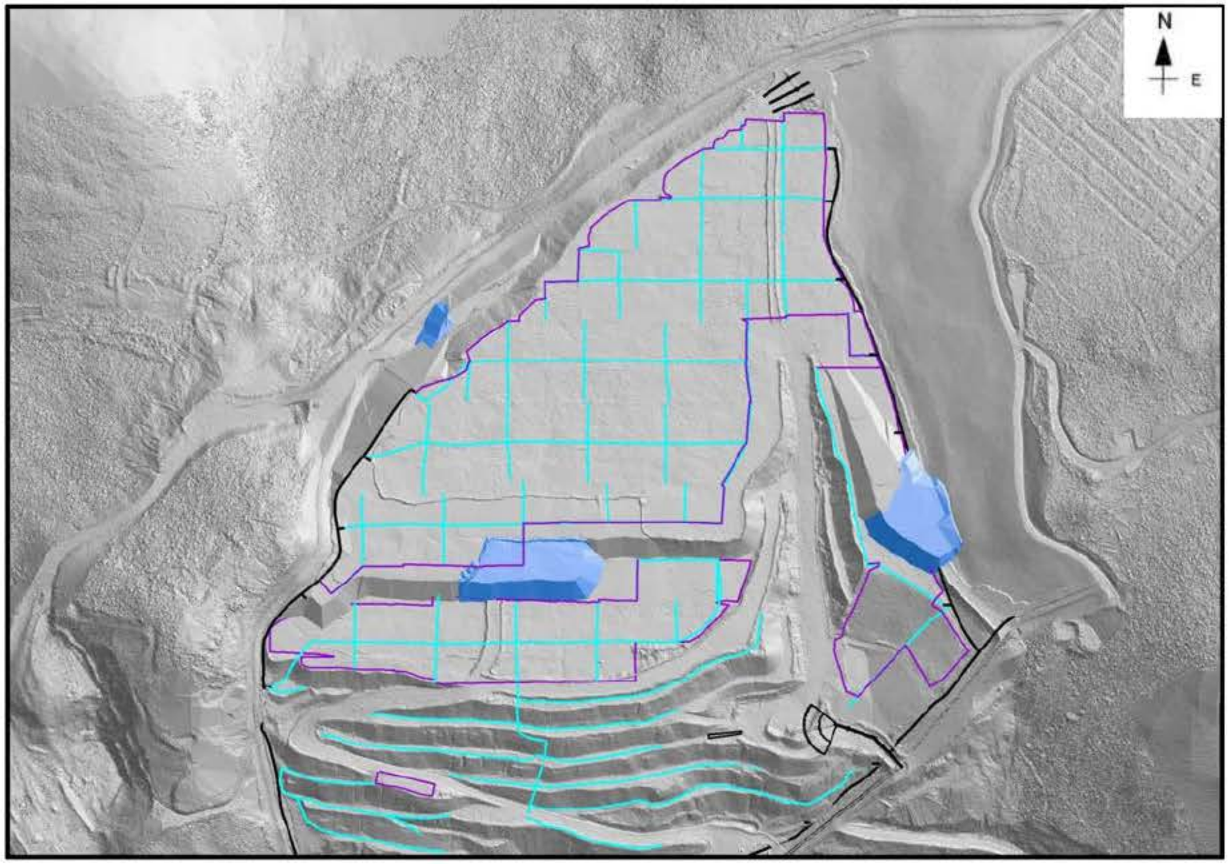
- Actual = 20,111 m²

Area in Prep:

- ~2,100 m²

Leach Area Change:

- **224,256 m² today**
- **225,466 m² last week**



Legend

Leach Online

24" HDPE

12"/4" HDPE

Stacking

HLF Ore Stacking Plan 2024-06-07 to 2024-06-13

HLF Stacking: Past 7 Day Performance (86,120 t)

Previous Week Statistics

Stacked Target: 31,286 tpd

- Actual = 12,303 tpd

7 Day Leach Added:

- Actual = 11,870 m²

7 Day Leach Removed:

- Actual = 4,005 m²

30 Day Leach Added;

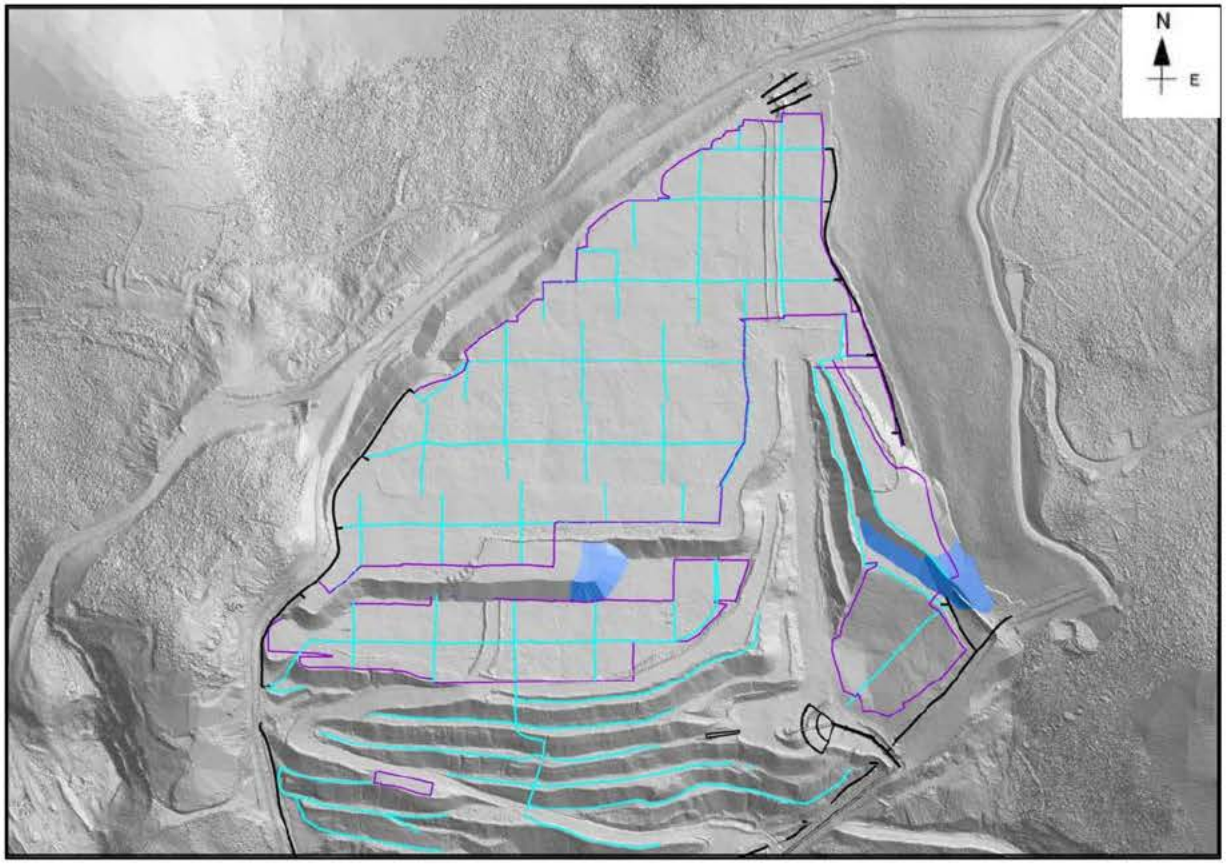
- Actual = 24,365 m²

Area in Prep:

- ~2,700 m²

Leach Area Change:

- **235,339 m² today**
- **235,466 m² last week**



Legend

- Leach Online
- 24" HDPE
- 12"/4" HDPE
- Stacking

HLF Ore Stacking Plan 2024-06-14 to 2024-06-20

HLF Stacking: Past 7 Day Performance (254,088 t)

Previous Week Statistics

Stacked Target: 31,286 tpd

- Actual = 36,298 tpd

7 Day Leach Added:

- Actual = 7,053 m^2

7 Day Leach Removed:

- Actual = 10,589 m^2

30 Day Leach Added;

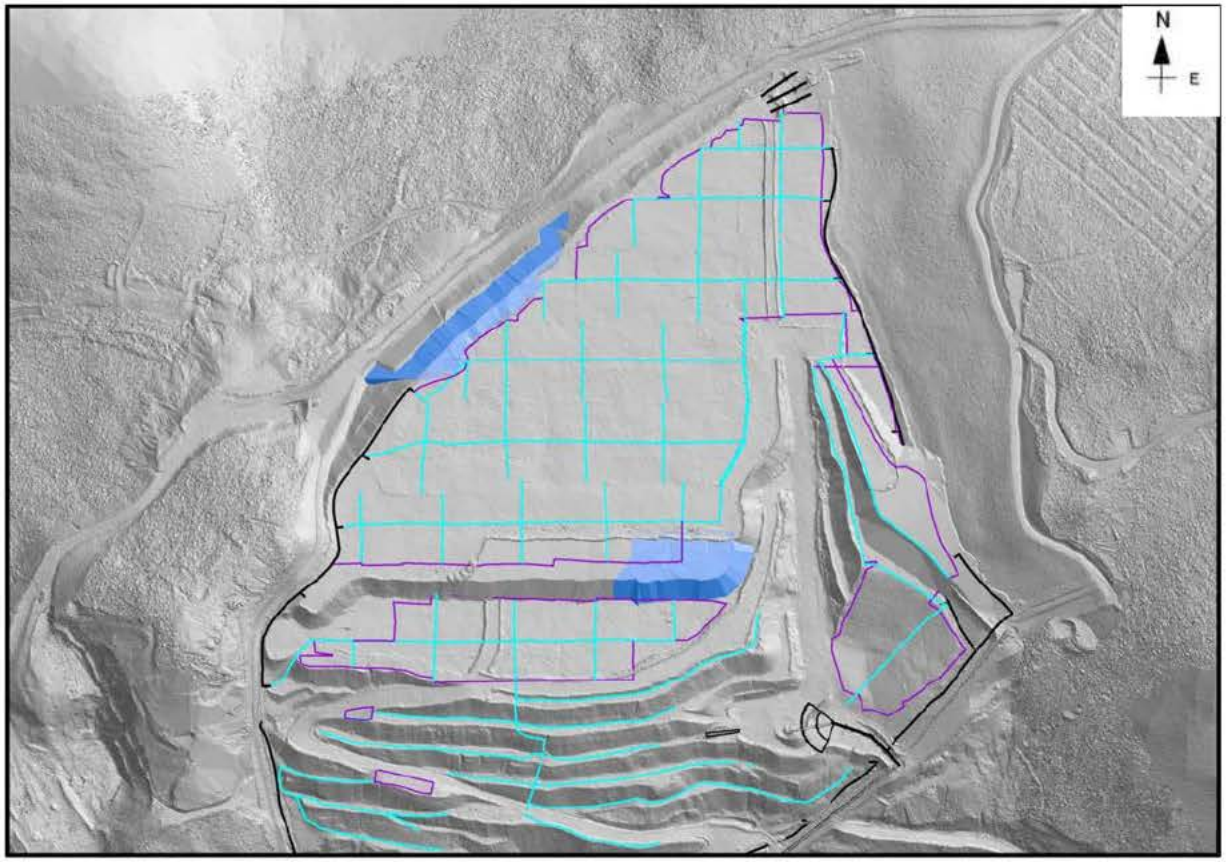
- Actual = 25,964 m^2

Area in Prep:

- ~1,900 m^2

Leach Area Change:

- **231,803 m^2 today**
- **235,339 m^2 last week**

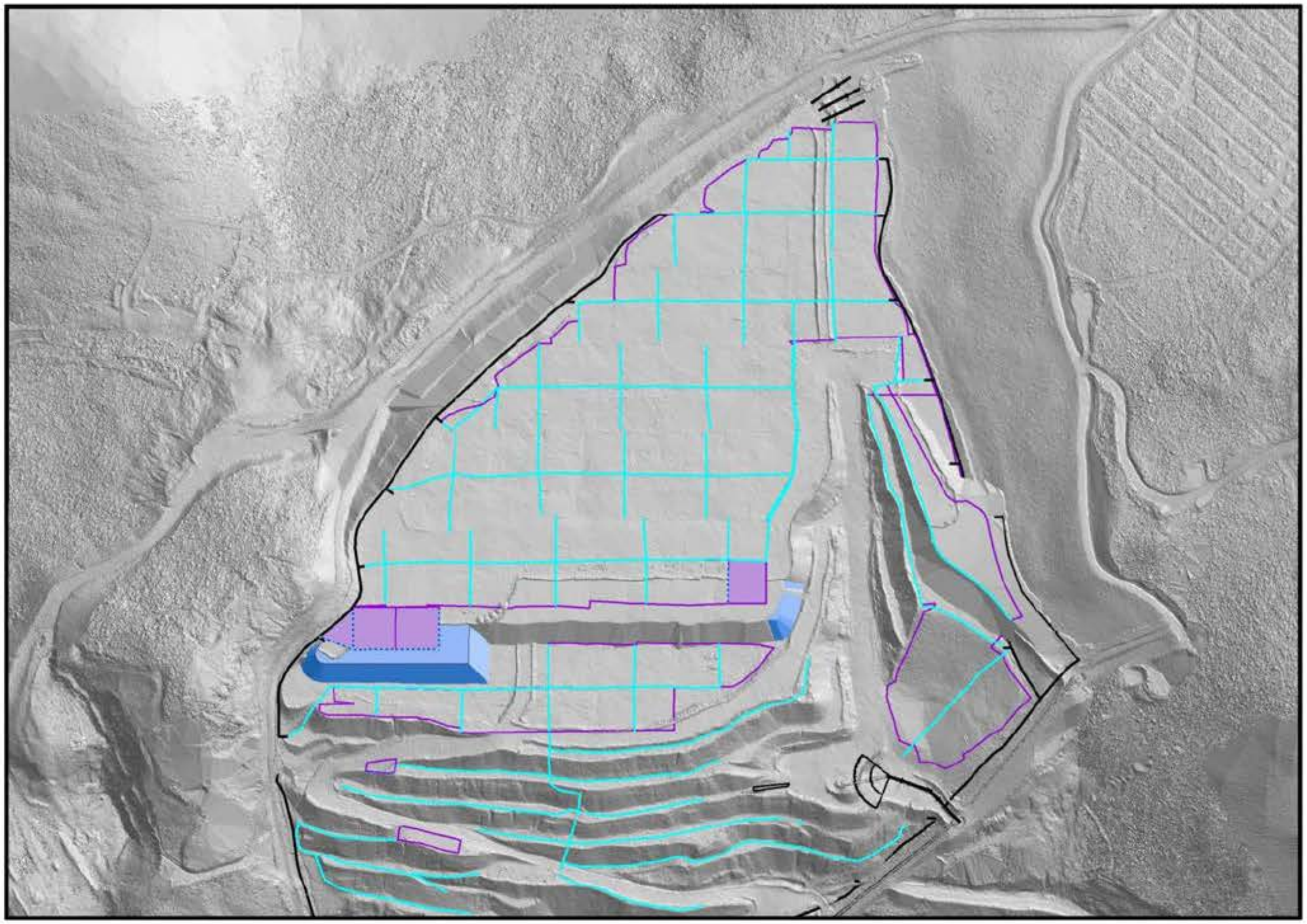


Legend

- Leach Online
- 24" HDPE
- 12"/4" HDPE
- Stacking

HLF Ore Stacking Plan 2024-06-21 to 2024-06-23 (inferred from plan)

~~HLF Stacking: One week look-ahead (June 21st - June 27th)~~



- Assumptions:
  - Continue 1065 Advancement
  - North ODF Leaching

Tonnes Stacked:

- **Week 1: 168,000 t**

Area Online:

- **Cells: 6,800 m²**

Area Offline: 6,700 m²

Appendix D Additional Modelling Output Results

Summary of Sections Assessed by Failure Mode

Failure Mode \ Section	1	2	3	1A
Mode 2B – Lining failure along the interface between LLDPE Geomembrane and GCL	Y	Y	Y	Y
Mode 2C – Lining failure along the interface between LLDPE Geomembrane and drainage gravel	Y	Y	Y	Y
Mode 2D - Lining instability due to slip failure within lining system (GCL)	N	N	N	Y
Mode 2A – Lining instability due to hydraulic uplift (basal heave)	Y	Y	N	Y
Mode 3A – Ore failure due to increased piezometric level	Y	Y	Y	Y
Mode 3B – Ore failure due to perched water tables	N	Y	N	N
Mode 3C – Ore failure due to hydrostatic uplift pressures	Y	Y	N	Y

Y: Assessed; N: Not assessed

Failure Mode 2B
Lining failure along the interface between LLDPE Geomembrane and GCL

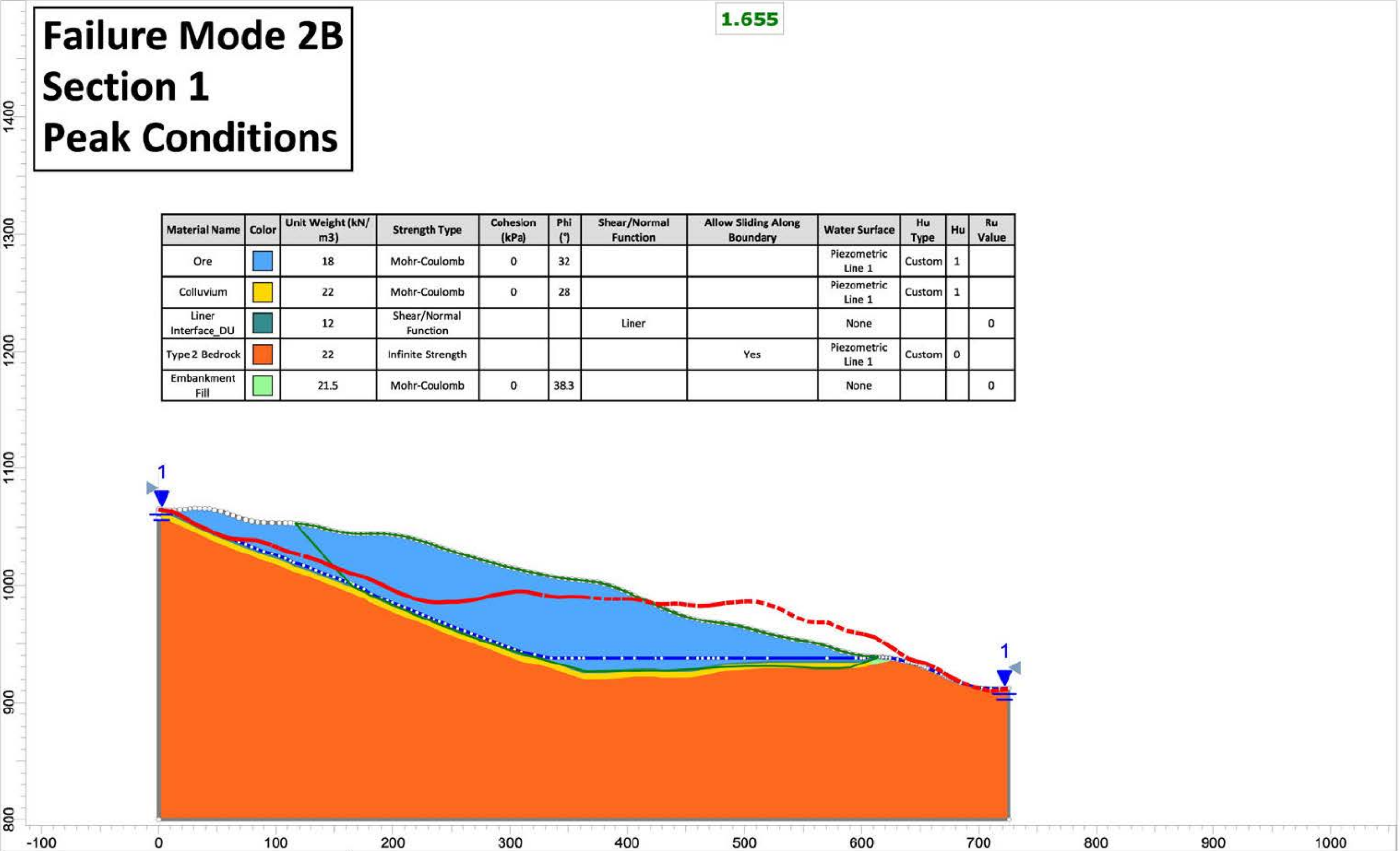
Refer to Section 6.2.1 of the report

Failure Mode \ Section	1	2	3	1A
Mode 2B – Lining failure along the interface between LLDPE Geomembrane and GCL	Y	Y	Y	Y

Failure Mode 2B
Section 1
Peak Conditions

1.655

Material Name	Color	Unit Weight (kN/m3)	Strength Type	Cohesion (kPa)	Phi (°)	Shear/Normal Function	Allow Sliding Along Boundary	Water Surface	Hu Type	Hu	Ru Value
Ore		18	Mohr-Coulomb	0	32			Piezometric Line 1	Custom	1	
Colluvium		22	Mohr-Coulomb	0	28			Piezometric Line 1	Custom	1	
Liner Interface_DU		12	Shear/Normal Function			Liner		None			0
Type 2 Bedrock		22	Infinite Strength				Yes	Piezometric Line 1	Custom	0	
Embankment Fill		21.5	Mohr-Coulomb	0	38.3			None			0

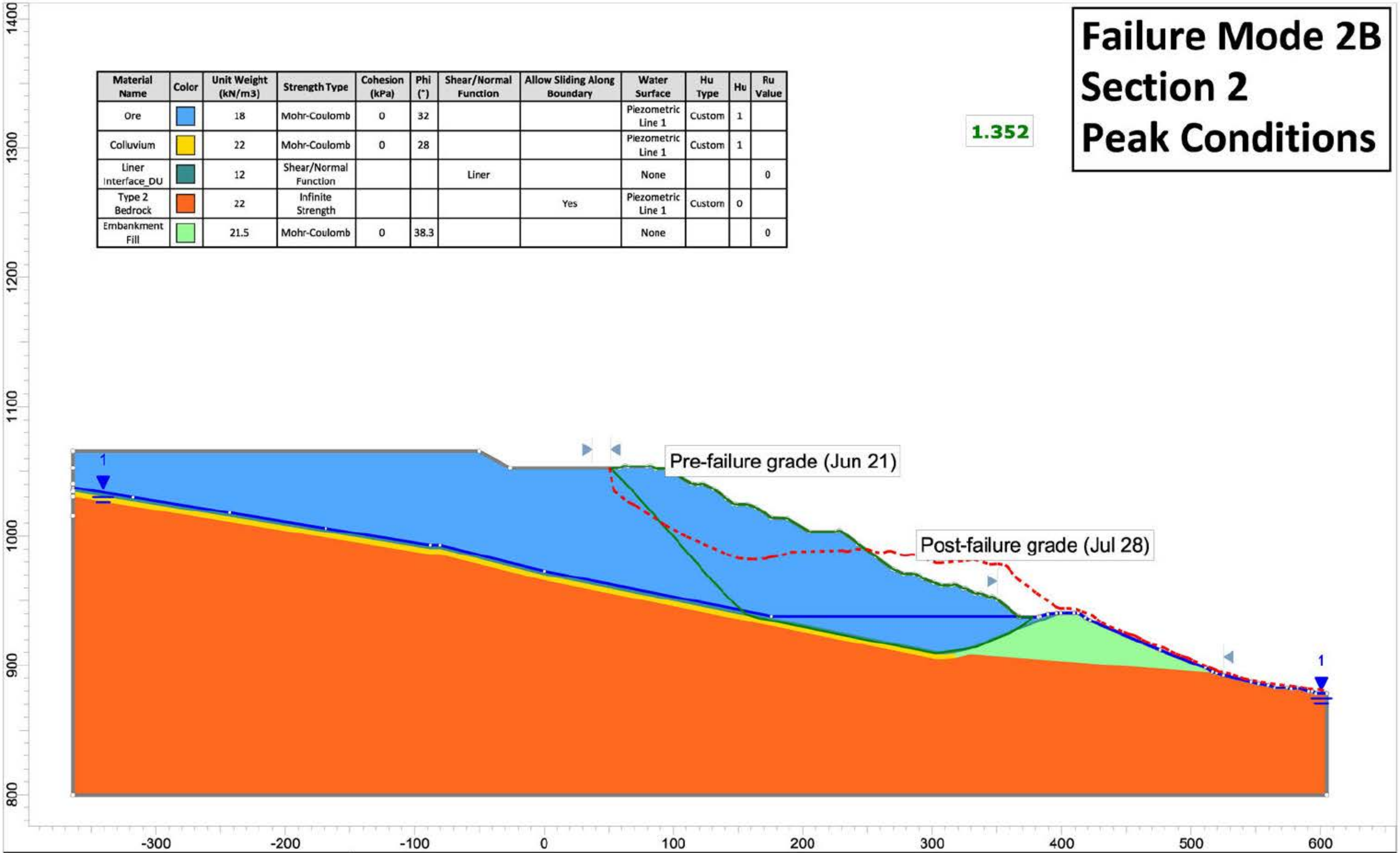


rocscience	*Project* Slide2 - An Interactive Slope Stability Program		
	Group Group 1	*Scenario* Master Scenario	
	Drawn By	*Company*	
SLIDEINTERPRET 9.034	*Date* 7/10/2024, 9:38:19 AM	*File Name* 1-SSGG.slmd	

Refer to Section 6.2.1 of the report

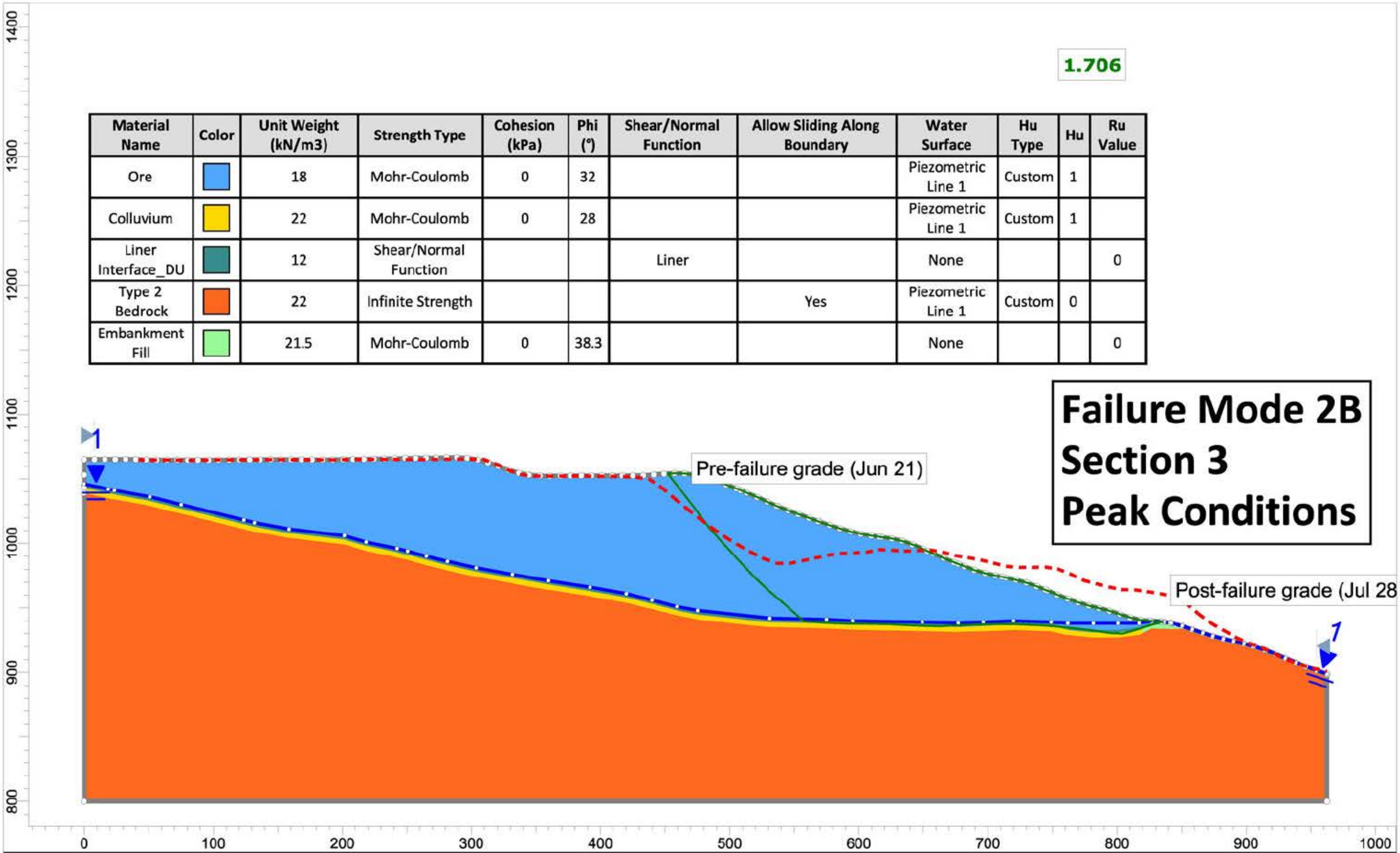
Failure Mode 2B Section 2 Peak Conditions

Material Name	Color	Unit Weight (kN/m3)	Strength Type	Cohesion (kPa)	Phi (°)	Shear/Normal Function	Allow Sliding Along Boundary	Water Surface	Hu Type	Hu	Ru Value
Ore		18	Mohr-Coulomb	0	32			Piezometric Line 1	Custom	1	
Colluvium		22	Mohr-Coulomb	0	28			Piezometric Line 1	Custom	1	
Liner Interface_DU		12	Shear/Normal Function			Liner		None			0
Type 2 Bedrock		22	Infinite Strength				Yes	Piezometric Line 1	Custom	0	
Embankment Fill		21.5	Mohr-Coulomb	0	38.3			None			0



rocscience	*Project*	Slide2 - An Interactive Slope Stability Program	
	Group Group 2	*Scenario* Scenario 2	
	Drawn By	*Company*	
SLIDEINTERPRET 9.034	*Date* 7/10/2024, 9:38:19 AM	*File Name* 2-SSGG.slmd	

Refer to Section 6.2.1 of the report



Material Name	Color	Unit Weight (kN/m3)	Strength Type	Cohesion (kPa)	Phi (°)	Shear/Normal Function	Allow Sliding Along Boundary	Water Surface	Hu Type	Hu	Ru Value
Ore		18	Mohr-Coulomb	0	32			Piezometric Line 1	Custom	1	
Colluvium		22	Mohr-Coulomb	0	28			Piezometric Line 1	Custom	1	
Liner Interface_DU		12	Shear/Normal Function			Liner		None			0
Type 2 Bedrock		22	Infinite Strength				Yes	Piezometric Line 1	Custom	0	
Embankment Fill		21.5	Mohr-Coulomb	0	38.3			None			0

rocscience

SLIDEINTERPRET 9.034

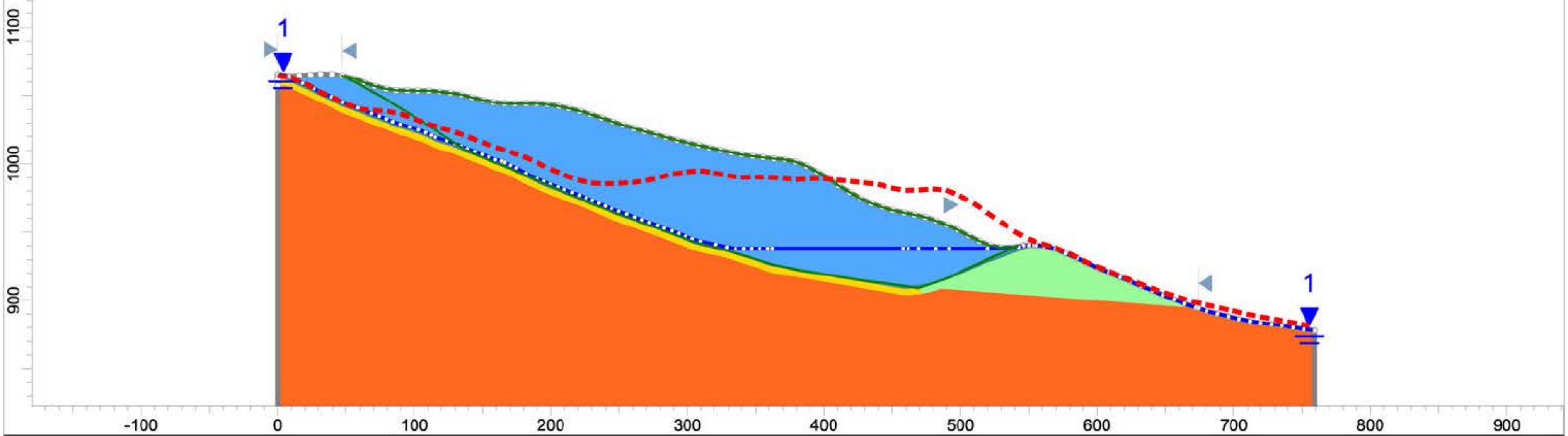
Project	Slide2 - An Interactive Slope Stability Program		
Group	Group 1	Scenario	Master Scenario
Drawn By		Company	
Date	7/10/2024, 9:38:19 AM	File Name	3-SSGG.slmd

Refer to Section 6.2.1 of the report

Failure Mode 2B
Section 1A
Peak Conditions

1.394

Material Name	Color	Unit Weight (kN/m3)	Strength Type	Cohesion (kPa)	Phi (°)	Shear/Normal Function	Allow Sliding Along Boundary	Water Surface	Hu Type	Hu	Ru Value
Ore		18	Mohr-Coulomb	0	32			Piezometric Line 1	Custom	1	
Colluvium		22	Mohr-Coulomb	0	28			Piezometric Line 1	Custom	1	
Liner Interface_DU		12	Shear/Normal Function			Liner		None			0
Type 2 Bedrock		22	Infinite Strength				Yes	Piezometric Line 1	Custom	0	
Embankment Fill		21.5	Mohr-Coulomb	0	38.3			None			0



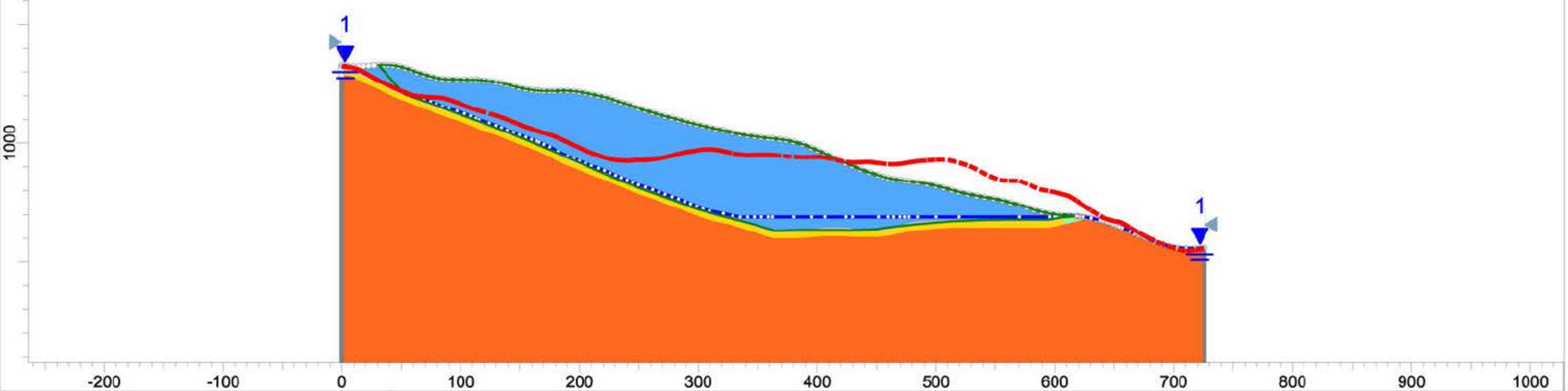
rocscience	Project	Slide2 - An Interactive Slope Stability Program	
	Group: Group 2	Scenario: Master Scenario	
	Drawn By	Company	
SLIDEINTERPRET 9.034	Date: 7/10/2024, 9:38:19 AM	File Name: 1A-SSGG.slmd	

Refer to Section 6.2.1 of the report

Failure Mode 2B
Section 1
Residual Conditions

1.140

Material Name	Color	Unit Weight (kN/m3)	Strength Type	Cohesion (kPa)	Phi (°)	Allow Sliding Along Boundary	Water Surface	Hu Type	Hu	Ru Value
Ore		18	Mohr-Coulomb	0	32		Piezometric Line 1	Custom	1	
Colluvium		22	Mohr-Coulomb	0	28		Piezometric Line 1	Custom	1	
Liner Interface_residualDJ		12	Mohr-Coulomb	3.6	13.1		None			0
Type 2 Bedrock		22	Infinite Strength			Yes	Piezometric Line 1	Custom	0	
Embankment Fill		21.5	Mohr-Coulomb	0	38.3		None			0



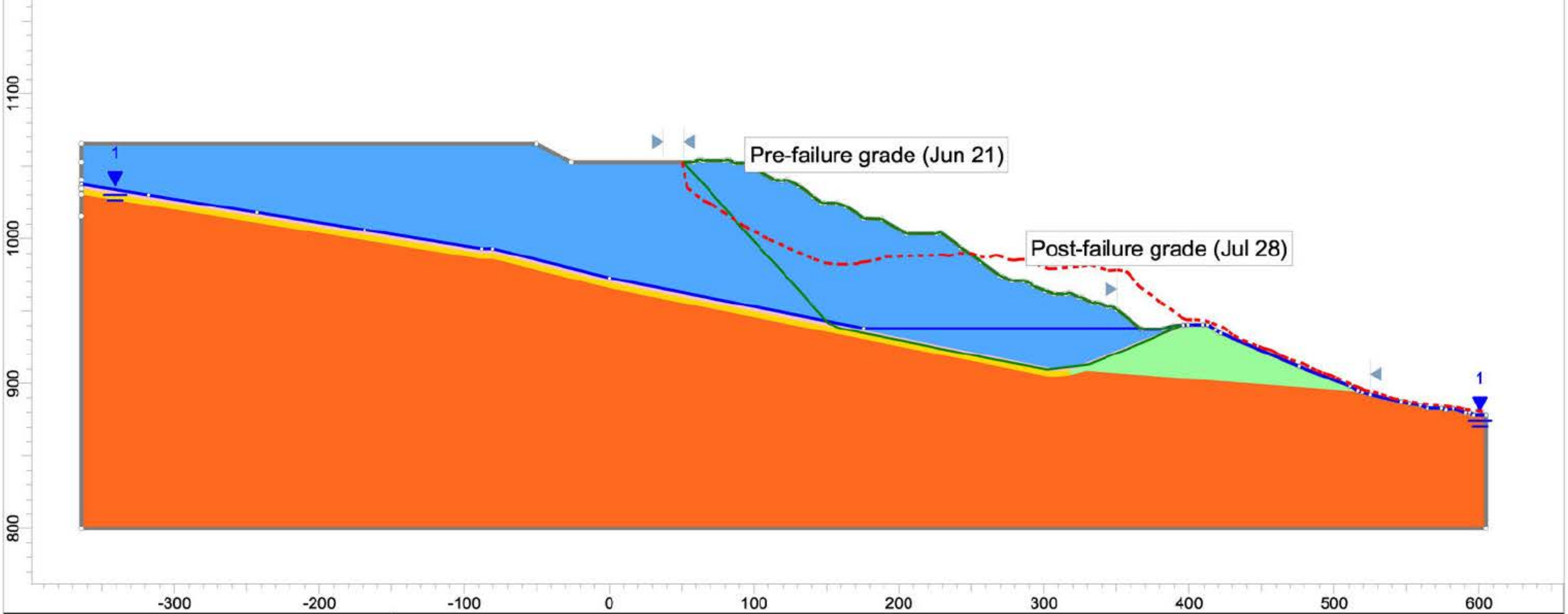
rocscience	*Project*	Slide2 - An Interactive Slope Stability Program	
	Group Group 1	*Scenario* residualDJ	
	Drawn By	*Company*	
SLIDEINTERPRET 9.034	*Date* 7/10/2024, 9:38:19 AM	*File Name* 1-SSGG.slmd	

Refer to Section 6.2.1 of the report

1.114

Material Name	Color	Unit Weight (kN/m3)	Strength Type	Cohesion (kPa)	Phi (°)	Allow Sliding Along Boundary	Water Surface	Hu Type	Hu	Ru Value
Ore		18	Mohr-Coulomb	0	32		Piezometric Line 1	Custom	1	
Colluvium		22	Mohr-Coulomb	0	28		Piezometric Line 1	Custom	1	
Liner Interface_residualDJ		12	Mohr-Coulomb	3.6	13.1		None			0
Type 2 Bedrock		22	Infinite Strength			Yes	Piezometric Line 1	Custom	0	
Embankment Fill		21.5	Mohr-Coulomb	0	38.3		None			0

Failure Mode 2B
Section 2
Residual Conditions

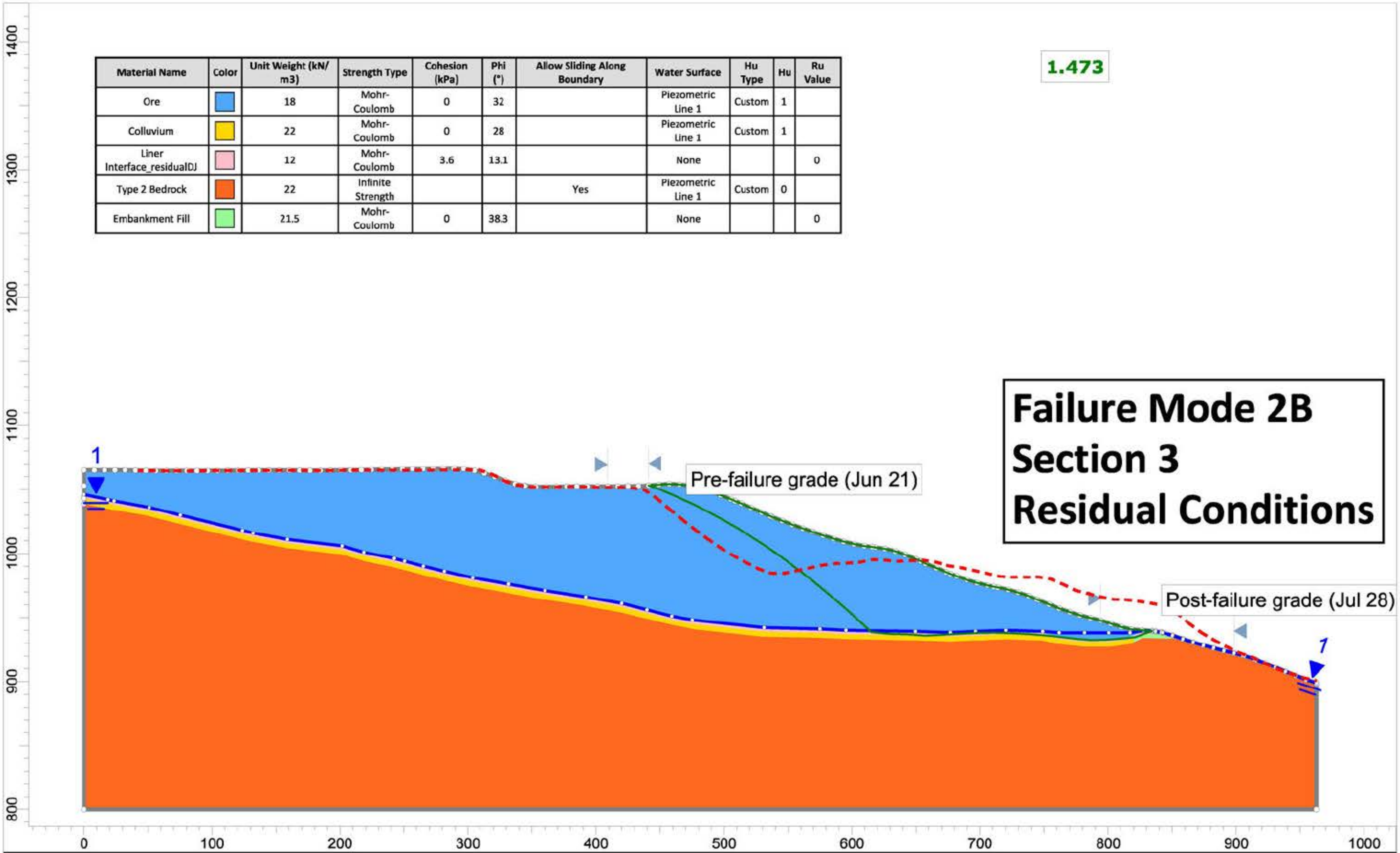


rocscience	*Project* Slide2 - An Interactive Slope Stability Program		
	Group Group 2	*Scenario* residualDJ	
	Drawn By	*Company*	
SLIDEINTERPRET 9.034	*Date* 7/10/2024, 9:38:19 AM	*File Name* 2-SSGG.slmd	

Refer to Section 6.2.1 of the report

Failure Mode 2B
Section 3
Residual Conditions

Material Name	Color	Unit Weight (kN/m3)	Strength Type	Cohesion (kPa)	Phi (°)	Allow Sliding Along Boundary	Water Surface	Hu Type	Hu	Ru Value
Ore		18	Mohr-Coulomb	0	32		Piezometric Line 1	Custom	1	
Colluvium		22	Mohr-Coulomb	0	28		Piezometric Line 1	Custom	1	
Liner Interface_residualDJ		12	Mohr-Coulomb	3.6	13.1		None			0
Type 2 Bedrock		22	Infinite Strength			Yes	Piezometric Line 1	Custom	0	
Embankment Fill		21.5	Mohr-Coulomb	0	38.3		None			0



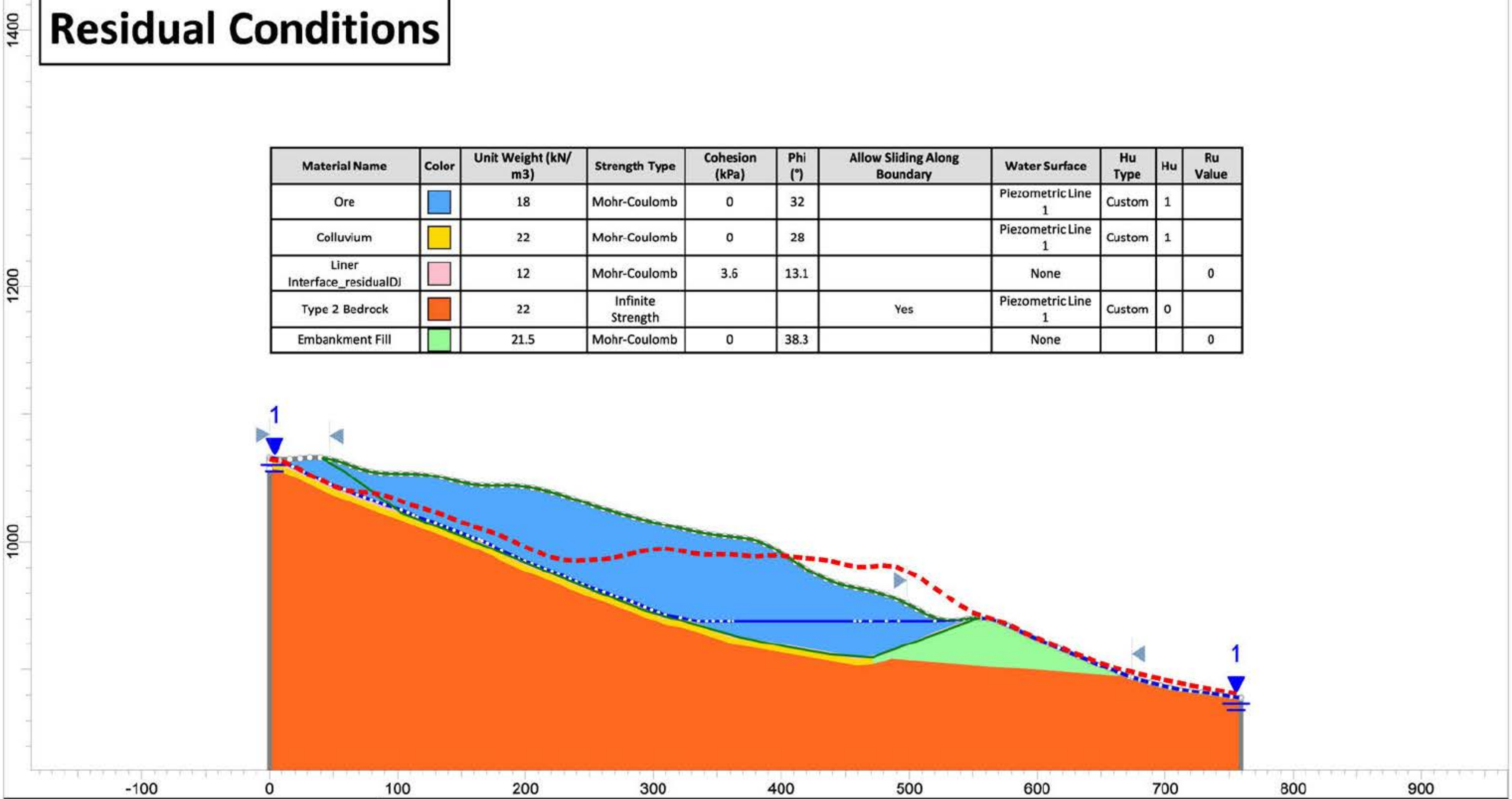
rocscience	*Project* Slide2 - An Interactive Slope Stability Program		
	Group Group 1	*Scenario* residualDJ	
	Drawn By	*Company*	
SLIDEINTERPRET 9.034	*Date* 7/10/2024, 9:38:19 AM	*File Name* 3-SSGG.slmd	

Refer to Section 6.2.1 of the report

1.014

Failure Mode 2B
Section 1A
Residual Conditions

Material Name	Color	Unit Weight (kN/m3)	Strength Type	Cohesion (kPa)	Phi (°)	Allow Sliding Along Boundary	Water Surface	Hu Type	Hu	Ru Value
Ore		18	Mohr-Coulomb	0	32		Piezometric Line 1	Custom	1	
Colluvium		22	Mohr-Coulomb	0	28		Piezometric Line 1	Custom	1	
Liner Interface_residualDJ		12	Mohr-Coulomb	3.6	13.1		None			0
Type 2 Bedrock		22	Infinite Strength			Yes	Piezometric Line 1	Custom	0	
Embankment Fill		21.5	Mohr-Coulomb	0	38.3		None			0



rocscience	*Project* Slide2 - An Interactive Slope Stability Program		
	Group Group 2	*Scenario* residual - DJ	
	Drawn By	*Company*	
SLIDEINTERPRET 9.034	*Date* 7/10/2024, 9:38:19 AM	*File Name* 1A-SSGG.slmd	

Refer to Section 6.2.1 of the report

Failure Mode 2C
Lining failure along the interface between LLDPE Geomembrane and drainage gravel

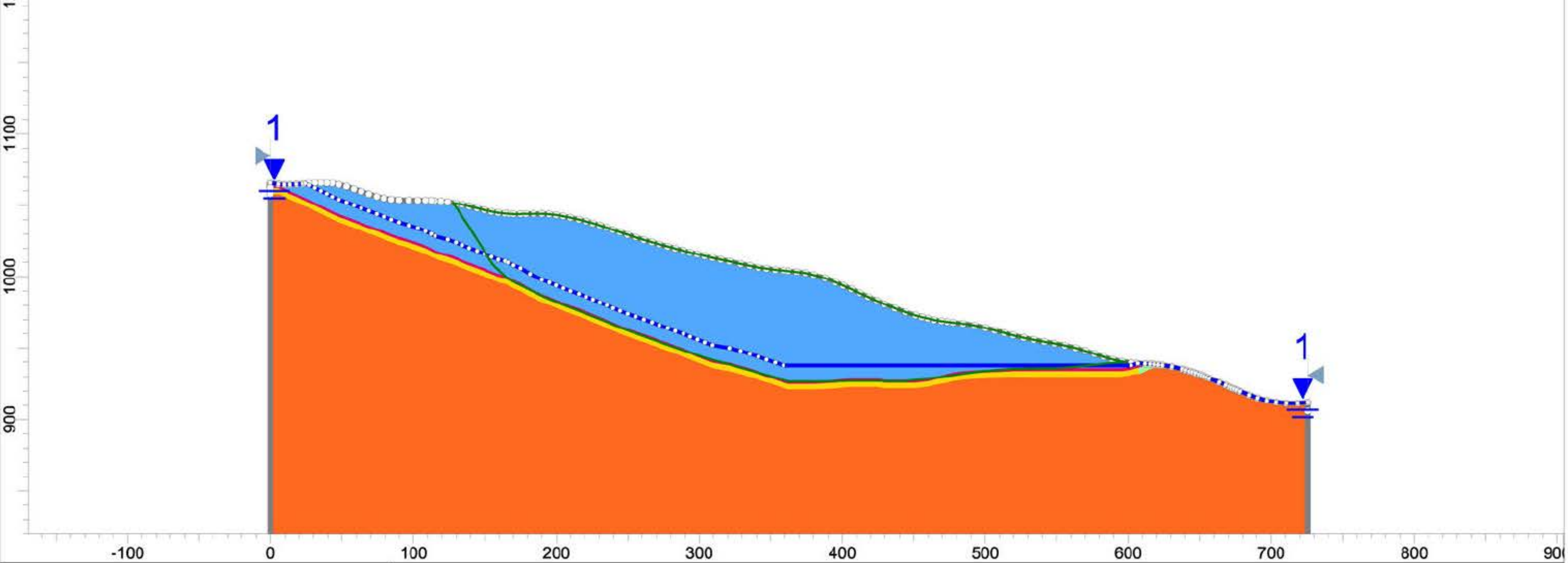
Refer to Section 6.2.2 of the report

Failure Mode \ Section	1	2	3	1A
Mode 2C – Lining failure along the interface between LLDPE Geomembrane and drainage gravel	Y	Y	Y	Y

Failure Mode 2C
Section 1

1.020

Material Name	Color	Unit Weight (kN/m3)	Strength Type	Cohesion (kPa)	Phi (°)	Allow Sliding Along Boundary	Water Surface	Hu Type	Hu
Ore		18	Mohr-Coulomb	0	32		Piezometric Line 1	Custom	1
Colluvium		22	Mohr-Coulomb	0	28		Piezometric Line 1	Custom	1
Type 2 Bedrock		22	Infinite Strength			Yes	Piezometric Line 1	Custom	0
Embankment Fill		21.5	Mohr-Coulomb	0	38.3		Piezometric Line 1	Custom	1
Gv_Gm interface-12deg		12	Mohr-Coulomb	0	12		Piezometric Line 1	Custom	1



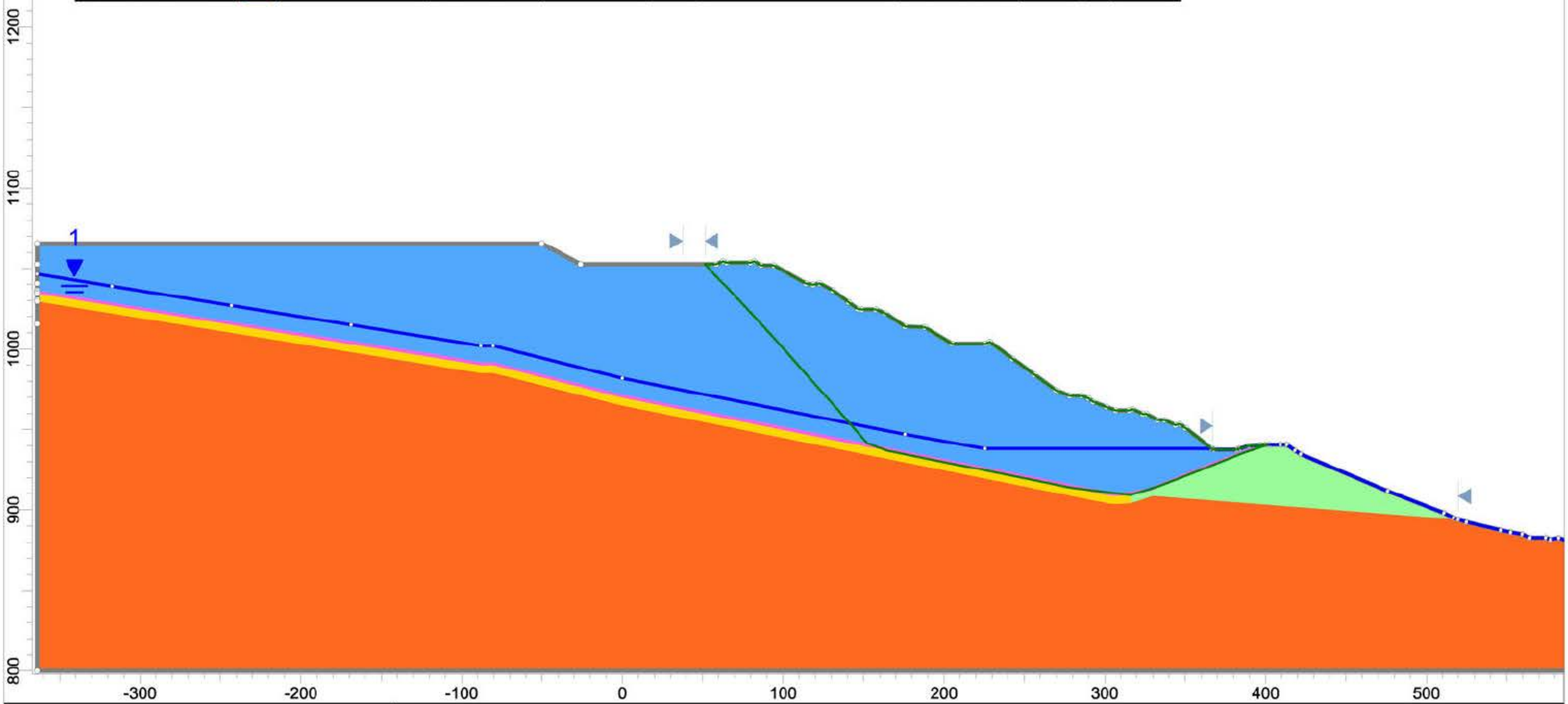
rocscience	*Project* Slide2 - An Interactive Slope Stability Program		
	Group 1-SS-GvGm - GW10m above liner	*Scenario* 12deg	
	Drawn By	*Company*	
SLIDEINTERPRET 9.034	*Date* 7/10/2024, 9:38:19 AM	*File Name* Section 1_0916.slmd	

Refer to Section 6.2.2 of the report

1.074

Material Name	Color	Unit Weight (kN/m3)	Strength Type	Cohesion (kPa)	Phi (°)	Allow Sliding Along Boundary	Water Surface	Hu Type	Hu	Ru Value
Ore		18	Mohr-Coulomb	0	32		Piezometric Line 1	Custom	1	
Colluvium		22	Mohr-Coulomb	0	28		Piezometric Line 1	Custom	1	
Type 2 Bedrock		22	Infinite Strength			Yes	Piezometric Line 1	Custom	0	
Embankment Fill		21.5	Mohr-Coulomb	0	38.3		None			0
Gv_Gm interface-15deg		12	Mohr-Coulomb	0	15		Piezometric Line 1	Custom	1	

Failure Mode 2C Section 2



Project	Slide2 - An Interactive Slope Stability Program		
Group	Group 2	Scenario	15deg
Drawn By		Company	
Date	7/10/2024, 9:38:19 AM	File Name	2-SSGvGm.slmd

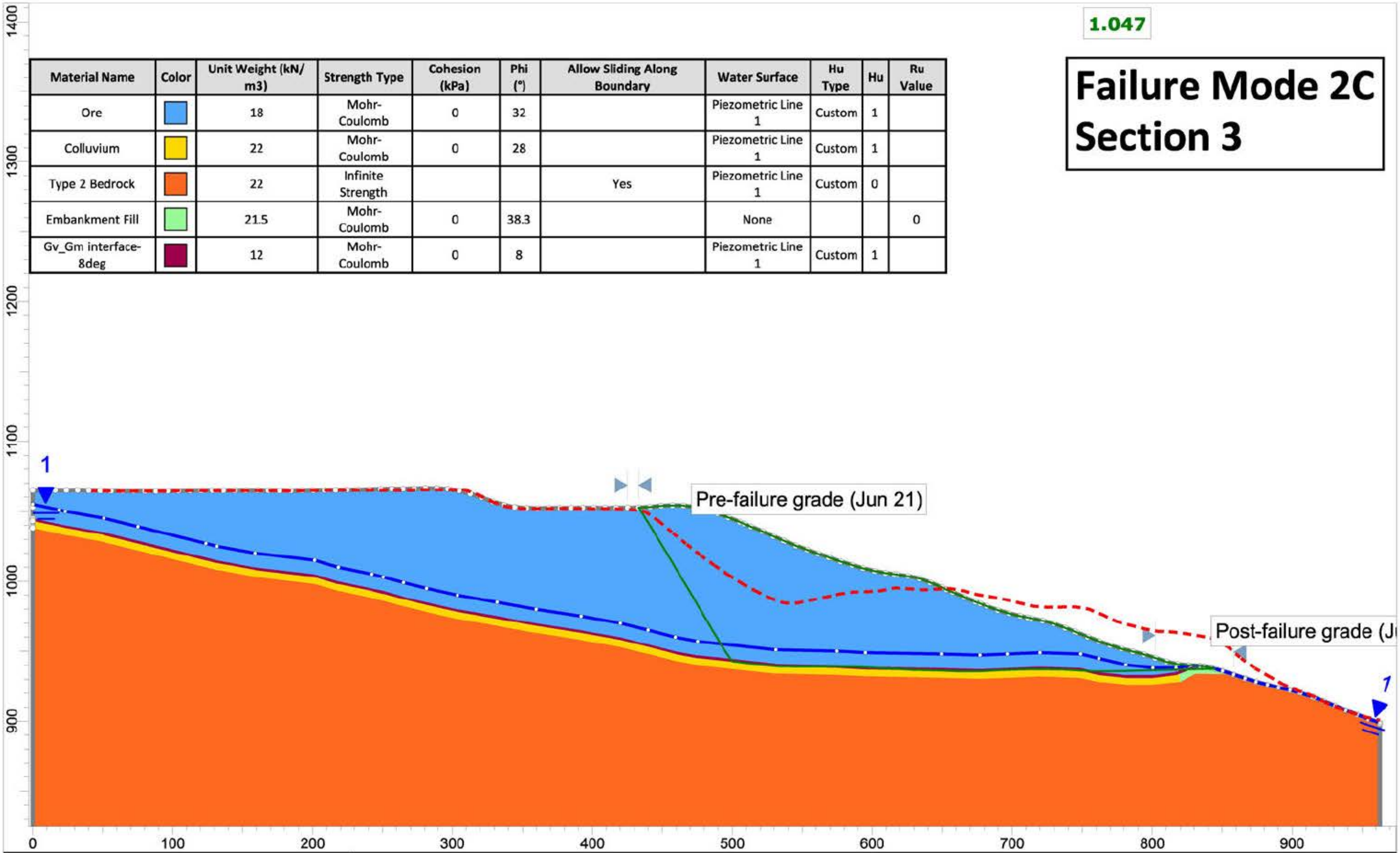
SLIDEINTERPRET 9.034

Refer to Section 6.2.2 of the report

1.047

Failure Mode 2C Section 3

Material Name	Color	Unit Weight (kN/m3)	Strength Type	Cohesion (kPa)	Phi (°)	Allow Sliding Along Boundary	Water Surface	Hu Type	Hu	Ru Value
Ore		18	Mohr-Coulomb	0	32		Piezometric Line 1	Custom	1	
Colluvium		22	Mohr-Coulomb	0	28		Piezometric Line 1	Custom	1	
Type 2 Bedrock		22	Infinite Strength			Yes	Piezometric Line 1	Custom	0	
Embankment Fill		21.5	Mohr-Coulomb	0	38.3		None			0
Gv_Gm interface-8deg		12	Mohr-Coulomb	0	8		Piezometric Line 1	Custom	1	



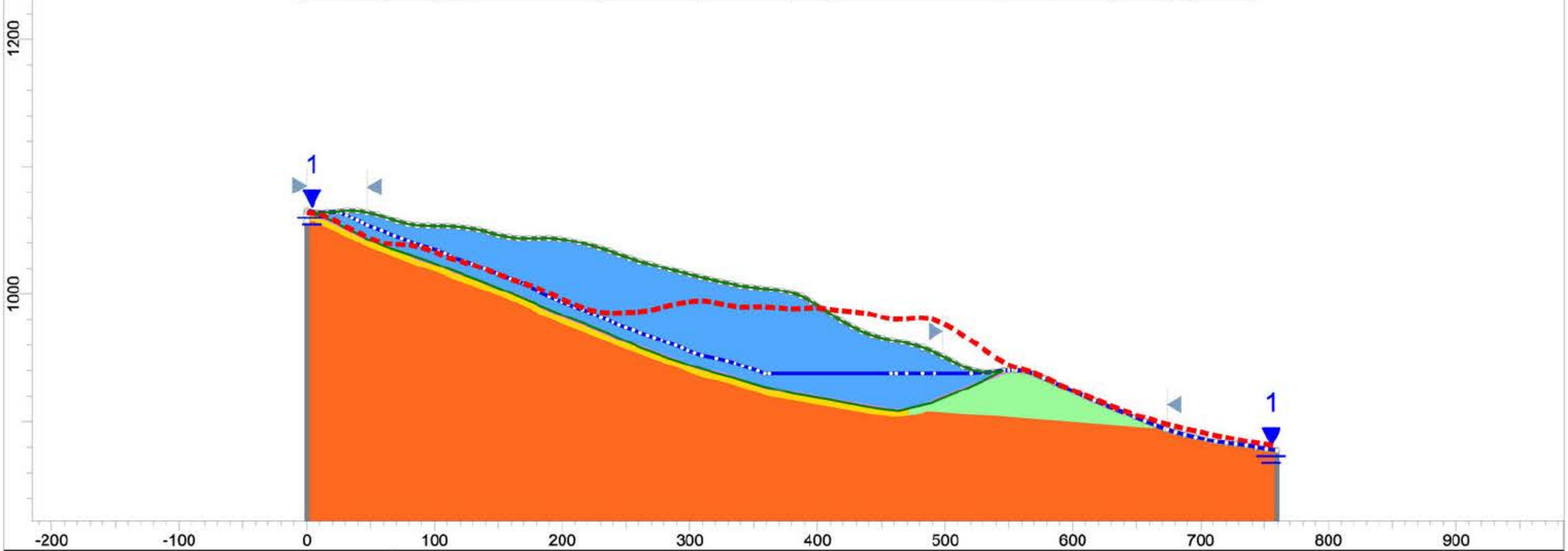
rocscience	Project	Slide2 - An Interactive Slope Stability Program	
	Group: Group 2	Scenario: 8deg	
	Drawn By	Company	
SLIDEINTERPRET 9.034	Date: 7/10/2024, 9:38:19 AM	File Name: 3-SSGvGm.slmd	

Refer to Section 6.2.2 of the report

0.920

Failure Mode 2C
Section 1A

Material Name	Color	Unit Weight (kN/m3)	Strength Type	Cohesion (kPa)	Phi (°)	Allow Sliding Along Boundary	Water Surface	Hu Type	Hu	Ru Value
Ore		18	Mohr-Coulomb	0	32		Piezometric Line 1	Custom	1	
Colluvium		22	Mohr-Coulomb	0	28		Piezometric Line 1	Custom	1	
Type 2 Bedrock		22	Infinite Strength			Yes	Piezometric Line 1	Custom	0	
Embankment Fill		21.5	Mohr-Coulomb	0	38.3		None			0
Gv_Gm interface-15deg		12	Mohr-Coulomb	0	15		Piezometric Line 1	Custom	1	



Project	Slide2 - An Interactive Slope Stability Program		
Group	Group 1	*Scenario*	15deg
Drawn By		*Company*	
Date	7/10/2024, 9:38:19 AM	*File Name*	1A-SSGvGm.slmd

SLIDEINTERPRET 9.034

Refer to Section 6.2.2 of the report

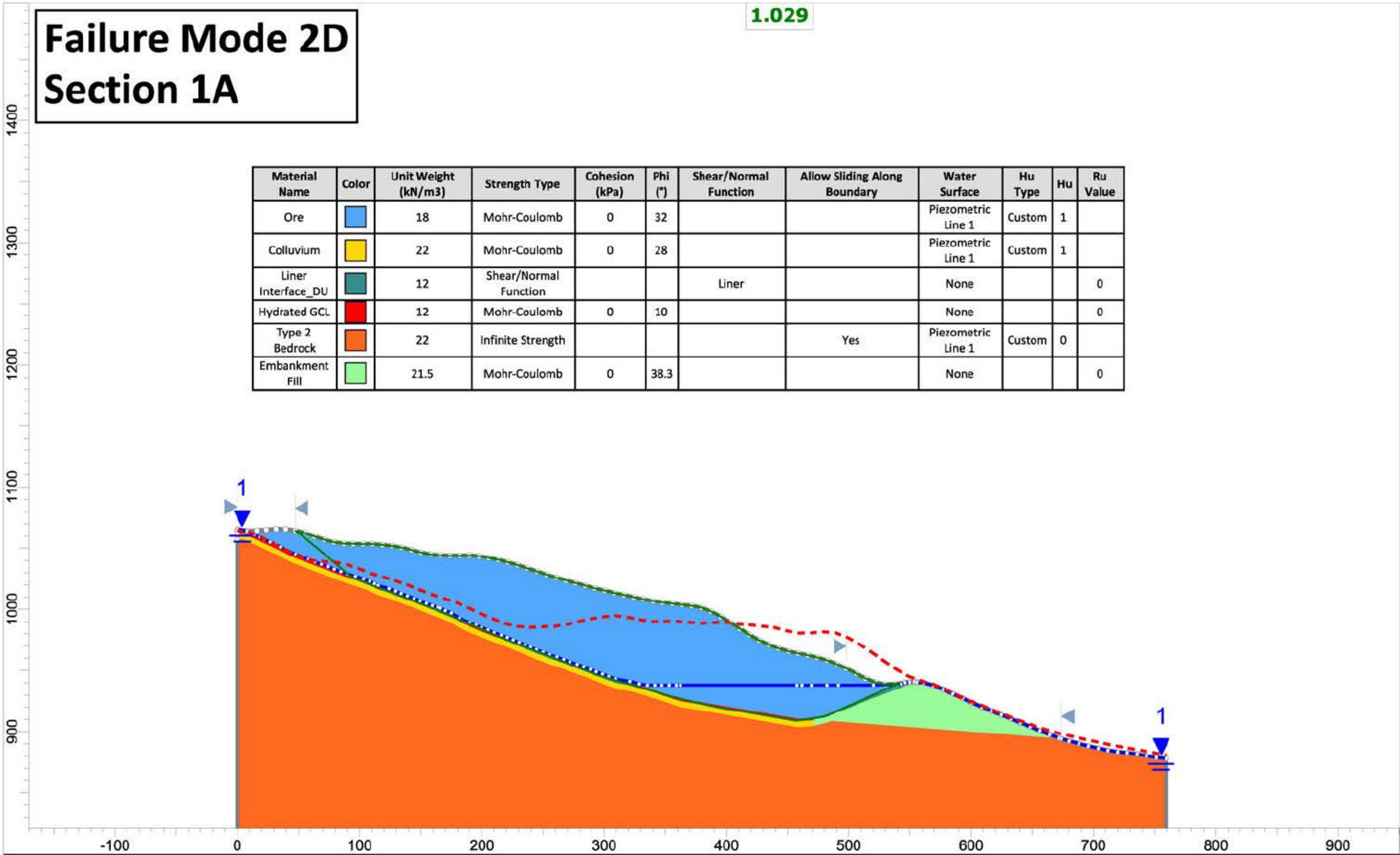
Failure Mode 2D
Lining instability due to slip failure within lining system (GCL)

Refer to Section 6.2.3 of the report

Failure Mode \ Section	1	2	3	1A
Mode 2D - Lining instability due to slip failure within lining system (GCL)	N	N	N	Y

Failure Mode 2D
Section 1A

Material Name	Color	Unit Weight (kN/m3)	Strength Type	Cohesion (kPa)	Phi (°)	Shear/Normal Function	Allow Sliding Along Boundary	Water Surface	Hu Type	Hu	Ru Value
Ore		18	Mohr-Coulomb	0	32			Piezometric Line 1	Custom	1	
Colluvium		22	Mohr-Coulomb	0	28			Piezometric Line 1	Custom	1	
Liner Interface_DU		12	Shear/Normal Function			Liner		None			0
Hydrated GCL		12	Mohr-Coulomb	0	10			None			0
Type 2 Bedrock		22	Infinite Strength				Yes	Piezometric Line 1	Custom	0	
Embankment Fill		21.5	Mohr-Coulomb	0	38.3			None			0



rocscience

Project	Slide2 - An Interactive Slope Stability Program		
Group	Group 2	*Scenario*	10deg
Drawn By		*Company*	
Date	7/10/2024, 9:38:19 AM	*File Name*	1A-GCL.slmd

SLIDEINTERPRET 9.034

Refer to Section 6.2.3 of the report

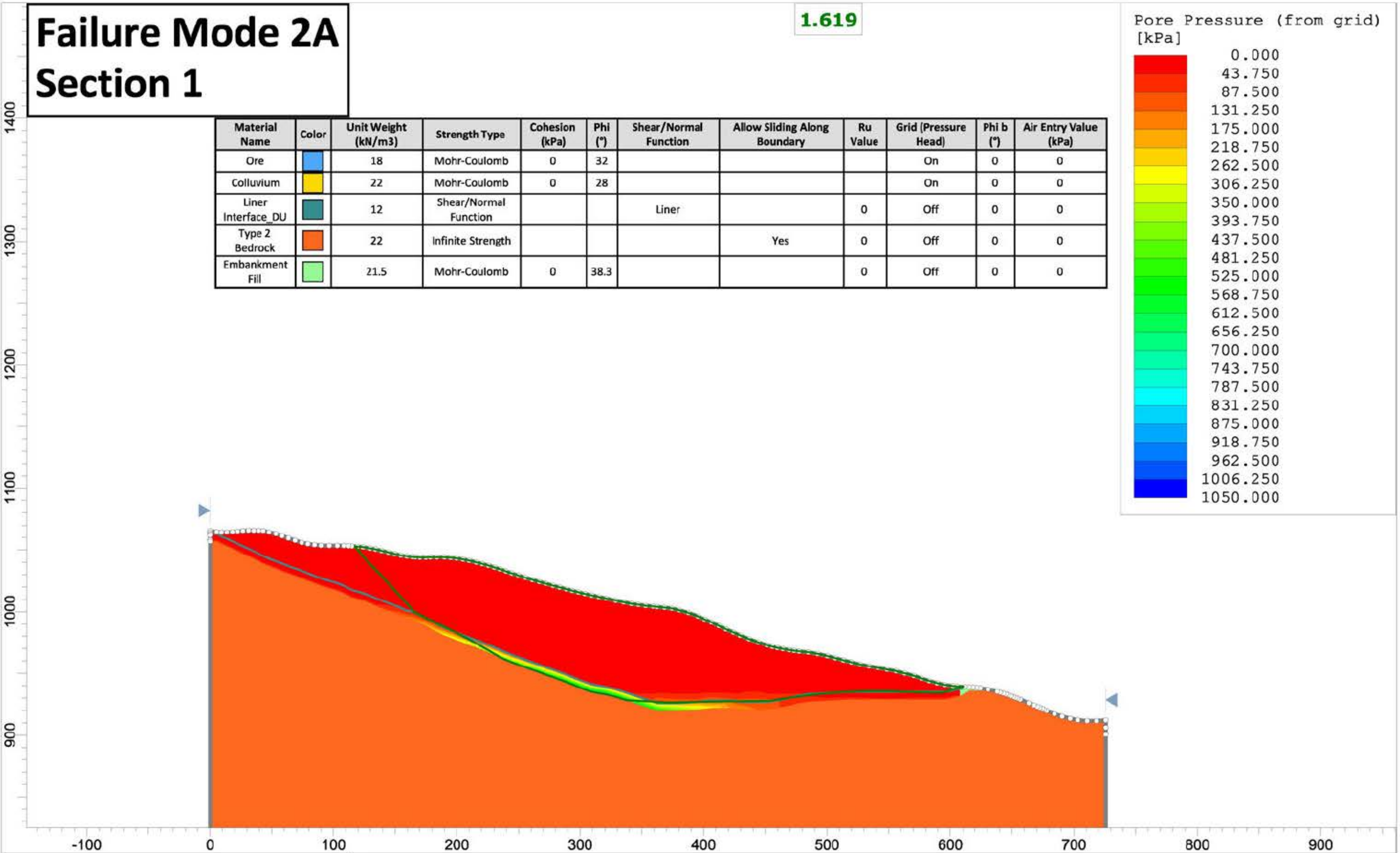
Failure Mode 2A
Lining instability due to hydraulic uplift (basal heave)

Refer to Section 6.2.4 of the report

Failure Mode \ Section	1	2	3	1A
Mode 2A – Lining instability due to hydraulic uplift (basal heave)	Y	Y	N	Y

Failure Mode 2A
Section 1

Material Name	Color	Unit Weight (kN/m3)	Strength Type	Cohesion (kPa)	Phi (°)	Shear/Normal Function	Allow Sliding Along Boundary	Ru Value	Grid (Pressure Head)	Phi b (°)	Air Entry Value (kPa)
Ore		18	Mohr-Coulomb	0	32				On	0	0
Colluvium		22	Mohr-Coulomb	0	28				On	0	0
Liner Interface_DU		12	Shear/Normal Function			Liner		0	Off	0	0
Type 2 Bedrock		22	Infinite Strength				Yes	0	Off	0	0
Embankment Fill		21.5	Mohr-Coulomb	0	38.3			0	Off	0	0



rocscience

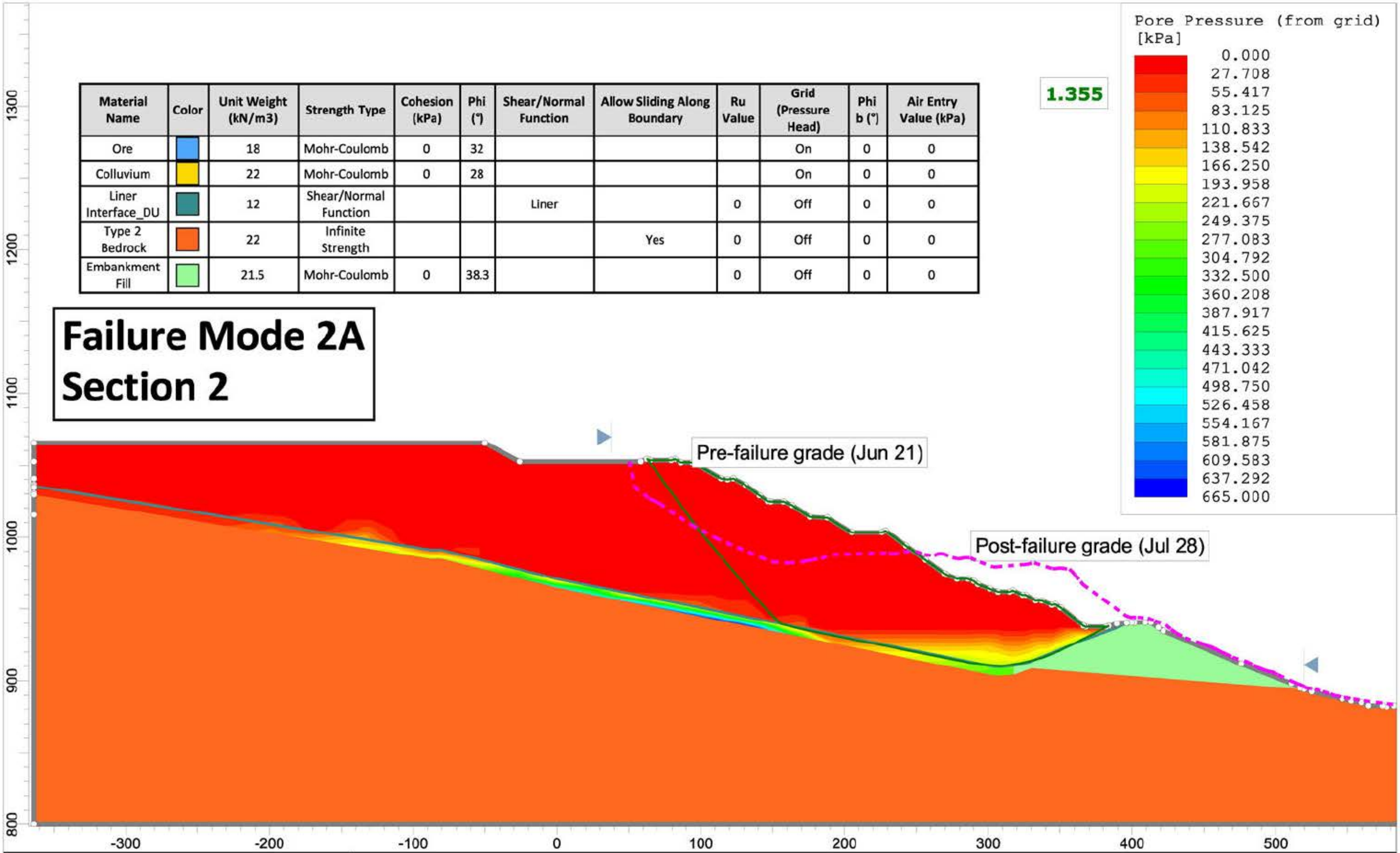
Project	Slide2 - An Interactive Slope Stability Program		
Group	Master/control scenario	*Scenario*	basal heave - 75m
Drawn By		*Company*	
Date	7/10/2024, 9:38:19 AM	*File Name*	1-excesspp.slmd

SLIDEINTERPRET 9.034

Refer to Section 6.2.4 of the report

Material Name	Color	Unit Weight (kN/m3)	Strength Type	Cohesion (kPa)	Phi (°)	Shear/Normal Function	Allow Sliding Along Boundary	Ru Value	Grid (Pressure Head)	Phi b (°)	Air Entry Value (kPa)
Ore		18	Mohr-Coulomb	0	32				On	0	0
Colluvium		22	Mohr-Coulomb	0	28				On	0	0
Liner Interface_DU		12	Shear/Normal Function			Liner		0	Off	0	0
Type 2 Bedrock		22	Infinite Strength				Yes	0	Off	0	0
Embankment Fill		21.5	Mohr-Coulomb	0	38.3			0	Off	0	0

Failure Mode 2A
Section 2

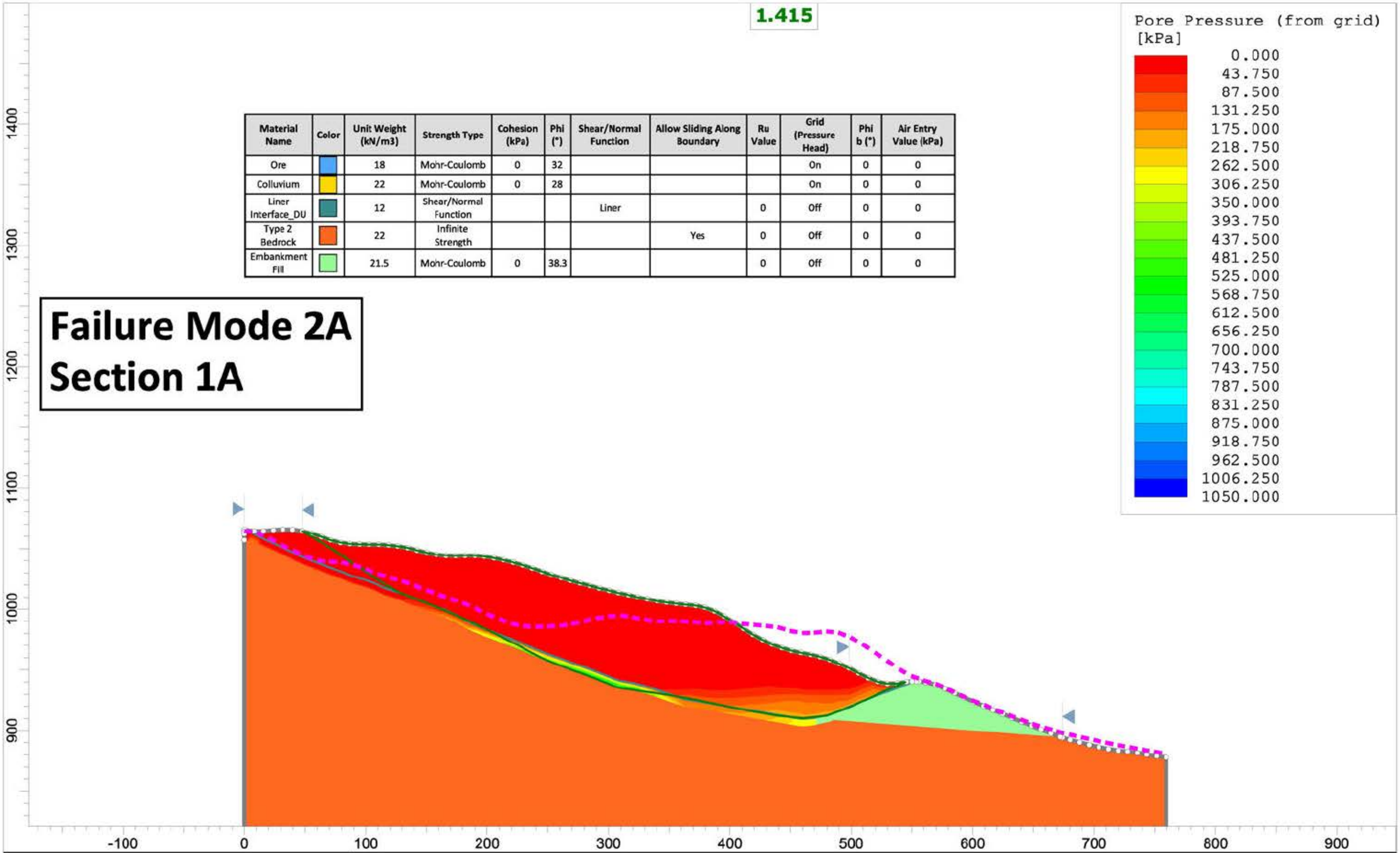


rocscience

Project	Slide2 - An Interactive Slope Stability Program		
Group	Group 1	*Scenario*	basal heave - 75m no bubble
Drawn By		*Company*	
Date	7/10/2024, 9:38:19 AM	*File Name*	2-excesspp.slmd

SLIDEINTERPRET 9.034

Refer to Section 6.2.4 of the report



Material Name	Color	Unit Weight (kN/m3)	Strength Type	Cohesion (kPa)	Phi (°)	Shear/Normal Function	Allow Sliding Along Boundary	Ru Value	Grid (Pressure Head)	Phi b (°)	Air Entry Value (kPa)
Ore		18	Mohr-Coulomb	0	32				On	0	0
Colluvium		22	Mohr-Coulomb	0	28				On	0	0
Liner Interface_DU		12	Shear/Normal Function			Liner		0	Off	0	0
Type 2 Bedrock		22	Infinite Strength				Yes	0	Off	0	0
Embankment Fill		21.5	Mohr-Coulomb	0	38.3			0	Off	0	0

rocscience

Project	Slide2 - An Interactive Slope Stability Program		
Group	Group 2	Scenario	basal heave
Drawn By		Company	
Date	7/10/2024, 9:38:19 AM	File Name	1A-excesspp.slmd

SLIDEINTERPRET 9.034

Refer to Section 6.2.4 of the report

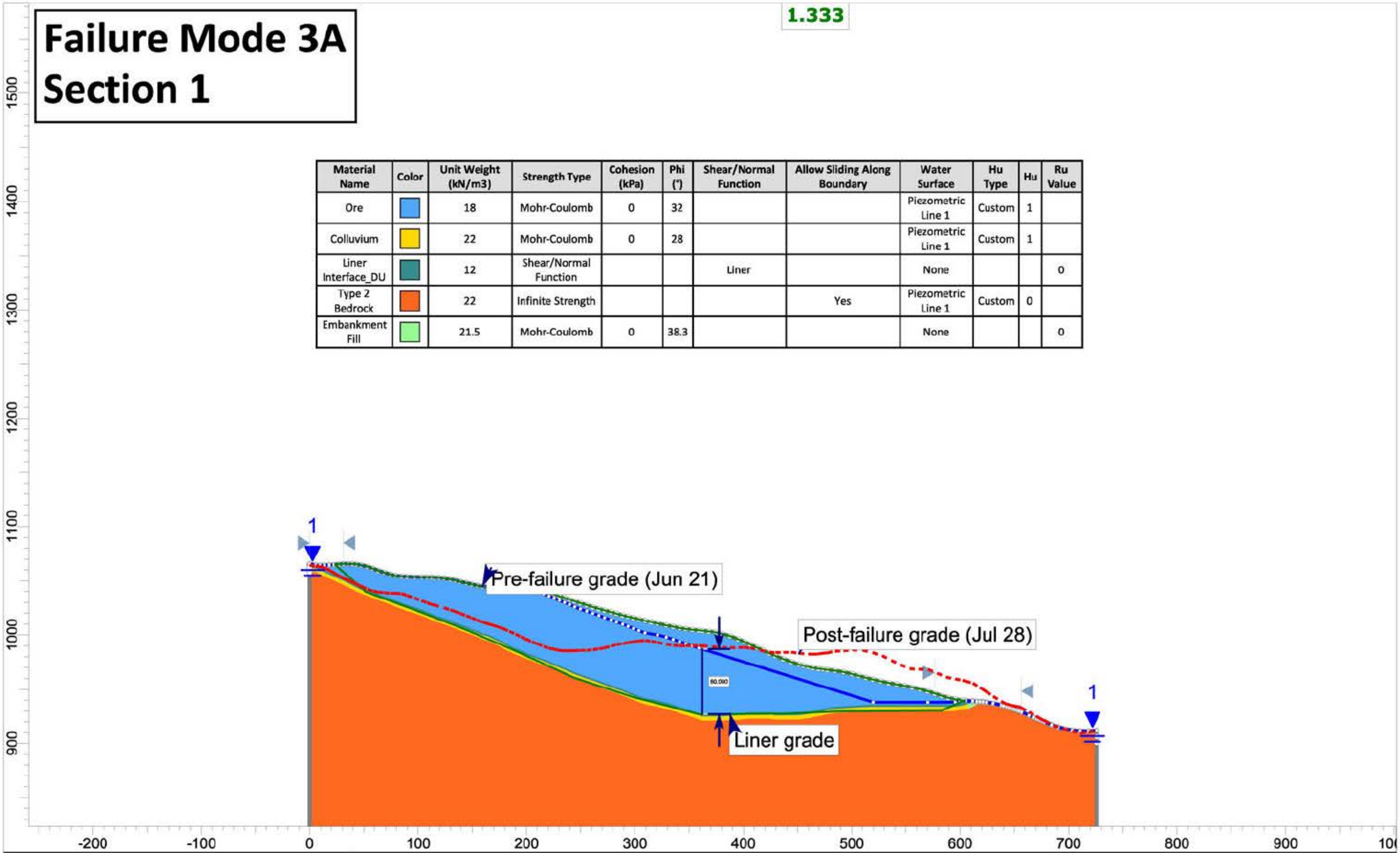
Failure Mode 3A
Ore failure due to increased piezometric level

Refer to Section 6.3.1 of the report

Failure Mode \ Section	1	2	3	1A
Mode 3A – Ore failure due to increased piezometric level	Y	Y	Y	Y

Failure Mode 3A
Section 1

Material Name	Color	Unit Weight (kN/m3)	Strength Type	Cohesion (kPa)	Phi (°)	Shear/Normal Function	Allow Sliding Along Boundary	Water Surface	Hu Type	Hu	Ru Value
Ore		18	Mohr-Coulomb	0	32			Piezometric Line 1	Custom	1	
Colluvium		22	Mohr-Coulomb	0	28			Piezometric Line 1	Custom	1	
Liner Interface_DU		12	Shear/Normal Function			Liner		None			0
Type 2 Bedrock		22	Infinite Strength				Yes	Piezometric Line 1	Custom	0	
Embankment Fill		21.5	Mohr-Coulomb	0	38.3			None			0



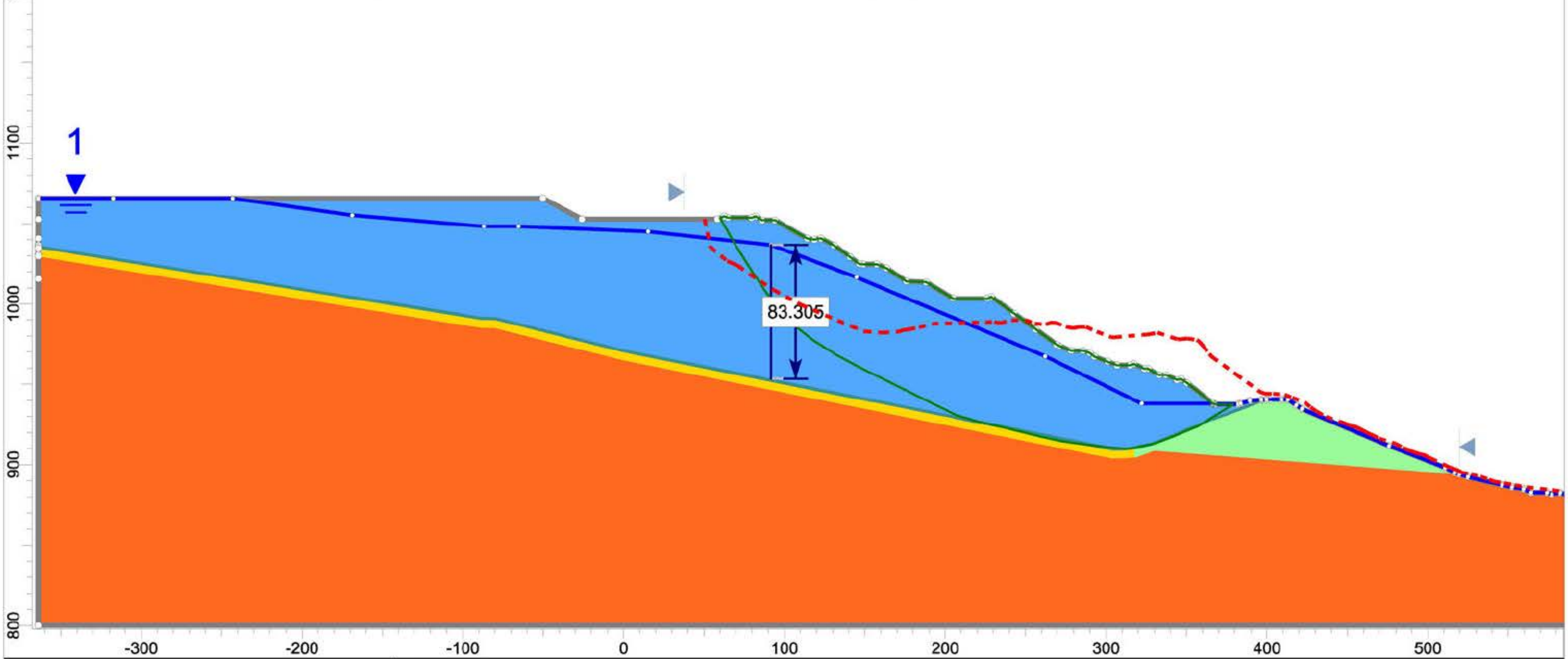
rocscience	*Project* Slide2 - An Interactive Slope Stability Program		
	Group Group 1	*Scenario* 60m	
	Drawn By	*Company*	
SLIDEINTERPRET 9.034	*Date* 7/10/2024, 9:38:19 AM	*File Name* 1-OFGWWC.slmd	

Refer to Section 6.3.1 of the report

Material Name	Color	Unit Weight (kN/m3)	Strength Type	Cohesion (kPa)	Phi (°)	Shear/Normal Function	Allow Sliding Along Boundary	Water Surface	Hu Type	Hu	Ru Value
Ore		18	Mohr-Coulomb	0	32			Piezometric Line 1	Custom	1	
Colluvium		22	Mohr-Coulomb	0	28			Piezometric Line 1	Custom	1	
Liner Interface_DU		12	Shear/Normal Function			Liner		None			0
Type 2 Bedrock		22	Infinite Strength				Yes	Piezometric Line 1	Custom	0	
Embankment Fill		21.5	Mohr-Coulomb	0	38.3			None			0

1.014

Failure Mode 3A Section 2



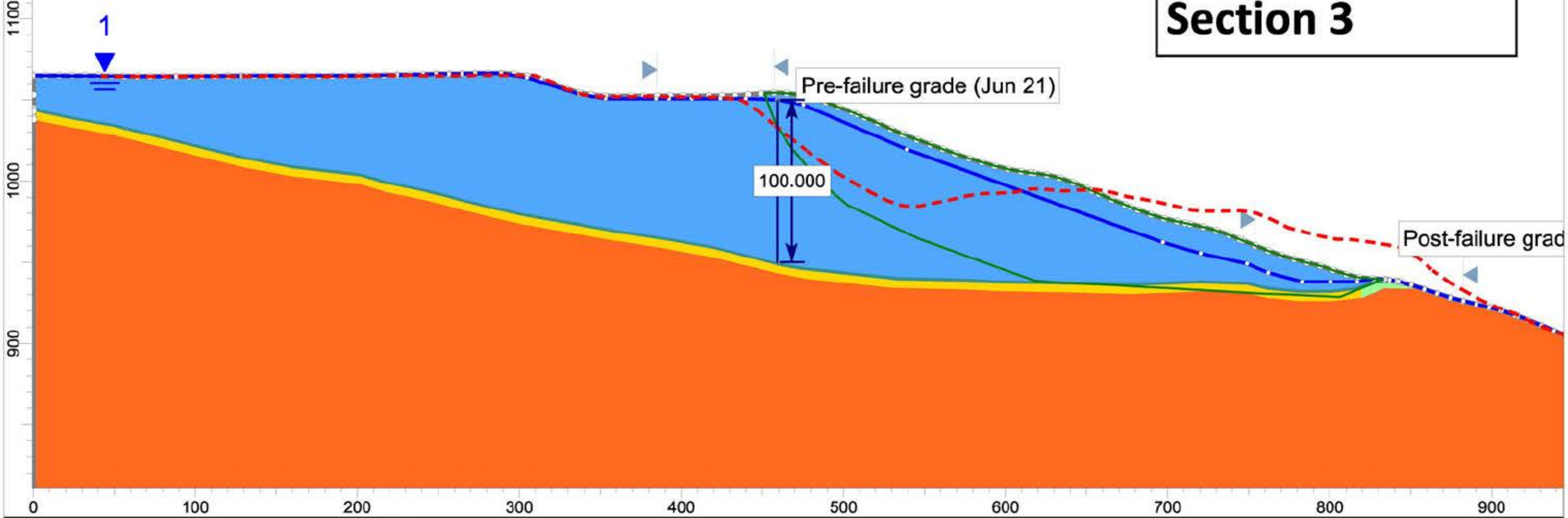
rocscience	Project	Slide2 - An Interactive Slope Stability Program	
	Group: Group 1	Scenario: Scenario 7	
	Drawn By	Company	
SLIDEINTERPRET 9.034	Date: 7/10/2024, 9:38:19 AM	File Name: 2-OFGWWC.slmd	

Refer to Section 6.3.1 of the report

1.143

Material Name	Color	Unit Weight (kN/m3)	Strength Type	Cohesion (kPa)	Phi (°)	Shear/Normal Function	Allow Sliding Along Boundary	Water Surface	Hu Type	Hu	Ru Value
Ore		18	Mohr-Coulomb	0	32			Piezometric Line 1	Custom	1	
Colluvium		22	Mohr-Coulomb	0	28			Piezometric Line 1	Custom	1	
Liner Interface_DU		12	Shear/Normal Function			Liner		None			0
Type 2 Bedrock		22	Infinite Strength				Yes	Piezometric Line 1	Custom	0	
Embankment Fill		21.5	Mohr-Coulomb	0	38.3			None			0

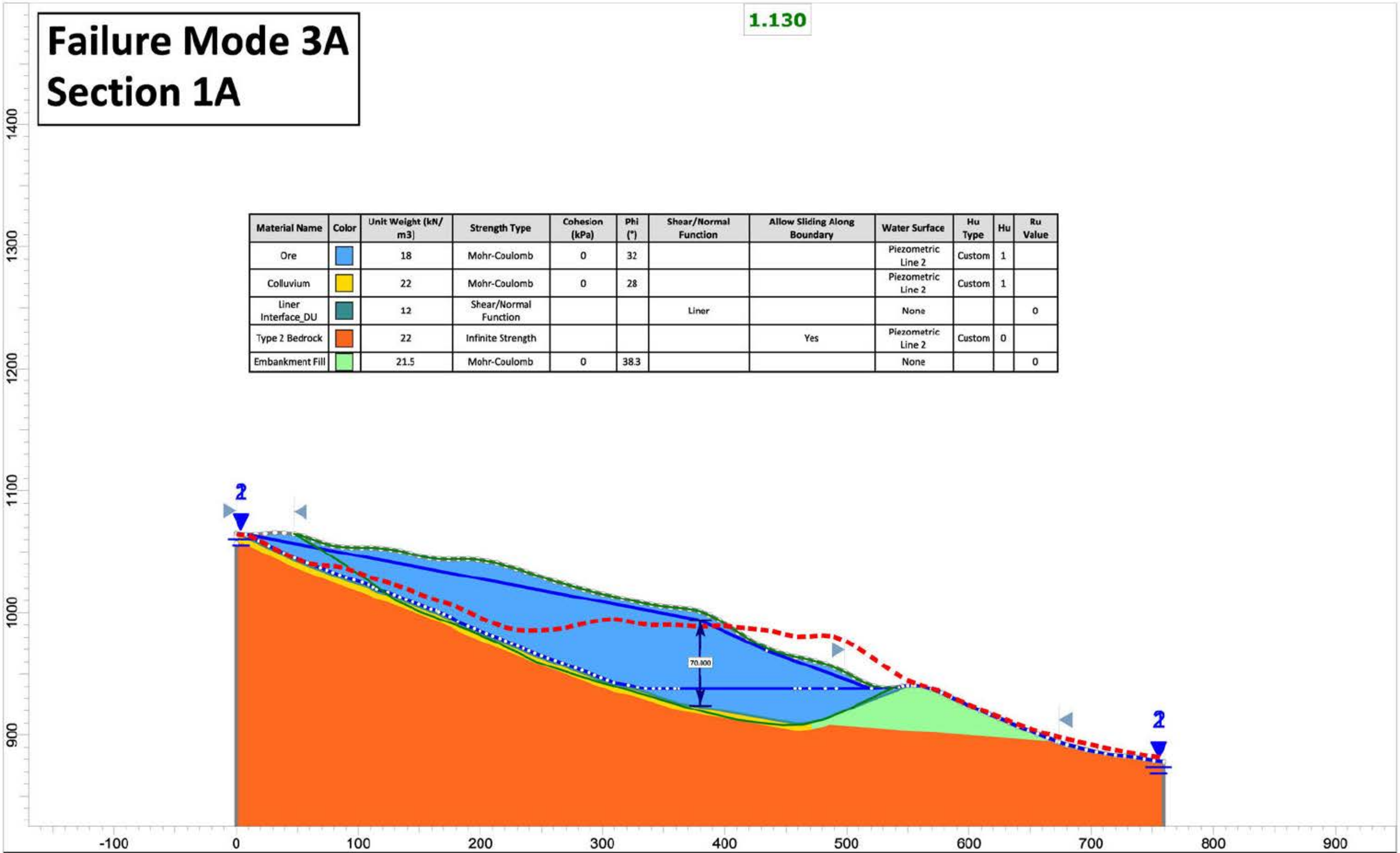
Failure Mode 3A
Section 3



rocscience	Project: Slide2 - An Interactive Slope Stability Program		
	Group: Group 1	Scenario: 100m	
	Drawn By:	Company:	
SLIDEINTERPRET 9.034	Date: 7/10/2024, 9:38:19 AM	File Name: 3-OFGWWC.slmd	

Refer to Section 6.3.1 of the report

Failure Mode 3A
Section 1A



Material Name	Color	Unit Weight (kN/m3)	Strength Type	Cohesion (kPa)	Phi (°)	Shear/Normal Function	Allow Sliding Along Boundary	Water Surface	Hu Type	Hu	Ru Value
Ore		18	Mohr-Coulomb	0	32			Piezometric Line 2	Custom	1	
Colluvium		22	Mohr-Coulomb	0	28			Piezometric Line 2	Custom	1	
Liner Interface_DU		12	Shear/Normal Function			Liner		None			0
Type 2 Bedrock		22	Infinite Strength				Yes	Piezometric Line 2	Custom	0	
Embankment Fill		21.5	Mohr-Coulomb	0	38.3			None			0

rocscience

SLIDEINTERPRET 9.034

Project	Slide2 - An Interactive Slope Stability Program		
Group	Group 2	*Scenario*	70m
Drawn By		*Company*	
Date	7/10/2024, 9:38:19 AM	*File Name*	1A-OFGWWC.slmd

Refer to Section 6.3.1 of the report

Failure Mode 3B
Ore failure due to perched water tables

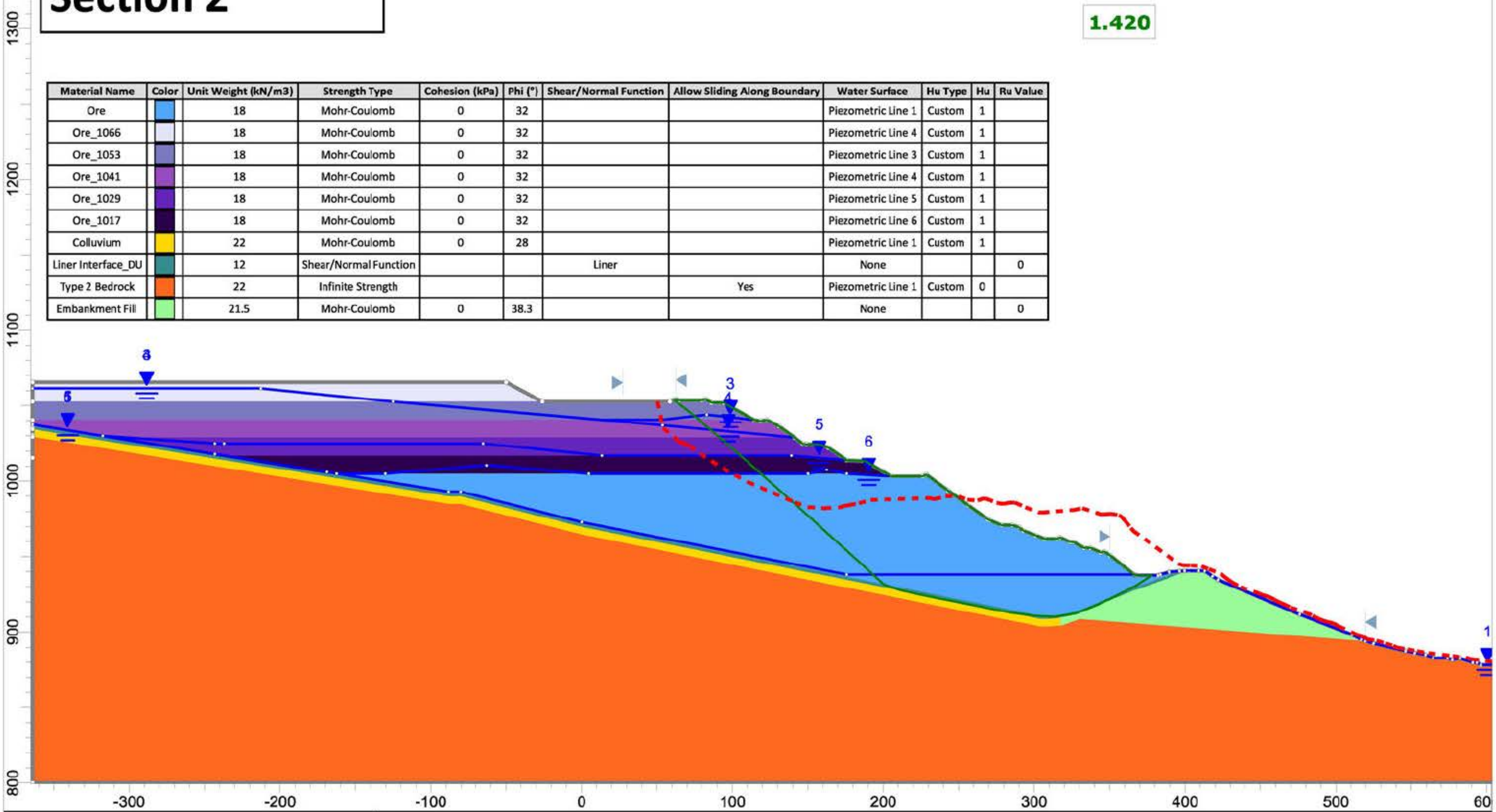
Refer to Section 6.3.2 of the report

Failure Mode \ Section	1	2	3	1A
Mode 3B – Ore failure due to perched water tables	N	Y	N	N

Failure Mode 3B
Section 2

1.420

Material Name	Color	Unit Weight (kN/m3)	Strength Type	Cohesion (kPa)	Phi (°)	Shear/Normal Function	Allow Sliding Along Boundary	Water Surface	Hu Type	Hu	Ru Value
Ore		18	Mohr-Coulomb	0	32			Piezometric Line 1	Custom	1	
Ore_1066		18	Mohr-Coulomb	0	32			Piezometric Line 4	Custom	1	
Ore_1053		18	Mohr-Coulomb	0	32			Piezometric Line 3	Custom	1	
Ore_1041		18	Mohr-Coulomb	0	32			Piezometric Line 4	Custom	1	
Ore_1029		18	Mohr-Coulomb	0	32			Piezometric Line 5	Custom	1	
Ore_1017		18	Mohr-Coulomb	0	32			Piezometric Line 6	Custom	1	
Colluvium		22	Mohr-Coulomb	0	28			Piezometric Line 1	Custom	1	
Liner Interface_DU		12	Shear/Normal Function			Liner		None			0
Type 2 Bedrock		22	Infinite Strength				Yes	Piezometric Line 1	Custom	0	
Embankment Fill		21.5	Mohr-Coulomb	0	38.3			None			0



rocscience

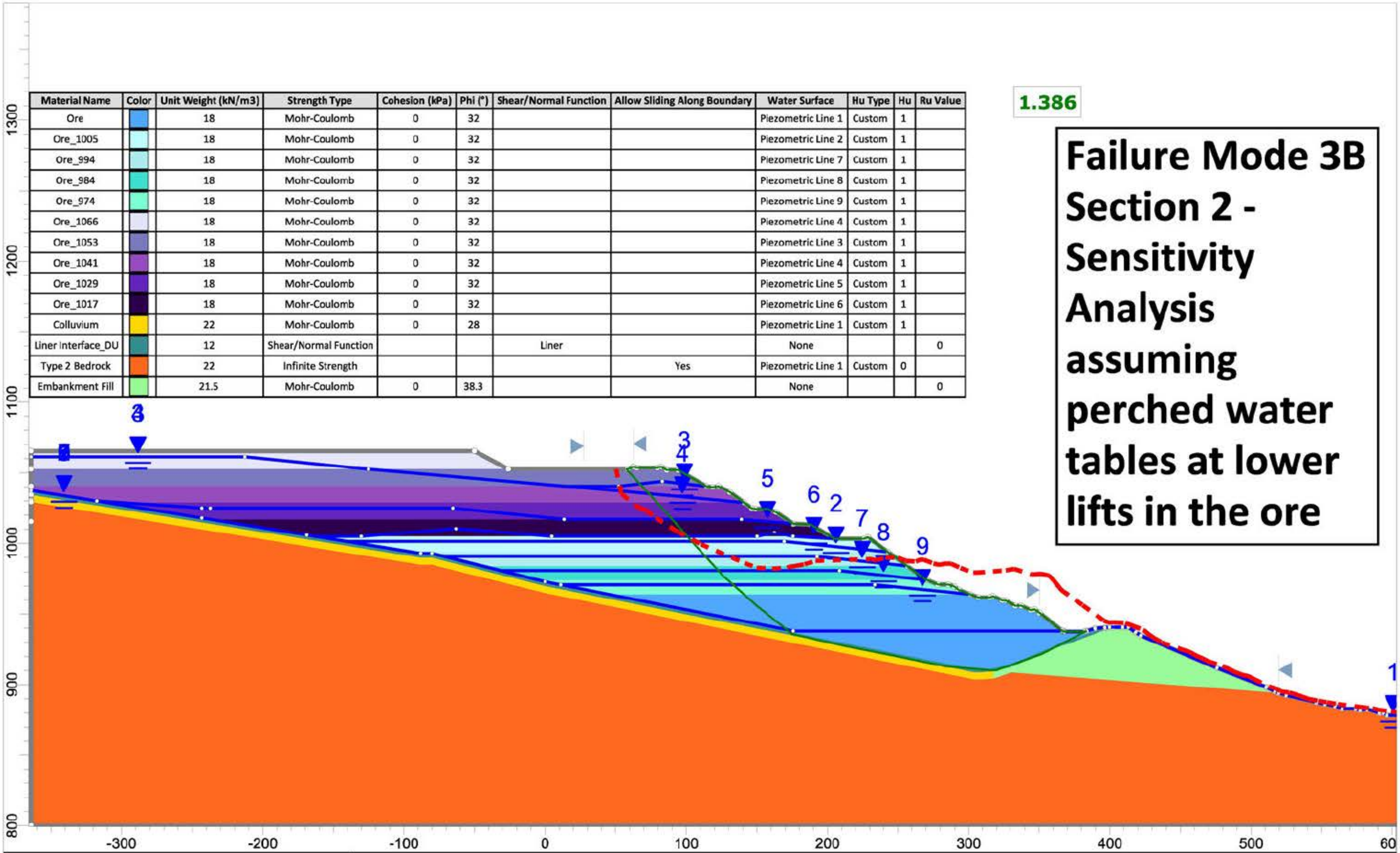
Project	Slide2 - An Interactive Slope Stability Program		
Group	Group 1	Scenario	Perched water tables
Drawn By		Company	
Date	7/10/2024, 9:38:19 AM	File Name	Section 2_perchedWT.slmd

SLIDEINTERPRET 9.034

Refer to Section 6.3.2 of the report

Failure Mode 3B Section 2 - Sensitivity Analysis assuming perched water tables at lower lifts in the ore

Material Name	Color	Unit Weight (kN/m3)	Strength Type	Cohesion (kPa)	Phi (°)	Shear/Normal Function	Allow Sliding Along Boundary	Water Surface	Hu Type	Hu	Ru Value
Ore		18	Mohr-Coulomb	0	32			Piezometric Line 1	Custom	1	
Ore_1005		18	Mohr-Coulomb	0	32			Piezometric Line 2	Custom	1	
Ore_994		18	Mohr-Coulomb	0	32			Piezometric Line 7	Custom	1	
Ore_984		18	Mohr-Coulomb	0	32			Piezometric Line 8	Custom	1	
Ore_974		18	Mohr-Coulomb	0	32			Piezometric Line 9	Custom	1	
Ore_1066		18	Mohr-Coulomb	0	32			Piezometric Line 4	Custom	1	
Ore_1053		18	Mohr-Coulomb	0	32			Piezometric Line 3	Custom	1	
Ore_1041		18	Mohr-Coulomb	0	32			Piezometric Line 4	Custom	1	
Ore_1029		18	Mohr-Coulomb	0	32			Piezometric Line 5	Custom	1	
Ore_1017		18	Mohr-Coulomb	0	32			Piezometric Line 6	Custom	1	
Colluvium		22	Mohr-Coulomb	0	28			Piezometric Line 1	Custom	1	
Liner Interface_DU		12	Shear/Normal Function			Liner		None			0
Type 2 Bedrock		22	Infinite Strength				Yes	Piezometric Line 1	Custom	0	
Embankment Fill		21.5	Mohr-Coulomb	0	38.3			None			0



rocscience	*Project* Slide2 - An Interactive Slope Stability Program
	Group Group 1 — *Scenario* perched water tables_lower lifts
	Drawn By — *Company*
SLIDEINTERPRET 9.034	*Date* 7/10/2024, 9:38:19 AM — *File Name* Section 2_perchedWT.slmd

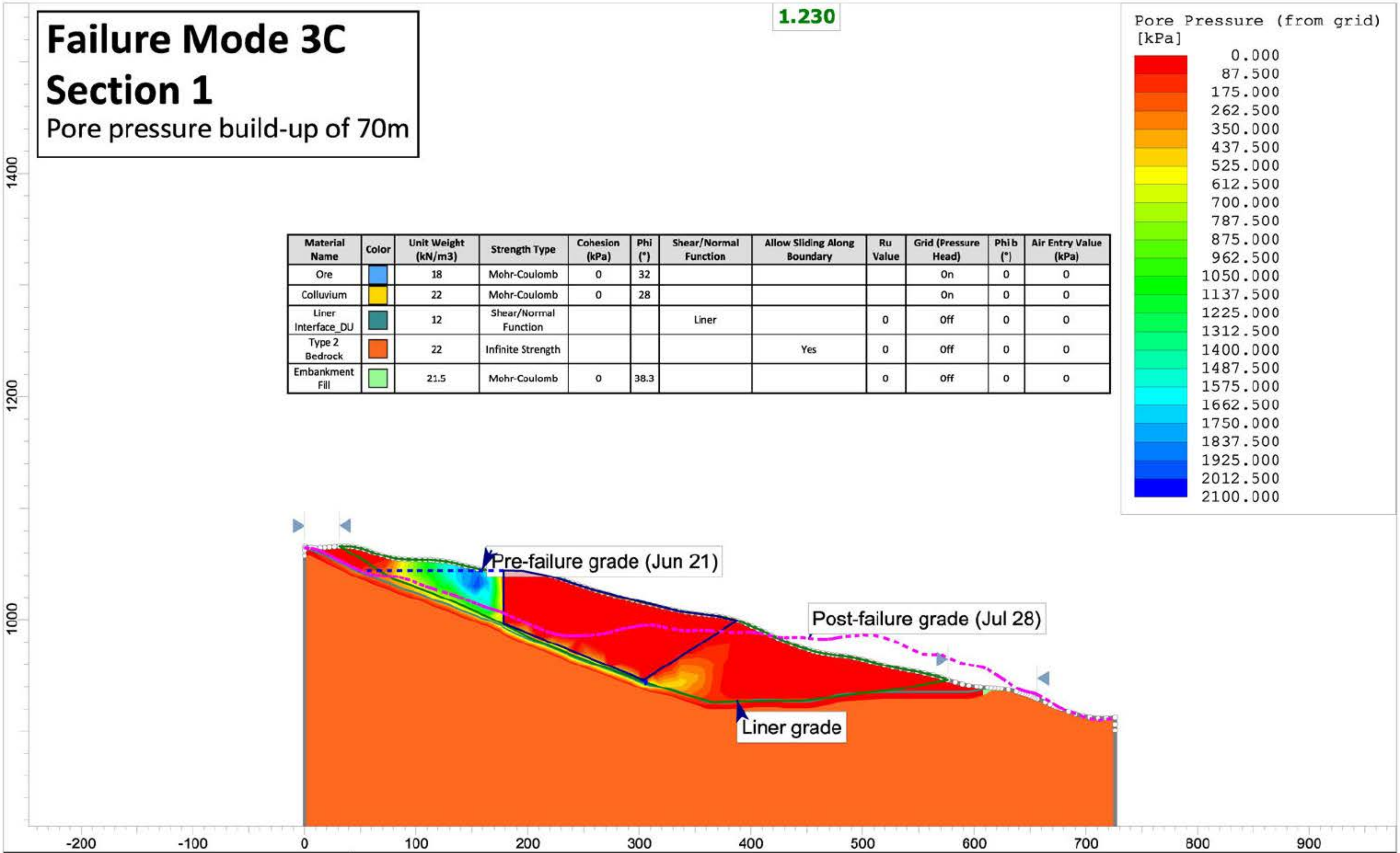
Refer to Section 6.3.2 of the report

Failure Mode 3C
Ore failure due to hydrostatic uplift pressures

Refer to Section 6.3.3 of the report

Failure Mode \ Section	1	2	3	1A
Mode 3C – Ore failure due to hydrostatic uplift pressures	Y	Y	N	Y

Failure Mode 3C
Section 1
Pore pressure build-up of 70m

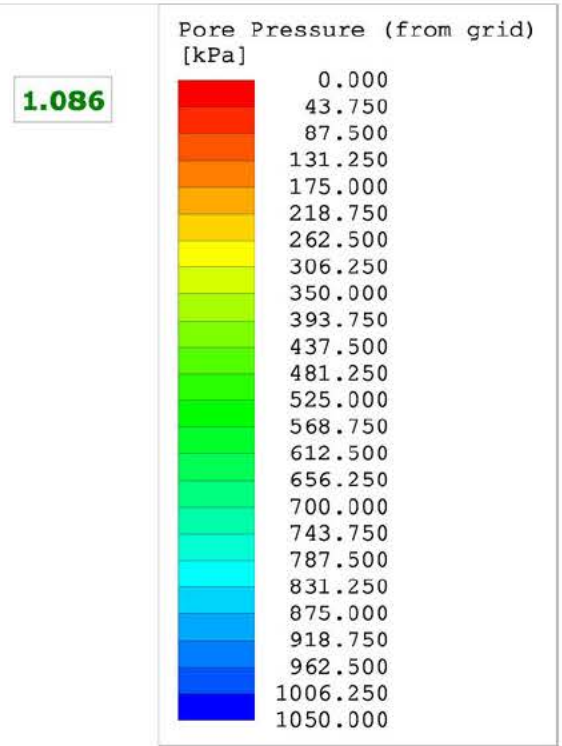


Material Name	Color	Unit Weight (kN/m3)	Strength Type	Cohesion (kPa)	Phi (°)	Shear/Normal Function	Allow Sliding Along Boundary	Ru Value	Grid (Pressure Head)	Phi b (°)	Air Entry Value (kPa)
Ore		18	Mohr-Coulomb	0	32				On	0	0
Colluvium		22	Mohr-Coulomb	0	28				On	0	0
Liner Interface_DU		12	Shear/Normal Function			Liner		0	Off	0	0
Type 2 Bedrock		22	Infinite Strength				Yes	0	Off	0	0
Embankment Fill		21.5	Mohr-Coulomb	0	38.3			0	Off	0	0

rocscience	*Project* Slide2 - An Interactive Slope Stability Program		
	Group Master/control scenario	*Scenario* impermeable block - 70m	
	Drawn By	*Company*	
SLIDEINTERPRET 9.034	*Date* 7/10/2024, 9:38:19 AM	*File Name* 1-excesspp.slmd	

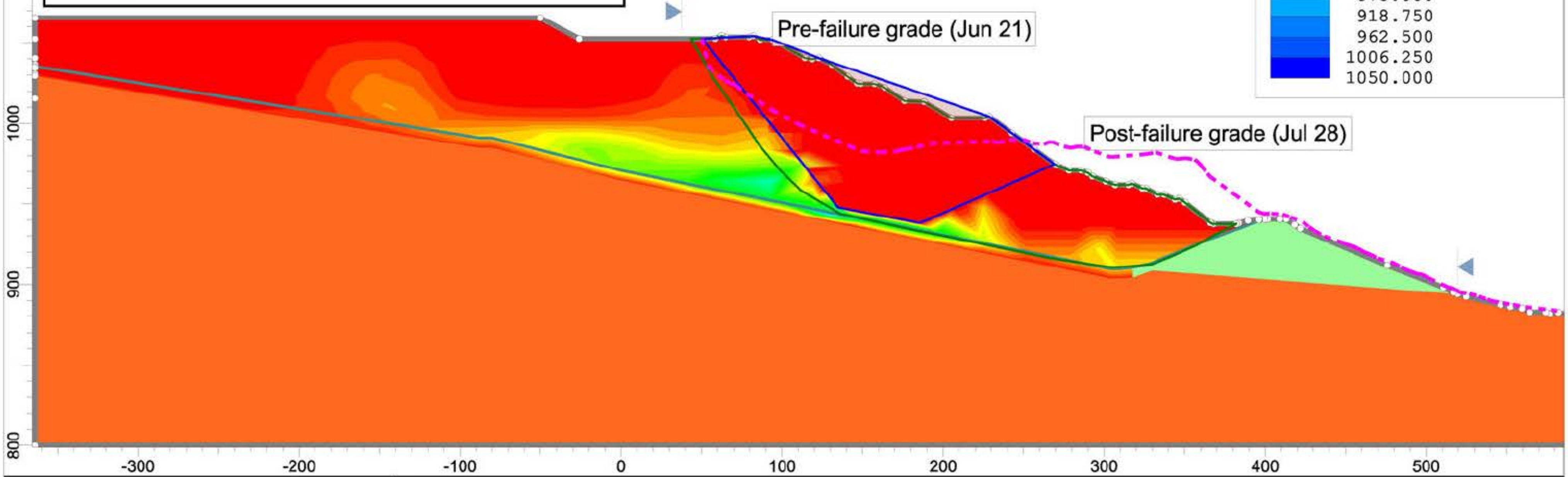
Refer to Section 6.3.3 of the report

Material Name	Color	Unit Weight (kN/m3)	Strength Type	Cohesion (kPa)	Phi (°)	Shear/ Normal Function	Allow Sliding Along Boundary	Ru Value	Grid (Pressure Head)	Phi b (°)	Air Entry Value (kPa)
Ore		18	Mohr-Coulomb	0	32				On	0	0
Colluvium		22	Mohr-Coulomb	0	28				On	0	0
Liner Interface_DU		12	Shear/ Normal Function			Liner		0	Off	0	0
Type 2 Bedrock		22	Infinite Strength				Yes	0	Off	0	0
Embankment Fill		21.5	Mohr-Coulomb	0	38.3			0	Off	0	0



Failure Mode 3C - Section 2

Pore pressure build-up of 70m



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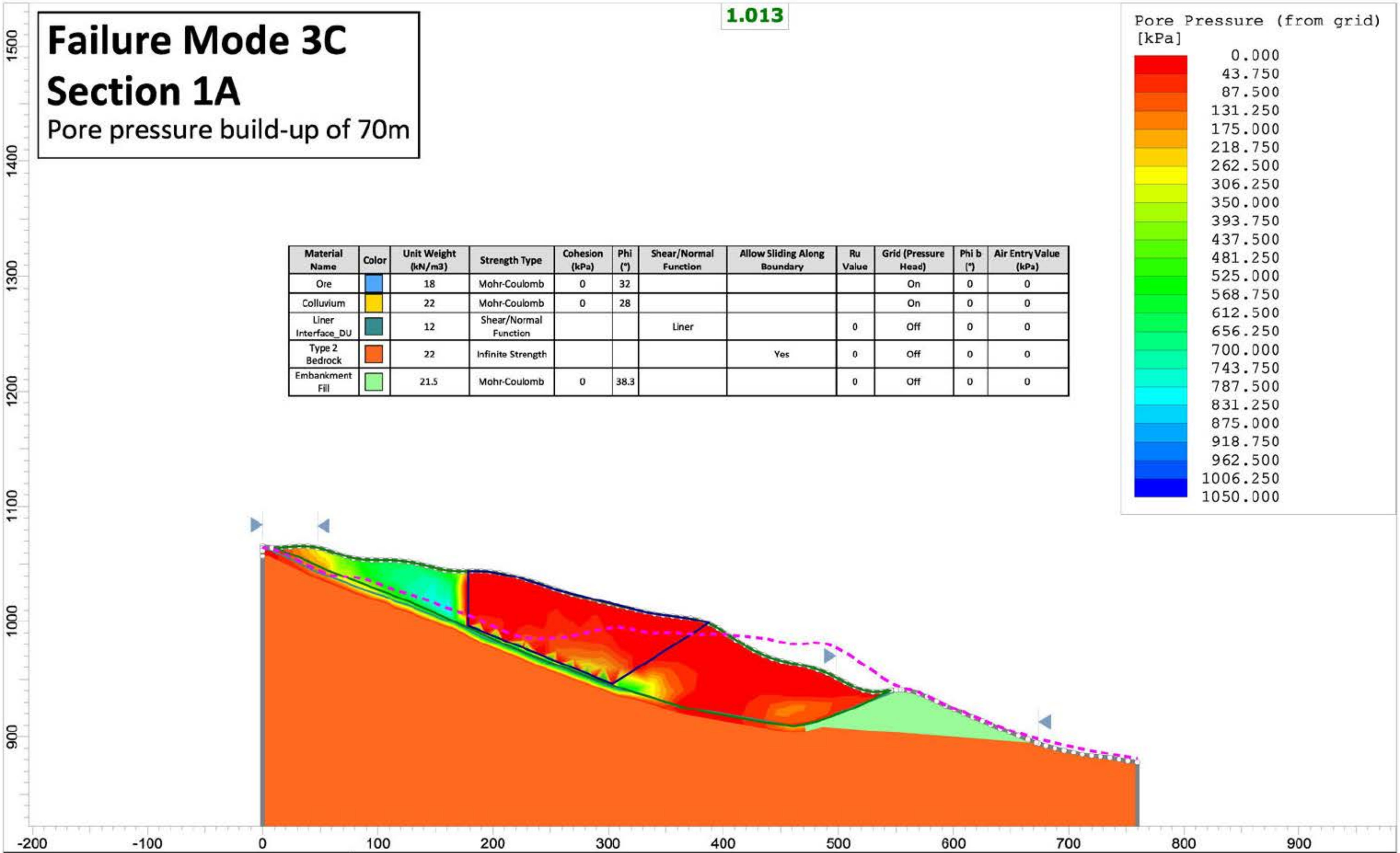
SLIDEINTERPRET 9.034

Project	Slide2 - An Interactive Slope Stability Program		
Group	Group 1	Scenario	impermeable block - 70m
Drawn By		Company	
Date	7/10/2024, 9:38:19 AM	File Name	2-excesspp.slmd

Refer to Section 6.3.3 of the report

Failure Mode 3C
Section 1A
Pore pressure build-up of 70m



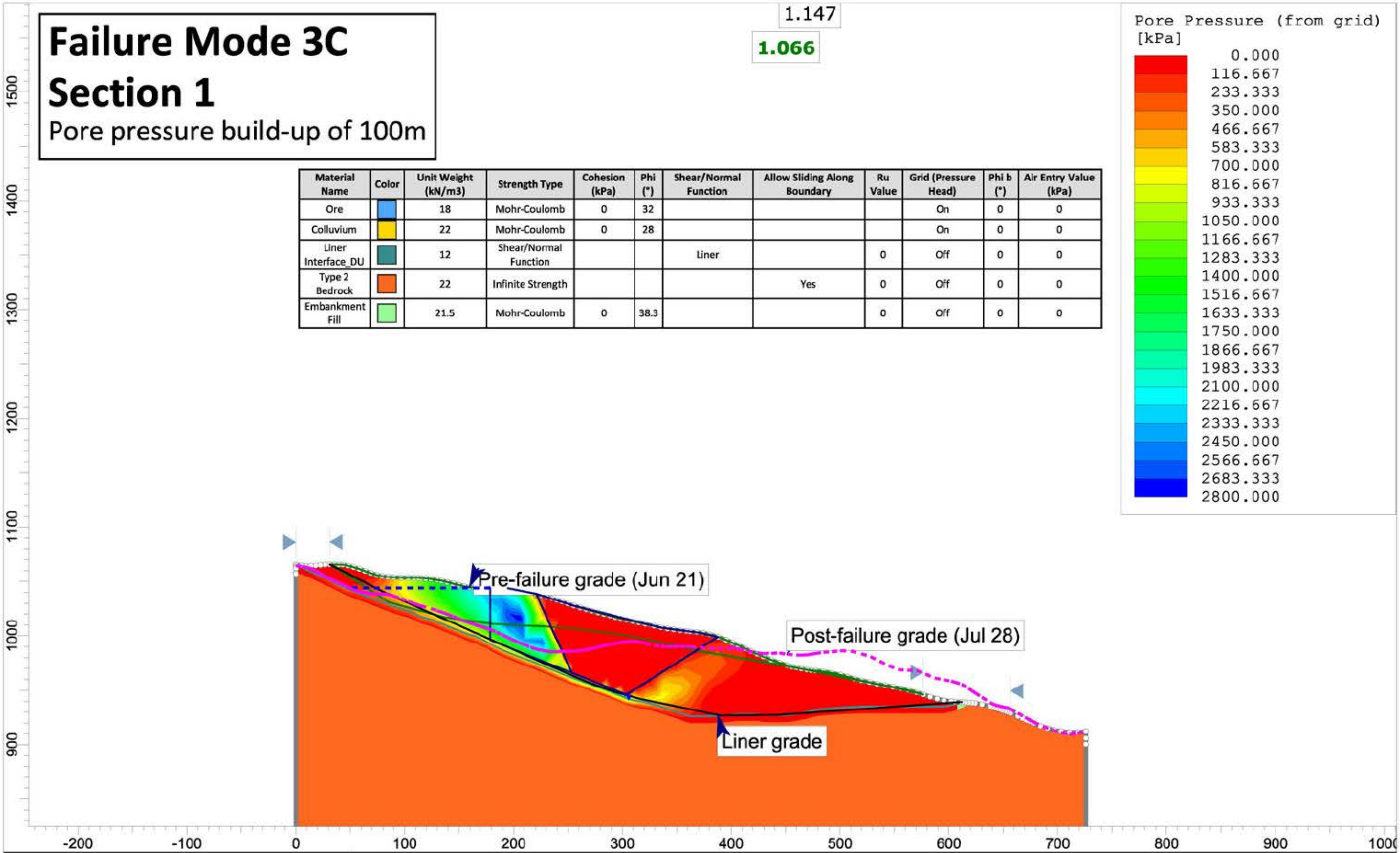
Material Name	Color	Unit Weight (kN/m3)	Strength Type	Cohesion (kPa)	Phi (°)	Shear/Normal Function	Allow Sliding Along Boundary	Ru Value	Grid (Pressure Head)	Phi b (°)	Air Entry Value (kPa)
Ore		18	Mohr-Coulomb	0	32				On	0	0
Colluvium		22	Mohr-Coulomb	0	28				On	0	0
Liner Interface_DU		12	Shear/Normal Function			Liner		0	Off	0	0
Type 2 Bedrock		22	Infinite Strength				Yes	0	Off	0	0
Embankment Fill		21.5	Mohr-Coulomb	0	38.3			0	Off	0	0

rocscience	Project	Slide2 - An Interactive Slope Stability Program	
	Group: Group 2	Scenario: Impermeable block - 70m	
	Drawn By	Company	
SLIDEINTERPRET 9.034	Date: 7/10/2024, 9:38:19 AM	File Name: 1A-excesspp.slmd	

Refer to Section 6.3.3 of the report

Failure Mode 3C
Section 1
Pore pressure build-up of 100m

Material Name	Color	Unit Weight (kN/m3)	Strength Type	Cohesion (kPa)	Phi (°)	Shear/Normal Function	Allow Sliding Along Boundary	Ru Value	Grid (Pressure Head)	Phi b (°)	Air Entry Value (kPa)
Ore		18	Mohr-Coulomb	0	32				On	0	0
Colluvium		22	Mohr-Coulomb	0	28				On	0	0
Liner Interface_DU		12	Shear/Normal Function			Liner		0	Off	0	0
Type 2 Bedrock		22	Infinite Strength				Yes	0	Off	0	0
Embankment Fill		21.5	Mohr-Coulomb	0	38.3			0	Off	0	0

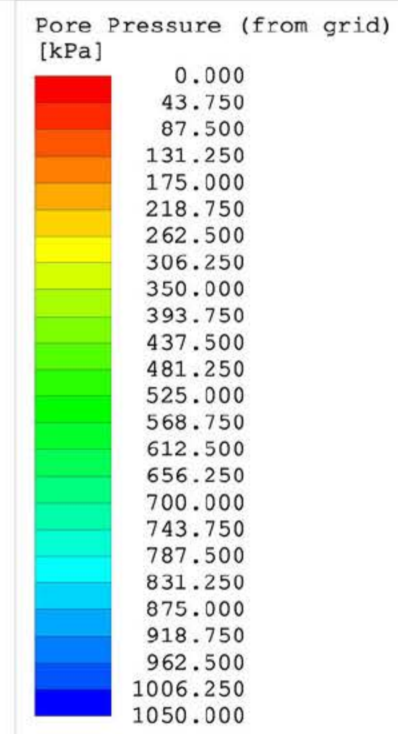


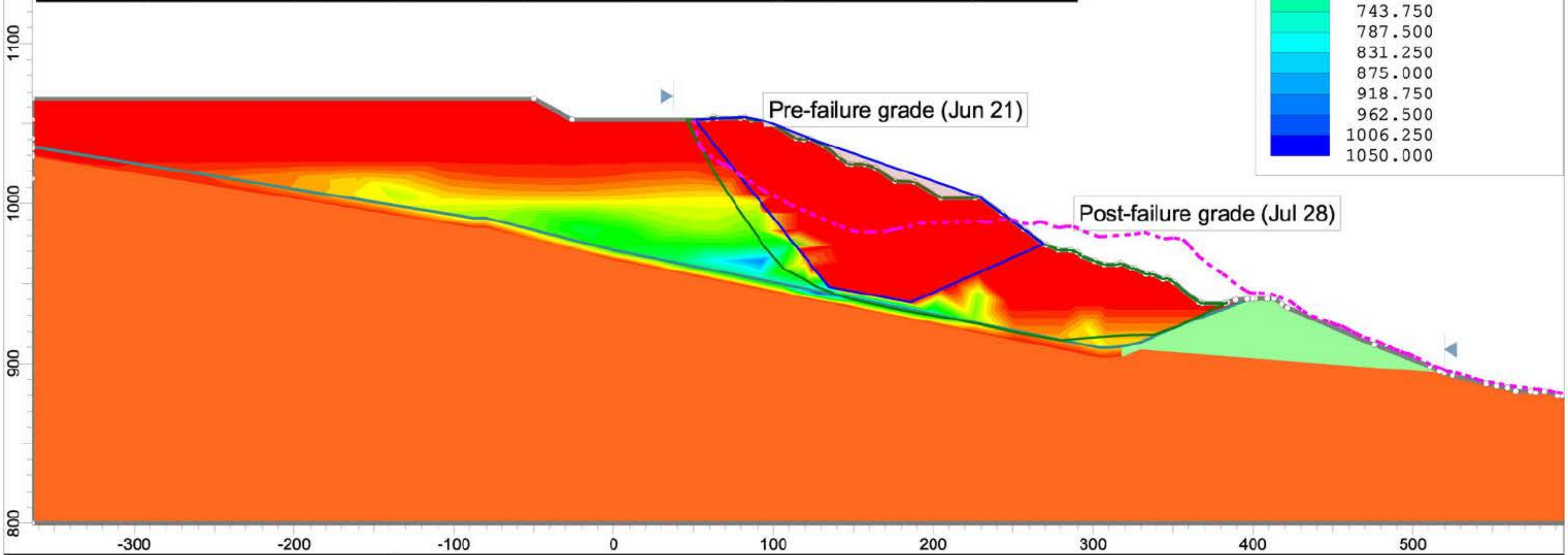
rocscience	*Project* Slide2 - An Interactive Slope Stability Program		
	Group Master/control scenario	*Scenario* impermeable block - 100m	
	Drawn By	*Company*	
SLIDEINTERPRET 9.034	*Date* 7/10/2024, 9:38:19 AM	*File Name* 1-excesspp.slmd	

Refer to Section 6.3.3 of the report

Failure Mode 3C - Section 2 Pore pressure build-up of 85m

Material Name	Color	Unit Weight (kN/m3)	Strength Type	Cohesion (kPa)	Phi (°)	Shear/ Normal Function	Allow Sliding Along Boundary	Ru Value	Grid (Pressure Head)	Phi b (°)	Air Entry Value (kPa)
Ore		18	Mohr-Coulomb	0	32				On	0	0
Colluvium		22	Mohr-Coulomb	0	28				On	0	0
Liner Interface_DU		12	Shear/ Normal Function			Liner		0	Off	0	0
Type 2 Bedrock		22	Infinite Strength				Yes	0	Off	0	0
Embankment Fill		21.5	Mohr-Coulomb	0	38.3			0	Off	0	0





rocscience	*Project* Slide2 - An Interactive Slope Stability Program		
	Group Group 1	*Scenario* impermeable block - 85m	
	Drawn By	*Company*	
SLIDEINTERPRET 9.034	*Date* 7/10/2024, 9:38:19 AM	*File Name* 2-excesspp.slmd	

Refer to Section 6.3.3 of the report

Appendix E Geosynthetic Installation Standards

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GRI-GCL5*

Standard Guide for

"Design Considerations for Geosynthetic Clay Liners (GCLs) in Various Applications"

1. Scope

1.1 This guide covers most major design procedures necessary for the application of geosynthetic clay liners (GCLs) in civil and environmental engineering projects. It describes the major design categories, some suggested parameters for consideration, and the relevant test methods to be utilized. This guide is not all encompassing and is not meant to address unique and/or extreme project specific requirements.

1.2 This guide is intended to aid designers and users of GCLs in establishing the possible adequacy of a candidate GCL to limit fluid migration and remain stable within the structure or system under consideration.

1.3 Units – The values stated in SI units are to be regarded as the standard. No other units of measurement are included in this standard.

1.4 This guide offers a set of instructions for performing one or more specific operations. This document cannot replace specialized education or related experience and must be used in conjunction with professional judgment. Not all aspects of this guide may be applicable in all circumstances. This GRI standard is

*This GRI standard is developed by the Geosynthetic Research Institute through consultation and review by the member organizations. This guide will be reviewed approximately every 2-years, or on an as-required basis. In this regard, it is subject to change at any time. The most recent revision date is the effective version.

not intended to represent or replace the standard-of-care by which the adequacy of given professional services must be judged, nor should this document be applied without consideration of a project's many unique aspects. The word "Standard" in the title of this document means only that the document has been approved according to the GRI adoption process.

1.5 This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.

2. Referenced Documents

2.1 ASTM Standards

- D 4439 Terminology for Geosynthetics
- D 4833 Test Method for Index Puncture of Geomembranes and Related Products
- D 5887 Test Method for Measurement of Index Flux through Saturated Geosynthetic Clay Liner Specimens Using a Flexible Wall Permeameter
- D 5888 Practice for Storage and Handling of Geosynthetic Clay Liners
- D 5889 Practice for Quality Control of Geosynthetic Clay Liners
- D 5890 Test Method for Swell Index of the Clay Mineral Component of Geosynthetic Clay Liners
- D 5891 Test Method for Fluid Loss of the Clay Component of Geosynthetic Clay Liners
- D 6072 Guide for Obtaining Samples of Geosynthetic Clay Liners
- D 6102 Guide for Installation of Geosynthetic Clay Liners
- D 6141 Guide for Screening the Clay Portion of a GCL for Chemical Compatibility to Liquids
- D 6241 Test Method for the Static Puncture Strength of Geosynthetics Using a 50-mm Probe
- D 6243 Test Method for Determining the Internal and Interface Shear Resistance of Geosynthetic Clay Liner by the Direct Shear Method
- D 6495 Guide for Acceptance Testing Requirements for Geosynthetic Clay Liners
- D 6496 Test Method for Determining Average Bonding Peel Strength Between the Top and Bottom Layers of Needle-Punched Geosynthetic Clay Liners
- D 6766 Test Method for Evaluation of Hydraulic Properties of Geosynthetic Clay Liners Permeated with Potentially Incompatible Liquids
- D 6768 Test Method for Tensile Strength of Geosynthetic Clay Liners

2.2 GRI Standard

- GCL3 Specification for Test Methods, Required Properties, and Testing Frequencies of Geosynthetic Clay Liners (GCLs)

2.3 ISO Standards

ISO 10318 Geosynthetics – Terms and Definitions
ISO 12236 Test Method for Geosynthetics Static Puncture Test (CBR Test)

3. Terminology

3.1 Definitions

3.1.1 Geosynthetic Definitions:

3.1.1.1 adhered geosynthetic clay liner (GCL), n—GCL product in which the clay component is bonded to a film or membrane by adhesion.

3.1.1.2 coated GCL, n—GCL product with at least one layer of a synthetic substance applied to the GCL as a fluid and allowed to solidify.

3.1.1.3 geomembrane, n—essentially impermeable geosynthetic composed of one or more synthetic sheets. The common acronym is "GM".

3.1.1.4 geosynthetic clay liner, n—factory manufactured geosynthetic hydraulic barrier consisting of clay supported by geotextiles or geomembranes, or both, that are held together by needling, stitching, or chemical adhesives . The common acronym is "GCL".

Note 1: GCL's are also called geosynthetic barriers-clay (GBR-C). GCL's and GBR-C's are precisely the same type of geosynthetics and the difference is merely terminology.

3.1.1.5 geotextile, n—a permeable geosynthetic comprised entirely of textiles.

3.1.1.6 laminated GCL, n—GCL product with at least one geofilm or geomembrane layer superimposed and bonded to the GCL by an adhesive usually under heat and pressure.

3.1.1.7 multicomponent GCL, n—GCL with an attached geofilm, coating, or relatively thin geomembrane thereby decreasing the hydraulic conductivity or protecting the clay core or both.

3.1.1.8 needle-punched GCL, n—reinforced GCL manufactured using barbed needles that punch fibers from a nonwoven cover geotextile through the clay core and carrier geotextile so as to bond the components together and increase internal shear strength.

Note 2: The carrier (lower) geotextile is generally either a woven slit film geotextile or another nonwoven needlepunched geotextile.

3.1.1.9 reinforced GCL, n—GCL that has discrete fibers, yarns or filaments attaching the upper and lower geotextile to one another so as to increase the internal shear strength.

3.1.1.10 stitch-bonded GCL, n—reinforced GCL manufactured by stitching yarns or threads that are passed through the cover geosynthetic, the clay core, and the carrier geosynthetic to increase the internal shear strength.

Note 3: Stitch bonding creates a directional orientation; therefore, the direction of allowable shear transfer is predetermined.

3.1.1.11 unreinforced GCL, n—GCL that does not have a discrete components (such as needle-punched fibers or stitch-bonded yarns) to increase internal shear strength.

3.1.2 Organizational Definitions

3.1.2.1 installer, n—party who installs, or facilitates installation of, any materials purchased from manufacturers or suppliers.

3.1.2.2 manufacturer, n—group, corporation, partnership, or individual that manufactures a product.

3.1.2.3 purchaser, n—person, company, or organization that purchases materials or work to be performed.

3.1.2.4 supplier, n—party who supplies material or services.

3.1.3 Quality Definitions:

3.1.3.1 quality assurance, QA, n—all those planned or systematic actions performed by the purchaser necessary to provide confidence that a material, product, system, or service will satisfy given needs. For geosynthetics, QA applies to both manufacturing and construction thereby becoming MQA and CQA, respectively.

3.1.3.2 quality control, QC, n—planned system of activities performed by the manufacturer or installer whose purpose is to provide a level of quality that meets the needs of users; also, the use of such a system. For geosynthetics, QC applies to both manufacturing and construction thereby becoming MQC and CQC, respectively.

4. Summary of Guide

4.1 This guide presents many key design criteria that should be addressed for proper hydraulic and mechanical performance of a GCL such as the calculation of leakage rates and shear stability. There are many other issues that will be presented as well. In general, the designer should go beyond this guide into the idiosyncrasies of the product-specific and site-specific considerations. GCLs in this guide are products fabricated using a bentonite clay layer sandwiched between geotextiles (occasionally a laminate or a coating is added to the upper geotextile) or to a geomembranes and are used to limit the movement of fluids and/or gases. Table 1 suggests various applications, with ratings from 1-important to 4-not relevant, and selected criteria that might be applicable for design consideration. In all cases, product-specific and site-specific conditions can, and should, prevail.

4.2 This guide does not address installation criteria, i.e., CQC and CQA. These are independent activities and are invariably site specific. They are performed after the design process is essentially complete. Current standards and or documents are Guide D 6102, Practice D 5889, Guide D 6495, and Specification GRI-GCL3). See also Daniel and Koerner (2007) as well as manufacturers' recommendations on GCL installation issues.

Table 1 – Subjective Ratings for Importance of Various Criteria of Common GCL Applications

Criterion	Landfill Covers	Landfill Base Seals	Dams/Dykes (GCL only)	Waterways (GCL only)	Surface Impoundments (GCL only)	Environmental Protection	Secondary Containment	Waste Covers
Hydraulic Conductivity - GCL - Seam	 1 1	 1 2	 1 1	 1 1	 1 1	 1 1	 1 1	 1 1
Long-term stability - Geotextile - Geofilm or Geomembrane - Bentonite	 1 1 1	 1 1 1	 1 1 1	 1 1 1	 1 1 1	 1 1 1	 1 1 1	 1 1 1
Intimate contact Contaminant flow	3 3	1 1	4 4	4 4	4 4	GCL only: 4; Comp: 1 GCL only: 4; Comp:1	GCL only: 4; Comp: 1 GCL only: 4; Comp:1	
Diffusion	3	1	4	4	4	2	GCL only: 4 Comp: 2	4
Settlement	1	2	3	3	2	3	2	1
Behavior - Freeze/thaw - Dry/wet	 2 1	 4 (1 if not frost protected) 4 (2 if not protected against dry/wet cycles)	 1 1	 1 3	 1 2	 2 2	 1 1	 1 1
Shear - Internal - Interface	 1 1	 1 1	 1 1	 1 1	 1 1	 1 1	 1 1	 1 1
Puncture Resistance - Fine cover - Sandy gravel - Coarse cover	 3 2 1	 Normally covered with geomembrane	 3 2 1	 3 2 1	 3 2 1	 3 2 1	 3 2 1	 3 2 1
Internal Erosion - GT < 250 g/m^2 - GT > 270 g/m^2	 4 4	 3 3	 1 2	 1 2	 1 2	 1 2	 1 2	 1 2
Bearing behavior (installation) 30/60/90 cm Cover Soil thickness	1/2/3	Normally GM covered	1/2/3	1/2/3	1/2/3	1/2/3	1/2/3	1/2/3
Root penetration	1	4	2	2	2	1	1	1

1 – important 2 – project dependent requirement 3 – rarely required 4 – not relevant GM – geomembrane GT – geotextile [Comp = Composite GM/GCL liners]

5. Major GCL Applications

5.1 This guide describes the major issues, as well as selected related design issues, and the various types of GCL tests for the following applications.

Note 4: Multicomponent GCLs might improve the performance over a standard GCLs in a specific application. However, they might only be suitable for short- or mid-term use.

Note 5: A geomembrane overlying a GCL, i.e., a GM/GCL composite, is always an alternative for long-term use in most applications.

5.1.1 Landfill Covers (or Caps) and Remediation Barriers—GCLs are used to inhibit the ingress of water and the escape of fluids and/or gases in the construction of solid or industrial waste facility cover or to cap contaminated soil. The typical confining stress is in the range of 10 and 50 kN/m^2. Hydraulic gradients are typically less than 50.

5.1.2 Landfill Base (or Bottom) Liners—GCLs are used to limit the escape of landfill leachate or gases in the construction of solid waste storage, heap leach pads, and disposal site base liners and to inhibit the ingress of groundwater. Confining stresses vary greatly, e.g., 100 and 1000 kN/m^2. The hydraulic head acting on the GCL in a well performing landfill base liner is usually regulated to be less than 300 mm. Thus, for a typical GCL thickness of 7 to 10 mm, the hydraulic gradient is typically less than 50. That said, conditions vary widely.

5.1.3 Canals, Streams, or Waterways Liners and Surface Impoundments or Ponds—In applications in which a significant water head is maintained, GCLs are generally used in combination with an existing soil barrier or in combination with a geomembrane, i.e., a GM/GCL composite. Under certain conditions they can be used alone. In all cases, the function of the GCL is to reduce seepage through the system thereby reducing water loss from the waterway or storage impoundment. The typical soil stress is less than 50 kN/m^2, however, the head acting on the GCL invariably exceeds 1 m. As a result, the hydraulic gradient is then higher than 100 and can even be 1000, or more, depending on site specific conditions.

5.1.4 Environmental Protection—The function of the GCL in these applications is to inhibit hazardous liquids or constituents resulting from vehicle, railway, or airline incidents from entering a sensitive location in the local environment. A GCL as the sole hydraulic barrier or a GM/GCL composite will often be used. The typical confining stress is in the range of 50 kN/m^2 and the hydraulic gradient is often less than 50.

5.1.5 Secondary Containment—The function of the GCL in this application is to inhibit hazardous liquids or constituents stored in storage tanks, silos or similar containments from entering the local environment. The concern is over leakage or failure of the storage facility which is the primary containment. The typical confining stress is in the range of 25 kN/m^2, whereas the hydraulic gradient is often less than 150.

5.1.6 Covers for Mine Wastes, Tailings, Coal Ash, etc.—Since most residues from mining, incineration and combustion rarely have liner systems beneath them (the notable exception being heap leach mining) emphasis is to be placed on the cover. In this regard, there is similarity with landfill covers in that confining stresses are in the range of 10 to 50 kN/m^2 and the hydraulic gradient is typically less than 50. One notable exception from landfill covers is the enormous size and scale of these waste piles. Another is the regulatory setting which is generally other than an environmental agency.

Note 6: GCL's are regularly used for waterproofing of underground concrete structures but such applications are not the topic of this guide.

6. Significance and Use

6.1 Introduction—GCLs (by themselves or with other geosynthetics and/or soils) must be properly designed in a manner consistent with anticipated field mechanical and hydraulic forces. For example, a GCL will only function properly if hydrated and under a confining stress. This guide suggests the types of analyses and testing required to achieve an acceptable level of field performance. Where minimum design factors-of-safety are recommended, it must be recognized that the designer has the responsibility to adjust the level of performance to reflect the criticality and permeance of the site-specific application.

6.2 Landfill Covers (or Caps)—Figure 1 shows a common usage of GCL within a final cover. Generally a GM/GCL composite will be the barrier, but in some cases, a multicomponent GCL may be used. In this application, the flux rate of fluid leakage through the GCL is influenced by the head of water acting on the GCL and the presence or absence of an overlying geomembrane. Typically, the head should be limited to the thickness of the overlying drainage collection system (in general, less than 300 mm for sand or gravel, and 1 cm for geosynthetic drainage systems). The flux rate of the GCL can be carried out with water as described in Test Method D 5887. The mechanical stability of the GCL is mainly influenced by the slope, the confining stress and the interface friction angle with adjacent layers. Additionally, the performance of the GCL is influenced by the elongation performance of the GCL during differential settlement. Freeze/thaw effects as well as dry/wet effects in this application are dependent on the location's climatic conditions and cover soil type and thickness. Although 1.0 m of soil cover may be sufficient, larger thicknesses may be required to prevent freezing of the bentonite clay component in the GCL. Thicker cover layers also benefit the sealing performance of the GCL; Bouazza (2002). In landfill cover (cap) applications in which the GCL is installed in a composite lining system, for example under a geomembrane, the gas permeability of the GCL is not a critical issue. However, in a GCL-only application, the performance of a GCL as a single clay component must be investigated because of the fact that desiccation of the bentonite can cause an increase of the gas permeation through the GCL; Vangpaisal and Bouazza (2001).

6.3 Landfill Liners—Figure 1 also shows the common usage of a GCL within a landfill base seal beneath the waste mass. In essentially all landfill liner applications, the GCL underlays a geomembrane forming a composite lining system i.e., a GM/GCL composite liner. In this application, the flux rate of fluid leakage through the GCL is influenced by the head of fluid acting on the GCL and the presence or absence of an overlying geomembrane. Essentially all regulations require that the head be limited to the thickness of the leachate collection layer or the leachate detection layer. This is typically 300 mm. In a composite lining system, for example, the flux rate of leachate leakage through the GCL is caused by defects in the geomembrane during installation or cover soil placement. The size and number of defects in the geomembrane is dependent upon good CQC and CQA and the proper design of the protection layer. The flux rate of the GCL can be carried out with water as described in Test Method D 5887 for short-term conditions simulating the initial landfill phase with no or very little waste over the leachate collection system. For the long-term, in many cases, if the GCL meets GRI-GCL3, no other long-term testing is necessary. However, in certain cases it may be necessary to use site-specific leachate as the permeation liquid or an approved synthetic leachate per D 6766. It may not be practical to replicate the hydraulic gradient as well as the confining stress to simulate on-site conditions. A lower confining stress will shorten the test time and yield a conservative result. A U.S. Environmental Protection Agency (EPA) study (Bonaparte, et al., 2002) indicates that GM/GCL composite liners have only nominal leakage (measurably less than geomembranes alone or GM/CCL composite liners) through the primary liners of 279 double lined landfill cells that were evaluated. Additionally, diffusion through the GM/GCL or GCL alone should be considered in design if deemed a concern, e.g., in cases of long lasting hydraulic head or high VOC concentrations, etc. Freeze/thaw effects as well as dry/wet effects are, in this application, only a design issue during the installation phase and are felt not to be an issue once the thickness of cover material over the GCL is greater than the first lift of waste, e.g., 3 to 5 m. The mechanical stability of GCL's is influenced by the slope, normal loads, and the interface friction with adjacent layers. The internal shear strength of reinforced GCLs should be investigated using site-specific conditions and product-specific samples and, perhaps more importantly, the interface shear strengths according to site-specific conditions for both materials above and below the GCL. See Gilbert, et al. (1996) and Fox, et al. (2002). In all cases, the appropriate test method is ASTM D 6243.

6.4 Canals, Streams or Waterways Liners, and Surface Impoundment—The use of a GCL to inhibit water loss in these applications is shown in Figure 2. Since the confining stress is typically low (less than 50 kN/m^2) in these applications, the GCL performance is controlled by the hydraulic head and the subsoil conditions. The hydraulic conductivity of the GCL can generally be carried out using water as described in Test Method D 5887. The leakage rate should be determined by Darcy's Law (per Section 10.1.1) using site-specific conditions. The mechanical stability of the GCL is influenced by the slope, the confining stress, and the interface friction with adjacent layers. Internal shear strength should be considered under the low confined stress applications using ASTM D 6243 under site-specific and product-specific conditions. For projects using a GCL as the only barrier, the erosion stability of the bentonite (during wave action of the water) as well as the bentonite piping (affected by the high hydraulic water head and subsoil conditions) are issues to consider. Freeze/thaw effects must also be considered in areas of concern. Dry/wet effects are a concern when there is intermittent storage, for example, irrigation canals and storm water retention ponds. Roots have been known to grow through GCLs, particularly on side slopes, and thus an ongoing maintenance program should be recommended.

6.5 Environmental Protection—The use of a GCL to inhibit hazardous liquids or constituents resulting from vehicle, railway, or airline traffic from entering a sensitive location in infrastructure applications is shown in Figure 3. Since the confining stress is typically low (less than 50 kN/m^2) in these applications, the GCL performance is controlled by the hydraulic head, which is generally a liquid other than water. The hydraulic conductivity of the GCL should be carried out according to Test Method D 6766 with the site-specific liquid or agreed upon simulated liquids. The mechanical stability of the GCL is influenced by the slope, the confining stress, and the interface friction with adjacent layers and is to be evaluated using ASTM D 6243 under site-specific and product-specific conditions. Freeze/thaw effects as well as dry/wet cycles in these applications are location dependent and often of design concern.

6.6 Secondary Containment—The use of a GCL to provide secondary containment for storage tanks is shown in Figure 4. The function of the GCL in this application is to inhibit any hazardous liquids or constituents leaking from tanks, silos, or similar containments (including pipes) from entering the local environment. Since the confining stress it typically low (less than 50 kN/m^2) in these applications, the GCL performance is controlled by the hydraulic head, which is generally a liquid other than water. The hydraulic conductivity of the GCL should be carried out according to Test Method D 6766 with the site-specific liquid or agreed upon simulated liquid. The stability of the GCL is influenced by the slope, the confining stress, and the interface friction with adjacent layers. Freeze/thaw effects as well as dry/wet cycles in these applications are location dependent and are of design concern. Although project dependent, the GCL can be placed around the perimeter of tanks (proper sealing of the GCL against the tanks is obviously required) or completely under the tanks.

6.7 Covers for Mine Wastes, Tailings, Coal Ash, etc.—At many geographic locations the spoils of mining, combustion and incineration are deposited in huge piles which rarely have liners or liner systems beneath them. As shown in Figure 5 they also are rarely covered. The lack of a cover leads to infiltration of rainfall and snowmelt, as well as surface erosion from water or air. The December 22, 2008 coal flyash spill of the Tennessee Valley Authority in Kingston, Tennessee has prompted concern and activity in covering such sites. GCL's by themselves or GM/GCL composite barriers are being used as waterproofing barriers for such sites. Beyond simply supplying such a barrier, however, regulations vary greatly. Sometimes cover soil is placed directly on a GCL, otherwise a drainage layer can be included in the cross section and then cover soil. In all cases long-term erosion control must be considered. Site-specific conditions will prevail as well as regulatory concerns which are often in other than environmental protection departments. The typical confining stresses are in the range of 10 to 50 kN/m^2. Hydraulic gradients are typically less than 50.

7. Related Considerations

7.1 Manufacturing Quality Control—Practice D 5889 provides guidelines for the manufacturer quality control testing of GCLs to be performed by manufacturers before the GCL is shipped to the project site. The practice provides types and frequency of tests required.

7.2 Acceptance Testing—Guide D 6495 provides guidelines for the acceptance testing and conformance verifications of GCLs to be performed by the CQA engineer for the GCL material. The guide provides types and frequency of tests required.

7.3 Storage and Handling—Guide D 5888 provides guidelines for the proper storage and handling of GCLs received at the job site by the end user.

7.4 Installation Guidelines—Guide D 6102 provides directions for the installation of GCLs under field conditions typically preset in environmental lining applications. Also see Daniel and Koerner (2007) as well as manufacturers literature in this regard.

7.5 Obtaining Samples—Practice D 6072 covers procedures for sampling GCLs for the purpose of laboratory testing.

7.6 Chemical Compatibility—Guide D 6141 suggests procedures and test methods to be used in the evaluation of the ability of the clay portion of the GCL to resist change as a result of exposure to liquids.

8. GCL Strength Properties

8.1 Wide-Width Tensile Strength—GCL's, as a composite material, are occasionally placed under wide-width tensile stress conditions and must be evaluated accordingly. Steep short slopes of canals, ponds and secondary containment facilities are situations where the GCL is contained at the top of slope in an anchor trench and tensile stresses may be imposed along the length of the slope. Based on limit equilibrium there are several models available to determine the induced stresses which must be counterpointed against the GCL's tensile strength as measured in ASTM D 6768. Reduction factors on the GCL's ultimate strength are appropriate to apply; see GRI White Paper #4 (2005). The resulting factor-of-safety is assessed by the designer upon consideration of the criticality and permeance of the situation.

8.2 Internal Shear Strength—GCLs are commonly divided into reinforced and unreinforced types. The reinforced GCLs have fibers, threads or yarns that connect the upper and lower geotextiles that form the two exterior surfaces of the GCL. Therefore, the internal shear strength of GCLs will be greatly influenced by the needled or stitched fibers that penetrate through the thickness of the GCL. In its hydrated state the bentonite itself will offer some, but very limited, shear strength by itself. These various components provide an internal shear strength that can be impacted by the degree of hydration of the clay, the normal load acting on the GCL, the type and amount of fiber reinforcement and the shear strain that has occurred across the thickness of the GCL. Test Method D 6243 measures the simultaneous contribution of all of these internal shear strength components. That said, the cited test method is silent on the essential parameters necessary to properly perform the test. These include, but are not limited to, normal stresses, saturation conditions, liquid type, consolidation time, shearing rate, shearing distance, etc. These (and others) are site-specific conditions and are at the designer's discretion. This section will elaborate on various aspects of internal shear strength.

8.2.1 Bentonite Shear Strength—The clay, in particular, bentonite, that forms the hydraulic barrier component of GCL's has a hydrated shear strength that is influenced by the degree of hydration and the normal loading. The shear strength of hydrated clays has been evaluated by Olson (1974) who produced a series of effective stress failure envelopes. From Olson's work, the lower limit of the effective shear strength of bentonite clay is approximately 35 kPa at a normal load of approximately 275 kPa. This shear strength can be increased by decreasing the percentage of bentonite in the clay but at a cost of increased permeability. At lower normal loads, the degree of hydration increases and the shear strength decreases to zero at no normal load. At somewhat higher normal loads, Daniel, et al. (1993) showed that the drained friction angle of the bentonite clay in GCLs approaches seven degrees. Data is not available at high and very high normal loads and site-specific testing is required for such sites.

8.2.2 Internal Reinforcement Strength—Needled punched fibers or stitched yarns that penetrate through the thickness of a reinforced GCL contribute the major portion of shear strength as the geotextile surfaces move differentially apart. The amount of shear strength added by the reinforcement at low strains may also be influenced by the anchorage or tensioning of the fibers to the geotextiles. The contribution of the reinforcing fibers of reinforced GCLs to the peak shear strength of a GCL is shown in Figure 6. Here the internal total stress peak shear strength data is compared to the effective shear strength of bentonite as determined by Olson, (1974). As expected, the majority of peak shear strength of the GCL is due to the contribution of the reinforcement fibers. This contribution is seen to be significant across the full range of normal loads. Recognizing that the internal shear strength testing of GCL's is intricate and time consuming (see Fox, et al., 2002) the peel strength test is used to evaluate consistency of the reinforcement at frequent intervals. The peel strength of a GCL is evaluated using Test Method D 6496.

8.2.3 Large Strain Internal Shear Strength—Continued shearing of a reinforced GCL beyond its peak stress produces a residual strength; see Figure 7a. The residual strengths are also compared with Olson's effective stress failure envelope for montmorillonite and the peak strength values of a unreinforced GCL; see Figure 7b. Data presented by Scranton (1996) indicates that the residual strength of an unreinforced GCL is from 60 to 100% of the peak strength. The data in Figure 7 clearly show that the shear strength of a reinforced GCL approaches that of an unreinforced GCL at large shear displacements. This was also observed by Gilbert, et al. (1996).

8.2.4 Peak Versus Residual—It is often debated whether to design using the peak strength or the residual strength of a GCL. In this regard, one must consider the type of GCL, the overall system behavior, and the specific conditions under which the GCL will be used. One must also consider the internal strength of the GCL product, the interfaces against its outer surfaces, the interfaces of other adjacent liner components considering both short-term and long-term conditions, and the shear strengths of other liner components in the design. The application will also influence the selection of design strength values. Typically, at lower normal loads, the peak interface strength of a reinforced GCL with adjacent materials is less than the peak internal strength of the GCL. If these materials are sandwiched together to form the sealing system and then subjected to a shear stress, sliding will occur when the applied shear stress exceeds the peak strength of the weakest material or interface. It is likely that once failure is initiated, displacement will continue along that particular slip plane; Thiel (2001) and Marr and Christopher (2004). Design using the lowest peak strength assumes that the peak strength of the interfaces and materials do not change with time.

Note 7: There are several other possible interpretations of selecting design shear strength based on peak, residual, or even large-displacement conditions.

8.2.5 Creep—It is well known that polymeric materials in tension can fail in sustained load creep at lower stresses than their short-term tensile strength. Creep and aging of polymeric materials placed in tension are handled in reinforced soil applications by applying reduction factors to the peak strength of the materials; see GRI White Paper #4 (2005). In the absence of long-term direct shear tests to determine the creep limit of the GCL reinforcement fibers or yarns (that is, the stress level above which the reinforcement will creep to failure within the design life of the project), a creep reduction factor of three has been recommended by Marr and Christopher (2004) based on creep reduction factors normally used for polypropylene (PP) fibers in tension. This value might be somewhat conservative due to anticipated composite bentonite-to-fiber reinforcement interaction that is not present in conventional creep tests used to obtain the stated reduction factor. Published papers by Koerner, et al. (2001), Siebken, et al. (1995), Trauger, et al. (1995) and Zanzinger and Saathoff (2010) have shown that the majority of internal shear displacement occurs during the first 100 h of loading. In this regard, the initial 10 to 30 days after installation is critical. At the GCL landfill cover slope tests in Cincinnati (Scranton, 1996) reinforced GCLs have remained stable with little or no ongoing deformation on slopes as steep as 2H:1V since 1994. This implies a minimum slope stability factor of 1.5 when applied to 3H:1V slopes. Of course, these are at low normal stresses. Unfortunately, there are no similar studies conducted at high normal stresses. The latest study by Müller (2008) states that a GCL with defined resin properties and an antioxidant package of the fibers of a double sided needle-punched nonwoven GCL has a lower limit of functional durability of at least 250 years at 15°C.

8.3 Interface Shear Strengths—In addition to internal shear strength of GCL's, the designer must consider the interfaces between its outer surfaces and the adjacent materials (as well as all other interfaces of other adjacent liner components and their respective shear strengths). In all cases, it is recommended to test product-specific materials to be used in the design and the applying site-specific conditions. The basic test procedure is according to ASTM D 6243. It is important to recognize that this test method is silent on selection of important test variables such as type of liquid, saturation, consolidation time and load, displacement rate, amount of displacement, etc. These are important decisions which will significantly influence the test results.

8.3.1 Shear Strength of Nonreinforced Bentonite GCLs—For those GCLs which have bentonite bonded to a geomembrane, a critical interface will be against or within the bentonite. As mentioned previously if the bentonite is hydrated (as it will be under most situations), the shear strength will vary from approximately zero to seven degrees depending on the normal stress. As such, this type of GCL usually deploys a field placed geomembrane against the exposed surface of the bentonite thereby encapsulating the bentonite between two geomembranes. The encapsulated and relatively dry bentonite has a significantly higher shear strength than when hydrated. In this case emphasis is then transferred to the geomembrane (smooth or textured) surfaces.

8.3.2 Interfaces With Woven Geotextiles—The typical woven geotextile used with GCL's is of the slit (or split) film type. This material with whatever is placed against it must be evaluated for its shearing resistance. Again, site-specific and product-specific conditions must be used in conducting the direct shear test. It is important to communicate the orientation of this woven geotextile, i.e., up or down, to the field installer.

The designer must also assess whether or not hydrated bentonite might extrude through the openings between the filaments of the woven geotextile. Vukelic, et al. (2008) has evaluated this situation in the laboratory and found that the shear strength of the interface can decrease appreciably when hydrated bentonite extrudes through the fabric's openings onto the adjacent material.

8.3.3 Interfaces With Nonwoven Geotextiles—For the nonwoven geotextile component of GCLs, and for those GCL's with nonwoven geotextiles on both upper and lower surfaces, extrusion of hydrated bentonite to the opposing interface(s) is unlikely if the weight of the geotextile(s) is adequate. While at the discretion of the designer, the GRI-GCL3 specification calls for a minimum mass per unit area of nonwoven geotextiles of 200 g/m^2.

9. Stability Evaluations Containing GCL's

9.1 Overview—The conventional method of evaluating the mechanical stability of a mass of soil or solid waste is using limit equilibrium procedures so as to formulate a factor-of-safety (FS) against failure. This includes situations which have GCL's located somewhere within the potentially unstable mass. The concept is embodied in Eq. 1.

$$FS = \sum \frac{Resisting\ Forces\ or\ Moments}{Driving\ Forces\ or\ Moments} \qquad (1)$$

All geotechnical engineering textbooks include information on the background and details of this approach. In the context of performing stability analyses which include geosynthetics (including GCL's), they are considered to be inclusions and very often form critical interfaces resulting in low, or even the lowest, FS-value.

Note 8: Details and procedures of stability analyses are so intricate and involved that it is beyond the scope of this guide. That said, its importance is paramount to the designer who must be properly educated and experienced in order to perform such analyses.

9.2 Stability of Large Masses—Slope stability analyses involving GCL's is necessary when dealing with large masses of materials such as landfills, waste piles, tailings piles, coal ash deposits, etc. While the fundamental factor-of-safety approach is traditional, an explicit formulation is usually not possible and a computer model becomes necessary. See Figure 10 for two very large landfill failures. Standard geotechnical engineering texts cover the situation and they should be used accordingly. For example, see Holtz and Kovacs (1981). It should be noted that the solutions are rarely explicit and a systematic search for the lowest FS-value requires a computer code to be used.

9.3 Stability of Veneer Layers—Relatively thin layers of soils, such as landfills and waste pile covers or leachate collection layers can translate gravitationally and the GCL must be evaluated accordingly. See Figure 11 for these types of slides. Koerner and Soong (2005) give such a procedure (there are others) for a number of possible scenarios. This is a special case of stability wherein an explicit solution for the FS-value is available.

9.4 Computer Codes for Stability Analyses—The most widely used soil stability computer codes often do not have provision for including layers of geosynthetics such as GCL's. While they can be adapted, the newer codes have such provisions. Of course, the designer must have interface shear strength values (internal and both external surfaces for GCL's) available for all interfaces as well as wide-width tension strengths. Reduction factors must be assessed and applied in many situations. The importance of properly determining the geosynthetic strengths (tensile and shear) is illustrated in Koerner and Soong (2000) who evaluated ten large landfill failures. All were translational along some particular geosynthetic interface. Conversely, without geosynthetics in the cross-section the failures were oftentimes rotational within the solid waste mass.

10. GCL Hydraulic Properties

10.1 The flow rate or flux, (q) of fluid movement through a saturated GCL is measured in a flexible permeameter according to ASTM D 5887. The flux is measured under a given normal load. The thickness of the saturated bentonite depends on the normal load and is measured in this test. Knowing the flux and bentonite thickness, the hydraulic conductivity (routinely called permeability) of the bentonite portion of the GCL can be evaluated by using the calculation methods given in D 5887.

10.1.1 GCL Barrier—The flow rate that liquids pass through a GCL can be quantified to evaluate the effectiveness of a GCL barrier system. The flow rate, Q, through a hydrated GCL is conventionally calculated using Darcy's Law as follows:

$$Q = K\,((h + t_{GCL})/t_{GCL})\,A \qquad (2)$$

where:

Q = flow rate or flux, (cm^3/sec)
K = permeability of the bentonite, (cm/sec)
t_{GCL} = effective thickness of the GCL, (cm)
h = height of the liquid above the GCL (cm), and
A = total area (cm^2).

10.1.2 Geomembrane/GCL Composite Barrier—The flow rate through a GM/GCL composite, based on a defect in the geomembrane, is assumed to be similar to a GM/CCL composite for which the following equations have been derived, Giroud (1997).

- Circular Defect, $Q = C_{qo}\, i_{avgo}\, a^{0.1}\, h^{0.9}\, K^{0.74}$ (3)
- Square Defect, $Q = C_{qo}\, i_{avgo}\, a^{0.2}\, h^{0.9}\, K^{0.74}$ (4)
- Infinitely Long Defect, $Q = C_{q4}\, b^{0.1}\, h^{0.45}\, K^{0.87}$ (5)
- Rectangular Defect, $Q = C_{qo}\, i_{avgo}\, b^{0.2}\, h^{0.9}\, K^{0.74} + C_{q4}\, (\mathbf{B} - b)\, b^{0.1}\, h^{0.45}\, K^{0.87}$ (6)

where:

C_{qo} = quality of GCL-geomembrane contact (C_{qogood} = 0.21, C_{qopoor} = 1.15),
i_{avdo} = average hydraulic gradient (dimensionless),
a = area of the defect (m^2)
h = head acting on the liner (m),
K = permeability of the GCL (m/sec),
b = side length of a square defect (m), and
C_{q4} = quality of geomembrane-to-GCL contact for the infinitely long case (C_{g4good} = 0.42, C_{q4poor} = 1.22).

10.1.3 Effects of Confining Stress on Permeability—Increasing confining stress on a porous material, such as highly compressible hydrated sodium bentonite, decreases the hydraulic conductivity as shown in Figure 8. With increasing confining stress, several detrimental aspects of hydrated sodium bentonites can be prevented; the main one being shrinkage of the bentonite creating cracks that would increase the hydraulic conductivity. These effects can occur as a result of dehydration of the bentonite or, for example, high concentrated calcium solutions that are extremely aggressive to sodium bentonite (see Section 10.2). Higher confining stresses mitigate this effect, and the hydraulic conductivity can possibly remain unchanged. In landfill liners beneath a waste mass, GCLs subjected to high confining stresses are felt to be less vulnerable to increases in hydraulic conductivity than GCLs in low confining stress applications, e.g., less than 20 kPa.

10.2 Cation Exchange

10.2.1 If a liquid containing significant electrolytes [for example, potassium (K+), calcium (Ca++), magnesium (Mg++), and aluminum (Al+++) cations] percolates down to and through a GCL, these positively charged cations will preferentially exchange with the sodium (Na+) cation in the bentonite of the as-manufactured GCL. This is referred to as cation exchange. It is somewhat controlled by the role of RMD, the ratio of monovalent to the square root of divalent ions. The phenomenon results in reduced swelling capacity (according to ASTM D 5890) and increased hydraulic conductivity of the bentonite. The higher the charge (or valence) of the cation, the more preferential and readily it will exchange with the Na+ cations within the bentonite structure. It should be recognized that most soils contain an abundance of salts that contain significant concentrations of K+, Ca++, Mg++, or Al+++. The least favorable cations with regard to exchange of Na+ in bentonite are the polyvalent cations. They have a charge of +2 or more.

Note 9: While there are several technical papers on the topic of cation exchange in sodium bentonite GCL's, the studies by Kolstad, et al. (2004, 2006) are quite comprehensive and illustrate the potential seriousness of the situation.

10.2.2 Free available calcium or magnesium from the surrounding soil will produce an ionic exchange within the sodium bentonite of the GCL within a time period of a few years depending upon site-specific conditions. It is, therefore, recommended to investigate closely the ionic content of the cover soil over GCLs, the cover soil thickness, and the type of bentonite for effects on the GCL's hydraulic conductivity.

10.2.3 ASTM Guide D6141 is used as a screening tool for determining the potential for a liquid or soil to impact a GCL insofar as ionic exchange is concerned. In D6141, sodium bentonite is tested for swell index (ASTM D5890) and fluid loss (ASTM D 5891) with a test liquid instead of deionized water. The test liquid is either the site-specific liquid or a synthetic liquid derived from the adjacent soil. Laboratory research by Jo, et al. (2001) has indicated that free swell tests can be a valuable tool for estimating how inorganic aqueous solutions affect the hydraulic conductivity of non-prehydrated GCL's, see Figure 9.

10.2.4 ASTM D 6766 is used to determine GCL long-term hydraulic conductivity when exposed to potentially incompatible liquids. Scenario 1 is used for those cases in which the GCL is expected to be prehydrated with water before exposure to the liquid. Scenario 2 is used for those cases in which the GCL is expected to be exposed to the site-specific liquid without any prehydration.

10.3 Diffusion of Inorganic and Organic Contaminants

10.3.1 Proper assessment of any barrier system containing potentially harmful pollutants requires a contaminant transport assessment of the barrier system, taking into account factors such as the service life of the collection system and the barrier system along with the surrounding hydrogeological setting. Such an analysis can be performed using a contaminant transport analysis program such as POLLUTE (1997). To perform such assessment, transport processes such as advective, diffusion, sorption, and biodegradation must be established for the barrier system of interest.

10.3.2 Diffusion, the movement of contaminants from areas of high concentration to areas of lower concentration, can be a significant transport phenomenon for low-hydraulic conductivity barrier systems such as those used at the base of municipal solid waste landfills. For the solutions that Goodall and Quigley (1977) tested, the GCL diffusion coefficients of inorganic and organic contaminants are equal to or lower than compacted clay liners. These include salt solutions at different concentrations and synthetic municipal solid waste leachate. Of course, there are site-specific conditions such as dry subgrade soils, which must be individually investigated. This suggests that when considering similar thickness barriers such as a 1-m thick compacted clay liner ($k = 10^{-9}$ m/s) versus 0.01-m-thick GCL ($k = 10^{-11}$ m/s) over an existing subgrade soil 0.99 m thick ($k = 5 \times 10^{-9}$ m/s), the diffusion transport will be equal to or better for the GCL system (provided the thickness of the two systems are similar). When considering similar hydration conditions, stress levels, and permeating fluids, the GCLs tested exhibited a linear relationship between final bulk GCL void ratios and diffusion coefficients. Even when a GCL was hydrated under low-stress conditions and subsequently consolidated to a lower final bulk GCL void ratio, it was the bulk GCL void ratio during diffusion testing that controlled the diffusion parameters. Generally, the diffusion coefficient was shown to decrease as the bulk GCL void ratio decreased. The final bulk GCL void ratio significantly affects the diffusion coefficient of the GCL; that is, the higher the void ratio, the higher the diffusion coefficient.

10.3.3 Organic diffusion results from Lake and Rowe (2004) show that the rates of contaminant migration proceeded through the hydrated GCL in the decreasing order of dichloromethane (DCM) > DCA > benzene >

trichloroethane (TCE), and toluene. This was attributed to varying degrees of sorption of DCA, benzene, TCE, and toluene to the geotextile component of the GCL as well as to the bentonite present in the GCL. Diffusion coefficients (Dt) deduced from volative organic compound (VOC) diffusion testing conducted on the GCLs at confining pressures lower than approximately 10 kPa range from approximately 2×10^{-10} m^2/s to 3×10^{-10} m^2/s. Based on the results presented for inorganic contaminants, these are expected to be upper bound values for the GCL with natural sodium bentonite since the bulk void ratio of a GCL installed for field conditions will be lower than that tested in the study. The effect of low temperature on diffusion of toluene through a needle-punched GCL was examined by Rowe, et al. (2007). Generally speaking, the lower temperatures used during testing resulted in lower rates of organic diffusion through the GCL. This influence of temperature can be critical in harsh northern regions as discussed by Li and Li (2001). The hydraulic properties of the GCL can result in a composite subgrade/GCL soil having very little hydraulic flow through the system. Since the diffusive properties of GCLs have been well established, a contaminant transport assessment of the barrier system can be performed to assess the performance of the proposed landfill barrier system and hydrogeologic setting.

11. Additional Design Considerations

11.1 Freeze/Thaw Cycling—The critical property of a hydrated GCLs insofar as freeze-thaw behavior is concerned is the increase in permeability. Daniel, et al. (1997) used a rectangular laboratory flow box and subjected the entire assembly to ten freeze-thaw cycles. The permeability showed a slight increased from 1.5×10^{-9} to 5.5×10^{-9} cm/sec. Kraus, et al. (1997) report no change in flexible wall permeability tests of the specimens evaluated after twenty freeze-thaw cycles. Podgorney and Bennett (2006) examined the long term performance of GCL's exposed to 150 freeze/thaw cycles and found no appreciable increase in permeability.

While the moisture in the bentonite of the GCL can indeed freeze, causing disruption of the soil structure, upon thawing the bentonite is very self-healing and apparently returns to its original state. In this regard, it is fortunate that most GCLs have geotextile or geomembrane coverings so that fugitive soil particles cannot invade the bentonite structure during the expansion cycle. Thus, the bentonite does not become "contaminated" with adjacent soil particles.

11.2 Dry/Wet Cycling—The behavior of dry and wet cycles insofar as a GCL's permeability is concerned is important in many circumstances. This is particularly so when the duration and intensity of the dry cycle is sufficient to cause desiccation of the clay component of the GCL. Boardman and Daniel (1996) evaluated a single, albeit severe, dry-wet cycle on a number of GCLs and found essentially no change in the permeability. Testing by Benson and Meer (2009) indicates that multiple wet-dry cycles, in conjunction with sodium for calcium ion exchange, may adversely affect the hydraulic performance of GCLs.

Perhaps more significant than change in permeability is that shrinkage can case loss of overlap and even separation at the roll edges or ends. If this occurs in the field, friction with the underlying surface will prevent expansion back to the original overlapped condition. Thus cover soil, placed in a timely manner and sufficiently thick to resist shrinkage, is necessary; see Section 11.6 for exposed conditions.

11.3 Puncture and/or Squeezing Resistance—Due to the relative thinness of GCLs compared with CCLs, puncture and/or squeezing resistance concerns are understandably often voiced. There are a number of tests that can be used with GCLs, including ASTM D4833, which uses a 8.0 mm probe; ASTM D6241, which uses a CBR probe of 50 mm diameter; and ISO 12236, which also uses a 50 mm diameter probe. Although all of these tests are straightforward to perform, it is important to recognize the self-healing puncture characteristics of GCLs which contain bentonite. Puncture tests by themselves cannot reproduce this self-sealing mechanism, since the GCL is being used as a hydraulic barrier and puncture per se may not be a defeating, or even limiting, phenomenon.

Lateral squeezing, however, can occur if a nonpuncturing load is stationed on a GCL which has insufficient cover soil. The degree of squeezing is dependent on the bentonite's initial moisture content, the type of GCL and the applied normal stress and duration. Koerner and Narejo (1995) have investigated this situation and found that a minimum of 300 mm of soil cover above a GCL is necessary (U.S. Corps of Engineers use 450 mm) in order to have the potential failure planes be contained in the overlying soil. By so doing, lateral squeezing of the bentonite does not appear to occur.

11.4 Internal Bentonite Erosion—For projects using a GCL by itself, i.e., without an overlying geomembrane, questions regarding the potential for internal bentonite erosion when placed over coarse grained soils or on open structures such as a geonet arise. High hydraulic gradient applications such as ponds and lagoons are of concern in this regard. This is in part because of the nature of the application and in part because GCLs are relatively thin and so large hydraulic gradients may occur if there is a significant head of fluid acting on the liner. Relatively little research has addressed subgrade requirements for GCLs and installation specifications generally report the same conditions for all GCLs. Some work is reported by Fernandes (1989) with modifications as described by Rowe and Orsini (2003) to investigate the GCL internal erosion performance. In general, woven geotextiles on coarse subgrades resulted in bentonite erosion but nonwoven geotextiles did not. This same result occurred with the GCL placed directly over a geonet. However, these results were under controlled laboratory conditions and are only representative for the geotextiles evaluated. Geotextiles with a lower mass per unit area may create higher bentonite internal erosion as one would expect with coarser subgrades or over geonets. Geosynthetics with higher mass per unit area geotextiles are likely to be more protective against erosion. One would also expect this with finer subgrades. Additionally, the effect of the hydraulic gradient needs to be considered in such investigations.

Note 10: The bentonite erosion issue is somewhat mitigated when using a GM/GCL composite or multicomponent GCL instead of a GCL by itself.

11.5 Total Settlement and Differential Settlement—GCL's (as with all geosynthetics in a layered liner system) will often be subjected to total settlement and/or differential settlement. Of the various applications mentioned in Sections 5 and 6, landfill covers and waste covers are of the greatest concern.

Note 11: Depending upon site-specific subgrade conditions any, or all, of the applications of Sections 5 and 6 might be of concern in this regard but likely to a lesser extent than covers.

Typical landfills will settle 10% to 30% of their initial thicknesses, Spikula (1997), and waste piles are anticipated to do likewise. If a GCL is in the cover cross section it will necessarily settle likewise. In this regard, total settlement can probably be accommodated (depending on site-specific conditions like contouring), but differential settlement is of concern.

GCL's have been laboratory evaluated for their performance in an out-of-plane deformation mode thereby simulating differential settlement. LaGatta (1992) used large-scale tanks with deformable bases to measure water breakthrough. Values for different GCL's were from 10 to 15% tensile strain. Koerner, et al. (1996) used large cylinders of 1.0 m diameter to measure tensile failure with results for different GCL's ranging from 15 to 20% tensile strain. Of course, these values must be counterpointed against field anticipated differential settlement which involves estimates of the size, depth, and shape of the anticipated deformation(s). These are, of course, important and difficult design considerations.

11.6 GCL Panel Separation—Geosynthetic clay liner (GCL) panel separation, *when placed beneath an exposed geomembrane (GM)*, has occurred in at least five instances. Separation distances between adjacent panel edges were from 0 to 300 mm except in one extreme case where they were significantly larger, (GRI White Paper #5, 2005). Again it is emphasized that the geomembranes overlying the affected GCLs were exposed to the environment at all times; i.e., from the time of placement until the separation situation was observed (from 2 months to 5 years). This type of GCL panel separation is not envisioned to occur for the more common situation where timely soil cover is placed over a GM/GCL composite liner. The following three mechanisms have been investigated:

- Longitudinal slope tensioning of GCL.
- GCL contraction on relatively flat slopes.
- GCL shrinkage; perhaps accompanied by cyclic wetting and drying; see Thiel and Thiel (2009) and Thiel and Rowe (2010).

Recommendations to avoid or mitigate the effects of GCL panel separation are as follows, GRI White Paper #5 (2005);

- Do not leave the GM/GCL exposed.
- Increase the overlap distance beyond the common value of 150 mm.
- Protect and/or insulate the surface of the exposed geomembrane.
- Heat-tack the GCL panel overlaps, see Thiel and Rowe (2010).
- Use a woven scrim in one of the geotextiles if the GCL has two nonwoven geotextiles associated with it, i.e., if it is a double nonwoven.

11.7 Sodium Modified Bentonite—By far, the largest deposits of sodium bentonite are in Wyoming and North Dakota in north central USA. This is significant since sodium bentonite has an extremely high swell potential resulting in extremely low hydraulic conductivity. It is ideal for waterproofing in many applications, including the manufacture of GCL's. What is readily available, however, is many calcium bentonite deposits. In this regard, the bentonite industry has been successful in treating natural calcium bentonite with a sodium mixture thereby creating a modified sodium bentonite. It is sometimes referred to as a "peptizing" process. This modified sodium bentonite is being used to manufacture GCL's in many worldwide facilities.

A GCL designer should always be aware of the origin of the bentonite used for the specified product. Presently, the major tests used to indirectly assess the quality of the bentonite are swell index via ASTM D5890 and fluid loss via ASTM D5891. Both values are embodied in the GRI-GCL3 specification. Whether these tests are adequate to assure the efficiency and permeance of the sodium modified bentonite is to be determined.

It should be noted that there is presently (2011) several ongoing research efforts in modifying both sodium and calcium bentonites, primarily (but not exclusively) with polymer additives. The goals of these efforts are to reduce cation exchange. Of course, the long-term performance of these polymers needs to be addressed, as well as the environmental impact. If polymers are added they should be noted in the product data sheets.

Note 12: The practice of heat tacking the overlapped GCL edges and ends has been shown to be helpful in mitigating panel separation. It can be done using either hot air or a hot plate.

Research is ongoing in this regard. See Thiel and Rowe (2010).

12. Keywords

13.1 design; GCL; geosynthetic clay liner; internal shear strength; ion exchange; leakage; stability

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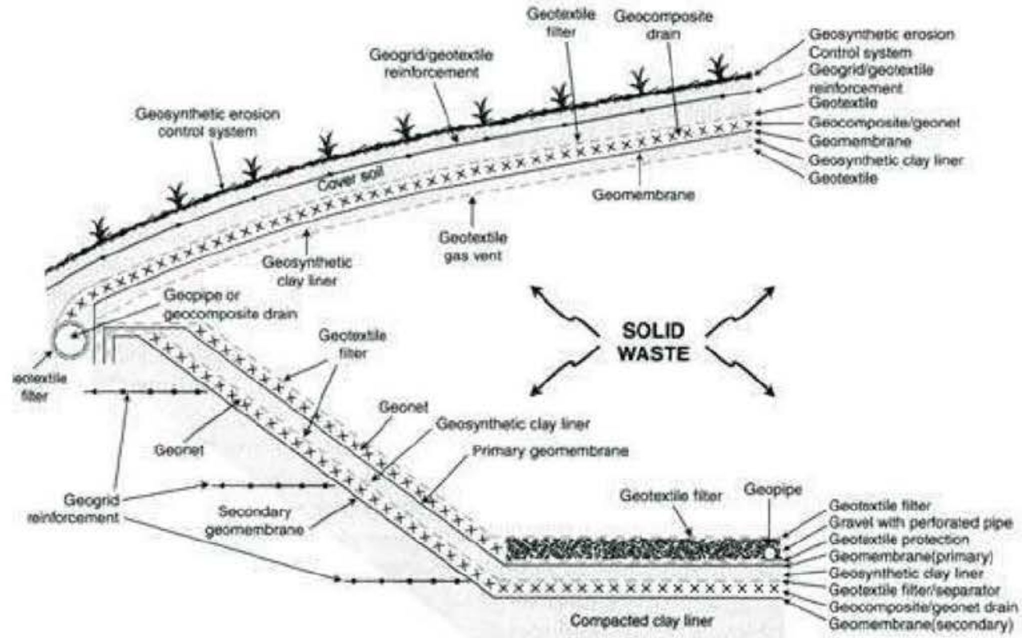


Fig. 1 – Solid Waste Containment System (Cover and Liner) with High Geosynthetic Utilization; Koerner (2005)

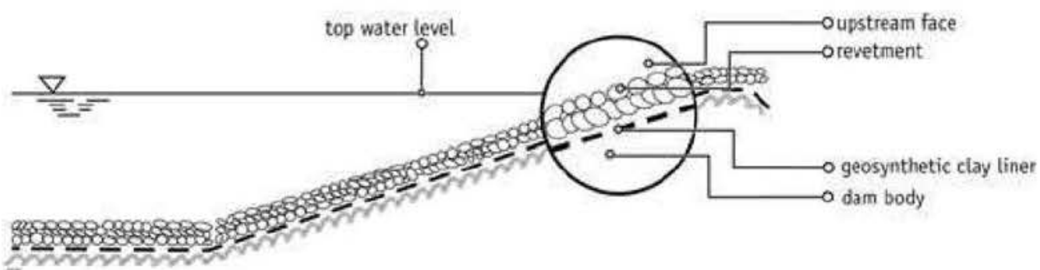


Fig. 2 – Canal Liner System with a Geosynthetic Clay Liner as the Hydraulic Sealing System

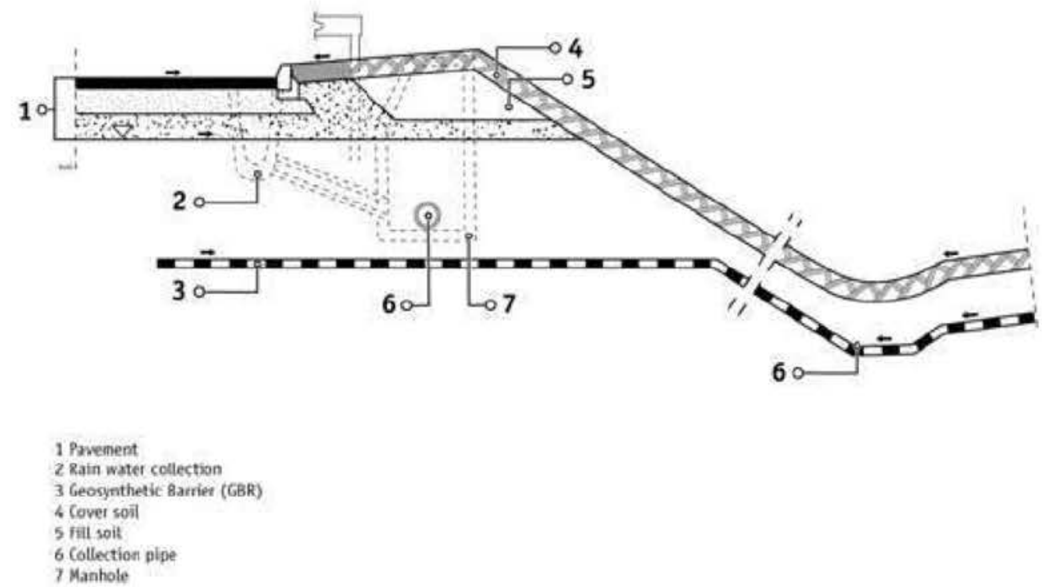


Fig. 3 – Environmental Protection Under a Road by Using a Geosynthetic Clay Liner as Groundwater Protection

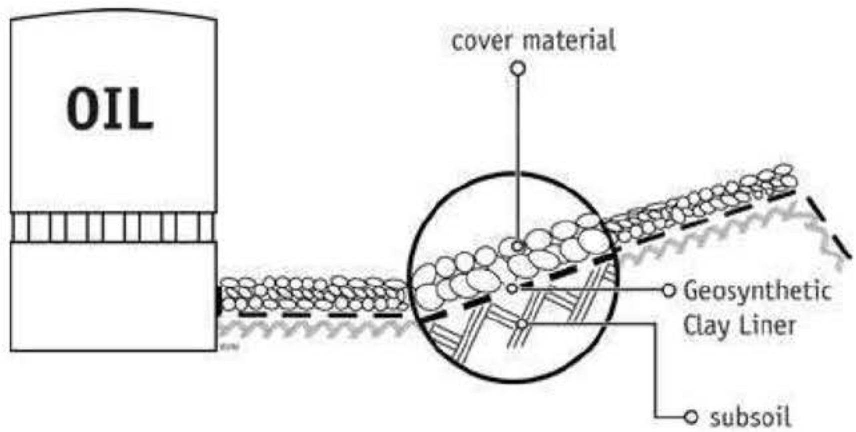


Fig. 4 – Secondary Containment System Using a Geosynthetic Clay Liner

Fig. 5 – Examples of Exposed Mine Waste and Canal Ash (Wikipedia)

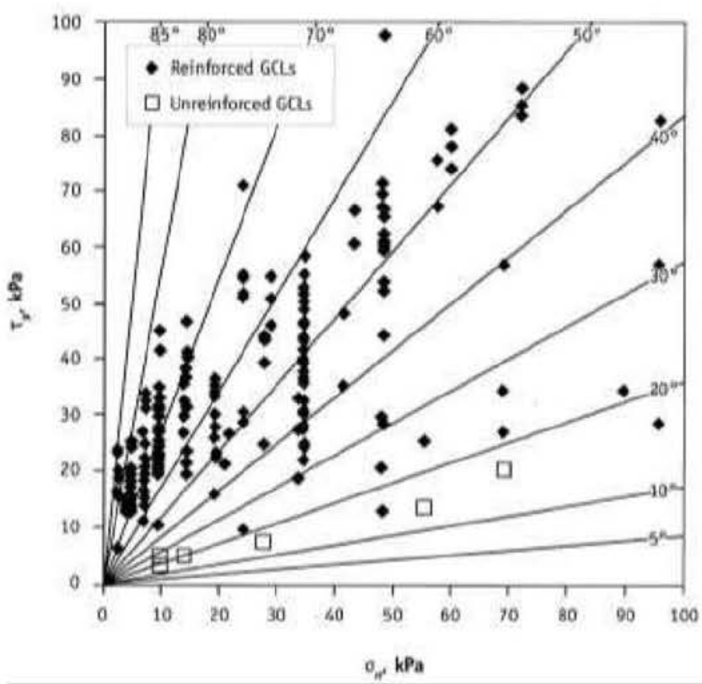
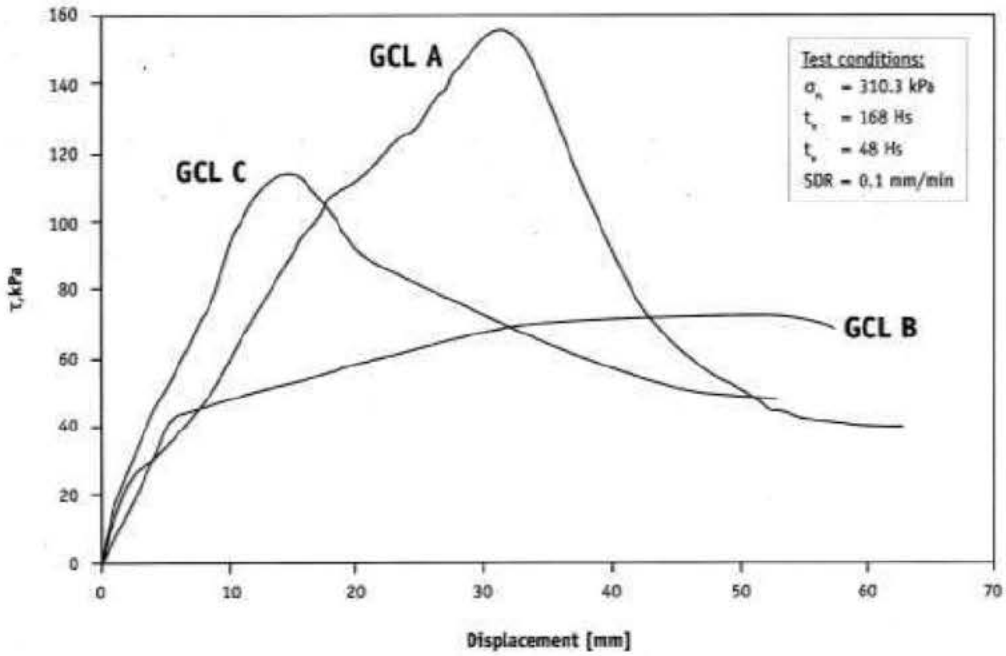
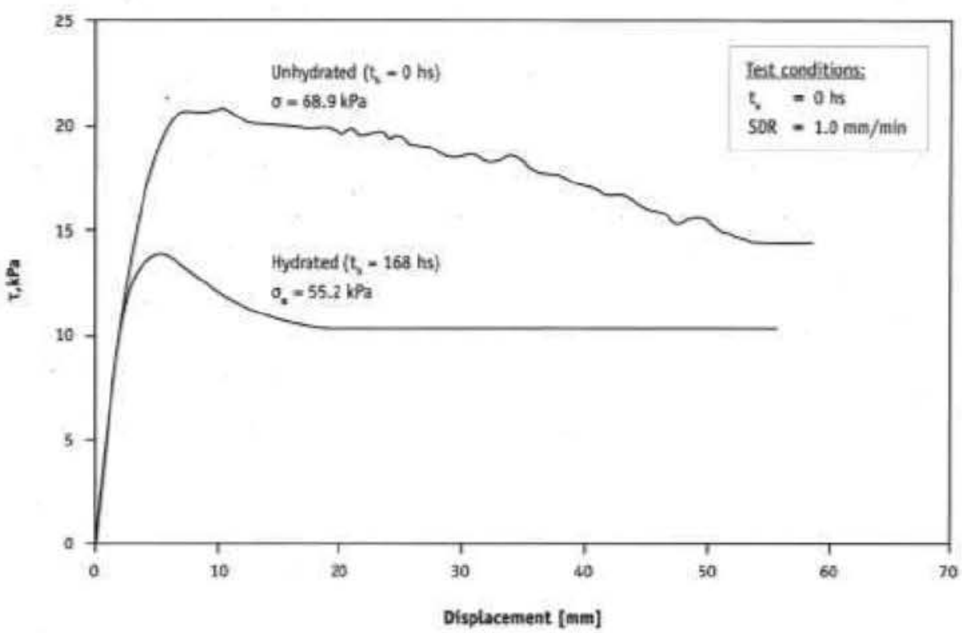


Fig. 6 – Peak Shear Strength Results for Reinforced and Unreinforced Geosynthetic Clay Liners; Zornberg, et al. (2005)



(a) Reinforced GCLs; "A" (needle punched), "B" (stitch bonded), and "C" (thermally locked)



(b) Unreinforced GCL "F"

Fig. 7 – Shear Stress Versus Displacement Curves for Different Reinforced and Unreinforced GCLs; Zornberg, et al. (2005)

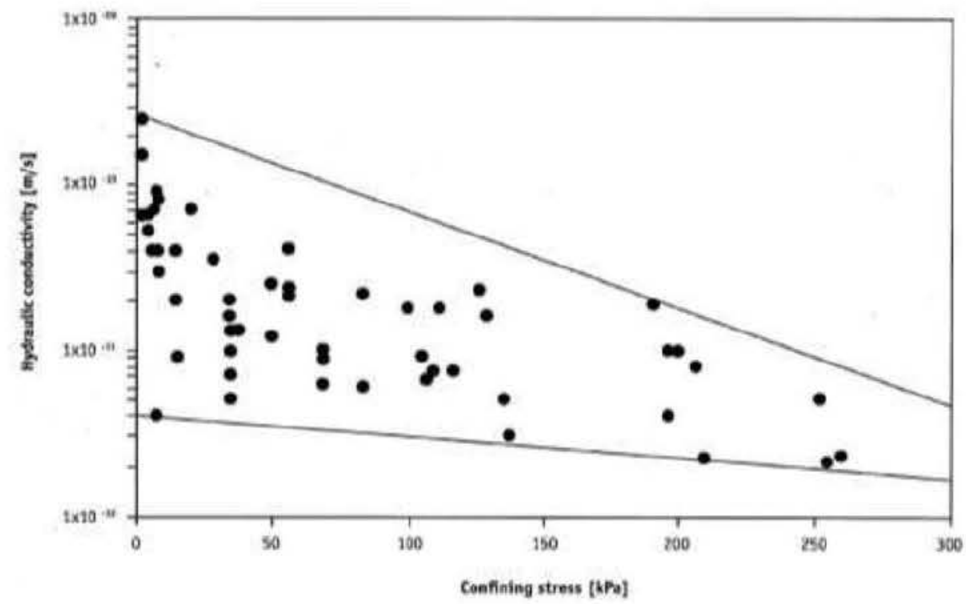


Fig. 8 – Variation of Hydraulic Conductivity Versus Confining Stress; Bouazza (2002)

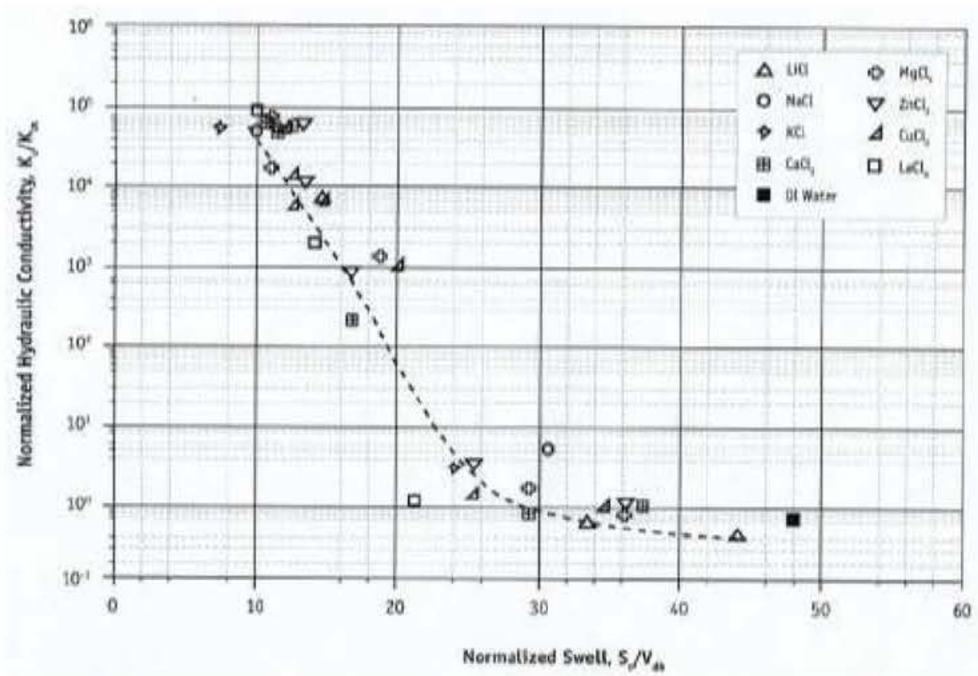
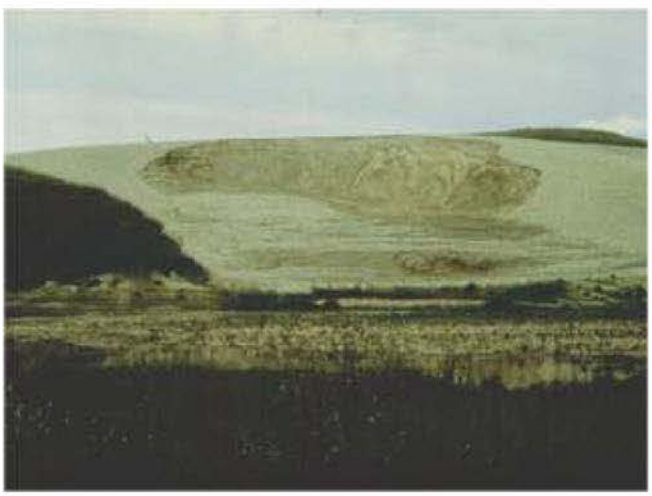


Fig. 9 – Correlation between Normalized Bentonite Free Swell and Hydraulic Conductivity; adapted from Jo, et al. (2001)

(a) Multiple rotational failure (500,000 m^3)

(b) Translational failure (1,000,000 m^3)

Fig. 10 – Two Large Stability Landfill Failures; Koerner and Soong (2000)



(a) Leachate collection slide

(b) Cover soil slide

Fig. 11 – Two Veneer Stability Slides at Landfills; Koerner and Soong (2005)

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GRI Test Method GM9*

Standard Practice for

"Cold Weather Seaming of Geomembranes"

This specification was developed by the Geosynthetic Research Institute (GRI) with the cooperation of the member organizations for general use by the public. It is completely optional in this regard and can be superseded by other existing or new specifications on the subject matter in whole or in part. Neither GRI, the Geosynthetic Institute, nor any of its related institutes, warrant or indemnifies any materials produced according to this specification either at this time or in the future.

1. Scope

1.1 This standard provides guidelines for the field seaming of geomembranes in cold weather. The applicable temperature range of the geomembrane sheet is from 0° to -15°C (32° to 5°F). This practice, however, is not to be considered as all-encompassing since each material and site specific condition presents its own challenges and special conditions.

1.2 This practice is focused on thermal fusion and extrusion fillet seaming methods for the seaming of thermoplastic geomembranes.

1.3 This practice is intended to be a guide for those monitoring geomembrane installations as well as an aid to installers for the seaming of geomembranes in cold climates and conditions.

1.4 This standard may involve hazardous operations, equipment and climates. This standard does not purport to address all of the safety problems associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.

* This GRI standard is developed by the Geosynthetic Research Institute through consultation and review by the member organizations. This specification will be reviewed at least every 2-years, or on an as-required basis. In this regard it is subject to change at any time. The most recent revision date is the effective version.

2. Reference Documents

2.1 ASTM Standards:

2.2 EPA Documents:
EPA/530/SW-91/051, "Inspection Techniques for Fabrication of Geomembrane Field Seams"

EPA/600/R-93/182, "Quality Assurance and Quality Control for Waste Containment Facilities"

3. Terminology

3.1 Definitions of Generic Terms

3.1.1 *geomembrane* - An essentially impermeable geosynthetic composed of one or more synthetic sheets. (ASTM definition)

3.1.2 *destructive tests* - Tests performed on geomembrane samples cut from a field installation or test strip to verify specification performance requirements, e.g., shear and peel tests of geomembrane seams during which the specimens are tested to failure.

3.1.3 *seam shear test* - A destructive test in which two seamed sheets on opposite sides of the seam are pulled in tension placing the seam in a shear mode of stress.

3.1.4 *seam peel test* - A destructive test in which two seamed sheets on the same side of the seam are pulled in tension placing the seam in a tensile mode of stress.

3.1.5 *Construction Quality Control (CQC)* - A planned system of inspections that is used to directly monitor and control the quality of a construction project. Construction quality control is normally performed by the geosynthetics installer and is necessary to achieve quality in the constructed or installed system. Construction quality control (CQC) refers to measures taken by the installer or contractor to determine compliance with the requirements for materials and workmanship as stated in the plans and specifications for the project.

3.1.6 *Construction Quality Assurance (CQA)* - A planned system of activities that provides the owner and permitting agency assurance that the facility was constructed as specified in the design. Construction quality assurance includes inspections, verifications, audits, and evaluations of materials and workmanship necessary to determine and document the quality of the constructed facility. Construction quality assurance (CQA) refers to measures taken by the CQA organization to determine if the installer or contractor is in compliance with the plans and specifications of the project.

3.2 Description of Terms Specific to This Standard

3.2.1 *field seams* - The seaming of geomembrane rolls or panels together in the field making a continuous liner system. Synonymous with *production seams*.

3.2.2 *trial seams* - Trial sections of seamed geomembranes used to establish machine settings of temperature, pressure and travel rate for a specific geomembrane under a specific set of atmospheric conditions for machine-assisted seaming as well as establishing procedures to be correctly used by the installation personnel.

3.2.3 *test strips* - Synonymous with "trial seams".

3.2.4 *test welds* - Synonymous with "trial seams".

3.2.5 *thermal fusion seams* - A seam which involves the temporary, thermally-induced reorganization in the polymer structure at the surface of two opposing geomembrane sheets which, after the application of pressure and the passage of a certain amount of time, results in the two geomembranes being permanently joined together.

3.2.6 *mouse* - Synonymous term for hot wedge, or hot shoe, seaming device.

3.2.7 *extrusion fillet seams* - A seam between two geomembrane sheets achieved by heat-extruding a ribbon of molten polymer over the overlap areas followed by the application of a nominal amount of pressure which results in the two geomembrane sheets being permanently joined together.

3.2.8 *gun* - Synonymous term for hand held extrusion fillet seaming device.

4. Significance and Use

4.1 Most federal and state environmental regulations call for special procedures for field seaming of geomembranes when sheet temperatures are less than 0°C (32°F). This standard practice is meant to give procedural guidance for seaming of geomembranes at sheet temperatures down to -15°C (5°F). Geomembrane seaming at temperatures below -15°C (5°F) is not generally recommended from both material and personnel perspectives.

4.2 The standard is focused on the two main types of thermal seaming methods, thermal fusion and extrusion fillet methods, where trial seam tests and production seam tests can be conducted within minutes after the seam is fabricated.

5. Procedure

5.1 Preparation of the geomembrane surfaces to be seamed:

5.1.1 Seaming is not to take place when it is snowing, sleeting or hailing on the geomembrane in the area to be seamed.

5.1.2 In the area to be seamed, all frost must be removed from the opposing surfaces of the geomembrane sheets in the regions where the actual seaming is to be performed.

5.1.3 The residual moisture left after removing frost must be wiped dry.

Note 1: Perhaps the most difficult surfaces to prepare in this regard are textured geomembranes where the texturing extends to the roll edges or roll ends.

5.1.4 The application of heat to remove moisture using a hand held hot air device can be used providing care against excessive heat application is taken. An assessment using trial seams is recommended.

5.1.5 The specific area to be seamed must be free of soil particles and other foreign matter.

5.1.6 For thermal fusion welding, such as the hot wedge method, the under side of the lower sheet should be free of frost so that the lower drive wheels of the device can move evenly and do not slip.

Note 2: It may be necessary to use a rub sheet beneath the area being seamed to separate the geomembrane from frozen soil subgrade. Various materials have been used for rub sheets including smooth membranes, smooth films and even certain types of geotextiles.

5.1.7 For fillet extrusion welding the thermal tacking of the sheets together should proceed as with similar welding at temperatures above freezing.

5.1.8 Preheating of the geomembrane area to be seamed is common but the amount of preheat and its timing preceding the actual production seaming is at the option of the installer based upon past practice and experience. An assessment using trial seams is recommended.

5.2 Thermal fusion seaming (e.g., using a hot wedge welding device):

5.2.1 In general, the rate of seaming, i.e., the speed of the hot wedge device, is usually slower than when seaming at temperatures above 0°C (32°F). Furthermore, the rate should decrease with decreasing sheet temperature.

5.2.2 Cold temperature seaming requires more frequent trial seams than when welding at temperatures above freezing. For example, if the CQA plan calls for two trial seams a day at temperatures above freezing, the number should be increased by one per day for each 7.5°C (13.5°F) less than freezing. Trial seams should be made at the discretion of the CQA Engineer.

5.2.3 Cold temperature seaming may also require more destructive tests on production seams than when welding above freezing. For example, in addition to the CQA plan written around above freezing temperatures, additional destructive seam samples may be taken at the end(s) of each continuous production seams.

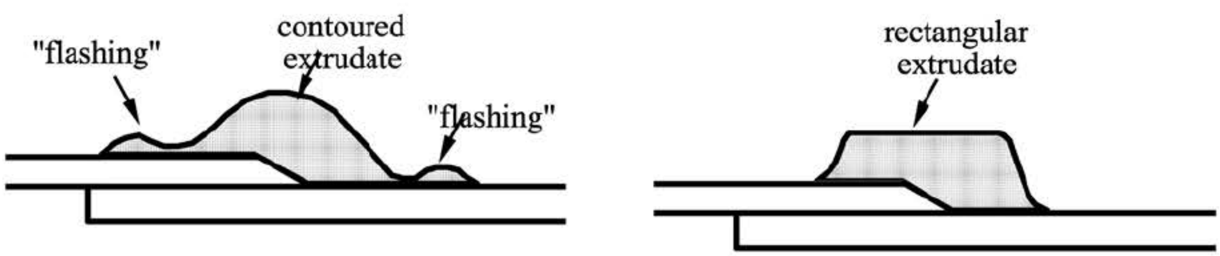
Note 3: The actual schedule for destructive test samples is at the discretion of the CQA Engineer.

5.2.4 Movable enclosures (i.e., tents) traveling along with the welding device and personnel are particularly effective at sites with high wind. Cold temperature, per se, will not demand the use of protective tents. The decision to use tents is that of the installer and CQC personnel.

5.3 Extrusion fillet seaming:

5.3.1 The necessary grinding of the geomembrane surfaces in preparation of placing extrudate should be no further ahead of the extrusion gun than 10 m (30 ft.), or as stated in the CQA plan.

5.3.2 At the discretion of the parties involved, the profile of the base of the extrusion gun barrel is often shaped more rectangularly than when seaming at temperatures above freezing. The reason for this is to minimize the cooling rate in the thinner extrudate regions, see Figure 1.



(a) Typical Cross Section for Temperatures > 0°C

(b) Alternative Cross Section for Temperatures < 0°C

Figure 1 - Extrusion Fillet Patterns

5.3.3 In general, the rate of seaming, i.e., the speed of travel, is slower than when seaming at temperatures above 0° (32°F). Furthermore, the rate should decrease with decreasing sheet temperatures.

5.3.4 Cold temperature seaming requires more frequent trial seams than when welding at temperatures above freezing. For example, if the CQA plan calls for two trial seams a day at temperatures above freezing, the number should be increased by one per day for each 7.5°C (13.5°F) less than freezing. Trial seams should be made at the discretion of the CQA Engineer.

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5.4 Seam Testing

5.4.1 In general, destructive testing of seams (both shear and peel) made in cold temperatures should follow the same protocol and test methods as for temperatures above freezing.

5.4.2 Destructive seam samples for CQA purposes should be taken as described previously and sent to the laboratory for testing at the designated test method conditions for above freezing temperatures.

5.4.3 Seam tests from trial seams can be taken to a field trailer, allowed to equilibrate to the designated test temperature and tested accordingly. However, seam tests from trial seams which are tested with a tensiometer on-site at temperatures less than freezing cannot be compared to geomembrane sheet strengths at room temperature. Numerous invalid results will occur if this procedure is practiced. Instead, the field tensiometer must be used to determine the strength of the unseamed geomembrane sheets at the same temperature as the seam test. The apparent strength will be higher as the temperature of the test specimen decreases. Acceptance of the trial seam is then based on the percentages of sheet strength as prescribed in the CQA plan, e.g., 90% in shear and 62% in peel for HDPE geomembranes.

Note 5: This type of testing whereby the seam test specimen results are compared to a single value of sheet strength is contentious since the value of sheet strength is not statistically reliable. Agreement by the parties involved is necessary.

6. CQA Report

6.1 The report should include hourly temperatures during cold weather seaming which includes the actual temperature of the surface of the geomembrane (using a pyrometer) and the ambient air temperature measured approximately 1 m (3 ft.) above the geomembrane.

6.2 The method of removing frost from the area to be seamed (if any is present), as well as drying and cleaning of the surfaces involved, should be described.

6.3 The condition of the subgrade beneath the area being seamed should be assessed. If a rub sheet is used during the seam process it should be noted.

6.4 Complete identification of the field seaming system used, including material, methods, preheat, seaming rate, use of tents or enclosures and other details of the procedure should be documented.

6.5 The type, nature, number, condition and details of trial seams, as well as the results of such tests, should be detailed.

6.6 The type, nature, number and details of destructive samples and disposition of sections of the sample should be described. Proper identification is required to identify results of CQA laboratory testing in the final as-built plans of the project.

6.7 Any unusual condition with respect to personnel, equipment, sampling and/or testing that may be attributable to the cold weather should be described and documented.